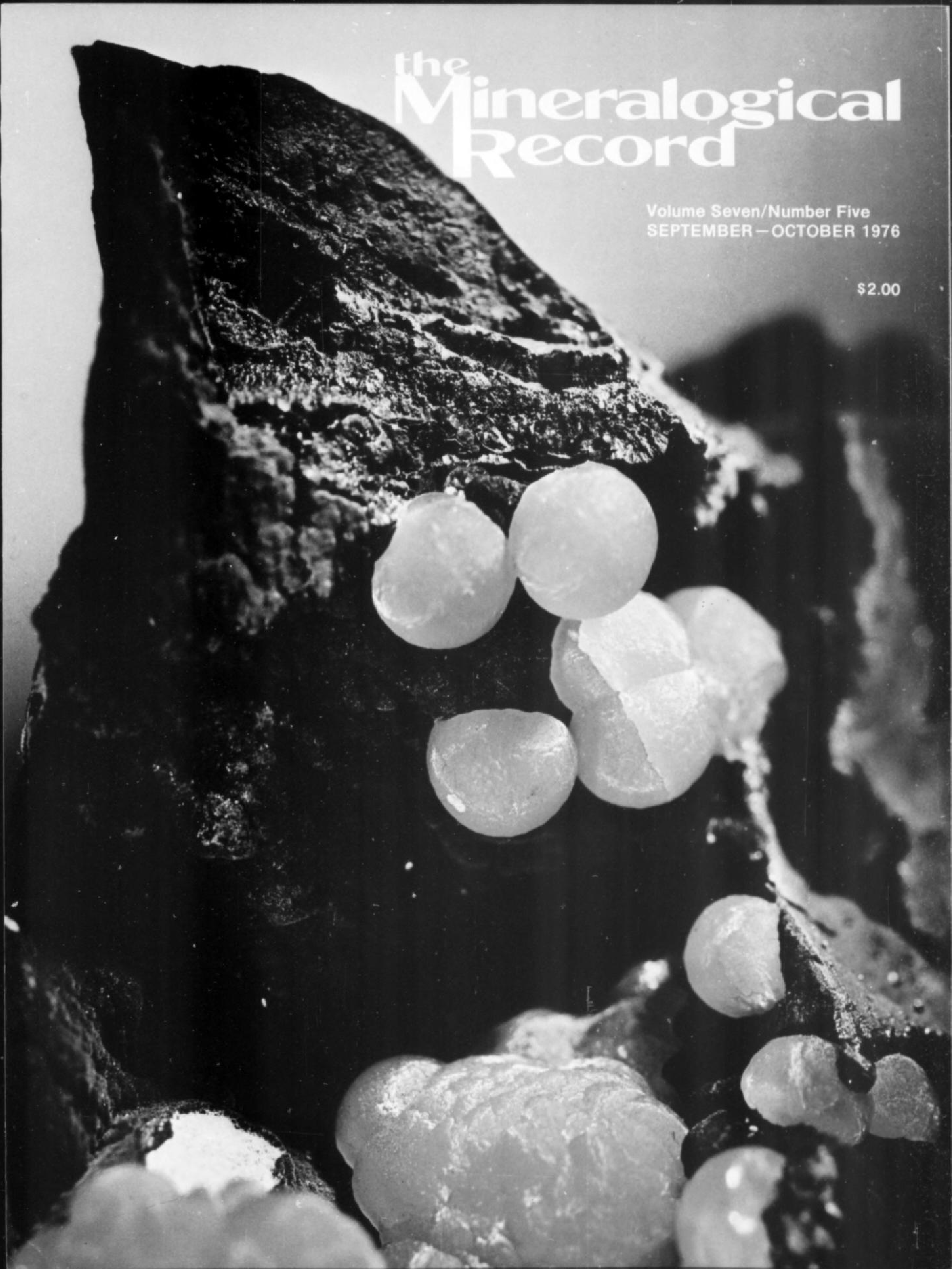


the Mineralogical Record
Volume Seven/Number Five
SEPTEMBER – OCTOBER 1976
$2.00

the Mineralogical Record

Volume Seven/Number Five
September—October 1976

affiliated with the Friends of Mineralogy

subscriptions

The Mineralogical Record costs $10.00 per year, domestic and foreign.

feature articles

departments

COVER: RHODOCHROSITE, from Waldalgesheim, West Germany. Specimen: Olaf Medenbach; photo: Olaf Medenbach and Rudolf Baensch. The rhodochrosite spheres are each about 8 mm in diameter.

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.

publishing information

The Mineralogical Record is published bimonthly by the Mineralogical Record, Inc., P. O. Box 783, Bowie, Maryland 20715

foreign payments

Remittance may be made in local currency to the following:
Canada: Mrs. J. W. Peat, 36 Deepwood Crescent, Don Mills, Ontario M3C1N8
England: Dr. R. S. Harker, 42 Oxford St., Leicester LE1 5XW
South Africa: Horst Windisch, 30 van Wouw St., Groenkioof, Pretoria

the Mineralogical Record, Post Office Box 783, Bowie, Maryland 20715 Telephone:301-262-8583 or 301-261-3912. Second class postage paid at Bowie, Md.

EDITORIAL

M.R. SUBSCRIPTION DRIVE IS ON

With this issue we are initiating a serious effort to increase our subscriptions. The *Record* is currently just making it, financially, and we want to see it become increasingly successful. Of course our readers will be the ones to benefit; we hope some day to have all issues in color instead of only the current two per year. We also add extra pages to issues whenever we can afford to; many of the recent issues have contained eight extra pages above the usual 48, and in fact, this issue contains an extra 16 pages! Given enough new subscribers we could even eventually consider going to seven or eight issues per year instead of adding extra pages.

Record readers comprise a sort of unofficial fraternity of mineral collectors. Because we are massively outnumbered by lapidaries (lapidary interests have all but taken over the other hobbyist publications) the *Record* is currently the only publication (in English) solely for mineral collectors. For this reason, *Record* readers are more inclined to think of the *Record* as their "own", and to freely communicate to us their likes, dislikes, and suggestions. Consequently we are asking readers to help us increase subscriptions. Here are some ways you can help:

(1) If you are employed by a company even remotely involved in some aspect of earth science you can strongly suggest that the company take out a subscription for their library.

(2) Check your university library; if they do not subscribe already you can assure them that a subscription is essential.

(3) Check your local public library; if they do not subscribe already you can assure them that a subscription is essential. University and public libraries are usually quite interested in the needs of their users, and are inclined to be cooperative.

(4) You might even suggest to the local high school library that they should subscribe. Show your copy of this issue, no matter which library you are asking to subscribe.

(5) Show this issue to a friend and suggest he or she subscribe. We have received letters saying "I'll always be grateful to the person who first turned me on to the *Record*..."; do someone a favor. And don't let them tell you it's "too technical" (this misconception is our biggest obstacle in getting new subscribers); they can examine any article in this issue and see that it is definitely not "too technical". This is not to say that we won't occasionally have a slightly more technical article, but our primary concern is to provide reading matter for the collector, and not for the purely professional mineralogist.

(6) Send us $1 and we will send a sample copy (this issue) to a friend in your name; they'll appreciate your thoughtfulness and so will we!

(7) Christmas is coming soon; why not consider giving subscriptions to your friends, relatives, or children? We will send a gift card in your name.

(8) Donate a subscription to your local public library, high school library, or university or college library. Any donation in this manner to a non-profit institution should be tax deductable.

(9) Suggest that your club take up a collection or use dues money to donate subscriptions to libraries.

(10) Bring your copy of this issue to your next club meeting and show it around. Many people have never seen a copy and don't know what they are missing!

(11) Finally, check your own address label to see when your subscription expires, and send in your renewal as soon as possible. Please don't wait for us to send you a renewal notice; it is expensive for us to send out thousands of renewal notices and reminders.

There are other ways you can assist the *Record* besides helping with the subscription drive:

(1) If you are a dealer, why not consider an ad? A small dealer who recently placed a single small ad in the *Record* has reported over $2000 in mail orders as a direct result... so far! You can now purchase a 1/2-inch ad, prepaid, for only $10; write for our rates on larger ads. And if you are a private collector selling your collection we are offering a special, prepaid, one-inch ad for $25. *Record* ads do bring business! A 1973 study indicated that *Record* readers spent nearly half a million dollars through mail order per year, as well as an additional $800,000 at shows and $700,000 in shops in a year...those figures can only have increased in the intervening 4 years! You can reach that market through an ad in the *Record*.

(2) If you are on a show committee you can suggest that the show place an ad in the *Record*. We do not run a current events column or a list of coming events because it takes space away from articles, but we do accept show ads.

(3) Perhaps now would be a good time to buy any back issues you still need; they are beginning to sell out and soon many issues will be unavailable. They are sure to become collectors' items. Some people prefer to buy one set which they put away or have bound and do not use, so as to keep it in perfect condition; they then use their other set as a well-thumbed reference. You can still do this, and will only need to insert copies of your first set into your set to be saved where those issues are currently sold out. You may also wish to replace worn copies in your collection.

(4) Do you have a copy of the *1975 Glossary of Mineral Species* by Michael Fleischer? At $4 it really is an inexpensive and indispensable aid to mineral collecting.

(5) Outright cash donations are, of course, always appreciated! Some lecturers make it a habit of donating their speaking honoraria to the *Record*. Some authors make a donation in return for reprints of their articles which we normally provide at no charge.

A special category of donation is the gift of the amount necessary to cover the added costs of a color issue...about $5000. We currently have two benefactors willing to make such contributions once a year; therefore we are now putting out two color issues per year. If anyone else would like to make this special-purpose donation we will be more than happy to put out a third color issue this coming year.

In short, the *Record* is your magazine, and it needs your help to become successful. Feel free to send us your suggestions for improvement, and feel free to promote the *Record* whenever you can.

W.E.W.

RECORD FORUM

COMPETITION — AGAIN

The rules and principles which today govern formal display competition at major mineral shows seem to generate endless controversy. Only the winners end up happy, and sometimes even they are (privately) dissatisfied. The *Record* has received a healthy stack of correspondence regarding this subject; the almost unanimous opinion seems to be that change is needed badly, for one reason or another. Before stating my own opinions, here are excerpts from some of the letters we have received on the subject.

From Harold Dunn, Rules and Awards Chairman, N.W.-F.M.S.:

For whom are Gem & Mineral shows staged? Is it the many who throng the aisles or the few who mount the displays? Do we place strong emphasis on educational features...rare and unusual crystal forms...tricky new techniques...intricacies...details of note only to the already informed? Or do we direct our preparational work to the presentation of what is eye-appealing and unique to the casual observer, thinking primarily in terms of entertainment? There must be financial realism connected with these public events. We shall, of necessity, look to the general public for those who will pay our admission charges. Perhaps someone will conduct a survey of these ticket buyers and establish a ratio of entertainment seekers to genuine mineral "buffs". Only then can anyone speak with authority as to where the exhibiting emphasis should be.

Neal Yedlin (*M.R.*, **6**, 268) deplores this lack of educational emphasis. I'll not disagree, exactly, but my reading of the people in the aisles indicates that the public who pay most of the expenses are not there to be instructed but rather to be entertained.

From Robert Jones, Arizonophile and ***Rock & Gem*** *contributor:*

Probably the major problem to be faced by clubs and federations at their shows is the question of how to deal with competitive mineral exhibiting. Interest in competition is falling off to a marked degree at a number of shows. The quality of material seen is not always top notch and the number of displays is down drastically at some shows. What are the problems and is there any hope that they can be overcome?

To begin with, mineral competition itself isn't even considered desirable by some clubs and many individuals. They argue that each display is unique and cannot really be judged against another, particularly under a sometimes cumbersome set of rules. The Mineralogical Society of Southern California, as an example, sponsors an excellent show each year with many fine mineral displays, yet there is no competition. Displays are all guest displays provided by members or invited friends. Everyone simply puts in a display of his own choosing and the show boasts some really outstanding material and excellent displays of minerals. There are only a few restrictions, no lapidary material can be shown at all and the show committee reserves the right to reject a display. All displays must be cleared ahead of time to be placed in the show. This would seem to be an almost ideal situation. However, such an approach might not work for many clubs. MSSC boasts an outstanding group of collectors with some quite remarkable displays, many of which have won top honors at federation shows in the past. So, although there is no competition as such, the competitive experience gained by these people at other shows directly contributes to the success of the non-competitive type show held at Pasadena each year.

Many individuals refuse to compete at a show, though they might willingly place an exhibit in the show if invited. Their reasons may seem trite but they are probably as valid as some used to explain existing competitive rules. Collectors often feel they are their own best judge and know best what their display should be like. I have had the experience of judging the same display several times, making what I thought were valid suggestions for improvement, yet seeing none of these suggestions implemented. So who is right? Was the collector right in sticking to his original idea? Was the judge right in his position, taking away points for what he thought was poorly displayed material? Since each has an opinion, how can the difference be adjudicated? Certainly not by point score alone.

For the sake of argument, let us assume that mineral competition should continue as a standard practice at most shows, including all the federation shows. What can be done to improve the quality and quantity of displays?

It might help to identify the things I think are right in competitive displaying. The spirit of competition, when properly guided, can be the most attractive feature of this activity. When a collector has a goal, in this case competitive displaying against all comers, he may gain tremendously from the experience. The individual learning, the effort, the involvement, the interests that grow out of the preparation of the exhibit, can be most rewarding to that person. Then too, the show visitors who are able to see and study a variety of fine mineral material, well displayed and correctly identified, can also gain from the experience. So, the competition engenders learning on the part of each competitor, and the display-viewing is educational to the show-goer. These are good reasons for continuing competition. Unfortunately, in my opinion, these are not enough. They do not seem to me to constitute all that is possible to develop as goals in mineral competition. Mineral competition's ultimate goal should be to educate to a greater degree than now occurs. Its goal should be to stimulate learning, which it does not always do. In identifying what's right with mineral competition we perhaps reveal fundamental failure as an important part of a mineral show.

So we return to the question, "What can be done to improve the quality and quantity of displays?" The answers come easily. They seem valid and are glibly tossed about by competitors, judges, and show visitors alike. Oft-heard answers fall into these general groupings: 1) get rid of the lousy judges 2) get more judges 3) make the rules less difficult to understand 4) make the rules tougher, to weed out the poorer displays 5) add more divisions to the rules so we can get greater variety 6) eliminate some divisions because there is too much variety 7) pay the judges more money and demand the best 8) get volunteer judges because they are more "dedicated" and will do a better job. And so it goes. You can add your own conflicting views to these. They are probably just as logically thought out and valid.

As long as we agree to live with competitive displays we might as well continue to try and improve them. Maybe what we need is to consider the goals of competition first. Once we can agree on goals we might see ways to reach them. Is the goal of the competitive exhibit to provide the *exhibitor* with an educational experience? Or is the competitive display designed to provide the *viewer* with an educational experience? Or both? Or neither? Perhaps competitive displays should only have the purpose of providing a window through which we see the best of a fellow's collection with no regard for learning, just mineral appreciation. There is nothing wrong with that. We seem to be falling into such a trend. Few, if any, educational exhibits appear on the scenes today. Most are just displays of the best minerals a collector can afford, placed in a case with labels, a neutral cloth background, good lighting, and a hope for a blue ribbon. If that is our goal, then why can't we show two outstanding wulfenite crystal groups in the same case? We demand variety ignoring the fact that every mineral specimen is unique in some way. This uniqueness should satisfy the variety requirements. You can see that we must necessarily begin to consider rules, pro and con, but not before the goals of a display are established. It will have to be the rules that guide the exhibitor toward the desired goals.

Competition is dying so we better do something if we want to save it.

John S. White, the publisher of ***M.R.****, comments:*

There are many critics of the labelling requirements. In particular, how foolish it is to demand chemistry on the labels while nearly totally disregarding locality information. It surely is a disservice to everyone to allow exhibitors to get by with putting only a country name or a state name on a label when additional details (such as mine, district or county) are easily obtained. Unlike chemistry, which can easily be found in the literature. the locality information is not elsewhere available. If not given on the label, it is essentially lost. The rule makers do not appear to recognize that the composition is simply an extension of the mineral's name, whereas the locality is not.

From Henry Fisher, Columbus, Ohio:

Before new criteria are proposed it is necessary to consider the purpose behind exhibitions and competitions. Is it only to display a "pretty" specimen, to be admired as a "jewel of nature"; or is it to display knowledge of mineralogy with the specimen as a visual aid? If the second reason is more important, then new rules are needed. It is my feeling that knowledge about the specimen is as important as the specimen itself. To follow this up, I propose that the criteria for judging be revised, with the new point values to be: quality = 50 points, writeup = 35 points, rarity = 10 points, and showmanship = 5 points.

Under the present rules for labelling, only mineral name, chemical composition and locality are required. This is analogous to "name, rank, and serial number". It is a bare minimum of data. I have known exhibitors to state a minimum of information to avoid spelling mistakes. Information regarding locality is not precise with only state or country given, partly to cut down on the chance of errors. It is childish to place great emphasis on spelling.

The major change I propose would be the omission of labelling as a criterion, with the substitution of writeup. The writeup need not be long, but should be pertinent. In addition to name, composition and locality (as specific as possible), the writeup should contain additional information. This would consist of: (1) crystal description including system, class, and possibly diagrams in which crystal faces are shown and named; (2) associated minerals; and (3) method or sequence of occurrence. Important physical or chemical characteristics might be added. It would also be desirable to state why a particular specimen is of interest, and why it was chosen for display. If one has the world's finest bayldonite crystal he (or she) should state it.

The criteria I propose place less value on the "prettiness" of a specimen than is currently done. It might even produce entries from those who cannot purchase a spectacular and expensive specimen. The criteria prevents a "rich" exhibit from winning a trophy if it is missing a writeup; and a minimum writeup in a rich exhibit may not be enough to surpass an exhibit of lesser quality specimens accompanied by a better writeup.

People do not go to displays with textbook in hand. For this reason I put the burden of education on the exhibitor, not the viewer. Furthermore, a display of unrelated minerals with writeups should not fall into the "Educational" category; an "Educational Exhibit" should have specimens related by a unifying theme.

There should be an underlying philosophy for displays, rather than having the display as an end in itself. There must be some distinction between an exhibit of scientific specimens and one of *objets d'art*.

From Roger Harker, Leicester, England:

Competitive exhibits are a new concept in Britain. Last November a show was held in Leicester; I was asked to be on the judging panel, and draw up a set of rules. So I took the bull by the horns and drafted a set of rules which emphasized mineralogy rather than pretty minerals. Briefly, each exhibit should have a theme, or concept, and the bulk of the marks (65%) were awarded for the presentation of that theme, whatever it was. Twenty-five percent of the marks were for identification and labelling, and only 10% for quality of specimens. To quote from the rules: "As regards quality, it is anticipated that most displays will make use of self-collected specimens; a well presented display of moderate quality, self-collected specimens will receive more marks than a poor display using top quality purchased specimens. (In this respect we differ from our transatlantic colleagues; in American competitions quality is one of the prime factors and, consequently, the wealthier the collector, the more likely is his chance of winning.)"

In short, I was asking the clubs to put on interesting and educational displays from which people could learn something of mineralogy. And I think the idea succeeded.

Back to the editor:

A common complaint, as mentioned by Harold Dunn, is that judges often seem to be no more than appraisers, and that mineral competition is largely a matter of seeing who can pack the highest dollar value into a case. I cannot really sympathize with this view. Taste is a critical factor; a specimen can be expensive beyond belief and still be a dog; the purchaser of it shows thereby his lack of taste. However the truly fine counterpart to that expensive dog must also be very valuable; it is valuable *because* of its quality, beauty and rarity. One should not complain that the same factors which people invariably judge as being desirable are also the factors which give a specimen a high dollar value. In reality it cannot be any other way; a "sleeper" may occasionally be found, but it is a sleeper because its selling price is far below its actual value, which *must* be high if it is a truly fine piece. I label all such complainers as sour grapes who are envious of those with the financial means to better satisfy their taste in minerals. Museums do not feel compelled to limit their displays to low-value items; on the contrary, they often display priceless treasures. Private collectors with the same ambition should not be discouraged. We should instead be delighted that the well-heeled collectors choose to display their treasures for us to see and enjoy. At the same time we should be proud to display our own collection; it is the evidence of our taste (within the context of our own financial means), as well as the extent of our interest in mineralogy.

A pattern can be seen to emerge from these discussions: the dichotomy of education vs. entertainment. Proponents of either side seem curiously uncompromising, and seem to insist that we must *choose* between the two. This assertion is not necessarily true, and is therefore probably the crux of the problem. People can compete using taste as the critical factor just as well as they can using education as the critical factor. We need not restrict ourselves to one or the other.

Some people (including our publisher) feel that there can never be an end to controversy where opinions on nebulous factors such as "quality" are involved. This is undoubtedly true, and perhaps we should stop bedevilling the rules committee and just learn to enjoy the controversy, or retreat into the non-competitive category if we are too dissatisfied with the way competitions are run. Happily, people are free to do this if they wish. Many prefer non-competitive display as sponsored by the Pasadena Show and others, because they are then free from the rules. They can have duplication if they wish; they can have lengthy labels with unconventional types of information on some pieces and short labels on others without worrying about points off for "inconsistency" or minor misspellings; they can choose any background color or lighting or showcase design that they wish; if they wish to get creative, the sky's the limit.

But some people feel the urge to compete. To them the chance for victory and recognition is a strong motivating force. There are many who wish, through the rules, to handicap the wealthier collectors in some way so as to give us ordinary folk a chance, at least, of winning something, and to protect us from being at a financial disadvantage.

So what should the goals of competition be? Exhibitors already have their own goals; why try to force them toward someone else's idea of a proper goal? If a person wants to pit his "pretty minerals" against someone else's he should be allowed to do so with a minimum of encumbrances and rules (obviously I differ with Neal Yedlin on this point). On the other hand, if a person wants to educate people with a display illustrating pegmatite zoning, for instance, he should be allowed to compete with others of similar bent, under rules related to educational accuracy and effectiveness. As a third alternative, a person my wish to display his entire, diverse collection with a labelling approach that illustrates and maximizes the educational potential of each piece, as Henry Fisher proposes. However, in the case of the people first mentioned above, the people who do not *want* to put an emphasis on education, the rules are currently oppressive and discriminatory, in my view. There is an educational snobbishness operating against them...a feeling that *all* displays should be educational beyond the simple viewing of specimens, and not just those displays entered in the "educational" category. I feel, however, that the urge to entertain rather than educate should not be interfered with.

I may draw some fire for seeming to come out against educational displays. But that is not what I am doing. I simply propose that the categories of display be drawn to reflect the needs of the exhibitors. I suggest three categories: *thematic educational, non-thematic educational*, and *open*. The first is the normally accepted educational category; the second is what many wish to make of the "non-educational" mineral competitions today: a display of minerals that is more than just "pretty pieces". Many of the suggestions voiced by Neal Yedlin and others in this forum could be applied here, and the rules would be strict. I differ with Fisher on this: if an educational approach is to be required, I think we might as well classify it as an educational display. However the third category is the new one. The only criterion would be correct mineral name and locality on the labels. From there it would simply be a test of who has the best minerals, and people could be as free in their approach as they could for a non-competitive display. Here would be the place for people who feel mineral collecting is *minerals*...not background cloth or machine-printed labels or arbitrary rules against "duplication" or "inconsistency", or even misspellings. And yet they could have the thrill of competition, with quality the only factor.

As to the problem of giving us a chance against the wealthy collectors, I don't think that is a reasonable request. If their specimens are better (and therefore more valuable) they should win, all other things being equal. However we can change the divisions to reflect the fact of life that some collectors have better financial means than others. The Master-Intermediate-Beginner categories could be loosely redefined to reflect financial rather than experience levels. Entrants in the Master category should have a number of specimens that are getting close to the world's best, and the quality-value level should be comparable with museums although not expectedly superior. Intermediate and "First Level" categories would be where the rest of us would compete. A novice category could be retained for first-time exhibitors if desired.

The above categorization leaves people free to compete in the way they wish, with the people they choose. As far as the viewer is concerned, it is immaterial whether specific exhibits are in competition or not. What matters to him is simply how many worthwhile exhibits are available to be seen. In my judgement the important goal of the rules committee should be to encourage more collectors to display; the rules must therefore be accommodating. Too many people with fine collections have given up public display because the rules of competition are too much of a hassle, and non-competitive display offers insufficient reward. We will all benefit if we can lure them back. And we will all have more fun if we have more freedom in competition ourselves.

W.E.W.

The Story of

THE ONTONOGAN COPPER BOULDER*

by Hope Pantell
Editor, Smithsonian Press
Washington, D.C.

Indians worshipped this copper boulder; many white men wanted it; and in 1843 the War Department seized the 3,000-pound mass from the man who had finally succeeded in moving it from its site along the Ontonagon River. This is the story of the legendary Ontonagon Copper Boulder, which will be on display at the Detroit International Gem & Mineral Show, (October 15-17), on loan from the Smithsonian Institution.

Much of the history presented here was derived from an 1895 report of the U.S. National Museum by Charles Moore, *The Ontonagon Copper Bowlder (Boulder) in the U.S. National Museum.*

Copper, a metallic element found widely in nature in many parts of the world, was known and used even in prehistoric times for ornaments, tools, weapons, and utensils. Before the arrival of Columbus, North American Indians valued copper as a symbol of wealth and position, as well as for what they believed were its supernatural powers.

When the first white men reached the wilderness around Lake Superior about the middle of the Seventeenth century, they found pieces of copper weighing from ten to twenty pounds among the Indians' most cherished possessions, passed down from generation to generation and often regarded as household gods.

Those early French explorers and Jesuit missionaries had come across evidence of what was to become one of the world's great copper-producing regions—located on Michigan's Upper Peninsula. Indian tradition told of great masses of copper there, weighing hundreds of pounds, which were worshipped as manitou (spirits or deities dominating the forces of nature).

In 1669 the French government sent Louis Joliet to search for copper deposits in the area, but Joliet instead went on to discover the Mississippi River together with Father Marquette.

Apparently, it was not until almost a century later that the first white man actually saw the Ontonagon Boulder. He was Alexander Henry, an English adventurer and fur trader, who made two trips up the Ontonagon River—in 1765 and 1771. Although Henry and his associates visited the boulder—located on the west bank of the west fork of the river—they failed to find extensive copper deposits. It is now known that the boulder had been transported by glaciers for some distance from the copper veins.

Writing in 1809 of his travels, Henry was unimpressed with the region's copper potential, "The copper ores of Lake Superior can never be profitably sought for but for local consumption...." Henry was no geologist—and he was entirely wrong in this estimate, for the great Michigan copper district has produced 5,400,000 tons of copper having a value of $5,724,000,000 (as of July 1971).

It was not until 1819 that the first exploration of the Lake Superior region was undertaken by the United States Government under the direction of Gen. Lewis Cass, then governor of Michigan Territory.

After inspecting the Ontonagon Boulder, Cass wrote to Secretary of War John C. Calhoun:

> Common report has greatly magnified the quantity, though enough remains...to render it a mineralogical curiosite....It was impossible to procure any specimens, for such is its hardness that our chisels broke like glass. I intend to send some Indians in the spring to procure the necessary specimens. As I understand the nature of the substance, we can now furnish them with such tools as will effect the object. I shall, on their return, send you such specimens as you may wish to retain for the Government or to distribute as cabinet specimens to the various literary institutions of the country.

---

* originally published by the
SMITHSONIAN INSTITUTION PRESS
Washington, D.C. 1971

According to Dr. Henry R. Schoolcraft, a mineralogist who was a member of the Cass expedition and who realized that there must be large copper deposits in the vicinity, "the quantity [of the boulder] may... have been much diminished since its first discovery, and the marks of chisels and axes upon it, with the broken tools lying around, prove that portions have been cut off and carried away." Evidence of such attempts can be seen on the boulder today.

Though diminished, enough of the giant copper mass remained to defeat the Cass party's efforts to move it very far from the river bank. About thirty cords of wood were cut, placed around the boulder, and set on fire. When the copper was hot, water was thrown on it. The vain hope had been that if the copper was heated and then quickly cooled, it would fracture. All that happened was that pieces of rock were detached from the main body of copper.

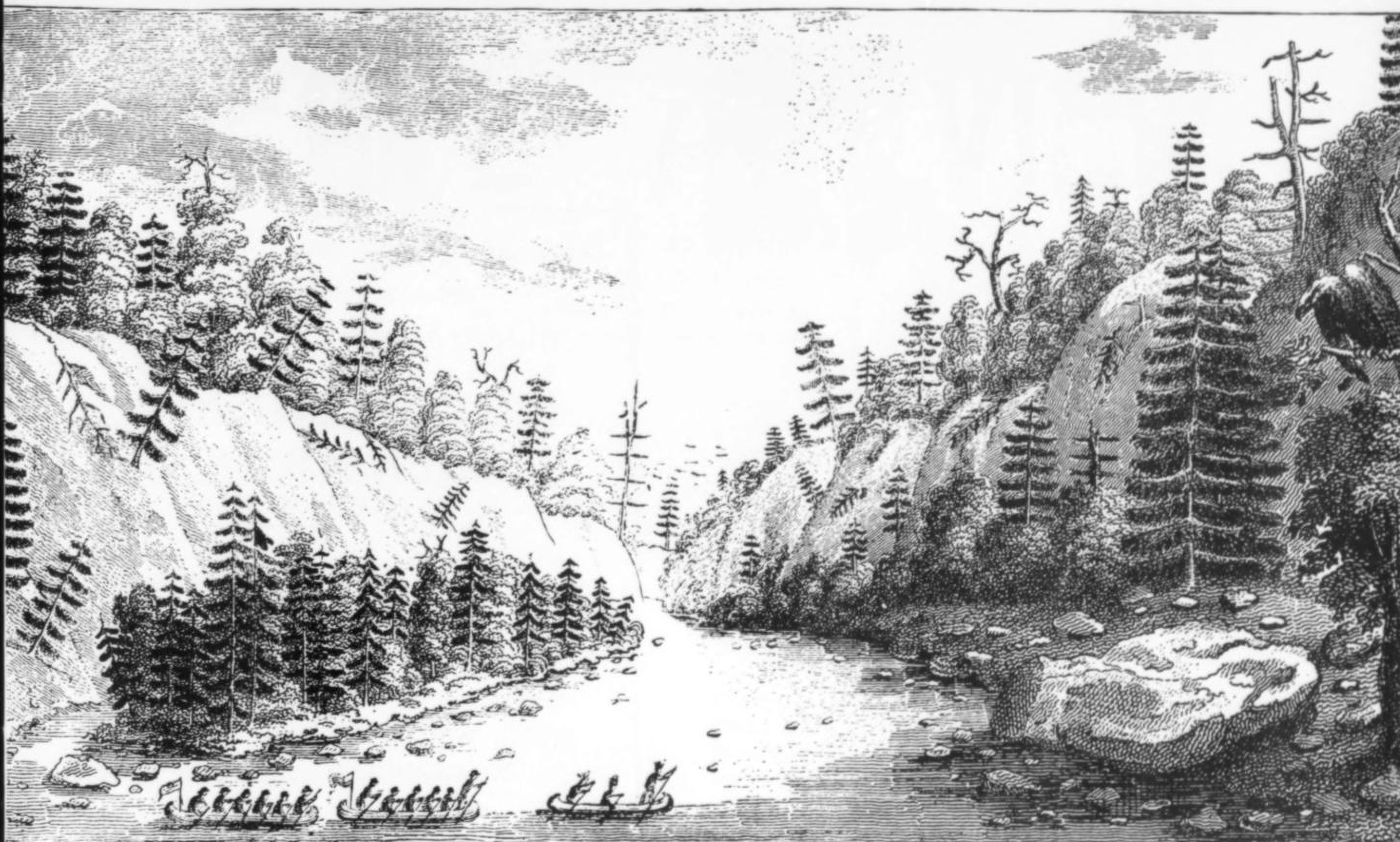
Discouraged, the Cass expedition left the site after having moved the boulder only about four or five feet from the river bank. Another expedition, starting from Sault Ste. Marie two years later, also failed to budge it.

However, Julius Eldred, a Detroit hardware merchant, heard about the seemingly immovable rock from a member of the Cass expedition. Eldred determined that he would succeed where others had failed, and for sixteen years he planned his strategy. He wasn't interested in the boulder for its value as ingot copper—it probably wasn't worth more than $600 at the time—but, as an enterprising businessman, he saw that it might be exhibited profitably for a fee as a curiosity.

In 1841, then, Eldred and an interpreter set out to buy the boulder from the Chippewa Indians on whose land it stood. He agreed to pay $150 for it; $45 in cash at once and the rest to be paid in goods two years later.

The first two expeditions led by Eldred were unable to do more than raise the boulder on skids. Then in 1843 Eldred tried again. He left his home in Detroit with wheels and castings for a portable railway and car and also—in order to protect his property rights—obtained a permit from Gen. Walter Cunningham, the U.S. mineral agent, to mine the section of land on which the boulder rested.

Much to his surprise and considerable chagrin, Eldred discovered that the copper rock he had bought from the Indians now apparently belonged instead to a party of Wisconsin miners who had located the land under a permit issued directly by the Secretary of War. Thus, Eldred did the only thing left for him to do under the circumstances: he bought the rock again. This time he had to pay $1,365.



The Ontonagon Bowlder in 1819.

It took Eldred's party of twenty-one men a week to haul the boulder up a 50-foot hill by the river, whose west fork was impassable because of rapids. They made a railway track from timbers, placed the copper rock on a car they fashioned, and moved it with capstan and chains. To quote from the U.S. National Museum report of 1895:

> For four miles and a half, over hills 600 feet high, through valleys and deep ravines; through thick forests where the path had to be cut; through tangled underbrush, the home of pestiferous mosquitoes, this railway was laid and the copper bowlder (sic) was transported; and when at last the rock was lowered to the main stream, nature smiled on the labors of the workmen by sending a freshet to carry their heavily laden boat over the lower rapids and down to the lake.

At this long-awaited, triumphant point, Eldred was confronted by an order from the Secretary of War to General Cunningham, directing that the copper boulder be seized for transportation to Washington.

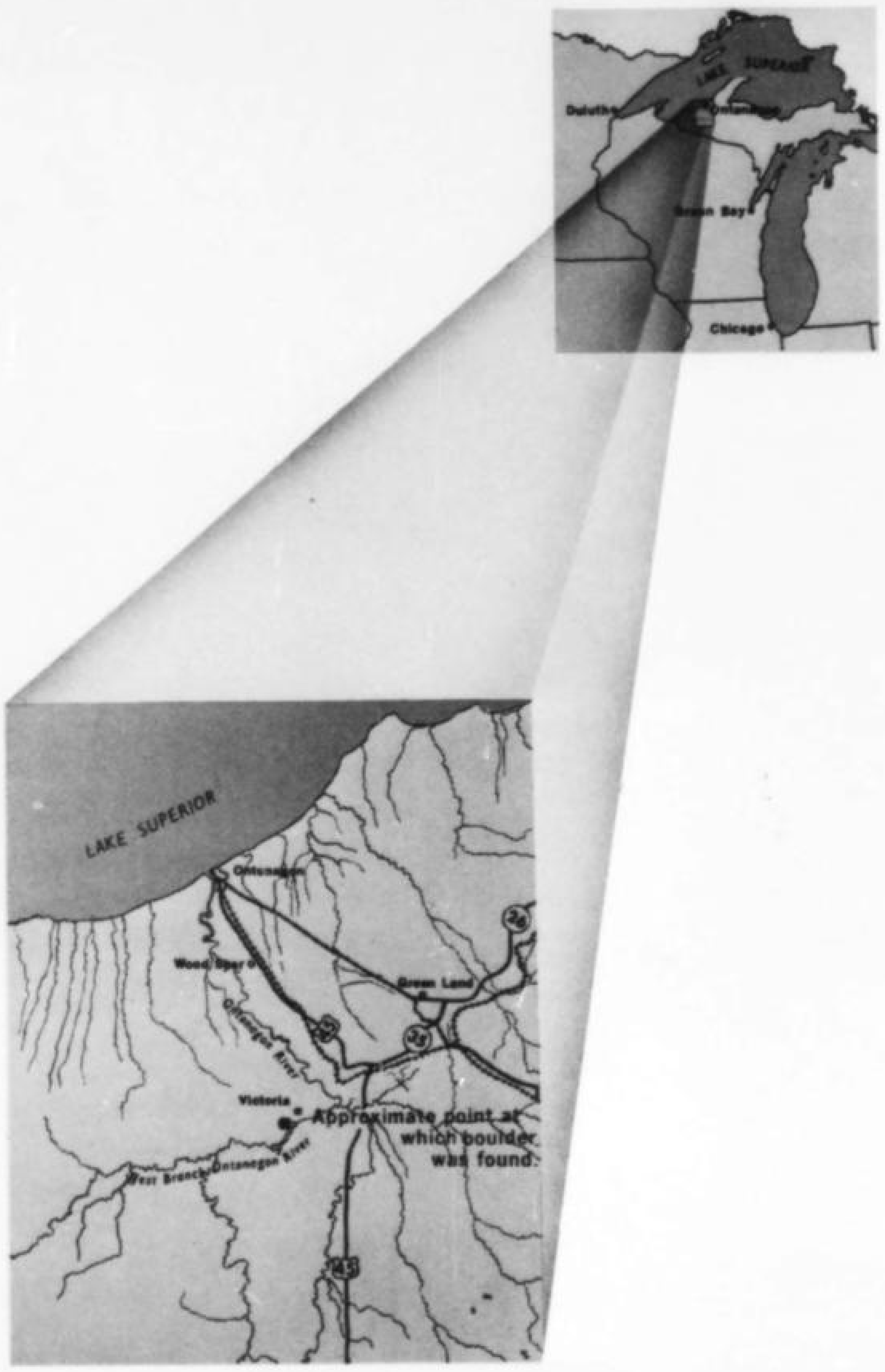
"The persons [Eldred and his sons] claiming the rock have no right to it," the Secretary decreed, "but justice and equity would require that they be amply compensated for the trouble and expense of its removal from its position on the Ontonagon to the lake; and for this purpose General C. will examine their accounts and allow them the costs, compensating them fully and fairly therefore, the sum, however, not to exceed $700...."

It will be recalled that—aside from the years of planning and the backbreaking work that had gone into the project thus far—Eldred had paid $150 the first time plus $1,365 the second time for the Ontonagon Boulder. This total of $1,515 was more than double the Secretary's top offer of "full and fair" compensation.

In view of this, General Cunningham agreed to allow Eldred to transport the boulder to Detroit, and on October 11, 1843, it was placed on public exhibition there for a fee of twenty-five cents.

Eldred had been exhibiting his rock for less than a month, however, when the U.S. District Attorney informed him that the revenue cutter *Erie* was waiting at the dock to carry it to Washington. So on November the boulder started its long journey by way of Buffalo, the Erie Canal, and New York City.

Understandably, Eldred wasted little time in appealing to Congress for redress. An exhaustive report on the Ontonagon Boulder and Eldred was made at the first session of the Twenty-Eighth Congress, and three years later, by an act of January 26, 1847, the Secretary of War was authorized "to allow and settle



The boulder was found on the West Branch of the Ontonagon, near its junction with the main river, in what is now Ontonagon County, Michigan.

upon just and equitable terms the accounts of Julius Eldred and sons for their time and expense in purchasing and removing the mass of native copper commonly called the copper rock." In the final settlement, Eldred received $5,664.98. (This is considerably more than its value as ingot copper today—about $1,590 in July 1971.)

The Ontonagon Boulder remained in the yard of the Quartermaster's Bureau of the War Department until 1855 when it was transferred first to the Patent Office and then, in 1858, to the U.S. National Museum. It was placed in its present position in November 1971. And there it rests after many adventures and many years.

Such large masses of native copper are no longer found, and its like is not to be seen elsewhere. The Ontonagon Copper Boulder is a unique specimen of its kind.

BERYL- A REVIEW

by
Richard V. Gaines
Hoffecker Road — R.D. #1
Pottstown, Pennsylvania 19464

Photos by
Wendell Wilson
except where noted

ABSTRACT

Beryl is the commonest of the 52 known minerals containing essential beryllium. It is found principally in pegmatites, but also to a minor extent in disseminations in granitic rocks; in skarns; schists; rhyolites; veins; and elsewhere. Beryl is mined from pegmatites and is a principal ore of beryllium, which is used in industry as an alloy with copper or nickel; as beryllium; and the oxide in ceramics.

Beryl is $Be_3Al_2Si_6O_{18}$ and crystallizes in the hexagonal system. Its structure is based on superimposed Si_6O_{18} rings which result in large diameter open channels parallel to the C-axis. These channels can accomodate water molecules, and atoms of Cs and other alkali metals. The Al atoms may be replaced by small amounts of Fe^{3+}, Cr^{3+}, and other ions; also a complete solid solution series is possible with Sc^{3+} substituting for Al, extending to he mineral bazzite $Be_3(Sc,Al)_2Si_6O_{18}$.

Be is present in the earth's crust to the average extent of 2 - 5 grams per ton. It is typically concentrated in silicic or alkalic igneous rocks and their derivatives.

Beryl is found in nearly every color, and the transparent varieties are important gems. These include emerald green, colored by Cr^{3+} or V^{3+}); common beryl (green or yellow green, colored by Fe^{2+}; aquamarine (blue or greenish blue, colored by Fe^{2+}& Fe^{3+}); heliodor (yellow to orange-yellow, colored by Fe^{3+}); morganite (rose pink to salmon pink, colored by Mn^{2+}); red beryl (colored by Mn^{2+}); goshenite (colorless, usually high in alkalis). Other names sometimes used to describe special composition/color varieties are vorobyevite, and rosterite.

The principal source of emerald is Colombia, where it is found in veins. Significant production also comes from Brazil and South Africa, Aquamarine comes mainly from Brazil; heliodor from Brazil and the USSR; morganite from Madagascar, Calif. and Brazil; and red beryl from the United States.

Emeralds have been synthesized by several different processes and their production is increasing. Other colors of beryl are not synthesized because their lower value makes the effort less worthwhile.

It is often useful to a crystal collector to be aware of gem material values, because some fine crystal specimens are often priced according to their **gem** *value, when it exceeds their specimen value.*

Figure 1. **Thirty-three tons of sacked industrial beryl in a warehouse in Governador Valadares, Minas Gerais, Brazil. (Sr. Rafãel Falcao at right). Photo by the author.**

I. Introduction

Beryl, the most abundant of the 52 recognized species containing essential beryllium, is of widespread occurrence throughout the world. It is a principal ore of beryllium, and its gem varieties have very great economic, aesthetic, and scientific interest. These are found in a wide range of colors, the most important gems being emerald and aquamarine. Beryl has a strong tendency to form good crystals, often of large size, and provides countless specimens, often of great beauty, for the mineral collector.

II. Mineralogy

A. Physical and chemical properties

The most usual habit is thick to thin prismatic, showing base {0001} and prism $\{10\bar{1}0\}$. Second order $\{11\bar{2}0\}$ and dihexagonal $\{2\bar{1}30\}$ prisms are also common. Pyramidal terminations are also found, especially when crystallized in vugs; common forms are $\{11\bar{2}1\}$, $\{10\bar{1}1\}$, $\{11\bar{2}2\}$, $\{20\bar{2}1\}$, and $\{2\bar{1}31\}$. In Na and Li -rich pegmatities, tabular habit flattened on {0001} is often seen, especially in vugs; such crystals may be highly modified. Crystals may reach large size, one crystal mined in 1932 in South Dakota being 2.3m in diameter and over 11m in length. Crystals weighing over 1000 kg have been found at many localities.

Radiating groups of crystals are also found, as well as acicular druses, and columnar groupings. Sectored crystals also known, as in trapiche emeralds. Also massive.

Crystal faces are often covered with characteristic growth and etching markings, which in the former case are usually vicinal hexagonal pyramids on {0001}, and in the case of solution (etching), negative hexagonal pyramids on {0001}, and negative rectangular pyramids on {1010}.

The structure of beryl consists of SiO_4 tetrahedra linked in rings of Si_6O_{18}. These rings are arranged in planes parallel to {0001} and are connected through 6-coordinated aluminum and 4-coordinated beryllium atoms which lie between the planes. The rings in superimposed planes are aligned so as to form channels through the centers of the rings, which are large enough to accomodate water molecules and ions of the alkali metals including cesium. The mechanism of inclusion of alkali metals in the composition of beryl is somewhat more complicated than a mere zeolite-like filling of holes with atoms; there is valence compensation of several kinds such as the substitution of Fe^{2+} for Al^{3+} or by the omission of a Be^{2+} ion. This results in the lowering of the Be content in high alkali beryls and the admission of Fe^{2+}, Ca^{2+}, Mg^{2+}, Mn^{2+}, Fe^{3+}, Cr^{3+}, V^{3+}, Sc^{3+}, and a few other elements, some of which, alone or in combination, account for the wide variation in color, specific gravity, and optical constants of beryl.

Inclusion of these foreign ions in the channels has little effect on the a_0 dimension of the unit cell, but does cause variation in the c_0 dimension. Pure $Be_3Al_2Si_6O_{18}$ has a theoretical cell of $a_0 = 9.20$, $c_0 = 9.17$. In high alkali beryl the c_0 dimension may increase to 9.23.

Measured specific gravity of beryls is invariably higher than the theoretical value because water or alkalis present in the channels do not enter into the formula nor do they distort the lattice to any extent, yet they do add to the total cell contents. Substitution of Fe and other heavier elements for Al or Si contribute to a smaller extent to increased observed gravities.

Refractive indices increase with content of Cs, Na, or other alkalis in the composition. The highest values are for a beryl with over 10% total alkalis.

Composition

Pure $Be_3Al_2Si_6O_{18}$ has not been found in nature. In the colorless or pink varieties especially, Na and Cs and small quantities of the other alkalis may enter the structure up to a maximum total of about 11%, with concomitant reduction of the percentages of Be, Al, and Si. Fe^{2+}, Mn^{2+}, Ca^{2+}, Mg^{2+}, Fe^{3+}, Cr^{3+}, V^{3+}, Li, and Sc^{3+} may all substitute in the octahedral Al position, and Al may substitute in the BeO_4 tetrahedra. In the channels two types of H_2O can be recognized in the I. R. spectra, and the alkalies, and Fe^{2+} may be lodged in one of at least two nonequivalent sites. H_2O is always present except in certain synthetic beryls and beryl from lithophysae in rhyolite; the average H_2O content is near 2%, and it is driven off only at a high temperature, with destruction of the beryl structure. Sc^{3+} may substitute for Al in a complete solid solution series, and compositions with $Sc > Al$ constitute the mineral bazzite, $Be_3(Sc,Al)_2Si_6O_{18}$. Since Sc has a very low abundance in the earth's crust, bazzite and Sc-rich beryls are quite rare and few complete analyses of these minerals have been made.

Diagnostic Properties

Beryl is recognized primarily through its usual hexagonal prismatic habit, common colors, and typical geologic environment; the parting is also a useful diagnostic feature. It is harder than feldspar but not enough harder than quartz to be easily differentiated from quartz on this basis. Under the microscope its higher indices of refraction and negative optic sign serve to readily distinguish it from quartz.

It is insoluble in common mineral acids and almost insoluble in HF. Before the blowpipe it is fusible only on thin edges, with difficulty. With Na_2CO_3 on charcoal it can be decomposed upon prolonged fusion.

B. Varietal names for beryl:*

1. Emerald - Bright "Emerald" green beryl used as a gem, colored by chromium and/or vanadium.
2. Aquamarine - Clear blue to greenish blue gem beryl.
3. Heliodor - Yellow to orange-yellow and greenish yellow gem beryl.
4. Morganite - Pink gem beryl, high in Cs and other alkalis.
5. Goshenite - Colorless or white beryl.
6. Vorobyevite - High alkali beryl, often pink but also white, pale blue, and other colors. Term in common use in the USSR and Europe.
7. Rösterite - Na/Li beryl, commonly white.

* The term beryl or common beryl, is used for all colors of non-gem quality beryl and industrial beryl. As used by jewelers "beryl" refers to gem quality green, bluish green, and yellowish green beryl the color of which is due to Fe^{2+} and Fe^{3+}.

8. Maxixe - a deep blue (sapphire or tanzanite-blue) beryl found in 1917 naturally in Brazil, and also induced by irradiation of some pale beryl.
9. Bixbite - Name proposed in 1912 for red beryl discovered in 1905 in rhyolite in Utah. Never accepted into common usage.
10. Bazzite - A distinct mineral, the Sc-analogue of beryl.

III. The Occurrence of Beryl

A. Geochemical abundance

Beryllium is present in the earth's crust to the average extent of 2 - 5 grams/ton. Probably much of this is in the form of discrete crystals of beryl; however much also forms other Be minerals, or Be may enter the lattice of other minerals such as vesuvianite, cordierite, etc.

Be is relatively concentrated in the granitic rocks, but very much reduced in the more mafic rocks such as basalt, periodotite, gabbro, or andesite. It is present in alkali syenites, but there it is more likely to occur in minerals other than beryl. It is extremely low or absent in sediments, especially limestones and sandstones, except where they have been subject to hydrothermal alteration.

B. Geologic Associations

Beryl may be found in a wide range of geologic environments. Far and away the most usual mode of occurrence is in pegmatites. All of the beryl of industry and most of the beryl gems are pegmatite derived.

A second association is as an accessory in granites. In this form, it may form erratic concentrations containing as much as 10% beryl or more, but the richer portions are normally restricted to scattered loci a few meters across, and such deposits discovered to date have not been commercial because the overall tenor has been too low if quantities larger than a few tens of tons are considered.

Contact metasomatic deposits may occasionally contain beryl. As a rule, however, beryllium associated with this type of deposit forms other minerals, especially members of the helvite group.

Extrusive acidic rocks that contain miarolytic cavities, especially if accompanied by topaz, fluorite, or other fluorine minerals, may contain minor quantities of beryl crystals.

Beryl and beryllium minerals show a strong geochemical association with fluorine, and to a lesser extent with tin and tungsten. Fluorine-rich metasomatic deposits almost invariably contain anomalously high concentrations of Be, in some instances approaching commercial size and concentration.

Hydrothermal vein deposits occasionally contain beryl, especially those associated with concentrations of Sn, W, or Mo minerals of primary origin. A unique example of hydrothermal veins containing beryl is the low-temperature emerald bearing veins environment of Colombia.

Beryl, including emerald, also may be found in schists, as in Austria, USSR, Egypt, Brazil, and elsewhere.

Greisens may also contain disseminated beryllium minerals, including beryl, but the concentrations found to date are too low for commercial exploitation.

C. Beryl in Pegmatites

The usual locus of pegmatitic beryl is in the feldspar zone (in zoned pegmatites), although it may penetrate a little distance into the quartz core and is also found, rather sparsely, in the intermediate (mixed) zone.

It has been estimated that the average BeO content of granitic pegmatites is 0.03%, which would be equivalent to 0.25% beryl, or one part in 400. A few pegmatites are of course richer, but concentrations found are so sporadic and irregular that estimates of grade are difficult to make, or unreliable. A typical fresh pegmatite exposure, in an actively worked dike, will show no trace of beryl, or else a concentration of log-like crystals making it appear to be very rich. After a few days work the situation may be completely reversed. Typical crystals will be a few centimeters in diameter and a few decimeters long, although as stated earlier, much larger ones are found. Beryl embedded in feldspar or quartz is normally too highly fractured to be transparent and useful as a gem, but occasionally crystals clear enough for cutting may be found within the quartz core. Most gem beryl is found in vugs near the central portion of the pegmatite mass, associated with crystals of microcline, muscovite, quartz, albite, schorl, and other minerals.

Rare metal pegmatites, especially those rich in Li, produce many of the more attractive specimens of beryl. This is especially true when the pegmatite is strongly zoned with development of albite and crystal-lined vugs. Typically, the beryl in such a setting may be colorless, pink, or pale blue, or parti-colored crystals showing zoning of these colors. Such crystals are usually tabular in habit. Accompanying minerals, also well crystallized, include elbaite, schorl, lepidolite, spodumene, muscovite, albite, topaz and quartz. Other, less common associated minerals are columbite-tantalite, cassiterite, spessartine, herderite, amblygonite, and other accessory phosphate minerals.

Beryl is a highly inert and resistant mineral and is little affected by weathering. Even in deeply altered and kaolinized pegmatites, the beryl usually remains unchanged or only moderately etched and can be recovered from the resulting eluvium. Much aquamarine is produced from such deposits, there being little danger of damage to the stones in the mining process. Since the specific gravity of beryl is near that of quartz and other rock-forming minerals, it is dispersed rather than concentrated in alluvial deposits.

Beryl, when altered, often changes to bertrandite which forms partial or complete pseudomorphs, or may deposit in fractures in the rock surrounding the empty cast after a dissolved beryl crystal. This process is usually hydrothermal in origin, rather than caused by weathering.

D. Non-pegmatitic beryl deposits

The most important non-pegmatitic beryl deposits are conventional quartz veins carrying beryl as a major accessory, sometimes accompanied by Sn, W, or Mo minerals. Such veins have been commercially mined in the USSR and in China, and the potential for substantial additional production is good when justified by market conditions.

A vein of this type was found at Brown's Gulch, Mt. Antero, Colorado, accompanied by much molybdenite; it was mined at one time for aquamarines. Other beryl-rich veins are known in Spain (with cassiterite), Germany, Brazil, and elsewhere. Sometimes the beryl is associated with phenacite, euclase, or bertrandite. The Colombian emerald veins are a special type of low-temperature vein deposit (see Feininger, 1970, in M.R.).

IV. Beryl in commerce

A. World Production

The principal producers of beryl (industrial) are, in order of importance, (1) Brazil, (2) South Africa, (3) Argentina, (4) Uganda, (5) Mozambique, and (6) Australia. The Soviet Union produces a moderately large tonnage, and if the figures were known would probably also fit in this group. About another dozen countries are occasional producers.

World production, which has never exceeded 12,000 tons (metric) per year, reached its peak during the years 1956-1961, and has declined steadily since that time. The average, 1951-1963, was over 8,000 tons/year, while the decline since 1969 has been dramatic, reaching an estimated 2,500 tons in 1974. This can be ascribed to several interrelated causes, but principally the decline in price due to competition from the Spor Mountain bertrandite ores which were first exploited in 1969. As a result the price of beryl today and since 1970 has been less than at any time since 1951; as all other costs during that interval have doubled or quadrupled, mining for beryl in most deposits is no longer profitable. Added to this is the depletion of some of the more important deposits. It is estimated that today at least half of all beryllium is derived from bertrandite ores of Utah.

The beryl production in individual years fluctuates sharply, partly because most production comes as a by-product of other mining activities and, as such, tends to be sporadic. The beryl produced, moreover, may be stockpiled for months or years before being released to world markets.

Few if any beryl mines contained measured reserves of the mineral, since the occurrence in any individual pegmatite is so erratic that systematic exploration techniques such as trenching or drilling are ineffective. In Brazil, which is typical, few pegmatites are exploited mainly for beryl. Most are exploited for feldspar, mica, lithium minerals, columbite tantalite, or gems. Many such mines are worked on a very small scale, entirely without machinery and by only one or two miners ("garimpeiros"). The beryl they produce may amount to only a few hundred kilos in a year's time. There are literally hundreds of such mines, which in the aggregate may produce 1,000 tons or so of beryl annually. Naturally, in such circumstances accurate statistics are hard to obtain, especially as the beryl so produced usually passes through the hands of several middle-men who clean, sort, sample, bag, and accumulate it into lots large enough for export. The amount of beryl produced in any given year depends principally on economic factors; when times are good and jobs in industry are easy to get, many garimpeiros prefer the certainty of daily wages to the uncertainty of scratching for gems in a garimpo (mine). Hence production falls. On the other hand, when times are hard, more garimpeiros take up mining and by-product beryl production rises.

B. Uses

Apart from the use of beryl as a gem which will be considered separately, all industrial beryl is used in the manufacture of beryllium metal, alloys, ceramics, and compounds.

As pure metal, the applications of beryllium are very limited, being confined largely to space hardware and missiles. As such, national governments are the principal and practically the only customers. Wider use is inhibited by the very high cost of the metal ($125./Kg. and up) and its inherent brittleness. Minor uses of Be metal are for X-ray windows and telescope mirrors for satellite observatories.

By far the largest use for Be is in the manufacture of beryllium copper. This alloy, which normally contains 97+% copper, about 2% beryllium, and a trace of cobalt, has the property of age-hardenability, which means that by annealing the alloy at about 400° C for several hours it will take on the physical characteristics of a mild steel. In addition, the alloy is chemically inert (rust free) and an excellent conductor of electricity. It has exceptional resistance to fatigue; springs produced from beryllium copper can be flexed billions of times without mechanical failure. Beryllium copper components are used in a host of industrial products, including electrical and electronic equipment—telephones, toasters, television sets, switches, undersea cable relays, bearings for airplane engines, non-sparking tools, fishing tackle, and altogether a list of products far too long to enumerate.

Beryllium is alloyed to a minor extent with other metals, principally nickel (beryllium nickel is similar in properties to beryllium copper, but even harder and tougher) and aluminum.

Beryllium oxide is an important ceramic for certain very specialized uses because, while being an excellent dielectric, it is an excellent conductor of heat and is highly refractory.

Other beyllium compounds find minor specialized uses in industry.

C. Toxicity

Certain beryllium products are highly toxic, notably the oxide and the powdered metal, especially if introduced into the lungs as dust, or into a cut. They produce a condition known as berylliosis, which in its extreme form can be fatal. Before this fact was recognized, in the early 1940's, a number of people engaged in the manufacture of beryllium products became sick and some died; there seems to be a predisposition to the disease in a small proportion of individuals, whereas the majority may be unaffected. There is no cure for berylliosis, once contracted.

Beryl itself or its powder have no known toxic effects.

V. Beryl Varieties

A. Emerald

Emeralds when nearly flawless, of good size, and of the best color, are the second most expensive gemstones, being exceeded in this regard only by the finest rubies.

Figure 2. **Beryl (variety emerald), Gachalá mine, Chivor district, Colombia. This crystal, probably the finest uncut emerald in the world, is known as the "Gachalá emerald"; it weighs 858 carats and measures about 4 x 4.3 x 6 cm. Smithsonian specimen, donated by Harry Winston.**

The term "nearly flawless" is used because large fine emeralds that are free from flaws visible with a loupe are virtually unknown.

From ancient times up to the 16th century all emeralds were derived from Egypt, Austria, or Russia, and other places in the Old World, and all these deposits were in schist. Since the discovery of the New World, the great majority of the world's finest emeralds have come from Colombia, where in a large region of the state of Boyacá there are a score or more of known deposits, all of them low-temperature veins in sediments of various kinds. The principal deposits are Muzo, Chivor, Cosquez, Gachala, and Peña Blanca. The subject of the origin and characteristics of emeralds from various localities, and their history, is one that has been treated by many investigators, and is too large to be covered more than briefly here. In recent years there has been substantial production from Brazil (near Carnaiba and elsewhere in Bahia) and from South Africa in the Transvaal. Both of these deposits are in schist, and while the finest stones from the mines are equal or nearly equal to those from Columbia, the really good ones have been found only in very small sizes, seldom exceeding 3 carats.

The physical characteristics of emeralds are as follows:

n_0 1.576 - 1.593 Birefringence .006 - .007

n_ϵ 1.569 - 1.586 Specific Gravity 2.69 - 2.77

Color in emerald is due to chromium, in the range 0.14% - 0.50%. When viewed through a Chelsea filter which cuts out all light except fluorescent red, natural emeralds look red, and this was long considered an infallible test for the gem. More recently it has been recognized that vanadium alone can give a fine emerald green color to beryl, and many emeralds contain both Cr and V, some with V in excess. Also it is now known that a little iron will quench the red fluorescence of emerald. Such stones do not give as red a color with the Chelsea Filter as those with Cr in excess, and if there is no Cr at all there is no red produced. This is therefore no longer considered a useful test.

The recognition of emerald and distinguishing of natural from synthetic stones is done on the basis of the indices of refraction, the color spectra, and especially the appearance of the micro imperfections and inclusions. The dark red fluorescence of most synthetics is a very important diagnostic tool in differentiating them from natural stones. The finest natural emeralds in a one carat size (range) have a wholesale value of $3,000 to $4,000/carat. Three to five carat stones are worth $5,000 to $8,000/carat. Stones over ten carats of the finest color are very rare and their value is upwards of $10,000/carat.

B. Other greenish colors

The common colors of industrial beryl, and of gem beryl as well, are shades of green: yellowish green, bluish green, greyish green. This range of colors, even in a gem, is not blessed with a special name, but is usually called beryl. Stones with these colors merge insensibly into emerald, aquamarine, and heliodor, and shades approaching any of these more appreciated varieties are invariably called by the more desired name. In spite of the fact that some of these yellowish green and bluish green varieties are extremely attractive, they command a much lower price than either fine aquamarine or heliodor, in the range of $15 - $40/carat wholesale for stones in the 10 to 25 carat range. The range of values is large because of the wide range of shades of color which are collectively classified as green. Because of the large difference in value between emerald and beryl, the dividing line between these stones has been rather rigidly defined. Nevertheless some stones come so close to this line that they command intermediate prices.

C. Aquamarine

Any clear blue beryl is called an aquamarine, but because of differences of intensity of color this stone can range from a washed-out pale blue of little attractiveness or value to a rich sky-blue color. Gemologists subdivide aquamarine colors into 12 categories of increasing intensity—the best color, #12, is known in Brazil and elsewhere in the trade as "Marta Rocha" after a famous crystal of large size and superb color that came to light about 15 years ago. Subsequently other stones of this quality have been found, but not many. The median wholesale value of good blue stones in the 8 - 10/ct. range would be $70 - $90/carat, whereas 10 - 25 carat stones of the best color would be at least $250/carat today.

The color of aquamarine is due to ferrous iron, in the range of 0.1% - 0.3%, in the axial channels at site "B" (Wood and Nassau, 1968). Ferrous iron in site "A" or replacing Al, imparts no color to beryl. The other properties are as follows:

n_0 1.575 - 1.585 Birefringence .006

n_ϵ 1.570 - 1.580 Specific Gravity 2.70

Many large stones of very good color have been found over the years. One of the largest was found at the Marambaia mine in Minas Gerais in 1910. It weighed 110 kg

***Figure 3.* A portion (wt. 6.0 kg) of a large aquamarine found in 1967 at Tres Barras, Minas Gerais, Brazil, being held by Sr. Aziz Cury, who purchased the crystal. Photo by the author.**

and is said to have been so clear that a newspaper could be read through the crystal looking down the c-axis, the crystal being 48.5 cm long. A fragment of this crystal weighing 6 kg is still to be seen in the Morgan gem collection at the American Museum of Natural History, New York.

More recently in 1967 at Tres Barras, Minas Gerais, a fine gem crystal was uncovered by a bulldozer being used to build a road to a microwave relay station. The crystal was about 1.0 m long and 18 cm diameter, and it also was near 100% gem transparent. The writer had the opportunity to examine a portion amounting to about 1/4 of the original crystal before it was cut (see Fig. 3). Although the find was made in an area which had produced many fine gems in the past, it precipitated a new rush which resulted in the find of many additional stones; however, none of the subsequently found crystals equaled the first one in size.

By far the largest portion of the world's aquamarine has come from Brazil, mostly from the state of Minas Gerais. Other productive areas are Madagascar, the USSR, Mozambique, and to a small extent in past years S.W. Africa, U.S.A., India, Eire, and others.

The color of aquamarines as mined usually contains a trace of green, due to a yellow color component caused by ferric iron substituting for octahedrally coordinated aluminum. Although this slightly greenish blue is often strikingly beautiful, comparable to the color of the tropical sea over a sandy bottom (the true derivation of the word "aquamarine"), fashion dictates that the color should be pure blue; hence any greenish tint is penalized in the price of finished stones. Long ago lapidaries discovered that by heating the stones for a short time at about 400° C, much of the yellow component which accounts for the greenish tint will disappear, leaving a stone with only blue color. This change is permanent but it can be reversed with gamma radiation. For this reason, every cutter in the gem regions will have a little electric muffle furnace in his workshop, and nearly all aquamarines, plus many other stones, are routinely heated for color enhancement. The heating is done after the stone is cut, for if it is done to rough crystals, imperfections which are normally present may develop into full fledged fractures ruining the stone. Hence uncut crystals can be presumed to have natural color.

There is one type of aquamarine which is even deeper colored than the "Marta Rocha" stones, and that is the so-called "Maxixe" beryl. The original stones were discovered in 1917 in northeastern Minas Gerais. They were a real sapphire-blue, almost cobalt blue. However, after a few days exposure to daylight they faded to colorless, or turned yellow or tan. No further mining was done, because of this; however, about four years ago numbers of deep blue beryls rather mysteriously appeared on the market, which were alleged to have been found at a new locality. Unfortunately, they also faded, but not before some had been sold at very high prices. It was subsequently established that this color could be produced by treating certain pink or pale beryls to intense gamma radiation or to neutrons in a nuclear reactor or to other radiation. Undoubtedly this is what had been done, repeating in 1972 what had been accomplished by natural radiation prior to the 1917 find. After fading, the deep color can be restored by irradiating again, but it cannot be made permanent. Despite this revelation, stones of this type continue to appear on the market.

D. Heliodor

Heliodor, or yellow beryl, is much less common than aquamarine, yet the best stones, of a rich golden-yellow tint, are very striking. The color of natural stones ranges from pale greenish yellow to brownish yellow, and the yellow color is caused by ferric iron substituting for aluminum in octahedral coordination.

The mean refractive index is 1.57, Birefringence .006, specific gravity 2.67 - 2.69.

Fine stones were early found in the USSR; however, like aquamarine, most heliodor now comes from Brazil. Minas Gerais has produced it from a number of localities, but in recent years the most prolific source both of cut gems and fine crystallized specimens has been a mine on Serra da Mesa, near Minacu in east central Goias state. This mine has also produced important tonnages of industrial beryl.

Fine heliodors have been found in several other countries including, in small quantities, the United States, both in Connecticut and in Maine. The wholesale value of yellow beryl stones, in the 10 - 15 carat range, is about $7 to $10/carat. The better quality of golden yellow heliodor would be in the $20 to $30 range. The finest quality of rich, deep golden-brownish-yellow has become very scarce and are seldom seen in the gem trade. When occasionally seen they bring prices of $50/carat and upwards. In contrast to aquamarine, heating only destroys the color

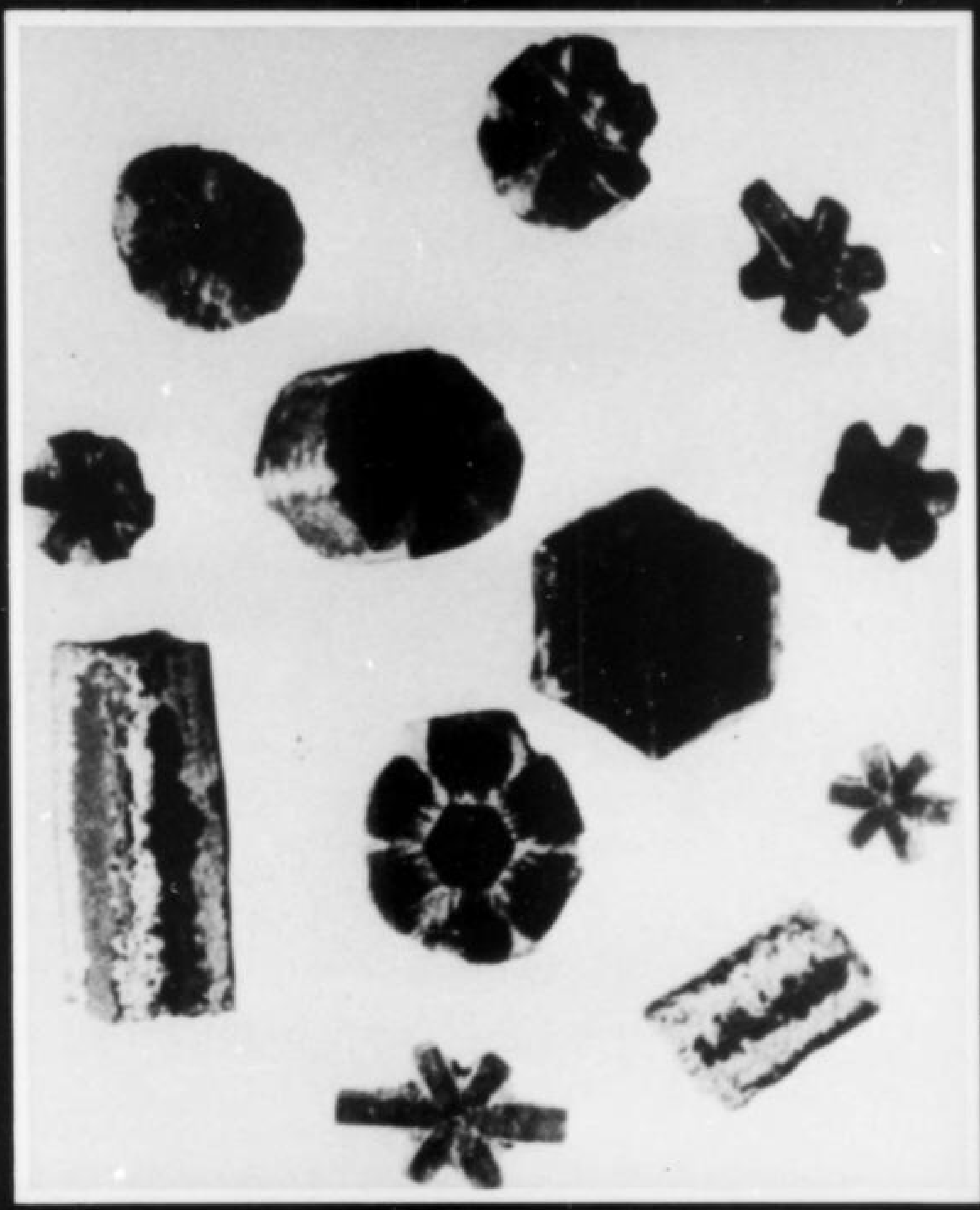
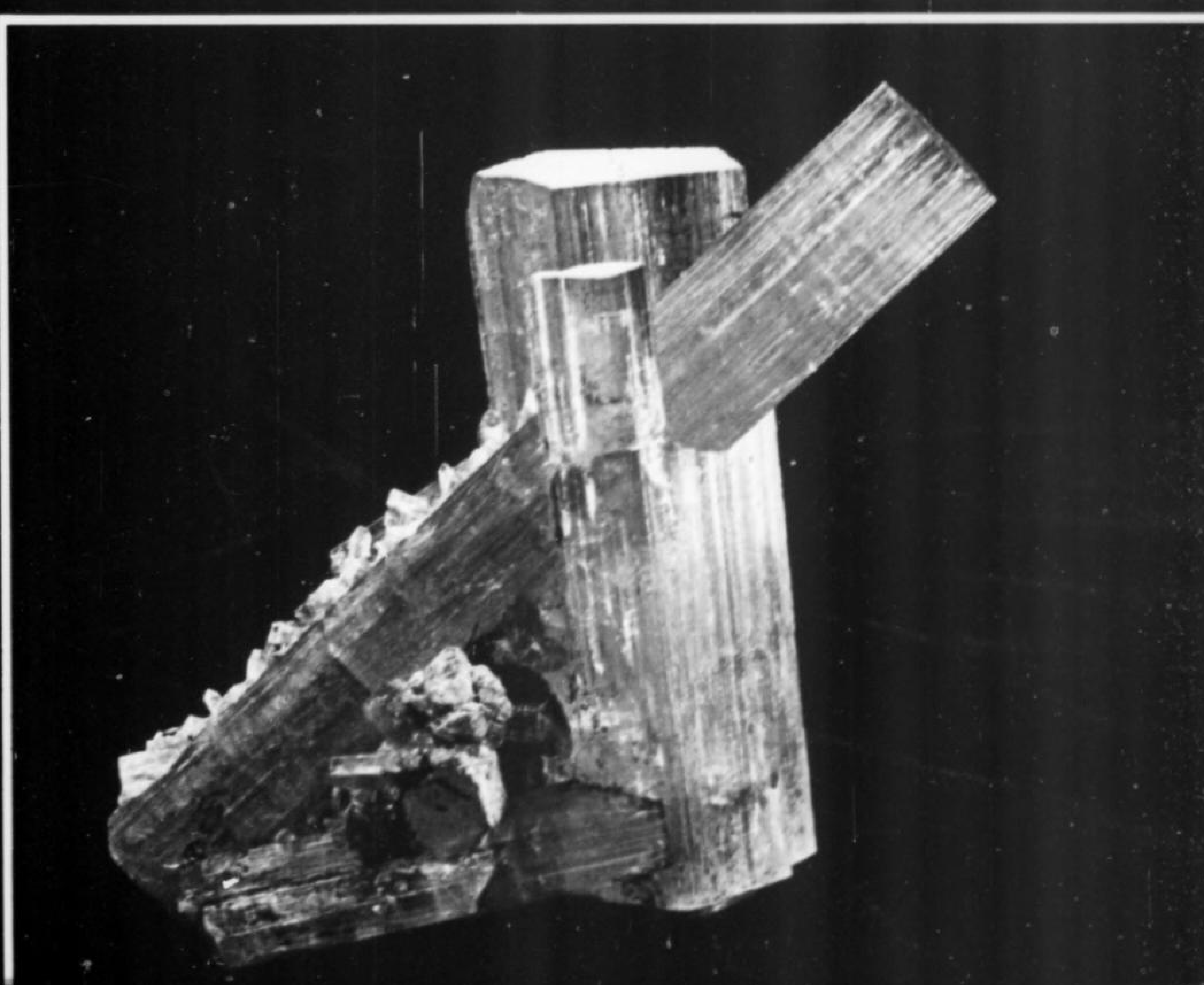
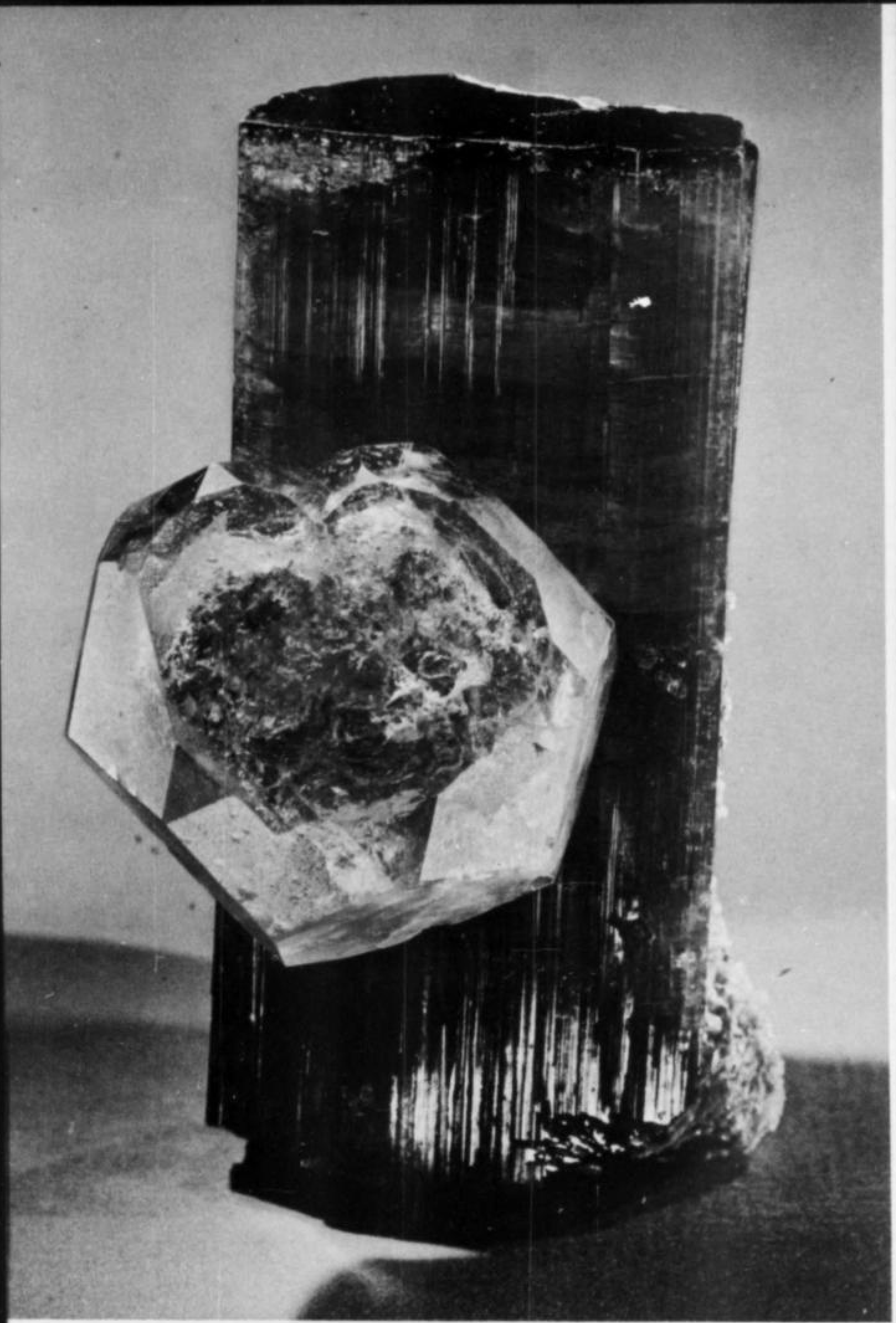


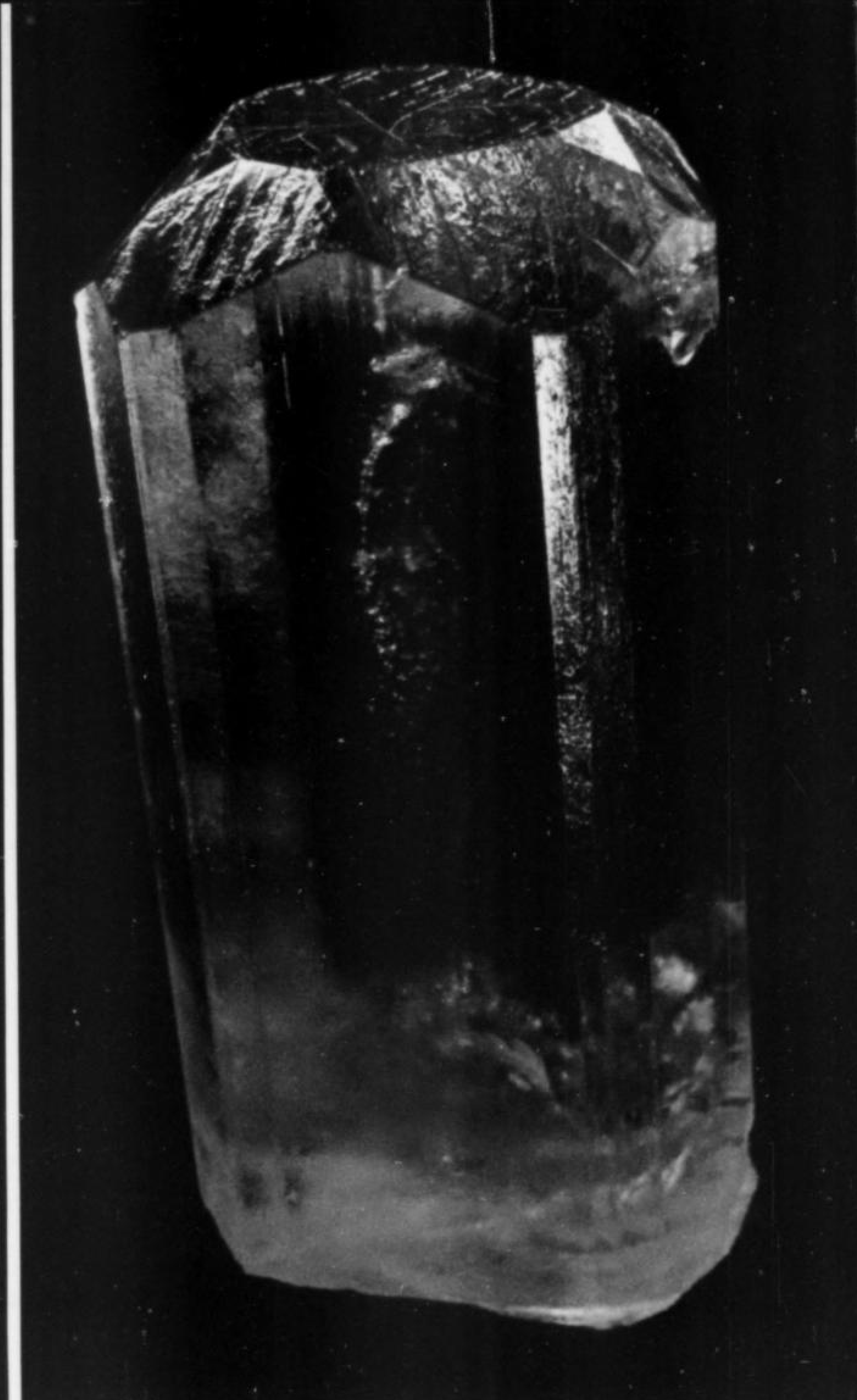
Figure 4. (above) **Specimens of a variety of beryl known as "trapiche" emerald.**

Green beryl, Figure 5. (above) **Conselheira Pena district, Minas Gerais, Brazil. This specimen is unusual in that the crystals have re-entrant angles suggestive of twinning. The specimen is 12 cm tall. Smithsonian specimen.**

Green beryl, Figure 6. (below) **Alabaschka, Siberia, U.S.S.R. The longest crystal is 11 cm; the small crystals along the diagonal crystal are topaz. Smithsonian specimen.**



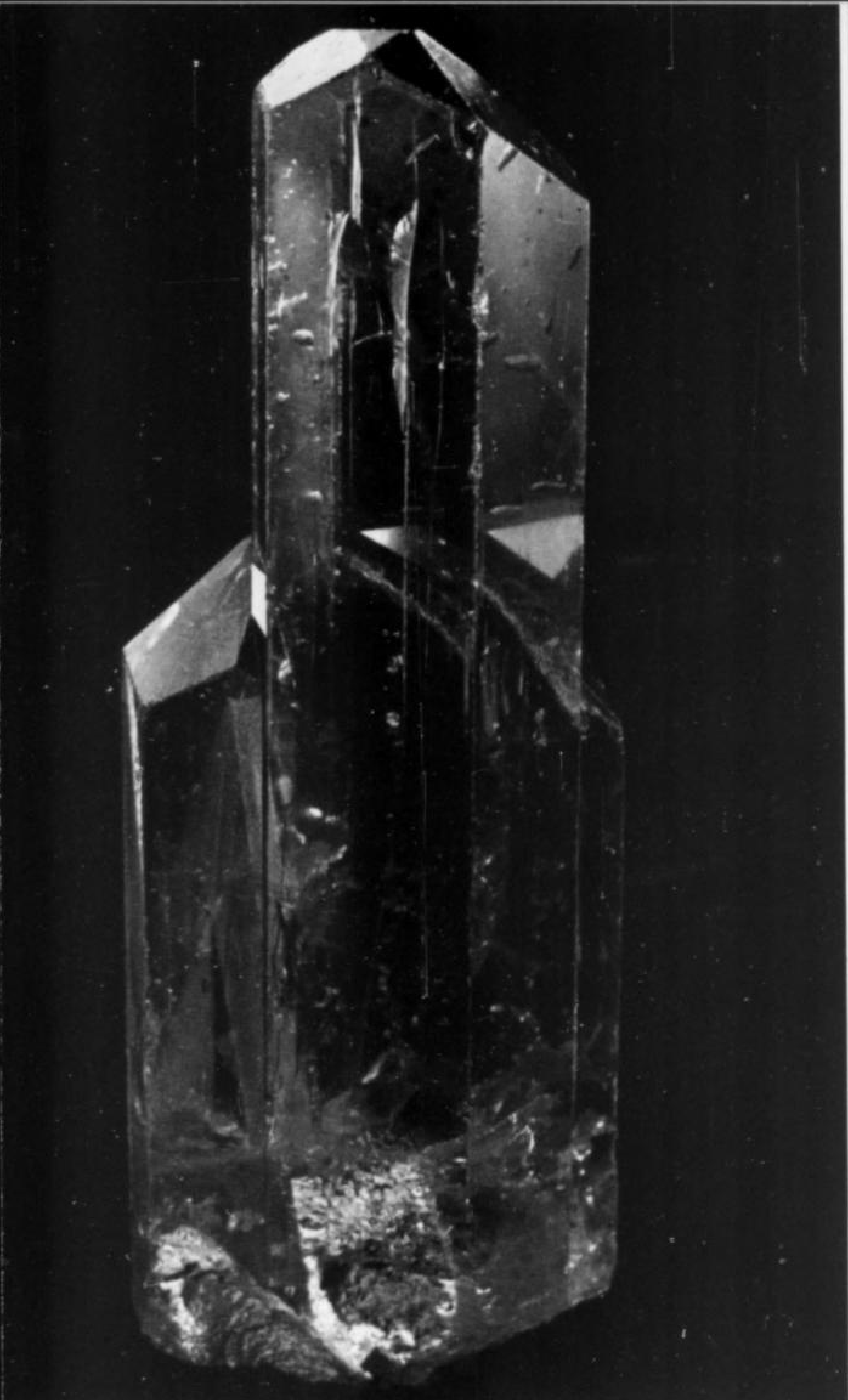


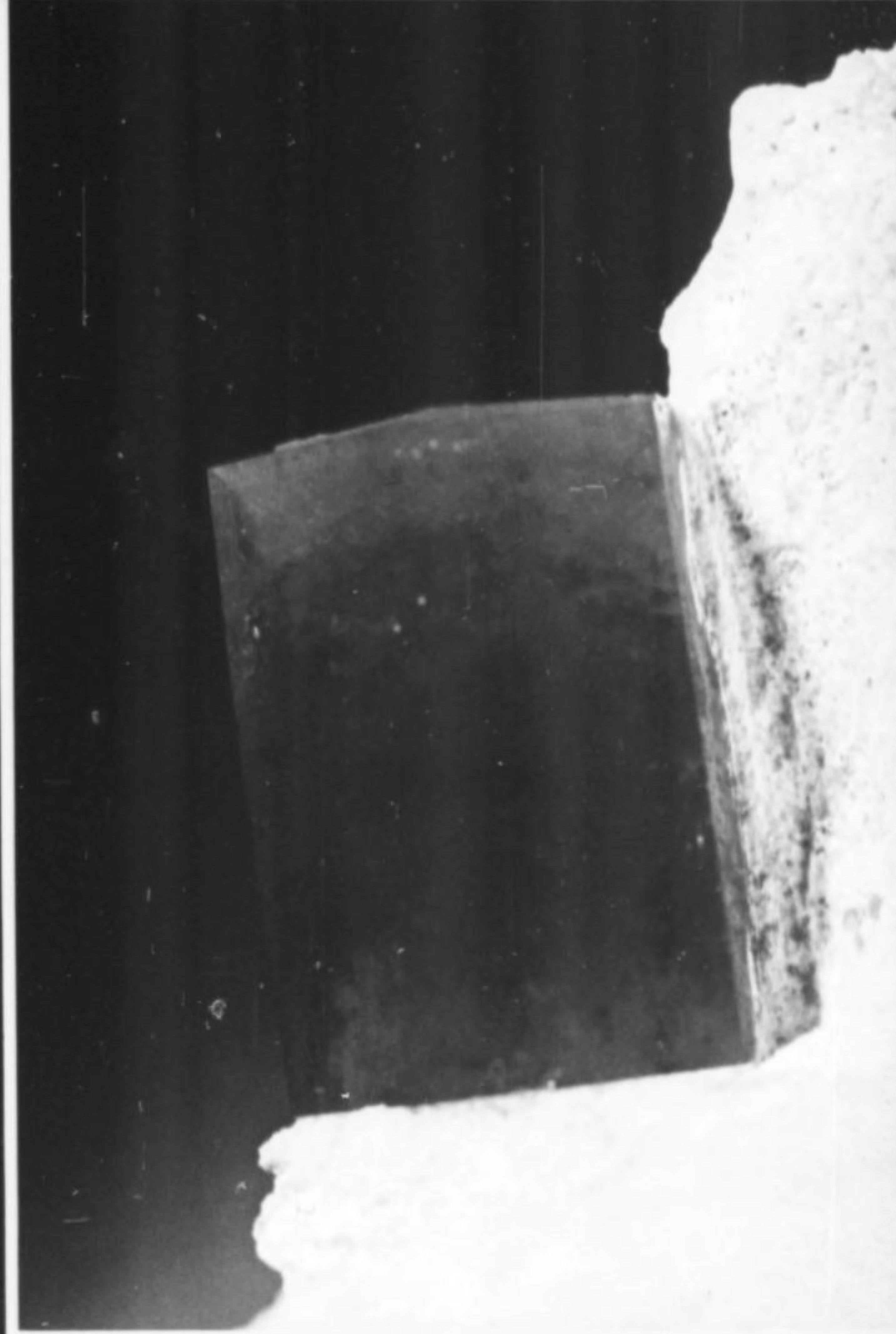


Morganite (var. of beryl) on elbaite tourmaline, Figure 7. (above left) **Tourmaline Queen mine, Pala, California. This specimen was found by William Larson and others of Pala Properties, and has spent most of the time since in the collection of Keith Proctor. It was recently acquired by David Wilber, who is assembling a Tourmaline Queen mine collection. The specimen is one of the three or four best pieces ever produced by that mine. Width of the morganite crystal is 6 cm. Photo by Van Pelt.**

Aquamarine (var. of beryl), Figure 8. (top right) **Tres Barras, Minas Gerais, Brazil. The crystal weighs 4500 carats (about 2 lbs.) and is 13.7 cm tall. Keith Proctor specimen.**

Emerald (var. of beryl), Figure 9. (right) **Crystals in calcite from Muzo, Columbia. The crystals are 3 cm tall. Smithsonian specimen 122087.**





Bixbite, or red beryl (var. of beryl), Figure 12. (above) **Wah Wah Mountains, Utah. The crystal is 1.3 by 1 by 1 cm. Richard Kosnar specimen and photo; specimen collected by Grant Richards.**

Aquamarine (var. of beryl), Figure 10. (above left) **Minas Gerais, Brazil. The crystal is 15 cm tall. Smithsonian specimen 123294.**

Heliodor (var. of beryl), Figure 11. (bottom left) **Mursinka, in the Ural Mountains, U.S.S.R. The crystal is 2.7 cm tall and is attached to a smoky quartz crystal. Smithsonian specimen B9818.**

Figure 14. (above) **The same crystal as shown in Fig. 3, with some gems cut from another portion of it. Note that the crystal is greenish blue, but the cut stones are pure blue having been heat-treated to improve their color. Photo by the author.**

Heliodor (var. of beryl), Figure 13. (above left) **Ilhia Allegri, Minas Gerais, Brazil. The crystal is 6.2 cm tall. Smithsonian specimen 123703.**

Green beryl, Figure 15. (below right) **Minas Gerais, Brazil. The crystal is in the collection of Jules Sauer, Rio de Janiero, Brazil.**

of heliodor, rather than enhancing it, but the color can be restored by irradiation.

E. Morganite

Pink beryl has been known for centuries. In 1908 the name vorobyevite was proposed for a variety of white beryl rich in Cs and other alkalis from the Urals; the name was also applied to alkali-rich beryl that was pink and of other colors, and has persisted in use in the USSR and to some extent in Europe. However, the name is perhaps a little strange sounding to many, and has not been used in English speaking countries.

Figure 16. **Neylson Barros, co-owner of the Corrego do Urucum mine, Minas Gerais, holding one of the fine morganite crystals found there in 1972. The specimen is now in the museum of the University of Paris (Sorbonne). Photo by the author.**

In the early part of this century a quantity of remarkably beautiful pink beryls were found at several localities in Madagascar. The color was a deep rose pink, called "fleur de pecher" or peach blossom, by far the most attractive pink beryl ever found. The eminent gemologist George F. Kunz of Tiffany's proposed in 1911 that this stone be called morganite, in honor of J. Pierpont Morgan, who has amassed a magnificant collection of gems. This name has since been applied to all alkali-rich pink beryls and is in common use in the U.S., Brazil, Madagascar, and parts of Europe. Whereas vorobyevite may refer to beryl of any color, as long as it is rich in cesium, "morganite" is specifically applied only to pink beryls rich in cesium and other alkalis.

The principal properties of the gem are as follows:

Mean refractive index 1.59 Birefringence .008
Specific Gravity 2.80

The color is due to a small amount of divalent manganese. The crystal habit is almost invariably thick to thin tabular. Color varies from pale pink to deep rose pink, and also yellowish or salmony pink. The deep rose pink color of the finest Madagascar stones has not been duplicated elsewhere, and since there has been no new production there in recent years, fine stones are seldom if ever seen and are considered unavailable. Anyone having the opportunity to purchase one of these stones will find that the price is as high as for a fine aquamarine. In contrast, the common pinks are quite inexpensive, commanding wholesale prices of $6 - $15/carat even for large stones.

Many Brazilian localities have produced fine morganites, one of the most remarkable finds having been made between 1965 and 1972 at the Corrego do Urucum mine, in the county of Galilea, Minas Gerais. In this pegmatite two huge vugs were found, so large that their emptying occupied several years' time. The vugs were completely filled with mud, clay, and debris, in which the minerals formerly lining the walls were scattered. One vug was the size of a large 3-story house, the other of a 2-story house, and between them they contained over 3,000 kgs. of gem spodumene, of which about 500 kgs. was kunzite of fine gem quality; and several hundred morganite crystals ranging in size up to 20 cm. between opposite prisms and 8 cm. thick. Much of the material was of gem quality, and all of the crystals were zoned, the inner zone showing simple hexagonal habit and being pale salmon pink, whereas the outer zone was pale rose pink and highly modified with several pyramidal forms. Associated minerals were albite, "nearly black elbaite" in networks of matchstick-like crystals often completely coating one or both pinacoids; spessartine, microcline, quartz, stokesite in remarkable radial-spherical aggregates, and other minerals.

Fine pink beryl specimens have also been produced in the gem pegmatities on the Island of Elba; these small brilliant crystals have the unusual property of being brightly fluorescent blue-white under ultraviolet radiation. In California the Tourmaline Queen mine in San Diego County has produced excellent pale morganite crystals, some of them perched on large gem rubellites. Other localities are at Ramona, Mesa Grande, and in Cahuilla, Riverside County. Fine crystals have been found in Haddam, Connecticut; in Maine; in Mozambique, the USSR, and China.

The color of morganites, especially those with a yellowish or salmon tinge, is enhanced by heating, because the yellow disappears as in the case of aquamarines.

F. Goshenite

The term goshenite was introduced in 1844 by C. U. Shepard to describe white beryl found at Goshen, Hampshire Co., Massachusetts. Although not widely used outside of the U.S., the term applies to any white or colorless beryl and gems made from colorless rough. White beryl is actually much more common than most people realize, because it is often mistaken for quartz or for feldspar. It is normally found in Li -rich pegmatites, and like pink beryl is rich in cesium and alkalis.

Crystals are commonly tabular in habit and have physical properties similar to pink beryl. It is found in Brazil, whence many fine crystallized specimens have come, and everywhere else that Li -pegmatities are found. One notable locality is the Bernic Lake mine, 30 miles E. of Lac du Bonnet, Manitoba, Canada, where white beryl is rather uniformly scattered through this large tantalum-bearing orebody in tabular or equant crystals up to 15 cm. in diameter. One analyzed sample of beryl from this mine contained 11.04% total alkalis, including 7.16% Cs_2O. This is the highest recorded alkali content of any beryl.

Gem goshenite is of interest to collectors but is not normally seen in the gem trade.

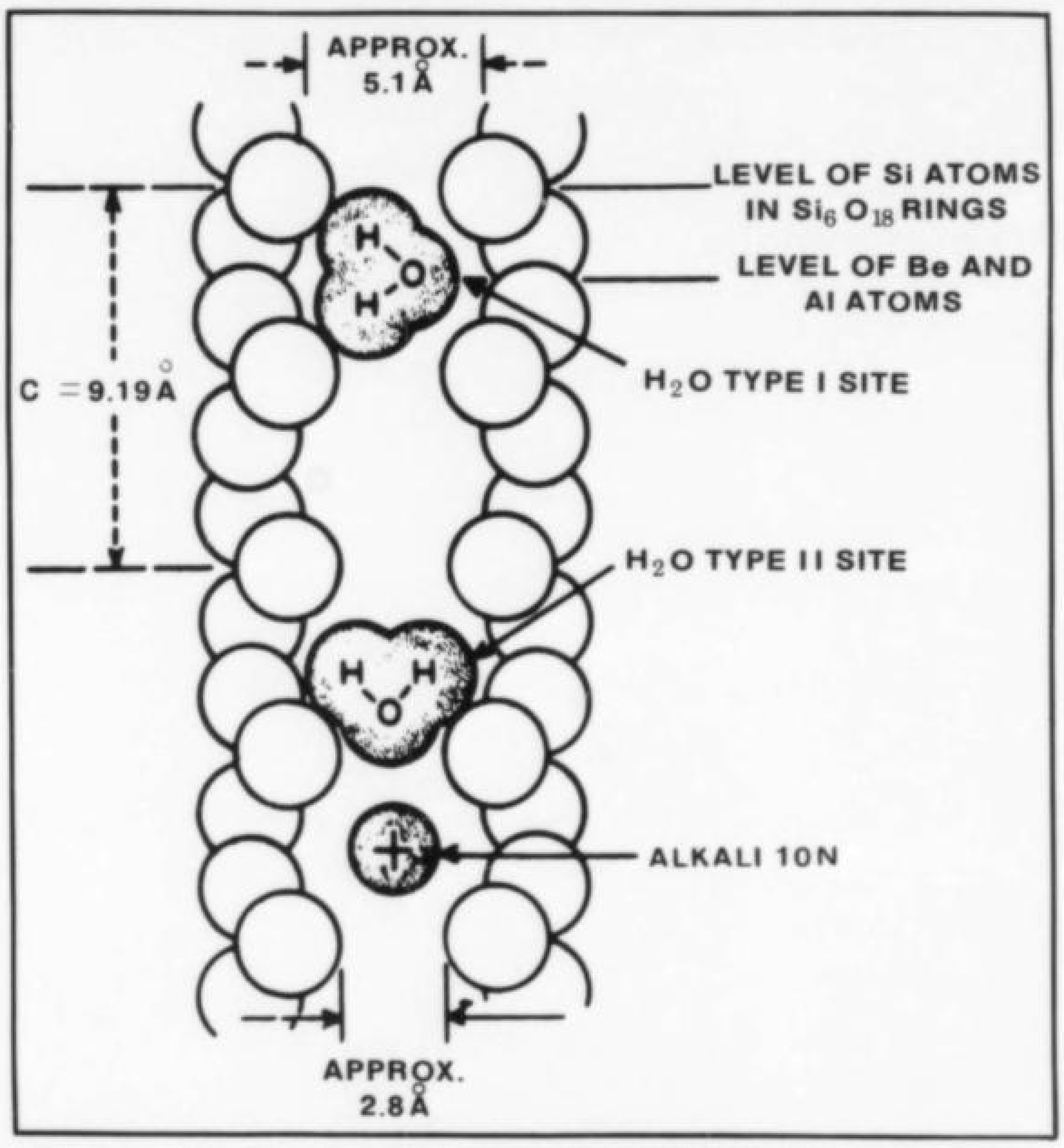


Figure 17. **Section of a portion of beryl structure in (10$\bar{1}$0) plane, showing locus of alkali ions or water molecules in open channels.**

G. Red beryl

One more variety of beryl is of limited and highly unusual occurrence and has unique properties. This is the red beryl found in gas cavities in extrustive rhyolite bodies of Utah, New Mexico, and the Republic of Mexico.

The first place this was observed was on Topaz Mt., in Western Juab Co., Utah, about 1905. It occurs in small, thick-tabular crystals with a maximum diameter of about 10 mm., in miarolytic cavities in rhyolite, associated with topaz crystals, quartz, fluorite, pseudobrookite, hematite, and bixbyite. The color ranges from deep pink to dark brownish red, and it often shows color zoning normal to the c-axis. It is one of the few places where beryl occurs associated with topaz, as these two minerals are not commonly found together in pegmatities. An interesting aspect of this occurrence is that within 5 km to the west are the large Spor Mountain bertrandite deposits, which are in tuffs and are genetically related to the Topaz Mt. rhyolite. These bertrandite deposits now provide almost half of all the beryllium produced in industry, and have reserves sufficient to last for generations.

The color of the red beryl is due to about .08% divalent manganese. Unlike morganite, the content of alkali metals is very low, totaling 0.13% or less. On the other hand, the Mn^{2+} content is about 20 times that in morganite, accounting for the more intense red color. What is really unique about this beryl is the fact that it is anhydrous, a factor which may be related to its obviously high temperature of formation under near-surface, low-pressure conditions. The physical properties are:

n_0 1.576 Birefringence .006
n_ϵ 1.570 Specific Gravity 2.67

Subsequent to the discovery of this beryl, a second locality turned up, said to be in the state of San Luis Potosí, Mexico. The crystals, which came through a mineral dealer in Palo Alto, California about 1925, were very similar to the Topaz Mt. red beryls but larger, attaining a diameter of 20 mm. The exact source in San Luis Potosí has never been pinpointed.

A third deposit was found near Black Mesa, New Mexico. Finally, in 1966, still another locality was found in Utah, in the Wah Wah mountains, southwest of the town of Milford, Beaver County. This locality is about 160 km south of the original Topaz Mt. site. It differs from Topaz Mt. in that the rock is less vuggy and the associated minerals are limited to quartz and feldspar.

The crystals from the Wah Wah Mts. are prismatic in habit, or rarely equant. The maximum size is about 20 mm. diameter of 30 mm. long. The color is a deep violet red, rather like the color of raspberry jam, and in contrast to the very white, hydrothermally bleached rhyolite matrix; the best specimens are very striking. Only a relative handful of specimens have been found, and good ones command high prices. A few small gems have been cut, not exceeding 1/10 carat in size; these are a rich, bright blood red and could easily be mistaken for fine rubies.

VI. Synthetic Beryl Gems

The manufacture of synthetic beryl presents serious problems to even an expert crystal grower; moreover, some of the equipment used, such as large platinum crucibles and control equipment, tends to be very costly. To make crystals of large enough size to be useful as gems is a slow business and requires great patience. Moreover, to make crystals of acceptable color, transparency, and size requires careful attention to details of melt composition, temperature, and other factors to the extent that the successful processes are highly secret, proprietary, and difficult to duplicate.

There has been no commercial synthesis of aquamarine, morganite, or any of the other semi-precious varieties of beryl, for several reasons: first, the value of the resulting gems would be low in relation to the time and effort required to make good stones. Second, these generally paler colored stones only look good in larger sizes, above 5 carats. This means that it would be necessary to manufacture gem crystals of several grams weight at least, which is no easy task.

On the other hand, emerald is highly valuable even in small sized stones, less than a carat. Smaller size synthetic crystals can still have considerable value. For this reason, great effort has been expended on synthesizing emeralds, with first real commercial success taking place over 30 years ago with the development of a process by C. F. Chatham. Subsequently other processes have been developed, especially those of Gilson, Zerfass, Lechleitner, and Linde. Only Chatham and Gilson are presently in production.

The process used by Chatham has never been revealed, but entails growth from a Li_2O - MoO_3 molten flux. The Gilson process is similar. The stones produced by Gilson and Zerfass are also flux-grown, whereas the Lechleitner and Linde processes are hydrothermal. It is believed that the largest and most perfect stones are made from rough produced by the Linde process; all of the processes except the Lechleitner can give stones of excellent color.

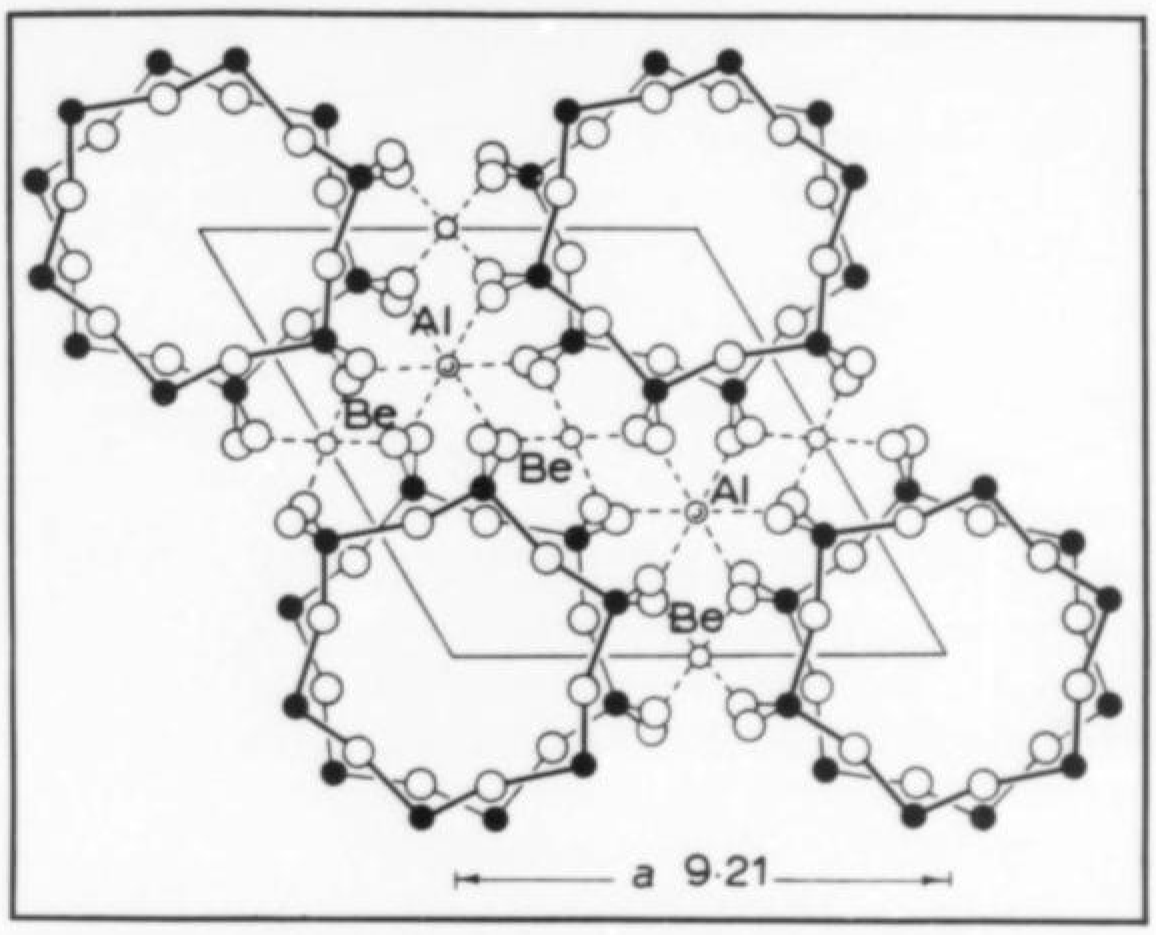


Figure 18. **The structure of beryl projected on the basal plane (0001) showing the rings on the upper plane and (in fainter line) those halfway down the cell (after Bragg, 1937).**

Table 1.

Physical and chemical properties of beryl:	
Composition:	$Be_3Al_2Si_6O_{18}$
Crystal system:	Hexagonal
Habit:	Prismatic to tabular
Point group:	6/mmm
Space group:	P6/mcc
Cell contents:	$2[Be_3Al_2Si_6O_{18}]$
Unit cell dimensions:	(beryl) $a_0 = 9.21 \pm .02$ $c_0 = 9.20 \pm .05$ (bazzite)$a_0 = 9.51$ $c_0 = 9.10$
Cleavage:	None
Parting:	Parallel to 0001, fair.
Fracture:	Conchoidal
Hardness:	7.5 — 8
Specific gravity:	2.62 — 2.90 (2.633 calculated for pure material)
Luster:	Vitreous
Color:	Variable; commonly shades of pale green or blue; also bright blue; emerald green; pale to golden yellow; pink; red; white or colorless; brown, nearly black; and many intermediate shades.
Optics:	$n_0 = 1.568 - 1.610$, Uniaxial negative $n_\epsilon = 1.564 - 1.602$, Dispersion low

The physical properties of the several synthetic emeralds vary rather widely. They tend to have lower refractive indices and lower specific gravities than most natural stones. More detailed treatment of the properties, differentation and identification of the synthetics has been covered in such publications as Flanigan et al (1967) and Santos Munsuri (1968). The synthetics can be differentiated from each other and from natural stones by a competent gemologist; nevertheless, they are finding a ready market at good prices, although of course lower than the prices for fine natural stones.

• • •

REFERENCES

ANDERSON, B. W. Gem testing for jewelers. 8th Edition London.

BEUS, A. A. (1966) Geochemistry of Beryllium. W. H. Freeman & Co.

DANA, E. S. (1896) System of Mineralogy. 6th Edition Wiley & Sons.

FEININGER, T. (1970) Emerald mining in Colombia: history and geology. *Mineral. Record.*, **1**, 142-149.

FLANIGEN, E. M. et al (1967) Characteristics of synthetic emeralds. *Amer. Mineral.*, **52**, 744-772.

HEY, M. H. (1965) Chemical Index of Minerals. British Museum (Nat. Hist.).

NASSAU, K. (1974) The effects of gamma rays on the color of beryl, smoky quartz, amethyst, and topaz. *Lapidary Journal*, April.

_______and D. L. WOOD (1973) The new Maxixe-type beryl. *Lapidary Journal*, October.

_______,_______PRESCOTT (1976) The new Maxixe-type beryl *Amer. Mineral.*, **61**, 100-107.

_______,_______(1968) An examination of red beryl from Utah. *Amer. Mineral.*, **53**, 801-806.

ROSS, M. (1964) Crystal chemistry of beryllium. U.S. Geological Survey, Prof. Paper 468.

SANTOS MUNSURI, A., La Esmeralda. Madrid.

SCHALLER, W. T. et al (1962) An unusual beryl from Arizona. *Amer. Mineral.*, **47**, 672-699.

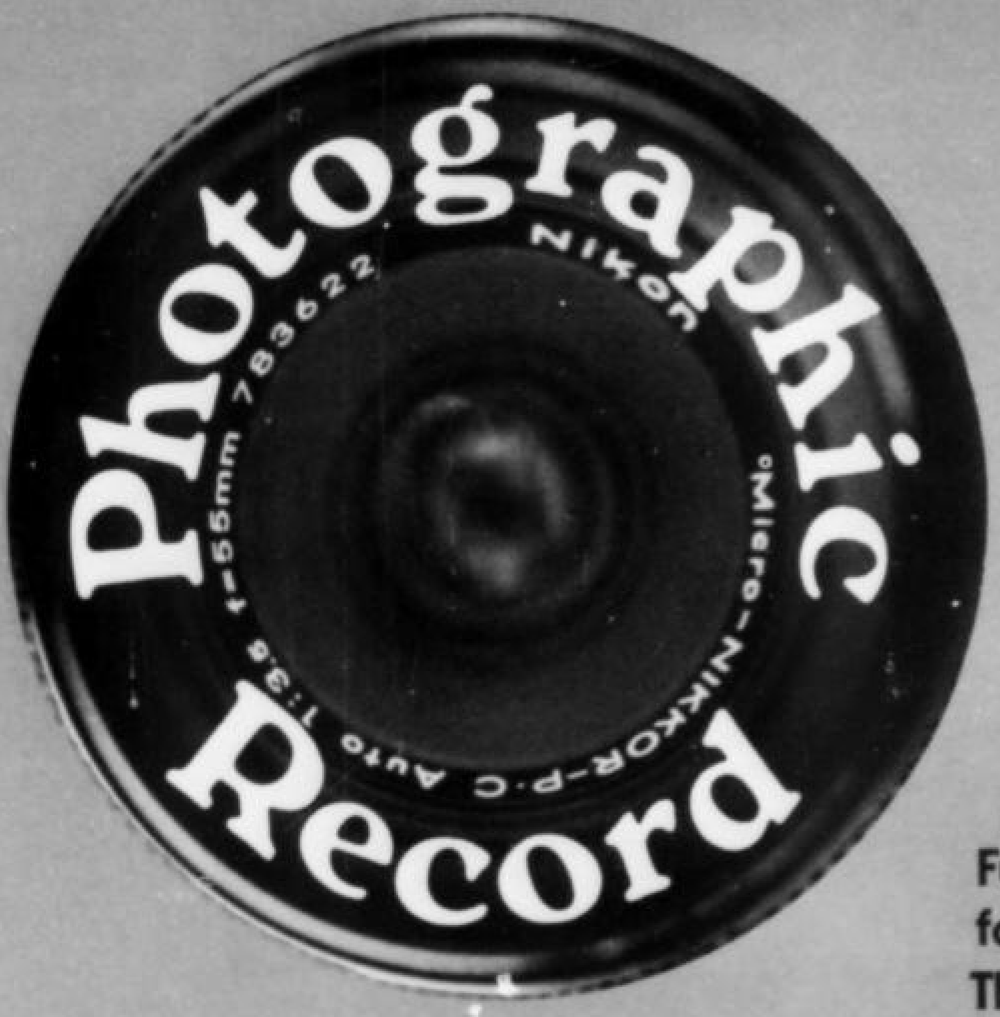
SIMPSON, F. (1974) The Mineralogy of pollucite and beryl from the tanco pegmatite at Bernic Lake, Manitoba. M. S. Thesis, U. of Manitoba.

SMITH, G. F. H., Gem Stones. Methuen & Co. London 12th Edition.

VLASOV, K. A. (Editor) (1966) Mineralogy of Rare Elements. Isreal Program for Scientific Translations.

WOOD, D. L. and NASSAU, K. (1968) The Characterization of beryl and emerald by visible and infra-red absorption spectroscopy. *Amer. Mineral.*, **53**, 777-800.

Photographing German micromounts



by Wendell E. Wilson
The Mineralogical Record
P.O. Box 783
Bowie, Maryland 20715

Werner Lieber should be no stranger to Record readers; his article "Trepča and its minerals" (M.R. 4, 56-61) contained some excellent photography, as well as interesting reading. He provided 117 color photos of minerals for the book Colorful Mineral Identifier (reviewed M.R. 4, 82), and also provided both text and 88 color mineral photos for his own book Kristalle unter der Lupe* (reviewed M.R. 4, 81). The latter publication is a tour de force of mineral photography generally acknowledged as a masterpiece. According to Paul Seel, it should be "within reach at all times to every lover of minerals...". He devoted a section of the book to a detailed explanation of his photographic technique; the 88 full page color photos make Kristalle unter der Lupe worth the price, but the text is in German.

For this installment of the Photographic Record Dr. Lieber has provided us with 17 photos of minerals from German localities. Localities in Germany are his specialty; he currently has a file of over 1000 photos of German minerals. His comments on the localities are given below. To supplement this presentation I have translated some of the text referring to photographic technique in Kristalle unter der Lupe. The following excerpts should be of interest to mineral photographers; the following photos should be of interest to everyone!

Eight of the photos presented here were first published in Kristalle unter der Lupe, along with notes regarding the technique applied in each photo. The translation of Dr. Lieber's comments on each of the previously published photos is given in the figure captions.

Further details regarding equipment and technique may be found in Dr. Lieber's book.

The localities represented:

Schneeberg, Saxony, East Germany. (Figures 1, 15, 17) Schneeberg is a famous locality; the name actually covers a number of mines in and around Schneeberg. These are all in hydrothermal vein deposits of the "silver-bismuth-cobalt-nickel formation", and are of the same type as the deposits at St. Joachimsthal (now Jachimov, C.S.R.), Annaberg, Marienberg, Johanngeorgenstadt, Schlema, Niederschlema and Aue. Many of these mines have also produced uranium ore, especially under the Russians after World War II.

St. Andreasberg, Harz Mountains, West Germany. (Figures 2, 3, 4) These were mines in lead-zinc-silver hydrothermal veins, which also contained carbonates and zeolites. They are now abandoned.

Hagendorf, East Bavaria, West Germany. (Figures 5, 6, 8) This is a large phosphate pegmatite which is still being mined.

Siegerland, West Germany. (Figures 12, 13, 14) This is an area of about 25 X 25 km containing many hydrothermal siderite veins. Mining has been carried on in Siegerland for about 2000 years, but was abandoned about ten years ago.

Grube Anton, near Wittichen, Black Forest in Baden, West Germany. (Figure 7) The mine is in small, hydrothermal veins containing bismuth, cobalt, silver and uranium minerals.

Obermoschel, West Germany (Figure 9)(sometimes referred to as "Moschellandsberg", although the correct name would be Landsberg at Obermoschel). The mine is in small hydrothermal veins containing cinnabar, and is now abandoned.

Neue Hoffnung Gottes mine, Bräunsdorf, near Freiberg, Saxony East Germany (Figure 11) This mine is in hydrothermal veins containing galena and antimony minerals. It has been mined for several centuries but was abandoned 50 years ago.

Schöne Aussicht mine, Dernbach, Westerwald, West Germany. (Figure 18) The mine contained iron-maganese ore but is now abandoned.

*Available directly by mail from Ott Verlag, Ch-3600 Thun 7, Switzerland. Send an international money order or check for $32, which includes postage.

Rauschermühle quarry at Niederkirchen, Pfalz, West Germany. (Figure 10) The quarry is in porphyritic rocks containing zeolite veins.

Rosenberg mine near Bad Ems, West Germany. (Figure 16) This mine is in hydrothermal lead-zinc ores. Although abandoned for about ten years, during their time the mines around Bad Ems yielded beautiful green to brown pyromorphite, sometimes in curved or barrel-shaped crystals.

NOTE:
Dr. Lieber is fluent in English. Readers may contact him at:
D-6900 HEIDELBERG 1
BADEN-BADENERSTRASSE 3
WEST GERMANY

Figure 1. (top left) **Silver**, Schneeberg. The wires are about 10 mm tall.
Figure 2. (bottom left) **Pyrargyrite**, (black with red internal reflections) St. Andreasberg. The photo is looking down the **c** axis; the crystal diameter is about 6 mm.
Figure 3. (bottom right) **Pyrargyrite**, (black with red internal reflections) St. Andreasberg. With stilbite crystals. The field of view is about 10 mm wide.

Figure 4. (top left) **Pyrostilpnite**, (brownish orange) St. Andreasberg, with stilbite. Crystal diameter about 2 mm. Photar objective; aperture: 16; exposure time: 10 seconds. The color and transparency of the thin crystal plate can be revealed only by strong illumination from above and behind, which also brightens the white background. Additional diffuse light from the front is used.

Figure 5. (top right) **Phosphophyllite**, (pale green) Hagendorf. The crystals are about 5 mm each.

Figure 6. (bottom right) **Stewartite** crystals (pale orange) on **Strunzite** needles, Hagendorf. Field of view is about 8 mm wide. Zeiss binoculer; aperture: 12 ; exposure time: 10 seconds. This exposure required special persistance. Two long crystals of strunzite lie in a small cavity, running from lower left to upper right in the photo. Thereon rest the clear stewartite crystals. Point-sources light shines across the specimen from the right and from the left leaving the background dark for contrast. Although the magnification is high the crystals stand almost entirely within the zone of sharp focus.

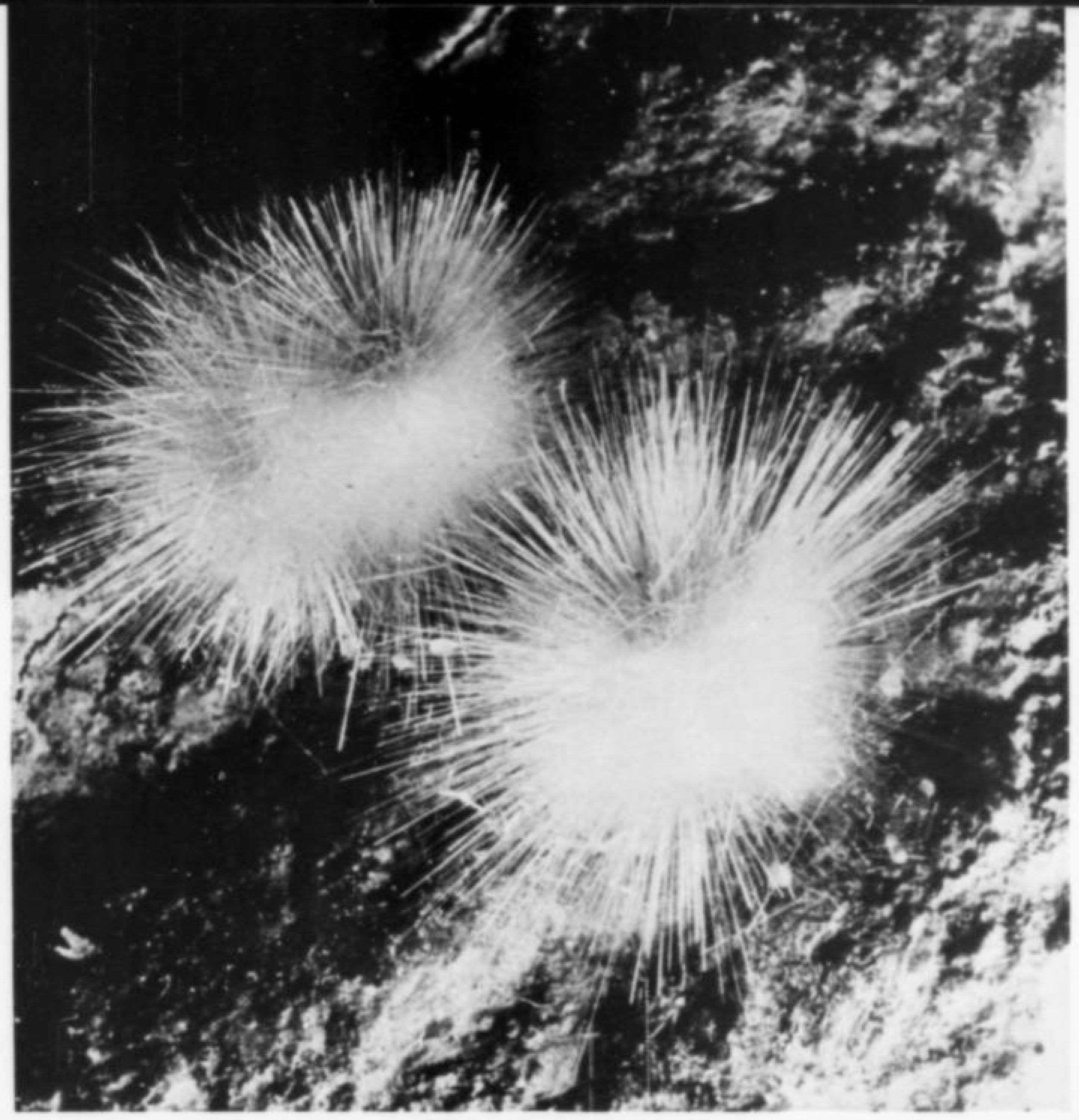


Figure 7. (top left) **Pharmocolite**, (white) Grube Anton, near Wittichen, Black Forest. Diameter of each aggregate is about 10 mm. Milar objective; aperture: 48; exposure time: 4 seconds. The thin individual crystals of these prickly crystal aggregates can only be shown when the background behind them remains dark. To accomplish this two light sources are used which shine on the specimen from the lower right and lower left.

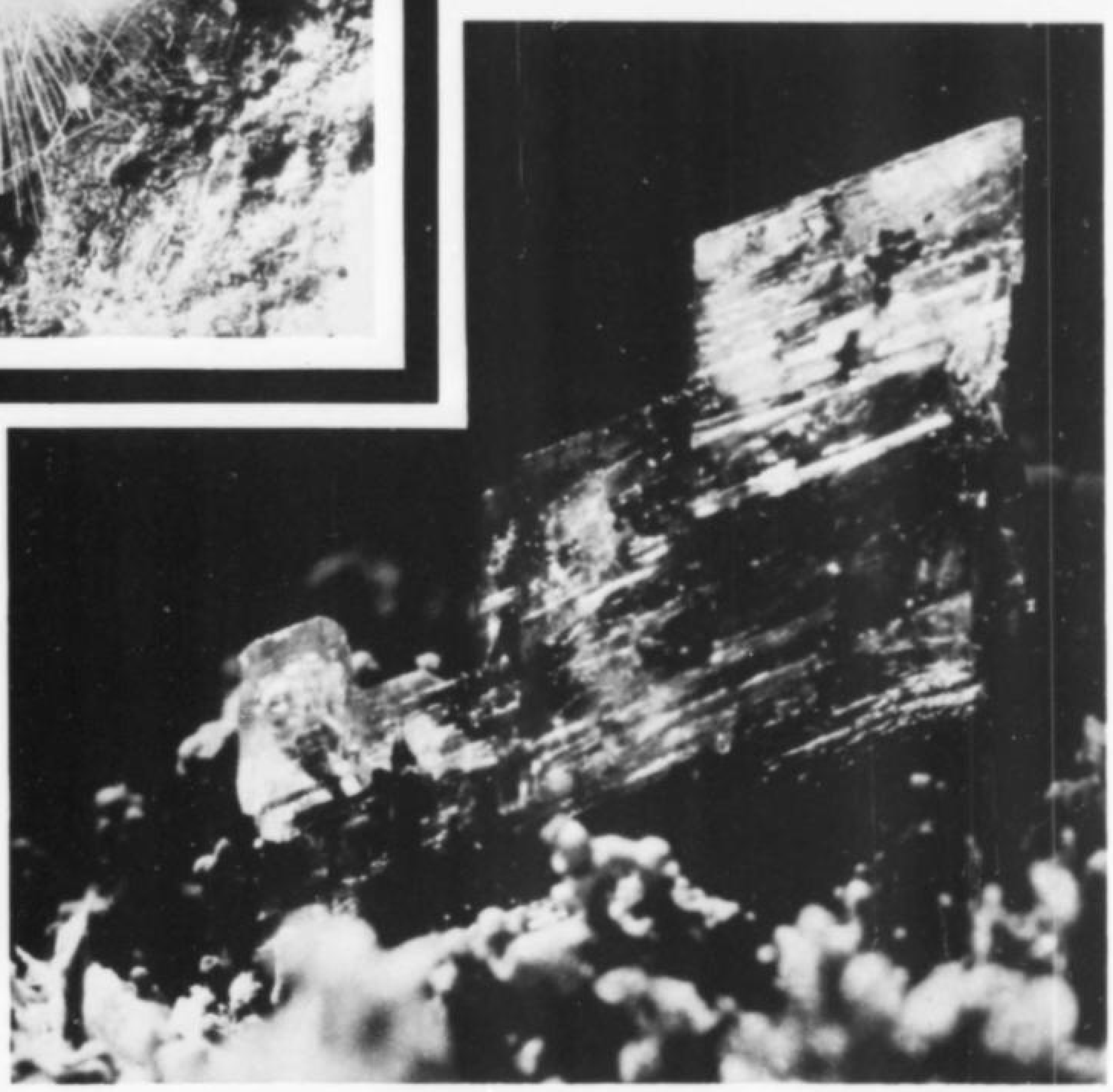


Figure 8. (middle right) **Laueite**, (deep yellow) Hagendorf. The largest crystal is about 2 mm.

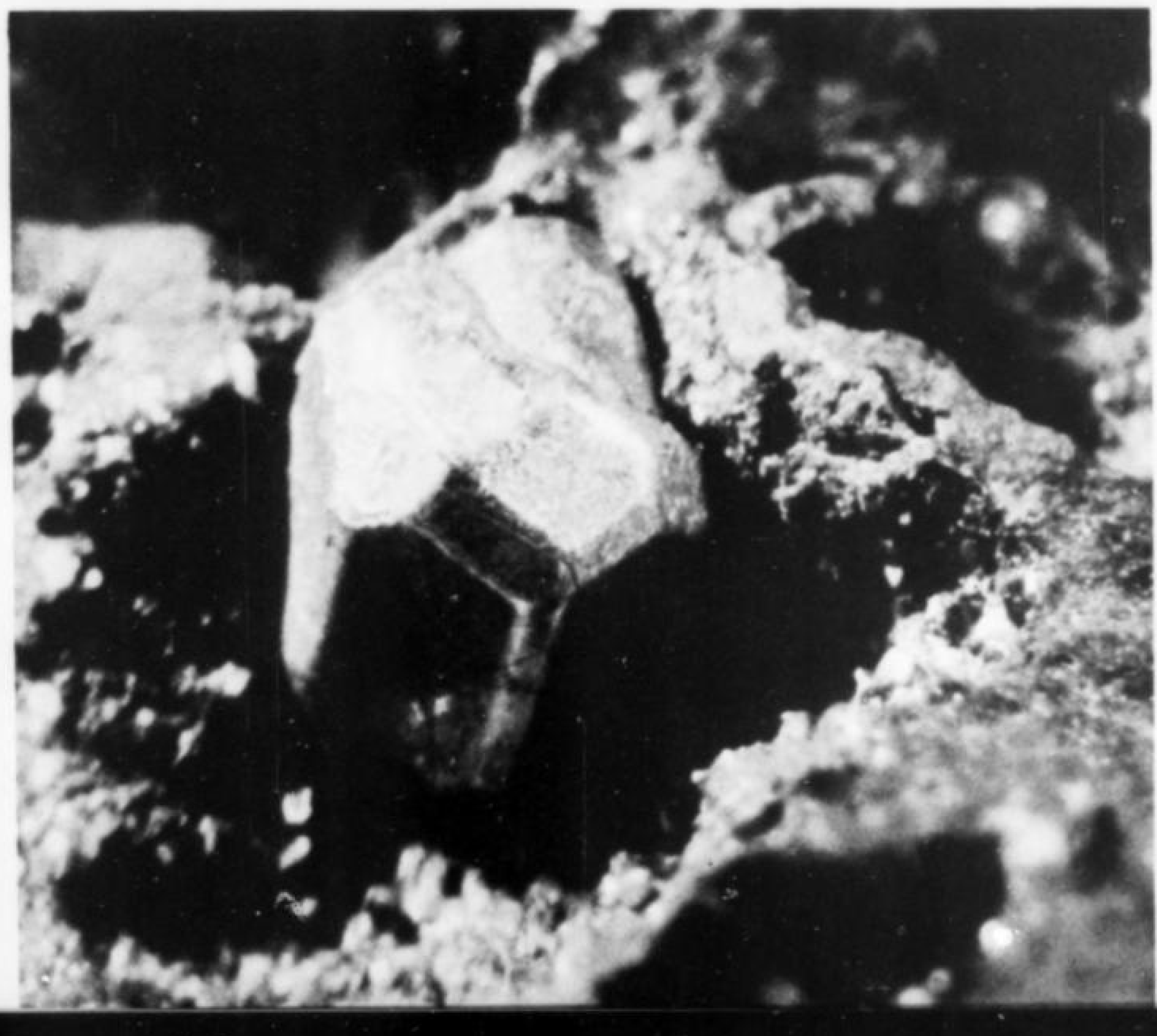


Figure 9. (bottom left) **Moschellandsbergite - (Landsbergite)**, (dark brown) in cinnabar, Obermoschel. Crystal size is about 8 mm. (instrument used:) Zeiss binoculr microscope; aperture used: 11; exposure time: 20 seconds. A smooth-faced crystal in a small cavity. It proved very difficult to photograph. An intense beam of light comes in from the left, and a second comes in from directly overhead so that an edge is illuminated (by yielding a reflection). The depth of field here is relatively small.

Figure 10. (top right) **Prehnite**, (colorless) Rauschermühle at Niederkirchen, Pfalz, West Germany. Crystal size is about 8 mm. Milar objective; aperture: 48; exposure time: 1.5 seconds. The excellent illumination of this crystal group comes from only two light sources: a diffuse light from below in front and a point-source light from the left. Edges are clearly visible and faces are well-highlighted. The composition is again diagonal.

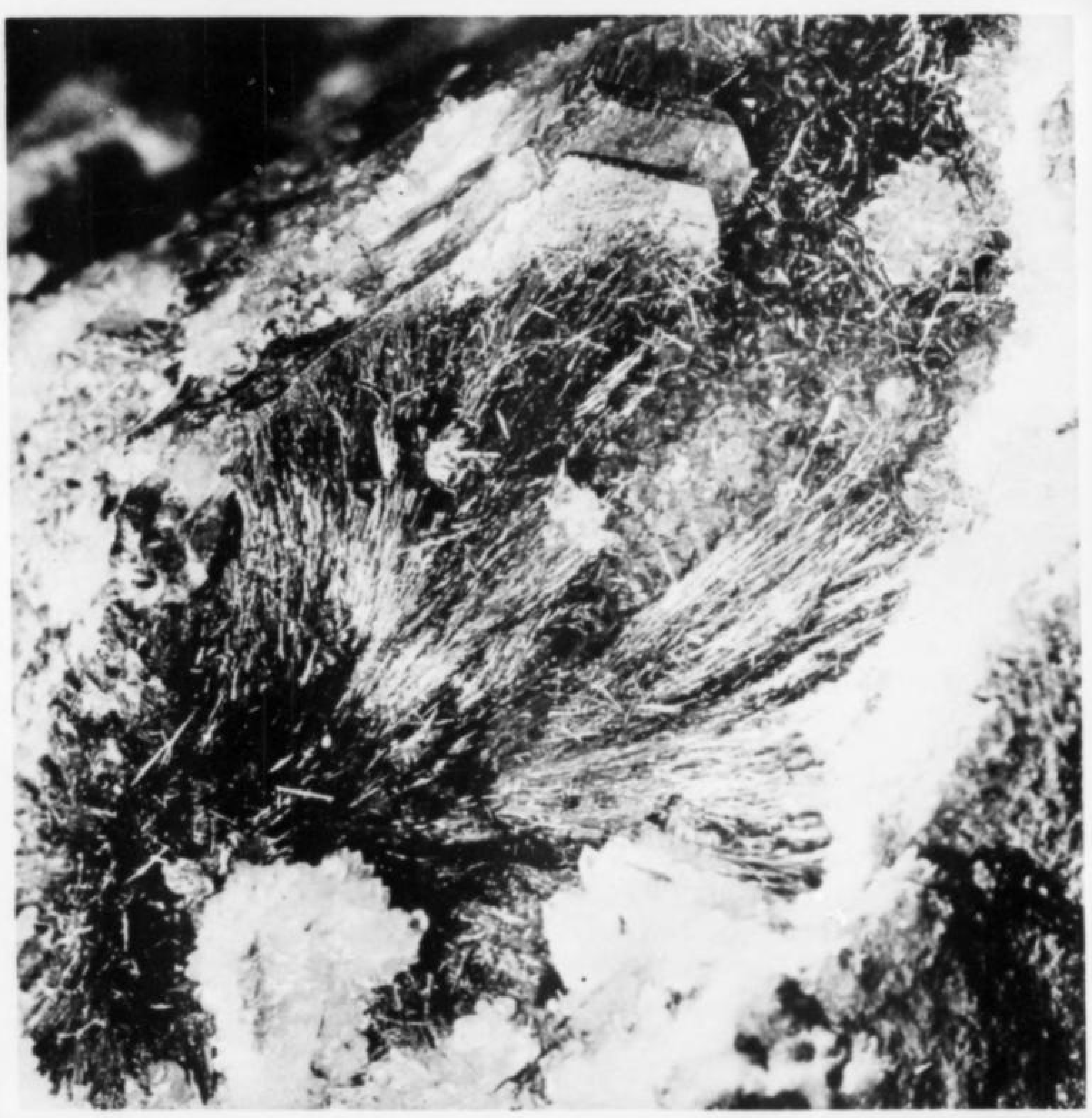


Figure 11. (bottom left) **Kermesite**, (dark red) on barite, Bräunsdorf. Size of the whole crystal group is about 12 mm. Milar objective; aperture: 48; exposure time: 5 seconds. A weak, diffuse light shines on the specimen from in front so that a reflection on the flat faces of the barite crystals is produced. This also produces better glistening of the acicular kermesite crystals. A second light source shines in from the lower right, and the composition is arranged to trend from lower left to upper right.

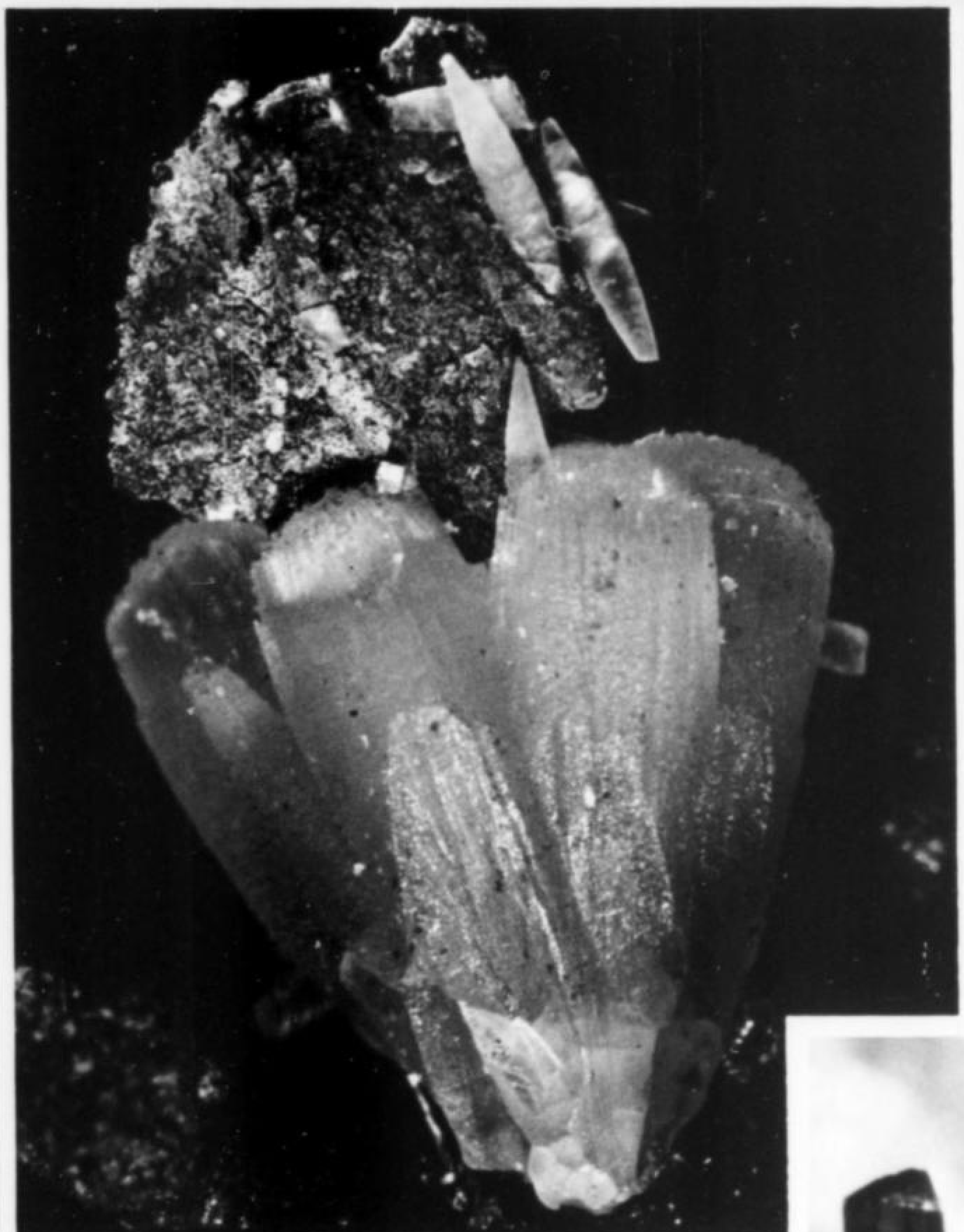
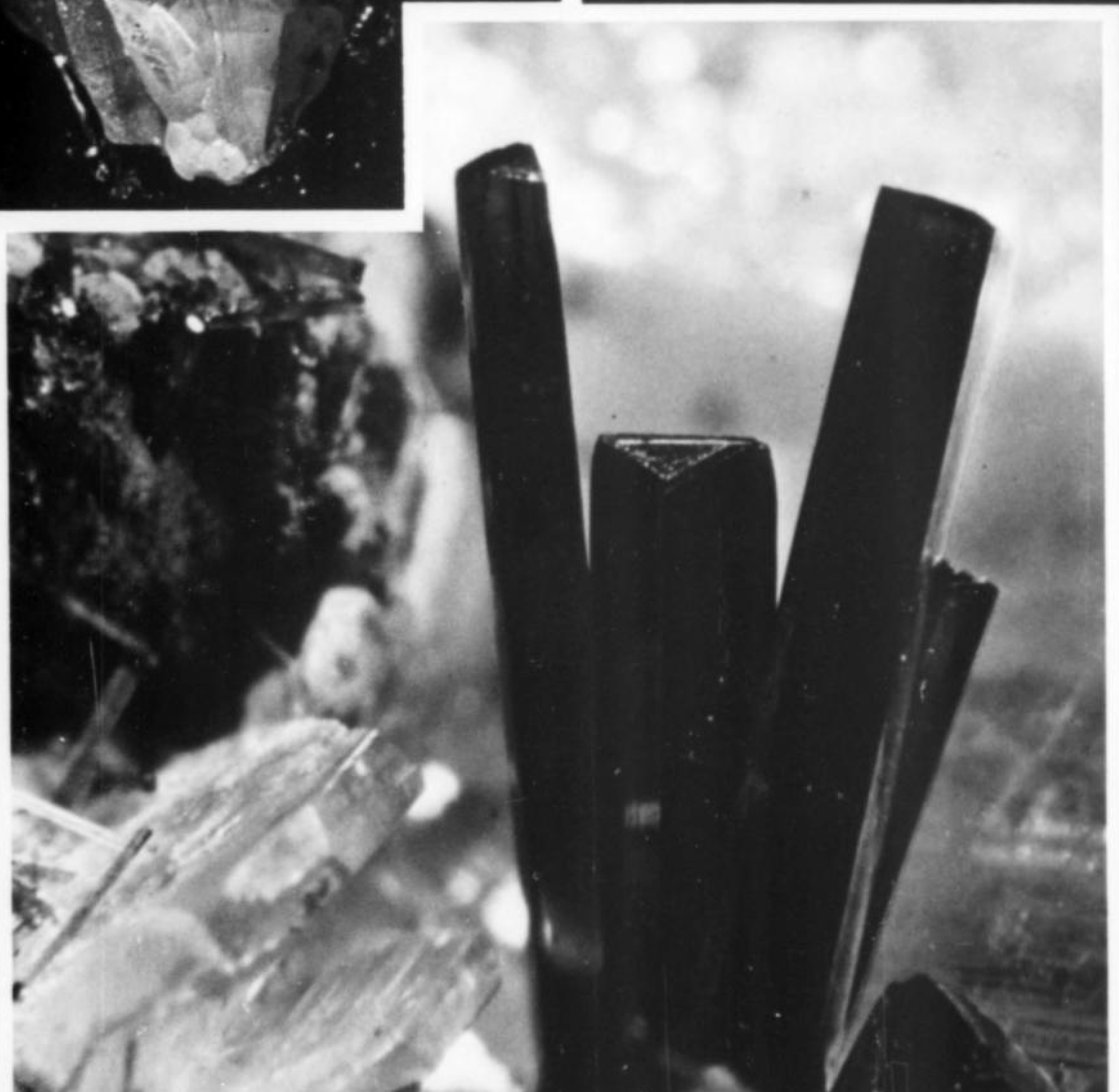


Figure 12. (top left) **Copper** on **Rhodochrosite**, Wolf mine at Herdorf, Siegerland. Complete group is about 4 mm tall.

Figure 13. (bottom right) **Malachite**, with cerussite on limonite, Friedrich mine at Niederhövels, Siegerland. Crystal height is about 4 mm. Zeiss binocular; aperture: 11; exposure time: 30 seconds. A point-source (fiber optic) light shines on the crystals from behind; farther to the right a light source shines on the crystals which makes the termination faces stand out. The background illumination becomes uniformly bright.



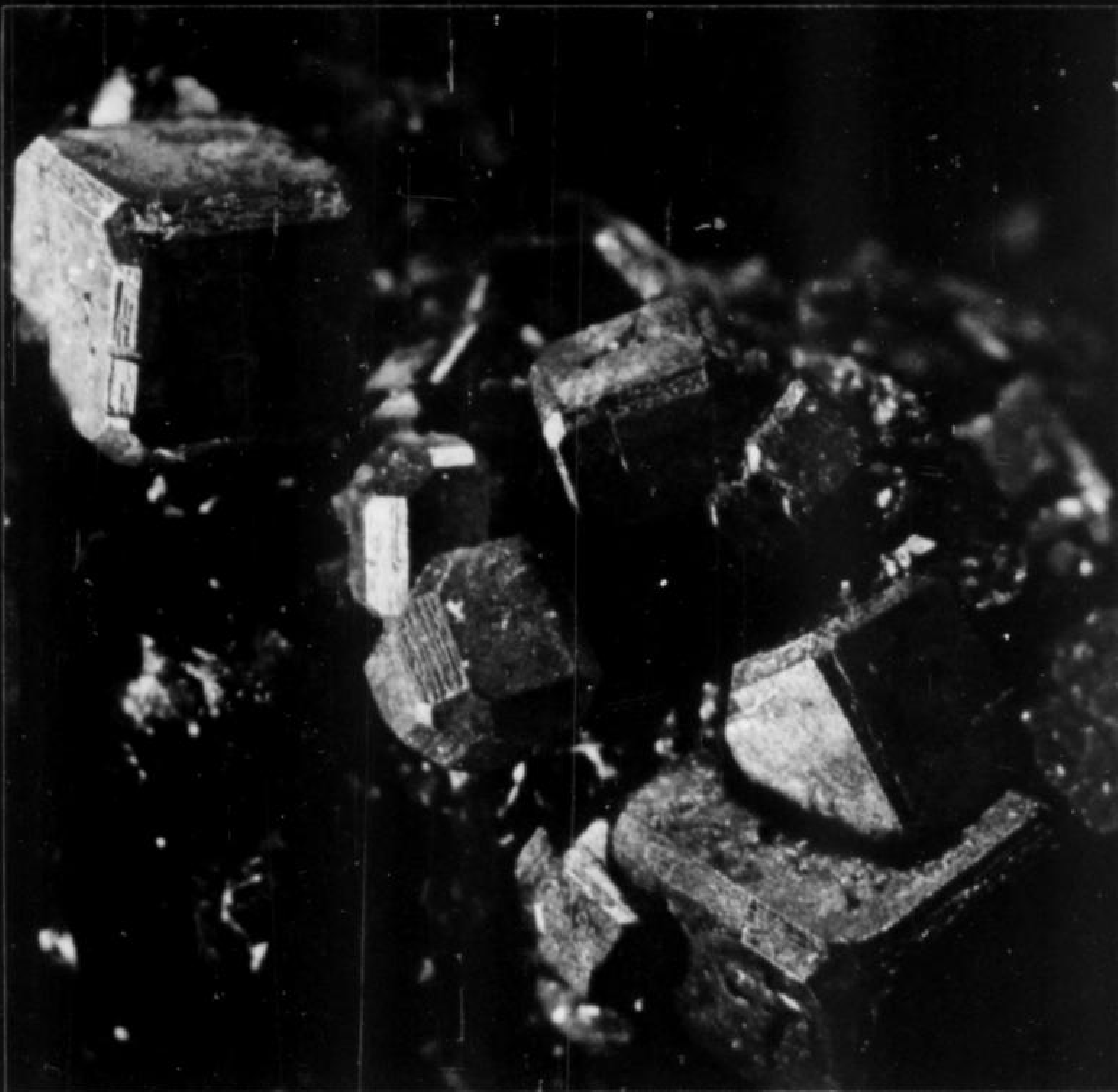
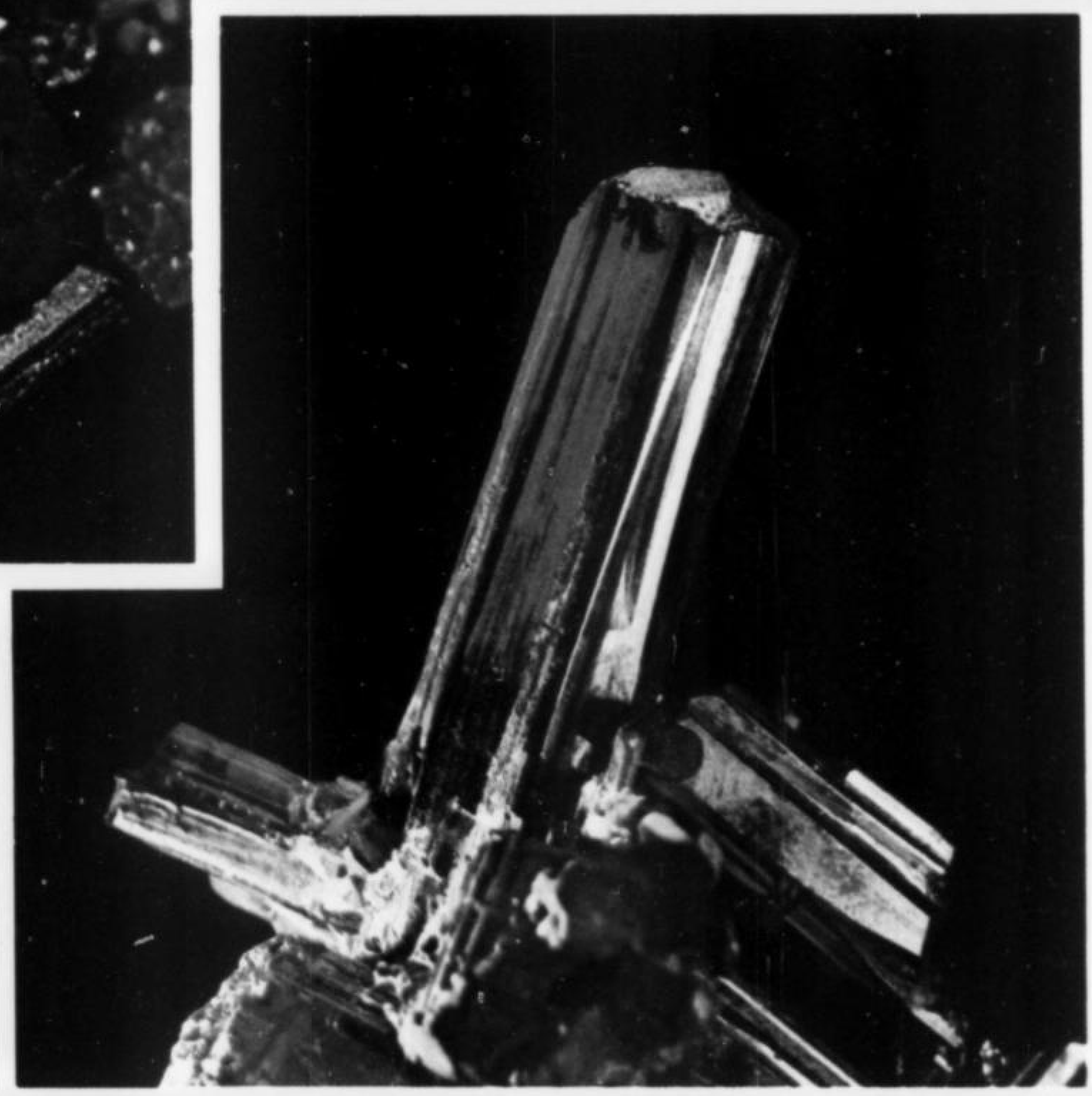


Figure 14. (top left) **Cuprite**, Neue Hoffnung mine at Wilgersdorf, Siegerland. Largest crystal is 4 mm.



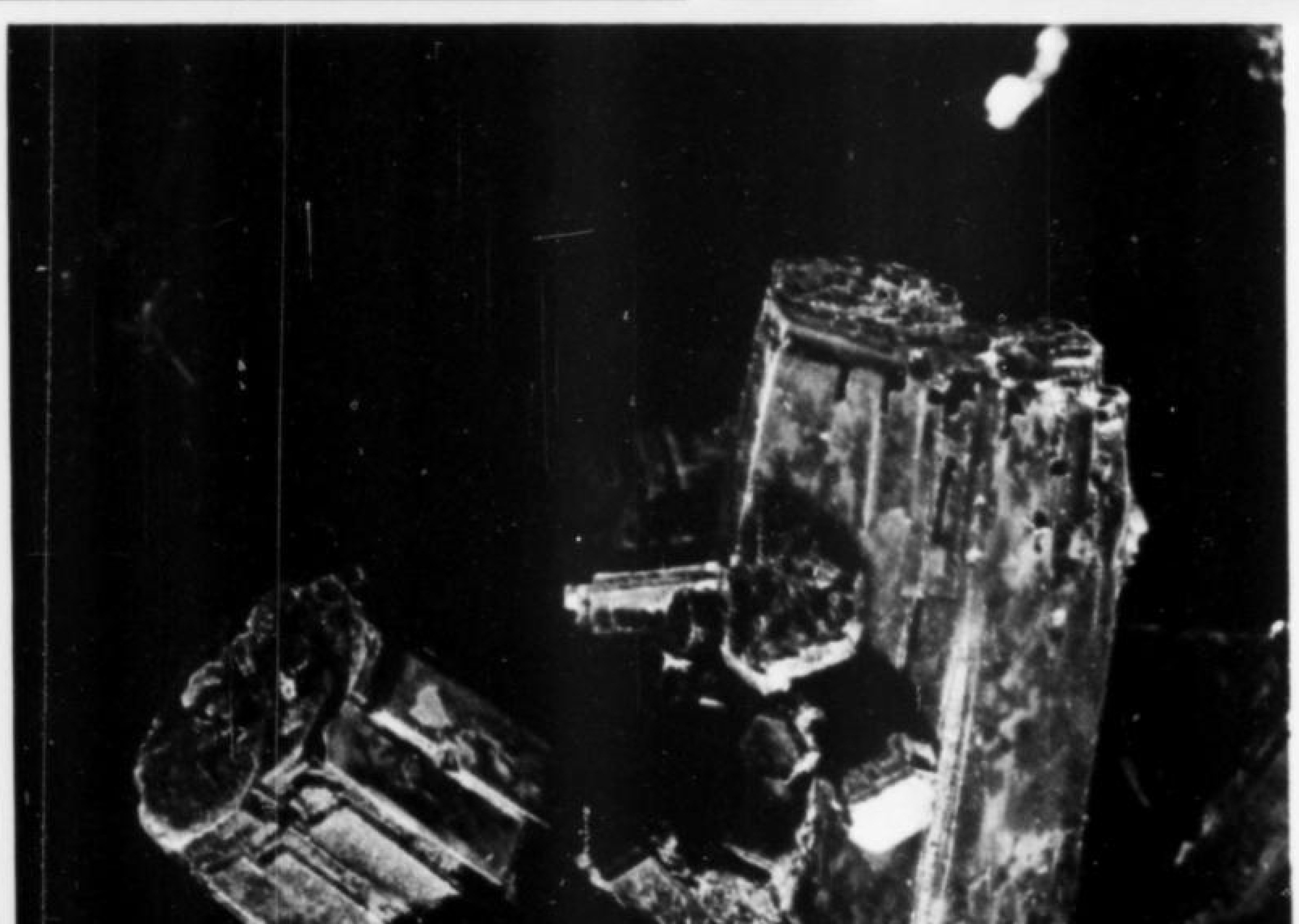
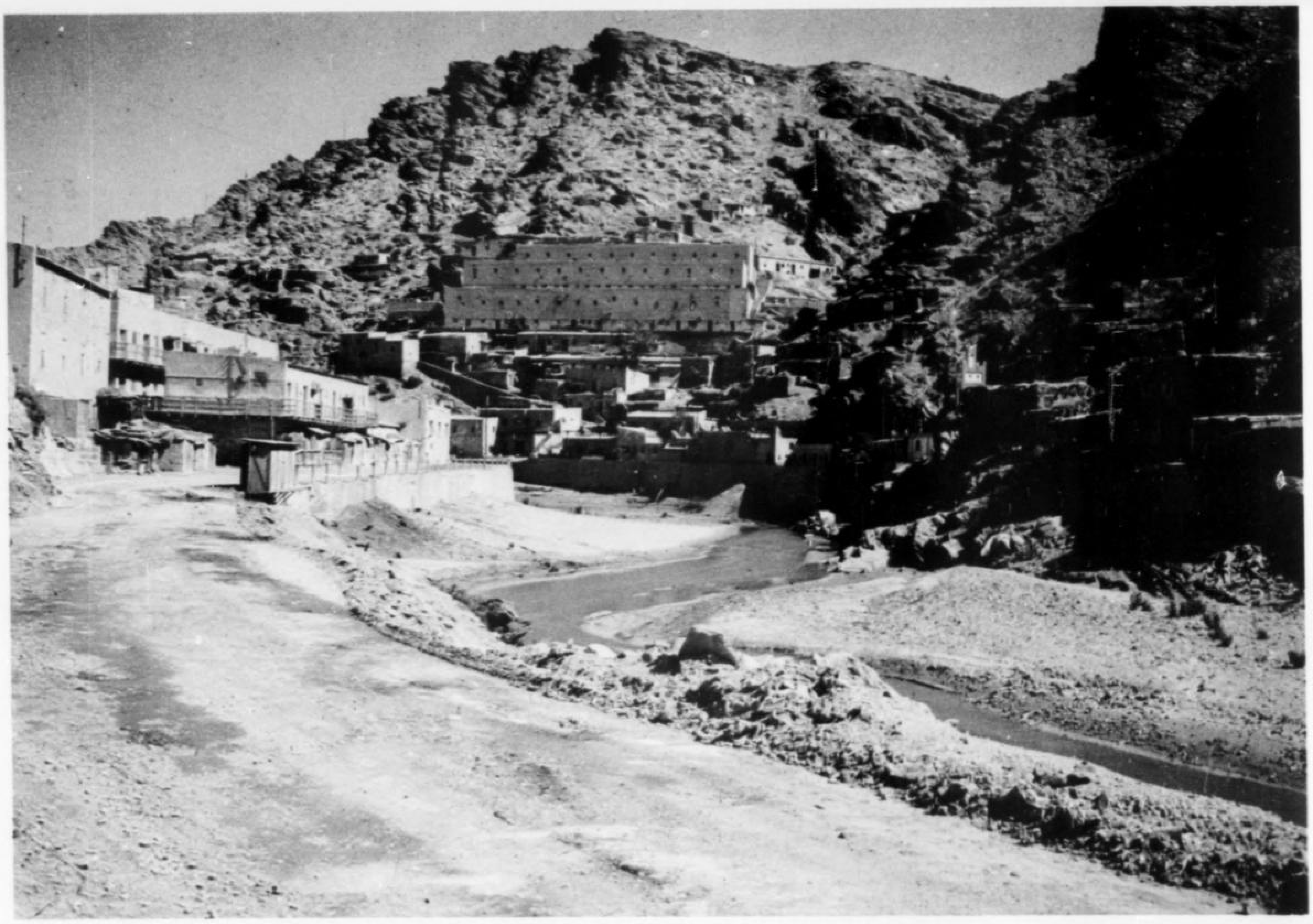


Figure 15. (above right) **Proustite**, Schneeberg. The length of the long crystal is about 12 mm. Milar objective; aperture: 48; exposure time: 2 seconds. The crystal is transparently clear, and that feature proved difficult to capture. An absolutely black background produced the best results. A weak light source was directed from above right and a little behind the specimen, whereby the faces at the top of the crystal become more easily discernable. A second light source comes in from the right and a third from the left. The large crystal is adjusted so that the composition is from lower left to upper right. A slightly different colored matrix—when it exists—can establish even more contrast.

Figure 16. (bottom left) **Pyromorphite**, Rosenberg mine near Bad Ems. Crystal size about 6 mm.

Figure 17. (left) **Roselite**, Schneeberg. The diameter of the crystal group is about 15 mm.

Figure 18. (right) **Iodargyrite**, Schöne Aussicht mine, Dernbach, Westerwald. Crystal height about 10 mm.



(Photo by Anne Voileau)
Figure 1. **Mine at Aouli.**

MOROCCO MINERALOGY

by
Anne Voileau
Editor: ***Le Monde et le Mineraux***
4, Avenue de la Porte de Villiers
75017 Paris, France

MOROCCO – AUGUST 1974 FOUR WEEK VISIT

This itinerary was designed to prove that within the context of classic vacations (except for winter), it is possible to have an extremely interesting mineralogical trip to Morocco. In any event, in one month it is impossible to visit all of the mines; it is therefore necessary to establish one's itinerary at the outset.

What we propose takes into account tourist interests, which would be a shame to neglect in such a passionate country, as well as mineralogical discoveries, since that is our main object.

In spite of everything, one must recognize that the choice or necessity of making the trip during the month of August involves certain inconveniences.

The multitude of tourists in that season causes prices to rise and makes it more difficult to find an exceptional specimen; nor must one underestimate the heat for those who suffer from it, especially if one desires to go as far as Taouz, and M'Fis, as we did. Moreover, many mines are closed; the engineers are away; as a result it is difficult to get technical information or to go underground.

However, because of the help of the miners in the villages our local investigations and our purchases and exchanges did not suffer.

One last and very important bit of advice: if you wish to go to Morocco by boat, and especially if you bring your car, be sure to make reservations one or two months ahead of time; some people have had to wait several days in Algesiras or Malaga before embarking.

It is after visiting Fez, when heading toward Azrou, that the mineralogical trip really begins. After the heat of the city one discovers, with increasing altitude, the forests, very beautiful mountainous countrysides and, all along the route, displays of minerals. It took us several hours to cover the 80 km which separate these two cities, as we wanted to stop at all the stands.

Figure 2. **Cerussite crystal. (Photo by Guy Chaminant)**

Already there were vanadinite, amethyst and aragonite from the Sefrou region, crystals of cerussite on barite, radial-fibrous malachite and crystallized azurite coming from the Midelt region. If you like a piece, don't hesitate to buy it; we had wanted to wait, for the vanadinites especially, until we were in Mibladen, but one cannot be sure of finding fine pieces later. Some beautiful specimens, once taken from the mine, are eventually sold far from their source.

If you are interested in wulfenite (the ones which are neither broken nor glued are rare) it is necessary to ask for it; the most beautiful pieces are rarely displayed. There is the possibility of going with some young Moroccan guides to look for aragonite *in situ* in the neighborhood of Sefrou, at Tagnagnait.

By stopping at every little stand and looking carefully, it is possible to find pieces of great mineralogical interest and value; they are often sold in error, under incorrect names.

Azrou is a town with an invigorating climate. The name means "rock". It is 1250 meters (about 4000 feet) above sea level and 125 km from Midelt, our next stop.

AZROU – MIDELT

Few vendors along the way. Arriving at Midelt (1500 m elevation) one of the first houses sells minerals; after traversing a shady garden, a large shed crammed with minerals. Nevertheless we are still awaiting our visit to the mine at Mibladen. It is not shown on the map, but there's no problem; every one gives you directions.

At Mibladen, if you want to stay a few days, you must sleep and eat with one of the inhabitants, or else return to Midelt, about 15 km by asphalt road.

Mibladen employs about 250 miners*. The shafts are as deep as 100 m. By 1968 its production of metal had reached 100,000 tons per year. The young people wait for visitors at the entrance to the mine village and invite them to come to their houses to see specimens, as well as to share *couscous* with them and the ritual of mint tea. One must be patient; the lots which we were offered in the beginning were not always interesting but, by staying in the village several days, the villagers can build up enough confidence in you to bring you by night to collect with them, or to offer finer pieces in their own homes. Little by little, all of the miners become aware of your presence and the quality of the pieces offered increases

* As of Jan., 1976, the mine has been closed; see Yount interview, this issue.

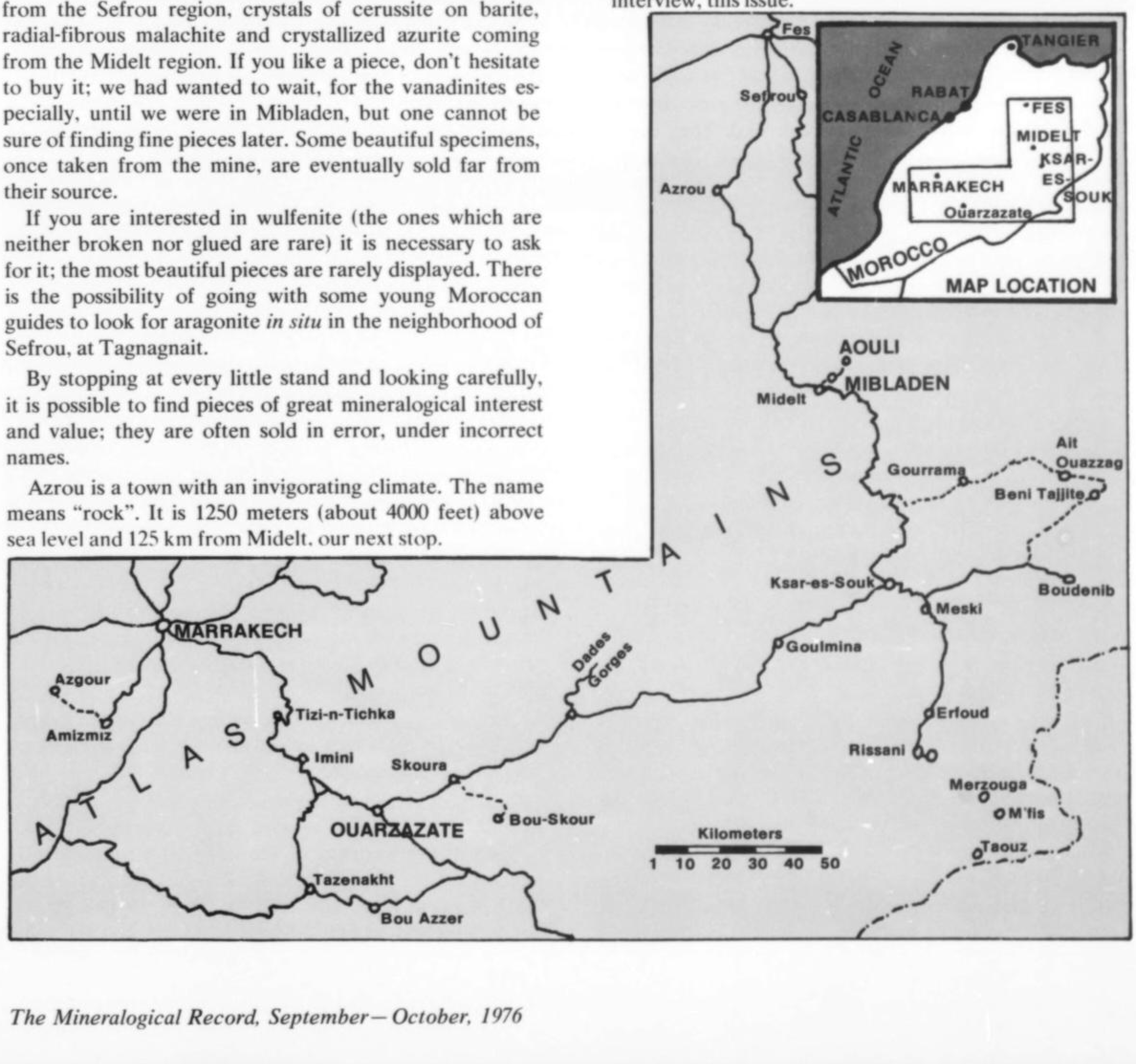


Figure 3. **Azgour mine.**

(Photo by Anne Voileau)

proportionately. We stayed at Mibladen three days, always appreciating the marvelous hospitality of the Moroccans. We went for walks in the village, following every child who had a few specimens to show, but it was only toward the end of our stay that we found some really interesting pieces: beautiful red vanadinite, well-crystallized; cerussite on barite; beautiful crystals of azurite; of anglesite...

The specimens which are exchanged or purchased are often finer than those which one can find. They can be had in exchange for all sorts of clothing as long as it is French (trousers, shirts, etc.). But it is nicer to give them the clothing as a gift to thank them for their welcome.

I will not dwell on the problem of the Frenchmen who brought back entire suites of minerals in exchange for the promise of a hypothetical work contract in France. The confidence which these families, desirous above all of finding work, accorded us, the hope that they showed in vain promises, have profoundly revolted us against this abuse of their feelings.

A visit to the mine office is prescribed, as well as to the company mineral sales room, where one can buy retail or wholesale, and receive an invoice so that one may pass through customs on the way back.

It is virtually impossible for the miners' families to obtain permission to sell. But it is no secret that the children go, after nightfall, to look for minerals. As a result, meetings with vendors are often made in the middle of the night in deserted spots.

From Mibladen we went to visit the mine of Aouli. No problems en route.

This mine employs about 350 workers. The Henri II shaft, which is the deepest, goes down 150 m, and two other levels are even deeper. It is a vein-type deposit with galena dominating. Production: 28,000 tons of lead per year, and 12,000 tons of zinc. We found malachite and azurite, banded and crystallized (Sidi Agad), native silver, and tourmaline.

Next we took the road which led to the village of Saida, a long, difficult, rocky road but transitable. In the village there is the possibility of finding very beautiful, crystallized wulfenite, but they are nearly always dinged, piled one upon the other; ridiculously low prices not worth haggling about; a very poor village where few tourists come.

It was with regret that we left our friends in Mibladen, village of strange miners, lost in the middle of a stony desert, with the promise of returning one day.

BENI TAJJIT

Along the road from Midelt to Ksar-es-Souk, take the road going to Gourrama, and continue via a passable road to the mine of Beni Tajjit. One must figure on at least three hours. A beautiful desert countryside, few villages. On this subject, watch your supply of petrol; no chance of replenishment and, even in the town of Beni Tajjit, we were unable to obtain any; there was only diesel fuel. Along the wav children asked for books, pencils, candy or cigarettes. Passed very pretty villages, such as Aït Ouazzag. Wells ten meters deep are found even inside the houses, and the outside irrigation works made it possible to have luxuriant vegetation around Ksour, even in August.

Annual production at Beni Tajjit: 32,000 tons lead, 26,000 tons zinc.

C.A.D.E.T. (the Center for Purchasing and Development, Tafilalet Region) is the company that handles exports from this mine. The ore is brought by truck to the village and dumped in the courtyard of the company. There under the open sky, the workmen sort the ore by hand; some pieces are broken by hammers, and so the piles, little by little, increase in size; the pieces of galena glint in the sunlight...

There is the possibility of collecting crystallized galena, and, if you have the luck to find an engineer at this season, maybe some smithsonite.

Preferably return by the same route to rejoin the Ksar-es-Souk road. We had wanted to go directly to Meski, in spite of the warnings of the miners (who abundantly replenished our food in case we should become lost), by the Belkassem Pass. The road on which we had started out at night was, at first, without problems. But the ridge

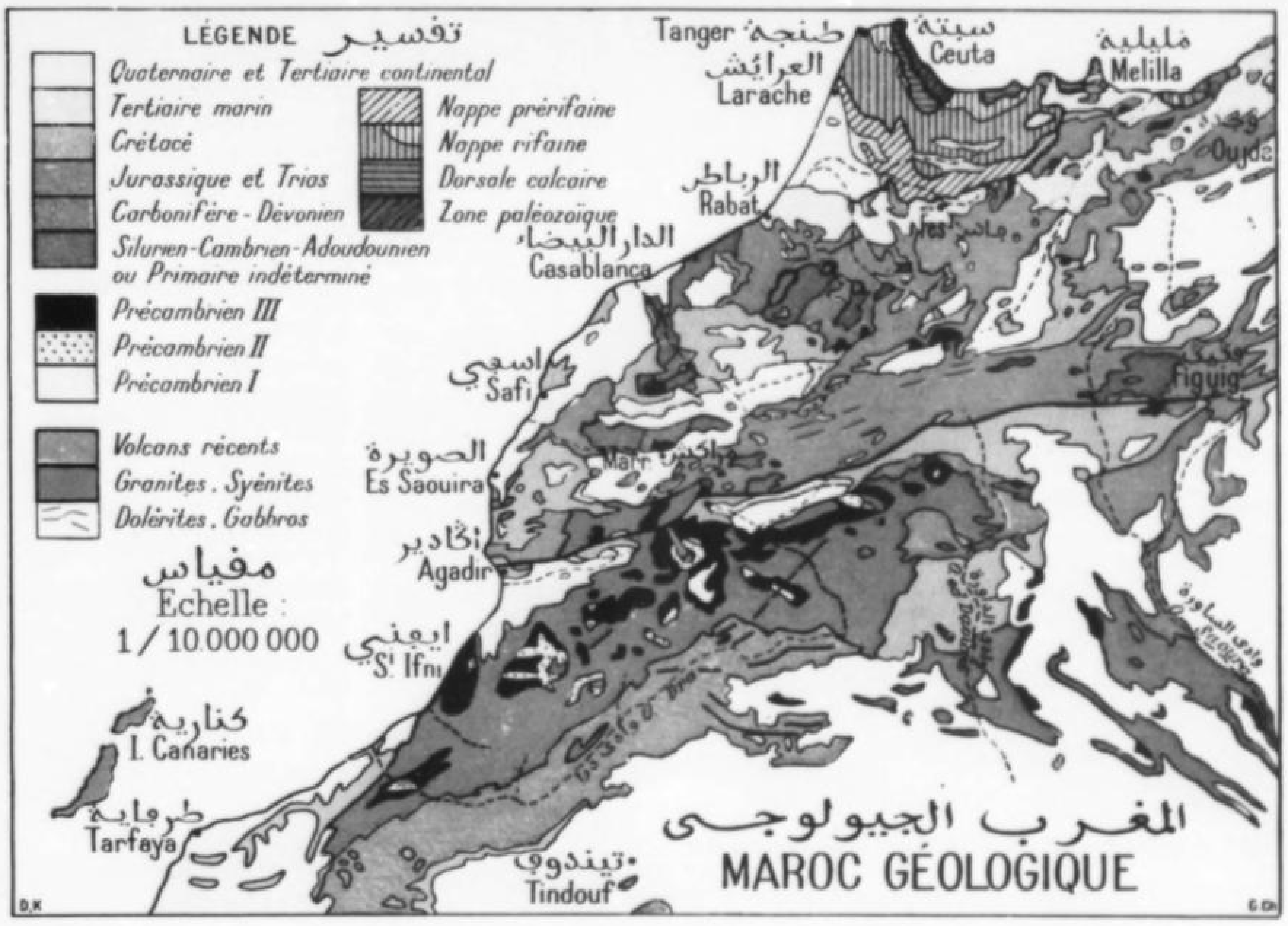


Figure 4. **Wulfenite crystal, 18 mm. (Photo by Guy Chaminant)**

itself is nearly impassable. At one point we were in a dry stream bed strewn with enormous boulders; it was almost impossible to advance or retreat; no automobile with low ground clearance could hope to get through. The only living being we saw on that night was a bicyclist. At last, the hoped-for tourist reward: the Blue Springs of Meski. What a letdown; a great mob bathing, surrounded by campers, by tourists who had arrived by car, etc. (difficult to take after the deserted expanses we had traversed).

ERFOUD – M'FIS

Erfoud is one of the clumps of palm trees in the Tafilalet region (800 m elevation). One finds many fossils along the way, and in the Bordj-Yerdi region, calcareous "onyx". There is the possibility in the market of finding very beautiful "sand roses", originating in Algeria. Bargaining is possible. Don't miss the Rissani market, of modern design, but full of activity – a camel market.

To get to the M'Fis mine there are two possible routes; one leads from Erfoud with little chance of getting lost, but corduroy for many kilometers. The one that leaves from Rissani requires a very good sense of direction or a guide (which are very numerous) but is more pleasant.

Leave very early in the morning, as the heat quickly becomes unbreathable; it is the entrance to the desert. Watch out for the hazards of a breakdown or for deep sand; bring extra water. Don't forget to see the Merzouga pink sand dunes, either at dawn or at sunset; one can pass the night in this village.

The M'Fis mine is seven km beyond the dunes but there are no roadsigns. If you have no guide, follow the power lines, since the trail is often invisible in the stony expanse.

M'Fis: lead and zinc mine. Impossible to go underground the engineers being away, but one can spend days looking in the open pits; on the dumps a few vanadinites, less beautiful than the ones from Mibladen; much barite ("coffin barite"). The miners were very glad to receive us; few tourists venture as far, especially in August.

KSAR-ES-SOUK – OUARZAZATE

From M'Fis return by one of the two routes as far as Erfoud, then head for Ksar-es-Souk to get to Ouarzazate via route P. 32: 309 km.

Figure 5. **Abandoned mine buildings at Azgour.**

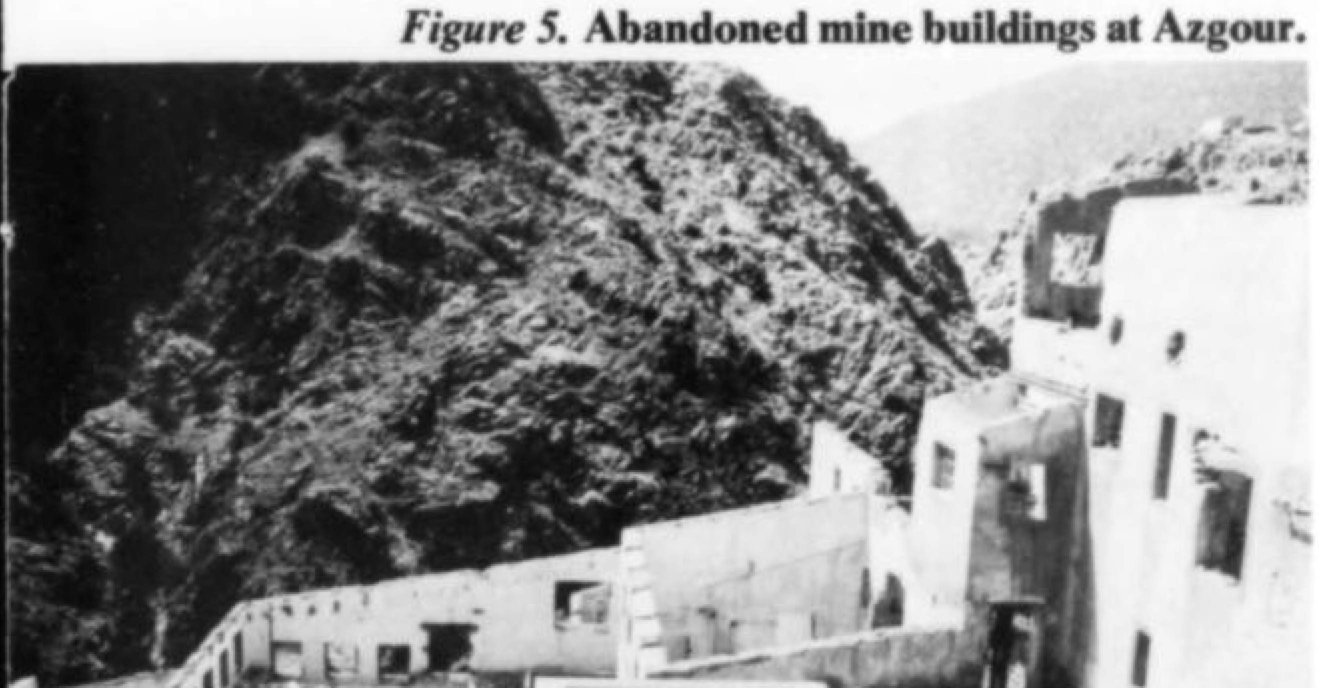


Figure 6. **Beni Tajjite (Society C.A.D.E.T.).**

Don't forget to visit the wild gorges of Todra and the more picturesque ones of Dades with their *Ksours* and their *Casbahs*.

If you have enough time, stop also at the market of Boulmane, little visited by tourists; one finds especially the usual things used by the inhabitants of this region (jewelry, rugs, etc.).

OUARZAZATE

Altitude 1160 m. Many hotels. Two hundred kilometers from Marrakech.

From Ouarzazate go to the hamlet of Taourirt, about one km from which is the Casbah, of medieval architecture, which was the home of the "Seigneur de l'Atlas".

At Ouarzazate our first stop was at the office of the Director of Mines; at the entrance is a glass case with a collection of mineralogical samples of things which may be found in the region. An engineer gave us all the information necessary about the principle mines and the condition of the roads leading to them. Here is the circuit which we recommend, leaving from Ouarzazate.

It seemed to us logical to go directly to Ouarzazate to find lodgings, and from there to radiate outward into the whole region, since it is necessary to count on about one day for each mine visited, and to return to Ouarzazate to sleep.

BOU AZZER

An asphalt road crosses the desert and a rocky region on the way to Tazenakht (67 km); from there an easy but stony road leads one 36 km farther to Bou Azzer.

One should be careful about tires and about the gas tank, especially for a low car. On the return trip we punctured the gas tank, something fairly annoying on a road where no one passes during the month of August. It is good advice to bring a cake of soap along; this enabled us to seal the hole fairly tight to last us the 100 km to Ouarzazate.

Bou Azzer: annual production 11,000 tons ore containing 11% cobalt. The mine is closed in August, but it is possible to search on the dumps for entire days; many

Figure 7. **Mineral vendor along the way.**
Figure 8. **Mine at M'fis.**
Figure 9. **Mine dumps at Bou Azzer.**

samples are very interesting, small pieces of erythrite, serpentine, skutterudite. In the village the miners sell minerals. It is very difficult to find well-crystallized erythrite, and the little that one can find is very expensive.

In every house we visited we saw minerals. In August the village is quiet; the men chat in front of the lone cafe-grocery store; the women in the interior courts weave carpets.

Returning by the same road, we spent the night at Ouarzazate, and left again the next mourning for Bou Skour.

BOU SKOUR

Take the road toward Ksar-es-Souk again, but after about 40 km take a turn-off to the right; there is a sign with the name of the mine.

Bou Skour: 12,000 tons of copper ore, 30-32% Cu.

Already on the road which leads to this mine, there are many places where one may stop to look for specimens.

The mine was not closed but was working at reduced capacity. We visited the mine installations and habitations, all very modern. Around the mine one can also prospect. We visited several miners, always receiving a warm welcome; in the garden of a little house we bargained for fine, crystallized azurite and radially fibrous malachite, both at fairly high prices.

After checking out the cooking at the "Foyer" we headed back to Ouarzazate.

OUARZAZATE – TIZI-N-TICHKA

Along this route, at about 40 km from Ouarzazate, stop at Imini.

Pyrolusite ore (70-92% MnO_2) is found here. About 520 men were working; the shafts to 150 m deep. Mining here started in 1930. Today's annual production is 200,000 tons of ore.

The mineral concentration is done right here. The engineer who received us let us visit the exhibit of all the types of specimens recovered from this mine since it started.

Before getting to Marrakech, it is necessary to cross the Tizi-n-Tichka Pass (2260 m). This is amethyst country; all along this 200 km of mountain road are beautiful mountain scenery and innumerable vendors of minerals, amethyst geodes, calcite, pyrolusite crystals on quartz, sand roses, but look out! Sometimes they stain quartz with violet ink to make "amethyst"; the ink gives the mineral a golden sheen in direct sunlight. It is impossible even for an amateur to be fooled, for when rubbing with a dampened finger the ink will come off. Some rock salt is also stained with red ink, and they try, although without much conviction, to sell it for amber.

MARRAKECH

Altitude, 550 m; 200 km south of Casablanca and 320 km from Agadir.

From Marrakech, arrange without delay to visit the Azgour mine. Take S507 toward Amizmiz, 55 km. In the heat of the summer on the way to this town we met only herds of sheep which stayed in the shade of the trees.

The road one must take is on the right as one leaves Amizmiz; one sees first of all a fine pine forest; the road is passable but difficult, for it is very narrow, with a cliff on one side and precipices on the other, which became more and more dizzying as we got higher and higher on the mountain.

The 20 km of this road leading to the mine seemed very long. In the distance one sees, upon arriving after having passed several houses, walls surrounded by cyprus trees. All of this gives an illusion of grandeur, but upon approaching the impression changes; the place is deserted, the roofs falling in ruins. Azgour mine is abandoned.

There is just a small village from where one must take the path descending toward the old mining installations. There, along the road, one can spend days searching among the rocks and the dumps which go down toward the deep gorge where a torrent flows. One can find garnets, vivianite, beryl and wolframite.

The collars of the shafts are walled because of the danger of falling in. But if you suffer from the heat approach one of the adits; the local children have opened a hole from which a glacial wind escapes from the depths.

The people of Azgour are even more hospitable than elsewhere, if that is possible, for the courageous collectors who venture this far are rare. They offered us coffee (no mint tea), bread baked in their own homes, with honey; their welcome is suited to the calm peaceful atmosphere.

It is strange to see all these installations, gardens, patios, houses, walls, falling into ruins, where the caretaker, an old man, doesn't even remember when the mine ceased to operate.

In Rabat they speak of a project to transform the abandoned buildings of the Azgour mine into a mineralogical museum. This mine had seemed inexhaustible, and its closing will have, among other things, awakened the conscience of the Moroccans with respect to their underground riches, making them understand the necessity of controlling their exports.

Today the Moroccan customs authorities permit the export of ten mineral samples per person, unless one has invoices or a permit issued in Rabat by the Director of Mines.

And then if you still have time, we recommend two more side trips:

MARRAKECH – MEKNES

Distance: 500 km. In Khenifra take the road to Tarmilate, then the road to Aguelmos, and after approximately 20 km take a road to the left. Thereby one will arrive at an antimony mine, with the possibility of finding stibnite. At Oulmes one can find tungsten minerals.

By the same road continue on to Meknes.

MEKNES – RABAT

After Meknes take route S-316, thence a passable road to the El Hammam mine. Beautiful crystallized fluorite occurs here.

We suggest that one rent an automobile in Morocco, for even in August when the weather is dry some of the roads put cars to a tough test.

We hope that this itinerary will help you pass a pleasant and interesting mineral collecting trip in Morocco.

We wish to thank the Ministry of Commerce and Industry, Mines, the Merchant Marine, and the Geological Division of the Department of Mines, Geology and Energy for their help. And we would like to point out that the "Centre de Documentation" in Rabat publishes notes, memoirs and geologic maps which can be ordered by mail.

Text and photos: Anne Voileau
English translation: Richard V. Gaines
Reprinted from *Le Monde et les Mineraux*; color separations courtesy of Anne Voileau

Figure 10. **Author and friends.**

M.R. INTERVIEW:

VICTOR YOUNT

Victor Yount has been a collector for 20 years and a wholesale dealer for nearly seven years. He has traveled to places most collectors only dream of visiting; Laurium, Greece; Trepča Yugoslavia; Almaden, Spain; Elba, Italy; Llallagua and Oruro, Bolivia; Casapalca, Peru; and Morocco. Morocco has been one of his favorite haunts in recent years, so we interviewed him in his motel room at the 1976 Tucson Show; in doing so we obtained a dealer's view of this interesting country to compliment the collector's view taken in the article by Anne Voileau (this issue). Vic is something of a nomad, and not the type to sit still long enough to write articles on all he's seen; he was therefore, an ideal subject for the interview format.*

MR: Do you have a home base?

YOUNT: That's a very good question... I've been traveling for seven years so I haven't really stopped anywhere.

MR: I guess the answer is no.

YOUNT: No, I've lived in Spain more than anywhere else; I've lived there for 14 years.*

MR: How many times have you been to Morocco?

YOUNT: Fourteen.

MR: What is the mining situation there right now, in the Mibladen district for instance.

YOUNT: I would say at least 80% of the miners have moved out of the area because mining has ceased. The town of Mibladen is closed down for all practical purposes; there's no mining operation going on at all...no *official* mining operation; there's a little bit of moonlighting by a few miners, most of them are foremen who hope to be hired back to the mine when it reopens, and that is dependent upon the Moroccans finding someone who wants to invest. They're hoping for Moroccan ownership as it was the French who were pulling most of the money out. All the miners who were working there are now out of work, looking for something else or have found something else, but there's no mining operation going on there at all. It's been closed now for about half a year...approximately...but the threat of being closed was imminent for years as it was becoming unproductive. And the mine tried all sorts of gimmicks to keep open; they even went into the selling of vanadinite specimens themselves...by *weight*. You had to buy big lots, some of the bigger lots that were bought were usually not very good quality because anything that was really good was stashed away by some miner, especially if it was small. But they sold a lot of material and made quite a few thousand dollars. There was a dealer in Mibladen who used to do all of his buying direct from the mine but on a sort of quasi-legal basis. He would go directly to the mine storehouse (they had a large selection to choose from) and he would buy lots from them and sell them (usually upon the arrival of a letter or something saying somebody was coming down to buy).

The mine more or less follows the road from north of Midelt. Coming into Midelt as you go south from Fez (which is probably the most direct route) you pass a series, for 15 miles or so, of old mine dumps. And then when you take the road up to Mibladen you do the same sort of thing; you see a long series of dumps. From the town of Mibladen you take the road that leads East and goes in the direction of Aouli. Aouli has really nothing of consequence now; they have quartz, fluorite and barite crystals; the fluorite tends to be a gray color sometimes with marcasite and pyrite inclusions, and sometimes as drusy coatings with barite that's mostly gray. There are also some micro chalcopyrite crystals on it. Then they had...the incorrect term I'll use is "primary malachite"...malachite crystals getting up to almost an inch, on a sort of a dolomitic frosting or druse. And then they had some azurite crystals that came out a couple years ago that were quite good, size range up to an inch and a half.

MR: Where are these from?

YOUNT: Those are from Kerouchen, which is a good azurite locality not far from Mibladen.

Figure 1. **Road marker on the way to Mibladen, seen through a dust-streaked windsheild.** V.Y.

*He has settled down since the interview: Rt. 1, Box 222, Afton, Virginia 22920.

V.Y.

***Figure 2.* The town of Mibladen.**

MR: What are the minerals you've seen from Mibladen...vanadinite, galena, calcite, anglesite, cerussite, barite, wulfenite ...any others?

YOUNT: Not really. It all occurs in a rhyolite, heavily faulted and brecciated.

MR: And they've been mining all these years for the galena?

YOUNT: Yes, mostly for the lead; I don't think it's argentiferous.

MR: Is there a primary zone with only unaltered galena below a certain level?

YOUNT: Most of the galena is capped with either anglesite or mostly cerussite ...there is a lot of cerussite in that mine. And the galena is usually in seams of a half inch thick, but also occurs disseminated. There's been a lot of water action, etching and leaching. The barites, as I say, occur in a wide variety of colors. Barite and cerussite is the most common combination, then you'll find barite and vanadinite. White, bladed barite covered with up to an inch and more of bright red and orange crystals of vanadinite ...that's probably the most classic or the most beautiful combination you can find; that zone was passed a long time ago.

MR: How long ago?

YOUNT: Oh, a year or so ago...more than that. That's the last time I saw any noticeable amount of specimens coming out.

The area is interesting scenically; it's very dry, fairly high, there are mountains very nearby, the Middle Atlas (Moyen Atlas) mountains. I'll show you some pictures here just taken recently. I have pictures of camels, and goats climbing trees, and snake charmers and castles built on the beach. Here are the goats climbing trees; it's the only place in the world that goats do that, that I know of.

MR: I wouldn't have believed it...

YOUNT: This fellow is a miner, a foreman, who saved this specimen out (Figure 3), he's now not working.

These are some of the mine workings at Aouli (Fig. 7, 8). There is an acicular or spray variety of aragonite that occurs close to Kerouchen, where the azurite was found. The only reason I'm giving you this information is because the area is relatively dead now. Otherwise this has been a big money-maker for me so I wouldn't necessarily be anxious for people to go sailing down there if there was much left. Besides it would take them about as long as it's taken me to find the good ones. The people who have the good ones, it's really funny the way they do business; I mean it's really unusual. An American wouldn't understand it at all because it doesn't involve the same ethics that we have, which is the Almighty Dollar; to them the Almighty Dollar is not almighty even if they're starving. If you don't approach them in the right way there's no way you can deal with them. There's a whole bunch of tricks of the trade, like knowing who to give a gift to, and coming with a gift, and if you don't have the appropriate gift you might as well forget it. All these things I learned the slow way. And I was never shown any good material until the last two or three years. And it was just because I finally got the approach down right, y'know. But even if they know you're a big buyer and you come in and you show a lot of money they're really not going to show you the good ones unless you approach them in the right way. They're sort of like the Japanese; they're very picky about protocol, customs. For instance you don't walk in and not ask them how their family is doing. Then you say "May I see your

V.Y.

***Figure 3.* Two Berbers offer to sell Renée Hotte an excellent vanadinite specimen.**

***Figure 4.* An open pit portion of the mines at Mibladen.**

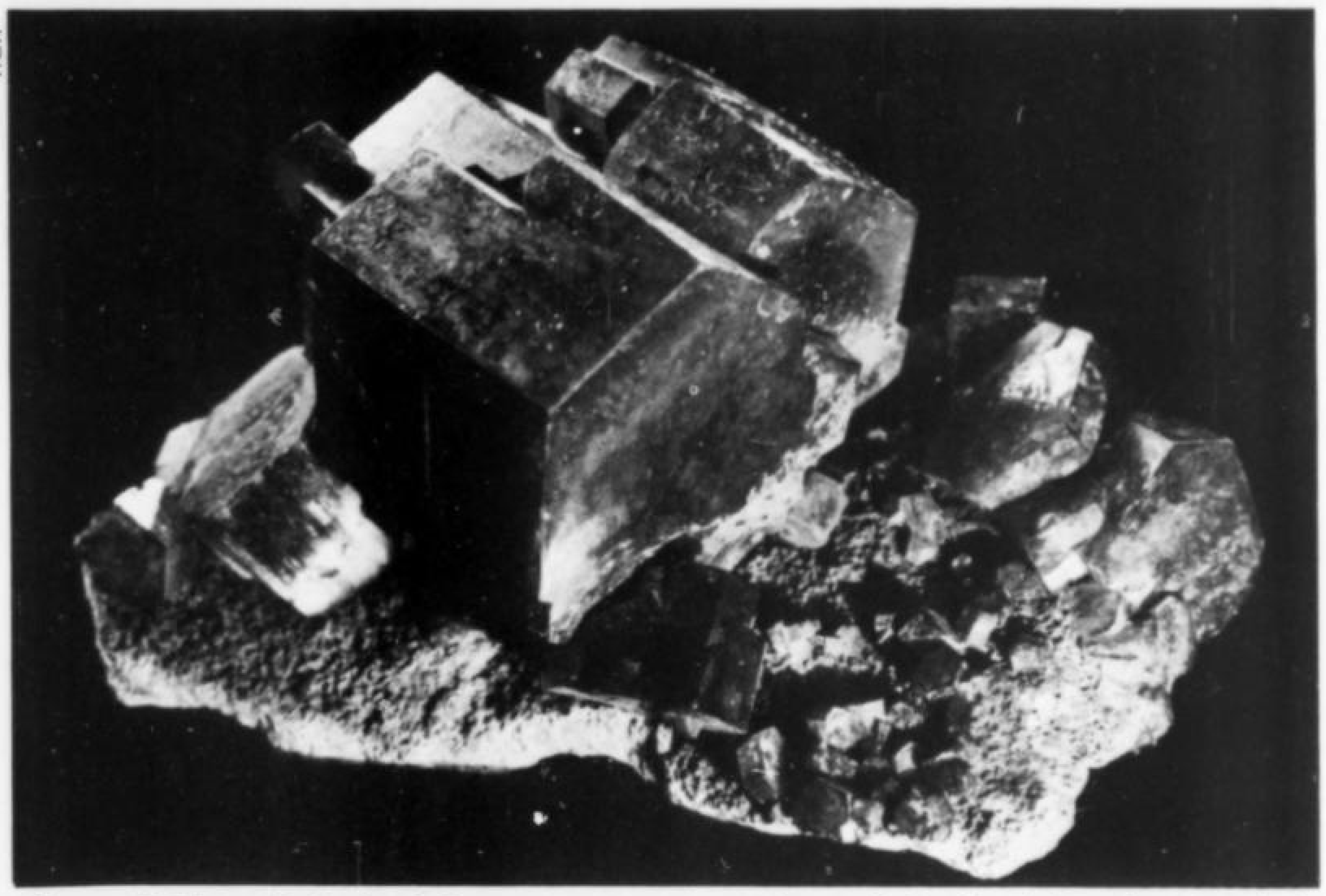


Figure 5. **Vanadinite (red, largest crystal is 1.8 cm), Mibladen, Morocco. Smithsonian specimen.**

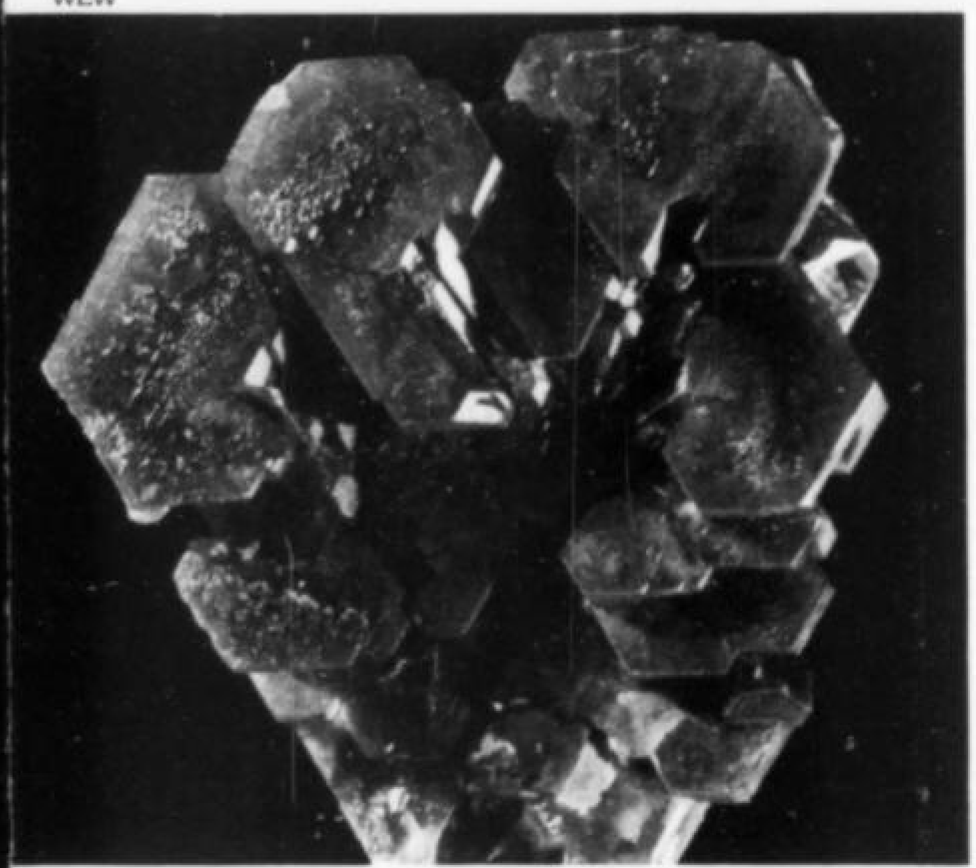


Figure 6. **Vanadinite in parallel growth (red, 3.4 cm wide), Mibladen, Morocco. Smithsonian specimen.**

wife" and you're introduced to the wife, and you give her a present. It has to be something that she'll like...if she doesn't like it that's trouble. I've been turned off of deals for some ridiculous reasons. Another thing: they won't *ever* quote you an opening price, never. Not once have they ever quoted me an opening price. So *you* have to say the price and if it isn't right the first time...if you aren't pretty close, they turn away, walk away, and that's it. You can't come back and say "Wait a minute I'll raise my price," or change your mind; that's it. Once you've insulted the guy that's it, for that day anyway. You may be able to come back the next day and plead with him, but then he's got *you* and he's going to get you for every cent he can because he knows you want the material enough to come back. So it's a completely different procedure that one uses here and I've found that differences occur in every country; there's a different way to approach the people. The Spaniards, my God, the Spaniards with their ego and all, it's really...

Getting back to Morocco, let's see if I can think of all the other associated minerals. Well there's calcite, too, that occurs in Mibladen, often as a drusy coating on vanadinite. The vanadinites occur in an infinite variety of color and form ranging all the way from almost black through the browns and dark browns to the reds to the lighter reds, then yellow. I would say the largest crystals never exceeded two inches--that would be exceptional. Then they go down to micro size of course, and they have the common hexagonal shape...sometimes barrel-shaped, sometimes thin, sort of poker chip shape, and they occur in conjunction with barite. I've never seen, I think, a wulfenite specimen with vanadinits on it. The wulfenite is always with barite.

MR: In the Old Yuma mine out here [near Tucson] you can go down one side of it and it's all vanadinite, down the other side it's all wulfenite, and in the middle there's nothing of either.

YOUNT: Well there's a lot of "nothing of either" that they have to contend with at Mibladen, and that's the reason, probably, why they closed it down. They hit fracture zones with brecciated rock and that's where you get these floaters of vanadinite and things like that; but then they're not after the vanadinite, they're after the galena, and those galena veins are very thin; it's a marginal thing. The rock is hard, there's a lot of blasting that has to be done, it's dangerous, it's expensive. I can see why they had to shut down.

MR: What does the wulfenite look like?

YOUNT: It looks very similar to the Old Yuma. It's not like the San Francisco mine, not like the 79 mine. It's usually toward the yellow side, not as orange as Old Yuma; although I've seen some that's almost red like the Red Cloud; but it's of the bipyramidal type, things like you've got from Los Lamentos. The crystals are very small, like a quarter of an inch, for the reddish type. The only good one I've ever seen with cerussite has a wulfenite bipyramidal crystal stuck into a cerussite crystal, and I donated that to the Smithsonian.

MR: What's the biggest wulfenite you've ever seen from Mibladen?

YOUNT: I saw a plate one time that was only about 5 by 5 [inches] or so, but it was covered with crystals. There was very little barite, it was mostly wulfenite and the wulfenite crystals were easily an inch. There were maybe thirty of them, all very well formed, and they stick straight up or at some angle--they're not lying flat--and very lustrous all the way around. It was a very nice piece. Very rare and it came out quite a long time ago. You still see a few but they're always tucked away in the barite and it's very rare that the barite is leached or etched away to the point where these things become easily visible.

MR: Are any of the other minerals anything to look at, like the anglesite for instance, or is it just a crust?

YOUNT: Just a crust, exactly. The cerussites are very sharp, some of them, and very lustrous. They reach maybe four inches tall and three or four inches wide. and they're the sixling pyramidal type: complete sixlings without the spoke effect, like the witherites from Cave-in-Rock, Illinois; very very similar.

MR: You say the barite comes in all colors?

YOUNT: Yes, it comes in a red, and then it goes through yellow and white and sort of orange. Sometimes micro crystals of orange vanadinite are drused over large areas, and these barite groups with cerussites get up to just about as big as you'd want to have them...maybe three

V.Y.

Figure 7. **Mosque at Aouli, with mine dumps in the background.**

or four feet across, depending on what the miner feels like carrying out, but there are not too many people who are interested in that.

MR: Are there any zinc minerals at the mine, such as hemimorphite?

YOUNT: It's not a lead-zinc-type combination.

MR: So what is the situation at Mibladen at the present.

YOUNT: The mine is closed, the Moroccan government is looking for someone to take it over...they want to nationalize it. But at the present it isn't working at all; Aouli is also closed, and all of the smaller mines around the area are officially closed. Now you have guards at the entrances of the main mines, the mines that were working most recently before the closing.

MR: How many major mines are there along that strip?

YOUNT: There are a lot of tunnels; you might call it all one deposit.

MR: Do they have different names?

YOUNT: They may have some system of identifying the different adits and levels -- actually it's not very deep; I don't think the mine is over 500 feet deep.

MR: All in the secondary zone?

YOUNT: Yes. But I'm not an expert on the geology here, so you may want to check with some other people on that.

MR: And people are still sneaking in to remove specimens?

YOUNT: Yes, well they're doing it in other mines which are 10-15 km away but still in the Midelt-Mibladen area.

MR: So what's the current specimen situation? Meager?

YOUNT: Right now it's meager; it was good right up until I went this last time. But this is the first time this guy [the one I deal with] has not painted a very bright picture.

MR: Have you ever been to the erythrite locality?

YOUNT: Yes, I've been there a lot, maybe ten times. It's working; they've closed down Bou Azzer though, the primary source of all the great erythrites. That is closed as closed can be. I've got pictures of the complete mine there; it's like a series shot of maybe five photographs with the mine dump going up to the old building...all the windows are knocked out, it's completely abandoned. They've moved over to what they call Bou Azzer Est (East), and they're working about three areas, all for skutterudite, the cobalt-nickel arsenate. It's mainly a cobalt mine -- that's the way they classify it.

MR: Are there many crystals [of skutterudite] coming out?

YOUNT: Oh there are a lot. They get up to sometimes two and a half, three inches. And the road going to Bou Azzer...my God. There is no road really; you have to take a compass reading! In Bou Azzer all the ore goes out by rail, so the roads are not well maintained. It's very hot there most of the year, they have some very heavy winds. The sandstorms down there are very frequent. I really don't care if anybody goes down there; I'll say there's material left but there's no good erythrite, it's all micro, enclosed in massive skutterudite. There was gersdorffite and stichtite from that locality, and also in a mine somewhere around there they had cobaltocalcite crystals which were very very pretty. They also have roselite; the best roselite in the world is from Bou Azzer. Crystals up to almost an inch. But the main thing right now is skutterudite.

When you go along the road you can see outcroppings of hematite and quartz, and you find asbestos and serpentine. I think all the skutterudite is imbedded in serpentine.

MR: What do you remember about the classic finds of erythrite at Bou Azzer?

YOUNT: Oh boy, it produced some really big ones! I'd say the Sorbonne got the best ones though, and Bariand let most of

Figure 8. **The mines at Aouli (Mines d'Aouli).**

V.Y.

them go in trades, while keeping the best Ecole du Mines (Paris) got good ones too.

MR: At what time did the best erythrite come out?

YOUNT: Oh I'd say from about 1963 to 1969. The biggest crystal I ever saw was maybe about two inches, two and a half inches.

MR: Any other minerals?

YOUNT: Well the skutterudite is the finest in the world, there's no question about it. They occur completely imbedded in calcite; you etch off the calcite or chip away the calcite and these bright shiny skutterudites come out. The octahedron is probably the most common form, cube is probably second, cuboctahedron, and sometimes even diploids. Pyritohedrons too.

The erythrite occurred in the upper portions of the mine and was worked more or less just to suit the demands of collectors; it was never common enough to be an ore.

MR: The mining people allowed that for the sake of collectors?

YOUNT: Not really. But most mines will try to please the serious collector, someone who's not trying to abuse the privilege. The first time I went there as a collector I was allowed to collect on the dumps. It was mainly because I spoke Spanish so well and the mining superintendant at that particular mine was Spanish. It was the first one in Bou Azzer Est; there are three mines in Bou Azzer Est, referred to just as "one", "two", and "three", (starting from West to East, I think, but I'm not sure).

It's hot around there, and there is the chance that if you ran out of gas you could have some serious problems, especially in the summer. It's a long walk [between Tazenakht and Bou Azzer] and there's nothing in between, absolutely nothing, not a living soul. And that road gets traveled very infrequently, maybe two or three shipments of food a week. If you get a flat it's pretty serious; carry a lot of water and carry spare tires. I had five flats in one day, and I really lucked out; I hit two trucks, one going in to the mine and one coming out, and if I hadn't had that I'd have had a lot of problems. I had two on the road going there. It took me two days to get there because I had to have one taken back to Tazenakht and this other guy came back in another truck going back to the mine, and he brought it back, you see. And then

WEW

Figure 9. **Wulfenite with pink barite, Mibladen, Morocco. The largest crystal is 1 cm; Smithsonian specimen.**

WEW

Figure 10. **Skutterudite (silver-gray, 6.2 cm wide), Bou Azzer, Morocco. Smithsonian specimen.**

Figure 11. **Vanadinite, Mibladen, Morocco. The large crystal is 1.5 cm across. Victor Yount specimen.**

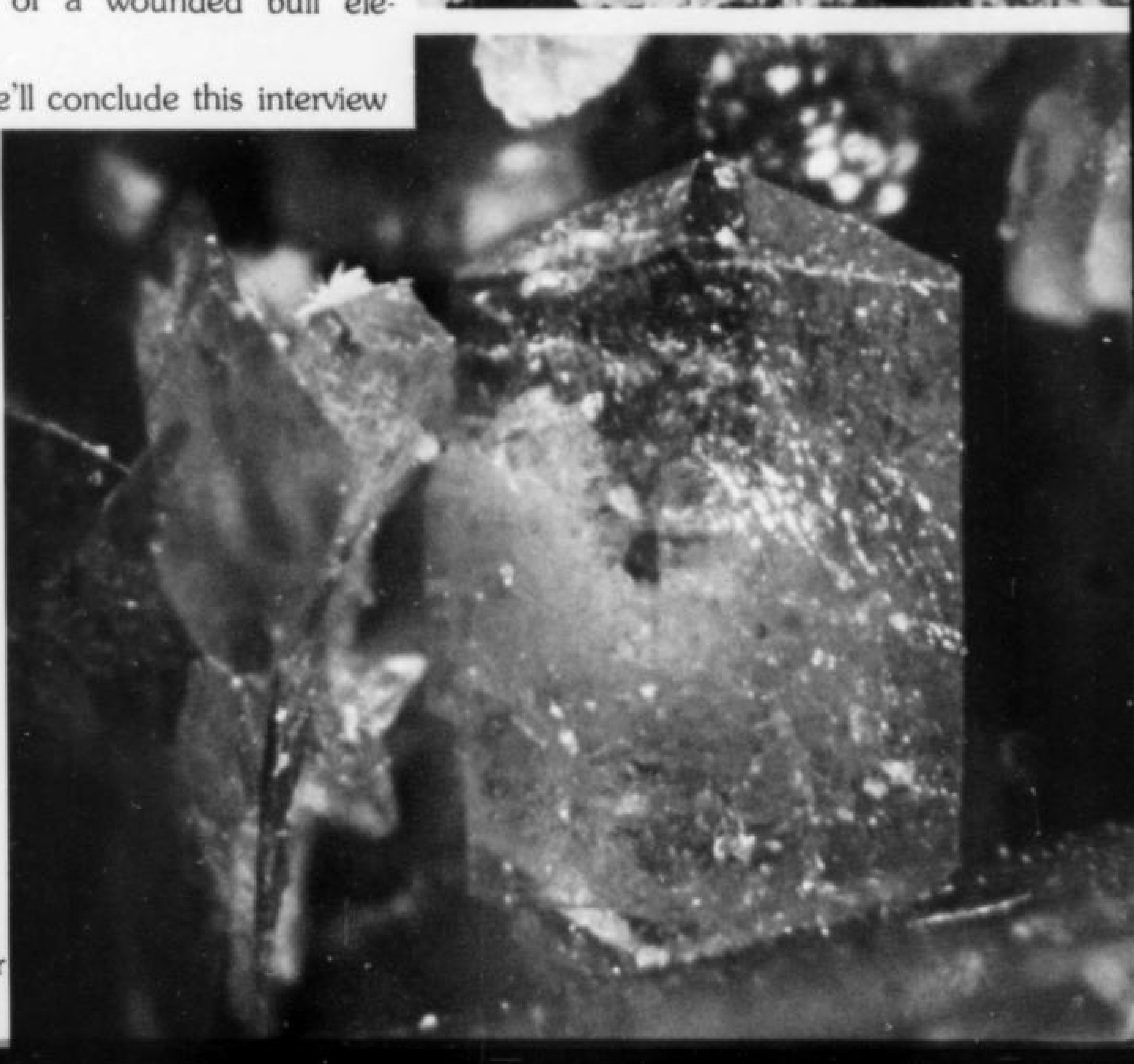
WEW

WEW

Figure 12. (top left) **Erythrite, Bou Azzer, Morocco. The large crystal is 2 mm; Smithsonian specimen.**

Figure 13. (middle right) **Erythrite (dark magenta, width is 4.2 cm), Bou Azzer, Morocco. Smithsonian specimen.**

Figure 14. (bottom right) **Roselite, Bou Azzer, Morocco. Julius Weber specimen.**



Julius Weber

as I was going again I had another one but I was close enough to the mine where I could put it on this guy's camel and he took it in and had it repaired and brought it back. And then when I was at the mine I had two flats there, and as I was leaving the mine I had another flat, and I luckily ran into someone else who could help.

MR: Was this because of nails or sharp rocks or what?

YOUNT: Sharp rocks...bad tires too, more than likely.

MR: How many languages do you speak?

YOUNT: Well I speak Spanish fluently, French, a little bit of Moroccan Arabic, Berber too. I can count and ask for most of the common things you use or eat.

MR: Without giving away any secrets, what are the hot items at the moment in Morocco?

YOUNT: The azurite locality is still producing slowly, it trickles out. There are only two Berbers who are actually mining it, if you want to call it mining. They have one of those hydraulic jacks -- that's all they have is one -- and they have to transport gasoline a long distance.

You've got to be a hardy person to travel in [the back-county of] Morocco and make it, I mean there's dysentery everywhere, they still use human fertilizer ...but getting back to minerals, skutterudite is still coming out; there are unbelievable fossils from Erfound; Bill Larson and Gary Hansen know all about that if you want to check it out. The Eureka Valley going from Ouarzazate to Marrakech is very productive in quartz geodes, amethyst, agates. Selenite roses occur very near the Algerian border.

Another thing, if anybody catches you with vanadinite, that's it. You forfeit all you have [in Morocco] at the border. And they have informers.

MR: How do you get them out?

YOUNT: It's mostly luck. I've had a lot taken away though. What I actually do, if you want to know the secret to the whole thing, is I buy a lot of "Moroccan ware" [cheap brass horns, bowls, touristy souvenirs] and stick it in sort of on top of the boxes, and as soon as they see that they say "Oh just another tourist".

MR: What's this on the bed here, some type of horn? [obviously native-made from brass, about 6 feet long in three sections, with tassles]

YOUNT: Yes, that's what I greet my guests with...bought it for ten dollars! [He raises it to his lips and produces a fair imitation of a wounded bull elephant]

MR: I think we'll conclude this interview on that note.

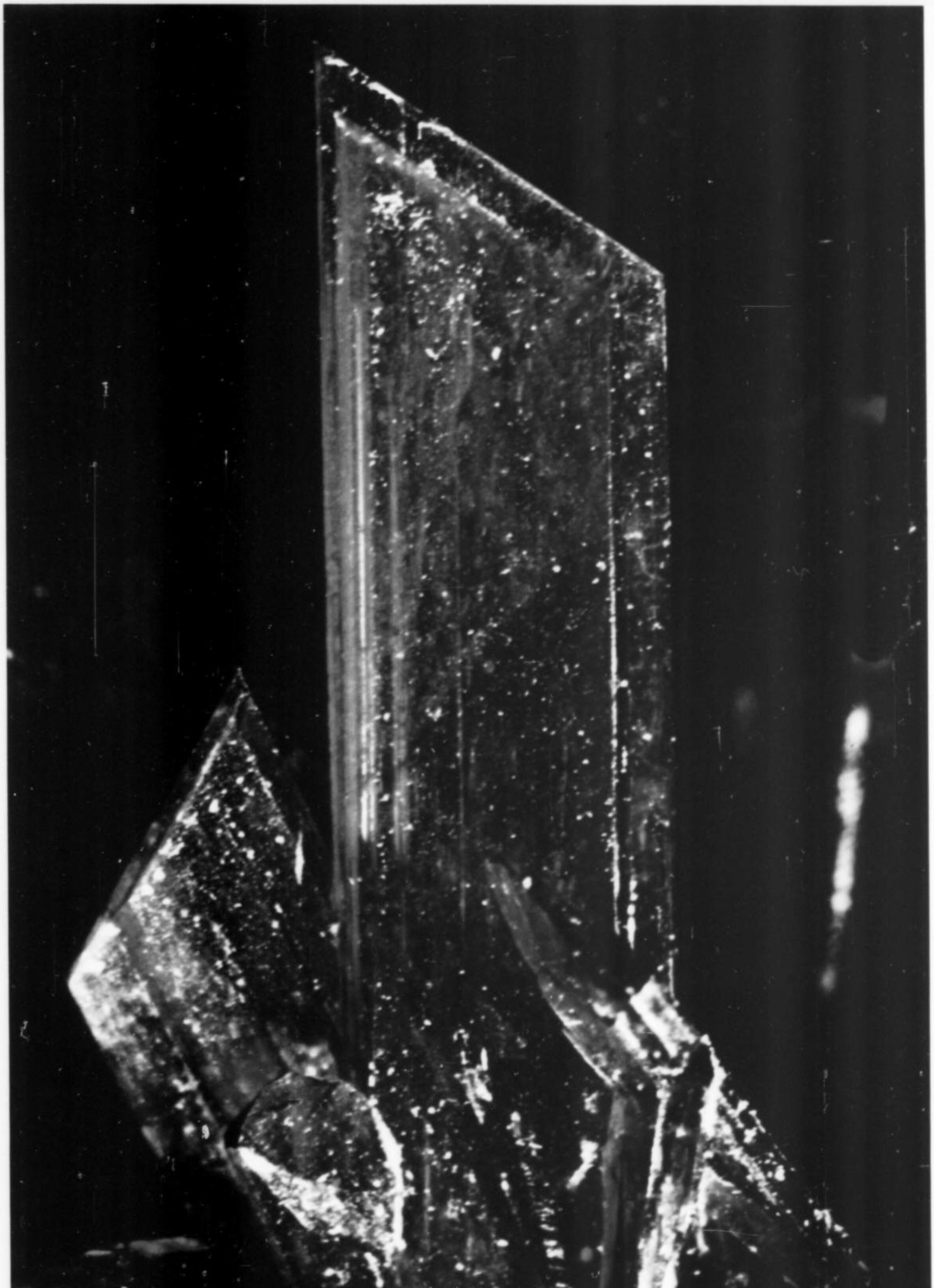


Figure 15. Erythrite, Bou Azzer, Morocco; 2 mm. Sorbonne collection. Nelly Bariand

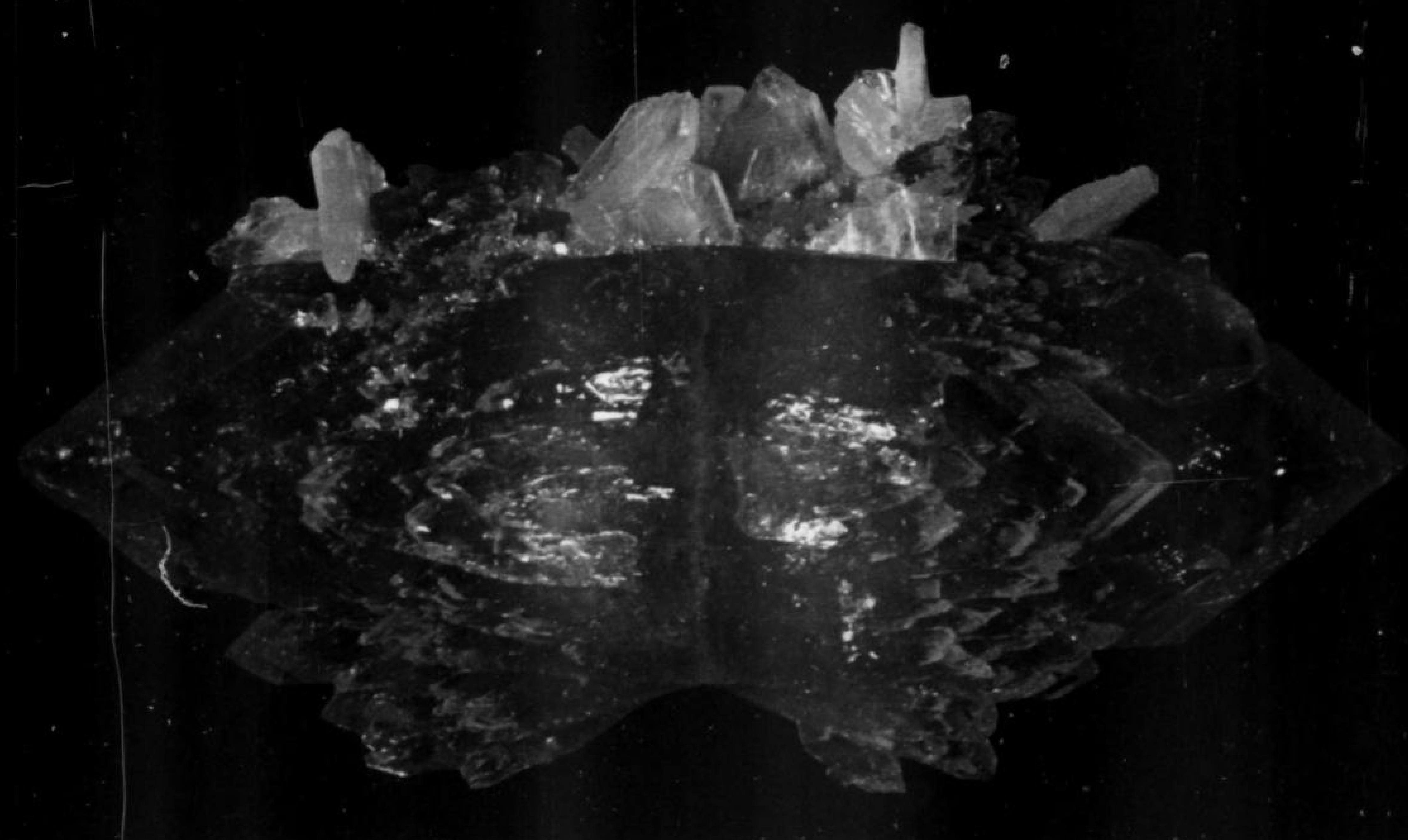


Figure 1. **Apophyllite with stilbite, Pashan, India. The specimen is 6 cm long.**

The Production of Zeolite Mineral Specimens from the Deccan Basalt in India

by Rock H. Currier, Box 8252, San Marino, CA. 91108

INTRODUCTION

The purpose of this article is to acquaint the readers with the production of mineral specimens from the Deccan basalt in India. Most of the information presented here has been derived from three trips to India by the author made during the last three years. On each of these trips I made many buying and collecting excursions to various dealers and the quarries. I am a wholesale dealer and collector of mineral specimens and my interests and travels in India are admittedly oriented to the acquisition of saleable mineral crystal specimens. I hope, however, that there may be enough information in this article to make it of some interest to the professional mineralogist.

GEOLOGY

The geology of the area is quite simple; 200,000 square miles of basalt. Although this immense basalt blanket was much larger at the end of the Cretaceous period than it is now, the eroded remnant still covers a large portion of west central India. The thickness of the formation varies from 10,000 feet near Bombay in the west to 2,000 to 500 feet in the east and south. There are many individual flows in the formation, still more or less flat lying, of slightly variable composition, varying in thickness up to 100 feet (Wadia, 1919). Parts of the formation are commonly vesicular. Amygdules, ranging in size from microscopic to "pockets" the size of several washtubs, are found filled with zeolites and associated minerals.

DISTRIBUTION OF "POCKETS"

I have seen only those basalts in the areas of Bombay, Poona, Nasik and Malegaon and they are, as described in the literature, full of amygdules, some of considerable size. When the amygdules are of sufficient size they commonly contain beautiful crystals of zeolites and associated minerals. For the purpose of simplicity, amygdules will henceforth be called pockets. Apophyllite, okenite and other zeolite-associated minerals, while not zeolites, will be understood as included in references to zeolites.

Although pockets with zeolites are found near all of the above mentioned cities, they are much more plentiful in the roughly triangular area formed by the city of Bombay to the west; Poona, 100 miles to the southeast; and Nasik, 100 miles to the northeast. Specimen production is not limited to this area; however a conservative estimate would put the productive area at about 4,000 square miles. It is safe to assume that India will be producing zeolite specimens for a long time to come.

During the winter the ground is relatively bare and it is not uncommon to find zeolite fragments lying in the thin soil; having weathered out of pockets in the basalt or still partially in place in weathered dirt-filled pockets exposed at the surface.

Fresh unweathered pockets of zeolites may be found whenever excavations are made in the basalt. Road cuts, building foundation, wells, rock quarries and railway tunnels have all produced specimens. Perhaps the first Indian zeolite locality to attract the attention of the world-at-large was a railway tunnel. Near the turn of the century the British built a railway through the mountains between Bombay and Poona. While driving one of the railway tunnels, large pockets of fine zeolite specimens were encountered. These pockets, as much as six feet in some dimensions, contained large pale green apophyllite crystals up to three inches and balls of pale orange stilbite (R. Kothavala, Pers. Comm.). The tunnel in which these pockets were found became known as the Jewel tunnel in allusion to the jewel-like appearance of the crystals in the pockets which sparkled in response to the lamplights of the workers. There may be a few specimens from the Jewel tunnel in the United States, but not many, and certainly few, if any, specimens have been produced from there during the last fifty years. I rode through the Jewel tunnel on a train to Poona, but nothing could be seen for steam locomotives have used the tunnel for many years, blackening the walls with soot.

THE QUARRIES

There is very little alluvial material in this part of India suitable for the production of aggregate for road building and construction purposes, so all such material must come from quarries. There are, of necessity, many quarries, and these are the most prolific sources of zeolite mineral specimens. Here the soil is always thin and basalt is always close at hand. Wherever there is road building or heavy construction, there is a quarry close at hand. Whenever rock is needed, a convenient basalt hill is quarried. If no hills are near, a quarry is sunk in any convenient flat area.

The production of specimens from quarries is sometimes self-limiting. Solid, non-amygdaloidal basalt is sold for more than basalt full of amygdules and zeolites. Some quarries have been abandoned because of an overabundance of zeolites and work has been shifted to an area where the basalt is of a more solid nature. Sometimes quarries become filled with water from the monsoons and it is easier to move work to another place rather than pump the water from the old quarry. Such water-filled quarries often provide a place to water animals and wash clothes.

With the exception of some larger quarries that have been worked for many years, most quarries are quiet small and are operated only when the need for building material arises. An average American home or two would be all that would fit on the floor of most quarries. Almost all of the quarries are operated for building material and the zeolite specimens, if any, are strictly a by-product of quarry operation. The only exceptions are a spectacular specimen-producing quarry near Nasik, now dormant, and one in the Pashan Hills, near Poona, that produces green apophyllite crystals. The quarry workers collect zeolite specimens to sell for extra money if they are aware that they can be sold, and if someone comes to the quarry to buy them.

Most quarry operations are primitive. The larger quarries near Bombay may have their own compressors, jackhammer drills and dumptrucks, but even there the trucks are loaded by hand. Women do most of this unskilled work. The smaller quarries may share a compressor and a drill if they can afford one. If not, all holes for blasting are drilled by hand. A four-foot steel bar, blunt at one end with a chisel point on the other, is used. The force of the bar on the down stroke is enough for the chisel edge to break the rock and drill a hole. Water poured into the hole keeps the bottom of the hole clear of rock chips and dust. When enough rock fragments are produced to form mud, the hole is cleared with a mucking spoon. A hole two or three feet deep can be drilled in about twenty minutes. The hole is then packed with black powder and tamped tight with dirt using the blunt end of the drilling bar. The blast may produce as much as a cubic yard of rock. Large quarries generally use dynamite, but benching, a common quarry procedure in the U.S., is not practiced. As a quarry is worked into a hill, the quarry face rapidly becomes very high. Workers drill on the quarry face regardless of the height, using ropes dropped from above as safety lines.

Quarry workers are generally paid by the number of truck loads of rock they produce and load into trucks, but the amount they are paid and the organization of the quarry workforce will vary from quarry to quarry. In a typical small quarry a crew of four to six workers might be paid six to eight rupees (about a U.S. dollar) for a truckload of rock. This would include drilling, blasting, breaking large boulders down to manageable size and loading the truck. Often families or relatives will work as a team. The man who does the drilling, blasting and breaking will usually get a larger share than the women who load the truck. A hard working crew may fill ten trucks a day. A truck holds about 1-1/2 brass, a local measure which is equivalent to 150 cubic feet. A man can earn about two dollars a day. In many quarries however, the yearly average per person would be less than a dollar a day.

SPECIMEN LOCALITIES

It is difficult to pinpoint localities in India because quarries generally do not have names of their own, but most often take the name of a village or landmark near the quarry. Commonly there will be several quarries near

Figure 2. **A typical landscape in the zeolite specimen producing area near Poona.**

Figure 3. **Massive zeolite mineralization at the Bombay quarry. White areas indicate the presence of zeolites and associated minerals.**

each other, some or all of which may be abandoned. Adding to the locality problem is that many villages or landmarks are not on any obtainable map and are known only by those living nearby. The locations of some quarries are difficult to find and are kept confidential by local mineral dealers. Most notable is the case of the "Bombay" quarry, one of many near Bombay in the Tan district, that produces spectacular specimens of okenite and gyrolite. I was shown the quarry by a specimen dealer on the condition that I not reveal its location, and I will call it only the Bombay quarry. Wherever possible, exact localities will be given, but in many instances it is not possible or meaningful to do so.

COLLECTING IN THE FIELD

It is easy to locate most quarries. They must be near a road, city or construction site and many may be seen in hillsides from the main roads. The quarries that cannot be seen from the road, like those sunk straight down in a level spot or behind a hill must be searched for. Quarry workers generally know about other quarries. Often specimen dealers will take good customers to producing quarries if they feel that the customer will not disrupt any business that they do at the quarry. Finding quarries takes a little logical thought, but persistance is more important that anything else.

In the past three years I have visited about 100 quarries plus numerous road cuts, and water well excavations. Almost all showed some indications of zeolites and perhaps 40% produced specimens or gave indications that good specimens had been found. In most quarries no objection is made to a collector digging to his heart's content, or even to his banging away on the walls without a hard hat. Only in the big quarries are any sort of safety regulations encountered, and only in the few quarries that produce large quantities of specimens will a collector encounter any objection to collecting. Even here, a few rupees judiciously given as *baksheesh* will usually resolve the problem. Even when not necessary it is wise to tip the workers

Figure 4. (left) **Hand drilling at a quarry near Poona.**

Figure 5. (below) **Pimplas quarry near Nasik. Large scolecite pockets are visible. The author found several fine terminated sprays of scolecite loose in one of them. Short vertical drill holes can be seen in the quarry wall.**

a rupee or two after you have examined a few rocks, for they will soon realize that you wish specimens and they may produce fine specimens for purchase along with the ever present abundant junk. Once in a quarry near Poona, a quarry worker dug down into the quarry floor about a foot and uncovered a small hoard of fine, unwrapped specimens which he sold to me on the spot. The quarry workers usually have no safe place to store specimens and sometimes prefer to bury or hide their specimens rather than keep them in their huts.

In most instances the quarry workers do not work exposed pockets for specimens but are content to pick up specimens from the blast pile. They sometimes will not even bother to lift specimens from a pocket that have been shaken loose by blasting. You can imagine my delight at reaching into a pocket of scolecite, to mention just one example, and lifting out a beautiful six inch terminated spray of scolecite. Recently, in some quarries, the workers have taken to chipping specimens out of pockets using a drilling bar for the purpose. Usually there is no other tool available in the quarries except for a big sledge hammer.

Figure 6. **Typical basalt pillows with zeolite pockets at the Bombay quarry. These pockets are about 15 inches across.**

In Bombay, Poona and Nasik there are one or more dealers who sell specimens. They obtain material either from direct purchase from workers at the quarry or from "runners" who buy material from quarry workers and sell to dealers at a profit. Sometimes, though not often, a quarry worker will bring specimens to a dealer. At each step, from quarry worker to runner, from runner to dealer, it is not uncommon for an extra zero to be added to the price. In past years, in Poona, there were some English speaking missionaries who visited the quarries and purchased specimens from quarry workers for certain people in Europe and the U.S. This has come to a halt because of objections by the Indian government. Many of the fine specimens produced in India during the last few years have been sold to European specimen dealers because they would pay high prices for such material. The Europeans are, or at least were, fond of large specimens and have generally left the small specimens alone, much to my delight. This year (1975) however, for the first time, there were indications that traditional European buying practices were changing toward smaller and better specimens.

ZEOLITES FROM VARIOUS LOCALITIES

The mineralization of the region is zoned. I will make a few general observations and describe various kinds of specimens from certain quarries but, for a more complete treatment of the subject, the reader is referred to an excellent paper by Sukheswala, et al (1974). Each area, and commonly each quarry, will produce specimens that are unique enough that the locality or area that produced them may be identified on sight. In some instances strange looking specimens will be seen on a dealer's shelf, but unless identical material can be found in place in a quarry, a guess must be made as to the locality. For three years I had seen flat, tabular, doubly-terminated pink stilbite crystals associated with stringers of grey sparkling chalcedony. The stilbite is translucent and has the unusual property of showing an "hourglass" in crystals when held to a strong light. I had supposed that the material came from Nasik because of the grey sparkling chalcedony matrix, typical of some Nasik material. This year I found identical material in place in a quarry near Malegaon and collected a few small specimens. Since Malegaon is not far from Nasik, the guess was not far wrong. Dealers who are familiar with material coming from many quarries can usually assign an accurate general locality to strange material.

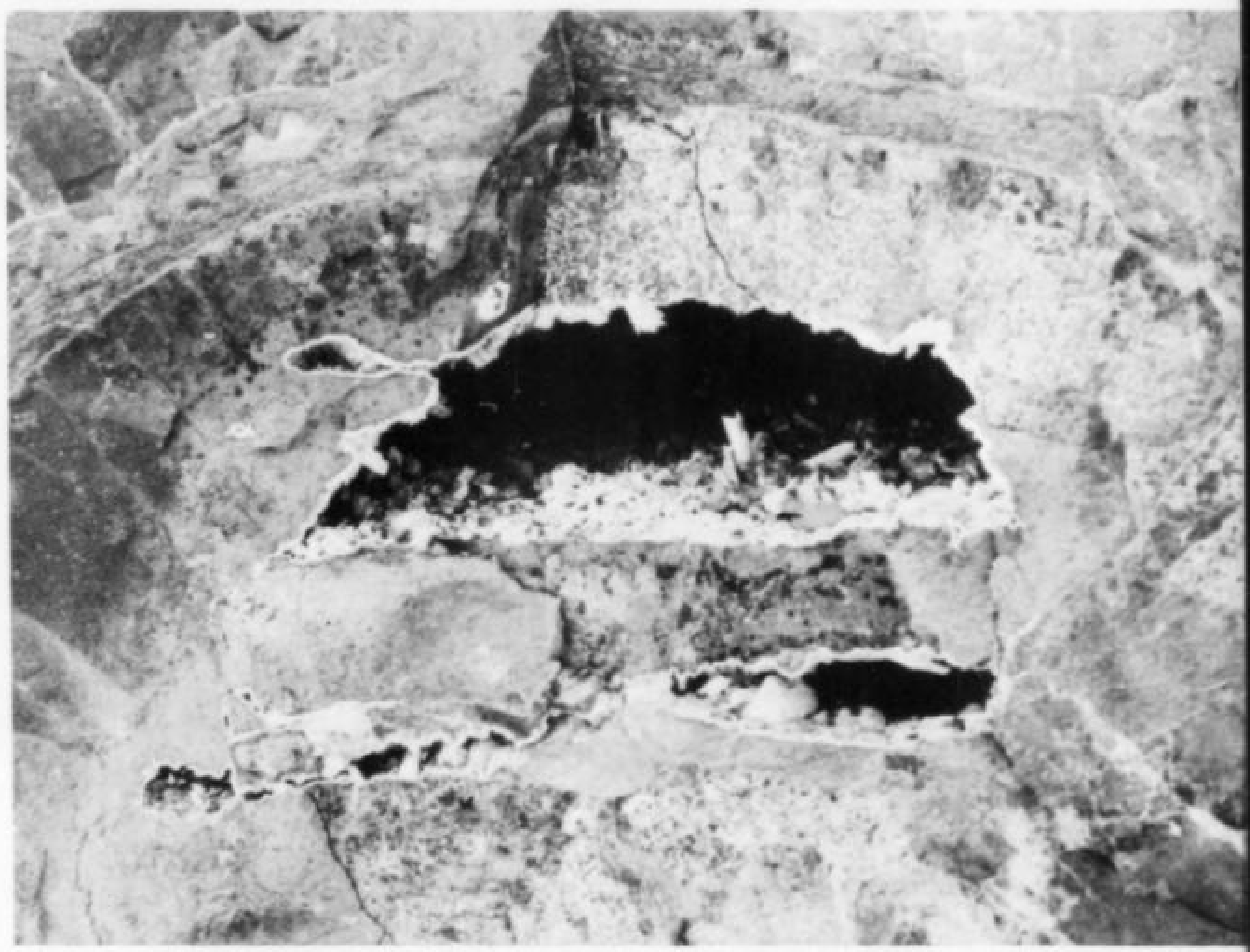


Figure 7. **A typical basalt "pillow" at the Bombay quarry containing laumontite and apophyllite. This pocket is about two feet across.**

THE BOMBAY QUARRY

In the Bombay area there are many quarries, and they are rich in laumontite. One quarry, the Bombay quarry, actually a quarry complex, produces spectacular specimens of laumontite, okenite, and gyrolite as well as fine to good specimens of prehnite, calcite, stilbite (rare), babingtonite, scolecite and apophyllite. Pyrite, quartz and gypsum are also found. The paragenesis in this quarry is interesting. From first formed to last it is approximately as follows: Pyrite calcite-quartz babingtonite-laumontite-prehnite-gyrolite calcite okenite-apophyllite. The species not separated by hyphens appear to have formed at very nearly the same time. Stilbite, scolecite and gypsum fit somewhere after laumontite and before apophyllite. It is interesting to note that in the crystal cavities in the basalt of the Wachung range of New Jersey, laumontite is the very last species to form whereas in the Bombay quarry it forms early in the paragenetic sequence.

Okenite takes the form of white furry-looking puffballs up to three inches across, of capillary-like crystals. Surprisingly, they are flexible to a certain extent, and may be petted carefully without damage. Entertaining your friends with an okenite will eventually wear down the puffballs and soil them beyond repair.

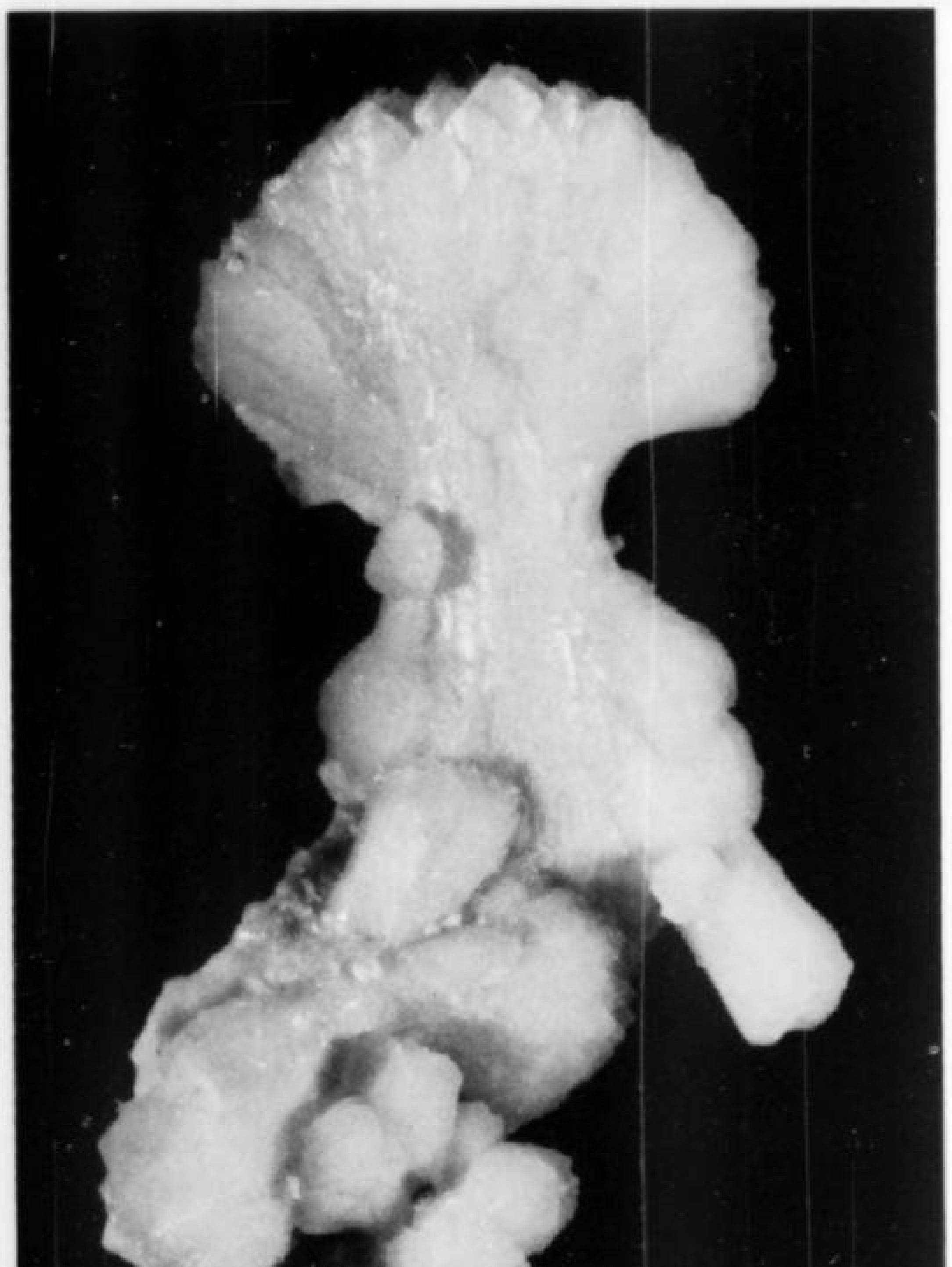
Gyrolite occurs as balls up to two inches in white, tan and pale green clusters of balls up to twelve inches across. Prehnite casts, apparently after laumonite crystals, are commonly found associated with well formed apophyllite crystals. Often striking combinations of okenite, laumontite, gyrolite, apophyllite and prehnite are found. Among these are snow white okenite puffballs with sharp glassy apophyllites poking out of the "fur", or prismatic laumontite crystals with puffballs of okenite growing on the prism faces and/or terminations. The babingtonite from the quarry forms sharp crystals, but a 1/4-inch crystal is large. Quartz is commonly a drusy pocket lining, but a few crystals up to one inch have been noted. Scolecite was noticed for the first time this year in brilliant prismatic divergent crystals sprays up to 1-1/2 inches long. Prismatic laumontite crystals up to six or eight inches long are found, often associated with other minerals. One and two inch crystals are common. The prehnite here is seldom green and commonly takes the form of translucent pale grey-green quarter inch blebs that the unexperienced may mistake for gyrolite. Calcite occurs several times in the paragenetic sequence and two or more of these occurrences may appear on the same specimen. One notable variety of calcite, formed before the quartz, is triangular in cross section and forms prismatic crystals up to five inches. The diameter of the prisms seldom exceeds 1/8 inch and varies little in thickness from one end to the other. The only specimens I have seen of this material have been covered with drusy quartz. The best of the calcite specimens from this quarry can be kindly described as being of good quality, but associated minerals might raise the quality to striking. Pyrite and gypsum have only been observed on two poor-quality specimens.

This year two unique specimens from the Bombay quarry came to light that I feel warrant description. One is a complete okenite sphere, slightly irregular, measuring about two inches in diameter. This puffball is growing on the end of a 2-1/2 inch quartz-studded prismatic calcite crystal. Growing up and down the thin druse-covered calcite crystal are minor small crystals of apophyllite, gyrolite, prehnite and calcite. To add to the unreality of the specimen are two, 3/8 inch sharp, glassy, apophyllite crystals growing out of the "fur" of the okenite puffball on one side of the specimen. The other is a specimen of gyrolite and laumontite measuring about three by five inches and about three inches high. It consists of an aggregate of pale tan/green balls of gyrolite to 5/8 inch in diameter rising steeply from the left center of the specimen. Growing out of the gyrolite clusters are more than fifteen well-developed, terminated, prismatic laumontite crystals measuring as much as 2-1/2 inches in length and 3/8 inch in diameter. The laumontite crystals are growing directly out of the gyrolite in a roughly sub-parallel manner around the sides of the mound of gyrolite balls. In some

Figure 8. **A typical small pocket of okenite and gyrolite at the Bombay quarry.**

Figure 9. **A pocket of scolecite and stilbite at the Pimplas quarry, near Nasik.**

instances the gyrolite balls are growing directly on the prism faces of the laumontite. The specimens from this quarry are so remarkable that I have devoted three drawers of a twelve drawer specimen cabinet of Indian zeolites to specimens from this quarry.



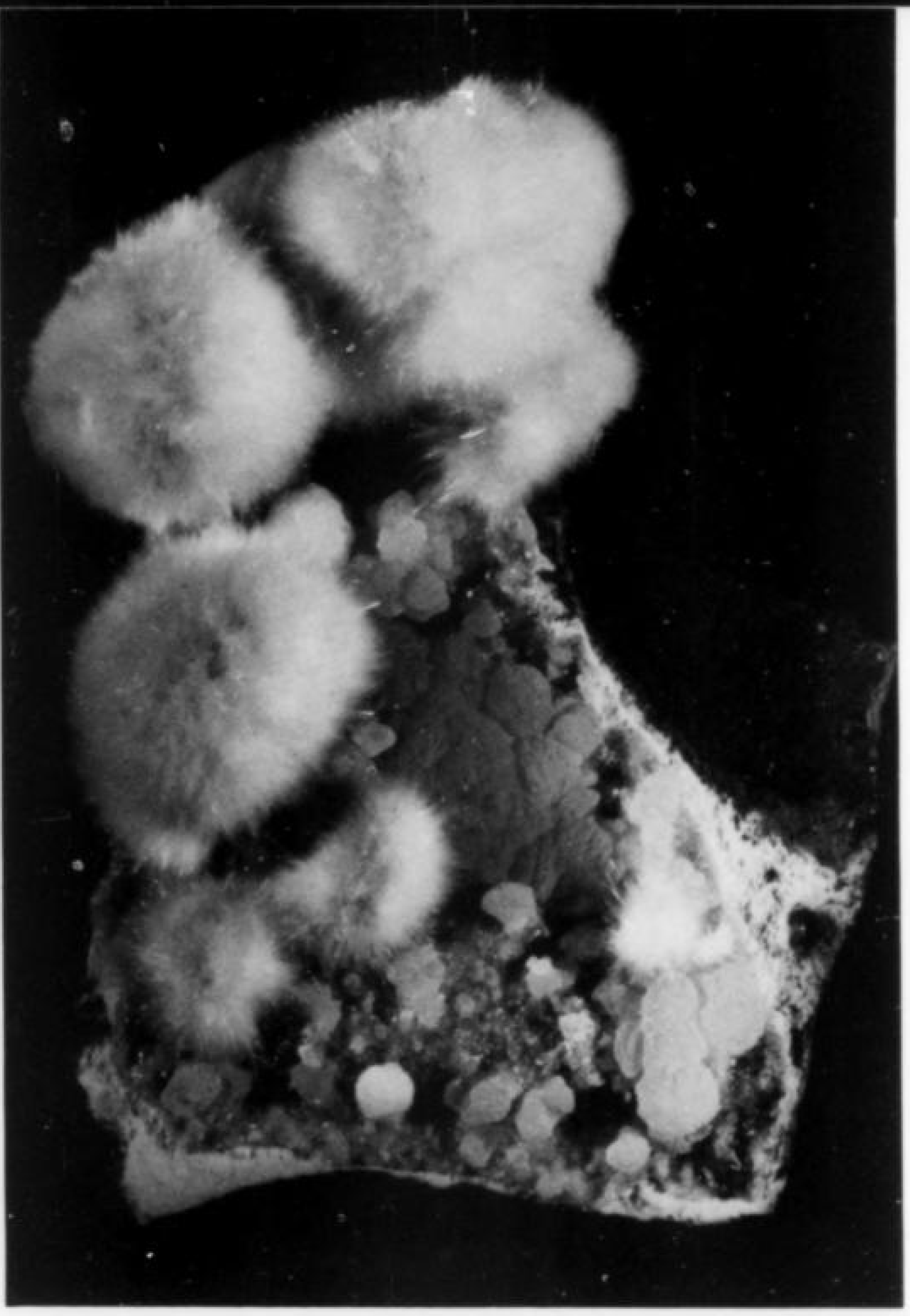
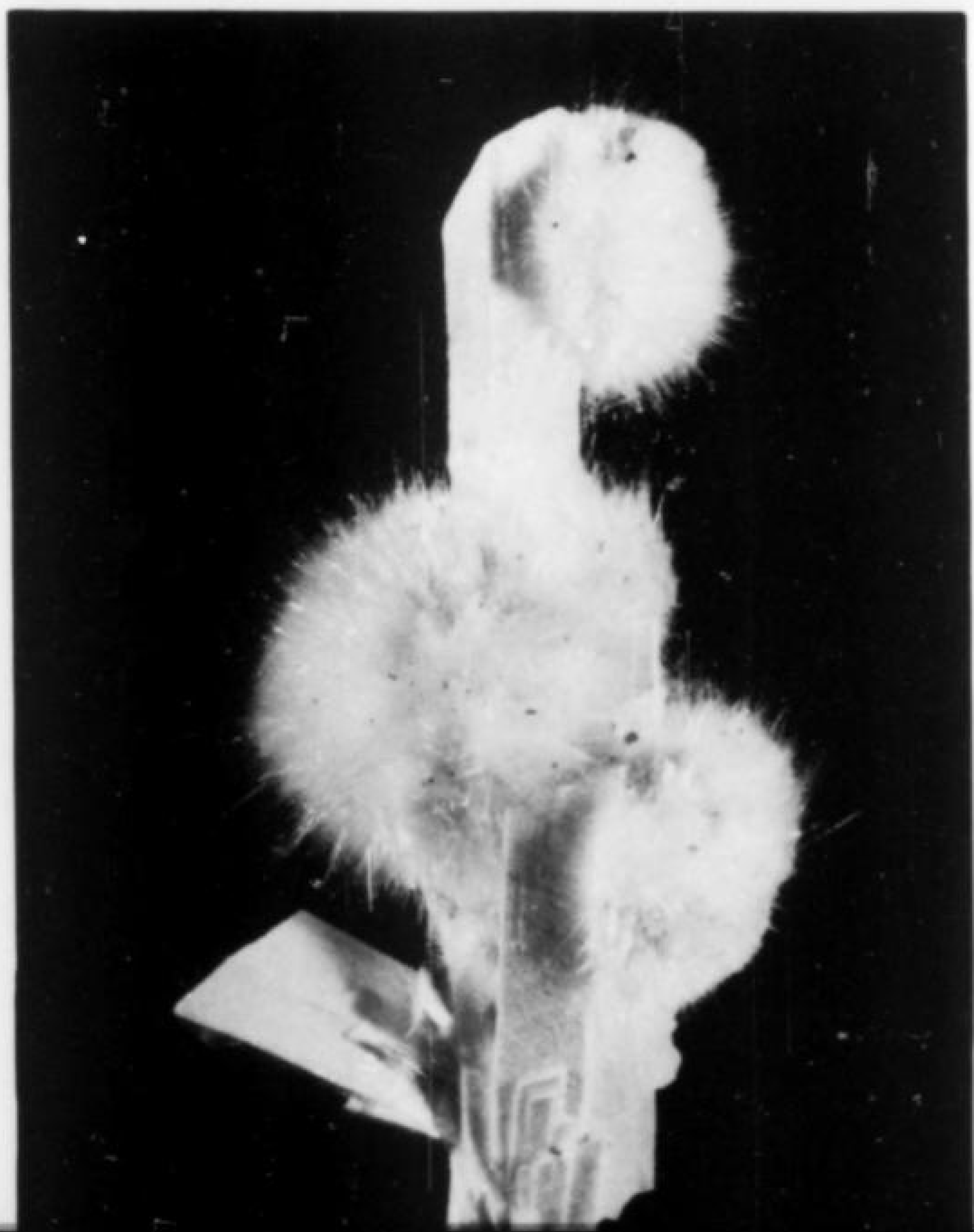


Figure 10. (top left) **White bow-tie of stilbite from Poona. This specimen was purchased at a parking lot rock swap in New York. The author has not been able to find a better one in India.**
Figure 11. (top right) **Okenite puffballs on prehnite and gyrolite from the Bombay quarry.**
Figure 12. (bottom right) **Okenite on laumontite from the Bombay quarry. Most of this material is destroyed during quarrying.**

The basalts here are classical pillow basalts, and in the center of many of the pillows is a dome-shaped pocket which may reach three feet in diameter. Below this main pocket are commonly one or more sub-parallel flat pockets. Sometimes there are other pockets between the pillows that are much richer in prehnite than the pockets located in the center of the pillows.

The production of specimens from the Bombay quarry is probably on the order of several thousand pounds per month. Much damage is done to the specimens during quarry operations and 80% of the specimens are of low quality and most never leave India. For the first time this year, however, it was noted that the quarry workers were starting to protect the specimens from damage. During the monsoon, due to decreased production of rock, the production of specimens almost stops. Little okenite is produced because dirty rain water destroys most of the material.

Housing for the quarry workers here as well as at other quarries will typically consist of a dirt or dung floored hut with bamboo walls and a thatched roof. Some huts may incorporate rocks or corrugated metal sheets or woven fiber mats in their construction. From such a hut at the Bombay quarry, a worker produced a box of babingtonite crystals. One of these consisted of a background of spark-



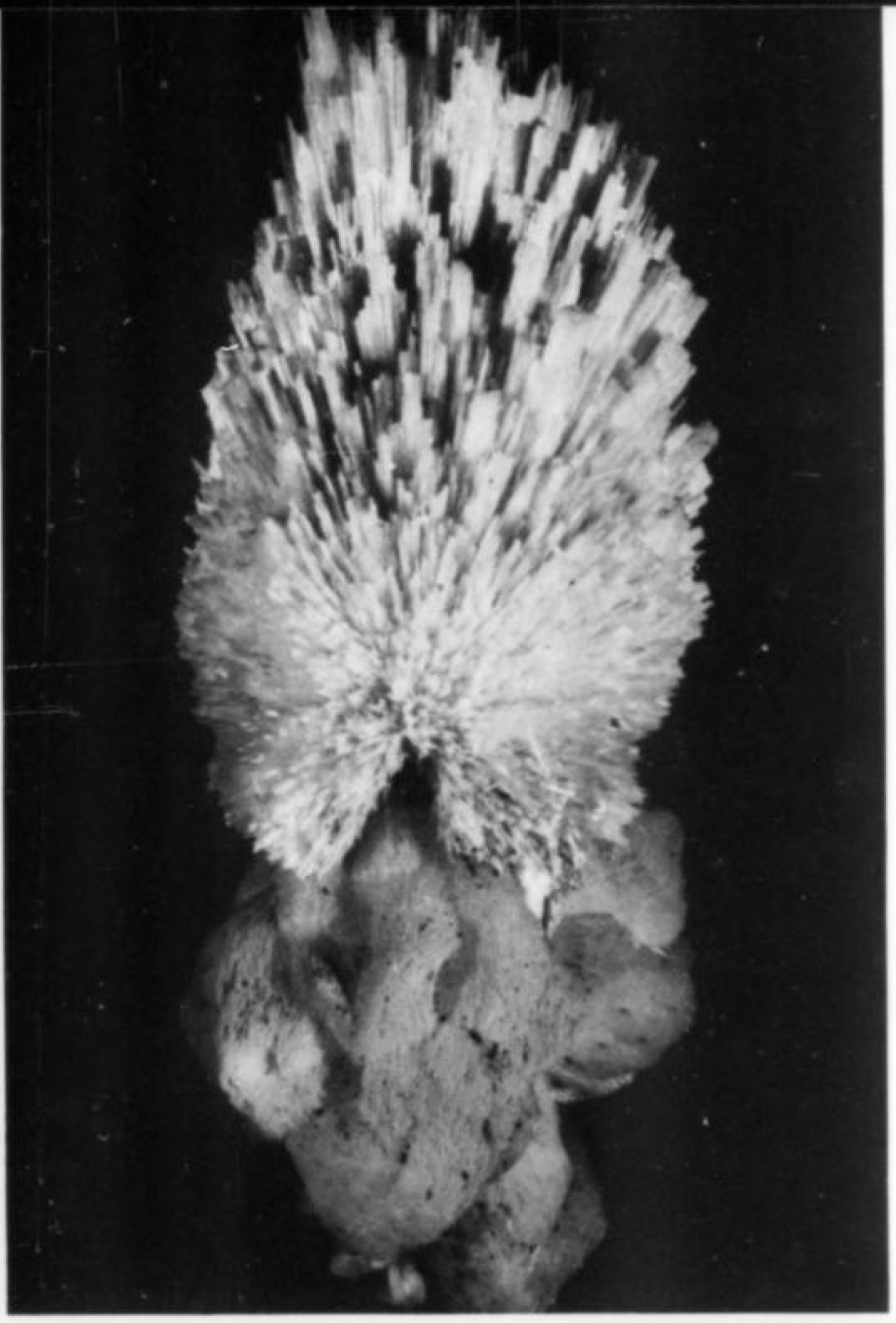
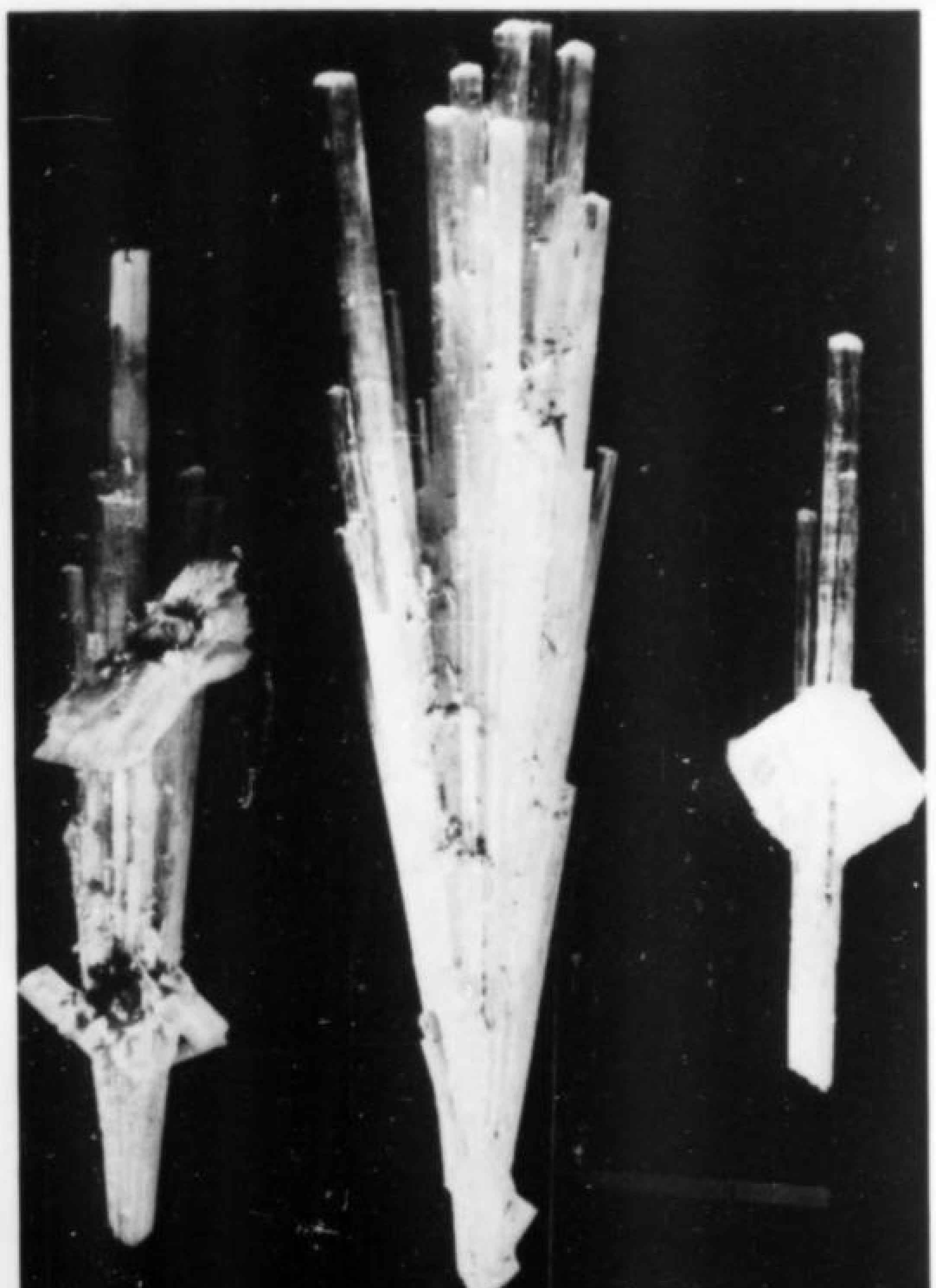


Figure 13. **Scolecite and stilbite from near Poona, India.**

ling small quartz crystals with eight small sharp babingtonite crystals artfully situated on the quartz. Six of the babingtonite crystals were glued on. Where the quarry worker got the glue, and what motivated his construction of the specimen (for he denied making it), will forever remain a matter of speculation.

Figure 14. **Scolecite crystal clusters. The one to the left is with a laumontite crystal. The cluster to the right is growing through an apophyllite crystal and was found loose in a pocket in a road cut near Nasik.**



Before proceeding with this commentary I would like to relate one further anecdote concerning specimens from the Bombay quarry. As stated before, most of the specimens produced at the Bombay quarry are of very low quality. During my second visit to India, I sorted through about a ton of specimens at one dealer's shop and created a large pile of junk specimens from the quarry, which was placed in the street for the municipal sanitation crews to haul away. Before they could do so, men from the grounds crew from the nearby general Bombay post office collected much of the material to use for ground cover under various trees and bushes near the post office. A supplier of specimens from the quarry, walking near the post office, saw the zeolite ground cover and was horrified. He felt that people would think that material from the Bombay quarry was worthless if it were used for such purposes and was on the verge of visiting the post office at night with a bucket of black paint to disguise the damning evidence. It took sometime to persuade him that it was not necessary.

FROM BOMBAY TO POONA

If one travels along the base of the Bombay, Poona, Nasik triangle to Poona, there are several places of interest that a collector should visit. As one crosses the bridge to the mainland from Bombay on the main road to Poona, the road passes through some low hills where there are some sizeable zeolite pockets in a road cut. Fine apophyllite crystals with pale pink stilbite can still be seen in place, as the pockets are deep and the rock is very hard. The first year I was in India, while I was collecting here, I was "apprehended" by a car full of local citizens who suspected me of being a C.I.A. agent. I was escorted to the local police station (I followed them in my car) where I was treated with great courtesy by the police. After several hours and many phone calls it was determined that "chopping rocks" was not illegal. I was released to continue chopping rocks if I wished. My hammer and chisel had been taken as evidence but were returned, and I had to split the specimens I had collected with the police chief.

Continuing on through the mountains toward Poona, the quarries near Panvil are encountered. They occasionally produce specimens of chabazite along with stilbite, calcite and green apophyllite. I have never seen chabazite in any other quarry, although it has been reported from other places. The chabazite crystals are typically white rhombohedra and a 3/4 inch crystal would be very large. The green apophyllite crystals are typically small.

Near Lonaula more quarries can be found near a dam and a military base. Most notably they produce large, rough, blocky, pale green apophyllite crystals. As Poona is approached, a quarry near the city of Chinchwad produces rather pleasing small amethyst crystals which may be associated with calcite crystals.

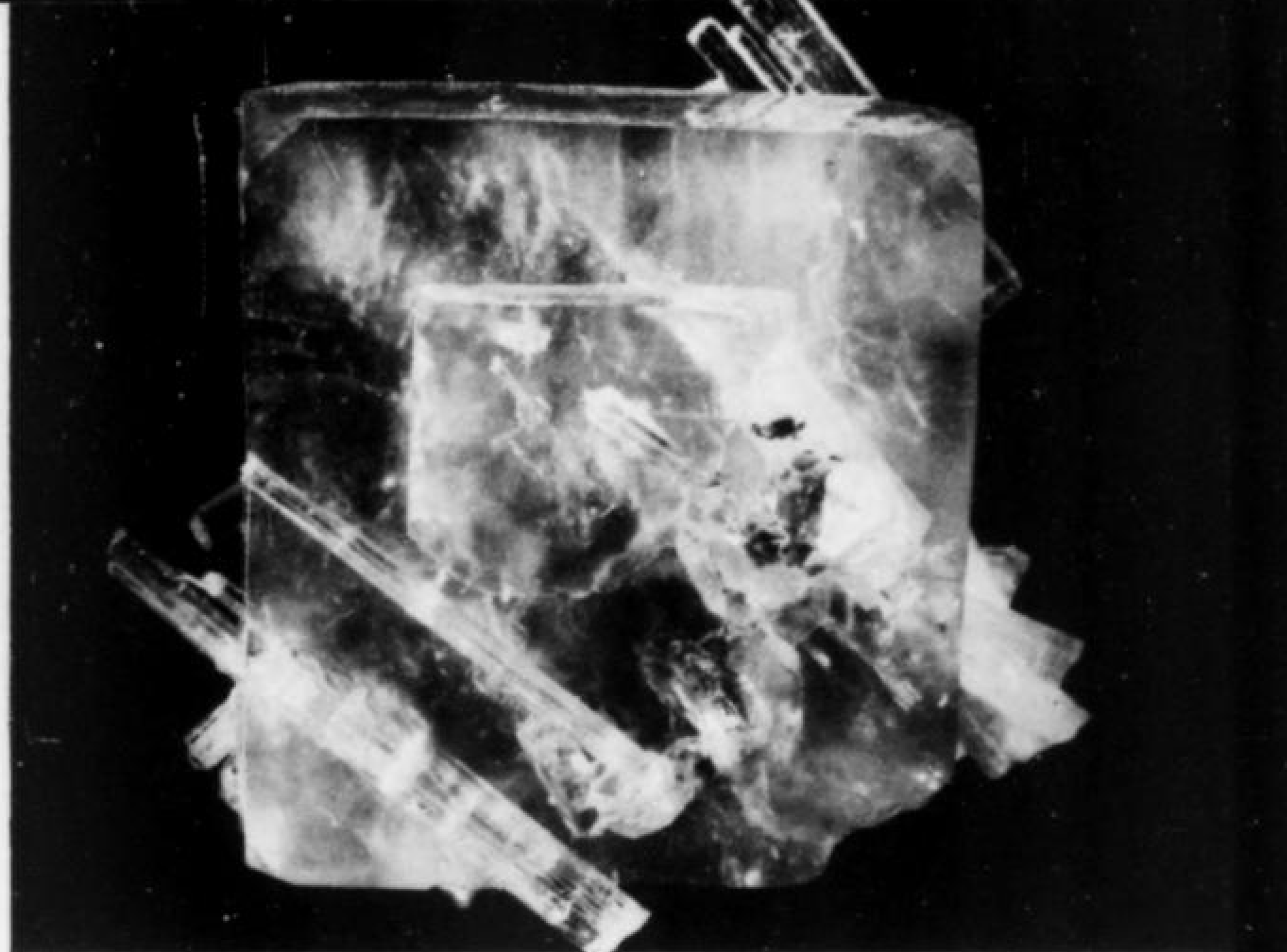


Figure 15. (top left) **Heulandite found on the floor of a quarry near a truck factory at Poona.** *Figure 16. (top right)* **Scolecite and pale green apophyllite. Probably from the Nasik area.** *Figure 17. (middle left)* **A cluster of laumontite crystals from Nasik.** *Figure 18. (bottom left)* **A cluster of apophyllite and stilbite crystals from a quarry near Malegaon.** *Figure 19. (bottom middle)* **Apophyllite crystal on prehnite casts after laumontite, from the Bombay quarry.** *Figure 20. (bottom right)* **Apophyllite crystals growing on a prehnite cast after laumontite from the Bombay quarry. These are found in pockets between the basalt pillows rather than in the pockets in the centers of the pillows.**

POONA

Near Poona, in the Pashan Hills, are a cluster of quarries that are renowned because it is here that specimens of deep green apophyllite crystals are produced. They are given their color by the presence of vanadium in their composition (Rossman, 1974). This group of quarries might also be given the name of Khadakvasla, since they are near that town. In this quarry complex, the quarries are located in the hills surrounding a small shallow valley, and it is only in the lower quarries that many specimens are produced. The deep green apophyllites are currently found in only one quarry, but have, in the past, been found in other places. The green apophyllite crystals commonly occur with white crystals of heulandite, white bladed stilbite and more rarely small white balls of gyrolite. Formerly, at another locality, green apophyllite crystals were found in association with long prismatic mesolite crystals. They make spectacular specimens. The quarry that produces the green apophyllite crystals is small, and along one wall of the quarry is the remnant of a meandering twenty foot pocket of weathered stilbite crystals. Much of the material has been collected by girls from a local village to be crushed into a white powder for use as a cosmetic. During my first visit to the quarry, much of the stilbite was still in place and since it also happened to be one of the few shady places in the quarry, humps of weathered stilbite crystals offered a convenient place to sit and rest after an exhausting stint of collecting. The pocket that exhausted me and my friend Robert Bartsch, who came to India with me on my first trip, was the size of several wash tubs and contained spectacular clusters of pale green apophyllite crystals. They were up to 1-1/2 inches in size and were growing on pearly white heulandite crystals with white stilbite crystals up to four inches, some of which took the form of the classical "bow tie". Good white to clear apophyllite crystals up to two inches are also found here as well as very pleasing specimens of pearly, complex, white clusters of heulandite. Also found are spectacular sprays (asteroids) of prismatic mesolite crystals up to about eight inches in diameter. These sprays are rarely collected on matrix.

The apophyllite crystals from the Pashan hills are somewhat blocky. Pale green apophyllite crystals from here have small prism and pinacoid faces and large pyramid faces. The deep green apophyllite crystals have very small prism faces, no pinacoid faces and very large pyramid faces. It may be that an increase in the vanadium content correlates with, and may be the cause of, the emergence and predominance of the pyramid faces at the expense of the prism and pinacoid faces. Deep green apophyllite crystals seem always to have small prism faces, and no pinacoid faces. Do not be fooled by a basal cleavage, and large pyramid faces.

Last year, in a quarry on a hill overlooking Poona, a large narrow, vertical, six foot pocket of stilbite crystals was encountered. The walls of the pocket were covered with a loosely attached lacework of stilbite crystals up to three inches. The blast which had exposed the pocket had shaken many fine stilbite crystals clusters to the bottom of the pocket where I retrieved them with considerable glee. Many of the stilbite clusters had "bow tie" crystals. The experience could be likened to picking popcorn out of a very big bag.

NASIK

On the road from Poona to Nasik, much evidence of zeolite mineralization can be seen. Material excavated from a well showed the weathered remains of large, pale green, blocky apophyllite crystals with stilbite and mesolite(?). Weathered zeolite fragments can be found in some of the fields along the way as well as in some of the road cuts. Last year (1974), in a road cut about ten miles south of Nasik, on the main road, two pockets of scolecite about the size of watermelons were found. There was no evidence that anyone had tried to collect any of the material and it was quite dirty from road dust; apparently having been exposed there for at least several months. A number of fine terminated sprays of prismatic scolecite crystals were collected. Some of the scolecite crystals were associated with rough, tabular, white apophyllite crystals.

The zeolites found around Nasik are distinctly different in character from those found near Poona or Bombay. The stilbite, heulandite and commonly the laumontite have a distinctly pink color. The apophyllite crystals are usually larger and of greater clarity than those from other areas. Most of the apophyllite crystals are white but some are pale green in color, especially toward the center of some of the larger crystals. The Nasik region is known for its glassy apophyllite crystals found on an attractive gray-blue chalcedony background. The first year in India I purchased about a pound of 1/2 inch faceting grade apophyllite crystals in Nasik.

Fine clusters of slightly complex laumontite crystals up to three inches long come from the Panduleni quarry complex near Nasik. Clusters of laumontite crystals up to fifteen inches across and larger have been found here, but most have been destroyed because no care was taken to preserve the specimens. This quarry complex also produces superb clusters of pink lustrous, salmon colored stilbite crystals as well as apophyllite crystals of considerable clarity and perfection. Pockets measuring six feet or more have been encountered.

Another quarry near Nasik, called the Pathardy quarry, has produced spectacular specimens. It is currently closed because of litigation concerning the sale of specimens and if it is reopened it will be worked mainly for specimens. Here, apophyllite crystals of great clarity are found and commonly on an attractive gray-blue chalcedony. Also found are lustrous pink stilbite crystals as well as laumontite and scolecite crystals. This is probably the best specimen quarry in India. The pockets are roughly spherical and abundant almost to the point of being ridiculous. From a distance it looks like someone has been painting

DALTON'S MINERALS

fine mineral specimens
free list
P.O. Box 17232,
Tucson, Arizona 85731

NATURE'S TREASURES

P.O. Box 982
Hawthorne, CA. 90250

Fine world-wide minerals in all sizes and prices.

Specialist in the Minerals of Tsumeb Southwest Africa

- o wide variety
- o rare minerals
- o museum pieces
- o single crystals

See us at the show in Munich, Germany
30 to 31 October 1976

Hours by appointment:
(213) 373-3601

Mathiasen Minerals

**41149 St. Anthony Dr.
Fremont, Calif. 94538**

FINE MINERAL SPECIMENS FROM WORLDWIDE LOCALES

"Micro to cabinet size" Send for current list or call 214-657-0994.

TOM DAUGHERTY
1021 LAWTON ROAD
COVINGTON, KY. 41011

GEMS• MINERALS

IMPORT • EXPORT
WHOLESALE • RETAIL
SHOWS • MAIL ORDER

PHONE (606) 291-4427

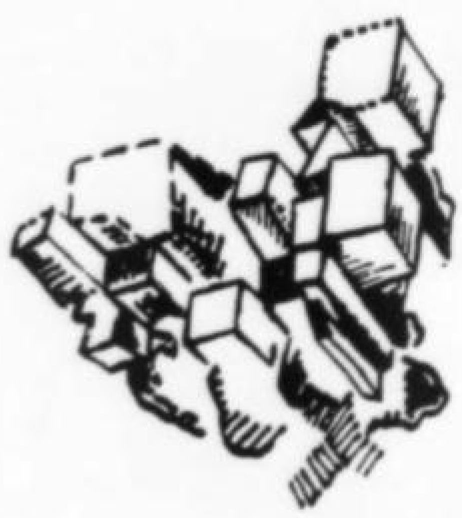
PETROLOGICAL THIN SECTIONS

Send us the rocks and we'll prepare the sections mounted on 30x40mm. slides. Individual sections $4.25; 5 from one sample, $3.50 each; 10 from one sample, $2.75 each, including airmail postage (we do not return the surplus rock). Individual quotations given for soft or friable rocks which require impregnation.

We hold in stock thin sections of over 40 British rock types @$2.50 each, inc. airmail postage. Write for list or send $3.00 for our full geological catalogue (refundable on first purchase).

LYTHE MINERALS
Geological Suppliers
36-38, Oxford Street,
Leicester LE1 5XW
England.

SPECIES COLLECTORS-rare minerals from worldwide locations: alumohydrocalcite, anapaite, bakerite, coeruleolactite, doverite, dypingite, heazlewoodite, hummerite, hydrotalcite, and more. List for stamp. Excalibur Mineral Co., 4504 Hoxie St., Bronx, N.Y. 10470.



ACANTHITE PARAMORPH after ARGENTITE

- Guanajuato, Mexico
- Sharp cubic crystal groups
- Crystals from 3 - 8mm. on an edge
- Mounted in perky boxes $3.50 - 18.00

THENARDITE CRYSTALS

- Carrizo Plain, San Luis Obispo, Calif.
- Loose single crystals 2 - 5cm. $2 - 6.00
- Crystal groups 2 - 4cm. $2 - 6.00

PLEASE REQUEST OUR NEW ARRIVALS LIST

DEALERS IN
- rare minerals
- fine minerals
- gemstones
- gem & mineral books

Si &Ann Frazier

1724 University Ave - Berkeley, California 94703 - 415-TH3-7564

posters or graffiti on the quarry walls. Most of the pockets here as well as at other specimen producing localities in the zeolite region appear to be roughly spherical even though they may be stretched out and meander for twenty feet or more. Mineralization is seldom observed in cracks or along faults.

The Odha quarry near Nasik, now closed, has produced many fine blocky white apophyllite crystals and, like elsewhere, the pyramid faces are small in relation to the prism and pinacoid faces. One pocket of pale amethyst spotted with small, curved, white heulandite crystals was observed. The pockets were numerous, but the crystals were firmly attached to the rock and many specimens were destroyed by blasting.

Another quarry called the Pimplas quarry, some distance from Nasik, near a sugar factory, has prolific mineralization. Some beautiful terminated sprays of scolecite were found lying loose in one pocket and good apophyllite crystals were collected from others. This year the Pimplas quarry was closed.

During the last three years, two specimens of translucent, golden, octahedral powellite crystals growing on apophyllite have been found in dealer's stocks. Both specimens almost certainly came from the Nasik area.

AURANGABAD

Near Aurangabad, southeast of Nasik, evidence of zeolite mineralization diminishes and chalcedony, often in the form of agate and jasper, become more common. In Aurangabad and the nearby town of Jalna, the chalcedony is collected and several agate dealers have small hills of various agates and jaspers for sale. This material includes some rather respectable bloodstone and green moss agate.

Near Aurangabad, at Ellora are some spectacular ancient temples carved into basalt hills. While visiting these temples on a pleasure trip, I found that it is almost impossible to escape zeolites while traveling in this part of India. While inspecting the temples I found a pocket of zeolites in the wall of a third floor gallery, in a corridor just outside of what was once the cell of a monk. It was about the size of a small watermelon and was lined with mordenite(?). Nestled in the back of the pocket were several 1/2 inch apophyllite crystals. The most accessable apophyllite crystal was dirty from the rubbing of countless

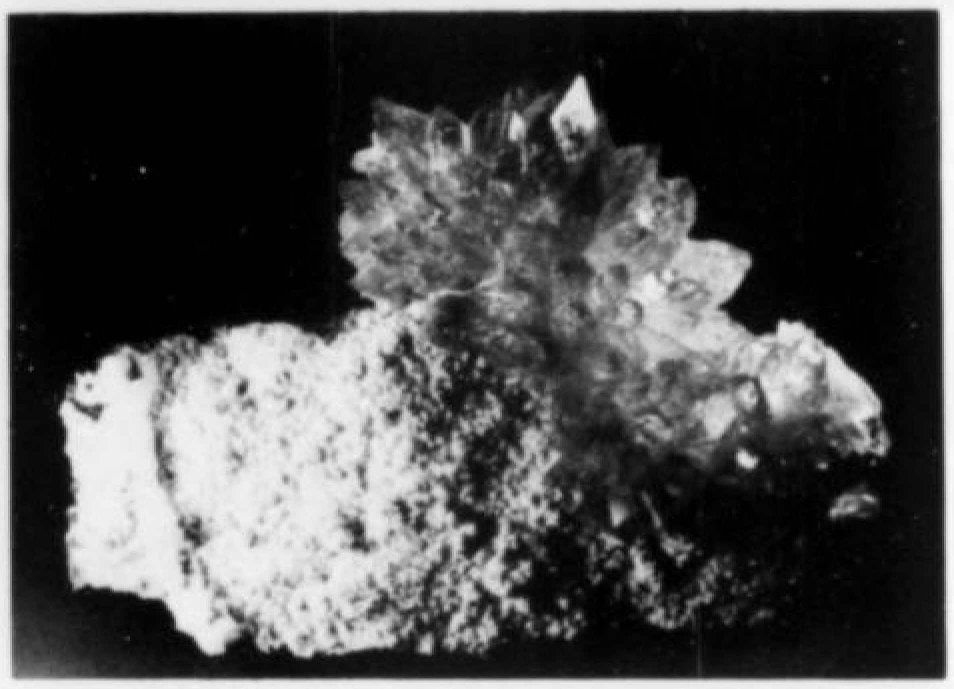


Figure 21. **Richly colored green apophyllite on white matrix; the specimen is about 6 inches long. From the Peter Bancroft collection.** Photo by Wendell Wilson.

fingers. I also rubbed the crystal with my finger and thought of the centuries the pocket had been a source of wonder for the monks and tourists alike.

TRAVEL IN INDIA

Travel in India is fascinating and should not be feared. In Poona I was "busted" (arrested) by the military police for taking a picture of the airport terminal building. Apparently it was "off-limited" to photography, as other similar institutions are, and have been since 1950. India's recent war with Pakistan has made all Indians sensitive of such regulations. The sign warning of the restriction had apparently been stolen, and although I was very politely detained for about an hour and questioned about my activities in India, I was released with my camera and film intact.

I have never encountered hostility in India and most Indians will go out of their way to help tourists. The poverty in India is great and it always comes as a shock to Americans and Europeans. This poverty is the most common reason given by people for not wishing to visit India. The conditions in India are not much different than much of Asia, Africa or South America. You can certainly travel in India more comfortably than you can on a camping trip, and the accomodations are better than can be found in many rural areas of the U.S. If you keep this in mind you will adjust much more quickly to the poverty and the press of humanity. I was able to adjust to conditions in about two weeks.

Good European hotels are available in Bombay and Poona, but not in Nasik or smaller cities. The best way to travel to the quarries is by car. Car rentals are expensive and agencies insist on providing a driver for your protection as well as that of the car. The driver will cost you two to three dollars a day. Gasoline cost exceeds a dollar (U.S.) a gallon and may be two dollars a gallon by the time this is published. The roads are dusty and food and water can be a problem if you insist on steak and French fries for every meal. You can always survive on bananas and tea if you can't adjust to the local food, until you get back to your hotel. Nasik produces superb onions and, with lime juice and salt, they are very tasty. The toilet facilities at the quarries may be limited to a bush. Take a bottle of Lomotil tablets. Poona can be reached in comfort by train or air, but not Nasik. A taxi can be rented in Poona or Nasik to visit the quarries. There are over 200 major languages and dialects spoken in India. but English is widely spoken among the upper classes and the business community. Make sure your driver can speak good English and if you tip him to do any necessary translating you will have few problems. India is a fascinating country and trips to the standard tourist attractions, especially the Taj Majal. should be made. They will be memorable and after two weeks of travel you will be much better prepared to withstand the "hardships" of the quarries.

DEALERS

In India I know of five dealers of note who specialize in zeolites. Kela in Nasik, and Makki and Sons in Poona. Makki and Sons have probably the greatest knowledge of the quarries and will sometimes act as guides. Mr. Makki is one of the most amazing old men I have ever met. In Bombay there is Burjor Mehta, Parasmani Trading Company and Hussein Tyebjee and Sons. Burjor Mehta has a good stock of specimens, some of which are displayed in the Taj Majal Hotel. I was able to buy specimens from Parasmani Trading Company during my first visit to India, but the following year I was shown no specimens and was told that they were now selling only by mail. Hussein Tyebjee of Wodehouse Road, Bombay, has a large reasonably priced stock of mineral specimens and has proved to be a reliable source of specimens.

In conclusion I would like to take this opportunity to thank Hussein Tyebjee, his wife Sara, and his two sons Salim and Faraz, for their help and hospitality which made my travels in India possible, productive and enjoyable. I would also like to thank William Wise, Rustam Kothavala and Rudy Tschernich for their assistance with mineral identification, and help with the manuscript.

TABLE I
MINERALS CITED IN THIS ARTICLE

ZEOLITES	NONZEOLITES
Chabazite	Apophyllite
Heulandite	Babingtonite
Laumontite	Calcite
Mesolite	Gypsum
Mordenite	Gyrolite
Scolecite	Okenite
Stilbite	Powellite
	Prehnite
	Pyrite
	Quartz (including amethyst and chalcedony)

REFERENCES

KOTHAVALA, R. (1958). With pick and knapsack, *Brewery Gulch Gazette*, Bisbee, Arizona, Dec. 4.

ROSSMAN, G. R. (1974). Optical spectroscopy of green vanadium apophyllite from Poona, India. *Amer. Mineralogist*, **59**, 621-622.

SOWANI, P. V. and A. V. PHADKE (1964). A note on apophyllite occurring around Poona. *Journal of the Univ. of Poona, Science and Technology Section*, **No. 28**, 81-83.

SUKHESWALA, R. N., R. K. AVASIA and M. GANGOPADHYAY (1972). Observations on the occurrences of secondary minerals in the Deccan traps of western India. *The Indian Mineralogist*, **13**, 50-68.

__________, __________, __________ (1974). Zeolites and associated secondary minerals in the Deccan traps of western India. *Min. Magazine*, **39**, 658-671.

WADIA, D. N. (1919). *The Geology of India*. MacMillan and Co., Ltd., London.