the
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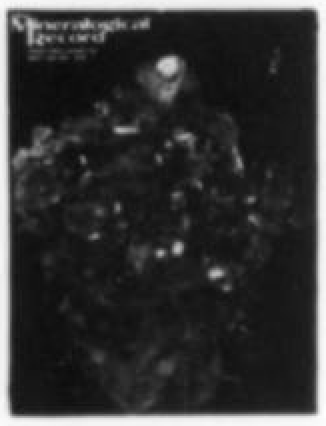

COVER: Quartz, variety amethyst, from Las Vigas, Veracruz, Mexico. The group is 19 cm tall. Chris Wright specimen; photo by Wendell E. Wilson.

notes from the EDITOR

A NEW MAGAZINE!

At the Munich Show this year a new mineral magazine made its debut: *Magma*. The editor and publisher is none other than Rainer Bode, who for several years has produced *Emser Hefte*. The hallmarks of *Emser Hefte* are in-depth locality articles and top-notch mineral photography (Bode is also among the world's top mineral photographers). So it is no surprise that *Magma* is a totally professional, beautifully conceived and illustrated mineral magazine, the first real competition for the other German mineral magazine, *Lapis*.

Magma's premiere issue is devoted in part to *Gold* (which fit in nicely with the Munich Show), with articles on the Golden Triangle area of eastern Europe. Also included are articles on Botallack, Cornwall, and Ceylon. The issue is 104 pages long, with color and with very little advertising. It's a superb effort, and anyone with even a rudimentary knowledge of German should have a subscription. It's not often that one has the chance to start a collection of a new and promising journal with volume 1, number 1.

Magma will be published six times a year; seamail subscriptions in the U.S. are $35 per year (in Austria, ÖS 624; in Switzerland, SFr 76.80; in Germany, DM 76.80). Send to: Magma, Verlag Rainer Bode, Krokusweg 13, D-4630 Bochum 7, West Germany.

For those readers of *Magma* and of the *Mineralogical Record* who do not read English or German, respectively, we will be cooperating through an occasional exchange, translation and republication of each other's articles. This should enrich both readerships, and possibly encourage more readers on each side to take a subscription to the opposite number. This is the same policy we will maintain with *Lapis* magazine. The Germans are fortunate indeed to have two such fine publications available.

(NOTE: I have received 15 copies of the premiere issue of *Magma*, pictured above, for distribution to our readers. They are available at $6 per copy postpaid.)

GOOD-BYE TO THE INCH

Since its inception, the *Mineralogical Record* has allowed the use of either the English or the metric system, provided that both systems were not used in the same article. This was in recognition of the broad range of our readership and authorship, from the professionals who are accustomed to metric, to American amateurs still more comfortable with inches.

Allowing both has always involved some disadvantages, including the problems that *all* of our non-U.S. readers (professional and amateur alike) have in visualizing how long three-eights of an inch is. Everyone knows that the U.S. has been unreasonably lazy and uncooperative in formally switching over to the measurement system used by virtually the entire rest of the world.

Mineral collectors must invariably be in some degree of contact with the science of mineralogy which, even in the U.S., has long operated on the metric system. So we at the *Mineralogical Record* hope that few if any of our readers will be overly distressed by the announcement that we are now converting exclusively to metric.

For the last time, here's what to remember: about 2½ cm equals an inch (a thumbnail specimen) so 5 cm is about 2 inches (a miniature). (Now might be a good time to start lobbying the various rules committees to change their definitions of miniature and thumbnail to metric.) One meter is about 39 inches. One kilometer is about six-tenths of a mile.

For the micromounter this should be no problem . . . most subjects for discussion are less than one-eighth of an inch in size anyway and so are more conveniently described in millimeters (of which there are about 25 to the inch).

Hardly anyone in the U.S. aside from farmers and real estate agents has a clear idea of how large an acre is so hectares are no more obscure, and are practically never used in geological or mineralogical writing. Volumetric measurements are almost as rare, aside from descriptions of laboratory procedures.

There must be a few exceptions to the rule. For example, quotations from the literature will not be converted. And there are many mines in which the various levels were actually named by the distance in feet from the collar, from the surface or from sea level . . . "the 300-foot level" will not be changed to read "the 92-meter level," though all other measurements in the mine will be converted. In short, English units will have historical use only.

So here's to consistency, simplicity, practicality, progressiveness and international cooperation; we probably should have done it a long time ago.

NOTICES

Died, Roger Harker, 40, of a heart attack, in Rothley, Leiscestershire, England. Roger Stuart Harker was for many years the British agent (volunteer) for the *Mineralogical Record,* and the proprietor of *Lythe Minerals.* He obtained a geology degree from the University of Leicester in 1964 and subsequently worked in the Surveyor's Department at the Geevor tin mine (Pendeen, Cornwall), and with Consolidated Goldfields in Scotland. He returned to Leicester in 1966 and was awarded his PhD in economic geology in 1971. Roger was an active member of The Russell Society, taught evening classes in mineralogy at Leicester, Derby and Nottingham, and maintained his business dealing primarily in educational materials for schools, colleges and universities.

Died, Elizabeth E. Gordon, 71, of cancer on Christmas eve, in Grenada Hills, California. Beth Gordon was a well known show dealer, having been a part of the Tucson and Detroit shows for many years. She began collecting minerals in 1952, and started her mineral business 20 years ago in 1964. As the mother of Brad Van Scriver and grandmother of Curt and Star Van Scriver, all mineral dealers, she represented one of three generations of the same family all simultaneously active as mineral dealers.

Collector's Diary

Iquique, Copiapo, and Chañarcillo

Mark Chance Bandy, 1935

On July 17, 1935 Mark Bandy, the noted American mining engineer and mineralogist, left his home in Redfield, Iowa, to begin the long journey to Chile. The diary of his three-month expedition in search of mineral specimens for Harvard and the Smithsonian makes interesting reading.

This is the second of three parts. The first installment appeared in the November-December 1983 issue.

IQUIQUE

I had never attempted to sleep on a rough-riding train and was not too successful. It was with a certain amount of relief that I got up the following morning about 8:00 to an unfamiliar pampa.

The only place I had ever seen that might be compared to the pampa of northern Chile was the Cerros de Sal of Atacama. The ground must have carried a very high percentage of salts of various kinds. It was all cracked in coarse polygons about a yard across and in many ways it looked very similar to a mud-cracked area if the broken masses might be turned over and the cracks thus closed and the interiors of the polygons raised. Of course the area I first saw was part of the Salar de Bella Vista. Another interesting feature of the salar was the obvious presence of deliquescent salts in the ground. Every raised area was a darker, wetter looking tint with the top part crusted with salts. Looking in the distance to those small salt incrusted areas they looked not unlike a field of white flowers, the only feature out of character was the entire lack of any green tint in the whole landscape. Later Mr. A. E. Aldrich said he believed that this was the deliquescent salt. The glauber salt or mirabilite at Chuquicamata is a dehydrating salt rather than a deliquescent one but due to its great rapidity of dehydration I was never able to observe it under any other conditions.

Two Chileans and I constituted the only sleeper passengers. I ate a cool breakfast and then sat in the dining car all morning watching the pampa pass along. It was interesting to observe so many nitrate oficinas working on the side of hills.

I did not know when we passed through Pintados. I had heard so much about the place and had read so much about this and that mineral coming from Cerro Pintados that I naturally expected a larger place, I suppose, and thus completely missed it. My only hope was that I might get to see it later in a trip to the pampa. We soon ran into camanchacas [clouds] and the noted trip from the pampa down to Iquique was in a great measure spoiled for me as regards scenic effects. The train ran for some time along steep cliffs, and one could not see either the bottom or top. After going downhill for an hour or so we began to run along the bottom of the cloud and got glimpses of Iquique and the ocean at our very feet, a thousand feet below. The train made a long run to the north of Iquique and then to turn around and head back to Iquique, it turned into the cliff and went around in a tunnel and we emerged headed south along the same cliff. This took us down to the city and the sea level.

After a poor lunch I slept a while, then wrote the rest of the afternoon and studied my Dana, learning formulas. I began to wonder if the fine blue mineral I got from near Cerritos Bayos was actually coquimbite or kornelite, a mineral with less water than coquimbite.

At 6:00 I went around to the Instituto de Fomento and the engineer there took me to the home of the head of the Aduana, Sr. Luis Cabrera. We drove out in a sea-going hack. The number of such hacks reminds one so much of the [Panama] Canal. They are legion in Iquique.

I saw and heard a lot of things in the home of Sr. Cabrera. I spent a pleasant hour and a half at his home and came away empty handed and a bit discouraged over the possibilities of obtaining specimens from this very rich area.

condensed and edited by **Peter C. Keller**
Gemological Institute of America
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The next day I slept until 8:30, breakfasted in bed and didn't dress and shave until almost 10:00. I started out with no definite objective when the manager of the hotel said that he had spoken to Dr. E. Lopez and he would be glad to see me any morning or afternoon. I started out and finally found the place and then found my first real collection of nitrate minerals. A truly fine specimen 10 x 10 x 3 inches, more or less covered by sharp rhombs of soda niter. A beauty indeed. The rhombs were about ⅒ inch in size and did not compare in size and beauty in any way with the specimen I sold Harvard University, but they were very good indeed. My how I regretted time after time, selling that specimen for $25.00 to Harvard. They evidently didn't know its value and certainly I didn't, although I knew it was worth more; but I needed the money and needed it badly at the time so took what they offered. He had some truly magnificent purple and various shades of yellow and orange caliche. All his caliche specimens were in great jars and on their way to the University of Chile. He had some fine large crystalline masses of soda niter, about an inch across some of them and as clear as salt. They were not in crystals but showed their crystalline system and their classification by the cleavage. Another notable specimen was a fibrous thenardite specimen. It would appear that the Oficina Anita and next the Oficina Progresso were the best ones as far as specimens went.

Monday was another day. The specimens began to appear. When I went to the office of the Instituto de Fomento to go to Huantajaya and Santa Rosa the engineer produced a specimen of what he called cerargyrite and one of huantajayaite [a poorly-defined Na-Ag chloride]. The former was mostly native silver, and the latter . . . ? It looked to me like halite with silver in the form of various salts. If that was true huantajayaite I doubt the authenticity of the mineral. There was a peculiar yellowish mineral present, though, so I bought the two mineral specimens, both the size of acorns, for 2 dollars, too much but I hoped to get the idea out that I was paying very good prices for minerals.

I went back for my hammer and finally we started, about 20 minutes late. Not bad. We went first to a mine between Huantajaya and Santa Rosa. The Instituto was financing the installation of a lixiviation [leaching] plant to treat the silver ores and they were opening up the mine. I went into the mine to look for specimens. They said that there were large crystals of huantajayite an inch long. Also that massive huantajayaite, called "lechedor" by the miners, was common in good specimens. There was nothing in the mine. I climbed around through caving stopes and everything else and got the sum total of a bumped head and back and nothing else. All the specimens were figments of someone's imagination. So we climbed out and the mine captain, much surprised that we didn't get such specimens as he had described, promised to send me a good specimen of lechedor to the hotel. The engineer from the Instituto said to send it there. That meant that even though it might be a good specimen, my chances of getting it were nil, or less.

From there we drove to Huantajaya and I saw my first Huantajaya mine. The first and only. They were also treating a dump by lixiviation. They form a silver sulfide and I learned later that the recovery of silver was about 5 percent or the total amount in the ore. It looked like a very fair ore and they said it ran about 7 ounces to the ton. A 5 percent recovery is no great help. I obtained some mine samples and that was all. One high-grade ore sample. It was supposed to run between 1 and 2 percent, maybe. We ate a banana with the fellow running the place and then beat it back to Iquique.

After lunch I lay down a little and then went to see Aldrich about the following day's trip to the pampa. He placed me in charge of his secretary, a Mr. Campbell, and I went around to see a Mr. Chas. A. Pye, who ran the light company and who was supposed to have a good meteorite. He took us to his home and he actually did have one, a large and heavy one but very badly oxidized and corroded. The story Aldrich told me was that Pye had seen it fall. This wasn't true and it had actually been dug up in the salitre or caliche of an oficina near Negrillos. Since Pye had had it, it had been through a fire but had suffered only heat. It was covered with iron oxide and some white material that might be caliche or it might be an efflorescent. If an efflorescent it was due to the fire or water after the fire, otherwise the conclusion was that it had been unaffected by the fire. I asked him if he wished to part with it and he said that he would for a consideration. I asked him how much and he said he didn't know but for me to place a price on it. I finally offered four pounds and he accepted it, I don't know whether he was disappointed or not. He then told me he had sold a much smaller one, about 40 years ago, for five pounds. Well, he only received four for that one and while it was worth more I didn't break down and get big hearted. We left it at the hotel and then I returned to the Instituto and found another specimen of huantajayaite, small, two small cubes of halite and a worthless piece of selenite and a fair specimen of coarse wire silver, "plata clavos." The same fellow wanted two dollars again for all of them. The huantajayaite was fair but I doubted its being what he said so I paid him 70 cents for the specimen and then took him to have a beer.

After the beer I tried to see my friend Dr. Lopez but couldn't as he was busy. I returned to the hotel and then went to the Instituto and took the engineer to the Casina Española. A beautiful club all finished in a Moorish design. It was really one of the finest looking clubs I had seen in a long time. I was very taken with it. We had a couple of drinks and then he went to the dentist and I went to the hotel and wrapped up some of the specimens and typed and read until dinner time. The city was certainly filling for the fiesta of diez-y-ocho. The next day was a great day.

COPIAPO

I started for the "dusty streets of Copiapo" in more or less of a cloud of dust as I left Antofagasta on the train. Copiapo is either favorably or unfavorably known for its dusty streets. Visitors know it unfavorably for this dust; its inhabitants appear to feel that it is better to be noted for anything than not to be noted at all. They may be right. My acquaintance with Copiapo to date had been only a passing one, but now I was being offered the opportunity to study it first hand and to meet it intimately face to face.

Eventually we sailed down the main street, or one of them, of Copiapo and arrived at a station swarming with people. I got off and in an antiquated Ford drove in state and style to the Pension Ahumada. I had wired for a room and they had one, right on the street. Cold and damp. I had breakfast and then went to bed.

The next morning I wasn't so bad and I wasn't so good either. I had a little fever and had felt much better in my day. Breakfast and a shave and then I started out to see Mr. Ferron. I do know that the two girls in the Pension were the dumbest pair that one seldom runs into. There was just no way to get them to go anything out of the usual run.

I walked to the American Smelting and Refining Company office and then found that Ferron was out of town but there was a Mr. Neidhardt in the office and I met him. He was busy so I asked if I could come back some later hour and made a date for that afternoon about 4:00. I then decided to go out to the School of Mines. I got me a "sea going hack" and started out. A long, quiet, nice and dusty ride to the west end of Copiapo. Copiapo is certainly a quiet place.

It is easy to understand how one born and raised in Copiapo would become so attached to it that every other city would seem strange the rest of their lives. There are very few buildings of two stories in the city. It sprawls in all directions and the streets are either unusually broad or exceptionally narrow, and they are at least as dusty as their reputation suggests.

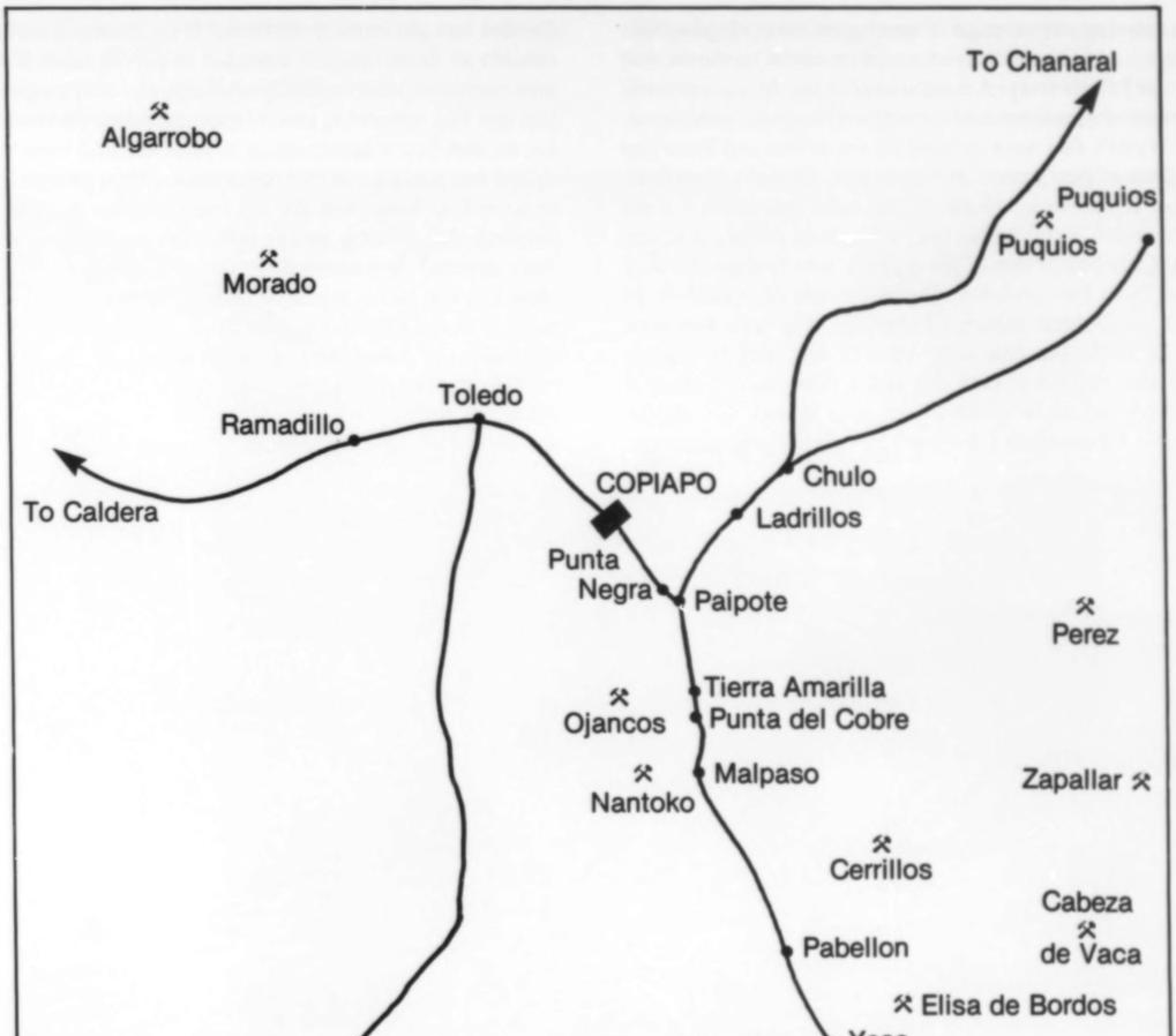


Figure 1. **General plan of the Copiapo District, Chile.**

At the school I met Mr. Torres and Mr. Villalobos at the same time. Villalobos was much fatter than when I knew him in Chuqui, in fact he had a *huata* that was a beauty. I talked with Mr. Torres, the director, for a while and then we went out to look at the collection of minerals. I was disappointed in the collection, as I had expected a much better one. A great lot of hopeless specimens and finally they got around to the gold specimens that were poor to valueless and then produced a proustite from Chañarcillo that was more or less valueless even though it was a great mass of quite light colored mineral, and then they produced a proustite specimen that simply took my breath away. A magnificent thing. It was evidently a strongly twinned specimen and I suspect that there were about four vertical crystals that were twinned on the prisms and there was a certain amount of intergrowth of the crystals. I hated to handle it, it was so fine. It was about 10 cm on the sides and about 7.5 cm high and was worth a thousand, twelve hundred dollars if it was worth a cent. Only one or two of the crystals were bruised and they didn't detract from the specimen. Domeyko tells of crystals 8–10 cm long from the Dolores Mines, Chañarcillo, that were exhibited in Santiago in 1875. But this one, My Oh My, just to have a specimen like that to look at each day and a sweet wife to enjoy it with you and life would be worth living, even though you almost starved to death. I'll never own one but I can always remember that specimen, if I never see one finer, *"Gotas de Sangre de Jesus."*

After that specimen I had no eyes for anything else until they got to meteorites. They had the roof off the building and it had rained last week and much of the collection was soaked and was covered. I had to return at a later date to see much of it but the meteorites were available and what a mess. They had one large and fine specimen. The main mass of the one I bought in Antofagasta but this one showed the reason for the great porosity. The meteor was made up of coarse grains of clear yellow olivine with thin walls of iron between them. This was a most extraordinary meteorite in my limited experience. The olivine grains were over a centimeter across in some cases. Apparently it must have been a large fall for they had two specimens that were large, one with much larger olivine grains, and a fragment similar to mine in which the olivine had weathered out leaving holes.

Then they produced three meteorites that just made me sick. They were weathered pieces of iron ore, magnetite-hematite ore. I said that I was sure they were and both men said that they were sure they weren't and I dropped the subject but they were wrong. One was labeled by the man they received it from and the label modestly stated that it was an "Aerolita de Fierro con Cliftonite, Moisanita y Troilita con piroxinita y olivinita." Now it takes a real meteorite to contain all those things. I intended to get the label some other day and examine it most carefully and copy the entire legend. They had this one fine meteorite, several specimens and also another meteorite, an iron that weighed about 30 kilos and had been badly cut and drilled but was a good one nevertheless. Why weren't they satisfied to have fine things and display them without dragging in a lot of phoneys and messing up the collection and leaving a bad taste in one's mouth? Specimens from around Copiapo were not represented in the collection as far as I could find out. Aside from the sulfates that I was to see another day, they had no nantokite, no chilenite, no domeykite, algodonite, huantajayaite, horsfordite, etc. No panabasite [tetrahedrite], caracolite, daviesite [hemimorphite], or a multitude of other minerals that Domeyko describes and gives the name of the mine and the depth even in some cases.

Figure 2. **The town of Juan Godoy, a deserted and depressing shell of a once grand and rich city of many thousands.**

Tuesday was a bad day. After breakfast I went up to the Plaza and started to bargain for a car to take me to Tierra Amarilla, Elisa de Bordos and to Chañarcillo. Tierra Amarilla is 16 km from here and Chañarcillo 66 km. I would use the car for two entire days, 9-6, and one day for two hours. The first fellow asked me the equivalent of $45 and the second, $55. I was so indignant that I just boiled. Just because I was a gringo. I was furious when I reached the American Smelting office to see about some horses. If I did go to T. Amarilla with Don Juan C., Neidhardt said he would send a man out at noon to see about the cost of a car for these three trips.

At noon, a chauffer appeared with a letter of introduction from my "muy amigo mio" Don Ramon A. recommending the fellow to me as a good man with a good car that would give me a rock bottom price for my trips. I couldn't figure out how Don Ramon knew that I was wanting a car until it finally worked out in my mind that when I was bargaining in the Plaza for a car I had said that on two of the trips I was going on I would have a passenger, Don Ramon one time and Don Juan C. the other. This chap must have heard about it and gone to Don Ramon for a letter of introduction. But a letter from Don Ramon wasn't any guarantee that I would get a good deal, in fact the opposite. After a long time of haggling he came down to 370 pesos as the bottom (one of several bottom prices quoted) and I told him to return at 8:00 and I would see. That is equivalent to $37 dollars but actually would cost a little over $18 at legal rates of exchange.

the dumps and looking down into the caved open parts of the Veta Descubridora where it was exposed. It was evidently the custom to have heavy, barred doors at the entrance to all the mines. From there I went to the Mina Huanquita and went over the dump there.

Figure 3. **The Chañarcillo mining district. The many dumps do not show up in the picture. This is on the west side of the district, the Veta Descubridora is in the background over the low divide.**

CHAÑARCILLO

More or less promptly at eight I started out for Chañarcillo. This was a trip I had been looking forward to for years and at last I was on it.

We made several stops and finally passed through Paipote and headed south. It was a pleasure to pass through points that I had read of and heard of so often: Tierra Amarilla, Nantoko, Pabellon, etc. Both the road and railroad follow the valley of the Rio Copiapo and all the inhabitants live in the valley and use the water of the river for irrigation, although they could irrigate much more than they do I would say. The hills that line the sides of the valley rise steeply in rocky terraces at the lower end of the valley.

As we approached Chañarcillo we passed many masses of a sort of doleritic tuff. The igneous rocks were of a wide variety of textures and, I judged, of more or less two general types of composition. Most of the dikes I looked at were very dark, fine grained andesites. We climbed up to a pass by way of five switchbacks on the side of Morro Chañarcillo or Morro Juan Godoy. From the pass it was about 15 km of a very rocky and rough winding road down a ravine to the old and all but deserted town of Juan Godoy, on the west side of the mines of Chañarcillo. The present population consists of two families of five adults and 17 children. All of the mines are deserted and without watchmen or anything else, including ore.

We got the son of the most influential citizen, the telegraph operator, to show us the road to the Mina Descubridora and away we went in a cloud of rocks and dust, up the very rough and rocky roads on the side of Chañarcillo. The boy, a lad of about 8, knew the area very well and we arrived in a few kilometers at the mine. A deserted and hopeless looking place. I spent two hours going over I rode part way back to Juan Godoy and then sent the car on down and I started to walk and look. I paid homage to the Delores Secundo and the Dolores Tercera, the mine so famous for proustite. The Delores Tercera and the Delirio were the great specimen mines of Chañarcillo, at least as far as proustite specimens went. Probably the Descubridora and the Carlota mines yielded the finest and richest specimens of native silver and cerargyrite. I paid my regards to the Santa Rosa mine and then returned to Juan Godoy.

The dumps yielded no specimens at all. Everything remotely related to silver minerals had either been removed by reworking, or else they cleaned the ore from the mines very well, or else the ore was very easy to separate. However, the dumps presented a wide variety of very interesting material. Evidently the north-south veins carried little or no gangue of barite while the northwest-southeast veins carried much barite. Some of the veins cut the limestone of the country rock without any visible signs of alteration while in other cases there were definite signs of reaction with the limestone. There was surprisingly little or no bleaching of the limestone on the dumps and fine grained breccias of sharp angular black limestone in coarse calcite and iron carbonates were very common.

Much of the limestone on the dumps, if not all of it, carried some scattered grains of sulfates, pyrite and possible other minerals. Some of the brecciated pieces of limestone in the carbonate carried pyrite in the breccia in rims about the fragments. There were three kinds of (and ages of) carbonate, calcite, ankerite and siderite. The age relationships were not clear in every case but I judged that the age relationships were those given above with the calcite the oldest. Quartz was rarely visible as a rule and when present its age could not be determined with certainty, but it was probably late. In the

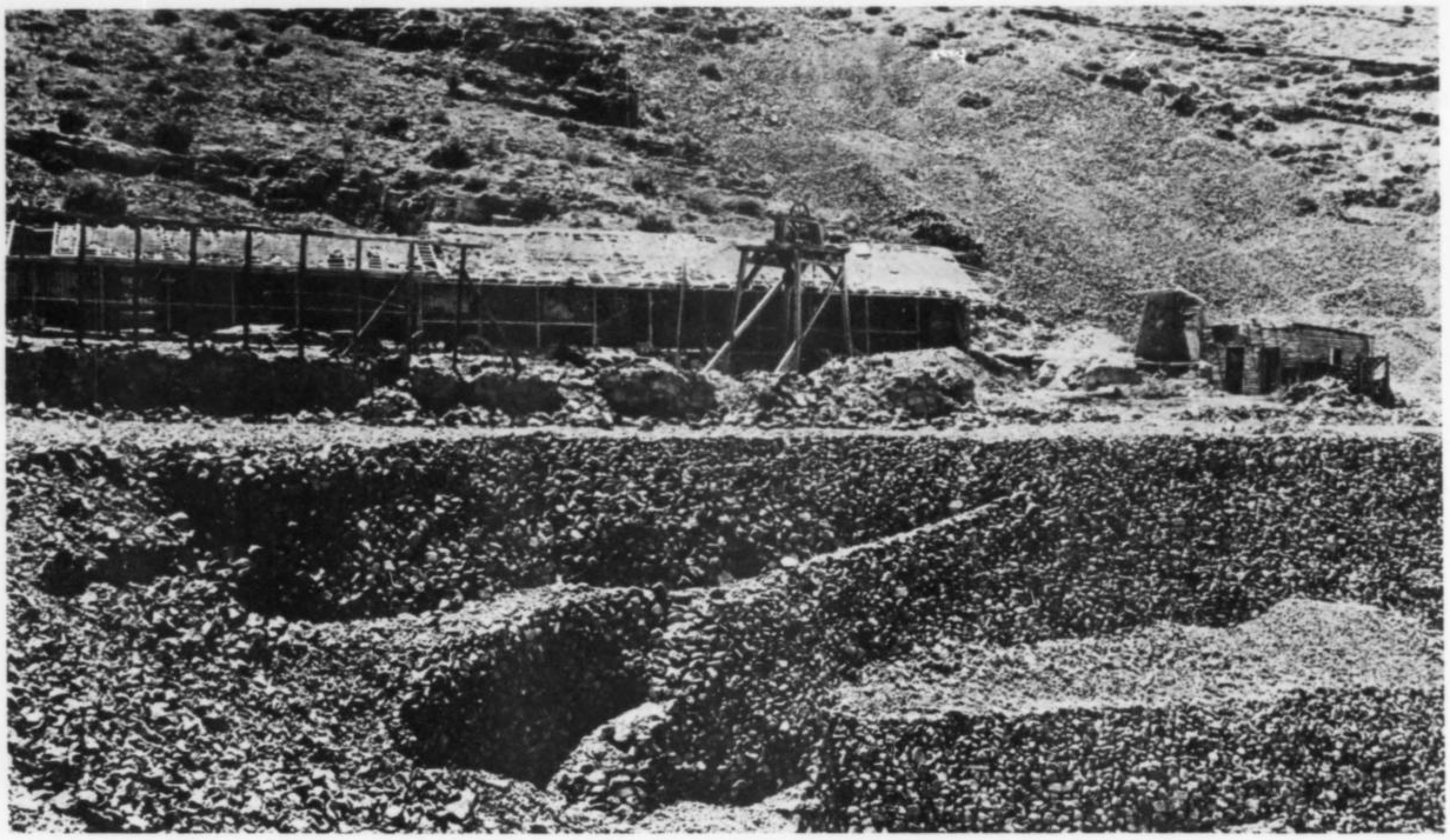


Figure 4. **Mina Descubridora. The shaft is on the Veta Descubridora.**

barite veins the barite was regarded as later than the carbonates and certainly was later than the siderite. Quartz in these veins was apparently later than the barite, at least in part. The sulfides present consisted of pyrite and pyrrhotite.

There were variable amounts of a dark green tuff on the dumps. It was most abundant on the dumps of the Dolores Tercera, Chacabuco, etc. In the vicinity of the Dolores Tercera, a few specimens of limestone or igneous rock, highly altered and recrystallized, showed contact minerals including garnet, vesuvianite and amphibole. Some of the outcrops of limestone in that same area showed lacing masses of some whitish mineral near the tops of beds, near crosscutting veins. This was supposed to be tremolite.

I ate lunch in a great series of wide and high open stopes with pillars, above the Delores Tercera, and enjoyed looking through the stopes as far as the light would permit. They gave the impression of high-grading but the most diligent search failed to reveal a trace of any visible silver mineral. The crosscutting veins, where observed, were about 16 m wide and high in barite. The sediment lay more or less horizontal. (I forgot my Brunton so was unable to get any strikes or dips.)

Silver was discovered at Chañarcillo on April 16, 1832, and active mining stopped about 1880, although there was considerable activity up until 1895. Since then only a little ore has been taken out of the mines on rare occasions of either a burst of confidence or a high price of silver. Many *mantos* were discovered in the various mines. Water became a problem eventually and caused the closing of the mines according to many; according to others, the grade failed. Today the mines to the north have little or no water and little or no ore in depth and the mines to the south and west have great quantities of water and according to some, good grade of ore in the bottom (I doubt it). Miguel Gallo, one of the original claim owners, had two sons, Pedro Leon and Juan. Now after three generations there are 93 Gallos who own portions of the Mina Descubridora. Chañarcillo is reputed to have produced over $2,000,000,000, and the Gallo family are supposed to have won something over $25,000,000. At least they won enough to buy a statue for the city of Copiapo and to finance a revolution of 1856 or some time therabouts.

Today the remarkable feature of Chañarcillo, and its ruination, is the great number of owners of the various mines. Almost everyone in Copiapo will talk to you of his mine at Chañarcillo that is going to make him and his family rich again one of these days. (It will if he ever sells it for what he wants for it.) His interest in a mine may consist of this. His ancestor at one time owned a fourth part of a *vara* of a large claim, let us say; there are any number of people in Chile today who own a 42nd or even less of a fourth of a *vara* of a mine. There are 300 *varas* in some of the mines; this makes his part of a mine 1/50,400th. There are literally thousands of people who own Chañarcillo. If it is ever worked, and I feel sure it never will be on account of the grade of ore more than anything else, the person or company working it will have to buy up this great number of shares and work it on a grand scale. When one realizes that the man with a 1/50,400th part of a mine expects at the least 100,000 pesos, the staggering figure of the present valuation of the district becomes apparent. And each generation increases the number of owners several fold.

At the telegraph operator's I talked mines and ores with the owner while his wife got the tea and then drove all the chickens out from under the table. The fellow produced a few specimens of *plomo ronco* (?) and gave me a piece. I paid two pesos for the tea, to the senora, and paid my guide of the morning a peso and we made off up the canyon and back to Copiapo.

On the return from Chañarcillo I tried to get some hot water to shave but there wasn't any in the place. I tried to get some tea and got a very little bit. In none too good a frame of mind I went up town to buy two empty cracker tins to pack my specimens in.

Figure 5. **Mina Dolores Tercera. This was the mine that produced most of the proustite specimens that made Chañarcillo famous, mineralogically.**

Figure 6. **Mina Alcaparrosa, Tierra Amarilla. The main entrance to the mine. The working to the right is on the bottom of a lens and the one of the left at the top of another lens. The upper hole is about 6 m above the floor.**

TIERRA AMARILLA

The chauffer arrived early as usual and waited until I finished my coffee and rolls. Sr. Juan Carabantes was phoning to Sr. Julio Olivares at Tierra Amarilla when we called for him. Sr. Olivares was to have the horses for us to go to the Mina Alcaparrosa. When he finally got through to the man, the horses hadn't been caught or brought in but they would be ready for us tomorrow. I had made arrangements through the American Smelting Company for them and Sr. C. had made arrangements for them also. Typically South American.

We left anyway and sailed along merrily until we came to the outskirts of the city of Tierra Amarilla and then decided to drive across the river and go to the mine in the car. The mine we wished to go to was just across the valley, a matter of perhaps a kilometer from the road. I wouldn't have thought of getting horses and bothering with them to get to the mine but would have planned to walk in the first place and wade the river. The river was easy to ford but the driving over the rocks in the river bed was bad and I wouldn't have taken a car over them but these people treat cars as bad as, if not worse than, horses and animals in general. The dump from the mine came right down to the river bed.

Mina Alcaparrosa proved to be a great vein of massive pyrite that had been altered to sulfates of various kinds and had been worked for these sulfates in days gone by. When I visited it the mine consisted of a series of connected stopes of great size. The first thing that struck me was the small size of the dump in proportion to the great open stopes. The sign of a good mine. The vein had a north 5 west strike and dipped 45–55 degrees to the west. The country rock was strongly altered and heavily impregnated with pyrite. The lower workings were filled with either water or talus material so none of the actual primary sulfides in the vein were observed. However, on the dump were pieces of almost pure pyrite in small grains.

Most of the vein material left as pillars was evidently too low grade to pay to take out. The walls were firm and stood well over great distances. At the entrance to the mine there were two veins, well developed apparently, from the stopes. The east vein was not worked below the level of the entrance, while the west vein was not worked very far above the level of the entrance. A sort of very tight and strongly overlapping en echelon structure. I suspected that there was another lens to the west, now under water, that was also worked. All the specimens were taken from the entrance to the mine. Minerals identified by sight were copiapite, coquimbite, botryogen, sideronatrite, gypsum, jarosite, kröhnkite or cupriferous gypsum, and pickeringite. Several good specimens were obtained.

From the Mina Alcaparrosa we drove back across the river and through Tierra Amarilla to the mine of the Carabantes, Mina Abundanca, in the hills to the east of Tierra Amarilla and a little south. There was a good road to the mine, although frightfully dusty and we had a tail wind. My chauffer dashed up the road in true and regular form. Sr. C. spoke with great feeling regarding the Mina Manto Verde that lay over a hill to the north of his mine. A very rich mine in its day, belonging to the Campbell family but it was so badly mismanaged or not managed at all that it paid little of the sum it should have.

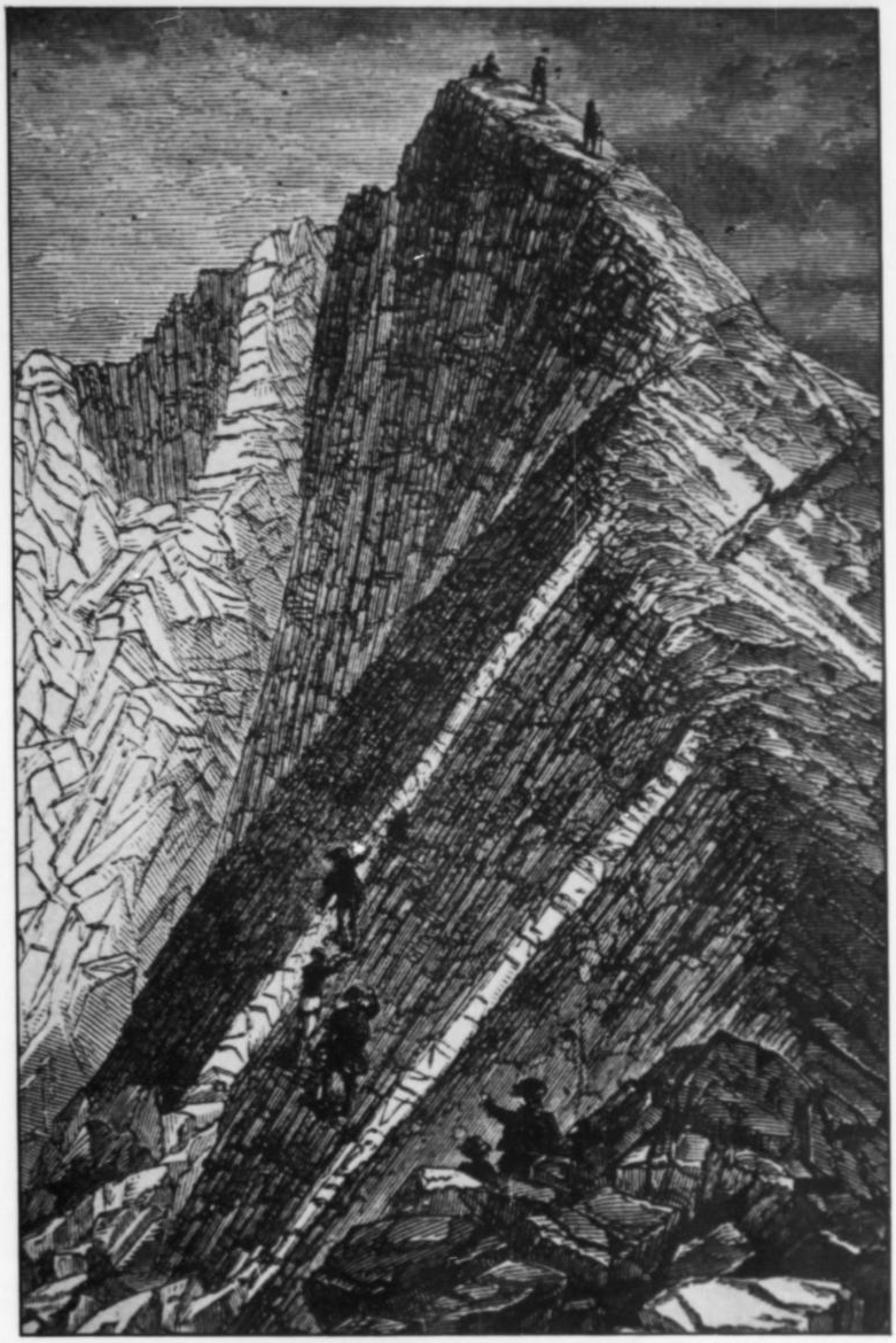
Mina Abundanca was apparently a very well managed mine, run by a brother of Sr. C. The striking feature of the mine was the abundance of native copper in the ore. Large pieces were shot through with fine wires of copper and many pieces were observed that must have run 40 percent copper, all in the native form. There was a little cuprite in the ore but the native copper specimens were the striking feature. All the material mined was in the oxidized zone. Other minerals observed were chalcocite, covellite, bornite (rare) and chalcopyrite with pyrite and hematite abundant in some specimens. Chalcopyrite is the primary mineral and the gold content ranges from 2–4 grams per ton. There was a considerable amount of the mineral they called "atacamite" and that I took to be malachite. Small crystals of aragonite was a peculiar feature of the ore and I obtained several specimens of the mineral common on the walls of old mines in Chile. I thought at Chuquicamata that it was cupriferous gypsum although some of the specimens I obtained looked very much like kröhnkite. An interesting problem and I had enough material to solve it. After a trip through the surface plant we departed for Copiapo.

After I returned from Tierra Amarilla I cleaned right up and went in to lunch. A terrible lunch that ran to mutton and spaghetti. I was tired after lunch and lay down for a few minutes but it was a foolish move. I had just dozed off when here came Don Anibal to see what I had heard about the specimen at Caldera. I told him I hadn't heard, and would go down and see him later in the afternoon. He hadn't more than left when in came a dizzy simpleton to sell me an arsenic mine. Of all things an arsenic mine. I asked him what percent his ore ran and he didn't know. I thought that it might be interesting if it was a good specimen mine or if the arsenic was in an oxide form so I tried to find out in what form the arsenic was, realgar or orpiment or oxides. It turned out that the fellow hadn't the faintest idea what the mine was or what it was like. He knew that the ore carried arsenic as the miners said so. I just threw up my hands and turned over in the bed but he then tried to sell me a piece of massive bull quartz because he knew it was valuable. You could hold it up to the light and see through it. I told him that I would be interested in a crystal of quartz only and it would have to be a crystal at least a foot and a half through with perfect form. I eventually got rid of him. I was so sore over all the foolishness that I got up and dressed and started for the American Smelting office and to buy some cans.

I visited around a little and then returned and had tea. Called on Don Anibal and talked quite a while to him and then purchased his specimen of native silver and cerargyrite from the Veta Descubradora of the Mina Carlota, Chañarcillo. He said it would cost me 300 pesos if it was for myself and 400 pesos if it was for the Museum. I paid 300 pesos and now all I have to do is to talk the Museum into giving me the specimen and making me an honest man. I was pleased that he offered me my selection of some small pieces of highgrade ore as a gift from him. I didn't take any at the time but would if I get another chance. I had a reason. Wrote until dinner time. Poor dinner and an early bed.

(to be continued)

Minerals of the Italian Mountain area Colorado



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The Italian Mountain area near Aspen, Colorado, is a remote and difficult region in which to collect. Most commercial ventures there since 1878 have been a failure, but more than 80 species including collector-quality grossular, vesuvianite, prehnite, cerussite, epidote and lazurite have been found.

INTRODUCTION

The Italian Mountain area is located approximately 170 km southwest of Denver and 15 km south of Aspen, Colorado (Fig. 3). The area is accessible for about five months each year, beginning in June. Elevations in the area range from 2440 m to 4078 m, and Canadian, Hudsonian, and Arctic-Alpine life zones are represented (Moenke, 1971). South Italian, Italian, and North Italian Mountains form a north-south line, the highest point of which is the 4078 m summit of Italian Mountain. A prominent ridge extends east from Italian Mountain and divides Star Basin on the north from Stewart Basin on the south.

HISTORY

The Italian Mountain area was the scene of active prospecting after the discovery of lead-silver ore at the Star mine in 1878 (Garrett, 1950). The remoteness of the mine discouraged development, and it was not until the 1900's that the Star reached full production. Even then production was not great; total production for the years 1927 and 1928 is valued at $8224.07 and averaged 40.9 percent Pb

***Figure 1.* Members of the Hayden survey at the summit of Italian Mountain in the early 1870's (Hayden, 1873).**

Figure 2. **Italian Mountain (top center), flanked on the left by South Italian Mountain, and on the right by North Italian Mountain. The ridge in the left foreground is American Flag Mountain. The ridge projecting toward the viewer from Italian Mountain is East Ridge, to the right of which is Star Basin, and to the left of which is Stewart Basin.**

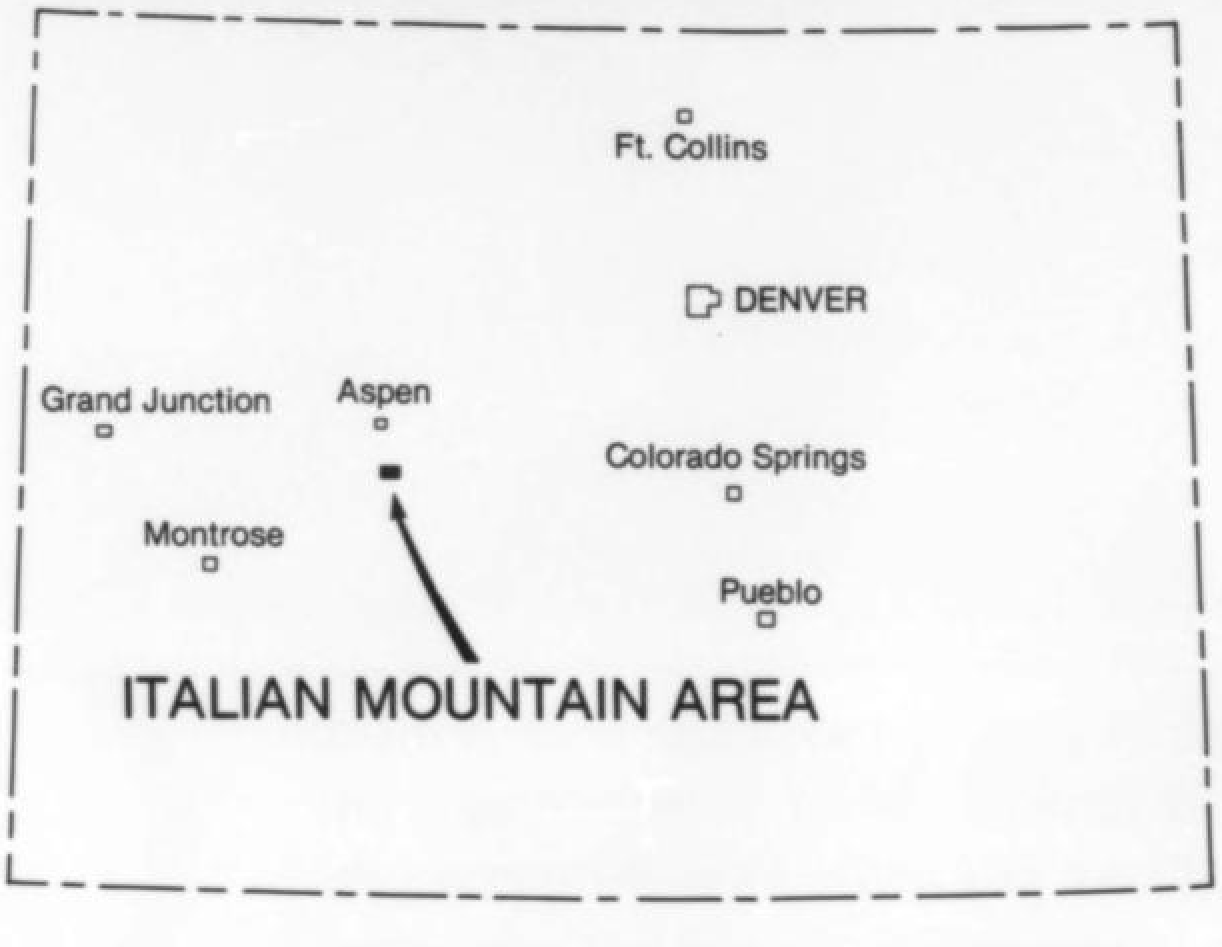

Figure 3. **Location of the Italian Mountain area in Western Colorado.**

and 26.72 oz./ton Ag (Garrett, 1950). A 1950 shipment of 144 tons from the Star mine contained 68,430 lb. Pb, 3648 lb. Zn, 2711 lb. (sic) Ag and 2 oz. Au (Roy, 1973).

The Clara L. mine, 300 m south of the Star, and the Stewart mine, in Stewart Basin, were actively promoted but produced little or no ore (Stewart, 1935).

In the early 1900's efforts were made to mine "graphite" from the summit of North Italian Mountain. A trail from the Star mine to the peak and a few prospect pits are all that remain of that enterprise.

Carl Anderson, a miner at the Star in 1939, prospected the west slopes of North Italian Mountain for facet-grade grossular. His grossular prospect was a failure, but he did succeed in discovering a small deposit of lapis lazuli in a nearby gully (Rosencrans, 1941). After an initial flurry of activity in the 1940's, the lapis mine settled into dormancy that was to last until 1980 when the deposit was worked on a larger scale by Paul Schultz of Oklahoma City (Schultz, 1981).

COLLECTING

The summit area of Italian Mountain is 450 m above the nearest road access, and in 1972 a trail was built from the Stewart mine to the summit to facilitate access. Late in the 1973 season, lapis lazuli was discovered near the summit and most of the short 1974 season was used to learn the locally complex geology and to dig ten prospect pits. However, none of the pits produced a sufficient quantity of well colored lapis to warrant mining. In 1975 another thirty pits were dug in the summit area in search of specimens and facet-

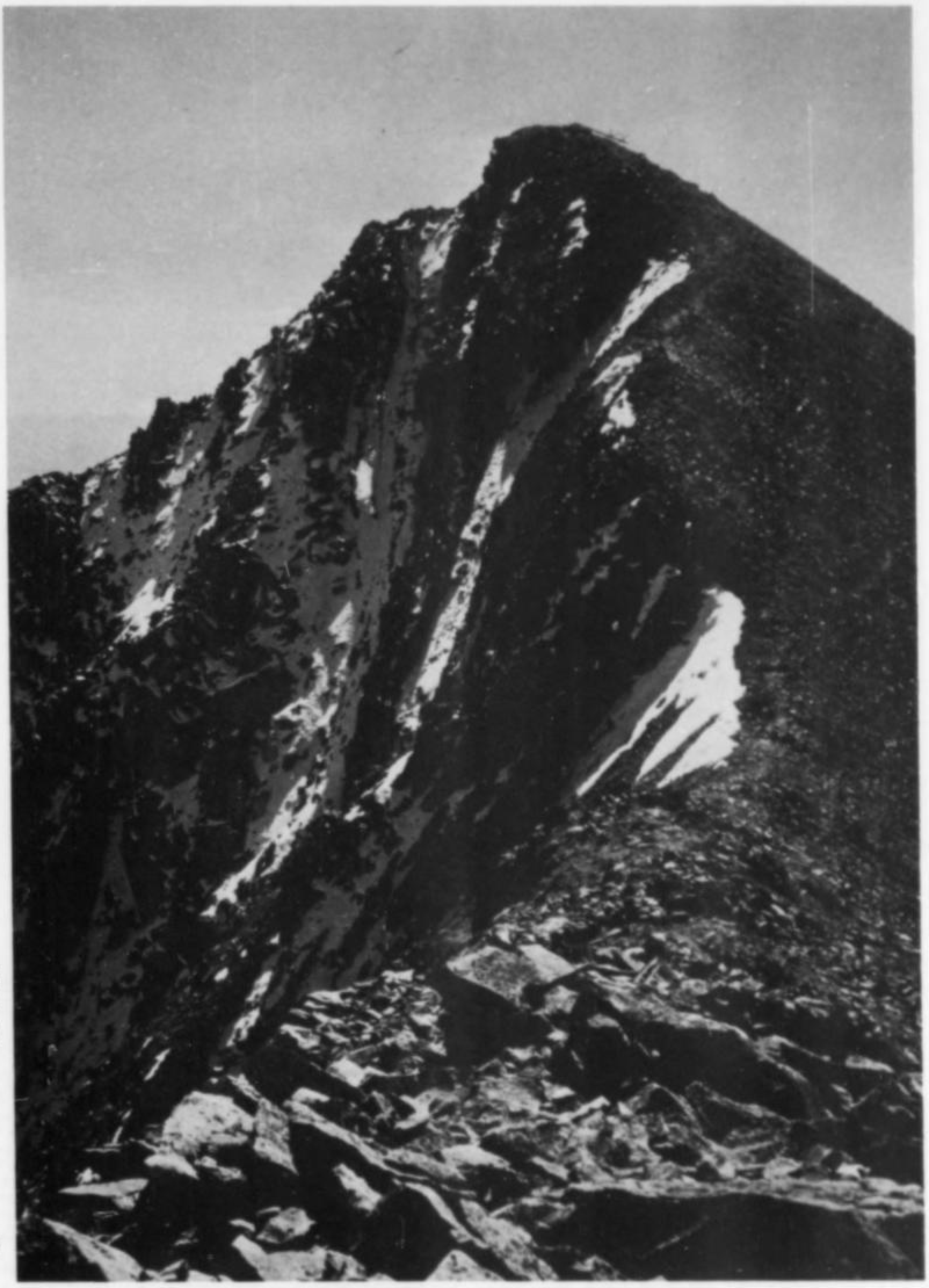

Figure 4. Summit of Italian Mountain, showing the contact of quartz monzonite porphyry (foreground) with sedimentary rocks of the Belden formation. Compare with Figure 1.

Figure 5. Extraction of specimens from the summit area, 1975.

Figure 6. **The Star mine, largest of the base metal mines. Italian Mountain in the background is composed of jagged rocks of the northern quartz monzonite porphyry stock in contact with sedimentary rocks of the Belden Formation (left).**

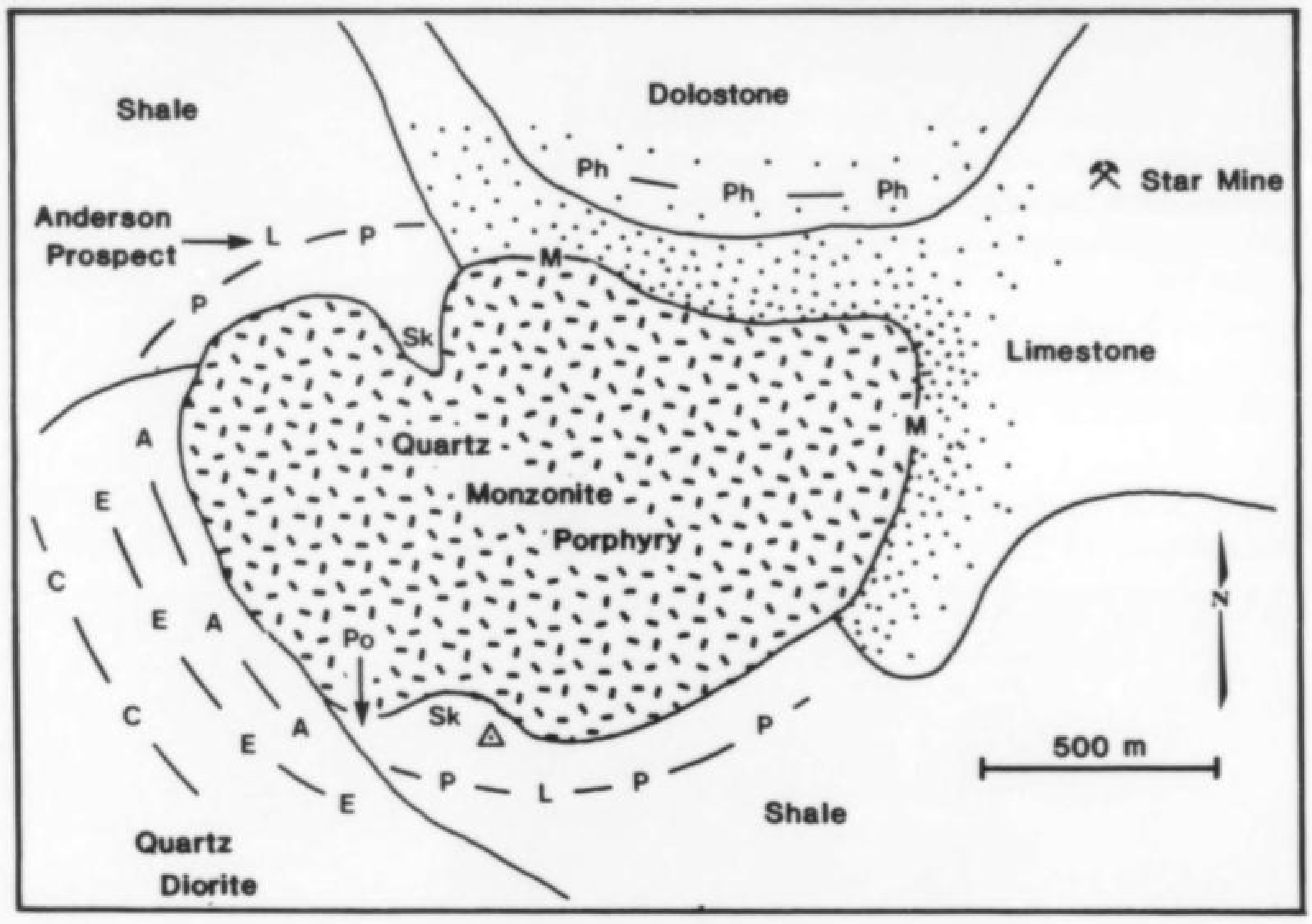

Figure 7. **Zonal relationship of mineral deposits around the quartz monzonite porphyry stock of the northern intrusive center. Note the dependence of mineralogy on host rock lithology. A = actinolite, C = chlorite, E = epidote, L = lapis lazuli deposit, M = magnetite deposit, P = pyrite, Ph = phlogopite, Po = pyrrhotite, Sk = garnet-diopside-vesuvianite skarn, and stippled pattern shows the area of marble in the limestones and dolostones (after Truebe, 1982). Small triangle shows the summit of Italian Mountain.**

quality grossular, vesuvianite, and prehnite (Fig. 5). Five pits produced about $3000 worth of specimens at a cost of $5000. Major problems encountered in operating the prospect were lightning storms, permafrost, and specimen damage due to natural pocket collapse.

GEOLOGY and MINERAL DEPOSITS

The Italian Mountain area is located at the point where the Elk Range Fold and Thrust Belt abuts the west flank of the Sawatch Range. F. V. Hayden, one of the first geologists to view the area (Fig. 1) described the rocks as ". . . thrown into a greater state of chaos than I have observed anywhere in the West . . ." (Hayden, 1873). The area has been studied by Emmons and Eldridge (1896), Cross and Shannon (1927), Garrett (1950), Prather (1961), Cunningham (1973), Roy (1973), Zoerner (1974), and Truebe (1982), with only a moderate amount of agreement concerning the structural geology.

The main feature of the geology of the area is a group of three igneous stocks, the youngest and northernmost of which cooled about 33.8 million years ago (Cunningham and Naesser, 1975). The stocks were emplaced along a north-south line and intrude a complexly faulted mass of Paleozoic sedimentary rocks and Precambrian igneous rocks that may be divided into three structural blocks (Truebe, 1982). Mineral deposits of the area formed around the youngest stock in specific geologic environments that are controlled by host rock lithology and by distance from the stock (Fig. 7).

Figure 8. **The Anderson lapis lazuli prospect, North Italian Mountain, in 1977.**

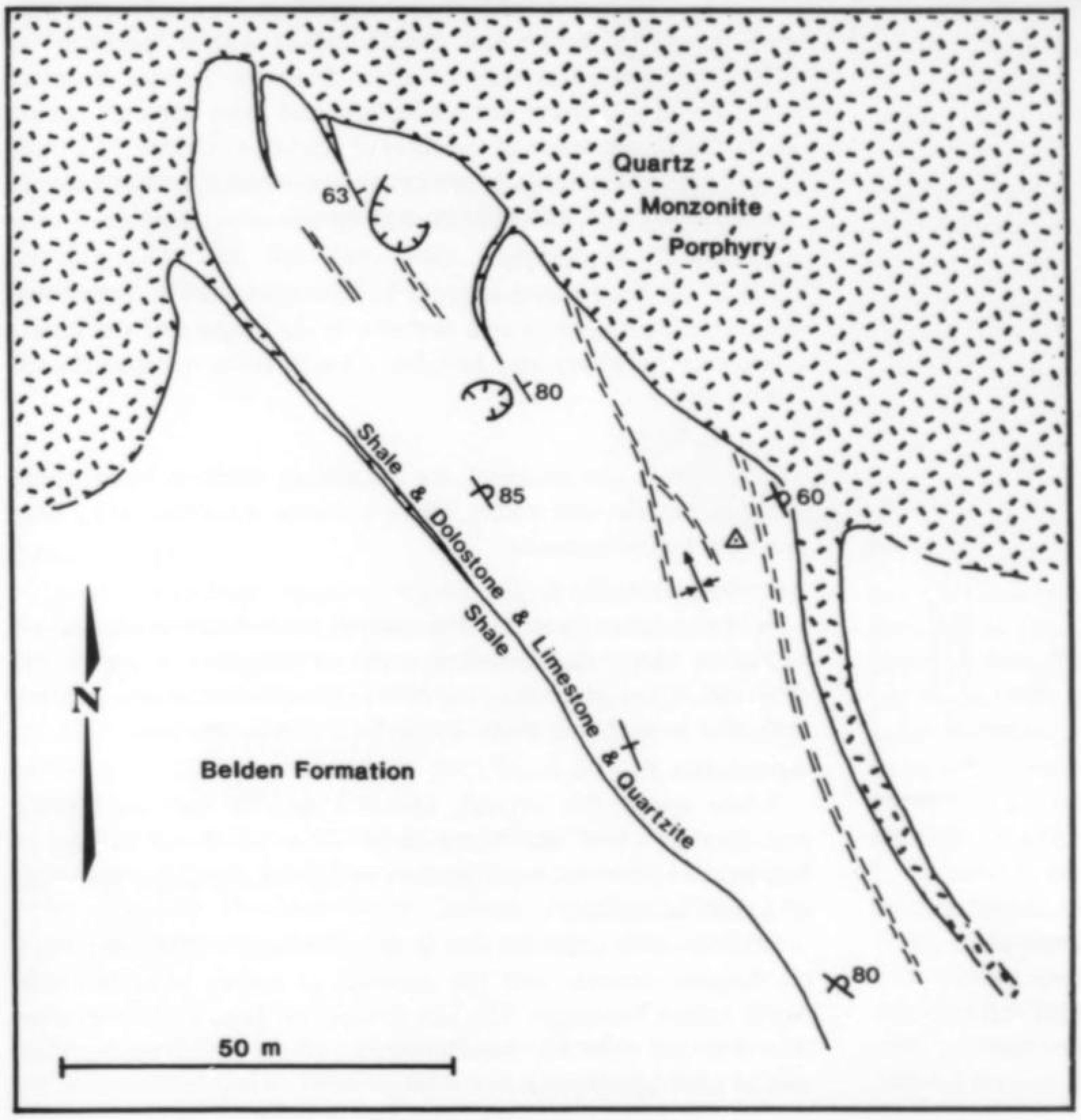

Figure 9. **Geology of the summit area, Italian Mountain. Important features are dikes of quartz monzonite porphyry, the contact of mixed Belden shale, dolostone, limestone, and quartzite with homogeneous Belden shale, faults (parallel dashes), and important prospect pits (hatchured lines). The triangle indicates the summit of Italian Mountain.**

While the stock is technically a granite porphyry (Dietrich and Skinner, 1979) it will be referred to here as quartz monzonite porphyry to maintain consistency with older literature.

Throughout this paper, many localities are referenced to a metric grid, the origin of which (000 m north and 000 m east) is at the summit of Italian Mountain (sometimes simply referred to as the summit). The grid is merely a devide to describe locations in the area and has no connection with any formal geodetic system.

The more than 80 mineral species described in this article may be considered to have formed in the halo of the northern intrusive center. In the discussions that follow they have been classified by environments of formation as minerals of the igneous rocks, skarns, the lapis lazuli deposits, and the hydrothermal replacement deposits.

Minerals of the igneous rocks formed either as magma cooled or as alteration products after cooling and fracturing of the intrusions. Quartz, orthoclase and plagioclase crystallized in small miraolitic cavities that formed in the northern stock. Fractures in both the northern quartz monzonite porphyry stock and the central quartz diorite stock are lined with actinolite, hornblende, feldspars and stilbite that formed when hot fluids moved through the fractures. Chemical reactions in the northern stock near its contact with surrounding rocks produced titanite and secondary biotite.

Bodies of amphibolite, magnetite, and garnet-diopside-vesuvianite form skarns (Gary *et al.*, 1972) at the contacts of the intrusions and the surrounding sedimentary rocks. The sizes of the skarn bodies decrease proportionately with decreasing altitude. The smallest skarns are composed of amphibolite at the northeastern contact of the granodiorite stock that forms South Italian Mountain. Small pods of magnetite are found at two places at the border of the northern stock. Cross and Shannon (1927) describe 28 species from the Italian Mountain area, most from the large garnet-diopside-vesuvianite skarns at the summits of Italian Mountain (Figs. 4 and 9) and North Italian Mountain. The paragenetic sequence of minerals at these skarns is: early grossular and diopside, intermediate vesuvianite and epidote, and late zeolites (Fig. 10). A small garnet-diopside-vesuvianite skarn at 850 m north 350 m east probably formed at a temperature of 450° to 525° C and a pressure of 300 to 750 atmospheres (Nordlie, 1965).

The lapis lazuli deposits are found at a particular horizon in the Pennsylvanian Belden Formation near, but not at, the point at which it is in contact with the northern stock (Truebe, 1977). The largest of the deposits is the Anderson prospect (Fig. 8), located in a gully at 1000 m north and 400 m west, on the north side of North Italian Mountain. The deposits are thought to have formed at a minimum temperature of 600° C and at a pressure of 247 atmospheres (Hogarth and Griffin, 1980).

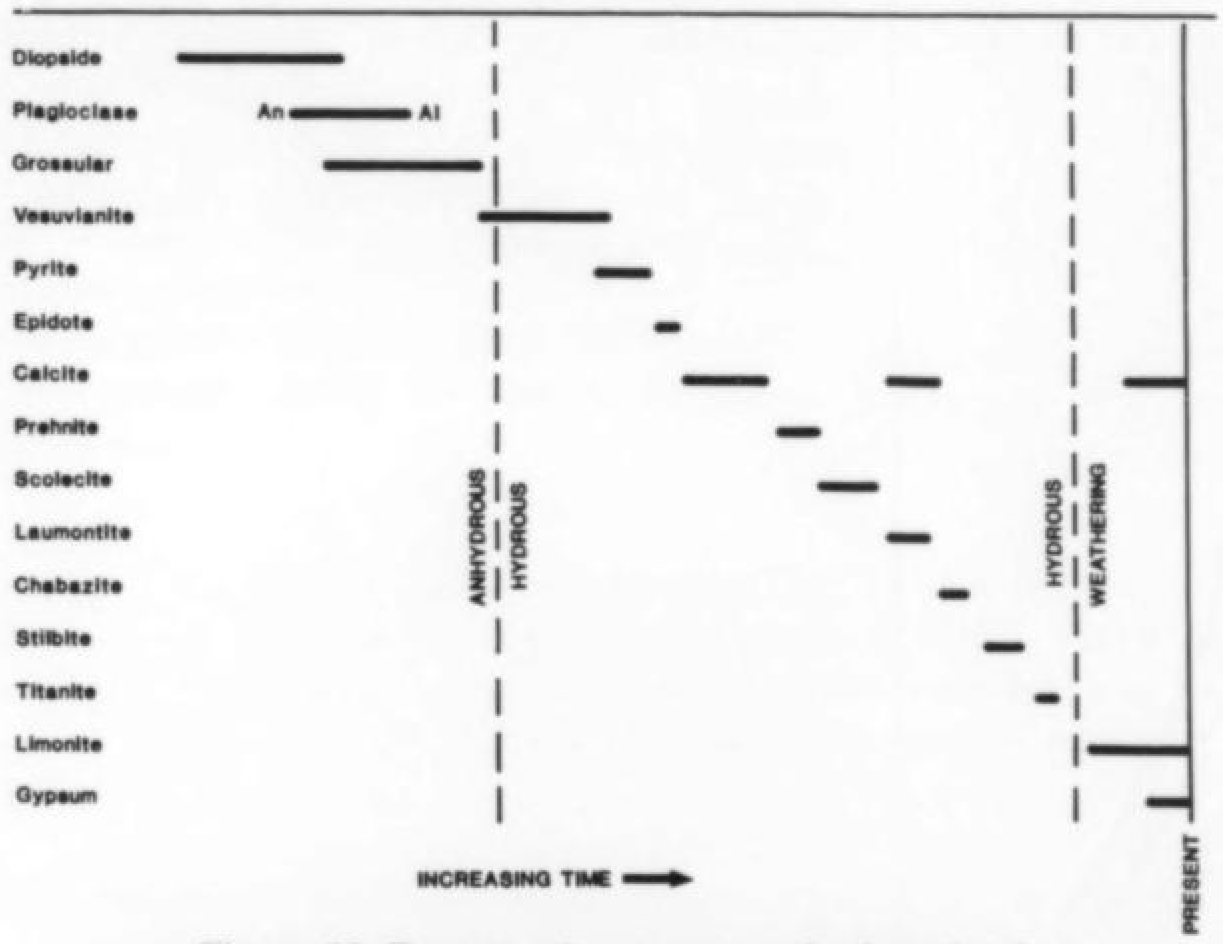

Figure 10. **Paragenetic sequence of minerals of the summit skarn, Italian Mountain. Note the change from early, anhydrous species to hydrous species with increasing time and decreasing temperature.**

The hydrothermal replacement deposits of Star Basin form a center of lead and zinc mineralization in the Italian Mountain area (Garrett, 1950, Cunningham, 1973, Roy, 1973). The Star (Fig. 6), Independent, and X-10-U-8 mines worked the largest orebodies. Galena, sphalerite, pyrite and barite mineralization filled open spaces and replaced fragments in a 9-meter-thick breccia near the middle of the Leadville limestone, and formed pods parallel to bedding and disseminations in undisturbed limestones above and below the breccia (Garrett, 1950). Primary sulfides remain on the third level of the Star mine (Garrett, 1950), but above the third level the ore is oxidized to a limonite gossan containing anglesite, cerussite, barite and a number of other species.

MINERALS

The following catalog provides general descriptions of the distributions and habits of mineral species found in the Italian Mountain area. Criteria used for identification are described in detail in the references given. Species terminology and formulas are from Fleischer (1983).

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

Actinolite occurs as felted masses of greenish crystals about 1 mm long coating walls and filling fractures in quartz diorite, as masses of needle-like crystals about 1 cm long in skarns at the summit, as *uralite* replacing pyroxenes along fractures in quartz monzonite porphyry, and as fine, hair-like masses of *byssolite* with epidote at the summit.

Albite $NaAlSi_3O_8$

Cross and Shannon (1927) note pale pink crusts of albite on fractures in altered diorite and describe albite with a "peculiar flat habit." Aggregated crystals of albite from the summit fluoresce bright red in shortwave ultraviolet light and show apparent zoning due to partial alteration of the cores of crystals to sericite. In a small pocket near the summit, bright crystals of albite less than 2 mm in size are associated with epidote and quartz.

Andradite $Ca_3Fe_2(SiO_4)_3$

Dark red-brown andradite in crystals to 3 cm is commonly associated with epidote and prehnite at the contact of the quartz monzonite porphyry and hornfels formed from metamorphosed Belden shales.

Anglesite $PbSO_4$

Anglesite is the principal ore mineral in oxidized replacement orebodies at the Star mine, where it forms anhedral, milky gray grains in limonite gossan.

Anorthite $CaAl_2Si_2O_8$

A large amount of anorthite is present in the skarn at the summit of Italian Mountain, though it is not as abundant as garnet and diopside. Cross and Shannon (1927) describe anorthite as being early and note that it molds an earlier rhombic mineral.

Apophyllite $KCa_4Si_8O_{20}(F,OH)\cdot 8H_2O$

White apophyllite crystals about 3 mm in size and having pseudocubic "cube" and "octahedron" faces are found in vugs in limestones of the Belden formation at a point along the east ridge of Italian Mountain.

White crystals about 0.5 mm in size with larger {100} faces occur on diopside crystals near the summits of Italian Mountain and North Italian Mountain. The morphology of these crystals suggests that they are probably pseudomorphs of an as yet unidentified species after apophyllite.

Barite $BaSO_4$

Barite is widespread in the Leadville limestone in Star Basin, commonly forming masses of white bladed crystals averaging about 5 cm in diameter. The crystals cement breccia, are themselves brecciated, surround sulfide minerals, and are sometimes included in pyrite masses. Simple tabular crystals of golden barite (Fig. 11) on walls of open spaces in replacement orebodies are found in three places; 1200 m north 1300 m east, 1100 m north 1200 m east, and 000 m north 2700 m east. Cross and Shannon (1927) describe zoned barite crystals to 8 mm in size on a fracture in metamorphosed sedimentary rock.

Figure 11. **Golden barite on limestone. The specimen is 6 cm wide and the barite is a moderate yellow in color. All specimens are from the author's collection.**

Figure 12. **Clinozoisite with crystals ranging in color from dusky yellowish green at the bases to grayish yellow at the tips, with stilbite. Specimen is 4.2 cm wide at the base.**

Calcite $CaCO_3$

Calcite forms huge masses of marble, fills fractures in carbonate rocks and cements breccia. Simple rhombs, nailhead rhombs, prismatic crystals, dogtooth scalenohedrons, and highly modified scalenohedrons have been observed in vugs throughout the area. A pseudomorph of scolecite after a rhombohedral mineral, possibly calcite, was found at the summit.

Carbon C (not a valid species)

Amorphous carbon, formed by partial metamorphism of carbonaceous shales in the Belden formation, is noted in 14 scattered areas. The best development of carbon, described as graphite (Cross and Shannon, 1927), is at the summit of North Italian Mountain.

Cerussite $PbCO_3$

White needle-like crystals of cerussite are found in vugs in barite at the Star mine and in limonite gossan at a prospect 100 m northeast of the Stewart mine. Roy (1973), probably citing Garrett (1950), describes the oxide ore at the Star as cerussite with significant silver in the crystal structure.

Chabazite $CaAl_2Si_4O_{12}\cdot 6H_2O$

Two to 5 mm, white to colorless rhombohedral crystals and penetration twins of chabazite are found near the summits of Italian and North Italian Mountain. The chabazite is commonly found on fracture surfaces and on earlier-formed silicate minerals, but in 1975 a 20-cm vug filled with quartz and chabazite sand was opened near the summit.

Clinozoisite $Ca_2Al_3(SiO_4)_3(OH)$

A glassy tan mineral, showing radial or fan-like habit and identified as clinozoisite (J. Murphy, 1974, personal communication) is common at the summit of Italian Mountain and less common at the summit of North Italian Mountain. Aggregates of crystals under 1 cm in length are composed completely of clinozoisite; in larger groups the lower portions of the crystals are greenish and are probably epidote (Fig. 12). Small, pink, prismatic crystals of manganiferous clinozoisite are found in a grossular-lined fracture near the summit.

Diopside $CaMgSi_2O_6$

Diopside is abundant only at the summit of Italian Mountain where masses of diopside rock make up 5 percent or more of the skarn body. The rock exhibits varying degrees of crystallinity, from a dense, dark green hornfels to a porous, pale green rock composed of 3–4-mm diopside crystals attached at their points of contact. Crystals of diopside up to 3 cm (Fig. 13) form in open spaces in the hornfels and are commonly twinned on (100). A small amount of diopside is found as rounded grains in calcite at the lapis lazuli deposits (Hogarth and Griffin, 1980). Optical properties and morphological data indicate a greenish black pyroxene with granular to prismatic habit to be sahlite (Cross and Shannon, 1927). They give no locality, but material fitting their description can be found 200 m west of the summit.

Epidote $Ca_2(Al,Fe)_3(SiO_4)_3(OH)$

Epidote is best developed near the summit where it displays several habits, but it is also found filling fractures and replacing feldspars in Precambrian rocks and in quartz diorite. At the summit epidote occurs as isolated lustrous crystals about 1 cm long associated with andradite, as slightly divergent clusters of lustrous, dark green crystals in diopside hornfels (Fig. 15), as 2-mm black tabular crystals with quartz and plagioclase, and as the basal parts

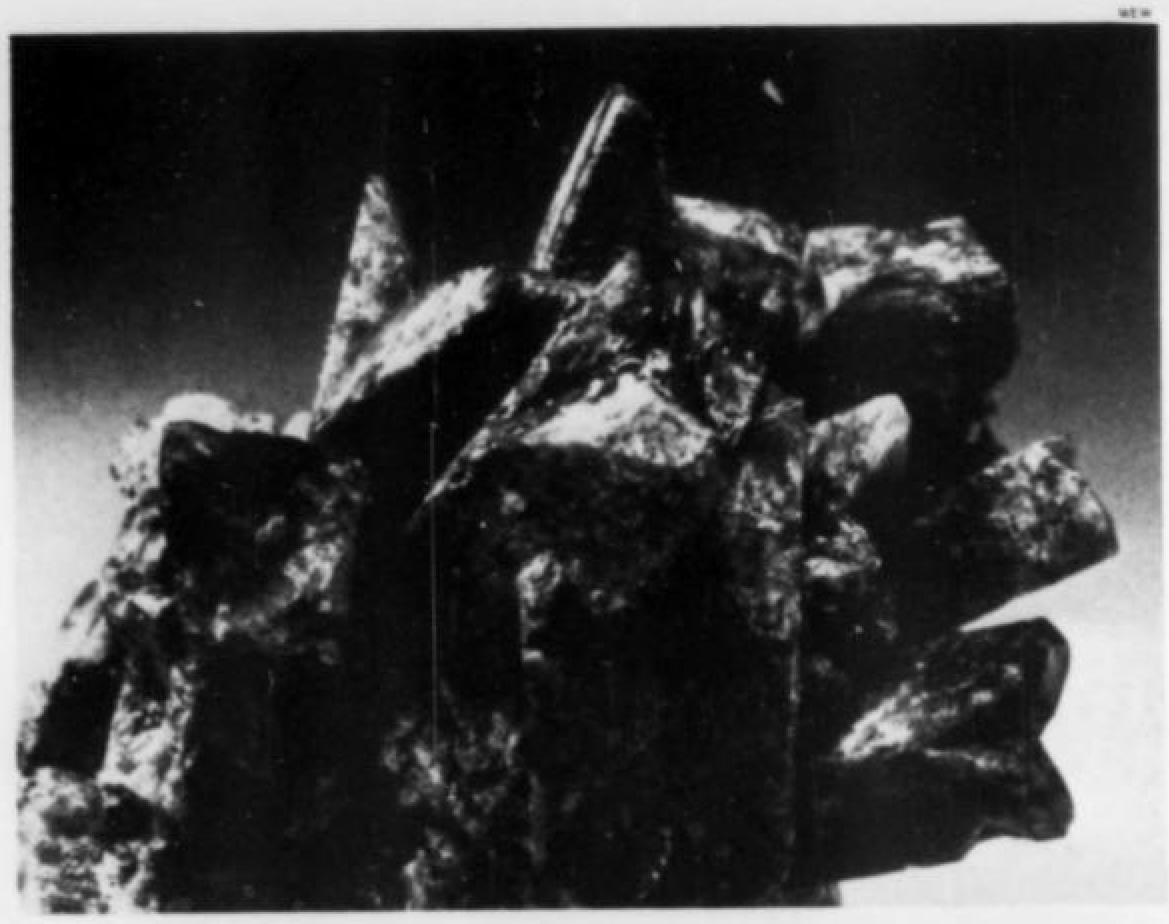

Figure 13. **Dark pine-green diopside crystals twinned on (100). The group is 5 cm across.**

Figure 14. **Line drawings of crystals of diopside, simple and twinned on (100), from Cross and Shannon (1927).**

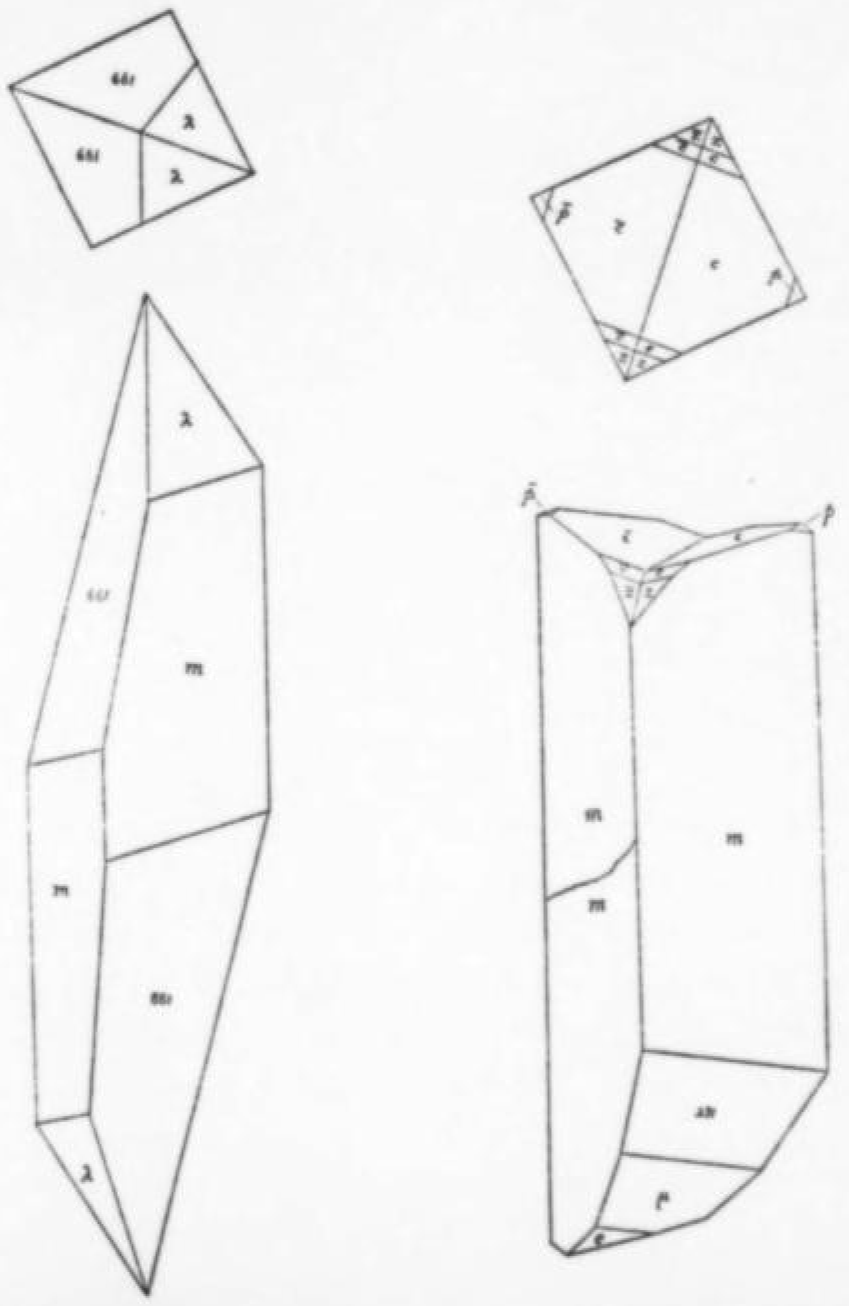

Figure 15. **Dark green epidote crystals; the group is 4.2 cm across.**

Figure 16. **A bicolored, 1-cm epidote crystal, pinkish brown on the top and blackish green below, with a spheroid of brownish prehnite having a gray-blue surface coating.**

of clinozoisite crystal groups described earlier. In the quartz diorite, epidote is confined to a band 400 m to 600 m from the quartz monzonite porphyry of the northern pluton.

Garnets (undifferentiated)

Distribution of garnets is confined to skarns on the western margin of the northern pluton. Garnets form massive garnet rock, garnet-diopside hornfels, aggregates of crystals, shells of pipe-like bodies filled with later vesuvianite and zeolites, and in one case as exsolution layers, or simple interlayers, in vesuvianite crystals. Garnets in the Italian Mountain area are commonly isomorphous mixtures of grossular and andradite and are found in a wide variety of colors, including red-brown, black, red, pink, yellow and green.

Grossular $Ca_3Al_2(SiO_4)_2$

The most common garnet species in the Italian Mountain area is grossular, and the best examples of the species are found at the summit of Italian Mountain. Crystals commonly exhibit dodecahedral faces {110} modified by the hexoctahedron {321}. Large crystals to 4 cm are opaque while small crystals are transparent and sometimes tinted reddish (Fig. 17). Finch (1967) describes apple-green and brown grossular associated with calcite, epidote, scolecite, plagioclase, chabazite and montecellite at the Grossularite prospect at 750 m north and 750 m west.

Laumontite $CaAl_2Si_4O_{12} \cdot 4H_2O$

Altered monoclinic crystals of a mineral with a habit resembling wooden matchsticks (Fig. 15) were collected in 1975. Oriented growths of the material are found in rhombohedral vugs in anorthite and jumbled growths are found in association with vesuvianite, grossular, prehnite, and other species. The morphology and the environment of its formation suggests that the mineral is a pseudomorph after a zeolite, perhaps laumontite. Its distribution is limited to the skarns of the summit area.

Lazurite $(Na,Ca)_{7-8}(AlSi)_{12}(O,S)_{24}[(SO_4),Cl_2Cl_2,(OH)_2(OH)_2]$

Lazurite from the Italian Mountain area is typically very fine grained (< 0.05 mm) and makes up less than 10 percent of even the bluest lapis lazuli (Truebe, 1977). Lazurite is associated with calcite, diopside, forsterite and pyrite at the deposits on the east side of Italian Mountain (Fig. 16) and the north side of North Italian Mountain. Hogarth and Griffin (1980) describe the deposits in detail.

Microcline $KAlSi_3O_8$

An unusual specimen consisting of blocky K-feldspar crystals averaging about 5 mm associated with colorless quartz crystals was found as float at 50 m south and 350 m west. Though the crystals

Figure 17. **Light brown grossular garnet from the summit area. The crystal is 2 cm across the dodecahedron faces.**

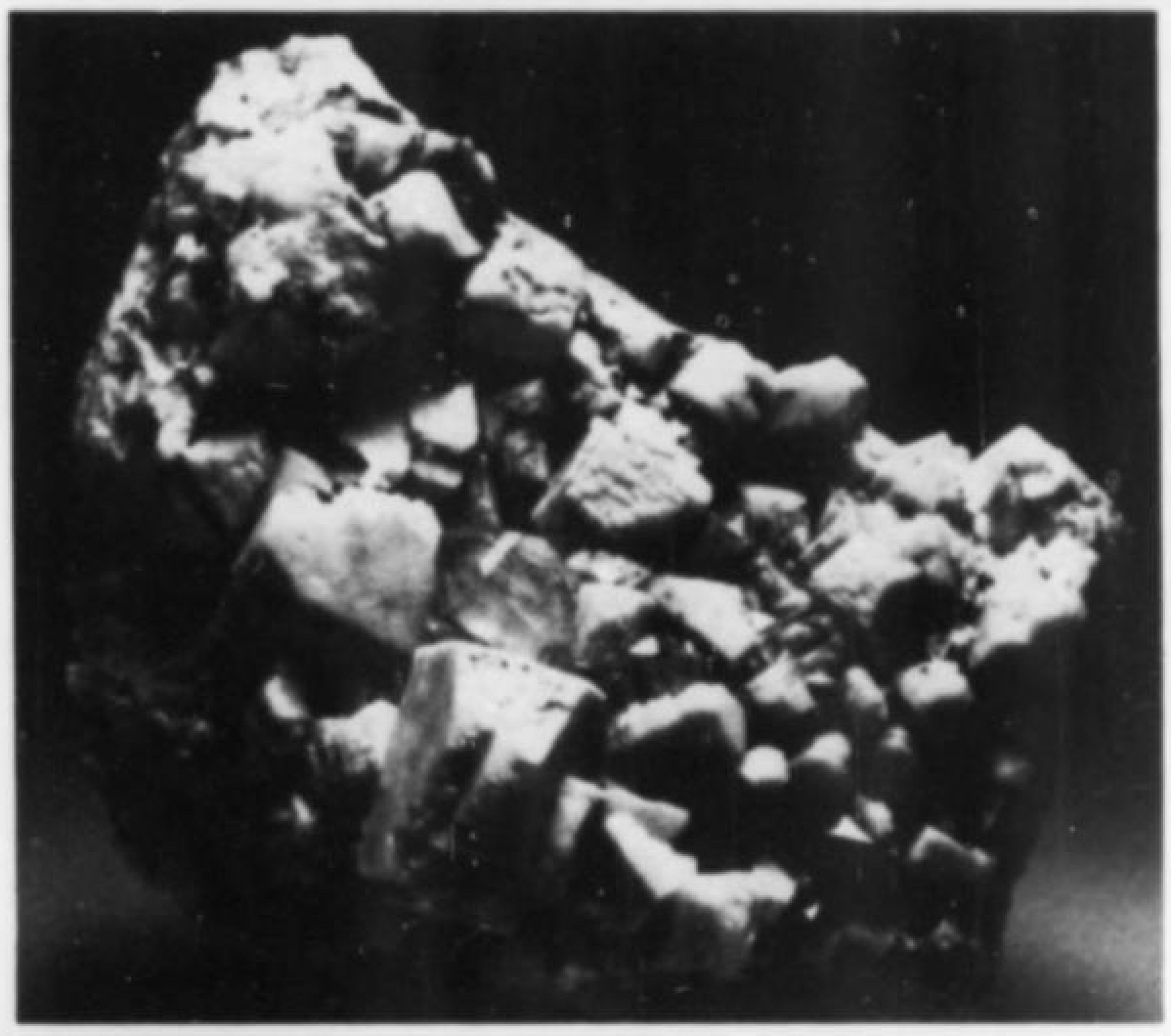

Figure 18. **White microcline crystals with quartz; the group is 6 cm across.**

Figure 19. **Yellowish gray prehnite; the specimen is 5 cm in width and has late rhombohedral crystals of chabazite.**

are small the material resembles pegmatite microcline. It shows enough similarity to other Italian Mountain material to confirm its origin there.

Pargasite $NaCa_2(Mg,Fe)_4Al(Si_6Al_2)O_{22}(OH)_2$

An intergrowth of iron-stained white crystals resembling wollastonite (long-sought) was found near the summit. X-ray diffraction gave a good match for the amphibole-group mineral pargasite, but the color and crystal habit of the specimen make this identification tentative.

Prehnite $Ca_2Al_2Si_3O_{10}(OH)_2$

Rounded bottons and globular masses of prehnite about 2 cm in diameter are found near the summit. The color of their radially structured crystalline interiors is pale tan, but surface coatings on the masses can be white, red, or blue (Fig. 19). Prehnite surrounds prismatic epidote crystals and is in turn adorned by late chabazite and stilbite. The prehnite is translucent and can be polished to form unusual gemstones.

Pyrite FeS_2

Pyrite is widespread within 1 km of the northern intrusion. Most commonly it occurs as disseminated grains and replacement bodies in igneous and sedimentary rocks but it is also found along fractures and veins. Crystal size varies from tiny grains in shales and quartz-sericite altered rocks to crude cubes 6 cm on an edge in pyrrhotite hornfels. Cross and Shannon (1927) described the morphology of pyrite in the area, noting pyritohedrons, octahedrons and more complex forms.

Figure 20. **A 2.1-cm cuboctahedron of pyrite from an area about 200 m west of the Italian Mountain summit.**

Quartz SiO_2

Quartz is uncommon in the Italian Mountain area. Its most conspicuous occurrence is an orange jasper-like bodies in the Leadville limestone on American Flag Mountain. Rather than being massive this "jasper" is actually an aggregate of micro-crystals of orange quartz. White druzy quartz cements breccia at 1000 m south and 1300 to 1400 m east, and milky quartz forms veins in Precambrian rocks. Quartz is rare at the summit where it forms clear crystals 1–5 mm long associated with feldspars and epidote, and coarse crystals about 2 cm in diameter imbedded in rock at the igneous-sedimentary contact. Interfacial angles measures on crude crystals superficially resembling topaz indicated that they are actually distorted quartz crystals (Cross and Shannon, 1927). The chalcedony described, without optical data, by Cross and Shannon (1927) strongly resembles the prehnite mentioned above.

Scapolite Group $Na_4Al_3Si_9O_{24}Cl - Ca_4Al_6Si_6O_{24}(CO_3,SO_4)$

Scapolite-group species are concentrated along the contact of the northern stock with shales of the Belden formation about 300 m west of the summit. Here, intergrown white sheaves up to 10 cm long are associated with andradite and epidote and are described as *mizzonite* by Cross and Shannon (1927).

Scolecite $CaAl_2Si_3O_{10} \cdot 3H_2O$

Scolecite is a common zeolite at the summit of Italian Mountain where it occurs as tufts of acicular crystals about 3 mm long on earlier-formed silicates and, more commonly, as partly altered radial masses of crystals to 3 cm long (Fig. 21).

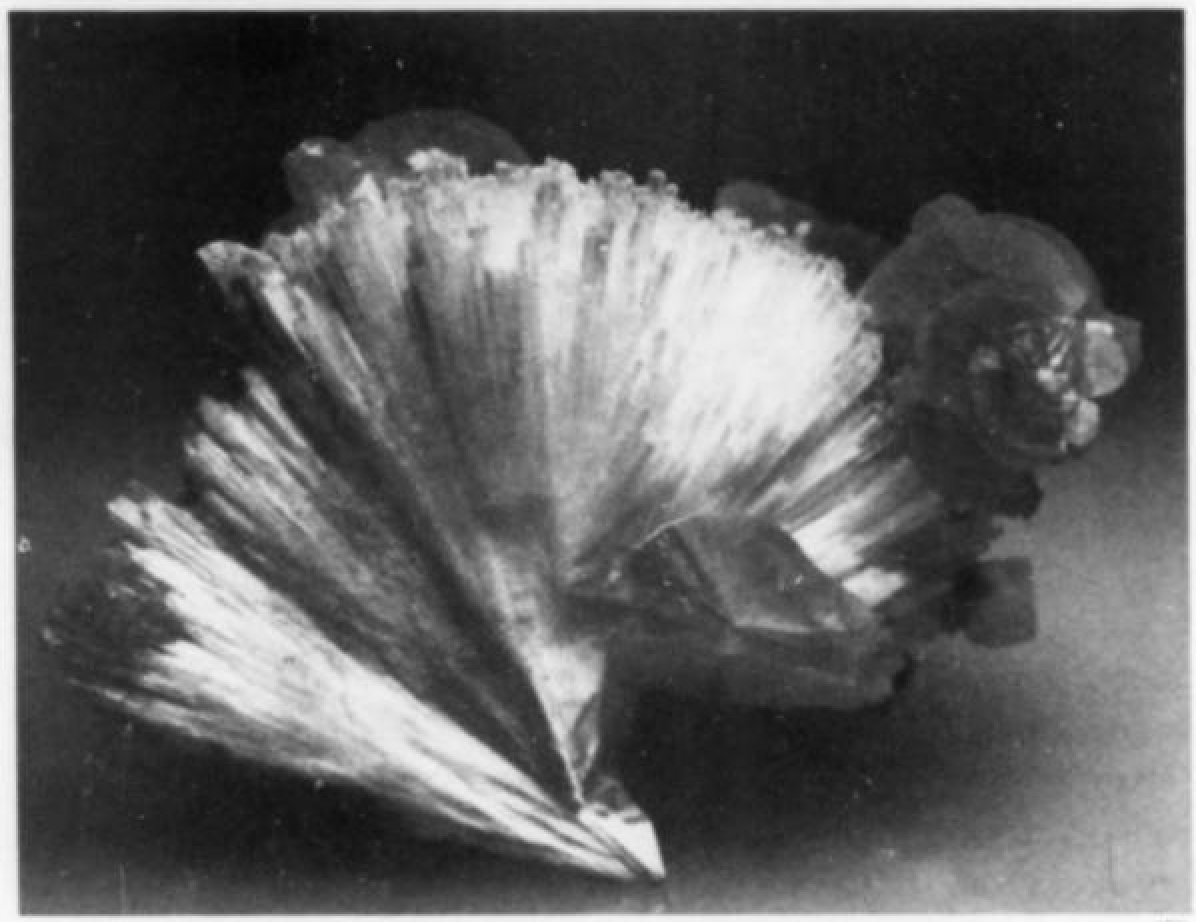

Figure 21. **Radial sheaf of scolecite crystals up to 2.6 cm in length, with earlier moderate greenish yellow prehnite.**

Sphalerite ZnS

Sphalerite is found in remnants of unoxidized ore at the Star and X-10-U-8 mines where it is yellow-brown, fine-grained and encloses occasional fragments of barite, pyrite or galena. Small amounts of sphalerite are associated with lapis lazuli at both deposits (Hogarth and Griffin, 1980). Sphalerite is a possible host for the 1000 ppm zinc contained in the pyrrhotite hornfels 200 m west of the summit. Bright orange grains about 0.1 mm in size found in fetid quartzite of the lower Belden formation at 600 m and north 1800 m east were determined to be sphalerite.

Stilbite $NaCa_2Al_5Si_{13}O_{36} \cdot 14H_2O$

Stilbite is the most common zeolite in the Italian Mountain area. By far the most abundant stilbite occurrence is in an area about 800 m in diameter, centered 500 m south of the summit. Here stilbite crystals fill fractures and cement breccia in small fault zones in the quartz diorite.

Titanite $CaTiSiO_5$

Titanite is fairly common in intrusive rocks and in skarns. Hogarth and Griffin (1980) recognized sphene from the Anderson prospect, and Cross and Shannon (1927) gave morphological data and illustrate twinned and untwinned titanite from the summit. There, titanite shows the typical envelope habit, with {111} and {001} dominant, and is commonly found perched on intergrowths of laumontite and epidote. The titanite content of the quartz monzonite porphyry increases from a trace to a conspicuous 2 percent at points along the contact of the intrusion and the sedimentary rocks.

Figure 22. **Pale greenish yellow vesuvianite on a fracture surface 5 cm across; from 100 m southeast of the summit.**

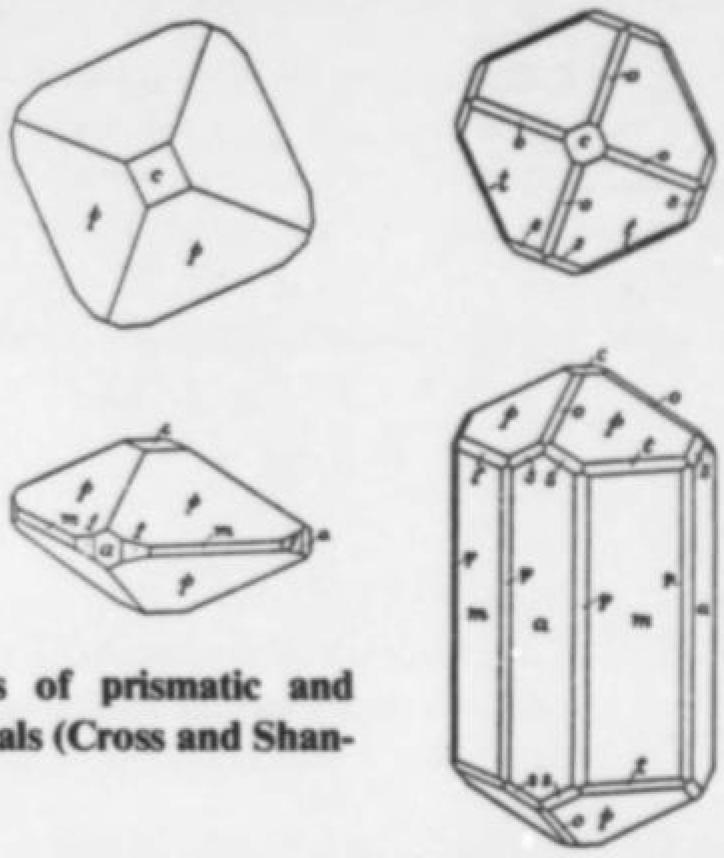

Figure 23. **Line drawings of prismatic and pyramidal vesuvianite crystals (Cross and Shannon, 1927).**

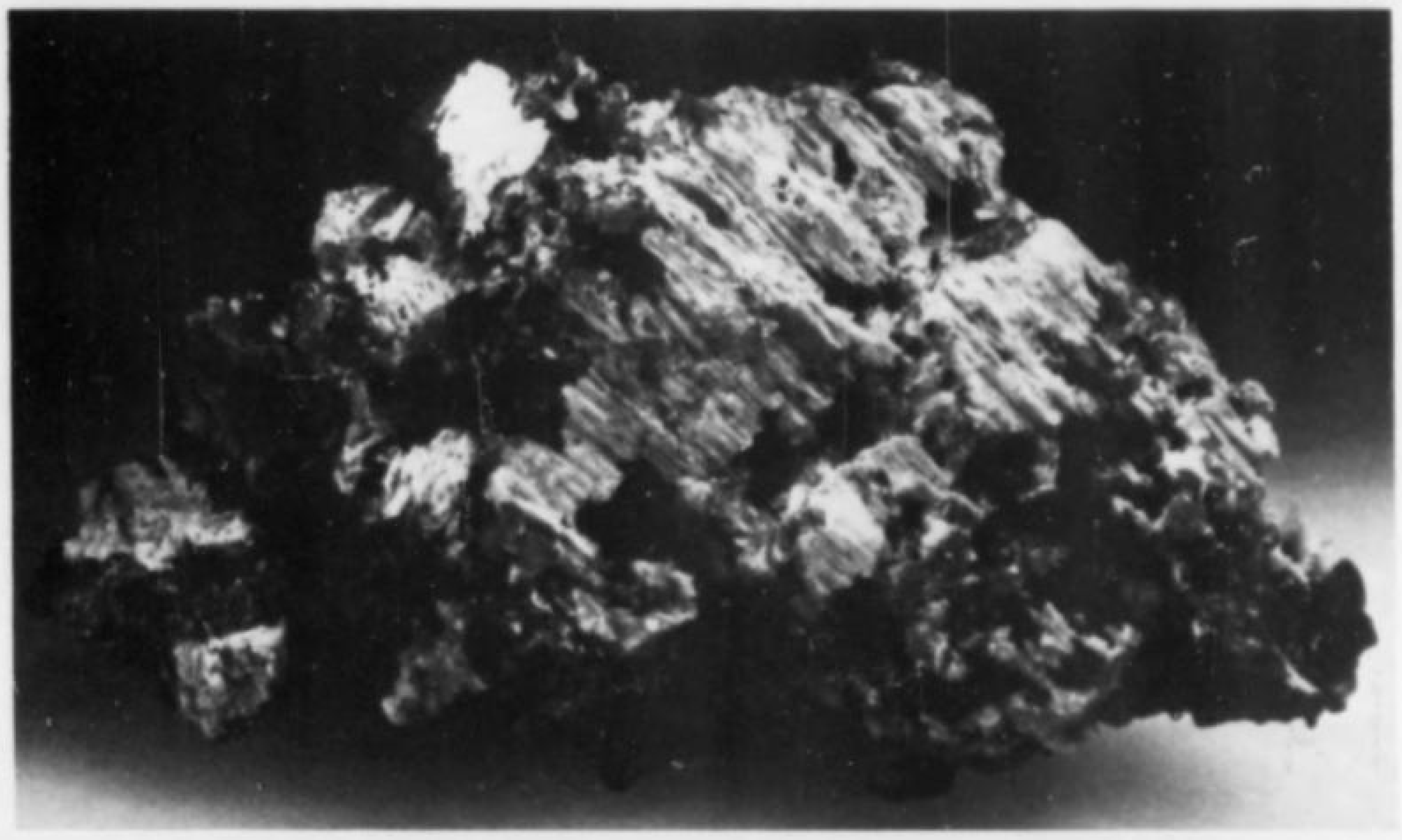

Figure 24. **Fibrous vesuvianite from the summit area. Field of photo is 3.5 cm wide; vesuvianite is grayish yellow.**

Figure 25. **Greenish amber-colored vesuvianite crystals to 9 mm with white stilbite and scolecite.**

Vesuvianite $Ca_{10}Mg_2Al_4(SiO_4)_5(Si_2O_7)_2(OH)_4$

Vesuvianite is limited in distribution to the skarns on Italian Mountain, North Italian Mountain, and at 850 m north and 450 m east. Vesuvianite is amber to green in color and can be found in any of half a dozen different habits. The most dramatic habit is the modified dipyramid {111} to prismatic {100} and {110} habit well illustrated (Fig. 23) by Cross and Shannon (1927). Blocky crystals of vesuvianite may reach 10 cm in length, but the sharpest and gemmiest crystals are about 1 cm in length. At places crystals of vesuvianite are partly corroded to masses of fibers (Fig. 24) with the fibers in optical continuity and aligned parallel to the *c*

Figure 26. **Superb greenish amber-colored vesuvianite crystals up to 2.3 cm across.**

Table 1. **Mineral species of the Italian Mountain area, Colorado. L = Lapis lazuli deposits, S = Skarns and metamorphic aureole, H = Hydrothermal replacement deposits, and I = Intrusive rocks. For more data on species without references see Truebe (1982). Species followed by an asterisk (*) have been identified using analytical techniques, the others by sight identification. Field terms are in quotation marks.**

Species		Description	Reference
Actinolite	I	See text	
	S	See text	
Alabandite*	L	In cores of pyrite grains	Hogarth and Griffin (1980)
Albite*	I	See text	
	S	See text	
Allanite	I	Micro crystal in vug	
Analcime*	S	In scapolite	Cross and Shannon (1927)
Andradite*	S	See text	
Anglesite	H	See text	
Ankerite	S	Saddle-shaped crystals in limestone	Cross and Shannon (1927)
Anorthite*	S	See text	
Apophyllite*	S	See text	
Azurite	H	With malachite at Star mine	
Barite	H	See text	
	?	See text	
Biotite*	S	Fine grained in Precambrian rocks	
	I	Secondary, near contacts	
Bornite	H	At "New Star" mine	Roy (1973)
Brucite*	S	With serpentine, etc. in marble	Finch (1967)
Calcite*	S	See text	
	H	See text	
Carbon	S	See text	
Cerussite	H	See text	
Chabasite*	S	See text	
Chalcopyrite*	H	Anhedral grains with pyrite	
	L	With pyrite	Hogarth and Griffin (1980)
"Chlorite"	S	Penninite and "iron-free" chlorite	Cross and Shannon (1927)
	L	Radiating groups	Hogarth and Griffin (1980)
Chrysocolla	H	Sky-blue glassy at X-10-U-8 mine	
"Clays"*	I	Mixed illite-montmorillonite in fractures	
	L	Saponite in vein-like aggregates	Hogarth and Griffin (1980)
	H	Alteration products of feldspars	
Clinozoisite*	S	See text	
Cordierite*	S	With diopside, plagioclase, etc.	Finch (1967)
Covellite	H	Reported at the Star mine	
Cyanotrichite*	H	Micro crystals in gossan	
Diopside*	S	See text	
Dolomite*	S	Forms dolomite marble	
Edenite*	S	Forms small body of edenite rock	
Epidote*	S	See text	
"Feldspar"	I	On fractures	Cross and Shannon (1927)
Fluorapatite*	S	Crystals to 6 mm with sahlite	Cross and Shannon (1927)
Fluorite*	I	Purple anhedral clots with biotite in Precambrian granite	
Forsterite*	L	Nearly pure	Hogarth and Griffin (1980)
	S	In rocks surrounding the northern stock	Finch (1967)
Galena	H	Anhedral clots with sphalerite and barite	
"Garnets"	I	See text	
Goslarite	H	Probable i.d. white powder	
Grossular*	S	See text	
Gypsum*	S	White crusts on oxidizing iron sulfides	
Halite	I	With sylvite, hematite, anhydrite, etc. in secondary fluid inclusions	Cunningham (1976)
Hematite*	H	Earthy in gossans	
	S	Specular with vesuvianite, thomsonite, etc.	Cross and Shannon (1927)
	I	With epidote on fractures in quartz diorite	
Hemimorphite	H	Micro crystals in gossans, Stewart mine	
Heulandite*	S	2-mm crystals with scapolite and andradite	
Hissingerite*	L	Concentric growths surrounding pyrite	Hogarth and Griffin (1980)
Hornblende*	I	Along walls of quartz monzonite dikes and fractures in quartz diorite	
Ice	S	Permafrost at high altitudes	
Labradorite*	S	In altered sedimentary rocks	Finch (1967)
Laumontite	S	See text	
Lazurite*	L	See text	
"Limonite"	S	From weathering iron sulfides	
	L	From weathering iron sulfides	
	H	From weathering iron sulfides	
Magnetite*	S	Small pods ‹ 10 metric tons, sharp crystals near summit	
	H	Replacing pyrite at Star mine	
Malachite	H	Most common copper-bearing mineral in gossans	
Massicot	H	Pulverent yellow lead oxide	
Microcline	S	See text	
Monticellite*	S	From Grossularite prospect	Finch (1967)
Opal	H	Cements breccia at 1000 m south, 1200 m east	
Orthoclase*	S	Replacing anorthite, associated with epidote, titanite and pyrite	Cross and Shannon (1927)
Pargasite*	S	See text	
Phlogopite*	S	In fractures in dolostone near northern stock	
	L	Subhedral crystals with up to 13.5 percent barium	Hogarth and Griffin (1980)
Plagioclase		See plagioclase series members	
Prehnite*	S	See text	
Pyrite*	H	See text	
	S	See text	
	L	See text	

Pyrrhotite*	S	Up to 40 percent of rock at contact with quartz diorite	
	L	In equilibrium with pyrite	Hogarth and Griffin (1980)
Quartz	H	See text	
	S	See text	
	I	See text	
Rhodonite	L	Small pink mass in Belden formation hornfels	
Schorl	S	Small radial cluster with epidote on fracture	
Sanidine*	S	Fine grained in hornfels	Finch (1967)
Scapolite*	S	See text	
Scolecite*	S	See text	
"Sericite"	I	Vent facies of northern stock	Cunningham (1976)
	H	Occasionally quite abundant	
	S	Late alteration product	
Serpentine*	S	Replaces chert in dolostone	
Siderite	?	Overgrown by calcite	Cross and Shannon (1927)
Silver	H	In oxidized ore at Star mine	
Smithsonite*	H	Dull white encrustations in gossan	
Sphalerite*	H	See text	
	S	See text	
	L	See text	
Spinel*	S	Rounded dark green octahedra in marble	
Stilbite*	S	See text	
Talc	S	In cavities in magnetite	Cross and Shannon (1927)
Thomsonite*	L	Alteration product of lazurite	Hogarth and Griffin (1980)
	I	In vein in altered diorite	Cross and Shannon (1927)
Titanite*	S	See text	
	I	See text	
Tremolite*	S	Metamorphic facies surrounding northern stock	Roy (1973)
Vesuvianite*	S	See text	
"Wad"	S	Widespread dendrites and earthy	
Unidentified	S	See text	

crystallographic axis of the original vesuvianite crystal (Cross and Shannon, 1927). The fibers have been shown to be vesuvianite by X-ray diffraction (Finch, 1967). Vesuvianite comprises about 2 percent of the summit skarn where individual masses of vesuvianite may be quite large, either replacing hornfels completely or forming 10 to 40-cm diameter spherical aggregates of 1 to 2-cm grains. Cross (1887) mentions vesuvianite in "branching forms" on North Italian Mountain. A 4-cm diameter "sunburst" found near 350 m south and 150 m east was determined to be vesuvianite (Truebe, 1982).

Unidentified

Parallel molds measuring 1 x 10 x > 5 mm were formed when an unidentified bladed mineral dissolved after having been enclosed in epidote.

ACKNOWLEDGMENTS

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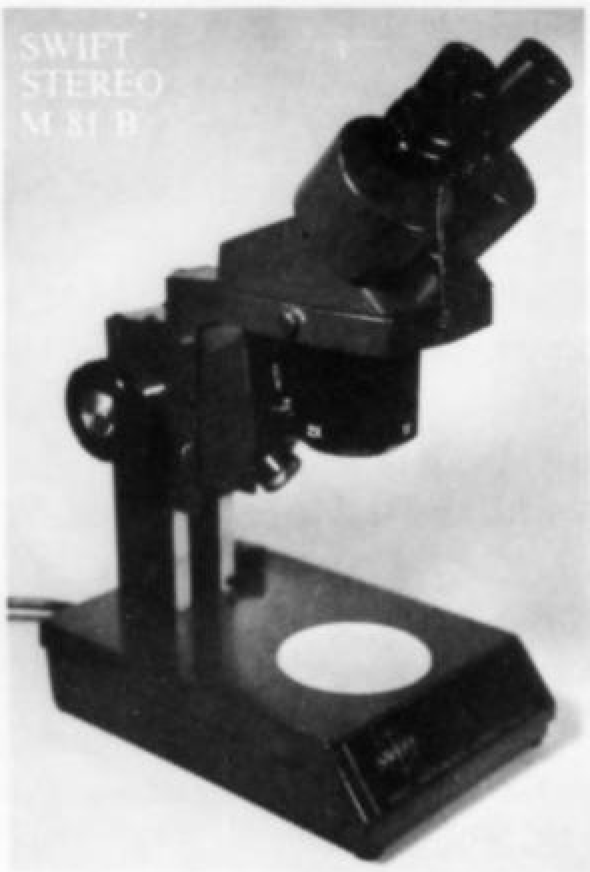

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mineral occurrences in Western Canada

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The ten western Canadian mineral localities described here have all yielded unusual species or euhedral crystals. Collectors who familiarize themselves with each site and allow sufficient collecting time will most likely be successful.

INTRODUCTION

Over the seven-year period during which I visited each of these ten mineral occurrences I encountered no difficulty in obtaining access to the properties and collecting specimens. However, potential visitors should bear in mind the often dynamic nature of mining claims (with respect to renewed mining and exploration) and their associated access roads. In each of the following descriptions the appropriate National Topographic Series index number has been included; these maps should always be consulted before a trip.

MENZIES BAY (92K/3)

This Vancouver Island locality is easily accessible from a road leading south from the Island highway. The road is 19 km north of the Island highway bridge on the north edge of the salmon fishing resort town of Campbell River.

The locality is of particular interest for the rare copper-vanadium minerals volborthite and calciovolborthite which occur as yellow and yellow-green crustings on interlava sedimentary rock. Volborthite [$Cu_3(VO_4)_2 \cdot 3H_2O$] forms an olive-green, smooth, waxy or fibrous crust associated with brochantite, langite, carbonate-cyanotrichite and malachite. The langite occurs in light to medium blue, scaly crusts and transparent to somewhat inky blue flakes. Azurite occurs as a bright blue vitreous crust and in terminated microcrystals within vugs. Chalcocite, connelite, cuprite and tenorite have been described from this locality as well. In light of the presence of numerous green minerals at Menzies Bay, hydrochloric acid is useful as a vanadium indicator in the yellow-green crusts. Exploration and development work at this deposit consist of several pits and open cuts. The area surrounding these excavations is covered with dense vegetation due to extensive rainfall on Vancouver Island. A map in a Geological Survey of Canada study by Rose (1973) outlines this unusual vanadium occurrence.

Two additional volborthite localities have been examined by the writer in the general vicinity. One of these occurrences is located on the island adjacent to Menzies Bay referred to as Quadra Island. Trenches which are northwest of the north tip of Gowland Harbor on Quadra contain a suite of vanadium minerals similar to the one documented at Menzies Bay.

MOUNT WASHINGTON COPPER MINE

(92F/14 and 92F/11)

This inactive open pit mine is located on the north side of Mount Washington approximately 24 km northwest of Courtenay on Vancouver Island. Check in at the Crown Zellerbach divisional office for logging road conditions and permission to use the road to the mine. There may be time restrictions or access limitations due to logging trucks using the road or the presence of forest fires in the area. For an exact position of the mine a map entitled *The Comox Valley and Forbidden Plateau,* published by D. Stastny and J. Boby, is recommended. Copies of this map are available in several sporting-goods stores in Courtenay where directions to the Crown Zellerbach office can be obtained as well. Several wash-outs were encountered on four-wheel drive roads up to the mine and, with a recent ski hill development on Mount Washington, alternate approaches to the mine via the ski resort may be more convenient.

Mount Washington is one of the few localities in the world at which the rare arsenic sulfide duranusite may be collected. Duranusite (As_4S) was first described by Johan *et al.* (1973) and was named after the type locality of Duranus, Alpes Maritimes, France. It is orthorhombic and occurs in minute grains associated with realgar and native arsenic at the type locality.

Duransite occurs as black, randomly oriented fibers or as wiry aggregates on quartz crystals. Duransite is found at the mine in one zone with realgar crystals, orpiment and stibnite. This mineralization is best exposed at the base of a cliff at the lower level of the open pit mine. In this zone native arsenic occurs in black sooty to sub-metallic patches on quartz. Scorodite forms greenish to gray-white crusts along with arsenolite as a grayish white powder on arsenic. Goethite occurs as brown aggregates in quartz. I collected

Figure 1. **Collecting sites in western Canada.**

attractive masses of bornite, chalcopyrite, covellite, molybdenite and well-terminated quartz crystals from the dumps. Sharp euhedral cubes and octahedrons of pyrite to 1.5 cm were also found in the dumps. Arsenopyrite occurs in sharp prismatic crystals to 5 mm. Marcasite, chalcocite, chalcostibite, wehrlite, tetrahedrite, pyrrhotite, sphalerite, magnetite, galena, malachite, hessite and native gold have also been reported from the Mount Washington copper mine in minor quantities (Carson, 1960, 1968).

The Mount Washington copper mine is also the type locality for pararealgar, a polymorph of realgar (Roberts *et al.,* 1980).

GLACIER GULCH SOUTH SIDE GROUP (93L/14W)

This inactive gold mine is located on the east slope of Hudson Bay Mountain 8 km northwest of Smithers, British Columbia. The Glacier Gulch bismuth telluride locality has been described by Scott (1971). The following supplementary directions to this locality should make access easier. Driving west on Highway 16 take a left-hand turn on to Lake Kathlyn Road. Follow the signs to Twin Falls over the railway tracks and park at the Glacier Gulch campground. Take a trail near the old abandoned mine workings (Glacier Gulch North Side group) marked by a red and white sign "To Glacier." The trail climbs sharply and the surrounding area is heavily overgrown with vegetation. On my last visit to this locality, the bismuth telluride occurrence had been marked by another sign along the trail, "Mine Shafts," en route to the Lake Kathlyn Glacier. The old molybdenum base camp situated at the base of the Lake Kathlyn Glacier is a considerable distance past the bismuth telluride occurrence along the trail.

The workings at the Glacier Gulch South Side group do not cover an extensive area. Unusual gold-bismuth mineralization occurs along altered and sheared zones in fine crystalline tuffs and is limited to a small area 46 m long and 23 m high. Most of the specimens I collected consist of bismuthinite in platy crystals less than 5 mm. One particularly attractive sample found, now preserved in the Glenbow mineral reference collection, contains blebs of native gold associated with tellurides. Joseite-alpha, joseite-beta, native bismuth, tetradymite and hessite have been described from this deposit (Scott, 1971). Most of the specimens I found were collected from a dump immediately below the workings and aerial tramway.

ROCHER DEBOULE MINE (93M/4E)

This inactive copper-cobalt underground mine is located on Roucher Deboule Mountain near Hazelton, British Columbia. A road leads north from Skeena Crossing Station on Highway 16 to the head of Juniper Creek, a distance of about 13 km. A four-wheel drive vehicle is essential due to wash-outs in the last 5 km of the road. At 1067 m elevation, follow the left fork in the road to reach the Rocher Deboule mine. Several buildings are still intact adjacent to the mill site. The ore dumps cover an extensive area and continue to the upper adits which are much higher in elevation on the mountain. This copper deposit is situated on the west contact of grandiorite which comprises the core of Rocher Deboule Mountain. The mine workings intersect four well-defined veins.

Two minerals of interest collected on the dumps are cobaltite crystals and posnjakite, $[Cu_4(SO_4)(OH)_6 \cdot H_2O]$. Cobaltite occurs in sharp, metallic, octahedral crystals to 1 cm associated with molybdenite. Posnjakite occurs as a blue patchy crust on quartz

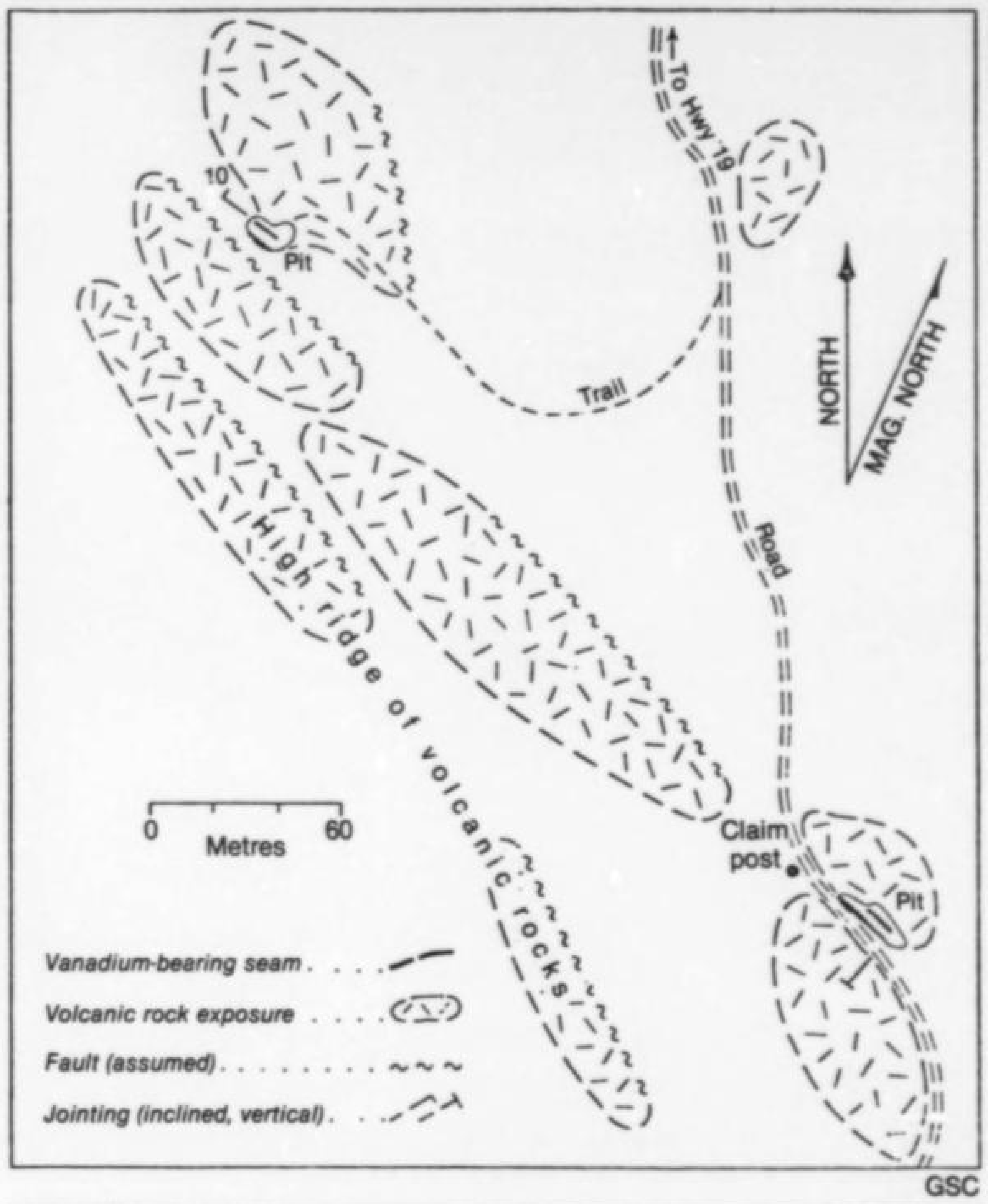

Figure 2. **Menzies Bay vanadium occurrences, south location (from Rose, 1973).**

Figure 3. **Yellow-green to bluish green volborthite crusts on matrix 8 cm across from Menzies Bay. Glenbow Museum specimen and photo.**

Figure 4. **Rocher Deboule mine buildings immediately below the dumps. Lyle Hartwig photo.**

associated with grayish black tetrahedrite. Arsenopyrite, brochantite, chalcopyrite, malachite, sphalerite and tennantite were also quite common on the dumps. In addition, a number of attractive specimens containing blebs and crusts of erythrite and large attractive masses of bornite were found. A geologist examining the Rocher Deboule mine on behalf of the Geological Survey of Canada reported smaltite-chloanthite, glaucodot, some complex cobalt-nickel sulfarsenides and euhedral crystals of white scheelite to 5 cm in diameter (Kindle, 1954).

BETTY GROUP (104 A/4E)

The Betty group consists of 6 reverted Crown Grant claims on which initial exploration and development was carried out during the 1920's. High silver values occur on the property in lenses of quartzose rock. The claims are located 6.4 km north of Divide Lake on the southern edge of Betty Glacier. A poorly maintained trail leads north from the Big Missouri mine road to the Spider claims which are located at the northeast end of Long Lake. From Long Lake a series of creeks and small lakes extend north through alpine meadows to the Betty claims. Due to extensive snowfall, access to the claims is limited to July and August. This silver selenide deposit is situated in the Middle to Upper Jurassic Bowser assemblage of rocks.

Work completed on the property consists of one short tunnel, two pits, an open cut, and an inclined shaft. The adit is still intact with an assortment of hand tools piled in a wheelbarrow at the entrance. The mineral naumannite (Ag_2Se) forms black sooty to dull powdery masses associated with quartz crystals in the workings. Galena in gray metallic cubes, pyrite and light yellowish to brown sphalerite are the sulfides associated with naumannite. Secondary minerals collected from the Betty claims include linarite, brochantite, hydrozincite, cerussite, malachite and goethite.

WILLETT MINE (82K/2)

A winding road on the west side of Highway 31 ascends a hill 0.5 km south of Lardeau. Follow this road for 0.8 km past a log shelter to the collecting area, the Willett mine, which consists of an open

Figure 5. **Area of the Betty group claims in late June. Photo by the author.**

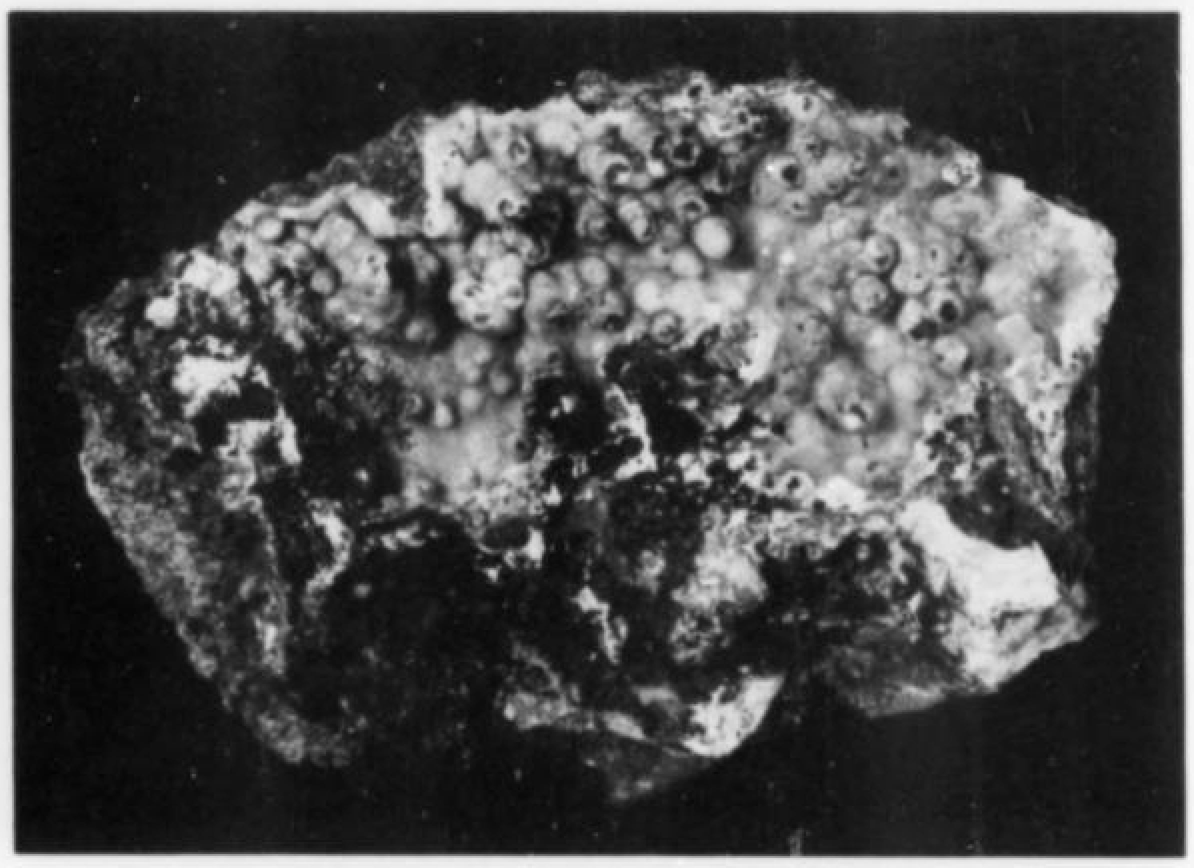

Figure 6. **Gray woodruffite, gunningite and smithsonite on matrix 14 cm across from the Willett mine. Glenbow Museum specimen and photo.**

stope. During visits to this locality in 1977 and 1978, automobiles were driven to a clearing immediately below the mine workings. The road is overgrown with vegetation in some areas.

Minerals of particular interest at this silver-lead-zinc deposit include the unusual zinc-manganese hydroxide, woodruffite, and gunningite, $(Zn,Mn)SO_4 \cdot H_2O$ (Sabina, 1978). The black woodruffite occurs in stalactitic, botryoidal and fibrous radiating smithsonite where it forms thin concentric layers and spheres. Gunningite, which is frequently associated with woodruffite, forms cream to white crumbly aggregates and crusts. Most of the smithsonite is grayish blue, however dark green, white an black specimens were also collected. Aurichalcite in light blue flaky aggregates and encrustations on limonite and smithsonite was also obtained. Kaolinite, hydrozincite, galena, sphalerite and goethite have also been identified from the specimens extracted in the heavily oxidized limonite zones within the stope. The hydrozincite, which forms a white powder and exhibits pale blue fluorescence under shortwave ultraviolet light, can be distinguished from gunningite with the use of hydrochloric acid. Caution must be exercised when collecting around the stope and adit to avoid falling rock.

SPATSUM CLAIM (921/11)

The Spatsum claim is located 18.3 km south of Ashcroft Manor on the Trans Canada Highway (Number 1), south of Cache Creek, British Columbia. The property is 0.8 km west of Highway 1 opposite the Highland Valley Pumping Station, and north of Spences Bridge. Copiapite, coquimbite, halotrichite, roemerite, rozenite, brochantite, chalcoalumite, hexahydrite, sericite and gypsum (variety *selenite*) were collected from one short adit and surface exposures in the immediate vicinity. Collectors should be aware of several of the efflorescent iron sulfates available from this deposit. The sulfate colors and frequencies of occurrence are as follows:

Copiapite: yellow, crystalline, quite abundant
Coquimbite: mauve, crystalline, rare
Halotrichite: white fibrous aggregate, quite abundant
Roemerite: reddish orange aggregate
Rozenite: dull white nodules
Brochantite: bright green crust grading to blue-green
Chalcoalumite: light blue botryoidal crust
Hexahydrite: amber, waxy, associated with rozenite

Due to searing heat during the summer months this occurrence is best visited during the fall and spring. Rattlesnakes have been reported in the general vicinity.

YELLOW LAKE (82/E)

This locality covers a highway roadcut and the hills surrounding Yellow Lake, British Columbia. The mineral deposit is located on

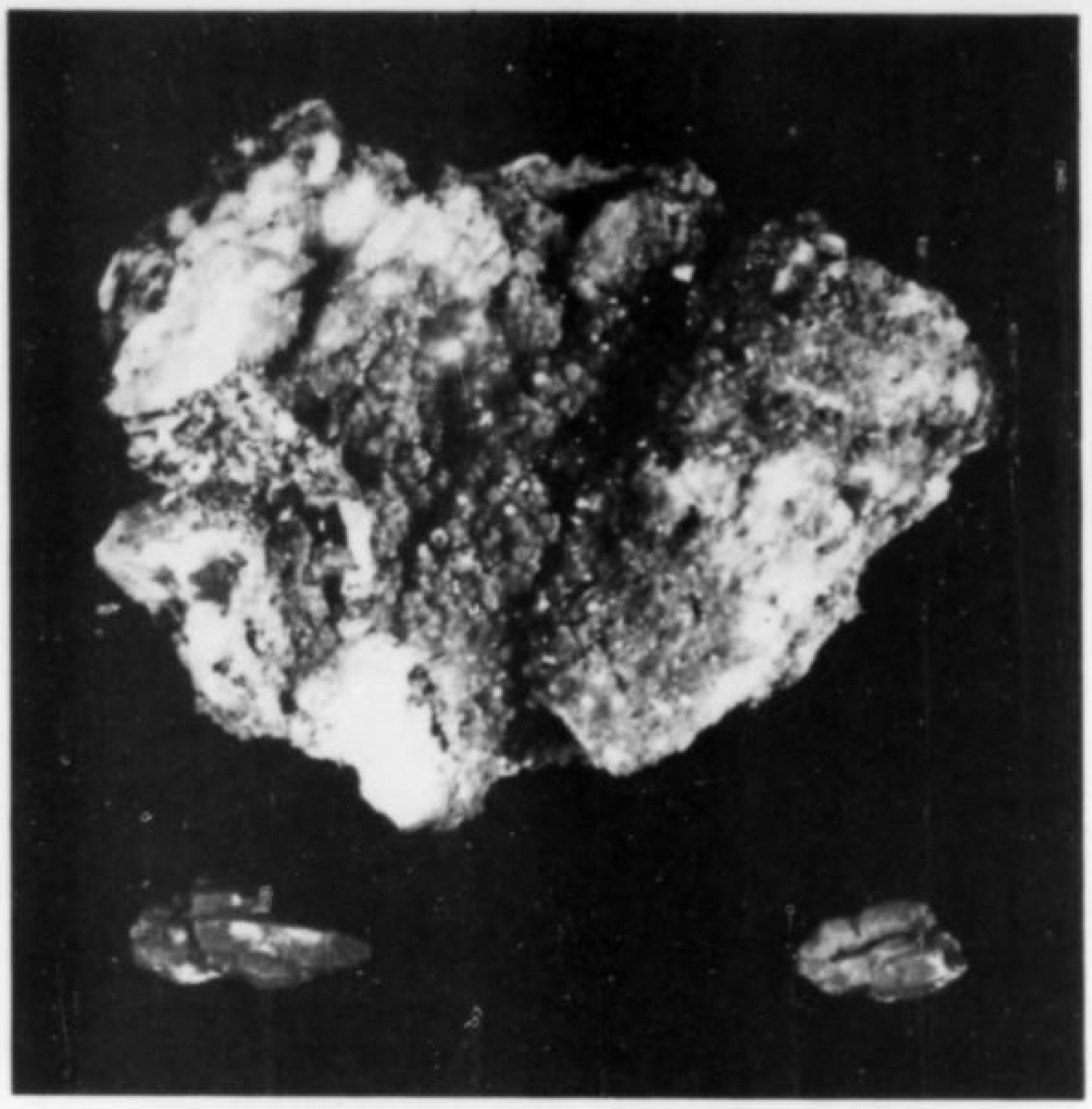

Figure 7. **Apple-green pyromorphite crystals on snow-white barite matrix 9 cm across from the Society Girl mine. Glenbow Museum specimen and photo.**

the Hope-Princeton Highway, Number 3A, near Olalla. Brewsterite occurs in a roadcut 1 km west of the Yellow Lake Pumping Station. On at least one occasion the Royal Canadian Mounted Police requested that a large group of collectors vacate the roadcut to prevent rock from pocket excavations falling onto the highway. Collecting efforts should be directed toward the hills above the roadcut at a reasonable distance from the highway.

The quality and size of brewsterite crystals at Yellow Lake rival the classic Scottish locality. Brewsterite, [$(Sr,Ba,Ca)Al_2Si_6O_{16}\cdot 5H_2O$], occurs as transparent and translucent, stubby prismatic crystals associated with analcime, scolecite and thomsonite. Thomsonite forms chisel-shaped, thin bladed crystals in pinkish sprays in vesicles and veins in the Tertiary volcanics surrounding Yellow Lake. According to Wise and Tschernich (1978): "Thomsonite forms stout to elongate pseudotetragonal prismatic crystals. These crystals have grown in flattened vesicles in porphyritic trachyte flows. The thomsonite is characterized by a large number of different crystal forms. The Yellow Lake thomsonite is associated with brewsterite, mesolite, calcite and analcime and has formed crystals ranging in width from about 0.5 mm to several millimeters." The size of the euhedral brewsterite crystals I have obtained varies from 1 mm to 5 mm. Aggregates of these crystals in matrix specimens larger than 5 x 17 cm are rare. Laumontite was also identified in specimens collected in pockets within the hard, dull gray rock.

SOCIETY GIRL MINE (82G/5)

The Society Girl Crown Grant claim on which most of the development work has been concentrated is reached by an old road from Moyie, British Columbia. This mine is difficult to locate due to its proximity to the large lead-zinc producer, the St. Eugene mine. Due to the elevation of this property at 1525 m near the headwaters of Farrell Creek, the property is usually only accessible from late June through August. The condition of the road requires the use of a four-wheel drive vehicle unless a good stiff hike is preferred. The main difficulty in locating the Society Girl is in distinguishing its small dump from those of the nearby St. Eugene. Disregard the locality map for the Society Girl mine in Geological Survey of Canada Miscellaneous Report 8, as the collecting locality outlined on the map is not positioned correctly.

This mineral occurrence has produced Canada's finest pyromorphite crystals. Excellent quality, bright green, barrel-shaped crystals have been collected from this property for many years since the original mining efforts for high grade lead-silver ore in the early 1900's (Nutt, 1977). Single crystals to 5 cm have been collected and fine matrix specimens 10 x 18 cm have been found at this mineral deposit in the last decade. However, due to extensive screening efforts directed toward the dump, single crystals to 8 mm are far more common. Rarely 1–2 mm golden wulfenite plates can be found perched on pyromorphite specimens. In addition to high quality pyromorphite, terminated cerussite crystals are occasionally found. These transparent to white crystals are usually less than 1 cm in length.

A number of collectors have entered a shaft and adit on the property at considerable personal risk. After examining several specimens retrieved from this underground exploration it was concluded that such efforts proved rather fruitless and that the dump and ore bin remain the best potential collecting sites.

The Society Girl mine is interesting mineralogically, but those collectors hoping to acquire large numbers of quality pyromorphite specimens should be aware that previous visitors to the property have already removed the bulk of the collectible material. Nevertheless the locality holds considerable promise for any hard-working collector who will be content with a few colorful euhedral crystals or thumbnail-size specimens of pyromorphite.

CROWSNEST PASS (82G/9)

This locality is in a roadcut on the north side of Highway 3 just west of the Coleman town limits. Melanite garnets can be collected in the pink volcanic outcroppings on the right-hand side of the highway driving toward the British Columbia/Alberta border. Slow down when approaching the 1-km town limits sign as the locality is just past this sign. The locality is 1.2 km east of the Historic Sites and Monuments "Volcanic Rock" point of interest sign.

Sharp, black, dodecahedral crystals of melanite (a titanium-bearing variety of andradite) to 7 mm weather out of the pink alkaline Crowsnest Volcanics. The contrast of the black crystals on a pinkish or olive-green matrix provides attractive cabinet and thumbnail specimens; excellent single crystals for micromounts are also found. Several hundred meters west along the highway and on the south side toward the railway tracks orthoclase phenocrysts to 4 cm were observed in several boulders.

Flesh-colored analcime trapezohedrons to 1.3 cm were collected in a olive-green matrix. Sharp, black trapezohedrons 2.5 cm in diameter have been extracted from pockets in Crowsnest Pass as a result of pipeline and road construction excavations. Future investigation of the Crowsnest Volcanics should uncover additional euhedral analcime specimens. Sharp trapezohedrons from a gas pipeline quarry southwest of Coleman (15-6-8-4-W5) are preserved in the mineral collection at the Provincial Museum of Alberta, Edmonton.

ACKNOWLEDGMENTS

I am indebted to Ann Sabina of the Geological Survey of Canada, Ottawa, for many of the identifications. The efforts of M. S. Evick, Curator of the Glenbow Museum Mineralogy Department in providing valuable research assistance are greatly appreciated. I would like to take this opportunity to thank W. Espitalier, S. Baker, D. Rhodes, G. Kuhlein, L. Hartwig, G. Nutt, U. Matern and E. Macullo for field observations and additional reference samples which were utilized in this survey. Marion Strachan typed the manuscript.

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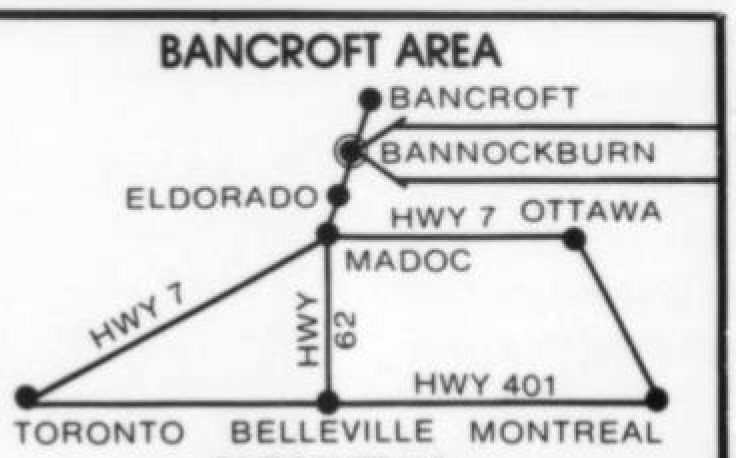

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minerals of the
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Occasionally museums receive suites of minerals from localities of which little is known, at least on the part of the recipients. Such was the case at the Smithsonian when Harold N. Taylor, of Indianapolis, Indiana, sent in about a dozen small samples of amygdaloidal basalt from the Puu o Ehu quarry, on the island of Oahu, Hawaii. Some of the fascinating crystals in these little amygdules defied immediate identification so an effort was made to X-ray all of those we could not readily identify. The identified specimens comprise an interesting addition to the National Collection, particularly in view of the paucity of minerals from Hawaii at the museum when these were received.

THE PUU O EHU QUARRY

The author has not visited the locality so no personal observations of it are possible in this note. Its location is precisely shown and detailed by Manhoff and Uyehara (1976) who note:

> "Zeolite site is on the north shore of Enchanted Lake (Kaelepulu Pond), and beside Keolu Drive. The south slope of Puu o Ehu (315 feet, 96 m) has been cut to obtain fills to create homesites in Kaelepulu Pond. The exposed bluff is the source of beautiful zeolites."

The site is on the northeast shore about 11 miles (directly) from Honolulu. An excellent map is provided on page 37.

THE MATRIX

The samples in the suite are all small, angular pieces of amygdaloidal basalt 3 cm or less in their greatest dimension. The round to ovoid cavities are relatively numerous with as many as ten appearing in one specimen. The rock is a reddish brown, hematitic-looking, dense basalt except for the amygdules.

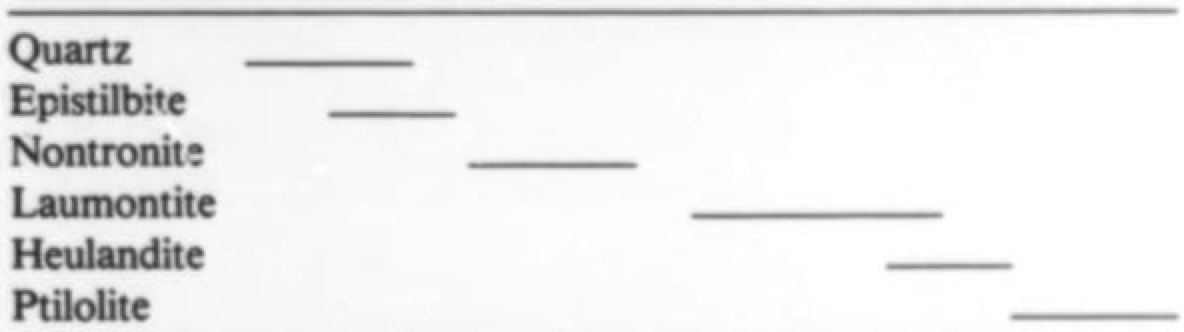
An early paper by Dunham (1933) described very similar material from the nearby Lanakai Hills as a "brown amygdaloid of exceedingly fine grain and aphanitic aspect, without phenocrysts. The microscope shows that it is non-porphyritic and almost cryptocrystalline." The rock described by Dunham and that which is the subject of this note are the same, a basalt known as the Lanakai lava.

A substantial proportion of the amygdules contain a thin internal "platform" of glassy chalcedonic quartz which is most often the color of caramel, but may grade into white layers that have a more sugary texture. Figure 1 shows one of the platform-containing amygdules. Many samples contain several such amygdules. The chalcedony layers are parallel, indicating that they all formed at the same time and suggesting that they must have been horizontal when that occurred. As they curve slightly from edge to center, it is tempting to assume that their original orientation was the same as that chosen for the illustration, but there is no strong evidence to support this assumption.

Following the formation of the platforms every amygdule appears to have experienced an episode of quartz crystallization, and many contain both quartz and epistilbite which grew in relatively large crystals at this stage. Following this, a thin layer of clay carpeted the inner surfaces of the amygdules with "delicate tufts of white needles" (Manhoff and Uyehara, 1976). The clay mineral in the specimens examined by the author is actually a cream to buff color, it is certainly not white. This is particularly apparent when contrasted with the pure white of some of the zeolite minerals which were subsequently deposited upon this druse.

The final phase of crystallization involved laumontite, heulandite and chabazite, and the deposition of tiny black specks of a chloritic mineral upon the clay. It is impossible to determine where in the latter sequence the black phase actually crystallized. Dunham (1933), based upon extensive observation of a collection made by A. S. Eakle from 1930 to 1932, and ultimately deposited at Harvard University, outlined the order of crystallization shown in Table 1.

Table 1. **Order of Deposition of Lanakai Minerals (Dunham, 1933)**



Quartz
Epistilbite
Nontronite
Laumontite
Heulandite
Ptilolite

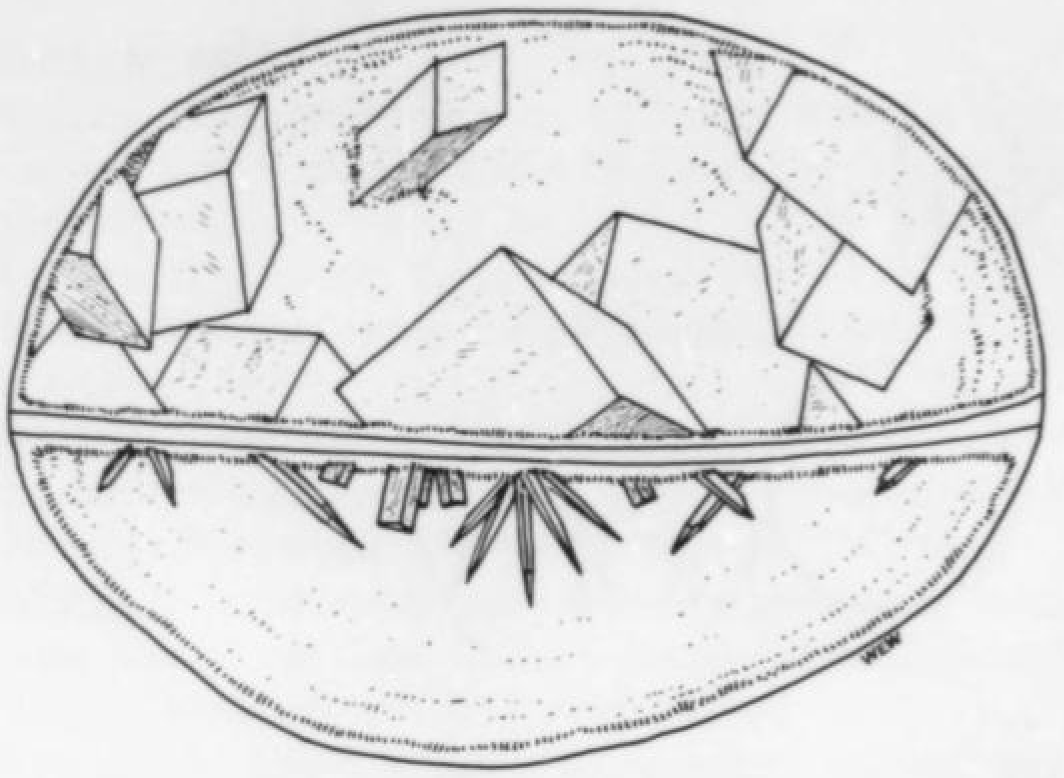


Figure 1. **A typical Puu o Ehu amygdule bisected by a thin chalcedony "platform." The space in the (presumably) above compartment contains large chabazite crystals on a druse of nontronite and quartz. The lower compartment contains epistilbite and larger quartz crystals on nontronite.**

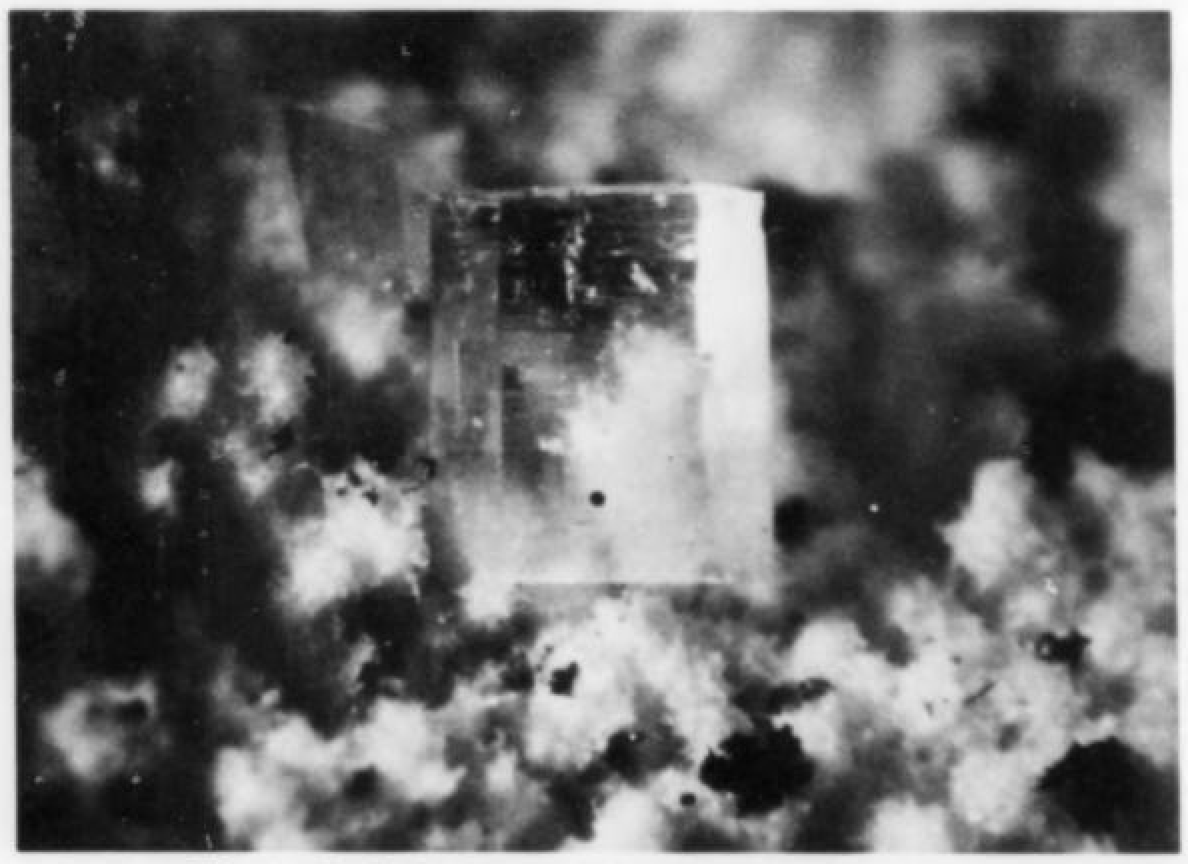


Figure 2. **Colorless heulandite crystal on nontronite and quartz druse with black clumps of chlorite.**

Figure 3. **Colorless epistilbite crystals with quartz.**

Figure 4. **Colorless epistilbite crystals thinly coated with hematite (?).**

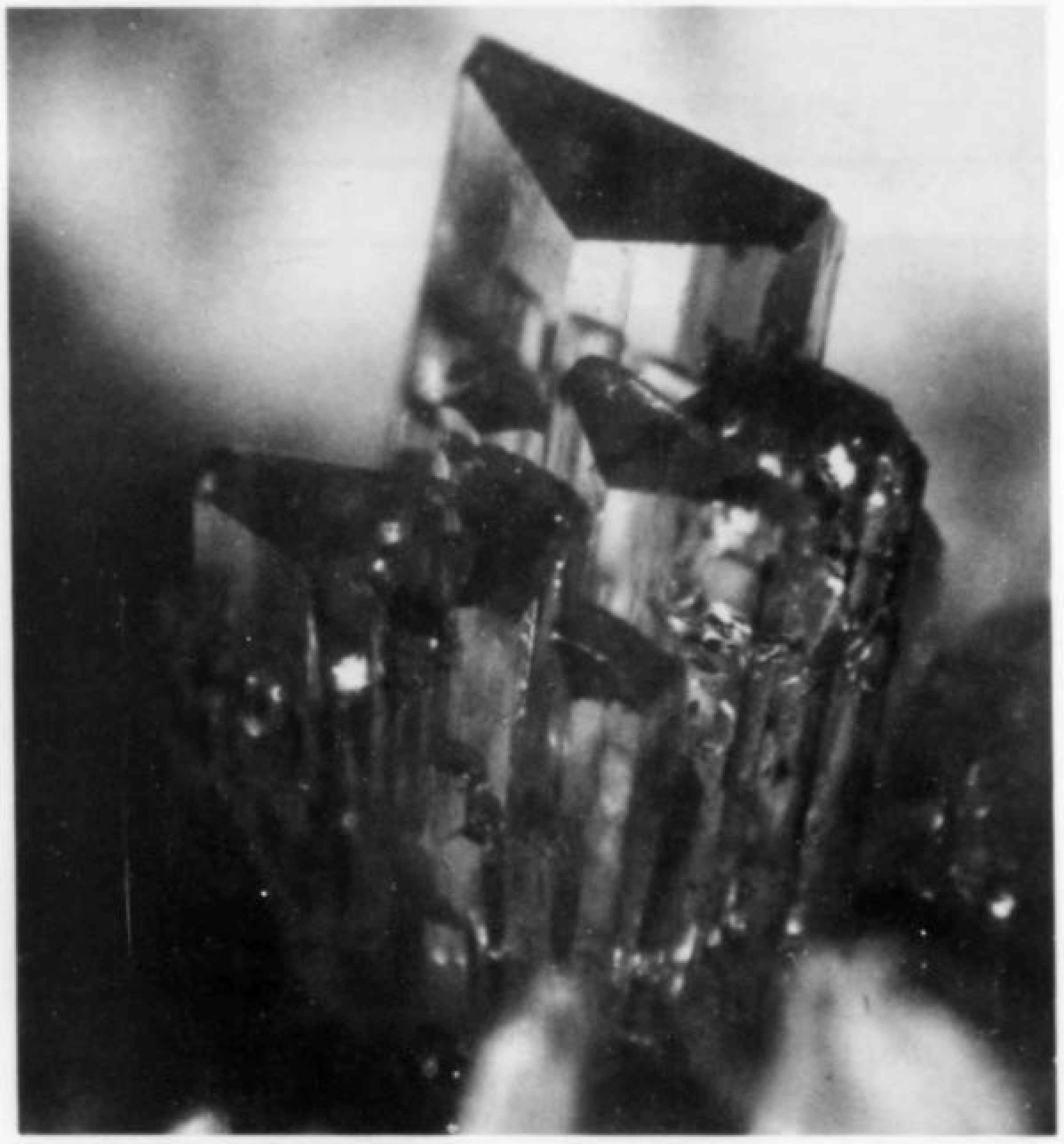


Figure 5. **Colorless epistilbite crystals.**

The observations of the author are essentially the same except that Dunham does not include chabazite, and "ptilolite" (now mordenite) was not observed in the specimens from Puu o Ehu. At Puu o Ehu chabazite is clearly later than the clay on at least one specimen.

An interesting characteristic of the platform-containing amygdules is that subsequent crystallization has resulted in the formation of different minerals on each side of the platform. Presuming the illustration is correctly oriented, the larger crystals are always on the top side. For the most part these are either chabazite or heulandite, sometimes both, and quartz may or may not be present. These minerals are rarely ever found in the bottom side cavity, but epistilbite and quartz are very common. The largest epistilbite crystals are found in the amygdules that are not subdivided in this way, and no laumontite has been observed in the divided amygdules.

Figure 6. **Colorless epistilbite and laumontite crystals, both coated by hematite (?).**

THE MINERALS

All of the minerals found in this material are, of course, micro size and among them are some superb micromount-quality crystals. The most exciting of the lot are the beautifully formed epistilbite groups attractively nestled within amygdules.

There are no chemical anomalies within the suite. All of the zeolites are essentially calcium and aluminum silicates.

Quartz

Observed in radiating clusters of tapering crystals attached to the walls of the amygdules. The crystals range from milky to colorless, and often show a steplike alteration between various steep rhombohedrons, which leads to the tapered shape.

Epistilbite

In crystals up to 3 mm, attached to amygdule walls and (usually) the underside of the platform. The crystals are colorless, transparent and form elongated tabular shapes, much resembling typical barite or celestite crystals.

Nontronite

The less than 1-mm-thick carpet of light-colored material coating the walls of the amygdules was X-rayed but the results are ambiguous, revealing only that it is a clay of the smectite group. As other authors (Manhoff and Uyehara, 1976; Dunham, 1933) refer to it as nontronite, the same designation is used here.

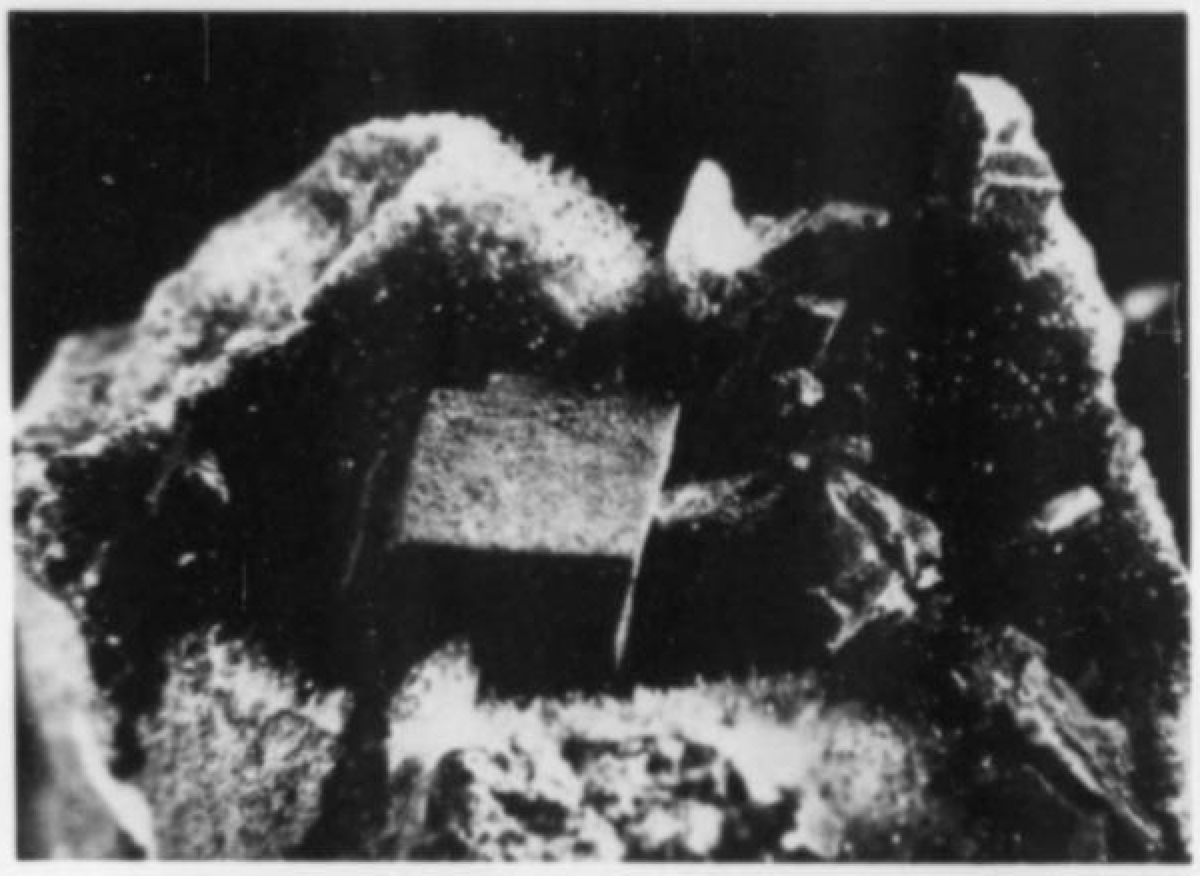


Figure 7. **Chabazite crystals thinly coated with hematite (?).**

Chabazite

Typical simple rhombic crystals, white in color, with characteristic undulatory patterns on the crystal faces. The crystals are as large as 2 mm in these samples.

Laumontite

This is one of the minerals that was X-rayed because the crystals which comprise the divergent sprays are much more acicular than laumontite usually is. The crystals are white in color, in delicate needles and after several years exposure to the atmosphere appear to be perfectly fresh and unaltered.

Heulandite

This mineral is also found in simple crystals, white to transparent, scattered over the nontronite druse. In some cases the crystals resemble rhombs, but most are more typically in the shape of an elongated diamond.

Hematite (?)

All of the crystals in several of the amygdules are coated with a very thin film having a dark hematitic red color.

ACKNOWLEDGMENTS

My thanks to Julius Weber for the excellent photographs.

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Kornerupine and Sapphirine

crystals from the harts range, central australia

Don McColl and **Gladys Warren**
Australian Mineral Development Laboratories
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Glenside, 5065, Australia

INTRODUCTION

North of Alice Springs in Central Australia, and extending across almost the full width of the state of Northern Territory, is a complex of Precambrian crystalline rocks known as the Arunta Inlier. It consists mainly of a varied sequence of schists and gneisses from 1,500 to 2,000 million years old. These outcrop on a discontinuous series of rugged and often spectacular mountain ranges in an arid, partially desert and peneplaned environment. One of the most striking is the Harts Range which is about 200 km northeast of Alice Springs and contains many small deposits of pegmatite and metamorphic minerals (McColl and Warren, 1980).

The first significant geological investigations in this area took place during World War II, when pegmatites were mined for muscovite mica. More detailed geological mapping is still continuing and, consequently, new discoveries of minerals occur from time to time.

The geological history of the Harts Range spans a long period of time and has involved at least two metamorphic epochs: an early high grade one followed by a second which was retrogressive. It is not surprising therefore that the region is becoming noted among Australian mineralogists as an exceptional source of crystallized silicates and other metamorphic minerals. Crystals of kornerupine [$Mg_3Al_6(Si,Al,B)_5O_{21}(OH)$] and sapphirine [$(Mg,Al)_8(Al,Si)_6O_{20}$] were found as detrital fragments by one of the authors (G.W.) during routine mapping in 1978. They were subsequently traced to an outcrop during the following field season (Fig. 1).

The locality is an area of low stony hills covered with the spiky spinifex bush, and is difficult of access even to four-wheel-drive vehicles. It is an almost climatic opposite to the kornerupine locality described by Petersen and Johnsen (1980) at Fiskenaesset in Greenland. The main field problems encountered in the Harts Range are heat, dust and flies.

GEOLOGY

Kornerupine and sapphirine were found together in a former granulite which is now of a more schistose texture, and consists of albite (Ab_{92}), phlogopite and biotite. Kornerupine is locally abundant, but sapphirine crystals are quite sparse. The kornerupine and sapphirine-bearing host rock is part of a lens about 10 x 50 meters in outcrop, composed of rocks containing cordierite, hypersthene, corundum, tourmaline, sillimanite and rutile. Grains of monazite have also been identified in some of these rocks, and a single fragment of geikelite was collected from surface gravel. The lens is enclosed within a sequence of biotite-quartz-feldspar gneisses, mafic granulite and cordierite-quartz-feldspar gneiss. Kornerupine and sapphirine are considered to be products of the first metamorphic epoch which was characterized by high temperature and moderate to high pressure which produced granulites. Subsequently pegmatites were introduced and hydrous alteration took place along localized shears developing minerals such as muscovite. Although such a shear passes close to the kornerupine-bearing lens, it was apparently only slightly affected.

***Figure 1.* Kornerupine crystals outcropping in the Harts Range, Northern Territory, Australia.**

The geological setting in which the lens occurs is believed to have originally been a mixture of siliceous volcanics, tuffs and basalts, with some thin layers of sediment. The lens itself is unusual, being rich in sodium, magnesium, aluminum and titanium, but poor in silica and lime. Boron is not particularly abundant. From the chemical composition and geological setting it is suggested that the lens was originally a soda-rich sediment deposited in a non-marine lagoon fed by hot volcanic springs. This may have resembled the playa lake deposits at Boron in California (Puffer, 1975) but with a lower borate content.

Another similar occurrence of kornerupine crystals has been

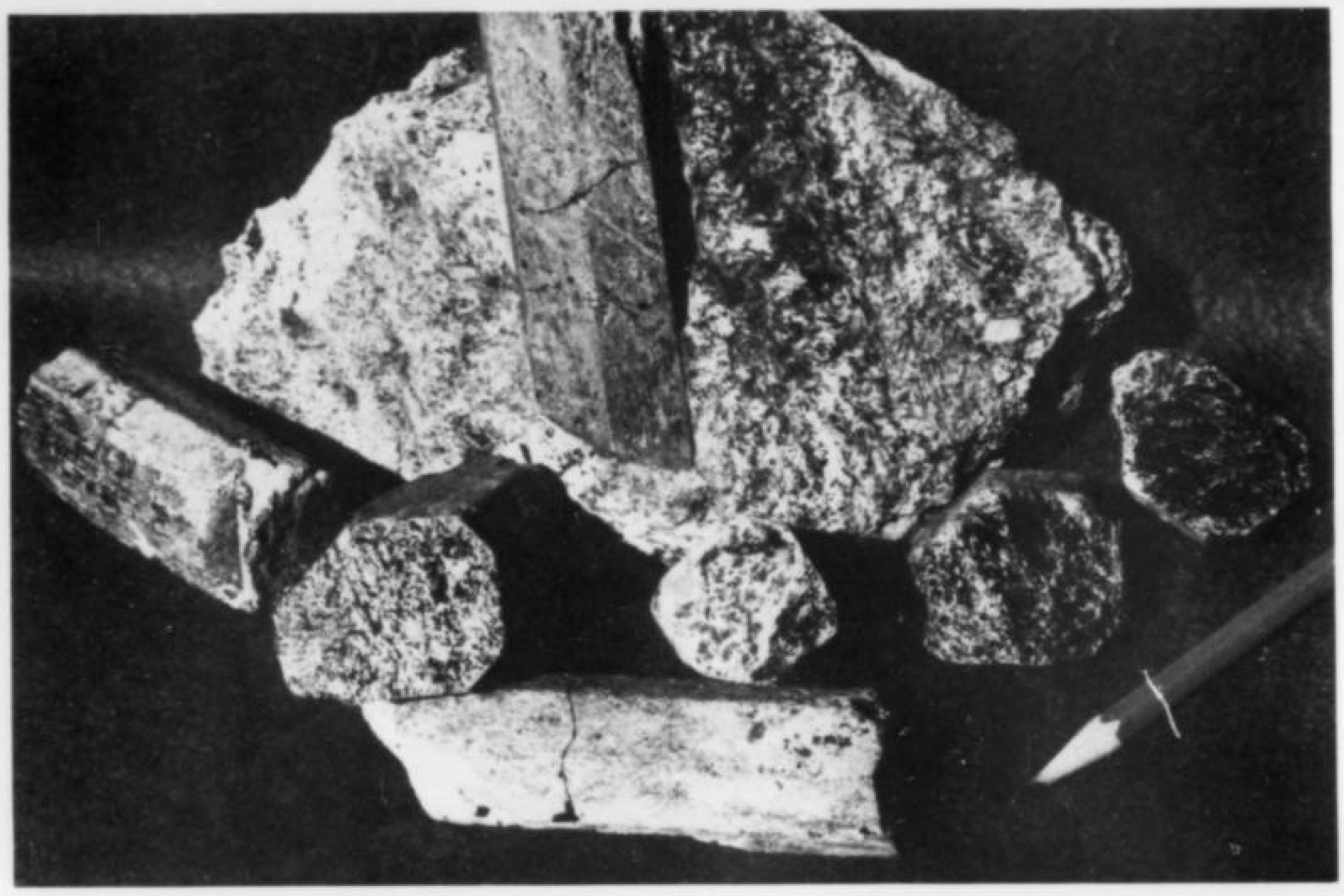


Figure 2. **Relatively large prisms of kornerupine from the Harts Range. The tendency to separate into short segments is pronounced.**

described (Wilson, 1978) from the eastern Strangways Range, about 60 km from this locality. It is in the same metamorphic complex but is considered to be in a stratigraphically higher, entirely sedimentary section.

KORNERUPINE

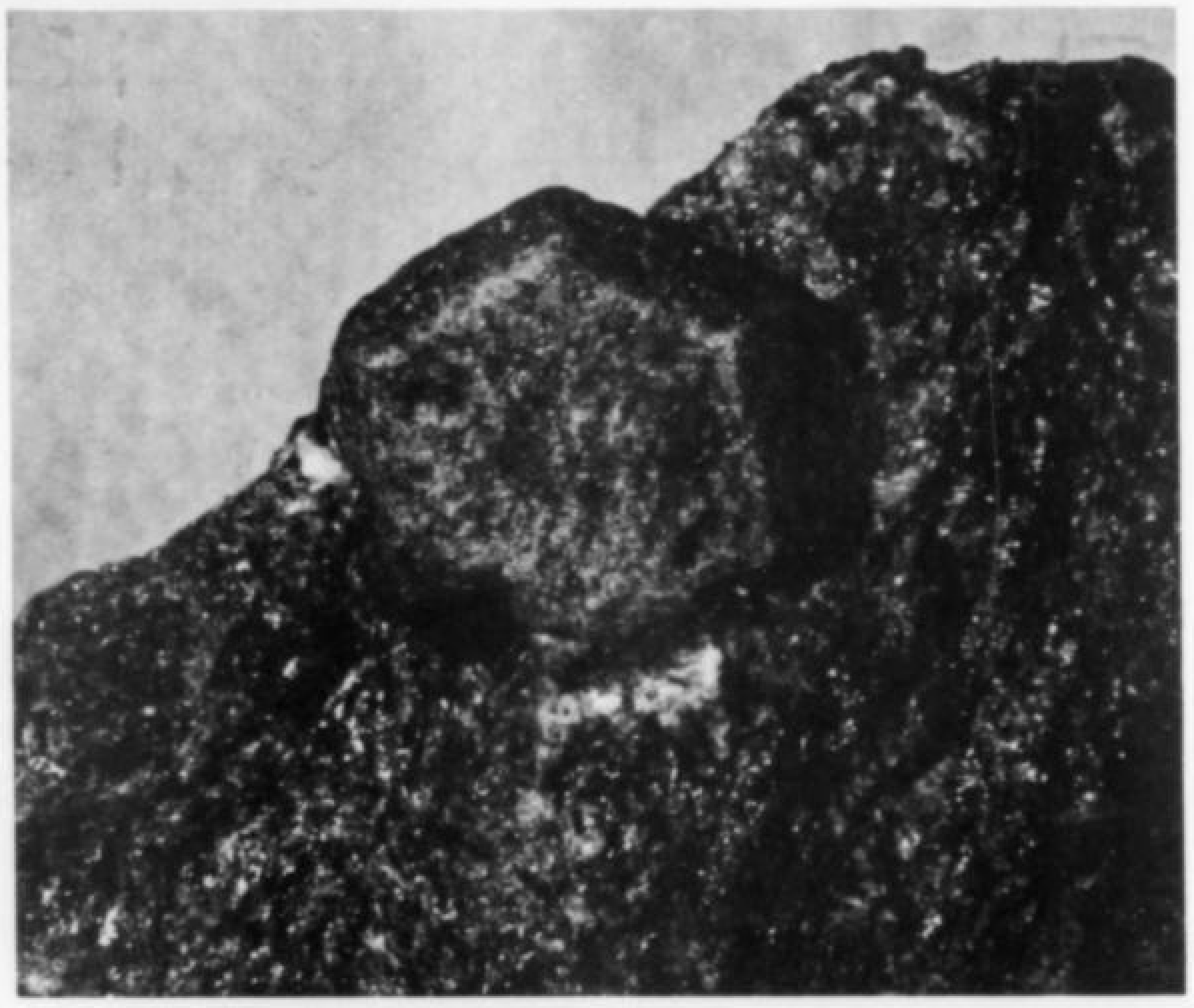
Kornerupine has formed very dark green, eight-sided prisms up to 20 cm long and 4 cm diameter, showing {110} as the most prominent prisms, with greater or lesser modification by {100} and {010}. At first sight the habit seems very similar to an unusually idiomorphic pyroxene.

All crystals show some degree of surface alteration, which ranges from a fraction of a millimeter up to 3 or 4 mm thick. This coating is principally a gray magnesian phlogopite which quite accurately duplicates the original external shape. This alteration has also invaded many transverse cracks and fractures so that the prisms have little longitudinal strength and tend to separate into short segments (Fig. 2).

Very few crystals show any meaningful indication of a termination, but some appear to have a pair of inclined surfaces which could be the dome {101}.

Figure 4. **Kornerupine crystal in feldspar enveloped in retrogressively altered granulite host rock from the Harts Range.**

Figure 3. **Sapphirine crystals from the Harts Range.**



Electron microprobe analyses indicate that many crystals have some degree of transverse compositional zoning and are richer in alumina around the margins and more magnesian in the core. Boron could not be directly observed by the microprobe but is also expected to be more abundant in the crystal cores. The first portions to form would presumably take up what little boron was available in the protolith.

SAPPHIRINE

Sapphirine crystals are very scarce by comparison with the kornerupine. They were only found in two layers about 10 cm thick, in close proximity to large, well formed kornerupine crystals. They were discovered during the process of breaking up specimen material. The sapphirine crystals are very much smaller; the largest found so far is a pseudo-hexagonal tabular plate about 20 mm in diameter and 5 mm thick (Fig. 3).

Like kornerupine, the sapphirine crystals have a surface coating, which in this case consists of a fine intergrowth of corundum, tourmaline and magnetite. The smaller crystals are commonly completely pseudomorphed, but several on cutting revealed a deep blue-black vitreous core of sapphirine. In thin section the sapphirine is strongly colored and vividly pleochroic from deep cobalt-blue to pale yellow. Optically it is biaxial with a small 2V (about 20°) and high dispersion. Much of the sapphirine shows three sets of fine, platy, opaque inclusions at 60°, which are possibly

Table 1. **Electron microprobe analyses of some crystals. Total iron expressed as FeO.**

	Kornerupine			Sapphirine	
	Edge	Core	Core		
SiO_2	29.93	29.78	29.87	13.09	13.06
TiO_2			0.13		
Al_2O_3	42.29	40.48	40.89	59.69	59.81
Cr_2O_3					0.15
FeO	8.29	8.27	8.27	10.04	10.23
MgO	15.29	16.52	16.53	17.05	16.53
Na_2O	0.45	0.28	0.32	0.21	0.34
Total	96.25	95.34	96.01	100.08	100.12

magnetite or hematite. Even the best of these crystals do not have clearly defined shapes; the pinacoid {010} is definitely present, and perhaps also the prisms {011}, {110} and {111}.

ACKNOWLEDGMENTS

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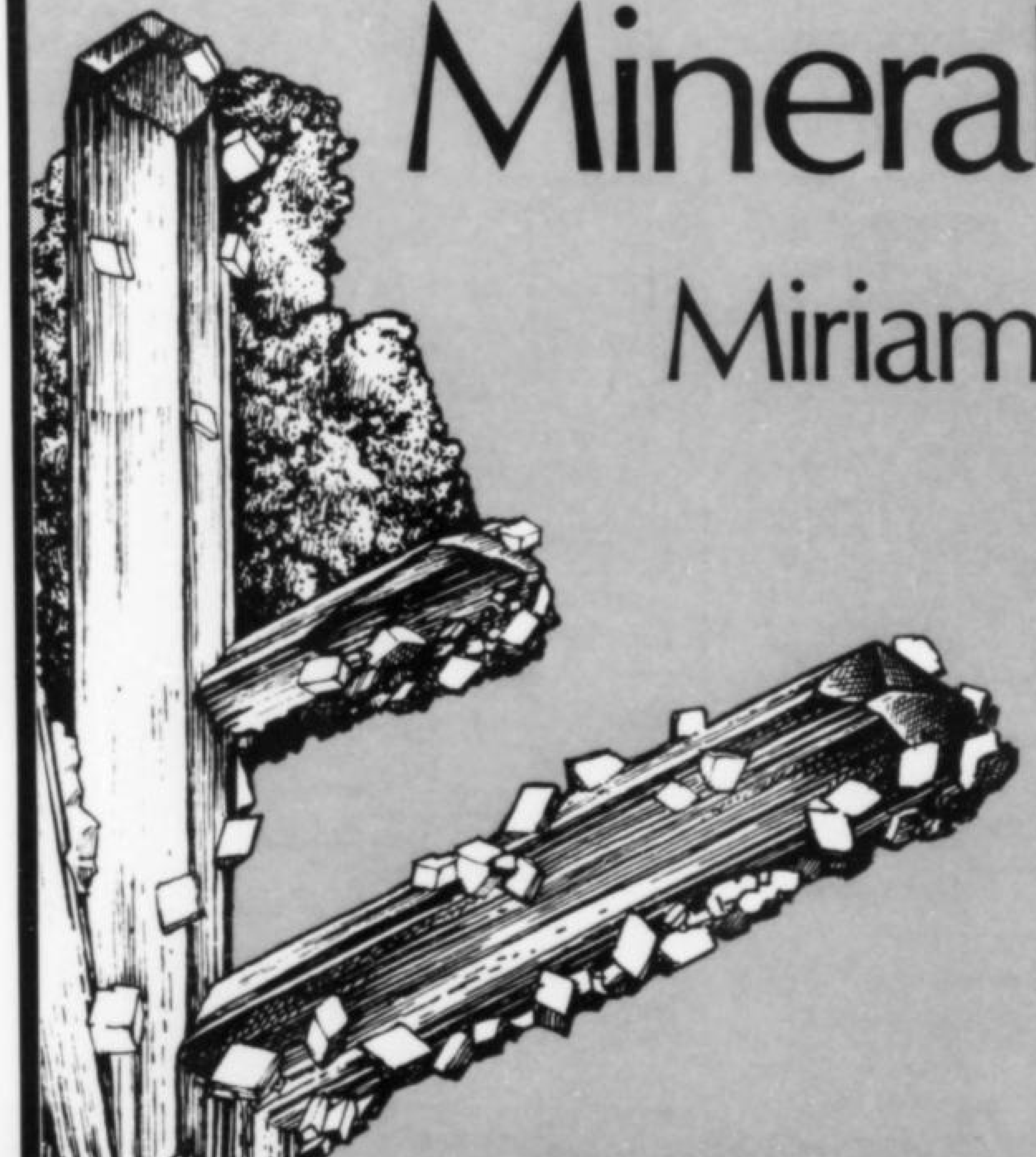


Cleaning Delicate Minerals

Mogens Hansen
Geological Museum
University of Copenhagen
Oster Voldgade 5-7
DK-1350 Copenhagen, Denmark

At the Geological Museum in Copenhagen we have for a rather long time been occupied with the cleaning of the white Ivigtut, Greenland, minerals (cryolite, thomsenolite, ralstonite, etc.) which often have a coating of yellow to dark brown limonite or iron oxide-hydroxides. These minerals do not tolerate the strong acids commonly used to dissolve the iron oxides. It was therefore important to find a more compatible cleaning solution.

We learned that in the Danish laboratories for petroleum prospecting a method for extracting iron oxides from powdered drill core samples is used which seemed very promising for our needs. The extraction solution is a buffer with a pH of 8 and containing 6.7 percent sodium dithionite, added in two increments at 75°C with a working time of 10 minutes. We tested this method on thomsenolite with a heavy yellow coating and the yellow color disappeared completeley. It left, however, a flat white surface which seemed to consist of very tiny crystals of thomsenolite. Apparently the yellow iron oxides had grown synchronously with a new layer of thomsenolite on the surface of the old larger crystals. So our job with cleaning the thomsenolite had not been fulfilled. We had not reached the primary thomsenolite but, nevertheless, we have a method for dissolving iron oxide coatings without disturbing the surface of a delicate mineral such as thomsenolite.

During the last two years we have tested this method on many different minerals. We have, however, been forced to modify the procedure somewhat, partly in order to avoid side reactions giving unpleasant sulfur-containing fumes during the work and partly because minerals containing heavy metals with dark sulfides (e.g. lead) could be contaminated on the crystal surface with a greyish coating (cerussite).

The method which we have used successfully for the last year is as follows:

1. The buffer solution is prepared first: 28 g ($NaHCO_3$ (sodium bicarbonate) and 59 g $(NaOOC)_3C_3H_4OH \cdot 2H_2O$ (sodium citrate) are dissolved in 1000 ml deionized (preferably tepid) water. When the solution is homogeneous, it is ready for the cleaning process.

2. The mineral is placed in a container (glass or plastic) of suitable size (a plastic bag may be used). Then as much buffer solution as is necessary for covering the mineral completely is added, taking care to note the volume used. For each 30 ml of buffer solution, 1 g sodium dithionite ($Na_2S_2O_4$) is sprinkled carefully over its surface. After five minutes another 1 g of sodium dithionite is added in the same way.

3. The mineral is left at ambient temperature for 24 hours, preferably under a lid. Occasional stirring is helpful. The next day the used solution is discarded (a normal sink may be used if the mineral is not too big, as the chemicals are not ecologically harmful after the reaction). The mineral is rinsed with a little buffer solution, whereafter it can be washed several times, perferably in an ultrasonic bath, the final wash in deionized water. After drying it will most often be found that the surface of the mineral is very much improved.

Irrelevant coatings on minerals very often contain at least small amounts of iron which will be dissolved by the chemical treatment, leaving a rather porous coating which may be easily removed during the ultrasonic treatment. This could explain the rather successful results we have obtained with many different minerals including quarts, calcite, fluorite, galena and barite. Even the surface of pyrite will usually become much most lustrous.

We are currently experimenting with marcasite in order to verify the impression we have that its decay may be arrested by this treatment. This may be due to the removal of the iron-containing coatings which may act as catalysts in the decay process.

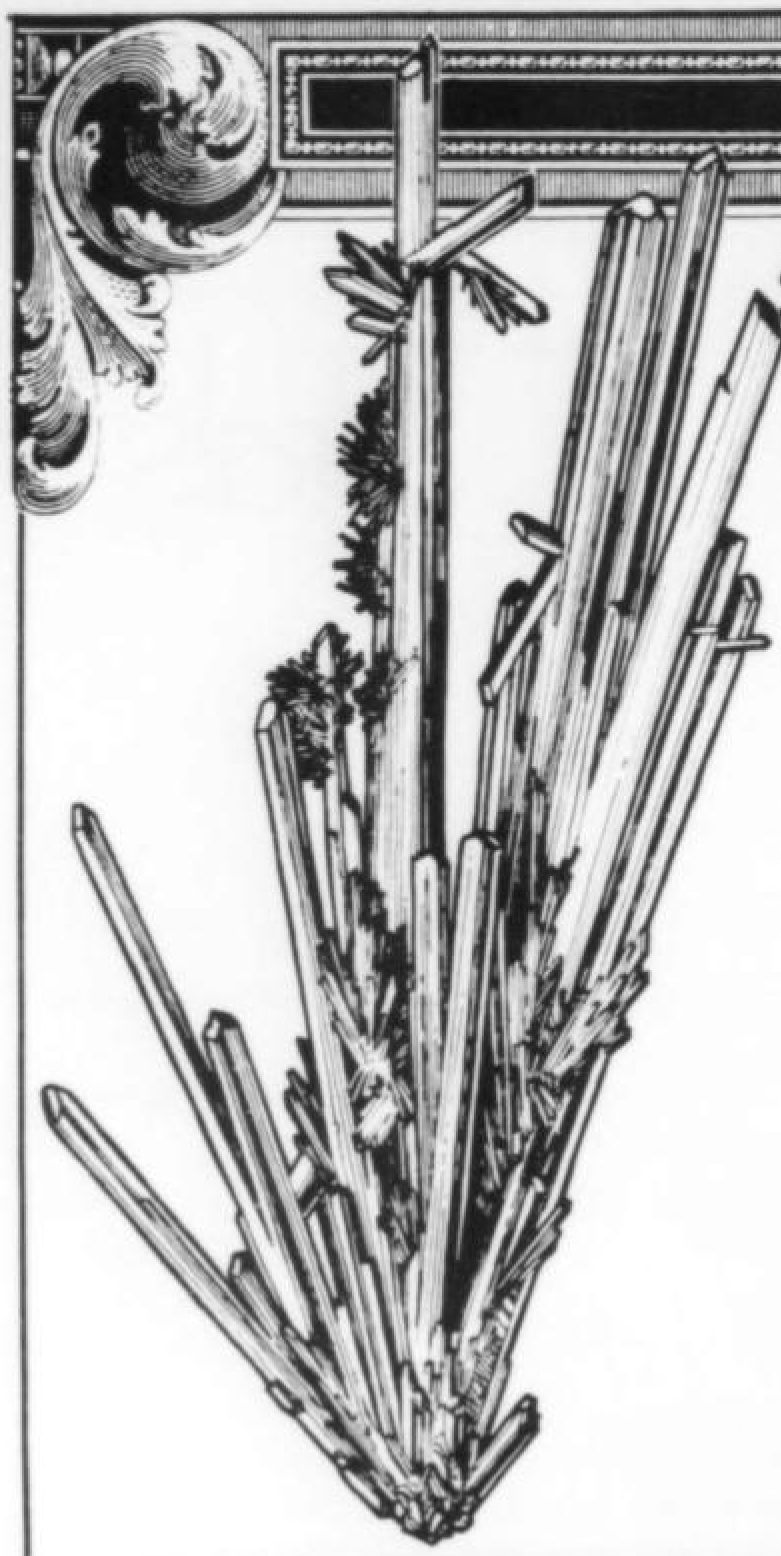
REMARKS ON THE CHEMISTRY

The treatment described above, accomplished at ambient temperature, will slowly liberate SO_2 (sulfur dioxide) and reduce Fe^{+3} to Fe^{+2}, which is very soluble in the citrate solution. Because the SO_2 disappears more rapidly at higher temperatures, the formation of sulfur and sulfides can become a problem. So this must be hindered by using a lower temperature and a lid.

If the mineral has small crevices or cracks, the resulting chemicals must be rinsed out carefully because the Fe^{+2} citrate in the solution may oxidize again during storage, creating yellow spots of Fe^{+3} on the mineral.

Another thing to note is that sodium dithionite is broken down by the humidity in the air. The lid must therefore be sealed carefully after each use.

Finally, some advice which may prove useful when a specimen contains a large amount of iron oxide, perhaps as matrix: these parts of the mineral may be isolated by dripping melted paraffin (melting point ca 50°C) or candle wax over them, thus sealing them against the chemical treatment. After cleaning, the wax can be removed by dipping in hot water and cooling it slowly. A waxy cake will then develop on the surface and must be removed before the final rinse in the ultrasonic cleaner. ◆

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Fine crystals of libethenite rivaling those from Hungary and Zambia have been found at the Burra mine, South Australia. Attractive crystals and pseudomorphs of other secondary copper species occur there as well.

INTRODUCTION

The Burra orebody lies some 150 km north-northeast of Adelaide, South Australia, in the northern Mt. Lofty Ranges. Discovered in 1845, the mine was worked virtually non-stop until impoverished sulfides were met with in 1877. During this period, 238,413 tons of 22-percent copper ore were removed.

The mine was reopened using open-cut methods in 1971 by Samin Ltd. after the proving of 3.3 million tons of 1.5-percent copper ore by the South Australia Mines Department. In 1978 the assets of that company were taken over by Adelaide and Wallaroo Fertilizers Ltd., who terminated mining of the orebody in late 1981, after mineable ore was exhausted.

The first period of mining at Burra saw some superb specimens come to light. Compact mammillary malachite studded with small but lustrous crystals of azurite are hallmarks of this mine and are masterpieces in their own right. These, however, have recently been overshadowed by the stunning crystal groups encountered in the "libethenite zone."

THE LIBETHENITE ZONE

A distinct mineralogical zone containing azurite, libethenite and associated supergene copper minerals was entered between the 430 and 480-meter benches of the Burra pit in late 1979. All minerals (excluding chrysocolla) frequently occurred as fine crystals; those of azurite and libethenite are of exceptional size and beauty. The secondary minerals, in order of crystallization, are: libethenite (first), chrysocolla, azurite, malachite, and pseudomalachite (last). Gangue minerals include apatite and drusy quartz.

PETROLOGY

The minerals mentioned were encountered in a coarse-grained open dolomitic breccia. The dimensions of the pod were approximately 4 by 8 by 50 meters, with mineralized vugs reaching up to 10 by 20 by 30 cm. The breccia exhibited significant and characteristic variations. It ranged from slightly weathered and brittle to intensely weathered and somewhat friable. In all cases the breccia was cemented with the secondary copper minerals mentioned. The pod was restricted in extent to the eastern pit wall, where it occurred as a branching lenticular channel between the 430 and 480-meter bench levels (Graham Sweetman, personal communication).

***Table 1.* Distribution of minerals within the pod.**

Top of Pod	Major minerals	Minor minerals
|	Libethenite Chrysocolla Pseudomalachite	Malachite Azurite
Transparent, golden apatite crystals were found throughout the pod.	Azurite Chrysocolla	Libethenite Malachite
|	Malachite Chrysocolla	
Bottom of Pod		

MODE OF OCCURRENCE

Azurite $Cu_3(CO_3)_2(OH)_2$

Azurite is present in two distinct forms:

1. As sharp, slender, individual blades reaching 5 cm in length. Found encrusting chrysocolla; occasionally shows some alteration to malachite.

Figure 1. **The libethenite-zone as exposed at the 445-meter level, east wall, Burra pit. Blue-green chrysocolla covers much of the exposure. Photograph courtesy of Graham Sweetman.**

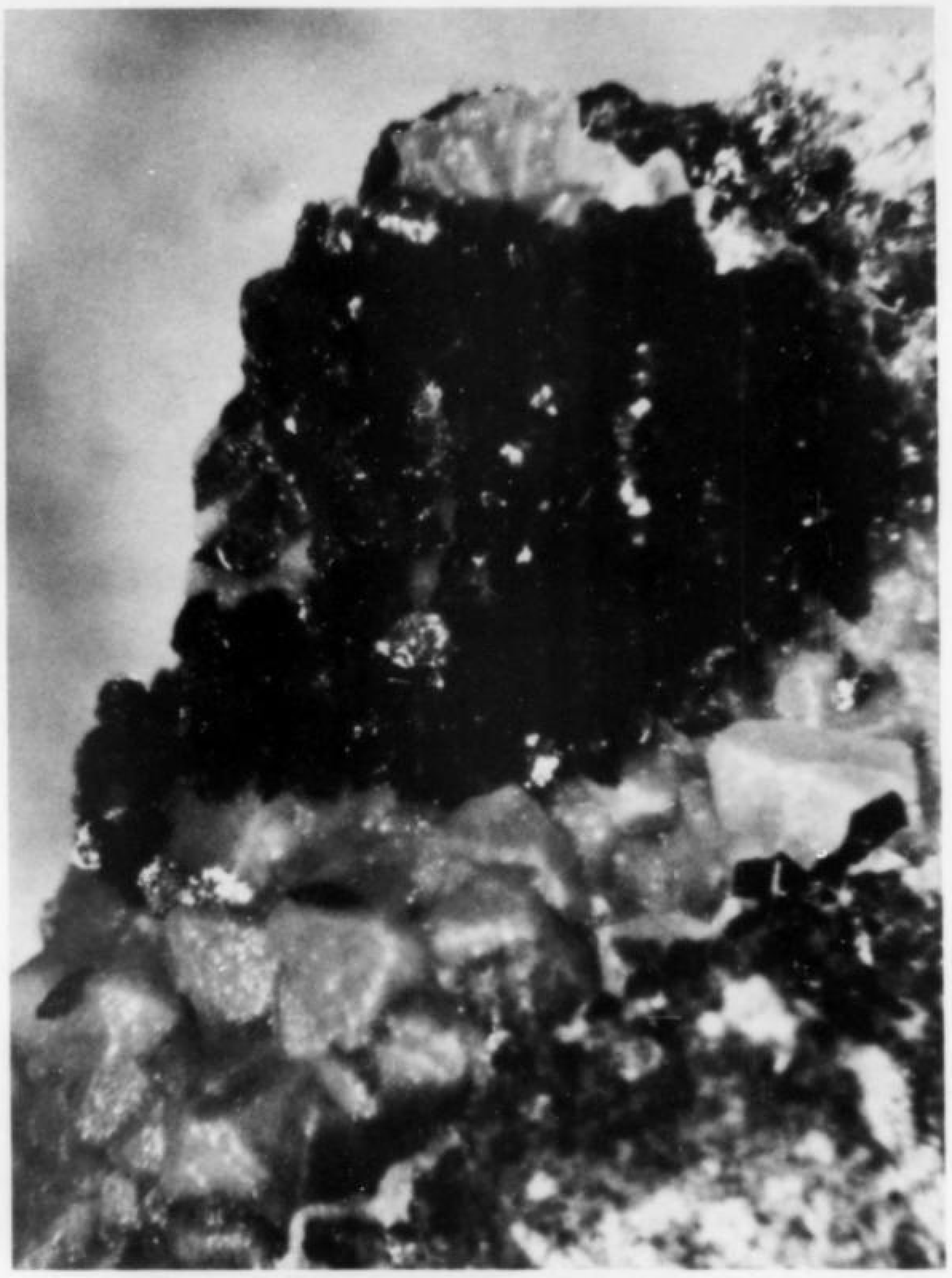

Figure 3. **Dark green pseudomalachite on blue-green chrysocolla encrusting libethenite. Largest libethenite is 3.5 mm in size. Author's specimen and photograph.**

Figure 2. **Dark green libethenite crystals reaching 1.5 mm in size. Author's specimen and photograph.**

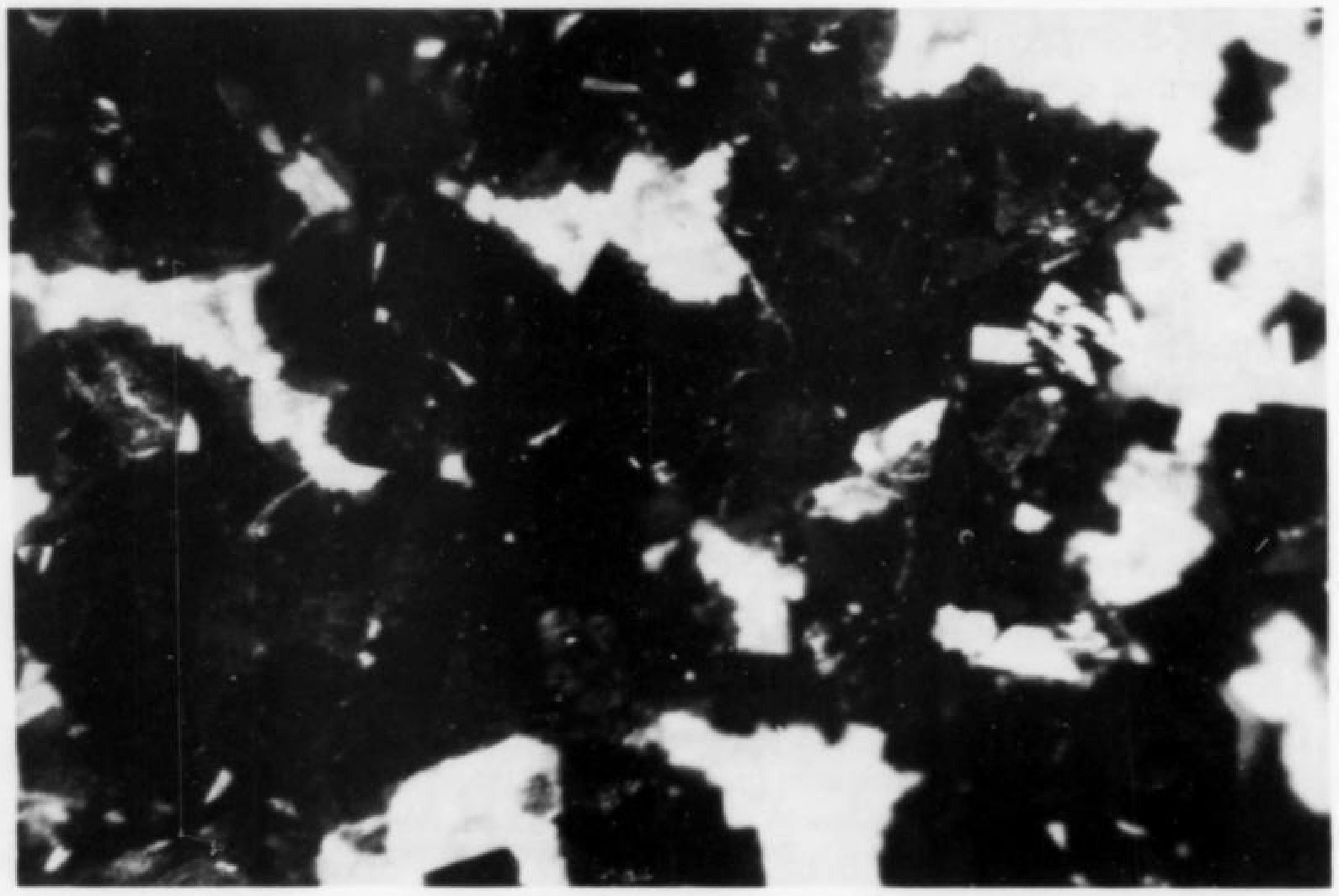

Figure 4. **Blackish green libethenite in and surrounding green botryoidal pseudomalachite. Center crystal is 2 mm in size. Author's specimen and photograph.**

2. As stunning rosettes of translucent, brilliantly lustrous crystals, reaching 5 cm in diameter, and associated with libethenite and chrysocolla. For sheer beauty these groups are foremost among Burra's most attractive specimens.

Chrysocolla $(Cu,Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$

Chrysocolla is by far the most common of the supergene copper minerals in the pod. It displays significant variations in its outward appearance, ranging from handsome botryoidal masses to jelly-

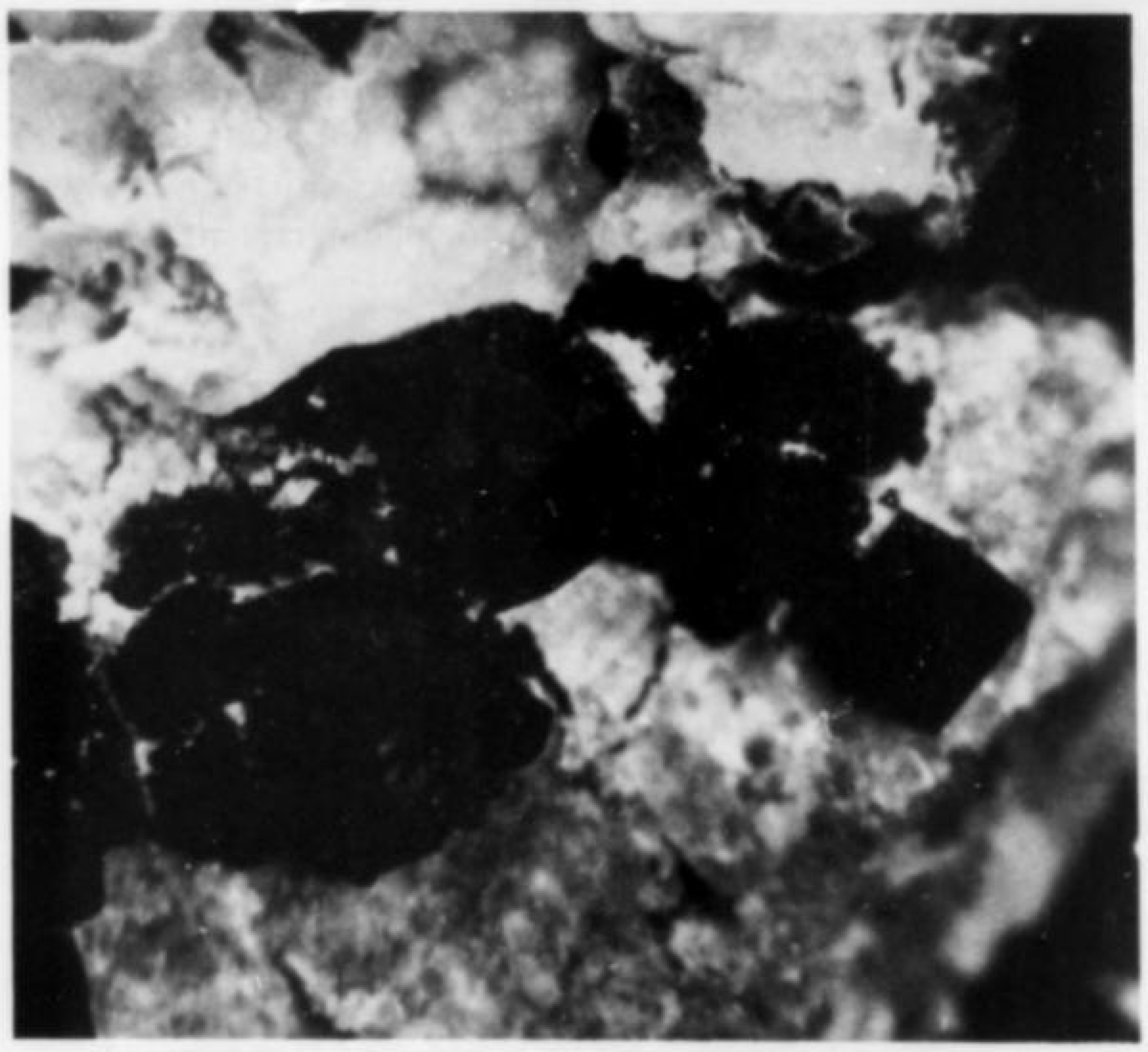

Figure 5. **Blackish azurite pseudomorphs after libethenite. Center crystal (exhibiting parallel growth) is 4 mm in size. Author's specimen and photograph.**

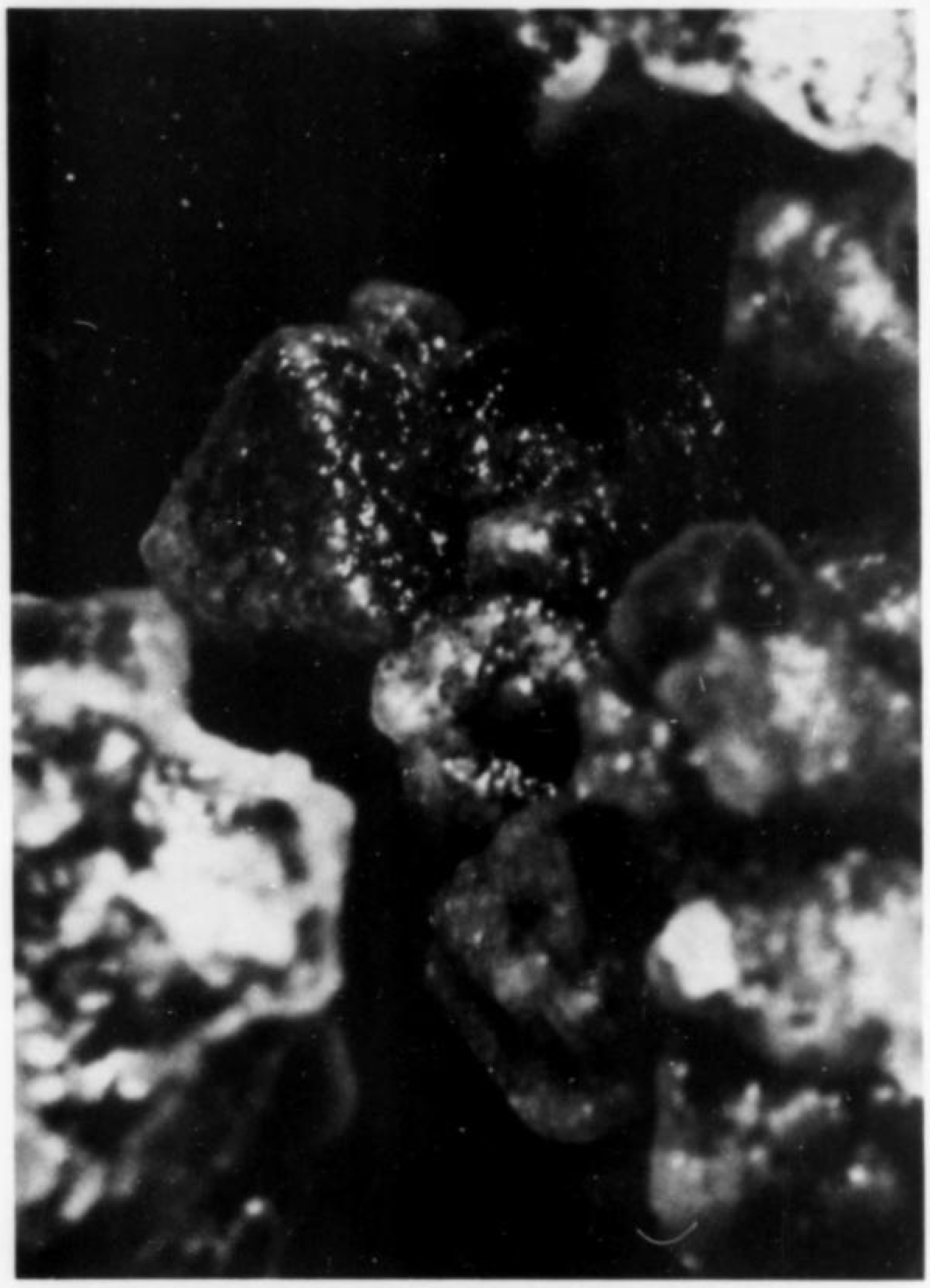

Figure 7. **Chrysocolla-encrusted libethenite with blackish green pseudomalachite crystals in the background. Central libethenite is 5 mm in size. Author's specimen and photograph.**

like, translucent vug fillings. This latter form is interesting in that it decrepitates into gravel-sized fragments upon dehydration.

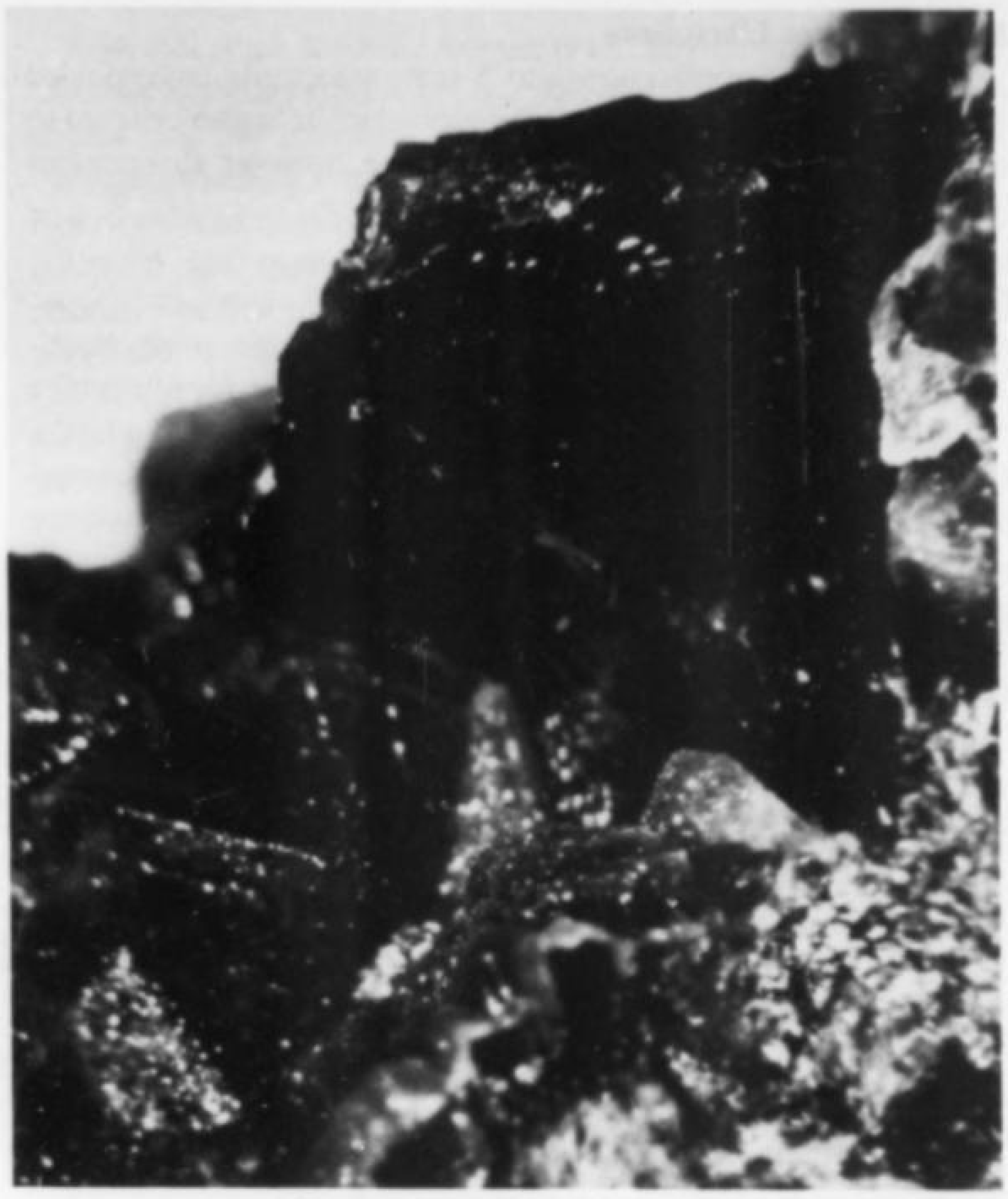

Figure 6. **Deep blue azurite crystals (upper) in vug with green libethenite (lower). Azurites reach 1 cm in length. Author's specimen and photograph.**

Libethenite $Cu_2(PO_4)(OH)$

Libethenite occurs typically as anastomosing vein and fracture fillings, rarely reaching 50 mm in diameter. Incomplete filling of vugs had led to the development of some superb crystal groups. Libethenite under these conditions occurs as deep emerald-green to jet-black crystals reaching 1 cm in size. Chrysocolla is frequently seen overlying these crystals either as fine, blue mammillary masses or as translucent waxy coatings.

In contrast to other occurrences, libethenite from Burra exhibits little habit variation. Crystals are characteristically equant or pseudo-octahedral with elongation and parallel growth being prevalent on the larger crystals (over 3 mm).

Malachite $Cu_2(CO_3)(OH)_2$

Malachite is restricted almost entirely to the deeper portion of the breccia pod. It occurred occasionally as well-developed tabular crystals to 3 mm, scattered on chrysocolla-encrusted libethenite. Also as fine botryoidal vug linings to 2 cm in thickness.

Pseudomalachite $Cu_5(PO_4)_2(OH)_4 \cdot H_2O$

Pseudomalachite is found frequently encrusting blue-green chrysocolla, as transparent, lustrous, apple-green plates to 5 mm. Also encountered were thin botryoidal encrustations.

PSEUDOMORPHS

A sizable number of both rare and common pseudomorphs have been recorded from the libethenite zone. Some of the rarer occurrences are noted below.

Azurite after Libethenite

As sharp, royal-blue crystals to 5 mm or as massive vein replacements. This probably constitutes the world's only occurrence of this type of pseudomorph (Noble, 1980).

Chrysocolla after Libethenite

As small, hollow encrustation pseudomorphs of a sky-blue color, commonly attended by drusy quartz.

Malachite after Libethenite

As deep green replacements to 5 mm, frequently intermingled with azurite in the same crystal. Pseudomalachite is also believed to have pseudomorphically replaced libethenite, however, this remains unsubstantiated.

CONCLUSION

The occurrence of libethenite at the Burra copper mine, South Australia, constitutes one of the three best localities for libethenite in the world. The classic localities of Libethen, Hungary, and the Rokana mine, Zambia (see Korowski and Notebaart, 1978), possess little if any supremacy over Burra libethenite in terms of average crystal size, perfection of form and splendor of the associated minerals.

ACKNOWLEDGMENTS

The author is indebted to Graham Sweetman (ex-mine geologist, Burra) for his cooperation and interest in supplying me with specific information on the occurrence. Thanks also to Peter Russ (Flinders University, South Australia) for photographing selected specimens.

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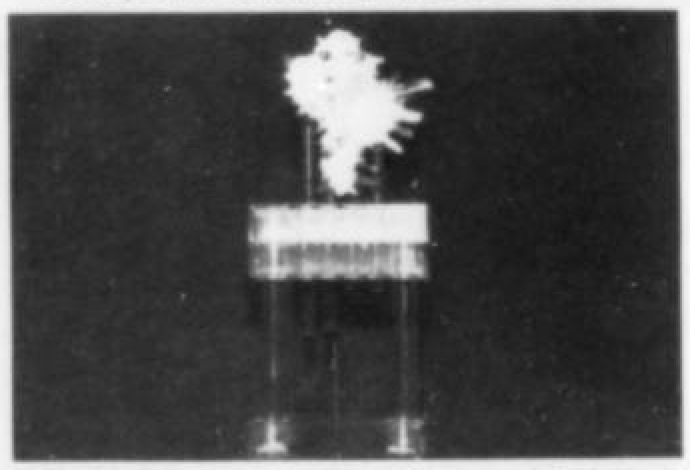

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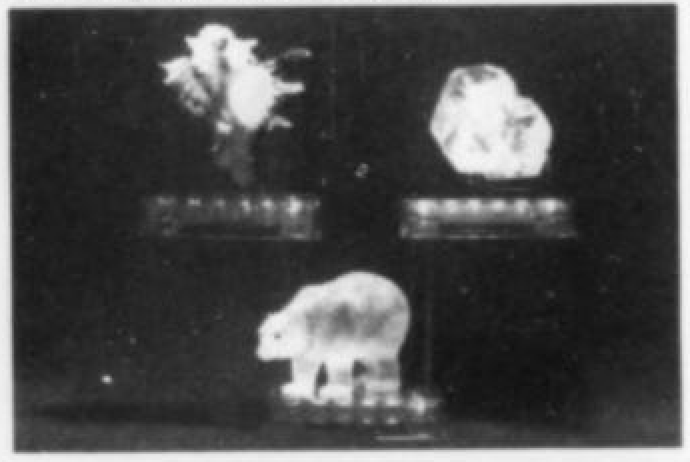

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More Trades

To begin, I must advert thrice to my previous column on swapping, the one appearing in the January-February 1983 issue. I made two booboos in the column, the first of which was in referring to non-isotropic minerals as biaxial. Of course, uniaxial minerals are also non-isotropic, and polarizing filters would be of use in photographing inclusions in them as well.

The second error was in the locality for the mordenite shown in Figure 11 and sent to me by Ruth Jacobsen. I assumed the mordenite was from the same locality as that sent me by three (!) other collectors who described it as "From Nelson, South Island, New Zealand." Not so. Ruth tells me that all this material is from Hikuai, Coromandel Peninsula, North Island. Further, she says that she is aware of the incorrect locality being bruited about, but that there is no mordenite to be found anywhere near Nelson on South Island.

In the same column, I described but did not show photographs of some superb material sent me by Peter Elliott (P.O. Carey Gully, South Australia 5144, Australia). Just to prove how nice the material is, I've since taken photos of several of his things, and they appear in Figures 1–8 of this article. The first three are all copper sulfides from the Cattlegrid pit, Mount Gunson mines, South Australia. The first of these (Fig. 1) is a very sharp and brilliant, striated crystal of chalcocite. In Figure 2 are shown lathlike crystals of the rare copper bismuth sulfide wittichenite; while in Figure 3 are to be seen brilliant, slightly rounded, blue tarnished crystals of digenite.

Figure 4 shows several tabular, bipyramidal crystals of hedyphane, a calcium arsenate member of the apatite group. These are the first crystals of hedyphane in my collection, and they come from the classic locality of Broken Hill in New South Wales. The brochantite from Yudnamutana (Fig. 5) is as sharp and clean as could be desired, while the hemimorphite from the Puttapa Zinc mine in Figure 6 shows nice, radiating crystals of this rather common mineral. I could not resist showing another of the glassy clear and extremely sharp groups of barite crystals from Moralana in the Flinders Range (Fig. 7). I would put these on a par, for brilliance and perfection of form, with the gorgeous barites from Frostburg, Maryland, although the crystal habits of the two are as different as night and day. The last specimen illustrating Peter Elliott's trading material is an interesting one. The crystals of malachite (Fig. 8) appear to be pseudomorphs after V-shape "twins" of azurite. Although I have not seen such twins before, I don't know what else they could be.

Rodney Lee of *Simkev Minerals* (942 Chevrolet Street, Oshawa, Ontario, Canada, L1G 4H8) is a dealer in microminerals. He has chosen for his company a rather neat motto, *Pulchritudo in Parvitas,* which is one of the major selling points of the hobby. Rodney has some very attractive micromaterial available at modest prices. A few specimens sent by him are shown in the next six photos. The first of these (Fig. 9) is larger than usual cream colored botryoids of dresserite from the Francon quarry, Montreal, Quebec. The group in the upper right shows what appear to be shrinkage cracks, while the chipped edge of the group at the lower left shows the radial structure of the mineral. From the same locality are the two species shown in the next photo (Fig. 10): the extremely rare mineral franconite (and/or the calcium analog thereof) in small botryoids on and with the merely rare mineral weloganite, which shows its customary pagoda-like habit. In Figure 11 are shown some unusual calcites, actually on the same specimen as the franconite but not even mentioned by Rodney. The crystals show positive and negative rhombohedrons, the intersecting edges of which are selectively coated with tiny pyrite crystals. It is interesting to speculate as to why these edges should be so preferred as resting places by the pyrite.

The next specimen obtained from Rodney shows quite tiny but well formed platy crystals of the rare calcium arsenate guerinite from Richelsdorf, Hessen, Germany. The specimen (Fig. 12) is made more attractive by the presence of equally small single crystals and groups of light pink erythrite. From Drygill, Cumberland, England, Rodney sent groups of mustard-yellow, tabular crystals of mimetite (Fig. 13). The crystals are growing in subparallel arrays to give both slightly cavernous groups and others of the campylite habit. From Tsumeb, he sent deep green groups of cuprian adamite in compact clusters contrasting nicely with the red iron oxide matrix (Fig. 14).

Not shown but also featured in Rodney's lists and available in attractive specimens are species such as collinsite from Brazil, chalcocite crystals from Cornwall, dussertite from Algeria, New Zealand vivianite, and deep yellow titanite crystals from the Eifel District in Germany. Also listed are Italian apuanite, Mexican carminite, frondelite from Brazil, Peruvian hutchinsonite, English liskeardite, a suite of very rare Franklin minerals, and suites of minerals from Kings Mountain, North Carolina (phosphates) and Ireland (zeolites). Write him and send a stamp for his current offerings.

Every now and then I get a package of really nice minerals from Wilfred L. Baldwin (602 Morrell Boulevard, Prescott, Arizona 86301). Bill is one of those lucky fellows who has collected throughout and has a large supply of colorful and sometimes rare minerals from the southwestern United States. He's a trader.

Some of the micros I have received from Bill are so gorgeous they almost break my heart. A few recent ones are shown in the next few photos. In Figure 15 are to be seen deep purple, very sharp cubes of fluorite showing distinct color zoning. These are with and on crystal-clear to opaque white hemimorphite crystals, and the combination is indeed striking. Of course, no package from Arizona would be complete without a couple of wulfenites, and Bill has sent them too. Those from the Rowley mine (Fig. 16) are bright orange and so clear that one crystal can be seen through another. In Figure 17 are wulfenites from the Great Southern mine. The straw-yellow color of these crystals is not striking, but they are as acicular as any wulfenites I have seen.

Figure 18 shows jet-black crystals of pyrolusite, unusual in that they are deeply striated lengthwise or else examples of parallel growth. The natrolites shown in Figure 19 are from the Santa Maria River. Out of focus behind them are accompanying clear analcimes, and both minerals are nestled in a tiny vug in what looks like rhyolite. Last but not least are the deep orange-red vanadinites in Figure 20 from the Apache mine. These are doubly attractive

Figure 1. **Brilliant, jet-black, 1.5-mm crystal of chalcocite with digenite from the Cattlegrid pit, Mount Gunson mines, South Australia.**

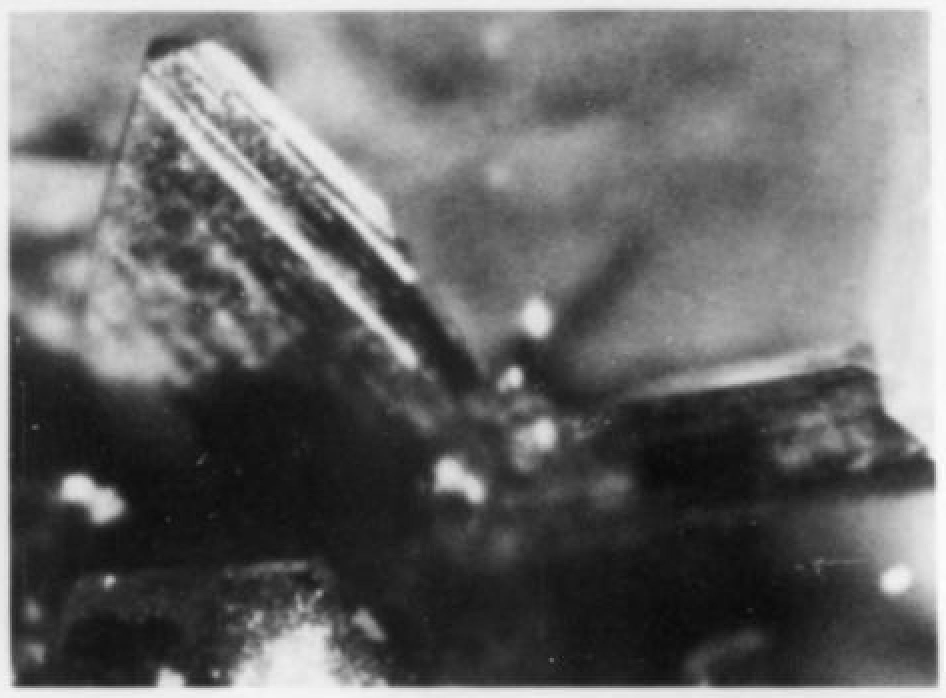

Figure 2. **Metallic, grey-black laths of wittichenite to 0.8 mm in length; Cattlegrid pit, Mount Gunson mines, South Australia.**

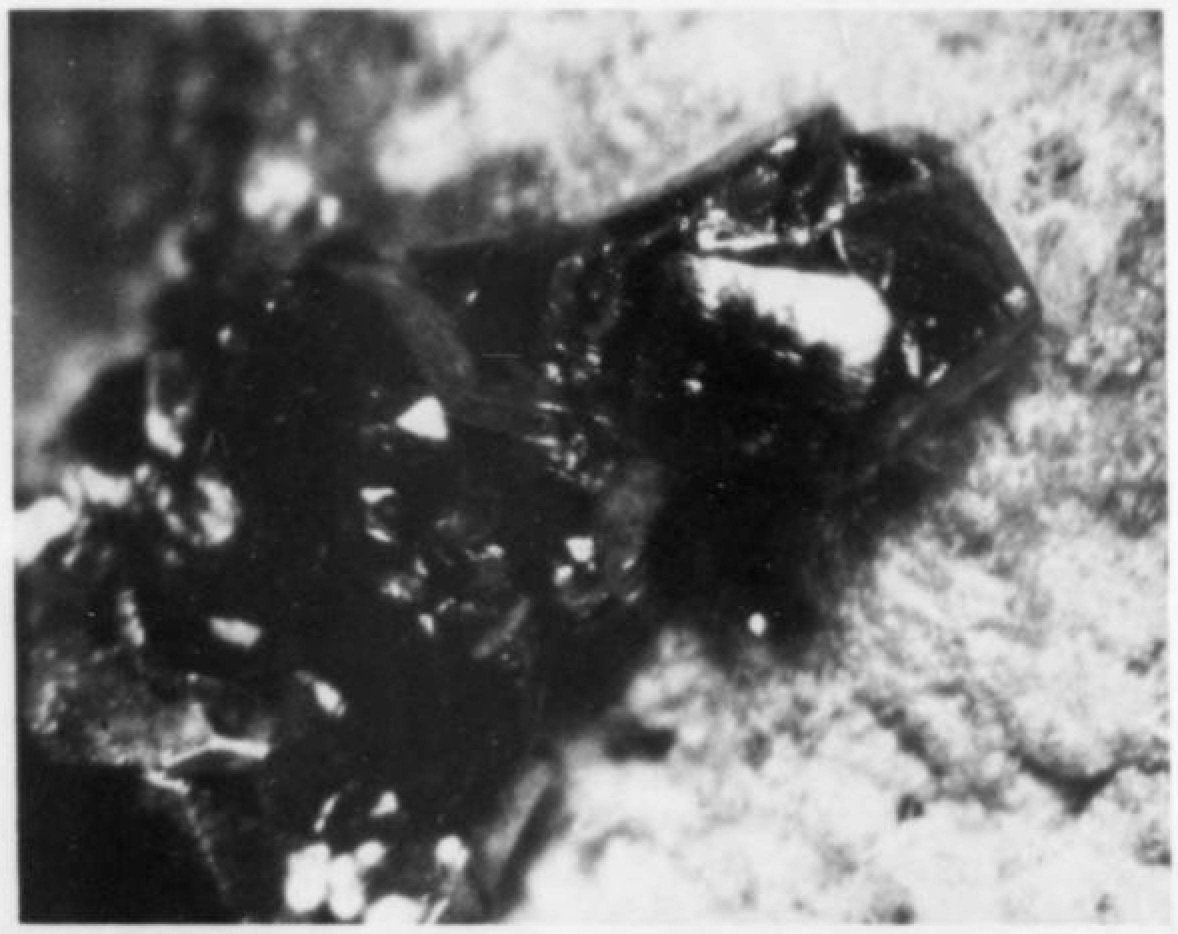

Figure 3. **Digenite, rounded, black crystals to 1.2 mm, with sphalerite, from the Cattlegrid pit, Mount Gunson mines, South Australia.**

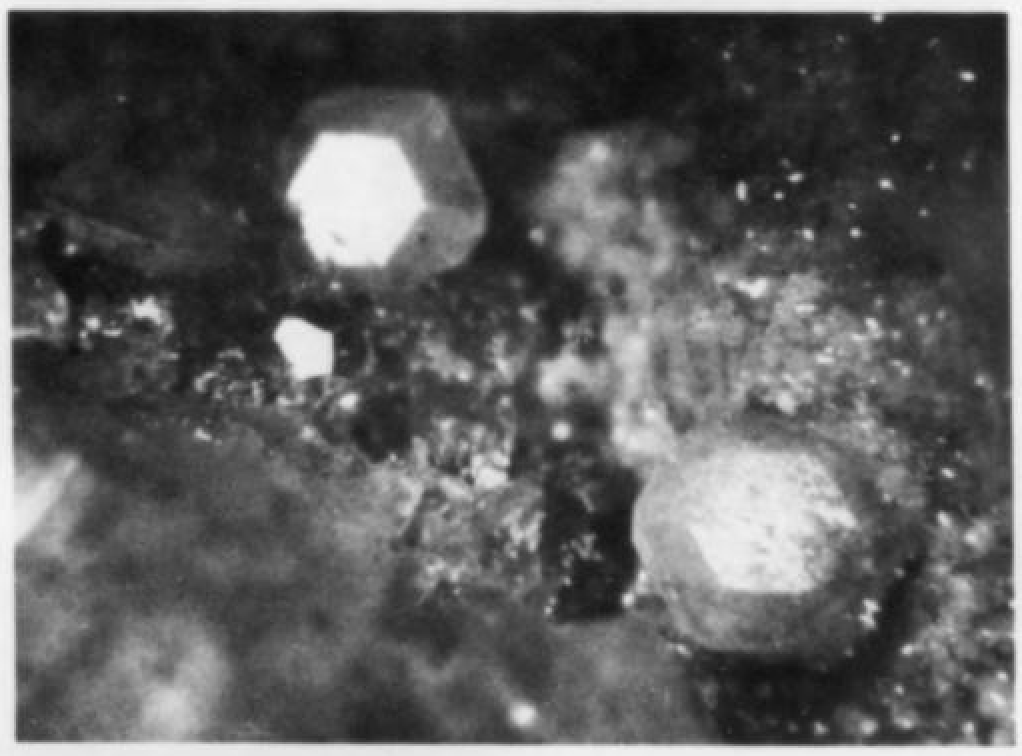

Figure 4. **Porcelain-white, tabular crystals of hedyphane, largest crystal 0.8 mm in diameter, with willemite, from the Puttapa Zinc mine, Flinders Range, South Australia.**

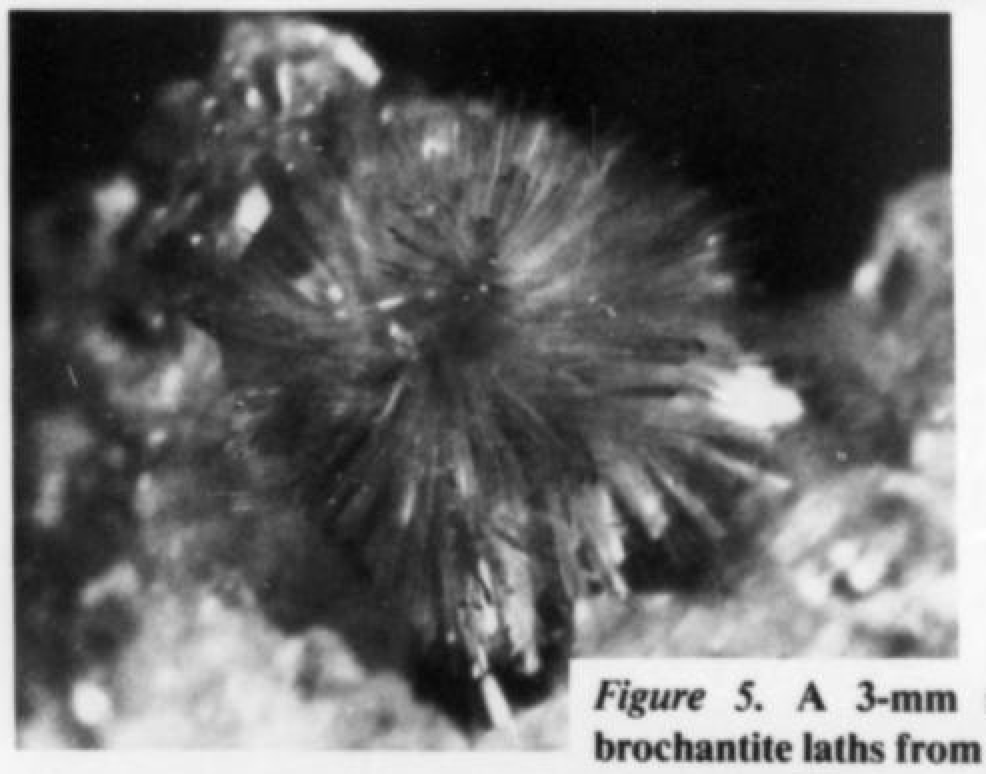

Figure 5. **A 3-mm spray of turquoise-blue brochantite laths from the Pinnacles mine, Yudnamutana, Flinders Range, South Australia.**

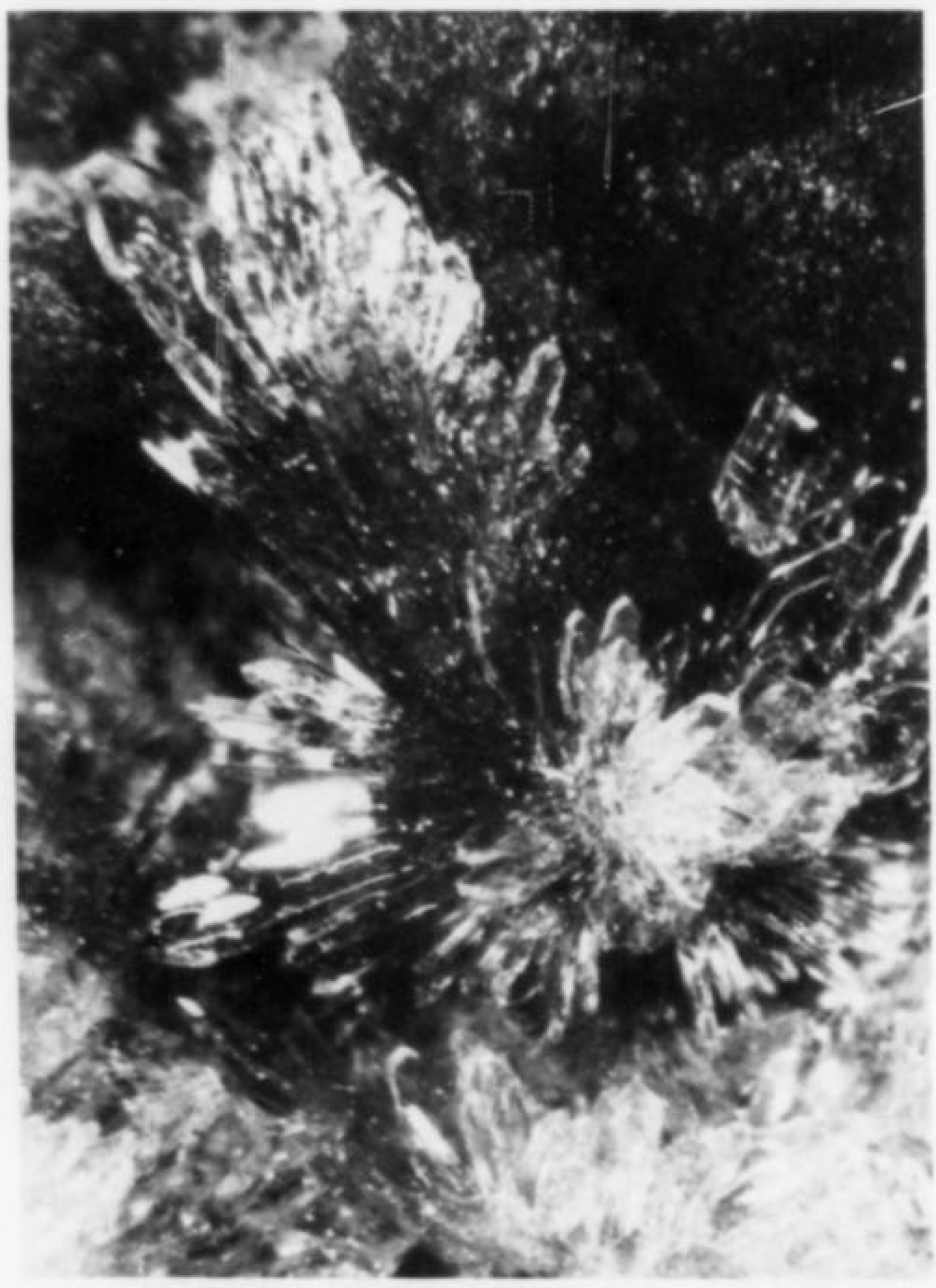

Figure 6. **Hemimorphite, 4-mm spray of colorless crystals on manganese oxides, from the Puttapa Zinc mine, Flinders Range, South Australia.**

Figure 7. Columnar barite crystals to 2.5 mm on goethite, from Moralana, Flinders Range, South Australia.

Figure 8. Malachite pseudomorphs after double V-shape twins (?) of azurite (field of view 8 mm), from the Burra mine, South Australia.

Figure 9. Cream-colored botryoids of dresserite showing shrinkage cracks and, where broken, radial fibrous structure, from the Francon quarry, Montreal, Quebec, Canada. Diameter of spheres, 3 mm.

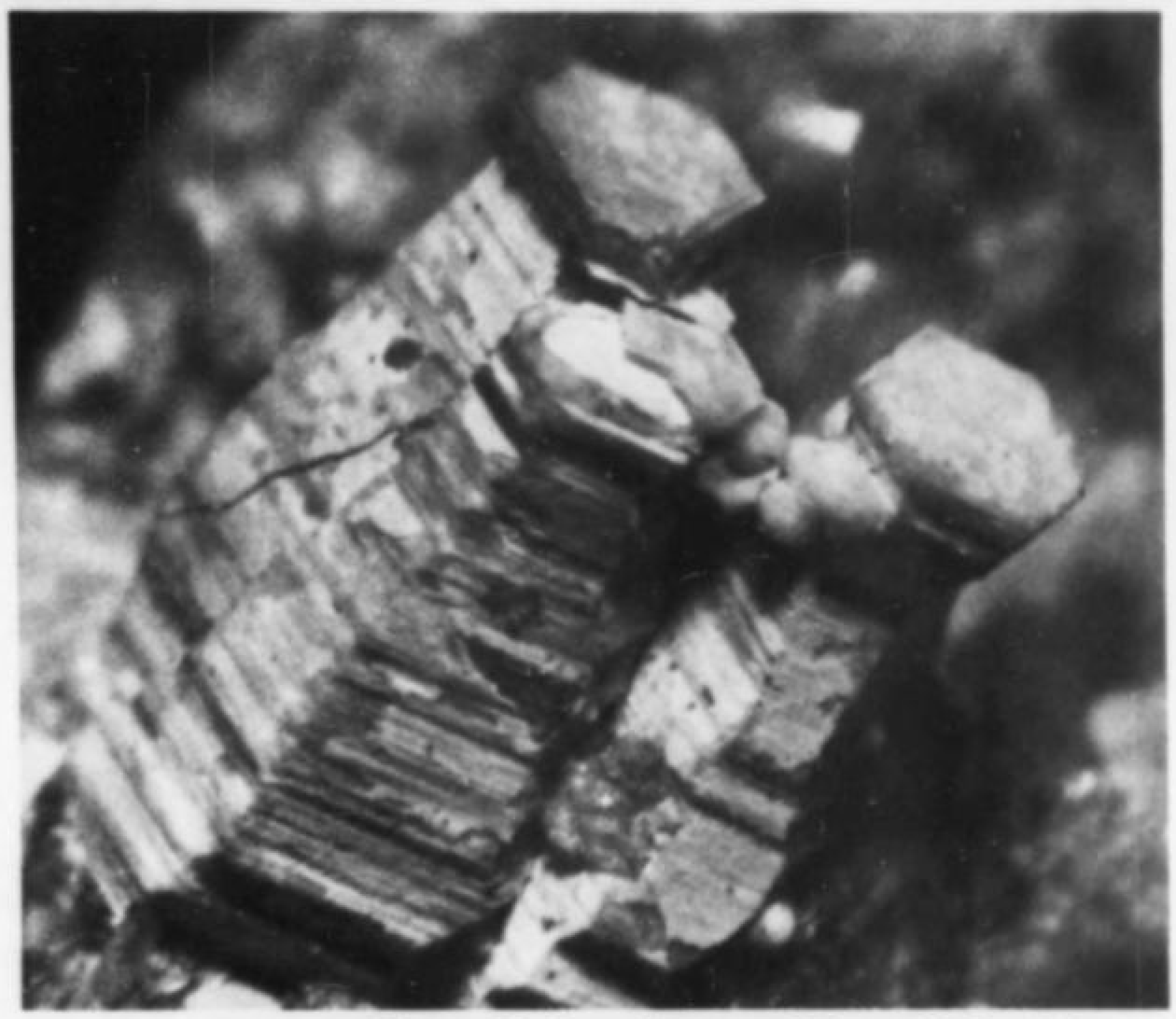

Figure 10. Porcelaneous, 0.3-mm balls of franconite and/or the calcium analog thereof on 4-mm, chalky white, pagoda-shape crystals of weloganite; Francon quarry, Montreal, Quebec, Canada.

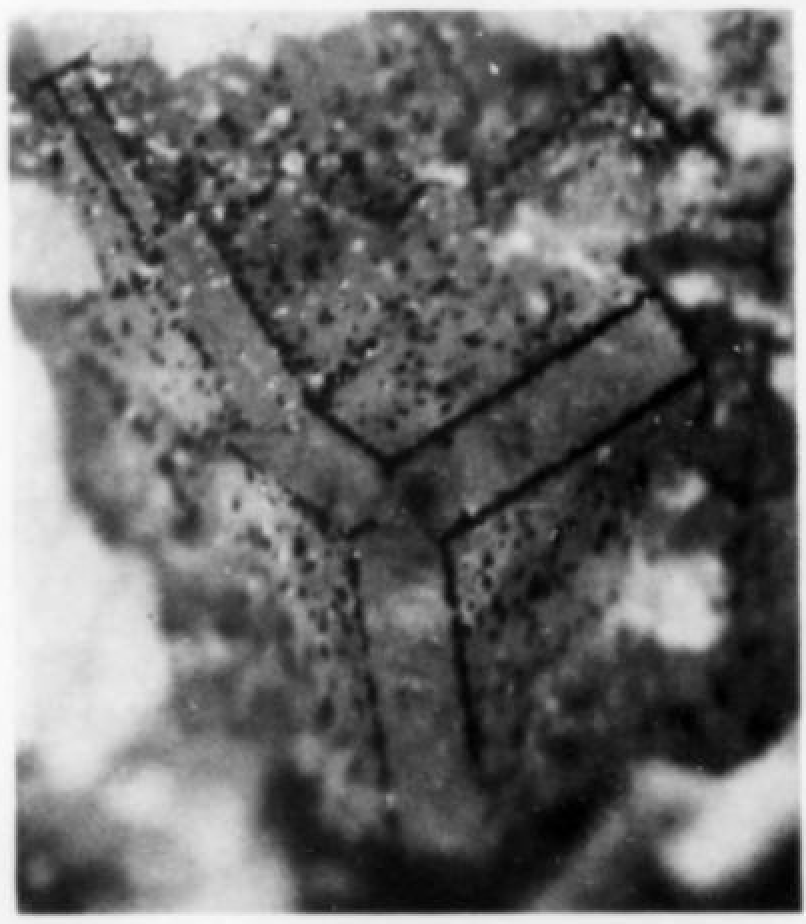

Figure 11. Tiny pyrite crystals growing preferentially on edges between positive and negative rhombohedron faces of calcite. The calcite crystal is 2 mm across; specimen from the Francon quarry, Montreal, Quebec, Canada.

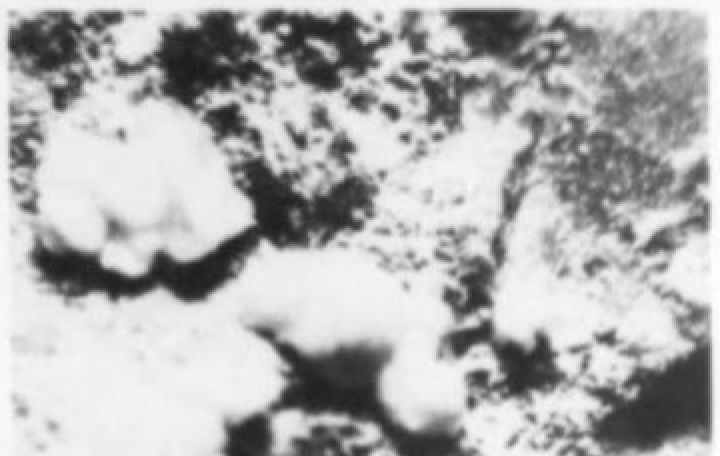

Figure 12. White, 1.5-mm spheres of guerinite with pale pink erythrite from Richelsdorf, Hessen, Germany.

Figure 13. **Mustard-yellow hexagonal plates of mimetite, the largest 1 mm in diameter, from Drygill, Cumberland, England.**

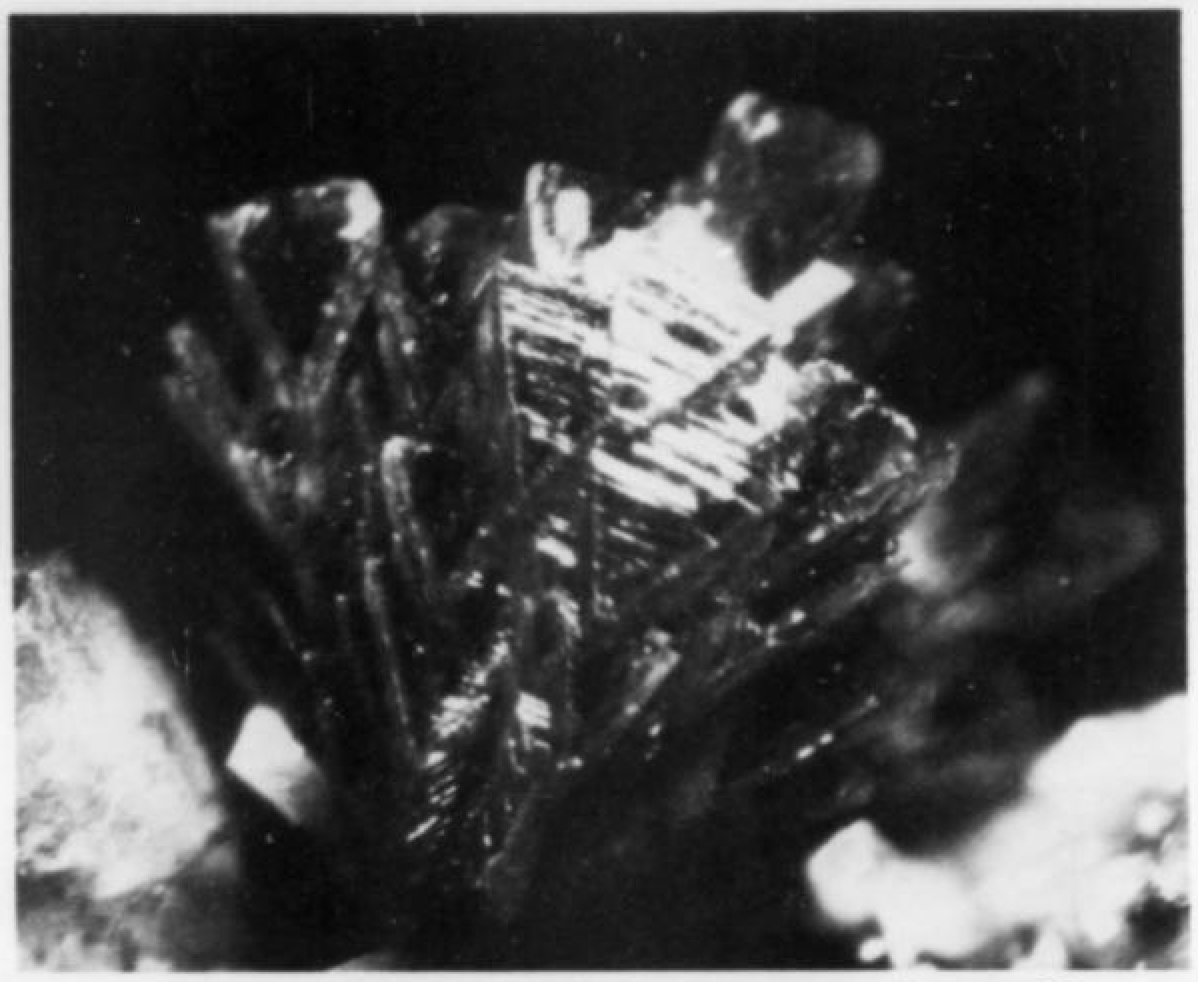

Figure 14. **A 4-mm group of emerald-green cuprian adamite from Tsumeb, Namibia.**

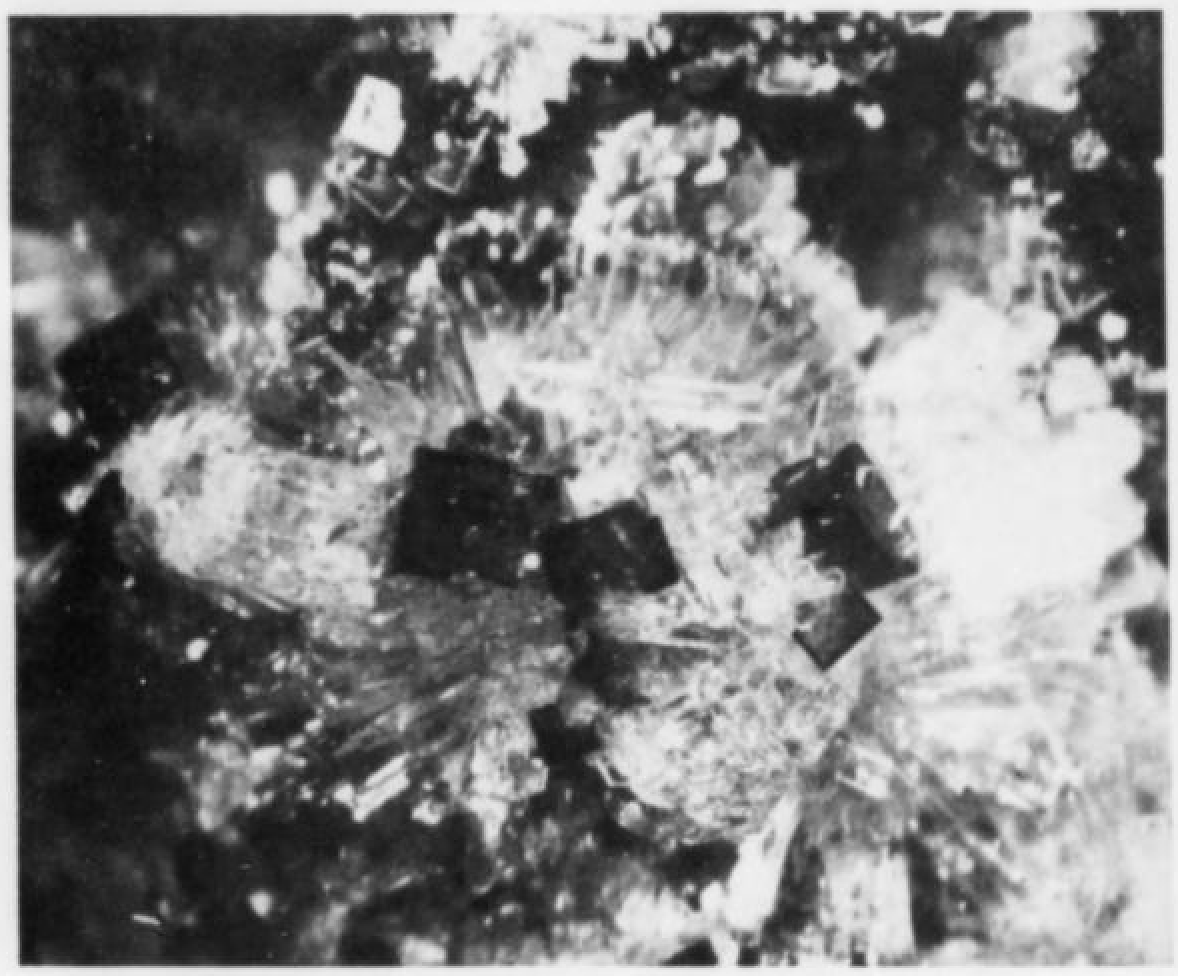

Figure 15. **Deep purple cubes of fluorite to 3 mm on colorless hemimorphite, the cube centers a much lighter color; from the McCrackin mine, Mohave County, Arizona.**

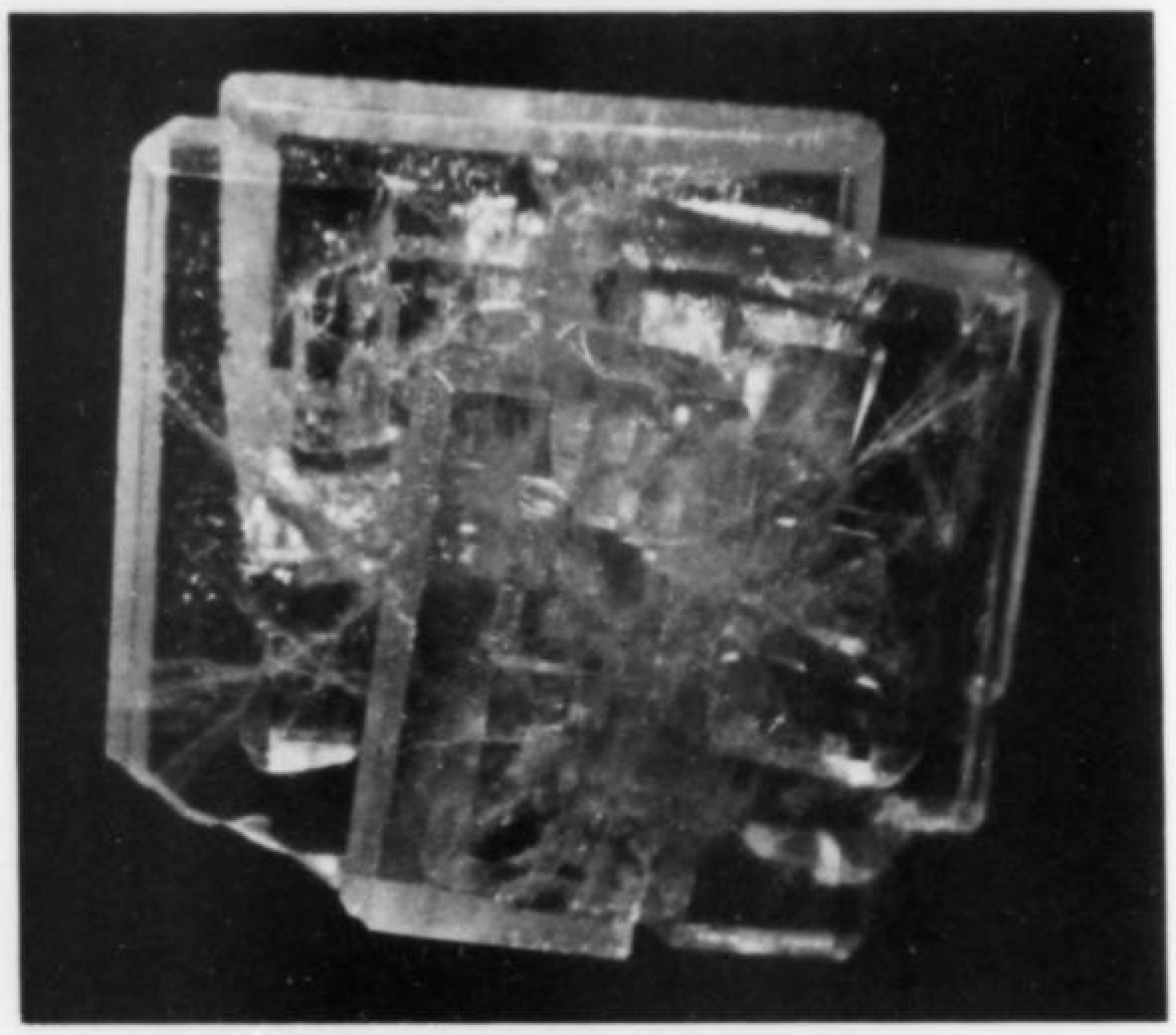

Figure 16. **Transparent, 7-mm, bright orange crystals of wulfenite from the Rowley mine, Maricopa County, Arizona.**

Figure 17. **Wulfenite in acicular, 1-mm crystals, straw-yellow in color, from the Great Southern mine, Yavapai County, Arizona.**

Figure 18. **Jet-black crystals of pyrolusite in parallel growth from Bouse, Yuma County, Arizona. Field of view, 5 mm.**

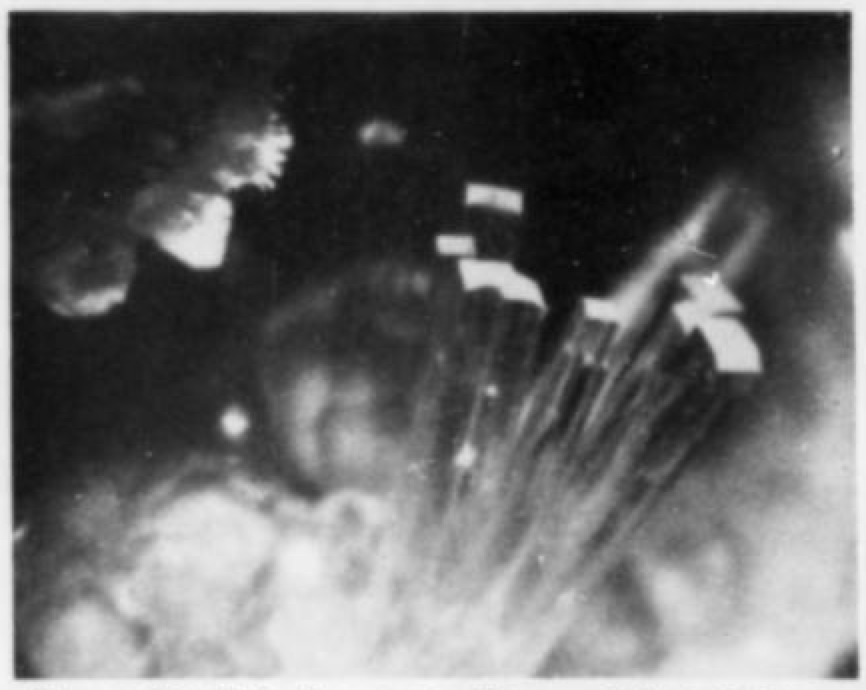

Figure 19. Colorless natrolite crystals to 2.5 mm in a cavity with analcime, from the Santa Maria River, Yavapai County, Arizona.

Figure 20. Orange-red, barrel shaped crystals of vanadinite to 3 mm with platy, greenish-brown descloizite and white rhombs of calcite, from the Apache mine, Pinal County, Arizona.

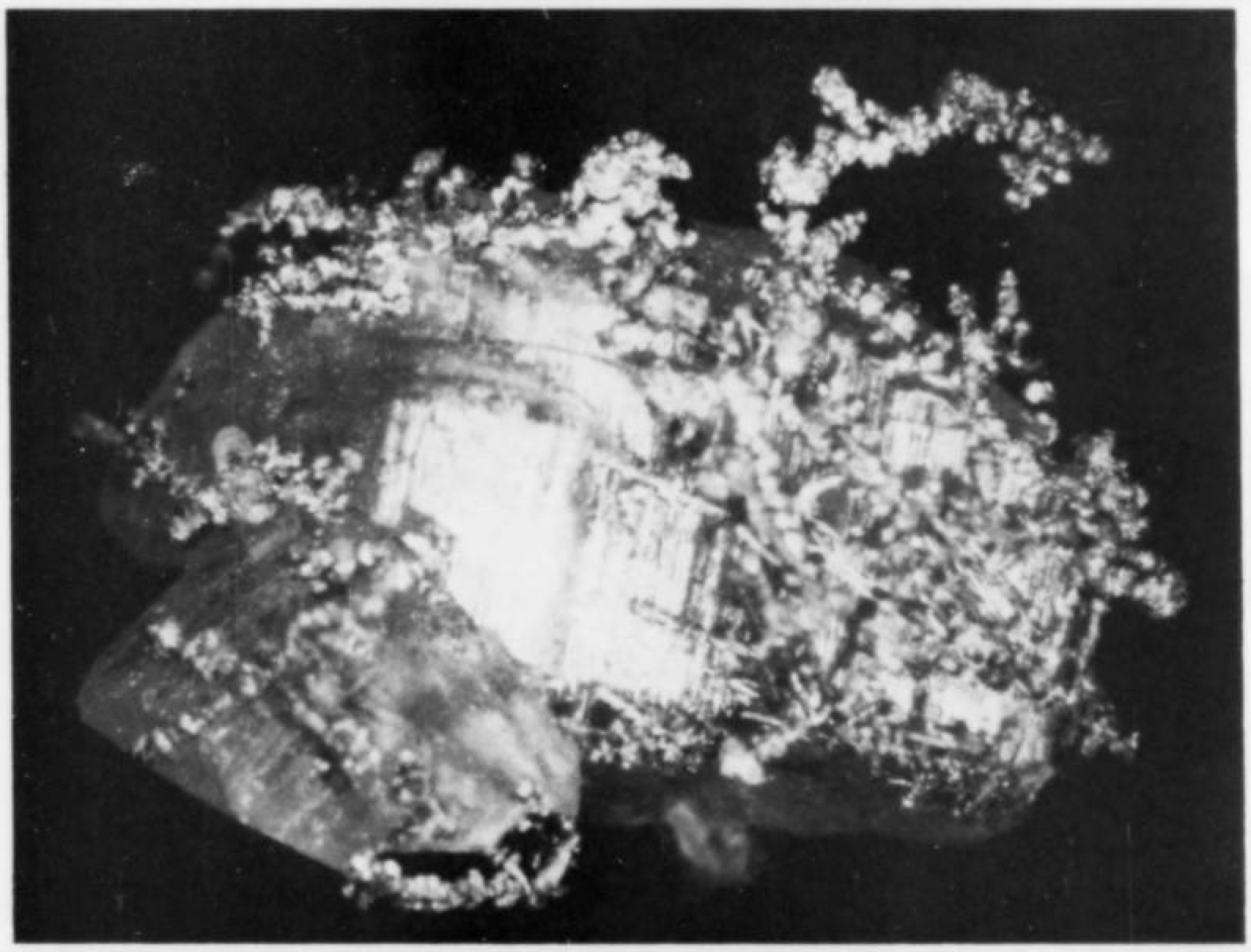

Figure 21. Wire silver decorated with silver crystals on cerussite from Aconci, Sonora, Mexico. Field of view, 5 mm. Al Stevenson photo.

Figure 22. Pale yellow, tabular crystals of paradamite from the Ojuela mine, Mapimi, Durango, Mexico. Field of view, 2 mm. Photo by Al Stevenson.

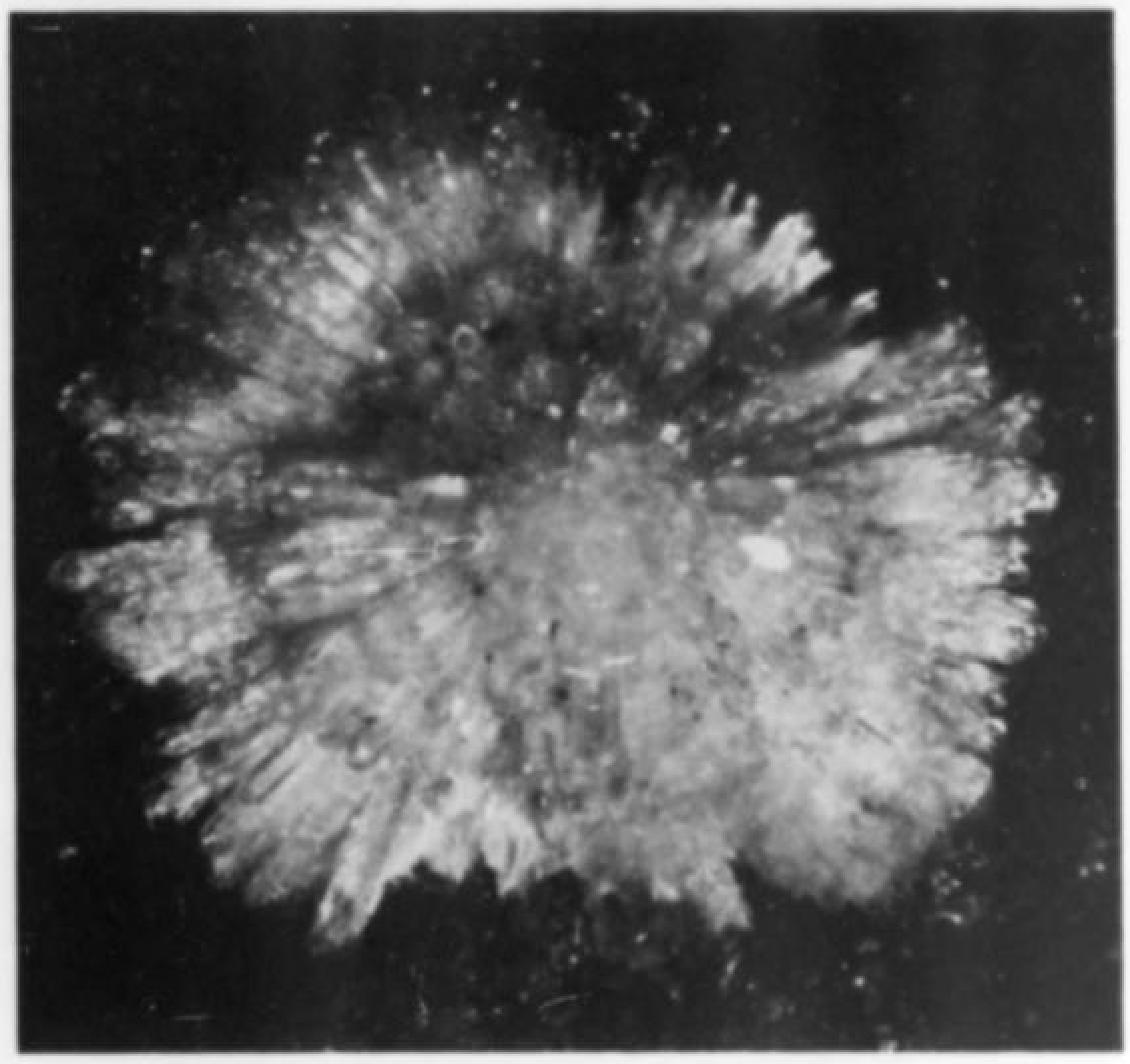

Figure 23. Light green to colorless austinite; field of view, 3 mm. From Gold Hill, Utah. Photo by Al Stevenson.

Figure 24. Colorless, equant crystal of datolite, 1 mm across, from Fort Lee, New Jersey. Photo by Al Stevenson.

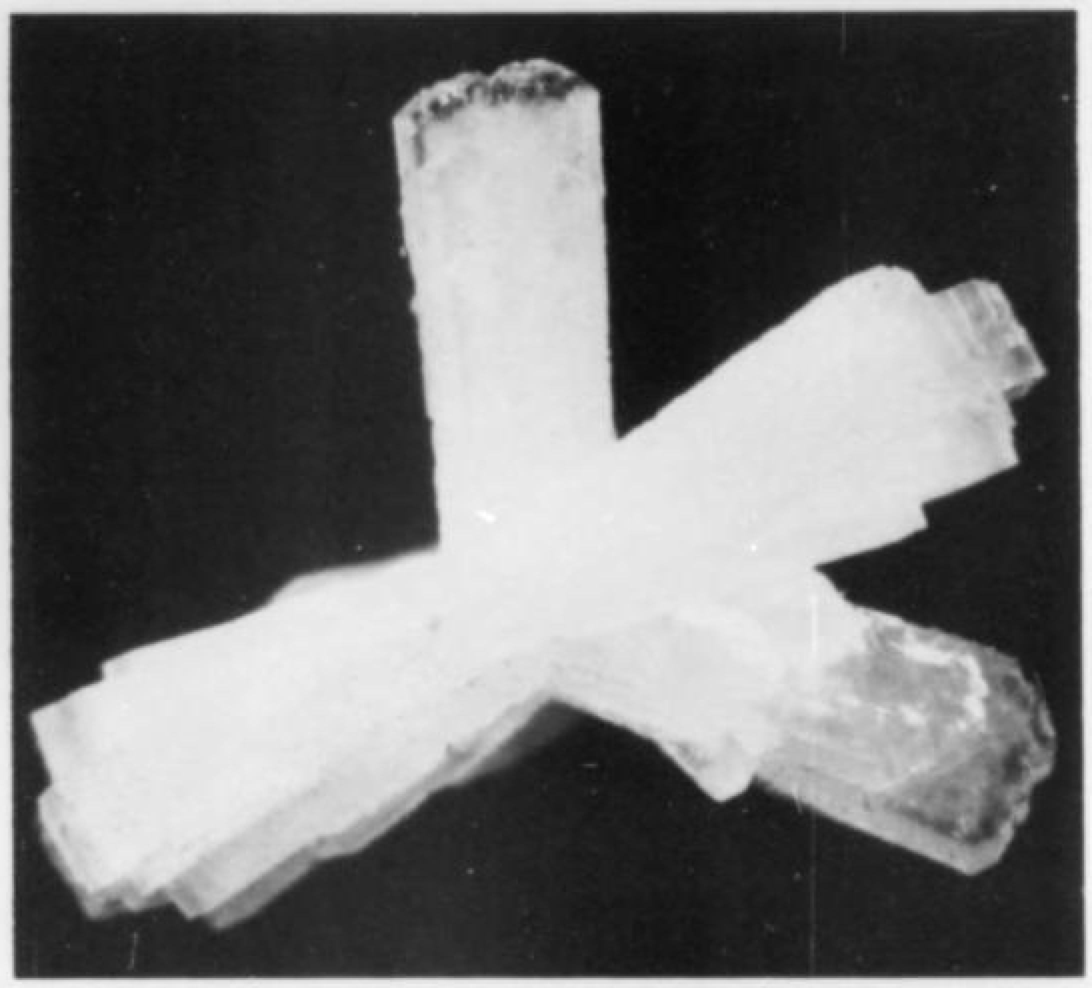

Figure 25. White 2-mm group of prehnite crystals from Riker Hill, Livingston, New Jersey. Photo by Al Stevenson.

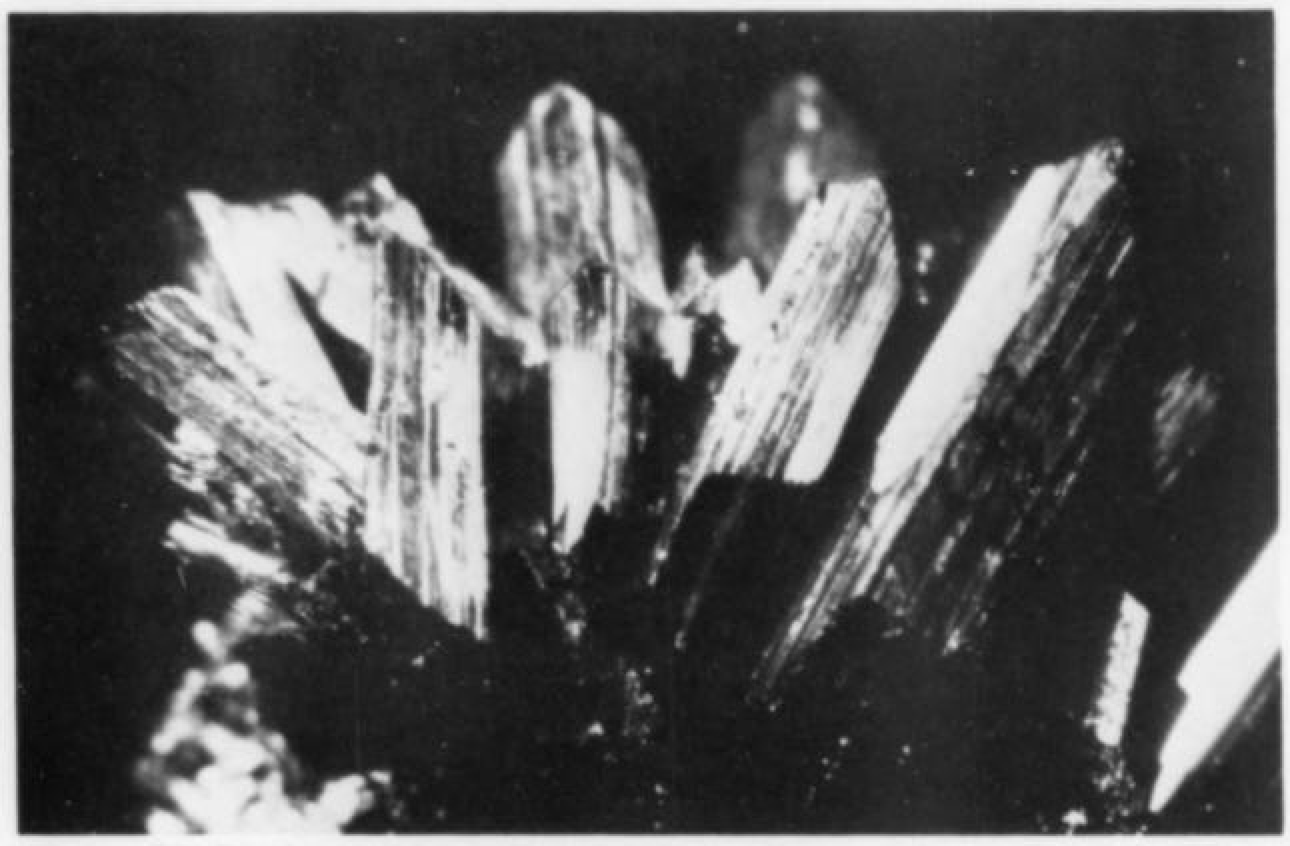

Figure 26. Steel-gray, 8-mm group of semseyite crystals from Kapnik, Romania. Photo by Al Stevenson.

Figure 27. Colorless, 2-mm crystal of danburite from Stegia, Val Medal, Switzerland. Photo by Al Stevenson.

Figure 28. Bright green, transparent, 1-mm crystals of annabergite from Laurium, Greece. Photo by Al Stevenson.

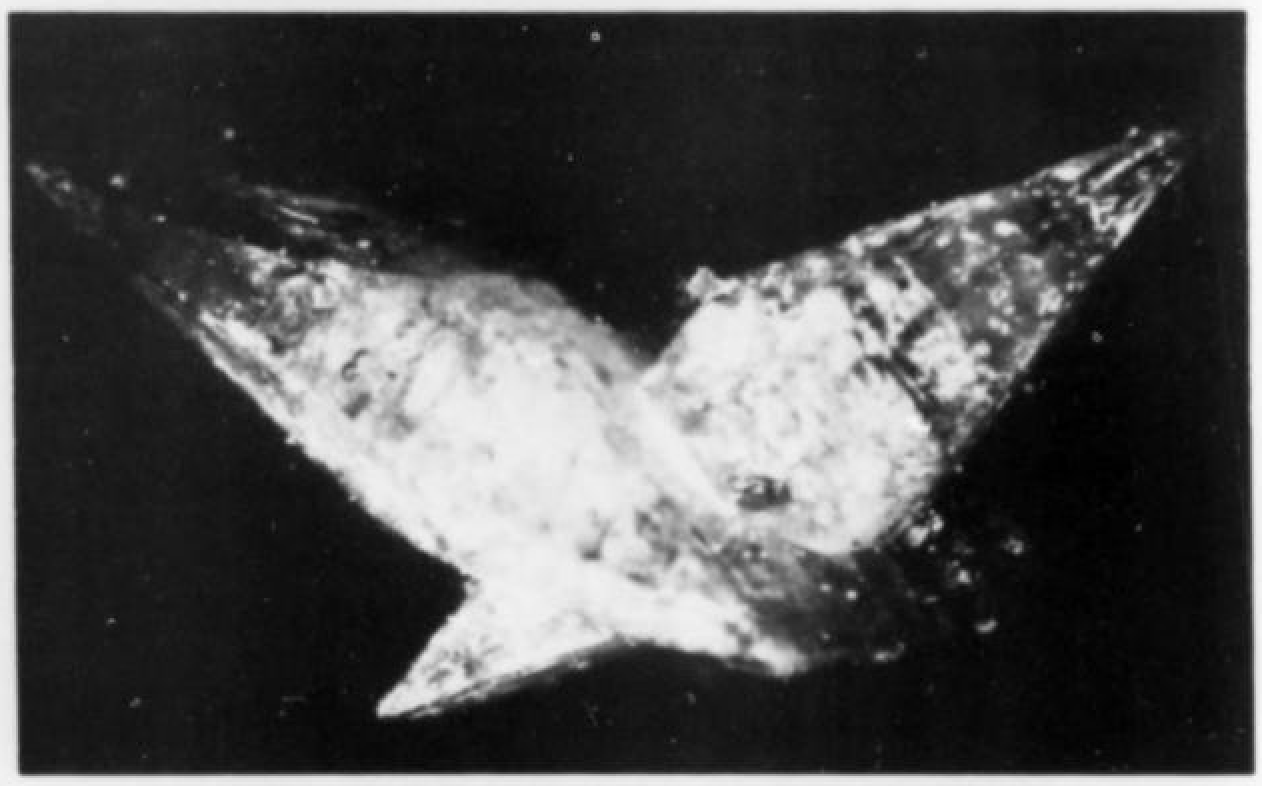

Figure 29. Red-stained, 4-mm group of prehnite crystals from the Jeffrey mine, Asbestos, Quebec, Canada. Photo by Al Stevenson.

because they are associated with smaller crystals of brown decloizite and growing on a base of white calcite.

Other attractive species Bill has to offer are greenish blue ajoite in radiating crystals, desautelsite, kinoite, large yellow crystals of bastnaesite, gorgeous alunite, and fine erionite from Thumb Butte, a locality new to me.

Alfred Stevenson (189 White Road, Minneola, New York 11501) is an extremely enthusiastic micromineral collector with a vast trading stock. Al sends much of his exchange material in very attractive, square cardboard boxes with his own printed labels. The boxes are of the old school, reminiscent of those used by Neal Yedlin, Fiss, Bement, Rakestraw and others. Al sends no exchange list as such, but has material personally collected throughout the east as well as in Arizona, Washington and Oregon. In addition, he has many duplicates obtained through the use of the silver pick. Pictured are a few specimens typical of what he has to offer.

Figure 21 shows very attractive wire silver on cerussite from Aconci, Mexico. Also from Mexico, this time from the Ojuela mine, are the well formed crystals of paradamite shown in Figure 22. From Gold Hill, Utah, are the radiating crystals of austinite (Fig. 23), while Figure 24 is of an extremely well formed datolite crystal from Fort Lee, New Jersey. The attractive prehnite group in Figure 25 is also from New Jersey. Some European specimens Al has sent are the sharp semseyite group from Roumania in Figure 26; danburite, very rare from Alpine clefts, from Switzerland (Fig. 27); and the bright green, radiating annabergite crystals from Laurium, Greece (Fig. 28). Last, I could not resist adding another prehnite of Al's, the crystals of a completely different habit shown in Figure 29 from the Jeffrey mine in Quebec.

Not shown, but other species Al has for exchange, are orange clinoptilolite from Madras, Oregon; superb cacoxenite from Garland County, Arkansas; latrappite and pyrochlore from Oka, Quebec; a large number of zeolites including erionite from Arizona; and a variety of new and very attractive species from the Christmas mine, Arizona.

Finally, and getting away from swapping by mail, I'd like to tell about a recent find of micromaterial. I visited the Seton Hall mineral show in New Jersey a couple of weeks ago. This is a medium size show with excellent dealers, speakers and exhibits, one I make it a point of attending every year. As usual, I did not overlook the small trays of loose specimens dealers relegate to the back end of their tables, and persistence paid off. John Medici had pyrite specimens, little 1-inch pieces or smaller, all from Duff's quarry in Huntsville, Ohio, and self-collected. But what pyrites! Every one was bright and shiny as a new penny, and all showed the diploid as the major face plus a number of minor modifying forms. I grabbed 15 of the pyrites plus a number of millerite/honesite specimens from Hall's Gap, Kentucky, all for a dollar a throw. How could I go wrong? I guess the moral is to look very carefully at the cheaper and less spectacular goodies in a dealer's display.

Good hunting!

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What's New in Minerals?

Wendell E. Wilson

MUNICH SHOW 1983

Europe's biggest and most impressive mineral show was particularly interesting this year because of the special displays relating to gold. Even the show program itself was a 96-page magazine containing feature articles, some in full color, on gold. Central to the various displays was an enclosed and heavily guarded exhibit containing dozens of superb gold specimens from a number of top sources including the Smithsonian, Siber and Siber, and Wayne and Dona Leicht. Another series of cases was devoted to the "Golden Triangle" area of Transylvania and neighboring regions, and there were other gold-related exhibits as well.

The buying and selling of minerals are what this show is all about, however, and there were many new and interesting finds to look over. Large quantities of superb stibnite from Bajuz, Romania, were available from a number of dealers (including *Intermin München* and *Gerhard Gerhardinger* of Mureck). Specimens of cabinet size were common, with some crystals exceeding 10 cm in length and 1.5 cm in width. Taken as a whole these were by far the finest lot of Romanian stibnite I have ever seen offered. Another dealer (*Edel Ella* of Sindelfingen) also had semseyite crystals exceeding 1 cm and jamesonite from Herja, Romania.

Giancarlo Fioravanti had some exquisite miniatures of epidote from Val di Viu, Piemonte. Equant, brilliant, complex crystals to 3 cm were available in competition quality for $100–$300. Fioravanti also had some beautiful, blackish green vesuvianite from Bellecombe, Aostatal.

Among the most impressive cabinet pieces at the show were the very large (to perhaps 15 cm *on an edge*), colorless and transparent halite crystals and crystal groups from Guewroccav, Seesie, Poland. These were carried by at least a couple of dealers (*Guiseppe Romero* of Viganello, Switzerland, and *Anna Chrapowicka* of Vienna). Other Polish minerals were available as well, including barite and sulfur from Machov.

Moroccan material was particularly plentiful in fine specimens. Triangular V-twins of cerussite have been known from Toussit for quite some time, but a few of the new ones are water-clear, perfectly lustrous, and of a beautiful smoke-gray color (*Morocco Mineralien*). Gemmy yellow anglesite crystals from 1 cm to several cm were available in quantity, as were vanadinite and fine wulfenite in several distinct habits (*Christian Gobin* of Venelles, France; *Olivier Szentessy* of Genf, Switzerland; and *Mineral Exquisit*).

Jack and Lynda Birch (*Mineral and Fossil Gallery of Santa Fe*) had a relatively new find of purple fluorite specimens with a white crust of an unknown mineral deposited preferentially on one side of the crystals. The groups, with individual crystals to about 2 cm, are from the Guadalupe mine, Durango, Mexico.

More Turkish kämmererite was available from several dealers (including *Hüseyin Dogan* of Bestwig, W.G.), although the vast majority of the crystals were damaged. Nevertheless, there were so many specimens available that a careful search still yielded several excellent pieces.

Two articles in the previous issue of the *Mineralogical Record* dealt with antimony deposits in Tuscany, and there were some truly remarkable specimens from this area for sale. Crystals of lustrous stibnite, thin and sharp and in large groups to 20 cm or more, were labeled as having come recently from the Tafone mine near Manciano. These specimens easily rank with Romanian stibnite in quality and displayability, although the individual crystals are narrower

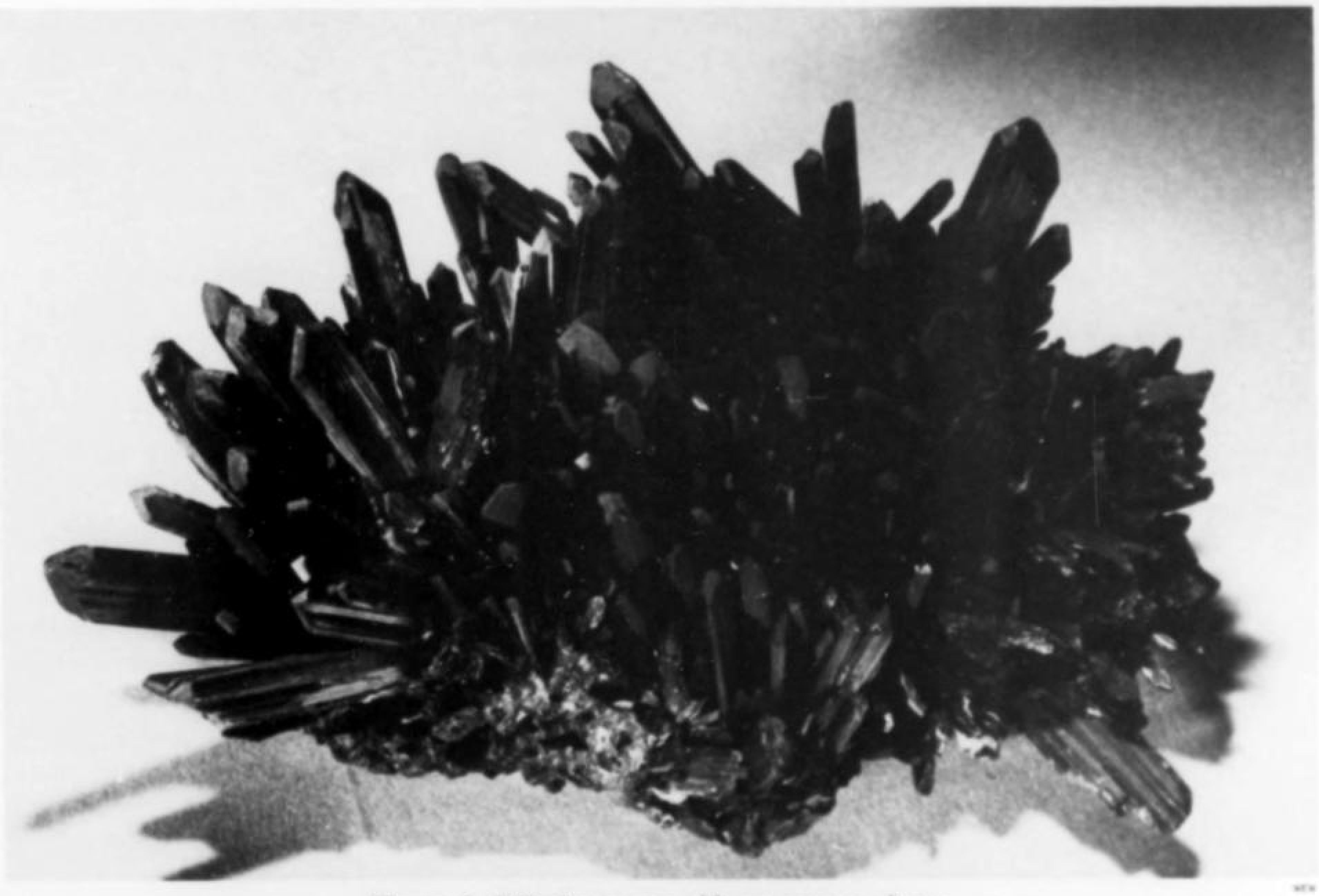


***Figure 1.* Stibnite group, 20 cm across, from Bajuz, Romania. Ella Edel specimen.**

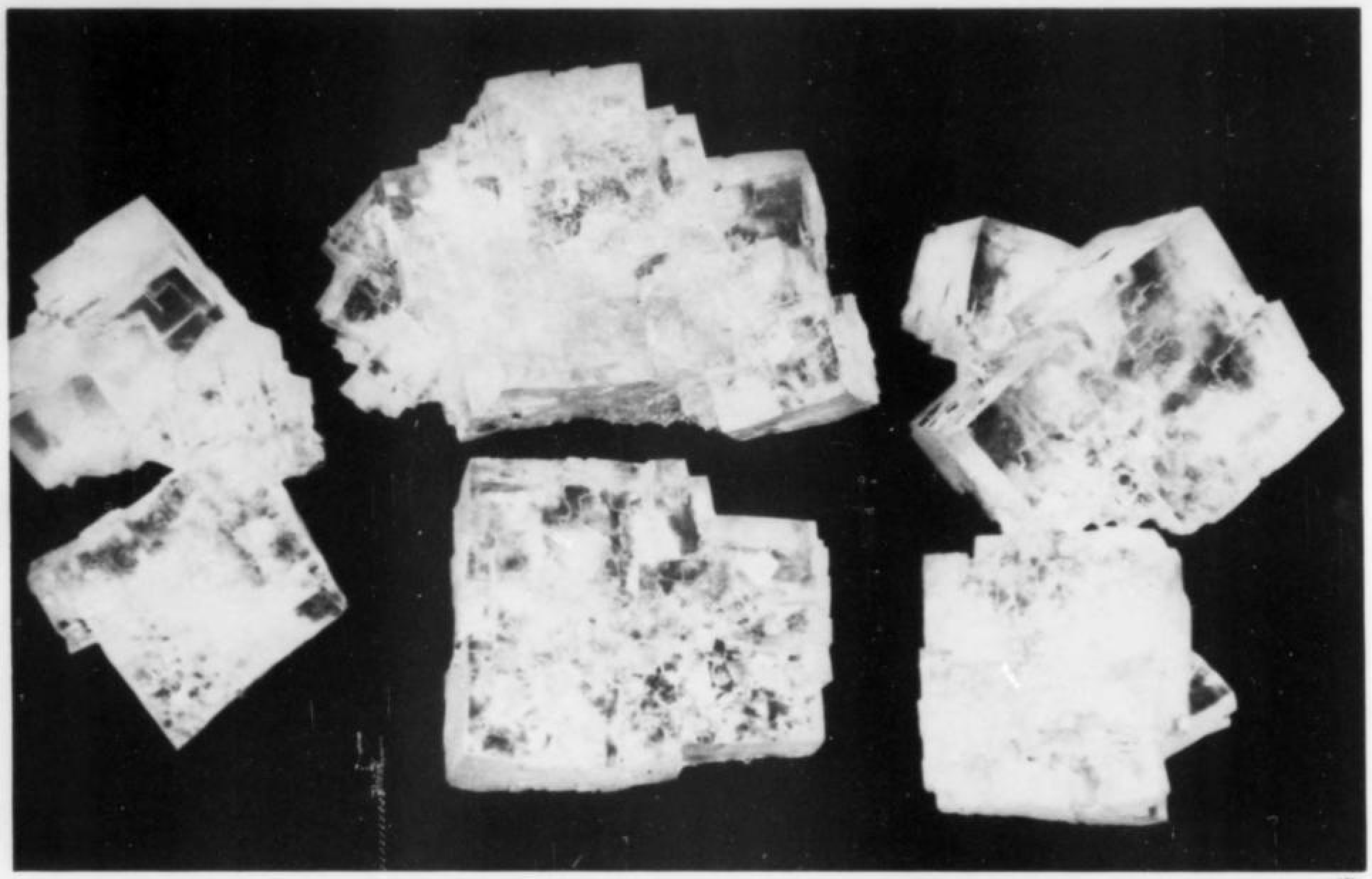


Figure 2. **Halite, the largest group about 25 cm across, from Guewroccav, Seesie, Poland. Guiseppi Romero specimens.**

in proportion to length. (These were seen in the booth of *Pierro Garonetti,* Pavia, Italy.)

A couple of strahler/mountain guides (*Charlet and Ghilini,* Chamonix, France) brought to the show a number of specimens of pink fluorite from Mont Blanc, France. The crystals are of a bright, clean color and measure up to 2.5 cm on an edge. The combination of good luster and clarity with good color and sparkling internal reflections makes these specimens exceptionally attractive, especially with the matrix of quartz crystals or white granite. Smoky quartz and quartz gwindels were also available.

A significant piece was the specimen of gemmy red cinnabar crystals to 1 cm on dolomite from Eisenerz, Austria (shown by *W. J. Knobloch,* Vienna). It was collected in 1978 and was unfortunately the only good specimen recovered, but it is definitely world-class.

Some very attractive marcasite groups from Misburg, Near Hanover, were available in the booth of *Die Rohsteinquelle* (Idar-Oberstein). Dozens of specimens, all partially to completely etched out of enclosing limestone, comprised the lot. The crystals are generally twinned into fourlings of pseudo-octahedral aspect, piled and intergrown in attractive groups, some with oriented micro pyrite crystals on the marcasite crystal faces. Thumbnail to cabinet specimens were priced very reasonably considering that many were competition quality.

For micromounters and species collectors, *Jürgen Kastning* (Reinbeck, W.G.) filled virtually his entire table space with minerals from Hagendorf-Süd. And, in general, many dealers carried species and micro material; in order to save time and trouble, they just spread the specimens out across the table, without bothering with cotton-lined boxes or individual labels like Americans do. One gets the feeling of rummaging through relatively untrimmed and unprocessed material fresh from the field, with perhaps more of a chance to find unobtrusive fragments having micromount potential.

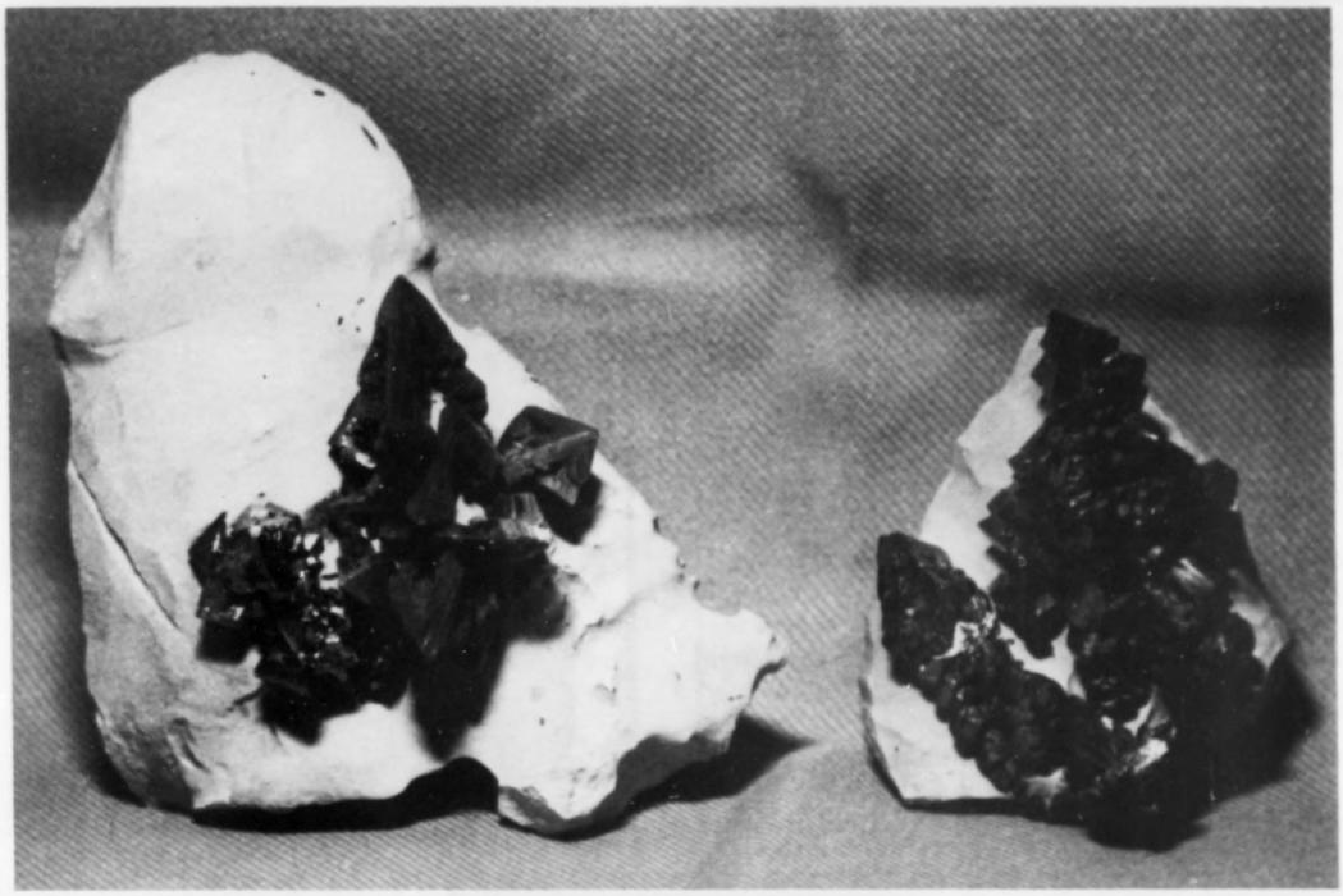
Indian zeolites and related minerals were more massively represented at the show than any other occurrence. Several dealers carried nothing but Indian minerals, and the quality throughout was uniformly excellent. For sheer poundage (or should I say kilogrammage?) the Indian quarries are a good candidate for the world's record in specimen output, and they show no signs of dwindling production.

Hans Bachleitner (Berlin) had many specimens from Anjanabonoina, Madagascar. The occurrence is a major pegmatite famous for tourmalines, but a recently discovered pocket yielded some remarkable phenakite crystals. The crystals are clear and colorless to milky or cloudy in places, well formed, prismatic with nice terminations, and generally without matrix. Crystal size ranges from about 5 mm wide and 1.5 cm long to a maximum of about 2.5 cm wide and *8 cm* long; that's big for a phenakite. About 50 crystals were recovered from the pocket, and these were priced at $15 to $120. From the same locality have come blocky yellow danburite to 4 cm, transparent spodumene crystals, large amazonite crystals, and of course the liddicoatite member of the tourmaline group. All of these species were available from Bachleitner, including some attractive polished slabs sectioned from liddicoatite crystals. Liddicoatite, with its intricate color zoning patterns, is one of the few crystallized minerals which is actually more interesting (I should bite my tongue) *after* lapidation.

One expects to see more European minerals at the Munich show than one would in the U.S., and that certainly proved to be true. One dealer, ironically an American, obtained for the show a major batch of Trepča, Yugoslavia, minerals (*Rena Schmidt,* Westfield, NJ). These included the classic rhodochrosites, sphalerites and other species for which Trepča is so well known.

Gonzalo Jara of Bogota, Colombia, specializes in Colombian minerals, particularly emerald crystals, and his little showcase in the booth of *Hamburger Mineralien Zentrum* was very attractive. A nice thumbnail-size crystal (8 x 16 mm) of emerald, having fine color, clarity and crystal form, but no matrix was priced at $125. At least a dozen matrix specimens and a dozen singles were available, all of them zingers. In addition, Gonzalo had in his pocket a special specimen: a well formed brown parisite crystal, about 1.8 x 2.5 cm, from Muzo, Colombia.

A find of approximately 100 cassiterite crystals from Ellsmore,



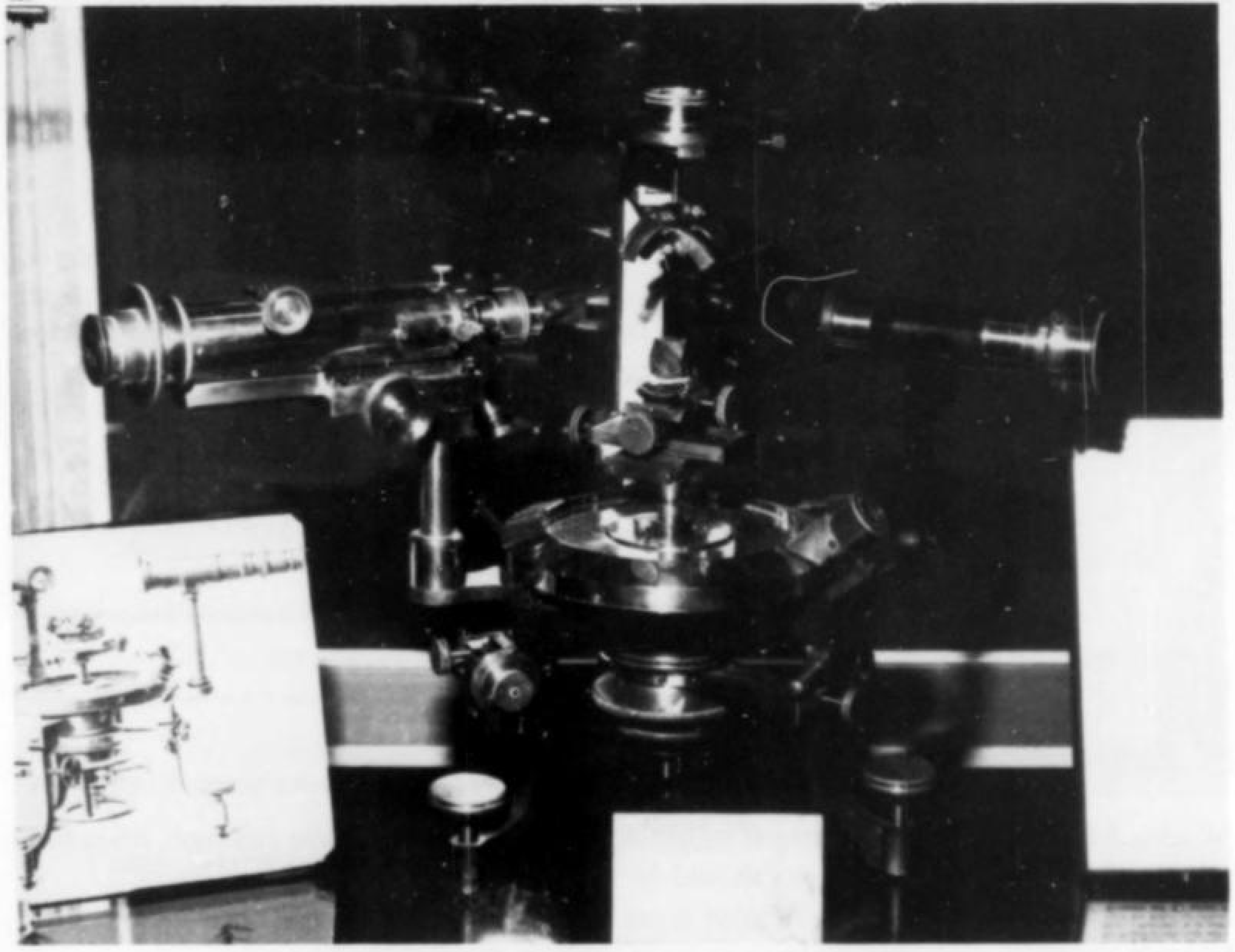


Figure 3. **Marcasite crystals in limestone from Misburg, near Hanover, West Germany. The specimen on the right is 6 cm tall. Die Rohsteinquella specimen.**

Figure 4. **One of several rare and valuable antique goniometers in the case of *Mineral Exquisit*.**

New South Wales, Australia, appeared in the booth of *Olivier Szentessy*. The largest crystal is nearly 5 cm, and many fine examples around 2.5 cm were in the lot as well, all on matrix. The crystals are fourling twins resembling a tetragonal prism and dipyramid combination, except for a small re-entrant at the point of each "dipyramid." The black, highly lustrous crystals are worked out of muscovite matrix and make fine, competition-quality specimens. The prices of $185 to $330 seemed reasonable considering the quality.

Of course this report does not begin to cover all of the minerals available at the show. Attractive blue aquamarine crystals continue to be available from Pakistan; silver specimens, freshly mined from a small specimen operation, have appeared from Kongsberg, Norway; Yvonne Barstow from Cornwall had many rare Cornish species; and there were others. As with the Tucson Show, one would have to visit personally in order to comprehend all that is available.

There were non-mineral items available too, of course. Several book and magazine publishers sold their wares, and one dealer offered used books. Several different styles of all-brass antique German miners' frog lamps were for sale, all of them fakes. A fantastic collection of antique goniometers was sold as a unit by Karin Burchard (*Mineral Exquisit*). There were seashells, faceted stones and jewelry too, though the lapidary arts are not emphasized at the Munich Show.

For Americans the Munich Show is a refreshing change in many ways and well worth the visit. Show Chairman Johannes Keilmann says that a few copies of the show program are still available for $10 (order from Mineralientage München, Postfach 60, D-8024 Oberhaching, West Germany). This program and *Lapis* magazine's recent gold issue make nice companion pieces to the *Mineralogical Record*'s own gold issue for readers who can understand some German.

One final item worth noting: each year the dealers select one or two of their very best specimens and place them in competition for the Victor Goldschmidt Prize. The winner this year was none other than Herb Obodda of Short Hills, New Jersey; and he won it with the Pakistani aquamarine group pictured in the last issue of the *Mineralogical Record,* p. 45. Congratulations Herb!

MONTANA QUARTZ TWINS

Chris van Laer (610 N. Alaska, Butte, MT 59701) reports as follows:

"I am enclosing photographs of Japan-law quartz twins that I recently found. In my capacity as geologist and mineral collector, I was asked to do some work at a locality called the P.C. mine in Jefferson County, Montana. Initial work uncovered several large pockets and a number of fine Japan-law twins, some with acicular inclusions of tourmaline. I worked the locality for several months last summer and found several hundred twins, the largest a floater measuring 11.4 x 12.7 cm on one member of the twin and 6.3 x 6.3 cm on the other member. This specimen I gave to the property owner, and he donated it to the Montana Tech Mineral Museum.

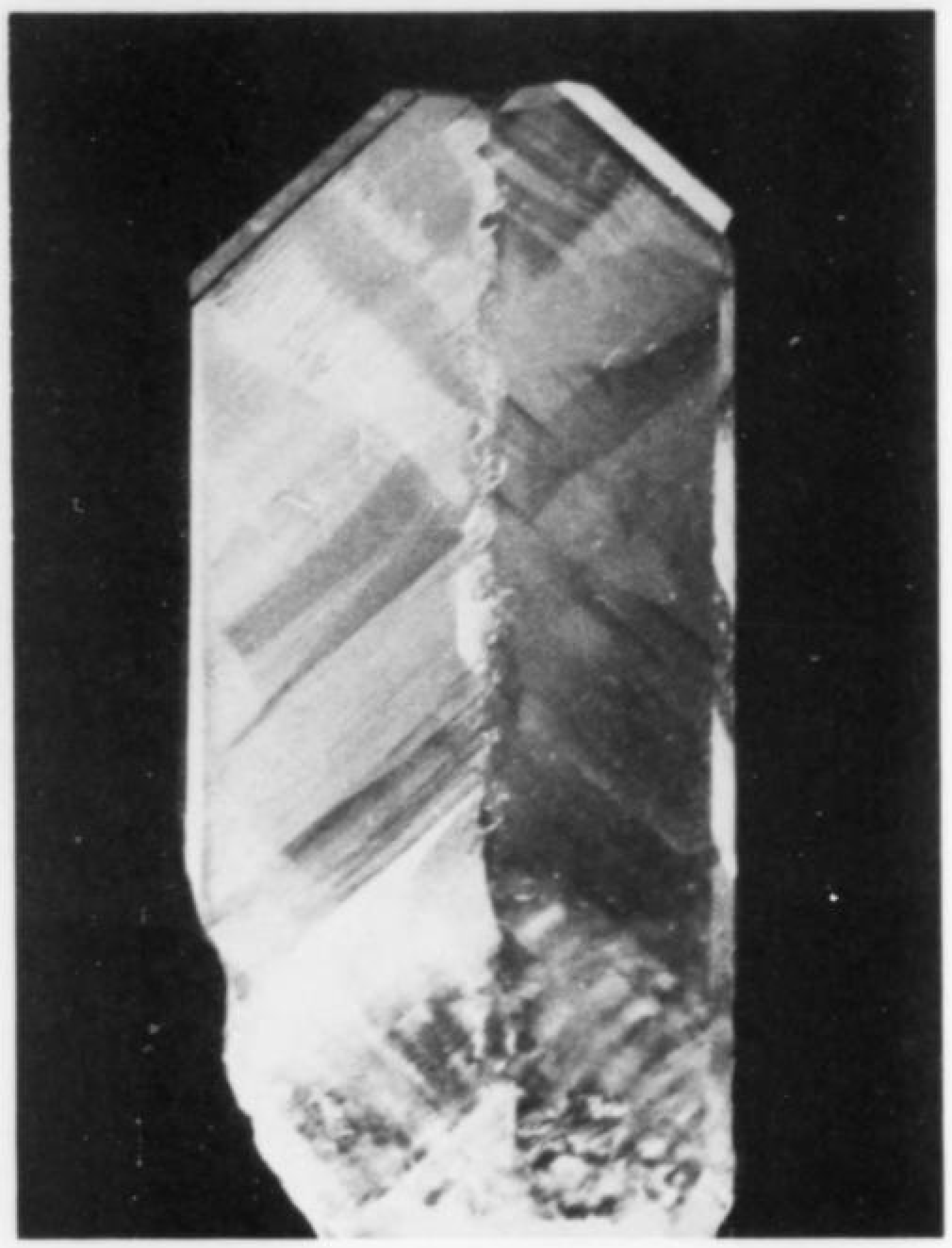


Figure 5. **Quartz Japan-law twin 3.3 cm tall, from the P.C. mine, Jefferson County, Montana. Chris van Laer specimen and photo.**

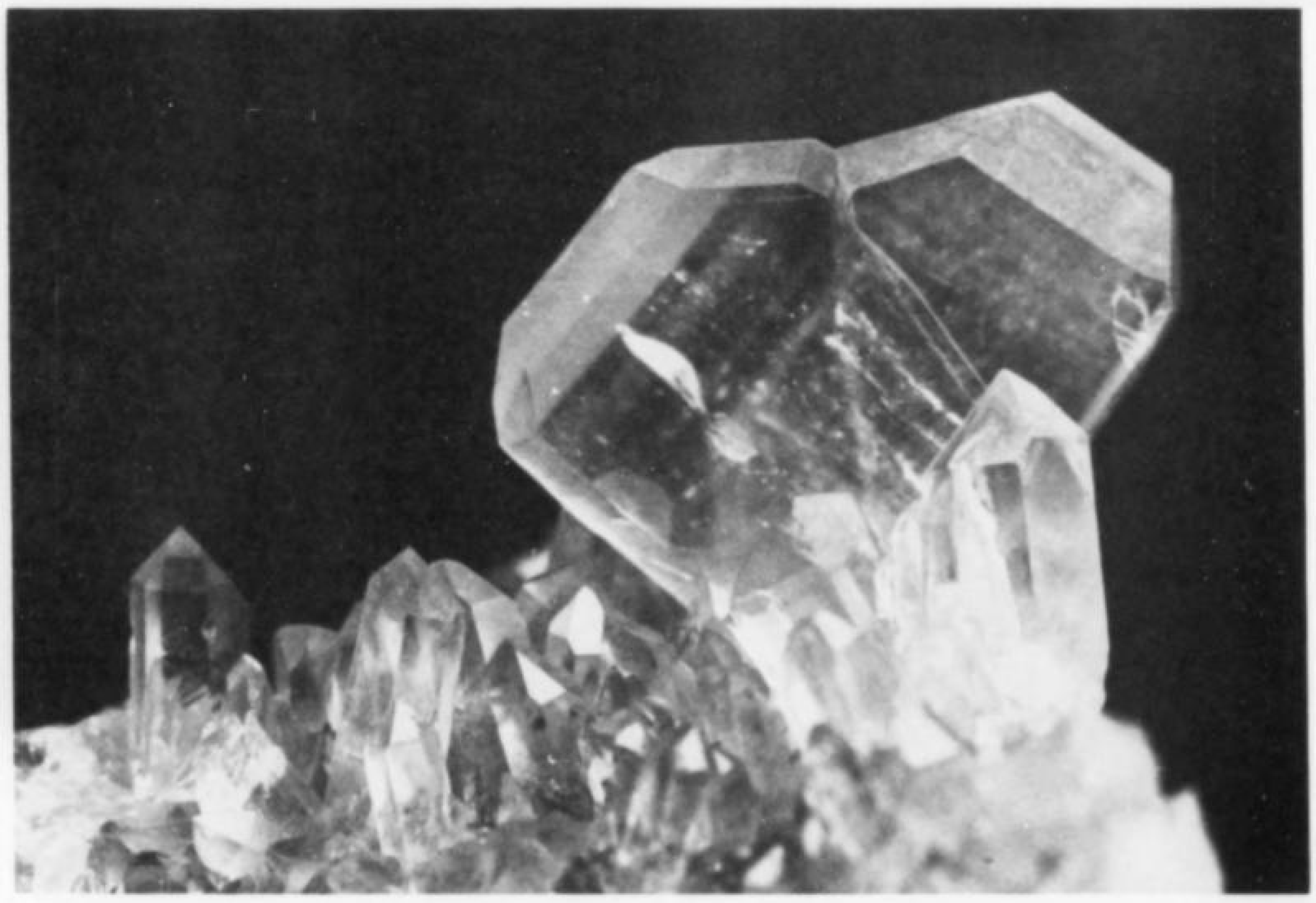
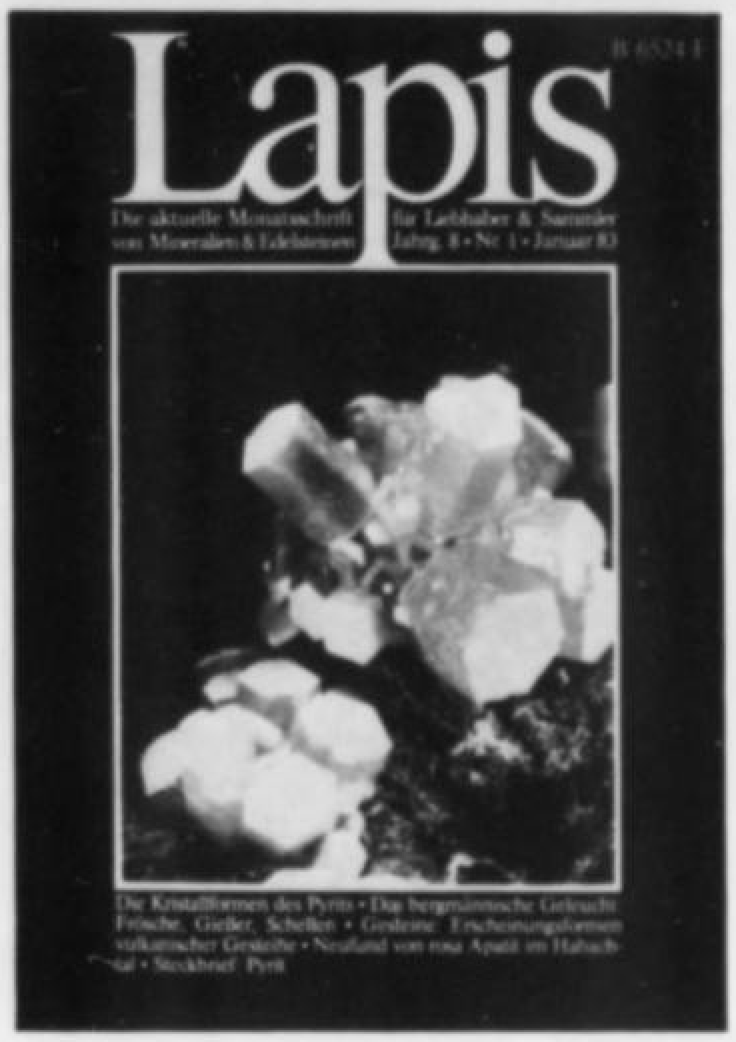


Figure 6. **Quartz Japan-law twin measuring 4.6 cm across, on quartz crystal and andesite matrix from the P.C. mine, Jefferson County, Montana. Chris van Laer specimen and photo.**

"The locality remains under snow at least seven months of the year. But there are literally thousands of small cavities exposed in the outcrop, and the initial work has barely scratched the surface. Commercial collecting will continue there next summer, when more specimens should be found.

"The deposit is on patented land and is not open to the public. Specimens will be for sale at the Tucson Show."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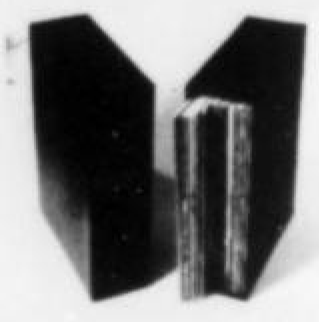

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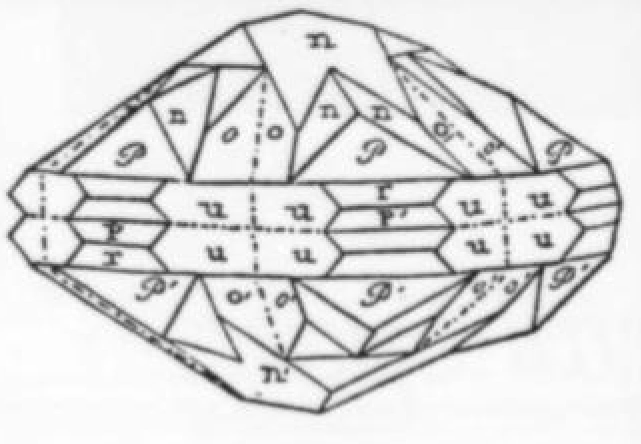

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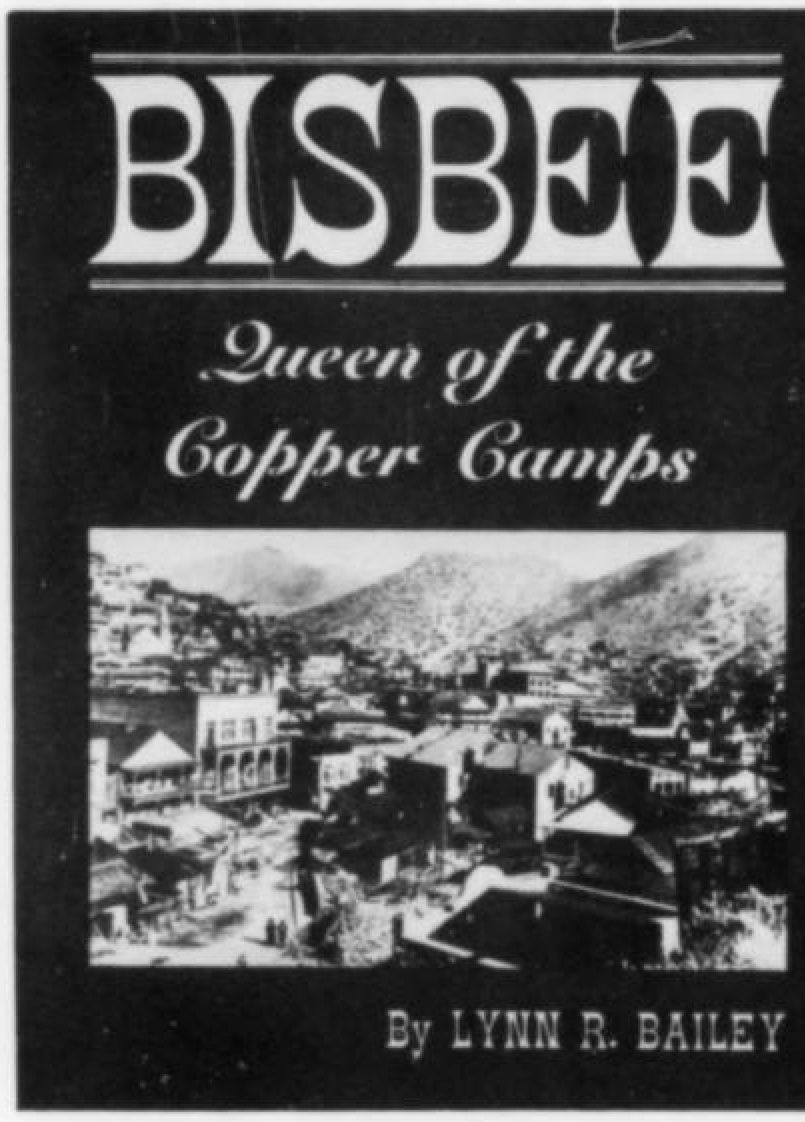
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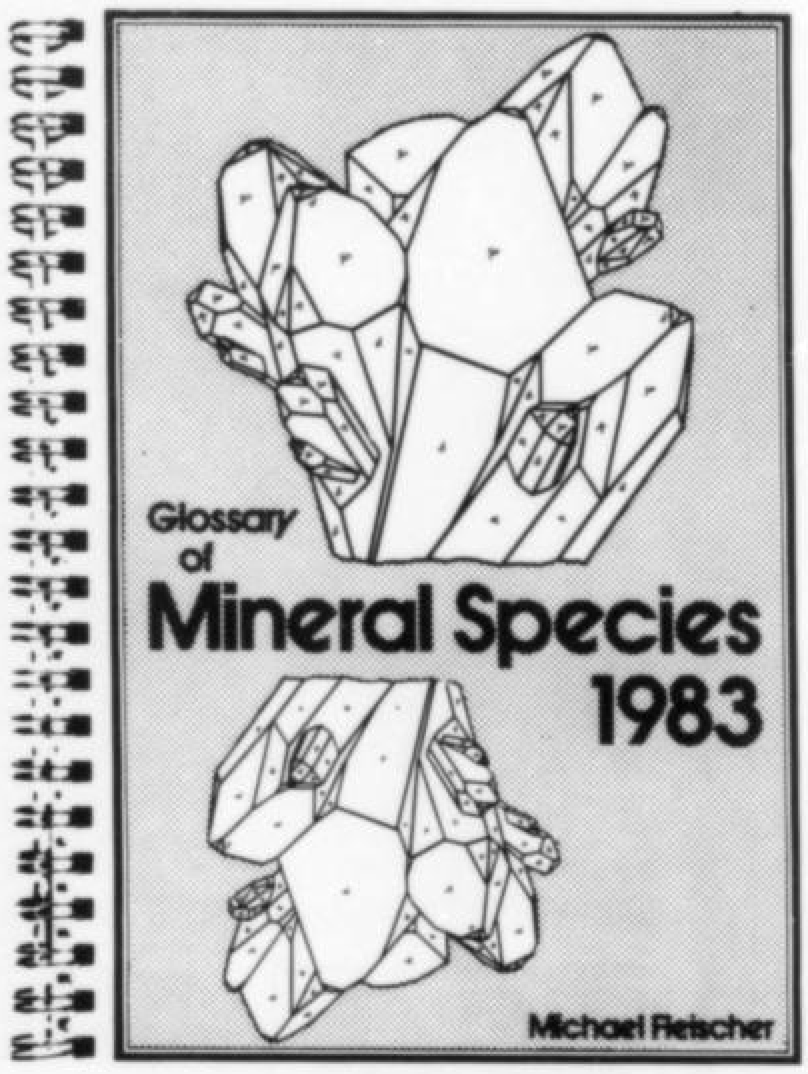
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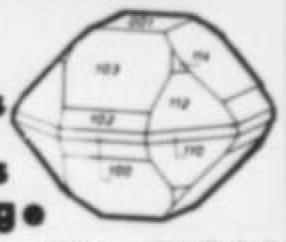

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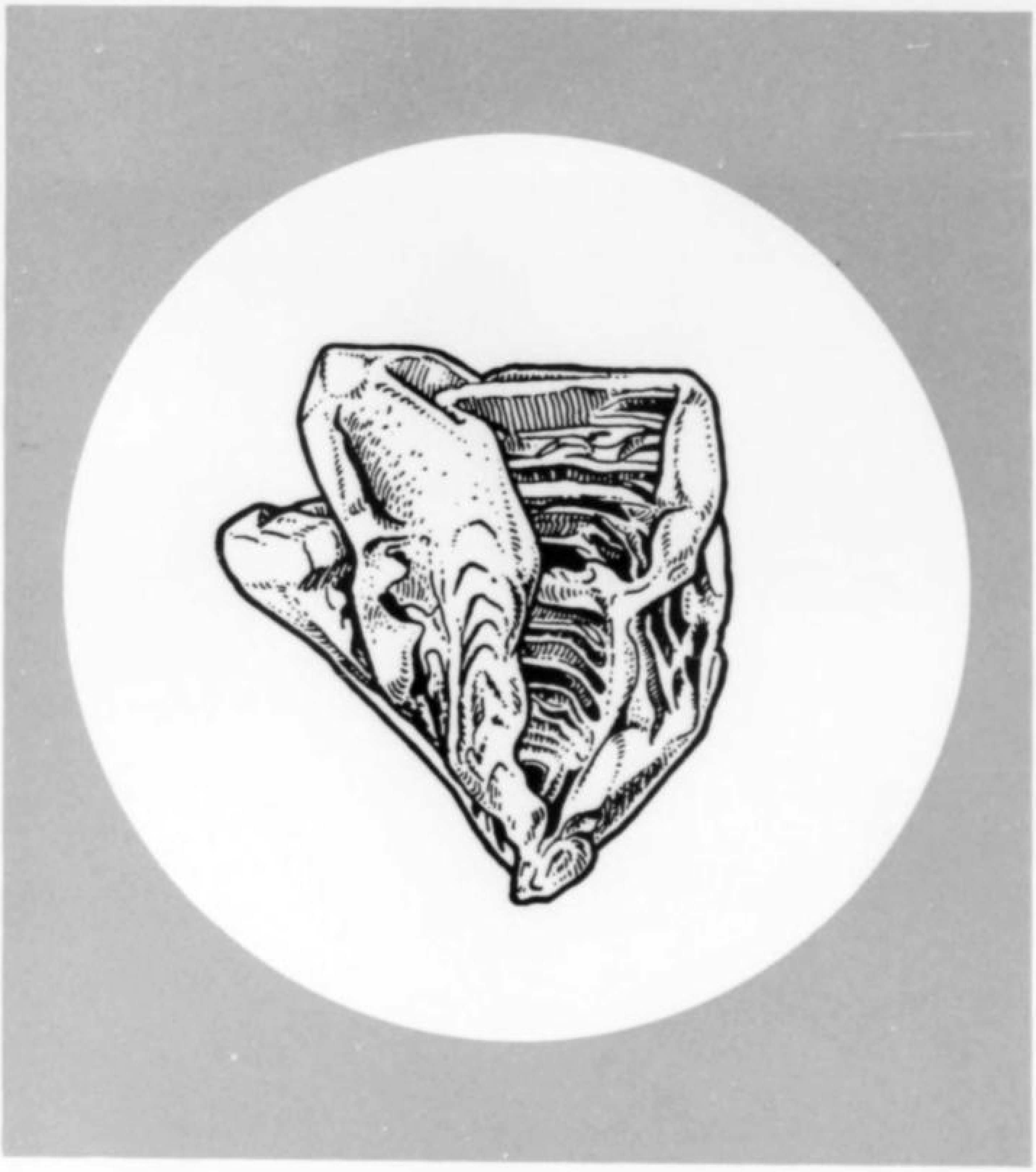

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