the Mineralogical Record

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KRISTALLE

Wayne and Dona Leicht, 332 Forest Avenue No. 8,
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photo by Harold and Erica Van Pelt, Los Angeles

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July-August 1983
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Articles

Departments

COVER: CHRYSOBERYL sixling twin from Itaguaçu, Espirito Santo, Brazil. The group measures 6.4 cm, and is from the collection of Wayne and Dona Leicht. For some interesting information on the locality see the interview with Allan Caplan in vol. 11, no. 6, p. 357–359. Photo by Harold and Erica Van Pelt, Los Angeles.

notes from the EDITOR

THUMBNAIL COLLECTORS UNITE!

A recent letter from M. L. Metersky announced the formation of the *International Thumbnail Mineral Collectors Club*. A monthly newsletter, silent auction and membership directory are provided to all members. The directory lists each member's individual interests and therefore can serve as an aid in exchanging specimens through the mail; the club has many swappers throughout the U.S., Canada and overseas. The newsletter is devoted to information on collecting sites, shows, exchanges and other subjects of interest to collectors in general.

Dues are $6 per year (North American) and $8 per year (all others). People interested in joining can obtain a sample newsletter, directory page and membership application form by writing to: **Larry Rush** (Treasurer, ITNMC), **P.O. Box 1457, Guilford, CT 06437.**

WHERE ARE THE COLLECTING STORIES?

Almost a year ago we published an item entitled: "Collecting stories: Los Lamentos, Mexico – 1949." This was intended to be the first of a series of collecting stories, and readers were asked to submit similar published or unpublished items for future use. Well, the feature received rave reviews from everyone I spoke with about it . . . but no one has submitted or suggested *any* additional collecting stories. Will this fascinating feature die of neglect?

OUT-OF-PRINT ISSUES

Thomas M. Bee of *Topaz-Mineral Exploration* (1605 Hillcrest, Grand Haven, Michigan 49417) wishes to announce that he is now stocking back issues of the *Mineralogical Record* and has just acquired two complete sets.

It's good to see more dealers becoming active in back issues because this makes it somewhat easier for our subscribers to find those elusive missing numbers. Readers will recall that Sharon Cisneros of *Mineralogical Research Co.* recently announced a major effort in that direction, and Si and Ann Frazier have been dealing in our out-of-print issues for many years.

Other dealers intending to handle out-of-print issues on a regular continuing basis may write to me for a mention in this column, and we will also maintain a listing of such dealers which can be mailed out to interested parties on request. We don't wish to become a clearing-house for everyone with a few issues to sell, but we will accommodate bona fide dealers.

BOOKS STILL NEEDED

My thanks to Richard Hauck and Thomas M. Bee for coming forward with some generous donations of old journals. These really are a big help in the editing and illustrating of the *Mineralogical Record*. There are still many items we can use, however, and donors will be entitled to some tax advantages. We still need:

American Mineralogist, vol. 1–45
The Mineralogist, vol. 1–7 and vol. 31 on
The Mineral Collector, all volumes
Hintze's Handbook, all volumes

And any books, of any age, devoted to mineralogy or mineral localities.

SLIDE COMPETITION

I regret to announce that the annual *Mineralogical Record* slide competition for mineral photography will no longer be held. The administrative aspects became too time-consuming since the competition was held in conjunction with the busy Tucson Show. My thanks to all who have entered in the past, and particularly to Dr. Richard Webster who provided prize money for many years. I trust the competition served its purpose as a stimulus to the improvement in mineral photography skills, and that all mineral photographers will continue to polish their techniques nonetheless. Any photographer who feels he has a particularly fine slide is invited to contribute it or a duplicate to our files; we may well use it in a future article.

By happy coincidence, a *new* photo competition is springing up at the Houston Show this coming September, and readers still have time to enter by the September 12 deadline. The rules are similar to the ones used for our own competition:

1. Amateurs and professionals are eligible.

2. Standard 35-mm slide mounts only, photographer's name marked on the mount.

3. Limit of two slides per entrant.

4. Include stamped, self-addressed envelope.

5. Include separate list showing mineral name and locality, photographer's name, address and phone number.

6. Mail entries in care of Ed Raines, 11902 Queensbury, Houston, Texas 77024.

7. Entries judged on the basis of subject, photographic skill and popular appeal.

8. Entrants agree not to hold the Houston Gem & Mineral Show liable for loss or damage to entries.

First, second and third place awards will be given, and the Mineral Study Section of the Houston Gem & Mineral Society plans to make this an annual event.

NOTICES

Married, Mary Lynn White, long-time Circulation Manager for the *Mineralogical Record,* and Richard Michela, Tucson attorney.

DONOR LIST ADDENDUM

Mitch Abel of *Abel Minerals* donated a fine stibnite to our annual auction and was inadvertently omitted from the published donors list.

LUDLAMITE ERRATUM

I regret to announce that the beautiful ludlamite crystal pictured in Bill Panczner's *Notes from Mexico* column last time (p. 170, Fig. 4) is not "3 inches across" after all. It's 1⅜ inches *tall.* The figure captions for Figures 3 and 4 were inadvertently switched; the data in each caption, other than the sizes, are identical.

New Minerals 1978–1982: a perspective

by **Pete J. Dunn** and **James A. Ferraiolo**
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Smithsonian Institution
Washington, D.C. 20560

INTRODUCTION

Five years ago, the *Mineralogical Record* published a compilation of data on new mineral species described in the five-year period from 1973 through 1977 (Dunn, 1978). At the time certain trends were noted, but it was not possible to ascertain whether or not they were significant because the sample (272 species in five years) was rather small for any statistical study. Accordingly, after another five years, another review and a comparison with the previous period is in order.

PROCEDURES

The data were compiled using the same classifications employed in 1978. For the benefit of *Mineralogical Record* readers who might not have seen the 1978 paper, the criteria used in classifying the data are:

Chemical Composition

The new species are categorized according to anionic group as in the Dana system of mineral classification. Some groupings are made, for example: tellurides and selenides are grouped with sulfides; hydroxides are grouped with oxides; vanadates with arsenates, etc. Several new species belong to several anionic groups; in these cases, the mineral is listed under both. Hence, totals in this section on *chemical composition* will be higher than the total number of species discovered.

Crystal System

The new species are assigned on the basis of their single-crystal X-ray crystallography. In those cases where such data cannot be obtained, but the powder data can be indexed on a given unit cell the symmetry of that cell is used. Those for which no symmetry data can be obtained, or which are amorphous, are listed as "unknown."

Locality

The new species are categorized on the basis of where they were found. For species described from several localities simultaneously, the type locality is used here. (No species were described without noting specific localities in the 1978 through 1982 reporting period.)

Mineral Name

As in previous years, the new mineral species have been named in a variety of ways. The categories used in the 1973–1977 compilation

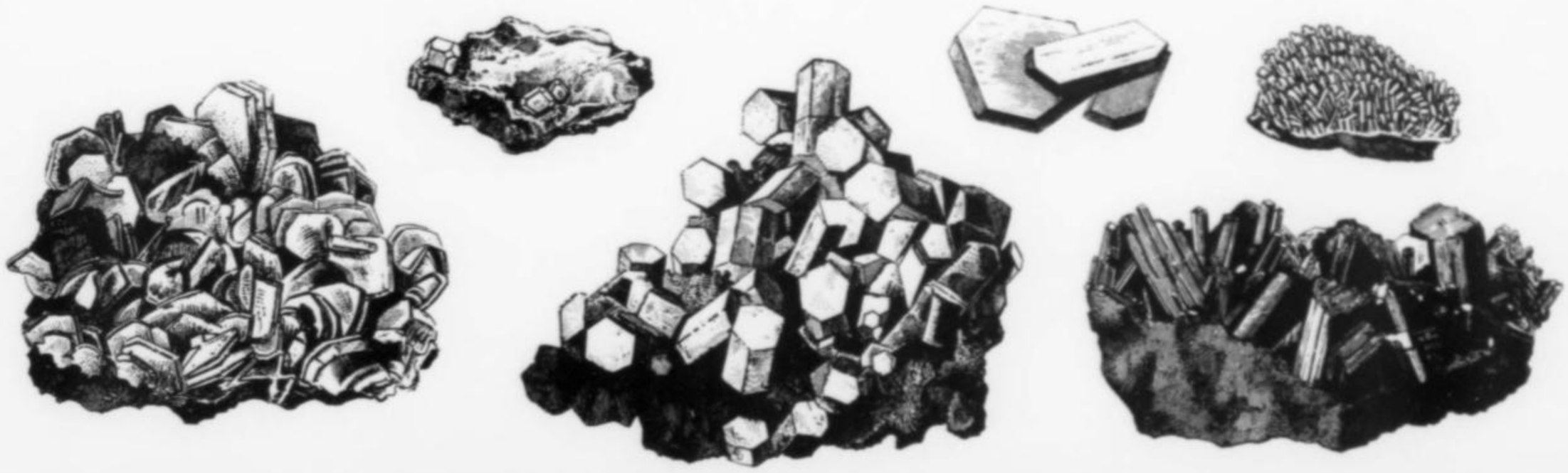

Table 1. **New minerals 1978–1982 arranged by anion group.**

	1978	1979	1980	1981	1982	1978 – 1982 Total	1978 – 1982 Percent	1973 – 1977 Total	1973 – 1977 Percent
Silicates	11	26	13	18	32	100	22	79	29
Phosphates	16	9	6	12	11	54	12	43	16
Arsenates	14	8	16	7	9	54	12	10	4
Sulfates	8	8	8	8	8	40	9	15	5
Tellurates**	4	6	5	1	1	17	4	9	3
Carbonates	7	6	1	9	7	30	6	20	7
Borates	2	2	2	1	3	10	2	6	2
Oxides	12	6	24	6	12	60	13	18	6
Sulfides	12	10	18	5	13	58	12	50	18
Halides	9	3	6	1	2	21	4	7	3
Others	0	3	3	4	7	17	4	19*	7*

* – adjusted for splitting off of tellurates and tellurites.
** – includes tellurates and tellurites.

involved subjective judgments on the part of the author, but were found to be quite satisfactory and they are employed in this compilation as well. They are unchanged from the previous paper (Dunn, 1978) and are:

Person-scientist – Individuals who are or have been employed as scientists.

Person-collector – Mineral collectors and dealers.

Person-other – Other persons such as miners, field assistants, mine managers, etc.

Place – Used when a mineral is named for a place (whether or not the mineral was found in that place).

Composition – Used only when the mineral name was derived *directly and totally* from the words used to represent the chemical elements or the symbols of the elements (examples: zinalsite, zincsilite).

God – Deity of some sort.

Class – A class of people or animals, such as a kingdom, a company, a tribe, etc.

Relationship – Used when the new mineral name relates to another mineral name (examples: clinohumite, ferrotantalite, paradamite).

Characteristic – Used when a mineral name is derived from some characteristic of the mineral, physical or otherwise (examples: pyrargyrite, pyrophyllite).

Other – for the very few left over!

OBSERVATIONS

The first and most remarkable observation to be derived from the new 1978–1982 data is the phenomenal increase in the number of descriptions. The 1978–1982 period witnessed the description of 432 new minerals: an increase of 63 percent over the 272 described in the previous five-year period! This increase suggests the discovery of a new mineral every 4½ days, on the average, over the last five years. The ten-year total (704) is vibrant proof of the growth of the science of mineralogy and, in particular, of the attention being paid to descriptive mineralogy. Perhaps no other discipline can boast of a growth in species of approximately 30 percent in the last ten years.

Chemical Composition

Data for the 432 new species are given in Table 1, together with percentages and comparison with similar data from the 1973–1977 period. In this compilation, we have combined tellurates and tellurites (treated under "others" in the 1973–1977 paper) so as to show the remarkable increase in the number of these rare compounds. There were nine found in the previous period which, combined with the 17 found in this period, increase this rare mineral group by 26. Most of these have resulted from the energetic efforts of Sidney Williams in investigating the secondary minerals at Tombstone, Arizona, and Moctezuma, Sonora, Mexico. Few other conclusions can be drawn from the data. The very substantial increase in oxides (from 18 in 1973–1977 to 60 in 1978–1982) is somewhat enigmatic. Mineral species continue to be found in all the major chemical classes, and in proportions that vary only slightly. The number of elements and alloy minerals has increased from nine in the 1973–1977 compilation to 17 in this period, perhaps reflecting an increased interest in the platinum-group minerals.

Discovery of non-silicate species has increased substantially. There were 193 non-silicate species described in the 1973–1977 reporting period and 332 non-silicate species in the 1978–1982

Table 2. **New minerals 1978–1982 arranged by crystal system.**

	1978	1979	1980	1981	1982	Total	Percent	Other percentages for comparisons 1973–1977 (Dunn, 1978)	Strunz (1970)	Shafranovsky and Feklichev (1982)
Isometric	5	6	18	4	9	42	10	6	12	11.2
Tetragonal	3	6	6	3	4	22	5	7	9	8.5
Hexagonal	14	14	19	15	19	81	19	17	18	17.7
Orthorhombic	16	14	19	18	26	93	21	29	22	23.4
Monoclinic	28	30	28	21	26	133	31	30	31	30.8
Triclinic	12	12	9	4	10	47	11	6	8	8.4
Unknown *	2	2	3	1	6	14	3	5		
Total	80	84	102	66	100	432	100	100	100	100.0

* – Those species for which the crystal system could not be determined, some of which are amorphous.

period, for a sum of 525. This represents 75 percent of all new discoveries and is an indication of the abundance of non-silicate minerals yet undiscovered. This increase of 525 non-silicate species represents an approximate 31 percent increase in non-silicates in just 10 years.

Crystal System

Data for the 432 new species are presented in Table 2. The new data are compared with those for the 1973–1977 period, those published by Strunz (1970), and a new compilation by Shafranovsky and Feklichev (1982). There is little information to be obtained from these data except to say that Father Nature continues to make crystals most abundantly in the orthorhombic and monoclinic crystal systems.

Locality

Table 3 presents a tabulation of the countries wherein the most new mineral species were found. Several trends are very obvious. First of all, the USSR has firmly taken the lead: 103 new minerals were discovered from the USSR, compared with only 59 from the U.S. in this five-year period. The number found in the U.S. (59) is only slightly lower than the 61 found in the previous five-year period. This quantum leap in Soviet discoveries appears to reflect a higher degree of funding for descriptive mineralogy in the USSR than was previously the case, together with more attention being given to rare minerals in the light of their sometimes uncommon physical properties.

Of the United States, only two States, Arizona and New Jersey, both richly endowed with mineralogical resources, produced new minerals in each of the last five years. Their contributions (New Jersey 13 and Arizona 14) comprise approximately half of the U.S. total. The 13 countries listed in Table 3 contributed 79 percent of the 432 new species. Those noted with an asterisk contributed

Table 3. **Countries in which the most new minerals occurred during 1978–1982.**

Country	Total number of species during 5-year period	Percentage of 5-year total	Percentage in 1973–1977
Australia	16	4	5
Canada	20	5	6
China	22	5	*
Czechoslovakia	3	1	3
France	12	3	3
Germany	26	6	4
Japan	13	3	7
Italy	19	4	3
Mexico	10	2	3
Namibia	20	4	3
USSR	103	24	15
USA	59	14	22
Zaire	17	4	*
Total	340	79	74

* – not included in 1973–1977 study as a separate category.

species in nine of the last ten years, indicating that they have localities which are continuing as producers of new species. There were four new species found in meteorites (compared to one in the 1973–1977 period), but none of these derived from the recent meteorite finds in the Antarctic.

Mineral Names

The 432 new species are arranged in Table 4 according to the way

Table 4. **New minerals 1978–1982 arranged to show the way they were named.**

	1978	1979	1980	1981	1982	Sum	%	% 1973 –1977
Scientist	30	28	28	25	29	150	35	40
Collector	10	7	3	2	4	26	6	10
Person-other	3	10	3	2	6	24	6	4
Place	20	22	27	20	33	122	28	26
Composition	3	4	11	6	9	33	7	8
God	0	0	0	0	0	0	0	2
Class	1	2	5	4	1	13	3	2
Relationship	12	10	10	6	14	52	12	6
Characteristic	1	0	3	1	3	8	2	0
Other	0	1	2	0	1	4	1	2
Total	80	84	102	66	100	432	100	100

they were named. As in the previous five-year period, the percentage of species named for scientists and localities stays fairly constant, with minor fluctuations from year to year. The percentage named for collectors has decreased in this recent five-year period from 10 percent to 6 percent. A possible explanation may lie in the fact that the Soviet scientists have an overwhelming tendency to use scientists' names and locality names. Because they have described 24 percent of the species in this 5-year period, their influence on these numbers is significant. Most USSR species are described by Soviet mineralogists.

The one significant difference in the way minerals are now being named lies in the two-fold increase in the number of minerals being named in allusion to their relationship to already known species. Of all the minerals described in the last five years, 12 percent were named in this manner, which has significant advantages in communicating information concerning the mineral. The rich tradition of diversity in the naming of minerals continues.

SUMMARY

The growth of new mineral species is increasing at a substantial rate. The average of 86 species per year in the last five years suggests that a period of great growth in mineralogy is here. Ten years ago, some dared to predict that someday there would be 3000 mineral species. With that figures nearly surpassed, some dare to suggest that we might attain 4000. Given the present growth rate, that number may be only 10 years away. Onward! There are wonderful minerals yet to be found!

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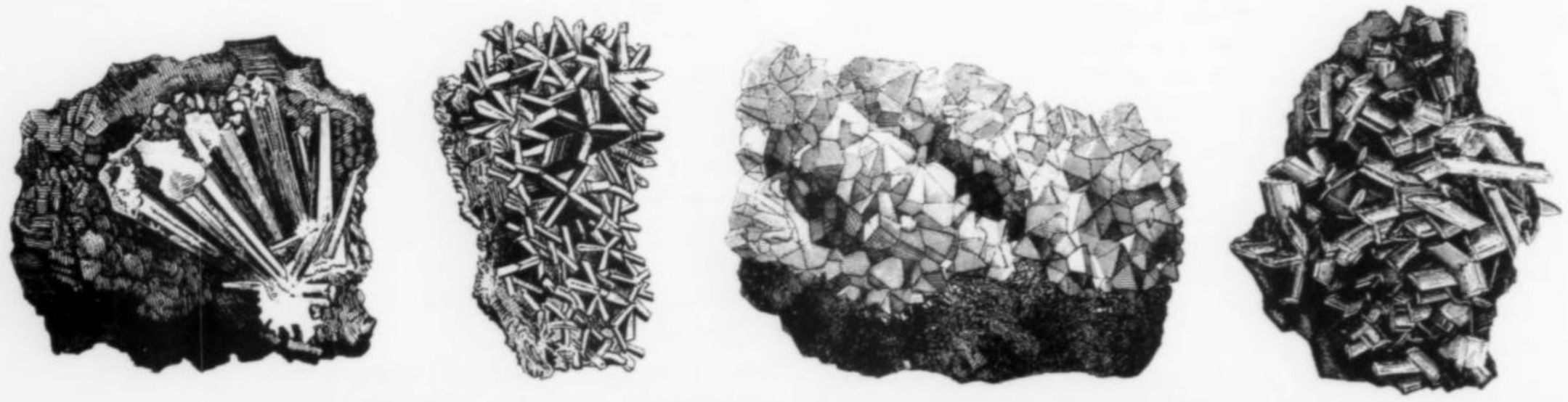

Specimen drawings from J. G. Heck (1851) Iconographic Encyclopaedia of Science, Literature and Art. 573 p.

a new Stolzite occurrence: broken hill, australia

by **Scott K. G. Bywater**
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Seaview Downs
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Stolzite, the tetragonal form of $PbWO_4$, is a rare and very handsome species avidly sought after by advanced collectors. The Broken Hill orebody yielded fine, very large crystals of stolzite years ago, but these are now virtually unobtainable. A new discovery, made in June of 1982, brought more crystals to light from a different part of the lode. Although much smaller in size they equal in perfection of form the "classic" old-time specimens.

PREVIOUS FINDS

Stolzite has previously been recorded from two portions of the Broken Hill oxidized zone. The Broken Hill Proprietary Company's pit, stretching for 1 km in a north-south direction across Blocks (mineral leases) 10–12, has been the source of some of the world's finest and largest crystals of stolzite (Ed. note: see also Foord and Conklin, 1982, for the best Tsumeb stolzite.) The highly oxidized portion of this cut yielded superb lemon-yellow to orange-brown tetragonal crystals occasionally reaching 2.5 cm in size, standing up on a leached, ferruginous gossan. Stolzite from this mine was occasionally seen overlying or associated with its earlier-formed dimorph, raspite.

In 1930 a second, less attractive form of stolzite was encountered in the lower oxidized portion (172-meter level) of the South mine in section Cc. The crystals are seated on altered sulfides (galena/sphalerite) or "psilomelane" and consist of opaque, smoke-gray pyramidal crystals reaching up to 12 mm in size and associated with smithsonite and cerussite (Smith, 1926).

Five distinct habits have previously been noted for stolzite from Broken Hill:

1. Short, straw-yellow, tetragonal tablets.

2. Short, thick, smoke-gray prisms with flat pyramidal terminations.

3. Large, tabular crystals light brown or fawn in color, to 13 mm in size.

4. Brilliant yellow, tetragonal "octahedrons" with a marked vitreous luster.

5. Large red-brown tetragonal "octahedrons." The largest and most solid variety, reaching 2.5 cm.

NEW OCCURRENCE

The new stolzite occurrence comes from a small and shallow extension of Blackwood's pit, which is exploiting a small block of highly oxidized ore near the center of Block 14. The crystals were found adjacent to the main shaft area east wall, about 10 meters below the surface, in a small (50 by 50 cm) lenticular pod of siliceous gossan carrying oxidized ore. Identification was made using energy-dispersive X-ray analysis (only lead and tungsten were detected).

The stolzite crystals occur in four assemblages, crystallized pyromorphite always being the initial gossan coating:

1. Perched atop or interpenetrating green, yellow or orange pyromorphite; situated typically on a ferruginous and kaolinized siltstone.

2. Interpenetrant with silky cerussite crystals or very typically embedded in a very thin layer of white crystalline cerussite.

3. As crystals deposited directly on a thin layer of amorphous coronadite overlying a compact gossan.

4. Rarely associated (never in contact) with small twinned anglesite crystals.

CRYSTALLOGRAPHY

The recently found stolzite occurs in a myriad of habits; however, three forms are most characteristic: ultra-thin tetragonal tablets, tetragonal "octahedrons," and (most commonly) simple tetragonal dipyramids. Although the largest crystals only reach 3 mm in size, nearly the entire batch of crystals is beautifully well-formed, most being perfectly transparent and highly lustrous. Relative to habit, the color of the new stolzites is reasonably consistent:

HABIT	*COLOR*	*LUSTER*
1. Tetragonal "octahedral"	Light orange	Vitreous
2. Tetragonal dipyramidal	Orange	Vitreous/resinous
3. Thin tabular	Orange	Vitreous
4. Tetragonal tabular	Straw-yellow to light brown	Vitreous

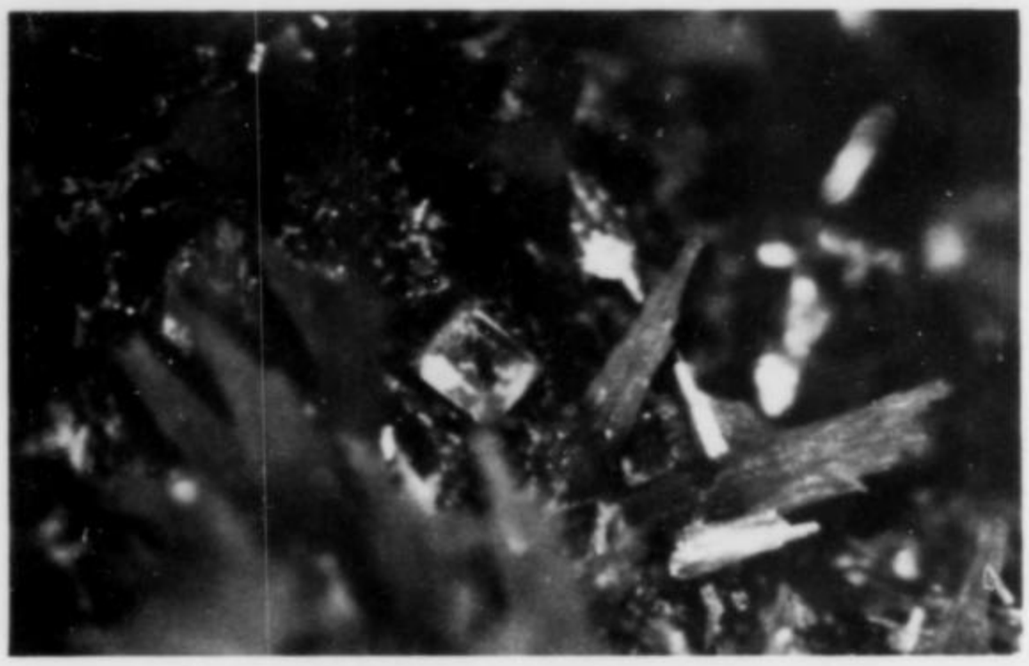

Figure 1. **Stolzite on pyromorphite; the crystal is 1 mm across. Author's specimen and photo.**

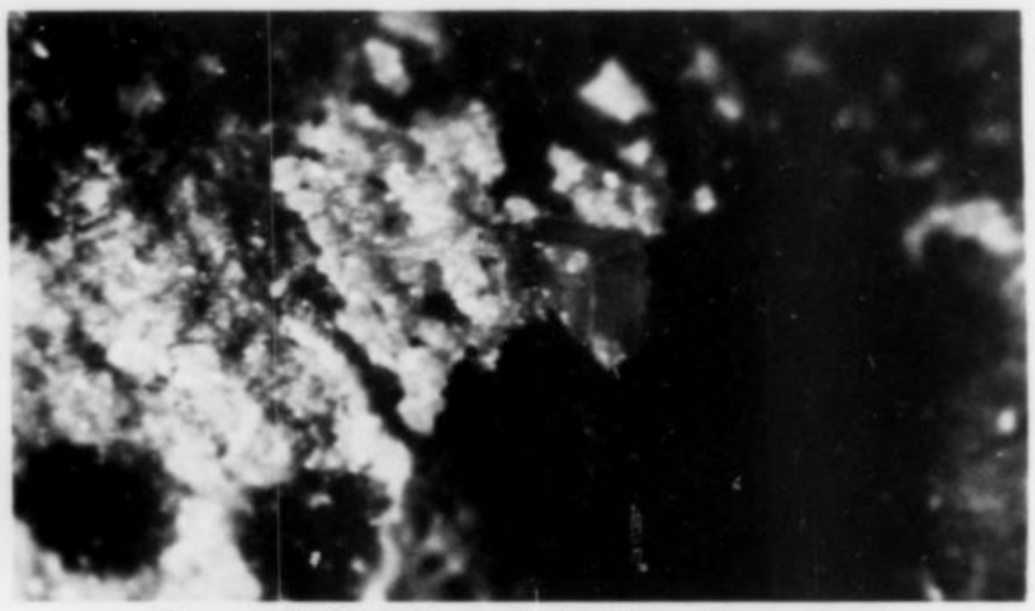

Figure 2. **Stolzite embedded in fine-grained cerussite; the crystal is 1 mm across. Author's specimen and photograph.**

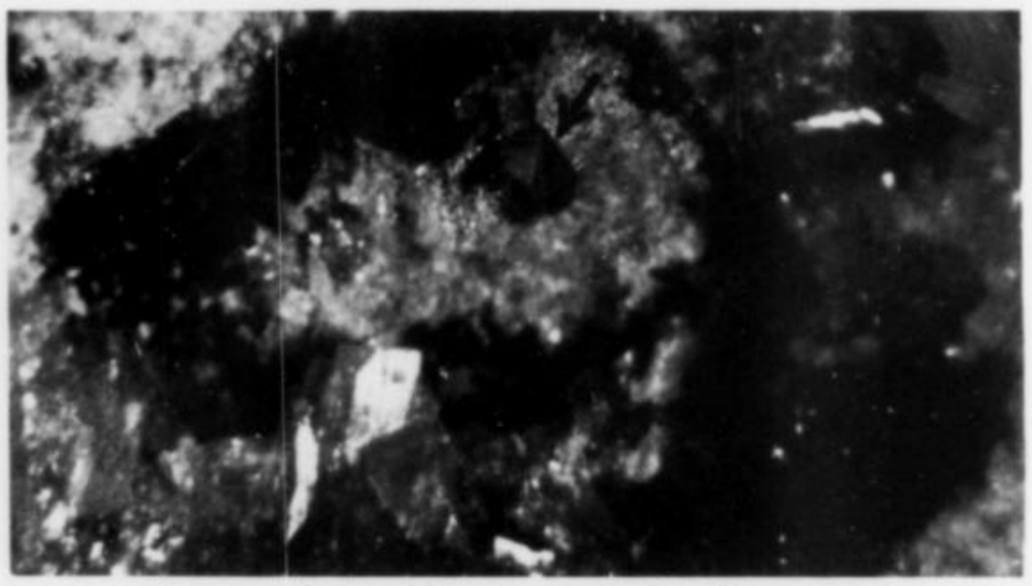

Figure 4. **Stolzite (arrow) in fine-grained cerussite with pyromorphite; the crystal is 1 mm across. Author's specimen and photograph.**

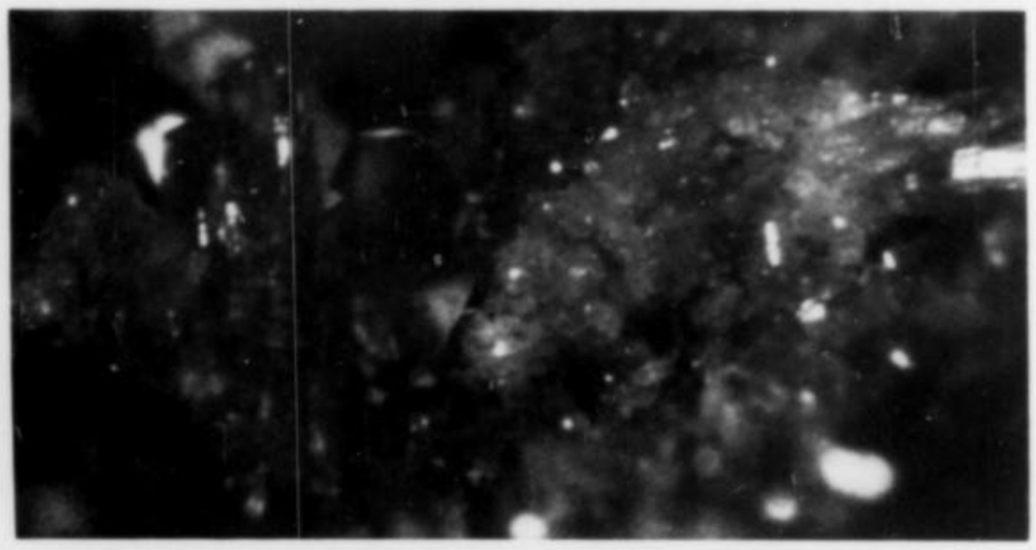

Figure 5. **Stolzite in contact with cerussite and pyromorphite; the crystal is 1.5 mm across. Author's specimen and photograph.**

Figure 3. **Stolzite encrusting a thin layer of coronadite with pyromorphite; the crystals are both 3 mm across. Author's specimen and photograph.**

BEST SPECIMENS

Although many of the specimens are not outwardly handsome, upon slight magnification both the stolzite crystals and the associated minerals become breathtakingly beautiful. Two specimens taken from Block 14 stand out from the rest. The first measures about 6 x 10 cm and consists of compact gossan overlain with a thin coating of coronadite. In the middle of this specimen lie two separate groups of two 3-mm, thin tabular, light brown, lustrous stolzite crystals. This specimen is unique in that it is almost devoid of associated minerals. The second specimen measures 8 x 20 cm and contains 118 crystals (most less than 1 mm) with several brilliant yellow tetragonal tablets up to 3 mm, and many orange tablets and dipyramids to 2 mm. This specimen contains a badly broken crystal about 6 mm on an edge. The quantity of crystals from this small pit was seemingly limited to about 450–500 (although mining operations must have removed many); scouring of the adjacent mineralized areas brought no further crystals or similar ore associations to light.

ACKNOWLEDGMENTS

The author is indebted to Bill Birch (curator, Department of Mineralogy and Petrology, National Museum of Victoria) and Ralph Segnit (CSIRO, Division of Mineral Chemistry) who carried out qualitative determinations on the crystals.

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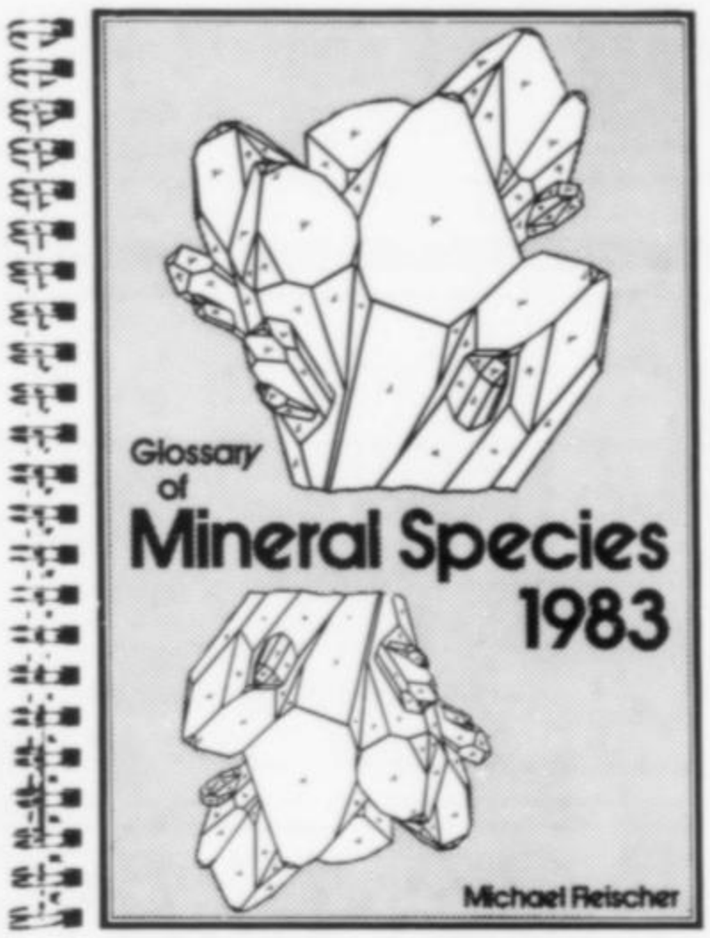

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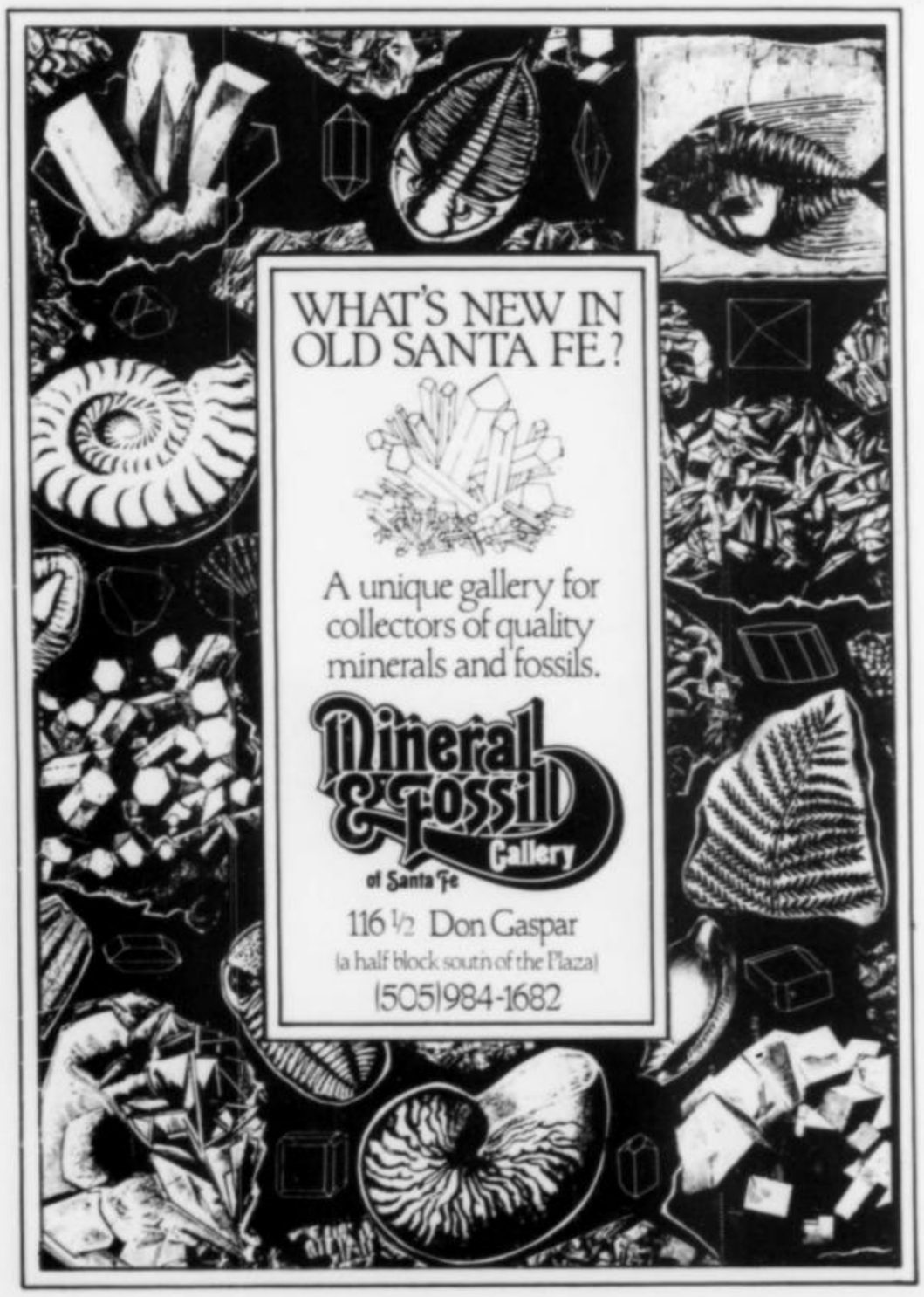

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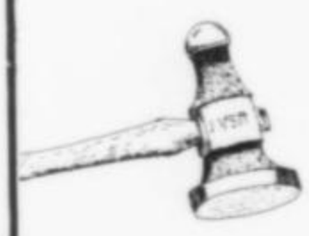

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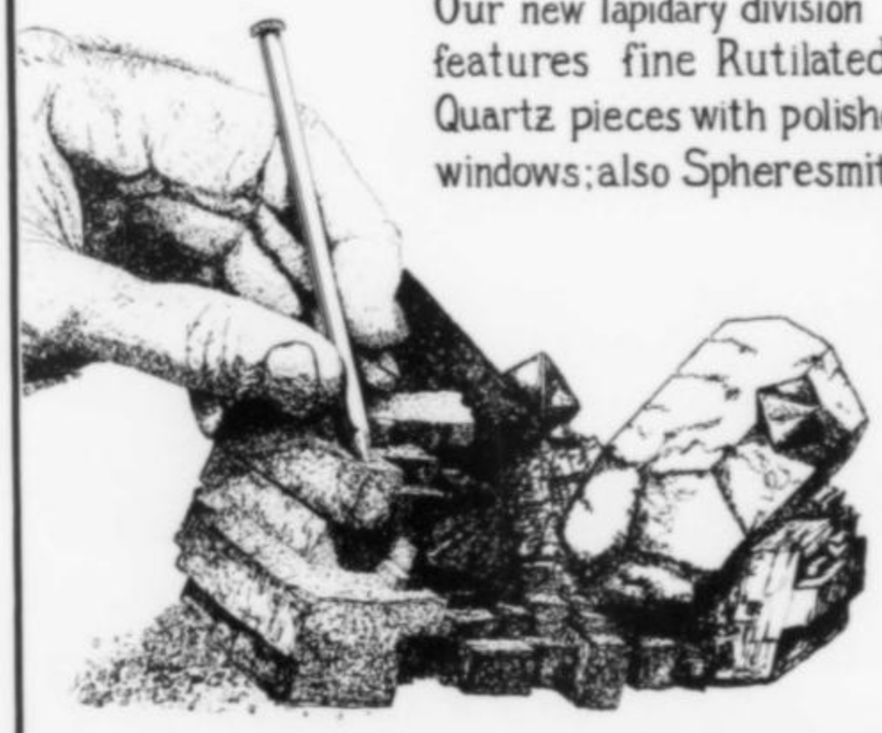

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Copper Country Microminerals

by **Dan Behnke**
2981 Landwehr Road
Northbrook, Illinois 60062

Michigan's Copper Country has yielded thousands of fine specimens over the years. Though large crystals have become increasingly difficult to acquire since the closing of most of the mines in 1969, microminerals can still be collected at many mine dumps.

INTRODUCTION

Evidence of primitive mining activities by prehistoric Indians led early explorers to the native copper deposits of western Upper Michigan, but it wasn't until about 1844 that the first serious commercial mining began. Large scale mining continued until about 1969 when nearly all of the mines closed down, although some exploratory work is still going on. The last major, currently operating mine is the White Pine mine in Ontonagon County at the southwest end of the district.

The great native copper belt of Upper Michigan occurs in a series of rocks made up of interbedded lava flows and conglomerates known as the Portage Lake lava series. The belt is from 2 to 4 miles wide and 100 miles long. It begins in Ontonagon County, continues northeast through Houghton County, out onto the Keweenaw Peninsula, past Copper Harbor to the point of the peninsula and, continuing northeast under Lake Superior, it can be traced into Canada. Copper has been mined on Isle Royale, now a National Park, which lies in northwestern Lake Superior.

Native copper deposits occur in sedimentary and volcanic rocks in fissures, amygdules, and conglomerates. Conglomerates are compacted and cemented gravels of widely varying grain size. The conglomerate deposits alternate with amydaloidal basalt flows. The fissure deposits are veins of copper which may either strike across, or lie parallel to, the beds of basalt or conglomerate. The major lodes or mines in the district were designated as amygdaloidal or conglomerate based on the type of deposit they contained. Basically, there is little variation in the nature of the minerals found in the mines along the belt. The majority of the ore was native copper with a few sulfide and arsenide deposits of economic importance.

Microminerals are found in all three types of deposits, in vugs and fractures in the basalt, in the calcite, prehnite and quartz veins, or in the interstitial spaces in the conglomerate. Also, some fine microcrystals can be obtained by dissolving some of the massive calcite or the calcite crystals in vugs.

Almost the entire area is dotted with mine dumps, some of which are easily visible and some hidden by overgrowth. Most contain microminerals. Locating specific mines can, at times, be problematical but maps contained in pamphlets are readily available in local

Figure 1. **Sign near the location of the Minesota mine, Rockland, Ontonagon County, Michigan.**

rock and souvenir shops, especially in Keweenaw and Houghton Counties. A stop at the A. E. Seaman Mineral Museum at Michigan Technological University in Houghton is always helpful. The major mine dumps located in populated areas may be fenced, posted and patrolled, but those in outlying areas are accessible. Going underground is strictly forbidden and care should be taken

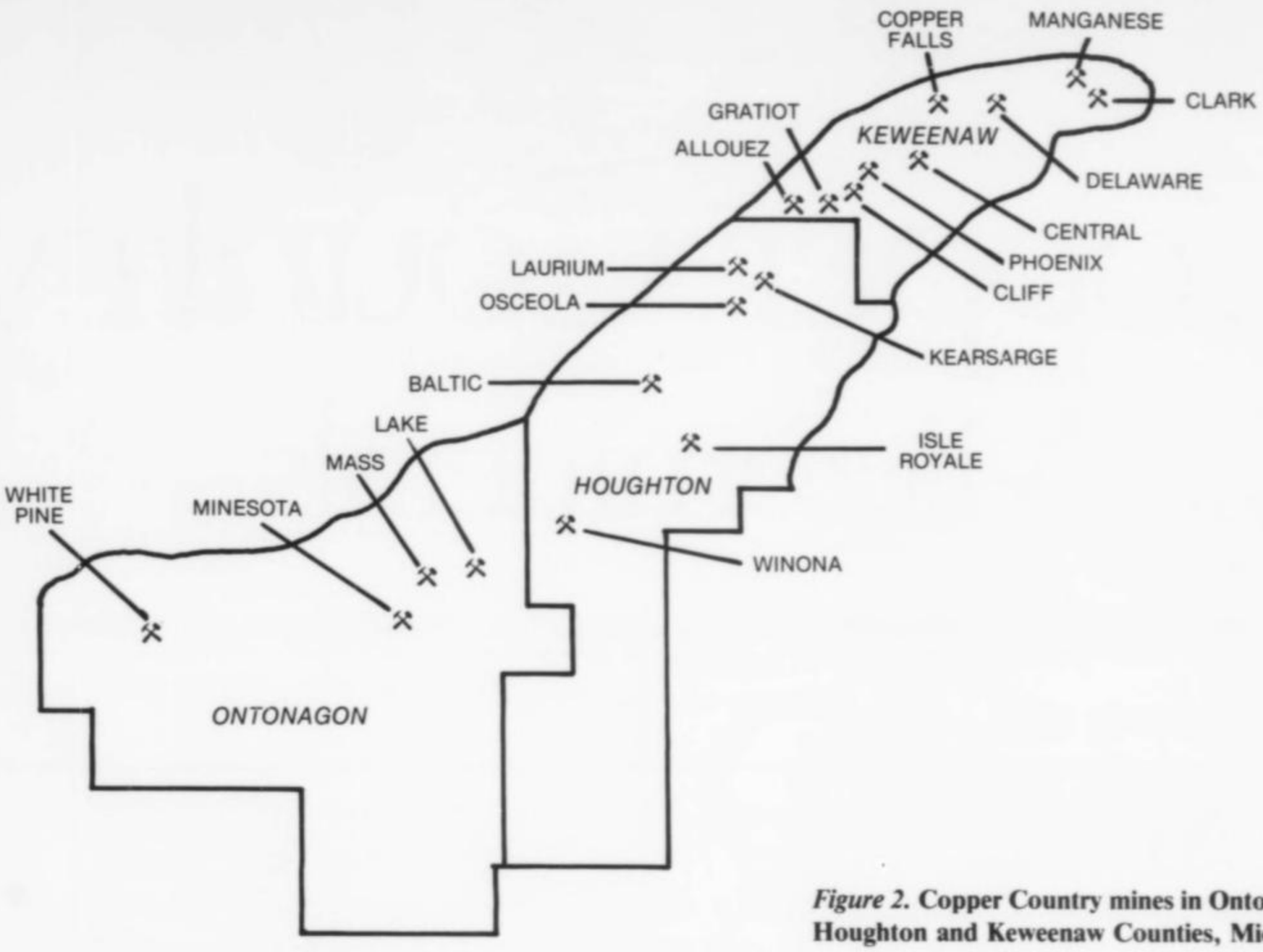


Figure 2. **Copper Country mines in Ontonagon, Houghton and Keweenaw Counties, Michigan.**

when exploring forested areas because open shafts may be hidden by leaves and other debris.

The most popular sport of some collectors is hunting chunks of native copper and silver on the dumps with metal detectors but there are a number of people who collect material for micromin-erals. There is little to offer in between these extremes aside from lapidary material (such as datolite) because hand-sized specimens of other minerals found on the dumps are badly weathered or are rare-ly available because of the limited current mining activity. All sizes of copper and silver specimens are available from dealers throughout the area; from time to time, other species become available as old collections appear on the market.

MICROMINERALS

There are probably over 50 species of micro-size mentioned in the limited micromineral-related literature on the area. I have about 30 species in my collection from 20 different mines, most of which I have acquired by collecting and swapping. The micros are usually very small and many require magnification up to 80x, but collectors who are willing to break open a lot of rock and examine each piece under the microscope will be rewarded with a nice representative collection. As additional collectors become interested I am sure that previously unreported species will come to light.

Copper microcrystals occur widespread in simple and complex forms varying from perfect cubes, octahedrons, dodecahedrons and tetrahexahedrons to flattened plates, wires, arborescent groups and clusters of intergrown modified forms. One crystal which ap-peared at first to be a distorted octahedron proved, upon further examination, to be a six-sided spinel-twin of copper having the aspect of a triangular pyramid.

Copper also occurs as inclusions in a wide variety of other species including calcite, quartz, datolite, analcime, prehnite, adularia, apophyllite and natrolite. Some localities are noted for crystals con-taining inclusions. I have a particularly attractive specimen of a single perfect copper crystal measuring about 0.1 mm included in a clear quartz crystal from the Cliff mine. Arborescent groups of microcrystals of copper from the Osceola mine have been leached out of a stilbite matrix.

While I have nice copper crystals from about nine mines, the best have come from the Clark mine near Copper Harbor, at the tip of the Keweenaw Peninsula, where mining operations date back to the early 1850's. The directions to the mine site are posted in the town of Copper Harbor as a tourist attraction so the dumps are pretty well packed down, but their size allows easy and productive collect-ing.

Native silver micros are fairly rare and occur in complex crystal forms, sometimes attached to copper crystals as "halfbreeds." Silver crystals are easily recognized because of their whitish metallic luster which contrasts with the usually dull and sometimes oxidized sur-faces of the copper crystals. The silver crystals do not always occur in vugs but must sometimes be leached out of the matrix, resulting in thin lacy networks of silver as well as single well-formed crystals. Examples in my collection came from the Osceola mine. A most striking micro is a halfbreed made up of a pyramidal silver spear piercing a copper crystal.

Epidote and pumpellyite are probably the two most commonly occurring species throughout the area. Epidote is found ranging from crude, opaque, lime-green to green translucent to very fine transparent, deep green crystals. It is most commonly found with pumpellyite, copper, quartz and adularia. Crystal habit, color and quality of individual crystals vary from mine to mine. The crystals which are thick to thin tabular are often so intergrown that it is dif-ficult to separate single crystals. I have some very nice single crystals from the Cliff mine and from the Kearsarge Lode where it occurs with quartz and fine prismatic brushes of pumpellyite.

Pumpellyite forms a series with ferropumpellyite and with

Figure 3. **Remains of the pump house of the Delaware mine, Delaware, Keweenaw County, Michigan.**

Figure 4. **Remains of the hoist house of the Delaware mine. Guided mine tours are available at the Delaware mine.**

julgoldite, and is closely related to the epidote family. It is green to bluish green and forms as intergrown prismatic brushes and radiating groups of prismatic crystals. A botryoidal variety filling cavities is known locally as *chlorastrolite,* a term which is usually reserved for the compact gemstone variety. Because of its abundance, attractive crystals of pumpellyite are rather easy to find. I have nice radiating clusters from the Delaware, Clark, Gratiot and Cliff mines, and some prismatic groups from the Kearsarge Lode.

In a single piece of material from the Clark mine, I found groups of dark greenish black, bladed crystals about 0.17 mm tall which, under X-ray analysis, proved to the julgoldite, the iron analog of pumpellyite. Julgoldite was described by Moore as a new mineral from Långban, Sweden in 1967 and was later reported from two localities in Scotland. It has also been found on inesite at the Hale Creek mine, Trinity County, California (Pemberton, 1982). However, to my knowledge, it has not been reported from the Upper Peninsula before. It occurs as sprays of bladed crystals in tiny vugs associated with copper.

Adularia, a variety of orthoclase, is another commonly occurring mineral. Found as cavity fillings, it may be associated with epidote, pumpellyite, saponite and chlorite. Although adularia may be found as single crystals, most of the crystals in vugs are so tightly packed that only the tips or edges of the crystals are visible. The colors are white, pink and orange. Some are translucent, but most are opaque with a pearly luster. Adularia from the Mass mine contains copper inclusions.

The secondary copper minerals malachite and cuprite are found associated with copper crystals in vugs in quartz or prehnite matrix

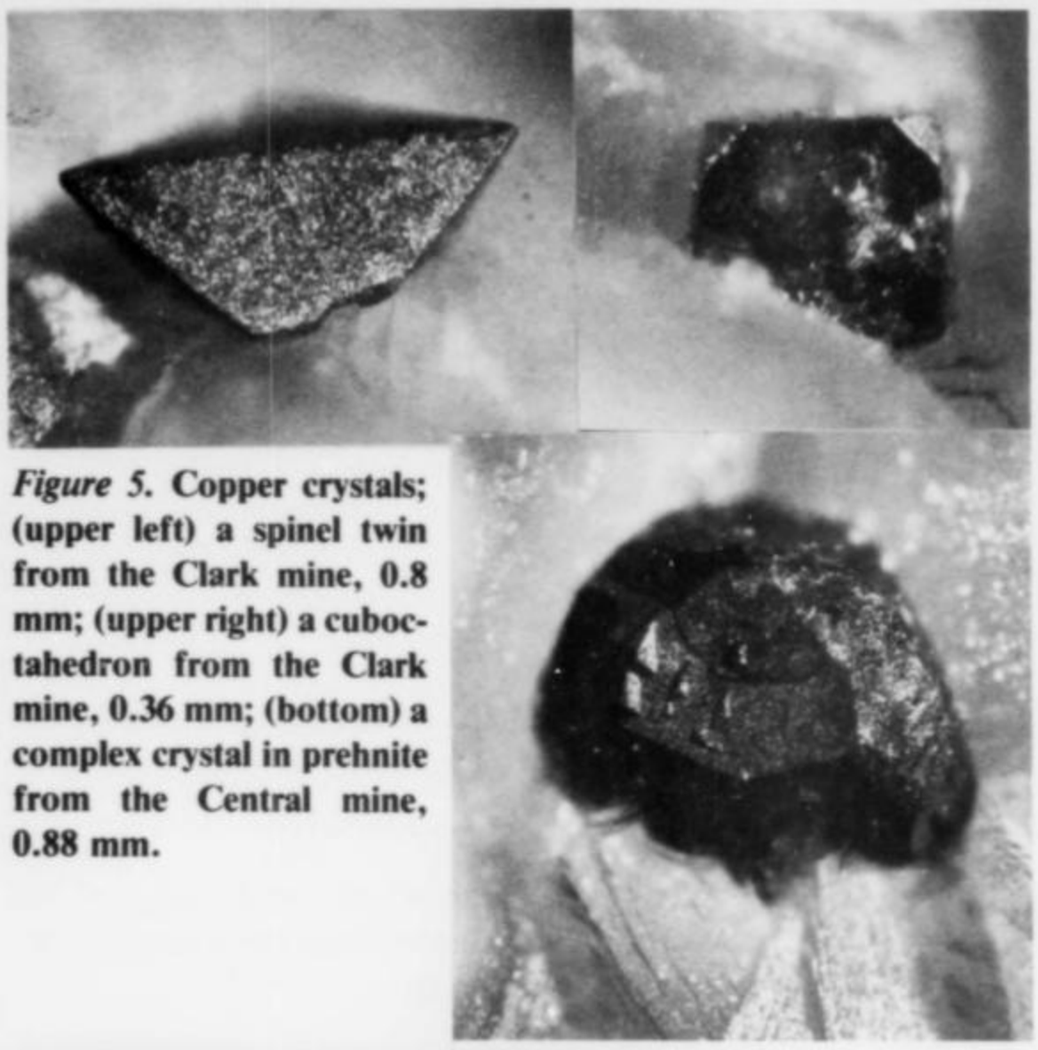


Figure 5. **Copper crystals; (upper left) a spinel twin from the Clark mine, 0.8 mm; (upper right) a cuboctahedron from the Clark mine, 0.36 mm; (bottom) a complex crystal in prehnite from the Central mine, 0.88 mm.**

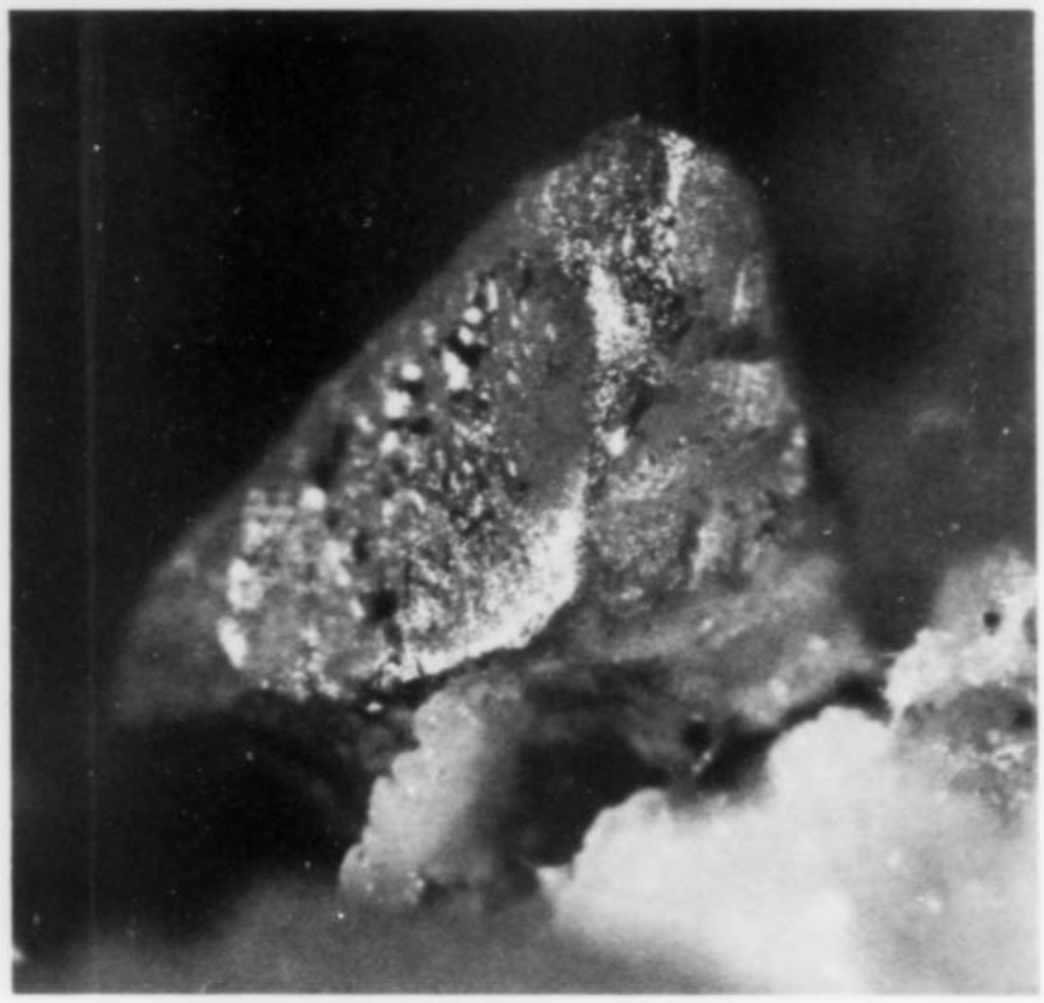


Figure 6. **A spinel-twinned silver crystal 1.2 mm in size from the Osceola mine.**

Figure 7. **Light green pumpellyite crystals in a spray 1.1 mm across from the Delaware mine.**

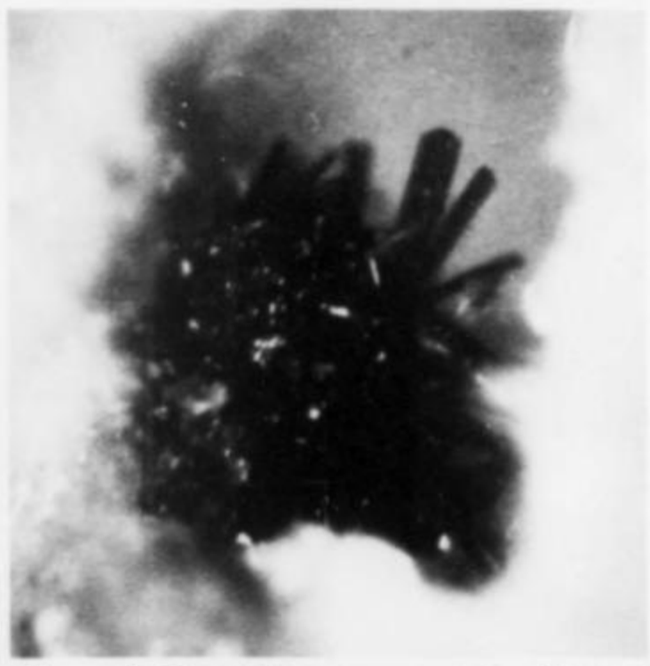


Figure 8. **Blackish green crystals of julgoldite to 0.17 mm from the Clark mine.**

Figure 9. **A bow-tie of emerald-green malachite 0.78 mm tall from the Osceola Lode.**

Figure 10. **A reticulated growth of distorted cuprite cubes 0.34 mm tall from the Clark mine.**

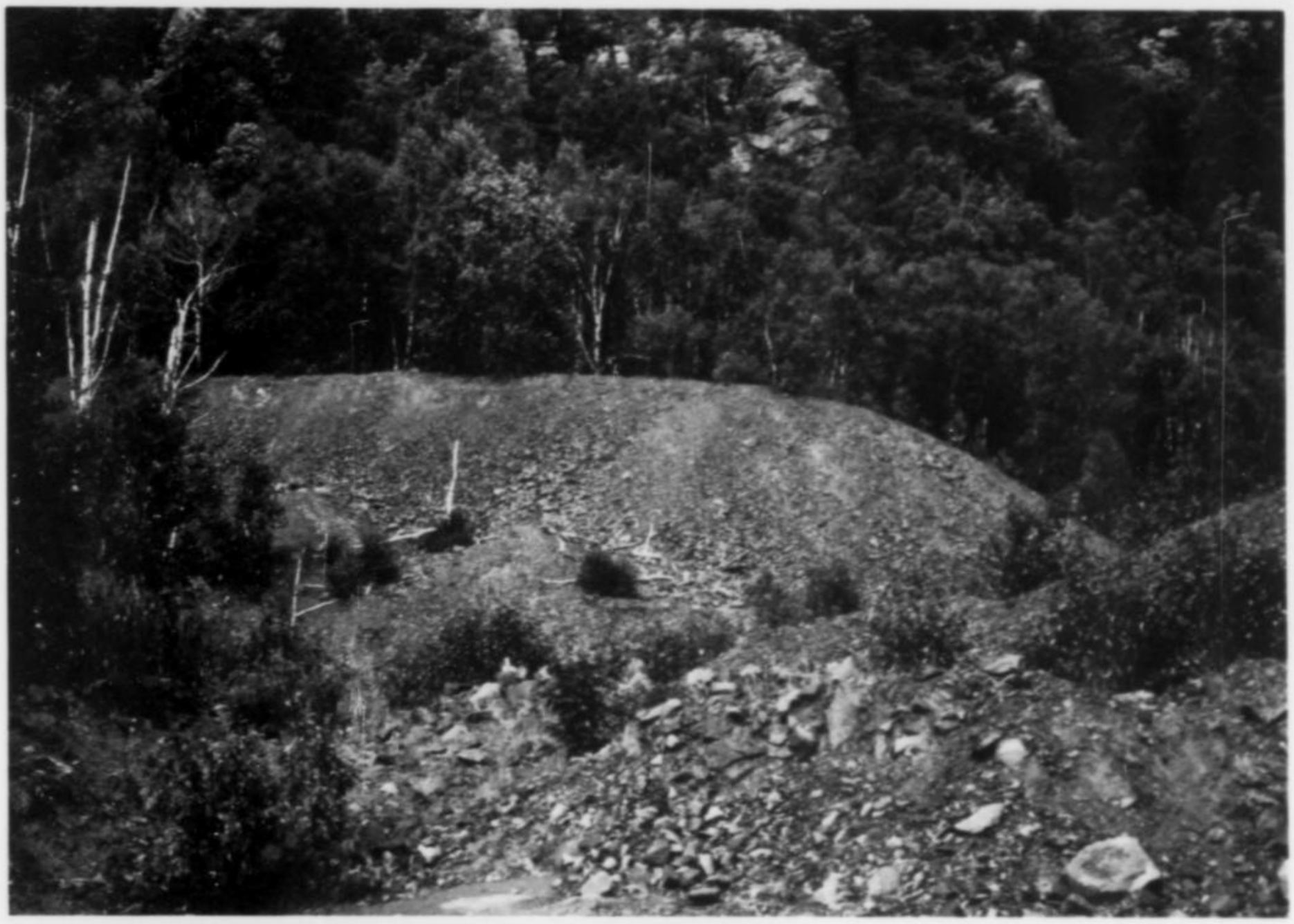


Figure 11. **Dumps of the Clark mine near Copper Harbor, Keweenaw County.**

Figure 12. **Mine building foundations near the dumps of the Mass mine, Mass City, Ontonagon County.**

or in the interstitial spaces in conglomerate. Malachite is found rarely as bright green, well-formed groups of prismatic crystals but more often as botryoidal clusters and as crusts and films coating copper and other minerals. Groups of very small spheres (0.06 to 0.09 mm) of acicular crystals are found at the Clark mine; I also have a small, sharp bow-tie group of prismatic crystals associated with chrysocolla from the Osceola Lode. The Allouez mine, a conglomerate deposit, has produced fine malachite and cuprite crystals. Part of the upper conglomerate was oxidized but was not removed by glaciation.

At the Clark mine, minute, elongated cubes of cuprite may be found with malachite and copper. The groups of cuprite are reticulated and the cubic faces are visible under high magnification. Chalcotrichite, the hair-like variety of cuprite, is also common. I have examples from the Minesota mine and the Allouez mine. The Minesota mine also produces octahedral and cuboctahedral forms as well as some elongated cubes. Cuprite crystals may also be found on copper crystals. I have a specimen with a pair of cuprite cubes 0.05 mm wide on a copper crystal 0.25 mm wide from the Clark mine.

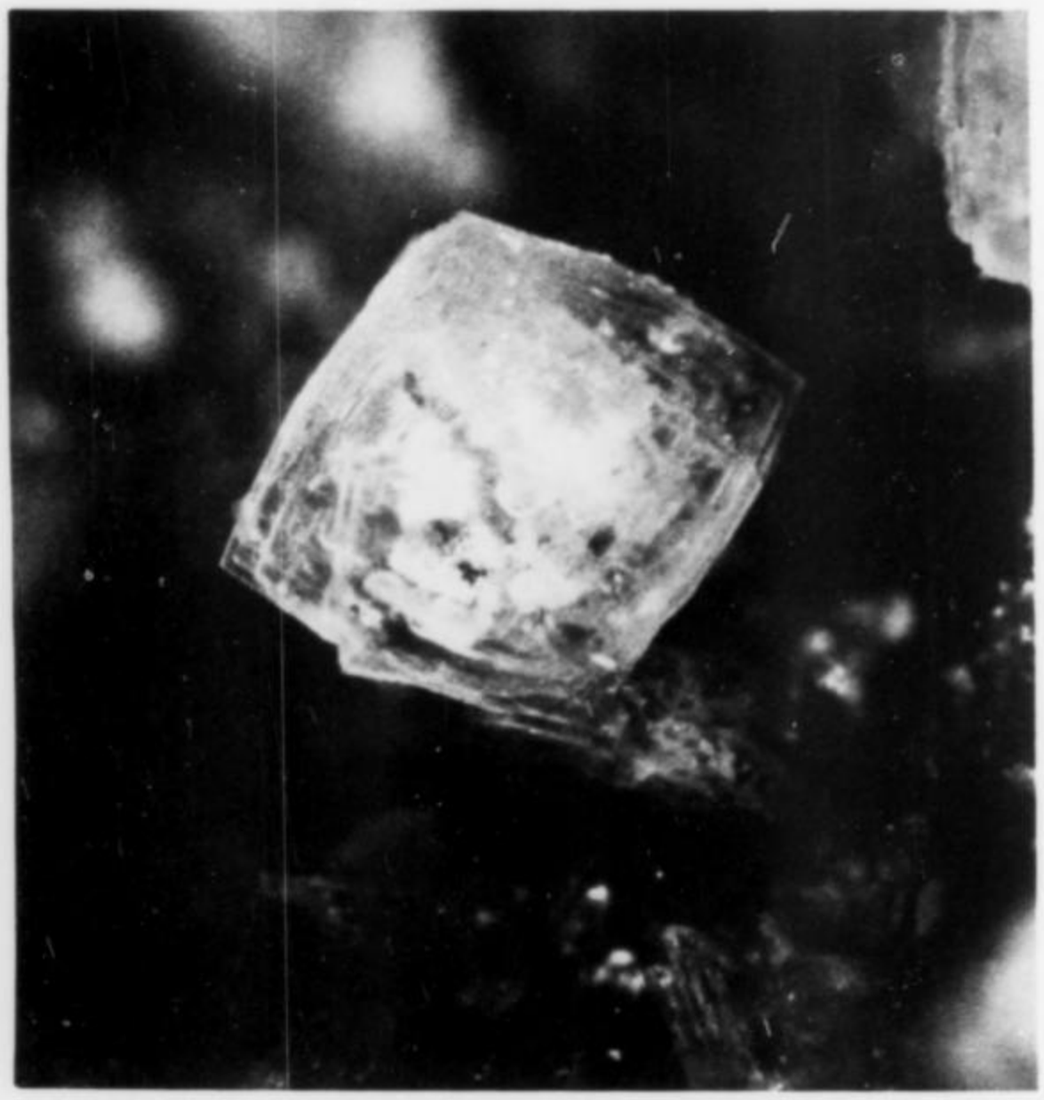
The Laurium mine is a locality for kinoite, a hydrous calcium copper silicate. Kinoite occurring as blue subhedral to euhedral monoclinic crystals in quartz and calcite was first described in 1977 (Ruotsala and Wilson, 1977). The crystals analyzed were extremely small, the largest reported to be 1.5 mm in length. The quartz and calcite crystals with kinoite inclusions occur in vugs associated with

epidote, pumpellyite, copper, silver and chlorite. Kinoite inclusions in calcite were used for analytical purposes but the occurrence in quartz is more attractive unless the kinoite is leached partially out of the calcite for viewing purposes.

Nodules of massive datolite, sometimes with copper inclusions, are a popular lapidary material. But datolite also occurs as clear equant microcrystals, occasionally with inclusions of copper. Some of the datolite crystals may show exceedingly complex forms.

Figure 13. **A group of white, clamshell-shaped prehnite crystals to 2.4 mm from the Isle Royale mine. Dorothy Auler collection.**

Figure 14. **A whitish rosette of prehnite 0.69 mm across, with inclusions of bright copper, from the Clark mine.**



Prehnite occurs in a variety of forms from massive matrix material to radiating botryoidal cavity fillings to small, square, platy crystals associated with copper crystals. The color varies from

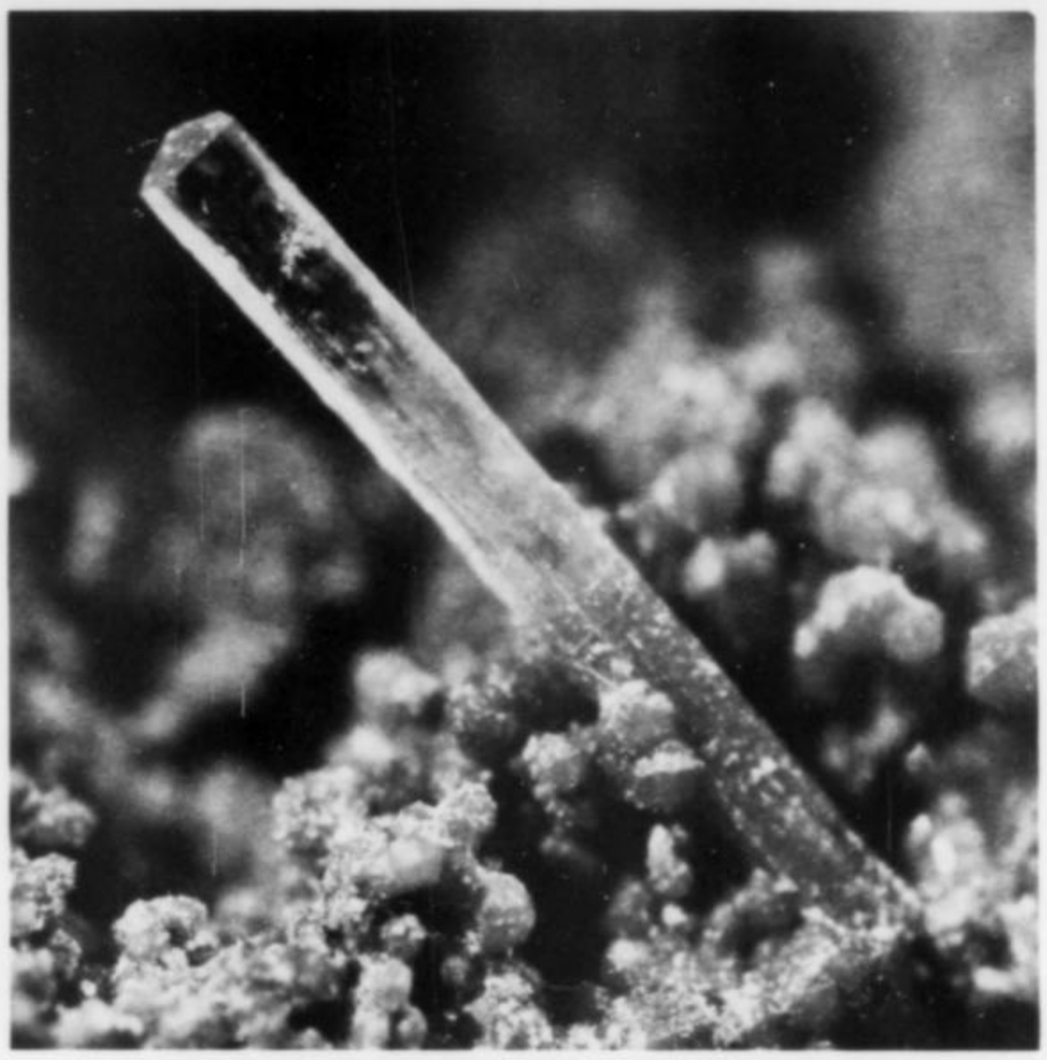


Figure 15. **Colorless natrolite crystal 3 mm long on reddish orange analcime from the Copper Falls mine.**

white to shades of green and pink, and the crystals often contain inclusions of copper, the cause of the pink coloration. Colorless, thin, square, bevelled crystals of prehnite on copper crystals have been reported from the Cliff mine (Moore and Beger, 1963). I have very nice, light green, radiating groups from the Central mine and a group of clear plates growing in a rosette arrangement around a copper core from the Clark mine.

A group of unusual, opaque, white crystals having the appearance of tiny clam shells, fractured examples showing a radiating structure, were analyzed and found to be prehnite. They occurred in quartz vugs at the Isle Royale mine.

Commonly occurring dark green, massive, earthy and sometimes botryoidal material associated with microminerals in vugs and cavities is usually identified only as "chlorite." Minerals of the chlorite group frequently occur as minute, intergrown foliae colored yellow, green and brown to black. In addition to vugs lined with compact foliated crystals, I have found single, light brown, minute, six-sided plates (0.05 mm) speared by white, unknown, acicular crystals from the Clark mine. Moore and Beger (1963) described green to greenish black intergrown foliae from several locations as pennine. Heinrich (1976), however, cautioned that because of the close physical and optical similarities of the individual chlorite species, identification requires X-ray diffraction determination.

Saponite, a silicate of the montmorillonite group of clay minerals, occurs throughout the area as crusts or replacements of other minerals. Of interest to micromineral collectors is the radiating, fibrous variety. I have examples of saponite on adularia and also as spheres of radiating crystals on an epidote crystal from the Mass mine. Very attractive groups of radiating, acicular crystals having the appearance of saponite on quartz with kinoite inclusions from the Laurium mine are an expandable clay in an expanded state (personal communication, M. Wilson).

Apophyllite occurs as equant to prismatic crystals with pyramidal terminations which are colorless or white. I have examples of both forms from the Clark mine. Several other localities are mentioned in the literature.

The zeolite group of hydrous aluminosilicates is represented in my collection of copper country microminerals by laumontite,

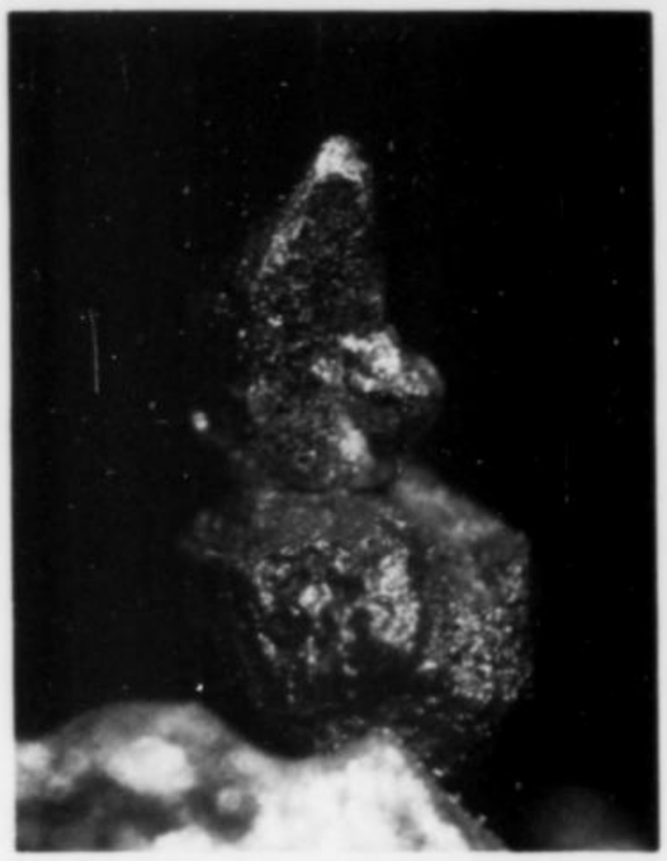


Figure 16. **A spear-shaped crystal of silver piercing a copper crystal from the Osceola mine; the two crystals together measure 0.7 mm.**

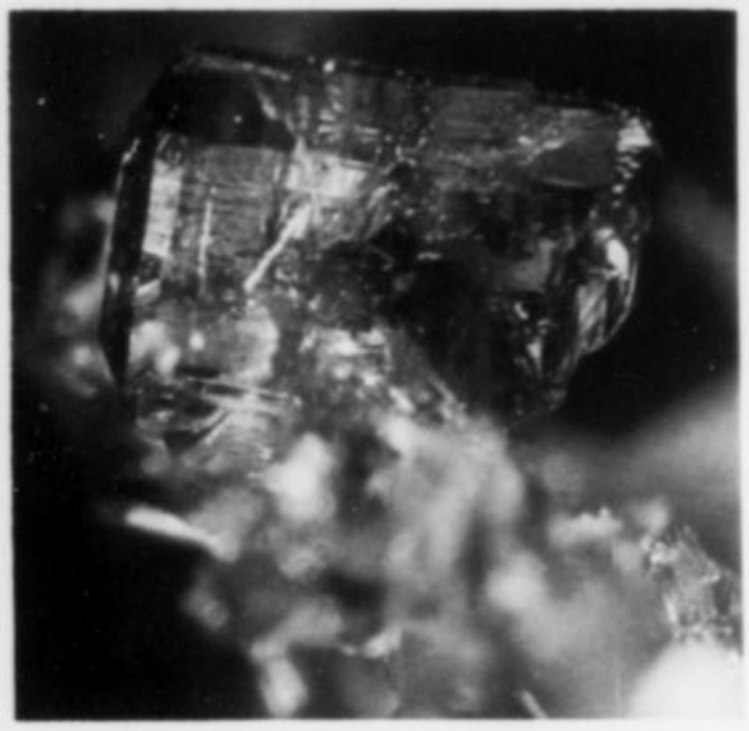


Figure 17. **An epidote crystal, 1.12 mm, on pumpellyite from the Kearsarge Lode.**

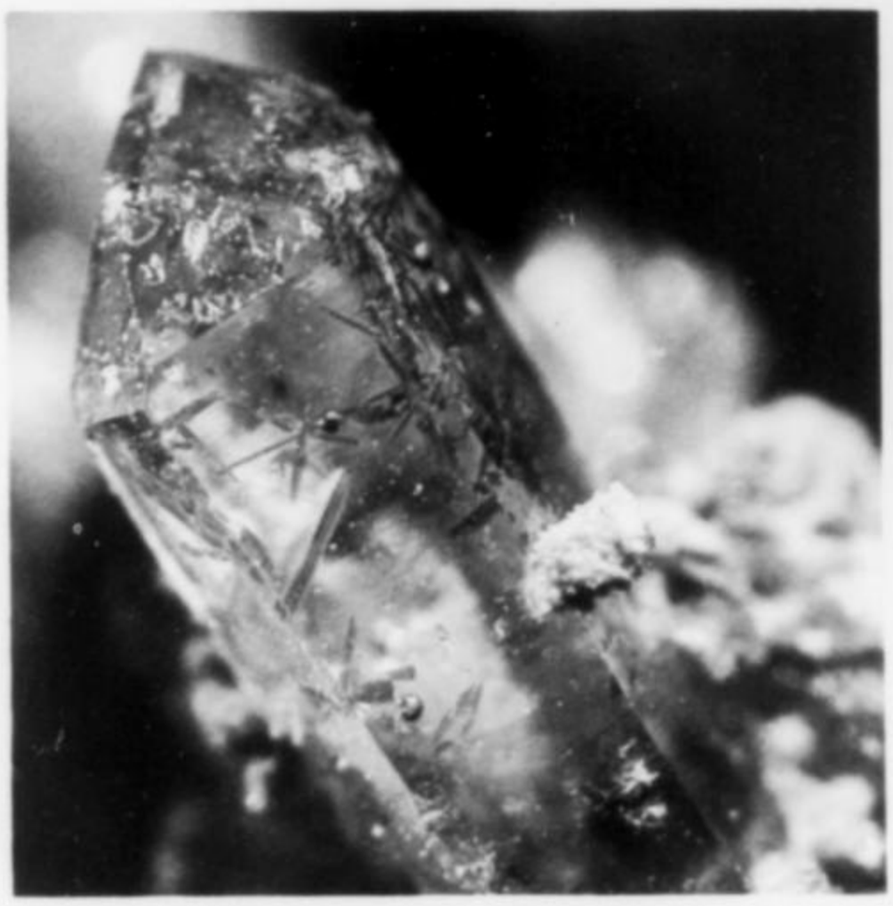


Figure 18. **Prismatic crystals of kinoite in a 2.7-mm quartz crystal from the Laurium mine.**

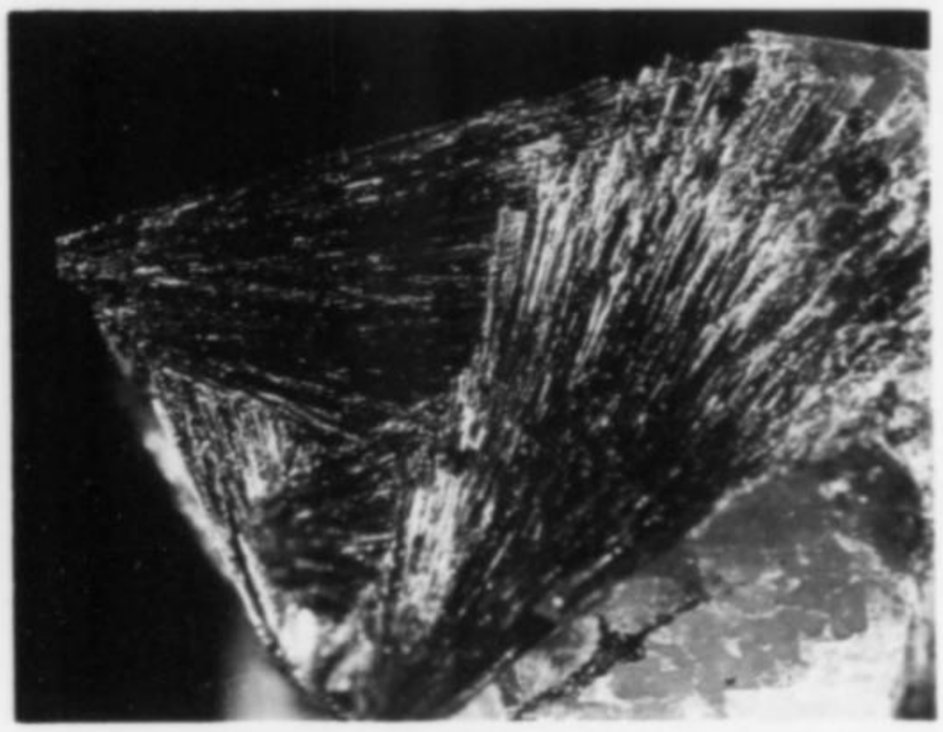


Figure 19. **Macfallite sprays to 3.5 mm from the Manganese mine.**

Figure 20. **Deep reddish brown macfallite crystals to 0.85 mm from the Manganese mine.**

stilbite, analcime and natrolite. There is a literature reference to the occurrence of chabazite in the copper district but I have not been able to locate any.

Laumontite occurs widespread as pink, crumbly masses and as small, white, prismatic crystals with steep terminations in vugs associated with epidote and pumpellyite. I have some examples of the latter from the Lake mine and the Gratiot mine.

Fine, red, trapezohedral crystals of analcime and prisms of natrolite with pyramidal terminations occur at the Copper Falls mine. I also have clear crystals of analcime from the Central mine and clear, prismatic crystals of natrolite from the Clark mine.

The occurrence of stilbite is rare in the Copper District. The one specimen of stilbite in my collection was found in a vug lined with very fine yellow saponite from the Central mine. The stilbite is light orange, has the form of a sheaf-like aggregate of crystals, and is 0.53 mm in length.

About a half hour's walk north of the Clark mine through the woods is the Manganese mine (also known as the Manganese Prospect and the Clark Exploration) which is the type locality for macfallite, a calcium manganese aluminum silicate. Macfallite occurs in calcite as intergrown sprays of crystals in shades of brown and reddish-brown and rarely as well-terminated crystals. Associated with macfallite are brown crusts and very small (0.18 mm) reddish brown prismatic crystals of orientite and microscopic, pyramidal, metallic black crystals of braunite, two other manganese silicates. Undoubtedly, there are other manganese minerals waiting to be found at this location.

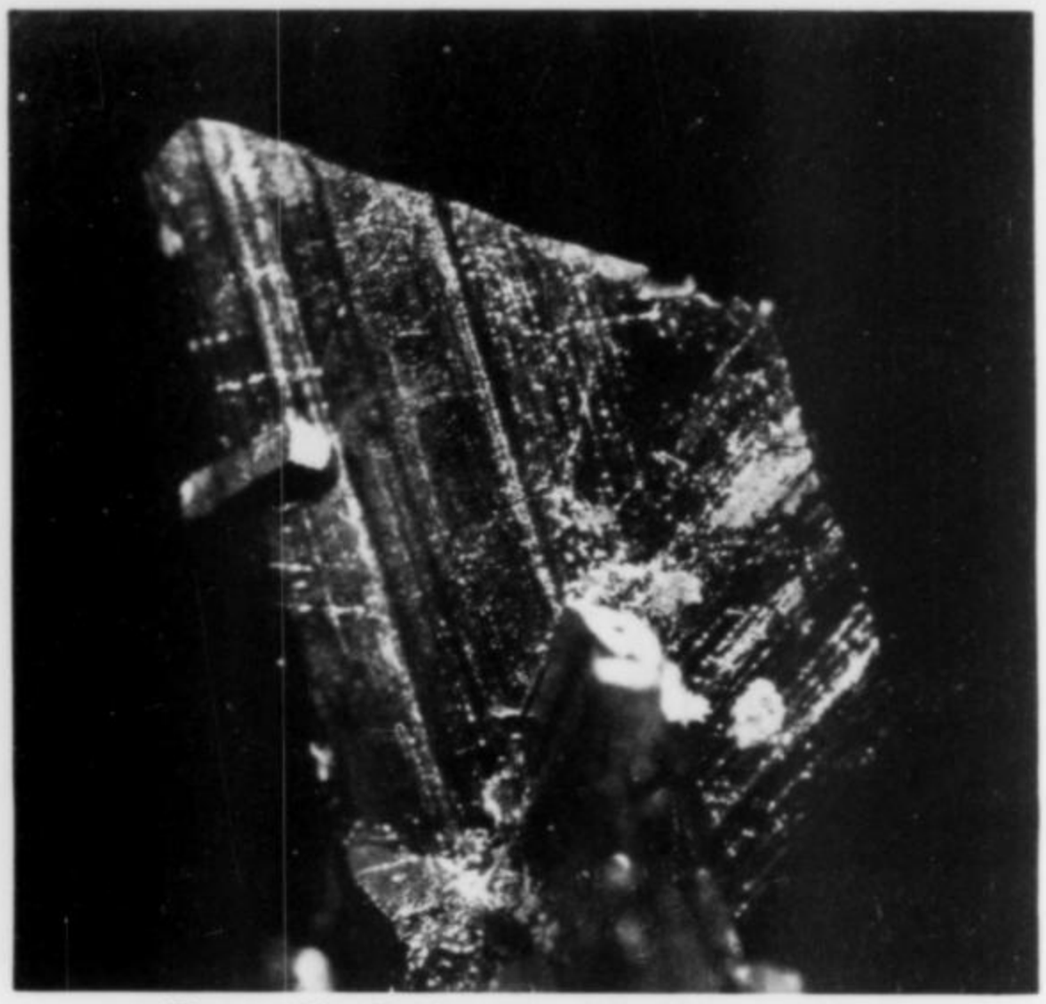


Figure 21. **Dark gray twinned crystal of chalcocite 4.4 mm tall from the White Pine mine.**

Figure 22. **Gray galena crystals to 1.4 mm on yellow chalcopyrite from the White Pine mine.**

As mentioned previously, the White Pine mine in Ontonagon County is the only major operating mine in the area. It is a copper sulfide deposit, the primary ore being chalcocite, with native copper comprising only 5 to 10 percent of the deposit. Consequently, the White Pine mine produces some species which are rarely, if ever, found elsewhere in the district. But, since the mineralization is from the same source throughout the district, there are similarities in the suites of minerals found at all of the mines as well as some differences mainly in terms of the relative quantities found.

At the White Pine mine, lead, iron and copper sulfides are represented by galena, marcasite, pyrite, chalcopyrite and chalcocite. Complex crystals and crystal groups of galena showing modifications of the cubic form have been found on botryoidal chalcopyrite. Cockscomb groups of marcasite, modified cubes of pyrite and bladed and tetrahedron-like disphenoids of chalcopyrite are also found. Chalcocite occurs as groups of intergrown prismatic to tabular crystals, but I have a single, twinned chalcocite crystal which is particularly attractive. Prismatic chalcocite crystals also occur at the Clark, Lake, Gratiot, Laurium, Baltic and other mines in the district. Barite occurs at the White Pine mine as colorless or amber singles and groups of bladed crystals and rarely as light blue intergrown groups of bladed crystals. Compared with the mines to the northeast, native copper is found rarely as crystals at the White Pine mine. I have a crude halfbreed of silver on copper attached to a larger piece of arborescent copper which has been leached from matrix. Calcite occurs as clear and honey-colored modified pyramidal crystals. Botryoidal hematite and bladed chalcopyrite occur on clear calcite.

There are numerous other species mentioned in the literature (Heinrich, 1976) as occurring at the White Pine mine. However, most are fine-grained and not well crystallized. Some may have been found as crystals but I have so far been able to locate only those listed above.

There are many more mines in the copper country than I have mentioned in this brief article. However, it was not meant to be a complete survey of the mineralogy of the area but rather an informal sampling of what can be found there which might encourage further collecting and study.

ACKNOWLEDGMENTS

I wish to express my appreciation to Karl Shafer, Marc Wilson and Bill Henderson for reviewing this article. However, I assume the responsibility for any omissions or errors. All but one of the specimens shown here are from my own collection and all of the photos are mine as well.

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famous mineral localities:

the Córrego Frio mine and vicinity, minas gerais, brazil

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Córrego Frio, Linopólis and Mendes Pimentel are names that evoke thoughts of magnificent brazilianite crystals from large and famous mines in a wide, productive region. Unfortunately, reality is a little different: the Córrego Frio is a small pegmatite vein in a once-productive area measuring less than 30 square kilometers. Today, virtually all the brazilianite mines are abandoned or caved in.

INTRODUCTION

The mineral species named for Brazil is, appropriately enough, a superbly beautiful gemstone occurring in large, lustrous and well-formed crystals. The type locality, Córrego Frio, has remained the source of the finest crystal specimens despite the subsequent discovery of a number of other occurrences and habits nearby. A certain amount of confusion surrounds the localities, the history, and even the spelling of the mineral name.

THE LOCALITY NAME

From the start, the name of the type locality has been a subject of confusion. Initially the mineral brazilianite was recorded as coming from Araçuaí, in the Jequitinhonha Valley; this was subsequently corrected to Córrego Frio. It was de Godoy (1945) who first pinpointed the location which, at the time, was within Conselheiro Pena township, in the Moscovita district (formerly known as the São Tomé do Norte district). Previous descriptions had been somewhat indefinite due to the difficulty of access: 63 kilometers of pack-trails from São Tomé to the mine.

Conselheiro Pena township was later divided, and Córrego Frio became part of Divino das Laranjeiras township, Linópolis district (Linópolis is a small village a few kilometers from the mine). At the same time, Moscovita was made the seat of Galiléia township.

The occurrence lies near the crest of the watershed between the Rio São Mateus and the Rio Doce, in the Serra de Mendes Pimentel branch. Mendes Pimentel is another small town nearby, and its name has also sometimes been applied to the mine.

Because Córrego Frio is located very near the boundary between Divino and Mantena townships, the name of the small town of Mantena has frequently been used to designate the mine. So also has the name of Divino Creek (Ribeirão or Riacho do Divino), into which flows the Córrego Frio (Cold Creek).

Today, the mine is locally known as Duquinho, Cabeceiras do Laranjal, Lavra (Velha) da Brasilianita, and João Firmino.

To summarize, the various names that have been applied to the Córrego Frio deposit are:

Townships	***Mountains***
Conselheiro Pena	Mendes Pimentel
Divino das Laranjeiras*	***Creeks***
Galiléia	Ribeirão (or Riacho) do Divino
Mantena	Ribeirão Laranjeiras
Districts	***Others***
Divino	Cabeceiras do Laranjal
Linópolis*	Duquinho
Moscovita	João Firmino
São Tomé do Norte	Lavra (Velha) da Brasilianita

NOTE: In Portuguese, "h" is sometimes pronounced as a "y" (as in Candinho and Duquinho) where it follows "n." A tilde over an "a" ("ã") indicates that the *following* letter is pronounced as an "n" (as in São Tomé, Sebastião, João Belmiro and Portão). Pronunciation of other letters is similar to Spanish.

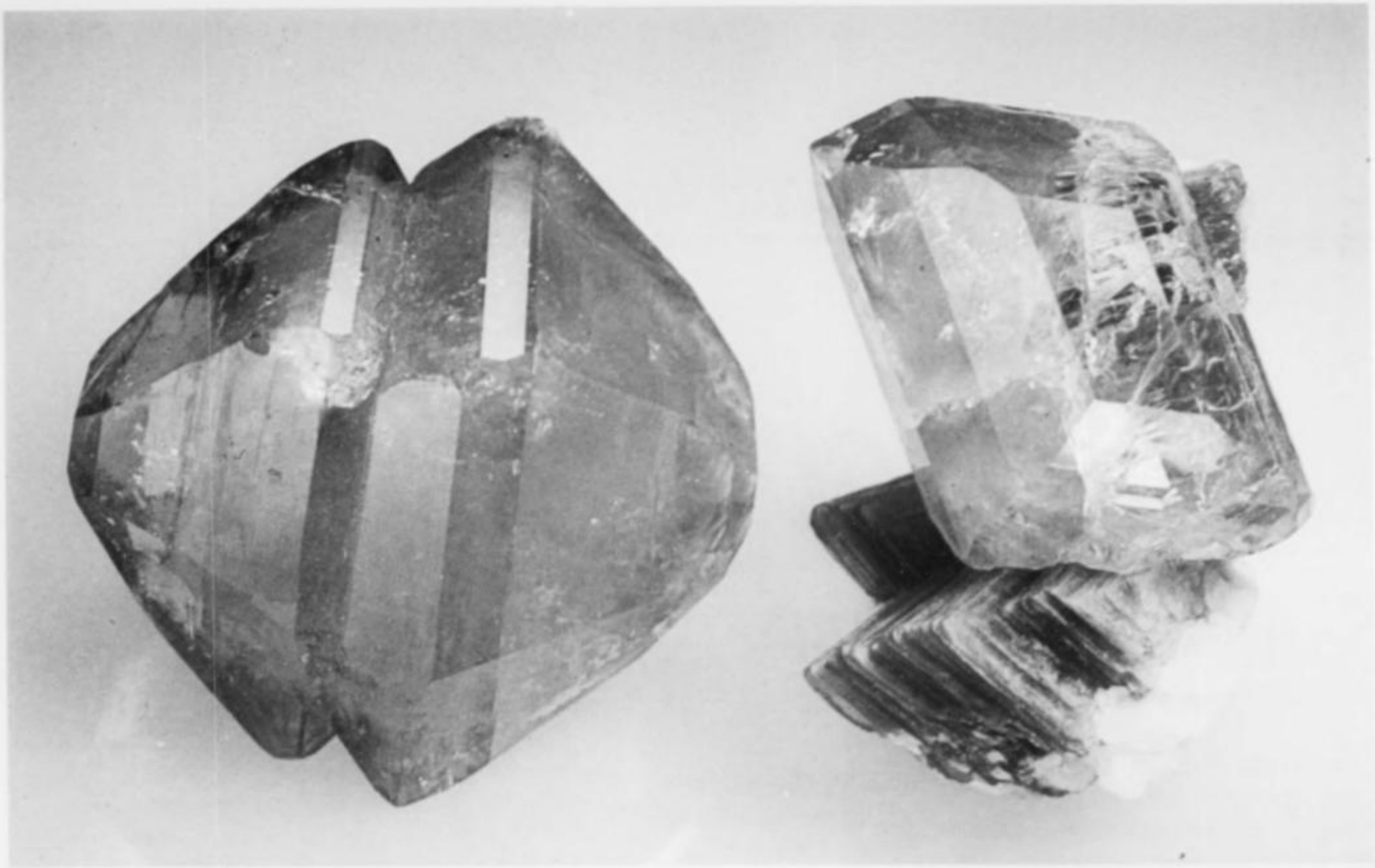

Figure 1. **Brazilianite crystals from Córrego Frio. The left crystal measures about 4.5 cm (Ed Bancroft collection); the right crystal measures about 4 cm diagonally (Wendell Wilson collection).**

Figure 2. **Large brazilianite crystal from Córrego Frio weighing nearly 1 kg and measuring 12.5 cm (Smithsonian specimen #C5797).**

Figure 3. **A remarkable childrenite-eosphorite crystal 9.3 cm tall, probably from the João Modesto mine. Smithsonian specimen no. 148431.**

Figure 4. **Main street of Linópolis, a small town near the brazilianite mines.**

Only those terms marked with an asterisk are still correct, so the type locality correctly given is Córrego Frio mine (or Lavra do Córrego Frio), Linópolis district, Divino das Laranjeiras township, Minas Gerais, Brazil.

HISTORY

The Córrego Frio occurrence was discovered in November of 1942 by Alfredo Severino da Silva during the cleaning of a cornfield on the bank of Frio Creek (Córrego Frio). The farmer collected about 3 kg of yellow-green crystals from a small concentration on a weathered pegmatite outcrop. The stones, first thought to be beryl or chrysoberyl, were immediately recognized as potentially valuable.

Eugênio Marcelo and two partners from Conselheiro Pena promptly staked a claim. Work began with two trenches, one in the creek and the other about 30 meters up the bank (de Godoy, 1945). An 80-cubic-meter excavation was also made at the site of the outcrop, and more than 40 kg of gemstones were produced. The surprising softness and well developed cleavage of the crystals at first led faceters to think them partially weathered or decomposed. With this in mind, two short adits were driven at a lower level in the hope of reaching unaltered pegmatite. However, gems found in these adits also proved very soft, and work was stopped in late 1943. By that time, other occurrences nearby had begun to yield similar crystals.

In August of 1944, Godoy purchased a crystal labeled "chrysoberyl" from a Moscovita mineral dealer and submitted it to the Institute of Technology in Belo Horizonte for identification. Results of those tests, if any, are not known. At about that time another sample, provided by a mining engineer, was under study by E. P. Scorza, Curator of the geology and mineralogy collections of the National Department of Mineral Production in Rio de Janeiro; Scorza spectrographically identified the unknown as fremontite (= natromontebrasite, a mineral of the amblygonite group very similar in composition to brazilianite).

Finally, in late 1944, F. H. Pough and E. P. Henderson communicated to the Brazilian Academy of Sciences their discovery of a new mineral found in the district of Divino, Conselheiro Pena township. The type specimen had been purchased in Belo Horizonte (E. Tavora, personal communication). They named the new mineral in honor of the country of its origin. During this time, E. R. Swoboda and Frederick Heuberg, two American mineral dealers, obtained a lease on the Córrego Frio property and began the supervision of new excavations.

Swoboda's work during 1945 and 1946 yielded many beautiful crystals which are now the pride of public and private collections worldwide. He also collected specimens on which Pecora and Fahey (1949) discovered two new phosphate minerals: scorzalite and souzalite.

A few small prospect holes were dug in 1947–1950, but after that the mine was abandoned. Landslides covered the excavations, and the adits caved in. During the 1960's and 1970's a few specimens of scorzalite and brazilianite were found near the dwindling dumps.

In 1978 a Linópolis resident attempted to reopen the mine by driving two new adits into the old workings. Little of the drusy zone was found remaining in the lower adit, but scorzalite and other phosphates were relatively common. Unfortunately the continuous and heavy rainfall accompanying the catastrophic floods of 1978–1979 caused massive landslides of clay which covered all the excavations. Work was again abandoned, this time for good. A small pit was dug in unstable colluvium overlying weathered schists on the opposite side of Frio Creek, west-southwest of the original workings, in 1980 but Linópolis residents currently feel that additional work is unlikely.

Written records or official reports do not exist for the other brazilianite occurrences nearby, and the current specimen production of all but one of these has dropped to zero. Outside of the Linópolis area, only three other Brazilian occurrences of brazilianite have been reported: at Alto Patrimônio (State of Paraiba) as veinlets and small subhedral crystals coating amblygonite (Murdoch, 1955), and at Boqueirão de Parelhas and Alto do Giz (State

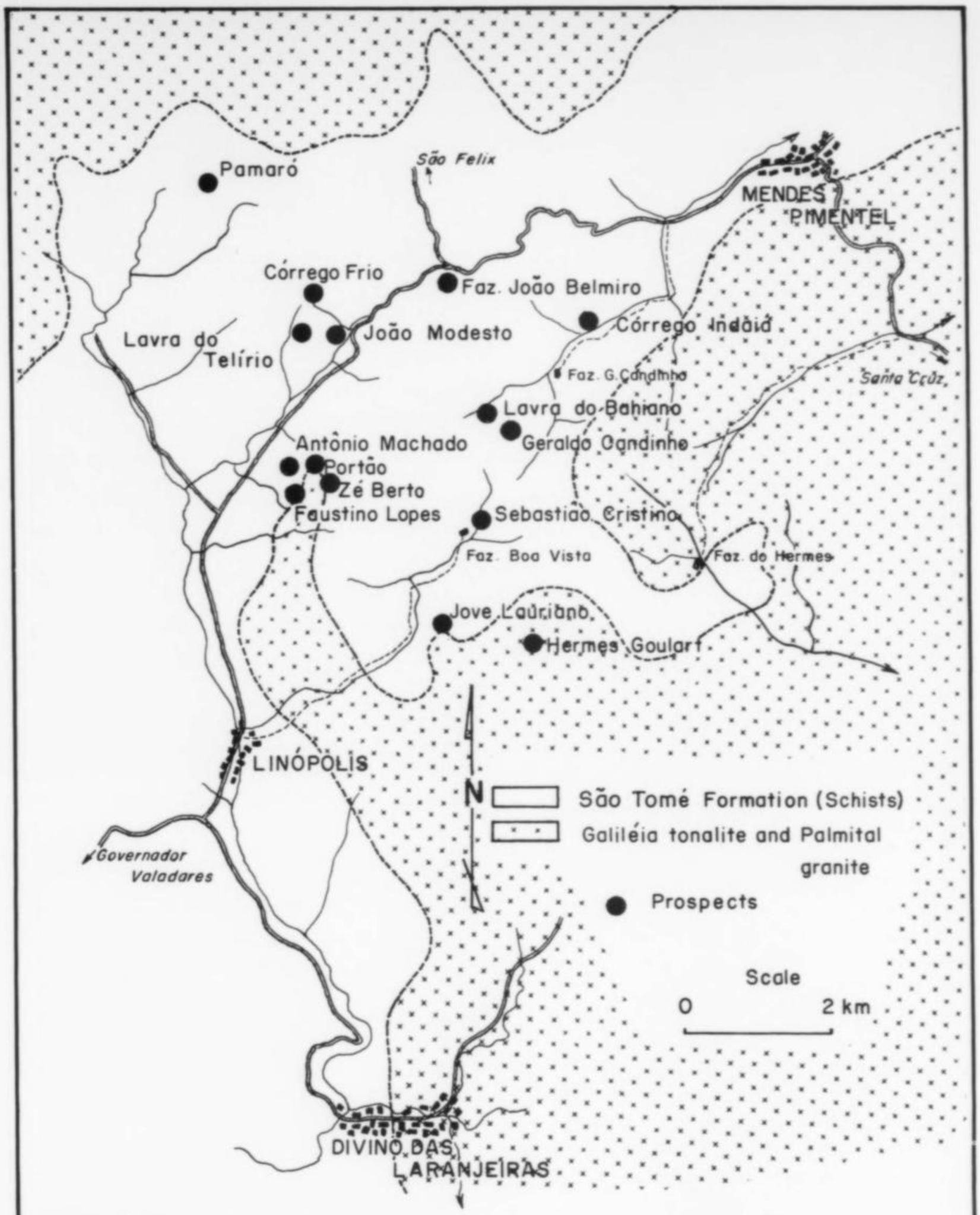

Figure 5. **The brazilianite-producing area.**

of Rio Grande do Norte; da Silva, 1975; no mineralogical data reported).

BRAZILIANITE OR BRASILIANITE?

The discoverers of the new species introduced into the literature three different spellings of the mineral name. In the English text of a short preliminary communication submitted to the Brazilian Academy of Sciences, Pough and Henderson (1945a) spelled the name "brasilianite." The same article, republished in Portuguese (Pough and Henderson, 1945b), spelled it "brasilianita." In September of that same year, the complete, formal description of the new species published in the *American Mineralogist* (Pough and Henderson, 1945c) spelled it "brazilianite." Fleischer (1983) uses the spelling from the formal description, and states further (personal communication via R. C. Erd) that "brasilianite" should be used only for the purpose of citing the first reference; all subsequent reference to the mineral should be given as "brazilianite."

CÓRREGO FRIO MINE

Location and Access

The Córrego Frio pegmatite lies on the west side of a south-flowing creek in the upper basin of Laranjeiras Creek. It is northwest of Linópolis, east of Governador Valadares and north-northeast of Rio de Janeiro. Access is from Governador Valadares by the Mantena road for 62 km, passing São Vitor (at 33.5 km). From Linópolis a road branches north toward Mendes Pimentel (see map); at a point 9 km after the fork one must leave the vehicle and climb a horse trail up the Córrego Frio valley to the mine, about a 40-minute walk. The Mendes Pimentel road is impassable during rains, even to 4-wheel-drive vehicles. The steep slopes around the mine are covered by high grass and a few trees. The scattered population lives by farming.

Regional Setting

Rock units in the area belong to the Lower Precambrian Paraiba group, about 1.98 billion years old. This consists of a mica schist

Figure 6. **The Córrego Frio mine, type locality for brazilianite, in 1978. Arrows mark caved adits.**

complex intruded by cupolas and pegmatites derived from a granitic batholith near Galiléia, dated at around 550–600 million years old. The São Tomé formation is a well-banded biotite schist of the almandine-amphibolite facies, containing quartz, garnet, muscovite and staurolite (Barbosa *et al.,* 1966). Thin quartz-muscovite layers occur sporadically intercalated.

The Galiléia tonalite and the Palmital granodiorite are lateral differentiations of the same pluton. They are gray, leucocratic to mesocratic gneisses containing many xenoliths.

Tectonically, the area lies within the Transamazonic belt, which was migmatized and reactivated during the Brazilian cycle (550–600 m.y.), resulting in the intrusion of various granites and pegmatites (Almeida *et al.,* 1976).

The Occurrence and Workings

The Córrego Frio pegmatite trends roughly north-northwest, is about 2.5 meters thick at maximum, and dips steeply to the east. When discovered it was exposed over a length of about 18 m. The exposure revealed a tabular, parallel quartz core and clear zonation.

There is no official or written record of the original workings on the vein. They were about 40 m in length and 25 m deep, with access by way of small, parallel crosscuts. A short ventilation adit was reopened in 1978. It intersected the upper part of the old workings, where only the border zone of the pegmatite remained; above this adit a small pegmatite outcrop was visible.

The lower adit penetrated 8 m of argillaceous colluvium and crossed subvertical schists to reach the vein. It followed the vein southeastward for 9 m before being cut off by old workings. To the north was a shaft more than 8 m deep and a small flooded incline.

Within the lower adit the vein, thinned to about 1 m in width at this depth, plunges steeply northward. The vein here is mostly massive with very few crystal pockets and many phosphate nodules. A little apatite and tourmaline and much muscovite are scattered about. Enclosing the vein is a hard, subvertical garnet-biotite schist containing quartz lenses, irregular quartz veins and diabase dikes.

Another outcrop of the vein, with workings presently caved and filled, can be seen downstream in the creek about 100 m to the south. Brazilianite crystal fragments are common on the dump, the creek bank, and south of a small, recent open pit.

Pecora and Fahey (1949) distinguished three well-defined zones in the pegmatite:

The Border Zone

The border zone is composed mainly of massive albite exhibiting cleavage faces up to 15 cm, and containing lesser amounts of quartz and muscovite. Elongated bluish to dark gray masses composed mostly of wyllieite and scorzalite measure up to 25 cm in length and extend across the zone perpendicular to the wall-rock contact.

The border zone was visible at both margins of the vein, where its contact with the wall-rock was well-defined and regular. At the surface the two border units were about equal in thickness and together accounted for about two-thirds of the pegmatite width. At a depth of about 10 m the vein has thinned, and the east border unit is somewhat thicker than the west; but together they still compose a little over two-thirds of the vein width.

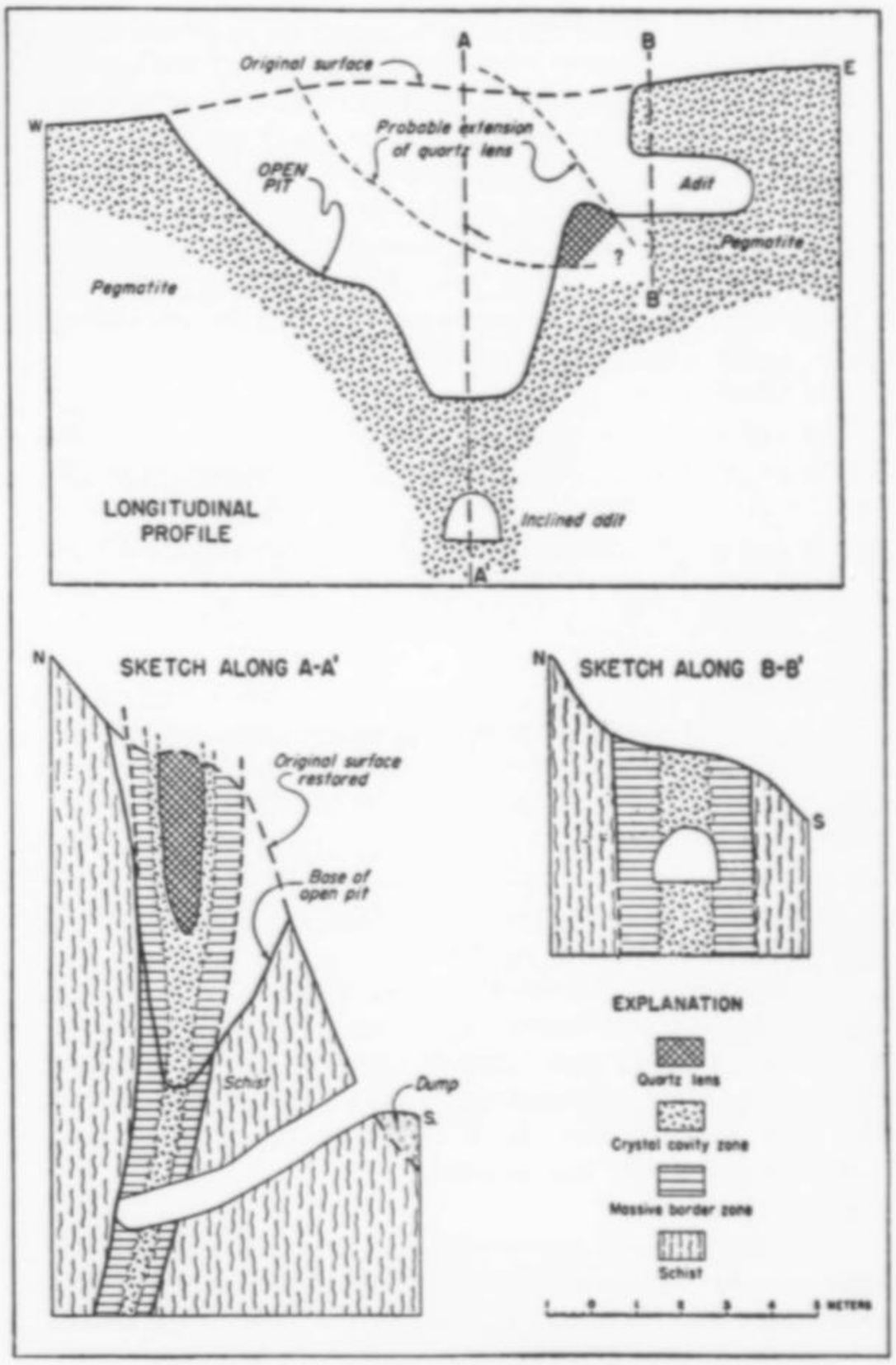

Figure 7. **Diagram of the Córrego Frio pegmatite body and associated workings (Pecora and Fahey, 1949).**

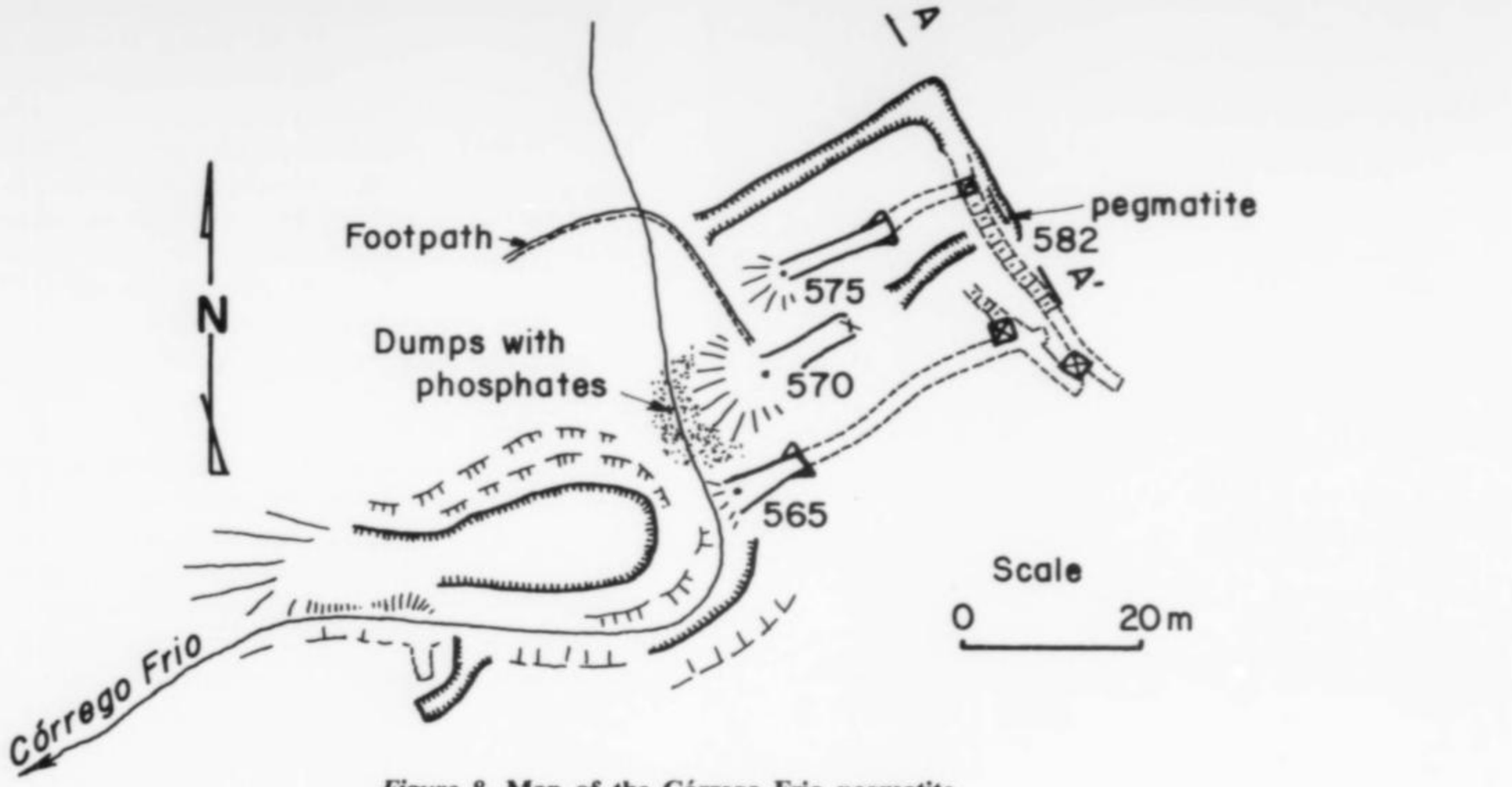

Figure 8. **Map of the Córrego Frio pegmatite workings.**

The Crystal Cavity Zone

The crystal cavity zone has an irregular, poorly defined contact with the massive border zone. It ranges in thickness from a few centimeters where it lies next to the quartz core, to about a meter where the quartz core pinches out. In its thickest parts and around the margins of the quartz core it is characterized by irregular vugs and crystal cavities lined with stubby, terminated quartz crystals, well-formed brazilianite crystals and limonite-stained muscovite. Cleavelandite albite and porous or massive albite occur in areas of higher quartz and muscovite content.

The Quartz Core

The quartz core was entirely removed during mining. According to Pecora and Fahey (1949), it was originally exposed on the surface for about 5 m along the strike, where it had a thickness of up to 1 m. It gradually thinned until pinching out at a depth of about 4 m. The lower edge was irregular, with a perceptible rake to the east, and was bordered by a mixture of cleavelandite and muscovite.

Mineralogy

Although brazilianite, scorzalite and souzalite were discovered at and described from the Córrego Frio pegmatite, no publication has thus far dealt with the paragenesis of this exceptional occurrence. Specimens collectible before the landslides of 1978 are listed, with mineralogical data, in Cassedanne and Cassedanne (1982). In the list presented here, those minerals not listed in Pecora and Fahey (1949) are marked with an asterisk (*).

Although brazilianite generally occurs as single crystals in vugs, many of the other phosphates occur as complex nodules imbedded in feldspar. Wyllieite and scorzalite comprise the bulk of these nodules, with other associated species in much smaller proportions. The main accessory minerals of the pegmatite are beryl, tourmaline, zircon, garnet and tapiolite.

Albite $NaAlSi_3O_8$

Albite occurs in large masses with good cleavage, as saccharoidal aggregates and as bladed crystals (*cleavelandite*). Material near phosphate nodules is usually stained green or black. Small crystals in vugs are suitable for micromounting.

Arsenopyrite* FeAsS

Arsenopyrite is rare at Córrego Frio, occurring as small crystals scattered in wylieite and scorzalite.

Beraunite* $Fe_6(PO_4)_4(OH)_5 \cdot 4H_2O$

Beraunite is very rare, occurring as small red needles in frondelite and dufrenite.

Brazilianite $NaAl_3(PO_4)_2(OH)_4$

Brazilianite is a relatively hard phosphate (5.5), commonly pale to deep greenish yellow in color, varying also to olive-green, dark yellow and chartreuse. Crystals are translucent to transparent, commonly milky. Some transparent specimens show very weak pleochroism. Inclusions of quartz, tourmaline, apatite and mica crystals have been observed, The mineral has one perfect cleavage {010} and a density of 3.025 (calculated) to 2.94 (measured).

The best developed crystals are doubly terminated and have 20 to 30 faces. The largest crystal found at the type locality weighed 2 kg, and quite a few crystals in the neighborhood of 1 kg were obtained which are now on display in various public museums. The dominant habit of Córrego Frio crystals consists of a narrow prism zone and considerable elongation along [100]. The habit is similar to that of New Hampshire brazilianite (Frondel and Lindberg, 1948). Crystals showing an elongated prism are less common (Pecora and Fahey, 1949). Crystals from the nearby João Modesto mine are also similar to those from New Hampshire.

Golden yellow to chartreuse, transparent or translucent crystals from Córrego Frio are recognizable by their general combination of habit and color. However, all of the other specimens in our study of

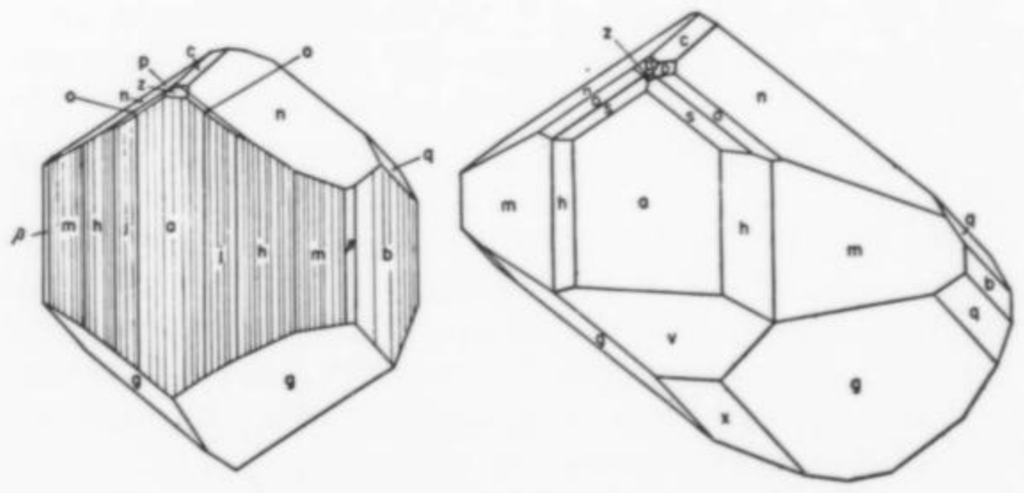

Figure 9. **Crystal drawings of Córrego Frio brazilianite from the original description (Pough and Henderson, 1945c).**

the various brazilianite occurrences are very similar to each other and are impossible to distinguish as to specific locality. This explains the imprecision of most locality data for brazilianite specimens in various collections throughout the world. We had hoped to be able to find some analytical test which might serve to identify the locality of individual specimens. Unfortunately, the indices of refraction, density and X-ray data for brazilianite from six different localities (Córrego Frio, Geraldo Candinho, Hermes, Sebastião Cristino, Bahiano, and Zé Berto mines) all proved to be essentially identical. This suggests that collectors should be skeptical with regard to most locality data accompanying brazilianite specimens; any such information was generally provided by a Brazilian dealer at some point, and our 25 years of experience in Brazil has shown that locations given for most minerals are commonly inaccurate or fanciful.

Childrenite* $FeAl(PO_4)(OH)_2 \cdot H_2O$

Childrenite is relatively common in clusters of needles up to 1 cm, imbedded in phosphate nodules or as free crystals in feldspar vugs. A partial analysis shows some manganese, indicating that these crystals are not pure end-member childrenite in the childrenite-eosphorite series.

Dufrenite* $Fe_5(PO_4)_3(OH)_5 \cdot 2H_2O$

Rare, thin botryoidal coatings of dufrenite in feldspar cavities appear to be an aluminum-rich variety.

Fluorapatite $Ca_5(PO_4)_3F$

Fluorapatite occurs in translucent, dark green to bluish milky crystals of prismatic habit reaching 3 cm in size. It appears to have formed earlier than brazilianite.

Frondelite* $MnFe_4(PO_4)_3(OH)_5$

Frondelite forms radiating nodules of a yellowish greenish brown color, imbedded in feldspar. It has replaced some primary phosphates, mainly scorzalite. Córrego Frio samples are iron-rich.

Garnet

Small salmon-colored grains of some garnet species occur scattered through albite masses.

Jahnsite* $CaMn(Mg,Fe)_2Fe_2(PO_4)_4(OH)_2 \cdot 8H_2O$

Jahnsite occurs at Córrego Frio as pale yellowish gray to orange, waxy, fine-grained rims on various other phosphate minerals, particularly scorzalite. Jahnsite veinlets cut wyllieite and are therefore later.

Microcline* $KAlSi_3O_8$

Microcline, scarce at Córrego Frio, occurs as pink cores in albite.

Muscovite $KAl_2(Si_3Al)O_{10}(OH,F)_2$

Muscovite occurs as large, golden brown books and crystals imbedded in the pegmatite and also accompanying brazilianite crystals in vugs. The brazilianite appears to have formed later than muscovite in vugs. The variety *sericite** has also been observed as small nodules in feldspar.

Quartz SiO_2

Milky quartz occurs generally as xenomorphic crystals in feldspar and also as transparent, doubly terminated crystals associated with brazilianite.

Roscherite* $Ca(Al,Fe,Mn)_3Be_2(PO_4)_3(OH)_3 \cdot 2H_2O$

Roscherite is very rare, forming small, tan globules perched on albite and overgrown by brazilianite.

Sabugalite* $HAl(UO_2)_4(PO_4)_4 \cdot 16H_2O$

Pale yellow spots of sabugalite have been observed in scorzalite.

Scorzalite $(Fe,Mg)Al_2(PO_4)_2(OH)_2$

Unattractive patches of pale blue to ultramarine-blue scorzalite to a few cm in size occur abundantly in feldspar and wyllieite. Samples can easily be collected on the dump. Scorzalite alters to a mixture of limonite and jahnsite, associated with childrenite clusters and souzalite needles.

Souzalite $(Mg,Fe)_3(Al,Fe)_4(PO_4)_4(OH)_6 \cdot 2H_2O$

Souzalite is rarer than scorzalite and occurs as subparallel needles and bundles of a lustrous, sometimes submetallic bluish green color. It is a hydrothermal alteration product of scorzalite. Very rare samples up to 10 cm were collected on the dump prior to 1978.

Strunzite* $MnFe_2(PO_4)_2(OH)_2 \cdot 8H_2O$

Strunzite has been found rarely as minute clusters of flexible fibers in feldspar vugs, associated with muscovite.

Tapiolite $Fe(Ta,Nb)_2O_6$

Tapiolite occurs as splendent, striated, tabular crystals up to 1 cm in length, embedded in albite and muscovite.

Tourmaline

Tourmaline occurs as sprays of small, green needles and black, fractured crystals embedded in muscovite.

Uraninite* UO_2

Uraninite forms small crystals imbedded in phosphate minerals.

Wyllieite* $(Na,Ca,Mn)(Mn,Fe)(Fe_3Mg)Al(PO_4)_3$

Wyllieite is the principal component of the phosphate nodules. It occurs as dark brown to grayish black material with a shining luster and good cleavage. It turns tan upon alteration, breaking up into prismatic pieces. It is replaced by various secondary phosphates, and formed earlier than brazilianite. Córrego Frio samples are manganese-rich.

Zircon* $ZrSiO_4$

Zircon occurs as small, colorless to purplish gray crystals in muscovite.

JOÃO MODESTO DOS SANTOS MINE

Also known as: the Lavra (= mine) do Zé Bento, Lavra inferior, Lavra (nova) da brasilianita.

This occurrence lies about 100 m from the Mendes Pimentel road and a little downstream from the confluence of Frio Creek and Divino Creek. It is 2.2 km from the Telírio ranch. Here a deep trench 40 m in length exploited a pegmatite vein about 3 m wide, striking S30°E and dipping about 75° to the southwest. Some pits were also dug along the vein (Cassedanne and Guillemin, 1971). These diggings were abandoned more than a decade ago and are caved in, filled with high grass, and in some cases flooded. The dumps have been washed away by creek floods.

This pegmatite was relatively homogeneous, with an average grain size of a few cm, and many crystal-lined vugs mainly in the southeastern portion. The vugs were lined with twinned muscovite of a fish-tail habit which was coated with childrenite crystals. Much childrenite was mined and sold as crystal specimens. Greenish yellow, translucent to opaque crystals of brazilianite were a common constituent of the vugs, in association with short, dark blue apatite prisms and much limonite formed by the breakdown of iron-rich phosphates. Vein minerals also included schorl, opaque beryl, orange garnet and pale smoky quartz.

Before it became exhausted this occurrence was one of the main brazilianite producers, superseding the Córrego Frio deposit.

Childrenite crystals occurred in groups measuring several tens of cm, the individual crystals being typically bladed or lath-shaped and up to 10 cm. The color ranges from orange-brown and translucent when fresh to opaque when oxidized. Limonite and manganese oxides partially coat some crystals. Minute, transparent, doubly terminated quartz crystals powder the crystals, which actually range in composition from a manganese-rich childrenite to an iron-rich eosphorite.

TELÍRIO MINE

This mine is situated south-southwest from Córrego Frio, north-northeast from Linópolis and west of the Mendes Pimentel road. Access is by way of a grassy footpath beginning at the João Modesto mine.

Here a heterogeneous pegmatite striking S30°E and dipping 60° to the southwest was mined for beryl and mica. Workings consist of

Figure 10. **The brazilianite-producing area is characterized by sparsely wooded grassy mountains and subsistence-level farming. (Note unnamed pegmatite dump in lower foreground.)**

an open pit about 20 m in diameter and two lower adits. The pit began to cave into the adits during the winter of 1971–1972, and was abandoned.

In 1978, a small vertical outcrop of pegmatite vein was still visible at the rim of the open pit. It contained large feldspar crystals and a quartz core with small smoky quartz crystals. West of the pit the vein has been faulted away and ends abutted against mica schists.

Today the open pit is covered by a landslide and the adits have caved in. The dumps are overrun with vegetation and are uninteresting except for a pile of manganiferous heterosite nearby. This heterosite forms large masses and branching growths in feldspar, rimmed by a thin layer of brown to bronze-colored ferrisicklerite.

Other minerals collected there on previous visits include greenish yellow, transparent brazilianite similar to crystals from the João Modesto mine, rather rare bluish apatite, yellow translucent amblygonite crystals, vivianite, frondelite, phosphuranylite, abundant eosphorite-childrenite as at the João Modesto mine, limonite nodules from the alteration of heterosite, cassiterite, columbotantalite, uraninite, beryl and large doubly terminated smoky quartz crystals with prominent inclusions. Limonite occurs as pseudomorphs after various minerals. A "considerable" but unrecorded production of brazilianite came from this mine.

PAMARÓ MINE

Also known as the Pamarol mine, Pamaroli mine, and the Morro do Cruzeiro mine.

The Pamaró mine lies about 3 km northwest of the João Modesto mine and north of Linópolis. From the Mendes Pimentel road a trail runs to the Vincente Pamaró farm. From there a narrow, grassy footpath climbs toward the east to the mine, which lies on the southern slope of a low mountain near an elevation of 390 m.

This was a heterogeneous pegmatite striking east to east-southeast and dipping 50° to 70° south. The vein, about 10 m in width, was exploited via several adits and irregular stopes (named the Boca Preta, Boca Rica, etc.), yielding amblygonite and tourmaline (de Godoy, 1945). The excavations, abandoned more than a decade ago, are caved and have been covered over by heavy landslides, except for a short adit about 10 m long at the east end. This adit penetrates fine-grained muscovite-rich pegmatite. The dumps have slid down the slope and are of no interest.

Minerals found here include quartz, feldspar, mica, schorl, pink and green gem tourmaline, white to green and bluish amblygonite,

apatite, beryl, uraninite, a few crystals of tantalite and cassiterite, spectacular eosphorite crystals and brazilianite identical in appearance to crystals from the João Modesto mine (Cassedanne *et al.*, 1971).

Eosphorite occurred in crystal groups up to 5 kg and shaped like a closed fan. Color ranges from yellowish to pinkish and grayish tan. The crystals, found lining vugs in cleavelandite, are commonly somewhat weathered and coated in patches with limonite and manganese oxides. In some cases the crystals have been pseudomorphically replaced by frondelite. Many specimens of museum quality were recovered, but unfortunately went unrecorded.

parent microcrystals having a waxy luster and concave faces. They occur irregularly scattered on albite in vugs associated with dark mica, quartz crystals, small apatite prisms and orange-brown coatings of oxides.

Apatite occurs as yellow or pink prisms scattered on feldspar and as acicular groups near tourmaline. Frondelite forms small acicular crystals in vugs. Loellingite and dark brown sphalerite in small grains occur scattered in feldspar. Rhodochrosite forms parallel intergrowths with indicolite near the quartz core, and muscovite forms elongated crystals and ruby-red groups making excellent micromounts.

Figure 11. **Local pegmatite miners at a prospect.**

JOVE LAURIANO MINE

Also known as the Juvenil, Joveni or Joventino mine, after Joventino Patrício, father of the present owner.

Access to the Jove Lauriano mine is by way of a dirt road branching off the Mendes Pimentel road beyond Linópolis. At a distance of 2.6 km the road crosses a small creek and then climbs its valley toward the José Moreira house. At 700 m from the ford, a sloping footpath about 500 m long leads to the mine, at an elevation of about 400 m. Many pegmatite dikes rich in schorl outcrop along the footpath.

The heterogeneous pegmatite, mined sporadically since World War II, has a width of about 20 m, strikes east-west and dips deeply to the south. It was exploited via two adits and tortuous connecting stopes. In 1980 it was cleared out after one of its numerous periods of abandonment caused by landslides.

The pegmatite consists of a large quartz core surrounded by abundant schorl, vugs with herderite in hydrothermally altered cleavelandite, long lath-shaped crystals of decomposed spodumene (eastern outcrop), a little pinkish brown lepidolite, indicolite, morganite, abundant pale pink garnet imbedded in tourmaline, rare apatite, loellingite, sphalerite, cassiterite, white amblygonite in feldspar, and much nontronite and manganese oxides. Some brazilianite is said to have been produced about ten years ago but no crystals have been saved by any local residents.

Hydroxylherderite occurs as abundant, translucent to trans-

SEBASTIÃO CRISTINO MINE

This occurrence lies about 500 m north of the Boa Vista farm, owned by Sebastião Cristino, on the west side of Linópolis (or Divino) Creek near an elevation of 370 m. It is located between the dirt road leading to the José Moreira house and the creek, about 1.6 km from the footpath leading to the Jove Lauriano mine, in the middle of the Boa Vista property.

The pegmatite here is several meters wide and strikes northeast, with a gentle northwesterly dip. It is embedded in east-west vertical schists and contains many schist xenoliths. It probably continues on the east side of the creek, beyond an eroded gulch. The mine was abandoned more than 12 years ago and the scanty dumps have been partially swept away by floods. Nearby to the south is another pegmatite which had yielded good collector-quality microcline crystals.

The dumps indicate a simple assemblage: quartz, graphic microcline and albite predominate. Intergrowths of quartz and club-shaped schorl are abundant. Vitreous, pink garnet in highly fractured nodules is heavily stained by manganese oxides. Apatite in irregular masses and prismatic crystals up to 2 cm is common and a little opaque pale green beryl has also been observed.

Brazilianite occurs there as irregular masses up to 20 cm, with a few faces showing here and there, and as single crystals to 1 cm.

These are found in limonite coated vugs in feldspar and in cavities in massive brazilianite. Fine micromounts and thumbnail specimens are collectible here. Specimens commonly consist of brazilianite on milky or transparent quartz crystals and coated by more small, doubly terminated crystals of quartz. Associations include a little cleavelandite and muscovite.

FAUSTINO LOPES MINE

A Jeep trail branching at 0.9 km beyond the Pamaró road leads to the owner's house. The pegmatite, near the mountain crest, produced a very few crystals of opaque beryl and some brazilianite crystals more than ten years ago. The workings are at present caved in.

ANTÔNIO MACHADO FARM

A small pegmatite located in a small forest remnant on the right side of the Mendes Pimentel road, about 4.5 km from Linópolis, is said to have produced some brazilianite crystals.

PORTÃO

A small pegmatite worked by João Modesto ten years ago is also said to have produced some brazilianite. It is located near a mountain crest at Portão Place (Sitio do Filô), east of the Mendes Pimentel road about 5.8 km from Linópolis.

ZÉ BERTO MINE

Access to the Zé Berto mine is by way of a pack trail from the Mendes Pimentel road about 6 km from Linópolis, which climbs a gulch (containing much staurolite) to the abandoned Zé Berto house at an elevation of about 480 m. The deposit, discovered in 1945 and abandoned in 1969, is reached via a steep footpath from the cabin.

The pegmatite strikes east-west and dips nearly vertically. It is currently overgrown by thick vegetation. Another unexplored pegmatite outcrops about 200 m to the west.

Still-visible dumps at the Zé Berto mine contain quartz, feldspar, schorl, mica books to 10 cm, highly fractured blue beryl, abundant limonite, some brazilianite fragments, arsenopyrite spots in feldspar, and weathered phosphate nodules. Frondelite occurs as greenish gray masses and lustrous needles lining vugs in feldspar. Landesite forms earthy coatings and small reddish crystals in frondelite. Childrenite has been collected in small clusters in feldspar and frondelite. Strunzite forms very small, yellow tufts in cavities and cyrilovite occurs as small, honey-yellow crystals identical to those from the Sapucaia mine.

JOÃO BELMIRO FARM

Just before the intersection with the road to São Felix on the Mendes Pimentel road, about 9.3 km from Linópolis, there is a small pegmatite on the João Belmiro property. This deposit is said to have produced some fine brazilianite crystals about 15 years ago.

CÓRREGO INDAIÁ

About a kilometer downstream from Geraldo Candinho's house, on the west side of Indaiá Creek, is a small pegmatite said to have yielded a few brazilianite crystals about ten years ago.

BAHIANO MINE

This small, nearly vertical pegmatite vein strikes N70°E and lies on the east side of Indaiá Creek (Córrego Indaiá). It was exploited by one short adit, then abandoned in early 1977. Dumps contain quartz, feldspar, beautiful six-sided mica crystals, schorl, and fragments of brazilianite crystals with striated faces.

Nearby to the east is a homogeneous, gently dipping schorl-rich pegmatite. It outcrops at the creek, and is exploited by a small adit at an elevation of 490 m. The relationship between the lenses is unknown.

GERALDO CANDINHO MINE

Access to the Geraldo Candinho mine is by way of the Mendes Pimentel road. The road to the mine leaves the Mendes Pimentel road about 2 km south of Mendes Pimentel and runs parallel to Indaiá Creek, then follows one of its tributaries to the farm at a distance of 3 km. Steep footpaths lead to the mine, which is situated on the slope of a high hill overlooking the farm.

Here a coarse-grained pegmatite containing many xenoliths is imbedded in subvertical schists and strikes northeast-southwest. A new adit penetrates the pegmatite at an elevation of about 435 m and extends for about 75 m. It begins in a direction of approximately N35°E, then turns toward the east. Two other adits a few meters higher are caved in.

The mineral assemblage is relatively simple. In addition to the usual quartz, feldspar and mica there is tourmaline, a little beryl, and some vugs lined with brazilianite crystals. Spots of loellingite associated with scorodite and small pharmacosiderite crystals occur scattered sporadically in quartz.

The brazilianite, formed later than quartz, is intimately associated with feldspar as xenomorphic aggregates to 40 cm. Vugs are commonly lined with brazilianite crystals; some are extremely well-formed and up to a centimeter in size. Very small, strontian plumbogummite crystals occur scattered in quartz and cavities in hydrothermally altered feldspar. Schorl with a brown or bluish tint occurs as small, doubly terminated needles perched on brazilianite in vugs in hydrothermally altered feldspar. Quartz, later than tourmaline and mica, forms transparent crystals to several cm lining vugs and coating brazilianite crystals. Limonite and manganese oxides stain many minerals, especially brazilianite, and spots of nontronite occur disseminated in vugs in feldspar.

This mine, reopened in 1979, is currently the only sporadically producing source of brazilianite specimens. Crystals are generally milky and of low value.

HERMES MINE

This mine, belonging to Hermes Goulart Matozinho, lies on the Rubiácea farm near the hamlet of Cabeceira do Laranjal. It was one of the more prolific producers of brazilianite after the closing of the Córrego Frio mine, but it too was closed in 1976.

Access is from Mendes Pimentel, via the Santa Cruz road which starts near the Mendes Pimentel church. The road proceeds for about 2.8 km, then a 6 km dirt road climbs up a broad valley to the Hermes farm at an elevation of about 465 m. The mine, situated in a thick bamboo forest, is reached following a tiresome one-hour hike across high grass and through forests.

The pegmatite outcrops at an elevation of 680 m, and strikes N30°E with a steep southeasterly dip. The surrounding rock is a tonalite. The deposit was explored by a small adit now caved in, and the mine was abandoned in 1969 after having produced only a few tourmaline crystals.

Twenty meters lower on the hillside a long adit following the pegmatite is also caved in. In addition to quartz, feldspar and mica it yielded a large, honey-yellow "childrenite" nodule, a little beryl, tourmaline, muscovite, and abundant brazilianite in aggregates to 40 kg imbedded in weathered feldspar.

Brazilianite is still abundant on the dumps, which are mineralogically poor otherwise. It can be found as cracked fragments to several cm having microcrystals very suitable for micromounting. The crystals are generally prismatic with a diamond-shaped cross-section and many-faced termination. Growth features are common on the crystal faces. A few rare fragments are of gem quality. The brazilianite here commonly contains quartz and mica crystal inclusions.

CONCLUSION

Brazilianite was produced in relative abundance at several mines in the upper Laranjeiras basin following the discovery of the first specimens at Córrego Frio (João Modesto, Telírio and Hermes being the principal other sources). However, a lack of distinguishing physical characteristics among specimens from the various pegmatites, combined with a lack of conscientiousness in maintaining locality information on the part of miners, dealers and property owners in the area, has resulted in most localities on labels being unreliable and unverifiable. Nevertheless, despite the disappearance of specimens from the Brazilian market, brazilianite, with its pleasing color and fine, large crystals continues to be eagerly sought after by collectors.

ACKNOWLEDGMENTS

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Bastnaesite
near ticonderoga, new york

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ABSTRACT

Several well-formed bastnaesite crystals, occurring in a quartz crystal-lined druse, have been found in the Upper Cambrian Potsdam formation in the Trout Brook Valley southwest of Ticonderoga, New York. The occurrence is in a fault contact zone with Precambrian gneisses. The X-ray powder pattern matches that of bastnaesite at Birthday Claim Mountain Pass, California. The strongest diffraction lines are: 2.85Å, 3.52Å and 4.82Å. There are only two recorded occurrences of bastnaesite in the Adirondack Mountains and relatively few localities worldwide yielding euhedral crystals.

INTRODUCTION

The specimens were found by the writer while mapping the Potsdam formation in the Trout Brook Valley near Ticonderoga, New York, during the summer of 1926, and subsequently set aside. Only recently were these specimens reinvestigated, at which time their mineralogical significance became apparent because of their rare occurrence in the Adirondack Mountains and general rarity as well-formed crystals reported in the literature (Dean, 1944; Glass and Smalley, 1945; Olson, Shawe, Pray and Sharp, 1954).

The geology of the region has been compiled and summarized by Swinnerton (1932). A fault, at which the bastnaesite locality occurs, is the western branch of the Street Road fault which is the boundary fault of the eastern Adirondack massif. The Potsdam formation has been down-faulted against the Precambrian gneisses on the north along this subsidiary structure in the Trout Brook Valley (Fisher, 1970; Swinnerton, 1932).

The other Adirondack Mountains occurrence of bastnaesite is at Mineville, Essex County, New York, some 10 miles due north, where it is reported to occur in fine-grained, small amounts associated and intergrown with rare-earth-bearing apatite (McKeown and Klemic, 1956).

PHYSICAL PROPERTIES

The mineral occurs in a druse faced with quartz crystals, in both short stout and long slender prismatic crystals with parting along lamellae parallel to the *c* axis (Fig. 1). Hardness and specific gravity are about 4 and 5, respectively. Color is honey-yellow to reddish brown; luster is vitreous to resinous.

The surviving crystal in Figures 1 and 2 measures 7 mm in the *c* axis direction and 6 mm across. The portion of the broken crystal showing in Figure 1 has been whittled away for use in X-ray analysis, hence only a faint trace of it shows in Figure 2. The slender crystal in Figure 3 has been sacrificed for further analysis because of a limited amount of mineral.

Figure 1. **Bastnaesite showing re-entrant angle on complete crystal and lamellar structure of broken crystal. Height of complete crystal equals 7 mm.**

CRYSTALLOGRAPHY

Bastnaesite is prismatic ditrigonal-dipyramidal (space group = $C\bar{6}c2$; Palache *et al.*, 1951). The crystal in Figure 1 displays an inverted pyramidal cavity when viewed from the top, which is prob-

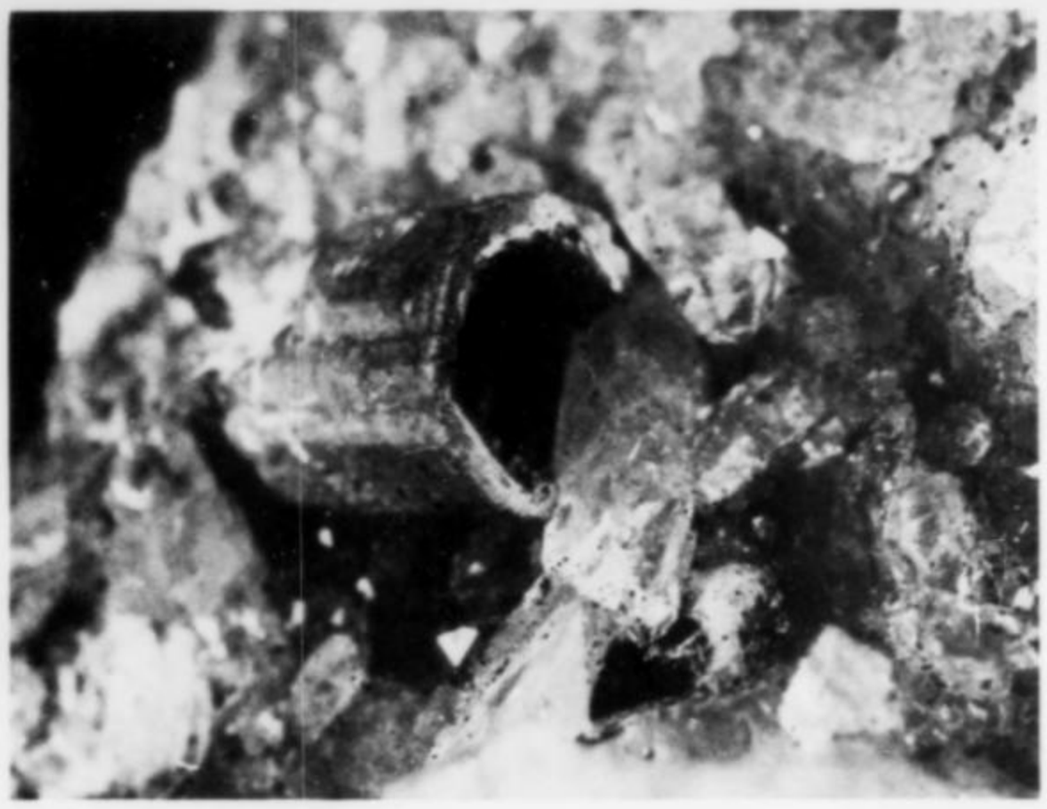

Figure 2. **Complete crystal shown in Figure 1 exhibiting inverted pyramidal depression, in a druse studded with quartz crystals. Broken crystal, as shown in Figure 1, has been removed for determinative purposes. Crystal diameter approximately 6 mm.**

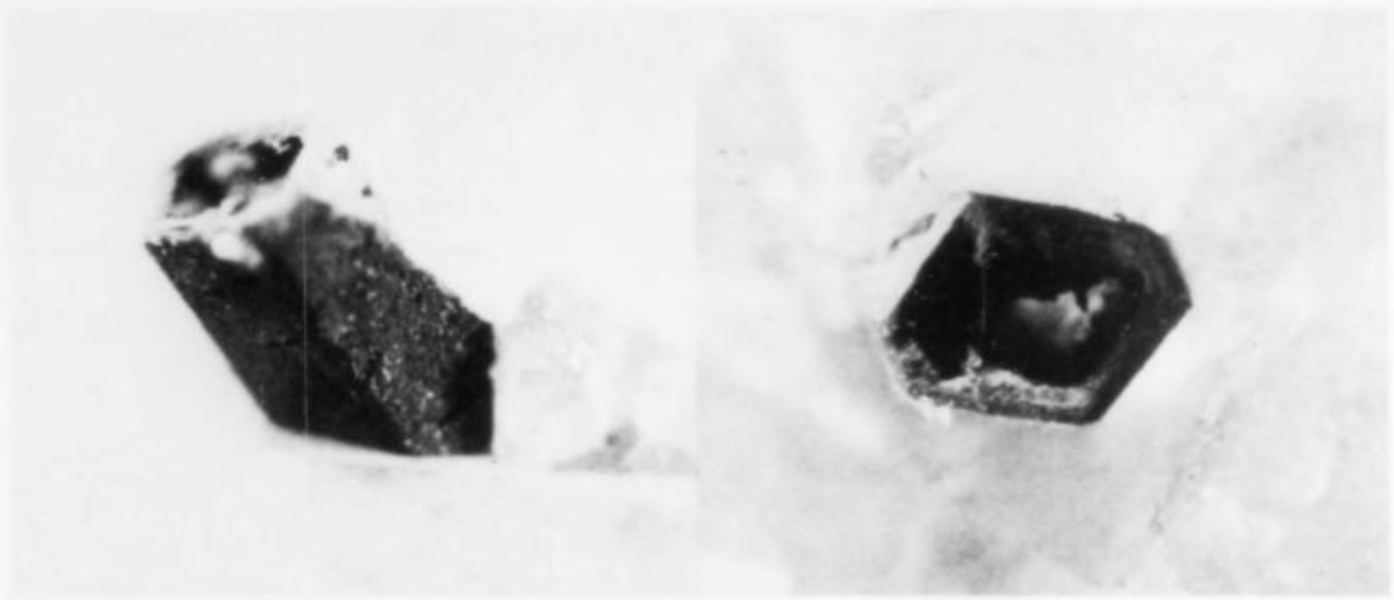

Figure 3. **Side and top views of specimen sacrificed for X-ray testing material. Maximum cross sectional dimension equals 3 mm.**

ably a growth phenomenon. Re-entrant angles (Figures 1 and 2) appear to indicate twinning of the crystal, although it is reported that twinning is rare in the hexagonal division of the hexagonal system. The re-entrant angles are parallel to the *c* axis. If these represent twins, then two potential twin laws are 180° rotation about the *c* axis or a twin plane parallel to the *c* axis and interleaved with the *c* glide plane.

X-RAY ANALYSIS

The powder diffraction analysis was done using a Norelco B2-3470 diffractometer equipped with a graphite monochrometer. Settings were 40Kv, 20ma, CuK alpha radiation, using a 1°2Θ/minute scan rate.

Bastnaesite is a fluocarbonate of the cerium metals $(RF)CO_3$. Table 1 shows the X-ray diffraction powder pattern measurements of the ten strongest diffraction peaks of the Trout Brook mineral, which compares favorably with those of the corresponding mineral from Birthday Claim Mountain Pass, California. All 16 of the Trout Brook *d*-values and intensities match those of the standard, which provides strong credence to the identification.

Table 1. **Comparative X-ray data, ten most intense reflections.**

Trout Brook Valley bastnaesite		Birthday Claim Mountain Pass bastnaesite	
I/I_o	*d*Å	I/I_o	*d*Å
52	4.82	40	4.88
62	3.52	70	3.56
100	2.85	100	2.87
19	2.42	9	2.44
31	2.03	40	2.05
36	2.00	40	2.01
28	1.88	40	1.89
16	1.66	21	1.67
11	1.56	15	1.57
9	1.29	15	1.29

ACKNOWLEDGMENTS

R. W. Grant made an X-ray analysis with a limited amount of material and was first to suggest that the mineral might be bastnaesite. J. C. Drake and D. P. Bucke, Jr., later confirmed Grant's finding. The writer is also indebted to J. C. Drake for his assistance in the section on crystallography and for the photograph, Figure 1. J. C. Drake and D. P. Bucke, Jr., critically read the paper.

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Across the San Juan Mountains

by **T. A. Rickard**

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Annotated and illustrated by
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In 1902, the well-known mining engineer and author T. A. Rickard toured the mines of Colorado's San Juan Mountains on horseback. His travels, published in 1907 as "Across the San Juan Mountains," took him through many famous collecting sites.

Second of Two Parts

We continued on our way up the valley of the Animas and soon passed through Howardsville, which figures largely in the early reports made by R. W. Raymond, F. M. Endlich, and other government officials during the seventies. It is now chiefly populated by Mr. Tom Trippe. Close-by is Cunningham gulch, where the andesite-breccia of the San Juan formation comes down to the Algonkian schists. Several mines, such as the Highland Mary, Ureteba and Green Mountain, exhibit this contact between Tertiary and Precambrian terrains. The best ore obtained from the lodes, which penetrate both formations, is said to have come from the schist just below the breccia; this was especially the case with the Green Mountain vein which had a large ore-body immediately under the volcanics. The next tributary valley is Maggie gulch, where there are several young mines, one of which, the Ridgway, is of importance.

The Animas valley swings around to the north, and the road brings the traveler into the main street of Eureka, the distributing point for the **Sunnyside, Mastodon, Silver Wing**, and other mines which have proved productive. Just as Tom Trippe occupies Howardsville, so Rasmus Hansen represents Eureka. These are among the very few of the pioneers who are still actively at work – strong, brave men, who have crowded the romance and vicissitudes of mining into their own lives; men with an indomitable pluck and a tireless activity like that of the torrent of the Animas which rushes past their cabin doors – sweeping with a vagrant energy that heeds neither the gladness of the radiant valley nor the gloom of the savage gorge until, after many wanderings, it abates its speed and hushes its voice in the still waters of the darkly flowing San Juan.

The **Sunnyside mine,** currently open, is the source of green fluorite and rhodochrosite crystals which were well known to collectors in the 1960's. Discovered in 1872, the mine was reopened in 1959; access is by way of the **American Tunnel** from Gladstone. The town of Eureka, near the mine, is now abandoned, with only the foundation of the large and once-impressive Sunnyside mill still visible on the mountainside. (AES)

Fine matrix specimens of tetrahedrite have been collected at the **Silver Wing mine**. This mine was an important source of specimens for the late Ed McDole, a famous mineral dealer of the 1950's and 60's. (RAK)

Beyond Eureka we passed the Silver Wing and the **Tom Moore mines**, and just below Animas Forks we turned eastward and started the ascent of Cinnamon pass. This is at an altitude of 12,600 ft. and separates the watershed of the Animas from that of the Lake Fork of the Gunnison river. On the divide is the **Isolde mine**, in the andesite-breccia, also the **Bon Homme**, in granite, and lower down we passed the tramway being constructed for the **Tabasco mine**. The bright glint of a thick copper wire bespoke a line of electric transmission connecting the mine and mill with a power station situated on the further edge of Burroughs Park.

Below the Tabasco mill we met a wagon heavily loaded with bedplates, for an engine, bearing the name of the Colorado Iron

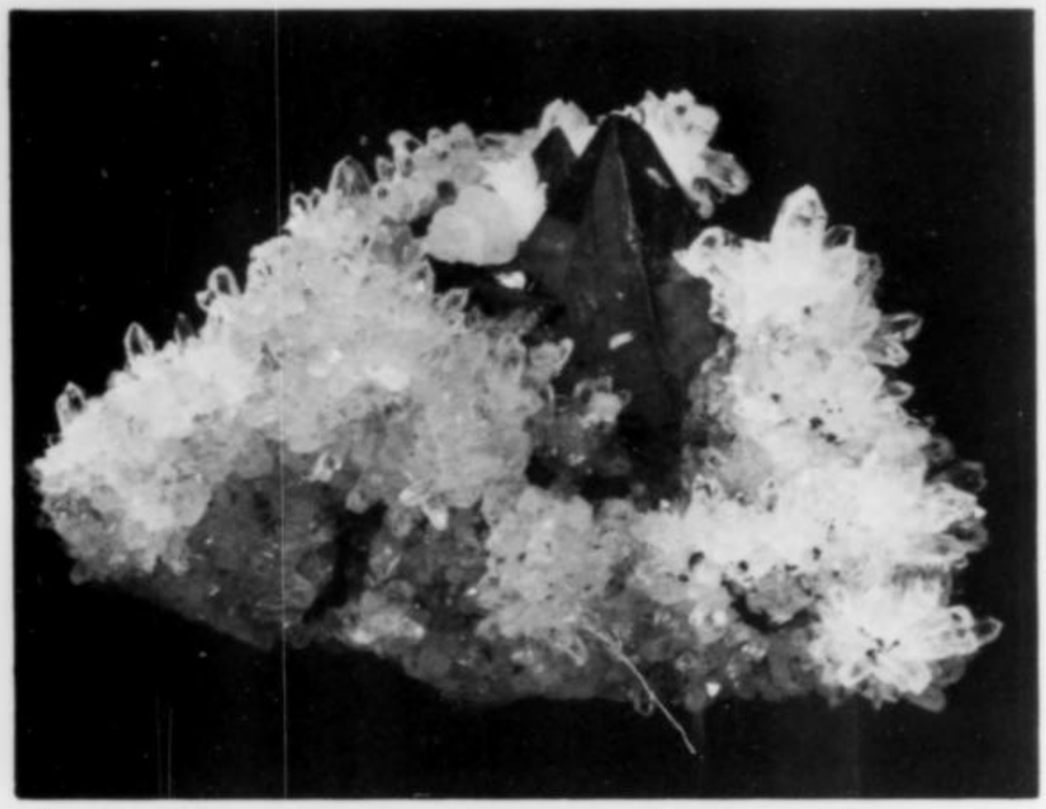


Figure 1. **A large tetrahedrite crystal measuring about 4 cm, with manganoan calcite and quartz crystals from the 912 stope, 900 level, Argentine vein, Idarado mine. Collected in 1957 by Clancy Fleetwood; an Ed McDole specimen. Kosnar photo; private collection.**

Works; and soon afterward, riding through a belt of pines, we found ourselves in the open valley of Burroughs Park. This district has been, during the past two years, the scene of active prospecting and some mining. We dismounted and partook of hospitalities tendered by Mr. George Peirce, who subsequently piloted us to the **Cleveland** group of veins. These are not as yet of economic importance, but they have characteristics which are interesting from a scientific point of view. They penetrate granite; the Monticello vein, which I saw, was about one foot thick; for the first 15 ft. in depth the vein consisted of cellular quartz marked by copper stains, but otherwise it was said to be barren; lower down it became metal-bearing, and at about 45 ft. deep I found a piece of copper pyrite coated with a gray film of chalcocite, suggestive of secondary enrichment.

In the afternoon we left this locality and rode down Burroughs Park and along the Lake Fork of the Gunnison until, in the evening, we pulled up at the **Golden Fleece mine**, beside Lake San Cristobal. The road follows the contour line of the lake shore and afforded us a glorious canter in and out among scattered young pines; there came glimpses of placid water reflecting the resplendent coloring of the aspens which clustered upon the encircling hillslopes, and the bright warm tints of clouds which caught the sunset glow. Suddenly, in turning a corner, the road ran amid a group of cabins and other buildings, the busy aspect of which told us we were at our destination, the Golden Fleece mine.

In the summer of 1896 the Golden Fleece mine shipped nine carloads of ore, weighing about ten tons each, the poorest of which netted $33,000 and the richest $49,500. In a few months the bonanza yielded $1,600,000. This rich ore was characterized by petzite (Au 25 percent, Ag 41 percent, Te 34 percent) and ruby silver (proustite) scattered through a dark chalcedonic quartz or hornstone.

The **Golden Fleece mine** is the type locality for hinsdalite (located in Hinsdale County). (RAK)

The story of this mine exhibits the uncertainties of digging for gold. In 1874 Captain Enos T. Hotchkiss, connected with a government surveying party which was laying out a toll-road from Saguache to Lake City, caught sight of the outcrop, standing conspicuously above the hillslope, and examined it. He located it as the "Hotchkiss" mine, and had some assessment work done while he was engaged in his survey-work in the vicinity. As far as is known, he found no ore. A year later, when Hotchkiss had abandoned his claim, it was re-located by George Wilson and Chris Johnson, under the name of "The Golden Fleece." They began what is now known as the No. 1 tunnel, but finding only little stringers of rich ore they ceased work. Others did similar desultory prospecting. O. P. Posey found a very rich bunch of ore in the croppings above the No. 1 tunnel and took out several hundred pounds, which were packed to Del Norte and sent thence to the Pueblo smelter. Then John J. Crooke took a lease and bond; he also extracted about $30,000 from the outcrop above No. 1 tunnel, which had been extended a little further, without result. This was between 1876 and 1878. In 1889 Charles Davis took a lease and bond; he did a good deal of work along the high croppings, and finally sank a shaft 30 ft. deep, which struck a body of ore yielding $40,000 in a very short time. Late in that year, 1889, George W. Peirce bought the mine for $50,000, and commenced extensive explorations. He found out very soon, indeed, that Davis had extracted all the ore in sight, and the outlook was not cheerful. All the work up to this time had been to the north, on the supposition that the vein had been faulted in that direction. The new owners cross-cut south at the No. 2 tunnel, which had been previously extended a little way, but had found nothing. The vein was picked up, but not much ore was encountered at first. They persisted, however, and within a year rich ore was cut on No. 2, and it was traced upward until it became easy to intercept the same body at No. 1. It was discovered that the former owners had been within ten feet of the main orebody of the mine, which from that time, and until 1897, was very profitable. Most of the rich ore of the Golden Fleece mine was shipped to the smelters, but the low-grade mill-stuff was treated on the spot. The values were chiefly contained in telluride minerals (principally petzite, but also some hessite).

We remained for two whole days with Mr. Peirce, and early on the 12th of September our journey was resumed. In crossing the valley of the Lake Fork of the Gunnison one cannot help noting the peculiarities of the surface. The eastern range, opposite the mine, is marked by a depression known as Slumgullion gulch. As seen from No. 3 tunnel it looks like a big landslide, the steep slopes of which have been obscured by weathering. However caused, it has extended down to the valley and dammed the stream so as to form Lake San Cristobal. It is said, by those living on the lake shore, to be still in motion and to be extending further across the valley. Slumgullion is commonly imputed to glacial action, but the observed facts do not require us to go so far afield.

At the top of Slumgullion gulch the road turns eastward to Creede; we turned northward and, picking up a trail which plunged into a pine forest, we eventually found ourselves at the headwaters of the Cebolla and followed it down. We were soon on a well-beaten path – the old Ute trail, used by the Indians in their migrations across the Gunnison country. They are gone from these hills and huddled on the reservation; so also the game which they hunted; that too has been driven away by the restless prospector. As we rode along in single file there was no sign of living thing for hours of travel; we followed the Cebolla, fringed with willows and threading narrow valleys overshadowed by cliffs of architectural aspect, battlemented masses and monumental pillars, like Egyptian pilons, among which a babbling trout-stream took its quiet way.

All of the succeeding afternoon was spent in a comfortable ride down the expanding valley of the Cebolla, which now began to exhibit cultivation, until, with a long gallop through the cool air of the twilight, we reached the Hot Springs. Here we put up overnight. From a distance the patches of white incrustation and clouds of steam told us of our approach to this scene of thermal activity. The

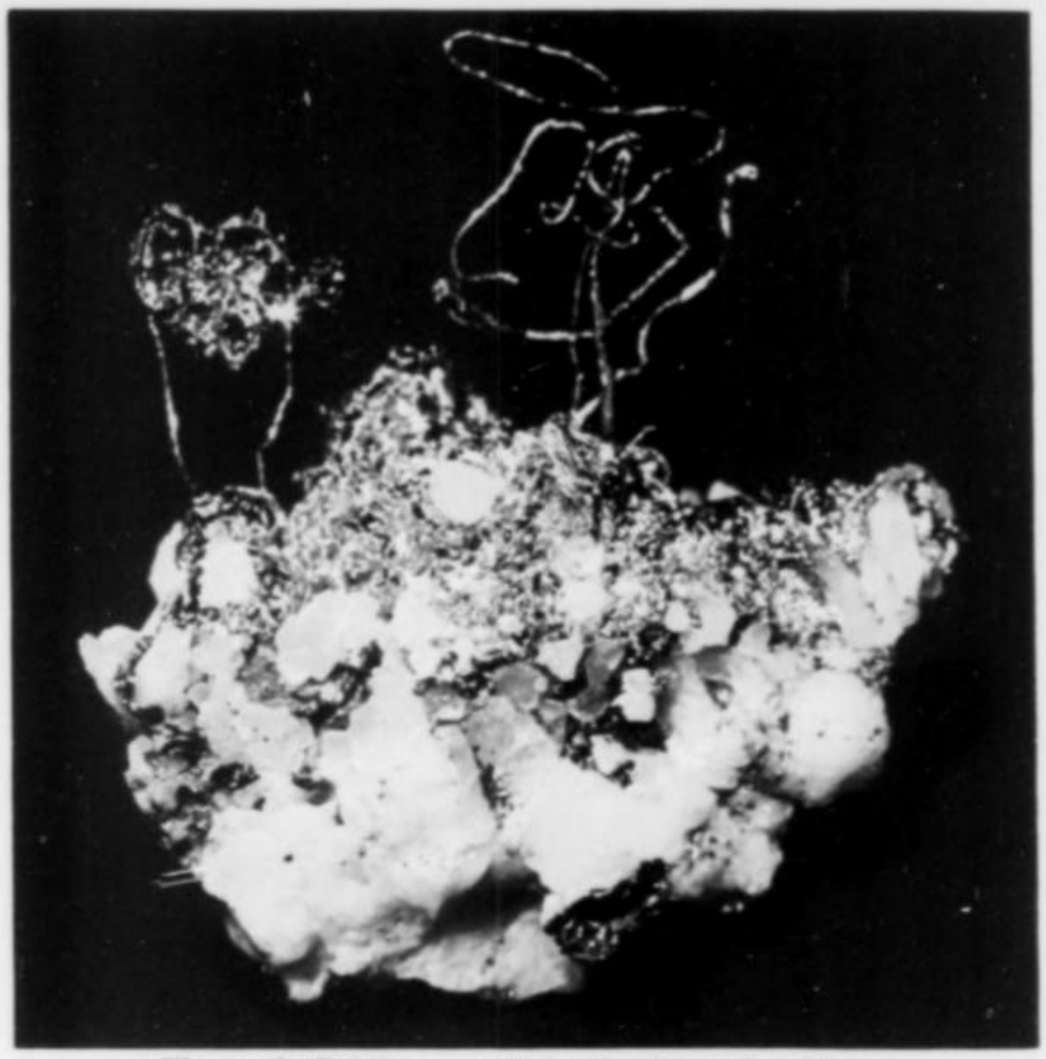


Figure 2. **Bright crystals and wires of gold on quartz, with micro petzite crystals and vein galena. The specimen measures 2.8 cm. From the 2030–2040 stope, main drift, D level on the La Belle Creole vein, Sunnyside mine near Gladstone, San Juan County, Colorado. Collected in 1971 by Ed Doose. Kosnar specimen and photo.**

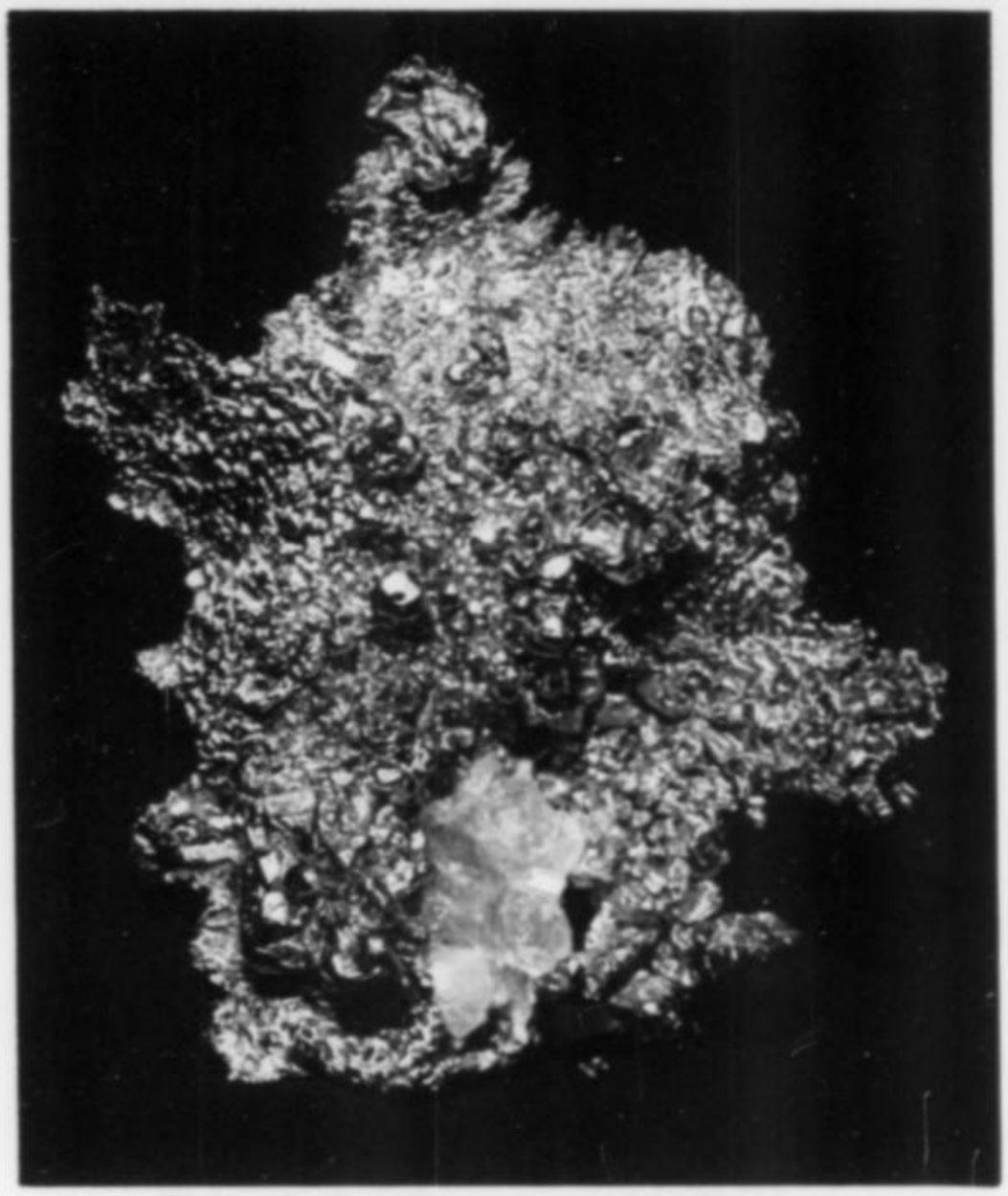


Figure 3. **Complex gold crystals forming a specimen 5 cm tall, from the 12,500 level (elevation), surface workings, Sheridan mine, Marshall Basin (above Telluride), San Miguel County, Colorado. Collected by John Fallon circa 1875–1876. Kosnar specimen and photo.**

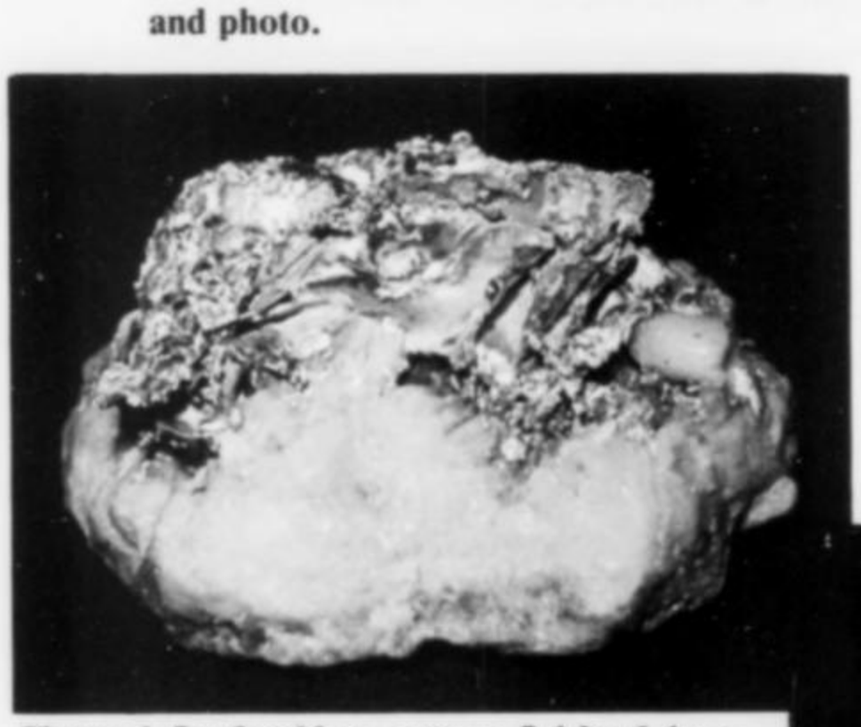
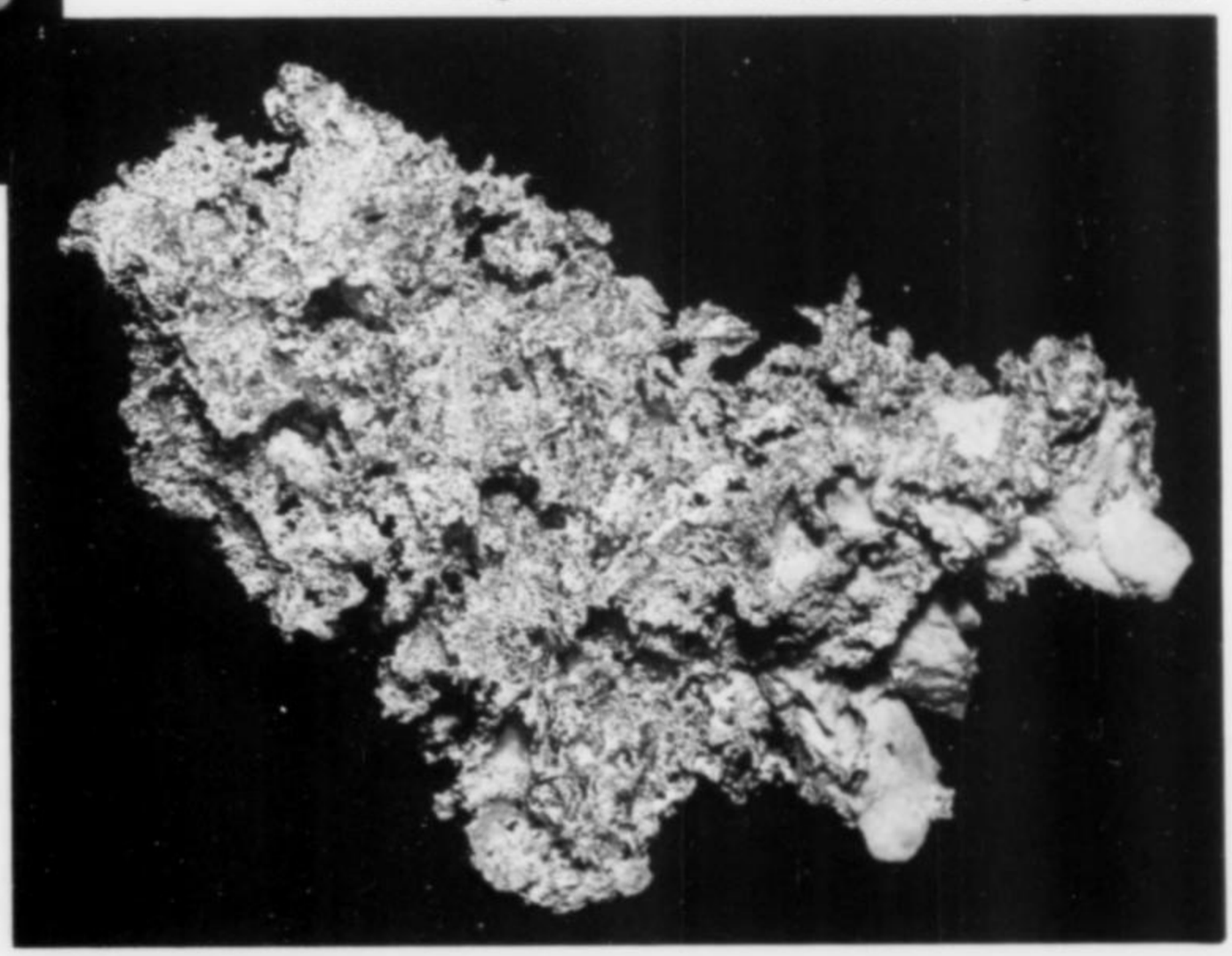


Figure 4. **Leaf gold on quartz, 5.4 by 6.4 cm, from the 12,600 level of the Smuggler mine, Marshall Basin, San Miguel County, Colorado. Collected circa 1878 by J. B. Ingram. Kosnar specimen and photo.**

Figure 5. **Sponge gold with quartz and sphalerite, 9 by 12 cm (16 ounces Troy), from the 908 stope, 900 level, on the lower Black Bear vein, Idarado mine. Collected in 1948 by Clancy Fleetwood. Kosnar specimen and photo.**

links between vein-formation and hot springs which are to be seen throughout this region are not lacking in suggestion.

Next morning, September 13, we turned eastward from the Cebolla valley and struck across country for Vulcan. At the foot of a high ridge we passed the **Old Lot mine**, cheerfully active. The dump indicated a vein carrying two or three feet of dark quartz streaked with galena. Close to the latter occasional spots of native



About a half mile northeast of the **Old Lot mine** is an occurrence of well-formed anatase crystals. The crystals, which reach 1¼ inches in length, occur in veinlets on joint planes in a diorite dike. They range in color from black to a good sapphire-blue, and I've seen a couple of cut stones that would pass for sapphires from Fergus County, Montana. (RAK)

gold could be seen – a handsome-looking ore. On the top of the ridge there was afforded an extensive view of the Gunnison plateau, bounded to the north by the deep gorge through which the swift Gunnison rushes, and to the south by the bold outlines of the San Juan mountains. Looking eastward the outlying summits of the Cochetopa hills broke the sky-line, but westward the sage-clad ridges stretched in sober gray until they faded into the blue of farthest distance. Though tame as compared to the grandly picturesque mountain-land from which we had just emerged, this plateau yielded a pleasure of its own in the glorious spaciousness and atmospheric radiance of a boundless horizon.

The **Good Hope** vein penetrates a greenish-gray sericite or hydrous mica schist, which has the greasy feel and fine texture characteristic of that rock. It forms part of the Algonkian series of crystalline schists which overlie the Archean granite of the Gunnison plateau. The vein has an approximately east and west strike and dips northward. At surface the vein has an outcrop of heavy iron sinter which eventually gives place underground to a band of country thickly impregnated with iron pyrite. The walls of the vein are smooth and soft, both features being due to a parallelism with the schistosity of the enclosing country. No selvage or casing was noticed, but the lode-matter breaks rather readily away from the country on account of a blocky jointing, which, added to the fissile character of the rock itself, makes mining operations dangerous unless the timbering is well attended to. The rich ore is associated with streaks and lenses of iron-stained schist traversed by stringers of quartz. Native tellurium is frequently present, but the mineral which carries the gold has not been detected with certainty. I found some spots of petzite, and it is likely that this is one of the enriching minerals.

In the upper levels there is evidence concerning the origin of the vein and its contents. The occurrence of a body of native sulfur has been emphasized practically, by its combustion to an extent that endangered the mine. The adjoining ground in the **Chimney** and **Vulcan** claims was abandoned on account of the burning of a similar body of sulfur. In the Good Hope there is a body of it 105 ft. deep, 4 to 6 ft. wide, and of a length which the owners thought it unwise to determine by further drifting. The top of the sulfur very nearly coincided with the first level, 90 ft. from the surface. This substance, occurring as a grayish-yellow loosely coherent powder, was shipped in carload lots to the Western Chemical Company, at Denver. It averaged 80 percent sulfur and also 3 to 20 dwt. of gold per ton. The water of the mines on this vein is very acid and green in color. It carries over 1 percent copper and 1.5 percent of sulfuric and sulfurous acids. Fire-opal is to be seen in occasional brilliant specks, and all sorts of dark jasperoid quartz are found, beautifully banded.

The Good Hope vein is rich in uncommon minerals. Tellurium occurs native, as a tin-white mineral with a metallic luster. Occasional specimens exhibit rhombohedral prisms. It is associated with petzite, the telluride of gold and silver, and a new mineral, the telluride of copper. A greenish-brown micaceous substance suggests roscoelite, a vanadium mica, which occurs in association with telluride gold ores in Boulder county and at Cripple Creek, Colorado, as well as at Kalgoorlie, Western Australia. One specimen, secured on the occasion of our visit to the mine, contained fine needles of berthierite, a sulf-antimonite of iron, which bears some resemblance to stibnite. The opal of the upper levels is said to have been very rich, especially in the purple-tinted spots; this may have been due to a telluride salt.

What Rickard mentions here as "a new mineral, the telluride of copper," was named *rickardite* in his honor, in 1903. The **Good Hope mine** is the type locality. Rickardite, Cu_4Te_3 or Cu_7Te_5, occurs as beautiful, purple, lenticular masses associated with tellurides and native tellurium. Rickard also mentions "fine needles of berthierite," but the material I have from the Vulcan district which matches this description has proved to be owyheeite. (X-rayed) (RAK)

From Vulcan our trail took us over the eroded stumps of granite hills and across the river into the level stretch over which the town of Gunnison spreads itself drearily and wearily. Gunnison was a boom town, and when the wind goes out of a boom the wreckage is not enlivening. In 1880-1885 there were three smelters at work, and the combination, in the neighboring mountains, of iron, coal and precious-metal deposits won for Gunnison the splendid title of a "new Pittsburg." The town attempts to cover an area of two miles square, so that when you think you are in Gunnison you are out on the prairie, and when you imagine you are out in the country you are on a main street. In spite of it all, Gunnison wears an aspect of resignation, as if to say "It is better to have boomed and bust, than never to have boomed at all."

The next day, September 14, we started for Crested Butte, the center of an important coal region. The road follows the main branch of the Gunnison, a famous trout-stream known to every follower of Izaak Walton; the valley broadens at times into a goodly expanse of farm-land, dotted with cheerful homesteads. A few miles below Crested Butte the river is flanked by mountains, among which the rhyolite cone of Round Mountain and the basalt-capped mass of Mt. Wilkinson are conspicuous. Finally the traveler reaches the confluence of several streams and a wide basin, on the western edge of which the town of Crested Butte has been built. A noble mountain, buttressed with steep cliffs and massive as an anchorage for an aerial tramway to Mars, overlooks the town from the east, and has given it the name of Crested Butte. It is a big stock of porphyrite. On the west and south the gentler slopes of Mt. Wheatstone, fringed with pines, merge with the valley, and to the north a perspective of successive peaks indicates the Ruby range. These gain height and mystery as seen through the smoke from the coke-ovens of Crested Butte, lying huddled under the long shadows of evening. In the center of the town we found a barrack-looking building, which turned out to be a very clean and comfortable hostelry. Next day, the 15th, saw us on the Coal Creek road, en route to Irwin and Floresta. On both sides of the cañon the hillslopes were a desolation of burnt timber, a glimpse of that destruction, through careless fires, which is gradually causing the deforestation of Colorado. The actual burning up of good trees is bad enough, but the effect of such fires on the young growth does the most serious injury to the possibilities of a future supply of timber from these devastated tracts of mountain-land.

As the higher altitude was gained, the scenery improved and became bolder. We were passing through a porphyrite country, and the large fragments which had rolled to the roadside showed handsome crystals of feldspar. A winding trail took us northward from the westbound road and brought us to the deserted hamlet of Irwin. The **Irwin mining district** was active in 1880 and succeeding years. The **Forest Queen mine** is credited with a production of over a million dollars. In 1893 the fall in the price of silver flattened out the life of the camp, and until lately it has remained practically deserted. Quite recently a consolidation of a group of mines has been effected, and there is now promise of some activity. We visited

Fine, bright red, translucent, acicular crystals of xanthoconite have been found in vugs with arsenopyrite and quartz at the **Forest Queen mine**. (RAK)

the **Ruby Chief mine**, under the kind guidance of Mr. P. F. Ropell.

The Ruby Chief vein traverses a bedded series of coarse sandstones and shales belonging to the Ruby formation of the Upper Cretaceous. The vein occupies a fault-fracture, as was indicated by a break in the continuity of a layer of shale seen underground. A 6 to 8-in. vein of white quartz, streaked with arsenical pyrite, mispickel, is the best ore. It usually carries ruby silver (proustite) and brittle silver (stephanite). Selected ore contains 65 to 100 oz. silver, and from 10 dwt. to 1 oz. of gold, per ton. The vein or 'leader,' is usually characterized by a definite streak of pyrite, accompanied by zinc-blende, which speckles the quartz in lines parallel to the walls of the vein.

The crystalline quartz, lining cavities or 'vugs,' is a very marked feature of the lode, more especially because this structure is so noticeable in the independent quartz-veins whih occur in the outer country alongside of the vein. The quartz incrusting the brecciated sandstone within the lode, appears banded, due to the contrast between layers of quartz and mispickel. Rhodochrosite was seen in a few specimens. Mr. Ropell informed me that the best ore had been obtained from the vein at the horizon where it traversed the conglomerate beds which form an integral portion of the Ruby formation.

Leaving Irwin, we retraced our steps for a mile and crossed the shoulder of Ohio peak at Kebler pass, named after the president of the Colorado Fuel & Iron Company. The winding road was followed through a pine forest until, on the northwestern slope of the ridge, it descended abruptly into a narrow ravine. To ride over a deserted mountain road and then to come suddenly into full view of a compact little mining settlement is a sensation which does much to break the monotony of cross-country riding. This was Floresta, boasting the only anthracite mine west of Pennsylvania. The old anthracite mine, known as Smith's, near Crested Butte, is now worked out, and the new anthracite region, tributary to Paonia, now being prospected between the Gunnison river and the Anthracite.

The output of the mine at the time of our visit was 100 to 125 tons per day. The manager, Mr. Thos. McLaughlin, to whom we were indebted for many courtesies, informed me that there is much difficulty in keeping miners at Floresta, because the mine is not in operation, on account of snow, for more than half the year, which prevents men with families from going there. Moreover, the narrowness of the seam and the conditions of working are such that only the most experienced miners can earn a good living. The work is much more arduous than that of ordinary lode mining, because of the cramped space and the subsequent disposal of the output.

We left Floresta the next morning, September 16, and crossed the Ohio pass, on our return to Gunnison, by a route different to that of our previous journey, which had now taken us around a group of three mountain peaks, Mt. Wheatstone, Mt. Axtell and Mt. Carbon, and from the watershed of the Slate river to that of Ohio creek, both tributaries of the Gunnison, into which they merge a little to the north of the town itself. Ohio pass, 10,033 ft. above sea level, is similar to other mountain crossings; there is a defunct sawmill with an untidy sawdust heap; an abandoned railroad grade, as though engineering skill had failed of breath.

We passed Carbon and Castleton, two coal camps, with all the hideousness which belongs to those unhappy-looking settlements; then a short stay, pleasant for man and horse alike, at a roadside range, prepared us for a long canter over the wide dusty road which finally, but we could never tell when, brought us into the unlimited city of Gunnison.

That night at Gunnison we heard the fishermen's tales. It is a great resort for the manipulators of rod and line. It is also a mining center for the surrounding hill country, so that there is no lack of fishy yarns. The unwary will hear of mountains of iron and acres of gold ore; but behind the exaggeration there is the fact that the Gunnison country, with the Elk mountains to the north and the granitic foothills which lead to the San Juan ranges, to the south, is extremely rich in a variety of mineral wealth – coal, iron, gold and silver – which would have undergone more substantial exploitation if the windy breath of a premature boom had not blighted it in the infancy of its development.

On September 17 we rode from Gunnison to Gate View. The road follows the Gunnison until it crosses the river at Iola, the shipping point of the **Vulcan district**. Taking a cross-country trail, we filed through the sage-bush, covering monotonous, low hills, the remnants of granite mountains which had yielded to the leveling hand of Time. Spencer and Dubois, two mining camps, were found almost deserted. Then, surmounting a ridge, we saw again the splendor of the San Juan ranges and the pleasant valley of the Lake Fork. After weary miles of sage-brush hillocks it was singularly refreshing to look upon a landscape through the diversified beauty of which the modifying influence of geological structure could be plainly discerned. At Gate View we passed a night. The name is given to a ranch and railroad section-house near the natural gateway of the Lake Fork, which flows through a gap cut into the andesite.

We reached Lake City at noon amid a rainstorm which was remarkable for the reason that it was the first bit of bad weather encountered during twelve days. It cleared in the afternoon, so, leaving our horses to rest, we walked the seven miles up Henson creek to the **Ute and Ulay mines**. These have been the mainstay of Lake City through all the vicissitudes of the past twenty years. The two veins have been worked at various times both jointly and separately. When I was last there the Ulay lode was the chief source of production; on the present occasion we found that the Ute vein was affording the principal stoping ground. This was above the main adit. The vein is from four to five feet in width; it is a simple quartz-vein containing argentiferous galena. Iron pyrite and zinc-blende are present in relatively small quantity. The lode is essentially an impregnation following a sheeted band in the andesitic breccia of the San Juan formation and has the characteristics already noted at the Camp Bird, Smuggler Union and other mines in the same region.

Some fairly nice rhombohedrons of pink rhodochrosite have come from the **Ute and Ulay mines**. (RAK)

Next day, September 18, saw us started on our final stage, from Lake City to Ouray. Our way took us again past the Ute & Ulay, where we stopped to get some further data from the millman. As we rode along up Henson creek it was pleasant to notice a good deal of mining activity; we passed under the Bleichert tramway of the Hidden Treasure, past the Moro mill, with a Leschen tram connecting it to an unseen mine on the pine-clad mountain-side and then, just below Rose's Cabin, the **Bonanza tunnel**, with a new mill in course of construction. Mr. Philip Newitt, superintendent of the Henson Creek Lead Mines Company, as it is officially styled, was kind enough to take us underground. The lode is the usual sheeted band of breccia-country carrying four to five feet of quartz in which gold, silver, copper and lead are carried by copper pyrite, galena and other less conspicuous minerals.

This pleasant interlude at the Bonanza mine was supplemented by a hearty dinner at the miners' boardinghouse before we mounted again.

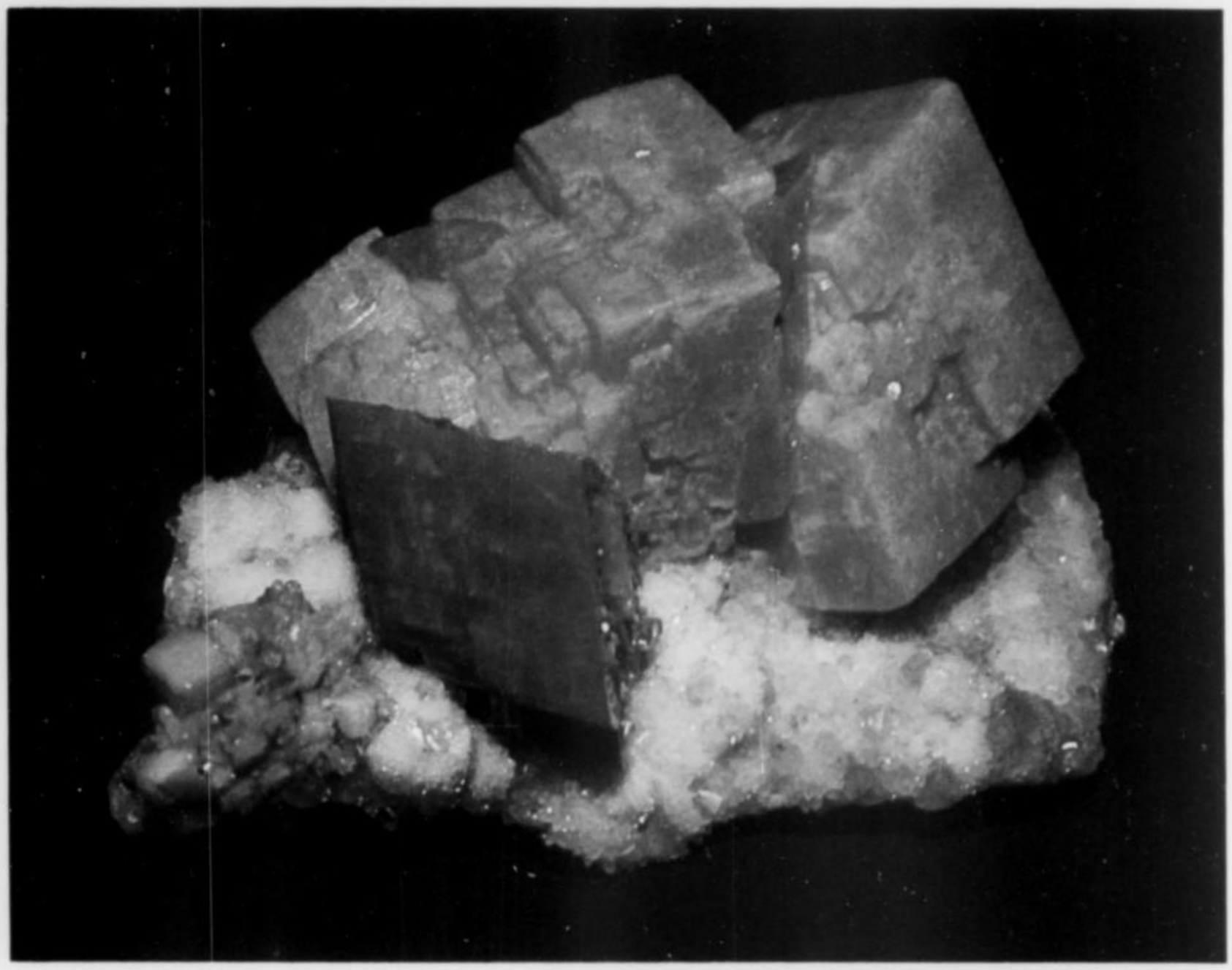


Figure 6. **Rhodochrosite crystals to 4 cm on quartz from the hanging wall stope off the main level, Sunnyside mine. Collected in 1967 by Les Morales. Kosnar specimen and photo.**

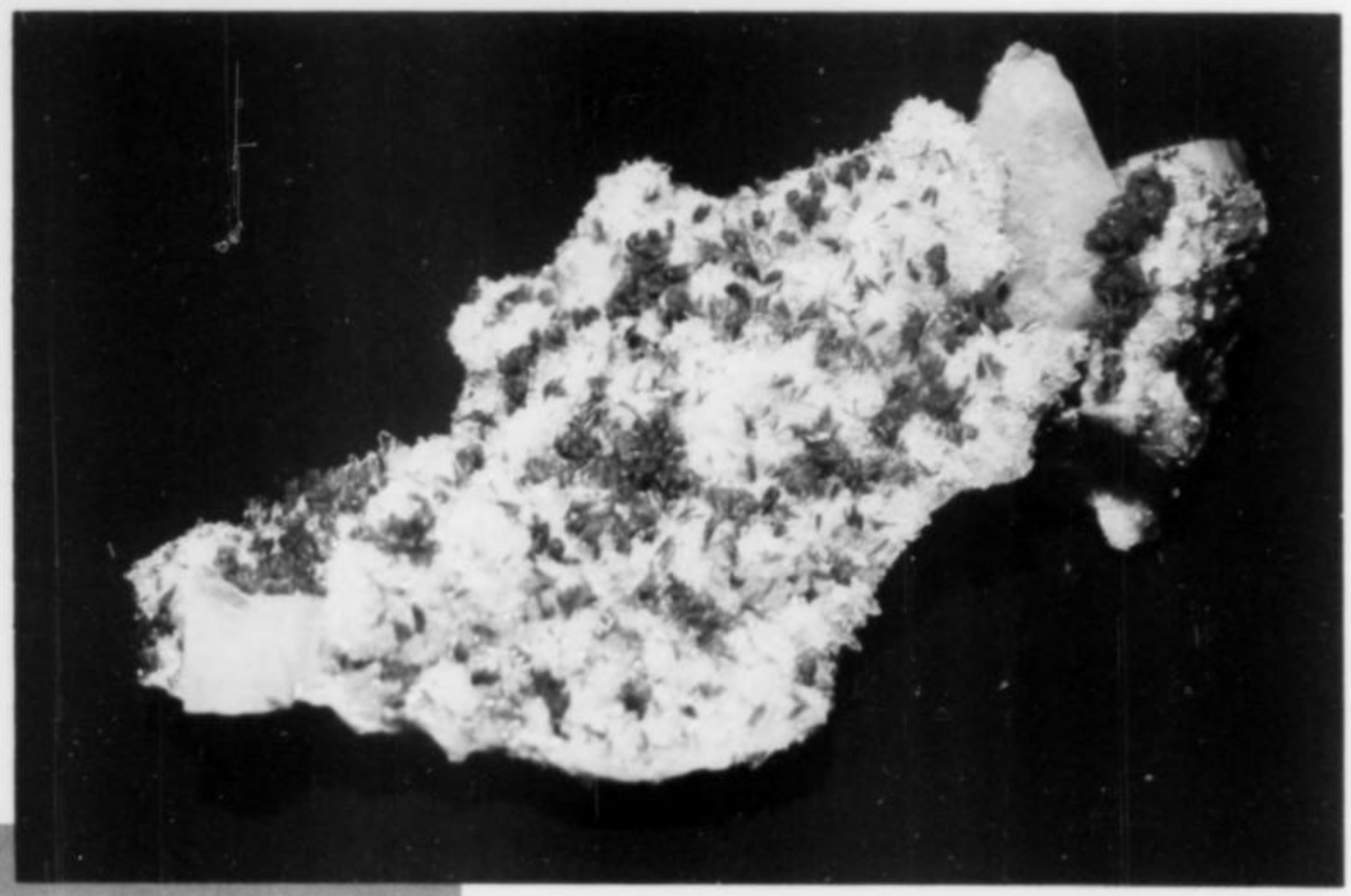


Figure 7. **Piemontite crystals averaging 5 mm on a 15-cm plate of drusy quartz and manganoan calcite from the 2400 level, Argentine vein, Idarado mine. Collected in 1978. Kosnar specimen and photo.**

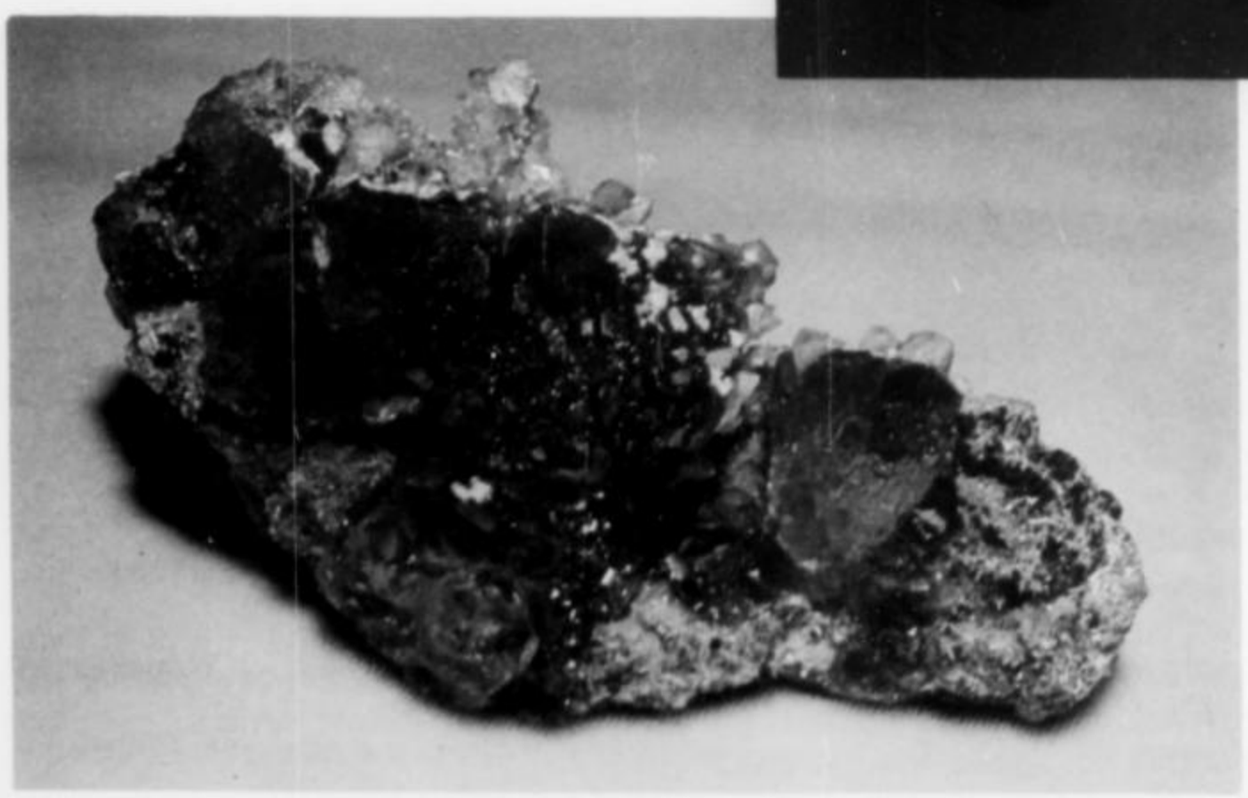


Figure 8. **Complex fluorite crystals composed of octahedron, dodecahedron and hexoctahedron faces, to 2.5 cm each, with small rhodochrosite crystals and drusy quartz, from G level, Sunnyside mine. Collected in 1967 by Les Morales. Kosnar specimen and photo.**

Figure 9. **Grizzly Bear mine in Bear Creek Canyon, north of Ouray, Colorado. Photo: American Heritage Center, University of Wyoming.**

Rose's Cabin, at 10,850 ft., just above the Bonanza mine-buildings, is a landmark. It was a stopping place in the old days of transmontane travel when long lines of pack mules and horsemen were wont to file up Henson creek on their way to Silverton, Rico and Ouray. We took the right-hand trail, past the Palmetto mill and along the old grade to the **Frank Hough mine**.

As we climbed the range the snow-mists gathered, and when we finally reached the crest, at 12,850 feet, the mountains were robed in all the magnificence of the storm. The cold blast from the cañon below swept up to the summit of the range, driving a chilly mist which flung itself fiercely around every crag and threw great shadows that stalked swiftly across the darkening slopes. Here and there amid the gloom a lonely peak caught the light, a Titan head above the sea of cloud. Thus we saw old Uncompahgre and the Wetterhorn, besides many another unnamed crest. While we waited, the hail and snow came fast, and so, without further delay, we began the slow descent of the other side, leading and pulling our shivering horses down the tedious talus slopes.

Soon we reached the warmer air of Bear creek basin, a spacious amphitheater near the timber-line, from which a well-marked trail took us into Bear creek cañon, a narrow gorge, lined by the most astounding precipices and picturesque to a degree which was astonishing even after two weeks of mountain scenery. We passed the **Yellow Jacket** and the **Grizzly Bear mines**, huddled under the beetling brows of breccia cliffs, where, here and there, a cluster of courageous pines clung hungrily for life, or a solitary cabin looked calmly over the abyss, or faint trails in unexpected tracery of line wound in and out of dark ravines with the veritable unconscious air of gentlemen who have no visible means of support.

Beautiful, pale pink rhodochrosite crystals on green chlorite-included quartz have been found at the **Grizzly Bear mine**. Associations include small, very lustrous, gemmy green tetrahedrons of sphalerite. (RAK)

Our progress, over a trail which was a narrow, albeit quite safe, ledge between rock and torrent, was necessarily, with horses, a slow business. At length, after hours of continuous descent which seemed interminable and gave one a singular feeling of going right into the depths of the earth, we emerged suddenly into full view of the Uncompahgre valley. It is no exaggeration to say that all four of us, some of whom had done our voyage round the world more than once, were amazed at the grandeur of the great picture before us.

We reached Ouray before dark, having completed a ride of fully 400 miles.

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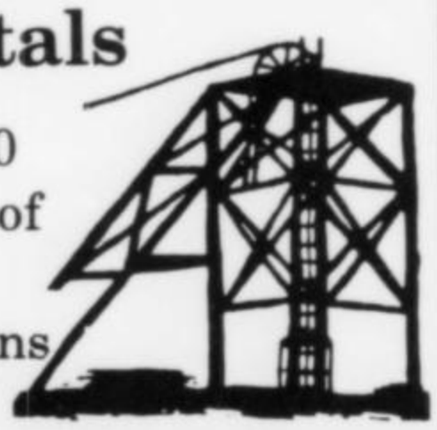

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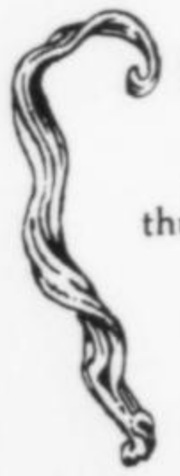

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INTRODUCTION

The recent discovery of a large number of specimens of dark red allactite at Sterling Hill, Ogdensburg, Sussex County, New Jersey, prompted an examination of previously found allactite samples from both Franklin and Sterling Hill. The new occurrence was called to the author's attention by John Kolic, a miner in the Sterling Hill mine, who found the material in late 1981 in seams in franklinite-calcite ore with minor willemite, sphalerite and serpentine. The ore has been fractured and surfaces are coated with microcrystalline druses of calcite and secondary willemite. Allactite is implanted on this willemite-calcite druse and forms divergent clusters up to 3.0 mm, of red to reddish brown crystals in divergent or sub-parallel growth (Fig. 1). The color of this allactite is, like many of the manganese silicates at Franklin and Sterling Hill, somewhat dependent on the type of illumination; crystals appear red in sunlight and rather brown under fluorescent light.

Figure 1. **Allactite from the new find at Sterling Hill, New Jersey. Width of cluster is approximately 1 mm.**

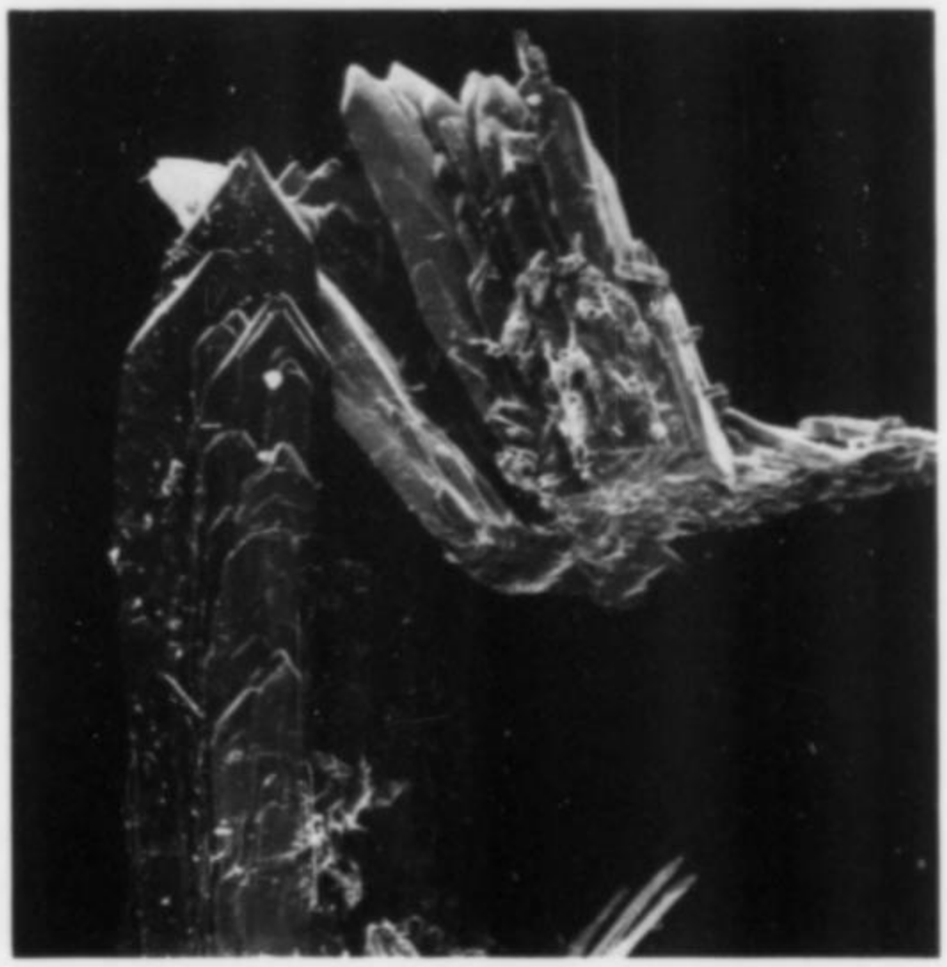

Figure 2. **Allactite, Franklin, New Jersey (NMNH R18244). Width of vertical crystal is approximately 0.5 mm.**

CHEMISTRY

The samples studies were chemically analyzed using an ARL-SEMQ electron microprobe utilizing an operating voltage of 15 kV and a sample current of 0.025 μA, standardized on brass. The standards used were manganite (Mn), synthetic olivenite (As), synthetic ZnO (Zn), and hornblende (Fe, Mg, Ca). Water was not determined directly due to paucity of material. The resultant analyses were corrected using the MAGIC-4 program of the Geophysical Laboratory. The data are presented in Table 1 and indicate that there is remarkably little solid solution of octahedral cations for Mn. The substitution is apparently limited to small amounts of Zn, Mg, Fe and Ca. Semiquantitative analyses of additional samples indicate that their compositions are quite similar to those of the fully analyzed samples.

Figure 4. **Allactite, Franklin, New Jersey (NMNH 148712). Width of specimen is approximately 1.5 mm.**

Figure 3. **Allactite, Franklin, New Jersey (NMNH R5413). Width of largest crystal is approximately 0.5 mm.**

Table 1. **Chemical analyses of Franklin and Sterling Hill allactite.**

	FeO**	MgO	CaO	ZnO	MnO	As_2O_5	H_2O	Total	Locality
THEORY					62.20	28.79	9.01	100.00	
94778	0.3	0.4	0.4	1.8	59.2	29.1	9.0*	100.2	Franklin
137876	0.3	0.4	0.9	1.7	59.9	27.3	9.0*	99.5	Franklin
153274	1.0	1.0	0.5	1.7	59.3	26.1	9.0*	98.6	Franklin
R18244	0.4	0.2	0.6	2.3	62.0	25.4	9.0*	99.9	Franklin
C4224	0.3	0.5	0.5	1.4	62.5	25.0	9.0*	99.2	Franklin
148712	0.3	0.8	0.6	3.0	61.6	25.5	9.0*	100.8	Sterling Hill

Accuracy of data: ±4 percent of the amount present.
* – H_2O from theoretical composition.
** – Total Fe calculated as FeO.

PARAGENESIS

The *in situ* occurrence of allactite from both Franklin and Sterling Hill has, for the most part, gone unrecorded. A review of such parageneses indicates that allactite might have been moderately abundant in the arsenate assemblages at Franklin, as reflected by the diversity of associations and ore textures. General observations of a number of varied parageneses suggest that chlorophoenicite was the most common arsenate at both Franklin and Sterling Hill (Dunn, 1981) and it appears that allactite and sarkinite were next in relative abundance. However, it must be clearly stated that all these arsenates are rare minerals and the above observations concern only their *relative* abundance. In almost all cases, allactite is found in the presence of carbonate minerals.

In addition to the parageneses noted by Palache (1935), allactite from Franklin apparently occurred with quite a variety of associated minerals, including pyroaurite, chlorite, leucophoenicite, hodgkinsonite, adelite, barite, friedelite and caryopilite (both arsenian) and others. Franklin allactite crystals are typically bladed, conform to the morphological description and crystal drawing of Palache (1935), and occur as acicular to bladed crystals in subparallel and slightly divergent aggregates. Representative SEM photomicrographs of Franklin allactites are shown in Figures 2, 3 and 4.

Sterling Hill allactites mimic those from Franklin in most respects; the stout crystals from the new occurrence (Fig. 1) are atypical. Such stout crystals have been found only rarely at Sterling Hill in past years. Allactite has been found in at least ten Sterling Hill occurrences in recent years. These occurrences, like those at Franklin, have carbonates present, usually in the form of calcite lining veins and solution pockets. Common associations include barite, kraisslite, rhodochrosite and sarkinite, the latter almost as abundant as allactite. Less common associations include friedelite, covellite, dodecahedral fluorite, secondary copper minerals, chlorophoenicite and others.

REFERENCES

DUNN, P. J. (1981) Magnesium-chlorophoenicite redefined and new data on chlorophoenicite. *Canadian Mineralogist,* **19**, 333–336.

PALACHE, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. *U.S. Geological Survey Professional Paper 180,* 122.

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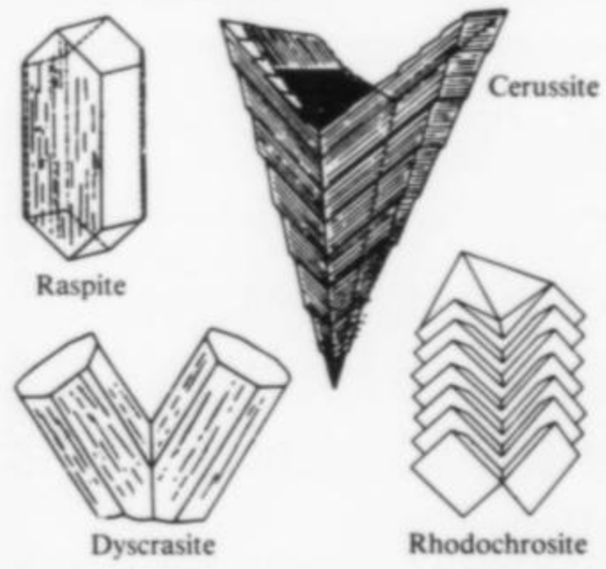
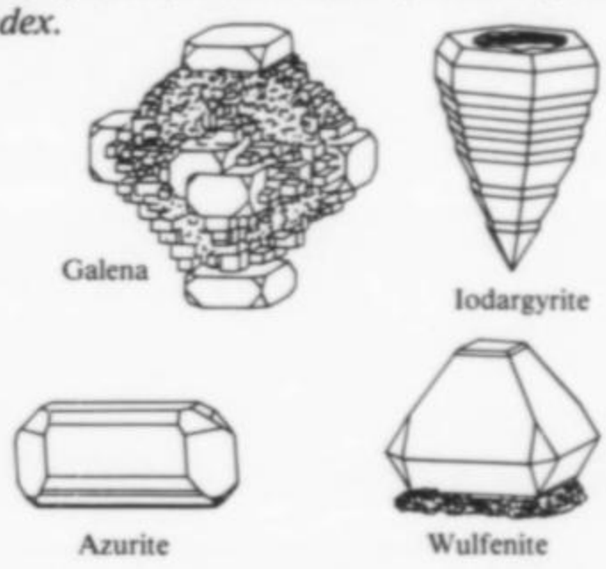
The Record Bookshelf

Minerals of Broken Hill, edited by H. K. Worner and R. W. Mitchell. Published (1982) by Australian Mining & Smelting Limited, 55 Collins Street, Melbourne, Australia. Hardcover, 10½ x 10½ inches, 259 pages, 170 color plates of minerals; $48 plus $2 postage. Order from the Mineralogical Record, P.O. Box 35565, Tucson, AZ 85740.

This magnificent volume was produced to commemorate the centenary of the discovery of the Broken Hill ore deposit, and is dedicated to Sir Maurice Mawby (1904–1977). Mawby was born in Broken Hill and rose from the position of a mine assayer to the chairmanship of CRA (Conzinc Riotinto of Australia), a premier mining conglomerate including the Zinc Corporation of Broken Hill. Throughout his life Maurice Mawby was keenly interested in Broken Hill mineralogy, and through that interest many fine specimens were preserved, donated to museums, and made available for mineralogical research. I can think of no finer tribute to him than this book.

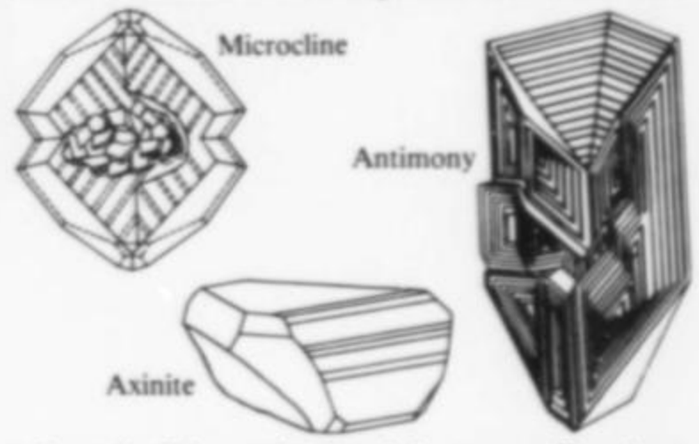


It comprises the following chapters: *Introduction,* by H. K. Worner and R. W. Mitchell (3 p.); *History,* by G. Blainey (10 p.); *Men, Minerals and Geology,* by R. O. Chalmers (14 p.); *The Making of the Minerals,* by H. F. King (6 p.); *Geology of the Ore Body and the Enclosing Rocks,* by N. L. Markham and B. P. Stevens (8 p.); *Minerals of the Primary Ore,* by I. R. Plimer (8 p.); *Minerals of the Secondary Ore,* by I. R. Plimer (8 p.); *Minerals of the Consols Mine and Mine Sequence,* by I. R. Plimer (2 p.); *The Minerals,* by W. D. Birch, A. Chapman, and S. R. Pecover (128 p.); *Summary of Mineral Data,* by W. D. Birch (28 p.); followed by *General References, Bibliography, Biographies* (of the authors), *Glossary,* and *Index.*



The Broken hill orebody is perhaps the greatest lead-zinc-silver deposit of the world, being continuous for a strike length of 7.3 km, with a depth of 850 m and a horizontal width of 250 m. It has played an important role in the history and development of Australia. Situated in the desert interior and subject to high summer temperatures and long periods of drought, Broken Hill, following its discovery in 1883, rapidly became and has remained one of the largest interior cities of Australia. The original mining company, The Broken Hill Proprietary (generally known as BHP), is now the largest industrial concern in Australia; although it ceased mining at Broken Hill many years ago, the profits of that operation provided the foundation for its future growth.

This book provides a comprehensive account which should interest mining geologists, professional and amateur mineralogists, and those interested in Australian history alike. However, for readers of the *Mineralogical Record,* the meat in the sandwich is the longest chapter, that simply entitled *The Minerals.* In alphabetical order, this covers some 300 mineral names applied to 180 species, and is illustrated by a superb series of 170 color plates. The authors have provided excellent descriptions, with literature references, for each species, and have diligently searched the major collections for the finest examples of the described



minerals. The entire book is very well written and, as far as I can judge, almost free of typographical errors or errors of fact – the only serious one I saw was the description of bindheimite as a "hydrous lead sulphate" (p. 87), but the correct formula is given on p. 202. I was somewhat taken aback to learn of "the American Museum of Natural History in Washington" (p. 88) – the specimen referred to is in the Smithsonian Institution – but this case of mistaken identity is understandable. Further investigation has shown that this specimen (NMNH R1332) was wrongly ascribed to Broken Hill, N.S.W. by Winchell and Rouse (*Mineralogical Record,* v. 5, p. 285, 1974). The specimen was sent to W. A. Roebling by George Smith, and his handwritten label reads "Percylite with Carbo-sulphate and Carbonate of Lead, Beltana Broken Hill Mine, South Australia." The Beltana Broken Hill Mine was a small lead-silver mine about 18 miles west of Beltana Station, South Australia, worked intermittently from about 1870 to 1903 (R. O. Chalmers, personal communication). The only known boleite from Broken Hill, N.S.W. is therefore the one in the British Museum collection. On p. 112, 114 and 215 nantokite is misspelled nantockite.

I have no hesitation in recommending this book. Australian Mining and Smelting Limited (a division of CRA), is to be commended for publishing this comprehensive account of one of the greatest mineral deposits of the world.

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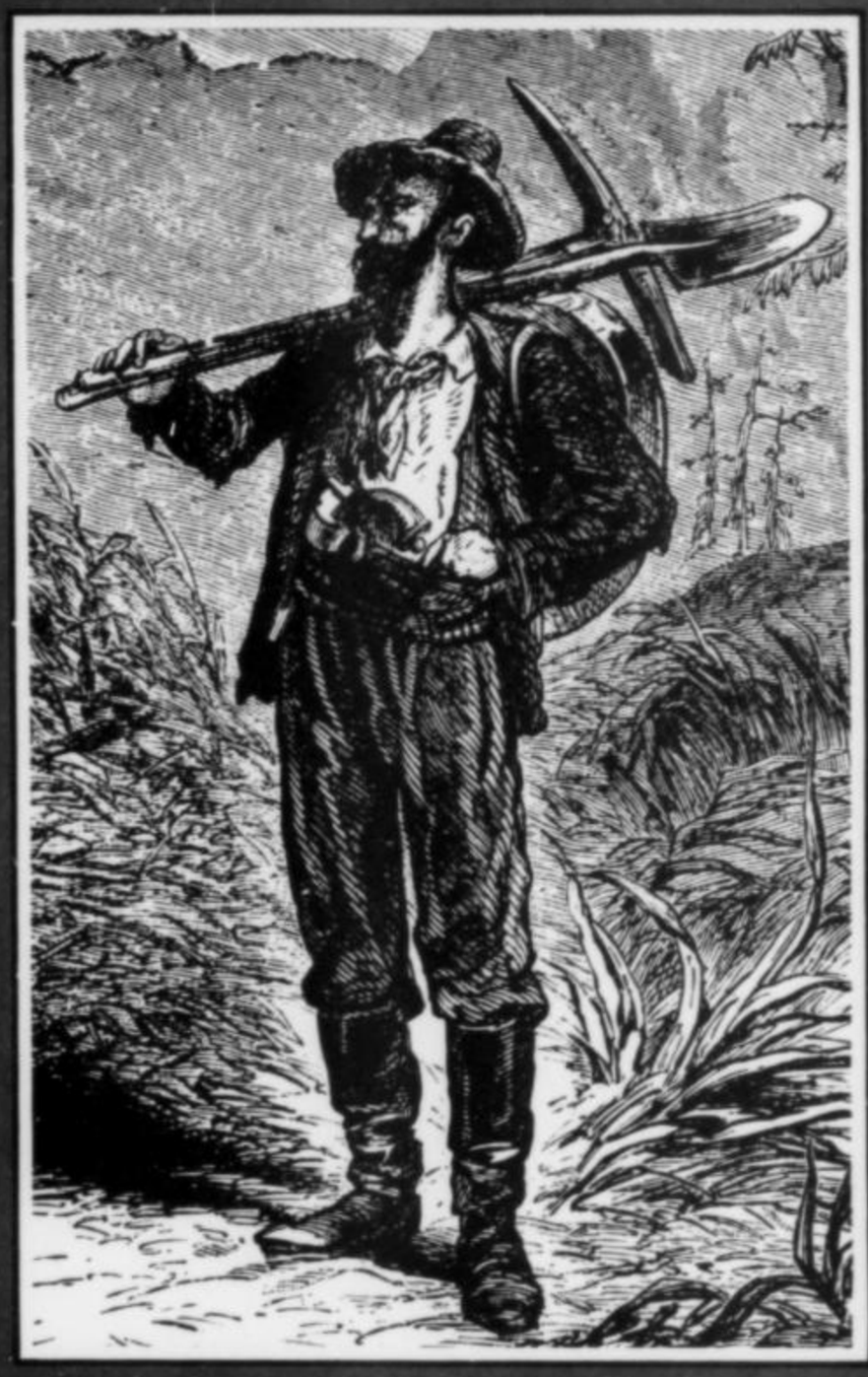

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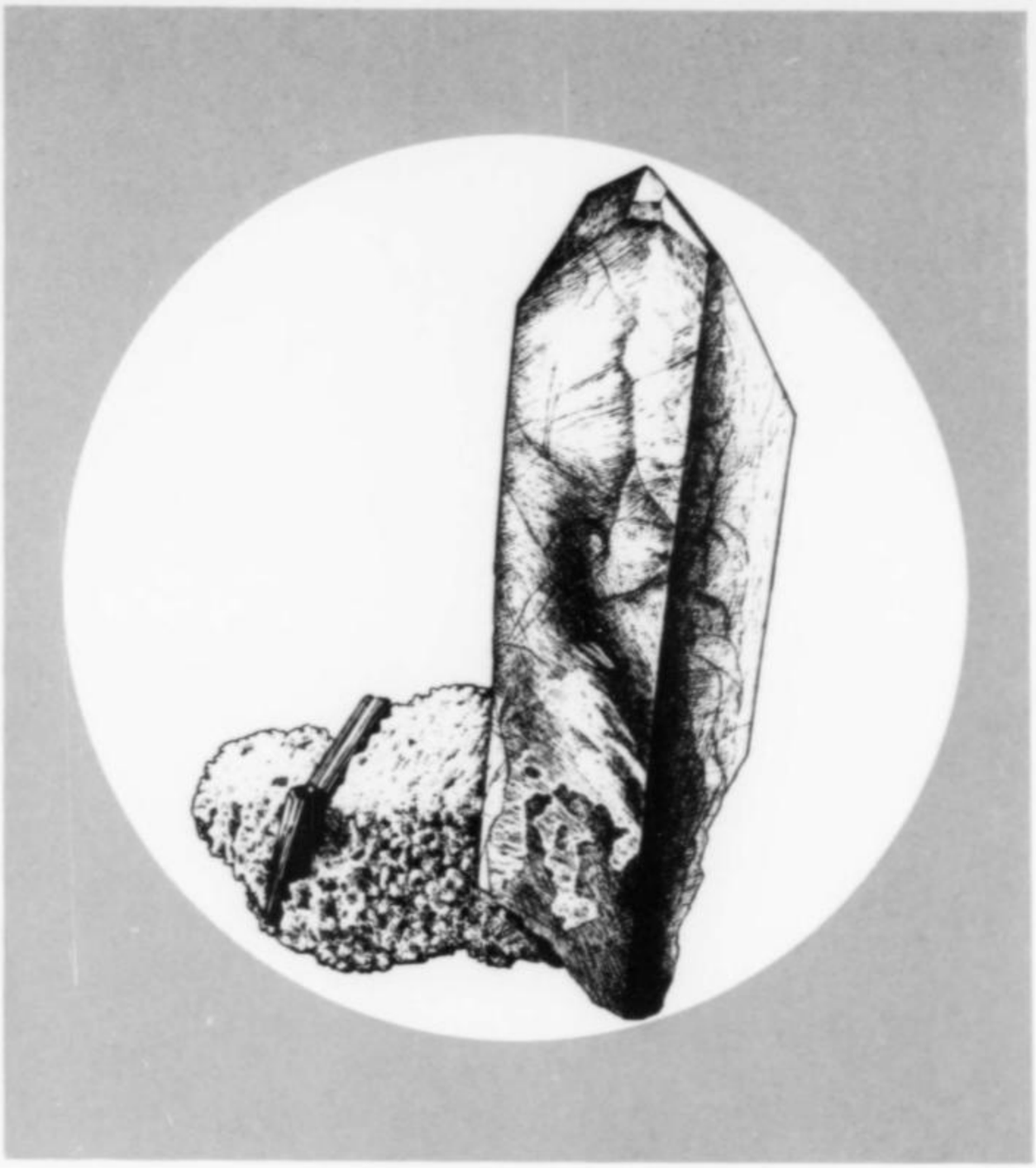

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