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EUROPE ISSUE

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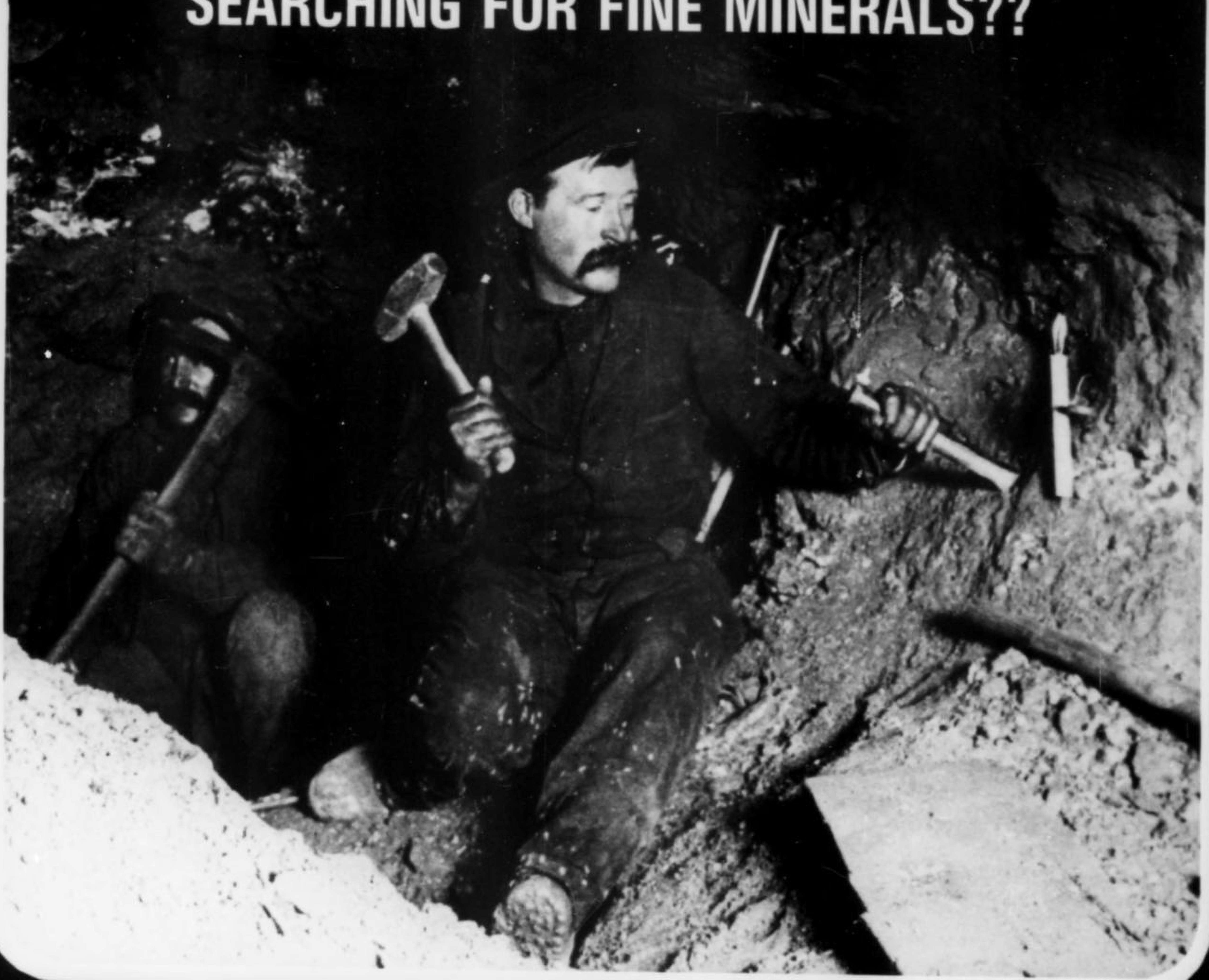


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the Mineralogical Record

Volume Eight/Number Four
JULY - AUGUST 1977

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COVER: REALGAR
on white dolomite from the Lengenbach quarry, Binna Valley, Valais, Switzerland (see articles in this issue); size of the crystal group is about 5 mm; collection of M. A. Magnenat, Basle, Switzerland; photo by Eric Offermann.

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GUEST EDITORIAL

by Johannes A. Dons*

This article was originally written for people working in Norwegian museums of art and cultural history, to ask for ideas and help in the work for a meaningfull use of museum-quality mineral deposits (Museumsnytt 1, 1975). It discusses the problem of mineral collectors from the standpoint of a small, understaffed national museum in a small country, faced with a growing horde of collectors, domestic and foreign. The ***Mineralogical Record*** *felt it would be of wider interest and the author was asked to present an abbreviated translation.*

MINERALS, MUSEUMS and AMATEURS

TEN to fifteen years ago, the only people in Norway who worked specifically with minerals were four to five museum employees. In addition, there was a small handful of amateurs whose number had remained almost constant for the last 200 years. Today there are many, many hundreds of amateur collectors in Norway; in the summers this number increases as hundreds of foreign tourists come here to collect minerals. The number of professional mineralogists has remained unchanged. There has thus arisen a situation that neither the country's laws nor its understaffed museums were prepared to meet.

What we are experiencing in Norway is only a delayed copy of events in Central Europe and the U.S.A., where many deposits are either emptied or closed to collectors by various prohibitions. In Holland there are amateur geological clubs with over 1000 members, whose greatest desire is to visit Norway on collecting tours. In Germany there are still more, also with their own journals. Foreigners write to the museums or to Norwegian amateur societies and private persons asking for itineraries and instructions on how to find the best collecting localities. Many do not write; they simply come to the country, which appears to lie open and invitingly untouched, and they have with them detailed guides inherited from earlier visitors. A "Director of Studies" in Germany has given out, despite Norwegian protests, a guide for amateurs in which many Norwegian localities are presented with maps, profiles and species lists. Sweden and Finland are given similar treatment and are, as far as we know, even less prepared than we are.

Representatives of foreign mineral firms travel every year around the country, partly to buy material from Norwegian collectors, partly to collect themselves. We have seen hair-raising examples of how these people have stolen material from under the noses of property owners or concessionaires, usually but not always working by night. These dealers, and the foreign amateurs, export each year minerals valued at about 1 million crowns (about $200,000). Although the monetary value is high, it is far more important that no Norwegian authority has had a chance to decide what material, because of its scientific or cultural value, should remain in the country, and what can be exported freely.

That minerals do have monetary value was discovered by the National Accounting Agency recently, following the burglary of the Mineral Gallery at the Mineralogical-Geological Museum in Oslo. This was apparently a robbery carried out on contract from a foreign "client", since the stolen material consisted primarily of minerals that are fashionable in Central European markets. Only a few specimens were picked out of the exhibits here and there but they represented a considerable sum. In November of 1975 there was a second burglary in which the complete exhibit of gold, silver, platinum and diamonds was removed. Now that money and the associated speculation have entered the scene an idyllic past is gone forever.

The Mineralogisk-Geologisk Museum, which is part of Oslo University, has a quite respectable collection. This has been built up by collecting, purchasing and exchanging, beginning in the eighteenth century when the Mining Academy (Bergseminaret) was founded in the town of Kongsberg. Kongsberg is known for the mining (now discontinued) of native silver; the Mining Academy, after which the famous Academy in Freiberg was modeled, gave instruction in many university subjects, including mineralogy. When Oslo University was founded in 1811 as the first Norwegian university the teaching collection of the Mining Academy was transferred to Oslo. This collection was the nucleus of the Museum's present collections and exhibits.

In the country's geological museums and institutes, we have regarded it as part of our duties to give the public information on geology—least on collecting, most on those subjects that give increased understanding and a richer experience of nature. This information is given in lectures in the museums; and amateur societies work with youth groups, excursions for the public, guidebooks for geological tours, popular articles, identification of specimens for the public, and so forth.

Thus we ourselves have helped to start and encourage a course of events that was further stimulated by the rising "collecting fever" abroad, and which has now led to a very complicated situation. A similar situation can be forseen for fossils but if a solution can be found to the mineral collecting problem the solution can also be applied to the fossil problem.

The unfortunate aspect of what is now happening in the mineral world is, in general terms, that *a non-renewable resource is being used, in an uncontrolled fashion, to little purpose.* The description of a new mineral is no longer any great goal; about 20-50 new ones are found every year. It is far more important to determine the physical and chemical environment responsible for the formation of the mineral, and for this we need not isolated specimens, but the whole paragenesis of the deposit. Because of this, a premature plundering of a mineral deposit will mean that the researcher must work with incomplete material. The same applies to fossil localities, where removal of the most obvious or most attractive individuals will give a distorted picture of the environment and population when the material is treated statistically.

A certain level of consumption of minerals must be allowed, to help maintain the public's interest in geology, but altogether too much is exported or wasted. Some is destroyed by mindless hammering; most collectors take home too much material from each deposit, only to discard it later. Others have so little

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***Director, Mineralogisk-Geologisk Museum, Sarsgt. 1, Oslo 5, Norway**

order in their collections that any information that might originally have been associated with the specimen is soon lost. Classic localities have been emptied, so that those who lead student excursions must take samples with them from the museums in order to study the mineralogy. The museums, which work on the behalf of society, seldom manage to collect material from a new locality for research and exhibition before the amateurs have been there in droves. Mineral dealers, both Norwegian and foreign, flood the world market with the same material, crippling the Museum's chances to build the collections by exchange of specimens.

Those working in museums of art and cultural history will recognize our situation from their own experience and can draw comparisons with conditions from many years ago. What they have achieved through a long, persevering effort to influence public opinion are national and international laws and treaties regulating ownership and trade. We have a "Law on Antiquities" that gives the State rights over pre-Reformation sites, buildings and artifacts; a corresponding "Law on Mineral Deposits" does not yet exist.

The Norwegian mining laws cover ore minerals (those containing a heavy metal), but they are aimed at minerals that can be extracted on an industrial scale. There is a special law for quartz deposits which requires a concession for mining. It is designed to regulate large-scale mining, but can also be applied to protect, for example, the alpine-type quartz veins on Hardangervidda.

A reading of the Laws of Norway also shows that it is forbidden to take anything (including minerals) from another to gain profit or other advantages. It is also punishable to dig on another man's property and to remove stone, sand, gravel, clay, minerals, etc. If the laws are to be taken literally, it would become impossible to carry out ordinary geological field work, and hikers would be forbidden to take home a stone souvenir for their mantlepiece. In reality the law puts matters in the hands of the property owner, who has a right to compensation for anything that is removed. Often the property owner is completely ignorant of the value of minerals collected on his land. Once he is informed, however, he will find that the law gives him the right to expell from his property anyone who has not received his permission to collect.

For collecting on public land, permission must be obtained from the Directorate of State Forests. This agency also can establish Nature Reserves, within which some mineral deposits could be protected. The agency is however, reluctant to declare individual places as off-limits to collectors, since this might be construed as implying that all *other* areas were *open* to collecting! Deposits can also be protected individually by law (as the islands of Låven and Skutesundskjaer in Langesundsfjord); this process takes several years.

Foreign mineral dealers must, according to law, have working permits to carry on their activities in Norway—also during the summer when they are camouflaged as "tourists". We also have customs regulations which could control the export of minerals. On the international scale, there is a UNESCO convention on illegal trade in cultural objects, in which minerals and fossils are especially mentioned, but this has had no noticeable effect on the Norwegian mineral market. As a first step in clearing up the legal aspects, the Mineralogisk-Geologisk Museum has asked the Department of Environmental Preservation to publish a guide, in several languages, telling foreign visitors what they can and cannot do with regard to mineral collecting, berry-picking and other outdoor activities in Norway.

At the Mineralogisk-Geologisk Museum in Oslo, where we have felt the mineral fever worst, we have mostly worked along other lines to guide developments. In the Mineral Gallery, new labels no longer give exact place names that can guide collectors to vulnerable deposits. We have established a data file where professionals, and those amateurs who cooperate with the museum, can deposit new locality information. This file is used in cases where premature publicity would probably lead to destruction of a locality.

In Southern Norway, seven or eight local geological clubs with about 100 members each have been formed in the last few years. The Oslo Area club (Oslo og Omegn Geologiforening) has its own premises with a library, collection and equipment. The clubs have a common council and publish a small magazine. The amateurs and their societies are dependent on the professional geologists and the museum, especially for difficult mineral identifications; a large proportion of the X-ray films made in our laboratories concern specimens sent in by the public. The amateur societies also need lecturers, course leaders, and special guided tours, and we have gone to considerable lengths to provide such assistance. In this way we have achieved, with many amateurs, a cooperation based on mutual trust, and the amateurs have in many respects become an extension of the museum.

Only a few years ago some Norwegian amateurs certainly were dangerous deposit-destroyers, but we believe that things have improved; there has been a change of attitude because of improved understanding. Not only do the amateur societies have rules about protection and sensible use of deposits, but the members also try to live up to them, to keep watch on one another and on foreign intruders. In the course of a summer the Museum receives several reports from amateurs on undesirable collectors, and in certain cases we have been able to put a stop to these activities.

The Museum has suggested a form of regulated collecting in the best areas, corresponding to a fishing license, or a local admission fee to particular localities. This has been tried in some areas, and appears to be one workable solution. Elsewhere in the country, hotels have specialized in minerals by setting up tours for their guests to deposits which can withstand the hammers of such large groups.

This discussion really has no ending; it is a report on what has been done and is being done now, and on everything that should be done with the minerals problem. It is a plea for understanding, advice and help in a difficult situation, a situation resembling the one that Goethe's "Sorcerer's Apprentice" found himself in. He knew and used his master's magic formula, and started the process. Only when the water began to rise, did he realize that he lacked the formula to tame the powers that he had unleashed.

NOTES FROM THE EDITOR

The foregoing editorial by Johannes Dons raises some interesting and possibly disturbing questions. Should minerals be the domain of only a select few (the "four or five museum employees" and the "small handful of amateurs" who "cooperate with the museum")? Should mineral localities be preserved untouched in any country until the local scientific establishment can peruse them to their satisfaction, no matter how long that may take? Are minerals really being "used up" when they are collected? Is a specimen of more value when it is buried, unseen, in the earth or when it has been collected and is on someone's shelf? (Is it of *any* value while it is still buried?) Is it necessary for a deposit *as a whole* to remain intact if it is to be studied properly, or can selective removal of specimens be done while still preserving representative portions of the deposit *in situ* for future study? Is there an unwritten law that mineralogists have the "right" to exclude amateurs and casual collectors from any occurrence the mineralogists deem scientifically interesting? Is it really true that "the description of a new mineral is no longer any great goal"? Is one field of study in the area of pure (without practical application) science any more important than another area? Is the provincial approach to minerals defensible, i.e. should all Norwegian minerals be considered state property and not allowed to leave the country except under special circumstances such as trades? Where would Norwegian museums be if all other countries took that attitude with their minerals, fossils, art objects, etc... would Norway have enough to trade? What would the world's great museums be like if they could contain little but that which has come from their own country? Should we in the United States consider visiting European collectors (including Norwegians) to be "foreign intruders"? Where would museums and collectors be without dealers to supply them? Are collector-owned specimens being "used to little purpose"? Is a dealer who excavates a locality and distributes its contents, carefully preserved, to museums and collectors all over the world a "plunderer"? Would it be possible for mineralogists and dealers to work together for a change when a new occurrence is discovered... the dealer providing the excavation/collection skills and financing while the mineralogist is on hand to study and sample the deposit at every stage of its dissection? Isn't the discouragement of waste and destruction most effectively carried out through cooperation and education rather than restriction and prohibition?

* * *

The Tucson Show (discussed in further detail in the *What's New in Minerals?* department) was an unqualified success for the *Record* this year. Eighty-three new subscribers were signed up at our booth (the booth space and the auction/lecture hall for Saturday night were graciously donated by the Tucson Gem & Mineral Society, for which we are boundlessly grateful!). Many of the new subscribers were gained through the help of some of our enthusiastic readers; I always enjoy seeing one of our readers with an arm-lock on a potential subscriber, marching him up to our table, uncapping his pen for him and urging, nay *insisting*, that he sign up! It warms my heart.

A number of people took advantage of our lifetime subscription offer ($150), and a minor disaster was averted in time when I dissuaded one of our volunteers (Pat Carlon) from selling a lifetime subscription to an institution library (they live forever!). This rate, along with our subscription rate, will probably have to go up next year to at least keep pace with inflation, so anyone contemplating this move should act soon.

The auction was an enormous success for us this year, thanks to the many donors and buyers who felt strongly enough about the *Record* to give this kind of support. The *Record* is now financially secure for another year, and will even be able to add pages and color to issues with some of the auction receipts; in fact, some of the extra pages in the Tsumeb issue and some of the color in this issue were paid for by auction funds, so you see the karmatic effect of helping the *Record*... it allows the *Record* to do more for you in return. Every reader owes thanks to the auction donors for their generosity; lest readers be left wondering who to thank, the names of the auction donors are listed below, with our deepest gratitude. (I certainly hope I haven't missed anyone.)

Thanks also to those who assisted us during the auction: Ann and Dean McCrillis, Leslie and Irwin Kennedy, Bill Pinch, Bill Shedenhelm, Bob Jones, Dick Thomssen, Dick Bideaux, Dick Hull, Wayne DeBrusk and, especially, Clarence Maier, our professional auctioneer who graciously donated his entertaining and valuable talents.

The unbelievable response to the Colorado Issue caught us all unprepared; it was completely sold out by the end of the Tucson Show. We suspected it would become a collector's item some day, but didn't really expect it so *soon*. Our profound apologies to people who did not get one and who wanted one. There is hope, however. Si and Ann Frazier (see their ad) will henceforth be handling out-of-print copies of the *Record*. They will buy and sell at whatever price the market for them dictates, and will be keeping a file of requests so if you need a particular issue that we cannot supply you should send your request to them. They also handle other out-of-print publications so you may also want

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to ask for their price list of such things. I am pleased that someone has stepped into the breach for us on out-of-print issues because it gives more recent subscribers (and older, more tardy ones) a chance to complete their collection...and we all know how important "completeness" can be to a collector.

As I write this the Tsumeb issue is just being mailed, so it will be awhile before responses to it come back and can be published. Needless to say, I am excited about it, as I hope readers will be. The issue amounts to a gift to our readers, since it cost much more to produce than the $1.67 which is one issue's-worth of the annual subscription rate everyone pays. Of course we cannot sell extra copies so cheaply. (Everyone should have received an order form for extra copies at $5.00 plus 50¢ postage each.) We have had a few extra printed, and the funds from extra issue sales will help support future issues. However, we expect our extra issues to sell out fairly soon, so we advise readers to buy an extra copy for binding or saving or whatever soon, if they intend to at all. It may be much more expensive as a collector's item once we are out of copies.

As you will see in an ad in this issue, arrangements have finally been made for readers to buy binders for their copies of the *Record*; you no longer have to hide your copies from people wanting to wrap fish or line a bird cage. Not only that, but you have your choice of an inexpensive yet good-looking shelf box, or a more expensive, well-made binder. It took a while to locate a type of binder that would accommodate a *variable* number of issues of *variable* thickness, but one finally was located; both are produced by the same company that supplies binders for *Smithsonian* magazine...they have a catalog of many other useful items and I recommend that you write for it.

W.E.W.

Anatase from Norway

by W. L. Griffin, T. Garmo, H. Løvenskiold and A. Palmstrøm
Mineralogisk-Geologisk Museum, Sars' Gate 1, N-Oslo 5, Norway

Norway is generally known among mineral collectors for its wide variety of rare minerals, but not as aproducer of showy specimens of more general interest. This situation changed dramatically four years ago, when quartz crystals speckled with large (5-10 mm) crystals of anatase and labelled "Hardangervidda, Norway" began appearing on the European market. They soon came to America as well (MR 7, 132).

This is the first major "alpine-type" deposit found in Norway, and is of considerable interest to geologists as well as to mineral collectors. The manner in which it has been exploited also raises some interesting points with regard to the Norwegian laws concerning mineral collecting. The deposit is now essentially exhausted, and this article tells what we know about it and its origin.

Location

The deposit is located at an elevation of 1300 metres on the western part of Hardangervidda (vidda = high plateau). It is inaccessible for 10-11 months of the year due to deep snow. The correct locality name is Matskorhae, Ullensvang Statsallmenning, Hordaland Fylke, Norway. Among collectors it is informally known as "Grisebingen" (The Pig Pen). The name refers both to "mineral pig" (the derogatory Norwegian equivalent of "rockhound") and to the incredibly dirty working conditions in the deposit.

History and Legal aspects

The surface expression of the deposit, before development began, was a large cavity (approximately 1 cubic metre) filled with quartz crystals up to 10 cm long, associated with a few scattered anatase crystals. Below this extended a large talus slope littered with quartz crystals. The cavity was exposed 6000 to 8000 years ago during the retreat of the last glaciers. It was probably known from antiquity, since a very old reindeer-hunting lookout was found on the cliff above the deposit. Quartz crystals from this place may well have been used for tools by stone-age hunters.

The locality was visited by collectors first in 1966, when a power company, Tyssefallene A/S, began building dams in the area, and several workmen heard about the hole from local residents. These workmen soon began removing groups of crystals with which to decorate their homes. Norwegian concession laws require that any finds of minerals on a concession property be reported to state authorities, for example to the Geological Survey or the Museum. So when a person falsely presenting himself as a professional geologist from one of the Norwegian universities visited the dam site and asked if any minerals had been found, the company led him to the locality. This "geologist" and his associates began mining operations in 1969, under the pretext of "scientific investigation" of the deposit; they, and the construction workers, extracted large quantities of material over the next five years. Unfortunately, there existed a ready market for small groups and single quartz crystals with anatase, so little or no attempt was made to remove large coherent groups. Much of the work done at this stage was apparently done with an L-shaped piece of 6 x 26 mm steel bar, with which crystals were broken loose from matrix and dragged out of the hole.

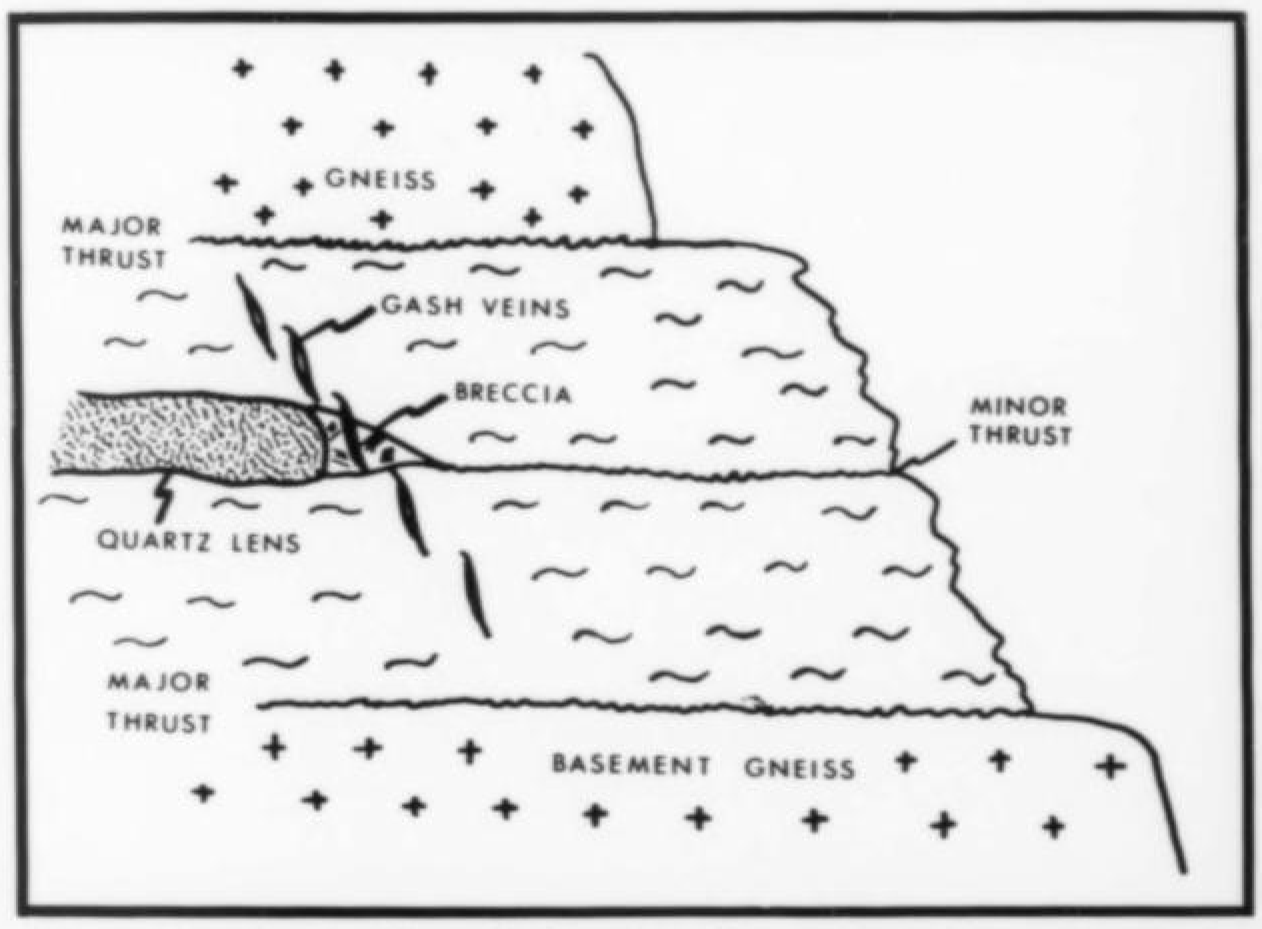

Figure 1. (above) **Sketch showing the geological setting of the deposit.**

Figure 2. (below) **Entrance to the tunnel. Note flat-lying foliation and abundant small quartz lenses in the phyllite. Scale: author (H.L.) is 190 cm (6'2") tall.**

This activity was illegal on three counts under Norwegian law:

(1) Removal of objects or material from another's property (in this case the State's) without permission is "simple theft." This prohibition, incidentally, applies to *all* collecting on Norwegian land, from either outcrop or loose material.

(2) A special law requires the granting of a concession for operation of quartz deposits, including rock-crystal deposits; no concession was even applied for.

(3) The sales activity involved in marketing the material was not registered as required, and thus no taxes were paid on the profits.

The matter is still under police investigation. (See the guest editorial in this issue for a further discussion of the legal and over-collecting problems in Norway.)

One of us (A.P.) located the deposit independently in 1972 on the basis of rumors, picked up some loose crystals, and identified the anatase. In 1974 a group of amateur mineralogists — H. Løvenskiold, A. Palmstrøm, T. Garmo and H. Chr. Olsen — visited the deposit and succeeded in taking out several remarkable groups. They then reported the deposit to the Mineralogisk-Geologisk Museum, donated their material, and suggested that the deposit be put under special protection to stop the vandalism being done by the commercial operators.

The Museum contacted Tyssefallene A/S, the State Forestry Authority (who administer all public land) and the police. The property is now posted, and the power company's warden is empowered to turn away unauthorized persons. The local sheriff also cooperates in controlling access to the deposit. Finally, the cable lift to the dam, which earlier provided relatively easy access to the area, has been dismantled since dam construction is now completed.

Museum personnel have examined the deposit during a short visit in 1975 and a longer one in 1976. These expeditions involved both amateurs and professional geologists, who did

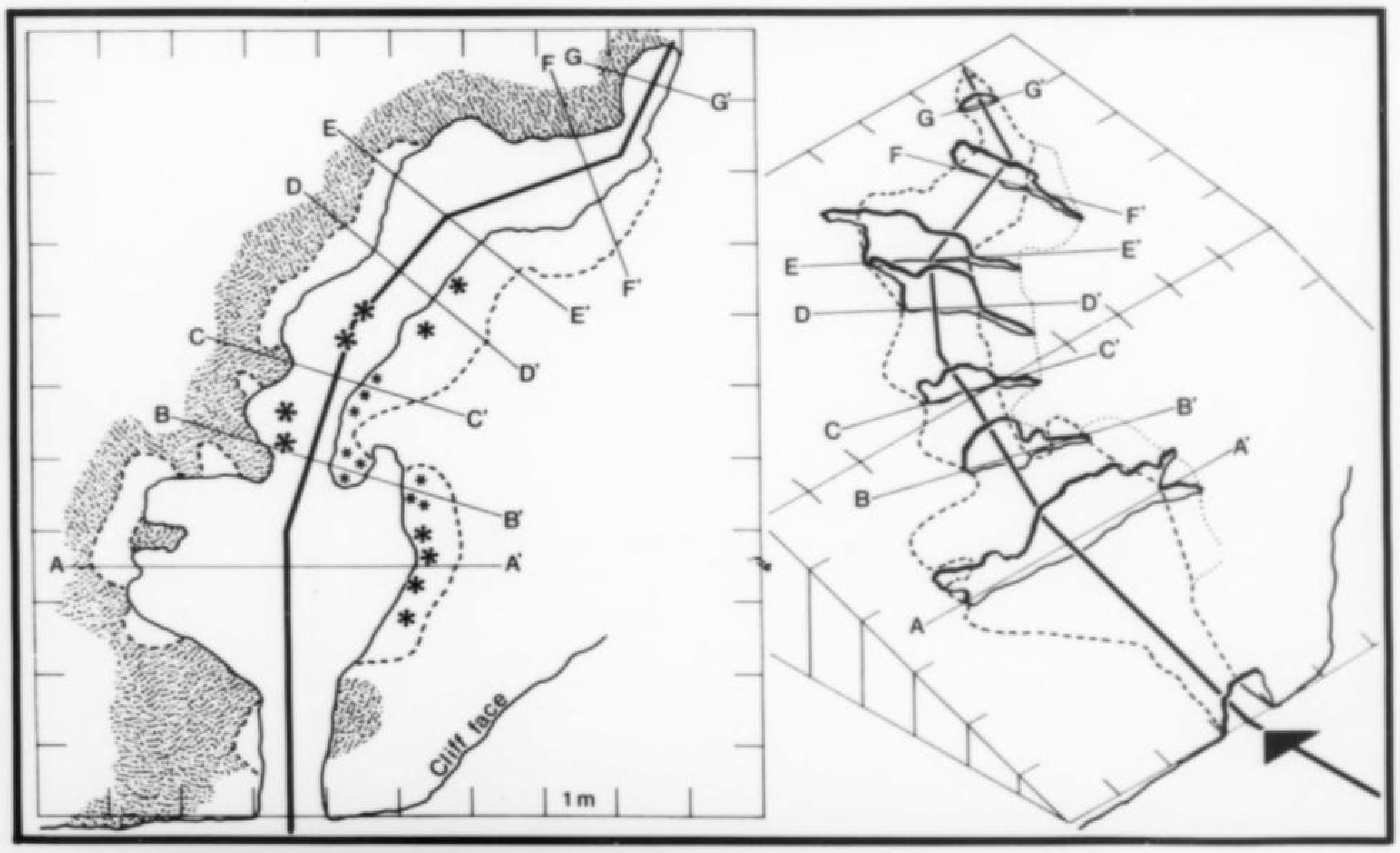

Figure 3. left: **Floor plan of Grisebingen tunnel. North is at bottom. Stars show anatase concentrations; the largest stars indicate where the best specimens were found. Stippled pattern is massive milky quartz visible in the wall of the tunnel. Solid line is the outline of main tunnel, dashed line shows where the breccia vein was cleaned out. Right: isometric drawing of the tunnel, with cross-sections.**

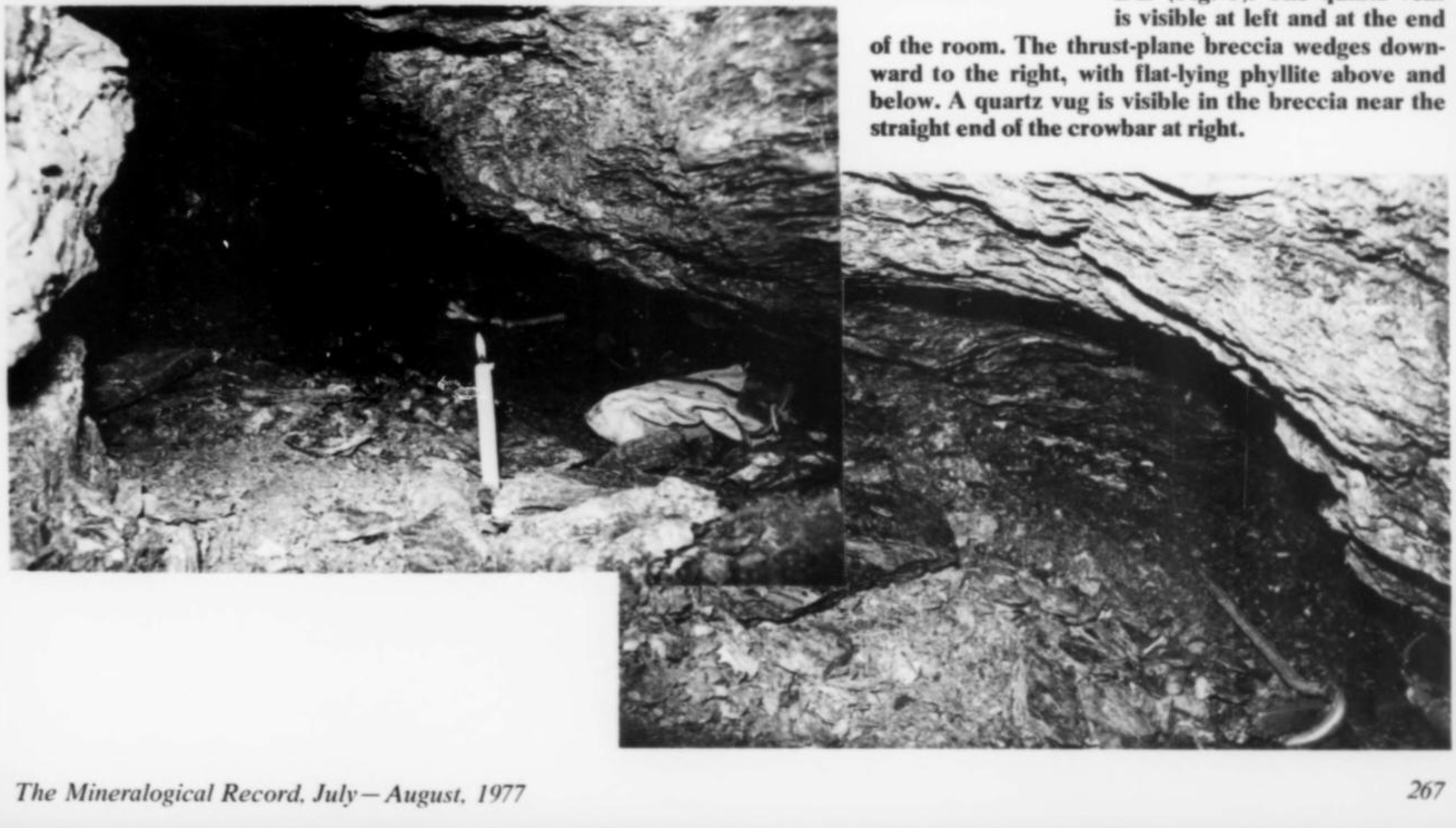

Figure 4. (below) **Panorama inward and to the right (east) from the west side of the tunnel at the cross-section line E-E' (Fig. 3). The quartz vein is visible at left and at the end of the room. The thrust-plane breccia wedges downward to the right, with flat-lying phyllite above and below. A quartz vug is visible in the breccia near the straight end of the crowbar at right.**

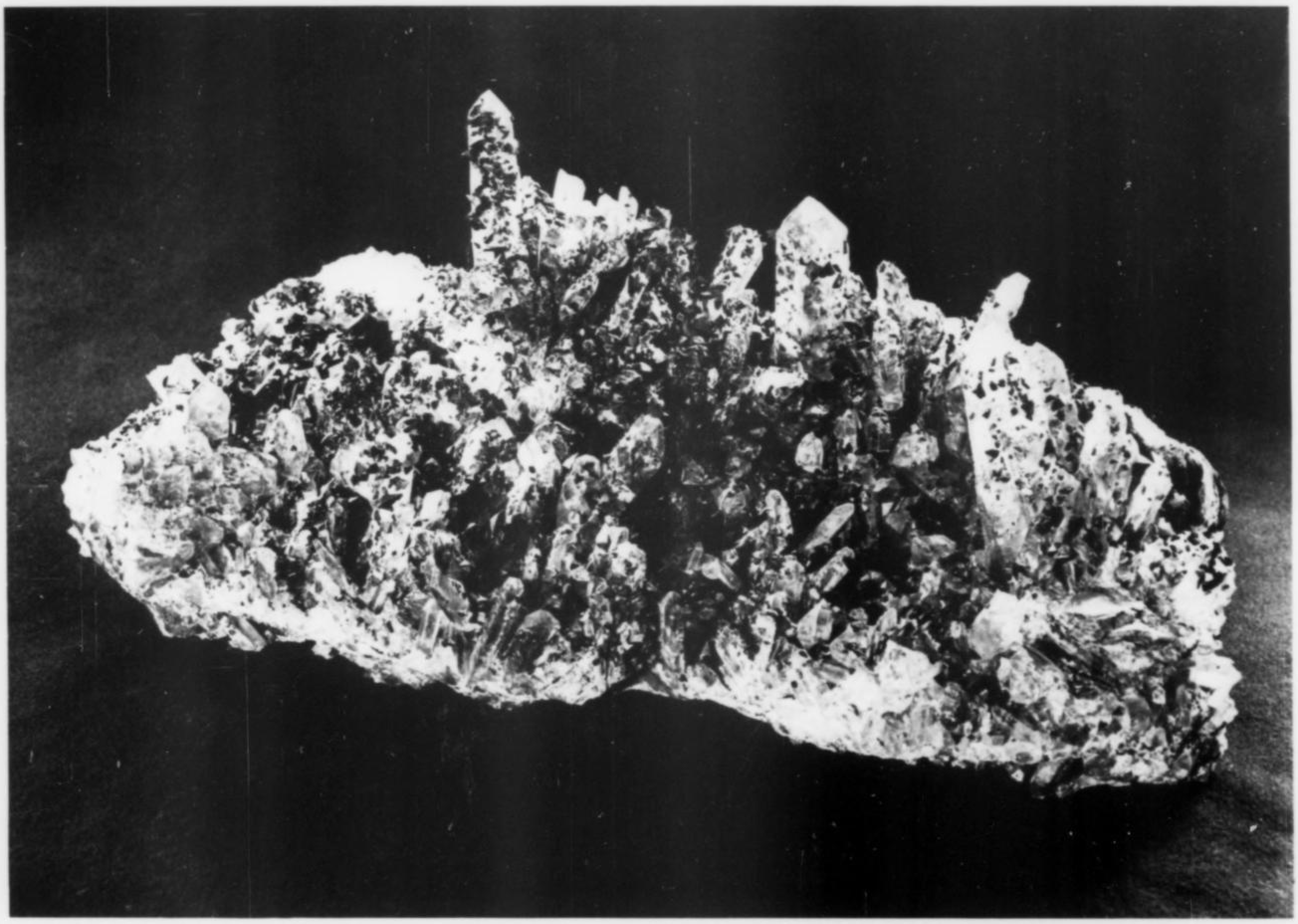

Figure 5(a). **Specimen (length 50 cm) from an anatase-filled vug in the quartz vein. Mineralogisk-Geologisk Museum collection.**

mapping, sampling and exploratory digging. It now appears that little significant specimen material can be taken out of the deposit without very extensive excavation, but the ruins of the deposit, including the extensive dump, are geologically interesting, and will remain under legal protection.

Geology

The deposit occurs in phyllites of the Cambrian (?) Holmasjø formation. Thirty to 50% of the rock consists of irregular quartz lenses up to ½ metre long. These phyllites form a sheet that was thrust over the Precambrian granitic basement from the northwest during the Caledonian orogenic event, about 400-410 million years ago. On top of the phyllites lies another thrust sheet, made up of Precambrian granites and gneisses. The foliation dips at low angles, and is cut by subhorizontal local thrust zones parallel to the major thrust faults. Some of these minor thrusts are filled with finely crushed rock, but others are breccias containing large (10-50 cm) rotated blocks of phyllite. Locally these breccia zones are filled with lenses of milky quartz, up to 1 m thick and full of drusy cavities. Following the thrusting, the phyllites were weakly folded, and developed two sets of conspicuous joints, running N20-40°E and N60-70°W. The northeast-trending set is commonly seen as *en echelon* gash veins (northwest block moving upward and southwestward), 3-5 cm thick and filled with drusy quartz. In these veins the quartz is commonly rutilated, and anatase is often found where open spaces have formed.

The deposit occurs at the end of a subhorizontal drusy vein of milky quartz, 30-100 cm thick and full of phyllite fragments, filling one of the minor thrust planes. The crystal druses within the vein contain only quartz, without anatase or rutile. These are limited to a zone where a set of the northeast-trending gash veins has cut into a weak, drusy breccia at the end of the quartz lens. There has been minor fault movement on the gash veins at several periods. This movement in the earlier breccia zone has provided access to a large amount of open space into which the mineralizing solutions have been able to deposit quartz and TiO_2 minerals. Movement in this zone continued during and after deposition of anatase; many anatase-covered quartz crystals have been broken off and some have regrown, so that doubly-terminated "floaters" are common.

The weak breccia zone, where the anatase was concentrated, is easily excavated. The present hole (Fig. 2-4) has been dug entirely with hand tools, mainly screwdrivers, crowbars and small picks. The tunnel follows the edge of the quartz lens; the direction is controlled in part by the orientation of the gash veins. The greatest concentration of anatase, and the largest crystals, occurred in a zone where the gash veins are still visible in the roof and floor of the tunnel. Both the abundance and the quality of the anatase dropped off sharply in all directions from this zone (Fig. 3).

The volume of the tunnel is about 20 cubic metres; about 5 metric tons of rock have been removed, making for a sizeable dump below the opening. We estimate that between 2 and 4 cubic metres have been recovered as specimen material, of which at least 75% was as single quartz crystals broken from the matrix.

The large "rooms" in the tunnel are places where the quartz vein was especially vuggy, and large quartz-crystal groups could be removed. Unfortunately, these were usually free of anatase. The major exception is shown by the first large asterisk in Figure 3, where a gash vein (still visible) had broken into a quartz vug and all of the crystals were thickly coated with anatase (Fig. 5). Most of the anatase in the deposit has, however, been deposited on quartz crystals growing on phyllite blocks in the breccia, or in a "vein" 5-10 cm thick, extending a short distance along the thrust zone (Figs. 3, 4). The quartz crystals come off the phyllite matrix easily, and great care was necessary to take out coherent groups— but Figure 6 shows that it could be done.

In the "vein" filling the thrust zone there is a great difference between the floor, where thin crystals stand up at 30-90° angles, and the roof, where thicker crystals grow flat on the surface (Fig. 7). Anatase is rare on the roof quartz, and most common on the lower parts of the "floor" crystals. The fluids that deposited the anatase apparently flowed down the thrust plane away from the gash veins, but did not fill all the open space in the vein. The roof of the vein has later collapsed onto the floor, causing extensive damage to the upright crystals, and further reducing the chances of recovering groups. With careful extraction, it is often possible to retain the broken crystals and repair the natural damage, if desired. Locally a quartz sole 1-5 mm thick was deposited on the phyllite before the crystals began to grow upward; these small groups are the most stable and often the most beautiful (Fig. 7).

Within the breccia zone, the distribution of anatase is very irregular. One vug may be thickly coated with anatase, while another only centimetres away contains none at all. This reflects

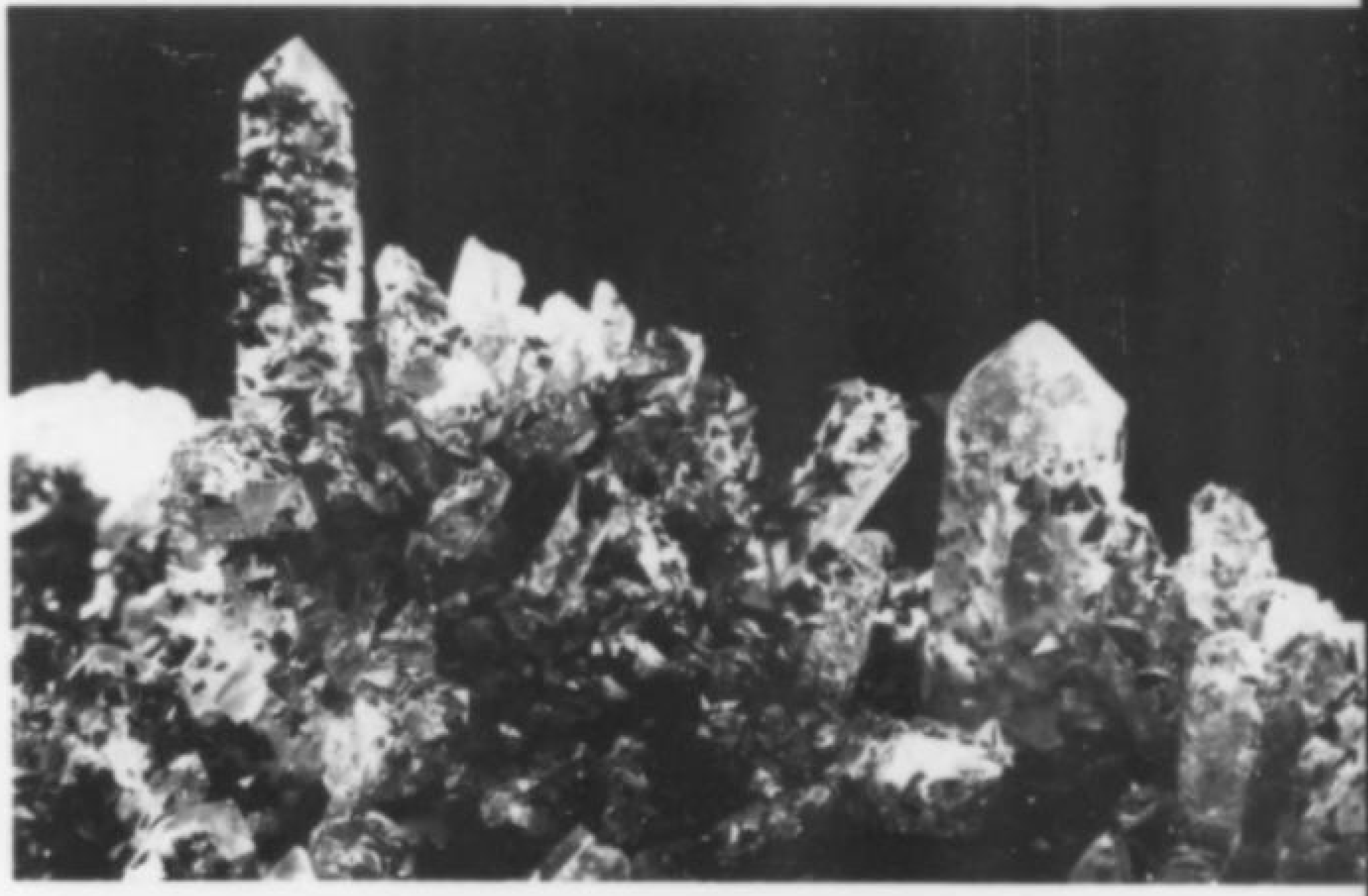

Figure 5(b). **Detail of the upper left corner of figure 5(a)**

Figure 6. **(a) Specimen (length 40 cm) from a quartz-anatase vug in the phyllite breccia. Note the uneven distribution of anatase within the vug.**

Figure 7. **Typical specimens from roof (left: black Mn-oxide coating not removed) and floor of breccia vein. Mineralogisk-Geologisk Museum collection.**

the fact that the TiO_2 was supplied by fluids moving along the gash veins and into the quartz-lined cavities in the breccia. Cavities not directly or indirectly connected to the gash veins simply remained "dry", and received no anatase.

Mineralogy

The mineralogy of the deposit is very simple—the only solution-deposited minerals are quartz, brookite, rutile and anatase, and possibly chlorite. The phyllite contains only quartz, albite, muscovite, chlorite and graphite, with rare rutile or anatase.

Quartz crystals are long-prismatic; almost all crystals show only the hexagonal prisms *m*$\{10\bar{1}0\}$ and the rhombohedrons *r*$\{10\bar{1}1\}$ and *z*$\{01\bar{1}1\}$. The trigonal pyramid *s*$\{11\bar{2}1\}$ occurs occasionally, and the trigonal trapezohedron *x*$\{51\bar{6}1\}$ very rarely. Both right- and left-handed crystals have been found. One face of the positive rhombohedron *r* is often much larger than the others, giving a characteristic sloped termination. Because many crystals have been repeatedly broken and regrown, extremely distorted forms caused by overdevelopment of one set of faces are common. No study of twinning has been done, but the interruption of striations on prism faces indicates that twinning, probably on the Dauphiné law, is common. Two possible examples of Japan law twins have been found.

The quartz from the surface of the deposit and the vugs in the quartz lens is colorless and water-clear, while crystals from the breccia and veins, in the underground workings, have a characteristic pale smoky color. The smokiness probably was caused by natural radioactivity in the phyllite. Several thousand years' exposure to sunlight has repaired the damage and bleached the crystals exposed at the surface.

The largest quartz crystal known from the deposit is 15 cm long and 5 cm in diameter; crystals 5-10 cm long and 1-2 cm in diameter are common. A late stage of quartz deposition, as tiny crystals coating both anatase and earlier quartz, is seen locally in the deposit.

The milkiness of the vein quartz is due to the presence of very abundant tiny fluid inclusions—small cavities filled with liquid trapped during deposition of the quartz. The clear crystals of the veins and cavities are generally free of fluid inclusions except near their base, while fracture planes in broken-and-regrown crystals are marked by planes of inclusions. These inclusions contain a fluid ($H_2O + \sim 2\%$ NaCl) and a bubble formed by contraction of the fluid during cooling. Heating the crystals to temperatures of ca. 140°C causes the bubble to disappear. A small pressure correction is necessary, but the temperature at which the anatase was deposited probably lay in the range 150-200°C.

Brookite occurs as red-brown blades up to 5 mm long, with a black longitudinal median stripe. It is found on the schistosity planes of the phyllite in and around the thrust breccia. Its age relations to the other TiO_2 polymorphs are unknown.

Rutile occurs as hairlike crystals up to 1½ cm long, in cavities in the phyllite. These have grown before the quartz, and are imbedded in the first quartz crystals, which often lie flat on the phyllite. It is not unusual to find rutile and anatase in the same cavity, or included in the same quartz crystal. In several cases rutile needles have been seen growing through anatase crystals, both included in quartz. It appears that the two polymorphs could and did crystallize simultaneously during the late stages of deposition.

Anatase occurs as tetragonal bipyramids {111}, embedded in the surface of quartz crystals. The pyramid faces are commonly striated horizontally. A few crystals with basal pinacoids have been found. The largest crystals found on quartz are 8-9 mm long; this is also quite a common size. The largest crystal known from the deposit is 13 mm long and incomplete, and occurs in a cavity in phyllite. Some of the anatase is transparent and deep blue, but most is opaque and black, with bright metallic luster. Anatase also occurs as groups of crystals in parallel growth, lying flat on the foliation planes of the phyllite within the breccia.

Chlorite is rare, but occurs in some cavities in the phyllite breccia as a fine-grained green sand similar to that found in the alpine cleft deposits. This material is included in some of the same flat-lying quartz crystals that contain rutile. The green sand may have been common in the cavities early in the depositional history, and been washed out later. Minor amounts of chlorite have also been seen embedded in the surfaces of the anatase and quartz in some areas of the vein.

Manganese oxide forms a thin black coating on the quartz and anatase in most of the deposit. It can be removed by scrubbing gently with a tooth brush and a soft scouring powder.

Other minor minerals include **pyrite** and **molybdenite**. No feldspar, carbonates or other minerals have been found here, despite an intensive search, but beautiful **albite** occurs in other smaller veins in the area.

The open spaces of the deposit are now filled with pulverized phyllite and a brownish-black muck. This muck is extremely fine-grained and sticky; it clings to everything it touches and is nearly impossible to wash off (though sandpaper is said to be effective). It is this muck that has given the name *Grisebingen* ("Pig Pen") to the deposit. Besides being very fine-grained, it is poorly crystallized, so that X-ray diffraction gives very poor patterns. The dominant component is a sheet silicate with a basal spacing of about 9.6 Å, (between talc and mica); it may be a sodium-rich mica. There are smaller amounts of 7Å/14Å material, probably a chlorite. Both of these sheet silicates probably are derived from low-temperature breakdown of the phyllite.

Genesis

The formation of the deposit involved several steps.

1) Breccias formed by movement along thrust planes.
2) Local filling of open spaces in the breccias by massive milky quartz and quartz-crystal druses took place. This was probably a long process, during which movement continued intermittently. The quartz lens acted as a buffer and protected a part of the thrust breccia from being ground down by the later movements. Such a protected zone is called a "pressure shadow" by structural geologists (Fig. 1).
3) Weak folding and minor faulting took place, leading to the opening of northeast-southwest gash veins. Fluids carrying silica and titanium flowed along the gashes, into the open spaces (mainly quartz-crystal druses) in the breccia zone around the end of the quartz lens. Fluid inclusions in the quartz crystals have filling temperatures of 140°C, suggesting that this was a low-temperature process. The silica and titanium were probably leached from the surrounding schists; no other source is obvious.
4) Continued minor faulting took place during and after deposition of the last quartz and anatase, causing collapse of the veins and brecciation of some druses. Late-stage deposition of quartz and Mn-oxide occurred.

The unusual concentration of anatase in this deposit seems to depend on a coincidence: the intersection of the vuggy pressure shadow at the end of the quartz lens by a set of the northeast-southwest gash veins. The gash veins are common in the region and often carry anatase but the veins are small and have little open space for crystal growth. These gash veins cut quartz lenses in other places but the amount of movement on them has been so small that the gash veins have not been able to break into the vugs that do exist in the lenses. Except in pressure shadows, like that at Matskorhae, the thrust planes now contain little open space. There is therefore no particular concentration of anatase where the gash veins cut the thrusts elsewhere in the area.

This series of coincidences suggests that the chances of finding another deposit of these dimensions are poor. But the Hardangervidda is a large area, and little investigated. The Mineralogist-Geologisk Museum, in cooperation with a selected group of amateur geologists, is now engaged in an investigation of the "alpine-cleft" deposits in this region.

Acknowledgements

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A HISTORICAL REPORT
by Joseph Imhof†, Prospector (1968)*
from the special issue;
Yearbook of the Natural History
Museum Berne,
Switzerland 1966-1968.
(Translated by Curt G. Segeler,
284 East 16th St., Brooklyn, New York, 11226.)

THE LENGENBACH MINERAL LOCALITY

BINNA VALLEY, VALAIS, SWITZERLAND

The first probings in the Lengenbach quarry in the Binna Valley, later to become world renowned, date back to the first half of the 18th Century. Only they were "scratching around" at that time for iron and not for minerals. In the year 1728, the Cantonal Council assigned to J. G. Courten, Governor of Valais, the job of finding experts to investigate the iron ore bodies of the Valley and to develop them. Two years later, therefore, two Englishmen named Mandel and Aston, who were then living in Paris, France, received the concession to exploit the ore occurrences in the Binna Valley. Nearby the two discovered the pyrite-rich veins in the dolomite of the Lengenbach (literally the Lengen Brook). There they drove an exploratory adit, known as the Englishman's adit. Incidentally, this was unexpectedly rediscovered in 1902 by Franz Jentsch during exploratory drilling operations.

The contract with the Englishmen encountered great resistance on the part of the local people, largely because the Englishmen were not Catholics. This threatened to come to an armed revolt and therefore the contract with the Englishmen was cancelled by the Valais Council in 1732.

As already stated, the two Englishmen were looking for iron, not minerals. Only later, at the beginning of the 19th Century, did mineralogists discover various minerals, unknown at that time, on the dump of the Englishmen's adit. In this way the fraternity of mineralogists became aware of this unique locality.

In the second half of the 19th Century there lived in the village of Binn a pastor, Theodore Walpen, who himself had a lively interest in minerals and understood something of them. Further, he felt that "prospecting" in mineral collecting might provide a supplementary income for the not exactly rich population of Binn. The attention of Pastor Walpen was drawn to the dolomite locality of Lengenbach by various mineralogists. His urging and explanations led, in 1900, to the founding of the Dolomite Company which began the exploration of the minerals of Lengenbach. Only men from Binn participated in the company including: the brothers, Franz and Leopold Jentsch, Anton Imhof (father of the author) and Leopold Tenisch. Franz Jentsch had the job of identifying the minerals and pricing them: Author Imhof was quarry superintendent: Leopold Tenisch ran the forge (the company owned its own forge) and served as cook while Leopold Jentsch was the bookkeeper. Although the Dolomite Company was not exactly a major industry nevertheless it regularly employed eight men (miners and handymen). Furthermore, the technical developments were quite modest at the time; the stone saw, donated to the firm by a certain Dr. Krantz of Germany, has survived and is still in use. Boring was done manually and the miners often ran contests to see who could strike the most sledge blows in a given time; even competitive sledging accuracy was practiced. Accuracy meant that the drill rod direction would be more accurately controlled. Blasting was done with black powder, rarely with dynamite. Blasting with black powder wasn't easy since great care was needed to secure a dry bore hole. Rubble (about 99% of the material) was carried out of the quarry in wooden wheelbarrows and washed out in flumes which were made from big tree trunks and connected to the brook. The brook too was controlled by wooden flumes. Thus water - as even today - was friend and foe at the same time. In summer there was much more water in the brook and, in increasing measure, it hindered the work in the deeper parts of the quarry. It really became necessary to hire one man just to pump out water.

Minerals were taken daily to the little hamlet of Weiler Giessen and there offered to interested buyers. At that time the best customers were Englishmen and therefore the finest specimens left Switzerland. Only the University of Freiburg in Üechtland assembled a rather good collection at that time. Surprisingly, the financial return was much bigger than today since the prices of Lengenbach minerals remained almost the same up to recent times while wages were 20 to 30 times smaller. A miner earned 2 francs (Swiss) per day - a handyman 1.8 fr; both received lunch which was the equivalent of about 0.27 fr more. Also, other costs were much lower. The author can readily remember those times. He went with his father and the English Professor R. H. Solly to the quarry almost every day, there to collect his first "treasures".

May I be permitted to relate a short anecdote about those days. Franz Jentsch, the mineral identifier, had grown to be a big redhead, not without personal ambition. Since newly discovered species were generally named after their discoverer or after the person who worked out their composition, Franz's co-workers often teased him saying that some day there would be a jentschite. Naturally, this flattered him. Then one day Prof. Solly, examining various rocks in the quarry, noted a little red spider on one of them. He also knew

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* Other historical reports differ slightly with respect to dates and persons involved but the main outlines are in agreement.

† Deceased (1969).

***Figure 1. (above)* Binn, Valais, Switzerland.**
***Figure 2. (right)* Lengenbach quarry.**
***Figure 3. (left)* Lengenbach quarry.**
***Figure 4. (below)* Lengenbach dump. (Photos by C. Segeler, 1971)**

about Jentsch's secret hopes so he ran with the spider carrying rock crying "jentschite, jentschite." At first great excitement—then roaring laughter. Mr. Jentsch felt quite humiliated and stayed away from work for three days. Only long pleading succeeded to move Jentsch to return to work.

During World War I, work in the quarry stopped since it became too difficult to dispose of the mineral yield. Then the quarry gradually deteriorated and avalanches filled it full of rubble. Only at a few exposed points could minerals now and then be obtained.

In 1945, the author once more began a small operation there. A few workers were engaged but costs rose too high and the work soon ceased. A giant realgar crystal measuring 7 x 3 cm and weighing 90 grams was found during this period. This is the largest realgar ever found in the Lengenbach quarry and is now in the Museum of Natural History in Berne.

This crystal stimulated the author to promote the Legenbach quarry among strong financial circles. In 1958 he found a capable voice in Dr. H. Grossglauser who approached Mr. R. Von Sinner then President of the Museum Commission in Bern and laid before him the plan for reopening the quarry. Von Sinner was enthusiastic about the idea and thus in 1958 the Bernese Working Partnership for the Reopening of the Lengenbach Quarry was formed. The Partnership included the Natural History Museum in Berne, the Mineralogical Institute of Berne University, the Bally Museum in Schonenwerd and the author. (Others were also contributors; see translator's note.) The first step was to clear the quarry using heavy construction machinery. Working ever deeper into the quarry, the wooden pit props stemming from the Dolomite Company operations were encountered. These supports were then in the seven-metre-deep quarrying area. The "old times" seemed to be resurrected. A spacious shed was erected in a protected spot, tracks were laid to carry rubble out of the quarry and a simple correction was made to divert the brook. In these ways work started under the supervision of the author. Soon the old mineral veins were encountered. Species long unavailable such as baumhauerite, jordanite, hutchinsonite, lengenbachite and others again came to light. Nor did it take long before new unique minerals were found and which were often named after the men who contributed to the mineralogical value of the quarry as, for example, sinnerite, nowackiite, imhofite.

Translator's Comment

The Lengenbach quarry rightly deserves its fame. Its minerals are on display in museums all over the world and they have found their way into many private collections as well. Even today one can find many of the fascinating sulfosalts and other minerals on the quarry dump. Should one tire, the magnificent view will soon rekindle ambition. The quarry itself is closed to collectors, but most minerals can also be found on the dump, which is open to collectors.

Accomodations in Binn are limited to a 60-bed boarding house and a few rooms in private homes so that collectors might find it more desirable to stay in nearby Brig (17 miles away) with its wide choice of hotels, camp grounds and other facilities. Binn (elevation 4200 ft.) lies 5½ miles SE from the main auto road which leads from Brig to the famous Swiss passes (Furka and Grimsel). For those without a car the Furka-Oberalp-Railroad (narrow gauge) can be used from Brig to Fiesch and thence by Postal Auto Service to Binn.

From Binn a narrow dirt road (passable by small cars) follows the Binna Brook upgrade - about an easy hour's walk - to the little bridge over the Messer Brook. At this point, the big white dump can be seen and a steep 10 minute climb leads to the quarry (elevation 5400 ft). About a half mile from Binn the dirt road passes an abandoned dolomite operation known locally as Turtschi which has yielded giessenite, geocronite, molybdenite-3R and other minerals. However, this dolomite does not belong to the Lengenbach geologic horizon.

This is a remarkable locality, yet, as Dr. Graeser points out, it is even more astonishing that the minerals from the Rogers mine in Madoc, Ontario show such extraordinary similarity to these from the Lengenbach. However, one important difference between the two is that Lengenbach minerals are arsenic species while those from Madoc are the corresponding antimony minerals; for example the Sb analog of dufrenoysite is veenite; the Sb analog of sartorite is twinnite.

So when you plan a trip to Europe be sure to include glorious Switzerland and once there do go to the Lengenbach quarry. You will certainly enjoy it.

FAMOUS MINERAL LOCALITIES:

LENGENBACH, SWITZERLAND

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Introduction

The name Lengenbach is known all over the world for the occurrence of extraordinary minerals, especially one class of minerals: the so-called sulfosalts. The locality Lengenbach lies in the Binna Valley (Binntal, Binnatal, Binnenthal), a small valley in the eastern part of the Canton Valais, Southern Switzerland (see Fig. 1).

This occurrence of uncommon ore minerals has been known since the early 18th Century, at which time there was an intensive search for productive ore deposits throughout the Swiss Alps. During these early years several poor deposits of ore minerals were mined from gneisses and dolomites of the valley for iron and, to a lesser extent, for lead. After construction of a small search gallery ("Engländerstollen") for prospecting the Langenbach outcrop, mining attempts were abandoned due to the complete lack of useful ore minerals.

About one hundred years later mineralogists became interested in the locality, but this time for purely mineralogical reasons. By around 1900 about 20 new minerals had already been described from Lengenbach. As depicted in the historical essay by the late Joseph Imhof (translation by C. G. Segeler) work in Lengenbach came almost to a complete end after World War I, and this period of inactivity continued until 1958, at which time the "Arbeitsgemeinschaft Lengenbach" was founded. This is a community of interests which had the goal to again work in this extraordinary mineral deposit. Since this time, after 18 years of activity, all the previously described rare minerals have been confirmed and several new minerals detected.

***Figure 1.* Location of the Lengenbach mineral deposit, Binntal, in southern Switzerland.**

Geological situation

The Binntal lies almost completely in the region of the Monte Leone nappe, one of the lowest of the Pennidic nappes (socalled Simplon nappes, see Fig. 2). The central part of the nappe consists of various gneisses and serpentinite, the outer part of younger metasediments, as Triassic dolomite and Jurassic schists ("Bündnerschiefer"). The sulfosalt mineralization occurs only in the dolomite that outcrops at many points in the valley (see Fig. 3), not only at Lengenbach but also at many other localities. The dolomite is generally white in color and often shows a crumbly sugary consistency ("sugar dolomite"). The thickness of the dolomite beds may reach up to about 200 m.

The minerals

We will describe here only one locality, which is the richest in minerals and yielded the most interesting minerals: Lengenbach. All the minerals that have been found hitherto in this deposit are compiled in Table I. The number of minerals known from this locality comprises some 60 species. As can be easily seen from this compilation, by far the most interesting group is that of the sulfosalt minerals, of which, even today, more than ten species have not been found elsewhere. From Table I it is understandable that the complex sulfides (or sulfosalts) can be characterized by one common generalized formula of the type:

$$Me_x(As, Sb, Bi)_y S_2$$

where Me represents various metallic atoms, as (for Lengenbach) Pb, Cu, Ag, Tl, Fe, etc. From the elements As, Sb, Bi, only As is of importance in Lengenbach; Sb has much less influence, and Bi seems to be absent in this deposit. Outside Lengenbach, Sb increases in importance even overtaking As. For this reason Sb-sulfosalts are of increasing importance with increasing distance from Lengenbach (geocronite, boulangerite, bournonite, tetrahedrite). Only one locality was found to contain Bi-sulfosalts (nr. 4 in Fig. 3, giessenite, GRAESER, 1963).

The recognition of these conditions was the result of a spectrochemical study of minerals in the fahlore group (tennantite - tetrahedrite) and jordanite - geocronite (GRAESER, 1965). In general, the sulfosalt minerals occurring outside Lengenbach are characterized by:

a) a smaller content of the elements As, Sb on the whole
b) a tendency towards minerals in which a solid solution be-

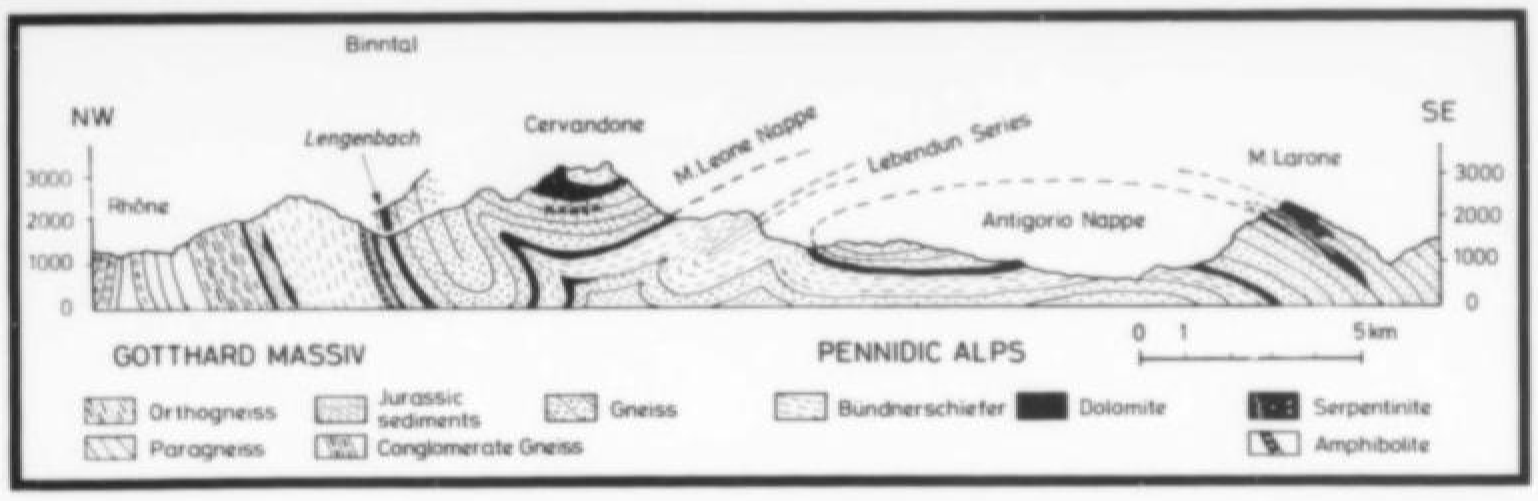
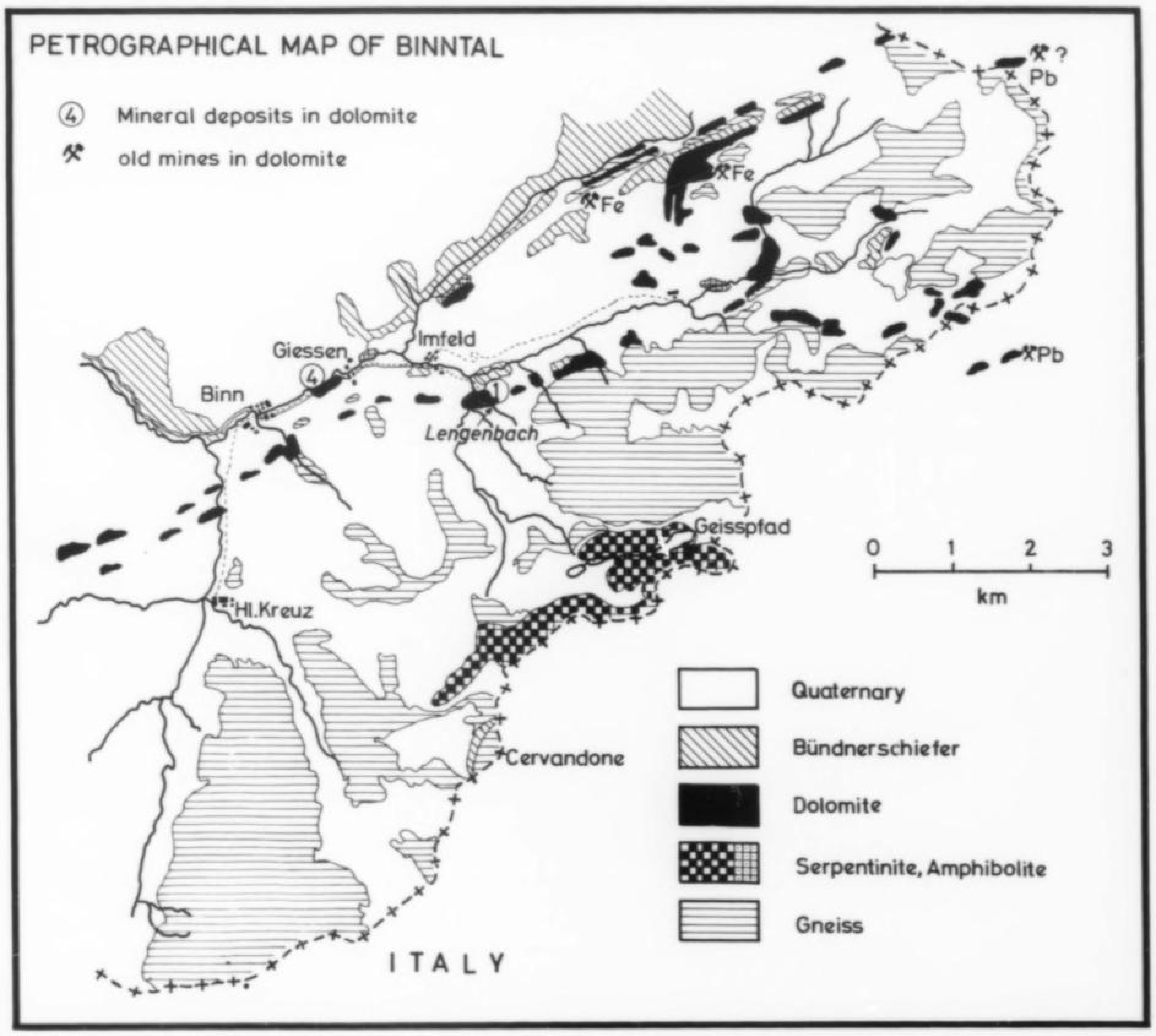


Figure 2. (left) **Geological section through Binntal, from Rhone-Valley in the north to the Italian Alps in the south. The location of the altered Cu-As-mineralization is marked by crosses.**

Figure 3. (below) **Petrographic sketch map of the Binntal region. The numbers near the dolomite outcrops designate mineral occurrences which were described in GRAESER (1965). Nr. 1 represents the Lengenbach quarry.**



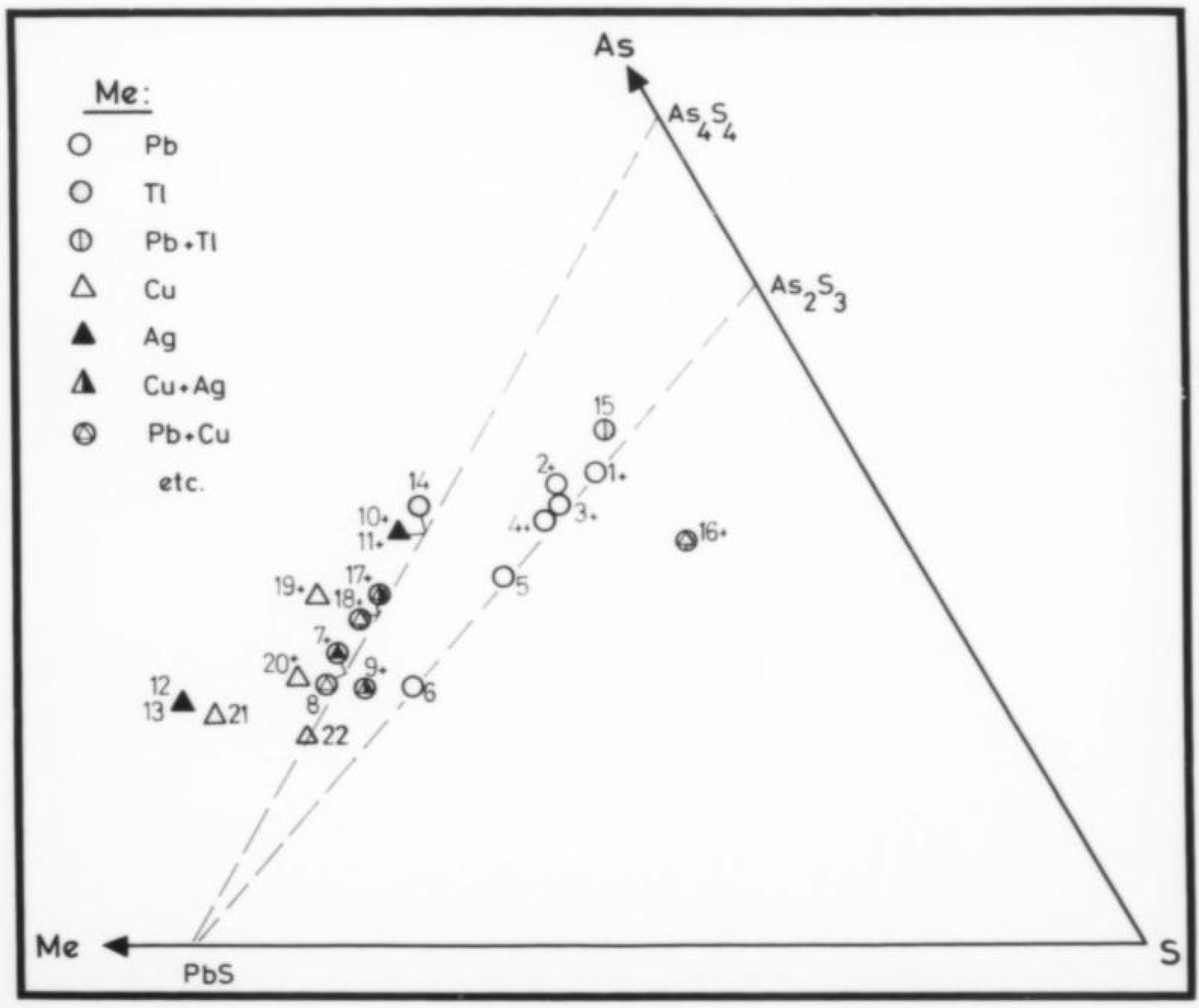


Figure 4. (left) **Triangular diagram Me - As - S illustrating chemical composition and chemical relationships of Lengenbach sulfosalts. A cross behind the number points out that this mineral occurs only in Lengenbach. The diagram clearly indicates that the special Lengenbach minerals preferentially lie on the As-rich side of the triangle (upper part).**

$(Pb,Tl)_xAs_yS_z$
- 1^+ **sartorite**
- 2^+ **rathite**
- 3^+ **baumhauerite**
- 4^+ **liveingite**
- 5 **dufrénoysite**
- 6 **jordanite**

$[Pb(Cu,Ag)]_xAs_yS_z$
- 7^+ **marrite**
- 8 **seligmannite**
- 9^+ **lengenbachite**

$Ag_xAs_yS_z$
- 10 **smithite**
- 11 **trechmannite**
- 12 **proustite**
- 13 **xanthoconite**

$(Tl,Pb)_xAs_yS_z$
- 14 **lorandite**
- 15 **hutchinsonite**

$[(Tl,Pb)(Cu,Ag)]_xAs_yS_z$
- 16^+ **imhofite**
- 17^+ **hatchite**
- 18^+ **wallisite**

$(Cu,Zn)_xAs_yS_z$
- 19 **sinnerite**
- 20 **nowackite**
- 21 **tennantite**
- 22 **enargite**

tween As- and Sb-members is possible.

This regularity of variations in chemical composition is an unexpected result found not only in the entire Binntal dolomite but also traceable within the small accessible dolomite outcrop of Lengenbach. Even this very restricted region (about 30 x 20 m) shows a distinct regularity in the occurrence of different minerals: in the southernmost part of the quarry occur the minerals richest in arsenic (like realgar, orpiment, sartorite, etc.), towards north minerals decrease in As-content (dufrénoysite, jordanite, lengenbachite) and in the northernmost part appears the As-free mineral galena. This zoning is usually so complete in the quarry, that in a single dolomite sample all of the minerals display a similar As-content galena (PbS) for example is not coexistent with realgar (As_4S_4) in a single sample).

If one plots the chemical compositions of Lengenbach sulfosalts in a triangular diagram Me — As — S (Fig. 4), it is obvious that most of the various sulfosalts lie more or less exactly on the tie-lines between the compositions of MeS and As_4S_4 (realgar) or As_2S_3 (orpiment), respectively.

Identification of Lengenbach minerals

Up to this point crystal size, which is of great importance for species determination, has not been discussed. From Table I it is obvious that many of the sulfosalt minerals (especially the Pb - As — S — minerals) are very similar in chemical composition and, therefore, the distinction of such minerals might be very complicated. Some of the pictures show clearly how similar they may appear in color and shape. A fact that makes things even more difficult is that most of the Lengenbach sulfosalts form elongated to acicular crystals of low symmetry (mostly monoclinic and triclinic). The difficulties connected with a clear identification of this material are accented by the realization that the maximum size of these minerals rarely exceeds a few millimetres, with the consequence that hardness or streak tests are impossible. There exists a number of minerals among the sulfosalts that can be identified without any difficulty, e.g. tennantite, most jordanites and lengenbachites. Yet, even these few minerals often appear in completely uncharacteristic specimens that are difficult to determine. If we need exact information on the nature of the sulfosalts we must make use of means of investigation other than visual inspection!

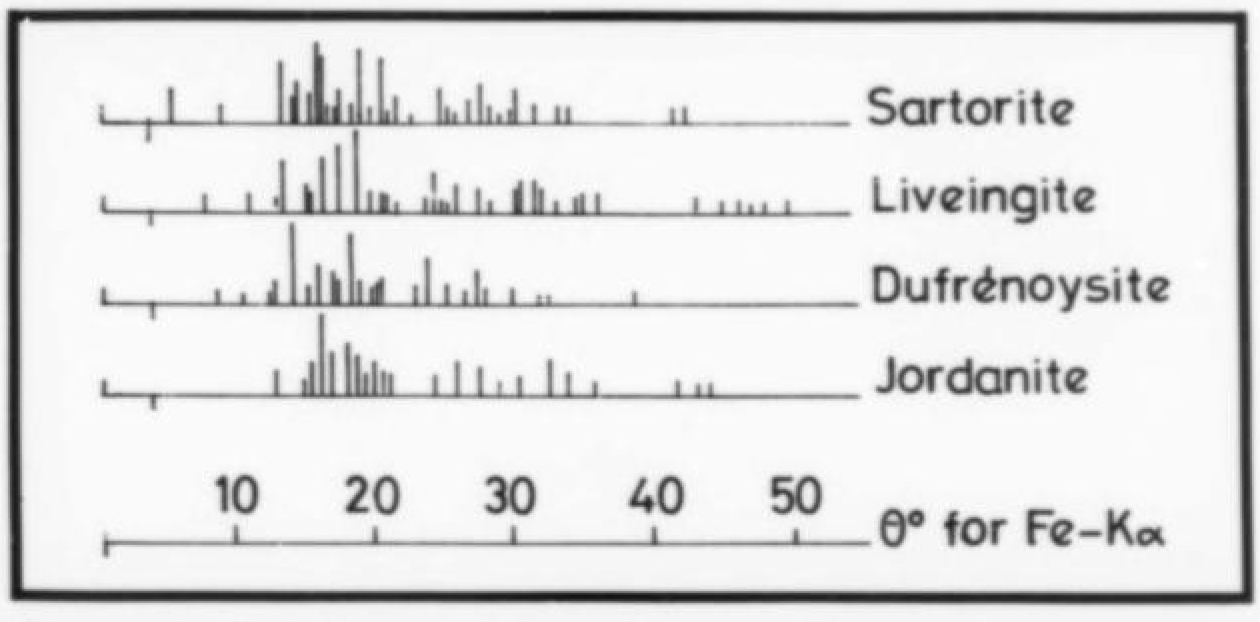


Figure 5. **Powder patterns of some characteristic sulfosalts from Lengenbach pointing out the similarity of diagrams. Nevertheless, the figure indicates the existence of small but significant differences between the patterns of different minerals.**

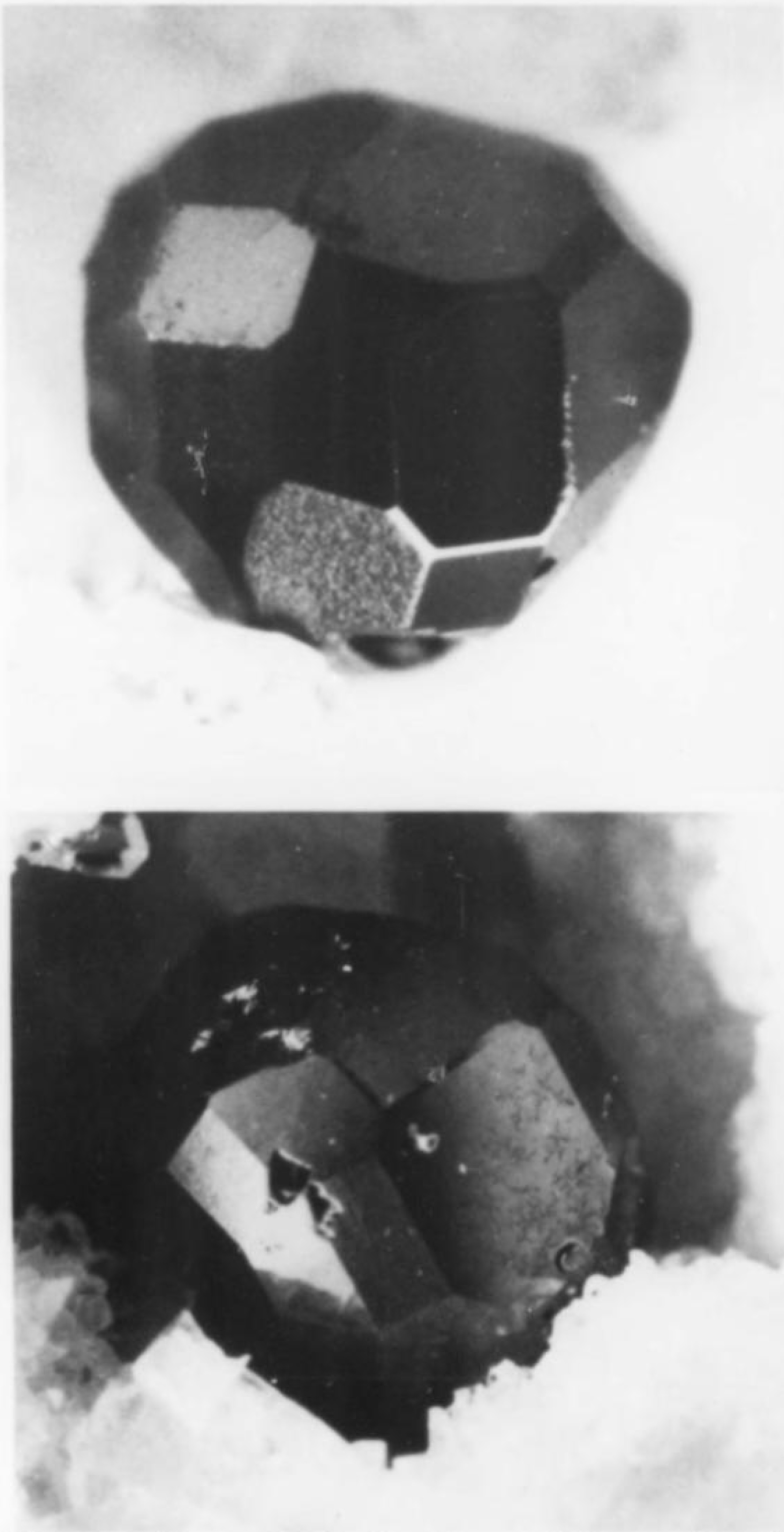


Figure 6. **Tennantite in the characteristic pseudo-holohedric form from Lengenbach, better known under the name "binnite". The crystal is steel-black and has a high luster. Size of crystal: about 0.8 mm, (Specimen: G. Günther) (a) - 1.5 mm, (Specimen: H. P. Stehlin) (b)**

The best and, by far, the quickest method is X-ray diffraction, especially the Debye-Scherrer method of pulverized material. In a comprehensive work on the Binntal sulfosalt minerals (GRAESER, 1965) we developed a determination system by direct comparison of the powder patterns with a file of streak diagrams of clearly determined minerals (see Fig. 5). Although the patterns for different minerals appear very similar to each other, the determination for pure phases is unequivocal. As the Pb-As sulfosalts produce many weak reflections at usually small glancing angles, it is advisable to use Fe-K$_\alpha$ radiation which yields better resolution. This method has the advantage that it requires only extremely small quantities of material, a fact that is very important regarding the small size of the minerals and the frequent tendency of different sulfosalts to occur finely intergrown with each other. Of course, this method is only feasible for minerals whose powder patterns are already known. For unknown material the determination is much more complicated: this case requires a complete single crystal study with X-rays and a chemical determination by means of a microprobe. Today the mineralogist has the possibility to carry out these determinations with a minimum of material (crystal fragments of much less than 1 cubic mm are sufficient!) but such analyses are extremely time consuming.

With the exception of 3 or 4 species all of the special Lengenbach sulfosalts were known before 1920. This means that they had to be determined without the means made available to the mineralogist by modern research! After an intensive study, the Lengenbach sulfosalts are quite well known regarding shape,

Figure 7. **Lengenbachite crystal in the typical shape: because the mineral is flexible (but not elastic), the crystals usually are bent. Color of the mineral is lead-gray, sometimes covered with irridescent colors (e.g. blue). Length of crystal: about 4 mm (Specimen: G. Barschwil)**

chemical and physical properties and crystal structure. This is in part due to the work of NOWACKI and coworkers, who determined the crystal structures of most of these minerals and also developed a new classification of the whole group of sulfosalts (NOWACKI, 1969), and also the work of the author dealing with ore microscopy, methods of identification, genesis of sulfosalt minerals (GRAESER, 1965, 1975).

Genesis of sulfosalts in Binntal

Though the occurrence of extraordinary minerals in Lengenbach has been known for about 150 years, a real attempt to give an explanation for their genesis dates back only to the year 1934 (BADER, 1934). Nevertheless, some very important observations were made quite early, as, for example, the fact that there exists a replacement rule among the As-sulfosalts in that minerals with lower As-content are replaced by such with higher As-contents. BADER's opinion was that all the material necessary for the formation of the various sulfosalts (including arsenic) was already present in the dolomite before the beginning of Alpidic metamorphism, and that through the influence of metamorphism, the mineralogical composition was changed thus forming the sulfosalts.

Our own investigations led to a different conviction; the most striking difference to BADER's theory being the assumption that all the arsenic was introduced into the dolomite from the outside at a much later time.

According to our theory, the formation of the mineral deposits in the Binntal dolomites might have occurred in the following way:

I. In the dolomite existed a primary mineral association of syngenetic origin consisting mainly of galena (PbS), sphalerite (ZnS), pyrite (FeS_2), barite ($BaSO_4$), etc. which is very common in numerous Triassic dolomite beds.

II. Toward the end of Alpidic metamorphism the dolomite was invaded by hydrothermal solutions containing As - Cu - Ag - Tl - Sb etc. which reacted with the primary ore minerals in the dolomite forming the various sulfosalts according to this generalized scheme:

$$x\,PbS + As_yS_z \rightarrow Pb_xAs_yS_z$$

The procedure took place in such a way that at first minerals were formed with a low As-content which, with a continuous As-supply, then gradually became replaced by more As-rich sulfosalts. This reaction went on until the minerals reached a point of saturation in As and only after reaching this point could the crystallization of free arsenic-sulfide (realgar, orpiment) take place. This procedure would nicely explain the fact that all the minerals occurring together within a restricted range

Figure 8. (above) **Sartorite (= scleroclase) in a beautifully developed crystal with typical striation parallel to the elongated axis and sharp edges of the crystal faces. Color steel-black, usually fresh with high luster. Length of mineral: about 4 mm (Specimen: Basle Museum of Natural History)**

Figure 9. (below) **Jordanite crystals from Lengenbach. The crystal on the left side clearly displays the characteristic pseudohexagonal habit of the monoclinic mineral. On the rounded edges, the striation caused by lamellar twinning is partially visible. Jordanite is usually lead-gray, a blue oxidation color is also very common. The crystals on the picture have diameters of about 2½ mm. (Specimen: Basle Museum of Natural History)**

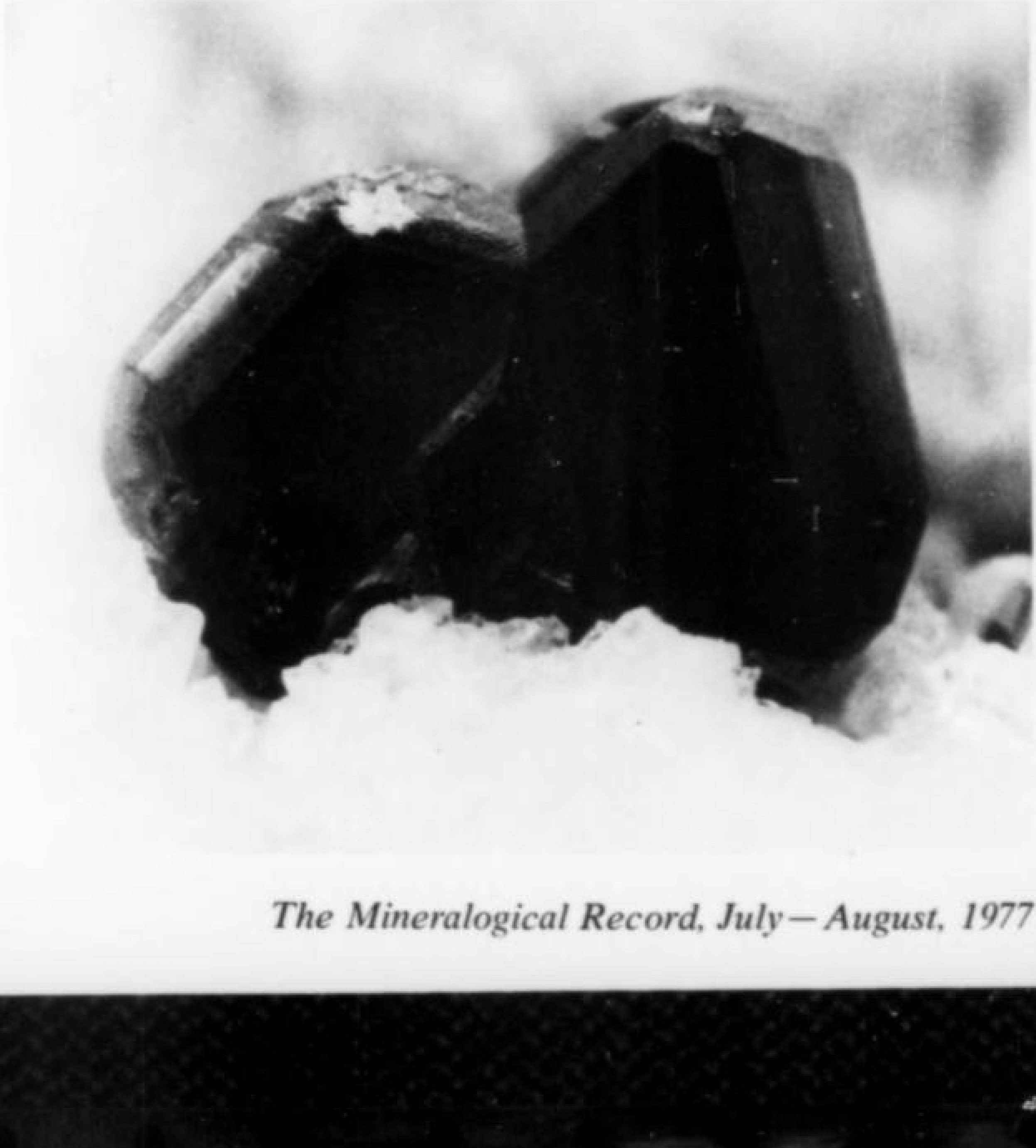


Figure 10. (above) **Baumhauerite, one of the most frequent members of the special Lengenbach sulfosalts. The crystals very clearly show the rounded edges and faces that are very important for the visual identification of the mineral. Color steel-gray to black. Length of the crystal: about 4 mm. (Specimen: G. Günther)**

Figure 11. (below) **Hatchite is one of the rarest and most precious minerals in Lengenbach. It was described as a new mineral in 1912, but the chemical composition remained unknown because of lack of enough material until 1963. On the picture it clearly shows its triclinic symmetry. Hatchite belongs to the very special red thallium-silver-sulfosalts. Its size on the picture is about 0.7 mm in the largest dimension. (Specimen: C. Vogel)**

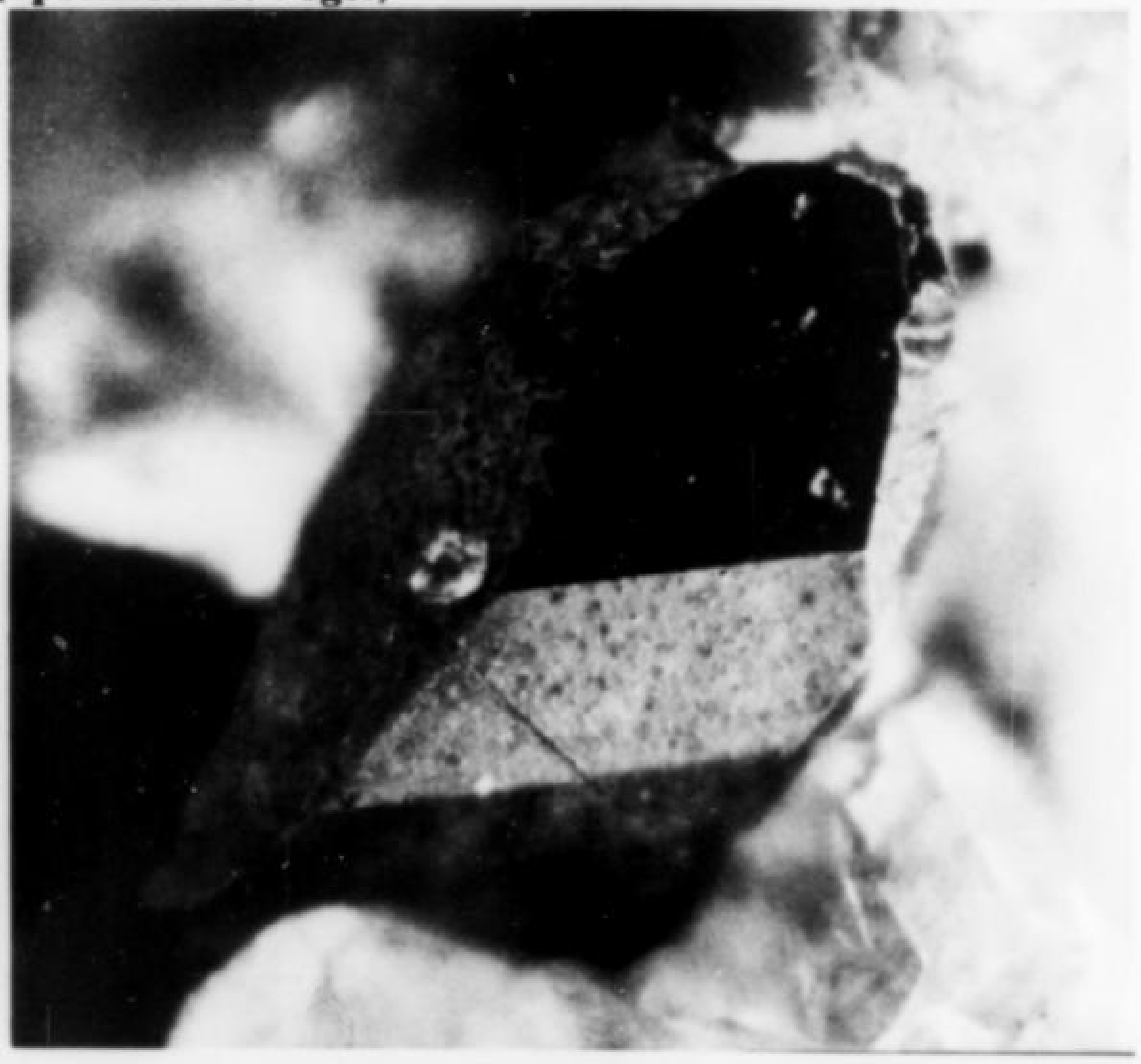


Table I. The minerals of the Lengenbach quarry

SULFIDES

a) simple sulfides

bornite	Cu_5FeS_4
chalcopyrite	$CuFeS_2$
galena	PbS
marcasite	FeS_2
molybdenite-3R	MoS_2
orpiment	As_2S_3
pyrite	FeS_2
realgar	As_4S_4
sphalerite	ZnS
wurtzite	ZnS

b) complex sulfides (sulfosalts)

arsenopyrite	$FeAsS$
*baumhauerite	$Pb_3As_4S_9$
boulangerite	$Pb_5Sb_4S_{11}$
dufrénoysite	$Pb_8As_8S_{20}$
*"fasriges Sulfosalz"	
*hatchite	$PbTlAgAs_2S_5$
hutchinsonite	$PbTlAs_5S_9$
*imhofite	$Tl_6CuAs_{15}S_{40}$
jordanite	$Pb_{13}As_7S_{23}$
*lengenbachite	$Pb_{37}Ag_7Cu_6As_{23}S_{78}$
*liveingite	$Pb_9As_{13}S_{28}$
lorandite	$TlAsS_2$
*marrite	$PbAgAsS_3$
*nowackiite	$Cu_6Zn_3As_4S_{12}$
proustite	Ag_3AsS_3
pyrargyrite	Ag_3SbS_3
*rathite	$Pb_3As_5S_{10}$
*sartorite	$PbAs_2S_4$
seligmannite	$Cu_2Pb_2As_2S_6$
*sinnerite	$Cu_{1.4}As_{.9}S_{2.1}$
smithite	$AgAsS_2$
stephanite	Ag_5SbS_4
tennantite (binnite)	$Cu_{12}As_4S_{13}$
tetrahedrite	$Cu_{12}Sb_4S_{13}$
*trechmannite	$AgAsS_2$
*wallisite	$PbTlCuAs_2S_5$
xanthoconite	Ag_3AsS_3

* = only known from Lengenbach (1976)

OXIDES
- anatase
- quartz
- rutile

CARBONATES
- calcite
- cerussite
- dolomite
- malachite

SULFATES (MOLYBDATES)
- barite
- wulfenite

PHOSPHATES
- apatite
- gorceixite
- goyazite

SILICATES
- adularia
- albite
- fuchsite
- hemimorphite
- hyalophane
- muscovite
- oellacherite
- phlogopite
- prehnite
- scapolite
- talc
- tourmaline

Figure 12. (left) **Galena - significantly a rather rare mineral in Lengenbach: most PbS was consumed in the process of Pb-As-sulfosalt formation. This crystal represents one of the typical Lengenbach crystals in cuboctahedral form, with clearly predominant octahedral form. Color lead-gray, size: about 1.5 mm (Specimen: G. Günther)**

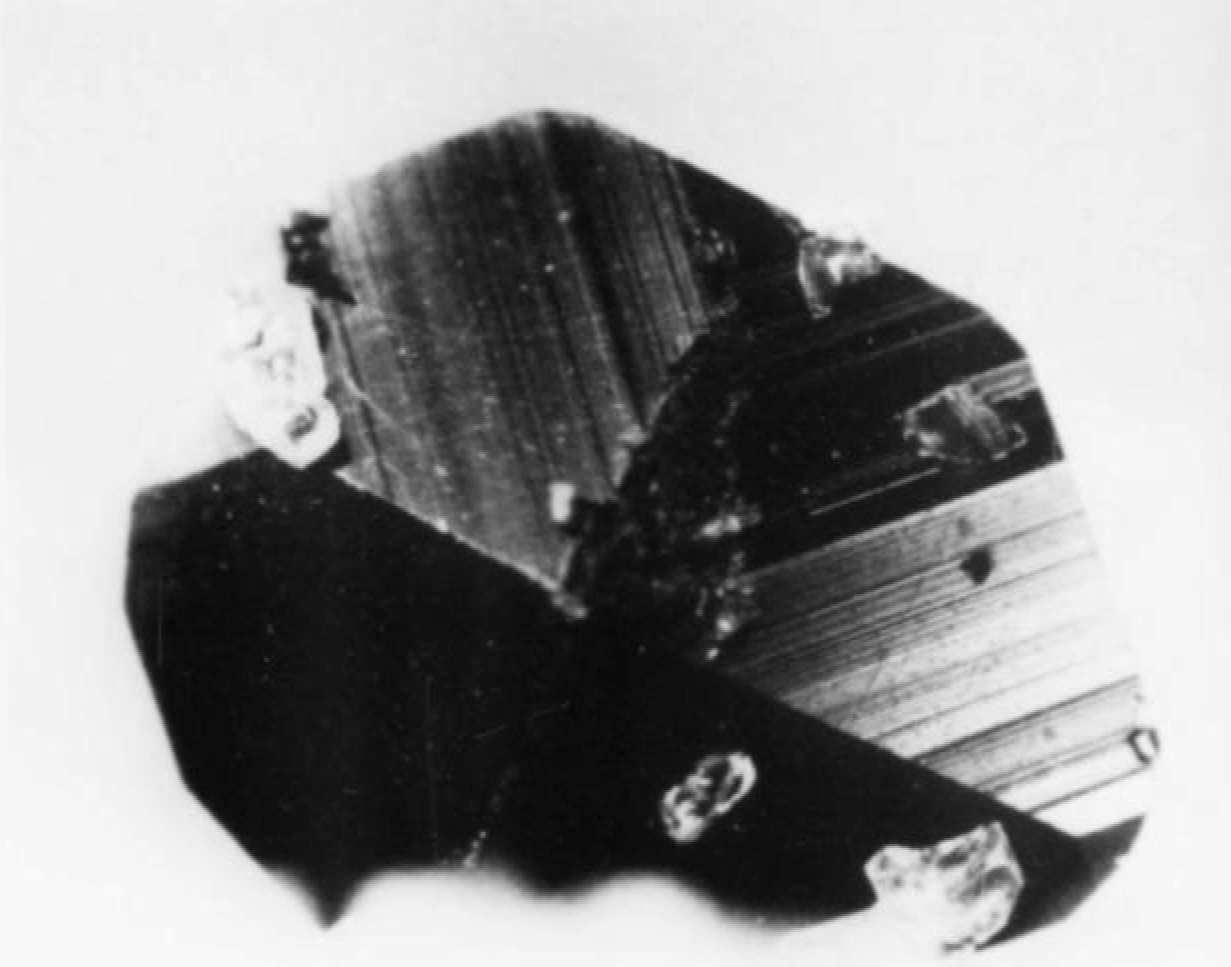


Figure 13. (top left) **Rutile crystal of the strange Lengenbach habit with almost pure bipyramidal form and usually absent prism faces. This rutile type commonly occurs together with As-rich sulfosalts. The color of the mineral is brilliant black, but very often it is covered with blue to red oxidation colors. Size: about 2 mm in diameter (Specimen: G. Günther)**

Figure 14. (top right) **Dolomite crystals from Lengenbach, as they occur in any druse of the dolomite beds, here as twins. The high birefringence of the mineral is marked by the impression that the picture is out of focus in the center. The crystals are colorless and completely transparent. Size is about 4 mm in diameter. (Specimen: E. Rupreclei)**

Figure 15. (above) **Barite from Lengenbach. The mineral occurs at this locality in at least 4-5 completely different types in morphology and in color. This specimen is whitish-yellow in the center and yellow-whitish in the outer part. Size: 3½ mm in diameter. (Specimen: Basle Museum of Natural History)**

Figure 16. (right) **Sphalerite crystal on realgar. Though sphalerite in Lengenbach is usually honey-yellow and translucent (like the crystal in the picture), there also occur opaque black specimens (due to a small content of manganese). This crystal nicely displays different crystal faces: positive and negative tetrahedron, cube and hexakistetrahedron. Size: about 1½ mm. (Specimen: G. Günther)**

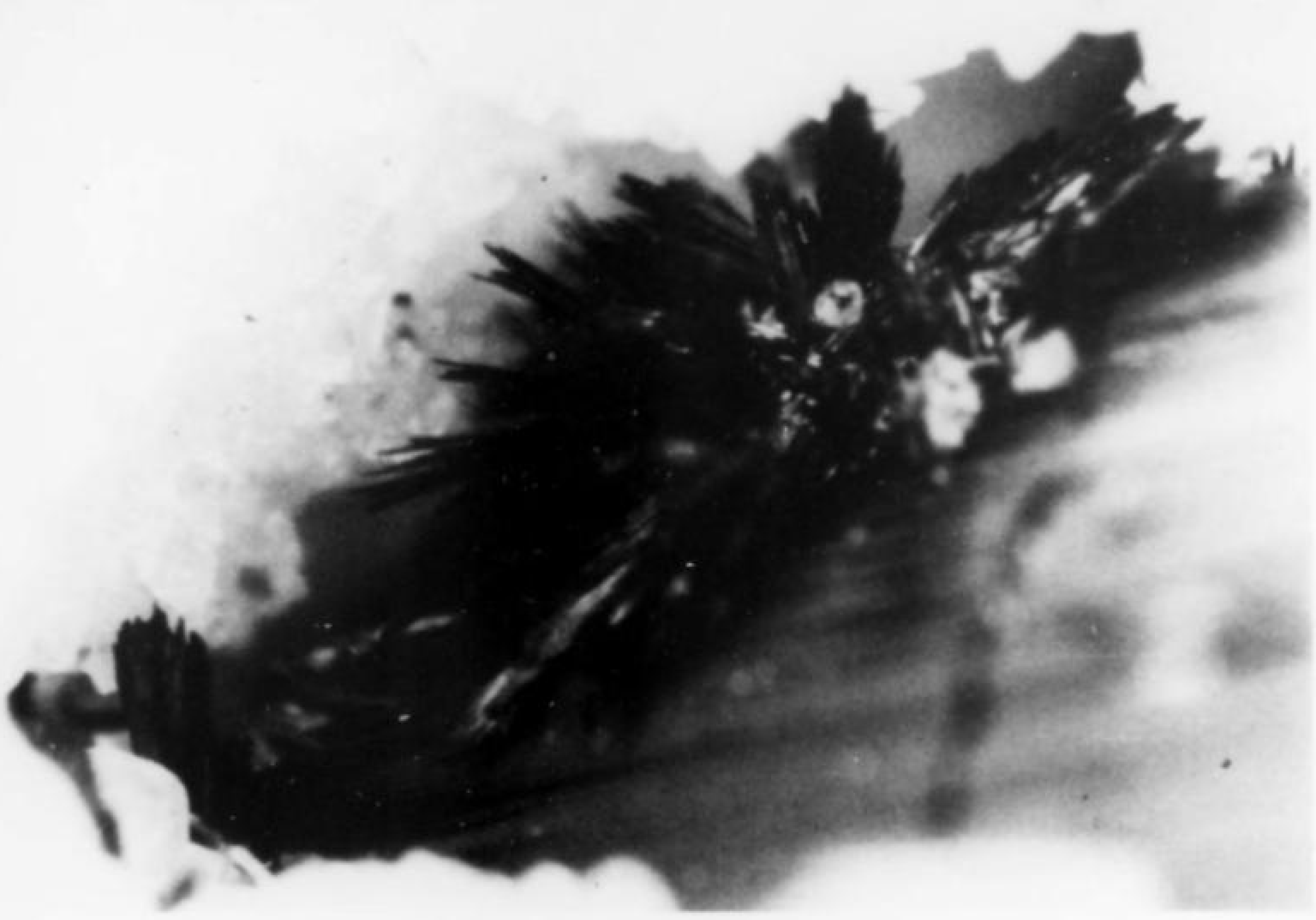


Figure 17. **Lengenbachite in an uncommon habit of ascicular aggregates. The single blades are very thin and small (about 0.5 mm long). Usually this lengenbachite type occurs as a cover on other sulfosalt minerals. (Specimen: Basle Institute of Natural History)**

(hand specimen) have similar As-contents, and that galena and realgar cannot coexist with each other: from galena (PbS) and realgar (As_4S_4) a Pb-As-sulfosalt would have been formed by the reaction of the two components. Because the content of As in the solution was much higher than that of Sb it is obvious that the solution became oversaturated in As much earlier than in Sb. This may be the reason that outside Lengenbach only minerals with small As-contents occur and that part of the As is replaced by antimony.

III. The elements As, Cu etc. that were enriched in the hydrothermal solutions, originated primarily in an old Hercynian ore deposit that at first was simply postulated (but which could be found afterwards!) in the gneisses of southern Binntal. In this region we found remnants of a rather extensive old Cu—As—ore mineralization. The primary ore minerals of this deposit consisted mainly of chalcopyrite and an As-rich fahlore (about 85% tennantite). Obviously, this copper-arsenic-deposit was strongly influenced by Alpidic metamorphism and large parts of it were remobilized; the ore minerals were dissolved and their constituents (Cu—As—Sb—Fe—S) were removed in hydrothermal solutions. From Fig. 2 it is reasonable to postulate that these solutions moved preferentially northwards (towards lower temperatures) where they finally met with the dolomite beds causing the reaction that led to the formation of the sulfosalts, as formerly described. On the way (northwards) due to the decrease in temperature, the dissolved substances were partially precipitated and crystallized within the gneisses to minerals of very uncommon chemical compositions. The consequent study of the whole region led to the detection of at least two new mineral species (asbecasit, cafarsite) and a remarkable number of rare and interesting minerals, significantly all representing a chemical composition on the basis of arsenic oxide. This comprehensive remobilization process has not stopped, as is proven by the existence of a mineral spring on the southern slope of the mountains at Alpe Veglia, the water of which is strongly arsenic-bearing.

Conclusions

The sulfosalt minerals in the dolomite of Binntal presumably were formed by a relatively complicated two-stage process. The procedure as described in this article might provide us with a satisfactory explanation for the uniqueness of the mineral deposit and of the individual minerals as well; a problem for which no reasonable solution previously existed. In this case, for the realization of the deposit and its minerals, it is necessary that at least three conditions had to be satisfied:

I. the existence of a primary ore mineralization in the dolomite previous to the Alpidic metamorphism;

II. the existence of an old ore deposit in the gneisses that could serve as a source for the required quantity of arsenic, copper, etc.;

III. an event that enabled the reaction between these two components: the Alpidic metamorphism.

The formation of the Binntal mineral deposits took place in the late phase of Alpidic orogeny, after the settlement of the large-scale tectonic movements. An age determination by the K-Ar method (PURDY and STALDER, 1973) performed on adularia from the dolomite in Lengenbach and from another dolomite outcrop yielded corresponding ages of 11 million years. As the adularia obviously crystallized prior to the sulfosalts, this age of 11 million years represents a maximum age for the sulfosalt minerals.

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What's New in Minerals?

TUCSON SHOW 1977

Normally we would have reported on the Tucson Show of last February in the May-June issue but that was devoted entirely to Tsumeb. Therefore an abbreviated report is presented here, bearing in mind that this news is incomplete and rather old by now.

The festive, vacation-like atmosphere of the Tucson Show has been expanding steadily over recent years. Part of the cause for this is that many people attempt to arrive just a little earlier each year in order to have first look at what is available. The European dealers in particular began arriving in the West up to a month before showtime. Western dealers may soon find it necessary to hide away some of their best things until the opening of the show in order to maintain a reasonable image with the general buying public. Pala Properties and Kristalle hold open-house parties and cocktail parties on the West Coast the weekend before the show (Pala Properties' "Mine Bash" is actually held at one of their mines in the Pala Mountains), and many people prefer to start their "Tucson Week" out there; others begin arriving in Tucson that weekend. The days before the official opening of the show are commonly spent socializing, buying from dealers in their motel rooms (although show dealers are prohibited from this), going out on informal field trips to the many localities in the southern Arizona area, or simply soaking up the sun and sight-seeing.

A breakthrough has been made recently by Pala Properties. They have come up with a chemical method of dissolving gibbsite off of **crocoite** without affecting the crocoite at all. A large block of gibbsite containing crocoite was subjected to this process and the crocoite specimens uncovered were truly astounding. Nothing like these has been seen for many years, if ever. The unique advantage is that the crocoite emerges exceptionally undamaged because it has been protected during mining, storage and transport by the solid, enclosing mass of gibbsite. Even small specimens showed many terminated crystals, and the cabinet pieces were extraordinary. I have heard that all such imbedded crocoite, once worth hardly anything, is now being frantically bought up in Australia and commands very high prices. Nevertheless there is still the probability that more will come into the U.S. and that we will be treated to a bonanza of superb crocoite the like of which has not been seen since A. E. Foote was in business.

Kristalle imported some very fine specimens of **blue barite** crystals to several inches on large pieces of matrix from Sardinia. The crystals are moderately thin and stand up handsomely on the matrix. No small specimens were available but the cabinet pieces are superb.

The first item of interest in Tucson was a find of **kämmererite** crystals of unprecedented size (up to 1 cm) from the well-known (to micromounters) locality at Kop Duglari, near Erzerum, Turkey. The prices were high but apparently not *too* high because Hamel Mining, the importer, had sold perhaps 80% of the entire find at Tucson before the show even began. The crystals were commonly twinned steep rhombohedrons (see drawing) and were scattered on matrix with a thin coating beneath them of much smaller crystals. The fine, deep magenta color is very striking. Other dealers were among the purchasers, so you may see some specimens still on the market from time to time.

An unusual find of **turquoise pseudomorphs** after apatite is being marketed by Crystal Cavern Minerals. The specimens exhibit crystals to about one-third inch imbedded in an altered granitic rock, although most crystals are one-eighth inch or less. The locality is near Baker, California. Identification was made at the Lawrence Livermore Laboratory (Univ. of Cal.) by X-ray diffraction and X-ray fluorescence. Although not unique (similar pseudomorphs are known from the Pilot Mountain mine in Nevada) these specimens are nevertheless a very rare type of pseudomorph and would be a fine addition to any pseudomorph collection. Over a hundred have been collected reasonably intact, but with great difficulty because of the hardness of the enclosing rock.

Crystal Cavern Minerals is also marketing newly collected **andradite garnet** specimens (referred to as "topazolite" when yellow to green and "melanite" when black) from a claim near the New Idria mine, San Benito County, California. The crystals are lustrous dodecahedrons, sometimes with modifications, commonly transparent to translucent, and ranging in color from yellow to green, brown and black. The crystals line fissures in rock and may occur individually or in groups. The largest crystal I have seen measured about one-third inch. Nearly all specimens are plates sawn from large blocks because the matrix is extremely hard and the crystals are brittle.

McGregor and Watkins have obtained some recently mined **stibiconite** in very sharp crystals smaller than those commonly known before. Fine miniatures are available, consisting of sharp crystal groups. The (purportedly new) locality is in western Zacatecas, Mexico.

Many other fine items were in evidence at the show, including some very beautiful small **tourmaline** crystals from **Nuristan, Afghanistan**, and some exceptional **spodumene** (kunzite) crystals to several inches from the same locality. Herb Obodda has been importing these, and may put together a mini-article on the locality for a future issue.

The sale of **old mining stock certificates** broke out into the open at Tucson this year. These items are tantalizing frameables costing only a few dollars each, and representing a wide variety of famous old mining (and mineral!) localities. The major dealer at the moment is Don Olson (Minerals International), and he reported selling several large batches of certificates to people planning to *paper the wall* of their shop or mineral room with the things! Like peanuts, it's hard to stop with just one; the artwork is fascinating, often showing old mining scenes, and they really do dress up a wall. Send for his price list, which includes

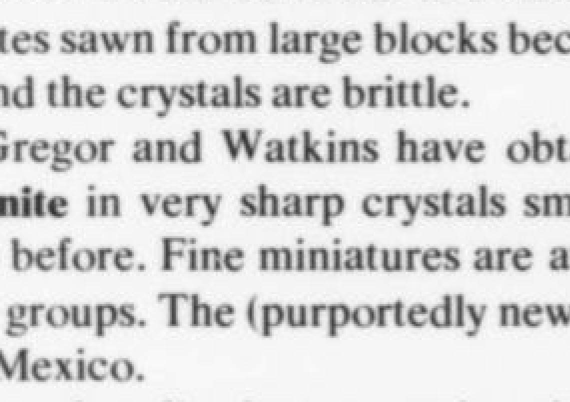
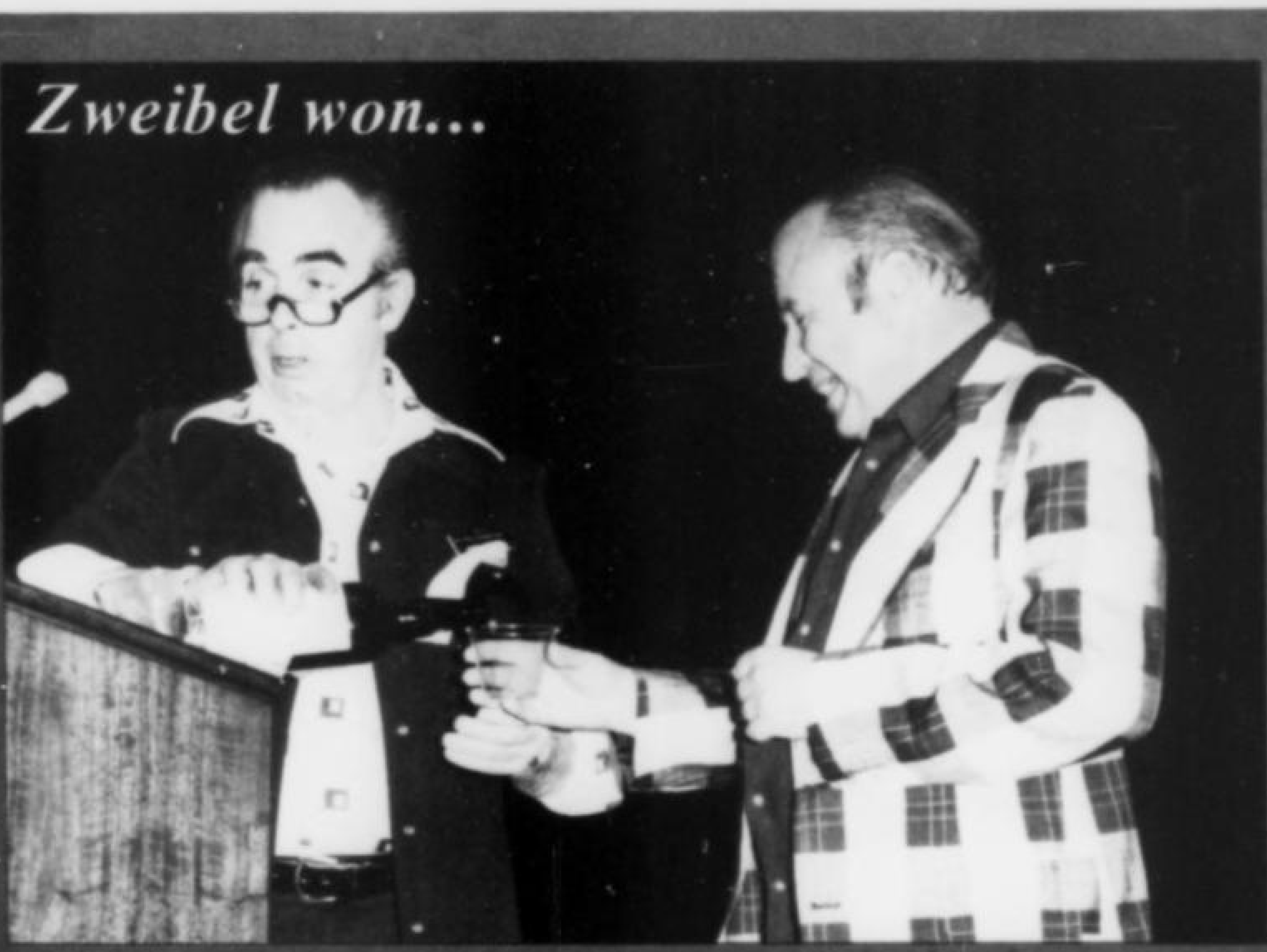


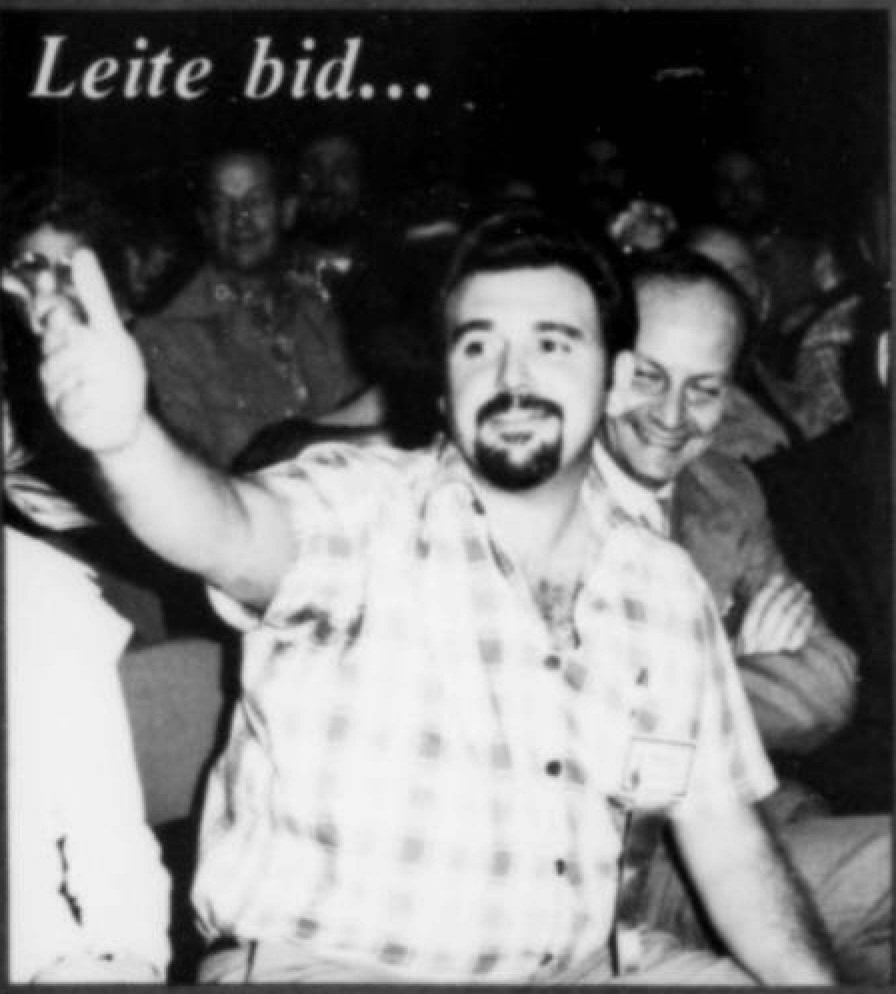
Figure 1. **Idealized kämmererite crystals, Kop Duglari, hear Erzerum, Turkey.**

GLIMPSES of Tucson

photos
by Kent England


Zweibel won...


Sinkankas signed...


Leite bid...


Maier pointed...


friends helped...


...browsers browsed.

Clockwise from upper left: Julius Zweibel receiving the McDole victory shot of rum; John Sinkankas autographing a book at the authors get-together sponsored by Si and Ann Frazier; Clarence Maier auctioning; some auction items suitable for framing; Irwin Kennedy, Ann and Dean McCrillis helping with the auction; Luis Teixeira-Leite bidding at the auction.


WEW

Rhodochrosite crystals from the Hotazel, South Africa, area. The group is 3.5 cm across, and is a brilliant red.

some reproductions to give you the idea.

Saturday night at the show was a treat as usual. Richard V. Gaines, *M.R.* associate editor and mineralogist, presented a slide show on Madagascar and its minerals. Then the Tucson Show awards were presented, and the winner of the McDole Trophy was Julius Zweibel. Julie's incredible group of specimens included the green smithsonite illustrated in color in the Tsumeb Issue. The McDole competition is the most prestigious in the country; the very finest collections are entered, and there are practically *no* rules. The Detroit Show is planning to institute a similar competition at their coming show this October.

As mentioned in *Notes From the Editor* in this issue, the **M.R. Auction** was extremely successful, and has given us funds to actually improve the magazine (more pages, color) above simple survival. Readers are invited to submit specimens for the auction too, at any time during the year. (Contributors should bear in mind that dollar value is the important characteristic of specimens for the auction, although any specimen will be cheerfully accepted. One hundred specimens, including low-priced pieces, will be selected from among the donations for auction and the others will be sold as lots to dealers after the auction.)

The **Tucson Slide Competition** was not held this year for various reasons, however it *will* be held this coming year, with some changes. There will be prize money and a category for both professionals and amateurs. Details will be spelled out at a later date, but entries will be accepted beginning now, and the entrant must specify whether he has ever been paid for photography (the criterion separating the professional from the amateur). Only 35mm color slides can be accepted.

The ROCHESTER SYMPOSIUM

The Rochester Symposium was held again this year, hosted by the Rochester Academy of Science and spearheaded by Bill Pinch. As mentioned last year in this column, the show has some unique features. A large number of interesting lectures was presented, and the panel discussion of what's new in minerals was of prime interest. It is not within the scope of this column to describe lectures or other activities not directly having to do with new mineral finds, but the lecture by Darko Sturman of the Royal Ontario Museum on the Yukon phosphate locality was especially valuable, and he has promised an article for *M.R.* on this new and unique locality.

The most exhilirating mineral find of the year, to this collector at least, was brought into the U.S. just four days before the Rochester Symposium. Prosper Williams was in South Africa at the time of the first strike of fine **rhodochrosite** in the Hotazel area in many years; he brought back with him over 200 of the finest African rhodochrosite specimens ever seen! The crystals are generally ½ to ⅝ inch long by ¼ inch thick, but a few much larger exist. They are often gemmy to perfectly, flawlessly transparent and of a beautiful deep rose pink to red color. Groups are the rule and many form plates of crystals to several inches without matrix, or on a black manganite (X-ray identified) matrix. The forms observed are two scalenohedrons and a frosty pinacoid of varying size; these three forms appear on nearly all crystals. Pala Properties received a shipment of their own after the show; 11 incredibly fine pieces (along with some smaller specimens) were in the lot, including one crystal nearly 2 inches long and another 2¾ inches long! The locality designation is a problem. There have been at least three different spellings of the mine name (Nchwaneng, Tswaneng, Thwaning), and there is some question about whether these all refer to the same mine. The district can be called the "Black Rock district," as it is called by the locals because of the black manganese ore mined there. Many mines exist in the manganese belt of the area, and it is even uncertain from which of the mines the original strike of "Hotazel" rhodochrosite came several years ago. Hotazel is a town nearby and not a mine. For labelling purposes the best course is "Black Rock district, near Hotazel, Northern Cape Province, South Africa." We will endeavor to obtain more information and assemble an article for the "Famous Mineral Localities" series. There are some other very unusual minerals that were also found at the time the rhodochrosite was found, and these are still being analyzed at the Smithsonian. Just to make sure that the rhodochrosite was not calcite soaked in cranberry juice by the natives, it was X-rayed and found to be rhodochrosite without doubt. (Late note: Zweibels have some too.)

NEAL YEDLIN SERIOUSLY ILL

It is with great sadness that I must report that Neal Yedlin, long time columnist for the *Record* and world-renowned micromounter, has suffered a severe stroke and is hospitalized. This is particularly tragic because his wife, Helen, is also seriously ill. The entire mineral collecting fraternity, I am sure, wishes Neal and Helen a return to health.

W.E.W.

Mineralogical Notes

This new department will provide a place for *research* notes of some interest to collectors. Such notes were previously published in the *What's New in Minerals*? department but did not seem entirely appropriate there, and were too difficult to abstract for *Min. Abs.* In the future, *What's New* will be reserved for non-research items of interest, particularly those dealing with new material on the mineral market. Contributors to *Mineralogical Notes* should attempt to eliminate numerical data tables as much as possible, and should remember that this journal is read primarily by collectors. Information of interest includes morphology, habits, composition, associations, locality details and history, as well as very brief crystallographic data. Brevity will be a great advantage in gaining acceptance for publication, although photos are encouraged.

Ed. →

ONORATOITE FROM TUSCANY

An interesting find was made recently in the old mine of Le Cetine de Cotorniano, situated about 10 km from Rosia, in the province of Siena, Tuscany, Italy. The mine has been closed for many years but the tunnels are still in good condition and it is not difficult to find good specimens of stibnite and other antimony minerals. The specimens found recently were examined by X-ray diffraction at the University of Florence and were found to be **onoratoite**, **$Sb_8O_{11}Cl_2$**.

The onoratoite was found as aggregates of very thin, acicular crystals up to 5 mm in length and of a brilliant white color. X-ray studies of these crystals have yielded data in conflict with previously published onoratoite parameters; the crystals appear to be monoclinic rather than triclinic. (Weissenberg *h0l* and *h1l* photos indicate a constant *b* of 4.06 Å, corresponding to monoclinic symmetry.) Data regarding the actual crystal structure are still being analyzed.

The specimens we examined consisted of onoratoite in small geodes with quartz, stibnite and stibiconite. Some specimens also contained acicular crystals of a pale yellow color for which the composition has yet to be determined.

The deposit of Cetine de Cotorniano was first exploited in 1878; it consists of abundant stibnite in geodes, nodules and masses in a large lens of blackish gray chalcedony. Stibnite is also found in the overlying cavernous limestone, along with other antimony minerals including stibiconite, kermesite and valentinite, and also small crystals of gypsum and sulfur.

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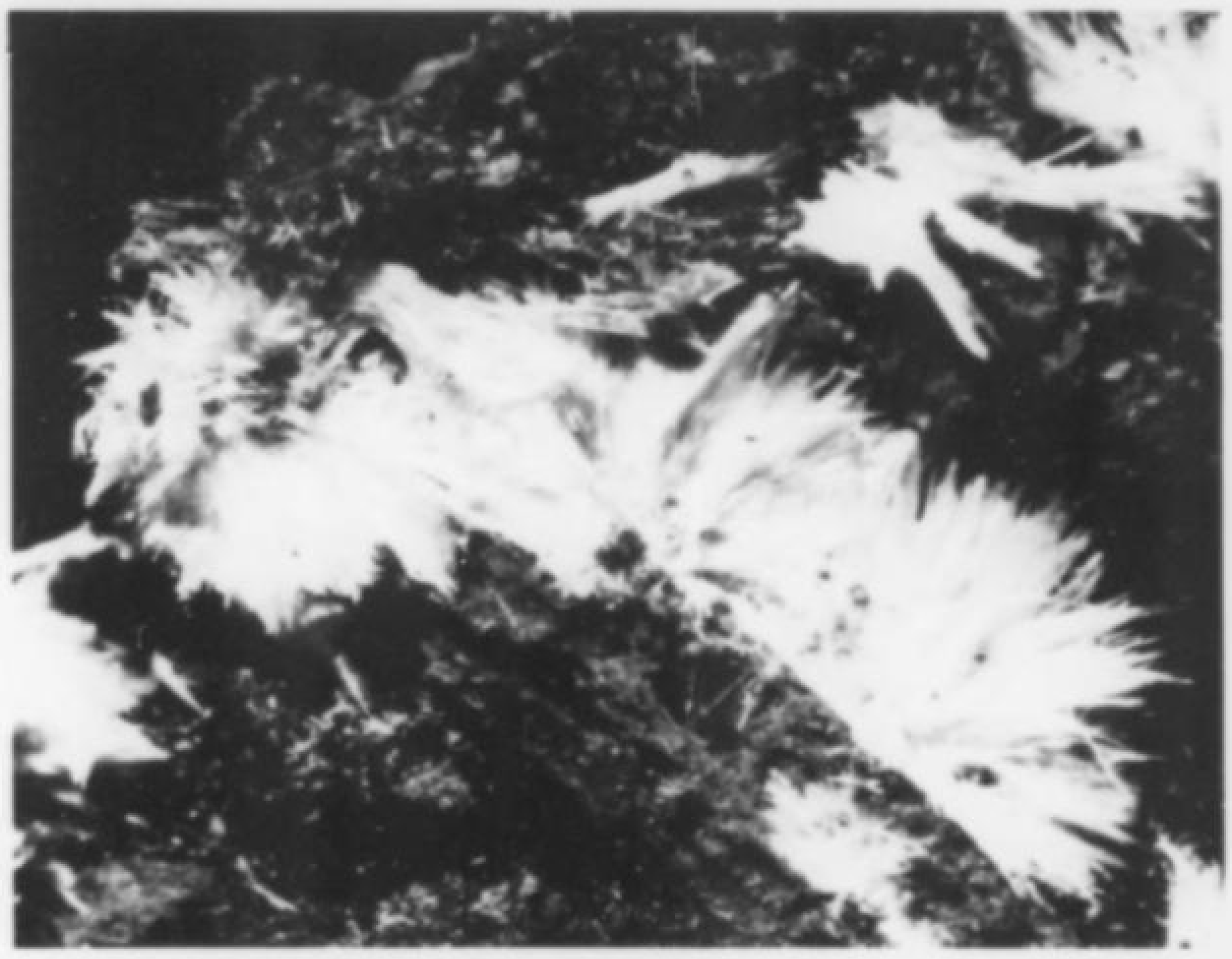

Figure 1. **Acicular white onoratoite sprays with quartz and stibnite from Le Cetine de Cotorniano mine, near Rosia, Siena, Tuscany, Italy. Photo by P. B. Scortecci.**

ERRATA

v. 8, n. 2, p. 110, Table 1: The phlogopite analysis was by P. *E.* (not *W.*) Hewson.

v. 8, n. 2, p. 110, Figure 1: The caption should have stated that this is the *black* variety of dravite.

v. 8, n. 1, p. 39, Figure 3: The correct locality is Wood's Chrome mine, Texas, Lancaster County, Pennsylvania.

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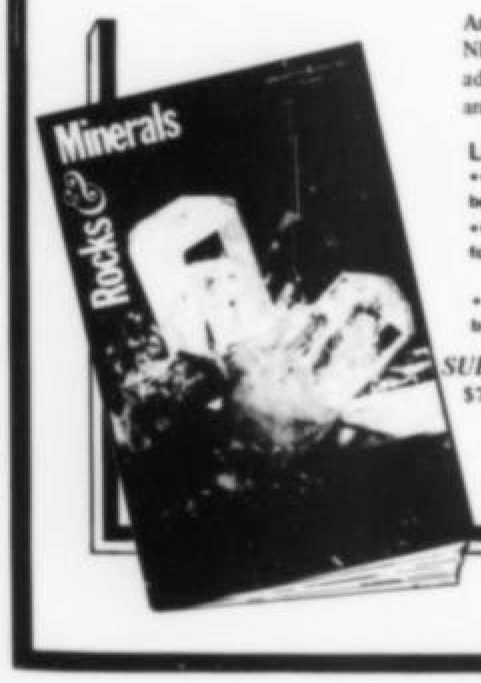

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RARE-EARTH MINERALS

IN THE ALPINE AND SUBALPINE REGION

by

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Among the "classic" rarities of the Alps are several rare-earth minerals. Some of these have been known for a long time: monazite (once called turnerite) and xenotime (once called wiserine) were first observed by Lévy in 1823 and by Kenngott in 1864, respectively, and the presence of these minerals in some Alpine localities, such as the valley of Binn (Binntal), Tavetsch and St. Gotthard is mentioned in older editions of *Dana's System of Mineralogy*.

Because of extensive discoveries in many parts of the world, rare-earth minerals are now known to be not as rare as it was believed one hundred years ago and the renowned Alpine localities are presently producing a quite insignificant portion of the specimens reaching mineralogical collections.

Why are these specimens still important for collectors, apart from specialists in Alpine minerals or in "historical" localities? There are some well-defined characteristics of Alpine specimens which often make them almost unique in appearance and interest. For instance, an Alpine xenotime, monazite or gadolinite crystal is quite different from "non-Alpine" specimens. Alpine crystals of these minerals are in general quite transparent and brilliant with sharp edges and a considerable number of faces belonging to different crystallographic forms. They often make excellent micromounts or thumbnails. Most of these qualities depend on the mode of formation of these crystals, which form from hydrothermal solutions on the walls of fissures, with ample opportunity for the development of good faces. Also the relatively "young" age does not permit metamictization or chemical alteration processes to go too far.

The crystal size for rare-earth minerals coming from Alpine fissures is usually small, 1 to 3 millimetres being the average for a good crystal. Famous exceptions exist, such as xenotime, gadolinite and kainosite crystals which exceed 1 centimetre in length: these, however, are to be considered as "museum pieces" of extreme rarity.

SIMPLE SPECTROSCOPIC IDENTIFICATION

How can these minerals be recognized without resorting to specialized work? To this purpose a well-known, practical method can be used by almost any amateur mineralogist: this method (which is non-destructive) can be applied to any crystal, provided it is transparent and visible through the microscope. In practice, when light transmitted through a rare-earth mineral is analyzed by means of a small spectroscope, we see very narrow absorption bands, which cross the "rainbow" (i.e. the continuous spectrum of the light source) like lines drawn by a pencil. The position of these lines is related to the elements contained in the mineral (here mostly neodymium for "cerium earths" or erbium for "yttrium earths") and, in a lesser degree, also to the particular nature of the mineral itself. For instance, distinctive spectra are afforded by monazite, the parisite group, gadolinite, xenotime, etc. The species which do not contain rare earths in significant amount, like titanite, have different absorption spectra with very broad bands, the limits of which are generally so faded as to be barely perceptible. Other species, such as scheelite or zircon, although they are not rare-earth minerals in the strict sense, frequently contain sufficient amounts of these elements to give quite definite absorption bands; in any case these are different from the bands given by the other minerals and provide a simple identification test.

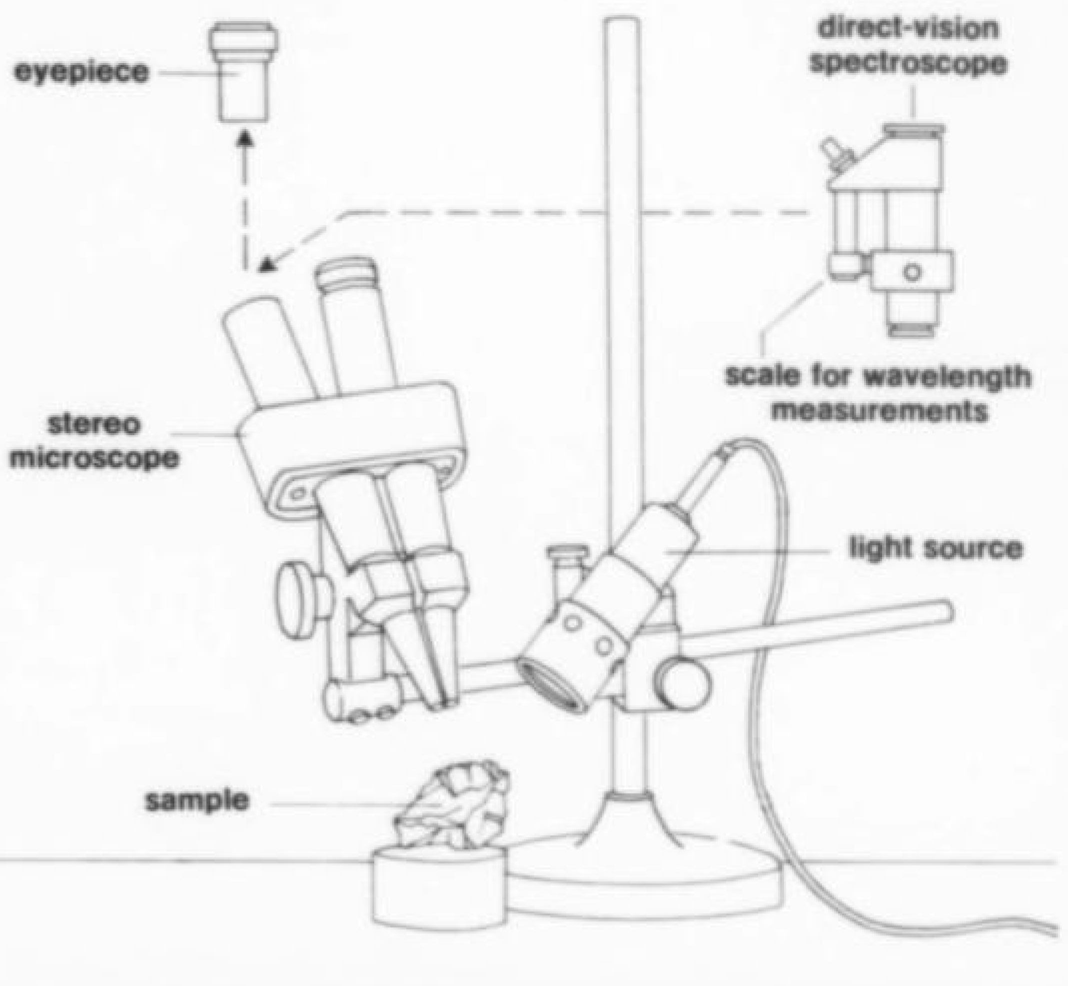


Figure 1. **The application of a direct-vision spectroscope to a stereomicroscope for identification of transparent crystals of rare-earth minerals.**

These characteristic absorption spectra depend on the particular electronic structure of the rare-earth elements and do not have any counterpart in other naturally occurring elements, except perhaps uranium.

The experimental procedure is very simple: the sample is placed under a strong light and the microscope is focused on the crystal, using sufficient magnification to have the image of the crystal occupying a considerable part of the field; then one eyepiece is replaced by a direct-vision spectroscope, which has previously been adjusted so that the slit is situated approximately where optical images are formed by the objective. This adjustment can be made once forever, and a small hard plastic sleeve can be used in order to ensure perfect connection between spectroscope and microscope. If a wavelength scale is available, this can be easily calibrated and a very small electric bulb can provide for proper lighting of the scale. Most transparent rare-earth minerals can be easily identified: a comparison with a known "standard" gives the best results.

MINERALS

Monazite $[(Ce,La,Nd)PO_4]$ is probably the most common rare-earth mineral in Alpine fissures. It is found at several localities, as small monoclinic crystals, generally elongated along the *b* axis and sometimes characteristically twinned. The most famous Alpine localities are probably those around Sedrun in the Tavetsch valley (Sontga Brida, Piz Blas, etc.) where this mineral was discovered for the first time in Switzerland (Vom Rath, 1862); other good, "classic" localities for monazite include Binntal (Binneltini), Maderanertal and St. Gotthard. Good to excellent specimens have been found in the Gross-Venediger region (Prägraten in Eastern Tirol, Habachtal in Salzburger and in Valle Aurina (= Ahrntal) on the Italian side, or still farther to the east (Rauris valley, etc.). In the Western Alps, crystals of this species are reported at Bourg d'Oisans in Isère (this was the original locality for "turnerite") and in the Mont Blanc massif.

Whereas in many celebrated Swiss localities monazite is found by specialized "strahlers," in other regions most specimens are occasionally found by expert collectors on various material purchased as quartz, anatase or rutile. In fact, due to the small size of crystals and their appearance (which is strikingly close to certain habits of titanite) monazite easily escapes the attention of most dealers and collectors, and the activity of specialized amateurs is presently considerably extending the number of known occurrences. When looking for this mineral in the field (or among the "unknowns" in dealers' shops) good clues to the presence of monazite are the presence of much anatase, brookite or other rare-earth minerals; not uncommon is the association with rutilated quartz, and quite exceptional (if ever observed) is the association with titanite.

Among the most interesting rare-earth bearing minerals from Alpine and subalpine pegmatites, a curious green variety of monazite can be mentioned which gives a characteristic absorption spectrum. Analysis by arc-emission spectroscopy shows an unusual distribution of rare earths, with lines due to lanthanum and cerium highly predominant, and very little neodymium (Gramaccioli, 1960). This partly explains some features of the absorption spectrum, such as the weakness of the neodymium band at 5700-5900 Å, which is instead the predominant one for most monazite specimens. Some other unusual bands, which appear in the red, green and blue region, might be due to uranium. The first specimens of this mineral were found in 1960 at Piona, Lago di Como, where remarkable pegmatites have been known for a long time (for an over-all reference, see Boscardin et al., 1970); later on a practically identical mineral was found at Sondalo in Valtellina and in Val Codera, a valley situated on the Italian side of the Bergeller massif (Gramaccioli, 1974). A greenish-yellow specimen from Craveggia is probably on the borderline between this variety and "ordinary" monazite, showing the considerable diversity of an unusual mineral.

Synchysite [$(Ce,La)Ca(CO_3)_2F$] was discovered in 1939 by Parker, De Quervain and Weber for the first time in the Alpine region at Piz Blas, Val Nalps. This celebrated locality is one of the most widely known in the Alps for the unique association of several rare-earth minerals (monazite, xenotime, synchysite, gadolinite, bastnaesite and perhaps aeschynite). The discovery of this species in other Alpine localities is quite recent (La Bianca: Weibel (1964); Beura near Domodossola: Huen and Gramaccioli (1969); Lodrino near Biasca, around 1970; Rauris: Kontrus and Niedermayr (1970); Monte Prosa, St. Gotthard: Gramaccioli (1974); Val Masino (1974)), so that this species may turn out to be even more common than monazite. In any case, synchysite seems to be the prevalent cerium mineral in the fissures in granite-like rocks whereas monazite prevails in mica schists.

Synchysite crystals show the typical habit of the parisite group: they are frequently striated, with step-like formations parallel to the base. As a great rarity, pyramidal crystals have also been found (at Beura) and this may indicate the absence of a center of symmetry and the presence of a polar axis. Crystals are usually of small size, not exceeding a couple of mm in length; very rich specimens have been found, especially at Lodrino where this species is relatively more common than elsewhere. Typical associations are anatase, brookite, hematite, pyrite and sometimes (but not always) other rare-earth minerals.

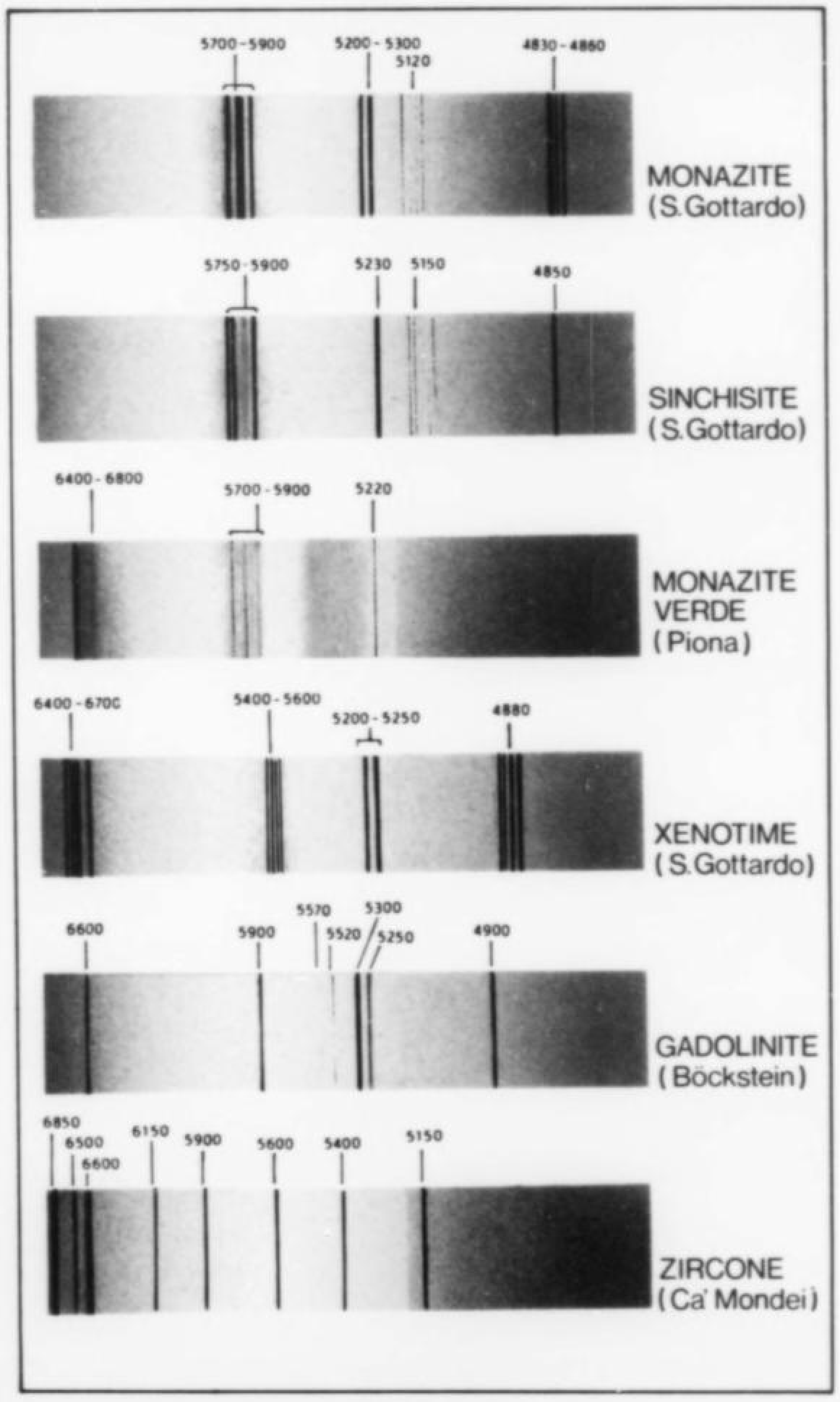
Bastnaesite [$(Ce,La)CO_3F$] is of recent discovery in the Alps (Iitaka and Stalder, 1961). In the Alpine fissures most specimens of this mineral are found as syntactical intergrowths with synchysite: these intergrowths can be easily recognized because they show alternating zones of different luster in what might otherwise be taken as a "single crystal" of synchysite. Bastnaesite is definately much rarer than synchysite; however, in recent times other localities have been discovered in addition to the original one at the Oberaar power works near Grimsel Pass: these include Piz Blas (Kipfer, 1973), similar (not yet X-rayed) specimens from Lodrino, Ticino (1974), and the Rauris Valley in Austria (Kipfer, 1976). Quite recently (Graeser and Stalder, 1974) homogeneous single crystals of bastnaesite were found near the Gotthard Pass at Ovi di Scimfüss, as brown, hexagonal prisms.

Other rare-earth carbonates found in the Alpine and subalpine region are **parisite, lanthanite** (?), **ancylite** and the so-called **weibyeite**. The only known Alpine occurrence of parisite is in a dolomite outcrop at Ochsenfeld, in the Valley of Binn: a single, brown, prismatic crystal was found (Graeser, 1965). In the subalpine region, parisite is mentioned as present in the granite at Montorfano near Baveno (Tacconi, 1905): these crystals are in reality synchysite (Gramaccioli, 1974). Therefore, at least in the Alps, parisite does not seem to occur in gneisses or granites, but is a species exclusively characteristic of carbonate rocks. Lanthanite is of doubtful occurrence: a single yellowish, tabular crystal has been reported at Grimsel Pass (Beck, 1959). Optical or X-ray data, however, are lacking. Recently, at Lodrino, a white platy mineral was found as an alteration product of synchysite: its refractive indices, however, are too high for it to be lanthanite. Weibyeite was found by Artini at Baveno in 1915: its identity is doubtful and these crystals are probably ancylite or bastnaesite. Ancylite itself has been discovered in the Alpine region only as a microscopic accessory constituent of the Predazzo granite (Emiliani and Gandolfi, 1964).

Xenotime [YPO_4] was found for the first time in the Alpine region in 1864. It seems to be definitely rarer than either monazite or synchysite. Crystals are usually prismatic, with prism faces somewhat corroded (bipyramidal crystals are also known); their size is usually small (2-3 mm), exceptionally large crystals having been found at times. The color of most Alpine xenotime is a characteristic greenish-brown or brown; pale yellow crystals are also found which are very similar to a lighter-colored variety of anatase, with which they are often confused. The old name "wiserine" includes specimens of either anatase or xenotime.

The best test for determining the authenticity of a xenotime specimen is to examine the absorption spectrum, which is very diagnostic. Prismatic habit and corroded prism faces are good clues to this species, helping to distinguish it from anatase; the association with other rare-earth minerals (monazite, synchysite, etc.) is also a good indication. The most typical localities are Swiss (higher Binntal, St. Gotthard, Val Nalps, Grimsel Pass, etc.); recently (about 1965) some crystals were also discovered in Austria (Rauris valley and Untersulzbachtal: see Kontrus and Niedermayr, 1970).

Gadolinite [$Be_2FeY_2Si_2O_{10}$] from Alpine fissures is probably the most typical example of a "young", non-metamict rare-earth mineral, especially if we compare it with typical specimens found elsewhere. Alpine gadolinite crystals are sharp and transparent, of a pale greenish or blue-green color; they are, however, extremely rare. A well-known locality is Piz Blas in Val Nalps, where this mineral (called "noble" gadolinite) was first found in 1939 by Parker *et al.* Similar crystals have also recently been found at Piz Rondadura (Kipfer, 1973); at this locality, gadolinite can be easily confused with a bluish variety of titanite, and a check of the absorption spectrum is essential for positive identification. Another possible Swiss locality for "noble" gadolinite is the Grimsel Pass, where only a single crystal was found (Stalder, 1964). Quite recently, exceptionally clear crystals have been found at Pizzo Rotondo, Val Bedretto (Ticino). In Austria, several crystals have come from a quarry at Böckstein near Bad Gastein (they were first found by R. Winkler in 1964: see Kontrus, 1965). These crystals are relatively large in comparison with the Swiss ones and have a nice color; their faces, however, are not so brilliant as those of the Val Nalps specimens. Surprisingly large crystals have been found in most recent times in the Deisl gneiss quarry in the Rauris valley (Meixner, 1976). As for many other rare species, all this seems to prove that gadolinite is also a widespread mineral in the Alpine fissures, although



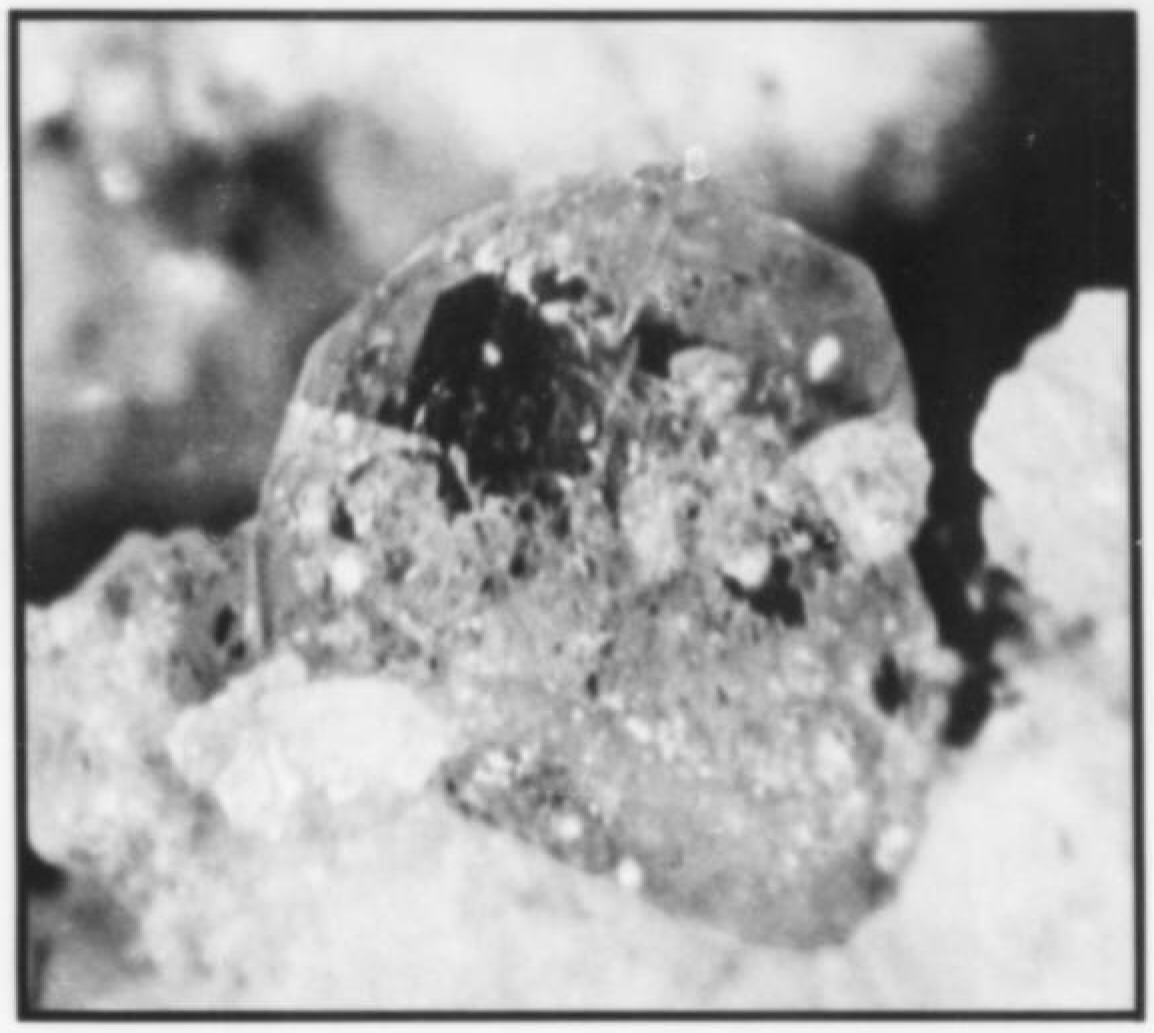
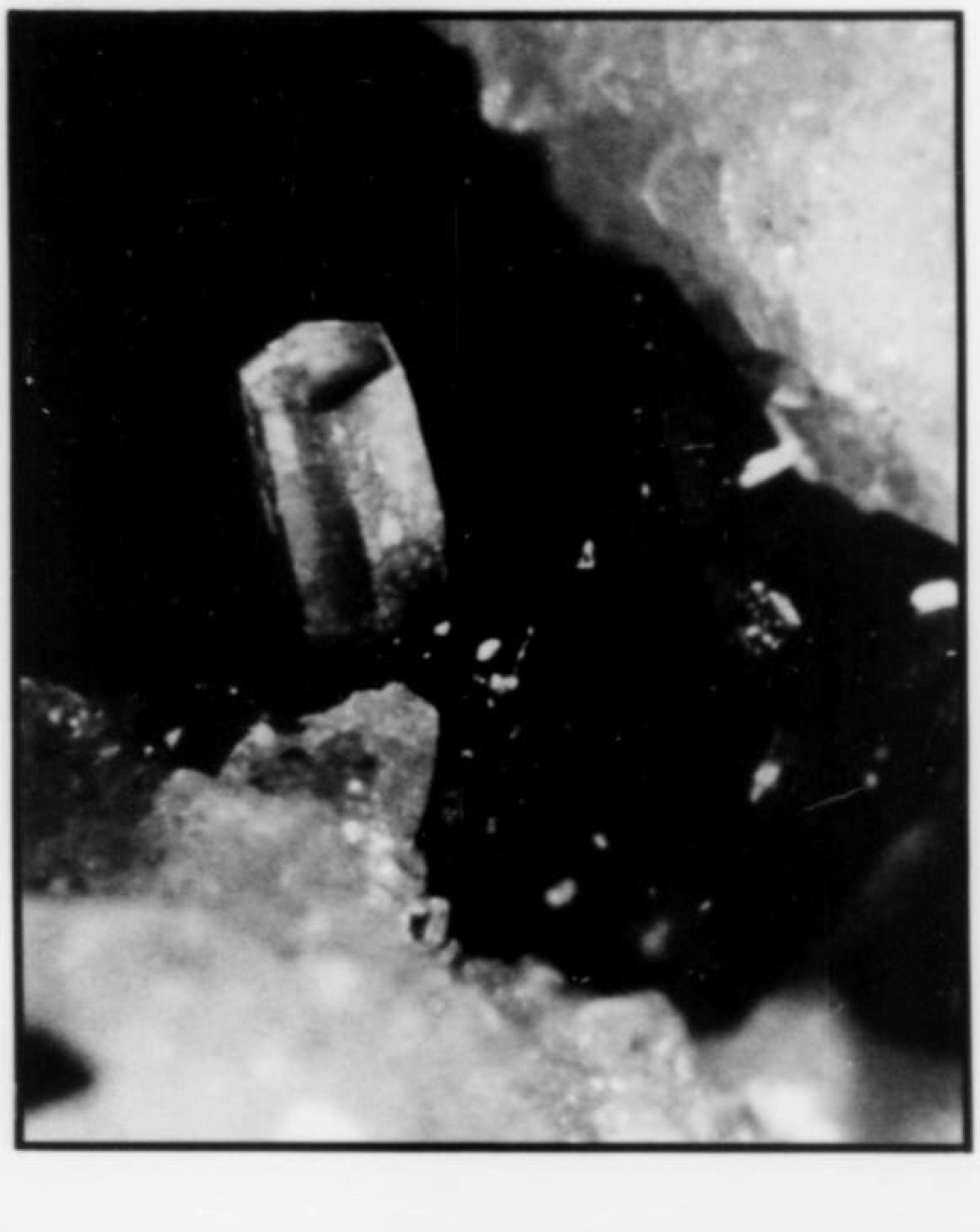


Figure 2. (left) **Absorption spectra (visible) of several Alpine rare-earth minerals. The spectra are mostly a function of the rare-earth elements contained (e.g. the cerium group and yttrium group) however other factors yield noticeable differences. For instance monazite and synchysite contain about the same distribution of rare-earth elements but their spectra are sufficiently different to permit identification.**

Figure 3. (above) **Monazite crystal (about 30X) from Alpine fissures at Monte Prosa, St. Gotthard, Switzerland.**

Figure 4. (below left) **Synchysite pseudo-hexagonal prismatic crystal with black anatase (40X), from Monte Prosa, St. Gotthard, Switzerland.**

Figure 5. (below) **A typical syntactical intergrowth of alternating layers of bastnaesite and synchysite (35X) from Val Nalps, Graubünden, Switzerland.**



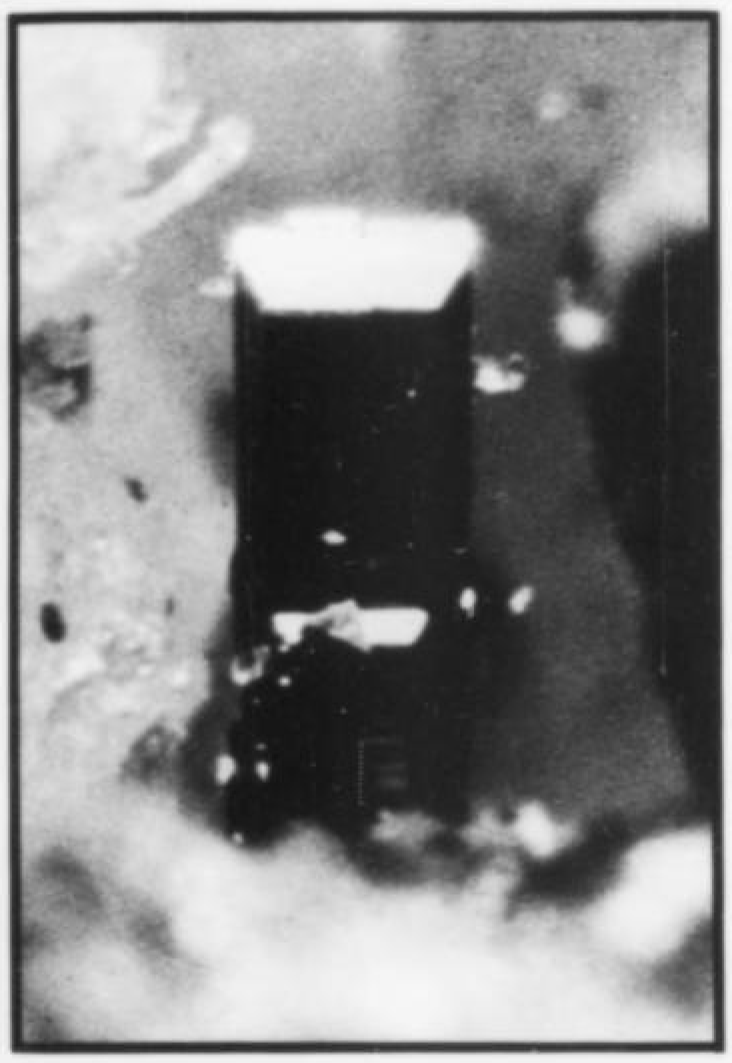


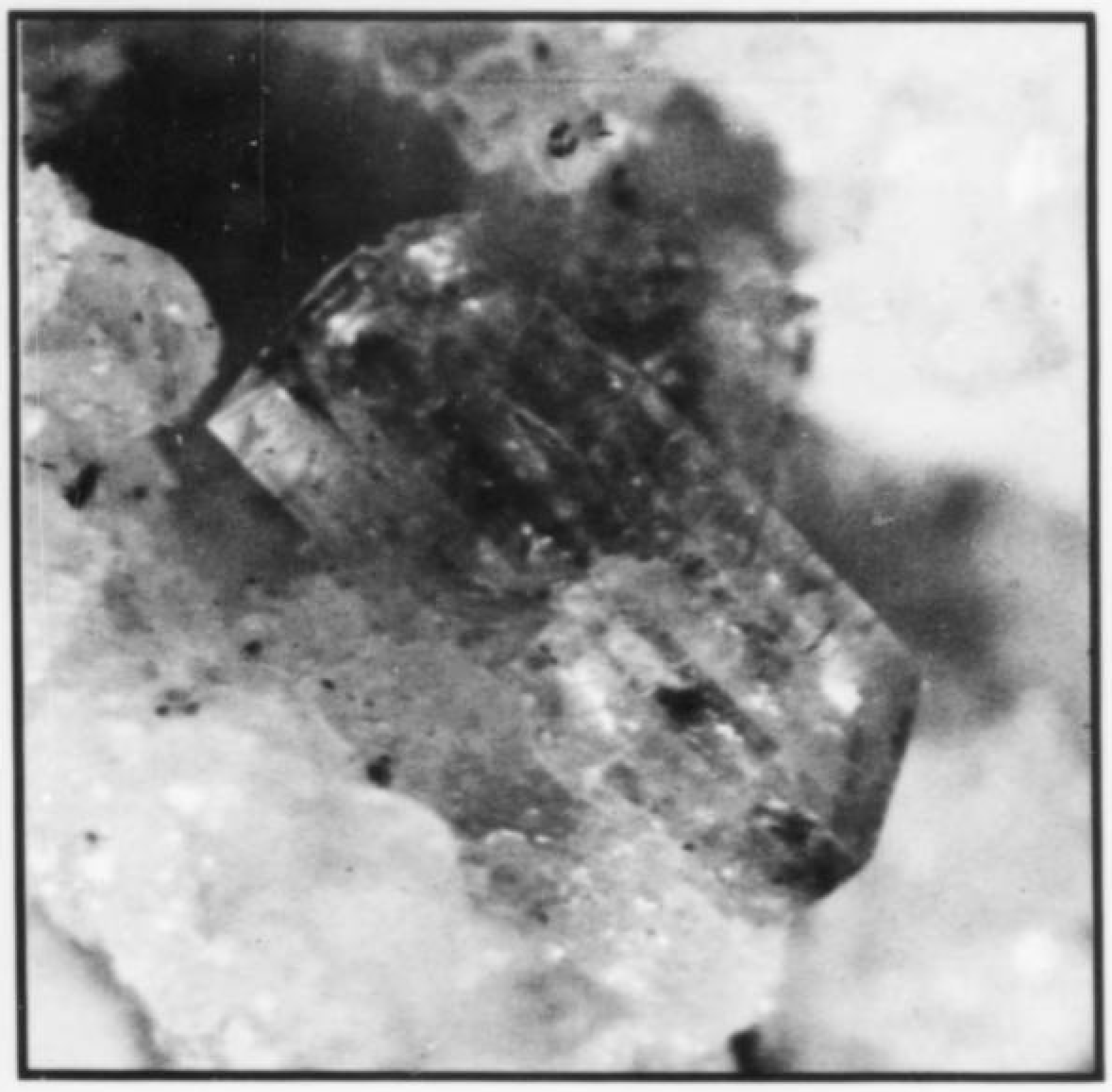
Figure 6. (far left) **Aeschynite, a sharp crystal (25X) from Pizzo Rotondo, Val Bedretto, Canton Ticino, Switzerland.**

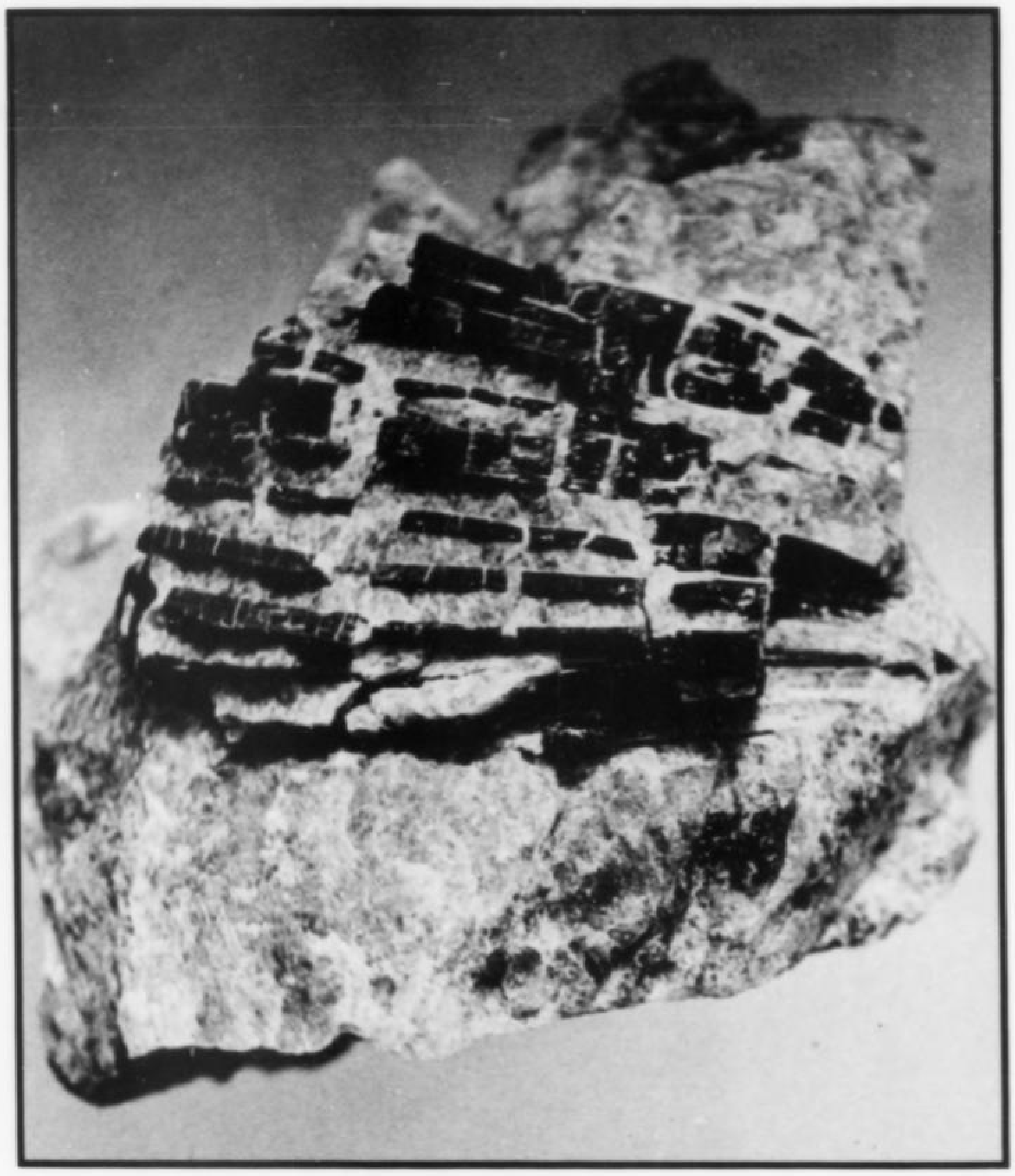
Figure 7. (left) **Xenotime, a prismatic greenish crystal (10X) from Monte Prosa, St. Gotthard, Switzerland.**

Figure 8. (left) **Gadolinite, of the "noble" variety (10X) from the Böckstein quarry near Bad Gastein, Austria.**

Figure 9. (below left) **Kainosite (Cenosite), a clear crystal (about 30X) from the Gotthard Freeway tunnel, Switzerland.**

Figure 10. (below) **Tanteuxenite, an exceptional group of crystals (1.5X) from a pegmatite at Craveggia, Val Vigezzo, Italy.**





always in very small quantity. In the subalpine region, good crystals of gadolinite are known to occur (rarely) in the granite at Baveno; most of them, however, are metamict, superficially altered and bear little similarity to the "noble" variety from Alpine fissures (Pagliani, 1941; Fagnani, 1950). Similar occurrences are mentioned at Cuasso al Monte near Varese (Fagnani, 1941) and at Montorfano near Baveno (Tacconi, 1903).

Kainosite (cenosite) [$Ca_2Y_2Si_4O_{12}(CO_3)\cdot H_2O$] is another typical rare-earth-bearing species of Alpine fissures but it is extremely rare. Kainosite crystals are yellowish, prismatic and may attain considerable size; an excellent article by Weibel (1970) about this species in the Alps has already appeared in this journal, and little can be added to it. In recent times two additional localities have been discovered: Grubhorn in Baltschiedertal (Valais), where an enormous crystal was found and also the Gotthard freeway tunnel (Graeser & Stalder, 1974).

Chernovite [$YAsO_4$] was discovered in 1966 in the Cervandone (Cherbadung) massif, across the border from Binnatal-Val Devero; owing to the scarcity of the material, extensive study could not be made until a few years ago and in the meantime this new species was described for the first time by Russians (Goldin et al., 1967). Crystals are yellowish, very small (less than 1 mm in size) and their habit is bipyramidal. They resemble bipyramidal crystals of xenotime, a species isostructural with chernovite. This very rare and interesting mineral is associated with other unusual species rich in arsenic (asbecasite, cafarsite, etc.), which indicate particular geologic conditions (see Graeser *et al.*, 1973).

Allanite (orthite) [$(Ce,Ca,Y)_2(Al,Fe)_3(SiO_4)_3(OH)$] is very rare as an Alpine fissure mineral. It was first found in 1926 as tiny black, brownish or purplish crystals at Ried in Reusstal, Uri, Switzerland. In 1970 the same mineral was found at Camperio in Canton Ticino, during construction of a new road to Lukmanier Pass (Lucomagno). A further recent occurrence is mentioned in Val Blenio (see Parker et al., 1973). Some quite beautiful specimens, one of which is shown in the glass cases of the ETH mineral collection in Zürich, have been found during the excavation of the Gotthard freeway tunnel (Kipfer, 1976). In the subalpine region, crystals of this species are found at Baveno: they are black, rich in faces, and up to 1 cm in length. There are also brownish spherical aggregates, not exceeding 1 mm in size, which encrust several minerals (Grill, 1937) but their identity is not quite certain.

In pegmatites apparently poor in titanium, the principal rare-earth minerals are allanite and monazite, which may occur as crystals several cm long, at least in the Italian part of the Bergeller massif (Val Masino); xenotime is also very widespread in minor quantities. In fact, we have a number of well-known Austrian occurrences (St. Leonhard in Saualpe, Hebalpenstrasse in Packalpe, and Kuppergrund in Koralpe: for an overall reference, see Weninger, 1976), and several recent discoveries have been made elsewhere in Italy (Valle Antrona: see Mattioli V. in Cantadore and Gramaccioli, 1969 and Roggiani, 1974; Val Masino; Le Chiuse near Bressanone, Südtirol: see Favretto, 1968).

Apart from Bergeller Massif, allanite is known in centimetre-long crystals in the tonalite rocks of the Adamello region (von Rath, 1864), in the Rauris valley (von Zepharovich, 1885, Meixner, 1971) etc.

Aeschynite -Y [$(Y,Ca,Fe,Th)(Ti,Nb)_2(O,OH)_6$] was first found in Alpine fissures in 1970 by J. Gloor as very small, brilliant, brownish crystals implanted upon adularia from Pizzo Lucendro (Gotthard): these crystals were identified as aeschynite-Y by Sommerauer and Weber (1972). Recently, aeschynite has been found at a considerable number of additional localities. Among these are Val Nalps in Tavetsch and Böckstein near Bad Gastein in Austria (Kipfer, 1973), La Bianca at the head of Val Cristallina-Casatscha, Andermatt, and Lentatal in the Adula massif (Graeser and Stalder, 1974), Tête Noire near Trient, Valais (Frey, 1974), Pizzo Cervandone (Graeser and Roggiani, 1976), Pizzo Rotondo in Val Bedretto (Kipfer, 1976), and still others for which the material is under investigation. According to these most recent data, aeschynite seems to be much more widespread in the Alpine region than previously supposed. Owing to the smallness of the crystals these have often been overlooked and possibly taken for rutile or brookite.

Besides these most typical occurrences in fissures, the Alpine region affords other interesting rare-earth minerals in pegmatites. All of them are rare; in general, crystals are small and, owing to the reasons explained above, they are on the whole quite similar to other non-Alpine occurrences. However, a considerable number of new localities and remarkable minerals has been found quite recently by amateur mineralogists. New and old data seem to fit a general picture, which is characteristic of extensive Alpine areas.

Tanteuxenite (once called "delorenzite") [$(Y,Ce,Ca)(Ta,Nb,Ti)_2(O,OH)_6$] was discovered in 1908 by Zambonini in a limited number of boulders mined for beryl in the years 1880-1900 at Piano del Lavonchio. The locality is a small idyllic spot situated near the village of Craveggia, in Val Vigezzo, not far from the Italian-Swiss border between Domodossola and Locarno. This material had also been examined by some earlier mineralogists, who apparently were not able to study it properly (Piccini, 1886). The original specimens of "delorenzite," presumably only two or three in number, were found associated with strüverite (Craveggia also being the original locality for this species), and no more of this mineral appeared for about 50 years.

It was only in 1957 when Francesco and Giuliana Cantadore, two advanced amateurs, succeeded in digging from the ground some fragments of the original boulders, which were covered by an extensive layer of grass and tree roots. In these fragments, besides traces of beryl, some interesting black minerals were evident and they were submitted to the attention of the present author, who found them to correspond with the original "delorenzite." Later on, this activity led to the discovery of the best specimens in existence of this mineral, one of which consists of crystals about 5 cm long. Fragments of these crystals were sent to Peter Embrey of the British Museum for study, and on the basis of a new analysis and X-ray powder data "delorenzite" was shown to be identical with tanteuxenite (Butler and Embrey, 1959). This identity is evident also in the single-crystal study by De Pol & Vescovi (1967). The occurrence is still interesting because members of the euxenite group with tantalum exceeding niobium are particularly scarce in nature, and the relative predominance of tantalum-bearing over niobium-bearing species seems to be characteristic of several Alpine and subalpine pegmatites (for instance, tapiolite and strüverite are very widespread). At Craveggia, no other rare-earth-bearing species were originally found by Zambonini accompanying "delorenzite"; later on, however, allanite (Gramaccioli, 1958), monazite and xenotime (Cantadore and Gramaccioli, 1969), and a still unidentified cerium-bearing species were found. An extensive search by Cantadore and Gramaccioli (1969) has shown the presence of "delorenzite-like" minerals in various additional localities in Val Vigezzo (Cortino, Arvogno), in Ossola (Trontano, Beura) and in Val Malenco; similarly, Simonetti (1972/3) showed a similar mineral to be present at Monti di Gorduno in Canton Ticino (referred to as euxenite). As at Craveggia, this mineral is sometimes accompanied by monazite and allanite (Beura), or xenotime (Monti di Gorduno); strangely enough, other rare-earth niobates-tantalates poor in titanium (fergusonite, samarskite) have not been discovered yet in macroscopic crystals.

Other rare-earth-bearing species are presently found at Orcesco in Val Vigezzo, in the fissures of an unusual pegmatite, which became world-famous a few years ago, because the very rare mineral **roggianite** [$NaCa_6Al_9Si_{13}O_{46}\cdot 20H_2O$] was discovered there (Passaglia, 1969). Among these rare species, **fersmite** [$(Ca,Ce,Na)(Nb,Ta,Ti)_2(O,OH,F)_6$] in small sharp crystals can be mentioned, a real delight for the micromounter (Graeser and Stalder, 1974; Mattioli, 1974).

CONCLUSIONS

In conclusion, the Alpine and subalpine region affords particularly characteristic specimens of rare-earth minerals, among which the ones from Alpine fissures are quite attractive. Pegmatite veins, though relatively little studied until recently, are yielding other specimens which might eventually prove to be almost as interesting, both to the advanced amateur and to the scientist.

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Re-discovery of

STOKESITE CRYSTALS

in Cornwall, England

A.G. Couper, Department of Mineralogy, British Museum (Natural History), London S.W.7. England and
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In June 1975 crystals of stokesite, $CaSnSi_3O_9 \cdot 2H_2O$, were found by one of the authors (RWB) at the Penryn Granite Company's quarry at Halvosso, about 6 km west of Falmouth in Cornwall and, immediately, interest was revived in the reported type locality for stokesite at Roscommon Cliff, near St. Just, about 40 km away from Halvosso. In September 1975, a search that was begun in 1899 by Arthur Hutchinson (1866-1937), then a fellow of Pembroke College, Cambridge, and continued by many others over a period of 76 years, ended when a small crystal, about 4 mm long, of this rare tin-bearing silicate was found (again by RWB) on axinite crystals collected at Wheal Cock Zawn, Roscommon Cliff.

The original specimen used in 1899 to describe stokesite as a new mineral (Hutchinson, 1899) had been found by Hutchinson while he was examining the Joseph Carne (1782-1858) collection acquired a little earlier for the Cambridge Mineralogical Museum. This collection had been the nucleus of the museum of the Royal Geological Society of Cornwall at Penzance. The specimen was catalogued as gypsum, which it closely resembled, from Roscommon Cliff, near St. Just, and in his second list of minerals collected in the St. Just area, Carne (1846) mentions "Selenite, or crystallized sulphate of lime, in its usual form, the oblique parallelopiped, from Roscommon cliff.". As it did not appear in the first list published in 1822 it seems probable that the specimen was collected between those dates. Dr. J. A. Paris mentions (Paris, 1816) that a miner at St. Just "of the name of James Wall who resides in the village of Carnyorth, had generally a variety of the local minerals for sale." while W. J. Henwood (1843), in a paper describing cassiterite crystals from the St. Just area, refers to the same man as "Captain James Wall, to whom we are indebted for the discovery of all the rare and curious minerals of the district,..." Sir Arthur Russell, in an unpublished paper the manuscript of which is in the British Museum (Natural History), concludes that no doubt James Wall was responsible for discovering "the axinite, prehnite, stilbite, almandine garnet, etc., and very probably the one unique specimen of stokesite which was in Joseph Carne's collection all from the cliffs in the neighbourhood of Botallack". It is probably irrelevant, though interesting, to note here that James Sowerby figures and describes (Sowerby, 1809) a specimen of 'White Tourmaline' from a mine in St. Just, Cornwall, which was undoubtedly phenakite, and this was 24 years before phenakite was described by Nordenskiöld as a new species in 1833 (Russell, 1920).

Hutchinson was puzzled by the unusual association of axinite with the 'gypsum' crystal and it was this that caused him to examine it more closely and discover its true identity. In the hope of finding more stokesite specimens Hutchinson visited Roscommon Cliff and found it to be a steep cliff descending abruptly to the sea, west of Trewellard. Although axinite was in evidence at several points no further stokesite was found. Hutchinson then examined axinite specimens from Roscommon Cliff in collections at the British Museum and at museums in Penzance, Camborne, Redruth, and Truro, but still without success. By comparing the axinite at Roscommon Cliff with the matrix of the specimen in the Carne collection, Hutchinson was convinced that the locality was the correct one, but an element of doubt has remained all the time that no specimens could be found there. The new find now establishes almost beyond doubt that the original crystal was found in the same vicinity.

After Hutchinson had made a thorough examination of the crystallographic, optical, and chemical characteristics of stokesite (Hutchinson, 1900), about half of the original 10 mm long crystal remained to be preserved in the Cambridge Museum collection (Spencer, 1939) and for 62 years it was the only known example of its species. In 1961 a cryptocrystalline cassiterite from a lithium-bearing pegmatite at Ctidružice in western Moravia was found to contain a small admixture of stokesite (Čech, 1961) and a few years later a third occurrence was described (Černý, 1966) as fine-grained aggregates on albite in a miarolitic cavity in the desilicated pegmatite at Věžná, also in western Moravia. Individual crystals were said to reach 0.5 mm but were usually much smaller and at the time the paper was written only one specimen with stokesite had been collected. The fourth, and perhaps best known, occurrence was reported in the *Mineralogical Record* (White, 1973) as spherical clusters of crystals from the pegmatite at Corrégo do Urucum, near Galiléa, Minas Gerais, Brazil, and many museums and private collections now possess specimens measuring up to 3 cm in diameter.

Stokesite from Penryn Granite Company's quarry, Halvosso, Cornwall.

The first of the two recent finds in Cornwall was made in June, 1975, at Penryn Granite Company's quarry, near Halvosso village, Mabe, about 6 km west of Falmouth. The quarry is shown as 'Kessel Downs quarry' on the 1:10,000 O.S. map at grid ref. SW 738338 although, locally, it is also known as 'Halvosso quarry'. Several crystals (B.M. 1975,541-546), the largest about 7 mm long but mostly about 3-5 mm, were found in two boulders that had fallen from the northern wall of the quarry and, initially, were thought to be bertrandite until they were determined optically as stokesite in the Department of Mineralogy, British Museum, (Natural History), a result that was later confirmed by X-ray methods.

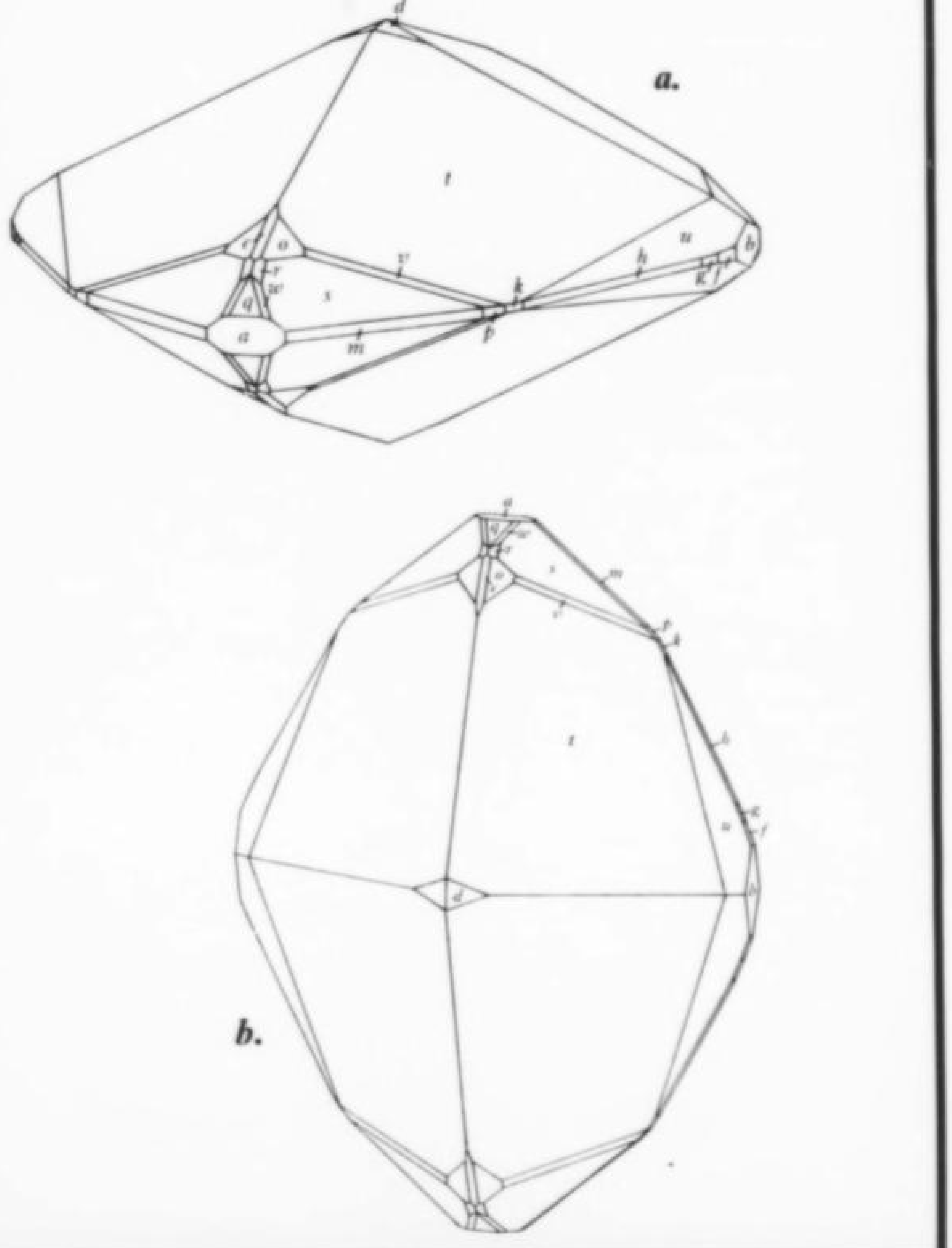
Stokesite from Halvosso occurs as clear, colorless to very pale pink, steep pyramidal orthorhombic crystals, either as individuals or as radiating groups on albite and orthoclase. Many of the crystals tend to be composite and all those examined so far have been singly-terminated with only slight indications of bipyramidal habit. Some are penetrated by acicular crystals of dark brownish-green to green tourmaline. Cleavage {010} is good and most crystals show signs of incipient cleavage in that plane. Fair cleavage was also observed for {011} and {100}. Hardness was judged to be 6½, streak white.

Optical data for Halvosso stokesite crystals are: $\alpha = 1.616$, $\beta = 1.619$, $\gamma = 1.626$, $2V_\gamma = 67°$ (calc.); $r < v$ perceptible.

The optical orientation is $\alpha \parallel [001]$, $\beta \parallel [010]$, $\gamma \parallel [100]$. The refractive indices are close to those obtained for material from Corrégo do Urucum, Minas Gerais, Brazil, with $\alpha = 1.616$, $\beta = 1.621$, $\gamma = 1.628$. Hutchinson calculated the refractive indices for the original Roscommon Cliff stokesite from the angle of minimum deviation measured on two pairs of faces in the form {121} and he obtained $\alpha = 1.609$, $\beta = 1.6125$, $\gamma = 1.619$ and these last figures match almost exactly those reported for the Věžná stokesite (Černý, 1966), $\alpha = 1.610$, $\beta = 1.613$, $\gamma = 1.620$.

The composite nature of most of the Halvosso stokesite crystals and the curvature and roughness of some faces made it difficult to measure the interfacial angles but three crystals (B.M. 1975,543-545) were studied on an optical goniometer and the mean of several readings was used to produce the idealized drawings (Figs 1a and 1b) and a calculated axial ratio of 0.8092: 1:0.3642. If the same orientation $c < a < b$ is used then the axial ratio as determined by Hutchinson is 0.8033:1:0.3463, while that obtained from the cell dimensions determined by an X-ray examination of the type specimen (Gay and Rickson, 1960) is 0.8056:1:0.3627. Stokesite belongs to the orthorhombic holosymmetric class. The crystal is also drawn (Fig. 1b) using Hutchinson's morphological orientation of $a < c < b$ so that a comparison can be made with his drawing of the original crystal (Fig. 2).

Figure 1. **Idealized crystal drawings of stokesite from Halvosso, Cornwall, with (a)** $c < a < b$ **and (b)** $a < c < b$**.**



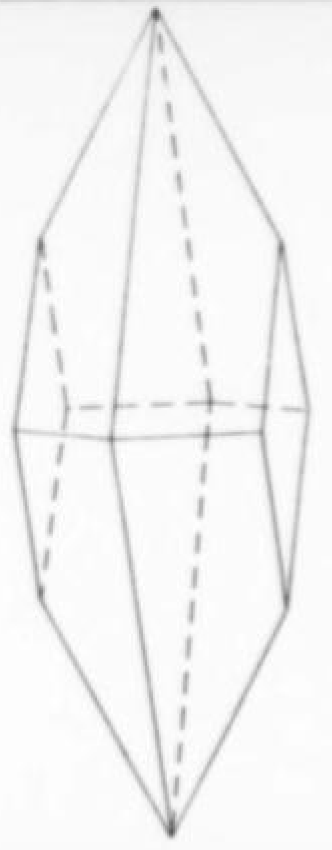


Figure 2. **A copy of Hutchinson's drawing of the original stokesite crystal from Roscommon Cliff, Cornwall.**

In all, eighteen forms have been recorded on the Halvosso crystals with the bipyramid t{243} dominant, but usually rounded by u{485}. Other forms that may be seen, though perhaps with the aid of a hand-lens, include a{100}, b{010}, e{101}, q{301} and s{221} as well as several of the forms {hkO}. The remaining forms are represented on the crystals by microscopic faces. The form d{011}, for instance, was recorded only as reflections from three very small faces on one crystal (B.M. 1975,544), although in the drawings 1a and 1b it is givern equal prominence with some of the other forms.

Geology

The country rock of the area around Halvosso is medium- to coarse-grained granite of the Carnmenellis boss (Hosking, 1954) and this has been extensively quarried for building-stone and, more recently, for aggregate and road metal. Granite of this district is cut in places by tin-bearing veins, especially around the village of Wendron, 2 miles to the west of Halvosso, where once there were numerous mines. The veins generally consist of tourmaline, quartz and chlorite, with intensely-altered wall-rocks carrying cassiterite. The general strike of the lodes is WSW-ENE.

The Penryn Granite Company's quarry is situated in normal white, coarse-grained, two-mica granite showing occasional phenocrysts of orthoclase up to about 4 cm in length and local segregations of biotite. A 2-10 cm thick vuggy banded quartz vein with inclusions of slightly chloritized granite trends EW across the northern end of the quarry. Its dip is 85°N and it lies between strongly decomposed iron-stained walls and forms part of the sheer northern face of the quarry.

Also observed was a sharply defined, fine-grained, pinkish granite dyke, about 1 metre wide, that trends N-S and dips 80°W. This cuts through the middle of the quarry and is well-exposed in the southern end but not in the northern end where the quartz vein is situated. The dyke contains numerous miarolitic cavities lined with euhedral crystals of pink orthoclase, quartz, muscovite, tourmaline, and occasionally sea-green apatite.

Fractures in the granite are well-defined and are of two types. The first are gently dipping (10°N) joints along which there is no alteration and only slight weathering. The second are major near-vertical fractures, locally in-filled with hematite and strongly decomposed. The latter cut the first set of joints and were probably the feeders for the occasional metallic minerals found in the pegmatites.

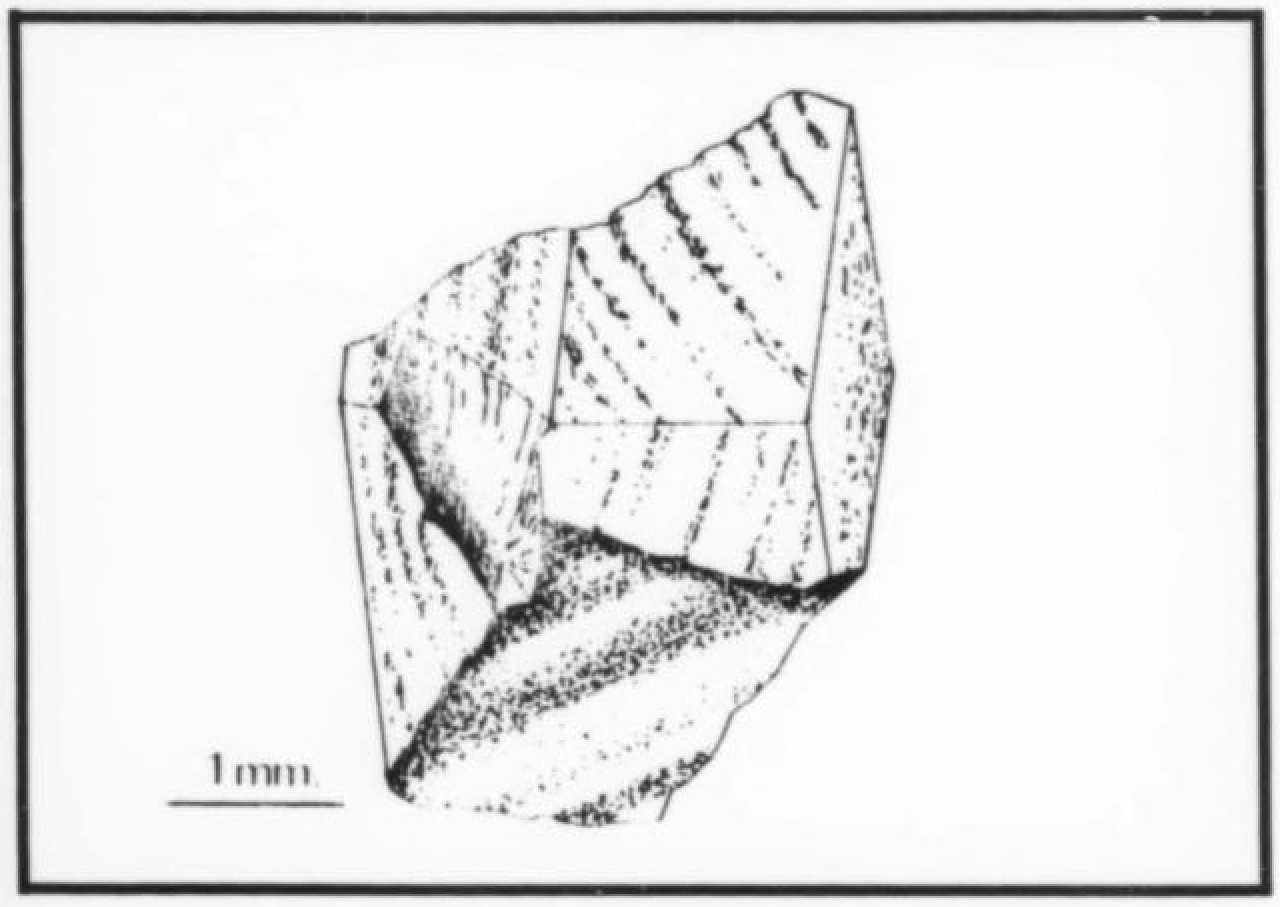
Pegmatite lenses occur sporadically throughout the granite, but are generally associated with the horizontal joints. Druses in these lenses are lined with well-formed orthoclase crystals, quartz (sometimes smoky), rosettes of muscovite, rods of tourmaline, occasional sea-green, pale blue, or purple apatite crystals up to about ½ cm in length, and albite in lustrous creamy-white crystals. Also found locally are plates of gilbertite, modified cubic crystals of pale-purple fluorite, well-developed blackish twinned crystals of cassiterite and, rarely, fractured pale brown crystals of sphalerite (ruby-blende), in sharp, clear crystals of up to 1 mm across, and small crystals of pyrite. The granite in the vicinity of the pegmatite druses is coarser-grained than elsewhere and is locally tourmalinized and contains slightly pinkened orthoclases.

The two large boulders in which the stokesite crystals were found had fallen from positions nearly adjacent to the E-W quartz vein in the northern wall of the quarry. These boulders contained small, discontinuous patches of pegmatite in which were druses about 10 cm in size lined with small, milky-white, euhedral crystals of albite, together with orthoclase, muscovite, quartz, acicular crystals of tourmaline, and a few pale-green apatite crystals. The granite in the vicinity of these druses was intensely albitized and tourmalinized for a short distance. Cassiterite was not seen in these cavities but was found in other druses nearby.

Stokesite found at Wheal Cock Zawn, Roscommon Cliff, near St. Just, Cornwall

The second find in Cornwall was made in September, 1975, at Wheal Cock Zawn in the mining district of St. Just, on the west coast of the Lands End peninsula (O.S. map 1:10,560 grid ref. SW363340). Wheal Cock is an old, abandoned tin and copper mine that, as long ago as 1778, was over 100 fathoms deep and worked far out beneath the sea (Collins, 1912). 'Zawn' is a local name for the steep-sided inlets into the rugged coast of the St. Just area where the mineralized veins, softer than the surrounding rock, have been eroded by sea action.

***Figure 3.* A drawing of the stokesite crystal (B.M. 1975, 547) recently found at Roscommon Cliff, Cornwall.**



The steep and dangerous cliffs at St. Just have attracted, and probably frightened, collectors for many years and Joseph Carne, describing (Carne, 1822) the occurrence of epidote at Botallack, wrote that it was found "in a part so difficult of access, that one would suppose that no specimens could be obtained from it but at the risque of life; yet the miners descend the precipice without fear".

The recently found stokesite crystal was in an almost inaccessible part of the sheer cliff that drops into the sea on the southern side of the zawn. A large, irregular, axinite-rich, vein-like body is exposed in the lower part of the cliff and it was while collecting axinite specimens from cavities in this vein that the solitary crystal of stokesite was found. The vein had been partly stoped away and there are old drill-holes in places where the site had been worked by local miners for axinite specimens in the last century. No detailed record of this locality seems to have been kept as no doubt the miners wished to keep the spot secret, but axinite specimens are commonly found in old collections labelled as from "Botallack", "St. Just", or "Roscommon Cliff" which is situated only a few hundred metres to the north-east of the site.

The crystal of stokesite, which was about 4 mm long, was attached to one side and towards the termination of one of the larger axinite crystals in a cavity in friable massive crystalline axinite, the whole specimen measuring about 4 x 3 x 1½ cm. The axinite crystals in the cavity are transparent, pale clove-brown and well-developed, the largest measuring about 1 cm across, and there are also small amounts of grossular, muscovite and orthoclase on the specimen.

The stokesite was sent to the British Museum (Natural History) for confirmation but, because it was in a cavity and delicately attached to an axinite crystal, any examination other than visual seemed unlikely. As it happened, the specimen was so friable that several axinite crystals, including the one with the stokesite attached, fell out of the cavity while being examined. The detached stokesite crystal and its matrix have been catalogued as B.M. 1975,547. Measurement of the interfacial angles was difficult because of the incomplete growth of the crystal, the attached axinite and deep impressions of other axinite crystals, and the curvature of the faces. Indeed, for some time it was thought that the alleged stokesite might be a feldspar and so it was decided to remove a very small amount for X-ray examination. The crystal was in this way identified as stokesite but in so doing the remaining axinite crystal became detached from it and it now appears as drawn in Fig. 3. It is bipyramidal but both terminations are missing and there are deep cavities and impressions where it grew around axinite crystals. The dominant form is the bipyramid {121} rounding to {243}, and well-developed {010}. Its habit is similar to that of Hutchinson's crystal from Roscommon Cliff which was described as having {121} and {010}, both largely developed; {100}, {565}, and {221}, all three very small. The last three forms do not appear in his drawing reproduced in Fig. 2.

Geology

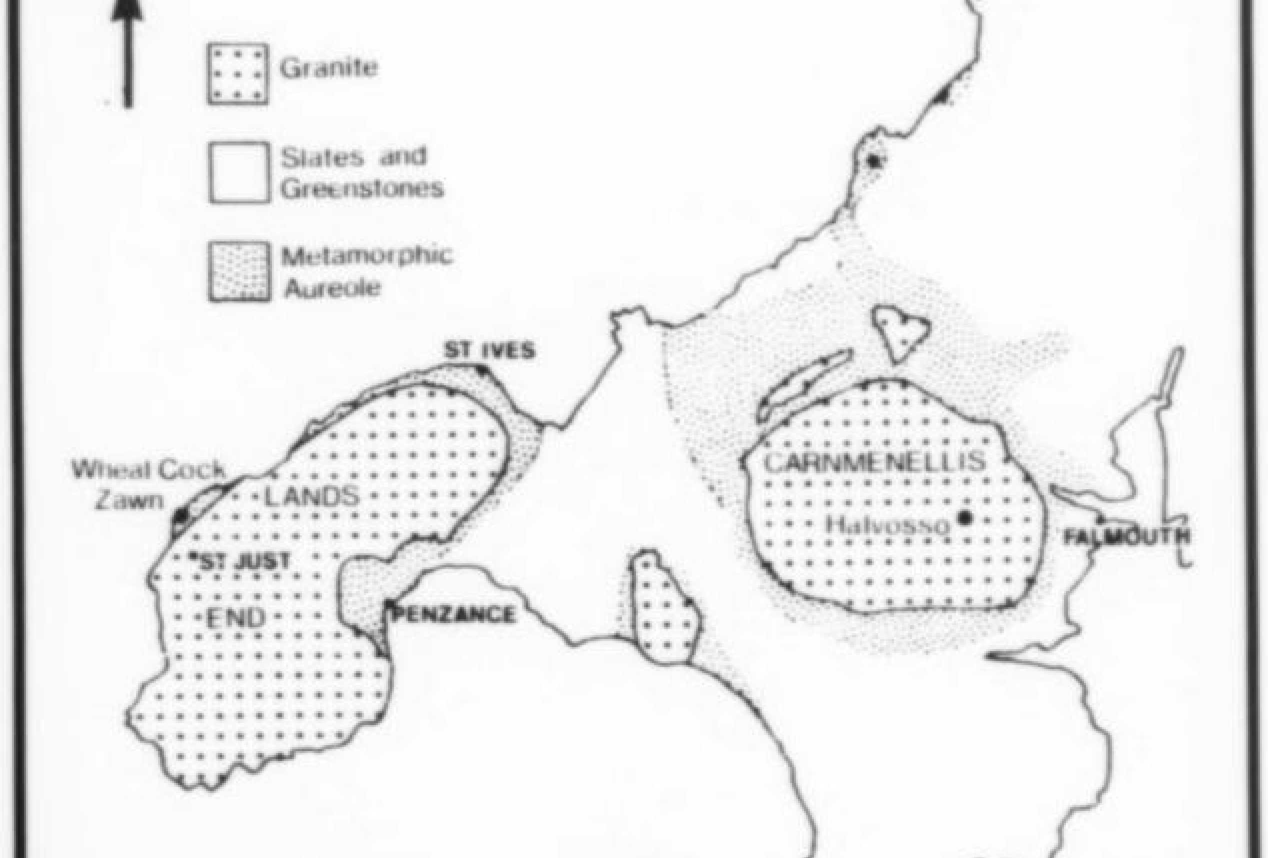
The country rock of the area is granite of the Lands End mass, with a strip of thermally metamorphosed slate (known locally as 'killas') and volcanic rocks (greenstones) along the northern coastal part. The district is rich in tin and copper lodes that have been worked since ancient times. Most of the lodes were mined out during the last century although one tin mine (Geevor) is still in active production.

Metasomatism of the greenstones within the granite aureole around Wheal Cock and areas close by, such as Botallack, has produced skarns. These are cut by discordant fissure veins and it was in one of these veins at Wheal Cock Zawn that the stokesite crystal was discovered.

The vein is exposed in the cliffs on either side of the zawn and it trends roughly NE making an angle of about 30° with the zawn, and about 90° with the main hypothermal tin and copper-bearing vein trend of the district. Towards the base of the cliff at its SW end, the vein flattens out and splits into two parts and then peters out at around high-water mark. To the

NE it dips nearly vertically into Wheal Cock Zawn and here consists dominantly of hard, massive, orange-brown grossular. Further outcrops along the strike of the vein can be found in Stamps and Jowl Zawn where the mineralogy is again dominantly grossular with small veinlets of calcite and hematite with sporadic axinite.

The vein is a discordant calc-silicate body which cuts microgabbro overlying a banded albite-epidote-actinolite amphibolite (Jackson and Alderton, 1974). The width of the vein varies from 50 cm to nearly 2 metres where there are local swellings. The average width of the consistent central portion is approximately 1 metre and thin irregular veinlets and masses split off into the country rock in places. The dominant minerals in the vein are axinite and grossular with local well-crystallized creamy apatite, sheaves and bands of bladed dark green pargasite, and locally crystallized epidote, tourmaline, magnetite and threads of chalcopyrite and pyrite. Late stage calcite infills some cavities in the axinite, particularly towards the lower part. In thin section titanite is detectable as small euhedral crystals. The orange-brown grossular is usually massive although some rough rhombic dodecahedra up to 2 cm across are found lining small cavities and joints while, occasionally, darker reddish-brown euhedral crystals occur in the axinite. The axinite is mostly light brown, friable, coarsely-crystalline massive with cavities ranging from 2-50 cm across, the majority being in the 5-10 cm range. Most of these cavities occur adjacent to joint-planes and are frequently lined with transparent, clove-brown, well-formed axinite crystals up to 3 cm across. The stokesite crystal was found in one of the smaller cavities near the top of the vein where there is a particularly wide swelling rich in axinite.



Generalised map of the Lands End peninsula

Geochemical studies of the minerals in the vein show a high concentration of tin. The axinite, amphibole, and epidote contain 750-950 ppm, the garnet and apatite 200-350 ppm. Dating of the amphibole by A. Halliday at Newcastle University (personal communication) gives a potassium-argon date of around 270 million years. This is the normal date for the emplacement of the granite of the area. It is interesting to note that the youngest minerals in the vein (i.e. axinite, amphibole and epidote) carry the highest tin concentrations, the tin being derived from emanations from the granite magma at the same time as the tin/copper lodes of the area were being deposited.

Acknowledgements

The authors are grateful to the Penryn Granite Company for permission to visit their quarries and to N. J. Jackson of the Geology Department, University of London, King's College, for help in describing the geology of the Wheal Cock Zawn vein and for providing geochemical data. Thanks are also due to two members of the Department of Mineralogy, British Museum (Natural History), Paul Hicks for his crystal drawings and map and Peter Embrey for his valued advice.

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MENDIPITE

AND
OTHER RARE OXYCHLORIDE MINERALS FROM
THE MENDIP HILLS,
SOMERSET, ENGLAND.

by R. F. Symes and P. G. Embrey
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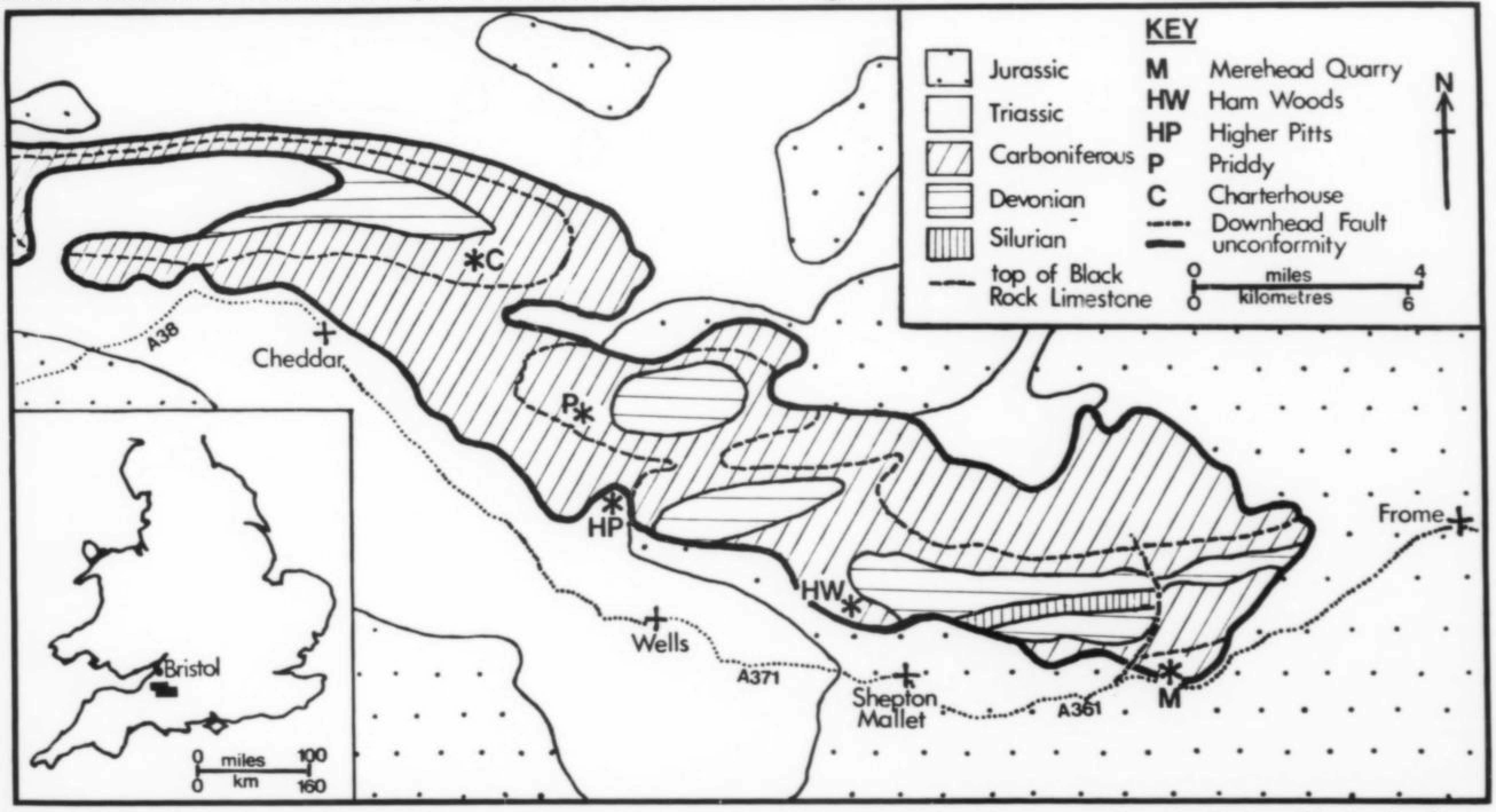


Figure 1. **Geological map of the southeastern Mendips showing the principal localities where secondary lead mineralization has been found.**

INTRODUCTION:

The mineral mendipite had been collected from the Mendips long before it was recognized as a distinct species, and several specimens survive in old collections. In 1923, Spencer and Mountain described the new species chloroxiphite and diaboleite associated with manganese and iron ores from the Higher Pitts mine, near Priddy. In the 1950's, large-scale limestone production was begun at Merehead Quarry, near Shepton Mallet, Somerset, and veins with rich pockets of manganese and iron mineralization carrying the oxychloride assemblage have been exposed. Many specimens from these veins are now finding their way on to the international mineral market.

GEOLOGICAL SETTING:

The Mendip Hills are a series of ridges of Paleozoic rocks reaching a maximum height of 300 m and extending approximately 51 km west north west from Frome in Somerset to Brean Down near Weston-super-Mare on the Bristol Channel. The structure is controlled by four major en-echelon folds with a dominant east-west axis, the folding being related to phases of the Armorican orogeny. The ridges consist mainly of Carboniferous limestone, which forms the dip slopes, with sediments of Old Red Sandstone age or volcanic rocks of Silurian age in the cores of the anticlinal structures (Fig. 1). Lower parts of the ridges are unconformably overlain by dolomitic conglomerate, consolidated screes of Triassic age. The Mendips were an important axis of uplift during most of the Jurassic period, so that relatively thin Rhaetic and Jurassic sediments directly overlie the Carboniferous limestone. During the deformation associated with the production of the major Mendip folds, a system of faults and joints were developed in the Carboniferous limestone. Many of these fractures later became solution courses and were infilled either by Triassic, Rhaetic, and Jurassic sediments, or by replacement deposits of iron and manganese oxides. It is in this latter environment that the rare lead, copper and manganese minerals are found. Other fractures in the Carboniferous limestone and dolomitic conglomerate became the sites for the Hydrothermal deposition of primary galena and smithsonite, which occur as veins or fissure fillings along with the gangue minerals calcite and barite. An averaged dating of galena from these primary deposits gives a Triassic age of 230 million years for this mineralization. Throughout the Mendips, small-scale primary sulfide mineralization can be found, along with deposits of manganese-iron mineralization, at or near the junction between the dolomitic conglomerate and the

Carboniferous limestone. The dolomitic conglomerate has in many places also undergone considerable secondary change: silicification, dolomitization, and an alteration of the iron mineral content to earthy 'red ochre'.

HISTORY:

The Mendips probably derive their name from the medieval term "Myne-deepes", and have been the scene of occasional mining and quarrying activity for some two thousand years. The principal activity at the present day is quarrying the Carboniferous limestone for ballast, but from Roman times until the beginning of this century the area was a commercial producer of lead, together with smaller amounts of zinc, and minor iron and manganese. Lead mining reached a peak in the 17th Century and thereafter declined. Most of the work in the 19th Century was confined to resmelting the extensive heaps of slag left by the early workers, especially in the Charter House area. Exploitation of the iron and manganese ores of the Mendips has always been on a small scale, unlike that of the iron ores of the Forest of Dean to the northwest. Mendip iron ores tend to be too siliceous for easy smelting, and extraction was concentrated on those occurrences where it was found suitable for use as a pigment, as at Winford. It should also be noted that traces of copper mineralization are widespread in the Mendips, but always in amounts too small for commercial exploitation.

A few specimens have been preserved that were mined more than a century ago and most of these are in the collection of John Woodward (1685-1728), now in the Sedgwick Museum, Cambridge University. Among these specimens are four of the lead oxychloride, mendipite: this was characterized as a distinct species in 1823 by the Swedish chemist, Berzelius, and named for the locality in 1838 by E. F. Glocker. Labelled as coming from the Mendips, it is probable that these specimens were not from a single locality, for small deposits of manganese-iron ore are often found at or near the junction between the dolomitic conglomerate and Carboniferous limestone. Two other early specimens are in the collection of Thomas Pennant (1726-1798) which was presented to the British Museum [Natural History] in 1913. A specimen of mendipite was figured in Rashleigh (1797), and came to the B.M. [N.H.] in the Russell Collection.

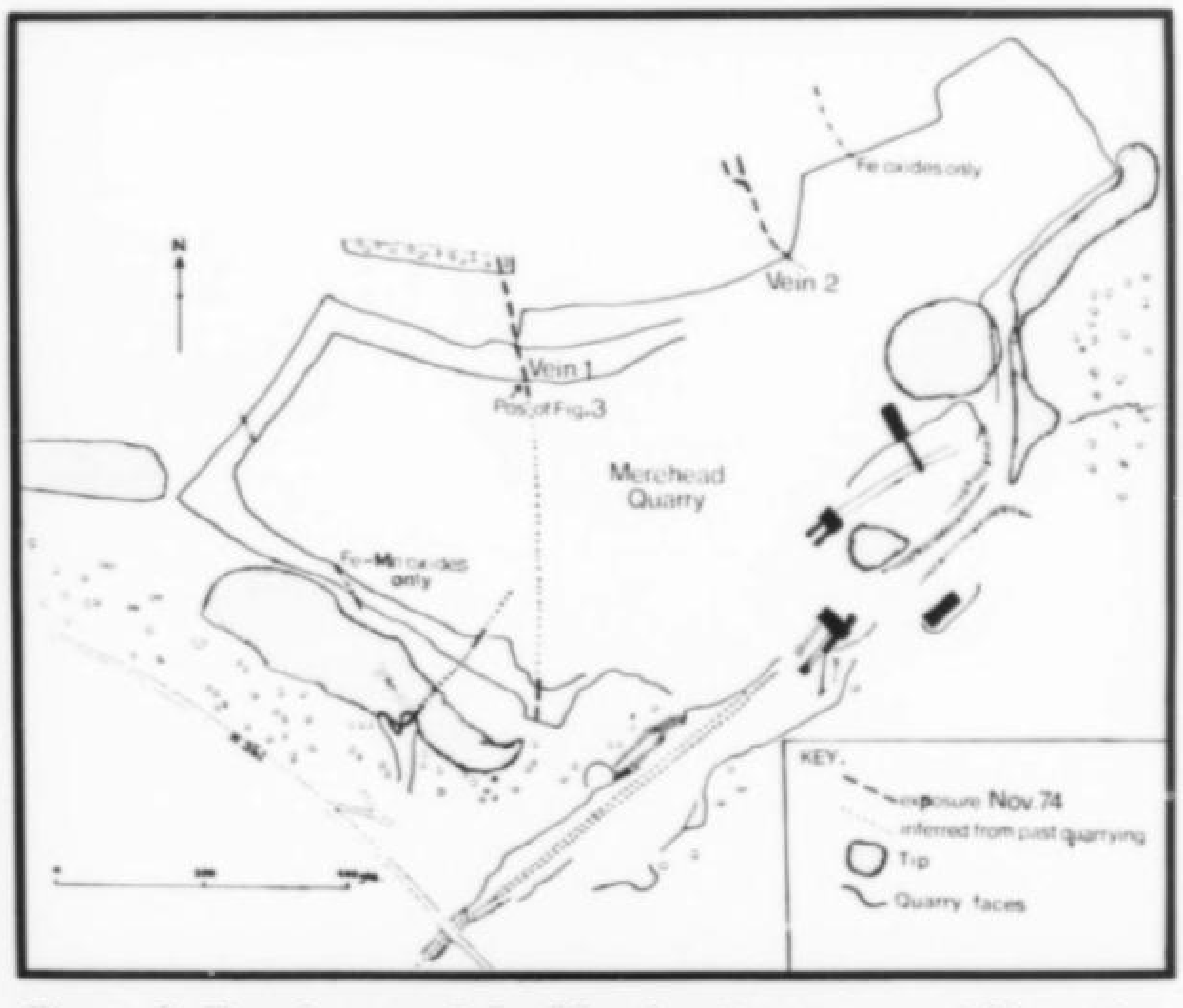
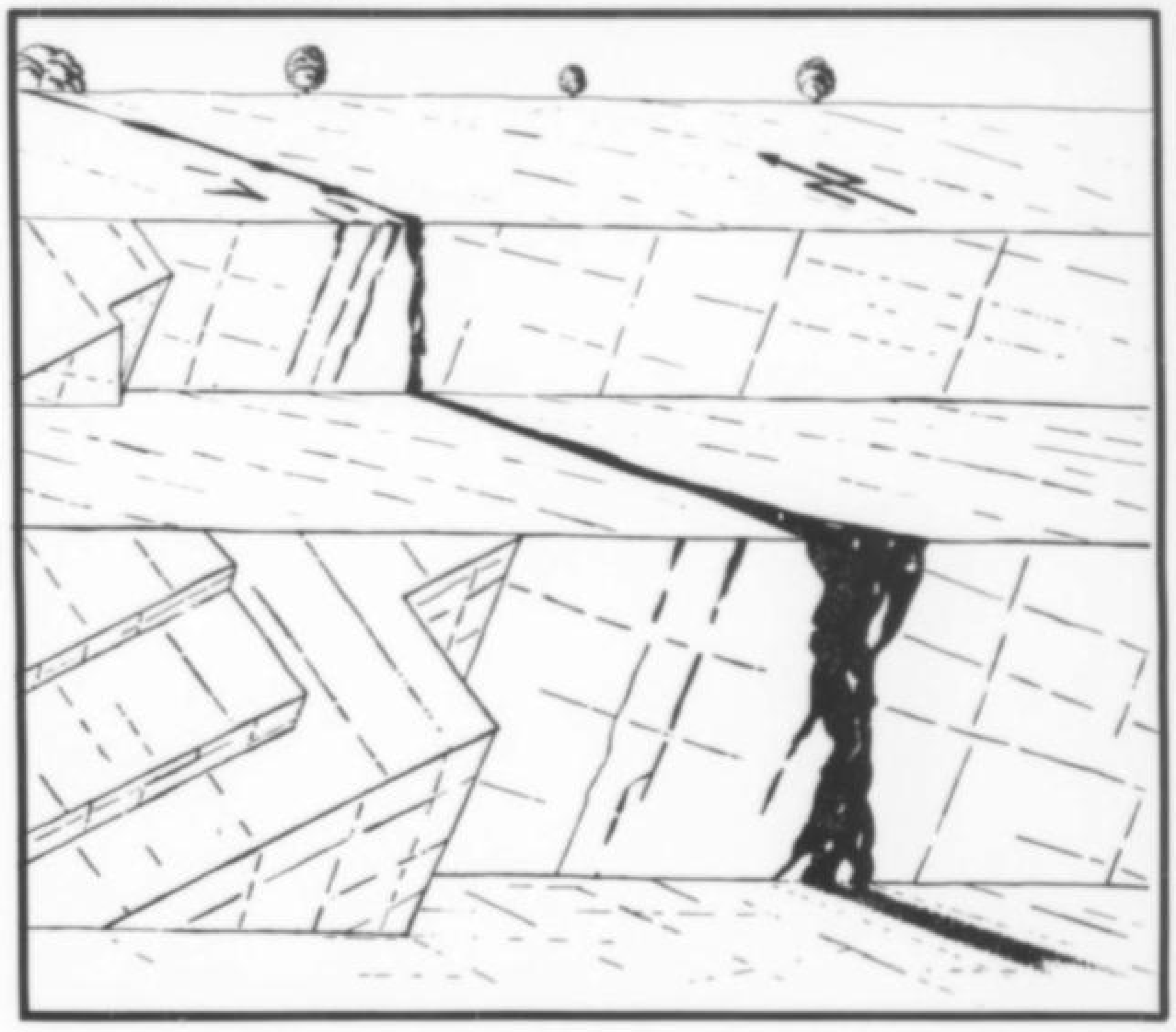


Figure 2. **Sketch map of the Merehead quarry as of November 1974, showing the principal manganses—iron veins which contain the oxychloride assemblages.**

After this early work on mendipite, little was done on Mendip minerals until 1898 when L.J. Spencer began to study specimens from a small iron mine at Higher Pitts near Priddy, which had been worked for iron and manganese from 1890 to 1893; many of these specimens were from the collection of S.G. Perceval (1838-1922). At Higher Pitts, Spencer found that the oxide ores of iron and manganese occurred as pockets in the dolomitic conglomerate, mostly at its base and in fissures or solution cavities in the underlying Carboniferous limestone. Scattered throughout the manganese ore was much intermixed calcite and small knobs of lead ore, usually cerussite but sometimes hydrocerussite or mendipite. Associated with this assemblage were rare secondary copper, manganese and lead minerals. This locality was remarkable for yielding two new species, chloroxiphite and diaboleite, both oxychlorides of lead and copper and described by Spencer and Mountain in their 1923 paper. Chloroxiphite has remained unique to the Mendip Hills, but diaboleite has since been found at the Mammoth-St. Anthony mine near Tiger, and the Rowley mine near Theba, both in Arizona. Further examples of this mineral assemblage have been found since, but mostly occur within small pods of manganese and iron oxides associated with the Carboniferous limestone in the large quarries of the area. At Halls quarry, Felton, just south of Bristol, mendipite and hydrocerussite were collected from a small pod of manganese oxide ore, and at Ham Wood near Shepton Mallet and in the Mendip quarry at Leighton, hydrocerussite has been found. Most of the deposits discovered were situated in the southern part of the Mendips and no deposit of any size was located until the late 1950's.

Figure 3. **Field sketch of the exposed part of Vein 1, Merehead quarry, in November 1974. Stipple = manganese mineralization; solid = iron mineralization. Maximum vein width = 12 feet (3.7 metres).**



MEREHEAD QUARRY:

In the 1950's a small limestone quarry that had been opened in the Carboniferous limestone at Merehead, near Cranmore at the eastern end of the Mendips, started work on a larger scale, and R.F.D. Parkinson, a local mineral dealer, began collecting specimens, most of which he passed on to the B.M. [N.H.] for study. The quarry was opened into the Clifton Down limestone series of the Carboniferous limestone on the southern flank of the Beacon Hill pericline. As quarrying has progressed, so have we been able to collect and study this oxychloride assemblage peculiar to the Mendip Hills, and with the removal of the thin, unconformable cover of Jurassic sediments it has been possible to see that the manganese and iron mineralization is concentrated into a series of veins, two of which have provided most of the oxychloride specimens (Fig. 2). The dominant trend of the veins is north-north-east, paralleling the Downhead fault which lies to the west of the quarry. These veins may pinch out or locally become thickened and vary in their mineral content. Vein 1 (Fig. 3) carries more massive manganese oxide and iron oxide than Vein 2. Specimens from Vein 2 are often cavernous, richer in cerussite and hydrocerussite and frequently lack the oxychloride assemblage. Since the late 1950's many smaller manganese-rich, iron-rich or calcite-and-breccia-filled veins or solution hollows have been exposed and removed by quarrying. Many are filled with limestone rubble cemented by further calcareous deposits. From within one such infill rounded, brecciated masses of the manganese ore have been collected. It is apparent from the distribution of the iron oxides that there has been more than one phase of iron mineralization.

MINERALOGY:

As quarrying has proceeded, fine but temporary sections of massive manganese oxide bodies, some containing cerussite, hydrocerussite, mendipite, and other rare secondary lead minerals, have been exposed. Crednerite, the rare copper manganese oxide, has also been found as a component of the assemblage. Evidence of the primary sulfide mineralization is scarce in these exposures. Only in some of the lower levels of the No. 1 Vein have good crystals of galena and chalcopyrite associated with barite been found, but small, rounded, detrital galena grains often occur associated with calcite in solution hollows. There is evidence of the leaching of these primary copper sulfides followed by secondary enrichment; for example, in a faulted part of Vein 1 chalcocite and native copper have been found along with cuprite, malachite, and azurite. Examination of polished sections of the opaque manganese oxide ores in reflected light has already shown that there are more species present than the pyrolusite, manganite, psilomelane, and crednerite previously reported, and work is continuing on their characterization and paragenesis.

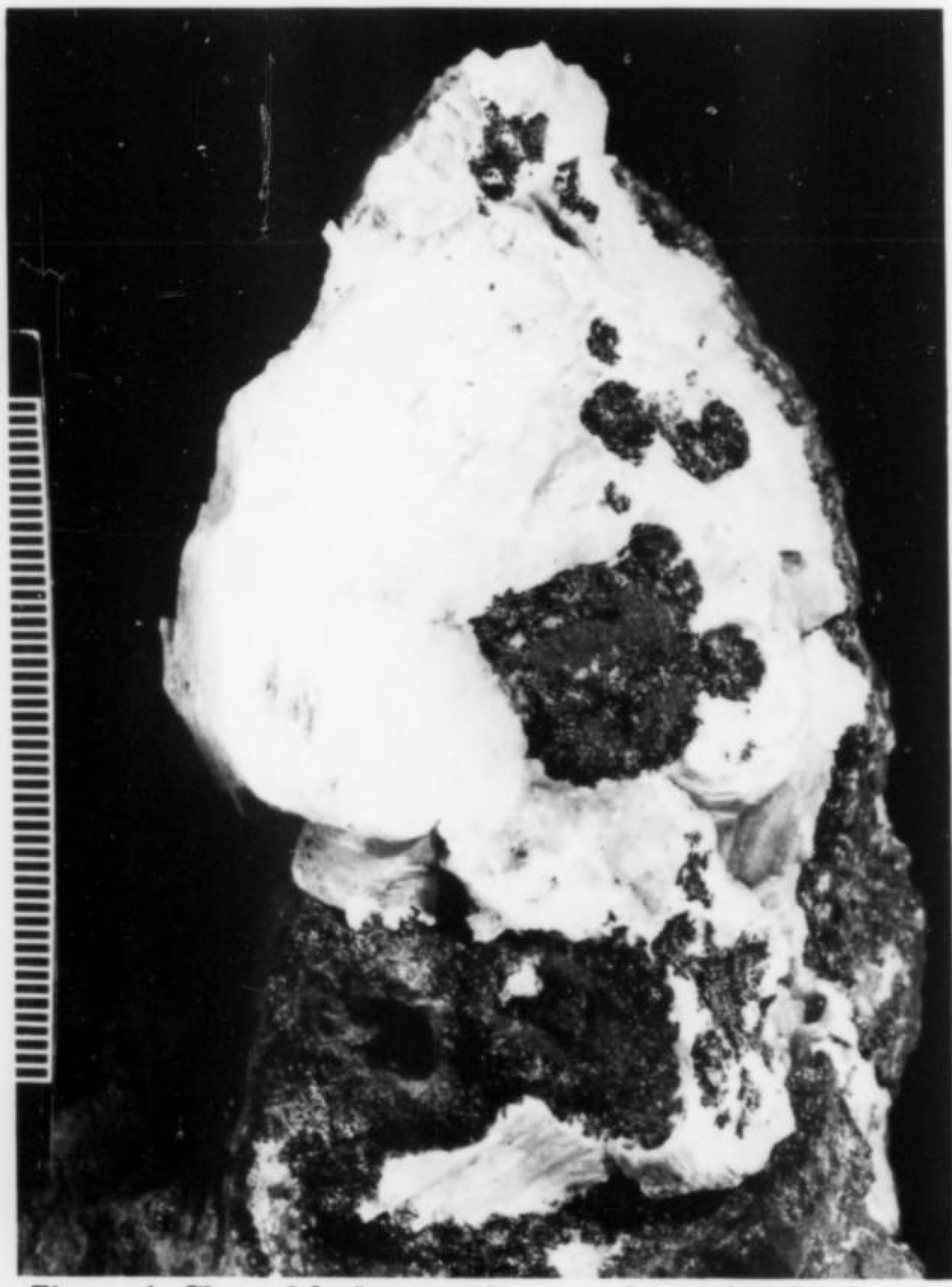


Figure 4. **Cleaved hydrocerussite crystal (pearly white) associated with a manganese oxide matrix (black), from the Merehead quarry. Maximum diameter = 6.5 cm (B.M.No. 1969, 162)**

Of more general interest than the manganese oxides, however, is the assemblage of lead and copper minerals that occur in cavities in some of the manganese ore. The most characteristic association, both at Merehead and at Higher Pitts as described by Spencer, is an inner core of mendipite, sometimes containing blades of olive green chloroxiphite, surrounded by layers of hydrocerussite and cerussite. The irregular external form of the mendipite suggests that it was partially dissolved after crystallization and that the hydrocerussite and cerussite are alteration products. Discrete crystals of the last two minerals, the latter considerably larger than have been reported elsewhere in the world, also occur in parts of the cavities not occupied by mendipite.

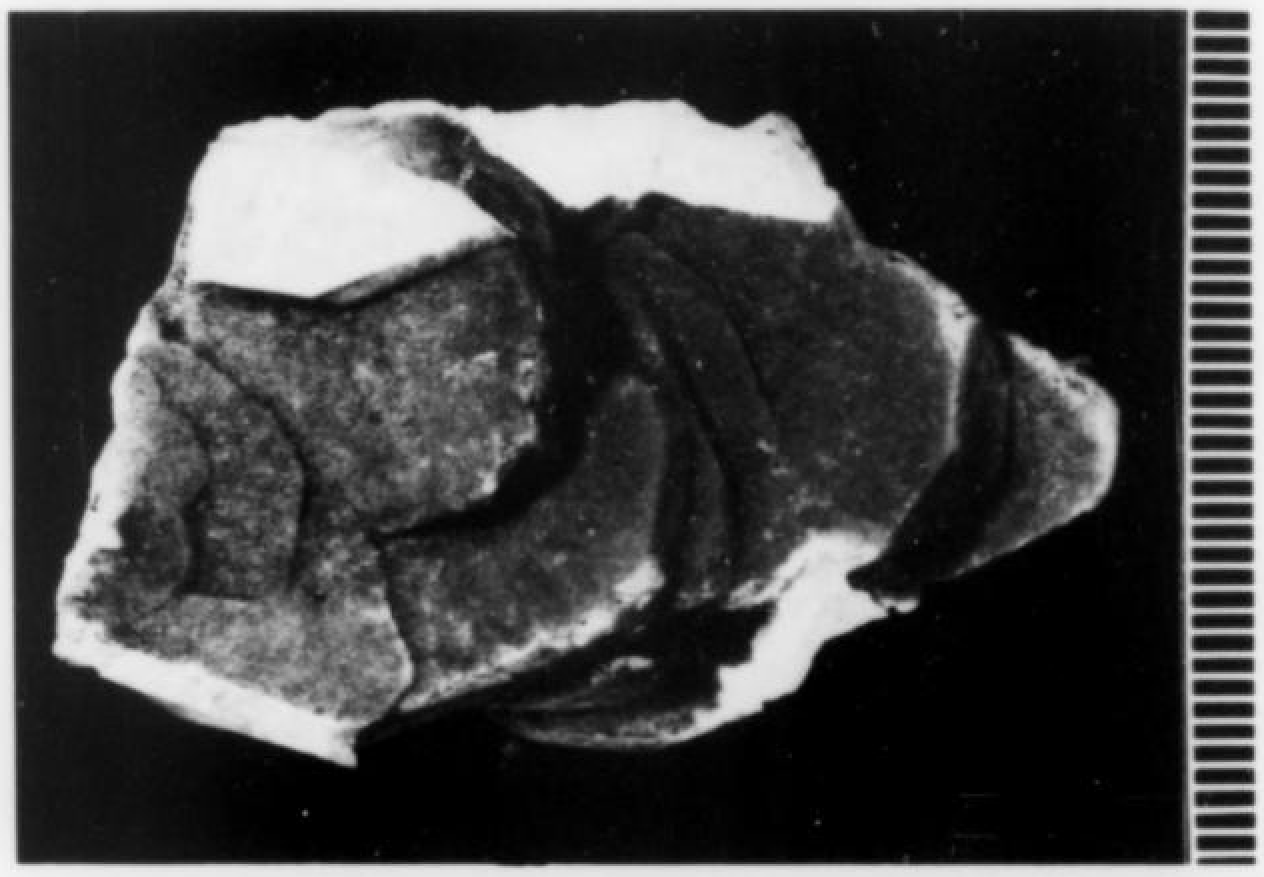


Figure 5. **A group of hydrocerussite crystals (pearly white) measuring 3 x 4.5 cm, from the Merehead quarry. (B.M.No. 1970,107)**

Mendipite [$Pb_3Cl_2O_2$]. The earliest reference to mendipite is given in Woodward (1728) and several specimens of mendipite collected from small manganese workings at that time are in the Woodward collection. In 1823 Berzelius described analyzed samples from a locality near Priddy. At Merehead quarry mendipite occurs commonly in the manganese-rich veins, especially in the No. 1 Vein, where it is found as irregular lumps filling cavities as well as thin veinlets which cut the black manganese oxides. When in cavities in the oxides, it has the characteristic alteration rim of hydrocerussite and cerussite. Broken surfaces show slightly translucent, silky, lustrous, cleavage plates and columnar or fibrous aggregates, varying in color from a waxy brownish-cream to white, and often pinkish-purple. No free-growing crystals have been found. In three specimens collected from Vein 1, an unknown red mineral was found as small crystals embedded in mendipite: this has proved to be a new lead molybdenum oxychloride.

Chloroxiphite [$Pb_3CuCl_2(OH)_2O_2$] was first described by Spencer and Mountain (1923) from the Higher Pitts locality and is still known only from the Mendips area. During the early 1960's several very rich pods of mendipite containing chloroxiphite were discovered at Merehead. In these the mineral forms subparallel groups of olive-green, bladed crystals, often curved, embedded in the mendipite. The crystals are brittle and friable and where they are broken a yellow-green powder can often be seen. Crystal groups up to 4 cm in length have been collected (Fig. 9). Diaboleite is often associated with the chloroxiphite, apparently as an alteration product.

Diaboleite [$Pb_2CuCl_2(OH)_4$] was also first described and recorded from Higher Pitts by Spencer and Mountain (1923). At Merehead it is mainly associated with chloroxiphite but is also found in hydrocerussite or mendipite where it may occur as azure blue, broken or poorly-formed prismatic crystals up to 9 mm in length, or as fine-grained, pale blue aggregates, often in the centers of chloroxiphite crystals.

Paralaurionite [$PbCl(OH)$] is rare at Merehead quarry but has been found in some of the manganese-rich oxide pods in Vein 1, where it occurs either as orange-yellow or light sulfur-yellow to almost colorless corroded masses with perfect cleavage. The translucent, sulfur-yellow material has been found in hydrocerussite and cerussite cavities in the black manganese oxide, and also intergrown with mendipite. It appears to alter readily to cerussite. The largest specimen in the collection at the British Museum [Natural History] measures 2.2 cm x 1.4 cm. Paralaurionite has not been recorded from other localities in the Mendips.

Blixite-like mineral. [blixite is $Pb_2Cl(O,OH)_2$] Reddish orange-yellow to pale yellow coarsely-crystalline masses of a mineral showing a vitreous lustre and good cleavage occur commonly in Vein 2. It is usually associated with hydrocerussite and cerussite although one specimen shows an intimate association with mendipite. X-ray studies give a powder pattern slightly different from type blixite; wet chemical and microprobe analyses are close to the original analysis of blixite from Långban, Sweden except for a slightly lower lead content, higher chlorine, and a small amount of boron. This mineral appears to be distinct from blixite. Boron appears to be a significant constituent of this assemblage, and is found elsewhere in the deposit in datolite.

Cerussite [$PbCO_3$] and **hydrocerussite** [$Pb_3(CO_3)_2(OH)_2$] occur with nearly all of these oxychloride minerals, commonly as an alteration rim around mendipite. Hydrocerussite forms vitreous, pearly, transparent to translucent crystalline groups some of which are 6.5 cm x 6 cm and are the largest known (BM No. 1969, 162) (Fig. 4). It occurs as nodules in cavities and again as veinlets in the black manganese ore. Both minerals often show a surface coloration of lime-green to yellow, which so far has not been distinguishable by X-ray or chemical means from the underlying material. Groups of tabular crystals (common in cavities) of hydrocerussite can be found; the pearly lustre shown

***Figure 6.* A layered group of platy crednerite crystals (black) with white calcite in psilomelane, from the Merehead quarry. Size: 1.5 x 3.5 cm.**

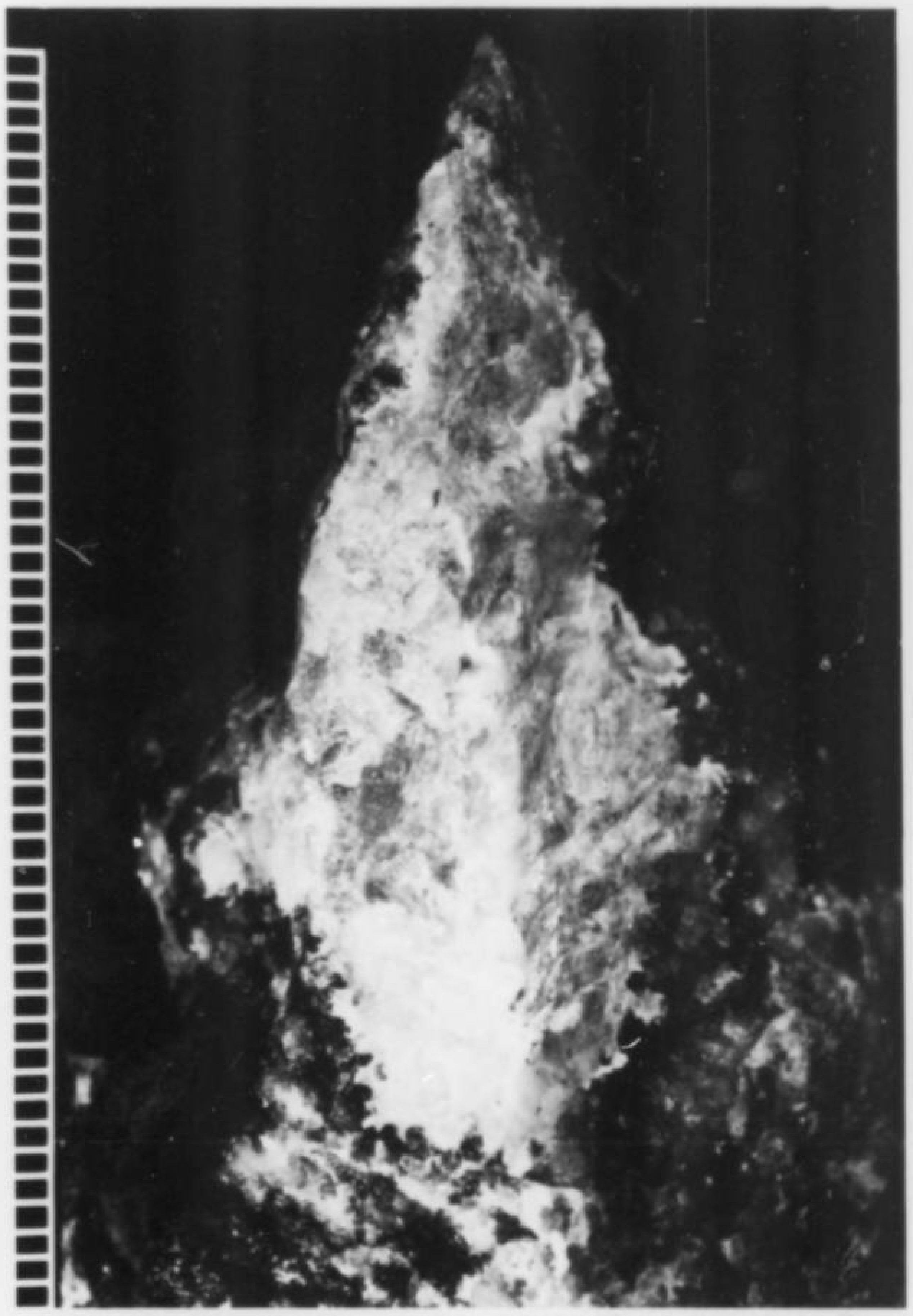


***Figure 7.* Cleavage mass of a blixite-like mineral (yellow-orange, right) with white calcite and hydrocerussite from the Merehead quarry. Size: 1 x 2.8 cm.**

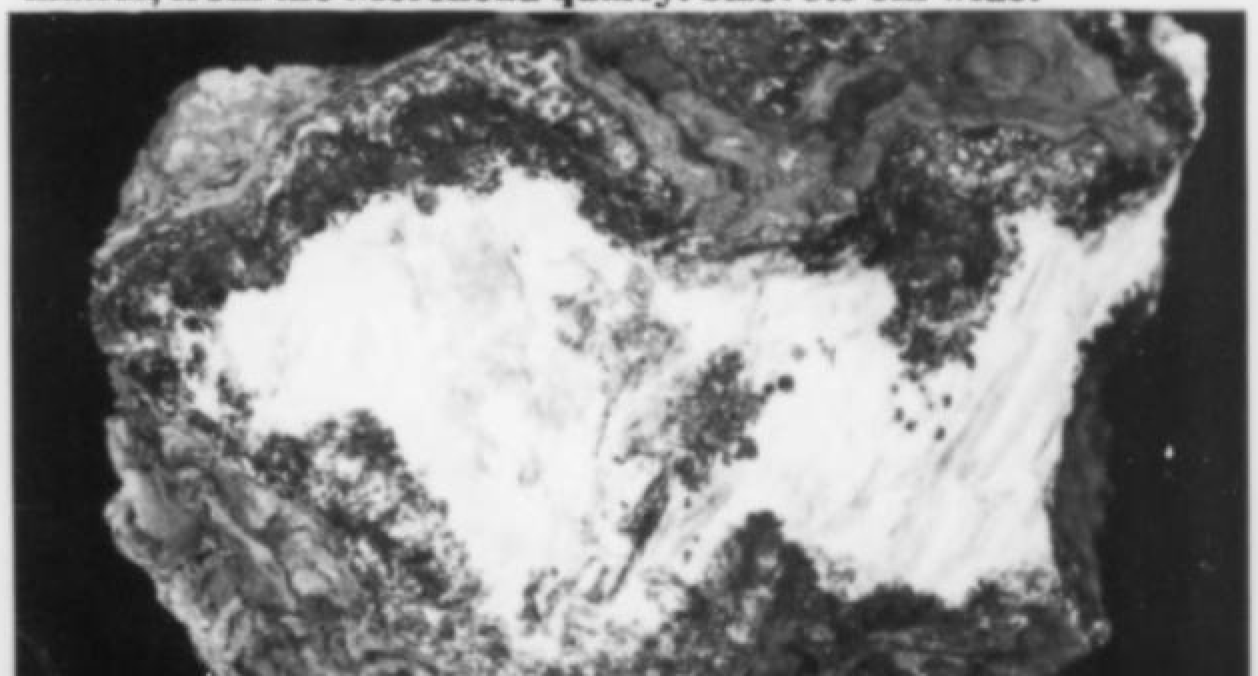


***Figure 8.* Mendipite (pale pink) showing typical alteration rims of hydrocerussite and cerussite in manganese oxide matrix, from the Merehead quarry. Size: 5.6 cm wide.**

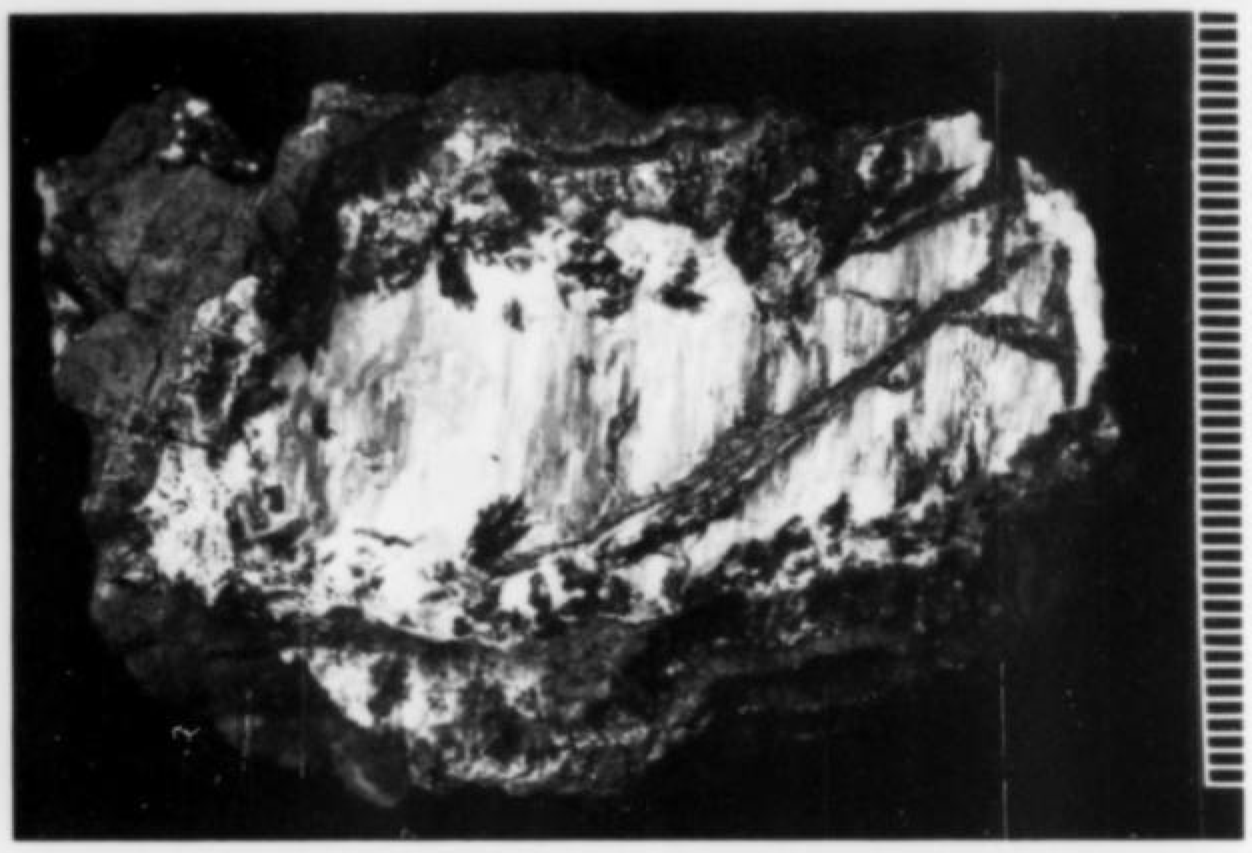


Figure 9. **Mendipite (white) cut by blades of chloroxiphite (dark green) from the Merehead quarry. Maximum length of blades = 4 cm.**

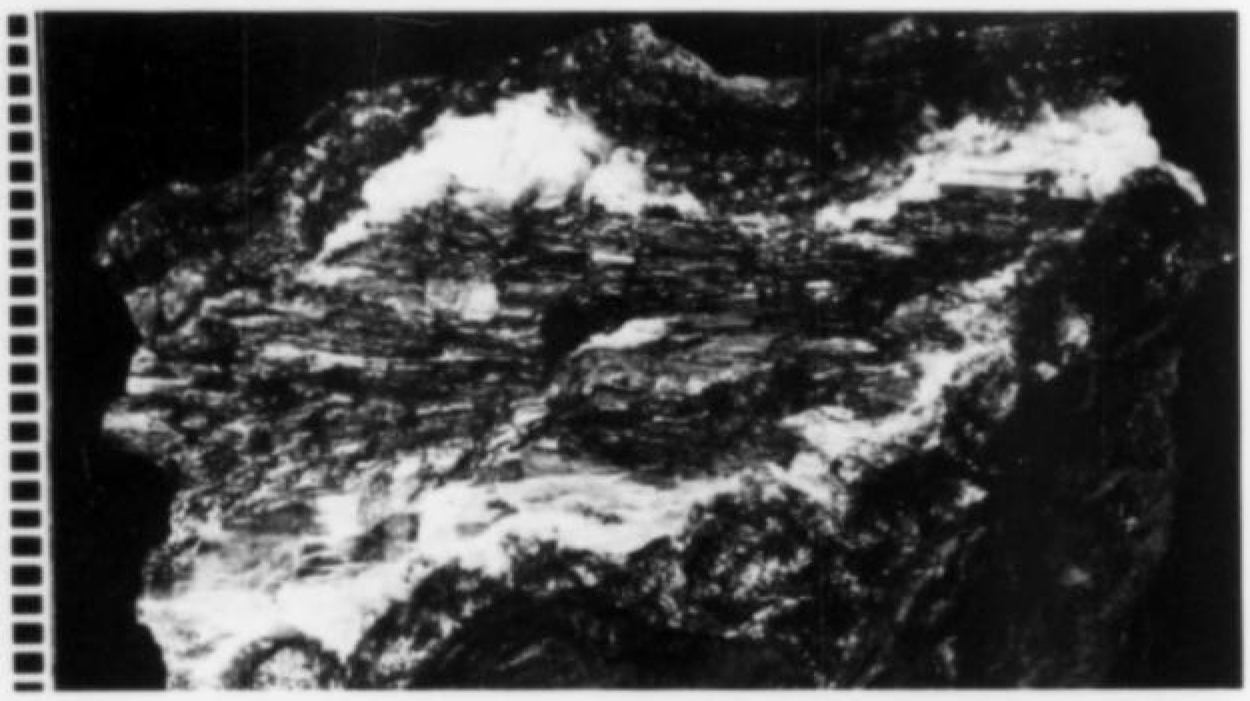


Figure 10. **Bladed crystals of chloroxiphite (dark green) in mendipite (white) from the Merehead quarry. Maximum dimension = 4 cm.**

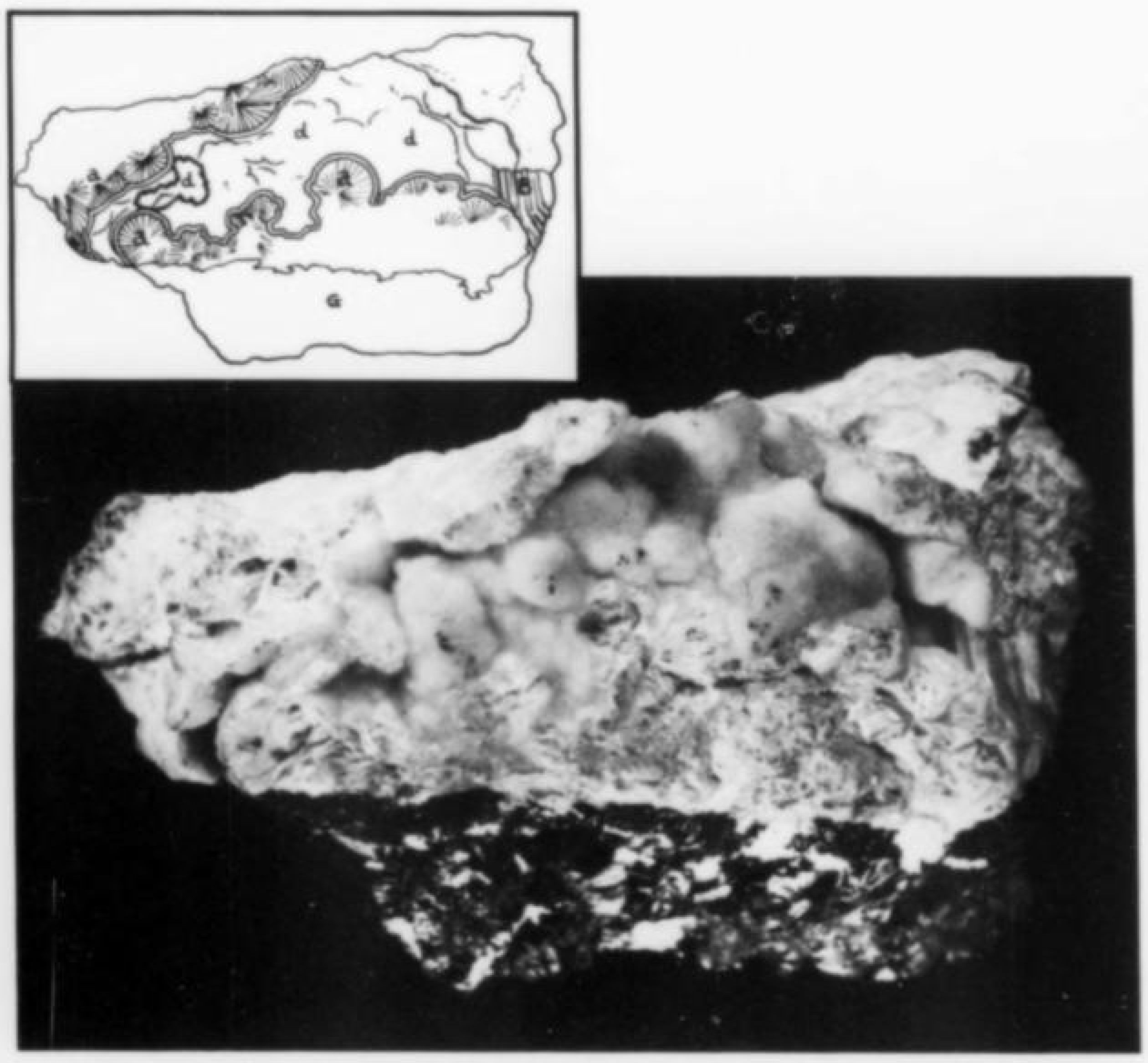


Figure 11. **Transparent datolite crystals and crusts (d) formed on botryoidal apophyllite (a) and barite (B), all on a matrix of goethite (G), from the Merehead quarry. Datolite and apophyllite have not previously been reported from the Mendips. Maximum dimension = 11 cm.**

on broken surfaces is due to the mineral's perfect (0001) cleavage. Cerussite, however, is often pseudomorphous after hydrocerussite; the latter is sometimes altered to an amorphous, white, dusty mixture. Corroded but large clear cerussite crystals are common, as are well-formed groups of reticulated twins. Emission spectrography indicates traces of strontium and barium in the cerussite but not in the hydrocerussite; strontium is often found in the Mendips as the mineral celestine, important in the Triassic of this area. It is interesting to note that the lead sulfate, anglesite, has yet to be found in the association of carbonates and oxychlorides, as have the lead carbonate chloride, phosgenite, and some of the other known oxychloride species. These absences must be taken into account in establishing conditions for the formation of the observed species.

Crednerite [$CuMnO_2$] was recorded and described by Spencer and Mountain (1923) from the Higher Pitts locality, where large, fine, layered groups of plated crystals were found intimately associated with the manganese oxides. Layered groups of black plated crystals up to 2.5 cm in length, associated with calcite and hydrocerussite or cerussite, are also found at Merehead (BM No. 1965,231). The edges of the crystals often show alteration to tufted green malachite, and X-ray studies show most of the crystals to be at least partially altered to a mixture of copper and manganese oxides. As well as occurring in platy crystals, crednerite at both Higher Pitts and Merehead takes the form of small spherules embedded in mendipite. Most of the larger crystal groups from Merehead were collected from the No. 1 Vein.

Wulfenite [$PbMoO_4$] has been recorded and described from Higher Pitts and is also found at Merehead where a 2.5 cm long crystal group of pale brown, plated crystals has been recorded (BM No. 1970, 118). It is probable that the Coal Measures of the Upper Carboniferous to the north of the Mendips are a possible source of not only the manganese but also the small amounts of molybdenum necessary for the formation of wulfenite and the new lead molybdenum oxychloride.

Pyromorphite and **mimetite** are relatively common throughout the Mendips, associated in the main with ancient lead workings. Indeed, the locality called 'Green Ore' may well have derived its name from the preponderance of pyromorphite in that area. At Merehead, mimetite is more common than pyromorphite,

Figure 12. **Poorly formed prismatic crystals of diaboleite (azure blue, center) enclosed in bladed crystals of chloroxiphite (olive-green) in mendipite (white) from the Merehead quarry. Scale is in mm.**

and forms sulfur-yellow, microcrystalline coatings on fractures or joints in the manganese oxide ore.

Datolite, apophyllite, and **barite** in association, overlying some of the goethite veins in juxtaposition to the manganese, are of particular significance since boron has been shown to be a constituent of some of the oxychloride assemblages. The datolite occurs as transparent, well-formed crystals up to 8 mm in length and also forms crusts on botryoidal, intermixed, apophyllite and barite.

PROBABLE ORIGIN OF THE DEPOSIT

Continued quarrying over the past years at Merehead has enabled fresh exposures of the manganese oxides and iron-rich ores to be studied. These exposures are better than any before seen in the Mendips, and have enabled us to suggest a probable sequence of events for the formation of these minerals. The deformation associated with the formation of the Mendip folds caused a system of joints and faults to be developed in the Carboniferous limestone. Some of these fractures became open fissures and solution hollows. Some time after the main folding episode, hydrothermal deposits of galena and minor copper sulfides were deposited in the fissures, along with some silicification of the fissure walls. A later stage involved the reopening of some of these fissures, particularly the north-north-east set, and with the apparent erosion of large quantities of the Coal Measure deposits of this area, iron and manganese were introduced into the fissures, fractures and possibly cave deposits. The indication is that the manganese was transported in the form of an oxide or hydroxide suspension in brine, since there is relatively little rhodochrosite present to indicate appreciable reaction of the manganese solutions with the limestone. High temperatures must be precluded for many reasons, such as the absence of iron and manganese silicates, and the hydrated state of several of the mineral species. The next stage was unusual, in that it involved prolonged reaction between the galena and copper sulfides and the manganiferous saline solutions to produce the minerals we observe today. Finally, there appears to have been another phase of iron mineralization that follows one of the dominant joint sets in the limestone of Merehead quarry, cutting across some of the earlier manganese veins (Fig. 3).

This unique assemblage of lead and copper oxychlorides makes the Mendips an interesting area mineralogically. Brines have often been postulated as mineralizing agents, but in other deposits they have usually left little trace apart from occasional liquid inclusions trapped in crystals. In the Mendips, the chloride ions of the brine have become incorporated as an essential constituent of the minerals as a result of some unusual conditions. It may be, however, that the unusual feature is not the formation of these rare minerals, but their having been protected by the surrounding manganese oxides from subsequent dissolution.

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Photographic Record

More German Minerals

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Some notes on the photography

For mineral photography I use a 6 x 6 cm (2¼-square in inches) Rolleiflex SL 66 with an integrated bellows allowing close-up photography to a scale of 1½:1. For larger specimens I use an 80 mm Zeiss-Planar lens, occasionally in the reverse position, sometimes employing daylight but usually using several photo floods with diffusing screens. For a background I prefer either black or white but with white it is sometimes difficult to avoid multiple shadows.

For magnifications exceeding 1½ the camera is attached to a copy stand and additional extension tubes are used. with a Zeiss-Luminar macro lens of either 25 mm or 63 mm focal length. The camera in Figure 1 is arranged for the photography of the faujasite (Fig. 4) with a magnification of 10x. To reduce vibrations that could drastically reduce sharpness the extension tube is connected by a bar to a deadweight (a metal cylinder filled with lead).

A fiber-optic light source (Schott lichtquelle KL 150) is very effective for illuminating the smaller specimens, as shown in Figure 1. In addition to this light source, small screens of translucent paper are often used to soften the light and avoid excessive contrast. For the final exposure the shutter is not used; instead the shutter is opened with the light off, then the light is turned on for the appropriate exposure duration, the light is then turned off, and finally the shutter is closed. This procedure also helps to avoid vibration (Betz, 1974).

I use Agfachrome 50L for color photography, and an exposure time of from 1 to 30 seconds. Filters must be used to compensate for the type of color film used and color-temperature of the light sources.

One very important aspect of mineral photography (and macrophotography in general) is the use of the optimal aperture. An aperture that is too small will reduce sharpness drastically because of diffraction around the opening; an aperture that is too large will lead to a very shallow depth of focus. Therefore mineral photography which requires much depth of field is limited to a magnification of 10-12. At greater magnification the depth of field becomes too narrow (e.g. 0.03 mm at 15x and f/5.6) and with a smaller aperture the sharpness suffers.

One special lens for macrophotography, the Zeiss-Tessovar, is useful for magnifications of up to 25x but photography through stereo microscopes of the kind used by micromounters produces poor results except with very flat or polished specimens.

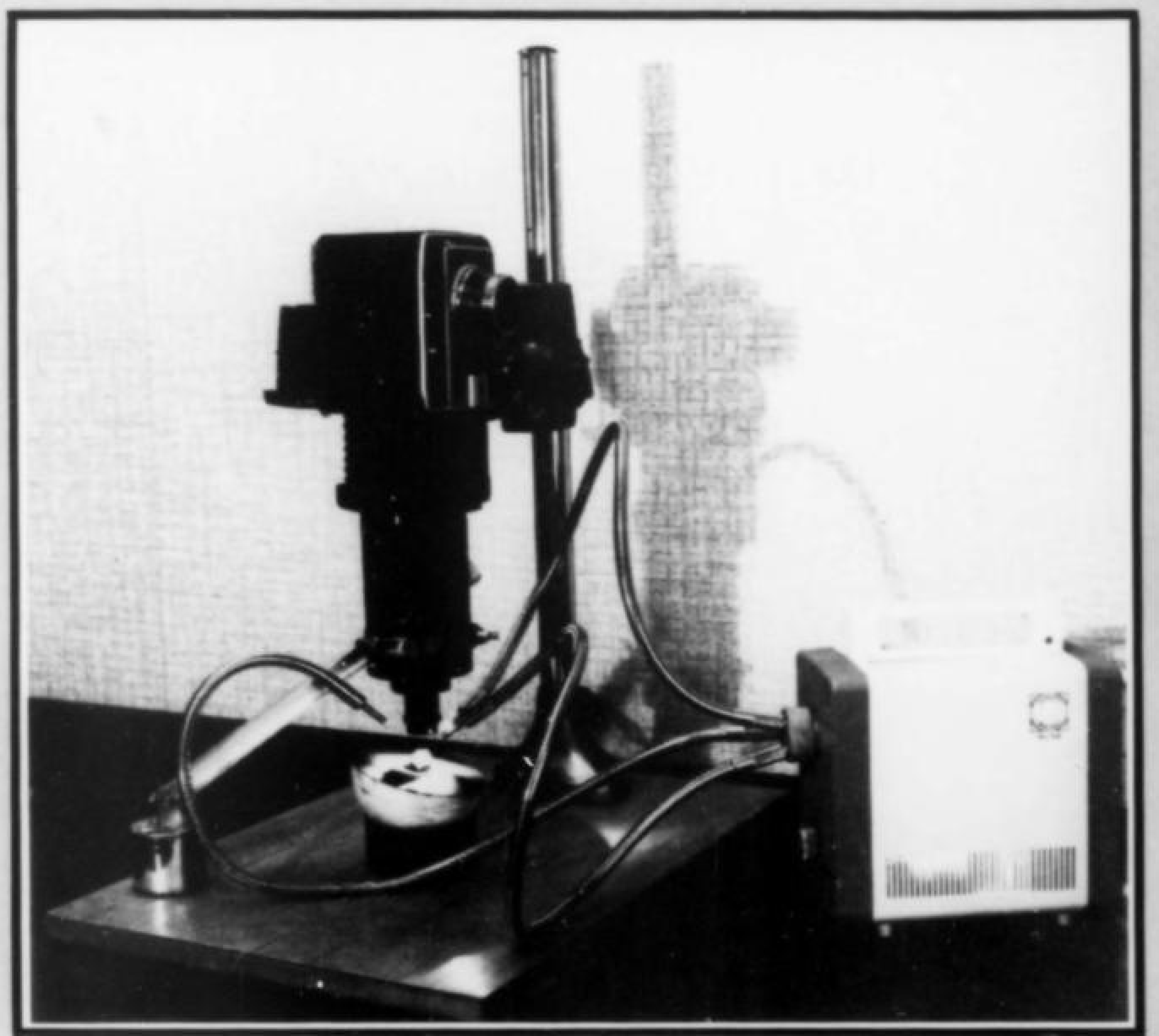
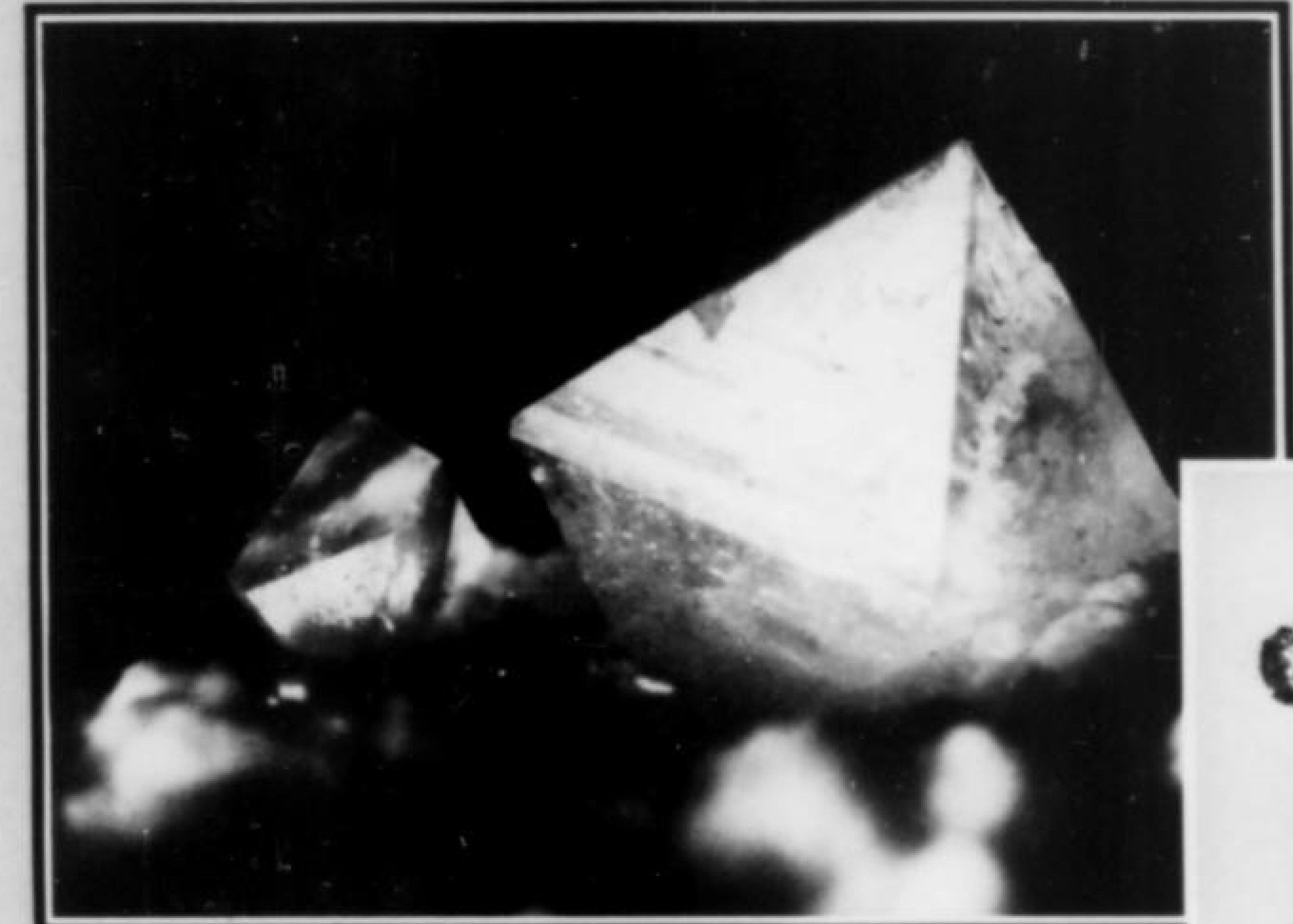


Figure 1. (above) **The 6 x 6 cm Roleiflex SL 66** on copy stand with fiber-optic light source by Schott, arranged for photography of the faujasite (Fig. 4).

Figure 2. (below) **Harmotome** on calcite from Oberstein/Nahe, Rheinland-Pfalz. The left crystal is a double twin, the right crystal is a 1.5 cm twin of reddish cream color. It is an old specimen; the label is dated 1889. The exact locality may be Karscholz, an area near Idar-Oberstein which is known for harmotome crystals to 2.5 cm (Dern, 1970). Harmotome can still be found near Idar-Oberstein but the usual size is 5 mm (Collection of V. Betz).

Figure 3. (left) **Phillipsite** twins of a yellowish white color and 3-4 mm in length from Oberwiddersheim near Nidda, Vogelsberg. The Vogelsberg basalts have been known for phillipsite and other zeolites since the 1800's (Naumann-Zirkel, 1901). In recent years there were good collecting possibilities at the lowest level of a large quarry at Oberwiddersheim. Chabazite, natrolite, analcime, calcite and phillipsite crystals to 1 cm were found. The most remarkable find is chabazite in well developed multiple twins ("phakolite") to more than 2 cm. Operations in the zeolite-rich area of the quarry have stopped for the present and good specimens are no longer being found. (Collection of V. Betz)

Figure 4. (below) **Faujasite** octahedrons (0.5 mm) with **phillipsite** spherules and **erionite-offretite** needles from Limberg near Sasbach, Kaiserstuhl, Baden. Limberg is the type locality for faujasite, first described by Damour in 1842. The mineral was found in crystals up to 3 mm (Wimmenaur, 1959) but the more common size of 0.5 mm crystals can still be collected; the pictured specimen was collected in March of 1976. Faujasite with phillipsite and erionite-offretite has been described by Rinaldi (1976) and Hentschel (1976). (Collection of V. Betz)



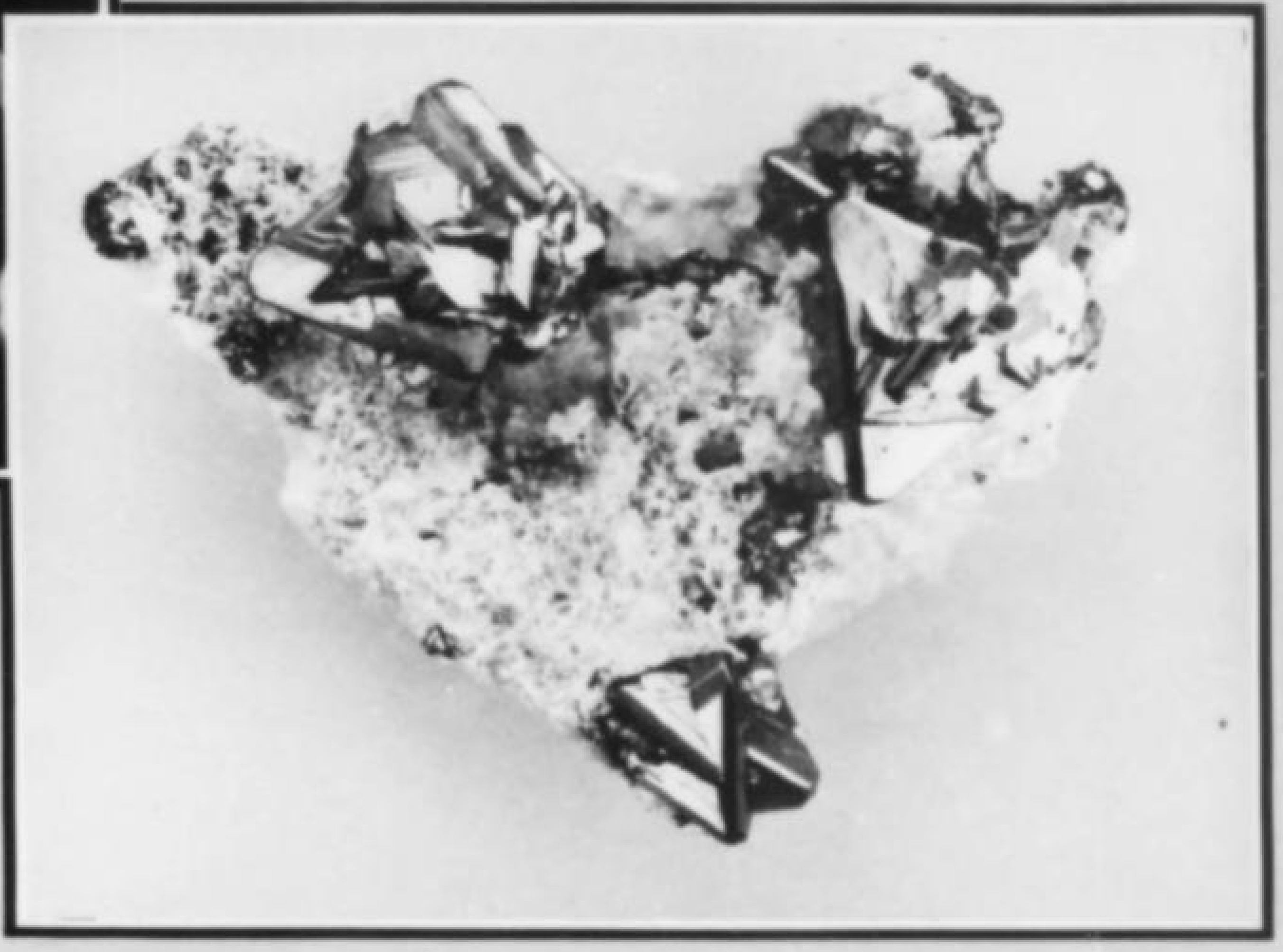
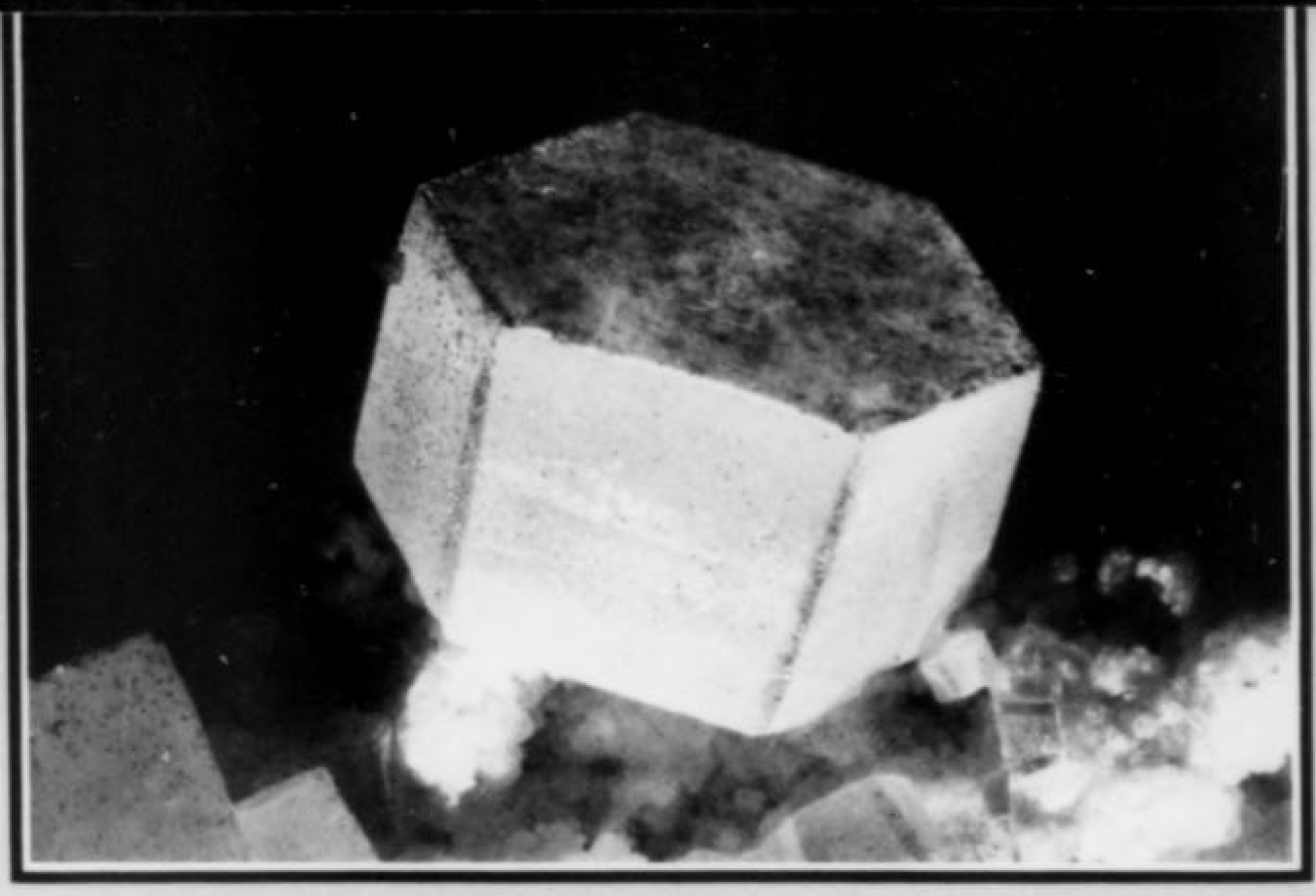


Figure 5. (above) **Gismondine** in white, transparent multiple twins on phillipsite from Arensberg near Zilsdorf/Eifel. The size of the larger crystal is 2.5 mm. The occurrence of this relatively rare zeolite in an abandoned quarry in Tertiary basalt has been described by Hentschel (1973). Gismondine is still found there in well developed crystals to 4 mm, associated with phillipsite, thomsonite, natrolite, apophyllite, calcite and tobermorite. (Collection of V. Betz)

Figure 6. **Tennantite** crystals on quartz from Mackenheim, Odenwald. The specimen is 3 cm wide. Mackenheim in the Odenwald (Odin's Forest) is one of the most surprising of new German mineral occurrences. The locality is a quarry in metamorphic rock. During operation of the quarry several mineral-bearing veins and quartz lenses were encountered. Calcite crystals from this locality are the most famous with collectors but bismuth, bismuthinite, cosalite, safflorite, chloanthite, emplectite and many others, over 30 in all, have been found (Fettel, 1973, 1976). Recently some pitchblende was also found and drilling was done to investigate the economic possibilities of the uranium content. (Collection of V. Betz)

Figure 7. (left) **Bismuth**, dendritic crystals partly covered with **safflorite** crystals from Mackenheim, Odenwald. The specimen is 3 cm in size. (Collection of V. Betz)



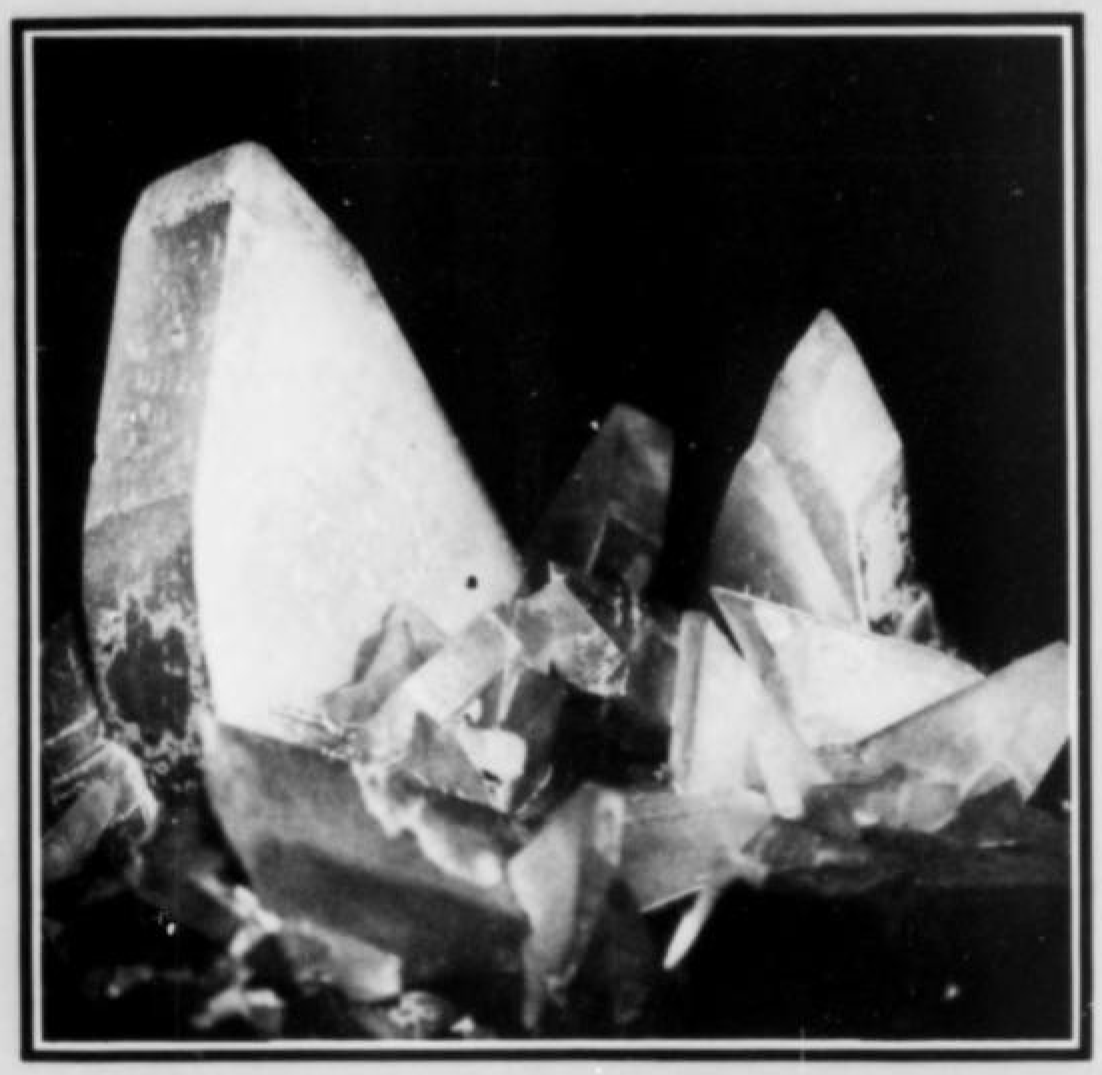


Figure 8. **Picropharmacolite**, white needles on barite from Grube Anton (Anton mine), Heubachtal, Wittichen mining district, Black Forest. The crystal spray is 8 mm across. The area around Wittichen is a very old mining district; first mining records date from November 7, 1517. During the 18th and the first part of the 19th century 52 mines operated on veins in a Co-Ni-Ag-Bi-U formation, but only a few mines persisted into more recent times (Wohleb and Schilli, 1950; Osann, 1927; Henglein, 1924). The last two mines to close were Grube Sophia (closed in 1856) and Grube Anton im Heubachtal (closed in 1864). The mines produced cobalt ore which was smelted in a factory near Wittichen to cobalt-blue and largely exported to the Netherlands. A third of the profit was attributed to silver; in May of 1760 1200 kg (2600 pounds) of native silver were found at Grube Sophia. After the Second World War the old mines and dumps were investigated for their uranium content (Kirchheimer, 1952) and many secondary minerals were subsequently collected. Walenta (1972) reported 88 secondary minerals and more than a dozen primary minerals known from Wittichen. The old dumps are still visited by collectors and, with enough perseverence, zeunerite, heinrichite, novacekite, mixite, erythrite, walpurgite, wittichenite, emplectite and silver can be found. (Collection of V. Betz)

Figure 9. **Calcite**, a white, hexagonal-prismatic crystal 1 cm in size from Mackenheim, Odenwald. (Collection of V. Betz)

Figure 10. **Barite**, the so-called "meisselspat" ("chisel spar"), in yellowish brown crystals from Grube Clara in Rankachtal near Oberwolfach, Black Forest. The largest crystal is 3 cm. Grube Clara is the last mine operating in an old mining district. The earliest mining documents date from 1652. Since 1850 the mine has produced barite, and even recently fine specimens have been found. The mine is also known for water-clear fluorite crystals and fine but small secondary minerals. Walenta (1975) reported 53 secondary minerals. The most abundant are malachite, olivenite, cornwallite, chlorotil, barium-pharmacosiderite and scorodite; collectors are admitted to the dumps at the barite mill near Wolfach for a fee of about $1. (Collection of V. Betz)

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Figure 11. (left) **Heinrichite** (yellow) with **erythrite** (pink) and Fe-arsenates on quartz from Schmiedestollenhalde, Wittichen, Black Forest. The large heinrichite crystal measures 1 mm. (Collection of V. Betz)

Figure 12. (above) **Linarite** with **malachite** on limonite from Grube Viktoria, Littfeld, Siegerland. The large crystal is about 1 mm long. Grube Viktoria is one of the Siegerland mines which operated in siderite veins and produced many fine mineral specimens. The most famous of the mines is Grube Wolf, source of superb rhodochrosite (see *M.R.* 7, #5, p. 229. Ed.). The last mine in the area closed in 1965 and collecting has almost stopped. The specimen pictured was collected by Dr. Leyerzapf, Eschborn, on the dump in the late 1960's. (Collection of V. Betz)

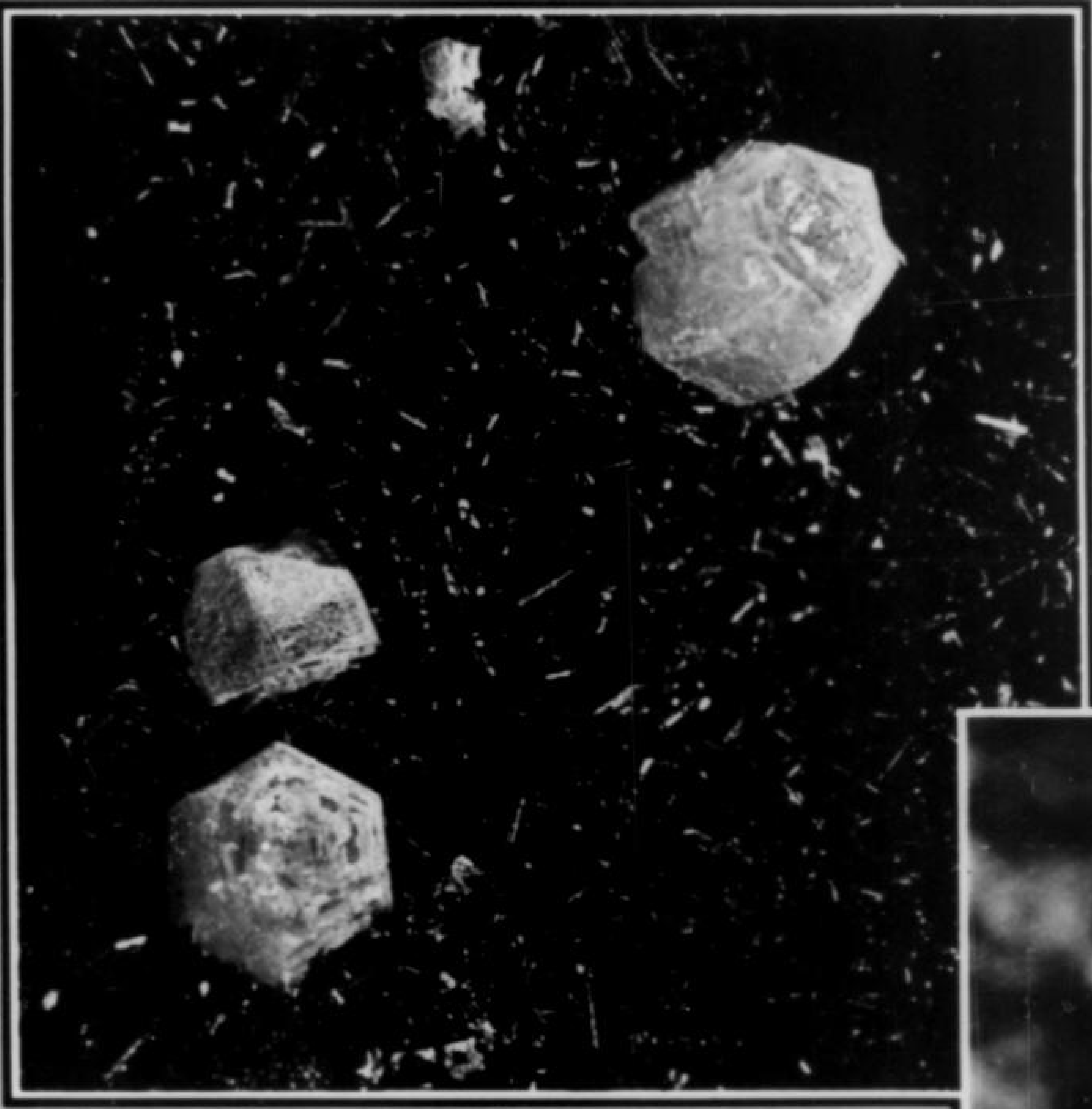
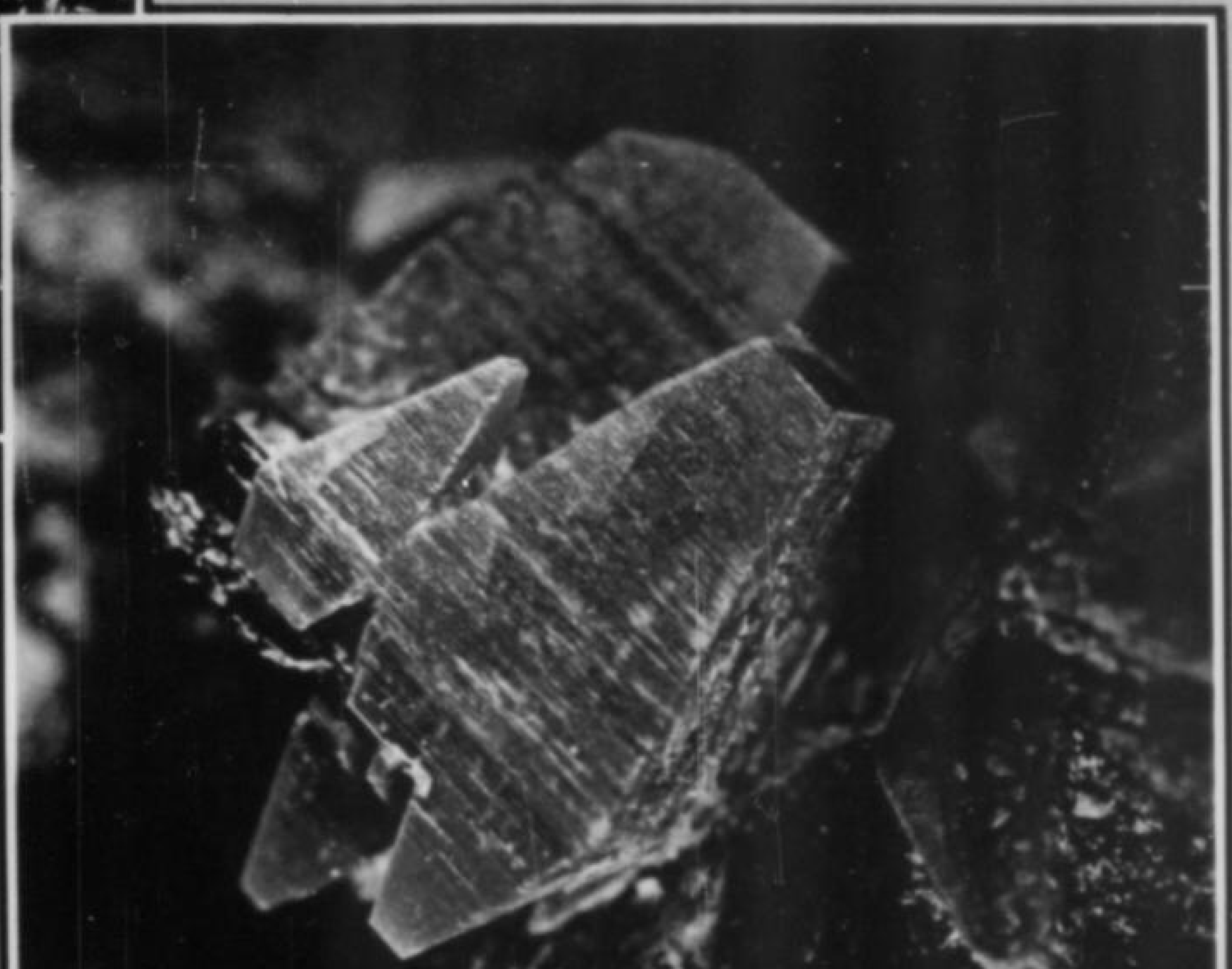
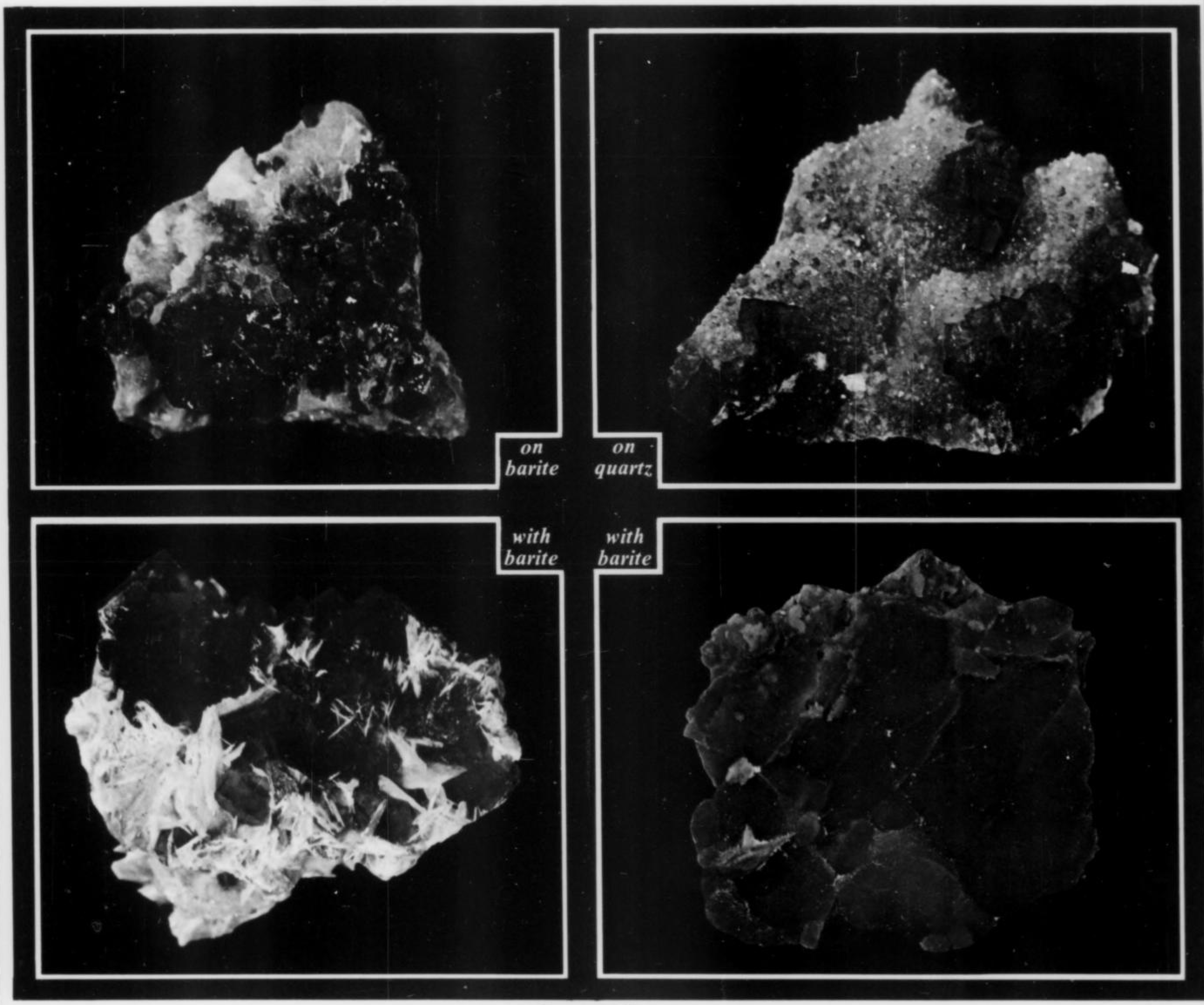


Figure 13. (above) **Pyromorphite** on **azurite** from Grube Phillipseck near Munster, Taunus, Hessen. The pyromorphite crystals are about 2.5 mm in size. Grube Phillipseck is one of several small, old mines at Taunus where the dumps were rediscovered by a collector's intensive search (Werner, 1973) after reading older publications (Köbrich, 1936). Nice specimens of azurite can be found easily on the dump but azurite with pyromorphite, as shown, is extremely rare. (Collection of V. Betz)

Figure 14. (right) **Metatorbernite** (As-rich) from Krunkelbachtal near Menzenschwand, Black Forest. The crystal measures 3 mm. Fine uranium minerals such as this were discovered in 1957 (Kirchheimer, 1964). Twenty-nine secondary uranium minerals have been reported (Bültemann, 1965; Walenta, 1967), some of very fine quality. The mine operates occasionally but is now closed to all collecting. (Collection of K. Pettijean, Worms)



fluorite


on barite

on quartz

with barite

with barite

from the
Font Sante Mine.
Esterel. Var. France

by
Frank A. Wilson
6 Pembroke Gardens
London W86HX England

Collectors, even in France, remain mostly unaware of the subtle beauty of the Esterel fluorite, although many must pass that way to the famous coastal resorts. Besides fluorite, there are several other minerals of interest. The fluorite veins occur in the Paleozoic region around the Tanneron and further West in the Var. The width of the veins varies from less than a metre up to around 2 metres, penetrating vertically for several hundred metres in the muscovite biotite gneisses. A few kilometres away range the colorful red Permian rocks of the Esterel, extending to the coast, while to the north, 3 to 4 km away, there is a Carboniferous exposure with poor quality coal.

The locality can be reached by leaving the autoroute at Les Adrets, about 15 km west of Cannes. Proceeding in the direction of the village, the road to the **Font Sante mine** turns off to the left after about 2 km. This is by far the largest mine in the region, and has provided the finest specimens. As different levels become exploited, various colors and habits of fluorite, barite and quartz have become available, so that pleasant surprises are always possible. Recently large specimens of a beautiful orange-pink crystallized quartz have turned up as well as deep mauve fluorite with white barite 'wings'. When mining and sorting were largely carried out by hand, good specimens were abundant. But recently mechanization and acid treatment on the site leave much less chance of good specimens surviving, the same sad story as in so many localities. But the miners have a good eye and, in spite of official discouragement, still salvage beautiful specimens. There are old dumps outside the mine enclosures, and material from the autoroute roadcuts is worth examining.

Minerals

The minerals are dealt with here in order of their potential interest to collectors:

Fluorite, CaF_2. Crystals are mostly cubes or modified cubes; modified octahedrons are rare. The habit most characteristic of the site is a sage-green variety built up of small cubes resulting in roughly curving forms resembling Paterson (New Jersey) prehnite. Unfortunately, the color tends to fade, although in some specimens it has held sufficiently well over several years. Other varieties: **(1)** fine, pale ochre yellow, limpid crystals often with mauve zoning, **(2)** a similar yellow color interspersed with pinkish mauve patches, **(3)** an orange yellow with snow-white barite, **(4)** dark and light violet, **(5)** a grayish green mauve which changes color under fluorescent light, **(6)** pale, clear grays, **(7)** a rare bluish mauve, **(8)** a red, due to included chalcedony, **(8)** light to dark brown, clear or zoned, **(9)** colorless or milky white, **(10)** a very pale clear pink. Some of the yellow varieties with a discreet irridescence are colored by a film of organic material. Zoned reddish brown to dark brown organic inclusions are common in some veins, as are dusty sulfides and zones or whisps of cloudy material, either barite or sellaite. The green and muave colors appear to be closely related to microparticles of sulfides, the color diffusing out around them. Striking, irridescent specimens are occasionally found.

Attractive combinations of mauve cubes on snow-white quartz and barite, with overgrowths of minute, sparkling quartz crystals, barite 'butterflies,' and shining marcasite have been found. Massive fluorite also comes in a beautiful sea-green color, with color banding in mauve and yellow. Elongated cubes, in minute parallel columns with stippled and stained modified cube edges provide interesting micromounts.

A fine snow-white dust, at times stained and usually indicating the direction of deposition, is very common and difficult to remove. But when white it can add to the beauty of a specimen, 'shadowing' the forms. The 'prehnite-like' growth produces occasional interesting stalactitic specimens, well crystallized on both sides and on most edges and beautifully translucent.

Fluorescence is variable, apparently more intense in the more colored varieties.

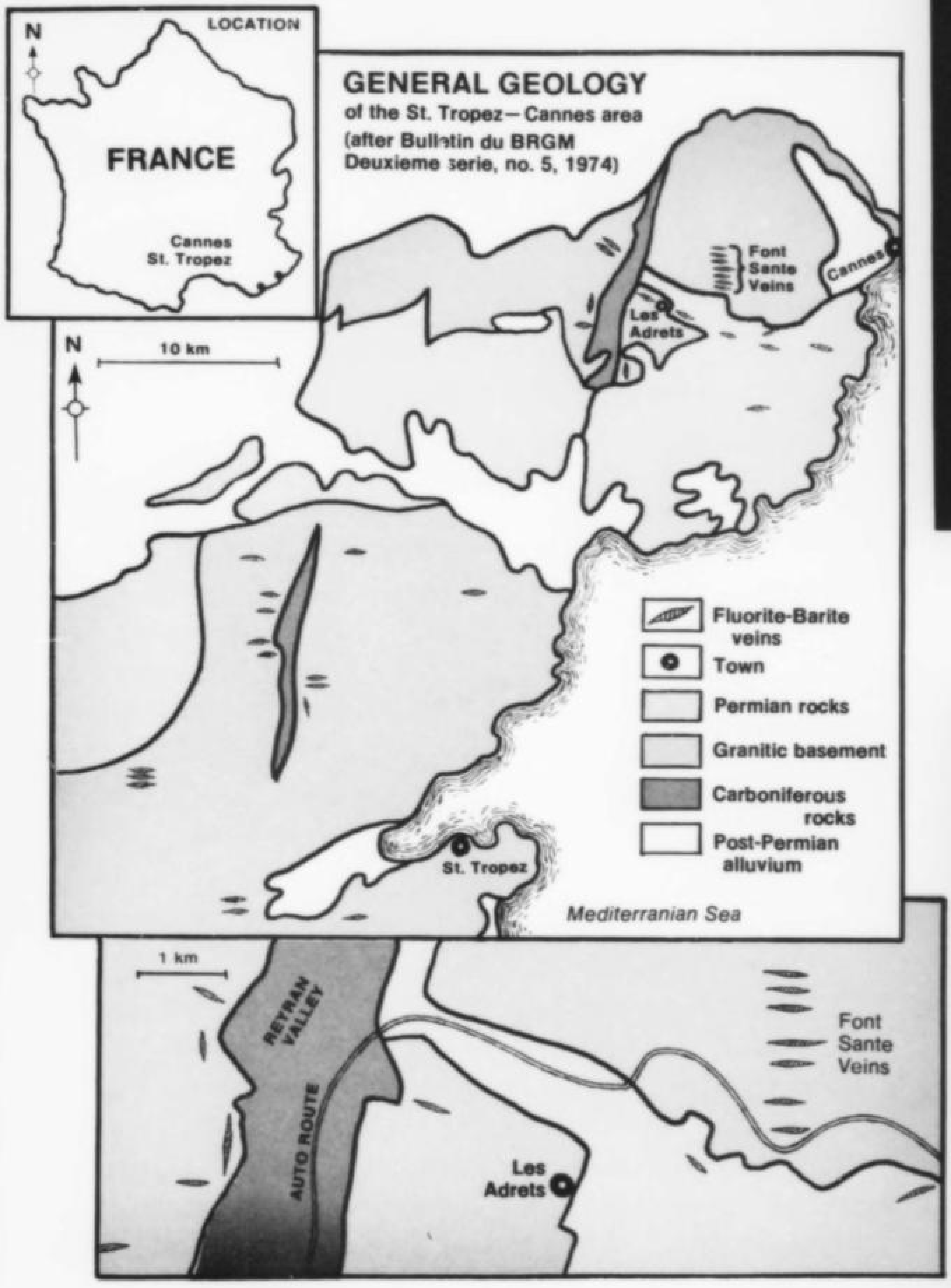
Barite, $BaSO_4$, is plentiful and very fine specimens have turned up, with white, cream or clear, colorless, curved blades up to 25 cm. Delicate 'butterflies,' covered with drusy quartz rest attractively on the fluorite. Attractive roseate forms also result, with vistas into the colored fluorite beneath. Pale, clear yellow blades contain parallel acicular inclusions which appear to be a sulfide.

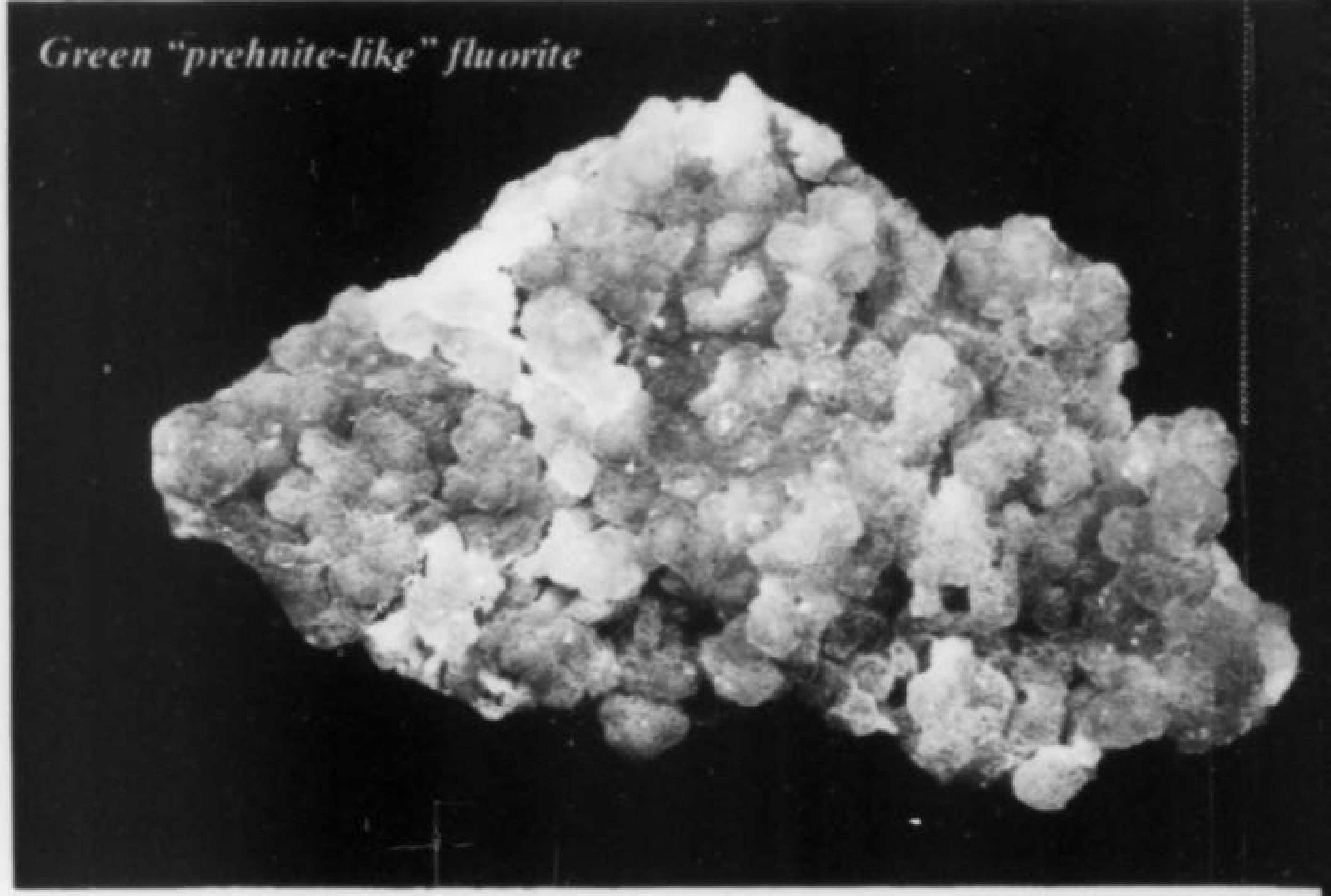
Quartz, SiO_2. The small, very bright, clear crystals on the fluorite are of micromount interest owing to their twinning; Dauphine twins are common as well as other unusual types of twinning. Owing to air spaces left between faces in heaped up groups, some specimens sparkle beautifully. Coralline reddish orange effects are due to included chalcedony. For micromounters there are brick-red chalcedony pseudomorphs after quartz crystals. Very pale blue limpid crystals result from included marcasite crystals. Growing over the prehnite-like fluorite forms, the quartz itself assumes mamillary, 'organic' aspects, white, green yellow, or orange color and, when clear, allows the fluorite color to show through. Some of these effects are of great beauty. In some specimens, the supporting fluorite has been dissolved away leaving extremely delicate shrouds of minute quartz crystals. Calcite has also left delicate molds of crystalline quartz outlining scalenohedra.

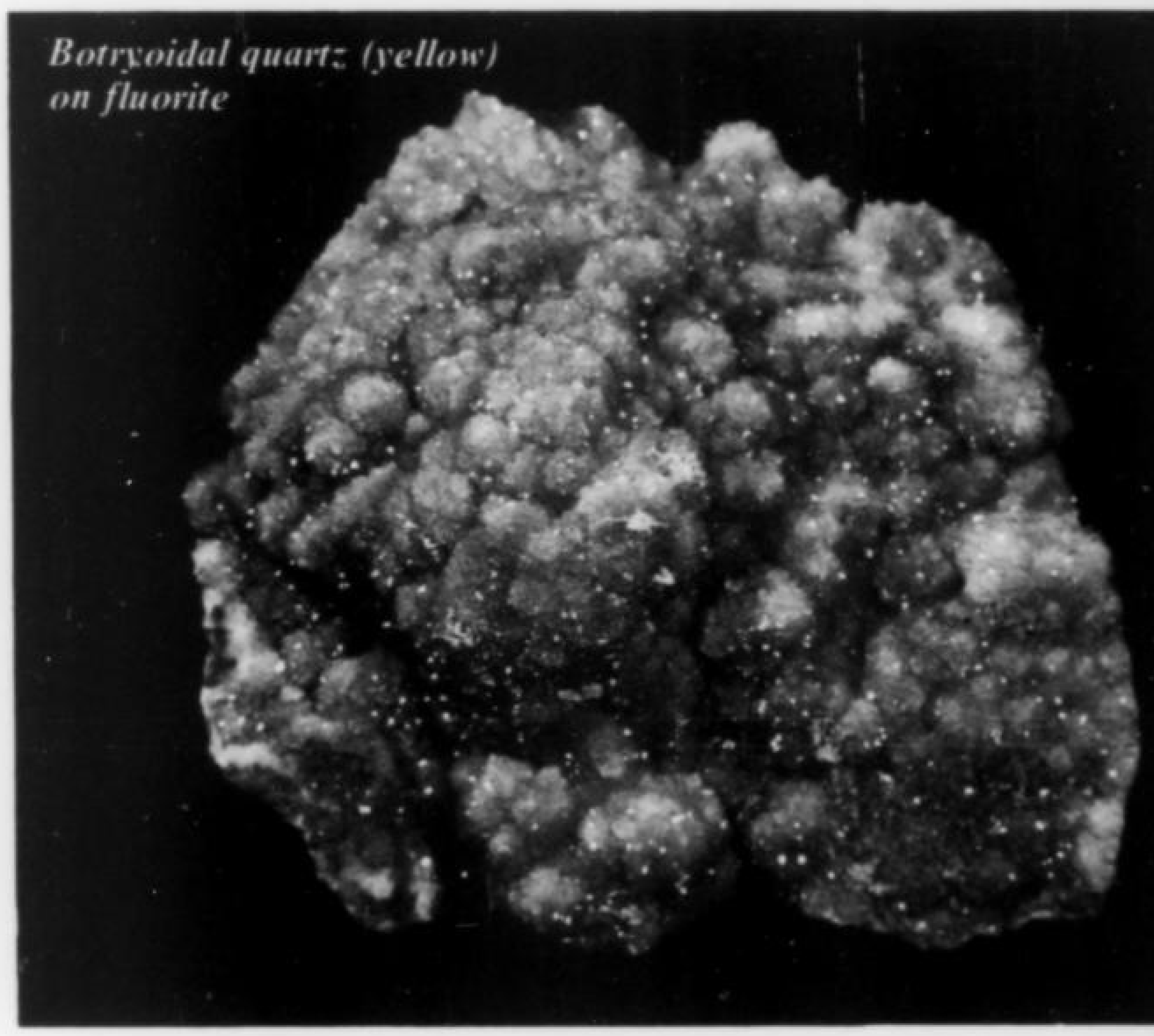
Marcasite, FeS_2, is plentiful as minute six-sided plates, very thin or thickened by twinning. The color is a very bright gold or silver due to a curious, zoned, parallel growth of bright micro-marcasite or pyrite crystals on the surface of the plates. Marcasite 'roses' up to 3 or 4 cm occur. The plates also tend to cluster in attractive winged forms on the fluorite, partially penetrating. The bright marcasite appears to be very stable; when dull gray alteration occurs more rapidly.

Pyrite, FeS_2. Although quite showy specimens are found elsewhere in the Esterel (e.g. at Boulouris), the crystals at the Font Sante mine are usually mediocre. However, eel-like forms up to 3 to 4 mm have been found and curved crystals abound.

Sellaite, MgF_2. A rare, unusual mineral, it is found here in surprisingly large amounts (up to 6% of the mined material at Font Sante). It is commonly present in fluorite specimens as cloudy whisps, or associated with micro-clusters of chalcopyrite, but as barite occurs in much the same habit, only a microscopic ex-




Green "prehnite-like" fluorite


Botryoidal quartz (yellow) on fluorite

amination can distinguish between them. However, virtually pure seams of sellaite have been found, of a pale whitish brown color which intensifies on moistening, in zones in which the sellaite assumes fibrous, crystalline, radiating forms. Distinct crystals of sellaite have not been found.

Organic material, as a brown, bituminous substance, especially in barite crevices, is common. Small, extremely bright, shining balls, perfectly round, of apparently the same material also occur. Dull, blackish brown spots occur on the surfaces of crystals, or as zones in their interior. This material has been studied by G. Mari, M. Boucarut, and G. Turco; a report in the Bulletin of the French B.R.G.M. is in press.

Other minerals, in small to very small amounts, are encountered: **galena**, in extended cubes with complex terminations, at times irridescent; **calcite**, as white to cream scalenohedrons; **melanterite**, as bright yellow spots on altered marcasite; **tetrahedrite**, as black, rough microcrystals with marcasite; **ankerite and dolomite** as microcrystals, the former with red quartz, the latter in beautiful crystals in green fluorite cavities, of a golden color; **sphalerite**, at times in small, well formed crystals; rare **bournonite**, not yet seen by the writer; **chalcopyrite** and **arsenopyrite** up to 2 mm; and a variety of other species not yet positively identified.

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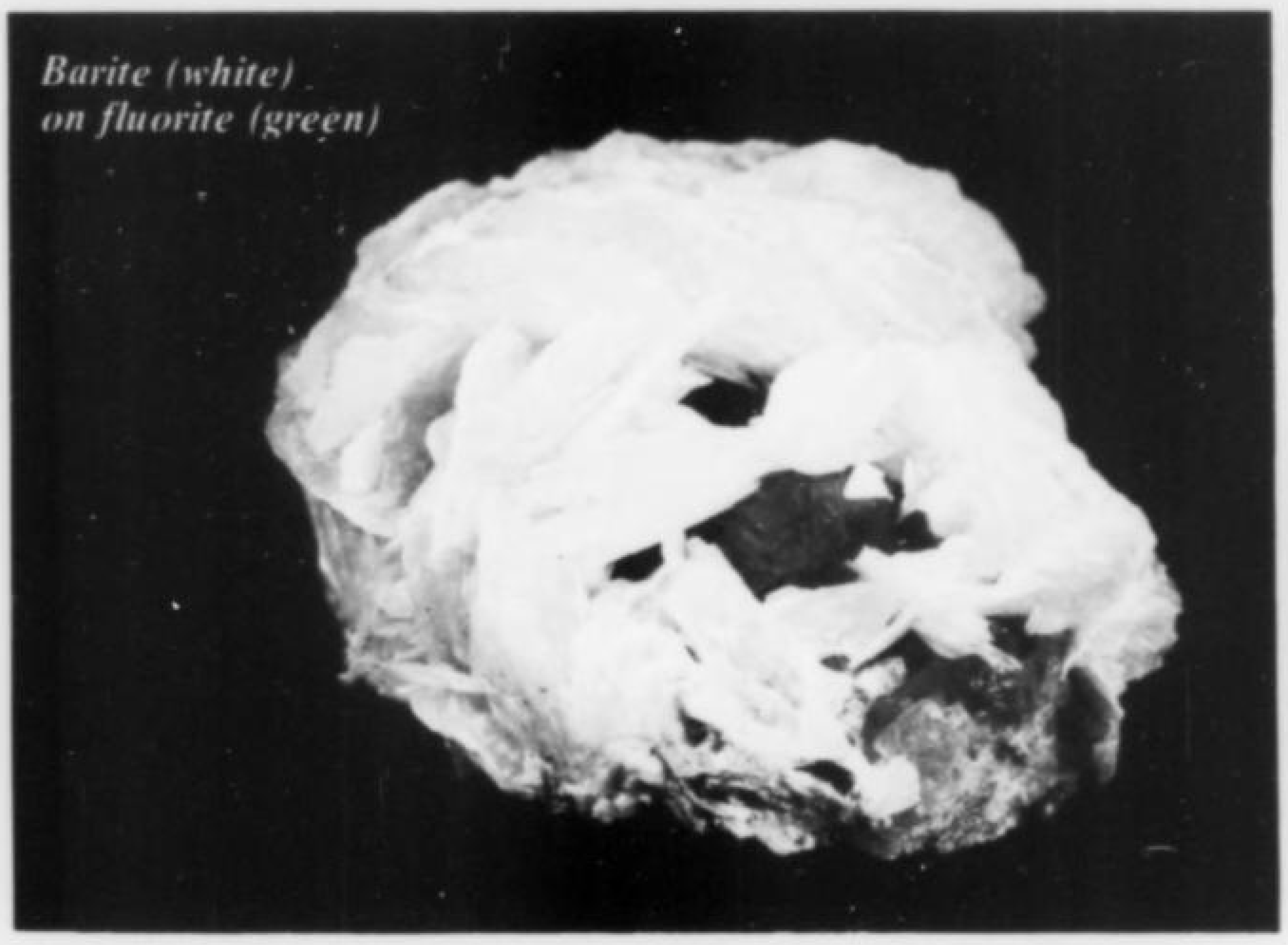
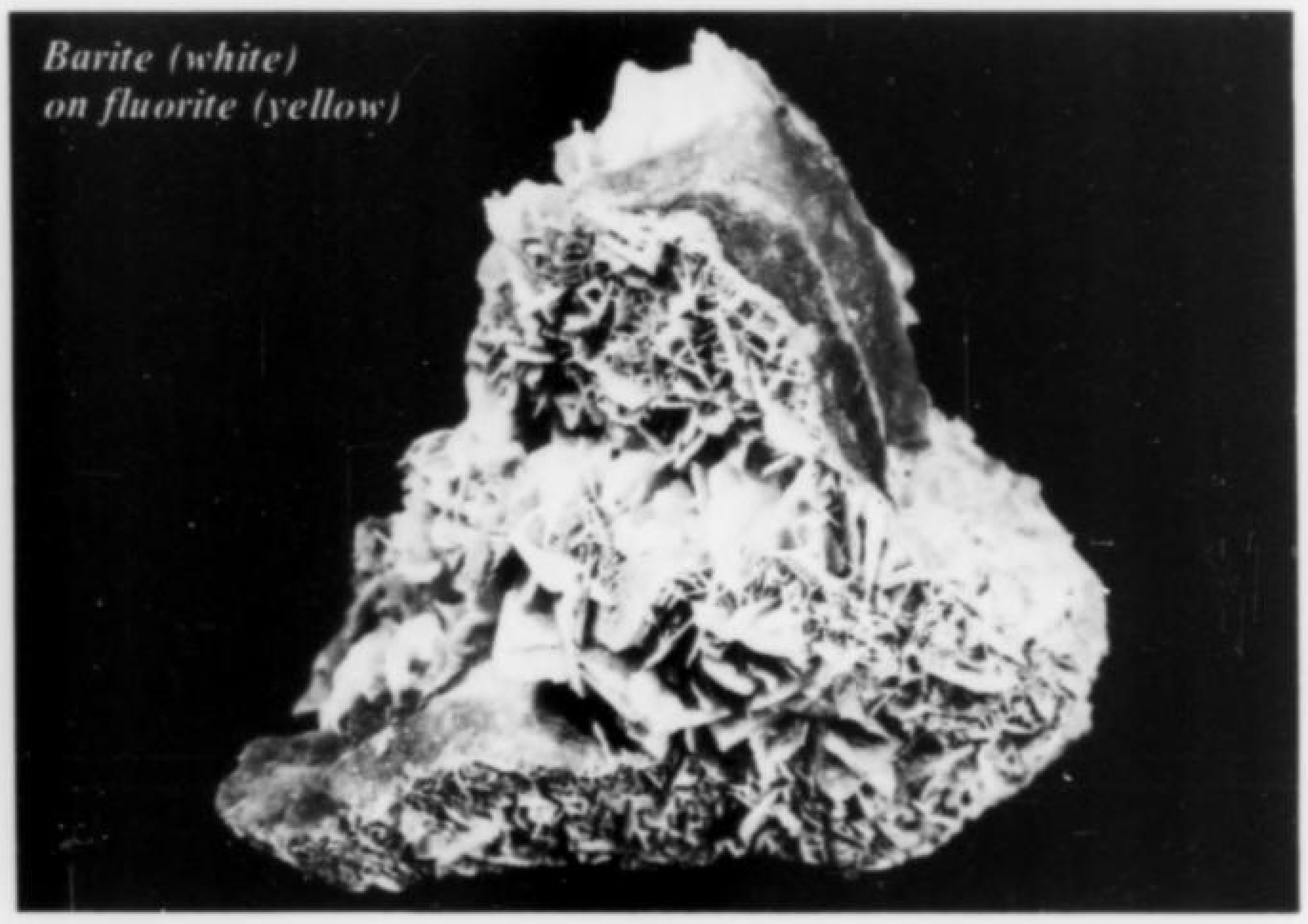
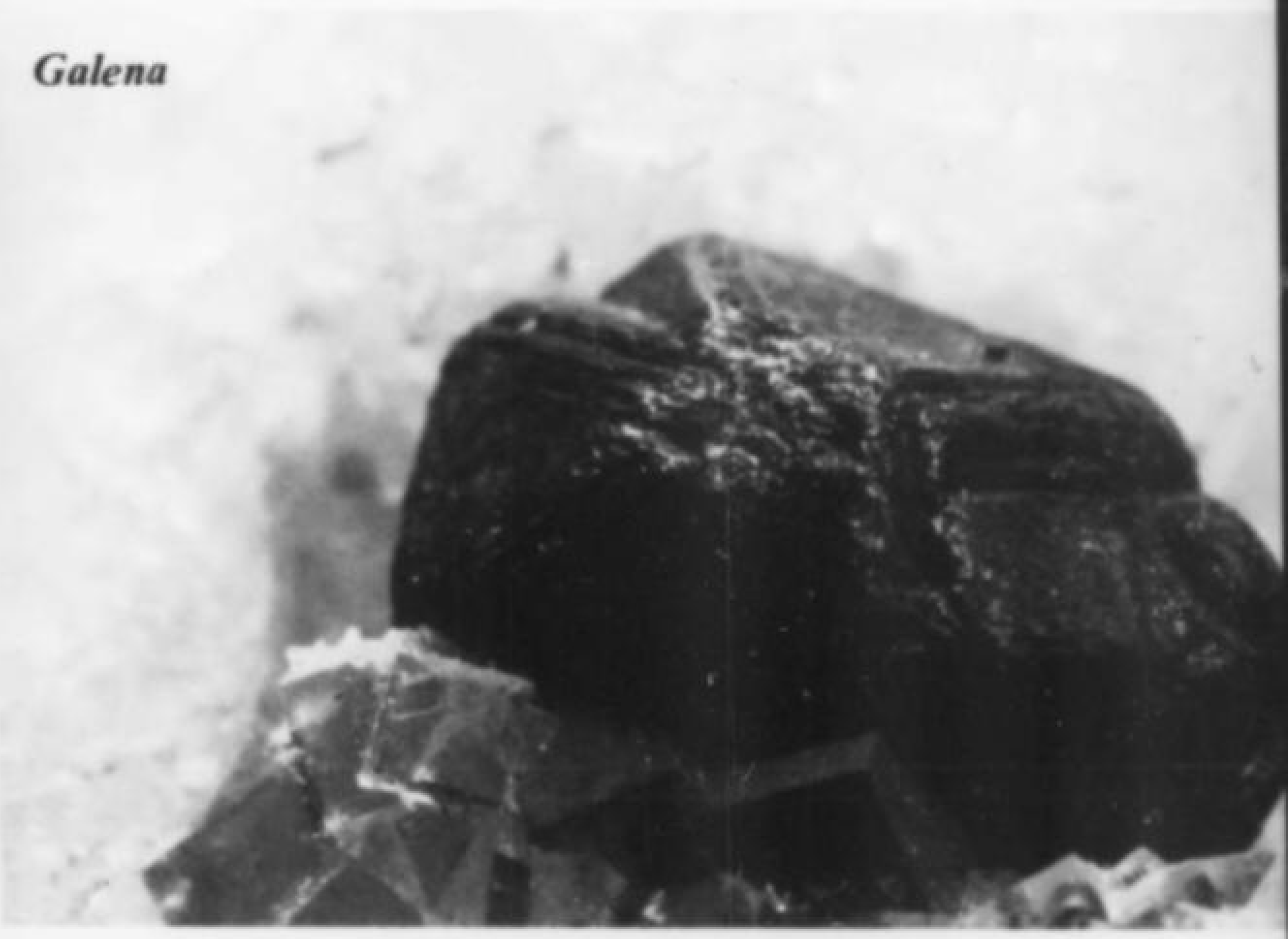


Barite (white) on fluorite (green)

Pyrite and marcasite

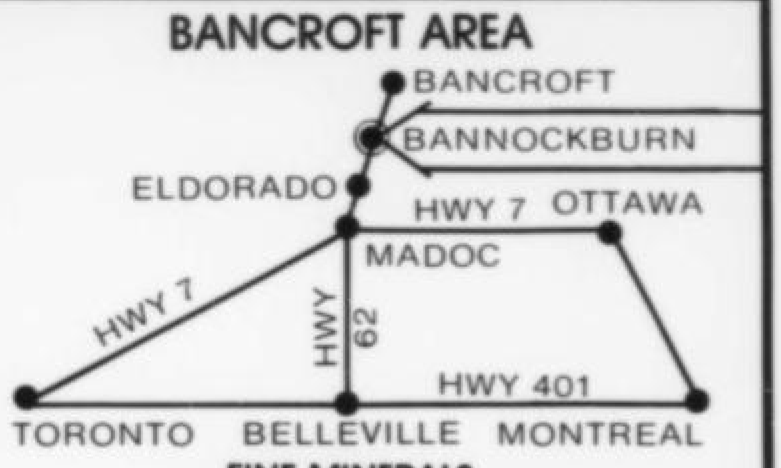


Barite (white) on fluorite (yellow)



Galena

photos by the author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HWY 7
OTTAWA
MADOC
HWY 7
HWY 62
HWY 401
TORONTO
BELLEVILLE
MONTREAL


Photo 1. **Zircon (brownish red, 1 mm) from Niedermendig, Laacher See volcanic area. (photo by Werner Lieber)**

Selected minerals from the volcanic district of

Laacher See, Germany

by
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F.R. Germany

Introduction

The Laacher See region is located in the eastern part of the Eifel district near the town of Andernach on the Rhein (see Fig. 1); the name is for Laacher Lake in the center of the district. It is also known as "Laacher Vulkangebiet" ("Laacher volcanic region"). Since the first scientific description of the area at the end of the 18th century it has been one of the classic fields for the study of geology, petrology and mineralogy. Since that time the great variety of rocks and minerals has stimulated the interest of scientists. Some of the history of science as well as the state of knowledge at that time is summarized in the description of the regional mineralogy by Brauns (1922) in which numerous older publications are cited. Only the more important descriptions of minerals are drawn on here. Results of modern petrologic investigations can be found in Frechen (1971).

Volcanism in the Laacher See area began about 500,000 years ago in the western-most section with the eruption of felsic[1] volcanic rocks. Results of this volcanism are domes of selbergite[2] and thick layers of selbergite tuff. Later alkali basalts[3] and basaltic pyroclastites[4] built up volcanoes of different types, some of them with extensive lava flows. In the latest period of volcanism, which ended about 10,000 years ago, large masses of trachytic[5] pumice[6] were ejected. They formed deposits in the eastern part of the region tens of metres in thickness. Because of the relatively young age of the volcanic activity the volcanic character of the surface is rather well preserved.

Various types of volcanic rocks have been utilized by men since ancient times for different purposes. For example porous, tough basalts were used for millstones (already in use in Neolithic times), paving stones, building stone and sculpture; dense, hard basalts were used for road construction and sea-walls; basaltic cinders were used for road construction; selbergite was used as a potassium-fertilizer and as raw material for the glass industry; selbergite tuff was used for building stones and facade plates; pumice was used for molded building stones; trass[7] was used by the Romans as a natural cement.

Note: to assist readers who are not familiar with petrologic terms and nomenclature, footnotes have been added. The definitions were adapted from *Glossary of Geology* (1972) editors: Gary, McAfee and Wolf; published by American Geological Institute, 5205 Leesburg Pike, Falls Church, Virginia 22041; hardcover, 858 p., $35.00. It is the principal terminology reference used by the *Mineralogical Record*, and is highly recommended to all readers.

Ed.

The intensity of mining has changed over the years. In recent years the exploitation of basaltic cinders has increased enormously and has opened opportunities for the study of the structures of strato volcanoes[8] as well as the minerals within the volcanic rocks.

Many of the minerals occur in different rocks in almost identical forms and therefore can be identified easily. Typical (but idealized) crystal drawings of most of the minerals from Laacher See, drawn from the author's collection, are shown in the accompanying figures. Real crystals can differ to varying degrees from the drawings because of distortion (preferential development of some faces at the expense of others), skeletal growth,

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[1] **Felsic:** refers to any light-colored, igneous rock having a high alkali-feldspar and silica content; also used in reference to such minerals. The opposite of mafic. Synonym (obsolete): acidic.

[2] **Selbergite:** a shallow-depth intrusive rock containing leucite, nosean, sanidine, acmite-augite, and biotite phenocrysts in a fine-grained groundmass of nepheline, alkali feldspar and acmite. The phenocrysts compose a higher percentage of the rock than does the groundmass.

[3] **Alkali basalt:** basalt containing olivine, augite and calcic plagioclase.

[4] **Pyroclastite:** a rock composed of materials fragmented by volcanic explosion.

[5] **Trachyte:** a group of fine-grained, generally porphyritic, extrusive rocks having alkali feldspar and minor mafic minerals (biotite, hornblende or pyroxene) as their principal components.

[6] **Pumice:** a light-colored, frothy, glassy rock of felsic composition.

[7] **Trass:** a pumiceous volcanic ash which, when mixed with lime, will harden under water.

[8] **Stratovolcano:** a volcano constructed of alternating layers of lava and pyroclastics. Synonym: composite volcano.

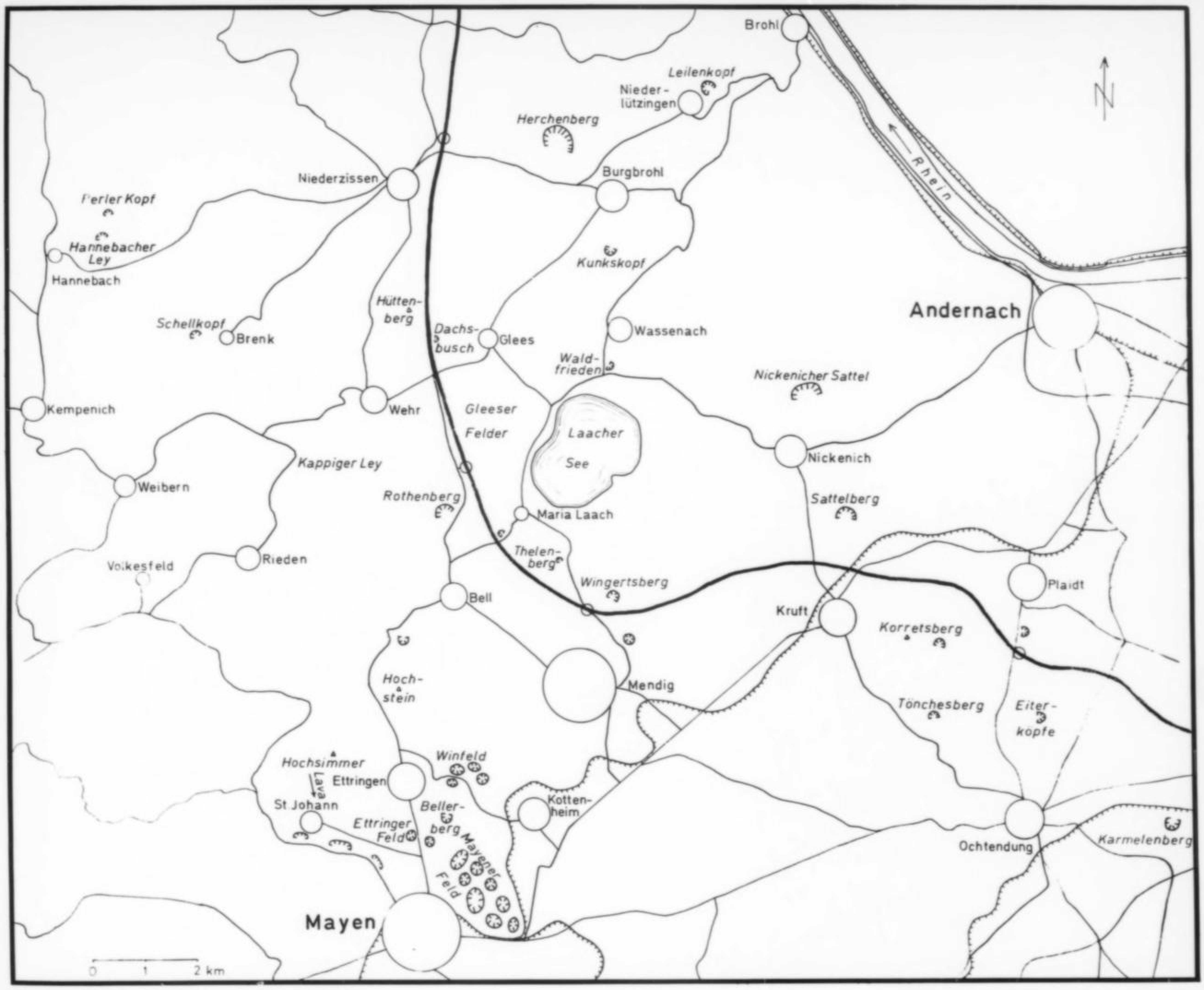

Figure 1. **Map of the Laacher See district.**

and other irregularities. Some of the distorted forms have been figured here.

Descriptions here are limited to those minerals which occur as single crystals in tuffs or as upright crystals or spherulites in cavities in the rock. Most of them are of micromount size (less than 1 mm).

Occurrences

The well-crystallized minerals found in cavities in the basaltic rocks of this district were recently described (Hentschel, 1975). The present paper also includes minerals found in cavities in non-basaltic rocks. Less important occurrences have not been considered. The locations of the various quarries and localities are shown on Figure 1.

Felsic volcanic rocks. Here we find selbergites (referred to as "nosean phonolite" in older papers) and selbergite tuff in the western part, and trachytes and trachytic pumice in the eastern part of the area. Mineralogically these tuffs and pumice are of no great interest, but they play the role of host rocks for the famous sanidinites.[9]

Out of several selbergite quarries only Schellkopf near Brenk is under operation today. The alkali-rich selbergite (about 18% Na_2O+K_2O) curiously contains a calcium-rich, almost alkali-free hydrothermal mineral paragenesis in fissures and vugs with phillipsite, calcite, aragonite, zeophyllite, thomsonite, gonnardite, chabazite, gismondine, fluorite, ettringite, thaumasite, and, as a new species, a calcium-fluorine-carbonate (investigation not yet completed).

Massive mafic[10] volcanic rocks. Within the Laacher See district different types of basaltic rocks occur within lava flows, dikes, and pipe fillings. The most interesting localities (quarries) are: Perler Kopf (haüyne-nepheline-leucoleucitite[11]) and Hannebacher Ley (melilite-nepheline-leucitite), near Hannebach; Hochstein (or Forstberg) near Bell; Hochsimmer (nepheline-leucitite) near St. Johann; Bellerberg (or Ettringer Bellerberg) with the lava flows of Ettringer Feld, Mayener Feld, and Winfeld (leucite-tephrite[12]) north of Mayen; Mendig (formerly Nieder-

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[9] **Sanidinite:** an igneous rock composed almost entirely of sanidine.

[10] **Mafic:** refers to any dark-colored igneous rock composed chiefly of one or more ferromagnesian minerals; also used in reference to those minerals. The opposite of felsic. Synonym (obsolete): basic.

[11] **Leucoleucitite:** a light-colored, fine-grained or porphyritic, sometimes extrusive igneous rock composed chiefly of pyroxene and leucite with little or no feldspar and without olivine.

[12] **Tephrite:** a group of basaltic, extrusive rocks composed primarily of calcic plagioclase, augite and nepheline or leucite as the main feldspathoids, with accessory sodic sanidine.

mendig) (nepheline-leucite-tephrite); and Plaidt. Usually the walls of pores, vesicles and fissures within the above-mentioned basaltic rocks are covered by at least some of the following minerals: green or black pyroxene, biotite, sanidine, leucite, nepheline, sodalite, magnetite, apatite, rarely also amphibole, melilite and perovskite.

The mineral assemblages in dikes within the cinders of Kunkskopf and of Nickenicher Sattel are somewhat different from the above occurrences in lava flows. In addition to the mineral species listed above, crystals of olivine, rhönite, and pseudobrookite have been observed.

Basaltic cinders. Included in this group are the various types of basaltic pyroclastites. They are usually highly vesicular or porous, but sometimes are more dense, resembling lava. Sizes range from large blocks to lapilli[13] or ash; degree of crystallinity ranges from almost complete glassy to microcrystalline, and sometimes coarser crystalline with visible grains. There is a great variety of colors; red or black cinders are abundant, but gray, greenish, brown, yellowish, and even blue oxidation colors also occur.

The most interesting workings in basaltic cinders at this time are: Herchenberg, northwest of Burgbrohl; Leilenkopf, east of Niederlützingen; Rothenberg, north of Bell; Kunkskopf, north of Wassenach; Nickenicher Sattel, near Nickenich; Sattelberg, north of Kruft; Tönchesberg, between Kruft and Ochtendung; Eiterköpfe, north of Ochtendung; and Karmelenberg, east of Ochtendung. Vesicles in the cinders can be lined with crystals of yellow pyroxene, amphibole, biotite, leucite, nepheline, noselite, andradite, hematite, pseudobrookite, and rhönite; reaction zones with felsic xenoliths[14] also contain sanidine, titanite, and SiO_2 minerals.

Inclusions. Inclusions of other kinds of rocks (xenoliths) are abundant in the volcanic and pyroclastic rocks; most of them are of small size (less than 1 cm). During heating by the liquid magma, thermometamorphic alterations in the interior of the xenoliths and reactions with the surrounding melt near the boundaries took place. These processes produced a great variety of petrographically very interesting rocks, many of them not yet studied. Cavities in some of these metamorphosed rocks or in the contact zones also contain interesting crystals. Felsic inclusions (quartzite, quartzo-feldspathic rocks, sanidinite, and others) are the most abundant; cavities in these rocks can be lined with crystals of pyroxene, sanidine, high-quartz, tridymite, cristobalite, hematite, titanite, etc.

At the Bellerberg quarry inclusions of marly limestones were converted by high-grade thermometamorphism into rocks composed of Ca-rich silicates and aluminates such as diopside, grossular, wollastonite, gehlenite, larnite, brownmillerite, mayenite, ettringite, hydrocalumite, portlandite, and tobermorite (Jasmund and Hentschel, 1964). Rare cavities in these rocks are lined with crystals of ettringite, hydrocalumite, afwillite, portlandite, gismondine, and stratlingite.

Sanidinites. With the eruption of large masses of selbergite tuff and trachytic pumice, fragments of other deep-seated rocks were occasionally carried along to the surface as xenoliths. They are of different origin: one group consists of subvolcanic[15] rocks of various compositions belonging to the alkali syenite[16]-sanidine gabbro[17] series, the haüyne foyaite[18]-hauyne sanidine gabbro series, carbonatites and other rock types. Crystalline schists, which have suffered major or minor metasomatic alterations (introduction of calcium and alkali elements or only alkali elements) by the magma, form another group of sanidinites.

These rocks have been the objects of petrographic investigations for more than 100 years and interpretations have changed repeatedly during that time. Also the term "sanidinite" (from the main mineral component, sanidine, which often comprises more than 50% of the rock) applied to many of these rocks has been defined in different ways. Here the term sanidinite will be used merely as a descriptive term without genetic implications.

Subvolcanites and metasomatites[19] were found in the vicinity of some old explosion pipes. The best known localities are: Volkesfeld; Kappiger Ley, southwest of Wehr; Dachsbusch and Hüttenberg, at the northwest border of the Wehrer Kessel (Wehr Basin); around the circumference of Laacher See at the localities of Waldfrieden, Gleeser Felder, Maria Laach or Maria Laach-Bell path, Thelenberg, Wingertsberg, the path to Nickenich, and Mendig (Niedermendig). They also occur as inclusions in some basalts.

Crystals of the following minerals have been described from miarolitic cavities in subvolcanites: dark green or black pyroxenes, amphiboles, biotite, sanidine, nepheline, noselite, hauyne, titanite, apatite, magnetite, hematite, zircon, pyrochlore, allanite, monazite, and andradite. From metasomatites: clinopyroxene, hypersthene, biotite, sanidine, corundum, spinel, cordierite, rutile, and almandine.

Minerals

Halides

FLUORITE, CaF_2, is a rare mineral in this area. Light gray spherulites have been found in two subvolcanites only (Kalb, 1939a). Recently fluorite was also observed at other occurrences: as spherulites in some Ca-rich xenoliths within cinders at Bellerberg (Hentschel, 1976) and as crusts and small vermicular forms at Schellkopf.

Oxides.

CORUNDUM, Al_2O_3, is a component of some metasomatites. Rarely idiomorphic[20] crystals project into cavities in these rocks (Brauns, 1922).

CRISTOBALITE, SiO_2, was found in the reaction zones of felsic inclusions in some basalts. Crystals are small octahedrons (Fig. 2), often platy, with two opposite faces better developed than the others. They are colorless and transparent or white, and sometimes exhibit sunken faces.

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[13] **Lapilli:** an accumulation of volcanic particles ejected through the air, individual particles of which have a size between 1 and 64 mm.

[14] **Xenolith:** an inclusion of a foreign rock within a different, genetically unrelated rock.

[15] **Subvolcanite:** an igneous rock emplaced near the surface but not extruded as lava.

[16] **Syenite:** a group of plutonic (deep level) igneous rocks containing alkali feldspar (usually orthoclase, microcline or perthite), a small amount of plagioclase, one or more mafic minerals and accessory (if any) quartz. The coarse-grained equivalent of trachyte.

[17] **Gabbro:** a group of dark-colored, mafic, intrusive, igneous rocks composed principally of calcic plagioclase (commonly labradorite or bytownite) and clinopyroxene (generally diallage augite), with or without olivine and orthopyroxene. The approximate coarse-grained equivalent of basalt.

[18] **Foyaite:** a nepheline syenite containing a predominance of potassium feldspar.

[19] **Metasomatite:** a rock whose chemical composition has been substantially changed by simultaneous capillary solution and deposition.

[20] **Idiomorphic:** euhedral. Bounded by crystal faces on all or nearly all sides.

Figure 2. **Cristobalite**

These white octahedrons were already noted as possibly being spinel in the middle of the 19th Century. Later, in the first description of cristobalite from Mexico by Rath (1886), these octahedrons were assumed to be identical with the new Mexican material.

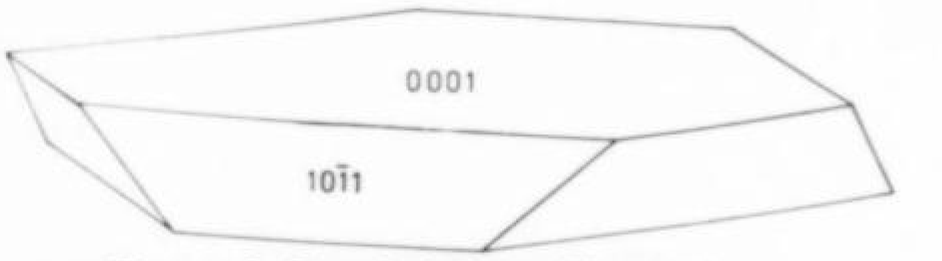

Figure 3. **Simple habit of hematite.**

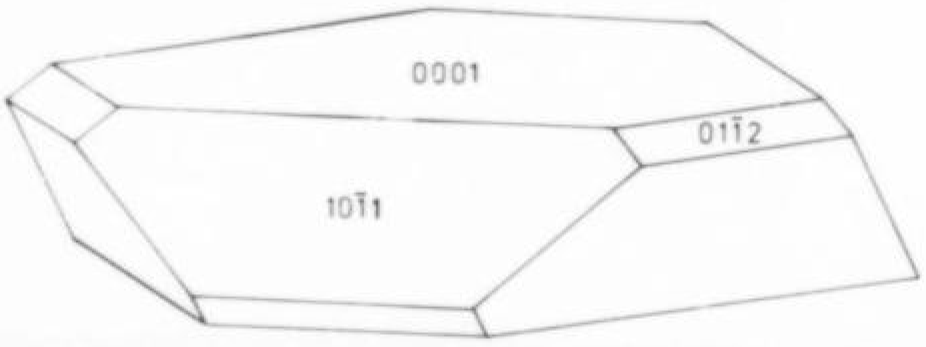

Figure 4. **Hematite crystal showing a positive and negative rhombohedron. Kunkskopf.**

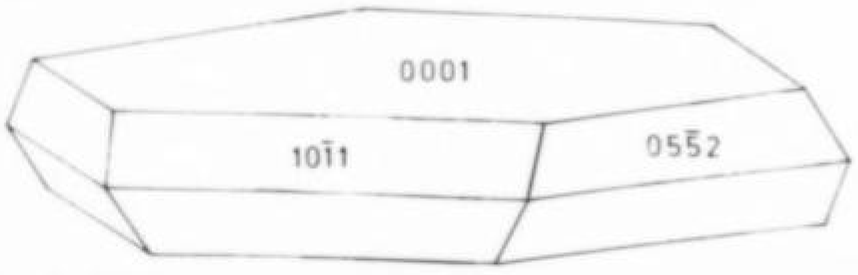

Figure 5. **Hematite crystal with the negative rhombohedron $\{0\bar{5}52\}$. Bellerberg.**

Figure 6. **Hematite crystal, the rhombohedron is dominant. Bellerberg.**

Figure 7. **Red hematite crystal (top view). Leilenkopf.**

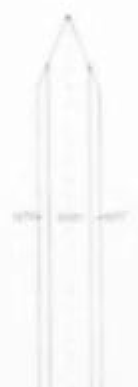

Figure 8. **Acicular hematite crystal. Sattelberg.**

HEMATITE, Fe_2O_3, frequently occurs in basaltic cinders. Crystals are usually platy parallel to (0001) and are bounded laterally by $\{10\bar{1}1\}$ (Fig. 3). If {0001} is only small in size, a pseudocubic habit results (Fig. 6). Figures 4 and 5 show combinations with negative rhombohedrons $\{01\bar{1}2\}$ or $\{05\bar{5}2\}$, respectively. The lateral faces are often sunken and the edges sometimes rounded. Hematite is black or dark gray with a submetallic lustre, and is occasionally tarnished. Sometimes the plates are so thin that they are transparent with a bluish-red color; their outline is rhomb-shaped (Fig. 7).

The surface of cinders along large fissures at many occurrences is covered by hematite crystals, as described by Rath (1886). They also show rhomb-shaped outlines and sometimes twin boundaries (on $(10\bar{1}0)$). Crystals of several centimeters in size have been found rarely by collectors. Often these cinder coatings are aggregates of poorly-developed crystals. An unusual acicular crystal from such an occurrence is outlined in Figure 8.

Hematite crystals of typical form (as in Fig. 3) also occur in sanidinites and in inclusions of basalt often with melted borders.

Figure 9. **Idealized high-quartz crystal. Bellerberg.**

Figure 10. **"Tailed" high-quartz crystal. Bellerberg.**

QUARTZ, SiO_2. Felsic xenoliths and the reaction zones between xenoliths and basalts sometimes contain crystals of quartz. Their forms are prisms with the normal pyramid and additional steep pyramids of equal development. Kalb (1933) found forms of the hexagonal, high-temperature polymorph of quartz there. Direct proof is not possible, as is well-known, because of the spontaneous conversion at 573°C to the trigonal, low-temperature polymorph.

Crystals are colorless and transparent. The following dipyramids have been observed: $\{10\bar{1}1\}$, $\{30\bar{3}2\}$, $\{20\bar{2}1\}$, $\{40\bar{4}1\}$ and $\{50\bar{5}1\}$. A typical crystal is illustrated in Figure 9. Growth irregularities sometimes produce crystals with extremely elongated pyramids (Fig. 10).

HERCYNITE, $(Fe,Mg)Al_2O_4$, occurs in metasomatites. The composition is known from only one analysis (Brauns, 1922) which indicated that Fe is dominant over Mg. The color is dark green to black and also reddish-violet. Rare crystals in vugs are combinations of the octahedron and the dodecahedron.

Figure 11. **Hydrocalumite crystal. Bellerberg.**

HYDROCALUMITE, $Ca_2Al(OH)_7 \cdot 3H_2O$, was observed in fissures in only a few limestone inclusions in the Bellerberg lava. Crystals are colorless, transparent, six-sided plates with {001} dominant, bounded laterally by {101} and {120} (Fig. 11). Striations on {001} are parallel to the edges. Usually they are twinned after (31*l*). Hydrocalumite is usually accompanied by crystals of ettringite, and also rarely by afwillite and portlandite.

Figure 12. **Common habit of magnetite.**

MAGNETITE, $Fe^{+2}Fe_2^{+3}O_4$, one of the most common minerals, is found in cavities in basalts and their inclusions and in sanidinites. Crystals are usually black and lustrous, but are sometimes gray and dull. The common form is the octahedron, often modified by the dodecahedron (Fig. 12). In sanidinites {311} has also been observed. Sometimes only rounded forms are visible. Some crystals from Hannebacher Ley are elongated along [111] and thus resemble trigonal pyramids.

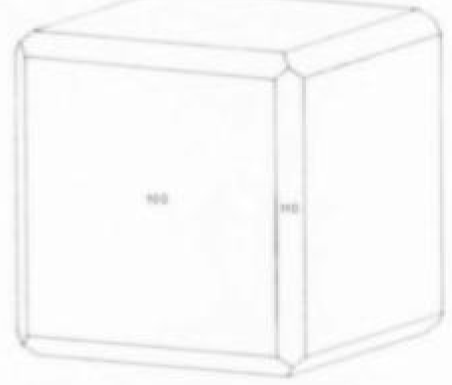

Figure 13. **Pseudocubic perovskite crystal. Hochstein.**

Figure 14. **Perovskite crystal, the (pseudo)dodecahedron is larger developed. Hochstein.**

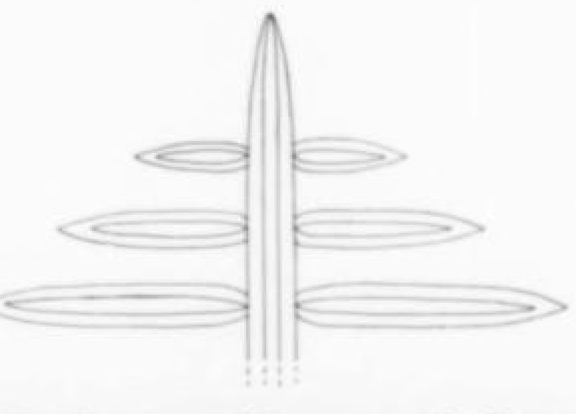

Figure 15. **Skeletal perovskite crystal, branching off perpendicular.**

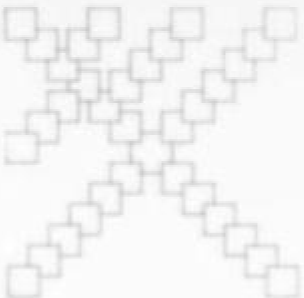

Figure 16. **Hopper-crystal of perovskite, composed of many cubes connected by the corners. Hannebacher Ley.**

PEROVSKITE, $CaTiO_3$, is a component of certain basalt types (Brauns, 1922). At Hochstein vugs contain crystals of the usual pseudocubic habit: the pseudocubes are sometimes modified by apparent dodecahedron faces (Fig. 13), rarely the apparent dodecahedron is more fully developed (Fig. 14). Sometimes sunken faces have been observed.

Pseudo-octahedrons of perovskite have been found in the contact zone of only one limestone inclusion in the Bellerberg lava. Of particular interest are the skeletal forms of perovskite. There are two different types of branching skeletal growth: in one type the crystals are acicular parallel to [010] and branch off perpendicularly (Fig. 15). This type has been observed on crystals from Hannebacher Ley, Herchenberg, and Bellerberg. Rarely non-branching acicular crystals also occur. In the other type crystals branch off in the direction of [111], i.e. perpendicular to the pseudo-octahedron faces. They are composed of pseudocubes connected at the corners. Sometimes all of the small pseudocubes of one "crystal" together form a large pseudocube, the faces of which are sunken almost to the center (Fig. 16).

The color of perovskite varies from brown to reddish brown to black.

PORTLANDITE, $Ca(OH)_2$, occurs as veinlets in some limestone inclusions of the Bellerberg lava. Also white clusters were found in a single fissure, with only indications of rough and uneven faces.

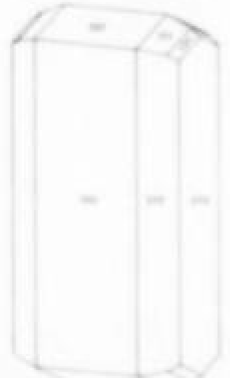

Figure 17. **Idealized pseudobrookite crystal.**

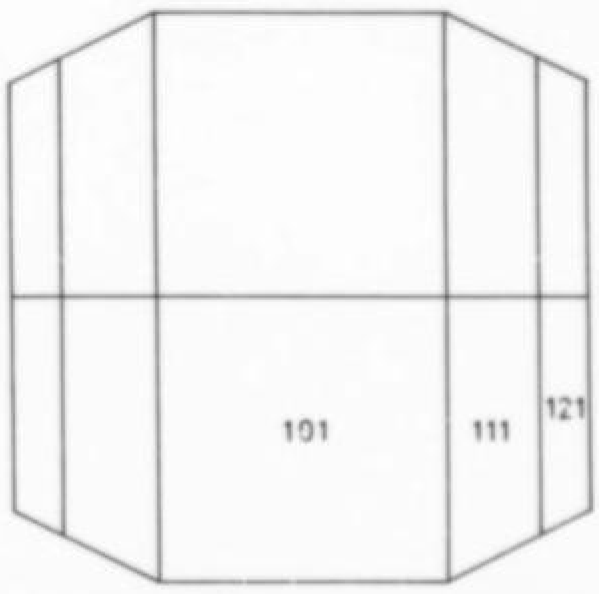

Figure 18. **Top view of fig. 17.**

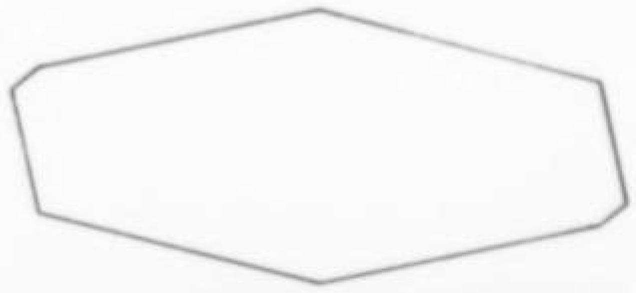

Figure 19. **Section of a "left-right" distorted pseudobrookite crystal.**

PSEUDOBROOKITE, Fe_2TiO_5, was reported in the older literature from some localities, e.g. Korretsberg (Lacroix, 1893). Crystals frequently occur in vesicles of basaltic cinders. The habit is usually prismatic to acicular along [001]; forms in this zone are {100}, {010}, and {210}. Terminal forms are {101}, {111}, and {121} (Fig. 17 and 18).

The relative sizes of the faces vary considerably, and therefore the habit is sometimes equant and sometimes platy. Figure 19 is a cross-section of a "left-right" unequal crystal. Some of the acicular pseudobrookite crystals obviously are curved in the *ac* plane. Sunken faces have been observed on the terminations.

Larger pseudobrookite crystals are dark brown to black with a submetallic lustre; thinner crystals are dark reddish-brown or dark red and translucent. In some specimens the brown crystals have an irridescence similar to that of "aventurine".

Figure 20. **Typical pyrochlore crystal.**

PYROCHLORE, $(Na,Ca)_2Nb_2O_6(OH,F)$, is an accessory mineral of certain subvolcanites. This mineral was described in the early 19th Century as "spinel". The identity with "pyrrhite" or "azorpyrrhite" was suggested by Hubbard (1886). The only chemical analysis was given by Brauns (1922) without estimating the ratio of Nb/Ta. Crystals are octahedral, usually modified by small {100} and {110} faces (Fig. 20). The color is yellow, yellowish-brown, reddish-brown or red.

RUTILE, TiO_2, is a component of some metasomatites. Rare, red transparent fibers were observed projecting into cavities by Brauns (1922).

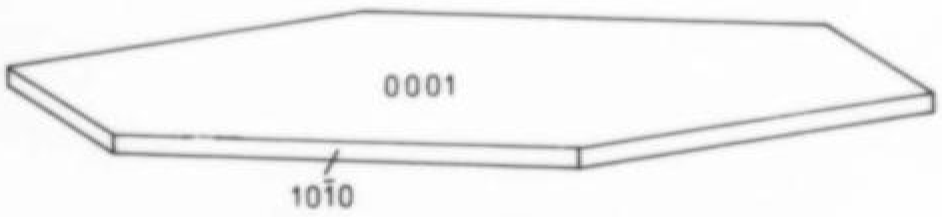

Figure 21. **Simple tridymite crystal.**

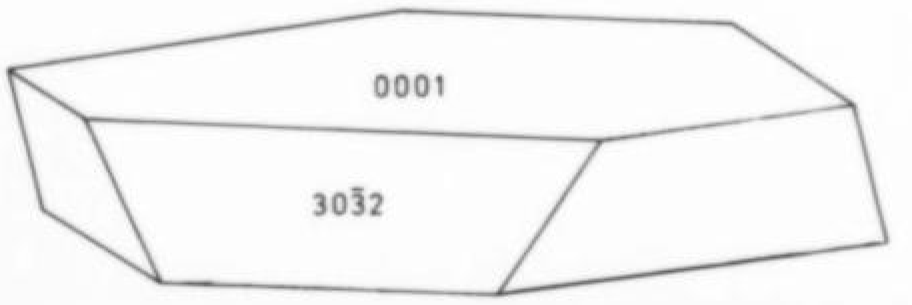

Figure 22. **Tridymite crystal, probably pseudomorph after cristobalite. Bellerberg.**

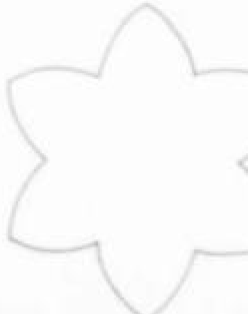

Figure 23. **Star-like tridymite crystal. Bellerberg.**

TRIDYMITE, SiO_2, is the most common high-temperature form of silicon dioxide in this area. Crystals have been found in cavities in quartz-rich inclusions and their reaction zones with basalts or basaltic cinders. They are colorless and transparent, or white because of micro-fractures or rough faces. Crystals are thin plates bounded laterally by prism faces (Fig. 21), and sometimes by very small, unmeasurable pyramids. Often the lateral faces are poorly-developed. The well-known trillings, after which the mineral was named, also occur in the Laacher See district.

Some crystal plates are bounded by faces of an apparent rhombohedron (Fig. 22). Occasional star-like skeletal crystals have also been observed (Fig. 23).

Carbonates.

ARAGONITE, $CaCO_3$, was found at Schellkopf and in some occurrences of basaltic cinders. Habits are very steep pyramids, delicate fibers or fibrous aggregates. They are colorless and transparent or white.

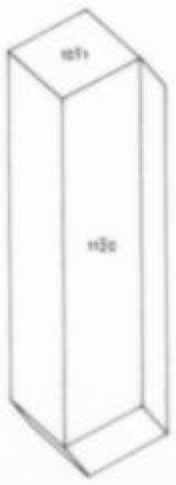

Figure 24. **Prismatic calcite crystal, Schellkopf.**

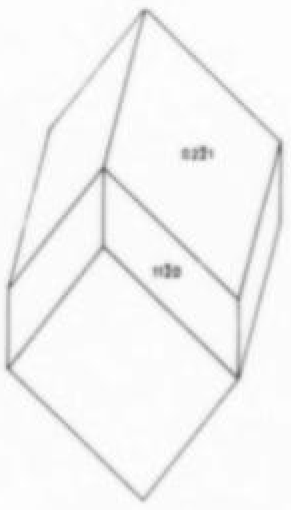

Figure 25. **Calcite crystal of rhombohedral habit. Schellkopf.**

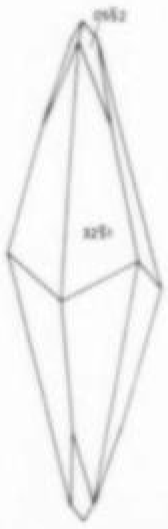

Figure 26. **Calcite, combination of scalenohedron with a negative rhombohedron. Schellkopf.**

CALCITE, $CaCO_3$, is a primary magmatic component of some carbonate sanidinites and carbonatites. Well-formed crystals occur is fissures and vugs in selbergite at Schellkopf. Habits are prismatic (Fig. 24), rhombohedral (Fig. 25), or scalenohedral (Fig. 26), and also various combinations of these forms. Calcite was formed mainly during weathering, in basalts, basaltic cinders and inclusions, and in such cases occurs as crusts or poorly-developed crystals.

Figure 27. **Acicular ettringite crystal. Bellerberg.**

Figure 28. **Barrel-shaped ettringite crystal. Schellkopf.**

Sulfates.

ETTRINGITE, $Ca_6Al_2(SO_4)_3(OH)_{12}\cdot 26H_2O$, was described as a new species from the limestone inclusions in the Bellerberg lava (Lehmann, 1874). It is a common component of these massive metamorphic rocks. Colorless, transparent crystals occur rarely in fissures. The habit is acicular along $[0001]$; forms are the prism $\{10\bar{1}0\}$, rarely also $\{11\bar{2}0\}$, the pyramids $\{10\bar{1}1\}$, $\{10\bar{1}2\}$, $\{10\bar{1}3\}$, $\{10\bar{1}4\}$, and the pinacoid $\{0001\}$. A typical combination of forms is shown in Figure 27.

A second locality for ettringite in this area is Schellkopf (Hentschel, 1968). Crystals show only the forms $\{10\bar{1}0\}$ and $\{0001\}$ and often are barrel-shaped.

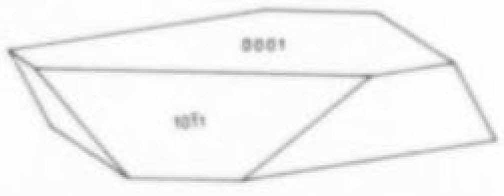

Figure 29. **Jarosite crystal. Mendig.**

JAROSITE, $KFe_3(SO_4)_2(OH)_6$, was observed recently in the form of crystalline crusts on pumice at Mendig (Hentschel, 1974a). Individual crystals are thick plates with $\{0001\}$ dominant, bounded laterally by the rhombohedron $\{10\bar{1}1\}$ (Fig. 29). The color varies from yellow to brown.

THAUMASITE, $Ca_3Si(CO_3)(SO_4)(OH)_6\cdot 12H_2O$. At both localities for ettringite the closely-related mineral thaumasite also occurs. This mineral is distinguished from ettringite by its much higher birefringence. Crystals occur as delicate white fibers in parallel or radiating aggregates.

Figure 30. **Short prismatic apatite crystal, as typical for subvolcanites.**

Phosphates.

APATITE, (Fluorapatite-chlorapatite), $Ca_5(PO_4)_3(F,Cl)$, is a common but unimportant component of almost all types of rocks at Laacher See. A detailed description was given by Brauns (1917). Crystals are usually colorless and transparent; the only forms are $\{10\bar{1}0\}$ and $\{10\bar{1}1\}$. The habit is short prismatic along $[0001]$ in subvolcanites (Fig. 30) or long prismatic to acicular in volcanic rocks.

MONAZITE, $(La,Ce,Nd)PO_4$. Only two crystals of platy green monazite have been found in subvolcanite (Rath, 1871).

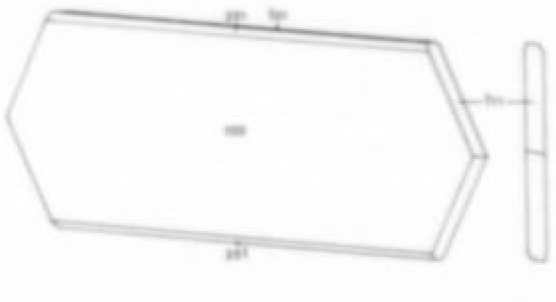

Figure 31. **Afwillite crystal. Schellkopf.**
Figure 32. **Projection along the direction of b of fig. 31.**

Silicates

AFWILLITE, $Ca_3Si_2O_4(OH)_6$. Cavities in only a few limestone inclusions in the Bellerberg lava contain colorless, transparent crystals of afwillite. They are elongated along $[010]$ and flattened along $[100]$. Common forms include $\{100\}$, $\{001\}$, $\{101\}$, $\{301\}$, and $\{011\}$ (Fig. 31 and 32).

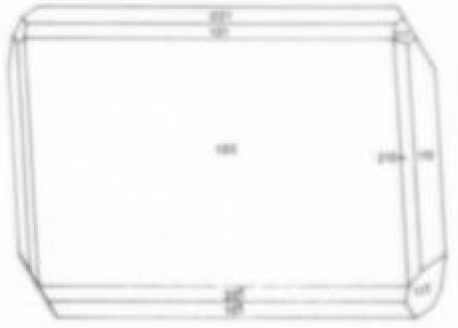

Figure 33. **Allanite crystal of somewhat simpler habit. Mendig.**

ALLANITE, $(Ce,Ca,Y)_2(Al,Fe)_3(SiO_4)_3(OH)$, is an accessory component of some subvolcanites. In the earliest reports this mineral was named "tautolite" or "bucklandite". Rath (1861) identified this species as orthite (a synonym for allanite) and gave a detailed description of the crystals. They are tabular parallel to $[100]$; common forms are $\{100\}$, $\{001\}$, $\{110\}$, $\{210\}$, $\{101\}$, $\{201\}$, $\{\bar{1}01\}$, $\{011\}$, $\{\bar{1}11\}$, $\{111\}$ and $\{\bar{1}12\}$. A simple combination is shown in Figure 33. Color is black; thin splinters are dark brown and translucent.

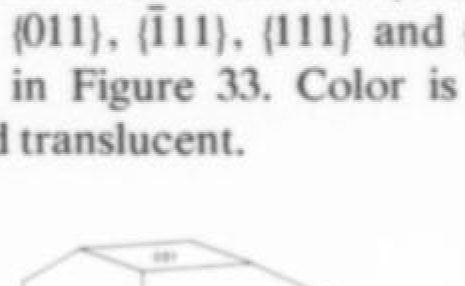

Figure 34. **Single Hornblende crystal. Korretsberg.**

Figure 35. **Top view of fig. 34.**

Figure 36. **Simplest habit of amphibole. Korretsberg.**

Figure 37. **Top view of fig. 36.**

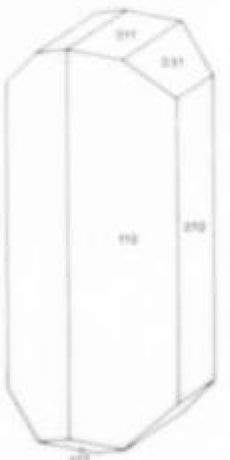

Figure 38. **Yellow amphibole crystal. Korretsberg.**

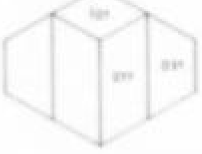

Figure 39. **Top view of fig. 38.**

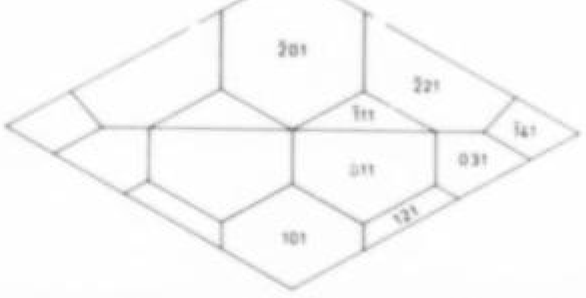

Figure 40. **Top view of a highly modified amphibole crystal. Kunkskopf.**

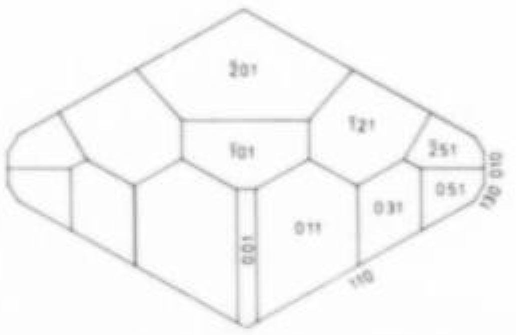

Figure 41. **Top view of another amphibole crystal. Bellerberg.**

AMPHIBOLE, $A_2B_5(Si,Al)_8O_{22}(OH,F)_2$, where A = Na, Ca, K, B = Mg, Fe, Ti, Al, Li, Mn. Minerals of the amphibole group of various compositions occur in basaltic rocks, in inclusions, and in sanidinites. For simplification only the group name is used in this description.

Black single crystals of basaltic hornblende up to several centimeters long occur in basaltic scoria, on the slopes of Korretsberg. Their habit is short (Fig. 34 and 35) or long prismatic along [001]; common forms are {010}, {110}, {011}, and {$\bar{1}01$}. The longer crystals are often twinned on (100).

Crystals in cavities in basalt and basaltic cinders usually are prismatic to acicular, sometimes even hair-like. The color varies from yellow and yellowish-brown (also with a touch of red) to brown, dark brown and black. The lighter colored crystals are transparent.

The simplest crystals consist of only the prism {110} and a prism of the zone [100], e.g. {021} (Fig. 36 and 37); their cross-section is rhombic. Usually the pinacoid {010} is also developed, resulting in a six-sided cross-section with almost equal angles of about 120° (Fig. 38 and 39). The terminations are often highly modified; the following forms have been observed: {001}, {011}, {031}, {051}, {$\bar{1}01$}, {$\bar{2}01$}, {130}, {$\bar{1}21$}, {$\bar{1}41$}, {$\bar{2}21$}, and {$\bar{2}51$}. Two examples are given in Figures 40 and 41. Skeletal growth sometimes produces crystals with open ends, or "hopper" development.

The core of some yellow amphiboles in basaltic cinders consists of rounded, dull, gray pyroxene crystals; this indicates the outer parts of older pyroxene crystals have been dissolved and amphibole then formed.

Well-formed crystals of amphibole also occur in cavities in inclusions and ejecta. They are usually black and similar in habit to the simpler, previously described crystals.

Figure 42. **Yellow andradite crystal. Herchenberg.**

ANDRADITE, $Ca_3Fe_2(SiO_4)_3$. Single crystals of black, titaniferous andradite ("melanite") occur in soil south of Perler Kopf. Their habit is rhombohedral, sometimes modified by small trapezohedron {211} faces.

Yellow, reddish-brown or brown transparent crystals of andradite were found in cavities of some basaltic cinders at Herchenberg, Leilenkopf and Bellerberg. Forms again are {110} and {211} but they are almost equally developed (Fig. 42). They have been investigated by Uhlig (1910).

Figure 43. **Simplest outline of biotite (top view).**

Figure 44. **Top view of a biotite crystal with additional (10*l*).**

Figure 45. **Top view of a twelve-sided biotite crystal.**

Figure 46. **Idealized biotite crystal. Kunkskopf.**

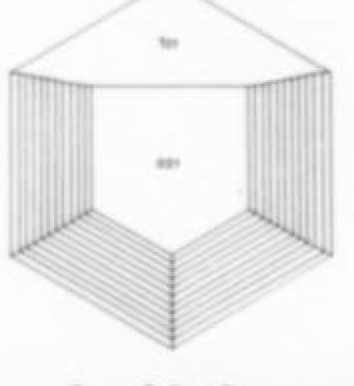

Figure 47. **Top view of a biotite crystal, step-wise composed of many plates. Herchenberg.**

Figure 48. **Biotite crystal, completely disintegrated into stripes. Kunkskopf.**

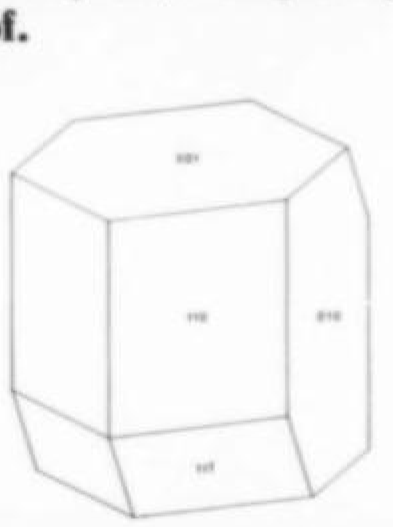

Figure 49. **Prismatic biotite crystal from a sanidinite. Mendig.**

Figure 50. **Spindle-like biotite crystal, Mendig.**

BIOTITE, $K(Mg,Fe)_3(Al,Fe)Si_3O_{10}(OH,F)_2$, is a common mineral in basaltic rocks, their inclusions, and in sanidinites. Anhedral macro-crystals of several centimetres in size frequently occur in basaltic pyroclastites.

In cavities in basaltic rocks crystals are much better developed than those described above. They are thin and tabular parallel to (001). The plates often are so delicate that lateral faces are not visible. Their shape is usually six-sided (Fig. 43). Often the edge between {11*l*} is blunted by {10*l*} (Fig. 44). If {10*l*} is dominant or laterally bounding (besides {01*l*} a rectangular shape results. Additional boundaries of {13*l*} can produce a twelve-sided shape with nearly equal angles of about 150° (Fig. 45).

The main forms of the thicker crystals are {001}, {010}, and $\{\bar{1}01\}$ modified by $\{\bar{1}11\}$ and {133}. Figure 46 shows an idealized simple crystal, "constructed" simply by adjusting the relative sizes of the faces. Real crystals are usually composed of many superimposed plates (often rotated about [001]), becoming smaller and smaller. Figure 47 is a schematic drawing of a crystal consisting of six-sided plates with only {001} and $\{\bar{1}01\}$ faces. In extreme cases the zone [100] is approximated by a fine, step-like alternation of {010} and {001}, and only $\{\bar{1}01\}$ is fully developed as a face (Fig. 48).

The color of this biotite is dependent upon thickness. The thinnest plates are yellow, yellowish-brown or light brown and transparent, as described by Rath (1886). Thicker crystals are darker brown or black.

Biotite crystals of similar shape also occur in sanidinites. They are often poorly-developed. Occasionally well-formed crystals have been found; their habit is thick tabular or even prismatic with {010}, {110} and {001} as the only forms or in combination with $\{\bar{1}11\}$ (Fig. 49). Long prismatic crystals with $\{\bar{1}11\}$ more fully developed, and with additional {021} faces, take on a spindle shape (Fig. 50).

Figure 51. **Idealized cancrinite crystal. Mendig.**

CANCRINITE, $(Na,K,Ca)_{6-8}(Al,Si)_{12}O_{24}(SO_4,CO_3,Cl)_{1-2}\cdot nH_2O$, is a component of some subvolcanic rocks. In miarolitic cavities the prisms $\{10\bar{1}0\}$ and $\{11\bar{2}0\}$ are occasionally visible. Rarely the termination is formed by the pyramid $\{10\bar{1}1\}$ (Fig. 51). Cancrinite is white and dull. For a long time these crystals were considered to be meionite; their true nature was discovered by Uhlig (1911).

Figure 52. **Chabazite. Schellkopf.**

CHABAZITE, $Ca(Al_2Si_4)O_{12}\cdot 6H_2O$, was found in a few fissures at Schellkopf. The only form of the colorless crystals is the rhombohedron (Fig. 52).

CORDIERITE, $Mg_2Al_4Si_5O_{18}$, is a component of some metamorphic or metasomatic rocks. Blue crystals in cavities were described by Rath (1874). They are prismatic parallel to [001]; the following forms were reported: {100}, {010}, {001}, {110}, {130}, {111}, {112}, {131} and {134}.

Some of the "cordierite" may actually be osumilite, as Miyashiro (1956) suggested, because the composition calculated from analyses of Laacher See "cordierite" agrees better with osumilite.

Minerals of the **FELDSPAR** group are very abundant in almost all types of rocks. Most of them at Laacher See are high-temperature alkali feldspars with potassium predominating. Therefore the name sanidine is used here for all members of this series. Feldspars of the plagioclase series are discussed separately.

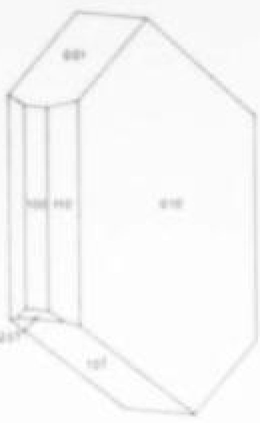

Figure 53. **Sanidine crystal from a fissure in basalt. Hochsimmer.**

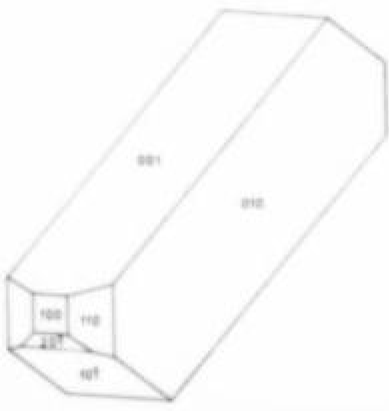

Figure 54. **Prismatic [100] sanidine crystal. Hochsimmer.**

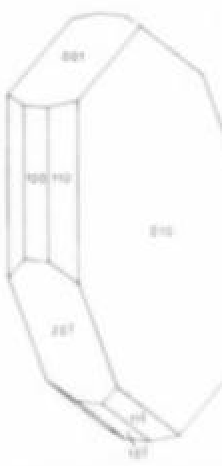

Figure 55. **Sanidine crystal from a subvolcanite. Mendig.**

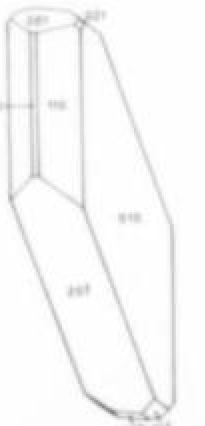

Figure 56. **Sanidine crystal elongated [102]. Dachsbusch.**

SANIDINE, (K,Na)AlSi$_3$O$_8$, was first described from this area as "glassy feldspar" by Nose (1790). Fragments of crystals up to decimetre size were found in selbergite tuffs. They are colorless or smoky brown and partially transparent. Faces are rarely developed. Crystals in cavities in basaltic rocks often are of poor quality or show skeletal forms. Their habit is usually tabular parallel to (010). The plates are bounded laterally by {001}, {$\bar{1}$01}, {100}, and {110}, from which an almost regular six-sided outline results (Fig. 53). Commonly {$\bar{2}$01} is poorly developed. Twin boundaries are sometimes visible, indicating Carlsbad twinning.

Some crystals are elongated parallel to (100) with {010} and {001} dominant, and resemble tetragonal prisms (Fig. 54). If {$\bar{2}$01} or another face of similar position is the only termination form the crystals take on a pseudocubic appearance.

Crystals in sanidine-rich ejecta or inclusions generally show more faces: additional forms are {130}, {021}, and {$\bar{1}$11}. The pinacoid {$\bar{2}$01} is often better developed (Fig. 55) or is dominant along with {010} on crystals elongated parallel to (102) (Fig. 56). Sanidine is colorless and transparent usually, but can also be white and dull.

PLAGIOCLASE, members of the albite (NaAlSi$_3$O$_8$)—anorthite (CaAl$_2$Si$_2$O$_8$) series. Idiomorphic crystals in miarolitic cavities in subvolcanites were described by Kalb (1934). They are always "albite twins". Their habit is tabular parallel to (010); forms include: {010}, {001}, {$\bar{2}$01}, {110}, {$\bar{1}$10}, {$\bar{1}\bar{1}$0} and {$\bar{1}$11}.

Figure 57. **Pseudotetragonal dipyramid of gismondine.**

GISMONDINE, Ca(Al$_2$Si$_2$)O$_8$·4H$_2$O, was found by Kalb (1959) in pores of the contact zone of some limestone inclusions in the Bellerberg lava, and recently in fissures in selbergite at Schellkopf. The colorless, transparent crystals often resemble tetragonal dipyramids (Fig. 57), but the higher symmetry is only simulated by twinning.

GONNARDITE, Na$_2$Ca(Al$_4$Si$_6$)O$_{20}$·7H$_2$O, has been found in recent years at Schellkopf as white crusts and spheres.

Figure 58. **Leucite.**

LEUCITE, KAlSi$_2$O$_6$. Grains of leucite occur in selbergite and other volcanic rocks in the western part of the Laacher See district, and in several types of basalt. The only form is the trapezohedron (Fig. 58). Edges are often rounded; complete "spheres" have even been observed. Unaltered leucite is colorless and transparent.

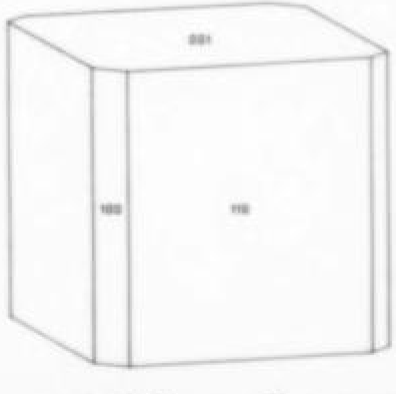

Figure 59. **Melilite crystal from the contact zone of a limestone inclusion of the Bellerberg lava.**

MELILITE, (Na,Ca)$_2$(Mg,Al)(Si,Al)$_2$O$_7$. Upright crystals occur in cavities in basalt at Hannebacher Ley and Herchenberg. They have also been found rarely in the contact zone around limestone inclusions in the Bellerberg lava. Their habit is short prismatic parallel to (001), to thick tabular. The dominant forms are {110} and {001}, often modified by small {100} faces (Fig. 59), and rarely also {101}. Edges are rounded and faces generally appear to be etched.

Fresh melilite is pale yellow and transparent. Weathering deepens the color to a more intense yellow or yellowish-brown.

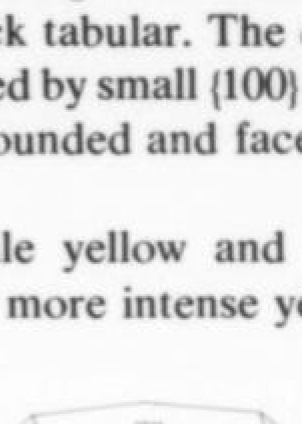

Figure 60. **Usual habit of nepheline.**

NEPHELINE, (Na,K)AlSiO$_4$. Crystals of nepheline occur frequently in pores and vesicles of basaltic rocks, and rarely in cavities in subvolcanites. Their habit is usually prismatic parallel to (0001), sometimes long prismatic to acicular, and rarely also thick tabular. Common forms are {10$\bar{1}$0}, and {0001}, often combined with subordinate {1011} (Fig. 60). In some specimens the pyramid is more fully developed than the base. Rarely {11$\bar{2}$0} and {11$\bar{2}$1} have also been observed. Incomplete growth sometimes has produced hopper crystals and stellate forms.

Nepheline is colorless and transparent or white, sometimes with a tinge of yellow.

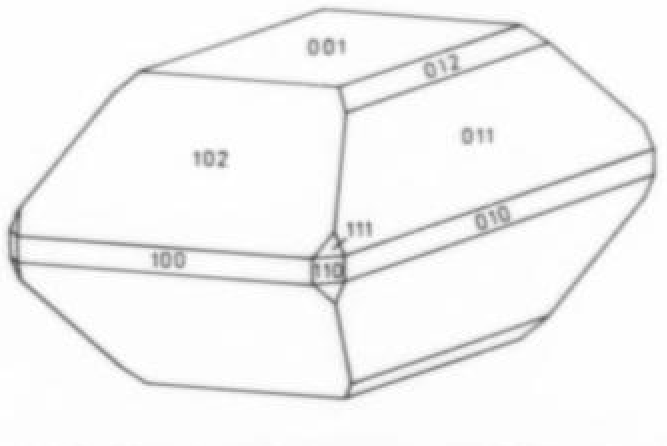

Figure 61. **Single olivine crystal. Hochstein.**

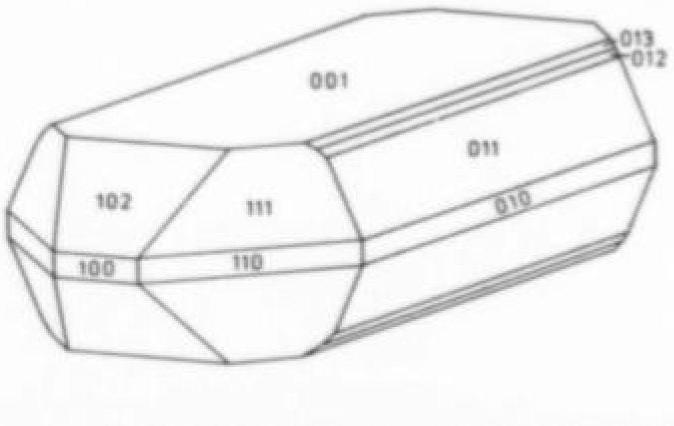

Figure 62. **Red olivine crystal. Kunkskopf.**

OLIVINE, members of the fayalite (Fe$_2$SiO$_4$)—forsterite (Mg$_2$SiO$_4$) series, is a rock-forming component of many of the darker types of volcanic rocks. Excellent single crystals occur at Hochstein. Their habit is short prismatic along (100), to tabular parallel to (001); common forms are {001}, {011}, {012}, and {102}, often modified by {100}, {010}, {110} and {111} (Fig. 61). Their color is olive green and sometimes red because of partial oxidation of Fe ^{2} to Fe ^{3}.

Upright crystals have been found rarely in cavities in basalt at Kunkskopf, Nickenicher Sattel and, as reported by Busz (1890), at Krufter Ofen. The crystals are colorless, pale red or brown and have been found at the contact with xenoliths. The colorless and brown crystals are transparent; the others are dull. Habits and forms are like the single crystals; additional forms are {101} and {013} (Fig. 62).

Crystals of red olivine have also been described from a single vug in sanidinite by Rath (1868), with the additional forms {014}, {201} and {112}.

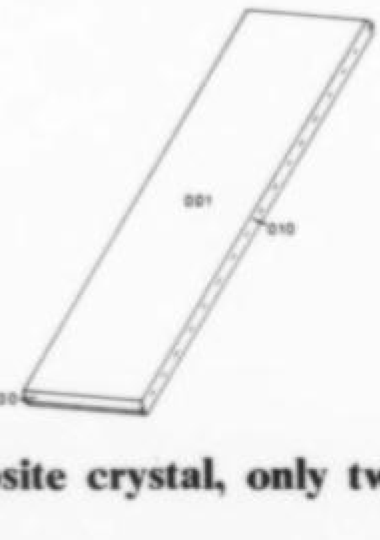

Figure 63. **Phillipsite crystal, only twinned (001). Schellkopf.**

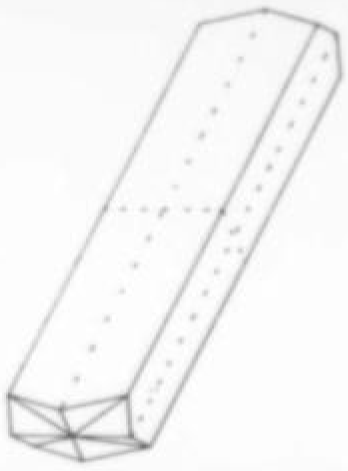

Figure 64. **Multiple twinned phillipsite crystal, showing only the base pinacoids. Schellkopf.**

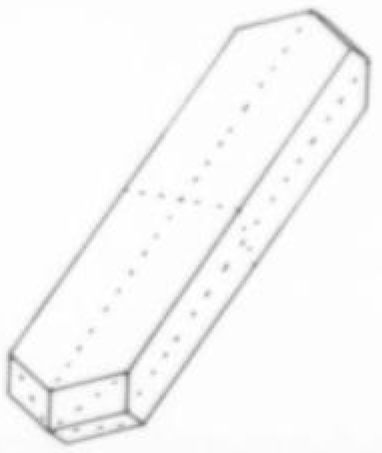

Figure 65. **Pseudotetragonal prismatic phillipsite crystal. Schellkopf.**

PHILLIPSITE, (K$_2$,Na$_2$,Ca)(Al$_2$Si$_4$)O$_{12}$·4-5H$_2$O, was reported as coatings in fissures at Perler Kopf (Busz, 1889). Minute acicular crystals occur in pores in basaltic cinders at Leilenkopf. At Schellkopf phillipsite is the most abundant mineral. The walls of fissures and vugs are usually covered by phillipsite crystals, often as radiating aggregates. Simple (001) twins have been found rarely. They are elongated parallel to (100) and flattened on {001}; the pinacoids {100}, {010}, and {001} are the only forms (Fig. 63). They are usually twinned on (011); their cross-section is cross-shaped or rectilinear (Fig. 64). If {110} is the terminal form a pseudotetragonal habit results without reentrant angles (Fig. 65). The crystals are colorless and transparent.

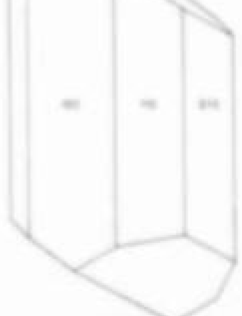

Figure 66. **Common habit of single augite crystals.**

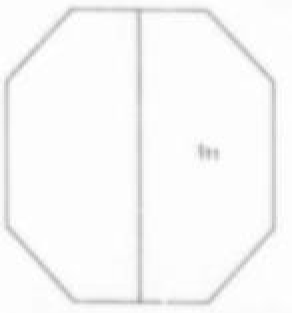

Figure 67. **Top view of fig. 66.**

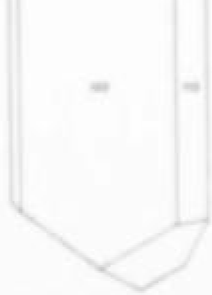

Figure 68. **Pyroxene crystal, flattened (100).**

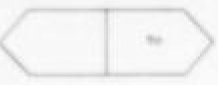

Figure 69. **Top view of fig. 68.**

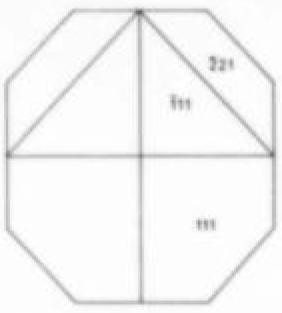

Figure 70. **Top view of a pyroxene crystal. Nickenicher Sattel.**

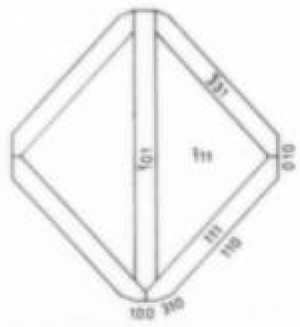

Figure 71. **Top view of a pyroxene crystal. Bellerberg.**

PYROXENES. Monoclinic pyroxenes, having the general composition $ABSi_2O_6$, where A = Na, Ca; B = Mg, Fe, Al, Cr, occur in almost all types of rocks in the Laacher See district. Many of them have not been investigated, therefore only the group name is used to refer to all pyroxenes except the rare orthopyroxenes.

Black single crystals of augite up to several centimetres in size have been found at many localities. Their habit is commonly short prismatic along (001); forms are {100}, {010}, {110}, and $\{\bar{1}11\}$ (Fig. 66 and 67); {021} and $\{\bar{2}21\}$ have occasionally been observed at Hochstein.

Upright crystals occur abundantly in fissures and vesicles in volcanic rocks, especially at the contact with felsic xenoliths. Their color varies greatly; in basalts the color is green or olive-green, sometimes dark green or black; at some xenolith contacts the color is brown, reddish-brown or red. Originally the green, prismatic pyroxenes were called "grünblende" or "porricine" (Nose, 1790, 1808, respectively). The principle color of pyroxenes in basalt cinders is yellow; pale yellow and transitional colors to brown and olive have also been noted.

The habit is prismatic to acicular, often flattened on (100), sometimes even hair-like, and almost colorless. The prisms on single crystals are composed of {100}, {010}, and {110}, resulting in an eight-sided cross-section with almost equal angles (Fig. 67). On flattened crystals {010} is very small or lacking (Fig. 68 and 69). Terminal faces include {111}, {001} and $\{\bar{2}21\}$. Additional forms observed on crystals from contact zones include {310}, {101}, {111}, and {331} (Fig. 70 and 71). Figure 71 shows the case where {110} is dominant resulting in an almost rectangular section. Hollow prisms have also been seen.

Pyroxenes in sanidinites are dark green or black and of similar shape.

HYPERSTHENE, $(Mg,Fe)_2Si_2O_6$. This orthopyroxene is a component of some metasomatites. A detailed description was given by Rath (1869), who first referred to it as "amblystegite". Short prismatic crystals of black color occur with the forms {100}, {010}, {110}, {120}, {111}, {212}, {211}, {232} and {014}.

Figure 72. **Rhönite crystal. Kunkskopf.**

RHÖNITE, $Ca_2(Mg,Ti,Al,Fe)_6(Si,Al)_6O_{20}$, as a product of the decomposition of amphiboles and biotite, was described by Brauns (1922). Crystals in cavities in basaltic rocks have recently been described by Hentschel (1974, b). Their habit is prismatic with six-sided cross-sections and almost equal angles. Terminations are rounded, as in Figure 72. The crystals are deep red and transparent.

SCAPOLITE, possibly **MEIONITE**, $3Ca(Al_2Si_2)O_8 \cdot CaCO_3$, has been identified by chemical analysis (Brauns, 1922). It occurs in some subvolcanites at Wehrer Kessel. Upright crystals are very rare. They are prismatic along (001); forms include {100}, {110}, {210}, {001}, {101}, {111} and {311} (Rath, 1863).

HAUYNE, $(Na,Ca)_{4-8}(Al_6Si_6)O_{24}(SO_4,S)_{1-2}$, in old descriptions was referred to as "sapphirine" (Nose, 1808). Grains of hauyne occur in trachytic rocks, in subvolcanites, and rarely in some basalts. Idiomorphic crystals have been found only rarely, in miarolitic cavities in subvolcanites. Their habit is rhombohedral, occasionally modified by small faces of the forms {100}, {211} and {111} (Brauns, 1922). Hauyne occurs in several shades of blue.

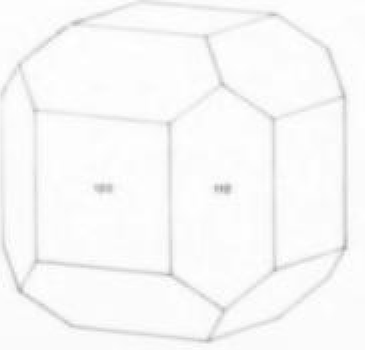

Figure 73. **Typical habit of noselite from vesicles in basaltic cinders.**

NOSELITE (or nosean), $Na_8Al_6(SiO_4)_6(SO_4)$, was named by Klaproth (1815) in honor of the first investigator of Laacher minerals, who had described this mineral previously from Schellkopf as "spinelane" (Nose, 1790).

Well-formed crystals occur in basaltic cinders and in some types of subvolcanites. The crystals in cinders are a combination of {100} and {110}, almost equally well-developed (Fig. 73). They are colorless and transparent or white.

In subvolcanites the rhombohedron {110} is the dominant form, modified by {100}, {111} and {211}. Sometimes crystals are flattened along (110). Penetration twins are alongated along (111) (Brauns, 1922). The color is gray or white, occasionally with a touch of other colors.

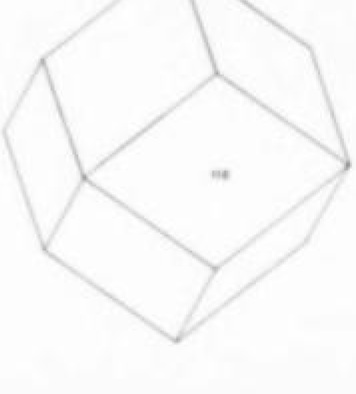

Figure 74. **Simple sodalite crystal.**

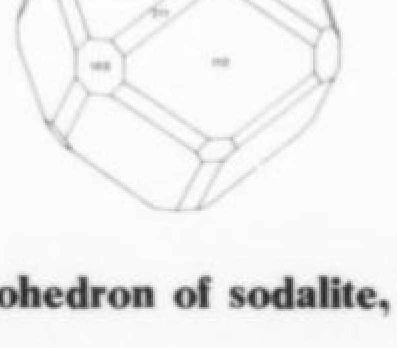

Figure 75. **Rhombohedron of sodalite, modified by other forms.**

SODALITE, $Na_4Al_3(SiO_4)_3Cl$. The only known occurrences of this mineral in the Laacher See district are fissures in basalts, which were first described by Kalb (1932, b). The rhombohedron {110} is often the only form (Fig. 74), but is sometimes modified by small {100}, {111} and {211} faces (Fig. 75). At some localities the crystals are elongated along (111). They are probably penetration twins similar to those of noselite; terminations are rounded and do not allow an exact identification of the forms. Hollow crystals with sunken faces have also been observed. Fresh sodalite is colorless and transparent.

Figure 76. **Strätlingite crystal. Bellerberg.**

STRÄTLINGITE, $Ca_2Al_2SiO_6 \cdot 8H_2O$. This new mineral was found in two limestone inclusions in the Bellerberg lava (Hentschel and Kuzel, 1976). Idiomorphic crystals were observed rarely in some vugs. They are thin, six-sided {0001} plates bounded laterally by {10$\bar{1}$0} (Fig. 76). Usually they form radial clusters or rosettes similar to hematite "iron roses". Crystals are colorless or light green and transparent.

THOMSONITE, $NaCa_2(Al_5Si_5)O_{20} \cdot 6H_2O$, has been found only at Schellkopf as white fibers on crystalline crusts of phillipsite.

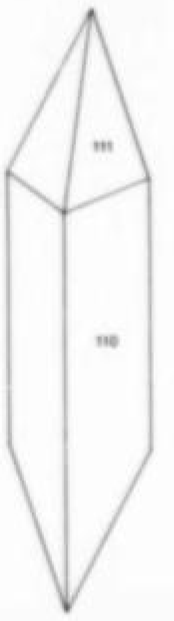

Figure 77. **Titanite crystal, prismatic [001], as found in cavities of basaltic rocks.**

Figure 78. **Titanite crystal, elongated [$\bar{1}$01], from a subvolcanite. Gleeser Felder.**

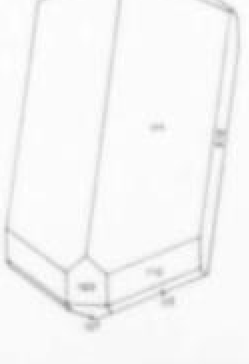

Figure 79. **Titanite crystal, elongated [$\bar{1}$01]. Dachsbusch.**

Figure 80. **Almost tabular (100) titanite crystal. Gleeser Felder.**

TITANITE, $CaTiSiO_5$, is a common accessory mineral in felsic volcanic rocks and in subvolcanites. The simplest crystals occur in the contact zones of xenoliths in basalt. They are long prismatic along [001] to acicular. The prisms {110} and {111} are usually the only forms (Fig. 77); sometimes other minute, unmeasurable crystal faces are observed.

The crystals in sanidinites in general are shorter prismatic along [001] or [$\bar{1}$01] with the additional forms {100}, {001}, {010}, {021}, {$\bar{1}$01}, {$\bar{1}$11}, {$\bar{1}$12} and possibly {214} (Fig. 78, 79 and 80). Crystals elongated along (001) (as in Fig. 80) are often twinned on (100).

Acicular titanite is pale yellow; larger crystals are light yellow or yellow, often with greenish, brownish or reddish tints; they are usually transparent. This mineral has also been referred to as "semeline" or "spinelline" (Brauns, 1922).

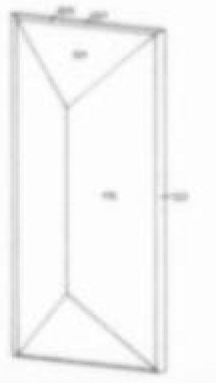

Figure 81. **Topaz crystal. Bellerberg.**

TOPAZ, $Al_2SiO_4(F,OH)_2$. Colorless, transparent crystals of topaz have been found in recent times in vesicles of the contact zone of an inclusion with cinders at Bellerberg (Hentschel, 1976). Their habit is prismatic along (001); dominant forms are {110} and {101}; subordinate forms are {120}, {001}, and probably {305} (Fig. 81), and {111}.

ZEOPHYLLITE, $Ca_4Si_3O_7(OH,F)_6$, was described as "radiophyllite" from Schellkopf by Brauns and Brauns (1924). Habits are botryoidal or spherulitic crusts, rarely forming almost complete single spheres. The color is white.

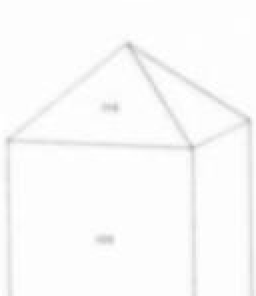

Figure 82. **Simple habit of zircone from subvolcanites.**

ZIRCON, $ZrSiO_4$, is an accessory mineral in felsic volcanic rocks and subvolcanites. Crystals are prismatic along (001) and are short prismatic or dipyramidal with only poorly-developed prisms. Common forms are {100} and {101} (Fig. 82). Sometimes {110}, {201}, {301} and {211} have also been observed. Crystals are colorless, pink, or pale green and are transparent or dull. On exposure to light the pink color fades, as was first observed by Nöggerath (1822).

Acknowledgments

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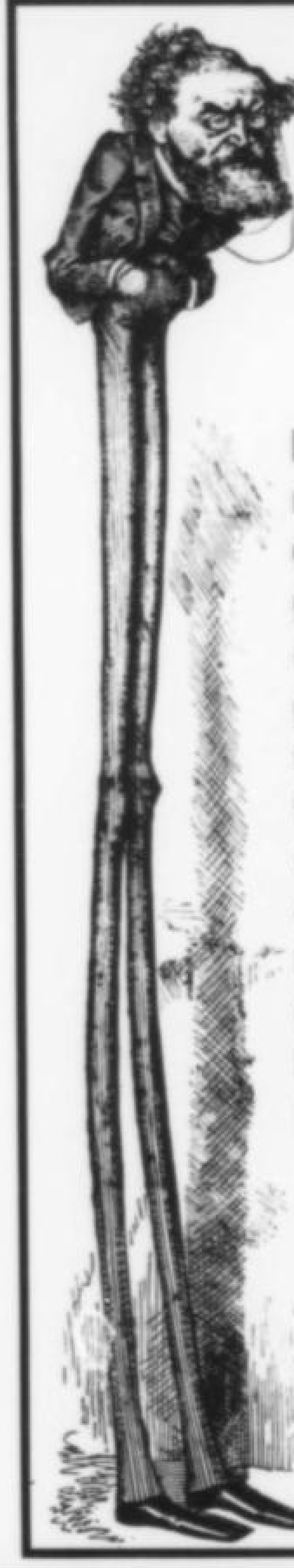

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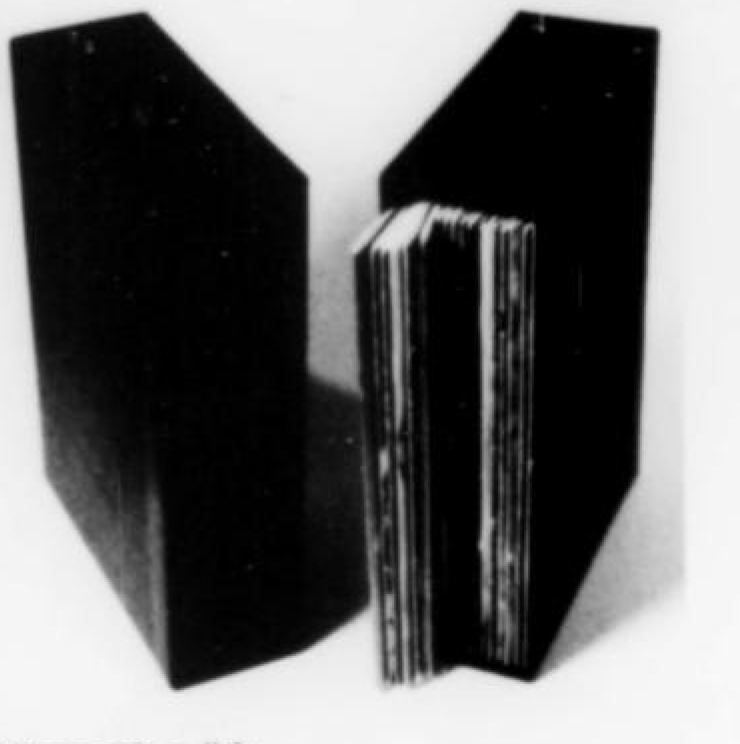

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Letters

MORE ON ST. JOHN'S ISLAND

Dear sir,

Congratulations on your article "St. John's Island, Egypt" (*M.R.* vol. 7, #6). We found the historical coverage on peridot most intriguing and the photos and sketches were extremely interesting.

My own search for St. John's crystals in Egypt began several years ago as a result of an Egyptian electronics program with which I became involved. My frequent trips to Cairo left me some time during the evenings and occasional weekends to haunt first the jewelry shops and later the bazaars in search of crystals for collectors. I spoke to hundreds of jewelers without success but finally located an old man in a bazaar who produced a small tobacco tin with some rough material in it. I managed to find about 20 small but beautifully formed crystals in it but the going price was steep.

The Egyptians highly prize their own gemstones; their cut peridots as well as true Egyptian turquoise are in great demand. They call the stone (peridot) and the island "Zarbarget" and never refer to "St. John's Island." Naturally I was interested to learn more about the locality and, hopefully, to visit it, but the dozens of people I asked were very "mum" about the subject. Finally it did come out (and I have since verified it) that around 1964 the entire island was converted to a secret military reservation at which the Egyptians trained for their subsequent attempted invasion of Israel.

Bob Sullivan
Oberwil, Switzerland

I heard rumors to that effect when I was researching the article but could never get documented evidence. I have since heard the story from several other independent sources, and I doubt if anyone in the near future will ever be able to actually document it, so now is probably as good a time as any to put it into print.

Ed.

EXCHANGES

Dear sir,

I have micromount material from Switzerland and Europe (especially from Lengenbach). I'm looking for rare minerals and uranium minerals from the U.S., Canada, Chile, Terlingua, Athabasca Lake, Tsumeb, Shinkolobwe and Långban.

Peter Steiger
Hornstr. 28
CH-8308 Illnau, Switzerland

Dear sir,

I have norbergite and chondrodite, both fluorescent, from Franklin, New Jersey, and would like specimens from the Midwest, Mexico and Canada.

Kenneth Walling
344 Grosvenor St.
Douglas Mann, NY 11363

Dear sir,

I would like to exchange anatase crystals on quartz from Norway (*see article in this issue, Ed.*). The quality is equal to the photograph in *M.R.* Vol. 7, no. 2, p. 132, Fig. 10.

In exchange I would like the better specimens from the U.S. (no MM or TNs) such as brookite on smoky quartz, boleite crystals on matrix (Mexico), large galena cubes on matrix, amazonite with smoky quartz and specimens from Tsumeb.

J. Stobbe
Goudsbloemstraat 30
Den Helder, Holland

Dear sir,

I am presently curator of the Dartmouth College Museum collection of minerals. The collection has many duplicate mineral specimens including the following: large beryl crystals from New Hampshire (up to 2 x 2 feet), specimens of galena, pyrite, calcite and quartz, many of which are from closed localities and are quite nice. Any suggestions as to how I could go about trading these valuable specimens?

W. David Hoisington
Dept. of Earth Sciences,
Dartmouth College
Hanover, New Hampshire 03755

FALLING INTO AN ERROR

Dear sir,

I was interested to note that Peter Leavens (in his critique of the new Hall of Minerals and Gems in the American Museum of Natural History, *M.R.* v. 8, n. 1, p. 28-31) has fallen into the common error of stating that the yellow, powdery, photoalteration product of realgar is orpiment. The yellow product is actually a polymorph or realgar (therefore having the same composition: AsS), whereas orpiment is As_2S_3. The yellow powder could probably be homologated as a new species if more about its structure could be determined.

Congratulations on the Colorado Issue… it is the very best *M.R.* has ever done. I have subscribed since number 1 and your standard gets higher every year! Keep up the good work.

F. V. G. Bird
Cabris, France

ULTRASONIC CLEANERS

Dear sir,

The following is a brief note on ultrasonic cleaners, their pros and cons, and a list of firms who offer cleaners in a price range of $60 to $100. Only a partial list of firms is included.

Use of ultrasonic cleaners is chiefly for removing grease, oils, and fingerprint stains as well as loose dirt from jewelry, gemstones, surgical or small tools, and drawing pens.

Most effective cleaning is obtained when items are suspended directly in the cleaning liquid, not resting on bottom of tank or in a smaller, separate container within the tank. The tank must be filled to about ½" from top and equipment should never be run when liquid is less than an inch deep. The liquids used may be recovered and stored in dark glass jugs for reuse. Also one should use adequate ventilation with most liquids.

Effective solutions to use in containers: 1) Trichlorethylene, 2) diluted NH_4OH, 3) methanol or ethanol alcohols, 4) acetone, 5) a solution of 1 part each vinegar, dilute NH_4OH, and water. Other solutions can be used, depending on material to be cleaned. Running time of 3 to 5 minutes is adequate for cleaning.

All cleaners have stainless steel tanks and most have lids and timers.

Ultrasonic cleaners will not: 1) disaggregate friable sandstone nor satisfactorily remove clay or iron stain from grains, 2) won't remove thick soap coating from prongs of rings, 3) will not remove *all* black silver sulfide from silver jewelry nor tarnish from silver. To clean silver best method is to use 1500 alundum powder and then use 15 micron Al_2O_3 for polishing before ultrasonic treatment. 4) Do not use on cemented stones as jade and turquoise since glue may dissolve or soften.

Important—outside housing should be metallic since some plastics are affected by chemicals.

Many types of cleaning liquids can be obtained from janitorial supply stores and chemical supply companies.

A partial list of firms selling ultrasonic cleaners:

1. In kit form- **Heath Company**, Benton Harbor, Michigan, 49022, cost-$69.95.
2. **Jensen Tools and Alloys**, 4117 N. 44th.

St., Phoenix, Az., 85018 models from $59.95 to $110.00.

3. **Koh-I-Noor Rapidograph, Inc.**, Bloomsbury, N.J. 08804 cost- $95.00, order from office and drafting supply stores.
4. **Cole-Parmer Laboratory Supplies**, 7425 N. Oak Park Ave. Chicago, Ill. 60648. Write for price list.

Eugene B. Gross
El Paso, Texas

BY CHANCE OR MISCHANCE

Dear sir,

Come November, I make up small mineral collections as Christmas gifts to beginning collectors, students, schools and colleges. Last November I was doing this, as usual, when I fell ill and had to delegate wrapping and mailing to someone else. This someone was, doubtlessly, as conscientious as he could be, yet somehow the list of packages and addresses did not tally. What was worse: two packages, not intended for mailing, had disappeared. By chance, they must have gotten in along with the gifts. These two contained first-rate specimens from my own collection. I had packed them to place them in a safe, as I did not want to leave them unattended during a forthcoming trip.

Anyone who knows minerals would instantly recognize these beautiful, fine specimens for what they are: precious native ores, Brazilian and Russian beryls too good to be used for cutting, emeralds and so on and on ... Should they in their wanderings, fall into the hands of a connoisseur I should be most grateful if he contacted me without delay.

F. W. Cassirer
(collecting since 1896)
11 Riverside Dr.
New York, NY 10023

COMPETITION IS WINNING AFTER ALL?

Dear sir,

I've heard so many times that competition at shows is on the decline I've come to accept it as fact. In fact, it's not true—at least in the Midwest. Cal George, chairman of the Midwest Federation Uniform Rules Committee, compiled some statistics that indicate competition has remained amazingly constant: the total number of competitive exhibits was **65** in 1973, **101** in 1974 (the year the Midwest Federation hosted the National Show in Lincoln, Nebraska), **64** in 1975, and **61** in 1976. Cal compiled the statistics simply to summarize records, not to prove anything, although it may prove interesting to your readers.

Marie Huizing
Cincinnati, Ohio

PULSIFER COMPETITION?

Dear sir,

I enjoyed your article on the Pulsifer quarry in the first pegmatite issue (*M.R.* v. 8, n. 2). I think it might be worth noting that at least one other American locality produced fine, large royal-purple apatite crystals which are essentially indistinguishable from Pulsifer specimens. Early in this century the Strickland quarry in Portland, Connecticut, produced an unknown number of very fine apatites. Two damaged crystals of the darkest purple color can still be seen in the Harvard collection and one exceptional crystal was, until recently, in the Wesleyan University collection. F. E. Strickland's personal collection contained a crystal measuring 5 x 3 x 1 cm, in a group with a number of smaller crystals, on a matrix of white albite crystals, and associated with a very minor amount of partially altered pyrite. Every knowledgeable dealer and collector to whom I have shown this specimen believed that any apatite of such size, color and clarity must have come from Maine. I hope that this history might prove informative; it illustrates the dangers of ascribing localities to specimens of uncertain origin.

Russell E. Behnke
Meriden, Connecticut

SETTING THE *RECORD* STRAIGHT

Dear sir,

I enjoy your publication and would like to bring something to your attention. In Vol. 8, no. 1, in your article "An experiment in specimen appraisal," the brucite is labeled as being from Wood's Chrome mine, Lancaster County, *Texas*. I believe it should be *Pennsylvania*.

Robert T. Price
Trout Run, Pennsylvania

Right you are. Just testing to make sure everyone is alert out there. Several others noticed the same error. The locality is near a town named "Texas." Ed.

FAN MAIL

Dear sir,

I would like to take this opportunity to clarify an error regarding the uvite occurrence in Horicon, New York, (*Pegmatite Issue*, page 106): Branch Lake should read Brant Lake.

I would also like to extend a vote of thanks to Pete Dunn for the tremendous job and wealth of information brought forth in his three articles. The presentation of analyses of specimens from both the new and classic localities is most informative, and provides an invaluable identification service for those of us who lack access to a microprobe. I would like to encourage the continuation of this kind of data compilation by *The Record* on a more regular basis. It is most truly appreciated.

George Robinson
Kingston, Ontario

Dear sir,

As a comment on John W. Hopkins' letter in v. 8, n. 1, I would like to compliment you on the way you organize your advertising, not because having full pages of ads keeps the ads from interfering with the articles, but rather for the opposite reason. I usually do not take any action on an ad while I am reading through an article, but instead tend to go back later to find the ad. The ads are much easier to find when they are all grouped together rather than when they are dribbled into odd corners throughout the magazine. I and many of my friends read the ads as ardently as the articles, and find it much more convenient when they are grouped.

James Johnson
New York, NY

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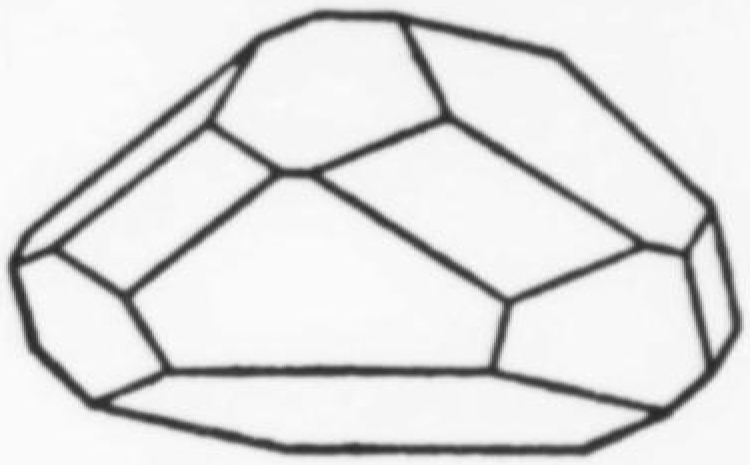

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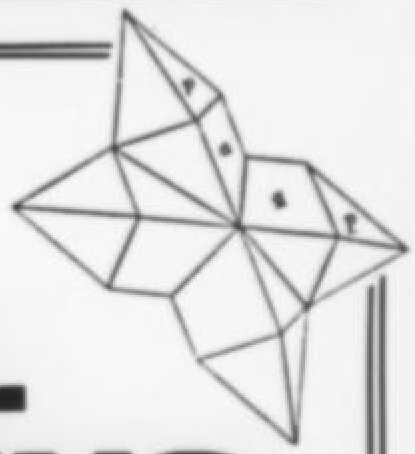

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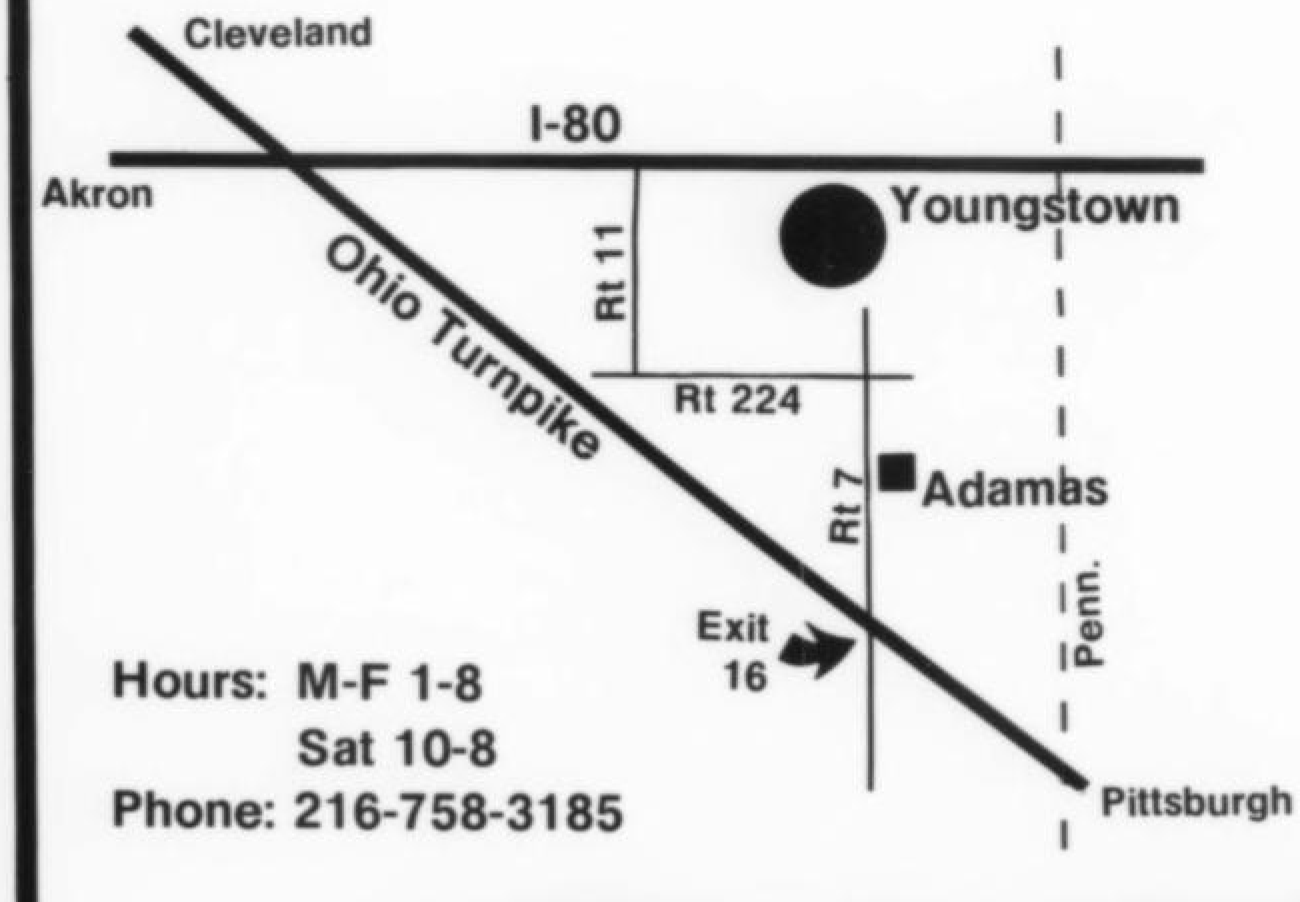

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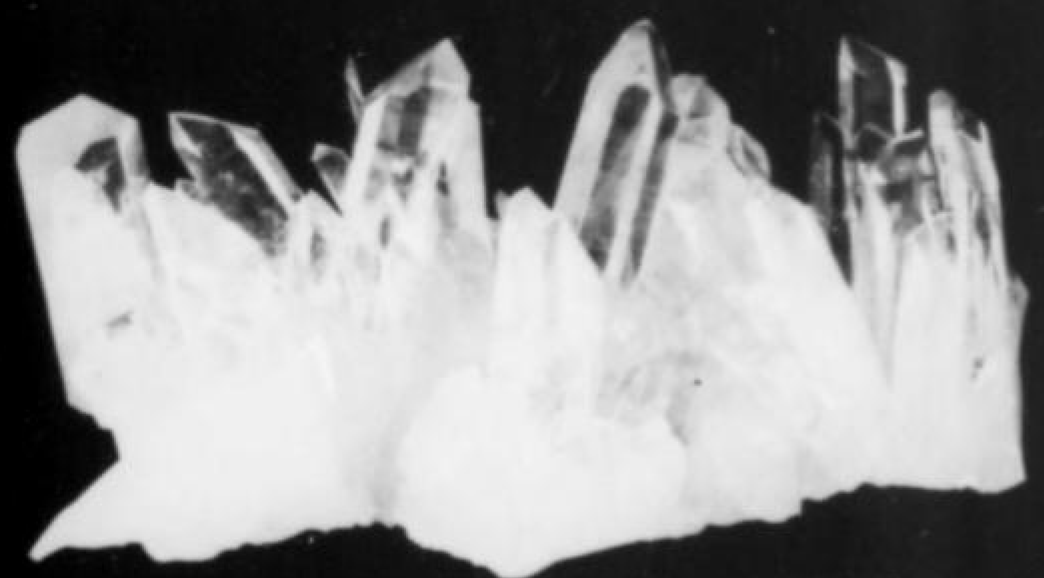

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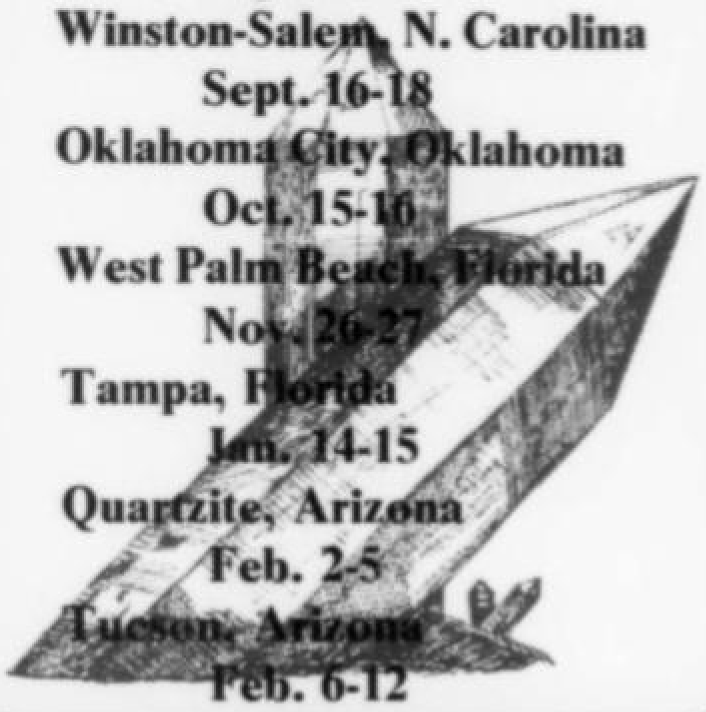

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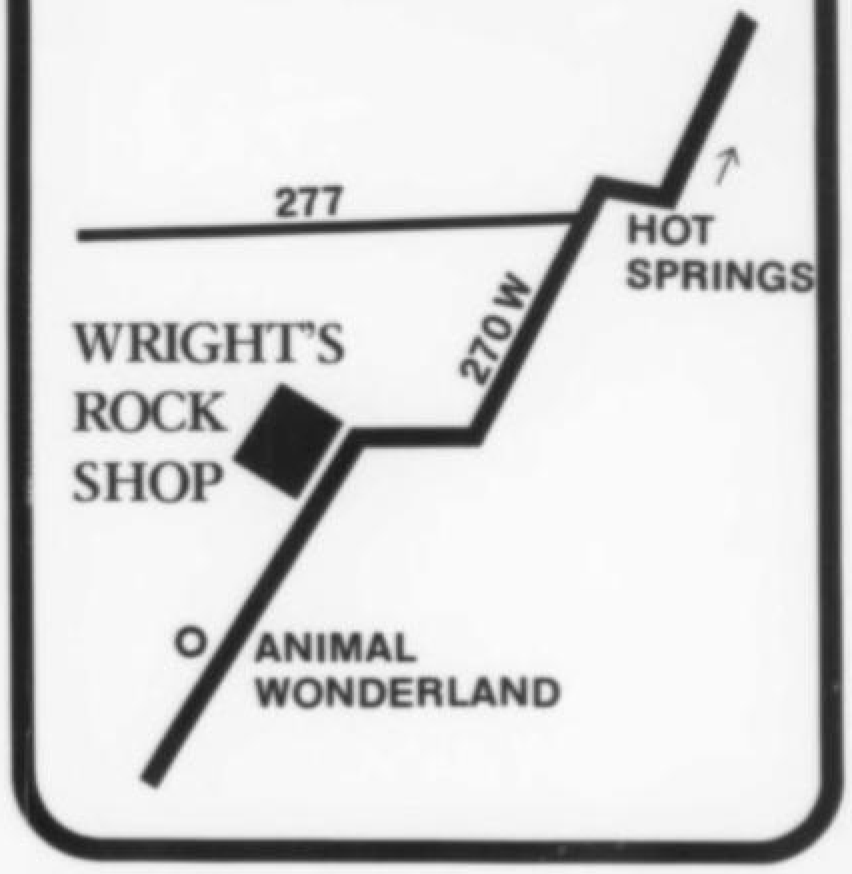

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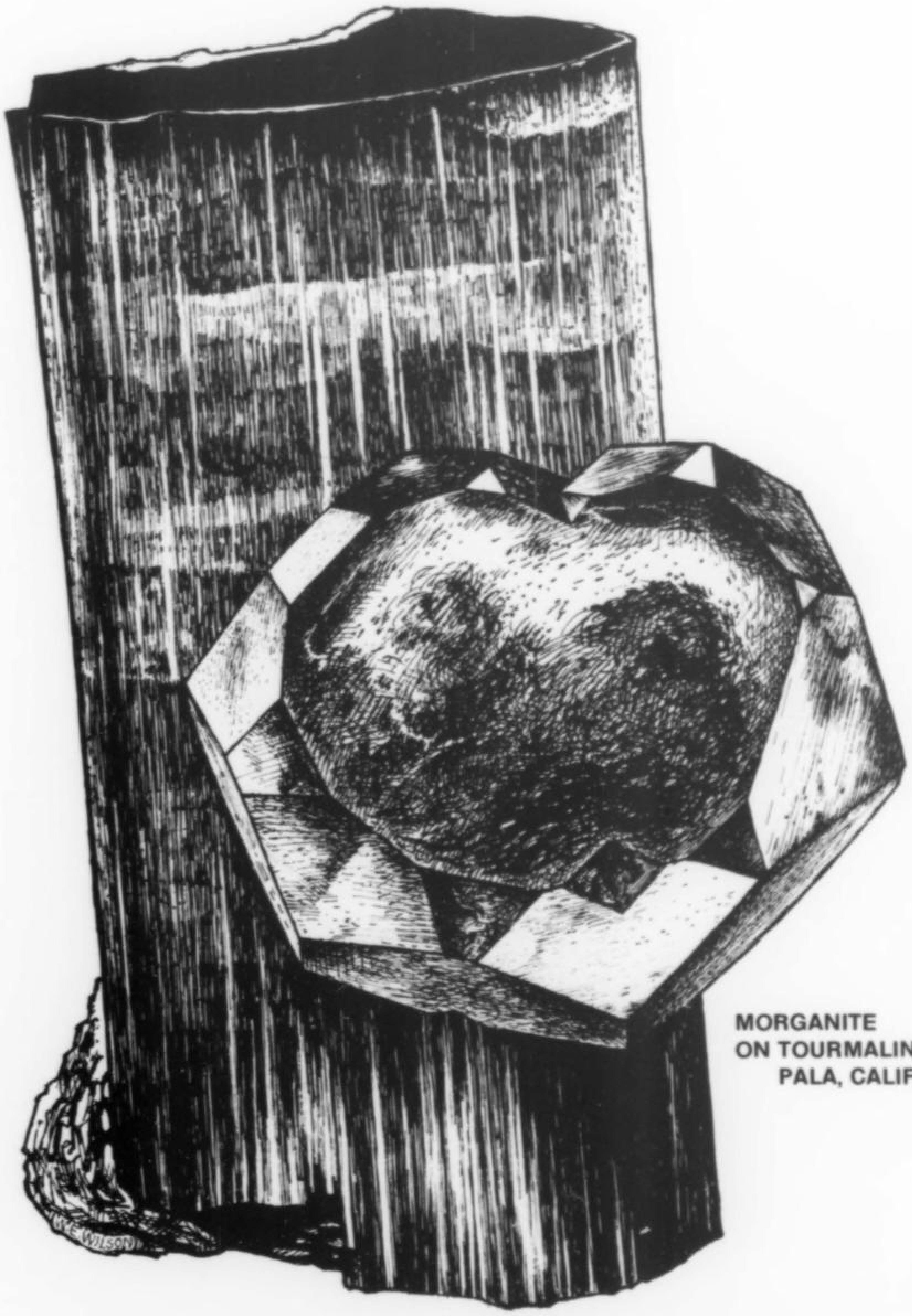

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