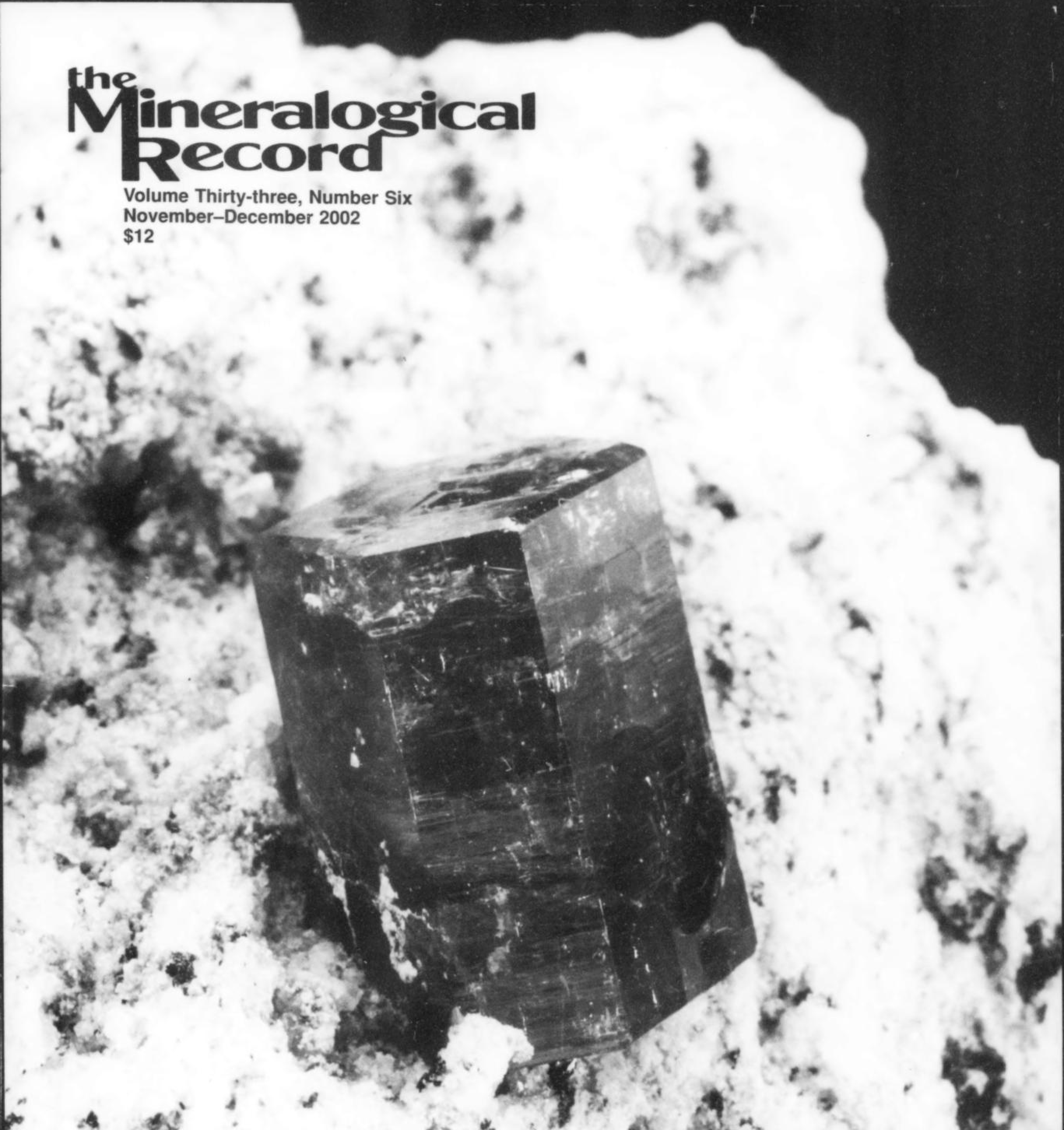
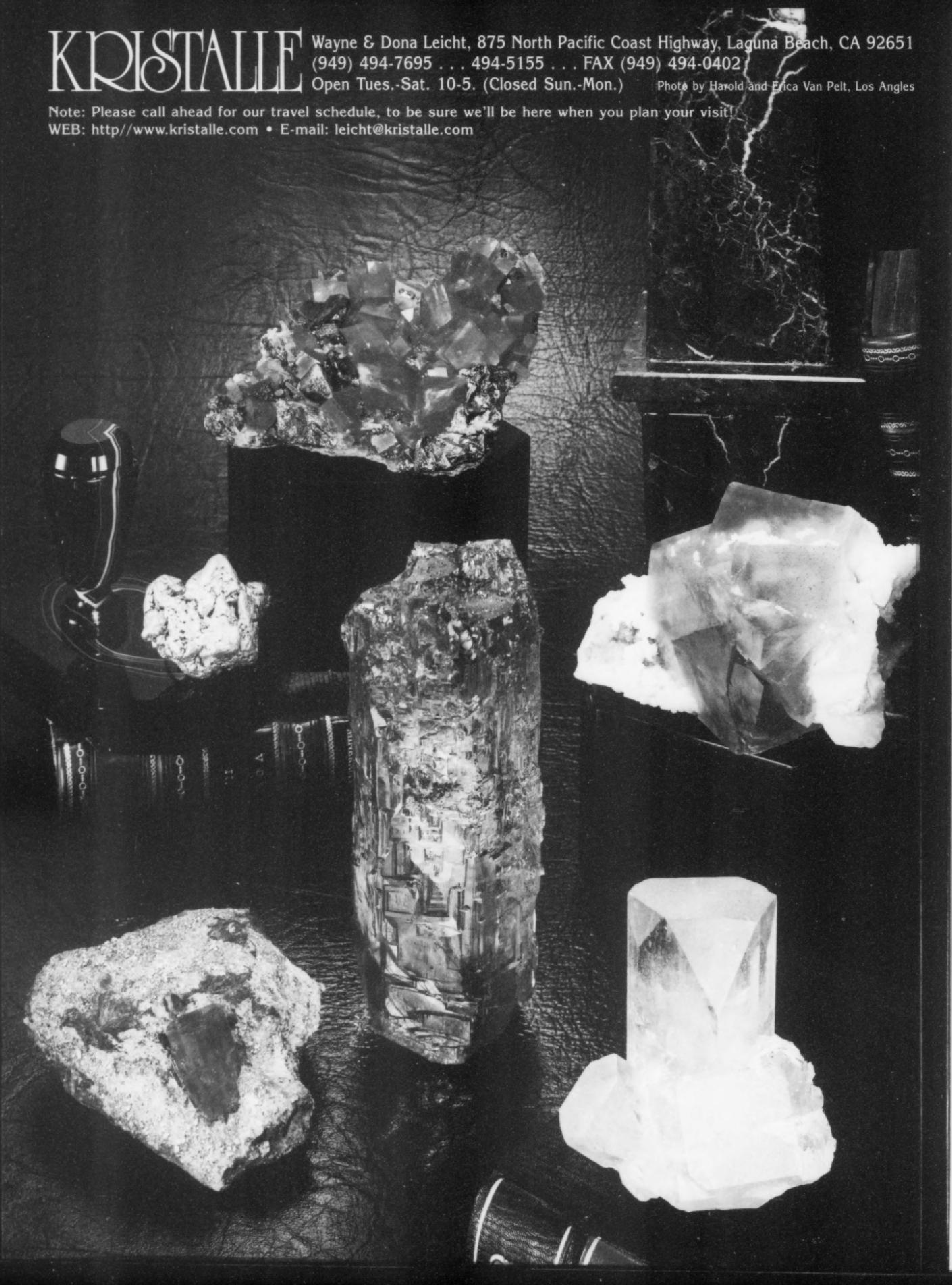
the Mineralogical Record

Volume Thirty-three, Number Six
November–December 2002
$12





THE MINERALOGICAL RECORD

November–December 2002 Volume Thirty-three, Number Six

Articles

Columns

COVER: BASTNÄSITE-(Ce) crystal, 1.3 cm, from Zegi Mountain, Khyber Agency, Fata, Pakistan. Herb Obodda specimen; Jeff Scovil photo.

Visit
our Website:
www.MINREC.org

The Mineralogical Record (ISSN 0026-4628) is published bi-monthly for $51 per year (U.S.) by Mineralogical Record, Inc., a non-profit organization, 7413 N. Mowry Place, Tucson, AZ 85741. Periodicals postage paid at Tucson, Arizona and additional mailing offices. POSTMASTER: Send address changes to: The Mineralogical Record, P.O. Box 35565, Tucson, AZ 85740.

Editing, advertising
4631 Paseo Tubutama
Tucson, AZ 85750
520-299-5274 • FAX: 520-299-5702
E-mail: minrec@earthlink.net

Subscriptions
(Subscriptions, back issues, reprints, book sales, shows)
P.O. Box 35565
Tucson, Arizona 85740
520-297-6709 • FAX: 520-544-0815
E-mail: minrec@aol.com

- **Individuals (U.S.):** $51 for one year; $96 for two years. (First-class mailing available; write to circulation manager for rates.)
- **Individuals (outside the U.S.):** $55 for one year, $99 for two years. (Airmail mailing available; write to circulation manager for rates.)
- **Libraries, Companies and Institutions (worldwide):** $150 for one year.

*Continued on p. 535

Guest Editorial

COLLECTION DISPOSAL

What to do with one's mineral collection now that the golden years have arrived and there are no apparent heirs, at least interested ones, in the picture? This is a classic dilemma and one certainly not unique to mineral collectors. But such collections often present special problems because, in most cases, it is only the collector himself or herself who has even a remote idea of the relevance of the collection, its approximate dollar value, its marketability, its potential appeal to others, and all the details relating to the acquisition of the specimens. Unfortunately, minerals still occupy one of the lowest rungs on the general popularity ladder of types of collectables, meaning that public ignorance of minerals and how to dispose of them is the rule. Unless members of the immediate family or close friends have been seriously involved in the collecting process over the years, they may be totally unprepared to wisely shepherd the effective disposition of a mineral collection. Therefore the collector must, at some point, come to grips with the fact that (1) he or she is not going to live forever, (2) this collection represents, perhaps, a life-time of effort and, for that reason alone, has value, and (3) if appropriate plans are not made for its disposition, whatever value the collection has may very well be lost altogether.

For obvious reasons the nature of this concern depends substantially upon the nature of the collection. Currently, those who collect what I like to call "trophy" minerals have little to worry about. If the minerals were acquired through purchase and selected with taste, there will always be a keen interest on the part of mineral dealers in handling their sale. If the collector is well-known by virtue of having exhibited at many shows, dealers will compete for the chance to handle the collection. As with most collectables, the very best specimens nearly always gain value over time. The only challenge in this case is trying to make sure that the collection ends up in the hands of a trustworthy dealer. This problem is easily solved if the collector himself selects that dealer and negotiates the terms of the sale in advance, or names a trusted agent to handle the sale later, after the collector has passed away.

Many other types of collections, however, present special problems. The number of people who have spent much of their lives collecting on club trips and solo excursions wherein their gleanings are moderate or even negligible in terms of marketability, even if precious in terms of satisfaction received, is unknown, but there are undoubtedly many thousands of such collectors. A similar number, probably, attend mineral shows, purchasing or swapping for everything from rare species to pretty rocks at modest cost. Both of these likely have self-collected as well as purchased or traded specimens in their collections, all having been acquired because they appealed to the collector for some particular reason, not because they will one day be entered into competition in a display case at a mineral show. In fact, the overall level of such collections is commonly mediocre in terms of crystal quality, rarity, and desirability. Nevertheless, it is one of the great advantages of mineral collecting that, despite this mediocrity, such a collection can provide a collector with a lifetime of enjoyment and a focus for learning. How this will transfer to others after the fact is problematical.

There are many possible subsets of mineral collections. There are those that represent a *specialization*, such as the minerals of a certain state or mine, the minerals of a particular metal or compositional group, or a specific mineral species. In fact, most collections tend quite naturally to have a strong local aspect to them. Specialization is not limited to collections of modest value; collectors at all levels may specialize. So, while the modest collection may be very rich in the minerals of the collector's immediate area, the trophy collector may have focused on gem crystals, such as beryl, tourmaline, garnet, etc. Then there are micromount collections which more often than not represent a higher level of dedication and knowledge of mineralogy by the collector than most other types. There are collections of single crystals and gems, pseudomorphs, stalactitic minerals, minerals with a particular aesthetic, and probably many others that do not immediately come to mind.

Selling or giving to museums

For most of the first half of the twentieth century and earlier it was quite fashionable for collectors to deposit their mineral (and gem, usually) collections in museums. It simply was what was done, and a large number of major museums owe the richness and the diversity of their holdings to that tradition. Usually this was without the incentive of tax savings; the collections were outright gifts. The collectors were, for the most part, quite affluent and, while they may have welcomed a tax break, they did not need the money which the sale of their collections might have brought, and were therefore able to give them away. These gentlemen (lady mineral collectors were virtually non-existent) were far more interested in assuring that their collections would remain intact and not be dispersed. What better way than to deposit them in a museum? Some donors placed restrictions upon the museum's ability to dispose of portions of these collections, others did not, and today very often what remains of these famous collections depends upon how rigid and binding those restrictions were. Museums were eager to acquire important collections and so they found themselves having to compromise their standards in order to win donations, and in the process making concessions that were probably not in their best long-term interests. Today, most museums have policies that preclude accepting collections with very restrictive terms, even though that may well reduce the number of collections given to them..

In any case, the attractiveness of passing along major collections to museums changed sometime around the middle of the last century and one does not see it occurring very often anymore. The laws governing tax benefits have changed, natural history museums have tightened up their acceptance policies (decades after art museums had done so), and modern collectors appear to want more from museums than the museums are able to provide. Established museums today usually find themselves in one of the following four situations when a collection becomes available to them:

1. Great collection available for purchase, but no funds with which to do so.
2. Excellent *display-type* collection offered as a donation, but largely redundant with the museum's existing holdings so it can't be justified, especially if the donor anticipates a hefty tax savings which means, in effect, that the government is actually buying it.
3. Excellent *reference* collection because it represents a strong regional emphasis or other specialization that will substantially enrich the museum's depth in specific and desirable holdings. Acceptance as a gift or purchase if affordable are options.
4. Modest to poor collection offered as donation, but mostly redundant and not worth the cost of accessioning, cataloguing, numbering, labeling and storing. Accessioning a large collection requires a major investment of time and resources. For these reasons it makes no sense for a museum to accept the offer of a mediocre collection no matter how important it was to the person who put it together. Additionally, low quality material is useless in trades for better specimens.

Situations 1 and 2 above are not dire because the collectors can always sell the minerals and probably profit on the transactions. Situation 3 is perhaps the most attractive from the museum's perspective because the collection has intellectual content and for that reason may represent an important acquisition. At least some of it may. If enough of the collection is suitably interesting, the museum may be able to justify taking the whole thing. Alternatively, the museum may want just a portion of it—the remainder, then having been diminished by that loss, will likely find itself in Situation 4.

Situation 4 is the one that presents a real disposal challenge. A collection that has no display potential, is largely redundant, and has little or no intellectual content is not going to be attractive to a museum. The most painful part for the collector is recognizing that his or her collection likely has no future beyond being thrown away, and it is usually a curator or fellow collector who must deliver this sad news; if not to the collector then the collector's heirs. Museums appear to be about the "only game in town" when it comes to anticipated destinations for mineral collections. Colleges and universities without museums wherein the minerals could be used for teaching are not really a viable option as too few offer courses or even units in mineralogy. Even if they did, the collector has to recognize that the collection will sooner or later be abused in the worst way. Labels will be lost, some specimens will be stolen, specimens will be dumped together in drawers, crystals will be used for hardness and solubility tests, and in a relatively short time the whole thing will end up in a dump somewhere.

Just the same, if the collector suspects that there are elements of the collection, if not the whole thing, that could represent an asset to a museum, an effort should be made to give the museum an opportunity to pass on it. Sadly, many curators have the reputation of being aloof, unapproachable and even insensitive, so collectors may be reluctant to invite them to see their collections. At the same time I find it difficult to understand how a collector of rather indifferent minerals and no particular specialization can believe that a museum might be interested in that collection. Surely he or she must realize that just about any respected museum is apt to already have superior specimens of just about everything in it.

Other options

There are few other options. There are mineral dealers who handle only moderate quality material, similar to that in the collection, who likely would be interested in buying some or all of it. This likelihood will be greatly enhanced if the collection is catalogued and precisely labeled so there is no confusion over what the minerals are and where they were collected, but then all collectors should already know that an uncatalogued and unlabeled mineral collection is practically worthless.

Perhaps the collection can be turned over to a local mineral club for them to dispose of as best they can. An advertised auction may result in finding new homes for some of it, while generating revenue for the club. This might be the most merciful exit for a collection that cannot be sold otherwise and is not wanted by a museum; it beats the heck out of its being loaded onto a dump truck.

A few words about selling

If the collection is of sufficient quality to attract the interest of a mineral dealer, then at least half the battle is won. Once dealers are interested, the collector (or his or her agent) must decide on the preferred sale process. There are two that one usually encounters. Once the dealer has appraised the collection, either an offer to buy it outright is made, or the dealer will agree to take the collection on consignment and make periodic payments once the commission has been deducted as sales proceed. In the latter case, the dealer's commission and the frequency of payments (accompanied by reports of sales) are the most important elements of the negotiations. Some collectors will insist that the dealer go through the collection and provide an estimate of what each piece is likely to be priced at, but this can only be an estimate on the dealer's part and the dealer must be relatively free to modify those numbers, especially if a piece has not sold after lengthy exposure to the market.

Consignment selling has some interesting ramifications. It is an attractive option to some dealers because they avoid having to invest a lot of money in the collection "up front." Also, since they don't have their own money in the specimens they can, perhaps, afford to offer the specimens at lower prices than they otherwise might. Of course this means less money for the collector, but the collector still should have the reasonable expectation that what he or she receives, less commission, will exceed what was originally invested in the piece if the collection has any age to it. Virtually all marketable specimens should have increased in value over time, even if just in keeping up with inflation and assuming that they were not damaged after being acquired. The importance of recording purchase prices in the catalog is evident, else how will the collector recall what was spent for each specimen?

The consignment agreement should specify intervals at which payments and reports are rendered, be it once a year, every six months or whatever. If dealers handling collections in this manner suspect that specimens will have to be trimmed, it would be wise for them at the negotiating stage to obtain permission to trim. A pre-appraisal is essential, if just to protect both parties in the event of the loss of or damage to consigned but unsold specimens. Finally, the realization must be granted by both parties that after a certain period of time there will be a residue of the collection that has not sold and likely may never be sold. A convenient way out of this is for both parties to agree to let the dealer buy the remaining pieces for some reasonable (low!) amount and be done with it.

Ongoing discussion

This is the sort of commentary that should only be opening the door to more extensive discussions. In this format it cannot attempt to be anything near exhaustive. The hope of this writer, and the editor as well, is that collectors and dealers alike will weigh in with additional ideas and suggestions so that a meaningful collection of commentary on this subject will evolve. I can only hope that, by agreeing to publish this as an editorial, the *Mineralogical Record* will have started the ball rolling.

John S. White
(former Curator, Smithsonian Institution)
P. O. Box 332
Stewartstown, PA 17363
e-mail: *john@jwkustos.com*

notes from the EDITORS

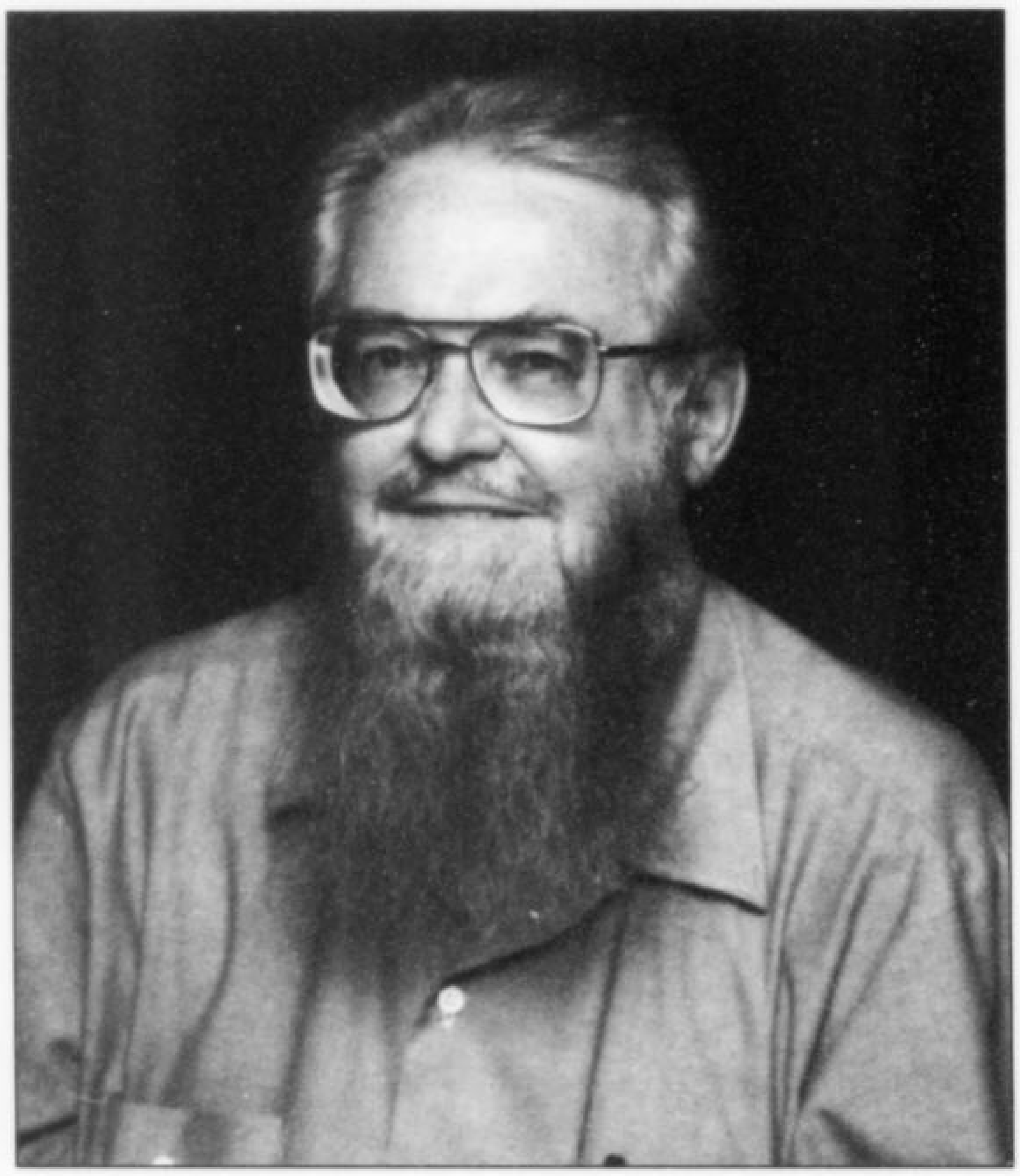


Figure 1. **Dr. Pete J. Dunn, U.S. National Museum of Natural History, Washington, DC**

HISTORY OF MINERAL DISCOVERIES

An interesting article appeared in the November-December 2001 issue of the Russian journal *Zapiski Vserossiyskogo Mineralogichesko Obschestva* ["Proceedings of the Russian Mineralogical Society"]. Authors A. G. Bulakh, A. A. Zolotarev and S. N. Britvin, reviewing "The history of mineral discoveries," found that the United States contains the type localities for the most species (637), followed by the former Soviet Union (573, of which 448 came from Russia), Germany (255), Italy (203), Canada (167), Sweden (162), Australia (109), France (104), Zaire (93), Mexico (83), China (76), Chile (71), Namibia (68), Greenland (65) and Norway (56).

A time-line graph of the discoveries shows that new species were described at a roughly constant rate of 10 to 20 per year during the period 1775–1956, despite numerous advances in investigative techniques. Following the establishment of the International Mineralogical Association [IMA] and its Commission on New Minerals and Mineral Names, however, the rate jumped to 30–50 per year.

A tally of the authors of the original descriptions of new species was also presented, and the winner is (drum roll please) none other than the Smithsonian's Pete J. Dunn, with 133 new species described, followed by Russia's A. P. Khomyakov with 81, the University of Michigan's Donald R. Peacor with 80, the Canadian Museum of Nature's Joel D. Grice with 67, and the Austrian mineralogist Wilhelm Karl von Haidinger (1795–1871) with 63.

ILLUSTRATED SPECIMENS

Mineral specimens illustrated in the *Mineralogical Record* are generally accompanied by caption data covering size, locality, photographer and specimen owner. Unfortunately, because specimens are constantly being bought, sold, exchanged or donated, we cannot always be certain that the owner cited is the *current* owner. Most experienced mineral photographers have thousands of photos in their personal archive, taken over several decades, and it would be impractical (in fact, impossible) for them to maintain a running tally of changes in ownership for these thousands of specimens. Neither can the *Mineralogical Record* begin an investigation into the current ownership of all specimens (sometimes well over 100) pictured in every issue before it goes to press—to do so would require us to have a Private Investigator on staff!

The convention used by most photographers is that the owner cited in the caption is the person or institution who owned the specimen *at the time it was photographed.* This is justifiable, considering that the owner at that time was the one who extended the courtesy, and shouldered the risk, of allowing the photographer to handle his specimen. Of course, if the specimen has changed hands since being photographed, and the current owner is indeed known to us, we have no objection to giving the most up-to-date citation of ownership. Sometimes we will cite the previous owner *and* the current owner. However, in cases where we acknowledge an owner earlier than the current one, we do not consider this to be an error per se, but simply a historical fact which may or may not still pertain. Therefore, we do not consider post-publication information provided to us on current ownership to be "errata," and we do not publish such "corrections" or updates. To do so might well require a regular column!

Collectors can feel justifiably proud to own an illustrated specimen, whether or not their name was the one cited. For many years we have offered free "Illustrated Specimen" labels upon request, which help to document the special status of such specimens for posterity. Write or e-mail the editor if you would like to have one or more of these labels for specimens you may currently own. Each label has spaces to write the volume, number, page and figure number of the illustration, as well as the species name and locality.

BACK ISSUES!

A TREASURE TROVE

OF MINERAL INFORMATION YOU'LL RETURN TO AGAIN AND AGAIN!

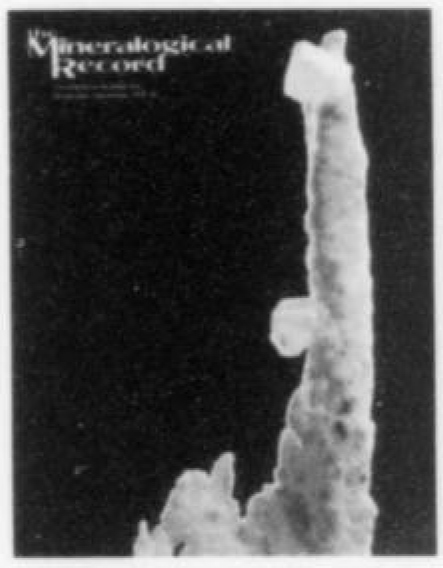
v.8/#5 Characterization of New Species, Twinning, Axinite (Brazil), Green River (WY) **$12**

v.8/#6 California Issue Benitoite, Gold, L.A. County Museum, Himalaya mine **$12**

v.9/#3 Kalahari rhodochrosite, Paterson (NJ), Brumado district (Brazil), Bosch Collection **$12**

v.9/#4 Elmwood (TN), Chester (MA), Pyrite XL Forms **$12**

v.9/#5 Turkish Kämmererite, Afghan pegmatites, Chuquicamata (Chile) **$12**



v.9/#6 Libethenite (Zambia), Quartz & Pyrite (WA), Hydroboracite (CA) **$12**

v.10/#1 Hydroxylherderite (Brazil), Books on U.S. minerals **$12**

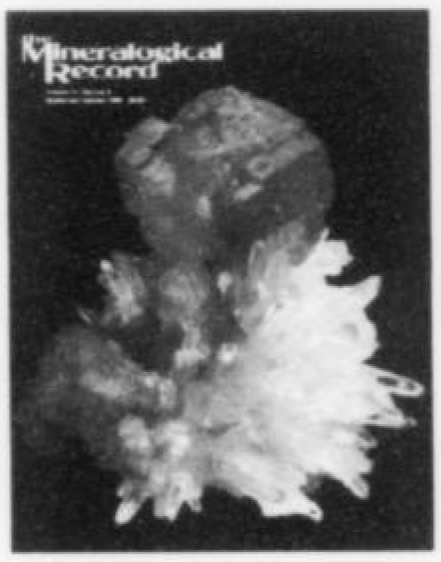
v.10/#2 Jeffrey mine (Quebec), Alpine Rodingites, Fluorite (Germany) **$12**

v.10/#3 Taewha mine (Korea) Japan Twins (Quartz), Bancroft (Ont.), Franklin **$12**

v.10/#5 Thomas & Wah Wah Ranges (Utah) (famous for Topaz, Red Beryl, etc) **$12**

v.11/#1 Toxic Minerals Barite from Hartsel (CO), Cassirer Memoirs (part II) **$12**

v.11/#2 Red Cloud mine (NM), Malachite (Australia, Uraninite, Kornerupine **$12**



v.11/#5 Los Lamentos (Mex.), Chromates (Iran), Nealite, Sperrylite, Mullica Hill **$12**

v.11/#6 Broken Hill (Zambia), Cruziero mine (Brazil), Caplan Interview, Rose Qtz. **$12**

v.12/#3 Pribram (Czecho.), Bald Knob (NC), Line Pit (PA-MD), Mcguinnessite **$12**

Order From: Circulation Manager
Mineralogical Record
P.O. Box 35565
Tucson, Arizona 85740

FAX YOUR CREDIT CARD ORDERS!
520-544-0815

MasterCard VISA

Postage $1 per copy– Order 10 copies or more and **we pay all postage.**

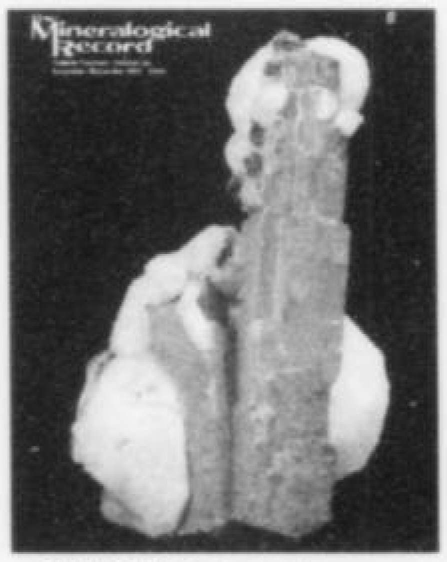
Supplies are Limited

BACK ISSUES!

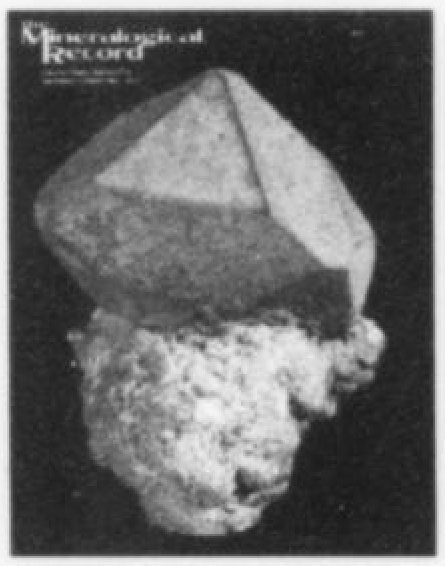

v.12/#4 Mineral Fakes, Mineral Fraud, Leadhills-Wanlockhead (England) **$12**


v.13/#4 Diamond (CO), Quartz (MT), Jeanbandyite. Bancroft (Ont.) **$12**


v.14/#1 Celestite (IN), Derbyshire (England), Lotharmeyerite (Mapimi) **$12**


v.14/#6 Chulquicamata (Chile), Univ. of Delaware Mineral Museum **$12**


v.15/#1 Darwin (CA), Pereta Mine (Italy), Cetine Mine (Italy) **$12**


v.15/#5 Jacupiranga mine (Brazil), Jensen quarry (CA), Cunha Baixa mine, Paulkerrite **$12**


v.15/#6 Bad Ems (Germany), Touissit Vanadinite, Hawleyite (IN), Fluorapatite (SD) **$12**

v.16/#1 Nevada Issue! Comstock Lode, Getchell, Steamboat, Majuba Hill, White Caps **$12**

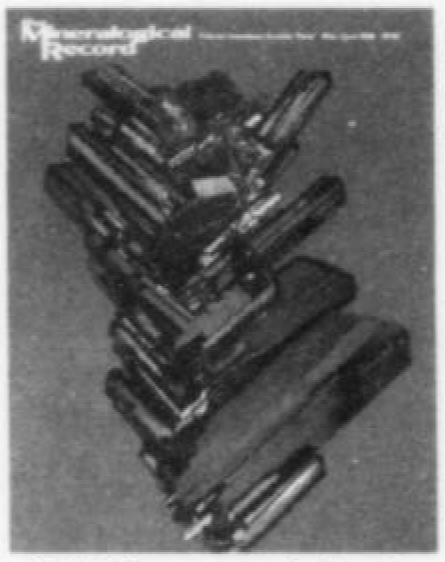
v.16/#3 Colorado-III Issue! Leadville, Rico, Cresson Vug, Pikes Peak, CSM Museum **$12**

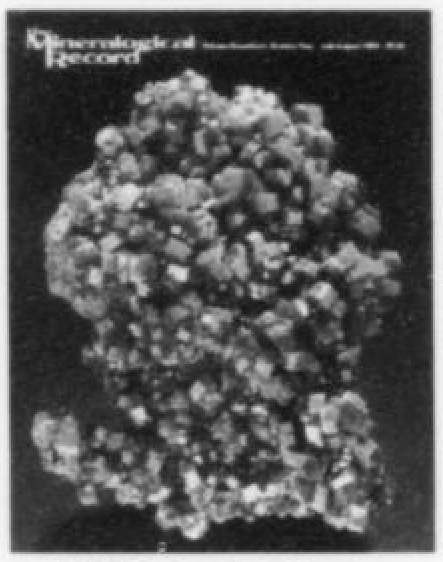

v.16/#4 Kingsgate mines (Australia), Mauldin Mountain Phosphates (AL) **$12**

v.16/#5 Tourmaline Issue! (112 p.) Elba, Maine, Pakistan, Nepal, California, etc. **$15**


v.16/#6 Graves Mtn. (GA), Gardiner Complex (Greenland), Canaphite, Hutchinsonite **$12**


v.17/#2 J. C. Holmes claim (AZ), Austrian Minerals, Marsturite, Franklin (NJ) **$12**

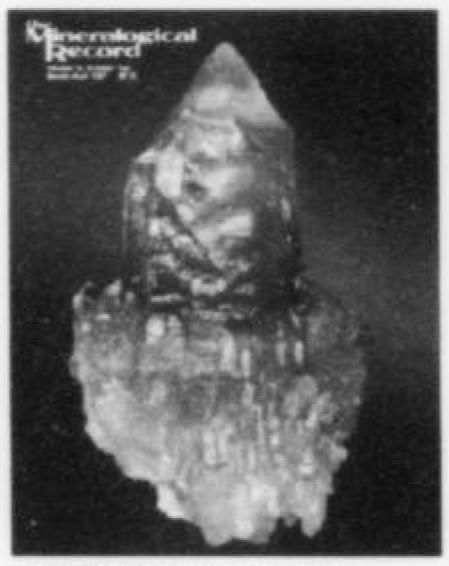

v.17/#3 Knappenwand (Austria), Laurium (Greece), Senaite (Brazil), Chalcophyllite (New Zealand) **$12**


v.17/#4 National Belle mine (CO), Tip Top mine (SD), Stoneham Barite (CO) **$12**


v.17/#5 Black Hills type localities, Urucum (Brazil), Kalkar quarry (CA), Kremsmünster **$12**


v.17/#6 Bleiberg (Austria), Brochantite (OK), Arsenopyrite (Ont.) Author's Guide **$12**

v.18/#1 Gold-II Issue! Australia, Calif., Breckenridge, Hopes Nose (England), etc. **$12**


v.18/#2 Elk Creek (SD), Teyler's Museum, Ramsbeckite, Neotocite, Phosphosiderite **$12**


v.18/#3 Uranium minerals (Sardinia), Garnet Hill (NV), Photographer's Guide, Library Guide **$12**

Postage $1 per copy–
Order 10 copies or
more and **we pay**
all postage.

Supplies
are
Limited

Circulation Manager
Mineralogical Record
P.O. Box 35565
Tucson, Arizona 85740

FAX YOUR CREDIT
CARD ORDERS!
520-544-0815

MasterCard VISA

ARGENTUM AUCTIONS & APPRAISERS, INC.

Presents two exciting auctions:

Monday, February 10, 2003: **Cummings Fossil Collection**

Tuesday, February 11, 2003: **The Choice Mineral Auction**

Previews 1 pm to 5 pm; Auctions begin 7 pm, at:

Smuggler's Inn, Tucson

6350 East Speedway, Tucson, Arizona
Convenient shuttle available from all major shows and hotels!

The Cummings Fossil Collection has not been seen by the general public in over 100 years! This is truly a rare opportunity to acquire some fine museum-quality fossils! Specimens to be auctioned include an *Icthyosaur intermediates* and a COMPLETE ***Ichthyosaur communis!*** The Cummings collection was assembled between 1870 and 1890. Most of the specimens are from Lyme Regis [England], Ireland, Scotland, Germany and the Paris Basin.

The Choice Mineral Auction will consist of approximately 75 lots, including an original Ed Over Red Cloud Wulfenite, Native Gold specimens from various localities, several Arizona Azurites, English Classics, a fine Bement Phosgenite, and also related mineral and mining memorabilia.

For Further Information, Pre-Registration, and On-Line Catalogs of these two auctions please visit our website:

www. argentumauctions.com

MARK YOUR CALENDAR and come check us out while you're in Tucson!

NOTE:
relocating
to Dallas
in 2003!

The Arkenstone, Dr. Robert & Bailey Lavinsky

WWW.IROCKS.COM

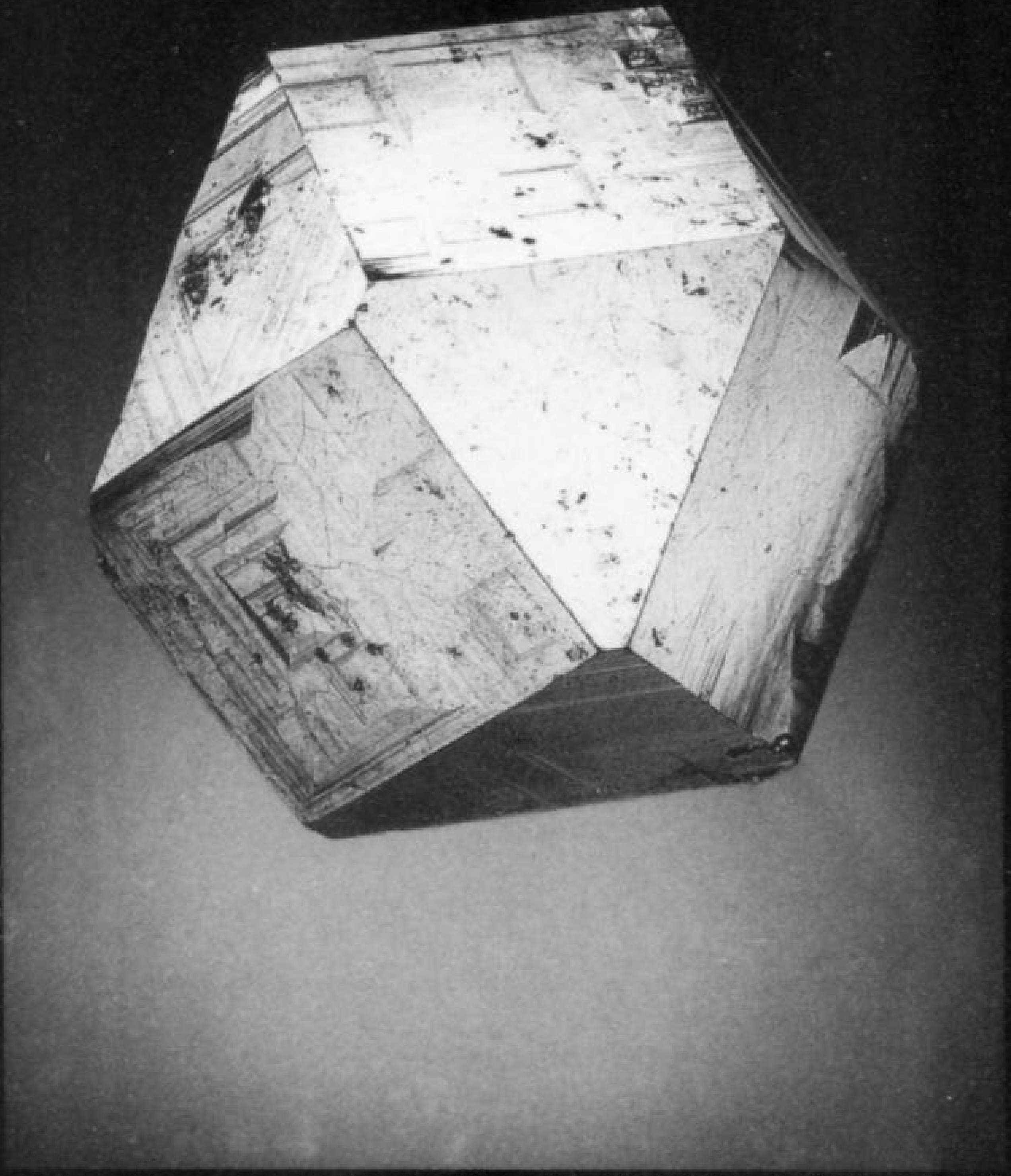
Consistently bringing fine minerals to the net since 1996!

UPGRADE POLICY!
We stand behind our specimens!

FAST FEDEX SHIPPING!
(upon request, domestic or intl.)

FREQUENT UPDATES!
Focus on suites and collections

CONSISTENT QUALITY!
That you can rely on . . .



Carrollite - Kamoya Mine - DRC - H: 5.1 cm - Photo by J.SCOVIL

HUBEITE

●

A NEW MINERAL FROM THE DAYE MINE NEAR HUANGSHI, HUBEI PROVINCE, CHINA

Frank C. Hawthorne and **Mark A. Cooper**
Department of Geological Sciences, University of Manitoba
Winnipeg, Manitoba, R3T 2N2 Canada

Joel D. Grice
Research Division, Canadian Museum of Nature
Ottawa, Ontario, K1P 6P4 Canada

Andrew C. Roberts
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario, K1A 0E8 Canada

William R. Cook, Jr.
684 Quilliams Road,
Cleveland Heights, Ohio 44121-1955

Robert J. Lauf
Metals and Ceramics Division, Oak Ridge National Laboratory,
Oak Ridge, Tennessee 37831-6085

ABSTRACT

Hubeite, ideally $Ca_2Mn^{2+}Fe^{3+}[Si_4O_{12}(OH)](H_2O)_2$, is a new mineral from the Daye mine near Huangshi, Hubei province, China. It occurs as radiating aggregates of intergrown crystals with well-developed terminal faces. Aggregates are less than 5 mm across and individual crystals do not exceed 2 mm in size. Individual crystals are bladed and are slightly elongate along the *b* axis with a rhombic cross-section and the forms {100}, {001}, {101}, $\{0\bar{1}1\}$ and {352}. Aggregates consist of divergent fan-like clusters of individuals that often repeat across ~{001} to form 'bow-tie' arrangements. Hubeite is dark brown to pale brown, depending on crystal size, with a pale orange-brown streak, a vitreous luster and no observable fluorescence under ultraviolet light. It is brittle with a conchoidal fracture, and has a good cleavage parallel to {001} and no observable parting. Mohs hardness is 5½, the observed density is 3.02(2) g/cm³ and the calculated density is 3.01 g/cm³. It is biaxial with an indeterminate optic sign and α 1.667(1), β 1.679(1), γ 1.690(1), 2*V*(*obs*) = 89(2)°, 2*V*(*calc*) = 87(5)°, strongly pleochroic with X = yellow-brown, Z = dark yellow-brown, Z > X, $X \wedge b = 20°$ (in γ obtuse), $Y \wedge c = 13°$ (in α acute), Z = *a*. Hubeite is triclinic, space group $P\bar{1}$, with the following unit-cell parameters refined from X-ray powder-diffraction data: *a* 9.960(6), *b* 13.87(2), *c* 6.562(7) Å, α 133.19(6), β 101.50(6), γ 66.27(5)°, *V* 601(1) Å³, Z = 2. The ten strongest lines in the X-ray powder-diffraction pattern are as follows: *d* (Å), *I*, (*h k l*): 9.072,

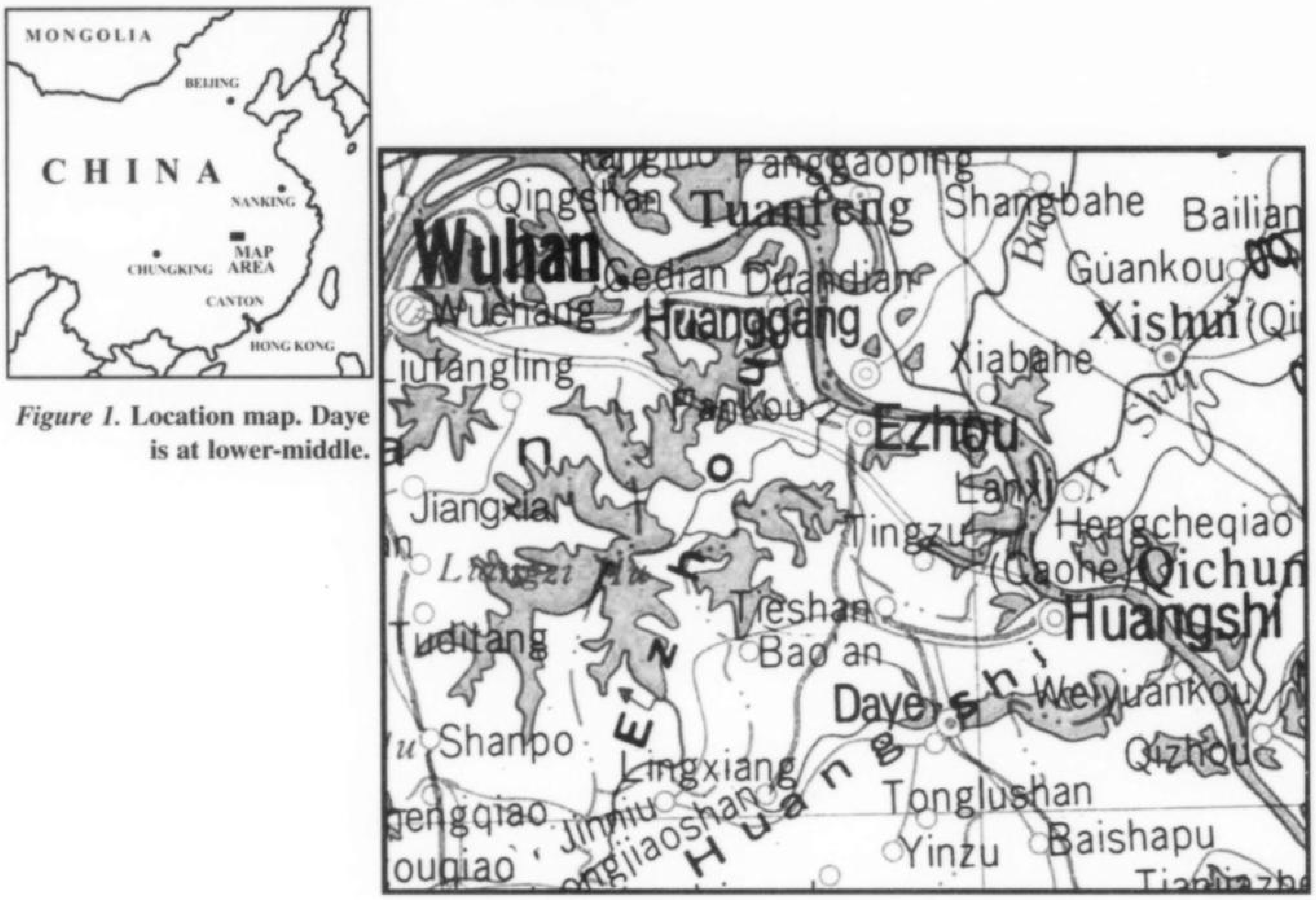


Figure 1. **Location map. Daye is at lower-middle.**

100, (1 0 0); 8.238, 90, (1 1 0); 5.000, 30, (1 2 0); 3.192, 30, (2 3 0); 3.126, 70, (3 2 0); 3.095, 70, $(\bar{1}\bar{4}2)$; 2.781, 60, $(\bar{2}\ 2\ 0)$; 2.695, 30, $(\bar{1}\bar{5}2)$; 1.993, 30, (3 3 1); 1.627, 30, $(\bar{1}\bar{5}4,\ 1\bar{7}3)$. Chemical analysis by electron microprobe gave SiO_2 44.39, Al_2O_3 0.38, Fe_2O_3 13.94, MnO 11.34, MgO 0.29, CaO 21.91, H_2O(calc) 8.32, sum 100.57 weight %, where the amount of H_2O was determined by crystal-structure analysis. The resulting empirical formula, calculated on the basis of 15 anions, [including 1 (OH) and 2 (H_2O)] is $Ca_2(Mn^{2+}_{0.87}Ca_{0.12})_{\Sigma 0.99}(Fe^{3+}_{0.94}Al_{0.04}Mg_{0.04})_{\Sigma 1.02}Si_{4.00}O_{12}(OH)(H_2O)_2$; the end-member formula of hubeite is $Ca_2Mn^{2+}Fe^{3+}Si_4O_{12}(OH)(H_2O)_2$. The mineral is named for the province in China in which it was found. Hubeite has been approved by the Commission of New Minerals and Mineral Names of the International Mineralogical Association. Hubeite shows no close relationship to any other known mineral.

INTRODUCTION

At the 1998 Tucson Gem and Mineral Show, two of the authors acquired an intriguing brown mineral from The Rocksmiths and from Michel Jouty. Subsequent examination by X-ray powder diffraction suggested a new mineral, and this was confirmed by crystal-structure solution and refinement (Cooper and Hawthorne, 2002). The new mineral has the ideal chemical formula $Ca_2Mn^{2+}Fe^{3+}[Si_4O_{12}(OH)](H_2O)_2$ and was named **hubeite** (HÜ-BĀ-ĪT) after the geographical location of the type locality in the province of Hubei, China. The new mineral and mineral name have been approved by the Commission on New Minerals and Mineral Names, International Mineralogical Association. The holotype specimen of hubeite is stored in the Display Series of the National Mineral Collection of Canada, housed in the Canadian Museum of Nature, Ottawa, Ontario, Canada (catalog # CMNMC 83268).

PHYSICAL AND OPTICAL PROPERTIES

Hubeite occurs as radiating aggregates of intergrown crystals with well-developed terminal faces. Aggregates are less than 5 mm across and individual crystals do not exceed 1 mm in size. Individual crystals are bladed and slightly elongate along the *b* axis with a rhombic cross-section. Dominant forms are {001} and {101} with minor {100}, $\{0\bar{1}1\}$ and $\{35\bar{2}\}$ (Fig.2). Aggregates consist of divergent fan-like clusters of individuals that repeat across ~{001}, or as "bow-tie" aggregates (Fig. 3). Hubeite is dark brown to pale brown (Fig. 4) depending on crystal size.

During the last two years, numerous hubeite-bearing specimens have come on the mineral market, representing at least two distinct parageneses. It occurs as isolated clusters of crystals, up to a few

Table 1. **Chemical composition (weight %)* and unit formula** of hubeite.**

SiO_2	44.39	Si	4.00
Al_2O_3	0.38		
Fe_2O_3	13.94	Fe^{3+}	0.94
MgO	0.29	Al	0.04
MnO	11.34	Mg	0.04
CaO	21.91		
H_2O ***	(8.32)	Σ	1.02
Total	100.57	Mn^{2+}	0.87
		Ca	0.12
		Σ	0.99
		Ca	2.00
		OH	1
		H_2O	2

* F, Na, K, Ti, Cr, V below detection limit; composition is the average of 25 points on 5 crystals

** calculated on the basis of 15 anions with OH = 1 and H_2O = 2 *pfu*

*** from the crystal-structure analysis of Cooper and Hawthorne (2002).

***Table 2.* X-ray powder diffraction data for hubeite.**

$I_{est.}$	$d_{(meas.)}$ Å	$d_{(calc.)}$ Å	h	k	l	$I_{est.}$	$d_{(meas.)}$ Å	$d_{(calc.)}$ Å	h	k	l
100	9.072	9.059	1	0	0	3	2.460	2.467	2	$\bar{2}$	2
90	8.238	8.227	1	1	0	* 5	2.377	2.377	0	0	2
10	5.843	5.848	$\bar{1}$	$\bar{2}$	1	* 5	2.287	2.287	3	2	1
″	″	5.845	0	$\bar{2}$	1	3	2.196	2.195	$\bar{3}$	2	0
5	5.576	5.565	$\bar{1}$	1	0	* 20	2.164	2.164	$\bar{1}$	$\bar{5}$	3
5	5.374	5.411	$\bar{1}$	$\bar{1}$	1	5	2.116	2.122	$\bar{2}$	$\bar{5}$	3
* 30	5.000	4.997	1	2	0	″	″	2.120	2	3	1
3	4.866	4.846	2	1	0	″	″	2.104	$\bar{2}$	$\bar{6}$	1
10b	4.723	4.753	0	0	1	* 3	2.088	2.088	0	$\bar{5}$	3
″	″	4.695	0	2	0	* 10	2.056	2.056	$\bar{1}$	$\bar{6}$	1
20	4.442	4.421	1	0	1	* 20	2.021	2.023	$\bar{2}$	2	1
* 20	4.013	4.024	$\bar{1}$	0	1	* 30	1.993	1.992	3	3	1
* 5	3.855	3.856	$\bar{2}$	$\bar{1}$	1	* 15	1.916	1.917	5	1	0
* 10	3.655	3.650	$\bar{1}$	2	0	3	1.900	1.899	1	$\bar{6}$	2
* 10	3.581	3.590	$\bar{2}$	1	0	* 15	1.818	1.818	$\bar{4}$	$\bar{7}$	2
3	3.516	3.512	2	$\bar{1}$	1	3	1.784	1.788	$\bar{5}$	$\bar{1}$	1
3	3.453	3.452	1	1	1	″	″	1.783	2	$\bar{2}$	3
* 15	3.403	3.414	0	1	1	3	1.763	1.770	0	$\bar{1}$	3
* 30	3.192	3.189	2	3	0	″	″	1.767	5	1	1
* 70	3.126	3.123	3	2	0	* 3	1.747	1.746	$\bar{3}$	2	1
* 70	3.095	3.088	$\bar{1}$	$\bar{4}$	2	* 3	1.725	1.725	$\bar{4}$	$\bar{4}$	3
* 10	2.991	2.988	$\bar{1}$	1	1	3	1.693	1.697	5	$\bar{1}$	1
25	2.932	2.943	$\bar{2}$	$\bar{3}$	2	″	″	1.693	$\bar{2}$	3	1
″	″	2.923	0	4	2	3	1.661	1.663	$\bar{5}$	$\bar{7}$	2
* 15	2.877	2.877	1	$\bar{2}$	2	5	1.648	1.652	4	1	2
* 60	2.781	2.783	$\bar{2}$	2	0	″	″	1.648	1	6	0
* 15	2.741	2.742	3	3	0	″	″	1.648	3	$\bar{5}$	2
* 30	2.695	2.694	$\bar{1}$	$\bar{5}$	2	″	″	1.647	3	2	2
3	2.652	2.653	$\bar{1}$	$\bar{1}$	2	30	1.627	1.627	$\bar{1}$	$\bar{5}$	4
* 10	2.614	2.613	2	$\bar{3}$	1	″	″	1.627	1	$\bar{7}$	3
3	2.562	2.555	2	2	1						
5	2.502	2.509	0	$\bar{5}$	2						
″	″	2.498	2	4	0						
″	″	2.495	$\bar{3}$	$\bar{3}$	2						

114.6 mm Debye-Scherrer powder camera; Co radiation, Fe filter (λ Co*K*α 1.79021 Å)
Intensities visually estimated; b = broad line; not corrected for shrinkage and no internal standard.
Indexed on the calculated intensities derived from crystal-structure refinement
* = reflections used for unit-cell refinement
refined unit-cell parameters: *a* 9.960(6), *b* 13.87(2), *c* 6.562(7) Å, α133.19(6), β 101.50(6), γ 66.27(5)°

millimeters across, perched on euhedral crystals of transparent to white quartz (Fig. 5). In some cases, these clusters are quite dense on a specimen (Fig. 6). A second association is as crystals covering both sides of flat, thin specimens (Fig. 7). Typically, one side is covered predominantly by hubeite with minor inesite and apophyllite, whereas the other side consists of approximately equal amounts of hubeite, pink inesite and white apophyllite (Fig. 8) or it can be dominated by pink inesite with only minor hubeite and apophyllite (Fig. 9). Hubeite can also occur with massive to radiating pink inesite that can be partly covered by a coating of honey-brown apophyllite and is associated with minor, small, equant, black prisms of ilvaite (Fig. 10).

Hubeite has a pale orange-brown streak, a vitreous luster and no observable fluorescence under ultraviolet light. It has a good cleavage parallel to {001}, no observable parting, and is brittle with a conchoidal fracture. Mohs hardness is 5½, the observed density is 3.02(2) g/cm³ (measured by suspension in methylene iodide) and the calculated density is 3.01 g/cm³. Optical properties

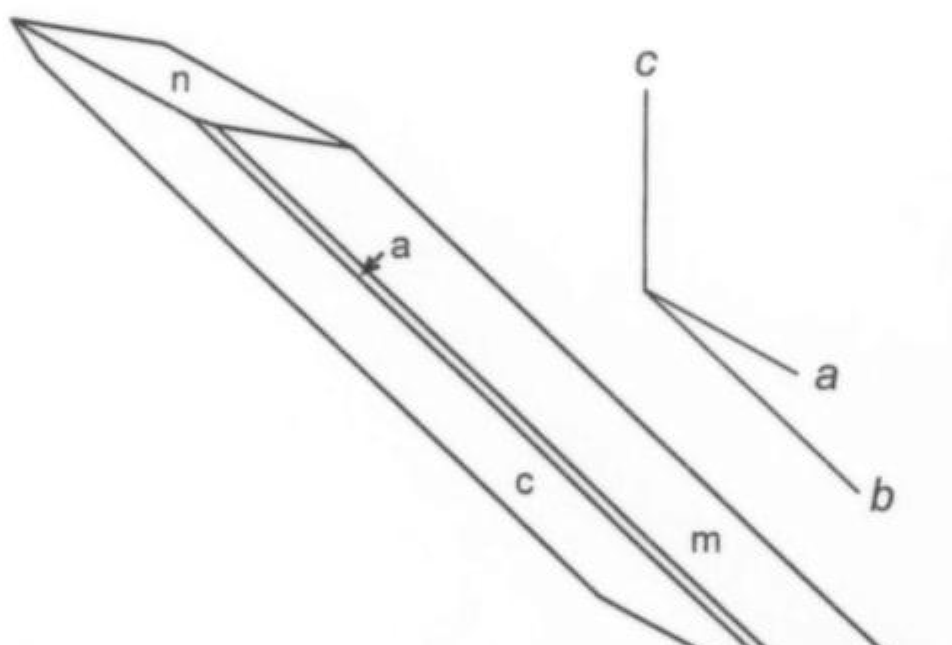


***Figure 2.* Idealized crystal drawing of hubeite. The setting of the axes is non-standard in order to maximize the number of forms visible; *a* = {100}, *c* = {00$\bar{1}$}, *m* = {101}, *n* = {0$\bar{1}$1}, *x* = {35$\bar{2}$}.**

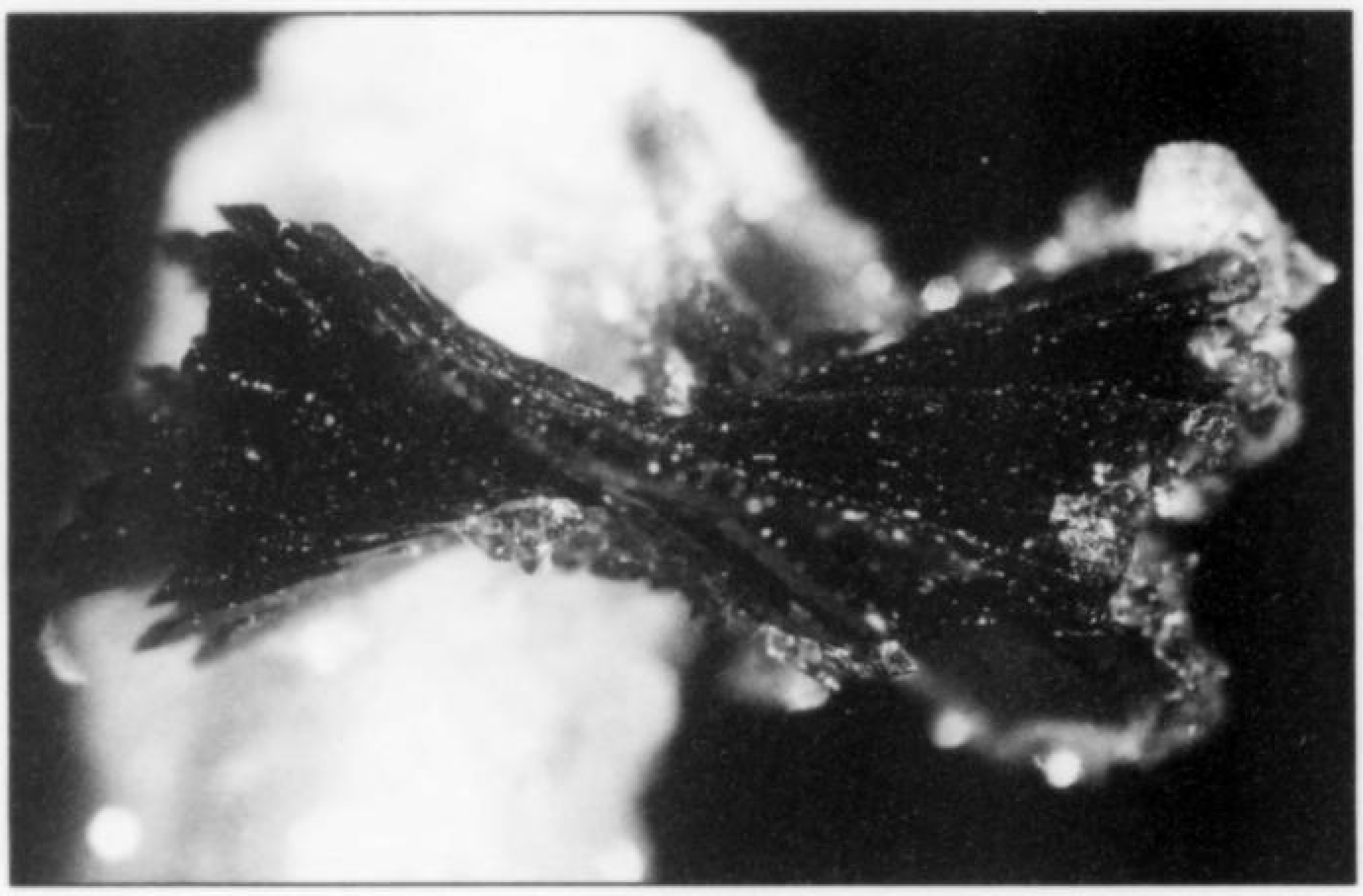


Figure 3. **A bow-tie aggregate of hubeite crystals (~5 mm across) with white apophyllite coating the tips of the crystals; the out-of-focus pink crystal is inesite that is partly coated by apophyllite and quartz. Photography by Richard Green, Bill Cook specimen.**

Figure 4. **A single large aggregate of reddish brown hubeite (4 mm across). Photograph by Richard Green, Bill Cook specimen.**

Figure 5. **Clusters of hubeite on transparent to white quartz with minor pink inesite and pyrite; the specimen is 18.4 cm high. Photograph by Jeff Scovil, Ernesto Ossola specimen.**

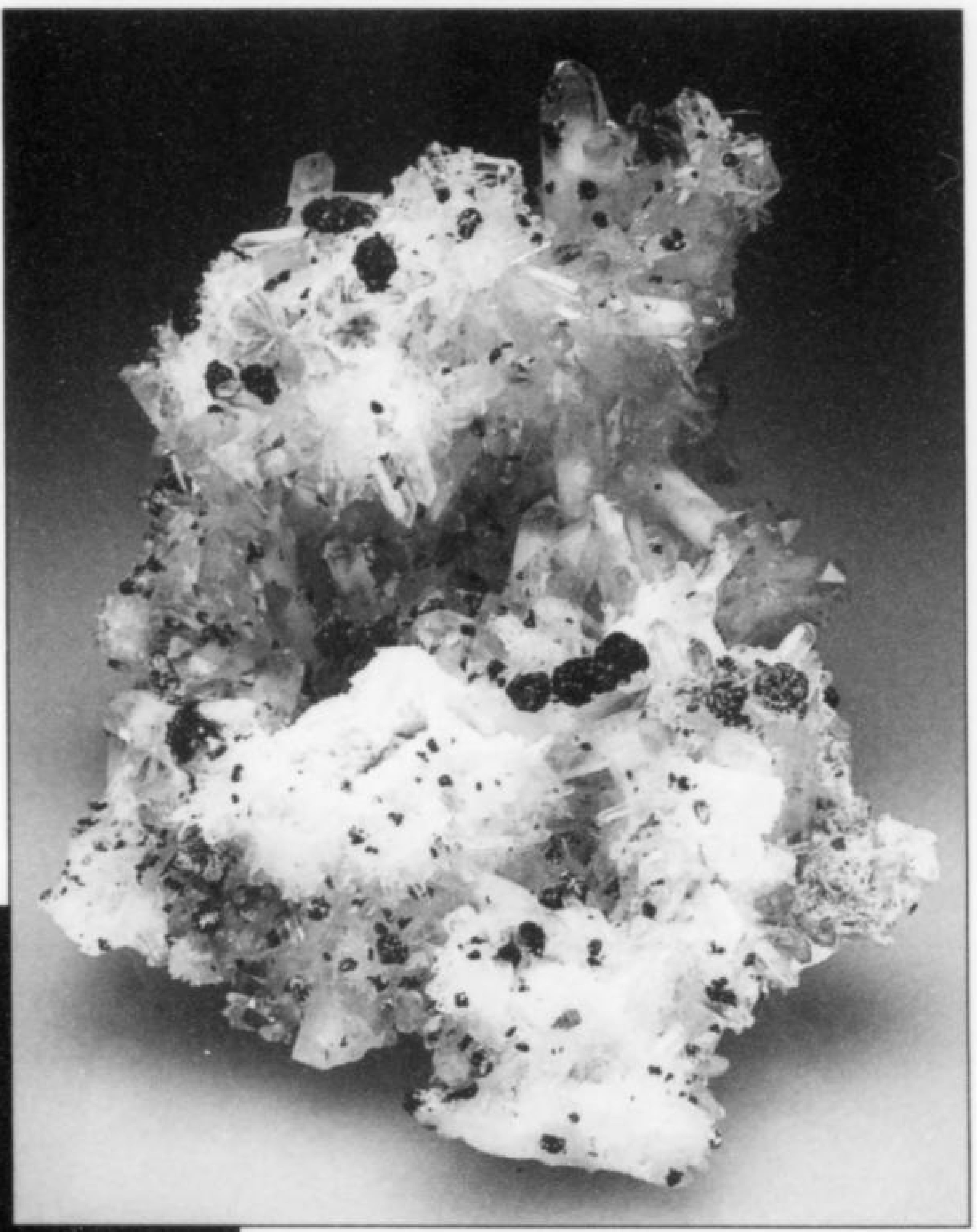


Figure 6. **Quartz with abundant hubeite; the specimen is 9 cm wide. Photograph by Jeff Scovil, Bill Pinch specimen.**

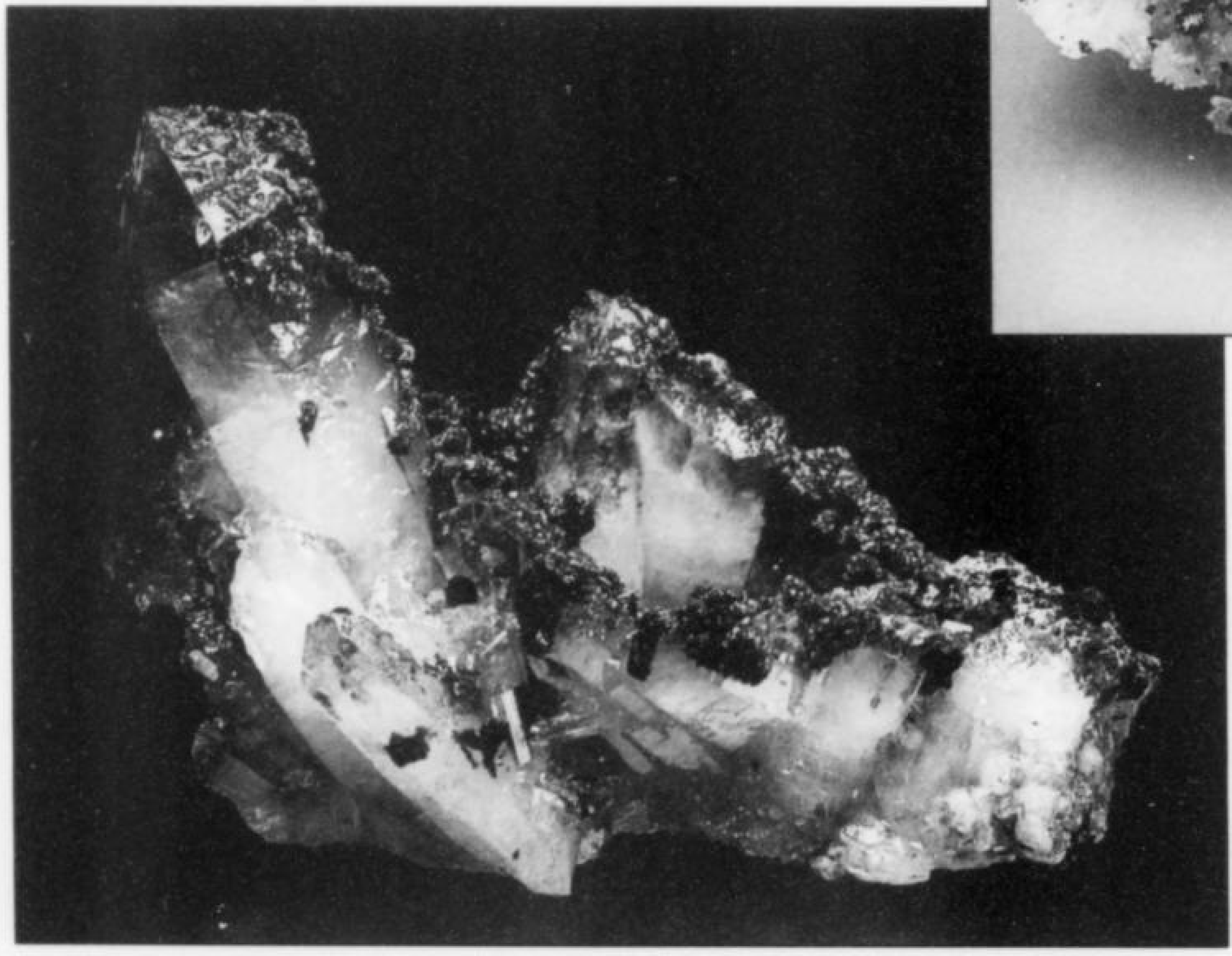


Figure 7. **A small (4 cm tall) plate of hubeite (dark brown to black) with minor inesite and apophyllite. Photograph by Jeff Scovil, Ernesto Ossola specimen.**

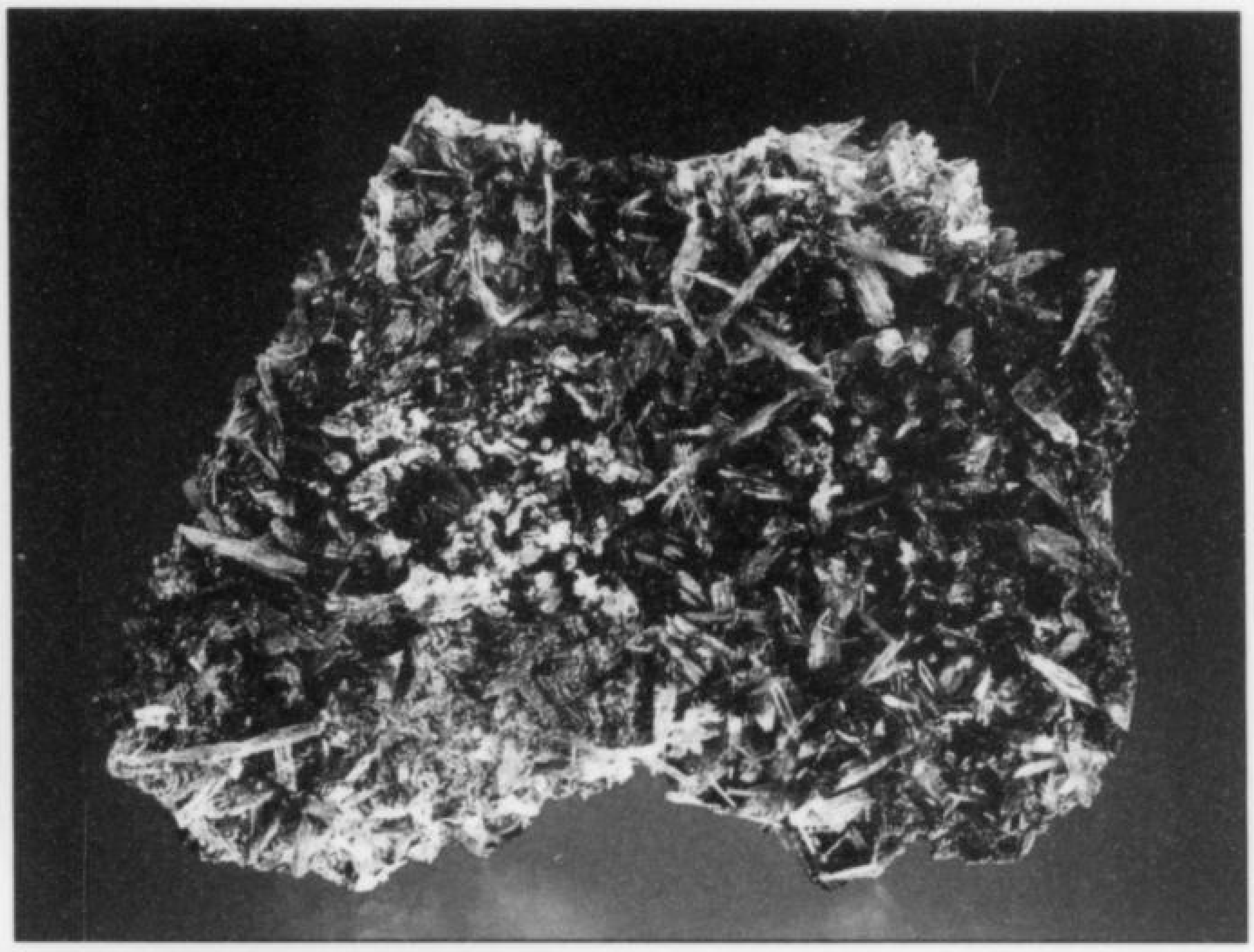


Figure 8. **A small (7 cm wide) plate of pink inesite, white apophylite and brown hubeite in approximately equal amounts. Photograph by Jeff Scovil, Ernesto Ossola specimen.**

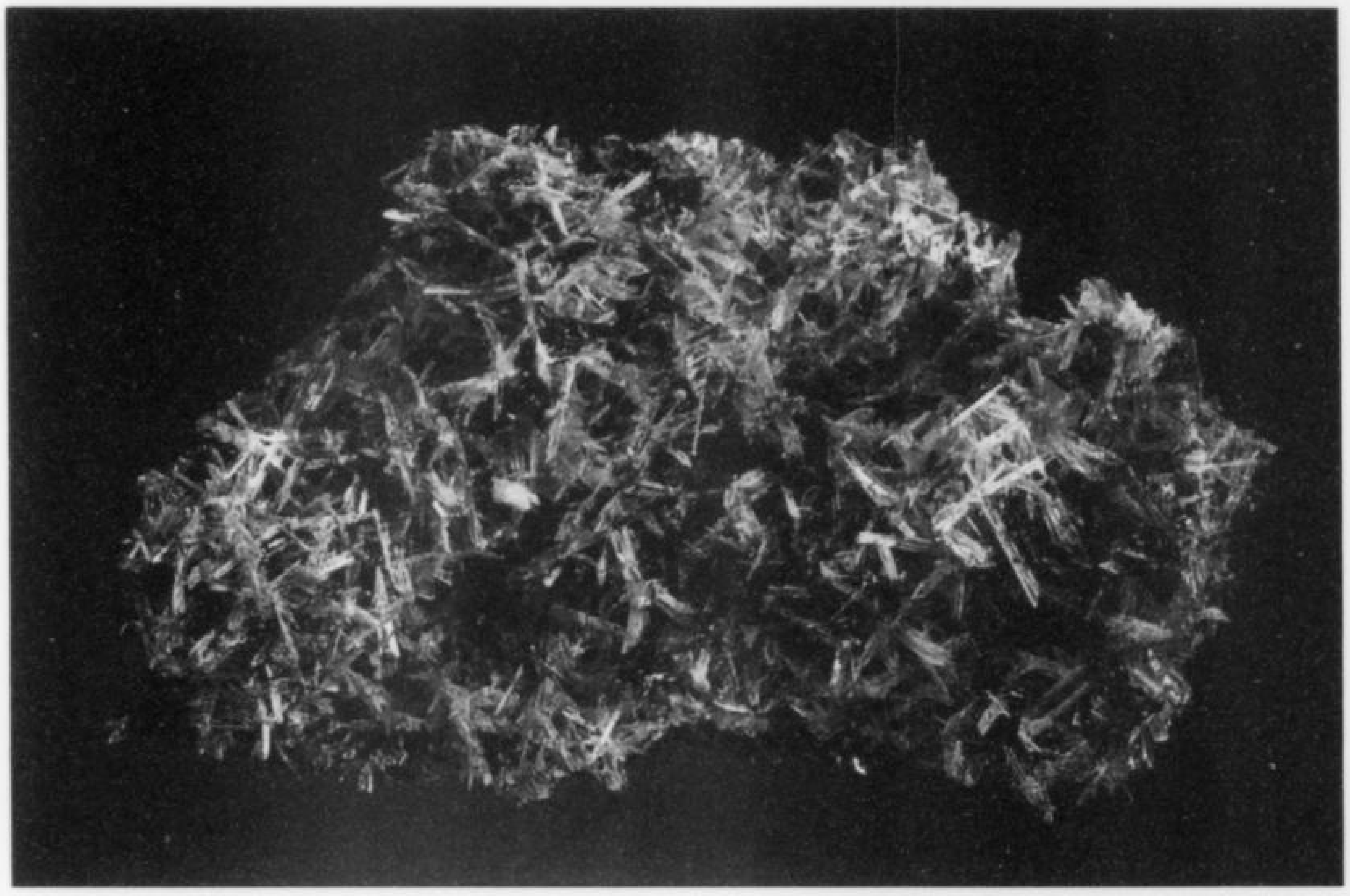


Figure 9. **A small (8.6 cm wide) plate dominated by pink inesite with minor hubeite and apophyllite. Photograph by Jeff Scovil, Ernesto Ossola specimen.**

Figure 10. **Massive pink inesite with a coating of honey-brown apophyllite crystals and minor hubeite and ilvaite (black crystals at the base of the specimen). Photograph by Jeff Scovil, Bill Pinch specimen (5.5 cm wide).**

were measured with the Bloss spindle stage for the wavelength 590 nm using a gel filter. Hubeite is biaxial with an indeterminate optic sign due to the fact that 2V is close to 90°. The indices of refraction are α 1.667(1), β 1.679(1), γ 1.690(1), the calculated birefringence γ–α is 0.023, 2V(meas.) 89(2), 2V(calc.) 87(5)°; orientation $X \wedge b = 20°$ (in γ obtuse), $Y \wedge c = 13°$ (in α acute), $Z = a$. Hubeite is strongly pleochroic, X = yellow-brown (with a greenish tint), Z = dark yellow-brown, with absorption Z > X.

CHEMICAL COMPOSITION

Crystals of hubeite were analyzed with a Cameca SX-50 electron microprobe operating in the wavelength-dispersion mode, with an accelerating voltage of 15 kV, a specimen current of 20 nA, and a beam diameter of 10 µm. The following standards were used: diopside (Si, Ca), spessartine (Mn), fayalite (Fe), andalusite (Al) and forsterite (Mg). The data were reduced and corrected by the *PAP* method of Pouchou and Pichoir (1984, 1985). The presence and quantity of OH and H_2O groups were established by crystal-structure solution and refinement (Hawthorne and Grice, 1990). The resultant chemical composition is given in Table 1, together with the formula unit based on 15 anions (including 1 OH and 2 H_2O groups) *pfu* (per formula unit). The end-member formula is $Ca_2Mn^{2+}Fe^{3+}[Si_4O_{12}(OH)](H_2O)_2$.

X-RAY POWDER DIFFRACTION

The powder-diffraction pattern was recorded with a 114.6-mm Debye-Scherrer powder camera using Fe-filtered Co$K\alpha$ X-radiation. Reflections were indexed by comparison of the observed pattern with the pattern calculated from the refined crystal-structure of hubeite (Cooper and Hawthorne, 2001). Table 2 shows the X-ray powder-diffraction data and the refined unit-cell dimensions of hubeite.

INFRARED SPECTRUM

The infrared spectrum was recorded according to the procedure described by Roberts *et al.* (1994) and is shown in Figure 10. There is a sharp peak in the principal (OH)-stretching region at ~3609 cm^{-1}, corresponding to an (OH) stretch. There is a broad envelope centered at ~3215 cm^{-1} with pronounced shoulders at 3455 cm^{-1} and 3115 cm^{-1} that may be assigned to stretching modes of one or more (H_2O) groups. The presence of (H_2O) groups is confirmed by the weak broad band at ~1609 cm^{-1} that corresponds to an H-O-H bending mode. All these bands are in accord with the results of crystal-structure solution and refinement that indicate the presence of both (OH) and (H_2O) groups. Lower frequency bands correspond to various modes of the (SiO_4) group.

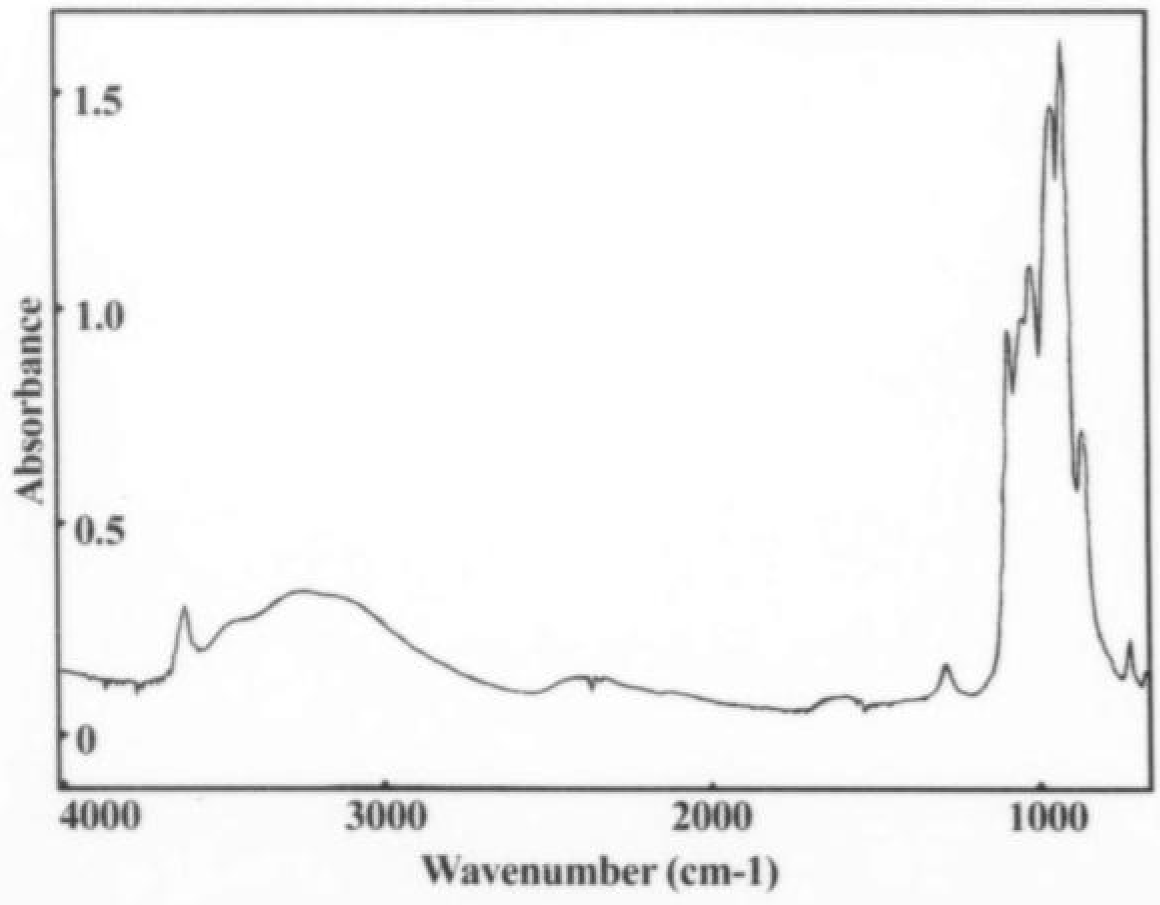


***Figure 11.* The infrared spectrum of hubeite.**

PARAGENESIS AND RELATED MINERALS

Hubeite occurs at the Daye mine near Huangshi, Hubei province, China, where it is associated with pink inesite [with 0.93 weight % F: $(OH)_{1.4}F_{0.6}$], colorless apophyllite, quartz, pyrite and colorless-to-white calcite. The apophyllite is zoned from a core of natroapophyllite ($Na_{0.8}K_{0.2}$) to a rim of fluorapophyllite ($K_{1.0}$). There have been several verbal reports of manganbabingtonite from this locality. We have examined several specimens in detail with regard to associated minerals, but have not found manganbabingtonite. Of course, this does not preclude the occurrence of this mineral here, particularly in view of the variety of parageneses of hubeite.

Hubeite is a sorosilicate, as is apparent from the silicate part of the formula: $[Si_4\phi_{13}]$ (ϕ = unspecified anion) is the correct stoichiometry for a four-membered chain fragment of tetrahedra, and this has been confirmed by crystal-structure study (Cooper and Hawthorne, 2001). The only other sorosilicate mineral known to possess a four-membered chain fragment is ruizite: $Ca_2Mn^{3+}_2[Si_4O_{11}(OH)_2](OH)_2(H_2O)_2$ (Hawthorne, 1984; Moore *et al.*, 1985). Both hubeite and ruizite are Ca-Mn silicates; however, all Mn is divalent in hubeite and trivalent in ruizite. In addition, ruizite is Fe-free, whereas hubeite contains significant Fe^{3+}.

Ruizite is known from two localities: the Christmas mine, Gila County, Arizona, and Wessels mine, Kalahari Manganese Field, South Africa. At the Christmas mine, the ruizite assemblage consists of junitoite, smectite, xonotlite, sepiolite and apophyllite (Williams and Duggan, 1977). At Wessels mine, ruizite is found with quartz, datolite, pectolite, orientite, inesite and apophyllite (Wilson and Dunn, 1978). It is noteworthy that both of these assemblages are Fe-free. At Wessels mine, ruizite (Mn^{3+}) and apophyllite are interpreted to have formed after inesite (Mn^{2+}) and orientite (Mn^{2+} and Mn^{3+}), suggesting highly oxidizing conditions during crystallization of ruizite.

Hubeite also occurs with apophyllite, inesite and pyrite. We can infer that conditions during the crystallization of hubeite were mildly oxidizing, and that sufficient Fe was available for hubeite formation.

ACKNOWLEDGEMENTS

FCH thanks Charles Key for initially bringing this mineral to his attention. We thank Bill Pinch and Ernesto Ossola for access to specimens, Forrest and Barbara Cureton for their efforts in investigating the correct spelling of (the province of) Hubei, China, and Jaye and Eldon Smith of The Rocksmiths for initial information on the locality for hubeite, Bob Gault (Canadian Museum of Nature) for measuring the density, Elizabeth Moffat (Canadian Conservation Institute) for recording the IR spectrum, and Paul Carrière (CANMET) for the X-ray powder-diffraction pattern. FCH thanks Ernesto Ossola for allowing him access to his specimens of hubeite for photography, and Jeff Scovil and Richard Green for the photographs. This work was supported by Natural Sciences and Engineering Research Council of Canada Research, Equipment, Major Installation and Major Facilities Access Grants to FCH; work at Oak Ridge National Laboratory was supported by the US Department of Energy, Laboratory Technology Research Program.

REFERENCES

COOPER, M. A., and HAWTHORNE, F. C. (2002) The crystal structure of hubeite, $Ca_2Mn^{2+}Fe^{3+}[Si_4O_{12}(OH)](H_2O)_2$, a novel sorosilicate. *Canadian Mineralogist* (submitted).

HAWTHORNE, F. C. (1984) The crystal structure of ruizite, a sorosilicate with an [$Si_4\phi_{13}$] cluster. *Tschemaks Mineralogische und Petrographische Mitteilungen*, **33**, 135–146.

HAWTHORNE, F. C., and GRICE, J. D. (1990) Crystal-structure analysis as a chemical analytical method: application to light elements. *Canadian Mineralogist*, **28**, 693–702.

MOORE, P. B., SHEN, J., and ARAKI, T. (1985) Crystal chemistry of the [$M^+\phi_2(TO_4)_2$] sheet: structural principles and crystal structures of ruizite, macfallite and orientite. *American Mineralogist*, **70**, 171–181.

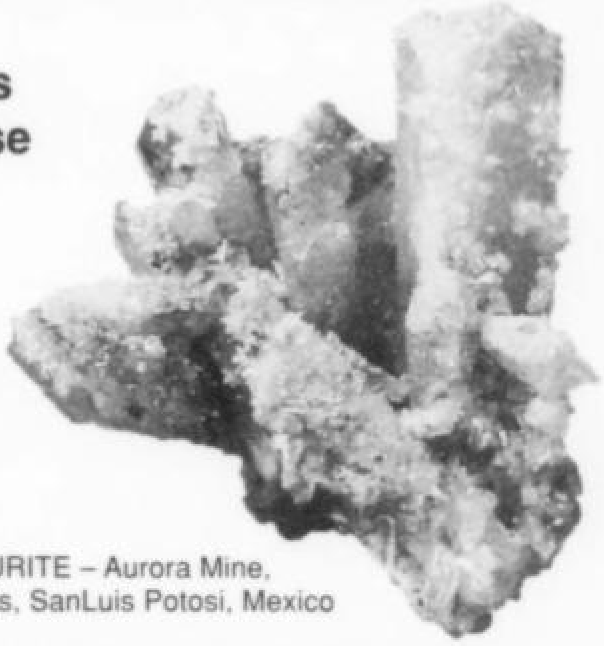
POUCHOU, J. L., and PICHOIR, F. (1984) A new model for quantitative analysis. I. Application to the analysis of homogeneous samples. *La Recherche Aerospatiale*, **3**, 13–38.

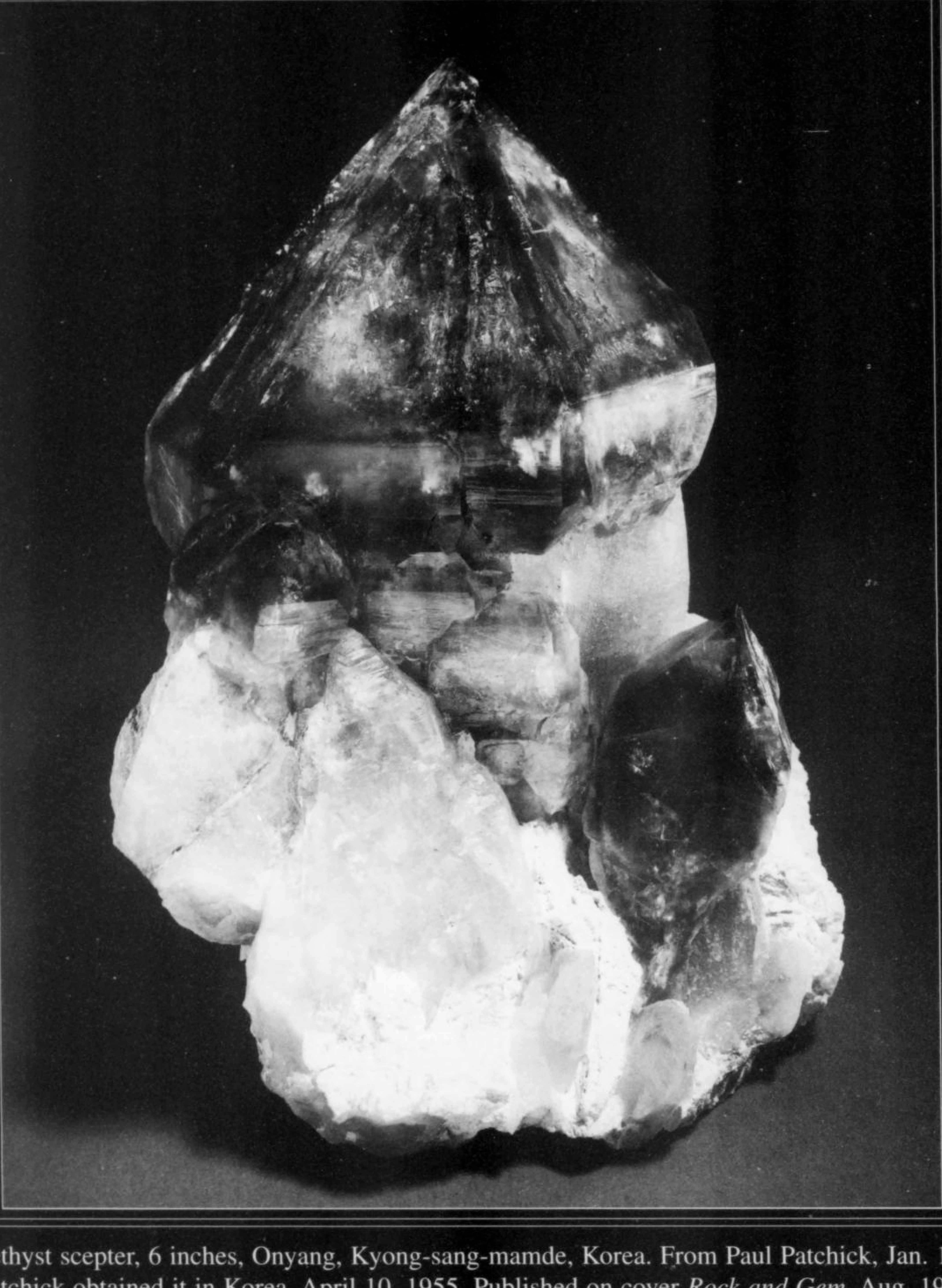
POUCHOU, J. L., and PICHOIR, F. (1985) "PAP" (ϕpZ) procedure for improved quantitative microanalysis. *In* Microbeam Anal.—1985, San Francisco Press, San Francisco, California, 104–106.

ROBERTS, A. C., ERCIT, T. S., CRIDDLE, A. J., JONES, G. C., WILLIAMS, R. S., CURETON, F. F., II, and JENSEN, M. C. (1994) Mcalpineite, $Cu_3TeO_6{\cdot}H_2O$, a new mineral from the McAlpine mine, Tuolumne County, California, and from the Centennial Eureka mine, Juab Country, Utah. *Mineralogical Magazine*, **58**, 417–424.

WILLIAMS, S. A., and DUGGAN, M. (1977) Ruizite, a new silicate mineral from Christmas, Arizona. *Mineralogical Magazine*, **41**, 429–432.

WILSON, W. E., and DUNN, P. J. (1978) The Kalahari manganese field. *The Mineralogical Record*, **9**, 137–153.





Amethyst scepter, 6 inches, Onyang, Kyong-sang-mamde, Korea. From Paul Patchick, Jan. 1976; Patchick obtained it in Korea, April 10, 1955. Published on cover *Rock and Gem,* Aug. 1972

Clara and Steve Smale

COLLECTORS

PHOTO BY STEVE SMALE

Into the Heart of Darkness

Searching for Minerals in the Democratic Republic of the Congo

Rock H. Currier
Jewel Tunnel Imports
13100 Spring Street
Baldwin Park, California 91706

Intrepid adventurer and mineral dealer Rock Currier traveled to Darkest Africa (The Congo) in 1997, searching for malachite, carrollite, cobaltoan calcite, uranium minerals, and other treasures. Here is his report on the condition of some of the famous Congolese mines at that time, what he was able to obtain there, and what he had to go through to get it.

In the 19th century, Africa was called "the dark continent," and only its general outline and the mouths of some of its rivers were known. "In its interior dwell dark people and the unknown," wrote Joseph Conrad in his novel *Heart of Darkness* (1902). As Conrad's protagonist Marlow was drawn to the giant Congo River, rumors of lost African cities and treasure have drawn men for centuries to Africa's "dark" interior. I am no different: my own distant drummer marched me to this fabled land, where fabulous specimens of malachite, carrollite, torbernite and cuprosklodowskite abound. Of course, the imagining far outstripped any possible reality, but I knew that if I could just get there I could find the treasures! As the comedian Judy Tenuta loudly and indignantly proclaims, "It could happen!"

In early 1997 the longtime president of Zaire, Mobutu Sese Seko Koko Ngbendu wa za Banga [translation: "The all-powerful warrior who, because of his endurance and inflexible will to win, will go from conquest to conquest leaving fire in his wake"], was forced to flee, after years of brutal, iron-fisted rule. During his dictatorship he had amassed a great personal fortune at the expense of his country. Now he had at last been replaced by (U.S.-backed?) Colonel Laurent Kabila. Was now the time to visit this legendary place?

"Oh, but honey!" my distraught mother wailed, "why Zaire?! They just had a war there. And the diseases!"

"Well, you see, Mom, I have always wanted to visit the place and I know this guy who says he can show me around."

"But honey, do you know him well? Who is he? Can you trust him?"—still worrying about the heart, body and soul of her delicate little 300-pound, six-and-a-half-foot, 57-year-old baby boy.

"Well, his name is Sam Benatar and he deals in malachite and I have been buying it from him for the last fifteen years or so. During that time he has always treated me well. He says that Americans are welcome in Zaire now because they helped the new guy kick Mobutu out. I only want to visit the mines in the copper belt, in the south, near Sam's hometown. Only about 200 or so were killed

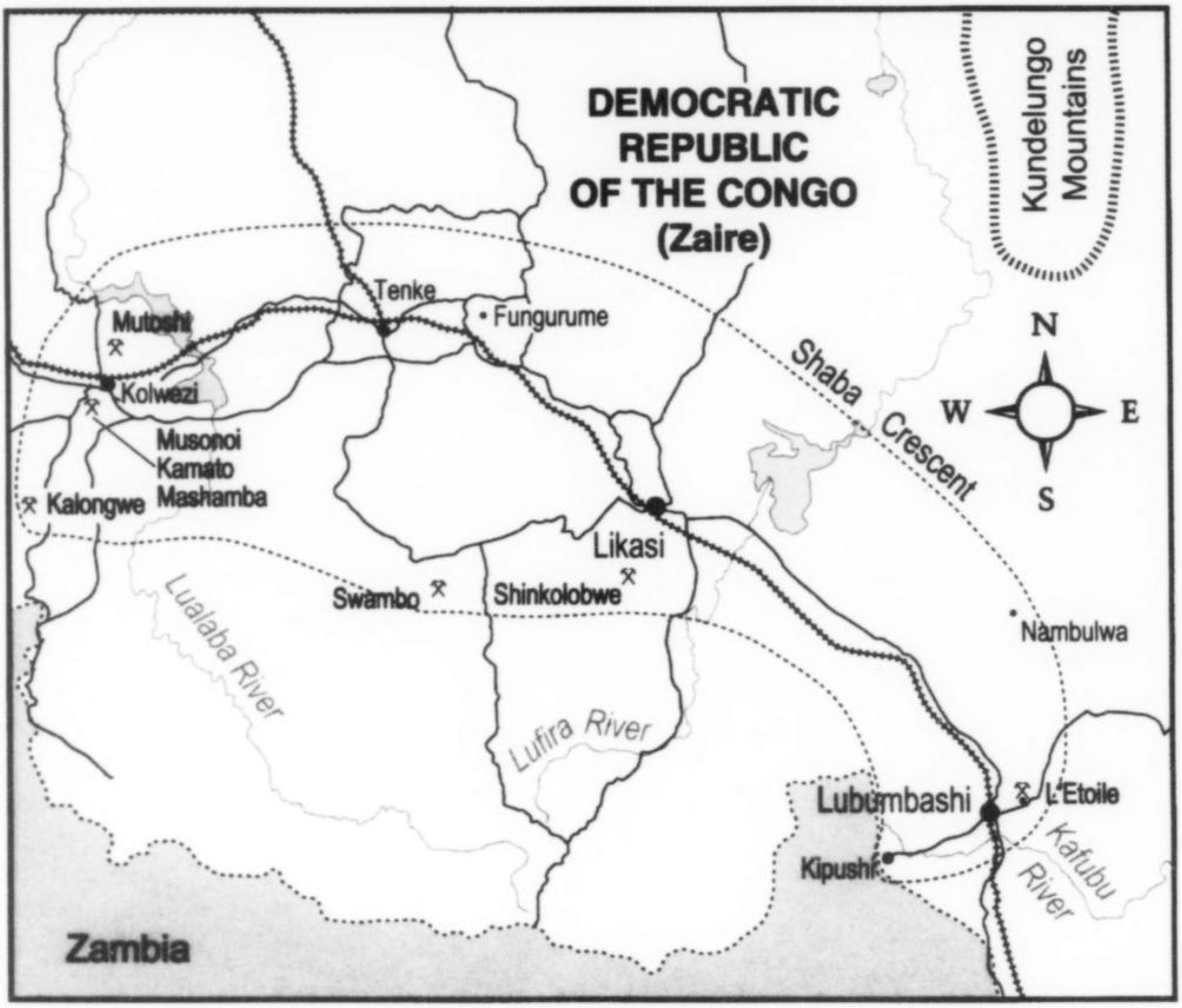


Figure 1. **The so-called "Shaba Crescent" in the Congo, wherein many copper, cobalt and uranium mines are located.**

during the fighting around Lubumbashi and it's all peaceful there now." Somehow this last part did not seem to calm her fears, so I hurried on. "Sam says that all the army roadblocks where money was extorted from people are gone, and that all we have to do is go to the border, get a visa, and drive through to his place in Lubumbashi."

Hearing this same information, my buddy Bob Bartsch, a mineral collector and experienced traveler, merely said "Are you completely out of your mind?"

Well, I counseled myself, newspapers, like wrestling promoters, are not well known for their sense of proportion. War and strife, not peace and tranquility, sell newspapers. I had been in Peru when the *Sendero Luminoso* ["Shining Path" guerillas] were active, yet when I reached home and read about it I wondered if the news was really about the place where I had just been. There seems to be an unwritten law prohibiting news people from reporting things in perspective. In the case of Zaire, I chose to believe someone whose judgment I trusted and who actually lived there.

So, on August 15, 1997, I met Sam Benatar and his son Victor at Jan Smuts Airport near Johannesburg, in the Republic of South Africa. Victor had formerly been involved in the malachite trade, and he thought that now might be a good time to get active again. At least he was going back to his hometown to see what was going on; car dealers might describe it as "kicking the tires."

The Air Zambia flight boarded two hours late, and for another two hours we sat in the plane on the tarmac. Then it was back off the plane to the terminal because of mechanical problems. After another two hours we reboarded and took off. Our original plan had been to meet Sam's people and his truck at the Ndola airport, drive immediately to the border, and cross into the Congo before the border closed for the day at 5:00 p.m. No such luck. I sensed that there would be a lot of "no such lucks" on this trip.

The immigration, baggage claim and customs inspection facilities at Ndola, Zambia were in an old airplane hangar. We and all the rest of the "civilized" passengers who left the plane were transformed instantly into something resembling a rugby scrum as we tried to get our luggage and leave the airport. It was clear that the English tradition of forming an orderly queue had not survived the change from colonial to home rule. I admired the way that Victor bulled his way through the mob and got us out in a reasonable time. This was not a place for the run-of-the-mill tourist. Left to myself, I would easily have been spotted as a mark, and it would have cost me several hours and probably a hundred dollars just to get out of the airport. When we finally emerged it was 10:00 p.m., and there was no one to meet us.

To make amends for the long delay, the airline put us up for the night in the Mukuba Hotel on the edge of Ndola. There was a small herd of slightly tame Springbok antelope on the hotel grounds. Ndola is at the southern end of the copper belt which stretches 500 kilometers northwest to Kitwe and Chingola, across the border into Katanga province, Congo (Shaba province, Zaire), and west through the towns of Lubumbashi (Elisabethville), Likasi and Kolwezi.

The next morning there was still no truck. Since there were no such things as taxis or rent-a-cars here, we caught the hotel van into

***Figure 2*. Border crossing from Zambia to Zaire. A rich source of income for locals and officials alike.**

town, where we finally found a guy willing to drive us the 75 miles to Kasumbalesa on the border for $100. But only to the border. What we would do when we got there was unclear. With all our bags, the car was more than fully loaded; it made me think of one of those little cars in a circus that a clown drives to the center ring, and from which 20 more clowns then emerge.

Border crossings in Zambia and the Congo are looked upon by the locals as prime opportunities to squeeze money from travelers. The locals have the squeeze down to a science, and are always working to improve it further. If you are unfamiliar with the process and are spotted as a mark, God help you. The Zambia/Congo border crossing is marked by welded iron barriers, with a no-man's-land of several hundred yards between them. At each border the traveler encounters a crowd of husky, aggressive black men eager to "help" with the bags, even if they have to be carried for only a few feet. One man per bag or briefcase is the rule, unless the traveler rants and raves in protest. Across no-man's-land, Victor spotted Sam's little Japanese pickup truck and two of Sam's employees. We got our passports stamped, and twenty dollars proved sufficient gratuity to allow Sam's truck to cross the no-man's-land to the barrier at the Zambian border. All we'd have had to do was lift our bags from our car and over the barrier and put them into Sam's truck, but Sam was wise enough to pay the squeeze and let the locals fight over who was going to transfer the luggage. Anything less would have caused a riot.

We drove across no-man's-land and stopped at the Congo barrier. Sam seemed to know everyone, and professionally schmoozed us through the visa-acquisition process; each visa cost $60, but only because Sam knew the ropes. My vaccination certificates were found to be not in order, even though they were correctly stamped and barely two weeks old. Of course, vaccination certificates are always found to be not in order. But not to worry, they said: they could give us the required vaccinations right there! Immediately, visions of an unlabeled vaccine bottle in a dirty drawer and an AIDS-contaminated hypodermic needle wiped on a shirtsleeve sprang into my head. There followed more ranting and raving between squeezer and squeezee. We had heard horror stories of tourists camping for days in their cars because of "irregularities" in their documents. Then came the customs-inspection gauntlet, and the inevitable discovery of "not permitted" items. We protested. We spoke English and they spoke French. We spoke French and they switched to Swahili. But when it came to extracting payment, they all spoke dollars.

Sam, who speaks Swahili and many other languages, is an old pro at this kind of stuff, and got us through it smartly. Even he was not completely immune to the squeeze, but they had to work hard to get anything from him. It was wonderful to watch him, and I tried hard to learn his technique; it was like watching a good high-bar gymnast, knowing that if you tried it yourself you would crash and burn. The many locals who knew Sam had given him the nickname "Kambeketi." The word means a little bucket, or more specifically the bucket that is often used to carry corn meal—"the man who brings food" was the general sense.

Once across the border, we began our penetration into the heart of darkness, which actually didn't look very dark. It was pretty smoky, though, as in places there were uncontrolled fires burning beside the road. At this dry time of year they burn the brush, but the process does not appear to be agriculturally related. Its purpose is

***Figure 3*. Specimens of pink cobaltoan dolomite, malachite and chrysocolla spread out for inspection and sale.**

***Figure 4*. Baskets full of botryoidal chrysocolla specimens that no one wanted.**

to clear the brush and to keep down the snakes and insects. The smoke stayed with us throughout the trip; it was just something we got used to and eventually ignored. Sam had told me that the roads were terrible, but all the way to Lubumbashi we had a good asphalt road, barring a few scattered large potholes and swarms of small ones. I had imagined that the roads would be as terrible as the ones in the Peruvian and Bolivian Andes, but these were a piece of cake (even though people kept assuring me that some of the roads in the Congo were among the worst in the world).

Our road was mostly free of traffic, except for occasional tractor-trailer rigs carrying big metal cargo containers or heavy loads of copper ingots. There were also a few smaller stake-bed trucks heaped with goods and sometimes comically overloaded with people hanging on every which way, pincushion style.

Along the road grew high scrub, and ubiquitous termite mounds of red earth, some more than 30 feet high. I was told that the earth from these termite mounds makes fine bricks. From high points in the road we could see similar countryside stretching to the horizon. The thatched native huts didn't look very different from those in some parts of rural India. Frequently the road ran past tall high-tension lines that were bringing electricity from the big dams on the Lualaba River. This part of Africa might be short on many things, but electricity is not one of them.

Every few kilometers we would come upon big (4 feet high) bundles of charcoal shaped like conga drums and propped upright with sticks, sometimes 15 or 20 in a row paralleling the road. We passed men pushing bicycles loaded with up to five of these charcoal bundles. Less frequently we saw rubber-wheeled carts, loaded with many more bundles, being pulled and pushed by fit, whip-thin young men. During our entire trip we did not see a single draft animal. These charcoal bundles cost about 600,000 Zaire dollars ($4 U.S.), and seem to be a staple of the economy.

One hour from the border, although there had been no road signs or other advertisements to mark its proximity, we were suddenly in Lubumbashi, a city of about 1.5 million people. Lubumbashi is the commercial hub of the southern part of the country, and the capital of Katanga province (known before the revolution as Shaba—"copper"—province). Most truck drivers refuse to drive into the Congo further than Lubumbashi.

Sam owns a sizable commercial building in the center of town. In his large apartment on the second floor, his staff of servants greeted us. If the supply of electricity was not a problem, the supply of water was. The water was always off during the day, and we learned to consider ourselves lucky if a little water had run into Sam's holding tank during the early hours of the morning. Some mornings, we had to make do with only a few cups of water. The sewer system was in even worse shape than the water system, and it took a long time for sinks and tubs to drain. The other main source of irritation were the mosquitoes that gained entrance to the apartment at night through the bullet holes in some of the windows. These holes had been made during the celebration of Mr. Kabila's victory in the recent revolution. Sam had a small satellite dish, and we could watch CNN and other familiar programs. Ladies were soon at the back door offering fresh vegetables for sale. Damn! this was almost civilized. The dark heart of Africa was looking brighter all the time.

As a householder and businessman here, Sam routinely dealt with problems that we in the west would never dream of. Upon our arrival, he found that the workers in his malachite factory had staged a mini-revolt and had thrown his manager out of the factory—that was just one of the things Sam had to deal with at once. Many of the problems happen because the people are so poor that they are forced to try to work any angle they can. The cook, for instance, would always insist on cooking huge meals, because that way there would be leftover food to take home. Foodstuffs and supplies vanish quickly; a kilo tub of margarine lasts less than a week. Also it was interesting to see how many of Sam's friends tended to show up at dinnertime unannounced. On the sidewalk outside, a guy sat all day waiting to sell lengths of used metal strapping for packing crates; many of the rusty lengths had been pieced together with homemade brads.

The next day, we went to visit Sam's malachite factory near Ruashi, a suburb of Lubumbashi, which was formerly the site of an old mine and mission. His operation was a walled compound with several buildings, including a large one housing the grinding and polishing wheels that turn chunks of rough into items that show the beautiful vibrant green bulls-eyes and flower patterns typical of high-quality malachite. Runners showed up every day, offering rough lapidary-grade malachite and mineral specimens.

The Congo produces more than 99% of all the lapidary-grade malachite available today in the world. Container-loads of the stuff are shipped/smuggled from Lubumbashi into Zambia, then sent by sea to Hong Kong. Quite a bit of the good cutting-grade malachite is sidetracked in Ruashi and worked into finished goods. Along the main road there is a long *palapa* (open-air thatch-roofed pavilion) where many malachite vendors sell their goods. The sales tables are covered with polished malachite beads, carvings, boxes, eggs, spheres, chess sets, cabochons, hearts, letter openers, etc. About 10% of the table space is used to sell mineral specimens.

In Ruashi there are many small, one and two-man lapidary workshops. They are mostly built outdoors, adjacent to the proprietor's house, and they use the most rudimentary machines. In this neighborhood the sounds of grinding wheels and diamond saws are constantly in the air, and here and there the telltale green sludge of waste malachite can be seen splashed on the rutted dirt lanes. It is hard to imagine that the beautiful finished products sold in the pavilion come from these primitive operations. Malachite is not a pleasant material to work. Long-term exposure to its toxic dust is unhealthy, and without proper precautions the dust leaves a terrible lingering metallic taste in your mouth. These shops would make any O.S.H.A.-like agency go ballistic.

In recent years the quality of the rough malachite available to the lapidaries in Zaire has been declining, and lower-grade malachite is now being used. The material is still beautiful, but it has more holes in it. To compensate, the workers have learned to fill the holes with fragmented and powdered malachite mixed with a green-tinted epoxy resin. When done skillfully, this treatment is difficult to detect. The trick in buying malachite is to choose pieces with no fill, or at least a minimum amount of fill; the larger the object, the greater the chance that some fill is present. Nowadays it is almost impossible to find a newly made malachite object larger than 6 inches that does not have some fill.

***Figure 5.* Finished malachite objects offered for sale in a roadside market near Lubumbashi.**

Figure 6. **Friendly soldiers at a typical roadblock.**

We had to obtain permits to take pictures, visit the mines, and buy malachite and mineral specimens. According to *The Lonely Planet Travel Guide*, the photography permit should be available free from the Ministry of Culture and Arts. The Ministry had moved, but with a little perseverance we managed to find it at approximately Ave. de Chutes #630—"approximately" because there were no house numbers or street signs. Such signs, taken for granted in more affluent countries, are often missing in third-world countries. The Provincial Division de la Culture et des Arts was located in what had once been an elegant colonial home with spacious grounds, but now resembled a busted-out crack house. Plaster was missing in places, water had stained the ceiling and walls, and many floor tiles were missing. The lighting fixtures had long since disappeared, and light bulbs dangled from wires. I wondered what sort of cultural and artistic activities were ministered to by this organization. Anyway, its director, a Mr. Mwiya-Kahozi Jean Pierre, politely received us in his office. He was seated behind a battered metal desk, and I gingerly sat down on a bent tubular metal chair that had seen much better days. We were informed that the cost of a photography permit would be $100. Obviously they needed the money to fix up the place. I explained that we did not want to make a Hollywood movie, only to take snapshots, as any other tourists would do. After a prolonged discussion we settled for about $50.

Back at Sam's apartment I read over the permit and discovered an appended list of things that could not be photographed; these included official residences, army installations, border posts, government buildings, police stations, post offices, jails, mines, and downtown Kasangani. Rather than do battle again at the Ministry, we decided that any permit was better than none; we would make do with what we had.

Next, we needed a permit from the Ministry of Mines to visit the mining region. Here we had better luck. The secretary told us that the permit would cost $100 and that we could pick it up later in the day. When we returned, we were told that the director wanted to see us. I gave him a copy of the Peru Issue of the *Mineralogical Record* and, stretching the truth just a bit, I told him that I hoped to write a similar article about the mines in Zaire. This colorful publication seemed to impress him. When I told him about being charged $50 for a photography permit, he expressed outrage, and I then asked him why he was charging us $100 for *his* permit. He promptly chewed out the secretary, and we got our permit for $15. Would wonders ever cease? But Victor's malachite-buying permit was more difficult to get, and the skirmish about it held up our trip to Kolwezi for an extra day.

One of the great places to visit in any third-world country is the local marketplace in a town. Here, in a very short time, you can experience the heart of a culture and get a pretty good feel for how things work. When Sam's cook needed to visit the market to buy a few items, I sensed that I had an opportunity to go with him and take some pictures. The market was everything I'd hoped it would be: a hive of humanity, with all kinds of strange foodstuffs and local products for sale. But as soon as I took out my camera the people became agitated and began yelling, and a riot nearly ensued. We jumped into our car and fled. I was later told that Mobutu had told his people that foreigners who took pictures were spies and did so in order to show the rest of the world how poor the people of Zaire are; therefore, people should not allow foreigners to take pictures. This is an experience I have had nowhere else, and I think it may be unique to Zaire.

After the market, we cruised around town. We looked at the upscale Karavia Hotel and at its high-priced residential neighborhood, where we saw Mobutu's relatives' homes which had been pillaged during the recent revolution. We stopped at Sam's malachite factory before heading back to his apartment, and there we found a mob of about 20 runners milling around in front of the little office building.

Spread out on the ground in front of the building were hundreds of mineral specimens. Several hundred specimens of drusy cobaltoan dolomite made a glittering pink carpet. The most sought-after specimens of this kind are flat plates covered with rose-red, intensely glittery microcrystals. The recent fashion of making jewelry from sparkling drusy minerals has doomed these specimens to the cutter's wheel. Many of the offered lots had already been picked clean of potential jewelry pieces, so that only "color rock" remained.

Next to the cobaltoan dolomites was a green carpet of sparkling malachite specimens, and then came a blue swath of bubbly chrysocolla and cornetite from the nearby Etoile mine. The chrysocolla and malachite were mostly botryoidal, but a fair proportion of the malachite consisted of druses of microcrystals to a millimeter or two. The only lusts aroused would be those of micromount collectors. Most specimens would not be worth the cost of the airfreight. Sam sat in the office directing traffic, and it was endless fun to rummage through the various lots as they were offered. Once in a while there was something worth buying, and, of course, there was always the chance that something great would show up.

There are no vehicle-rental agencies in Lubumbashi, so it was fortunate that Sam had a small but serviceable pickup truck which we could use to visit the mines. In our trip supplies we included about 20 gallons of gasoline, as we could not count on finding any unadulterated fuel along the way.

At last we were off to see the mines of the Shaba Crescent portion of the copper belt. Victor and I rode in front while Sam's main malachite buyer and two other helpers rode in the small camper shell in the back. On the outskirts of Lubumbashi we ran into our first army roadblock. Victor's gift of gab, plus a small gratuity, got us past with minimal delay; truck and bus drivers who would not or could not pay the squeeze were not so fortunate.

On the outskirts of Likasi, an old colonial mining center, we encountered a more serious roadblock. A soldier who looked about 15 years old pointed the muzzle of his machine gun up my left nostril, and other soldiers pawed through our luggage. During this procedure, Victor kept good-naturedly jabbering at the soldiers in French, and just as they were reaching for the last suitcase a deal was struck that allowed us to go on our way. That was most fortunate, because that last suitcase contained a large amount of local currency, and if the soldiers had discovered it there would have been God knows what problems. A suitcase is needed to carry several thousand dollars in local currency: the highest denomination of bill we could get was worth about five U.S. dollars.

Leaving Likasi we hit yet another roadblock—one of ten in all we encountered during our trip. These roadblocks are simply a way for the soldiers to get enough money to eat, and for an occasional beer (the soldiers receive very little salary, and must sometimes wait months to be paid). These roadblocks should be thought of as tollbooths where you must negotiate fees, understanding that if your negotiations are unsuccessful the toll collectors can rob, beat or shoot you. We even came upon little impromptu roadblocks put up by the natives. One enterprising crew pretended to be volunteer road repairmen, filling in potholes and requesting contributions. Army roadblocks provided great opportunities for the locals to crowd around the car and thrust all manner of things to eat in our faces. We were offered some large rats (?), the haunches of small antelope (?), and bunches of sparrows dangling on strings which were shaken to make the sparrows flap their wings so that we would know that the birds were still fresh. Some offerings were even more gruesome.

Near the large village of Fungurume we stopped at the roadside home of a local chief who sometimes had specimens to sell. He had a handful of stones to show us: blebs of melted green glass that he called peridot, little pieces of azurite that came from a local hillside dig, and a tiny piece of gem silica. However, his *pièce de résistance* was an incredible hexagonal emerald crystal, 3 x 8 cm, that was mostly clean except for a few internal fractures. It would have cut at least 200 carats of high-grade gems. The only problem was that this fabulous piece of "gem" rough had striations on the prism faces normal to the *c*-axis, just like a quartz crystal. In fact, it *was* a quartz crystal. What in the world had they done to it? Close examination indicated that most likely it had been thermally cracked and the green color introduced by allowing green oil to seep into the cracks, which were then covered with a mixture of epoxy resin, dirt and small mica flakes.

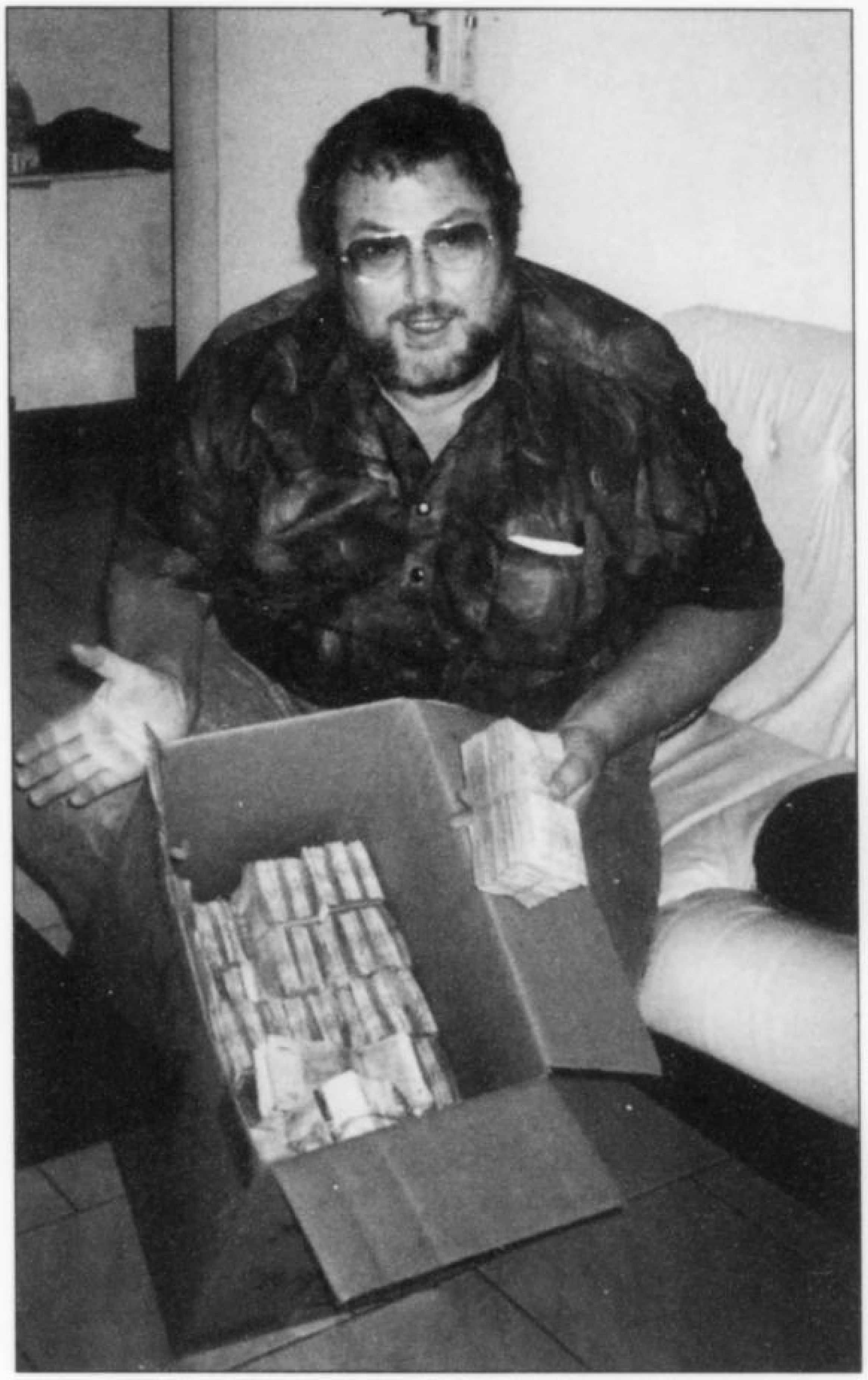


***Figure 7*. About $2000 worth of the Zaire currency.**

As we neared Kolwezi, roadside vendors appeared, offering fish for sale from nearby Lualaba Lake and the Lualabe River. The Lualaba River, originating just a few miles southwest of Kolwezi, is the largest tributary of the Congo River. At Kasangani [Stanleyville] the Lualaba River becomes the Congo River. Lake Lualaba was created in 1952 when the Union Miniere mining company dammed the river to produce hydroelectric power. The big power lines from the hydroelectric plant, which carry a direct current of 500kV, and use the river for one leg of the circuit. A number of other dams on the river generate large amounts of electricity that is sold to Zambia. Tall high-tension lines parallel much of the road to Kolwezi. Under the power lines, at a pit stop, I spotted a vein of malachite cropping out in the ground. I pointed it out to my companions, who just shrugged it off, saying that it

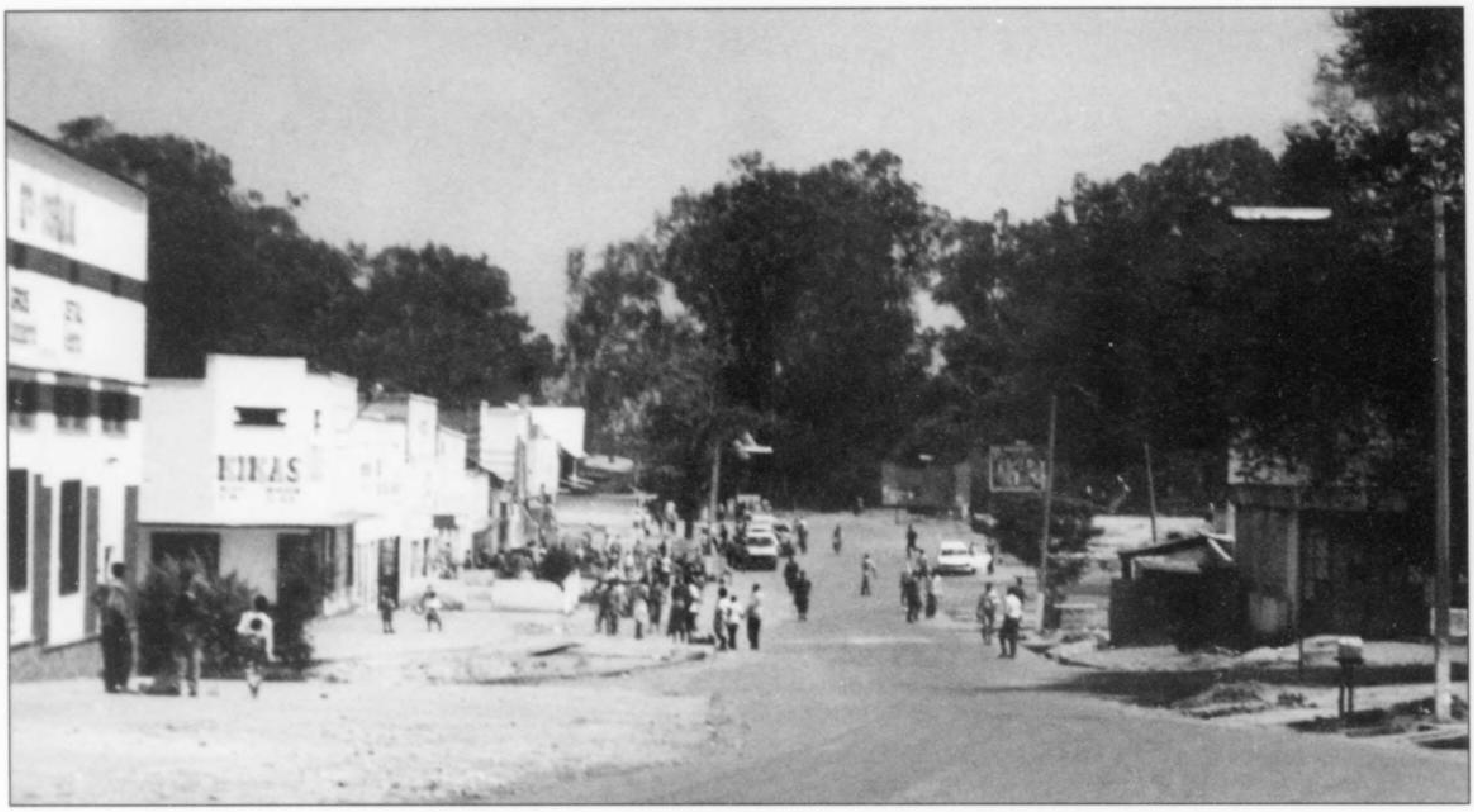


Figure 8. **Rush hour in downtown Kolwezi. No parking problem here.**

was normal for that part of the country. Jules Cornet, one of the first geologists to visit Katanga, called its great (almost obscene) amount of mineral wealth a "geological scandal."

We seemed to be always giving people rides. Three guys whose car had broken down needed a lift into Likasi to get parts. Some officials at roadblocks wanted rides into town. It got pretty crowded in our camper shell, and I couldn't help but think of the slave ships of yesteryear.

Soon after crossing the Lualaba River we were in Kolwezi. The place where 30 or 40 of Mobutu's soldiers had been killed some weeks before was pointed out. We drove to the home of one of the few white expatriates still in town, and he took us to the local office of Gecamines (Generale des Carrierres et des Mines), the national mining company that was created when the mines were nationalized in 1967. Gecamines also controls thousands of square kilometers of mineral-rich concessions in the Shaba Crescent. We soon arranged for rooms at the little company hotel, and for a tour of the mines. We were introduced to the chief geologist, shown the map room, and given the basic rundown on the mines and the Precambrian sedimentary strata in which the ore is found. The map room contains hundreds, if not thousands, of maps of the various mines, going back to Belgian colonial times.

Our "hotel" was like a run-down motel with 12-foot ceilings. My room had no electric light in the bathroom and, of course, no hot water. You definitely would not want to drink the water that did come out of the tap. Complaining to the management quickly brought an anxious servant to try to please the big foreigner who, for his $40 per night, was making unreasonable demands. The servant produced a large metal bucket which he filled with brown water and attempted to heat with a large immersion heater. Mosquitoes, at least, were available at any hour of the night, and I was glad for the insect repellent in my ditty bag.

Kolwezi has 250,000 people but no gas stations. The streets were almost empty of traffic. On some street corners men were selling little bottles of what I at first thought was cooking oil, but was actually gasoline: these were the local gas stations. The bigger "stations" boasted a five-gallon plastic jug or two along with the smaller bottles. All of the downtown buildings, even the churches, had heavy metal grills on their windows. Of the few restaurants in town, the best is the Florianna, a little second-story place run by a couple from Switzerland who have been there since 1949. They have a ranch near town where they raise chickens and rabbits for their restaurant. You can even get frog legs, but the rabbit has to be ordered a day in advance. We found ourselves eating at the Florianna almost every evening: it was much better than the second-best place.

Men from the mayor's office had spotted us at the roadblock on our way into town, and Victor said that we definitely needed to tell

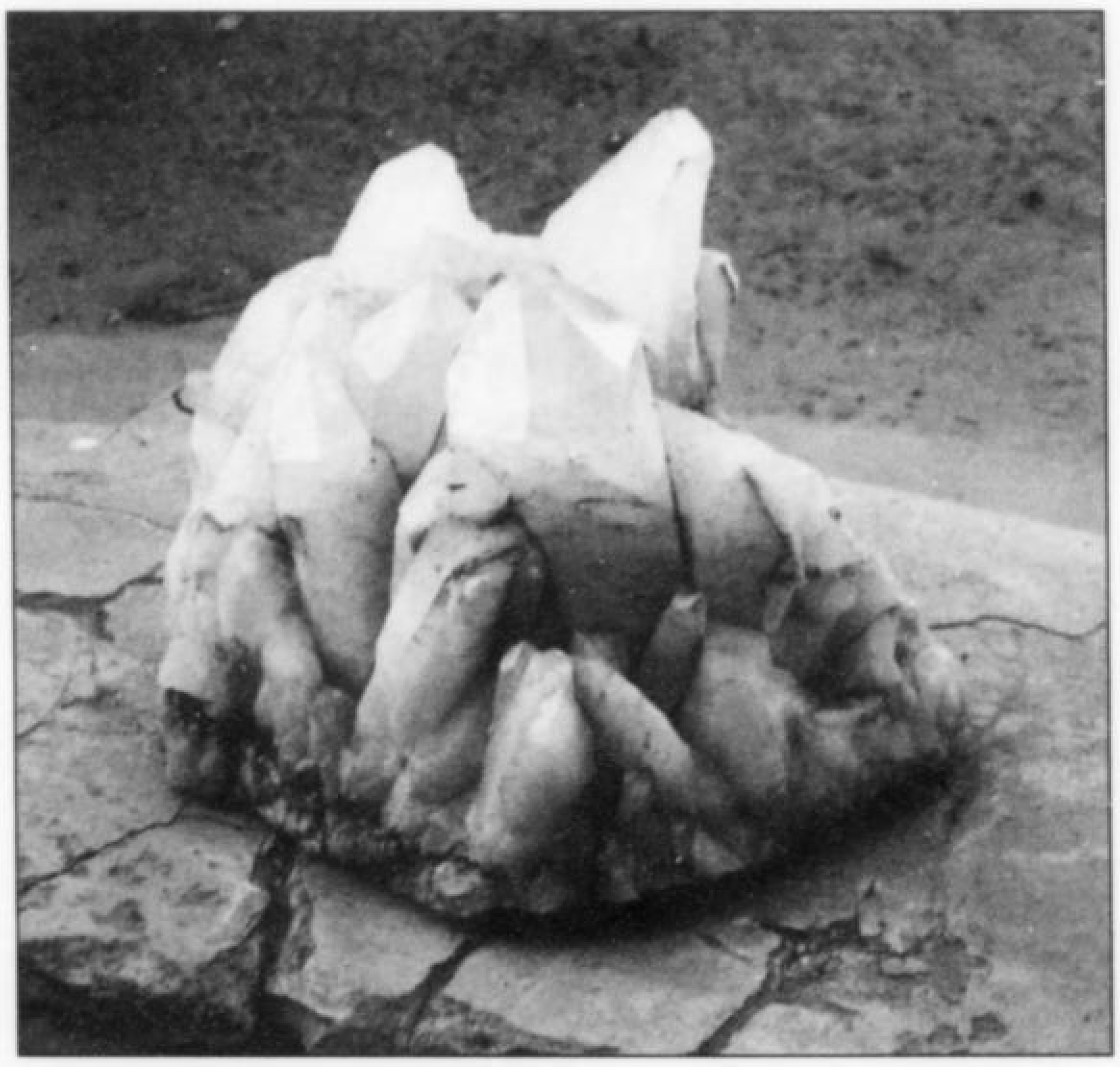


Figure 9. **A cluster of quartz crystals too heavy to be worth the air freight to take it to market.**

Figure 10. **The Komoto cobalt mine in Kolwezi.**

the authorities what we were up to. The mayor had a fancy office and was gorgeously dressed in a well-fitting suit. He had been trained as a surgeon in Switzerland and in trauma care in South Africa. We had a pleasant chat, he seemed amenable to our visit, and he stamped our documents. Then we visited the police chief and came away with more stamps.

Our little pickup was going to be busy hunting malachite in the concessions with Sam's men, so we had to hire another vehicle to visit the mines. Gecamines could not spare a vehicle to show us around. One car we tried to rent looked as if it had barely survived a car bomb: the back seat was patched with all sorts of stitched-together fabric, and patches on the fabric had holes in them in turn, which were covered with cardboard. Pavement could be seen through the car's floorboards. There was no reverse gear; to back up, the driver had to get out and push the car backward. The driver took one look at me and moaned, "This is the last day for my poor car." We ended up renting an old van for $100 per day (with driver) in which to visit the concessions.

The concessions are large mining claims, some of which have villages on them. Our first visit was to the KOV pit. KOV is an acronym for Kamoto (the name of the orebody), Olivera (the Portuguese operator of the pit from 1950 to 1960) and Virgule (the French word for "comma," in reference to the shape of the orebody). When we drove down into the mine it was evident that production was at a very low level. The big power shovel appeared to be loading only two 150-ton trucks, and 20 or 30 men were standing around with nothing in particular to do (in well-run open pit mines it is rare to see many men on foot). Copper mineralization could be seen in many places. One wall of the pit had big boulders covered with small pink crystals of cobaltoan dolomite. There was not much in sight worth picking up, but I would dearly love to have the specimen-collecting concession in this mine if a lot of ground is to be moved. The Musonoi mine, famous for its fine torbernite specimens, is part of this pit, but is now mostly backfilled with waste from other mining operations. We walked a kilometer down into the Musonoi on the backfill, and saw bits of malachite and black bubbly heterogenite scattered everywhere.

We then visited the Kamoto cobalt mine, perhaps best known for its remarkable carrollite crystals. In fact, carrollite is the main cobalt ore at the mine. This is an underground mine, still operating but fallen on hard times. Cobalt, a high-value export, was always a ready source of cash for Mobutu. Needing money, he ordered increased production but without making the additional investment in equipment to make it possible. When management chose to rob ore-rich pillars to meet the production quotas, big sections of the mine collapsed. Current production is about 10% of its former level. I was invited to go underground, but figured that my time would be better spent talking to the geologists. My calculation was that my chances of locating specimens would be much better outside than if I spent a day in a mostly collapsed mine, trying to find a place where the miners and geologists had overlooked something. Even taking up full-time residence in the mine probably would not pay. Sure enough, one of the geologists asked me if I could use some single carrollite crystals. Matrix specimens would have been better, but I accepted his offer. Unfortunately for me, the great discovery of the great carrollite crystals on calcite at the Kamoya II mine took place *after* my visit to Kolwezi.

We drove past big junkyards full of rusting equipment that was slowly being overgrown by brush and scrub. It must have taken a long time for so much of this old equipment to pile up. Finally we came to the Mashamba mine, which is also a big open pit, but abandoned, with a lake in the bottom which marked the local

Figure 11. **The KOV pit at Kolwezi. Copper ore is being loaded into a truck.**

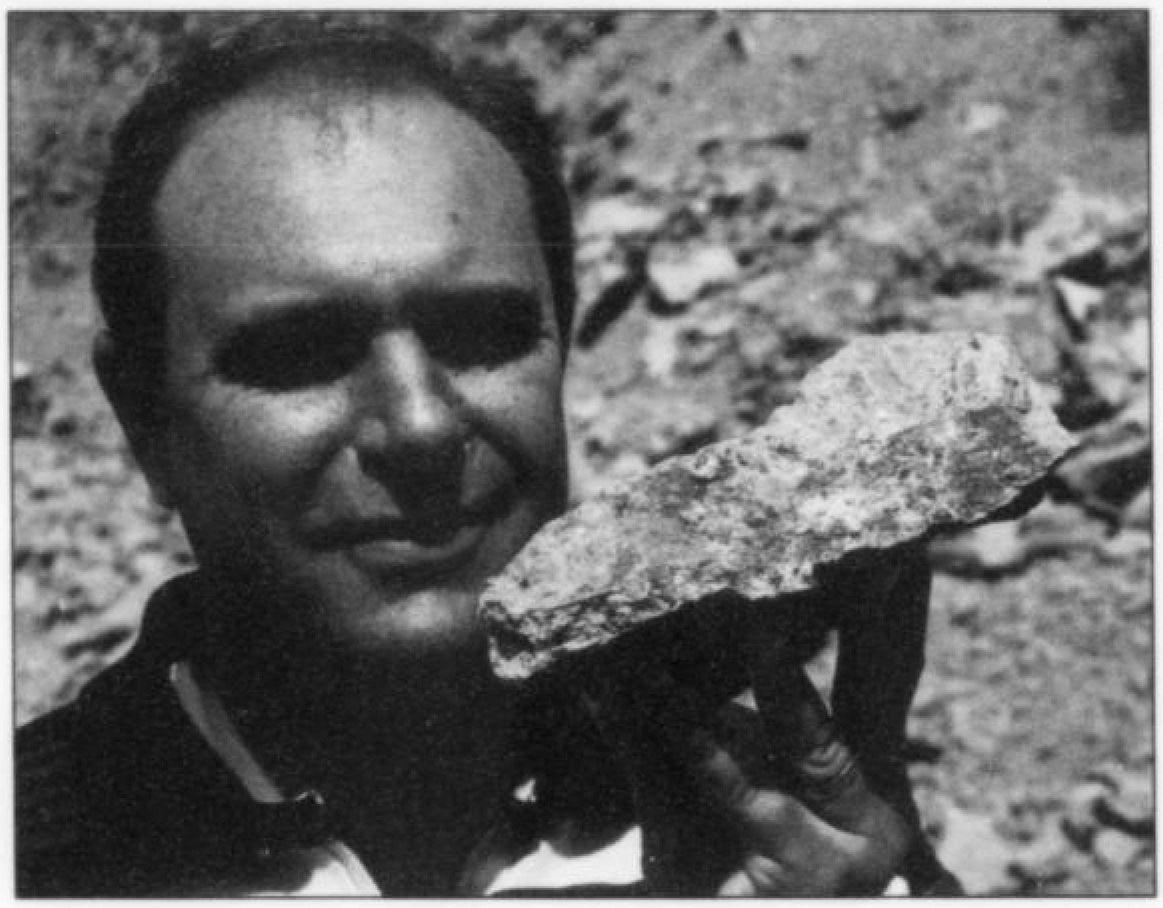


Figure 12. **Victor Benatar with a typical specimen of cobaltoan dolomite picked up in the KOV pit.**

groundwater level. The absence of tire tracks showed that there had not been any recent vehicular traffic, but a narrow path of smooth powdery dust along the access road showed that there had been a lot of foot traffic from nearby Kapata village. We wound down and around into the pit, and ended up on a bench dotted with small mounds of waste rock from many small round shafts that the locals had dug. The shafts went down about 50 feet in the bench to reach a horizon where gem-quality malachite was found. There were about a dozen two-man and three-man teams working the place, and they were initially fearful that we were from the mining company and therefore a threat to their rice bowl. They warmed up to us when they realized that we were foreigners interested in what they were doing, and potential customers as well.

The men had only shovels and small iron bars to dig with, and buckets to remove the waste. For fine work they used valve stems from internal combustion engines sharpened on one end to chisel points. They worked very hard for a small reward. They had only a few 2 to 3-inch pieces of malachite to show us.

Victor said he had never been down in the mines, and I did my best to explain the geology and mineralogy around us, as well as the techniques that were used in the mining process. He had often come to the area to buy malachite, but had always bought it in Kolwezi, except for one time in the nearby village of Kapata.

The story of Victor's visit to Kapata is worth telling: He was taken to Kapata by his trusted malachite buyer, and he bought a lot of good malachite from the miners. Usually he bought it from the African matriarchs ("mamas") who controlled much of the malachite production in Kolwezi. The mamas, hearing about his visit to Kapata village, feared that he would cut them out of the trade by buying directly from the miners; they barged into the mayor's office screaming, yelling, removing all their clothes, and complaining that *mutoto* (baby) Benatar was going to ruin the malachite business. In the face of this avalanche of feminine outrage the mayor did the only thing any sane man could do: he caved in to their demands. The next morning the mayor called Victor into his office and told him to buy his malachite in Kolwezi and stay out of Kapata village, or go to jail.

The next stop on our tour was the Mutoshi mine, which in the past was perhaps the greatest producer of gem-grade malachite. Pieces weighing in excess of 200 pounds were found here. In 1903 gold had been discovered near Mutoshi village by prospectors of

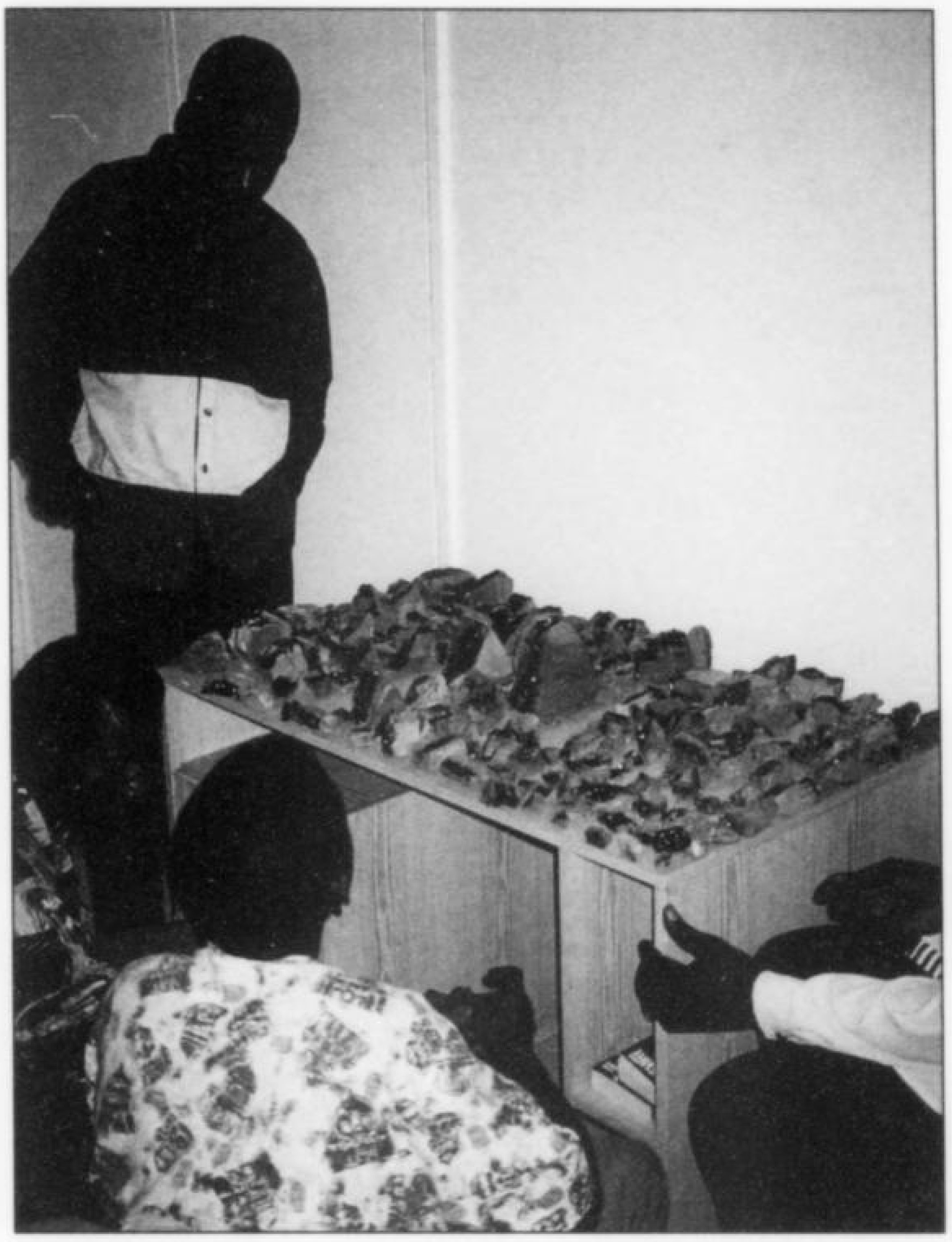


Figure 13. **Young mineral dealers offering libethenite specimens for sale.**

the Tanganyike Concessions, Ltd. The site was operated as a gold mine at various times, and more recently as a copper mine. When this played out, too, the mine was abandoned, with a good-sized lake in its bottom. We descended into the pit along another powdery little footpath, and once again came upon a crew of men digging for malachite. They had dug a pit that extended below the water level, which a little gas-driven pump was working hard to drain. Chips and crumbs of cutting-grade malachite were everywhere, weathering out of the floor and walls of the earthy white bench. Unfortunately they didn't have much to show us.

Our Gecamines guide took us to the site of a mini-gold rush going on near the mill and near the Musonoi "River." There were several hundred people digging up a hill and carrying the dirt down to a stream, where other men panned out the gold. There was even a small impromptu village of fast food stands that had grown up along the dirt track that led to the river. Circulating through the throngs were local gold buyers who were conspicuously more prosperous-looking than everyone else.

The gold had a rather unusual origin: it came from sandstone near the bottom of the Mutoshi orebody. The sandstone ore had been processed in big rod mills. During the grinding process the gold tended to concentrate in the bottoms of these mills and even stick to the iron. Periodically the mills were cleaned out and the residue dumped in a pile which ultimately became a hill. The locals eventually discovered that this hill had a substantial amount of recoverable gold, and the rush was on. Here was a chance, I thought, to document photographically a little gold rush in progress. Out came my camera, and I got two or three shots before a great hue and cry arose from the locals. Photo! Photo! were the only words I could make out. Our guide suggested that we calmly leave so, just as we had in the market, we made a nervously wary retreat. It was one of the few times in my travels when I have felt really threatened.

Our geologist guide was good and helped to keep us out of trouble, but I had wrongly assumed that his services were free. When our visits to the mines were over he said we owed him $75. Of course we negotiated a more modest price. In the Congo you must assume that people are going to hit on you for anything they can, and you must be careful to nail down the cost of everything in advance.

One evening we went to the little home of a geologist and were offered a small table full of specimens. They were all of low quality, good only for study or reference purposes. There was a small lot of poor secondary uranium minerals that I was told came from the Musonoi Extension mine. Most interesting were several small specimens covered with tiny dark green libethenite crystals; I bought these for less than a song, and two days later the geologist showed up at the hotel with about 200 more libethenite specimens. Most were less than two inches in diameter, and the largest was a hand-sized sandstone fragment with one side covered with isolated two to three-millimeter crystals. "How much?" I asked. "Seven dollars each," I was told. Well, if you don't know what things are worth and are dealing with a dumb, rich foreigner, you might as well start high. Raised voices and expressions of outrage followed on both sides of the negotiation. I told him that I thought a few dollars per kilogram would be all I would pay for such rubbish. If he wanted more money, I told him, he should bring me centimeter-sized crystals like the ones they had in Zambia. Indignantly he wrapped the specimens and took them away rather than throw them away for a nothing price to an unappreciative foreigner. Two days later, he was back, and the price negotiated for the libethenite was much closer to my view of their worth than to his. Even if you are able to buy some things at a throwaway price you must keep in mind the high cost of getting the specimens out of town, and then out of the country. Even to take malachite and specimens from Kolwezi you must pay the local government its due. Officials normally assess a huge tax, which you must negotiate down to a price you can live with.

After a few days it became generally known that foreigners were buying malachite and mineral specimens, and most evenings and some mornings miners and runners would bring us things to buy. Most of the material was rubbish and not worth the cost of export. The geologist from the Kamoto mine came one evening with several hundred loose carrollite crystals. Many were not worth buying, but I was able to get about 200 crystals at a modest price. Those crystals and the libethenite specimens were the best things I was able to buy on my trip to the Congo, but their sale would cover only a small part of the cost of the trip.

During our negotiating sessions, I had a chance to talk to many of the young men who made their livings entirely or partly by selling specimens and malachite. They were not dummies. They could sight-identify all of the minerals produced in the region, including the more obvious uranium minerals. They certainly knew what exceptional specimens looked like, even if they could not place an accurate value on them. They were all fascinated by the Peru Issue of the *Mineralogical Record*, and looked carefully at each mineral photo, wanting to know what each mineral was and how big the specimen was. They used their fingers to give reality to the dimensions, and they compared notes with their friends. Some talked enthusiastically about the big red 7-cm cuprite crystals growing on blue chrysocolla that they were going to get from the KOV pit when it mined down to the next level. These have yet to materialize, but I am sure that we will eventually see some of these young men at the Tucson show, or see their specimens offered for sale on the Internet.

***Figure 14*. Author and malachite boulder in the Musonoi mine, with the KOV pit in the background.**

***Figure 15*. A superb cuproslodowskite, 4 cm across, from the Musonoi mine, Kolwezi, Congo. Currier photo.**

One of these dealers visited me at my warehouse just before the 2001 Denver Show and tried to sell me 2-inch carrollite crystals that would have been spectacular if all the faces had not been ground and polished. One European dealer/collector experienced in such things said about them, "I think they are all crooks. Some are very skillful at gluing together fake specimens . . . remember the fake stalactitic malachite specimens?"

Victor was not getting much malachite, and what he was getting was not of the best quality. One reason was that there had just been a big malachite heist. Some guys drove into Kapata village and said that they had buyers for cutting-grade malachite at a price considerably above the going rate, but that the deal had to be done quickly. They convinced the mamas to take a ton of malachite out of hiding; the material was weighed and loaded onto the truck. The mamas got into the truck too, to go along and get paid, but were instead driven out into the country and ordered off the truck at gunpoint. The truck and the malachite disappeared. I wanted to find a few large pieces of malachite from which I could make some 12 to 15-inch bowls like the one I obtained some years ago and that several of my friends have lusted after. I could not even find a piece suitable for an 8-inch bowl.

The malachite is there in the ground, but most of the mines were either closed or operating at vastly reduced capacity. We were told that in 1980 there had been a fleet of 140 big mine trucks, and 50 more 150-ton trucks had been purchased. In that same year,

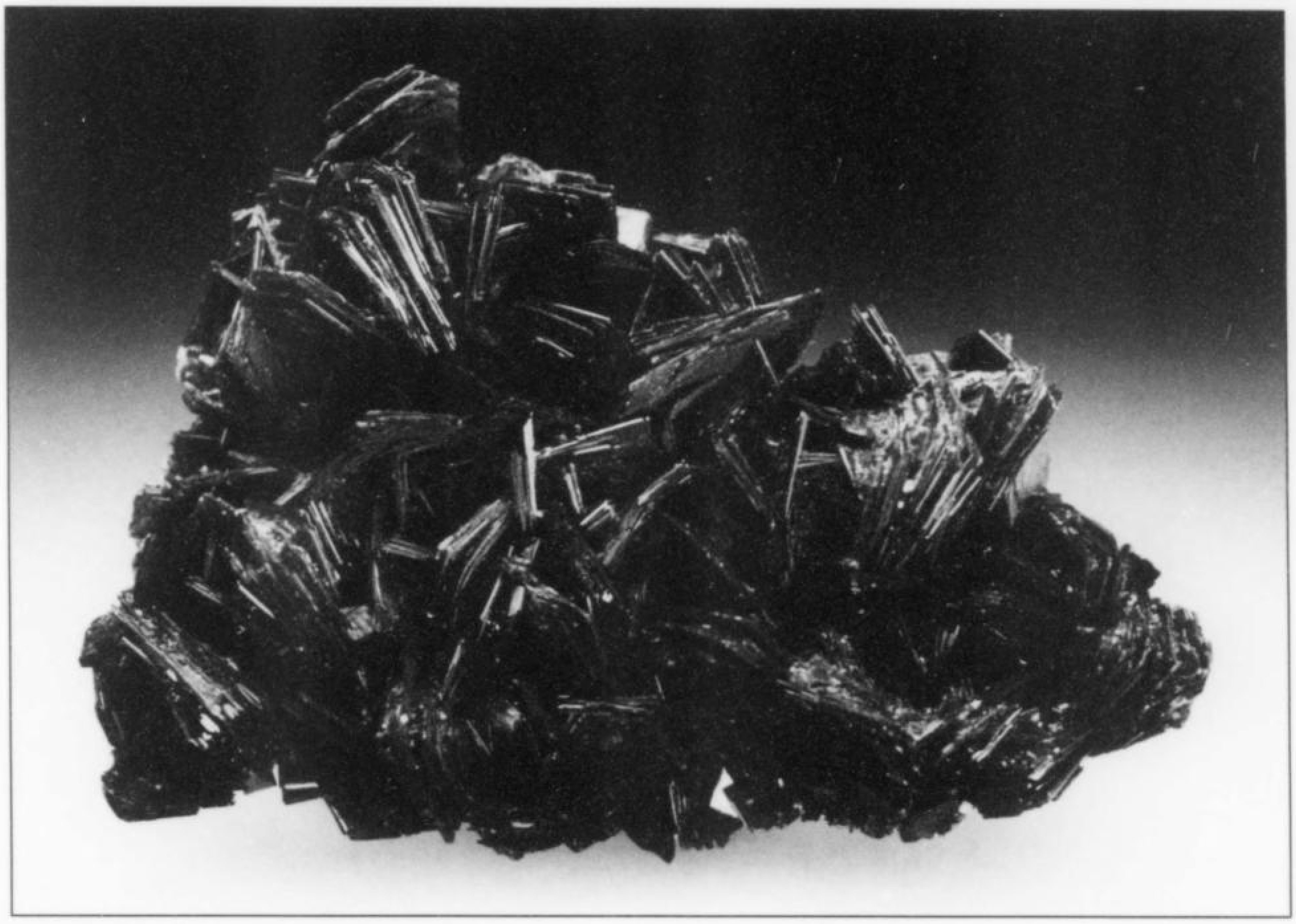


Figure 16. **Metatorbernite, 7 cm, from the Musonoi mine, Kolwezi, Congo. Forrest and Barbara Cureton collection: Wendell Wilson photo.**

Figure 17. **The Mutoshi mine, now abandoned, was a great producer of gem-grade malachite. Now a few locals dig in its benches for malachite.**

450,000 tons of copper and 12,000 tons of cobalt were produced with the labor of 36,000 Africans and 1200 expatriates. Today, two trucks are running, and 30,000 tons of copper and 2000 tons of cobalt are being produced by 28,000 Africans and 100 expatriates. The mines have been going downhill for years, not because of any exhaustion of the ore, but because of the political situation and the corruption of government officials.

The government is apparently trying to privatize the mines, since it has become clear that the government itself cannot run the mines at a profit. The situation is very similar to that in Peru, Bolivia and Chile, where many mines were nationalized, milked for many years by the governments, and finally bankrupted by mismanagement and/or corruption. At this point, generally, new outside investors are invited to bid on properties and then operate them. One wonders if this will eventually lead to yet another round of nationalization when the mines become profitable again.

The mines looked very rich to me, and I thought that money could be made just by reprocessing the dumps with modern mining and milling techniques. I was told that foreign mining companies would not even think of trying to mine anything here with an ore value less than 4% copper. At the big copper mine at Bingham Canyon, Utah, the mining company makes due with ore that runs only 0.3% copper. But even with rich ore, foreign companies are reluctant to get involved in mining in Katanga, and for many reasons. How do you estimate the cost of doing business in such a politically unstable place? How much of the infrastructure are you going to have to recondition or build from scratch? How do you get educated, well-trained people to work in a place like the Congo? How do you factor in the likelihood that the mine may be destroyed or nationalized during a revolution?

Our expatriate friend told us that there are 21 transformers in the electric house, but only half of them are working. Each transformer holds 1,200 liters of highly toxic oil. During the 1978 revolution, some of the troops used the oil for cooking, among other things, and when the oil level got low enough in one of the transformers it heated up and caught fire. Signs were posted that the oil was poisonous, but many locals still think that the signs are just a lie to discourage them from using the oil. Stories like that abound. Most

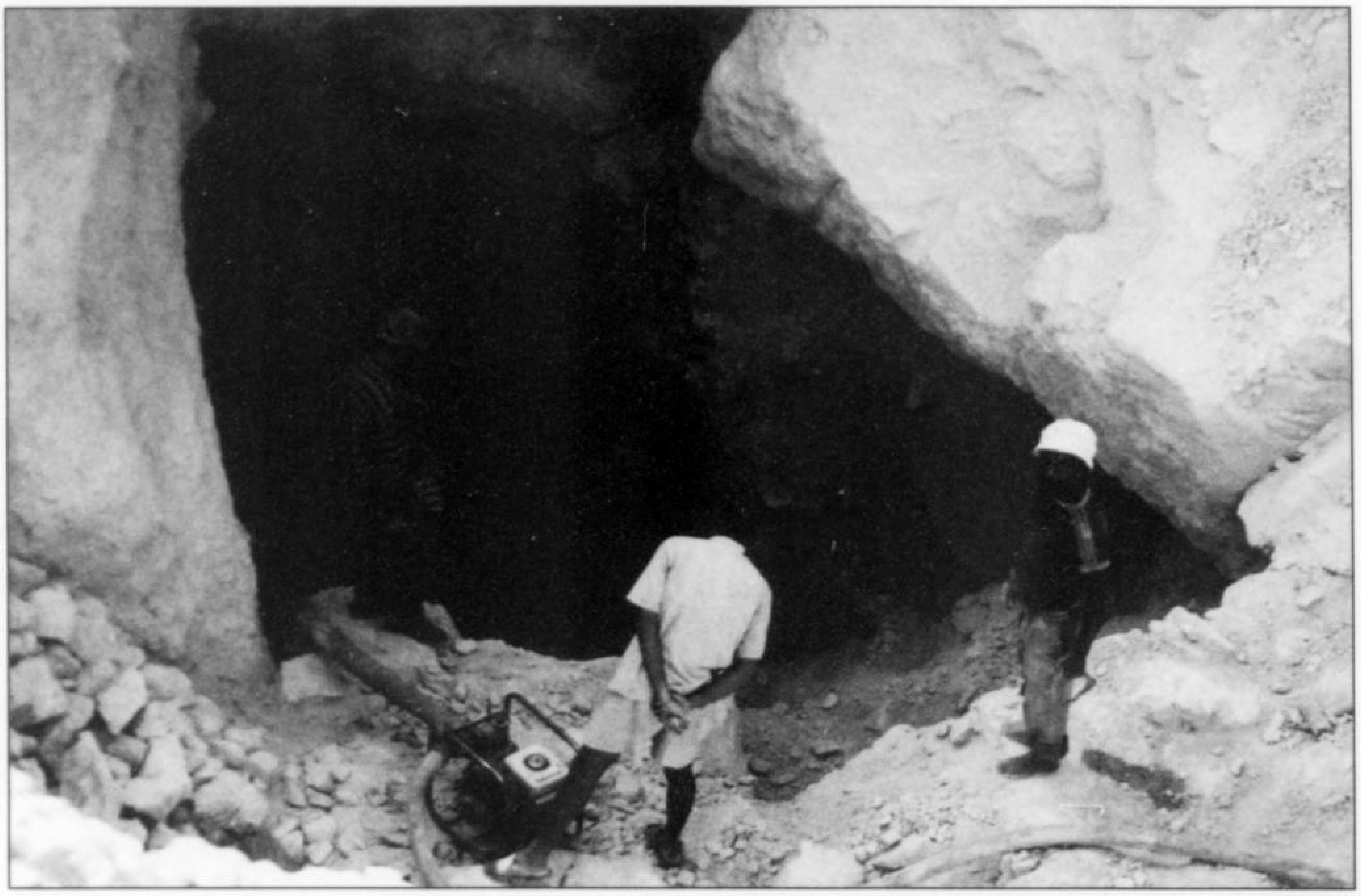


Figure 18. **Shirttail miners digging for malachite at the Mutoshi mine.**

people we talked to were optimistic that the Kabila regime would improve conditions in Zaire; however, another foreigner thought that things would continue to get worse, and that in another five years they would be putting biohazard stamps on maps of the Congo.

One Sunday when we had nothing much to do, we were taken out for a picnic to the Dengue Nautical Club. This is a little community of perhaps 30 vacation cottages built mostly by expatriates on the edge of the 80 kilometer-long Lake Lualaba. The community had been destroyed three times during revolutions, most recently in 1991. One cottage was being reconstructed for the fourth time. There used to be a clubhouse, badminton courts, and even a water system for the community; now, all the houses are shells without windows, doors or roofs. Locals had taken the ceiling beams and window frames. We had lunch on what had been the veranda of one of the homes. At this time of year the water in the lake was way down, and I could walk far out on the fingers of sand that stretched into the lake. I noticed that here and there were patches of black sand speckled with minute grains of malachite. I was told that the mill at the Mutoshi mine was set up to concentrate malachite. The ore was processed, the malachite was floated on top of magnetite sand, and the magnetite was removed by magnets, leaving the malachite behind. Some of the magnetite sand with malachite had been washed into the lake.

At this point we were growing acutely aware that our time on this trip was running short. In Kolwezi I felt as if we were out on the end of a long logistical rope that could break at any time. In this unpredictable country it would not take much to prevent us from making it to the upcoming Denver gem and mineral show. Anyway, on the way home I wanted to stop in Likasi to see the Gecamines museum, which I'd heard had some fine specimens, and to visit the famous nearby uranium mine of Shinkolobwe. This was the mine that had produced the uranium used to make the atomic bomb that was dropped on Hiroshima at the end of the Second World War.

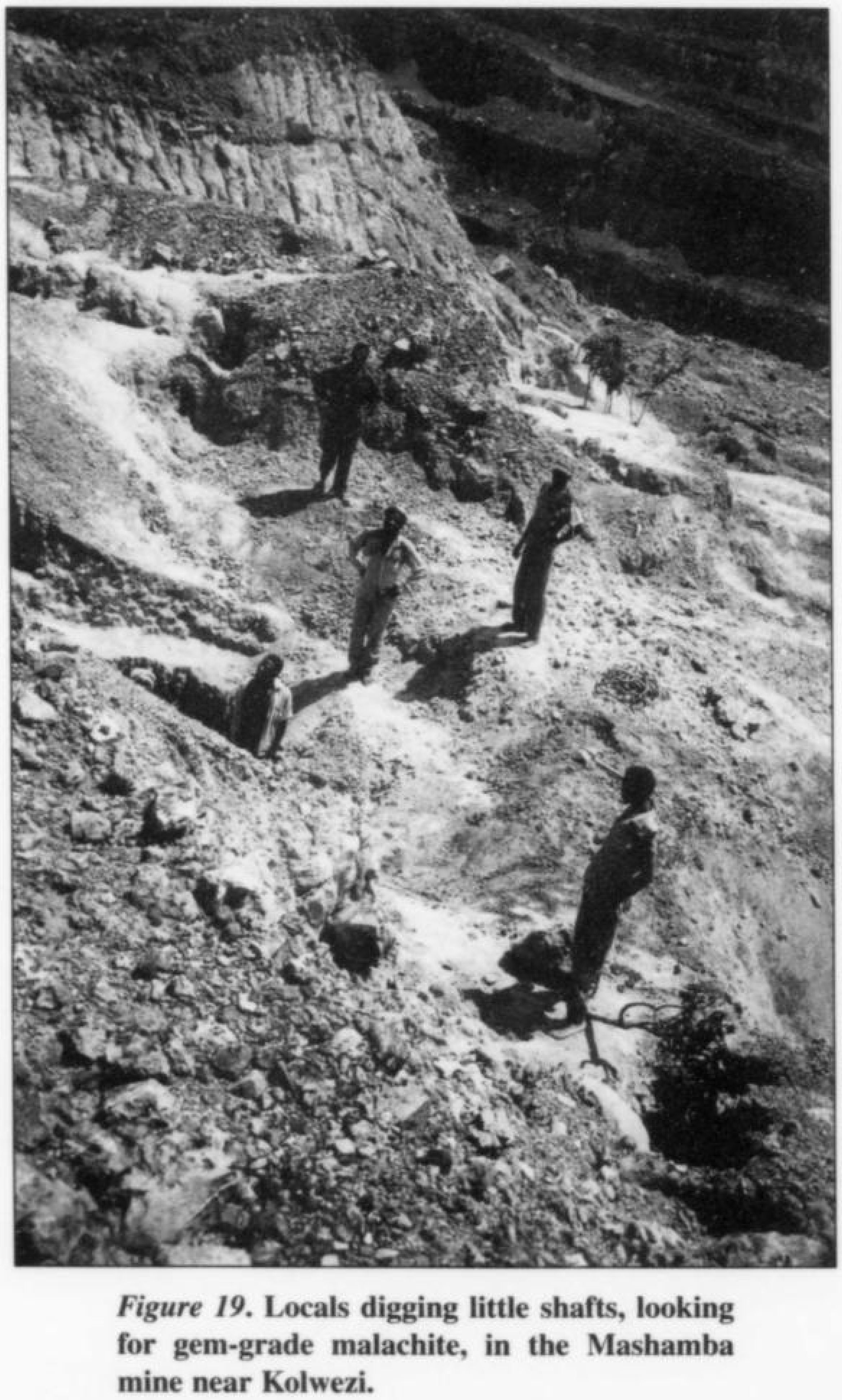


Figure 19. **Locals digging little shafts, looking for gem-grade malachite, in the Mashamba mine near Kolwezi.**

The trip back to Lubumbashi through Likasi was disappointing. When we asked permission to visit the museum in Likasi and to visit Shinkolobwe we were told that we did not have the correct permits. We spent three hours running down the mayor of the town, but he gave us the same answer. I imagined that maybe during the recent revolution the collection had been pillaged, and they were not eager to have that fact advertised. If anyone knows the current status of this collection, I would be glad to hear about it.

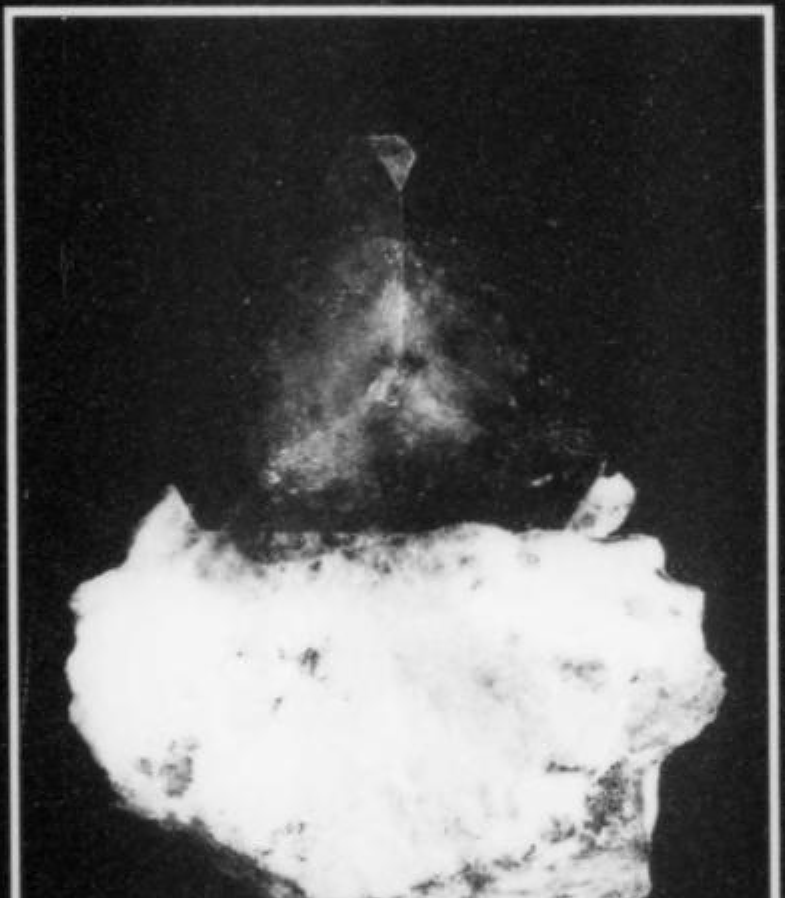
After passing only a few more roadblocks we would be home. Roadblocks were always a source of worry—but Sam said that in Mobutu's time there had been twice as many. At one of the army roadblocks we got chummy with the soldiers, and I got a great photo of them brandishing their weapons. I tried to take some pictures in the rural market place at Fungurume, but again the hue and cry of the people drove us away. We made it back to Lubumbashi before 6:00 P.M., as was necessary, since the army closed off the city at night (those who arrived late got to spend the night at the roadblock).

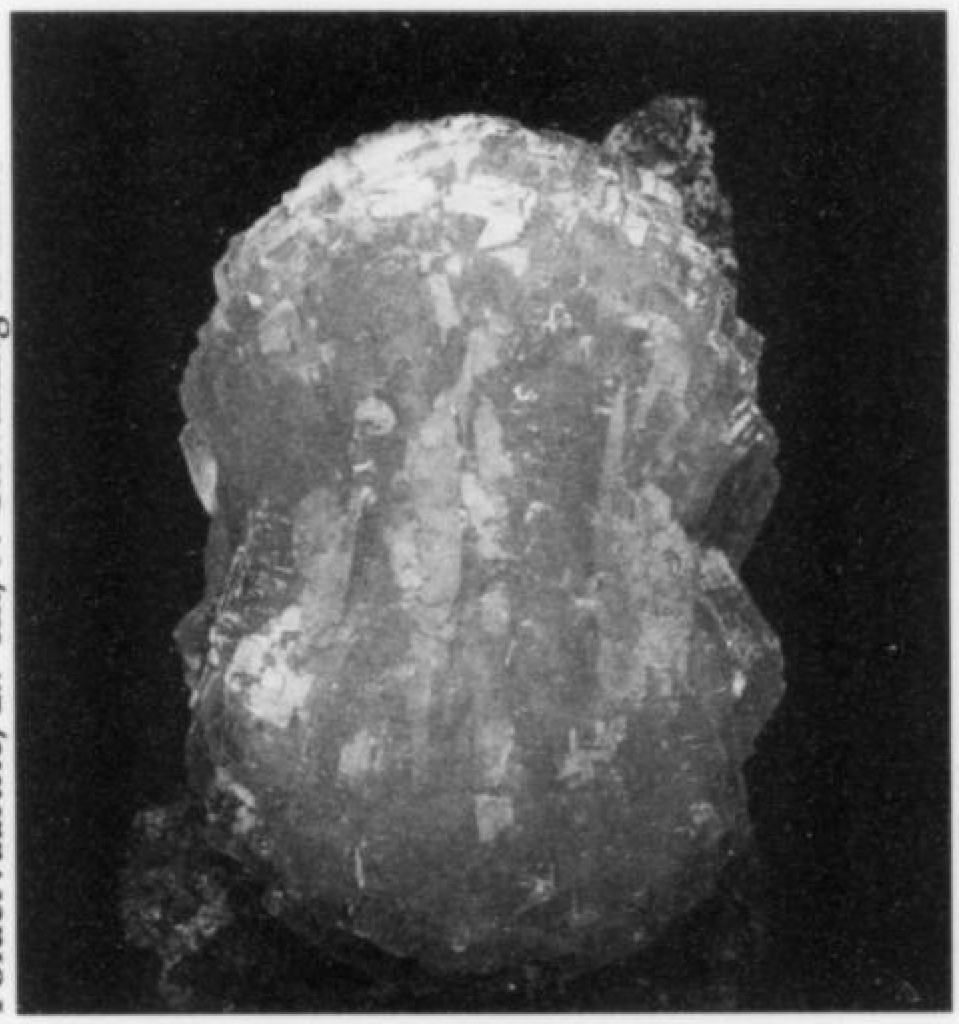
After the Spartan conditions of Kolwezi it was nice to be back in the relative luxury of Lubumbashi. There was nothing much to do except to select items of cut and polished malachite and happily paw through boxes of specimens brought to us by the runners. There was one 12-kg lot of hematite crystals from the Kundelungu Mountains, a little to the north of Lubumbashi: these were interesting, but few would end up in display cases. All of the specimens we were offered were of low quality, and most were damaged. Malachite specimens accounted for about 80% of our total haul.

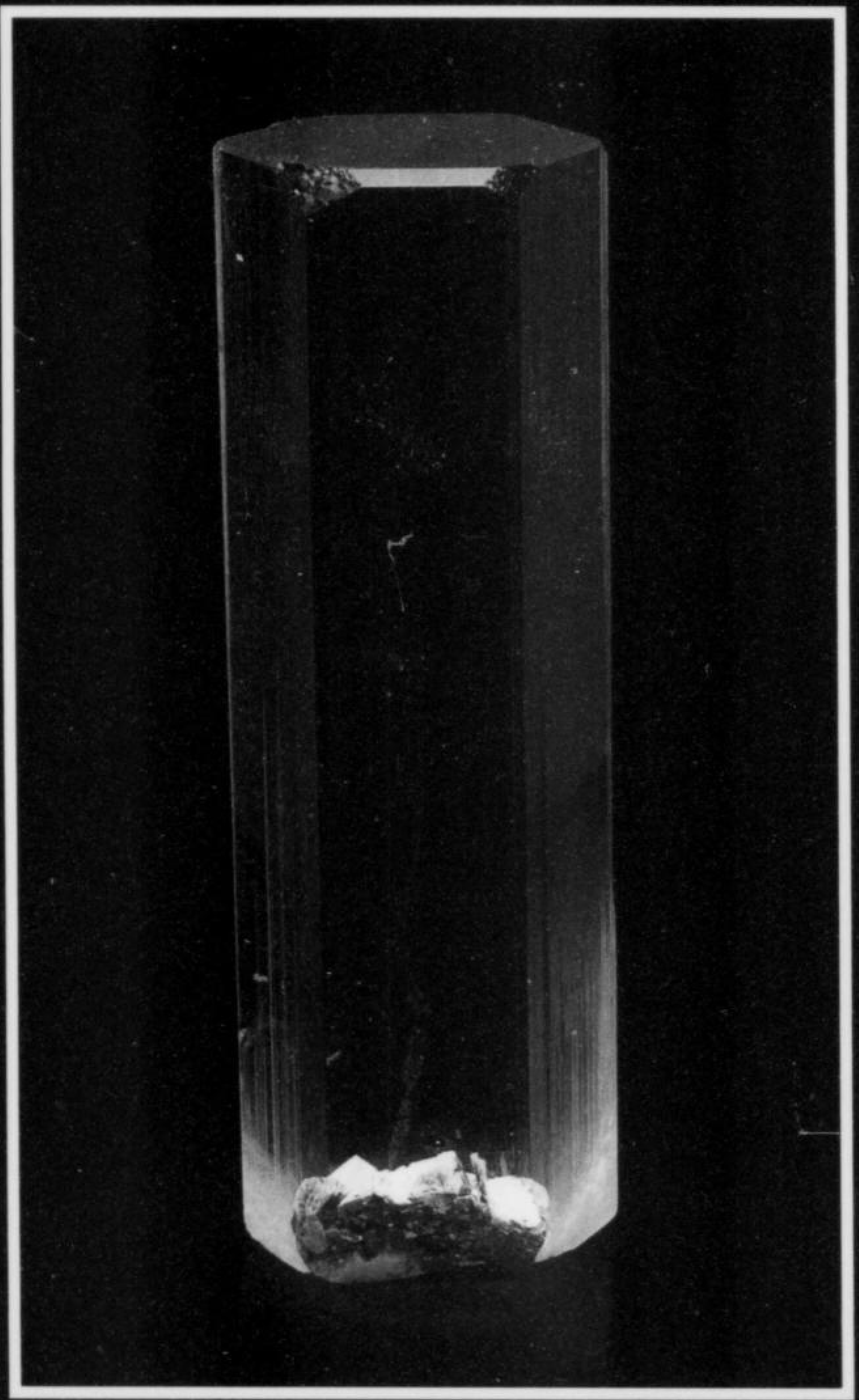
The Etoile is an abandoned mine just outside of Lubumbashi. Etoile is French for "star," so sometimes labels will give the locality as the Star mine, though the locals know it as the Kalukuluku mine, named after the nearest village. It has produced a seemingly unending stream of chrysocolla specimens that no one seems to want—mostly breccia fragments coated with bright blue botryoidal chrysocolla that I suspect is a product of post-mining mineralization. I bought 50 kilograms of these specimens, and I think that when it becomes possible to export specimens from the Congo cheaply, these chrysocolla specimens will become common in the U.S. and Europe.

A new air service from Lubumbashi to Johannesburg had been inaugurated while we were in Zaire, and we decided to take advantage of its first flight. There was a mad rush to get all of our material packed up, and the paperwork generated and processed. We were up into the small hours of the morning. The negotiations for the permits, and the usual squeeze, made the whole process a real cliffhanger. Air freight costs, squeeze, brokerage, etc., can easily drive the cost of an air shipment to more than $10 per kilogram.

The airport had suffered during the recent revolution: the glass in the terminal building doors was broken out, and all the chairs had been stolen, so there were no places for passengers to sit. On our way through immigration control we were informed that Victor and I were in the country illegally, because our visas were only good for a week (we hadn't noticed). It cost each of us $75 extra to get onto the plane. Sam, being a resident, could come and go as he pleased. Even on the way out of the country, we were told that our vaccination certificates were invalid. We made a stop at the airport at Ndola, Zambia, apparently just so the officials could make us all get off the plane, go into the terminal building, and be charged a $25 transit fee. But on the flight out of Zambia we had a fine view of the great Victoria waterfall.







The
NUEVA VIZCAYA MINE
Burguillos Del Cerro
Badajoz, Spain

José González del Tánago
Department of Petrology and Geochemistry
Fac. Ciencias Geologicas, Univ. Complutense
28040 Madrid, Spain
e-mail: tanago@eucmax.sim.ucm.es

Borja Saínz de Baranda Graf
Miami, 3, 4°C
28027 Madrid, Spain

Superb, idiomorphic, La-dominant allanite/REE-rich epidote crystals have been found in the Nueva Vizcaya mine, Burguillos del Cerro (Badajoz Province). The occurrence is remarkable for the beauty, sharpness and size of the crystals (to 4 cm).

INTRODUCTION

The Fe-Ca skarn-type deposits of southeastern Spain form a small metallogenic province, that includes some of Badajoz, Huelva and Seville provinces. These skarns were the focus of mining in the 1950's and 60's, especially those that are situated around the Burguillos del Cerro batholith (Extremadura community). After this period of maximum development, mining ceased and the workings were abandoned. Most of the specimens now in public and private collections were found in the last 20 years, in the old dumps, as a result of the systematic work of diligent collectors.

In the course of this work, La-rich allanite, and epidote rich in rare earth elements (REE) were found during the 1974–1990 period in a small prospect, the Nueva Vizcaya mine. Because of the diligent work of these collectors, many specimens were saved for science (most of the productive dumps were recently bulldozed), so we dedicate this paper to them.

Allanite and REE-rich epidote were previously known as microscopic accessory minerals from some of the skarns in the Burguillos del Cerro mining district, such as the Sierra del Cordel (Cordel Mountains) skarns. Arribas (1962) wrote about an allanite (actually REE-epidote) from the Monchi mine containing 2.0% Ce_2O_3 and 2.5% La_2O_3, but did not provide a complete analysis. However in the analysis of the allanites and epidotes from this district made recently for the current study, we were not able to confirm those earlier results; instead we always found that Ce > La > Nd. This appears to happen commonly in the microscopic allanite of this district. For this reason, the macroscopic La-dominant allanite and

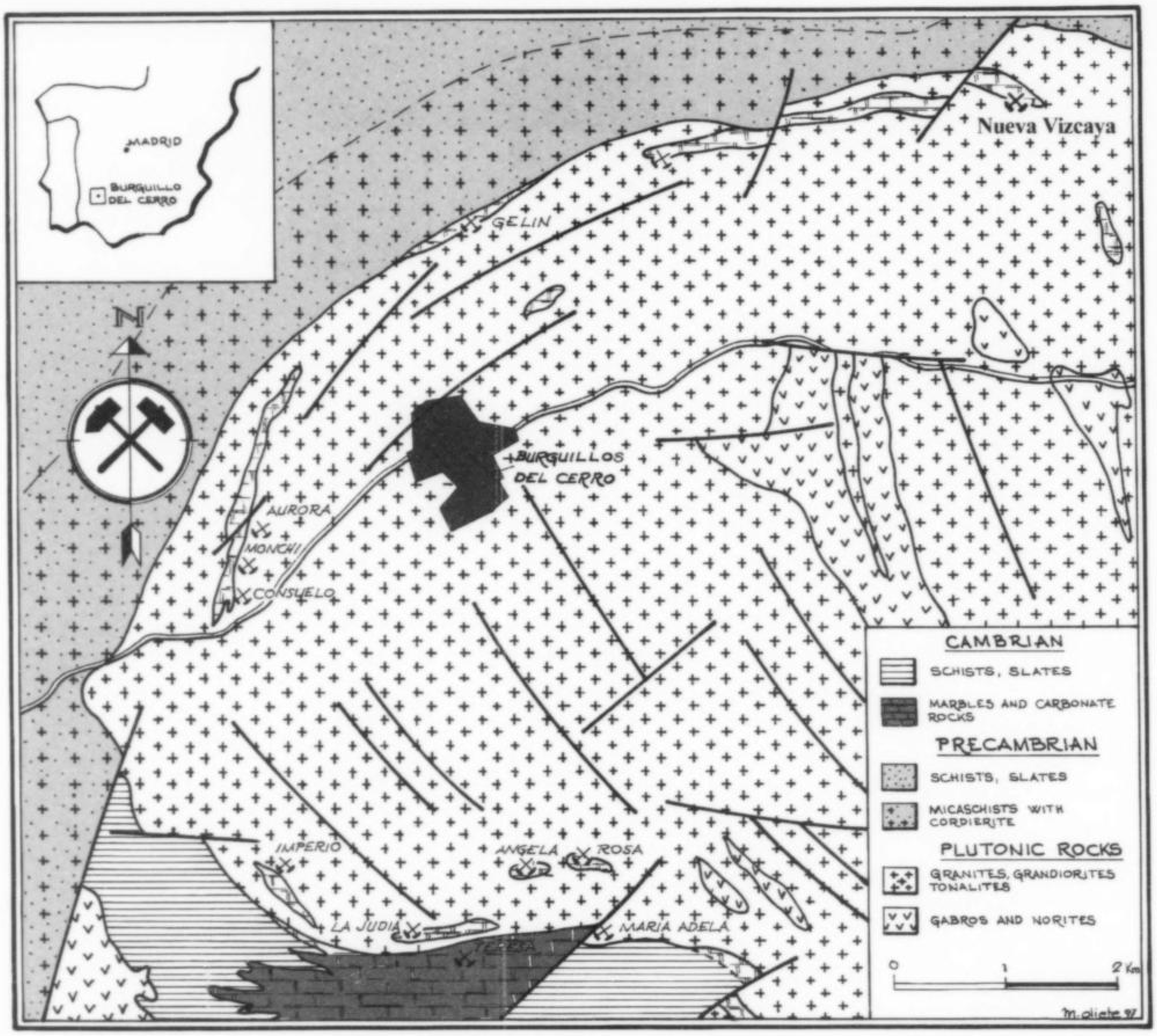


Figure 1. **Regional geology of the Burguillos del Cerro area showing the main old magnetite mines.**

REE-rich epidote crystals found in Nueva Vizcaya mine are unique.

Some of the physical and crystallographic characteristics of this material have already been studied (all of this as allanite) by Forteza *et al.* (1989) and Alvarez and Dominguez (1996). However, no complete analysis of REE, U and Th has been presented before now.

GEOLOGY

The magnetite skarn deposits of southeastern Spain (Burguillos del Cerro, Jerez de los Caballeros, Santa Olalla de Cala, etc.) are related to a late Hercynian magmatism of wide-ranging composition (granites to gabbros) that affected carbonate rocks of Cambrian age. This has traditionally been interpreted as occurring inside an active continental margin of circum-Pacific belt type.

The geological setting of the Burguillos del Cerro area (Fig. 1) could be summarized as a basement of Upper Precambrian age which crops out in the center of the Olivenza-Monesterio anticlinorium, formed by successive levels of schists, graywackes, shales and graphitic quartzites affected by a low-grade regional metamorphism (Benito *et al.*, 1977).

The following sequence of Cambrian units is located over the Precambrian rocks: Basal Conglomerates and Lower Detritic Series (shales and sandstones), Carbonate Series (limestones and calc-schists) and Upper Detritic Series (shales and sandstones). In the south part of the anticlinorium these units are replaced by a volcanic-sedimentary series with periods of iron oxide and sulfide mineralizations (Benito *et al.*, 1977).

All of these formations were modified by the Hercynian Orogeny, with an intense diastrophism during the first stage of deformation, after which some magmatic bodies were emplaced. Later there was a second diastrophism, followed by emplacement of the main intrusive bodies (granites, granodiorites, tonalites, diorites, gabbros), with a complex history of consolidation-intrusion.

One such body is the Burguillos del Cerro Batholith, which crops out over a large area of somewhat less than 100 km^2, with a contact metamorphic aureole 1 km wide. The carbonate rocks were transformed into marble and, at a postmagmatic stage, mineralization formed in the contact zone with the intrusive rocks.

The origin of the iron for the formation of the deposits is not completely clear in all cases. Most likely a metasomatic process was responsible, as suggested by Casquet and Velasco (1978) and Casquet (1991) for the Santa Olalla skarns, which are very similar to the skarn at the Nueva Vizcaya mine. Other authors, however, suggest an origin by assimilation of iron-rich sedimentary materials by the intrusive bodies (Ruiz, 1976; Calvo, 1980).

MINING

There are many magnetite deposits related to the Burguillos del Cerro batholith. At present, all the mines in these deposits are closed; reactivation of the workings in the near future is unlikely because of the high cost of the operations (Anonymous, 1987 and 1993). The most important mines in the Burguillos del Cerro district are the Monchi, Consuelo and Aurora claims, usually referred to as the Monchi mine. It is located 2 km west of Burguillos del Cerro village. Underground mining reached more than 300 meters in depth in 1978, when mining ceased in this complex because of low reserves and excessive depth (Vazquez Guzmán, 1980).

The ore minerals are magnetite and vonsenite. Bi-Co-U-REE minerals are very sparse, usually only as microscopic minerals without economic value. Occasionally this mine has produced some good löllingite and vonsenite specimens. Several other mines in the Burguillos del Cerro district (La Judia, La Herreria, Bilbaina, Coto Real, Los Perdigones etc.) have yielded excellent minerals typical of skarn deposits (epidote, amphibole, hedenbergite, andradite-grossular, magnetite etc.), but so far macroscopic allanite has not been found in the other mines.

The Nueva Vizcaya mine is a small prospect started in 1959, which operated for only two years. Four men worked the mine, two outside on the hoist, and two in the deep workings. According to an old miner, the 2 x 2-meter square shaft reached 35 meters in depth, and two small galleries were driven at this level. Now only part of the shaft and part of the dump are visible.

The mine is situated about 7 km northeast of Burguillos village (UMT coordinates: x = 127,60, y = 325,15). The gravel road to the Nueva Vizcaya mine is not in very good condition. It wanders through a landscape typical of Extremaduran grazing-land. Permission of the property owner is necessary to enter.

EXPERIMENTAL METHODS

The X-ray diffraction identification was conducted with a Phillips model PW 1840 X-ray diffractometer, using CuKα radiation, a solid-state counter and scanning rate of 0.005° 2θ/s.

The chemical analyses were conducted by WDS using a JEOL JXA-8900M superprobe electron microprobe at the Universidad Complutense (Madrid), operating at 15 to 20 Kv and 20 to 50 nA, with a beam width between 2 and 5 microns. The standards used (Jarosewich *et al.*, 1980; and Jarosewich and Boatner, 1991) were supplied by the Smithsonian Institution (Washington). REE values have been chondrite-normalized according to Evensen *et al.* (1978) and adjusted according to Taylor and McLennan (1985). The Fe^{2+}/Fe^{3+} ratio has been estimated according to Droop (1987).

MINERALOGY

The most interesting minerals from the Nueva Vizcaya mine are the La-dominant allanite/REE-rich epidote crystals. Magnetite and several other minerals including actinolite, albite, Ca-garnets, calcite, chlorites, epidote (REE-free), quartz, scapolite, titanite, zircon and some sulfides are associated. It is interesting to note that all of these minerals are typical of a retrograded calcic skarn (aposkarn) in a postmagmatic phase. High-temperature skarn minerals and host rock minerals are scarce and incompletely represented in the old dumps, so no description of them is offered here.

Actinolite $Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$

Amphiboles (hornblende, actinolite-tremolite) are common in the skarn deposits of the Burguillos del Cerro area, as late-stage minerals replacing pyroxene. This is seen in the Nueva Vizcaya mine, where Fe-Mg amphibole is very abundant and sometimes constitutes a major component of the rock. It forms large prismatic to acicular, dark green crystals to 2 cm in size.

According to the Leake *et al.* (1997) classification, and considering the generic formula for the amphibole group, $AB_2C_5^{VI}T_8^{IV}O_{22}(OH)_2$, the chemical analysis of the amphibole from the Nueva Vizcaya mine shows Si filling the T position, and the A position remaining vacant. Furthermore, the ratio Mg/(Mg+Fe) is very similar in all analysis performed, in the range 0.71–0.75; so these amphiboles could be assigned to actinolite in the tremolite-ferroactinolite series. One representative analysis selected (Table 1) indicates for 22 oxygens the following empirical formula: $(K_{0.02}Na_{0.02}\square_{0.96})(Ca_{1.9}Na_{0.10})(Al^{VI}_{0.24}Fe^{2+}_{1.32}Mn_{0.02}Mg_{3.42})(Si_{7.8}Ti_{0.02}Al^{IV}_{0.18})$.

Albite $NaAlSi_3O_8$

Albite has been found in clusters of tabular crystals in parallel growths up to 4 cm and, less commonly, in isolated xenomorphic or subidiomorphic crystals to several millimeter size. The crystals have distinctive pink-rose color. Microprobe analysis gave a very low calcium content, indicating an albite very close to the end-member composition.

La-dominant allanite $(Ca, La)_2(Al,Fe^{3+})_3(SiO_4)_3(OH)$

Allanite belongs to the epidote mineral group, with a general chemical and structural formula $A_2M_3Si_3O_{12}(OH)$ (Dollase, 1971) where A = Ca, Mn, Y, REE, Th; M = Al, Fe^{2+}, Fe^{3+}, Mg, Ti. This structure is similar to that of epidote, and the two minerals form a complete solid solution series (Deer *et al.*, 1986; Pan and Fleet, 1990) by means of the substitutions involving $(REE)^{3+}Fe^{2+}Ca^{2+}_{-1}Fe^{3+}_{-1}$, although minor substitutions involving $Al^{3+}Fe^{3+}_{-1}$ and $(Fe^{2+},Ca)Mg_{-1}$ may also occur. The complex chemistry of these minerals increases with the introduction of other elements into the structure, like Be, Sr, V, Ga, Zn, Zr, Ge, Cr, etc. (Deer *et al.*, 1986; Pan and Fleet, 1991).

The REE-rich epidote and allanite boundary is where the Ca/REE ratio equals 3. On the basis of 12.5 oxygens per chemical formula (without OH group) the mineral is considered to be allanite only when Ca < 1.5 and REE > 0.5 cations. However it is common to find in the mineralogical literature that REE-rich epidotes are considered to be allanites, with REE contents as low as

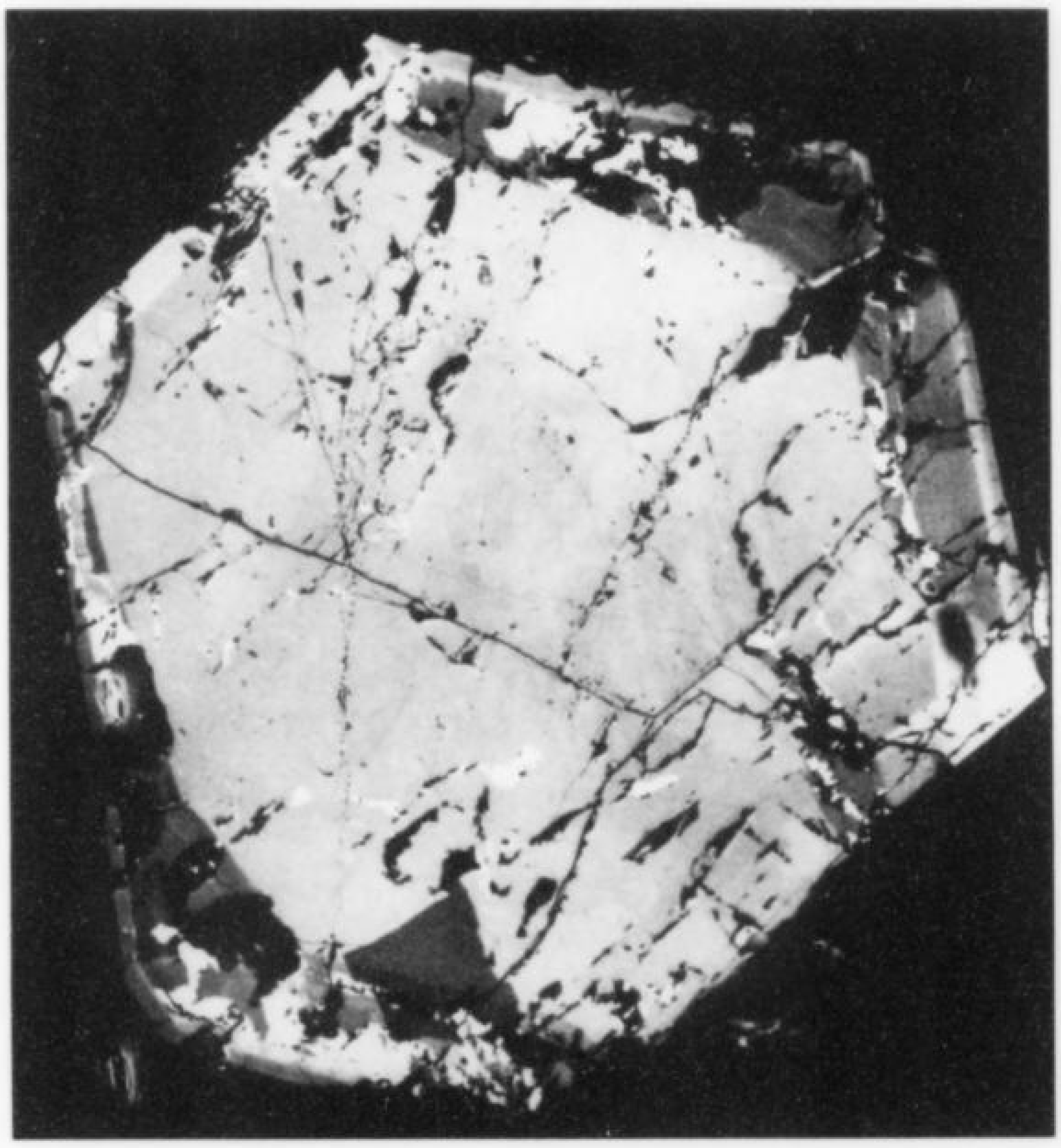


***Figure 2.* Back-scattered electron image of a composite crystal of La-dominant allanite/REE-rich epidote; white areas are allanite. A. Fernández Larios photo.**

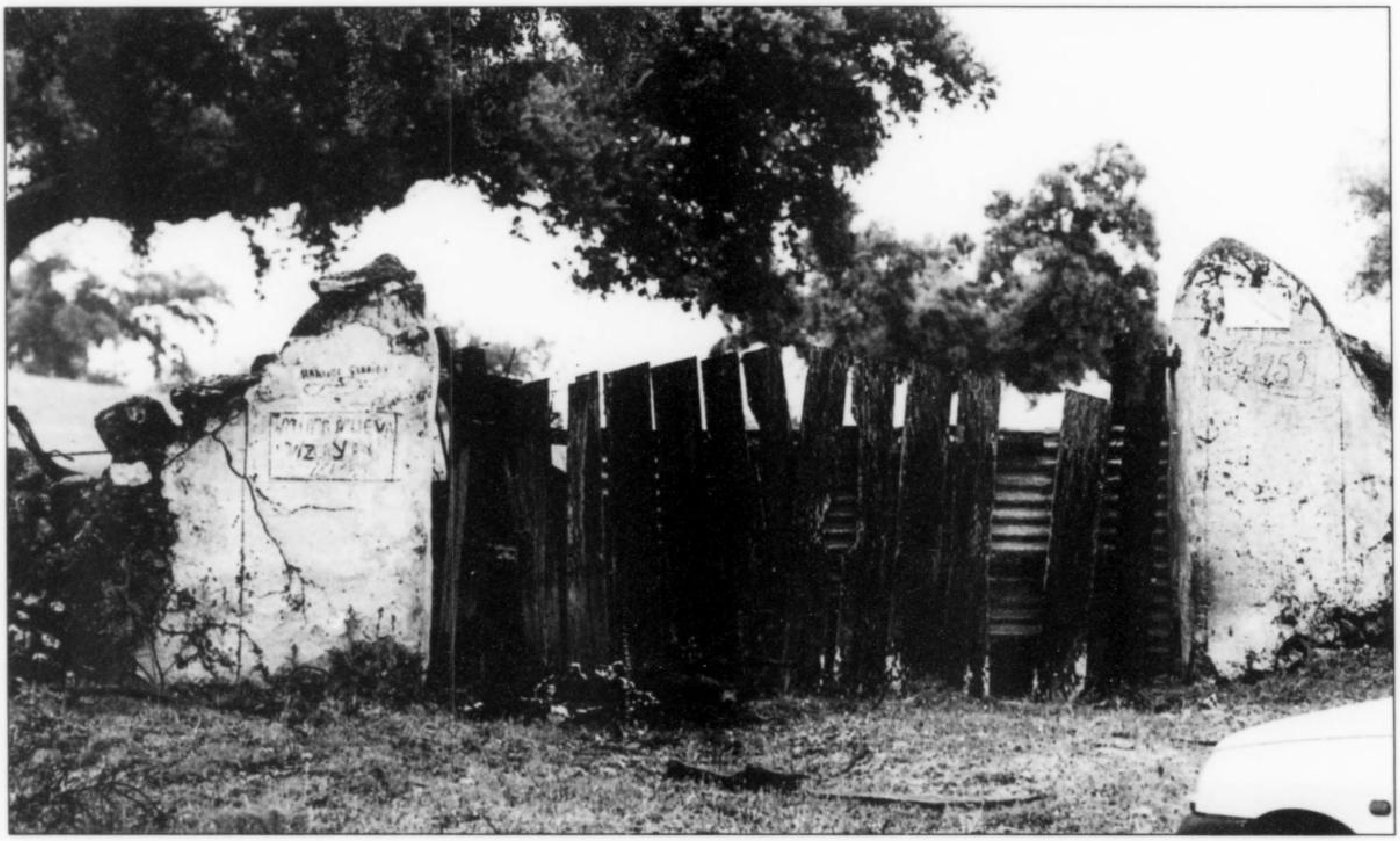


Figure 3. View of the entrance to the Nueva Vizcaya mine area. On the wall is written: "Mina Nueva Vizcaya. 1959." Photo by J. M. Gordillo, April 1997.

Figure 4. View of the old dumps of the Nueva Vizcaya mine in January 1991. Photo by Borja Sainz de Baranda.

Table 1. **Representative electron microprobe analyses of Nueva Vizcaya mine minerals.**

	*act**	*grt**	*chl**	*epd**	*scp**	*tit**	*zrn**
SiO_2	53.23	37.53	26.03	38.24	51.47	30.59	30.90
Al_2O_3	2.46	11.27	18.68	23.92	24.53	1.13	<0.01
FeO_{total}	10.77	13.34	25.77	11.61 (1)	0.05	0.86 (1)	0.87
MnO	0.15	0.24	0.43	0.22	<0.01	<0.01	0.17
MgO	15.64	0.44	14.21	0.02	<0.01	<0.01	<0.01
CaO	12.09	35.79	0.01	23.61	11.68	30.33	1.20
Na_2O	0.41	0.01	<0.01	0.02	6.88	<0.01	nd
K_2O	0.11	<0.01	<0.01	<0.01	0.65	<0.01	nd
TiO_2	0.19	0.60	0.01	0.01	0.01	35.41	<0.01
Cr_2O_3	<0.01	0.02	<0.01	—	—	—	nd
NiO	0.01	—	—	—	—	—	nd
Y_2O_3	—	—	—	<0.01	—	0.16	0.67
S	—	—	—	—	0.12	—	nd
Cl	—	—	—	—	2.03	—	nd
F	—	—	—	—	0.02	—	nd
Total	95.13	99.24	85.14	97.03	97.43 (2)	98.58	97.71 (3)

Number of Ions on the basis oxygens:

	22	*12*	*14*	*12.5*	*24*	*5*	*4*
Si	7.80	2.95	2.84	3.04	7.35	1.02	1.00
Al^{IV}	0.18	0.05	1.16	—	0.65	—	—
Al^{VI}	0.24	1.00	1.25	2.23	3.51	0.04	—
Ti	0.02	0.04	—	—	—	0.89	—
Cr	—	—	—	—	—	—	—
Fe^{3+}	—	0.98	—	0.69	—	—	—
Fe^{2+}	1.32	—	2.35	—	—	0.02	0.02
Ni	—	—	—	—	—	—	—
Mn	0.02	0.02	0.04	0.01	—	—	—
Mg	3.42	0.05	2.31	—	—	—	—
Ca	1.90	3.02	—	2.02	1.81	1.08	0.04
Na	0.10	—	—	—	1.87	—	—
K	0.02	—	—	—	0.11	—	—
Y	—	—	—	—	—	—	0.01
S	—	—	—	—	0.01	—	—
Cl	—	—	—	—	0.49	—	—
F	—	—	—	—	0.01	—	— (4)

*act = actinolite; grt = garnet; chl = chlorite; epd = epidote; scp = scapolite; tit = titanite; zrn = zircon; nd = not determined.
(1) $Fe_{tot} = Fe_2O_3$; (2) Total 96.93 if F = O, Cl = O, S = O; (3) including ZrO_2 = 56.99, HfO_2 = 0.89, ThO_2 = 0.04, UO_2 = 4.80, PbO_2 = 0.08, Y_2O_3 = 0.67, La_2O_3 = 0.2, Ce_2O_3 = 0.10, total other TR-oxides = 1.10. (4) more ions: 0.03 of U, 0.90 of Zr and 0.01 of Hf-.

0.29 cations (Deer *et al.*, 1986; Pan and Fleet, 1991) or only 10% $(REE)_2O_3$ (weight) equivalent to 0.33 REE cations (Fleischer, 1985).

Allanite-(Ce) and allanite-(Y) are known (Mandarino, 1999). A lanthanum analog, however, has not officially been named. González del Tánago (1997) described an Nd-dominant allanite from a Spanish granite pegmatite. Most of the allanites described in the bibliography are allanite-(Ce), as are the allanite from localities listed by Clopton and Wilson (1995). La-dominant allanite is very scarce (perhaps none known in hand-specimen), and few references to it are found (Hugo, 1961; Zhirov *et al.*, 1961; Pan and Fleet, 1991). Only nine of the 506 allanites analyzed by Fleischer (1985) were La-dominant.

In the Nueva Vizcaya mine the La-dominant allanite (REE > 0.5 cations) forms small, irregular zones or patches in REE-rich epidote crystals. The boundary between the two minerals is not sharp, so the La-dominant allanite can only be distinguished by back-scattered electron (BSE) images. Furthermore, it is near-impossible to obtain a pure La-dominant allanite fragment sufficient to make a study of its crystallochemical structure. For this reason, at the present, it has been impossible to describe the structure of this allanite (Ron Peterson, personal communication).

The La-dominant allanite/REE-rich epidote specimens were found in the Nueva Vizcaya mine in a specific part of the dump (A. Roldán and J. M. Gordillo, personal communication, and as the authors have been able to verify), where it was relatively common. The specimens were embedded in white or, more frequently, orange calcite. The orange calcite constituted an excellent guide to prospecting for allanite.

The crystal size is variable, to 4 cm in maximum length, although crystals are most common in the 0.5 to 2 cm range. The larger crystals are black in color (sometimes with red or brown internal reflections) and translucent, whereas the smaller are brown, with typical resinous luster. Prismatic (parallel to "b" axis) and tabular are the two typical habits of these crystals (Fig. 5); frequently the prismatic crystals are larger.

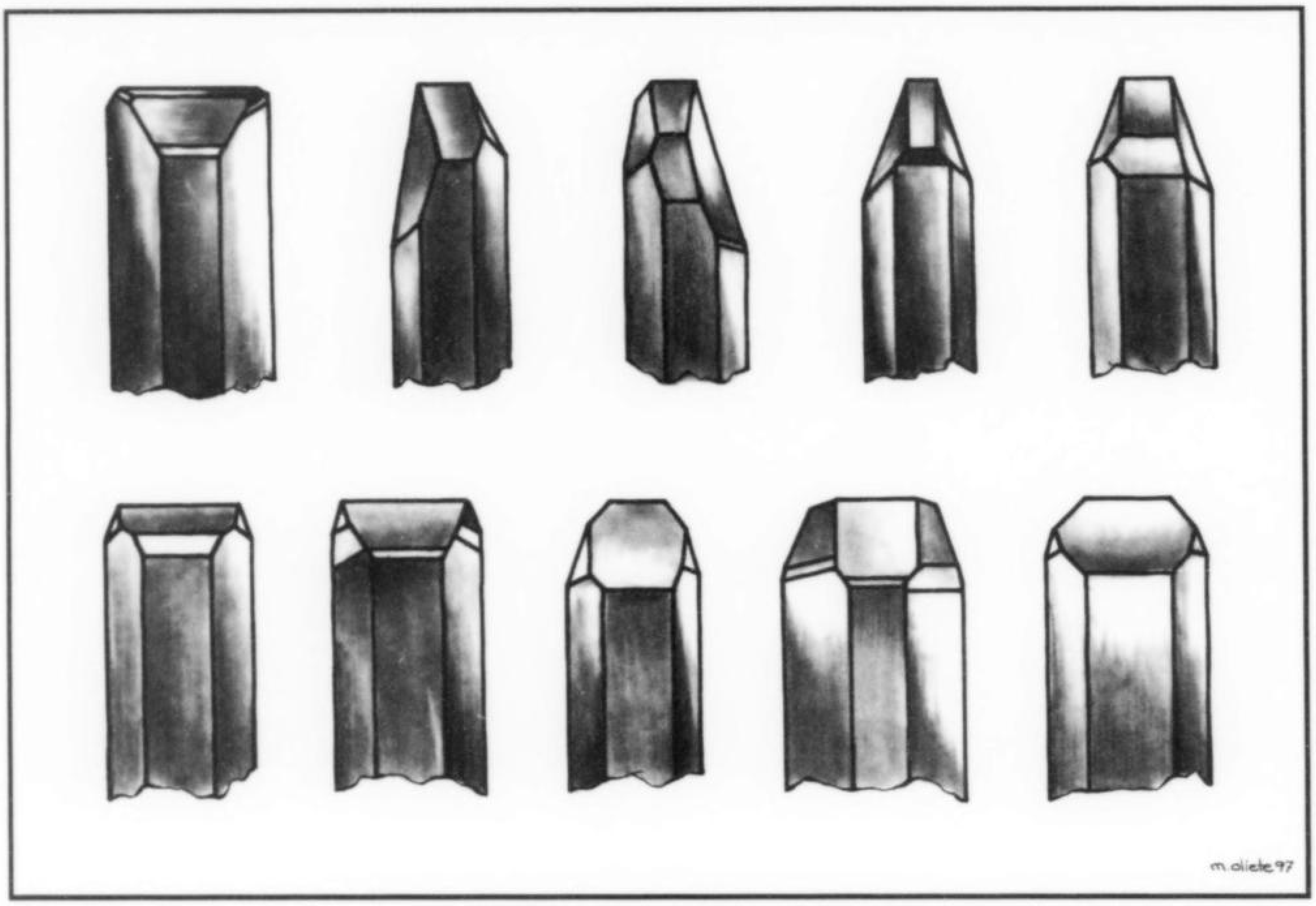


***Figure 5.* Sketches showing the common habit of the Nueva Vizcaya mine La-dominant allanite and REE-rich epidote crystals, by B. Sainz de Baranda and M. Oliete.**

Representative analyses of these crystals are listed in Table 2. Always La > Ce > Nd > Y is found in all zones. The La/Ce ratio ranges from 1.08 to 1.25 in 16 different analyses performed. One later generation of epidote with very low REE has been found (sometimes epitactic on allanite), and will be described later.

The cationic substitution $(\mathrm{REE})^{3+}\mathrm{Fe}^{2+}\mathrm{Ca}^{2+}_{-1}\mathrm{Fe}^{3+}_{-1}$ in the analyzed crystals is represented in the diagram REE + Y + Fe^{3+} + Mg versus Ca + Mn + Al + Fe^{3+} (Fig. 3). The spots are situated near the line where the solid solution allanite-epidote is represented, confirming the continuous solid solution (Pan and Fleet, 1990).

The REE content of La-dominant allanite, when referred to the chondrite normalized REE pattern (Fig. 4), shows poor H-REE, typical of this mineral which is higher in L-REE in contrast to H-REE (Deer *et al.*, 1986).

Yttrium and scandium contents are low, as well as uranium and thorium. The very low grade of metamictization of these allanites (as shown by the X-ray diffraction patterns) is consistent with the chemical composition.

Andradite-Grossular $\mathrm{Ca_3Fe^{3+}_2(SiO_4)_3}$ - $\mathrm{Ca_3Al_2(SiO_4)_3}$

Garnet group minerals are scarce in the late paragenetic sequence of the Nueva Vizcaya mine. Garnet usually appears as very small trapezohedral crystals, with rounded faces of brown color, enclosed in actinolite. Microprobe analysis indicates an intermediate composition between andradite and grossular, with 49 to 58% andradite. Minor Mn, Mg and Ti contents are present (Table 1).

Chlorite group $\mathrm{(Mg,Fe^{2+},Al)_6(Si,Al)_4O_{10}(OH)_8}$

Chlorite group minerals appear as small crystals of hexagonal habit up to 3 mm in size. Crystals are pale green and, as a very late mineral in the paragenetic sequence, are found on magnetite, scapolite, amphibole, etc. Chemical analyses show Mg/Fe near 1, with Mg either > or < Fe in different zones of a single crystal. Si content is just under 3 ions for 14 oxygens, so according to Wiewiora and Weiss (1990) the species is in the sheridanite-ripidolite series. One representative analysis, shown in Table 1, corresponds to the following empirical formula: $\mathrm{((Mg_{2.31}Fe^{2+}_{2.35}Mn_{0.04})\text{-}Al_{1.25}\square_{0.05})(Si_{2.84}Al_{1.16})O_{10}}$. (OH) groups have not been considered.

Epidote $\mathrm{Ca_2(Fe^{3+},Al)_3(SiO_4)_3(OH)}$

REE-free epidote is a very common late-stage mineral in this deposit, appearing as small, prismatic crystals and groups to 3 cm in length, sometimes epitactic on La-dominant allanite/REE-rich epidote. The crystals have a pale green to yellow-green color with a high luster.

Qualitative electron microprobe analysis (Table 1) indicates a variable content in clinozoisite-end member (5.88 to 24.33%), and minor amounts of Mn and Mg. No significant quantities of REE, U and Th have been detected in this late-stage epidote.

Magnetite $\mathrm{Fe^{2+}Fe^{3+}_2O_4}$

Magnetite is the most abundant mineral in the Nueva Vizcaya mine dumps. The oldest magnetite generation occurs as xenomorphic crystals included in the La-dominant allanite/REE-rich epidote.

A later generation of magnetite usually occurs as idiomorphic, octahedral crystals to 8 mm in size (although sharp crystals to 2 cm have incidentally been found). One very typical habit of the magnetite from this mine is as flat groups of octahedral crystals with star-shaped form, perhaps because of repetitive spinel-law twinning. Dodecahedral forms have not been found, though common in other mines of Burguillos del Cerro district.

The presence of inclusions of octahedral magnetite and La-dominant allanite/REE-rich epidote within each other indicates that for a time both minerals were crystallizing simultaneously, although magnetite growth continued longer. The presence of both

***Table 2.* Representative microprobe analyses of La-dominant allanite/REE-rich epidote of Nueva Vizcaya mine*.**

	a1	*a2*	*a3*	*a4*	*e1*
SiO_2	33.22	33.06	32.90	32.00	35.30
Al_2O_3	17.72	18.64	18.41	17.43	20.58
FeO_{tot}	13.47	13.25	12.85	13.12	12.51
MnO	<0.01	<0.01	0.01	<0.01	<0.01
MgO	0.23	0.19	0.01	0.22	0.33
CaO	13.16	14.16	13.59	12.74	18.87
TiO_2	0.16	0.07	0.15	0.10	0.13
ThO_2	0.09	0.02	0.01	0.07	0.04
UO_2	0.01	0.05	0.03	<0.02	0.09
Y_2O_3	0.01	0.12	0.14	0.09	0.04
La_2O_3	10.70	8.88	9.42	10.23	5.21
Ce_2O_3	8.58	8.13	8.95	9.22	4.50
Pr_2O_3	0.68	0.53	0.07	0.39	0.24
Nd_2O_3	0.54	0.71	1.06	1.70	0.49
Sm_2O_3	0.10	0.24	<0.05	0.18	0.12
Eu_2O_3	<0.04	<0.04	<0.04	<0.04	<0.04
Gd_2O_3	<0.03	<0.03	0.14	0.18	<0.03
Tb_2O_3	<0.04	<0.04	<0.04	<0.04	<0.04
Dy_2O_3	<0.04	0.01	0.08	0.11	<0.04
Ho_2O_3	0.02	<0.10	0.08	0.12	0.01
Er_2O_3	0.07	0.03	0.03	0.13	<0.12
Tm_2O_3	0.02	0.01	<0.06	<0.06	0.01
Yb_2O_3	0.02	0.01	0.01	<0.04	<0.03
Lu_2O_3	<0.03	<0.03	<0.03	0.01	<0.03
Total	98.25	98.25	97.90	98.01	98.53
			Number of ions on the 12.5 oxygens		
Si	3.03	2.98	3.01	2.99	2.98
Al	1.91	1.98	1.99	1.92	2.05
Fe^{3+}	0.30	0.41	0.29	0.33	0.64
Fe^{2+}	0.73	0.60	0.69	0.69	0.24
Mg	0.01	0.03	—	0.03	0.04
Ti	0.01	—	0.01	0.01	0.01
Mn	—	—	—	—	—
Ca	1.29	1.37	1.33	1.27	1.71
Th	—	—	—	—	—
U	—	—	—	—	—
Y	—	0.01	0.01	—	—
La	0.36	0.29	0.32	0.35	0.16
Ce	0.29	0.27	0.30	0.31	0.14
Pr	0.02	0.02	—	0.01	0.01
Nd	0.02	0.02	0.03	0.06	0.01
Sm	—	0.01	—	0.01	—
Eu	—	—	—	—	—
Gd	—	—	—	—	—
Tb	—	—	—	—	—
Dy	—	—	—	—	—
Ho	—	—	—	—	—
Er	—	—	—	—	—
Tm	—	—	—	—	—
Yb	—	—	—	—	—
Lu	—	—	—	—	—

*All analyses of Sc_2O_3 are less than 0.01%.

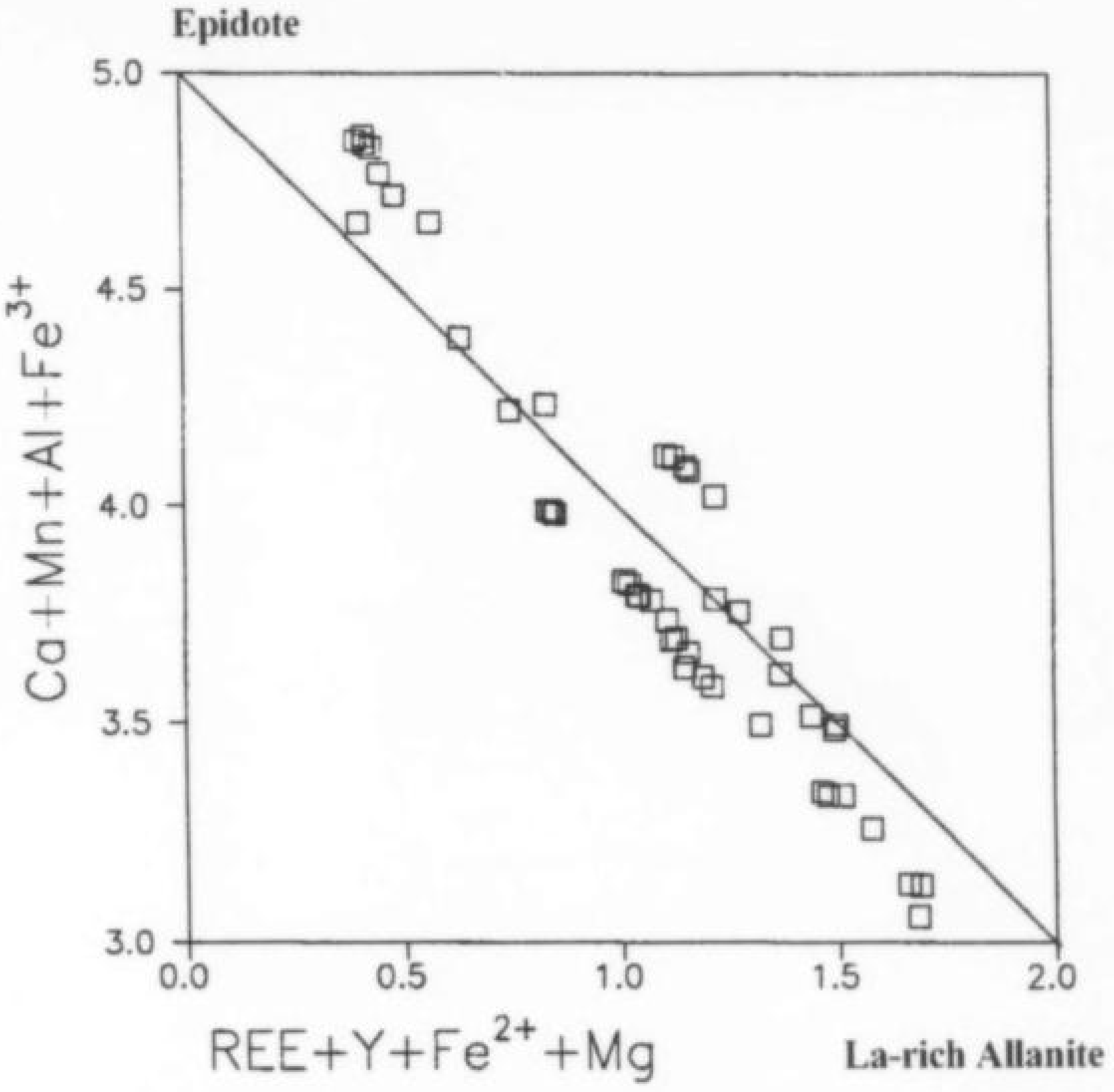


***Figure 6.* REE + Y + Fe^{3+} + Mg versus Ca + Mn + Al + Fe^{3+} plot showing continuous solid solution between epidote and allanite from Nueva Vizcaya mine.**

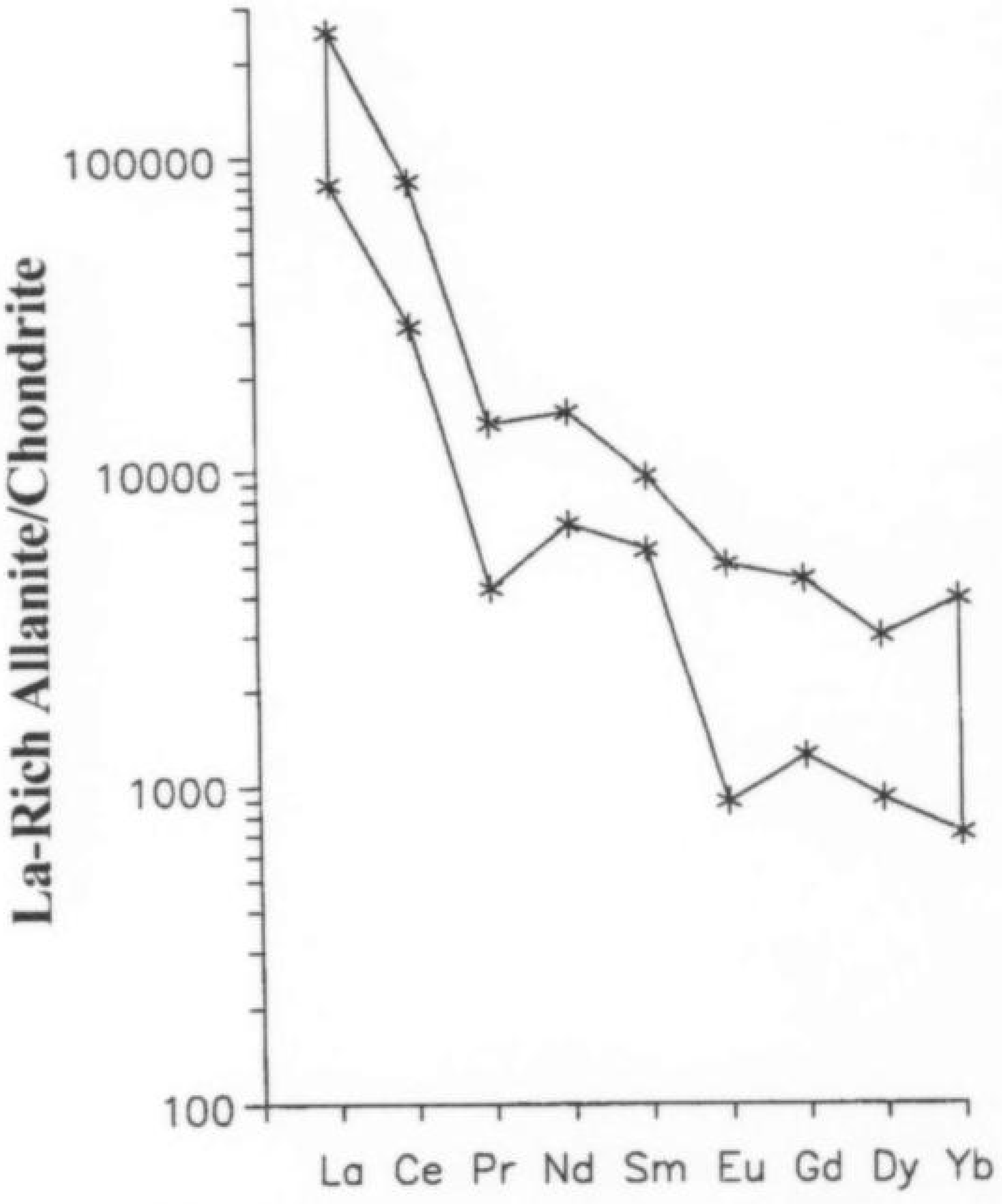


***Figure 7.* Chondrite-normalized REE patterns (maximum and minimum values) of La-dominant allanite from the Nueva Vizcaya mine.**

magnetite types is not surprising because, as Casquet and Velasco (1978) state, the magnetite formation took place over an extended period of time.

Chemical analyses of both types of magnetites show different Ti contents. Magnetite of the highest temperature may contain up to 0.7% TiO_2, whereas octahedral, low-temperature magnetite shows TiO_2 contents lower than 0.2% (Table 1).

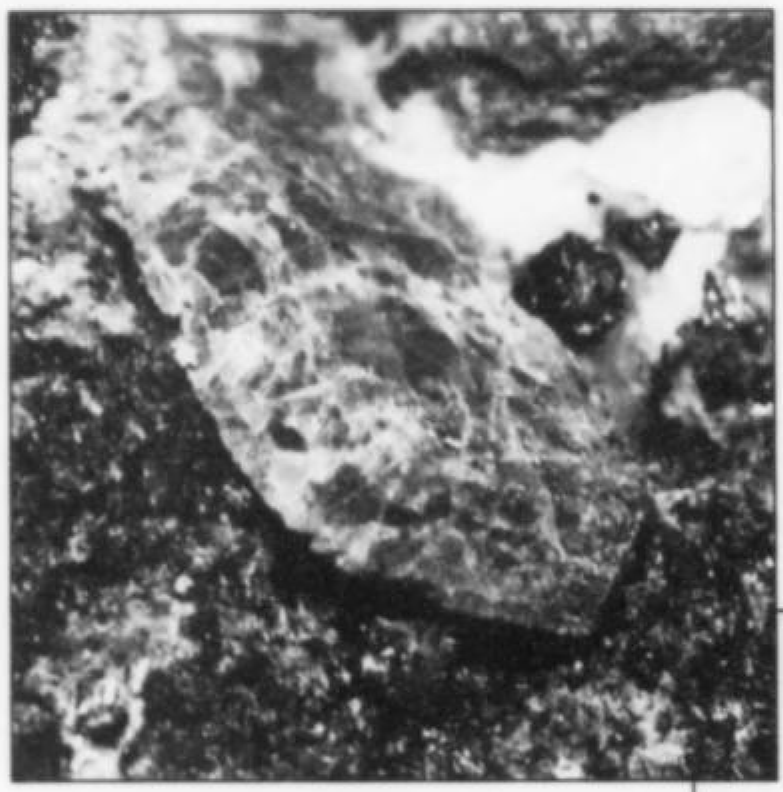


Figure 8. Titanite crystal, 1.8 cm, with zircon crystal group to 3 mm, epidote and magnetite. On the same specimen is a 3.5-cm crystal of titanite (broken). Collected in September 1984. Borja Sainz de Baranada (B.S.B.) collection and photo.

Figure 9. Magnetite octahedrons to 4 mm on edge with epidote crystals. Overall size of the specimen: 4.5 x 5.0 cm. Collected in January 1988. B.S.B. collection and photo.

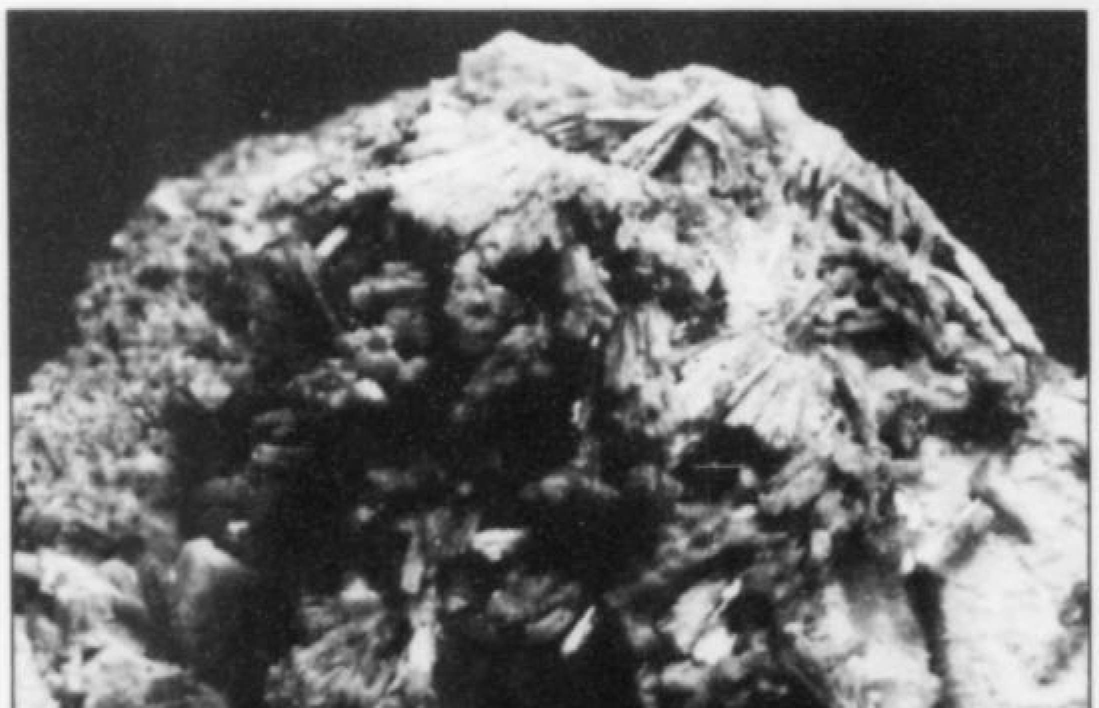


Figure 10. REE-free epidote crystal group on pink albite. Size of the specimen: 3.5 x 4.0 cm. Collected in September 1984. B.S.B. collection and photo.

Figure 11. La-dominant allanite and REE-rich epidote crystal, 6 x 18 mm, with magnetite octahedrons. Collected in January 1990. B.S.B. collection and photo.

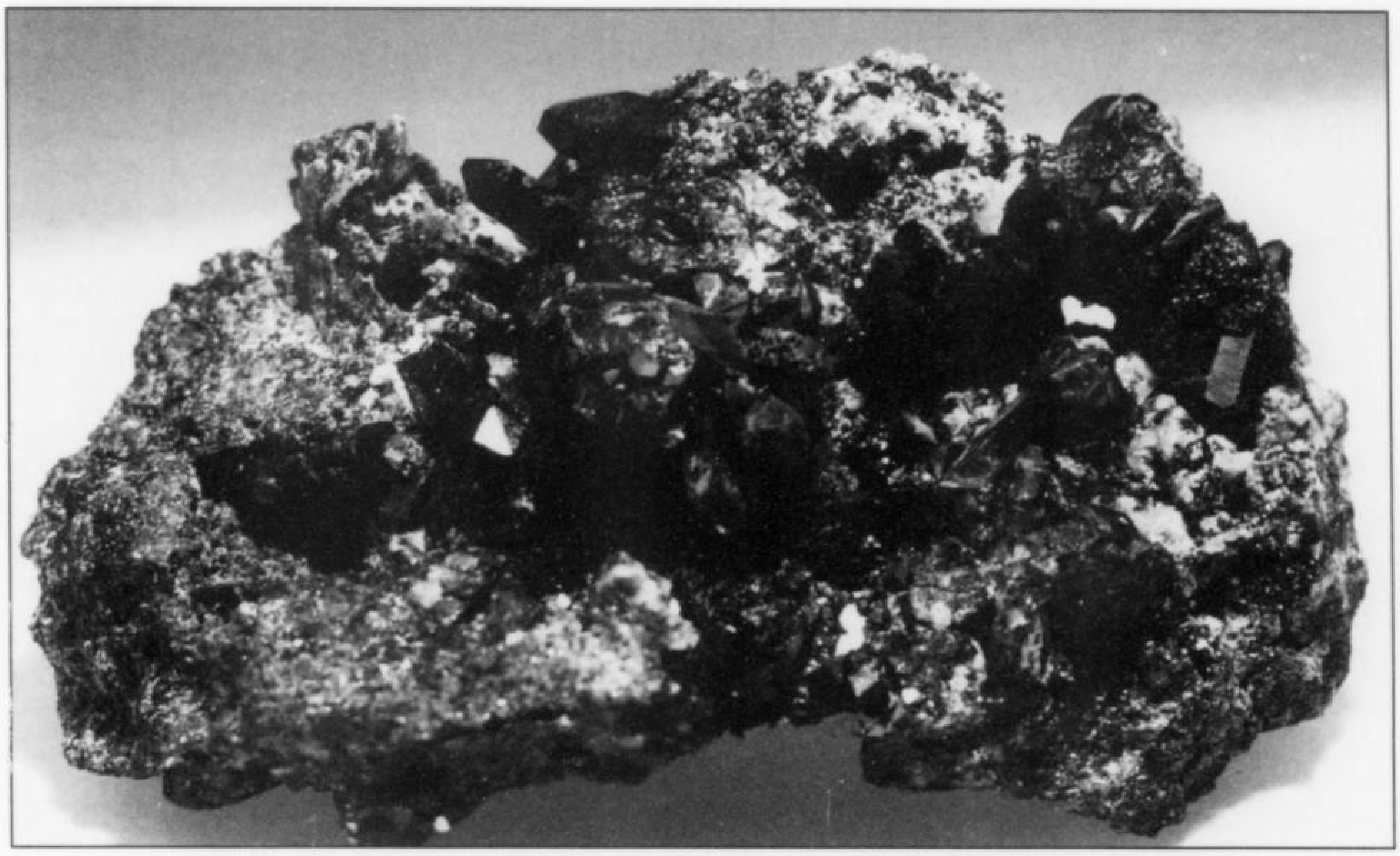


Figure 12. **Prismatic La-dominant allanite and REE-rich epidote crystals to 1.4 cm with minor epidote and magnetite. Overall size of the specimen: 4.0 x 7.5 cm. Collected in March 1988. B.S.B. collection and photo.**

Figure 13. **Large specimen (7.0 x 15.0 cm) with La-dominant allanite/REE-rich epidote crystals to 1.4 cm, magnetite (1.7 cm on edge), REE-free epidote (in part, epitactic on La-dominant allanite/REE-rich epidote) and one crystal pseudomorph after unknown early mineral. Collected in January 1988. B.S.B. collec-**

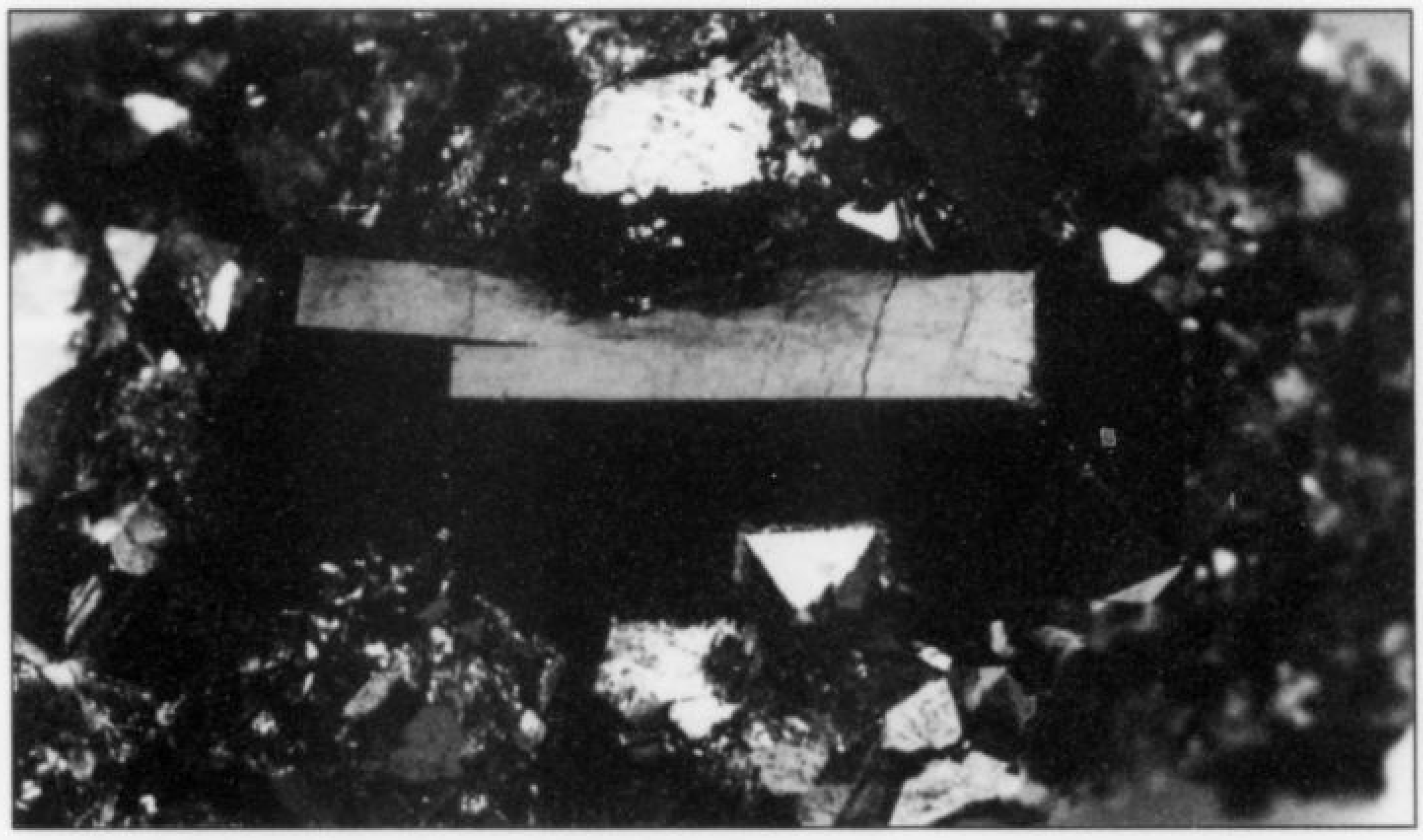


Figure 14. **La-dominant allanite and REE-rich epidote crystal, 1.2 cm, on magnetite, with minor epidote. J. M. Gordillo collection; B.S.B. photo.**

It is interesting to note that sometimes there is a low but significant content of La and Ce in the octahedral magnetite, as well as a low ratio of La/Ce, opposed to the La-dominant allanite/REE-rich epidote. This could be explained by the smaller ionic radius of Ce^{3+} versus La^{3+}, and therefore greater readiness of Ce to couple in octahedral coordination in the magnetite structure.

Marialite-meionite $Na_4Al_3Si_9O_{24}Cl$ - $Ca_4Al_6Si_6O_{24}(CO_3,SO_4)$

Scapolite group minerals are found in small quantities in the mine. The colorless, white or gray crystals show an octagonal outline, and less frequently, a quadrangular outline. Crystal size ranges from microscopic to 2 cm.

Marialite-meionite forms a solid continuous solution. Analyses performed in the scapolites from this deposit (Table 1) show marialite contents very near to 50%, but slightly higher than meionite.

Titanite $CaTiSiO_5$

Titanite is found sparingly in small crystals to 3 mm in size throughout the entire deposit. Some exceptionally large crystals to 3.5 cm have been found by one of the authors (B.S.B.) in a specific part of the deposit. The typical habit consists of pale brown perfect monoclinic crystals.

Chemical analysis (Table 1) indicates very pure titanite, with low Al and minor REE content.

Zircon $ZrSiO_4$

Zircon is scarce in the deposit. It occurs as prismatic crystals of 1–2 mm in size, and clusters of brown-red crystals to 5 mm with rounded crystal faces. Crystal forms observed are the prism and dipyramid.

Microprobe analysis of zircon indicates a high uranium content (Table 1), decreasing from the center to the border of the crystal in an irregular manner. Maximum content in the center of the crystal is 11.22% UO_2, and minimum contents in the border is 2.72%. In contrast, Th content is very low. As in magnetite, La/Ce ratios are <1 (in contrast to allanite), with a small enrichment in Y and H-REE.

Other species

A number of other species have been found in the Nueva Vizcaya mine, such as quartz, hematite (platy crystals and pseudomorphs after magnetite), pyrite (crystal groups with rounded faces) and chalcopyrite (associated with pyrite).

DISCUSSION

The different Fe-Ca skarn deposits of southeastern Spain, each with its own specific plutons and host-rock, are all retrograde to some extent, the process having occurred simultaneously with the magnetite mineralization stage. Some deposits in this area show a large period of aposkarn formation down to low temperatures, with formation of mica, chlorite group minerals, etc.

The skarn period is characterized by the formation of one-mineral or two-mineral rocks in the clinopyroxene (Fe-rich diopside, hedenbergite) or Ca-garnet (andradite-grossular, near 60–40%) facies. The different activity of alkalis (Na, K) in the fluids produced plagioclase (oligoclase-andesine), potassium feldspar and scapolite (Ruiz, 1976; Casquet and Velasco, 1978; Casquet, 1991). During the period of skarn formation minor accessory minerals are formed; in the Monchi mine, uraninite and allanite are found, enclosed in pyroxene (Arribas, 1962).

For the nearby deposits of Santa Olalla de Cala, Casquet and Velasco (1978) suggest a temperature under 600°C during the first period of skarn formation, which could be similar in the Nueva Vizcaya deposit.

In a second period, temperature decreased and a hydrothermal stage occurred, with local replacement of the higher temperature minerals (aposkarn). Some spaces are filled by hydrated silicates such as amphibole and epidote, as well as plagioclase (albite) and calcite. When the acidity of the fluids increased, magnetite was deposited, sometimes in association with vonsenite and ilvaite (Monchi mine). Finally, sulfides (pyrite, pyrrhotite, löllingite, chalcopyrite, cobaltite, bismuthinite) were deposited. According to Ruiz (1976), temperatures less than 500°C for the magnetite mineralization and less than 300°C for the sulfide deposition are most likely.

A textural study of some accessory minerals in Nueva Vizcaya mine such as albite and titanite indicates a formation period along this episode. Related to this episode is the formation of accessory minerals found in other similar deposits of the Burguillos del Cerro area, such as rutile, scheelite, ferropyrosmalite (J. Viñals, personal communication), schorl, axinite, apatite, bavenite (rare) etc.

One special case is the zircon formation. High uranium content and the absence of uraninite in the aposkarn of the Nueva Vizcaya mine may indicate the source of the uranium in the early uraninite (of similar temperature to the uraninite from the Monchi deposit). The La-dominant allanite/REE-rich epidote formation came later, with an absence of uranium in the hydrothermal fluids.

Finally, quartz and calcite formed at a very low temperature.

In the Nueva Vizcaya deposit, La-dominant allanite/REE-rich epidote and associated minerals (without anhydrous silicates) were formed in the aposkarn period. A temperature range of 300° to 500°C is assumed. However the epitactic epidote (REE-free) grown over La-dominant allanite/REE-rich epidote, and the fact that the majority of the magnetite (principally the octahedral idiomorphic one) formed after REE-rich epidote, makes one believe that the REE epidote and La-dominant allanite must have formed at the start of the aposkarn, probably at about 450°C.

In the Monchi deposit as well as other skarn deposits of the Burguillos del Cerro area, the microscopic allanite (Ce > La) observed is much earlier and it is linked to the skarn period. The close association with pyroxene confirms an early development (Arribas. 1962).

Thus we can consider two different types of allanite in the skarn deposits of Burguillos del Cerro area. The first-formed, in a higher temperature period, is a microscopic allanite-(Ce), widespread in the deposits. The later La-dominant allanite with REE epidote in larger crystals, of lower temperature, has only been found in the Nueva Vizcaya mine to date.

The source of the REE could be related to the dissolution of an early allanite during the hydrothermal period of aposkarn. This hypothesis is supported by the absence of other associated REE minerals.

The abundance of La-dominant allanite/REE-rich epidote in this deposit may indicate a lengthy period of hydrothermal fluid circulation and leaching of the high-temperature skarn minerals. The specific fractionation of the REE to form La-dominant minerals could be due to the simultaneous crystallization of large quantities of magnetite, which preferentially incorporate cerium over lanthanum in their structure. Because of the large quantities of magnetite, very low Ce in the structure of magnetite could still be enough to yield La > Ce in allanite/REE-rich epidote. According to Pan and Fleet (1991), one similar process occurs in the Hemlo gold deposits (Canada), in this case because of the simultaneous formation of titanite (in the Nueva Vizcaya mine the low quantity of titanite observed is not enough to support this theory). At the end of the allanite/REE-rich epidote formation period, REE in the hydrothermal fluids had become exhausted, and REE-free epidote formed.

The very low REE in this later epidote could be indicative of a new mineralization episode.

The later, low-temperature hydrothermal fluids do not affect the allanite crystals, which always show highly lustrous faces and an absence of corrosion textures. This explains the absence of secondary REE-minerals (carbonates, etc.) in the Nueva Vizcaya deposit.

It is interesting to note that the skarn episode occurs in epizonal conditions (<1 Kbar, <3 Km), according to Casquet and Velasco (1978), a fact which allows the circulation of hydrothermal fluids and favors the development of fluid-filled cavities where the different mineral phases may crystallize in idiomorphic forms.

CONCLUSIONS

The Nueva Vizcaya mine, in the Burguillos del Cerro district, should be considered the principal locality for La-dominant allanite and REE-rich epidote. Possibly the finest and most thoroughly characterized crystals of this material in the world have come from this locality. World-class specimens are presently owned by major private and public mineral collections. Furthermore, the locality has been a producer of collector-quality specimens of magnetite, titanite, scapolite group minerals and epidote.

The La-dominant allanite/REE-rich epidote crystals are optically and chemically zoned, with REE oxide content in a range of 9 to 22.55%. In all the zones analyzed, La > Ce > Nd > Y. Low uranium and thorium have been detected, and low-grade metamictization is observed.

The La-dominant allanite/REE-rich epidote crystals formed at the beginning of the aposkarn period, together with idiomorphic octahedral magnetite, at an estimated temperature of 450°C. Subsequently, epidote (with very low REE contents), actinolite, sulfides, calcite, quartz and chlorite were formed.

High lanthanum in the allanite-epidote is explained as resulting from a process of dissolution of an early allanite followed by the crystallization of magnetite, which could incorporate some cerium in its structure and thereby increase the La/Ce ratio in the hydrothermal fluids.

Presently the termination of mining in the district and the disappearance of the old dumps of the Nueva Vizcaya mine make the discovery of more La-dominant allanite/REE-rich epidote specimens very unlikely.

LABELING

We consider proper labeling of the specimens to be: "La-dominant allanite/La-dominant REE-rich epidote, Nueva Vizcaya mine, Burguillos del Cerro, Badajoz province, Spain." Nevertheless, we also would consider appropriate a shorter labeling such as: "La-dominant allanite, Nueva Vizcaya mine, Burguillos del Cerro, Badajoz province, Spain." This is because:

(1) Allanite and epidote are both always present in each zoned monocrystal; a specific analysis would have to be performed to determine whether allanite > REE-rich epidote or vice versa.

(2) A solid solution exists between La-dominant allanite and La-dominant REE-rich epidote. Chemical analysis shows epidote zones with 0.3–0.45 cations per unit formula of allanite, which has been called "allanite" by some authors (Deer *et al.*, 1986; Pan and Fleet, 1991).

(3) > Ce in the epidote and allanite zones.

(4) A minimum of 9% REE oxides have been detected in the epidote zones in all the specimens analyzed.

Although the name "allanite-(La)" was used by Pan and Fleet (1991), the species was never formally described, nor has the species and name been approved by the International Mineralogical Association. Consequently the use of that name should be discouraged for the time being.

ACKNOWLEDGMENTS

Jose Manuel Gordillo and Angel Roldán found the first specimens of allanite in this mine. We are grateful to them for providing much information as well as some specimens for photography. We would also like to thank A. Fernández Larios (Universidad Complutense de Madrid) for technical assistance in EPMA analysis and BSI photography, and Martín Oliete for his skillful drawings.

REFERENCES

ALVAREZ, M. A., and DOMÍNGUEZ-BELLA, S. (1996) Estudio mineralógico y contenido de T.R.L. en allanitas y epidotas de la mina Nueva Vizcaya, Burguillos del Cerro (Badajoz). *Bol. Soc. Española Miner.*, **18**, 39–52.

ANONYMOUS (1987) *La minería en Extremadura*. Published by Consejería de Industria y Energía, Dirección General de Industria, Energía y Minas, Junta de Extremadura, Mérida, 323 p.

ANONYMOUS (1993) *La minería en Extremadura*. Published by Consejería de Industria y Energía, Dirección General de Industria, Energía y Minas, Junta de Extremadura, Mérida, 516 p.

ARRIBAS, A. (1962) Mineralogía y metalogenia de los yacimientos españoles de uranio: Burguillos del Cerro (Badajoz). *Estudios. Geol.*, **18**, 173–192.

BENITO, J., GARCIA DE FIGUEROLA, L. C. G., HERNANDEZ ENRILE, J. L., MUELAS, A., and SOUBRIER, J. (1977) *Memoria y explicacíon geológica de la hoja 853 (Burguillos del Cerro) del Mapa Geológico de España, escala 1:50.000.* Instituto Geológico y Minero de España, Madrid, 41 pp.

CALVO, B. (1980) Estudio genético del yacimiento de magnetita-pirita de Cala (Huelva). *Tecniterrae*, **34**, 5–110.

CASQUET, C. (1991) Skarns. In *Yacimientos Minerales*, pp. 265–286. Editors R. Lunar and R. Oyarzun, Madrid.

CASQUET, C., and VELASCO, F. (1978) Contribución a la geología de los "skarns" cálcicos en torno a Santa Olalla de Cala (Huelva-badajoz). *Estudios Geol.*, **34**, 399–405.

CLOPTON, E. L., and WILSON, W. E. (1995) *The Mineralogical Record Index, volumes I–XXV, 1970–1994.* Published by The Mineralogical Record Inc., Arizona. 312 p.

DEER, W. A., HOWIE, R. A., and ZUSSMAN, J. (1986) *Rock-forming Minerals.* Vol. 1, Longman, London, 629 p.

DOLLASE, W. A. (1971) Refinement of the crystal structures of epidote, allanite and hancockite. *American Mineralogist*, **56**, 447–464.

DROOP, G. R. T. (1987) A general equation for estimating Fe^{3+} concentrations in ferromagnesian silicates and oxides from microprobe analyses, using stoichiometric criteria. *Mineralogical Magazine*, **51**, 431–435.

EVENSEN, M. N., HAMILTON, P. J., and O'NIOS, R. K. (1978) Rare earth abundance in chondritic meteorites. *Geochimica et Cosmochimica Acta,* **42,** 1192–1212.

FLEISCHER, M. (1985) A summary of the variations in relative abundance of the lanthomides and yttrium in allanites and epidotes. *Bulletin of the Geological Society of Finland*, **57**, 151–155.

FORTEZA, M., DOMÍNGUEZ-BELLA, S., CORNEJO, J., and ALVAREZ, M. A. (1989) Estudio mineralógico de allanitas presentes en rocas metasomáticas con magnetita de Burguillos del Cerro. *Actas IX Bienal, Real Sol. Española Hist. Natur.*, **1**, 211–225.

GONZALEZ DEL TANAGO, J. (1997) Allanita-(Nd) y minerales de elementos raros en las pegmatitas graníticas de La Cabrera.

Madrid (Sistema Ibérico Central). *Rev. Sol. Geol. España*, **10**, 83–105.

HUGO, H. W. (1961) The allanite deposits on Vreda Gordonia district, Cape Province. *Rep. Suid-Afrika Dept. Mynwese Gel. Opiname Bull.* **37**, 1–65.

JAROSEWICH, E. J., and BOATNER, L. A. (1991) Rare-earth element reference samples for electron microprobe analysis. *Geostandards Newsletters*, **15**, 397–399.

JAROSEWICH, E. J., NELEN, J. A., and NORBERG, J. A. (1980) Reference samples for electron microprobe analysis. *Geostandards Newsletters*, **4**, 43–47.

LEAKE, B. E., WOOLEY, A. R., BIRCH, W. D., GILBERT, M. C., GRICE, J. D., HAWTHORNE, F. C., KATO, A., KISCH, H. J., KRIVOVICHEV, V. G., LINTHOUT, K., LAIRD, J., MRESCH, W. V., NICKEL, E. H., ROCK, N. M. S., SCHUMACHER, J. C., STEPHENSON, N. C. N., UNGARETTI, L., WHITTAKER, E. J. W., and YOUZHI, G. (1997) Nomenclature of amphiboles: Report of the Subcommittee on Amphiboles of the International Mineralogical Association Commission on New Minerals and Mineral Names. *Mineralogical Magazine*, **61**, 295–321.

MANDARINO, A. (1999) *Fleischer's Glossary of Mineral Species 1999*. The Mineralogical Record Inc., Tucson. 225 p.

PAN, Y., and FLEET, M. E. (1990) Halogen-bearing allanite from the White River gold occurrence, Hemlo Area, Ontario. *Canadian Mineralogist*, **28**, 67–75.

PAN, Y., and FLEET, M. E. (1991) Vanadian allanite-(La) and vanadian allanite-(Ce) from the Hemlo gold deposit, Ontario, Canada. *Mineralogical Magazine*, **55**, num. 381, 497–507.

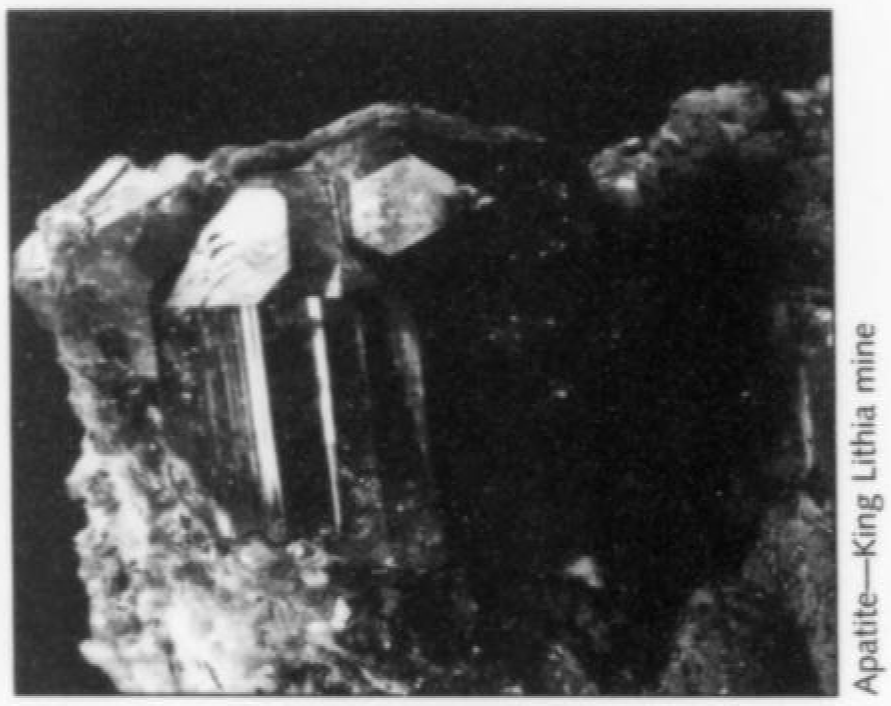
RUIZ, C. (1976) Génesis de los depósitos de hierro del suroeste de la provincia de Badajoz: mina Monchi. *Bol. Inst. Geologico y Minero*, **87**, 15–31.

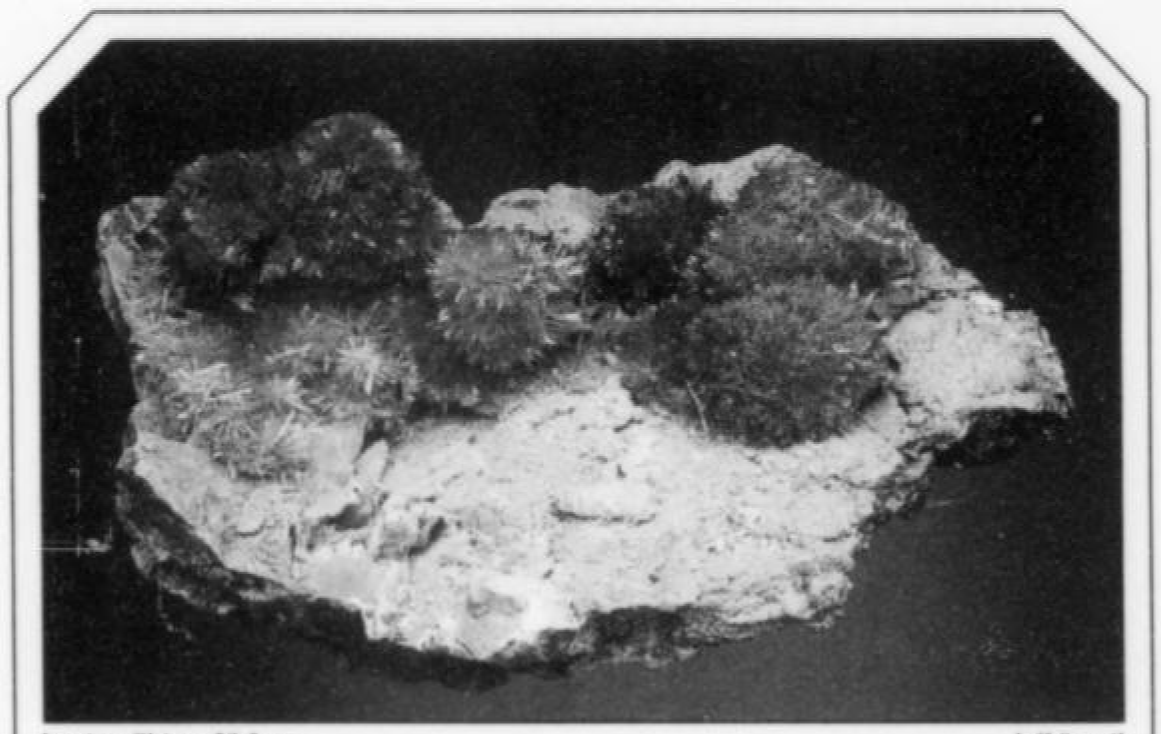
TAYLOR, S. R., and McLENNAN, S. M. (1985) *The Continental Crust. Its Composition and Evolution.* Blackwell Science Publishers, Oxford, 312 p.

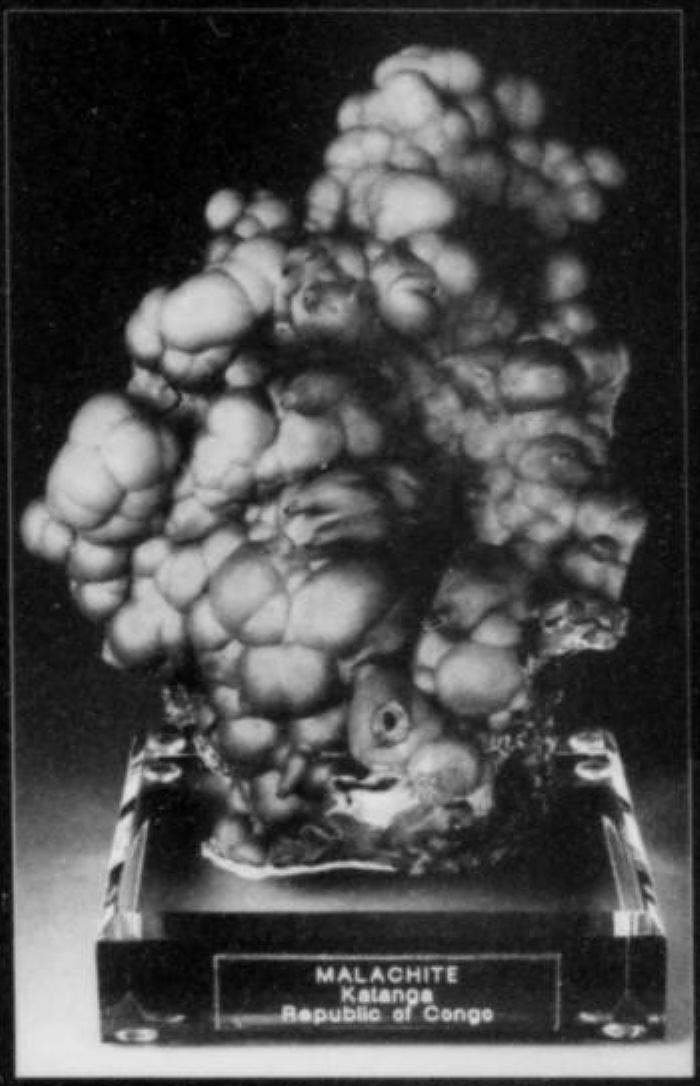
VAZQUEZ, F. (1980) *Depósitos Minerales de España*. Published by ITGE, Madrid, 153 p.

WIEWIORA, A., and WEISS, Z. (1990) Crystallochemical classifications of phyllosilicates based on the unified system of projection of chemical composition: II. The chlorite group. *Clay Miner.*, **25**, 83–92.

ZHIROV, K. K., BANDUKIN, G. A., and LAVRENTYEV, Yu. G. (1961) Geochemistry of rare elements in pegmatites of North Karelia. *Geokimiya*, **11** (English translation), 1107–1118.

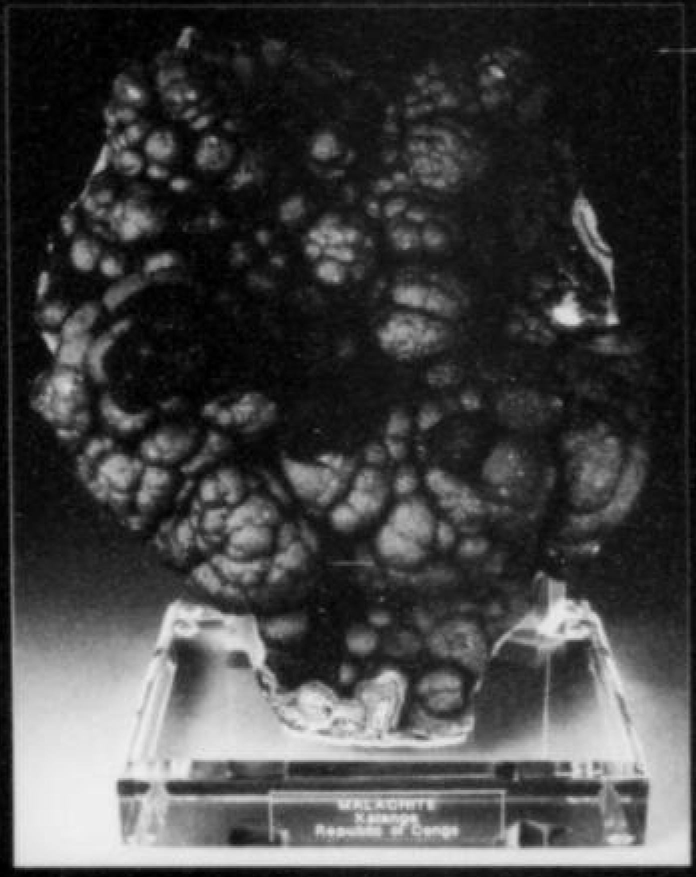





MALACHITE
Katanga
Republic of Congo


TSC3793
MALACHITE after AZURITE
Mashamba West, Katanga Province
Dem. Rep. of the Congo


RHODOCHROSITE on QUARTZ
Scott's Pocket, Sweet Home Mine
Alma, Colorado


MALACHITE
Katanga
Republic of Congo


TSC3744
RHODOCHROSITE, FLUORITE,
& TETRAHEDRITE
Celebration Pocket / Fluorite Raise
Sweet Home Mine, Alma, Colorado


RHODOCHROSITE, FLUORITE & SULFIDES
Rob's Pocket, Sweet Home Mine
Alma, Colorado

THE MUSEUM DIRECTORY

New York State Museum

Curator (Geol.): Dr. William Kelly
Tel: 518-474-7559
Collections Mgr. (Geol.):
Michael Hawkins
Tel: 518-486-2011
Fax: 518-486-3696
3140 Cultural Education Ctr.
Albany, NY 12230-0001
Website: www.nysm.nysed.gov
Hours: 10–5 daily (closed Thanksgiving, Christmas, New Years)
Specialty: New York & worldwide minerals
Support Org.: NY State Acad. of Mineralogy (www.nysm.nysed.gov/nysam)

Geology and Meteorite Museums University of New Mexico

Curators: Barry Kues (Geology), Rhian Jones (Meteorites)
Tel: (505) 277-4204
Dept. of Earth & Planetary Sciences
Northrop Hall, Univ. of New Mexico
Albuquerque, NM 87131
Hours: 8–12, 1–4 M–F (closed on school holidays)
Specialties: Worldwide minerals and meteorites, New Mexico fossils, Harding Pegmatite Mine Collection

Colburn Gem & Mineral Museum

Curator of Collections: Christian Richart G.G. (GIA)
Tel: (828) 254-7162
Fax: (828) 257-4505
Website: www.main.nc.us/colburn
Pack Place Education, Arts & Science Center
2 South Pack Square
Asheville, NC 28801
Hours: 10–5 Tues.–Sat.
1–5 Sun.
Closed Mondays and holidays
Specialties: North Carolina and worldwide minerals and gems
Accessible to persons with disabilities

Montana Tech Mineral Museum

Curator: Dr. Richard Berg
Tel: 406-496-4172
Fax: 406-496-4451
e-mail:dberg@mtech.edu
Program Director: Ginette Abdo
Tel: 406-496-4414
e-mail:gabdo@mtech.edu
Website: www.mbmg.mtech.edu /museumm.htm
Montana Bureau of Mines & Geology
Montana Tech of UM,
1300 W. Park Street
Butte, Montana 59701
Hours: Mem/Day to Labor Day 9-6 daily; Rest of year M-F 9-4; Open Sat & Sun May, Sept & Oct 1-5 pm
Specialties: Butte and Montana minerals, worldwide classics

Harvard Mineralogical Museum

Curators: Dr. Carl A. Francis
William Metropolis
Tel: (617) 495-4758
24 Oxford Street
Cambridge, Mass. 02138
Hours: 9–4:30 M–Sat.; 1–4:30 Sun.
Specialties: Systematic Mineral Coll'n

Western Museum of Mining & Industry

Curator: Terry A. Girouard
Tel: (719) 495-2182
email: curatewmmi@juno.com
Dir. of Educ.: Gary Renville
Tel: (719) 488-0880
Fax: (719) 488-9261
www.wmmi.org
1025 North Gate Road
Colorado Springs, CO 80921
Hours: 9–4 M-Sat., (12-4 Sun., June–Sept. only), closed holidays
Specialties: Colorado minerals & ores, Western mining memorabilia, 14,000-vol. research library

The Gillespie Museum of Minerals, Stetson University

Curator: Dr. Bruce Bradford
Tel: (904) 822-7331
E-mail: bbradfor@stetson.edu
Assistant Director: Holli M. Vanater
Tel: (904) 822-7330
E-mail: hvanater@stetson.edu
Fax: (904) 822-7328
234 E. Michigan Avenue
DeLand, Florida
Mailing: 421 N. Woodland Blvd., Unit 8403, DeLand, FL 32720-3757
Hours: 9–noon, 1–4 M–F when university is in session (closed on holidays, university breaks & in the summer)
Specialties: Worldwide comprehensive collection of rocks & minerals; Florida rocks, minerals & fossils; large historic fluorescent collection

The Denver Museum of Nature and Science

Curator of Geology: Jack A. Murphy
Tel: (303) 370-6445
Dept. of Earth Sciences
2001 Colorado Blvd.
Denver, CO 80205
Hours: 9–5 daily
Specialties: Colorado minerals

Geology Museum Colorado School of Mines

Curator: Paul J. Bartos
Tel: (303) 273-3823
Golden, Colorado 80401
Hours: 9–4 M–Sat., 1–4 Sun. (closed on school holidays & Sundays in the summer)
Specialties: Worldwide minerals; Colorado mining & minerals

A. E. Seaman Mineralogical Museum

Director: Stan Dyl
Curator (mineralogy):
George W. Robinson
Adjunct Curator: Dr. John A. Jaszczak
Tel: (906) 487-2572
Michigan Technological Univ.
Houghton, Michigan 49931
Hours: 9–4:30 M–F
Specialty: Michigan minerals, copper minerals & worldwide minerals

Additional listings welcome!

Send vital information, as shown, to the editor. There is a modest annual fee (lower than our regular advertising rates).

Museums listed alphabetically by city

THE MUSEUM DIRECTORY

Houston Museum of Natural Science

Curator (mineralogy): Joel Bartsch
Tel: (713) 639-4673
Fax: (713) 523-4125
1 Herman Circle Drive
Houston, Texas 77030
Hours: 9–6 M–Sat., 12–6 Sun.
Specialty: Finest or near-finest known specimens

Natural History Museum of Los Angeles County

Fax: (213) 749-4107
Website: http://nhm.org/minsci
Curator (Mineral Sciences):
Dr. Anthony R. Kampf
Tel: (213) 763-3328
e-mail: akampf@nhm.org
Collections Manager:
Dorothy L. Ettensohn
Tel: (213) 763-3327
e-mail: dettenso@nhm.org
900 Exposition Blvd.
Los Angeles, CA 90007
Hours: 9:30–5:00 Daily
Specialties: Calif. & worldwide minerals, gold, gem crystals, colored gemstones
Support organization:
The Gem and Mineral Council

California State Mining and Mineral Museum

Website: http//parks.ca.gov/parkpages/park_page.asp?lvl_id=227
Curator: Peggy Ronning
Tel: (209) 742-7625
Fax: (209) 966-3597
e-mail: mineralcurator@sierratel.com
5005 Fairgrounds Rd.
Mariposa, CA 95338
Mailing Address:
P.O. Box 1192
Mariposa, CA 95338
Hours: 10–6 Daily (May–Sept.)
10–4 Wÿ¥.–Mon. (Oct–Apr.)
Specialties: Gold, California minerals, California mining

Arizona Mining & Mineral Museum

Department Director: Doug Sawyer
Curator: Sue Celestian
Tel: (602) 255-3795
1502 W. Washington Avenue
Phoenix, AZ 85007
Hours: 8–5 M–F, 11–4 Sat., closed Sun. & holidays
Specialty: Arizona minerals

Carnegie Museum of Natural History

Collection Manager: Marc L. Wilson
Tel: (412) 622-3391
4400 Forbes Avenue
Pittsburgh, PA 15213
Hours: 10–5 Tues.–Sat., 10–9 F, 1–5 Sun., closed Mon. & holidays
Specialty: Worldwide minerals & gems

Museum of Geology

Curator: Thomas J. Campbell
Tel: (605) 718-2288
South Dakota School of Mines & Technology
501 E. St. Joseph St.
Rapid City, SD 57701-3995

New Mexico Bureau of Mines & Mineral Resources—Mineral Museum

Director: Dr. Virgil W. Lueth
Tel: (505) 835-5140
E-Mail: vwlueth@nmt.edu
Fax: (505) 835-6333
Associate Curator: Robert Eveleth
Tel: (505) 835-5325
E-mail: beveleth@gis.nmt.edu
New Mexico Tech,
801 Leroy Place
Socorro, NM 87801
Hours: 8–5 M–F, 10–3 Sat., Sun
Specialties: New Mexico minerals, mining artifacts, worldwide minerals

Penn State Earth & Mineral Sciences Museum

Curator: Dr. Andrew Sicree, PhD
Tel: (814) 865-6427
E-mail: sicree@geosc.psu.edu
Steidle Building
University Park
State College, PA 16802
Hours: 9–5 M–F & by Appt. (closed holidays)
Specialties: Mineral properties exhibits; "velvet" malachite; old Penna. minerals, mining art

Arizona-SonoraDesert Museum

Fax: (520) 883-2500
Website: http://www.desertmuseum.org
Curator, Mineralogy: Anna M. Domitrovic
Tel: (520) 883-3033
E-mail: adomitrovic@desertmuseum.org
2021 N. Kinney Road
Tucson, AZ 85743-8918
Hours: 8:30-5 Daily (Oct.-Feb.)
7:30-6 Daily (Mar.-Sept.)
Specialty: Arizona minerals

Pacific Mineral Museum

Director/Curator: Mark Mauthner
Tel: (604) 689-8700
E-Mail: markm@pacificmineralmuseum.org
848 West Hastings Street
Vancouver, B.C., Canada V6C 1C8
Hours: M–F 10–5, Weekends 10–6 (Closed Mondays in winter)
Specialties: BC–Yukon–Pacific NW, worldwide, gold, silver

U.S. National Museum of Natural History (Smithsonian Institution)

Curator: Dr. Jeffrey E. Post
e-mail: minerals@nmnh.si.edu
Collection Managers: Paul Pohwat and Russell Feather
(Dept. of Mineral Sciences)
Washington, DC 20560-0119
Hours: 10 am–5:30 pm daily
Specialties: Worldwide minerals, gems, research specimens

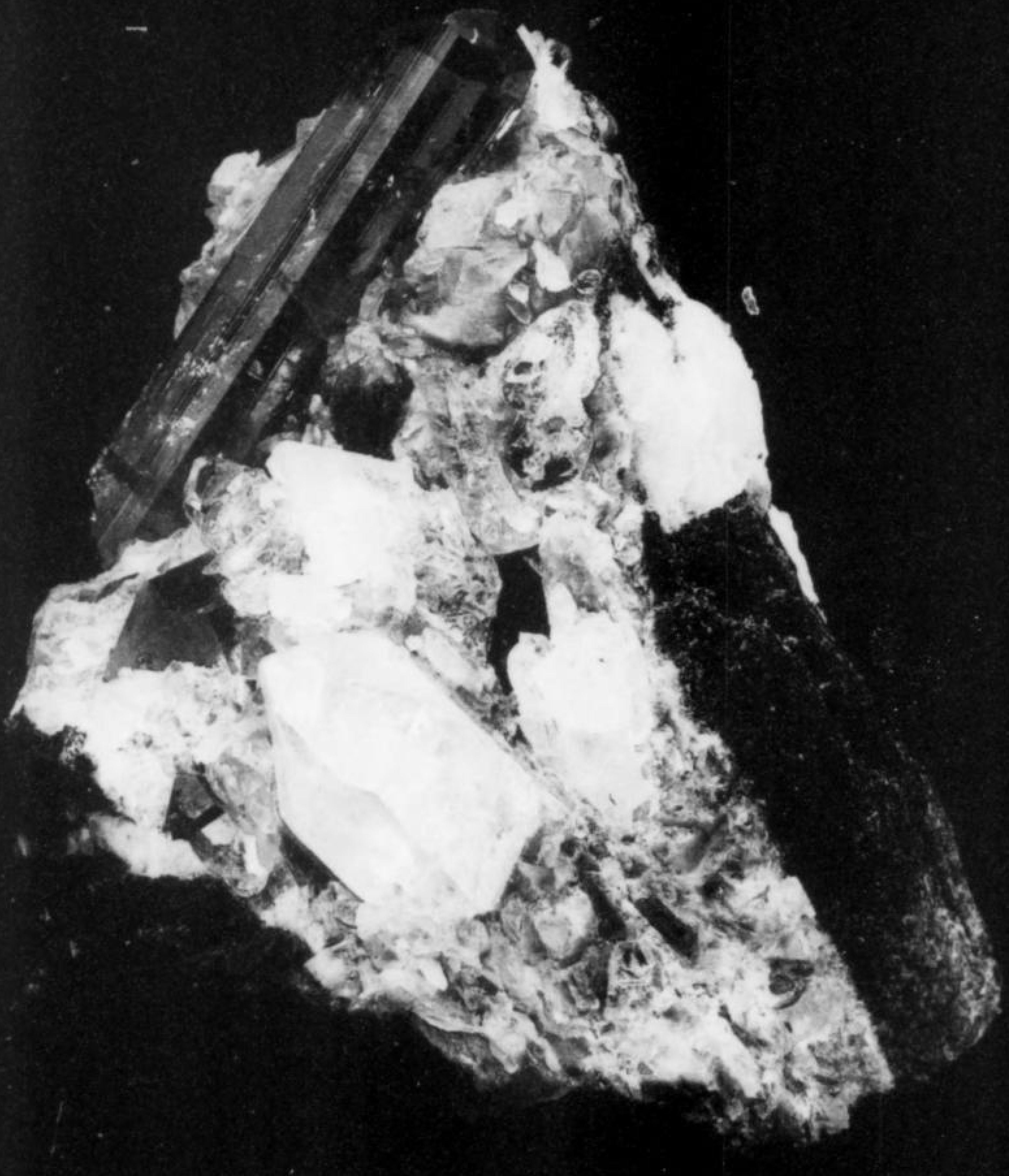
William Weinman Mineral Museum

Asst. Curator: Doug Gravely
Tel: (770) 386-0576
51 Mineral Museum Dr.
White, GA 30184
Hours: 10–4:30 Tues.–Sat., 2–4:30 Sun.
Specialty: Georgia & worldwide minerals & fossils

Europe

Museo Civico di Storia Naturale

Curator: Dr. Federico Pezzotta
Tel: +39 02 8846 3326
Fax: +39 02 8846 3281
E-Mail: fpezzotta@yahoo.com
Associate Curator: Alessandro Guastoni
Department of Mineralogy and Petrography
Corso Venezia, 55
I-20121 **Milano,** Italy
Hours: 9 am–6 pm daily
Specialties: Italian minerals, pegmatite minerals



MANGANOTANTALITE FROM THE ALTO DO GIZ AREA, EQUADOR, RIO GRANDE DO NORTE, BRAZIL

George W. Robinson[1] and **John A. Jaszczak**[2]
A. E. Seaman Mineral Museum & Dept. of Geological Engineering & Sciences[1]
Department of Physics[2]
Michigan Technological University
1400 Townsend Drive
Houghton, Michigan 49931

Reinhard R. Wegner
Universidade Federal Da Paraiba
Dep. de Mineração e Geologia
Cidade Universitária, Bloco BS
58.100 Campina Grande
Paraiba, Brazil

Owen P. Mills
Dept. of Metallurgical and Materials Engineering
Michigan Technological University
1400 Townsend Drive
Houghton, Michigan 49931

Remarkable twinned crystals of both black and red manganotantalite have been recovered from two recently discovered pegmatites near Alto do Giz, Equador, Rio Grande do Norte, Brazil.

INTRODUCTION

Granitic pegmatites in the Parelhas-Equador area of Rio Grande do Norte, Brazil, are well-known for their tantalum minerals (De Almeida *et al*., 1944; Pough, 1945; Ercit *et al*., 1986). Perhaps the most famous is the Alto do Giz pegmatite, renowned for its remarkable crystals of simpsonite (Guimares, 1944; Pough, 1945). The Alto do Giz ("hill of chalk") forms a long, white ridge approximately 500 meters east of the highway connecting Equador and Parelhas. Its white color is due to intense kaolinization of feldspar. Today, the pegmatite is only worked sporadically by a few *garimpeiros*, and relatively little tantalum is being produced. The new manganotantalite specimens described here do not come from the Alto do Giz pegmatite, but rather from two smaller, more recently discovered pegmatites roughly parallel to it. These are located on the western slope of a larger hill, just east of Alto do Giz, and separated from it by a small valley (Fig. 1). Access is by

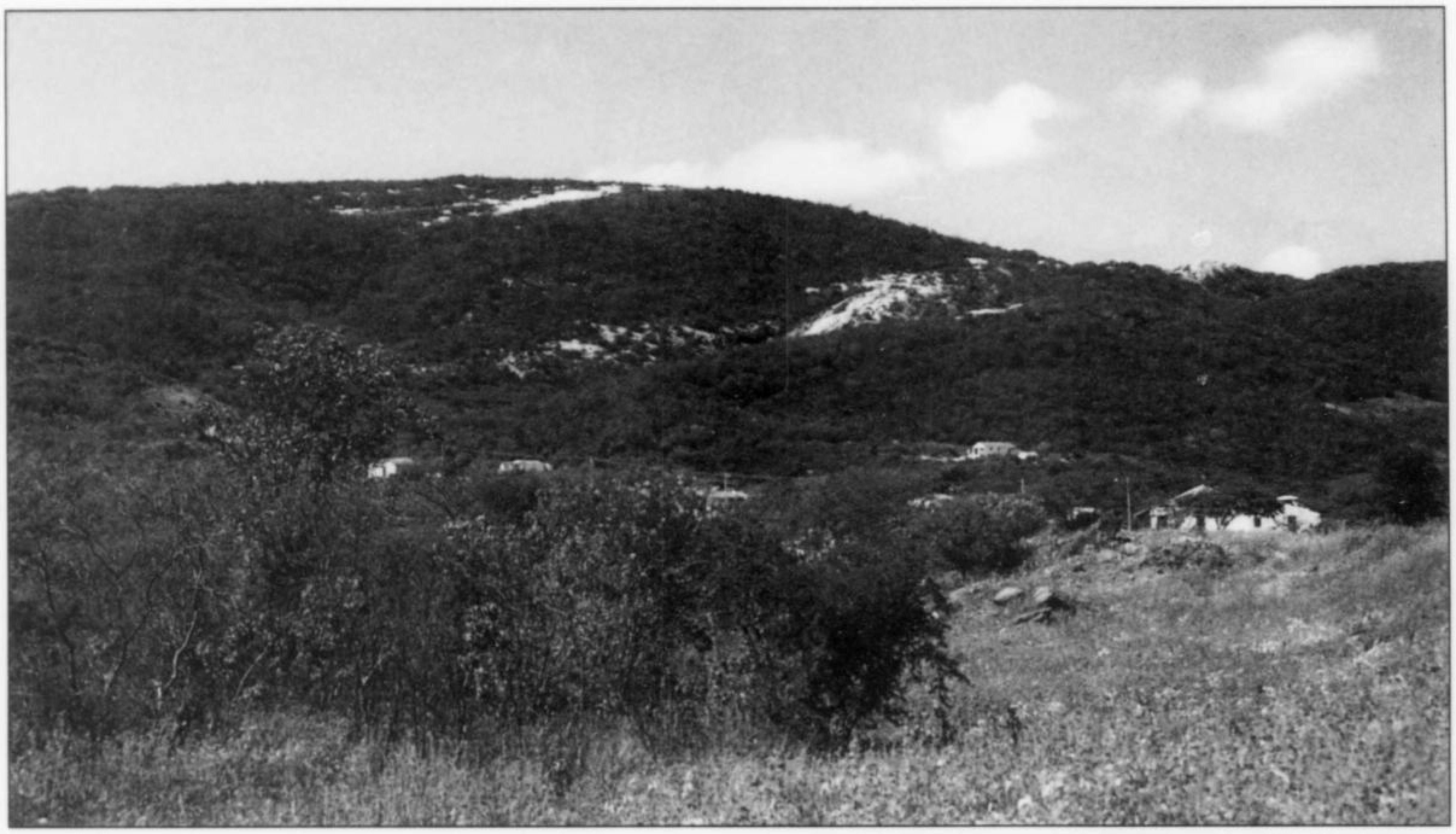


Figure 1. **A general view of the various pegmatites on the Alto do Giz, looking south from the road between Equador and Parelhas. The Alto do Giz pegmatite is near the center of the photo, with Alto do Giz II appearing as a small line directly above it. Alto das Furnas is to the left and near the top of the hill. Photo by Reinhard Wegner.**

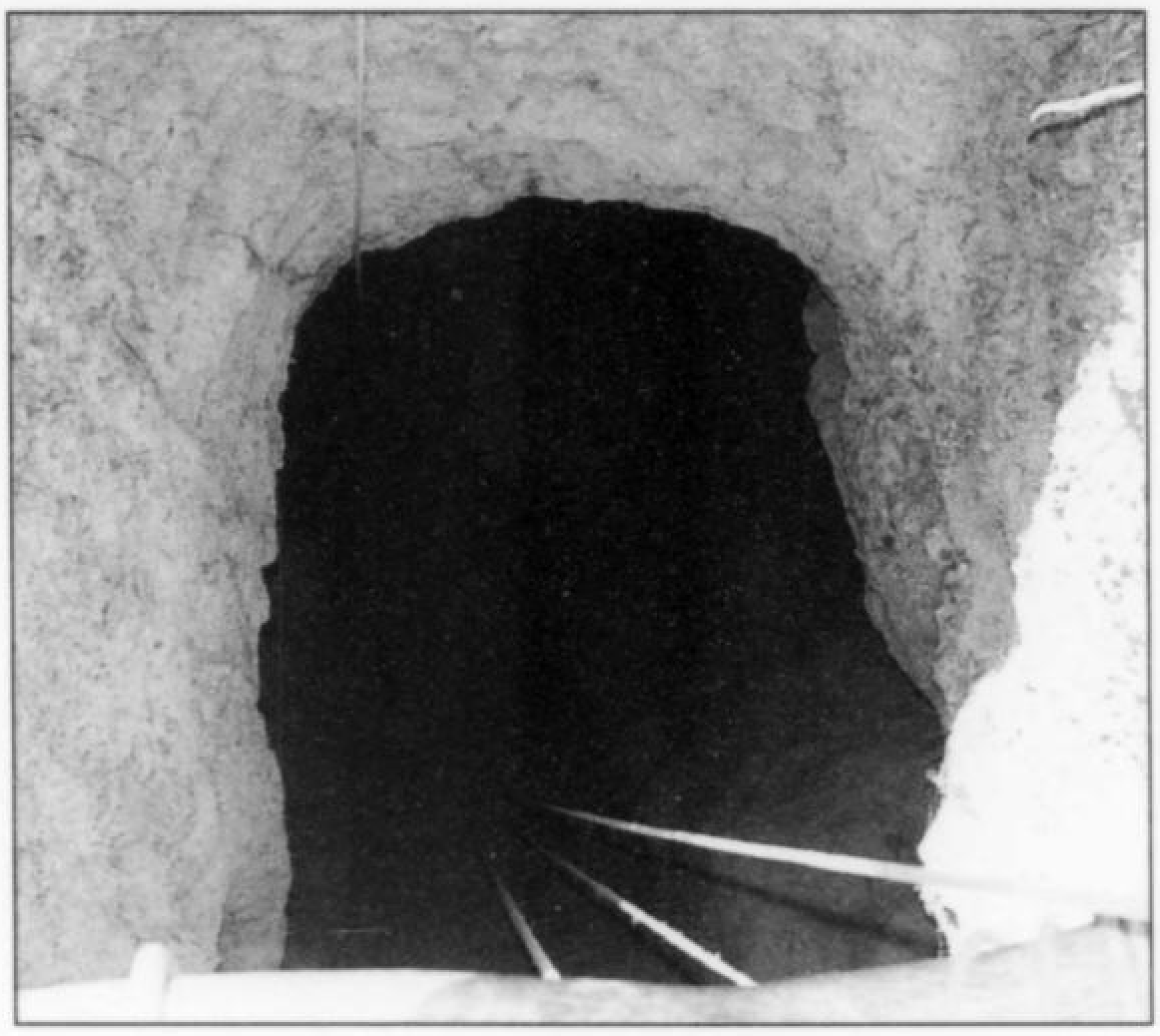


Figure 2. **View looking down the main entrance shaft at the Alto do Giz II pegmatite. Photo by Reinhard Wegner.**

a paved road leading north from national road No. 230, approximately 2 km west of the village Junco do Seridó. About 8 km beyond the village of Equador, Alto do Giz is clearly visible to the southeast from the road.

The first of these pegmatites, called Alto do Giz II, is located approximately 400 meters east of the original Alto do Giz pegmatite, and lies near the middle of the slope. The second pegmatite, named Alto das Furnas, lies about 300 meters further east, near the crest of the hill. Mining began at Alto do Giz II late in the summer of 1997, and at Alto das Furnas, about 6 months later. Both pegmatites are roughly parallel to the main Alto do Giz pegmatite, striking N55–60°E. While the Alto do Giz pegmatite stands almost vertically, the two smaller ones both dip ~50–60° to the southeast. Each is exposed by a series of small surface diggings that extend about 200 meters, though their principal workings are underground, and are reached by vertical shafts from 30 to 60 meters deep.

ALTO do GIZ II PEGMATITE

The Alto do Giz II pegmatite appears to have a maximum width of about 8 meters. In the deeper underground workings the central quartz core lies asymmetrically closer to the eastern contact with the host rocks (micaceous quartzites of the Equador Formation). In the upper workings, the quartz core bifurcates into two separate bodies. The major minerals of the pegmatite are quartz, muscovite and kaolin (altered feldspar), with columbite-tantalite and some microlite as ore minerals. One huge mass of tantalite weighed nearly 600 kg. Thus far, columbite has been confined to the upper workings, suggesting a possible vertical zonation with respect to niobium and tantalum. Of primary interest to mineral collectors is the occurrence of well-formed, twinned crystals of black manganotantalite.

Manganotantalite ($Mn^{2+}Ta_2O_6$) forms a solid solution series with manganocolumbite ($(Mn^{2+},Fe^{2+})(Nb,Ta)_2O_6$) and ferrotantalite ($Fe^{2+}Ta_2O_6$). Hence, most natural manganotantalite contains both Mn and Fe as well as Ta and Nb, the relative proportions of which govern the nomenclature of the species. When pure, manganotantalite is red, but it becomes black with increasing Fe content. Because the crystals described here appear nearly black in hand specimens, they were originally labeled as "tantalite."

Figure 3. **Garimpeiros gathered at the rest hut at the Alto do Giz II pegmatite. Photo by Reinhard Wegner.**

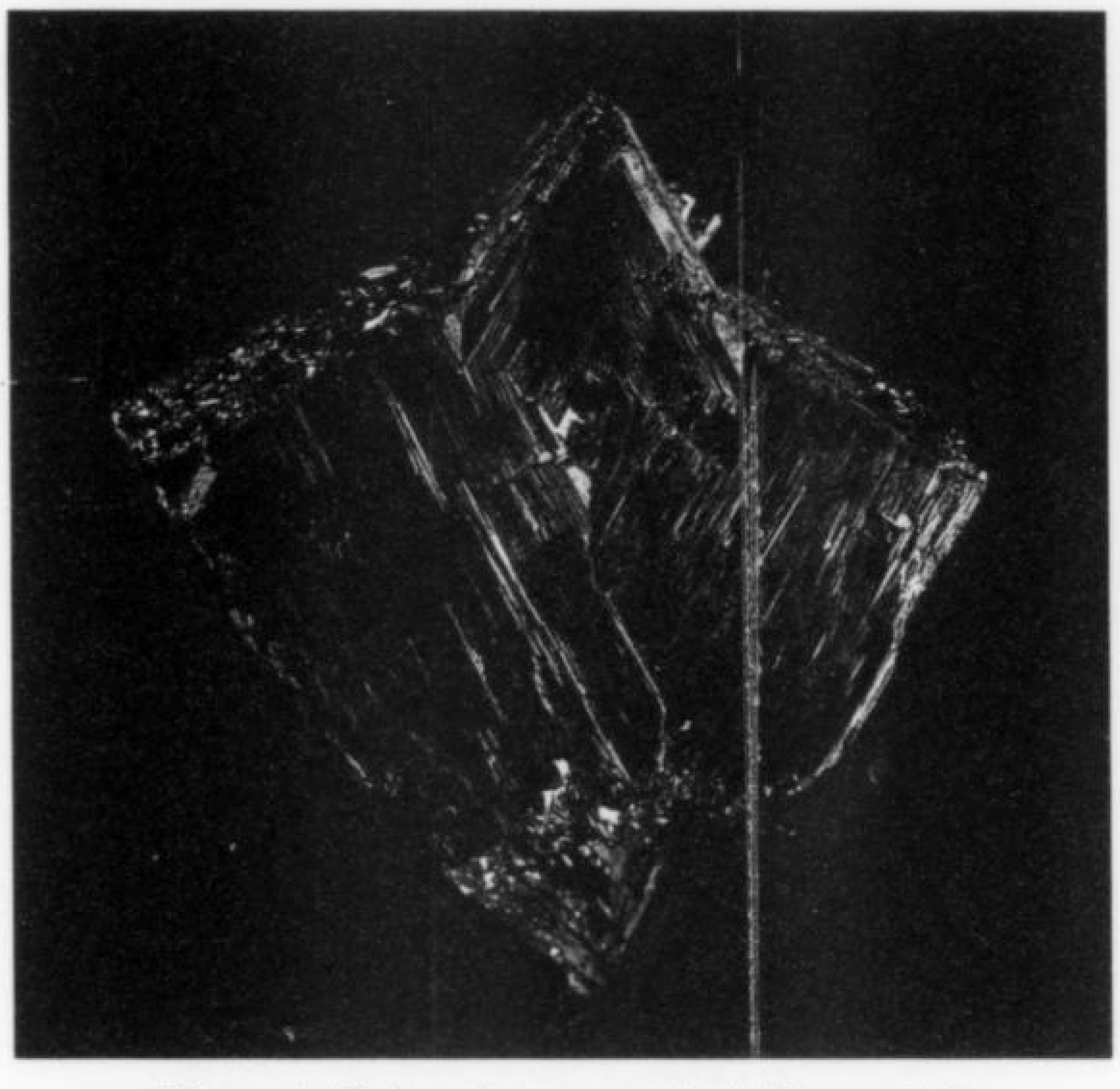


Figure 4. **Twinned manganotantalite crystals from the Alto do Giz II pegmatite, 6 x 6 cm, A. E. Seaman Mineral Museum specimen. Photo by George Robinson.**

An X-ray powder diffraction pattern quickly established the mineral as a member of the manganotantalite-ferrotantalite series, but it became clear that chemical data would be required to determine the species. Therefore, six chips extracted from two different crystals were mounted in epoxy resin and prepared for electron microprobe analysis. A preliminary examination employing backscattered electron imagery and energy dispersive X-ray spectra showed the crystals to be zoned with respect to Nb-Ta, with Nb-rich domains located along cleavage planes and outer crystal margins. No elements with atomic numbers greater than 11 were observed in the energy dispersive X-ray spectra other than Mn, Fe, Nb and Ta.

Wavelength dispersive analyses utilizing a four-channel JEOL KXA-8600 SuperProbe with an Oxford Specta automation system were conducted on both the main Ta-rich and minor Nb-rich phases. Standards used were pure niobium and tantalum metals (Nb, Ta), Rockport fayalite (Fe), Nuevo garnet (Mn) and Webster fosterite (Mg). $Fe_{K\alpha}$ and $Mn_{K\alpha}$ were measured on LiF crystals, $Ta_{M\alpha}$ and $Mg_{K\alpha}$ on TAP crystals and $Nb_{L\alpha}$ on a PET crystal. Data reduction was by Oxford's Specta automation program, which implements a standard ZAF routine. Instrumental operating conditions were 15kV accelerating voltage, and 20 nA beam current. Samples and standards were analyzed under identical conditions, with count times of 20 seconds (or 30,000 counts) at peak positions and 5 seconds at background positions. Mg was sought, but none was detected (estimated minimum detection limit 0.01 weight %).

The results of the wavelength dispersive analyses are presented in Table 1. The major portion of each crystal is manganotantalite, with an average composition of $(Mn_{0.81}Fe_{0.18})_{\Sigma 0.99}(Ta_{1.96}Nb_{0.05})_{\Sigma 1.01}O_6$ for crystal 1, and $(Mn_{0.76}Fe_{0.23})_{\Sigma 0.99}(Ta_{1.90}Nb_{0.11})_{\Sigma 1.01}O_6$ for crystal 2. The smaller Nb-enriched zones show a greater compositional range. Most are still manganotantalite, with average compositions $(Mn_{0.72}Fe_{0.29})_{\Sigma 1.01}(Ta_{1.16}Nb_{0.84})_{\Sigma 2.00}O_6$ for crystal 1, and $(Mn_{0.66}Fe_{0.36})_{\Sigma 1.02}$-$(Ta_{1.03}Nb_{0.96})_{\Sigma 1.99}O_6$ for crystal 2, though one point analysis on crystal 2 gave a composition of $(Mn_{0.65}Fe_{0.35})_{\Sigma 1.00}(Nb_{1.02}Ta_{0.98})_{\Sigma 2.00}O_6$, proving that manganocolumbite is also present. Manganocolumbite is a relatively uncommon mineral, since ordinarily, high-Nb members of the series tend to be Mn-poor (Gaines *et al.*, 1997).

While twinned crystals of columbite-tantalite series minerals are probably less common than untwinned crystals, they certainly are not rare. Gaines *et al.* (1997), Palache *et al.* (1961) and Mason and Berry (1968) all cite heart-shaped contact twins with twin and composition plane {201} as "common." However, *each* of these authors chose a *different* unit cell orientation, yet cited the *same* twin plane as the most common! Gaines *et al.* (1997) give a = 14.440, b = 5.766, c = 5.093 Å; Palache *et al.* (1961) give a =

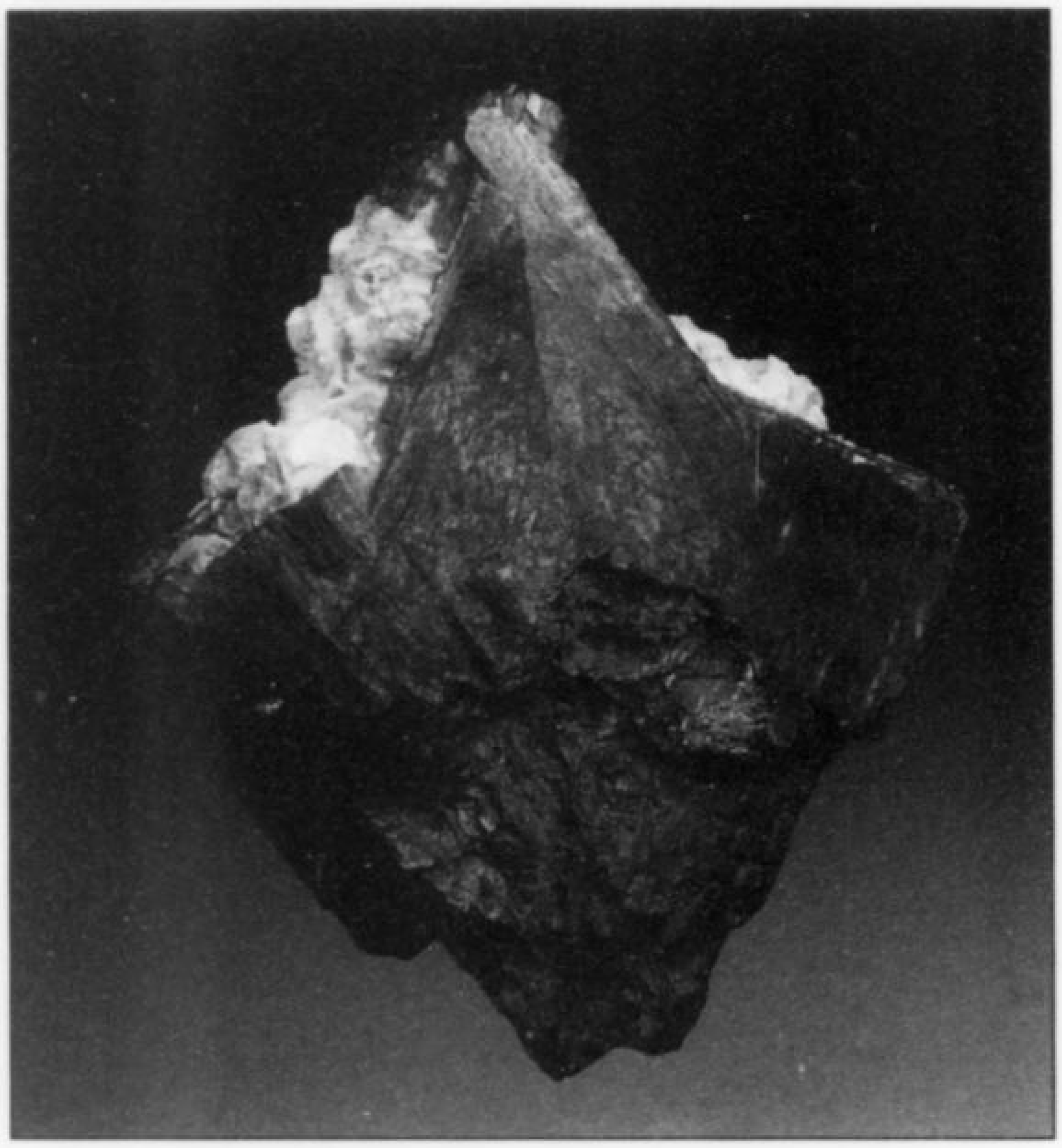


Figure 5. **Twinned manganotantalite crystals from the Alto do Giz II pegmatite, 6 x 6 cm, Reinhard Wegner collection. Photo by Jeff Scovil.**

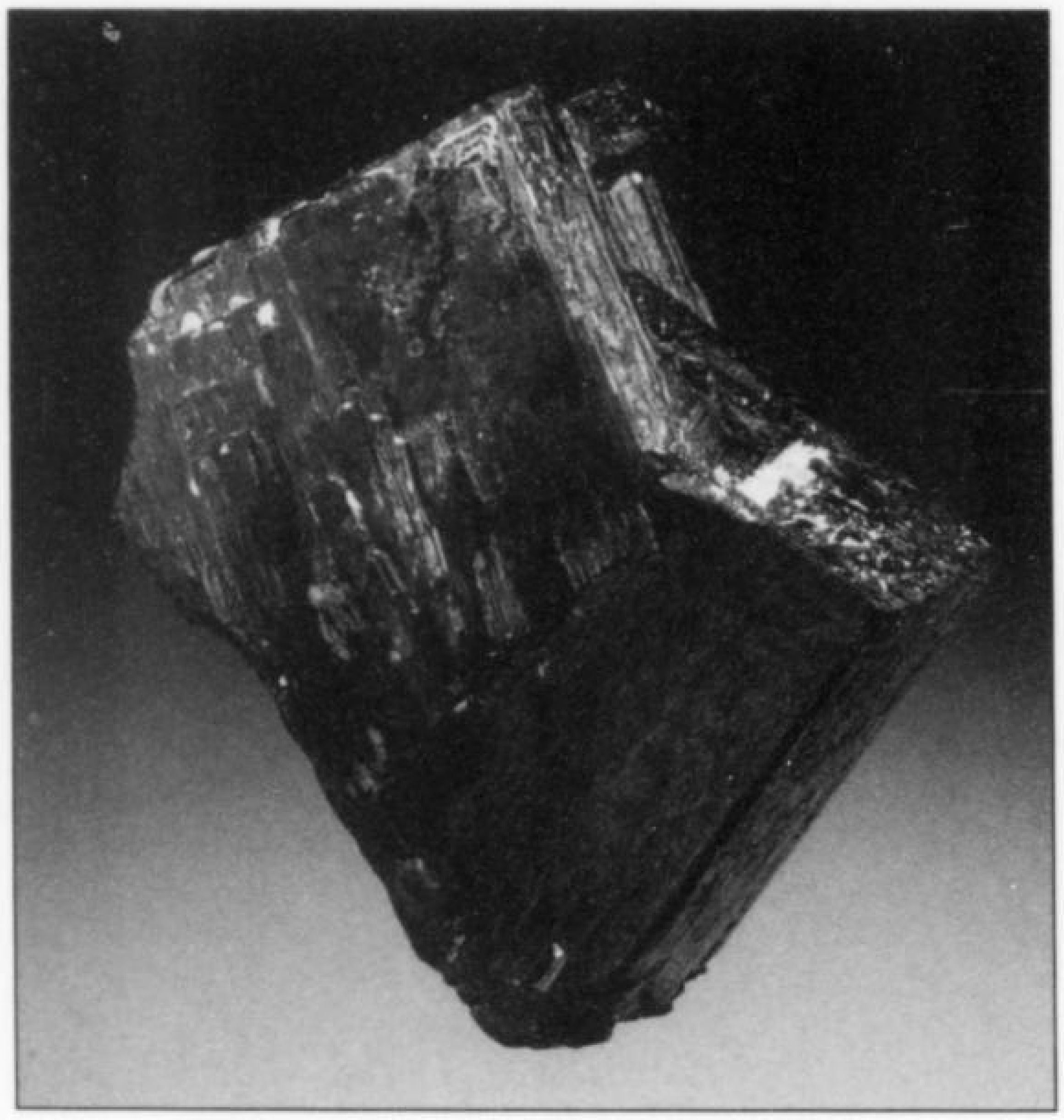


Figure 6. **Twinned manganotantalite crystals from the Alto do Giz II pegmatite, 4.5 x 5 cm, Reinhard Wegner collection. Photo by Jeff Scovil.**

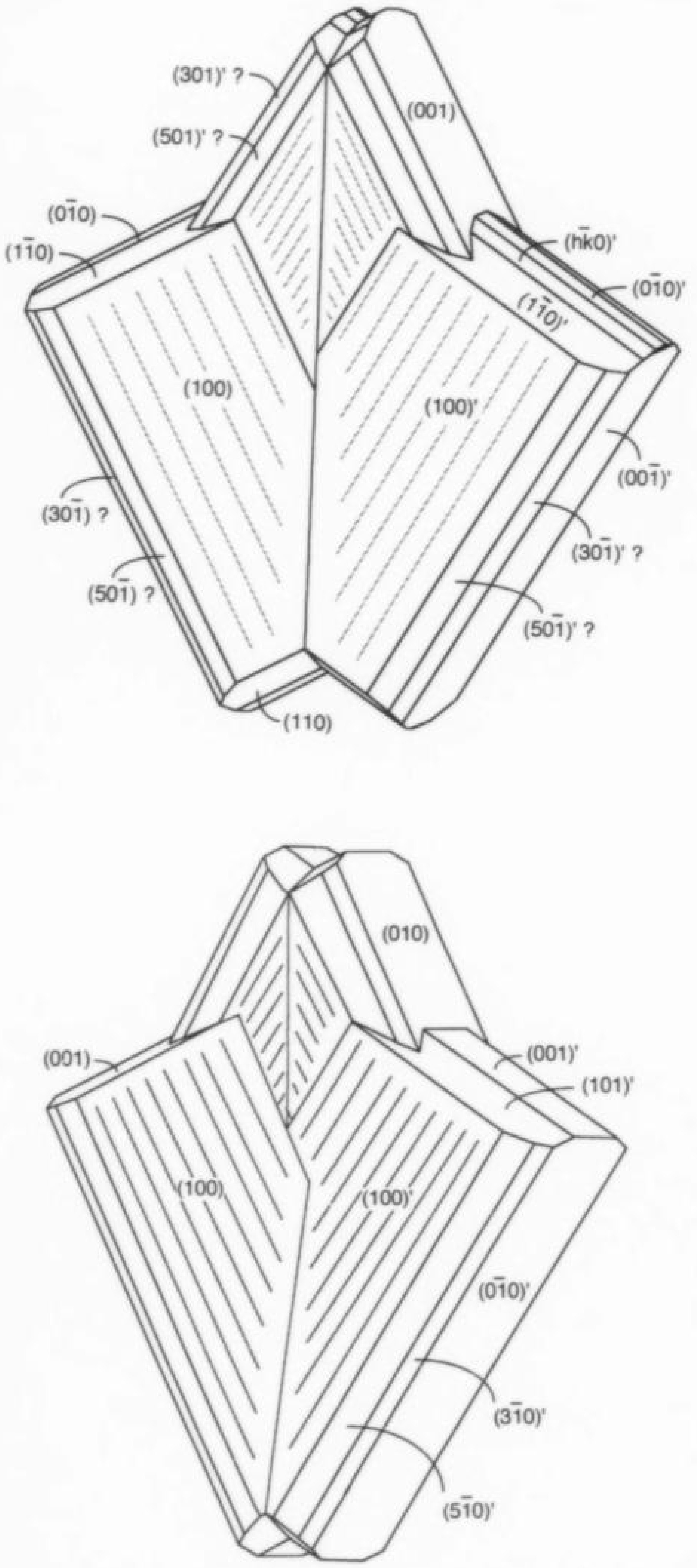


Figure 7. **Crystal drawings of twinned manganotantalite crystals from the Alto do Giz II pegmatite. *(Top:)* Twin and composition planes {023} oriented vertically. *(Bottom:)* Twin and composition planes {021} oriented vertically. SHAPE crystal drawings by J. Jaszczak.**

5.082, b = 14.238, c = 5.730 Å; while Mason and Berry (1968) chose a = 5.74, b = 14.27, and c = 5.09 Å. Clearly the (201) plane referenced relative to each of these unit cells must be different, since their principal axes have been interchanged.

Dana (1901) illustrates heart-shaped twins, twinned by reflection on both {021} (cited as "common") and {023} (cited as "rare"), but uses a different axial ratio 0.82850:1:0.88976. As an aside, this ratio determined from morphological crystal measurements corresponds exactly with the ixiolite subcell reported by Grice *et al.* as determined by X-ray crystal structure analysis 75 years later.

None of the above twin-law descriptions is consistent with another, and some are inconsistent with themselves. Unfortunately, such inconsistencies are not uncommon in the mineralogical literature (Mandarino, 1993) and require detailed studies to resolve. Grice *et al.* (1976) determined the true cell of tantalite to be orthorhombic, space group P*bcn*, with $a \sim 14.4$, $b \sim 5.8$, and $c \sim 5.1$ Å. They also noted a strong subcell with $a' = a/3$, $b' = b$, and $c' = c$, which is the true cell of ixiolite. Subsequently, Wise *et al.*

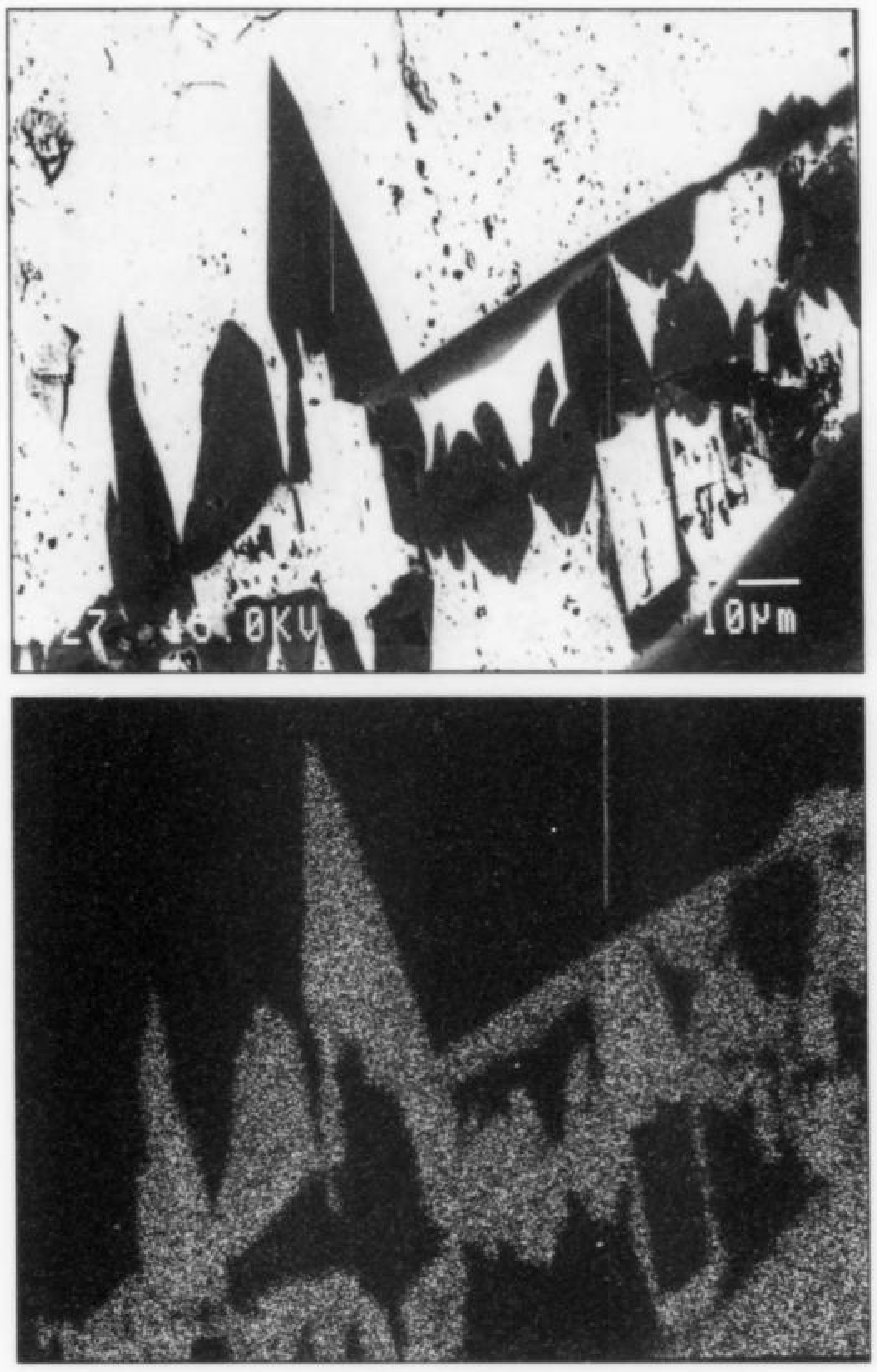


Figure 8. **a) Backscattered electron image showing inclusions of manganocolumbite (darker gray areas) within a crystal of black manganotantalite from the Alto do Giz II pegmatite. b) Corresponding $Nb_{L\alpha}$ X-ray map showing compositional zoning between Nb and Ta. Photographs by Owen Mills.**

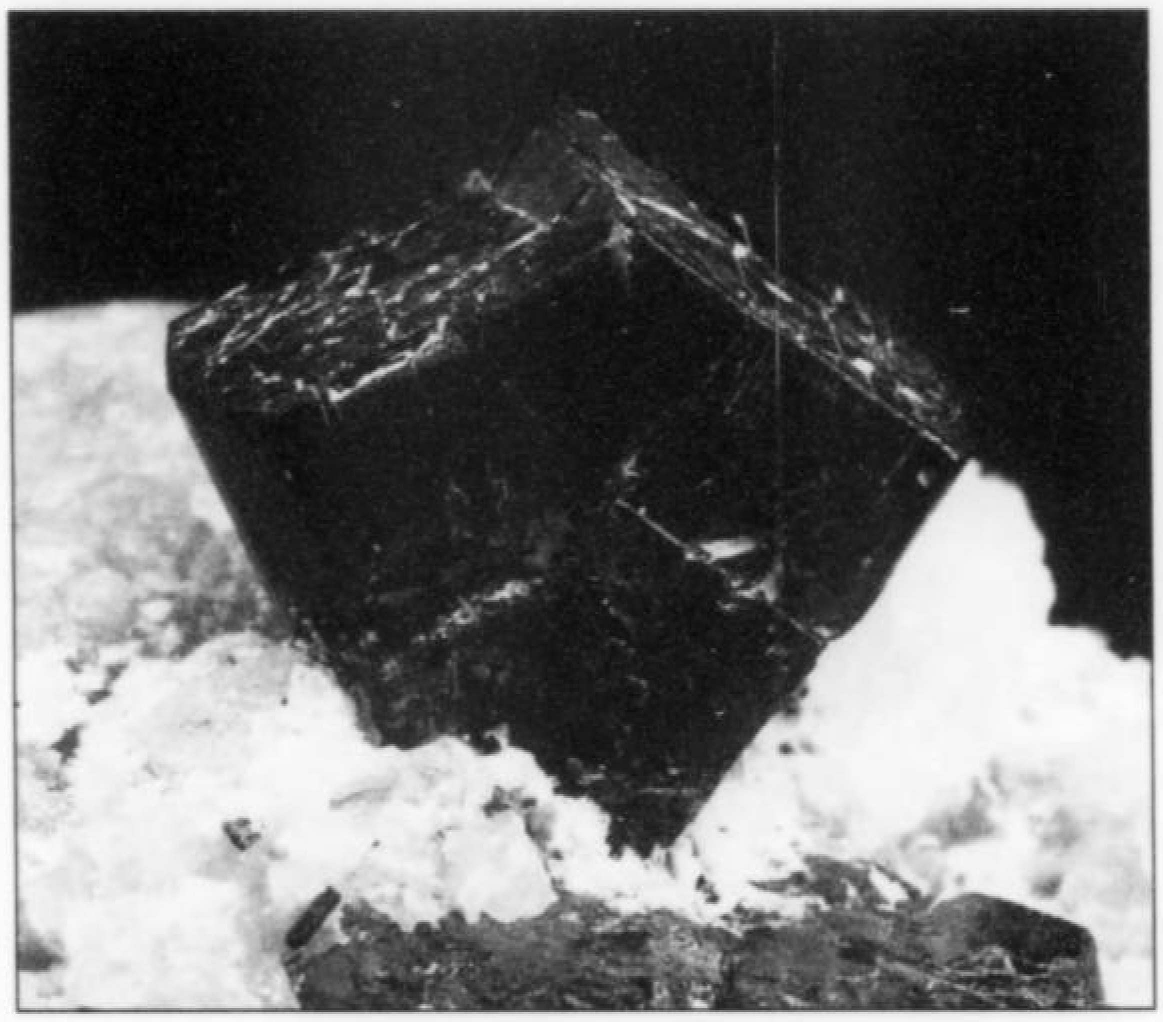


Figure 9. **Twinned, red, 1.5 x 1 cm manganotantalite crystals on quartz from the Alto das Furnas pegmatite, Reinhard Wegner collection. Photo by Jeff Scovil.**

Table 1. **Summary of electron microprobe analyses.**

Crystal 1

Oxide Weight %	*Main Phase* (Ave. 10 Analyses)	*Main Phase* (Range)	*Nb-Rich Phase* (Ave. 8 Analyses)	*Nb-Rich Phase* (Range)
FeO	2.59	2.36 – 3.01	4.77	3.64 – 6.24
MnO	11.30	10.99 – 11.47	11.58	10.41 – 12.92
Nb_2O_5	1.26	1.01 – 1.65	25.30	12.67 – 29.49
Ta_2O_5	85.44	84.77 – 86.08	58.27	53.35 – 71.44
Sum	100.59	99.53 – 101.75	99.92	98.53 – 101.25
Cation Proportions*				
Fe^{2+}	0.18	0.17 – 0.21	0.29	0.22 – 0.38
Mn^{2+}	0.81	0.79 – 0.82	0.72	0.64 – 0.79
Nb^{5+}	0.05	0.04 – 0.06	0.84	0.45 – 0.95
Ta^{5+}	1.96	1.94 – 1.97	1.16	1.06 – 1.54
Sum	3.00	2.98 – 3.01	3.01	2.99 – 3.02

Crystal 2

Oxide Weight %	*Main Phase* (Ave. 4 Analyses)	*Main Phase* (Range)	*Nb-Rich Phase* (Ave. 2 Analyses)	*Nb-Rich Phase* (Range)
FeO	3.30	3.23 – 3.40	5.92	5.90 – 5.94
MnO	10.87	10.59 – 11.07	10.76	10.68 – 10.84
Nb_2O_5	2.89	2.30 – 3.41	29.55	27.38 – 31.71
Ta_2O_2	84.20	83.32 – 85.36	52.50	50.74 – 54.25
Sum	101.26	100.73 – 101.65	98.73	98.21 – 99.23
Cation Proportions*				
Fe^{2+}	0.23	0.22 – 0.24	0.36	0.35 – 0.36
Mn^{2+}	0.76	0.74 – 0.78	0.66	0.65 – 0.66
Nb^{5+}	0.11	0.09 – 0.13	0.96	0.91 – 1.02
Ta^{5+}	1.90	1.88 – 1.92	1.03	0.98 – 1.08
Sum	3.00	2.99 – 3.00	3.01	3.00 – 3.02

*Calculations based on 6 oxygen atoms.

Table 2. **Summary of crystallographic measurements.**

Measurement	*Calculated Value*	*Observed Value*
100 ^ 010	90.0°	89°–91°
001 ^ 100	90.0°	89°–91°
100 ^ 510	26.61°	26°–30°
100 ^ 310	39.86°	37°–40°
$101 \wedge \bar{1}01$	38.97°	40°–42°
101 ^ 100	70.51°	68°–69°
$0\bar{1}0_{XL1} \wedge 0\bar{1}0_{XL2}$	58.92° (Twin Plane {021})	61°–62°
$0\bar{1}0_{XL1} \wedge 0\bar{1}0_{XL2}$	61.16° (Twin Plane {023})	61°–62°

(1985) refined the unit cell parameters for ordered columbite-tantalite end members, but did not propose a different unit cell.

In conformity with the true crystal structure, we have used the settings determined by Grice *et al.* (1976), and the following actual observed cell constants refined from the X-ray powder data throughout our study: *a* 14.407(16), *b* 5.752(5), *c* 5.098(5) Å. Using these cell dimensions, the twin planes {201} and {203} reported by Palache *et al.* (1961) correspond (with axes transposed) to {021} and {023} in the settings used here. Likewise, the

Figure 11. **Brilliant red twinned manganotantalite crystals from the Alto das Furnas pegmatite, 3 x 3.5 cm, Reinhard Wegner collection. Photo by Jeff Scovil.**

{021} plane used here is also consistent with the {201} plane for the settings reported by Mason and Berry (1968).

In order to unambiguously determine the orientation of the Alto do Giz crystals, a small chip was removed from one individual and ground flat parallel to the three principal pinacoid faces with the aid of a faceting machine. This oriented section was then mounted in putty so that X-ray diffractograms of the three orientations could be obtained.

Surprisingly, the X-ray results suggest *both* reported twin laws are simultaneously operative! Only strong {200}, {400} and {600} reflections are evident from the largest "front" pinacoid face (see Figure 7), establishing it as {100}. Both a strong {020} reflection and a weak {002} reflection are obtained from the longer "side" pinacoid; and strong {002}, {021} and moderate {020} reflections are obtained from the smaller "end" pinacoid. The only explanation that accounts for all the reflections observed is that the crystals are predominantly twinned by reflection on {021}, and subordinately so on {023}.

The crystal drawings in Figure 7 show that the two twin types are virtually indistinguishable in hand specimens. Because of the relatively large size of the Alto do Giz crystals, their interfacial angles could only be obtained using a hand-held contact goniometer. Measurements are generally limited to ±1° accuracy, and indices for smaller faces with rounded surfaces could not be determined at all. The forms identified are given in Table 2, and include pinacoids {100}, {010} and {001}; two {*hk*0} prisms (probably {301} and {501}); {101} and a small {*h*0*l*} prism.

ALTO das FURNAS PEGMATITE

Whereas its structural environment is similar to that of the Alto do Giz II pegmatite, the Alto das Furnas pegmatite shows some distinct differences. First, the pegmatite itself is much wider, reaching nearly 20 meters in the central part of the current workings. Vertical zonation with respect to niobium and tantalum appears to parallel that of the Alto do Giz II pegmatite, but horizontal zoning with respect to bismuth is evident at Alto das Furnas, with that element confined largely to the northernmost part of the pegmatite. Approximately 200 kg of bismutite, some of it associated with bismoclite, is produced weekly.

Manganotantalite from Alto das Furnas is red; sometimes brilliantly so (Fig. 10). Some specimens show an intimate intergrowth of pale red and dark red crystals. Both single and twinned crystals similar in habit to those from Alto do Giz II have been found, as have matrix specimens on quartz. Several generations of manganotantalite are apparent. A few perfectly formed "floater" crystals completely encased in kaolin probably represent an early generation that formed contemporaneously with microcline. Other crystals have their terminations embedded in quartz. Their opposite ends protruding from the quartz show numerous kaolin-filled molds once occupied by albite (*cleavelandite*), implying the former existence of a cleavelandite replacement body near the central portion of the pegmatite. These red manganotantalite crystals probably began to crystallize near the end of albite formation and ended with the final episode of quartz crystallization. Subsequent crystallization of manganotantalite is limited, as evident from a few very rare specimens with their terminations protruding from late-stage quartz.

POSTSCRIPT

Pegmatites of the Alto do Giz have been producing interesting mineral specimens for over half a century. Since the beginning of this investigation, another twinned manganotantalite has been obtained by one of us (RRW) from a garimpiero. This small, red trilling appears to be multiply twinned by reflection on {021}, and is reported to have been found at or near one of the pegmatites described here. With continued mining, additional and perhaps yet different specimens may come to light.

ACKNOWLEDGMENTS

We wish to thank Ed Laitila for his assistance with the X-ray powder diffraction analysis and unit cell refinement calculations. We are grateful to R. Peter Richards for alerting us to the morphological similarity of specimens twinned by each of the twin laws.

REFERENCES

DANA, E. S. (1901) *A System of Mineralogy,* 6th Edition. John Wiley & Sons, 1134 p.

DE ALMEIDA, S. C., JOHNSTON, W. D., JR., LEONARDOS, O. H., and PENA SCORZA, E. (1944) The beryl-tantalite-cassiterite pegmatites of Paraiba and Rio Grande do Norte, northeastern Brazil. *Economic Geology*, **39**, 206–223.

ERCIT, T. S., HAWTHORNE, F. C., and CERNY, P. (1986) Parabariomicrolite, a new species, and its structural relationship to the pyrochlore group. *Canadian Mineralogist*, **24**, 655–663.

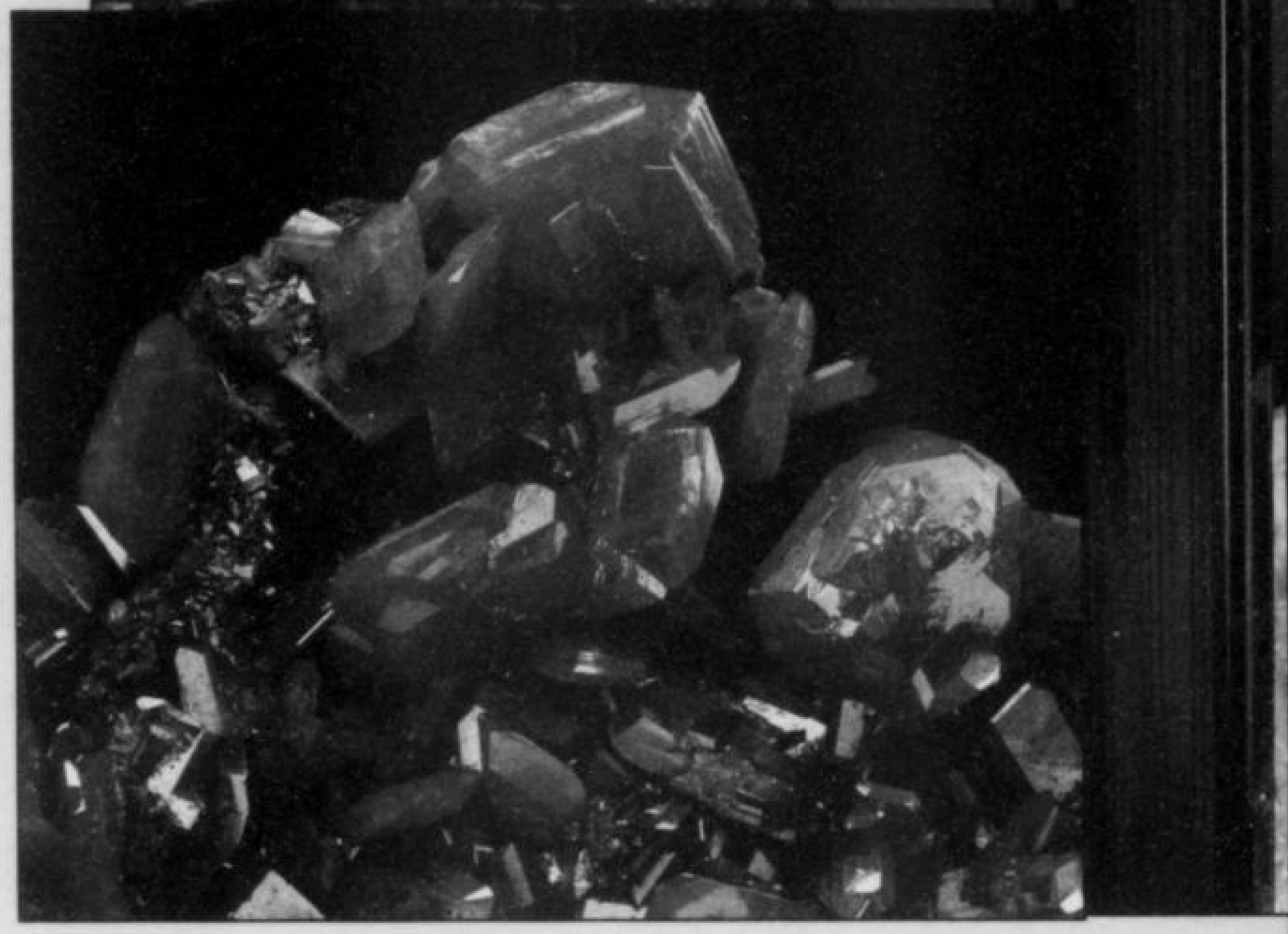
GAINES, R. V., SKINNER, H. C. W., FOORD, E. E., MASON, B., and ROSENZWEIG, A. (1997) *Dana's New Mineralogy*. John Wiley & Sons, 1819 p.

GRICE, J. D., FERGUSON, R. B., and HAWTHORNE, F. C. (1976) The crystal structures of tantalite, ixiolite and wodginite from Bernic Lake, Manitoba, I: tantalite and ixiolite. *Canadian Mineralogist*, **14**, 540–549.

GUIMARAES, C. P. (1944) Calogerasita, um novo mineral da familia dos tantalatos. *Mineracao Metalurgia*, **8**(44), 135–136.

MANDARINO, J. A. (1993) Changes in properties of minerals caused by publication. *Rocks & Minerals*, **68**, 220–225.

(continued on page 521)



Alain Martaud
Andreas Guhr—Mineralien Zentrum
Andreas Weerth
Brian Kosnar—Mineral Classics
Classic Minerals
De Natura—Les & Paula Presmyk
Fine Minerals International—De Trin
Heliodor
Ian Bruce—Crystal Classics
Lawrence Stoller—CrystalWorks
Mike Bergmann Minerals
Pala International
Rob Lavinsky Minerals
Rob Sielecki—Ausrox
Steve and Clara Smale
Victor Yount
Wayne Thompson Fine Minerals

Tucson
WESTWARD LOOK
Mineral Show

Exclusively Fine Minerals

FEBRUARY 7–11

WESTWARD LOOK RESORT
245 E. INA ROAD, TUCSON

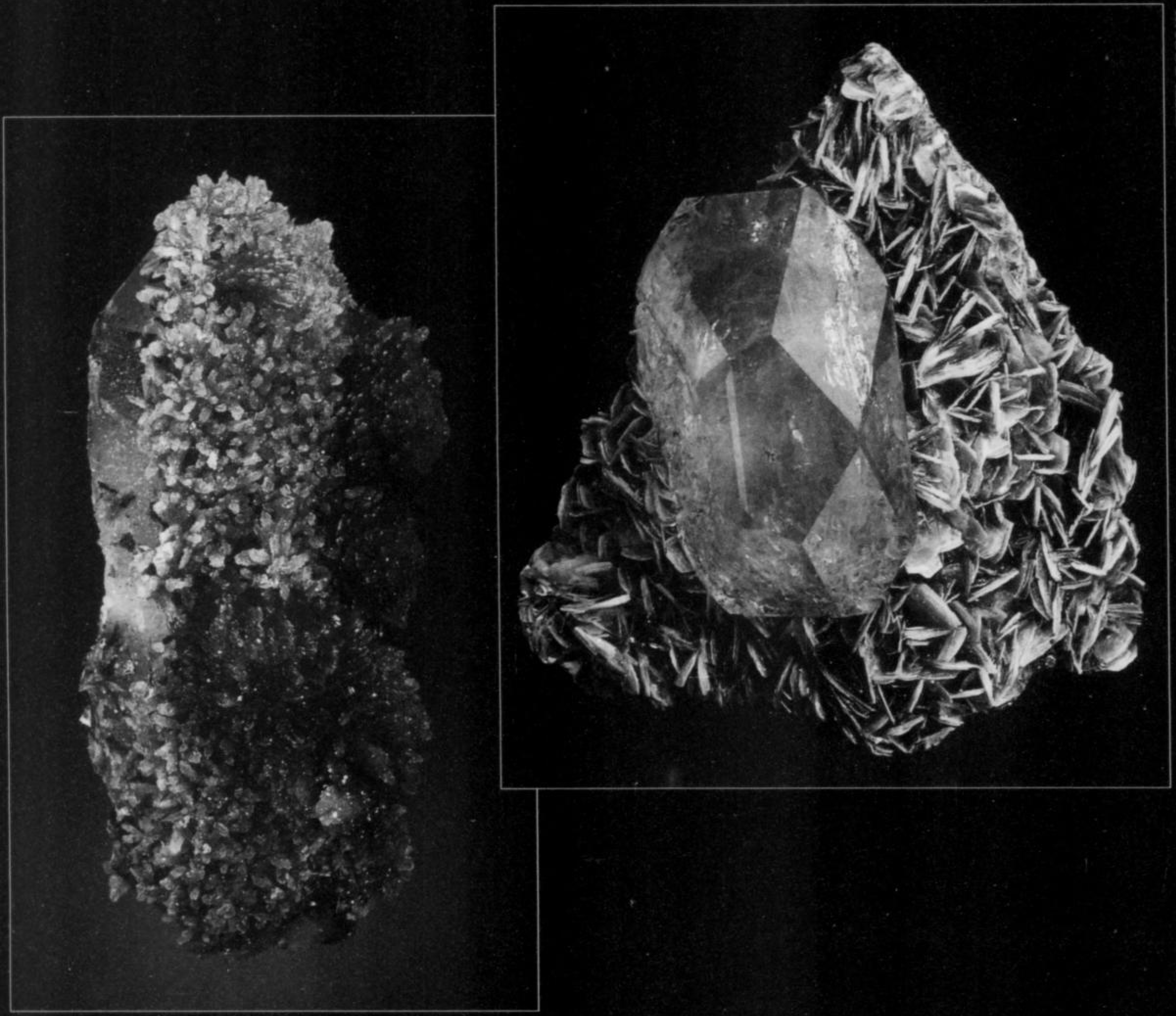
FOR INFO & RESERVATIONS CONTACT: DAVE WAISMAN
509-458-2331

GENE MEIERAN DAY!

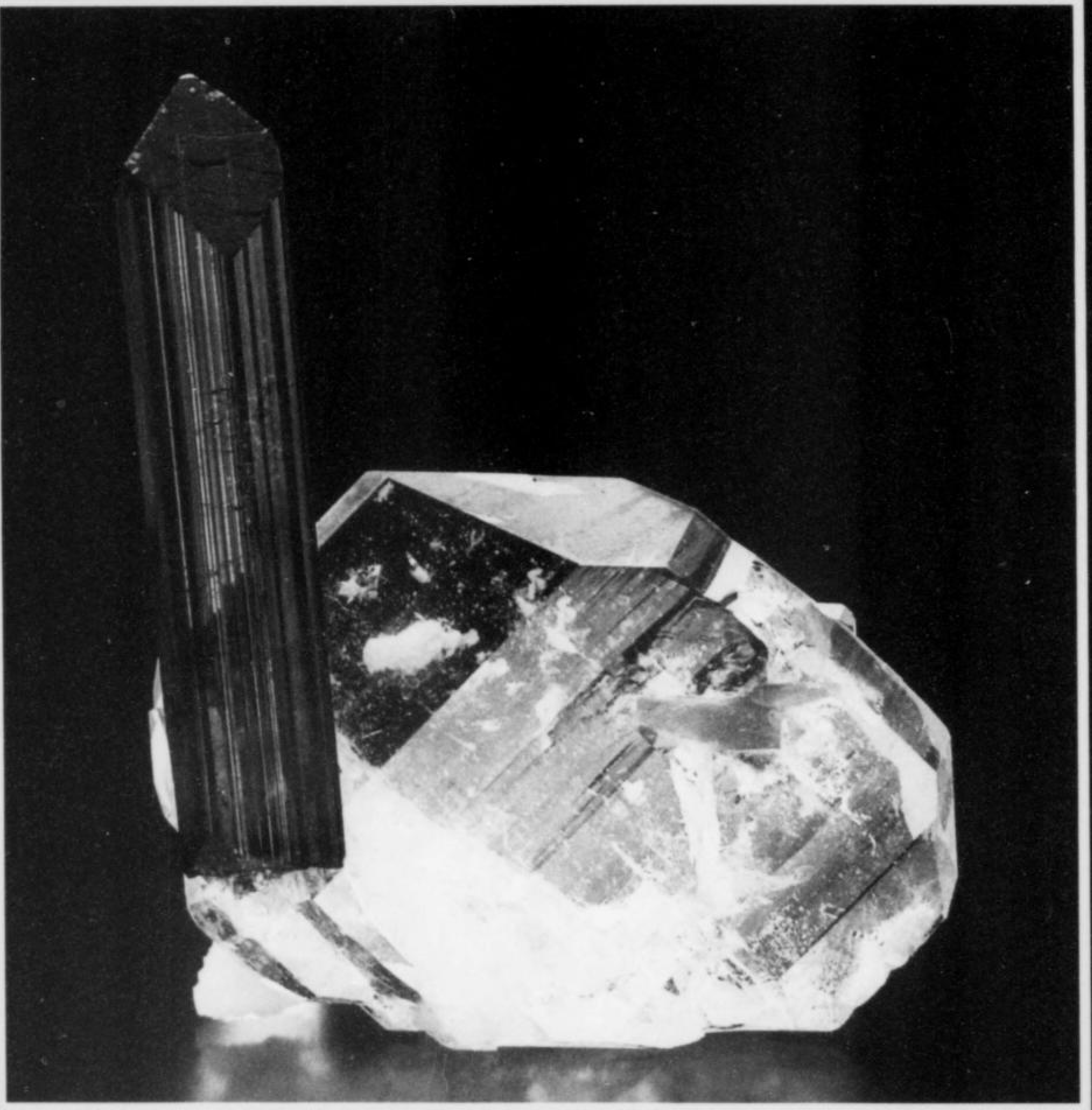
Special Saturday Show Feature!

Top Pieces from the Gene Meieran Collection, most of them never before displayed in public, and Gene will be there to chat with!

SUNDAY PROGRAM begins 6:30 pm, hors d'oeuvres, and Speakers at 7:30 pm: Richard Bideaux, Rock Currier



JEFF SCOVIL



QUARTZ SCEPTER CRYSTALS FROM THE ENTIA VALLEY, HARTS RANGE, CENTRAL AUSTRALIA

Don McColl
Curator of Minerals (retired)
Museum of Northwest Queensland
Present address: P.O. Box 252
Glenside, South Australia 5065
Australia

Scepters and other unusual growth habits are found in colorless, amethystine and smoky quartz crystals from Entia Valley. The formation of scepter crystals may result either from co-crystallization of quartz with calcite or from quartz crystallization at different points of nucleation from discontinuous solution flows.

INTRODUCTION

The Harts Range is one of the more notable localities in Australia for some of the rarer well-crystallized metamorphic mineral species, some of which have been found in gem-quality crystals. Crystals of ruby corundum, kornerupine, titanite and epidote have been reported on by McColl *et al*. (1980, 1984, 1990). Mica-group minerals are the only species which have been mined commercially in the Harts Range—briefly, about fifty years ago. At that time, some remarkable quartz crystals, including some having the classical scepter habit, were collected as curiosities by the mica miners. The crystals were not generally seen as having any significant value, and were obtained by barter from the local Arrente Aboriginal people. Since that time, casual "fossicking" (crystal hunting) has continued to produce some very unusual and sometimes superb specimens.

The best recent material has been gathered, principally by the Aboriginal people, from an area of the eastern Harts Range known as the Entia Valley. During the period 1986–1991, I was living in Alice Springs, only 200 km southwest of the Harts Range, and actively encouraged the people of the nearby Atitjere Community to continue to collect quartz crystals for sale. Over this time some remarkable specimens were found, some of which I purchased, and are the basis for this article. Specimens have also reached the American market.

GEOLOGY

The Entia Valley is a massive drainage basin which is shown on the "Quartz" 1:100,000 series geological map produced by the Bureau of Mineral Resources in Canberra (Shaw *et al*., 1990). This map is appropriately named, as many of the rugged mountain ranges of that area are liberally seamed with massive veins of quartz and granite pegmatites. These cut through the local rock, which is an inlier of much more ancient metamorphic rocks known

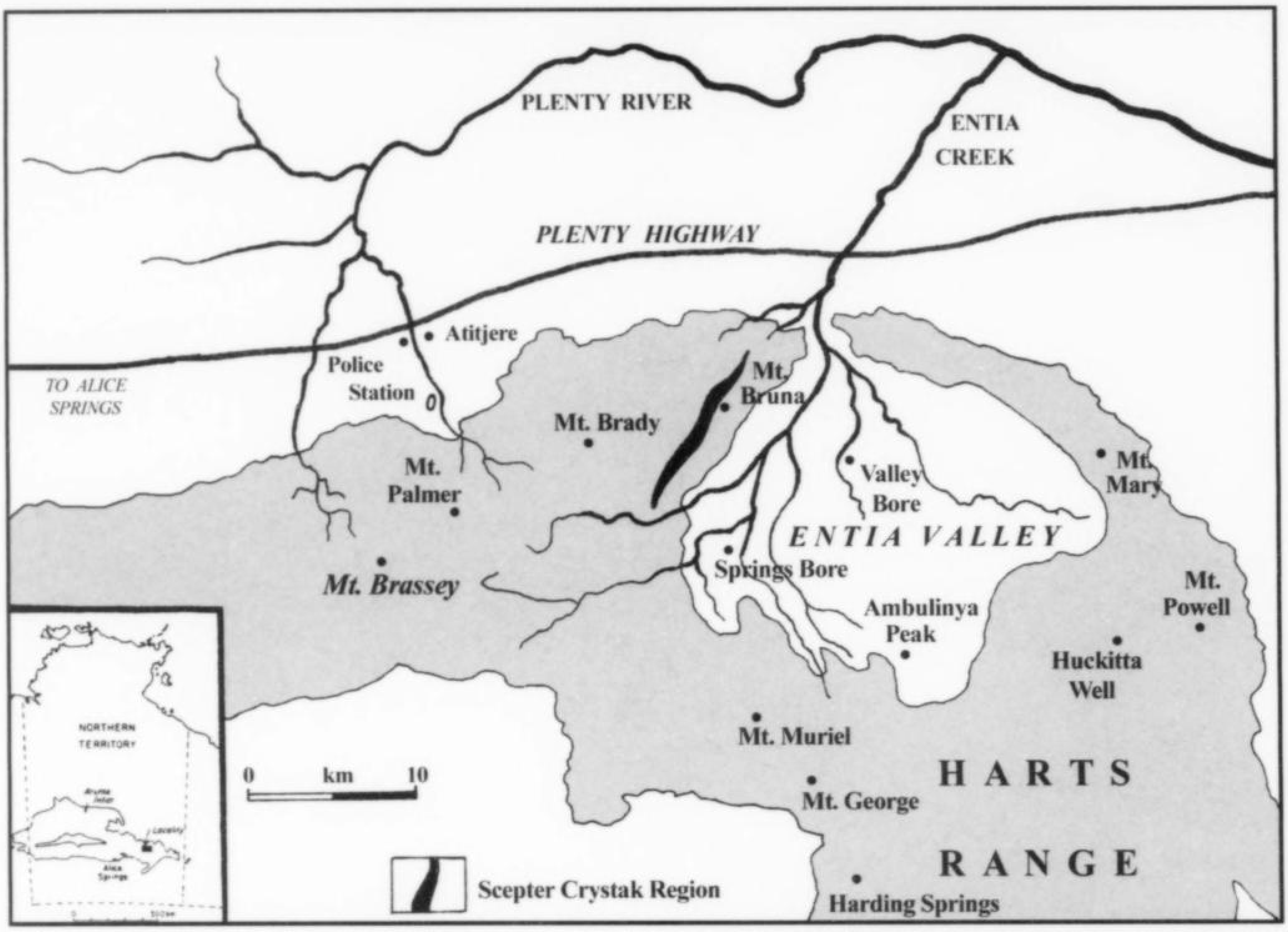


***Figure 1*. Location diagram of the Harts Ranges, showing the Entia Valley and the principle area in which much of the scepter quartz crystallization has been found.**

***Figure 2*. Arrente Aboriginal prospector Lindsay Cavenagh, standing in an excavated typical scepter crystal site. Note the small size of the vein and the distinctive torroidal outcrop of the amphibolite host rock.**

as the Arunta Block, a Precambrian complex that occupies much of Central Australia and extends across almost the whole width of the Northern Territory.

The rocks of the Arunta Block are up to 2 billion years old and are believed to represent a former accumulation of lavas, volcanic ash beds and minor sediments which have been intensely metamorphosed by downwarping to depths greater than 10 km within the crust, producing metamorphic alteration up to granulite facies. The Riddock Amphibolite member is a well-defined horizon consisting essentially of hornblende-plagioclase amphibolites, with minor bands of garnet-mica-feldspathic schist grading to granitic rocks of more gneissic texture.

The best quartz crystal specimens have come from exposures of the Riddock Amphibolite horizon on the western side of the Entia Valley. The valley itself has developed within a large convex domal structure, in which the older and softer rocks exposed in its core have been preferentially eroded throughout the vast watershed of the Entia Creek. Along the western perimeter the more resistant gneissic rocks of the Riddock Amphibolite form spectacular, prominent ridges with frequent outcrops of massive pegmatites and quartz veins. It is in this area that the veins containing the best scepter quartz crystals have been found, invariably located within amphibolite bands.

The quartz-bearing veins are all very small, and appear to be products of the late-stage hydrothermal alteration of the metamor-

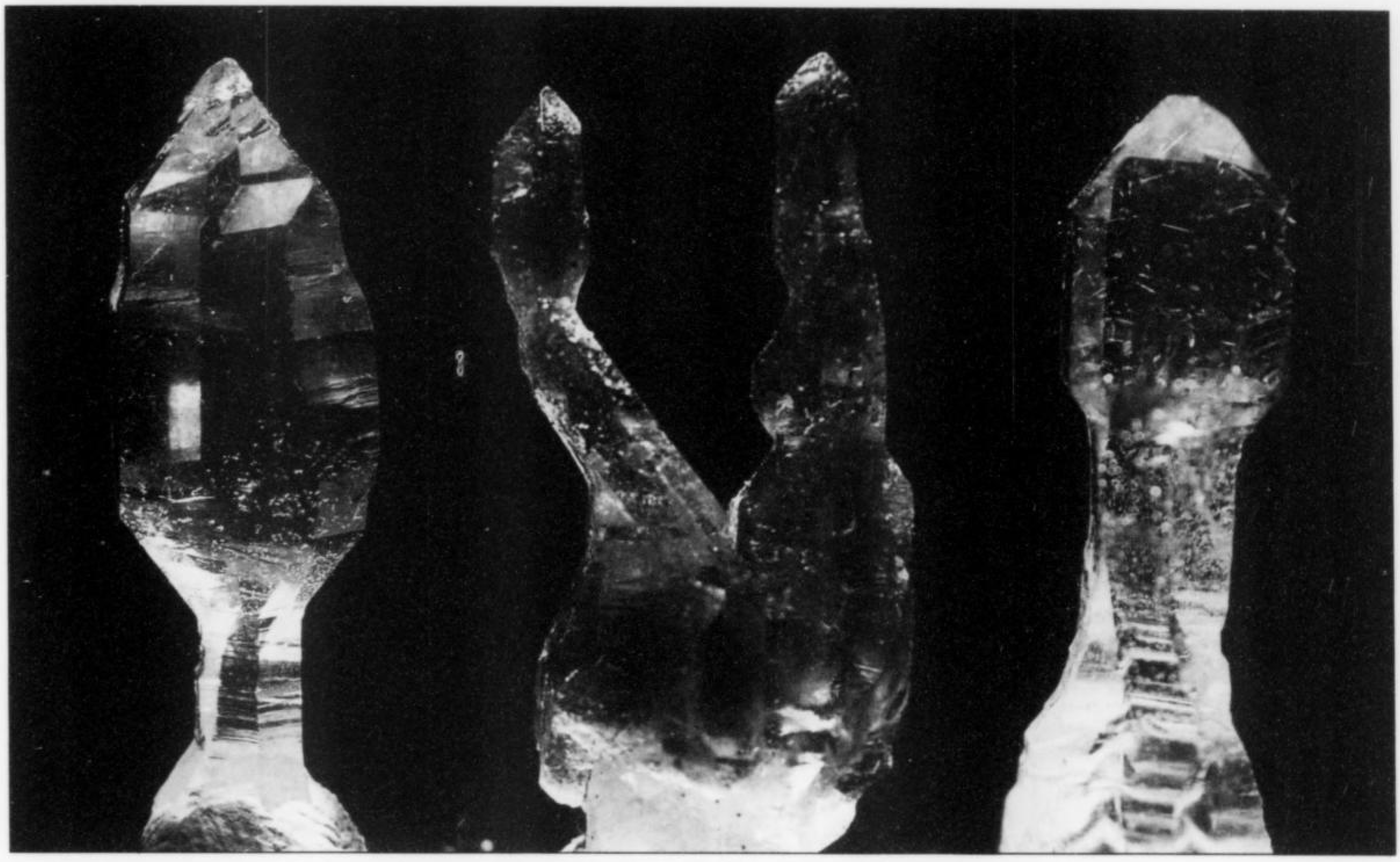


Figure 3. (Left:) **Gem-quality amethystine scepter, 3 cm, with narrow stem. Author's collection.** ***(Center:)*** **Distorted double scepter crystals, 2.5 cm, varying in intensity of coloration.** ***(Right:)*** **Amethystine scepter crystal, 5 cm, with twisted stem prism faces. Author's collection.**

phosed volcanic rocks, where percolating steam and hot liquids reworked the pyroxenes and amphiboles. These watery fluids were probably introduced into the metamorphic rocks as remnants of the pegmatite-forming process which is believed to have taken place in conjunction with the Alice Springs Orogeny, a period of mountain-building activity about 300 million years ago. At this time, sections of the deeply buried metamorphic rocks of the Arunta Block were raised to the surface, and the large pegmatite bodies crystallized.

All of the scepter crystal-bearing veins occur in outcrops of a very specific band of amphibolite which may be a metabasalt. Weathered exposures of this rock have a distinctively toroidal shape. Most crystal occurrences seem to be within a few hundred meters of one of the massive pegmatites, which are therefore inferred to be the likely source of the hydrothermal mineralizing fluids. Locally these fluids have grossly altered the amphibolites, in some places producing deposits of metasomatic lime-rich minerals such as epidote and titanite (McColl *et al.*, 1990, 1997), as well as albite and rutile. The alteration is also the probable source of the calcite-quartz veins where the scepter crystals occur.

MINERALIZATION

Scepter crystals are essentially normal crystals which, as a result of peculiar circumstances of growth, develop unusually large, bulbous terminations on thin prismatic stems. They have been recognized as exotic crystal rarities for a long time; Scovil and Wagner (1991) described a famous occurrence in Arizona. However, scepter crystals are only one kind of unusual distortion of quartz crystal growth, and often occur with others, e.g. long, spiky prisms or complex, bent, twisted and flattened forms. At the Harts Range occurrence, amethystine, smoky and colorless quartz frequently occur in close conjunction, sometimes even within a single crystal, and within each vein there are often distinctive peculiarities of color and form. Most of the sites visited have shown remnants of calcite (possibly ferroan) as an original associate of the scepter quartz crystals.

The majority of the crystals have been collected from eluvial deposits in the Entia Valley. In this arid region of very infrequent rainfall, erosion only slowly removes the weathered mineral detritus of the veins, so that the soil overlying and adjacent to a crystal-bearing vein can accumulate an abundance of quartz fragments and eluvial crystals. Apparently these were distributed sparsely in the original vein, but during the slow weathering process, with the relatively gentle removal of fine weathered fragments, the more resistant crystals have simply remained sunken into the subsoil and have accumulated there, rather than appearing as floaters on the surface. Some sites have been found where an accumulation of up to 100 or so loose crystals are present in a weathering pod just a few centimeters below the soil surface. That the crystals are found in this way explains why so few matrix specimens exist.

CRYSTALLOGRAPHIC HABITS

The classical form of a scepter crystal is shown by the superb example in Figure 5 *(left)*, which corresponds fairly closely to the idealized form shown in some older textbooks. Very few, however, are so large or so perfect as this example. The bases of the stems of many of the scepter crystals sometimes show the associated hydrothermal minerals, such as the albite and rutile noted on the crystal in Figure 5 *(center)*. That there was an irregular supply of nutrient

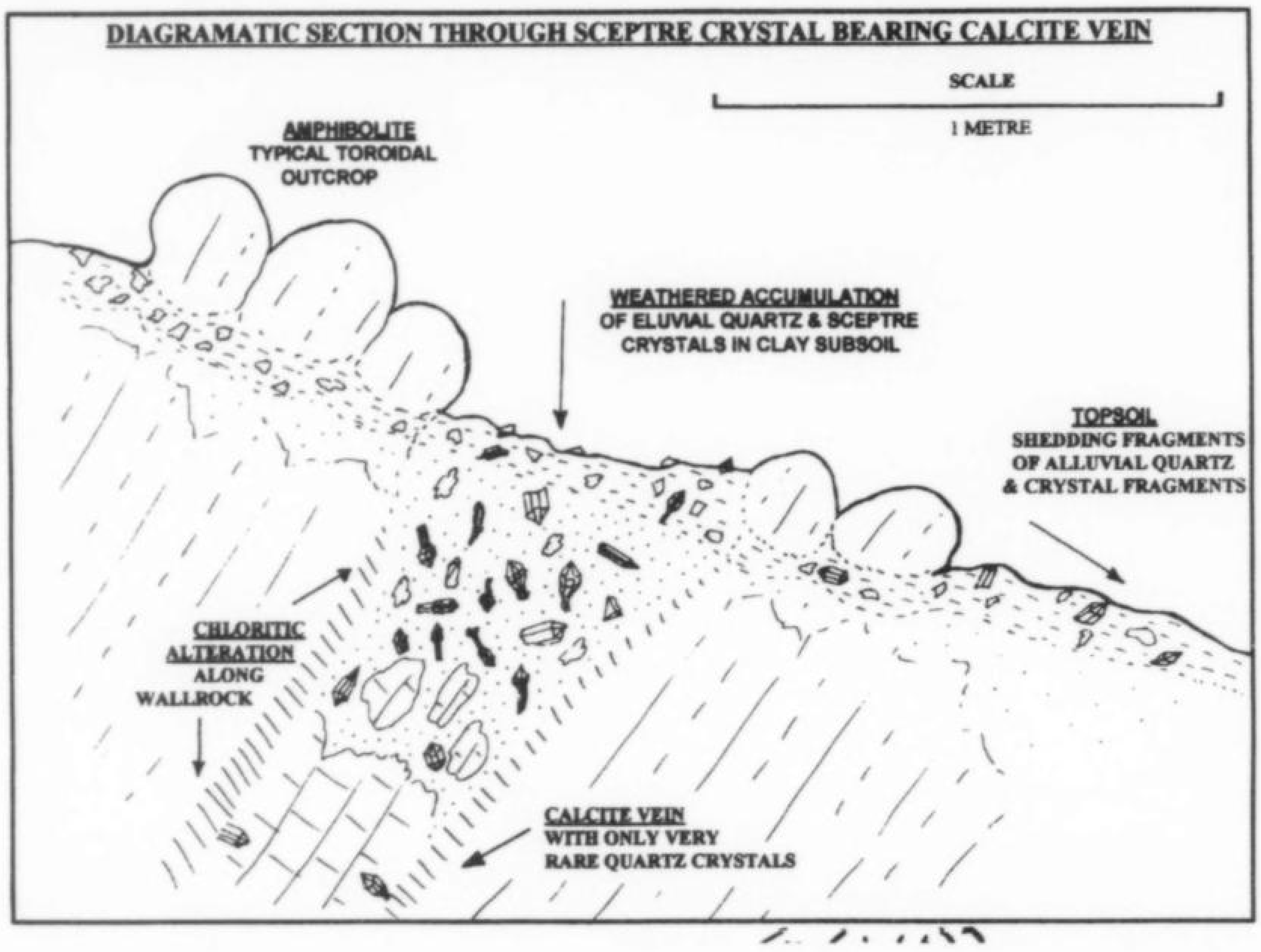


***Figure 4.* Idealized section through quartz-calcite vein, showing the type of eluvial weathering accumulation of quartz crystals which develops in the subsoil.**

fluids to the growing crystals is suggested by the spire which has grown on the termination of the crystal in Figure 5 *(right)*. Some crystals also show plentiful liquid inclusions, including even a few mobile gas bubbles, which also indicate rapid, irregular growth.

Some crystals have very obviously grown in environments where there was some mutual interference between mineral species, and competition for space. Figure 6 shows a doubly terminated quartz crystal which has a narrow waist because there was a barrier in the middle. This seems likely to have been a calcite crystal which grew simultaneously with the quartz, but later dissolved away during weathering.

Some crystals show very gross distortions, like the one in Figure 7, which seems to have grown both around a barrier and in a constricted space. This crystal, which is mainly colorless, is also unusual in that the tips of the horn-like parallel growths on the upper face are amethystine.

GENESIS OF SCEPTER FORMS

Crystals excavated at several sites have shown some similarities and some differences which are probably of genetic significance. Two distinct types of scepter crystals have been recovered, suggesting that two mechanisms of formation have been involved.

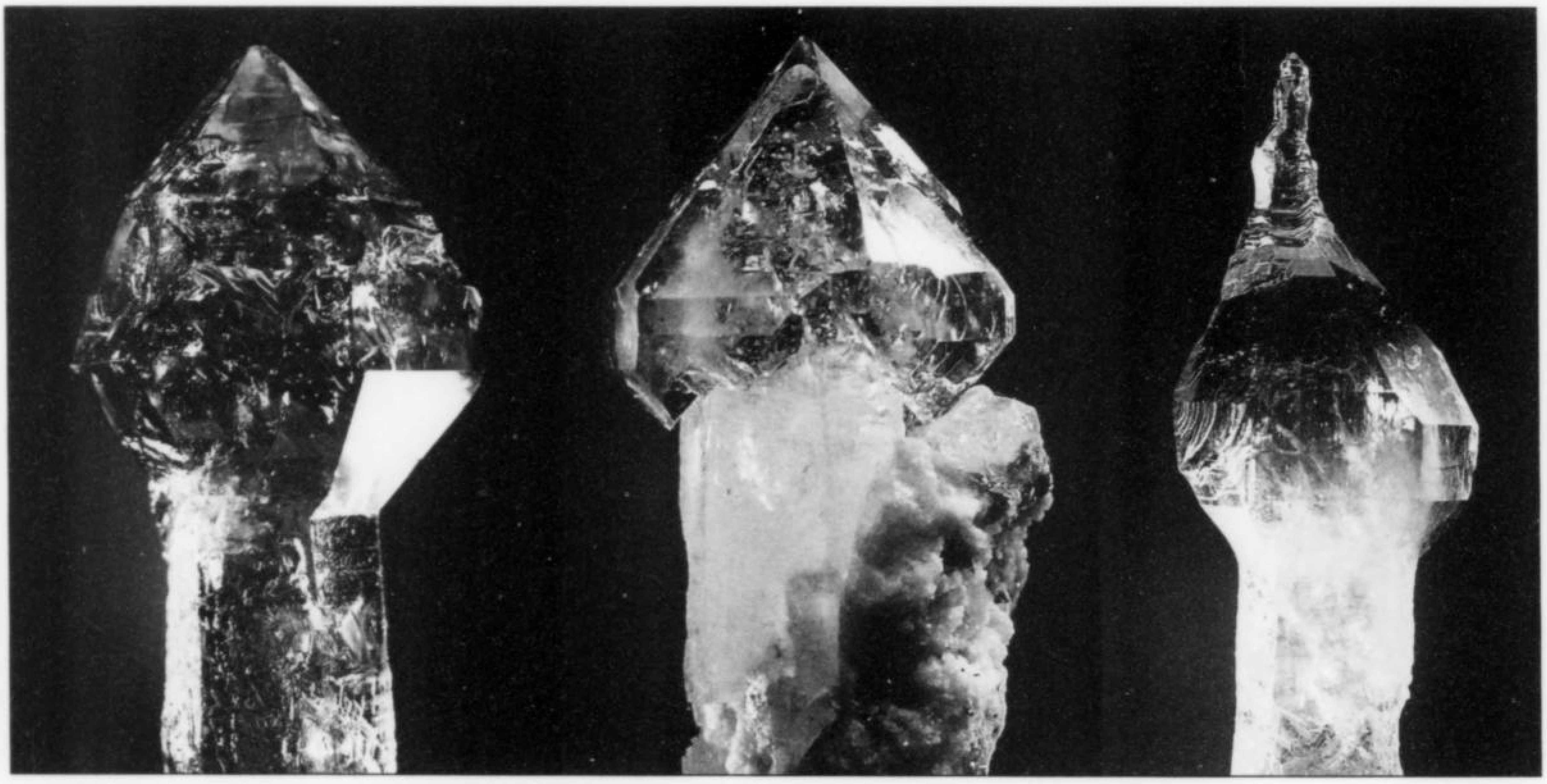


***Figure 5.* *(Left:)* Well-formed quartz scepter crystal, 3 cm wide at maximum width. *(Center:)* Well-formed quartz scepter, 3 cm across, with albite and traces of rutile at the base. *(Right:)* Scepter quartz crystal, 6 cm tall, with pointed spire. Author's collection; Tom Roschi photos.**

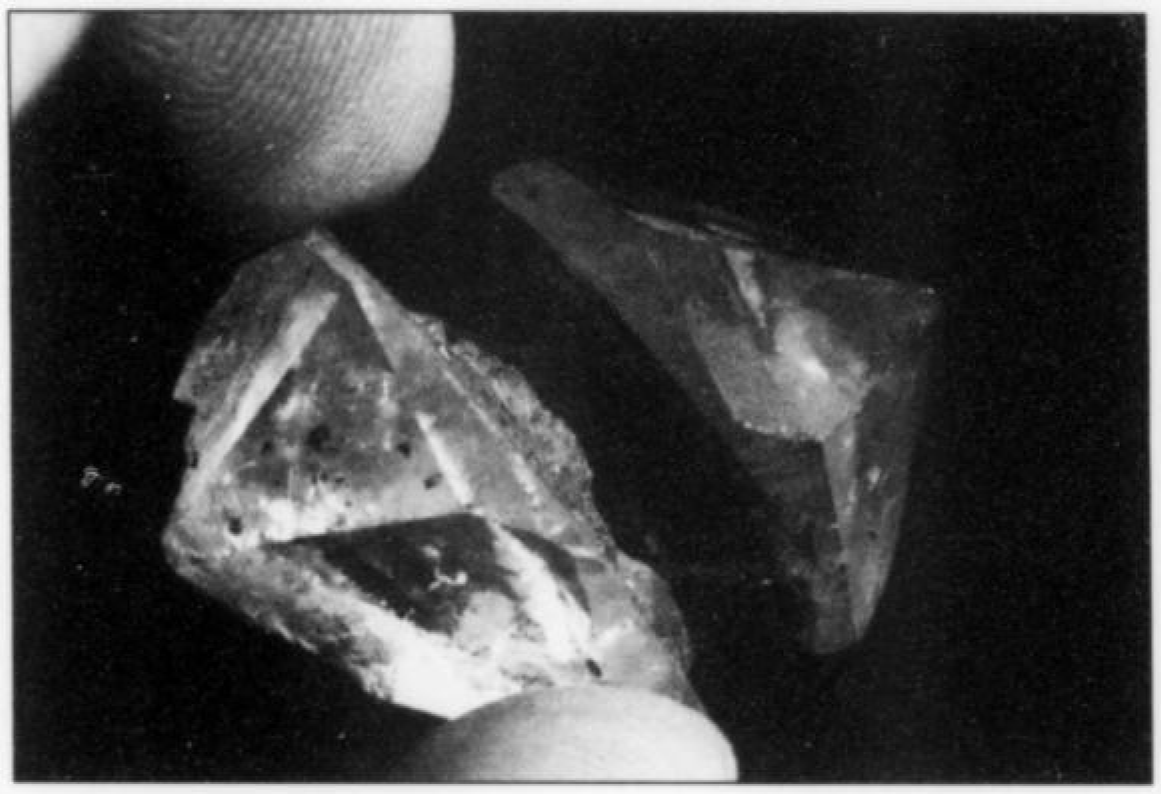


***Figure 6.* Doubly terminated quartz crystal 3 cm long with central waist due to crystallization through a barrier, since lost by weathering. Collection of the author.**

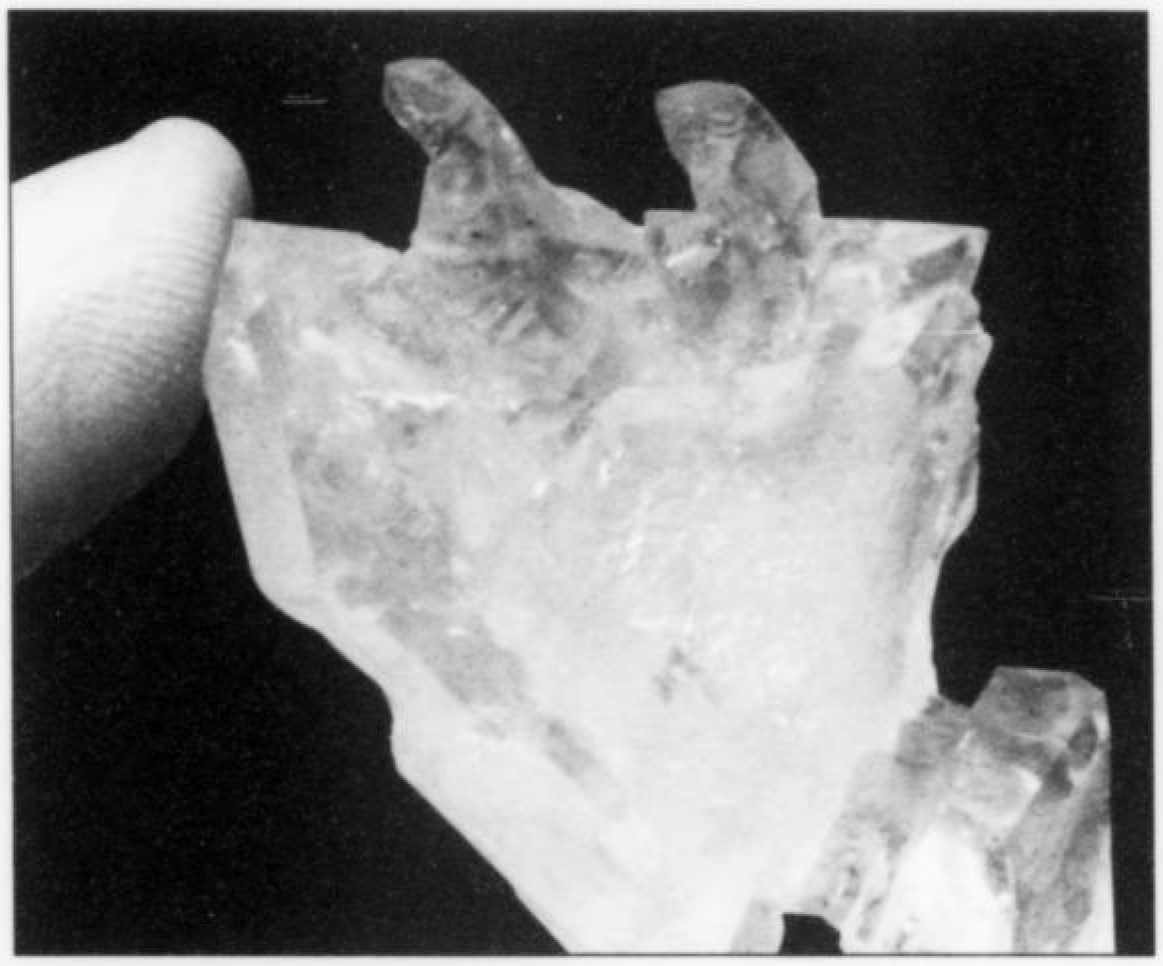
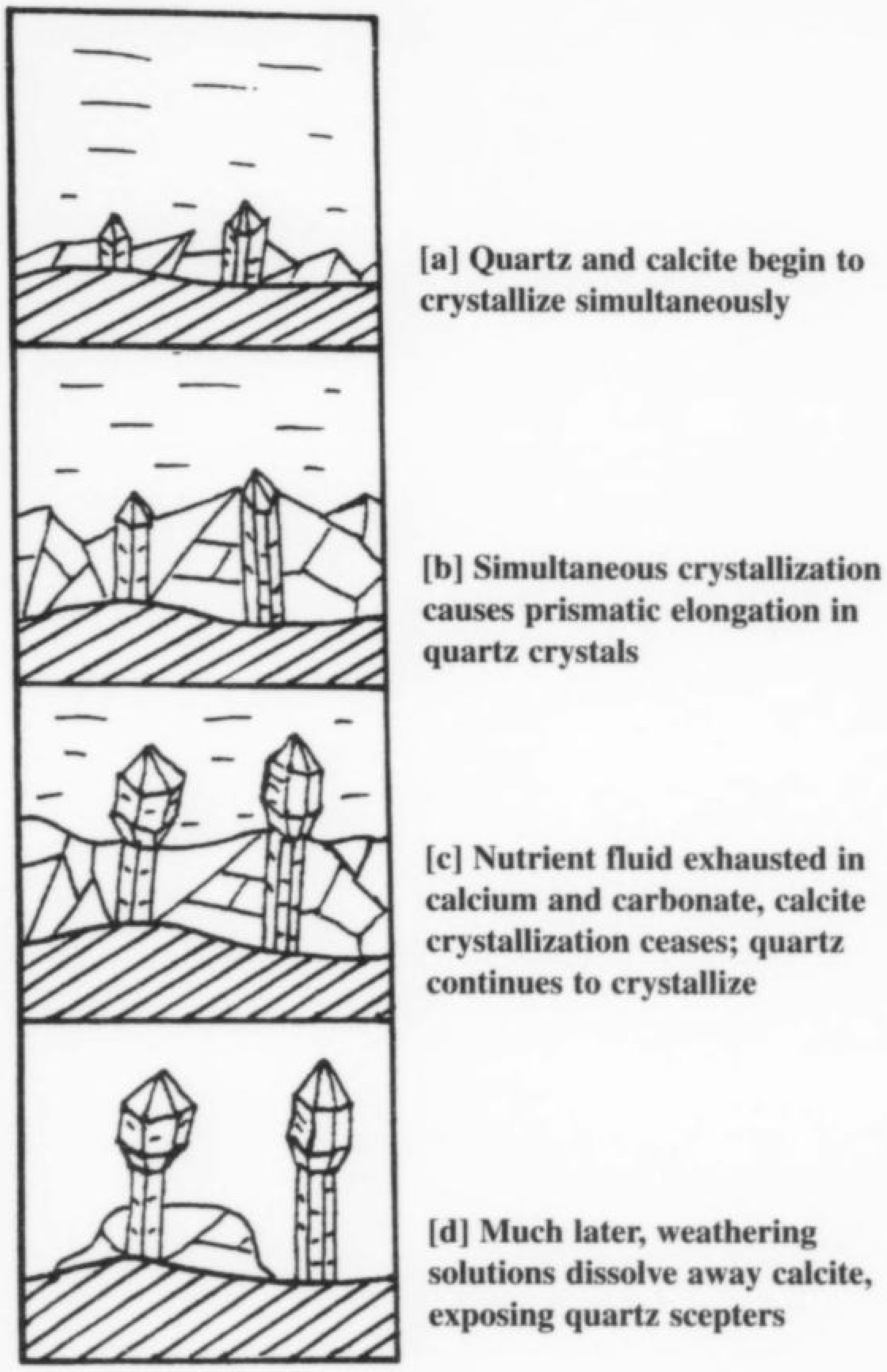


***Figure 7.* Quartz crystal grossly distorted through co-crystallization with calcite. The tips of the crystal terminations on the upper surface are amethyst-tinted. The crystal measures 3 x 6 cm. Collection of the author.**



[a] Quartz and calcite begin to crystallize simultaneously

[b] Simultaneous crystallization causes prismatic elongation in quartz crystals

[c] Nutrient fluid exhausted in calcium and carbonate, calcite crystallization ceases; quartz continues to crystallize

[d] Much later, weathering solutions dissolve away calcite, exposing quartz scepters

***Figure 8.* Diagram of suggested stages in the co-crystallization mechanism for the growth of quartz crystal scepters in conjunction with calcite.**

First, those scepter crystals in which the stem and crown are one continuous piece of quartz—as for all of the crystals in Figures 3 through 7—have possibly all developed by co-crystallization of quartz and calcite; the calcite having restricted the growth of the quartz laterally (see Fig. 8). This circumstance initially limits the quartz to elongation, promoting horizontal growth striations because of competition; then, with a change in the composition of the nutrient liquid, one crystal, either the quartz or the calcite, develops preferentially. This explains the formation of enlarged or constricted sections partway along or at the termination of the prism. Such scepter crystals are clearly composed of one single, though distorted, column of quartz, although there may be amethystine or smoky color variations anywhere along the length of the crystal. Scepter crystals of quartz intimately intergrown with calcite have been observed in the field.

However, several scepter-type formations have been noted in which this process has not been completed for one reason or another. One such example is a cluster of tapering amethyst crystals for which, it would appear, the crystallization of the surrounding carbonate was so rapid as to finally close off and bury the quartz, checking its further development. The crystals are still complete, and the tapered prism faces end in tiny rhombohedral terminations at the apices. It is theorized that in this competition the carbonate, probably calcite, by growing faster than the amethyst, finally enveloped it, cutting it off from further nutrient, and freezing development of the cluster at that stage.

A few clusters of small milky quartz crystals with amethyst scepter overgrowths have been recovered which, it is suggested, developed by a second mechanism—point nucleation. These were apparently vein-wall linings growing into empty fissures. Some of the crystals in these clusters have sceptered amethystine overgrowths of distinctly different composition and color. In the Entia Valley, such crystals are often filled with rutile needles, and are quite spectacular, although individual crystals are quite small: only two or three centimeters high (Figs. 11 and 12). There seems to have been no carbonate present in this mineralization, and no competition for space; the secondary amethyst overgrowth has merely been initiated on the pointed termination of the underlying milky quartz crystal. In some examples, part of this underlying termination can still be seen, incompletely covered by the amethystine overgrowth (Fig. 12). In others, the secondary growth has developed in various directions, even extending down the side of the supporting crystal, like wax dripping down the shaft of a candle.

Figure 9. Small quartz scepter, partly weathered from massive calcite with some surface iron staining from weathering. The scepter crystal is about 1 cm tall and has apparently formed by the co-crystallization mechanism.

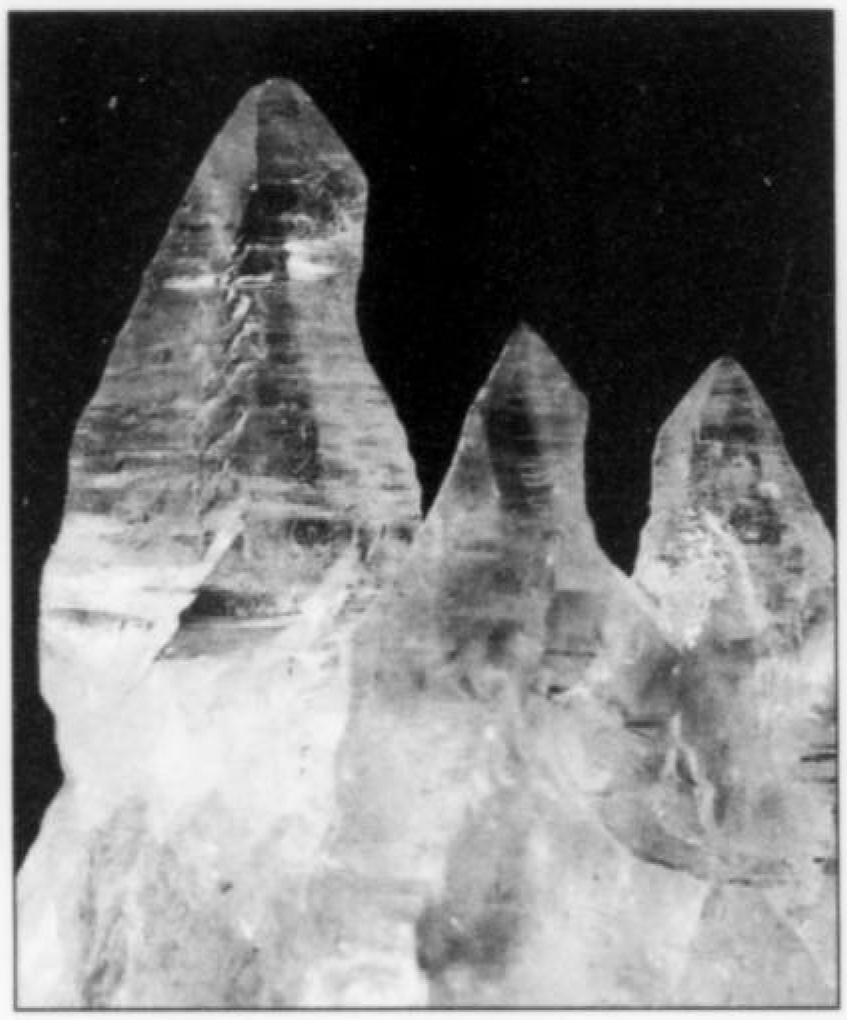


Figure 10. Cluster of pale amethyst crystals with tapering habit, probably developed from competition with faster-growing calcite. The cluster measures 3 x 5 cm. Keith Berlin collection.

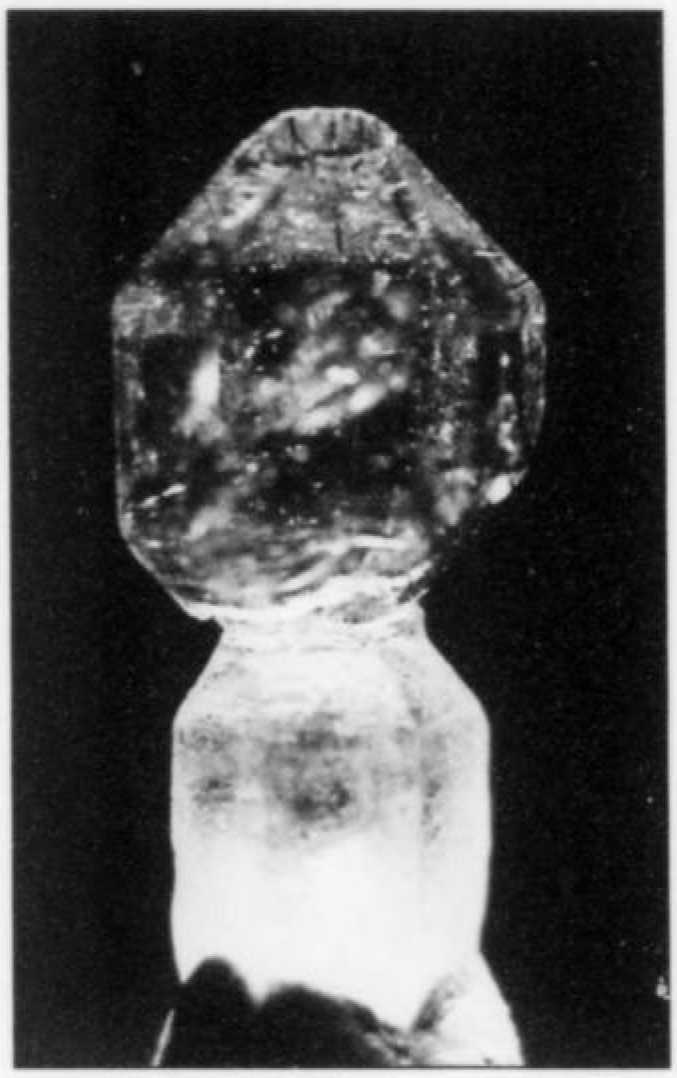


Figure 12. Single scepter crystal from the same locality as the one in Figure 11. The colorless stem shows part of the original termination, and a stepped crown of pale amethyst crowded with rutile needles, apparently grown by point-nucleation at the termination of the original crystal. 3 cm tall.

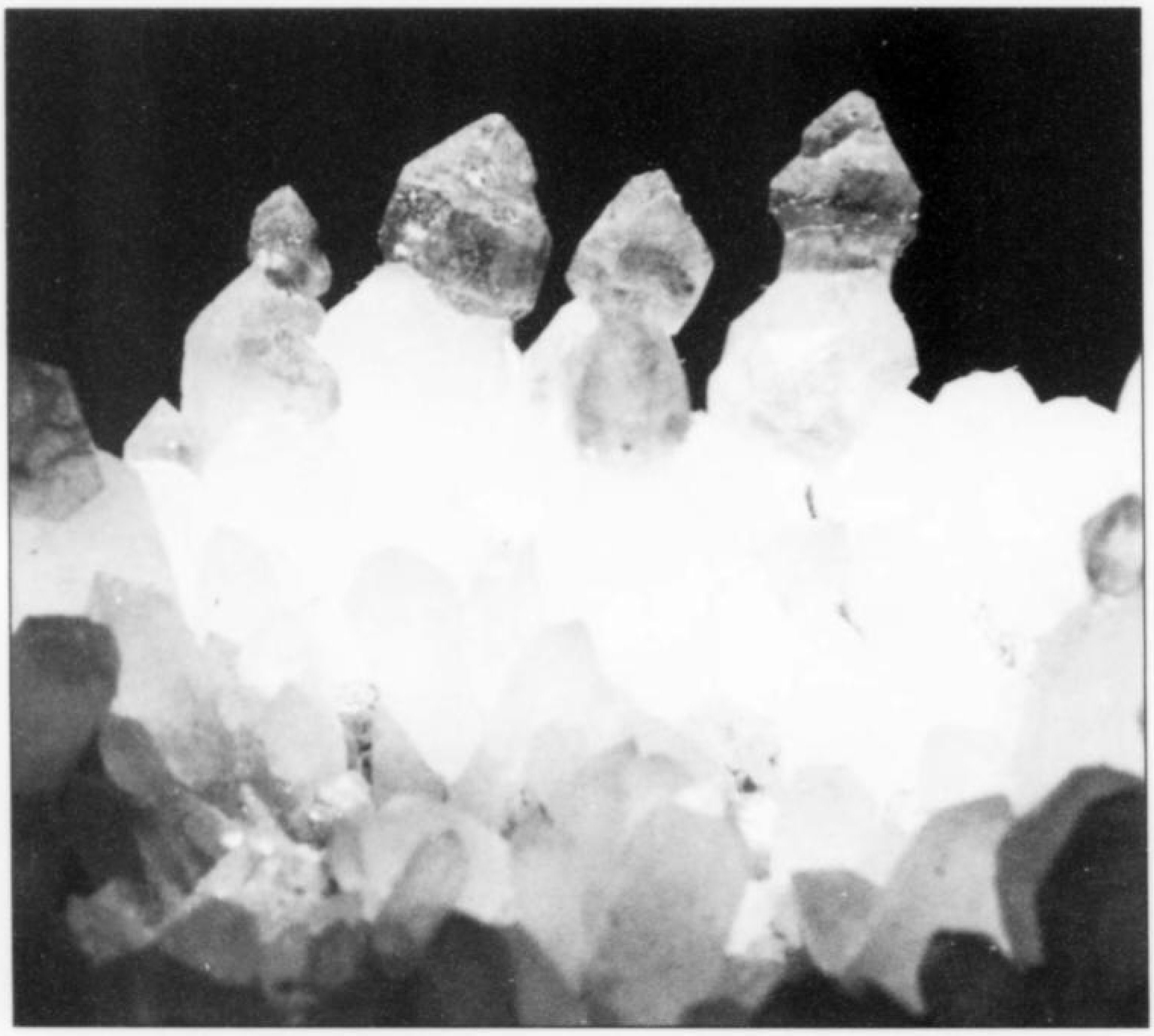


Figure 11. Cluster of tiny quartz crystals measuring about 5 x 6 cm, taken from the wall of a small vein. Several crystals with scepter terminations can be seen, apparently grown by point-nucleation at the terminations.

Figure 13. Smoky scepter crystal grown on a support of three smaller, colorless crystals. 4 cm tall.

CONCLUSIONS

Quartz crystal distortions have always been attributed to factors such as constricted growth environment, directed nutrient flow, and variations of nutrient composition. The examples from the Harts Range described above allow us to hypothesize about the specific manner in which these factors produced some very remarkable scepter shapes, and how the geological history of this region contributed to their formation. The terms "co-crystallization" and "point nucleation" are suggested to denote the two alternative mechanisms.

ACKNOWLEDGMENTS

The author particularly wishes to thank his wife Lois who, on so many occasions, shared with him the discomforts of travel in the hot and dusty conditions of the Harts Range. Thanks are also due to Dick and Anne Cadzow of Mt. Riddock cattle station for their friendly support, and to Aboriginal prospector Lindsay Cavenagh, whose help and companionship was greatly appreciated during many intriguing field trips. (Two other skilled and very competent Aboriginal men also helped greatly, but because they have since died, they are not named here, in deference to Aboriginal tradition.) This paper was first presented to the combined Mineralogical Societies of Australia annual seminars held in Brisbane in 1991.

BIBLIOGRAPHY

McCOLL, D. H., and WARREN, R. G. (1980) First discovery of ruby in Australia. *Mineralogical Record*, **11**, 371–375.

McCOLL, D. H., and WARREN, R. D. (1984) Kornerupine and sapphirine crystals from the Harts Range, Central Australia. *Mineralogical Record*, **15**, 99–101.

McCOLL, D. H., and PETERSEN, O. V. (1990) Titanite crystals from the Harts Range, Central Australia. *Mineralogical Record*, **21**, 571–574.

SCOVIL, J. A., and WAGNER, L. JR. (1991) The Fat Jack mine, Yavapai County, Arizona. *Mineralogical Record*, **22**, 21–28.

SHAW, R. D., FREEMAN, M. J. *et al.* (1990) Quartz (1:100,000 scale geological map). Bureau of Mineral Resources, Geology & Geophysics, Canberra, Australia.

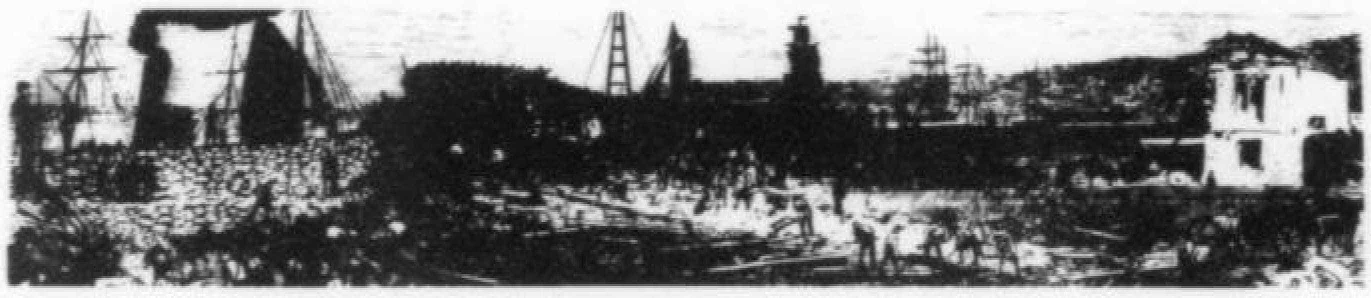
Manganotantalite *(continued from page 510)*

MASON, B., and BERRY, L. G. (1968) *Elements of Mineralogy*. W. H. Freeman & Co. 550 p.

PALACHE, C., BERMAN, H., and FRONDEL, C. (1961) *Dana's System of Mineralogy*, 7th Edition. Vol. 2, 780–787.

POUGH, F. H. (1945) Simpsonite and the northern Brazilian pegmatite region. *Geological Society of America Bulletin*, **56**, 505–514.

WISE, M. A., TURNOCK, A. C., and CERNY, P. (1985) Improved unit cell dimensions for ordered columbite-tantalite end members. *Neues Jahrbuch für Mineralogie, Monatsheft*, **1985**(8), 372–378.



INTERNET DIRECTORY

Alpine Mineral Company
Fine Alpine and Gem Pegmatite Minerals
www.alpineminerals.com
e-mail: kevin@alpineminerals.com

ARCH Minerals
Established Internet Mineral Pioneer
www.archminerals.com
e-mail: rhoek@archminerals.com

Argentum Auctions & Appraisers
Auctioneers of Minerals, Gems, Fossils & Mining Memorabilia
www.argentumauctions.com
e-mail: silver@argentumauctions.com

The Arkenstone
Fine minerals since 1996
www.irocks.com
rob@irocks.com

Attard's Minerals
Fine Worldwide Minerals, Equipmt., Services
www.attminerals.com
e-mail: attard@attminerals.com

Bob's Rockshop
Content & connectivity for rockhounds
www.rockhounds.com
www.tucsonshow.com

British Lapidary & Mineral Dealers Association
Member Directory, UK Mineral Fair Dates
www.blmda.com
e-mail: mansemins@btopenworld.com

Broadstone Minerals
Quality British & Worldwide Minerals
www.broadstoneminerals.com
mike@broadstoneminerals.com

CK Minerals
Cyril Kovac
www.ckminerals.com.au
minerals@netlink.com.au

Colorado Gem & Mineral
Fine Minerals, Gems, & Collectibles
www.coloradogem.com
jacklowell@earthlink.net

The Crystal Hopper
Australian and Worldwide Minerals
www.crystalhopper.com.au
e-mail: goodgame@vianet.net.au

Crystal Showcase
Collector-Quality Mineral Specimens
www.crystalspecimens.com
mineralspecimens@hotmail.com

Crystal Vine
UK Website: Worldwide & British Minerals
www.crystalvine.co.uk
e-mail: saragiller@crystalvine.co.uk

Cyberocks
Worldwide Minerals, Fossils, Fluorescents
www.cyberocks.com
e-mail: steven@cyberocks.com

Dakota Matrix Minerals
Cab. To MM, Rare, Fine, Weekly Specials
www.dakotamatrix.com
e-mail: dakotamatrix@rushmore.com

Douglass Minerals
Quality Worldwide Affordable Minerals
www.douglassminerals.com
e-mail: douglassminerals@aol.com

Edwards Minerals
Purveyors of Fine Specimens
www.edwardsminerals.com
e-mail: emr@edwardsminerals.com

Excalibur Mineral Company
Rare Minerals & Analytical Services
www.excaliburmineral.com
e-mail: info@excaliburmineral.com

Fabre Minerals
High-Quality Worldwide Minerals
www.fabreminerals.com
enquiry@fabreminerals.com

H&P Minerals and Gems
Thumbnail and Miniature-size Minerals
www.hpminerals.com
e-mail: halprior@louisacomm.net

Jewel Tunnel Imports
Indian & Worldwide Minerals Wholesale
www.jeweltunnel.com
rockcurrier@compuserve.com

Key's Mineral Collection
Kiyoshi & Eriko Kiikuni
www.keysminerals.com
keys@keysminerals.com

Marin Mineral Company
Fine xls, great prices, freq. site updates
www.marinmineral.com
e-mail: mike@marinmineral.com

Martin Zinn Expositions
Tucson, Denver, Springfield and Costa Mesa Shows!
www.mzexpos.com
e-mail: mz0955@aol.com

Mineralogy Database
On-line User-Frndly, Up-to-date Mineral Data
http://webmineral.com
e-mail: dbartheimy@webmineral.com

Mineral Shop
Worldwide Classics & Rarities
www.minservice.com
info@mail.minservice.com

Minerals Unlimited
Rare Species to Common Minerals
www.mineralsunlimited.com
minerals_unlimited@hotmail.com

Mineralsweb
Brice & Christophe Gobin
www.mineralsweb.com
gobin@club-internet.fr

North Star Minerals
So. Illinois & Eastern European Minerals
www.northstarminerals.com
northstarminerals@comcast.net

Ososoft Mineral Connection
Worldwide Minerals at Reasonable Prices
www.osomin.com
e-mail: george@osomin.com

Pala International
Best in Worldwide Gems & Collector Minerals
www.palagems.com
john@palagems.com

Penn Minerals
Classic Pennsylvania Minerals our Specialty
www.pennminerals.com
e-mail: SteveCarter@pennminerals.com

Pequa Rare Minerals
Rare, unique and new minerals
www.pequarareminerals.com
e-mail: josef1@optonline.net

Pickens Minerals
Fine Worldwide Minerals, Acrylic Stands/Mounts
www.pickensminerals.com
e-mail: reo@pickensminerals.com

SIBER+SIBER Ltd.
High-quality minerals since 1964
www.siber-siber.ch
e-mail: siber-siber@bluewin.ch

Simkev Micromounts
Finest quality minerals since 1979
http://www.simkevmicromounts.com
e-mail: simkev@kos.net

Spheres to You
More than 5,000 Beautiful Mineral Spheres
www.spherestoyou.com
e-mail: spheres@iswest.com

The Sunnywood Collection
Bill and Elsie Stone
www.sunnywood.com
minerals@sunnywood.com

Trafford-Flynn Minerals
Affordable Worldwide Quality Minerals
www.trafford-flynn.com
e-mail: info@trafford-flynn.com

UV Systems, Inc.
SuperBright and TripleBright UV lights
www.uvsystems.com
e-mail uvsystems@aol.com

The Vug
A very extensive mineral link portal
www.the-vug.com
partdragon@aol.com

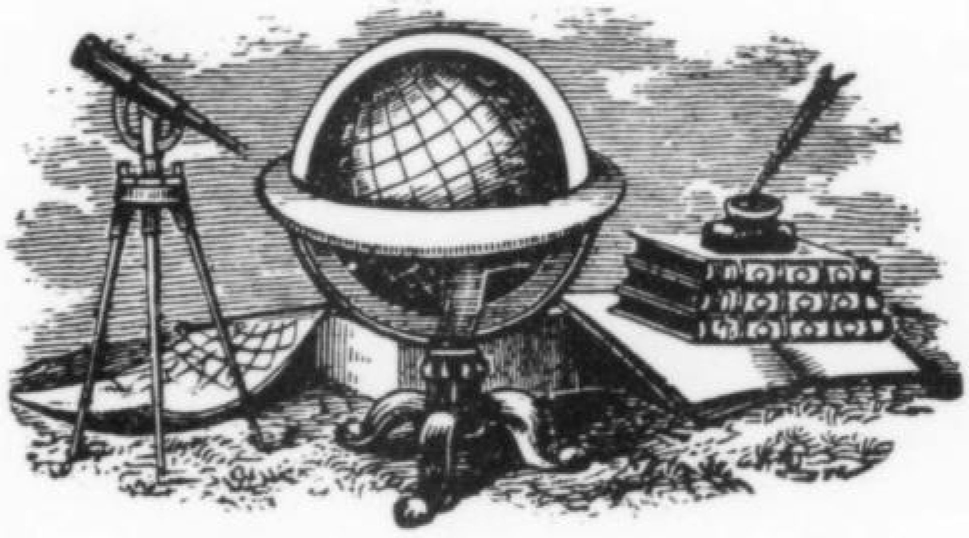
The Webmineralshop
Specializing in Fine Italian Minerals
www.webmineralshop.com
e-mail:webminerals@libero.it

Western Minerals
Finest Quality Worldwide Minerals
www.wmtucson.com
e-mail: schlepp@wmtucson.com

Wright's Rock Shop
Fine Worldwide Minerals
www.wrightsrockshop.com
wrightsr@ipa.net

**List your internet site here! Contact the editor at minrec@earthlink.net*

What's New



in Minerals

Springfield Show 2002

by Joe Polityka

At sunrise on Friday August 9th I was on my way to my 14th annual East Coast Gem and Mineral Show in West Springfield, Massachusetts. The Northeast was locked into an extended heat wave with temperatures expected to reach, and exceed, 90 degrees Fahrenheit over the weekend. In contrast to previous years, no rain was expected. In fact, the sky was so clear that I was able to see the mountains of Vermont, 60 miles distant, from my 14th floor room at the Marriott. The prospect was green as far as the eye could see.

This year 200 dealers (wholesale and retail) were set up at the show. The featured mineral exhibit was from the collection of the late James Minette and his wife Dawn. After Jim's death in January 2002, Dawn contacted the show committee to ask that they proceed, somehow, to exhibit the collection as a memorial to her husband. With the help of Dave Bunk and Les Presmyk, Dawn was able to set up about 50 cases of exceptional mineral specimens. The Minettes specialized in smithsonite and thumbnails; therefore, there were many prime specimens of these types from worldwide locations too numerous to mention, as well as exceptional specimens of other species, especially barite, gold, and beryl. Some of the specimens have been featured on the cover and inside the pages of the *Mineralogical Record* and *Rocks & Minerals*. Most specimens were set up in cases according to the country, state or continent of origin and were accompanied by information cards which provided details on the localities, and dates and methods of acquisition. Needless to say, I returned to the exhibit area many times during the weekend to study and admire my favorite specimens.

Perhaps the most impressive single case, marked "Favorite Thumbnails," contained about 50 astonishingly fine pieces, all measuring around 1 x 1 inch. Three of the best-of-the-best may be enjoyed vicariously if you own a copy of Bancroft's *Gem and Crystal Treasures* (1984): they are the California benitoite pictured on p. 92, the elbaite from Elba pictured on p. 358, and the Ojuela mine, Mexico "bowtie" legrandite pictured on p. 130 (a smallish thumbnail: the dimensions given in Bancroft are too large by a factor of two). The little legrandite was shown on a field of black on the Springfield 2002 T-shirt which many people (including Dawn Minette) were wearing, and so became the show's semi-official emblem. Thank you, Dawn, for allowing us to see your and your husband's fine collection, obviously the product of a lifetime of love, devotion and lots of perspiration.

Now down to the business of "What's New?" There were some exciting finds at the show this year, one of which is from a locality long past its heyday. At the booth of *Phil Scalisi* (Raynham, Massachusetts) were several large matrix specimens of **cerussite** from the Wheatley mine, Phoenixville, Pennsylvania (for the locality article see vol. 20, no. 5, p. 369). The white, translucent, glassy cerussite crystals (some twins) reach 3 cm and are scattered on a rust-colored limonite matrix. Some single crystals, large-toenail-sized, and thumbnail-sized sixling twin groups, without matrix were available. Phil told me the specimens came out of the collection of E. R. Chadbourn of Lewiston, Maine, and that Chadbourn had purchased them from A. E. Foote between 1880 and 1910. The large specimens were purchased by the Carnegie Museum and will be put on display in the near future.

Wright's Rock Shop had a large selection of **barite** on massive white aragonite from Hammam Zriba, Tunisia. The bladed, sky-blue crystal aggregates average about 2 cm and are scattered attractively (though sparsely) on the aragonite matrix. Most matrix specimens are mound-like in appearance, which adds to their appeal. The crystals have not been X-rayed; however, Chris Wright feels they are barite although he admits some crystals contain strontium. I recommend you buy one that appeals to you and wait for the final analysis.

Minerals America had five specimens of water-clear **barite** from the Book Cliffs area near Grand Junction, Colorado. The specimens, all miniatures, sport crystals up to 2 x 5 cm, on a fine-grained tan sandstone. These top-of-the-line specimens are from an old locality being reworked by *Collector's Edge Minerals*. At the booth of *Mountain Minerals International* I was shown some **bastnäsite** crystals from Zegi Mountain, Khyber Agency, Fata, Pakistan. The big, brown, hexagonal tabular crystals (some are squat prisms) average about 3 cm in diameter. They are mostly translucent; however, Dudley told me that one transparent broken crystal will be cut into a 40-carat stone. Dudley also told me that in Europe he sold a specimen which had a main crystal 6.5 cm in diameter, and had earlier sold a couple of superb, sharp, lustrous, translucent thumbnail-size crystals. Well-formed crystals of bastnäsite are, of course, quite rare, although they are getting less so: some extraordinary specimens have been emerging over the last year or so (see the 2002 Tucson Show report).

Mountain Minerals also had some matrix specimens of **emerald** from Gamintha, Laghman Province, Afghanistan. The deep green translucent crystals (averaging 5 cm) sit on a black schist matrix; specimens mostly come in large miniature to small cabinet sizes.

Kristalle was featuring some large cabinet specimens of **kunzite** from Mawi, Laghman Province, Afghanistan. Pink single crystals to 10 cm long sit on a white albite matrix. The crystals are transparent to translucent, and the color combination of pink and white, which is typical of this locale, is quite attractive.

IC Minerals had a large selection of recently collected specimens from the Kalahari Manganese Field in South Africa. Among them were **calcite**, in brilliant, colorless, transparent scalenohedral crystals to 3 cm; thumbnail and miniature-sized hematite crystal clusters with bright red **grossular**, the hematite mirror-faced and bright black; and odd-looking specimens of satiny blue **celestine** in rounded crystals to 1.5 cm on matrix. *Superb Minerals, India* had their usual large selection of **zeolites** and related minerals from the Deccan basalt of India.

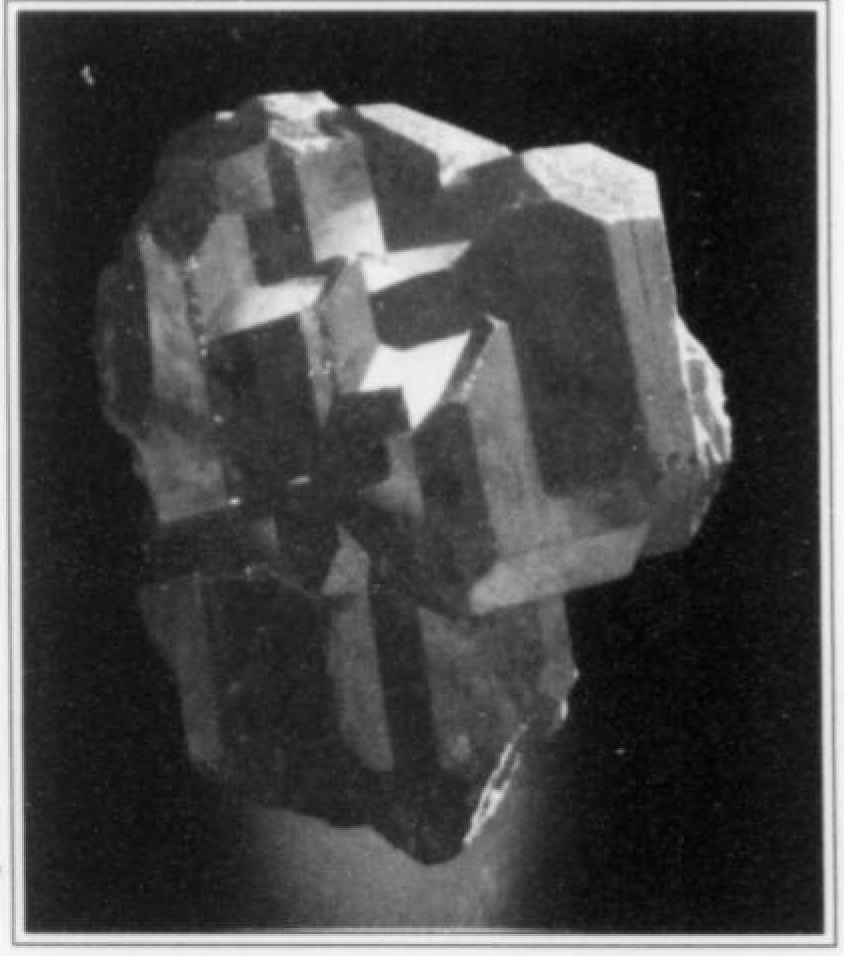
As in previous years, there were many one-of-a-kind specimens available. *Donald K. Olson & Associates* was disbursing a collection of classic specimens. Don had many pieces from Alpine localities in Switzerland, Austria and Italy, along with some old-timers from Europe and the United States. *Kristalle* had a case full of old-time eastern U.S. specimens, including **pyromorphite** from Phoenixville, Pennsylvania, **willemite** from Franklin, New Jersey, **chalcocite** from Bristol, Connecticut, and a few European oldies too, including some small specimens of very bright wire **silver** from Příbram, Czech Republic.

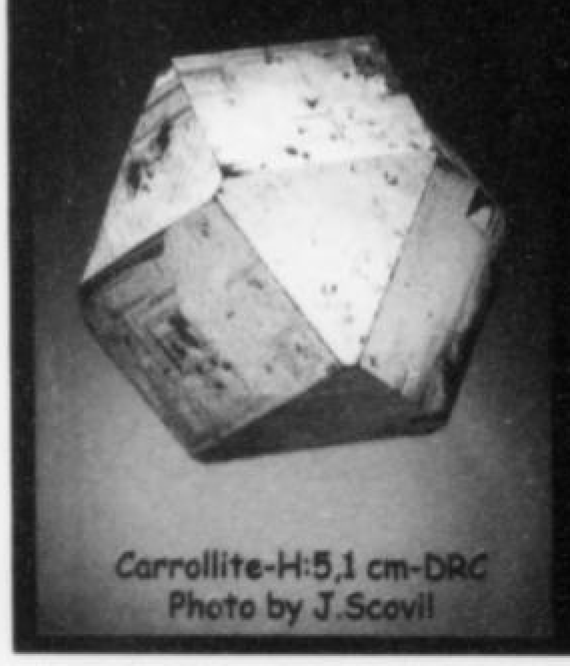
Frank and Wendy Melanson of *Hawthorneden* had a different version of an old standard: **hydroxylherderite** twins from Brazil. These twins are dark tan to brown, are off matrix and squat in appearance, and average about 2.5 cm wide by 5 cm long. They were found recently in a tunnel that was excavated under the old Corrego Frio prospect, Linopolis, Minas Gerais, Brazil. Frank and Wendy do not know if more will be available, so if you collect pegmatite minerals, or twinned crystals, these would make a nice addition to try to pick up now, while you can

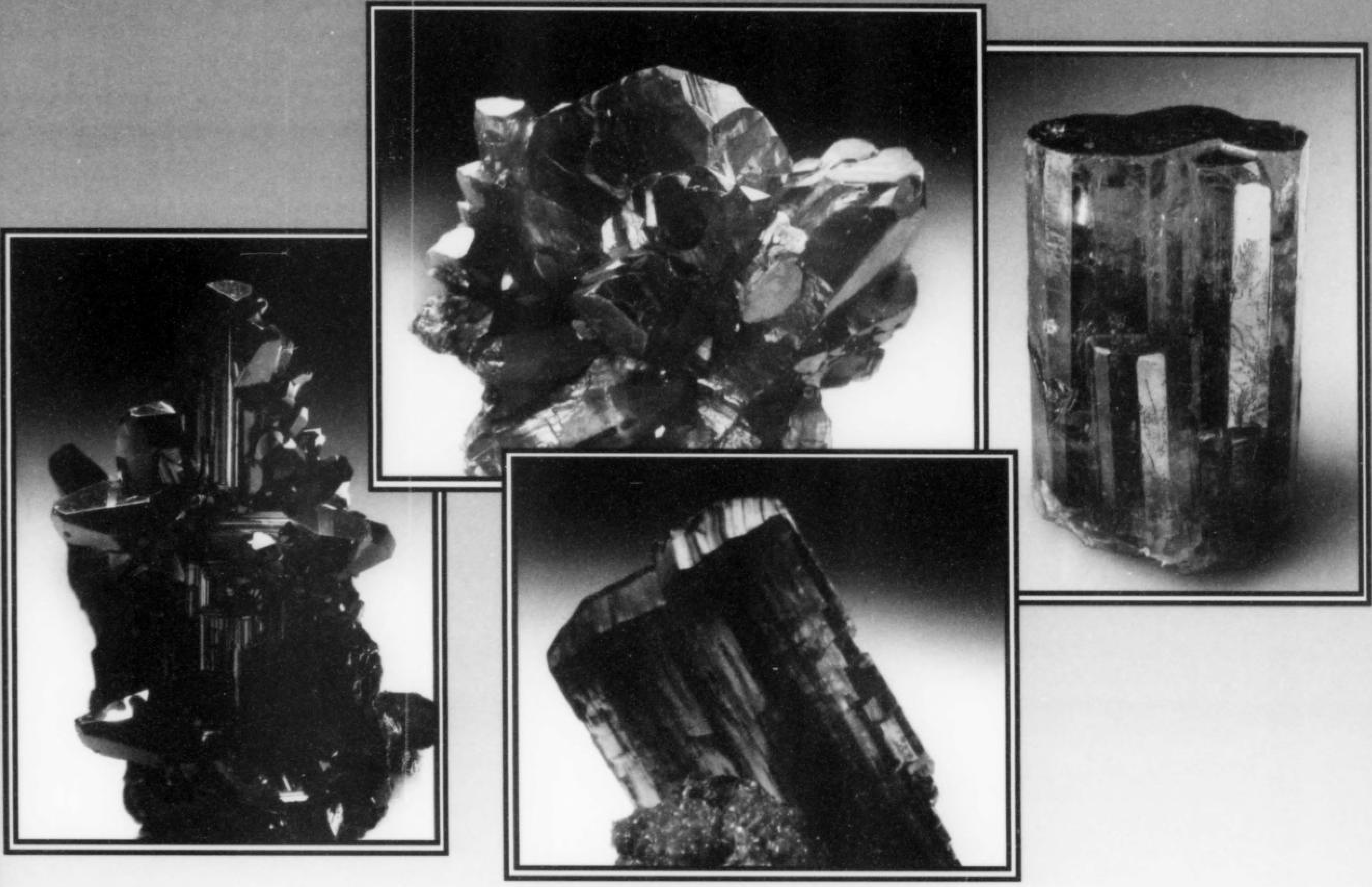
The intrepid Ross Lillie of *North Star Minerals*, now a specialist in minerals of Eastern Europe, surprised me by having several **calcite twins** in matrix from Bergamon, Meknes, Morocco. The V-twins sit on a grayish matrix of earlier-generation calcite casts. According to Terry Huizing (who bought the two best specimens), this is a new twin law for calcite from Morocco, although somewhat similar twins were once found at the El Hamman mine in 7 to 8-cm crystals, so the new twins might be from the same location. There is also some concern about "Bergamon"; Terry feels that something might have been lost when the locality name was translated into English.

Phamily Minerals (57 Mudtown Road, Wantage, New Jersey 07461), had a large selection of minerals from Tsumeb, Namibia that were formally in the Marshall Sussman collection. I suggest you drop them (the Phillips family) a line to see what they have available.

Overall, this year's show was one of the best ever: the weather was great, the minerals were fine and the crowd and staff were friendly. What's in store for next year? According to the Show Program: "The 2003 show exhibitor is a world traveler/mineral dealer who has intrigued all other collectors for many years. Rock Currier of Jewel Tunnel Imports, Baldwin Park, California has agreed to bring some of his finest minerals across the entire USA, just so we can take a look at his goodies. Mark your calendar for August 8–10, 2003." ⚒







The Friends of Mineralogy, Inc.

Visit the national
Friends of Mineralogy
website at
www.indiana.edu/~
minerals/fm.html

Who We Are:

Vol 1, No 1, Mineralogical Record, Spring 1970

The *Friends of Mineralogy* was founded in Tucson, Arizona, on February 13, 1970. Its objectives were to promote better mineral appreciation, education and preservation. The chief aims and activities of *FM* include:

- Compiling and publishing information on mineral localities, and important mineral collections.
- Encouraging improved educational use of mineral specimens, collections, and localities.
- Support a semi-professional journal of high excellence and interest designed to appeal to mineral amateurs and professionals, through which *FM* activities may be circulated.
- Operating informally in behalf of minerals, mineral collecting, and descriptive mineralogy, with voluntary support by members.

The Mineralogical Record has agreed to an affiliation with the Friends of Mineralogy whereby it will publish its written material and news of its activities. The *Friends of Mineralogy* will support the *Mineralogical Record,* since the aims of both are similarly educational and directed toward better coordination of the interest and efforts of amateurs and professionals.

Co-Sponsor, with the Tucson Gem & Mineral Society and the Mineralogical Society of America, of the Annual Tucson Mineralogical Symposia.

Werner Lieber Photo Contest and Traveling Museum Exhibit

Sponsored by Friends of Mineralogy

A traveling Museum exhibit will be created from the best photographs submitted for the contest

Categories: Juniors, Amateur Adults—(a) Micro and (b) Macro Minerals, Professionals, and Digital/Computer-Enhanced Photography

Contest Rules:

1. Matted 8″ x 10″ print. Mat must be 11″ x 14″.
2. The photo must be related to the contest theme: Minerals of the Andes.
3. Each photo must have a caption with locality, bar scale or description of crystal size, photographer, category, and other information submitter deems relevant. Caption should be attached to back of mat.
4. Photos will be displayed at the 2003 Tucson Gem and Mineral Show. Photos will be judged by the FM board of directors during the annual board meeting. Winners will be announced at the FM annual meeting and awards presented at the TGMS Saturday night awards banquet.
5. All photos become the property of FM. Copyright will be retained by author, but FM has royalty free use.
6. A non-monetary award will be presented to the winners.
7. Contest deadline: November 1, 2002.
8. Mail submittals to Dr. Karen Wenrich, P.O. Box 5054, Golden, CO 80401—(303) 278-1218 (phone & fax); email: CrystalsUL@aol.com.

2002 National Officers

President
Susan Eriksson, Virginia Tech, 1013 Draper Road, Blacksburg, VA 24060
540 231-5360, E-mail: serikssn@vt.edu

Vice-President
Bill Dameron, 1609 NW 79th Circle, Vancouver, WA 98665
360 546-1267, E-mail baritebill@aol.com

Secretary
Virgil Lueth, New Mexico Tech, 801 Leroy Place, Socorro, NM 87801
505 835-5140, E-mail vwlueth@nmt.edu

Treasurer
Jim Hurlbut, 2240 South Adams St., Denver, CO 80210
303 757-0283 or 303 279-7796, E-mail jfhu@vanion.com

Newsletter Editor
Andrew Sicree, Penn State University, 122 Steidle Building,
University Park, PA 16802
814 867-6263 or 814 865-6427, E-mail sicree@geosc.psu.edu

Chapter News

Colorado Chapter
Order now!! *Minerals of Colorado*
Order from: Friends of Mineralogy—Colorado Chapter
P.O. Box 11005, Denver, CO 80211-0005
$150 + $3 p.&h. (Colo. residents add 7.3%)
For Chapter information, contact Peter Modreski, President,
3555 Miller St., Wheat Ridge, CO 80033; Tel: 303 425-9549 or
303 236-5639, E-mail pmodresk@usgs.gov

Midwest Chapter
Visit our website at www.indiana.edu/~minerals
For Chapter information, contact Nelson Shaffer, President, 530 Cabot Ct., Bloomington, IN 47408, Tel: 812 339-6623 or 812 855-2687,
E-mail shaffern@indiana.edu

Mississippi Valley Chapter
For Chapter information, contact Mark Sherwood, President,
P.O. Box 436, Oak Grove, MO 64075, Tel: 816 690-8226,
E-mail msherwod@swbell.net

Pennsylvania Chapter
Order now!! *Reminiscences of a Mineralogist* by Arthur Montgomery.
$20 plus $3 p.&h. Order from: Arnold Mogel, PA Treasurer,
15 Oak Rd., Schuykill, PA 17972
For Chapter information, contact Roland Bounds, President,
315 Stamford Dr., Newark, DE 19711, Tel: 302 731-8407,
E-Mail 25628@udel.edu

Pacific Northwest Chapter
The 28th Annual symposium will be held in Longview, WA, Sept. 28-29, 2002. Featured topic is "The Inside Story-Inclusions" with guest speakers John Koivula and John S. White. Contact Sharleen Harvey at bill-sharleenharvey@att.net for additional information.
For Chapter information, contact Jim Etzwiler, President, 3935 Interlake Ave. N, Seattle, WA 98103, Tel: 206 633-1512, E-mail kd7bat@arrl.net

Southeast Chapter
Visit our website at http://members.cox.net/fomse01/
For Chapter information, contact David J. Babulski, President, 2677 Colony Circle, Snellville, GA 30078, Tel: 770 985-1772 or 678 584-6004, E-mail dbabulski@lanier.com

Southern California Chapter
Visit our website at www.mineralsocal.org/scfm
For Chapter information, contact Robert E. Reynolds, President,
220 S. Buena Vista St., Redlands, CA 92373, Tel: 909 792-3548 or
909 798-8570, E-mail jreynold@empirenet.com

CALIFORNIA DEALERS

Attard's Minerals
John & Kathy Attard
P.O. Box 17263
San Diego, CA 92177
Tel: (619) 275-2016
www.attminerals.com

The Arkenstone
Rob & Bailey Lavinsky
P.O. Box 12801
La Jolla, CA 92039
Tel: (858) 587-1141
www.thearkenstone.com

Coogan Gold Company
Ed and Kay Coogan
P.O. Box 1631
Turlock, CA 95381
Tel: (209) 634-5222
Micromounts, TN's, Min., Cab.

Si and Ann Frazier
Si and Ann Frazier
Suite 306, 6331 Fairmont Ave.
El Cerrito, California 94530
Fax: (510) 558-8486
e-mail: siannfraz@aol.com

Gemini Minerals
Joe & Susan Kielbaso
P.O. Box 70062
San Diego, CA 92167
Tel: (619) 223-0620
FAX: (619) 223-0385
E-mail: geminiminerals@home.com
We buy collections

Cal Graeber Minerals
Cal and Kerith Graeber
P.O. Box 2347
Fallbrook, California 92088
Tel: (760) 723-9292
By Appointment Only

Jewel Tunnel Imports
Rock H. Currier
13100 Spring Street
Baldwin Park, CA 91706-2283
Tel: (626) 814-2257
FAX: (626) 338-4617
Wholesale Only

Kristalle
875 North Pacific Coast Hwy.
Laguna Beach, California 92651
Tel: (949) 494-7695
E-mail: leicht@kristalle.com
WEB: http://www.kristalle.com

Debbie Meng's Minerals
Debbie Y. Meng
P.O. Box 8393
Monterey, CA 93943
Tel: (831) 484-7418,
Fax: (831) 484-7419
E-mail: debbie_meng@usa.com
Specialty: Fine Chinese Minerals

Pala International & The Collector
912 So. Live Oak Park Road
Fallbrook, California 92028
Tel: (760) 728-9121
US Wats 1-(800)-854-1598

Steve Perry Minerals
P.O. Box 136
Davis, California 95617
Tel/Fax: (530) 753-7861
e-mail: steve@steveperrygems.com
website: steveperrygems.com

Bruce & Jo Runner Minerals
13526 South Avenue
Delhi, California 95315
Tel: (209) 634-6470
Micromount List $2
Showroom by Appt. only

Andy Seibel Minerals
Andy Seibel
P. O. Box 2091
Tehachapi, CA 93581
Tel: (661) 823-8091
www.andyseibel.com

Silverhorn
Mike Ridding
1155 Coast Village Road
Montecito, California 93108
Tel: (805) 969-0442

MOUNTAIN MINERALS INTERNATIONAL

Mountain Minerals "au natural"

No polymers, epoxies, oils, or paraffin.
No "reconstructions," fake terminations, dye impregnations, or any other questionable practices.
Just nice minerals, like nature intended.

Mountain Minerals International
P.O. Box 302 • Louisville, Colorado 80027-0302
Tel: (303) 665-0672 • FAX: (303) 664-1009
www.mtnminitl.com

Oceanside
gem imports, inc.

Huge stock of fine minerals—many never shown. Wide range of Sizes/Prices. List avail. for *cut stones* only. NO SHOWS. Write or call for more information.

P.O. Box 222
Oceanside, NY 11572
Tel: (516) 678-3473 • Hrs. by Appt.

Gem Crystal Treasures

Specimen and gem-quality crystals available.
Send for free list or visit our website.
Ty Lawrence
P.O. Box 14042
Portland, OR 97293
tel: (503) 731-6503 • www.gemcrystals.com

WILLIAM SEVERANCE COLLECTION

JEFF SCOVIL PHOTO

Calcite enclosing Copper, 6.8 cm

Quincy Mine, Pewabic Amygdaloid Load
Houghton County, Michigan

Ex Robert Hess Collection, 1952

THE ROCKSMITHS Inc.

FAREWELL TOUR 2002 SHOWS

Nov. 2–3 Concord, CA
Nov. 8–10 Fenton, MO (St. Louis area) (A "Physical Equipment Auction" Pick-up Show)
Nov. 16–17 W. Palm Beach, FL
Dec. 6–8 Austin, TX (A "Physical Equipment Auction" Pick-up Show)
Dec. 7–8 Los Angeles, CA (MSSC Show) (A "Physical Equipment Auction" Pick-up Show)

Please visit us at www.rocksmithhs.com for complete "Farewell Tour" events, souvenirs, and mineral sales.

5th & Toughnut, Box 157, Tombstone, Arizona 85638

NEW IN STOCK

Magazine filers, MR or R&M $6.95/Ultrasonic Cleaners, 3x7" $98.50
Stereo microscopes, 20X $114.95/Hand Lenses, 5 & 10X $2.25
Dual Fiber Optic Light, 90W, $669.50/Magnifier lid micros, 10 for $4.80

Over 1,000 Mineral Listings plus Boxes & Supplies
—Send $1.00 for a 72 page catalog—

DAVID SHANNON MINERALS
6649 E. RUSTIC DR., MESA, AZ 85215 (480) 985-0557 PHONE/FAX

WRIGHT'S ROCK SHOP

Fine Mineral Specimens! We Buy Collections!

—SHOW SCHEDULE 2002—

Feb. 3–15 Tucson, AZ (Rm 128 InnSuites)
Feb. 23–24 Jackson, MS (State Frgrds., in the Merchandise Mart Bld.)
Raleigh, NC (State Frgrds., Kerr Scott Bldg.)
Apr. 27–28 Franklin, NJ
May 17–19 Costa Mesa, CA (Bristol Holiday Inn)
Aug. 9–11 Springfield, MA (Great States Exposition Ctr.)
Sep. 11–15 Denver, CO (Hol. Inn North, Rm 115)
Sept. 20–23 Houston, TX (Humble Civic Center)
Oct. 11–13 Detroit, MI (So. Macomb Comm. Coll. Expo Ctr., Warren)
Nov. 22–24 Pittsburgh, PA (Carnegie Museum)

New Acquisitions: carrollite, malachite, cuprosklodowskite from the Congo.

Visit our Website: wrightsrockshop.com
e-mail: wrightsr@ipa.net

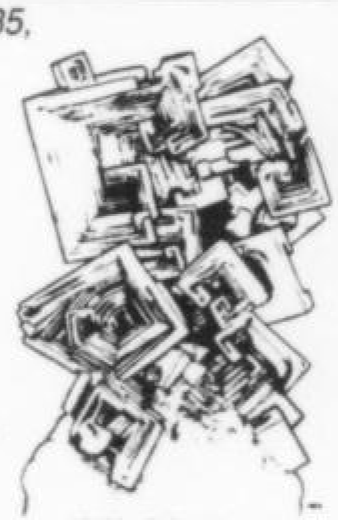
3612 ALBERT PIKE, HOT SPRINGS, AR 71913 • Tel: (501) 767-4800

2003 Show Schedule: *Tucson, Executive Inn room 135, Jan. 31–Feb. 15 • Cincinnati, April Springfield, Aug 8–10 • Denver Sept. 10–14 Detroit, October • Carnegie Nov.*
Visit our website: www.northstarminerals.com

NORTH STAR MINERALS

SPECIALIZING IN THE MISSISSIPPI VALLEY-TYPE DEPOSITS OF SOUTHERN ILLINOIS
New minerals direct from buying trips to Bulgaria and Eastern Europe

Ross C. Lillie
7249 Woodlore Dr., W. Bloomfield, MI 48323
Tel./Fax: (248) 926-9929 • E-mail: northstarminerals@comcast.net



Michigan Silver

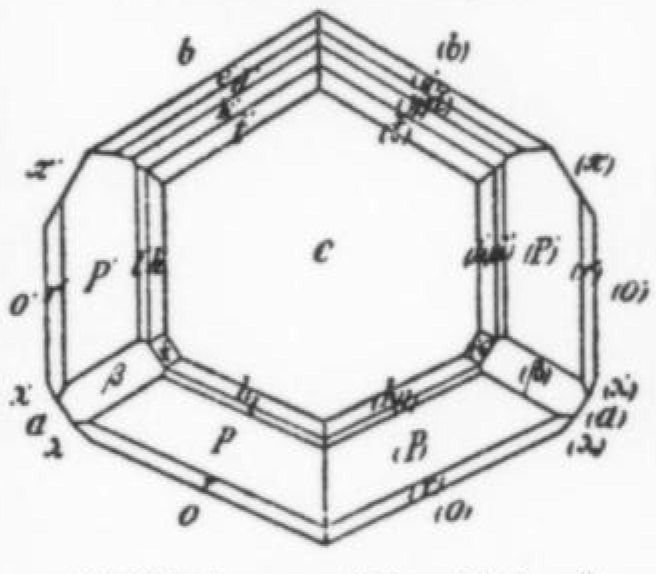
GREGORY, BOTTLEY & LLOYD

Established by James Gregory in 1858

13 Seagrave Road, London SW6 1RP • Tel: 0207-381-5522 Fax 0207-381-5512

Brian Lloyd looks forward to seeing you when you are next in London.
Our showrooms are open weekdays 9:30 to 5 pm—other times by appointment.

Rare Species? Common Minerals?



$3.00 brings our "New Listings" for one year. Visit: www.mineralsunlimited.com

Minerals Unlimited
P.O. BOX 877-MR
RIDGECREST, CALIF. 93556-0877

RARE MINERALS since 1974!

Old classics, rare species, microprobed samples, meteorites and thin sections, plus a full line of microscopes, geiger counters, our comprehensive photo CD, UV lamps and old & new books. Request a specific catalog or view our well illustrated website @ www.excaliburmineral.com. Analytical services offered.

Excalibur Mineral Corporation

1000 N. Division St. – Peekskill, NY 10566
Tel: (914) 739-1134 Fax: (914) 739-1257
email: info@excaliburmineral.com

Crystal Clear.

The Meiji EM Series of Modular Stereo Microscopes.

MEIJI TECHNO

If you are looking for precision, durability, quality and value in a Stereo Microscope, we invite you to take a closer look at Meiji's EM Series of Stereo Microscopes.

The modular design (A wide variety of bodies, single magnification or zoom - rotatable 360°, auxiliary lenses, eyepieces, stands, holders, etc.) gives you the freedom to create the ideal instrument for your specific need or application, and Meiji stands behind every instrument with its ***"Limited Lifetime Warranty."***

For more information on these economically priced Stereo Microscopes, please call, FAX, write us or log on to our website today.

MEIJI TECHNO AMERICA

2186 Bering Drive, San Jose, CA 95131,
Tel: 408.428.9654, FAX: 408.428.0472
Toll Free Telephone: 800.832.0060 or visit our website at www.meijitechno.com

Colorado Dealers!

Dave Bunk Minerals
Dave Bunk
1441 W. 46th Avenue, #8
Denver, CO 80211
303-477-6897
www.davebunkminerals.com
email: dave@davebunkminerals.com

COLORADO MINERAL AND FOSSIL SHOW
Holiday Inn Denver North
SEPT. 11-15, 2003
10 a.m. to 7 p.m. Daily
INFO: P.O. Box 999
Evergreen, CO 80437

Columbine Mineral Shop
Benjy & Liz Kuehling
P.O. Box 541
633 Main Street
Ouray, CO 81427
970-325-4345, 9 a.m. to 9 p.m.
Open 7 days, May 1-Oct. 31
Fine Minerals for Collectors
www.collectors-mall.com/cms
email: bkuehling@rmi.net

Glacier Peak Art, Gems & Minerals
Joseph & Susan Doris
P.O. Box 413
Manitou Springs, CO 80829
Tel: (719) 685-4479
Producing Colorado Amazonite & Smoky Quartz
Fine Worldwide & Colorado Specimens
email: glacier@frii.com
web: www.frii.com/~glacier

Denver Gem & Mineral Show
Sept. 13–15, 2003
P.O. Box 621444
Littleton, CO 80162
www.denvermineralshow.com
Held Annually at the Denver Merchandise Mart

Green Mountain Minerals
Stanley Korzeb
15064 E. Bails Place
Aurora, CO 80012
303-368-1209 (Call for Appt.)
Species, Fine Minerals, write for List

Mountain Minerals International
Dudley Blauwet
P.O. Box 302
Louisville, CO 80027-0302
303-665-0672
FAX: 303-664-1009
www.mtnminitl.com
Minerals, Gems, Gem Rough

The Sunnywood Collection
Bill & Elsie Stone
Aurora, CO
303-363-8588
Premium Minerals, Fossils, & Carvings Artistically Mounted on Wood or Acrylic
email: minerals@sunnywood.com
http://www.sunnywood.com

XTAL—Dennis L. Beals
Dennis & Diane Beals
6006 S. Holly St., PMB 256
Englewood, CO 80111-4251
303-771-9225 (by Appt. only)
FAX: 303-771-9308
DBXTAL@aol.com
www.xtal-dbeals.com
Fine Mexican minerals & more

Arizona Dealers

De Natura
Les & Paula Presmyk
P.O. Box 1273
Gilbert, Arizona 85299
Tel: (480) 892-0779
FAX: (480) 497-8349
Website: www.denatura.com
See us at the Tucson & Denver Shows, specializing in fine minerals from Arizona and the Southwest; Professional trimming & cleaning services

Top-Gem Minerals
1201 B North Main Street
Tucson, Arizona 85705
Tel: (520) 622-6633
FAX: (520) 792-2928
Mon-Fri 8:30–4:30 and by Appt.
No Catalog or List
Wholesale Only
Mex. & Tenn. minerals, boxes

David Shannon Minerals
David & Colleen
6649 E. Rustic Drive
Mesa, Arizona 85215
(480) 985-0557
Minerals, Boxes & Supplies.
Send $1 for 72-page catalog.

Evan Jones Minerals
3520 N. Rose Circle Dr.
Scottsdale, Arizona 85251
Tel/Fax: (602) 946-5826
e-mail: evjonesusa@netscape.net
By Appointment Only.
Fine Minerals for Collectors.
Specializing in Arizona, Mexico & Worldwide Classics.
We Buy Collections.

Douglass Minerals
P.O. Box 69550
Tucson, Arizona 85737
(520) 742-0294
www.douglassminerals.com
e-mail: douglassminerals@aol.com
Quality, affordable, world-wide minerals

Kino Rocks & Minerals
6756 S. Nogales Highway
Tucson, Arizona 85706
(520) 294-0143
9–11:15/Noon–5:30 (Closed Sun.)
No Catalog—No List

TYSONS'
FINE MINERALS

Wholesale & Retail
Canadian Mineral Specimens
Eggs • Spheres
Stone Bead Jewellery

Rod & Helen Tyson
10549-133 St., Edmonton, AB, Canada T5N 2A4
Tel: 780-452-5357 Fax: 780-451-9541
www.tysons-minerals.com

Gold!

Incredible Native Gold Specimens from Goldcorp Inc.'s
RED LAKE MINE, ONTARIO CANADA

Beautiful, rich specimens now available from one of the richest gold mines in the world. Mining is now under way in the "Jewelry Stopes," and specimens are being preserved for institutions and private collectors. Sizes from small to huge, with great aesthetics. To see and purchase specimens visit our website.

www.davidjoyceminerals.com
David K. Joyce
P.O. Box 95551, Newmarket, Ontario, Canada L3 8J8 • dkjoyce@attcanada.ca

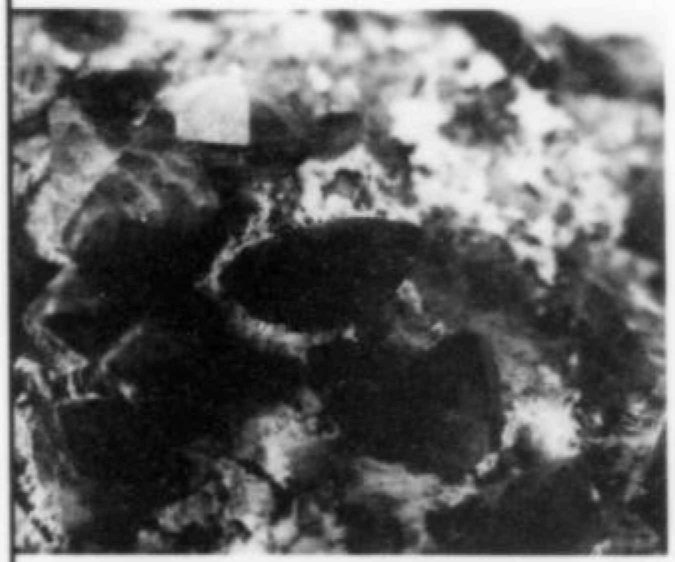
UNUSUAL CRYSTALS
FROM
AROUND THE WORLD

CORUNDUM IS
OUR SPECIALTY!

GEM-FARE
P.O. Box 213
Pittstown, N.J. 08867
Phone/Fax (908) 806-3339
REQUEST CRYSTAL LIST

Mesolite: Lonavla, Nasik, India, 7.5cm x 23cm x 28cm

Aesthetic*



Benitoite and Neptunite with Joaquinite on Syenite Schist:
Dallas Gem Mine, San Benito County, CA 12.5cm x 18cm x 30.5cm

Rare*

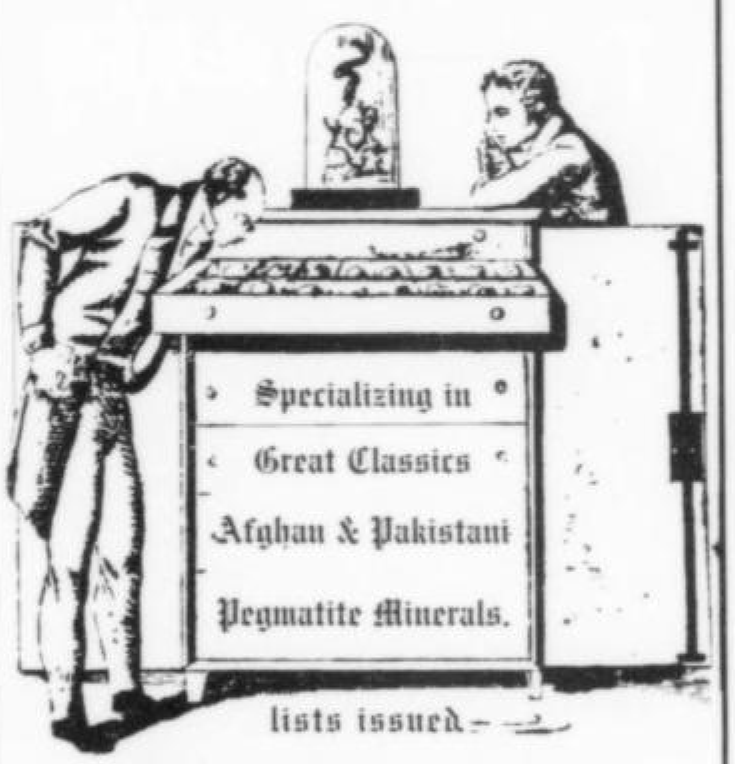
Inesite: Hale Creek Mine, Trinity County, CA, 32cm x 34 cm x 43cm

Exceptional*

STONETRUST
GEM, MINERAL & JEWELRY AUCTION

* The Galas Collection. Available exclusively at www.stonetrust.com

Fine
Mineral Specimens



lists issued.

H. Obodda
Box 51 • Short Hills, N.J. 07078
(973) 467-0212

www.carouselminerals.org
Carousel

1202 Perion Drive
Belen, New Mexico 87002
505-864-2145
Please send $2 U.S. ($4 outside U.S.) for a 1-year subscription to our mineral list.

JOHN BETTS
FINE MINERALS
www.johnbetts-fineminerals.com

New Minerals
Added Every Week

Send for list
John Betts
215 W. 98 St.
NY, NY 10025
(By Appointment)
212-678-1942

Cash Paid for Mineral Collections

Simkev Micromounts
fine microminerals for discriminating collectors
MICROS ONLY—FREE LIST
Box 3118, Brighton, Ontario, K0K 1H0, Canada
Ph: (613) 475-9552 Fax: (613) 475-0906
E-mail: simkev@kos.net
www.simkevmicromounts.com

Arizona Minerals
TUCSON SHOW 2003
• EXECUTIVE INN Rm. 128 •
Dick Morris • Mark Hay

WASHINGTON, DC AREA
- BUYING & SELLING FINE MINERALS AT SHOWS, BY APPOINTMENT IN VIRGINIA, AND BY MAIL (NO LISTS)

C. CARTER RICH
—FINE MINERALS—

- SPECIALIZING IN FINE OLD CLASSICS AT FRANKLIN, NJ SEP 27–28; DETROIT, MICHIGAN OCT 10–12; CARNEGIE, PITTSBURGH NOV 21–23.

PO BOX 69 (703) 327-6373
ALDIE, VA 20105 richjeana@aol.com

Mineralogical Record Inc.
Board of Directors
Patricia A. Carlon (secr.)
1110 E. Emerson
Bloomington, IL 61701
carlon@gte.net
Thomas M. Gressman (treas.)
7753 Emerald Peak
Littleton, CO 80127
tgressman@aol.com
Anthony R. Kampf (pres.)
Mineral. Section,
Natural History Museum
900 Exposition Blvd.
Los Angeles, CA 90007
akampf@nhm.org
Mary Lynn Michela
7413 N. Mowry Place
Tucson, AZ 85741
minrec@aol.com
George W. Robinson (v. pres.)
Seaman Mineral Museum, MTU
1400 Townsend Drive
Houghton, MI 49931-1295
robinson@mtu.edu
Bill Smith
1731 Daphne
Broomfield, CO 80020
smith72@attglobal.net
Art Soregaroli
1376 W. 26th Ave.
Vancouver, BC V6H 2B1
rockdoc@infinet.net
Marshall Sussman
618 Hartrey
Evanston, IL 60202
tsumebmine@aol.com
Wendell E. Wilson
4631 Paseo Tubutama
Tucson, AZ 85750
minrec@earthlink.net

Volunteer Coordinators
Eastern U.S.
Charles & Marcelle Weber
1172 West Lake Ave.
Guilford, CT 06437

Advertising Information
All advertising in the Mineralogical Record must be paid in advance of the closing date. Telephone orders not accepted. Write to the editor for rates.

Closing dates:
Jan.-Feb. issue ...... Oct. 15
March-April issue ..... Dec. 15
May-June issue ...... Feb. 15
July-Aug. issue ...... April 15
Sept.-Oct. issue ..... June 15
Nov.-Dec. issue ...... Aug. 15

An additional 20 days past the closing date are allowed in which advertisers may make changes (excluding size changes) in ads already paid for.

Design
Wendell E. Wilson

Graphic Production
Capitol Communications
Crofton, MD

Printing
Cadmus Journal Services,
Easton, MD

Color Separations
Hollis Phototechnics
Tucson, AZ

Belgium
Paul Van Hee
Marialei 43
B-2900 Schoten

Great Britain
Paul Lowe
"Endsleigh"
50 Daniell Road
Truro, Cornwall TR1 2DA

Italy
Renato & Adriana Pagano
P.O. Box 37
I-20092 Cinisello Balsamo MI

Japan
Bon Earth Sciences
Tsukasa Kikuchi
Nagata Bldg. 201
19-10 Kitaotsuka 2-chome
Toshima, Tokyo 170

Netherlands
Arnold Verbeek
De Bodemschat
Borgmanweg 15
7558 PN Hengelo OV.
The Netherlands

Norway & Sweden
Geir Wiik
N-2740 Roa
Norway

South Africa
Horst Windisch
30 Van Wouw Street
Groenkloof, Pretoria

Germany
Christian Weise Verlag
Oberanger 6
D-80331 München 2

Fine Australian & Worldwide Minerals, Fossils, Rare Species, Meteorites, Tektites, Opal Specimens, Gold. Retail & Wholesale supplier since 1984.

Robert Sielecki

See You In:
Tucson, Tokyo,
Denver, Munich and
hopefully AUSTRALIA

42 Hex St., Tottenham
Melbourne, Victoria 3012
Australia (phone (61-3)9-314-9612)
FAX: (61-3)9-315-1819

PLATINUM
SPECIMENS

www.siberiaberkut.com

Searching the world . . .

. . . to bring you the finest in mineral specimens and meteorites at competitive prices.

- ***Fine Display-Quality Mineral Specimens, Rare Species, and Fluorescent Minerals:***
  Send for our lists of thumbnail, miniature, and cabinet specimens. First quality mineral specimens for collection and display, plus rare species for systematic collection, reference, and research. Fluorescent minerals are available for display and systematic collections.
- ***Micromount and Specimen Boxes of All Kinds:***
  Separate listings are available detailing prices and sizes of micromount, plastic magnifier boxes, white cotton-lined specimen boxes, display stands, gem display boxes, paleomagnetic sampling cubes, showcase boxes, white folding boxes, display bases, etc.
- ***Meteorites, Tektites, Moldavites, Fulgurites, and Trinitite:***
  Specimens of all sizes for private collections and institutional display, from worldwide localities. New and used books also available.
- ***Mineralogical Books:***
  Send for our separate price list with information covering new books on mineralogical subjects, as well as older, out of print mineralogical and geology books.
- ***Back Issues of the Mineralogical Record:***
  Ask for our listing of out-of-print issues currently in stock. Send us your want list, if you need back issues to complete your set. Send us your offers, if you have back issues available for sale.
- ***Worldwide Mail Order Service:***
  For more than 35 years, since 1959, we have been supplying Minerals, Meteorites, Books, Boxes, and back issues of the Mineralogical Record to collectors around the world. Orders can be placed by mail, phone, FAX, or e-mail—addresses are given below.
- ***Price Lists:***
  Send a very large SASE for price lists on any of the above subjects. Non-USA, send two International Reply Coupons. OR . . . . . Check out our new web site on the internet to see price lists and color photographs: http://www.minresco.com

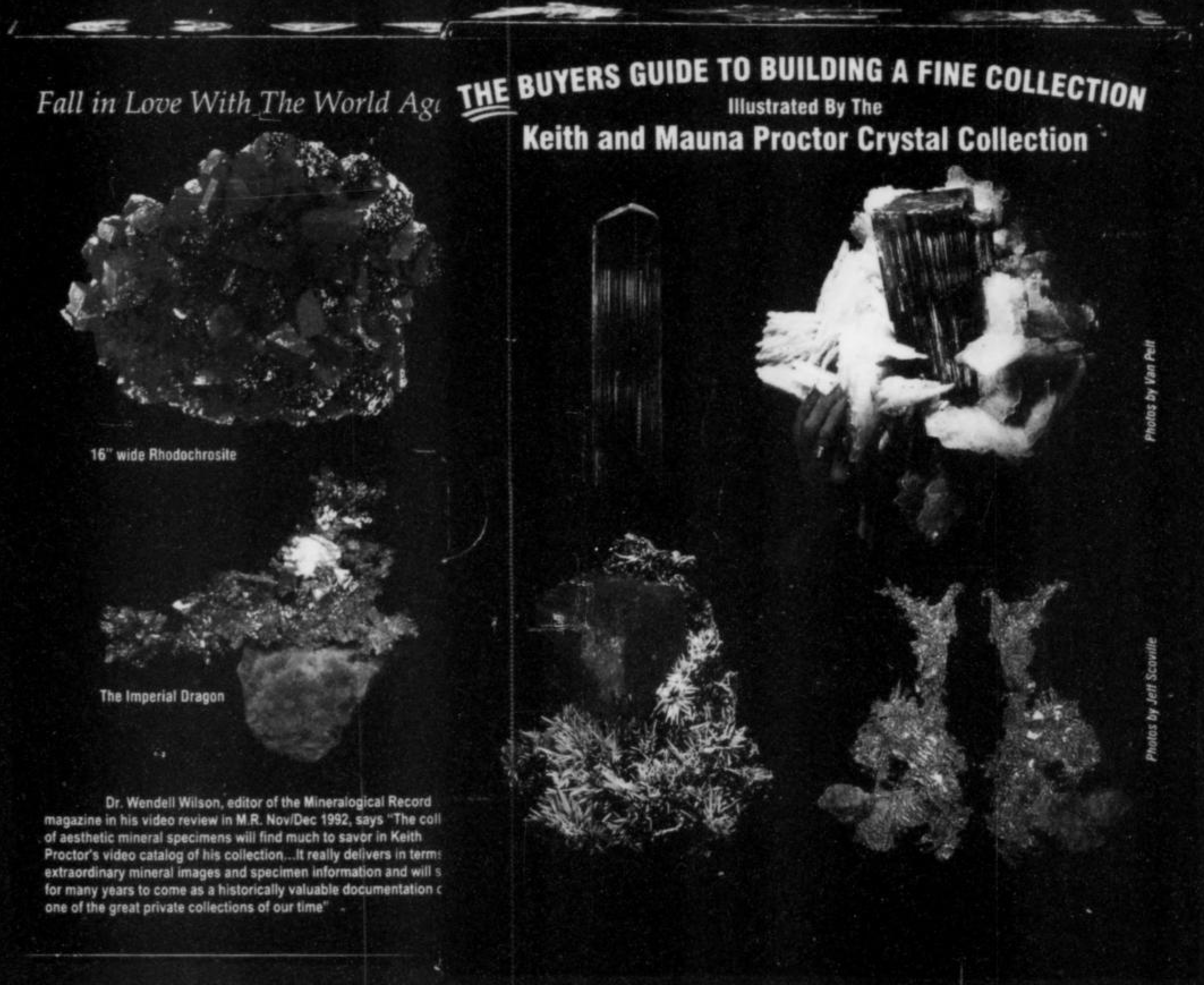
Mineralogical Research Co.

Eugene & Sharon Cisneros
15840 East Alta Vista Way, San Jose, California 95127-1737, USA
e-mail: xtls@minresco.com • PHONE: 408-923-6800 • FAX: 408-926-6015
Look for our booth at major Western U.S. Shows
A Division of the Nazca Corporation

http://www.minresco.com
WE'RE ON THE INTERNET!
CHECK OUT OUR
WEB SITE!

Advertisers Index

NEW VIDEO! An Exhaustive Buyer's Guide and Tour-de-Force of the Gem Species and Native Elements. Hundreds of Specimen and Locality Photos!



Fall in Love With The World Ag

16" wide Rhodochrosite

The Imperial Dragon

Dr. Wendell Wilson, editor of the Mineralogical Record magazine in his video review in M.R. Nov/Dec 1992, says "The coll of aesthetic mineral specimens will find much to savor in Keith Proctor's video catalog of his collection...It really delivers in term extraordinary mineral images and specimen information and will s for many years to come as a historically valuable documentation one of the great private collections of our time"

THE BUYERS GUIDE TO BUILDING A FINE COLLECTION
Illustrated By The
Keith and Mauna Proctor Crystal Collection

Photos by Van Pelt

Photos by Jeff Scoville

DOUBLE-LENGTH VIDEO—135 Minutes! $39.75 postpaid

"I'm very impressed with your Buyer's Guide video—a grand presentation of exquisite minerals with excellent photography illustrating the stunning depth of a premier collection with select specimens carefully chosen for the critical collector who also wants investment potential . . . Congratulations!"

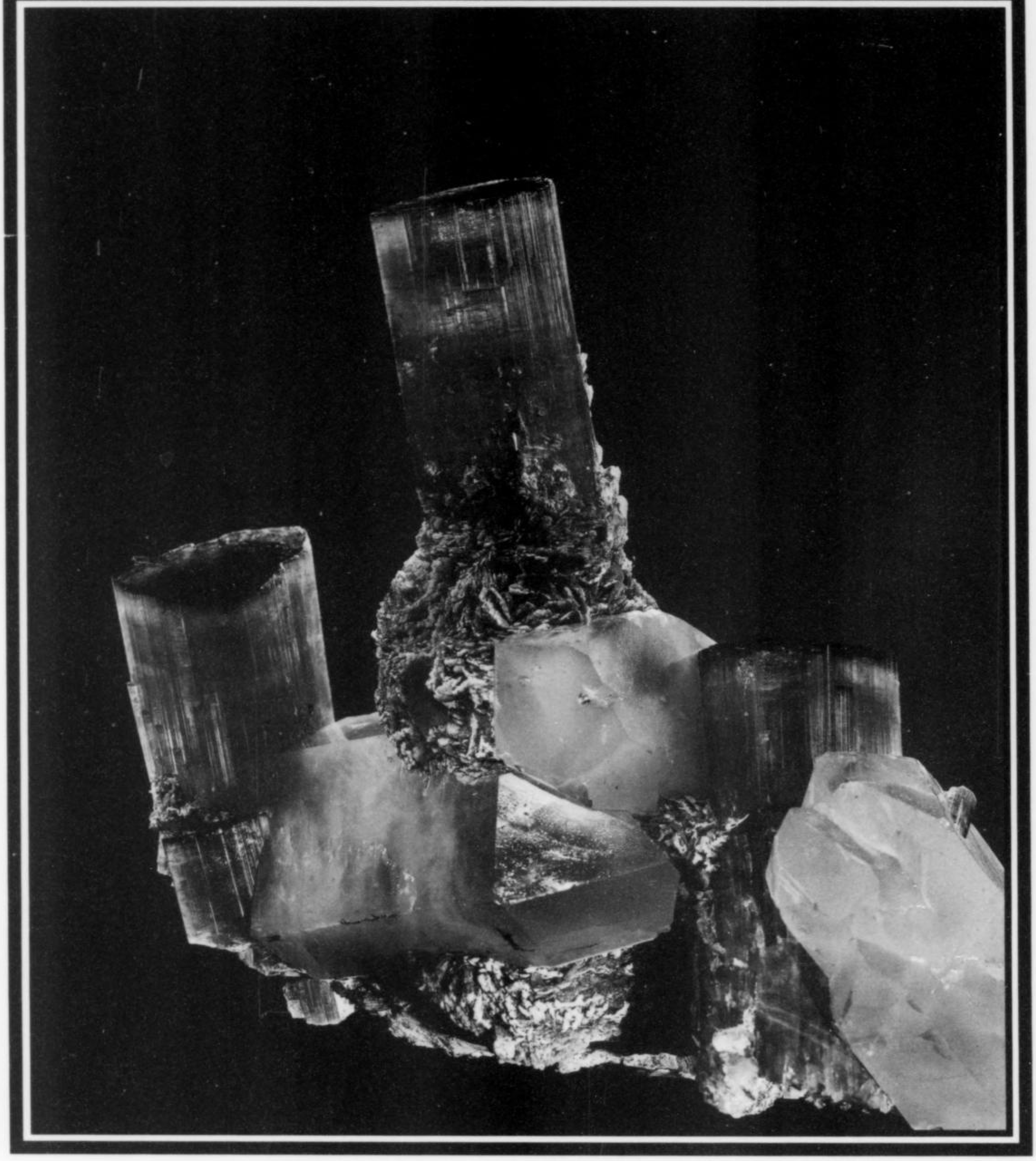
Dr. Peter Bancroft

"A symphony of superb color, form and spectacular images from the Mineral Kingdom backed up by the experience and insight of two accomplished collectors. This video provides a wonderful learning experience—an invaluable resource for novices and veteran collectors alike. It will undoubtedly inspire a new generation of serious-minded collectors."

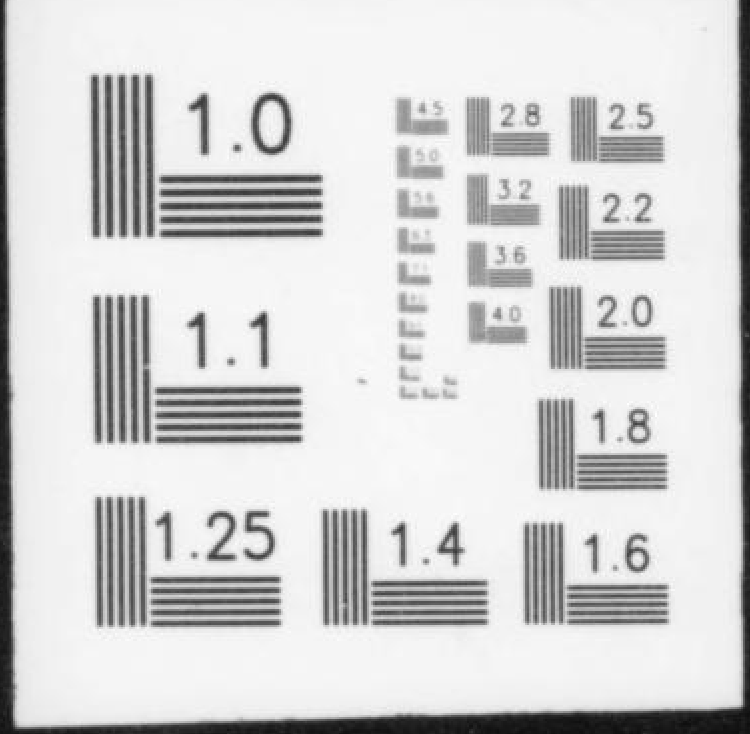
Steve Voynick, contributing editor, Rock & Gem magazine

ORDER FROM: KEITH PROCTOR

c/o Brook Proctor, 2087 E. 4500 South, Salt Lake City, UT 84020 • Tel: 801-671-7188



Blue-cap tourmaline, "The Candelabra," 30 cm, from the 1972 pocket at the Tourmaline Queen mine near Pala, California. Smithsonian collection; photo by Harold and Erica Van Pelt


1.0
4.5
5.0
5.6
6.3
7.1
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6