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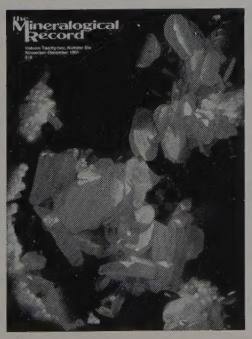
Articles

Columns



COVER: WULFENITE from the Hilltop mine, Cochise County, Arizona. See the article on this locality in vol. 14, no. 2. The crystals measure up to 1 cm. Smithsonian collection; oil painting on canvas by Wendell E. Wilson (Jane Dietrich collection).

Guest Editorial:

DIVERSITY

Last February I entered the competition for the Desautels Trophy, the successor to the now-retired McDole Trophy. I did not win this competition. It may sound like "sour grapes" to say so, but I thought then and and still think now, that not only was my display a more suitable candidate for recognition, but at least one other display was better yet. None of these remarks are intended to slight Gene Meieran; he is by all reports a very personable and congenial man. Furthermore he obviously has built a collection of great beauty and value. My quarrel lies in the lack of diversity of species in the winning display. Of the approximately 34 specimens on display, eight were beryls, six were tourmalines, and four were topazes; there were no more than 15 distinct species on display, of the nearly 4,000 provided by nature.

Actually this restrictive selection of species is in keeping with the outlook of the eponym of the new Trophy. Several years ago, also at Tucson, Paul Desautels told me that, in his view, there are only 100 displayable species. We had a brief dispute over this dictum, but since we were at dinner we moved on to less contentious topics. And I will not defend the thesis that my outlook on collecting is the right one, only that some room, and some recognition, should be made for those of us who believe that there is more to collecting than the 100 "worthy" species. I will go one step further, however, to warn of a specific danger in the purely "aesthetic" judging of minerals: awards will automatically go to the displays that cost the most to assemble. This is because the valuation of minerals, as sold by the dealer community, strongly follows "aesthetic" judgements, modified to a small degree by rarity. Topaz, a common aluminum fluosilicate, has been found in literally millions of beautiful crystals, but it can still be very expensive; $10,000 will buy a wonderful topaz, but nevertheless, far away from being anywhere near the best. Yet if crystals of dickite, 2 cm across, were found on a contrasting jet black matrix, the best cabinet specimen might sell for a thousand dollars. However if you want to win a trophy, you had better use the topaz, not the dickite! Thus the danger in the "displayable species" rule: the winner of the competition *ought* to be the one who spent the most; if he or she does not win, the material he purchased was "overpriced." This reduces competition to a tautological exercise.

That the question of diversity is not a new one is attested by an editorial from John White in the *Mineralogical Record* (vol. 6, no. 3, May-June, 1975). In this essay he voices his chagrin, in retrospect, at having rejected a fine bayldonite at an AFMS competition. The bayldonite was from the famous 1973 find at Tsumeb, and may have been the world's finest extant specimen. He and the other judges downgraded this "unaesthetic specimen" because it "was dark green, almost black, and rather formless overall." John's expression of perplexity drew many letters over the next year (including one from the bayldonite owners), many discussing arcane interpretations of the AFMS points for "rarity." Bob Jones, in a letter provoked by John's editorial, said "Let exhibitors get arty if they wish, but judge that artistic ability separately."

And so to "diversity." Allowing all the species of nature to really compete (not just on entry forms, but in our heads), will bring factors other than who spent the most to the contest. I claim that the best catapleite in the world (it must be from Mont Saint Hilaire) is intrinsically more mineralogically interesting than the 9,000th-best topaz, however elegant this topaz may be. It is important that this argument not be viewed as an argument against current pricing. In the first place all arguments against pricing are futile; the market is the market, and moralistic arguments against market pricing have universally failed to change the market. Secondly, the market is *right*. I would not pay more than a thousand dollars for the best dickite in the world, but I might pay $5,000 for a fine topaz, even though it is only the 9,000th-best in existence. The point is that market prices do not encompass the entire value nor interest of a mineral specimen. If you visit my collection, I would be more likely to point out the best dickite in the world (if I had it) than my fine topaz, even though I refused to pay as much for the dickite. All experienced dealers are aware that there is much more to the specimens in their stocks than they encompass in their prices. So do our accomplished writers: Thomas Moore, in his recent report from Europe, extols the new salammoniac groups, and Wendell Wilson in his Report from Tucson is quick to tell about the new antimony crystals.

Though I urge opening competition, as well as contemplation, to more than "aesthetics," I don't intend that there be no "beauty contests." The best-of-species awards at Tucson are great fun; we need more, not less, of these. And collecting solely on the grounds of beauty is surely legitimate. Many years ago I heard (this is an unverified story) that Dave Wilbur said, when he began assembling his great collection, that he wanted to hear no science, that he was collecting on the basis of beauty only, and that he would be deflected by no other considerations. I respect Dave for his candor and single mindedness, not to mention his magnificent specimens. But I have to wonder whether beauty can legitimately be the sole attractor in mineral specimens. Corning Glass can mold us objects mimicking any outward crystal form, of almost any color or luster. Competent plastic manufacturers can make objects in the whole spectrum of colors and forms, so that the layman will find them equally or more beautiful than nature's products. Among our "displayable" species we may find such aesthetically suspect examples as galena, stibnite, and manganite. And think of the rage for cavansite; I have one I am proud of, but in aesthetic terms alone it is merely a collection of globs of bright blue dots, perhaps like a pointillist painting. This is why I frequently encase "aesthetic" in quotation marks.

Recently I received a letter from Arthur Montgomery, who had just heard of the putative decision to not replace John White as curator at the U.S. National Museum following his retirement. In his letter he had this to say:

> I've seen this development in progressive lack of appreciation for minerals move on inexorably toward the present situation. It is why Ray Grant and I tried to start a movement [i.e. Friends of Mineralogy[1]], however small, to oppose those deteriorating tendencies we could see so well doing their ruinous work down

[1]Sad to observe that Friends of Mineralogy has in large part failed in its mission! [Bill Smith comment]

the road. More and more: commercializing minerals, judging them in terms of monetary value, glorifying them (almost) for their color, beauty, crystal perfection—their spectacular appeal to the human possessive instinct. Giving them the glamour assigned to the Hollywood stars, who are no more characteristic of what makes humans tick than these glamorized aspects of minerals . . . deal with the essence and marvel of what they truly are, where they stand as an essential part of Nature—the Lord's creation—provide the framework of the rocks of the earth and all of geology—show us in their outward crystal form the clue to the marvelous internal atomic construction of solid matter.

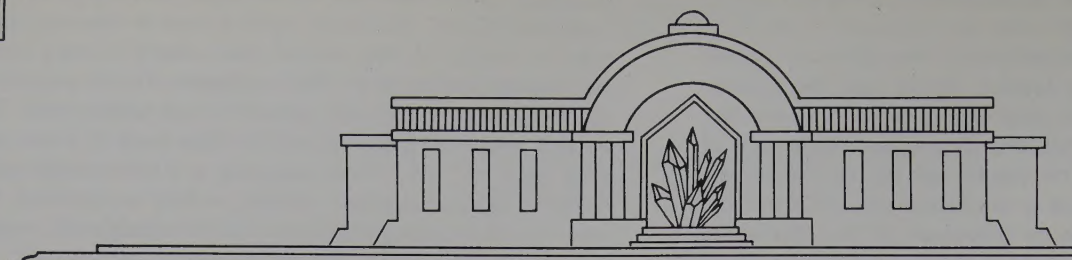
End result: more and more seen primarily as pretty objects, and the collecting of them much the same as collecting stamps or snuff bottles. No wonder that the museums find exhibiting them less and less worthwhile. The real meaning of minerals is: what they are in themselves, even the lowliest specimen just as much as the most glamorous one; what they can teach us through what they truly are. That is proper mineral appreciation. It has never developed—a tragedy! Scientists, who study and delve into them in remarkable and powerful ways for scientific knowledge and industrial use, are apt to appreciate them least of all, through complete failure to "know" them.

Here is the inevitable tragedy of our times, both for us who harbor a deep and true feeling for them and for those of mineralogical science, and as well as for all the others of students and public who could be enlightened and brought closer to them.

My dealer friends know that I do not agree with Art's views on the "commercializing" of minerals, nor do I object to someone collecting them as "stamps or snuff bottles"; there should be many rooms in our mineralogical mansion. What I complain of is the propensity for *all* of mineral collecting to be reduced to such narrow terms. This is the real threat, and judgments such as those made in Tucson do not help. Arthur is right: mineral collecting as a well-rounded *mineralogical* (as opposed to purely aesthetic) activity is threatened. If you doubt that the mineralogic/scientific side is being neglected, remember that Neal Yedlin's dictum "buy and use a good mineral book" is not adhered to by all readers of the *Mineralogical Record,* nor do most mineral collectors even subscribe to this publication. Let me quote Paul Desautels again, as cited in Wendell Wilson's essay on connoisseurship in the *Mineralogical Record* (vol. 21, no. 1): "The greatest mineral collectors of all time collected both scientifically and aesthetically." Wendell closes with a paragraph containing a pregnant line, "The connoisseur sees instead a rare opportunity to indulge in a field where the sciences, history and the humanities meet and intermingle." Let's bear that in mind, and give this (mythical) dickite a break!

I pray this essay does not induce more people to tell me that I am "the last of a dying breed." I already feel like a dinosaur staring at the iridium in the K/T boundary.

Bill Smith
1731 Daphne Street
Broomfield, Colorado 80020



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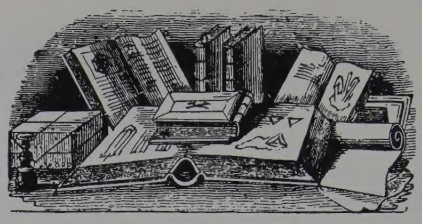


The Wagholi Cavansite Locality
near Poona, India

Rustam Z. Kothavala
511 Van Buren Avenue
Oakland, California 94610

A trove of royal-blue cavansite specimens that astonished the mineral community at the Tucson Show in 1989 was collected from a quarry in the vicinity of Wagholi village. Thousands of fine examples, the best ever seen for the species, were found there. Additional occurrences in quarries nearby have now been discovered.

INTRODUCTION

The Wagholi quarries are located on Ahmadnagar Road, about 20 km northeast of the center of Poona (or Pune), Maharashtra, India. The occurrence was first described by Wilke *et al.* (1989) and Wilson (1989). In December of 1989 I visited the Wagholi quarries and learned more about the geological aspects of the cavansite occurrence. Conversations with local people also disclosed some circumstances during exploitation of the find, which readers may find entertaining.

I had a special reason to investigate this occurrence. Back in 1973 I had found, among thousands of unlabeled specimens in Burjor Mehta's stock in Bombay, five or six specimens of white stilbite spotted with radiating tufts of bright blue acicular crystals (Kothavala, 1982). Upon returning to America, I took the blue mineral to Harvard University, where it was identified as the recently described mineral, cavansite. Two of those first specimens went to Harvard, I retained one for myself, and disposed of the rest. Compared with recent material, those first cavansite specimens were mediocre. But they were far superior to the type material. I therefore set myself the goal of finding the source of those specimens in India, surmising that they were most likely from the area around Poona because the white, sheaf-like clusters of stilbite on the specimens were typical of that region. Bill Birch (1977) similarly encountered cavansite in specimens obtained in 1974 from the Poona area, but the specific location of the occurrence remained unidentified. For 15 years I searched in vain. Though I criss-crossed Maharashtra state during those years, examining hundreds of quarries and thousands of specimens, I did not again encounter any Indian cavansite until the spectacular find in October, 1988. Alas, I had missed examining the quarries at Wagholi.

THE WAGHOLI QUARRIES

For many years, the principal quarry at Wagholi has produced a dense, unaltered black basalt that is excellent for construction purposes. The rock is worked from a horizontal flow, largely free of vugs or vesicles, whose top, being resistant to weathering, forms much of the ground surface for some square kilometers around the village of Wagholi. This basalt flow has a thickness, more or less uniform, of about 10 meters. It rests, with sharp boundary, on a formation of distinctly different composition. The underlying rock consists of andesite[1] and andesitic tuff, ranging from gray to reddish brown in color; it is too porous and too friable to serve as construction material. Consequently, quarrying at Wagholi is never carried to a depth greater than the base of the overlying black basalt. It is this circumstance which kept the sensational Wagholi cavansite from being disclosed to mineral dealers (myself included) during the many years that the quarries have operated, because, as I shall show, the field evidence strongly points to the andesitic tuff as the local source-rock for cavansite mineralization.

Several quarries of irregular shape are clustered immediately north and west of Wagholi. The most extensive, called Main quarry, is the site of the best cavansite find to date. Early in the operation of this quarry a vertical zone of altered and brecciated rock, no more than 10 meters across, was encountered in the otherwise fresh black basalt member. Since the rock in this zone was unsuitable for construction stone it was avoided as quarrying progressed. As years passed, this altered breccia stood as a vertical pillar isolated from the receding working faces of the quarry. And thus it might have remained indefinitely, but for one circumstance: the pillar provided an excellent viewpoint and benchmark from which government tax collectors would

[1]Rock and mineral samples from Wagholi have been analyzed by William Metropolis at the Harvard Mineralogical Museum. Petrological study of the rock samples I collected on site confirmed the field identification of the two prevalent formations as basalt and andesite, respectively. Mineralogical examination of random specimens from two quarries also affirmed megascopic identifications and revealed the presence of prehnite.

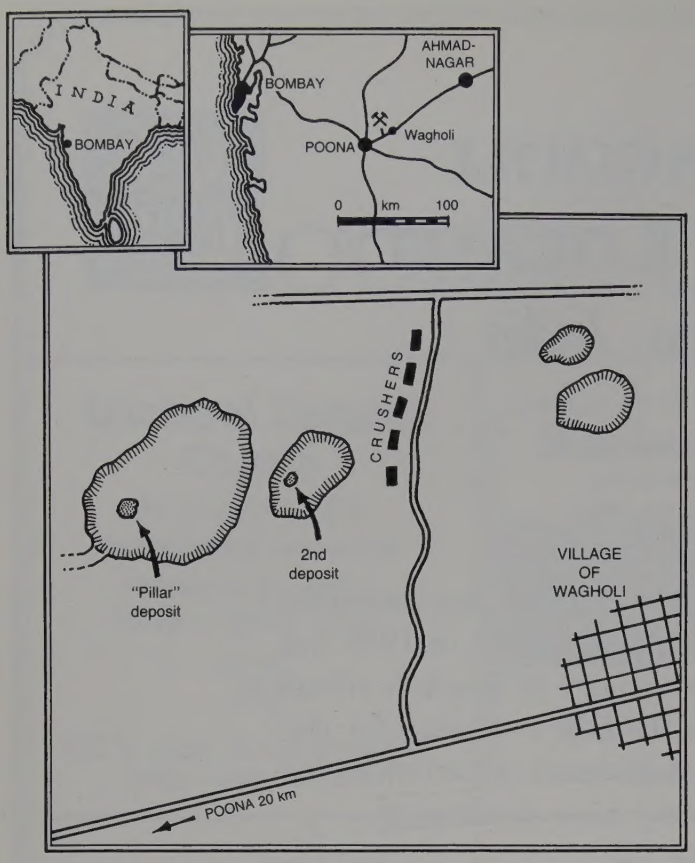


Figure 1. **Location map (not to scale).**

regularly survey the increasing extent of the quarry and accurately estimate how much rock had been removed. The owner would then be charged a royalty on that amount. In order to deprive the tax collectors of their convenient survey station, the quarry owner decided in 1988 to remove the long-standing benchmark.

DISCOVERY AND REMOVAL

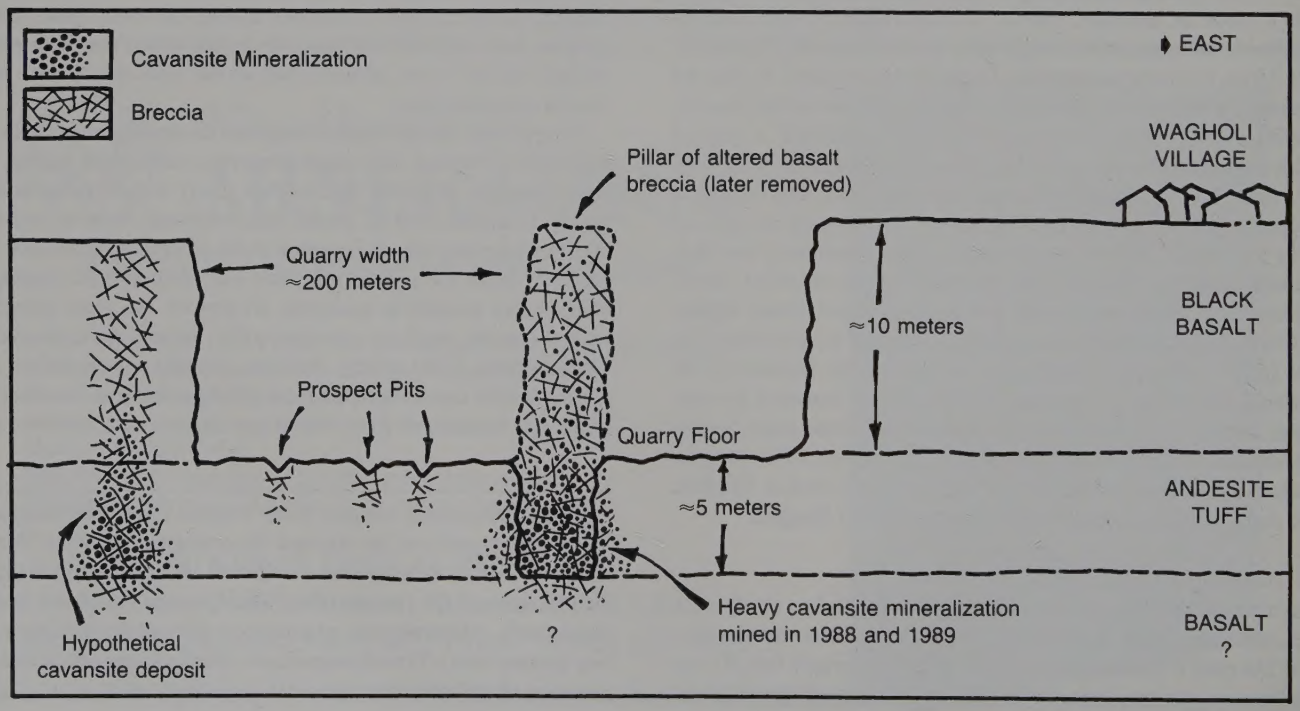
As the pillar was being demolished workers encountered blue crystals accompanying stilbite and calcite in open breccia. Specimens were quickly shown to several dealers in Poona, but it was Arvind Bhale and his colleagues who first identified the material as cavansite (Wilke *et al.*, 1989) and succeeded in striking a deal with the quarry owner for the rights to mine specimens.

Sparse sprays of cavansite encountered in the upper reaches of the pillar gave way to more abundant mineralization as the demolition proceeded downward. With the pillar all but removed, spectacular cavansite mineralization was found at quarry floor level (i.e., ostensibly at the contact horizon between the overlying basalt formation and the underlying andesitic layer). Wilke *et al.* (1989) have described how the quantity and quality of the cavansite improved as excavation of the breccia zone was carried deeper. At a depth of 5 meters below the quarry floor they report that digging was abandoned because of encountering a hard black basalt horizon beneath, and because the inflow of ground water was too great to permit further excavation during the post-monsoon season. Virtually all the cavansite that appeared in Tucson in February 1989 was the result of this excavation.

But there is more to the cavansite story than has appeared in print until now. Even though the quarry owner is reported to have received substantial sums in return for granting Bhale and his colleagues the right to mine and remove cavansite, the bonanza in the main quarry may, ironically, have proved to be more of a curse than a boon for him. As soon as the workers realized that the blue mineral had extraordinary value (by their financial standards), they naturally enough preferred to covertly extract cavansite rather than attend to their usual quarrying routines.

When excavation of the pillar reached the cavansite-rich zone, nightfall would find the quarry abuzz with workers diligently digging away in the breccia by the glow of flashlights. Specimens so obtained were quickly taken to Bhale's rival dealers in Poona. These worthies paid the workers or "runners" handsomely for specimens that arrived

Figure 2. **Schematic cross-section of Main quarry, Wagholi, showing relationship of cavansite mineralization to alteration and breccia in basalt and andesite layers (not to scale).**



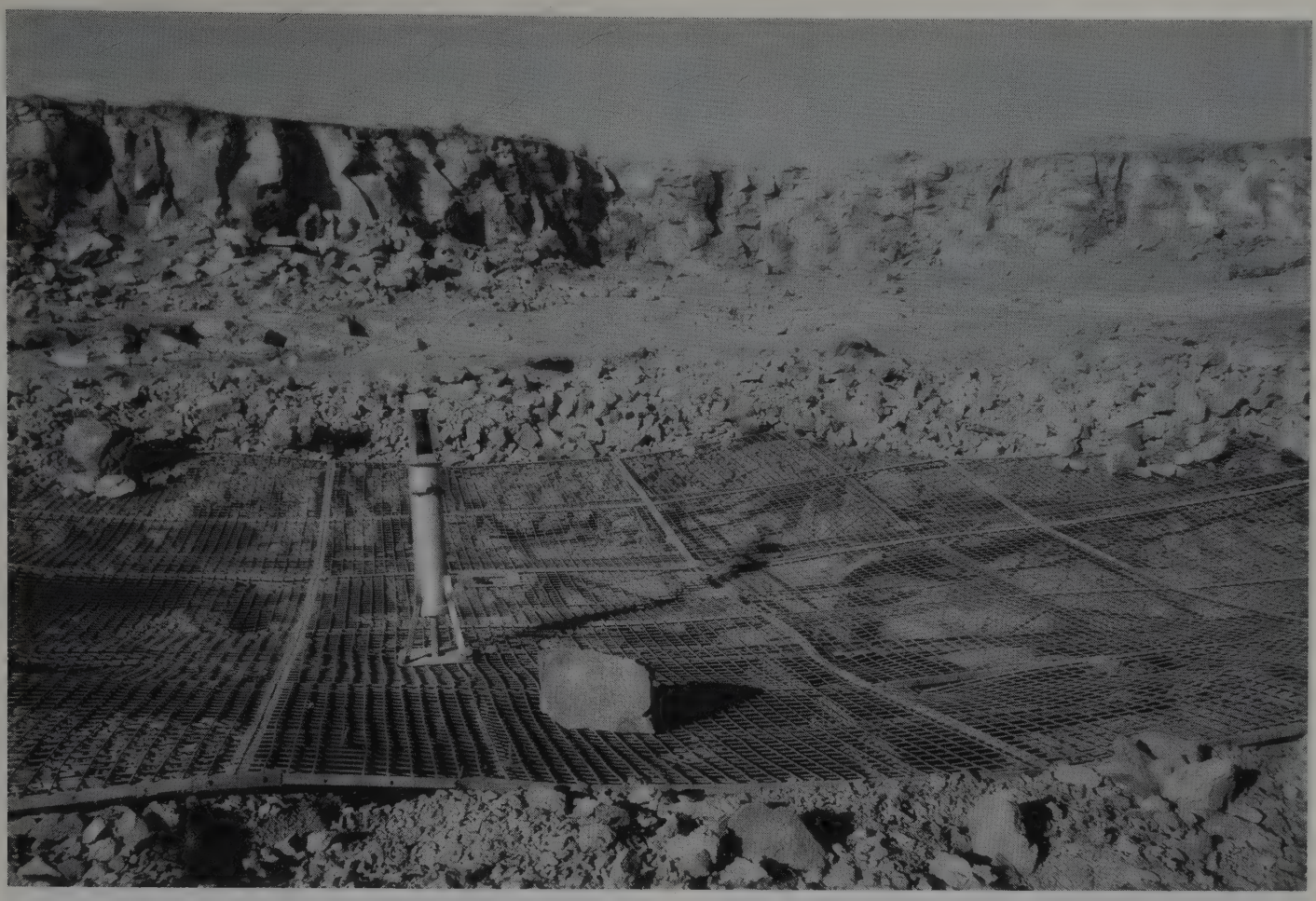


Figure 3. **View from the floor of the Main quarry, Wagholi. The vertical working face in black basalt is seen in the background. The quarry floor lies at the contact between basalt and underlying andesite tuff. As a security measure, a heavy metal grating in the foreground covers the pit from which the cavansite bonanza of 1988/1989 was removed. Photo by the author.**

unsolicited at their doorsteps. A decent specimen would fetch a worker several times more than he could possibly make from a month of legitimate, back-breaking labor at the quarry. No wonder, then, that workers would stagger out of the quarry with sacks of cavansite specimens before dawn each morning. These could be sold by midday for sums that were incredible. Often, an orgy of celebration and intoxication would follow, keeping the delighted workers from their daytime drudgery for days on end. Inevitably, the regular stone quarrying operations suffered.

To counter this difficulty and also, of course, to stop the nocturnal pilferage, management enlisted help. In villages in that part of India it is not unusual to find a gang or family of toughs who have established themselves as the local bullies. Wagholi's bully-boys were recruited, at handsome wages, to guard the breccia pipe during the hours of darkness. Surreptitious night-time removal of cavansite was halted for a short time. A very short time, it turned out; only as long as it took for the toughs to learn that they could collect considerably more than just their salaries by co-operating with the night operators. Management was left with no alternative but to excavate the breccia zone to its lower limit as hastily as possible. The hole, some 3 meters across, above the breccia pipe in the quarry floor, was sealed with a heavy iron grating to discourage clandestine digging. That was the position back in India, when cavansite fever was infecting collectors during the Tucson Show in 1989.

At the Main quarry in Wagholi, the excavation where the pillar had stood was filled by ground water to within a meter or two of the surface. The water proved a more effective deterrent to pilferers than the metal grating that covered the hole. When the dry season arrived and the water level dropped, enterprising night operators simply burrowed from the grating's perimeter to obtain access to the central cavity. The legitimate lessees, choosing not to expand the excavation further, may have taken solace from the knowledge that the richest material had already been recovered during the initial operational phase.

Other problems had appeared, however. For one, now that the quarry workers were attuned to the value of cavansite, any sight of the blue mineral in the area would immediately lead to furious digging. Since cavansite in small specks is widespread in the underlying andesitic formation, pits soon pock-marked the entire quarry floor. As quickly as these appeared, the owner would be obliged to call for a truckload of dirt to bury each fledgling excavation. The cost and aggravation to the owner has continued to mount but no solution is yet in sight to solve the dilemma. If he institutes draconian measures to halt cavansite moonlighting by his workers, he risks strikes, sabotage, or worse. If he turns a blind eye to the extracurricular activities, then the quarry's productivity will continue to suffer. The cavansite genie is now out of the bottle. Getting it back inside remains an unsolved problem.

Another kind of headache has emerged for the embattled lessees who, one can safely infer, have sunk a bundle of money into their cavansite enterprise. With every pair of eyes around Wagholi now eager to spot the color blue in every rocky outcrop, it should not be surprising if other significant concentrations of cavansite are discovered nearby. One such occurrence was detected early. It occurred in association with a red breccia in a small quarry (with a different

Figure 4. **Cavansite crystal cluster, 2.6 cm, from the Main quarry. Tim Sherburn collection.**

Figure 5. **Cavansite crystal cluster, 1.6 cm, from the Main quarry. Hans-Jurgen Wilke specimen.**

operator) perhaps 500 meters from the Main quarry. Here the appearance and mineral associations of cavansite were distinctly different from those in the first deposit.

CAVANSITE

In the pillar deposit, cavansite occurred most commonly in parallel or radiating sprays, and sometimes as rosettes, of acicular crystals (Wilson, 1989). These are associated with abundant bladed or sheaf-like white stilbite with white calcite, sometimes coarsely crystallized, and in a minority of specimens, with small transparent blades of heulandite. Commonly a sprinkling of tiny stilbite crystals are perched atop cavansite sprays and rosettes. Several specimens also contain barely visible needles of a black mineral growing on stilbite matrix. These have been identified as chalcocite (Peter J. Modreski, personal communication).

In the second occurrence, all the specimens I have observed (perhaps 20) show cavansite rosettes, rather than sprays. They possess an even richer blue color than cavansite from the pillar location. The rosettes, around 1 cm across, are free of stilbite and are surrounded by a dense, pure white carpet of extremely fine, vertical needles of mordenite. Embedded in the mordenite and perched on the cavansite rosettes are colorless, glassy plates of heulandite. Sharp, transparent rhombs of calcite are also common.

CONCLUSIONS

Field observations, together with laboratory analyses of rock and mineral samples, suggest working hypotheses about the origin of the cavansite at Wagholi and about the future outlook for specimen production at this locality.

Basalts and related volcanic rocks of the Poona region of Maharashtra state are exceptionally rich in vanadium (Ghodke *et al.*, 1976). They contain between 600 and 750 ppm of the element, compared to a typical worldwide average of 250 ppm for basaltic rocks (Prinz, 1967). Prinz points out that most of the vanadium in these rocks is contained in the ubiquitous minerals magnetite and pyroxene. There is no reason to doubt that these same minerals served as the original source of vanadium for the cavansite at Wagholi.

Cavansite is widespread, albeit in tiny needles, in the underlying tuffaceous andesite formation. It is absent, except in obviously brecciated zones, in the overlying basalt layer. The key distinction between

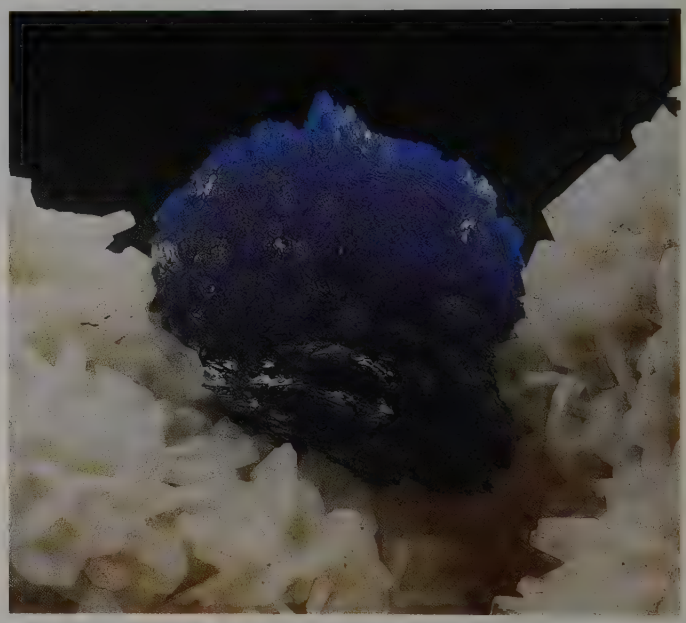


Figure 6. **Cavansite crystals from the Main quarry, 1.8 cm, in rare parallel growth. Mark Feinglos collection.**

Figure 7. **Cavansite crystal cluster, 1.8 cm, from the Main quarry. Museum of Victoria specimen; photo by Frank Coffa.**

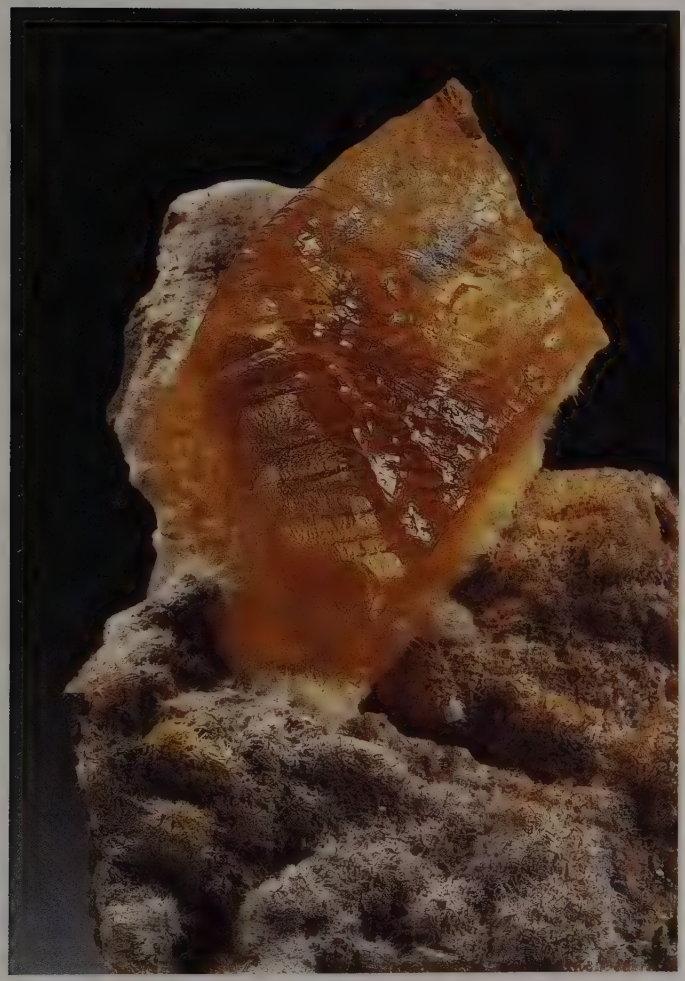


Figure 8. **Rhombohedral calcite crystal, 5 cm, showing solution features, from the third Wagholi quarry. Rustam Kothavala specimen.**

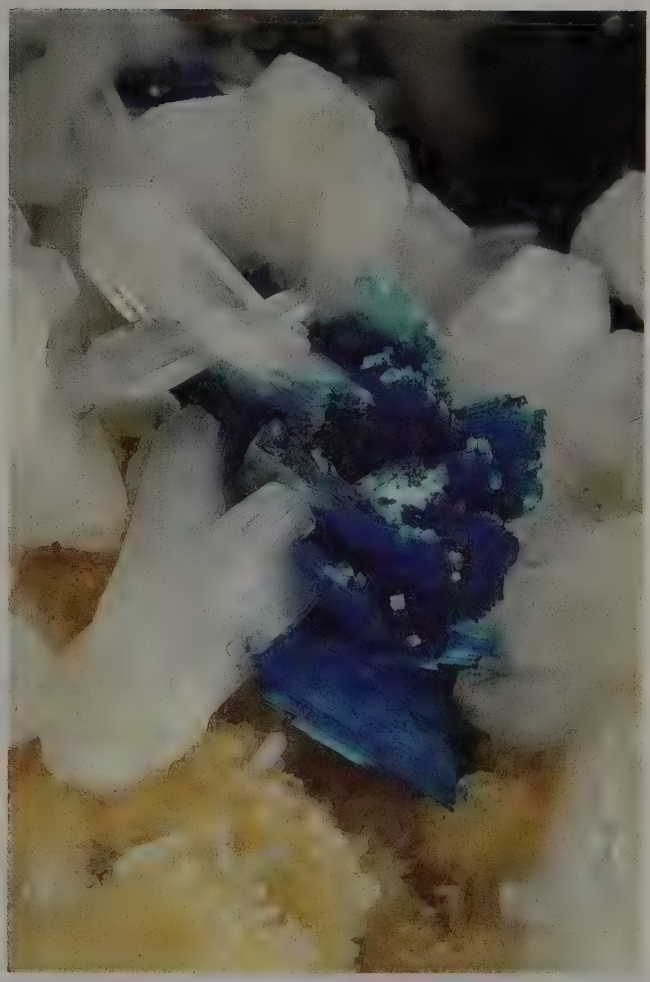


Figure 9. **Cavansite with stilbite, 2.5 cm across, from the Main quarry. Canadian Museum of Nature specimen 54028; photo by George Robinson.**

these two formations is not in their mineralogical or chemical compositions, but rather in their relative porosity and permeability. Regional studies (Raja Rao, 1976) have established that, following their eruption, the volcanic rocks in the area were subsequently buried by a few thousand feet of younger volcanics that have since been eroded away. Heated ground waters, circulating at depth through the porous, permeable tuffaceous andesite during burial, would have had ample opportunity to leach vanadium from the original iron oxides and pyroxenes in the tuff. Vanadium is particularly sensitive to ambient acidity and oxidation state, as Evans and White (1987) point out, and is easily released or precipitated by changes in these environmental factors. The other components of cavansite (calcium and silica) are ubiquitously abundant breakdown products of andesitic/basaltic rocks.

Field observation indicates that cavansite has crystallized in available cavities in the rock. The greatest degree of crystallization has occurred where open spaces and channelways are best developed, namely, in the breccia zone in the tuff beneath the former pillar. The brecciated rock of the pillar probably provided significant depositional control by acting as a passageway for solutions charged with vanadium, calcium and silica, to ascend through the relatively impermeable overlying basalt.

Explorers for additional cavansite concentrations near Wagholi might benefit by searching for altered and brecciated zones exposed in the basalt layer. Such zones might well have served as channels for upward migration of loaded fluids, and as loci for crystallization of dissolved materials. They may be promising indicators of cavansite concentrations in the andesite below.

The abundance of exploratory pits dug by workers in the Main quarry virtually guarantees that the lowest grades of cavansite from Wagholi will continue to appear on the mineral market for the indefinite future. The prices of this low grade material in Tucson in 1990 were well below those of 1989. I anticipate this trend will continue until a stable base price is reached.

The outlook for fine specimens is very different. It may be years, if ever, before another bonanza as rich as the 1988 find is discovered. In the Deccan basalts of India, other localities producing rare and exceptional minerals have shown a typically irregular production pattern over their life spans. One example is Quarry #2, in the Pashan hills near Poona, which produced green apophyllite and mesolite from the early 1970's until it closed in September 1989. Another is Pandulena Hill, near Nasik, which continues to provide unsurpassed specimens of powellite ever since the mineral was discovered there in 1974 (Kothavala, 1982). In both these cases the supply of highest quality specimens has been sporadic. In some years almost none were obtained. At other times, when individual rich concentrations were uncovered, a large number of fine specimens came on the market simultaneously. The geological setting of the cavansite deposits uncovered at Wagholi suggests that the same sporadic pattern of availability of high quality specimens is likely to prevail here too.

Of course, it is by no means established that all the cavansite in the original find has been mined out. Operations there were curtailed, according to Wilke *et al.* (1989) because of excessive inflow of ground water. It is possible that more efficient mining techniques or lateral extension of the existing excavation in the andesite may again produce startling material.

Figure 10. **Water being pumped from a quarry near Wagholi where more cavansite was discovered in 1990. The best specimens, essentially identical to the first examples found at the Main quarry nearby, came from the rock prominence at upper right. Photo by M. F. Makki.**

RECENT DEVELOPMENTS

Interesting events have developed at Wagholi since this paper was originally submitted for editorial review. Mr. M. F. Makki, perhaps the most experienced specimen miner in India, highly regarded for having extracted superb mesolite and green apophyllite specimens from his Pashan quarry for two decades, turned his attention to Wagholi in 1990. He, along with those before him, was denied permission by the owner of the Main quarry to attempt further development of the "pillar" deposit. He then attempted excavation at the second deposit that was discovered. Unfortunately, the few specimens the deposit had already yielded were apparently all that exist. But a thorough search of all the quarries near Wagholi, utilizing the guidelines discussed, uncovered a third deposit in a neighboring quarry. According to Makki (personal communication), at this location too, cavansite mineralization accompanies fissures and alteration in the andesitic layer below the quarry floor level.

This third cavansite deposit, discovered in May of 1990, has proved to be as prolific and as problem-ridden as the first. Judging from the few hundreds of specimens that have been shipped to America, the range of quality of cavansite is analogous to the first deposit. Cavansite crystal clusters, blades and rosettes, indistinguishable from those in the earlier deposits, have been collected. A noteworthy feature is the occurrence of large, transparent rhombs of honey-colored calcite with mordenite and heulandite. Surfaces on the calcite rhombs show marked channeling from re-solution. No more than 1 or 2 % of the specimens show cavansite associated with mordenite and heulandite. The remainder show cavansite associated with stilbite, as was the case in the pillar deposit. The existence of both associations in the same deposit suggests that the depositional conditions for the two assemblages are not drastically different.

The lateral extent and depth of this third deposit are roughly similar to the first. Makki states that all of the cavansite had already been extracted before the monsoon commenced and his lease expired in June 1991.

ACKNOWLEDGMENTS

I am obliged to Dr. Arvind Bhale, D. H. Wilke, Mr. M. F. Makki, and several friendly but anonymous citizens of Wagholi for giving me the benefit of their perspectives and experience relating to Wagholi cavansite. I am particularly grateful to Agnes Pilot for translating the German article in *Lapis* into English, for my benefit; and to Bill Metropolis of Harvard University for performing laboratory analyses of specimens I collected at Wagholi. Bill Metropolis, Carl Francis and Shelley Monaghan, all of Harvard University, were also kind enough to read the rough draft of my manuscript and offer useful comments.

REFERENCES

BIRCH, B. (1977) What's new in minerals?: Cavansite from the Poona district, India. *Mineralogical Record,* **8**, 61–62.

EVANS, H. T., and WHITE, J. S. (1987) The colorful vanadium minerals: a brief review and a new classification. *Mineralogical Record,* **18**, 333–340.

GHODKE, S. S., POWAR, K. B., and KANEOGAONKAR, N. B. (1976) Trace element distribution in Deccan Trap flows of the Dive Ghat area, Pune district, Maharashtra. In *Geological Survey of India Special Publication No.* **14**, *Proceedings Symposium on Deccan Trap and Bauxite,* 1984, 55–62.

KOTHAVALA, R. Z. (1982) The discovery of powellite at Nasik, India. *Mineralogical Record,* **13**, 303–309.

PRINZ, M. (1967) Geochemistry of basaltic rocks: Trace elements in basalts. *In* Hess, H. H. and Poldervaart, A. (eds.) *Basalts,* **1**, 271–324, Interscience, N.Y.

RAJA RAO, C. S. (1976) The thickness of Deccan Trap. In *Geological Survey of India Special Publication No.* **14**, *Proceedings Symposium on Deccan Trap and Bauxite,* 1984, 1–6.

WILKE, H. J., SCHNÖRRER-KÖHLER, G.l, and BHALE, A. (1989) Cavansit aus Indien. *Lapis,* **14**, 39–41.

WILSON, W. E. (1989) What's new in minerals? [Tucson Show 1989]. *Mineralogical Record,* **20**, 234–236.

Rare Minerals of the Kombat Mine

Namibia

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The Kombat mine has two separate, diverse and equally interesting mineralogies. One consists of a copper-lead-silver sulfide orebody with secondary mineralization. The other, described in this article, consists of manganese silicate-carbonate-oxide lenses associated with the orebody. Both have provided fine specimens of common and rare species.

INTRODUCTION

The Kombat mine in Namibia has been in operation for over 27 years, but only in recent years have Kombat minerals been available to collectors. Of particular note are superb specimens of azurite, cerussite, malachite and cuprite from the oxidized zone of the sulfide orebody. In general the quantity of secondary minerals which have found their way to the specimen market has not been large (especially relative to those from nearby Tsumeb). Hence, such minerals from Kombat may always be considered as uncommon.

A number of rare and unusual species, many new to science, have recently been described from the iron-manganese silicate-carbonate-oxide units, which are the focus of this article. These include johninnesite, kombatite, holdawayite, asisite, ribbeite and others under study. Additionally, some rare species, known from other localities only in small or poor-quality specimens, have been found here in abundance; among these are wiserite, nambulite, sakhaite and a mcgovernite-like mineral. Several suites of minerals have remarkable similarities to some from such famous and enigmatic deposits as Långban, Sweden and Franklin and Sterling Hill, New Jersey. All these features combine to make the Kombat mine a most fascinating mineral deposit.

Because so little is generally known of the rare minerals from the Kombat deposit, this paper was written at the request of the editor to provide a brief overview and introduction to its geology and some of the mineralogy. The most recent publication on the detailed geology and mineralogy of the Kombat mine is by Innes and Chaplin (1986), from which the background for this paper is drawn.

LOCATION

The Kombat mine is located 37 km east of Otavi and 49 km south of Tsumeb in the north-central part of Namibia. The mine is accessible from both Windhoek, the capital, and Walvis, a port, by both rail and road. According to Innes and Chaplin (1986), the mining property's surface structures include a township of 100 houses, a hostel, a mill processing 1300 tons/day, and other mining structures. The deposit supports a population of 1000 persons. The mine is operated by the Tsumeb Corporation, which also operates the famous Tsumeb mine to the north.

MINING HISTORY

Francis Galton, in 1851, was the first European to report minerals from the Kombat area (Innes and Chaplin, 1986). This resulted in intermittent prospecting by German and British interests. In 1911 the Otavi Minen- und Eisenbahn-Gesellshaft (O.M.E.G.) started serious mining operations and recovered 4957 tons of ore by 1925, when flooding caused the cessation of mining. The ore recovered contained 17.8% copper and 173 grams/ton silver.

Exploratory drilling beneath these old workings was begun by the Tsumeb Corporation in 1954; this drilling resulted in the discovery of additional ore lenses to the west and east. The first ore from the Kombat mine was sent to the mill in 1962 and the mine has been in operation ever since, until just recently. From April 1962 to December of 1981, the mine produced 553 million tons of ore containing 2.23% Cu, 1.94% Pb, and 18 grams/ton Ag. Ore reserves, calculated in 1981 (with a cut-off of 1% Cu or 3% Pb), were 241 million tons containing 2.94% Cu, 1.89% Pb, and approximately 20 grams/ton Ag. Operations in 1985 yielded approximately 25,000 tons of ore.

In November, 1988, an underground aquifer was encountered during mining operations and flooded the mine, shutting it down. An account of this disaster is given by Olson (1989).

THE IRON-MANGANESE SILICATE-CARBONATE-OXIDE UNITS

Associated with the sulfide orebody, but not in contact with it, are at least six discrete lenses of differentiated iron and manganese ores. These are "always associated with feldspathic sandstone, close to the contact of dolostone and slate in discrete, steeply oriented zones of transposition which are oblique to the bedding" and are spread over a distance of "3 km along the disconformable contact between the Huttenberg Formation and the Kombat Formation" (Innes and Chaplin, 1986). These lenses are layered, both in terms of texture and com-

position; the layering is discernible on both microscopic and megascopic scales and is pervasive. The large ore units are composed of hematite and magnetite, interlayered with manganese oxides and silicates. Small sandstone lenticles and minor sulfides occur within these ore units. It is the manganese-bearing units which are of the most mineralogical interest because they are host to a number of rare minerals, some of which are new.

The manganese units vary from fine-grained to medium-grained and many specimens exhibit a typical metamorphic granular texture. Individual bands of mineralization commonly contain 3–5 species, so that many hand-specimens contain from 8 to 12 species! Innes and Chaplin (1986) reported a typical example of idiomorphic hausmannite alternating with bands of leucophoenicite-copper-tephroite and kutnohorite-barite-barysilite in 1–6 mm bands over a distance of 1.5 meters.

Subsequent to their formation, the sulfides and the iron-manganese silicate-carbonate-oxide units were partially reworked by late hydrothermal solutions, resulting in transgressive vuggy veins of calcite, chalcopyrite and quartz. Innes and Chaplin (1986) described a rare assemblage consisting of manganite, nambulite, brushite, cahnite, serandite, barite, kentrolite, calcite and gypsum occurring as a 10-cm-thick vein cutting the previously formed minerals. It is from here that the superb Kombat nambulite crystals came. A second epithermal assemblage contains ptygmatic-like veins of lead oxychlorides and lead chloro-arsenates.

Rare Minerals

Most of the manganese-rich assemblages contain calcite; alleghanyite, pyrochroite, hausmannite, barite and tephroite are also common. Subordinate in abundance, but locally common, are vesuvianite, spessartine, glaucochroite, rhodonite, copper, barysilite and kutnohorite. Specific uncommon assemblages deserving special mention are described below.

The lead oxychlorides

In addition to some silicate assemblages, and the differentiation of Mn and Fe, the lead oxychlorides are one more feature which link the Kombat deposit to that at Långban. The occurrence of Kombat of sahlinite (in quantities which constituted ore); kombatite (sahlinite's vanadium analog), asisite and other minerals presently under investigation, suggests that other related species may also occur here.

The lead silicates

Lead silicates are rare; they are known in quantity only from Långban and Franklin. The occurrence at Kombat of abundant barysilite (with appreciable Ca), melanotekite, kentrolite and molybdophyllite is indeed noteworthy and suggests that other lead silicates may also be found here.

Other rare minerals

The similarity of other Kombat assemblages to those commonly associated with the complex mineralogies of Franklin and Sterling Hill, and Långban, is noteworthy. For example, ganophyllite, manganberzeliite, hematophanite, cahnite, leucophoenicite, cuspidine, glaucochroite, hedyphane, manganosite, lead, copper and other minerals occur at Kombat. Many mineral assemblages in these lenses are also found in whole or in part at Noda-Tamagawa, Japan; Harstig, Sweden; and the Franciscan Formation in California.

NEW MINERAL SPECIES FROM THE KOMBAT MINE

Asisite $Pb_7SiO_8Cl_2$

Recently described by Rouse *et al.* (1988), asisite is a rare mineral which occurs as sparse, pale yellow to greenish yellow crystals associated with hematophanite, barite, jacobsite, copper, molybdophyllite, chlorite, and some unnamed minerals presently under investigation. The root name "Asis" means "drinking place" in the local Nama language. Asis is also the name of the large farm upon which the Kombat mine is located.

Holdawayite $Mn_6(CO_3)_2(OH)_7(Cl,OH)$

Holdawayite was found in great abundance; it is estimated that 200–300 metric tons were removed during mining in the E15-11 South stope between the 1238 and 1241 meter elevations. Holdawayite was first collected in 1982 on the 11 level of the Asis West sector of the Kombat mine, but was not found in other parts of the mine. It was named in honor of Dr. Michael J. Holdaway of Southern Methodist University by Peacor *et al.* (1988a); the crystal structure was described by Peacor and Rouse (1988). Holdawayite has a deep red-pink color, resembling rhodonite when fresh, but the color lightens appreciably on exposure, then eventually turns brown; finally a sooty black coating may form on the surface. Some crystals, to several mm, were found on vein surfaces, but the predominance of the material is massive. Some material resembles rhodonite. It is associated with a large number of species, including ribbeite, a mcgovernite-like mineral, pyrochroite, calcite, clinochlore, jacobsite, alleghanyite, kutnohorite and others.

Jaffeite $Ca_6Si_2O_7(OH)_6$

Jaffeite, recently described by Sarp and Peacor (1989), is the natural analog of a compound that has long been known to the cement industry as "TSH" (*t*ricalcium *s*ilicate *h*ydrate). Jaffeite is found as 0.4-mm crystals with hexagonal cross-sections, and forms within other minerals, especially defernite. It is also associated with hillebrandite, vesuvianite, apatite, glaucochroite and other minerals. Jaffeite was named in honor of Professor Howard Jaffe of the University of Massachusetts.

Johninnesite $Na_2Mg_4Mn_{12}As_2^{+5}Si_{12}O_{43}(OH)_6$

Johninnesite was first described by Dunn *et al.* (1986) from the epithermal mineral assemblage described above. It was found in 1975 in the Zero-8 Stope, 8-level, 1396 meter elevation, in the Kombat Central sector of the Kombat mine. Johninnesite is pale yellowish brown in color, prismatic, and has a decidedly fibrous habit; some specimens may resemble anthophyllite. It is associated with rhodonite, kentrolite, and richterite, and was named in honor of John Innes, then Senior Mineralogist for the Tsumeb Corporation. The best specimen is at Harvard University.

Kombatite $Pb_{14}(VO_4)_2O_9Cl_4$

Kombatite, the vanadium analog of sahlinite, was described by Rouse *et al.* (1986). It occurs as bright yellow millimeter-sized grains indistinguishable from the locally more abundant sahlinite. It is associated with hematite on the only known specimen. The name is for the Kombat mine, which is in turn an anglicized version of the Herero names for two local springs "Okombahe Tjinene" and "Okombahe Katiti," which mean, respectively, "the large drinking place of the giraffe," and "the small drinking place of the giraffe."

Ribbeite $Mn_5(SiO_4)_2(OH)_2$

Ribbeite, a polymorph of alleghanyite, was described by Peacor *et al.* (1987); it had been found in 1982 in the E15-11 South stope, 11 level, 1241 elevation, in the Asis West sector of the Kombat mine. Ribbeite forms as a granular aggregate of 0.5-mm glassy pink crystals, associated with alleghanyite, a mcgovernite-like mineral, pyrochroite, clinochlore, galaxite and jacobsite. Ribbeite was named in honor of Dr. Paul Ribbe of Virginia Polytechnical Institute and State University. It was found in moderate quantities locally.

OTHER RARE KOMBAT MINERALS

In addition to new species, the investigation of other rare minerals found here has resulted in much new knowledge regarding some previously incompletely described species and others.

Defernite $Ca_6(CO_3)_{2-x}(SiO_4)_x(OH)_7(Cl,OH)_{1-2x}$ ($x < 0.5$)

Defernite was found in 1976 in the W90 stope, 12 level, 1189 elevation, in the Asis West sector of the Kombat mine. It was very abundant. Approximately 2000 metric tons of defernite-bearing hausmannite rock were mined, almost all of which was smelted for the native copper which was pervasively disseminated throughout the material. The original occurrence of defernite, in Trabzon County, Turkey, was of poor quality material, exceedingly sparse in occurrence. The Kombat occurrence permitted the redefinition of the species (Peacor *et al.*, 1988b), resulting in the formula given above. Kombat defernite is wholly dissimilar in appearance to the colorless original material; it forms bright pink crystals to 1.0 cm, flattened on {010}, with perfect cleavage on {010} and distinct cleavage on {100}. It occurs as idiomorphic crystals distributed abundantly in granular hausmannite. Many of the defernite crystals are aligned.

Mcgovernite-like mineral

$(Mn,Mg,Fe,Al)_{273}As^{+3}_{12}As^{+5}_{30}Si_{42}O_{324}(OH)_{252}$

A mcgovernite-like mineral was found in 1982 in the E15-11 South stope, 11 level, 1241 elevation, in the Asis West sector of the Kombat mine, and was described by Dunn *et al.* (1988). It occurs as pale to bright yellow, platy aggregates up to 1.5 cm in diameter, associated with ribbeite, alleghanyite, galaxite, pyrochroite and other minerals. It differs from true mcgovernite, known only from Sterling Hill, by the absence of zinc (apparently replaced by manganese) and the absence of ferric iron (apparently replaced by aluminum). It remains unnamed in the absence of a crystal structure determination for true mcgovernite.

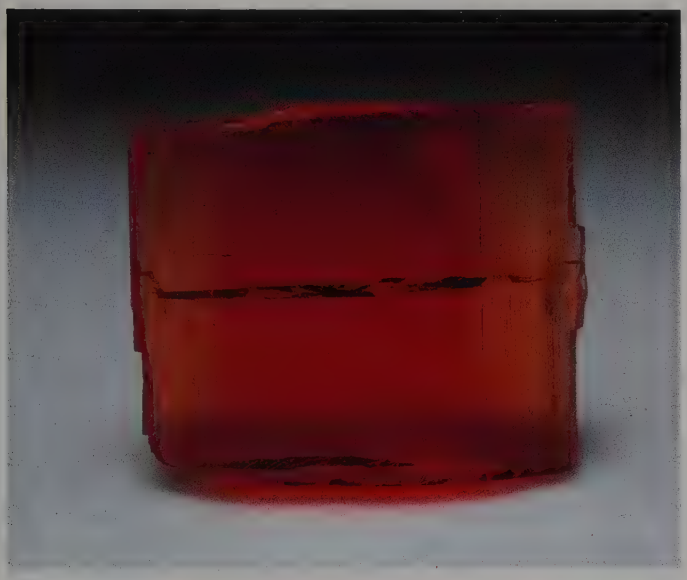

Figure 1. **Nambulite crystal, 6 cm, from the Kombat mine. Canadian Museum of Nature collection; photo by George Robinson.**

Nambulite $(Li,Na)Mn_4Si_5O_{14}(OH)$

Nambulite was first described from the Kombat mine by von Knorring *et al.* (1978). This occurrence produced the finest nambulite known to date. The crystals are flattened prismatic, bright pink to red, and up to 6 cm in length.

Sakhaite-like mineral

$Ca_{24}Mg_8(BO_3)_8[(BO_3)_y\{AlSi_4(O,OH)_{<16}\}_x](CO_3)_8\cdot<8H_2O$

(with $x = 0.75$ and $y = 5$)

Because of its similarity to harkerite, this material was locally known by that name until detailed studies were completed (Dunn *et al.*, 1990). The sakhaite-like mineral occurs as idiomorphic, euhedral crystals of octahedral habit. Many such crystals are zoned with a colorless to faint pink core surrounded by a turbid exterior zone. Transparent crystals are pale violet-pink in color. Much of this material occurred in granular, somewhat friable hausmannite on the 1208-meter elevation of the W90 (southeast) stope on 12 level in the Asis West sector of the mine. The mineral is interesting from a crystallochemical viewpoint because it has more aluminosilicate substitution than formerly known for sakhaite and is apparently more highly hydrated.

Wiserite $\{Mn_{14}(B_2O_5)_4(OH)_8\}[Si_{1-x}Mg_x][O_{1-x}(OH)_x]_4Cl_{2x}$

(with x approximately 0.5)

Wiserite had been a poorly characterized species, in large part because of the poor quality of the extant very fibrous crystals. The Kombat occurrence provided superb single-crystals, permitting a determination of the crystal structure (Pertlik and Dunn, 1989) and the publication of much new data (Dunn *et al.*, 1989). Wiserite was found in the 1978–1980 period in the 1150 West stope, 10 level, 1284-meter elevation, in the Asis West sector of the Kombat mine. Here it formed 1-mm-wide prismatic crystals, up to 1 cm in length, with a pale pinkish brown color, no cleavage and a vitreous luster. It is associated with hausmannite, jacobsite, calcite, alleghanyite and pyrobelonite. Much material with the very fibrous habit of common wiserite was also found at the Kombat mine.

CONCLUSION

The rare minerals found so far at the Kombat mine suggest that it, too, like Franklin and Långban, will be known as a classic locality for uncommon assemblages. Much work remains to be done on the minerals from this fascinating locality.

NOTE ADDED IN PROOF

Damaraite, $3PbO\cdot PbCl_2$, has just recently been described in *Mineralogical Magazine,* **54**, 593–598 (1990). It is a colorless lead oxychloride associated with jacobsite, hausmannite, hematophanite, copper and other minerals in the Asis West sector of the Kombat mine.

REFERENCES

DUNN, P. J., FRANCIS, C, A., and INNES, J. (1988) A mcgovernite-like mineral and leucophoenicite from the Kombat Mine, Namibia. *American Mineralogist,* **73**, 1182–1185.

DUNN, P. J., FRANCIS, C. A., RAMIK, R. A., NELEN, J. A., and INNES, J. (1989) Wiserite, new data from a new occurrence at the Kombat mine in Namibia. *American Mineralogist,* **74** (in press).

DUNN, P. J., PEACOR, D. R., NELEN, J. A., RAMIK, R. A., and INNES, J. (1990) A sakhaite-like mineral from the Kombat mine in Namibia. *Mineralogical Magazine* (in press).

DUNN, P. J., PEACOR, D. R., SU, S.-C., NELEN, J. A., and VON KNORRING, O. V. (1986) Johninnesite, a new sodium manganese arsenosilicate from the Kombat Mine, Namibia. *Mineralogical Magazine,* **50**, 667–670.

INNES, J., and CHAPLIN, R. C. (1986) Ore bodies of the Kombat Mine, South West Africa/Namibia. *in* Anhaeusser, C. R. and Maske, S. (Eds.). *Mineral Deposits of South Africa,* Vols. 1 and 2. Geological Society of South Africa, Johannesburg, Republic of South Africa, pp. 1789–1805.

OLSON, D. (1989) Kombat mine disaster. *Mineralogical Record,* **20**, 161.

PEACOR, D. R., DUNN, P. J., SU, S.-C., and INNES, J. (1987) Ribbeite, a polymorph of alleghanyite and member of the leucophoenicite group from the Kombat mine, Namibia. *American Mineralogist,* **73**, 213–216.

PEACOR, D. R., ESSENE, E. J., ROUSE, R. C., DUNN, P. J., NELEN,J. A., GRICE, J. D., INNES, J., and VON KNORRING, O. (1988a) Holdawayite, a new manganese hydroxyl-carbonate from the Kombat mine, Namibia. *American Mineralogist,* **73**, 632–636.

PEACOR, D. R., and ROUSE, R. C. (1988) Holdawayite, $Mn_6(CO_3)_2(OH)_7(Cl,OH)$, a structure containing anions in zeolite-like channels. *American Mineralogist,* **73**, 637–642.

PEACOR, D. R., SARP, H., DUNN, P. J., INNES, J., and NELEN, J. A. (1988b) Defernite from the Kombat mine, Namibia: a second occurrence, structure refinement and crystal chemistry. *American Mineralogist,* **73**, 888–893.

PERTLIK, F., and DUNN, P. J. (1989) The crystal structure of wiserite. *American Mineralogist,* **74** (in press).

ROUSE, R. C., DUNN, P. J., and INNES, J. (1986) Kombatite, the vanadium analogue of sahlinite, from the Kombat Mine, Southwest Africa. *Neues Jahrbuch für Mineralogie Monatshefte* (1986), 519–522.

ROUSE, R. C., PEACOR, D. R., DUNN, P. J., CRIDDLE, A. J., STANLEY, C. J., and INNES, J. (1988) Asisite, a silicon-bearing lead oxychloride from the Kombat mine, South West Africa (Namibia). *American Mineralogist,* **73**, 643–650.

SARP, H., and PEACOR, D. R. (1989) Jaffeite, a new hydrated calcium silicate from the Kombat mine, Namibia. *American Mineralogist,* **74**, 1203–1206.

Minerals Recorded from the Kombat Deposit

The following is a tabulation of all the mineral species thus far reported from the Kombat mine, prepared by the editor as an adjunct to the preceding article. The list was compiled primarily from Innes and Chaplin (1986), with the addition of occurrence reports published subsequent to that time (see preceding article).

An asterisk indicates some uncertainty in the species identification. The geologic environment and relative abundances are given according to the code shown below.

VC	Very common
C	Common
MC	Moderately common
S	Sparse
R	Rare
VR	Very rare—localized occurrence only
M	Manganese-iron silicate carbonate lenses
E	Epithermal veins
D	Dolostone-hosted

Actinolite	$Ca_2(Mg,Fe^{+2})_5Si_8O_{22}(OH)_2$	M-S
Aegirine	$NaFe^{+3}Si_2O_6$	M-R
Albite	$NaAlSi_3O_8$	M-R, D-S
Alleghanyite	$Mn_5^{+2}(SiO_4)_2(OH)_2$	M-C
Anglesite	$PbSO_4$	D-R
Anhydrite	$CaSO_4$	D-VR
Aragonite	$CaCO_3$	D-R
Arsenopyrite	FeAsS	D-R-S
Asisite	$Pb_7SiO_8Cl_2$	M-VR
Azurite	$Cu_3^{+2}(CO_3)_2(OH)_2$	D-S
Barite	$BaSO_4$	M-VC, D-MC, E-C
Barysilite	$Pb_8Mn(Si_2O_7)_3$	M-S
Bastnäsite*	$(Ce,La)(CO_3)F$	M-VR
Bayldonite*	$PbCu_3(AsO_4)_2(OH)_2 \cdot H_2O$	D-VR (?)
Betekhtinite	$Cu_{10}(Fe,Pb)S_6$	D-VR
Biotite	$K(Mg,Fe^{+2})_3(Al,Fe^{+3})Si_3O_{10}(OH,F)_2$	D-R/S, M-S
Bornite	Cu_5FeS_4	D-VC
Brucite	$Mg(OH)_2$	M-R
Brushite	$CaHPO_4 \cdot 2H_2O$	E-VR
Cahnite	$Ca_2B(AsO_4)(OH)_4$	E-VR
Calcite	$CaCO_3$	E-VC, D-VC, M-VC
Carbonate-hydroxylapatite	$Ca_5(PO_4,CO_3)_3(OH)$	D-MC
Cassiterite	SnO_2	M-VR
Cerussite	$PbCO_3$	D-MC
Chalcocite	Cu_2S	D-VC
Chalcopyrite	$CuFeS_2$	M-S, D-VC, E-VC
Chlorite (unspecified species)		D-S
Chrysocolla	$(Cu^{+2},Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$	D-R
Clinochlore	$(Mg,Fe^{+2})_5Al(Si_3Al)O_{10}(OH)_8$	M-R
Clinozoisite	$Ca_2Al_3(SiO_4)_3(OH)$	D-R
Colusite*	$Cu_{26}V_2(As,Sn,Sb)_6S_{32}$	D-VR
Copper	Cu	D-MC, M-MC
Covellite	CuS	D-S
Crednerite	$CuMnO_2$	M-MC
Crocoite*	$PbCrO_4$	D-VR
Cuprite	$Cu_2^{+1}O$	D-C
Cuspidine	$Ca_4Si_2O_7(F,OH)_2$	M-VR
Damaraite	$Pb_4O_3Cl_2$	M-VR
Defernite	$Ca_6(CO_3)_{2-x}(SiO_4)_x(Cl,OH)_{1-2x}$	M-R
Digenite	Cu_9S_5	D-MC
Dioptase	$Cu^{+2}SiO_2(OH)_2$	D-R
Dolomite	$CaMg(CO_3)_2$	D-VC
Duftite	$PbCu(AsO_4)(OH)$	D-VR
Enargite	Cu_3AsS_4	D-S
Epidote	$Ca_2(Fe^{+3},Al)_3(SiO_4)_3(OH)$	D-R/S
Fluorite*	CaF_2	D-VR
Galaxite	$(Mn^{+2},Fe^{+2},Mg)(Al,Fe^{+3})_2O_4$	M-R/S
Galena	PbS	M-S, D-VC, E-C
Ganophyllite	$(K,Na)_2(Mn,Al,Mg)_8(Si,Al)_{12}O_{29}(OH)_7 \cdot 8–9H_2O$	M-VR
Glaucochroite	$CaMn^{+2}SiO_4$	M-C

Gypsum	$CaSO_4 \cdot 2H_2O$	E-R
Harkerite	$Ca_{24}Mg_8Al_2(SiO_4)_8(BO_3)_6(CO_3)_{10} \cdot 2H_2O$	M-C
Hausmannite	$Mn^{+2}Mn^{+3}_2O_4$	M-C/VC
Hedyphane	$Pb_3Ca_2(AsO_4)_3Cl$	M-VR
Helvite	$Mn^{+2}_4Be_3(SiO_4)_3S$	E-R
Hematite	Fe_2O_3	D-MC, M-C
Hematophanite	$Pb_4Fe^{+3}_3O_8(OH,Cl)$	M-MC
Hillebrandite	$Ca_2SiO_3(OH)_2$	M-VR
Holdawayite	$Mn^{+2}_6(CO_3)_2(OH)_7(Cl,OH)$	M-VR
Hollandite*	$Ba(Mn^{+4},Mn^{+2})_8O_{16}$	M-VR (?)
Hydroxylapatite	$Ca_5(PO_4)_3(OH)$	M-R
Jacobsite	$(Mn^{+2},Fe^{+2},Mg)(Fe^{+3},Mn^{+3})_2O_4$	M-VR
Jaffeite	$Ca_6Si_2O_7(OH)_6$	
Johninnesite	$Na_2Mg_4Mn^{+2}_{12}As^{+5}_2Si_{12}O_{43}(OH)_6$	M-VR
Kaolinite	$Al_2Si_2O_5(OH)_4$	D-C
Kentrolite	$Pb_2Mn^{+3}_2Si_2O_9$	M-VR, E-VR
Kombatite	$Pb_{14}(VO_4)_2O_9Cl_4$	M-VR
Kutnohorite	$Ca(Mn^{+2},Mg,Fe^{+2})(CO_3)_2$	M-S
Lautite*	CuAsS	D-R
Lead	Pb	M-VR
Leadhillite	$Pb_4(SO_4)(CO_3)_2(OH)_2$	D-R
Leucophoenicite	$Mn^{+2}_7(SiO_4)_3(OH)_2$	M-S
Magnetite	$Fe^{+2}Fe^{+3}_2O_4$	D-MC, M-VC
Malachite	$Cu^{+2}_2(CO_3)(OH)_2$	D-C
Manganberzeliite	$(Ca,Na)_3(Mn^{+2},Mg)_2(AsO_4)_3$	M-VR
Manganite	$Mn^{+3}O(OH)$	E-R
Manganosite	$Mn^{+2}O$	M-VR/R
Mcgovernite-like mineral	$(Mn,Mg,Fe,Al)_{273}As^{+3}_{\sim 12}As^{+5}_{\sim 30}Si_{\sim 42}O_{324}(OH)_{252}$	M-VR
Melanotekite	$Pb_2Fe^{+3}_2Si_2O_9$	M-R
Microline	$KAlSi_3O_8$	D-C
Mimetite	$Pb_5(AsO_4)_3Cl$	E-R, D-VR
Molybdenite*	MoS_2	D-VR
Molybdophyllite	$Pb_2Mg_2Si_2O_7(OH)_2$	M-VR
Monazite-(Ce)	$(Ce,La,Nd,Th)PO_4$	D-R/S
Mottramite	$PbCu^{+2}(VO_4)OH$	D-MC
Muscovite	$KAl_2(Si_3Al)O_{10}(OH,F)_2$	D-C
Nambulite	$(Li,Na)Mn_4Si_5O_{14}(OH)$	E-VR
Oligoclase	$(Na,Ca)AlSi_3O_8$	D-C
Orthoclase	$KAlSi_3O_8$	D-S
Phlogopite	$KMg_3Si_3AlO_{10}(F,OH)_2$	D-R
Pyrite	FeS_2	D-MC, M-S/MC
Pyrobelonite	$PbMn^{+2}(VO_4)(OH)$	M-VR
Pyrochroite	$Mn^{+2}(OH)_2$	M-C
Pyrolusite	$Mn^{+4}O_2$	D-MC
Pyromorphite	$Pb_5(PO_4)_3Cl$	D-VR
Pyrophyllite	$Al_2Si_4O_{10}(OH)_2$	D-R
Quartz	SiO_2	D-C, M-S, E-VC
Renierite	$(Cu,Zn)_{11}(Ge,As)_2,Fe_4S_{16}$	D-VR
Rhodochrosite	$Mn^{+2}CO_3$	E-S
Rhodonite	$(Mn^{+2},Fe^{+2},Mg,Ca)SiO_3$	M-S
Ribbeite	$(Mn^{+2},Mg)_5(SiO_4)_2(OH)_2$	M-VR
Richterite	$Na_2Ca(Mg,Fe^{+2})_5Si_8O_{22}(OH)_2$	M-S
Sahlinite	$Pb_{14}(AsO_4)_2O_9Cl_4$	E-MC
Sakhaite-like mineral	$Ca_{24}Mg_8(BO_3)_8[(BO_3)_y\{AlSi_4(O,OH)_{<16}\}_x](CO_3)_8 \cdot <8H_2O$	M-VR
Serandite	$Na(Mn^{+2},Ca)_2Si_3O_8(OH)$	E-VR
Siderite	$Fe^{+2}CO_3$	D-S
Siderite (magnesian)	$(Fe^{+2},Mg)CO_3$	E-C
Silver	Ag	D-MC
Smithsonite*	$ZnCO_3$	D-R (?)
Spessartine	$Mn^{+2}_3Al_2(SiO_4)_3$	M-R
Sphalerite	(Zn,Fe)S	D-MC
Sussexite	$(Mn^{+2},Mg)BO_2(OH)$	M-VR
Talc	$Mg_3Si_4O_{10}(OH)_2$	D-S
Tennantite	$(Cu,Fe)_{12}As_4S_{13}$	D-S
Tephroite	$Mn^{+2}_2SiO_4$	M-S/MC
Vesuvianite	$Ca_{10}Mg_2Al_4(SiO_4)_5(Si_2O_7)_2(OH)_4$	M-MC
Wiserite	$(Mn^{+2},Mg)_{14}B_8(Si,Mg)O_{22}(OH)_{10}Cl$	M-VR
Witherite	$BaCO_3$	M-VR
Wulfenite	$PbMoO_4$	D-VR
Zircon	$ZrSiO_4$	D-S

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Graphite from Crestmore
California

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Exceptional graphite crystals of various habits and associations occur in limestone at the Crestmore quarries, Riverside County, California. Several twin laws have been observed, as well as crystals exhibiting spiral growth steps. Many graphite crystals are epitaxically oriented with clinochlore.

INTRODUCTION

Although graphite is a rather common mineral of important industrial use (Russell, 1988), it is seldom represented in mineral collections due to the rarity of good quality[1] crystals (Sinkankas, 1964). It has been said that near ideal crystals of graphite may be rarer than diamonds (Ubbelohde, 1965). Whether or not this is true on earth, it is probably true in outer space, where interstellar graphite is believed to be 200 times rarer than interstellar micro-diamonds. Even so, hexagonal crystals of interstellar graphite have recently been isolated in meteorites (Amari *et al.*, 1990). Mantell (1946, 1968) has noted that perfect graphite crystals are found in crystalline limestone at Pargas, Finland, but further claims (citing no reference) that the best specimens have been obtained from meteorites.

Sharp crystals of graphite from Sterling Hill, New Jersey, have been described in detail by Palache (1941), who noted the most common forms as the basal pinacoid {0001}, the first-order prism $\{10\bar{1}0\}$, and less commonly, the first-order dipyramids $\{10\bar{1}1\}$ and $\{10\bar{1}2\}$. He noted the occurrence of many rarer forms as well. Goldschmidt (1918) illustrated several crystals of graphite from Finland, Ticonderoga (New York) and Ceylon; those from Ceylon (after Sjögren, 1884) show deformation twinning. Due to the industrial significance of synthetic graphite, related literature is immense (see, for example, Fredriksson and Hillert, 1985). Graphite crystals grown in nickel and iron melts (Austerman, 1968) often show remarkable morphological similarity to those that occur naturally in calcite (Lauf and Pasto, 1983; Ubbelohde and Lewis, 1960; Palache, 1941). In the 1960's graphite crystals in calcite from Ticonderoga, New York, became a standard of perfection for experiments and for comparison with laboratory-grown crystals. Even in the case of that occurrence, however, considerable search was necessary to locate well-formed crystals.

In my experience, some of the most interesting and well formed natural graphite crystals occur (up to 2 mm in size) in the white and blue calcites from the Crestmore quarries, Riverside County, California. Similar graphite also occurs at the nearby Jensen quarry (DeVito and Ordway, 1984). All of the samples illustrated in this article were isolated from specimens purchased from the Jurupa Mountains Cultural Center, Riverside, California, and were labeled as being from Crestmore. All of the graphite crystals shown were mechanically trimmed (possible because of the transparency of the calcite) in order to preserve the calcite matrix and associated minerals. Now that the Crestmore quarries are open to collecting again, through the Jurupa Mountains Cultural Center which has exclusive rights for collecting trips (Kirkby, 1990), there is a continuing possibility of finding similar specimens in the future. Careful examination of specimens from the Crestmore and Jensen quarries already in collections might also prove fruitful.

OCCURRENCE

The famous Crestmore mineral locality, now a coalesced collection of quarries and underground workings operated by the Riverside Cement Company, is located in the Jurupa Mountains about 3 miles north of Riverside, in Riverside County, California. The area mainly consists of two hills of highly crystallized limestone, metamorphosed by a series of igneous intrusions, on a base of granodiorite. The area geology is more extensively discussed by DeVito *et al.* (1971), Murdoch (1961), Daly (1935) and Eakle (1917). The north hill, well known for its blue calcite, is called Sky Blue Hill. The south hill, called Chino Hill, consists largely of a white marble. Graphite occurs in both of the metamorphosed limestones, but seems to have been more prominent in the Chino Hill limestone. Graphite's occurrence

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[1]For an exceptional specimen of graphite crystals on matrix, see Robinson and Chamberlain (1982).

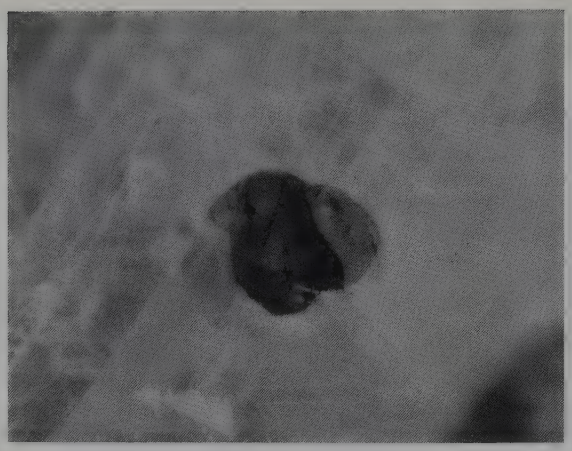

Figure 1. **Graphite and brucite after periclase in calcite. The brucite pisolite is 1 mm across. JAJ specimen #1024 and photo.**

there was first noted by Eakle (1917), who described it as forming crude flakes and scales intimately associated with waxy white brucite (after periclase) pisolites in calcite; the latter appearing gray in color due to the high concentration of brucite and graphite (Fig. 1). Despite the abundance of graphite there, Eakle (1927) noted that at Chino Hill there was "nothing of special interest to the collector." Graphite has also been noted by several authors as occurring at Sky Blue Hill, although little or no detailed discussion has been published.

In addition to the calcite, graphite from Crestmore has been cited in association with humite, chondrodite, diopside, geikielite and brucite after periclase (Eakle, 1917; Jenni, 1957). I have also noted clinochlore, phlogopite, spinel, pyrrhotite and ludwigite, and additional associations are likely.

SINGLE CRYSTALS

Despite its prominent occurrence, little has been written about Crestmore graphite. In addition to the type of graphite described by Eakle, crude graphite crystals have been observed along the grain boundaries in pale blue, crystalline, anhedral calcite. Although these make attractive specimens, the crystals typically are randomly oriented, have a frosty luster, and do not show a hexagonal outline (Fig. 2). By

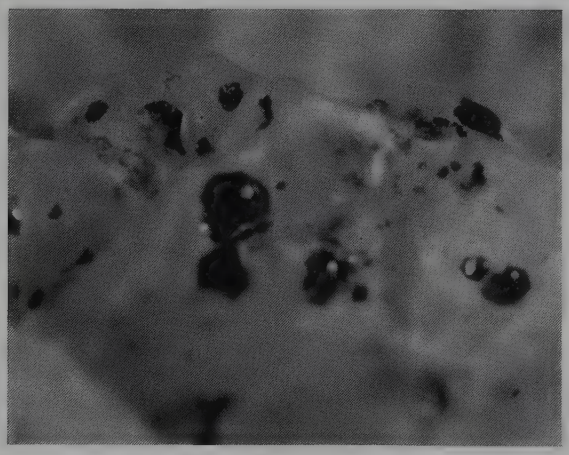

Figure 2. **Typical rough graphite crystals, to 2 mm across, in coarsely crystalline calcite. JAJ specimen #889 and photo.**

contrast, a variety of graphite morphologies has been observed in a single 12-cm specimen (#888) of pale blue calcite, associated with transparent green diopside, light green or yellow clinochlore, pale and transparent ellestadite (?), black prismatic ludwigite (?), and an unidentified fibrous white mineral. Overall, this specimen seems similar to those from the Gouverneur Talc Company's wollastonite quarry, Lewis County, New York (author's collection), and the Lead Hill mine, Ticonderoga, New York (Lauf and Pasto, 1983). However, unlike most graphite crystals, even those with sharp hexagonal outlines, some Crestmore crystals show first-order dipyramids, and several crystals were found with lustrous and relatively large first-order prism faces (Fig. 3). Typically the prism faces are very small and

Figure 3. **Relatively thick, sharp, 0.5-mm graphite crystal with diopside in calcite. JAJ specimen #888 and photo.**

striated if visible at all. This same 12-cm specimen, containing graphite crystals exhibiting growth twinning, growth spirals, and epitaxic orientation on clinochlore, is the source of the crystals described below.

TWINS

Crystals of graphite are invariably mechanically twinned on $\{11\bar{2}1\}$, as evidenced by the striae parallel to $<1\bar{1}00>$ directions on the basal pinacoids; this results either from natural metamorphism or from accidental deformation in the laboratory. For a time, the profuse twinning caused some confusion regarding the actual symmetry of graphite, which is now accepted as generally being hexagonal (Freise, 1962). A metastable rhombohedral polytype also exists to some extent in highly metamorphosed deposits, and can be induced in hexagonal graphite by grinding (Bacon, 1950; Laves and Baskin, 1956; Freise and Kelly, 1963; Kwiecińska, 1978). The always present striae, accompanied by gliding of (0001) planes, were noted in 1884 by Sjögren, and were shown to be twins by reflection on $\{11\bar{2}1\}$ by Palache (1941). A detailed analysis of this and other reflection twin laws in graphite has been given by Freise and Kelly (1961), Baker *et al.* (1966), and Shafranovsky (1981, 1982, 1983). Well characterized twins have been observed on $\{11\bar{2}1\}$, $\{11\bar{2}2\}$ and $\{10\bar{1}1\}$, with the $\{11\bar{2}1\}$ twins being by far the most common. In synthetic graphite crystals, *growth* twins have been observed and documented (Austerman, 1968), in addition to the much more common deformation twins. In natural crystals of graphite, however, discussion of growth twinning by reflection seems to be limited to the works by G. I. Shafranovsky (1981, 1982, 1983), who discusses (in Russian) and diagrammatically illustrates both simple growth twins and rare multiple growth twins from Botogol, USSR. Interestingly, I. I. Shafranovsky and G. I. Shafranovsky (1983) have proposed twinning as playing a primary role in the formation of graphite pseudomorphs after diamond, which have been found in the Beni Bousera peridodite massif in northern Morocco (Pearson *et al.*, 1989; Slodkevich, 1982). Moreover, Minkoff and Lux (1985) have proposed twinning as a possible mechanism for the formation of spherulitic graphite which occurs synthetically as well as naturally in pegmatites and meteorites (see also Minkoff, 1985).

Several crystals from Crestmore have been observed which are clearly growth twins on $\{11\bar{2}1\}$ and which very much resemble some

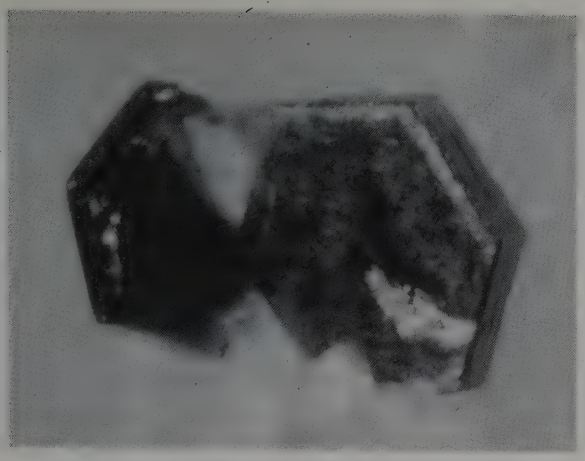

Figure 4. **Simple graphite growth twin on {11$\bar{2}$1}, on calcite. The large crystal is 1 mm wide. JAJ specimen #888 and photo. Note also the small first-order dipyramidal faces of the large crystal.**

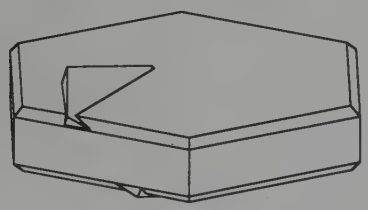

Figure 5. **Simple graphite growth twin on {11$\bar{2}$1}.**

synthetic growth twins (Austerman, 1968). Figures 4 and 5 show a simple, small, growth twin on {11$\bar{2}$1}, visible on the basal pinacoid of a larger graphite crystal. The angle of inclination of the twin with the basal pinacoid of the larger crystal is approximately 21°. A rare multiple growth twin on the same twin law is shown in Figure 6. As

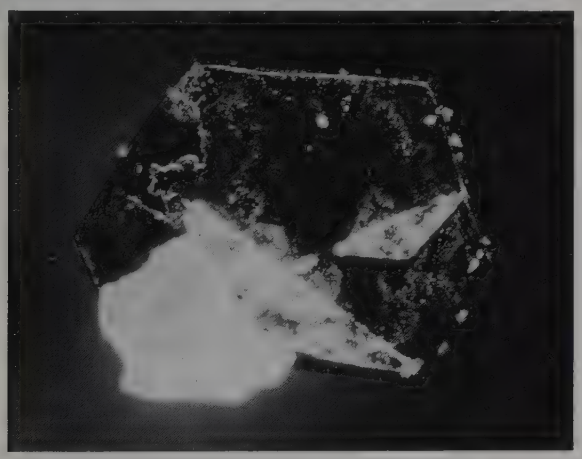

Figure 6. **Multiple graphite growth twin on {11$\bar{2}$1} with calcite, from Crestmore. Large crystal is 1.5 mm wide. JAJ specimen #888 and photo. Specimen is now in the collection of Dan Behnke.**

a crude indication of their frequency of occurrence, note that six {11$\bar{2}$1} twins were found out of approximately 122 graphite crystals deemed worthy of saving after carefully trimming through half of the 12-cm specimen mentioned above, and discarding most of the graphite crystals encountered.

Of the less common {11$\bar{2}$2} and {10$\bar{1}$1} graphite twins observed in synthetic crystals, {10$\bar{1}$1} twins have only been seen as narrow bands

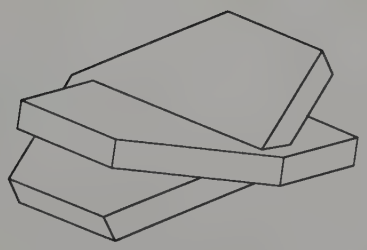

Figure 7. **Hypothetical graphite twin on {10$\bar{1}$1}.**

in synthetic crystals, and have not yet been found at all as growth twins at Crestmore. A hypothetical graphite twin on {10$\bar{1}$1}, whose [0001] axes are inclined by 35°, is shown in Figure 7. A growth twin on {11$\bar{2}$2}, however, has been observed in Crestmore graphite and is illustrated in Figure 8. The angle of inclination of the [0001] axes in

Figure 8. (top) **Simple graphite growth twin on {11$\bar{2}$2} in calcite, photographed using a polarizing filter. Large crystal is 0.5 mm wide. JAJ specimen #888 and photo;** ***(bottom)*** **sketch of the same twin.**

such twins is approximately 42°. It seems probable that twinning according to rarer twin laws on {h.h.$\bar{2}$h.l} or {h0$\bar{h}l$}, as discussed by Shafranovsky (1981, 1982, 1983), might also be discovered in Crestmore and Jensen quarry material with diligent searching.

Rotation twins, composed of crystals rotated about [0001] with {0001} composition planes, have also been observed from Crestmore. Due to the weak bonding between {0001} planes, the rotation angles are not always crystallographically precise, and usually form simple twist grain boundaries (Freise, 1962). This can be a factor in promoting a tabular crystal habit (Minkoff, 1979, 1985). Rotations about [0001] by 90° form true twins, and have been described by Wesselowski and Wassiliew (1934) (Fig. 9), and noted by Frondel (1972). Several crystals of graphite from Crestmore appear to be such rotation twins, as shown in Figure 10 (compare to Figure 1 in Bollmann and Lux, 1975).

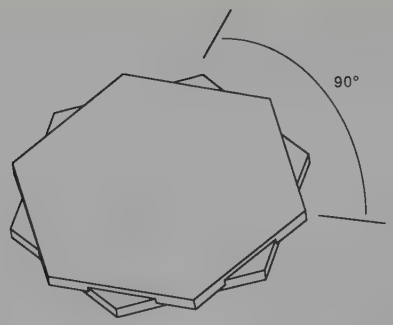

Figure 9. **Graphite contact rotation twin, by 90° about [0001].**

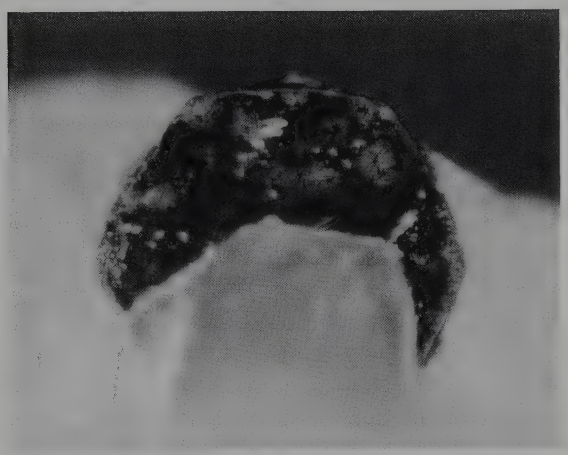

Figure 10. **Graphite contact rotation twin, by 90° about [0001], in calcite. Crystal is 1 mm across. JAJ specimen #888 and photo.**

SPIRALS

In addition to the common mechanical-twinning striae that are visible on graphite's basal pinacoids, growth spirals are also a commonly observed surface feature on some Crestmore graphite crystals. These spirals, typically composed of steps approximately 500Å high, have been noted in graphite crystals in limestone from the Grenville series (ranging from the Adirondacks to north of Quebec), and have been suggested as having originated from screw dislocations reaching the {0001} surfaces (Horn, 1952; Weiner and Hager, 1987). Unlike the Grenville specimens, however, some specimens from Crestmore show spirals imprinted on the calcite where it makes contact with the graphite crystals. The growth spirals are most easily made visible by reflecting light from the edges of the steps. In one unique Crestmore specimen, however, the steps seem to be naturally etched, which renders the spiral much more visible (Fig. 11).

Spiral growth from screw dislocations has long been recognized as an important element in the growth of crystals in general (Frank, 1949), and in the growth of whisker crystals in particular (see, for example, Henderson and Francis, 1989). The reason is that where a screw dislocation meets a crystal surface, a perpetual step is created (visible as the growth spiral) providing an energetically favorable location for the further attachment of atoms to the crystal. Correspondingly, under conditions of dissolution, screw dislocations provide favorable locations for detachment of atoms. Anisotropic distributions of screw dislocations can affect the overall morphology of growing crystals, with whiskers being an extreme example. Various types of whisker crystals of graphite have been observed in synthetic graphite (Lieberman *et al.*, 1971) as well as in natural graphite from Ticonderoga, New York (Patel and Deshapande, 1970). However, no graphite whiskers have yet been observed from Crestmore, nor do the

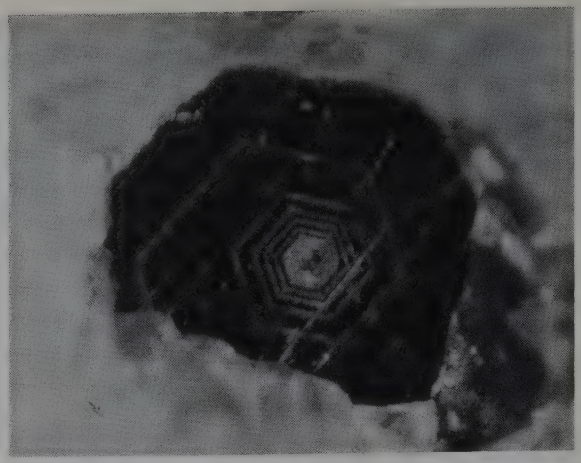

Figure 11. **Naturally etched growth spiral on a 1-mm graphite crystal in calcite. JAJ specimen #888 and photo.**

screw dislocations appear to have changed the usual tabular morphology of the graphite crystals. On the other hand, one crystals has been found to show small etch pits and a rough hole in the center of the {0001} face (Fig. 12). One might speculate that this is due to more

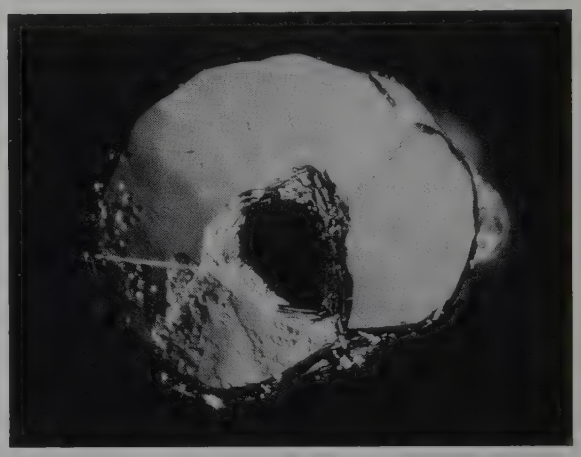

Figure 12. **Graphite crystal, 1.3 mm, from Crestmore, with a 0.4-mm hole and numerous etch pits. JAJ specimen #1205 and photo.**

rapid dissolution of the graphite at screw dislocations. (See also Minkoff, 1979.) The combination of screw dislocations and impurities can have interesting effects on the graphite morphology (Lux *et al.*, 1975).

EPITAXY

Numerous graphite crystals have been observed associated with pale green or yellow clinochlore. Since the lattice parameter mismatch between two hexagonal carbon rings in graphite and one hexagonal silicate ring in clinochlore is under 9%, it should be energetically favorable for epitaxic association. Almost invariably, when the two minerals are in close association, they make contact on their basal planes (Fig. 13), strongly suggesting that they are epitaxically associated. In many cases clinochlore sandwiches the graphite completely, which protects the graphite from damage as it is trimmed from the enclosing calcite matrix (Fig. 14). In such cases, graphite's high luster can often be seen through the clinochlore. Most commonly, the clinochlore is found as a small transparent crystal on a basal face of a slightly larger graphite crystal (Fig. 15). Unfortunately, the clinochlore crystals usually have a rounded outline, making it difficult to visually establish its orientation on the graphite.

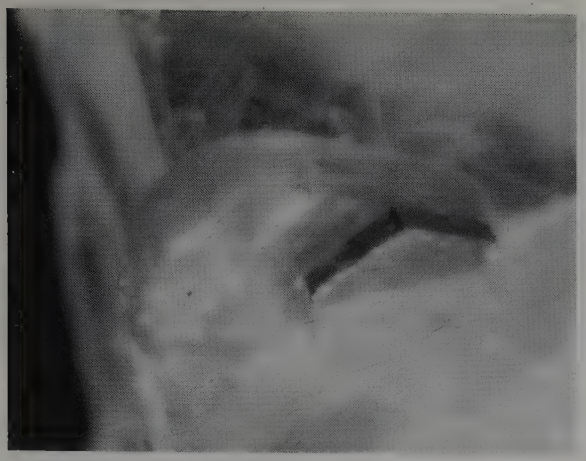

Figure 13. **Epitaxic graphite (0.5 mm) on a green clinochlore crystal in calcite. JAJ specimen #888 and photo.**

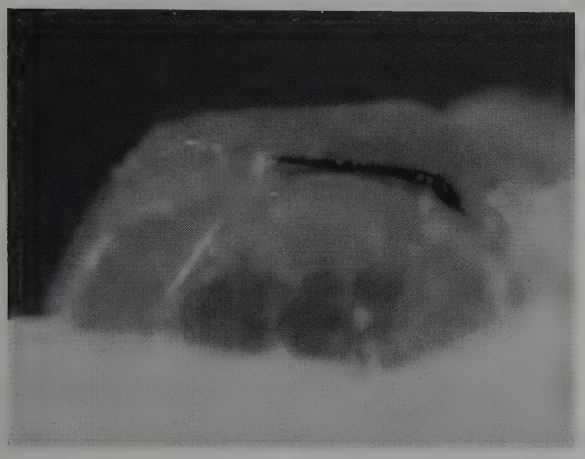

Figure 14. **Epitaxic graphite (1 mm) and clinochlore in calcite. JAJ specimen #888 and photo.**

Figure 15. **Epitaxic graphite and clinochlore, 0.3 mm wide, in calcite. JAJ specimen and photo.**

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REFERENCES

AMARI, S., ANDERS, E., VIRAG, A., and ZINNER, E. (1990) Interstellar graphite in meteorites. *Nature* (London), **345**, 238–240.

AUSTERMAN, S. B. (1968) Growth of graphite crystals from solution. In *Chemistry and Physics of Carbon,* P. L. Walker, Jr. (editor). Marcel Dekker, New York, 137–183.

BACON, G. E. (1950) A note on the rhombohedral modification of graphite. *Acta Crystallographica,* **3**, 320.

BAKER, C., GILLIN, L. M., and KELLY, A. (1966) Twinning in graphite. In *Second Conference on Industrial Carbon and Graphite,* Society of Chemical Industry, 132–138.

BOLLMANN, W., and LUX, B. (1975) Grain boundaries in graphite. In *The Metallurgy of Cast Iron,* B. Lux, I. Minkoff, and F. Mollard (editors). Georgi, St. Saphorin, Switzerland, 461–471.

DALY, J. W. (1935) Paragenesis of the mineral assemblage at Crestmore, Riverside County, California. *American Mineralogist,* **20**, 638–659.

DEVITO, F., and ORDWAY, A., JR. (1984) The Jensen quarry, Riverside County, California. *Mineralogical Record,* **15**, 273–290.

DEVITO, F., PARCEL, R., and JEFFERSON, G. T. (1971) Contact metamorphic minerals at Crestmore quarry, Riverside, California. In *Geological Excursions in Southern California,* W. A. Elders (editor). University of California, Riverside Campus Museum, Riverside, 94–125.

DOWTY, E., and RICHARDS, R. P. (1988) SHAPE, a computer program for drawing crystals.

EAKLE, A. S. (1917) Minerals associated with the crystalline limestone at Crestmore, Riverside Co., California. *University of California Publications Bulletin of the Department of Geology,* **10**, 327–360.

EAKLE, A. S. (1927) Famous mineral localities: Crestmore, Riverside County, California. *American Mineralogist,* **12**, 319–321.

FRANK, F. C. (1949) The influence of dislocations on crystal growth. *Discussions of the Faraday Society,* (5) 48–54.

FREDRIKSSON, H., and HILLERT, M., editors (1985) The physical metallurgy of cast iron. *Materials Research Society Symposia Proceedings,* **34**. North-Holland, New York, 1–86.

FREISE, E. J. (1962) Structure of graphite. *Nature* (London), **193**, 671–672.

FREISE, E. J., and KELLY, A. (1961) Twinning in graphite. *Proceedings of the Royal Society* (London), **264**, 269–276.

FREISE, E. J., and KELLY, A. (1963) The deformation of graphite crystals and the production of the rhombohedral form. *Philosophical Magazine,* **8**, 1519–1533.

FRONDEL, C. (1972) *The Minerals of Franklin and Sterling Hill, a Check List.* John Wiley & Sons, New York, 94 p.

GOLDSCHMIDT, V. (1918) *Atlas der Krystallformen.* Carl Winters Universitätsbuchhandlung, Heidelberg. Facsimile reprint (1986) Rochester Mineralogical Symposium, Rochester, New York, vol. 4.

HENDERSON, W. A., JR., and FRANCIS, C. A. (1989) On right-angle bends in filiform pyrite. *Mineralogical Record,* **20**, 457–464.

HORN, F. H. (1952) Spiral growth on graphite. *Nature* (London), **170**, 581.

JENNI, C. M. (1957) Crestmore and its minerals. *Gems & Minerals,* (238), 34, 79.

KIRKBY, R. A. (1990) Letter to the editor. *Rocks and Minerals,* **65**, 113.

KWIECIŃSKA, B. (1978) On the rhombohedral modification in natural graphites and semi-graphites. *Mineralogica Polonica,* **9**, 3–15.

LAUF, R. J., and PASTO, A. E. (1983) Graphite from the Lead Hill mine, Ticonderoga, New York. *Mineralogical Record,* **14**, 25–30.

LAVES, F., and BASKIN, Y. (1956) On the formation of the rhombohedral graphite modification. *Zeitschrift für Kristallographie,* **107**, 337–356.

LIEBERMAN, M. L., HILLS, C. R., and MIGLIONICO, C. J. (1971) Growth of graphite filaments. *Carbon,* **9**, 633–635.

LUX, B., MINKOFF, I., MOLLARD, F., and THURY, E. (1975) Branching of graphite crystals growing from a metallic solution. In *The Metallurgy of Cast Iron,* B. Lux, I. Minkoff, and F. Mollard (editors). Georgi, St. Saphorin, Switzerland, 495–508.

MANTELL, C. L. (1946) *Industrial Carbon*. D. Van Nostrand, New York, 19.

MANTELL, C. L. (1968) *Carbon and Graphite Handbook*. John Wiley & Sons, New York, 61.

MINKOFF, I. (1979) Graphite crystallization. In *Preparation and Properties of Solid State Minerals*. W. R. Wilcox (editor). Marcell Dekker, New York, 1–48.

MINKOFF, I. (1985) The spherulitic growth of graphite. In *The Physical Metallurgy of Cast Iron,* H. Fredriksson and M. Hillert (editors). Materials Research Society Symposia Proceedings, **34**. North-Holland, New York, 37–45.

MINKOFF, I., and LUX, B. (1985) Graphite growth from metallic solution. In *The Metallurgy of Cast Iron,* B. Lux, I. Minkoff, and F. Mollard (editors). Georgi, St. Saphorin, Switzerland, 473–493.

MURDOCH, J. M. (1961) Crestmore, past and present. *American Mineralogist,* **46**, 245–257.

PALACHE, C. (1941) Contributions to the mineralogy of Sterling Hill, New Jersey: morphology of graphite, arsenopyrite, pyrite, and arsenic. *American Mineralogist,* **26**, 709–717.

PATEL, A. R., and DESHAPANDE, S. V. (1970) Whisker growth in natural graphite. *Carbon,* **8**, 242.

PEARSON, D. G., DAVIES, G. R., NIXON, P. H., and MILLEDGE, H. J. (1989) Graphitized diamonds from a peridotite massif in Morocco and implications for anomalous diamond occurrences. *Nature* (London), **338**, 60–62.

ROBINSON, G., and CHAMBERLAIN, S. C. (1982) An introduction to the mineralogy of Ontario's Grenville province. *Mineralogical Record,* **13**, 71–86.

RUSSELL, A. (1988) Graphite: current shortfalls in flake supply. *Industrial Minerals,* (255), 23–43.

SHAFRANOVSKY, G. I. (1981) [New graphite twins.] *Zapiski Vsesoyuznogo Mineralogicheskogo Obshchestva,* **110**, 716–720. (In Russian.)

SHAFRANOVSKY, G. I. (1982) [Graphite twins and triads.] *Mineralogicheskiĭ Zhurnal,* **4**, 74–81. (In Russian with English summary.)

SHAFRANOVSKY, G. I. (1983) [Classical and non-classical graphite twins.] *Zapiski Vsesoyuznogo Mineralogicheskogo Obshchestva,* **112**, 577–581. (In Russian.)

SHAFRANOVSKY, I. I., and SHAFRANOVSKY, G. I. (1983) ["Cubicity" in hexagonal crystals.] *Kristallographiya,* **28**, 837–839. (In Russian.) [*Soviet Physics-Crystallography,* **28**, 497–498. (In English.)]

SINKANKAS, J. (1964) *Mineralogy for Amateurs*. Van Nostrand Reinhold, New York, 290.

SJÖGREN, H. (1884) Om grafitens kristallform och fysiska egenskaper. *Öfversigt af Svenska Vetenskapsakademien Forhandlingar,* **44**, 29–53.

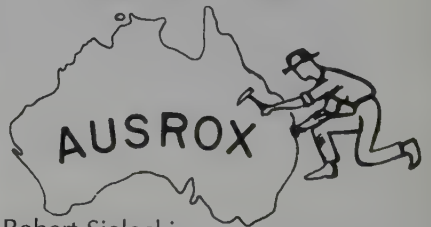
SLODKEVICH, V. V. (1982) [Graphite paramorphs after diamond.] *Zapiski Vsesoyuznogo Mineralogicheskogo Obshchestva,* **111**, 13–33. (In Russian.) [(1983) *International Geology Review,* **25**, 497–514. (In English.)]

UBBELOHDE, A. R. (1965) The anisotrophy of graphite. *Endeavour,* **92**, 63.

UBBELOHDE, A. R., and LEWIS, F. A. (1960) *Graphite and its Crystal Compounds*. Clarendon Press, Oxford, 178.

WEINER, K.-L., and HAGER, H. (1987) [Growth spirals on graphite crystals.] *Lapis,* **12** (1), 31–33. (In German.)

WESSELOWSKI, W. S., and WASSILIEW, K. W. (1934) Zwillingsbildungen bei Graphitkristallen. *Zeitschrift für Kristallographie,* **89**, 494–496. (In German.)



The Mineral Collection of MORITZ AND ADOLF LECHNER *Vienna*

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The Lechners built one of Europe's largest and finest private mineral collections. It lay in Vienna, for sale but ignored, for more than 40 years before finally being dispersed. Ultimately, many of the best specimens were sold to American museums and private collectors.

INTRODUCTION

In December of 1955 Dr. George Switzer, then Curator of Mineralogy at the U.S. National Museum of Natural History (Smithsonian Institution), invited Paul Desautels (then teaching chemistry at Towson State College) and myself to accompany him on a trip to Schortmann's Minerals in Easthampton, Massachusetts. The purpose of Switzer's trip was to inspect and purchase specimens from a remarkable European collection that had come into the hands of the Schortmanns; Paul and I were to help George wade through the thousands of specimens efficiently and quickly. This unusual arrangement had been agreed to by Ray Schortmann with a stipulation: "We have no objection to either Smith or Desautels coming along as long as it is understood that they will not be permitted to make any private purchases from the lot at this time" (letter in the possession of the USNM). Thus it was that the three of us set out on a mineralogical adventure: a visit on December 13th and 14th, 1955, to see the Lechner collection, one of the finest European collections to arrive on our shores.

At the time of our visit we knew nothing of the Lechner collection; at the end we knew a great deal about the specimens, but precious little else. For the better part of 1990 and 1991 I have been attempting to fill in the great gaps in my knowledge; this essay is the result. Much is still unknown or unclear, but what follows is what I've been able to uncover.

THE COLLECTION

The collection was formed in Vienna by Moritz Lechner,[1] who died in 1904. It was added to by his second son, Hofrat (Privy Councillor) Dr. Adolf Lechner, who ended his juridical career as the Staatsproukuratur of the Republic of Austria, equivalent to the U.S. Attorney General. The younger Lechner was an important and long-standing member of the Vienna (later Austrian) Mineralogical Society, and was among the 150 members of the Society in 1910. His fellow members at that time included such familiar names as Gustav Seligmann, Gustav Tschermak, Hans von Karabacek and Victor Goldschmidt. During this period Lechner and his collection resided at Schaumburgerstrasse 6, in Vienna (Loehr, 1911). He was elected a Fellow of the society on 10 December 1951, shortly before his death on 6 March 1952.

The Lechner collection, according to Loehr (1911), had absorbed the Fodor, Pohl and Seeland collections, and it contained many specimens from the collections of Beroldingen, Beranger, Frenzel, Hochberg, Koch, Lhotzky, Lill, Dom Pedro II, Rosthorn, Scherzer, Töpli and Uslar (see sidebar, next page). Gerhard Niedermayr, Curator at the Vienna Museum of Natural History, has this to say about the Pohl elements of the Lechner collection (personal communication, 1990):

> [In my opinion,] the most important part of these collections must have been the specimens from Pohl. Pohl was one of the leading scientists who guided the Austrian Princess Leopoldina, wife of Crown Prince Dom Pedro of Brazil, to Brazil and later traveled on various routes through [that] vast country, by chance collecting a lot of rocks, ores and minerals for the Imperial collection in Vienna (and most probably also for himself).

The collection was fixed at 8,314 specimens no later than 1911 and was at that time being offered for sale (Loehr, 1911). It apparently remained almost intact and on sale for over 40 years!

The Lechner collection was characterized by several features: (1) It contained specimens of most of the species considered valid in the early years of the twentieth century: (2) It was extremely rich in *named* varieties. (3) It was extremely rich in specimens from Central European localities, both classic and obscure. (4) Especially notable were its acanthites, proustite-pyrargyrites, argentopyrites and other silver minerals. (5) There were no large nor very small specimens; most were

[1]Various spellings seen include "Lichtner," "Leichtner," "Leichner, etc., but the correct spelling is "Lechner."

LECHNER'S SOURCES

Lechner purchased all or part of many earlier collections in the course of assembling his own, as listed briefly by Loehr (1911). Dr. Gerhard Niedermayr of the Vienna Natural History Museum; Otto Fitz, a Viennese collector and historian; and Dr. Wendell E. Wilson* have provided the following information on those early collectors.

BEROLDINGEN, JOHANN ANTON SIGISMUND VON (1738–1816), German cleric and brother of Franz Cölestin, Baron von Beroldingen (1740–1798) another mineral collector. Franz's 14,000-specimen mineral collection was sold to the British Museum by his nephew in 1816. Johann's collection was purchased by Moritz Lechner.

BERANGER, probably Ing. A. Béranger, an employee of the Imperial Railroad Company and an Inspector on its southern branch. Between the years 1870 and 1882 the Vienna Natural History Museum acquired many specimens from his mineral collection.

DOM PEDRO DE ALCANTARA (1825–1891), second and last Emperor of Brazil. He was forced to abdicate in 1889 when the republic was proclaimed; he moved to Europe, taking his mineral collection with him, and died in Paris two years later.

FODOR, possibly Ladislaus Fodor, Professor of Mathematics at the Mining Academy in Schemnitz.

FRENZEL, FRIEDRICH AUGUST (1824–1902), mineralogist and professor at the mining academies in Schemnitz and Freiberg.

HOCHBERG (nothing known)

KOCH, GUSTAV ADOLF (1846–1921), Professor of Geognosie at the Vienna Academy for Soil Science ("Hochschule für Bodenkultur").

LHOTZKY, probably Johann Lhotzky (there were several collectors named Lhotzky), Bergrat and later Oberbergrat of the Ministry of Agriculture ("Ackerbauministerium"). During the years 1879–1888 the Vienna Natural History Museum acquired many interesting ore specimens from the Johann Lhotzky collection.

LILL VON LILIENBACH, ALOIS (died 1871 in Pribram), mining engineer, "Gubernialrath," and later Royal Imperial Ministerialrath and Bergoberamtsdirektor in Pribram, Bohemia. His collection was inherited by his brother, Maximilian (who died 1893 in Vienna). It is uncertain which brother sold specimens to Lechner.

POHL, JOSEF (1825–1900), son of Prof. Dr. Johann Emanuel Pohl, who was probably responsible for forming the bulk of the collection. The elder Pohl, a physician, mineralogist and botanist from Prague, was an important Austrian naturalist and member of an Austrian expedition to Brazil financed by Austrian Emperor Franz I. The younger Pohl, from whom Lechner obtained the collection, was Professor of Chemistry and Technology at the Technical University of Vienna ("Technische Hochschule").

ROSTHORN, FRANZ EDLER VON (1796–1877). Rosthorn studied mining engineering and geology at the Mining Academy in Schemnitz from 1814 to 1818, and later (in 1823) under Friedrich Mohs in Vienna. He was a companion and friend to Archduke Johann (mineral collector and founder of the "Joanneum" in Graz), and was a founding member of the Carinthia Natural History Museum and Association.

SCHERZER, possibly Karl von Scherzer (1821–1903) or Franz Scherzer of Vienna.

SEELAND, FERDINAND (1822–1901). He studied mining engineering at the Mining Academies in Schemnitz and Leoben until 1855, when he took the position of mining engineer and mine manager at the Lölling iron mine in Carinthia. He was made Oberbergrat in 1891, and was President of the Naturwissenschaftlichen Verein für Kärnten.

TÖPLI, probably Töply von Hohenfest (born 1817 in Vienna); but perhaps William Topley (1841–1894), English geologist.

USLAR, perhaps Julius Wilhelm Louis von Uslar (born 1828).

*From his manuscript, "The history of mineral collecting, 1530–1799," soon to be published.

between 4 x 6 cm and 8 x 10 cm. Arthur Montgomery wrote (personal communication, 1990):

> High quality [was] possessed by almost every specimen . . . When I had that unique chance to look carefully at all those specimens in all those drawers, I gained enormous respect for the taste, discrimination, [and] thoughtful care which the owner lavished on his collection . . .

Another interesting commentary, not only on the Lechner collection, but on the valuation of minerals over the years and in different countries, is that of Anton Berger, the famous mineral dealer of Mödling, Austria, who wrote in a letter of 4 January 1952 to Willard Perkin (letter in the possession of Willard Perkin):

> We were relieved to learn that you liked the minerals out of the collection of Dr. Lechner, for the prices are unfortunately higher than those of our own minerals. This is due to the fact that 50 years ago fine minerals had to be paid at manifold higher rates than now-a-days. Today Mr. Lechner gets for his minerals practically only the 10th of that value which his father had to pay about 80 years ago. We shall, of course, try to get more of Mr. Lechner's minerals for you, first of all unusual and nicely colored specimens. To [tell] the truth the collection does not contain too much of those minerals for at former times collections in Europe were put together from the scientific point-of-view: now and then especially rare or valuable material was added. These sorts of specimens are rather frequent in Mr. Lechner's collection and we should like to send you some samples but are afraid that your friends will be startled at the high prices. The Californian collectors cannot very well be acquainted with the fact that certain specimens (sometimes even looking rather mean) have always been very rare and respectively expensive with us in Europe and they will certainly prefer fine looking minerals when they make up their mind to spend much money. Prof. Foshag told us that the greatest collector in California is Mr. [Magnus] Vonsen in Petaluma. Are you in touch with this gentleman? Perhaps you can occasionally inquire [of] him if he were interested in very rare and valuable specimens from ancient and famous European localities which he could not get elsewhere. We should then send you a small selection of exquisite pieces which you might show the above gentleman. If he really knows a thing or two about minerals he will surely be glad getting the opportunity of buying such material.

It would be interesting to see a tally of the species and locality

distribution of the entire Lechner collection; unfortunately this is impossible at the present time. But I do have statistics on 711 specimens sold to American institutions and collectors:

Elements	35	Carbonates	52
Sulfides	106	Sulfates	142
Sulfosalts	82	Phosphates, arsenates	
Oxides	57	and vanadates	112
Halides	17	Other (Cr, Mo, W, etc.)	20
		Silicates	188

Obviously elements, sulfides and especially sulfosalts were disproportionately numerous, reflecting the strengths of the collection.

Also of interest is the locality distribution, which I provide in its pre–World War I form, taken from 680 American purchases (the smaller number here is due to the lack of valid locality data for some specimens as supplied to me):

Austria-Hungary	229	Russian Empire	35
Hapsburg Empire)		Sweden	29
German Empire	147	United States	17
Italy	46	Norway	16
Switzerland	46	France	13
United Kingdom	46	Other	47

"Other" includes Spain, Iceland, Serbia, Greece, Brazil, Bolivia and Mexico, plus such unlikely 19th-century collecting haunts as Australia, Chile, Venezuela, Argentina, Cuba, Belgium and Borneo. (Readers should recall that virtually all of Central and Eastern Europe at that time lay in the three empires.)

SALE THROUGH BERGER

On February 18, 1952, Anton Berger wrote Willard Perkin saying that "We have already spoken to Mr. Lechner and in about a week we shall be able to let you have a short list" [of outstanding specimens in the collection.] This indicates that before Dr. Lechner died negotiations were already under way for the sale of at least some of the collection to buyers in the U.S. Unfortunately for Mr. Perkin, Berger reported on May 26th that Dr. Lechner had died, and "His heirs do not know anything about minerals and, therefore, it is very difficult to do reasonable business with them." How often has the mineral community heard that refrain! Berger says further that there are "still" about 7000 specimens," so apparently about 1,000 had been disposed of before Dr. Lechner's death. It is evident from the content of the August 16th letter that more of the already disposed-of material had been sent by Berger to Perkin (letter in the possession of Willard Perkin):

> Our differences with the family Lechner are still existing but this day a month or two at the latest we shall see whether these people can be brought to their other senses. We would send you gladly some more boxes similar to No. 37 and when we shall have come to terms with Lechner's heirs again we shall again be able to do so. In the meantime you will have to content yourself with those pieces which are still in our stock but which, we are sorry to say, are not quite as fine as those of box No. 37.

Following that hopeful comment is the last word from Berger in a letter to Willard Perkin of December 2, 1952 (letter in the possession of Willard Perkin):

> About a year ago a boaster had promised to the Lechner family to sell their whole collection to a rich Californian friend. The Lechner family trusted the man and on account of his words did not sell any single pieces as they did not want to reduce the value of the collection. As was to be foreseen, the rich friend from America did not appear up to now and will probably never turn up at all, for the price which is demanded for the collection is a too high one. It is said that the Lechner-family is not willing to sell the collection at all but we are sure that it will be possible to get single pieces out of it.

It is obvious from the Berger-Perkin correspondence that Anton Berger was attempting to be the agent for the disposal of the remainder of the Lecher collection. It is my inference that he was successful, and that he was the agent who sold the collection to the Schortmann brothers. Scott Williams (personal communication, 1990) says:

> I do not know a lot about the disposal of the Lechner collection—but I am sure it was handled primarily through Anton Berger, the noted Viennese mineral dealer, who was quite active at the time of the dispersal of the Lechner collection. Mr. Berger sold his minerals here in the States through Schortmann's on the East Coast and Willard Perkin on the West Coast. I tried to deal with Berger but he refused to sell to me, as he had promised his two outlets (Schortmann's and Perkin) he would not sell to any other American dealers. It is my understanding that Berger handled or at least was "in on" the dispersal of the Lechner collection. How much Schortmann's obtained of the original collection I do not know. I did obtain Berger specimens and a few Lechner pieces through W. F. Davidson, who was Berger's English sales outlet.

Furthermore, since Berger was the pre-eminent Austrian dealer at this time, and since trans-Atlantic shipment of thousands of delicate and valuable specimens required a knowledgeable eye and a practiced hand (which Berger surely had), there is no reasonable alternative for the intermediary between the heirs and the Schortmanns. This question might be finally resolved if the Schortmann accounts were to be found.

There is a discrepancy between the 7,000 specimens Berger reports in May of 1952, and the number the Schortmanns actually received. The latter number can be known with certainty only from unavailable Schortmann's records, but recent estimates provided by Arthur Montgomery and Dr. Switzer, as well as my own "guesstimate" suggest that approximately half of the original 8314 specimens arrived in the U.S. What happened to the missing 2500 or 3000 pieces? Dr. Gerhard Niedermayr (personal communication, 1990) recently wrote:

> Just a few days ago I was informed by a private collector, that the collection of Dr. Adolf Lechner had not been sold en bloc, because several collectors in Austria had obtained small parts of it, as also has our museum. We obtained about 80 specimens from Austrian localities, some of them very fine pieces.

It may well be that during 1953 and 1954 Berger extracted more specimens from the heirs, and that he resold within Europe, or to Perkin or others, while he attempted to consummate the major portion of the transaction.

THE SCHORTMANN'S ACQUIRE THE SPECIMENS

The Schortmann brothers, Raymond and Alvin, were prominent U.S. dealers of the 1940's and 1950's. They began collecting minerals in 1937 or 1938, financed by Ray through the sale of his collection of gold coins. They entered the mineral business at the encouragement of Arthur Montgomery, and marketed much of the later finds of the Art Montgomery–Ed Over partnership (e.g. Utah variscite "cannonballs" and Red Cloud wulfenites). They operated their business from Easthampton, Massachusetts, under the name *Schortmann's Minerals*. "But it was for them most of all a labor of love in supplying and working with the minerals they truly respected and cherished," says Arthur Montgomery. Their primary source of income was from their housepainting business. The full story of the Schortmann brothers is far too rich and ramified to be covered here; more details can be found in Bentley (1978). Ray died in 1962; Alvin sold the remainder of the

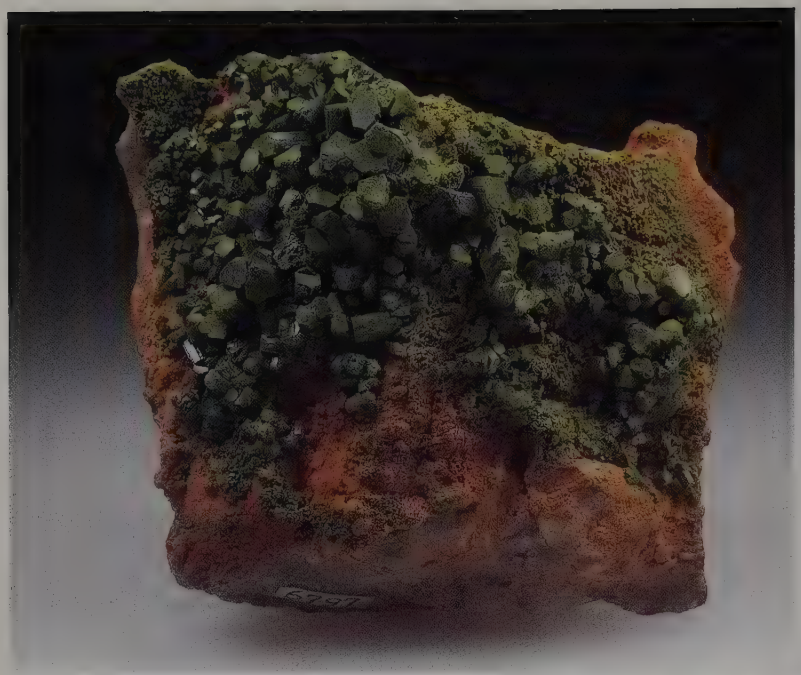

Figure 1. Pyromorphite crystals on matrix, 8.5 cm, from Pribram, Czechoslovakia. Lechner specimen, now in the Harvard collection.

Figure 2. Tetrahedrite crystal, 9 mm, on matrix, from Grube Georg, Horhausen, Germany. Lechner specimen, now in the Bill Smith collection.

Figure 3. Cassiterite crystal group, 4.4 cm, from Schlaggenwald, Bohemia, Czechoslovakia. Lechner specimen, now in the Harvard collection.

Figure 4. Prehnite crystal group, 5.9 cm, from Ankogel, Carinthia, Austria. Lechner specimen, now in the Harvard collection.

Figure 5. Garnet crystal, 1.2 cm, on clinochlore from Val d'Ala, Piemonte, Italy. Lechner specimen, now in the Bill Smith collection.

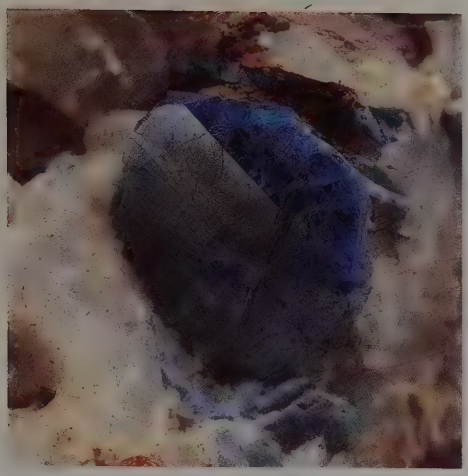

Figure 6. Lazulite crystal, 1 cm, in matrix, from Werfen, Salzburg, Austria. Lechner specimen; Harvard collection.

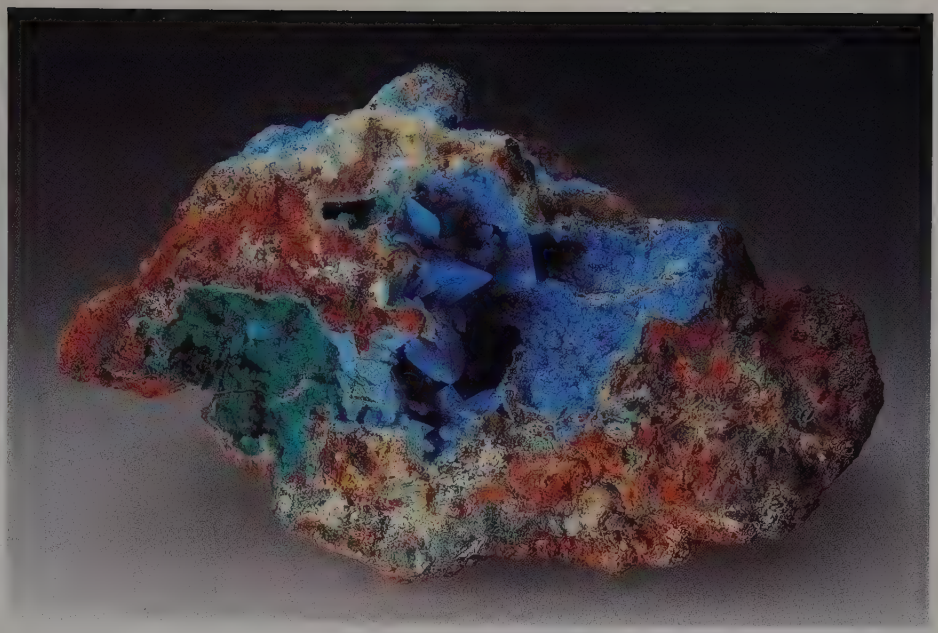

Figure 8. Liroconite crystals to 8 mm in vugs in matrix, from Wheal Gorland, Cornwall, England. Lechner specimen, now in the Bill Smith collection.

Figure 7. Senarmontite crystals to 1.3 cm on an edge, from Constantine, Algeria. Lechner specimen; Harvard collection.

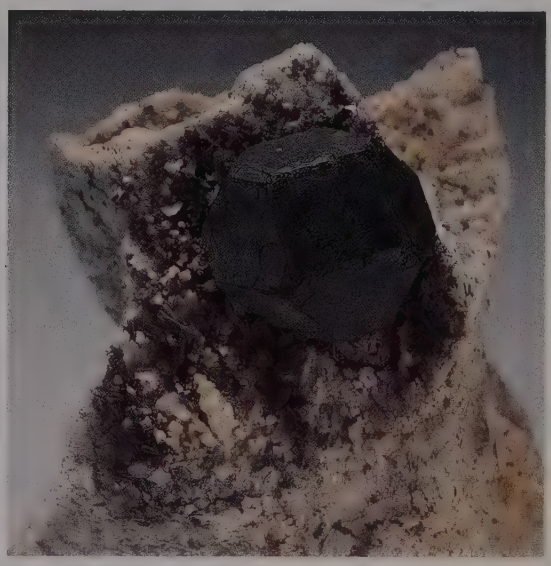

Figure 9. Cafarsite crystal, 1.5 cm, on matrix, from Alp Lercheltini, Switzerland. Lechner specimen, now in the Bill Smith collection.

Figure 10. Hörnesite crystals on matrix, 10 cm across, from Cavnik, Romania. Lechner specimen; Harvard collection.

business, including the remaining Lechner specimens, to Ron Bentley in 1971. Alvin died in 1975.

When the Lechner collection was made available by the Schortmanns, beginning in 1955, customers were discouraged from making *any* inquiries about the collection, its former owner, or the circumstances of the Schortmanns' acquisition. Thus a veil of mystery covers much of what happened. This was during a period when the Cold War was at its most frigid; we originally suspected that perhaps the collection had come from behind the Iron Curtain, and that it might be impolitic to ask uninvited questions. We know now that the Cold War had nothing to do with the Schortmanns' secretiveness, so why were they so unforthcoming? I can only speculate, but I believe the answer lies in some combination of three reasons. The first is that the heirs made this stipulation, one not unusual when valuable objects and money cross borders. The second is that the brothers were normally close-mouthed about their business dealings. The final reason might be the following: Anton Berger was a close family friend of Willard Perkin, so he did not want to hurt Perkin's feelings. It may be that Perkin lacked the resources to buy the whole collection, so Berger turned to Schortmann's, but asked them not to broadcast their "coup" so as to spare Perkin disappointment. I have no substantive evidence to support these speculations; any other guess might be just as good.

Buying a very large European collection sight unseen (as the Schortmanns did), might seem, to most of us, a risky business. Mrs. Ray Schortmann confirms (personal communication, 1990) that the brothers thought it so; she says that the brothers "agonized" over their decision, and consulted several bankers before committing to the purchase. As Art Montgomery says "[it] took lots of courage; plus an abundance of trust and goodwill on both sides." The collection was shipped in about 79 boxes or crates; shipping took a significant period of time, probably during 1954 and 1955. As the specimens arrived, each got a *Schortmann's Minerals* label, usually bearing a three-part numerical code typed in the upper left corner of the label. The number first part has up to four digits and is the Lechner's specimen number in the original 8,314 piece collection. The specimens were ordered according to *Dana's System of Mineralogy,* sixth edition (or a Continental equivalent) and then numbered consecutively; thus 143-42-7 is a copper (native element), and 8178-5-54 is a wulfenite (molybdate). Since the specimens appear to have been numbered sequentially, the numbering must have occurred after the collection was frozen in size. The second part is a one or two-digit number designating the parcel in which the specimen was shipped, and the third part is a one, two, or three-digit number, probably indicating the specimen number within the parcel. (There are exceptions to these rules.)

The collection was stored and displayed in Ray's basement. If it ever entered their showroom, it was many years after its arrival in Massachusetts.

Arthur Montgomery, with his formidable knowledge of classic minerals, provided the brothers with invaluable aid in pricing this material. Prices varied from 50¢ to $150. The price the brothers paid for the portion of the Lechner collection that they received has been variously estimated at "about $12,000" and "$10,000 or more." It is appropriate at this point to lay to rest several widespread myths: that Arthur Montgomery "discovered" the collection, and pointed the Schortmanns in its direction; and that he financed the purchase, or otherwise was instrumental in the acquisition. As I have shown, Anton Berger knew plenty about the U.S. mineral market, and he was perfectly capable of developing his own sales. In any event, Montgomery says that he knew nothing of the Lechner collection until the brothers told him of it, and that his involvement lay in helping price the specimens.

SALE BY SCHORTMANN'S

In the Fall of 1955, when the Schortmann brothers offered Harvard first choice of their Lechner material, Dr. Clifford Frondel purchased specimens both for Harvard's general collection, and specifically to assist in the compilation of his famous *Systematic Mineralogy of Uranium and Thorium* (USGS Bulletin 1064) (personal communication, Carl Francis, 1990).

Second choice was given to the United States National Museum (Smithsonian Institution), which sent Dr. George Switzer. Switzer purchased 355 specimens for $3756.50, using Roebling Fund money, so all such specimens have since been considered part of the Roebling collection (and have been assigned Roebling numbers).

Switzer viewed his opportunity to select from the Lechner collection as the USNM's best chance to obtain samples of rare and obscure (but nevertheless recorded) European varieties. Among the novel names and rare varieties he selected are:

Epiphanite (chlorite group)	Porpezite (Gold)
Funkite (Diopside)	Prasine (Pseudomalachite)
Kakochlor (Wad)	Pyrgom (Fassaite)
Muckite (Retinite)	Spinthere (Sphene)
Mussite (Diopside)	Wolnyn (Barite)
Oncosin (pseudeomorphous mica)	Zorgite (clay group)
Pissophane ("Paraluminite")	Zygdite (Albite)

These names suggest opportunities for novel collecting specializations. Frondel saw a similar opportunity, but his oddities had more euphonious names (personal communication, Francis, 1990):

Hydrophite Pyrrharsenite Rhodochrome

It is unclear when the collection was opened for sale to private collectors. As late as 1959 Paul Desautels, by that time curator at the USNM, purchased 249 more specimens from the Lechner collection (again using Roebling funds); from appearances the Lechner stock had been little disturbed since 1955 and the prices were unchanged. It would not be surprising if the Schortmanns had withheld the collection from sale for a long period. By the early 1960's the remaining Lechner specimens had been released for sale to the general public. Subtraction suggests that at least 3000 Lechner specimens were sold directly to U.S. collectors. Perhaps you have a Lechner specimen in your collection?

ACKNOWLEDGMENTS

This article could not have been written without the help of Mrs. R. E. Schortmann, Arthur Montgomery, Dr. Gerhard Niedermayr (NHM Vienna) and Willard Perkin. Others who provided essential information are George Switzer, Carl Francis, Paul Desautels, Scott Williams and the staff of the U.S. National Museum (Smithsonian Institution), especially John Sampson White, Russell Feather, Kathryn Kilduff and Paul Powhat. Valuable help was also provided by Joe Cilen, Larry Conklin, Dr. Clifford Frondel, Marie Huizing, John Marshall, Mrs. Kay Robertson and Jack Jago Trelawney. Dipl. Ing. Otto Fitz (Vienna) provided some of the information on the names of collectors listed in Loehr (1911) whose collections were acquired by Lechner. Dr. Wendell Wilson supplied both information and editorial guidance, and provided the specimen photography.

The data used to provide the tabulations of Lechner species and localities is compiled from the acquisition records of the USNM, Harvard University, and the private collections of Joe Cilen, John Marshall, and my own collection, as well as from specimens formerly owned by Carl Francis and Willard Perkin. These data were also used to decipher the Schortmann's three-part numeric code.

REFERENCES

BENTLEY, R. E. (1978) The Historical Record: Schortmann's Minerals. *Mineralogical Record,* **9**, 107.

LOEHR, A. R. von (editor) *Mineralogisches Taschenbuch der Wiener Mineralogischen Gesellschaft.* Published by the Wiener Mineralogischen Gesellschaft, Vienna, 192 p.

Minerals of the Madan Orefield
Bulgaria

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During the last few years, many fine specimens of galena and sphalerite, along with a variety of other species, have come from mines in the Madan Orefield. Known since ancient times, the large lead-zinc orebodies are part of an extensive vein system.

INTRODUCTION

The Madan Orefield is situated near the town of Madan in the southern Rhodope Mountains, about 160 km south-southeast of Plovdiv (ancient Philippopolis), and just 10 km north of the border with Greece. For the last several years, attractive mineral specimens have been recovered in significant numbers and have enriched the collection of the Bulgarian National Museum of Natural History in Sophia. Many fine specimens, particularly galenas and sphalerites, have also reached the American and European mineral markets, inspiring curiosity among collectors, curators, dealers and mineralogists about the Madan deposits.

HISTORY

Some of the orebodies in the Madan area have been known since antiquity. The Koilaleti tribe of Thracians was among the first to mine ore there during the 5th and 6th centuries B.C. Ancient Greek coins from Tasos and the Aegean Island have been found inside the Borieva mine.

When the Romans conquered the area they found a well developed system of mining already in operation, and they expanded it through the use of local Thracian and imported Egyptian slave labor. A Roman clay lamp found in the old workings of the Strashimir mine dates from this period (4th–5th centuries A.D.).

Following the fall of the Roman Empire, mines in the Madan area were eventually taken over by people known as the Proto-Bulgarians, who continued operations during the First Bulgarian Kingdom (618–1018 A.D.) and the Second Bulgarian Kingdom (1186–1396), with brief interruptions during times of war. Saxon miners came to settle in the region around 1300–1330, bringing more sophisticated mining techniques and the Saxon Rules of Mining, which greatly advanced the development of Bulgarian mining. Remnants of Saxon timbering, Saxon mining instruments, tools including a wooden spade, rake, trough, and an ore sack, and fragments of a Saxon miner's clothing have been recovered from old workings in the Strashimir mine (Konyaroff, 1953).

The operation of the mines continued under the Ottoman Turks beginning in 1396; the name "Madan" dates from this period—it means "ore" and "mine" in Arabic. The decline of the Ottoman Empire during the 1700's was due to a deep internal crisis and to military defeats. The breakdown in central authority, and heavy taxation, led to a further decline in mining activity. Much of the local population fled in response to enforced Islamization, resulting in the loss of experienced miners and the further disruption of operations. Competition from gold and silver produced in the Americas brought

Figure 1. **A Roman clay lamp, 4th to 5th century A.D., found in the Strashimir mine. Collection of the National Polytechnical Museum in Sofia; photo by E. Georgieva.**

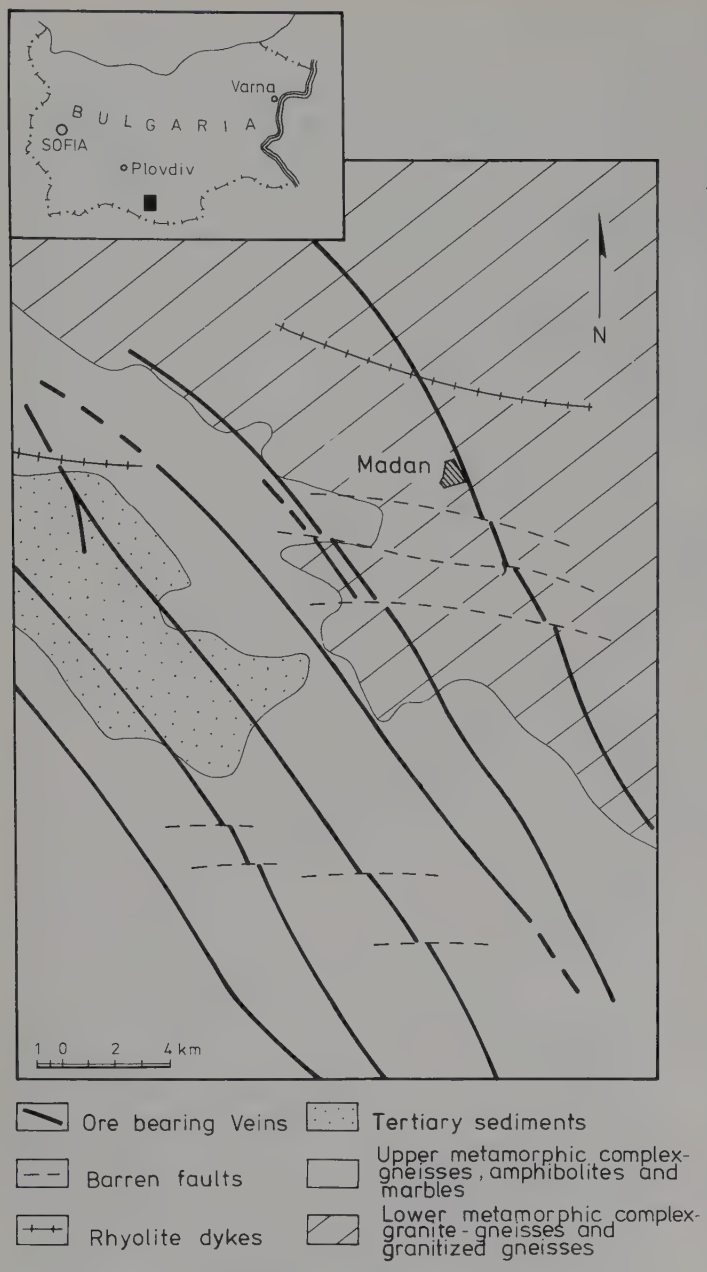

Figure 2. **Location map (inset) and geologic sketch map of the Madan district.**

an end to mining in parts of Bulgaria and Europe (Konyaroff, 1953).

The liberation of Bulgaria in 1878 found mining in the Rhodopes to be in a severe state of decline. Following World War I, a portion of the Rhodope Mountains (including Madan) which had remained a part of Turkey after 1878 was transferred to Bulgaria.

Rhodopski Metal Company, the first Bulgarian mining company, was established in 1924. The Pirin Company, a joint Bulgarian-German venture, was founded at about the same time. Both of these companies carried out geological and mining surveys in the Rhodopes, and exploited the rich lead-zinc deposits in the Madan region. A number of new mines were opened at this time, including the Borieva, Erma, Gjudjurska, Petrovitsa and Stratiev Kamak mines. A flotation plant was constructed in the town of Kardzhalii, in the eastern part of the range, and was linked to some of the operating mines by a cable line. Intensive exploitation of the deposits also resulted in the recovery of the first mineral specimens from the district (galena, sphalerite, chalcopyrite and quartz) to reach museums and private collections.

Following World War II the state government bought out the Rhodopski Metal Company. The Pirin Company, formerly under East German control, became a Soviet mining company. Gorubso, a Soviet-Bulgarian mining venture with offices in Kardzhalii and later Madan, was established in 1950; five years later the Soviet Union transferred its share to Bulgaria.

Intensive geological surveys were conducted throughout the region in order to more fully delineate the orebodies and their structural control. The opening of a number of new mines, the extension of older ones, and associated improvements in the flotation mill and the road network brought new life to the settlements in the district. The newly opened or reopened mines (Strashimir, Spolouka, Sharenka, Gradiushte, Batantsi, Petrovitsa and Krushov Dol) yielded many fine crystal specimens of galena, sphalerite, chalcopyrite, arsenopyrite, pyrite, quartz and calcite. Many of these have reached private collections and museums worldwide, as well as the small museum in Madan established by the Gorubso Company. In 1986 a special exhibition hall was installed there, devoted to crystal specimens of hydrothermal minerals from the Madan orebodies.

At present there are companies in Bulgaria which have begun dealing in mineral specimens, but the associated restrictions have resulted in a decreased number of specimens on the international market.

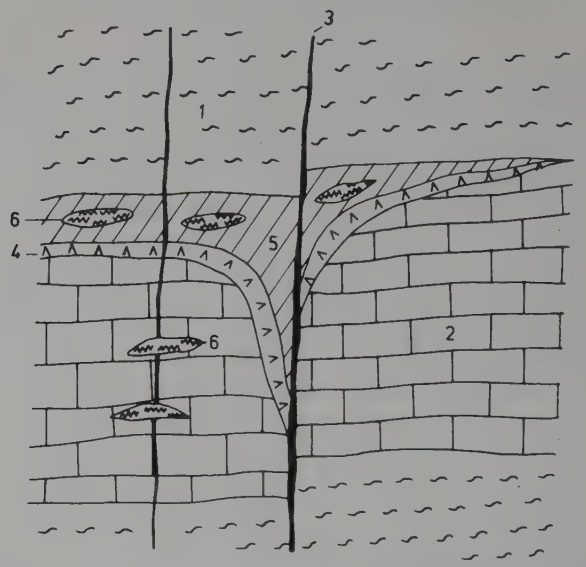

Figure 3. **Schematic cross-section of a skarn orebody in the 9th of September mine. (1) Gneiss, (2) marble, (3) ore vein, (4) johannsenite-rhodonite, (5) ore zone, (6) vugs filled with crystals of galena, sphalerite, chalcopyrite, quartz, etc.**

GEOLOGY

Geologically the Madan Orefield is part of the West Rhodope district in the Rhodope structural-metallogenic zone. This zone consists of Precambrian metamorphic rocks divided by a tectonic unconformity into two suites: a lower (probably Archean) suite of marble, granitized gneisses and granite gneisses, and an upper (Proterozoic) suite of alternating marbles, amphibolites, injection gneisses and schists. These rocks, which form a short, broad anticline, are intruded by rhyolite dikes in the Madan area, and these dikes are in turn cut by ore veins (Bogdanov, 1982). Isotopic age dating of lead in the galena indicates an age of approximately 35–45 million years, that is, Oligocene to lower Miocene (Amov *et al.*, 1977).

Sulfide ore mineralization has been found along six principal subparallel fracture zones trending north-northwest over a total distance of about 15 km (Bogdanov, 1960). Pulsatory deposition took place along the faults and as replacements invading marble beds cut by the faults. The veins, generally 2 to 5 meters in width, contain the majority

Figure 4. **The Borieva mine in 1955 (State Archives photograph).**

Table 1. **Mines and deposits in the Madan area.**

Baram	Kroushev Dol
Barska Radina	Kroushkova Mahala
Batantsi	Laikov Choukar
Belevista	Metlivko
Borieva Reka	Mogilata
Buchovitsa	Murzyan
Chepintsi	Osikovo
Deveti Septemvri	Ostra Chouka
("9th of September")	Pechinsko
Dimov Dol	Petrovitsa
Erma Reka	Ribnitsa
Golyam Palas	Shahonitsa
Gradishte	Sharenka
Gyudyurska	Shumachevski Dol
Karaalievsko	Spolouka
Konski Dol	Strashimir*
Kralev Dol	Stratiev Kamuk
Kriviya Gabur	Vurba

*This mine is *not* the type locality for strashimirite, which was discovered instead at the Zapachitsa copper deposit in the western Stara-Planina zone, Bulgaria, and named in honor of the Bulgarian petrographer Strashimir Dimitrov. Strashimirite does not occur in the Madan district.

of lead-zinc ores in the area. Vein mineralization is of quartz-carbonate-sulfide composition, and crystal-lined cavities are common (Minceva-Stefanova, 1980). The metasomatic deposits stemming from these veins began with the crystallization of silicate skarn minerals (at over 400° C) followed in turn by sulfides (210–350° C) carbonates (90–160° C) and sulfates (50° C). Typical of the skarns are radial aggregates of johannsenite and rhodonite. Manganese is abundant (Bogdanov, 1961; Dimitrov and Krusteva, 1972; Kilkovski and Petrov, 1972). The evidence suggests that the veins are essentially hydrothermal and formed at a depth of 1 to 3 km.

At least 35 orebodies have been located in the Madan area (see Table 1), of which the Deveti Septemvri ("9th of September") mine has been particularly prolific in its specimen production; the Petrovitsa and Krushov Dol deposits have also yielded some specimens.

MINERALS

The Madan region has yielded a reported 50 mineral species (see Table 2). Only those of collector interest are described below. Epitaxial overgrowths are relatively common, especially where some of the secondary minerals and rare sulfides such as tetrahedrite, tennantite, polybasite and arsenopyrite have overgrown chalcopyrite, pyrite, galena and sphalerite (Bonev, 1973).

Arsenopyrite FeAsS

Arsenopyrite is found in the upper levels of a number of the deposits, as part of an assemblage including pyrite, chalcopyrite and quartz. The habit is long prismatic to spear-shaped, dominated by {101} and {010}. Small pseudocubic prisms have been found but are rarer.

Barite $BaSO_4$

Barite, the principal sulfate mineral in the veins, is of limited distribution. The milky, grayish white to yellow-brown crystals are semi-opaque to opaque, and occur zonally associated with fine-grained quartz, pyrite, galena, calcite, kaolinite and other minerals.

Calcite $CaCO_3$

Calcite is a common mineral in the Madan Orefield, forming in a range of habits in two generations. The earliest calcite is commonly tabular or rhombohedral to long prismatic, in sizes up to 12 cm. It is generally tinted pink by manganese. Second-generation calcite (of late

Figure 5. **Galena, chalcopyrite and sphalerite group, 14 cm, from the Madan district. Forrest and Barbara Cureton specimen.**

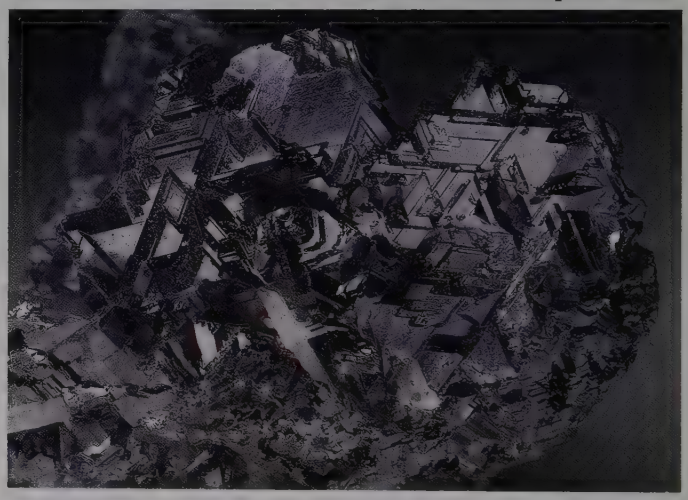

Figure 6. **Galena, 4.5 cm, from the Madan district. Forrest and Barbara Cureton specimen.**

hypogenic origin) typically occurs as flattened rhombohedral crystals showing prism and scalenohedron faces. The color is a much paler pink to almost colorless. Composite scalenohedrons, spherulities and acicular aggregates are also known.

Chalcopyrite $CuFeS_2$

Chalcopyrite is commonly encountered in small quantities representing five generations of crystal growth. The first and second generations are the most important. Second-generation chalcopyrite has been observed as coarse-grained aggregates and as crystals up to 7 cm dominated by {112}, {012}, $\{1\bar{1}2\}$ and {110}. Crystals twinned on (112) also occur. The other generations are characterized by small crystals with indigo-blue surface alteration.

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

Ferromanganoan dolomite forms small rhombohedral crystals, granular crusts (chiefly on calcite) and radial fibrous aggregates. It is also

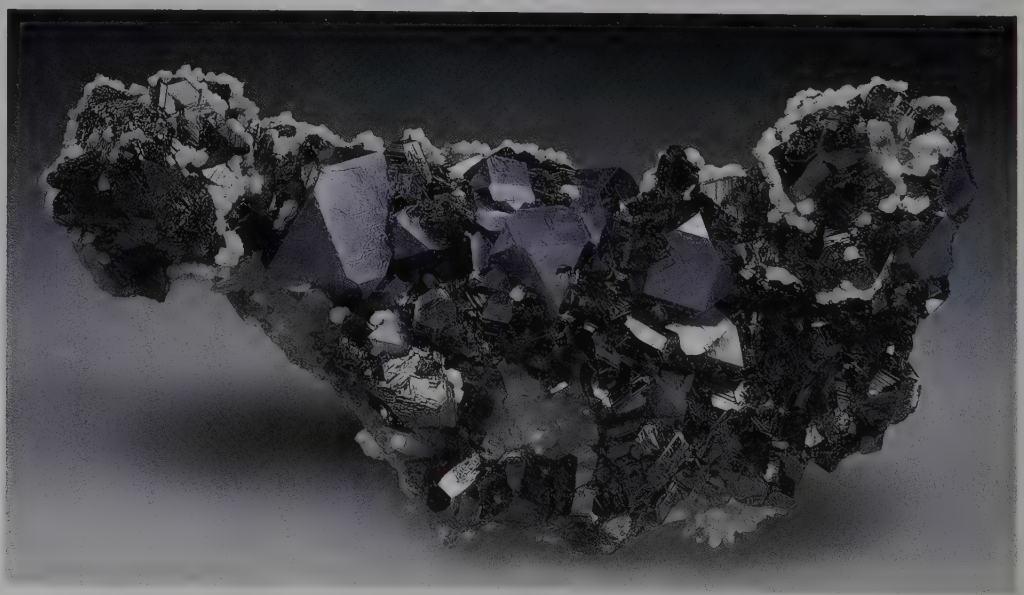

Figure 7. **Galena with sphalerite, quartz and calcite, 13 cm, from the Madan district. Forrest and Barbara Cureton specimen.**

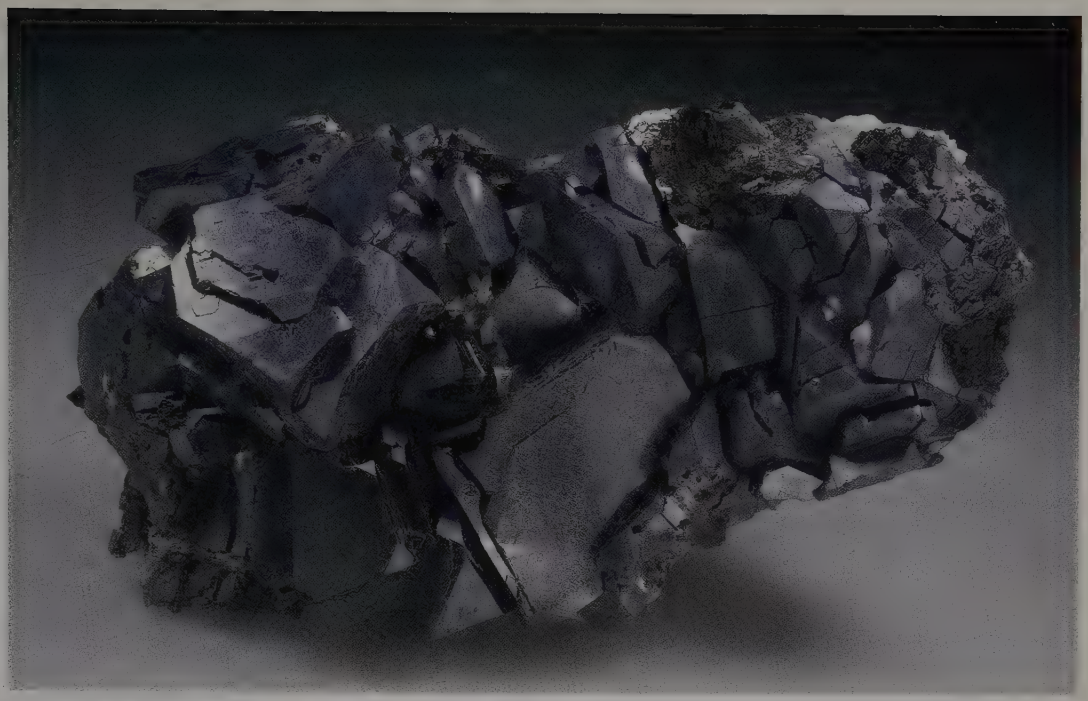

Figure 8. **Galena, 14.5 cm, from the Madan district. Forrest and Barbara Cureton specimen.**

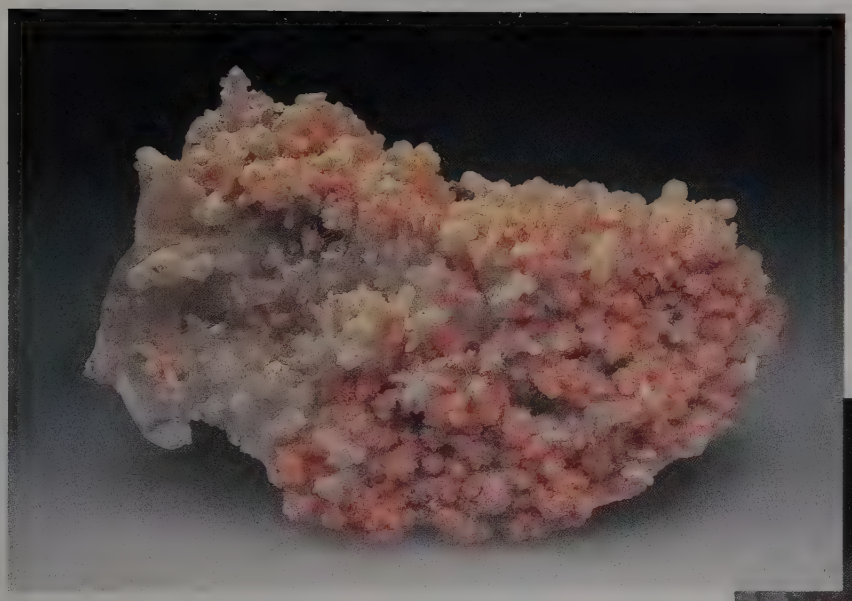

Figure 9. **Rhodochrosite with stilbite on quartz, 10 cm, from the Madan district. Forrest and Barbara Cureton specimen.**

found as paramorphic crusts surrounding calcite crystals that have been leached away. The color is pale pink to cream-colored and brown.

Galena PbS

Galena occurs in granular aggregates and also in particularly well-formed crystals with high luster. Four generations of crystal growth have been identified. The first is represented by coarse, granular aggregates with individual domains measuring up to 7 cm, and also cuboctahedral crystals 2 to 3 cm in size. Heavy druses with large crystals up to 20 cm also occur. (A number of these extraordinary specimens have been preserved in the National Museum of Natural History in Sofia, Bulgaria.) Tabular spinel-law twins on (111) are not uncommon.

Second-generation galena consists of cuboctahedral crystals to 1.5 cm. Third-generation galena is cubic with very minor octahedral faces on the corners, and is quite sparse in its distribution. Dodecahedral crystals have also been observed. Fourth-generation galena is even more scarce, occurring in smooth-faced cubes to 5 mm (Minceva-Stefanova and Gorova, 1965; Bonev, 1980).

Some galena crystals show surface indentations on cubic faces where fluid inclusions had formed (Piperov *et al.*, 1977). Galena also occurs

Figure 10. **Sphalerite crystals, 1 cm, with galena and quartz, from the Madan district. Forrest and Barbara Cureton specimen.**

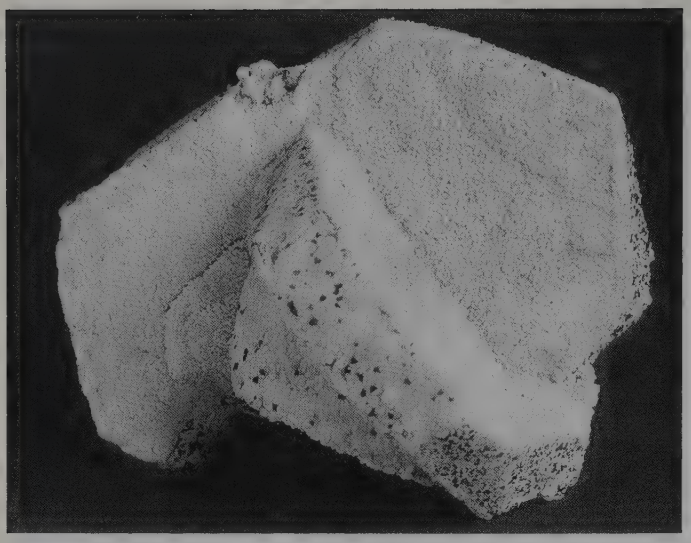

Figure 11. **Ferromanganoan dolomite pseudomorph after calcite, 19 cm. Collection of the Bulgarian National Museum of Natural History in Sofia.**

as whisker crystals, untwinned platelets, skeletal crystals and composite crystals, especially in the metasomatic replacement orebodies.

Johannsenite $CaMnSi_2O_6$

Johannsenite is the main skarn mineral, occurring as radially fibrous spherulitic aggregates and rod-shaped growths. Individual crystal domains within these masses may reach 20 cm in length. The mineral is pale green to blue-green, altering with time to pale brown and medium brown. The bluish color is a consequence of the Mn^{+2} content (Minceva-Stefanova *et al.*, 1984).

Pyrite FeS_2

Pyrite crystals have been found in all deposits in the Madan Orefield. Four generations of crystal growth have been recognized. The crystal habit ranges from cubic to pyritohedral, typically with striated faces, in sizes up to 6 cm. Large chalcopyrite crystals sometimes have a pyrite metacryst core (Minceva-Stefanova and Gorova, 1965).

Pyrrhotite $Fe_{1-x}S$

Pyrrhotite is rare in the district, occurring as plates and bipyramids (some showing twinning). Most of them have been pseudomorphically replaced by marcasite and pyrite.

Quartz SiO_2

Quartz is abundant and widespread throughout the orebodies. Five generations of crystal growth have been identified. The fourth is the most important volumetrically, occurring as fine, long or short prismatic crystals to many centimeters in length. Rare amethyst of the fifth generation has also been observed.

Rhodochrosite $MnCO_3$

Rhodochrosite is unevenly distributed in the district, as granular, spherulitic and coralloid aggregates. Crystals, which are small, pink and rhombohedral in habit, are rare.

Rhodonite $(Mn,Fe,Mg,Ca)SiO_3$

Rhodonite is one of the skarn minerals, usually occurring near the skarn peripheries. It forms pink, compact, granular aggregates and (rare) poorly formed tabular crystals.

Sphalerite ZnS

Sphalerite and galena are the principal ore minerals and the most common sulfides. Three generations of sphalerite crystal growth are known. The first is characterized by tetrahedral crystals to 7 cm; the smaller crystals are dark brown to black and the larger crystals are medium brown. Also part of this generation are granular aggregates of polysynthetic (111) twins.

Second-generation sphalerite crystals are pseudo-octahedral and up to 1.5 cm in size. The pale brown crystals generally occur covering first-generation crystals.

Third-generation crystals are colored in shades of yellow, yellow-green and green. Lustrous, semi-opaque dodecahedrons reach 4 cm in size. Some of these crystals have been cut into attractive gemstones. Almost all third-generation sphalerite occurs as overgrowths on earlier sphalerite. Furthermore, there is a consistent progression of habits from tetrahedral (first) to pseudo-octahedral (second) to dodecahedral (third generation) (Minceva-Stefanova, 1980), which appears to be a function of iron content and/or temperature of formation. Tetrahedral sphalerite was formed at high temperatures (285–350° C), and carries a high iron content (3 to 10%), whereas dodecahedral crystals show a lower temperature of formation (144–233° C) and a lower iron content (under 0.8%). The green coloration may be caused by traces of cobalt (up to 0.01%), and the yellow coloration by cobalt (0.003%) and iron (0.5 to 0.8%) (Minceva-Stefanova *et al.*, 1983).

Table 2. **Minerals reported from the Madan region (Minceva-Stefanova, 1978).**

Acanthite	Fluorite	Plagionite
Aikinite	Freieslebenite	Polybasite
Alabandite	Fülöppite	Pyrargyrite
Ankerite	Galena	Pyrite
Aragonite	Garnet group	Pyrrhotite
Arsenopyrite	Gold (incl. electrum)	Quartz
Barite	Greenockite	Rhodochrosite
Bustamite	Hedenbergite	Rhodonite
Calcite	Hematite	Sericite
Chalcopyrite	Heteromorphite	Silver
Chlorite	Ilvaite	Sphalerite
Cobaltite	Johannsenite	Talc
Cosalite	Kaolinite	Tennantite
Cubanite	Mackinawite	Tetrahedrite
Diopside	Marcasite	Tremolite
Dolomite	Matildite	Wollastonite
Epidote	Palygorskite	

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REFERENCES

AMOV, B. G., BALDJIEVA, Ts. T., GADGJEVA, T., and LILOV, P. (1977) Age and the genesis of the ore mineralizations in the Erma River Area according to lead-isotope and potassium-argon data. *Comptes rendus de l'Academie bulgare des sciences,* **30** (12), 1745–1748.

BOGDANOV, B. (1960) Geologie und Gefüge das Erzgebietes von Madan. *Annual of the Higher Mining-Geological Institute,* **6** (1/2), 3–45.

BOGDANOV, B. (1961) Stages of mineralization, mineral paragenesis and zonality in the lead-zinc deposits of the Madan and Nedelino ore districts. *Review of the Bulgarian Geological Society,* **22**, 134–160 [Bulgarian text with English summary].

BOGDANOV, B. (1982) Bulgaria, *in* F. W. Dunning, W. Mykura and D. Slater (eds.) *Mineral Deposits of Europe*, volume 2: Southeast Europe, published by The Mineralogical Society (London), p. 215–232.

BONEV, I. (1973) Genesis of the oriented overgrowths and intergrowths in the Madan ore. *Bulletin of the Geological Institute, series Geochemistry, Mineralogy and Petrography*, **22**, 91–105.

BONEV, I. (1980) Crystal morphology of galena from the Central Rhodopes lead-zinc ore deposits. I Growth forms. *Geologica Balcanica*, **10** (1), 33–56.

BONEV, I. (1982) Madan—lead-zinc vein and metasomatic ore deposits. In *Guide-book Central Rhodopes*, International Mineralogical Association—13 General Meeting—Varna, Sofia, 72 p.

DIMITROV, D., and KRUSTEVA, M. (1972) Dekripitatsionni krivi na kvartsa ot Madanskite olovno-tsinkovi mestorozhdenija. *Izvestia geol. Inst., Ser. Rudni i nerudni Pol. Izk.*, **21**.

KILKOVSKI, B., and PETROV, P. (1972) Vurhu temperaturata na rudoobrazuvane v nahodishtata po razloma Spoluka—Lajkow chukar, Madansko. *God. Sofia Univ., Ser. Geol.*, **64**, 225–233.

KONYAROFF, G. (1953) Beitrag zur Geschichte der Bergbau und Hüttenwesen in Bulgarien. *Publishing house of the Bulgarian Academy of Sciences*, Sofia, 172 p. [Bulgarian text with German summary.]

MINCEVA-STEFANOVA, J. (1978) Introducing a unified principle in the construction of diagrams for the sequence of mineral deposition. *Review of the Bulgarian Geological Society*, **39**, 187–192.

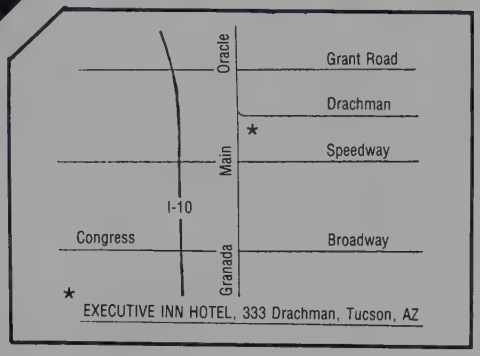
MINCEVA-STEFANOVA, J. (1980) Typomorphism of sphalerite. In *Scientific Bases and Utilization of the Typomorphism of Minerals*. Proceedings of the International Mineralogical Association—9th General Meeting, Novosibirsk, Nauka, Moscow, 252–267.

MINCEVA-STEFANOVA, J., and GOROVA, M. (1965) Mineralogie und Geochemie der Blei-Zink-Lagerstätte Gradiste in erzbezirk Madan. *Travaux sur la Geologie de Bulgarie, serie de Geochemic, Mineralogie et Petrographie*, **5**, 117–191.

MINCEVA-STEFANOVA, J., KHOMENKO, B. M., PLATONOV, N. A., BONEV, I. K., and TARAN, M.N. (1984) Optical spectroscopic study of Johannsenites from the deposits of Madan ore region. *Geochemistry, Mineralogy and Petrology*, **18**, 18–30.

MINCEVA-STEFANOVA, J., PLATONOV, A. N., OSTAFIJCUK, I. M., and MACJUK, S. S. (1983) Colorimetric study of Sphalerites of low iron from some Bulgarian deposits. *Geochemistry, Mineralogy and Petrology*, **17**, 29–40.

PIPEROV, N. B., PENCHEY, N. P., and BONEV, I. K. (1977) Primary fluid inclusions in galena crystals. II Chemical compositions of the liquid and gas phase. *Mineral Deposits* **12** (1), 11–89.



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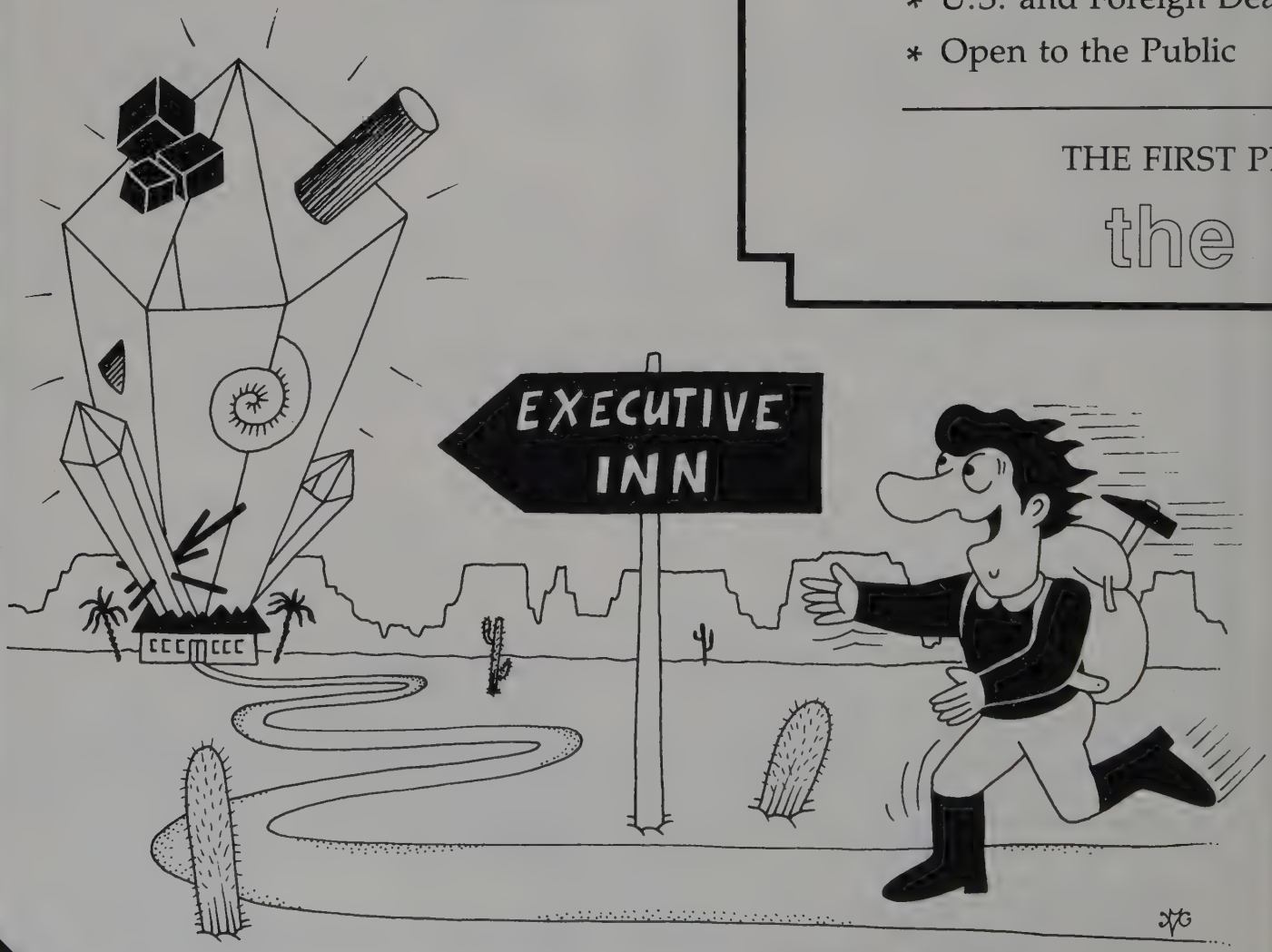

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Minerals of the Beltana Mine
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Discovered relatively recently, the Beltana deposit has produced excellent specimens of adamite, austinite and hedyphane, as well as a number of rarer species including tsumcorite.

INTRODUCTION

The Flinders Ranges are an ancient range of low mountains which extend over a distance of 400 kilometers in a north-south direction through the mid-north and far north regions of South Australia. The ranges are renowned for their scenic beauty and, from a mineralogical point of view, for the small but rich mineral occurrences which are scattered throughout. These are mainly copper, uranium or silver-lead deposits; most are uneconomic or were worked out in the last century or early this century (Brown, 1908).

The Beltana zinc-lead deposit, however, is unusual in that it is primarily a zinc occurrence, it is comparatively large and was not discovered until relatively recently. It is located at Puttapa on the western side of the range, 9 km south of Leigh Creek and 450 km north of Adelaide. It is also sometimes referred to as the Puttapa deposit.

A small settlement of transportable buildings at the site is, except for the permanent caretaker, inhabited only during intermittent periods of mining.

This study is based largely on specimens collected between 1978 and 1987, both from the old dumps and various stockpiles of ore.

HISTORY

The Beltana deposit was discovered in 1966 by Anaconda Australia Incorporated as a result of geochemical sampling in selected areas where Cambrian limestone crops out in the northern Flinders Ranges. Significant lead and zinc anomalies were found in the Puttapa area and subsequent rock sampling located outcrops of willemite associated with hedyphane and iron and manganese oxides. It has been suggested that the outcrops of willemite were overlooked by earlier prospectors who may have thought it was barite, which is common throughout the area. However the willemite may have been recognized but ignored due to the lack of uses for zinc at the time.

Detailed mapping was undertaken by Whitehead (1967), and the resultant report concluded that the deposit had no economic value. On the basis of this report, Anaconda relinquished their title. An exploration title was obtained by Electrolytic Zinc Company of Australasia Limited, which commenced a program of diamond drilling which located one major and several minor willemite orebodies (Johns, 1972; Muller, 1972).

The willemite ore posed great problems in concentration and treatment. A feasibility study was undertaken and, although an entirely new hydrometallurgical method of ore treatment was developed, no way of concentrating the ore on site could be found. This problem remained unsolved and the entire project was halted until December of 1973 when a contract to supply 15,000 tons of ore was negotiated with a West German buyer (Rangott and Sear, 1975).

Mining, by open cut methods, commenced in February of 1974 and has continued intermittently, depending on ore sales, since this time. A total of 300,000 tons of ore was exported to West Germany from 1974 to 1988.

GEOLOGY

The Beltana deposit is situated in Lower Cambrian sediments, the Ajax Limestone, at the northern end of the Beltana diapir, one of many such structures in the area. Diapiric intrusion has resulted in extensive brecciation and subsequent dolomitization of the limestone. Associated faulting was critical in the distribution of the willemite orebodies. Like other Flinders Ranges diapirs, the rocks associated with the intrusive breccia are shales, siltstones, dolomite and quartzite derived from the underlying Upper Proterozoic beds (Coats, 1964; Leeson, 1970). A feature of the siltstones is the occurrence of well-formed casts after halite crystals.

The deposit consists of a number of closely spaced orebodies which crop out over a distance of 400 meters and extend to a depth of 100 meters. The ore varies from almost pure willemite to low-quality clay-rich material. Total ore reserves are approximately 700,000 tons, averaging 40% zinc and 3% lead (Muller, 1972). Several smaller deposits have been located up to 80 km away. Of these only the Aroona deposit 10 km to the northwest is considered to be economic.

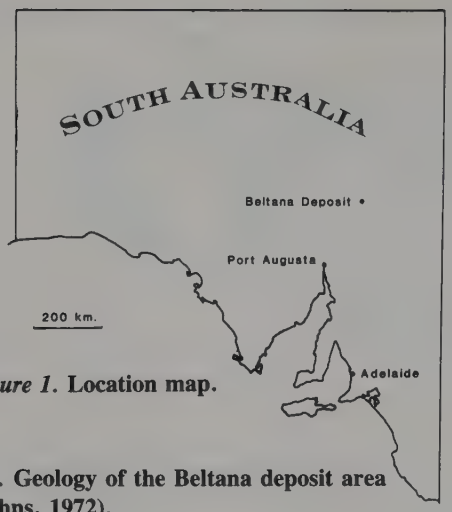
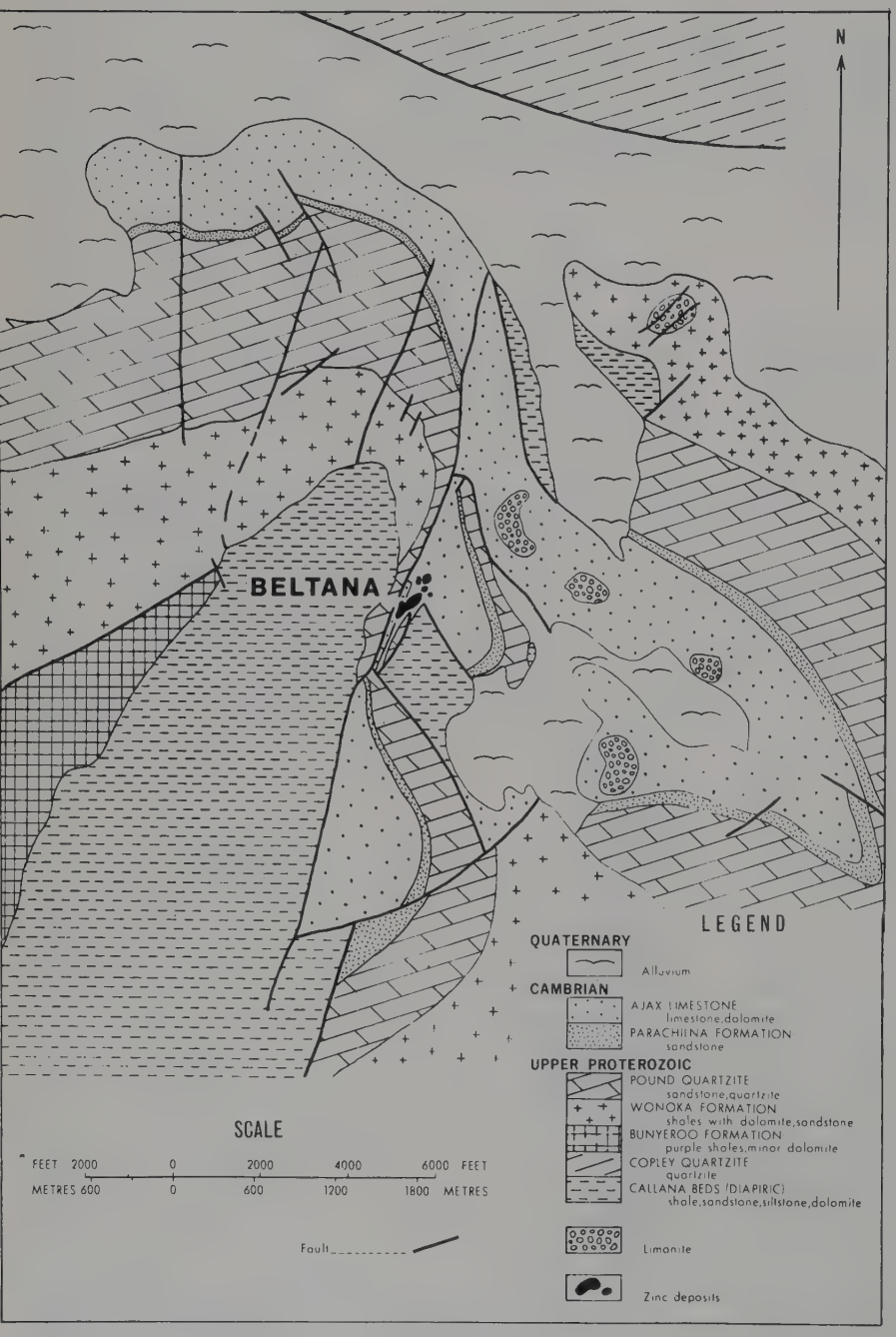


Figure 1. **Location map.**

Figure 2. **Geology of the Beltana deposit area (after Johns, 1972).**



The geology and genesis of the Beltana deposit have been described in detail by Grubb (1971) and Muller (1972). Muller believes that the present willemite orebodies are the result of oxidation of primary sulfides of Upper Cambrian–Ordovician age. Although no sulfide mineralization has been seen during mining operations, small amounts of galena, sphalerite, pyrite, marcasite and chalcopyrite were encountered 170 meters below willemite during drilling.

Intrusion of hydrothermal fluids which deposited the sulfides was controlled by intensive localized faulting, particularly the "mine fault" on which the largest orebody is situated. Sedimentation ceased during the Cambrian, and oxidation and weathering have occurred since. Oxidation of sulfides produced acidic solutions and resulted in their replacement by smithsonite. Zinc and iron were deposited as a mixture of hematite and willemite, replacing wall rock and filling cavities. Circulating ground waters concentrated and recrystallized willemite, with zinc minerals being deposited in the upper cavernous zone and the less soluble lead and iron minerals being deposited at the base. Introduction of oxygen produced abundant manganese oxides, and arsenic was recirculated and recrystallized as arsenates in cavities. Slightly acidic rain waters dissolved near-surface zinc which recrystallized in the brecciated dolomite. Manganese combined with lead and, to a lesser extent, barium and zinc to form coronadite, hollandite and hetaerolite.

MINERALOGY

The deposit can be divided into three main zones depending on the dominant mineral present, these being willemite, coronadite and hedyphane. The coronadite-rich and mimetite-rich rocks are generally compact, and associated minerals are found in thin seams or tiny cavities. Cavities in the willemite and surrounding dolomite, however, can reach 30 cm in size. Associated minerals generally form well-developed crystals.

All minerals described below have been confirmed by X-ray powder diffraction, energy dispersive X-ray analysis and microprobe analysis where appropriate. Crystal measurements were performed on a reflecting goniometer. An earlier paper by Grubb (1971), which was concerned largely with the genesis of the deposit, was based on specimens taken from the deposit during early prospecting; he reported a number of species that could not be confirmed by this study. Unfortunately, as far as can be determined, Grubb's specimens were not preserved. The occurrence at the Beltana mine of several species reported by Grubb, especially the sulfosalts baumhauerite and dufrenoysite, remain unconfirmed (see Table 1).

Adamite $Zn_2(AsO_4)(OH)$

Glassy crystals of adamite to 1 cm are abundant as individuals, clusters and fan-shaped groups of subparallel crystals. Color is variable, from colorless, white and gray to pale green, yellow, orange and purple. Crystals are commonly color zoned; green, yellow or purple in the center, grading out to colorless or pale green. Crystals are usually transparent to translucent but can be opaque black or brown, due to inclusions of coronadite, or red-brown due to inclusions of hematite. Most commonly, crystals are equant with equal development of {010} and {011} and usually, but not always, showing one or more of {120},

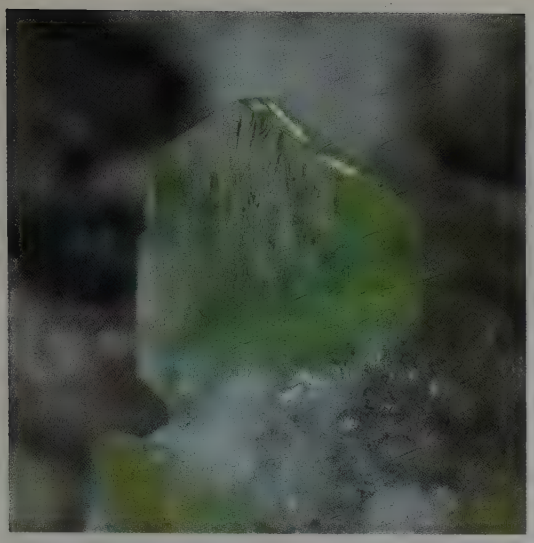


Figure 3. **Adamite crystal, 2 mm, on willemite. Author's specimen and photograph.**

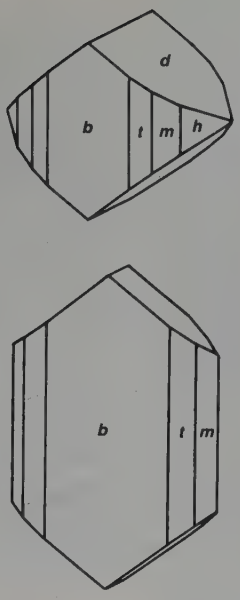


Figure 4. **Adamite crystals showing the forms *b*{010}, *t*{120}, *m*{110}, *h*{210} and *d*{101}. Author's crystal drawings.**

Figure 5. **Adamite crystal groups, 3 mm, on willemite. G. Whimpress specimen; author's photograph.**

{110} and {210}. Some crystals are elongated parallel to [010] or [001], or may be flattened on (010) to form a very thin, bladed habit.

Aragonite $CaCO_3$

Aragonite was commonly found during early mining as colorless acicular crystals to several millimeters lining cavities in willemite. It also occurred as druses of tiny crystals in coronadite and dolomite associated with calcite, quartz and hemimorphite and as crystals to 5 mm in massive goethite with quartz crystals and botryoidal hollandite.

Austinite $CaZn(AsO_4)(OH)$

Austinite is common throughout the deposit. Crusts, globules and druses of austinite have formed over earlier minerals. Austinite also occurs as translucent to transparent crystals to 5 mm, although crystals less than 2 mm are more typical. Color ranges from colorless, white and gray to yellow, orange and green. Green crystals, which are cuprian austinite, sometimes show a bright yellow termination. Crystals are usually prismatic, elongated along [001] (using the orientation

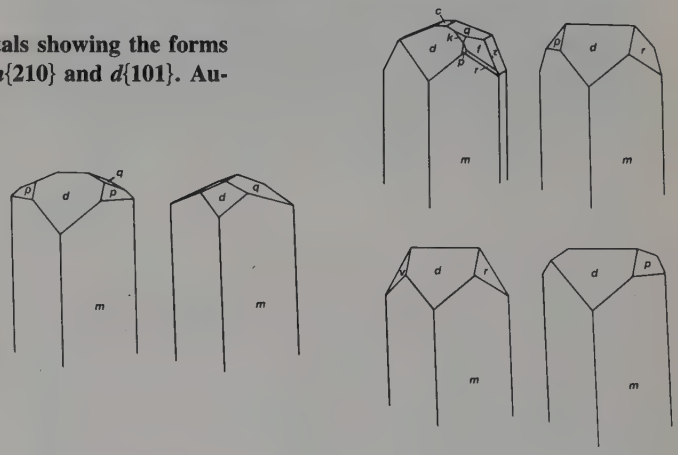


Figure 7. **Drawings *(above and below)* showing the range of morphology of austinite crystals. Forms shown are *c*{001}, *b*{010}, *q*{012}, *z*{011}, *u*{021}, *m*{110}, *d*{101}, *p*{111}, ρ{1$\bar{1}$1}, *r*{121}, *v*{1$\bar{2}$1}, *k*{112} and *f*{132}. Author's crystal drawings.**

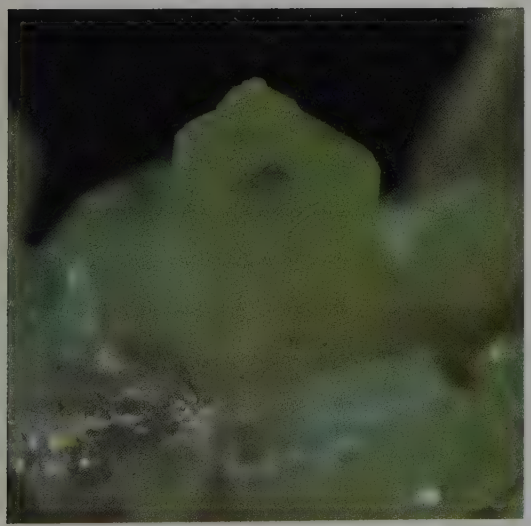
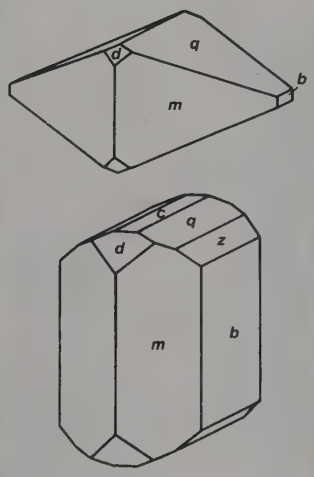


Figure 6. **Cuprian austinite crystals to 1 mm. Author's specimen and photograph.**



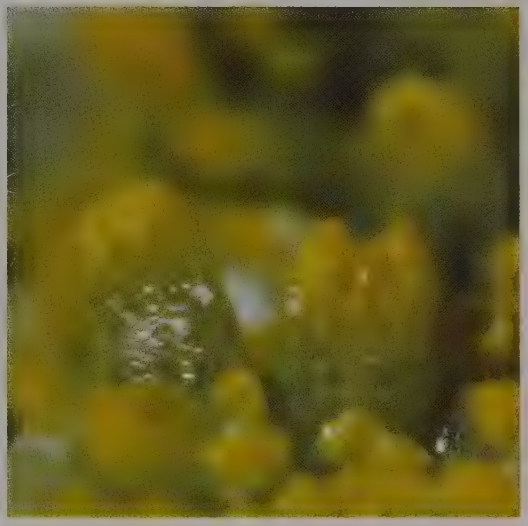


Figure 8. **Cuprian austinite crystals to 1 mm. Author's specimen and photograph.**

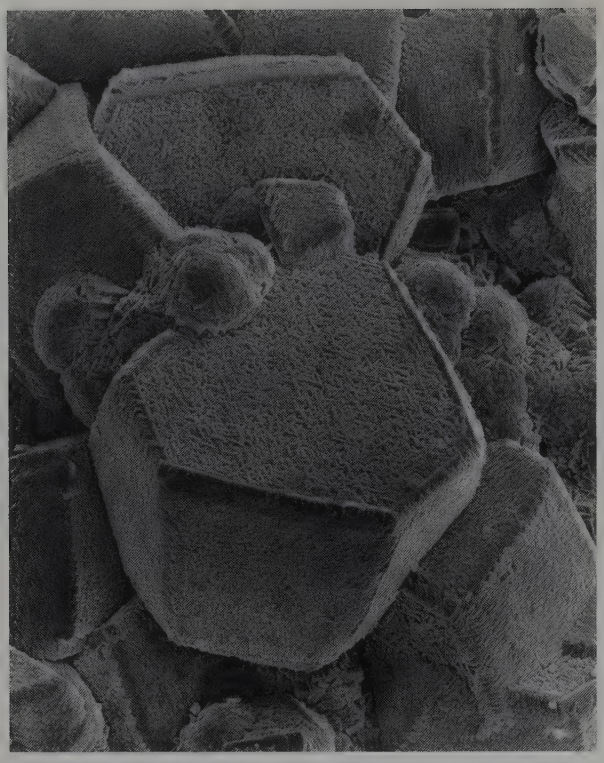


Figure 9. **Chalcophanite crystals to 70 μm with coronadite.**

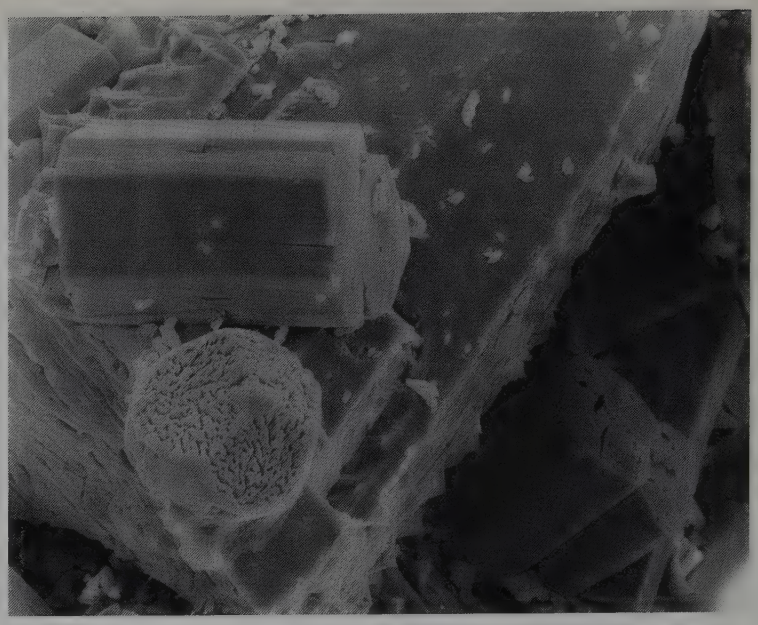


Figure 10. **Brilliant, black, prismatic crystals of coronadite with smithsonite on austinite. Largest crystal is 40 μm in length.**

of Staples, 1935). Dominant forms are {110} and {101}, usually with small {012}, {111}, and {1$\bar{1}$1}, {121} or {1$\bar{2}$1} faces. Occasional equant crystals show equal development of {110} and {012}. Other forms rarely seen are {001}, {010}, {130}, {021}, {112}, {1$\bar{1}$2}, {132} and {1$\bar{3}$2}. Of these, the forms {001}, {012}, {021}, {112}, and {1$\bar{1}$2} are additional to those reported for austinite crystals from Gold Hill, Utah (Williams and DeAzevedo, 1967).

Much of the austinite at the Beltana mine contains appreciable amounts of lead.

Barite $BaSO_4$

Barite is rare, occurring as white masses to several centimeters in willemite and dolomite. It also occurs as tabular or prismatic colorless and white crystals to 2 mm.

Calcite $CaCO_3$

Calcite is widespread but not common. It is found as rhombohedral, colorless or white crystals to 1 cm.

Chalcophanite $(Zn,Fe^{+2},Mn^{+2})Mn_3^{+4}O_7 \cdot 3H_2O$

Chalcophanite has been found on only a few specimens as tabular or equant crystals to 1 mm showing {0001} and {10$\bar{1}$0} forms. The crystals are very lustrous with a distinctive blue-black color and are associated with willemite and coronadite.

Coronadite $Pb(Mn^{+4},Mn^{+2})_8O_{16}$

Coronadite is one of the major components of the deposit and large masses were recovered during early mining. It is common throughout the willemite rock as dull brown to black masses and crusts. Rare, lustrous prismatic or acicular crystals, which are sometimes hollow, reach 2 mm in length. Coronadite also forms hollow casts after calcite crystals to 6 mm.

Descloizite $PbZn(VO_4)(OH)$

A powdery yellow coating on one specimen has been identified as arsenian descloizite (E. R. Segnit, personal communication).

Dolomite $CaMg(CO_3)_2$

Dolomite comprises the country rock in which the willemite occurs. Color is white to gray, various shades of red and also yellow and black. Rhombohedral dolomite crystals to several millimeters usually line cavities in massive dolomite. Crystals of later calcite, quartz, hemimorphite, hollandite, adamite or austinite commonly occur on the dolomite crystals.

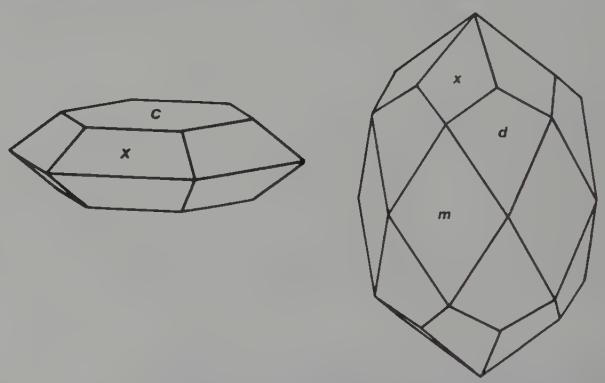


Figure 11. **Drawings of hedyphane crystals. Crystal A shows the most common habit with the forms *c*{0001} and *x*{10$\bar{1}$1}. Crystal B shows *m*{10$\bar{1}$0}, *x*{10$\bar{1}$1} and *d*{22$\bar{4}$1}. Author's crystal drawings.**

Hedyphane $Ca_2Pb_3(AsO_4)_3Cl$

Hedyphane is the most abundant of the arsenate minerals at the Beltana mine. In arsenate-rich areas masses of almost pure hedyphane to several centimeters have been found.

White to gray crystals to 3 mm are relatively common; occasionally crystals to 1.2 cm are found. Colorless, yellow to pale orange or brown crystals are less common. Luster ranges from dull to highly lustrous and greasy. Crystals are usually tabular showing only {0001} and {10$\bar{1}$1} forms. Occasionally the prism {10$\bar{1}$0} is also present to form thick tabular or prismatic crystals which sometimes also show {11$\bar{2}$0}, {11$\bar{2}$2} or {21$\bar{3}$0} forms. The crystals on several specimens also have {22$\bar{4}$1} faces.

Hedyphane was first reported from Beltana by Whitehead (1967) as being tentatively identified by X-ray diffraction. It was also mentioned by Grubb (1972) and Muller (1972). Their means of identification are unknown. Several specimens of hedyphane from Beltana were examined by Barclay and Jones (1971) using microprobe analysis and X-ray diffraction; these specimens were then identified as calcian mimetite rather than hedyphane, based on the definition of hedyphane as it was at the time, i.e., $(Ca,Pb)_5(AsO_4)_3Cl$ with Ca>Pb (Foshag and Gage, 1925).

As a result of a study of lead calcium arsenate apatites from Franklin, New Jersey, and Långban, Sweden, Rouse *et al.* (1984) reported that they failed to find any lead-bearing specimens that conformed to the criteria of Foshag and Gage. Initially most of these specimens had been reported as being calcian mimetite (Dunn *et al.*, 1980). Further study, in particular a determination of the crystal structure, resulted in the redefinition of hedyphane, and most of the Franklin and Långban material is now considered to be hedyphane (Rouse *et al.*, 1984).

Hematite α-Fe_2O_3

Hematite is common and inclusions of hematite are responsible for the red coloration of the willemite. It also occurs as deep red, submetallic masses in earthy goethite.

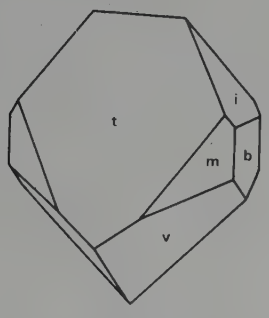


Figure 12. **Hemimorphite crystal showing the forms *b*{010}, *i*{031}, *t*{301}, *m*{110} and *v*{121}. Author's crystal drawing.**

Hemimorphite $Zn_4Si_2O_7(OH)_2 \cdot H_2O$

Colorless hemimorphite crystals are rare in willemite but are common in cavities in dolomite, associated with calcite, quartz, adamite and hollandite. Hemimorphite is usually seen as divergent sprays of bladed crystals which are elongated along [001] to varying degrees, but tabular individuals also occur. On several specimens the hemimorphite crystals show dominant {301} faces resulting in an unusual wedge-shaped habit.

Hetaerolite $ZnMn_2^{+3}O_4$

Gray to black bipyramids of hetaerolite to 3 mm are rare in cavities in willemite. The crystals usually show stepped or curved faces and are commonly associated with austinite crystals.

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

Hollandite is less common than coronadite, though it is visually indistinguishable. It occurs as dull brown and black masses and botryoidal coatings and also as lustrous black prismatic and acicular crystals to 4 mm.

Mimetite $Pb_5(AsO_4)_3Cl$

Mimetite, though not as abundant as hedyphane, is relatively common and usually occurs as prismatic or acicular crystals. Brown botryoidal mimetite has been found associated with tsumcorite. Crystals are generally yellow to orange or brown and reach 5 mm in length.

Opal $SiO_2 \cdot nH_2O$

Tiny, 0.5-mm globules of opal, variety hyalite, have been observed on several specimens. The globules are colorless and transparent and occur with willemite and coronadite.

Figure 13. **Sprays of black hollandite crystals to 200 μm on dolomite.**

Quartz SiO_2

Quartz is relatively uncommon and occurs as druses of colorless crystals and also as doubly terminated individuals to 1 cm, in some cases perched on willemite or dolomite crystals.

Rhodochrosite $MnCO_3$

Orange-brown, botryoidal rhodochrosite is found occasionally in willemite, associated with hedyphane and smithsonite. Curved, 0.5-mm rhombohedra of zincian, calcian rhodochrosite occur as individuals, druses and spherical groups of crystals.

Smithsonite $ZnCO_3$

Smithsonite is the most common carbonate mineral. Large masses were found at the margins of the orebody (Muller, 1972). It commonly occurs as white to gray earthy crusts and also as druses of tiny colorless crystals on willemite, dolomite, hedyphane and austinite. Larger crystals to several millimeters are less common and are generally simple rhombs, typically with curved faces. These crystals are commonly an attractive yellow or orange color. Smithsonite often contains appreciable manganese or calcium.

Tsumcorite $PbZnFe^{+2}(AsO_4)_2 \cdot H_2O$

Tsumcorite has been found in a small, localized area of the northern opencut in goethite-rich willemite. It occurs as pale to lemon-yellow,

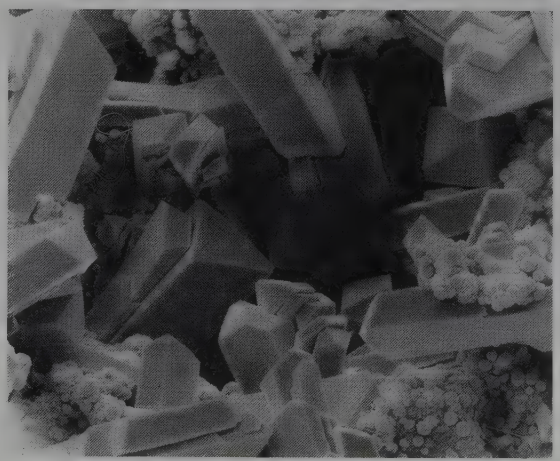


Figure 14. **Bright lemon-yellow tsumcorite crystals to 30 μm on goethite.**

Figure 15. Hedyphane crystals, 3 mm, on willemite. Author's specimen and photograph.

Figure 16. Hedyphane crystals, 1 mm, on willemite. Author's specimen and photograph.

Figure 17. Group of acicular mimetite crystals, 2 mm across, on smithsonite crystals. Author's specimen and photograph.

Figure 18. Rhodochrosite crystal groups, 0.5 mm in diameter, on willemite. Author's specimen and photograph.

Figure 19. Smithsonite crystals to 1 mm. Author's specimen and photograph.

Figure 20. Smithsonian pseudomorph after calcite, 4 mm, on willemite. Author's specimen and photograph.

prismatic, bladed or equant crystals to 0.3 mm. Associated minerals include colorless quartz crystals, yellow-brown botryoidal mimetite, green adamite crystals and globules of gray plumbian austinite (Elliott *et al.*, 1988).

Several specimens of deep red microcrystals of tsumcorite have also been collected. Associated minerals are willemite, hedyphane and austinite. Microprobe analysis has shown that the crystals are manganoan tsumcorite.

Figure 21. **Colorless willemite crystals to 150 μm.**

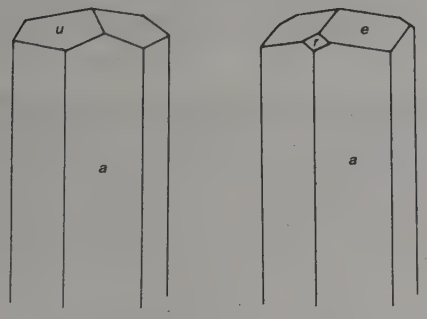


Figure 22. **Willemite crystals showing the forms $a\{11\bar{2}0\}$, $r\{10\bar{1}1\}$, $e\{0\bar{1}\bar{1}2\}$ and $u\{2\bar{1}\bar{1}3\}$. Author's crystal drawings.**

Willemite Zn_2SiO_4

Willemite is the main ore mineral and makes up some 60% of the orebodies (Muller, 1972). The willemite has a mottled red and white appearance, ranging from white mammillated colloform bands and spherulitic aggregates to a compact cryptocrystalline pink to red-brown rock. Individual spherules of radiating willemite crystals can reach 8 cm in diameter.

Colorless to white, translucent to transparent crystals to several millimeters are often seen lining cavities. The crystals are elongated prisms, $\{11\bar{2}0\}$, usually terminated by $\{01\bar{1}2\}$ or $\{2\bar{1}\bar{1}3\}$ faces. Less frequently $\{10\bar{1}1\}$, $\{21\bar{3}1\}$, $\{3\bar{1}21\}$, $\{12\bar{3}2\}$ and $\{4\bar{1}\bar{3}2\}$ faces also occur.

Willemite also occurs as opaque, milky white pseudomorphs after an unknown rhombohedral mineral, possibly smithsonite or calcite.

CONCLUSION

The Beltana deposit has been a source of fine specimens for some 15 years. Although there has been no mining for over two years, several hundred thousand tons of ore remain unrecovered. If and when mining recommences, the mine should continue to produce specimens, and the discovery of species new to the deposit is most likely.

Table 1. **Minerals reported from the Beltana deposit.**

Sulfosalts
- *Baumhauerite
- *Dufrenoysite

Oxides
- Chalcophanite
- Coronadite
- Goethite
- *Cryptomelane
- Hematite
- Hetaerolite
- *Hydrohetaerolite
- Hollandite

Carbonates
- Aragonite
- Calcite
- *Cerussite
- Dolomite
- Rhodochrosite
- Smithsonite

Sulfates
- Barite
- *Gypsum

Arsenates/Vanadates
- Adamite
- Austinite
- Descloisite
- *Duftite
- *Finnemanite
- Hedyphane
- *Koettigite
- Mimetite
- *Olivenite
- *Parasymplesite
- Tsumcorite
- *Vanadinite
- *Doloresite

Silicates
- Hemimorphite
- *Larsenite
- Opal
- Quartz
- Willemite

*Species reported by Grubb (1971) not confirmed by this study.

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REFERENCES

BARCLAY, C. J., and JONES, J. B. (1971) A comparison of the lead phosphates from the oxidised zone, Broken Hill ore body with those of some other Australian localities. *Journal of the Geological Society of Australia,* **18**, 207–213.

BROWN, H. Y. L. (1908) *A Record of the Mines of South Australia,* 4th edition. South Australian Government Printer, Adelaide.

COATS, R. P. (1964) Geology and mineralization of the Blinman Dome Diapir. *South Australian Department of Mines, Report of Investigations,* **26**.

DUNN, P. J., PEACOR, D. R., and NEWBERRY, N. (1980) Johnbaumite, a new member of the apatite group from Franklin, New Jersey. *American Mineralogist,* **65**, 1143–1145.

ELLIOTT, P., PRING, A., and BIRCH, W. D. (1988) Tsumcorite from Puttapa, South Australia. *Australian Mineralogist,* **3**, 67–69.

FOSHAG, W. F., and GAGE, R. B. (1925) Hedyphane from Franklin Furnace, New Jersey. *American Mineralogist,* **10**, 351–353.

GRUBB, P. L. C. (1971) Mineralogy and genesis of the Beltana zinc-

lead deposit, Puttapa, South Australia. *Journal of the Geological Society of Australia,* **18**, 165–171.

JOHNS, R. K. (1972) Base metal occurrences within Lower Cambrian sediments of the northern Flinders Ranges. *Geological Survey of South Australia, Report of Investigations,* **37**, 16–19.

LEESON, B. (1970) Geology of the Beltana 1:63,360 map area. *South Australian Department of Mines, Geological Survey, Report of Investigations,* **35**.

MULLER, D. W. (1972) The Geology of the Beltana willemite deposits. *Economic Geology,* **67**, 1146–1167.

PALACHE, C., BERMAN, H., and FRONDEL, C. (1951) *Dana's System of Mineralogy,* 7th edition. John Wiley and Sons, New York.

RANGOTT, M. F., and SEAR, J. H. (1975) E. Z. mining operations at Beltana. *Mineral Resources Review, South Australia,* **141**, 36–40.

ROUSE, R. C., DUNN, P. J., and PEACOR, D. R. (1984) Hedyphane from Franklin, New Jersey and Långban, Sweden: cation ordering in an arsenate apatite. *American Mineralogist,* **69**, 920–927.

STAPLES, L. W. (1935) Austinite, a new mineral from Gold Hill, Utah. *American Mineralogist,* **20**, 112–119.

WHITEHEAD, S. (1967) Report on Beltana Concession S.M.L. 113, S.M.L. 136, and S.M.L. 142 South Australia. *South Australian Department of Mines, Open File Envelope* **623**, **732**, and **733**.

WILLIAMS, S. A., and DE AZEVEDO, J. (1967) Austinite from Gold Hill, Utah. *American Mineralogist,* **52**, 1224–1226.

Notes from Europe

by **Thomas Moore**

Czechoslovakia 1991

Long ago as a callow youth, inexperienced in international mineral collecting, I would sometimes open my old red copy of Dana's *Textbook of Mineralogy* just to pore over the locality information for species—you may recall the faintly eccentric heading "Obs."—and indulge happily in travel/collecting fantasies for a while. What I remember best now is the fascinating "foreignness" of the repeated Slavic (I guessed) place names, with enough peculiar slashes and squiggles over enough letters as to seem to rule out pronunciation entirely: Příbram, Stříbro, Tepliče, Kutná Hora, all of these given as lying in "Bohemia," a region apparently lavish in well crystallized native elements, sulfides and sulfosalts. Gradually I somehow learned that Bohemia is the western third of Czechoslovakia, abutting both East and West Germany, while Dana's "Saxony" meant the southernmost strip of East Germany, and the "Erzgebirge" were the range of hills straddling the Saxon-Bohemian, or East German–Czech, border. Thus came also, with its separate allure, the knowledge that Příbram and the lesser stars in the constellation lay actually *behind the Iron Curtain*. Anyone who went there, venturing bravely eastward from safe NATO-blue into scary Warsaw Pact–red, would certainly need the powers of a James Bond.

Figure 1. **Town hall at Tišnov (all photos by the author).**

And I admit that this is more or less where my attitude toward the East remained, even throughout most of my adult years of living in Western Europe. About the notion of going to Czechoslovakia, for example, there lingered yet some childish sense of danger; I knew it would be an unspeakable hassle to get the required visas, suffer paranoiac searches at borders, and wonder whether or not to lower one's loud American voice (or beg one's children to lower theirs) in public places. But then in late 1989, as everyone knows, things suddenly began to change; the lurid Red Curtain of our simple youthful world-view crumpled all in a heap. The once frightening Oz behind the Curtain stood revealed, finally, as a rather creaky affair of canned effects, loose pulleys and screws, insecurity, frayed ropes and hopes. So, although we anticipated the embarrassments of playing Rich [Triumphant?!] Westerners in these forlorn places, my wife and I nevertheless made our preliminary contacts, budgeted time, planned a mineral-rich and culture-friendly route, broke the news to the kids that they would be coming along, and set out at last to see a large piece of western Czechoslovakia. We kicked off, one cold April morning, from a friend's home in Nürnberg, not far from the border.

The Czech countryside *is* forlorn, though with a damp, gray-green, lugubrious beauty, or potential beauty (especially as seen under the spitting snow showers that followed us throughout our trip), and you feel that this could be a brighter, more conventionally pretty landscape if, well, if only they cleaned up the place a little. As matters stand, the roads are horribly potholed and the road signs vague, absentminded or just simply absent; the lakes and ponds are lined with mudflats suggestive of sewage; trash dumps are everywhere, as are the smells of petrochemicals in the air. The two small cities we briefly explored, Plsen and Brno, have their points but are too dilapidated and remote-seeming for tourists' comfort, and there is far too much teenage drinking in the streets.

Prague, however, is an amazing oasis in the general unkemptness. Surely one of the world's most beautiful cities, it is lively, self-consciously busy—willingly at the disposal, in fact, of the hoards of Westerners who come each day on the tour buses to shop for bargains in Bohemian "crystal" and in much else. And tourists with more than economically exploitive motives will find here some world-class urban-aesthetic experiences: the ancient Charles Bridge, lined with soot-blackened statues, for pedestrians over the Vltava; the sky-lining Hradcany Castle complex of battlements, Gothic cathedral, museums,

Figure 2. **Tišnov show in progress.**

Figure 3. **Downtown square in Prague.**

and modern seat of government, and the spectacular square where Baroque buildings surround the generously spreading skirts of the Jan Hus memorial.

As for the people's character or mood now, as the country comes out of its long isolation, well—pompous generalizations coming up here—the archetypal "hero" apparently much prized in the folk culture of today is the "Good Soldier Schweik," the lovably lazy, anarchistic World War I shirker of Jaroslav Hasek's novel. Czechs seem friendly, but, like Schweik, can be sullen in the presence of Authority, or even of Foreignness; much psychological change will have to happen if the country decides that it's really serious about fully joining the wider European order. This dazed inertness is of course felt most strongly in rural areas. By the roadside near one country village, a large billboard that had been put up (the fine print said) by the Austrian State Tourist Agency announced simply, in English, "I am a billboard. I can sell your products." Random grafitti defaced it, and weeds grew around it, and the hamlet just on the other side of it seemed to sleep, gaunt, grimy and timeless, as if nothing had stirred in its cobblestone streets at least since the Thirty Years War.

This village was near Tišnov, a Moravian town about halfway along the country's east-west axis, and the destination of our first day's drive. I had heard and read that the annual Tišnov (pronounced Tishnov) mineral show is not only Czechoslovakia's biggest but is in fact "the Tucson [or Munich] of the East." Since the place apparently is not itself a mineral locality and is otherwise undistinguished-looking, I can only attribute this eminence to the organizational skills of Andrej Sučko, Tišnov resident and show chairman. I had corresponded with Mr. Sučko but never caught up with him at the show; instead, I talked at some length with his two adult sons, who sketched for me something of Tišnov Show history. The event began 16 years ago as purely a local collectors' gathering, but with each year since it has become more international and more "commercial"—I saw one American, one British, one Italian, and numerous German dealers, as well as the many predictable Poles, Hungarians, Soviets, etc., among the 300 or so stands. This was the first year in which the show has run for two days instead of just one, and the Sučkos marveled at how "uncrowded" it therefore was on this first day; I must say, though, that there were times when the crush of bodies in the aisles was great enough to preclude my moving at all in any direction. The problem, besides the show's increasing popularity, is its close quarters: the stands are crammed very tightly into three rooms, plus a balcony area, in a low concrete building that looks, except for the inevitable leprous disrepair, like a typical small-town convention hall almost anywhere in the U.S.

In fact, in its general atmospherics and buzz, the Tišnov Show felt much like comparably large ones in more familiar places. True, a money-changing booth was constantly busy turning spot sums of cash in all manner of Western currencies into Czech koruna. But in the entrance lobby there were cheerful banners, publicity for other shows, and a drawing-lottery with specimens for prizes. A chaperoned busload or two of schoolchildren suddenly coalesced by the ticket window, blocking entry from outside. In the main show chamber there were remarks from avuncular dignitaries on stage, and elsewhere in the building there was a good-sized sitdown restaurant with a surprisingly good lunch menu. In short, this show is a busy and pleasant one, not at all as exotic as you might think (or fear, or hope); may it continue to prosper.

It is, of course, *not* Tucson or Munich, either in size, scope, or intrinsic qualities of the best materials available. Except for a small selection of stout old Russian alexandrites briefly shown by Herb Obodda (who disappeared after the show's first couple of hours), there were no "competition" quality specimens here. But there were, as I'd hoped, many interesting things old and new from Eastern Europe, and meanwhile the Cosmopolitanism Cup goes to the Italian dealership

(*Mineralogical Collection Casagrande*, Via dei Bagnetti 3/2, Livorno 57123) which covered two huge tables with a great spread of fair-to-good specimens including Tasmanian crocoite; Peruvian rhodochrosite and enargite; Moroccan skutterudite; Bolivian cassiterite; and Ojuela mine, Mexico, adamite, calcite and hemimorphite. The Italians offered also about 20 cabinet specimens, matrix plates up to 20 cm across, of very pale blue to white anhydrite from Campiano, Tuscany, in dense, solid coverages of thin terminated prisms to 1 cm on limestone.

"Systematic" species dealers from Czechoslovakia, Poland and the U.S.S.R. had many rarities from classic Eastern localities. At one stand, to mention just one example, were thumbnail-sized colloidal masses of gray native arsenic (or perhaps allemontite) from the Třebsko deposit, Příbram, which harbored microcrystals of such things as andorite, pyrostilpnite and xanthoconite.

Stanislav Horsky (Stjerova 19, 040 00 Kosíce, Czechoslovakia) had some fine cabinet-sized Romanian stibnites (Baiut) and tetrahedrites (Cavnic), as well as a few of the glassy cluster-sprays of aragonite from Podrecany, Slovakia, which first hit the western markets a few years ago.

From venerable old Banska Štiavnica, Slovakia (German name: Schemnitz), comes beautiful calcite, in clusters of sharply pointed scalenohedrons, some of them stepped composites of parallel-growth rhombohedrons, to 3 cm long, growing from massive white calcite matrixes to 25 cm across; their aesthetic distinction is a very thin, iridescent "limonite" coating that gives them an oilslick-rainbow aspect. These were collected only four years ago, and the biggest one, 30 cm across, sold for only about $50; the handler was the COLOREM Company (Pod Doubravkou 9, 41501 Teplice, Czechoslovakia).

Quite a few stands caught my attention by, in effect, refreshing my memory of modest but appealing old standbys from Eastern places. I'm thinking for instance of the sharp, dull black to blackish green, perfect crystals of augite from Paskapole, Bohemia; a few of these were still in the matrix of fine-grained volcanic rock in which they occur as phenocrysts, but most were floaters, both singles and twins, in textbook monoclinic forms, ranging up to 5 cm long. Three or four dealers had these; some specimens were dated 1989, and none cost more than about $8.

Similarly, several dealers had classic, grayish white, pitted, slightly rough but complete floaters of orthoclase in Carlsbad twins from the type locality for such twins—the distinguished old spa town of Karlovy Vary (German: Karlsbad), just south of the Erzgebirge, in Bohemia. These ranged from thumbnail-sized to 6 cm long. A Bulgarian dealer, Alexander Dikov (Bl. 5B, vh. A, ap. 23, 1404 Sofia, Bulgaria) had more, smaller but pinker, Karlsbad-twinned orthoclase, as well as sharp, cement-gray twins of sanidine, both from Kyustendil, Bulgaria; a good thumbnail of the sanidine could be had for $2. Dr. Dikov is to be commended also for his excellent spread of showy specimens, thumbnail to large cabinet size, from the new, Trepča-like locality in Bulgaria whose fame is rapidly growing: the 9th of September mine near Madan. Here were sphalerites in groups of sharp, bright black pseudo-octahedrons; brilliant galenas of the skeletal growth habit typical of this source; and very respectable pyrites, calcites, and rhodochrosites, and most possible combinations of all these, and everything very low-priced indeed.

Here and there around the show I spotted a few small specimens of the lovely waterclear tabular barite crystals on reniform goethite from Stanislawow, Poland, which I have praised more than once in these pages (see the photo on p. 485 of vol. 20, no. 6). There were also some surprisingly handsome specimens of glossy black goethite, performing all on its own, from the same locality. A more recent Polish find has been the hauerite from the Jeziorska mine in Silesia: dull to submetallic black cubes, octahedrons, and cuboctahedrons, averaging only 2 or 3 mm but exceptionally to 1.5 cm, marketed either loose or on marly gray matrix. Excellent matrix thumbnails, with sharp hauerite crystals to 5 mm, could be had for about $20 from Roman Bielewicz (Plac Grunwaldzki 8–10, 40–127 Katowice, Poland). Also at this stand were good matrix thumbnails of the classic vesuvianite, in perfect greenish tetragonal prisms with pyramids and basal faces, from the locality often vaguely given as "Vilui River" but here specified, I trust and hope more accurately, as Czemyszewsk, Yakutsk, Siberia, U.S.S.R.

Speaking of Soviet minerals, Bielewicz also had an array of mostly cabinet-sized specimens representing the odd syenite-hosted assemblages of Lovozero and other places on the Kola Peninsula, Russia. Kyanite, phlogopite, eudialyte and lorenzenite in very sharp chocolate-brown crystals were among the species offered. I mentioned the lorenzenites in my 1989 Munich report, when these and the wonderful zircons from Lovozero were first appearing in the West, partly thanks to the *glasnost* of the Fersman Museum in Moscow. Well, there were scatterings at Tišnov, too, of the bright, glassy clove-brown zircons, all without matrix, most under 2 cm, and none exactly cheap.

The most dramatic Soviet items on view were the glittering, vivid green solid druses of uvarovite (individual crystals to 2 mm) over black chromite from the Urals; there was a whole tablefull of these, in miniature and cabinet specimens, at the stand of S. V. Molakanov of the U.S.S.R. (sorry, no address here), who also had a few pitted prisms of Wolodarsk, Ukraine, heliodor beryl which he was selling by the gram as gem rough.

To conclude the show survey I'll mention an occurrence of interest in what Germans now are habitually calling "the former East Germany." The new whewellite from the Paitzdorf mine, Ronneburg, Thuringia, is also something I've mentioned in an earlier Note—but the specimens on view at Tišnov, it seemed to me, were better than the ones I saw at the 1990 Munich Show. The dealer, H.-J. Hartmann (Str. d. Einheit 61, 4113 Teutschenthal, Germany), told me that this old uranium mine is now no longer working, so the few good whewellites collected last year are already the end of the line. Most are single, thin, wedge-shaped crystals to as much as 3 cm across, though there are a few small V-twins and a few jumbled groups. The crystals are either a dull dark gray or, much more attractively, glassy and colorless but *stained* gray to black by organic inclusions, and these glassy ones are often decorated with golden pyrite dustings on or just below the transparent faces. The best specimens are miniatures and thumbnails, with an average thumbnail costing about $25—and I recommend them highly, if any remnants of the strike should ever make it to the U.S.

From Tišnov we drove a while on the country's only Autobahn (Bratislava–Brno–Prague) to come up on Prague from the east. I had an appointment to visit the collection of the Narodní (National or "Patriotic") Museum, and so was delighted to find an affordable hotel only a couple of blocks away down Vaclavské Naměsti, the wide boulevard at whose end the Museum dramatically looms, behind an equestrian statue of St. Wenceslas. When Peter Bancroft visited here for his work on "Mineral Museums of Eastern Europe" (vol. 19, no. 1), he had to photograph the Narodní's facade when it was covered in scaffolding. But you may recall this stately building, the Wenceslas statue and spacious boulevard in news photos from 1968, when the "Prague Spring" and the coming of Soviet tanks brought millions of Czechs to this place in ecstasy, in anger, then in despair. In no other capital that I know of does a Natural History Museum building occupy such a prominent space at the center and source of the national life. Inside, not even Bancroft's excellent interior photograph quite conveys the lovely rococo luminousness, the Old European peacock-display, of the grand stairway in the entrance hall. In late April, 1991, I found the museum staff mildly obsessed with their preparations for the big ceremony, on May 17, to mark the 100th anniversary of the building, although the mineral collection itself is, as Bancroft makes clear, of much greater antiquity, going back to the late 18th century days of the collectors Sternberg and Born and of the highly supportive Empress Maria Theresa.

The "General" section of the collection is extremely fine, of course,

Figure 4. **Hematoid quartz, Cínovec (Zinnwald), Bohemia, 11 cm across. Narodní Museum collection.**

but, like so much in Czechoslovakia, has now to recover from the effects of some 40 years of mismanagement. Before World War II the collection had been kept up to date in the usual way, i.e., by trading extensively with other collections in Europe and beyond. But such healthy activity has been largely forbidden under the Communist regime, with the result that today's collection, while fabulously rich in old Central European minerals, is very short on contemporary material. Looking at row upon row of marvelous old silvers, stephanites, pyrargyrites, bournonites, etc. from Příbram and Jáchymov, I kept thinking of how far just a small trade investment of a few of these pieces would go toward bringing the riches of Mexico, Brazil and Tsumeb to the Narodní . . . but not yet, not quite yet, said young Dr. Petr Korbel, shaking his head in regret. A post-doctoral student at Prague's Charles University and a devoted member of the collection staff, Petr patiently showed me around, regaled me with the collection's history, and incidentally threw in a horror story: the great matrix Jáchymov proustite pictured in Bancroft's article, which was given to the Museum by Emperor Franz I in 1820, was stolen last year from the public display area, and so far has not been recovered. Security, you may be sure, has been greatly tightened since then.

There are three mineral display rooms: one for the general collection, one for metallic ore minerals from Czech localities, and one for Czech non-metallics. Certainly the metallic-ore room was the most fascinating—the silver minerals from Příbram and Jáchymov, as I've said, are astonishing. Here I saw again some of those old, magic, unpronounceable names from my old red Dana, plus others I couldn't recall ever having heard of: Příbram and Jáchymov (German: Joachimsthal) of course, but also Stříbro, Ratibořice, Kšice, Olovi, Krupka, and many others; you get the idea.

Both Czech rooms are lavishly educational. Some dazzling purple apatite specimens taught me, for instance, that the high-temperature tin veins of Horní Slavkov (German: Schlaggenwald) and Cinovec (Zinnwald) can yield things just as fine as can the similar but better known Ehrenfriedersdorf deposits, over the German border. Of the locality known in German as Herrengrund, in Czech as Spania Dolina, I learned that the beautiful aragonite clusters resembling Sicilian specimens came long ago from only one limited pocket zone in this old copper mine, nobody now knows exactly where. And the half-dozen loose yellow-brown gemmy prisms of aragonite (to 15 cm) from Hořonec reminded me of how confusingly prolific this small country is in sources of excellent aragonite—witness also the older "Horschenz" and newer "Podrecany" pieces.

And one learns, when visiting national hoards like this, of local serendipities which never quite make the mineralogical Evening News but are quite remarkable nonetheless. It seems that once in the 1920's, during road work near Křepice u Vodňan, Bohemia, a single quartz boulder when broken open revealed shallow vein fillings of beautiful leaf gold (actually it proved to be electrum, with up to 40% Ag) to 10 cm across the leaves. The *in situ* source was never discovered, nor even were any other gold-bearing boulders found. Of the 20 or so good specimens, a few reached the elite of the Central European collectors but most were deposited at the Narodní, where today a row of seven dramatic miniatures may be admired. Who ever heard of such good gold from Czechoslovakia? Come here and see it.

Of course I asked Petr Korbel about the current status of some of the classic localities, and once again heard some depressing tales out of Cold War history. As is well known, the long-worked Ag-Pb-Cu ore veins at Příbram and Jáchymov were finally exhausted for profitable mining in the 1970's; the few small mines still working exploit uranium ores, and indeed the Narodní displays some fine, recently mined reniform uraninites from both localities. But it is strongly suspected

Figure 5. **Model of the Anna mine, Příbram Mining Museum; 1.7 meters high.**

Figure 6. **Příbram Mining Museum: taken from a window in mineral-display building.**

that good specimens of the silver minerals continued to be found by the miners, at least at Příbram, almost to the end. The fact that none reached the outside world leads some to suspect that Soviet mine supervisors may have stashed them away, or that the miners, many of whom were political prisoners and hence even more paranoid about on-hours collecting than miners usually are, sent all crystals to the crusher. In any case, really good specimens of Jáchymov or Příbram silver minerals are much greater rarities than they probably should be. The one major exception, the spectacular Příbram dyscrasites of the last few years (see the specimen pictured in the Carnegie Catalog, in vol. 21, no. 5), were found in the uranium workings in the early 1980's, and the enclosing native arsenic was dissolved away to free the fragile, splintery groups.

With rumor and lore like this still fresh in my head, how could I not, on the return trip to Germany, make a brief stop at Příbram itself? I had heard and read of a mining museum there. And although the children, tired from a hard week of touring, at first balked at following me to yet another mineralogical shrine, they proved bribable with a "California pizza" (with overtones of kiwi fruit and orange rind) at an idiosyncratic cafe on the edge of town.

Příbram turns out to be a sizable and (by Czech standards) bustling town and business center. But there are many old people, and the usual rutted streets, and it's clear that the truly booming days of mining here are about as dead as the Austro-Hungarian Empire. Many old mine structures can be seen, black and spidery, on the surrounding hillsides, and barred entrances to extinct *Stollen* ("tunnels") appear in roadcuts close to the center of town.

The museum, out along the road south from Příbram to Brezevy Hory, consists of two handsome stone buildings flanking an old head-frame. One knocks at the door of one of the buildings and applies for

Figure 7. **Boulangerite, 15 x 12 cm, Příbram. Příbram Mining Museum.**

a guide: ours turned out to be a plump, friendly, sixtyish lady who unlocked the mineral-display building, then paused inside the door to direct us to put on clownishly outsized, fuzzy fur slippers for wear on the polished hardwood floor. The displays are modern and bright, thorough and thoughtful. There are old maps of the district, documents, photos and mining paraphernalia. The glass specimen cases are carefully arranged so as to distinguish between uranium mineralization

presently being mined and the products of yesteryear's base metal veins. The inevitable ornamental gee-wow specimens, in their large individual glass cases, include a cluster of pink manganocalcite rhombohedrons and a mass of acicular stibnite needles, each about 60 cm across. But the really good stuff, of course, is to be found in the upright cases with their very extensive arrays of ore and gangue minerals. The silver sulfosalts come close in general quality to those at the Narodní. Then there are great "feather-ore" specimens of boulangerite and jamesonite; outstanding tetrahedrites and bournonites; galena in brilliant, petite little cuboctahedrons perched singly on drusy quartz; lovely pocket sprays of pyrostilpnite; and very nice specimens of secondaries like cerussite, pyromorphite, scheelite and wulfenite. A 1.7-meter-high, scrupulously detailed model of the Anna shaft in full operation ca. 1900 gave the kids something more wonderful to marvel at and to savor than even that California pizza.

Thus was concluded another mineralogical amateur's tour which, I must now regretfully say, will be my last as European Correspondent for *The Mineralogical Record*. I'll be moving back to the United States in a matter of days. In the future I may nevertheless still contribute travel and show reports from time to time, but meanwhile would like to thank everyone who has responded—in nearly all cases kindly, supportively and appreciatively—to these past six years' worth of purplish prose effusions. To all, then, *auf wiedersehen* and *glück auf*. (Never *could* come up with a good standard closing line . . . .)

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MINERAL STORIES

Lawrence H. Conklin

The Arthur Montgomery Mineral Sale of 1939

[The following story is from Martin Plotkin of Massapequa Park, New York.]

As a young boy I learned about minerals under the expert tutelage of Junius Claudius (Jack) Boyle. [See *Mineralogical Record,* vol. 15, p. 231–236.] The only opportunities I'd had to obtain minerals up to that time were in the form of gifts from Jack Boyle and purchases made during a visit to John Grenzig. Grenzig operated an electrical equipment store in Brooklyn where he also sold mineral specimens. An argon bulb purchased from him was my first source of ultraviolet light for the purpose of studying fluorescent minerals.

Boyle notified us, the members of the Brooklyn Pick and Hammer Club at the Brooklyn Children's Museum, that a mineral exhibition and sale was to be held at a hotel in Manhattan, under the supervision of Arthur Montgomery. When I arrived, before the start of the sale, there was an anteroom filled with people waiting for the doors to open to this "mineral promised land." On tables in an anteroom were small white cards for prospective buyers to write their names on; if they wished to buy a certain specimen they were to place a card in the tray containing that specimen. No specimens were to be removed until the buyer, ready to leave, rounded up all his purchases. In this way the minerals were on display for as long as possible.

It was, of course, a very sad feeling to pick up a desperately wanted specimen only to find someone else's card already there. In some cases there was more than one card in the tray, as a second person, hoping the first buyer would change his mind, would add his card to the tray. This maneuver sometimes worked because, with so much material available, a person seeing something more desirable later on might remove his card from the first item, freeing it for someone else.

Finally the doors opened, and there, spread out on three sides of the room, were tables covered with specimens which Edwin Over and Arthur Montgomery had, for the most part, personally collected in the field. Red Cloud mine wulfenite, Old Yuma mine vanadinite, Fairfield, Utah variscite nodule slabs, Alaskan epidote and garnet, Bisbee Azurite, Colorado amazonite, and on and on.

One outstanding specimen that I remember distinctly was a Red Cloud wulfenite group with 3.8-cm crystals for the price of $12.50. At this time I was attending college on a 25¢ a day budget (subway round-trip, 10¢, and lunch, 15¢) so unfortunately, as far as that wulfenite was concerned, it almost seemed as though I was in a nickel-a-piece candy shop with only a penny to spend. That was not really true, however, and the situation was far from a total loss. There were many specimens available for as low in price as 10¢ and 25¢, and I had to be very selective to stay within the total of my available funds, which was under ten dollars. But, happily, this bought a lot of material.

A gorgeous thumbnail-sized, fan-shaped group of several 2 to 2.5-cm azurite crystals from the Copper Queen mine I got for 50¢. I added a yellow 1-cm wulfenite crystal on matrix from the Hilltop mine for 25¢, and a skeletal 2-cm vanadinite crystal from the Old Yuma mine for 10¢. The epidotes, at least those in my price range, were: a 5-cm terminated crystal, a thumbnail with unusual short stubby crystals, and a translucent 2-cm crystal which exhibits very good dichroism. The total for the three specimens was 75¢. A 1.3-cm Red Cloud wulfenite cost 15¢.

The wonderful thing about this sale, as distinct from any other I've attended in over 50 years, was that every specimen was a "good" specimen. There were no massive pieces of ore minerals, no lapidary materials (except, of course, the variscite,) no jewelry or findings, just MINERALS. The show that came closest in overall quality to this one, in my opinion, would be one of the series of sales held in the Hotel Lexington in New York City by the Schortmann Brothers, in the early 1950s. These followed the style and pattern started by Montgomery in 1939 and, although much fine and even similar material was available, it was not like that first show I ever attended.

A Franklin Saga

[The following story is from Walter Pickut of Wellsville, New York.]

In my imagination, this story begins a billion years ago when nature created the fantastic zinc-plus-everything orebodies of Franklin and Sterling Hill, New Jersey. In only a few centuries' time the miners harvested just about all there was to take, and when the famous Franklin mine closed in mid-century, it seemed to end one of the great sagas of mineralogy, *but I have that last moment captured in a display case.*

Sometime during the summer of 1989 I went for a long drive from my home in western New York to visit Ewald Gerstmann in Franklin, New Jersey. As I drove up the steep hill toward his home I noticed a long line of cars parked on both sides of the street. That certainly was a signal that something was up. Almost always it meant that a significant collection had been acquired and that the re-distribution of the specimen wealth was under way.

This *was* indeed one of those special events, but on this particular afternoon Ewald was not at his usual station holding court in the Gerstmann Mineral Museum, but was in his garage, surrounded by piles of rock. The floor looked like the ghost of mining-past had dumped the contents of two ore cars at his feet. This was to be an unusual afternoon, even for Ewald.

After offering the usual friendly greeting, he explained that an old miner had finally given up his hold on the glory days of Franklin, all two tons of it. This was not the collection of a mineralogist-miner, a connoisseur of the mine, but rather of a hard-working but unschooled fellow who had simply learned that this stuff was important and worth saving. His friendship with the familiar and common species, however, had been firm.

So, as Ewald stood over the roughly grouped piles of boulders, the collecting theory at work here was evident. If a little piece was good, then an enormous chunk was better. I inspected esperite-laden ore the size of cantaloupes, chunks of zincite as big as my head, masses of pink and honey-colored friedelite, and the inevitable piles of franklinite of various descriptions. Many collectors milled through the garage, talking and sifting the goods. The pickings weren't to my liking, however, as either I had better examples already, or wasn't in need of doorstops at the time. Although Ewald Gerstmann often offers for sale world-class collectibles at prices that encourage the sincere amateur, I decided that, for that day at least, I was there for the conversation.

Not accepting the idea that anyone really interested should go away empty-handed, Ewald directed me to the darkest corner of his garage. "Over there Walt," he said. "Don't look first, just take it if you want it. Fifty bucks. Its all the junk I couldn't fit into any of the piles."

I had learned that Ewald's "junk" was sometimes very special. He seemed to delight in the excited return of past customers and their chirping about the really neat thing—the surprise goodie or the un-

The "picking table" at Franklin, New Jersey (ca. 1945), where low-grade ore, timber fragments and tramp steel were culled out. Photo: Robert Svecz.

expected oddity carried home previously as a "two dollar wonder." So, after a little more chatting, I bought the bucket of junk and drove home, alternately congratulating and scolding myself for acquiring the 100-pound bucket of folly.

That is where I found my piece of history. The bucket, indeed, was full of junk, but it also contained some very fine microscopic crystals of friedelite and a few very nice clear apple-green willemite crystals of the kind that only Franklin produced. All in all, it seemed to have been a good gamble. But then, at the very bottom of the dusty bucket, I found my real prize.

It was a lump of very ordinary, massive black franklinite, and I was about to toss it onto the pile that was going to the garden as fill, when I felt a scrap of adhesive tape stuck to its underside. Written on the tape in uneven capital letters was "LAST PIECE OVER TABLE FROM MINE, FRANKLIN NJ." That old miner had stood his station at the picking table one last minute more at the closing of the great Franklin mine, and, grasping that passing moment of history, had made it his.

All I know about him is that his name was Davis and he was there that last day. I had paid a lot more for some very fine specimens in my collection, but I like this one very much. To me it seems to hold the beginning and the end of a story that was a billion years in the making.

Mineral Collecting, American Style

[The following story is from John C. Marshall of Dedham, Massachusetts.]

After several years of mineral collecting on foot and via bicycle, I managed, on my sixteenth birthday that summer day of 1947, to get my driver's license. So, off I went the very next day in my $125 Model A Ford, with a collector-friend, on the way to the Berkshires with our ultimate destination being the rhodonite locality in Cumington, Massachusetts.

Not having any directions to the mine, we stopped at the gas station and general store that comprised all of downtown Cumington. We asked the proprietor, who was pumping gas, "Can you tell us how to get to the manganese mine?" Standing next to the pump was an elderly gentleman who promptly replied, "I know where it is, but its closed and you can't go there because I own the mine." Somewhat disappointed, we drove off; but, being sixteen and cocky, we were determined not to be denied. After an hour of searching and more queries, we arrived at the Betts farm, behind which, we were told, was the mine. As we drove up to the farmhouse we could see a man sitting on the front steps, and to our embarrassment, it was the gentleman from the gas station. He looked at us for a few seconds and then said, "Kinda figured you fellas would show up." We were then given a guided tour of the mine and told we could collect to our hearts' content.

Tale of a Book Collection

Sometime during the month of November, 1979, I received a telephone call from Joseph O. Gill (noted bibliophile and author of *Gill's Index To Journals, Articles And Books Relating To Gems And Jewelry,* Santa Monica, Gemological Institute Of America, 1978) who at that time was the resident gemologist of J. & S.S. De Young, Jewelers of Boston, Massachusetts.

Joe had just turned up a highly important collection of early gem and mineral books in faraway New York City, and needed some help in digesting it. (I learned, much later, the identity of the collector, of this unique and superb specialized library, which was begun in 1959; *this* year (1991) I purchased directly, his small but interesting collection of gem crystals, all obtained originally from Hugh A. Ford!) How Gill managed to accomplish this formidable task, using only the telephone wires and the U.S. mails, without (I believe) seeing a single book in advance, and also without so much as setting one foot down in New York City until the deal was consummated, is a story, I believe, worth telling.

My first hint at what was to come arrived with a letter from Gill dated 11-16-79 in the form of a list that had *originally* been eleven pages long and *had* contained at least 73 listings of books, letters and manuscripts. Gill had cut, pasted and rearranged the list, removing from it what he wished to purchase, and *that,* calculating from the missing numbers listed, amounted to at least 25 items. He, of course, admitted freely to doing precisely this in his letter, but refused to disclose—(1) what the excised items were; (2) what prices he was paying for them; (3) who had the books and; (4) the answers to sundry other questions that I posed. His covering letter read as follows:

> Dear Larry Conklin,
>
> Here is your list minus my 25 items. You are the only [?] person I have contacted. I have figured [my books at a] full price. If you figure [your books at a] top price we will have a

once in a lifetime chance. Please be strong, and answer as soon as possible but you must answer by Wed. Nov. 21, 1979.

Call as soon as you receive these papers so I can sleep easier.

Cordially,

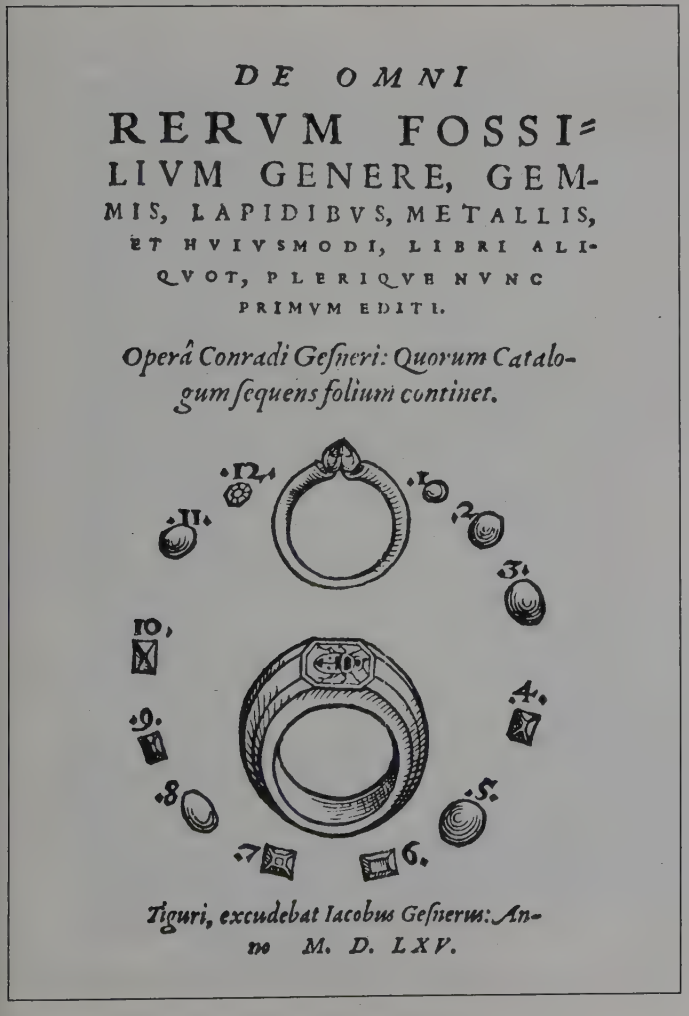
Joe Gill

[P.S.] I don't think we can figure this deal at anything less than a full price, and if we don't, we go down together."

Needless to say I did not sleep easy either. Here, even in its abbreviated form, was a book collector's wish-list come true. Never before, and not since, have I seen such a comprehensive list of early mineralogy and gemology books, *all of which were actually available to me for sale, and essentially, at my own prices*. Collectors like myself are accustomed to going through an entire catalog received from a bookseller, finding one or perhaps, at most, two items of interest, and then after placing a prompt order for either one by telephone are informed that these desiderata have already been sold. This was not the case on that November day. *Everything* left on that list was available to me, but how would I choose? And what should I pay? Working in a vacuum, as it were, is not easy and for the most part, I had never seen such books offered for sale. Of the 48 lots left on the list, and after *much* soul searching and agonizing, I settled on the following books and offered to pay the individual prices for each item noted below with its original number. How I arrived at each price I cannot now remember.

1. Leonardus, Camillus. *Speculum Lapidum*. Venice, 1516. $800. (For some interesting information on the rarity of this work, see my article in *Mineralogical Record*, vol. 19, p. 78–79.) (This copy could bring $4,000 today.)

4. Gesner, Conrad. *De omni rerum fossilium* . . . Zurich, 1565. $400. (Price today: $10,000–$15,000!)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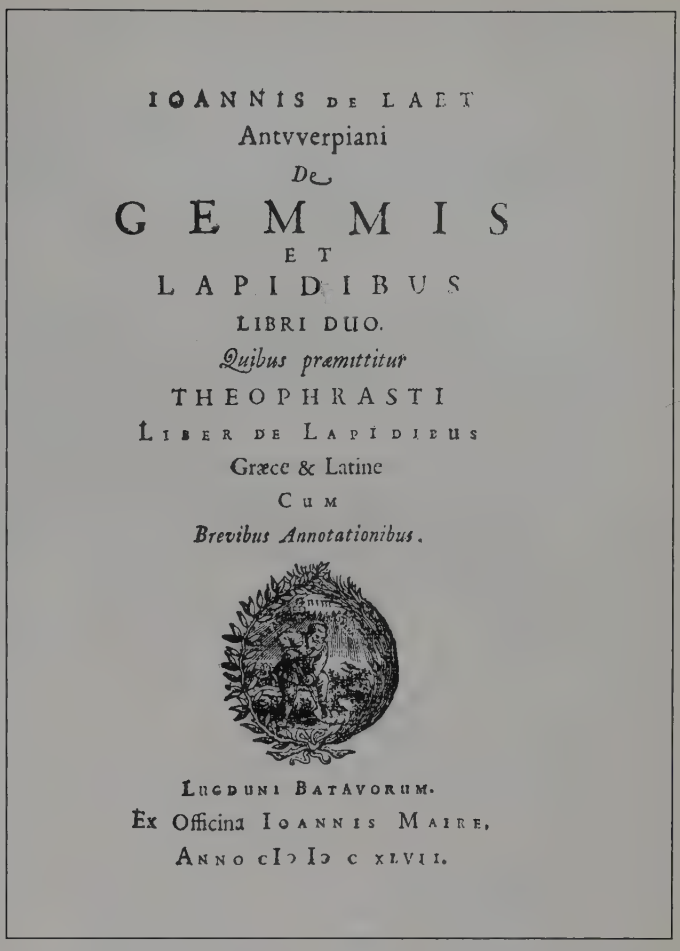
IOANNIS DE LAET
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GEMMIS
ET
LAPIDIBVS
LIBRI DUO.
Quibus præmittitur
THEOPHRASTI
LIBER DE LAPIDIBVS
Græce & Latine
CUM
Brevibus Annotationibus.

LUGDUNI BATAVORUM.
Ex Officina IOANNIS MAIRE,
ANNO cIↃ IↃ C XLVII.

15. Baccius, Andreas. *De gemmis lapidibus pretious*. Frankfort, 1603. $850. (Today: $2500)

20. De Boodt, Anselmus Boetius. *Gemmarum et lapidum historia*. Hanover, 1609. $300. First Edition (Price today: around $5000)

26. de Laet, Johannes. *De gemmis et lapidibus*. Louvain, 1647. $500. (Today: still about $500)

28. Nichols, Thomas. *A Lapidary, or the History of Pretious Stones*. Cambridge, 1652. $800. Gill's copy of this work, comparable to this example in binding and condition, brought $1000 at auction in 1987.

38. de Berquen, Robert. *Les Merveilles des Indes Orientales et Occidentales* . . . Paris, 1661. $400. (Today: $2500)

41. Chappuzeau, Samuel. *Histoire des Joyeux et des Principles Richesses de L'Orient* . . . Geneva, 1665. $400. (Today: $4000)

45. Boyle, Robert. *An Essay About the Origine and Virtues of Gems*. London, 1672. $800. (see discussion below)

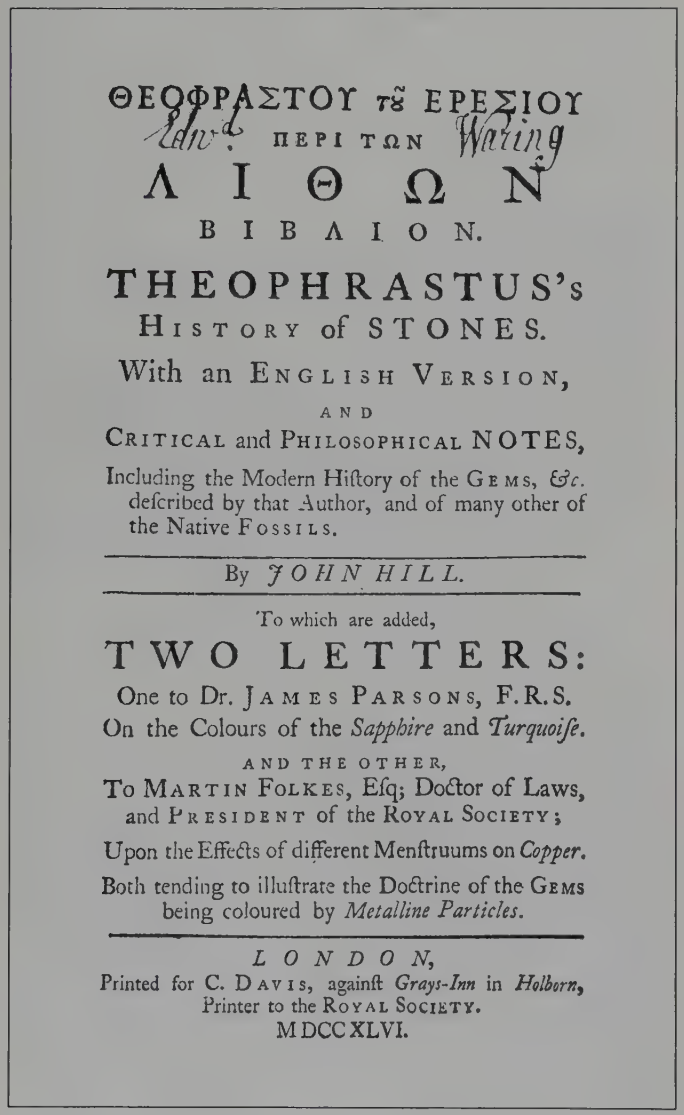
58. Hill, John. *Theophrastus's History of Stones*. London, 1746. $450. (Today: $1200)

61. Jeffries, David. *A Treatise on Diamonds and Pearls*. London, 1750. $350. (Today: $1000)

One of the lots left on my list (Number 72) was very interesting: "Kunz, George Frederick. A collection of over 50 autograph [written by hand] and typed letters signed, comprising about 25 from the great gemmologist himself, and over 30 to him from fellow scientists and others. Vp [various places], 1894–1906." If this description sounds similar to items from my Kunz archive, which around that time I had just sold, it is because (as I later found out) that is precisely the case. This was one of a few small lots that my supplier, the late Raphael Gould, had put up at auction years before I had met him and worked out a deal to buy all the letters that he had left, almost 8000 pieces. What price it brought at auction cannot now be determined. In the light of what I had sold and still held at that time, I passed on this lot.

Another interesting and important item that I could have chosen was Number 73. It was a two page manuscript inventory of Crown jewels of Charles I of England, dated June 10, 1629. It contained a description of what may well be the very famous large ballas ruby (actually, a red spinel) that escaped destruction during the Commonwealth period, and which today is the centerpiece of the Imperial Crown. It was amusing for me to read, years later, in one of the major English Crown jewelry books, the title of which I cannot now recall, that original inventories of Crown jewels of Charles I are not known to have survived!

In the end, and for reasons of economy, I rejected the Gessner (why I chose that particular volume to delete from my list and not another, I cannot recall, but, in hindsight it looks foolish indeed) and was cajoled into paying $6000 for the balance. The path to the conclusion of my part of this deal was not at all smooth, however. Still not knowing what books Gill had earmarked for himself, and not knowing what he was paying, *if anything,* for them, I was informed that in addition to *my* $6000, $15,500 more had to be raised to pay for the balance of the books. Gill stated that he did not want to buy any more books than those he had already chosen (he collected only in the English language) and I certainly could not afford any more. It was then decided that I was to offer the books to Richard Hauck and, of course, I would be discreet about the already spoken-for volumes, both Gill's and my own. Dick surmised immediately that there was maneuvering going on behind the scenes, but he was wise and mature enough to recognize a good deal when he saw one, even though he may have suspected that someone else might have been getting an even better deal. He was equal to the occasion and bought the remaining 38 lots for the required sum. That price, incidentally, included the copy of the Gessner that I had passed up, which today is worth over $10,000!



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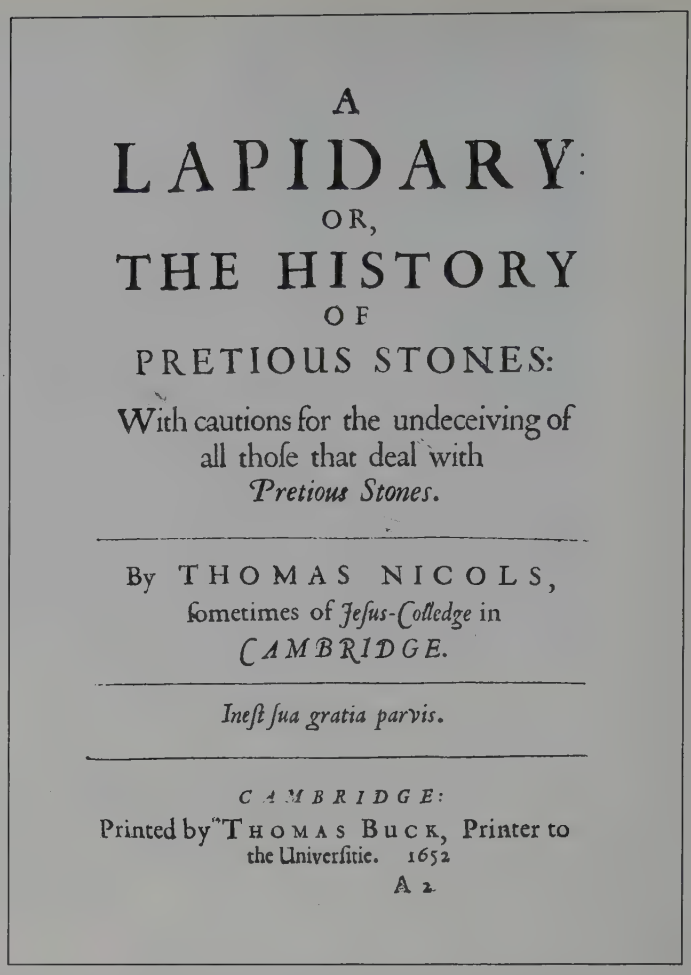
To which are added,

TWO LETTERS:
One to Dr. JAMES PARSONS, F.R.S.
On the Colours of the *Sapphire* and *Turquoise.*
AND THE OTHER,
To MARTIN FOLKES, Esq; Doctor of Laws, and PRESIDENT of the ROYAL SOCIETY;
Upon the Effects of different Menstruums on *Copper.*
Both tending to illustrate the Doctrine of the GEMS being coloured by *Metalline Particles.*

LONDON,
Printed for C. DAVIS, against *Grays-Inn* in *Holborn,*
Printer to the ROYAL SOCIETY.
MDCCXLVI.



A
LAPIDARY:
OR,
THE HISTORY
OF
PRETIOUS STONES:
With cautions for the undeceiving of all those that deal with *Pretious Stones.*

By THOMAS NICOLS,
sometimes of *Jesus-Colledge* in
CAMBRIDGE.

Ineſt ſua gratia parvis.

CAMBRIDGE:
Printed by THOMAS BUCK, Printer to the Universitie. 1652
A 2

A high spot on the *original* list (a copy of which I did finally manage to obtain) and a book that went, originally, to Gill, was John Mawe's *A Treatise on Diamonds and Precious Stones,* London, 1813, a first edition in boards that was a presentation copy from the author to Dr. William Wavell of wavellite fame. This book I managed to squeeze out of the Gill library in 1980.

I enjoyed *my* new acquisitions for only about one year. They went when I sold my entire mineralogical library to Stephen Byer in 1980. Byer installed the books in a private museum in Evanston, Illinois, that was soon after destroyed by fire. Somewhat later Richard Hauck made a deal with Byer and purchased those of my books that had survived the fire, the smoke and of course, most importantly, the water, but that is another story. One exception was the Boyle, which was retained by Byer. It had cost me $800, more or less, in the original division, and when Byer sold it at auction 10 years later, it brought $3500 *from a dealer.*

Joseph Gill added his newly-acquired books to an already important gem-library, and then sold his collection at auction in 1987. Dick Hauck attended the sales at Christie's in New York and purchased a number of the important Gill books.

And finally, *Hauck's* gem and mineral library which included the 38 lots of early books, has just recently been sold (with the exception of the Charles I inventory, which he had previously and most graciously relinquished to me), placing, one can hope, all those bibliophilic treasures back on the wheel for yet another turn.

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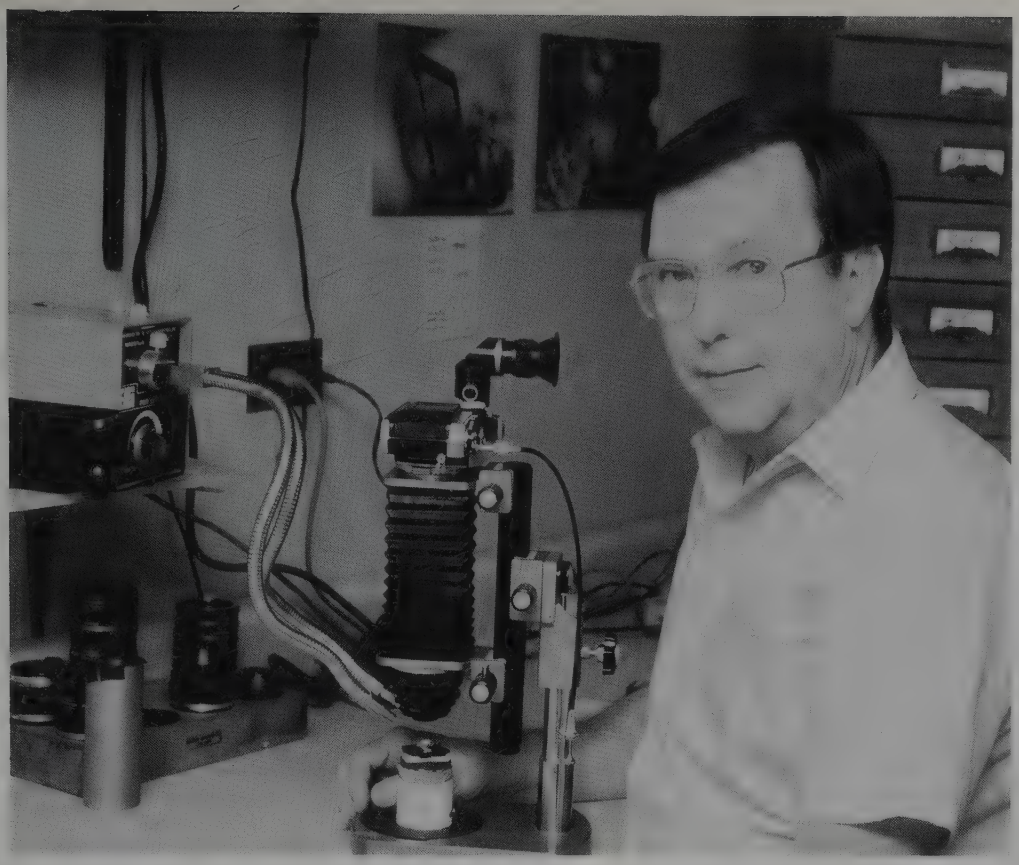


Dan Behnke

Microminerals

I am very pleased to welcome Dan Behnke of Northbrook, Illinois, as a guest writer for the Microminerals column. Several years ago, Dan switched to using macro lenses and bellows for photographing microminerals, and the results he has obtained strongly suggest that his technique is superior to photography through the microscope. His photographs of microminerals have appeared in articles in the *Mineralogical Record, Earth Science,* and *Rocks & Minerals,* while a number of others are to be found in the second edition of the *Encyclopedia of Minerals*.

He is on the Board of Associate Photographers of the *Mineralogical Record,* is a member of the Board of Directors of the Friends of Mineralogy, and is author of "Copper Country microminerals," which appeared in the July-August 1983 issue of the *Mineralogical Record*.

His column is an excellent introduction to the use of macro lenses and bellows for photographing microminerals.

Bill Henderson

Photomacrography of Microminerals

by **Dan Behnke**

INTRODUCTION

The use of a bellows system in conjunction with a single lens reflex camera as a method of photographing microminerals has received a great deal of attention during the past few years. The use of the bellows has proven to be an excellent alternative to the low-power microscope as a means of magnifying the image of a specimen for photographic purposes. The bellows system produces sharper and more colorful images with greater depth of field than those produced using a microscope. The major drawback of using the bellows is that the highest working magnification is considerably less than that obtainable when using a microscope. However, the magnification range of the bellows (up to about 25X) under normal conditions is generally adequate for producing photographs of average-size microcrystals (0.5 to 3.0 mm).

Obtaining sharp, clear, color-correct and aesthetically pleasing photographs of microminerals presents challenges to the photographer that are not simple to overcome. Even a photographer who is expert in "normal" photography faces a whole new world to conquer when attempting to take photos of microminerals. Sharpness, depth-of-field and lighting take on entirely new dimensions.

Photographs of microminerals are judged on several criteria. First and foremost, the crystal being photographed must be of high quality. There is not much that can be done to obtain a breathtaking photo of a crude, dirty or damaged specimen. The best that can be produced is a technically correct photograph of a crude, dirty or damaged specimen, simply showing it as it is. Therefore, start with the best specimen you have, after cleaning it.

The other criteria are sharpness, color and contrast. Sharpness not only affects just how clearly the specimen is represented but also its color rendition. Colors become brighter and more vivid in contrast as the image becomes sharper. Color and contrast are also affected by the type of film used and the method of lighting. The most important factor affecting sharpness is, however, the quality of the lens.

A variety of photographic and technical equipment is available with which high-quality photographs of microminerals 3 mm to hundredths of a millimeter in size can be produced. What then is "The Best"?

The "best" is the equipment that produces the desired results, and may vary depending upon the specific applications. Scientific photography of specimens which require magnification up to several hundreds or thousands of times for technical purposes requires equipment designed specifically for extremely high magnification. Low-power equipment will not suffice, nor can larger specimens be readily handled by the more sophisticated equipment. On the other hand, there are

several equipment options for the photography of specimens at low power for artistic or educational purposes. The first is the microscope.

The average cost-conscious collector with some interest in photography will usually turn to the piece of equipment readily at hand—the low-power microscope. One eyepiece can be adapted to hold the camera; or a microscope with a built-in third ocular designed to hold a camera can be used. Lack of sharpness and/or poor resolution, aside from the lack of any depth of field, are problems that are often encountered when using the microscope, primarily because the optics of the low-power microscope are not designed specifically for photographing three-dimensional objects. That type of microscope works best with flat-field objects, like thin specimens mounted on glass slides.

The second equipment option is the use of a bellows system with standard photographic lenses (reversed), while the third option is the use of the bellows with specially designed "macro" lenses. Although the second option will produce photographs of better quality than the microscope, the third option, that of using macro lenses with a bellows system, will be the one covered in this article.

The use of a bellows is an application of the principle that, when the optics are moved away from the film plane of the camera, the image of an object on the film becomes larger. While we are concerned here with close-up photography, the same principle applies in standard photography when a telephoto lens is used to photograph distant objects. The longer the telephoto, the larger the image. There are laws of optics which come into play involving focal length of the lens, resolution and diffraction of the image, but basically, the further away the lens is from the film, the more magnified the image is on the film.

This article will not be highly technical nor will it explore the theoretical aspects of the use of bellows and lenses, but rather it will lay out in a rather pragmatic way one method of obtaining high-quality photographs of microminerals. Moving beyond taking acceptable photographs into the area of producing artistic photographs depends upon the skill of the photographer to see crystals as more than scientific objects and to skillfully apply techniques of lighting and composition to the work. That is a subject worthy of a paper in itself.

EQUIPMENT

The amount of photographic equipment required is substantial. The system (see Fig. 1) is composed of a bellows, a bellows stand, the camera, and several lenses. In addition, a high-quality light source is required, as well as a device to hold the specimens motionless in any position. The cost of these components may vary based on the brand and quality chosen but may easily exceed the cost of a good low-power microscope. By canvassing used equipment suppliers, the costs may be reduced somewhat, but caution should be used in purchasing any equipment because it is difficult, if not impossible, to obtain high-quality photos using new or used inferior equipment.

Bellows

A bellows is an expandable light-tight cloth device mounted on a rail or bar and placed between the lens and the camera body. It is used simply to adjust the distance between the camera and the lens so as to increase or decrease the size of the image on the film. Actually a two-track bellows is most convenient; the upper track permits adjustment of the extension distance between lens and camera body (i.e., the magnification), and the lower track permits adjustment of the distance between the camera-bellows-lens assembly and the subject (for focusing). Once the desired extension/magnification is selected, focusing the image is accomplished by moving the entire assembly toward or away from the subject using the focusing knob on the lower bellows rail. In other words, there are two steps that take place: first, the selection of the magnification and second, the focusing.

Extension Tubes

Extension tubes may be used for the same purpose, but instead of being continuously adjustable they are rigid and, in combination, provide only one set of magnifications. Tubes are available in varying lengths (see Fig. 2) depending upon the magnification desired. The image, when using an extension tube, is of fixed magnification for

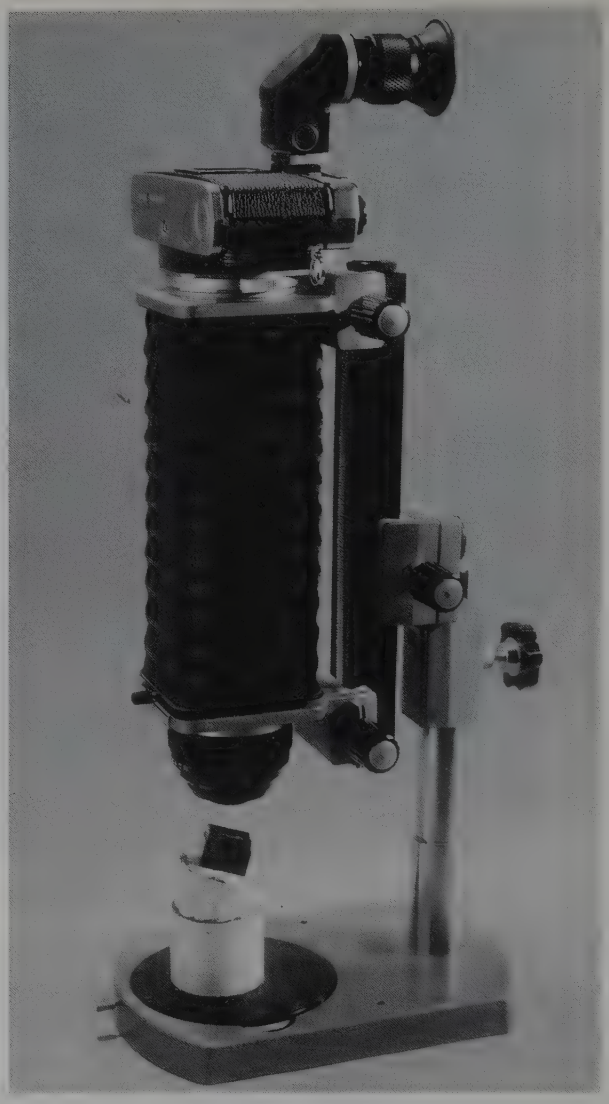


Figure 1. **Single-lens reflex camera with right-angle viewfinder attachment on a vertically mounted bellows with macro lens.**

Figure 2. **Extension tubes (7-mm, 14-mm and 25-mm), useable individually or in combination.**

that tube length while the magnification obtained when using a bellows may be varied by simply expanding or contracting the bellows. Extension tubes and bellows may be used together to further increase the magnification beyond that of the bellows alone, but there are optical constraints which ultimately limit the distance that a lens can be placed from the film and still produce an acceptably sharp image. Experimentation will show what those limits are, depending on the lens being used.

Camera Body

The camera of choice for this type of photography is the 35-mm single-lens reflex camera because the specimen can be positioned and the lighting adjusted while looking at the image on the ground glass of the camera. The amount of light transmitted through the ground glass is very important. The brighter the image on the ground glass, the easier it is to position and properly illuminate the specimen. Unfortunately, the focusing screens that are provided as standard equipment on cameras are designed for focusing on more distant objects rather than for close-up work. When used with the bellows, the image is too dark and in the case of split-image focusing screens, the center may even be partially blacked out. Therefore, the normal focusing screen should be replaced with a screen designed for higher magnification photography. Not all cameras feature changeable screens; when purchasing a camera specifically for this type of photography, changeable screens should be a requirement. The special screens are nearly clear and transmit substantially more light, thus making composition, lighting and focusing much more accurate. Always follow the manufacturer's recommendations when matching screens to lenses because a mismatch may make focusing more difficult or even impossible even though the image is brighter. A screen designed for photomicrography, for instance, may not work for a longer focal-length macro lens.

Another important operating feature of the camera that should be selected carefully is the means of determining the correct exposure. There are very sophisticated systems available, some of which may be more complex or expensive than necessary for this type of photography. What is required is a metering system which will function accurately when using the bellows and macro lenses. It should be kept in mind that any automatic exposure control system may be affected by the color of the crystals being photographed, as well as the contrast between the subject and the background. White or pale colored crystals on dark backgrounds or dark crystals on light backgrounds may cause false meter readings which result in overexposed or underexposed crystals, while the backgrounds are properly exposed. Experience will show what degree of compensation to the automatic exposure control system is necessary to overcome the false readings. Remember, the more that the automatic exposure control can be depended upon, the more the photographer is able to concentrate on lighting and composition. It also saves expensive color film by reducing the need for bracketing exposures in order to get at least one good image.

Viewfinder

An invaluable accessory is the right-angle viewfinder attachment for the camera, which slightly magnifies the image on the ground glass and which has an adjustable diopter setting to enable persons who normally wear eyeglasses to focus without them; working without eyeglasses provides a better view of the image on the ground glass. The right-angle feature also makes it physically more comfortable than when trying to look straight down into the camera. Always remember that (depending on the brand of camera being used) the image as seen on the viewing screen is usually somewhat less edge-to-edge than the image on the film. Since there will be slightly more on the film, tight cropping of the image may not work out as planned unless that difference is taken into account.

Lenses

The lenses best suited for use with the bellows, although designated as "macro" lenses, should not be confused with the adjustable "macro" lenses used in close-up photography of flowers, insects and belly buttons. The macro lenses used with the bellows are in non-focusing mounts and cannot be used independently on the camera as standard lenses. Focusing is accomplished, as mentioned previously, by moving the entire fixed camera/bellows/lens assembly up and down by means of the focusing rail to which it is attached. These special macro lenses are available in several different focal lengths which determine the minimum and maximum image sizes when used on the bellows. The shorter the focal length, the larger the image on the film.

One group of macro lenses is available in 20-mm, 38-mm, and 80-mm focal lengths (see Fig. 3). Available focal lengths may vary from

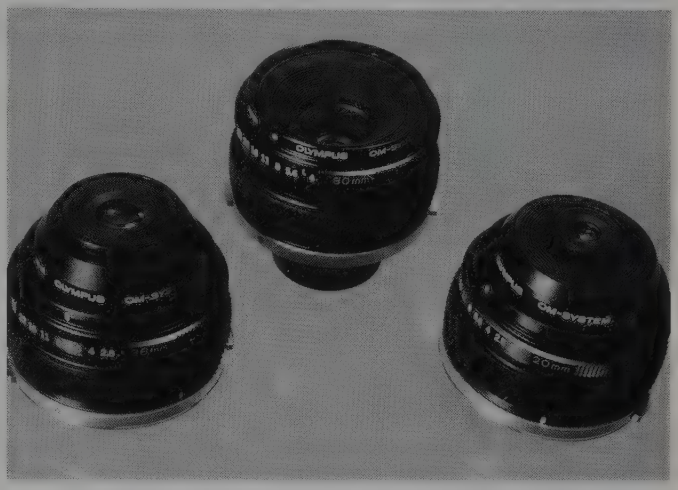


Figure 3. **Fixed-focus macro lenses (38-mm, 80-mm and 20-mm).**

manufacturer to manufacturer but will be within the same general range. Since the images on the film vary not only depending on the focal length of the lens but also on the extension of the bellows, there is usually a scale in millimeters on the rail of the bellows which indicates the length of extension. Technical charts provided with the lenses give data regarding magnification and field of view at specific distances by focal length. The table below shows a series of lenses by focal length, the image sizes and the field width for fully contracted and fully extended bellows. Data for intermediate distances are not shown but fall within the ranges given.

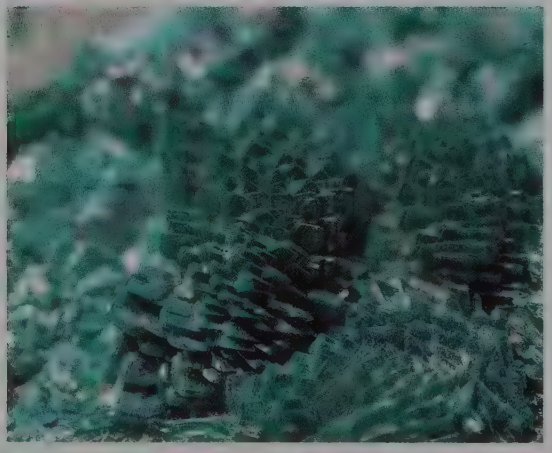
Magnification and Field Ranges

Lens	Bellows Contracted		Bellows Fully Extended	
	Magnification	Field	Magnification	Field
28mm f/2	5.3x	6.6mm	13.6x	2.5mm
38mm f/2.8	2.3x	15.2mm	6.7x	5.2mm
80mm f/4	0.25x	140.0mm	2.3x	15.2mm

Choice of the appropriate lens to use in a given situation is dependent upon the size of the crystal specimen and the image size that is wanted on the film. Larger specimens require longer focal length lenses while the smaller crystals require the shorter focal lengths to provide adequate images on the film. As the above chart shows, the highest magnification that can be obtained is 13.6X, with the 20-mm lens and the bellows fully extended. A crystal that is 1 mm wide will appear 13.6 mm wide on the film (which is 35 mm wide) or, in other words, it will fill about one-third of the width of the slide. In this instance if a larger image is needed, extension tubes could be added to increase the distance between the lens and the film plane. The technical charts provided with the lenses should be consulted for more specific data.

a.

b.



c.

d.

Figure 4. **Pseudomalachite crystals clusters to about 2.4 mm in size, from the Harquahala mine in Yuma County, Arizona. Photos taken at (a) f/2, (b) f/4, (c) f/11, (d) f/16.**

SPECIMEN SIZES

Sizes of microcrystals and sizes of images can become very confusing when working with such small numbers. When labeling slides, therefore, the actual size of the crystal should be listed because, in the case of publication, the image will be further enlarged and the magnification at which the slide was taken will no longer be applicable. Similarly, during projection at slide programs, the crystal size should be noted rather than magnification because in the process of projecting the slide, the original magnification is increased a hundredfold and is meaningless. The size of the actual crystal, however, is a measurement that is more meaningful to the audience. A simple way to approximate the actual size of the crystal is to measure the image on the film and divide that figure by the known magnification. For instance, if the image on the film is 10 mm and the photo was taken at 5X, the actual size of the crystal is 2 mm. One caveat for users of microscopes is that the magnification that the scope is set on it not always the magnification of the image on the slide. To test for actual magnification photograph a millimeter scale and measure the resulting distance between millimeters marks on the film. If the distance is 5 mm, the magnification at that setting on the microscope (or bellows) is 5X.

APERTURE EFFECTS

Depth-of-field is the key issue in examining the differences between using a bellow system and using a microscope to take micromineral photographs. Macro lenses have built-in diaphragms which are used to adjust the amount of light passing through the lens. When the diaphragms are closed down to decrease the amount of light reaching the film, the depth-of-field is increased. Depth-of-field is the distance the image is in focus in front of and behind the point on which the lens is focused. The depth-of-field can be either non-existent for all practical purposes, as it is when using a microscope, or it can be great enough to provide a clear image of the crystal in its matrix with surrounding details.

Figure 4a was taken with the 20-mm macro lens wide open at f/2. The point of focus was midway in the center cluster of crystals, which measures about 2 mm tall. Almost nothing is in focus in front of or behind the crystals in the center. Figure 4b shows the same view with the lens stopped down to f/4. Note the increase in sharpness of the crystals around the center point. Figures 4c and 4d show the same specimen photographed at f/11 and f/16 respectively. Now compare the image in 4d with the image obtained in 4a. They are of the same crystals but the resulting photographs are very different.

While depth-of-field is used primarily to bring more of a crystal or crystal group into focus, depth-of-field can also be used selectively to place an unwanted background out of focus to eliminate distractions in a photograph. It is therefore important to examine the image on the ground glass at different f/stops so that the best looking image can be selected. There are several problems that may arise when selecting the proper f/stop. The first is that there is a limit to the highest f/stop that can be selected at high magnification. As the lens is stopped down at high magnification, a dispersion of the image begins to take place (due to refraction of light around the edges of the aperture) so that while the depth-of-field continues to apparently increase, the overall image itself begins to deteriorate and lose sharpness. There is an optimum f/stop for each degree of magnification, to the point where only one f/stop may be possible at 13.6X with the 20-mm lens before the image begins to lose sharpness. The gradual loss of sharpness can be observed if the lens is stopped down very slowly after focusing has taken place.

The second problem is that reflections on crystal faces may be diminished; in fact, a reflection that was carefully placed with the lens wide open may entirely disappear when the lens has been closed down to the desired f/stop. It is therefore more practical to make the final lighting adjustment after the lens has been stopped down. This makes the need for a bright focusing screen all the more important.

Figure 5. Barite crystal, 2.2 mm, from the Magma mine, Superior, Arizona.

Figure 6. Cronstedtite crystals to 2.5 mm from Kisbanya, Romania.

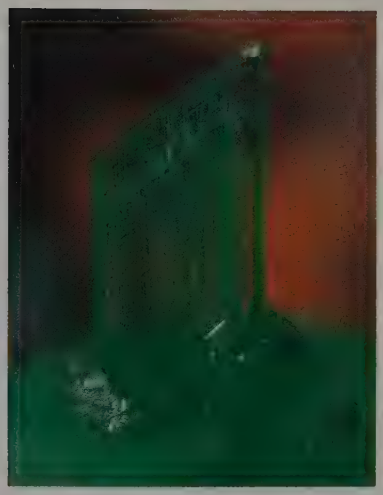


Figure 7. Annabergite crystal, 1.2 mm tall, from Kamareza, Laurium, Greece.

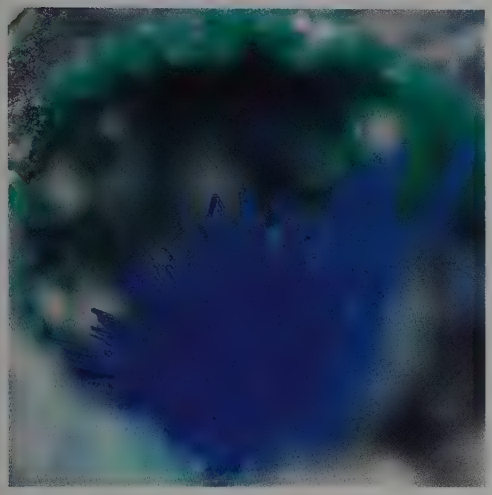


Figure 8. Linarite crystal cluster, from Wanlockhead, Scotland.

Figure 9. Proustite (front crystal, 0.8 mm) from the El Dorado mine, Yankee Boy Basin, Ouray County, Colorado.

Figure 10. Orpiment crystal cluster, 1.1 mm, on hutchinsonite, from Quiruvilca, Peru.

Figure 11. Ulrichite crystal spray, 1.25 mm, from near Lake Boga township, northwestern Victoria, Australia.

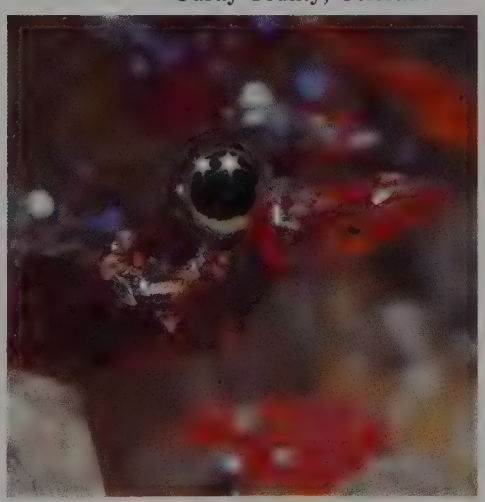


Figure 12. Mercury (0.18 mm) on montroydite from the Socrates mine, Sonoma County, California.

Figure 13. Cinnabar crystals, 1.7 mm, from the Culver-Baer mine, Sonoma County, California.

When working with the standard low-power microscope, since it is not possible to "stop down" the lens, there is little or no depth-of-field at any time and the photos may look basically the same as the image in Figure 4a at that magnification. Inserting a diaphragm into a microscope system does increase the depth-of-field but that capability is not usually available on the relatively less expensive equipment used by micromineral collectors.

FILM and LIGHTING

The type of film used and the light source must match. Daylight type color film must be used in daylight or be filtered for use in artificial light. Tungsten-balanced film must not only be used with artificial light but the light source must be of the matching color temperature. A film rated at 3200° K must be used with a 3200° K light source or be filtered to match the light source. Lamp specifications may have to be consulted or controlled tests conducted to determine whether or not a specific lamp can be used without filtration.

For those using a light source with a variable intensity control it is important to remember that the color temperature of the light changes depending on the intensity setting. Lower settings produce more reddish light while the higher settings turn the light more bluish. These changes cannot be seen visually. Once a setting has been determined to produce correct color rendition, always return to that setting. Along those same lines, aging lamps also change color temperature, so if your slides begin to show a shift in color balance, it may be due to a lamp getting ready to burn out or suffering from old age.

The ideal lighting equipment for this type of macro photography is the fiber optic illuminator with two fiber optic arms. The use of two light sources enables the photographer to balance light and shadows for subtle degrees of illumination of the specimen. It may be a little more difficult sometimes to control unwanted reflections but overall the extra effort results in more pleasing photographs. Use of a single light source too often creates unbalanced lighting with harsh highlights and deep shadows.

A word about choice of film type. It is very tempting to use a high-speed film but in reality, a slow-speed film of the correct color temperature will give the best results. Since the sharpness of an image on film is not only affected by the quality of the optics but also by the graininess of the film, the slower-speed films, being finer grained, can yield sharper images. Some of the slower tungsten films are designated by the manufacturers as "Professional" films and are designed to be used at longer exposure times (one second or more) without undergoing sensitivity or color balance changes. This is not true for the higher speed films which are designed for short exposure times and which may require filtration or changes in exposure times when used at the longer exposure times.

DOCUMENTATION

It is important to keep detailed notes while taking the pictures, so that mistakes can be avoided in the future and successes replicated. It is easier to tell what went wrong if you know what you did in the first place. It is especially important to keep records if you switch from one film type to another on a regular basis. Although I highly recommend choosing the film type that works best for you and sticking with it for consistency, at times it is necessary to try new techniques or films. And finally, since your slides should carry all the important information regarding the specimens and the photo data, detailed documentation makes the wearying job of labeling slides less onerous.

CONCLUSION

In conclusion, it should be remembered that mineral photography is an evolving art both in terms of equipment and techniques. What was considered the best 20 years ago has been replaced today by state-of-the-art equipment capable of much higher quality results than could have been imagined earlier. It is likely that the same increment in quality will be possible over the next 20 years. It is therefore very important to keep up with improvements in equipment and techniques and apply them to your specific needs whenever possible.

Dan Behnke
2981 Landwehr Road
Northbrook, IL 60062

A couple of comments are in order with regard to the use of a microscope or bellows in photographing microminerals. First, as Dan said, a microscope can be used to take photographs of much smaller objects, perhaps one-fifth to one-tenth the size of the smallest crystals photographable using bellows. Many micromounts in the average collection are too small to be photographed by his method.

Second, a microscope can indeed to stopped down to give greater depth of field. I do so by punching a single hole through a piece of black paper, and attaching it immediately below the objective lens of my microscope using masking tape. By so doing, I get an enormous increase in depth of field. Still, I do *not* recommend this as a general procedure since there is substantial risk of dropping microscope parts or damaging the optics while installing the homemade aperture.

Last, although I hate to admit it, I am becoming convinced that the results using the bellows method are significantly better than those obtained using a low-power microscope.

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Letters

OLD SWEDISH COLLECTION

Your note (vol. 22, p. 223) about the existence of an old Swedish collection was very much appreciated. Indeed the letter created a breath-taking and thrilling atmosphere.

Partly out of our own curiosity and partly in order to prevent future burglary attempts from unscrupulous mineral hunters, I have tried to trace the collection. But, unfortunately, I have failed. I have asked the King's Secretary and the Royal Huntmasters but they could not give me the slightest clue to the background of Oppold's statement.

Bengt Lindqvist
Swedish Museum of Natural History
Stockholm, Sweden

'MBUMBA DIOPTASE

Regarding the Congo dioptase mentioned in your "What's new in minerals?" Tucson Show report (vol. 22, p. 217): " 'Mbumba near Sanda" is not a "new" locality. 'Mbumba is a hill which, along with about ten other occurrences, is known collectively as the Pimbi deposit. The production of fine to very fine thumbnail to fist-size specimens began when the workings were first opened in 1908–1911. The district was studied by the French B.R.G.M. between 1950 and 1962. Several occurrences there are currently being mined.

F. Danet
Anduze, France

UNUSUAL ZINCITE

At the 1991 Tucson Show, a Polish dealer in the Desert Inn had some samples labeled "Zincite, from the Great Mine Fire." There was much discussion as to whether they were natural or really man-made, as well as to their identification. The peculiar thing was that all were elongated, almost needle-like, some with a hexagonal cross-section (expected, for zincite), and some with a "square" cross section, implying two *different* needle orientations, sometimes on the same piece! I bought one "square" cross section sample for identification; these are the results.

(1) The material is ZnO, "zincite," as shown by an X-ray powder diffraction pattern.

(2) The side faces of the needle (which are visibly not quite perpendicular to each other) are $\{10\bar{1}1\}$. The axis of the needle is therefore approximately $[40\bar{4}7]$.

(3) Consistent with this, a $\{10\bar{1}0\}$ cleavage was present diagonally across the base of the needle.

We still have the question of why it grows with two possible needle orientations in the same environment: a *c* axis, and a roughly $[40\bar{4}7]$ axis.

William R. Cook Jr.
Cleveland Heights, OH

OLD MINERAL LABELS

The editorial note on the establishment of a mineral label archive (vol. 22, no. 4) struck a chord. I am a firm believer in the preservation of specimen labels. Working with the mineral collection of Gerard Troost (1776–1850), I have encountered a plethora of different labels.

Labels do more than describe the mineral; they tell the story of who owned the specimen! I have found *eight* different categories of labels which tell the history of this collection. I have gone so far as to list which labels occur with the mineral on the catalog sheet which is used in the database.

The "L0" label is one that Troost received when he purchased a specimen. They are typically printed in German and are very rare.

The "L1" label is in Troost's handwriting. It may contain information that is not in the catalog. Many of these labels became coated with mud during the 1937 flood and need to be cleaned to be made legible again.

"L2" labels date from the early history of the Museum of History and Science, when it

was called the Kentucky Polytechnic Society. The K.P.S. labels date to the early 1880's. There are three different types of the "L2" labels. Some incorrect labels from this period indicate that the collection documentation had deteriorated in the 25 to 30 years following Gerard Troost's death. (The collection was buried to prevent looting by Union soldiers during the Civil War.)

The "L3" label is the first cardboard display label associated with the Polytechnic Society.

The "L4" and "L5" labels post-date the 1937 flood, when nature wrecked havoc with this venerable collection. "L4" labels are hand-written on paper. "L5" labels are similar to "L3" labels in that the same walnut mineral stands were used.

I believe that retaining old labels with the specimens is important and should be done whenever possible. They add "distinction" to "antique" minerals. As a collection moves through different owners and becomes dispersed, each specimen accumulates a "paper trail," documenting its provenance, for current owners to appreciate.

Alan Goldstein
Museum of History and Science
Louisville, KY

BALLARAT GOLD

In the article by Tom Vallance and myself in the Australia Issue ("Early Australian mineralogy," vol. 19, p. 363), a sketch of some fine crystals of gold is reproduced from Liversidge's *Minerals of New South Wales* (1888). The specimen was "said to be in the Edinburgh Museum." Alec Livingston of the Department of Geology, Royal Scottish Museum in Edinburgh, confirms that the specimen is indeed there, and sent the accompanying photo. Although the Edinburgh register does not say how it was obtained, Livingston reports that it

weighs 6.5 ounces and is about 10 cm long. Fine Victoria gold specimens certainly found their way around the world.

Howard K. Worner
Wollongong, New South Wales

CHEERS AND JEERS

I am happy to enclose our renewal check. Please continue the fine work on the magazine. It is amazing how with each issue you manage to maintain the high editorial and pictorial standards you've set for yourselves. Having spent nearly 17 years as an editor and publisher, I can appreciate how hard it is to maintain quality issue after issue—but you're doing it.

Merce Dostale & Michael Tarachow
Pentagram Press
Minneapolis, MN

I would like to take this opportunity to make two comments about the *Mineralogical Record*. First, and by far most important, I thank you and the rest of the *Mineralogical Record* staff for providing such a consistently fine publication. I do not know of its equal, both for the niche it so neatly fills and for quality of presentation. I particularly value the commentaries at the beginning of many issues, some of which discuss controversial topics with no easy solutions and stir people up a bit. In this the *Mineralogical Record* performs a most valuable (if sometimes uncomfortable) service—and for that, my sincere thanks.

On the flip side, I was discouraged to find in the present issue the stiff paper insert advertising mineral videos. This advertising trick is used by many lesser magazines, but it never occurred to me that the *Mineralogical Record* would resort to it. What it amounts to is recognition through irritation, by assuring that one cannot easily leaf through the magazine without "tripping" over the card. I save a lot of money by refusing to subscribe to magazines that contain such inserts and by refusing to patronize businesses who advertise on them. Please do not let this be the start of a new trend for the *Mineralogical Record*; once is quite enough.

Again, however, please do accept my compliments for a job well done. I cannot imagine how you folks manage to do so much good for the mineralogic community at the rapid pace you do, but somehow you manage it. Thanks for being there, all of you.

Earl R. Verbeek
Golden, CO

In defense of our advertiser, Stuart Wilensky, I must say that he had no intention of using such a "trick." He originally asked that a postcard be inserted loose, which would drop out on the first reading. However, we had to inform him that recent changes in the ever-inscrutable U.S. postal regulations make a loose card hundreds of dollars more expensive than a stapled-in card. He therefore agreed to have it stapled in, and allowed our printer to decide exactly where it would go. If we decide to accept such cards again we'll lay them in over the title page where they won't interfere with flipping through the issue. By the way . . . I've seen Stuart's mineral video, and it's excellent. Ed.

ERRATA

On page 284 of our "Kalahari update" article (vol. 22, no. 4), *friedelite* is incorrectly listed on Table 1 (295) as being among the sulfides and sulfosalts, and is accompanied instead by the chemical formula for *friderichite*. The caption to Figure 8 should indicate the N'Chwaning "I" mine. [These corrections to the galley did not reach the *Mineralogical Record* office in time to be made before publication. Ed.]

I have also received the final formula for the new blue copper mineral from George Harlow [American Museum of Natural History]; $Ca_6Cu_3(SO_4)(OH)_{12}\cdot 2H_2O$, just prior to its being submitted to the I.M.A. Commission on New Minerals and Mineral Names.

A surprising new identification is *brandtite*, $Ca_2(Mn^{+2},Mg)(AsO_4)_2\cdot 2H_2O$, the first arsenic-containing mineral to be reported from the Kalahari Manganese Field. It occurs as minute, milky white blebs on bultfonteinite, with charlesite and bruceite, from the Wessels mine. Identification is by Gregory Cavallo [A.M.N.H.]

K.-L. von Bezing

In our article on the Fat Jack mine (vol. 22, no. 1) errors appeared in the formulas given for osarizawaite. The correct formulas are: (approximate formula proportions) $(Pb_{0.63}Na_{0.22}K_{0.01}Ca_{0.01})Cu_{0.98}(Al_{1.92}Fe_{0.24}^{+3})(SO_4)_2(OH)_6$ and (average molecular composition) $(Na_{0.38}K_{0.34}Pb_{0.09}Cu_{0.08}Ca_{0.02})(Al_{2.80}Fe_{0.27}^{+3})(SO_4)_2(OH)_6$. The analysis given for stolzite should read: PbO 47–51%, CaO 0.0–0.1%, WO_3 30–40%, MoO_3 3–15%, Total 90–98 weight %. On page 26, the captions for Figures 15 and 16 are switched.

J. A. Scovil and L. Wagner

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