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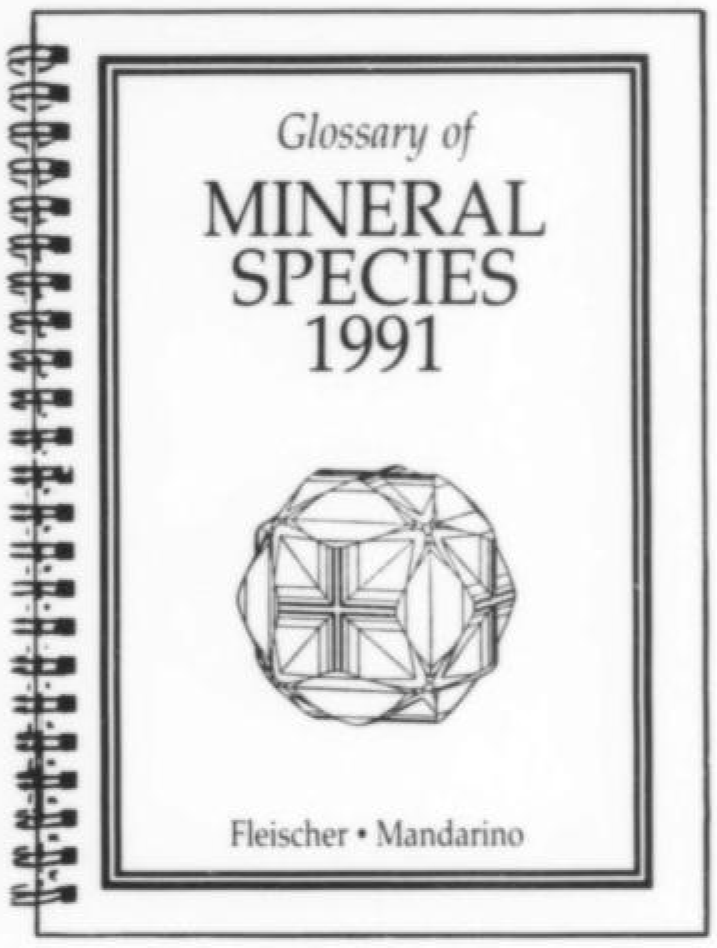
COVER: CUPRITE with malachite on chrysocolla, from the Mashamba West mine, Shaba, Zaire. Sorbonne collection, Paris: photo by Nelly Bariand. See the article in this issue, beginning on page 13.

notes from the EDITOR



NEW GLOSSARY EDITION!

We are pleased to announce the publication this month of the **sixth edition** of Michael Fleischer's *Glossary of Mineral Species*. For the 1991 edition, Dr. Joseph A. Mandarino (Chairman of the I.M.A.'s Commission on New Minerals and Mineral Names) joins Dr. Fleischer as co-author. The successive editions of the *Glossary* (1971, 1975, 1980, 1983, 1987) have long been considered the most authoritative and indispensable mineralogical reference for collectors. All known mineral species and their chemical formulas are listed, along with other data and references. In addition to the assistance provided by Dr. Fleischer's distinguished co-author, the new edition has also benefitted from careful proofing of the additions and changes by Richard A. Bideaux (co-author of the massive *Handbook of Mineralogy*), and a general proofing by Prof. Paul B. Moore. The 1991 edition, therefore, must surely rank as the most authoritative and carefully checked edition of the series to date. Order your copy now from the Circulation Manager, Mineralogical Record, P.O. Box 35565, Tucson, AZ 85740. The price is $15 plus $1 shipping in the U.S. ($2 to foreign countries).

We want to thank the many collectors, curators and researchers who together have made the *Glossary* the leading pocket reference in mineralogy. Sales of each of the five editions since 1971 have been an important source of revenue for us; your continued patronage of this work is a way of supporting publication of the *Mineralogical Record* magazine.

READER'S AID

Thorough readers of the *Mineralogical Record* like to plow their way through all sections of an article, even if unfamiliar terms are present. Most readers simply skip over these words and press on, while their unsatisfied curiosity slowly fades. Even among professionals it occasionally slips the mind as to exactly how old "Proterozoic" is and what the precise difference between "eluvium" and "alluvium" might be. In some cases we try to explain terminology in the text, but we can't provide a full-scale geological glossary.

It is useful, therefore, to have some sort of "reader's aid" at one's elbow while assimilating each issue. The ideal book for this purpose is *Glossary of Geology* (1987), edited by Robert L. Bates and Julia Jackson. Now in its third hardcover edition, *Glossary of Geology* contains 37,000 entries gleaned from 2,150 references dating back to the early 1790's. It is considered an essential reference for everyone in the American geoscience community, and should be in the library of every scientifically oriented mineral collector as well.

Happily the book is still in print, and is available at $80.50 per copy postpaid (in the U.S.). Order from the American Geological Institute, 4220 King Street, Alexandria, VA 22302.

TUCSON SHOW FUND-RAISER

Each year for the last 20 years the *Mineralogical Record* has held a fund-raising auction at the Tucson Show. In recent years the event was expanded to include a show-long silent auction for inexpensive specimens as well as the traditional Saturday night auction of the best items donated.

Over the years, however, the auction had become so predictable that it lost much of its old excitement. Although we received more donations each year, the average quality had been slowly declining. Our large staff of hard-working volunteers began to grow weary, and the $1,600 booth fee for the silent auction took a big bite (the Saturday night auction hall was provided free by the Tucson Gem & Mineral Show). At last it seemed time for a change.

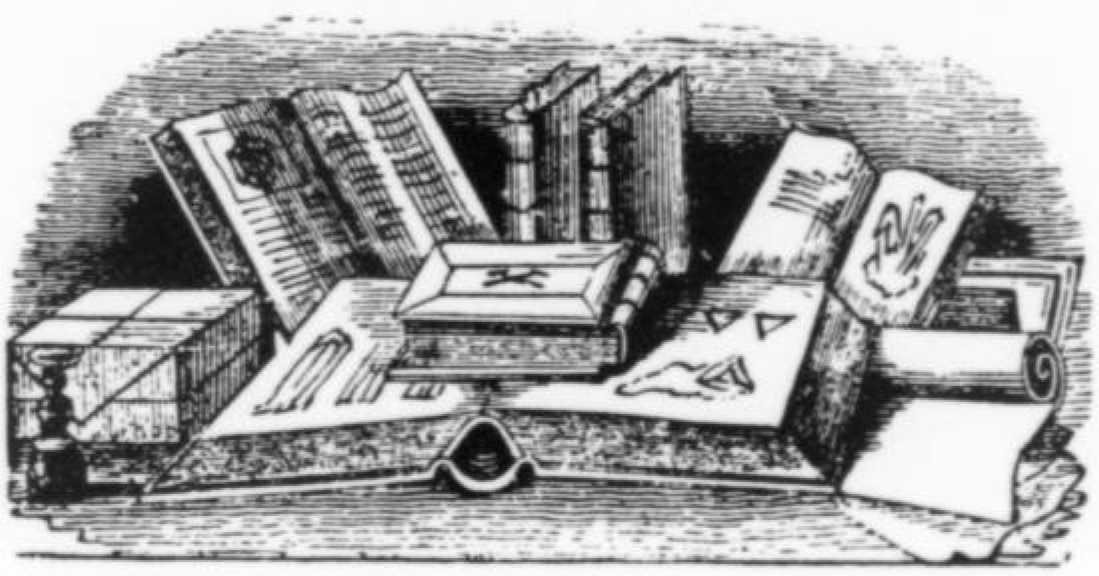
We now have a new fund-raising event planned for the 1991 Tucson Show. I am not permitted to explain here exactly how it will be conducted. But it will involve a magnificent, 6.3-cm Virgin Valley, Nevada, opal specimen (see photo on page 70!), officially appraised by Dr. Gary Hansen at $12,000. It's a beautiful, historic specimen first sold by Ward's in 1919, and stored dry for the 72 years since then. It would enhance the shelf of *any* mineral collection.

Be sure to stop by our booth at the show for details, or see one of our roving volunteers. The event will culminate at the Saturday evening program at the Convention Center.

Incidentally, Marie Huizing, editor of *Rocks & Minerals* magazine, recently sent me a clipping from the Cincinnati *Enquirer* which describes a fund-raising event sponsored by a local high school. It's called a "Cow Dump." "The event entails sectioning off the football field in square yards, setting a cow loose on it and waiting for the inevitable." The numbered squares are sold for $5, and the cow determines the winner. Unfortunately we were unable to locate an available football field near the Convention Center . . . but thanks for the idea anyway Marie.

HOPE DIAMOND REPRODUCTION

Sure, it's been lapidated, but the Hope Diamond is still one of the most famous and most valuable chunks of mineral matter on the planet. Now you can buy a reproduction in hand-cut blue glass surrounded by a pin-pendant setting with 16 prong-set quartz stones, for $63.25 postpaid. (You can always remove it from the setting for display purposes.) Order (item #4000) from The Smithsonian Institution, Dept. 0006, Washington, D.C. 20073-0006 or place a credit card order by calling (703) 455-1700.



ANTIQUARIAN REPRINT SERIES

The second in our series of antiquarian reprints, Hebenstreit's *Museum Richterianum* (1743), is now sold out, despite the edition size having been increased from 30 to 50 copies. We have given the original back to its owner, and will make no more. We will, however, maintain a "waiting list" of people still wanting a copy of any book in the series; this list will be made available in the future to anyone who may wish to resell a copy.

My sincere thanks to all of the people who have supported the series, thus allowing it to continue. We will be producing one or two new titles this year, in strictly limited editions of 50 copies. Keep an eye on this column for details when the time comes.

INVESTMENT ADVICE

Peter A. Barone, writing in *Coin World* (September 5, 1990), gave some advice to investment-oriented coin collectors which may have some value to mineral collectors as well.

Rule No. 1. "Buy only accurately graded coins." Although there is no comparable grading system for minerals, a coin's grade determines its price, so the rule might be restated to say "Don't buy overpriced mineral specimens."

Rule No. 2. "Do not buy common coins no matter what the grade of them may be." This is just common sense. Demand cannot drive prices up on minerals that are easily available to anyone. However, here is a rule that is contrary to the simple enjoyment of mineral beauty; perhaps ten (or a hundred) equally beautiful but common mineral specimens might be purchased for the same total price as *one* with investment-grade rarity. Furthermore, it might be noted that *too much* rarity in a mineral specimen can make it so unfamiliar that it cannot establish a commensurate market price.

Rule No. 3. "Always remember a *collector* is the only true consumer . . . to expect an unending supply of uneducated investors is simply ludicrous." In other words, don't buy with the expectation of later finding a sucker. "It is critical to remember that you will be selling to individuals more knowledgeable than yourself . . ."

Rule No. 4. "If you are planning to sell on the sight-unseen market, think again." Buyers of investment-quality specimens will be reluctant to buy from a mail list, and will always demand return privileges. The specimen must be seen to be properly evaluated.

"The answer," says Barone, "is quite simple and can be summed up in a single word: knowledge." If you cannot precisely evaluate specimens yourself, "Put your money in the bank, and you'll be much better off in the long run." To become thoroughly educated in the field, he observes, is to realize how enjoyable it can be. Collecting while also investing then "is like having your cake and eating it too." Solid advice for all of us cake-eaters.

Numismatic newsletter editor Maurice H. Rosen gave some additional suggestions at an August 25 investment seminar conducted during a coin convention in Seattle (reported in *Coin World*, October 3, 1990). He also advocated buying true rarities and avoiding common pieces, but he put more emphasis on the collector's relationship with dealers:

"Rely on skilled specialists," he said. "Establish yourself as a preferred customer," and "distinguish yourself" in your relationship with dealers. On the other hand, he cautioned against trusting dealers too much, and against "overtrading" ("churning" your specimen portfolio with too many transactions).

Among his strongest points was that the investment-oriented collector must "stay informed," and "update the information" about each specimen on a continuing basis. "Consider the population of the coin," that is, be knowledgeable about the *other* top specimens of the same coin. In mineral collecting this has a close corollary in knowing about *all* of the best specimens (say, the top ten) from major discoveries. "Knowledge of rarity is vital," he said.

New York coin dealer and author Scott A. Travers made some final remarks on investing. He observed that the most important secret of the stock market applies to coins as well: "The market will go up and down," he said. Beyond that, luck is an important factor. In his opinion, a person should have no more than 15% of his investment portfolio in coins, and he should "deal with reputable dealers."

Perhaps the most important factor separating coin investment from mineral specimen investment is the emergence of certified coin grading services. Coins are professionally graded and then encapsulated in plastic to guarantee preservation. There can be no similar service in mineral collecting. In looking back at the 1980's and earlier, before coin certification, coin collectors and dealers alike view the market in those days as uncontrolled, inefficient, and a hazard for newcomers. So it still is with investing in mineral specimens, and probably always will be.

TRAVELER'S NOTE

Mineral collectors, curators and dealers tend to travel relatively often, and are unfortunately exposed to a loathesome variety of infectious diseases that may be locally active. Now the U.S. Public Health Service's Communicable Disease Center (CDC) in Atlanta is offering an automated, 24-hour, telephone hot-line service providing health information for people planning to travel abroad.

By pressing buttons on your touch-tone telephone in response to menu instructions, you can quickly obtain constantly updated messages on the specific countries you plan to visit. Types of information available (where applicable) include malaria and other diseases, food and water precautions, travelers' diarrhea, immunization recommendations, and current disease outbreaks. Call 404-332-4559.

BACK ISSUES

Readers who are still building their set of back issues, or who just want some interesting mineralogical reading, should be sure to carefully examine the double-page back issues ad on pages 80–81. It lists every issue still in stock up through vol. 15, no. 3, even those which we have only a few of. And note that postage is free on orders of ten copies or more. Next time we'll list all available issues from vol. 15, no. 4, to the present.

STERLING HILL UPDATE

[Charles B. Ward, of the *Committee for Historic Preservation of the Sterling Hill Mine*, provides the following news on the ongoing efforts there to preserve the recently privatized mine and open it as a tourist attraction:]

As the curtain lifts on a new chapter in the lengthy history of the Sterling Hill mine in Ogdensburg, New Jersey, the Hauck brothers Richard and Robert, who last year privately acquired the mine, see the water rising. The Haucks and many dedicated volunteers have made herculean efforts to save equipment and minerals from the depths of the mine. On the surface they have uncovered artifacts and old workings, and have created paths to and through the Passiac open pit to connect to a newly blasted and opened tunnel. They have created an attractive entrance and gift shop to welcome all. A unique experience awaits visitors, including an informative tour underground to the "Rainbow Room" where minerals under ultraviolet light fluoresce in situ. The tour ends at the Mine Museum where ore cars, crushers, mine lamps and mineral displays educate all on Sterling Hill mining.

The Haucks and their volunteers continue to work very long hours to recover equipment and minerals from one of the oldest mines in the United States. Even as the water rose to flood the 1000-foot level, fluoborite was discovered and preserved. On the 900-foot level, realgar and mcgovernite have been rediscovered. Specimens of realgar, mcgovernite, hedenbergite, chabazite, barite, wollastonite and some of the best stilbite ever found have been preserved in the Mine Museum. Unfortunately, in October of 1990 the 900-foot level was lost to rising water. Even as you read this update, sand tailings used for backfill in the stopes are settling and moving to lower regions in the mine, ending forever our opportunity to study and preserve those portions of the unique mineral and mining history of Sterling Hill.

We feel it is essential to support the Hauck's endeavor to secure the right to pump out the water and historically register the mine site for future generations. We have therefore established a trust fund for the purpose of raising the $50,000 required to start up the pumps to prevent water from claiming the mine. It is also hoped that once the pumps are working the water level will fall and more of the history of Sterling Hill will be revealed.

The Committee for Historic Preservation of the Sterling Hill Mine has been authorized to make the following offer: For the sum of $25 you can receive a small cabinet-size specimen of recently recovered fluorescent minerals to make a special addition to your collection and, at the same time, you will know that you are contributing to preserve a piece of Natural History. Those who are able to contribute larger sums will receive appropriate specimens for their collection.

Please support this worthwhile effort to save this geologically significant and unique mine by way of contributions. To order your piece of history please select from one of following minerals and forward your remittance of $25.00 plus $3.95 shipping and handling (N.J. residents please add $1.50 sales tax) to: SAVE THE MINE, % Charles B. Ward, C.P.A.—Trustee, C.H.P.S.H.M., 56 Chambers Road, Danbury, CT 06811. You may specify (1) fluorescent willemite-calcite, (2) zincite, or (3) fluorescent wollastonite. You will also receive: a certificate stating mineral species, location within the mine, and date; and a free pass for a tour of the mine ($6.50 value).

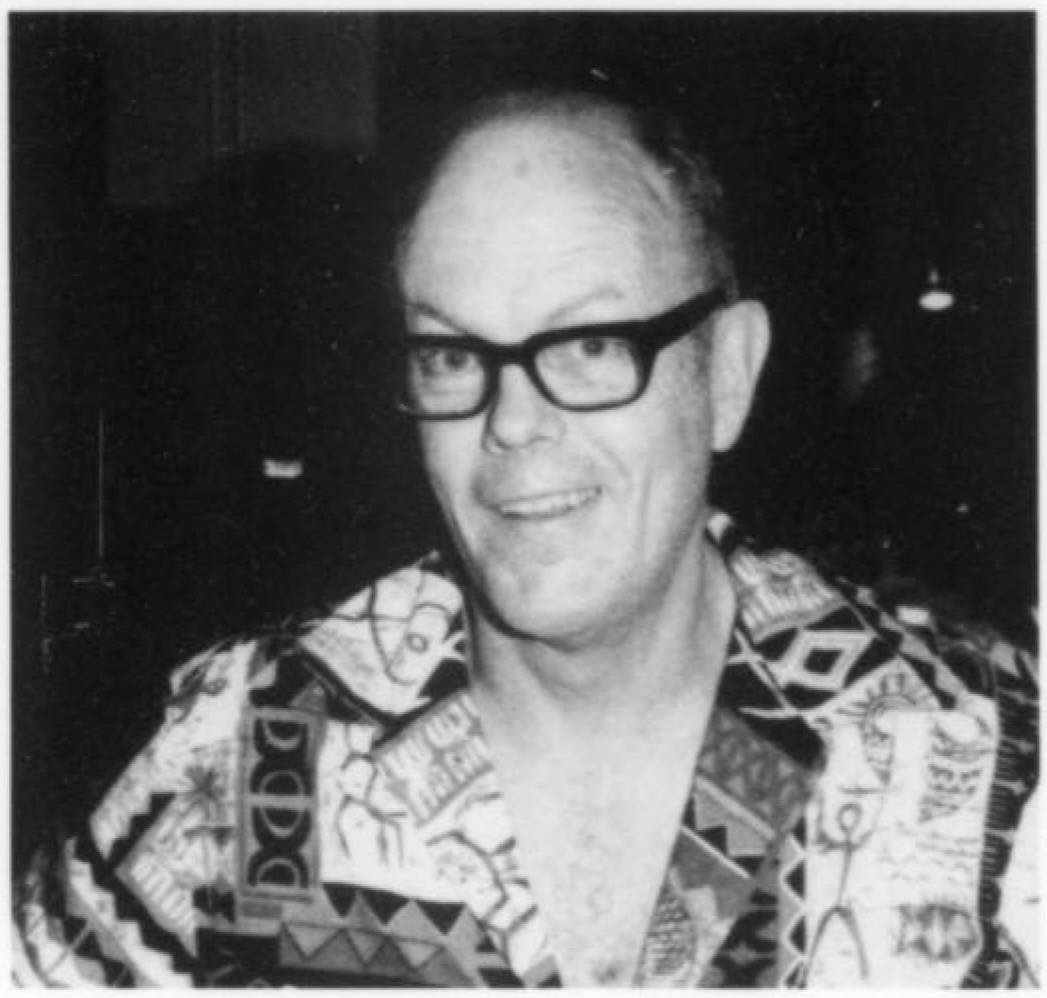
Plan to visit the mine, located at 30 Plant Street, Ogdensburg, New Jersey 07439; tel.: (201) 209-7212.

NOTICE

Died, Albert Leo McGuinness, 64 (born 17 August 1926; died 27 September 1990). Al McGuinness was born and raised in Oakland, California. His interest in minerals began when he was a Boy Scout, and continued for the rest of his life. At the University of California, Berkeley, he studied mineralogy under Adolf Pabst, and graduated with a degree in Mining Engineering in 1948. A year later he married Joanna Stepanek, and they moved to Portland, Oregon, where their children (Mark, 1951; Maureen, 1953) were born.

In 1955 Al accepted a job in Butte, Montana, selling explosives for Atlas Powder Chemical Company. It was there that he met the legendary and eccentric mineral dealer, Ed McDole, and they became close friends, spending many weekends together field-collecting minerals.

A promotion took Al and his family to Eugene, Oregon, in 1958, and following another promotion in 1968 they moved to San Mateo, California. In 1972 Al decided to give up his job with Atlas and become a full-time mineral dealer. He field-collected minerals, made appraisals for museums and private collectors, and attended many of the major mineral shows each year, especially the Tucson Show.


Kent England photo, 1979

Al McGuinness (1926–1990)

His first mineral-buying trip abroad took him to Europe, Morocco and South Africa with "Jack" (John Jago) Trelawney. On this trip Al met fellow mineral dealer Luis Leite, and they struck up a lasting friendship. Together they later made several collecting trips to Europe, Africa and South America. In the following years Al continued to travel widely, collecting and trading with dealers and museums.

Al's wife Joanna died unexpectedly in 1984, and he continued his business until 1988 when several minor strokes forced him to limit his activities. Following the 1989 Tucson Show he was advised to retire from active business. He moved to Lake Oswego, Oregon, and from there to Portland in August of 1990, where he died quietly in his sleep of a heart attack. He is survived by his two children and five grandchildren.

Al was known worldwide in the mineral community, and had friends everywhere. He was always scrupulous and fair in his dealings, and was an expert in the sight-identification of mineral specimens and their localities, freely sharing his broad mineralogical knowledge with others. He served for a number of years as a Tucson Show auctioneer for the Mineralogical Record, and was the ceremonial co-presenter of the McDole Trophy (which will now be retired) and the Lidstrom Award.

Al's personal mineral collection of roughly 950 specimens contained several museum-quality pieces which he had personally collected in the field. Particularly prominent in this collection were zeolites from the Pacific Northwest; quartz from California; uvarovite from California; ilvaite from South Mountain, Idaho; inesite from Hale Creek, California; schorl from Thompson Peak, California; and artinite, andradite, strontiojoaquinite and perovskite from San Benito County, California. Most of his specimens were miniature to small-cabinet in size, and the scope of his collection covered all the major collectible species, from famous as well as relatively unknown localities, in good to excellent quality. Many other specimens which he personally field-collected or handled are now in prominent museums around the world, and others he donated to various mineralogists for research purposes.

One mineral, which he collected and recognized as an unknown species, was named *mcguinnessite* in his honor, and was formally described in the *Mineralogical Record* (vol. 12, p. 143–145).

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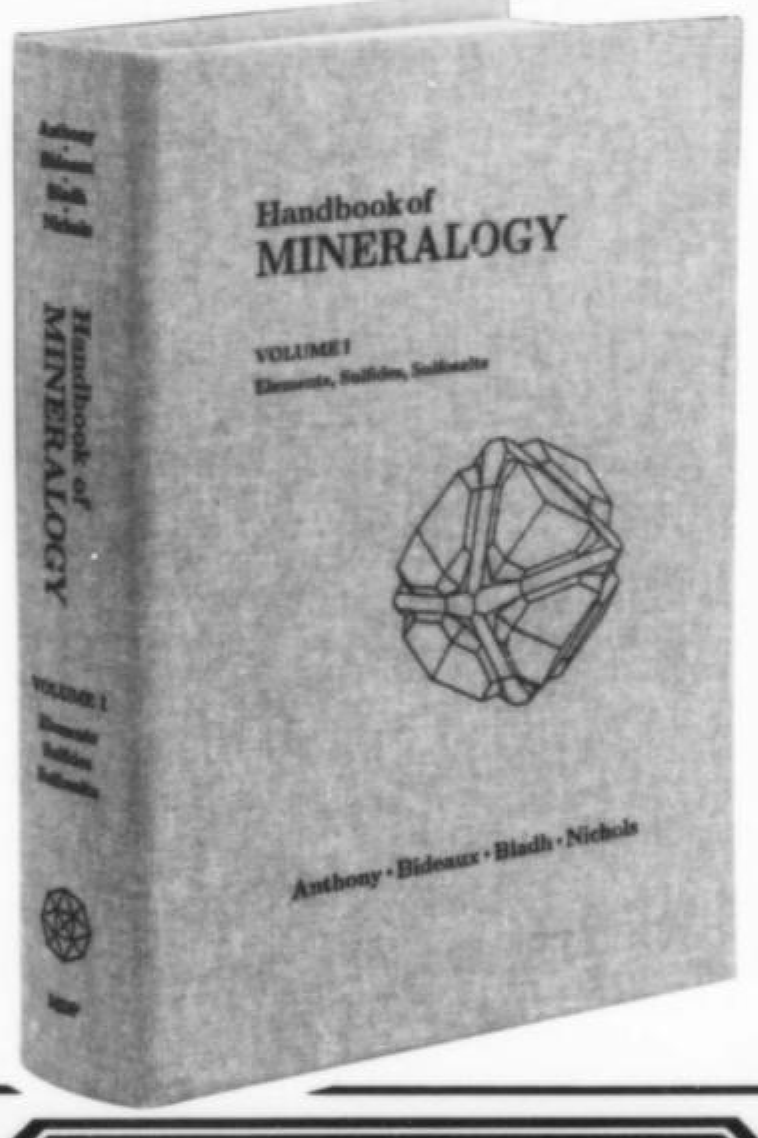

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Museum work is multi-faceted; mineral curators and museum staff play many roles simultaneously. Responsibilities commonly include duties of administration, specimen conservation, specimen acquisition, collections management, policy making, fund raising, public education, advising, supervising exhibit planning, and many others. Some of these many and varied roles are in the public eye, but others are not as visible, and one of the least public of these is research.

INTRODUCTION

This paper is written partly to answer an inquiry we hear in the public arena: "What do curators do?" There is much scientific activity underway in institutions where many curators work! Mineral research in museums is important, varied, stimulating, rewarding and downright fun.

Much as the job of the curator is varied in its parts (as noted by Embrey, 1987), so too is the process of doing good research. Uncommon today, but more prevalent in the past, is the one-man project. Increasingly, challenging and difficult problems commonly require the expertise of a number of investigators working in tandem, each practicing his or her specialty and forming part of a specially assembled team. Such a division of labor might be accomplished internally if one museum is large enough and has the facilities, equipment and staff to do the whole job. This is not often the case, however, and usually the more difficult projects are accomplished by investigators from different institutions, each bringing strengths and insights to the task at hand. The final publication of results also benefits from this approach inasmuch as diverse minds are forced to turn their combined talents toward a unified common objective; the resultant publication is almost always stronger than if written by only one investigator.

THE BREADTH OF MINERALOGICAL RESEARCH

Research has as its primary purpose the discovery of new knowledge through diligent and systematic inquiry. The fundamental definition of research is that it is a critical and systematic investigation or experiment, aimed at generating, synthesizing, and communicating knowledge pertinent to a particular science. The practice of mineral research, however, is very broad and can encompass a variety of abilities and applications.

The collector community knows that new mineral species are discovered and named, and that some curators are active in this important work. However, mineral research, particularly in museums, extends far beyond our own discipline into other areas of science, and also into the art world. For example, the museum mineralogist may be involved in paleontological studies because the mineralogic constituents of fossils are an important part of such efforts. He may also be active in anthropological and archeological studies, perhaps in the investigation of bones or artifacts, or the estimation of the locality of the source materials used in the making of man-made objects. Mineralogists are sometimes involved in art research as well, because the early painters used powdered minerals as paint pigments. Additionally, the investigation, dating and provenance-determination of ancient bronzes, statuary and the like, frequently involve mineralogical expertise in part.

Although we are concerned here with specimen-based mineralogy foremost, it should be mentioned that mineralogy is used frequently, indeed on a day-to-day basis, by our colleagues in volcanology, petrology, paleontology and other geological specialties. In fact, where the sole resident curator is a meteoriticist or petrologist, and the collections have the appropriate strengths, the mineral research done may be almost wholly of that character. What we refer to as mineral research, conducted for its own sake ("pure research," so to speak) rather than as an intended aid to industry or investment is, for many others, both in academia and in industry, only one of several pursuits in a vast array of investigative methods. The science of mineralogy is much broader than presented here in this discussion, which is intentionally focused on museums and mineral specimens.

The broad subject of museum mineral research can be divided into two areas: (1) collection management and conservation research, and (2) taxonomic and systematics research.

COLLECTION MANAGEMENT AND CONSERVATION RESEARCH

Not all scientific work involves the gathering of quantitative data. Mineral curation, among other duties, requires collection development based on correcting informational deficiencies and perhaps adding knowledge either in systematics or geographical representation. Such research on a collection can lead to useful descriptive, geographical and bibliographic lists. Collection documentation requires provenance (locality) determination and validation. The problems associated with this activity sometimes require intensive geographical research and/or special field trips to establish the proper sites and to validate old maps or even old labels (see Bentley *et al.*, 1986).

Conservation research involves detailed studies of specimen preservation and preparation. Included are stability studies to assure proper storage conditions for species which are unstable in a collection room or display environment. Sample preparation research involves the development of methods for cleaning and repairing specimens to safely restore or enhance them. (This important field of research has been dealt with in detail by Waller, 1991.)

The museum's collections are the supporting base upon which the work is done, and they are, in turn, enriched by having been studied; specimens from which data have been gathered (i.e., described specimens) are particularly valuable to scientists. In fact, museum collections may grow specifically as a result of a curator's research interests, and thus will form a discrete studied collection as well as a record of research. The collections are our greatest assets. They are endless in the challenges they present, as is the work which needs to be done with them; indeed, some curators' whole research careers are fostered by specialized collections that they care for and develop. The process is often symbiotic, and the collections are enhanced and prosper as a result of a mineralogist's focus on a particular field of study, whether it be a specific deposit, a mineral group, or other speciality. The availability of the collections to researchers for comparative purposes is a critical advantage because the museum mineralogist, unlike his peers in industry and academia, has at his fingertips a *breadth* of information which is unique and invaluable. Often he can at once obtain an overview of a species' occurrence, and then simultaneously study the species from a number of different localities and/or environments.

Large mineral collections are of particular value to the research in a number of ways. They permit large-scale broad-based comparisons of varied properties, be they chemical, optical, physical, textural, paragenetic or others. Additionally, large collections commonly have some (or many) well-studied specimens which can be used for comparison purposes. National museums, in particular, are important and essential repositories for type specimens, which are needed for species redefinitions and discreditations, and similar studies (Dunn and Mandarino, 1988a).

However, it is not only large collections which play pivotal roles in mineral museum research; small, well-focused and well-documented collections may be every bit as valuable to specialized research needs. Indeed, for topographical mineralogy, they are invaluable, and for many other types of studies they are a useful and highly valued resource. Small, yet strong collections are of great significance once developed; many eventually become part of larger collections, and thus become even more valuable.

The collectors' contributions to the process of mineral research are substantial and varied. Those related to new mineral discoveries have been addressed in part by Dunn (1975, 1977), but the collectors' contributions are broader than just those concerning new minerals. Most critical is precise locality information, and the field collector or field-collecting curator is in a unique position to document this information carefully. Well-documented acquisitions are the best augmentation a collection can have, and complete suites can be assembled from important localities. The donation of mineral specimens, whether those specimens are studied at the time of donation or not for many years, is a very important contribution: it enables researchers as yet unborn to advance the science after the donor-collectors have passed on, and this action thus perpetuates the significance of their collecting efforts (White, 1973; Dunn, 1979).

TAXONOMIC AND SYSTEMATICS RESEARCH

The traditional thrust in museum research in mineralogy is in taxonomy, classification and systematics, leading to the defining of mineral species and their relationships to one another in mineral groups. This *basic* or pure type of research provides the fundamental knowledge of the science. It is in this area that museum mineralogists can make their maximum contributions. In contrast, *applied* research, which is geared to the solution of specific problems, often of a commercial nature, has always been within the realm of industry and, more recently, university and government laboratories, due to changes in funding policies. Thus, more and more, in North America, the responsibility of basic systematic mineral research is being left to museums. Some similar work is done at universities, but it evolves rapidly and is not, in general, as specimen-based, taxonomic and systematic as that done in museums.

One of the unique aspects of research in museums is that it is done on specimens, as noted above. This is also the domain of most interest to the readership of the *Mineralogical Record*, and reflects the principal interests of the writers. Such research is in part internally stimulated by the curator's need to resolve curatorial specimen-related problems, and his own creativity, and in part externally stimulated by problems and/or specimens called to the museum's attention by others, many of whom are mineral collectors.

Such systematic and taxonomic specimen-based studies are done in many different, yet related, specialities. For example: the description of new mineral species, the solution of crystal structures, the discreditation of invalid species, the redefinition or validation of previously poorly defined species, the definition of structural relationships among mineral groups, locality-based studies, and many others. Some such efforts are long-term, resulting in definitive monographs which discuss a limited topic or locality in great detail. Such treatises are assuredly among the most valuable research contributions of museum mineralogists.

SPECIFIC TYPES OF MINERAL RESEARCH

New Mineral Descriptions

This area of investigation is placed first only because the process starts at this point for any species; however, the description of new minerals is not necessarily any more important than many other areas of investigation. The process of describing new minerals (set out by Dunn, 1977) has been greatly enhanced in the last ten years by technological advances. In particular the development of better analytical capabilities for light elements, more sensitive methods of chemical analysis, and the application of methods not previously in common use, have made it possible to fully describe a new species with but a few millimetric grains or less, in ideal cases. The ideal case, however, is rare. Additionally, the increasing role of crystal structure analysis in the early stages of characterization is yielding many benefits. As the science has become more capable, the standards which must be met for a species' approval have also been raised and refined (Mandarino, 1987). All new species require approval by the I.M.A. Commission on New Minerals and Mineral Names (Dunn and Mandarino, 1988b). An average of 66 new species have been described each year for the past six years.

Crystal Structure Analysis

One of the most satisfying experiments in mineralogy is crystal structure analysis. Determining the spatial arrangement of atoms gives a clear perspective of the fundamental building blocks of nature. Remember, an atom is generally less than one angstrom unit (Å) in diameter (Å = 10^{-7} mm = 0.0000001 mm) and the most satisfactory technique for resolving an atomic structure is with a mathematical synthesis of X-ray diffraction data.

For each mineral species there is a specific crystal structure. Knowing there must be a final answer to each particular research endeavor is gratifying, but it may not be easily obtained, and it is this precise aspect of mineralogy that separates it from the other more descriptive natural sciences.

Once a mineral structure has been determined, many questions can be answered. Some are simple, for example: "What is the exact chemical composition or formula?"; or "Is it a new species because of a distinctive chemical formula or crystallography?" Additionally, some of the more important scientific questions can be answered, for example: "Why does this mineral exist?"; "Why does this chemical composition have more than one structure?"; "Why are certain physical, chemical and optical properties observed for this species?" And often the results of a crystal structure determination contribute directly to the solution of applied research problems.

If crystal structure analysis reveals new information which substantially changes the original interpretation of the symmetry or composition of the mineral, thus redefining it, such changes require the approval of the I.M.A. Commission on New Minerals and Mineral Names (Nickel and Mandarino, 1987; Dunn and Mandarino, 1988).

Discreditations

From time to time, it becomes clear or probable that a mineral species is not valid. This is usually due to observations not made previously. The mineral may be another valid species, or it may be a mixture of several minerals, or a non-natural compound, or it may be invalid for other reasons. The new insights usually are not made by better scientists seeing truths which were unobserved earlier. The truly common case is that new technologies have permitted new insights which could not have been made in earlier years when these species were first discovered. It's sad, in a way, to have to discredit a species when the new investigator sees how careful the original investigator was; many such early studies were superb efforts for their time. However, this work is an essential part of the museum mineralogist's responsibilities, and such matters *must* be investigated, the truth be made known, and the literature carefully and accurately corrected. Discreditations are sometimes no fun at all; it's like a funeral in part, but this work is needed for the integrity of the science.

Discreditations are not easily done; to be sure of one's findings, type specimens must be re-examined if they exist (Dunn and Mandarino, 1988a). Sometimes they do not exist, and for many such species, unless an overwhelmingly strong argument can be made, discreditation is difficult; they stand valid (though marked as questionable in compendia) until new findings of data or specimens permit their formal discreditation. As with the birth of a new species, discreditation also requires approval of the I.M.A. Commission on New Minerals and Mineral Names. The methodology of discreditation was given by Dunn (1990).

Redefinitions and Revalidations

Oftentimes, contemporary museum research reveals that the currently accepted definition of a mineral is incorrect in part; this then requires the scientist to correct the definition, obtain approval of the new definition if needed, and publish the results. Recourse to type specimens may be needed, as well as comparative studies of specimens from other localities. Like discreditation, this matter must be approached with utmost caution. This is not a very active field; typically less than 10 are formally redefined each year.

An uncommon problem is revalidation, the process of finding a species to be valid at some time after it has been erroneously (but likely in good faith) discredited. Such instances are fortunately rare and, like discreditation and redefinition, require the study of type specimens when available, and the approval of the Commission on New Minerals and Mineral Names.

Systematic Studies of Species or Groups

Not all mineral museum research involves the integrity of individual species, as discussed above. Museums provide a great opportunity to do studies of mineral groups, thanks in good part to the advantage of the breadth and depth of the mineral collections. For example, such a study might be conducted on the apatite group, the garnet group, or others. Such efforts often yield insights into the limits of compositional variation, which may in turn spawn other studies. Similarly, large collections permit the scientist to study a given species, a solid solution series, or group using specimens from a large number of geographical localities and, much more importantly, from a range of geochemical environments, thus shedding much light on the minerals' diversity, stability and conditions of formation.

Locality-oriented Mineral Studies

Owing in large part to the collections, museum mineralogists are often well-positioned to do locality-based research. If a given mineral locality is well-represented in the collections, then detailed paragenetical studies can be performed, and commonly to a greater extent than is possible without large collections in one place. Additionally, the museum's collections, built over a period of many years, have much in the way of historical or archival material no longer available to others. Here lies the great strength of regional museums which have great depth in local materials.

Publication

Although the above-mentioned studies, and others, can be done by competent scientists, they are nearly useless unless published. The publication process can be demanding of time and energy (both scarce commodities in the curatorial life), but it is *essential* that it be done. Although a curator could argue, somewhat weakly, that the results are "on file" in the museums, this does not serve the broader base of the science of mineralogy as a whole, and the practice should be aggressively discouraged. Similarly, the publication of significant results should always be submitted to well-refereed, professional and semi-technical journals, and not hidden away in "gray journals" (obscure journals of limited circulation), local publications, and internal reports of very limited distribution. Curators should tell the world what they are doing scientifically; *too few have done so*.

ACKNOWLEDGMENTS

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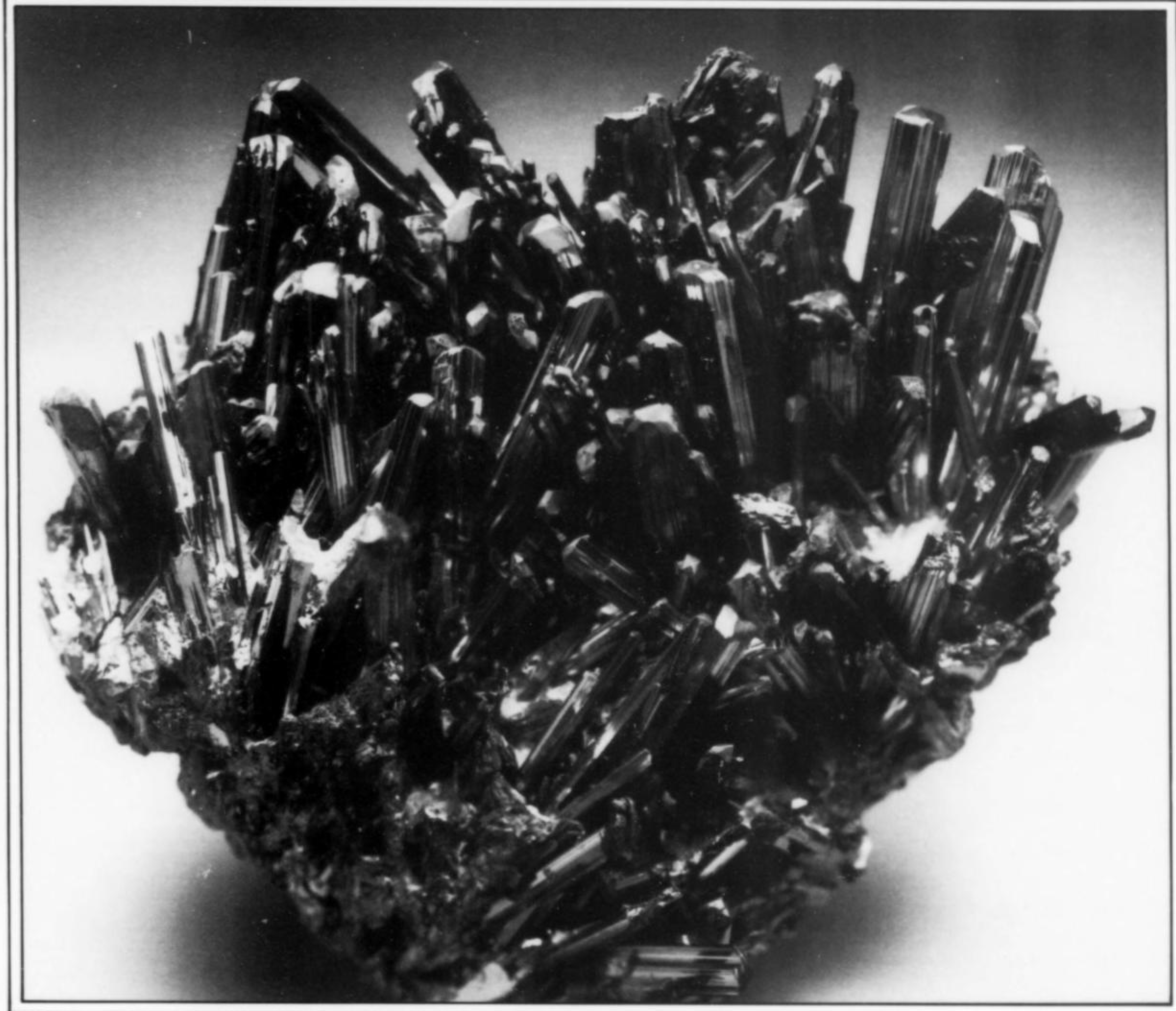

Romanian Stibnite—16.5 cm—now in the Carnegie collection, Pittsburgh

THE MASHAMBA WEST MINE SHABA, ZAIRE

Joseph J. Lhoest
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F-78600 Maisons Laffitte, France

Vandall T. King
P.O. Box 90888
Rochester, New York 14609

Over the last six years the Mashamba West mine has produced world-class specimens of cuprite, pink cobaltoan calcite, carnotite, duhamelite, kolwezite, malachite, metatyuyamunite and vesignieite.

INTRODUCTION

The Mashamba West copper mine and the adjacent Dikuluwe mine are located in the western portion of the famous African mining district known as the Shaba Crescent (see Gauthier *et al.*, 1989, for a review of the mines and deposits in this area). The name *Mashamba*, in the several native dialects, means "a place of cultivated land." This term first appeared on topographic and geologic maps of the area prepared by Armand François and his staff; they noted the literal presence of *mashambas*. As a result, the term has since been adopted as a name for the general area. The Dikuluwe mine is named for a swampy stream nearby.

Since 1985 the Mashamba West–Dikuluwe area has produced many world-class specimens, from cabinet-size display pieces to rare species, and has become famous among mineral collectors.

The private ownership of minerals is restricted in Zaire, primarily as a check on the smuggling or theft of gold and diamonds. A special permit is required for ownership and another for exportation. These permits are issued by the State Department of Mines and must be countersigned by a Justice Officer. At border crossings, customs officers and special services personnel check for illicit "precious substances" including any mineral specimens. The procedures for exporting malachite have been relatively well established, but permits and stamps are still required.

The local language, Kiswahili, is common in the countries of eastern Africa. It evolved from Swahili through the influence of early Arabic-speaking traders, who recognized the need for a language conducive to trade. They spread it through their territories of commerce, and it has extended farther still. The official state language of Zaire is French, used primarily by professional people and government workers.

LOCATION and ACCESS

Kolwezi City (population ca. 200,000) is the largest town in the area, and hotels are available there, though they are not as good as those in the provincial capital of Lubumbashi (population ca. 500,000). The asphalt road into the district, especially the portion from Likasi to Kolwezi, is generally poor and local fuel shortages are common. In general, however, the local infrastructure of roads, public utilities and accommodations is quite good. Public transportation is rare except for an electric railway built in the 1960's.

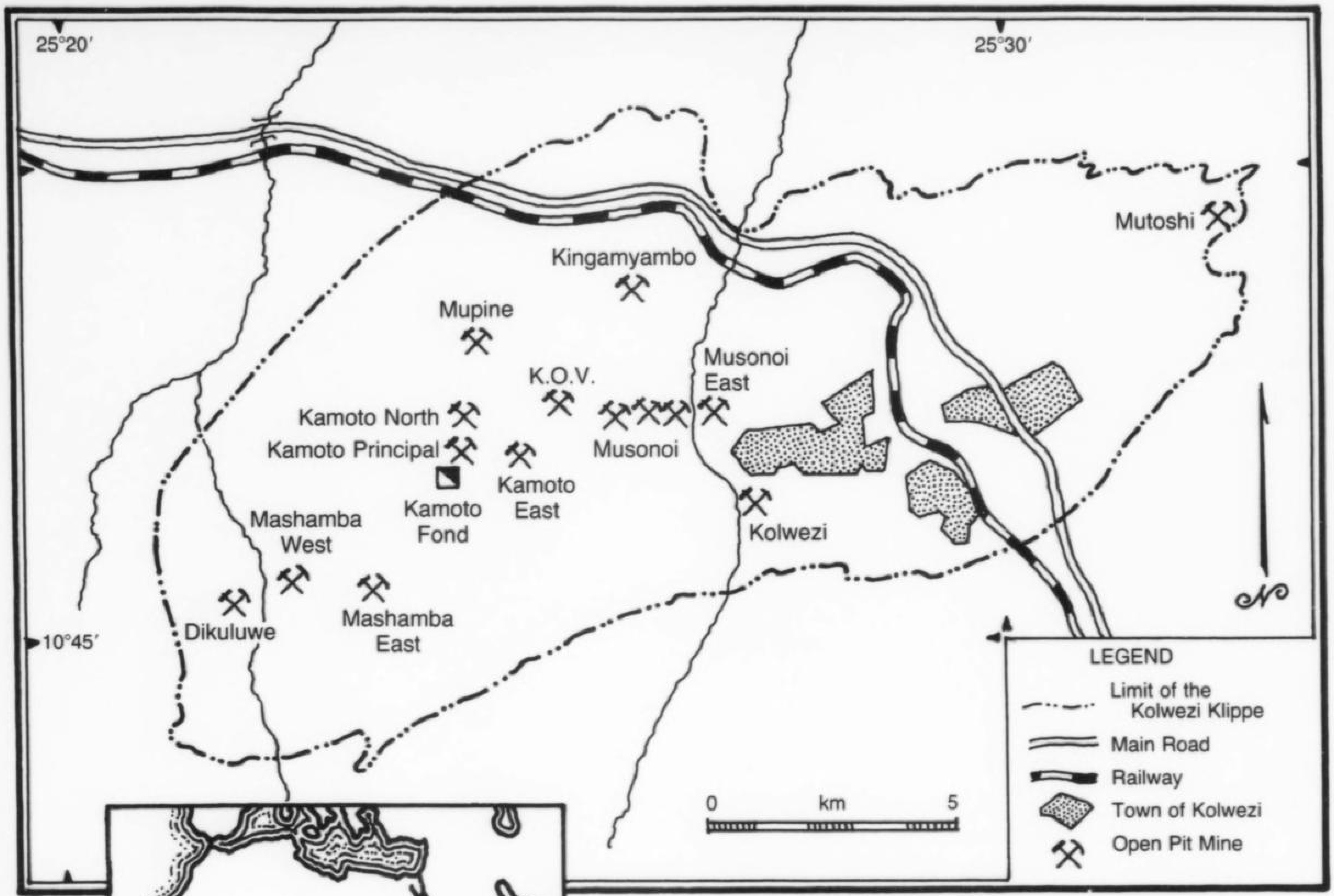
The Mashamba West and Dikuluwe mines are situated together near the township of Kapata, a settlement built for mine workers and their families.

The Division of Public Relations of "Gecamines" (an acronym for *La Generale des Carrieres et des Mines*) can grant permission for a visit, but only in a company vehicle, and with a company official as guide. Mineral collecting and picture taking are not permitted during visits to the mines.

HISTORY

The mining and metallurgical history of the deposits of the western Kolwezi Klippe, like that of Shaba Crescent as a whole, dates back several hundred years. The Dikuluwe, Kolwezi and Musonoi mines showed evidence of primitive mining and smelting by local indigenes (Gauthier *et al.*, 1989). During the late 19th century, European pioneers explored the area. Prospecting and mining progressed, as a rule, from east to west; the first workings excavated manually, generally no deeper than the water table.

Metallurgical treatment plants in Zaire have produced copper and cobalt, as at Kipushi, since 1927. When the Union Miniere du Haut-



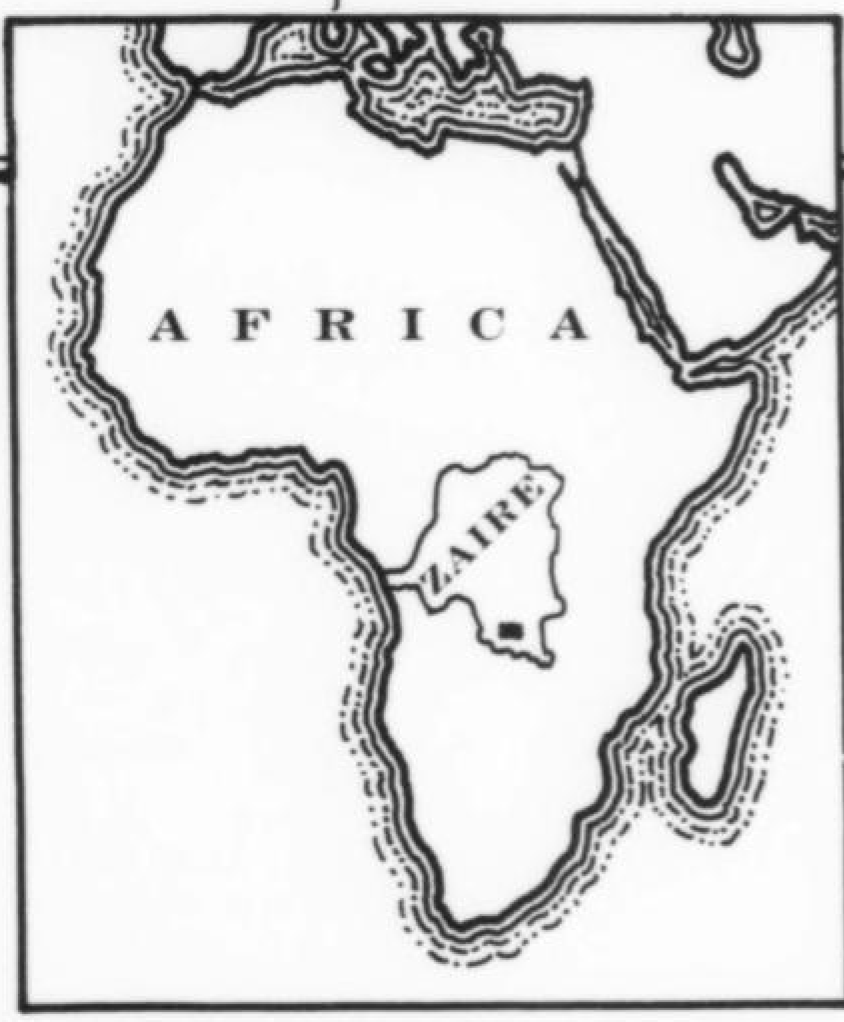


Figure 1. **Location map showing the mines in the Kolwezi Klippe.**

Figure 2. **European pioneers setting up shop in Shaba, ca. 1910.**

Katanga first began mining in the district, the smelter furnaces were wood-fired. Copper production began experimentally in 1911, and commercially on a small scale in 1913. Beginning in 1913, coal from Zimbabwe was used at the Lubumbashi smelter. Production by Union Miniere of hydroelectric power began in 1930; construction of the Lualaba River generating stations facilitated the opening of the Kamoto mine. However, metallurgical treatment on a large scale was not possible in the western Shaba Crescent until the 1950's.

In the 1970's Gecamines made the decision to increase copper production from 300,000 to 450,000 metric tons. An electric power line was built from the Inga power station in western Zaire to a terminal near Kolwezi. As part of this expansion the Dikuluwe and Mashamba mines were opened, the processing capacity of the Kamoto concentrator was increased, and the Luilu electrolytic refining plant was modernized. Although ore concentrate from the Kolwezi and Kamoto plants currently requires further refining outside of Zaire, a new refinery is now under construction at Luilu.

All mines in the district are benched open pits with pumping stations in the sumps. They operate today with up-to-date mining equipment for drilling, blasting and loading; the ore is transported by heavy-duty 100-ton and 150-ton dumpers to the Kolwezi and Kamoto concentrator facilities.

Because of Shaba's inland location (1300 km from the Atlantic Ocean, 1650 km from the Indian Ocean), transportation of metals to world markets has always been a problem. Formerly the shortest route was by way of the Benguela railway to Lobito, Angola, but this route

Figure 3. **European settlers arriving in Shaba with a "locomobile," 1910.**

is currently unusable because of the civil war in that country. Zaire has a port at Matadi but it is 2800 km by road from the Shaba mines, so only a portion of mine production can go by that route. The rest of the region's commerce flows through South African ports, mainly at East London and Port Elizabeth.

Mashamba-Dikuluwe Workings

In 1975 the Dikuluwe mine was opened in the Dikuluwe depression, 16 km west of Kolwezi City by road. The open pit there is now 1 km long (north-south) and about 300 meters wide. The Mashamba West pit was opened in early 1978 about 1 km east of the Dikuluwe mine. Both mines have been managed together (referred to locally as the Di-Ma mines), and are planned to be joined later for the exploration of their sulfide zones.

A crusher has been built near the two mines so that ore can be transferred directly by dumper. The crushed ore is then transported by conveyor belt to the Kamoto concentrator. Part of the ore is stockpiled in dumps which are drawn from according to the needs of the Kamoto and Kolwezi concentrators, to balance the mill feedstock.

In 1987 the Mashamba West pit reached its current dimensions of roughly 1 km (east-west) by 700 meters across, and 150 meters in depth. The mine is still in the oxidation zone. Removal of the overburden between the Dikuluwe and Mashamba West pits has begun, preparatory to their merger.

A pit called the Mashamba East was opened 3 km east of the Dikuluwe pit in 1985. It is thus far not planned to join with the others. Specimen production there has been small.

GEOLOGY

The principal tectonic feature of the western Shaba Crescent is the Kolwezi Klippe, a complexly structured overthrust block of dolomitic sediments. The klippe is bounded on all sides by faults, separating it from its metamorphic roots. It measures 10 x 23 km on the surface and extends to a maximum depth of about 1.2 km. The detailed geology of the Shaba Crescent has been summarized by Gauthier *et al*. (1989).

Mineralization at the Dikuluwe and Mashamba mines is concentrated along fault breccias. Due to the complex folding and faulting of the rocks, mineralized zones have been unpredictably offset into a virtual patchwork of variously sized fragments. Some of the faults acted as solution channels for secondary enrichment. Mineralization appears to have taken place through a series of recurring and overlapping sequences.

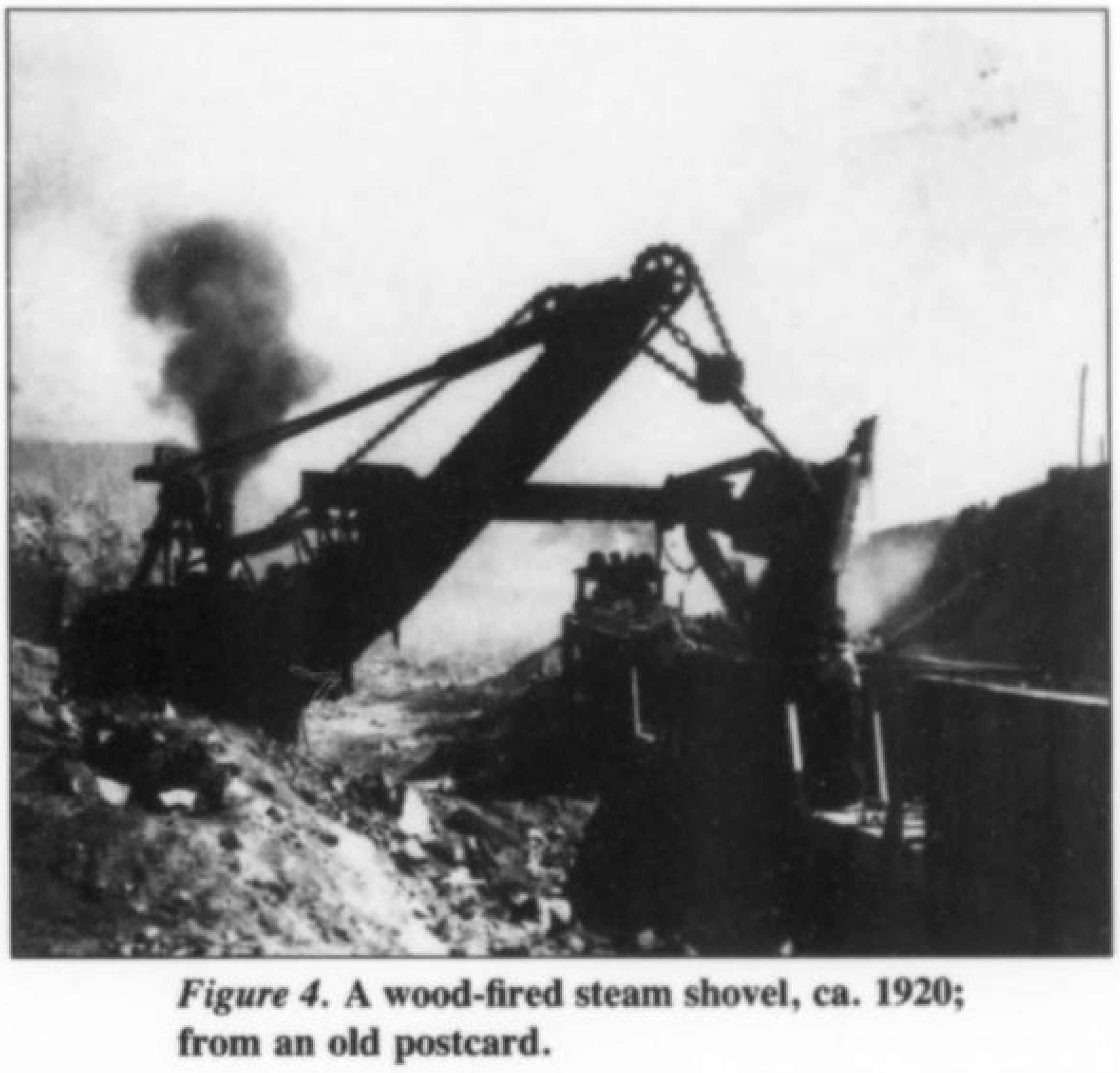


Figure 4. **A wood-fired steam shovel, ca. 1920; from an old postcard.**

***Figure 5.* A shovel loading ore trucks in the Mashamba West open pit, 1983.**

MINERALOGY

Barite $BaSO_4$

Some nice vugs of barite have been recovered which contain beautiful, transparent yellow or honey-colored crystals to 2 x 4 cm, associated with malachite, cuprite and/or cobaltoan calcite. Most of the yellow barite is opaque and butterscotch-yellow to caramel-brown in color. The crystals have a relatively simple prismatic habit, sometimes occurring in attractive color combinations. Some colorless and transparent crystals to less than 1 cm have been found on malachite.

Of particular interest are the multiphase pseudomorphs after barite. Most of the barite at the Mashamba West mine has been replaced by bright green malachite covered by pale-blue, earthy chrysocolla. The pseudomorph specimens have a rosette-cluster shape consisting of 3 to 5-cm blades up to 1 cm thick. The epimorphic coatings of chrysocolla are rounded.

Calcite $CaCO_3$

Calcite is abundant at the Mashamba West mine. Transparent to milky white scalenohedra are common, with striated, lustrous faces. Most crystals are less than 3 cm but a few up to 10 cm in size are known. Due to their relatively drab coloration, few specimens have been collected and saved. Transparent, colorless crystals to 1 cm, twinned on (0001), have also been found. Some nearly spherical clusters (to 2 cm) of white calcite crystals have also been found at Mashamba West, studded with small scalenohedral spikes of calcite.

Although rarer at the locality, the bright pink cobaltoan variety[1] of calcite is preferentially represented in collections because of its value and beauty. The pink color results from generally less than 1 weight % cobalt.

The bright "hot pink" cobaltoan calcite from the Mashamba West mine is the world's best. Crystals are generally a uniformly intense pink in each crystal; color zoning is uncommon, though some opaque crystals have a subtly mottled appearance. Even zoned crystals show color uniformity within zones. Most of the cobaltoan calcite crystals are transparent to sub-transparent, and paler shades of pink tend to predominate. There is no correlation thus far observed between crystal habit and intensity of coloration.

Although several other neighboring localities have produced cobaltoan calcite (including the Musonoi and Mupine mines), the specimens from the Mashamba West mine reach the highest level of quality. The first good specimens indeed came from the Mupine mine; but many later and better specimens so labeled were actually from the Mashamba West mine, and were purposely mislabeled to shield the new occurrence from publicity. Specimens of equivalent quality from the two mines are indistinguishable, and came on the market at about the same time (Wilson, 1986a, 1986b).

The finest Mashamba West specimens were recovered during a short period in late 1984 and perhaps early 1985. Since then, pink cobaltoan calcite has been found repeatedly in smaller and less spectacular specimens. Even many of the lesser specimens, however, are far superior in quality to any found elsewhere in the world, and a few have even been faceted into gemstones.

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[1]It has sometimes been labeled as *cobaltocalcite*, a now-disused varietal term proposed by Millosevich in 1920, and later unsuccessfully recommended by Palache, Berman and Frondel (1951) to replace the species name sphaerocobaltite ($CoCO_3$). True sphaerocobaltite, which forms a series with calcite and must contain over 50 mole % $CoCO_3$, is known with certainty in the Shaba Crescent only at the Musonoi Principal mine and the Mupine mine.

The most common crystal habit for cobaltoan calcite at Mashamba West is simple scalenohedral, and examples to 4 cm are known. The surfaces of the larger crystals are frequently composed of slightly offset parallel-growth crystals yielding a somewhat rough aspect. Surface pits lined with crystal faces contribute to this effect, giving an etched appearance. A similar surface irregularity can be seen on the uncolored calcite crystals. Perfectly smooth scalenohedra are rare at Mashamba West. Some of the pink crystals have a white outer zone resembling a frosting.

Cobaltoan calcite crystals showing a complexity of forms are relatively common. Often the scalenohedron is modified by the typical positive rhombohedron and also a steep positive rhombohedron, but the scalenohedron is generally dominant. In some cases the spacing of vicinal crystals is so coarse that a pineapple-like effect results, bulging in the center. These complex crystals are usually paler than average in color. A few penetration twins showing rotation about the *c* axis have also been found; they are generally 2 to 3 cm in size. The best example of the complex scalenohedral cobaltoan calcite is now in the collection of the Smithsonian Institution.

The least common habit of cobaltoan calcite is the low-angle rhombohedron, typically with no other forms present although a slightly higher-angle rhombohedron sometimes modifies small portions of the crystal along the edges. These crystals are frequently "stacked" in parallel growth along the *c* axis, resembling multi-roofed pagodas. Simple rhombohedra showing some saddle-shape curvature have been observed. Uncurved rhombohedra to 3 cm across are also known.

As a rule the cobaltoan calcite is found with relatively few other species in association. Where present, malachite, chrysocolla, kolwezite and others are quite subordinate. In some cases cuprite and, even less commonly, dioptase are seen with pink calcite. A few rare examples show brilliantly contrasting color combinations of associated species.

Carnotite $K_2(UO_2)_2V_2O_8 \cdot 3H_2O$

Carnotite occurs at Mashamba West as sharp, tabular, yellow plates to 2 mm isolated on matrix or stacked in groups. A second habit is represented by bladed, transparent, yellow-orange crystals to 2 mm having a sort of "Roman sword" termination (M. Deliens, personal communication). Carnotite is a species rarely found as recognizable crystals; the specimens from Mashamba West may well be the world's best.

Chalcocite Cu_2S

The world's finest chalcocite crystals have been found at the nearby Kamoto Fond mine (individual crystals to 7 cm, in clusters to 20 cm), but Mashamba West has produced several specimens which show promise. Crystals to 4 cm, with rounded and incompletely developed faces, were found at the base of the oxide zone. Most chalcocite at Mashamba West occurs as minutely crystallized material in vugs lined with white calcite. Some secondary copper minerals may be present as well.

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

Chrysocolla at the Mashamba West mine is powdery and very pale blue, forming a coating around breccia fragments and lining vugs in the breccia zone. It is found both as a substrate for, and a coating on, various minerals, especially large cuprite crystals.

Copper Cu

Native copper is quite rare in the Shaba Crescent. It has been found at the base of the oxidation zone in the Mashamba West mine, as small arborescent groups (usually under 1 cm in size), some with twinned spikes to 3 mm which (under magnification) are reminiscent of specimens from Ray, Arizona. Chalcocite crystals are sometimes associated. The copper is generally found in small vugs with calcite having a pink outer zone, and also as inclusions in white calcite.

Cuprite Cu_2O

Cuprite was known in the Shaba Crescent, prior to the opening of the Dikuluwe and Mashamba West mines, primarily as massive material only occasionally showing vugs of small crystals. A notable exception is the Likasi mine on Panda Hill (in the central part of the crescent), where one of the world's finest cuprite geodes was found. Cuprite there was also found impregnated with rare minerals such as buttgenbachite, connellite, gerhardtite and likasite. The M'sesa mine near Kambove, also in the central part of the crescent, produced cuprite impregnated with claringbullite (P. Bariand, personal communication), buttgenbachite and spangolite (M. Deliens, personal communication). But the best cuprite locality previously known in the crescent was the Kamoto mines, where some attractive but small crystals were found. All of these are easily distinguished from the remarkable specimens found at the Mashamba West and Dikuluwe mines.

In 1980 the first fine crystals of cuprite were produced at the Dikuluwe mine. The crystals are generally 1 to 2 cm, very lustrous and fiery red; small sections are facetable. The crystal habit of Dikuluwe cuprite consists of the octahedron modified by tiny dodecahedron and trisoctahedron faces along the edges, with equally minor tetrahexahedron faces modifying the points. Equivalent modifying faces tend to be unequally developed around each crystal. Several vicinal faces have not been measured. Chrysocolla is generally absent on Dikuluwe mine specimens; the cuprite crystals typically rest on tiny colorless calcite rhombohedra. Dikuluwe cuprite specimens are thus easily distinguished from their counterparts at the Mashamba West mine.

By far the greatest discovery of cuprite crystals in all of Zaire took place at the Mashamba West open pit in 1983. The first specimens included malachite and, in some cases, cobaltoan calcite. In 1987–1988 a large discovery was made at a deeper level in the mine; these specimens were introduced to the mineral market at the 1988 Denver Show (Wilson, 1989). Yet another major find, with perhaps the best specimens to date, took place in April of 1989 and reached the market at the show in Bad Ems, Germany (Moore, 1989); the best were apparently saved for the Ste-Marie-aux-Mines Show in July. Although sometimes associated with malachite and calcite, most of the 1989 cuprite is on, or coated by, pale blue powdery chrysocolla.

The quality of the cuprite specimens found in 1987–1989 rivals that of any other occurrence worldwide. About 100 truly fine, world-class specimens were recovered, including ten that stand out from the rest as the major pieces. Hundreds of lesser specimens were also found. Three of the best went to the Harvard Mineralogical Museum, the A. E. Seaman Mineralogical Museum (in Houghton) and the Natural History Museum of Los Angeles County.

The Mashamba West cuprite appears to have been deposited during two major periods. First-generation cuprite is dominated by the octahedron and has brilliantly lustrous faces. Chrysocolla (which may also have formed earlier) then coated the first-generation crystals; but it is loosely attached and easily picked off or washed off by a high-pressure water jet. This cuprite is relatively simple in habit and only occasionally shows minor modifications. Crystal size reaches about 3 cm maximum. Second-generation cuprite was then deposited on the chrysocolla and on the earlier cuprite crystals which had not been coated with chrysocolla. These second-generation crystals are distinctive because of their red-brown color (vs. pure red) and their duller luster. Small crystals (under 5 mm) tend to be highly complex, showing up to three trigonal trisoctahedral forms and three tetrahexahedrons in combination on a single crystal. Such a crystal, ideally, would have 146 faces. As the second-generation crystals grew larger, though, the rare forms grew more rapidly and disappeared. These crystals reached a maximum of about 7 cm in size, but the most attractive examples are generally under 5 cm.

Subsequent crystallization of minor malachite and a little chrysocolla followed second-generation of cuprite on some specimens. The majority of the Mashamba West specimens were recovered with a

Figure 6. Cuprite crystal, 1 cm, on chrysocolla from Mashamba West. Herb Obodda specimen.

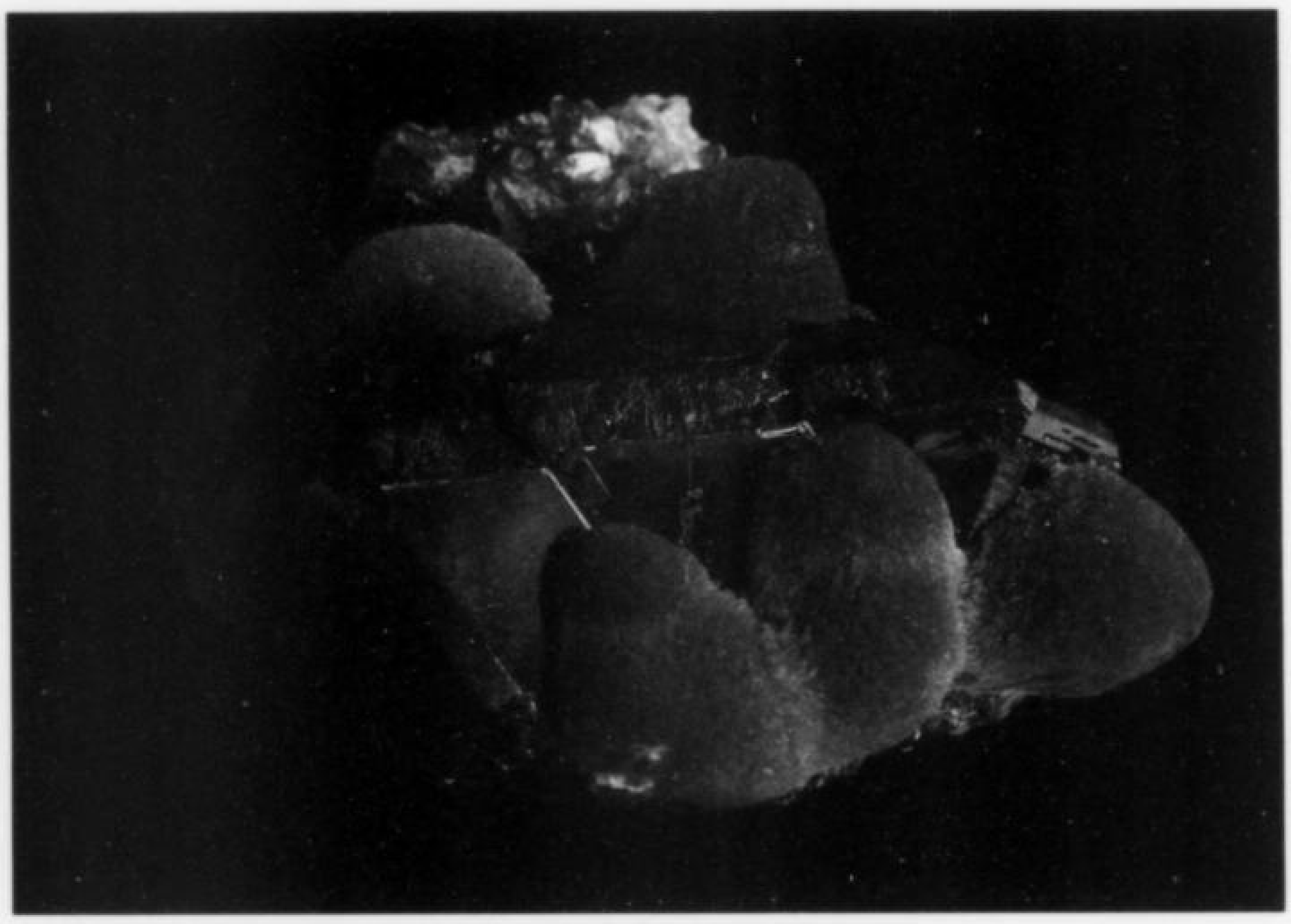

Figure 7. (above) Cuprite crystal, 2.5 cm, with velvet malachite, found at Mashamba West in 1984. Lhoest collection and photo.

Figure 8. Cuprite crystal group, 4.6 cm, from Mashamba West.

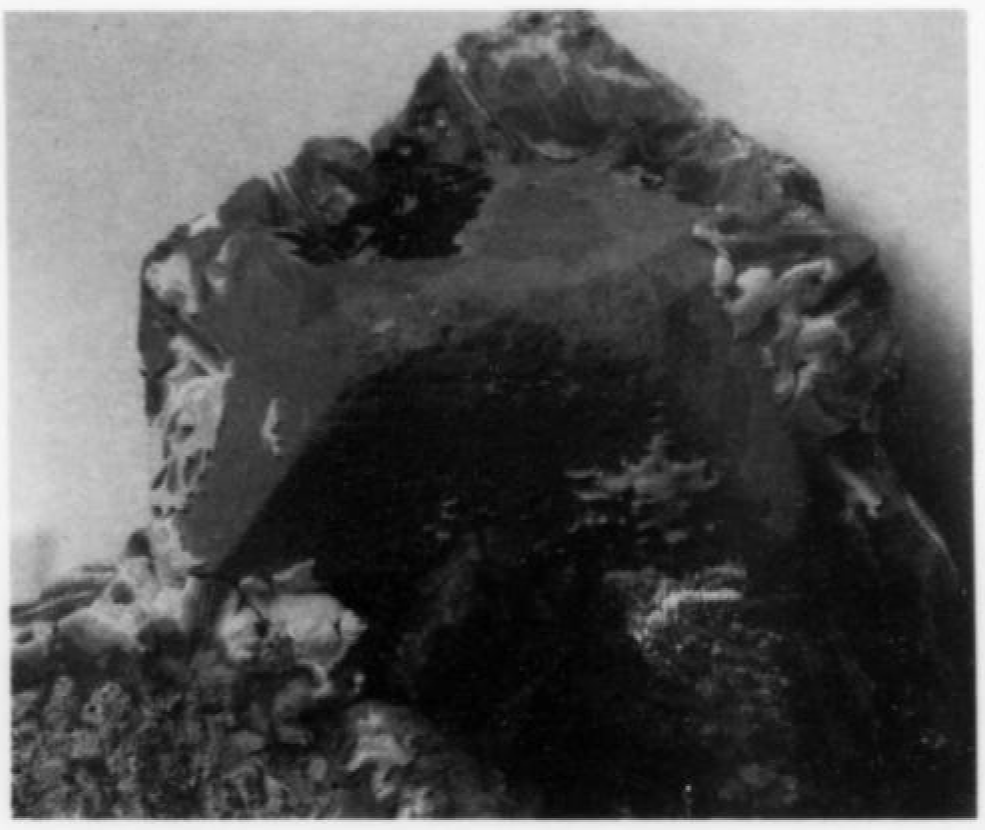

Figure 9. Chrysocolla-covered cuprite crystal, 2.5 cm, found at Mashamba West in 1986. Lhoest collection and photo.

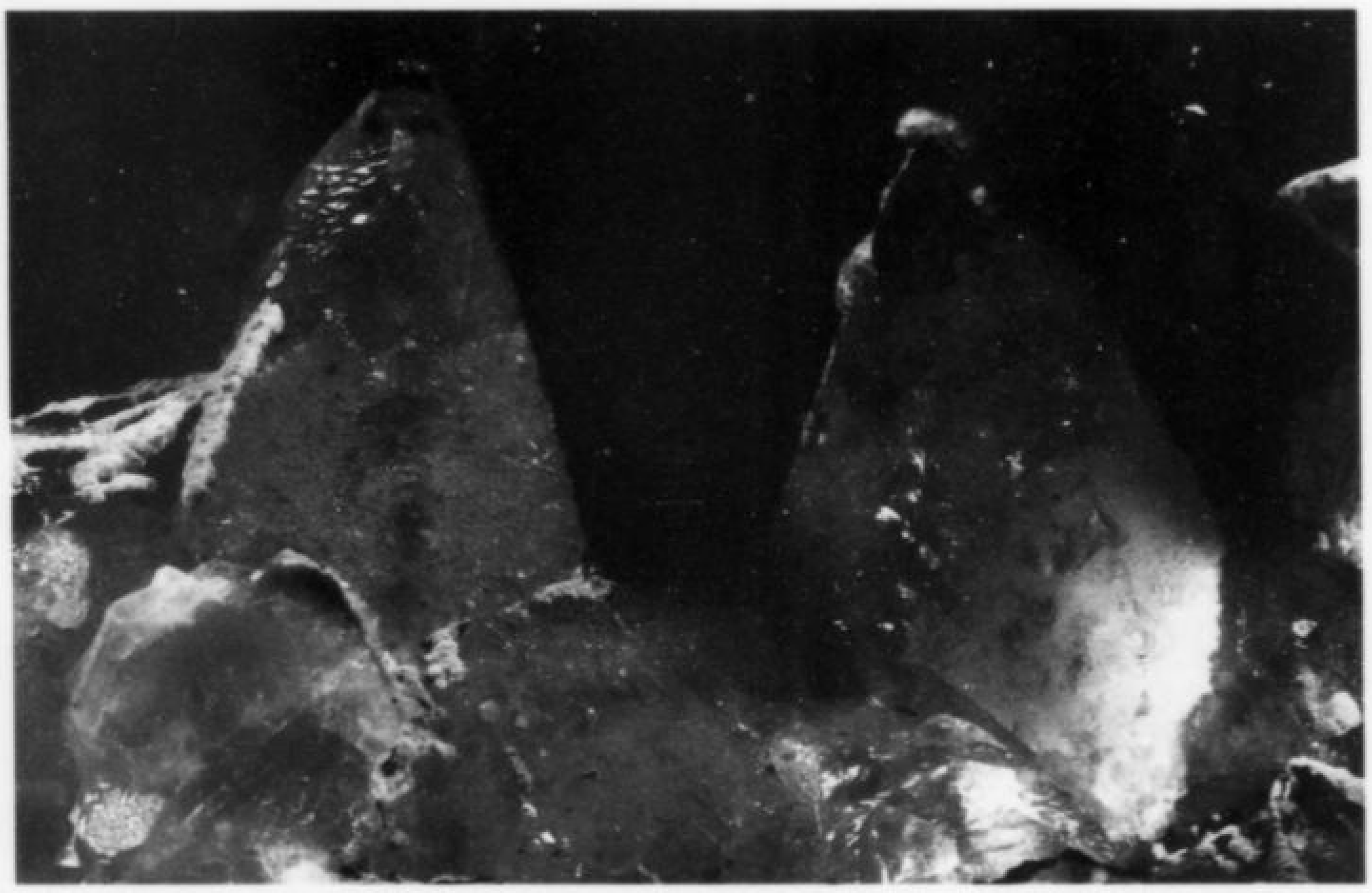

Figure 10. Cobaltoan calcite crystals to 1.5 cm, from Mashamba West. Sorbonne collection; photo by Nelly Bariand.

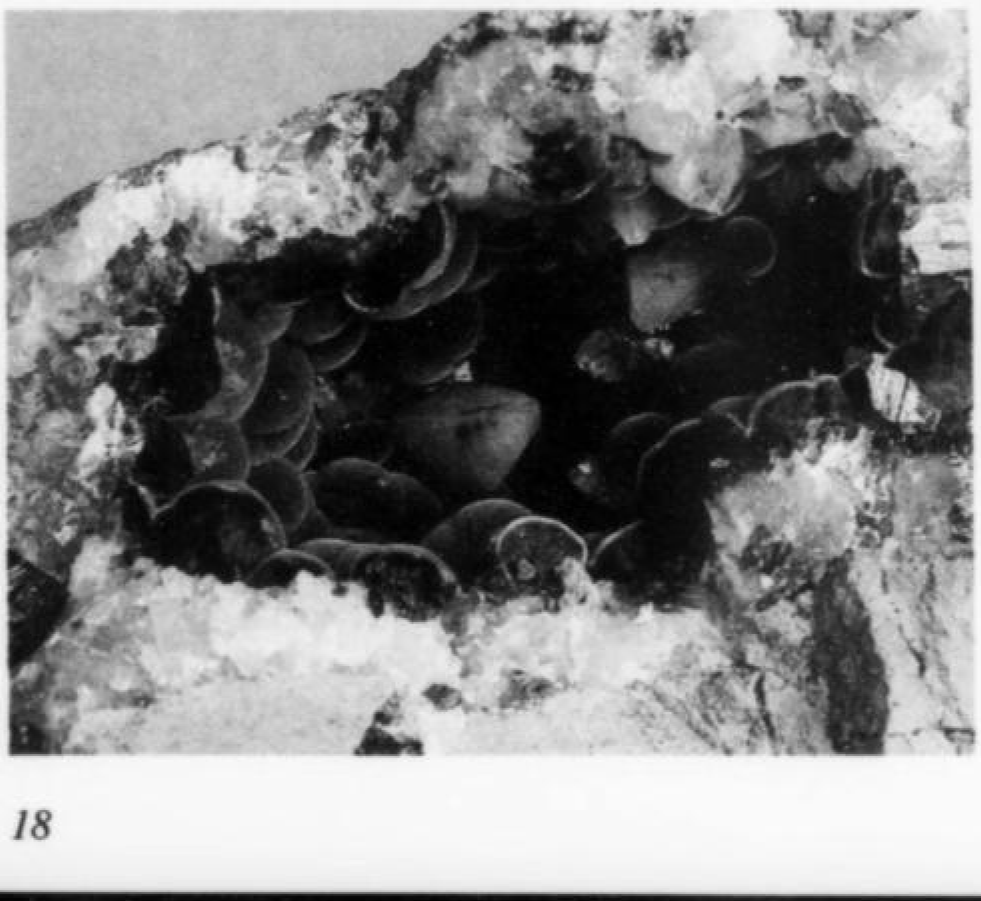

Figure 11. Kolwezite vug 3 cm across, with calcite, from Mashamba West. Lhoest collection and photo.

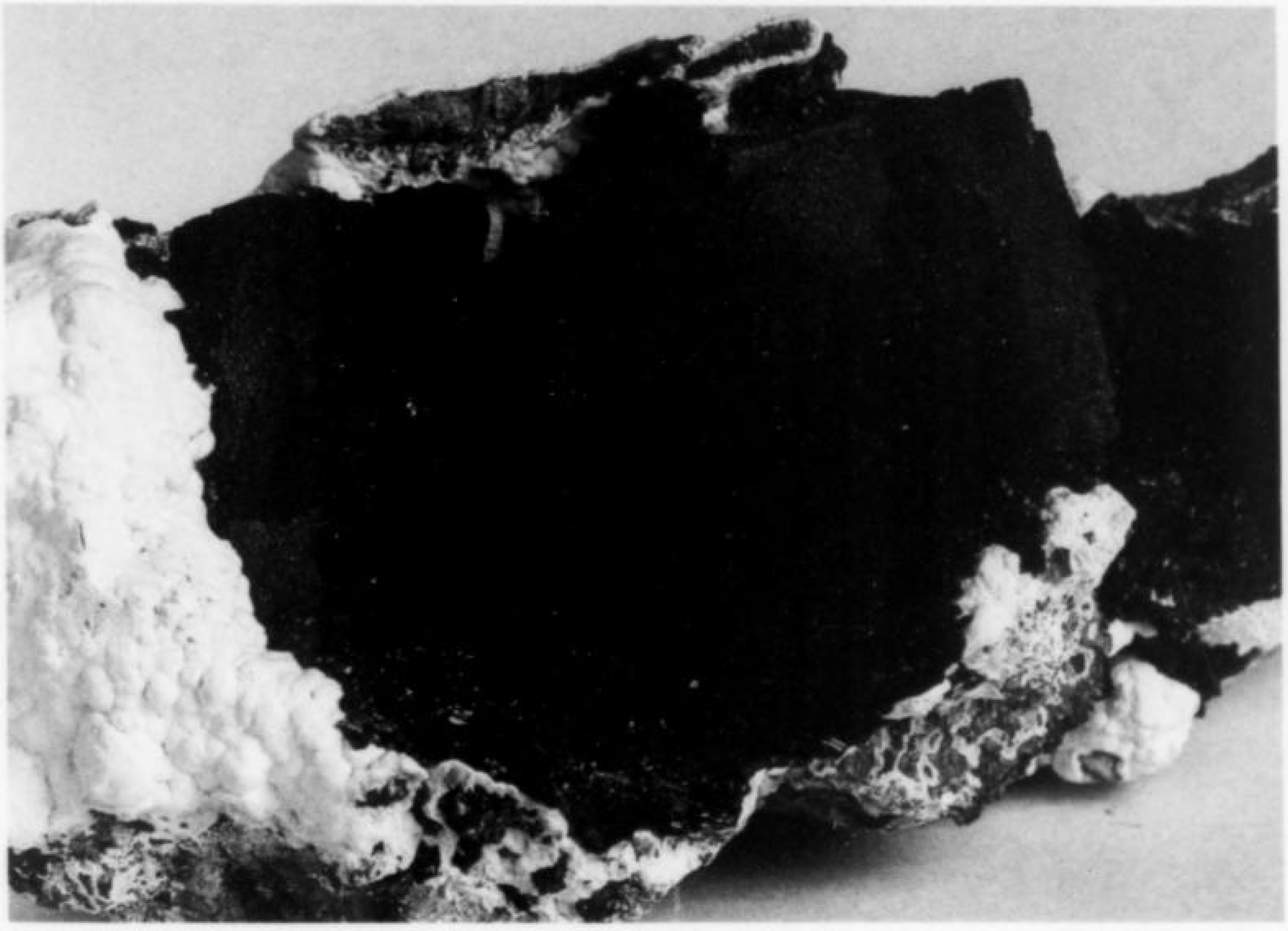

Figure 12. Large malachite crystals on matrix, 7 cm, from Mashamba West. Lhoest collection and photo.

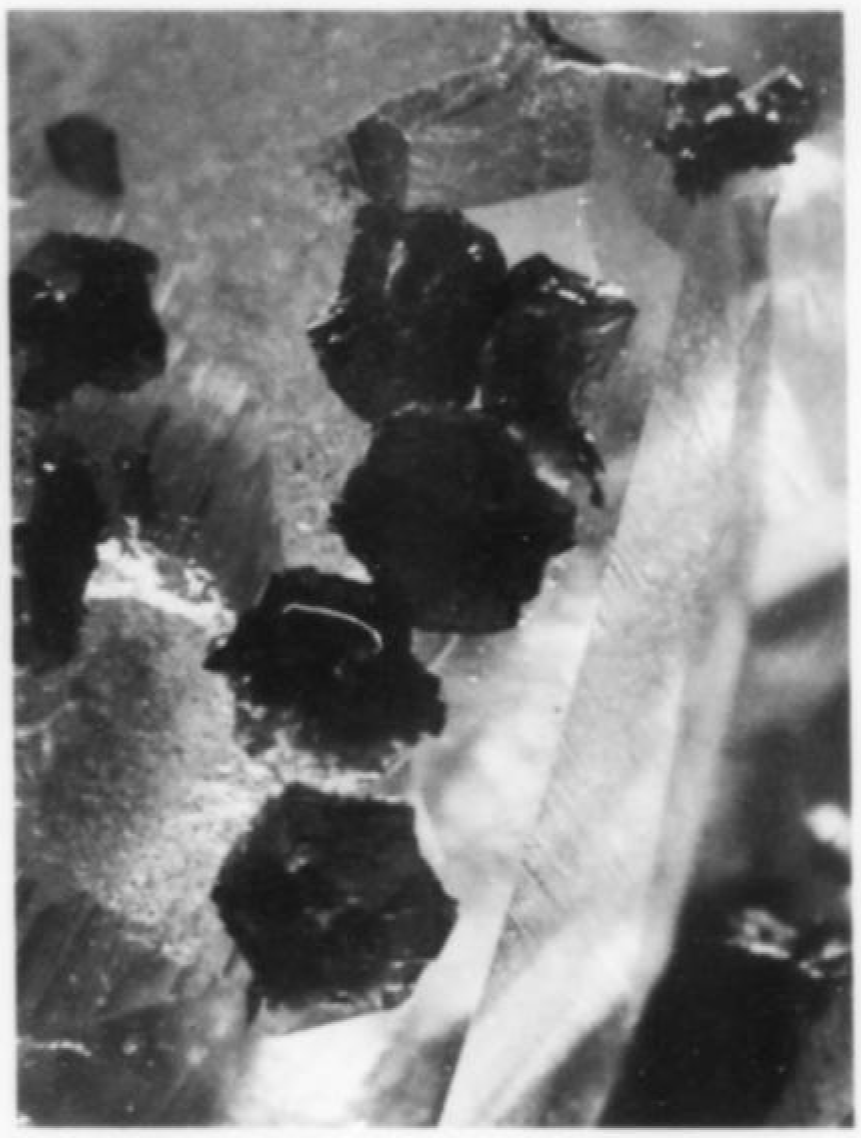

Figure 13. Vesignieite crystals on calcite from Mashamba West; view is 2 mm across. Lhoest collection; E. Van der Meersche photo.

Figure 14. Duhamelite spray, 1 mm, from Mashamba West. E. Van der Meersche photo; Lhoest collection.

Figure 15. Shattuckite spherules, about 5 mm, on calcite from Mashamba West. Philip Scalisi collection; G. W. Robinson photo.

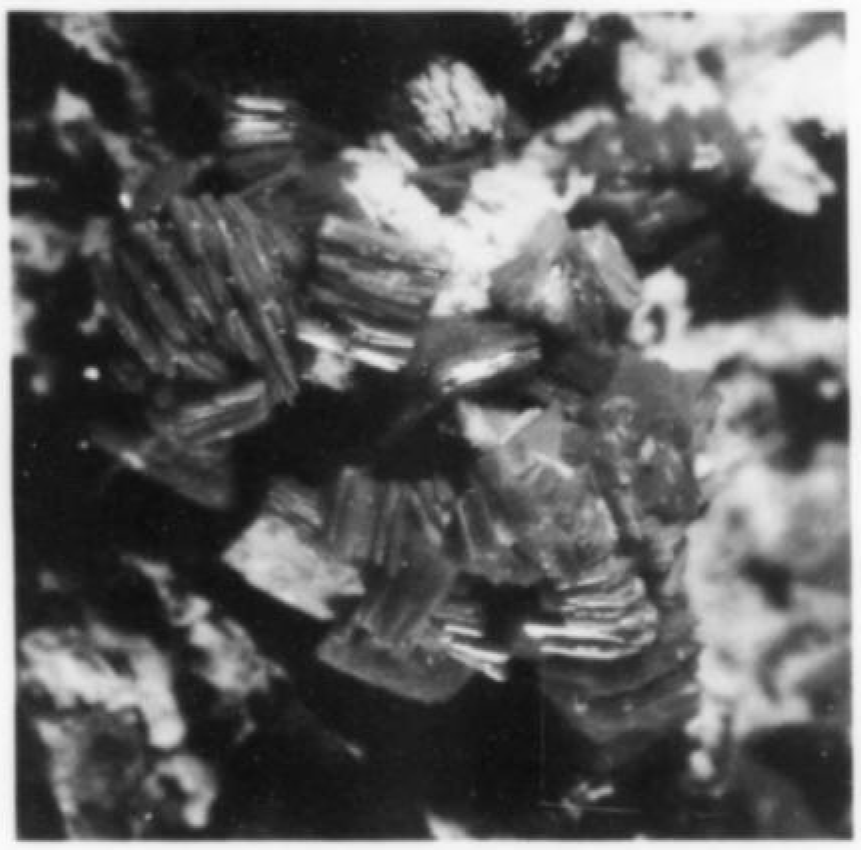

Figure 16. Carnotite crystals, 7 mm, from Mashamba West. E. Van der Meersche photo; Lhoest collection.

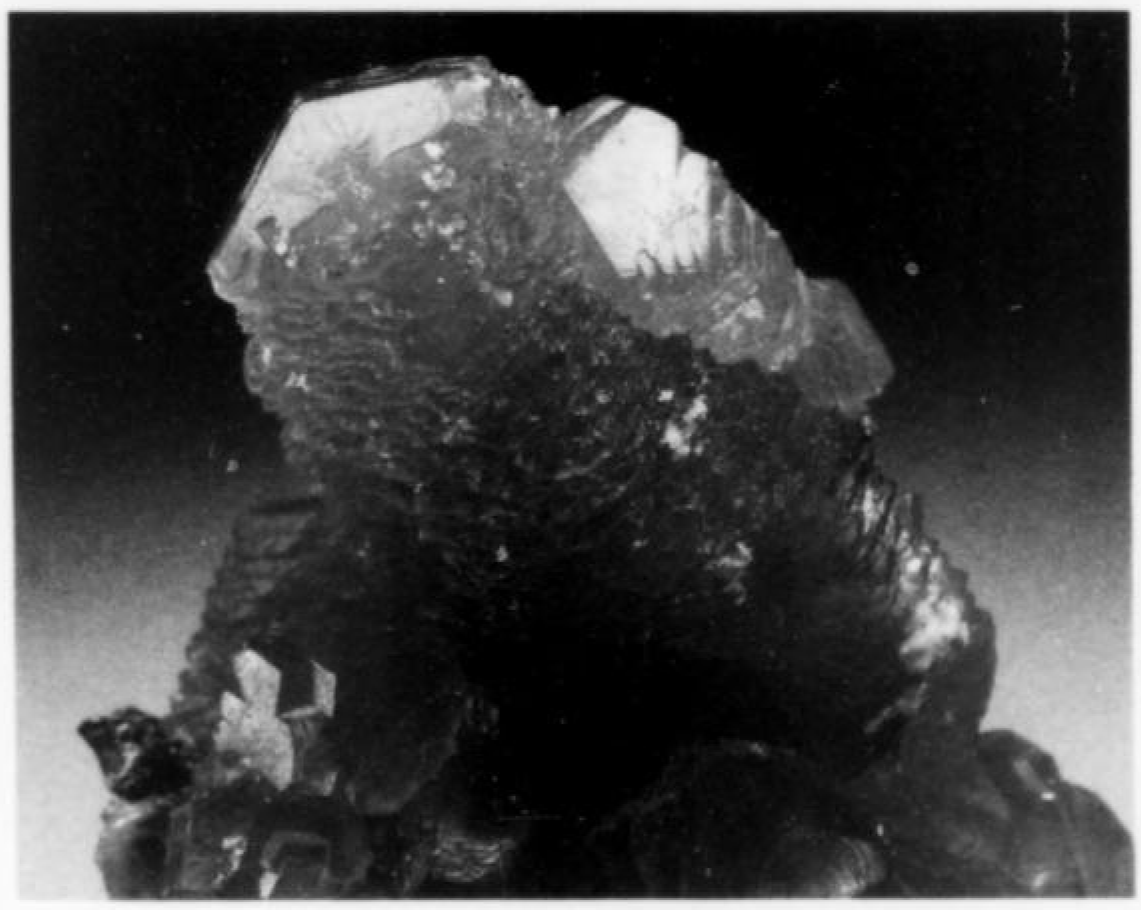

Figure 17. Cobaltoan calcite crystal group, 5.7 cm, from Mashamba West. Ken Roberts specimen.

Figure 18. Cobaltoan calcite group, 15 cm, from Mashamba West. Lhoest collection and photo.

generous amount of matrix, many exceeding 5 x 7 cm; thus most of the specimens consist of beautiful red, dark red and red-brown crystals on contrasting pale blue chrysocolla on rock. This distinctive type of powdery pale-colored chrysocolla makes the Mashamba West specimens easy to recognize; to date the association has not been found elsewhere.

A few very lustrous cuprite crystals to 3 cm were found with white calcite crystals (and no other associated species). The habit is a combination of octahedron and dodecahedron about equally developed. The dodecahedron faces commonly show a sort of "warty" cuprite overgrowth here and there. Presumably this is first-generation cuprite.

Dioptase $CuSiO_2(OH)_2$

Small dioptase crystals to about 3 mm, simple prismatic in habit, have been found sparsely implanted on cobaltoan calcite at Mashamba West.

Dolomite $CaMg(CO_3)_2$

Dolomite occurs widely as a constituent of the host rocks. Pink cobaltoan dolomite crystals are quite scarce, and when found are usually misidentified as cobaltoan calcite. A drop of acid will distinguish the two (dolomite will not effervesce). Fine-grained cobaltoan dolomite sometimes forms a thin, bright pink coating on dolomite matrix.

Duhamelite $Pb_2Cu_4Bi(VO_4)_4(OH)_3 \cdot 8H_2O$

Duhamelite, originally described from Payson, Arizona (Williams, 1981), has subsequently been identified from several other localities. However, the Mashamba West specimens are far superior to those from any other occurrence. Individual stout to acicular crystals reach 2 mm and form aggregates over 1 cm in size. Associated minerals may include powdery chrysocolla and cuprite in white-calcite-lined vugs. Duhamelite is the first bismuth-containing species to be found in the entire Shaba Crescent.

Kolwezite $(Cu,Co)_2(CO_3)(OH)_2$

Kolwezite, a member of the rosasite group, was first described on cobaltoan "dolomite" by Deliens and Piret (1980). They gave the type locality as the "Kolwezi-Kamoto-Musonoi" copper and cobalt deposit. The mineral generally occurs as small, olive-brown botryoids 3 to 4 mm in diameter, sometimes coalescing into clusters or crusts 4 cm across. The velvety surface resembles that of rosasite. Kolwezite also occurs on chrysocolla and malachite.

Malachite $Cu_2(CO_3)(OH)_2$

Malachite is the most abundant copper mineral in Shaba province, constituting the main copper ore throughout the Shaba Crescent. Azurite is virtually non-existent in the district.

Mashamba West malachite is typically fibrous to silky, but also includes some of the best idiomorphic crystals known. The crystals are extremely varied in habit. Surprisingly, stalactitic and banded malachite is unknown at Mashamba West (although it does occur nearby at the Dikuluwe mine). The color varies from medium green through darker shades to black. Impurities such as iron and cobalt are responsible for the darkening.

The first really good malachite crystals were discovered in the third bench level of the Mashamba West pit in 1982, and have continued to be found right up to the present. The most outstanding, blocky crystals of malachite were first found in 1986. Individual crystals show wide variations in elongation and multiple-growth. but upon close inspection seem to be limited to the same combination of crystal forms. The prism faces tend to be lustrous whereas the terminal faces appear dull or etched.

Most malachite at Mashamba West is fibrous or silky, the acicular bundles frequently reaching 2 cm long. Dense coverage of the matrix yields fine display specimens 20 cm and larger in size. Even the acicular crystals clearly show pinpoint reflections from their well-developed terminal faces. The malachite forms very attractive vugs completely lined with crystals of a deep green color; also shaving-brush clusters and completely crystallized stalactiform aggregates. A few clusters of malachite have been found with 1-cm botryoids of crystallized malachite still showing minute crystal faces. Crystallized malachite is, in rare cases, covered by powdery chrysocolla, and in other rare cases has cuprite crystals grown directly upon it.

By far the most significant malachite specimens from Mashamba West are those consisting of enormous (to 3 cm) idiomorphic crystals, sometimes in clusters to 6 cm. Individual crystals are frequently intergrown in rosettes of dark green color which are emplaced attractively on contrasting pale blue chrysocolla. The larger crystals are composites built up from numerous, slightly offset smaller crystals. Crystal edges show light green highlights and internal reflections in minute crystal extensions growing out from the main body of the crystals. The result is a slight chatoyancy on the edges, the effect being more pronounced on the smaller crystals. The general habit of the largest crystals is tabular to blocky. The 5–10 mm rosettes are sharpest and most lustrous, with excellent crystal separation and definition. Crystals over 1 cm commonly have an etched appearance, revealing additional faces in minute multiple growth. The best known specimen is in the Canadian Museum of Nature in Ottawa.

Occasionally, kolwezite has been found coating malachite.

Metatyuyamunite $Ca(UO_2)_2V_2O_8 \cdot 3H_2O$

Metatyuyamunite was originally described by Stern *at al.* (1956) on the basis of 3-mm crystals from the Small Spot mine in Colorado. Though many occurrences have since become known, the Mashamba West specimens are the finest, and the only ones to exceed the quality of specimens from the type locality. Mashamba West crystals are about the same size (3 mm) but are more perfectly formed. Fan-shaped groupings of sharp, bladed, "Roman-sword" crystals are typical. The color varies from sulfur-yellow to yellow-orange. It occurs with fine crystals of carnotite.

Shattuckite $Cu_5(SiO_3)_4(OH)_2$

Shattuckite occurs at the Mashamba West mine as robin's-egg-blue botryoids grouped as separated individuals on pale blue chrysocolla coating tan to gray scalenohedral calcite. These botryoids, 4–7 mm in size, have a smooth surface and a radially fibrous internal structure.

Vesignieite $BaCu_3(VO_4)_2(OH)_2$

Vesignieite was originally described by Guillemin (1955) on the basis of specimens from Friedrichsrode, Thuringia, Germany. Type material consists of platy aggregates of crystals under 1 mm resembling poor-quality volborthite. Although additional localities have since been found, the quality of specimens is generally poor (small platy cleavages).

Vesignieite is relatively abundant at the Mashamba West mine, where it forms individual crystals to 2 mm on white scalenohedral calcite with malachite tufts. Dark olive-green crystal aggregates and botryoids to 4 mm also occur on orange to brown, iron-stained, massive or minutely crystalline calcite.

CONCLUSIONS

The Mashamba West open pit has produced an impressive array of high-quality mineral specimens including the world's finest examples of cobaltoan calcite, carnotite, duhamelite, kolwezite, metatyuyamunite and vesignieite, and surely some of the world's finest and most beautiful cuprite and malachite specimens. The oxide zone of the Mashamba West orebody will soon be exhausted, as the open pit merges with the Dikuluwe mine. Perhaps progress into the sulfide zone will yield additional surprises.

(continued on page 28)

The Fat Jack Mine, Yavapai County, Arizona

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Fine amethyst and smoky tipped quartz scepters have been collected since 1985 at the Fat Jack mine south of Crown King, Arizona. A suite of interesting secondary minerals has also been found there, including osarizawaite and stolzite.

INTRODUCTION

The Fat Jack mine is located at an elevation of 6,800 feet in heavy timber on the north face of Lane Mountain in the Bradshaw Mountains, Tiger mining district, Yavapai County, Arizona (Crown King 15-minute quadrangle, Sections 1 and 2 of T9N, and 35 and 36 of T10N, R1W).

The Fat Jack mine is not Arizona's only quartz scepter locality, but it may be finest in terms of specimen quality, beautiful scenery and interesting minerals.

HISTORY

The property was located on June 18, 1896, as a gold lode claim by Ernest Campbell and A. M. Heath. Campbell, an old time prospector and a colorful character, was tall and very thin and was nicknamed "Fat Jack" (Helm and Helm, 1945). His partner was Major Strong, who was purported to be short and fat; he was nicknamed "Slim Jim" (a name also given to an associated claim). The name of H. C. Strong first shows up in the records in an August 13, 1903, claim amendment. A. M. Heath's name does not appear after the initial locating of the claim.

Helm and Helm (1945) report considerable "chloriding" of ore and a quantity of high-grade ore was packed out in the early days. It may have been brought to the Tip Top mill located a few miles down the mountainside. Evidently Campbell and Strong had some disagreements and Strong left the partnership. Campbell's name last appears in the records in a 1919 assessment. Campbell died in the early 1940's in the Pioneers Home in Prescott, Arizona.

Claim ownership passed to Percy Ralph Helm, Jr., Charles W. DeMund and L. D. DeMund sometime before July 29, 1929, when they filed an assessment. The sequence of ownership becomes somewhat confused thereafter, with the claims sometimes referred to as the "Fat Jim" and "Slim Jack." It seems the claims passed through several different hands before the present claim owner, Fred Lorette of Mayer, Arizona, located the property July 4, 1981. It was originally located as Fat Jack claims 1-3, then amended to Fat Jack claims 1-8 in January 1983. Fred Lorette has been actively exploring the gold potential of the mine.

Collecting History

Little is known about the early collecting history of the Fat Jack mine. Local mineral collectors familiar with the area speak of Sunday trips there with their children, resulting in buckets full of loose, common quartz crystals accompanied by an occasional amethyst-tipped scepter.

It was not until the fall of 1984 that the potential of the mine as a specimen producer was realized. That year a case of minerals on display at the Arizona State Fair aroused the interest of local collectors seeking a "new" locality to work. The case contained sceptered groups, singles and doubly terminated quartz crystals.

Little could be done until the following spring when collecting began in earnest. Several collectors from the Phoenix area made significant finds that season. The largest pocket to date was uncovered in the summer of 1986 by Mesa collector/dealer David Shannon. Hundreds of amethyst scepters were collected, some in fine cabinet-size groups, along with a large quantity of ordinary quartz crystals. Shannon's pocket also yielded the first known Japan-law quartz twins found at the mine.

In the fall of 1986 collecting was all but halted when the property was sublet for the purpose of commercial collecting and "No Trespassing" signs became a harsh reality. These efforts failed to produce any significant amount of sceptered quartz. It was not until early in the summer of 1987 that collecting by the public was able to resume.

During this time of renewed collecting, the authors uncovered a pocket containing approximately 80 amethyst-tipped scepters packed tightly in a mud-filled cavity. The pocket was unique from others in that the scepter heads were much gemmier and the shafts were more slender than scepters collected previously. These characteristics are obvious in the one matrix specimen recovered from the pocket (Fig. 4).

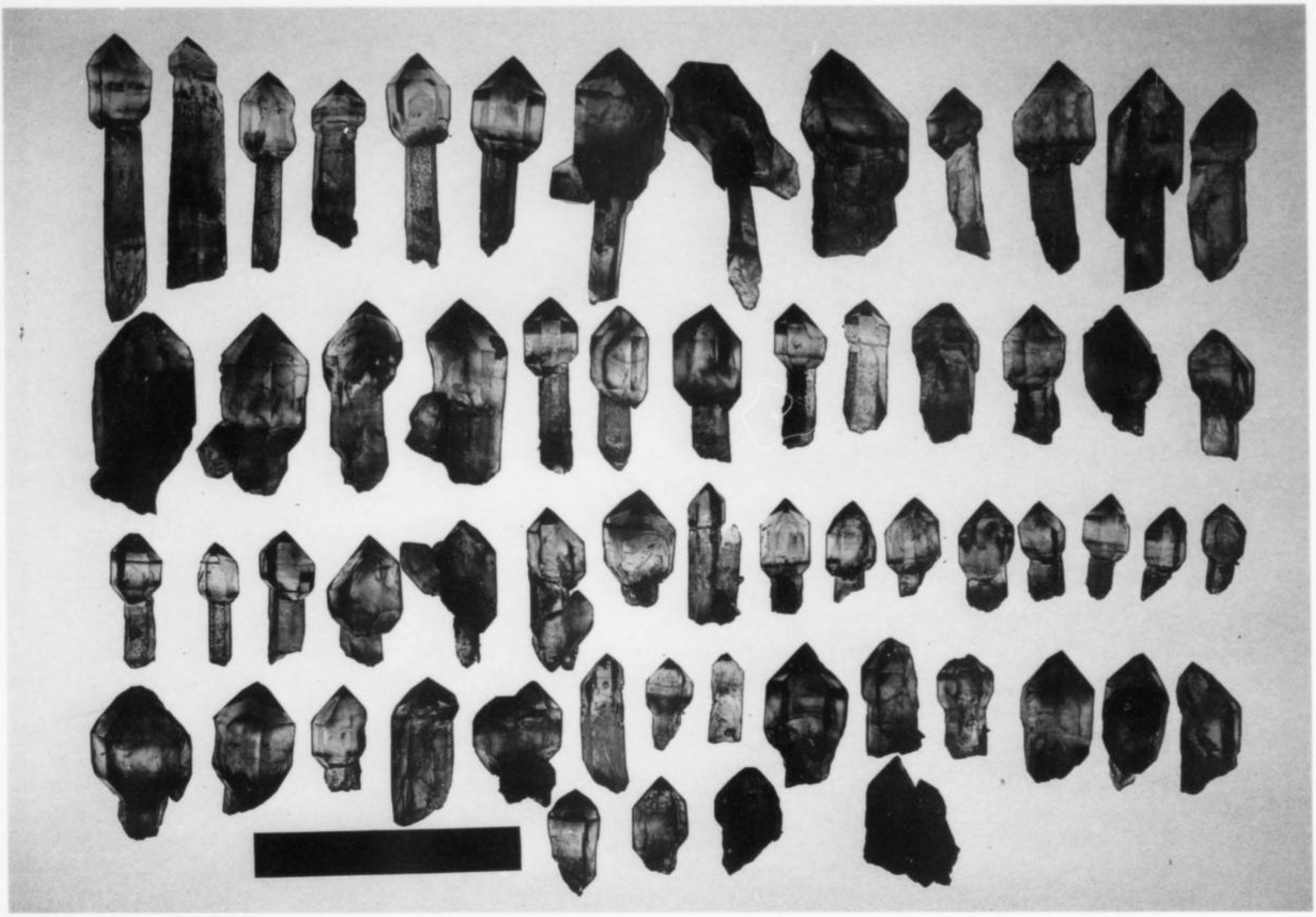

Figure 1. **Quartz, partial contents of a single pocket collected summer 1987. Jeff Scovil collection, photo by J. Scovil.**

Figure 2. **Quartz, center crystal 6.6 cm high. David Shannon collection; photo by J. Scovil.**

Figure 4. **Quartz, 7.8 cm high. Les Wagner, Jr. collection; photo by J. Scovil.**

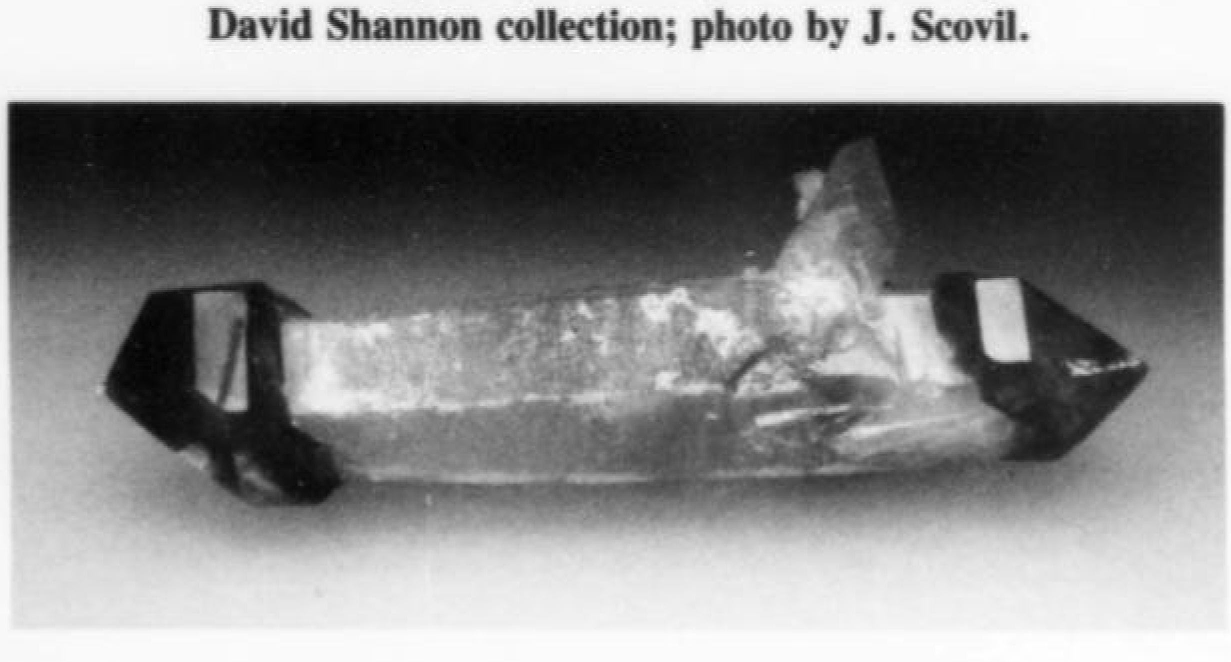

Figure 3. (left) **Quartz, double scepter, 8.4 cm long. Harold Michel collection; photo by J. Scovil.**

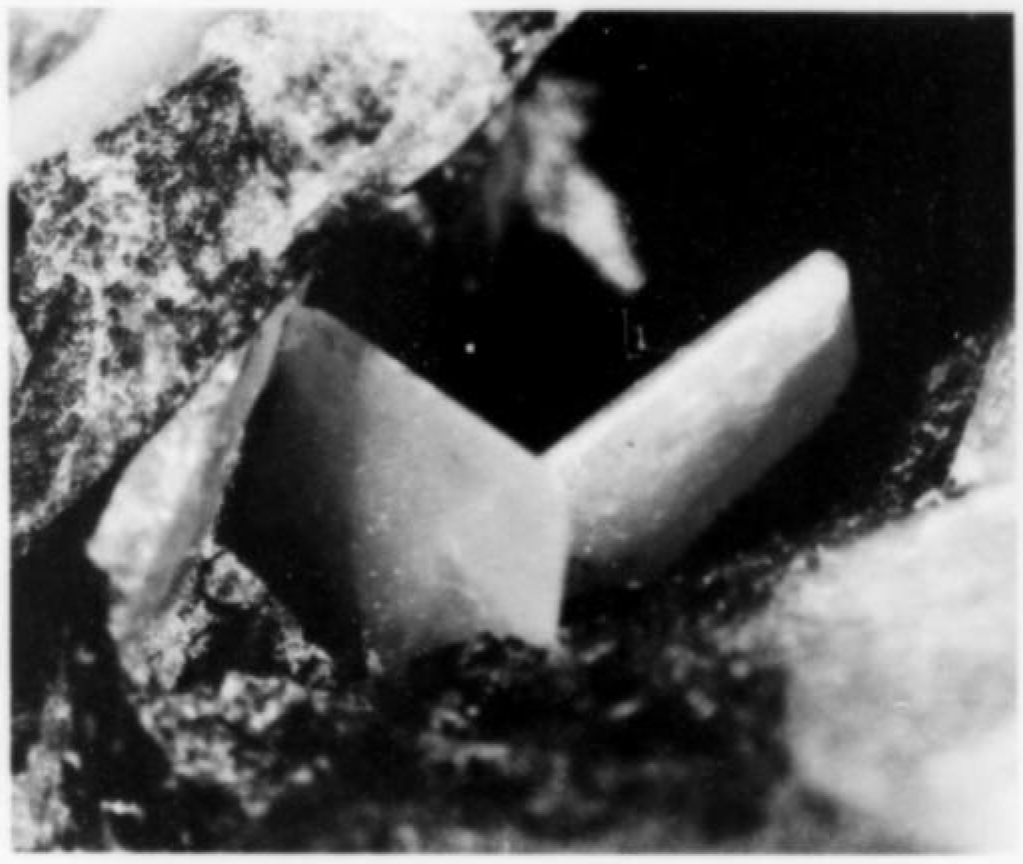

Figure 5. Stolzite crystals to 4 mm. Jeff Scovil collection and photo.

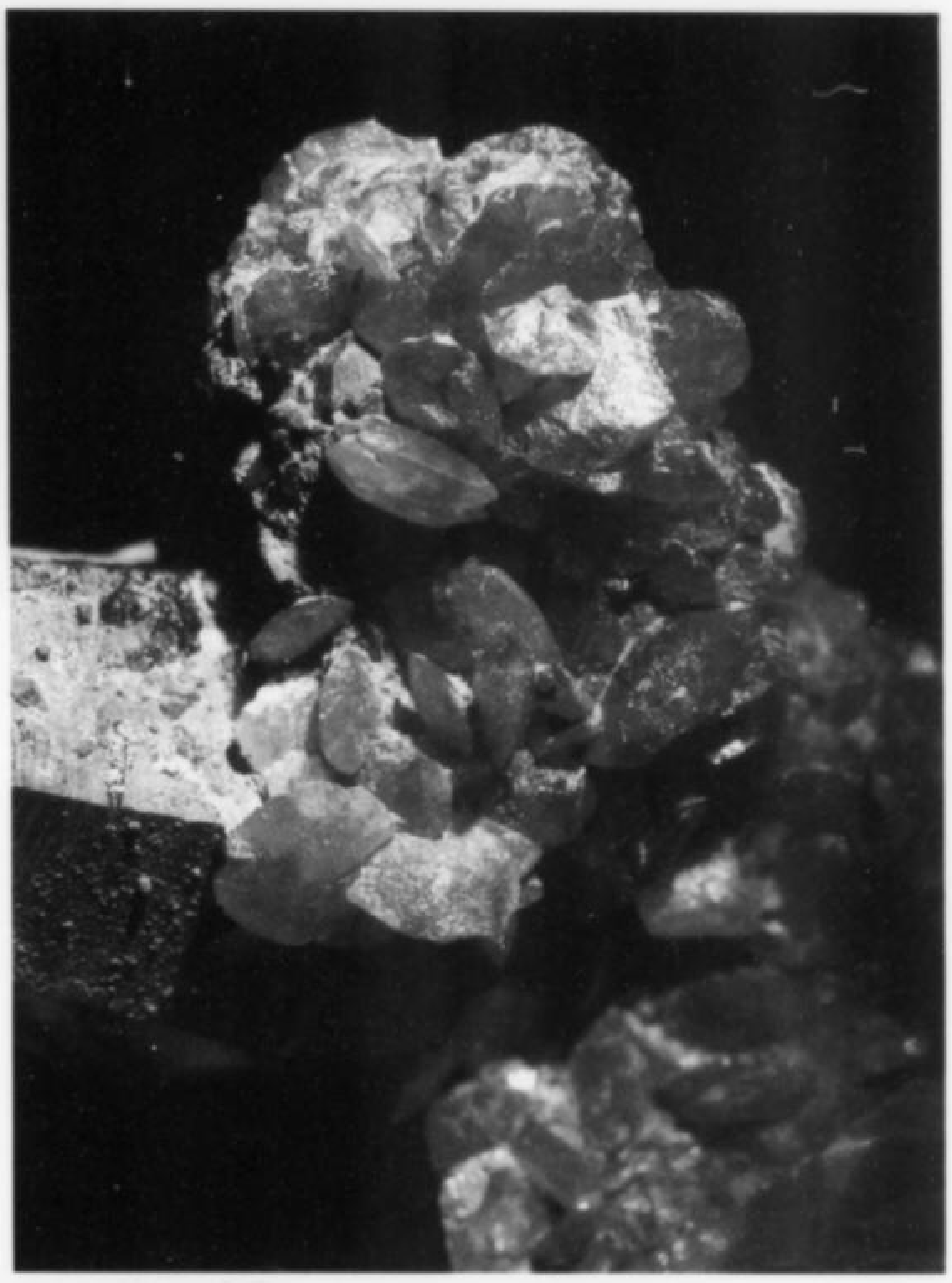

Figure 6. Stolzite, field 1.2 cm. Jeff Scovil collection and photo.

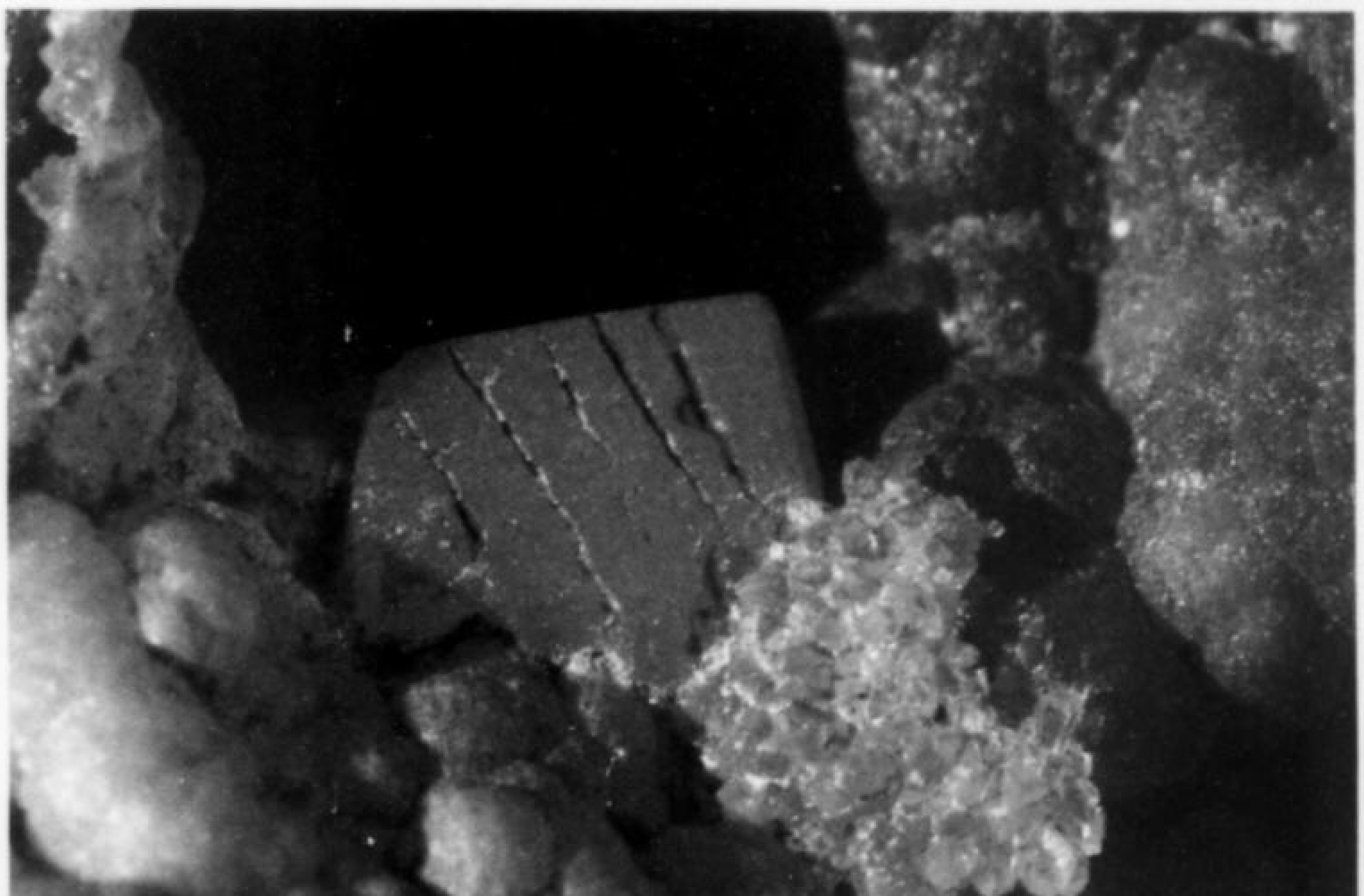

Figure 7. Stolzite crystal on quartz with "hyalite" opal, crystal 2 mm across. Les Wagner, Jr. collection; photo by J. Scovil.

Figure 8. Stolzite crystal, 4 mm. Jeff Scovil collection and photo.

Figure 9. Pyromorphite, field 1.2 cm. Jeff Scovil collection and photo.

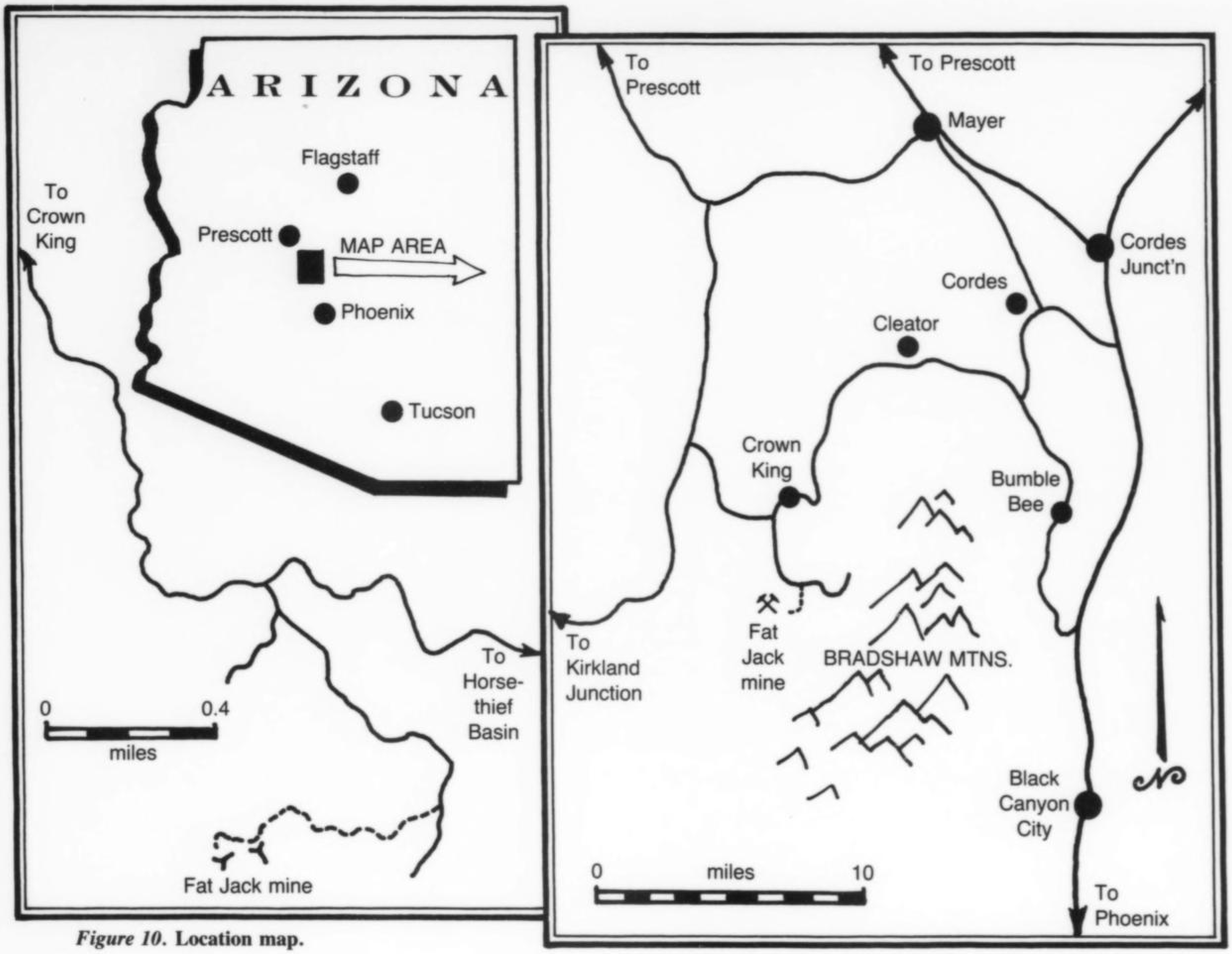

Figure 10. **Location map.**

GEOLOGY

The Fat Jack mine is located in a large schist inclusion in the Crazy Basin quartz monzonite. The schist is a metasedimentary member of a mixed group of rocks referred to as pelites by Dewitt (1976). The schist consists of quartz, muscovite and biotite with minor amounts of garnet, staurolite, andalusite and sillimanite. The rocks mapped as pelites by DeWitt are stratified sedimentary rocks consisting of slates, conglomerates, arkoses and shales. They unconformably overlie and truncate Precambrian volcanics.

The schist is situated near the western edge of a quartz monzonite batholith about 200 square kilometers in extent. The monzonite has a slightly sheared margin of medium-grained alaskite and a core of coarse-grained, phaneritic, porphyritic quartz monzonite. The mineral constituents are plagioclase, orthoclase, quartz, muscovite and biotite (Anderson and Blacet, 1972).

The batholith contains inclusions and septa of pelites and is cut by simple pegmatites ranging from 50 cm to 8 meters in thickness. These pegmatites also intrude the pelitic rocks following foliation planes. Dewitt (1976) considers the pegmatites to be genetically related to the Crazy Basin quartz monzonite batholith which is Precambrian and has been dated at 1,700 million years (N. Niemuth, personal communication, 1986). The pegmatites consist of quartz, orthoclase, plagioclase, muscovite, schorl and occasional beryl.

The schists have been referred to in the past as the Yavapai Schist, and the monzonite as the Bradshaw Granite (e.g., Lindgren, 1926).

Quartz crystals and associated minerals are found in quartz veins cutting a monzonite/schist contact and are generally concordant with the foliation of the enclosing schist, dipping northwest and striking northeast. The veins also cut simple pegmatites. This zone of mineralization is the "orebody" referred to by Flagg (1945).

According to Lorette (personal communication, 1990) the source of mineralization is the breccia pipe. Extensive drilling and testing by Lorette revealed quartz veins extending from the breccia pipe at a depth of about 77 meters from the surface. These veins extend west toward the surface workings.

WORKINGS

The workings consist of a vertical shaft to 11 meters where about 30 meters of drifts explore the width of the mineralized zone (about 10 meters wide at that depth). There are also several shallow opencuts, pits and a short adit (about 9 meters long). Just downhill from the upper workings, near the remains of an old cabin, is another adit, now backfilled. This adit was evidently driven in an attempt to intersect the underground workings at the 11-meter level. The vertical shaft was capped and inaccessible until recent work by Lorette intersected it about 3 meters from the surface.

What is currently considered the Fat Jack mine is actually a group of claims consisting primarily of two adjoining mines, the Fat Jack and the Slim Jim. The Fat Jack consists of the upper workings and a "blowout" above these workings. The "blowout" is a breccia pipe consisting of brecciated schist and monzonite cemented by drusy quartz and hematite. The breccia fragments are large (to 50 cm) and very rounded. There is a short adit on the west side of the outcrop. The Slim Jim consists of the backfilled tunnel adjacent to the old cabin.

Figure 11. **Fat Jack mine area, 1985.**

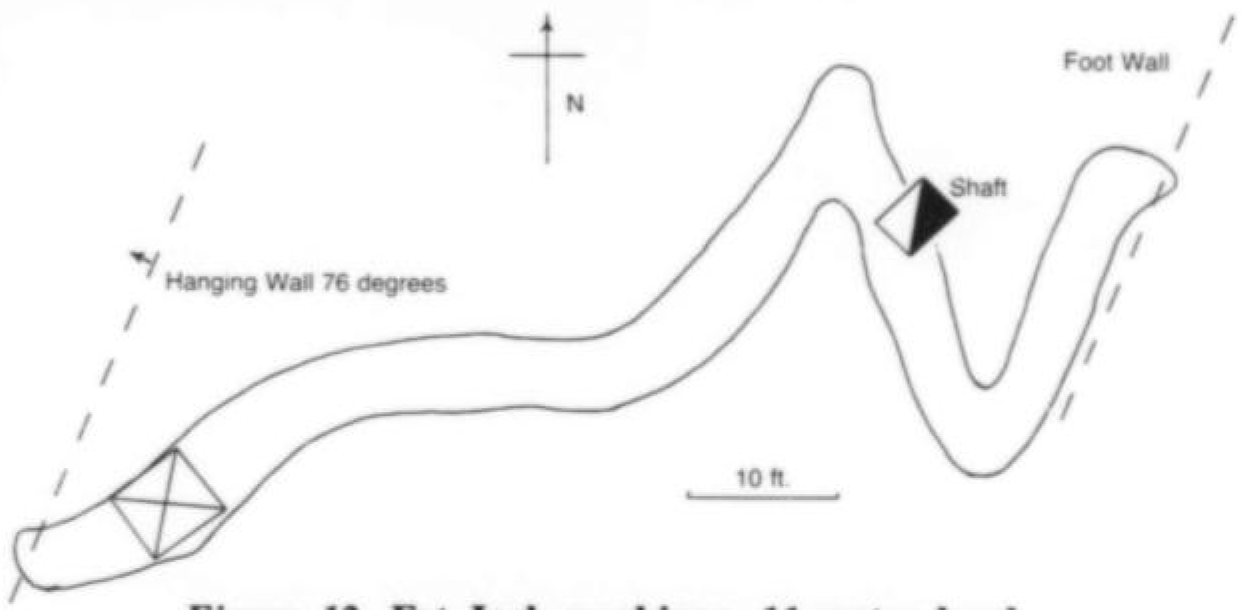

Figure 12. **Fat Jack workings, 11-meter level (after Flagg, 1945).**

MINERALS

Anglesite $PbSO_4$

Lorette reports anglesite occurring at depth in the mine (personal communication, 1986).

Ankerite (?) $Ca(Fe^{+2},Mg,Mn)(CO_3)_2$

It is likely that the alteration precursor of limonite was ankerite; the species is reported from many mines in the area, whereas dolomite is less common, and calcite even rarer. Ankerite crystallization was initiated shortly before quartz completed its growth phase. Ankerite is always embedded in the quartz crystals. Some quartz crystals exhibit tiny, hollow, rhombohedral molds (presumably of now-gone ankerite) of late-stage drusy quartz imbedded on their surfaces.

Barite $BaSO_4$

Barite is rare, occurring as small (to 5 mm long) flattened, radiating blades on quartz. Associated minerals are stolzite, cerussite and pyromorphite.

Cerussite $PbCO_3$

Cerussite is uncommon at the Fat Jack mine. It has been found as irregular gray crusts and twinned crystals up to 2 cm long, and as a massive alteration product of galena. Some crystals are hollow and lined with pyromorphite, an apparent alteration product. The cerussite fluoresces orange under longwave ultraviolet radiation.

Chalcocite Cu_2S, **Covellite** CuS

A metallic, blue/black mineral has tentatively been identified as chalcocite and/or covellite. It is found as irregular masses (to 4 mm) within the pseudomorphous boxworks formed by cerussite after galena, associated with chrysocolla.

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

A rare mineral at the Fat Jack mine, chrysocolla is found as irregular micro-crusts on chalcocite/covellite replacing galena. Associated minerals include quartz and cerussite.

Galena PbS

Argentiferous galena has been found in masses in quartz up to 2.2 cm across. It is altering to cerussite, and is associated with malachite.

Gold Au

Flagg (1945) reports that gold has been found here in pyrite, finely disseminated in massive quartz, and as free, sometimes visible grains in hematite. Assays by both Flagg and Lorette ran as high as 0.4 ounces per ton. Lorette has panned free gold in the form of dust and at least one small wire (about 4 mm long) from concentrates obtained from the quartz veins.

Hematite Fe_2O_3

Hematite formed quite late in the sequence. It is found as irregular

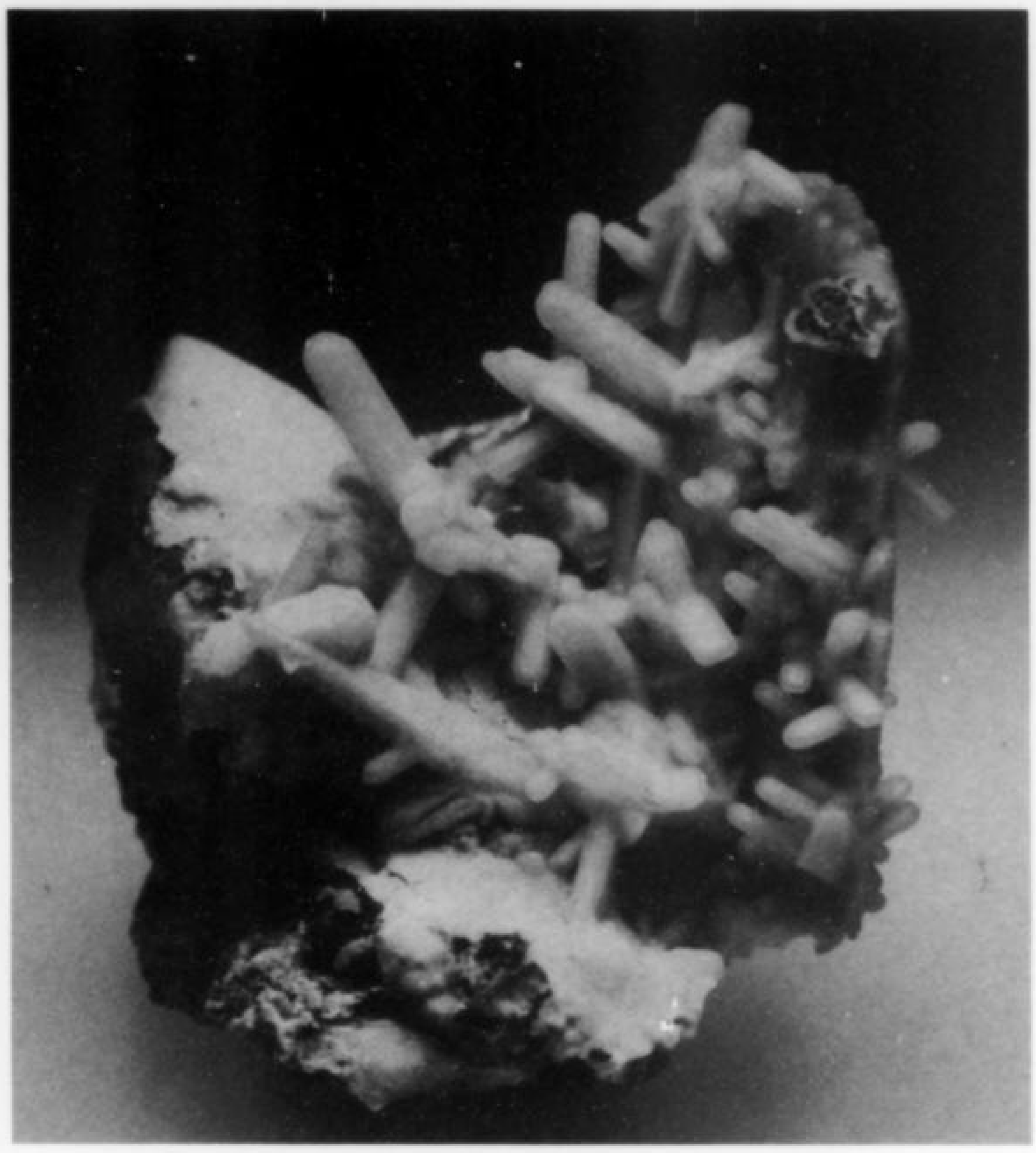

Figure 13. **Cerussite, quartz and "hyalite" opal, 3 cm high. David Shannon collection; photo by J. Scovil.**

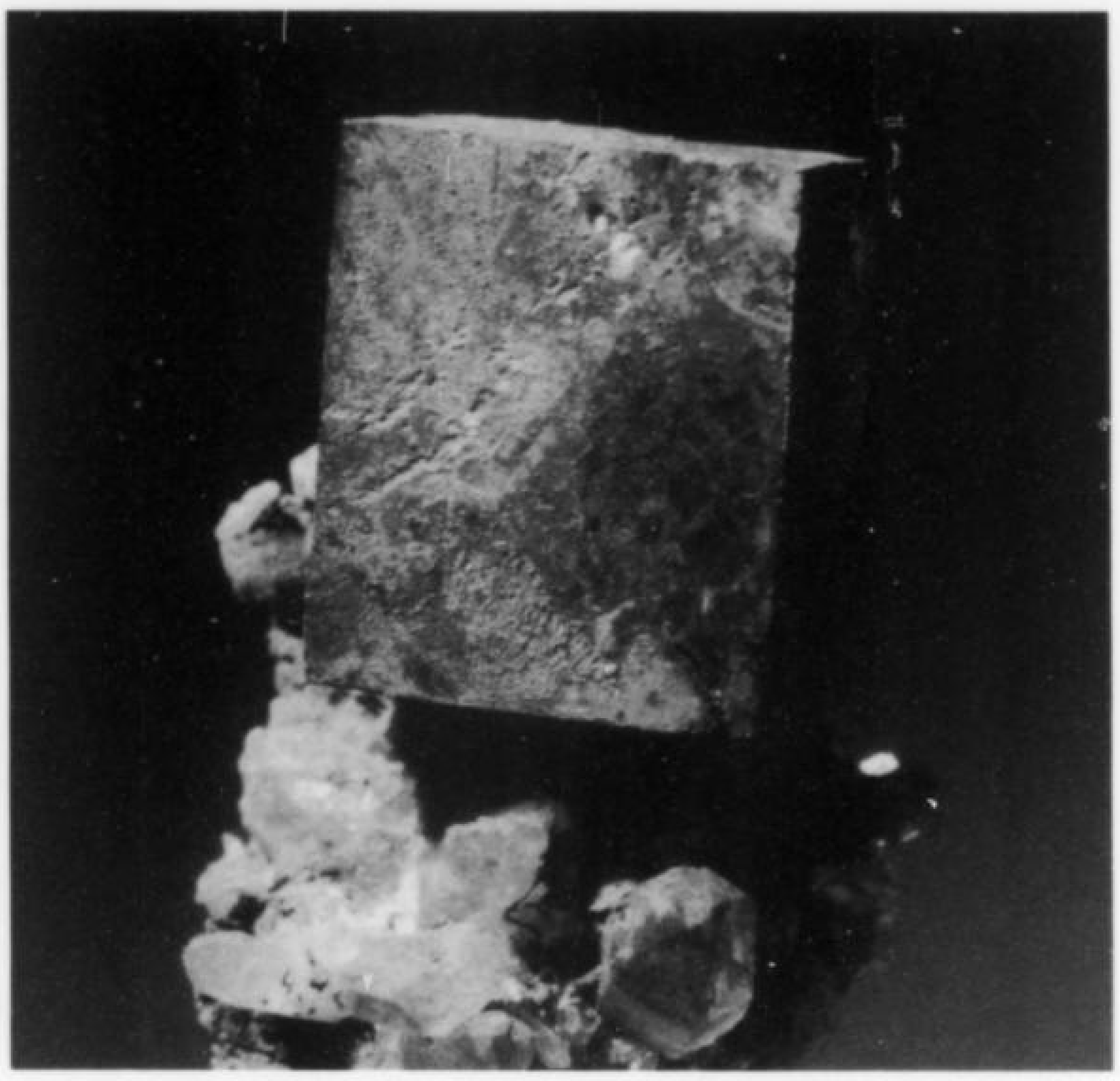

Figure 14. **"Limonite" pseudomorph after pyrite, 3.2 cm high. Jeff Scovil collection and photo.**

crusts on quartz crystals and in massive form cementing fractured pocket contents. The hematite is reported to be auriferous (Flagg, 1945). Subhedral hematite occurs rarely as inclusions in quartz, but no distinct hematite crystals have been observed.

Jarosite $KFe_3^{+3}(SO_4)_2(OH)_6$

Jarosite occurs as gold-brown, tabular, six-sided plates to 1 mm with the pinacoid dominant and with minor rhombohedral modifications. It occurs on quartz as a fine powder, often filling interstices among the crystals, and is commonly a major constituent of unidentified pocket clays.

"Limonite" unidentified hydrous iron oxides

Unidentified hydrated iron oxides are sometimes found as pseudomorphs after pyrite crystals to 5 cm, and after curved, saddle-shaped rhombohedra of ankerite. The pseudomorphs after pyrite range from quite solid to dark spongy masses with little trace of the original crystal form. Pseudomorphs after ankerite tend to be soft and easily destroyed during cleaning.

Malachite $Cu_2(CO_3)(OH)_2$

Malachite is a rare mineral at the Fat Jack mine. It is found as irregular sprays and seam linings in vuggy quartz associated with galena and cerussite. On one specimen the malachite is overgrown by drusy quartz, coloring the quartz a brilliant green.

Mottramite $PbCu(VO_4)(OH)$

Yellow-green mottramite is found coating faces and broken surfaces of quartz crystals. It occasionally underlies stolzite. Mottramite also occurs as lustrous, discoidal, bipyramidal, bottle-green crystals.

Opal $SiO_2 \cdot nH_2O$

Pocket contents are occasionally coated with a thin layer of "hyalite"

Figure 15. **Jarosite; SEM photo by Peter Modreski, U.S. Geological Survey.**

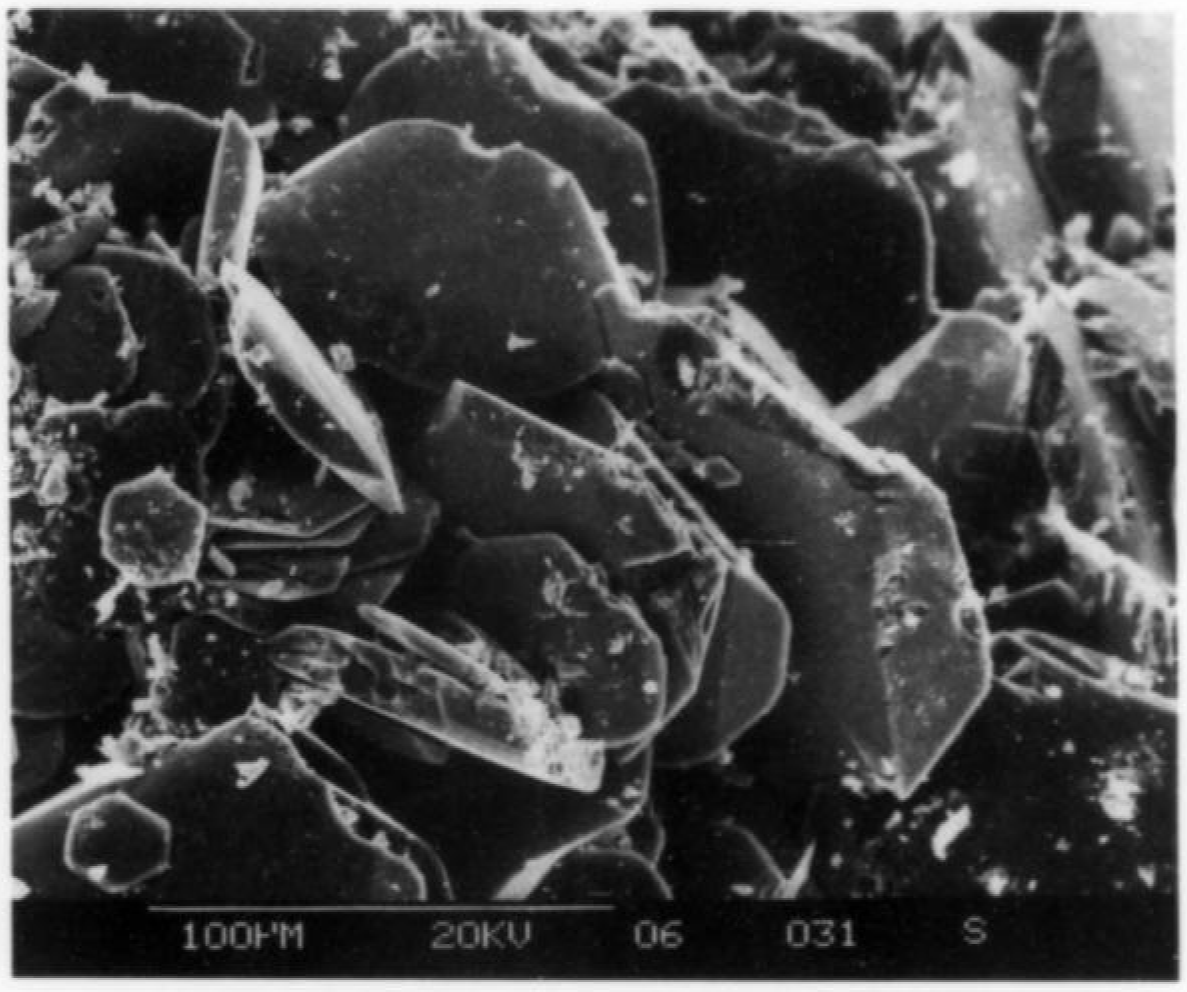

Figure 16. **Osarizawaite; SEM photo by Peter Modreski, U.S. Geological Survey.**

opal which fluoresces a brilliant green under shortwave ultraviolet radiation.

Osarizawaite $PbCuAl_2(SO_4)_2(OH)_6$

The Fat Jack mine is the fourth reported occurrence for osarizawaite in Arizona. It has previously been reported from Bisbee; the Omega mine, Pima County; and the Silver Hill mine, Pima County (Stolburg, 1988).

It usually occurs as a massive, pale green pocket filling, ranging from soft and clay-like to hard and cherty. These massive forms are impure, and contain large amounts of silica. More rarely, osarizawaite is found as lustrous, lime-green, transparent pseudocubic rhombohedra less than 1 mm in diameter. They have been found implanted on the massive variety, and in spongy quartz associated with stolzite and pyromorphite. One crystal shows a distinct hexagonal prismatic habit with a cavernous termination.

The crystals are zoned, with deeper-green centers of osarizawaite and thin (10–25 micron) near-colorless rims of alunite-natroalunite. The identity of the osarizawaite was confirmed by semiquantitative microprobe analysis (P. Modreski, personal communication) on broken, unpolished crystal fragments, and also by optical analysis and X-ray diffraction. The interior of the crystals has a composition approaching that of end-member osarizawaite, but also containing minor amounts of Na and Fe, and traces of K and Ca. The analysis yields the formula $(Pb_{0.63}Na_{0.22}K_{0.01}Ca_{0.01})Cu_{0.99}(Al_{1.92}Fe^{+3}_{0.24})(SO_4)_2(OH)_6$, corresponding to the generalized formula $(Pb,Na)Cu(Al,Fe^{+3})_2(SO_4)_2(OH)_6$. The outer rim consists of an intermediate solid solution between natroalunite and alunite, generally closer to natroalunite, and containing minor Pb, Cu, Fe, Ca and Sr. Its average molecular composition is $(Na_{0.39}K_{0.34}Pb_{0.39}Cu_{0.09}Ca_{0.02})(Al_{2.90}Fe^{+3}_{0.27})(SO_4)_2(OH)_6$.

Pyrite FeS_2

Pyrite is rare and has only been found completely enclosed in massive quartz. All exposed crystals have been completely oxidized.

Pyromorphite $Pb_5(PO_4)_3Cl$

Pyromorphite formed quite late in the sequence, and is frequently found on the broken surfaces of quartz crystals and the hydrated iron oxides coating them. Other associations include jarosite and stolzite. The color ranges from white to gray to dark olive green. Crystals (to 1 cm) occur in clusters and crusts of divergent aggregates of acicular hexagonal prisms terminated by the pinacoid (identification confirmed by energy-dispersive X-ray analysis, P. Modreski, personal communication, 1989).

The pyromorphite fluoresces brilliant orange under long-wave and pale orange under short-wave ultraviolet radiation.

Quartz SiO_2

The majority of quartz crystals are milky, simple prisms to 8 cm in length. Most are found loose in vugs in narrow quartz veins. A small percentage are amethyst-tipped or smoky-tipped scepters. Such crystals have been found up to 15 cm in length.

Although most crystals are simple in habit, the scepters nearly always show more complex zoning and parallel growth, and are often gemmier at the tips. Most pockets exhibit late stage shattering of their contents with a varying degree of regrowth. The Fat Jack mine has also produced a number of Japan-law quartz twins.

Sphalerite ZnS

Sphalerite has been tentatively identified as yellow-green irregular inclusions in a single quartz crystal. Sphalerite has been found in many of the mines of the district.

Stolzite $PbWO_4$

Stolzite is found sparingly in four habits and assemblages. Specimens from a trench to the south of the adit are associated with quartz and limonite pseudomorphs after pyrite and ankerite. These crystals are orange, rounded, tabular and rough. Some are "doughnut" shaped with a hole in the center as if formed around an earlier mineral, subsequently leached away. These crystals fluoresce peach-pink under longwave and shortwave ultraviolet light. The fluorescence is blotchy and not as bright under shortwave. The stolzite also exhibits a bluish white to greenish white cathodoluminescence under electron bombardment in the microprobe (Modreski and Scovil, 1990). The largest stolzite of this type (now in the J. Scovil collection) is 8 mm across.

Stolzite is also found in very vuggy massive quartz with pyromorphite and osarizawaite where it typically occurs as pale yellow translucent to transparent acute dipyramids and the more typical tabular crystals. Crystal size is usually less than 1 mm.

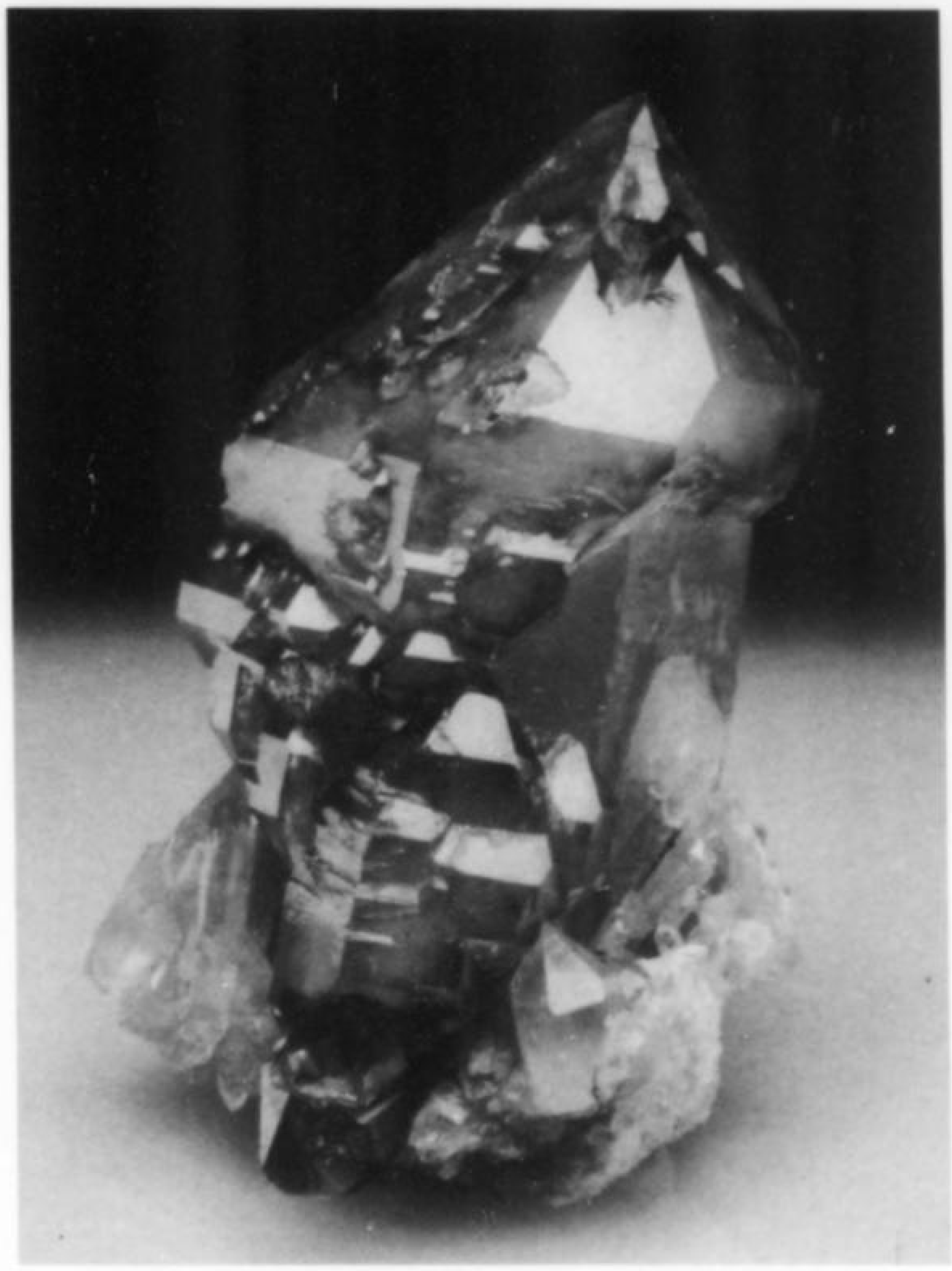

Figure 17. **Quartz, 8.5 cm high. David Shannon collection; photo by J. Scovil.**

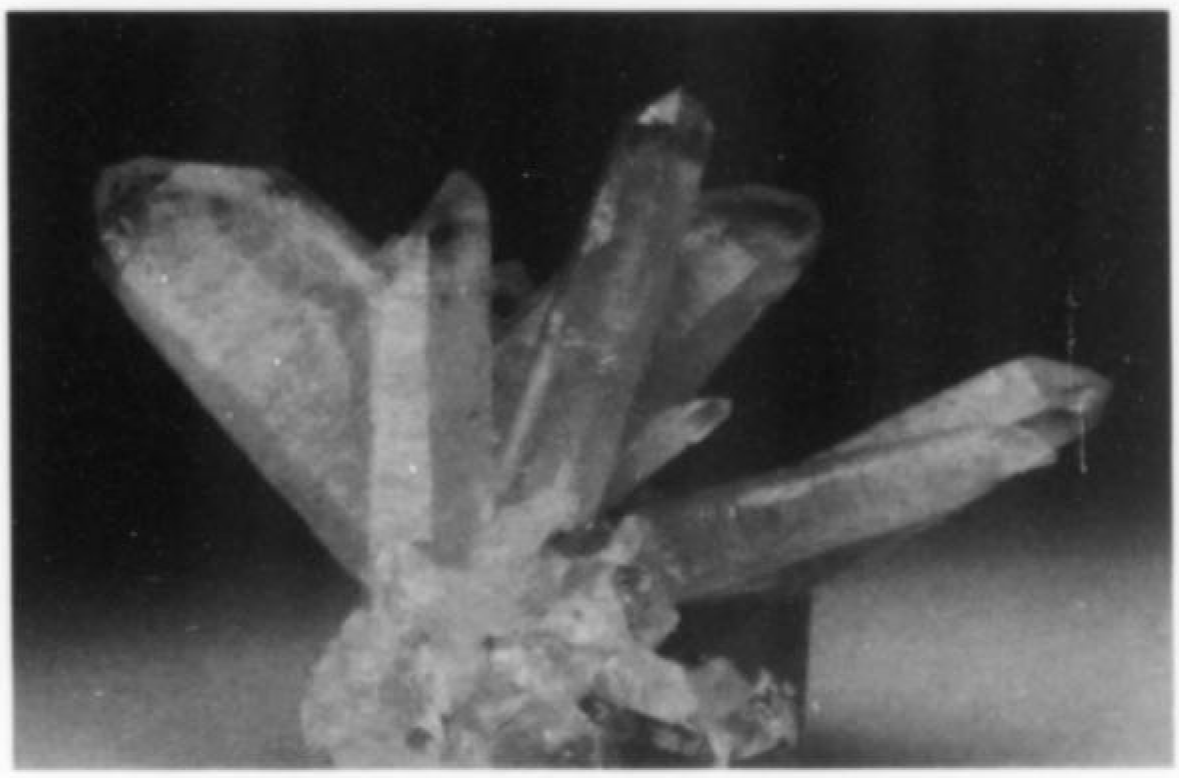

Figure 18. **Quartz, Japan-law twin, 5 cm across. David Shannon collection; photo by J. Scovil.**

Stolzite occurs as very simple, thin, yellow, tabular crystals which are square in outline. The best formed crystals are small (to 2 mm) thick tablets, and orange in color, usually associated with drusy pyromorphite. Some tabular yellow stolzite crystals have been found that have a faint orange spot in the center.

Samples of stolzite, originally thought to be wulfenite, were analyzed by SEM semiquantitative energy-dispersive analysis and found to be stolzite (P. Modreski, personal communication). A complete microprobe analysis produced the following data:

PbO	47.0–51.1 wt. %
CaO	0.0– 0.2 wt. %
WO_3	3.0–45.0 wt. %
MoO_3	3.0–15.0 wt. %

The average composition yields the following formula: $Pb_{1.02}Ca_{0.005}(W_{0.74}Mo_{0.25})O_4$.

The average composition is about 75 mole % stolzite, and 25 mole % wulfenite: a molybdenum-bearing stolzite. Analyzed stolzite samples showed a range in composition from 50 to 80 mole % stolzite.

DISCUSSION

Much work needs to be done on the geology of this area and the nature of the Fat Jack deposit in particular. Lindgren (1926) points out that there are basically two types of ore deposits in the district. The most economically significant type is the bedded massive sulfide deposits as at the Iron King mine (see Creasey, 1952).

The second type is the vein deposits. These are fissure veins, usually straight and narrow, striking generally north, dipping steeply, with well-defined walls. They are primarily of milky, drusy quartz grading into a well-defined comb structure. Sericitization and carbonatization of the country rock is the rule.

Free gold is usually present but it occurs more commonly in intimate intergrowth with sulfides. Galena is usually argentiferous. Ankerite is a common gangue mineral. Silver-bearing veins usually contain barite. Lindgren considered these veins to be late Mesozoic or early Tertiary and mesothermal. The Fat Jack deposits seem to fit this vein type in most particulars, although there are some differences. Chalcopyrite and sphalerite, while common in other vein deposits of the area, are extremely rare in the Fat Jack. Pyrite is very common throughout the area, but is seldom altered to the degree that it is at the Fat Jack, where it is not common.

CONCLUSION

This paper is an introduction to a new locality on which little geological, mineralogical or paragenetic work has been done. Additional mineral species will probably be reported as collecting progresses.

At the time of this writing, the mine is open to collecting. Since active exploration continues at the mine, it is essential that collectors respect any equipment and do not interfere with the mine's operation. The collecting of quartz crystals is allowed, but not potential gold-bearing ore.

ACKNOWLEDGMENTS

A number of people deserve thanks for their assistance in the preparation of this paper: Nyal Niemuth and the Arizona Department of Mines and Mineral Resources; Fred Lorette; David Shannon; and William Hunt. Peter Modreski of the U.S. Geological Survey performed the microprobe, EDX and X-ray diffraction analyses.

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(continued from page 20)

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The Monitor-Mogul Mining District

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The Monitor-Mogul district, mined for gold and silver since 1857, has produced many fine specimens of hübnerite and rhodochrosite as well as a range of attractive microminerals.

INTRODUCTION

The Monitor-Mogul mining district is located in Alpine County, California, about 10 miles southeast of Markleeville and 60 miles south of Reno, Nevada. Surface oxidation of a variety of sulfide minerals has resulted in several brightly colored mountain peaks which have historically aroused the curiosity of travelers (Raymond, 1873). The district contains numerous gold and silver deposits and has also produced fine mineral specimens, as Clark and Evans (1977) have noted: "Monitor and Mogul . . . have long been favorite places for the collecting of mineral specimens."

The district's gold and silver deposits have been mined sporadically since the first discovery in 1857. The majority of production from the district has been from the Zaca group, a general name given to the mines on Colorado Hill.

HISTORY

The discoveries of gold and silver in the late 1850's and early 1860's, with reported assays of $1000–$3000 per ton, brought many fortune-seekers to the Monitor-Mogul district. The first silver discovery in the district is credited to L. L. Hawkins, a local rancher and mining engineer, who located a deposit along Monitor Creek in 1857 (Clark and Evans, 1977). The first gold discovered in Alpine County, reported by Logan (1922), may have been in 1861 on Boulder Hill, northwest of Colorado Hill. Large boulders were found which, when milled, yielded "a fabulous rate of free gold, $20,000 being obtained from a few tons of ore" (Logan, 1922).

Many felt the discoveries in the Monitor-Mogul district represented a continuation of the Comstock lode in Virginia City, Nevada. Gaertner (1876) stated, "This lode bears great similarity to the Comstock. There are ample reasons to suppose that there is a connection existing between them and that both may even be traceable to a common origin." Miners came from Virginia City and other Nevada mining camps during the boom period and established the towns of Monitor and Mogul. The boom did not last long, peaking about the time Alpine County was organized in 1864.

English investors raised considerable capital which was used to develop several mines in the district, the most notable of which was the Imperial tunnel. Many ill-advised mining ventures and difficult recovery of metals gave the county a poor reputation among mining people (Logan, 1922).

In 1863 the first stamp mill was built at the Colorado (Tarshish) mine, but it only recovered about 50% of the values. Neither free milling nor amalgamation would work on the gold and silver ores. In 1867 crushing, kiln drying with roasting and Fretburg barrel amalgamation were used at the Morning Star mine but proved to be unsuccessful. Some of the high grade gold-silver-copper ore from the Morning Star was shipped long distances by wagon and finally to mills in Swansea, Wales, where this difficult ore could be treated. In 1872 a mill was constructed that failed due to the inability of a new furnace to perform. Logan (1922) states, "it is easy to see that the natural difficulties of pioneering were augmented by the inexperience of the metallurgists with this type of ore, which was different from anything they had handled before." In 1878 a mill was finally constructed at the Zaca group that obtained 90–95% recovery of the gold and silver, but demonitization of silver had already signaled the end of the boom days.

During 1863–1864 the population of Alpine County was about 11,600 with most of the inhabitants in Markleeville or in Silver Mountain City, originally known as Konigsburg (from the Scandanavian miners). Smaller mining communities of several hundred residents were located at Monitor and Mogul. Monitor had a telegraph office, a post office, a newspaper, a Wells Fargo station, hotels, breweries and saloons. Miners were paid $3.50 to $4.00 per day while room

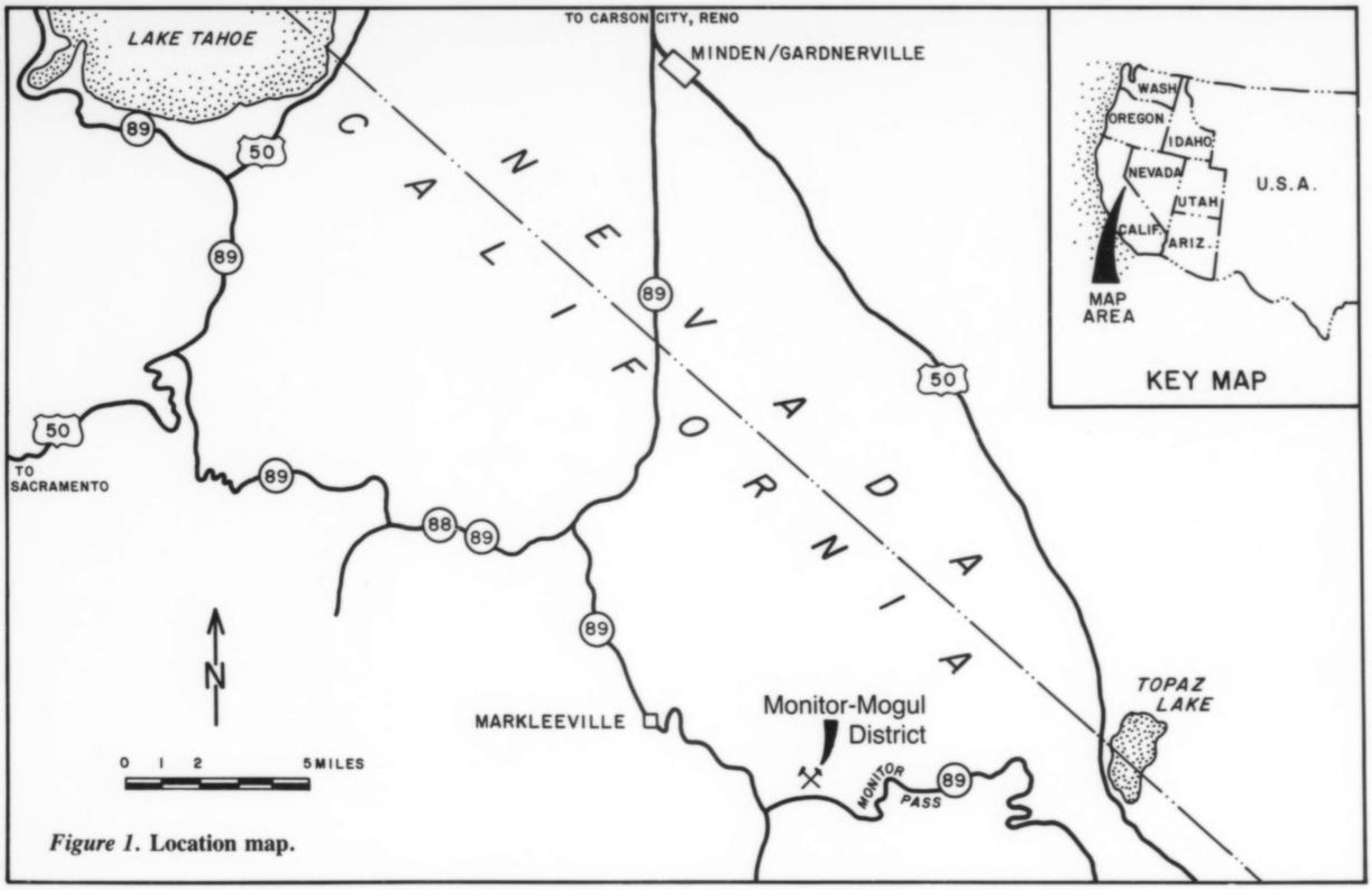


Figure 1. **Location map.**

and board at Monitor cost about $7.00 per week (Winchester, 1868). By about 1868 most of the residents had departed from Alpine County, and only 1200 people remained (Jackson, 1964). By 1886 Silver Mountain City, which at one time had a population of about 3000 people, had ceased to exist (Clark and Evans, 1977). The county's population continued to fall and between 1920 and 1950 averaged fewer than 300. The present population of Alpine County is about equal to its 1868 population of approximately 1200.

The mines were worked intermittently from the boom days of the early 1860's up to 1981. California Silver, Inc. now controls the Zaca group and in 1986 began construction of a mine and heap leaching facility. The operation recovers gold and silver from low-grade ores found above most of the old mine workings of the Zaca group.

GEOLOGY

The Monitor-Mogul district is located on the eastern edge of the Sierra Nevada, in an area that is characterized by a thick sequence of Miocene and Pliocene volcanic rocks which overlie the Sierra Nevada granite. Generally north-trending faults cut the sequence and are probably related to Basin and Range faulting. Mineralization occurs in a wide variety of the rocks in the district.

The oldest rocks exposed in the area are the andesite flows and flow breccias of the Relief Peak Formation. This unit has undergone widespread weak to strong epithermal alteration which has resulted in the brightly colored exposures at Flint and Boulder Hill and the silicified caps and ridges present throughout the district

Immature clastic sediments, andesitic lahars, rhyolitic volcaniclastics and a bedded pumice breccia overlie the andesite flows in the vicinity of Colorado Hill.

Rhyolite plugs intruded this sequence of volcanics. Most of the rhyolite is flow-banded and has phenocrysts of quartz and potassium feldspar. Biotite phenocrysts are common in one of the plugs. The largest known rhyolite intrusion is approximately 615 meters in diameter and makes up Colorado Hill.

Mineralization in the Monitor-Mogul district is subdivided based on lithology of the host rock. It occurs in (1) silicified rock, (2) andesite, (3) volcaniclastic rocks, and (4) rhyolite. Stratigraphic relationships in the area indicate that at least two periods of mineralization occurred. The earlier period resulted in the deposits in the andesite and silicified rock while a later period mineralized the volcaniclastics and rhyolite.

Gold is locally associated with the silicified caps which formed during the epithermal alteration of the andesite. This silicified rock forms relict boulders throughout the district and was mined predominantly on Boulder Hill.

Mineralization in the andesite is also found as lodes, pods, veins, and zones parallel to bedding and along shear zones. Ore of this type was produced from the Curtz, Georgiana, Globe, Constitution, Lincoln, Morning Star, Orion, Red Gap and Flint mines. The mineralization consists of pyrite, sphalerite, galena and copper sulfides, and locally it is very rich in silver-bearing enargite. In general this ore was difficult to treat.

The volcaniclastic-hosted mineralization is localized along a north-trending sheeted fracture zone at the Alpine mine. Very little is known about the mineralogy of the ore, but it appears to have been primarily pyrite, silver sulfosalts and gold.

At the Zaca group the ore is almost entirely restricted to the Colorado Hill rhyolite plug. The high-grade mineralization occurs as soft, sericitic masses in irregular chimneys, pods and pockets, often near the rhyolite contact. In addition, lower grade mineralization surrounds these chimneys and forms large, irregular zones in the eastern half of the rhyolite plug. This mineralization is primarily restricted to thin (2 mm), regularly spaced fractures, but it is also found as disseminations and wider-spaced irregular pockets.

The main metallic minerals of the Zaca mines are pyrite, sphalerite, galena, argentite, tetrahedrite (freibergite) and proustite-pyrargyrite. The main accessory minerals are hübnerite, rhodochrosite and orthoclase (adularia). A strong geochemical zoning is present throughout

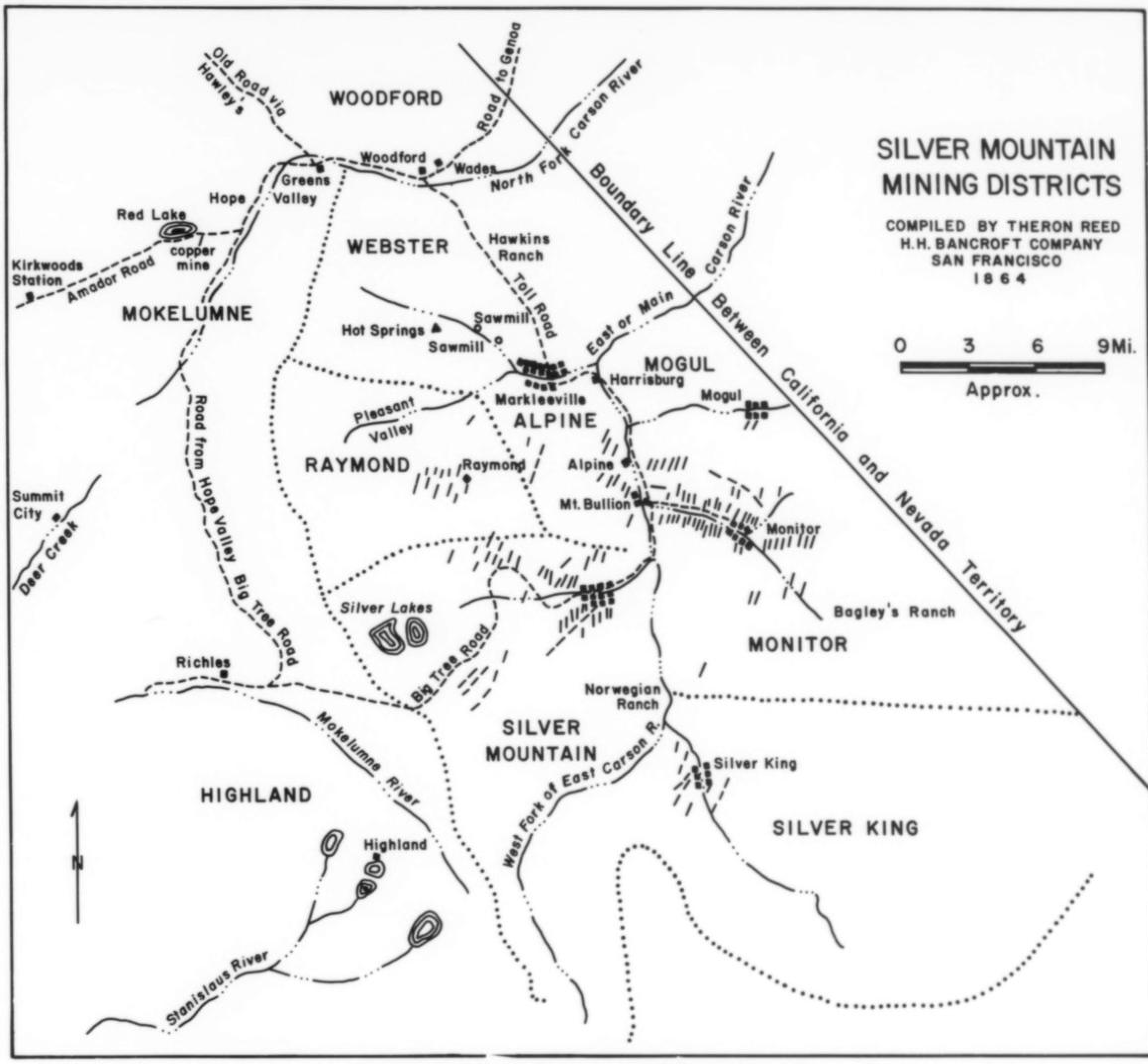


***Figure 2.* A copy of an old map of Alpine County showing the mining areas and principal lodes (Logan, 1921).**

the rhyolite. At Steve's Cut, near the top of Colorado Hil!, the mineralization is gold-rich (Ag:Au = 5) and at the lower workings silver (Ag:Au = 30) and base metals increase. The gold occurs as micron-sized grains, primarily in the sulfosalts and pyrite.

Alteration in the Zaca mines is typified by a quartz-sericite assemblage. It grades from weak to strong and can grossly be correlated with the grade of mineralization. A weak kaolinitic halo surrounds the ore.

Paragenetic relationships in the Zaca mines indicate that base metal mineralization predated precious metal mineralization. Quartz and/or pyrite deposition occurred throughout the period of mineralization. Proustite-pyrargyrite can occur as a replacement product of freibergite. The manganese-bearing minerals, hübnerite and rhodochrosite, were deposited late in the ore-forming process.

MINES

Zaca Group

The Zaca Group is the present-day name for the group of mines on Colorado Hill. These interconnected mines include the Advance, Bennett, Colorado, Galeries, Jardine, Hercules, Lovestedt, Marion, Silver Glance, Steve's Cut and the Tarshish mines. At various times different names were applied to the same mine, for example, Tarshish is an early name for what was later known as the Colorado mine. The underground workings of the group total about 3,100 meters on seven main levels over a 277-meter vertical extent.

The Zaca deposits, discovered in 1857, were among the first to be found in the area (Clark and Evans, 1977). The mine was first called the Tarshish and was operated by the Schenectady Silver Mining Co. The Monitor and Northwest Mining Company operated the Advance mine, located on the Tarshish lode, and constructed a mill on the East Fork of the Carson River at Mount Bullion. Early-day mining ventures generally resulted in failure. The ore was not freemilling and high-grade material was often associated with clays which baffled the early operators. Much was expected of the mines: the *Alpine Miner* (September, 1870) stated, "Above, below and on all sides the Tarshish (Zaca) is proving to be a great and continuous mine, and anybody who doubts the future prospects of Monitor would see cause to doubt that of the United States of America" (Clark and Evans, 1977). Unfortunately the Tarshish proved to be of only moderate size, and production and extraction experimentation expenses nearly equaled

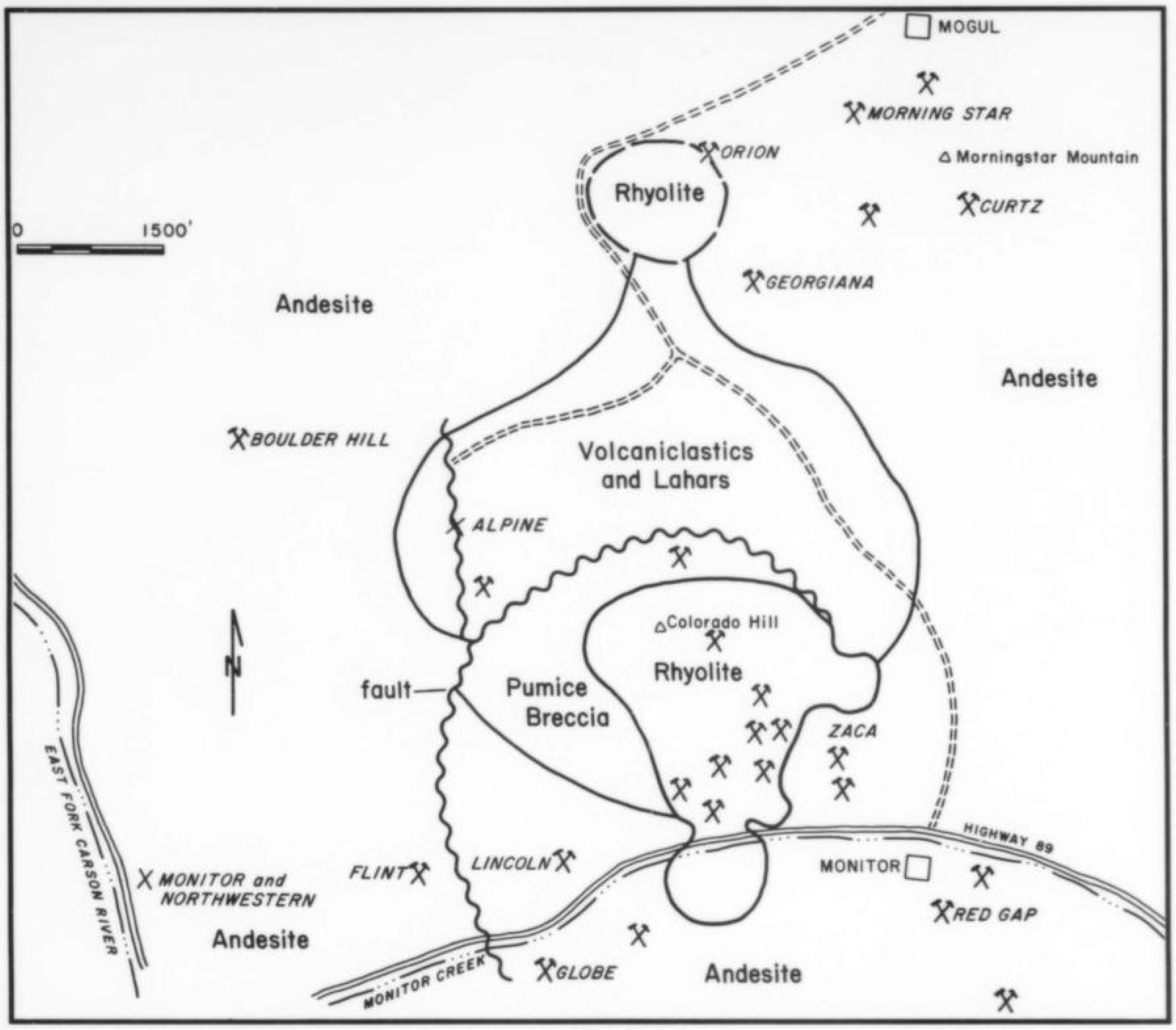


Figure 3. **Mine locations and general geology in the Monitor-Mogul district.**

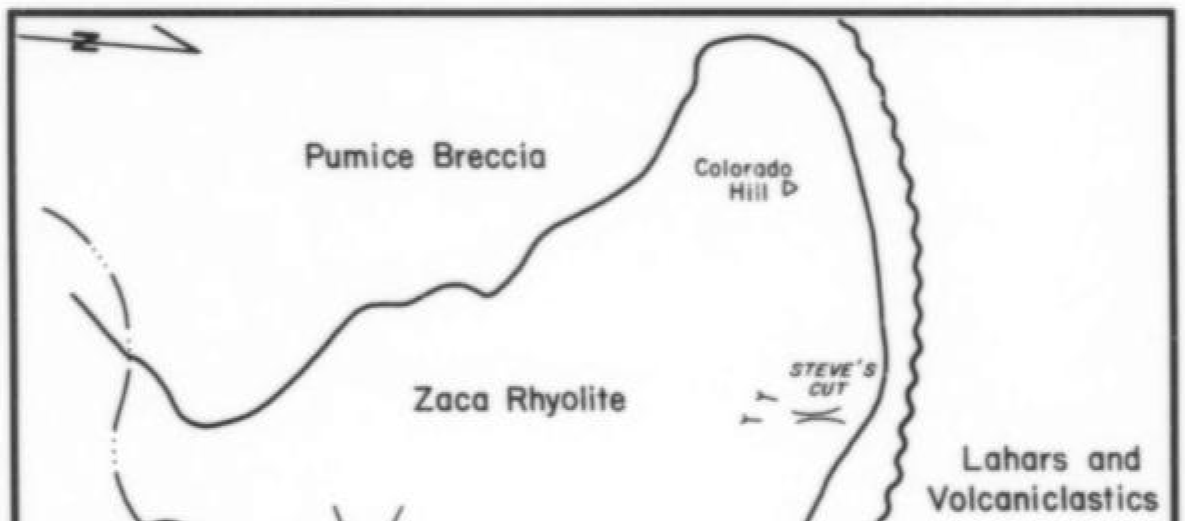


Figure 4. **Plan view and cross section of the Zaca mine group.**

sales. In 1872 a 20-stamp mill was built at the Tarshish, replacing the original mill built in 1863. In 1876 this mill, which originally cost $100,000, was sold at a Sheriff's sale for $6544 and judgment costs (Jackson, 1964). Good mill recovery of gold and silver was not obtained until 1878 when Peter Curtz operated the Zaca group, mining easily obtainable ore and employing Ottokar Hoffman, a metallurgist familiar with worldwide gold/silver ores. The mill built in 1872, capable of processing 50 tons per day (Hoffman, 1881), was used to feed to a chlorination section. The chlorination roasting process resulted in high (> 90%) extraction of gold and silver and, although successful, is thought to have only operated about one year. The mill was torn down in 1921.

The activity of the mines between 1880 and 1920 is unknown, although they were reported to be inactive in 1888 (Irelan, 1888). The mines became active again in 1912 when Du Boise leased the property. A. M. Dahl was associated with the property and drove a tunnel from the northeastern flank of Colorado Hill (Dahl Tunnel) without intersection any high-grade orebodies. During the late 1920's the Colossus Mining Company was formed and in the mid-1930's a 100-tons-per-day flotation mill was constructed at the Advance mine.

In 1936 the Zaca Mining Corporation acquired the property and operated the mill intermittently until 1941, working the Colorado and Advance mines. During 1940 and 1941 they worked a small open pit, several short tunnels and a shaft collectively called Steve's Cut. Since this area was located near the top of Colorado Hill, a tube was constructed for the screened gold and silver ore to slide down the face of the hill to the mill at the Advance. Free gold from the cut area is often observed with the aid of a 20-power hand lens and occasionally is coarse enough to see with the naked eye.

In 1960 the Siskon Corporation gained control of the claims on Colorado Hill, leasing part to Claude Lovestedt during the period 1961 of 1981. Lovestedt constructed a 75 tons-per-day flotation mill at the former townsite of Monitor. He worked the Advance and Colorado mines, the Galeries (also called "B" and "C" tunnels), Steve's Cut and the Dahl tunnel.

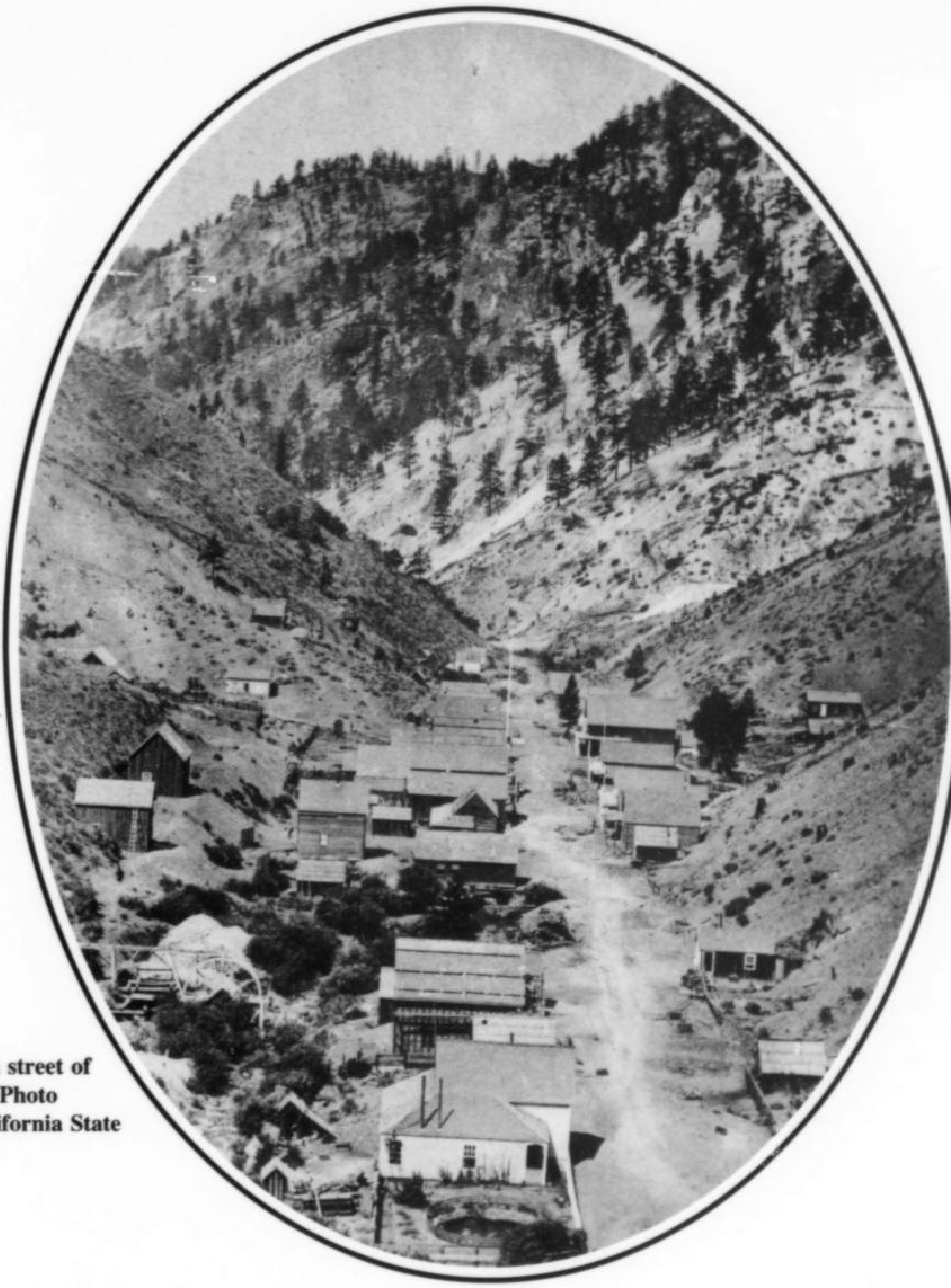


Figure 5. **The main street of Monitor, ca. 1870. Photo courtesy of the California State Library.**

Schrader (1946) estimates 86,000 tons of production from the Zaca group prior to 1909, with an estimated value of about $6 per ton. Most of the early production was apparently sold to the San Francisco mint with reported purchases from the Tarshish of about $625,000 by 1882 (Burchard, 1882).

Lovestedt produced about 20,000 tons during the period of his lease. Typical values recovered were about one-tenth ounce of gold per ton, 5–7 ounces of silver, 5 ounces of copper, 1.5 pounds of lead and 1.8 pounds of zinc per ton (Clark and Evans, 1977). State records indicate production of about 10,000 ounces of gold and about 340,000 ounces of silver from 1920 to the present.

California Silver, Inc., a wholly owned subsidiary of California Silver, Limited, purchased the property in 1981. Exploration and development work have included a 215-meter adit, named the Jardine adit after its miners, and about 15,000 meters of drilling. A deposit totaling about 8,000,000 mineable tons of ore containing 262,000 ounces of gold and about 5,000,000 ounces of silver has been delineated. The deposit is located above most of the previously mined areas, but includes Steve's Cut and parts of the Galeries. The Zaca mine, as it is now called, uses open-pit mining and heap leaching technology.

Morning Star Group

The Morning Star group is composed of the mines associated with the Morning Star deposit, on Morning Star mountain, including the Curtz, Georgiana and Orion mines.

Production commenced at the Morning Star mine in 1863 when a large body of gold and silver-bearing enargite/famatinite/pyrite ore, was discovered. Initially the sulfide ores could not be treated locally and higher grade ore was shipped to Swansea, Wales, for processing. Records indicate the ore was mined steadily until 1904 and intermittently through 1957 (Clark and Evans, 1977). Logan (1921) notes considerable production ($100,000) from cement copper amalgamation in 1882 when Louis Chalmers operated the mine. Total production from the mine was estimated by Logan (1921) to be about $600,000 with more of the value from gold and silver than copper. The Morning Star is developed by a 370-meter adit on the 148 level and was also worked on the 220 and 280 levels.

Figure 6. **The Tarshish and Union hotels, Monitor, ca. 1870. Photo courtesy of the California State Library.**

The ore from the Morning Star contained solid masses of enargite which carried gold and silver in addition to copper and antimony. The higher grade ores which were shipped carried up to 34% copper and had values of $400/ton including the gold and silver. Logan (1921) described old stopes and dumps containing a "great deal of massive pyrite, some of it showing intimately mixed enargite. The pyrite carries gold and silver, probably in payable quantity if the enargite did not interfere with cyaniding, but not rich enough to ship." The gangue material is jasper, quartz and altered andesite.

The Curtz mine is located on the top of Morning Star Mountain about half a mile southeast of the Morning Star mine. The Curtz is a southeast continuation of the Morning Star ore zone. Mineralized jasper was discovered in 1863 at the crest of the hill. The silicified ores range from a "soft, bleached, kaolinite-rich rock to a hard, grayish, silicified breccia" (Clark and Evans, 1977). Common ore minerals are chalcopyrite, galena, enargite, sphalerite and arsenopyrite.

The Georgiana was developed to intersect the Morning Star–Curtz ore zone on the 480 level (Clark and Evans, 1977). The 615-meter Georgiana adit did not encounter the southward extension of the Morning Star–Curtz ore zone; however, it did encounter a narrow "feeder ore stringer" assaying $16 in gold and silver and 3% copper (Logan, 1922). The Georgiana (or Georgia) is located just east of Forest City Flats. A 100 ton/day mill was erected at the Georgiana about 1914. The ore minerals were the same as the Curtz.

The Orion mine is located about 400 meters west of the Morning Star mine, near the floor of Mogul Canyon. Two tunnels and a shaft were developed in the 1880's. The 60-meter upper tunnel developed ore similar to the Morning Star, while a 90-meter lower tunnel developed a 2-meter-wide body containing silver, gold and as much as 50% lead.

Other Mines in the District

Alpine mine

The Alpine mine was first worked in the 1860's. In the early 1900's a water-powered 20-stamp mill was constructed on the East Fork of the Carson River about 300 meters below the mine. A 1200-meter aerial tramway was constructed between the mine and mill (Clark and Evans, 1977). The mine was developed by several adits on two levels containing about 600 meters of workings. The mine was believed to be rich in free gold; however, very little ore was processed and the stamp mill was converted to a power house. The mineralization from the Alpine was largely flint and chalcedony in a soft iron-stained clayey material (Eakle, 1916). Production from the mine is reported to have been $378,000 in gold and silver (Logan, 1922), however, there are no records.

Boulder Hill

The silicified boulders on Boulder Hill were crushed, using an arrastra, at the rate of about 2 tons/week, recovering about $80/ton in gold. No production from a "mine" was actually established, as claim owners worked the boulders within the confines of their claims (Jackson, 1964). A tunnel was driven by Scotts Hill Consolidated Tunnel Company, apparently without intersecting an ore zone (Jackson, 1964).

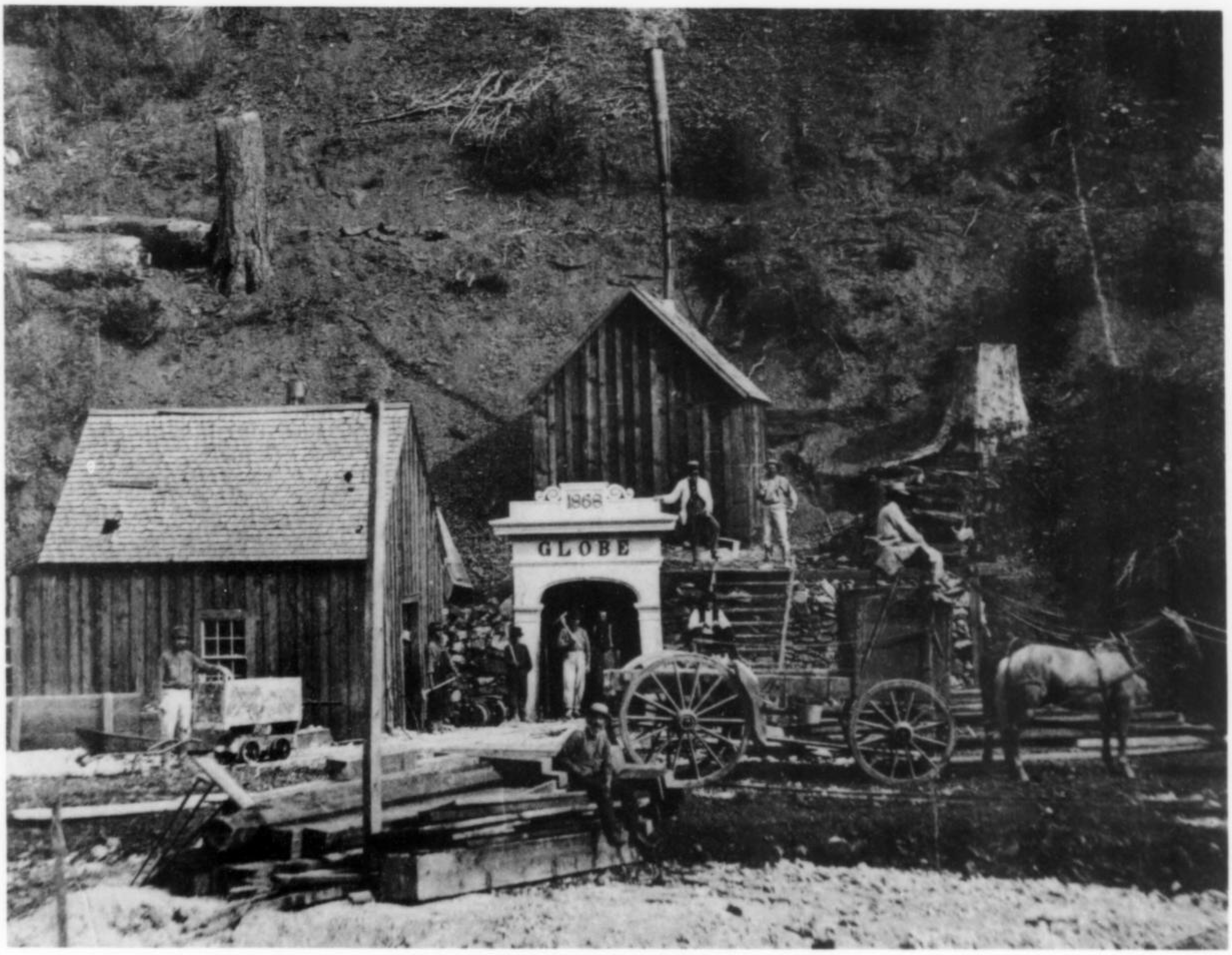


***Figure 7*. Entrance of the Globe mine, ca. 1870.**
Photo courtesy of the California State Library.

Constitution

The Constitution, located just below the Globe mill, intersected a 6-meter vein of argentiferous copper ore with flakes of copper in the gangue material (Raymond, 1874).

Flint

A group of patented claims to the west of Colorado Hill was developed by a short adit called the Flint mine. No production is reported.

***Globe mine** (Worden, Manchester, Winchester)*

The Globe mine was first worked in 1862 when a pocket containing $3000 in gold and silver was discovered on the south side of Monitor Creek (Clark and Evans, 1977). The mine was developed by a 300-meter adit and west-trending crosscuts that extended to the vein of pyrite, chalcopyrite, chalcocite and enargite. Production records are not available, and the mine is currently caved. Raymond (1873) describes a stockwork of gray copper sulfide about 90 meters from the portal that assayed as high as 37% copper, $20 in silver and a trace of gold.

***Imperial Tunnel** (Sovereign)*

An 550-meter tunnel was driven toward the Alpine and Zaca deposits from the Carson River, cutting a series of parallel lodes (Raymond, 1873). No production is reported. A diagram illustrating the tunnel location was used in the prospectus of the Imperial Silver-Quarries Co. Ltd.

Lincoln mine

The Lincoln mine is located about 800 meters west of the Zaca mine group on the north side of Monitor Creek across from the Globe. The mineralization is in a 30–60 meter wide zone that strikes north. Clark and Evans (1977) reports about 600 meters of workings.

Monitor and Northwest Tunnel

A 1.8-km tunnel was planned to be driven under the Alpine, Lincoln and Zaca group mines from the East Fork of the Carson River just north of Monitor Creek. The tunnel is referred to in various of Raymond's reports; however, the maximum extent mentioned was 250 meters.

Red Gap mine

The Red Gap mine is located on the south side of Monitor Canyon above Lovestedt's mill. Unlike the other mines in the district, the mineralization was discovered recently (1963) by Claude Lovestedt. Several open cuts were made, as well as an adit cross-cutting the mineralization.

Clark and Evans (1977) noted the "deposit appears to be in the same zone of alteration and silicification that contains the Morning Star and Curtz mines, some 2 miles to the northwest." The Red Gap mineralization appears to be localized along a flow contact and contains pyrite, chalcopyrite, galena and chalcocite in highly altered soft and clayey andesite. No production is reported.

Others

Other mines of the district that may be of interest include the Leviathan sulfur mine (chalcanthite, halotrichite, melanterite, römerite and sulfur) and the Mogul Peak mine (cinnabar).

MINERALS

Most of the minerals found in the district generally occur as small micromount-size crystals, although several species can be found in small-cabinet sizes. Clark and Evans (1977) note, "The Monitor-Mogul district is best known for its considerable variety of sulfide minerals. The minerals occur either as disseminated individual crystals in zones of alteration or in thin seams and veinlets, and in crystal-lined cavities." The minerals described on the following pages include the more important minerals of the gold and silver mines of the district.

Acanthite Ag_2S

Acanthite is found associated with other silver minerals in quartz-lined cavities, white clay pockets and sulfide veinlets. Acanthite also occurs disseminated in rhyolite. Raymond (1873) describes the Zaca ores as "pure sulphuret of silver glance—the gangue being often a putty-like kaolin, but more frequently harder rock of the same character." Merrick (1981) notes the majority of silver mineralization occurs as crystalline to sooty acanthite.

Andorite $PbAgSb_3S_6$

Merrick (1981) has tentatively identified andorite as a very rare occurrence of small (up to 10 μm) inclusions in freibergite.

Arsenolite As_2O_3

Arsenolite is reported to be associated with the gold and silver ores of the district (Clark and Evans, 1977). Arsenolite occurs as a white crust or earthy matter resulting from the decomposition of arsenical ores (Dana, 1892).

Arsenopyrite FeAsS

Well-formed crystals of arsenopyrite have been described from the Morning Star mine (Nichols, 1946). Clark and Evans (1977) also noted its occurrence at the Orion mine. Curtz (1914) notes "stringers of arsenical pyrite giving assays of $120 per ton (six ounces) in gold" from the Morning Star mine.

Barite $BaSO_4$

Clark and Evans (1977) describe barite from the Morning Star as a minor gangue mineral. Several specimens of barite have been found in the Zaca mine group. In the Lower Advance a 15 x 60-cm clay-filled pocket was found lined with groups of small sphalerite crystals coated by drusy quartz, upon which small (up to 6 mm) white barite crystals are sprinkled. Several groups of white or colorless barite crystals up to 1.9 cm have been found in the quartz-lined pockets on top of Colorado Hill in the vicinity of Steve's Cut.

Bornite Cu_5FeS_4

Merrick (1981) has identified bornite from polished sections of high-grade ore.

Calcite $CaCO_3$

Colorless scalenohedrons of calcite up to 1.2 cm have been found in the district.

Chalcanthite $CuSO_4\cdot5H_2O$

Clark (1977) notes that "chalcanthite is usually found as coatings in mine openings."

Chalcocite Cu_2S

Chalcocite has been found at the Morning Star, Red Gap and Globe mines. Logan (1921) noted the occurrence of chalcocite carrying gold and silver from the Globe mine. Logan (1922) noted that chalcocite only occurred in minor amounts at the Morning Star mine, and that numerous geologists have "considered it probable that zones of secondary enrichment (chalcocitic) carrying larger and better orebodies than any yet mined may be found some distance deeper than any yet reached."

Chalcopyrite $CuFeS_2$

Chalcopyrite has been reported from most of the gold-silver mines of the district. Chalcopyrite was an important ore mineral at the Morning Star, Orion, and Red Gap mines. It occurs at the Zaca group as exsolution blebs in sphalerite and as minute crystals in small quartz pockets and veinlets.

Chlorargyrite AgCl

Chlorargyrite has been found coating quartz-lined vugs and may be a common constituent of high-grade oxidized ore (Merrick, 1981).

Copper Cu

Native copper is reported from the Constitution mine as flakes in gangue material (Raymond 1874).

Covellite CuS

Covellite has been identified in polished sections (Merrick, 1981) as rims on other copper minerals.

Enargite $Cu_3(As,Sb)S_4$

Enargite was the principal ore mineral of the Morning Star, Curtz, Georgiana and Orion mines. Eakle (1919) described a large mass of pure enargite and pyrite encountered in the Morning Star mine. He also listed an analysis of enargite made by B. W. Root in 1868: S 31.68; Cu 47.21; As 14.06; Sb 6.19; total 99.14 weight %.

The antimony replaces arsenic to a considerable extent in some areas, with the mineral grading to famatinite. Eakle (1919) states up to 1 ounce of gold and 100 ounces of silver have been obtained from the enargite-bearing ore. Enargite in massive form can be found on the dumps of the Morning Star and Curtz mines and occasionally occurs as small crystallized pockets in the massive material. It has also been found at most of the other mines of the district.

Famatinite Cu_3SbS_4

Famatinite occurred at the Morning Star mine as reddish brown masses in the enargite ores (Eakle 1919).

Freibergite $(Ag,Cu,Fe)_{12}(Sb,As)_4S_{13}$

Freibergite is an important ore mineral of the district. Raymond (1873) describes intersecting a stockwork of "tetrahedrite" (probably freibergite) at the Globe mine. Freibergite is found in the ore veins and as minute crystals up to 3 mm in quartz-lined cavities.

Galena PbS

Galena occurs as small masses in sulfide veins and as crystals up to 2 mm in vugs from the Zaca mines.

Gold Au

Free gold occurs sparingly throughout the district. It is found at the open cut (Steve's Cut) on top of Colorado Hill, on Boulder Hill, at the Alpine mine and in the Zaca mine group. At Steve's Cut the gold is associated with limonite on oxidized fractures and is possibly of secondary origin. The free gold is generally less than a pinhead in size. Gold also occurs as blebs in and adjacent to several sulfides including pyrite, proustite, enargite, chalcocite, tetrahedrite and sphalerite.

Goethite FeO(OH)

Goethite is present as a pervasive stain, as fracture coatings and as an oxidation product replacing sulfides.

Gypsum $CaSO_4\cdot2H_2O$

Transparent gypsum crystals up to 2.5 cm have been found at the Zaca mine in vugs associated with hübnerite. Gypsum has been found in the Alpine and Lincoln mines as poorly formed crystals, in veinlets in altered andesite, and in the float of Colorado Hill.

Hematite Fe_2O_3

Hematite, like the other iron oxides, is found as a pervasive stain and on druse in vugs and fractures, replacing pyrite and other sulfides.

Hübnerite $MnWO_4$

Hübnerite is one of the minerals that occurs in crystal groups up to several centimeters in size. Sprays up to 7.5 cm have been reported from float on Colorado Hill. Hübnerite is associated with ores from the Lincoln and Zaca mines. Gianella (1938) reports:

> The hübnerite is light to dark brown, reddish brown, or dark red in color. In general it is translucent, but many of the smaller reddish crystals are clear and transparent. Hübnerite is found encrusting the ore minerals and drusy quartz, in cavities within the stony quartz, and in quartz or rhodochrosite veinlets. . . . A slab from a cavity in a rich ore shoot is composed of dense, stony quartz coated with fine drusy quartz. Upon the drusy surface are occasional quartz crystals to 2 cm in length. On this slab are many clusters of hübnerite crystals. The crystals are prismatic in shape and arranged in both parallel and radiating groups. . . . The relationships, discussed above, evidence late introduction of the manganese tungstate mineral . . . hübnerite is looked for because it is commonly associated with the richer ores.

Gianella (1938) goes on to report an analysis of fresh hübnerite run by Professor William Smyth of Nevada State Analytical Lab: MnO 23.64; WO_3 73.97; FeO 2.38; total 99.99 weight %.

Several hübnerite crystals have been found coated with drusy quartz.

Jarosite $KFe_3^{+3}(SO_4)_2(OH)_6$

Merrick (1981) has noted jarosite along with the possible occurrence of argentojarosite. Yellow-green jarosite coats sulfide-bearing rock that has been exposed to surface oxidation for a year or two.

"Limonite" hydrous iron oxides

Clark and Evans (1977) reports limonite ranging from yellowish to reddish brown occurring as stains and in cavities and veinlets from the district.

Malachite $Cu_2(CO_3)(OH)_2$

A coating, probably malachite, was found in the Lower Advance tunnel.

Marcasite FeS_2

Marcasite has been found in quartz-lined cavities, sometimes associated with rhodochrosite. The mineral generally occurs as flat tabular blades and rosettes up to 6 mm across, with each blade made up of minute cubic crystals. Some of these crystals appear to be pyrite after marcasite.

Molybdenite MoS_2

Molybdenite has been found in several drill cores within the Monitor-Mogul district.

Opal $SiO_2 \cdot nH_2O$

Logan (1922) notes "a large mineralized zone of low-grade ore, with the silver sulfides scattered through the kaolin in grains and in minute opal seams" in the Advance mine.

Orthoclase $KAlSi_3O_2$

Transparent to translucent orthoclase has been found lining small vugs as small blocky crystals up to 1.6 mm in size.

Polybasite $(Ag,Cu)_{16}Sb_2S_{11}$

Polybasite is a relatively common ore mineral at the Zaca mine. Thin, tabular crystals up to 1.6 mm have been found in quartz-lined cavities. Merrick (1981) observed polybasite inclusions in proustite in polished sections of high-grade ore. Microscopic crystals are also reported by Eakle (1919) from the Morning Star mine.

Proustite Ag_3AsS_3

Proustite was an important ore mineral of the district, where it and pyrargyrite are often found associated with high-grade ores. Proustite occurs as small grains and minute crystals in quartz-lined vugs, and in fractures filled with quartz.

Pyrargyrite Ag_3SbS_3

Pyrargyrite is an important ore mineral of the district, and appears to be more abundant than proustite. It is a common ore mineral of high-grade ore zones and occurs in veinlets, grains and crystals up to 3 mm in quartz-lined pockets.

Pyrite FeS_2

Pyrite is the most abundant sulfide mineral. It occurs as massive veinlets, as grains in veinlets, and as cubic and octahedral crystals up to 3 mm across in crystal-lined pockets. It is disseminated throughout most of the Zaca rhyolite. Andesite commonly contains up to 5% disseminated pyrite, occasionally as small, euhedral crystals.

Pyrochroite $Mn(OH)_2$

Pyrochroite is a common mineral of the Zaca mines associated with other manganese minerals. It is identified by its quick color change under sunlight, from colorless or white to brown in a few days, then to black on the exposed surfaces.

Quartz SiO_2

Quartz is the major gangue mineral at the Zaca mine group and is common at the other mines of the district. Quartz-lined pockets have been observed up to 60 cm in length, but are more typically several centimeters across. In the upper portions of the plug the pockets commonly occur in series, parallel to the flowbanding, and probably represent gas bubbles. Elsewhere in the rhyolite, cavities are discordant to the flowbanding and are products of alteration and dissolution. Crystals vary widely in size and shape, ranging from minute druses to 13-cm crystals. The shape is also variable, but the rhombohedron faces are generally dominant, forming crystals with three-faced terminations. The quartz crystals are generally clear, and are occasionally covered by iron oxides. Sceptered crystals have been found near the top of Colorado Hill in the open cuts.

Realgar AsS

Realgar is one of the sulfides found at the Morning Star mine (Clark and Evans, 1977).

Rhodochrosite $MnCO_3$

Rhodochrosite is a common gangue mineral of the Zaca mine group. Gianella (1938) describes the ore minerals at the Lower Advance as being:

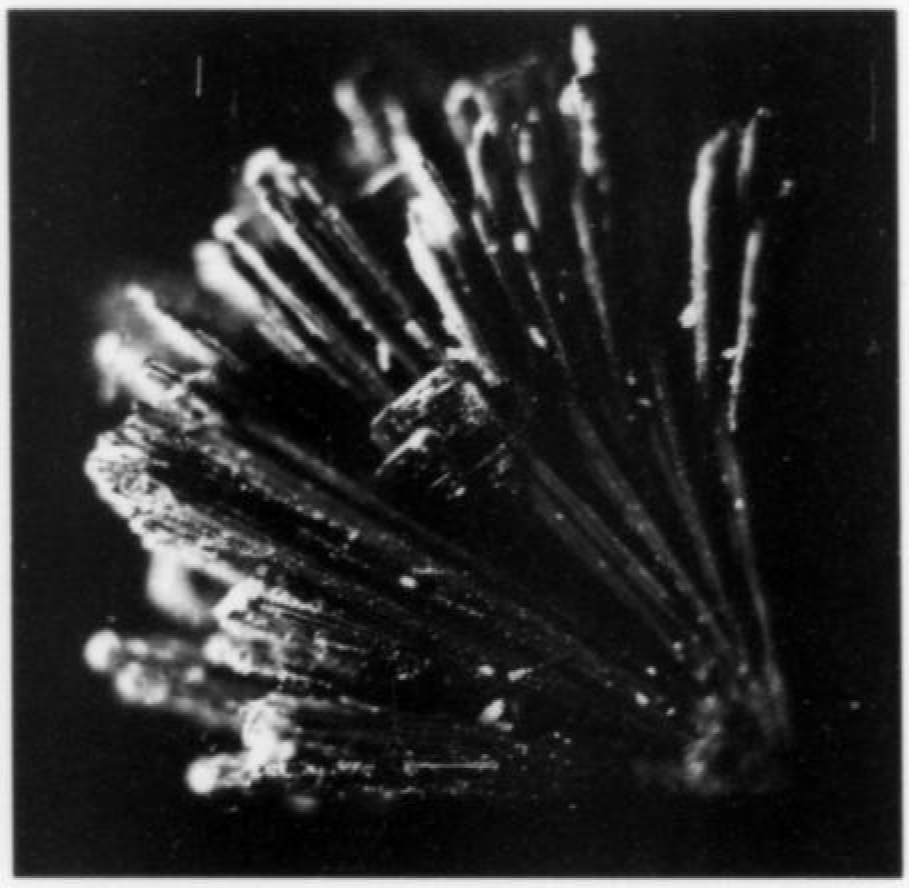
> associated with both quartz and rhodochrosite, but more commonly with the manganese carbonate. The rhodochrosite commonly contains numerous small cavities covered with druses of clear quartz crystals. . . . Rarely crystals of rhodochrosite are found resting upon the drusy quartz and are in turn partially covered with minute quartz crystals.

The rhodochrosite also occurs as veinlets with ore minerals; as spherical aggregates up to 6 mm in quartz-lined cavities; and as minute to 7-cm aggregates of long, flattened, tabular crystals to 6 mm. Rhodochrosite is locally associated with hübnerite. It is generally pink and similar in color to typical rhodochrosite from Silverton, Colorado. The color may fade to light pink on exposure. Crystals may be coated by pyrochroite which will turn brown on exposure, then black. Raymond (1873) describes rhodochrosite in the vicinity of rich clay pockets. Logan (1922) notes that "veinlets and feeders of rich ore with rhodochrosite extend through the altered andesite and have at times been followed until they turned into good sized orebodies."

Figure 8. **Hübnerite crystal pocket, 7 cm, from the Zaca mine. Neil Prenn collection.**

Figure 9. **Hübnerite crystal spray, 2.5 cm, from the Zaca mine. Neil Prenn collection.**

Figure 10. **Hübnerite crystal group, 1.9 cm, from Colorado Hill. Neil Prenn collection.**



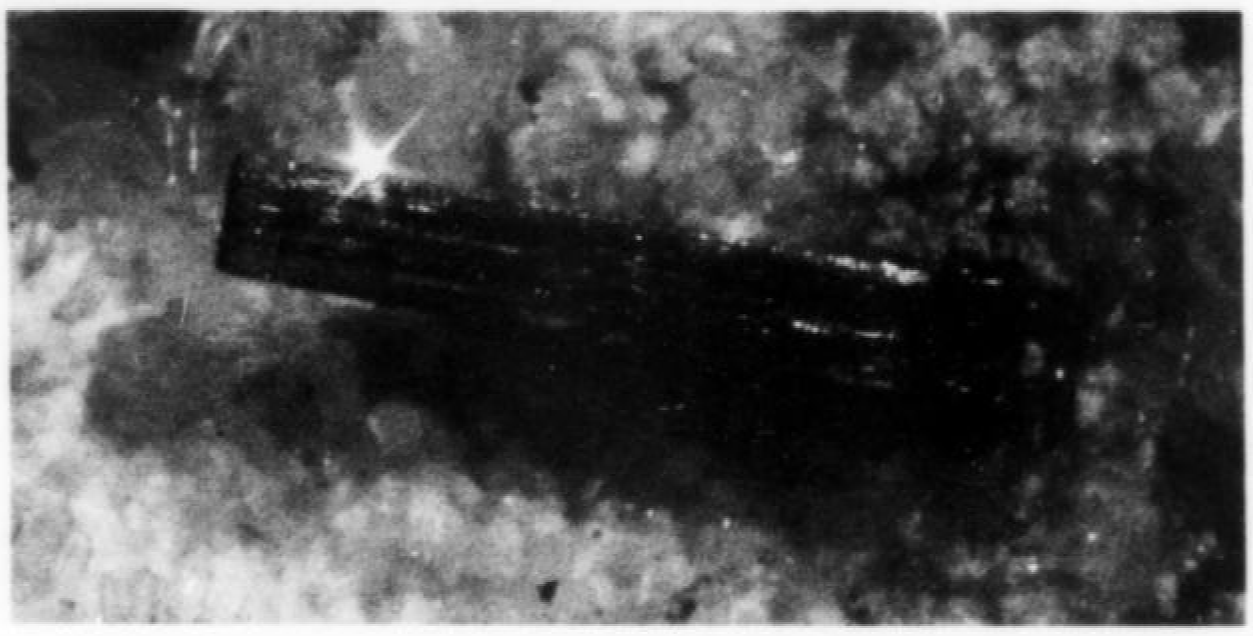


Figure 11. **Hübnerite crystal, 1 cm, in vug; Zaca mine. Neil Prenn collection.**

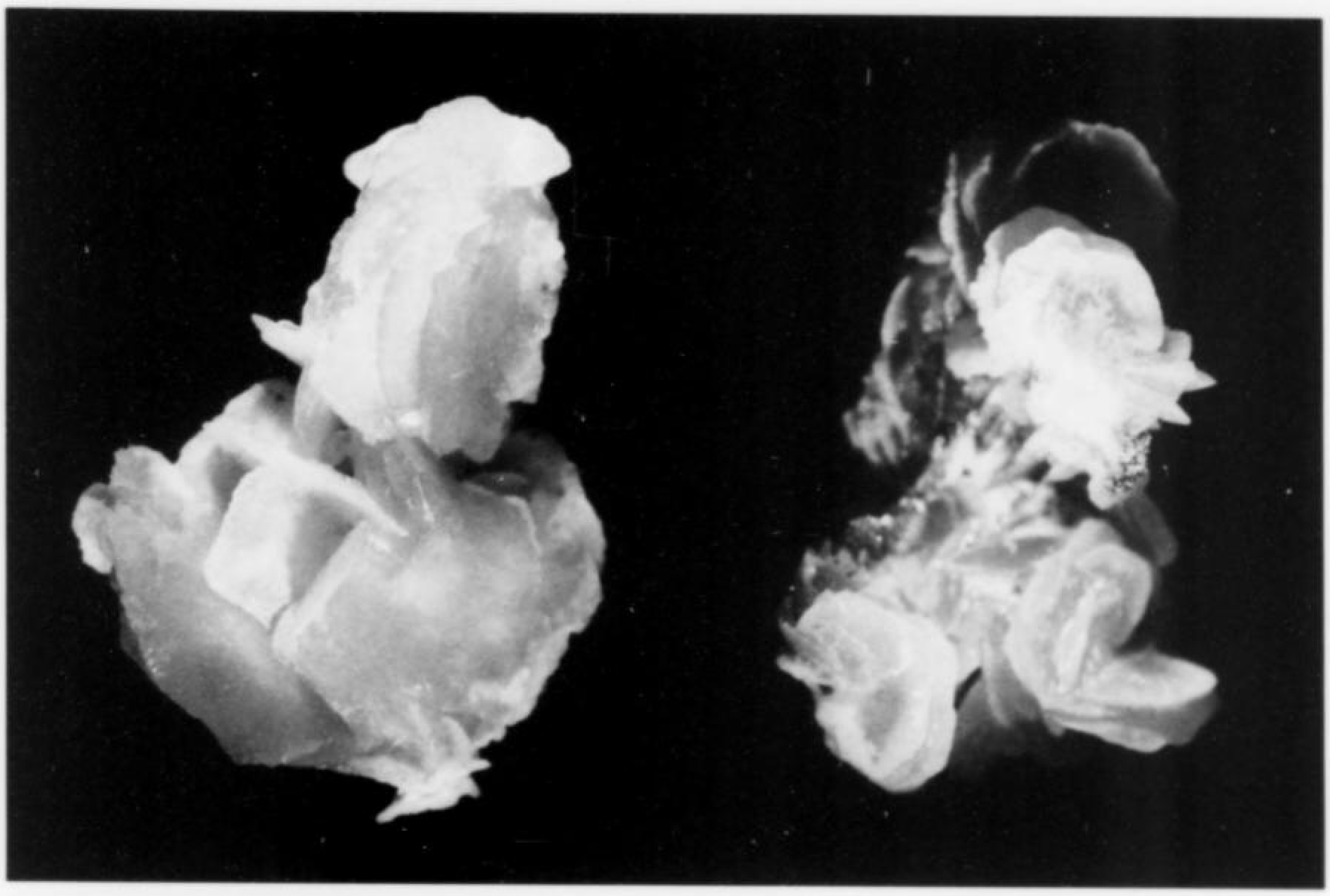


Figure 12. **Rhodochrosite crystal groups, each about 1 cm, from the Zaca mine. Neil Prenn collection.**

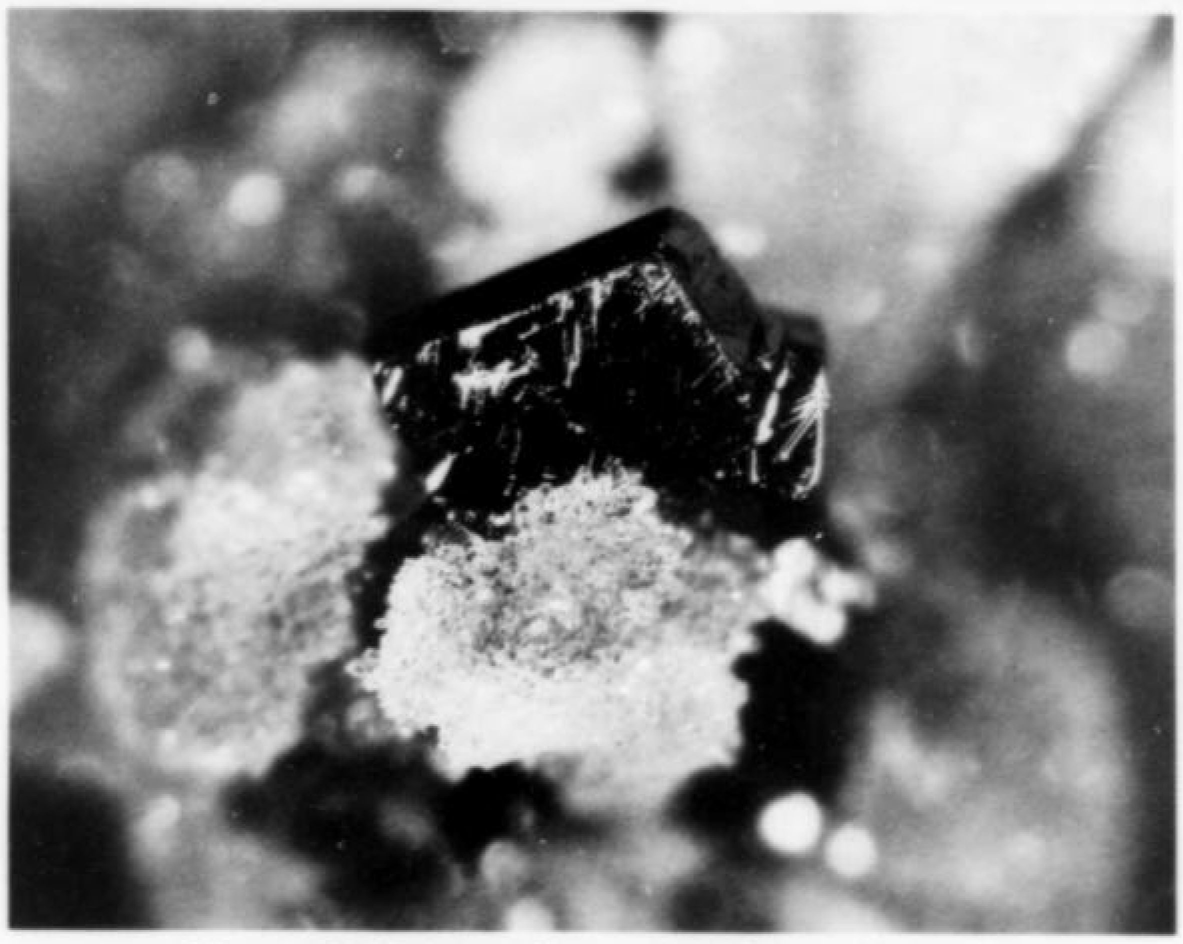


Figure 13. **Pyrargyrite crystal, 2 mm, from the Lower Advance mine. Vi Frazer photo; Kent England collection.**

Silver Ag

Raymond (1872) reported native silver from the district. Lovestedt reported native silver in the Colorado mine (personal communication, 1981).

Smithsonite $ZnCO_3$

Clark and Evans (1977) noted minor amounts of smithsonite from the district.

Sphalerite (Zn,Fe)S

Sphalerite is a common mineral from the district, associated with ore zones. Crystals up to 6 mm have been found associated with hübnerite, quartz, barite and silver minerals in quartz-lined pockets. Merrick (1981) observed inclusions of chalcopyrite, argentite, hübnerite, freibergite, polybasite and gold in sphalerite. Sphalerite also occurs in veinlets and disseminated grains. It is generally dark brown in color.

Stephanite Ag_5SbS_4

Stephanite occurred at the Morning Star mine and the Zaca mine (Pemberton, 1983).

Stromeyerite AgCuS

Stromeyerite occurred in the ores of the Zaca and Morning Star mines (Eakle, 1919). Crawford (1894) identified a rich silver-bearing mineral as probably being stromeyerite.

Tellurium Te

An assay (Hanks, 1932) of some float on Colorado Hill that ran 26 ounces per ton gold and 313 ounces per ton silver has a note attached indicating tellurium associated with the sample. Eakle (1919) mentions, "Tellurides are said to have occurred in the Colorado No. 2 mine." The reported occurrence of tellurides has not been substantiated by recent studies.

Tenorite CuO

Clark notes the occurrence of tenorite in the Monitor-Mogul district.

Wolframite $(Fe,Mn)WO_4$

Clark and Evans (1977) observed wolframite from the district.

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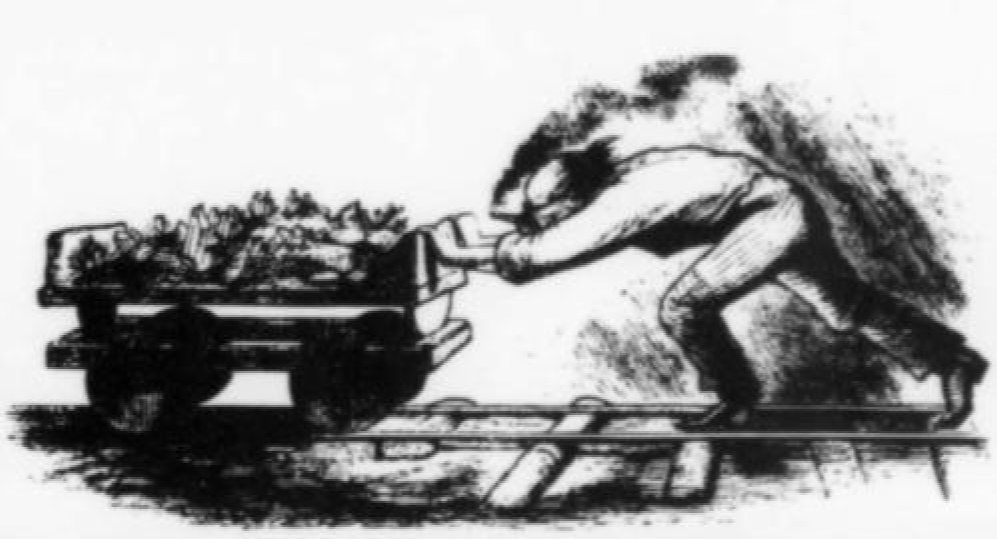
Colorado  Dealers

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In which the Mineralogical Record*'s European Correspondent, hammer in one hand, pen in the other and tolerant family in tow, peregrinates across the mineralogical highpoints of Scandinavia from Copenhagen to Stockholm, Oslo, Kongsberg, the Kopparberg Show, Långban, Harstigen and Nordmark.*

INTRODUCTION

Like many who live snug, logjammed lives in demographically dense parts of the U.S. or continental Europe, I had never thought too seriously of going on a tour (mineralogical or otherwise) of Scandinavia. What? inspect fjords and herring fisheries and dairy farms and moose licks, when Sicily, Provence, Bohemia, the Erzgebirge and Transylvania are calling invitingly? But such lazily stereotypical thinking began to change when, late in the summer of '89, in response to something I'd said in one of my Notes, I got a long letter from one Dr. Knut Eldjarn of Oslo, Norway. He invited me and my family to come up for the big mineral show—Scandinavia's biggest and best, he said—at Kopparberg, Sweden, in June of 1990. On the page Knut seemed a likable sort, and seemed most willing to act as my host, general tour guide, wellspring of Scandinavian mineralogical knowledge and lore, and provider of warm beds and showers at his home in Oslo.

Winter-long consultations with my wife Lynn and with my academic employers followed, as did an exchange of increasingly pointed, date-specific letters with Knut. Somewhere in the haze of March or April I found myself procuring a luggage rack for our new Toyota Starlet, a primitive tent (sleeps four) and other tyro camper's gear, arranging for substitute teachers to handle my classes for two weeks in June, and creatively abridging the school and kindergarten careers of eleven-year-old Alexey and six-year-old Andrew.

On June 8, still feeling a little hazy about it all, we were off, with touring plans more grandiose (I thought) than could ever be fulfilled given the allotted time, absurd camping gear, and our optimistically short stack of travellers checks.

The plans, though, *were* all fulfilled somehow, during a trip that totalled 4600 kilometers and cost the Toyota no greater trauma than a cracked exhaust pipe, easily welded, somewhere in Denmark on the return stretch. Really there were three trips in one, three major themes: mineralogical learning, note-taking, and acquisition for me; culture, history, and scenery for both grownups; and Camping Fun for the kids, with incidental treats—e.g., Legoland (the Lego toy paradise in Denmark) which I think Andrew still believes to be a fourth Scandinavian country.

This article will of course deal primarily with the first, the mineralogical goal. But let me use a paragraph or two to remove or at least refine a bit some of those stereotypes of the tourist's Scandinavia. First, just as one of the guidebooks promised, "Scandinavia sparkles" in June; the weather was ideal for camping, to our great relief. The exception was southern Denmark which, like adjacent Saxony, proved drizzly as well as boggy and flat on both outbound and homecoming legs; these were mostly high-speed Autobahn cruisethroughs, anyway. But then came the ferry crossing to Sweden, where Helsingør Castle (said to be Hamlet's "Elsinore") glowers out after departing boats on the strait. And after that came the Swedish farm landscape under unfailingly spectacular stratocumulus clouds, sparkling richly in vivid tricolor: deep maroon-colored barns, green fields full of healthy crops, and intensely blue, cloud-daubed sky. The breadbasket health of the prospect reminded me of more prosperous parts of upstate New York, Pennsylvania and the upper Midwest, where so many Swedes came long ago to transplant just this blue-green-maroon color motif among just such fertile low hills as these. Norway, we later found, is wilder,

Figure 1. **The route.**

ruder, pinier. West of Oslo and just above Kongsberg came finally the moose, the second-gear climbs through dark conifer tunnels, the snowcapped mountains off in the distance, and the truly virginal-looking glacial lakes. I thought of the wilderness area in Idaho where I worked during two college summers.

Yes, of course, we visited the standard tourist stops in all three countries: Tivoli Gardens, the zoo, and the Little Mermaid in Copenhagen; boat trip around Stockholm harbor; preserved Viking ships and the huge and wonderful Norwegian Folk Culture Museum in Oslo; the otherworldly wooden stave church in Norway that dates back to the very beginnings of Christianization there; and Legoland. But I think I first believed in Scandinavia as quite a *different* part of the world when we came to the Swedish island of Öland—the long skinny one off the southeast coast—and let the guidebooks talk us into spending a day exploring it from our campsite there. Öland is flat, with purplish heather and scrub, grazing sheep, ancient stone walls, innumerable ruined windmills, and, strewn all over the island and still standing upright, rune stones with pagan symbols and schematic designs. There's an Iron Age burial ground and a reconstructed fortified 5th-century village . . . and by all these many signs one knows that one is in the homeland of those mysterious Gothic folk who spilled southward to Germanize and ultimately to destroy Rome's empire. In short, eerie Öland is most plausibly the epitome of far-off misty pagan margins of mainstream-historical Europe. And it was at the campsite there that I first noticed that a fringe of sky to the north never got fully dark all night. The effect would intensify, the fringe overspreading the whole sky, farther north, but I'll never forget the sight of the road bridge from the mainland (Europe's longest road bridge, by the way: four kilometers over the shallow Baltic) lifting itself against that visionary northern paleness.

I might mention also the spectacular marine beauty of the ferry crossing from Göteborg, Sweden, back to the northern tip of Denmark; Oslo, Europe's least citified capital city, nestled in its narrow fjord and seemingly about to be swarmed over by the thousands of mosquito-like private sailboats in its harbor; and the flat, gray, glacially scoured shield rocks that form steppingstones out to sea everywhere on the coasts, so that it seems one might leapfrog forever. Sweden and Norway have an incomprehensible driving law forcing cars to drive with their headlights on in broad daylight, I could not begin to understand the languages (much less like English or German than I'd hoped), and as for the *prices* of everything—well. So much, though, for negative waves. Go almost anywhere Scandinavian in early summer and I promise that you'll be invigorated, charmed, on the best days perhaps even awed, by all these unexpected manners and modes of Nordic sparkle.

THE MUSEUM COLLECTIONS

While making the rounds of the capital cities—Copenhagen, Stockholm, Oslo, in that order—I made a point of looking in on the three great national mineral collections in the respective natural history museums. Necessarily I couldn't lavish great spreads of time on any of them (those who have traveled with children will understand), but, armed with Burchard's *Mineral Museums of Europe* as a general guide, I did try to appreciate the highlights and personality of each collection in turn.

Copenhagen

Copenhagen's museum (on the second floor where the minerals are) boasts what is certainly one of the classier museum foyers I've seen: a central rotunda where a huge world globe slowly revolves under flamboyant ceiling murals. The mineral rooms open out from there. In one room the general collection is displayed conventionally in flat cases for systematic mineralogy and upright wall cases for the big pieces. To the specimen highlights as recommended by Burchard I will add a note of praise—admittedly biased by my personal collecting tastes—for the unusually large number of top-quality thumbnails on display. In particular I remember a perfect 2.5-cm Magnet Cove, Arkansas, rutile sixling, but dozens of others are just as fine. Wooden and glass crystal models are often thoughtfully placed next to specimens, particularly the thumbnails, showing the same habit. The 21-cm Kongsberg wire silver in one of the wall cases (pictured in Peter Bancroft's Kongsberg chapter in *Gem & Crystal Treasures*) is surely one of the most amazing such pieces extant, its peers at Kongsberg notwithstanding (see later).

The most distinctive and distinguished feature of the Copenhagen collection is a second roomfull of fine minerals, these all from Greenland localities. From the famous old mine at Ivigtut there are enormous blocky boulders of weathered cryolite, some with cryolite crystals on open seams, all with vugs filled with colorless, transparent (some slightly Fe-stained brown) thomsenolite and pachnolite crystals to several cm long, and ralstonites to 1 cm. And all along one wall in this room is a creatively conceived case devoted to the minerals of three more recently developed Greenland localities: Narssarssuk, Ilimaussaq, and the Gardiner Complex. The back walls of these cases are covered by greatly enlarged photos of busy field collectors chipping at rocks against bleak landscapes, and along the floors of the cases are jumbled piles, pseudo-morainal outwashes, of matrix or euhedral floater specimens of eudialyte, acmite, fibrous astrophyllite in vugs, tugtupite in pink masses, etc. The idea is to show how specimens are commonly found weathered out of the rock in this fierce Arctic climate.

Figure 2. **The Old Town section of Stockholm.**

Downstage center in these three cases are pristine units of narrow glass shelving with superlative thumbnail and miniature specimens (mostly) of such things as epididymite, catapleiite, neptunite and kornerupine. In the Gardiner Complex case, magnificently sharp groups of large (to 3 cm on edge) octahedral magnetite crystals, black melanite garnet clusters on a similar scale, and perovskite crystals to 8 cm on an octahedral edge stand out. All in all this Greenland room is a short course in the exotic mineralogy of the island, and a testimony to the Copenhagen museum's heroic field work at the forbidding sites.

Stockholm

The Stockholm collection, while also impressive, seems rather antiquated by contrast. Whereas at Copenhagen a special case displays a dozen or so things acquired at the 1989 Tucson Show (including the best small cabinet specimen of Batopilas, Mexico, silver I've ever seen), hardly anything on display at Stockholm seems to postdate the First World War. The refurbishment of the display room, mentioned by Burchard as having been planned in 1984, seems not yet to have taken place, and the relatively greater emphasis on very large specimens, including some which must be dubbed clunkers, adds to the chamber's "dated" feeling.

One of the most striking things about the general collection's display room is its plenitude of extremely handsome 19th-century specimen cabinets, most with large pieces bearing collection labels of Hjalmar Sjögren (1856–1922), the great Swedish mineralogist. One wonders, even while admiring the cases, what treasures may be hidden behind their locked doors, in the pull-out drawers that fill the bulk of the volume in these beautiful pieces of furniture.

On the other hand, the museum offers a wealth of sophisticated explanatory material (whose only fault, for me, was that the texts were all in Swedish) on regional geology, ore paragenesis, and mining histories. And two more handsome old cases along one wall are filled with large pieces from the classic localities of Långban and Ytterby, Sweden. The fact that Långban minerals tend to be massive or microcrystalline and drearily colored dooms the Långban case to a certain aloof and austere drabness. But Paul B. Moore, who apparently got to browse in the museum's "back room" Långban collection, the world's most complete, testified (1970) not only to the presence of

Figure 3. **Original cabinets containing the Hjalmar Sjögren collection. Naturhistorika Riksmuseet, Stockholm.**

some gorgeous specimens there but more importantly to the rich scientific use to which this Långban lode has been and presumably is still being put.

In fairness to this collection, one can point to the many marvelous specimens, especially Swedish ones, hiding away among more mundane fellows in the flat cases. Examples include the incredibly large and sharp pyroxene (hedenbergite) crystals and the immense, curved, greenish pyrosmalite crystals from Nordmark, the Långban pyroaurites, and the giant cobaltites from Håkansboda, to mention only a few.

Oslo

The Oslo collection, fully the equal of the other two in general quality, is displayed in a more likable, perkier-looking and better lighted chamber. Here Norwegian minerals perform at their peak: the two-foot quartz cluster with brilliant blue anatase from Hardangervidda is a predictable show-stopper, while devotees of rare-earth pegmatite species will find here giant crystals of such things as gadolinite, thorite, columbite, thortveitite and blomstrandine from classic localities near Kristiansand. To my taste the most remarkable specimen (which Burchard for some reason only deigned to call "good") is a native lead that must certainly far excel any other lead specimen in captivity: ten or so sharp, gray, 2-cm cuboctahedrons in a shapely 9-cm cluster with calcite and shiny black pyrochroite. Unfortunately, the locality of this piece is an enigma: Nysten (1984) and other relevant references I have found insist that good, visible native lead crystals were found only at the Harstigen mine in the Swedish Bergslagen, but the label that came with this piece when the museum brought it in 1916 says that the locality is Långban.

Kongsberg

On our last Oslo-based day we made a mandatory pilgrimage to the legendary silver mine at Kongsberg, there to share a chaotic mine-tour experience with a bevy of German teenagers whose scurrilous asides seemed to inspire in our Norwegian tour guide such emotions as probably haven't been felt here in full force since about 1940. We were impressed, anyway, by this museum's large and innovative presentations of mine history, technology and sociology. And then, in a reverent hush, came the "treasure room," where perhaps a quarter of the world's supply of great Kongsberg silver specimens is on effective display, with spotlights precisely aimed at the specimens in their dark wooden cases. Having expected to be dazzled, I was more than that—stupefied, awestruck, brought nearer to God—by these silvers, row after row of them, from tiny thumbnails to monsters. Most are of the wire habit but some are leafy or arborescent, and one, reputedly the world's best silver miniature, is a sharp blocky twin crystal, with small adhering wire arabesques, about 5 cm across. I remember also a 12-cm "tree" whose trunk is of bright ropy-interwoven silver wires and whose leaf canopy is of brilliant black microcrystals of argentite on wire silver webbing. A tourist cliché, but true: *no one* (or at least no one even vaguely mineral-minded) should miss this display, or for that matter this museum or mine tour. The German teenagers have by now long since departed. The silver hoard represents, after all, a substantial part of the gleanings from three centuries' worth of specimen highgrading, and this mine, which ceased all operations in 1957, will never again produce even remotely comparable pieces. A slight qualifying remark is in order, however: in recent years a small group of expert collectors has been allowed access to some areas of this tremendous mine—whose central shaft is three Eiffel Towers deep—and a few good silvers have been taken out posthumously, as it were. But unfortunately, at the Kopparberg show none such were being offered, and one of my greedy little personal fantasies was thus thwarted.

THE KOPPARBERG SHOW

Every second weekend in June for about 12 years now there has been a Kopparberg, Sweden, mineral show. It's almost entirely an outdoor affair: 120 trade participants inhabiting a little labyrinth of interconnected jerry-built wooden stands optimistically unprotected from any rain (and indeed, I'll admit, there was none). The labyrinth threaded around and among some old disused barns of the familiar maroon-slatted style. One of these deigned to shelter some overflow stands, constituting the only "indoor" section. The whole atmosphere was determinedly casual and rustic. There was even a sort of Swedish-nittygritty four-piece band which first struck up at noon on Saturday what went on to be a continuous background sound, of a genre that might be called country-pop-Nordic. Some of the regular dealers and traders sported the wide-brimmed black hats that are, I was told, a tradition, a sort of Kopparberg show uniform. But, all rusticity aside, this is a good and a sophisticated show, well established by now as Scandinavia's best. Besides the heavy majority of Scandinavian dealers and Scandinavian field collectors who came to sell off surplus materials, there were six German dealers, two Dutch, one Pole, and one Czech. Amid the abundance of Scandinavian specimens great and small one could also spit fine Tsumeb things, Zaire uranium secondaries, and Erzgebirge and other eastern European material. One dealer even had a small swarm of brilliant loose crystal groups, small-thumbnail-sized, of the dramatic new sperrylites from Tagil Norilsk, Siberia. Undeniably the show's farm-country locale is remote, off any plausible general-tourist track, but the Kopparberg town tourist office does its best to promote the event and to guide people to it, and there's even a satellite event, an "Open Gold Panning Championship" held at a nearby (seeded) stream in the afternoons.

On Friday night, wearied by the long drive from Stockholm, we gratefully pitched camp (free of charge) in a large meadow at the show site, among early-arriving dealers' trailers and tents, amid an early buzz of mineralogical sociability, and awaited Knut Eldjarn's arrival from Oslo. When he appeared he proved to have had the foresight to bring along his six-year-old daughter Eileen to befriend Andrew and thus to help free the grownups for the following day's obsessive activities. Alexey, for her part (and for a small fee), was also to help out during the show by manning (girling?) Knut's stand, even selling off a few of his specimens for him, while he cruised on weightier business.

On the evening before the show, Knut took me on a few country kilometers' drive to drop in on the conclave of regulars already in progress at the house, and all over the lawn, of show manager Ingemar Johansson (no relation to the heavyweight boxing champ of the 1950's). Many in this mineralogical hard core were already in advanced states of cordiality thanks to a kind of Swedish moonshine passing around among them in mean-looking little flasks; my common sense, more than my dignity as representative of the *Mineralogical Record*, militated against my trying the stuff. From the good-natured melee of barbequeing, volleyballing and specimen-flashing going on on the lawn, then, I was hospitably extracted and taken to Ingemar's basement to look at his "systematic" collection, in total number of species the largest private collection in Sweden. Thousands upon thousands of pieces in all sizes are crowded thickly on floor-to-ceiling shelving, their scrupulous labels dropping names of an alarming number of species I'd never heard of. Even *sans* moonshine this interlude at Ingemar's constituted a most pleasant welcome to the Kopparberg scene.

Back again at the show campsite, more surprises awaited me. A Norwegian field collector, Andreas Corneliussen, conspiratorially motioned me behind his trailer—the sense was of some old "Hey, G.I. . . . dirty pictures?" cartoon—to flash at me one of the best ilmenite crystals I've ever seen, a beautifully sharp, nearly complete, brown-black 4-cm floater with hopper development on a couple of faces. These, now, are the classic ilmenites most often vaguely labeled

***Figure 4.* Stalls at the Kopparberg Show.**

"Arendal, Norway," and still, I learned, sparsely collectible at the site, whose precise designation is Omdal, Froland, about 75 km northwest of the town of Arendal. They should not be confused with the somewhat similar-looking though in fact duller-lustered black *hematite* crystals in waxy yellow-green serpentine matrixes from Dypingal, Snarum, Norway. Behind the trailer, too, I got an update on the Norwegian zircon situation: those sometimes gigantic, sometimes gemmy red-brown crystals in black biotite matrixes from Seiland Island (or "Alta Fjord") in Finnmark, in the northernmost reaches of Norway, which have been fairly plentiful on the market in recent times, will almost certainly be plentiful no longer, as collecting at the site has now ceased. The sole collector to date has gotten sick of hassling with poaching Lapps and has abandoned the work. So procure your Seiland Island zircon *now,* if you can.

I'm not sure about the other three sardines in my family, but I slept poorly in our tiny tent that night: too much all-night conversation outside, and too great a midnight-sun effect at that latitude. By nine o'clock the next morning most of the dealers were already in possession of their stands, and so, having first helped Knut take possession of his, I commenced sleepily to explore the labyrinth. Naturally most of my discoveries were of Scandinavian things, but let a couple of foreign guests go first.

The lone Czech dealer, J. Hyršl (Heverova 222, 280 00 Kolín 4, Czechoslovakia), had a recent discovery of some very unusual and attractive barite from the Jenikov quarry near Tepliče, Bohemia, Czechoslovakia. The crystals, equant and blocky and very sharp, measure up to 3 cm across, and are scattered liberally over flat gray matrixes of a tough quartzite; the largest matrix on hand was about 12 cm across. The crystals are basically a deep orange, and near-gemmy, but a light frostedness on the faces makes them look brownish to gray from any distance. The find is about two years old; collecting is now proceeding, and probably there will be more of these aesthetically very appealing barites at the next Munich show and (presumably) thereafter.

The expert young German field collector Mathias Rheinländer, who is half of a partnership called *World Mining* (Eckenbornweg 5m, D-3400 Göttingen, Germany), staged, on his rickety wooden stand, a quietly spectacular display of self-collected specimens from many places. Among numerous others, there were fine gem aquamarines, both loose and on matrix, from the pegmatites of Pakistan; octahedral fluorite crystals to 10 cm on edge from Astak, Pakistan; excellent thumbnail ascebasite from Cherbadung, Switzerland; Arizona wulfenites and vanadinites of irreproachable aesthetics and no visible damage . . . I wish I had noted down more, for the variety was as impressive as the overall quality. Rheinländer's evident dedication to the field collector's art, and his willingness to explain things and share information, constituted truly a show-stopping act.

Did you know that one of the world's best localities for stilbite in beautiful orange sheaves, bundles and spheres is Malmberget, in far northern Sweden? I'd never heard of the place myself—until, sensitized by some pieces I'd seen at Ingemar Johansson's the previous evening, I halted at several different dealers' stands to look at arrays of this material, which apparently is old stuff to experienced Swedish collectors. Malmberget stilbite is deep orange to pale orange-yellow; it glistens bright in wheat-sheaf aggregates and complete spheres, in specimen sizes ranging from thumbnails to giant, solidly blanketed matrix plates tens of centimeters across. The source is an unusual calcite pegmatite, and matrix, when present, is a complex mixture of white or yellow calcite, feldspars, amphiboles and quartz. In fact, calcite itself also occurs in fine specimens at Malmberget; some are delicate, with very thin, pale yellow scalenohedrons, while others are solid, large cabinet-size clusters of deep orange transparent dogteeth.

Not far from Malmberget is the remarkable locality for phosphate species described by Carl-Gustav Bjällerud (whom I met at the show) in vol. 20, no. 5, of the *Mineralogical Record*: the Leveäniemi iron mine near Svappavaara, Sweden. Since their discovery on the dumps in 1985, the rare phosphates (strengite, cacoxenite, kidwellite, beraunite and others) have been "collected out," it appears. Bjällerud affirms with conviction that the specimens he had at Kopparberg will be the last of the lode. They are excellent things, and I'm pleased to have obtained some by trade. The strengite, especially winning, occurs as perfect radiated spheres of a delicate pale violet color with glittering surfaces and usually about 3 mm across, perched in vugs in a dark matrix of iron oxides and massive secondary phosphates. At Kopparberg, excellent strengite thumbnails of this type were not particularly expensive, but certainly they will become so as the locality, by virtue of its exhaustion, acquires "classic" status. But, looking to the future, Bjällerud describes enthusiastically and hopefully a new locality where pink to deep red, occasionally gemmy rhodonite crystals and good diopside crystals (both of these sometimes filmed over by native *silver*) are found enclosed in massive galena, and where, in some vein fillings, beautiful microcrystals of pyrargyrite also occur. It sounds a lot like Broken Hill, Australia, but in fact it's Garpenberg, Sweden, some 200 km northwest of Stockholm. So far no really superlative specimens have been found, but we're told we should all Just Wait.

Next, Denmark—not normally thought of as a specimen-producing country, but don't forget the two hot Danish properties in the North Atlantic: Greenland (a former property), and the lonely little Farøe Islands, these perched on a branchline of the Mid-Atlantic Ridge between Britain and Iceland. Two very nice ladies, Clausen Hovedgård and Florence Ulsig (Rungstedvej 5, 8000 Århus C., Denmark), go up to the Farøes regularly to collect zeolites from the basalt flows there, and at Kopparberg they were selling some of the pickings at absurdly low prices, and with winning smiles and chat besides. My favorites were the snowball-like loose rounded groups of pure white stilbite crystals, individuals averaging 1 cm and the groups about 5 cm, and the just as pristinely white chabazites in loose clusters of sharp translucent rhombs, individuals here again averaging 1 cm.

Many of the little-known oddities of Greenland mineralogy were being offered by Richard Schøler (Grøftehuset 5, 2670 Greve Strand, Denmark); his is the only show dealer's spread I have ever seen devoted entirely to Greenland minerals, unless I count the stock being sold off by the Copenhagen Natural History Museum at the Bad Ems show of 1987. I was glad that my memories of that show and of my still-warm visit to the Greenland room at the Copenhagen museum prepared me for Schøler; otherwise I'd have felt incompetent to be looking at his stock. Greenland things can easily make one feel like that. From Ilimaussaq there were red-brown eudialyte masses with open cavities showing 3-cm faces of glassy crystals. The radioactive silicate steenstrupine, also from Ilimaussaq, was found in dull black but sharp flattened octahedrons, both as loose thumbnails and embedded in white matrix, the crystals averaging 2 to 3 cm across. Weighing down the front of the stand were three dull black prisms of Ilimaussaq arfvedsonite which looked like burnt campfire logs, the biggest one 20 cm long. Greater rarities even than these included sorensonite in glassy pink thumbnail-sized subhedrons; a 1.5-cm plate of metallic black chalcothallite (Tl, Cu, Sb sulfide) embedded in a white matrix; villiaumite in purple cleavages and crude crystals to 1 cm in matrix, and lots of others. Most of these, though they do not take one's breath away with their beauty, are nevertheless outstanding representations of their species, and interesting, too, in their power to suggest the similar mineral suites both of the Langesundfjord/Oslo region and of Mont Saint-Hilaire, Quebec. Schøler is rather close-mouthed, but I had the impression from him somehow that Greenland materials like these will increasingly manage to percolate onto world markets.

I'm cleaning up at Kopparberg now; Knut wants to pack up and get on the road to the Harstigen mine and Långban. Let's see—there is an attractive occurrence of pink scapolite in rough prismatic crystals with associated acicular actinolite from Sønderled, Norway. Dull green but well-formed epidotes to 5 cm long, associated with quartz and massive brown garnet in an apparent Price of Wales, Alaska-like skarn, are coming out of Borlänge, Sweden. And Sørøya Island in Finnmark, Norway—farther north even than Seiland Island—is proving a source of excellent diopside in part-gemmy, glassy, slightly rounded, medium-green crystals. Mostly thumbnail-sized, the crystals easily pop out from their massive white calcite matrix, and so most were being sold loose (I got a handsome 2.5 cm crystal for about $10), but there was also one magnificent matrix piece: a hunk of cleaved calcite 8 cm wide with a beautiful green diopside 3.5 cm long about one-third embedded in it.

Finally I browsed a bit at the table of Långban rarities put out by the dedicated species collectors of the Långban Society, and was surprised to see there quite a few nice oldtime New Jersey franklinite octahedrons and other Franklin/Sterling Hill material mixed in with (and mostly upstaging) the Långban things. Not so odd, I guess, this affinity between devotees of the world's two leading localities in number of species, both places short on dramatic crystals, long on complex and strange geochemistry; the Franklin and Långban species assemblages don't much resemble each other but the associated collecting scholasticisms do. More of this when we get to Långban later. Anyway, it was over the lumpish Långban and fitful Franklin specimens that I stretched out my hand to shake Ingemar Johansson's, to thank him for a fine show experience. No, I wasn't staying for the Open Gold Panning Championship.

THE BERGSLAGEN DISTRICT

Four hours' drive due west of Kopparberg lay Oslo, Knut's hospitable home, and those hot showers and genuine beds. On the way there, guided by Knut, we stopped for some desultory investigation of some of the old localities in the Swedish Bergslagen mining district north of the town of Filipstad, province of Värmland. I looked forward most to the ever-satisfying experience of being able to substitute real images of real places for the old, odd, cryptic bare words on specimen labels, e.g., Långban, Harstigen, Nordmark (which we visited), and Pajsberg and Jakobsberg (which we did not). Even around these latter gaps which obtusely persist in my memory-map there is now, at least, all that lovely, quiet, faintly mournful Bergslagen scenery: low wooded hills, red barns, glacial lakes, and oh yes, the nude-bathing area on a bank of one of those lakes, to which Knut led us (sorry, readers, no photos here).

In a magisterial paper in the *Mineralogical Record*'s first volume (Winter 1970), Paul B. Moore presented and synthesized much of the earlier published data and much personal study concerning the geochemistry of Bergslagen deposits generally, and of Långban, the largest and most famous one, in particular. I can but briefly paraphrase his results here. Nearly all of the thousand-odd iron and manganese mines in the region exploited small, geochemically similar iron ores (mainly hematite and magnetite) and much less extensive manganese ores (hausmannite and braunite). These were segregated and stratified in beds and long pods in a geologic setting of thermally metamorphosed volcanic rocks (leptites) and limestones (dolomites), with some granitic intrusives. Closely associated with the orebodies, and often displaying the same banded textures, were metamorphosed silicate skarns ("skarn," by the way is originally a Swedish word meaning "trash" or "waste"). Moore postulates an original sedimentary deposition of iron and manganese "proto-ores," hydrothermally infused with significant lead, arsenic and antimony originating in nearby volcanism. Then a complex sequence of metamorphic events, during which highly mobile Pb, As and Sb, as well as Ca from the limestones, reacted with proto-ores and country rocks to form such unusual suites of rare minerals as the lead silicates of the skarns and the Ca and Mn arsenates in seams and fissures in the re-cooked manganese oxides. Indeed, the most complex mineralogy in these occurrences is consistently found in the manganese (not the iron) ores and in the contacts of manganese ore with the silicate skarns. A distinctive feature of many local para-

Figure 5. **Manganese ore dump and old mine building at Långban. The fence separates the "permitted" from the "forbidden" collecting areas.**

geneses is the presence of minerals containing cations not normally found together in other deposits, for example Sb and Be. From Långban alone more than 300 species have by now been described—fully a third of them since 1979 (Adolfsson).

Harstigen

The little Harstigen mine, whose dump was the first site we visited, offers typical skarn and Mn rocks dominated by richterite, schefferite (a manganoan pyroxene), rhodonite, tephroite and garnets. One learns to look hopefully for the densely packed, grayish green, fibrous amphibole veinlets in contact with metallic black hausmannite, and for small, glinting, reddish or yellowish faces of rhodonite or garnet crystals peeking through these veinlets. Knut, being by main inclination a species collector, turned his practiced eye chiefly to looking for microcrystals of the very rare arsenates and silicates found here: brandtite, flinkite, ganophyllite, harstigite, hedyphane, bementite, sarkinite, etc. But the Harstigen's chief fame among collectors rests on two species found in spectacular examples during the active mining period of the late 19th century: rhodonite, in beautiful, deep pink, gemmy crystals to 1.5 cm long, and the world's only good euhedrons of native lead, in an array of isometric forms, the largest crystal on record being a 3-cm single in the University of Oslo collection. Our own hasty investigations yielded no more than a few crude rhodonite crystal faces, tiny garnets, and a tiny single sharp book of bronzish manganophyllite found by six-year-old Eileen. By the dump is a weathered wire fence enclosing the water-filled pit of this mine from which a total of only 153 tons of manganese ore were taken before operations ceased in 1889. The rest of the mine site consists of dense brush, mosquitos, and what's obviously a very thoroughly picked-over dump.

Långban

Moving on to Långban, and taking advantage of the unique (in Europe) chance that Norwegian and Swedish law affords to hike and camp freely on unfarmed land, we set up our tents that night by an outlying iron ore (hence mineralogically barren) dump. The next morning we went to dig in the more promising Långban manganese dump—rather, in the small part of it that is still open to private collecting. A sturdy wire fence straddles the giant rockpile, separating this "open" section from the forbidden one, the latter having been closed off in the mid-1970's because, as Adolfsson reports (1979), people from other countries had been loading rocks by the ton into cars and buses and hauling them off. Moore mentions a general feeling in Sweden that private collecting at mineral-rich sites is scientifically reprehensible and thus to be discouraged. It is this feeling that, for better or worse, underlies the discouraging fact that the best Långban specimens in institutional collections are several orders of magnitude better than anything that anyone has ever found on the dumps. Nearly from the outset of its modern development the Långban mine has been very closely monitored by professional mineralogists who have seen to it that the best specimens and most unusual rarities were immediately grabbed up and taken to the museums, especially to the one in Stockholm. In effect, therefore, the dumps were thoroughly highgraded even while they were forming. So our own paltry couple of hours there predictably yielded nothing too thrilling. We found a few pieces of massive rhodonite and tilasite, and once Knut pointed out to me an inconspicuous yellow stain which was, he said, berzeliite, one of the most common of the Långban arsenate species—but that was all. The ore in any case is dense, with almost no visible seams or vugs, and to spot the tiny blebs, smears and stains of the rare species takes an experienced eye, since, as Knut likes to say, "the rare things look common and the common things look rare."

But some compensation, and much further education, came when we inspected the private Långban collection of Roland Eriksson, whose little mineral museum adjoins his house in a former mine building on the edge of the manganese dump, amid old water-filled entrances to the underground workings. Here were specimens with 8-cm open seams filled with arborescent native lead, and delicate blue-green wermlandite spherules in cavities, and large sharp plates of pyroaurite, and bladed masses of margarosanite and other rare lead silicates, and, naturally, many more impressive old-timers. Eriksson, who now has, he says, exactly 296 of the 315 known Långban species, is enough of a loyalist to his locality to have informed me quickly that since

Figure 6. **An old mine entrance at Långban.**

Figure 7. **Phenakite, 2.5 cm, from Drammen, Norway. Torgeir Garmo specimen and photo.**

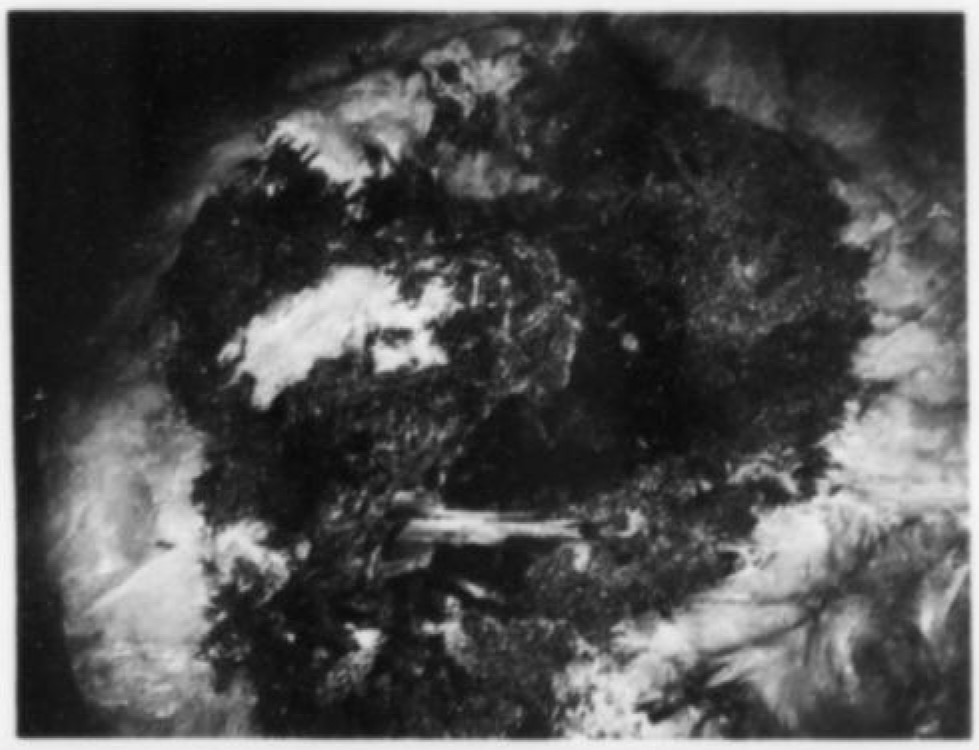

Figure 8. **Diaspore crystals in a cavity 5 cm across, from Tvedalen, Langesundfjord, Norway. Knut Eldjarn specimen and photo.**

Figure 9. **Grossular with diopside (green), 15 cm across, from Beiaren, Nordland, Norway. Knut Eldjarn specimen and photo.**

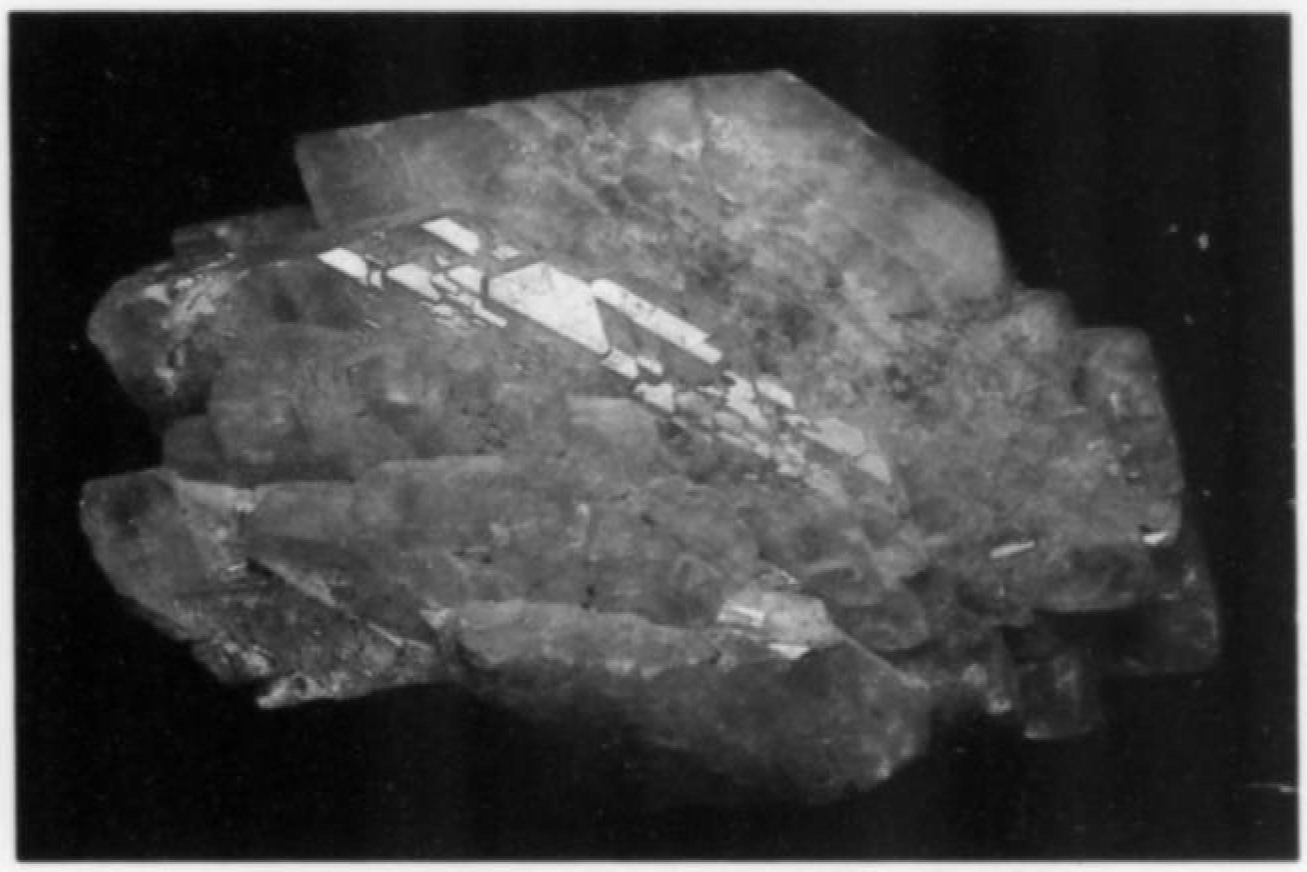

Figure 10. **Barite, 9 cm across, from Bamble, Telemark, Norway. Knut Eldjarn specimen and photo.**

Franklin/Sterling Hill is two separate ore bodies and Långban just one, the latter is *really* the world's most species-rich place. There can't be more than a dozen people on earth who care very deeply about which of the two localities deserves the palm, but unquestionably I was talking to one of them, and I found his devotion admirable.

Some modest improvements for the sake of Långban visitors are presently afoot or planned. In 1991 some water will be pumped out to make some old underground workings accessible for tours, though Roland Eriksson doubts that these will include the more mineralogically interesting parts of the mine. Anyway there is always, of course, the Eriksson collection itself to gape at. A small museum devoted to the history of the Långban mine is being organized at the site, and in August of 1990 a small mineral show will be held there, the second of its kind, the first having been mounted with some success in 1989.

Nordmark

The last stop on our modest Bergslagen reconnaissance tour was the pair of very small mines conventionally referred to on old labels as "Nordmark"—actually the Eastern Moss and Brattfors mines, near the tiny hamlet of Nordmark, both worked for iron and manganese between ca. 1700 and 1962. The mineralogy is similar to Långban's, though simpler; the main species occurring in good specimens were manganosite, pyrochroite, pyrosmalite, hedenbergite and the arsenates allactite, synadelphite and retzian. At Stockholm I'd seen the amazing large Nordmark hedenbergite prisms in matrix, and the 6-cm, curved, brownish green crystals of pyrosmalite (resembling Bad Ems pyromorphite). But the pits are water-filled now and dumps are almost nonexistent. According to Knut, a severe drought a few years ago enabled some alert local collectors to find some interesting things when the water level in the pits temporarily fell, but our activities were confined to a weary trek through the woods and some picture-taking among ruined mine buildings and scattered private houses.

THE ELDJARN COLLECTION

My immense indebtedness to Knut Eldjarn for his many kinds of help during this trip will have long since been obvious to the reader—but perhaps his greatest service to me of all was his allowing me to pore over his wonderful private collection at his home in Oslo. Not that doing so was exactly a hardship for him . . . we both had, I think, one of those mineralogical peak experiences that only true fanatics know, while admiring and discussing, throughout one evening and until after 2:00 the next morning, his more remarkable things. The most remarkable of all, in general, were the Norwegian specimens, most of them field-collected by Knut and representing occurrences quite unknown to me previously. Here, as a sort of yummy dessert with which to conclude this article, I'll list a few of these "new" Norwegian occurrences, and offer supporting photos of some of their specimens, courtesy of Knut's expert camera eye.

An old, now-closed locality within Oslo's city limits once produced perfect crystals, with dodecahedral and trapezohedral forms predominating, of beautiful, rich brown grossular garnet to 4.5 cm across.

Miarolitic cavities in granites in the Drammen area about 25 km southwest of Oslo have yielded excellent specimens of many typical pegmatite minerals: large groups of smoky quartz crystals (including some very dark, only dimly transparent ones of the kind that Europeans still call "morion"); part-gemmy phenacites to 1 cm across; sharp orthoclase groups to "museum" size; one (at least) beautiful 3.5-cm terminated prism of gem aquamarine; and gemmy blue topaz to 5 cm.

A variety of unusual minerals occurs in miarolitic cavities in the

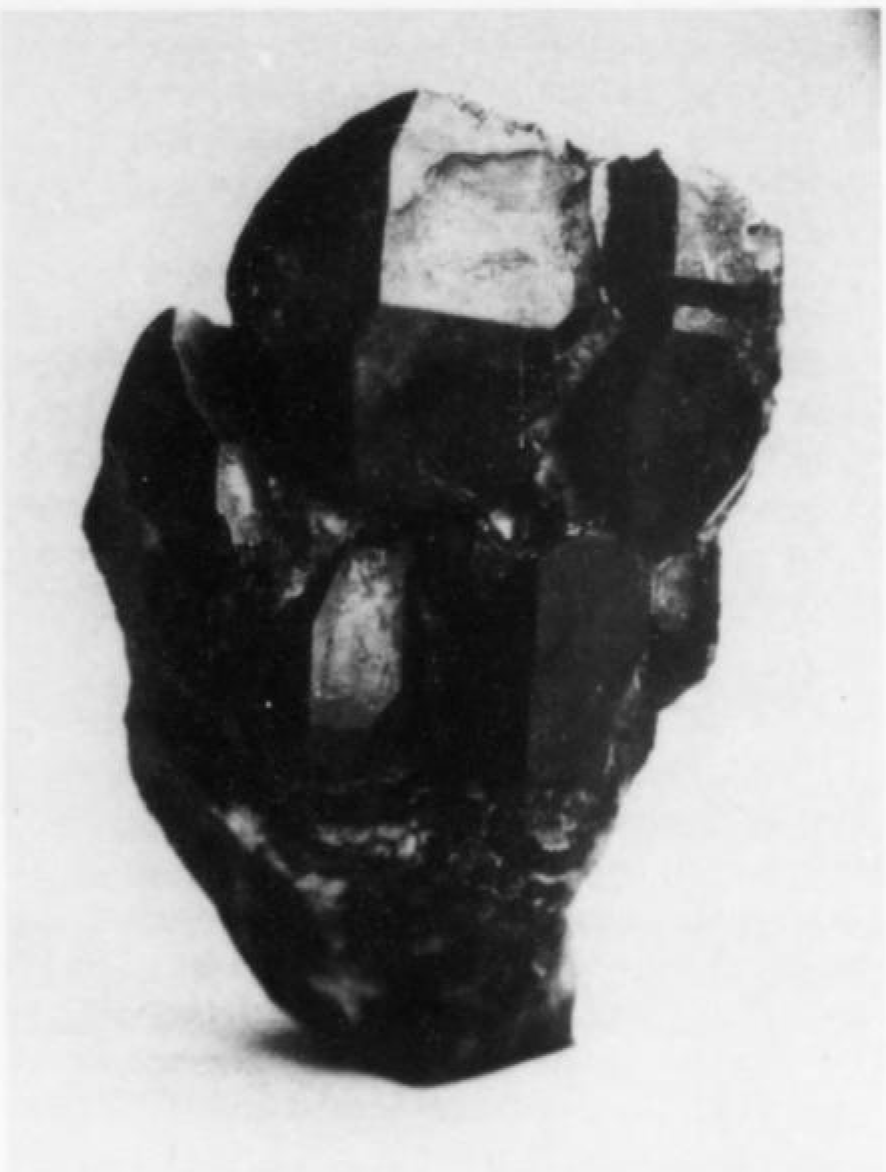

Figure 11. **Gadolinite crystal group, 15 cm, probably the world's finest, from Dauren, Frigstad, Iveland, Norway. Knut Eldjarn specimen and photo.**

St. Hilaire-like syenites and syenite pegmatites of the Oslo and Langesundfjord areas of southern Norway; for partial accounts of these see Raade (1972) and Larsen (1981). The groundmass of these rocks is composed chiefly of microcline, aegirine, and biotite, with areas where nepheline and sodalite have hydrothermally altered to produce a white, fibrous to massive zeolite material locally called *spreustein*. From pockets here come fine, large, stout, terminated natrolite crystals to several cm long resembling those from Bound Brook, New Jersey. *Spreustein* pockets also sometimes yield druses of bright orange-brown helvite in fine tetrahedral crystals to 1 cm across, as well as spectacular nests of prismatic to acicular, lilac-purple diaspore crystals to 5 mm long. Within the last few years this same prolific region has given up such species-collector desiderata as glassy berborite crystals to 1 cm on white thomsonite; rich orange crystal druses of chiavennite; sharp rose-colored hexagonal crystals of gagarinite (mostly microcrystals but one to nearly 1 cm); and sharp brownish götzenite crystals to 5 cm.

A quarry at Bamble in the Telemark region of south-central Norway has produced a few fine, large specimens of yellow to orange to faintly bluish barite crystals, some of them transparent, in beautiful clusters with individuals to 15 cm across.

Some of the Precambrian rocks southwest of Oslo are famous for rare-mineral-bearing granite pegmatites. In particular the Iveland-Evje area north of Kristiansand has produced large crystals of a number of the rare species already mentioned as well-represented in the Oslo museum collection. A small prospect pit in such a pegmatite at Dauren, Frigstad, Iveland, intermittently worked (mostly for specimens) in the 1950's, produced what are probably the world's best gadolinite crystals: perfectly sharp, smooth-faced, glassy, blocky, greenish brown to brownish black individuals up to 10 cm across. Knut has a 15-cm group which I'd venture to guess (as would Knut) is the single finest gadolinite specimen in existence (see photo). Also noteworthy from Iveland is a fairly recent find of exceptionally sharp, light brown, tetragonal bipyramids of xenotime to 3 cm in matrix.

Forsterite in transparent, gemmy crystals (the gem variety *peridot*) has been found at Almklovdal, Sunmöre, western Norway. The crystals have rough, etched outer faces and thus lack the morphological splendor of the Egyptian peridots from Zabargad Island, but they are every bit as gemmy, are of a distinctively different color—more bluish—and reach more than 5 cm across.

Speaking of peridot, serpentine pseudomorphs after giant peridot crystals to 12 x 15 cm occur embedded in massive magnesite at Dypingal, Snarum, Norway. This is the locality for the more familiar hematite crystals in serpentine, and the type locality, incidentally, for hydrotalcite.

At Hundholmen, Tysfjord, in northern Norway, in a rare-earth pegmatite which also contains good allanite, still more good gadolinite crystals, and parisites to 8 cm long, Knut has collected what are undoubtedly the world's champion crystals of the rare yttrium silicate thalenite: euhedrons to 3 cm across, of a lovely transparent flesh-pink color, embedded in pegmatite matrix. Bob Sullivan once mentioned these in his "Letter From Europe" column (vol. 9, no. 5, p. 318).

A metamorphic skarn at Beiaren, Nordland, more than halfway up Norway's long panhandle, has produced large groups of gemmy orange grossular garnet crystals with individuals to 2 cm across. Associations are deep green diopside, vesuvianite, and axinite and some of the specimens strongly suggest (and rival the best of) the classic Ala Valley, Italy grossular/diopside specimens.

By all accounts the Scandinavian mineral-collecting community is growing rapidly both in raw numbers and in intensity of activity. In 1990 there will have been more than 20 mineral shows held in the region. And such a healthy subculture needs a good magazine in an appropriate language to serve it, right? Enter *STEIN*, formerly *NAGS-NYTT* ("Norwegian Association of Geological Societies"). The Norwegian publication, to which Knut is a frequent contributor, comes out four times a year and costs 125 Norwegian Kroner (about 20 dollars) for a year's subscription: the address is c/o Geir Henning Wiik, N-2740 Roa, Norway.

ACKNOWLEDGMENTS

My profuse thanks, of course, to Knut Eldjarn, as well as to Roland Eriksson, Ingemar Johansson and Gunnar Raade for many species, subspecies and varieties of assistance. Gratitude to Paul B. Moore for his 1970 Långban paper. More thanks to Wendell Wilson and (again) to Knut, for reviewing the manuscript. And finally, the most deep-seated thanks of all to my wife Lynn, for patiently looking at so many collections and clambering over so many rockpiles with me, while somehow watching and entertaining the kids at the very same time.

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What's New in Minerals?

DENVER SHOW 1990

The talk of the Denver Show this year was **beryl**, in world-class specimens from two different localities: Utah and Pakistan. The Utah specimens were discovered just days before the show by Ed and Rex Harris, operators of the famous red beryl mine known as the Violet claims, in the Wah Wah Mountains (see the article in vol. 10, no. 5, p. 261–278). Two of the specimens, which qualify as the finest examples of red beryl ever found, have doubly terminated, highly lustrous and undamaged 2.7-cm crystals on matrix; one stands vertically on the matrix, with a cluster of smaller crystals at the base, and the other rests horizontally. To see these specimens in the bright Colorado sun is almost a religious experience. John Barlow acquired them both during the show, and will be exhibiting them along with the rest of his extraordinary red beryl suite at the February Tucson Show. Two other specimens found are a large single crystal without matrix and a slightly damaged group of two crystals leaning together on matrix.

The other **beryl**, from Dusso (or Dassu) in Pakistan (see vol. 16, no. 5, p. 393–411), was being gently carried around in a little cotton-lined suitcase all its own by Dudley Blauwet of Mountain Minerals International. It needs its own suitcase because it's nearly a foot long (26.7 cm)! The simple-hexagonal, pale blue crystal is lustrous, largely gemmy and well terminated by a simple pinacoid. Some extremely beautiful specimens have come from Pakistan in recent years, and this is surely one of the finest.

We seem to be living in the Golden Age, quite literally, of mineral collecting these days; fine **gold** specimens in quantity have come on the market from many different localities. Wayne and Dona Leicht's superb California golds have dominated this field, but other localities have been producing as well. Mt. Kare near Porgera in Papua New Guinea is the most recent example. Earlier specimens from this occurrence have been somewhat lusterless, but a new batch of thumbnails, perhaps 60 to 70 specimens, brought out by Stefan Stolte (*Mineralien & Fossilien Galerie*, Frankfurt), is much better. The specimens are brilliant and lustrous leaves with small crystals, and also small exquisite crystal groups. Stefan says he obtained 3 kilograms of gold, mostly as 1–3 gram specimens, also a few sheets to 5 cm, and some large masses of crumpled and intergrown leaves to 10 ounces. Wayne Leicht and other dealers have had specimens from the same occurrence. According to Stefan, a major mining operation is under construction at the site, and may well become the world's largest gold mine outside of South Africa.

A sizeable number of relatively sharp, octahedral **gold** crystals are said to have come from Venezuela recently, and I have seen two of them. They are about 1 to 2 cm in size and totally unlike other Venezuelan gold crystals. At first glance they appear suspicious: the details of the octahedral habit are more reminiscent of alum than of gold, the edges have a slight but peculiar rounding (not like stream-rounding), and there is a lack of any real sharp, razor-edge detail anywhere on the crystals. No matrix is present either. It is distinctly possible that these are castings. Collectors should examine any suspect specimens carefully under high magnification for further evidence of natural or artificial origin (e.g. casting bubbles, traces of molding compound, micromorphological features too small to be cast, bits of matrix, etc.). Caveat emptor.

Dozens of flats of newly collected **stibnite** specimens from Baiutz (or Bajuz), Romania, were available from several dealers including Tony Jones (*California Rock & Mineral Supply*) and Stefan Stolte. The groups are generally miniature to small-cabinet size (i.e. 5 to 8 cm), with striated crystals typically about 4 × 10 mm across and 3 to 6 cm long. The terminations are well formed but the luster is generally rather dull.

Jim Walker and Mary Fong/Walker (*Ikon Mining*, Fallbrook, California) had a large lot of old (should we call them "historic" or "antiquarian"?) specimens, many of them "classics" dating to 1840–1900. Included were some fine miniature wire silvers from Freiberg, Saxony; a **pyrargyrite** from Cochabomba, Bolivia; **pseudomalachite** from Rheinbretbach, Germany; a large Phoenixville, Pennsylvania, **anglesite**; a Haddam Neck, Connecticut, green **tourmaline** with an 1897 Clarence Bement label; and a very beautiful and bright cabinet specimen of Bisbee, Arizona, **azurite.** Among the newer specimens in their stock were more of the fine **sperrylites** from Talnach Norilsk, Siberia, including one with a large composite crystal or parallel growth crystal showing many individual but parallel crystal faces.

The most significant collection to come on the market, at least partially, at the Denver Show was the collection of Robert Dietrich of San Francisco. Wayne and Dona Leicht (*Kristalle*) obtained the entire 4000-specimen collection to sell on consignment for Bob's widow (he died in 1982). About half of the collection consists of very high-quality display specimens including some fine **silvers, coppers,** and a large **stibnite** group from Manhattan, Nevada. Wayne has promised us an article on the collection (only about 150 specimens of which had been brought to Denver).

Gilbert Gauthier had his usual selection of Zaire minerals, including 20 specimens of **carrollite** ($Cu(Co,Ni)_2S_4$) recently collected at the Kamoto Fond mine, Shaba province, Zaire. "Fond" means "deep," signifying the underground mine of the Kamoto group, all the others being open pits. The crystals are typical in being very lustrous cuboctahedrons with modifying trisoctahedron faces, to about 1 cm, on matrix singly and in groups.

Many other fine specimens were available from the large number of dealers in attendance at the Merchandise Mart (Denver Council of Gem and Mineral Societies Show) and at the Holiday Inn North (Marty Zinn's satellite show, now filling three floors of the motel). *Zeolites India* had a sparkling selection of green **apophyllites** from Poona and Nasik. Alain Carion had some excellent French **baddeleyites** and **stolzites** (Isere province). Don Knowles (*Golden Minerals*) had a huge lot of Peruvian minerals including good **pyrite, chalcopyrite, sphalerite** and **galena** from the Huaron mine (Pasco Dept.); **calcite, rhodonite** and pink **manganaxinite** from the Pachapaqui mine; **calcites** from the Huanzala mine (Huanuco Dept.); **bournonite** miniatures from the Mercedes mine (Huanuco Dept.); some interesting **stibnite** specimens with stout, frosty crystals, to about 7 cm, from the Raura mine (Lima Dept.); and nice **rhodochrosites** from the Uchucchaqua mine (Lima Dept.). *Mineral Kingdom* had some new, blocky **azurite** crystals and groups from the upper levels of the Tsumeb mine, Namibia, taken out in September-October 1989 and May 1990, including some very aesthetic combinations of lustrous blue-black azurite on pale green smithsonite. Marty Zinn exhibited some of the beautiful Argentinian **rhodochrosite** that has been coming out lately—in polished slabs cut from interconnected stalactites, from the La Capillita mine, Catamarca province. Keith Williams had some very aesthetic thumbnails and miniatures, including the best thumbnail of Rapid Creek, Yukon, **lazulite** I have ever seen: a single, lustrous, undamaged, well-formed bluish black crystal, 1.6 cm, on matrix with siderite. Rod Tyson is maintaining a good stock of Nanisivik mine **pyrite** (see previous issue). Horst Burkhard had some new and extremely beautiful groups of bladed **azurite** crystals, lustrous and sharp with deep gemmy

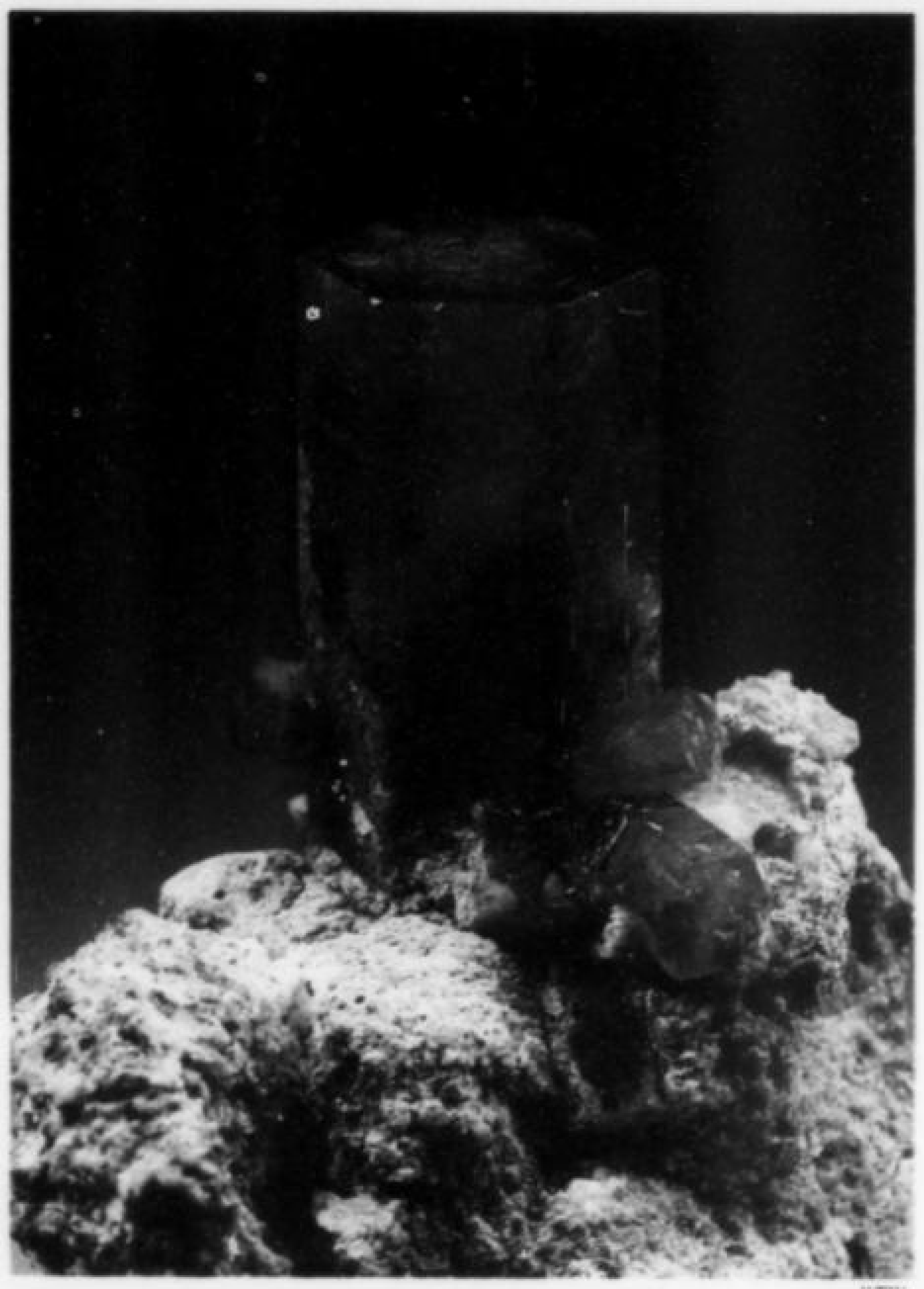

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Figure 1. Beryl crystal, 2.7 cm and doubly terminated, on matrix from the Violet claims, Wah Wah Mountains, Utah. The lower (partial) termination is visible from the back, along with nearly a dozen smaller crystals in a cluster. Found in September 1990; now in the F. John Barlow collection.

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Figure 2. Beryl crystal, 2.7 cm and doubly terminated, on matrix from the Violent claims, Wah Wah Mountains, Utah. Found in September 1990; now in the F. John Barlow collection.

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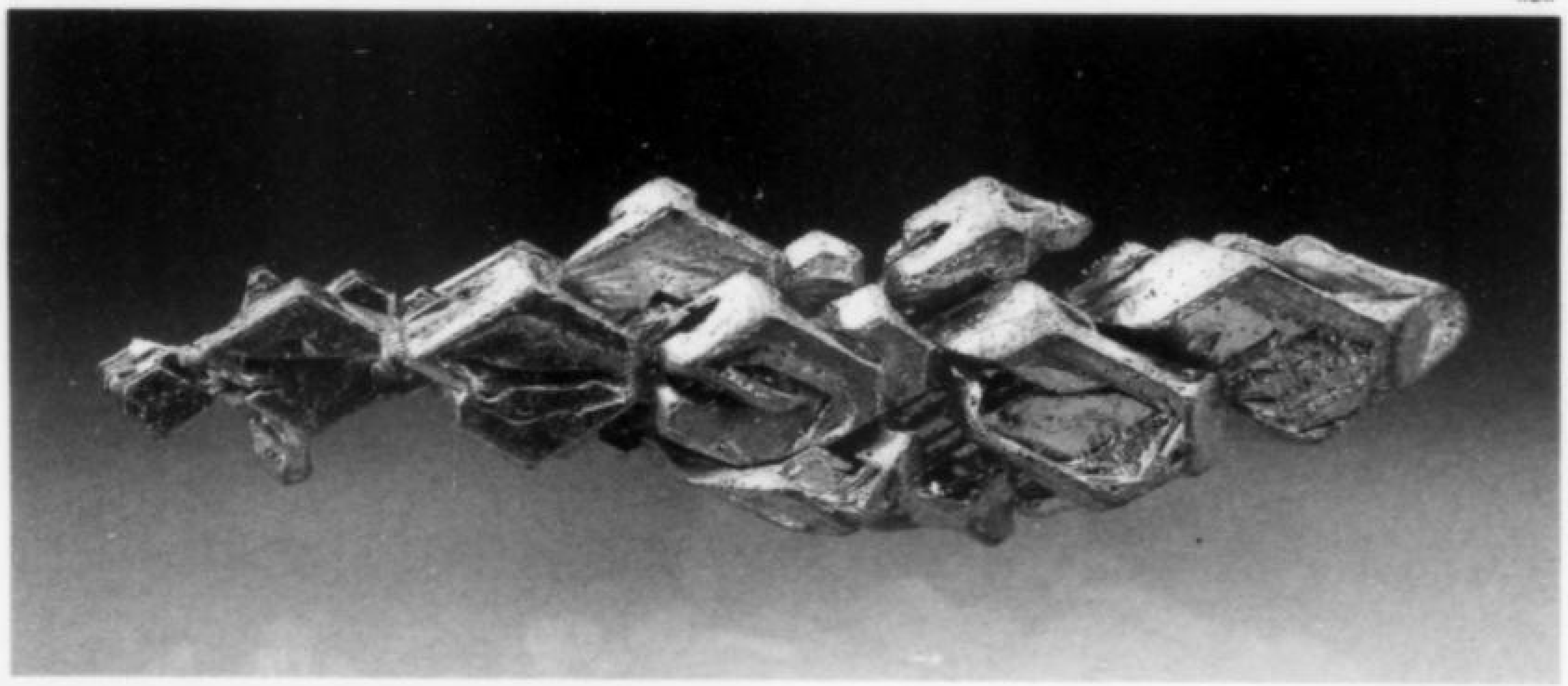

Figure 3. Gold crystal group, 1.7 cm, from Mt. Kare, near Porgera, Papua New Guinea. Stefan Stolte specimen.

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Figure 4. Carrollite crystals to 1.2 cm, on matrix, from the Kamoto Fond mine, Shaba, Zaire. Gilbert Gauthier specimen.

Figure 5. Stibnite crystal group, about 16 cm across, from Manhattan, Nevada. Robert Dietrich collection, sold by Wayne and Dona Leicht, *Kristalle*.

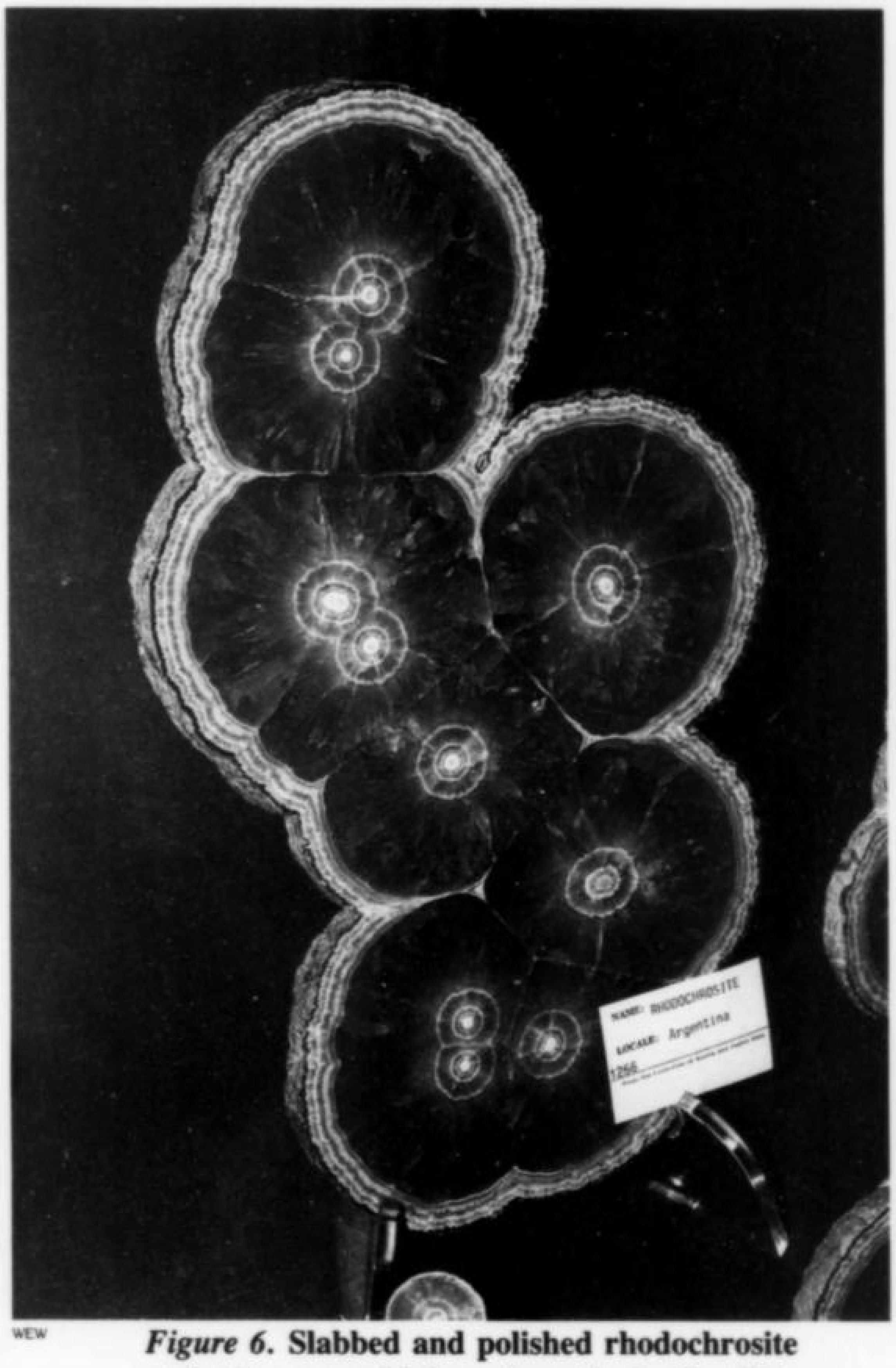

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Figure 6. **Slabbed and polished rhodochrosite stalactite group, 29.5 cm, from the La Capillita mine, Catamarca province, Argentina. Marty Zinn collection.**

Figure 7. **Beryl crystal, 26.7 cm, from Dusso, Pakistan; held by Dudley Blauwet (*Mountain Minerals International*).**

WEW

blue transparent areas, in miniature and small cabinet sizes, from the Touissit mine, Morocco. And there were many others.

The displays included many fine rhodochrosite specimens from localities worldwide, that being the designated species to be featured this year. However, a special tip of the hat must go to Ralph Clark's display case of thumbnails, the best single exhibit of thumbnails (in my opinion) to appear in many years.

W.E.W.

friends of mineralogy

The Friends of Mineralogy, having been organized during a Tucson Show, continues to hold its annual meetings in Tucson in February. The breakfast meeting of the Board of Directors was held at Days Inn on Friday, February 9, 1990.

The newly elected Directors were Dan Behnke (Northbrook, Illinois), a micromineral collector and photographer; Richard W. Thomssen (Carson City, Nevada), a geologist consultant and past Executive Director of the Mineralogical Record; and Art Smith (Houston, Texas), petroleum geologist, who is interested in microminerals, mining history and writing for the hobby magazines. Re-elected were Raymond Lasmanis (Olympia, Washington), State Geologist for the State of Washington and past President of FM; Kay Robertson (Los Angeles, California), mineral collector since 1950 with emphasis on historical localities of Central Europe and Germany; and Arlene Handley (Vancouver, Washington), a mineral collector for over 35 years and Chairman of Asia Mineralogical Association.

Other members of the Board are Russell Boggs (Cheney, Washington); Gene Foord (Golden, Colorado); Mike Groben (Coos Bay, Oregon); Robert Jones (Scottsdale, Arizona); Betty Tlush (Belen, New Mexico); Marcelle Weber (Guilford, Connecticut); Richard Hauck (Bloomfield, New Jersey); Jay Lininger (Dillsburg, Pennsylvania); Peter J. Modreski (Littleton, Colorado); Al Kidwell (Houston, Texas); Anthony Kampf (Los Angeles, California); and Marie Huizing (Cincinnati, Ohio).

The officers of the organization are elected by the Board of Directors from its membership. The current officers are Al Kidwell, President; Arlene Handley, Vice President; Art Smith, Secretary; and Dick Thomssen, Treasurer.

The annual meeting of the membership was held in the Greenlee room on Saturday, February 10 at 4:30 P.M. A highlight of the meeting was a lively discussion concerning the rules and regulations of collecting on public lands and the various interpretations and manner in which such regulations are enforced.

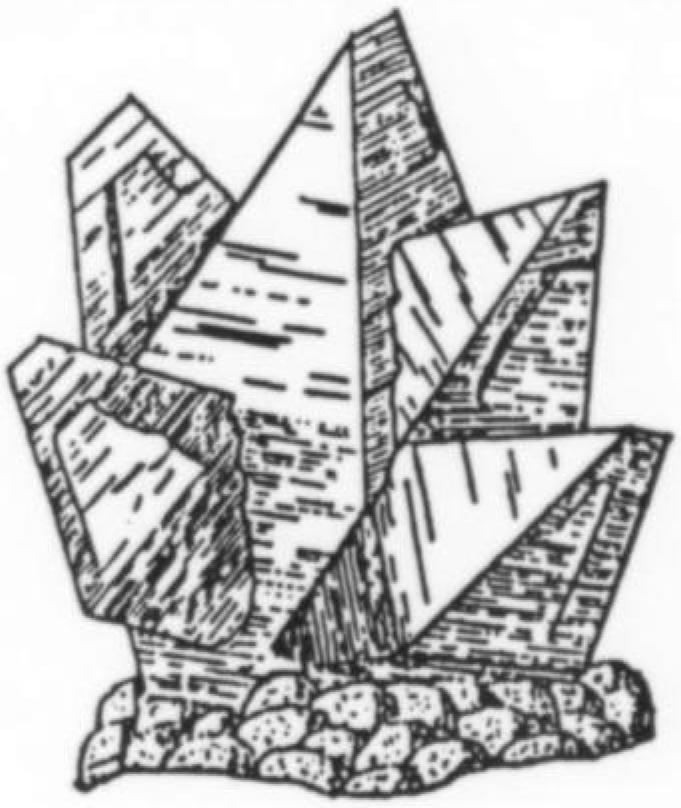
A mini-symposium on wulfenite, sponsored by Friends of Mineralogy, Tucson Gem & Mineral Society and Mineralogical Society of America, took place on Saturday morning, Dr. Karen Wenrich served as Chairman. Abstracts of the papers have appeared in the January-February issue of the *Mineralogical Record*. The 12th Annual Symposium is scheduled for Saturday, February 16, 1991, with the topic "Azurite and Other Copper Carbonates."

Symposia are excellent vehicles "to advance mineralogical education . . . ," one of the goals of FM. These programs, planned and executed by the national organization or its Chapters, are open to all interested individuals.

The 15th Annual Mineralogical Symposium sponsored by the Pacific Northwest Chapter, FM, featuring "Zeolites," was held September 29, 30 and October 1, 1989, in Tacoma, Washington. Of particular interest during this event was the announcement of two new zeolites from Goble, Oregon: boggsite and tschernichite. Cowlesite was first described as a new mineral at the Pacific Northwest Chapter's First Annual Symposium.

The abstract which follows is of a paper distributed by Rudy Tschernich following his talk, "Zeolite Minerals of the Pacific Northwest," at The Thirteenth Annual Neal Yedlin Micromount Symposium during the Tucson Show.

Tschernichite was first found in 1971 by Rudy Tschernich in the Eocene basalt on top of the cliff between Goble Creek and Near Road, north of Goble, Columbia County, Oregon, while collecting another new species, cowlesite (which William Wise and Rudy Tschernich named in 1975 after John Cowles). At that time only one small block of hard rock, containing what is now known to be tschernichite, was excavated from the bottom of the trench and mistakenly identified as an unusual form of apophyllite. In 1985, Russell Boggs determined



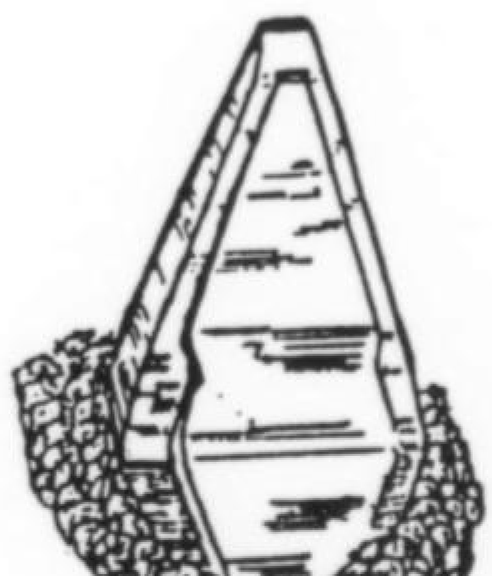


***Figure 1.* Tschernichite crystals on clay.**

that the X-ray pattern indicated a new species and proposed to name it after Rudy Tschernich.

At that time, only eight tiny microspecimens existed. Repeated searching had turned up no more until December, 1985, when Bob Boggs collected samples for the description of the new species. In 1986, Rudy Tschernich and Don Howard found more of the material in tiny vesicles. In a very few cavities, tschernichite was intergrown with tiny white-colored radiating groups. This, also, was a new species, named after Bob and Russ Boggs (father and son) for relocating the tschernichite site which led directly to the discovery of boggsite.

Both new zeolites have been approved by the IMA.

Tschernichite (chur-nick-ite) has a range in composition from low silica to high silica: low silica formula is $Ca_{.97}Na_{.05}Mg_{.08}Si_{5.95}Al_{2.00}Fe_{.02}O_{16}\cdot 7.96H_2O$ and high silica formula is $Ca_{.73}Na_{.11}K_{.02}Si_{6.33}Al_{1.69}Fe_{.02}O_{16}\cdot 3.98H_2O$, $Z=8$. The mineral is tetragonal or pseudotetragonal, colorless to white with conchoidal fracture and no cleavage or parting. It forms beautiful crystals which range from tiny, smooth, colorless, 0.1 to 1-mm hemispheres, to radiating, pointed groups, drusy linings 1 to 2 mm thick, blocky stout individuals, and larger singles, twins and groups up to 5 mm iong, with one doubly terminated crystal 1 cm long.

Crystal form is usually a simple-appearing steep tetragonal dipyramid {302} with horizontal striations {502} and {101} often terminated by a dull or rough {001} face. Twinning is very common on (101) and (302). A white phantom is often present in the core of the dipyramid.

Boggsite (baghs-ite), $Ca_{7.8}Na_{2.9}K_{.2}Mg_{.1}Fe_{.1}Al_{18.3}Si_{77.6}O_{192}\cdot 70H_2O$, Z=4, is orthorhombic but not twinned. It is colorless to white with conchoidal fracture and exhibits no cleavage. Boggsite crystals are a maximum of 0.5 mm long and 0.2 mm wide, forming radiating hemispheres 0.8 to 2 mm in diameter. The crystals are colorless, thin, chisel-shaped blades, elongated along the *b*-axis and displaying the forms {102}, {001} and {100} with a small rectangular termination {010}. The hemispheres are composites formed from a generally milky colored, fine-grained, weakly radiating fibrous mass, often covered by a very thin, white, smooth fibrous shell, or covered by coarse-grained colorless boggsite crystals.

Boggsite is always found with tschernichite and clay, and very rarely also with copper, chalcedony, heulandite, aragonite and calcite. Tschernichite is usually found alone on a clay lining but rarely is found with boggsite, copper, calcite, aragonite, analcime, okenite, opal, chalcedony, mordenite, phillipsite, cowlesite, apophyllite, heulandite, chabazite, levyne, thomsonite and erionite.

The tschernichite-boggsite bearing rock has been mined down to the basal vesicular flow which contains neither of the new minerals. Other outcrops in the area have failed to produce even a trace of them. There are less than 100 boggsite specimens known. Tschernichite is the more abundant but still limited.

Marcelle H. Weber
Past President
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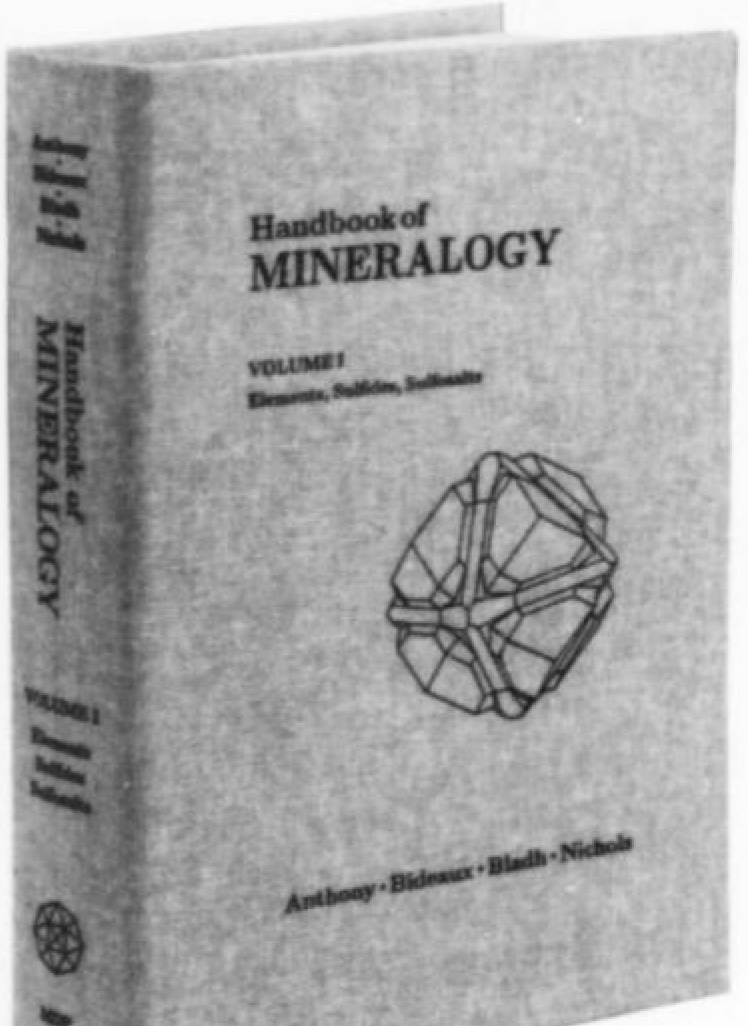
Book Reviews



Handbook of Mineralogy

Volume 1: Elements, sulfides, sulfosalts. by John W. Anthony, Richard A. Bideaux, Kenneth W. Bladh, and Monte C. Nichols. Published (1990) by Mineral Data Publishing, P.O. Box 37072, Tucson, Arizona 85740. Hardcover, buckram, without dustcover, 18 x 26 cm, 588 plus vii pages, ISBN 0-9622097-0-8, $82.50 plus $5.00 shipping and handling.

The *Handbook of Mineralogy* has been eagerly awaited by all who have known of its pending publication, and the wait has been very worthwhile indeed. It is the first in a set of 5 planned volumes, and provides a list of the contents of the next four; volume 2 will be on silicates. It is immediately obvious that this has been a well-planned project; one might disagree with a format-decision or two, but it is clear that everything was carefully decided, and nothing left to whimsey. One evidence of this is provided in a very important feature omitted by too many compilers; the cut-off date, for which the authors should be praised. This volume covers the literature through 1988 for elements, alloys, intermetallics, sulfides, antimonides, arsenides, bismuthinides, selenides, sulfhalides, sulfoxides, tellurides, and sulfosalts.

The book is a substantial one, well-bound in an attractive, high-quality hardcover which bears a nice crystal drawing of tennantite epitactic on pyrite from Quiruvilca, Peru (*Mineralogical Record,* **4**, 159–163). There are no other crystal drawings or illustrations in the book. For those who value books by considering the number and quality of illustrations, this volume has no appeal, but for those who read and use mineralogic information, it is worth the steep price ($82.50), which works out to about 14 cents per species. The volume is printed on high-quality, acid-free, white paper of adequate opacity, and it accepts pencil-writing (and erasing!) very well, a significant asset for a book that will assuredly be a gracious host to many handwritten additive notes as the years progress and the literature expands. The book lies flat when opened, all the way from page 1 to page 588, and is a comfortable book to hold and read; unlike some of larger page size, it is not unwieldy. The whole volume is useful; there are no fat margins or gimmicks to expand the number of pages. There is no padding, no corner-cutting, and no nonsense; this compilation is both well done and well published.

All the minerals in the chemical classes covered (elements, sulfides, sulfosalts, etc.) are combined in **one** alphabetically arranged volume (from acanthite to zvyagintsevite). For those familiar with the chemical-class separations of the Data System, this requires some adjustment (copper follows cooperite and precedes corderoite). For those who have used and learned the Dana System, this format requires even more adjustment; for most, the adjustment should be easy. It took a few days before I was wholly comfortable with it and, begrudgingly, acknowledged the benefits of the format. Each page contains one mineral only, a format which might draw some criticism: it is difficult to distill the abundant locality information for the more common minerals. Localities for the rarer species are given in more comprehensive detail, so white space is not excessive, even on pages discussing the rarer minerals. What white space exists is in just the right places and will no doubt be useful; it is on pages which discuss minerals for which there is sparse data, and provides space for future annotations. I am pleased it is available.

The overall presentation is well-balanced. The top of each page contains the mineral name and chemical formula, and here another thoughtful technique has been employed. The mineral names are in all cases at the outer edge of the page; the chemical formula is near the spine. Thus, the header is reversed on alternate pages, and the book is very easy to use; it can be thumbed through rapidly in a search for a specific mineral name. Indeed, this is a searching asset which, together with the alphabetical arrangement, makes a table of contents and an index unnecessary. However, this alphabetical arrangement precludes the exposition of relationships among minerals. One of the great advantages of compilations and compendia is that the user comes to recognize groups of minerals and how they are related. This important and great concept of group relations is missing, nearly entirely, in this alphabetical work. Regretably, the authors have not attempted to compensate for it in appropriate sections, by adding this group-membership information to the "polymorphism and series" section where it would logically fit, or by adding a group section or groups appendix. The pyrite section mentions only one other of the 19 members of the pyrite group; the linnaeite section mentions only one other of the 13 members of the linnaeite group; the goldfieldite, hakite, and giraudite sections made no mention of the parent tetrahedrite group, and so on.

The page presentation format, explained briefly in the introduction, consists of headings for crystal-data, physical properties, optical properties, cell data, X-ray powder pattern, chemistry, polymorphism and series, occurrence, association, distribution, name, type material, and references. Only a few of these need explanation here. The "crystal-data" section provides crystal system, point group, appearance, forms, and twin laws; there are no angle-tables or crystal drawings. The "occurrence" section describes geological processes and physicochemical environments of origin. The "distribution" section lists the most important localities, up to twelve.

I checked the numerical data for a large number of species and found it to be carefully recorded. Typographical errors were not observed; much attention has been given to diacritical marks and spelling; editing has been careful; and the authors' attention to detail is obvious and praiseworthy.

However, some criticisms of parts of the work are warranted. The uneven presentation of interaxial angles using both degree/minute format and decimal format is regretable. Although the authors state that "locality information is not referenced," they do not clearly state if it is all supported by the literature (some is). Clearly, the authors consider it reliable or they would not have published it, but they do not convince the reader, nor attempt to. Thus, the given information cannot always be evaluated for reliability. In this matter, as in a few others, the introduction is weak in depth and explanatory detail; it is very well written, but inadequate.

The references in general frustrate this reviewer. Not only is the locality information not referenced, but no other data or information is linked to a cited reference either. There is no way to tell which data or information came from which reference, and this flaw diminishes the scientific usefulness of the book. For the mineralogist, this is a substantial shortcoming. The references are numbered sequentially (1, 2, 3, etc.) but these numbers serve no apparent purpose; they are not cited or used in text. Apparently, all they do is separate the references from each other. Additionally, they are in part confusing inasmuch as the same digits (and type-size) are used for the different chemical analyses; this can lead the casual reader to presume the analytical data (analysis #2 for example) are drawn from the reference with the corresponding number (#2). This confusion is compounded in some instances because for younger species, the first reference is for the first description of the mineral and the first analysis *is* drawn from it. The authors should have used some other symbol as a reference-divider or, at least, a different size type for reference numbers.

These few criticisms notwithstanding, this is a very significant volume, compiled by mineral people for mineral people. I will use it, treasure it, and here tell everyone that the authors deserve much gratitude for actually doing what others have only talked about. Bravo!

Pete J. Dunn
Mineral Sciences
Smithsonian Institution

Microminerals

Bill Henderson

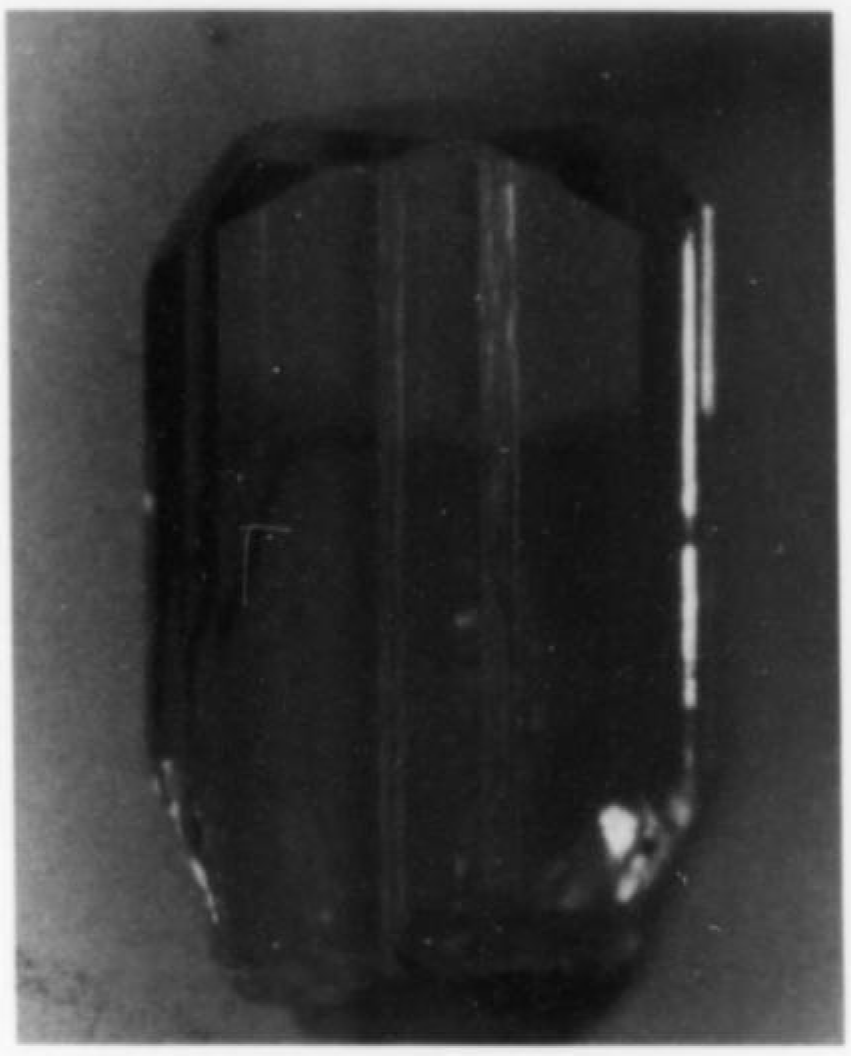


Figure 1. **A colorless, 5-mm barite crystal from the Paga mine, Cartersville, Bartow County, Georgia.**

On Barite and Other Matters

During the last several months, my good wife and I have been so involved with selling one house, buying and fixing up another, moving, and retiring, that important things such as minerals have suffered from neglect. Now, with things slowing down, I find time to write my first column on microminerals in over a year. Before getting on to minerals themselves, I would like to ask the reader's help in two areas, both of which will aid me in improving the column.

First, I would like your opinions of past columns. What did you like? Dislike? How could columns be improved? What topics for columns did you like? What would you like to see as topics of future columns?

Second, I have from time to time written about micromineral news and about specimens sent to me by readers; I would like to do more of this. I would welcome news, photos, or the loan of specimens for photographing where readers have something they think would interest other micromineral collectors. Contributed text will, of course, be acknowledged, and would appear either verbatim or rewritten by myself. However, I would much prefer to receive a written description of what readers wish to submit before looking at any specimens in the flesh.

In the past, I have tried to respond to every letter I have received, and I will try to continue doing so. However, I cannot predict the response the above will elicit, so it may be a long time before I can reply to everyone.

* * *

The subject of this column, barite microminerals from various localities, was inspired by some truly phenomenal examples I received a while ago from Russell Smith of Cartersville, Georgia. The locality is the Paga mine, located in Cartersville, Bartow County, Georgia. Opened in 1916, the mine is still going strong. Russell writes that the deposits there are residual in nature, left over from the weathering of barium-containing rocks. They are associated with the Weisner quartzite and Sandy limestone formations, but are found in boulders in the residual deposits. The microcrystals (there are hand specimens to be found also) occur in large barite boulders and in limonite concretions. Russell has a family interest in the deposit, since his uncle was vice-president of Thompson-Weinman, the company that operated the mine from 1938 to 1948. It is now owned by Cyprus Minerals Corporation.

The first crystal shown, like most of the other barite microcrystals from the Paga mine, is white, glass-clear, extremely sharp, and exhibits a number of different crystal faces. While many of the barites are singles, there are frequent crystal groups such as that shown in Figure 2 and, less frequently, crystals in parallel groups such as the ones in Figure 3. Figure 4 is interesting for what appears to be a series of three crystals in parallel growth and with a sawtooth configuration. In fact, these are portions of a single crystal with, at first, a columnar habit. This now appears as a faint phantom in the upper portion of the photo. In the second period of growth, the crystal grew sideways, assuming almost a square-tabular habit, and giving the final sawtooth form. Part of this specimen and many others are coated with manganese oxides. Figure 5 shows still another crystal group with very sharp, black phantoms of manganese-coated barite covered by a second generation of barite.

Russell is very fortunate in being the only person, or one of very few, who is allowed to collect at this remarkable locality. He has told me that he is ready to exchange either microcrystals or larger hand specimens, but he is only interested in hand specimens in return. Write first before sending anything. His address is P.O. Box 983, Cartersville, GA 30120.

Even more complex crystals of barite, with an equant habit, are found on dark brown siderite at Frostburg, Allegany County, Maryland. Shown in Figure 6, they are also colorless and glassy clear. Some of the crystals are heavily striated. The specimens shown here were gifts from the late Neal Yedlin, received from him in 1956.

Figure 7 shows a barite crystal from Elk Creek, Meade County, South Dakota. Pale yellow in color, it is entirely unlike those from the previous localities in that it is rounded and distorted, rather than complex and sharp. As with most microcrystals, it is clearer than most hand specimens. Some of the features in the photo, for instance the little dimples near the base, are actually on the back of the crystal, not the front. Near the top is a healed fracture. I could not resist showing this fine microcrystal even though the location has been written up in this journal in the past (*Mineralogical Record*, **18**, 125–130 (1987)).

Australia has produced some excellent barite microcrystals such as the group of subparallel crystals shown in Figure 8. These are from Moralana, in the Flinders Range of South Australia. Again, the crystals are transparent and without color. They are contained in a small dissolution cavity in coarse, massive barite, and are all growing from a single larger crystal. This explains why they, and other groups of

Figure 2. **A 4-mm group of colorless, striated barite crystals from the Paga mine.**

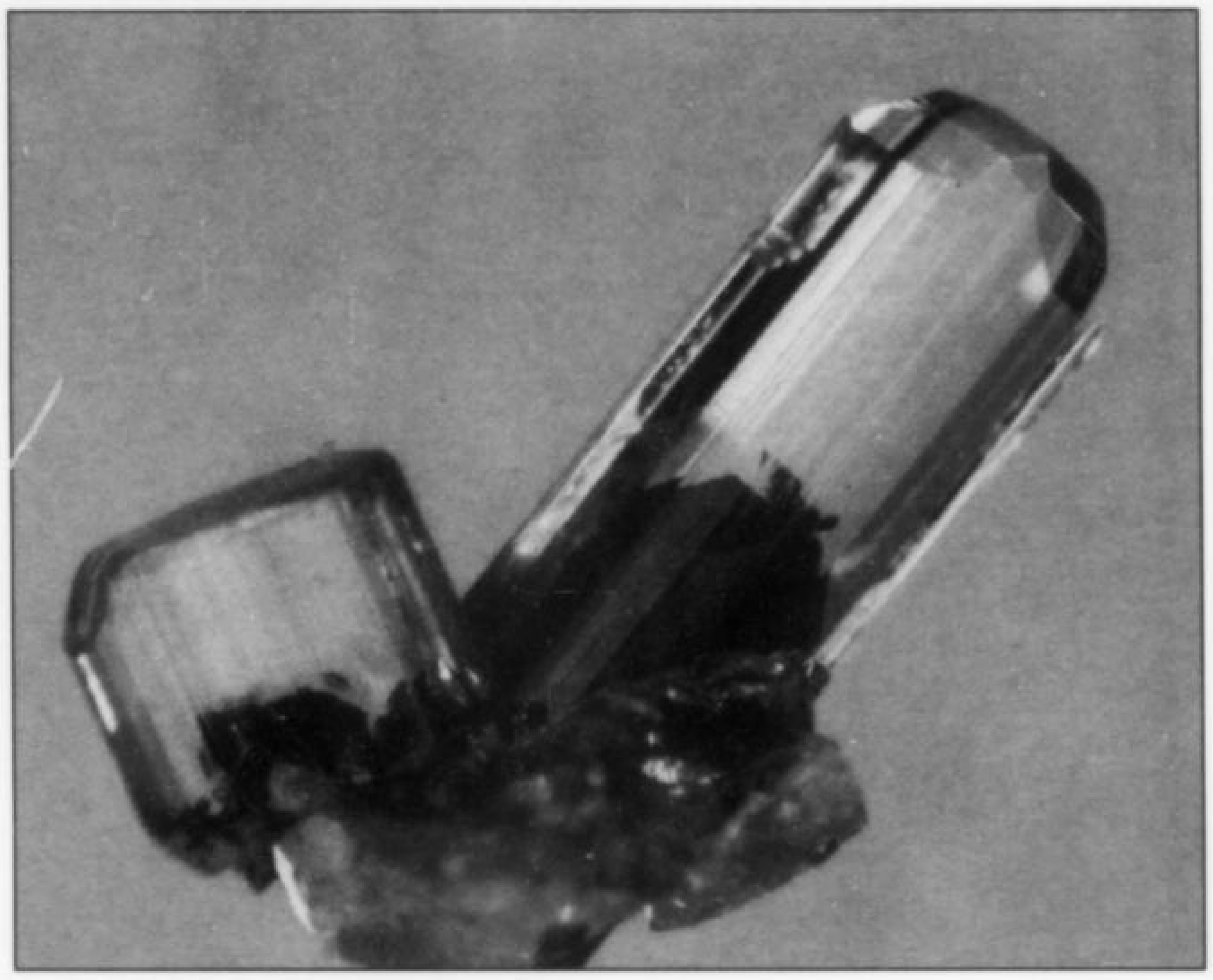


Figure 5. **Barite crystals from the Paga mine, colorless but with black phantoms covered with manganese oxides. The larger crystal is 2.5 mm long.**

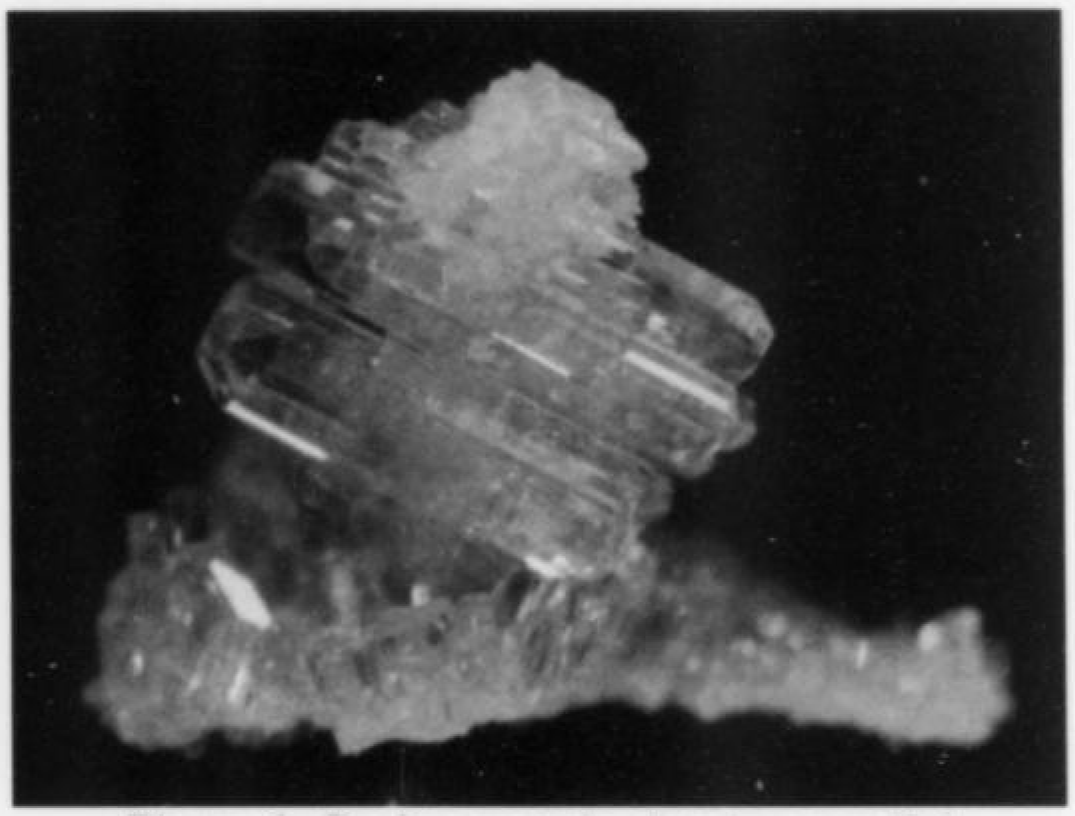


Figure 3. **Barite crystals showing parallel growth, from the Paga mine; the group is 5 mm across.**

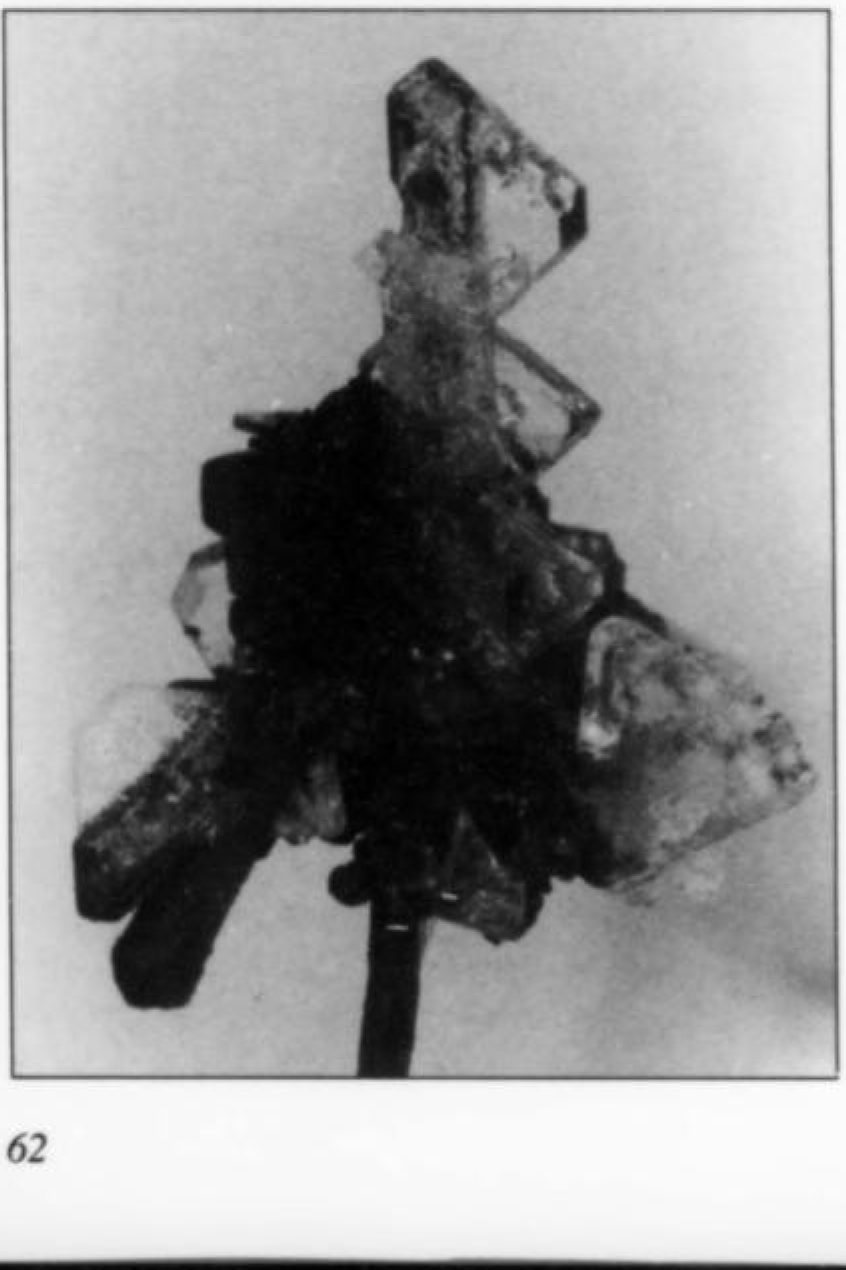


Figure 4. **Colorless barite crystals from the Paga mine, some coated with manganese oxides. The crystal at lower left shows a first generation of columnar growth followed by a second generation in which the saw-tooth projections were formed. Size of group, 3.5 mm.**

crystals within the cavity but on other larger barites, are all in parallel growth. The crystal shown in Figure 9 was sent to me by another collector, the locality being given as "30 km north of Hawker, South Australia." Since the crystal form and occurrence of the two specimens were so similar, I suspected that the two localities were one and the same. I wrote to Peter Elliott, of Carey Gulley, South Australia, who had sent me one of the two specimens. He writes: "I am sure the specimens are from the same locality. There was a group of localities in the Moralana area almost exactly 30 km north of Hawker. The quarries were filled in several years ago. . . . The area is one of the most scenic in a beautiful mountain range. . . . The Moralana deposit was first worked in 1947 by the Broken Hill Proprietary Company.

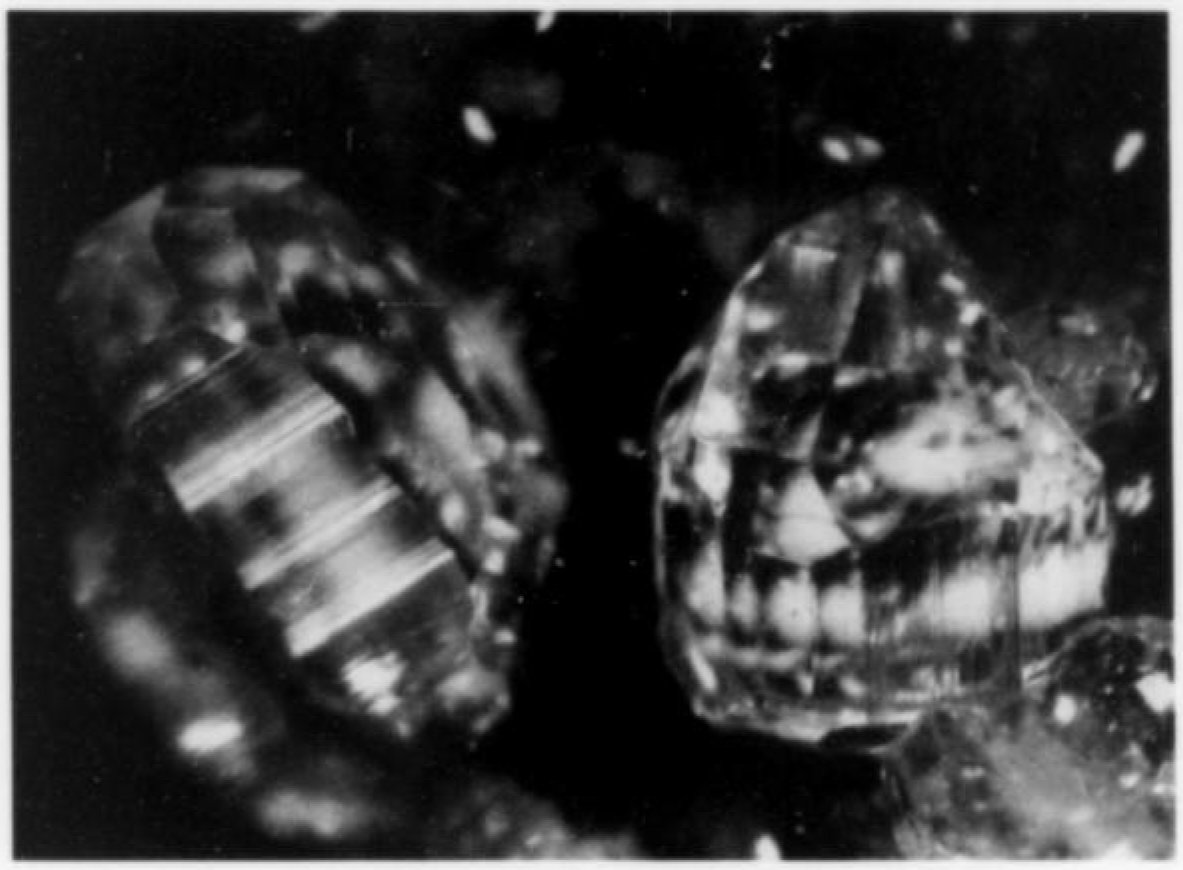


Figure 6. **Two colorless, 1.5-mm crystals of barite from Frostburg, Maryland.**

Figure 7. **Tan crystal of barite, 9 mm long, from Elk Creek, Meade County, South Dakota.**

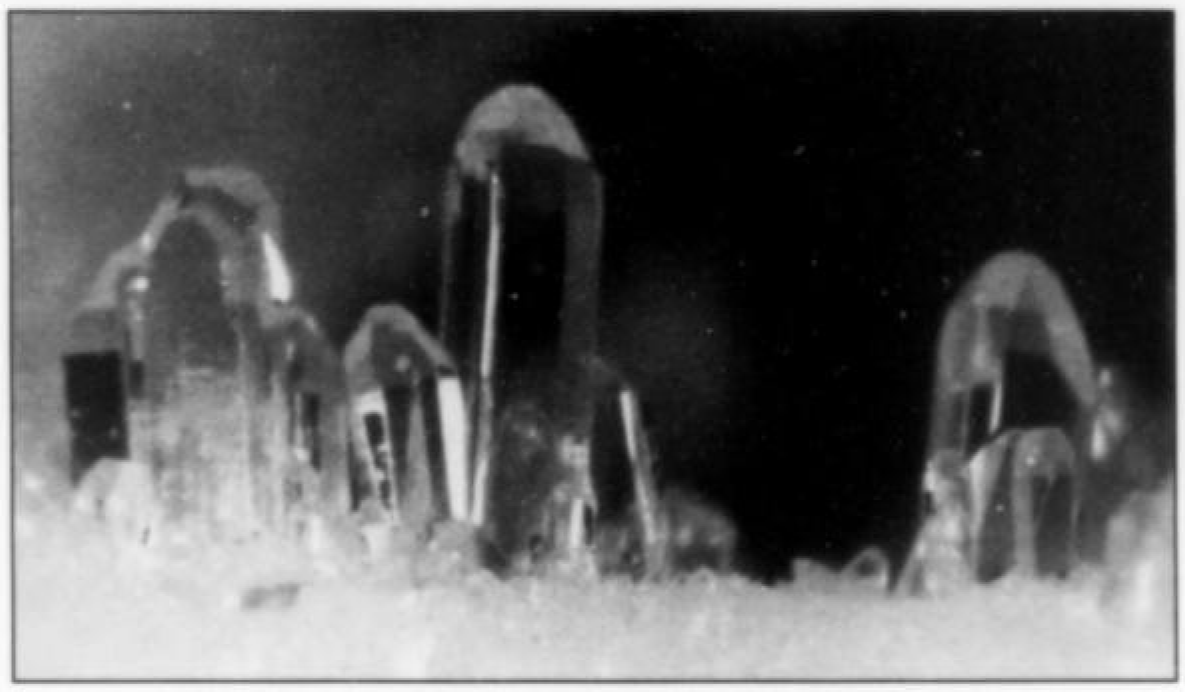


Figure 8. **Colorless, columnar crystals of barite in parallel growth in a solution cavity in barite. The crystal group, from Moralana, Flinders Range, South Australia, Australia, is 3 mm across.**

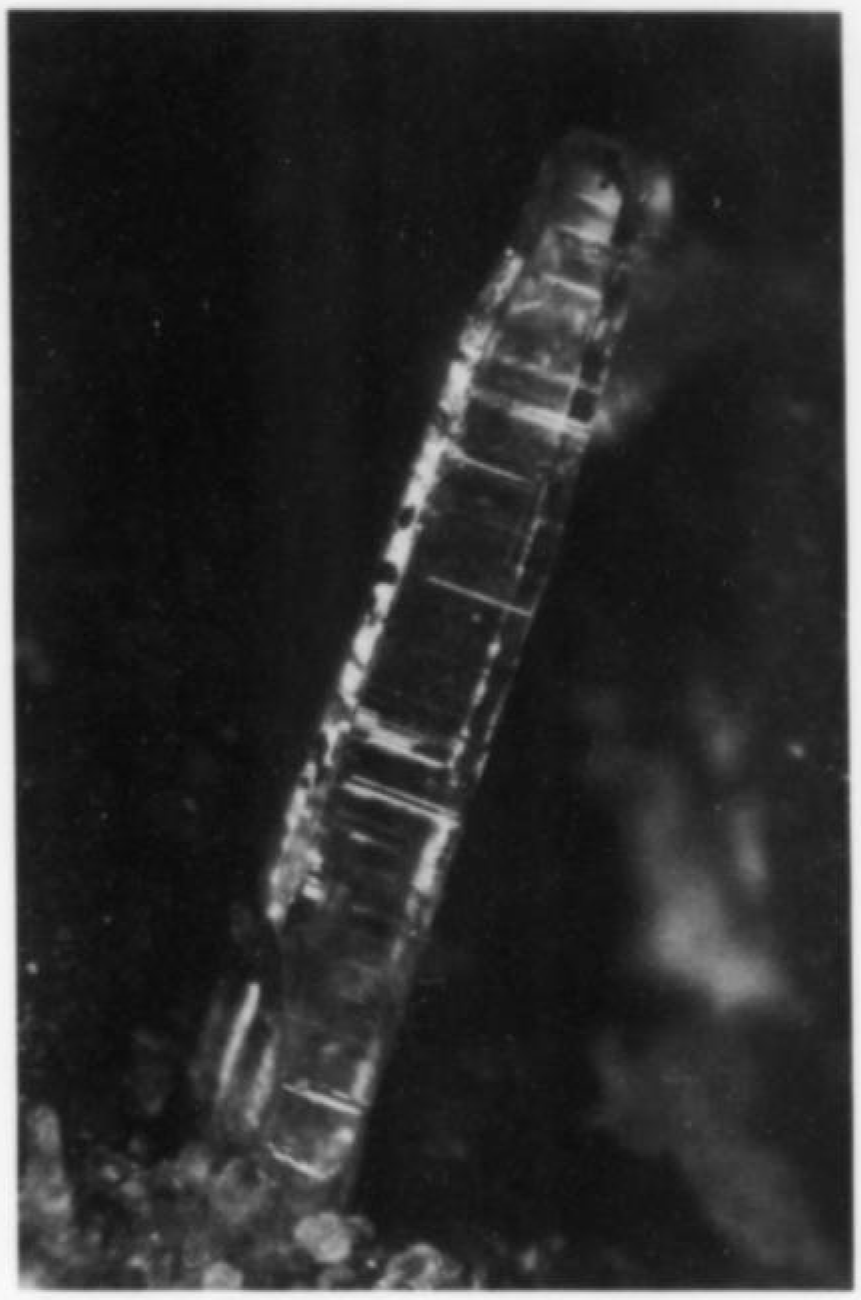


Figure 9. **Colorless, striated, 2.5-mm barite crystal in a cavity with manganese oxides. From 30 km north of Hawker, South Australia, Australia.**

Figure 10. **Pale tan barite crystals, the largest 4 mm in height, from the Rio Tinto mine, Huelva, Spain.**

. . . The barite occurs in veins and lenses emplaced in fault and breccia zones cutting across the folded country rock . . . associated minerals are minor hematite, goethite and romanechite."

The crystals from the Rio Tinto mine, Rio Tinto, Huelva Province, Spain (Fig. 10) are pale tan in color. The largest are about 4 mm

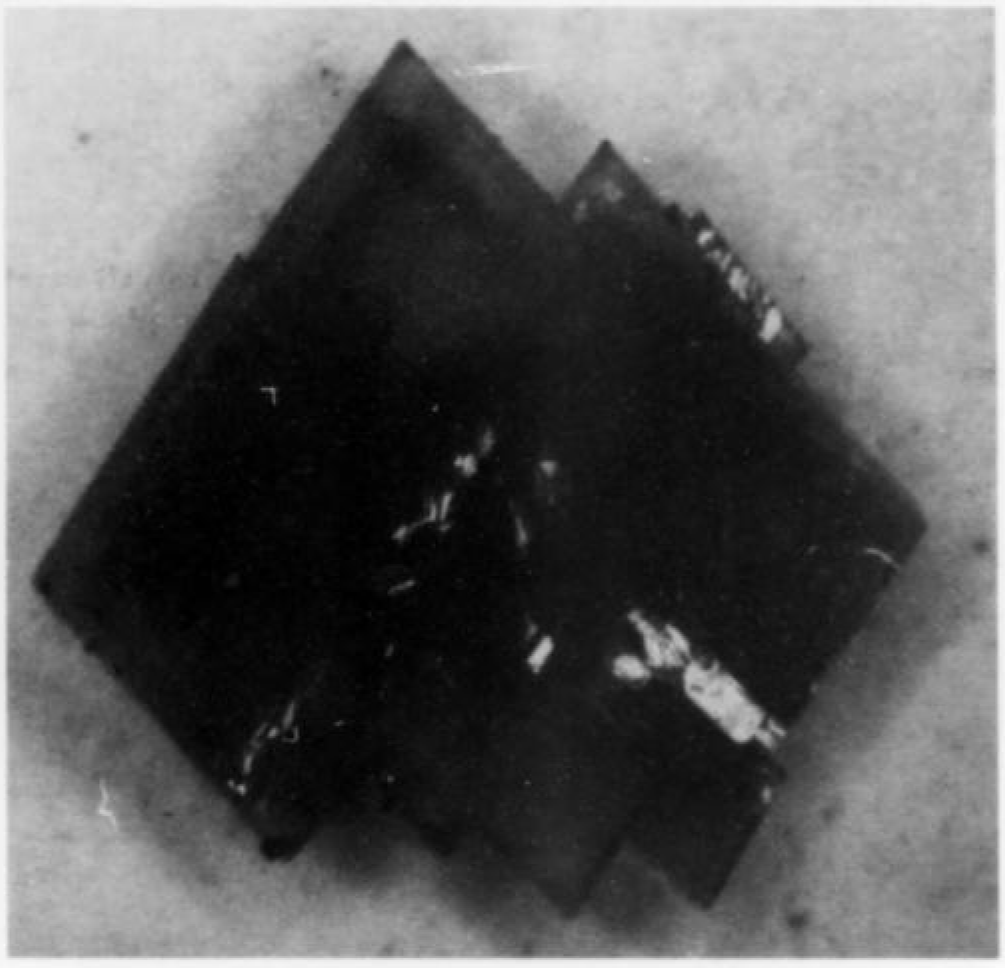


Figure 11. **Transparent, orange, tabular crystals of barite with pyrite inclusions. The group is 3.5 mm across, and is from Metaline Falls, Pend Oreille County, Washington.**

long, and they differ from earlier barites shown in that their form is tabular and with a lens-shaped cross-section.

Barite microcrystals from Metaline Falls, Pend Oreille County, Washington, are well known to collectors of micromounts. The ones in Figure 11 are in parallel growth, and have a tabular habit. Their color is a dull orange, and they often show inclusions of small pyrite crystals. Some of the pyrites are acicular, as are the ones in this photo.

The last barites shown are bright yellow, acicular crystals from the Old County mine, Wymore, Gage County, Nebraska. They are found in small cavities, and are associated with a colorless, rhombohedral carbonate, most likely calcite.

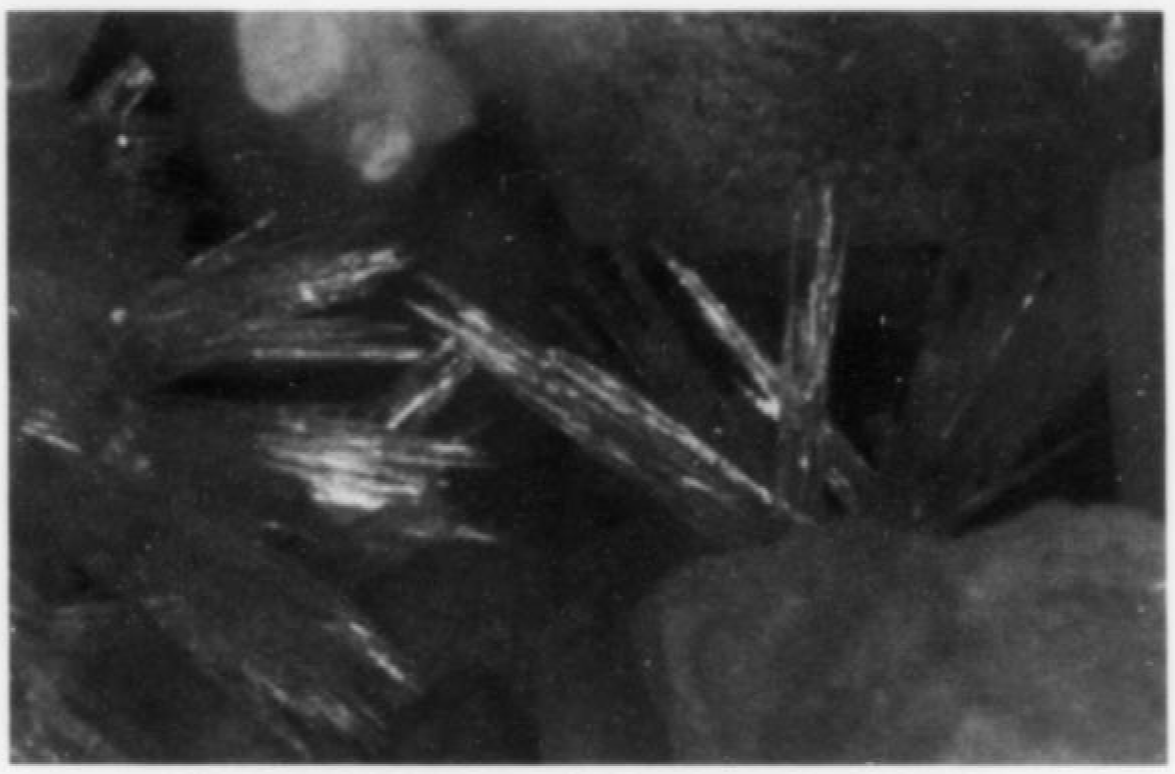


Figure 12. **Yellow, acicular crystals of barite from the Old County mine, Wymore, Gage County, Nebraska. The field of view is 3 mm.**

I will end this column with a request which would be found in the section of English newspapers called "Personals." Would the person who sent me for identification colorless to rusty brown, acicular crystals in partially euhedral quartz crystals please write again? I have the mineral identification, but have misplaced his letter.

Happy hunting!

Wm. A. Henderson, Jr.
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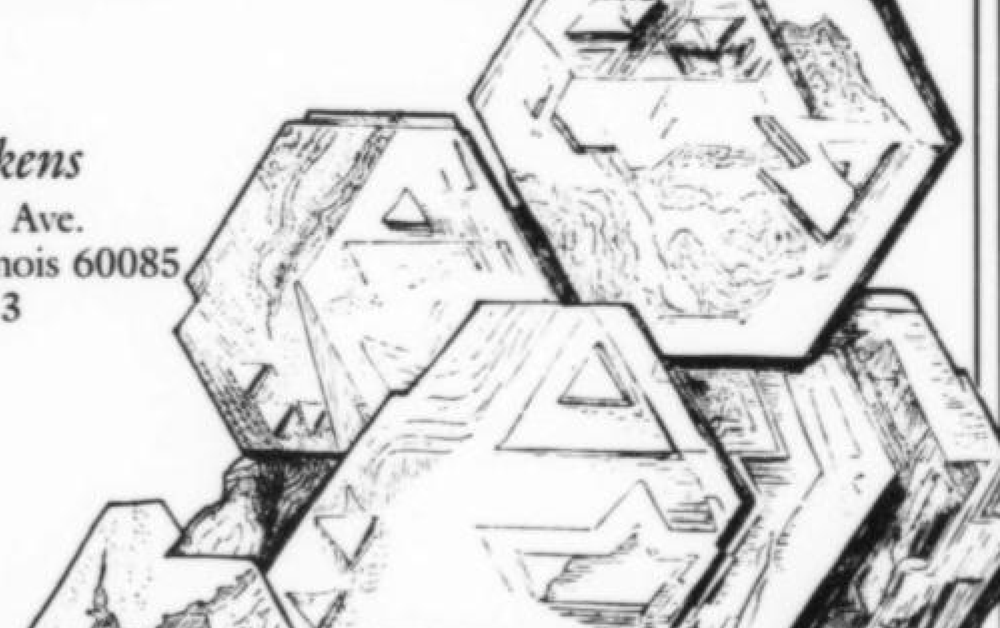
Madison, CT 06443



FM-TGMS-MSA SYMPOSIUM ON AZURITE AND OTHER COPPER CARBONATES

The 12th annual Tucson Mineralogical Symposium, sponsored by the Friends of Mineralogy, the Tucson Gem and Mineral Society, and the Mineralogical Society of America, is to be held on Saturday, February 16, 1991, in conjunction with the Tucson Gem and Mineral Show. Azurite is the featured mineral at the 1991 Tucson Show, and hence, was chosen as the subject for the 1991 mineral symposium. Because azurite shows no significant compositional variation, and little color variation, the symposium discussions will also include other copper carbonates.

Azurite occurs as azure-blue, monoclinic, prismatic to blocky crystals. Its habit varies widely, and its luster is vitreous to adamantine for transparent crystals, but dull and earthy for massive forms. Azurite, and all other copper carbonates, are secondary minerals that form in the oxidized surface environment. They are commonly associated with ore deposits. Malachite is the most abundant copper carbonate and occurs in almost all outcrops of copper-bearing ore deposits. Its common occurrence, emerald-green color, and botryoidal morphology have permitted it to be one of the most widely known minerals among the general population. Azurite can be found throughout the world; the most notable localities in the United States are Bisbee and Morenci, Arizona, and Kelly, New Mexico.

With the exception of kolwezite (which is black to beige) all other known copper carbonates are blue, green, or shades of these two colors. The following list includes most of the known copper carbonates:

Aurichalcite	$(Zn,Cu)_5(CO_3)_2(OH)_6$
Azurite	$Cu_3(CO_3)_2(OH)_2$
Caledonite	$Pb_5Cu_2(CO_3)(SO_4)_3(OH)_6$
Callaghanite	$Cu_2Mg_2(CO_3)(OH)_6 \cdot 2H_2O$
Carbonate-cyanotrichite	$Cu_4Al_2(CO_3,SO_4)(OH)_{12} \cdot 2H_2O$
Carrboydite	$(Ni,Cu)_{14}Al_9(SO_4,CO_3)_6(OH)_{43} \cdot 7H_2O$ (?)
Chalconatronite	$Na_2Cu(CO_3)_2 \cdot 3H_2O$
Claraite	$(Cu,Zn)_3(CO_3)(OH)_4 \cdot 4H_2O$
Georgeite	$Cu_5(CO_3)_3(OH)_4 \cdot 6H_2O$
Glaukosphaerite	$(Cu,Ni)_2(CO_3)(OH)_2$
Kolwezite	$(Cu,Co)_2(CO_3)(OH)_2$
Malachite	$Cu_2(CO_3)(OH)_2$
McGuinnessite	$(Mg,Cu)_2(CO_3)(OH)_2$
Nakauriite	$Cu_8(SO_4)_4(CO_3)(OH)_6 \cdot 48H_2O$
Rosasite	$(Cu,Zn)_2(CO_3)(OH)_2$
Schuilingite-(Nd)	$Pb,Cu(Nd,Gd,Sm,Y)(CO_3)_3(OH) \cdot 1.5H_2O$
Schulenbergite	$(Cu,Zn)_7(SO_4,CO_3)_2(OH)_{10} \cdot 3H_2O$
Tyrolite	$CaCu_5(AsO_4)_2CO_3(OH)_4 \cdot 6H_2O$
Voglite	$Ca_2Cu(UO_2)(CO_3)_4 \cdot 6H_2O$ (?)
Wherryite	$Pb_4Cu(CO_3)(SO_4)_2(Cl,OH)_2O$
Zincrosasite	$(Zn,Cu)_2(CO_3)(OH)_2$

12th ANNUAL MINERALOGICAL SYMPOSIUM

10:15 A.M. - 1:00 P.M.
Saturday, February 16, 1991

10:15-10:25	Introductory remarks—Symposium Chairperson ***Dr. Karen J. Wenrich***
10:25-10:50	Azurite and malachite: chemically and structurally related minerals ***Dr. Paul H. Ribbe*** and ****Dr. Susan C. Eriksson***
10:50-11:15	Azurite and malachite from the Morenci and Metcalf mines, Greenlee County, Arizona ***Robert M. North***
11:15-11:40	Azurite and other copper carbonates in northern Arizona solution-collapse breccia pipes ***Dr. Karen J. Wenrich***
11:40-12:05	Azurite roses—A comparison of their morphologies at Bisbee, Arizona, and Grant County, New Mexico ***Richard W. Graeme***
12:05-12:30	New Mexico azurite ***Ramon S. DeMark***
12:30-12:55	Habits and haunts of azurite microcrystals ***Dan Behnke***

* = Speaker

ABSTRACTS

Azurite and Malachite: Chemically and Structurally Related Minerals

Paul H. Ribbe and **Susan C. Eriksson**
Department of Geological Sciences
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061-0420

Azurite [$Cu_3(CO_3)_2(OH)_2$] and malachite [$Cu_2(CO_3)(OH)_2$] are commonly found in supergene copper deposits. They have closely related compositions, differing only in the ratio of CuO, CO_2 and H_2O—azurite is 3:2:1 and malachite 2:1:1. The occurrence of malachite pseudomorphs after azurite can be explained by the simple reaction:

2(azurite) + 1(water) → 3(malachite) + 1(carbon dioxide)

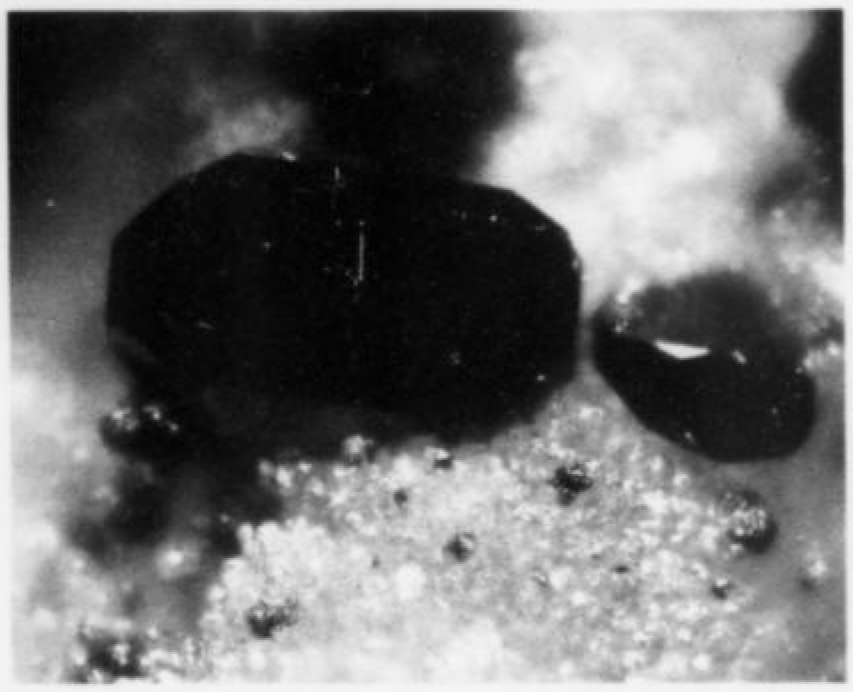


Figure 1. **Azurite crystal, 0.4 mm, from the Tynagh mine, County Galway, Ireland. Dan Behnke collection and photo.**

Figure 2. **Azurite crystal, 1.0 mm, from Cap Garonne, France. Dan Behnke collection and photo.**

Figure 3. *(below)* **Azurite crystal group on matrix, 6.4 cm, from Chessy, France. William Larson collection.**

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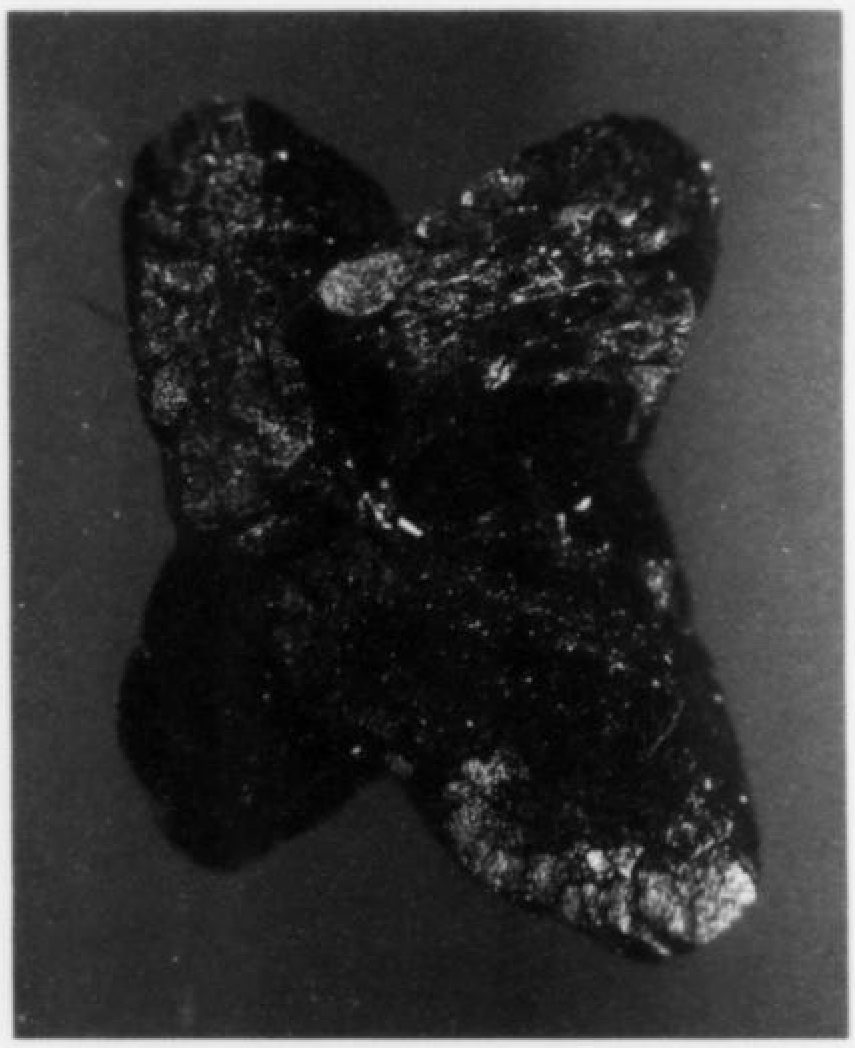


Figure 4. *(left)* **Intergrown (twinned?) azurite crystals, 3 cm, from the Emma mine, Fierro, Grant County, New Mexico. Monica Graeme collection and photo.**

WEW

Figure 5. **Azurite crystal, 5.8 cm, from Bisbee, Arizona. Gene Schlepp specimen; now in the Richard Graeme collection.**

or $2(3CuO{\cdot}2CO_2{\cdot}H_2O) + H_2O \rightarrow 3(2CuO{\cdot}CO_2{\cdot}H_2O) + CO_2$

Azurite and malachite owe their respective idiochromatic blue and green colors to the presence of divalent copper, Cu^{+2}, which has 9*d* electrons. In both structures the copper atoms are bonded to four oxygens (O^{-2}) and/or hydroxyls (OH^-) arranged at the corners of a distorted square. The Cu-(O,OH) interatomic distances range from 1.93 to 1.99 Å in azurite and 1.92 to 2.12 Å in malachite. There are additional near-neighbor oxygens and/or hydroxyls bonded to Cu^{+2} cations in azurite (at 2.36 to 2.98 Å) and in malachite (at 2.35 to 2.63 Å). These seemingly small differences in bonding produce significant differences in the ways that the *d* electrons of Cu^{+2} absorb energy from a beam of light. This is a "crystal field" effect. A careful comparison of the structures of azurite and malachite sheds light on the striking differences in color of the two closely related minerals.

Azurite and Malachite from the Morenci and Metcalf mines, Greenlee County, Arizona

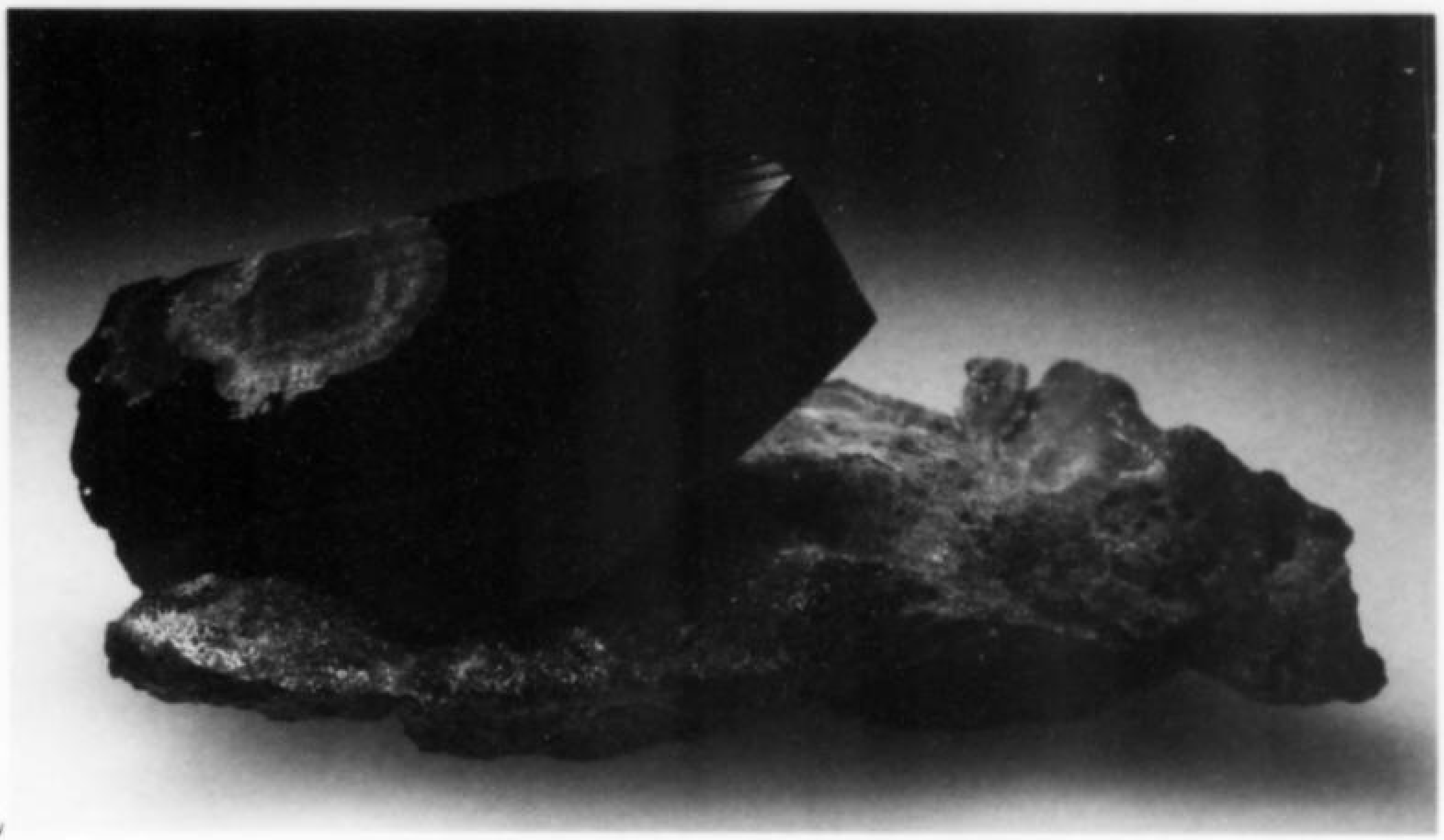
Robert M. North
Phelps Dodge Morenci, Inc.
P.O. Box 187
Morenci, Arizona 85540

Azurite and malachite are common in oxidized skarn deposits in Paleozoic carbonate rocks adjacent to Laramide porphyry intrusives in the Morenci district. Malachite with minor azurite also commonly occurs in fractures in the oxidized ores in other rock types in the district. Specimen-grade material is generally restricted to the oxidized skarn occurrences.

Figure 6. (above) **Malachite (non-pseudomorphous) crystals on matrix, 6 cm, from the Emke mine, Onganja, Namibia.**

Figure 7. (below) **Malachite pseudomorph after azurite, 7.2 cm, from Tsumeb, Namibia. Wayne and Dona Leicht collection.**

Figure 8. **Azurite crystal, 6 cm, showing incipient alteration to malachite, from Tsumeb, Namibia. Collection of the Harvard Mineralogical Museum.**



The Paleozoic section at Morenci includes two carbonate units, the Ordovician Longfellow Limestone and the Mississippian Modoc Limestone, both of which have some dolomitic beds. Calc-silicate skarn has been developed in both units on the southeast side of the Morenci mine where they have been intruded by monzonite porphyry dikes and sills. The skarns contain diopside, epidote, garnet and tremolite with some localized actinolite, chlorite, magnetite, idocrase, specular hematite and talc. Primary sulfide minerals occurred as late-stage pyrite-chalcopyrite ± bornite in veins. Azurite and malachite formed when these veins reacted with oxygenated water, forming acidic solutions which were then almost immediately neutralized by calcite and perhaps dolomite. Other minerals that formed by supergene oxidation of the skarn deposits include chrysocolla, tenorite and occasionally native copper and cuprite. Azurite and malachite commonly occur as alternating layers, usually with chrysocolla, and as coatings on bedding planes. Azurite crystals up to about 2 mm occur locally in druses completely lining vugs and fissures; these are some of the more attractive mineral specimens from the district. Azurite and malachite stalactites are also well known among collectors. Well-formed, deep-blue, blocky to platy azurite crystals up to 2 cm have been found in a vuggy hematite-goethite matrix along a fault cutting Longfellow Limestone and a monzonite porphyry dike in the southeastern portion of the Morenci mine. Pseudomorphs of malachite after azurite are common from this zone. Cuprite and native copper also occur in the fault, with cuprite crystals up to 1 cm, commonly coated by a silky, pale green aggregate of malachite and sericite.

Skarn deposits also formed on the north side of the Metcalf pit where the Longfellow and Modoc Formations are in contact with a granite porphyry stock and associated dikes and sills. This zone is less extensive than the skarn on the east side of the Morenci pit, but it contains some attractive layered azurite and malachite, and drusy azurite similar to that from the Morenci pit.

Azurite and Other Copper Carbonates in Northern Arizona Solution-Collapse Breccia Pipes

Karen J. Wenrich
U.S. Geological Survey
MS 939, Federal Center
Denver, Colorado 80225

Azurite and other copper carbonates have been known for more than 100 years in approximately 35 old copper mines scattered throughout the Grand Canyon. The finely tuned eyes of 19th century prospectors roaming the canyons in search of wealth missed few surface exposures of malachite or azurite along the stepped cliffs bordering the canyons of the Colorado River and its tributaries. Most, though not all, of these copper mines were located within solution-collapse breccia pipes. Among them are such well known mines as the Grandview (from which the first reliable optical data for cyanotrichite were obtained), Grand Gulch, Orphan, Ridenour, Copper Mountain, Copper House, Savanic, and Apex mines (although not located in the Grand Canyon proper—the Apex is only about 50 miles north of the Grand Gulch mine).

Dissolution of the Mississippian Redwall Limestone in Late Mississippian time and subsequent later collapse by the overlying Pennsylvanian and Permian sandstones formed a major district of solution-collapse breccia pipes. This Paleozoic karst development was so extensive that over a thousand of these breccia pipes have been mapped. Approximately 8% of the mapped breccia pipes exhibit surface expressions of mineralized rock—either recognizable copper minerals, most notably malachite, azurite, chrysocolla, or brochantite, or gamma radiation in excess of 2.5 times background.

By the close of Triassic time fluids passing through these porous vertical breccia pipes had precipitated primary sulfides and economic concentrations of uraninite. Prior to uraninite precipitation a large suite (over 30 sulfides identified to date) of Cu-Pb-Zn-Ag-As-Ni-Co-Mo-V minerals were deposited by low temperature (80–173° C) brines. Sulfides such as pyrite, sphalerite, galena, chalcopyrite, enargite, tennantite, lautite, bornite, chalcocite, djurleite, digenite, covellite, arsenopyrite, marcasite, bravoite, siegenite, millerite, gersdorffite, nickeline and rammelsbergite are still preserved in many unoxidized breccia pipes. Most of these primary orebodies have been preserved from azurite-forming and malachite-forming oxidizing groundwaters in part by their "pyrite caps." Underground workings provide the only access to unoxidized orebodies that still contain primary minerals. The orebodies generally lie about 300 meters below the plateau surfaces, although where the pipes crop out along the canyon walls they can be accessed by adits, as at the Orphan mine.

Little alteration of the primary orebodies probably occurred prior to about 5.5 m.y. ago when the present period of canyon dissection became intensive. Since then, canyon erosion has dissected many of the breccia pipes, subjecting the generally dull gray, very fine-grained (<1 mm) sulfides and uraninite to oxidation that created colorful copper carbonates, copper sulfates, iron oxides/hydroxides and uranium oxides. Malachite stalactites and azurite coatings have formed on ceilings above drifts within the primary sulfide ore zone of the Orphan mine since the mine closed in 1969. These secondary minerals are concentrated in the ring fracture zones surrounding the breccia pipes where access was greatest, due to increased porosity, for descending oxidizing ground waters. Minor concentrations of supergene minerals also occur within the breccia matrix of the pipe.

The dominant copper carbonates are azurite and malachite; others that occur in the breccia pipes include aurichalcite at the Grandview mine (more abundant there than azurite or malachite) and rosasite and aurichalcite at the Apex mine. Azurite occurs as deep azure-blue, short prismatic crystals resembling some specimens from Bisbee and Tsumeb. It is most commonly found associated with iron oxides/hydroxides. The chemistry of azurites from the breccia pipes is similar to that found in most azurites from around the world; essentially pure $Cu_3(CO_3)_2(OH)_2$ with little chemical substitution. Scanning electron microscope energy dispersive studies of azurite from the Ridenour mine found no minor or trace elements in concentrations above 5000 ppm. Yet, the azurite is not pure. Brochantite ($Cu_4(SO_4)(OH)_6$) needles (<10 μm) occur included within the azurite, the sulfate supporting the conclusion that secondary minerals in the breccia pipes had their metal source in the primary sulfide orebodies.

Azurite Roses: A Comparison of Morphologies at Bisbee, Arizona, and Grant County, New Mexico

Richard W. Graeme
Sharon Steel Natural Resources
One Tabor Center
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Denver, Colorado 80202

Azurite, certainly one of the more aesthetically pleasing of all minerals, occurs in a wide range of habits. Perhaps the most striking of its manifestations is that referred to as "azurite roses" (or "rosettes"). This habit might best be described as subparallel, tabular crystals in an overlapping arrangement around a nucleus; the resulting overall shape grades from rhombohedral to lenticular to crudely spherical. Generally, these aggregates are euhedral "floaters" with no point of attachment.

While it has long been known that this habit of azurite occurs randomly in clays, either as isolated roses or in clusters of several roses, at Bisbee and Grant County, the occurrences have little else obviously in common. However, field observations of six individual occurrences have revealed some markedly similar characteristics.

The localities studied are in the Warren mining district, Cochise County, Arizona, and the Hanover-Fierro and Mimbres mining districts, Grant County, New Mexico. In the Warren mining district (Bisbee) three occurrences were studied, two were looked at in the Hanover-Fierro area, and one in the Mimbries district.

In Bisbee, the three sites are: the **Czar mine** (between the 200' level and the 400' level), the **Cole mine** (on the 800' level near the Cole interior shaft), and the **Lavender pit** (Holbrook extension). The Hanover-Fierro sites are: the **Anson S. mine** (open cut) and the **Emma mine** (between the first and second levels). The Mimbries district site was the **Copper Rose mine.**

All of the occurrences had the following characteristics in common:

(1) The hosting clays are in fault zones.
(2) The clays are largely fault gouge, heavily altered by supergene solutions and perhaps hydrothermal fluids.
(3) Non-reactive rocks (sandstone, porphyry) have been faulted into juxtaposition with limestone.
(4) The non-reactive rocks are the source of the copper.
(5) The structures are steeply dipping (55°–85°).
(6) Post-ore movement has occurred along the faults.
(7) Azurite occurs relatively close to a carbonate source.

New Mexico Azurite

Ramon S. DeMark
6509 Dodd Place, N.E.
Albuquerque, New Mexico 87110

Azurite has been reported from 21 of New Mexico's 32 counties. The southwestern portion of the state has the largest number of, and most significant, azurite localities. Although azurite occurrences are widespread in New Mexico, important specimen-producing sites are limited. From the 1890's until after the turn of the century, the Magdalena district in Socorro County produced the largest volume and most aesthetic azurite specimens. Many beautiful specimens associated with malachite, smithsonite, allophane, aurichalcite and fraipontite, primarily from the Kelly, Graphic and Juanita mines, surfaced during the mining of lead and zinc ores. Most of the specimens from this area were dispersed to major Eastern and European collections—few still exist in New Mexico collections.

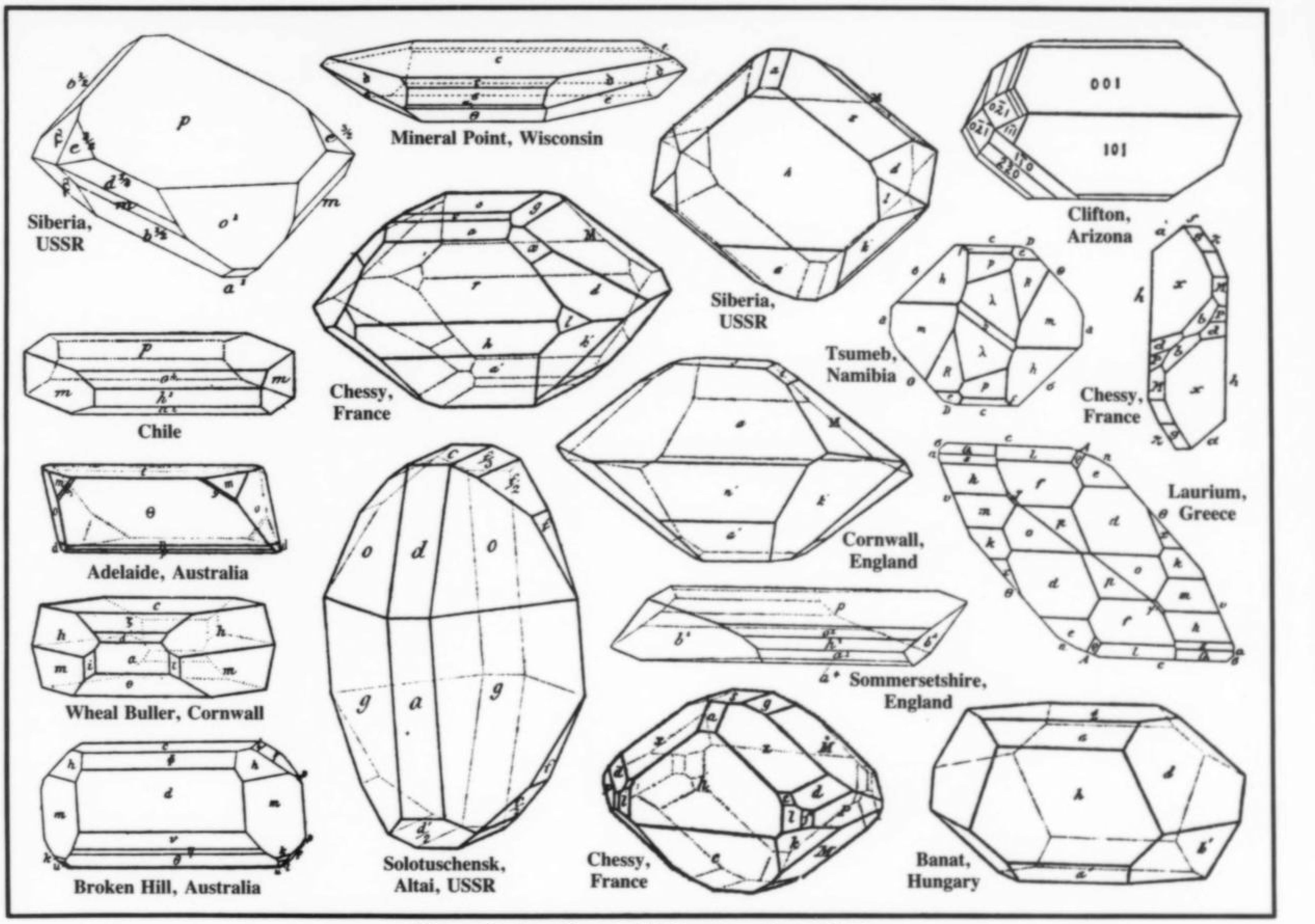

Figure 9. **Azurite crystal drawings from Goldschmidt's *Atlas der Krystallformen* (1918).**

In October, 1981, the most important azurite discovery in recent New Mexico history took place at the Hanover #2 mine in the Fierro-Hanover mining district of Grant County. Individual, highly lustrous, rhombohedral crystals up to 2.5 cm were common along with balls of intergrown crystals, and clusters up to 8 cm across. The crystals occur in a kaolinized fault gouge and were easily retrieved with a pocket knife. Thousands of specimens were obtained and have been widely distributed. The Hanover #2 mine is owned by Sharon Steel Corporation, and access is prohibited without company approval.

The Rose mine in the Georgetown district of Grant County is noteworthy for the occurrence of chalcocite and copper pseudomorphs after azurite crystals. Individual crystals exceeding 4 cm, along with rose clusters and crystal aggregates, occur primarily in the dumps of this mine. Metal detectors are an indispensable tool in locating the copper pseudomorphs. The mine is on Kennecott Copper company property and approval must be obtained before entry.

Habits and Haunts of Azurite Microcrystals

Dan Behnke
2463 N. Lincoln Avenue
Chicago, Illinois 60614

Most mineral collectors have a few outstanding specimens of azurite from notable localities in their collections, but consider the possibility of building a *suite* of azurite specimens from all over the world in a complete range of color and habit. This is not a difficult task if microminerals are included.

Azurite, together with its associated mineral, malachite, occurs throughout the world as a secondary mineral in copper deposits. Localities producing fine crystals in hand-specimen sizes are relatively few in number, but fine microcrystals occur at many additional locations.

While some of the localities discussed will be familiar to the collector, azurite will also be described from such diverse U.S. occurrences as Michigan, Wisconsin, Connecticut, New Jersey and Utah. Foreign localities include England, Ireland, France, Greece, Switzerland, Africa and Australia. Although the danger of overdose exists, some localities will also be described from Arizona, New Mexico, Nevada and Mexico.

Monoclinic crystals of azurite occur in tabular, short prismatic or equant forms as single crystals, groups of single crystals, composites, subparallel groupings or spherical aggregates. Azurite nodules containing crystals are also common. Malachite replacement of azurite produces some interesting pseudomorphs.

To get an idea of the variety of possible habits, consider that there are 305 drawings of azurite (kupferlasur) crystals in Goldschmidt's *Atlas*, taken from numerous worldwide localities (though it is notably short on examples from the Western United States). Azurite occurs in shades of blue from bright, nearly transparent blue to dark blue, almost black and opaque. The azure-blue color and vitreous (almost adamantine) luster of azurite make it a difficult species to photograph. The microcrystals featured range in size from several millimeters to tenths of a millimeter and were photographed using bellows and macro lenses.

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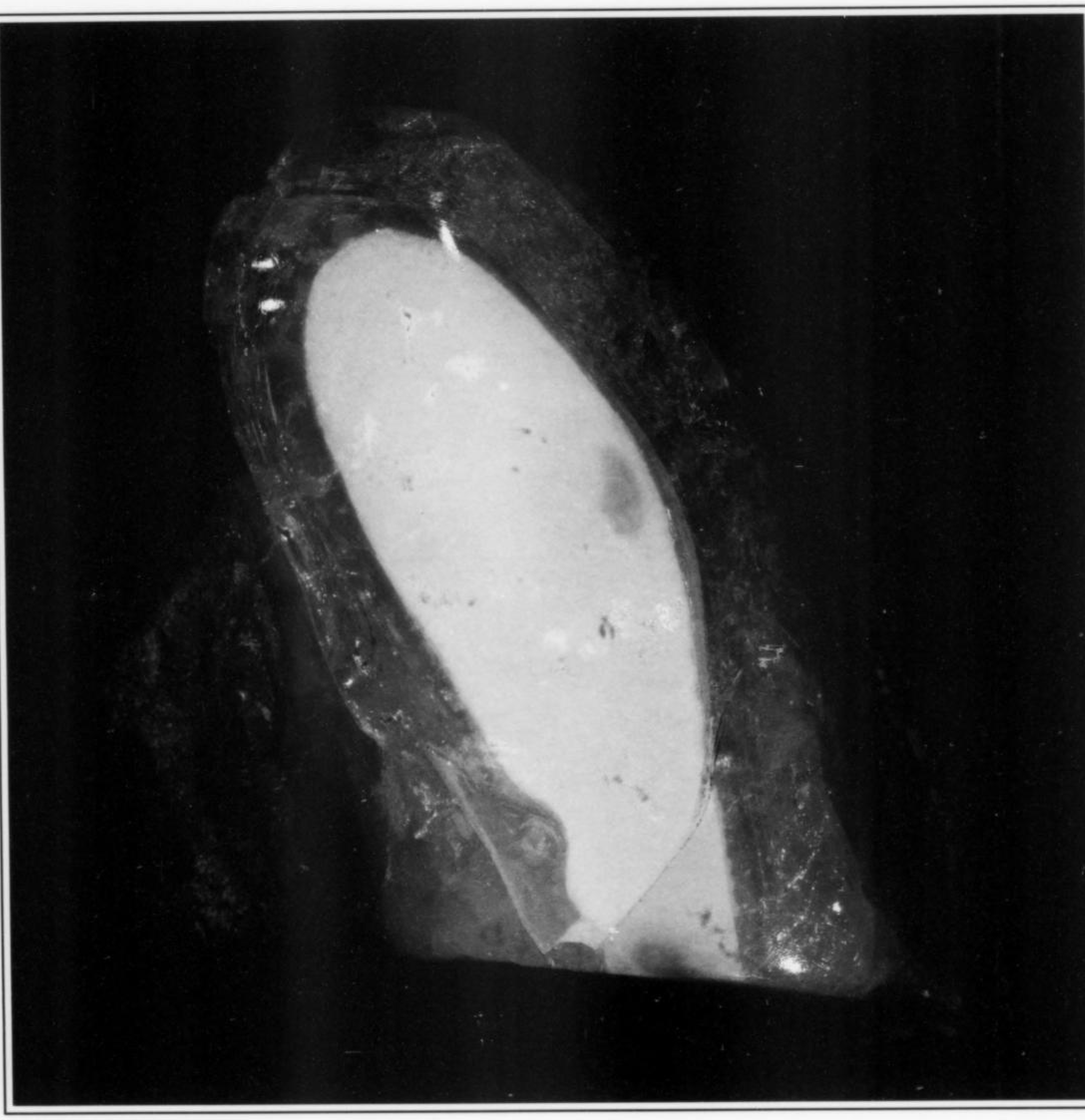

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Letters

CARNEGIE MUSEUM

I want to congratulate you and your team for the fine work you are doing, especially with regard to the Mont Saint-Hilaire issue and the Carnegie Museum catalog. Having personally visited many mineral museums in Europe and in North America, I found it refreshing and a nice change to hear of a mineral museum that is getting better instead of the other way around, like the British Museum, the Strasbourg Museum and the Royal Ontario Museum (still without a new mineral display after the old one was dismantled several years ago). Within a year I will make a special trip to Pittsburgh to see this beautiful museum. Can you publish their hours, address and telephone number?

Jacques Poulin
Westmount, Quebec

Certainly. The Carnegie Museum is located at 4400 Forbes Avenue, Pittsburgh, PA 15213. Their telephone number is 412-622-3131. Currently their hours are 10–5 Tuesday, Wednesday, Thursday and Saturday, 10–9 Friday, 1–5 Sunday, closed Monday and Holidays. An admission fee of $4 is charged for adults and $2 for children. Ed.

RIGHT ANGLE PYRITE

Regarding the article "On right angle bends in filiform pyrite" by Henderson and Francis (vol. 20, no. 6, p. 457), I would like to report another locality from which many possibly unsuspecting collectors may have acquired specimens in the last few years. The calcites on "mountain leather" from Metaline Falls, Washington, especially the dirty looking specimens, are the ones. The "dirt" is acicular pyrite, with right-angle bends being almost the norm. At least this is true of the specimen I have and the few others I've examined.

Lee Riechel
Bothell, Washington

PARIS EXPOSITION SPECIMENS

Here at Redpath Museum we were especially interested in your article in the *Mineralogical Record* on the Paris Exposition of 1900. It has led us to further study of a specimen we have had on display for many years, a superb mica with a label glued to its surface stating that it received the silver medal at the Paris Exposition of 1900. It is from the Grenville Precambrian area north of the Ottawa River at Templeton, Quebec.

Stimulated by your article, I was able to determine that the Canadian exhibits were organized by the Geological Survey of Canada under the guidance of a senior Survey geologist, A. P. Low, who was given the entire year of 1900 on leave from Ottawa to supervise the exhibit. This must have been quite a contribution for the Geological Survey since they were a very small group at that time.

However, judging from the records of both Kunz and Bourgeois, it seems to have been "Mr. Fairbault" who was in charge when the exhibit was open. I can only presume that Low looked after the setting up and dismantling of the exhibit, leaving the guidance of visitors to his Survey colleague. E. R. Fairbault was a geology graduate from Laval University who worked for the Geological Survey of Canada from 1884 until 1932; he would have been very much Low's junior at the time of the Paris Exposition, but he seems to have done a good job providing what Bourgeois called "valuable information."

The apatite crystals mentioned were probably the same, or similar to ones we have from the Grenville area north of the Ottawa River. At that time there were apatite mines, worked for the phosphate content, and mica mines in the same area. Both Kunz and Bourgeois also mention the slabs of labradorite which were

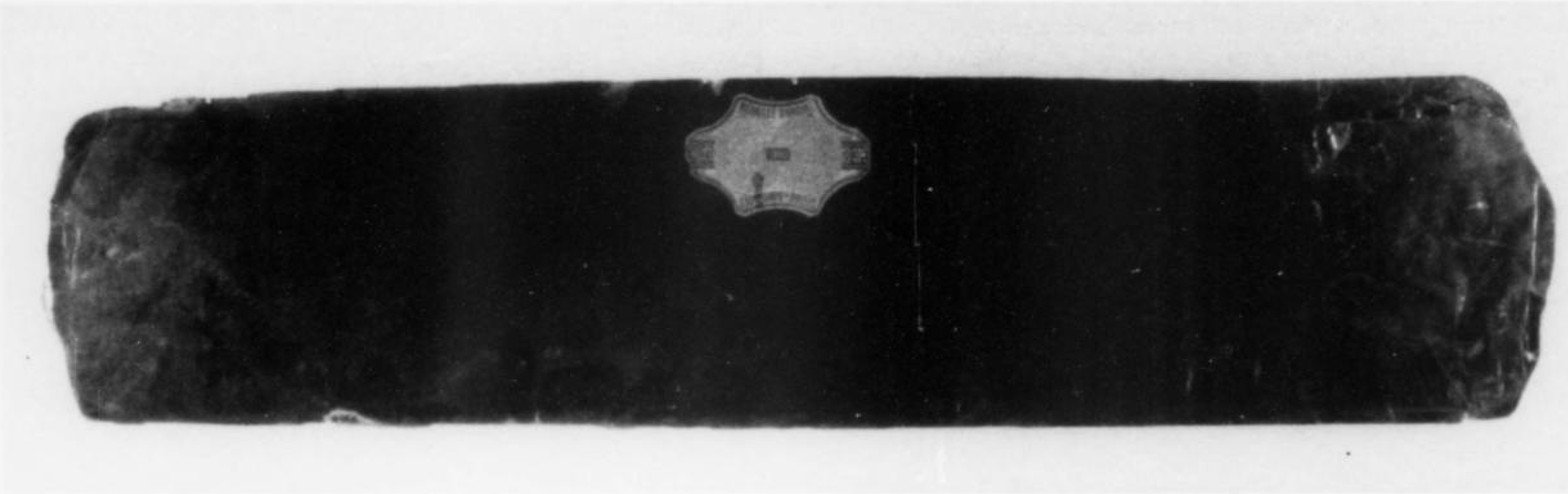

***Figure 1.* A single crystal of phlogopite 41.8 cm long, from Templeton, Quebec, in the Redpath Museum, McGill University; the affixed label signifies a Silver Medal won at the Paris Exposition of 1900. Photo by Murray Sweet. Detail: an enlarged view of the label.**

probably from the Isle of Paul, Labrador, the type location; a very remote spot but one accessible, more then than now, to whaling ships.

It is sad that we do not know more about the disposition of the Canadian exhibit specimens. Perhaps the valuable gold specimens were on loan and were returned to their owners, but I would expect that much of the Klondike gold would have belonged to the Survey and would still be in their collections. After all, Low did have the entire year to devote to the safe transport of the Canadian collection.

I will let you know if any further specimens come to light from the Paris exhibition. Canadian mineral collections are now being computerized and the information is being placed in a single data bank in Ottawa. We will hope that more information will thereby come to light. In any case, we are glad to have the information that you were able to provide.

Louise S. Stevenson
Advisor in Geology
Redpath Museum
McGill University, Montreal

GOLDSCHMIDT INDEX

A few weeks ago I purchased an excellent old-time pyromorphite at Marty Zinn's Springfield [Massachusetts] Show. The label read "Brisgaw, West Germany." The dealer had no other provenance for it.

Not being able to find "Brisgaw" on any maps, and suspecting that it didn't sound like a German name, I ordered your *Goldschmidt's Index*. There I readily found "Breisgau, Germany," a cerussite locality. Now I am 99% sure we have an adulterated spelling as the piece went from dealer to dealer over the years.

Thanks very much for a fine job.

John Marshall
Dedham, Massachusetts

An old gazetteer would certainly list "Breisgau." We use Lippincott's Complete Pronouncing Gazetteer, or Geographical Dictionary of the World, *2336 pages, published in Philadelphia in 1879, and there are many others. But (unlike the* Goldschmidt Index*) gazetteers will not tell you that secondary lead minerals occurred there. Ed.*

GRATACAP INDEX

In 1912 L. P. Gratacap of the American Museum of Natural History published *A Popular Guide to Minerals*. Besides being interesting reading, it contains a large number of photographs of mineral specimens, including many from the famous Bement collection (see vol. 21, no. 1, p. 47–62). It is always frustrating trying to locate specific photos in this book, photos made all the more interesting by the fact that some specimens have since been traded out of the museum and are now in private hands. To solve this problem I prepared an index to all the Gratacap photos, primarily for my own use, but I will be happy to provide copies at no charge to anyone else who is interested.

Lawrence H. Conklin
2 West 46th Street
New York, NY 10036

BRITISH MUSEUM PLANS

Having heard that the British Museum (Natural History) plans to dismantle its venerable and extensive systematic exhibit of minerals (see Museum Notes, September-October issue, p. 493–494) and replace it with a much smaller exhibit of showy pieces aimed at the general public, I wrote to Museum Director Neil R. Chalmers requesting an explanatory statement for our readers. Here is his reply. Ed.

The Geological and Natural History Museums in London have recently been amalgamated under a single management. When the amalgamation was brought about, we took the opportunity of reviewing our service to visitors and came to the conclusion that substantial improvements should be made. The most significant of these involve the exhibition galleries where work of two kinds is called for. Firstly, we need to rationalize the organization of the galleries, so that all the exhibitions on the earth sciences are in one building. And secondly, we need a substantial program of new exhibitions to cover modern scientific developments and to ensure that all our galleries are as effective as they can possibly be from the educational point of view. Our overwhelming objective in the public galleries is to provide a stimulating source of up-to-date and relevant information for interested but non-specialist visitors. An important sector of the public which traditionally patronizes the Natural History Museum is children and we need to provide plenty for them, not least because of the requirements of the new National Curriculum. But this is not a children's museum; most of our work is for adults.

The gallery of minerals is one of the older displays in the Museum which is set out in a very old fashioned manner. Basically it is a huge, systematically organized collection of minerals with very little by way of explanation of mineralogy to help non-specialists to understand the subject. We are immensely proud of the collection, but the current display fails to meet modern standards on almost every count.

We therefore plan, within the next two years, to replace the display with a new one in the geological galleries. This display is being designed to present the modern science of mineralogy to the general public in a way that makes sense to them, is relevant to them, and encourages them to want to know more about the subject. We have prepared for this project by undertaking detailed research work with visitors so that we are properly briefed about their background knowledge and interests. We also, of course, have access to unrivalled academic expertise. When the new exhibition opens we are confident that it will be the best exhibition on the subject to be seen anywhere.

Inevitably, the space in the exhibition given over to systematic displays will be substantially less than at present. Where specimens that are currently on show are not needed for the new display, they will be returned to the reserve collections where visitors with a special interest can examine them under conditions which are much more appropriate than a glass case in a public gallery.

Neil Chalmers
Director
The Natural History Museum, London

ENCYCLOPEDIA OF MINERALS

I cannot begin to understand Paul Moore's gratuitous trashing of *Encyclopedia of Minerals*, 2nd edition. I found his review (*MR* **21**: 496–497, 1990) off the mark, greatly exaggerated in its negativism, and totally unfair to the book.

Moore structured most of his criticism on perceived faults with the data for mitridatite and steenstrupine. The structure of the former mineral, by the way, is one that Moore helped decipher, a fact that he took great pains to tell the reader in a long self-congratulating passage in the review! He ended the review by recommending Fleischer's *Glossary of Mineral Species* as an alternative because it provides "a reference for each species." While I heartily endorse the *Glossary*, I should like to point out that the fifth edition (which is the edition used for the *Encyclopedia*) gives the very formula for mitridatite that Moore tells us is wrong, and both books cite the same reference (Moore, *American Mineralogist* **59**: 48–49, 1974). In the case of steenstrupine he faults the *Encyclopedia* for its failure to provide a reference for the chemical formula, yet it is the same formula given in the *Glossary*, where one does not, by the way, find a reference either, in spite of Moore's claim that it would be there.

With his only two specific "faults" shown to be tenuous at best, one must suspect the substance of the rest of his comments. I reviewed the book also, but my reaction to it was altogether different. If your readers would like to see a *very* positive review I refer them to *Gems and Gemology* **26**:169–170, 1990. For those who don't have access to that journal I will summarize it: The *Encyclopedia of Mineralogy*, 2nd edition, is a fine book for the amateur mineralogist and the authors deserve much credit for the great care and effort that went into its preparation.

John Sampson White
Curator-in-Charge
Division of Mineralogy
Smithsonian Institution

Rebuttal

My! Such invective! Allow me to remark that I picked mitridatite and steenstrupine as examples because (1) they are exceedingly complex compounds (and locally important ones at that), (2) structure study was laborious on both and required numerous references to earlier study, (3) they can be easily retrieved in *Mineralogical Abstracts* and, (4) I was involved in studying them. Only a masochist or a fool would pick minerals where an intimate attachment was not already established, in objectively appraising their treatment in *EM2* (or any book, for that matter). Besides, the mitridatite and steenstrupine structures are elegant—downright beautiful!

Mr. White, however, did correctly imply that my praise of *Glossary of Mineral Species, Ed. 5* (along with supplementary addenda and corrigenda) was too exuberant and that this convenient little book is flawed by sins of omission, too. Let me further remark that I have found many errors in the latest *Glossary* and its supplement. I can only conclude that the authors of both *EM2* and *Glossary* seemingly failed to seek out truly competent professionals in mineralogy/chemical crystallography who would have offered much advice and comment on these treatises before they went into print.

Lord knows whom these books will serve. In such compendia, the Higher Truth "The chain is as strong as the weakest link" always holds. At present, I see no good treatise on the mineral species in sight—for both amateur and professional.

Mineralogy is a science. I assume amateur mineralogists want a scientific treatise *laden with the best references*. Or do amateurs/professionals only want to read what they already know or believe? If this is so, then mineralogy as a science is dead. To keep a science alive, one must learn, one must study, one must have good facts with references. For the references connect us to our rich heritage. A collector must bear this in mind.

Paul B. Moore

Editor's Note: *Since writing this rebuttal, Professor Moore has been invited (and has agreed) to review and make recommendations for the 6th edition of* Glossary of Mineral Species *due to be published this month. After examining the galleys he has pronounced it much more free of errors than the previous edition.*

Having just written a positive review of the 2nd edition of *Encyclopedia of Minerals* (*Rocks and Minerals*, vol. 65, no. 5, p. 446), I feel it necessary to respond to Dr. Paul B. Moore's less than enthusiastic review of the same book. In my opinion Dr. Moore has somehow entirely missed the reason for, and value of, the *Encyclopedia of Minerals*. The audience is not simply those professional mineralogists whose primary concern might be whether or not what they consider to be the best or most recent reference to a particular species is used, but all those interested in mineralogy who need a single quick reference for fundamental data. The *Encyclopedia of Minerals* is far more than a source of other references, it is a compendium of basic mineralogical data, much of it quite useful in a wide variety of situations. Its value lies in the fact that for any given species one can rapidly find out what it looks like, what it is made of, what its optical and physical properties are, and in what environments and localities it occurs. I ask Dr. Moore to name another such single-volume reference, and in his inability to do so admit that he now understands the value of the *Encyclopedia of Minerals*. As Dr. Moore points out, about 3½ species are covered per page. As I pointed out in my review, at ten cents per page it's a great bargain. Less than three cents per species sounds even better.

Robert B. Cook
Professor and Head
Department of Geology
Auburn University

Rebuttal

I believe I have already covered most of the comments raised by Prof. Cook. Several textbooks and handbooks of mineralogy already exist, perhaps the best being *Klockmann's Lehrbuch der Mineralogie* by P. Ramdohr and H. Strunz (1978). Again, my concern focuses on (1) faithful representation of data and (2) a panoply of references. Without these, a book is unreliable and has no cross-checks, especially for an amateur who needs the best contemporary information. Professionals can easily get to the sources.

Then again, the American amateur philoliths seem motivated by forces other than scientific curiosity and enlightenment. If they are satisfied with a mediocre product, then let them eat cake!

Recently, *Handbook of Mineralogy*, v. 1 by J. W. Anthony, R. A. Bideaux, K. W. Bladh and M. C. Nichols (1990) came into my hands. This marks the beginning of a magnificent work of five volumes. I trust the other volumes will continue in the same excellent fashion as the elements, sulfides, sulfosalts now available.

Paul B. Moore

It is with much pleasure that I write this letter to inform you that the *Encyclopedia of Minerals* has been selected as the Best Reference

Book for 1990 by the Geoscience Information Society.

We felt that the encyclopedia is an outstanding, comprehensive reference tool of great value to the research scientist and information specialist. The photographic work enhanced the publication by effectively showing the form, structure, and beauty of so many minerals. The book was chosen because of its high quality, easy to understand format, and excellent presentation. It provides geoscientists in research centers and libraries throughout the world with a very useful reference book for mineralogical data which reflects the new information generated by the science of mineralogy.

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Please plan to attend the presentation of the **1990 Carnegie Mineralogical Award** during the *T.G.M.S. Awards Ceremony,* 9:00 p.m. Saturday evening, February 16th, 1991, at the Tucson Convention Center.

Nominations for the **1991 Carnegie Mineralogical Award** will be accepted until December 31, 1991. If you have a candidate for the Award, please send your nomination to the address below. An official form will be sent to you by return mail. Thank You!

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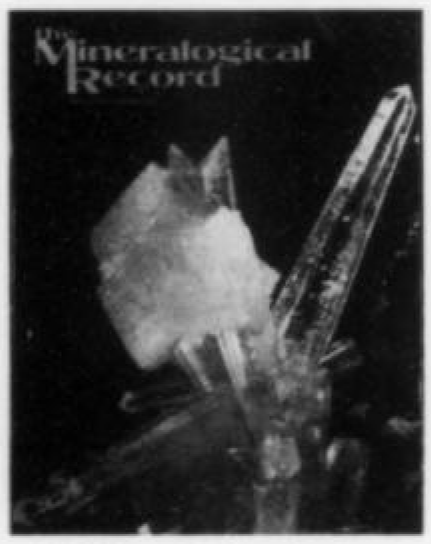

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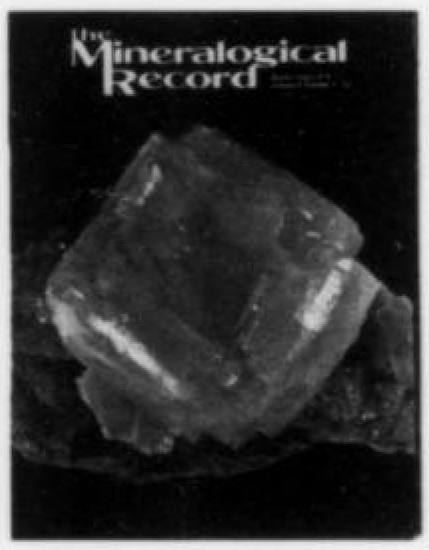

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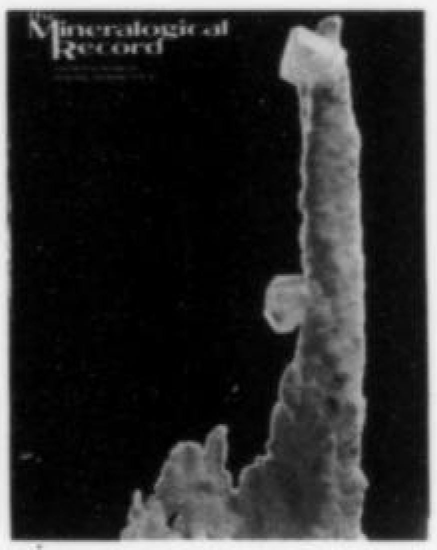

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