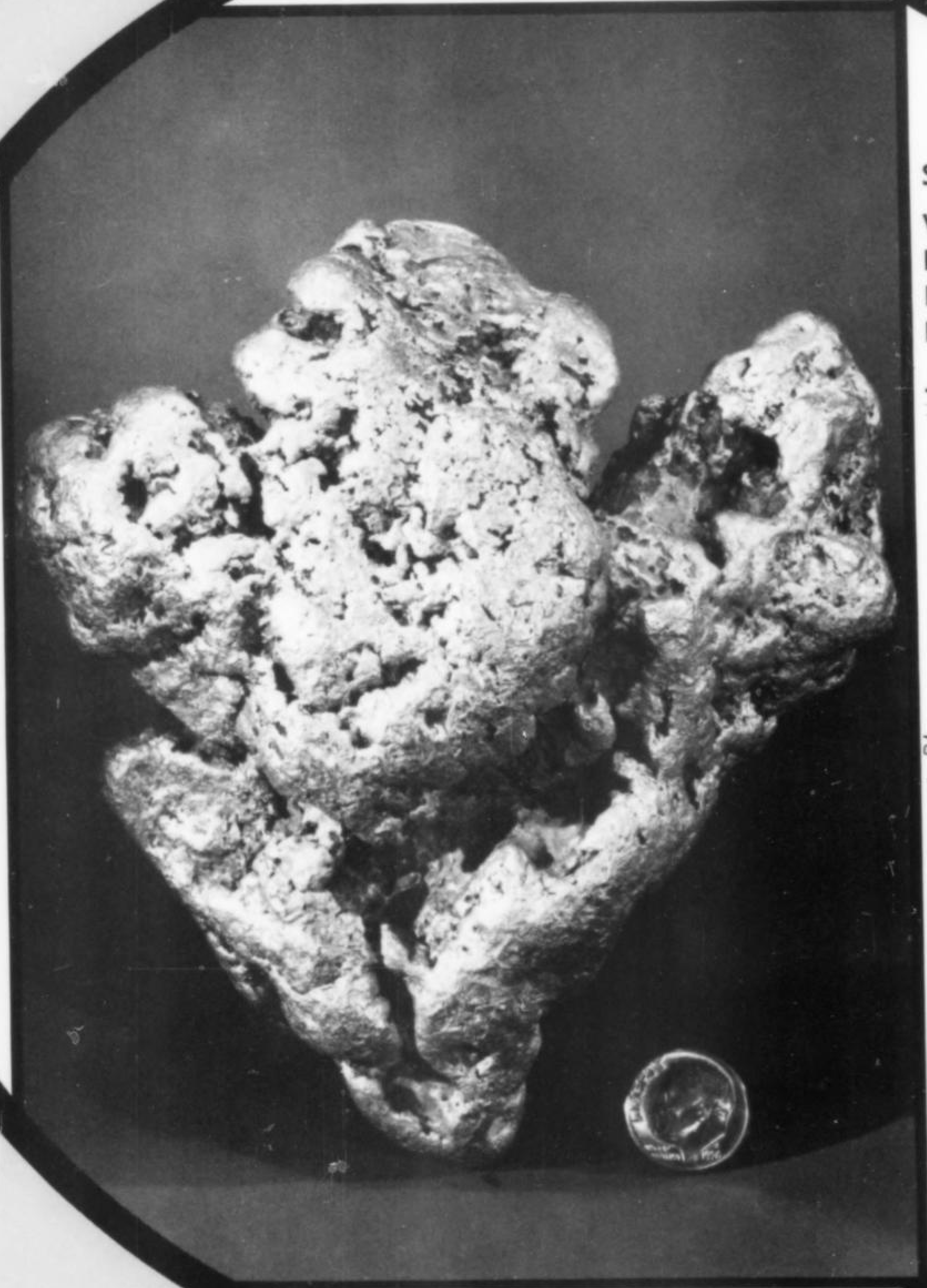
the Mineralogical Record

Volume Nine, Number Three
May - June 1978 $3



SHOWS:

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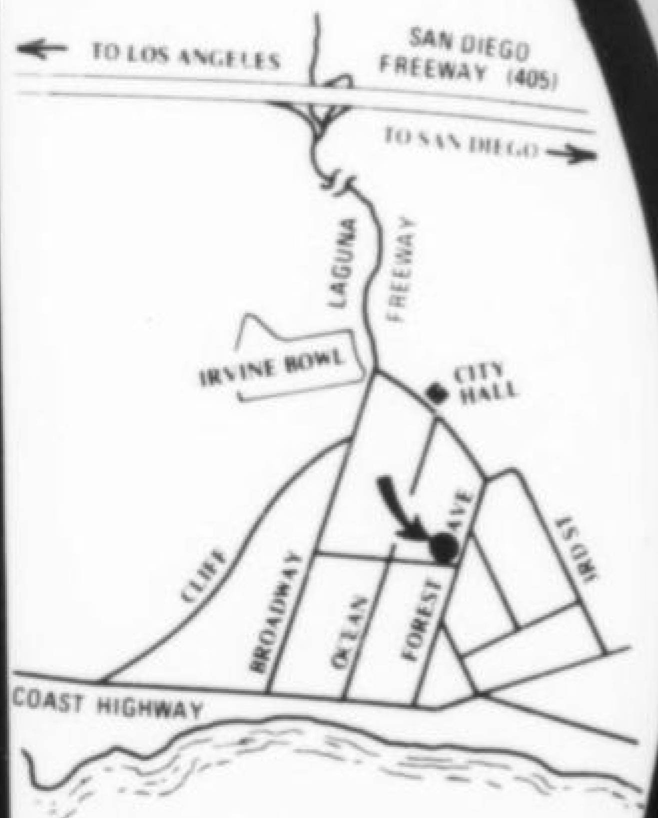

HOURS: Tues. - Sat. 10-5
Sunday 12-5 (evenings
by appointment only)

the Mojave Nugget
Found December
1977, Mojave
Desert, Calif.;
5½ x 5 x 2¾ in.;
156 troy oz.;
13 lbs.

Inquiries invited.

KRISTALLE

Wayne and Dona Leicht, 332 Forest Ave. #8, Laguna Beach, Cal. 92651 [714]494-7695

affiliated with the Friends of Mineralogy

the Mineralogical Record

Volume Nine/Number Three
May—June 1978

feature articles

departments

RHODOCHROSITE from the N'Chwaning mine, Kalahari Manganese Field, Cape Province, South Africa. The group is about 7 cm tall. Photo by Harold and Erica Van Pelt; from the collection of William Larson.

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The Mineralogical Record costs $13.00 per year, domestic and foreign.

editorial matter

Contributed manuscripts and news items are welcomed, but acceptance is subject to the approval of the editorial board. They should be mailed to the editor at the afore-mentioned address, and should be accompanied by a stamped, self-addressed envelope. No responsibility can be assumed for unsolicited material. See vol. 9, no. 3, p. 135, for suggestions for authors, or write to the editor for a copy.

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notes from the EDITOR

ANNUAL AUCTION

Our annual auction at the Tucson Show was as successful this year as it was last year, and that's saying something! It was made possible by more than a hundred donors, an enthusiastic audience, the Tucson Show Committee (who provided the auditorium), and our staff of volunteers. Our professional auctioneer Clarence Maier officiated again this year, and did an admirable job of working with the huge audience, keeping the pace up, and entertaining everyone. Bob Jones and Dick Hull helped as spotters in the audience, Bill Pinch helped introduce specimens, and Ann and Dean McCrillis, Don Olson, Pat Carlon, Ron Bently, Dick Thomssen, Walt Risch, Star Northam, Carolyn Wilson, John Muntyan and Wayne DeBrusk assisted with record keeping and specimen handling.

Listed below are all (I hope) of the people who have made donations to the *Mineralogical Record* within the last year, except for those who wish to remain anonymous. Most donated specimens to the auction, but Randolph Rothschild, Forrest Cureton, David Wilber, Miguel Romero, Richard Webster, John Barlow and Rustam Kothavala made cash donations, in some cases in addition to auction donations. On behalf of the readers and staff of the *Mineralogical Record* I would like to thank all of these people; their generosity will help maintain and even raise the quality of this journal.

Donations are accepted from anyone at any time of the year. Because the *Mineralogical Record* is a non-profit organization such donations carry excellent tax advantages.

TSUMEB AND COLORADO ISSUES

By the time the Tucson Show opened this year, orders had been taken for the last remaining copies of the Tsumeb issue (vol. 8, no. 3)...sold out in about nine months. This is particularly remarkable because we printed 10,000 copies at a time when we had only about 5,000 subscribers. In any case, we have no more available. I have been asked several times about the possibility of reprinting the Tsumeb issue; I can say without question that this will be impossible. The combination of color photography, length, paper quality and binding style made the Tsumeb issue so expensive to produce that we could never have done it without grants, and could certainly not produce a reprint without additional grants. Were we to receive additional grants we would rather use them for new projects instead of reprinting old ones. We are content to allow those copies of the Tsumeb issue al-

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ready in existence to become valuable collectors' items, and do not plan to dilute the market with reprints. (Copies are already selling for $15 to $20 in Europe, but Si and Ann Frazier —see their ad— still have some available at the original retail price.)

Despite an offer to *buy* copies of the Colorado Issue (vol.7, no.6) for $3 each (the cover price was $2 and subscribers paid only $1.67 as part of their subscription), Si and Ann Frazier have not been offered a single copy. They have recently doubled their offer to $6 (and will resell any they get for $12); they have plenty of customers waiting, so if you have an extra copy please let them know.

ILLUSTRATED SPECIMENS

Any specimen which has been illustrated in a book or periodical is of particular interest to many people. The specimen is documented in print for all time, and will carry with it this "pedigree" for as long as it survives. The Smithsonian Institution, for instance, maintains a card file on specimens in its collection which have been described in the literature, and indicates on the label if a specimen has been figured. Of particular pride is a group of specimens from the old Seligmann collection (later part of the Bosch collection; see Arthur Roe's article on page 181 of this issue) which were all illustrated in the 1903 book *Das Mineralreich* by Reinhard Brauns.

During the 8½ years since the first issue of the *Mineralogical Record* we have published photos of about 1500 mineral specimens from institutional and private collections all over the world. Collectors owning illustrated specimens are (we trust) proud; institutions owning illustrated specimens may wish to keep track of the details but may not yet have established a system. In order to assist collectors and curators with the preservation of this information we are offering, at no cost, labels of the type shown below to anyone owning specimens that have at one time been illustrated in the *Record*. Simply send us a stamped, self-addressed envelope and a cover letter telling which specimens you have; an appropriate number of these cards will be returned to you. This offer is also open to label collectors (limit of two cards per person). The cards are printed on heavy, high-quality business card stock. They may be stapled to or stored with your own label and/or other labels you have for your specimens. Although these cards are anyone's for the asking, we feel their use will not be abused; it will be a simple matter for any future owner to check back and compare with the photo in the *Record* to be certain his specimen is really the one illustrated.

This specimen was figured in the

Mineralogical Record

Vol.__no.__p.____Fig.__

ERRATA

In the California Issue (vol.8, no.6, p.451,452,456), in the article on the Benitoite Gem mine, it was stated that the Mina Numero Uno, a nearby mine having a similar mineralogy, is under claim by Eugene and Sharon Cisneros. This is only partially correct. Mina Numero Uno is claimed and worked jointly by the Cisneroses and Gary and Carol Mathiasen (Mathiasen Minerals, Fremont California).

NOTICE!

FOURTH JOINT MSA-FM MEETING AND SYMPOSIUM

DETROIT, MICHIGAN

OCTOBER 15-16, 1978

The fourth joint meeting of the Friends of Mineralogy and the Mineralogical Society of America will be held at the Detroit Armory, Detroit, Michigan, in association with the Greater Detroit Gem and Mineral Show. These will include both general sessions and a symposium, the title for which is **"Descriptive Mineralogy: Discovery and Characterization of New Minerals."**

Papers are solicited for both the general technical sessions and the symposium. An abstract consisting of a maximum of 250 words should be sent to:

Donald R. Peacor
Department of Geology
and Mineralogy
The University of Michigan
Ann Arbor, Michigan 48109

The **deadline** for receipt of abstracts is **September 1, 1978,** but all potential contributors are urged to contact D. R. Peacor in advance. Authors should keep in mind while preparing abstracts that attendance at the technical sessions is marked by significant numbers of both professional and non-professional mineralogists.

ADVANCE REGISTRATION

Advance registration materials may be obtained through:

Mr. Keith Alcorn
1691 Oak St.
Birmingham, Michigan 48009

The cost of advance registration is $20.00 before September 15 and $25.00 after that date.

NOTICE!

WORLD DIRECTORY OF MINERAL COLLECTIONS

Second Edition 1977

The Commission on Museums announces the publication of the second, greatly enlarged edition of the World Directory of Mineral Collections. Just as with the first volume, the second edition has been compiled according to responses to the questionnaires distributed by the representatives of the Commission in the countries which are membees of the IMA. Thanks to the enormous cooperation of these members the second edition contains much new information from countries which have not been represented in the first edition, as well as from countries hardly mentioned in it. On the whole, there are included from 32 countries 455 collections in the new edition, whereas the first edition included 231 collections from 22 countries.

For each collection, on a separate page, the description includes the name of the owner, the location, the name of the person in charge, the total number of specimens, the number of minerals, rocks, ores, gems and meteorites, the specialities and uses of the collection, the availability of specimens for study, loan, or exchange, the admission hours, and miscellaneous notes.

The price of the volume is US $10,–, *including surface mail all over the world.* There will be an additional postage charge if airmail is requested.

Copies may be ordered from **Dr. Ole V. Petersen,** Geological Museum, Øster Voldgade 5-7, DK-1350 Copenhagen K, DENMARK. Please, send your remittance with the order and make checks or money orders payable to the International Mineralogical Association.

BOB SULLIVAN'S

LETTER from EUROPE

As I write this the first snows have already arrived, most of the fall and early winter mineral *bourses* (shows) are over and the end of the European mineral season is fast approaching. Thanks to all of you who have written and commented on my column and for those of you who have asked or urged—I do intend to keep it up, for there is no lack of material to write about. I was somewhat surprised by the interest in my letter in Europe, particularly since it has been oriented more toward the American readers. Seems the Europeans, via club activities, their own countries' magazines, bourses, etc., are pretty much on top of events in their own country, but are somewhat out of touch with the goings on in others. I never realized the "fences" were quite that high.

Several readers have requested the dates of various European bourses but for a number of reasons I cannot provide this information directly. The dates are usually changed from year to year, many are announced very late, and the best bet is to write or subscribe directly to one or more of the European mineral magazines. Most are quite complete on their own countries' bourses and the German magazine *Lapis* tries to cover most of the major European ones.

The fall bourses, with one exception, produced no spectaculars, but minerals were more plentiful than ever and prices averaged generally lower in terms of European currencies. Visiting Americans—both dealers and collectors, including some of "the museum people"—were confronted with a steadily falling dollar and were somewhat shocked at prices, particularly in Munich and Zurich, when the dollar hit a low of about 2.20 Swiss Francs—slightly higher on the German Mark. The slide has continued and at this moment the dollar is under 2 Swiss Francs, a fall of over 25% in the last year. Where or when the slide will stop is anybody's guess, but one thing is certain: the cost of virtually all imported minerals will be much higher in the days to come, and now is a good time to buy from existing U.S. dealers' stocks. Unlike gemstone dealers, who mostly adjust their prices with daily money market changes, most mineral dealers tend to sell their stock at prices based upon their original cost.

At Altdorf, Switzerland's traditional first fall bourse, over 5000 visitors flooded this tiny alpine town to peruse the wares of some 138 dealers from 6 different countries. The Swiss *strahlers* reported it had generally been a pretty lean summer, however I noted three different offerings I thought quite outstanding.

Our worldwide roving young Swiss friends, Olivier and Francois, passed up another jaunt to that axinite locality in Australia to search the high Alpine clefts in the Mont Blanc Swiss-French border region. They really hit the jackpot with a pocket of pink fluorite on beautiful smoky quartz. About a dozen hand-size specimens were taken out, each with three to six deeply colored, pink, 1 to 2 cm, octahedral fluorite crystals laying atop and at the base of clusters of rich brown smoky quartz crystals 2½ to 3½ cm in length. They worked very hard over a period of several days to extract the specimens virtually damage free, and needless to say they went fast even though prices were close to the kilobuck region.

Another rope-climbing strahler who had worked the high altitudes of the Göscheneralp (canton Uri) region also offered about 40 variously sized specimens of pink octahedral fluorite associated with clear quartz. Typically the pink color of the Göscheneralp fluorite was weaker but there were a number of highly sought after floater crystals up to 3 cm to be had. I also saw a few large floaters from nearby Fibbia. Frankly any pink Swiss fluorite on the market these days is automatically classed as a rarity and commands a very steep price.

Swiss collectors were highly excited about a new find of gemmy titanite from an unspecified Alpine locality that was hit just 10 days before the Altdorf bourse. While the crystals were somewhat small by Swiss standards, about 1 to 2 cm, they were a very brilliant, rich, golden brown color and were prolifically scattered on a white milky quartz matrix, making very attractive specimens. The strahler who hit this large pocket was selling them like hotcakes at from $20 to $500 apiece and had a 2-meter table full of them. I made a quick calculation of the table value and come up with a figure of over $30,000—who says you can't make a living digging rocks?!

Being somewhat of a crystal nut, I was especially attracted by another strahler's table that was loaded with a couple of hundred of those famous Swiss "Cavradischlucht" (Cavradi Gorge) hematite crystals from the St. Gothard area. The crystals ranged from 2 to 10 cm(!), most off matrix, others perched on clear quartz with typically some 20-30% of them having thin, millimeter-size, elongated, orange-brown, striated rutile crystal blades on the surfaces of the hematite. The hematite crystals were mostly single and multiple thin crystal plates, most under ½ mm thickness, a few in rosette form, but several unusually thick ones caught my eye. Here the hematite crystals were perfectly terminated, particularly brilliant and ranged from 2 to 8 mm in thickness. The thicker crystal specimens were quite pricy, but the majority of the specimens were more reasonable than I had ever seen them before.

A fine collection of some 800 Swiss Lengenbach quarry specimens (see the *Record*, vol. 8, no. 4) was shown by another strahler, this the result of his two weeks of digging there this past summer, plus many hours of trimming, mounting and identifying this fall. Prices to me seemed reasonable considering his effort, although the rare ones such as lengenbachite, imhofite and binnite (tennantite) are commanding pretty good prices over here in a booming European micromount market. The few Swiss who offer lengenbach material claim only visual identification for a species and say that prices would otherwise be way out of reach. This can produce some surprises both ways.

France's "Mine Des Farges," now known as "the pyromorphite place," continues to come up with surprises. This fall at several bourses it was pyromorphite again, but this time a striking two-color variety which has been baptized "polka dot" pyromorphite. The elongated hexagonal crystals ranged from 1 to 3 mm in diameter by 2 to 6 mm in length, and were a bright tannish brown color. The tips of all the crystals were thickly capped with a bright yellow coating giving a most pleasing effect. I have seen a few yellow capped crystals varying from a light green-brown to a dark grey-green color making an even more dramatic contrast. The best of these "polka dots" are small 2½ to 3½ cm stalactitic clusters, or those in which the pyromorphite has more or less completely coated small floater pieces of dark brown barite somewhat resembling the bark of a tree. The yellow tips have been called mimetite, but to my knowledge positive identification has not been made. Regardless, they are attractive and to me are somewhat of a "sleeper" since prices were generally moderate.

Another rather pleasant surprise this fall was the reappearance of that superb Turkish kämmererite (the *Record*, vol. 8, no. 4, pg. 282) on several dealers' tables. As a result of several Summer and early Fall expeditions to this remote mountainous area of Turkey, a variety of specimens were available and at prices somewhat more moderate than earlier. Crystal sizes generally seemed to run larger and color deeper than the first finds, but many lacked the exceptional brilliance of initial lots. Top thumbnails and miniatures, particularly those on which the kammererite completely covered the top surface of the chromite matrix, were still commanding top prices however. The originally very secret mountain locality in Turkey is now being given as "Erzincan," but it is still incomplete. The word is that this one has now peaked out, but time will tell. Incidentally an excellent paper on this occurrence of kämmererite has been received by the *Mineralogical Record* and will appear shortly.

An interesting note is the fact that at the Brussels bourse one Belgian dealer was offering a small collection of kämmererite on chromite from Russia. Locality was stated as "Werbljuge, Ural, U.S.S.R.," and the specimens were remarkably similar to the Turkish ones. Crystals were much smaller (1-2 mm) and less brilliant with quality being strictly average, but prices were moderate.

The mid-Fall Geneva bourse was in every respect a successful event, even though no spectacular minerals (with the possible exception of a superb Indian powellite on matrix) appeared on the scene. This year's committee worked hard to put it across and was rewarded by nearly double normal attendance. They did limit the number of dealers to "only" 65 (most of whom went home very happy), arranged special tables for club sales by the juniors, free tables for traders, and a very fine exhibit of classical Swiss minerals by the Geneva Museum of Natural History. Curator Jacques Deferne was on hand both days to explain his several display cases as well as, it seems, to continually turn down offers to trade off some of his top exhibit pieces! One indeed did tempt me—but let me tell you about that one.

Some years ago I remember reading an article about the world's largest crystals which, among other things, described the world's biggest anatase crystal as a 2½ cm specimen from Slidre, Norway, resting in the National Museum in Oslo. During a subsequent visit to this charming city, I inquired about it and curator Bill Griffin informed me that it had been stolen along with many other fine specimens a couple of years before. However, "it was more like 2 cm," he said, still a giant by any standard.

As I walked past the Museum of Natural History display in Geneva, one specimen caught my eye and gave me quite a jolt. It was a huge, brown, doubly terminated fat anatase crystal perched sassily on a matrix approximately 2½ by 3½ cm. Beside the large crystal was another "smaller" one I roughly estimated to be close to 1½ cm. When I asked Jacques Deferne how large the monster anatase was, he said it had never been measured! "But it could be the world's largest anatase" I said and "certainly for posterity its dimensions should be recorded." Sometimes I wonder if he really believed me, but he did agree to get me the vital statistics. Within a few weeks a fine color photo of the giant arrived plus a sketch which indicated the anatase was 4½ cm long and 1.8 cm wide! According to Jacques, it was purchased by the Museum in 1900 for the then huge sum of 330 Swiss Francs. It had been found in the late 1800's in the Binntal (Binna Valley), canton Valais, Switzerland. Needless to say, it was "unavailable." I thought surely this *must* be the world's largest anatase crystal, but Wendell Wilson tells me there is one in the Smithsonian's Carl Bosch collection measuring 5.0 cm! The Bosch specimen was purchased by someone on August 23, 1883 (when Carl Bosch was only 9 years old) for 520 Swiss Francs (or German Marks). It is a slightly brownish yellow and the locality is given as Alp Lercheltini, Binnental, Switzerland. Does anyone know of a still bigger crystal than this?

Speaking of anatase, and one of my favorite minerals ever since I encountered the world famous blue Norwegian ones (see the *Record*, vol. 8, no. 4, pg. 266) a few years back, one of the best offerings at Geneva was a collection offered by two young French collectors. It was from Glacier Des Lanchettes, Massif Mont Tondu (range), in France's Savoie province. The deep blue crystals were sharply terminated tetragonal bipyramids, highly striated and ranging to 5 mm in length. They were abundantly scattered on a light gray matrix along with very gemmy, clear albite crystals up to 1½ cm. The rich color of the anatase was particularly striking, and the albite was as good as I have ever seen.

The Geneva bourse is one I do recommend to overseas visitors as a good group of dealers from the nearby Alpine regions of northern Italy and southeastern France participate. Unlike some of the more highly advertised northern Swiss and German bourses, prices are more reasonable, and eating out in the beautiful city of Geneva is great.

Although the number of "super" minerals available this fall was rather limited, many fine specimens were available at the bourses; but for most it took a bit of looking and digging to find them. At Munich alone I counted over 60 different countries whose minerals were well represented on various dealers' tables.

The fall's most spectacular mineral without a doubt was a fabulous collection of red beryl from the Wah Wah Mountains area in Utah, offered by American John Barlow at the Zurich bourse. Single cyrstals, matrix specimens and a number of faceted stones were shown, but prices were very high (justifiably, in my opinion), and while they were much admired by the Europeans, there were few takers in our continuing depressed market. John does deserve full credit for putting a spark of life in what was otherwise a pretty unexciting bourse—again layed out in a typically "supermarket style." In all fairness to the organizers it should be pointed out that Zurich followed the Munich bourse by one week, with more than one-half the dealers doing both, and showing pretty well picked-over material by Zurich time. Italian dealers were also conspicuous by their absence as they were mostly attending their own top show in

(*Above*) The anatase in the Geneva Museum of Natural History (1.8 by 4.5 cm crystal) (Brownish black).

(*Above*) The Smithsonian's anatase (3.5 by 5.0 cm crystal) (Yellow-brown).

Torino the same weekend. Torino advertises itself as the bourse "with over a kilometer of tables"—can you imagine how long that is in miles by now?

Munich, on the other hand, was voted a great success and visiting Americans, of which there were many, claimed it was the top European bourse without hesitation. Many fine museum and private collections were on display including the Keith Proctor collection. The Saturday night supper dance held in a typical Munich beer hall was a real success. First prize for the most beautiful mineral exhibited went to Roger Titieux of France for a very fine matrix group of deep red rhodocrosite from Colorado. We all especially got a kick out of the bourse's closing ceremonies when one of Munich's top "oompah bands" marched through in full regalia to ring down the curtain. Good minerals, tradition and fine Bavarian hospitality were certainly coupled to make this one an event.

There was one stand at Munich that I found most interesting. It was that of a German schoolteacher who had spent most his summer vacation hunting and digging minerals in Greece and Turkey. The photos of his trip were most fascinating and many of the minerals truly unique since, to my knowledge, most had not been previously brought into central Europe. There was a nice selection of the famous bright green annabergite specimens from the Laurium mines in Attica, Greece (the *Record*, vol. 7, no. 3) which to me was surprising as I had been informed that this collecting area was finished several years ago. He assured me that it was not! Also displayed was a fine selection of crystallized azurite, cuproadamite and malachite specimens from the same locality. The azurite crystals were limited to the 1 to 3 mm size but were brilliant and attractive. Some of the azurite was in nodular formations very reminiscent of the famous "chessylite" azurite from France.

From northern Greece there were some fine, aesthetic, sky-blue aragonite clusters resembling very much the Italian ones, rectangularly shaped "window" crystals of red hematite edged clear barite up to 2 cm on matrix and some really attractive purple grading to light blue fluorite—some with beautiful phantoms—with crystals to over 2 cm. I was particularly impressed with the quality of his self-collected epidote specimens from Xanthi in northern Greece. The crystals were quite gemmy and ranged to 5 cm in length. The best of these had been sold or traded shortly after his return, and from his description of those in his personal collection, I gathered this area could produce some real winners. Turkish minerals generally are rarely seen in Europe as they are seldom "flashy" (kämmererite and floater octahedral pyrites excepted), but there were also some very fine self-collected kyanite specimens on his table from near Balikesir. Color was a deep blue and the thin bladed crystals ran to 8 cm in length.

It is perhaps incorrect to describe a mineral as just plain nice, but one of the nicest minerals I have seen in a long while was the Austrian strontianite shown at both Munich and Zurich. Strontianite from Oberdorf An Der Laming (River) has been around for some time, but seldom has been impressive. This year's find, however, produced some fine, clean-looking matrix specimens with stubby thick crystals up to 8 cm in length attractively clustered on a cream-colored base. A number of the crystals were doubly terminated. Colors ranged from relatively clear to opaque white to yellow-white and surfaces were exceptionally brilliant. Would you believe I just plain forgot to buy one of these for my own collection?!

"New" Romanian minerals continue to trickle into Europe in a slowly increasing supply in spite of the strictly enforced export ban, but still nothing like the "old days" of 5 to 7 years ago. At Munich I saw fine stibnite groups from Baiuti, very aesthetic quartz clusters from Baia Mare and really good large chalcopyrite crystals (some twinned and occasionally with black sphalerite) on white barite also from Baia Mare. Most of the stibnite specimens were short, stubby, thick crystalled groups, heavily striated on the *c*-axis and rather bright. They looked like they had been stroked with a fine wire brush (but were not), and the best of these had toppings of small, gemmy, white barite crystals, making them very attractive. Realgar on Romanian stibnite is the rare one to look for by the way.

Even if one were able to peruse the approximate 1500 tables and booths of the combined nearly 600 exhibitors at the Munich and Zurich bourses, I doubt if it would be possible to cover the many more interesting minerals offered in several such letters as this. A special thanks goes to collector Glenn Williams of St. Louis, Missouri, whom I believe, in six solid days of effort, managed to cover about every inch of every table at both Munich and Zurich. Acting as a "spotter," Glenn brought sev- of the previously described minerals to my attention in what was a very busy time for both Maudine and me. Glenn and his wife Wilma arrived on their first trip to Europe loaded down with two foam-lined suitcases full of trading material, and by the end of the Zurich show Glenn had managed to dispose of most of it. I still have not figured out how he did it since he speaks not a word of any foreign language. He had a real ball, however, and even managed to hook me on a trade. His English is real good!

A fine selection of minerals was offered at these two bourses by collectors and dealers from outside of Europe. Very good Peruvian and Australian specimens, both relatively scarce over here, were shown by visitors from those countries. Similarly, the minerals of Korea, South Africa, Southwest Africa, Gabon, India, Morocco and Madagascar were available at good prices from citizens of those lands.

In my opinion the outstanding collection of non-European minerals at Munich and Zurich was a group of copper minerals shown by a dealer who made it all the way from Chile. The atacamite on chrysocolla from Mina La Farola (the Farola mine) some 500 miles north of Santiago in the department (province) of Copiapo was outstanding and "the best ever found" according to the dealer. These specimens in which the brilliant, dark green, thick, needle-like clusters protruded through thin coatings of white halloysite (called endellite in Europe) were especially sought after by collectors. Another copper mineral, brochantite from Mina La Verden, only a few miles from Mina La Farola, was also great. One of my friends described these most appropriately: "dark green needle igloos on a dark blue Mars landscape (chrysocolla) criss-crossed with light blue (also chrysocolla) canals." Very fitting, really.

Very good specimens of several other rare copper minerals were also well represented in the collection. Blue cyanotrichite from Mina La Vieja near the village of Portrerillos, some 50 miles from Chile's famous El Salvador mine, was one, and volborthite, a rare hydrated copper vanadanate from Mina La Verde, was another. Both were attractive on chrysocolla matrix. The volborthite appeared to have partially dehydrated, as the 1 to 2 mm crystals were a pale yellow green rather than their characteristic dark green color.

This group of minerals is currently under study in Germany and some marvelous color photos of them have been taken by Werner Lieber. They will probably be included in an article for the *Record* being prepared by Helmuth Weidner of Chile (to whom I am indebted for the above locality information) and Robert Cook (Auburn University).

Cheers,

Bob Sullivan

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Switzerland

SUGGESTIONS FOR AUTHORS

Both professional and amateur mineralogists and collectors are invited to contribute articles to the *Mineralogical Record.* The editorial staff is always available to assist with editing, rewriting, photography, crystal drawings and technical aspects.

Any article of potential interest to amateur mineralogists and mineral collectors will be considered for publication. Articles on *famous mineral localities* and collector-oriented *descriptive mineralogy* are particularly welcome.

Authors of papers at the professional level may refer to guidelines published by the *American Mineralogist* regarding any questions or conventions not discussed below.

(1) When beginning work on an article, write to the editor informing him of your chosen topic. This topic will then be reserved for you, and you need not worry about someone else submitting an article on the same topic before you have completed your work. Your reservation of the topic will be valid for six months.

(2) All manuscripts must be typed and double-spaced, on 8½ x 11-inch paper. Do not use script type or all-caps style.

(3) Figure captions should be typed together (rather than individually on figures) to make typesetting easier.

(4) Photographs are eagerly solicited with articles. Photos must be approximately 5 x 7-inch **glossy black and white prints.** (Check with the editor before submitting color photography.) Submit photos in individual, numbered envelopes; do not place glue, tape, or writing on either the front or back of photos.

Every mineral photo should be accompanied by the following information in the caption:

(a) Species ***name*** and ***locality***
(b) Specimen or crystal ***size*** (not magnification power)
(c) Specimen ***color***
(d) Specimen ***owner***

Other optional data that may be in the caption include the credit for the photographer, crystallographic details, and the specimen's history.

NOTE: *If authors have difficulty obtaining photos of specimens, the editorial board may be able to supply photos as needed. An article should be written and approved by the editor before photographs can be solicited from the editorial board.*

(5) Locality articles published in the *Record* generally have similar structure, and include the following sections:

(a) ***Introduction*** (discusses the significance of the locality to collectors, its precise location, and other details)

(b) ***History*** (discovery and mining or collecting history, including mention of particularly significant specimens, veins or pockets, the history of ownership, and the current collecting status.)

(c) ***Geology*** (a brief overview of the important geologic features of the setting and the deposit, especially as applies to the origin of the deposit.)

(d) ***Minerals*** (a discussion of each species found there, with emphasis on those favored by collectors. Best specimens, rarity, important discoveries, typical characteristics, descriptive mineralogy.)

(e) ***Discussion*** (theories on the origin of the deposit, paragenesis, mineralogical peculiarities, etc. All speculation should be reserved for this section; other sections should be strictly factual.)

(f) ***Acknowledgments***

(g) ***References*** (All articles should be thoroughly referenced.)

Locality articles generally benefit by having a **locality map** or two, possibly a general **geology map,** a photo of the locality, and photos of good specimens of as many minerals as possible.

(6) References: All references must follow *Record* format:

(a) Author(s) name(s) all in capitals, initials following each name.

(b) Year of publication in parentheses.

(c) Title of the article, first letter only capitalized except for proper nouns and foreign language titles, followed by a period.

(d) Journal title completely spelled out (no abbreviations), and underlined, followed by a comma.

(e) Volume number with a wavey underline, comma, page numbers, period.

An example of correct reference form is as follows:

LAIRD, J., and ALBEE, A. L. (1972) Chemical composition and physical, optical and structural properties of benitoite, neptunite and joaquinite. American Mineralogist, 57, 85-102.

(7) Numerical tables. Camera-ready numerical tables are requested where such tables are absolutely necessary; numerical tables are discouraged where the data can be presented in summarized form within the text. Tables of X-ray data will not be accepted unless markedly different from existing data, or entirely new.

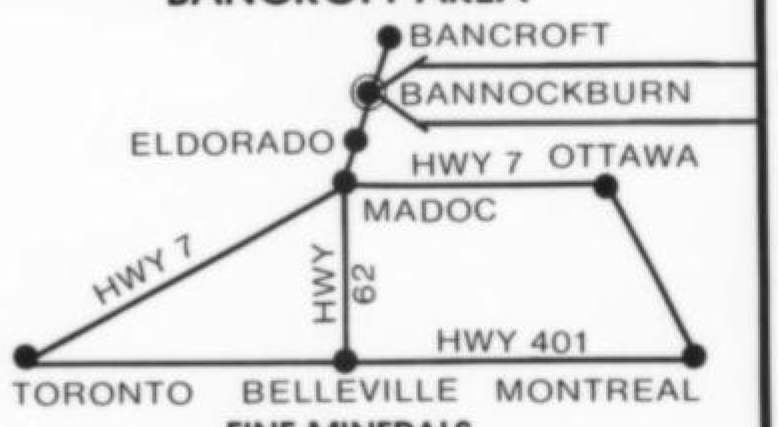
(8) Authors should give their complete mailing address, including zip code, under the article title.

(9) One original copy and one xerox copy of the article and figures should be enclosed. Authors should retain a **third copy** as protection against postal mishaps.

(10) Metric or English units may be used, but should not be mixed.

(11) Articles received will be acknowledged by post card, then sent out for critical review. After review, articles may be returned to the author for alterations. When the final version of an article has been accepted the author will be informed of the approximate publication date. Two months prior to this date the article will be typeset and the author will receive a galley copy to proofread for typographical errors. All other changes at the galley stage are expensive and are therefore discouraged.

(12) Reprints. Generally 50 reprints are available. Authors with institutional backing are requested (but not required) to pay a page charge of $35 per page.


BANCROFT
BANNOCKBURN
ELDORADO
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OTTAWA
MADOC
HWY 7
HWY 62
HWY 401
TORONTO
BELLEVILLE
MONTREAL


GALAS MINERALS

famous mineral localities:

the KALAHARI manganese field

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The Kalahari manganese field in northern Cape Province, South Africa, ranks as one of the largest and richest known manganese deposits in the world. The Hotazel and N'Chwaning mines have produced mineral specimens of worldwide interest, most notably rhodochrosite in fine, large, transparent crystals. The first study of the minerals of the N'Chwaning and Wessels mines, including a description of the second world occurrence of ruizite and five other species not previously reported from the Kalahari field, is here presented, along with a mineralogical summary of previous studies at the Hotazel and other mines in the area.

LOCATION

The Hotazel, Devon, Langdon, Smartt, Adams, Mamatwan, Wessels, Black Rock and N'Chwaning mines are located within a 40-km zone of the Kalahari Desert north of Sishen and west-northwest of Kuruman, northern Cape Province, Republic of South Africa. Most of the area is covered by sand of the Kalahari desert in varying thickness. The climate is semiarid with a summer rainfall of about 38 cm; there is no surface water and the two main rivers are dry most of the time. The region is approximately 1000 m above sea level; the only topographic prominence in the area is Black Rock, an isolated hogback rising 27 m above the surrounding country.

HISTORY

The northern part of the Cape Province was mapped by Rogers in 1904-1905. In 1922 manganese was discovered by Captain T. L. H. Shone just north of Postmasburg. Subsequent investigations by Hall (1926) and Nel (1929) revealed manganese deposits of primary importance in two parallel belts extending northward from Postmasburg for about 38 miles, where they disappear under the Kalahari sand.

Black Rock was examined by Boardman (1941). Ores from the Hotazel and Smartt mines were examined mineralogically by Frankel (1958). Subsequent studies by J. de Villiers (1960 b) and Boardman (1961, 1964) dealt in greater detail with the Kalahari field, and P. R. de Villiers (1971) published an excellent recent study of the geology and mineralogy.

Between 1951 and 1954 the area south and east of Black Rock was prospected by geophysical methods and drilling, and the manganese body was delineated over a distance of 56 km. Mining commenced soon thereafter at the Smartt mine, where the sand cover is not thick, and subsequently also at the Hotazel, York, Langdon and Devon mines. The Smartt mine was closed in 1962, and the Devon and Langdon mines a short time later. The Wessels mine was opened in 1973, and the N'Chwaning mine in 1974. A new mine called the Gloria, a short distance south of the N'Chwaning mine, is scheduled to open this year, and a mine near Hotazel, to be called the Perth mine, is under development (D. Sacco, personal communication).

Associated Manganese Mines of South Africa, Ltd., owns the N'Chwaning, Black Rock, Adams, Devon, Gloria and Perth mines. South African Manganese Mines, Ltd., owns the Wessels, Hotazel and Mamatwan mines. The Black Rock, Wessels and N'Chwaning mines are the only large underground manganese mines in South Africa (Hammerback and Taljaardt, 1976). A labor force of over 200 is employed at the N'Chwaning mine, primarily for hand-sorting the ore according to luster (shiny ore is richest, about 55% Mn or more; non-shiny ore contains about 50% Mn).

At least two major discoveries of high quality rhodochrosite specimens have reached the international mineral market. The first was made at the Hotazel mine around 1965 and specimens continued to be found there for a number of years. The second major occurrence was found at the N'Chwaning mine, where rhodochrosite was encountered at a depth of 30 to 40 m shortly after the mine opened in 1974. Specimens of major importance did not begin appearing on the mineral market until 1977. As of this writing (March, 1978) new pockets of rhodochrosite are continuing to be discovered at the N'Chwaning mine.

Virtually all specimens have been collected by miners or mine personnel (a visit to the mine by the authors was not possible due to a paucity of funds), so it has not been possible for us to personally substantiate the precise nature of the occurrences. We are indebted to N'Chwaning Mine Director Desmond Sacco for information on the occurrence of ore and minerals at the N'Chwaning mine.

The N'Chwaning mine rhodochrosite discovery has been far more productive of specimens, both in quantity and quality, than the earlier occurrence at the Hotazel mine.

GEOLOGY

The ore-bearing unit in the Kalahari manganese field is known as the Gamagara formation, located near the top of the Upper Griquatown banded ironstones which form part of the top of the Pretoria Series of the Transvaal System (Precambrian). Manganiferous beds are intercalated with banded ironstone, and the area is cut in places by sills and dikes of bostonite, a diabase-like igneous intrusive rock. The ore bodies are stratiform, continuous or lenticular, distinctly layered, and sometimes folded conformably with the enclosing ironstone units. Strata immediately above and below the main ore zones are calcareous and, in places, laminated.

The manganiferous strata, interbedded with ironstone, rest atop the Ongeluk lava formation. Within the lower 100 m of the iron formation, up to three layers of manganese protore are developed; the lowest is up to 25 m in thickness, the middle is thin and impersistent, and the upper layer is about 6 m thick.

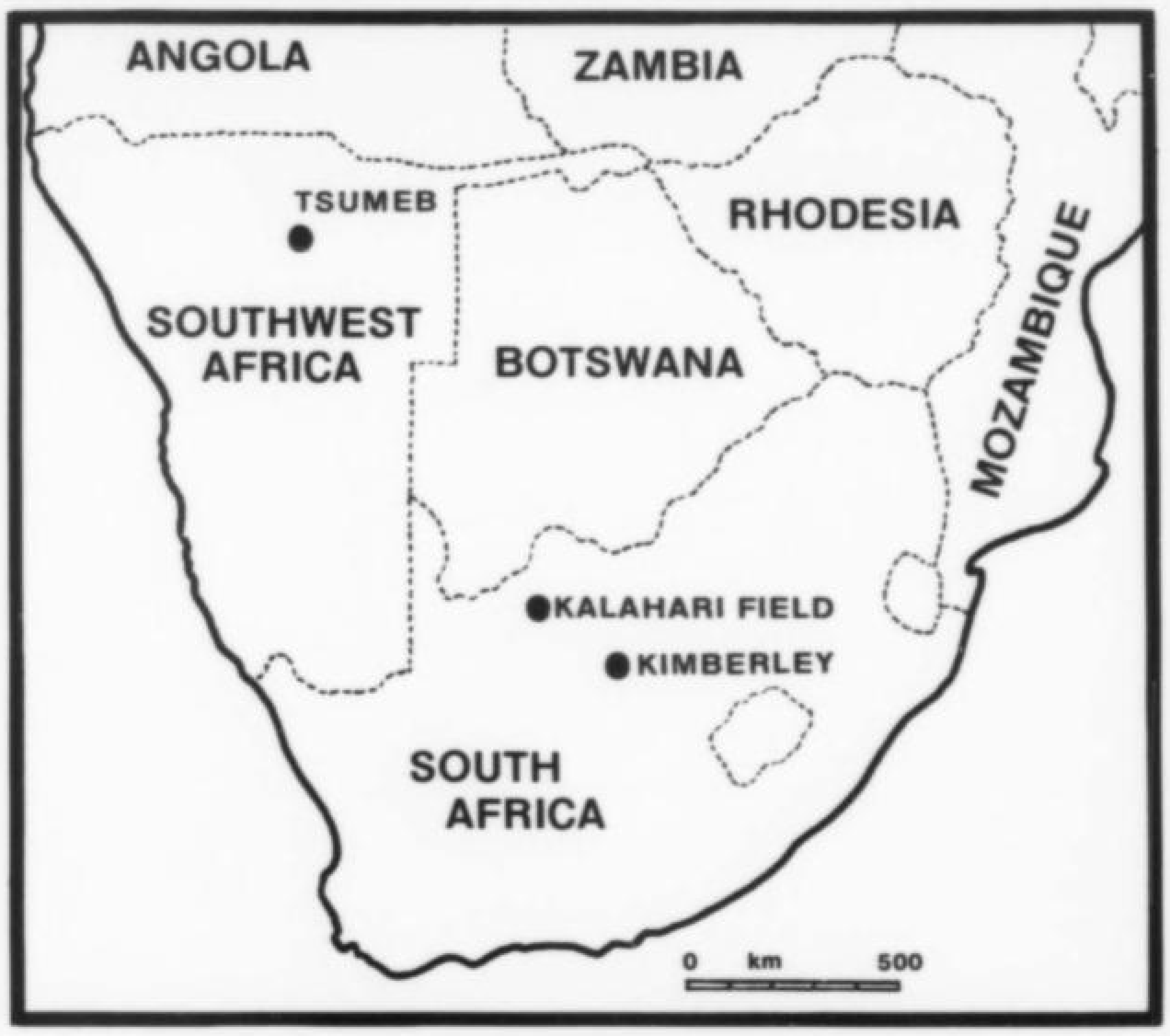
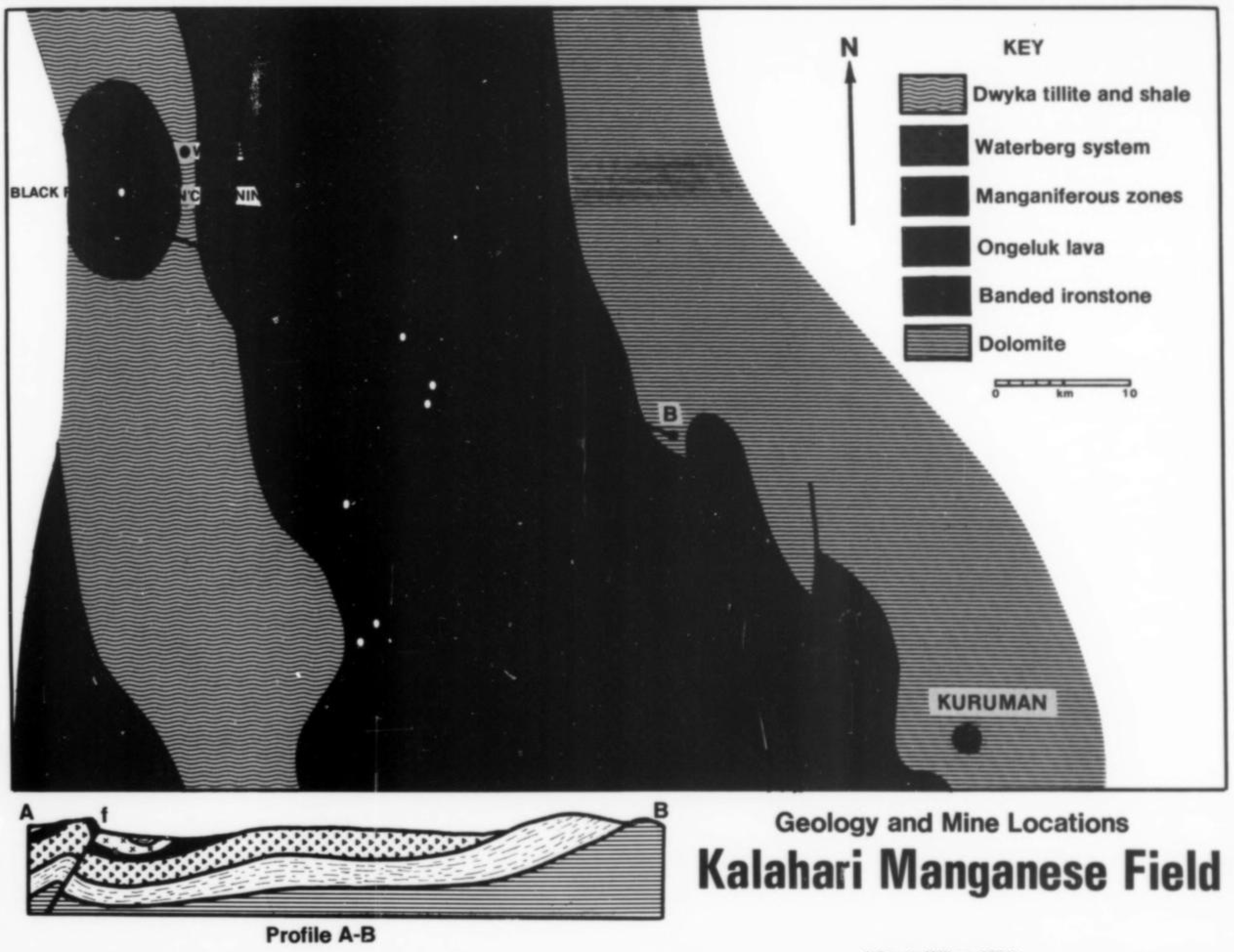


***Figure 1.* A map of southern Africa showing the location of the Kalahari manganese field, and also the locations of the Kimberley diamond mining area and the Tsumeb mine.**

Economically mineable zones are confined to enriched, near-surface regions. This enrichment was probably a multi-stage process involving both supergene and hypogene reactions (de Villiers, 1971). The Kalahari field, with known reserves of 9 billion tons (30% Mn), constitutes one of the largest manganese deposits in the world. Ore at the N'Chwaning mine consistently contains at least 50% Mn, and locally as much as 60-62% Mn (D. Sacco, personal communication).

The Kalahari manganese deposits are currently considered to be syngenetic, that is, formed contemporaneously with the enclosing rocks and later subjected to supergene enrichment and replacement. De Villiers (1971) concludes that beds of the

***Figure 2.* A view of the Hotazel mine in 1963, showing the main open pit. (From de Villiers, 1971.)**



Geology and Mine Locations
Kalahari Manganese Field

(after de Villiers, 1971)

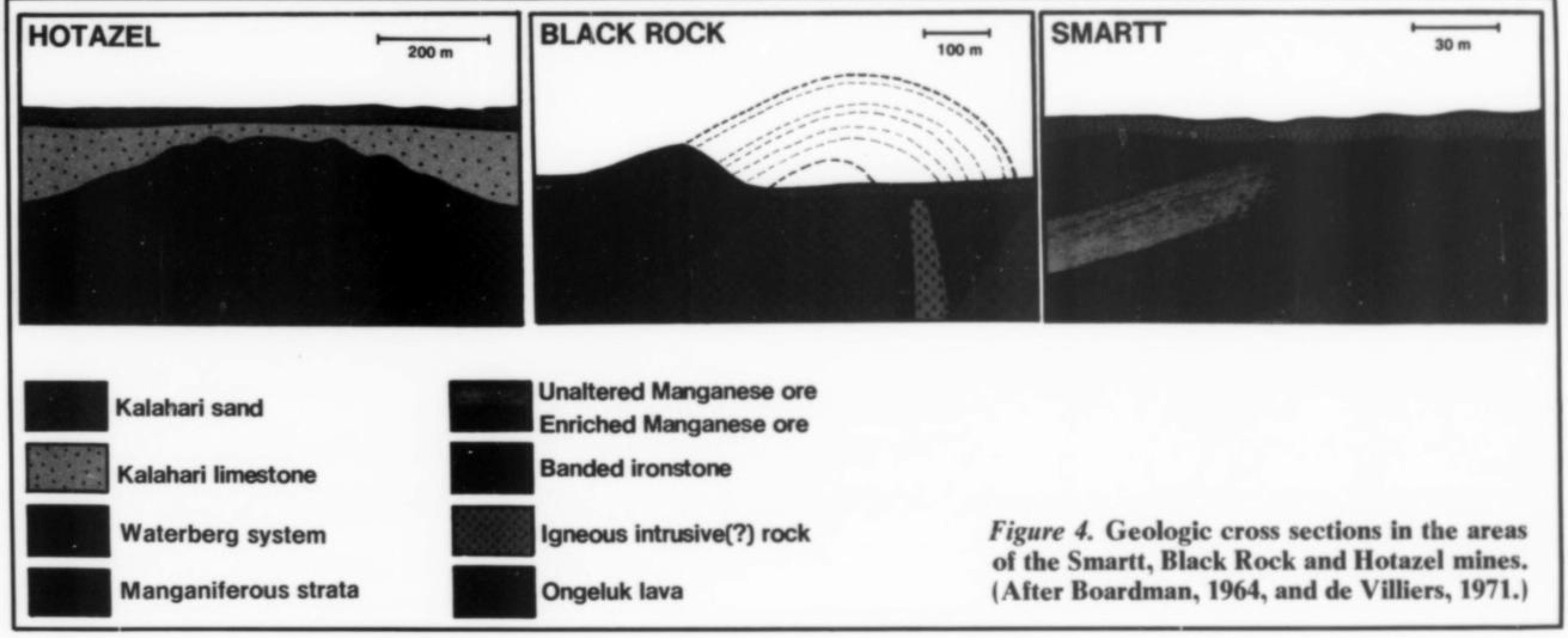


Figure 4. **Geologic cross sections in the areas of the Smartt, Black Rock and Hotazel mines. (After Boardman, 1964, and de Villiers, 1971.)**

ore zone were probably originally deposited as a primary sedimentary mixture of manganese hydroxide, manganese carbonate and calcium carbonate, with localized iron hydroxide and calcium-magnesium carbonates. A variety of sedimentary textures including oolites and nodules still remain. The sediments which formed the Gamagara formation were most probably deposited in a closed-basin environment partly or wholly separated from the open sea. Precipitation may have been aided by strong surface evaporation from the shallow, warm and highly saline waters (de Villiers, 1971). Depending on the prevailing pH, manganese oxides or calcium carbonates are known to precipitate in colloidal form (Deer, *et al.*, 1962).

The manganese ore strata are generally layered, with different groups of manganese minerals predominating in certain layers. The principal ore minerals include braunite, bixbyite, rhodochrosite, hausmannite and jacobsite. The ultimate source of the manganese remains unknown although weathering of pre-existing dolomite formations or deposition from volcanic exhalations have been proposed. Several of the mineral constituents (braunite, bixbyite, jacobsite, hausmannite) form a high-temperature suite in certain areas, the origin of which is in dispute as well. De Villiers (1971) proposes a combination of thermal and load metamorphism assisted by metasomatism, but other researchers argue that there is no obvious source of heat for metamorphism in the area.

MINERALOGY

Because the N'Chwaning and Wessels mine species and Hotazel mine rhodochrosite were the objects of this study, they are discussed in the first subsection below. Species from the Kalahari field that have been reported or discussed by others but not observed in this study are presented in the second subsection. Data in the second subsection have been summarized, for the most part, from de Villiers (1971).

Species examined in this study

Rhodochrosite $MnCO_3$

Hotazel mine rhodochrosite

Rhodochrosite has been previously reported from the Smartt, Adams, Mamatwan and Hotazel mines. At the latter it occurs as excellent rhombohedral to scalenohedral crystals in vugs with gypsum. Material reported by de Villiers (1971) occurs in rhombohedrons $r\{10\bar{1}1\}$ with perfect cleavage parallel to the crystal faces. Specimens in the Smithsonian Institution examined in this study consist of steep scalenohedrons, probably $v\{21\bar{3}1\}$ and $y\{32\bar{5}1\}$, capped by the pinacoid. Specimens of a different habit perhaps best described as "trigonal wheat sheaves" are also in the Smithsonian collection and several well-known private collections. The specimens consist of a bundle of semi-parallel individual rhodochrosite crystals having their *c* axes divergent. What makes these aggregates different from a typical "wheat sheaf" habit is the progressive three-fold divergence of the *c* axes. This produces a triangular aspect when viewed down the *c* axis. These crystals commonly occur individually or in groups on a matrix of small (2 to 4 mm) manganite crystals, and measure 2 to 3 cm in size. Scalenohedral rhodochrosite crystals from Hotazel are commonly around 1 to 1.5 cm in length, but occur as large as 4 cm or more.

The color of Hotazel rhodochrosite ranges from deep rose-red to yellowish pink, red-brown and gray. The red-brown to gray material is mostly fine-grained.

The molecular percentage of $CaCO_3$ in the rhodochrosite from Hotazel was reported by de Villiers (1971) to be 2.0%; other elements analyzed for included MgO (0.13%) and FeO (0.2%). De Villiers concluded that the rhodochrosite was diagenetic, that is, it was part of the original sedimentary material which has obviously undergone recrystallization.

N'Chwaning mine rhodochrosite

The majority of specimens seen by the authors consists of manganite followed by the deposition of light-colored, fine-grained rhodochrosite and, finally, a magnificent growth of superb rhodochrosite scalenohedrons. (These have sometimes been labeled "Black Rock" although they are from the N'Chwaning mine.) The scalenohedral crystals range in size from a few mm to more than 7 cm and are, in many cases, gemmy throughout. The color of the large crystals ranges from a rich pink to a vibrant red, a deep orange-red, and a somewhat blackish red. Isolated crystals on matrix are relatively rare; the crystals more commonly occur completely covering the matrix to a depth of several cm. Some pockets have produced plates covered by

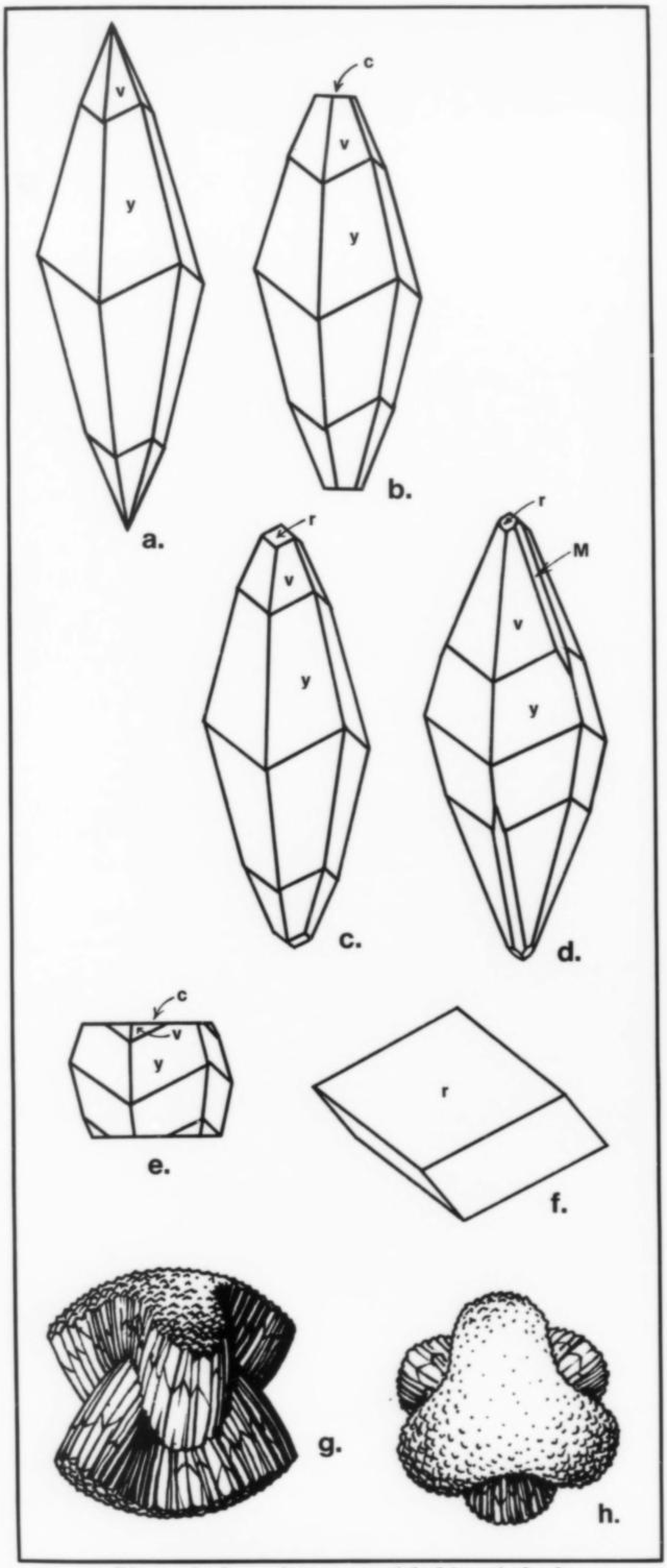


Figure 5. **Crystal forms and habits of rhodochrosite from the N'Chwaning mine (a, b, c, d, e) and the Hotazel mine (b, f, g, h). The forms shown are v $\{21\bar{3}1\}$, y $\{32\bar{5}1\}$, c $\{0001\}$, r $\{10\bar{1}1\}$ and M $\{40\bar{4}1\}$. Forms *r, M* and *c* are generally frosty whereas the others are usually lustrous. The scalenohedron faces (v, y) are commonly striated parallel to their lines of mutual intersection. Figures g and h illustrate the trigonal wheat sheaf habit observed on some Hotazel mine specimens; g is a side view, h is a top view.**

Figure 6. (above) **Seven of the best brilliant rose-red N'Chwaning mine rhodochrosite specimens in the batch brought to the United States by Prosper Williams at the time of the 1977 Rochester Symposium. The largest specimen is about 12 cm in maximum dimension; photo by WEW.**

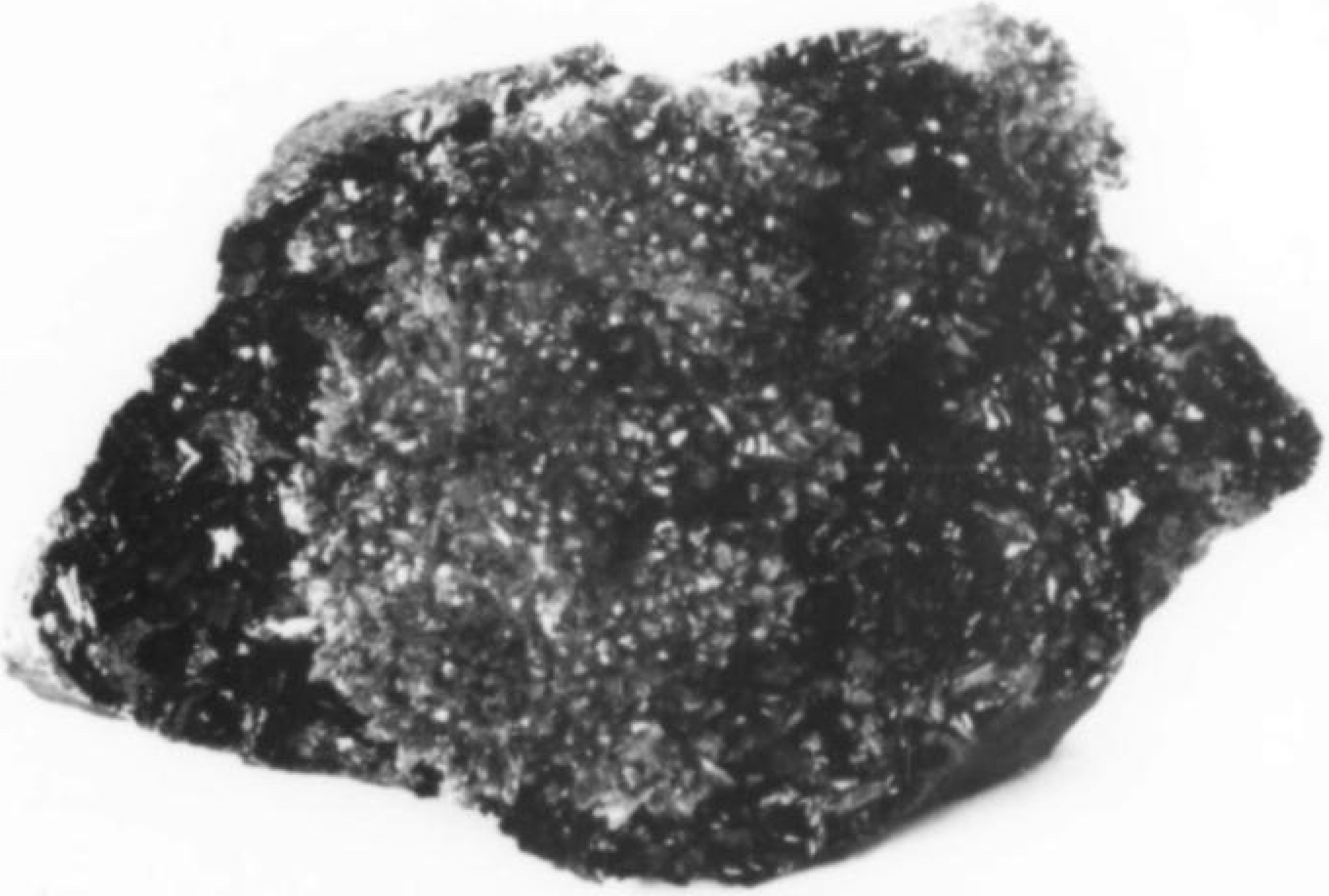


Figure 8. (above) **A group of small, brilliant red rhodochrosite crystals on a manganite crystal matrix from the N'Chwaning mine. The specimen measures about 12 cm across. Miriam and Julius Zweibel specimen; photo by WEW.**

Figure 7. **A closer view of the lower left specimen in Figure 6; the specimen is about 7 cm tall and of a brilliant rose-red color. Prosper Williams specimen; photo by WEW.**

Figure 9. **A sub-parallel arrangement of small, red rhodochrosite crystals on manganite matrix from the N'Chwaning mine. The specimen is about 3.5 cm wide. Miriam and Julius Zweibel specimen; photo by WEW.**

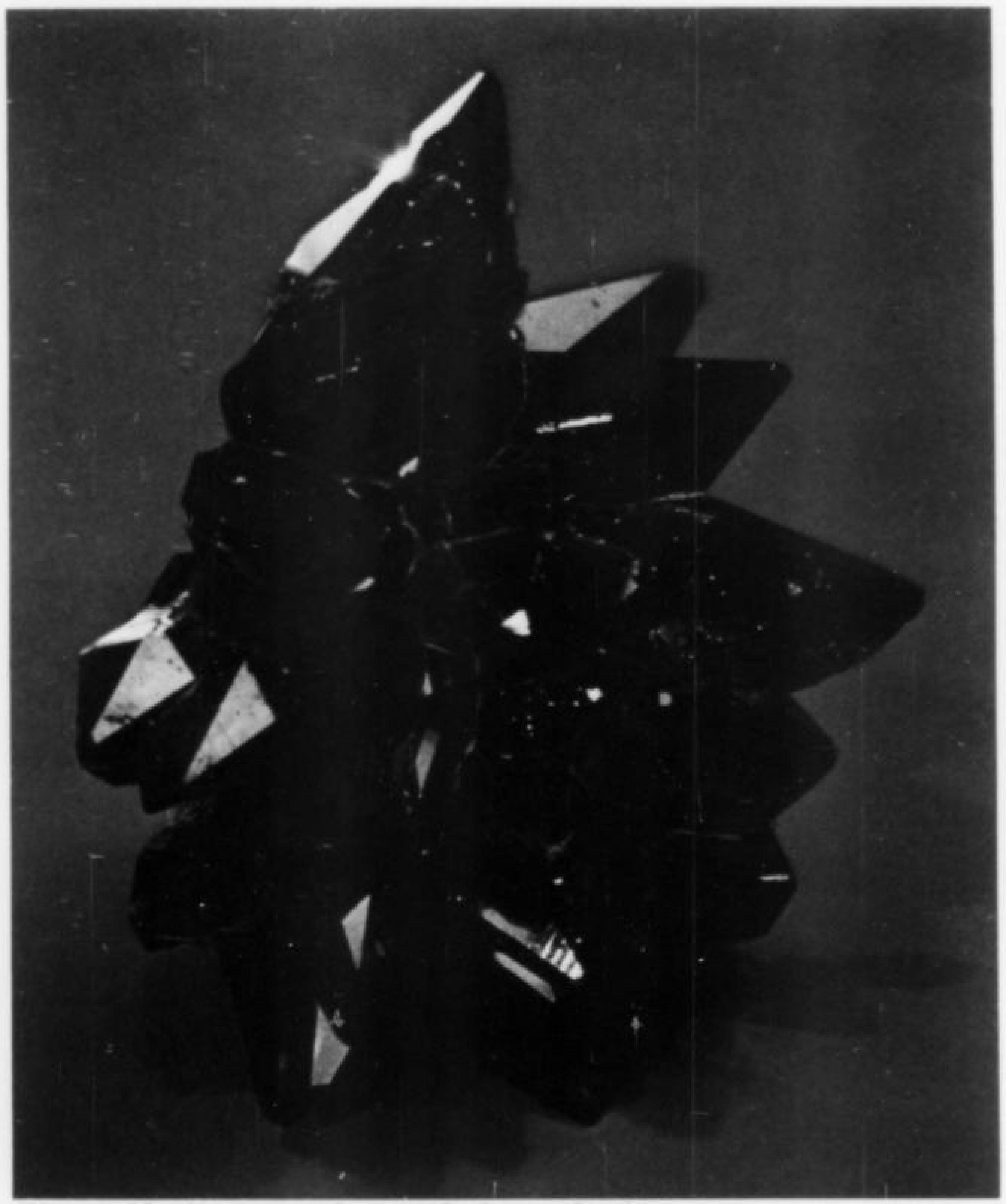


Figure 10. A group of crystals from the best and most recently discovered pocket at the N'Chwaning mine. The crystals are a deeper red than earlier specimens. They appear stouter due to the predominance of the lower angle scalenohedron *(v)*, and are gemmy throughout. Minute quartz crystals are present at the crystal intersections. The specimen is 5 cm tall. WEW specimen and photo.

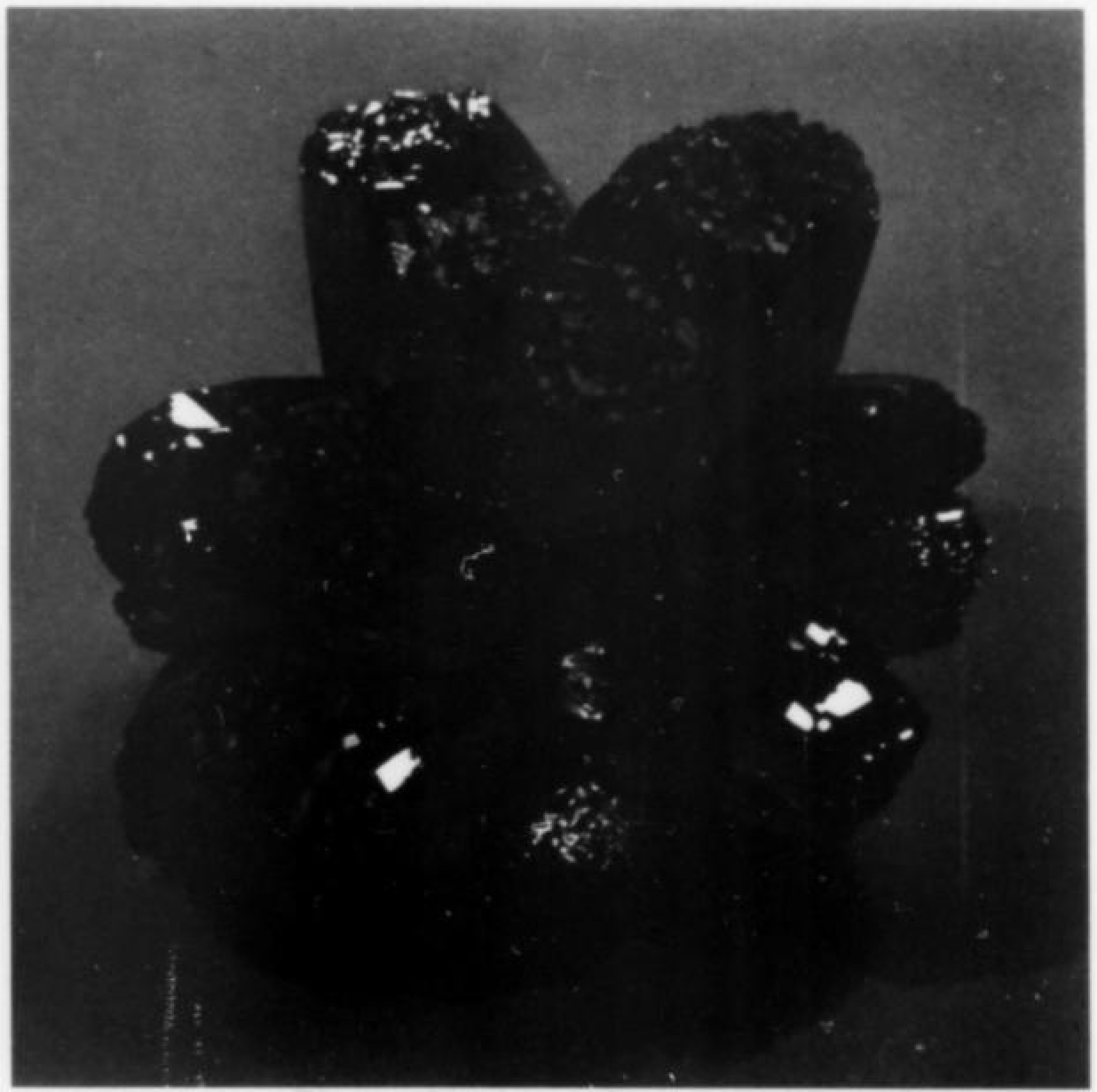


Figure 11. A specimen of unique habit from the N'Chwaning mine, it was the only one salvaged intact from a small (30 cm) pocket. The group measures 3.1 cm wide. Pat Carlon specimen; photo by WEW.

Figure 13. Rhodochrosite crystals in a rose-shaped arrangement 3.7 cm across, from the N'Chwaning mine. WEW specimen and photo.

Figure 12. (left) Rhodochrosite crystals on manganite from the N'Chwaning mine. Photo by Olaf Medenbach.

Figure 14. Rhodochrosite crystals, each about 1 cm or less, in a manganite-lined vug from the Hotazel mine. This specimen was sold to the Smithsonian Institution by Martin Ehrmann in 1965. Smithsonian specimen #C6568; photo by WEW.

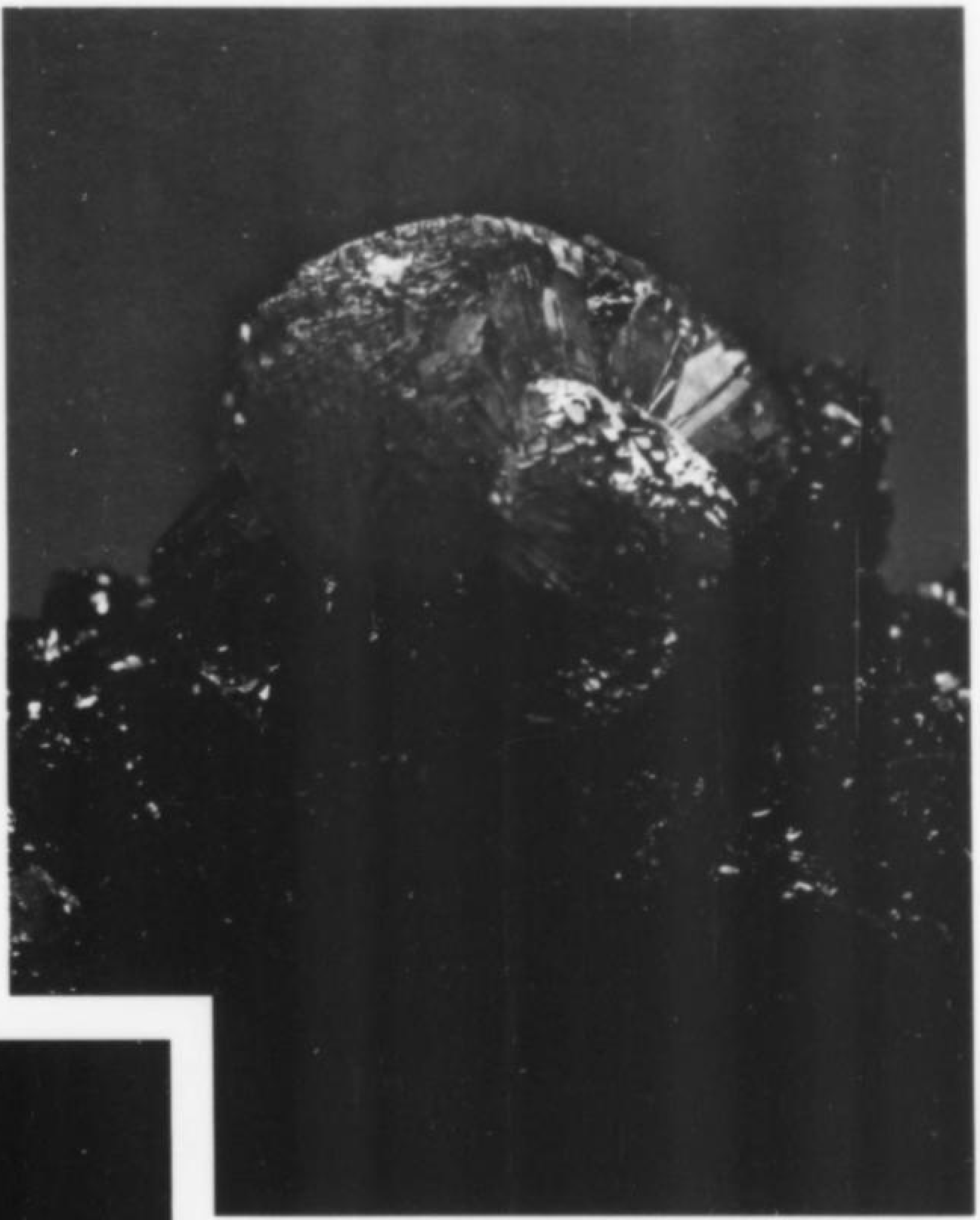


Figure 15. Rhodochrosite in the trigonal wheat sheaf habit from the Hotazel mine. The crystal group 2.5 cm across and rests on a manganite crystal matrix. Smithsonian specimen #126820; photo by WEW.

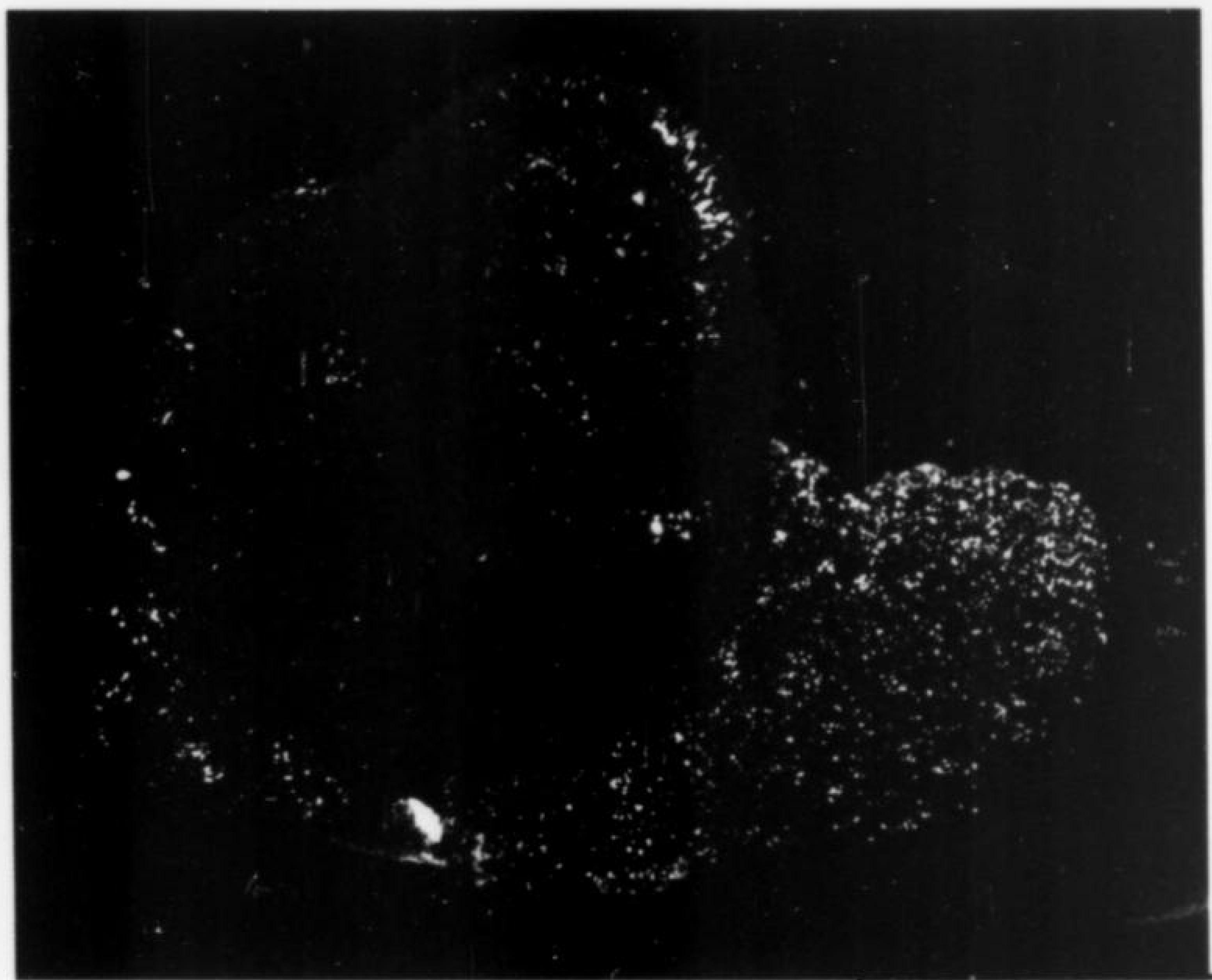


Figure 16. (above) Intergrown spherical aggregates of rhodochrosite crystals from the N'Chwaning mine. The specimen is about 8 cm wide. William Larson (Pala Properties) specimen; photo by Bob Jones.

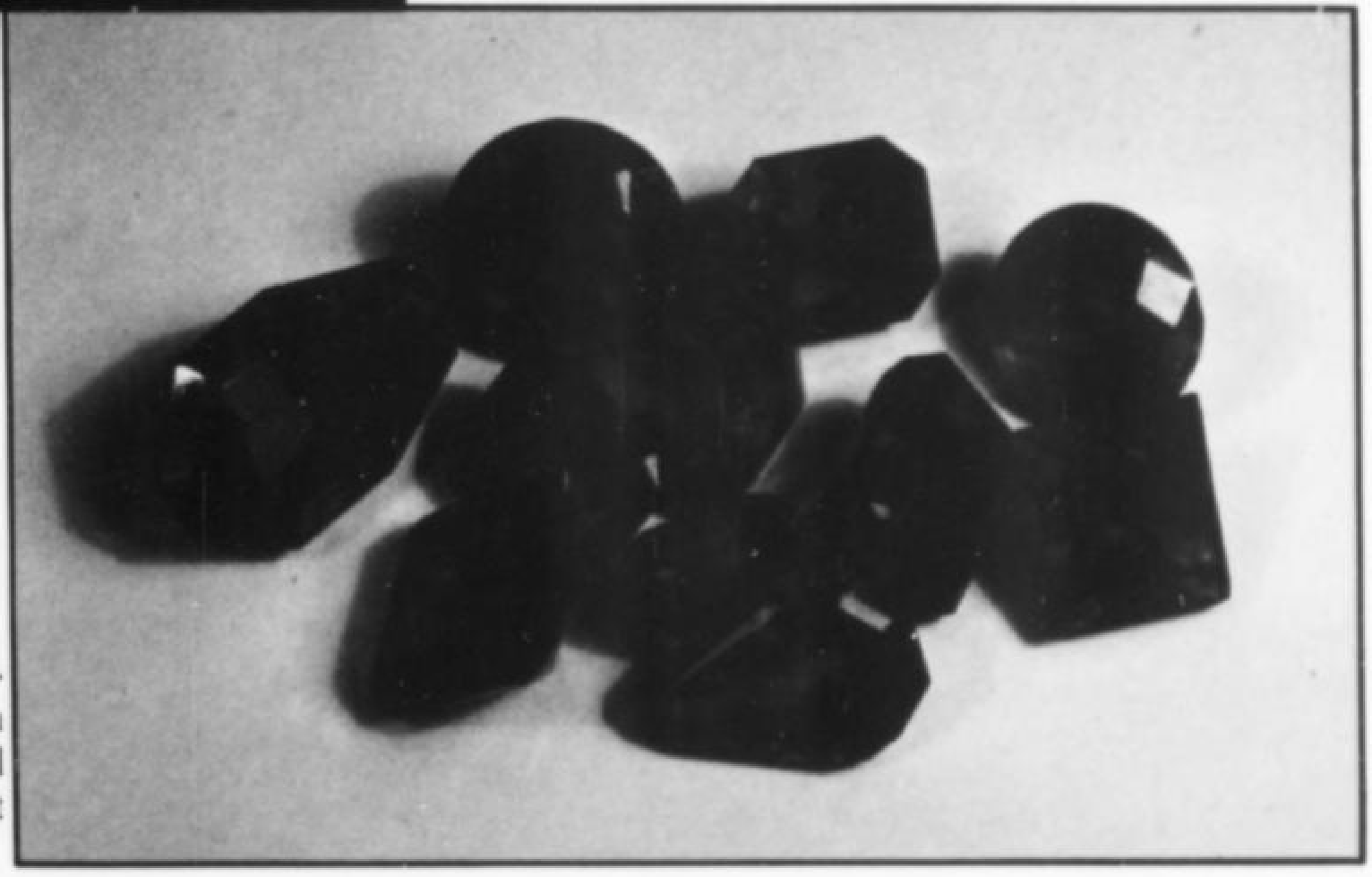


Figure 17. (right) A group of faceted N'Chwaning mine rhodochrosites from the collection of Desmond Sacco. The large pear-shaped stone at the extreme left is 18 mm in longest dimension. Photo by WEW.

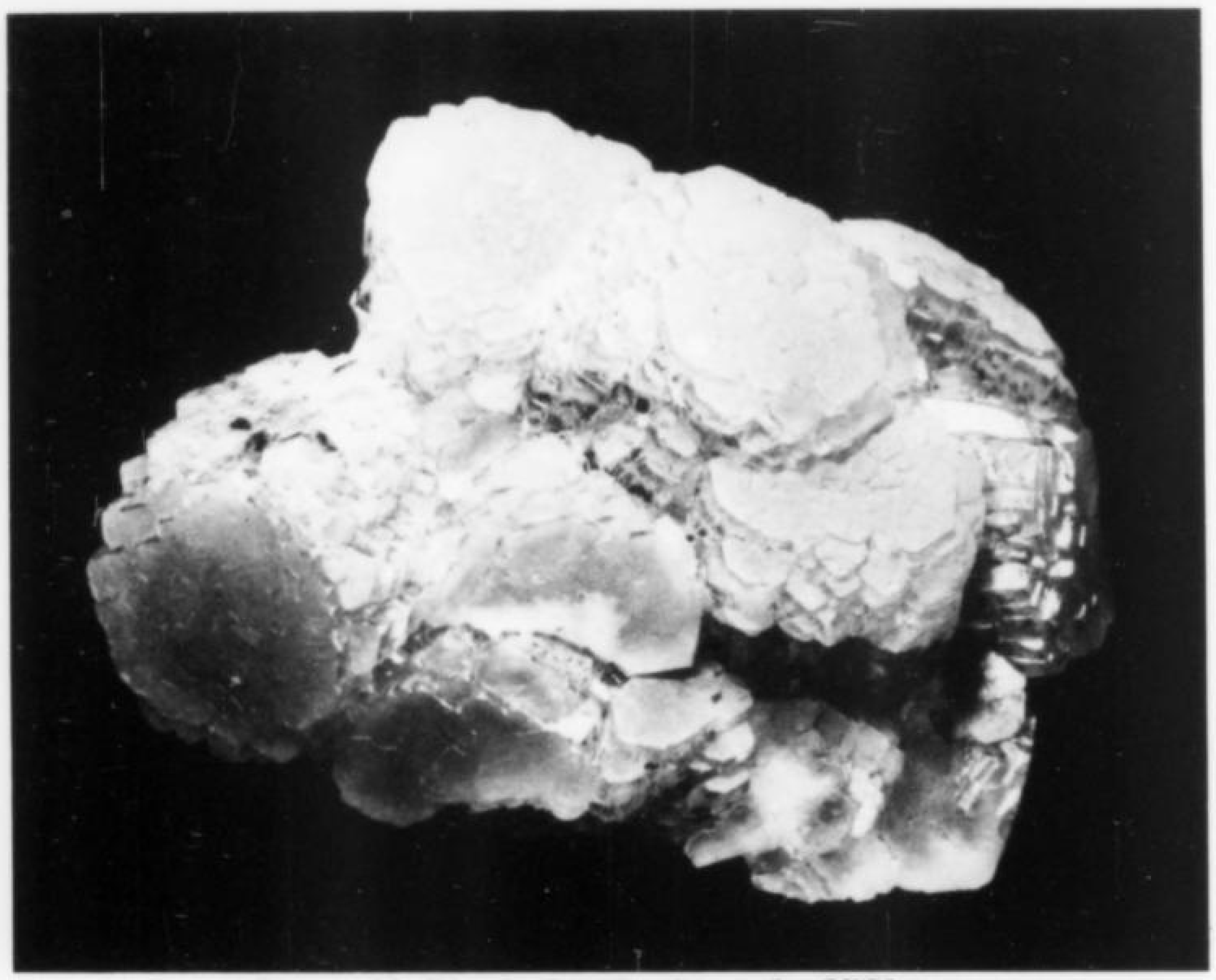


Figure 18. **Rhodochrosite from the N'Chwaning mine, showing the flattened habit with the pinacoid dominant. The group is 7 cm across and a medium pink in color. Abraham Rosenzweig specimen; photo by WEW.**

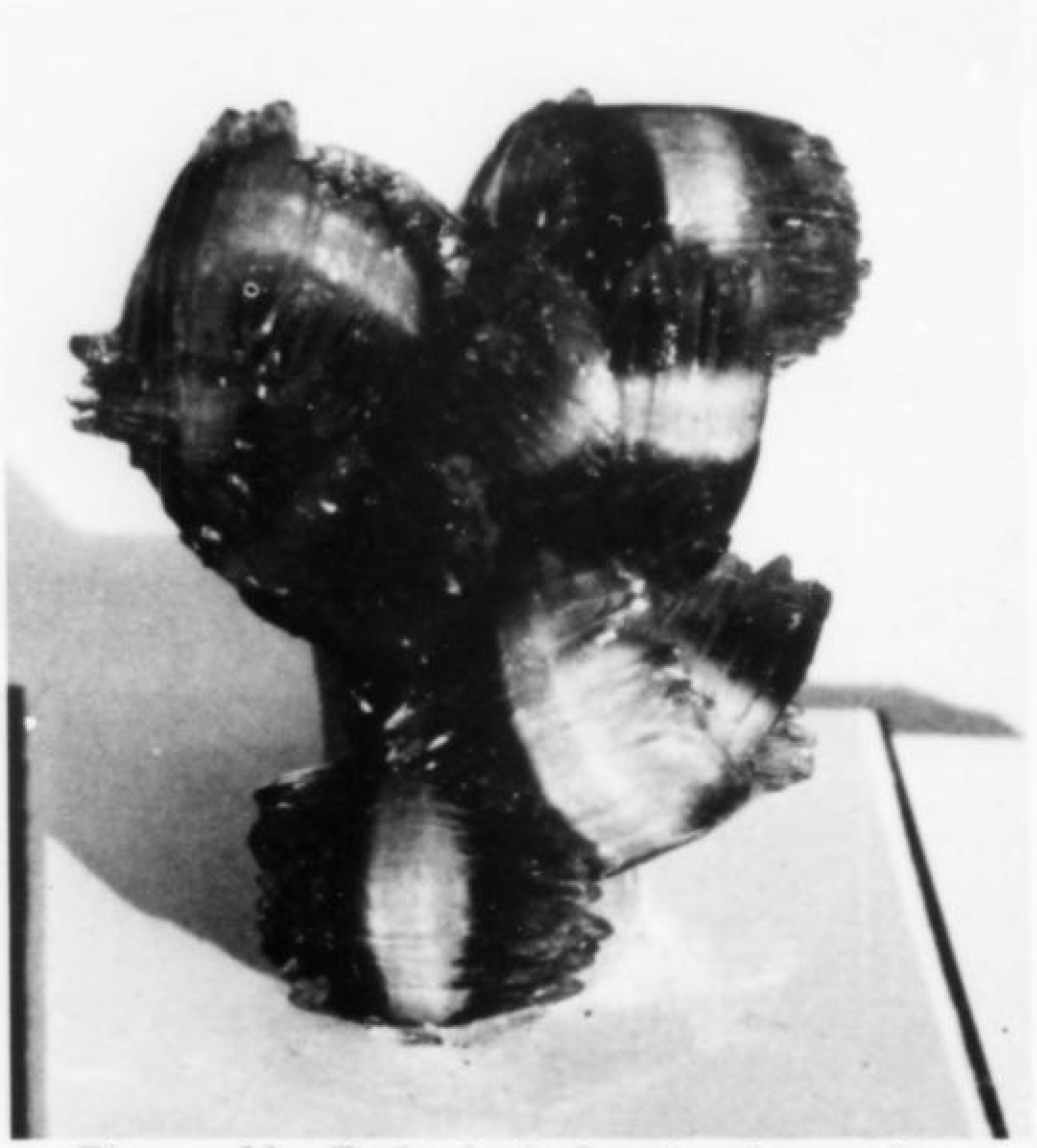


Figure 20. **Red rhodochrosite from the N'Chwaning mine, showing a distinctive barrel habit with milky, pale pink central zone. The specimen is about 3 cm tall. John Barlow specimen; photo by WEW.**

single crystals, whereas other pockets have produced plates covered by multiple crystals. The multiple crystals occur with 4 to 10 individuals in close parallel growth with the *c* axes parallel; in some instances the *c* axes diverge slightly. The specimen shown on the cover of this issue is among the finest examples and probably the finest known miniature of this habit. The multiple crystals observed so far reach a maximum size larger than any known single crystals from the deposit.

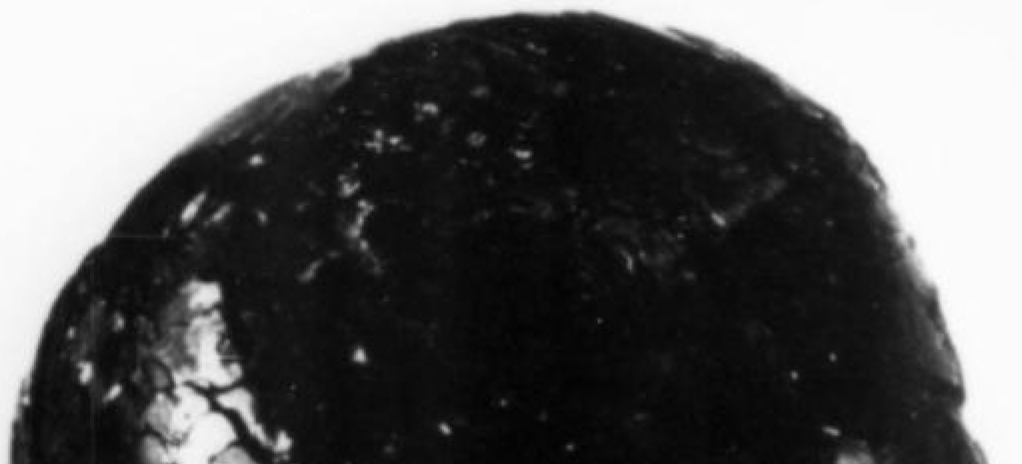


Figure 19. **A spheroidal crystal aggregate of red rhodochrosite from the N'Chwaning mine. The surface is composed of pinacoid faces. The spheroid is about 3.2 cm in diameter. Miriam and Julius Zweibel specimen; photo by WEW.**

A number of loose crystals of rhodochrosite from the N'Chwaning mine were graciously supplied by Miriam and Julius Zweibel. Although many of the crystals had slightly rounded faces, several suitable for optical goniometry were found. Good reflections representing four forms were obtained: the low rhombohedron *r* $\{10\bar{1}1\}$, the scalenohedrons *v* $\{21\bar{3}1\}$ and *y* $\{32\bar{5}1\}$, and the pinacoid *c* $\{0001\}$. The steep rhombohedron, probably *M* $\{40\bar{4}1\}$, was observed on other specimens but not on crystals which we were able to obtain for study. The scalenohedrons have a brilliant luster whereas the other forms are frosty on all specimens we have seen. The scalenohdrons are commonly (but not always) striated lightly parallel to the *v-y* lines of intersection (which, incidentally, is also parallel to the *r-v* and the *y-y'* intersections).

The habit is variable; at least 10 relatively distinct variations of habit have been observed by the authors, and more are probably known by others or are soon to be discovered. Known habits include the following:

(1) The aforementioned multiple crystal habit exemplified by the cover specimen.
(2) Parallel crystal growths forming barrel shapes up to 1 cm in diameter, having a distinct white or pink planar central zone parallel to the pinacoid and multiple small terminations (Fig. 20).
(3) Predominantly pinacoidal but flat (Fig. 18).
(4) Predominantly pinacoidal but domed or spherical (Fig. 19).
(5) Equal development of the pinacoid and the *y* scalenohedron (Fig. 11).
(6) Predominantly scalenohedral *v*, sometimes with minor development of *y*, *M* and *r* (Fig. 10).
(7) Predominantly scalenohedral *y* with minor development of *v* and *c* or *r* (Fig. 12).
(8) Drusy (Fig. 8, 16).
(9) Predominantly scalenohedral with reversed or cavernous terminations.
(10) Botryoidal, resembling Kelly mine smithsonite in shape and luster but with a light pink color.

The two rhombohedrons are never well developed and are commonly missing.

A light sprinkling of opaque black crystals of platy manganite just under the surface of some rhodochrosite crystals darkens their color. Some specimens consisting of relatively transparent crystals on a black manganite matrix present an ironic dilemma for the collector accustomed to believing that matrix specimens are best: the dark color of the matrix shows through the transparent crystals and makes them appear considerably darker and less attractive. Groups of crystals detached from matrix are not color-impaired and are therefore more attractive in many cases. An insulating layer of white or pink fine-grained rhodochrosite beneath the transparent crystals allows many specimens on manganite matrix to retain a brilliant red color.

N'Chwaning mine rhodochrosite, both light and dark colored, is essentially pure $MnCO_3$ with only 0.2% FeO and 0.1% CaO indicated by microprobe analyses (a calcian rhodochrosite was also found—see under calcite). The refractive indices are $\epsilon = 1.597$ and $\omega = 1.812$, both ±0.003.

Gems up to 60 carats have been faceted from N'Chwaning mine rhodochrosite crystals. Faceting quality crystals and crystal sections are readily available at the present time, the highest quality finished stones selling for between $30 and $50 per carat. We certainly hope that only damaged crystals unsuitable as specimens are being faceted. Rhodochrosite, of course, is far too soft to wear as jewelry and all faceted stones are of interest only to the collector of rare gems, although this appears to be a burgeoning market. The finished stones are remarkably attractive. Those shown in Figure 17 were cut from the most recent find (as exemplified by the specimen shown in Fig. 10) and show an exceptionally rich color.

According to Mine Director Desmond Sacco the pockets of rhodochrosite are completely isolated in the high grade bixbyite-braunite ore; stringers, veins or other possible indications of the nearness of a pocket are absent. Pockets vary in size from a few cm to as large as 1½ m deep and 60 cm wide (4 feet deep and 2 feet wide!), often completely lined with fine rhodochrosite crystals. Pockets 15 to 20 cm in size are not uncommon but many are destroyed by the mining process. One specimen weighing 136 kg (300 pounds) was salvaged from the large pocket mentioned above and now resides in a South African museum.

N'Chwaning rhodochrosite is without doubt the most attractive rhodochrosite found outside of the Americas in many decades and ranks with specimens from Colorado, Mexico and Peru as a true classic. Although specimens are relatively abundant on the market they typically command very high prices; cabinet pieces costing several thousand dollars are not uncommon.

Manganite MnO(OH)

Manganite has previously been identified from only the Adams and Hotazel mines, where it forms veins and masses in pyrolusite associated with braunite. Small crystals in vugs are striated parallel to the elongation, rarely twinned, and sometimes partially altered to pyrolusite. Hotazel mine specimens in the Smithsonian collection were examined in this study; all were associated with rhodochrosite and sometimes quartz.

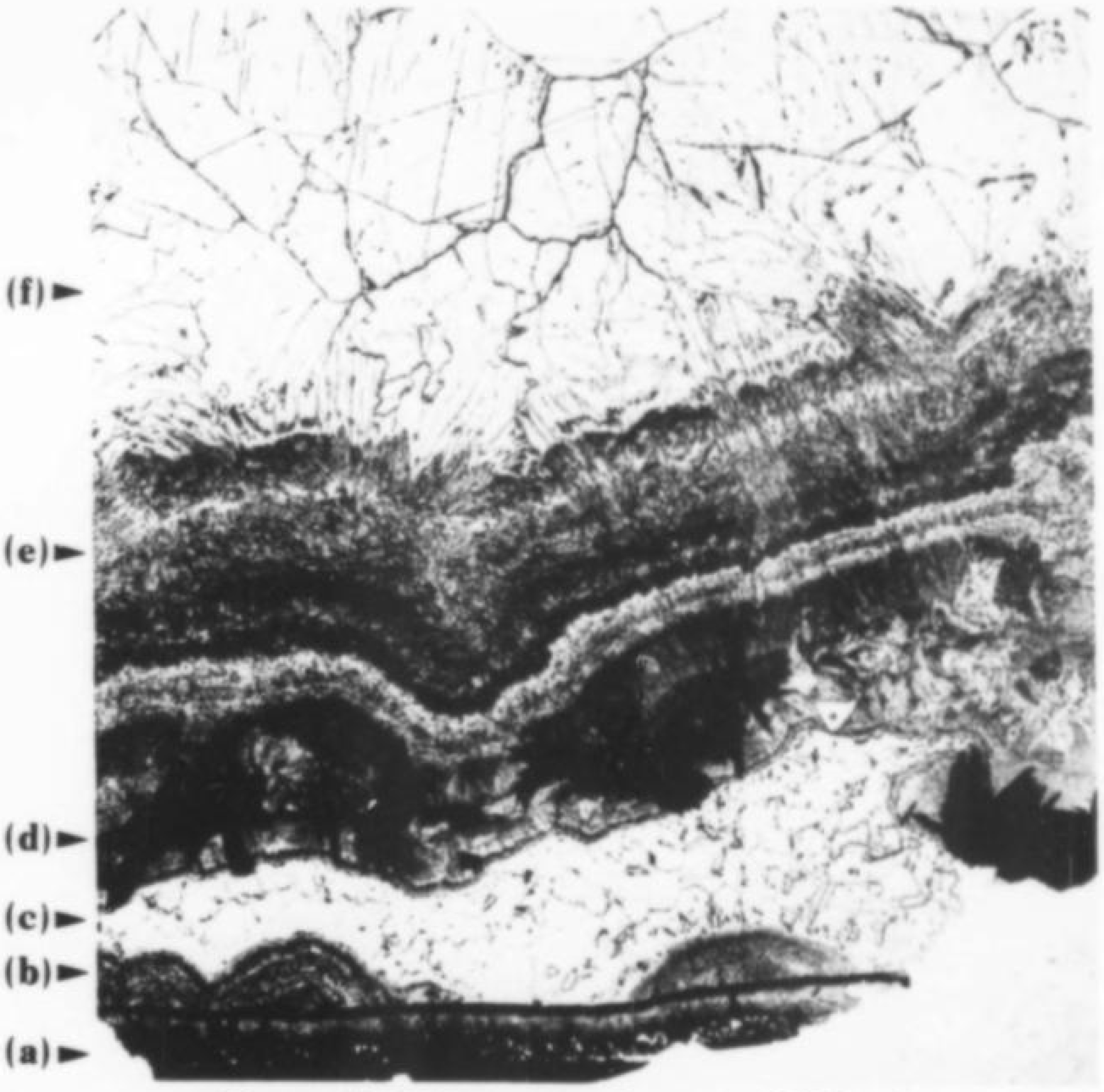


Figure 21. **Thin section in normal light showing a section through a rhodochrosite crust from the N'Chwaning mine. Several generations of rhodochrosite and manganite can be seen in this section. The black areas are manganite and the transparent areas are rhodochrosite of varying textures. Earliest formed layers are at bottom. Smithsonian specimen.**

N'Chwaning manganite occurs in excellent crystals to several mm. A thin-section of a specimen representative of the manganite-rhodochrosite paragenesis (Fig. 21) consists of a very fine-grained base *(a)* of impure manganite followed by a mixture of fine-grained rhodochrosite and manganite *(b)* about ½ mm thick. Rhodochrosite within the *(b)* layer contains about 0.4% FeO. Atop layer *(b)* is a layer *(c)* of more coarsely crystalline rhodochrosite containing less iron and very small amounts of calcium. Following rhodochrosite layer *(c)* is a second generation of manganite unlike layer *(a)*; it is composed of euhedral crystals up to 2 mm in length. This second-generation manganite contains less iron, about 0.2% FeO. Fine-grained rhodochrosite *(e)* and finally large, gemmy rhodochrosite *(f)* complete the sequence. The crystals are very lustrous and make fine manganite specimens even when not accompanied by rhodochrosite.

An extraordinary specimen of N'Chwaning mine manganite (Fig. 22) in the Smithsonian collection is composed almost entirely of twinned crystals. The crystals are twinned on (011), with elongation along the *b* axes, to form "bow ties" from 3 to 7 mm in size. The crystals are striated parallel to *c*.

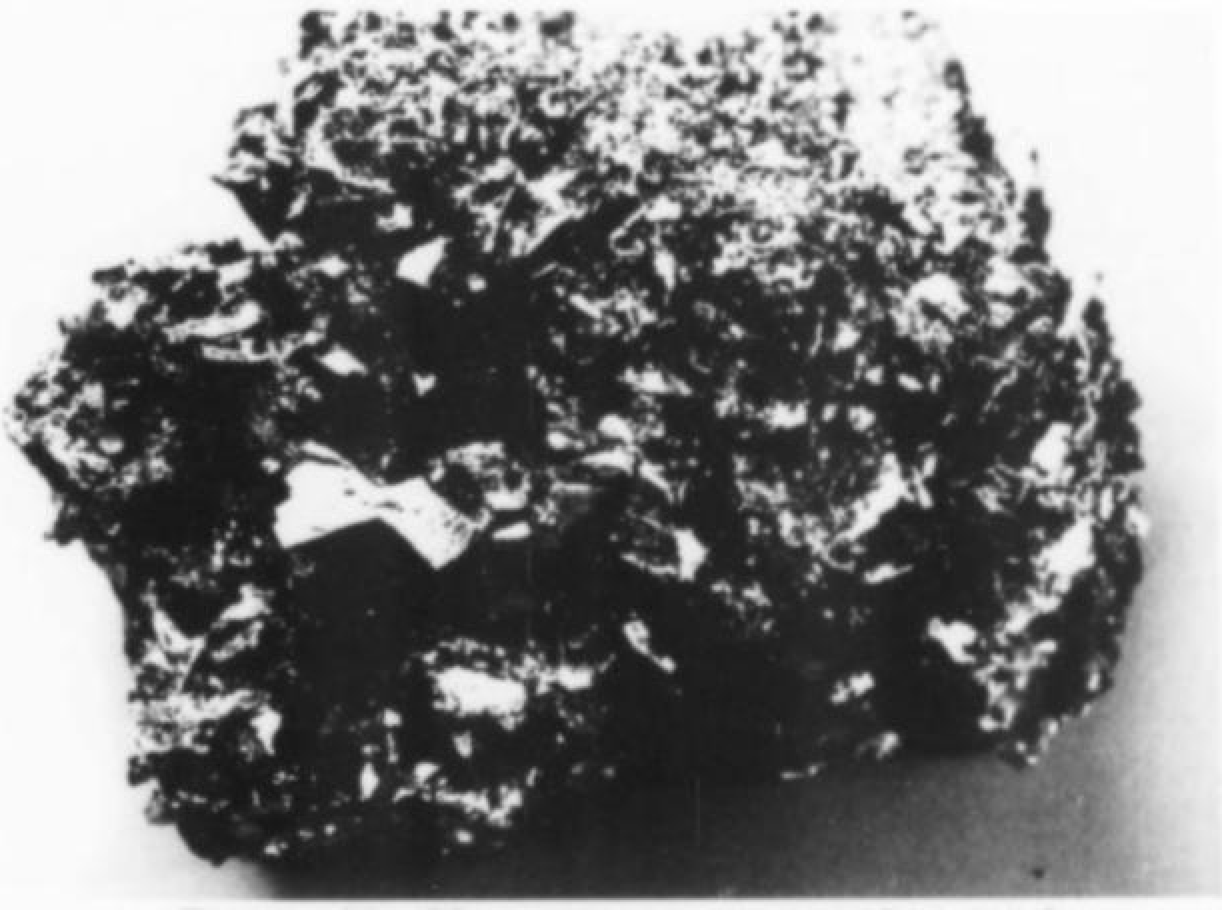


Figure 22. **Manganite in twinned crystals from the N'Chwaning mine. The twins resemble bow ties in shape; the one highlighted near the center measures 7 mm, and the entire specimen is 4.5 cm across. Smithsonian specimen; photo by WEW.**

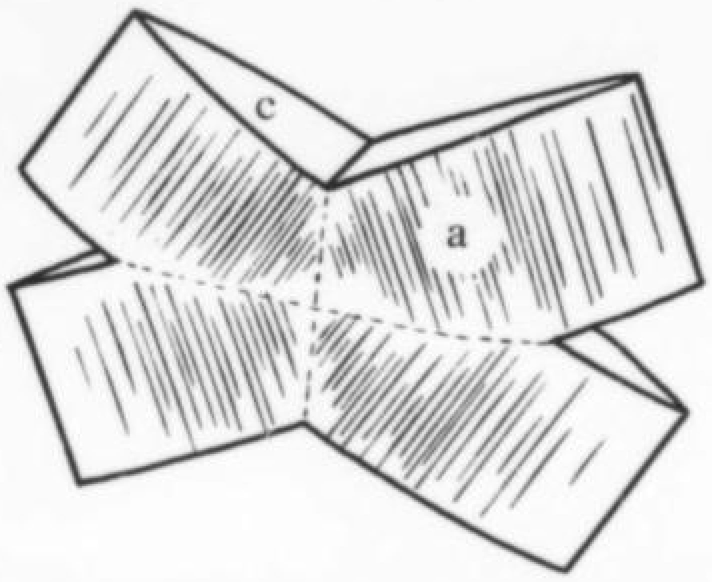


Figure 23. **A sketch illustrating the twinning of manganite from the N'Chwaning mine. The crystals are elongated along *b*, twinned on (011), and striated parallel to [001].**

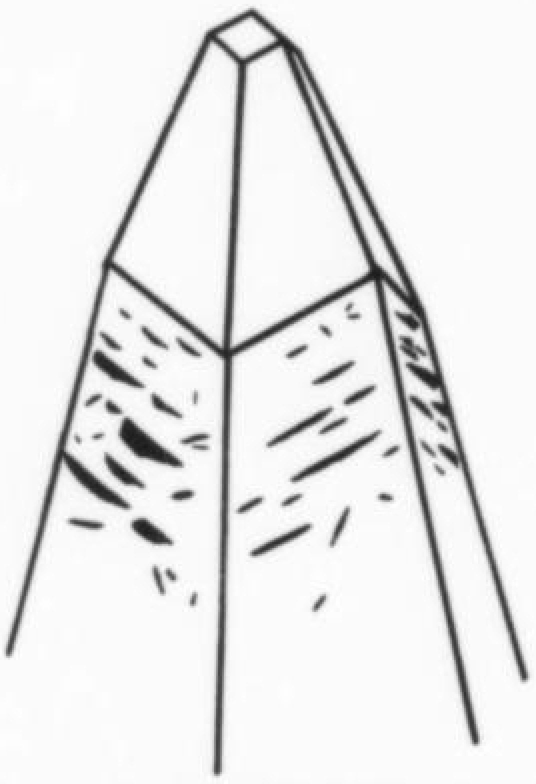


Figure 24. **A sketch illustrating a possibly epitaxial intergrowth/overgrowth of small manganite crystals in/on a rhodochrosite crystal from the N'Chwaning mine. The manganite plates appear to be oriented parallel to the cleavage rhombohedron in many places. Smithsonian specimen.**

A large specimen of N'Chwaning mine rhodochrosite in the Smithsonian collection shows small (1 to 3 mm) platy manganite crystals in a possible epitaxial intergrowth/overgrowth with rhodochrosite (Fig. 24). The small manganite plates occur protruding from the faces of the higher angle scalenohedron, and are mostly (but not exclusively) oriented parallel to the cleavage rhombohedron $\{10\bar{1}1\}$. Further study will be needed to confirm this as an epitaxial relationship and to establish the precise mutual orientation; such a relationship is unexpected because of the lack of common crystal structure elements.

Table 1.
Microprobe analysis of Wessels mine ruizite

	Wessels	Theoretical***
CaO	17.62 %	18.68 %
Mn_2O_3	27.94 %**	26.29 %
SiO_2	39.46 %	40.03 %
H_2O	14.98 %*	15.00 %
Total	**100.00**	**100.00**

* - H_2O by difference
** - Total manganese calculated as Mn_2O_3
*** - from Williams and Duggan (1977)
Accuracy of data - ± 3% relative.

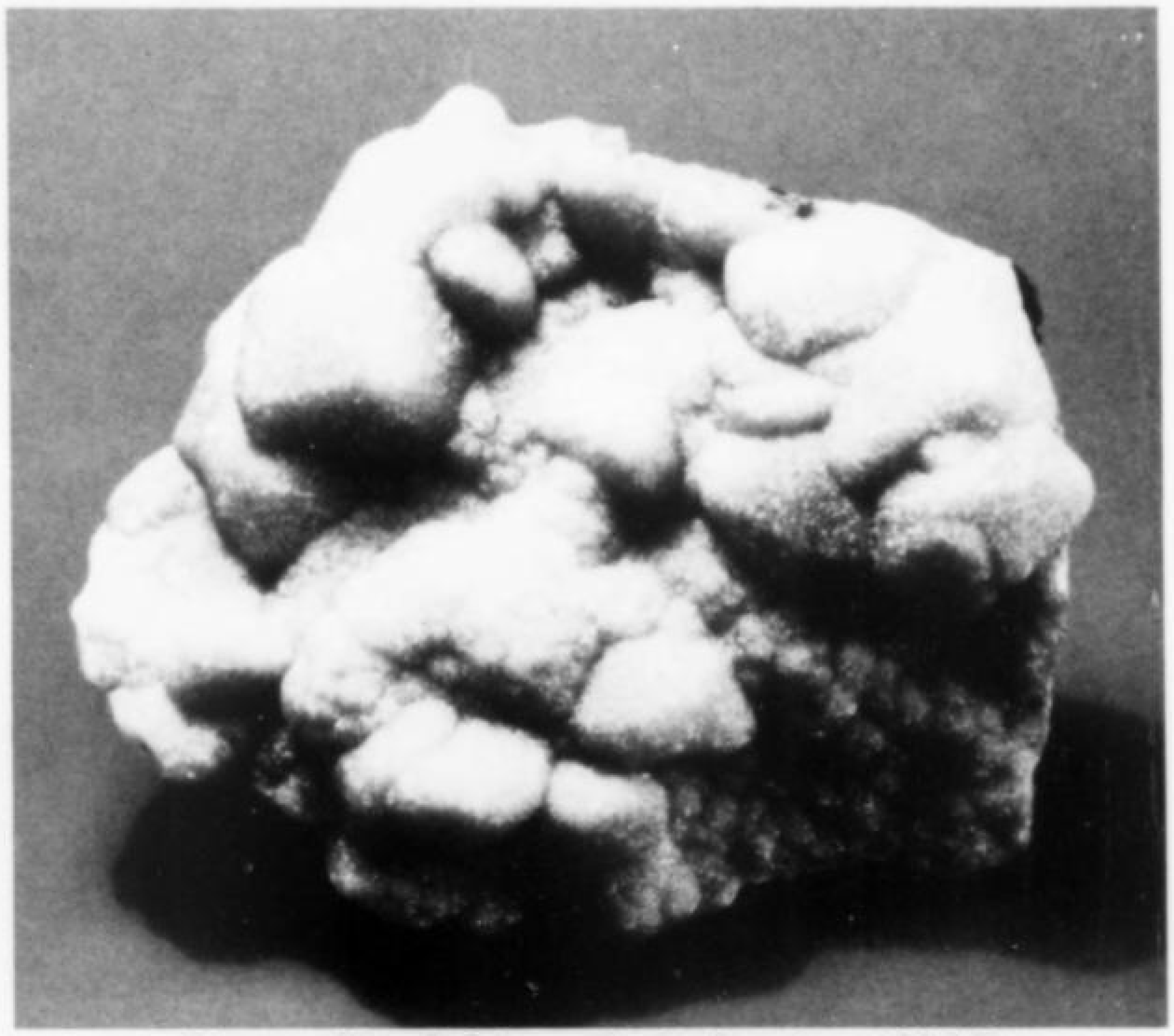


Figure 25. **Calcian rhodochrosite (44.16% MnO, 12.72% CaO) from the N'Chwaning mine. The crust appears to cover rhombs of calcite; 5.5 cm long. Smithsonian specimen; photo by WEW.**

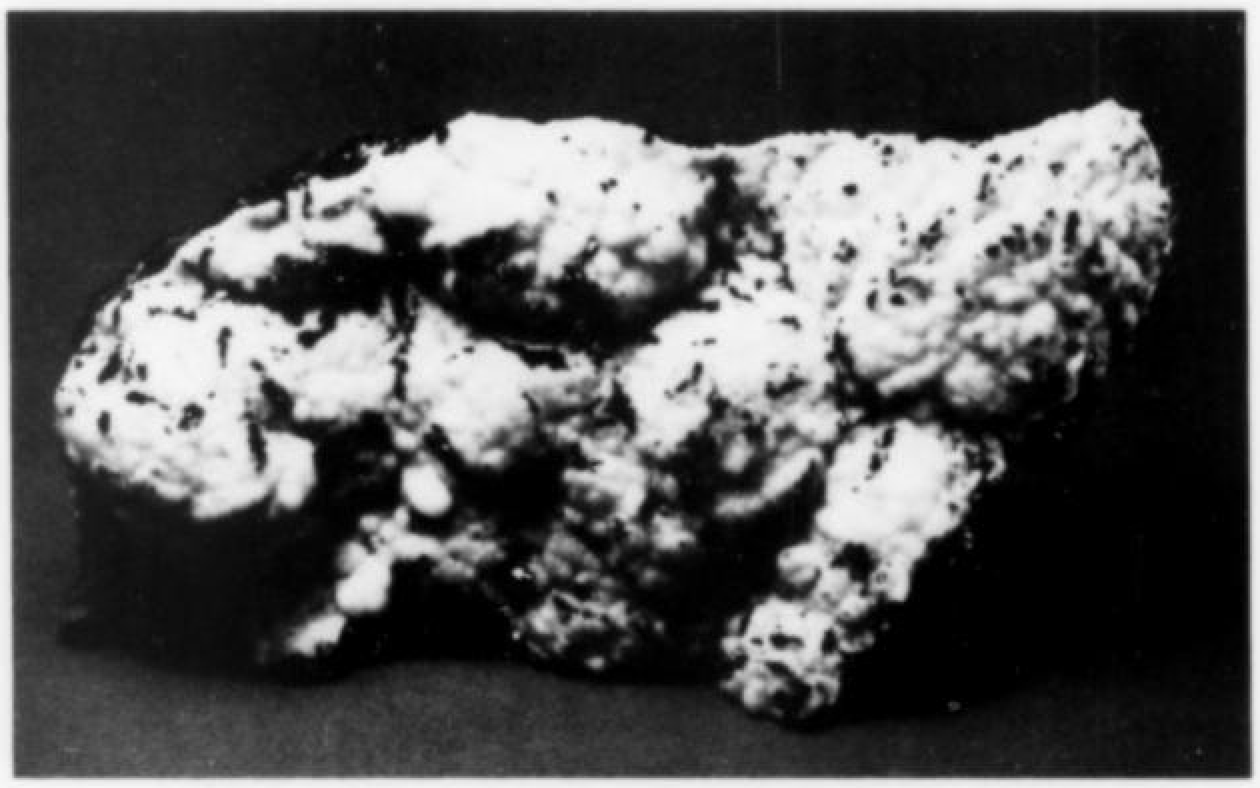


Figure 26. **A crust of manganoan calcite (14.15% MnO, 40.46% CaO) about 7 cm across from the N'Chwaning mine. Smithsonain specimen; photo by WEW.**

Calcite $CaCO_3$

In addition to the manganite-rhodochrosite assemblage, several other specimens from the N'Chwaning mine were studied. Some of these were intermediate in composition between rhodochrosite and calcite. Of particular interest was a peculiar specimen consisting of a pearly pink crust coating rhombs of calcite which, in turn, rest on impure manganite. This pink crust is very attractive and we hope that more such specimens will be found and saved. Microprobe analysis of the crust yields 44.16% MnO, 12.72% CaO and 1.74% MgO, yielding a Mn:Ca ratio of 3:1—the material is therefore a calcian rhodochrosite. A second Smithsonian specimen consists of a nearly white crust on manganite. This crust contains 14.15% MnO, 40.46% CaO and 0.78% MgO, yielding an Mn:Ca ratio of nearly 1:3—it is therefore a manganoan calcite.

Another specimen consists of frosted rhombs of calcite with an oriented overgrowth of white acicular calcite needles elongated along the *c* axis. It fluoresces a weak pink in both long and short wave ultraviolet light, perhaps due to manganese activation.

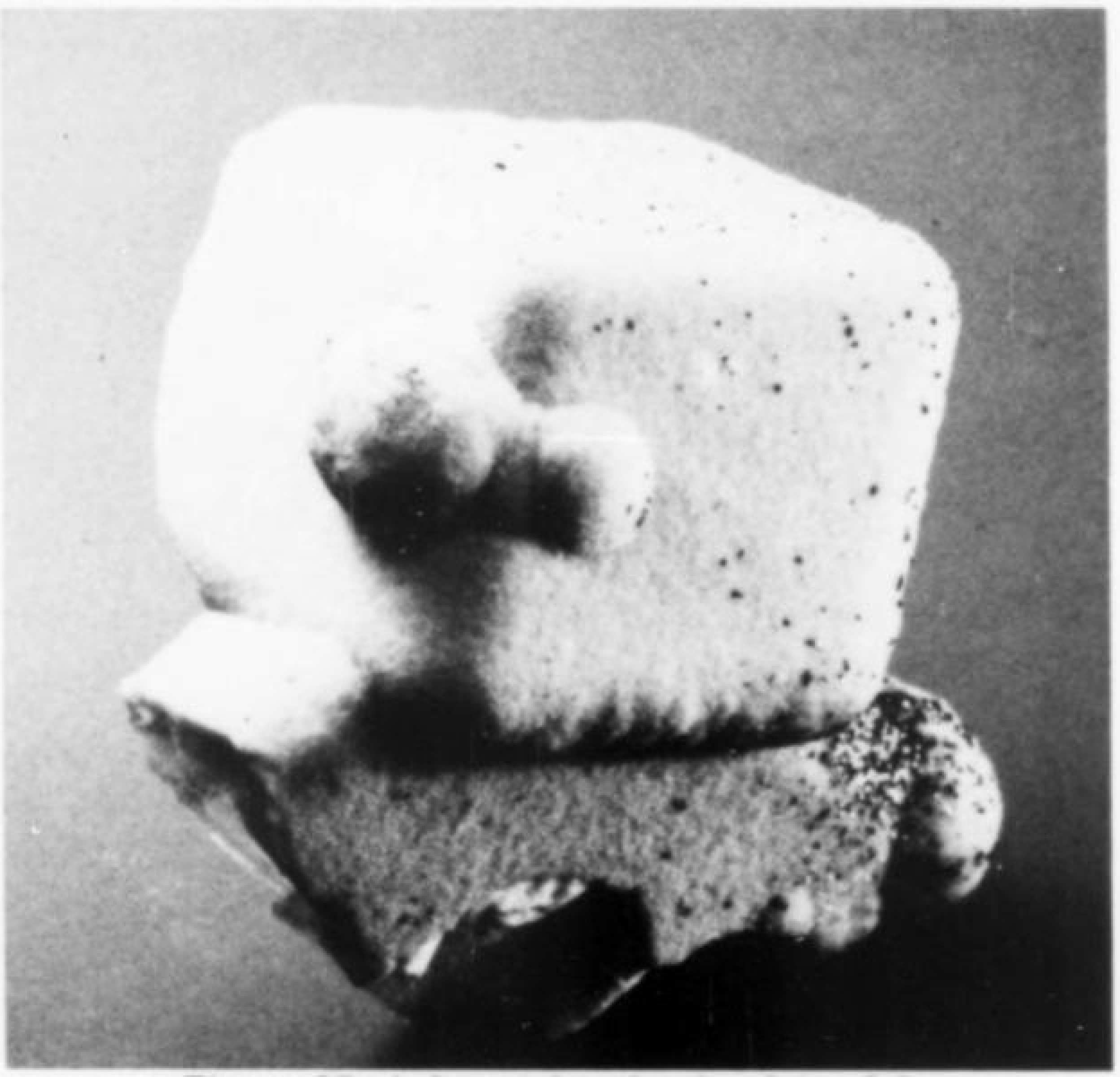


Figure 27. **A large rhomb of calcite 2.5 cm in size coated by an overgrowth of fine-grained calcite from the N'Chwaning mine. Smithsonian specimen; photo by WEW.**

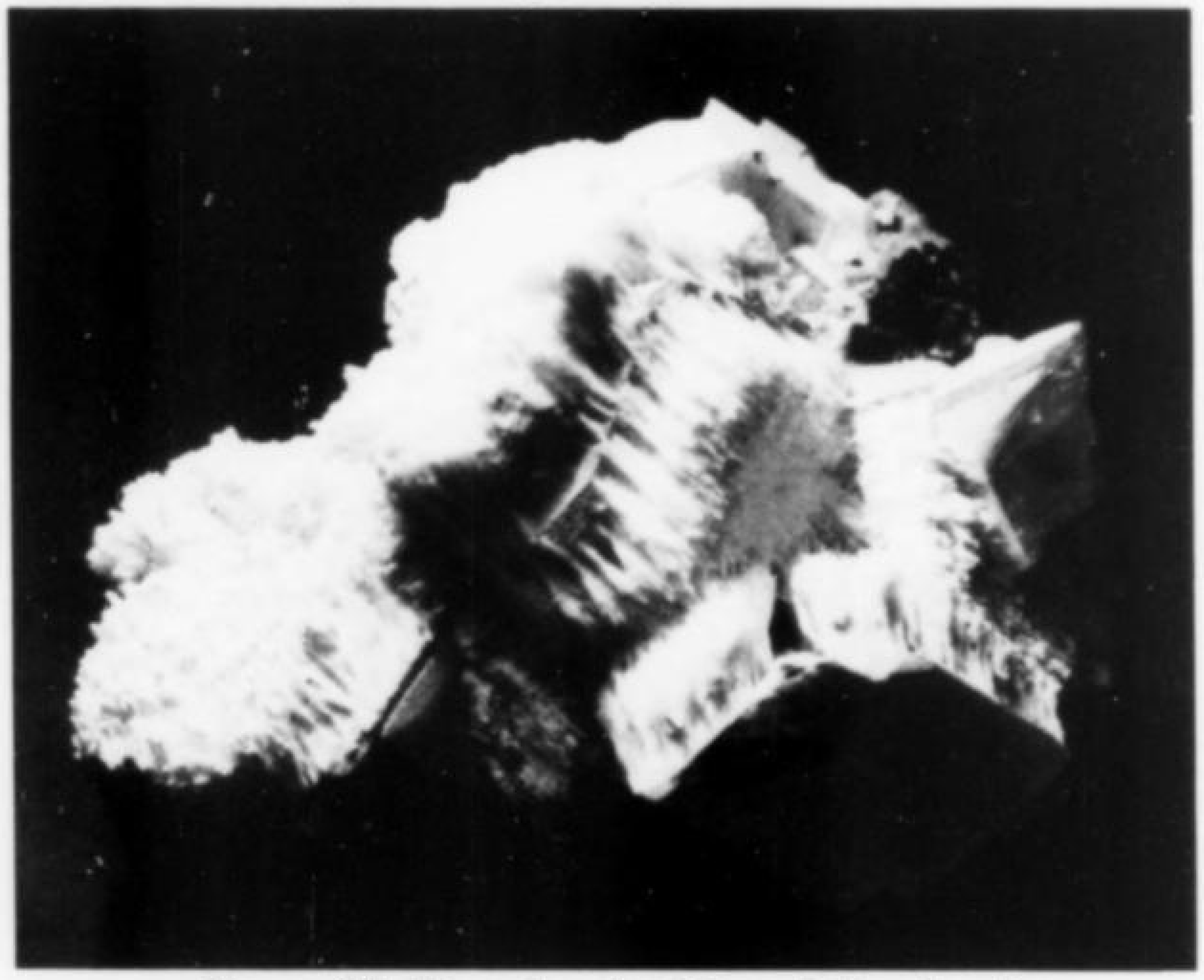


Figure 28. **Rhombs of white calcite showing an oriented overgrowth of acicular calcite. The group is 6 cm wide. Smithsonian specimen; photo by WEW.**

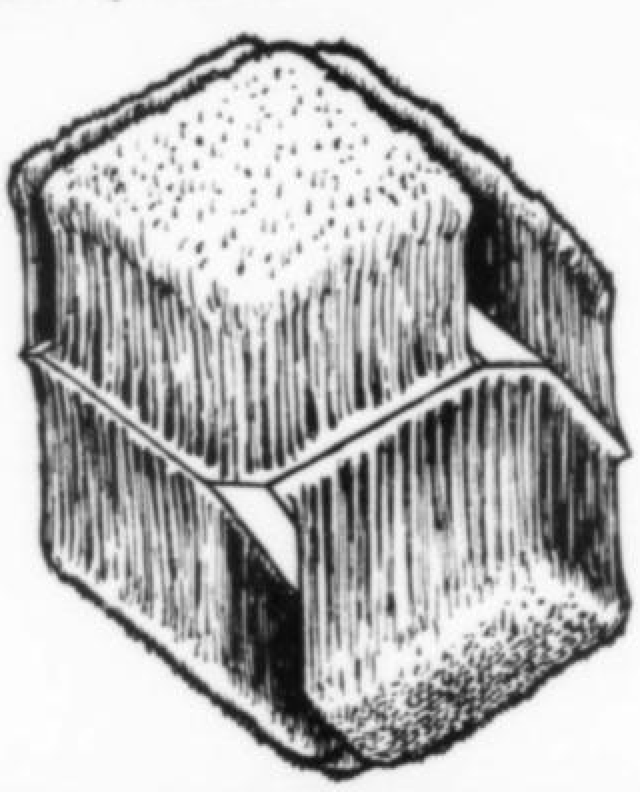


Figure 29. **A sketch illustrating the calcite overgrowth on calcite crystals in the preceding figure. The calcite needles appear to be elongated parallel to [0001].**

Figure 30. **A crust of manganite crystals overgrown on a clear (broken) rhomb of calcite from the N'Chwaning mine. The specimen is about 6 cm across. Smithsonian specimen; photo by WEW.**

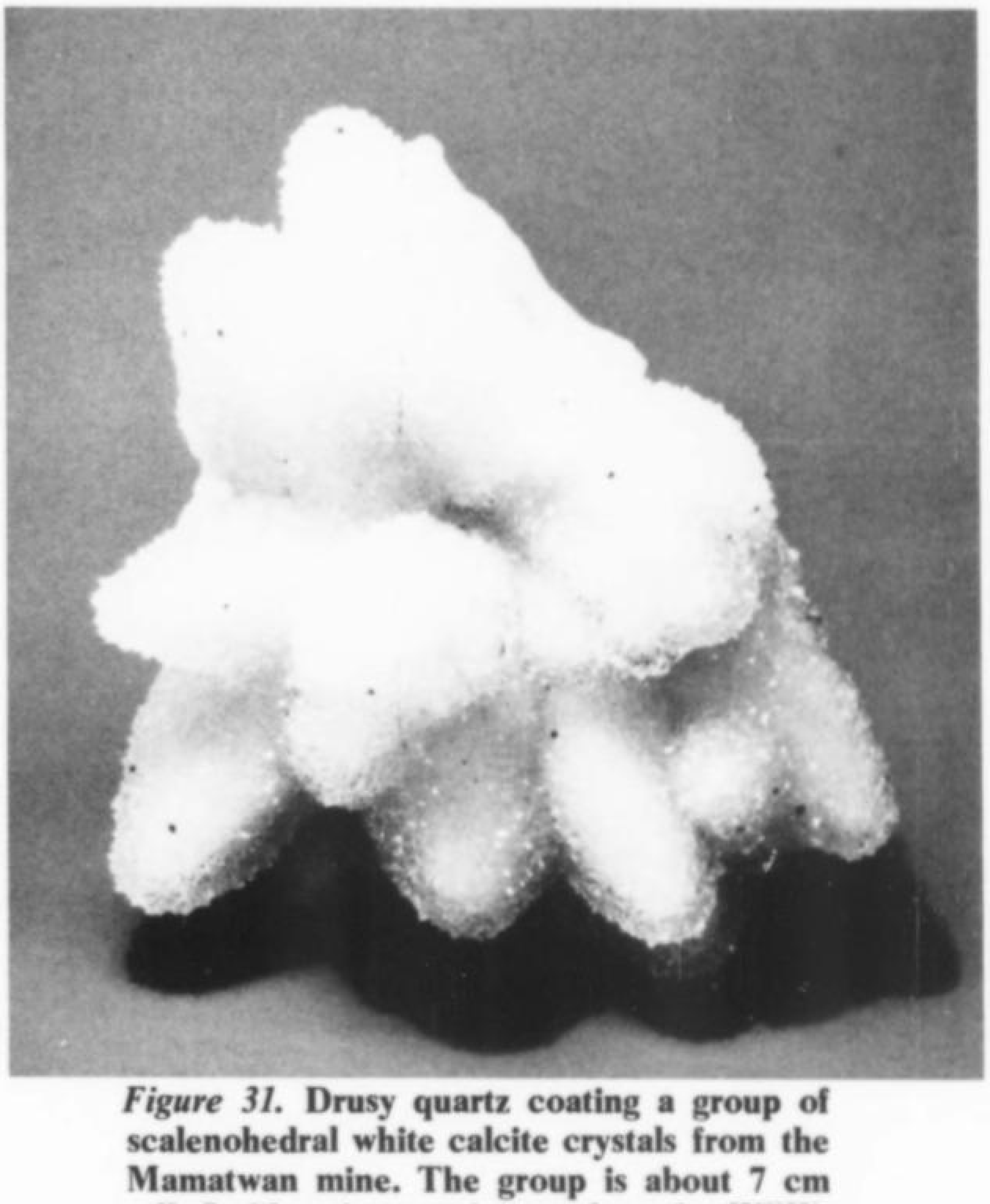


Figure 31. **Drusy quartz coating a group of scalenohedral white calcite crystals from the Mamatwan mine. The group is about 7 cm tall. Smithsonian specimen; photo by WEW.**

Other N'Chwaning mine calcite specimens show a variety of habits and features. A large (6 cm), transparent rhomb of calcite in the Smithsonian collection is coated with a layer of manganite crystals; a group of scalenohedral crystals is covered by a layer of clear, drusy quartz; a group of large crystals 8.5 cm tall appears to be composed of large platy calcite crystals overgrown by a second generation of oriented small scalenohedral crystals several mm in size.

Judging from this small sampling, it is probable that the locality has much more to offer in the way of interesting and varied cal-

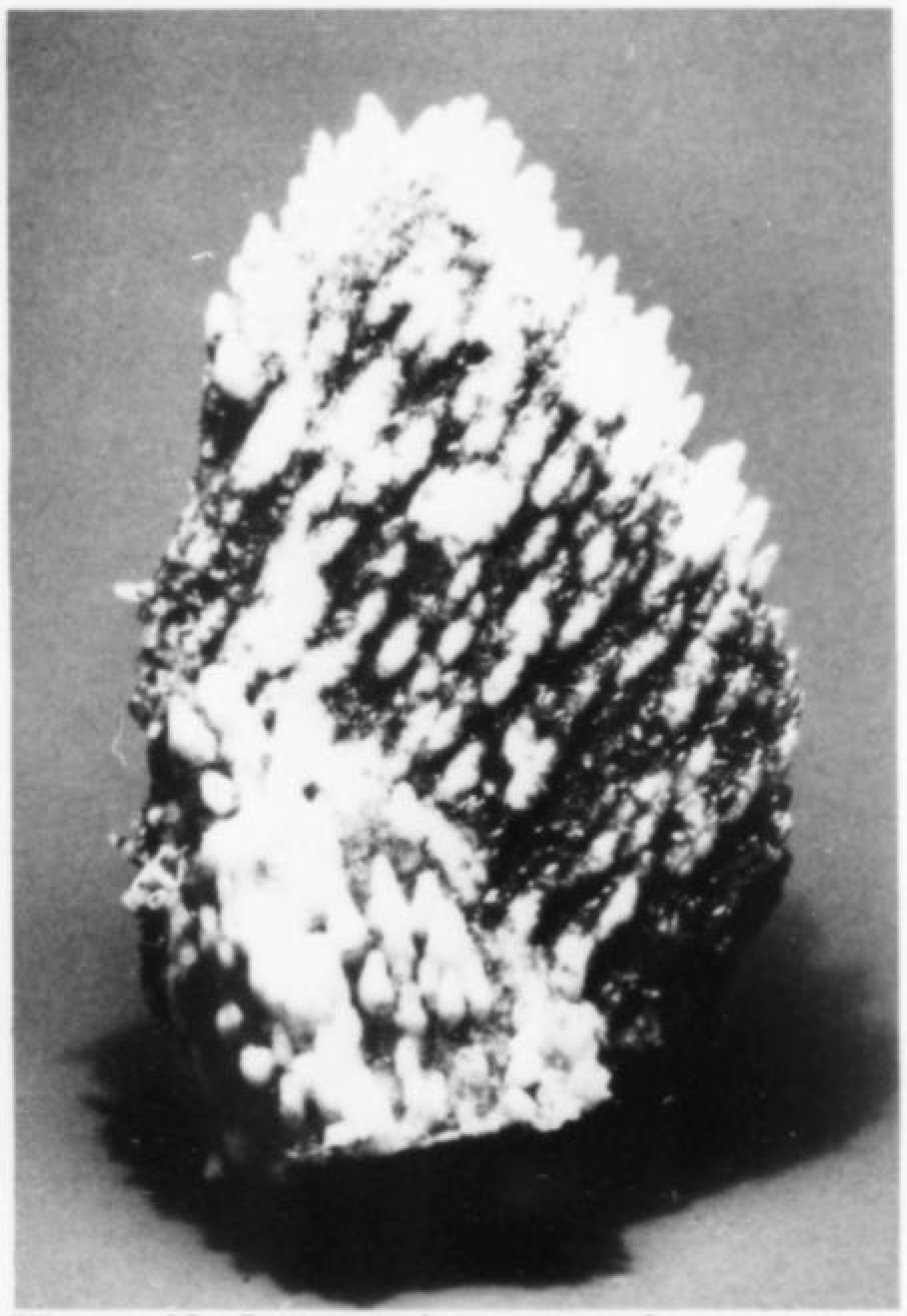


Figure 32. **Large calcite crystals overgrown by small, oriented calcite crystals from the N'Chwaning mine. The group is 9 cm tall. Smithsonian specimen; photo by WEW.**

cite habits. De Villiers (1971) reported that calcite has been found as secondary vein fillings in all mines of the Kalahari field. According to Desmond Sacco (personal communication) an extensive zone of calcite was encountered in the upper levels of the N'Chwaning mine shortly after its opening in 1974, and many interesting habits were seen though almost none were saved. The rhodochrosite zones were encountered below the calcite areas.

Gypsum $CaSO_4 \cdot 2H_2O$

Gypsum was observed in this study on one manganite specimen from the N'Chwaning mine. The light brown gypsum crystals are imbedded in the manganite and are exposed on a fracture surface. Microprobe analysis revealed no detectable manganese in this gypsum.

De Villiers (1971) reported clear, crystalline gypsum in association with fine rhodochrosite crystals from the Hotazel mine.

Inesite $Ca_2Mn_7Si_{10}O_{28}(OH)_2 \cdot 5H_2O$

Four very attractive specimens from the Wessels mine were loaned to us for study by William Larson of Pala Properties International, Inc. Inesite, datolite, pectolite, apophyllite, ruizite, orientite and quartz were all observed on the largest of these specimens, comprising a unique assemblage. Of these species, only quartz has been previously reported from the Kalahari field.

The main specimen (Fig. 33) consists of a layer of inesite about 2 cm thick, with inclusions of anhedral quartz grains to several mm. The inesite is a very pleasing medium pink color, in crystal clusters up to 10 mm in length and tightly packed. Although the top of the crust of inesite is overlain with other minerals (see below), crystal terminations may be observed in crevices along the sides of the specimen. Though not parallel, the long direction of the crystals is roughly perpendicular to the crust base. The quality of the inesite is high and such specimens would be in demand even if the other minerals were absent.

Datolite $CaBSiO_4(OH)$

Implanted directly on the top of the crust of inesite are colorless datolite crystals to about 1.0 mm in size. Microprobe analysis indicates that the datolite is manganese-free.

Figure 33. **Sprays of pink inesite (center) with a drusy coating of datolite (top) and imbedded euhedral quartz grains (lower left) from the Wessels mine. The field of view is 2 cm tall. William Larson specimen; photo by WEW.**

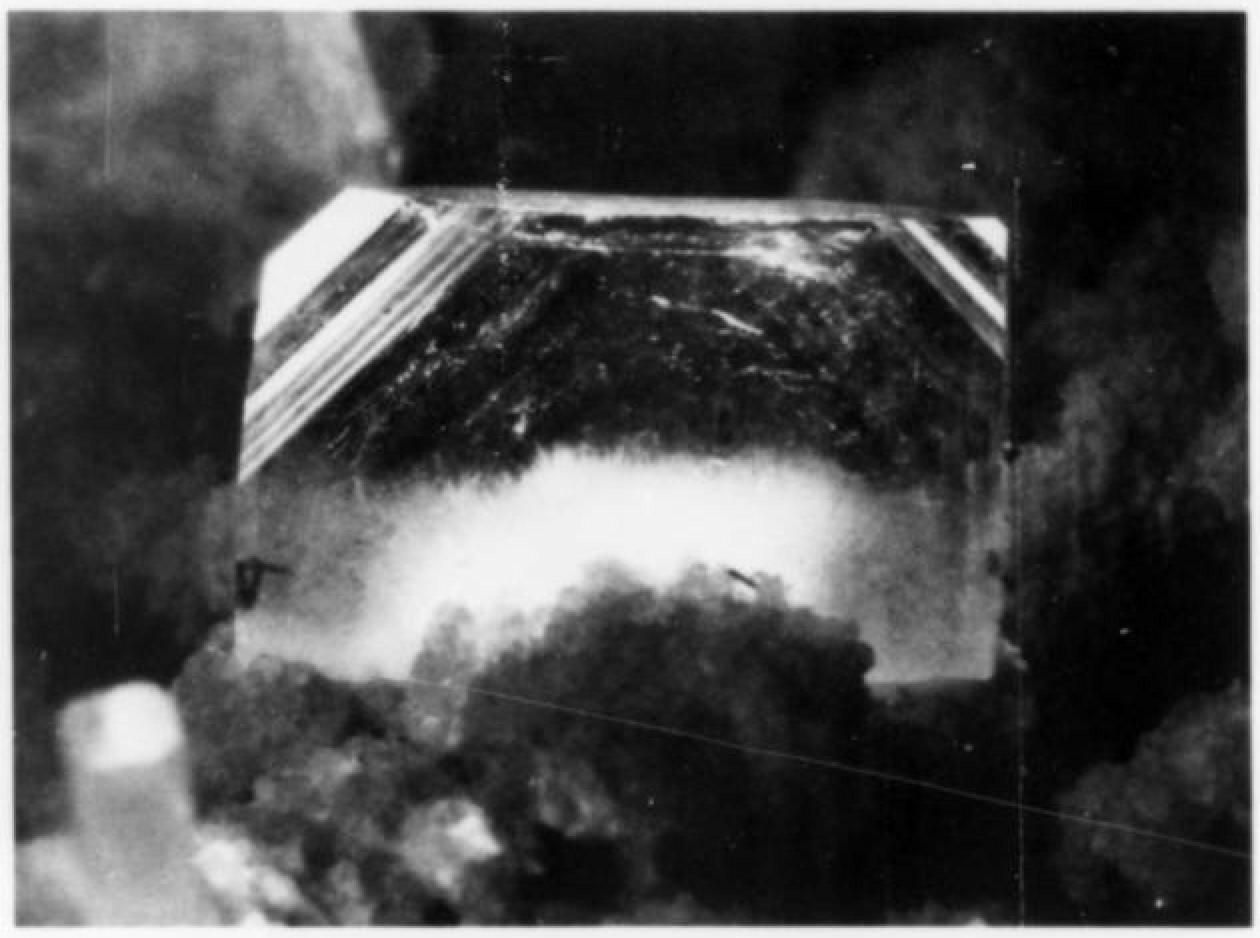


Figure 34. **Apophyllite showing three pyramid forms on the corners. The crystal is surrounded by a druse of datolite with small, dark ruizite crystals, and the interior of the crystal shows white pectolite needles on the datolite, protected by the enclosing apophyllite. The crystal is about 1 cm across, from the Wessels mine. William Larson specimen; photo by WEW.**

Pectolite $Na(Ca,Mn)_2Si_3O_8(OH)$

Most of the datolite crystals on the Larson specimen are in turn covered with a mat of tiny white fibers. The X-ray pattern matches a pattern for manganoan pectolite (the variety *schizolite*), and microprobe analysis reveals a CaO content of about 20% and a MnO content of about 16%, confirming the X-ray identification. Most of the crystals appear to have been crushed or broken down, possibly by handling or washing. However, undamaged crystals may be clearly seen *within* apophyllite crystals, the apophyllite protecting the pectolite over which it grew. The fibers within the apophyllite crystals are 1 to 2 mm in length and exceedingly thin.

Apophyllite $K(Ca,Mn)_4Si_8O_{20}(F,OH)\cdot 8H_2O$

Very well formed, transparent crystals of apophyllite about 1 by 1 by 0.4 cm in size are present on the Larson specimens. They have grown on top of and around datolite and pectolite crystals. Microprobe analysis indicates approximately equal amounts of fluorine and hydroxyl; therefore these crystals are appropriately referred to as apophyllite, rather than fluorapophyllite or hydroxyapophyllite (Dunn, *et al.*, 1978, Dunn and Wilson, 1978). These crystals are notable in that they also contain about 1.8% MnO; manganese is not commonly found in apophyllite.

The morphology of these crystals is interesting. Apophyllite in general is rather limited in the development of forms; crystals from other localities commonly have only one prism, the pinacoid (pearly luster), and possibly one dipyramid. The crystals on the Wessels mine specimens of Larson have three different dipyramids as well as a prism and pinacoid, a most unusual assemblage of forms.

Quartz and Opal $SiO_2 - SiO_2\cdot nH_2O$

Small grains of quartz to about 2 to 4 mm in size occur imbedded in the inesite of the Larson specimens. They appear to be anhedral and may have formed simultaneously with the inesite.

Quartz and opal are common elsewhere in the Kalahari field, and are components of the sedimentary units. Secondary chalcedony has been observed and chert is very common.

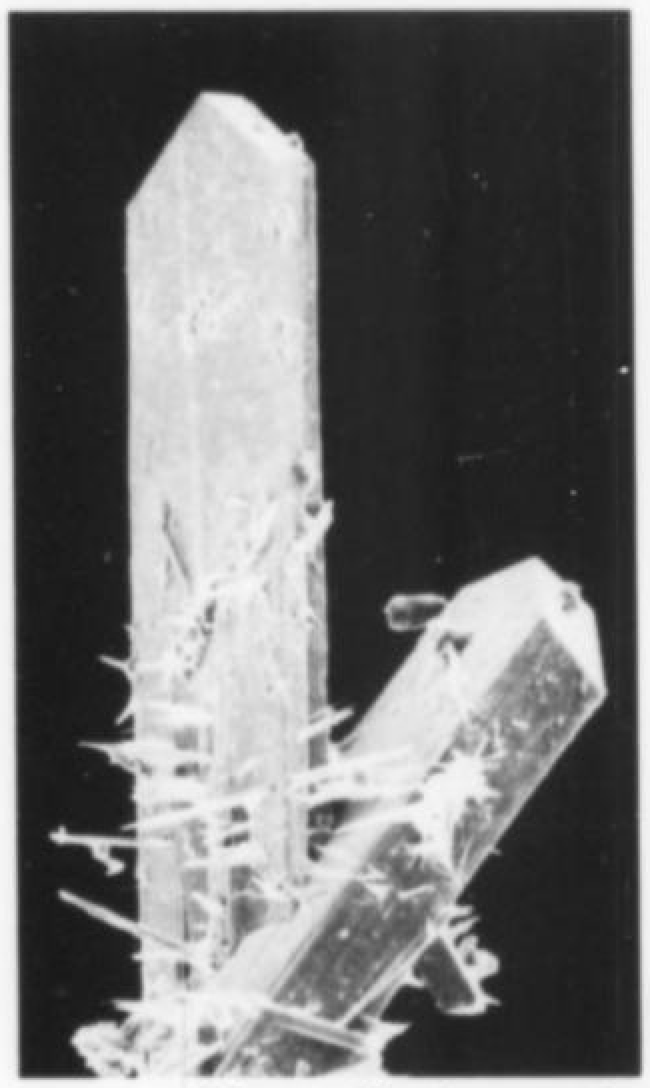
Ruizite $CaMn^{+3}(SiO_3)_2(OH)\cdot 2H_2O$

One of the more exciting minerals found at the Wessels mine is ruizite, which was recently described as a new mineral from the Christmas mine, Gila County, Arizona (Williams and Duggan, 1977).

Figure 35. **Ruizite on pectolite from the Wessels mine, photographed in normal light. The ruizite crystal is about 1 mm tall and has a dark red color. William Larson specimen; photo by WEW.**

The ruizite crystals from the Wessels mine were first noted by William Larson of Pala Properties and called to the authors' attention by John S. White Jr., who noted their dark reddish orange color and thought they might be unique in some way. The discovery that these crystals were ruizite was indeed a case of mixed emotions; we thought we had a new mineral based on the available data for known minerals and only after a day of much excitement did we note that this beautiful mineral was identical to a new mineral then before the IMA Commission on New Minerals and Mineral Names for voting.

However, the last may in some ways be first and we have, in the Wessels mine, ruizite crystals far better and larger than those from the type locality. The crystals (Figs. 35-37) are implanted on the previously described pectolite-datolite assemblage. The order of deposition is as follows: inesite with orientite and quartz, followed by datolite and pectolite, followed by apophyllite and ruizite. The apophyllite and ruizite appear to have formed at the same time; some of the ruizite crystals are imbedded in apophyllite. This is most interesting because the same conditions exist at the Christmas mine where ruizite is encased, in some cases, in apophyllite.



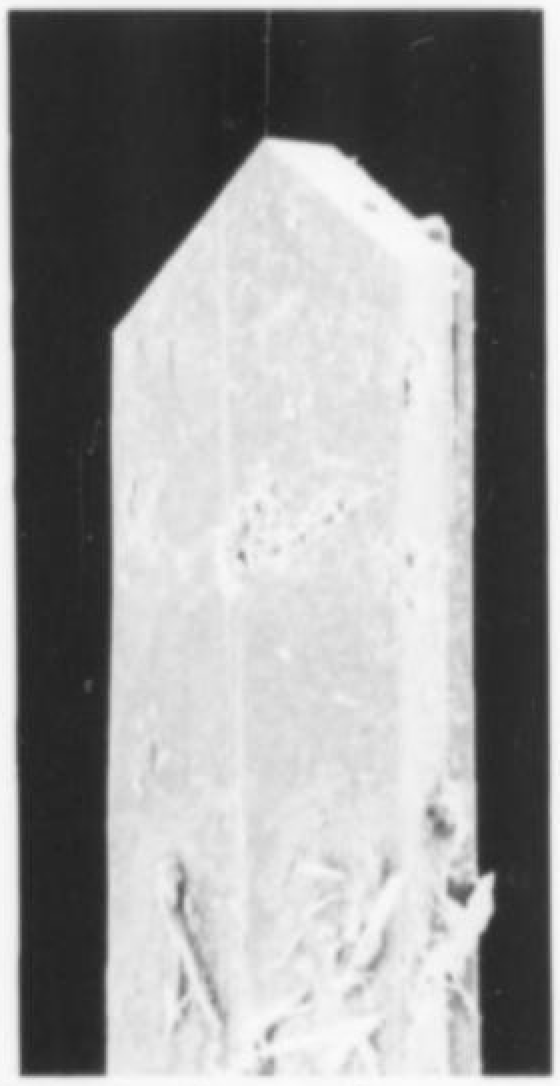


Figure 36. **A scanning electron micrograph of two intergrown ruizite crystals with white crystals of pectolite (?) adhering, from the Wessels mine. The crystals are about 0.2 mm in width. Smithsonian specimen #136812; photo by PJD/MJM.**

Figure 37. **SEM photo of a crystal in the previous figure showing a re-entrant angle on the right side indicative of twinning on (100). The crystal is about 0.2 mm wide and about 0.03 mm thick. Smithsonian specimen #136812; photo by PJD/MJM.**

The Wessels mine ruizite crystals are superb. They are much larger (up to 1.0 mm) than those at the type locality, and quite attractive. The morphology is rather simple; the crystals are prismatic in habit, are elongated on [010], and flattened on {100} (Sidney Williams, personal communication). Scanning electron microscope (SEM) photographs of some of the ruizite crystals are shown in Figures 36-37. The twinning on *a* (100), as noted by Williams and Duggan (1977) on the Christmas mine material, is evident on these crystals as a re-entrant angle on the side of the large crystal shown in Figure 37. The white acicular crystals growing on ruizite are unknown and could not be identified because of their small size. However, considering the associated minerals, and the habit, it is very likely that they are pectolite.

The ruizite was chemically analyzed using an electron microprobe utilizing an operating voltage of 15 kV and a beam current of 0.15 μA. The data were corrected using Bence-Albee correction factors in a computer program. The standards used were diopside for silicon and calcium, and manganite for manganese. A wavelength-dispersive scan indicated the absence of any elements with atomic number greater than nine. The resultant analysis is given in Table 1, and is in good agreement with the theoretical composition. The X-ray powder pattern of the Wessels mine ruizite is identical to that of the ruizite from the Christmas mine.

Unlike the readily available rhodochrosite/manganite specimens, ruizite was noted on only four specimens owned by William Larson and may not be available in any substantial quantity.

Figure 38. **Reddish black orientite crystal 2 mm in size, partially imbedded in pink inesite, from the Wessels mine. William Larson specimen; photo by WEW.**

Orientite $Ca_2Mn_3^{+3}(SiO_4)_3(OH)$?

A second trivalent manganese silicate was also found on the Larson specimens. Orientite occurs as anhedral to subhedral blebs up to 3 mm intimately associated with inesite and quartz in the inesite seams. The orientite is very dark red in color, almost black to the unaided eye, and was first noted by one of the authors (WEW), who questioned its identity.

The X-ray powder pattern of the Wessels mine orientite matches that of the type orientite from Oriente Province in Cuba. Our preliminary analytical data have raised questions about the correct chemical formula for orientite, but single crystals of the Wessels mine material were not found. Aware that other investigators may be pursuing this topic, we wish here only to report the existence of orientite at this mine, inasmuch as it is a rare mineral.

Hematite Fe_2O_3

Hematite is a common mineral in the ore of the Kalahari field. It occurs as minute inclusions in jacobsite, as coarse or fine-grained crystals sometimes rimmed by jacobsite, as inclusions in bixbyite and jacobsite, as veins relatively late in the paragenetic sequence, and in the banded ironstone formations.

Superb crystals of hematite have been found at the Wessels mine (Clive Quiet, personal communication). One such specimen in the Smithsonian collection consists of brilliant crystals to 2 cm on matrix; the crystals are equant in shape with the hexagonal prism and pinacoid predominating and small rhombohedron faces truncating all corners.

Crystals to many cm in size but more crudely developed have been observed at the N'Chwaning mine near the bostonite contact (D. Sacco, personal communication).

Other species

Several other species have been privately reported from the Kalahari field but have yet to be confirmed by the authors and so will not be mentioned here. However, new study material is continuing to come to the authors through various channels; further findings will be reported in the *Record.*

Species reported by others.

Acmite $NaFeSi_2O_6$

Dark brown, crystalline aggregates of acmite have been observed in hand-specimens from the Black Rock mine.

Andradite $Ca_3Fe_2^{+3}(SiO_4)_3$

Brown andradite in distinct, dodecahedral crystals having a weathered appearance occurs rarely at Black Rock and Hotazel. It is found in vugs and also disseminated in the ore and in the banded ironstone.

Ankerite $Ca(Fe,Mg,Mn)(CO_3)_2$

Ankerite of a red color has been reported in drill cores from the footwall of the Mamatwan mine.

Barite $BaSO_4$

Barite has been identified as relatively common in the ore from the Black Rock mine. The ore from all other mines in the area contains appreciably less barium.

Table 2. Minerals reported from mines within the Kalahari manganese field. (principal ore minerals in italics)

Hotazel mine

Cryptomelane, braunite, hausmannite, jacobsite, wad, bixbyite, ramsdellite, pyrolusite, todorokite, chalcophanite, gypsum, lithiophorite, manganite, nsutite, goethite, hematite, rhodochrosite, tremolite, hollandite, andradite, cymrite, "manganous manganite," calcite, piemontite, nontronite, hydromica

Devon and Langdon mines

Cryptomelane, braunite, hausmannite, jacobsite, pyrolusite, todorokite, goethite, hematite, nontronite, calcite.

Mamatwan and Adams mines

Cryptomelane, braunite, hausmannite, jacobsite, rhodochrosite, ankerite, manganite, todorokite, minnesotaite, talc, calcite, lithiophorite, goethite

Smartt mine

Braunite, todorokite, jacobsite, rhodochrosite, calcite, goethite

Black Rock mine

Braunite, bixbyite, cryptomelane, hausmannite, andradite, pyrolusite, lithiophorite, goethite, hematite, calcite, cymrite, barite, acmite, nontronite, hydromica, marokite

Wessels mine (as reported in this study; importance as ore not determined)

Rhodochrosite, hematite, inesite, datolite, pectolite, ruizite, apophyllite, orientite

N'Chwaning mine (as reported in this study)

Braunite, bixbyite, manganite, rhodochrosite, calcite, gypsum, hematite

Bixbyite $(Mn,Fe)_2O_3$

Bixbyite is common in veins at the Hotazel and Black Rock mines. It also forms intergrowths with braunite along certain crystallographic directions, replacement residues in pyrolusite and goethite, and idioblasts in pyrolusite. The color in reflected light is khaki-green. Euhedral crystals have not been reported from the Kalahari field, except as 5 mm cubes from the N'Chwaning mine (D. Sacco, personal communication) where it is present as a major ore mineral.

Braunite $3Mn_2O_3 \cdot MnSiO_3$

Most analyses of braunite from the Kalahari field agree reasonably well with the theoretical formula. De Villiers (1945) reported a so-called ferroan braunite from Black Rock which contained less than half the normal amount of silica, and an appreciable amount of iron and "alkali earths." De Villiers (1971) concluded that this ferroan braunite, which he called *braunite II*, contains atoms of "alkaline earth" in an ordered arrangement but would not go so far as to propose it as a new species.

Braunite (ordinary) is present in all the mines of the Kalahari field (including the N'Chwaning mine; Desmond Sacco, personal communication) and is a major constituent of these ores except at Hotazel.

Braunite II occurs in crystals 0.5 to 20 mm in size, including penetration twins and contact twins. In reflected light it is yellow-brown in color, whereas ordinary braunite is light brown. Braunite II occurs only at the Black Rock mine, often in vuggy ore associated with andradite. Some of the crystals are rimmed and replaced by cryptomelane.

Chalcophanite $(Zn,Fe,Mn)Mn_3^{+4}O_7 \cdot 3H_2O$

A tentative identification of chalcophanite in microscopic quantity from the Hotazel mine has been reported; identification was based on optical properties.

Chamosite $(Fe^{+2},Mg,Fe^{+3})_5Al(Si_3Al)O_{10}(OH,O)_8$

Chamosite has been identified only in iron ore from the Olive Pan claim (no working mine) about 5 km west of the Hotazel mine.

Cryptomelane $K(Mn^{+4},Mn^{+2})_8O_{16}$

According to Frankel (1958) cryptomelane forms a major portion of the ore at Hotazel, Langdon and Smartt mines. It has been reported by other writers throughout the Kalahari field. Nearly always of secondary origin, it forms botryoidal aggregates of very fine needles oriented perpendicular to the botryoidal surface. It also occurs as replacement ore, in veins and cavity fillings, and as massive, cryptocrystalline ore.

Cymrite $Ba_2Al_5Si_5O_{19}(OH) \cdot 3H_2O$

Hexagonal, colorless crystals of cymrite resembling nepheline or apatite are present in an altered rock called bostonite at the Black Rock and Hotazel mines. The crystals exhibit good cleavage.

Hausmannite $Mn^{+2}Mn_2^{+3}O_4$

Coarse and fine-grained hausmannite has been reported from Hotazel; coarse-grained material shows twinning. Hausmannite is also common at the Devon, Langdon, Mamatwan, Adams and Black Rock mines.

Goethite $FeO(OH)$

Goethite has been observed as a common constituent of the ore at all mines in the area except the Langdon and N'Chwaning. It is fine-grained and occurs disseminated or in veins and nodules.

Hollandite $Ba(Mn^{+4},Mn^{+2})_8O_{16}$

Hollandite has been identified in only one sample from Hotazel mine; the sample was too small for either X-ray methods or spectrochemical analysis for barium, and identification was reportedly made by optical methods alone (de Villiers, 1971).

Hydromica $(K,Na,H_3O)Al_2(Al,Si_3)O_{10}[(OH)_2,H_2O]$

Hydromica associated with nontronite as an alteration product of bostonite has been observed at the Hotazel and Black Rock mines.

Jacobsite $(Mn^{+2},Fe^{+2},Mg)(Fe^{+3},Mn^{+3})_2O_4$

Jacobsite is present at Hotazel, Langdon and Smartt mines. It generally contains minute inclusions of hematite and is occasionally intergrown with hausmannite. At Hotazel jacobsite occurs with andradite, suggesting thermal metamorphism to some degree, whereas it appears to have formed at low temperature at the Smartt mine.

Lithiophorite $(Al,Li)Mn^{+4}O_2(OH)_2$

Lithiophorite has been identified from the Black Rock, Adams and Mamatwan mines, usually in microscopic quantities as veins and aggregates.

Magnetite Fe_3O_4

Magnetite has been found as a mosaic of round grains and also as idiomorphic crystals and distorted veins. It is also a component of the ironstone formations accompanying the ore strata.

"Manganous manganite" $MnO_2 \cdot Mn(OH)_2$

Feiknecht and Marti (Ljunggren, 1955), during an examination of the oxidation of manganese hydroxide, found the final product of oxidation to be approximately $4MnO_2 \cdot Mn(OH)_2$, and named it *"manganous manganite."* The X-ray pattern consists of only five reflections, the most diagnostic of which represents a *d*-spacing of 7.13 Å. De Villiers (1971) obtained the 7.13 Å line from cryptomelane-wad ore from the Hotazel mine and concludes that "manganous manganite" is present.

Marokite $CaMn_2^{+3}O_4$

Marokite was first described by Gaudefroy *et al.* (1963) from Tachgagalt, Morocco; it has subsequently been identified by de Villiers and Herbstein (1968) in black, bright, orthorhombic crystals on one sample from the Black Rock mine. It occurs as remnants in an unidentified alteration product associated with pyrolusite, cryptomelane, opal and hematite in vugs. Minute specks of hematite are included in the marokite.

Minnesotaite $(Fe,Mg)_3Si_4O_{10}(OH)_2$

Minnesotaite has been positively identified from drill cores at the Mamatwan mine, where it was found with dolomite and rhodochrosite. It may be present at other mines in the area as well.

Nontronite $Na_{0\cdot 33}Fe_2^{+3}(Al,Si)_4O_{10}(OH)_2 \cdot nH_2O$

Nontronite of a pale green color has been observed as an alteration product of bostonite rock at the Hotazel, Devon and Black Rock mines.

Nsutite $Mn_x^{+2}Mn_{1-x}^{+4}O_{2-2x}(OH)_{2x}$

Nsutite at the Kalahari field is poorly crystallized and intimately intergrown with other manganese minerals. It is of supergene origin and has been positively identified only in ore from the Hotazel mine where it occurs as veins and replacements after hausmannite.

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

Piemontite occurs in small laths only in altered bostonite at the Hotazel mine.

Pyrolusite $\beta\text{-}MnO_2$

Pyrolusite occurs in two modes in the Kalahari field. Primary, unaltered crystals (once referred to as *polianite*) and crystals pseudomorphous after other minerals. Primary crystals have been found only in ore from the Hotazel mine. Pseudomorphous crystals, identifiable by their shrinkage cracks, have been found in many samples from the Black Rock, Hotazel, Devon and Langdon mines. Shrinkage cracks in coarse-grained crystals may be filled with cryptomelane or bixbyite. Slender needles

Table 3. Minerals reported from the Kalahari manganese field (*Reported here for the first time)

Manganese minerals	
Pyrolusite	β -MnO_2
Ramsdellite	γ -MnO_2
Wad	undetermined Mn oxides
Hausmannite	$Mn^{+2}Mn_2^{+3}O_4$
Hollandite	$Ba(Mn^{+4},Mn^{+2})_8O_{16}$
Marokite	$CaMn_2^{+3}O_4$
Cryptomelane	$K(Mn^{+4},Mn^{+2})_8O_6$
Bixbyite	$(Mn,Fe)_2O_3$
Jacobsite	$(Mn^{+2},Fe^{+2},Mg)(Fe^{+3},Mn^{+3})_2O_4$
Todorokite	$(Mn^{+2},Ca,Mg)Mn_3^{+4}O_7 \cdot H_2O$
Chalcophanite	$(Zn,Fe,Mn)Mn_3^{+4}O_7 \cdot 3H_2O$
Manganite	$MnO(OH)$
"Manganous Manganite"	$MnO_2 \cdot MnO(OH)$
Nsutite	$Mn_x^{+2}Mn_{1-x}^{+4}O_{2-2x}(OH)_{2x}$
Lithiophorite	$(Al,Li)Mn^{+4}O_2(OH)_2$
Rhodochrosite	$MnCO_3$
Ankerite	$Ca(Fe,Mg,Mn)(CO_3)_2$
Braunite	$3Mn_2O_3 \cdot MnSiO_3$
Piemontite	$Ca_2(Al,Mn^{+3},Fe^{+3})_3(SiO_4)_3(OH)$
*Inesite	$Ca_2Mn_7Si_{10}O_{28}(OH)_2 \cdot 5H_2O$
*Pectolite	$Na(Ca,Mn)_2Si_3O_8(OH)$
*Ruizite	$CaMn^{+3}(SiO_3)_2(OH) \cdot 2H_2O$
*Orientite	$Ca_2Mn_3^{+3}(SiO_4)_3(OH)$
*Apophyllite	$K(Ca,Mn)_4Si_8O_{20}(F,OH) \cdot 8H_2O$
Other minerals	
Hematite	Fe_2O_3
Magnetite	Fe_3O_4
Goethite	$FeO(OH)$
Calcite	$CaCO_3$
Barite	$BaSO_4$
Gypsum	$CaSO_4 \cdot 2H_2O$
Quartz	SiO_2
Opal	$SiO_2 \cdot nH_2O$
Acmite	$NaFeSi_2O_6$
Andradite	$Ca_3Fe_2^{+3}(SiO_4)_3$
Minnesotaite	$(Fe,Mg)_3Si_4O_{10}(OH)_2$
Chamosite	$(Fe^{+2},Mg,Fe^{+3})_5Al(Si_3Al)O_{10}(OH,O)_8$
Cymrite	$Ba_2Al_5Si_5O_{19}(OH) \cdot 3H_2O$
*Datolite	$CaBSiO_4(OH)$
Hydromica	$(K,Na,H_3O)Al_2(Al,Si_3)O_{10}[(OH)_2,H_2O]$
Nontronite	$Na_{0.33}Fe_2^{+3}(Al,Si)_4O_{10}(OH)_2 \cdot nH_2O$
Tremolite	$Ca_2Mg_5Si_8O_{22}(OH)_2$
Talc	$Mg_3Si_4O_{10}(OH)_2$

and vein fillings have also been observed, particularly in association with veins of cryptomelane and nsutite.

Ramsdellite γ-MnO_2

Ramsdellite was identified by De Waal (1969) in the lower orebody of the Hotazel mine.

Talc $Mg_3Si_4O_{10}(OH)_2$

Minute, slender needles and laths of talc have been identified from the Mamatwan mine; pseudomorphs of opal after talc have been reported from the Hotazel, Mamatwan and Smartt mines.

Todorokite $(Mn^{+2},Ca,Mg)Mn_3^{+4}O_7 \cdot H_2O$

Todorokite was first described by Yoshimura (1935), who considered it to be a hydrothermal alteration product of inesite. It has thus far been identified in all of the mines in the Kalahari field except the Black Rock and N'Chwaning mines. The N'Chwaning mine contains the only reported occurrence of inesite in the area.

Plates many cm in length covered with "dog-tooth" todorokite crystals have been observed (and figured: de Villiers, 1971, p. 77); fine-grained, asbestiform and flaky textures are also common. It is considered to be of secondary origin, as a replacement of hausmannite commonly in association with gypsum and calcite. It is sometimes replaced by cryptomelane.

Tremolite $Ca_2Mg_5Si_8O_{22}(OH)_2$

Tremolite has been observed as very slender needles in thin sections from the Hotazel mine; the occurrence was found very near cracks filled with andradite.

Wad Mn oxides, undetermined

Soft, black material that is apparently amorphous has been called *wad*, although this is not strictly a species name. The amorphous material contains minute hematite granules dispersed throughout.

PARAGENESIS

De Villiers (1971) recognized a broad sequence of mineral formation at the Kalahari field which consisted of five periods:

(1) *Original sedimentary material.* Ore strata appear to have formed as sedimentary rocks consisting of oolitic carbonates, gelatinous manganese and iron hydroxides, iron carbonate, and hydrous silicates of magnesium and iron.

(2) *Minerals formed by lithification.* During diagenesis the gels were dehydrated and eventually the minerals cryptomelane, braunite, jacobsite, rhodochrosite and calcite crystallized.

(3) *Metamorphic minerals.* (a) Early stage: braunite, jacobsite, magnetite, cryptomelane, pyrolusite, goethite, talc and minnesotaite were formed as a result of low-grade metamorphism. (b) Main stage: hausmannite, jacobsite, hematite, andradite, tremolite, talc, bixbyite, braunite and manganite were formed.

(4) *Supergene minerals.* Cryptomelane, nsutite, todorokite, pyrolusite, lithiophorite, goethite probably originated under supergene conditions as replacements and cavity fillings.

(5) *Hydrothermal minerals.* Acmite, cymrite and piemontite appear to have been formed in the bostonite by hydrothermal action at some time after the main period of ore formation.

The above paragenetic sequence applies to the Kalahari field as a whole; local departures are numerous and the full sequence cannot be observed at every mine.

LABELING RECOMMENDATIONS

Collectors and curators are justly concerned with determining the most correct way of labeling specimens. Specimens from the Kalahari field have generated considerable labeling confusion, and we would therefore like to make some recommendations. The term "Black Rock" should not be used unless the dealer can say with certainty that the specimen came from the Black Rock *mine.* Some dealers are using "Black Rock" as a district designation and this is incorrect. Confusion is also caused by the fact that the N'Chwaning mine is very near the Black Rock *hill* (so named before any mines were opened), as is the Black Rock *mine.* South African professional literature indicates that the correct locality name should be given, for example, as:

N'Chwaning mine
Kalahari manganese field
Cape Province, South Africa

The phrase "near Kuruman" is also correct and is recommended for museum labels. The names of very small towns, such as the town of Hotazel, should be avoided if possible because the town may cease to exist in a few years and be dropped from maps. Kuruman is a large town which should be easy to locate on maps for many decades to come.

"Cape Province" is sometimes prefaced by "northern," which is also correct, but "northern" should not be capitalized because it is not a part of the Province name.

To give a second example, a specimen from the Hotazel mine could be correctly cataloged in greater detail as follows:

Hotazel mine, near Kuruman,
Kalahari manganese field,
northern Cape Province,
Republic of South Africa

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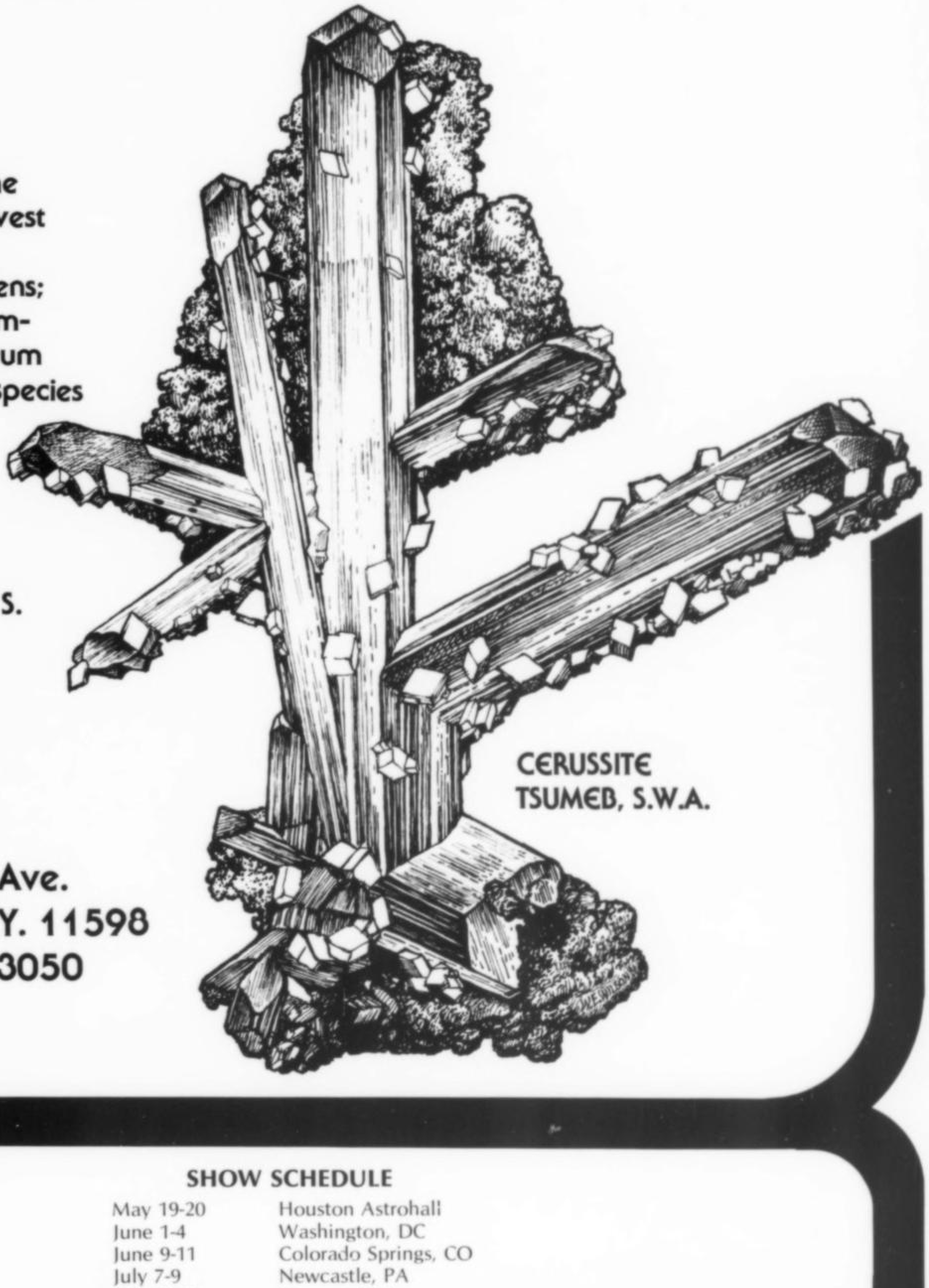

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INTRODUCTION

Basalt, formed from solidified lava, comprises a ridge that winds its way through the city of Paterson, New Jersey, and is known as the First Watchung Mountain. This basalt is very fine-grained, tough, and resistant to the elements, characteristics which make the basalt ideally suited for use as aggregate and railroad and roadway ballast. Numerous quarries were opened within this ridge in Paterson and the immediate vicinity, as well as elsewhere along the First Watchung Mountain, to produce this rock which is sometimes referred to by its mining term: "trap rock." A number of beautiful minerals in cavities in the basalt have been exposed by the quarrying process. Mason (1960) described 59 mineral species that had been previously described or reported from the New Jersey trap rocks. He briefly described the secondary minerals found not only in the extrusive basalts but also in the intrusive diabase occurrences of New Jersey. The present authors feel that a detailed discussion of the secondary minerals of the Paterson area quarries is long overdue. Our article is intended to supplement Mason's 1960 study. We will particularly emphasize mineral associations, crystal morphologies and colors, and will omit discussion of the physical characteristics (hardness, cleavage, etc.) of the described minerals as these data can be found in most good mineralogy reference texts. The geology of the area is reviewed and references given. The locations and histories of the various quarries and collecting sites of the area are cited and information on the current collecting status is given if available.

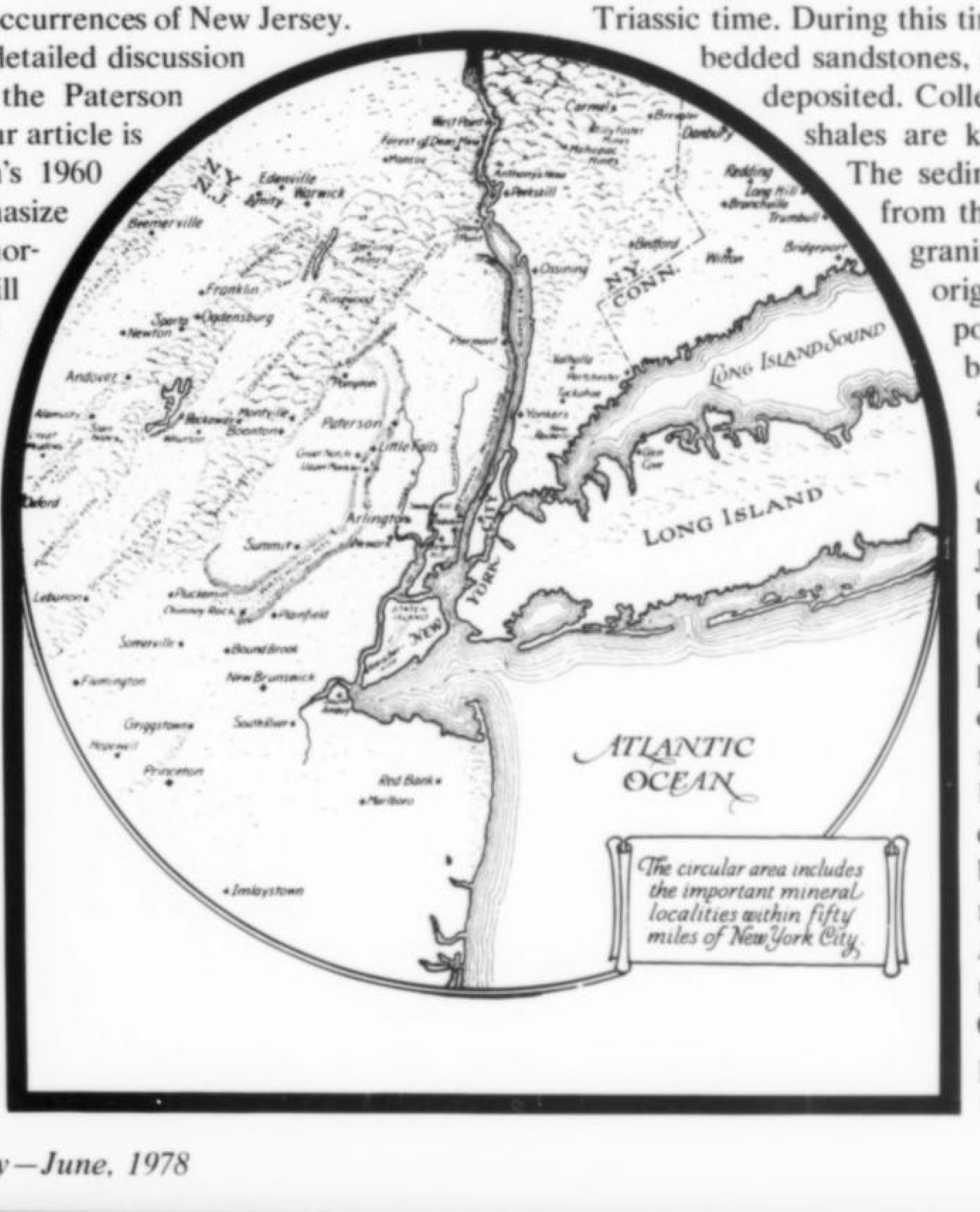


Figure 1. **A map showing mineral localities in New York and New Jersey that are within 50 miles of New York City. (From Manchester, 1931, courtesy of the New York Mineral Club.)**

GEOLOGY

The Paterson area is located in the Piedmont Geologic Province, a northeast-southwest trending belt of Triassic sedimentary rock formations and basalt ridges. The province is bordered on the northwest by the New Jersey Highlands, a belt of Precambrian gneisses, schists, and granites and on the southeast by the Atlantic Coastal Plain, which consists of Cretaceous through Recent consolidated and unconsolidated sediments. The geologic history of the area is complex and involved the following: **(1)** faulting and development of grabens; **(2)** numerous episodes of faulting and sedimentation; **(3)** igneous activity—extrusion of basalt and intrusion of diabase; **(4)** down-dropping of the contents of the graben (basin) with concommitant arching of the rock layers; **(5)** erosion. The most important aspects of this history happened about 200 million years ago, during Late Triassic time. During this time, a thick sequence of interbedded sandstones, shales, and basaltic rock was deposited. Collectively, these sandstones and shales are known as the Newark group. The sediments were derived primarily from the erosion of the gneisses and granites of the highlands. Streams originating in the highlands deposited the sediments in shallow basins or depressions in the adjacent lowlands.

According to Faust (1975), during the Late Triassic period and probably into the Jurassic period which followed, the supercontinent of Pangaea (at that time all of the world's landmasses were contained in one large continent) was under much tensional stress. This buildup of stress eventually caused this supercontinent to break up, forming the continents of North America, South America, Europe, Africa and the North and South Atlantic Oceans. This breakup also produced large rifts or cracks in the earth's crust (the Tri-

]

assic basins or grabens). Large outpourings of basaltic lava are associated with these rifts. Lava was extruded along fissures in the crust out onto the surface of the sediments and was later buried when additional sediments were deposited in the basins. The basaltic magma which was not able to reach the surface was injected between sedimentary strata to form sills. Subsequent arching of the contents of the graben, followed by erosion of the strata, produced a series of three basalt ridges, the Watchung Mountains, with valleys underlain by sandstones and shales, and a magnificent cliff of diabase facing the Hudson River, the Palisades Sill.

The quarries at Paterson and Prospect Park, New Jersey, are located in the northern part of the First Watchung Mountain. This ridge consists of multiple lava flows and represents the first and hence the oldest of the extruded basalts. In places, the lava apparently poured out into lakes or at least a water-saturated surface of some type, as the structure of the basalt is not massive but appears in rounded, lumpy masses called "pillows." Direct observation of pillow basalt formation was not possible until a few years ago when still and motion picture photographs documented their development during the recent eruptions of Mt. Kilauea in Hawaii (Moore, 1975). The pillows in Paterson are generally 0.5 to 1 m in diameter. Mineralization is directly associated with the pillows or may be found on a smaller scale in small cavities formed when gas bubbles became trapped in the partially congealed lava to form vesicles. These cavities are usually 1 cm or smaller in size but may be larger where cavities overlap each other. Such lava, when mineralized, is termed amygdaloidal basalt. However, the best mineral specimens are confined to the pillow basalts where sufficient open space (at the intersections of multiple pillows) was available for crystallization. Most of these minerals were derived from the dissolution (by the circulation of heated waters) of the metastable glassy crust that constitutes the outer surface of the lava pillows. This circulating water invaded cooling cracks which penetrated to the interior of the pillows (Fenner, 1910). Fenner (1910) also observed that mineralization is scarce or absent in the massive, columnar basalt of the area and Faust (1975) confirms the lesser intensity of this type of mineralization.

LOCALITIES

The New Street Quarries, Paterson

There are two quarries located on both sides of New Street in Paterson. The old or Upper New Street quarry was worked during the years 1893-1925 (Mason, 1960) and was also known as Burger's quarry. The best specimens were found during the 1920's and 1930's though the site remained open to collectors until about 1973 when the quarry was utilized as an automobile junk yard. At the present time (November 1977), the quarry is abandoned and a locked fence has been placed across the entrance. Collecting is not permitted. The Lower New Street quarry was worked between 1900-1936, according to Mason (1960), with collecting allowed until sometime during the period 1955-60; a factory was built on the quarry site in 1960. From 1962 through the present, the Richardson Chemical Company has occupied the site and its management has allowed limited

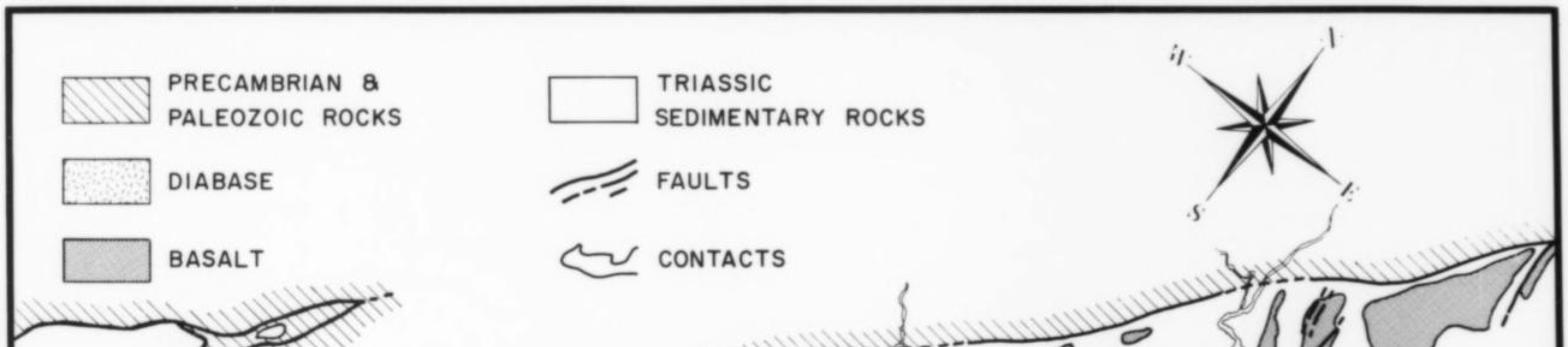


***Figure 2.* A map showing the location of Paterson with respect to other quarries and the Triassic basalts of New Jersey. (After Mason, 1960.)**

access to the quarry for university professors, students and museum curators. Collecting is permitted (by permission) on Mondays through Fridays only. According to Schaller (1932), both quarries were operated by the Paterson Crushed Stone Company, while local tax records reveal that both quarries were

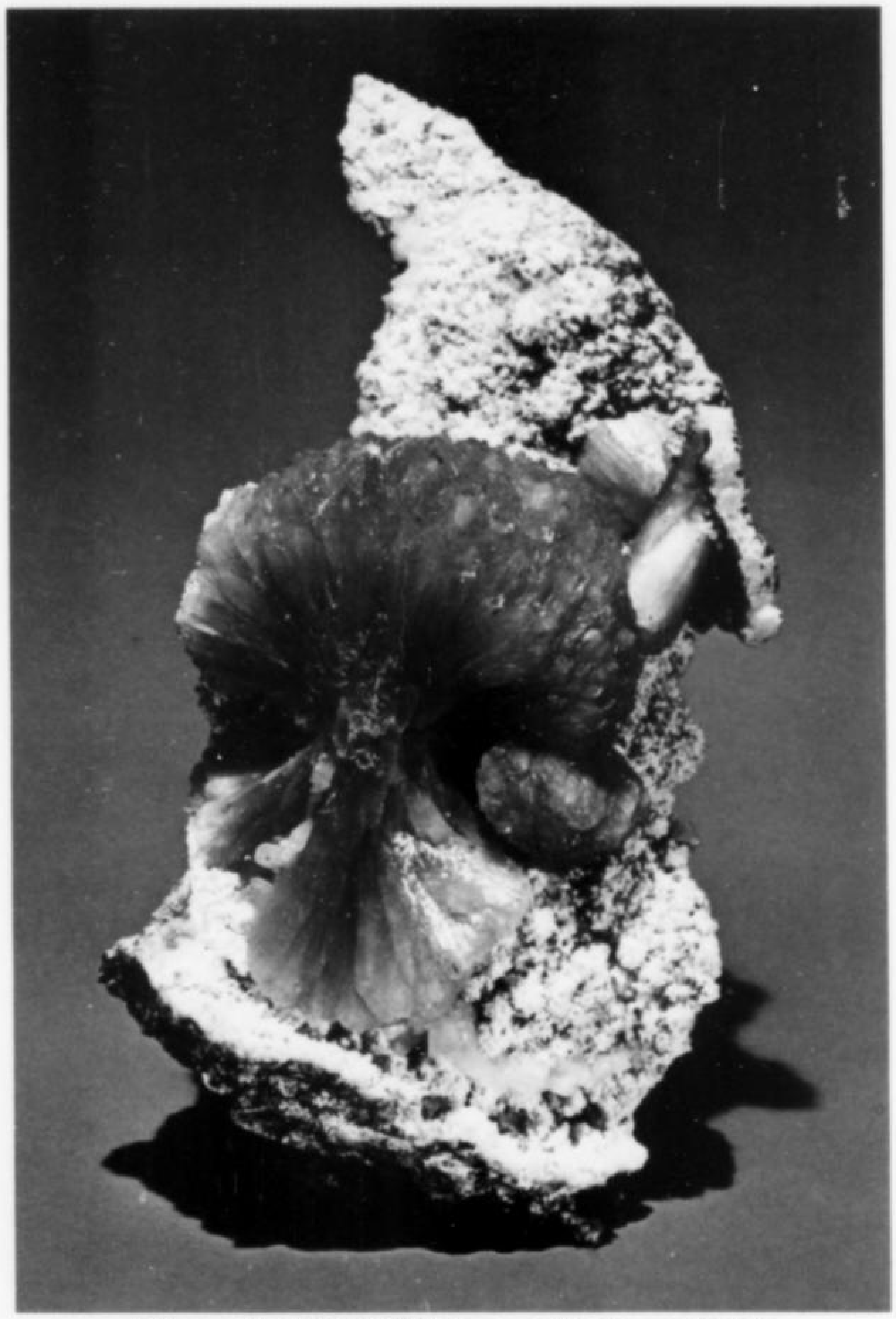


Figure 3. STILBITE "bow tie" (7 cm high) from Prospect Park, New Jersey. Smithsonian specimen R15600; photo by Lee Boltin.

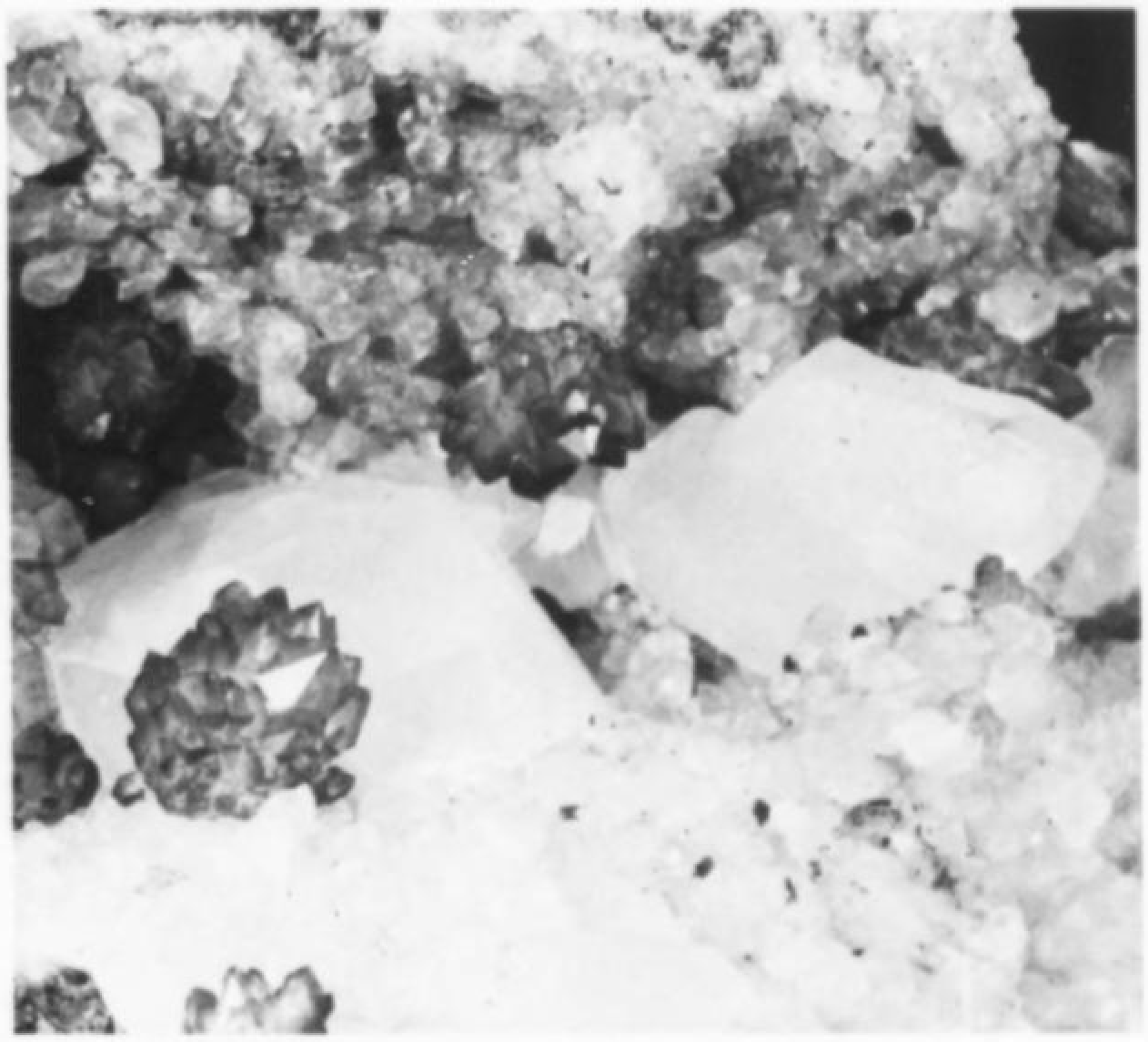


Figure 4. QUARTZ, with inclusions of red HEMATITE, on white calcite (the quartz crystals are up to 3 mm in diameter), from the McKiernan & Bergin quarry. Paterson Museum specimen #P-129.

Figure 5. CHABAZITE on quartz crystals (the large chabazite crystal is 18 mm in diameter), from the Prospect Park quarry. Paterson Museum specimen #P-140-63.

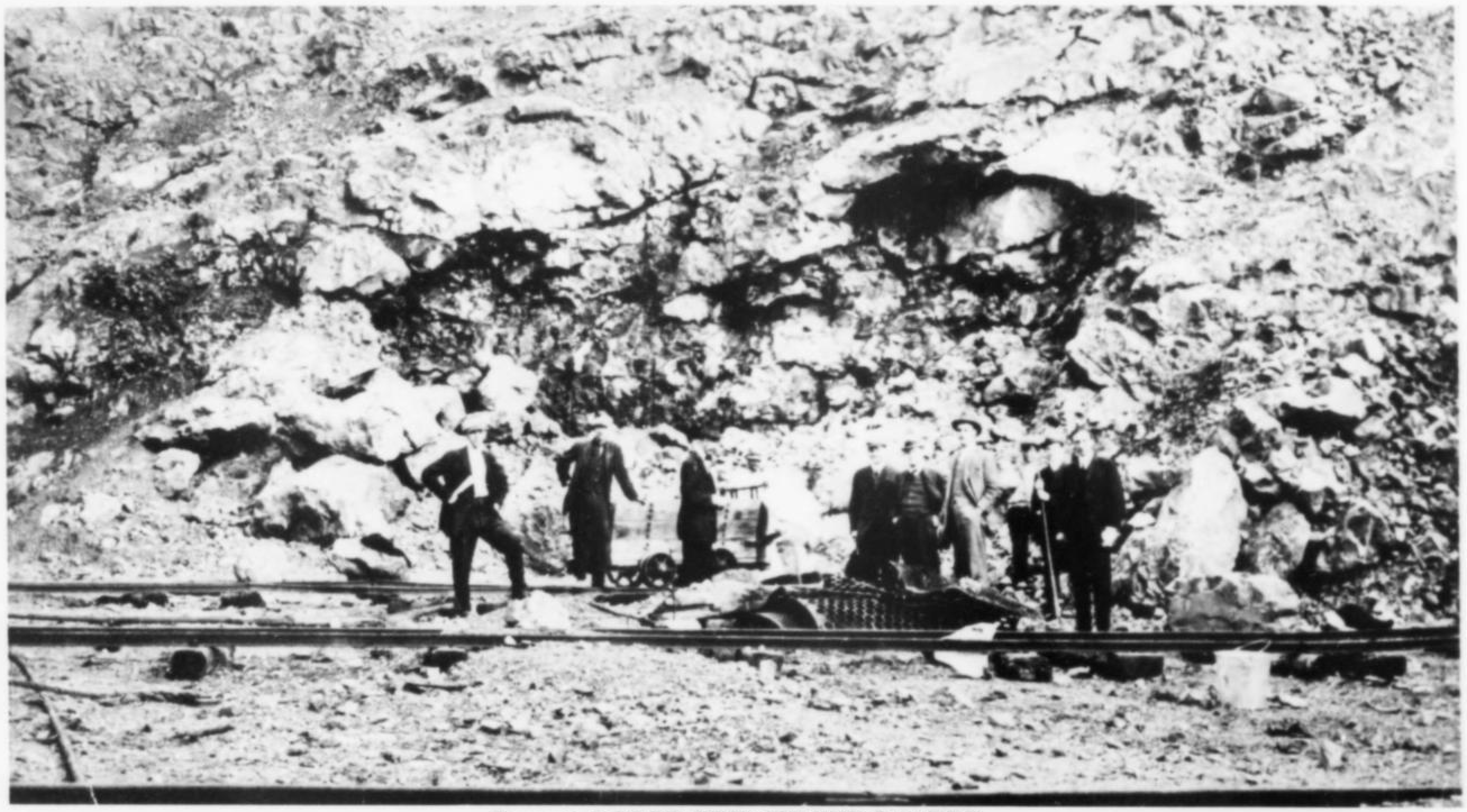


Figure 6. **LOWER NEW STREET QUARRY, Paterson, in 1917. Left to right, the men pictured are: unknown, unknown, Westervelt, Giles, Manchester, Hoadley, unknown, unknown, and Ihnen. Photo courtesy of the New York Mineral Club.**

Figure 7. **UPPER NEW STREET QUARRY, Paterson, in 1915. Photo by William H. Broadwell, courtesy of the New York Mineral Club.**

Figure 8. **MCKIERNAN & BERGIN QUARRY, Paterson, in 1915. Photo by William H. Broadwell, from Manchester (1931), courtesy of the New York Mineral Club.**

Figure 9. **WARREN BROTHERS QUARRY, Prospect Park, in 1968. Photo by Lubov Drashevska.**

Figure 10. **The cliff at the slope of Garret Mountain (First Watchung Mountain), north of Lambert's Castle, Paterson. The contact between the interbedded, reddish brown sandstone and shale of the Brunswick group (Triassic) and the overlying basalt is clearly visible. Photo by Lubov Drashevska, 1976.**

owned by the former North Jersey Quarry Company of Morristown, New Jersey, during their early history. Both New Street quarries have been listed in various publications as the West Paterson quarries; however, these quarries, although close to the Paterson-West Paterson border, are actually located in Paterson.

Prospect Park Quarry, Planten Avenue, Prospect Park

Paterson's next-door neighbor, the borough of Prospect Park, is the home of one of the few remaining operating quarries in the area. It first began operations around 1900 (J. Critchley, personal communication, 1976) and has been referred to in the past as the Sowerbutt quarry and Vandermade's quarry, named for previous owners. Presently, it is operated by Warren Brothers, Inc. All of the owners, especially the Vandermade family, have cooperated with mineral collectors, universities and museums in the preservation of minerals found on their property. Certain members of the mineral collecting fraternity have, however, abused their collecting privileges to the point where no collecting is presently allowed. This ban includes collecting by personnel of institutions of higher learning. This situation is most regrettable but probably understandable. Quarrying should continue here for some time because land adjacent to the quarry has been obtained from the borough.

McKiernan & Bergin Quarry, McBride Avenue, Paterson

This quarry was located on McBride Avenue at Henderson Street in Paterson but is usually noted in publications as being in West Paterson. It was closed in 1916 and built over not long afterward. This site produced some fine casts of quartz after glauberite (Schaller, 1932).

Hoxie's Quarry, Paterson

This locality, which is one-half block south of Union Avenue and Marion Street in Paterson (Schaller, 1932), was closed in 1891 and built over. Very few labeled specimens from this quarry are known.

Route I-80 Roadcut, Paterson and West Paterson

Construction of Interstate Route 80 through Paterson and West Paterson in 1969 provided ample opportunity, during a period of about 2 years, to collect fine zeolites and their associated minerals. The roadcut paralleled New Street and cut through the back portion of the Lower New Street quarry, exposing the pillow lava zone. Readers are referred to articles by Peters (1970) and Rothstein (1970) for further information concerning this roadcut.

Hinchcliffe Stadium, Great Falls Park, Paterson

Construction of a tunnel for a 116-inch storm drain adjacent to Hinchcliffe Stadium in 1955 brought to light many good mineral specimens. According to the records of the Paterson Engineering Department, the mineralized area may have been located between Maple and Walnut Streets. This information seems reasonably correct because the surface exposure of basalt in

Figure 11. **A close-up photo of basalt pillows. Note the dark, altered rind with quartz (white) occupying the space between the pillows. Open pockets lined with quartz and occasional zeolites and/or associated minerals are found at these pillow junctures. Route 80 roadcut, Paterson. Photo by Lubov Drashevska, 1969.**

this area consists of rounded pillows whereas the exposures at the terminus of the tunnel exhibit a massive texture with no obvious expressions of secondary mineralization.

John F. Kennedy High School, Totowa Avenue, Paterson

Construction of Kennedy High School around 1963 revealed numerous pockets of excellent prehnite.

INTRODUCTION TO THE SECONDARY MINERALS

Following is a description and discussion of the minerals found in the area, listed in the sequence of crystallization (the mineral paragenesis). We use Schaller's (1932) classification which is an enlarged and revised version of Fenner's (1910) earlier conclusions. This paragenesis applies only to the mineralization of the First Watchung Mountain.

Period 1. **Solidification** of the basaltic glass of the pillows and the basalt of the flows.

Period 2. **Saline Period.** Calcium, sodium and sulfate derived from the lake waters crystallize as anhydrite and glauberite. There is considerable overlapping of periods 1 and 2. Additional water enters the system and silica (SiO_2) becomes stable, crystallizing as quartz.

Period 3. **Quartz Period.** Much quartz forms and replaces the basalt but not the anhydrite and glauberite which are encrusted by the quartz. At this point, the solutions are in equilibrium with the earlier formed anhydrite and glauberite. Glauberite stops forming and begins to dissolve.

Period 4. **Prehnite Period.** Additional water enters the system. Glauberite dissolves but anhydrite is still stable; rhombic cavities in quartz are formed (after glauberite). Anhydrite stops forming. The dissolution of anhydrite and glauberite then releases calcium and sodium to the aqueous system. Minerals high in calcium such as pectolite, and datolite (a borosilicate—the source of boron being the volcanic emanations) crystallize. Prehnite forms before the anhydrite dissolves, forming a mantle around it. As the crystallization of these minerals that are high in calcium and silica continues, the depletion of calcium causes anhydrite ($CaSO_4$) to become unstable and to dissolve. Rectangular cavities form where anhydrite dissolves except where it is protected by basalt or quartz from the action of the solutions.

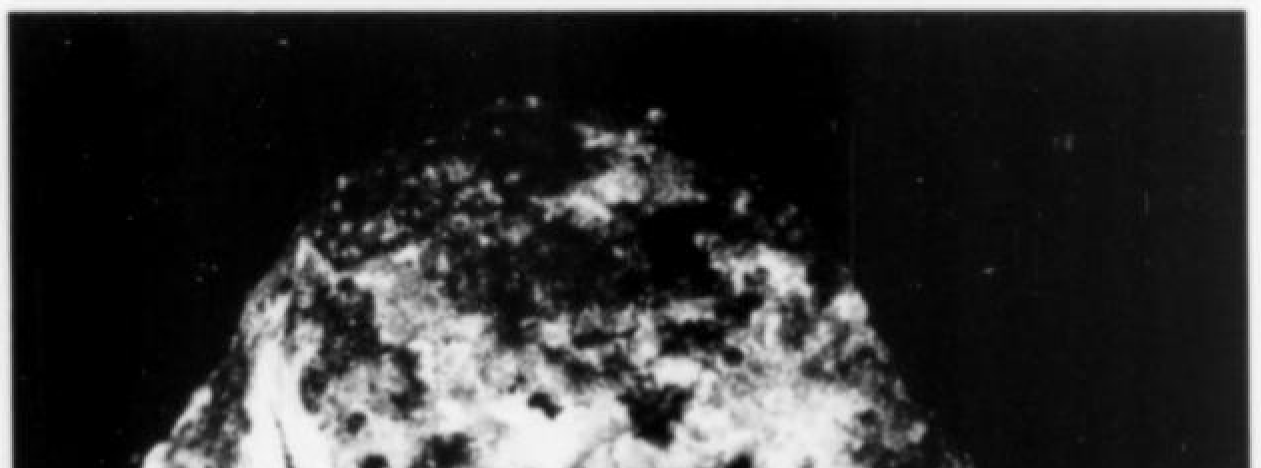


Figure 12. **ANHYDRITE, in white, unaltered, radiating, prismatic crystals (the specimen is 7.5 by 10 cm) from the Prospect Park quarry. Paterson Museum specimen #P-1081.**

Period 5. **Zeolite Period.** The dissolution of the earlier formed anhydrite and glauberite liberates elements that help to form zeolite minerals, which are aluminosilicates with a framework (tectosilicate) structure having one or more cations of the alkali or alkaline earth elements. The ratio of silicon plus aluminum to oxygen is 1:2.

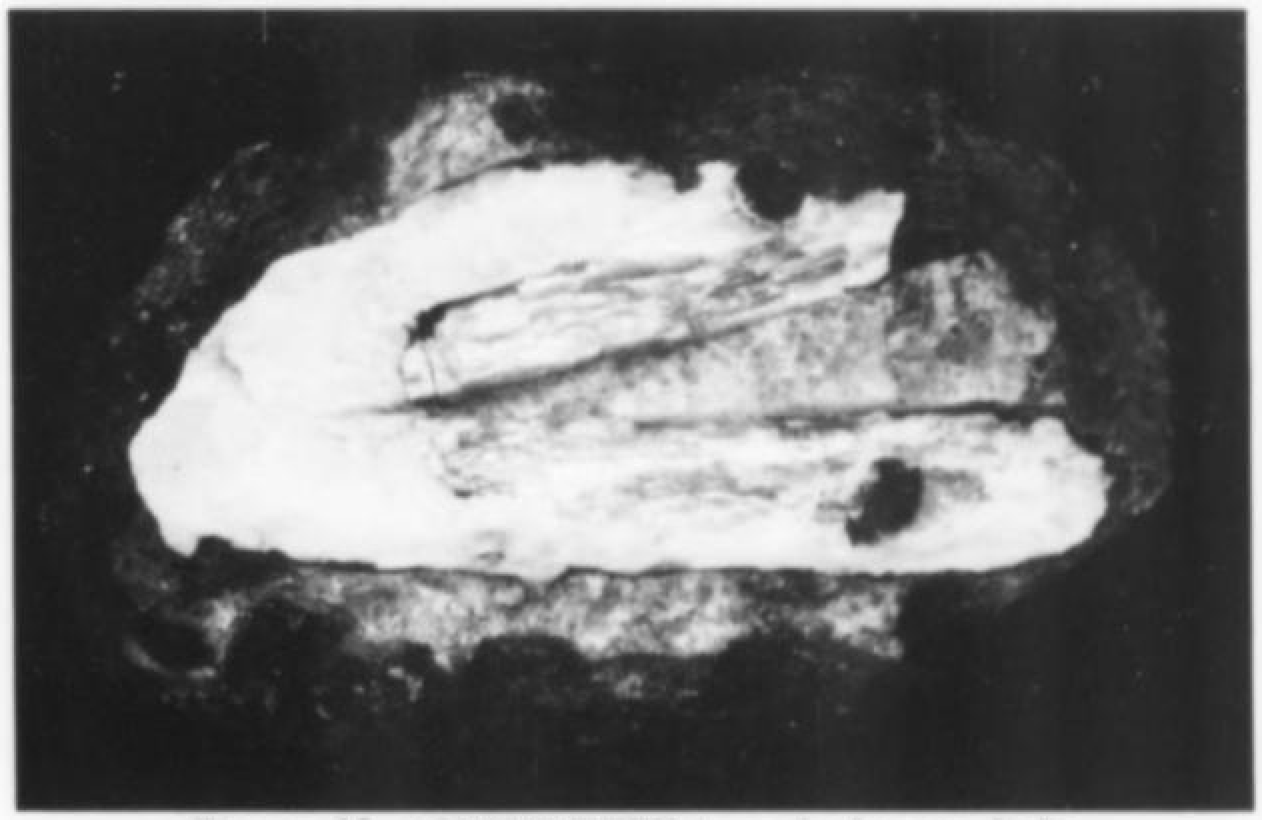


Figure 13. **ANHYDRITE in colorless to light blue prismatic crystals altering to lighter colored fine-grained gypsum (the specimen is 10 by 15 cm) from the Prospect Park quarry. Paterson Museum specimen #P-1089.**

Period 6. **Calcite Period.** Calcite crystallizes. Any remaining anhydrite and glauberite may be changed to gypsum and/or thaumasite.

Note: Some minerals such as babingtonite and calcite crystallized during more than one period.

MINERALS OF THE SALINE PERIOD

Anhydrite

Unaltered crystals of anhydrite are quite rare. When found they usually show some alteration to fine-grained gypsum; the gypsum in turn may be altered to thaumasite. Unaltered anhydrite is found as long, rectangular, colorless, white or pale blue crystals that may attain a length of 10 cm. Crystals have been found in the Prospect Park quarry and both of the New Street quarries. Anhydrite is not often represented in collections; however, specimens of quartz commonly exhibit rectangular or lamellar cavities formerly occupied by crystals of anhydrite that were partially enveloped by quartz, the anhydrite having later dissolved completely. The identity of the original mineral producing these cavities was not known until 1914 "when a mass of unaltered anhydrite was found in place in 'West Paterson' to settle this question definitely," (Schaller, 1932). According to Fenner (1914), rectangular cavities 7 to 10 cm long are not uncommon, and in one specimen he observed impressions of a group of fan-like crystals "which measured 8½ inches in length and 7½ inches in greatest breadth. Apparently a considerable portion of the center of the group has been broken away, so that the original length was probably 3 or 4 inches greater." All of the quarries have produced good specimens. Prehnite cavities after anhydrite are very common. Excellent specimens have been found in the Lower New Street quarry and the Prospect Park quarry.

Glauberite

Glauberite has rarely been found in the New Jersey trap rocks in its original, unaltered state. Its only documented occurrence dates to 1932 when John Obert discovered loose crystals in a cavity in the Lower New Street quarry. The largest crystal found measured 2 by 3 cm though most were much smaller. The crystal forms noted on the glauberite were: *c*{001} and the pyramid *s*{111}. Occurring with the glauberite were crystals of gypsum. A fine-grained gypsum also covered the glauberite crystals (Hawkins, 1933). Only one micromount specimen (Robert Fitton collection) was examined by one of the authors (T.P.) and it conforms to the original description as stated previously. Other specimens from this occurrence undoubtedly exist.

The presence of glauberite is documented in collections in the form of encrustation and infiltration pseudomorphs of quartz. Rhombic cavities formed when the glauberite was completely dissolved away from the enclosing quartz overgrowths. Sometimes these rhombic cavities were infiltrated by another generation of quartz to produce casts. Such casts were found in abundance in the McKiernan & Bergin quarry and approached a size of 10 cm measured along the diagonal.

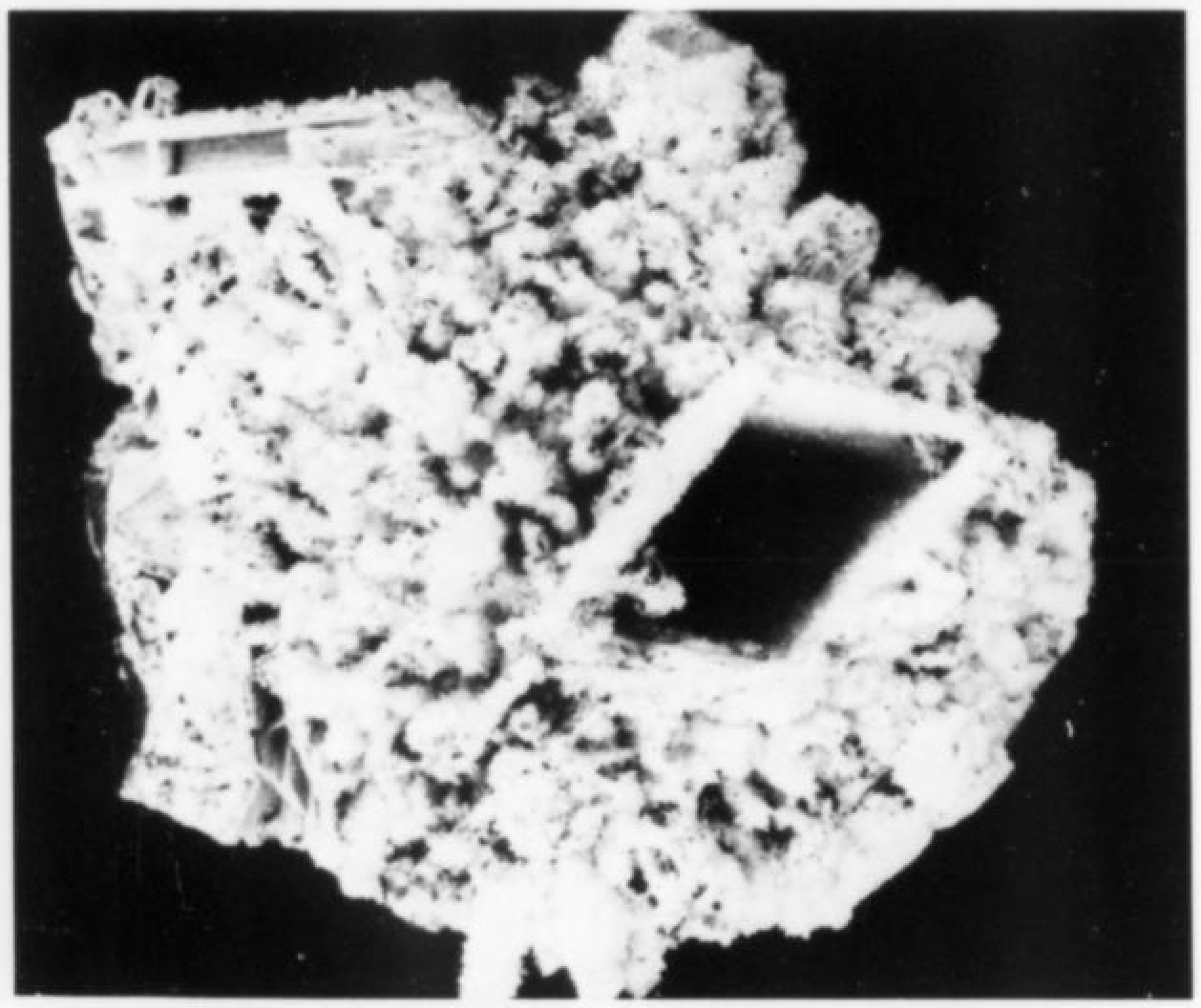


Figure 14. **QUARTZ containing a rhombic glauberite cavity in the lower right corner and an anhydrite cavity in the upper left. The glauberite cavity is 7.5 cm along the diagonal, and the specimen is 12.5 by 17.5 cm. Paterson Museum specimen #P-196.**

According to Schaller (1932), "The rectangular and lamellar cavities are very rarely associated with the rhombic cavities. Where two varieties are found on the same specimen they usually occur in separate groups, not intermingled." This situation may not be as rare as Schaller stated; the authors have seen specimens with both anhydrite and glauberite cavities occurring on the same specimen. In such instances, cavities of one of these two minerals greatly predominate over the other; moreover, it appears that both types of cavities formed at the same time.

A study of these various cavities and casts leads one to conclude that some beautiful groups of these saline minerals were formed. Radiating groups of rectangular anhydrite crystals and diamond-shaped crystals of glauberite are now represented by cavities or pseudomorphs (casts) after quartz and in some cases after datolite, pectolite or prehnite. Had these minerals not been dissolved by the watery solutions, we might today have some of the best crystals of these species known, because good localities for crystallized anhydrite and glauberite are very few in number. Readers particularly interested in these crystal cavities and pseudomorphs should read Schaller (1932).

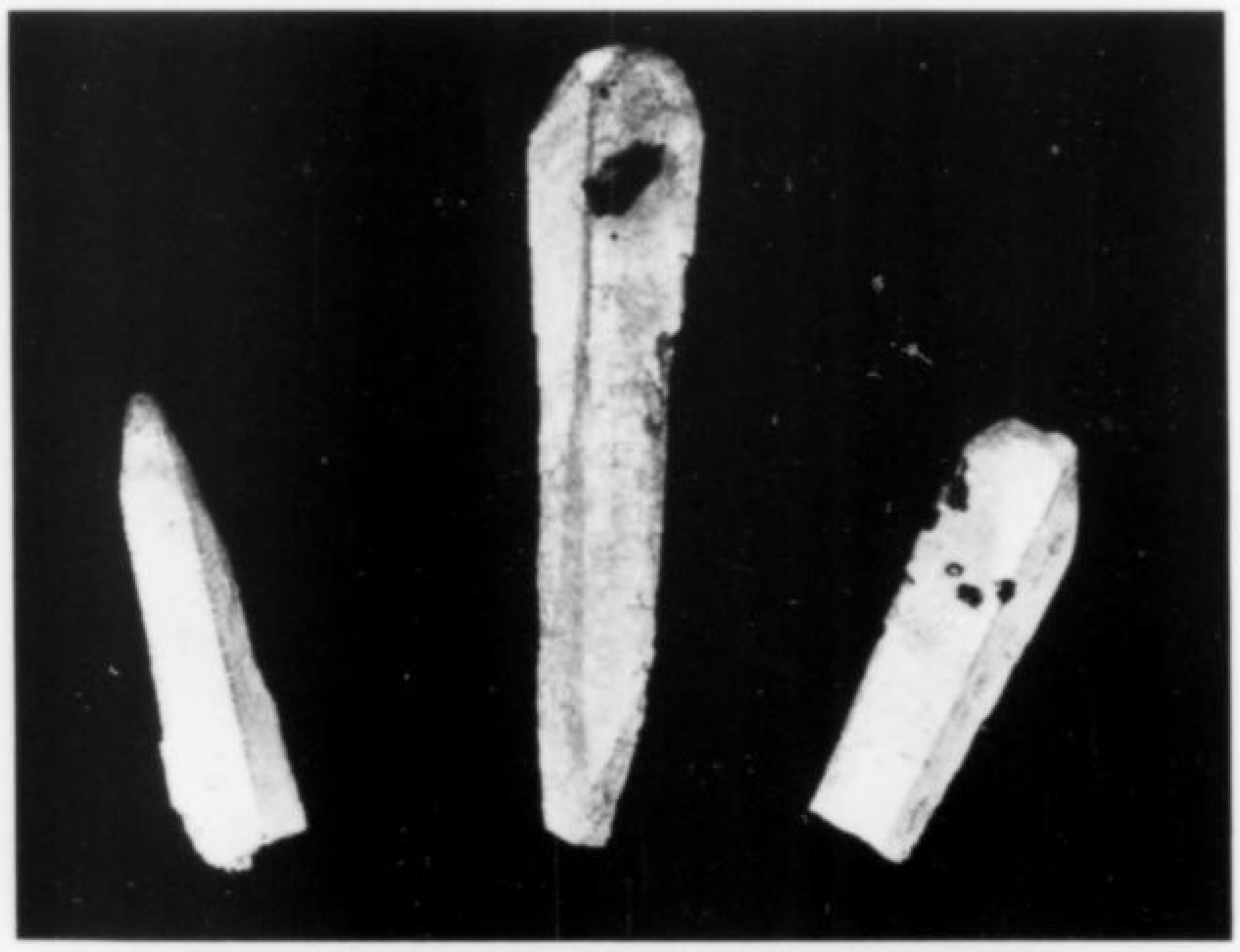


Figure 15. **QUARTZ casts after GLAUBERITE crystals, retaining the original glauberite morphology (the largest is 1.7 by 7.1 cm), found by J. Hawkins, superintendent of the McKiernan & Bergin quarry in 1914. American Museum of Natural History specimen #18027.**

MINERALS OF THE QUARTZ PERIOD

Quartz

Quartz is quite common in the Paterson area. Though previously mentioned as casts and cavities after anhydrite and glauberite, quartz also occurs as the varieties *amethyst* (shades of purple) and *smoky* (shades of gray or brown to black). Crystals of these varieties reach to 2.5 cm in diameter. Superb amethyst (Fig. 39) has been found in the Prospect Park quarry and smoky quartz has been found in attractive specimens from the McKiernan & Bergin quarry on McBride Avenue. Some quartz has been selectively coated on the faces of one rhombohedron with hematite. This coating is blood-red in color and produces a pinwheel design. Good specimens of this type were obtained from the Upper New Street quarry and the McKiernan & Bergin quarry.

Quartz has been observed as simple rhombohedral crystals coated with hematite. This rare pseudo-cubic aspect consists of the positive rhombohedron, *r*{$10\bar{1}1$}. Such specimens have been found in the Upper New Street quarry; however, this is a rare occurrence.

Babingtonite

Babingtonite is related to the pyroxenes. It may occur as black, splendent, wedge-shaped crystals which have a characteristic diamond-shaped cross-section. These are associated with calcite and/or quartz. It may also be found as thin, black crystals coated on all faces except one set of pinacoids (one of these pinacoids is usually embedded in the matrix; therefore, only one pinacoid is left uncoated) by hairlike crystals that are a very light blue (diopside) or dark brown (acmite) in color. Crystals are generally a few mm long but crystals to 12.5 mm have been found. Associated minerals may include albite, quartz, calcite, prehnite, stilbite, datolite, chabazite, and laumontite. The best localities are the Upper New Street quarry and the Prospect Park quarry.

Albite

Four distinct habits of albite have been found in Paterson. The first consists of small, pink, hemispherical aggregates up to 3 mm in diameter, associated with quartz, calcite, and chalcopyrite. These were found in the Upper New Street quarry and the Prospect Park quarry. The second type is found as cream-colored, curved aggregates of crystals that greatly resemble dolomite. It is generally found alone as a crust on altered basalt, but may be associated with stilpnomelane or calcite. Much of this material was collected in the Upper New Street quarry. The third type consists of millimeter-sized, thin, diamond-shaped crystals that are colorless and transparent. They are inconspicuous and are frequently overlooked. Crystals of the fourth type are doubly terminated, with a bow-tie or hour-glass shape, colorless to white, with a small rim colored pink or red by hematite inclusions. The rim in some cases may be white. A few crystals have been found that are a deep rose-red color with no obvious rim. In the past, this material has been confused with some varieties of stilbite. Specimens were found in abundance in the Upper New Street quarry resting upon drusy quartz.

Figure 16. **QUARTZ cast after GLAUBERITE (bottom) with quartz molds after anhydrite (top), from the McKiernan & Bergin quarry. The specimen is 10 by 12.5 cm in size. Note the crenulations in the glauberite cast, demonstrating the episodic nature of its growth. Paterson Museum specimen #P-198.**

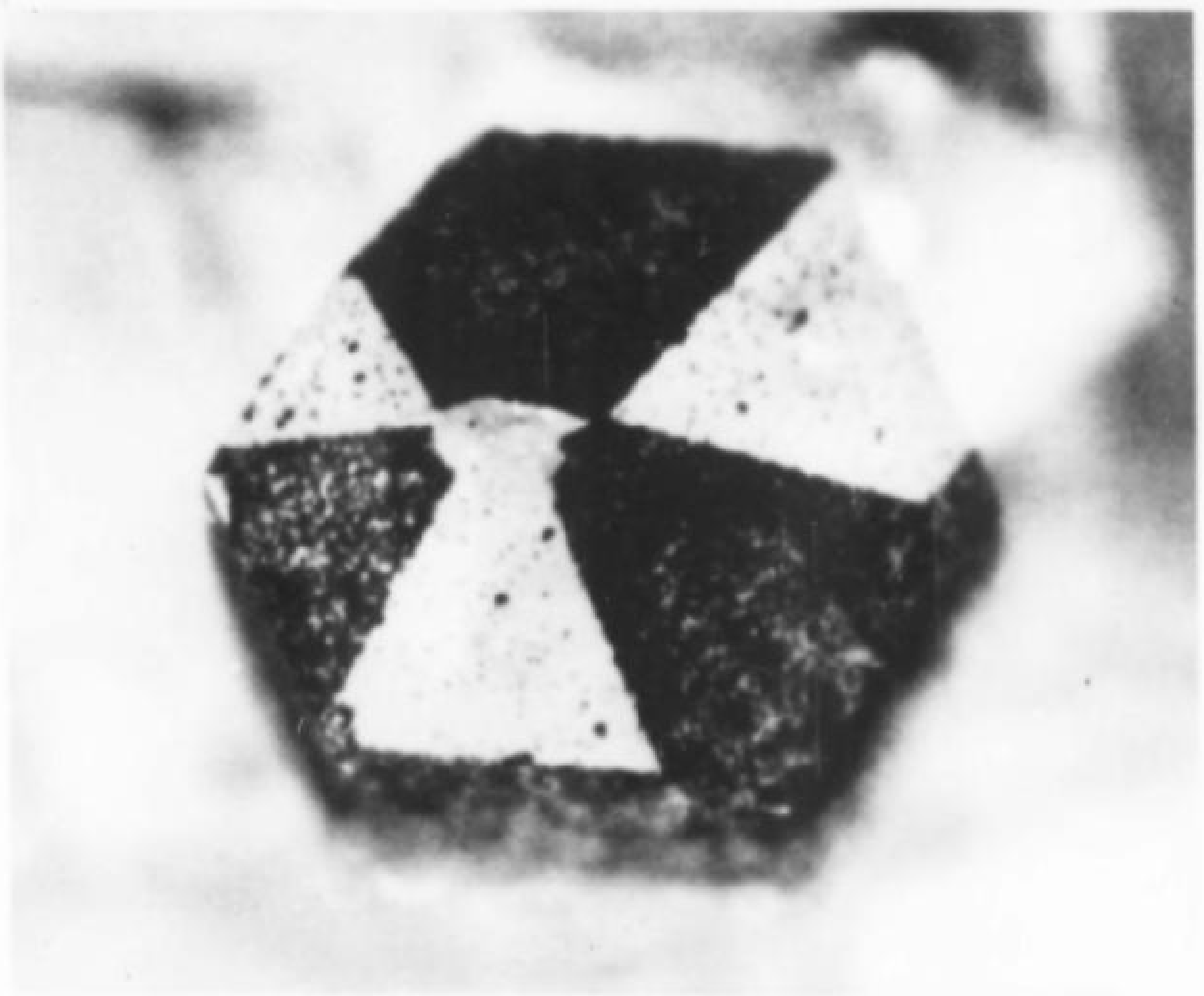


Figure 17. **QUARTZ crystal with HEMATITE coating on alternate terminal faces (1 mm in diameter) from the Upper New Street quarry. Paterson Museum specimen #P-93-76.**

MINERALS OF THE PREHNITE PERIOD

Prehnite

If we had to select a particular mineral from the Paterson area which is actively sought by collectors everywhere, our choice would invariably be the mineral, prehnite. Beautiful examples have been found here and have been distributed to collectors and museums throughout the world. It usually occurs in beautiful shades of green; but yellow and blue varieties are known, though rarely seen. Typically it occurs around cavities after anhydrite and, rarely, glauberite. Glauberite was almost entirely dissolved by the time prehnite started to crystallize; hence, the rarity of this type of cavity.

Crusts of prehnite have been found up to 1 m across, especially from the Route 80 roadcut, but hand-size specimens are the rule. Besides being found around cavities after anhydrite,

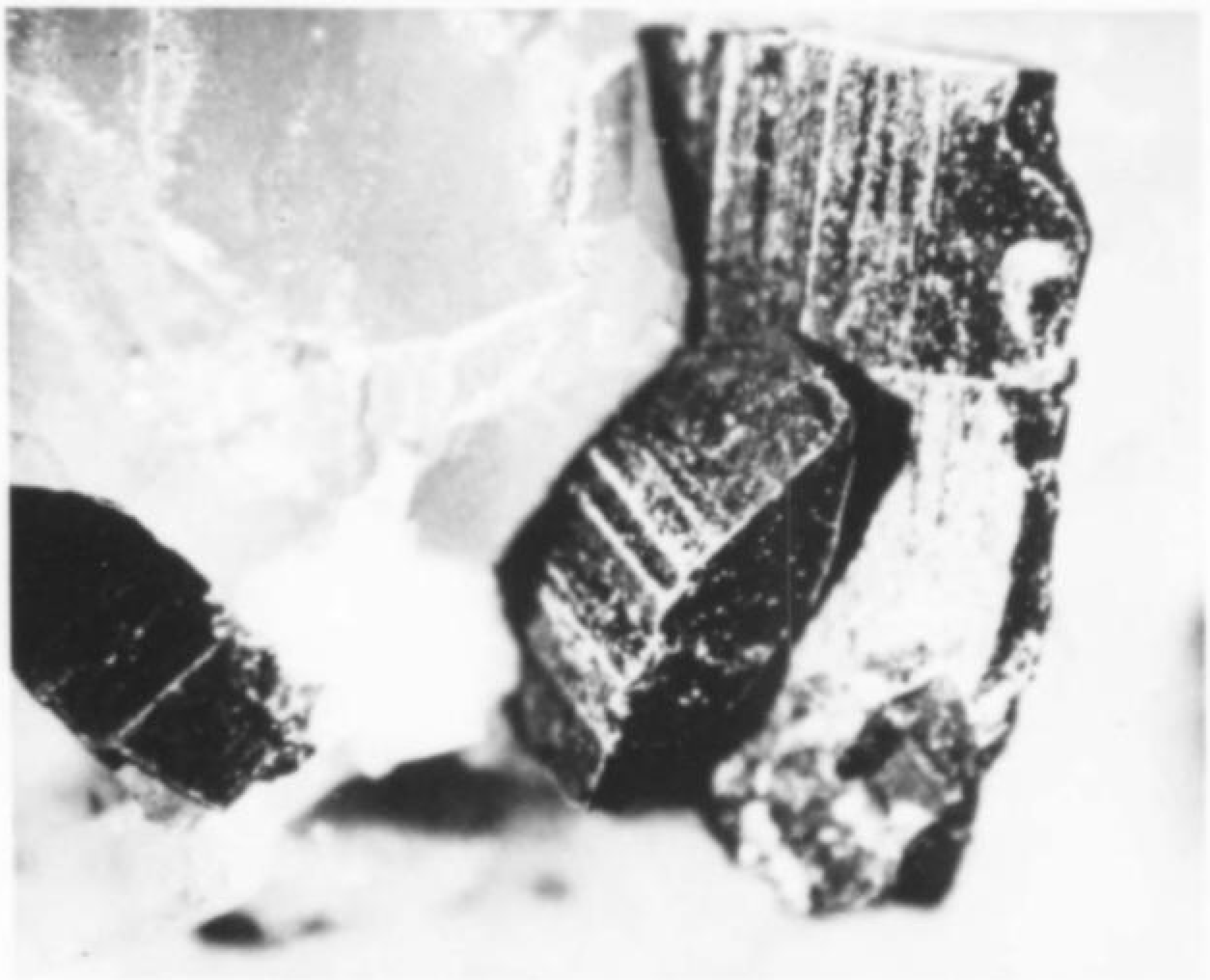


Figure 18. **BABINGTONITE, in splendent, black, wedge-shaped crystals (3 mm long) on calcite from the Prospect Park quarry. Russ DeRoo micromount collection.**

it is also found as botryoidal or grape-like masses. Rarely, complete single spheres of prehnite are found that have little evidence of points of attachment.

Prehnite in the Paterson area rarely occurs as isolated single crystals; however, small crystals (2mm) were found in the Lower New Street quarry.

Another unusual occurrence is as crystals resembling the "wheat sheaf" bundles of stilbite or possibly resembling thomsonite. This material has been found at the Prospect Park quarry. Specimens have been observed in local collections, usually labeled as "stilbite." Associated with this particular type of prehnite are actinolite in green needles, calcite rhombohedra and datolite crystals.

Prehnite is usually found with one or more of the following: pectolite, datolite, analcime, thomsonite, laumontite, natrolite, mesolite, gmelinite, phillipsite, calcite, chlorite, and barite. Excellent specimens are well known from the Lower New Street quarry and the Prospect Park quarry.

Datolite

Datolite is one of the most beautiful minerals from the area; lustrous, transparent to translucent crystals up to 3.75 centimeters across having been found. The colors include shades of yellow-green, green, colorless and, in rare cases, an opaque white. The best examples were found in the Upper New Street quarry and the Prospect Park quarry. Although datolite is usually found alone, associated minerals may include prehnite, babingtonite, quartz, calcite, apophyllite, chalcopyrite, hematite, heulandite, gmelinite and stilbite. Datolite cavities after anhydrite and glauberite have also been found, particularly at the Prospect Park quarry.

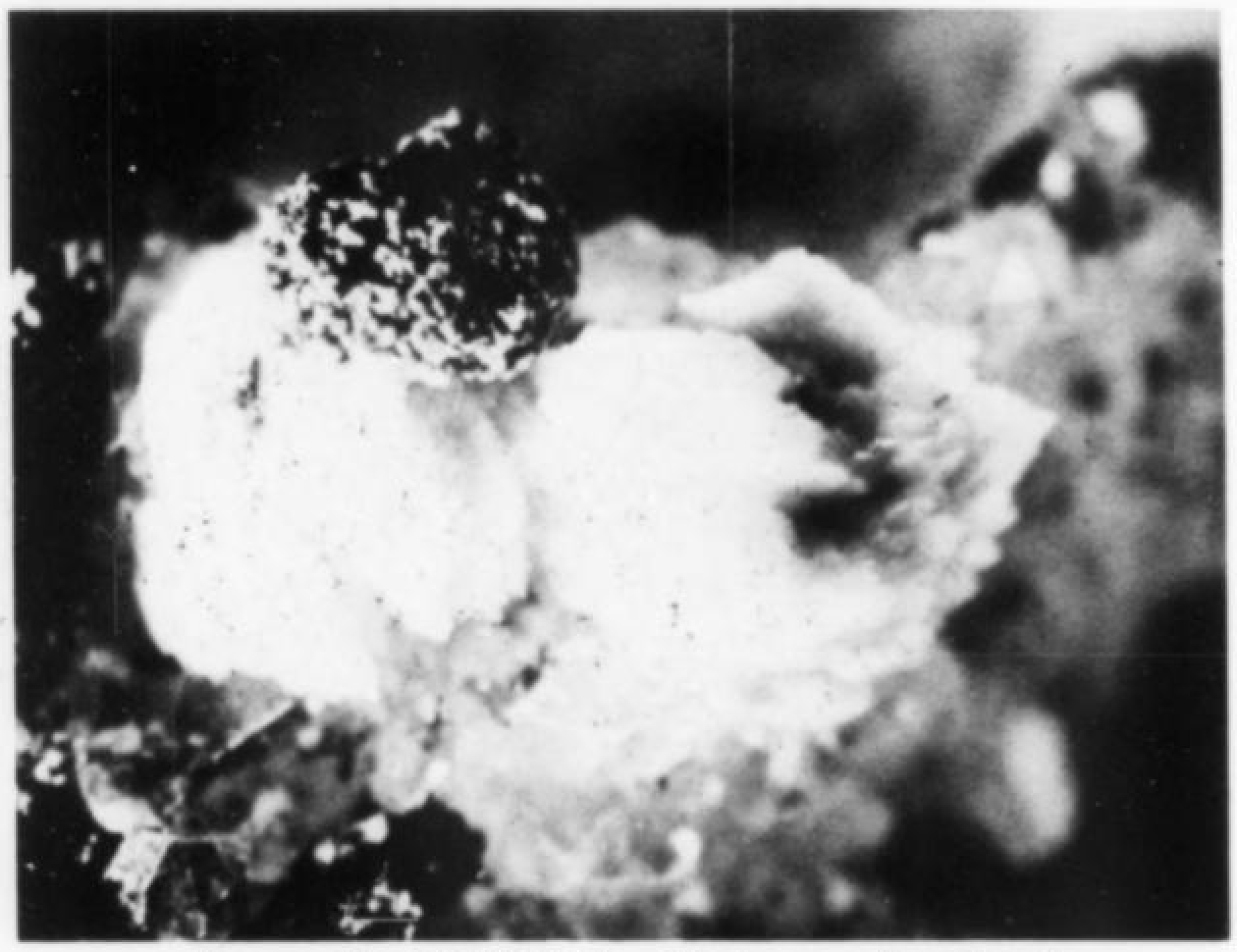


Figure 19. **ALBITE, in pink to peach-colored rosettes (each rosette is 3 mm in diameter) from the Prospect Park quarry. Paterson Museum specimen #P-37-72.**

Pectolite

Most collectors soon become experts at identifying the local pectolite. It occurs as white, silky, radiating balls of needle-like crystals which readily penetrate the skin of your hands causing much discomfort. Balls of pectolite have been found up to 8.75 cm in diameter. Specimens displaying single terminated crystals are quite rare but have been noted particularly from the Lower New Street quarry. Associated minerals may include prehnite, calcite, chabazite, datolite, quartz, thaumasite, and apophyllite.

Pectolite is sometimes found in an attractive pink color. This coloration indicates a partial alteration to the clay mineral, stevensite. Stevensite is a magnesium-rich member of the montmorillonite group. The radiating structure of the pectolite is preserved initially in this alteration process but as the process moves toward completion, the pink color deepens toward brown and the radiating structure is destroyed. The final end-product is a dark pink to brown, waxy-appearing mass of stevensite. Stevensite was abundant at the Route 80 roadcut.

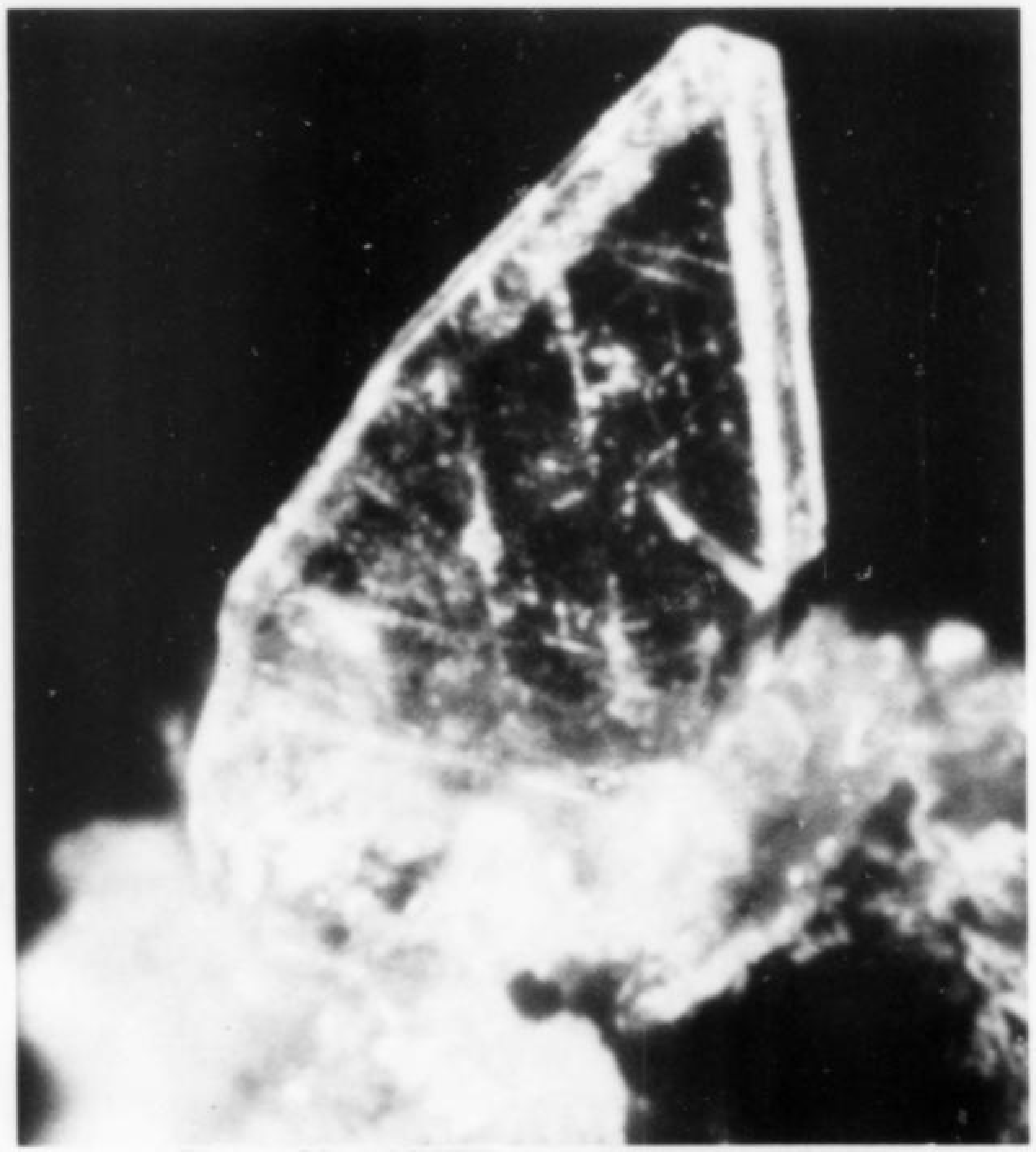


Figure 20. **ALBITE, a transparent, colorless crystal (0.3 mm long) from the Upper New Street quarry. Paterson Museum specimen #P-39-77.**

In the Canfield Collection (now part of the Smithsonian collection), there were found some unusual pseudomorphs of pectolite after quartz (Bates, 1909), where the morphology of small quartz crystals was faithfully preserved by cream-colored pectolite. The specimens were found in the Lower New Street quarry and are quite rare.

Another rare and unusual form of pectolite is in the form of cavities after anhydrite. The pectolite in this case tends to be a much less splintery variety (more compact) than the radiating aggregates usually collected.

MINERALS OF THE ZEOLITE PERIOD

Zeolites comprise a large group of minerals that formed under conditions of low temperature and pressure and are found in many localities throughout the world in host rocks of varying composition; however, the best specimens are found in cavities or open veins in basalt and diabase.

Only 10 of the 39 known zeolites occur in the Paterson area. These contain calcium and/or sodium in the alkali/alkaline earth site with the exception of the potassium zeolite, phillipsite. Phillipsite has recently been identified in a single specimen from Paterson. Zeolites containing barium, strontium, magnesium and cesium have not yet been identified from the area. If found, it is likely that they will be very rare and local in their occurrence, because these particular elements in the host rock, basalt, either have not been detected or are present only in small amounts. The one exception to this statement is magnesium,

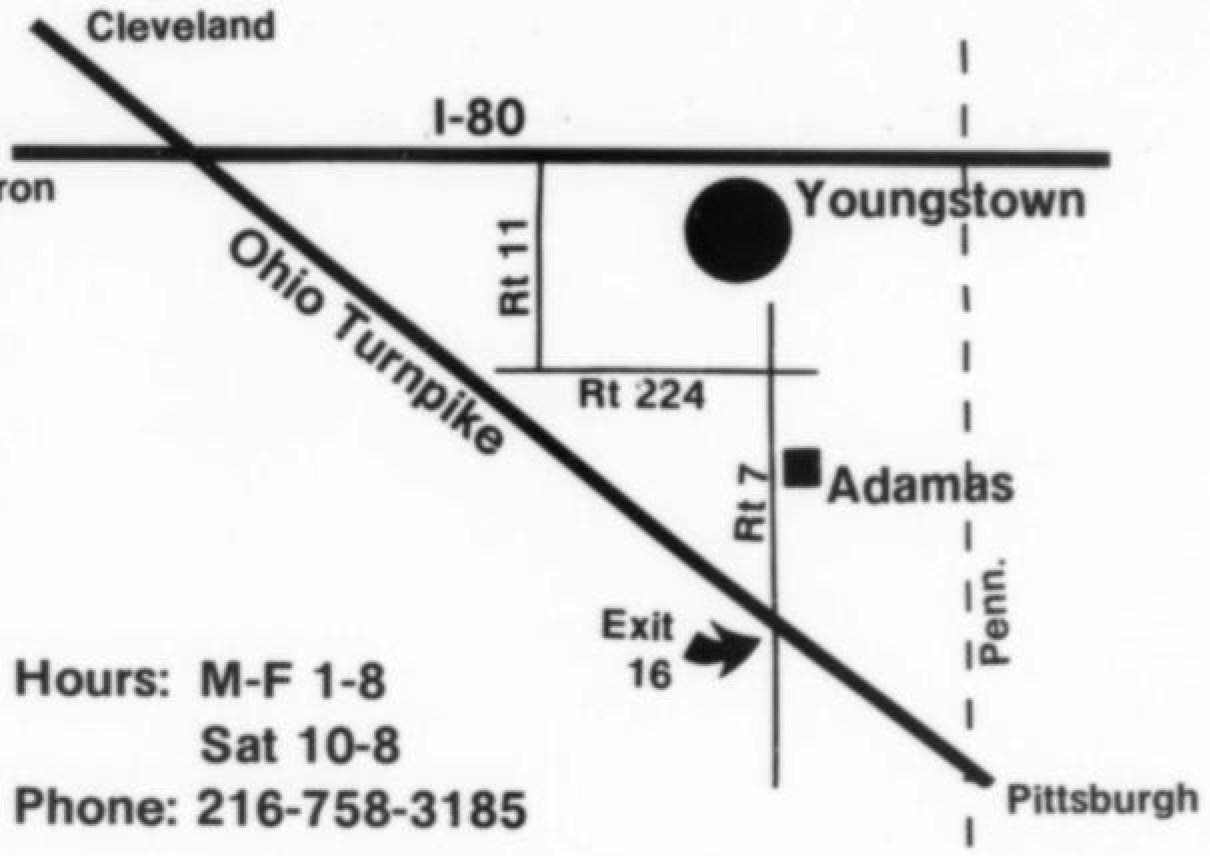
(continued on pg. 171)

ADAMAS

"MINERALS FOR MINERAL COLLECTORS"

ADAMAS IS LOCATED 2 MILES NORTH OF THE OHIO TURNPIKE (EXIT 16) AND 20 MINUTES SOUTH FROM I-76 & 80. IF YOU PASS THROUGH YOUNGSTOWN GOING EAST OR WEST AND YOU ARE A MINERAL COLLECTOR, WE THINK YOU WILL FIND THE VISIT TO ADAMAS WORTHWHILE.

WE WOULD LIKE TO TAKE THIS OPPORTUNITY TO INTRODUCE OURSELVES AND EXTEND TO YOU A MINERAL COLLECTOR'S INVITATION, FOR WE ENJOY NOTHING MORE THAN TALKING TO MINERAL COLLECTORS. THE ADAMAS MUSEUM IS A MUST FOR ALL THAT SEE BEAUTY IN THE MINERAL KINGDOM AND HOUSES THE FINE COLLECTION OF THE LATE CLARENCE SMITH SR., AS WELL AS OUR RECENT ADDITIONS. WE THINK YOU WILL AGREE THAT THE MUSEUM ALONE IS WORTH THE VISIT, HOWEVER WE DO HAVE THE LARGEST VARIETY OF CRYSTALLINE ARCHITECTURES AVAILABLE TO THE COLLECTOR, THAT WE CAN MUSTER. AMONG THE RECENT ADDITIONS TO OUR STOCK ARE A FINE SELECTION OF HUBNERITE CRYSTALS FROM SILVERTON COLORADO AND SOME EXCELLENT TREMOLITE/ACTINOLITE AFTER PYROXENE FROM SALIDA, COLORADO. WE ARE PERHAPS MOST PLEASED TO OFFER YOU OUR ASSEMBLAGE OF CALCITE PENDLETON TWINS FROM ANDERSON, INDIANA. WE BELIEVE THE ABUNDANCE OF PERFECT TWINS TO BE NATURE'S ACCOMPLISHMENT OF AN INCOMPREHENSIBLE IMPROBABILITY. WE ARE NOT A SHOW DEALER AND HAVE NO LIST, BUT WE ARE EASILY ACCESSIBLE FROM MAJOR HIGHWAYS AND EXTEND A WARM INVITATION. WE WOULD BE PROUD TO SHOW YOU ADAMAS. PLAN TO VISIT US AND WHEN YOU COME TO YOUNGSTOWN; ASK FOR 'ANDY'.



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which is present in basalts in significant amount. There is only one zeolite that contains a significant amount of magnesium: ferrierite. Apparently, only this particular zeolite is suitable for the inclusion of magnesium in its structure. To date, it has not been identified from the area.

The small amount of barium available is contained in very localized occurrences of the mineral barite.

A major factor controlling zeolite crystallization is the amount of silica plus alumina present in the mineralizing solutions. A theory suggesting the tendency of zeolites to occur in different environments depending upon the availability of silica in solution was proposed by Coombs *et al.* (1959) and seems to account for the restricted number of zeolites that have crystallized in the Paterson area.

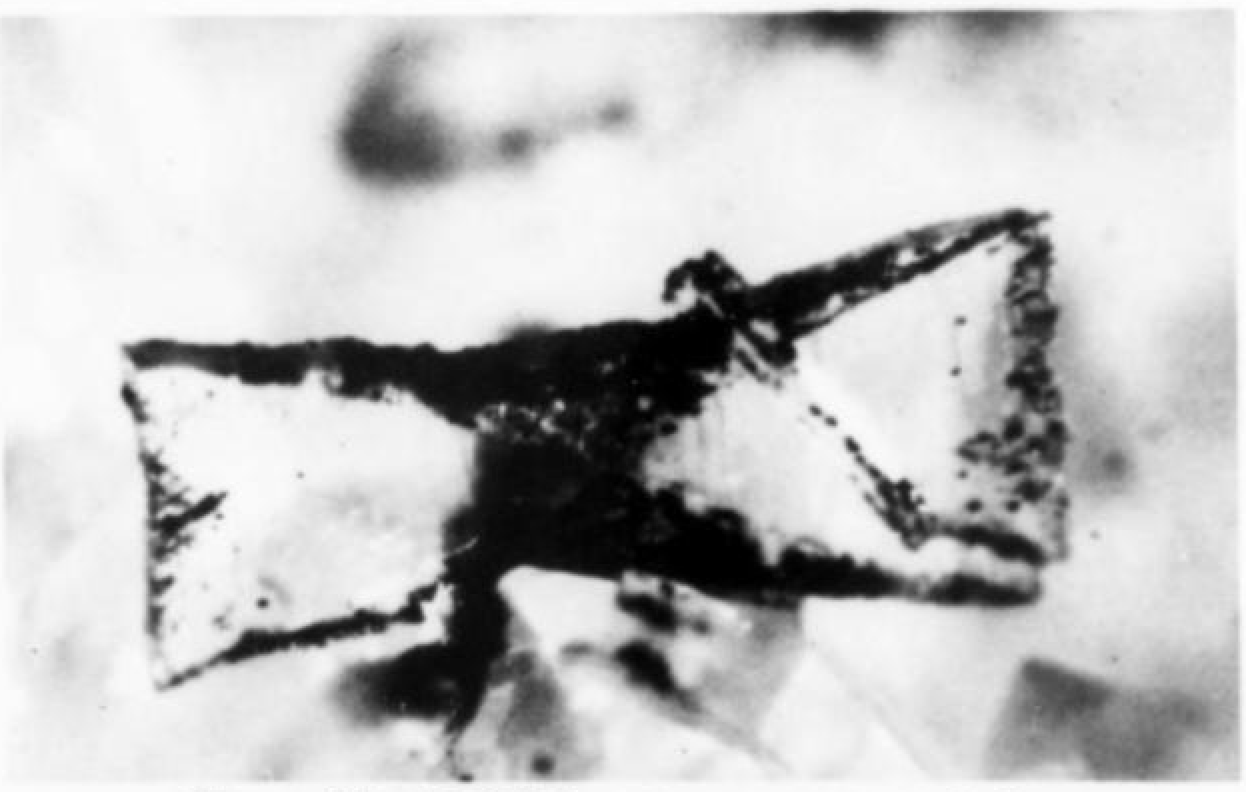

Figure 21. **ALBITE, a transparent, colorless crystal (1 mm long) rimmed with hematite, found in the Upper New Street quarry in 1964. Paterson Museum specimen #P-130-76.**

ZEOLITES

Analcime

Good display-quality specimens of analcime are difficult to obtain from Paterson. Typical 24-sided crystals (trapezohedra) up to 6.2 cm in diameter have been found and range in color from white to colorless or may be stained orange or red by inclusions of hematite. It is found associated with any of the following: prehnite, datolite, pectolite, calcite, chabazite, gmelinite, stilbite, natrolite, and apophyllite. The best specimens were found in the Lower New Street quarry.

Chabazite

Chabazite occurs as rhombohedral crystals that have a pseudocubic aspect. They are sometimes colorless, but most often are stained various shades of red by hematite (Fig. 5) or green by chlorite. Crystals range in size from 1 mm to 3.7 cm in diameter. They are sometimes found as penetration twins. Associated minerals may include heulandite, stilbite, laumontite, natrolite, analcime, quartz, hematite, calcite, chlorite, chalcopyrite, pectolite and prehnite. Excellent specimens were found in the Upper New Street quarry and the Prospect Park quarry.

Gmelinite

Gmelinite is quite similar to chabazite both in physical appearance and in chemistry. It can usually be identified by its pyramidal crystal faces versus the pseudo-cubes (actually rhombohedra) of chabazite. Like chabazite, gmelinite is found as small crystals stained red by hematite. Colorless crystals have been found in the Prospect Park quarry but are quite rare. Crystals tend to be 6 mm or less in diameter but have been found to 12 mm. Associates may include analcime, datolite, calcite, apophyllite and prehnite. The Lower New Street quarry and the Prospect Park quarry have produced fine specimens.

Heulandite

Heulandite typically occurs in coffin-shaped crystals with a pearly luster on the {010} crystal faces. In some instances, however, numerous individuals merge to form rounded, globular aggregates up to 5.6 cm in diameter. They may be white, colorless, shades of red (due to hematite inclusions) or shades of green (due to chlorite or malachite stains or inclusions). Fine examples were found in the Upper New Street quarry and the Prospect Park quarry. It may be associated with stilbite, laumontite, chabazite, chalcopyrite, datolite, calcite, albite, quartz, chlorite, and pectolite.

Natrolite Group Minerals

Natrolite, mesolite, and scolecite are a series of physically and chemically related minerals differing principally in the relative amounts of sodium and calcium present. Natrolite is predominantly sodium-bearing while scolecite is the calcium end-member of the series; mesolite is an intermediate member containing both sodium and calcium. It is impossible to distinguish members of this series by sight. The easiest means of identification is by measurement of their refractive indices or extinction angle. Natrolite is by far the most common member of the group found in the area. Crystals of natrolite may attain a length of 12.5 cm (Rothstein, 1970) but are usually 3 cm or less. Specimens are quite fragile and are easily destroyed by the quarrying process or by careless handling by collectors. Excellent examples of natrolite were found in the Upper New Street quarry, the Prospect Park quarry (Fig. 38) and the Route 80 roadcut. Mesolite was found quite commonly in the Lower New Street quarry as exceedingly fine, silky, white, radiating needles (Mason, 1960). To the authors' knowledge, scolecite has not been verified from the area. Associated minerals can include chabazite, thomsonite, stilbite, calcite, prehnite, albite, datolite, hematite and pectolite.

Laumontite

Laumontite is found as sprays of tiny, white, prismatic crystals with an oblique termination. These crystals rarely exceed 3 mm in length. It is usually associated with the other zeolites, particularly heulandite, stilbite and chabazite. Other associates are prehnite, apophyllite, calcite, quartz, and datolite. It is found in both of the New Street quarries and the Prospect Park quarry.

Stilbite

Stilbite is found in radiating aggregates of intergrown crystals

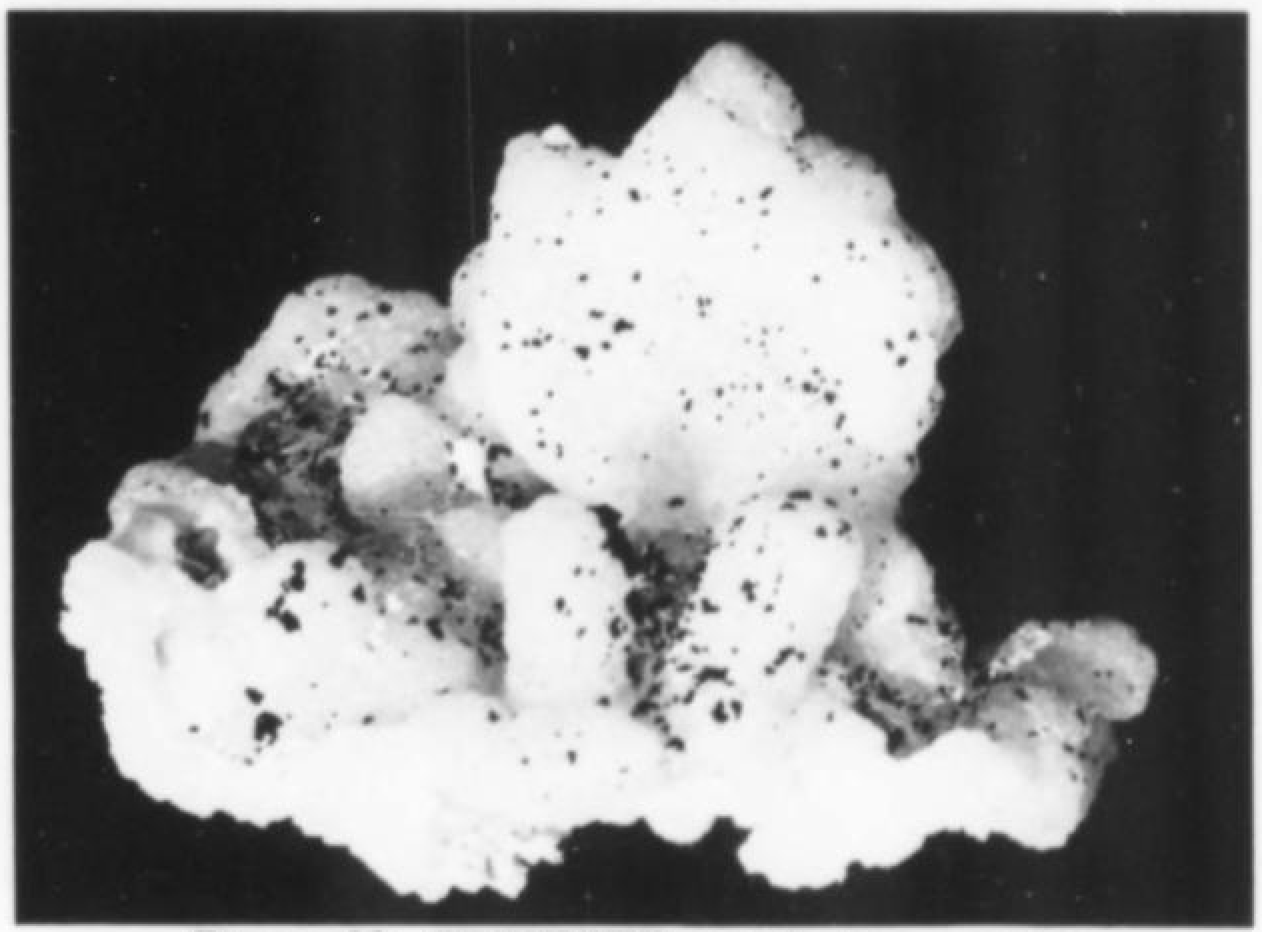

Figure 22. **PREHNITE enveloping scepter crystals of anhydrite which were later dissolved away, leaving internal molds after anhydrite (7.5 by 10 cm in size), from the Lower New Street quarry. Paterson Museum specimen #P-870-65.**

resembling sheaves of wheat, bow-ties, or as distinct "single" crystals having the shape of a slat in a picket fence (the {001} face is dominant). In actuality, what appear to be "single" crystals are actually interpenetrant twins on *c*(001) producing a pseudo-orthorhombic appearing "single" crystal.

Stilbite is most often brown in color but can be red (Fig. 3, 40) due to hematite inclusions or green due to malachite stains or inclusions. Red "single" crystals to 3 mm were found in the Prospect Park quarry in association with laumontite and datolite. "Wheat sheaves" of stilbite up to 10 cm across have been found. Stilbite is commonly associated with laumontite, heulandite, chabazite, gmelinite, calcite, apophyllite, datolite and quartz. The Upper New Street quarry and the Prospect Park quarry have yielded excellent examples of this mineral.

Thomsonite

Thomsonite occurs in thin, bladed, radiating crystal aggregates not unlike stilbite, but is usually white in color and its luster is markedly pearly. Single crystals of thomsonite have flat terminations rather than the pointed terminations {010} of stilbite found in Paterson. Smooth spheres of thomsonite up to 5 cm across have been found. Thomsonite's most frequent associate is prehnite. The best examples were collected in the Lower New Street quarry and the Prospect Park quarry. Good specimens are not readily obtained.

Phillipsite

This mineral is reported here for the first time from Paterson. It occurs in small (less than 1 mm) crystals that are colorless, transparent and universally twinned. Two types of twins were noted. The first are simple twins with *c*(001) as the twin plane. The second type consists of 2 simple twins that are joined together to form "fourlings." These have (021) as the twin plane. The phillipsite is implanted upon a botryoidal crust of yellow-green prehnite which contains a colorless to bluish mass of platy barite that has undergone partial solution. The specimen measures 2.5 by 6.2 cm and resides in the collection of Leonard Morgan who collected it at the Hinchcliffe Stadium site. To date, it is the only specimen of phillipsite identified from Paterson. The identification was made on the basis of a positive qualitative test for potassium. The indices of refraction are within the reported range of values. These tests were performed by Curt Segeler.

NOTE: The following minerals crystallized sometime during or after Period 4. Their exact position in the sequence is unknown. They are arbitrarily described following the zeolites.

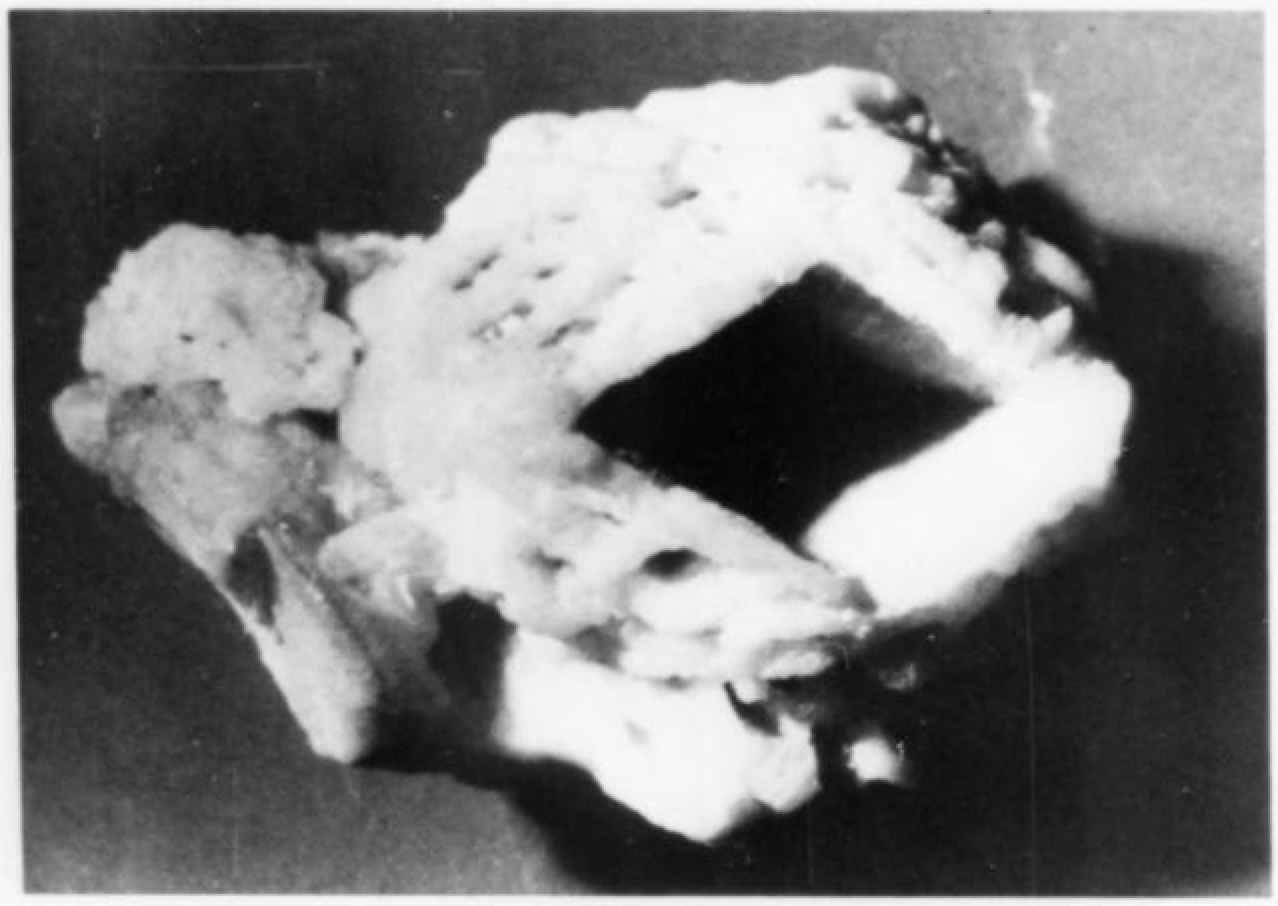

Figure 23. **PREHNITE containing a GLAUBERITE cavity (very rare), light green in color (the cavity is 1.25 cm long). Paterson Museum specimen #P-1560.**

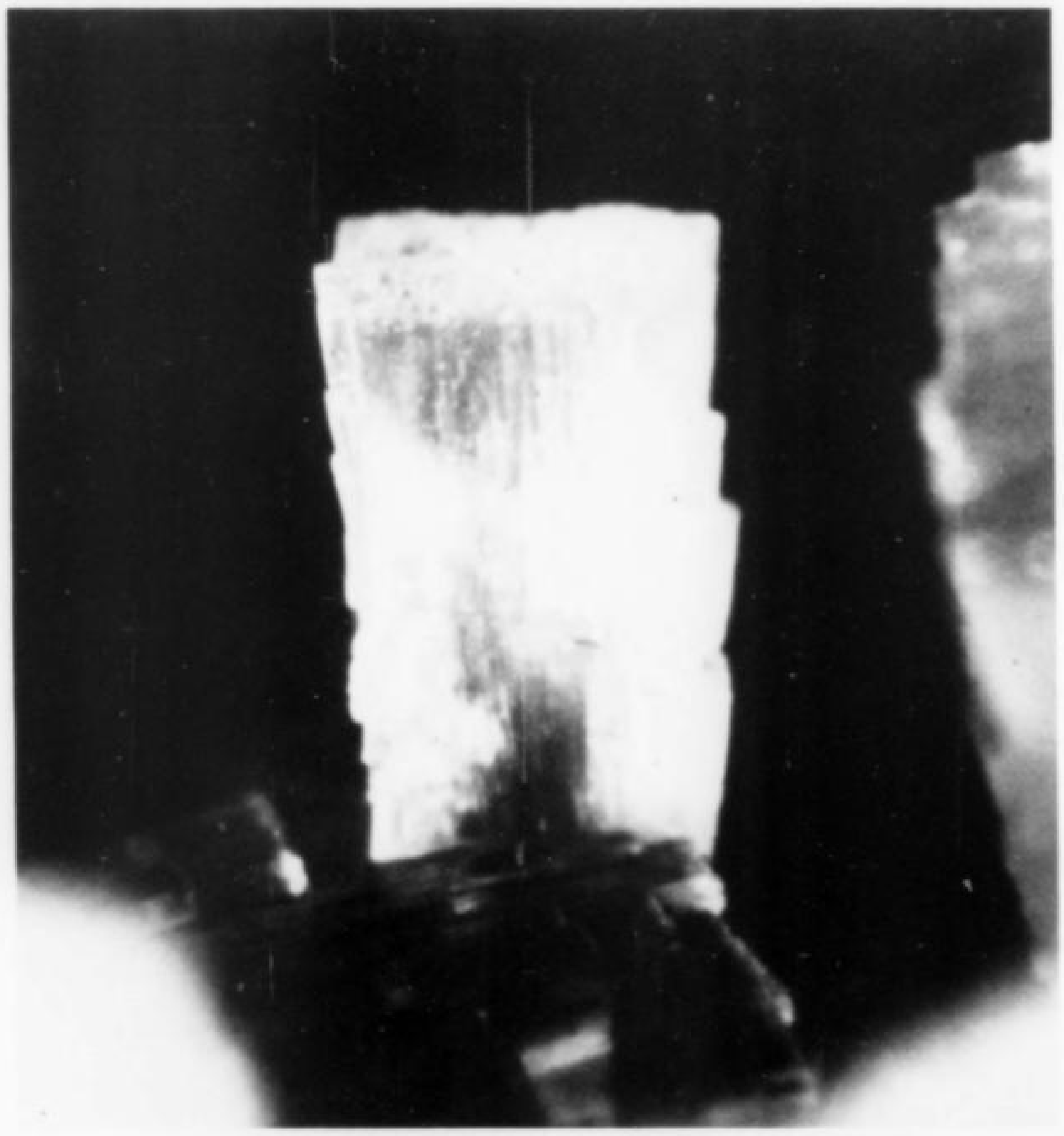

Figure 24. **PREHNITE, in a parallel growth of light green crystals (2 mm tall) from the Lower New Street quarry. Paterson Museum specimen #P-186-63.**

Silver

According to Morton (1930), specimens of wire silver were found with calcite crystals in an open pocket in a vein containing copper sulfides, principally bornite, in 1930. Two specimens of note are described here. The most notable specimen, pictured in plate No. 3 of Manchester (1931), is about 2.5 by 3.7 cm in size. The specimen was collected by Charles Hansen who made the following notation in his copy of *The Minerals of New York City and Its Environs* (Manchester, 1931) next to the specimen photograph: "Pocket containing calcite and native silver was in a large piece of trap, through which ran veins of bornite cop-

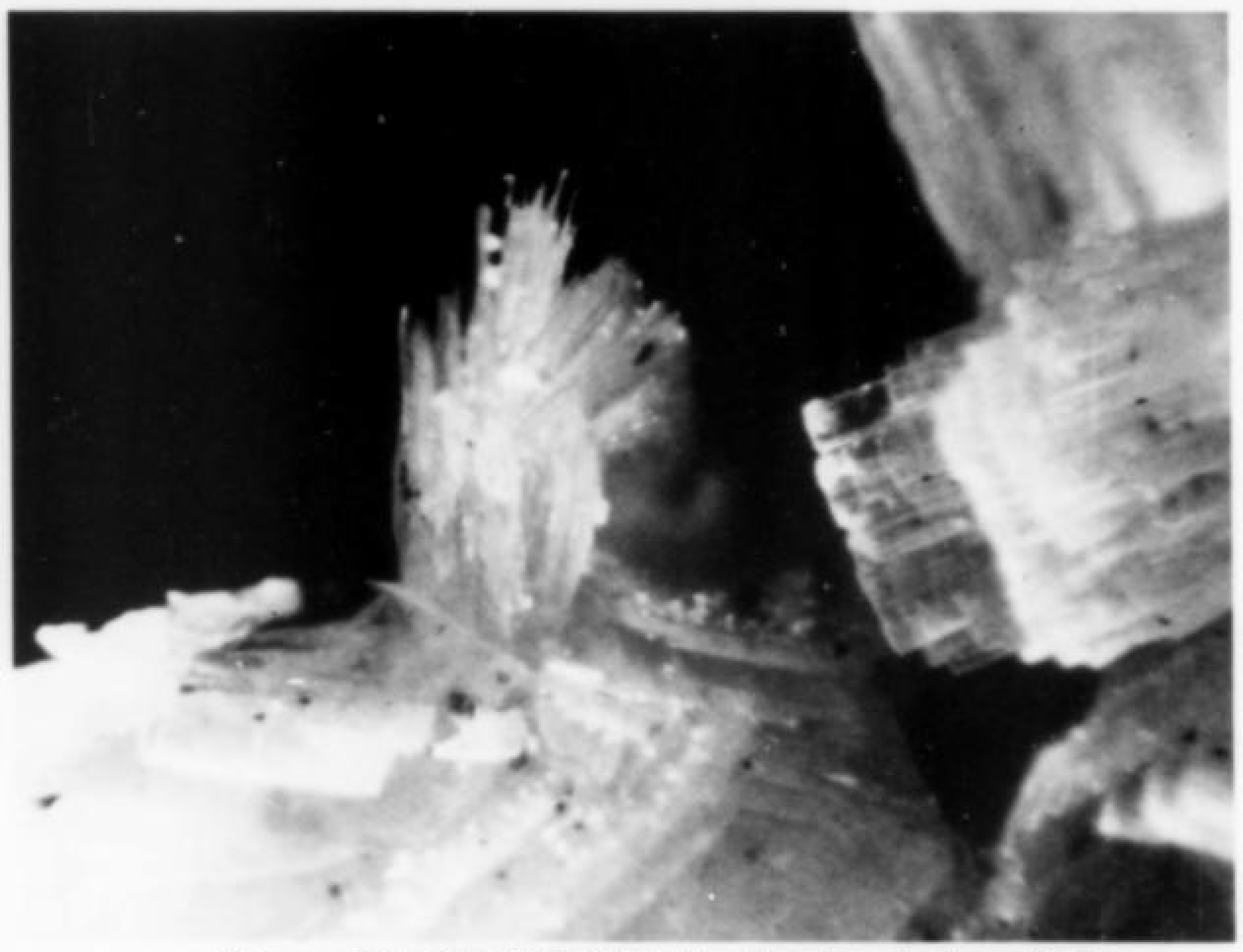

Figure 25. **PREHNITE, in thin-bladed, radial aggregates (individual blades to 1.5 mm), light green in color, which resemble some stilbite and thomsonite. Found by L. Jochem in the Prospect Park quarry in the 1930's. Paterson Museum specimen #P-56-77.**

per. Found March 1930 Prospect Park Quarry." This specimen now resides in the collection of Richard and Elna Hauck of Bloomfield, New Jersey. The other specimen, which belongs to the Paterson Museum, is 3.7 by 6.2 cm with a small mass of wire silver about 8 mm across resting upon calcite crystals.

The Copper Minerals

The copper minerals chalcopyrite, bornite, chalcocite and covellite were found in an unusual occurrence in the Prospect Park quarry in 1929 (Morton, 1930). These minerals were found in a highly brecciated zone of the basalt. Both the walls of the vein (at the basalt contact) and the basalt breccia fragments showed evidence of chemical reaction with hydrothermal solutions. Bornite comprised the bulk of the vein filling with chalcopyrite being locally abundant. Microscopic examination reveals that the bornite is sometimes replaced by chalcocite and/or covellite. Quartz is universally present, while galena and native silver are rarely associated with the assemblage.

Small crystals of chalcopyrite are abundant in all of the Paterson quarries. They are bronze or brass-colored or may have an irridescent coating due to surface alterations. Sometimes chalcopyrite is altered to malachite or rarely to chrysocolla. The matrix for these crystals is quartz, calcite, or prehnite. Most of the brass to bronze-colored sulfides found in the area have proven to be chalcopyrite rather than pyrite; the latter being rather rare.

A single specimen of chalcopyrite, bornite, covellite and chrysocolla was found associated with yellow prehnite from the Route 80 roadcut by one of the authors (T.P.). A similar specimen was also examined that came from the Prospect Park quarry (J. Cilen collection).

No verified specimens of native copper or cuprite have been seen by the authors from the Paterson quarries.

Figure 26. **PECTOLITE, in white, radiating aggregates of needle-like crystals (to 5 cm in length; entire specimen measures 15 by 22.5 cm), found by quarry superintendent Robert Mercer in the Lower New Street quarry. Paterson Museum specimen #P-654.**

Pyrite

Pyrite, a mineral found abundantly in the diabase occurrences at Laurel Hill (Snake Hill) and Fort Lee, New Jersey, has proven to be quite rare in the area. The Paterson Museum has only one specimen from the Prospect Park quarry that exhibits cubic crystals less than 1 mm on datolite with minor babingtonite. This near absence of pyrite in the basalt quarries was noted by Lewis (1916).

Sphalerite

Sphalerite is found as a rare associate of prehnite in a specimen from the Lower New Street quarry. It is a cleaved crystal, dark brown in color, embedded in prehnite.

Greenockite

Greenockite is a relatively rare mineral in the area. It is usually associated with prehnite and/or datolite as small, hexagonal prisms (Fig. 41) or tabular plates (Fig. 42) ranging in color from yellow to dark brown. The crystals are a few mm across. Whitlock (1929) described a specimen of greenockite from the Lower New Street quarry found in 1925 and characterized it as being twinned according to a new law, $z\{11\bar{2}2\}$. This specimen is preserved in the Paterson Museum. Localities for greenockite are: the New Street quarries, Hinchcliffe Stadium, Prospect Park quarry and the Route 80 roadcut.

Orpiment-Realgar

Orpiment is extremely rare in the area, with only three or four specimens having been recorded from the Lower New Street quarry sometime prior to 1930 (Morton, 1930). A specimen from the Paterson Museum collection is 2.5 by 5.0 cm and consists of partially crystallized calcite with a small amount of orpiment and realgar embedded in it. This specimen is the only one known from this occurrence.

Figure 27. **PECTOLITE pseudomorph after QUARTZ (largest crystal is 2 mm across) from the Lower New Street quarry. E. R. DeRoo micromount collection.**

The Iron Oxides

The iron oxide minerals, goethite and hematite, are found in the area, the latter being especially widespread in its occurrence. Hematite readily stains many of the secondary minerals a blood-red color. Small, black, metallic, platy rosettes of hematite are very common. Goethite has been found in the Prospect Park quarry as yellow-brown needles on plates of hematite in association with quartz crystals (some of the "quartzoid" variety, i.e. no prism faces). It has also been found in radiating balls of needles on calcite crystals.

Pyrolusite

Small dendrites of pyrolusite coat the joint surfaces of the basalt. Pyrolusite inclusions in transparent blades of stilbite have been found in the Prospect Park quarry.

Amphibole

Two types of occurrences of the amphibole group minerals have been identified. The first is actinolite in very tiny, dark green needles in association with prehnite, calcite, quartz, and datolite. Specimens of this type have been found in the Prospect Park quarry. The second type is a variety known as "mountain leather" which is found in white to brown matted crusts of fibers. These mats frequently coat prehnite. The mats contain trapped air bubbles between their layers and consequently are extremely lightweight. Specimens were found in the Route 80 roadcut.

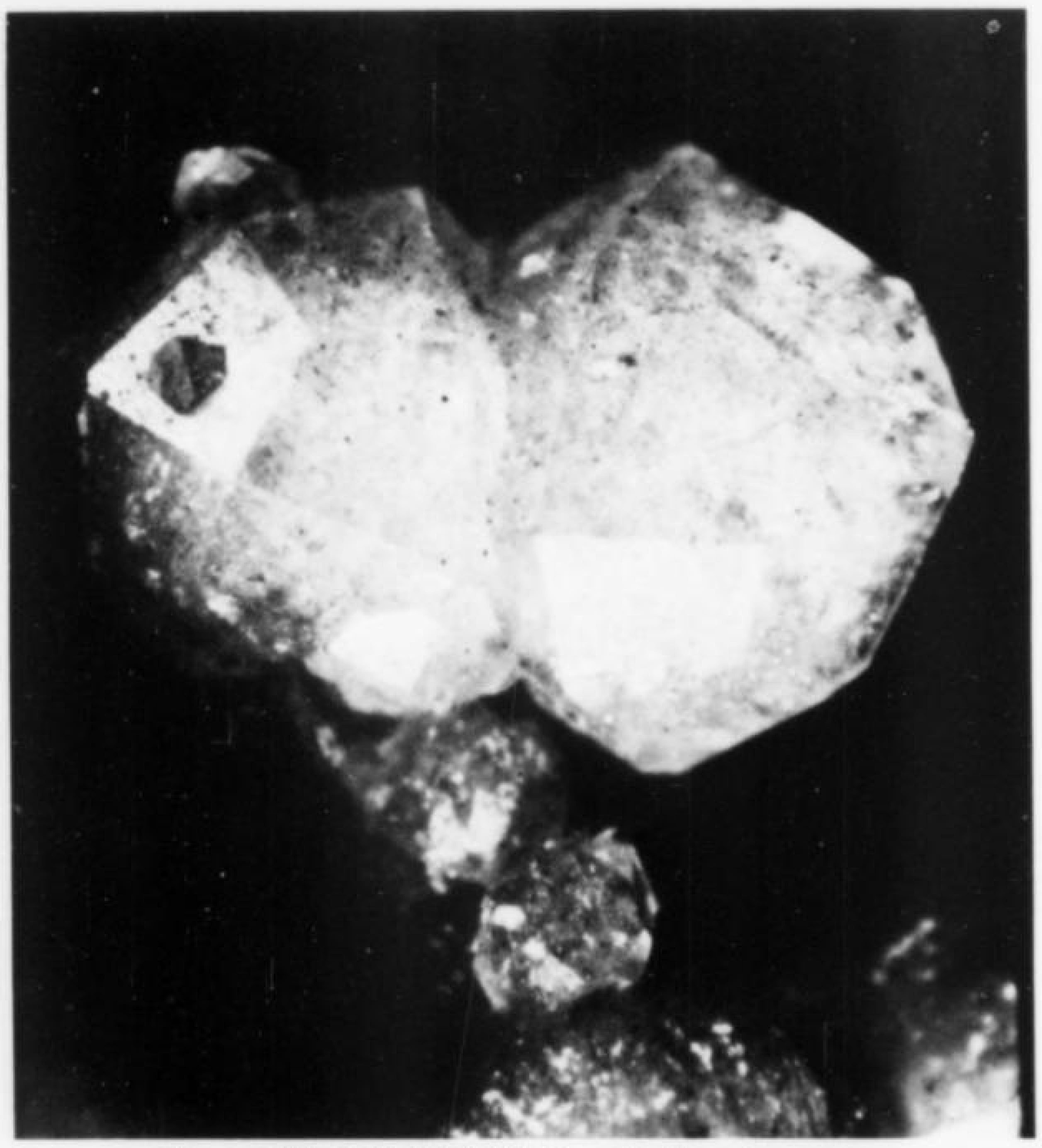

***Figure 28.* ANALCIME, in colorless to orange trapezohedra (2 mm across) from the Prospect Park quarry. E. R. DeRoo micromount collection.**

***Figure 29.* ANALCIME, in colorless crystals (1.5 mm across) perched atop an albite blade, from the Lower New Street quarry. Paterson Museum specimen #P-37-77.**

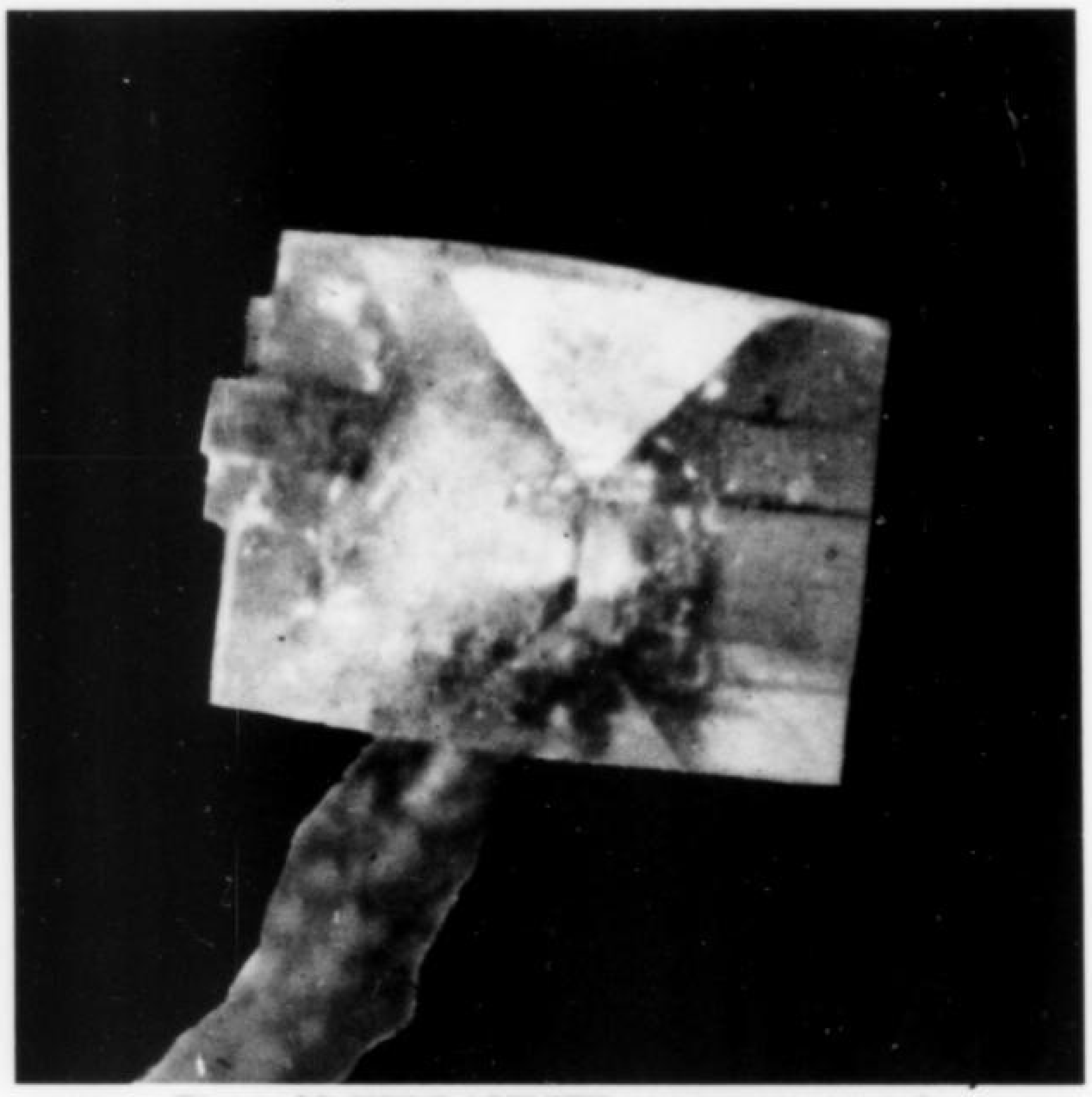

***Figure 30.* HEULANDITE, a transparent, colorless crystal (1 mm) perched on a blade of albite, from the Prospect Park quarry. E. R. DeRoo micromount collection. Photo by T. Peters.**

Epidote

Extremely small (less than 1 mm), yellow-green prismatic crystals of epidote have been found in the Prospect Park quarry. The common associates are prehnite, calcite, and quartz.

Chlorite

Chlorite is present in small amounts in all of the quarries. It occurs as small, dark green or brown, velvety balls or crusts coating other minerals or lining amygdules in the basalt.

Stilpnomelane

This mineral occurs as exceedingly fine flakes or crusts coating prehnite, calcite or albite. It is of a distinctive golden bronze color with an almost metallic luster.

Pumpellyite

Pumpellyite has been identified as a constituent of the amygdaloidal basalt from the area but is frequently misidentified as chlorite.

Apophyllite

Apophyllite is found in equant, tetragonal crystals that are usually colorless or white but are sometimes stained pink or green. Crystals to 5 cm on an edge have been found. Associated minerals may include quartz, calcite, albite, stilbite, heulandite, pectolite, datolite, laumontite, chalcopyrite, chlorite, prehnite, chabazite, and thaumasite. Outstanding specimens were found in the Upper New Street quarry. A recent study by Dunn (1978) suggests that most Paterson apophyllite is fluorapophyllite, but "several opaque, white, chalky crystals" of hydroxyapophyllite from Prospect Park were identified by chemical analysis.

MINERALS OF THE CALCITE PERIOD

Calcite

Calcite is one of the most abundant secondary minerals in the Paterson traprocks. It ranges in size from less than 1 mm to many cm across. It is generally colorless or white but may be stained orange or red by hematite. Yellow, green and purple varieties are also known. The larger crystals tend to cleave rather easily producing excellent examples of transparent "Iceland Spar." A myriad of crystal forms have been described for the mineral calcite from localities throughout the world. Most commonly found in Paterson are rhombohedra, $r\{10\bar{1}1\}$ and scalenohedra, $v\{02\bar{2}1\}$. Calcite is readily identified by its perfect rhombohedral cleavage and its effervescence in dilute, cold hydrochloric acid. Calcite is ubiquitous in its occurrence and can be associated with almost any mineral found in the Paterson area, but its most frequent associate is quartz.

TABLE 1. MINERALS FOUND IN THE PATERSON, NEW JERSEY, AREA

NAME	*CRYSTAL SYSTEM*	*CHEMICAL COMPOSITION*
Acmite	Monoclinic	$NaFeSi_2O_6$
Actinolite	Monoclinic	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$
Albite	Triclinic	$NaAlSi_3O_8$
Analcime	Isometric	$NaAlSi_2O_6 \cdot 2H_2O$
Anhydrite	Orthorhombic	$CaSO_4$
Apophyllite (fluorapophyllite to hydroxyapophyllite)	Tetragonal	$KCa_4Si_8O_{20}(F,OH) \cdot 8H_2O$
Babingtonite	Triclinic	$Ca_2(Fe^{+2},Mn)Fe^{+3}Si_5O_{14}(OH)$
Barite	Orthorhombic	$BaSO_4$
Bornite	Isometric	Cu_5FeS_4
Calcite	Trigonal	$CaCO_3$
Chabazite	Trigonal	$Ca(Al_2Si_4)O_{12} \cdot 6H_2O$
Chalcocite	Monoclinic	Cu_2S
Chalcopyrite	Tetragonal	$CuFeS_2$
Chlorite	Monoclinic	$(Mg,Fe)_{5-6}(Al,Si)_4O_{10}(OH)_8$
Chrysocolla	Monoclinic	$(Cu,Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$
Covellite	Hexagonal	CuS
Datolite	Monoclinic	$CaBSiO_4(OH)$
Diopside	Monoclinic	$CaMgSi_2O_6$
Epidote	Monoclinic	$Ca_2(Al,Fe)_3Si_3O_{12}(OH)$
Galena	Isometric	PbS
Glauberite	Monoclinic	$Na_2Ca(SO_4)_2$
Gmelinite	Hexagonal	$(Na_2,Ca)(Al_2Si_4)O_{12} \cdot 6H_2O$
Goethite	Orthorhombic	$FeO(OH)$
Greenockite	Hexagonal	CdS
Gypsum	Monoclinic	$CaSO_4 \cdot 2H_2O$
Hematite	Trigonal	Fe_2O_3
Heulandite	Monoclinic	$(Na,Ca)_{4-6}Al_6(Al,Si)_4Si_{26}O_{72} \cdot 24H_2O$
Laumontite	Monoclinic	$Ca(Al_2Si_4)O_{12} \cdot 4H_2O$
Malachite	Monoclinic	$Cu_2(CO_3)(OH)_2$
Mesolite	Monoclinic	$Na_2Ca_2(Al_6Si_9)O_{30} \cdot 8H_2O$
Natrolite	Orthorhombic	$Na_2(Al_2Si_3)O_{10} \cdot 2H_2O$
Orpiment	Monoclinic	As_2S_3
Pectolite	Triclinic	$NaCa_2Si_3O_8(OH)$
Phillipsite	Monoclinic	$(K_2,Na_2,Ca)(Al_2Si_4)O_{12} \cdot 4\text{-}5H_2O$
Prehnite	Orthorhombic	$Ca_2Al_2Si_3O_{10}(OH)_2$
Pumpellyite	Monoclinic	$Ca_2MgAl_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$
Pyrite	Isometric	FeS_2
Pyrolusite	Tetragonal	MnO_2
Quartz	Trigonal	SiO_2
Realgar	Monoclinic	AsS
Silver	Isometric	Ag
Sphalerite	Isometric	$(Zn,Fe)S$
Stevensite	Monoclinic	$Mg_3Si_4O_{10}(OH)_2$ (Defect Structure)
Stilbite	Monoclinic	$NaCa_2(Al_5Si_{13})O_{36} \cdot 14H_2O$
Stilpnomelane	Monoclinic	$K(Fe^{+2},Fe^{+3},Al)_{10}Si_{12}O_{30}(OH)_{12}$
Talc	Monoclinic	$Mg_3Si_4O_{10}(OH)_2$
Thaumasite	Hexagonal	$Ca_3Si(CO_3)(SO_4)(OH)_6 \cdot 12H_2O$
Thomsonite	Orthorhombic	$NaCa_2(Al_5Si_5)O_{20} \cdot 6H_2O$

An unusual specimen found in the Prospect Park quarry consists of a stalactite of calcite which exhibits growth rings in cross-section and is capped by drusy quartz (Gene Vitali collection).

Gypsum

Gypsum is found as transparent plates entirely filling cavities or as fine-grained masses, white in color, as an alteration product of earlier formed anhydrite.

Thaumasite

Thaumasite, an alteration product of gypsum, is found in snow-white masses but small, transparent crystals may be found in the massive material. Good specimens came from the Upper New Street quarry and the Route 80 roadcut.

Barite

Barite was found in a vein in the Prospect Park quarry in 1926 as opaque, colorless to white to bluish white crystals (Morton, 1930). The usual specimens are intergrown plates or large, rough crystals up to 15 cm in length. Small bluish white crystals were found in the Hinchcliffe Stadium site. A single specimen from this site contained phillipsite in association with barite (see phillipsite).

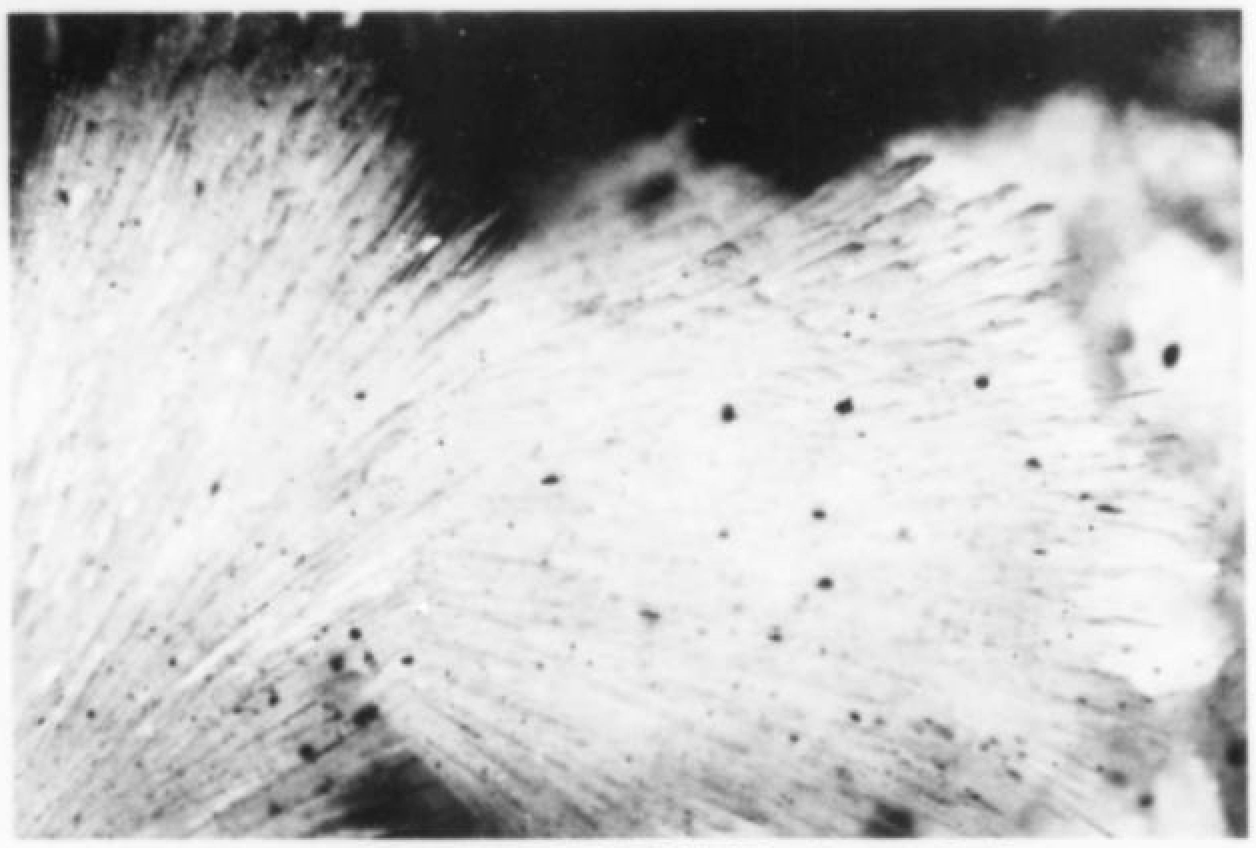

Figure 31. **THOMSONITE, in colorless, bladed, radiating aggregates found in the Lower New Street quarry by Herman Papke in 1935. American Museum of Natural History specimen #19674.**

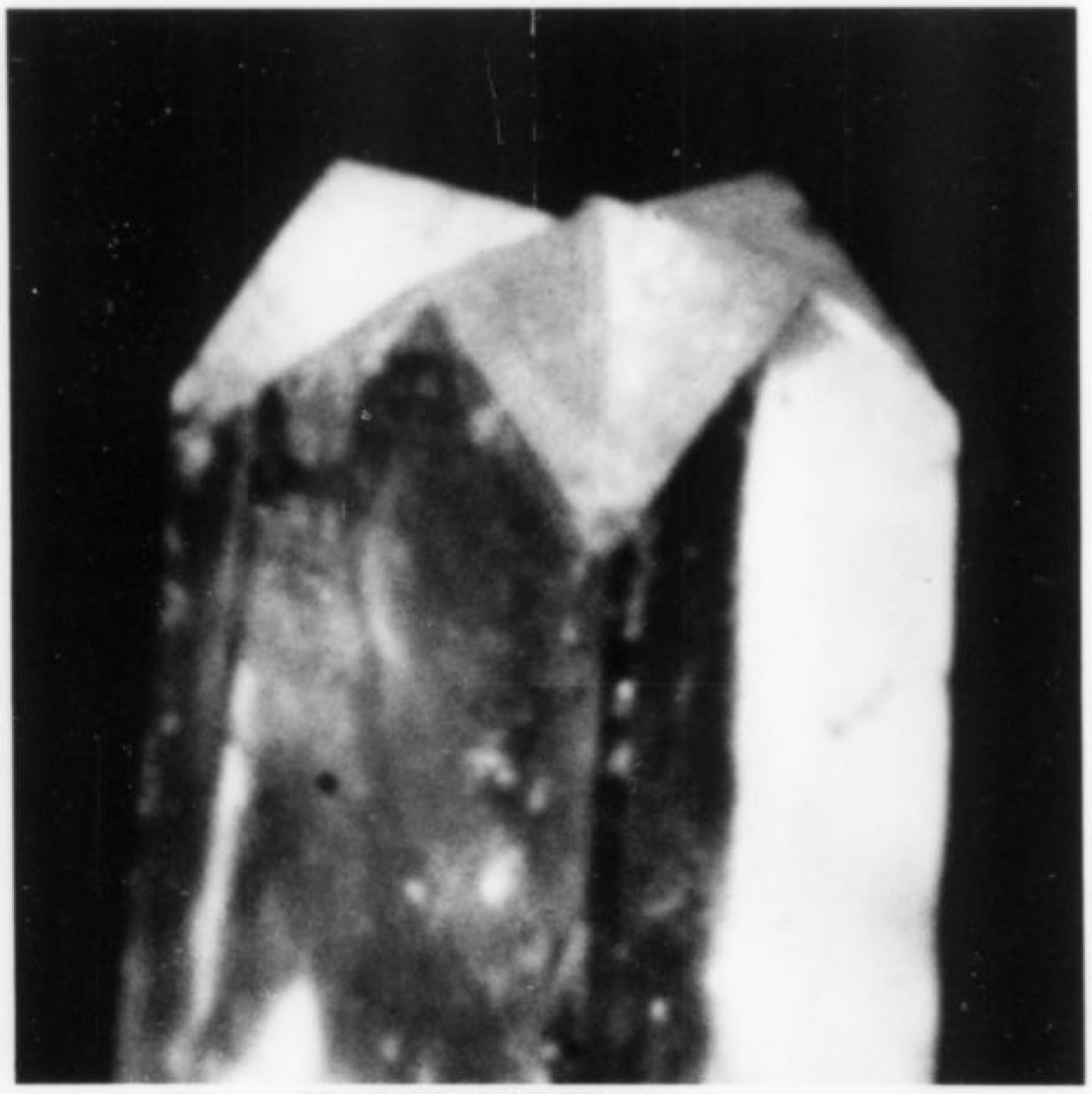

Figure 32. **PHILLIPSITE, in a transparent, simple twin (about 0.5 mm wide) with (001) as the twin plane within each member, and the four members twinned on (021) to form a "fourling." This specimen, from Hinchcliffe Stadium, Great Falls Park, Paterson, is the first reported phillipsite from Paterson. Collected and owned by Leonard Morgan.**

Figure 33. **SILVER (about 3 mm in length) found by Charles Hansen in a bornite vein in the Prospect Park quarry in 1930. Paterson Museum specimen #P-52.**

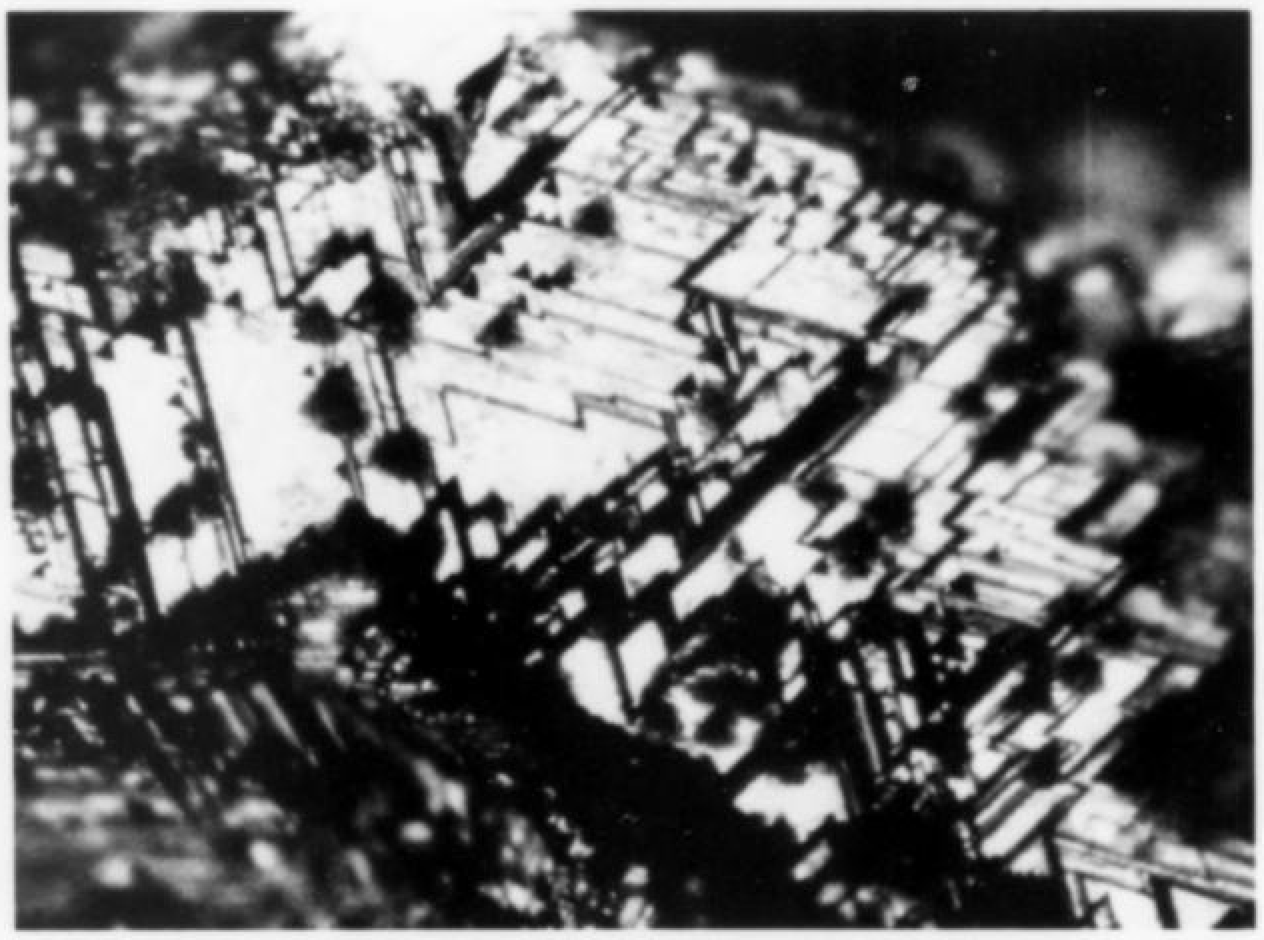

Figure 34. **CHALCOPYRITE, in bronze-colored crystals (less than 1 mm) from the Upper New Street quarry. Paterson Museum specimen #P-38-77.**

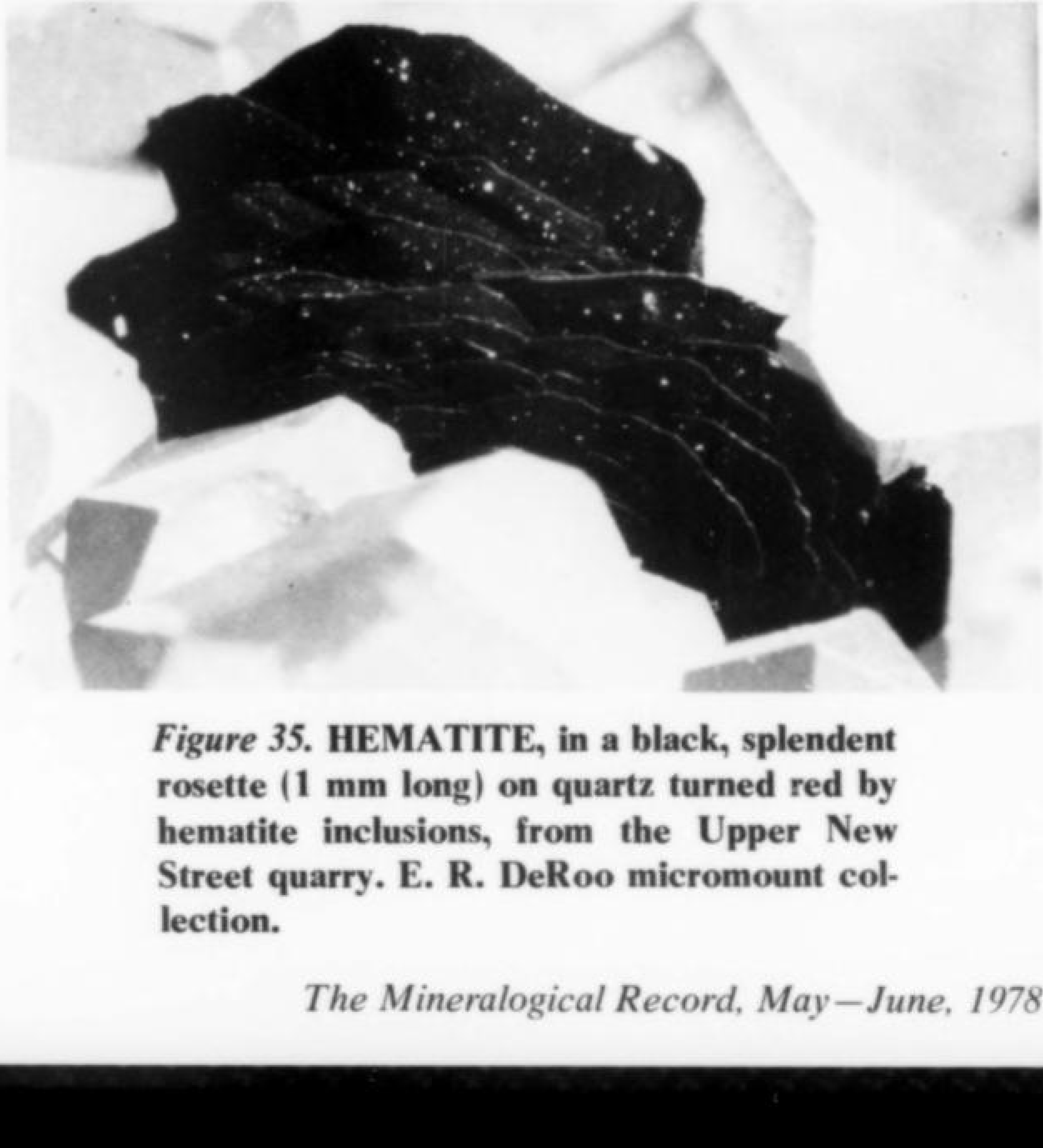

Figure 35. **HEMATITE, in a black, splendent rosette (1 mm long) on quartz turned red by hematite inclusions, from the Upper New Street quarry. E. R. DeRoo micromount collection.**

MINERALS REPORTED FROM PATERSON BUT NOT VERIFIED

Native Copper
Cuprite
Siderite
Dolomite
Azurite
Orthoclase
Scolecite

Figure 36. **APOPHYLLITE, in white crystals (the largest is 3 by 5.5 cm) on matrix from the Upper New Street quarry. Paterson Museum specimen #P-732.**

CONCLUDING REMARKS

The authors have described or listed 49 species that are known with certainty to have been found in the Paterson, New Jersey, area quarries. Seven mineral species previously reported from Paterson by Mason (1960) have been deleted from our list because specimens could not be found in the collections examined.

ACKNOWLEDGMENTS

The help of the following is greatly appreciated: Ted Dembrowski, Plant Manager, Richardson Chemical Company, Paterson, N.J.; Richard Hauck; Leonard Morgan; Joseph Cilen and E. Russell DeRoo, all of whom contributed useful information and/or provided specimens for study and photography. The cooperation of the New York Mineral Club with regard to the loan of the James G. Manchester photo collection is greatly appreciated.

We would also like to thank our colleagues, Lubov Drashevska and Gene Vitali of the Paterson Museum; Martin Prinz and George Harlow of the Department of Mineral Sciences of the American Museum of Natural History; George T. Faust, Research Mineralogist of the United States Geological Survey and Curt G. Segeler for critical reviews of this article.

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Figure 37. **CALCITE, in colorless, transparent scalenohedra (to 2 mm long) from the Prospect Park quarry. E. R. DeRoo micromount collection.**

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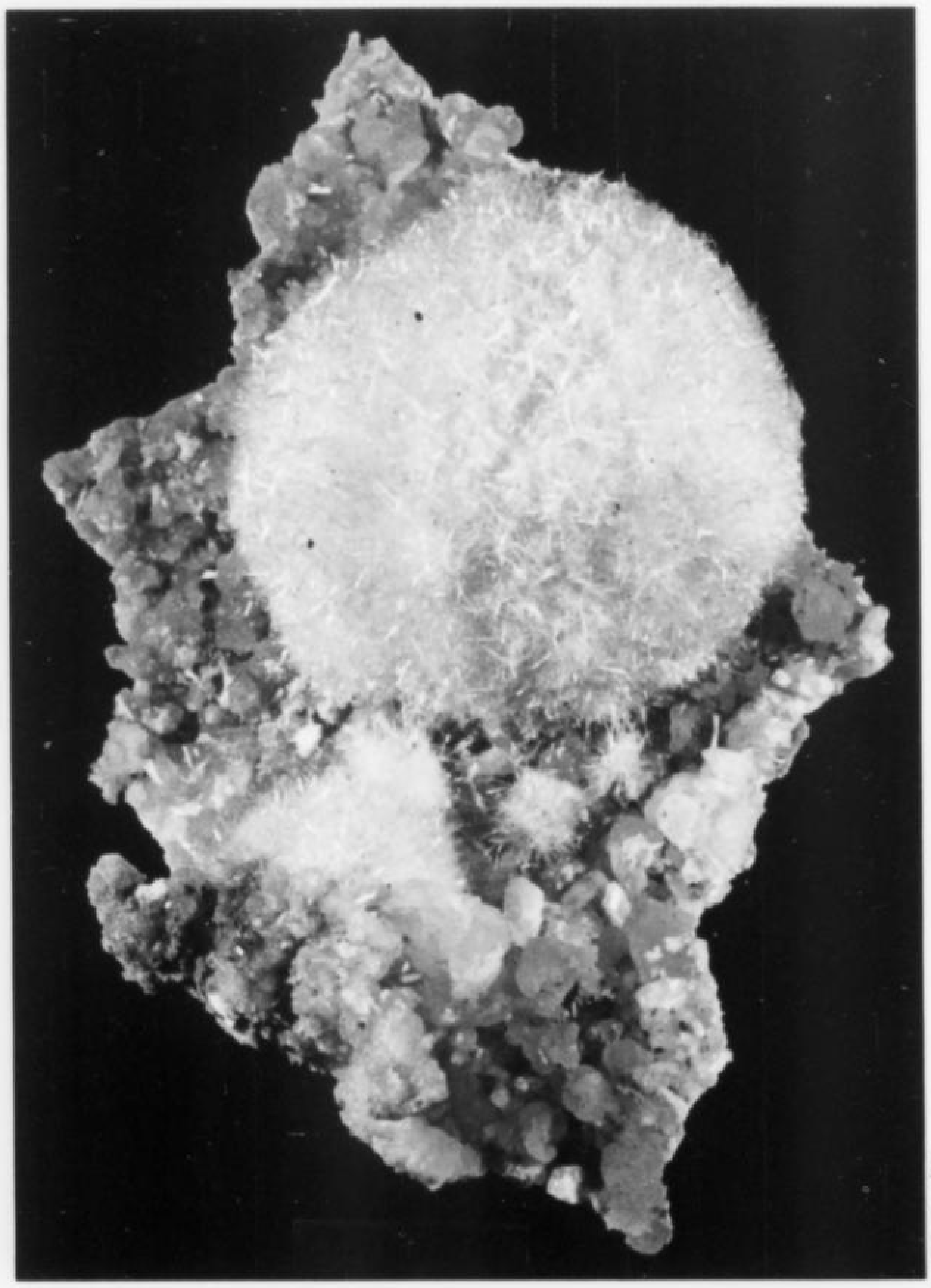


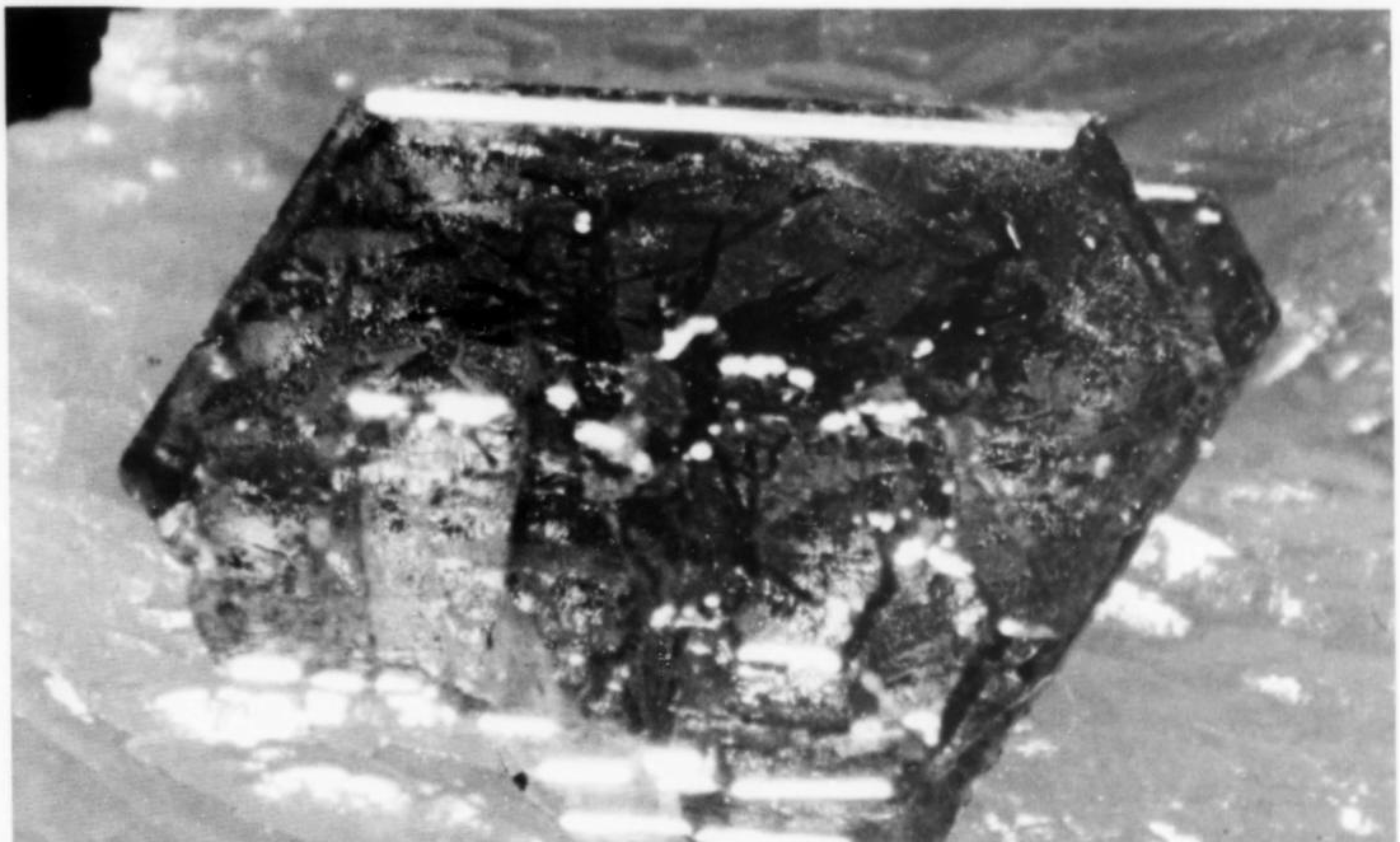
Figure 39. **QUARTZ, variety amethyst (the crystals are about 2.5 cm in diameter) from the Prospect Park quarry. Paterson Museum specimen #P-1182-67. Photo by T. Peters.**

Figure 38. **NATROLITE on green PREHNITE (the natrolite ball is 7.5 cm across) from the Prospect Park quarry. Steven Pochek collection. Photo by Rock Currier.**

Figure 40. **STILBITE (brown), HEULANDITE (reddish), and LAUMONTITE (white) (the specimen is 10 by 12.5 cm in size) from the Prospect Park quarry. Steven Pochek collection. Photo by Rock Currier.**

Figure 41. **GREENOCKITE crystal (1 mm) on prehnite and datolite matrix, found by Frederick L. Smith in the Prospect Park quarry. Gene Vitali collection.**

Figure 42. **GREENOCKITE crystal (3 mm across) on prehnite, from the Hinchcliffe Stadium, Great Falls Park, Paterson. Collected and owned by Leonard Morgan.**



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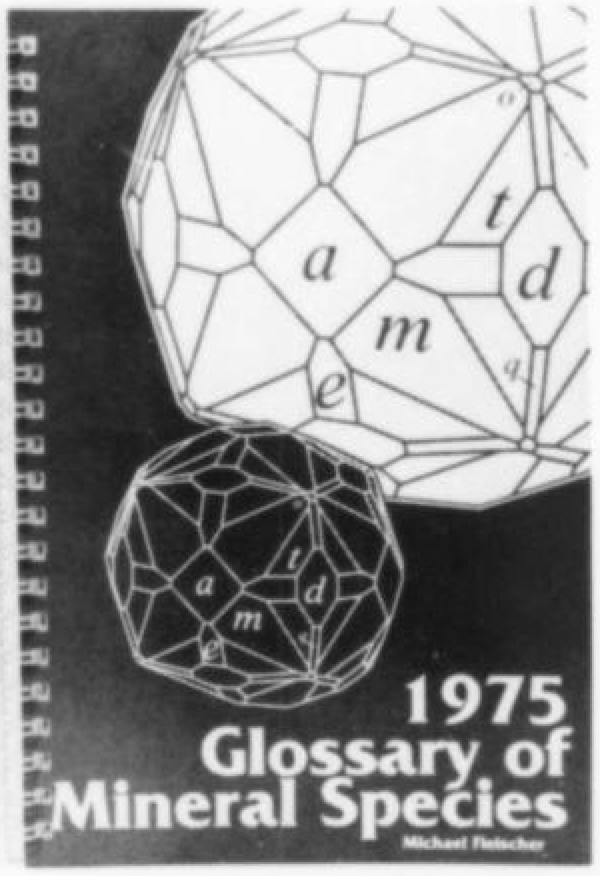
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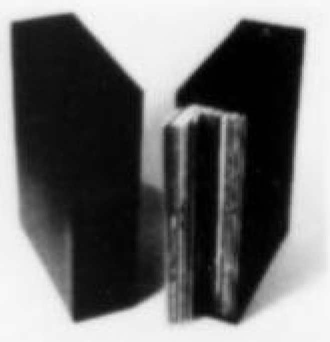
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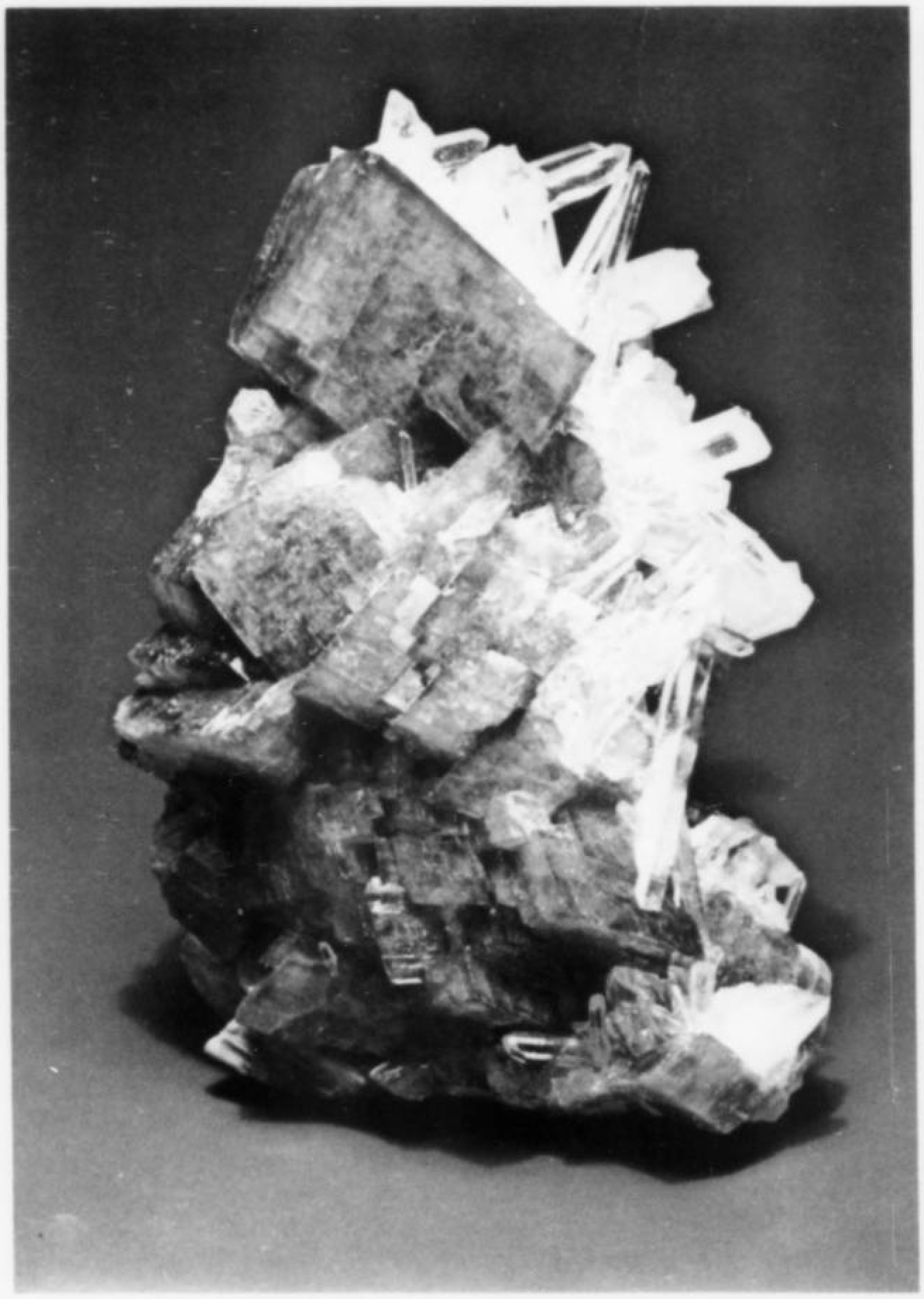
WHAT would it feel like to be the Curator of one of the world's largest and best mineral collections, and to learn that a unique old European collection of over 25,000 minerals, 3000 gems and stones and about 600 meteorites was for sale—particularly if you knew that the collection was strongest where your own collection was weak? Paul Desautels of the Smithsonian had that pleasant and potentially frustrating experience in the Spring of 1965. He had heard that the Carl Bosch mineral collection, on loan to Yale University since 1951, was to be sold. On April 28, 1965, he wrote a memorandum to S. Dillon Ripley, Secretary of the Smithsonian, telling of the collection and asking if the Smithsonian should try to acquire it. Late in July, while the difficult matter of financing the purchase was still being discussed, a letter from Frank B. Jaekel, a New Jersey banker, told Paul that Henning H. Borchers, a Mountainside, New Jersey, attorney, was handling the sale, acting for Bosch's son, Carl Bosch, Jr., of Florida.

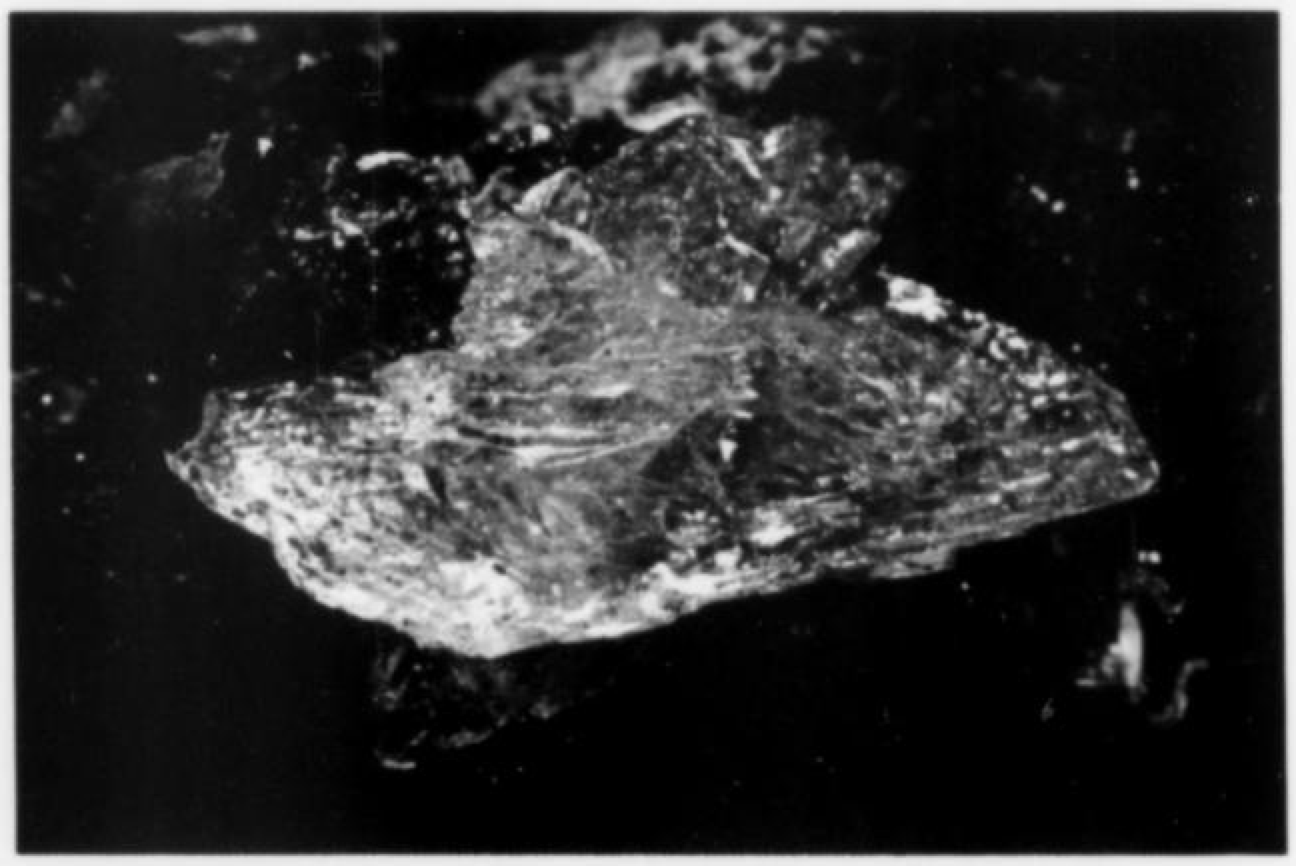
Dr. Carl Bosch
(1874 - 1940)

Paul, under whose feet grass doth seldom grow when a new mineral is in sight, talked with Borchers and on August 2, 1965, received from him an offer to sell the collection to the Smithsonian. An option to buy was tendered by the Smithsonian on November 30, 1965, with a payment of $3000, the option to be exercised before March 1, 1966. Martin Ehrmann, a well-known mineral dealer, placed a value of $400,000 on the collection; Bosch offered the collection to the Smithsonian for $250,000 to be paid over a period of four years after a down payment of $60,000. It was agreed that the Bosch family would contribute about $70,000 toward the purchase price (in addition to the $150,000 reduction from the assessed value) after some cash payments had been made. A total of $180,000 was eventually to be paid by the Smithsonian, and the Bosch collection would be theirs.

So Paul won the battle but not necessarily the war; he had to raise a good deal of money rather quickly (others interested in purchasing the collection included H. R. H. Prince Phillip for the British Museum; The Royal Ontario Museum; The National Museum of Canada; a Swiss group; the Los Angeles County Museum of Natural History; and Martin Ehrmann). To make a long and quite harrowing story short, he did it! A crucial grant of $42,500 was made by the National Science Foundation on April 5, 1966, and a bill of sale was written on April 7 (an extension of the original March 1, 1966 option deadline having been granted). Several individuals and organizations made important contributions toward the down payment, including the Xerox Fund; American Metals Climax; the Litton Industries Foundation; the Consolidated Coal Company; The Mineralogical Society of the District of Columbia; The Gem and Lapidary Society of the District of Columbia; the Gem, Mineral, and Lapidary Society of Montgomery County, Maryland; the Franklin Ogdensburg Mineral Society; and others. The Bosch family contributed over $71,000 before the purchase was completed on November 24, 1970.

Was it worth the struggle? Rather! To paraphrase an article by Paul Desautels in the Smithsonian *Contributions to the Earth Sciences, 1972,* p. 87-89: "For several reasons, it was considered imperative to acquire and place the Bosch collection in the Smithsonian for conversion to maximum use as part of the National Collection of Minerals and Meteorites. First, the collection was of major size... Collections of such size rarely become available for wholesale reinforcement of constantly changing needs of the National Collection. In numbers, though not in quality or species representation, it was the largest single collection of minerals ever acquired by the National Museum of Natural History. Also, the collection contained extensive suites of rare reference specimens now unobtainable through normal channels. Even specimens duplicating those already in the museum were considered usable by supplying material to meet ever-increasing research and exchange demands. Several hundred pieces were of public display quality. The strong representation of old central European mineral occurrences was especially significant, because this would strengthen the weakest part of our museum collection. The presence of the included Seligmann collection, with its many figured specimens, greatly increased the significant pieces. The meteorite material had unusually high and current scientific importance and needed to be carefully conserved. Finally, the





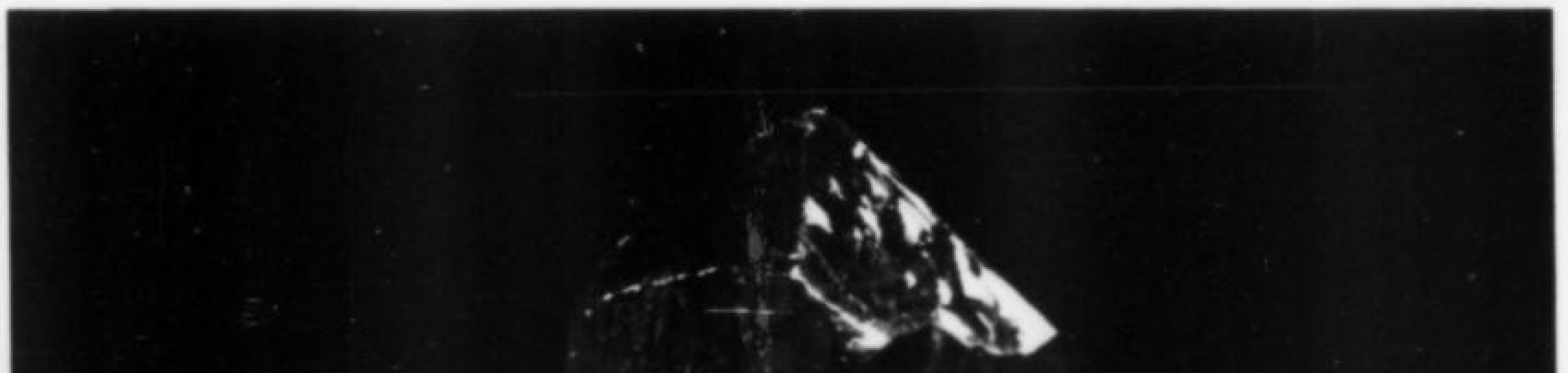


Figure 2. SIDERITE *(above left)* with quartz from Allevard, Isere, France. The group is 8 cm tall. Smithsonian specimen #B9888; photo by WEW.

Figure 3. MIMETITE *(top right)* from Johanngeorgenstadt, East Germany. The specimen is 3.5 cm wide. Smithsonian specimen #B5842; photo by WEW.

Figure 4. ANAPAITE *(above)* from Halbinsel (Anapa), Taman Peninsula, Russia. The crystal is 1.1 cm across. Smithsonian specimen #B8530; photo by WEW.

Figure 5. PROUSTITE from Chanarcillo, Chile. The group is 3 cm tall. Smithsonian specimen #B5847; photo by WEW.

Figure 6. **PYROMORPHITE from the Friedrichssegen mine, Bad Ems, Germany. The group measures 12 cm across. Smithsonian specimen #B10619; photo by WEW.**

Figure 7. **PYROMORPHITE from the Friedrichssegen mine, Bad Ems, Germany. The largest crystal measures 1.7 by 3.0 cm. Smithsonian specimen #B10618; photo by WEW.**

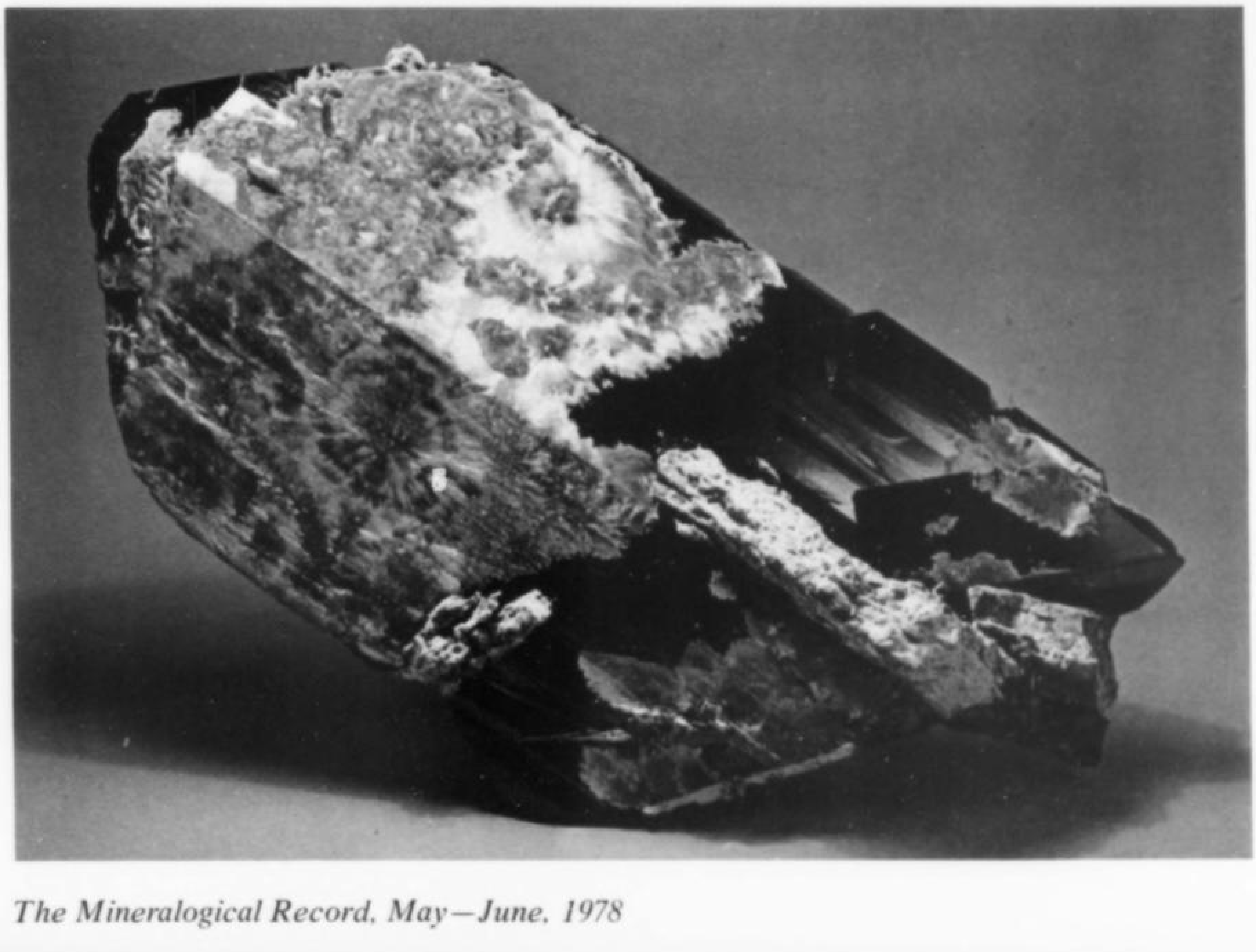


Figure 8. **AZURITE altering to malachite from Tsumeb, Southwest Africa. The crystal is 16 cm (about 6 inches) long. Smithsonian specimen #B10629; photo by WEW.**

excellent state of preservation and organization of the collection made it possible to convert it to maximum use in minimum time."

Dr. Bosch was born in Germany in 1874 and died in 1940. He was a physical chemist of considerable renown, having won the Nobel Prize in Chemistry in 1931 together with Friedrich Bergius, "...for their services regarding the invention and development of chemical high pressure methods." He became interested in minerals at an early age and, as he grew more affluent, his collection grew rapidly. It eventually was housed in 38 handsome oak cases, about 1.25 by 1.4 by 0.6 meters, most having 20 drawers (but some with 16 larger ones) concealed behind two oak doors. Thirty-six of the cases were surmounted by a glass-enclosed cabinet with four risers for displaying larger and more spectacular specimens. In addition to the mineral and meteorite collections, Bosch had an insect collection of some four to five *million* specimens (eventually acquired by the Smithsonian), a minor fossil collection, and a large scientific library. Fortunately these collections, in Heidelberg, survived World War II. In 1947 Dr. Carl Bosch Jr. decided to bring them to this country. With the help of the U.S. Army, the collections were transported in two Liberty ships, and were stored in Brooklyn.

The gem collection did not survive intact the voyage from Heidelberg. It was being transported from Heidelberg by rail in two suitcases. During the trip one on the suitcases—the one with the best stones—disappeared, and has not been heard of since. The gems in the other case did arrive in the United States; some were kept by the Bosch family, and the rest were donated to the Smithsonian.

The scientific library fared even less well. It survived the voyage and was safely stored in a warehouse in Brooklyn. Somehow, someone neglected to pay the storage fee, and the books were sold *en masse* to a second-hand book dealer, and dispersed. Neal Yedlin, of New Haven, once found two of them, with the Bosch insignia in each, for sale; he bought and donated them to the Smithsonian.

The younger Bosch decided to place the mineral collection at Yale University, on loan, for 15 years, pending a decision on its eventual disposition. It went to Yale on April 10, 1951. There many of the specimens were marked with a number (black ink on a yellow background), perhaps in expectation that the loan would be made permanent. Bosch, however, decided to sell the collection; the decision was made well before the 15-year loan period was up. After the April 1966 purchase, the Smithsonian insured the collection for $250,000 and took responsibility for its move to Washington. On April 19, 1968, Paul Desautels, John White, Harold Banks and Peter Leavens triumphantly brought the collection from New Haven to the nation's capital in two moving vans.

TABLE 1. A survey of phenakite specimens in the Carl Bosch collection.

Phenakite localities listed in *Dana's System of Mineralogy*, Sixth Edition	**Number of specimens in the Bosch collection**	**Number of specimens previously in the NMNH (Smithsonian) collection**
Takovaya, USSR	8	11 Total USSR
Ilmen Mtns., USSR	7	
Framont, France	10	0
Reckingen, Switzerland	5	0
Rhone Glacier, Switzerland	11	0
Cerro del Mercado, Mexico	0	0
near Florissant, Colorado	9	33 Total Colorado
Crystal Park, Colorado	2	
Pikes Peak, Colorado	1	
Mt. Antero, Colorado	12	
Amelia Court House, Virginia	0	8
Bald Face Mountain, New Hampshire	3	0
North Chatam, New Hampshire	1	0
Other localities		
San Miguel di Piracicaba, Brazil	11	5 Total Brazil
Idaphera, Minas Gerais, Brazil	1	
Brazil (unspecified)	1	
Ober Neusattel, Bohemia, Czechoslovakia	2	0
Bamle, Norway	1	7 Total Norway
Kragero, Norway	8	
Strzegom, Wroclaw, Poland	1	0
Tschirnitz, Silesia, Poland	11	0
Klein Spitzkopje, Southwest Africa	2	4
TOTAL	107	68

Only a few of the Bosch minerals are on public display at the Smithsonian; many more will be when the present Mineral Hall is redesigned (don't hold your breath!). About 30 were displayed at the Tucson Gem and Mineral Show in February, 1977. Thousands are in the museum's study collection, and many have been exchanged.

A catalog of the Bosch collection was prepared in the late 1930s, at Bosch's request, under the direction of Professor Kalbeck of the Academy of Mining at Clausthal, Germany. Apparently some of the catalogers were not mineralogists; gross inaccuracies and errors in spelling abound, which anyone knowledgable about minerals simply would not have made.

While it is not possible to mention all the outstanding specimens in the collection, some of the best should be noted: Kongsberg silver; gold; Swiss anatase, magnetite and hematite; English

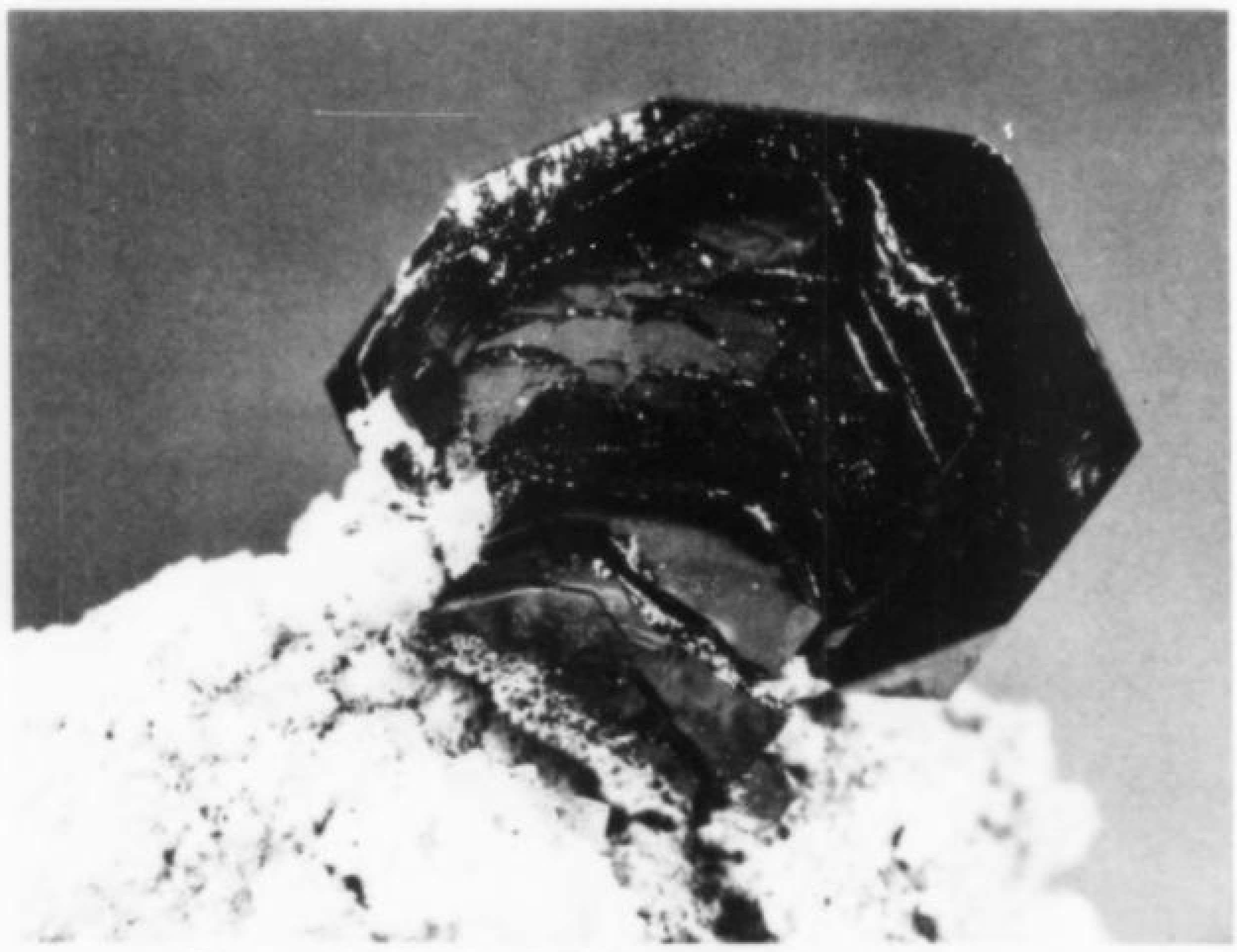


***Figure 9.* HEMATITE from Urnerloch, near Andermatt, Switzerland. The crystal is 1.7 cm across. Smithsonian specimen #B9087; photo by WEW.**

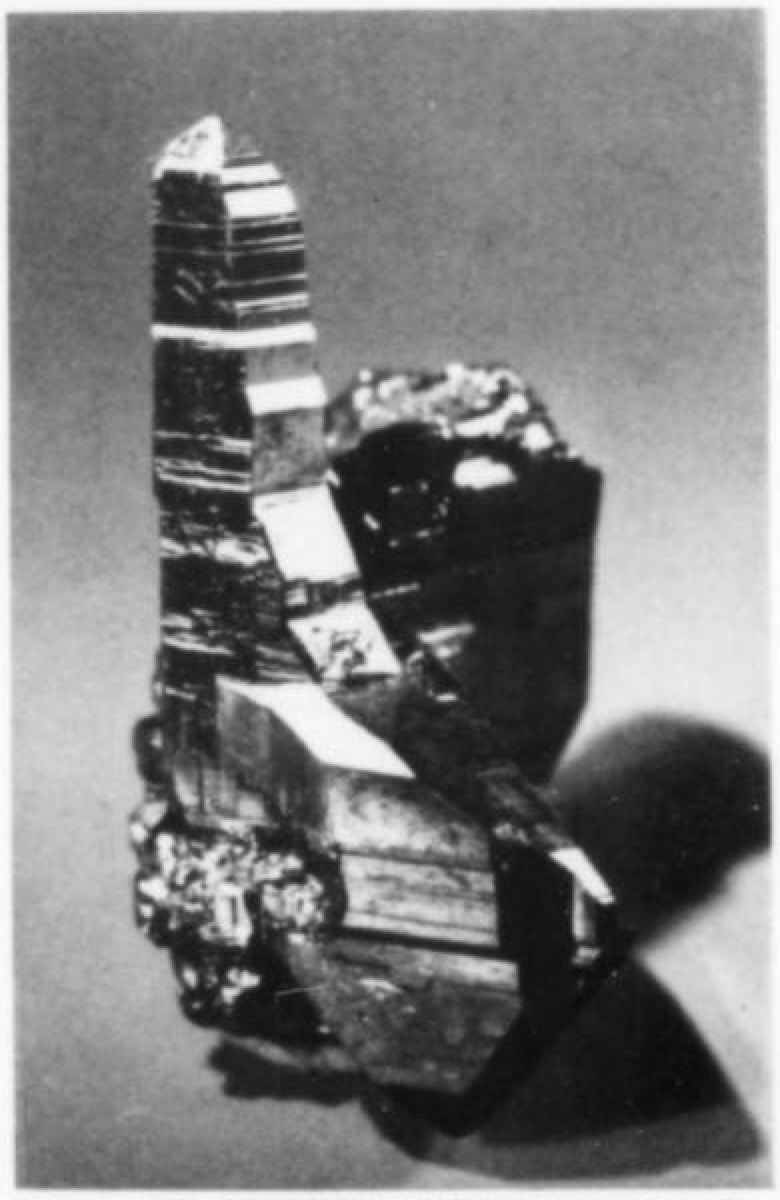


Figure 10. **STEPHANITE from the Gesegnete mine, Bergmann's Hoffnung, Freiberg, Saxony. The crystal is 2.5 cm tall. Bosch paid 100 German marks (DM) for this specimen on 22 October 1887; that would be about $275 today. Smithsonian specimen #B3692; photo by WEW.**

Figure 11. **ATACAMITE from the Burra district, Australia. The longest crystals measure about 3 cm. Smithsonian specimen #B5820; photo by WEW.**

Figure 13. **TETRAHEDRITE with siderite from Allevard, Isere, France. The crystal measures 2.3 cm. Bosch paid 400 DM for the specimen on 1 February 1905; that would be about $950 today. Smithsonian specimen #B5872.**

Figure 12. **ACANTHITE (after argentite) with stephanite and polybasite from Freiberg, Saxony. The crystal measures 1.4 by 1.6 cm. Bosch paid 90 DM for this specimen on 26 August 1881; that would be about $250 today. Smithsonian specimen #B5858; photo by WEW.**

Figure 14. **SILVER from Kongsberg, Norway. The specimen measures 14.5 cm across. Smithsonian specimen #B212; photo by WEW.**

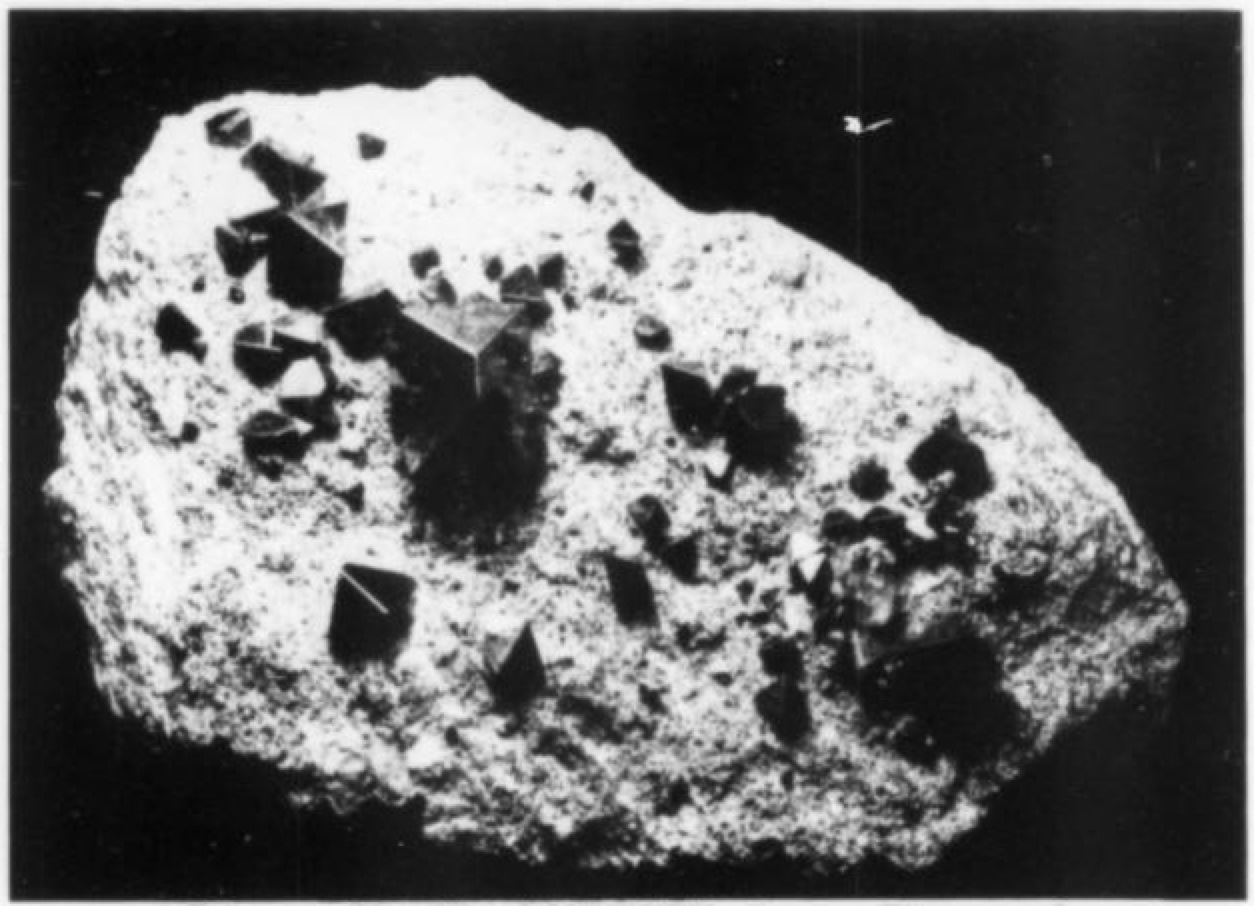


Figure 15. **MAGNETITE from Binnental, Switzerland. The largest crystal measures about 2.3 cm diagonally. Smithsonian specimen #B10614; photo by WEW.**

barite; Binnental minerals; Elba elbaite; Russian uvarovite; German proustite and pyromorphite; and pyrargyrite. The collection had remarkable depth in certain species. For example, there were 218 magnetites, 77 from Switzerland; 273 specimens of anatase, 149 from Binnental alone; 217 rutiles, 85 of which were from Switzerland and 22 from Graves Mountain, Georgia; and over 65 pachnolites from Ivigtut, Greenland.

Another great strength of the Bosch collection is its locality representation—particularly of older localities. Bosch was seldom satisfied with one specimen from each locality; he usually had at least several. To illustrate this, Table 1 shows the number of phenakites from various localities in the Bosch collection, contrasted with phenakites previously in the NMNH (Smithsonian) collection from these same localities.

Carl Bosch's knowledge of minerals was extensive, and his perception keen. One fine specimen in his collection, an isometric crystal on quartz, was labeled as an unknown. It is now in the Smithsonian collection labeled cafarsite, a mineral which was not characterized until 1966. In a sense, then, Bosch "discovered" the mineral many years before it officially entered the mineral family.

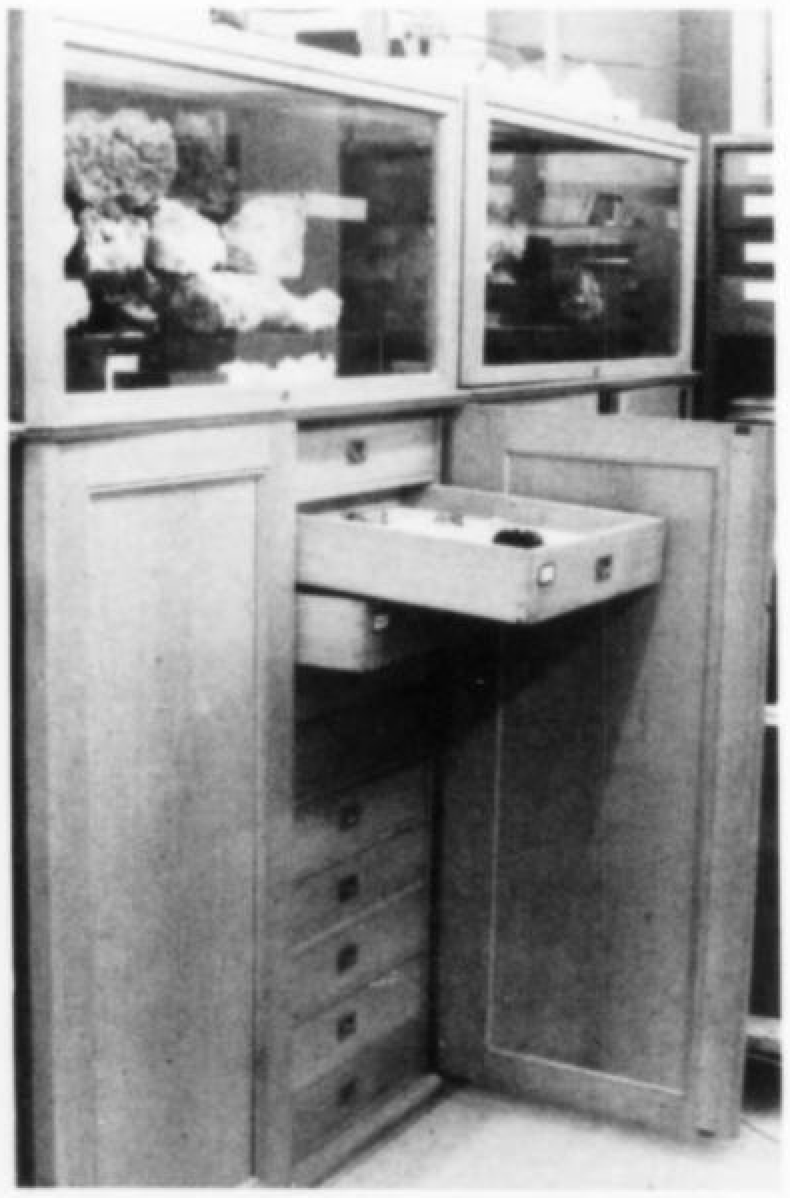
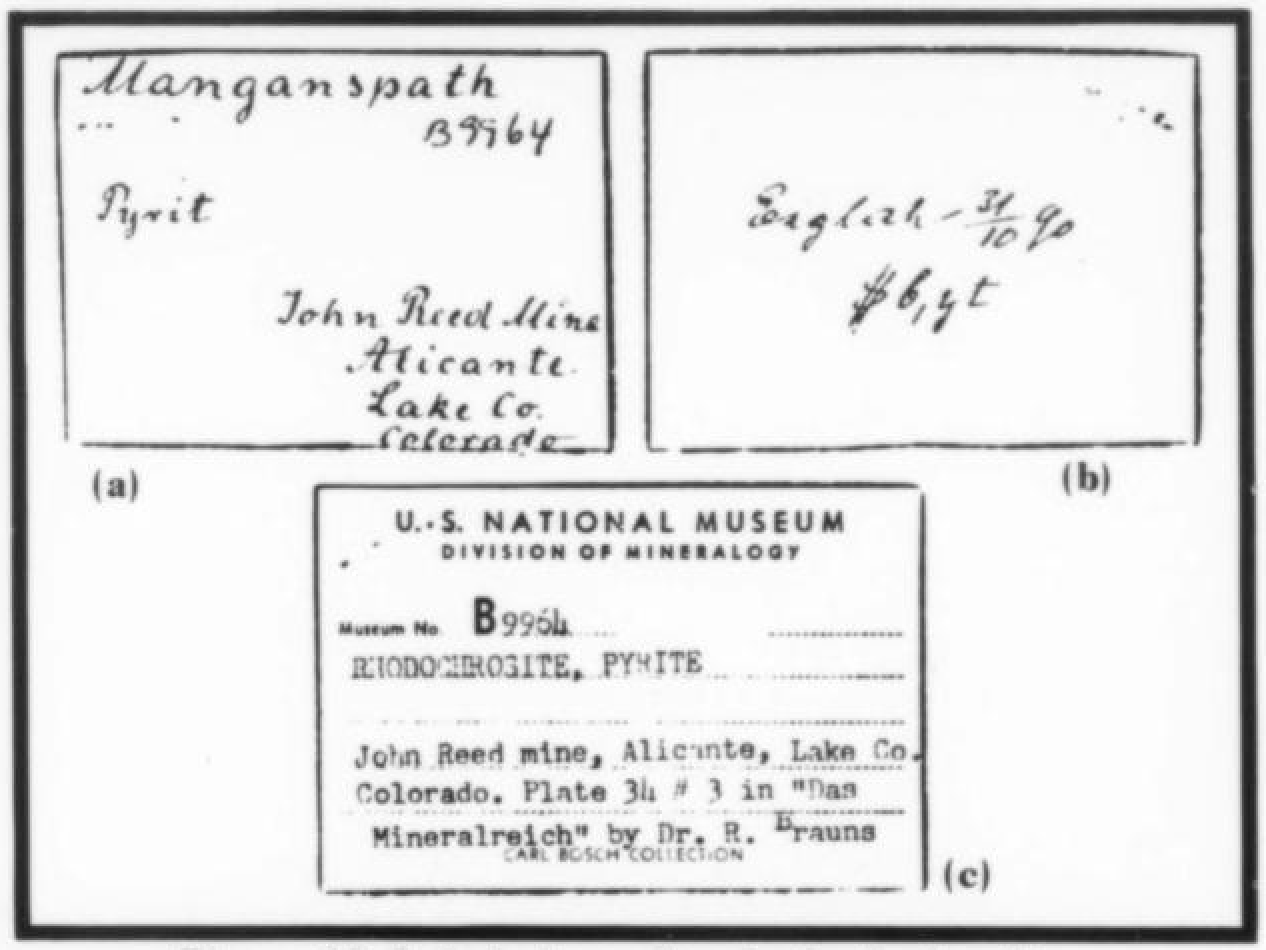


Figure 16. **One of the Bosch mineral cabinets.**



Manganspath
B9964
Pyrit
John Reed Mine
Alicante
Lake Co.
Colorado

(a)

English – 31/10 90
$6,yt

(b)

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RHODOCHROSITE, PYRITE
John Reed mine, Alicante, Lake Co.
Colorado. Plate 34 # 3 in "Das
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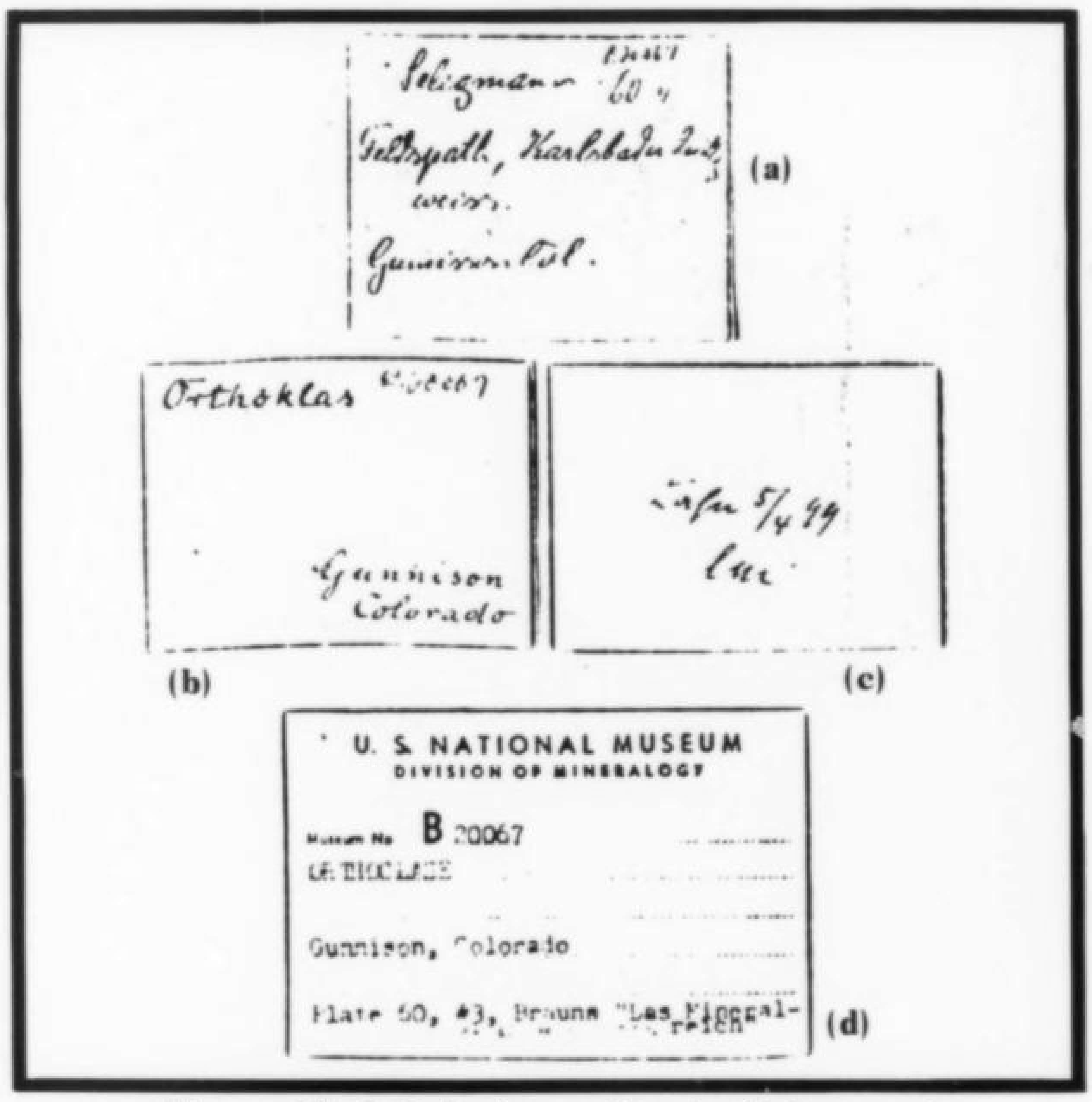
CARL BOSCH COLLECTION

(c)

Figure 17. **Labels for a Bosch rhodochrosite. (a) Bosch label: obverse. (b) Bosch label: reverse. (c) Smithsonian label.**



Seligmann 60 4
Feldspath, Karlsbader Zw.
weiss.
Gunnison Col.

(a)

Orthoklas B20067
Gunnison
Colorado

(b)

[illegible] 5/4 99
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(c)

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ORTHOCLASE
Gunnison, Colorado
Plate 60, #3, Brauns "Das Mineral-reich"

(d)

Figure 18. **Labels for a Bosch (Seligmann) orthoclase. (a) Seligmann label. (b) Bosch label: obverse. (c) Bosch label: reverse. (d) Smithsonian label.**

As might be expected the collection contains a number of falsified or "manufactured" specimens, especially from many of the Alpine localities in Austria, Italy and Switzerland. Chief among these are specimens of hematite, rutile, magnetite, anatase, apatite, titanite and epidote. Experienced collectors have come to know that one must look very closely at these minerals from the Alps because assembled specimens abound. One of the most obvious things to look for is the presence of fine-grained material completely encircling the bases of the crystals that seem to be attached to matrix. Very close scrutiny is sometimes required as the fabrication is often skillfully done. In the case of epidote from Untersulzbachtal, one should look for a dense mat of *byssolite* hairs at the points of attachment of the epidote crystals.

The author would be remiss if he did not say a word about the labels accompanying the Bosch specimens. He had the privilege and pleasure of cataloging almost half of the collection; this task was completed in 1973 (almost! As this article was being put in final shape, the author was informed that one complete case of the collection had somehow escaped the cataloger's weary eye, and is even now awaiting further attention!). The labels were diverse in character. Some were handsomely printed, and some were the original labels bearing the name of the dealer from whom the specimen was purchased. Many, alas, were on bits of paper, and in a variety of hands—mostly bad; these were in German script, with many abbreviations, apparently written in great haste, with little regard for their later being deciphered. Many of the labels do contain interesting information, on the back as well as on the front. The backs of most show the date of acquisition (from which it is apparent that the major growth of the collection was in the years before 1910), the name of the supplier, and a code which is probably the price paid for the specimen.

The existence of the code on the reverse side of the Bosch labels was brought to the attention of associate editor Richard Thomssen by John S. White of the Smithsonian, who suspected the code to consist of the letters of a 10-letter word, each letter representing a corresponding number from one to nine and also zero. *Tourmaline,* a 10-letter word without repeated letters, was used by the late mineral dealer Martin Ehrmann as a pricing code word. The problem was somewhat complicated by the fact that Bosch's code word would probably be in German, quite probably a German mineral name (naturally!). The unit of currency referred to by the code letters was probably the mark rather than the pfennig. Double-letter values (the most abundant) would therefore indicate values from 10 to 99 marks.

To test the hypothesis, Thomssen examined 92 specimens of anatase from Switzerland, listing their code and size, and assigning a quality rating (1 excellent, 2 good, and 3 average). Some 29 of the code combinations of one, two, and three letters proved to end in "t" (most likely meaning "zero"). Because German mineral names end in "t" rather than "e," it appeared that the use of a mineral name as the code word might actually be the case. Of the 92 specimens, 11 of the highest quality pieces were coded with a three-letter combination. Four of these started with "a" and four with "m." It seemed likely that one or the other of these two letters represented the number one. The remaining letters found were: l, g, i, n, y, b, o. After a little reflection using "a" as the first letter and "t" as the last, White came up with the name *amblygonit* (ten letters, none repeated). Subsequent tests have not contradicted the hypothesis that *amblygonit* is the code word.

More should be said about the Seligmann collection, briefly mentioned earlier. Gustav Seligmann, of Coblenz, Germany (after whom seligmannite is named), had an extensive private collection which Bosch acquired and incorporated into his own collection. Many Seligmann specimens are illustrated in a two-volume book, *Das Mineralreich,* by Reinhard Brauns, published in Stuttgart in 1903. The second volume contains 87 plates, each containing from one to a dozen tinted lithographs of mineral specimens in Europe's finest collections of the time. There are 132 of Seligmann's minerals illustrated. Of these the Smithsonian acquired 104 as part of the Bosch collection.

Because many of the specimens were obtained before World War I, and because that war and the following one changed the map of Europe drastically, tracing the *fundort* (locality) was in many instances a formidable chore.

American mineralogy is considerably indebted to Carl Bosch, Jr., for his decision to sell his father's fabulous collection to the Smithsonian, and for his generosity in reducing the cost to the Institution by contributing handsomely to the purchase price.

ACKNOWLEDGMENTS

The author acknowledges with thanks the following people: John S. White for supplying ideas and the data for Table 1; Wendell E. Wilson for supplying the photography; Richard W. Thomssen for notes on how the code was broken; and PaulE. Desautels for helpful comments on the manuscript.

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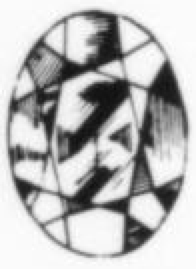

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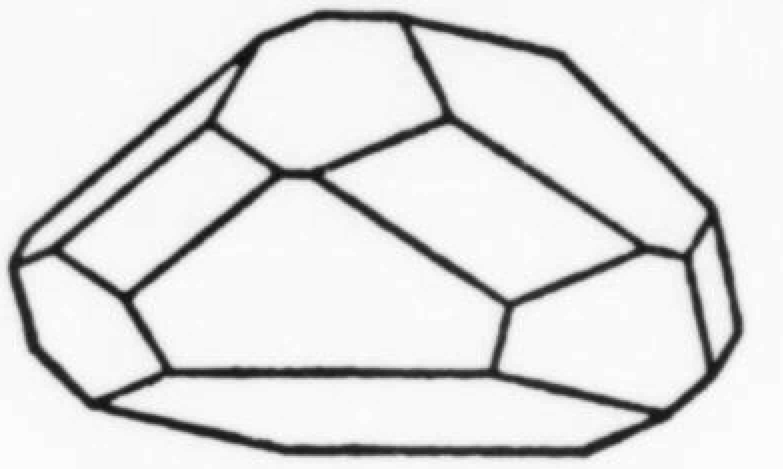

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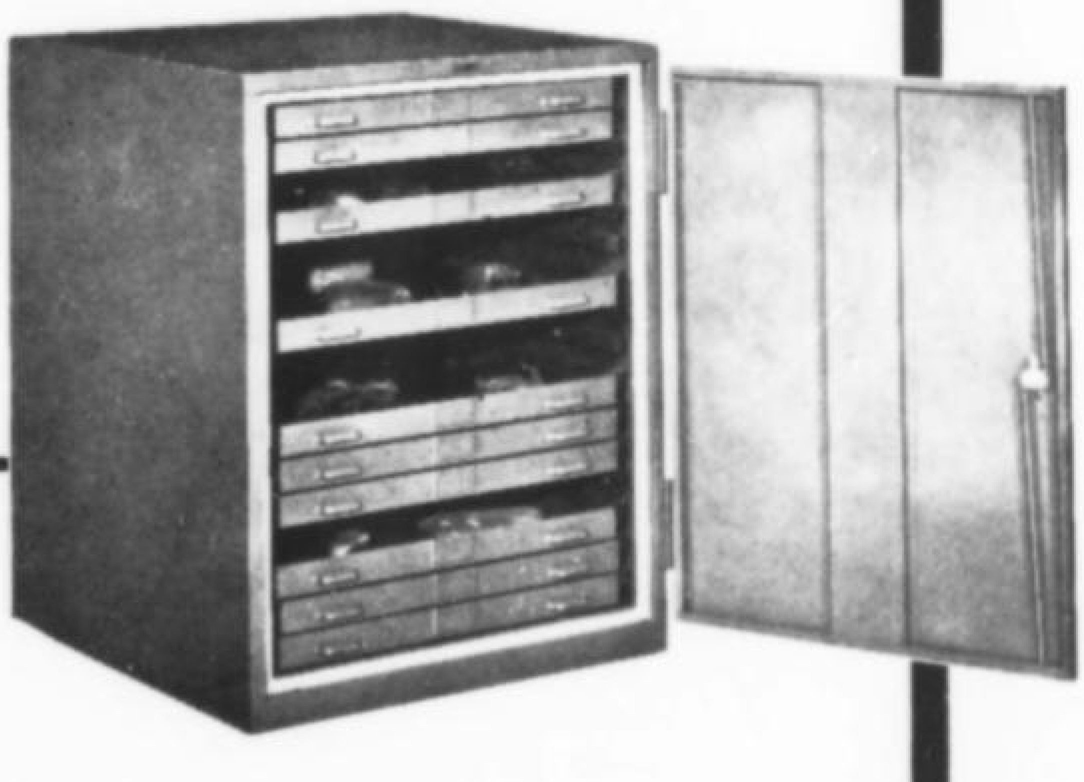

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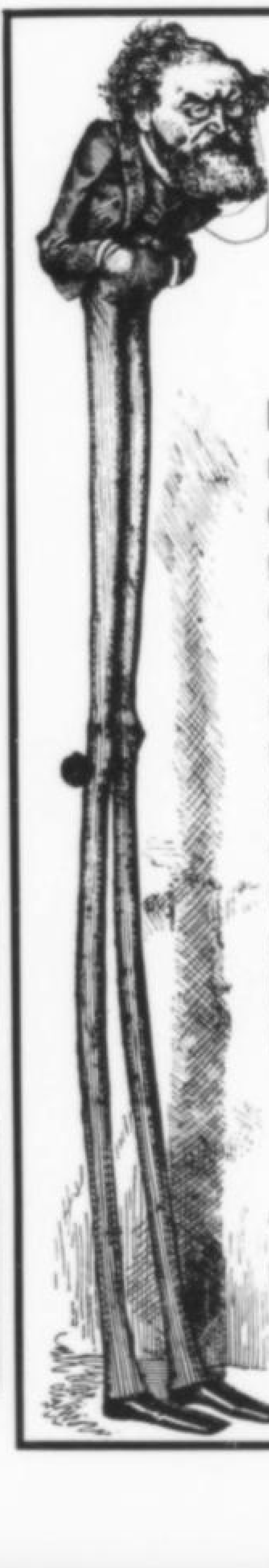

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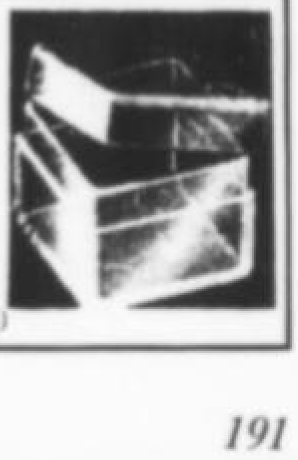

What's New in Minerals?

TUCSON SHOW 1978

Despite unseasonably cool temperatures and an absurd (for Arizona) amount of rain, this year's Tucson Show once again proved worth waiting for. Visitors to the show were greeted by what must surely have been the finest collection of displays ever assembled under one roof.

Three specimens were of sufficient magnificence to have each a case all to themselves. There was the Newmont azurite, generally considered to be the world's finest azurite (from Tsumeb; see the Tsumeb issue, p.48). According to the label it was found in 1952 and used by a miner to pay off a $230 debt at a local hotel. The largest crystal is about 13 cm (5 inches) and all crystals are well formed and lustrous (Fig. 1). Newmont Mining, part owner of Tsumeb, plans to donate the azurite to the American Museum of Natural History, New York. Then there was the enormous "Aztec Sun" legrandite exhibited by Jack Amsbury of El Paso. The group weighs 1½ kg (3.2 lbs.) and measures 18 cm (7 inches!) in longest dimension, virtually all of which is legrandite. The locality, of course, is the Ojuela mine, Durango, Mexico, and the original collector is Felix Esquivel. Pictured here (Fig. 6) is the back side of the specimen, photographed through the case window as it rotated on a motorized stand. An article by Bob Jones in the March issue of *Rock & Gem* (p. 48) includes a photo of the even more beautiful front side. A third specimen deserving its own case (although some books and mining memorabilia were displayed with it) was the new gold from the Colorado Quartz mine in Mariposa County, California. This magnificent group (Fig. 7) stands about 18 cm tall and may well be the most aesthetic matrix gold specimen in the world. It was put on display by Wayne and Dona Leicht of Kristalle, who have a contract with the mine for the sale of specimens.

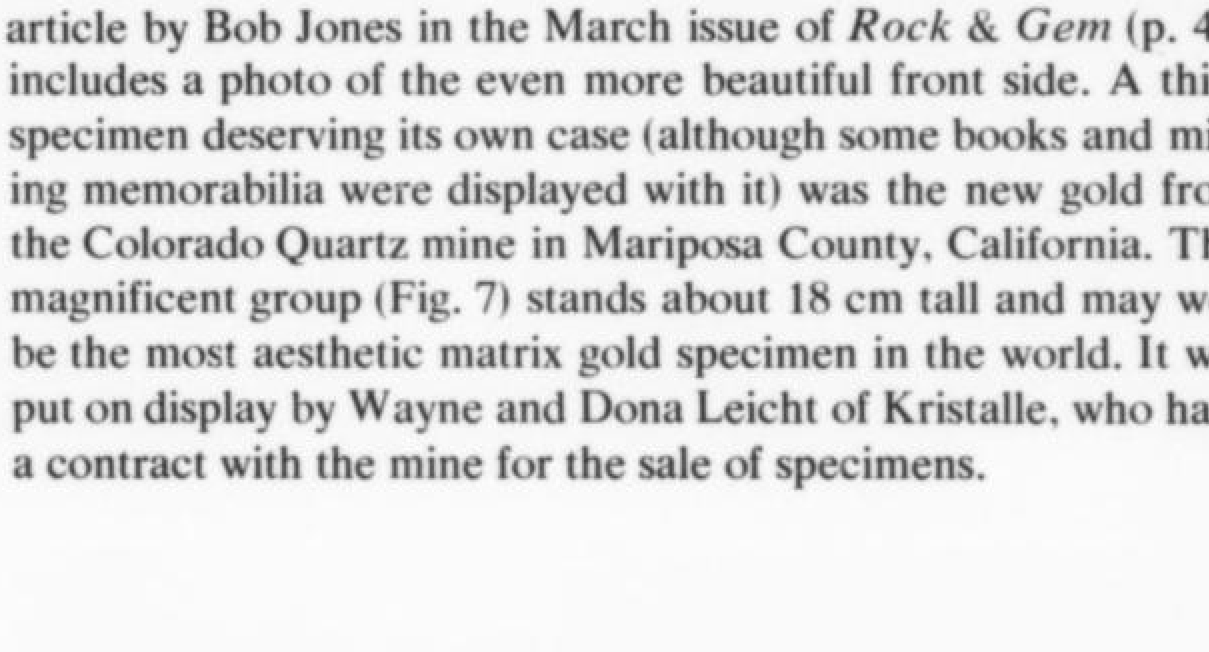

***Figure 1.* The Newmont azurite, from Tsumeb, generally acknowledged to be the finest azurite in the world. The largest crystal measures about 13 cm (5 inches). Newmont Mining, part owner of the Tsumeb mine, plans to donate this specimen to the American Museum of Natural History.**

A number of other cases contained only one or just a few large specimens. Robert Gill's case contained one specimen of neptunite on matrix. . .but the matrix was close to a meter across and covered on one side by excellent crystals. A case of vanadinite from a newly discovered Arizona locality (the Gray Horse mine) contained four matrix specimens to about 40 cm, covered on one side by crystals up to a centimeter in size. The discoverers, Gary Fleck and Andy Clark of Superior, Arizona, are writing an article on the locality for a future issue of the *Record.*

Remarkable was the number of fine silver specimens from Köngsberg, Norway, on display in various cases. I didn't count them all but there were at least nine and possibly as many as a dozen, in various sizes, as wires or fine crystals. Fine Köngsberg silver is not commonly found in collections, and seeing this many such pieces at one show, possibly the largest number ever assembled outside of Norway, gives an indication of the quality of the displays.

***Figure 2.* Yellow-white crystal of barite from Silius, near Cagliari, Sardinia. Herb Obodda specimen.**

Private collections on exhibit were greater in number and quality than at any past Tucson Show that I can remember. I won't endeavor to mention them all, but the collections of Ed Bancroft, Rex Bannister, Steven Smale, Keith Proctor, John Barlow, Bill Larson, George Holloway, Pat Carlon, Raymond Thompson, Les Presmyk, Helen Hoyet, Gerhard Becker and Hermann Bank come to mind.

Institutional displays were equally overwhelming. The Smithsonian's case of minerals from Brazil could probably not be equalled by any other museum in the world. The Arizona-Sonora Desert Museum displayed a case of minerals from the Sonoran Desert which contained a 20 cm (8 inch) gold specimen from the Dos Cabezas Mountains, Arizona, and a variety of fine Bisbee copper minerals, to mention only a few. A case was put in by the National Museum of Canada, as well as a superb case of specimens from the Philadelphia Academy of Natural Sciences (the recipient of many old Sam Gordon discoveries). Displays by the Sorbonne (University of Paris) and the Los Angeles County Museum of Natural History, as well as several others, were also impressive.

Dealers at the show carried a wide variety of particularly excellent material this year. Among the new items Herb Obodda had more than a hundred specimens of yellowish-white barite from Silius, near Cagliari, Sardinia (Fig. 2, 3). The crystals were lustrous, well formed, commonly on matrix and sometimes containing phantoms. The specimens were mostly small cabinet size and carried crystals to 8 cm. Herb also had some enormous pink and green tourmaline crystals from Nuristan, Afghanistan (Fig. 4).

Hamel Mining had a large number of excellent kämmererite specimens from Turkey. The *Record* has received an excellent article on the locality by Roland Dietrich and Olaf Medenbach which will appear in issue #4 or #5 of this year.

Rustam Kothavala (Crystals of India) was offering specimens of ruby crystals in matrix from a new locality in the Mysore district, India. The crystals, not gemmy but a good red, occur as fine, sharp euhedra in a white gneiss matrix. Careful work on the matrix yielded many specimens with 1 to 2-cm crystals, rarely 2½ cm, perched on the attractive white matrix. The finest of the specimens were selling for no more than $100: the best buy of the show.

Gene Schlepp of Western Minerals completed a major exchange with Harvard University just before the show. Among the Harvard pieces he had to offer were a superb Red Cloud matrix wulfenite once sold by A. E. Foote around the turn of the century, a brilliant Bisbee azurite with a 5-cm crystal, a fine old silver group 7 cm tall from Santa Eulalia, Chihuahua, Mexico, an excellent Chilean proustite (purchased by John Barlow), and a 4-kg (8½ lb.) Köngsberg silver!

Activity in the motels was brisk as usual. Most of the mineral dealers were concentrated in the Desert Inn and the Sands Travelodge, but others were to be found at the Holiday Inns (both North and South), Sheraton Pueblo and Marriott. "Wholesale" lapidary shows were in operation at the Holiday Inns and the Marriott.

***Figure 3*. A flat of fine barite from Silius, near Cagliari, Sardinia. Herb Obodda specimens.**

The floor plan and room numbering system at the Marriott are so unusual (confusing) that it is sometimes necessary to telephone the dealer you wish to see from the lobby, and let him give you directions for how to find his room. The intrepid explorer at the Marriott was well rewarded if he chanced upon the room of Miriam and Julius Zweibel (Mineral Kingdom of Woodmere). Julie had been first on the scene in South Africa when a major strike of rhodochrosite was recently made at the N'Chwaning mine; he had several flats of absolutely magnificent rhodochrosite, as well as a good but dwindling supply of Tsumeb material. The new rhodochrosite was of a particularly deep color and formed crystals both large and gemmy. One of these is shown in Figure 10 on page 138 of this issue.

At the Holiday Inn (South) nearly everything was lapidary except for John Holfert and Mike Sprunger, two Utah dealers who had recently removed an exceptional number of very fine specimens of topaz from the Thomas Mountains topaz locality in Utah. Their topaz, all from a single seam, was the finest lot of such material I had ever seen. In addition they had collected a pocket of bixbyite groups unlike anything previously found at the locality. These brought very high prices. Holfert has written an interesting 52-page pamphlet on the area entitled *A field guide to topaz and associated minerals of Topaz Mountain, Utah.* If you would like a copy send $3 to John Holfert, 109 West 2700 South, Bountiful, Utah 84010. Detailed maps to several of the collecting areas are included.

***Figure 4*. A large pink, green and white tourmaline crystal from Nuristan, Afghanistan. Herb Obodda specimen.**

For this issue I had expected to have an article about the new discovery of hureaulite at a mine in Minas Gerais but the article has been delayed due to additional discoveries of other minerals at the same locality. Carlos Barbosa, at the Desert Inn, had a large selection of excellent specimens. The crystals are an attractive, translucent to transparent pink and form druses and masses of crystals associated with a variety of other minerals. The hureaulite crystals exceed 1 cm on some specimens, making these among the finest known examples of the species. Rather than go into additional detail I will ask readers to wait for the article, possibly in the next issue.

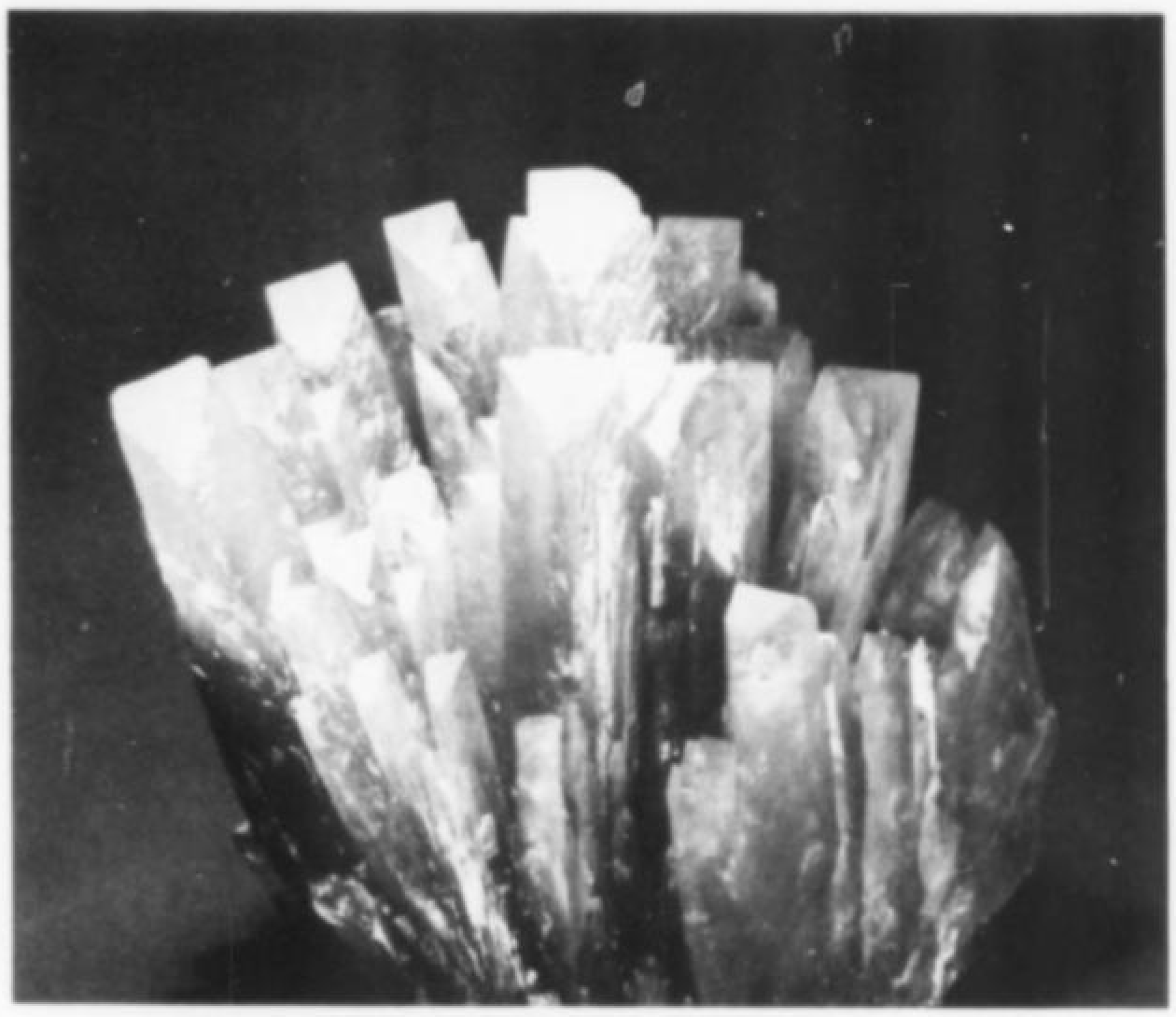

***Figure 5*. A group of brownish yellow barite crystals from le Main mine, Autun, France; the spray measures 7.5 by 8 cm, and was collected by Pierre Bariand. From A. L. McGuiness, currently in the collection of Jonathan Weiss.**

An interesting group of barite specimens were for sale in A.L. McGuinness' room. The crystals, from le Main mine, Autun, France, were of a pleasing brownish yellow color and reached 10 cm (4 inches) in length (Fig. 5). About half of the 35 specimens in the lot were cabinet size and the rest were large miniatures. Their pedigree was of note: personally collected by Pierre Bariand, curator of minerals at the Sorbonne (University of Paris).

Because this column is supposed to be devoted primarily to what is *new* on the mineral market, I will not dwell on the dozens of other dealers who carried an enormous array of fine minerals from localities seen before. In general, however, a rich selection of old classics was available through many dealers. Many of the most famous contemporary localities, such as Virgem da Lapa, Brazil, for instance, are still producing specimens. Other material, such as minerals from Tsumeb, Southwest Africa, and Panasqueira, Portugal, was present in smaller quantity than in previous years.

SATURDAY NIGHT

The only program during the year which is officially sponsored by the *Record* is held annually at the Tucson Show on Saturday night. Beginning at 8:00 pm, the program includes a lecture and slide show on a famous mineral locality, the slide competition, the Tucson Show awards ceremony, and the *Record* auction.

This year's lecture was by Robert Cook, on mineral collecting in Bolivia and Chile. Following that came the awards ceremony. John Barlow won the McDole trophy, thereby becoming the only person ever to win it twice. The winner must drink a shot of old black rum that once belonged to Ed McDole; there is some question as to whether anyone can survive more than two such drinks, so John may think twice before entering again! The Tucson Open was deservedly won by Keith Proctor; everyone I spoke with agreed that Keith's case was the most striking of all the displays. Second place in the Open went to John Barlow, who must still have been feeling his rum because he signed over his $500 check for second prize to the *Record*! Third place was won by Steve Smale.

After the awards came the slide competition. As previously announced, this year's competition was divided into two divisions: professional and amateur, with a $100 first prize and $25

***Figure 6.* Gold from the Colorado Quartz mine, Mariposa County, California. The specimen is 18 cm tall, of which 11 cm are visible here. Wayne and Dona Leicht specimen. Photo by Bob Jones.**

***Figure 7.* The "Aztec Sun" legrandite, 18 cm wide, from the Ojuela mine, Mapimi, Durango, Mexico. Jack Amsbury specimen.**

second prize in each category donated by Richard Webster. Over 90 entries were received; the twenty semi-finalist slides (ten in each division) comprised the finest selection in the history of the competition. First place among the professionals went to Dane Penland, a staff photographer at the Smithsonian complex (Fig. 8). Second went to Harold Van Pelt for his photo of a Washington amethyst scepter. Among the amateurs, the first place winner was Joe Taggart of the New Mexico Bureau of Mines (Fig. 9); second place went to Lyle Peters for his photo of a plumose South African rhodochrosite specimen. A close runner-up for second place was a photo of blue paravauxite by Paula Presmyk. The rules for next year will be identical and entries will again be invited. Entrants should remember than the final winners are chosen by audience vote, so the slides selected should be "crowd pleasers," more spectacular than subtle.

After the show was over I drove out to the Arizona-Sonora Desert Museum to see how work is progressing on their new Earth Sciences Center. The project is about half finished. Curator Bill Panczner took us on a tour of the "limestone" cavern (all man-made) which is now open to the public, then allowed a visit to the back rooms where the museum collection is accumulating. When the center is finished a re-created mine with mineral displays and crystal-lined pockets in the walls will be there to dazzle visitors and give them a genuine feeling for the underground. The Desert Museum is unquestionably among the most innovative in the world; even in its unfinished state it merits a visit by everyone.

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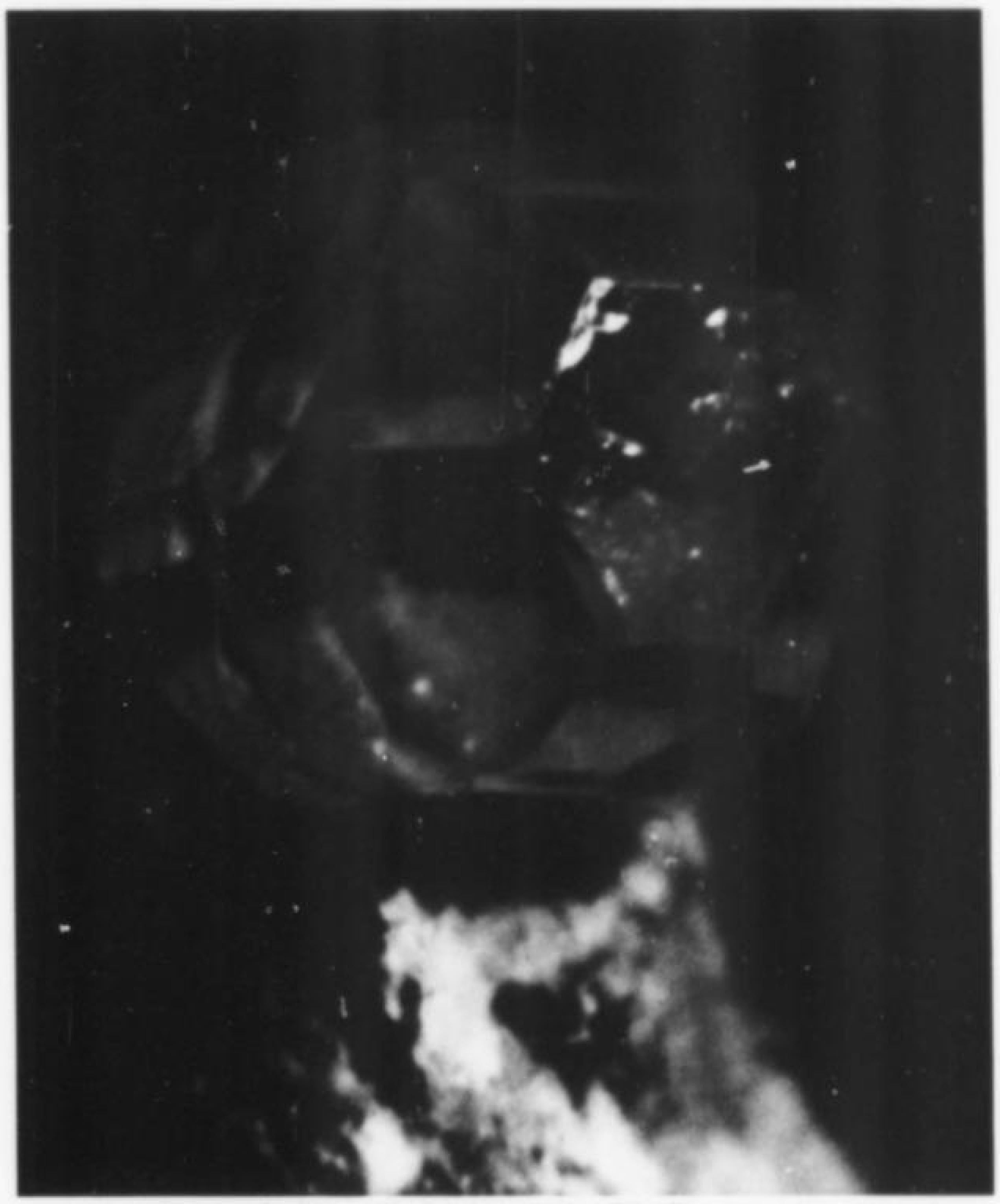
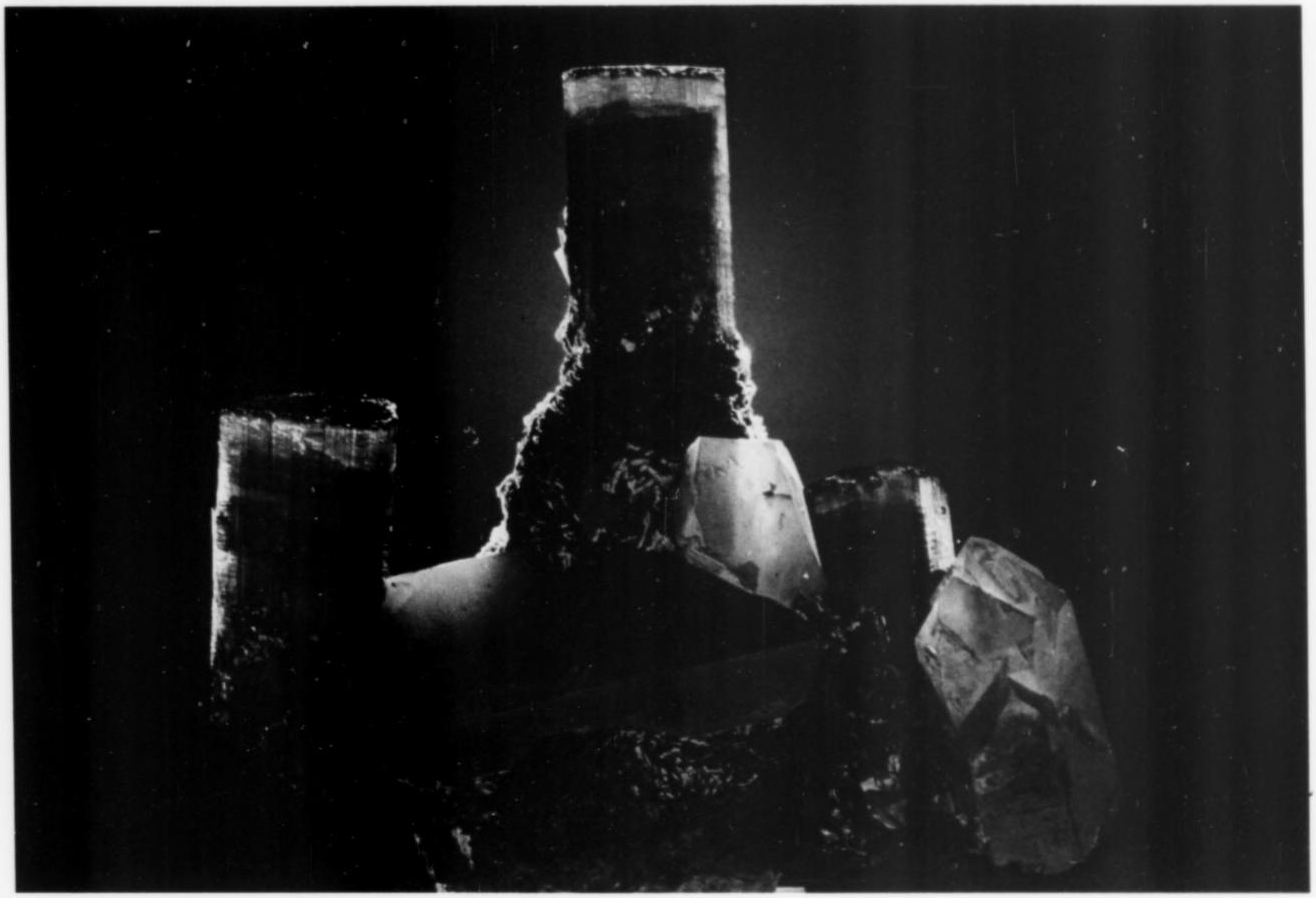


***Figure 9*. Vanadinite from the Old Yuma mine, Pima County, Arizona. The photo, by Joe Taggart, won first place in the amateur category of the slide competition.**

***Figure 8.* Elbaite tourmaline (23 cm tall) from the Tourmaline Queen mine, California, nick-named "the candelabra"; from the Smithsonian collection. The photo, by Dane Penland, won first place in the professional category of the *Mineralogical Record's* annual slide competition.**



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Institute of Geosciences, Cidade Universitaria
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To the mining geologist the Brumado or Serra das Éguas district is one of the largest magnesite deposits in the world. But for the mineralogist and mineral collector it is, above all else, a famous locality from which have come extraordinary specimens of twinned quartz, magnesite, beryl, topaz, metazeunerite, novacekite and more.

LOCATION

Brumado, the town after which the district was named, was formerly known as *Bom Jesus das Meiras*, a designation sometimes found on old mineral labels. It is the largest town in the area and lies in the southern part of Bahia to the west-southwest of Salvador and east-northeast of Brasilia. Brumado lies on the west bank of the Rio do Antônio, a north-flowing tributary of the Rio de Contas which empties into the Atlantic Ocean 150 km south of Salvador (see location map).

Access is easy from Vitória da Conquista, on the paved highway which joins Rio de Janeiro and Salvador (the Rio-Bahia Highway). At km 1074 the unpaved road to Bom Jesus da Lapa forks to the west and reaches Brumado in 145 km. The mine offices are located 10 km further south on the same road. Good private roads and tracks serve all of the mines and occurrences. Both Brumado and Vitória da Conquista have operating airports.

The Brumado area is part of an extensive peneplane sloping gently eastward. Recent erosion has cut the region into low hills with isolated mountains such as the Serra das Éguas projecting higher to the west of Brumado where the deposits are located.

The *serra* is 20 km long, 6 km wide, and rises about 600 m above the lowlands. From a distance its longitudinal profile

Figure 1. **The Pedra Preta open pit. The Jatobá talc deposit is in the pass at top left. In the lower right corner the wall is cut along the main talc vain (containing actinolite). The open pit is 160 m deep. Photo by JPC.**

Figure 2. **Location map.**

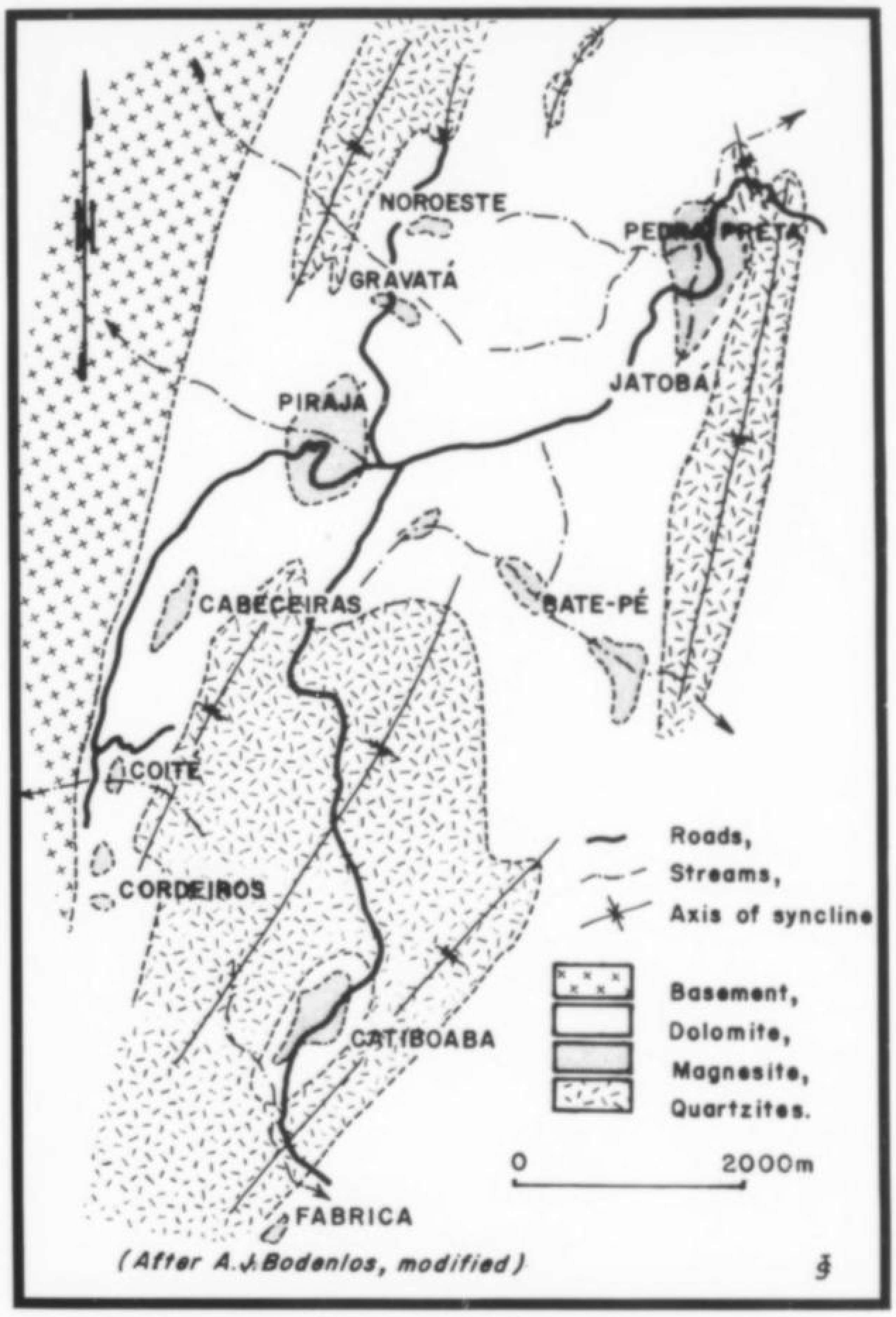


Figure 3. **Geologic map of the northern Serra das Éguas, modified after Bodenlos (1954).**

resembles a whaleback with a few rounded prominences projecting above the generally smooth crestline. The top of the range (near 1050 m) is flat and the flanks are comparatively steep.

The climate of the region is classified as tropical semi-arid with an annual temperature averaging 23°C and rainfall from 500 to 1000 mm. During the rainy season between October and March the sky is generally overcast and fog is common near the top of the range.

Vegetation is sparse in the lowlands, consisting of a dry shrubby forest with many cacti. Along the mountain streams it is more dense, consisting of trees as tall as 30 m. Grasslands occur on top of the serra.

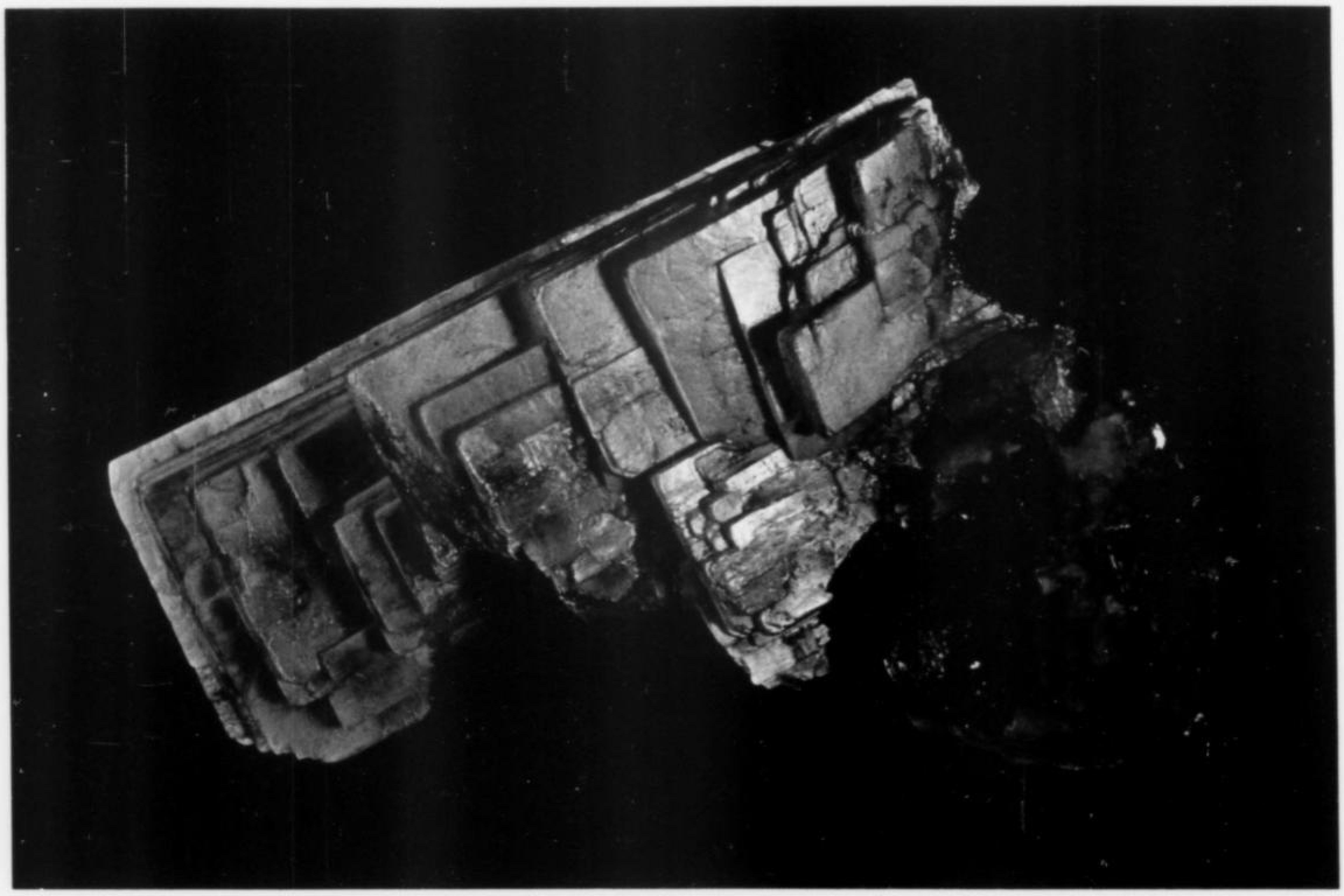
Water is scarce and only the mountain streams and Rio Antônio are perennial. The scattered population lives by farming.

HISTORY

Banded iron ore and pocket minerals were known in the Serra das Éguas as early as the latter half of the nineteenth century. Saxe Cobourg-Gotha (1885) mentions topaz, beryl, specular hematite, rutile, quartz and opal, but does not give the exact locations. A specimen of parisite collected at "Bom Jesus das Meiras" during this time is in the Natural History Museum of Paris.

During the early part of the Twentieth Century a local inhabitant mined and smelted a small amount of banded iron ore for a short time.

Probably around 1912-1913, emeralds were discovered on the west side of the Pirajá Valley. They were recovered from a



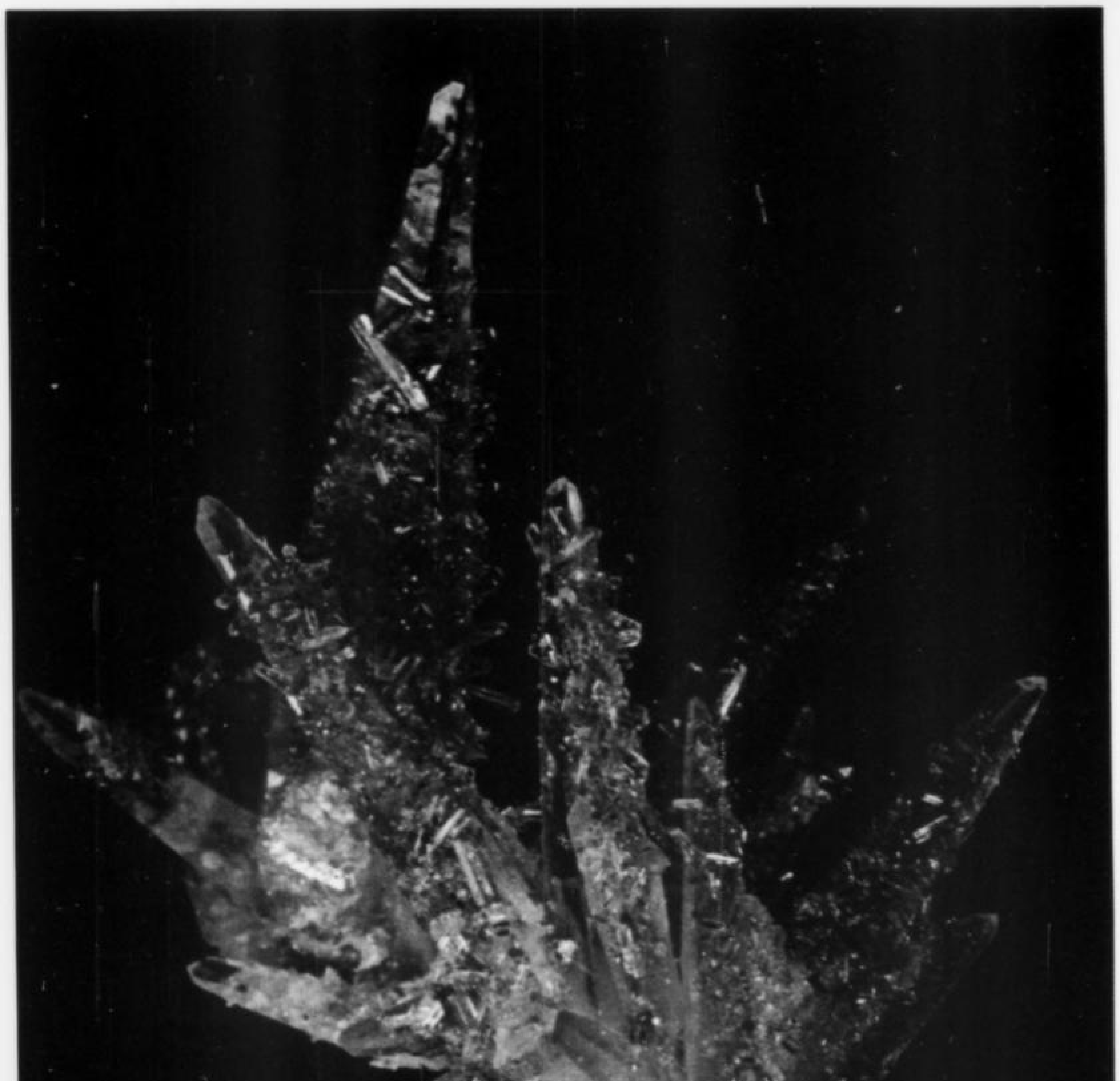


***Figure 4.* Novacekite *(above)*, 5 cm in size, from the Pedra Preta pit. Specimen from the collection of the Sorbonne (University of Paris); photo by Bob Jones.**

***Figure 5.* Topaz (pink) on quartz *(left)* from the Pirajá deposit. The group is about 15 cm in longest dimension. Carlos Barbosa specimen; photo by WEW.**

***Figure 6.* Metazeunerite crystals *(right)* to 3 cm on magnesite from the Pedra Preta pit. Specimen and photo: R. V. Gaines.**

quarry, surface pits, and alluvial placer deposits. Five hectares of ground were panned and sieved during the following 20 years.

In 1923 several large emeralds and other specimens were obtained by O. C. Farrington, who visited the Pirajá deposit (then known as *Bom Jesus das Meiras*) in the course of an expedition made for the Field Museum of Chicago. Two of the best emeralds, which are on exhibit at the Field Museum today, weigh 175.3 g and 128.6 g. The former is 7.7 cm long (3 inches) and the latter is 12.3 cm long (4.8 inches). They are of a pale emerald-green color. The shorter crystal is a simple hexagonal prism with a pinacoidal termination; the longer crystal has a complex pyramidal termination. They are transparent and, because of the large crystal size, they appear to be more deeply colored than they really are. The two crystals are superb as specimens. Stones cut from similar crystals are intermediate in color between true emerald and fine green beryl. Today the gem field is extensively covered by magnesite dumps from the Pirajá deposit. Also from this period came a large hematite crystal (labeled *Bom Jesus das Meiras*) in the Museu Nacional, Quinta da Boa Vista, Rio de Janeiro (Fig. 7).

The magnesite deposit of Pedra Preta was discovered in the early part of 1939 by two prospectors who subsequently acquired the concession to the occurrences. Lacking capital, they interested a group of financiers in Belo Horizonte; the company was reorganized under the name *Magnesite S.A.* Today this group is still working the deposit; ore reserves are estimated at 300,000,000 metric tons.

During World War II optical grade quartz, found in pockets in magnesite, was mined, but this mining ended in late 1945 and the small prospect pits have since caved in.

During 1945 geological mapping of the Serra das Éguas was sponsored by the United States Geological Survey in cooperation with the (Brazilian) National Department of Mineral Production (D.N.P.M.). In his final report, Bodenlos (1954) mentions various prospects where cm-size magnesite crystals were found as well as kyanite, tourmaline, topaz, beryl and hematite.

Mining operations began during the late 1940's, a town site and railroad station were built at Catiboaba, a refractories plant at Belo Horizonte and a talc grinding mill in Rio de Janeiro. During the development of the Pedra Preta prospect into a mine, good but small magnesite crystals, large, transparent rhombohedrons of dolomite and attractive samples of actinolite were recovered. Good dravite specimens were found in the Jatobá talc prospect.

With the rapid increase in mining that followed advancements in Brazilian metallugy in recent years, more fine specimens have been found, in particular the finest known specimens of novacekite (Fig. 4) and metazeunerite (Fig. 6) in the world. The discovery of these two minerals was first made known by Alvaro Lucio, then consulting metallurgist for Magnesite S.A. Large single crystals and groups of magnesite crystals were also found at this time, during experimental mining of the Pirajá prospect.

Most recently a small vug of magnificent Japan-law twinned quartz and small topaz crystals (Wilson, 1976) was discovered at the Pirajá prospect by foreman A. X. de Matos, well known as "Bino" among mineral dealers.

The current daily production of magnesite ore at the Pedra Preta open pit is about 6,000 metric tons; this ore is processed at the Catiboaba and Pedra Preta magnesite calcining plants. There is also important talc production, coming mainly from the Jatobá quarry.

GEOLOGY

The Brumado area consists primarily of Precambrian basement rocks, mainly gray gneiss and schists with granitic intrusions and amphibolite dikes, all dated Lower to Middle Precambrian (Galvao, *et al.*, 1973).

Overlying these rocks is a metamorphosed sequence of dolomite and quartzite correlated in many ways with the Minas series in southern Minas Gerais (de Morais Rego, 1932).

Dolomite

A sequence of dolomite strata more than 450 m thick forms the lower unit which directly overlies the basement complex.

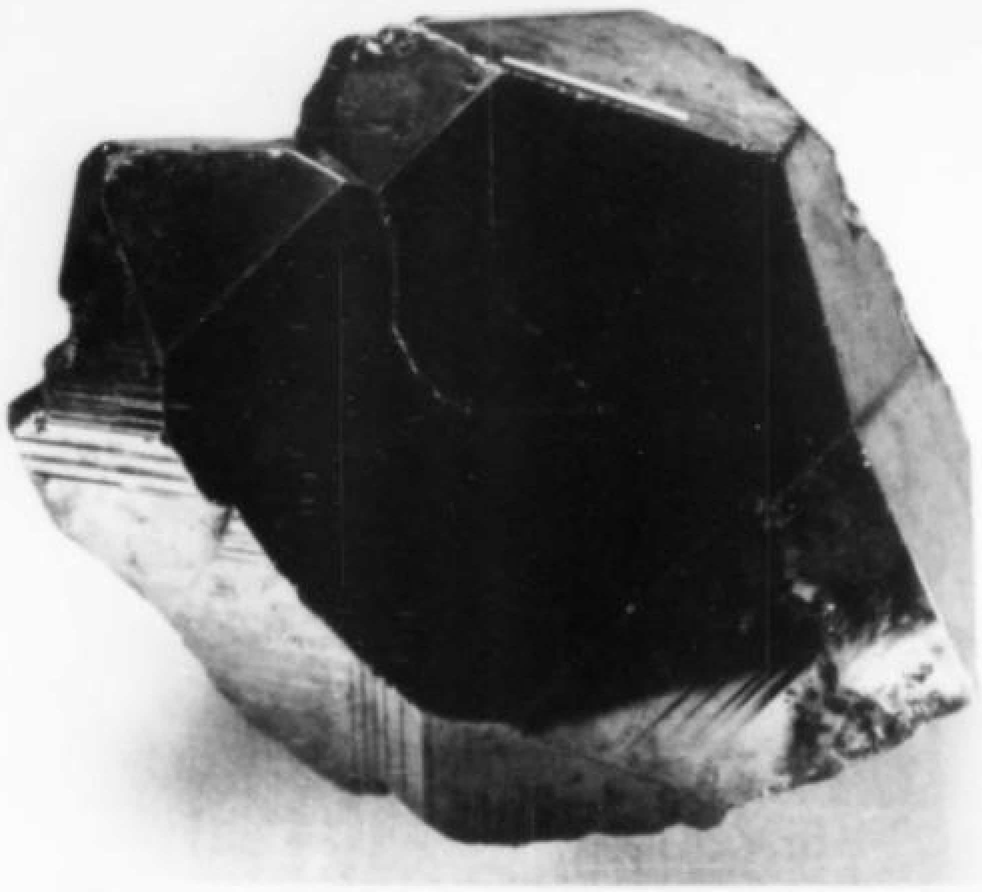


Figure 7. **A large hematite crystal from an old Pedra Preta outcrop. The crystal is 16 cm in longest dimension. Specimen and photo: Museu Nacional (Rio de Janeiro).**

It consists mainly of dolomite with subordinate thin layers of quartzite. In most places the texture is saccharoidal and the color light gray although pink and cream colors occur randomly. The rock is composed of euhedral grains ranging from 0.2 to 1.5 mm in diameter. Weathered material is medium gray or buff and moderately hard. The most extensive outcrops are in the Pedra Rolada area north of the Gravatá and west of the Pirajá deposits.

Quartzite

The upper unit is mainly quartzite with a lower part of massively bedded, fine-grained and generally white or gray quartzite which forms craggy outcrops. The upper parts are thin bedded and weather to a red or brown color. The upper part contains itabirite layers and quartz-biotite schist layers intercalated with the quartzite. The thickness of the formation is unknown but must be several hundred meters.

Structure

Study is limited by the scarcity of outcrops, lack of evidence of bedding in the carbonate rocks and complex folding that also prevents a detailed description of the stratigraphic sequence. The area was subjected to orogeny and metamorphism, followed by the intrusion of igneous dikes and quartz veins. The age of dolomitization of the carbonates is unknown. Later the area was extensively peneplaned.

Dolomite and quartzite strata of the Serra das Éguas are closely folded in a large syncline striking about N20°E. This structure plunges south at a low angle but reverses in the vicinity of the Catiboaba Valley so that the structure of the range as a whole is canoe-shaped. The tectonic style is close and repeated folding with faults few and of small displacement.

Figure 8. **Small magnesite crystal group 12 cm in width, on a matrix of sandy magnesite, from level 2 of the Pirajá deposit. Specimen and photo: JPC.**

Mineralization

Replacement and fracture-filling are the two mechanisms by which magnesite was deposited in the Serra das Éguas and, of these, replacement has been by far the more important volumetrically. During mineralization the ore-forming solutions and minerals deposited changed in composition. This process was interrupted by several periods of fracturing as follows:

(1) The first and most important stage of mineralization was characterized by deposition of most of the magnesite as a replacement of dolomite and as an alteration of quartz and silica minerals to magnesium minerals (enstatite and talc). Hematite was deposited in magnesite (coloring it red) and as crystals throughout the stage. At the end, the area was extensively fractured with open fissures and breccia zones formed.

(2) The second stage of mineralization was characterized by deposition of coarse grained magnesite in open spaces, with euhedral crystals in cavities. Some dolomite and beryl were formed at the end of this stage.

(3) Deposition of silica and alumino-silicates characterized the third stage of mineralization. Quartz in various forms (including minor amounts of chalcedony) was deposited in fissures together with hematite crystals, tourmaline and beryl, and also a small amount of oxide and phosphate minerals.

(4) Minor fracturing preceded the fourth stage, during which opal, cryptocrystalline magnesite and calcite were deposited.

It has not been possible to date these stages of mineralization.

The magnesite was deposited from hydrothermal solutions and is therefore hypogene; it has been classified as mesothermal by Bodenlos (1954), from whom many other data presently quoted were taken.

Figure 9. **A magnesite rhombohedron partially included in a quartz crystal from the Jatobá deposit. The specimen is an old sample and measures 5 cm. Specimen and photo JPC.**

URANIUM MINERALS

About 10 years ago a remarkable find of uranium minerals was made in the Pedra Preta open pit. Along one of the benches a series of small vugs was opened containing **metazeunerite**, $Cu(UO_2)_2(AsO_4)_2\cdot 8H_2O$, **novacekite**, $Mg(UO_2)_2(AsO_4)_2\cdot 12H_2O$, and rarely **sklodowskite**, $Mg(UO_2)_2Si_2O_7\cdot 6H_2O$.

The specimens of metazeunerite and novacekite (see Figs. 4 and 6) exceed by an order of magnitude the best previously known specimens of either mineral found elsewhere in the world. Perched on coarse druses of magnesite and quartz, the best metazeunerite specimens consist of multiple square tablets about 3.5 cm on an edge, lustrous and a bright deep green. The best of the novacekite specimens are a little smaller in crystal size, about 2.5 cm on an edge, bright yellow in color, and highly fluorescent. The sklodowskite specimens are smaller but nevertheless equal to or better than anything previously known; they occurred as druses of needles 4 mm long and of an orange-yellow color.

Associated with a few of these specimens are irregular blebs of lustrous black uraninite up to 3 cm across imbedded in the matrix.

Mining eventually progressed beyond this small uraniferous zone, and no further specimens of these minerals have been found for several years.

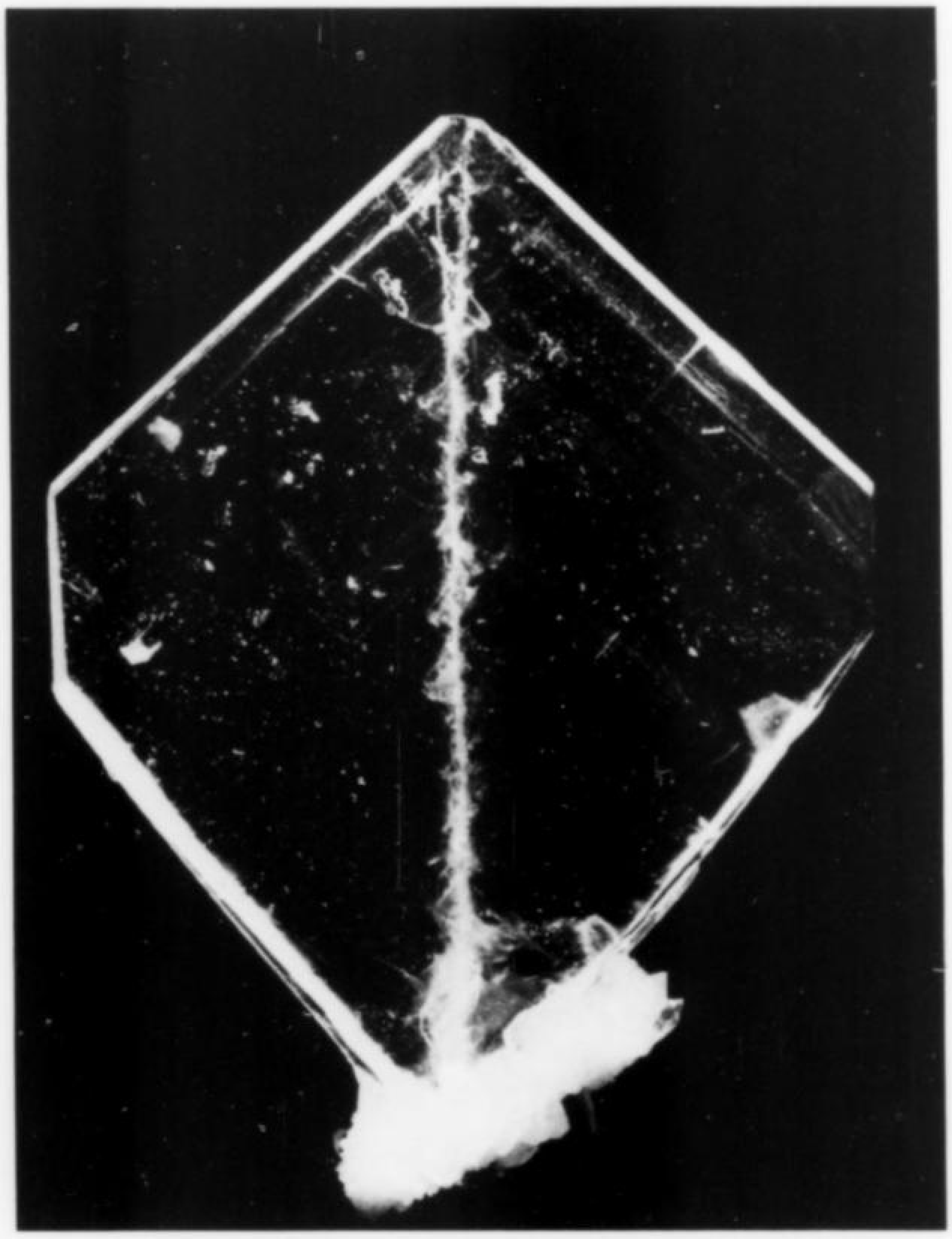


Figure 10. **Japan-law quartz twin from level 2 of the Pirajá deposit. The twin is 9.5 by 12.8 cm. Carlos Barbosa specimen; photo by WEW.**

MINERALS THAT MAY BE PRESENTLY RECOVERED

The minerals listed below are those which a collector can probably find at the Pedra Preta mine and other prospects in the area. Many specimens of each were identified by X-ray and/or microscopy.

Hematite Fe_2O_3

Hematite occurs abundantly in the district in three forms: disseminated small grains in reddish magnesite, irregular platy aggregates, and as fine, euhedral crystals.

The first type is of little interest to collectors; the second type provides good micromounts and thumbnail specimens on a matrix of reddish to purple magnesite with small translucent quartz crystals. The third type is the most attractive; such crystals are found in vugs in magnesite, mainly at the Pedra Preta mine. The crystal size ranges from micromount to more than 10 cm, always with well developed and striated faces. Fine specimens such as the one belonging to the Museu Nacional (Fig. 7) are very rare.

An additional type occurs as mm-size needles (frequently mistaken for manganese oxides) and globules coating groups of magnesite rhombohedrons and quartz.

Magnetite Fe_3O_4

Numerous octahedral crystals of magnetite as large as 3 cm occur with dravite in the residual argillaceous soil near the 950 level of the Pedra do Ferro prospect. This prospect lies 4 km from the Pirajá deposit, in an area of iron-rich magnesite.

Manganese oxides

Manganese oxide minerals occur as small blebs on magnesite and fine dendrites on quartz crystals at the Pirajá deposit. Small fissures containing manganese oxides have been found at various locations in the district.

Pyrite FeS_2

Small dodecahedrons of pyrite, some limonitized, are found in spongy, second generation quartz coating earlier quartz crystals (third stage of Bodenlos) in association with green tourmaline.

Magnesite $MgCO_3$

Magnesite is found abundantly in the district and is commonly crystalline although a few veins of cryptocrystalline magnesite are known. It occurs as massive, bladed, or lath-like aggregates and euhedral crystals. The massive magnesite forms the bulk of the deposits and resembles crystalline dolomite or marble in texture. Colors include snow-white (Pirajá deposit), cream, light gray, yellowish, orange (Pedra Preta deposit), chestnut, buff, pink, dark red and purple (Pedra Preta deposit). A mixture of colors is common. The grain size varies from fine to coarse. Only ore or petrographic samples may be expected from the massive magnesite.

Magnesite crystals are found lining fissures and, less commonly, vugs in massive magnesite. Some crystals are euhedral but with most only a few faces are well developed in the group or aggregate of crystals. The edges and corners of the rhombohedral crystals are sometimes modified by small faces. For a description of the various forms present see da Gama (1946). The crystal faces are fresh but many crystals have been etched along incipient cleavage planes or invaded by films of impurities. Some are corroded into irregular stepped shapes, others exhibit good growth or etch figures. Many specimens are naturally cleaved, probably by subsidence of the deposit.

Figure 11. **Japan-law quartz twin from the Pirajá deposit. The specimen is 9.2 cm wide. Smithsonian specimen; photo by WEW.**

Figure 12. **The Pirajá deposit. This photo was taken from the Mineiros tremolite outcrop (see Fig. 17). The white dump at center is from level 3, from which many large magnesite crystals were collected. The smaller dump above is from level 2, the source of the twinned quartz and topax on magnesite. Photo by JPC.**

Most crystals are transparent, colorless rhombohedrons although white, orange and red crystals occur locally (Pedra Preta deposit). The crystal size is variable, ranging up to 30 cm at the Pirajá deposit where crystals 3 to 15 cm in size are common. Crystals from Pedra Preta and other deposits are generally smaller.

Large magnesite crystals and groups are sometimes coated by smaller magnesite crystals, quartz, topaz or tourmaline. Crusts of chalcedony and patches of limonite are common near outcrops. The magnesite matrix ranges from hard (Pedra Preta) to sandy (Pirajá, Fig. 8).

Presently the best magnesite specimens come from the Pirajá deposit (Fig. 12) where two benches have been cut. The bench at level 2 (at an elevation of 810 m) has produced twinned quartz and astounding groups of clear magnesite rhombohedrons to many cm in size. Good material is still common on the quarry floor. Level 3, below level 2, has produced huge crystals of magnesite up to 30 cm in vugs and fissures cutting white powdery magnesite.

Crystals of magnesite are found at other deposits in the area, mainly at Pedra Preta as small, transparent rhombohedrons lining vugs in white and red magnesite.

Figure 13. **Modified dolomite rhombohedrons from level 2 of the Pirajá deposit. The large crystal measures 2 cm. Specimen and photo: JPC.**

Cryptocrystalline, "amorphous," or "Greek" magnesite is snow-white with a dull luster and conchoidal fracture giving the appearance of unglazed porcelain. Nodular aggregates form small veins cutting massive magnesite. Good samples of nodular magnesite up to 5 kg may be found in the Cabeceiras prospect between Gravatá and Pirajá, as well as a small quantity in the Coite and Pedra Preta mines.

Dolomite $CaMg(CO_3)_2$

Dolomite accompanies magnesite as unreplaced residual rock in large masses and, to some extent, in cavities. Crystals are generally small, lining fractures or scattered in vugs as at the Pedra Preta mine where transparent, 10-cm rhombohedrons are sometimes recovered. Highly modified 1-cm rhombohedrons sometimes are found coating large magnesite crystals (Fig. 13) at the Pirajá deposit. Secondary quartz or chalcedony is a common associate. Dolomite is easily distinguished from magnesite by X-ray diffraction.

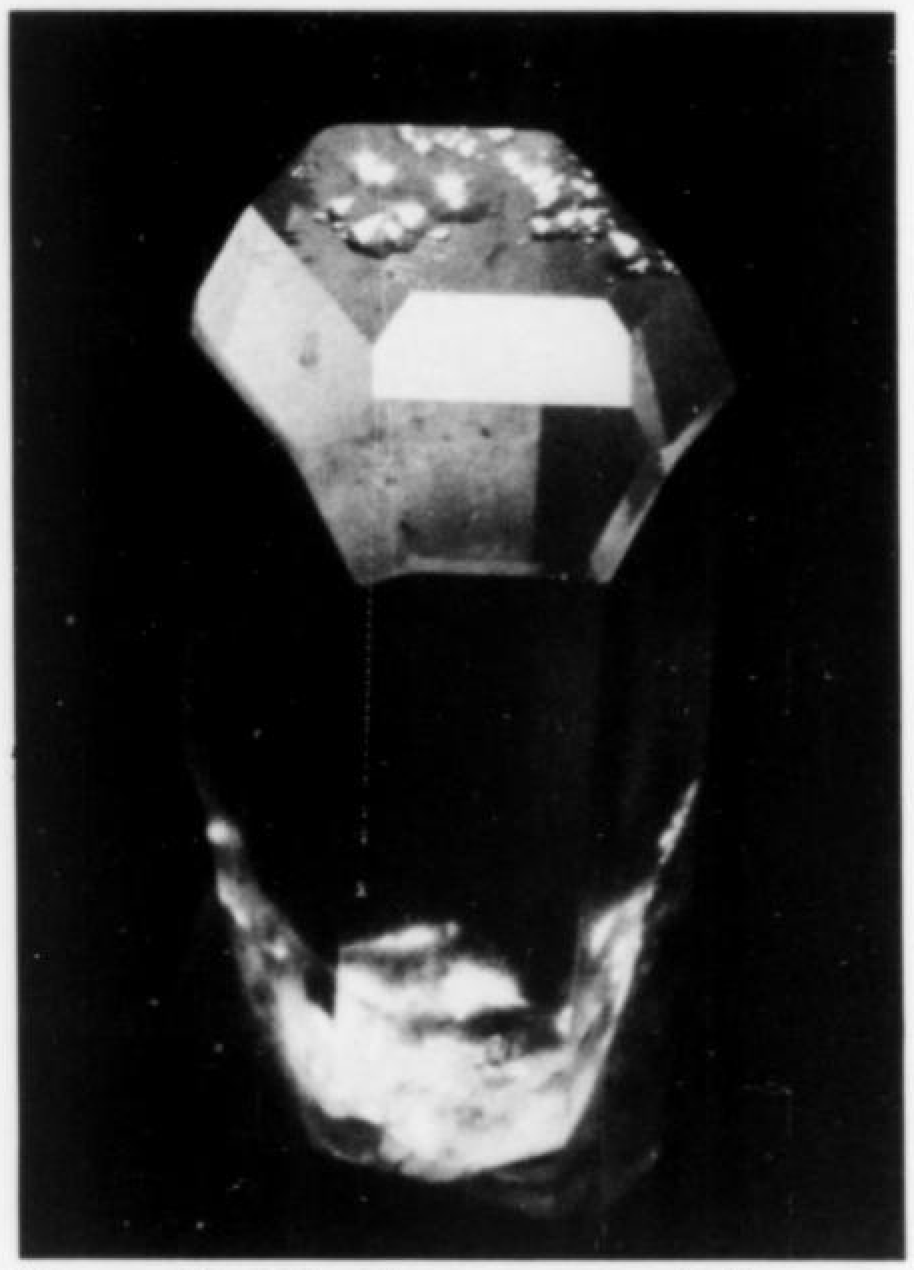


Figure 14. **Pale blue-green beryl from the Pirajá deposit. The crystal is 2.2 cm tall. Carlos Barbosa specimen; photo by WEW.**

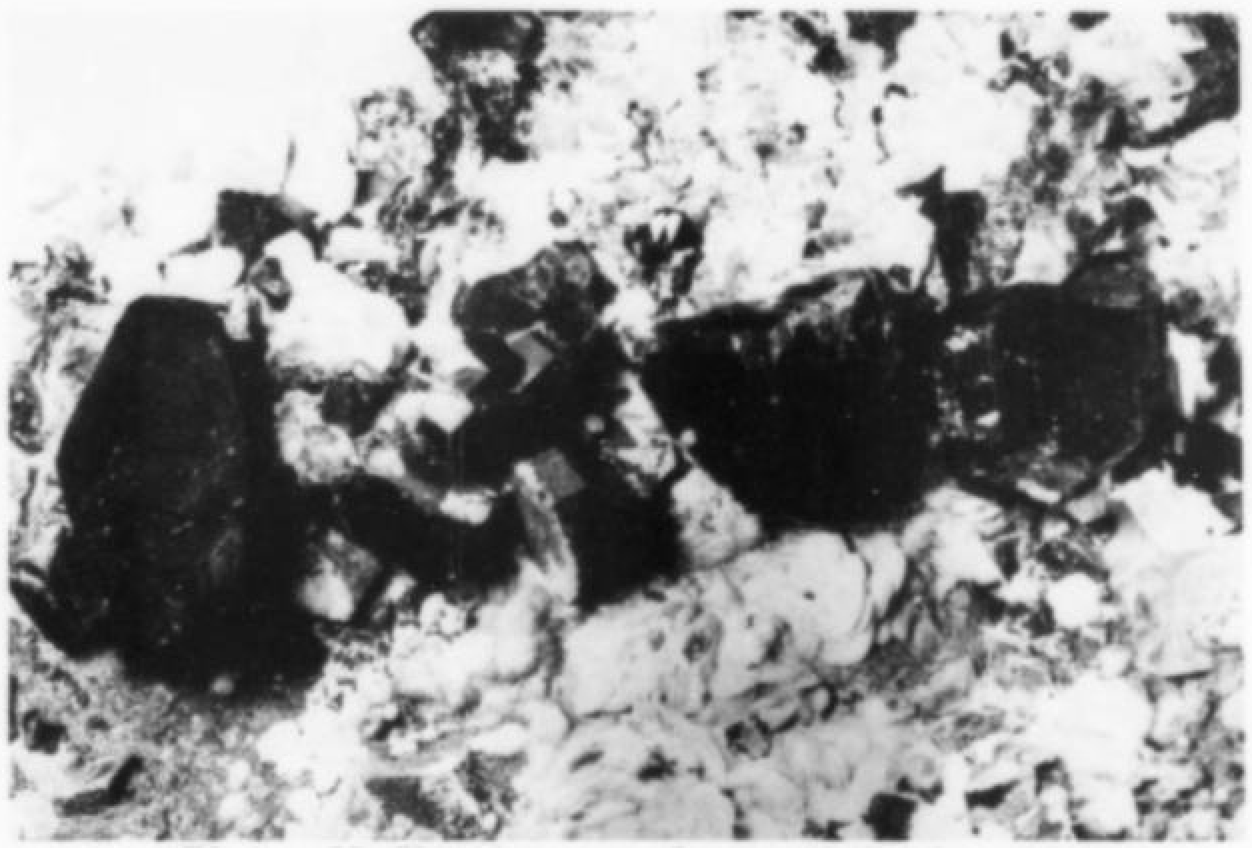


Figure 15. **Dravite crystals on magnesite matrix coated with small dolomite crystals, collected from the Jatobá deposit in 1962. The large crystal at left is 1.2 cm wide. Specimen and photo: JPC.**

Calcite $CaCO_3$

Calcite is sometimes found filling fractures but does not occur in good specimens.

Quartz SiO_2

Quartz occurs mainly as loose crystals up to 20 cm in size, associated with magnesite, coating magnesite crystals or, more frequently, in veins cutting across the carbonate rocks.

Loose crystals may be of typical quartz habit or sometimes of the alpine type (Tessin habit) steep rhombohedron. Transparent specimens are commonly short with many inclusions and fracture-fillings of limonite as at the Pedra Preta outcrop. Elongated prisms from the Pirajá deposit have a light purple core surrounded by argillaceous red hematite, the whole being covered by small, whitish, quartz terminations in parallel orientation which produce rough faces with multiple terminations. Small transparent groups from the Jatobá and Pirajá deposits make fine collector specimens.

Cavities between rhombohedral crystals of magnesite are locally filled with prismatic milky quartz crystals to 20 cm in length. A gradation exists between single quartz crystals with included magnesite crystals (Fig. 9) to massive quartz with little associated carbonate minerals. Spectacular specimens of boxwork quartz, formed by the dissolution of included magnesite crystals, are known from micromount size to samples weighing 10 kg and more.

Prismatic quartz crystals to several cm are sometimes partially coated by much smaller crystals of quartz and occasionally pink topaz (Praça Saõ Paulo). These quartz crystals commonly enclose small magnesite rhombohedrons. The association of quartz and magnesite is part of the first generation (third stage of Bodenlos, 1954).

Small milky quartz druses coat large magnesite rhombohedrons at the Pirajá deposit, and form boxworks where natural leaching has removed the magnesite. This drusy coating, sometimes itself coated by limonite, formed later than topaz and tourmaline and belongs to the second quartz generation (fourth stage of Bodenlos). Such quartz sometimes coats the broken ends of first generation quartz crystals several cm in size. This arrangement is evidence of natural fracturing in the deposit, probably by subsidence. At Pirajá magnesite also forms aggregates with broken quartz crystals.

A meter-sized elongate vug in the floor of level 2 of the Pirajá deposit recently produced beautiful specimens of Japan-law twinned quartz to 15 cm in size. The specimens were found loose in sandy white magnesite or perched upon groups of rhombohedral magnesite crystals. The twins are generally thin, rarely thick, colorless, transparent to milky, and varying in habit from V-shaped (Fig. 11) to plates virtually without a re-entrant angle (Fig. 10).

Kyanite Al_2SiO_5

Clear, sky-blue crystals of kyanite to several cm in length and 1 cm in thickness are disseminated in white, coarse-grained magnesite but are not found in clusters. They are associated with glassy, platy crystals of talc. The best collecting sites include an area a few m above the Praça Saõ Paulo prospect and the Pirajá deposit (level 3).

Topaz $Al_2SiO_4(F,OH)_2$

In recent years topaz has been found west of the Pirajá deposit in the Praça Saõ Paulo prospect, coating quartz crystals scattered in the powdery, snow-white magnesite. The latest discovery (Fig. 5) was in the Pirajá deposit (Wilson, 1976). There the small, pink to orange topaz crystals, up to 1 cm in size, partially coat large magnesite and quartz crystals. The topaz crys-

Figure 16. **Acicular tremolite crystals from an outcrop near the Pirajá deposit. The sample has been cleaned with oxalic acid. The scale bar is 3 cm. Specimen and photo: JPC.**

Figure 17. **Tremolite crystals in an outcrop at the Mineiros deposit; the ball point pen is 15 cm long. Photo by JPC.**

tals are commonly doubly terminated, striated prisms or aggregates which make excellent micromounts. Small green tourmaline crystals are occasionally found on the topaz.

Beryl $Be_3Al_2Si_6O_{18}$

As mentioned in the *History* section, the emerald area is now completely covered by dumps and no beryl is currently recoverable. This statement is corroborated by the geological staff of the mine. Future mining at Piraja will perhaps produce other interesting discoveries of this type.

Dravite $NaMg_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$

Brown dravite and occasionally a light green tourmaline have been found in the district. The best dravite samples come from level 2 of the Pedra Preta deposit, also known as Jatobá, at an elevation of 830 m, in a small pit mined for talc. Dravite is found there as loose crystals to 1 cm scattered in a sandy, very ferruginous, buff to violet-colored soil as well as, more rarely, in red magnesite or talc rocks. In red magnesite the dravite forms short, cm-sized crystals perched on clear magnesite rhombohedrons or on a thin, white, platy dolomite matrix (Fig. 15). Dravite also occurs in an acicular brown habit with chlorite and phlogopite, lining small magnesite druses. Small dravite crystals are also found in sandy magnesite, under a quartz crust, on some specimens from the Pirajá deposit.

A light bottle-green tourmaline occurs as small, transparent crystals growing upon or partially enclosed by topaz crystals at the Pirajá deposit. The crystals are elongated prisms terminated by many faces and are very suitable for micromounts. Some needles also occur in the cavities between magnesite rhombohedrons.

Figure 18. **Curved actinolite crystals from the lower level (Nível J 1) of the Pedra Preta mine. The sample is 20 cm wide. Specimen and photo: JPC.**

Enstatite $Mg_2Si_2O_6$

Enstatite is common as clusters and massive vein aggregates to 40 cm cutting dolomite and magnesite. The crystals are cm-sized, frequently wider than tremolite crystals (described next), and very fractured. The outcrops of enstatite are chestnut-colored and prominent but turn milky after leaching with oxalic acid. Chemical analysis shows this enstatite to be almost iron-free. Large acicular or platy crystal groups are easily recoverable at several deposits, notably Pirajá, Praça Saõ Paulo, and also in Cabeceiras and Cordeiros.

Tremolite $Ca_2Mg_5Si_8O_{22}(OH)_2$

Tremolite is very abundant in the Brumado district, mainly as veinlets cutting massive magnesite and as scattered large crystals which make excellent specimens. It also occurs as lenses and disseminations in the various magnesium-bearing rocks of the area.

Figure 19. **A pale green talc crystal 6 mm long in a magnesite vug from the Pedra Preta mine. Specimen and photo: JPC.**

Veinlets contain compact, cm-sized clusters and aggregates of acicular crystals. Weathering turns them buff-colored in outcrops, where they are prominent in the wall rock (as at the Mineiros, Pirajá, and Praça Saõ Paulo deposits). Large flat samples are easily collected but may require cleaning in oxalic acid to remove the limonitic coating (Fig. 16). Caution should be taken because the delicate needles are sharp and prickly.

The best outcrop of single crystals lies northeast of Pirajá in the Mineiros prospect, near an elevation of 850 m. The occurrence lies on the left side of a roadcut where a track crosses the Gravatá concession. Here are found elongated crystals to several cm, some as long as 40 cm, irregularly disseminated in sandy white magnesite (Fig. 17). Unfortunately they are always cracked and it is not possible to extract complete single crystals; however good matrix specimens can be removed. The tremolite crystals are cream to light buff-colored on the surface of the occurrence; cleaner crystals are found in fresh rock where some crystals are quite gemmy but always with fractures. Microscopic studies show that tremolite crystals are partially replaced by magnesite in the core and along cleavages. Clusters, parallel growths and twins are uncommon at this outcrop, and no preferential orientation has been noted.

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

The best collecting area for actinolite lies in the lower level of the Pedra Preta mine at an elevation of 680 m, in a vertical, sheared zone running N25°E. Here a large mass of white, fine-grained talc was developed during the first stage of mineralization. The talc vein is several meters in width but actinolite is

Figure 20. **A ripidolite crystal 7 mm long in magnesite from the Pedra Preta mine. Specimen and photo: JPC.**

found mainly in a strip a few tens of centimeters wide on its eastern border near the vertical wall of the open pit.

The actinolite crystals reach a size of more than 25 cm in length and 2 cm in width, but generally contain transverse microfractures invaded by talc. They are of a brilliant luster, light to dark green, and occur in groups and clusters without preferential orientation. Some crystals are curved (Fig. 18). Large, attractive samples may be easily collected here.

Talc $Mg_3Si_4O_{10}(OH)_2$

Talc is very abundant in all deposits of the district and is currently being mined from the Jatobá open pit at a level higher than that of the Pedra Preta mine. The commercial quality is excellent, the ore being almost completely free of other minerals. The color of the talc varies from white to gray and a delicate pink. Grain size is very small; large, compact masses occur as veins or lenses in dolomite and magnesite, mainly in a sheared zone that crosses the Jatobá and Pedra Preta deposits.

Talc also occurs as small crystals associated with chlorite, phlogopite and enstatite. The best specimens are cm-sized, glassy, platy, thin crystals on small magnesite rhombohedrons lining fissures at the top of the Pedra Preta deposit. Small chlorite crystals frequently occur together with talc. Fine, short, light green crystals are occasionally found in magnesite vugs (Fig. 19) and make good micromounts.

Phlogopite $KMg_3(AlSi_3)O_{10}(F,OH)_2$

Well crystallized yellow flakes to 1 cm in size occur scattered in magnesite and in talc, or form a rim between the two (as at Pedra Preta). Good micromounts may be recovered.

Chamosite-Ripidolite-Clinochlore

$(Fe,Mg,Fe)_5Al(Si_3Al)O_{10}(OH,O)_8-(Mg,Fe)_5Al(Si,Al)_4O_{10}(OH)_8$

Ripidolite and other chlorites are generally scattered in magnesite and, where present, lend a green color. Well formed, mm-sized crystals occur in a mass of smaller crystals associated with talc and magnesite or at the boundary between magnesite and quartz (as at the Pirajá deposit).

Single crystals to 8 mm are sometimes found in vugs in magnesite at the Pedra Preta mine. The X-ray diffraction pattern of the sample shown in Figure 20 is identical to that of ripidolite from Chester, Vermont.

Other minerals

Apatite has been reported from the Serra das Éguas but the exact locality is not known.

Rutile is found mainly in mica schists of the bedrock on the northwestern flank of the Serra das Éguas. However, our friend Richard V. Gaines obtained a good sample of rutile in magnesite. No recent discovery of this mineral is known to the resident mining geologists.

Corundum specimens labeled "Catiboaba" are currently in the mineral museum of the Ouro Preto School of Mines (Minas Gerais), but were probably found in basement rock outcrops southeast of the Serra.

Malachite and **azurite**, as alteration products of **chalcopyrite**, occur in a small outcrop near the Catiboaba burning plant.

Spodumene, lepidolite, albite, monazite, xenotime, zircon, titanite and **garnet** have been reported by the early writers, without exact locations given. They are presently not recoverable in the mine workings.

ACKNOWLEDGMENTS

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Many thanks also to our colleagues, Richard V. Gaines and Wendell E. Wilson, who kindly revised the English manuscript and provided information on several of the species.

Note: The authors have no specimens to sell.

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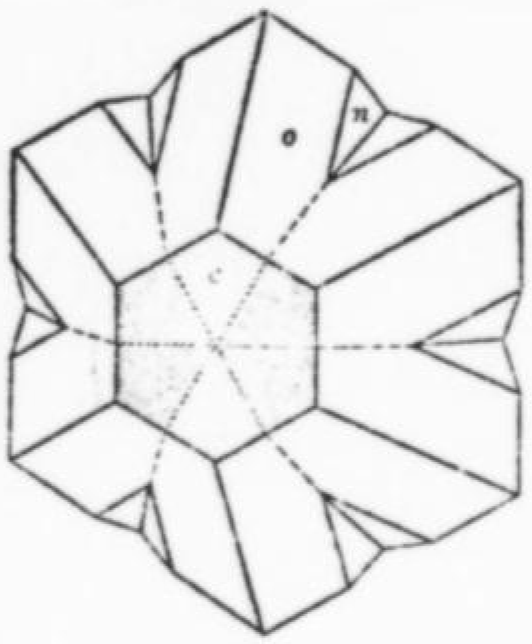

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