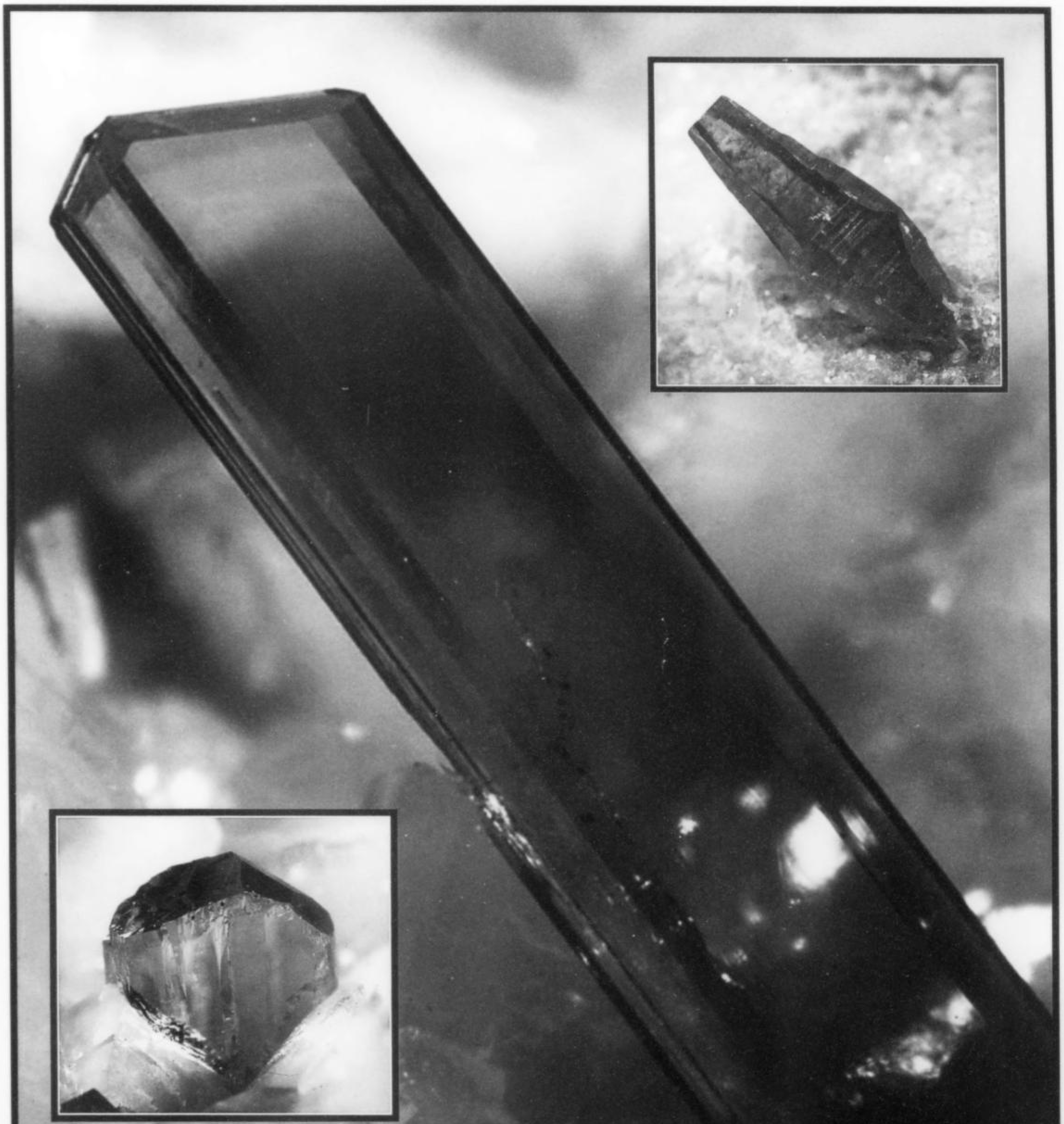
RARE EARTHS!



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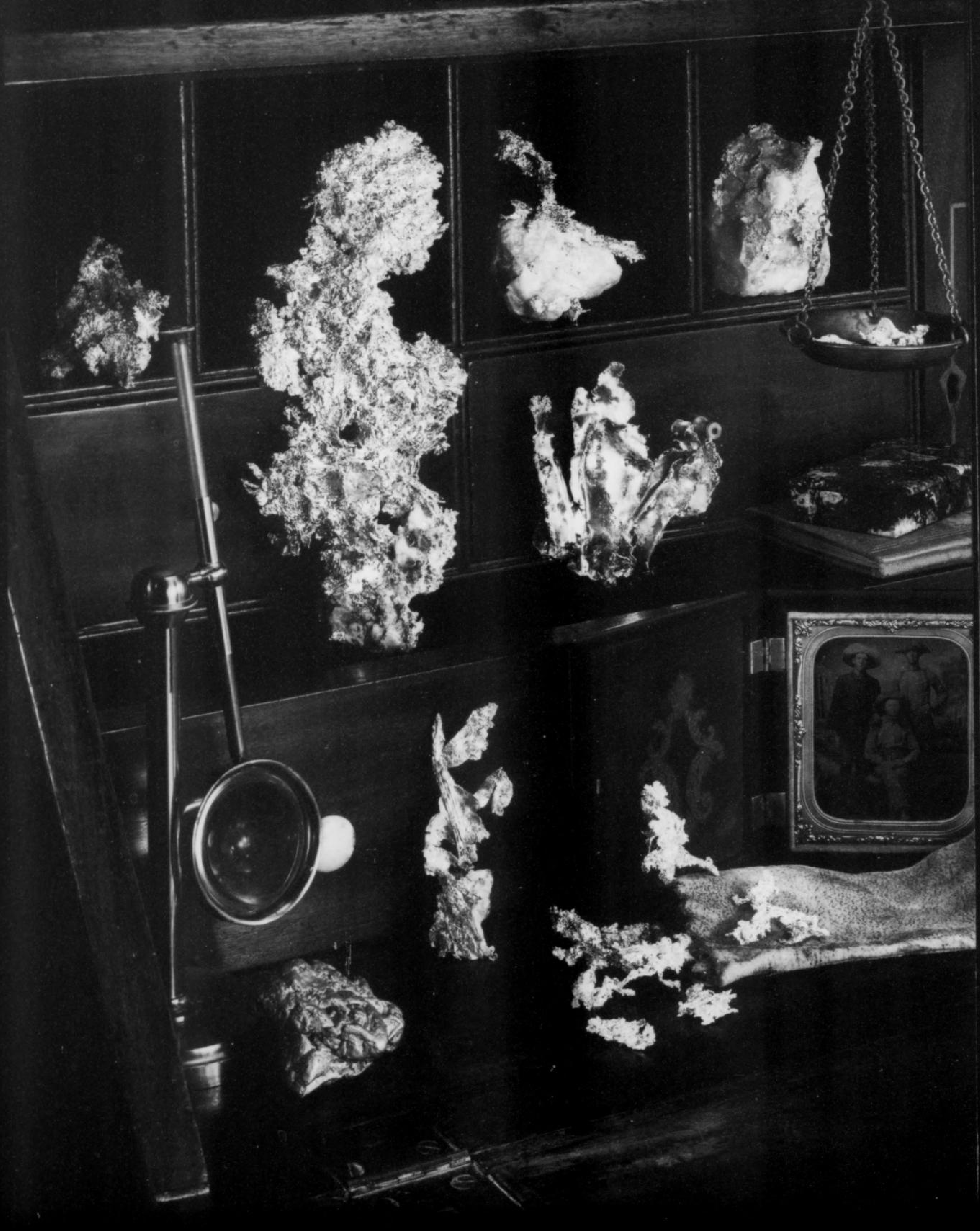

THE MINERALOGICAL RECORD

May–June Volume Thirty-five, Number Three

Articles

Columns

What's new in minerals

COVER: (center) ALLANITE-(Ce) crystal, 6 mm; (upper right) PARISITE-(Ce) crystal, 5.5 mm; (lower left) IIMORIITE-(Y) crystal, 2 mm—All from the Trimouns talc quarry near Luzenac, France (see the article beginning on page 225). Freddy Marty specimens; Robert Vernet photos.

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

Subscriptions
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520-297-6709 • FAX: 520-544-0815
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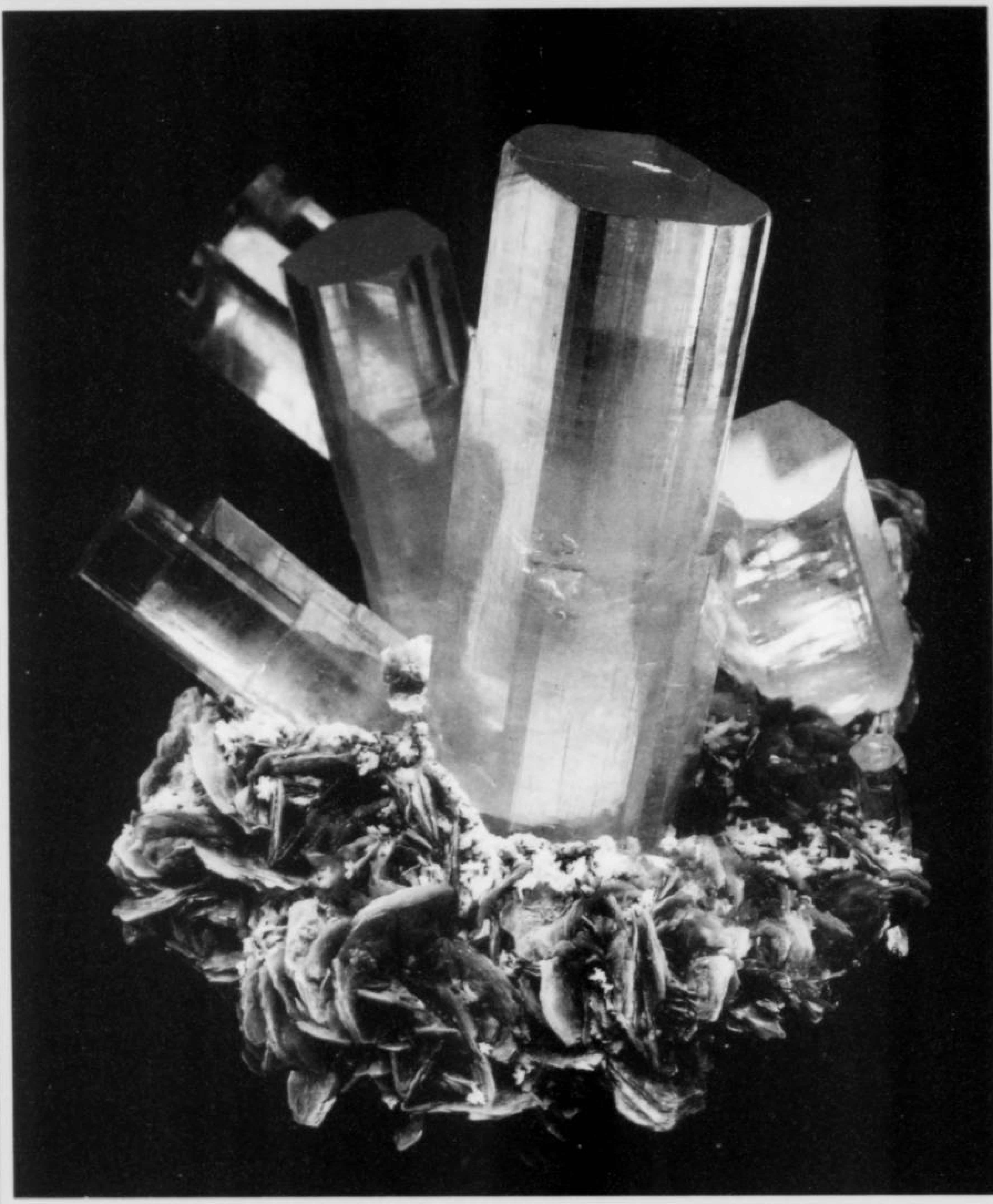


FAMOUS MINERAL LOCALITIES:

THE BASTNÄS MINES

RIDDARHYTTAN ORE FIELD, BERGSLAGEN DISTRICT, VÄSTMANLAND, SWEDEN

Lennart Öhman
Högviltsvägen 5
SE-722 42 Västerås
Sweden

Per Nysten
Institute of Earth Sciences
Uppsala University
Norbyvägen 18B, SE-752 36 Uppsala
Sweden

Jögen Langhof
Stationsvägen 2, Långban
SE-682 92 Filipstad
Sweden

The remarkable cerium occurrence in the Bastnäs ore field was the first deposit ever mined for cerium, and one of the few localities in the world for cerium minerals. For a long time it was the only known locality for cerite. It is also the type locality for allanite-(Ce), bastnäsite-(Ce), cerite-(Ce), lanthanite-(Ce), törnebohmite-(Ce) and linnaeite, as well as for the elements cerium and lanthanum.

INTRODUCTION

The Riddarhyttan ore field is situated in the county of Västmanland, south-central Sweden, about 70 kilometers northwest of Västerås and 180 km west-northwest of Stockholm. Specimens from Bastnäs, e.g. of cerite, are rather widespread in public and private collections in Europe, and the collection of the Naturhistoriska Riksmuseet (Swedish Museum of Natural History) in Stockholm contains a large suite of Bastnäs specimens, including the type specimen of törnebohmite.

For many years the authors and other collectors have dug in the dumps at Bastnäs in the hope of finding the classic rare-earths-containing species once mined here. In the mid-1980's a rich zone

Figure 1. **Location map showing the county of Västmanland and the Riddarhyttan ore field.**

of rare-earth minerals was discovered at a depth between 0.5 and 1 meter in the dumps, about 30 meters from the Sankt Göransgruvan mine. The zone contained many cerium minerals, as well as some species new for Bastnäs and for Sweden (bismutite, brochantite and wroewolfeite). Presently, 37 species are known from the locality.

HISTORY

The Riddarhyttan ore field is part of the vast mining and foundry area named Bergslagen, in south-central Sweden, where tens of thousands of different mines have been worked for nearly a thousand years. Iron, copper, cobalt and cerium have been intermittently mined in the Riddarhyttan ore field for about six centuries. The ore field is divided into some 15 smaller fields, with approximately 300 large and small mines. Iron ore mining began in the mid-14th century, and prospecting for copper ore began during the 16th century, on the initiative of the Swedish king Gustavus I (Gustav Vasa). The last active iron and copper mine, Bäckegruvan, was closed by its owner, Fagerstabruk, in 1978.

Unless otherwise indicated, the following data concerning the mine's history are compiled from Carlborg (1923). Mining at Bastnäs is recorded with certainty from the mid-14th century, making this district one of the oldest in Sweden. Though the mine was mainly worked for iron ore, copper ore production was also important during the 17th, 18th and 19th centuries. The first known extraction of copper ore dates from the middle of the 16th century, from a rather small prospecting pit. A second attempt was made in 1616, when the old mines were reopened and a small smelter was constructed by the prospector Jacob Urbansson, who, two years later, also involved his brother Hans Urbansson in the work. In 1620, Hans Urbansson was granted tax reductions to expand the mines and produce raw copper. In the 17th century, such tax credits were a common means by which the Swedish government (i.e. the King) supported the national economy. The Thirty Years War, in which Sweden was involved at the time, had to be financed, and copper production was extremely important for the gun-making foundries. The Falu mine in the northern Bergslagen area was Europe's most important source of copper, and the world's largest copper producer during the 17th century. Intermittently, two-thirds of the world production of copper was accounted for by the Falu copper mine. During this time, production at the Riddarhyttan ore field was irregular, and from time to time the mines were closed down.

During the second half of the 18th century, mining, and above all the prospecting for new orebodies, were performed more rationally under the direction of leading Swedish experts such as the famous mineralogist, chemist and assayer Axel Fredrik Cronstedt (1722–1765). The ore separation and smelting processes were improved, and consequently the economy of the mines improved also. But during the first half of the 19th century, copper production dropped, finally ceasing in 1873, though minor amounts of copper ore were mined later on. In about 1850, plans for the extraction of cobalt ore were made, and the construction of a chemical-technical factory for manufacturing various cobalt chemicals, red paint, glaubersalt and other products in Riddarhyttan was discussed. These ideas were never realized, however. In 1892 and 1893, a total of 130 tons of cobalt-bearing pyrite/pyrrhotite ore was extracted from old dump material.

Iron ore extraction, which had previously been minimal, now increased. In 1877 the company was reconstituted and renamed the Riddarhytte Company, and its facilities were transformed from a copperworks to a typical ironworks. The business of such a concern included, in Sweden, the manufacture of bar iron and pig iron, as well as forestry, timber trading and even farming. Almost no iron ore was exported; all was processed for domestic use.

History of the Bastnäs Ore Field

The Bastnäs ore field is divided into the Gamla Bastnäsfältet (the Old Bastnäs ore field) and the Nya Bastnäsfältet (the New Bastnäs ore field). In all it consists of nearly 60 separate large and small mines. Some 20 of these were mined for copper ore, the rest for iron ore, plus some prospects for molybdenum and cobalt ore. There are also about ten small limestone quarries within the field. The Old Bastnäs ore field, which is one of the oldest parts of the Riddarhyttan ore district, was mainly mined for copper during the 18th century. Mining in the New Bastnäs ore field, mainly for iron, began in the early or middle 18th century. Among the important and famous mines in the New field are Stora Bastnäsgruvan, Ceritgruvan and Sankt Göransgruvan (or Sankt Görans koppargruva). The two latter mines produced cerium ore, and hence are of chief interest here.

The Ceritgruvan is described as a copper mine on a mining map dated 1765. The mine was named Ceritgruvan because it contained large amounts of cerite. Around 1848, small amounts of cerium ore (mainly cerite) were taken from the mine and from the old dumps. In the 1880's, an increased demand for cerium ore led to more extensive mining in Ceritgruvan; it was worked solely for cerium ore during 1886–1888, and the old dumps yielded additional ore (Högrelius, 1996; Tideström, 1890). A shaft was sunk to a depth of nearly 17 meters, measuring 6.7 x 3.8 meters at the bottom. According to Geijer (1920), high-grade cerium ore consisting of cerite and allanite was mined in the period 1875–1888, the total production amounting to 4465 metric tonnes.

Close to the Ceritgruvan is the Sankt Göransgruvan mine, also called the Nya Bastnäsgruvan copper mine. This mine opened in 1692, but operated only intermittently. It was reopened in 1742 and worked until 1755. By around 1750 the mine had reached a depth of 18 meters (Cronstedt, 1781). The mine was not worked again until 1862–1864, when it produced 287 tons of copper ore. Cerite and allanite had already been noted in the mid-18th century by Cronstedt, but it is not known whether Sankt Göransgruvan was ever mined specifically for cerium ore.

The dumps were reworked for cerium ores several times during the 20th century. During 1937–1938 several crates of extracted cerite ore were exported to Norway, and the dumps were again hand-picked in the late 1940's, but the material was never sold and was later dumped in a nearby mine (Högrelius, personal communication, 1994).

Of the numerous mines in the Bastnäs ore field, the most significant ones are listed here and numbered on the mining map:

237 Lilla Bastnäsgruvan—iron ore
240 Stora Bastnäsgruvan—iron ore
241 Långgruvan or Ahlströmers shaft—iron ore
244 Ceritgruvan—copper and cerium ore
245 Sankt Göransgruvan—copper ore
251 Stora Skarpbergsgruvan—iron ore
251a Södra Skarpbergsgruvan or Darsbogruvan—iron ore
254 Lilla Skarpbergsgruvan—iron ore

History of the Mineral and Element Discoveries at Bastnäs

It is not known precisely when the peculiar heavy red mineral was first noticed in Sankt Göransgruvan. Cronstedt was probably already aware of its existence in the 1740's. The word "tungsten" appears on a specimen label from 1746 (Nordenskiöld, 1873). In 1750 Cronstedt reported a "dense, reddish, rather heavy ironstone" and also described a "black wolfram" containing iron (Tideström, 1890); this is probably the first note on the cerite and allanite from Bastnäs. The red mineral was described by Cronstedt (1751) under the name of "tungsten" (heavy stone) together with another heavy mineral which, however, was white and from Bispberg in the northeastern part of Bergslagen. The latter turned out to be scheelite, containing the new element tungsten. The red mineral became known as "Bastnäs tungsten" (the "heavy stone of Bastnäs," or reddish tungsten).

In 1782 Wilhelm Hising, then only 15 years old (and to be called Hisinger after his ennoblement in 1787), sent a piece of the Bastnäs "tungsten" to the famous chemist Carl Wilhelm Scheele (1742–1786) in Köping, Sweden. Scheele, despite his well-known analytical skill, could not find anything in the sample but silica, alumina, and a little iron—no tungsten. In 1787 an artillery officer, Carl Axel Arrhenius (1757–1824), found a black mineral in the quartz and feldspar quarry at Ytterby, northeast of Stockholm, which was shown by the chemist Johan Gadolin to contain a new "earth"—yttria. This discovery of the element yttrium marked the beginning of more than a century of research on the rare-earth elements. The black mineral was later named gadolinite. After hearing this news Hisinger turned back to his mineral collection, which he housed in one of the two wings of his castle-like mansion in Skinnskatteberg, about 5 km east of the Riddarhyttan ore district. Wilhelm Hisinger (1766–1852), now a wealthy foundry proprietor, had studied natural sciences at Uppsala University, under famous teachers like Torbern Bergman (Heijkenskôld, 1934). His wide range of interests included chemistry, mineralogy, geology, paleontology, botany, meteorology and topography. His financial independence gave him opportunities to travel and to spend comparatively large amounts of money on his spare-time occupations. He published several books on mineralogical, geological and paleontological subjects, printing them, to a great extent, at his own expense (Regnéll, 1990). He also had a well-equipped laboratory where he performed analyses of various minerals, rocks, ores and foundry products.

Figure 2. **Wilhelm Hisinger. After a wax medallion made by L. Posch in Berlin in 1821. Photo by Erik Jonsson.**

Hisinger speculated on whether yttria could be found in the red mineral from Bastnäs. He got promising results, and when the 23-year-old Jons Jacob Berzelius (1779–1848) visited him in the spring of 1803, mineralogical and chemical subjects were discussed, and these of course included the problematic "Bastnäs tungsten." Berzelius and Carl von Linné are the two most famous Swedish scientists of all time, and Berzelius is one of the most renowned chemists in history. In 1802 Berzelius had moved from Uppsala to Stockholm, where he soon came in contact with the wealthy Hisinger, who shared his love for the natural sciences. For Berzelius this was a very fortunate friendship, because Hisinger became not only a life-long friend but also, in the beginning, an important benefactor to the young scientist. Berzelius, among others, introduced the new chemical classification system for minerals in 1814; he also gave the elements new chemical symbols which are still in use. His contributions to science cannot be

Figure 3. **Hisinger's castle-like mansion in Skinnskatteberg, about 5 kilometers east of the Riddarhyttan ore district. His mineral collection was housed in the west wing, at the left in this postcard from about 1900. Collection of Jörgen Langhof.**

overestimated, and are too extensive to summarize here (see Jorpes, 1966; Melhado, 1981; and Moore, 1988).

Hisinger and Berzelius performed new analyses of both gadolinite and the red Bastnäs mineral and came to the conclusion that a new element having several characteristics in common with yttria was contained in the "Bastnäs tungsten." Further analyses done during the winter of 1803–1804 confirmed this. Berzelius gave the new element the preliminary name "bastium," after the locality, and found it present in two states of oxidation.

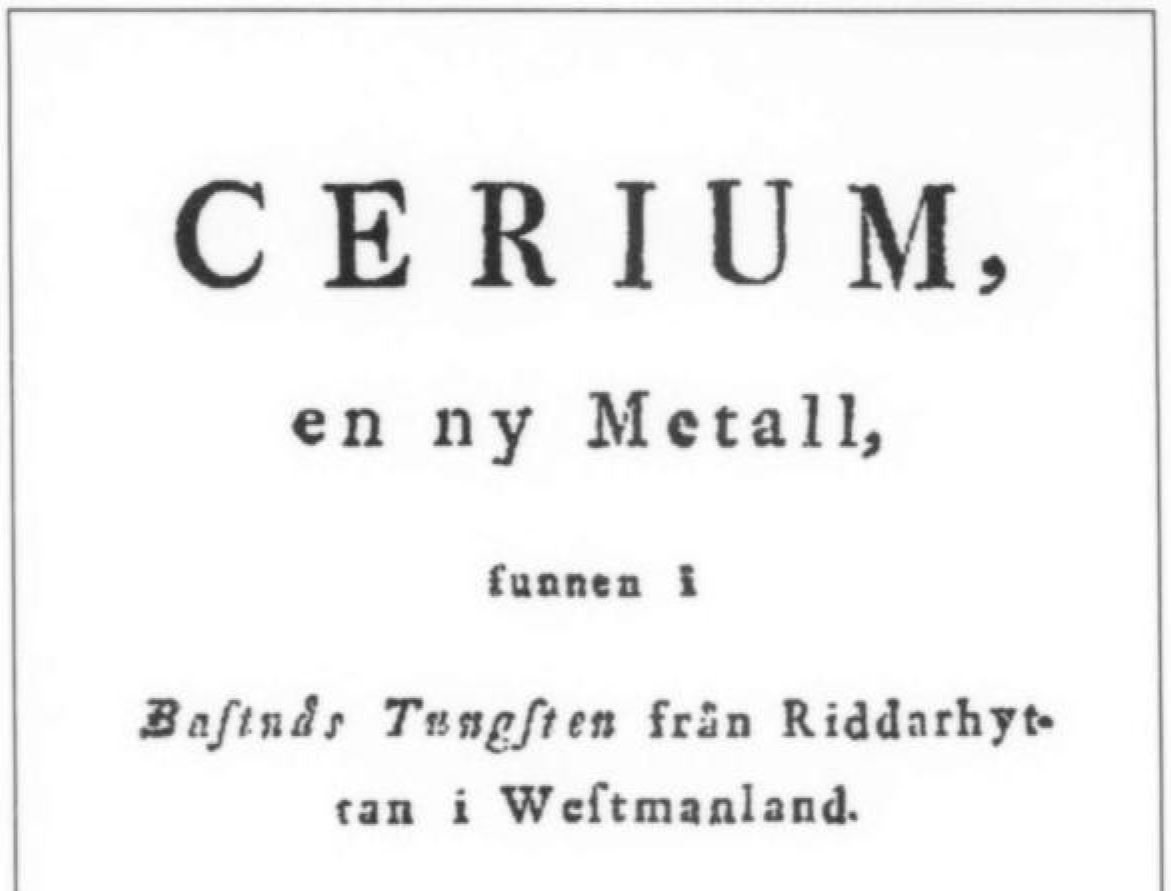
Bastium was renamed cerium (Ce) a short time later (Trofast, 1996). This name was inspired by the discovery of the "planet" Ceres by the Italian astronomer Giuseppe Piazzi in 1801. The cerium-containing mineral was then named cerite.

The discovery was announced to Berzelius' former chemistry teacher, Professor Johan Afzelius (1753–1837) at the Uppsala University. Rather than being pleased and proud about the accomplishment of his former student, Afzelius and his colleagues questioned Berzelius' ability to make reliable chemical analyses. On the basis of a few perfunctory tests, these scientists decided that cerium was a mixture of yttria and iron or something similar. Several other renowned Swedish chemists including Anders Gustaf Ekeberg (1767–1813) and Johan Gottlieb Gahn (1745–1818) became involved in the discussions. Berzelius and Hisinger won this battle, but a new, much more serious challenge lay ahead.

Berzelius and Hisinger's paper on the discovery of cerium had been approved by the German chemist Adolph Ferdinand Gehlen (1775–1815) for immediate publication in his journal; however, in the third issue of the same journal, which was just about to be printed, there was a report of the discovery of a new "earth" from the same mineral, written by the German chemist Martin Heinrich Klaproth (1743–1817) in Berlin (Trofast, 1996). Klaproth (1807) called the new "earth" ochroite (terre ochroite), because of the light brown color of the pure substance. This was disappointing for Berzelius and Hisinger, but Hisinger, at his own expense, had their Swedish version of the paper, a pamphlet of 24 pages, printed in 50 copies in May 1804, to be distributed among their mutual scientific friends. When the paper appeared in Gehlen's journal (Hisinger and Berzelius, 1804b) it attracted much attention among the chemists of Europe. It was published in different languages in other journals around Europe, and the news spread quickly. Because of

Figure 4. **Jacob Berzelius. Johan Elias Cardon after a German lithographic printing. This is a Swedish reproduction printed by Gjöthström and Magnusson in Stockholm in 1835.**

Figure 5. **Chemicals prepared by Jacob Berzelius from Bastnäs cerium minerals, e.g. "ceroxid" and "lantanoxid." From the Berzelius museum in Stockholm, Royal Swedish Academy of Sciences. Photo by Lars Falck.**



CERIUM,

en ny Metall,

funnen i

Baſtnäs Tungſten från Riddarhyttan i Weſtmanland.

Af

W. Hisinger och J. J. Berzelius.

STOCKHOLM,
Tryckt hos Henrik A. Nordström, 1804.

***Figure 6.* The title page of Hisinger and Berzelius's 1804 description of the new element cerium.**

this simultaneous publication of the discovery by two different parties, a priority dispute began between Berzelius/Hisinger and Klaproth; disappointment and strange rumors spread among the three of them. After many letters and explanations, and after Gehlen and the French scientist Louis Nicolas Vauquelin (1763–1829) had reviewed the analyses, Berzelius' and Hisinger's discovery was awarded priority. This decision was eventually accepted by Klaproth (Trofast, 1996), who, however, suggested that the name could as well, or better, be derived from the Greek word *cera*, meaning wax; he proposed the names "cererum" for the element and "cererite" for the mineral (Klaproth, 1807).

Berzelius, who was only 25 years old at the time, had no particular reverence for the European scientific establishment, and his work had implied that a changing of the guard was at hand. The discovery of cerium had brought on more controversy, in Sweden and abroad, than any other discovery made by a Swedish scientist since the days of Carl Wilhelm Scheele and the great controversy about oxygen (Jorpes, 1966).

In the 1820's, Carl Gustaf Mosander (1797–1858), chemist, surgeon and mineralogist, continued the investigation of cerite from Bastnäs. Mosander was one of Berzelius' numerous pupils; he ended up as curator of minerals at the Naturhistoriska Riksmuseet (the Royal Natural History Museum). Earlier, he had succeeded Berzelius as Professor at the Karolinska Institutet (the Carolinian Institute), where he taught chemistry, pharmacy and mineralogy. During his work with the cerium oxides, "Pater Moses," as Mosander was nicknamed, had become increasingly suspicious regarding the true nature of these substances. He had obtained results suggesting that they were a mixture of rare earths. But it was not until 1839 that, after much pushing by Berzelius, he published the discovery of the new element lanthanum (La)—from the Greek word *lantánein*, "being hidden." In the same year the Swedish mineralogist and geologist Axel Erdmann (1814–1869) also discovered lanthanum, in a Norwegian mineral which he named mosandrite in honor of Mosander's discovery (Lundgren, 1987). Four years later Mosander published another discovery resulting from his work on the red Bastnäs mineral. He named this new element didymium (Greek for "twin") because, as he said, it seemed to be "an inseparable twin brother of lanthanum" (Weeks, 1968). Didymium, however, proved to be a mixture itself and was separated into neodymium (Nd) and praseodymium (Pr) in 1885 by the Austrian chemist Karl Auer von Welsbach (1858–1929).

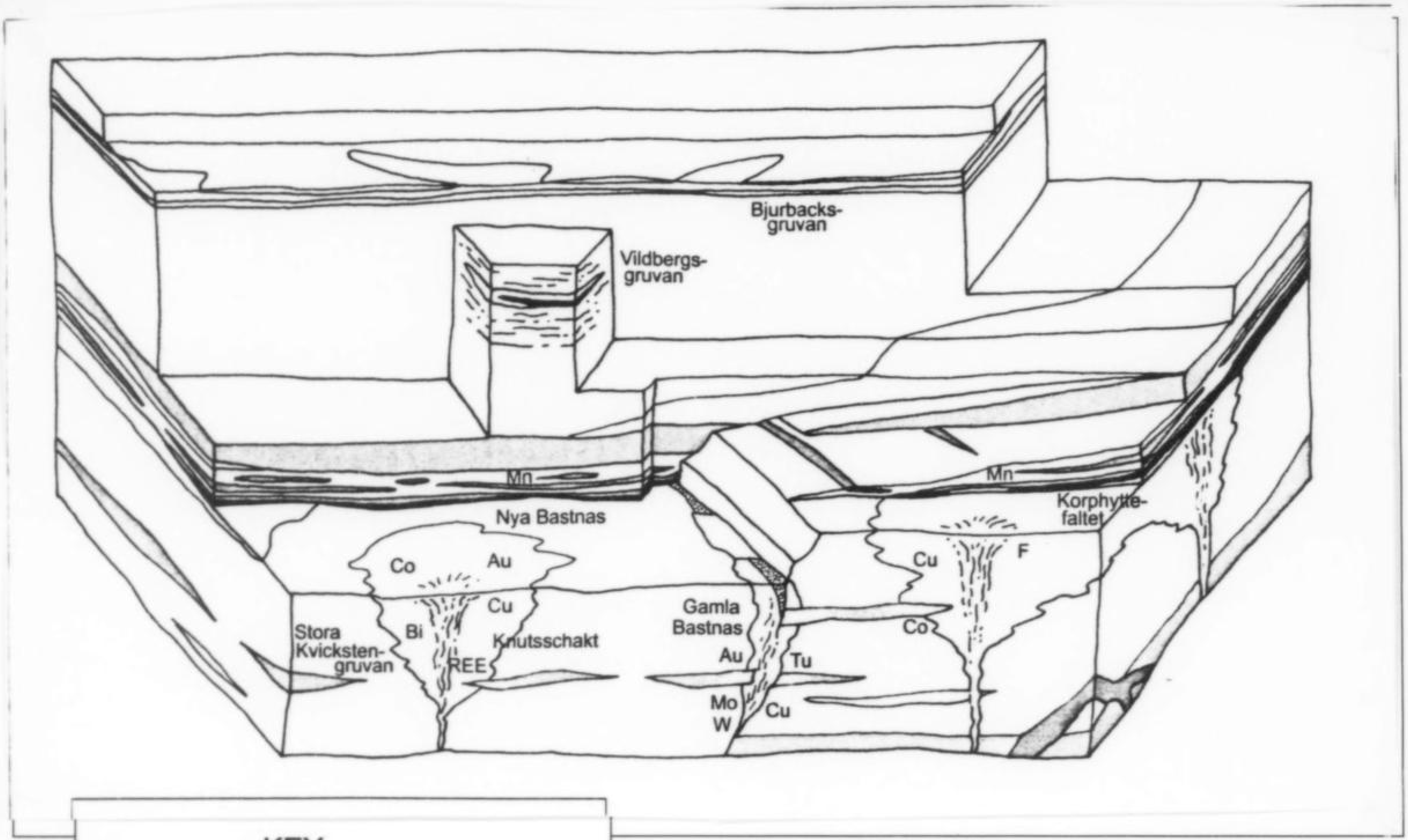


***Figure 7*. Stratigraphic block diagram showing the geology of the Riddarhyttan ore field (by P. Ihre and S. Sädbom, Sveriges Geologiska AB, 1986). Au = gold; Bi = bismuth, bismuthinite; Co = cobaltite; Cu = chalcopyrite; F = fluorite; Mo = molybdenite; REE = rare earth elements; Tu = tourmaline; W = scheelite.**

GEOLOGY

Like almost all other ore deposits in the Proterozoic of central Sweden, those of the Riddarhyttan ore district occur within a supracrustal rock sequence, including various felsic metavolcanic rocks and metasediments, known as the Leptite Formation. In Riddarhyttan the formation consists of metavolcanites (originally lavas and pyroclastic rocks), mica schists with cordierite and often also andalusite, and subordinate limestone-dolomite layers (Geijer, 1929).

There are several different types of ore deposits: quartz-banded iron formation (BIF); iron and copper ores with quartz and fluorite, well banded in some areas; "skarn ores" in limestones, the skarn minerals being mainly actinolite, diopside, garnet and fluorite; and finally magnetite ores with anthophyllite, accompanied by metamorphic cordierite-anthophyllite quartzites (Geijer, 1923).

The first type of ore exhibits a number of features pointing decidedly to a sedimentary origin, while the skarn ores are epigenetic deposits in the carbonate rocks. The ores and surrounding country rocks have been deformed in a complex manner involving several generations of folding. Recent prospecting activities in the area have led to a more complete understanding of the ore-forming environment.

Quartz-banded ore, mainly hematite, was exploited in a number of mines in the Bastnäs area. Parallel to the hematite ore belt, and sometimes adjoining it, runs a zone of amphibole skarn; the main amphibole species is a pale to dark green actinolite. Replacement relicts of limestone are sometimes observed in the skarn. Magnetite occurs at several points in the skarn zone, and chalcopyrite has been found in some quantity. The cerium ore also belongs to the skarn zone, where it is associated with chalcopyrite.

In the Sankt Görans copper mine, the cerium ore formed a narrow band that accompanied the copper ore and ended at a depth of 30 meters. In the nearby Cerite mine there was one band of cerium ore 30 to 60 cm wide and 6 to 7 meters long, and one narrower band; both ended at about 20 meters depth (Geijer, 1920).

MINERALS

Most of the minerals described below were found and determined during the operation of the mines. Many of the mines have a common dump on the slope of the hillside, so that materials from different mines have probably been mixed; hence collectors used to call the dump Nya Bastnäs (New Bastnäs). Many of the hydrous

Figure 8. **Collecting cerium minerals at the old dumps near the mines Sankt Göransgruvan and Ceritgruvan, 1975. Photo by Urban Strand.**

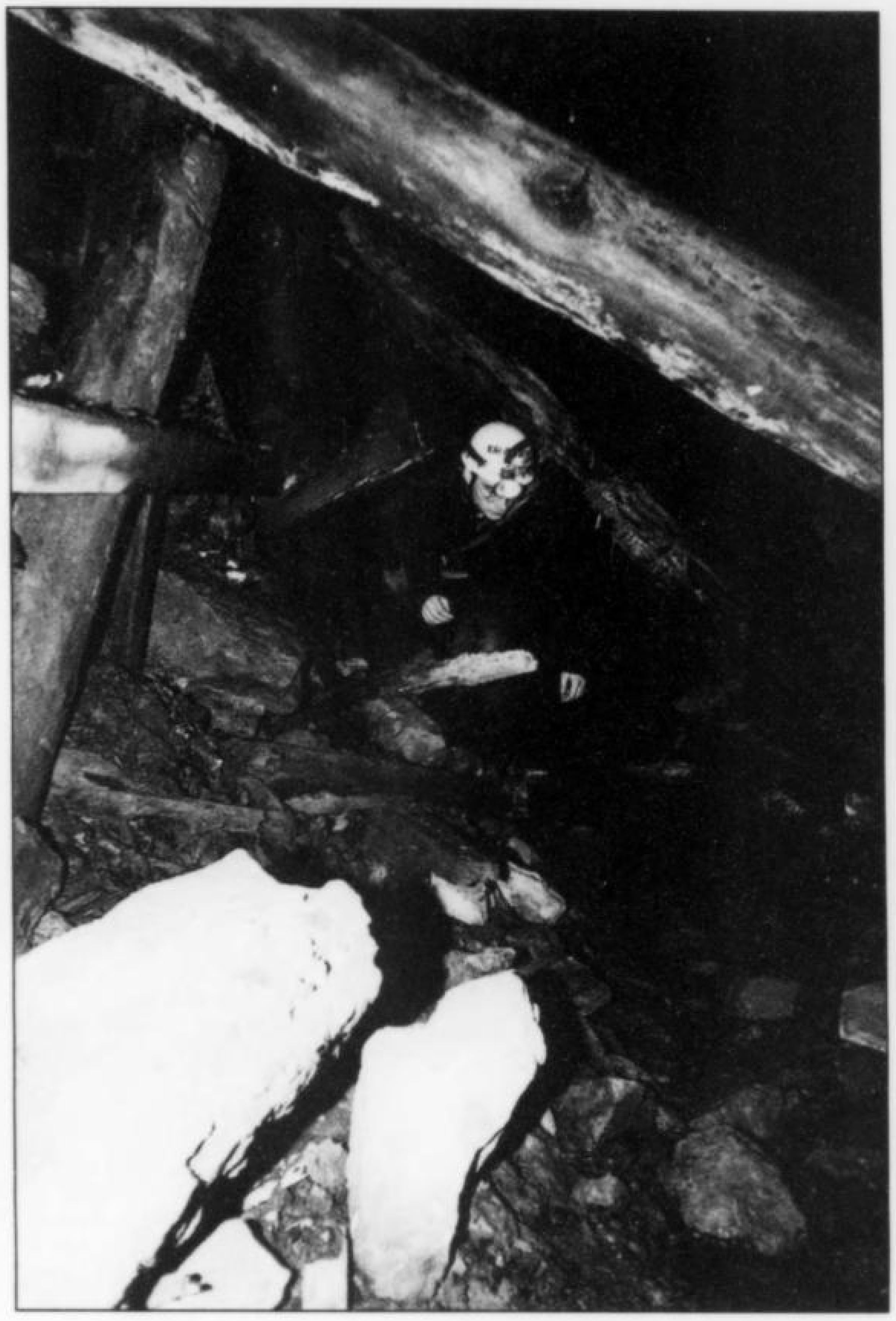


Figure 9. **Underground on the first level in the Bastnäs mines, close to the partially collapsed shaft at the mine Ceritgruvan, 1992. This part of the mine is still accessible via an adit. Photo by Erik Jonsson.**

minerals found on the dump, e.g. azurite, bismutite, brochantite, lanthanite-(Ce), malachite and wroewolfite, are of secondary origin and may have formed there as a result of post-mining processes.

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

Pale to dark green actinolite is the main skarn silicate of the cerium ore. A similar occurrence of actinolite accompanies the magnetite ore. The actinolite occurs as parallel to radiating crystals in fibrous masses, and rarely as slender elongated crystals embedded in bismuthinite. It commonly shows an asbestose texture.

Allanite-(Ce) $(Ce,Ca,Y)_2(Al,Fe^{2+},Fe^{3+})_3(SiO_4)_3(OH)$

Allanite-(Ce) was first known as "schwarzen wolfram" (black wolfram) in the mid-18th century (Cronstedt, 1781; Hisinger, 1790, 1808; Tideström, 1890). When investigated around 1810, by which time it had come to be considered a kind of hornblende (Hisinger, 1810), the mineral was found to contain one-third cerium oxide, and was given the name cerine (Hisinger, 1811). A thorough investigation was also performed by Hisinger a few years later; he showed it to be closely related to allanite (Haüy, 1822). For a long time it was also known as orthite, being related to the "orthite" and "pyrrorthite" described by Berzelius from the granitic pegmatites in the Falun area in northern Bergslagen. The chemistry was characterized by Cleve (1862), and the optical properties by Zenzén (1916). Allanite is the most common cerium-bearing mineral at Bastnäs, although well-developed crystals are very rare. It occurs as jet-black to brownish masses, typically exhibiting a platy habit, within the amphibole skarn, and as compact masses with cerite. Chalcopyrite, bismuthinite, bastnäsite and rarely linneite occur with the allanite-(Ce).

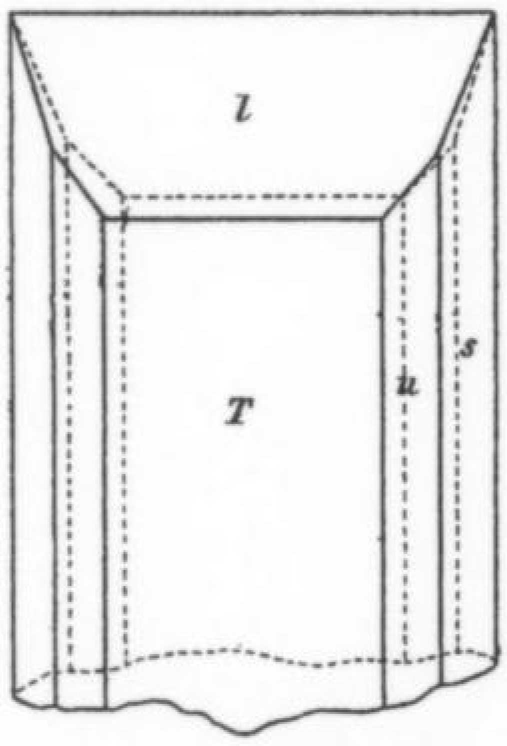


Figure 10. **Crystal drawings of "cerin" (allanite-(Ce)) from Nordenskiöld (1870).**

Crystals of allanite were first investigated by Rose (1830), who first considered them to be trigonal, later calling them monoclinic

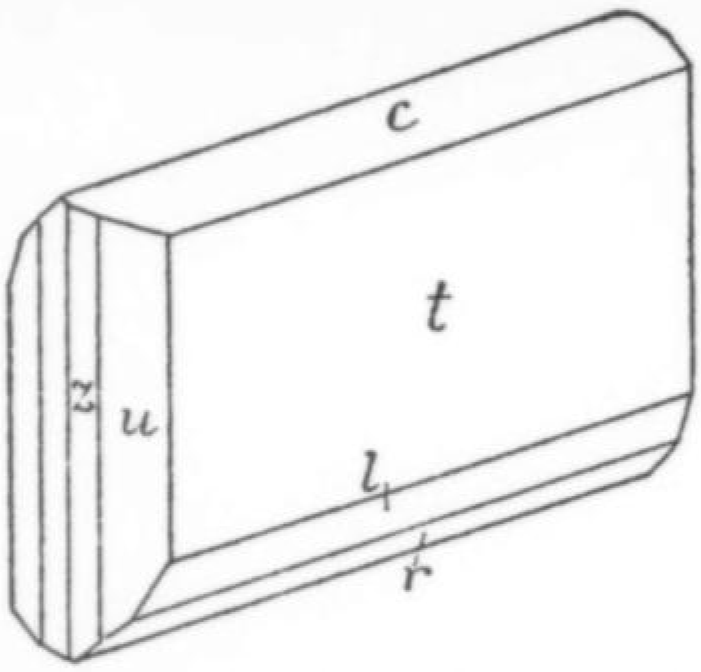


***Figure 11.* Crystal drawing of "orthite" (allanite-(Ce)) from Flink (1917).**

(Rose, 1852). Nordenskiöld (1870) made some new measurements confirming Rose's latter results. The crystals have a tabular or long-prismatic habit; according to Flink (1917) they may reach sizes up to 5 mm. Dump finds of larger crystals have been made, but these are platy and rough-faced. The crystals reported by Nordenskiöld occurred in small druses with yellow bastnäsite.

Andalusite Al_2SiO_5

Andalusite is found as yellow to brown masses with cordierite in mica schist.

Anthophyllite $Mg_7Si_8O_{22}(OH)_2$

Anthophyllite occurs as white to gray radiating aggregates in a quartzitic metavolcanite.

Azurite $Cu_3(CO_3)_2(OH)_2$

Azurite occurs in very small quantities as blue surface coatings on chalcopyrite, together with malachite and wroewolfeite.

Barite $BaSO_4$

Barite is rare at Bastnäs. It occurs in small quantities as pale red-brown crystals filling cracks in metavolcanic rocks.

***Figure 13.* Bastnäsite with allanite from Bastnäs; the field of view is 5 cm.**

Bastnäsite $(La,Ce)(CO_3)F$

Bastnäsite was described by Hisinger (1838) under the name of "basiskt fluor-cerium" (basic fluorine-cerium), although Berzelius (1825) reports an orange-yellow "flusspatsyradt cerium" in what is likely the earliest published notice of the mineral. It was called "hydrofluocerite" in several mineralogies in the mid-19th century. Nordenskiöld (1868) made a renewed investigation of the material and found that the mineral did not contain any water, contrary to what Hisinger's analysis had seemed to indicate, and hence he gave it the name "hamartite," from the Greek word for "making a mistake," apparently without knowledge of Huot's (1841) naming of the mineral. Other early names for bastnäsite were "basicérine" (Beudant) and "fluocerin" (Hausmann).

Both Hisinger (1838) and Nordenskiöld (1868) report that bastnäsite is very rare at Bastnäs. On the contrary, it is rather common, but generally as small grains in the cerium mineral association. Larger platy crystals are rare.

Bastnäsite is found as yellow plates, masses and grains filling the interstices between allanite plates and within allanite masses. It also occurs mixed with cerite together with bismuthinite and small amounts of chalcopyrite. One possible crystal, in association with bismuthinite, was located by Flink (1910) in the collection of the Swedish Museum of Natural History. Homogenous pieces are sometimes larger than 20 cm across. Crude bastnäsite crystals up to 5 cm have been found on the dumps during the last 10 years.

***Figure 12.* Bismuthinite from Bastnäs, 2 cm across.**

Bismuthinite Bi_2S_3

Bismuthinite occurs quite abundantly as small tin-white spots in the cerium ore. It is generally associated with allanite, filling the interstices between allanite grains, and is also found as masses, or rarely as parallel intergrowths with actinolite skarn. Masses up to the size of a fist have been found.

Bismuth ore was noted by Cronstedt (1781) in the mid-18th century. Berzelius (1823) made a blowpipe analysis of a bismuth ore sample from Bastnäs which showed it to contain tellurium, the first discovery of this element in Sweden. Specimens collected in the mid-19th century were consequently called "tellurvismut," though no quantitative analysis was ever performed. A wet chemical analysis by Lindström (1906) found 0.95 weight-% tellurium in the bismuthinite—a normal amount.

Bismutite $Bi_2(CO_3)O_2$

Bismutite, recently found on the dumps, occurs as spherules in specimens containing bismuthinite, in cavities in allanite, and as surface coatings. The color is usually pale to dark green, but the spherules tend to be yellowish white.

Bornite Cu_5FeS_4

Bornite is occasionally found as masses in the quartz-bearing skarn surrounding the cerium ore.

Figure 14. **Brochantite crystals to 0.5 mm, from Bastnäs.**

Brochantite $Cu_4(SO_4(OH)_6$

Pale to deep green, thin-prismatic crystals of brochantite are found on surfaces and in pockets of the iron skarn, together with chalcopyrite, malachite and wroewolfeite.

Cerite-(Ce) $Ce_9^{3+}Fe^{3+}(SiO_4)_6[(SiO_3)(OH)](OH)_3$

Cerite was probably characterized as a species in the 1740's; long before that time the mineral was known as "Bastnäs tungsten" (= "heavy stone of Bastnäs"). Hisinger and Berzelius (1804a) discovered in it the new element cerium, and named the mineral cerite.

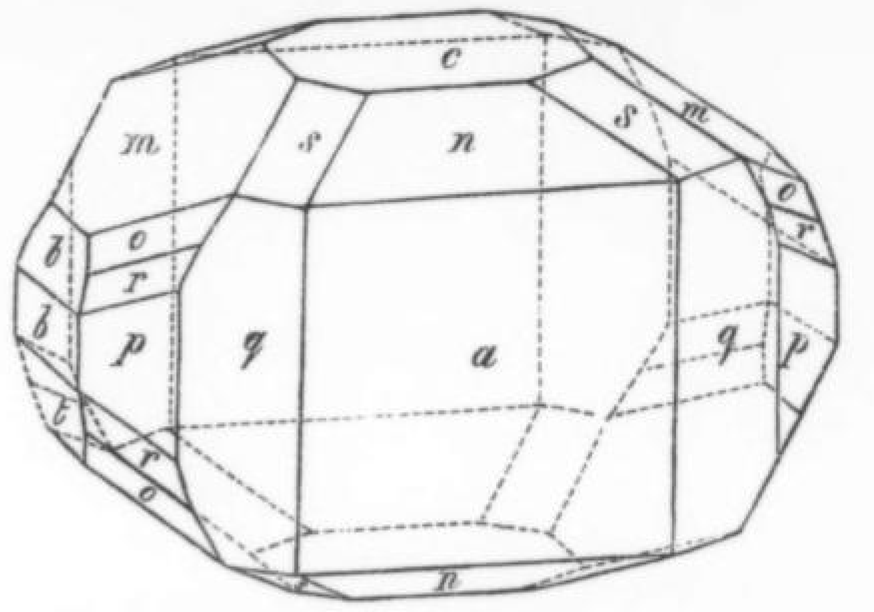


Figure 15. **Crystal drawing of cerite from Nordenskiöld (1873).**

Nordenskiöld (1873) looked through thousands of specimens of dump material as well as in various collections, but found only one specimen containing crystals of cerite. The specimen, from the Bergskollegium (Board of Mines) collection, was collected in 1746, and is labeled "Wismuthglants and green copper ore in Tungsten and black skörlberg [probably allanite-(Ce)]. Vestmanland. Skinnskattebergs S:n Bastnäs Gr. [mine] 1746." On this specimen rounded, pale red crystals up to the size of a pea and showing numerous faces are embedded in bismuthinite, together with small allanite crystals. The cerite crystals were all, unfortunately, consumed in the process of the chemical analysis that confirmed their identity (Flink, 1917). But in the collections of Naturhistoriska Riksmuseet the original sample is still preserved. Close examination reveals that the specimen still contains gray-red, garnet-like crystals of cerite up to 5 mm, though poorly developed. Four or five loose crystals and a 5-mm crystal fragment, probably broken off from the matrix specimen, were also noted by Nordenskiöld.

Cerite has a flesh-red to gray color and occurs as large, dense masses up to 30 cm, associated with amphiboles, allanite, bastnäsite and törnebohmite. Microscopic inspection reveals numerous inclusions, primarily of bastnäsite, but also of various sulfides. Cerite-(Ce) may be replaced by allanite-(Ce), bastnäsite, and more rarely lanthanite-(Ce) (Geijer, 1920).

Chalcocite Cu_2S

Chalcocite, like bornite, is found as masses in quartz. Rarely, small spots of chalcocite can be seen in the cerium ore assemblage.

Chalcopyrite $CuFeS_2$

Chalcopyrite was the main ore mineral exploited in these mines before the discovery of the cerium minerals. It occurs frequently in the cerium ore as minor spots and masses, and in moderate quantity in various associations surrounding the cerium ore. Rarely, intergrown chalcopyrite crystals to 1 cm, partly altered to malachite, have been found.

Clinochlore $(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$

Acid-removal of calcite from an iron-bearing skarn specimen revealed a small number of nice colorless clinochlore crystals, associated with hematite crystals.

Copper Cu

Native copper has been found in small amounts together with cuprite and other secondary copper minerals in the quartz-banded iron ore.

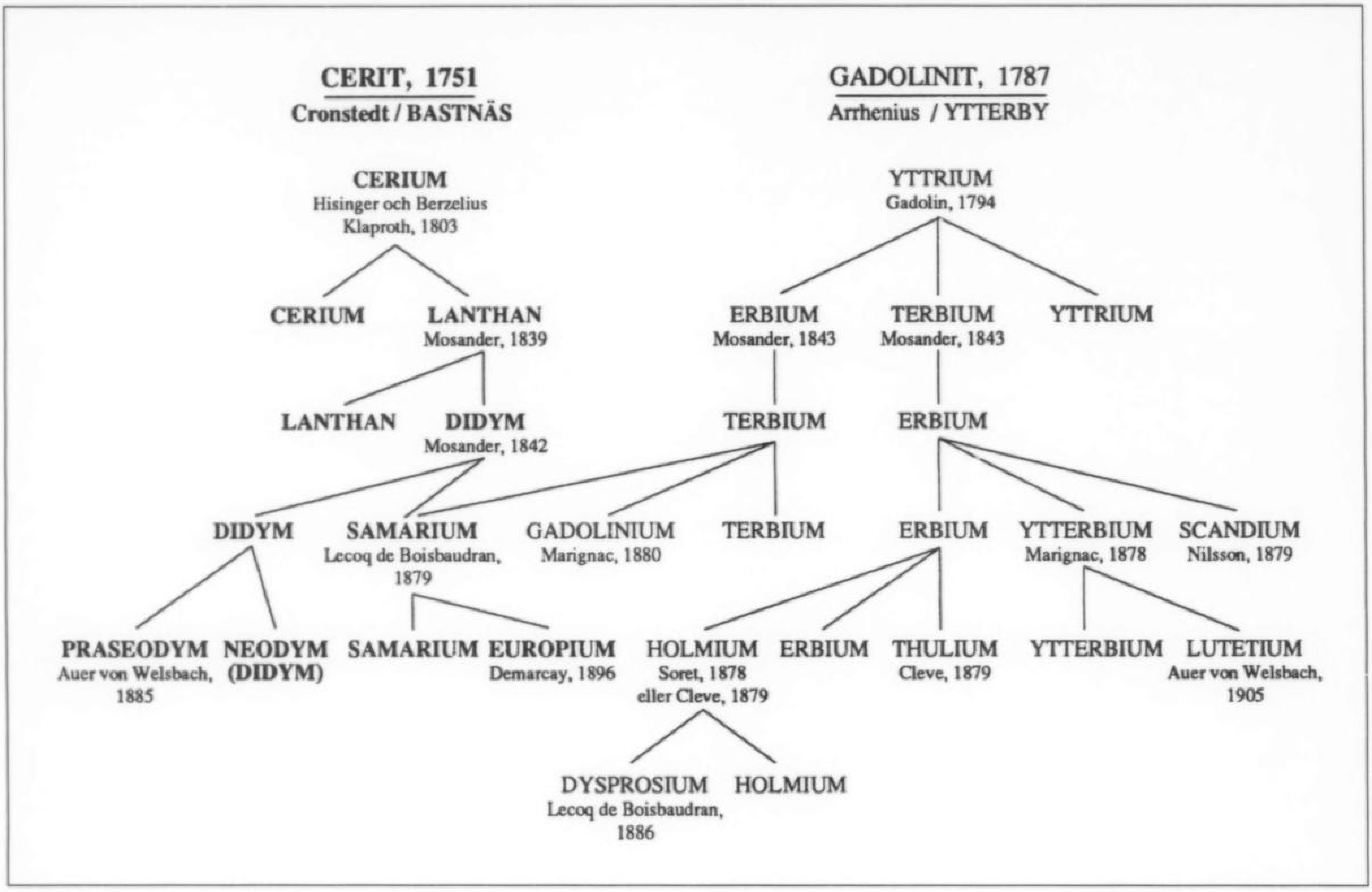


Figure 16. **The sequence of discovery of the rare-earth elements in cerite and gadolinite.**

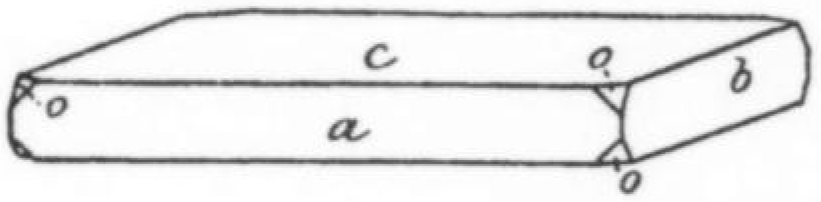


Figure 17. **Crystal drawings of lanthanite-(Ce) from Flink (1910).**

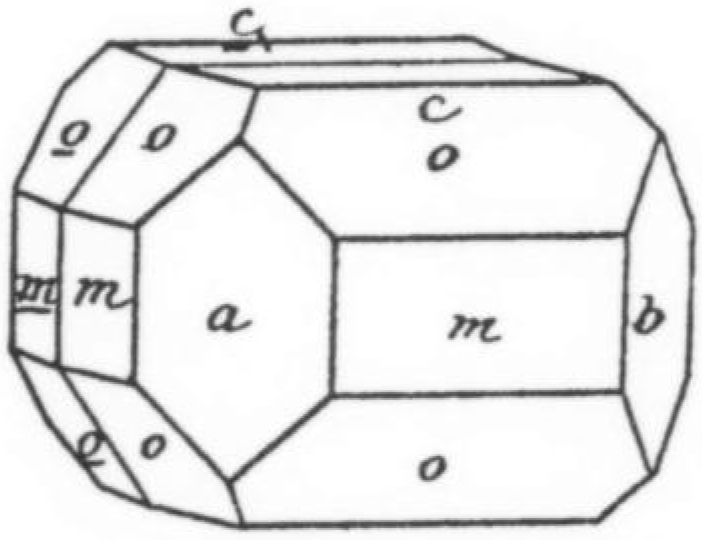


Figure 18. **Drawing of a lanthanite-(Ce) twin crystal from Flink (1910).**

Cuprite Cu_2O

Cuprite occurs in a magnetite-quartz-actinolite association. Small red crystals are found in cracks and as druses, but usually the mineral occurs as masses covered with malachite and sometimes wroewolfeite.

Fluocerite-(Ce) $(Ce,La)F_3$

Fluocerite-(Ce) is one of the rarest cerium minerals at Bastnäs. It is found as anhedral yellow to white porcelain-like grains up to about 2 mm in törnebohmite-bearing cerite-(Ce) specimens. Geijer (1920), who first reported fluocerite-(Ce) in mocroscopic amounts, also noted its replacement by bastnäsite along cleavage cracks in the fluocerite.

Gold Au

The assessor Bengt Andersson Qvist found native gold as thin coatings in a hornblende-bearing skarn association from Bastnäs in the middle of the 18th century (Cronstedt, 1781; Hisinger, 1790). Recently, a 1-mm gold flake in quartz was found on the dumps, in an actinolite-rich skarn association (Björn Karlsson, 1993, personal communication). Microscopic amounts of gold also occur in the bismuthinite-allanite-(Ce) association.

Hematite Fe_2O_3

Hematite is found in fine crystals in calcite-filled cavities in the iron ore. It also occurs abundantly as masses, and in bands with quartz or skarn minerals.

Lanthanite-(Ce) $(Ce,La,Nd)_2(CO_3)_3{\cdot}8H_2O$

Lanthanite-(Ce) was first described as "kolsyrad ceroxidul" by Berzelius (1824), and Hisinger (1826) gave a short description of its physical characteristics and its reaction with the blowpipe. The name *lanthanite* was introduced by Haidinger (1845); other obsolete names include "carbocérine" (Beudant, 1832), "hydrocerite" (Hartmann, 1843), and "hydrolanthanite" (Glocker, 1847). The chemical composition was determined by Lindström (1910), and crystallographic measurements were performed shortly afterwards by Flink (1910).

Lanthanite is distinctly a late-stage, low-temperature mineral. It usually occurs as a white to pale pink crystalline film coating

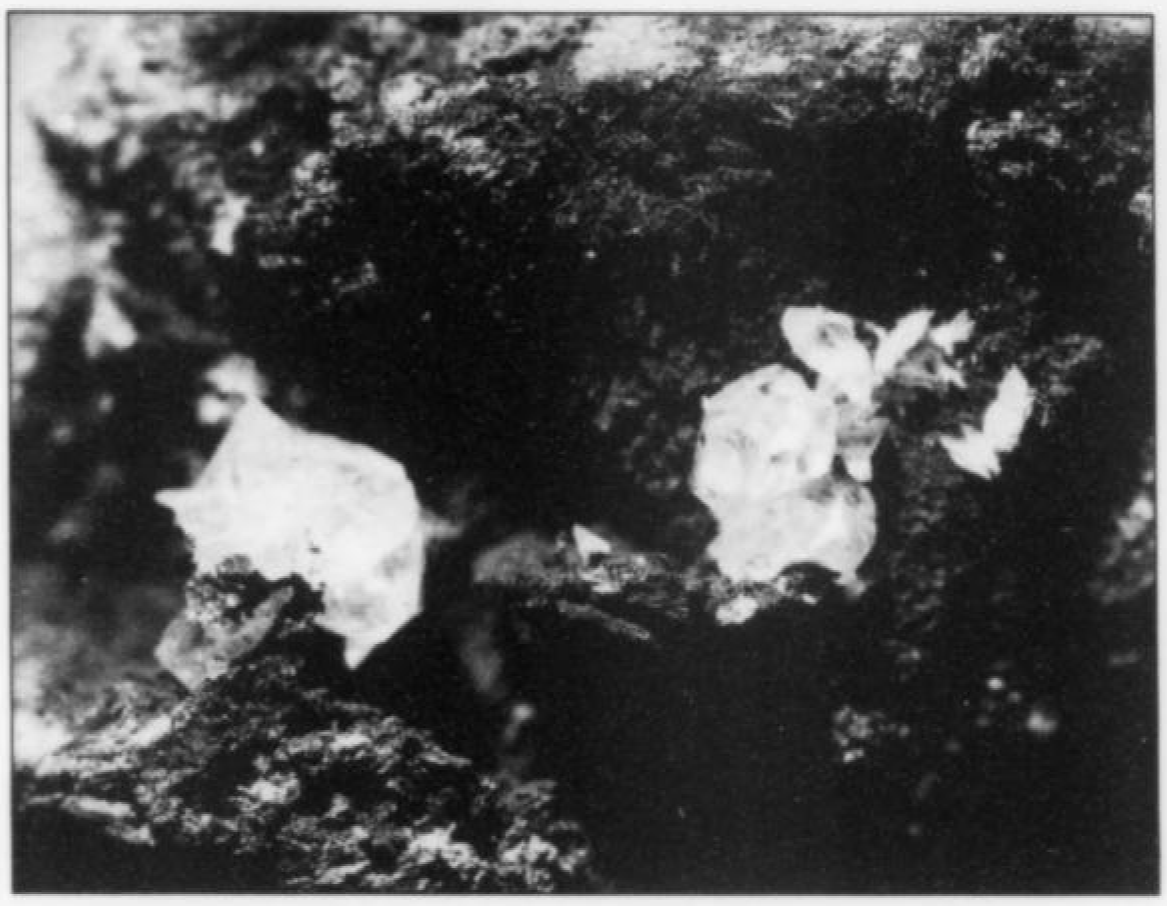


Figure 19. **Lanthanite-(Ce) crystals to 1.5 mm, from Bastnäs.**

Figure 20. **Tabular equant lanthanite-(Ce) crystals to about 0.5 mm in an open pocket in a cerite-allanite association. Collection and photo: Erik Jonsson.**

Figure 21. **Lanthanite-(Ce) crystals to 1 mm, from Bastnäs.**

cracks in the cerium ore. Sometimes tabular or equant crystals of 0.5 to 1 mm, rarely up to several mm, are found as druses and in cracks in allanite-bearing actinolite skarn; when fresh, they are colorless with a pink tint. All of the thicker tabular crystals of lanthanite show contact twinning (Flink, 1910).

Linnaeite $Co^{2+}Co_2^{3+}S_4$

A new mineral discovered in the Sankt Göransgruvan mine in 1743 was found to contain cobalt, iron and sulfur (Brandt, 1746). The mineral was known under several different names during the late 18th century (Flink, 1908), and was finally given the name linnaeite, after Carl von Linné, by Haidinger (1845). The first quantitative analysis was performed by Hisinger (1810).

Linnaeite is among the rarest minerals at Bastnäs. It occurs as small subhedral grains, rarely in masses up to 3 cm, in chalcopyrite, or with grains of chalcopyrite and magnetite in a clinochlore skarn. Steel-gray octahedral crystals of linnaeite, rarely up to 1 cm, occur with chalcopyrite and pyrite, and sometimes in allanite-(Ce) veins in the cerium ore.

Magnetite $Fe^{2+}Fe_2^{3+}O_4$

Magnetite is seen rarely in the cerium ore. It occurs commonly on the dumps, associated with the skarn minerals actinolite, talc and tremolite. Well-developed simple octahedrons are quite often encountered in mica-rich schistose rocks.

Malachite $Cu_2(CO_3)(OH)_2$

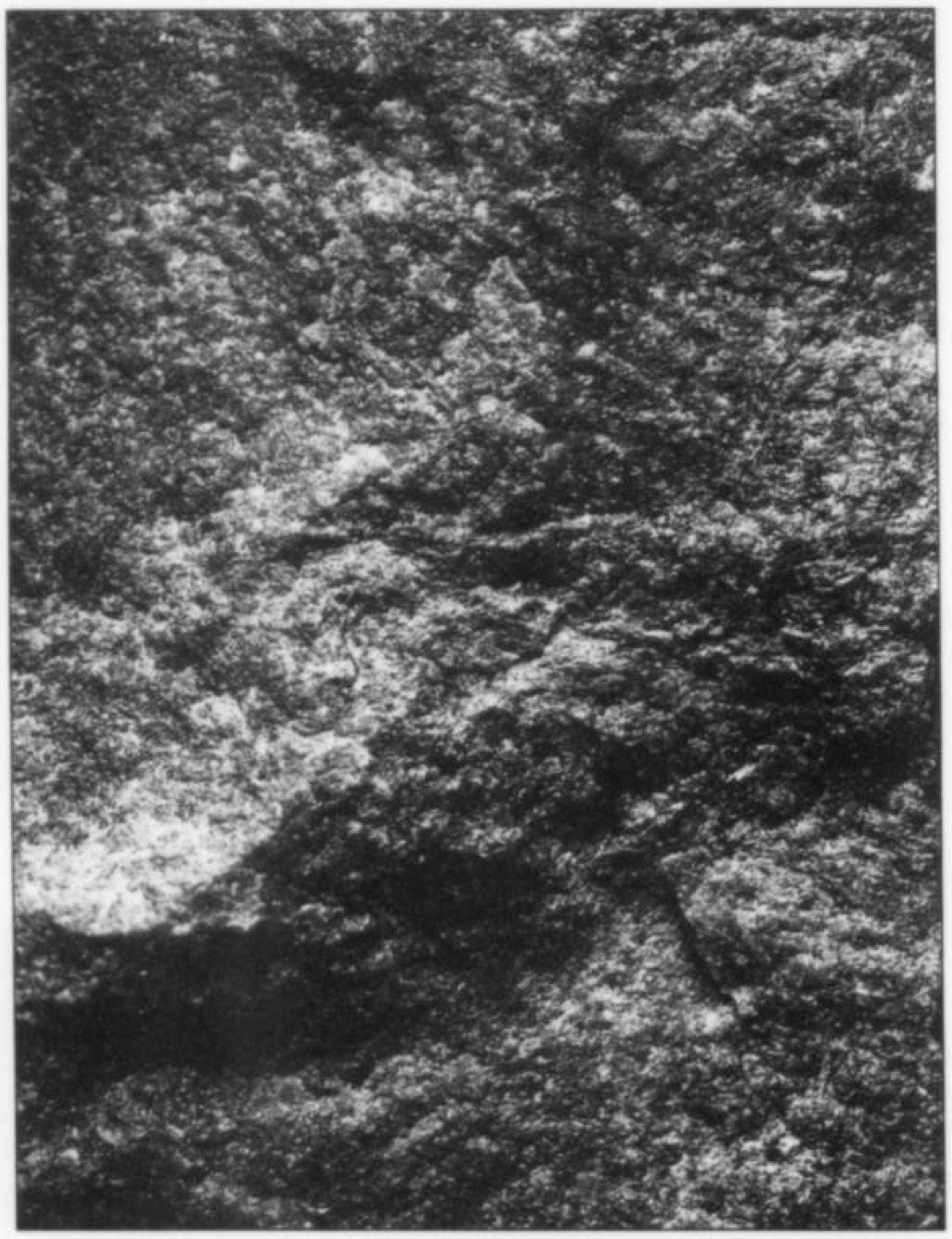
The most common secondary mineral at Bastnäs is malachite. It is seen all over the dumps in small quantities, as thin coatings and as radiating green spherules in druses in the actinolite skarn.

Molybdenite MoS_2

Molybdenite is farily common as 1 to 2-mm flakes in association with allanite-(Ce), and more rarely in cerite-(Ce) masses. Sometimes larger bladed masses of molybdenite are found in the actinolite skarn and the cerium-mineral association.

Figure 22. Wroewolfeite crystals to 1.5 mm, from Bastnäs.

Figure 23. Massive cerite and törnebohmite, 4 cm across, from Bastnäs.



Pyrite FeS_2

Pyrite is rather common as masses and as small cubic or octahedral crystals in cerite-(Ce) veins containing allanite-(Ce) and chalcopyrite.

Rhodonite $(Mn^{2+},Fe^{2+},Mg,Ca)SiO_3$

Massive pink rhodonite occurs in veins in the hematite ore surrounding the cerium ore.

Talc $Mg_3Si_4O_{10}(OH)_2$

Thin plates of talc sometimes up to 5 cm occur in the allanite veins.

Törnebohmite-(Ce) $(Ce,La)_2Al(SiO_4)_2(OH)$

Törnebohmite is found in the dense cerium ore as pale green to olive-green fine-grained masses, and as grains disseminated or gathered in patches in cerite, particularly in the vicinity of allanite-(Ce) veinlets. The mineral was described by Geijer (1920), who named it after the Swedish geologist Alfred Elis Törnebohm (1838–1911). The first to notice this mineral was probably Cossa (1878); later, Lacroix (1915) also noticed the unknown green mineral which turned out to be törnebohmite.

Wroewolfeite $Cu_4^{2+}(SO_4)(OH)_6 \cdot 2H_2O$

Wroewolfeite has, until recently, been unknown at Bastnäs. Sharp, deep blue crystals up to 2 mm have been found in the iron ore, on massive cuprite. Wroefolfeite crystals also occur in druses with lanthanite crystals in the actinolite skarn.

Figure 24. Wroewolfeite crystals with lanthanite crystals to 1 mm, from Bastnäs.

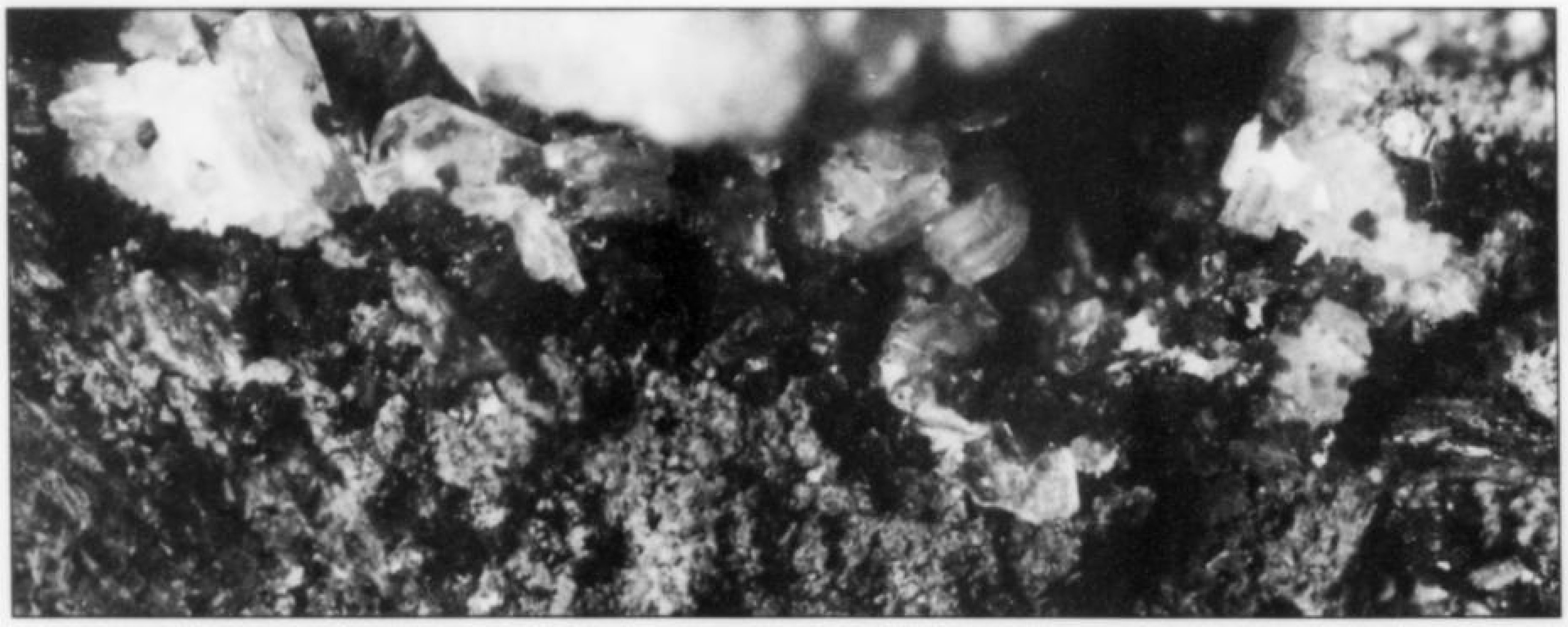


Table 1. **Minerals of Nya Bastnäsfältet (the New Bastnäs ore field).**

Elements	
Copper	Cu
Gold	Au
Oxides	
Cuprite	Cu_2O
Hematite	Fe_2O_3
Magnetite	$Fe^{2+}Fe_2^{3+}O_4$
Sulfides	
Bismuthinite	Bi_2S_3
Bornite	Cu_5FeS_4
Chalcocite	Cu_2S
Chalcopyrite	$CuFeS_2$
Covellite	CuS
Linnaeite	$Co^{2+}Co_2^{3+}S_4$
Molybdenite	MoS_2
Pyrite	FeS_2
Sulfates	
Brochantite	$Cu_4(SO_4(OH)_6$
Wroewolfeite	$Cu_4^{2+}(SO_4)(OH)_6 \cdot 2H_2O$
Halide	
Fluocerite-(Ce)	$(Ce,La)F_3$
Carbonates	
Azurite	$Cu_3(CO_3)_2(OH)_2$
Bismutite	$Bi_2(CO_3)O_2$
Bastnäsite	$(La,Ce)(CO_3)F$
Calcite	$CaCO_3$
Lanthanite-(Ce)	$(Ce,La,Nd)_2(CO_3)_3 \cdot 8H_2O$
Malachite	$Cu_2(CO_3)(OH)_2$
Sulfate	
Barite	$BaSO_4$
Silicates	
Actinolite	$Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$
Allanite-(Ce)	$(Ce,Ca,Y)_2(Al,Fe^{2+},Fe^{3+})_3(SiO_4)_3(OH)$
Andalusite	Al_2SiO_5
Anthophyllite	$Mg_7Si_8O_{22}(OH)_2$
Biotite series	$K(MgFe)_3(Al,Fe)Si_3O_{10}(OH,F)_2$
Cerite-(Ce)	$Ce_9^{3+}Fe^{3+}(SiO_4)_6[(SiO_3)(OH)](OH)_3$
Clinochlore	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$
Cordierite	$Mg_2Al_4Si_5O_{18}$
Ferrohornblende	$\square Ca_2[Fe_4{}^{2+}(Al,Fe^{3+})](Si_7Al)O_{22}(OH)_2$
Quartz	SiO_2
Rhodonite	$CaMn_4Si_5O_{15}$
Talc	$Mg_3Si_4O_{10}(OH)_2$
Tremolite	$\square Ca_2Mg_5Si_8O_{22}(OH)_2$
Törnebohmite	$(Ce,La)_2Al(SiO_4)_2(OH)$

DISCUSSION

In addition to Bastnäs, ten other localities in the vast Bergslagen area are known to contain cerium-bearing minerals in similar environments (Geijer, 1961). Cerite has been found in seven of these, but only two contain cerite in large lumps. Recently cerite has also been found at yet another locality (the Rödbergsgruvan mine, near Nora in the southwestern part of Bergslagen) as pale reddish masses in an amphibole skarn hardly distinguishable from the Bastnäs material (Kjell Gatedal, 1989, personal communication). These zones of cerium mineralization, which, taken all together, contain perhaps thousands of tons of cerium minerals, may possibly all occur at the same stratigraphic level in the metavolcanic sequence of rocks. It should be pointed out that no modern attempts have been made to solve the interesting problem of the origin or the cerium. A study of the modes of occurrence of cerium minerals in different parts of the Bergslagen could supply geologists with important clues to the understanding of ore-forming processes.

CONCLUSIONS

Bastnäs awaits a modern mineralogical investigation which probably would throw new light on some of the poorly understood mineral species and associations occurring there, and increase the number of known Bastnäs species dramatically. All of the important minerals from Bastnäs, including the cerium minerals, are still collectable at this famous site in the heart of the Bergslagen ore district.

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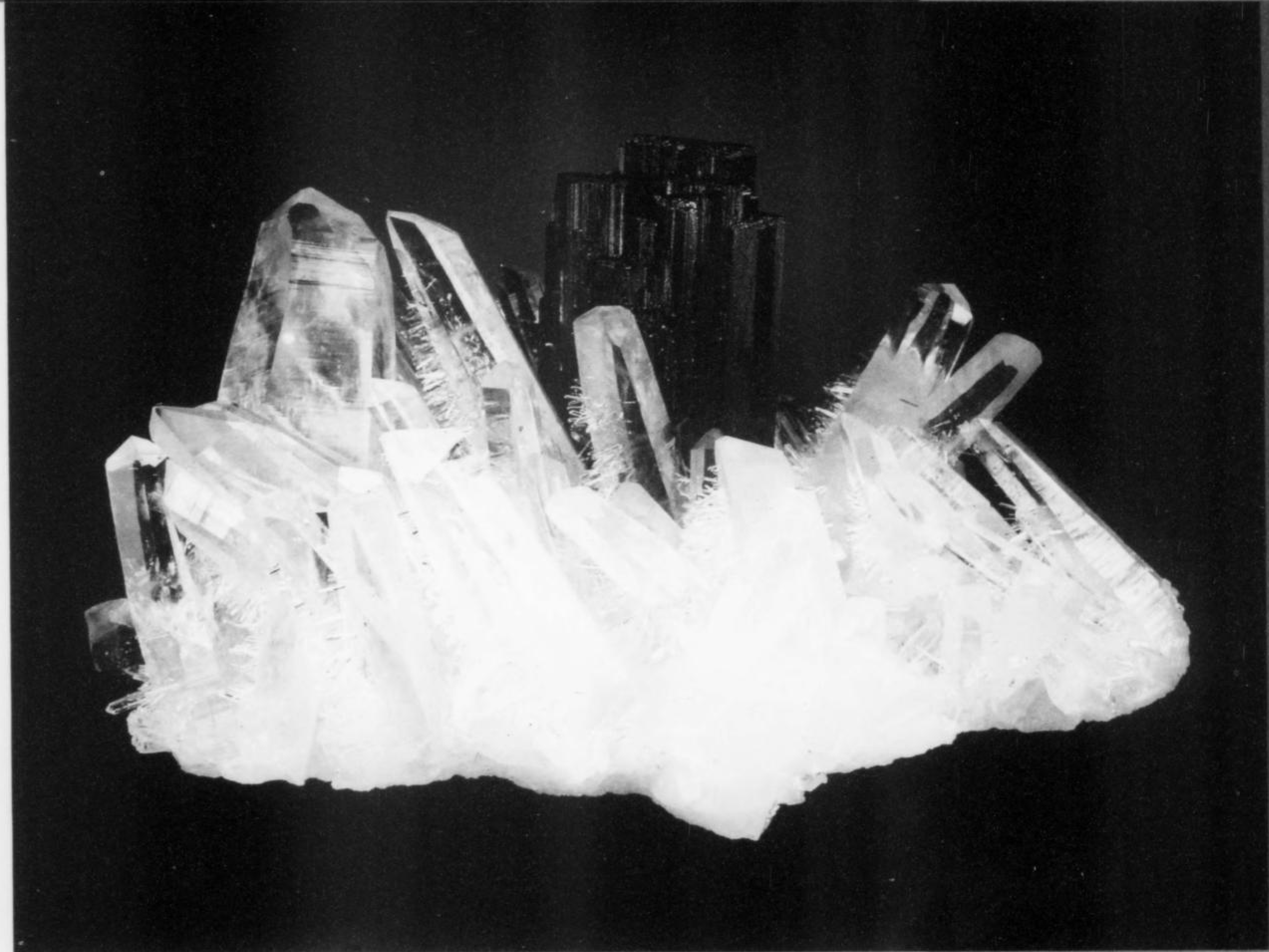
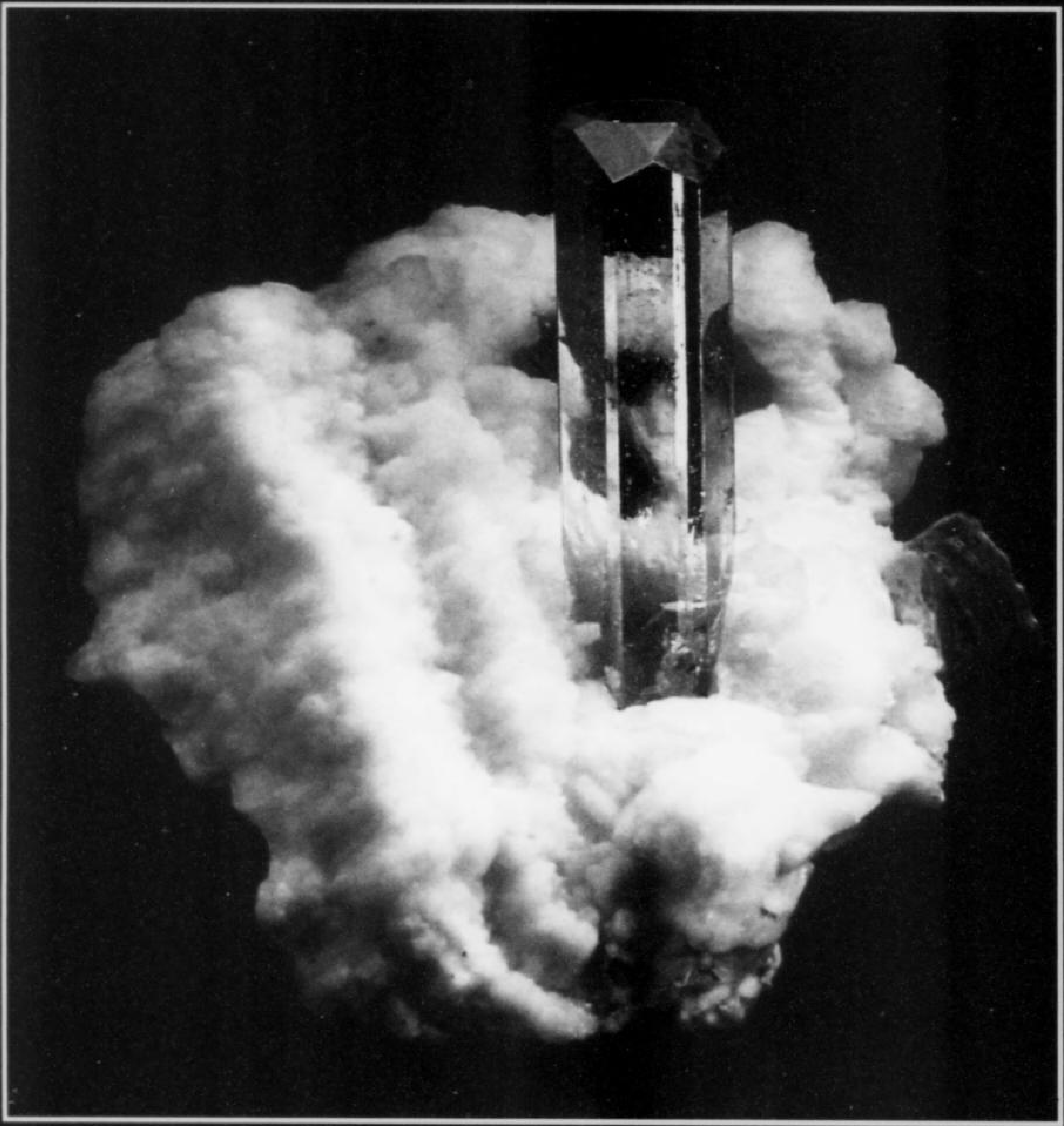
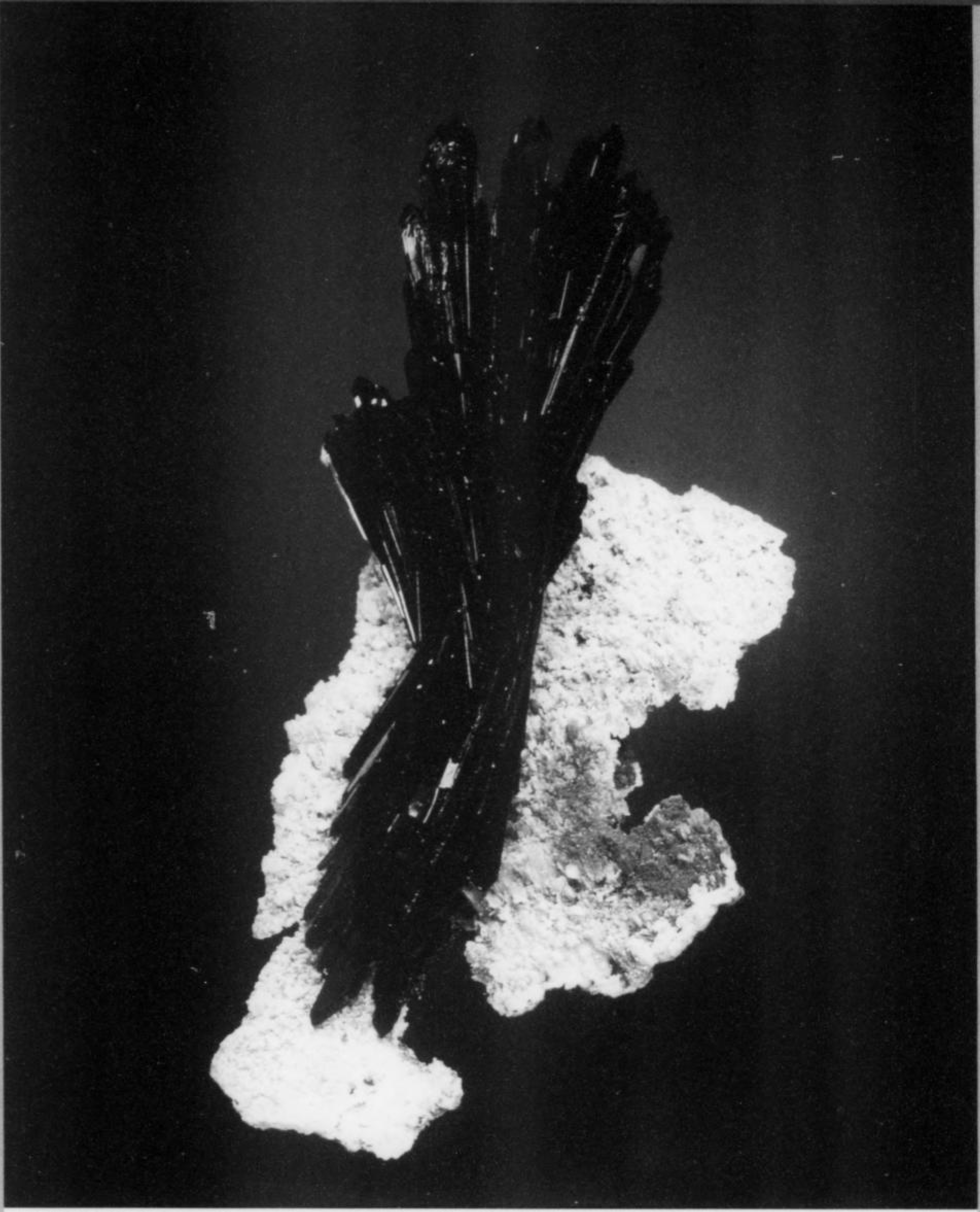






AZURITE, Tsumeb, 6.5 cm. Photo by Jeff Scovil.

Smoky Quartz on Amazonite, Teller County, CO

Frederick A. Wilda©2003

ZAGI MOUNTAIN

NORTHWEST FRONTIER PROVINCE PAKISTAN

Herbert Obodda
Box 51
Short Hills NJ 07078

Peter Leavens
Department of Geology
University of Delaware
Newark DE 19716

Zagi Mountain and related sites near Peshawar on the border between Pakistan and Afghanistan have recently begun to produce what are probably the finest specimens of bastnäsite, xenotime, and baotite known. The minerals occur in alpine-type veins in alkali granite gneiss of the Warsak igneous complex.

INTRODUCTION

New York had been having a typically hot and humid August day when I (HO) boarded the 747, but the fierce heat I found when I arrived in Peshawar, Pakistan was truly shocking. It had been only a month since my last trip, but I was eager to see my good friends and associates, some of whom I had known for over 30 years, or more than half my lifetime!

Peshawar, the provincial capital of the North West Frontier Province, was the first stop on what promised to be a most exciting adventure. For years, the city has been a center for trade in the minerals of northern Pakistan and Afghanistan, the latter country lying only 30 miles to the west, over the Khyber Pass. As early as February 1999, very fine crystals of bastnäsite and other unusual minerals had begun to appear on the market in Peshawar. They were reportedly found in Shinwaro, "high in the mountains" of Kunar in Afghanistan. I had been told not only that the crystals were difficult to find, but also that getting to this very dangerous area took many hours of arduous hiking. Various dealers, including myself, Dudley Blauwet of *Mountain Minerals International* (Moore, 2001a; Moore, 2001b), François Lietard, Andreas Weerth, and several Pakistani dealers (Moore, 2002; Polityka, 2002) had already brought out small lots of bastnäsite crystals. At the end of 2001 the true locality was at last revealed: Zagi Mountain, only about 30 km (20 miles) northwest of Peshawar, very easy to reach by car and foot. Instantly I decided to go there and assess the potential of the locality.

PESHAWAR

Peshawar, a bustling town of about 30 square miles and 750,000 people, lies on the west side of the Peshawar sedimentary basin in western Pakistan, at an altitude of about 300 m (1000 feet). The

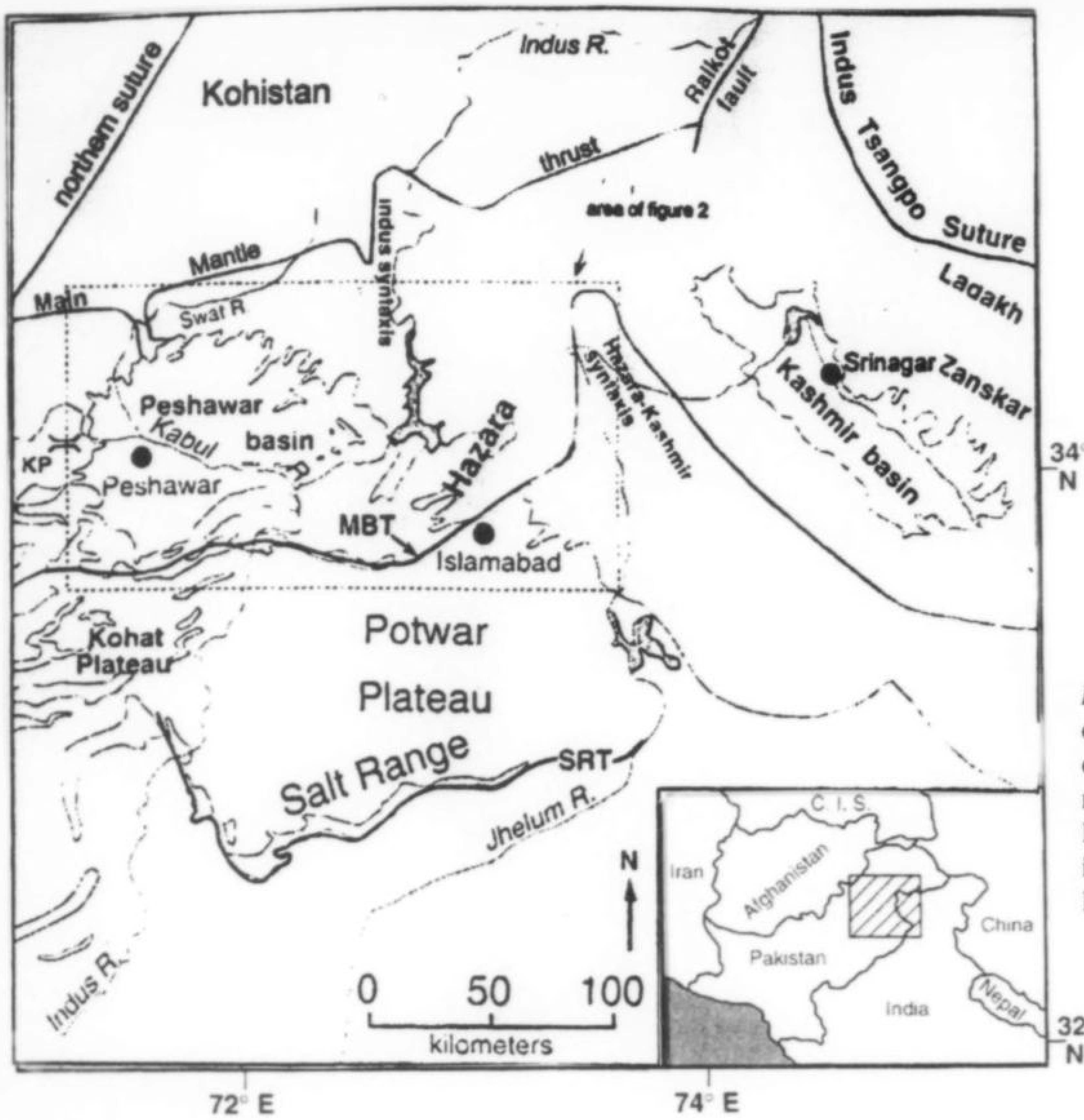


Figure 1. **Location map of the Himalaya of northern Pakistan and northwest India. KP is the Khyber Pass. Selected major faults are shown as dark lines. MBT is the Main Boundary Thrust; SRT is the Salt Range Thrust. Simplified from Pogue *et al.*, 1999.**

topography is nearly flat, and the region immediately around the city produces no mineral specimens. Because of the influx of a huge number of Afghan War refugees in the past 30 years, Peshawar has become very overcrowded, and it is certainly one of the world's most polluted cities. The dense, uniform blanket of photochemical smog lying over it is produced by unregulated cooking fires, by poorly tuned automobiles and trucks, and most of all by the most popular mode of transport, the "rickshaw." This vehicle is nothing more than a boxlike attachment to a Vespa-type motor scooter. The scooter is powered by a small two-cycle engine, usually fueled with low-grade petrol sometimes adulterated with kerosene and always mixed with large amounts of often reused motor oil. When started up or accelerated, the rickshaw's motor belches a huge cloud of blue smoke.

The preferred and traditional dress in the Peshawar area is the *shalwar kameez*: a pair of extremely baggy pants secured to the torso by a woven drawstring, and a shirt that ends somewhere below the knees. I started wearing the *shalwar kameez* after 9/11 to present a lower profile, but a much-appreciated side benefit is the comfort which the outfit provides on humid summer days when temperatures can exceed 120° F. Beards, along with turbans and other head coverings, are commonly but not universally worn.

In this area of Pakistan the *purdah* ("curtain") system is observed fairly strictly. A girl can walk around until about age 12, after which she retreats to the sanctity of her family's house. Women rarely venture into the city, and when they do they wear *burqas* or *chaddars* which envelop them completely, with a cloth mesh covering the face. In this male-centered society, almost all duties outside the home, including shopping for clothing and food, fall to the man.

Eating can be a perilous adventure. Food is available in the open-air markets and in the shops (many "shops" are just pieces of covered alleyways crammed between buildings), from street vendors, and in restaurants. Some food items are safe and some more-or-less safe, but some are "death sentences" for weak Westerners whose systems haven't built up the required immunities to the wide varieties of microbes present. Open sewers in gutters alongside the road add to the unhygienic conditions. The modern streets have grates over the sewers, but flies and foul odors pervade some areas nevertheless. I always marvel at the hydro-engineering that keeps the system flowing despite the flatness of the area.

Walking through the narrow markets, one can smell the rich aroma of freshly baked *naan*, or *roti*, the flat bread that is a staple of the Pakistani diet. The breads are baked in a large, wood-fired, urn-shaped clay oven sunk into the earth. When you order one of the breads, the baker moistens a flattened lump of sourdough and sticks it onto the inside wall of the oven above the fire. After a few minutes have passed and the baking is complete, the baker uses a long iron hook to extract the roti with an elegant motion. The mouth-watering aroma promises a most delicious and safe culinary delight.

One is offered a good variety of meat, except pork, the eating of which is forbidden by the Muslim religion. The most common and popular meat is mutton, taken from the fat-tailed sheep native to the area. When the tail is cooked, its store of fat is converted to flavorful cooking oil. A typical restaurant in the bazaar area has its own butcher and its own cook. The butcher cuts the meat and sells it at a price fixed by the government. Since this price is relatively inflexible, the haggling involved in purchasing the meat is for the quality (or cut) that you are offered—the butcher trying to put in extra bones and gristle and the consumer trying to get only the choicest loin chops. After the deal is made, the meat is given to the cook, either to be prepared in a wok-shaped pot (*karai*) or to be put on skewers and grilled over charcoal. Since it would be possible for the cook to substitute a piece of inferior meat for the choice cut already bargained for, he is watched by his customers until the meal is cooked and delivered to the table. The stoves over which the meat is prepared are fired by wood logs up to 6 feet long. As its end burns the log is simply pushed further into the fire, eliminating the need to chop the wood, thus saving labor and time.

It is advisable not to buy one of the numerous skinned chickens that hang in the dusty air for hours until cooked and consumed. The locals have no problem eating these, but I have become violently ill almost every time I have tried one. It is much better to purchase live poultry from a street vendor, have it slaughtered, and take it immediately to your favorite restaurant to have it cooked as you desire. Purveyors of dairy products (such as the custard seller, ice cream man, and yoghurt merchant) are prone to deliver a dose of gastroenteritis with their wares. It is much safer to buy fresh cheese, now usually sold wrapped in plastic foil instead of the newspaper used years ago (when one could "read" the cheese from the transferred newsprint).

The city is roughly divided into three sections; the one that most interests the mineral dealer is the Old Town, which includes the Namak Mandi (literally "salt market") and the Sarafa Bazaar or Gold Market. Here are the mineral stores and mineral dealers, with stacks of wooden flats reaching to the ceiling in the backs of the dusty shops. The occasional fine or rare specimen might be found in one of the crates or bags, so it is necessary to search through tons of inferior pieces and outright junk. Because the minerals arrive here after having passed through many hands, they are usually accompanied by only partial—or totally false—information regarding their origin. Sometimes accurate locality information can only be determined by persistent detective work, including questioning and re-questioning the dealers and analyzing their often ambiguous answers. For example, the world's best chloritoid was at first said by one dealer to have come from "the Northern Areas," and said by a few others to have come from "Nuristan, Afghanistan." The preponderance of "Nuristan" in the dealers' reports means that I must take it as correct until I meet someone who found the material himself and can testify otherwise.

Some of the dealers are very observant but not very knowledgeable mineralogically; thus, when they notice species or crystal habits they have not seen before, they assume them to be rare and valuable. One might find a $500 price on a fluorite that would cost $5 if it came from any non-Pakistani locality. The asking price depends on how much the dealer paid, how big his bills are, how rich you look, how interested you seem (don't look interested!), and any number of other factors, perhaps including the phase of the moon.

Most larger lots and finer specimens are purchased through a commission agent. I work with an agent who is able to make much better deals for me than I would be able to make on my own. The broker and buyer visit the seller's shop and, after a lengthy exchange of polite inquiries about health and family, and after the obligatory cup of *kava* (green tea), the sellers might start negotiating their bottom line among themselves, exchanging finger signals under a shawl or cloth to insure the secrecy of their price. Then, using the same method in order to keep their lowest price hidden from me, the buyer, they communicate the figure to my broker. If the asking and bid price are far apart, the broker must slowly and diplomatically nudge the asking price lower and the offer higher until he thinks an agreement can be made. When he feels that both parties are near agreement, he clasps the hands of seller and buyer, pats them three times, and announces the non-negotiable binding price.

ZAGI MOUNTAIN

There are several variants on the name of the locality, the main ones being Zagi, Zaga, Zagai, and Zaguh. Dudley Blauwet prefers the spelling "Zegi" because generally a long *a* or *ay* sound in Urdu is transliterated as an e, and long *e* sound is transliterated as *i*. The locality is pronounced "Zaygee" by some of the local people.

Zagi Mountain is located about 5.5 km southeast of Warsak Dam on the Kabul River, in the Peshawar District of the North West Frontier Province of Pakistan, just a few miles from the Afghan border. The Warsak Dam is a major producer of hydroelectric power in western Pakistan. The area is adjacent to the Khyber Agencies, a Federally Administered Tribal Agency (FATA). (In fact, some of the locals claim that Zagi is in the Khyber FATA, not in the North West Frontier Province—Dudley Blauwet, pers. comm. 2003.) Despite the phrase "federally administered," the central government has very little real power in the FATAs, which are ruled in effect by the local *jirgas*, or tribal councils. A number of small villages are within a few kilometers of Zagi; Mullagori village is sometimes mentioned on labels. There are several villages by that name in the area; the largest is about 7 km southeast of Zagi, on the main road to Peshawar.

Zagi Mountain is actually a low hill covering an area of about 3 x 5 kilometers and rising about 150 to 200 meters above the surrounding plain. It is one of the first foothills of the rugged mountain range separating Pakistan and Afghanistan. Although Zagi Mountain has produced most of the bastnäsite and other rare minerals, a number of matrix specimens have come recently from Tor Ghar or Torghur (Black Mountain), a ridge northwest of Zagi and south of the Kabul River in the Khyber FATA. At the time of this writing, this second locality has not been visited by any Westerner. Specimens from Tor Ghar are characterized by hard, undecomposed matrix of the same alkali granite that occurs at Zagi. The specimen on the cover of the *Mineralogical Record*, November-December 2002, is probably from Tor Ghar rather than Zagi. Spera Ghar, and Tora Mena, other mountains in the Khyber FATA, have begun producing specimens as well. Specimens of uncertain locality can be labeled "Warsak alkali granite, Warsak district, Pakistan."

COMMENTS BY HERBERT OBODDA

Because Zagi Mountain is located near (or possibly in) the FATA, and therefore lies outside the jurisdiction of the central Pakistan government, special precautions had to be observed for my visit. The first order of business was to contact the landowner of the site and surrounding area. By good fortune I found that my export agent lived in a neighboring village and knew the owner well. Connections mean everything in this part of the world, and the friendships I have nurtured during my 35 years of going to the area proved to be a great advantage.

In this part of the world, preparations—however simple—take days to complete, and this trip was no exception. We were to travel with an entourage which included armed bodyguards. Finally, on a bright and humid day, the hottest of my trip, our party of five departed from Peshawar on a road leading northwest and met a second party of four on the way. Arriving in Hammedabad, near the village of Kafur Dheri, we were warmly greeted by the landowner, Mr. Abdul Kaduss, and his son, Ali Khan. Abdul kindly offered us the use of his pickup trucks and several bodyguards. After what seemed an eternity of tea and chitchat the guards arrived, armed with AK-47's and M16's, and soon we were on our way!

After a twenty-minute ride in a caravan of pickup trucks we discovered that the easy road into the area was blocked by flooding, and we were forced to double back and find another

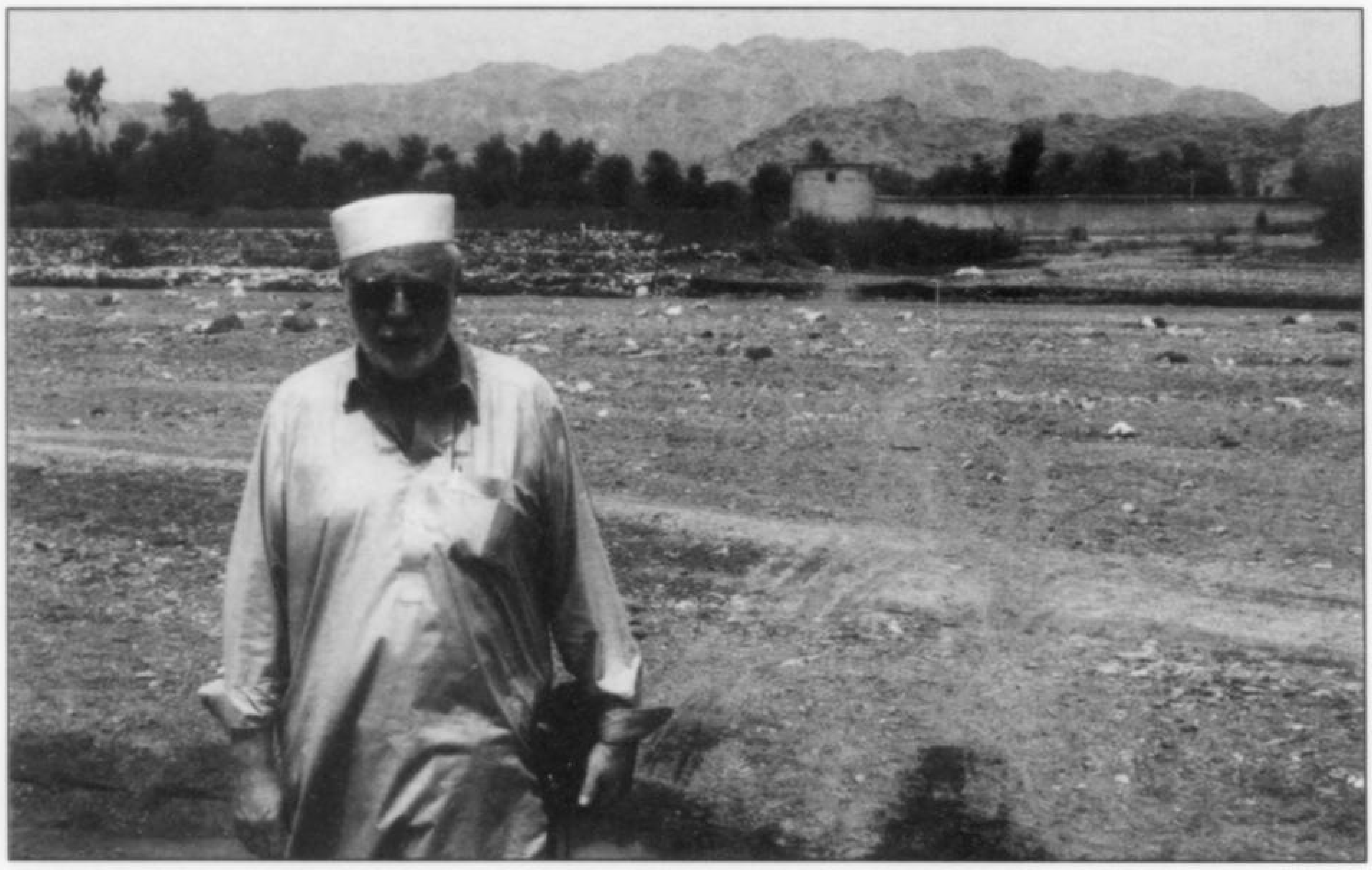


Figure 2. **Herb Obodda, Zagi Mountain in the background and Tor Ghar Mountain in the distance.**

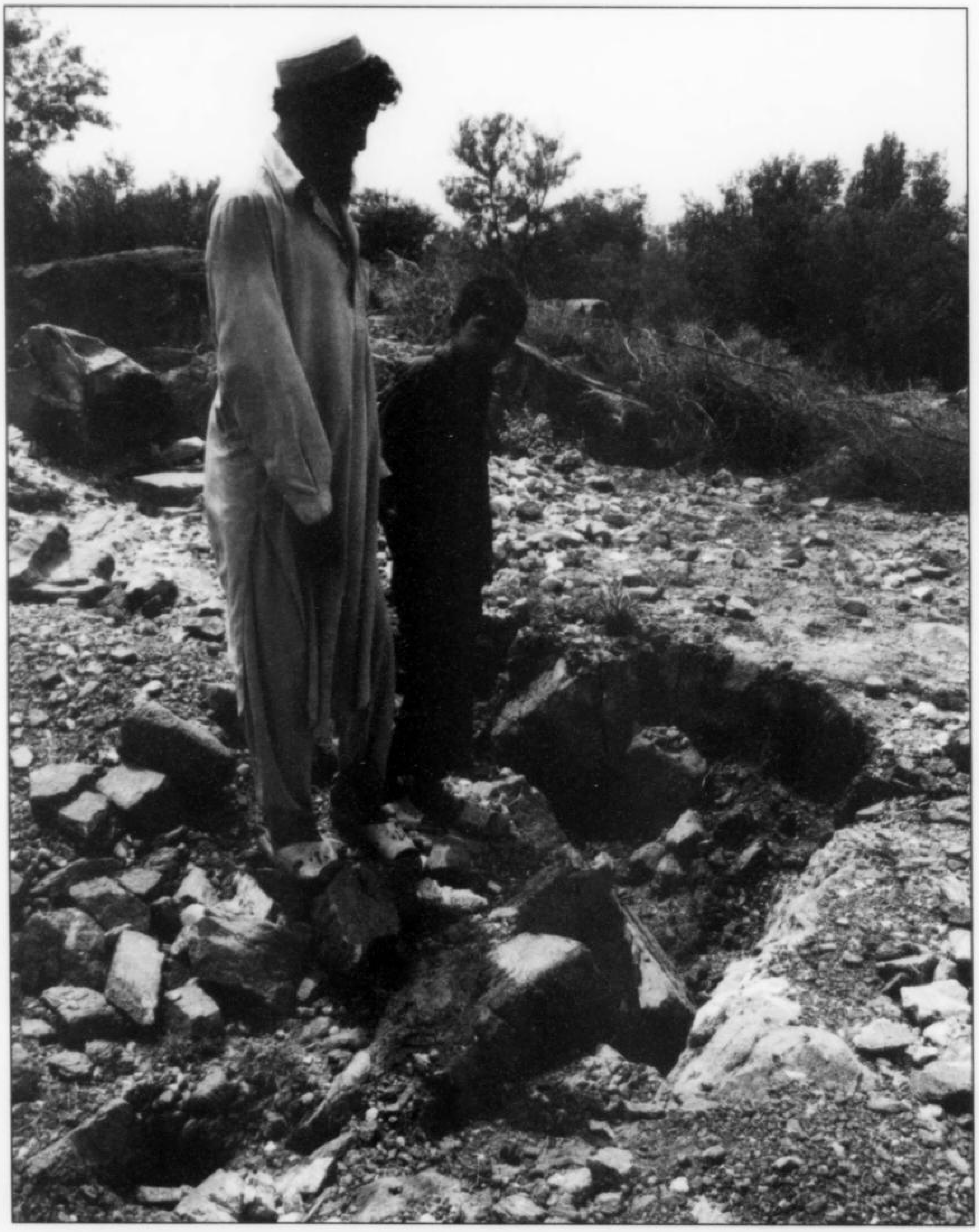


Figure 3. **The remains of a bastnäsite-(Ce) pocket on Zagi Mountain. Herb Obodda photo.**

***Figure 4.* Miners posing in front of the Zagi Mountain bastnäsite-(Ce) collecting site. Third from left (standing) is Hazrat Ali, said to have been the first person to have found a bastnäsite-(Ce) crystal at the locality. Herb Obodda photo.**

route. It quickly became clear that erosion on this alternate route would make it impossible to continue the journey by vehicle: we would have to proceed on foot in the 120° temperature. We crossed a boulder-strewn dry wash, climbed the opposite bank, and entered a village. I was advised to keep silent, since we were going through Abdul Rehman Qila (Fort), an Afghan refugee village established during the early days of the Soviet-Afghan war in the 1980's; for a while this had been the training camp of Gulbadin Hekmatyar, a powerful Afghan warlord. Heckmatyar is the leader of the anti-Soviet (and later anti-Taliban) mujahideen group Hizbi-Islami, which was heavily supported by the United States during that conflict. Now, however, Heckmatyar, an Islamic extremist opposed to the Karzai government and the American presence in Afghanistan, is being sought by American Special Forces in the area.

Just after leaving the village we sighted our goal—Zagi Mountain. After passing some sugar cane fields and fording a small stream we finally reached the diggings: the place was so hot that even the rocks seemed charred. The bastnäsite and accompanying minerals are found over a wide area in collapsed pockets in the heavily weathered rock and in the alluvium associated with it. Specimens have been found in alluvial gravel up to 1 km from the foot of the mountain.

Most of the people digging for minerals at Zagi Mountain are from Abdul Rehman camp. Many of them once worked in a nearby marble-processing facility which has recently been closed because of a dispute over charges for electric power between the Khyber Tribal Agency and the Pakistani Government. Digging for bastnäsite at Zagi Mountain began around late 2000 and increased tremendously in early 2002. The miners live in the camp and work the deposit during the cooler weather. Often, two or three generations of the same family work in groups of six to 15 people, digging with sticks, iron rods and shovels; the groups may include children as young as eight. The labor is intense and the conditions harsh; the returns are small, but usually are enough for the miners to survive on. My agent and I looked through the miners' treasures and were able to purchase a few specimens that will remain with me as souvenirs of my great adventure.

As of February 2004 there has been no appreciable collecting for six months at Zagi Mountain—a local chieftain with some measure of control over the digging site and/or over the diggers has forbidden it. The future of Zagi Mountain as a productive mineral locality seems at the moment quite uncertain.

COMMENTS BY DUDLEY BLAUWET

I traveled to Zegi Mountain in June, 2002, and along with bodyguards hiked to the top of the mountain, which is an area of interest to archaeologists as well as mineral collectors. There are many indications that the area was inhabited by the Ghandara civilization, a pre-Islamic Buddhist culture that flourished here ca. 500–200 BC. On strategic high points on the mountain are small fortifications, originally unearthed by antique collectors and still preserved, as well as a series of stone steps leading from the south

Figure 5. **Mr. Arifullah and Mr. Ali Khan examining a day's production of crystals at the bastnäsite-(Ce) locality. Herb Obodda photo.**

ridge past a dolphin-shaped outcrop called Rabab ("guitar") Ghunday to the summit, where there are the remnants of a Ghandarian fort called Naway Ghad. As this is the first mountain outcrop rising above the flat Kabul River plains below, it was obviously of strategic importance. Unsubstantiated reports suggest that some bastnäsite beads, attributed to the Ghandarian culture, were unearthed about six meters below the surface. In the last two years several heads of statues have been found around Zegi. Trained archaeologists have not worked the site, so collecting is not systematic or organized, and potentially useful archaeological information has probably been lost.

In May, 2003, while I was in Peshawar, I met a retired major of the Frontier Corp from the Tor Ghar area, who has prospected for minerals there for the previous seven years. He said the locals preferred the term *Tor Pattay* (literally "Black field mountain") and that the area had been a wheat field years earlier, but is not now being farmed. There is a drivable road that approaches to within a one-hour walk from the foot of the mountain. The final village on the road is called Paindi Lalma. As you start the walk you pass by a mountain called Tamber Ghar en route to the Rambat Nala (Nala is a narrow valley), a major drainage for Tor Pattay. A secondary route up the mountain is called the Loya Nala (Big Nala in Pushtu). There the Frontier Corp Scouts have set up a picket. The very top of Torr Pattay is called *Sher Sar* ("Lion's Head" in both Pushtu and Urdu). Years ago wild lions inhabited this area.

Very early in the mornings the local village women travel to the upper reaches to gather grass for animal fodder and wood for cooking, returning by about 10:00 or 11:00 am. By custom, even local men are not allowed to go up the mountain for mineral exploration until all of the women have returned.

GEOLOGIC SETTING

Much of northern Pakistan, including the Zagi Mountain region, lies in the foothills of the High Himalayan Crystalline Zone, between the Main Boundary Thrust and the Main Mantle Thrust (DiPietro *et al.*, 1999; Pogue *et al.*, 1999), a region characterized by multiple east to northeast-trending thrust faults formed during the collision of India with south Asia in the Cenozoic. The geology is extremely complex on both large and small scales, and much of the region has not been mapped in detail. The bedrock at Zagi Mountain is part of the Warsak igneous complex (Ahmand *et al.*, 1969; Kempe, 1973; Khan, 1990), which is itself part of the Peshawar plain alkaline igneous province, a group of alkaline granites, syenites and nepheline syenites which crop out around the margins of the Peshawar basin. Prior to about 350 Ma (million years ago), what is now south Asia was part of the supercontinent of Gondwana and was connected to southern Africa. Roughly 300-350 Ma, "Cimmeria" (now Iran, Afghanistan, and Tibet) split away from Gondwana and drifted north to collide with Asia. During this interval of rifting, the rocks of the alkaline igneous province were intruded (Pogue *et al.*, 1992). Much later, in the Cenozoic, the Indian plate, including what are now India and Pakistan, started to drift northward, eventually to collide with Asia and form the Himalayas. During the collision, about 40–45 Ma by K/Ar dating, the earlier intruded igneous rocks were heated and metamorphosed to greenschist or lower amphibolite facies. The formation of the mineral-bearing veins probably postdated the peak of metamorphism; K/Ar dating of the pocket feldspars would be necessary to establish the time of the first stage of pocket development.

The principal rock of the Warsak igneous complex is a medium-grained, gneissic alkaline granite (Kempe, 1973) composed of microcline with minor albite, quartz, aegirine, riebeckite and astrophyllite. The gneissic lineation is imparted by the alignment of riebeckite and aegirine needles and is considered by Ahmad *et al.* (1969) to be flow alignment formed during intrusion rather than a metamorphic texture. The most common accessory minerals are ilmenite, zircon and fluorite. The bastnaesite-bearing veins are in the alkaline granite.

Zagi Mountain is situated in an outlier of the main exposure of the alkali granite. Understandably, mineral dealers are reluctant to bring geological samples instead of salable mineral specimens back by air and through customs, so the matrix of only a few specimens could be examined for this report; this matrix is gneissic riebeckite granite. Matrix specimens of any of the crystallized minerals are rare; the majority of specimens are single crystals found loose in the decomposed rock or in the alluvium of stream beds. The relative abundances of the minerals of the locality are almost impossible to judge, as there is a high degree of selectivity on the part of both the miners and the buyers of specimens in favor of unusual minerals, and some minerals are found only in restricted areas.

Although some dealers have said that the crystals occur in pockets in alkaline pegmatites, the pockets more nearly resemble

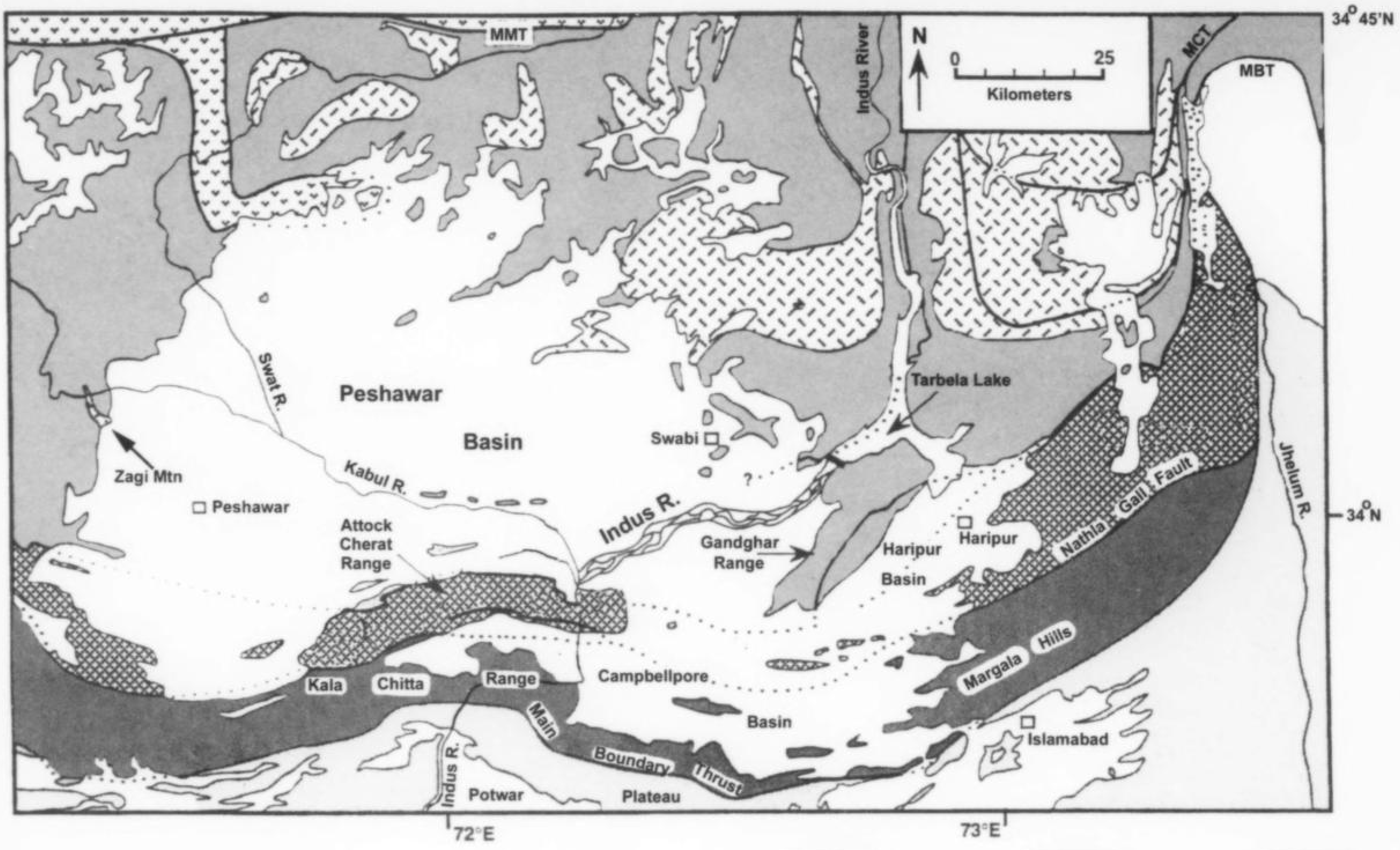


Figure 6. **Tectonic map of the Himalayan foothills of Northern Pakistan, showing the locations of Peshawar and Zagi Mountain. MCT is the Main Central Thrust; MMT is the Main Mantle Thrust; MBT is the Main Boundary Thrust. Simplified from Pogue *et al.*, 1999.**

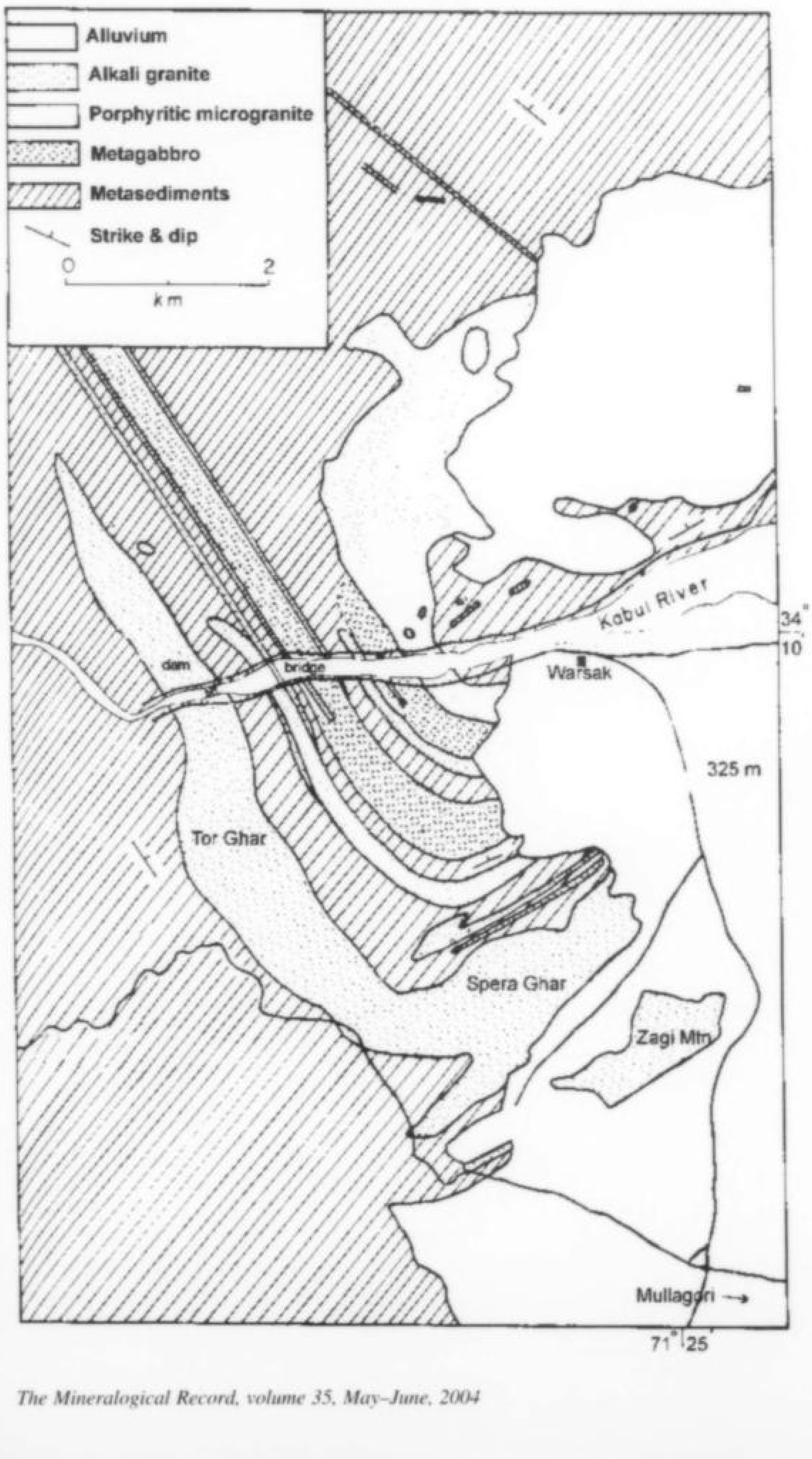


Figure 7. **The geology of the Warsak area. Heavy lines indicate roads. The location of Zagi Mountain was determined from unpublished maps by S. Murad Ali Shah and S. Wahab-u-Din at the University of Peshawar. The position of Tor Ghar is approximate. Simplified after Ahmand *et al.*, 1969.**

alpine veins in a number of ways: alpine veins typically occur in gneissic rocks like the rocks at Zagi, but pocket pegmatites are more typical of coarse-grained, massive intrusive rocks; there is no development of pegmatitic textures such as graphic intergrowths or sudden coarsening of grains in the rock on the walls of the pockets; the common feldspar is translucent adularia, characteristic of alpine veins, rather than the more opaque perthitic microcline found in pegmatite pockets; and finally, the rare minerals are more typical of alpine veins than of pegmatites.

Table 1. **Minerals from Zagi Mountain.**

Halide	
Fluorite	CaF_2
Oxides	
Hollandite	$Ba(Mn,Fe)_8O_{16}$
Ilmenite	$Fe^{2+}TiO_3$
"Limonite"	$Fe(OH)_3$
Rutile	TiO_2
Carbonates	
Bastnäsite-(Ce)	$(Ce,La)CO_3F$
Parisite-(Ce)	$Ca(Ce,La)_2(CO_3)_3F_2$
Phosphates	
Rhabdophane-(Ce)	$(Ca,La)PO_4 \cdot H_2O$
Xenotime-(Y)	YPO_4
Silicates	
Aegirine	$NaFeSi_2O_6$
Albite	$NaAlSi_3O_8$
Astrophyllite	$(K,Na)_3(Fe,Mn)_7Ti_2Si_8O_{24}(O,OH)_7$
Baotite	$Ba_4Ti_4(Ti,Nb,Fe)_4(Si_4O_{12})O_{16}Cl$
Eudidymite (?)	$Na_2Be_2Si_6O_{15} \cdot H_2O$
Genthelvite	$(Zn,Fe,Mn)_4Be_3(SiO_4)_3S$
Microcline	$KalSi_3O_8$
Quartz	SiO_2
Riebeckite	$Na_2(Fe^{2+},Mg)_3Fe^{3+}_2Si_8O_{22}(OH)_2$
Thorite	$ThSiO_4$
Titanite	$CaTiSiO_5$
Zircon (?)	$ZrSiO_4$

MINERALS

All the minerals listed in this report were confirmed by X-ray powder diffraction analysis (XRD), using a computer-controlled diffractometer operating in step-scan mode. Identifications were made using search-match software and the 1990 ICDD (International Centre for Diffraction Data) powder diffraction data set on CD. Some identifications, particularly of the feldspars, were supported by optical examination using polarized-light microscopy (PLM). Selected samples were mounted on glass discs, polished, carbon-coated, and analyzed chemically by energy-dispersive spectroscopy (EDS), using a JOEL JSM6335F field-emission, cold cathode SEM, operated at 15Kv and 12.5μ with a 12.5-mm working distance. Spectra were gathered with a PGT light-element-capable analyzer and refined with the IXRF program EDS 2000, which uses a standardless ZAF analysis routine. The instrument is housed in the Department of Physics, University of Delaware, and operated by Gerald Poirier.

The lack of appropriate standards renders the analyses only semi-quantitative; however, experience shows that the ratios of heavier elements derived by the data-reduction program are quite accurate, but that the proportions of light elements (S and below) are less reliable. Fortunately, most of the minerals of interest at Zagi can be characterized by the presence and proportions of heavy elements such as Ce and La, or by the presence or absence of lighter elements such as P.

Aegirine $NaFeSi_2O_6$

Although common in the alkali granite, aegirine appears to be rare in the alpine veins. Small green blades that occur sparsely in quartz crystals are aegirine, and recently a few dark green, short prismatic, single crystals and 4 to 5-cm crystal groups have turned up. The individual crystals measure 1 to 2 cm. They do not have attached granite matrix.

Albite $NaAlSi_3O_8$

Albite is less abundant than the potassium feldspar microcline; it occurs as tabular, twinned crystals up to 1 cm, associated with microcline and quartz. In specimens studied, it is white and less translucent than microcline. It does not fluoresce. In PLM it can be distinguished from microcline by its higher indices of refraction and sharper twin lamellae. Like the microcline, the albite has almost pure end-member composition, with very little K or Ca.

Astrophyllite $(K, Na)_3(Fe, Mn)_7Ti_2Si_8O_{24}(O,OH)_7$

Straw-yellow to pale reddish brown blades of astrophyllite are abundant as inclusions in quartz crystals. The fibrous, golden-yellow needles and fur-like swarms that are observed as inclusions in microcline, xenotime, bastnäsite and other minerals are also astrophyllite rather than rutile. Free-standing astrophyllite crystals have not been observed. A pale reddish brown blade contains K about five times Na, with major Fe, minor Mn, Nb and Ta, and trace Zn.

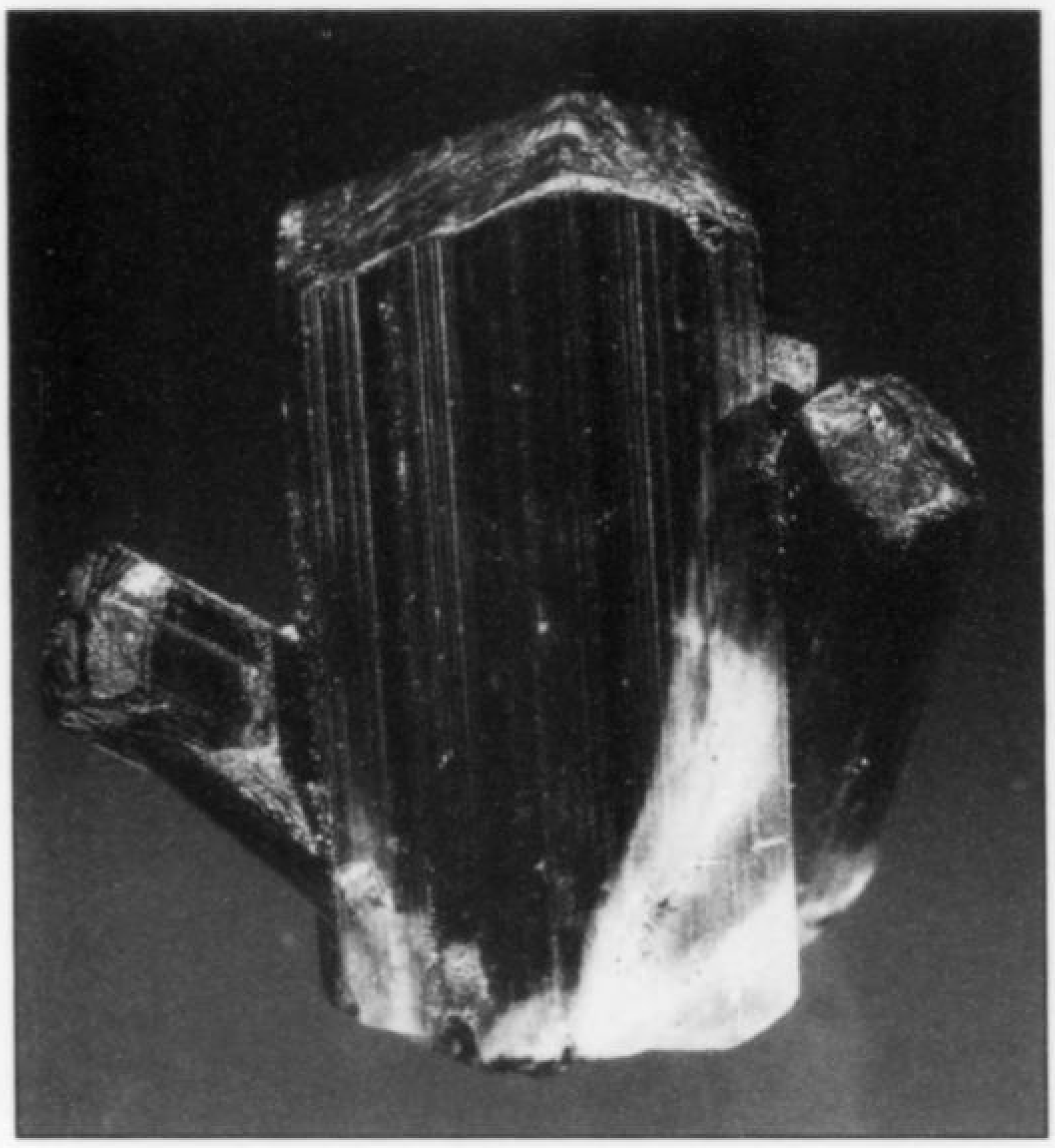
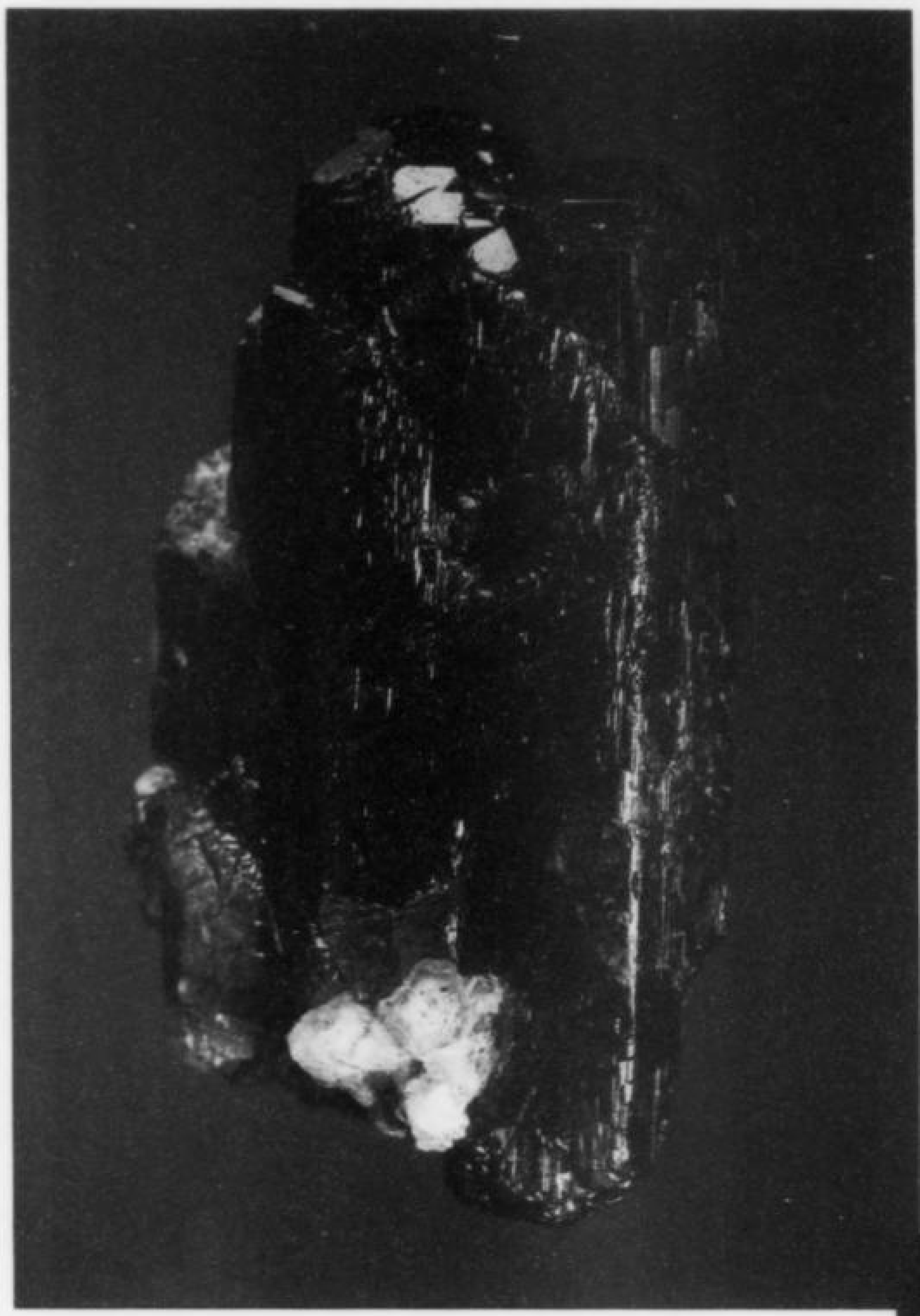


Figure 8. **Baotite crystal cluster, 1.6 cm, from Zagi Mountain. Herb Obodda specimen; Jeff Scovil photo.**

Baotite $Ba_4Ti_4(Ti,Nb,Fe)_4(Si_4O_{12})O_{16}Cl$

One of the recent surprises at Zagi has been the discovery of the extremely rare silicate baotite, as black to greenish yellow crystals to 4 cm, with adamantine to resinous luster. These are among the best crystals of baotite known—specimens from the type locality at Baotou, China are reportedly up to 10 cm (Peng, 1960) but have not been seen in the West. The Zagi crystals are short to long-prismatic and striated parallel to the c-axis, with simple low-angle pyramid terminations. Baotite is tetragonal, but the crystals are commonly so deformed as to appear monoclinic, very different in appearance from the beautifully formed crystals of xenotime, which is also tetragonal. Prismatic crystals of rutile are rarely associated with baotite. No matrix specimens are yet known. Baotite is another mineral of restricted occurrence, and as of this writing (June 2003) no specimens have been found for almost a year.



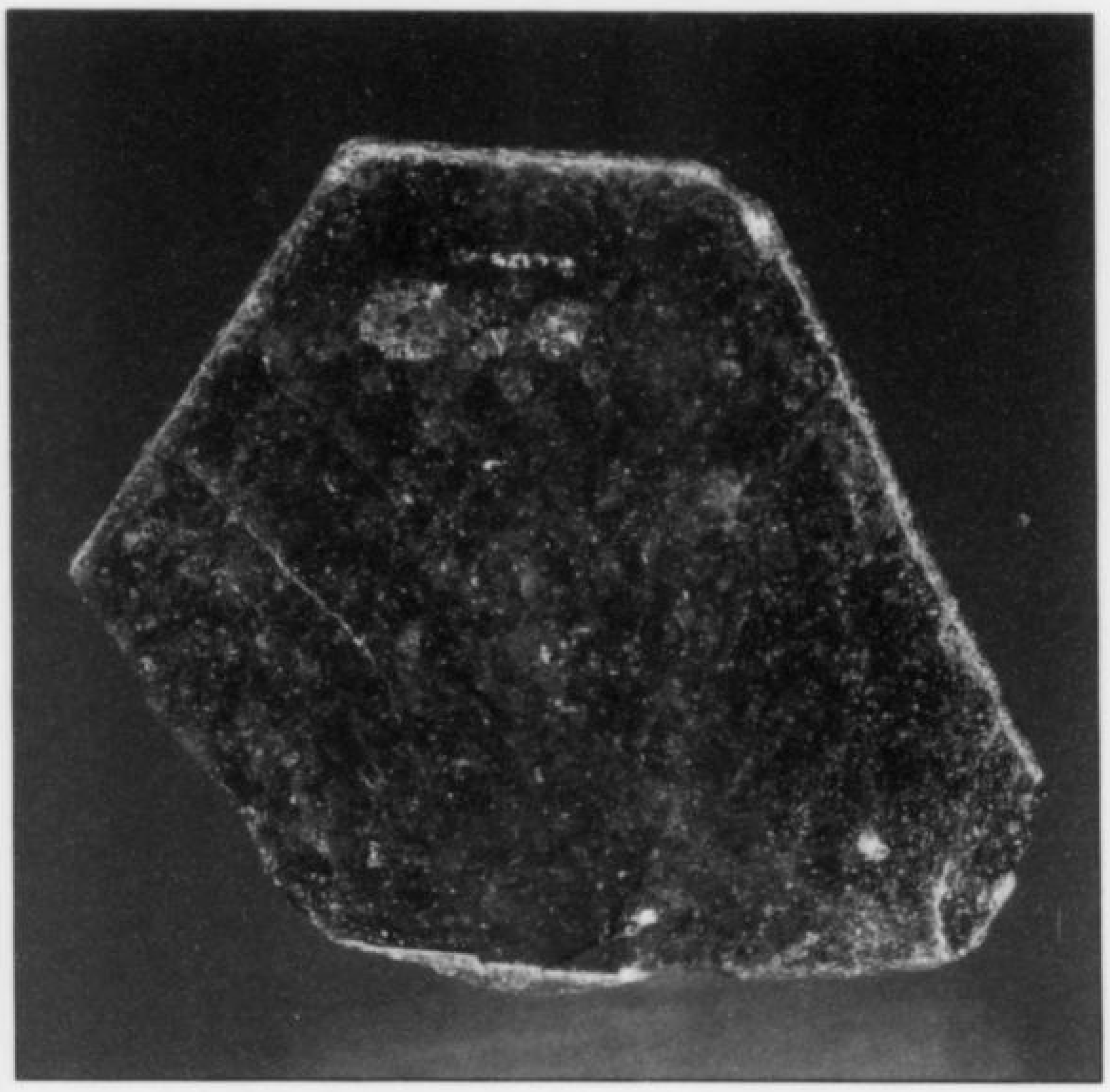


Figure 10. **Bastnäsite-(Ce) crystal, 4.5 cm, from Zagi Mountain. Andreas Weerth specimen, now in the William Pinch collection; Jeff Scovil photo.**

Figure 9. **Bastnäsite-(Ce) crystal, 3.6 cm, from Zagi Mountain. Andreas Weerth specimen, now in the William Pinch collection; Jeff Scovil photo.**

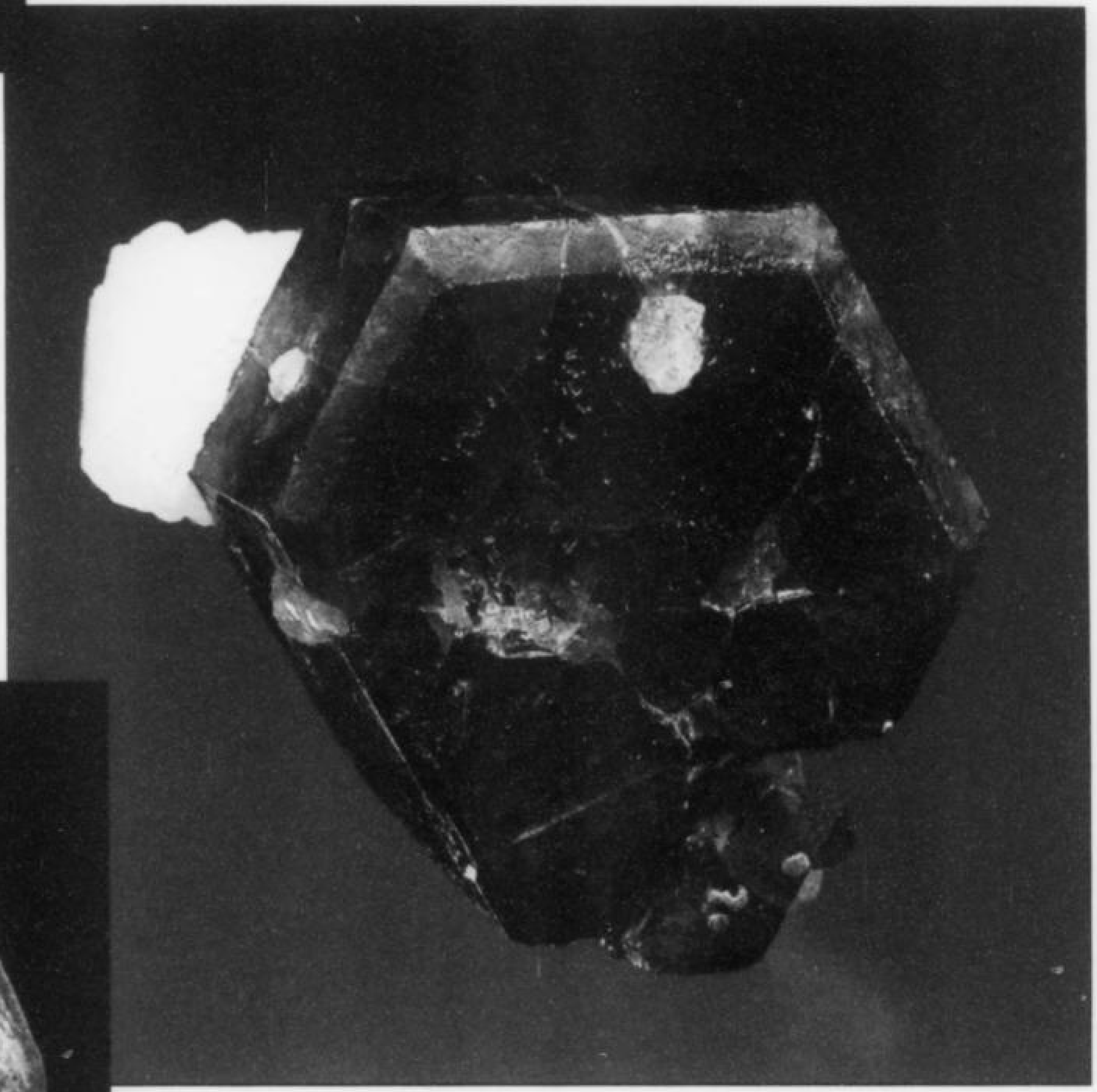
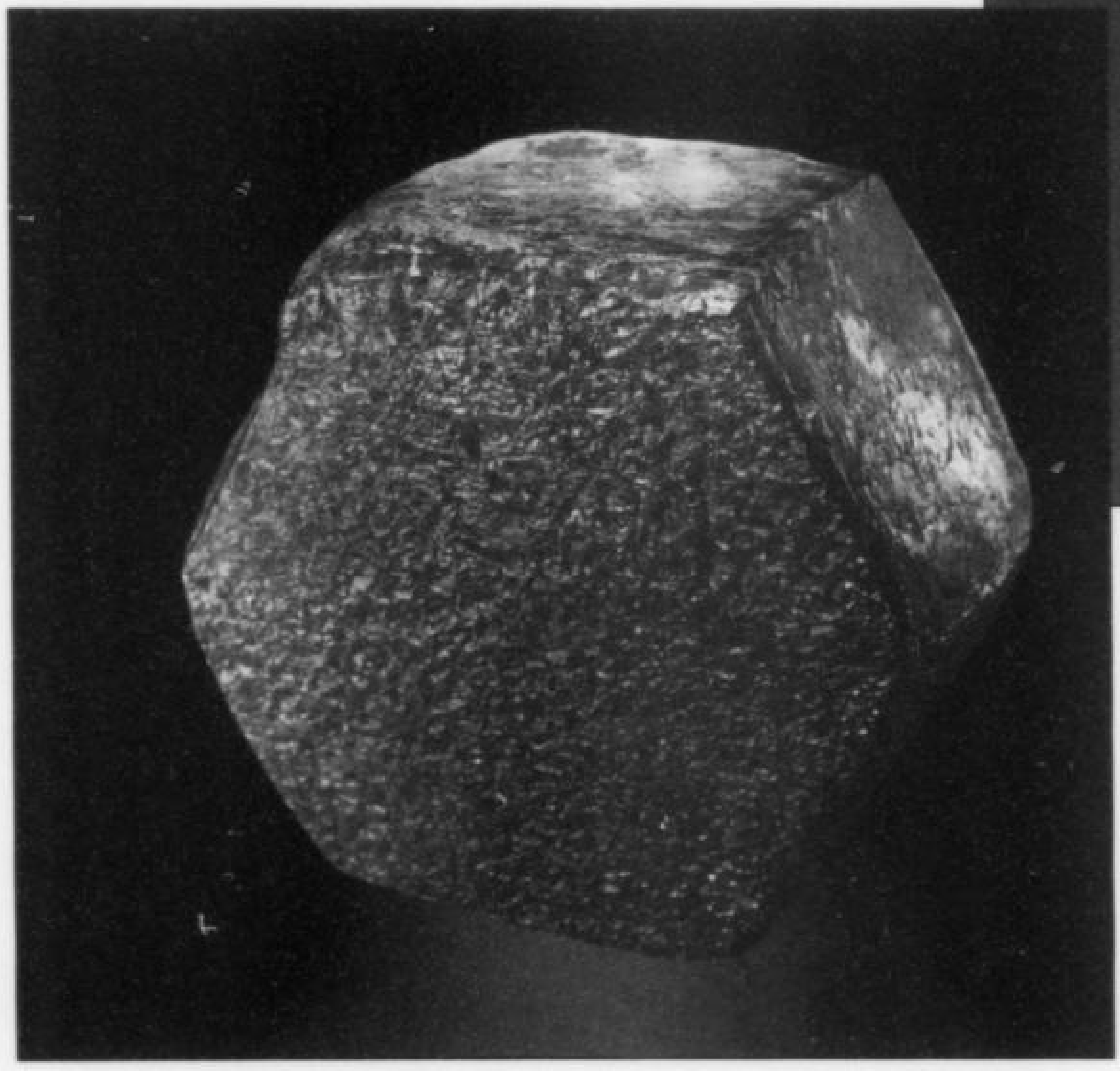


Figure 11. **Bastnäsite-(Ce) crystal, 2.2 cm, from Zagi Mountain. Herb Obodda specimen; Jeff Scovil photo.**

Figure 12. **Bastnäsite-(Ce) crystal, 2.6 cm, from Zagi Mountain. Dave Bunk specimen; Jeff Scovil photo.**



Bastnäsite-(Ce) (Ce,La)CO_3F

Bastnäsite crystals from Zagi are undoubtedly the largest and finest ever found. They are blocky to tabular hexagonal prisms and plates of a medium-brown to rich orange-brown color, and with dull to vibrantly glassy luster. The crystals are generally sharp and crisp, though some are rounded slightly along the edges. Crystal size ranges from 1 to 2 cm, but some of the finest crystals are up to 6 cm. The prism and pinacoid forms are dominant, but many crystals are also modified to some extent by low-angle pyramidal

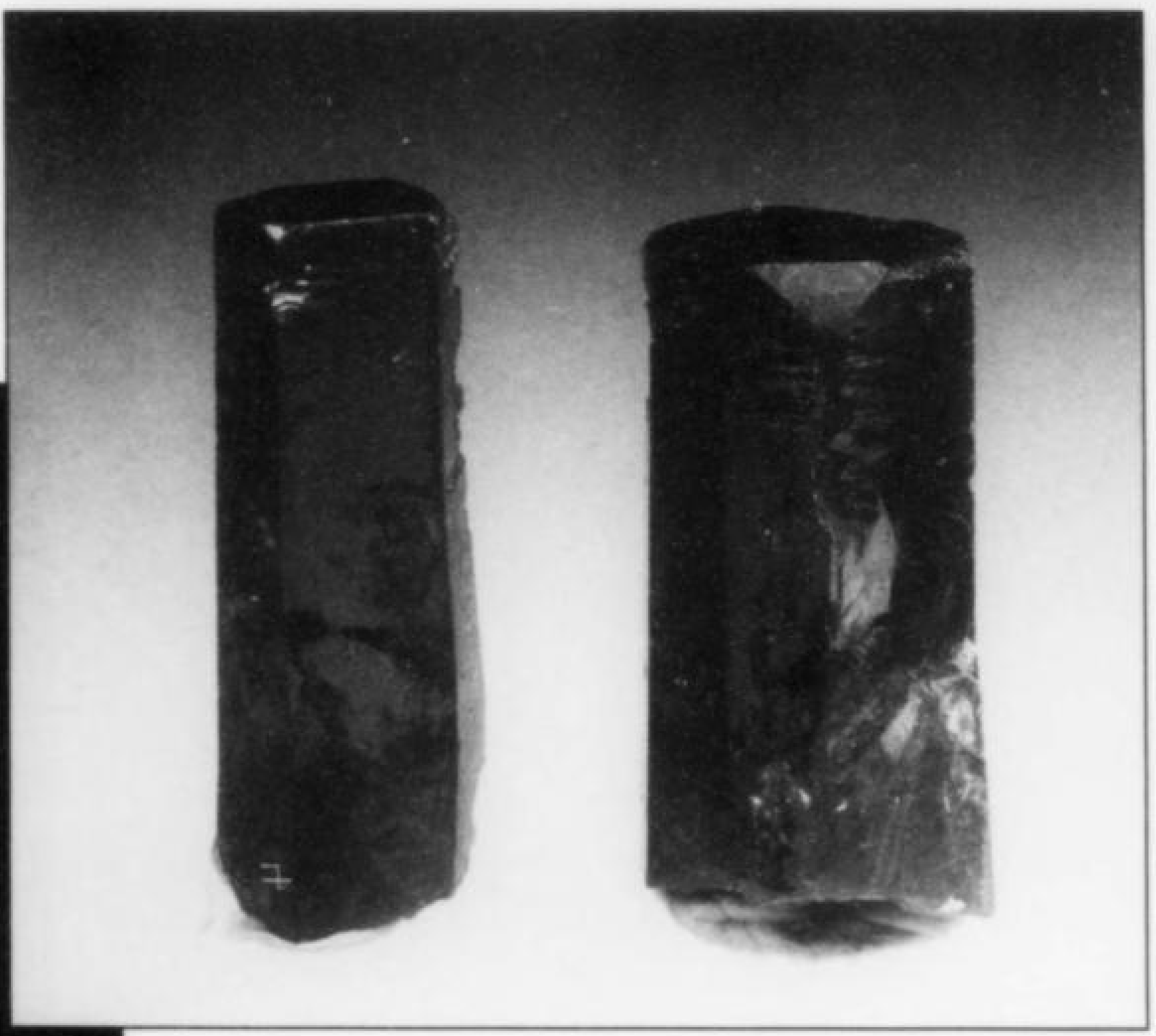


Figure 13. **Bastnäsite-(Ce) crystals, 2 cm each, from Tor Ghar. Mountain Minerals International specimen, now in the Wendell Wilson (left) and Ralph Clark (right) collections; Wendell Wilson photo.**

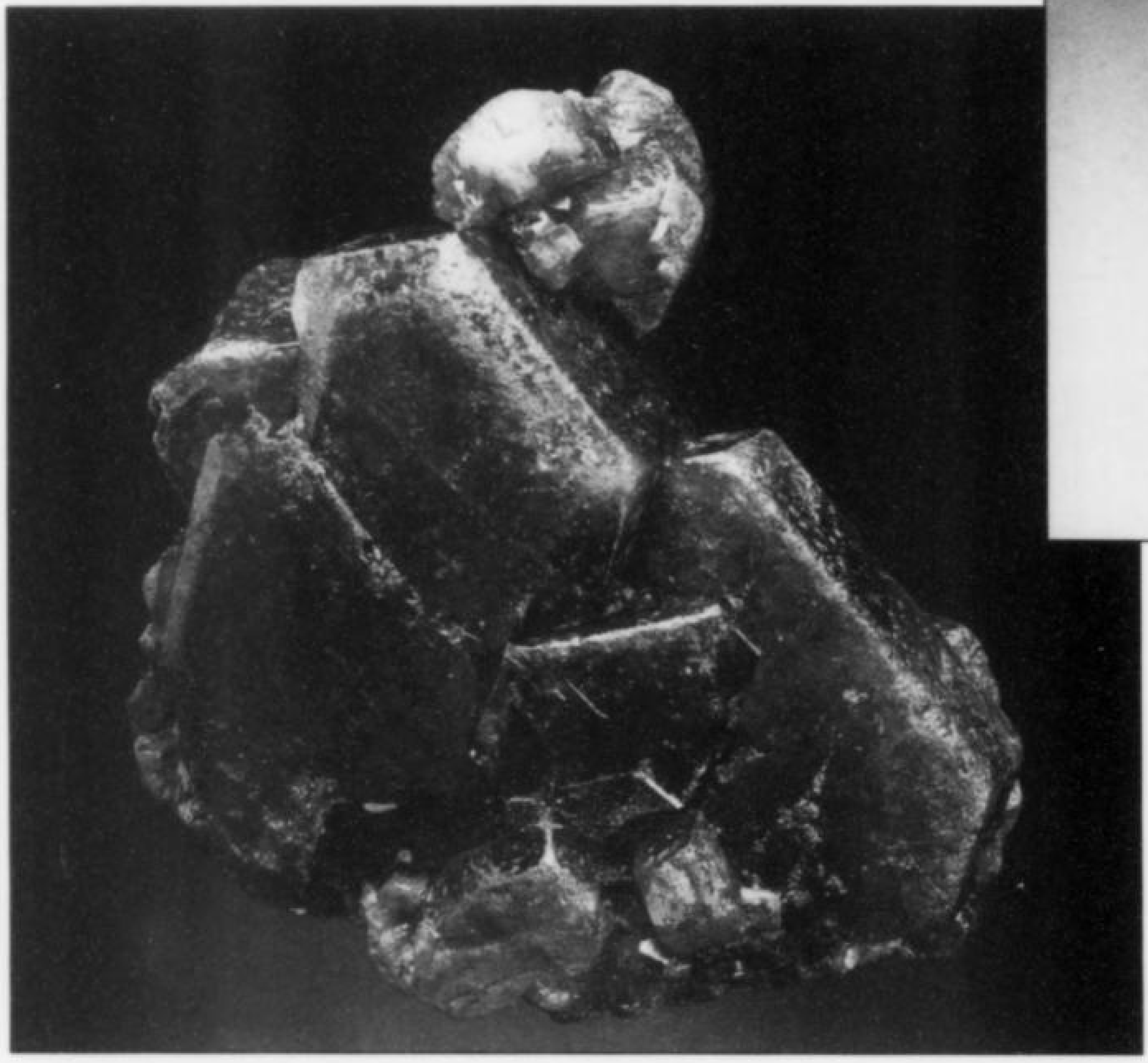


Figure 14. **Bastnäsite-(Ce) crystal cluster, 6.6 cm, from Zagi Mountain. Mountain Minerals International specimen; Jeff Scovil photo.**

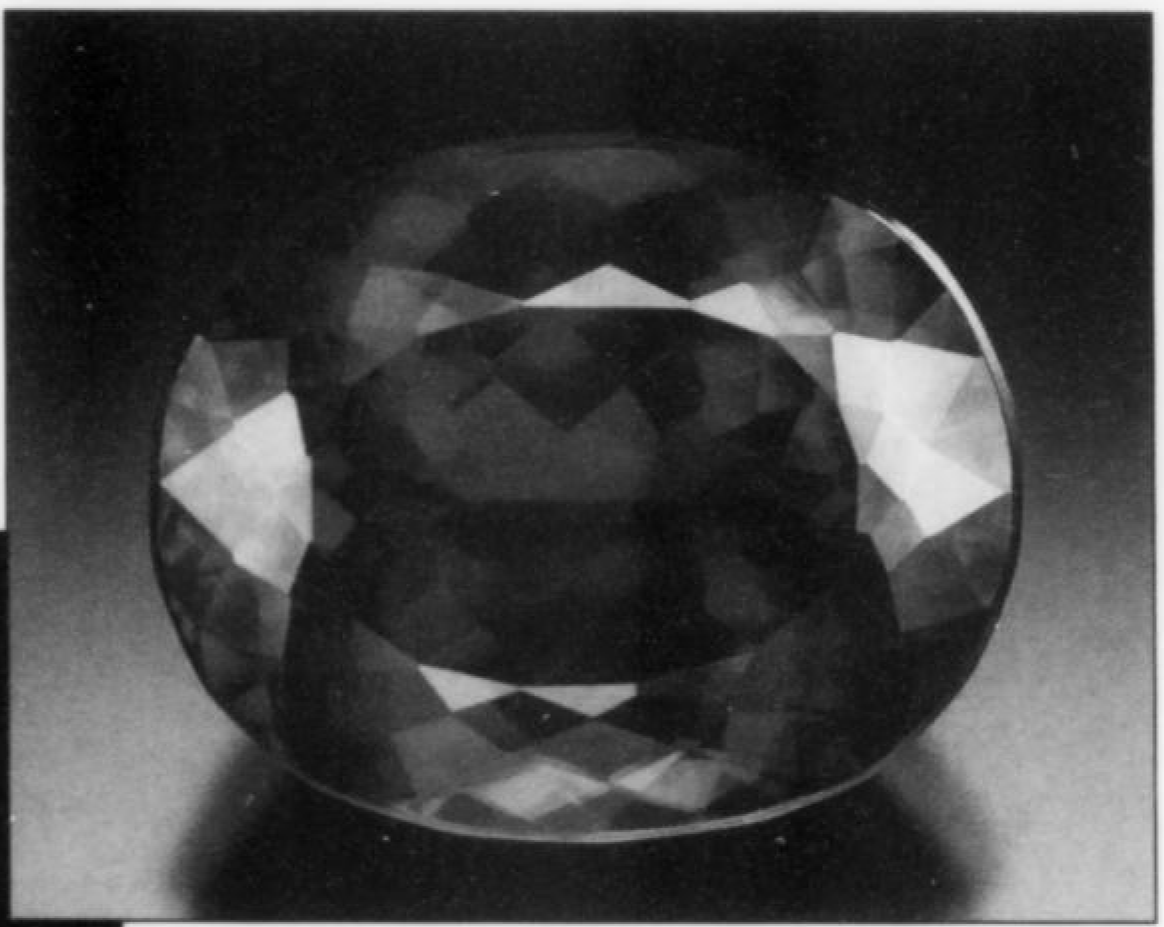


Figure 16. **Faceted bastnäsite-(Ce), 18.61 carats, from Zagi Mountain. Herb Obodda collection; Jeff Scovil photo.**

Figure 15. **Bastnäsite-(Ce) crystal, 4.2 cm, from Zagi Mountain. Herb Obodda specimen; Jeff Scovil photo.**

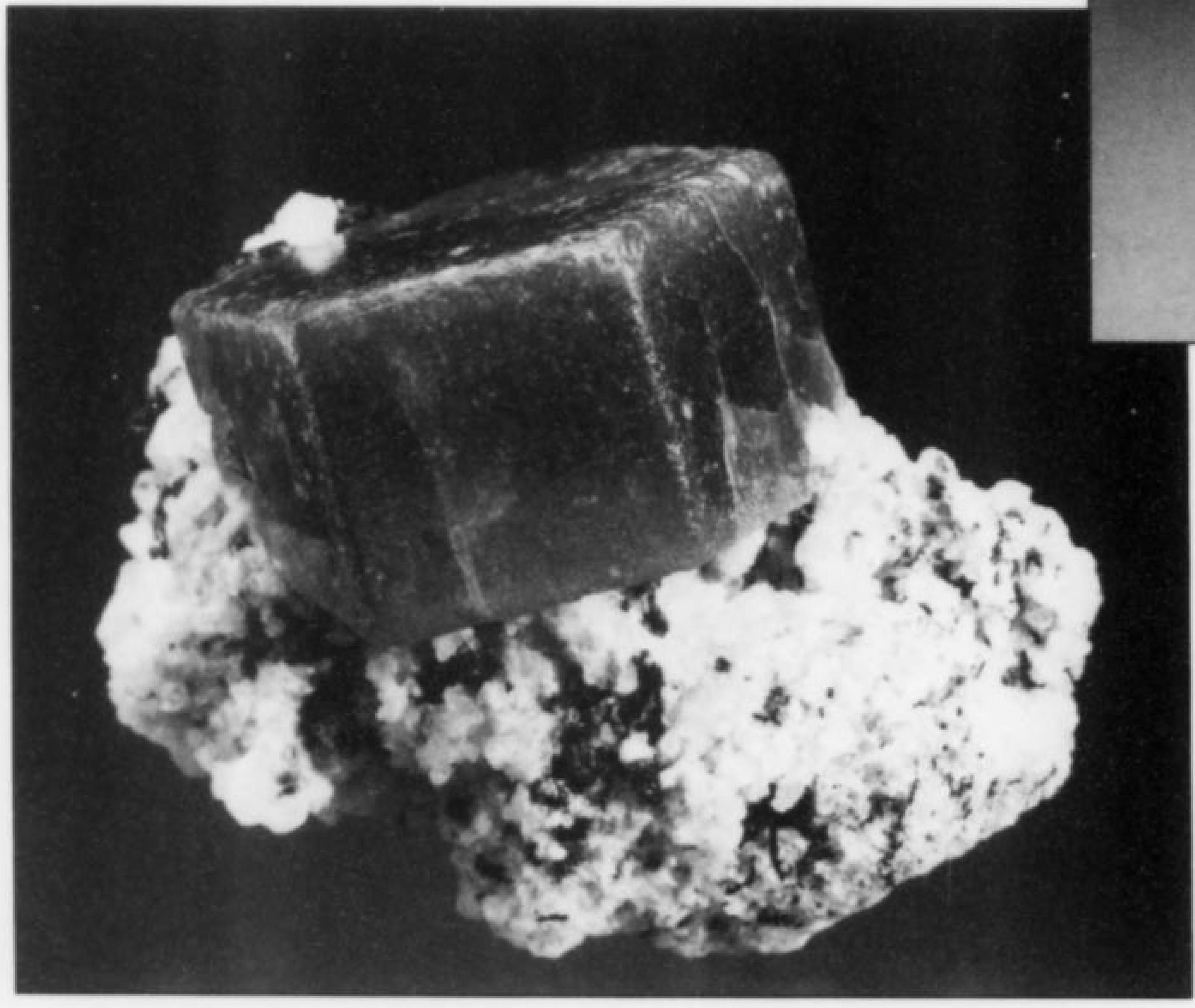


Figure 17. **Bastnäsite-(Ce) crystal, 1.5 cm, from Tor Ghar Mountain. Martin Zinn collection; Jeff Scovil photo.**

Figure 18. **Bastnäsite-(Ce) crystal, 1.4 cm, from Tor Ghar Mountain. Herb Obodda collection; Jeff Scovil photo.**

faces. These crystals range from opaque to translucent to beautifully transparent; in fact, some gemmy fragments have been faceted into attractive gemstones. A recent (May 2003) find of bastnäsite yielded exceptionally lustrous, complex crystals, some on friable matrix, with associated fluorite. The area on the north side of Zagi Mountain where these crystals have been found is referred to by the collectors as *Berrudge Ghundai* (or *Bheruj Gunday*), or "Tourmaline Hill," tourmaline being the term used for any dark, non-quartz mineral. As noted above, crystals on fresh matrix, including the one on the cover of the November-December 2002 *Mineralogical Record*, are more likely to be from the Tor Ghar area than from Zagi Mountain.

Chemically, the bastnäsite contains both Ce and La, with Ce roughly 2.5 to 3 times as abundant as La in samples examined. Other rare earths were not noted. The bastnäsite and other REE minerals are slightly radioactive, indicating the presence of trace U or Th.

Eudidymite $(Na_2Be_2Si_6O_{15}\cdot H_2O)$

At the 2003 Tucson show (Moore, 2003), Andreas Weerth had a few loose samples identified as eudidymite, in thin, transparent, platy crystals and cleavage fragments, colorless to brownish white, to 5 cm. He cited them as being from near Mullagori village at the foot of Zagi Mountain, near the Warsak Dam in the Tribal Areas of Pakistan. The lot included many of the confirmed Zagi species. No sample from Herr Weerth could be examined for this report. Other purported eudidymite specimens turned out to be albite.

Fluorite (CaF_2)

Fluorite occurs in green cuboctahedral crystals to 4 cm. They fluoresce bright blue under longwave ultraviolet light, and bright blue with persistent green phosphorescence under shortwave ultraviolet light.

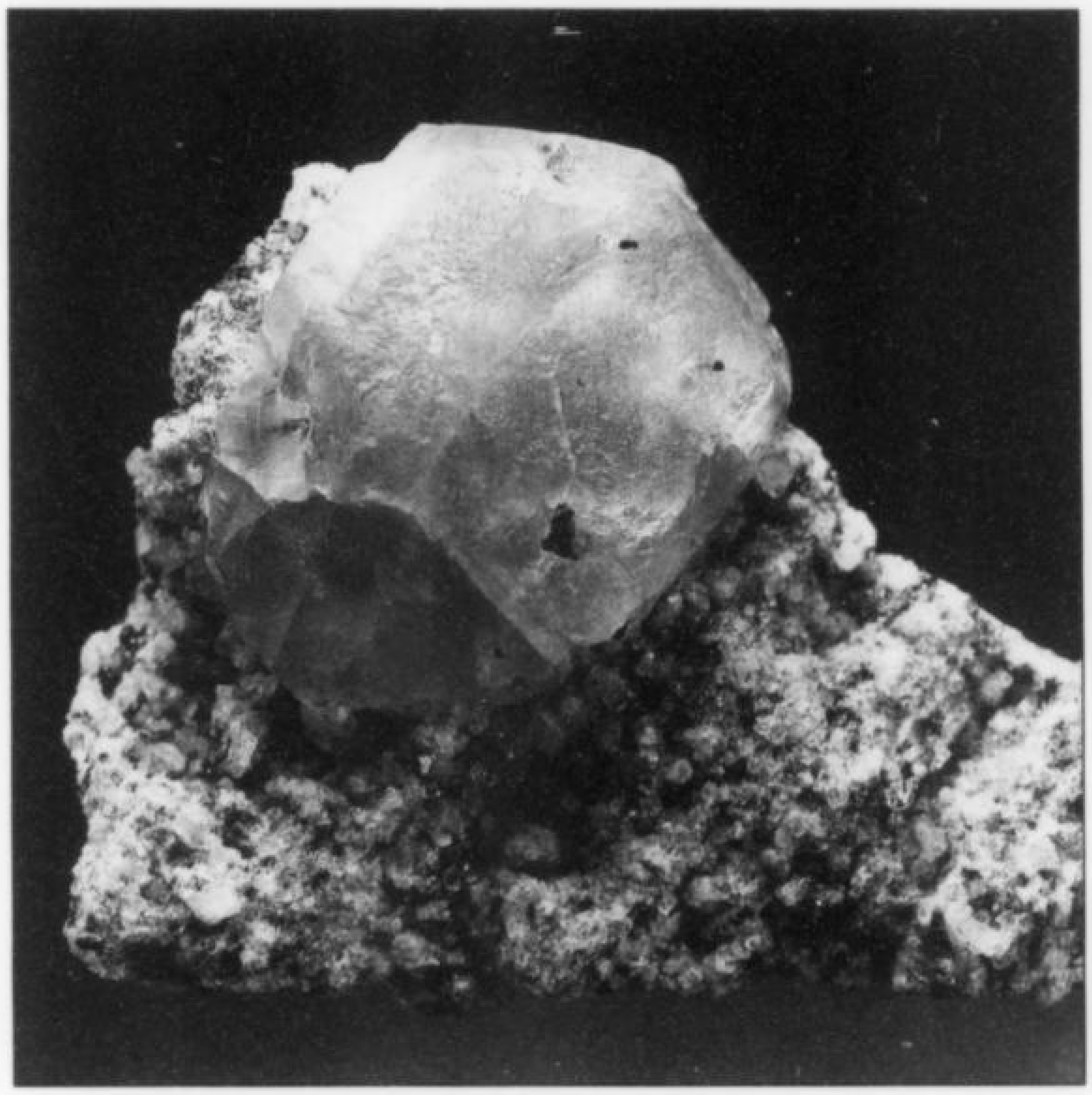


Figure 19. **Fluorite crystal on matrix, 6.5 cm, from Zagi Mountain. Herb Obodda collection; Jeff Scovil photo.**

Genthelvite $(Zn,Fe,Mn)_4Be_3(SiO_4)_3S$

Genthelvite has been found in sharp, yellow to dark reddish brown tetrahedral crystals to 5 cm, with one exceptional 12-cm crystal that weighs in excess of 2.3 kg and thus by itself constitutes a significant fraction of the world's known genthelvite! This large crystal displays both the positive and negative tetrahedrons, with the negative tetrahedron extremely rough and stepped. The crystals have all been found loose; significant matrix specimens are unknown.

Chemically, all specimens analyzed are genthelvite, with Zn > Fe + Mn. A distorted yellowish crystal has $Zn_{.98}Mn_{.02}Fe_{<.01}$, and a dark reddish brown crystal has $Zn_{.68}Mn_{.16}Fe_{.17}$.

Grossular $Ca_3Al_2(SiO_4)_3$

Grossular in lustrous, dark honey-colored crystals to 3.5 cm, showing the dodecahedron, tetrahexahedron, and minor rough (and very unusual) cube faces occur in the Mohmand FATA about 30–50 km (20–30 miles) from Zagi, but labels on some marketed specimens have attributed them to Zagi Mountain, apparently to enhance their value. Associated minerals include minor diopside and traces of chlorite. A few cut stones of several carats have been offered as bastnäsite. Cloudy, pale orange-brown crystals of grossular to 5 cm, some associated with pale green diopside blades, are reportedly from Zagi, but are identical in appearance to ones from a locality in the Khyber Agency, close to the Afghan border and about 20 km distant.

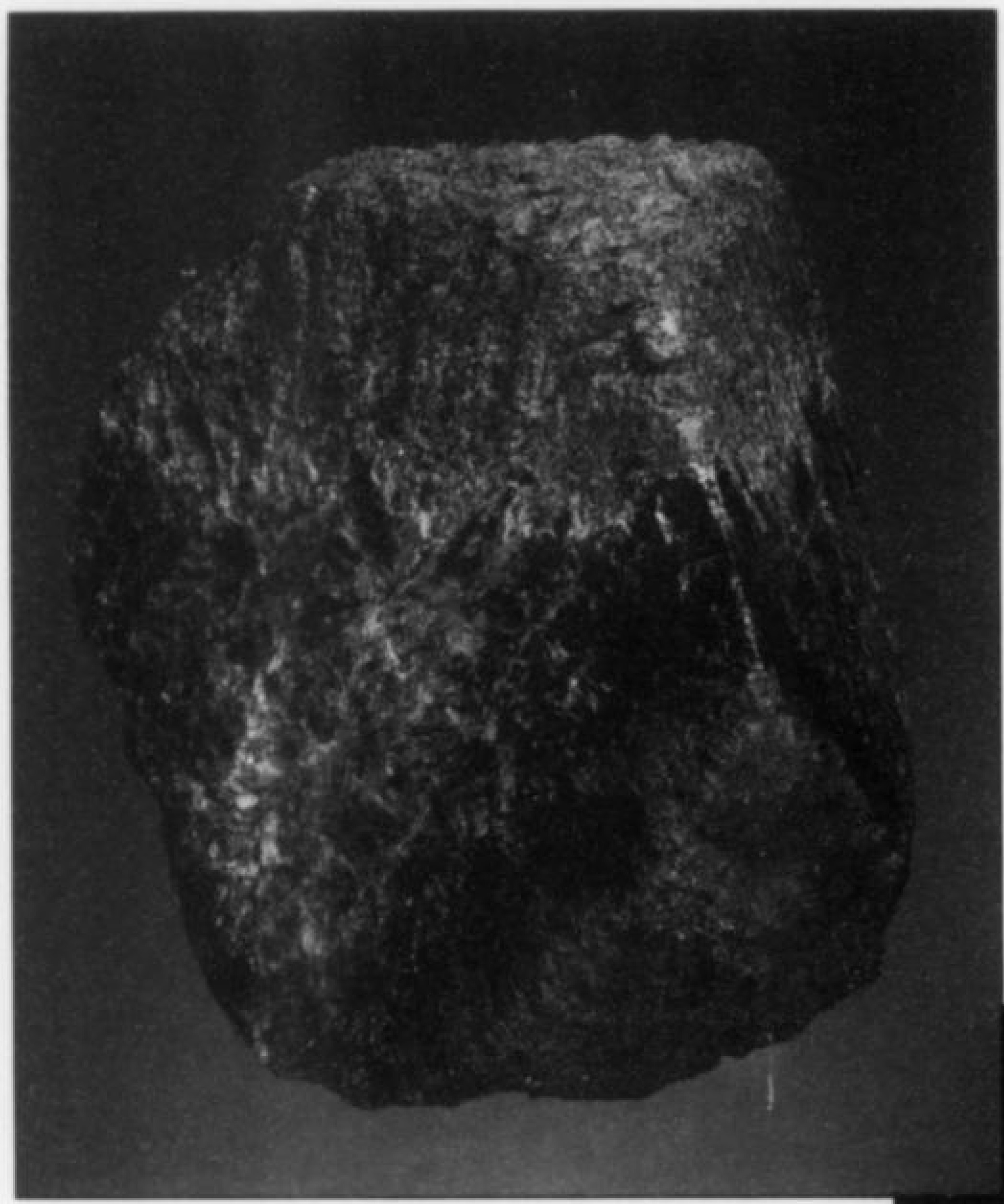


Figure 20. **Genthelvite crystal, 5 cm, from Zagi Mountain. Herb Obodda collection; Jeff Scovil photo.**

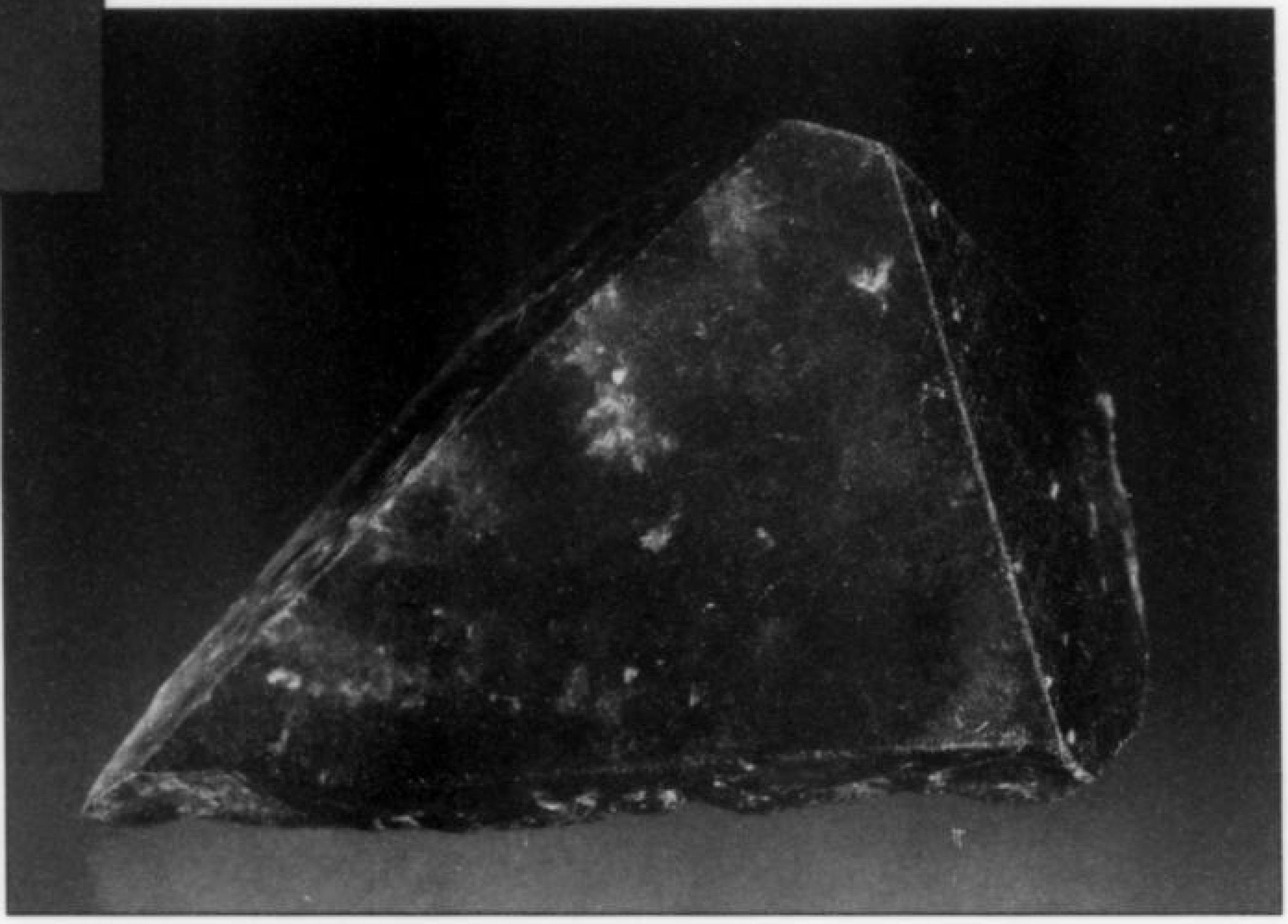


Figure 21. **Genthelvite crystal, 12.5 cm, from Zagi Mountain. Herb Obodda collection; Jeff Scovil photo.**

Figure 22. **Ilmenite crystals, 6.6 cm, from Zagi Mountain. Herb Obodda collection; Jeff Scovil photo.**

Hollandite $Ba(Mn,Fe)_8O_{16}$

Black botryoidal crusts of manganese oxides occur widely at Zagi, coating other minerals. They are probably weathering products rather than part of the hydrothermal assemblage. One sample gave an XRD pattern that is a fairly good match for hollandite. Another, poorer, pattern is a fair match for cryptomelane, KMn_8O_{16}.

Ilmenite $Fe^{2+}TiO_3$

Ilmenite occurs in a number of habits: (1) as brilliant, sharp plates to 1.5 cm, both loose and on matrix with quartz and microcline; (2) as thick tabular crystals to 2 cm with brilliant terminations and pitted rhombohedron faces on matrix; and (3) as thin, composite plates up to 5 cm across, somewhat resembling iron roses. One such iron rose group has epitaxial rutile crystals about 5 mm by 12 mm forming six-rayed stars, as on Swiss hematite specimens. EDS analysis of the second type by Bart Cannon, of Cannon Microprobe in Seattle, on samples supplied by Dudley Blauwet, show that it is a manganoan ilmenite, with Fe:Mn about 3:1. Ilmenite in plates to 5 cm embedded in quartz are reportedly from Zagi, but the specimens are not from the veins in the alkali granite.

"*Limonite*" Hydrous iron oxides

Yellow to orange weathering films and crusts of poorly crystallized iron hydroxides are common at Zagi. Although it was hoped that some might prove to be secondary Ce minerals, none has been confirmed as anything but limonite. Limonite also occurs widely but sparsely in the veins as pseudomorphs after pyrite crystals. The crystals are pyritohedral and range up to about 1 cm.

Microcline (adularia) $KAlSi_3O_8$

Microcline is the common feldspar in the granite and in the veins; it is the most widely distributed silicate species at Zagi, coating most matrix specimens. It occurs in several habits: (1) most commonly, as crystals with the distinctive adularia morphology, with the prominent diamond-shaped prism {110}; (2) as flattened, arrowhead-shaped Carlsbad twins; and (3), occasionally, as crystals with the usual microcline morphology, similar to Colorado amazonite. The crystals typically measure a few millimeters but can reach 5 cm. The smallest crystals are nearly colorless and transparent, with lustrous faces; larger crystals are milky and translucent. Many are crowded with minute, golden needles of astrophyllite. Adularia is commonly termed orthoclase, and is usually a mixture of domains with different degrees of internal order (and therefore a mixture of orthoclase and microcline), but the feldspar at Zagi is identified as microcline because all samples examined under the polarizing microscope showed grains with crosshatch (combined albite and pericline) or spindle (deformed albite) twinning, both of which are characteristic of microcline. In addition, the XRD patterns of samples more closely match microcline than orthoclase, although the two patterns are similar. Microcline in both the veins and the granite fluoresces a characteristic dull red. EDS analysis showed that the microcline is almost pure $KAlSi_3O_8$, with very little Na. This is usual in microcline adularia.

Parisite-(Ce) $Ca(Ce,La)_2(CO_3)_3F_2$

Parisite is found in medium-brown hexagonal-tabular crystals to 3 cm, and also as epitactic overgrowths on bastnäsite crystals. At the 2002 Tucson show, Moore (2002) saw a 6-cm crystal of deeper honey-brown bastnäsite with a paler brown outer layer, which he was told was epitactic parisite. Microprobe analysis by Bart Cannon of Cannon Microprobe in Seattle on samples supplied by Dudley Blauwet reveal that some crystals are indeed zoned, part parisite and part bastnäsite. One 8-mm equant bastnäsite shows a belt of slightly paler parisite; Dudley Blauwet has seen fewer than

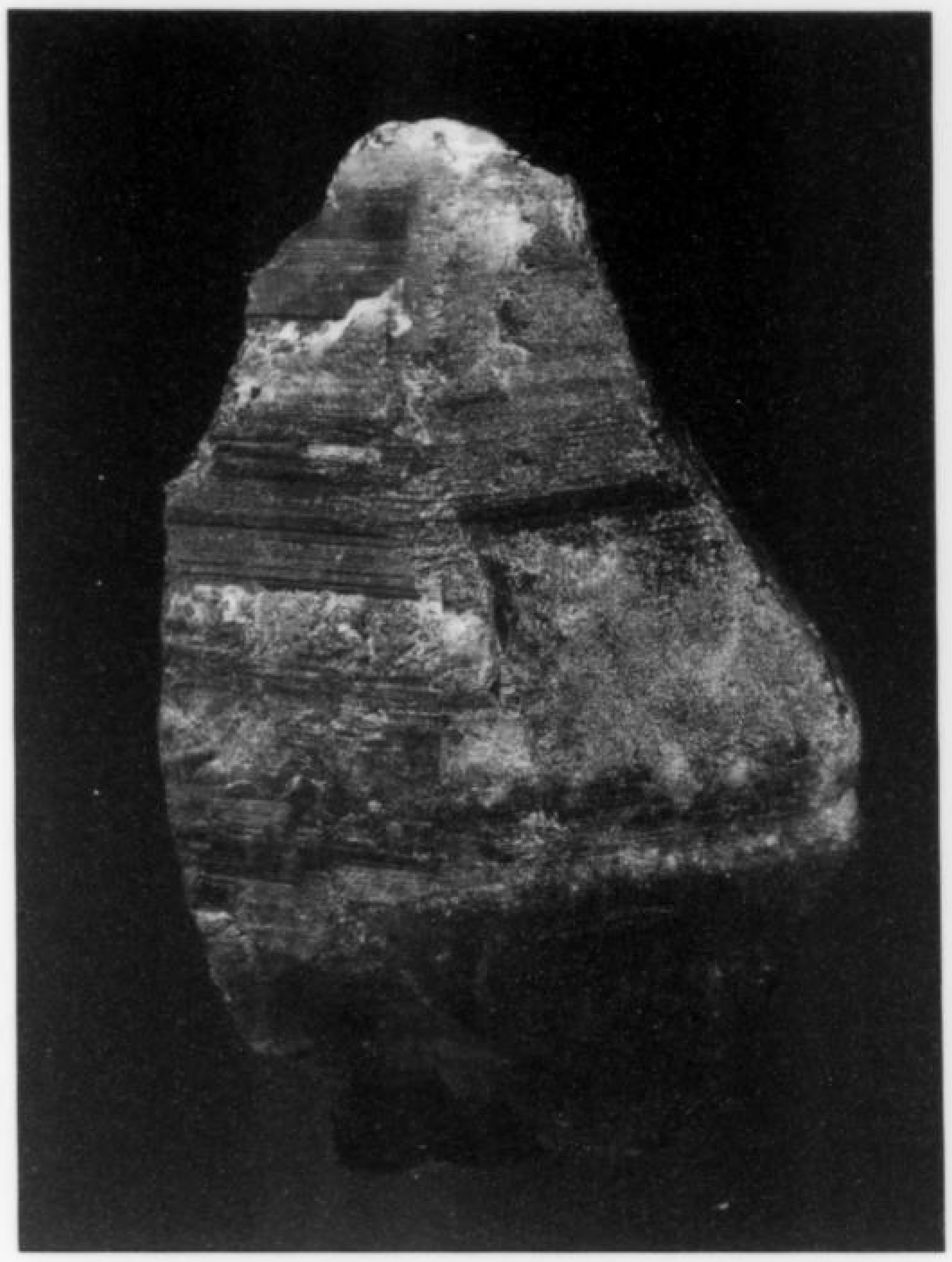


Figure 23. **Parisite crystal, 3.1 cm, from Zagi Mountain. Herb Obodda specimen; Jeff Scovil photo.**

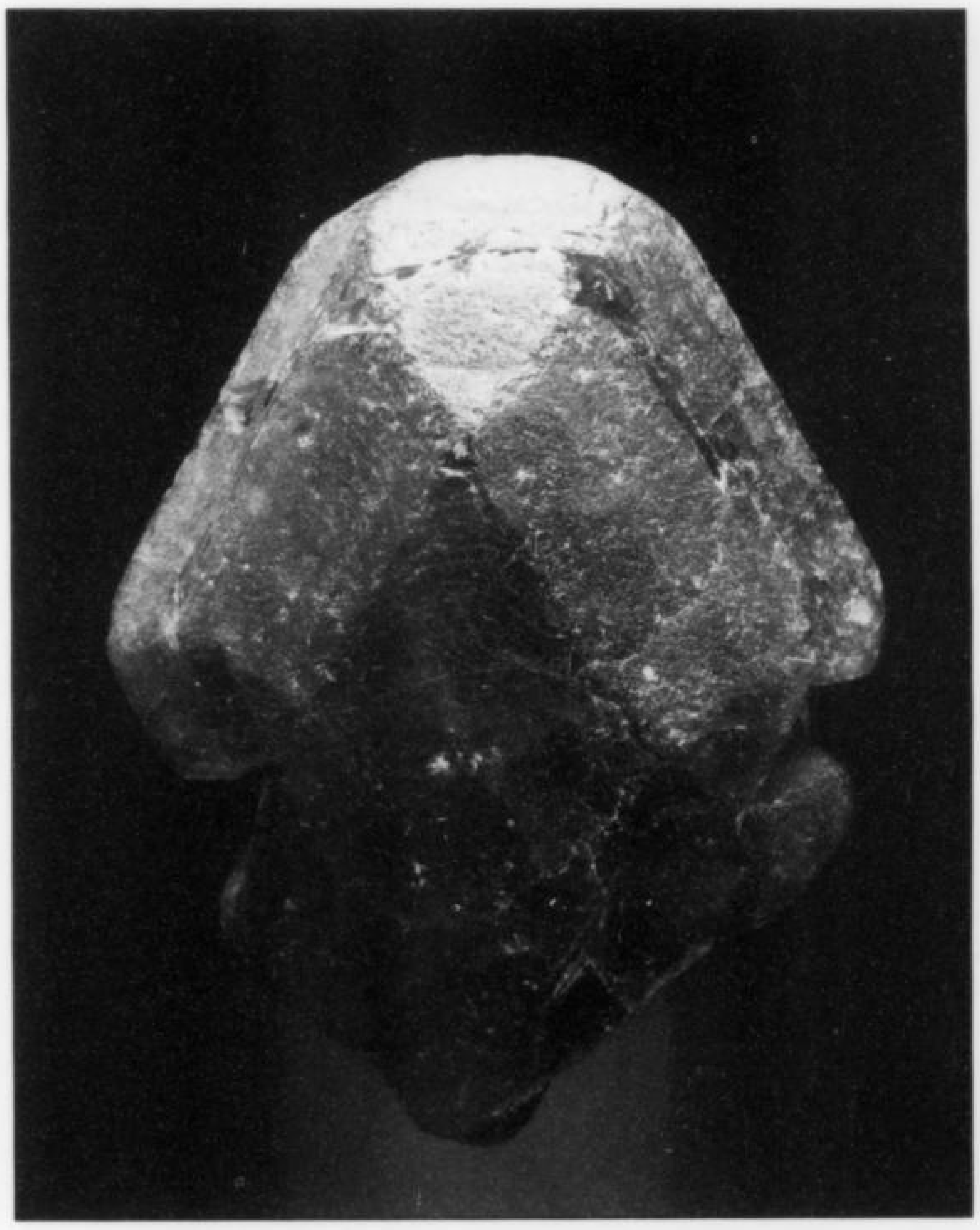


Figure 24. **Parisite crystal, 2.2 cm, from Zagi Mountain. Stephen T. Hall collection; Jeff Scovil photo.**

Figure 25. **Riebeckite crystals to 3.3 cm with bastnäsite-(Ce) from Zagi Mountain. Herb Obodda specimen; Jeff Scovil photo.**

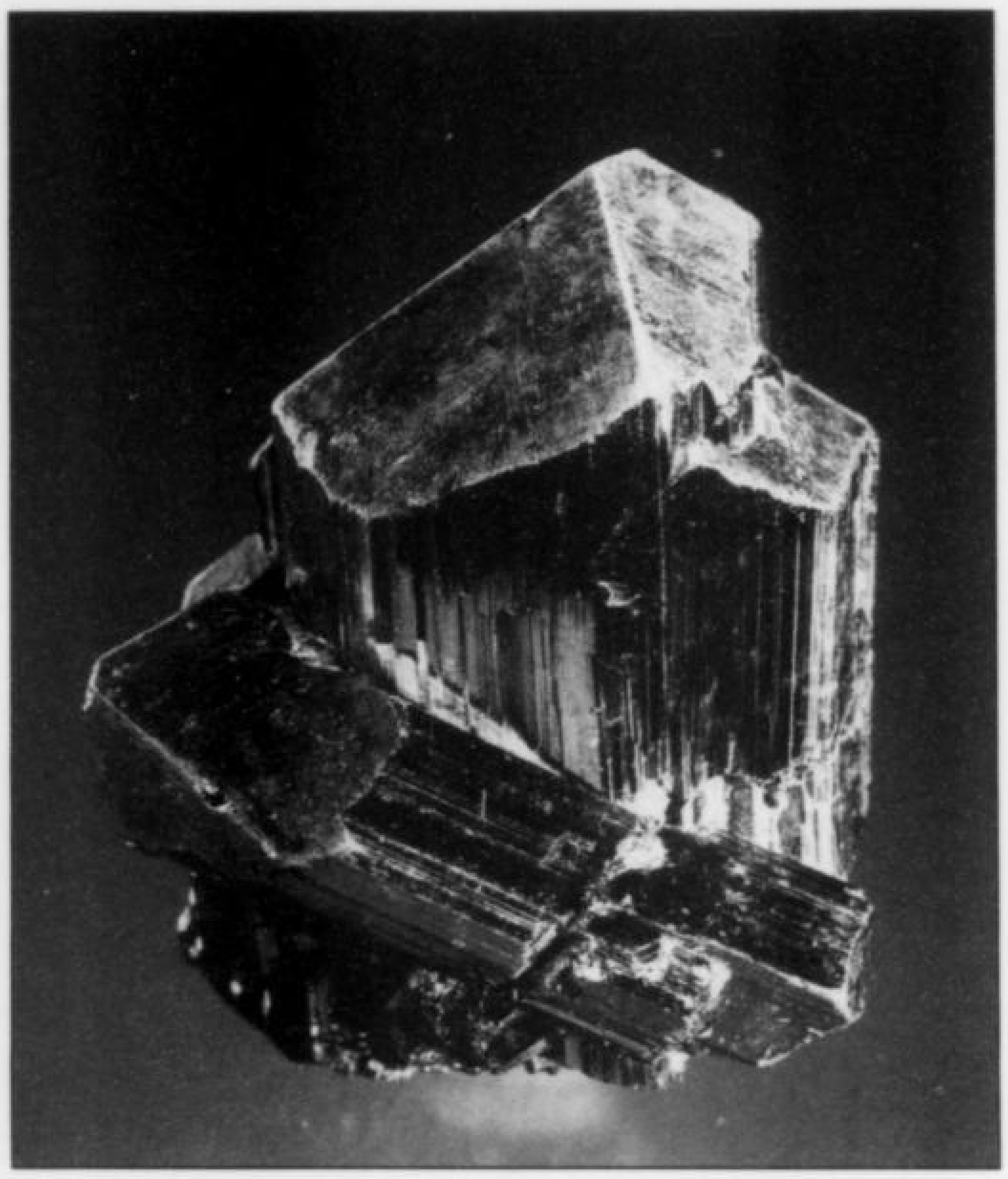


Figure 26. **Rutile crystals, 2.7 cm, from Zagi Mountain. Herb Obodda specimen; Jeff Scovil photo.**

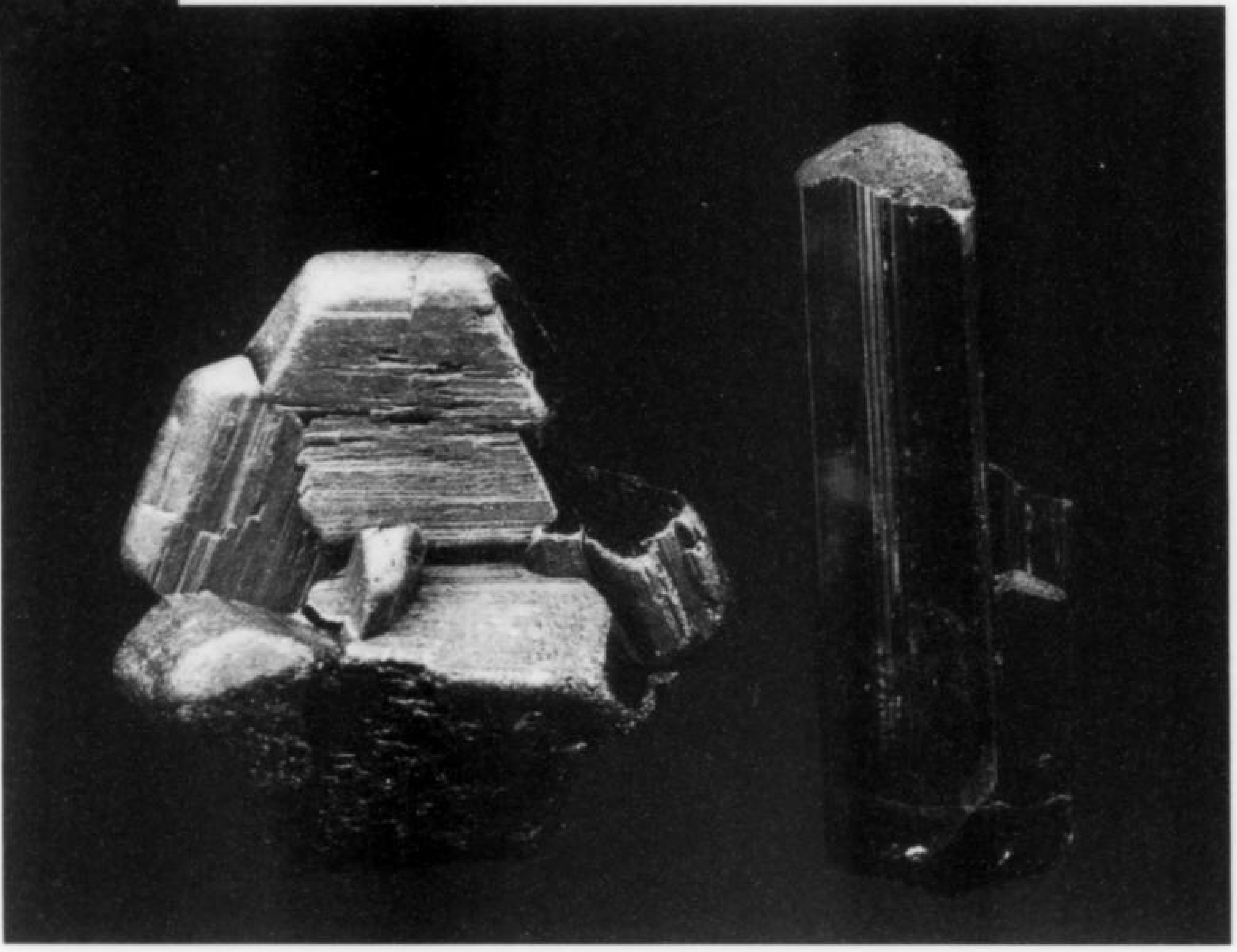


Figure 27. **Rutile crystals, 3 cm and 3.5 cm, from Zagi Mountain. Herb Obodda specimen; Jeff Scovil photo.**

half a dozen such pieces. One analyzed sample of parisite contained both Ce and La, in the ratio of 2.78:1, similar to the ratio in bastnäsite.

Quartz SiO_2

Quartz is a constituent of the gneiss and also occurs in colorless to smoky, gemmy, lustrous crystals to 10 cm, and in 15-cm aggregates of individual crystals to 5 cm; crystals have been found at Zagi, at Tor Ghar, and at Spara Ghar, a hill between the two localities. Most quartz crystals have inclusions of black acicular riebeckite, or of golden astrophyllite, and some have free-standing, finger-thick rutile crystals on and below the quartz crystal faces. Rarely, well-formed crystals of xenotime or bastnäsite to 5 mm occur as inclusions in quartz crystals.

Rhabdophane-(Ce) $(Ce,La)PO_4 \cdot H_2O$

Rhabdophane was noted as a yellowish tan, fine-grained, compact coating on a 3-cm cluster of bastnäsite crystals. The rhabdophane appears to be a replacement of the bastnäsite rather than an incrustation or overgrowth, and has roughly the same Ce:La ratio.

Riebeckite $Na_2(Fe^{2+},Mg)_3Fe_2^{3+}Si_8O_{22}(OH)_2$

Riebeckite is a constituent of the granite gneiss bedrock. It is also found as acicular inclusions in a number of minerals, particu-

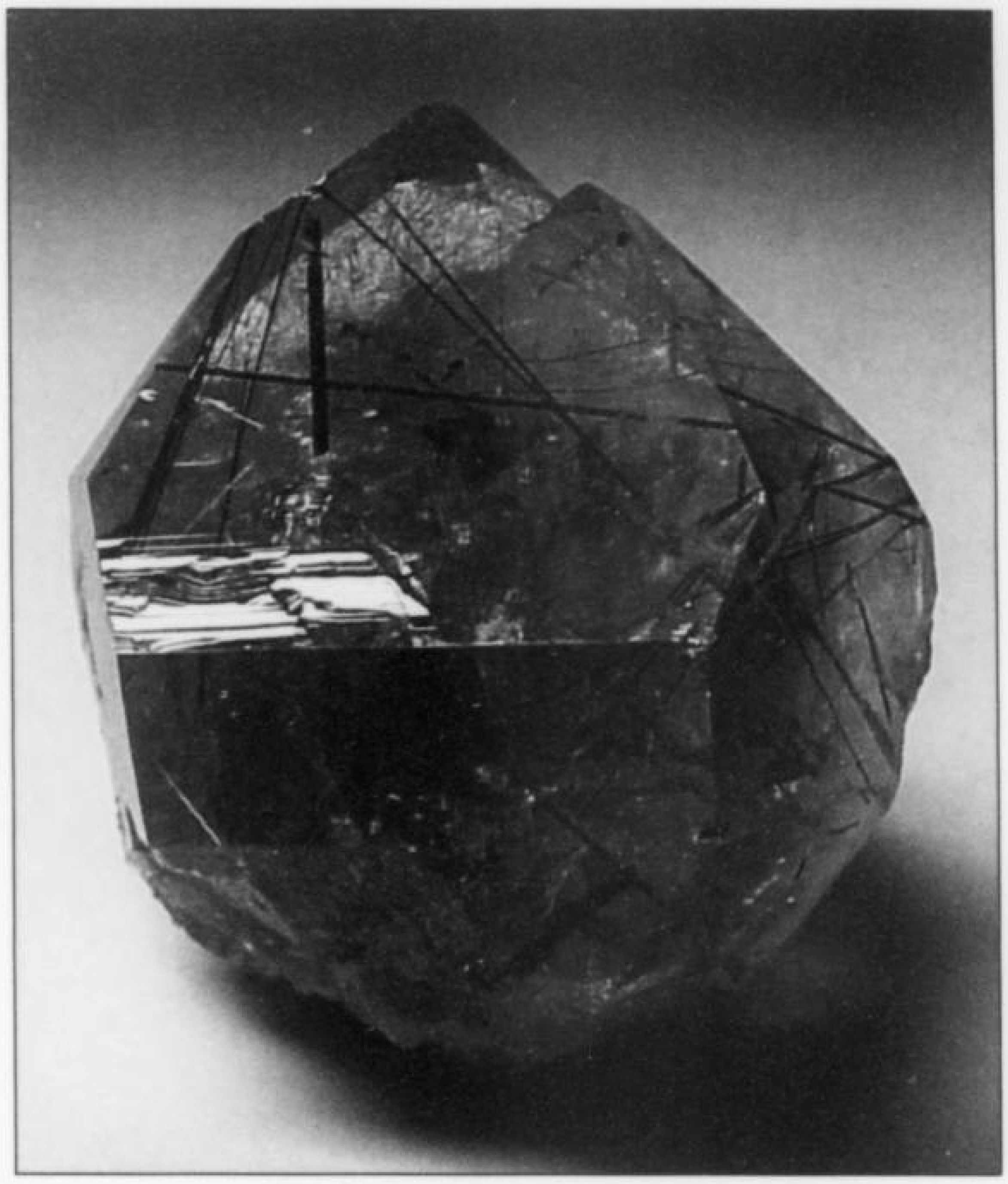


Figure 28. **Quartz crystal with astrophyllite/riebeckite inclusions, 5 cm, from Zagi Mountain. Herb Obodda specimen; Jeff Scovil photo.**

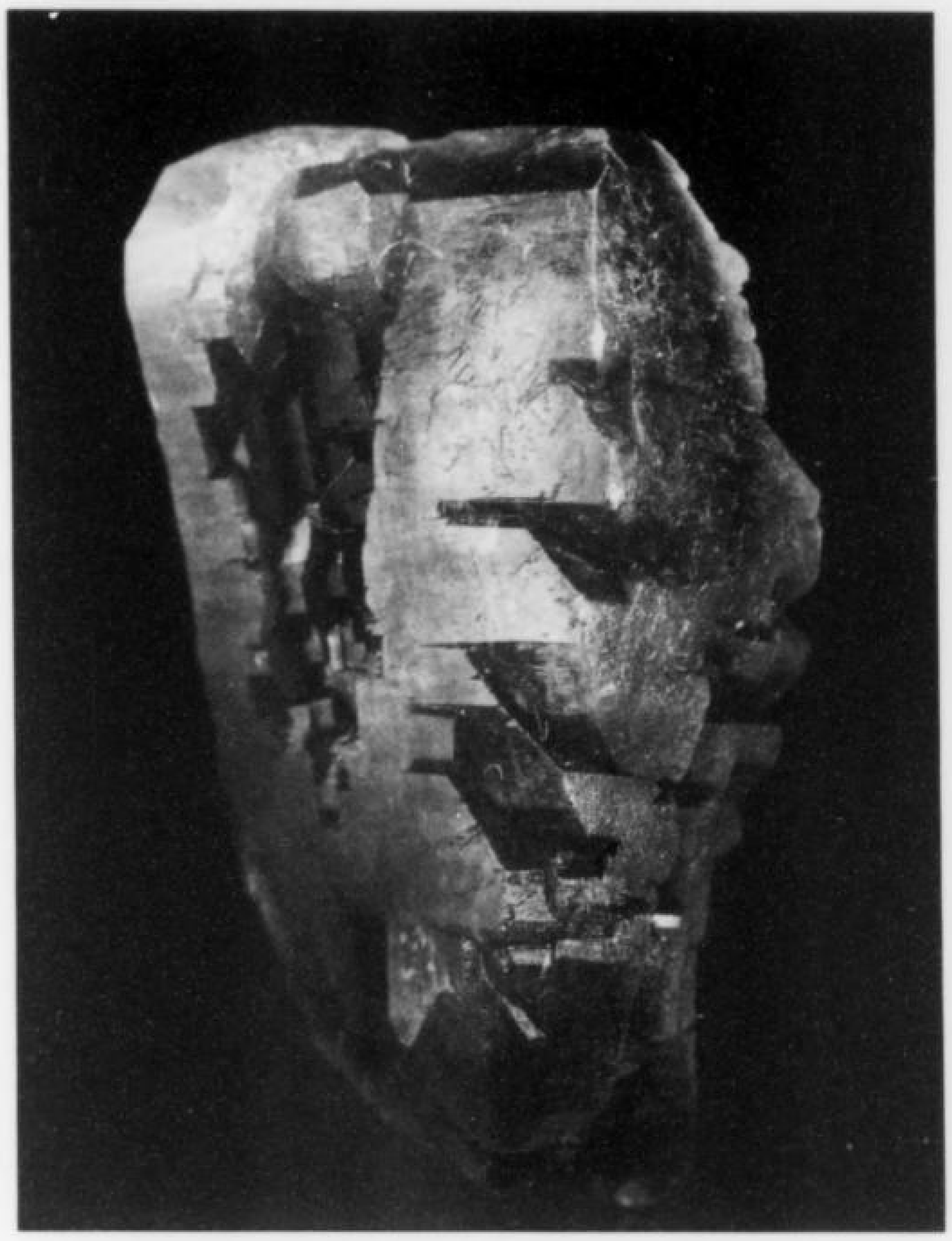


Figure 29. **Xenotime-(Y) crystal, 2.9 cm, from Zagi Mountain. Herb Obodda specimen; Jeff Scovil photo.**

larly quartz and titanite, and occurs in bladed crystals to 8 cm. Riebeckite is the commonest black mineral in the deposits. An analyzed grain is close to pure riebeckite, but has some K and Ca as well as Na, and minor Mn and Mg substituting for Fe, as well as trace Al, probably substituting for Si.

Rutile TiO_2

Rutile occurs in prismatic crystals as long as 3.8 cm, associated with quartz and microcline. A slightly abraded sixling twin about 2 cm across that appears to be a complete floater was found in a stream bed. Rutile has also been found growing epitaxially on ilmenite, as mentioned above. EDS analysis of a typical crystal indicates 1.8 to 3.7 atomic % Fe, as well as several weight % (but only about 1 atomic %) Hg (mercury), which is not reported in standard textbooks as an observed trace element in rutile.

Thorite $ThSiO_4$

A single irregular, opaque orange-brown crystal of thorite has been found. It has bits of granite adhering to all surfaces, suggesting that it is from the granite rather than being a later pocket mineral. It is radioactive, and the XRD pattern has broad, low peaks, indicating that the structure is partly metamict (broken down by internal radioactive bombardment).

Titanite $CaTiSiO_5$

Titanite forms yellow to orange, commonly twinned crystals to 4 cm. The crystals are generally opaque and somewhat crude in form, but some superb, yellow to orange-red, translucent to transparent crystals were found recently at Zagi. Needles to slender prisms of riebeckite commonly penetrate the titanite crystals.

Xenotime-(Y) YPO_4

Xenotime is restricted in its occurrence and has been found in only a few areas. It forms prismatic, tetragonal crystals from 1 mm to 6 cm; many of the larger crystals are composite, with numerous

Figure 30. **Xenotime-(Y) crystals on matrix, 7 cm, from Zagi Mountain. Herb Obodda specimen; Jeff Scovil photo.**

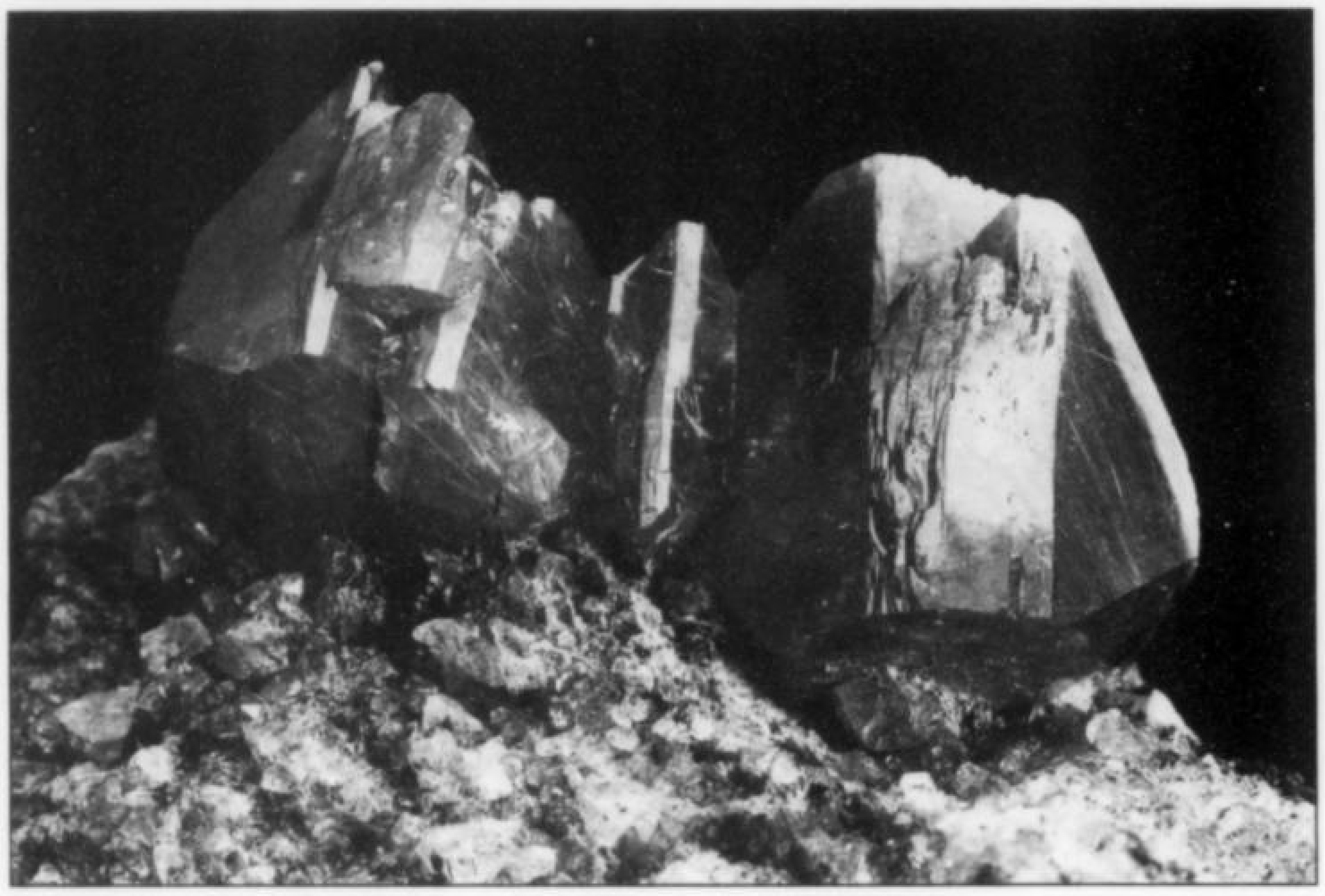


Figure 31. **Xenotime-(Y) crystal group on matrix, 1.8 cm, from Zagi Mountain. Herb Obodda specimen; Jeff Scovil photo.**

stepped faces. One 3.5-cm composite crystal shows a distinct twist about the c axis, like a gwindel. Some are among the largest and arguably the finest crystals of xenotime known. Microcrystals are lustrous, pale yellow and transparent. Larger crystals are slightly translucent and many show a remarkable color change, from pale yellow brown or brownish green in daylight to salmon-red in incandescent light. One matrix specimen includes 1 to 2-mm crystals of xenotime, quartz, and microcline; all three minerals have inclusions of fine yellow needles of astrophyllite, suggesting that crystallization of xenotime was contemporaneous with that of the other minerals. Xenotime crystals look remarkably like zircon, with which it is isostructural, but are paler in color and softer.

The one xenotime sample analyzed is chemically more complex than the bastnäsite or parisite. It contains slightly smaller REE (rare earth element) cations, including dysprosium (Dy), gadolinium (Gd) and europium (Er), as well as yttrium (Y), in the proportions $Y_{.73}Dy_{.17}Er_{.06}Gd_{.04}$.

Zircon $ZrSiO_4$

Transparent, orange-brown pieces of zircon showing alluvial abrasion have been observed by Dudley Blauwet mixed in with parcels of bastnäsite cutting rough in Peshawar, but there are no confirmed specimens from Zagi; zircon is uncommon as a cavity mineral. Microscopic, accessory zircon grains do occur in the massive alkaline granite gneiss.

FUTURE POTENTIAL

Zagi Mountain can still be worked (barring local political problems) and may continue producing specimens for a considerable time, especially if work continues into the less altered bedrock. The new localities in the Khyber FATA have just begun to be developed, and their existence suggests that bastnäsite-bearing veins may be widespread in the Warsak alkali granite. Rocks very similar to those at Zagi crop out on the eastern side of the Peshawar basin, and the Peshawar plain intrusive complex also includes a number of carbonatite bodies, so the potential for the discovery of additional productive or interesting occurrences in the region is substantial. However, finds are sporadic and in some cases the specimen may be unique. It appears unlikely that specimens as fine as the best of what has already discovered at Zagi Mountain will ever be abundant.

ACKNOWLEDGMENTS

We thank Dudley Blauwet, Andreas Weerth, and Tom Moore for additional information on this locality.

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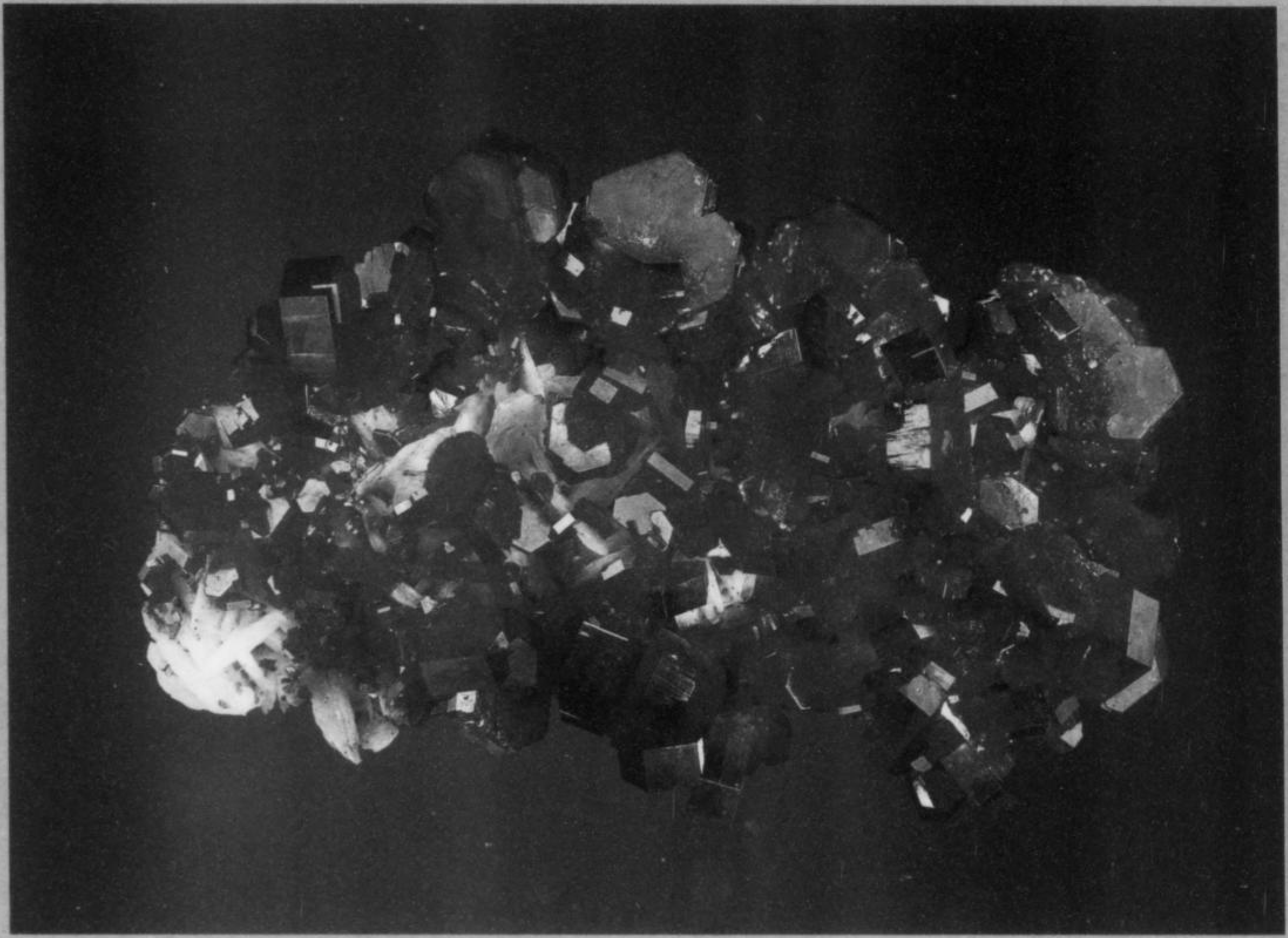
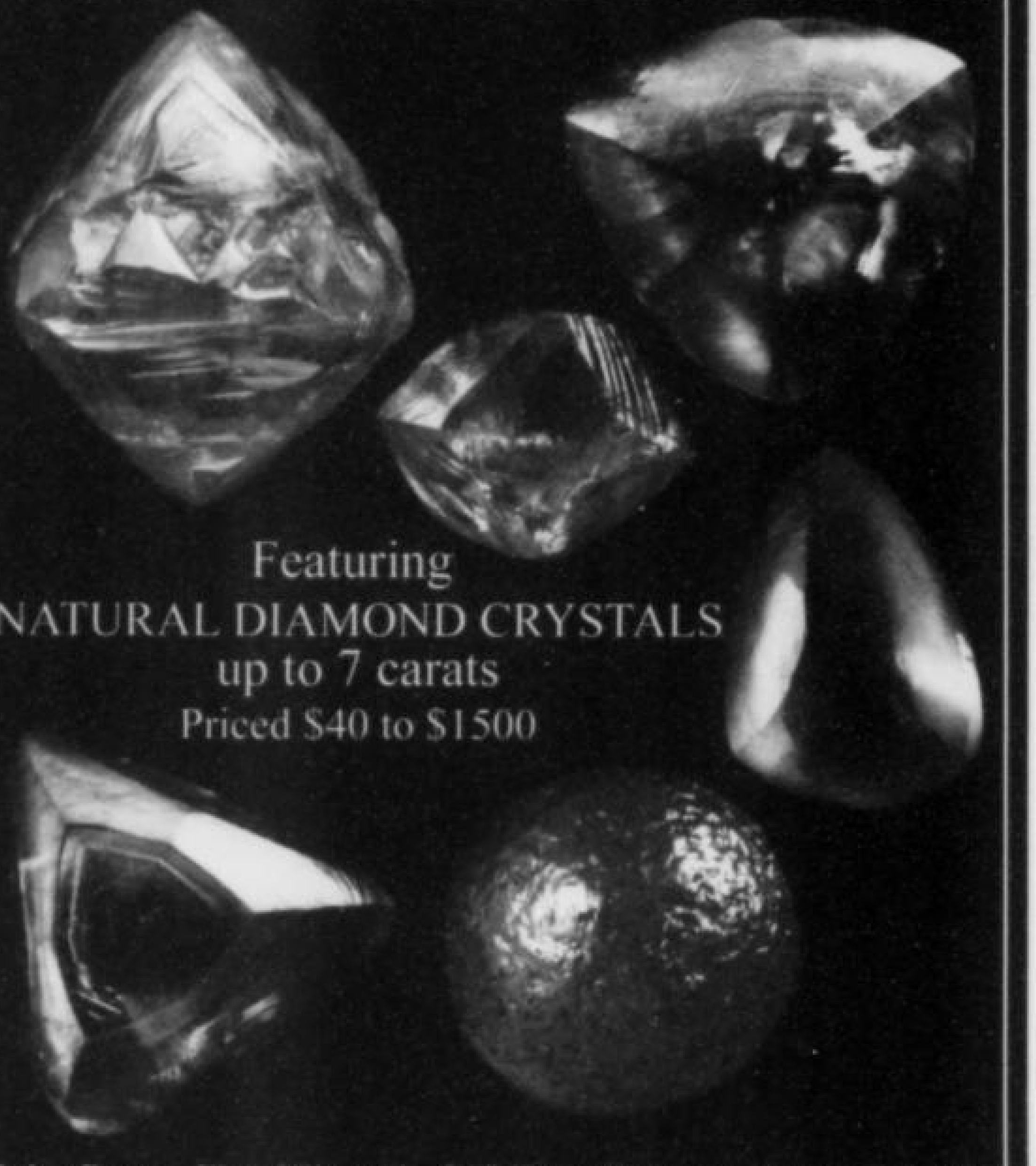
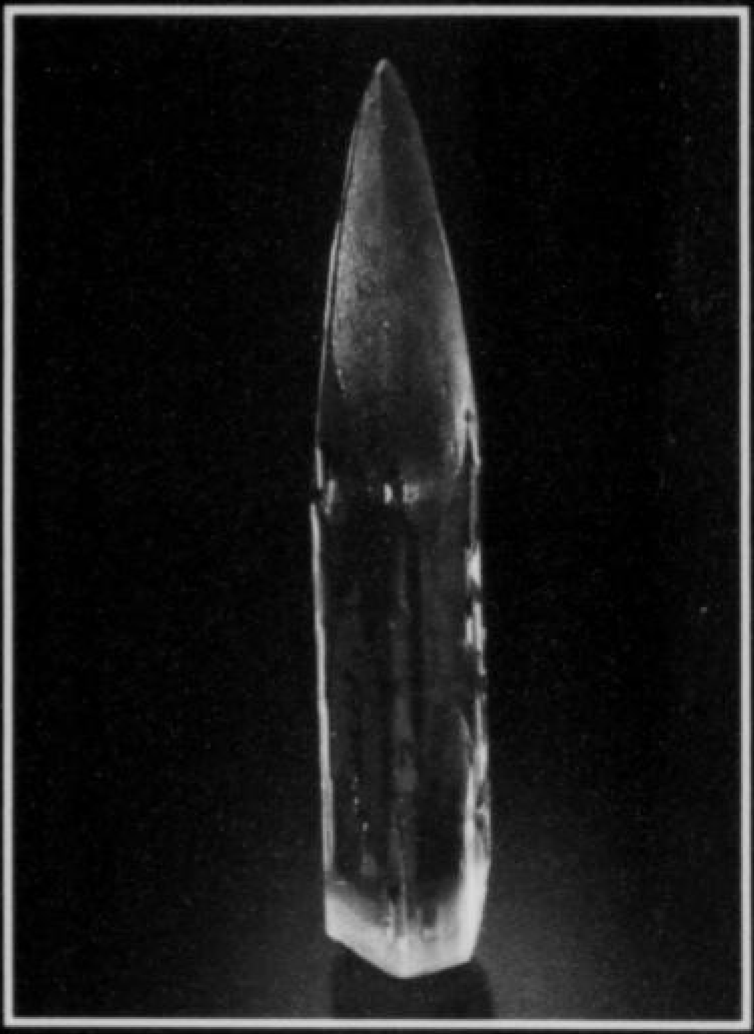
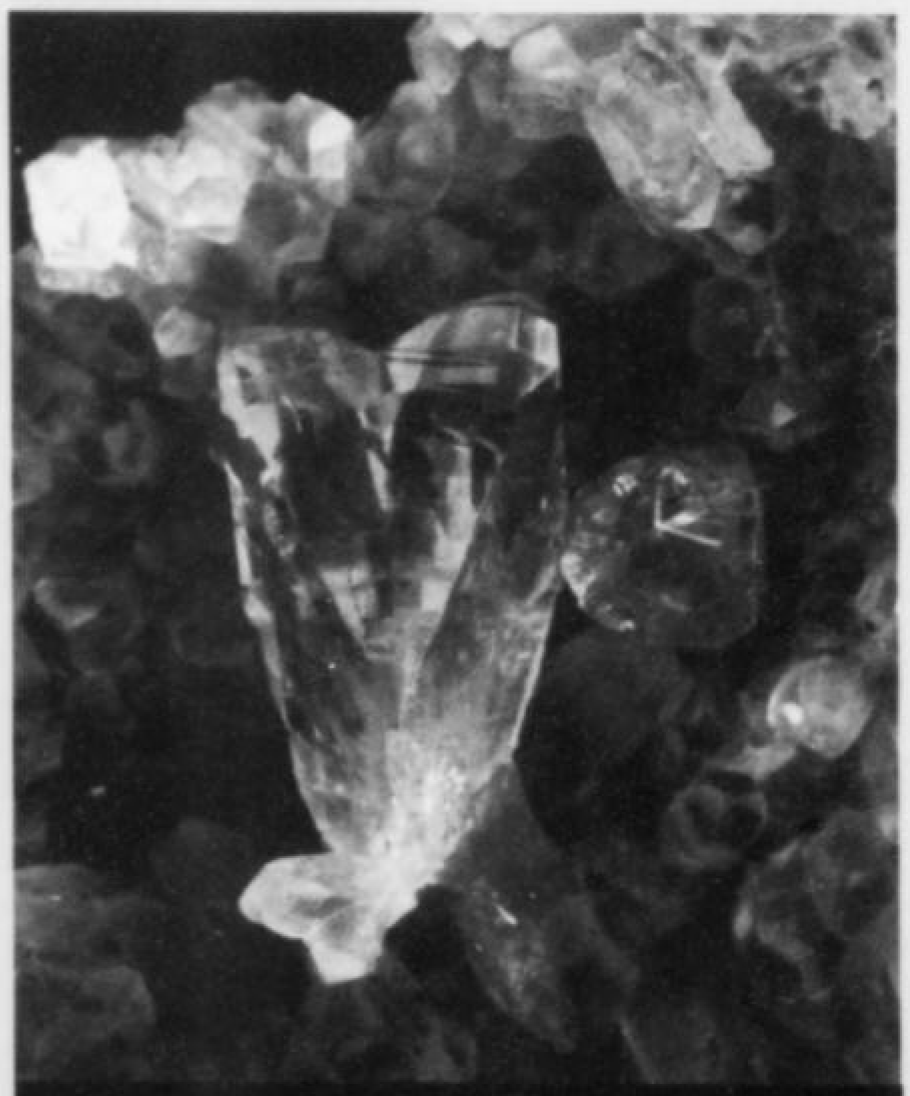



The Ultimate







The Trimouns Quarry

LUZENAC, ARIÈGE, FRANCE

Freddy Marty
Rue de l'Hôpital
11230-Chalabre
France

In recent decades, the Trimouns quarry has become well known as a source of outstanding crystals of several rare earth element-bearing minerals, including familiar species such as allanite, parisite and bastnäsite, as well as very rare ones such as hingganite, iimoriite and dissakisite. Beautiful micromount-size specimens are the rule, but attractive crystals of several species exceeding 1 cm have also been found. These minerals occur in dolomite vugs in a contact zone of the Trimouns talc/chlorite deposit, where large-scale mining for talc may now be approaching its end.

INTRODUCTION

The Trimouns talc-chlorite deposit is a mineral locality of international significance, producing fine crystal specimens of rare earth element-bearing species including allanite/dissakisite, bastnäsite, synchisite, parisite, hingganite and iimoriite. Also, Trimouns is the type locality for two recently described species, trimounsite and gatelite.

The deposit is located in the Ariège Departement of southwestern France, 6 km northeast of the village of Luzenac, 40 km (via Spain) from the Principality of Andorra, and 115 km from Toulouse. It lies at an altitude of 1800 meters on the west slope of the St Barthélémy massif, the peaks of Saint Barthélémy (2348 meters) and Soularac (2368 meters) towering above it. Because of the heavy winter snowfalls, talc is quarried for only 6 months of the year, from May through October.

The name Trimouns comes from the *langue d'Oc* words *Très Monts* (three mountains), in reference to the three peaks that overlook the quarry. *Langue d'Oc* is a regional language of Latin origin; it is traceable to the Middle Ages and is still spoken today in southern France, in the region known as Languedoc—the equivalent in northern France is *langue d'oïl*.

HISTORY AND MODERN WORKINGS

The Trimouns deposit was first described in print in 1841 by Engineer François in the *Annales Agricoles Littéraires et Industrielles de l'Ariège*. In 1905 the quarry was acquired by the *Société des Talcs de Luzenac* (Mengaud, 1909); in 1988 it was purchased by the *Groupe Luzenac*, a wholly owned subsidiary of Rio Tinto Zinc (RTZ), the world's foremost producer of talc at 1.3 million tonnes per year. The quarry employed some 100 workers at the beginning of the 20th century, when the ore was hand-sorted (de Launay, 1913). Today the talc is quarried by modern hydraulic shovels, and the ultra-white ore is sorted by laser camera.

Trimouns, the largest talc occurrence in France, possesses estimated reserves of 16 million tonnes, sufficient for half a

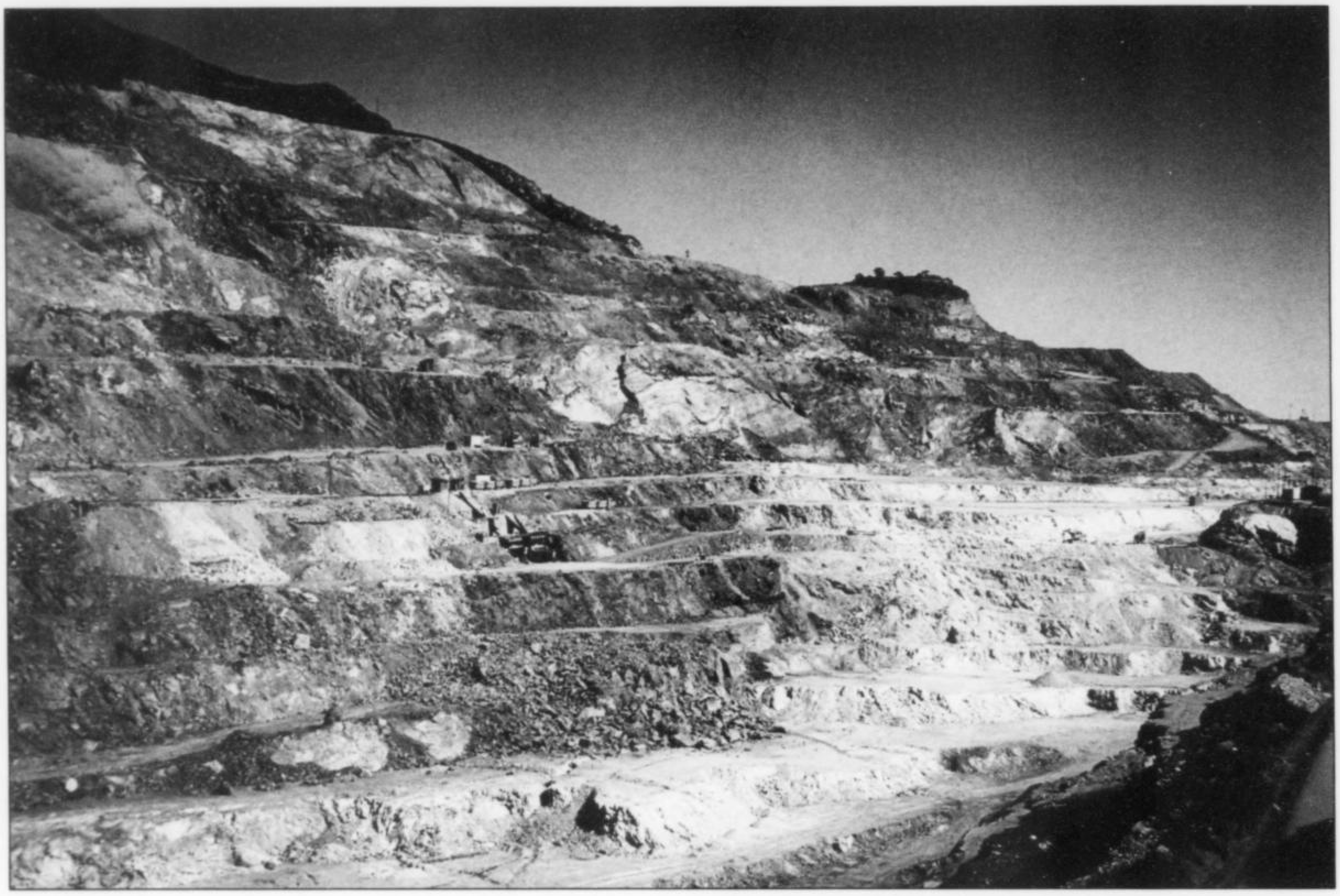


***Figure 1.* The Trimouns quarry, Luzenac, France. Robert Vernet photo.**

***Figure 2.* Location map.**

century. The quarry employs 300 people and is the largest talc-chlorite mine in Europe, producing more than 400,000 tonnes annually.

The ore is quarried both mechanically (85% of the tonnage) and manually from successive benches. The ore is then sorted, partly on the basis of their degrees of whiteness (see below). Each year 10.35 million cubic meters of waste rock are extracted by a 210-tonne mechanical shovel with a 25-tonne capacity bucket. The rock is loaded into 8 dumpers at a rate of 16 tonnes/hour; each dumper has a transport capacity of 120 tonnes/day.

The mine cars, each with a 1 cubic meter capacity, are filled with talc and then transported by cable car from the quarry to the processing plant in the valley 5.5 km away. The altitude difference is 1100 meters and the journey takes 24 minutes.

Eighteen grades of ore are distinguished on the basis of two criteria: chemical composition and whiteness. The chemical composition corresponds to the distinction between dominantly talcose and dominantly chloritic ore, and to the amount of barren inclusions (unaltered rock: residual dolomite, pegmatite and mica schist). The degree of whiteness is assessed visually by the seasonal laborers, mainly Moroccans and Portuguese. About 80 of these workers extract and sort some 300 kg of ore per hour on each mine bench; this manually extracted ore represents 15% of the total ore tonnage produced. Optical laser sorting in the storage plant over the past few years has significantly increased the yield. A laser beam sorts each bit of talc by analysing its whiteness and directs a jet of compressed air to offload it from the conveyor belt at the correct place.

Talc is used in the manufacture of paper, polymers, paint, cosmetics and pharmaceuticals, ceramics, foodstuffs and fertilizer, among other things.

Figure 3. **The "Rognon" pit (Rognon = "Kidney," in reference to the shape of the pool) at the Trimouns quarry. This area, rich in Rare Earth minerals, is at a schist/dolomite contact near the roof of a talc lens. Robert Vernet photo.**

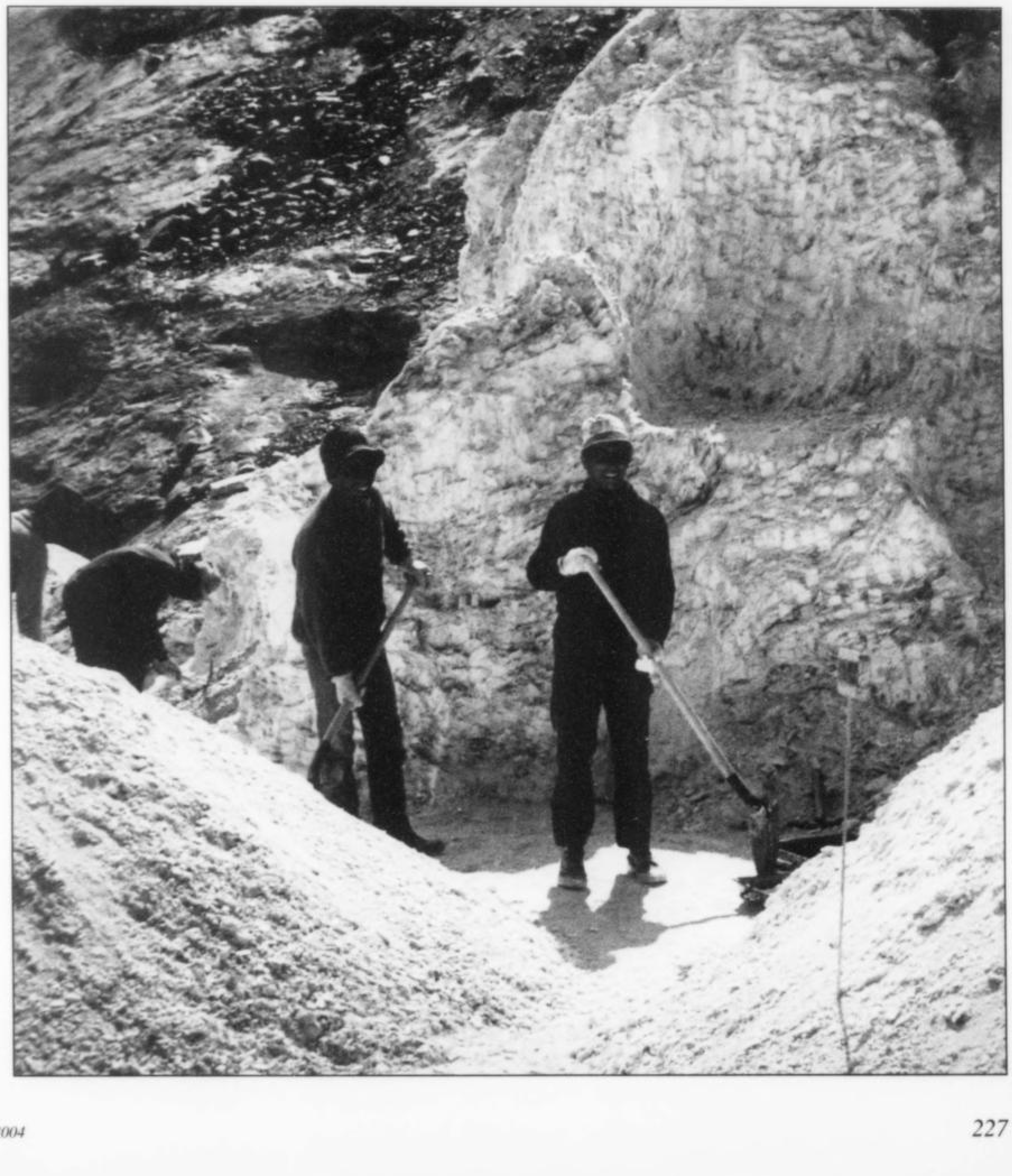


Figure 4. **Talc miners at work in the talc zone of the Trimouns quarry. Robert Vernet photo.**

Figure 5. **The white talc zone at the bottom of the Trimouns pit. Robert Vernet photo.**

GEOLOGY

The Pyrenees Mountains are the product of two superimposed orogenies, the Hercynian Orogeny during the Paleozoic and the Alpine Orogeny during the Tertiary. The mountains, forming a natural barrier between France and Spain, extend for almost 600 km in a generally east-west direction, from the Gulf of Lions, in the Mediterranean Sea, to the Bay of Biscay, in the Atlantic Ocean.

The Saint Barthélémy massif is composed of three major units, in places separated by unconformities: a basal gneiss unit, a migmatite unit overlain by a mica schist envelope, and finally a weakly metamorphosed Paleozoic succession. The talc deposit lies at the contact between the crystalline gneiss and the heterogenous migmatite of the Saint Barthélémy massif and its epimetamorphic cover rocks. At the contact with the mineralized orebody, these cover rocks are represented by Ordovician chlorite-graphite schist with thick dolomitic intercalations.

The basal gneiss unit of the massif has an apparent monoclinal structure with a slight northerly dip, and can be subdivided into three types defined by their structural features and their parageneses. From base to top, these are (1) migmatitic gneiss, (2) augen gneiss characterized by a fairly constant blastomylonitic texture probably related to shear movements, and (3) intermediate gneiss that has preserved the augen structure but has apparently undergone slight migmatization.

The migmatite unit is heterogeneous, ranging from metatexite to diatexite facies, and incorporates leucocratic muscovite granite bodies.

The weakly metamorphosed Paleozoic succession includes all the Paleozoic formations that can be dated either by their fossils or by their facies analogies. The oldest formations datable through facies are Ordovician; these are conformably overlain by Silurian, Devonian and Carboniferous units.

Ordovician rocks are ubiquitous on the northern edge of the Saint Barthélémy massif. A typical succession from the base up is:

(1) Sandstone (100 meters): decimeter to centimeter-thick interbeds of schist and fine-grained sandstone.

(2) Carbonate-sandstone (0–80 meters): alternating decimeter-thick to meter-thick beds of sandstone and dolomitic limestone.

(3) Pale schist-sandstone (0–200 meters)

(4) A very fine-grained limestone-sandstone (5 meters) that, because of its consistency, makes a very good stratigraphic marker.

(5) An upper carbonate unit (100–150 meters) showing major and rapid facies variations.

(6) An upper schist unit (0–100 meters) rich in phyllite (chlorite-sericite).

Silurian rocks are mainly represented by black oil shale with varying amounts of organic matter: this appears to be a homogeneous unit deposited under euxinic conditions.

Devonian rocks occur in a thick succession (400–500 meters) that is clastic at the base and essentially carbonate at the top.

Four successive phases of regional Hercynian deformation are recognized in the Pyrenees; these have been designated as D1 through D4:

Phase D1 was very discrete in the vicinity of the Saint Barthélemy massif. In the sub-Paleozoic terrain it has generally been obliterated by the later phases and associated major recrystallization.

Phase D2 gave rise to the main structures of the massif. It affected the various horizons differently, metamorphosing sedimentary units to different degrees.

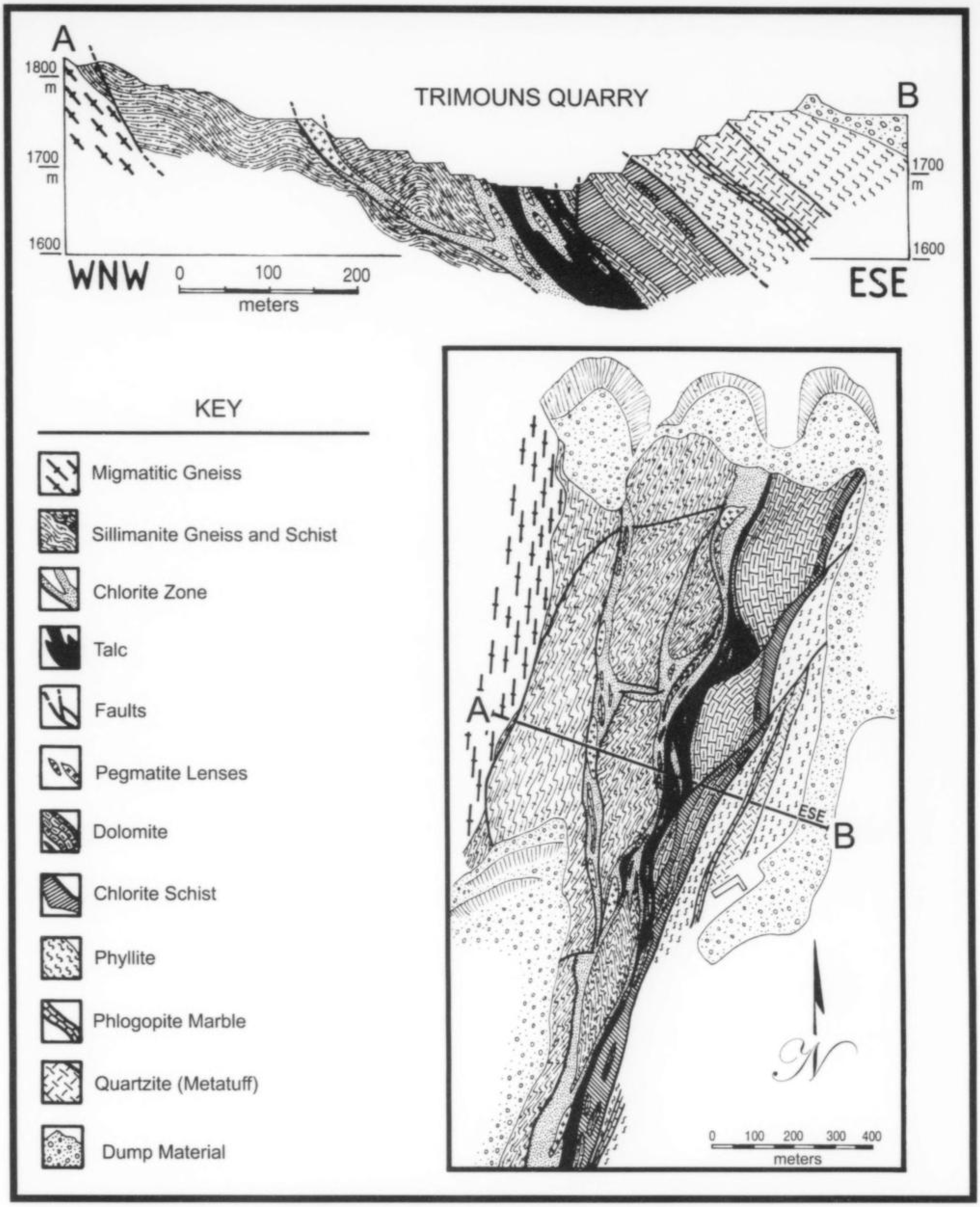


Figure 6. **Geology of the Trimouns quarry area (after Fortune *et al.*, 1980).**

Phase D3, the most apparent in outcrop, corresponds to the peak terminal phase of the migmatization in the deepest levels, with constant interaction between the folds of the sediments and the pegmatite injections.

Phase D4 is reflected in the mica schist and migmatite by very broad (10 to 100 meters wavelength) folds, with an axial plane that is either vertical or slightly west or east-dipping. Most of the thrusts and brittle faults in the region can be assigned to this phase.

Locally, in the Trimouns quarry area, five tectonic phases have been determined; these have been designated as P0, P1, P2, P3 and P4:

Phase P0 (=D2) corresponds to the development of the cleavage or foliation of the rocks during the major Hercynian metamorphism. It was at this stage that the metamorphic zoning of the schistose envelope took place, ranging from sillimanite facies at the footwall to muscovite-chlorite and chlorite-sericite facies at the hanging wall. The migmatization of the mica schist was accompanied by the emplacement of pegmatite bodies.

Phase P1 (=D3) at the footwall is represented by very supple flow-microfolding on a 10-cm to 10-meter scale, deforming the pegmatite veins. In general the axis of these folds, striking north-south, is horizontal. In the epimetamorphic schist of the hanging wall, this movement is marked by meter-long to 10-meter-long folds with an axial strike of N40°.

Phase P2 (=D4) is a phase of large-radius (10 to 100 meters) folding, rarely observed in outcrop but evident from stereographic analysis, particularly in the footwall mica schist.

It should be noted that a spatial stress-related zoning is observed for P0 to P2, with greater intensity at the base than at the top of the structure. A time-related zoning is also evident in the variable intensity of deformation, with the following deformations at the footwall: (1) flux and plastic flow at P0; (2) axial cleavage and plastic deformation at P1; and (3) broad deformation with no foliation at P2.

Phase P3 (=D4) is the last major phase in the thrust of the hanging wall over the footwall, producing specific physiochemical conditions that favored alteration of the mineralization. This phase was responsible for a major reduction in the thickness of the metamophosed Paleozoic units, for the imbrication of most of the units in the thrust plane, and for the permeability favoring the circulation and action of hydrothermal fluids.

Phase P4 corresponds to the Late Hercynian, or Pyrenean, movements. The major movement of this phase was a relative sinistral (leftward) flow of the hanging wall with respect to the footwall. "This phase was responsible for the large thickness variations in the deposit, locally stretched and laminated and elsewhere broadened to give a boudinaged lenticular aspect" (Pinato, 1999).

The structure corresponds to a décollement plane of the epimetamorphic cover over the foliated metamorphic rock, giving rise to irregular alternating layers of talc and chlorite.

The formation of the deposit resulted from a telescoping of geological events, i.e. the last Hercynian phase of folding, the overthrusting of the basement by the cover rocks with lamination of the dolomite and country rock, the percolation of magnesian hydrothermal fluids and chloritization of the aluminosilicate facies (mica schist, aplite, pegmatite), and finally metasomatic "talcification" of the dolomite and siliceous rocks.

The talcose mineralization has a close relationship with the magnesian unit of the hanging wall.

The mineralized (talcose-chloritic) formation, trending North-South to N10E° with an easterly (25° to 80°) dip, lies between the foliated metamorphic rocks of the footwall (gneiss, heterogenous migmatite) and the pelitic formations, with dolomitic intercalations, of the hanging wall. Its thickness varies from 20 meters at the ends to more than 80 meters in its central part. All of the rare-earth minerals come from this zone (Fortune, 1971; Fortune *et al.,* 1987; Gatel , 1990).

Footwall rocks (Cambrian): The footwall consists of pegmatite and calc-silicate gneiss overlain by a few thrust outliers of mica schist or aluminosilicate formations in contact with the chloritic mineralization.

Hanging-wall rocks (Late Ordovician carbonates): The hanging wall is composed of dark-colored to black chlorite-graphite schist with thick, variably metamorphosed, intercalations of dolomite that in places has a banded or striped apppearance. Locally this formation can harbor a vuggy fracture zone.

The suite of rare-earth element-bearing minerals present at Trimouns is remarkable, and is of great scientific interest for the study of how rare-earth elements are distributed among the different mineral families (carbonates, silicates, etc.) under low-temperature hydrothermal conditions. Thermometric and fluid-inclusion studies of chloritic and scarce apatite ore have revealed that the formation temperature of the deposit was 320°C for a pressure of 2.5 kbar (Parseval, 1992). The age of the deposit, as determined by U-Pb chronometry on samples of xenotime and monazite (Schärer *et al.,* 1999), is between 97 and 112 million years.

WHAT ARE "RARE EARTHS?"

The Rare Earths form a group of 17 elements in the Periodic Table accounting for approximately one-sixth of all the known elements. These include scandium, yttrium, lanthanum and the lanthanides. The term "Rare Earths" derives from the fact that these elements were not predictable and had not yet been discovered when Mendeleev derived the Periodic Table; thus they were considered rare when they were discovered.

Table 1. **The Rare Earths Elements.**

21 Sc (Scandium) * Parodi 1998
39 Y (Yttrium) *
57 La (Lanthanum) *
58 Ce (Cerium) *
59 Pr (Praseodymum) *
60 Nd (Neodymum) *
61 Pm (Promethium)
62 Sm (Samarium) *
63 Eu (Europium)
64 Gd (Gadolinium)*
65 Tb (Terbium)
66 Dy (Dysprosium)*
67 Ho (Holmium)
68 Er (Erbium)
69 Tm (Thulium)
70 Yb (Ytterbium)
71 Lu (Lutetium)

* present at Trimouns (Moëlo *et al.,* 1974)

All of the Rare Earth elements occur naturally, with the exception of the unstable promethium, a product of uranium fission. Moreover, the qualifier "rare" is actually not justified for most of these elements, some of which, such as cerium, lanthanum and neodymium, are more common than lead in the Earth's crust (Forret and Pomerol, 1954).

Most of the rare earths are "transition" elements, characterized by the fact that the electron sublayers *d* or *f* are filled after the higher sublayers *s* and *p*. In the cases of scandium (atomic number 21) and yttrium (atomic number 39), these are, respectively, sublayers *3d* and *4d*. For the lanthanides, starting at cerium, it is sublayer *4f* (lanthanum is not a transition element).

This anomaly in the filling of the sublayers is explained by the energy of the atomic orbitals in relation to the number of protons and neutrons in the nucleus. As a consequence of this anomally, the trivalent ions formed by the various Rare Earth elements (through the loss of the outer electrons *s* and *d*) all have the same remaining outer electron envelope (corresponding to xenon for the lanthanides). It is therefore impossible to separate the Rare Earths chemically; this problem was only understood through the efforts of the Manhattan Project.

The physical properties of the Rare Earths effectively depend on the total number of *4f* electrons, and thus the properties vary. In the solid state, lanthanum and the lanthanides preserve the free atom properties that they share with the actinides in the Periodic Table. Among other things, the ionic radii decrease slightly with increasing atomic number (this phenomenon is called the lanthanide contraction). The lanthanide ions thus possess discrete energy

Table 2. **Rare earth minerals found at Trimouns.**

Carbonates

Bastnäsite-(Ce)
Parisite-(Ce)
Synchisite-(Ce)

Phosphates

Monazite (Ce)
Xenotime-(Y)

Silicates

Aeschynite (Y)

Oxides

Allanite-(Ce)
Dissakisite-(Ce)
Gatelite-(Ce)
Hingganite-(Y)
Iimoriite-(Y)
Thortveitite-(Sc)
Törnebohmite-(Ce)
Trimounsite-(Y)

Table 3. **Minerals found at Trimouns and their abundances.**

Native elements

- Graphite ++++
- Sulphur +

Sulphides

- Arsenopyrite +
- Chalcopyrite +
- Galena +
- Pyrite ++++
- Pyrrhotite +
- Stibnite +

Oxides

- Aeschynite-(Y) ++
- Anatase +
- Brookite +
- Cassiterite ++
- Goethite +
- Hematite +
- Limonite +++
- Niobo-Tantalate +
- Quartz +++
- Rutile + +

Halides

- Halite +

Carbonates

- Aragonite ++
- Bastnäsite-(Ce) +++
- Calcite ++++
- Dolomite ++++
- Malachite ++
- Parisite-(Ce) ++
- Synchisite-(Ce) +++

Sulphates

- Gypsum ++

Phosphates

- Fluorapatite +
- Monazite-(Ce) ++
- Xenotime-(Y) ++

Silicates

- Albite ++
- Allanite-(Ce) +++
- Almandin ++
- Chabasite +++
- Chlorite ++
- Clinochlore (Sheridanite) +++
- Clinozoizite +
- Diopside +
- Dissakisite-(Ce) +++
- Epidote ++
- Gatelite-(Ce) + (type locality)
- Hellandite-(Y) +
- Hingganite-(Y) ++
- Iimoriite-(Y) ++
- Microcline ++
- Muscovite +++
- Natrolite ++
- Palygorskite ++
- Phlogopite +++
- Schorl (tourmaline) ++
- Stellerite +
- Talc ++++
- Thorite +
- Thortveitite-(Sc) +
- Titanite (sphene) ++
- Törnebohmite-(Ce) +
- Tremolite ++
- Trimounsite(Y) + (type locality)
- Zircon ++

+	very rare
++	rare
+++	common
++++	abundant

levels, both in solution and in solids, which cover the entire wavelength spectrum from infrared to violet. Industry exploits these energy scales, e.g. for the phosphor dots of television screens, fluorescent tubes, lasers and energy converters.

Certain lanthanide ions are paramagnetic and can give rise to interactions. Alloys containing Rare Earth elements can make very powerful permanent magnets that are increasingly in demand.

The Rare Earths now play major roles in advanced technologies. This is a continuing process, and the extent of industrial consumption of Rare Earths is a good indication of a country's technological level (Caro, 1994).

MINERALS

The Trimouns deposit has been the subject of many publications since the mid 19th century, and our knowledge of the mineralization improves with each new study (Capdecomme, 1950; Zwart, 1954; Thiebaut *et al.*, 1965, 1966, 1968; Aranitis, 1967; Artigue, 1978; Fortune *et al.*, 1980, 1986; Moine *et al.*, 1989).

The deposit consists of alternating dominantly talcose and dominantly chloritic layers. It extends over a strike length of 1.5 km and varies in thickness between 20 meters and 80 meters, such that the mineralization has a boudinaged, lenticular appearance. The variation in thickness is due to deformations of the hanging wall, with a flow of the mineralized unit along the broad folds.

The mineralogical uniqueness of the Trimouns deposit is due to the presence of Rare-Earth-Element (REE) minerals in the hanging wall of the talc-chlorite structure. These are found in dolomite vugs and microfissures reminiscent of the Alpine type (Laforet *et al.*, 1980; Descouens and Gatel, 1987; Parseval *et al.*, 1997). However, no equivalent deposit is found in the standard literature on Alpine fissures (Desbuissons, 1909; Niggli *et al.*, 1940; Parker, 1954; Stalder *et al.*, 1973; Gramacioli, 1977; Weibel, 1990; Albertini *et al.*, 1993); not even the classic Lengenbach deposit in Valais, Switzerland, with crystals in a dolomite gangue, is comparable, and REE-bearing pegmatite zones, such as those of Greenland, do not contain a similar paragenesis (Petersen and Secher, 1993). And yet the style of Trimouns crystal specimens resembles that of specimens from Alpine fissures: isolated crystals in matrix, having an aesthetic appearance highly valued by collectors.

Aeschynite-(Y) $(Y,Ca,Fe,Th)(Ti,Nd)_2(O,OH)_6$

Aeschynite is found in the hanging wall of the talc-chlorite mineralization zone, filling saddle-dolomite vugs commonly associated with calcite. Three habits are present: (1) transparent prisms averaging several millimeters in size, pinkish brown to yellowish brown, in places straw-colored, forming groups of interlaced individuals and more rarely isolated crystals; (2) tabular crystals up to 4 cm long and less than 1 mm thick, orange-beige in color, sprinkled with millimeter-size euhedral crystals of "limonitized" pyrite; and (3) orange-yellow acicular sprays.

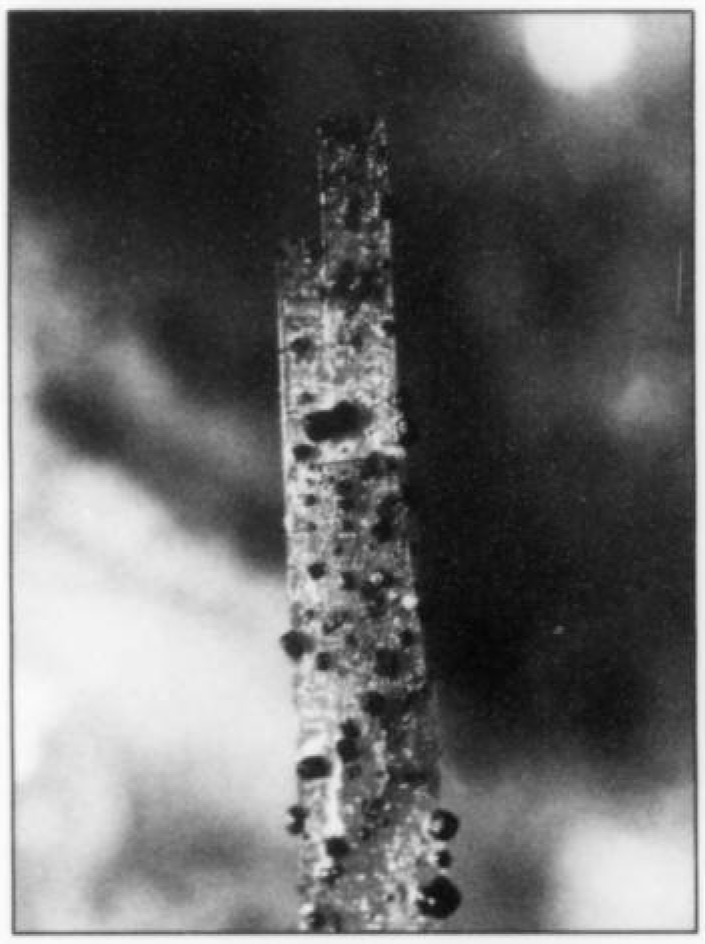
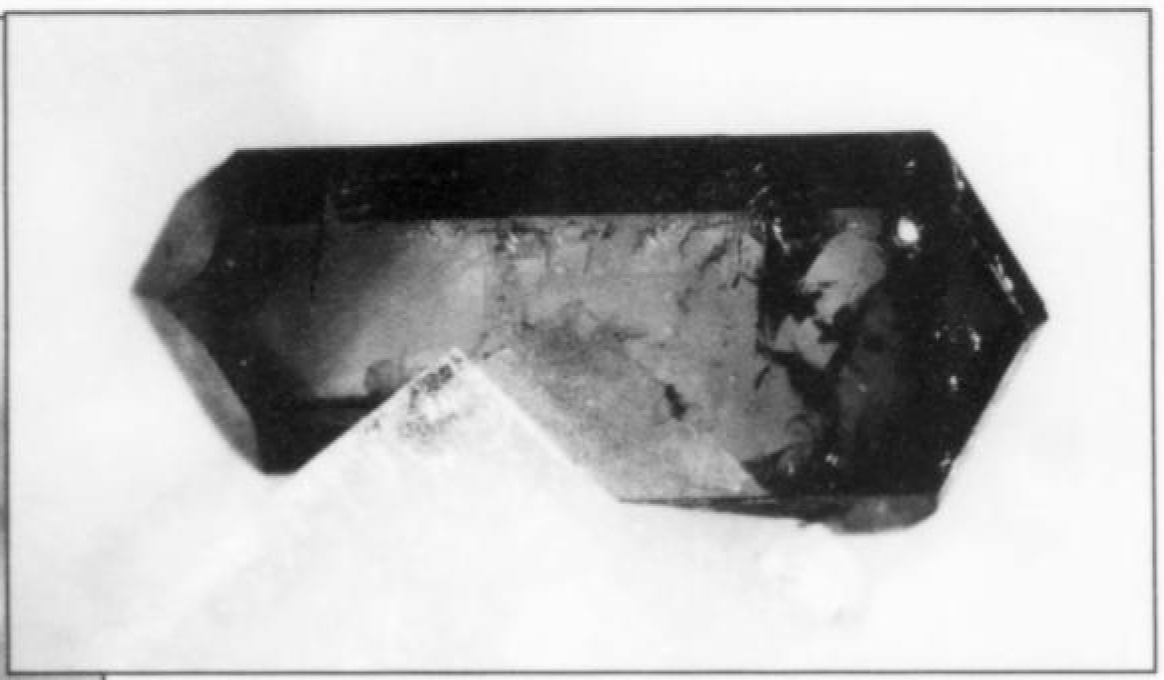


Figure 7. **Aeschynite-(Y) crystal, 0.5 mm wide, from Trimouns. Robert Vernet photo.**

Electron probe microanalysis of a yttriferous aeschynite gave the ideal formula Ti_2 (REE)$(O,OH)_6$. The unit cell is $a = 5.174$, $b = 10.76$, $c = 7.59$. Of note is the presence of yttrium, gadolinium, samarium, neodymum, and dysprosium (Deliens, 1991; Zappel and Leverkusen, 1986).

Albite $NaAlSi_3O_8$

Albite is asociated with slightly smoky quartz. Most of the crystals come from the footwall in the talc-chlorite zone, though the mineral is also found in the hanging-wall pegmatite of the talc structure. The albite crystals are several millimeters to 1 cm in size, translucent, and white to colorless; some are twinned.



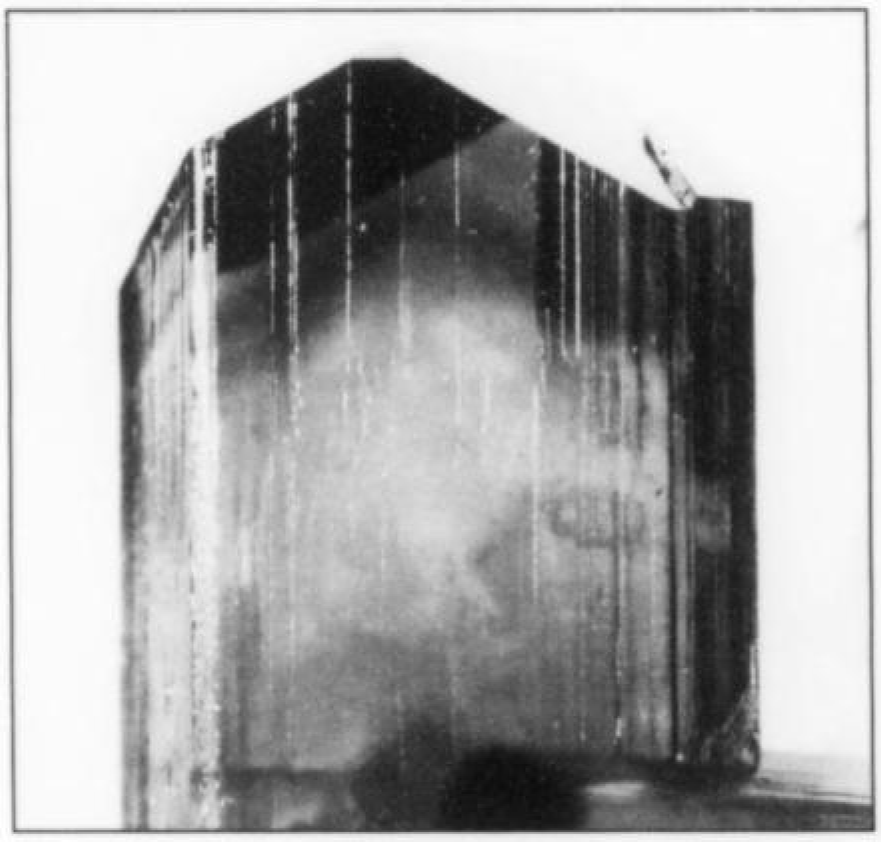


Figure 8. **Allanite-(Ce) crystal, 3.7 mm, from Trimouns. Robert Vernet photo.**

Figure 9. **Allanite-(Ce) crystal, 6 mm, from Trimouns. Robert Vernet photo.**

Figure 10. **Dissakisite-(Ce) crystal, 3 mm, from Trimouns. Robert Vernet photo.**

Allanite-(Ce) and/or **Dissakisite-(Ce)**
$(Ca,Ce,La)_2(Al,Fe^{2+},Fe^{3+})_3Si_3O_{12}(OH)$
$Ca(Ce,La)MgAl_2(SiO_4)_3(OH)$

Allanite and dissakisite are chemically similar, and are distinguished primarily on the basis of the Fe:Mg ratio. Individual crystals tend to be rather homogeneous; many line scans carried out by a scanning electron microscope (SEM) analysis of a crystal and the corresponding diffractogram for the same crystal demonstrate this (Pinato, 1999). Dissakisite was first discovered at Balchen Mountain, Antarctica (Grew *et al.*, 1991).

Allanite from Trimouns was described by Moëlo *et al.* in 1974 and identified by X-ray diffraction and qualitative analyses. Chemical analysis shows that it is a magnesium-bearing allanite that occurs as elongate crystals, and more rarely as flattened prisms; it is associated with the banded dolomite with intercalated millimeter-thick graphitic beds, and with white crystalline dolomite. The translucent crystals, with generally smooth (more rarely rough) faces, are brown, reddish brown, purplish brown, greenish brown, and pale brown to pale chestnut. They are found in a gangue of white to gray dolomite and as doubly terminated "floater" crystals in geodes and vugs (of several centimeters) in talc that has crystallized into translucent folia. Some crystals show growth phantoms. It would appear that when the color is pale the species is dissakisite and when the color is darker the mineral is probably allanite.

Allanite and dissakisite form isolated crystals to 6.5 cm long and a few millimeters thick, and as groups of enmeshed individual crystals each several millimetres in length. The crystals can show etch figures indicating that conditions changed near the end of the crystallization; these figures could be confused with signs of incipient metamictization, but the mineral is not metamict. The crystals are invariably pleochroic, as are all crystals of the minerals of the epidote group.

Allanite/dissakisite can be associated with bastnäsite, synchisite, parisite, quartz, calcite, and very rarely with hingganite. It is the most common REE species in the Trimouns deposit and has been consistently found since the appearance of the first REE minerals in the hanging wall of the talc-chlorite zone, in the hydrothermally altered zone at the contact of the dolomite (top part of the lenses) with Ordovician black shales.

Almandine $Fe^{2+}_3Al_2(SiO_4)_3$

Red-brown to dark brown almandine crystals from 1 mm to 1 cm occurs in the pegmatite zone in the footwall.

Anatase TiO_2

Anatase occurs in the hanging wall of the talc-chlorite mineralization, in white saccharoidal dolomite. It is very rare in the deposit, and only a few specimens have been found. The crystals are everywhere less than 1 mm in size and brown in color. Identification was by Raman spectroscopy.

Aragonite $CaCO_3$

Aragonite was found in 1987 in the footwall of the talc structure, forming whitish to beige, acicular, stalactitic crystals in a fracture zone in contact with indurated black rock. Rare radial sprays, less than 1 mm in size, have been reported in geodes in dolomite, in the hanging wall of the talc structure.

It has been found in association with pyrite.

Arsenopyrite FeAsS

Around 1900, arsenopyrite was reported as forming crystalline masses, with rare millimeter-size crystals, near the footwall of the talc mineralization in contact with pegmatite associated with quartz. The following faces were noted: {100}, {011}, {101} and {001} (Lacroix, 1896). Arsenopyrite has not been seen at the deposit since then.

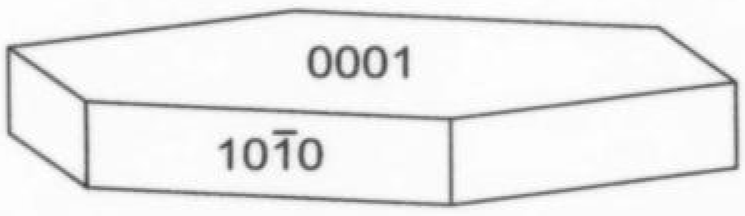


***Figure 11.* Bastnäsite-(Ce) idealized crystal drawing, Trimouns (Favreau, 1994).**

Bastnäsite-(Ce) (Ce,La)(CO$_3$)F

Three types of bastnäsite have been found at the site. Most commonly it occurs as brown to orange-red, hexagonal prismatic crystals, exceptionally to 3.5 cm long and several millimeters thick, with $\{10\bar{1}0\}$ and {0001} as the main forms. The best specimens were collected in 1985 and 1986.

Thin-tabular hexagonal crystals to several millimeters across also belong to this first type. Aggregates of these crystals may be parallel-growth stacks or regularly offset clusters up to 3 cm across, similar to the "iron roses" of Alpine hematite. Isolated, pale pink tabular crystals to 1 mm are also found.

The second type consists of columnar bastnäsite-(Ce) crystals, some of them partially gemmy, less than 1 mm thick but reaching 2 cm long. Their color varies from orange-yellow to reddish brown.

In the third type, bastnäsite-(Ce) forms squat, orange-red to brown, hexagonal crystals reminiscent in form of the vanadinite crystals of Morocco; they also resemble the generally more elongated bastnäsite crystals of Zegi Mountain, Northwest Frontier Province, Pakistan. The best crystals of this type reach 6 mm long.

All of these crystals are found in vugs or in fissures in calcite within a crystalline dolomite marked by bands of dark blue to blackish graphite a few millimeters thick. The vugs are located in the footwall of a fractured area within the hydrothermally altered zone, near its contact with the black shales forming the hanging wall of the talc mineralization.

Bastnäsite-(Ce) crystals of the first type are commonly found in

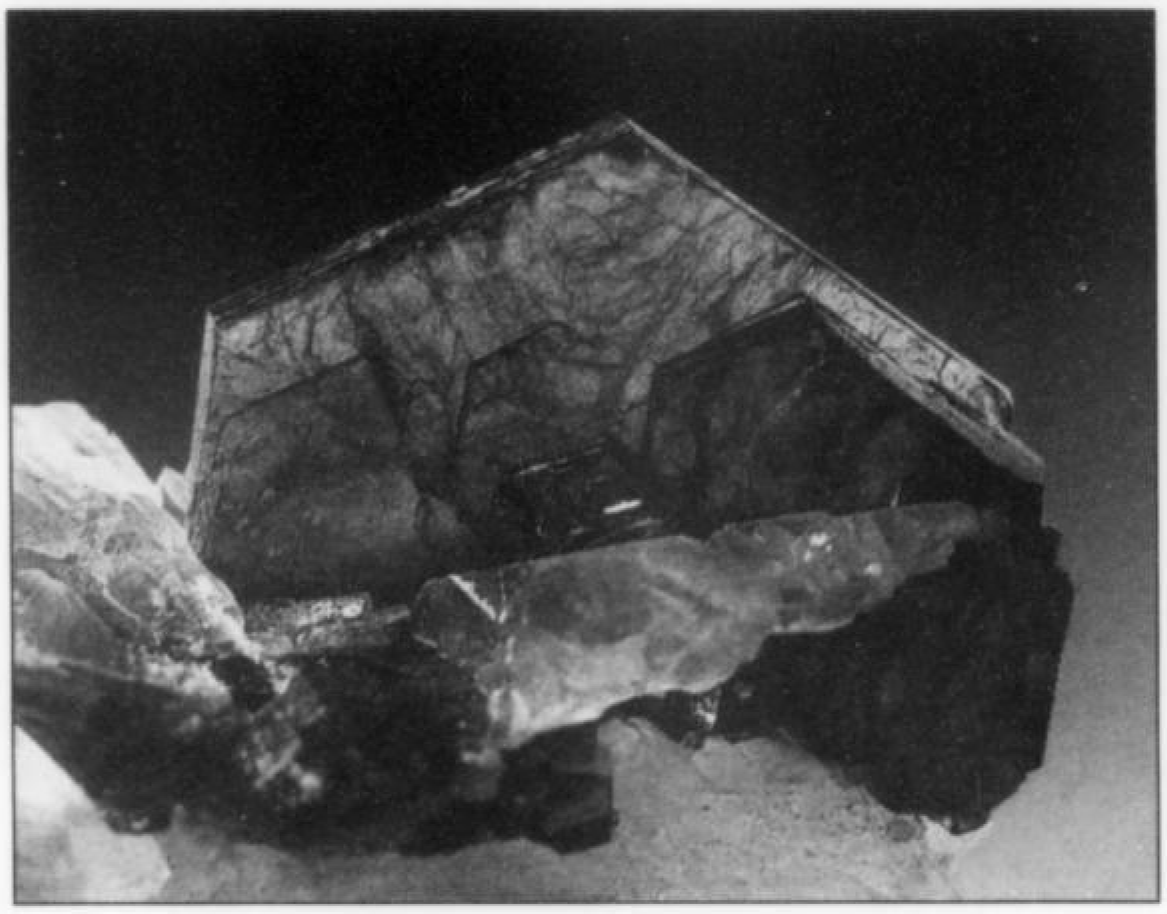


***Figure 12.* Bastnäsite-(Ce) crystal, 2.5 cm, on calcite, from Trimouns. F. Marty collection; Robert Vernet photo.**

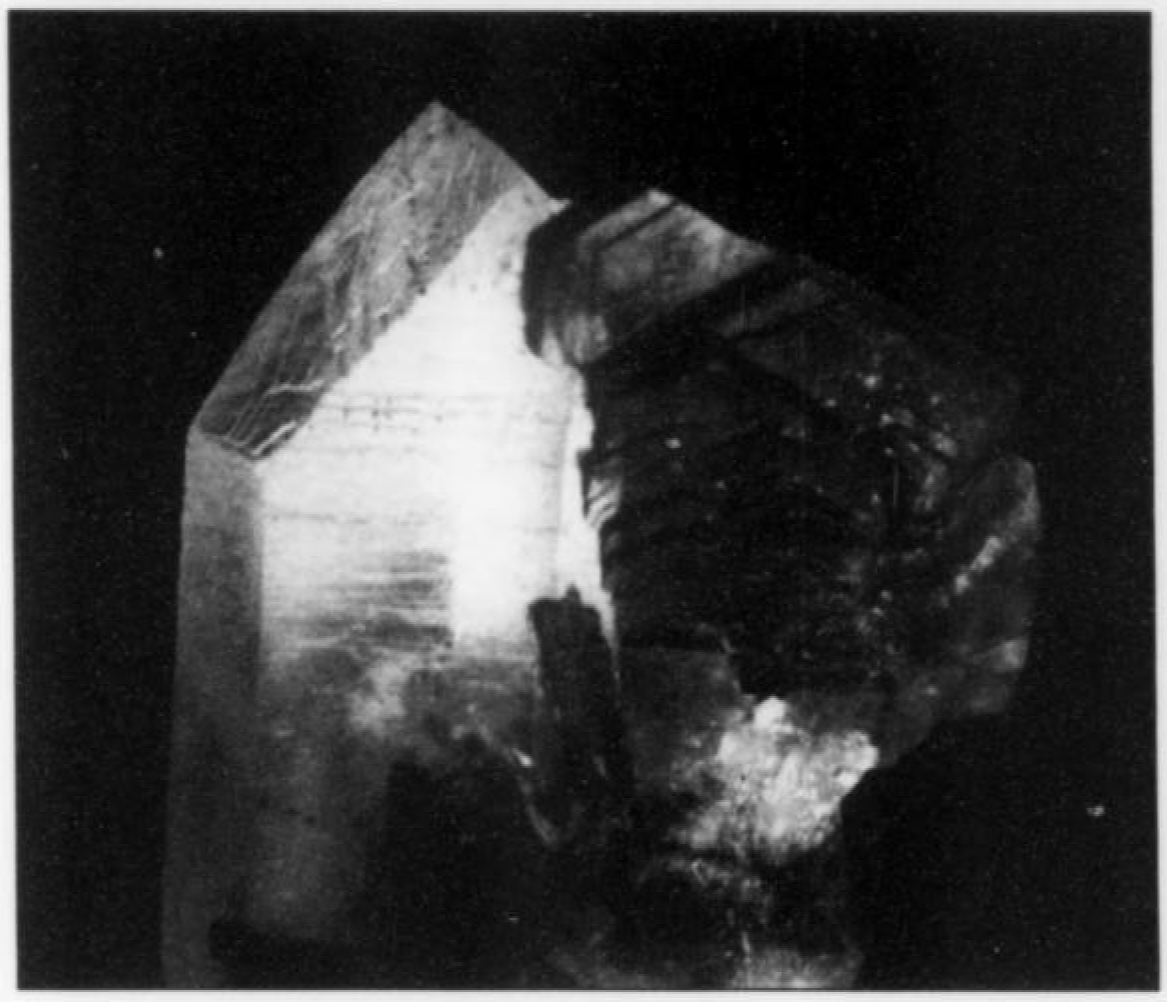


***Figure 13.* Bastnäsite-(Ce) crystals to 7 cm on quartz from Trimouns. Robert Vernet photo.**

***Figure 14.* Bastnäsite-(Ce) crystal, 1 cm, on dolomite from Trimouns. Martin Zinn collection; Jeff Scovil photo.**

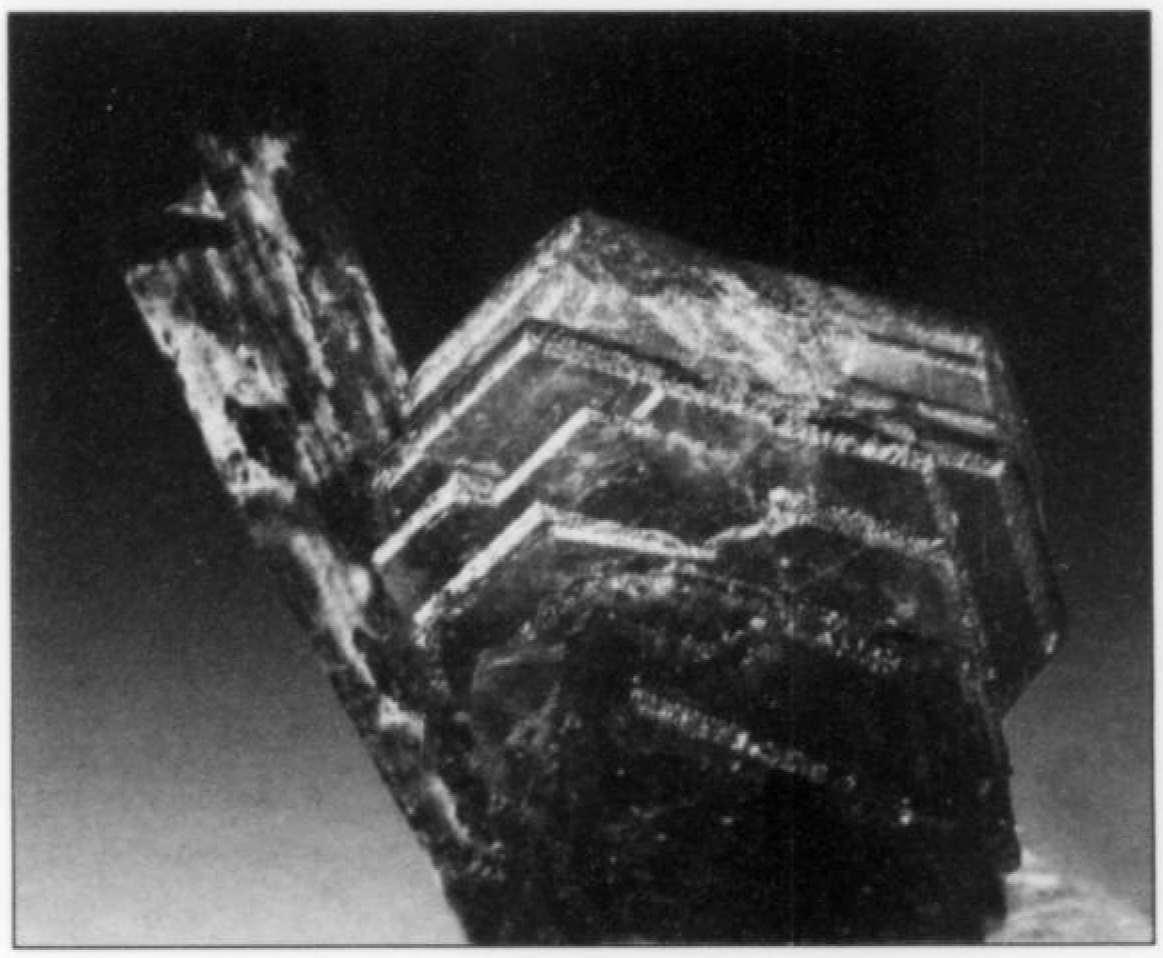


***Figure 15.* Bastnäsite-(Ce) crystals with allanite-(Ce), 7 mm, from Trimouns. Robert Vernet photo.**

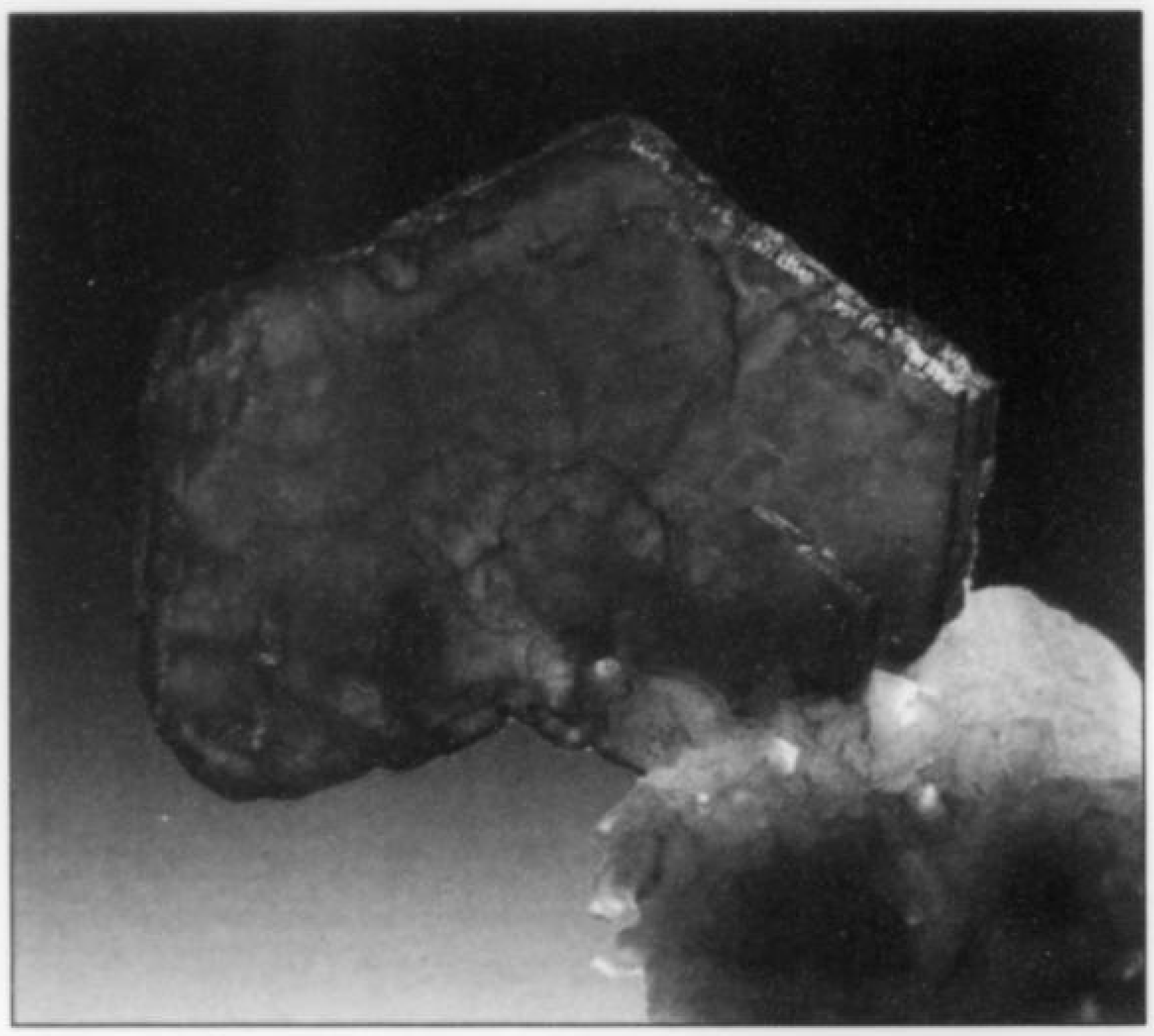


Figure 16. Bastnäsite-(Ce) crystal, 2.4 cm, on dolomite from Trimouns. F. Marty collection; Robert Vernet photo.

Figure 17. Bastnäsite-(Ce) crystal, 2.4 cm, on dolomite from Trimouns. F. Marty collection; Jeff Scovil photo.

Figure 18. Bastnäsite-(Ce) crystal, 2.4 cm, on dolomite from Trimouns. F. Marty collection; Jeff Scovil photo.

Figure 19. Bastnäsite-(Ce) crystal. 5.2 mm, on dolomite from Trimouns. F. Marty collection; Robert Vernet photo.

Figure 20. Bastnäsite-(Ce) crystals to 7 mm, on dolomite from Trimouns. Robert Vernet photo.

association with allanite and/or dissakisite, and less commonly with quartz (Doll, 1983). A particularly remarkable association should be noted: it consists of millimeter-size flakes of bastnäsite deposited as a crown around synchisite (a syntactic intergrowth). These specimens are found in gangue of whitish to bluish-gray crystallized dolomite, more rarely on calcite crystals (some of the "nailhead spar" habit), or on talc crystallized as nacreous flakes lining pockets many centimeters across.

Brookite TiO_2

Brookite occurs in the same environment as the anatase and rutile and has an identical paragenesis; it is visually distinguishable from the two polymorphs. The crystals are brown and less than a millimeter in size (Favreau, 1994).

Calcite $CaCO_3$

Abundant in the deposit, calcite occurs as isolated crystals or in attractive clusters. Prismatic crystals of varying length/width ratios reach 20 cm long, and often display the classic "nailhead" form (Lacroix, 1962). Crystals twinned on (0001) or (02$\bar{2}$1) may be several cm long. Calcite crystals are commonly perched on a matrix of rhombohedral dolomite, including curved, saddle-shaped dolomite crystals, and more rarely on crystalline talc. Large "floater" crystals of calcite were discovered in 1983. Rarely pinkish violet in color, the crystals fluoresce green in shortwave ultraviolet light, and are in some cases associated with quartz.

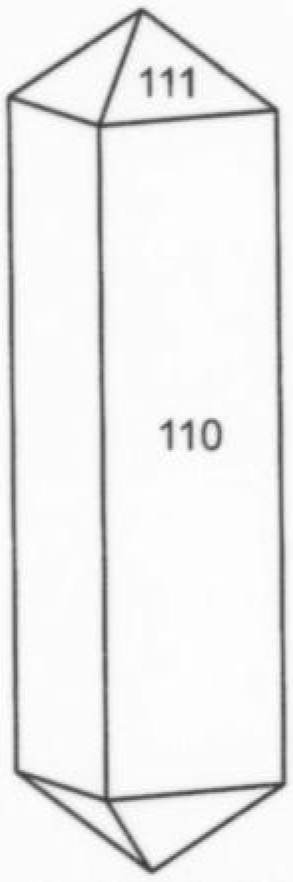


Figure 21. **Cassiterite, idealized crystal drawing, Trimouns (Favreau, 1994).**

Figure 22. **Cassiterite crystals to 3.3 mm from Trimouns. Robert Vernet photo.**

Figure 24. **Cassiterite twin, 1.8 mm from Trimouns. F. Marty collection; Robert Vernet photo.**

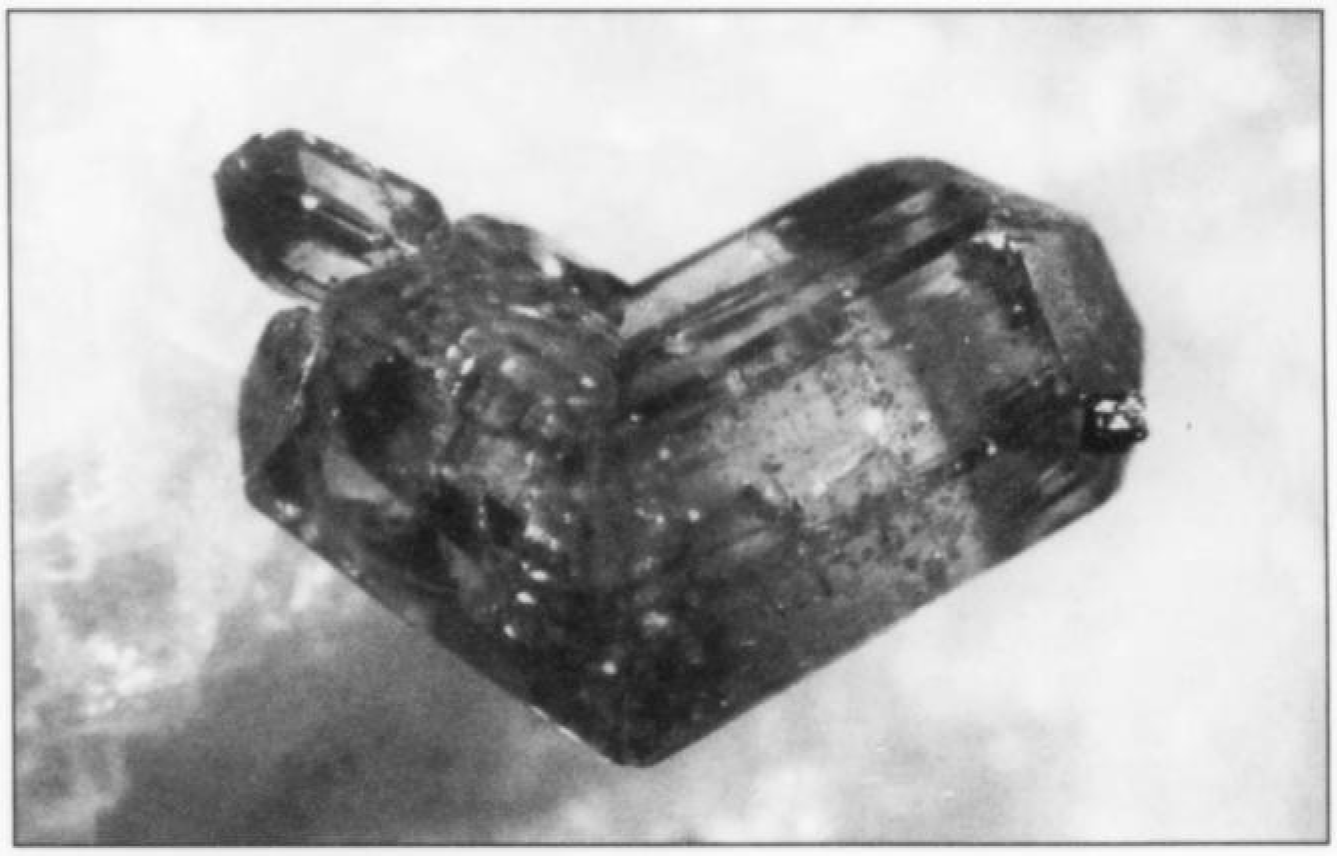


Figure 23. **Cassiterite crystals to 4.5 mm from Trimouns. Robert Vernet photo.**

Cassiterite SnO_2

Cassiterite occurs as elongated, translucent dark brown tetragonal prisms of the "needle tin ore" type. The crystals average several millimeters long, a few exceeding a centimeter, and the terminations are formed by pyramidal faces {111} or {101} in combination with {110} and {100} respectively.

Large euhedral crystals as much as 3.5 cm long were found in 1994 associated with flakes of talc.

Astonishing yellow-brown cassiterite crystals, commonly twinned and partially of gem quality with darker zones near the tops of the crystals, were found in 1995 in the hydrothermally altered part of the hanging wall. They were collected from a vug near a fracture zone, associated with calcite and more rarely quartz. The same environment yields colorless to yellowish, millimeter-size crystals, as well as very rare dark brown, twinned crystals several millimeters in size, with flat terminations, resembling ekanite crystals.

Chabazite-Ca $Ca_2(Al_4Si_8O_{24})\cdot 13H_2O$

Chabazite crystals from the deposit are white, translucent, and average several millimeters in size; they are commonly confused with dolomite. They come from the foliated metamorphic rocks in the footwall of the talc-chlorite structure, often in association with stilbite and pyrite (Favreau, 1994). Penetration-twinned crystals are common.

Chalcopyrite $CuFeS_2$

Chalcopyrite has only been identified visually thus far, and so the identification remains uncertain. The crystals are poorly formed (in places as pseudo-scalenohedrons), rarely reach a millimeter in size, and may be associated with aragonite. They come from the footwall of the talc-chlorite mineralization in dark indurated rocks close to the contact with the pegmatite zone (Favreau, 1994). In spite of many searches, the mineral has not been found since the mid-1990's.

Chlorite Group $(Mg,Fe^{2+},Al)_6[(OH)_8I(Al,Si)_4O_{10}]$

Crystals of an unidentified chlorite-group mineral several millimeters in size are found in the footwall of the hydrothermal zone close to the contact with the pegmatites and in the same environment as the clinochlore. They form dark-green tablets and vermiculate spherules as much as 2 cm in diameter (De Parseval *et al.*, 1991). One can find it in association with apatite, titanite, talc and rutile.

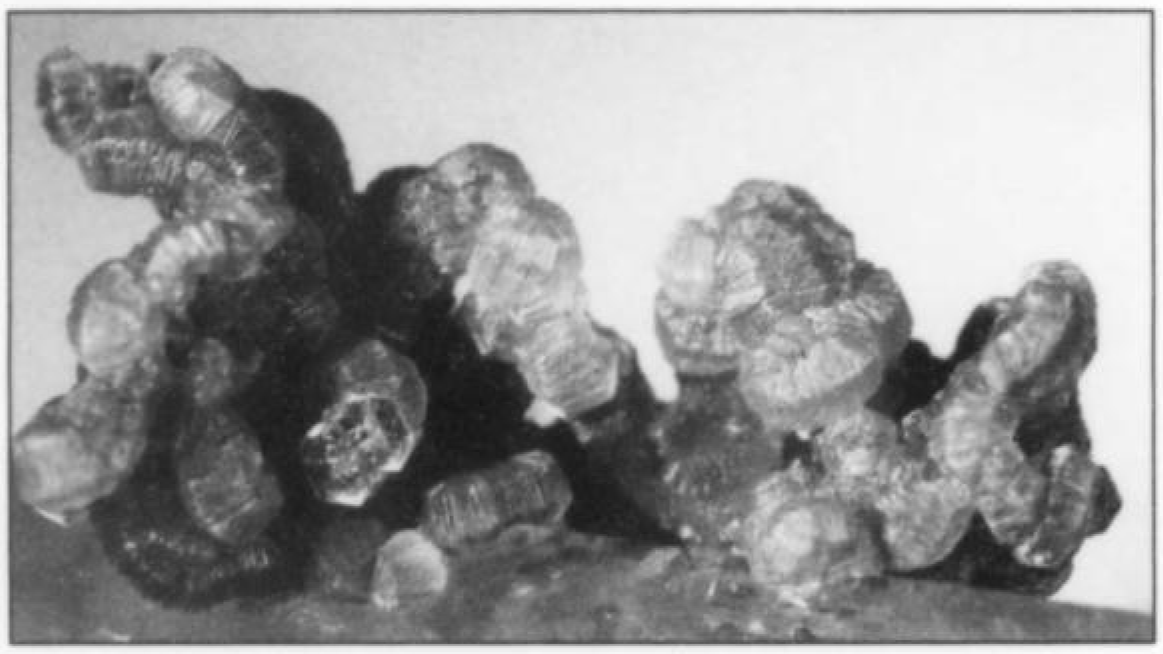


Figure 25. **Clinochlore crystal cluster, 7 mm, from Trimouns. Robert Vernet photo.**

Clinochlore $(Mg,Al)_6(Si,Al)_4O_{10}(OH)_8$

The minerals of the chlorite group are widely represented in the zone close to the footwall of the talc-chlorite structure. Clinochlore occurs in its vermicular form in felted masses with curious subaerial shapes, commonly reaching 2 cm in length for a diameter of less than a millimeter, in a dolomitic gangue. It is also found in the hanging wall of the structure associated with bastnäsite and very rarely with thortveitite.

Clinozoisite $Ca_2Al_3Si_3O_{12}(OH)$

Clinozoisite was found in 1986 in the chloritized zone of the footwall of the talcose structure, as colorless, millimeter-size prisms with a nacreous luster; the crystals are striated longitudinally and in places show a {001} termination.

Diopside $CaMgSi_2O_6$

Diopside is reported in the footwall of the talc structure, forming millimeter-size tabular crystals associated with chlorite.

Dissakisite-Ce (see Allanite)

Dolomite $CaMg(CO_3)_2$

Dolomite is the most abundant mineral in the deposit. It is commonly found crystallized in lenses in the hanging wall, and as saddle-shaped crystals, several millimeters to several centimeters in size, lining the bottoms of geodes, vugs and joints (1st generation), and as undistorted rhombohedral crystals several centimeters in size, perched on the saddle-shaped crystals (2nd generation). Twinning of crystals on (0001) is common.

Dolomite is commonly found in association with calcite and quartz, and is almost always the matrix hosting crystals of bastnäsite, synchisite, and allanite and/or dissakisite.

Epidote $Ca_2Al_2(Fe^{3+},Al)Si_3O_{12}(OH)$

Epidote has been found in a loose block at the entrance of the quarry, but has never been found *in situ*. However, törnebohmite and gatelite, with similar chemical compositions, have been collected in the quarry.

Ferrocolumbite-Ferrotantalite $Fe^{2+}Nb_2O_6$ / $Fe^{2+}Ta_2O_6$

Brown-black to red-brown patches and aggregates a few tenths of a millimeter in size, coming from pegmatite and granitoid in the hanging wall of the talc-chlorite structure, were found in 1992. Microprobe analysis and thin-sections from the chloritized zone confirm that the species is part of the ferrocolumbite-ferrotantalite series (Gatel, personal communication, 2001).

Fluorapatite $Ca_5(PO_4)_3F$

A few colorless, millimeter-size crystals of fluorapatite were found in 1986. They came from the footwall of the talc structure in the chloritized zone close to the pegmatite.

Galena PbS

Found in the deposit in 1998, galena occurs as patches of several millemeters filling very small vugs in dolomite in the hanging wall of the structure. Visual identification of the material as galena was made on the basis of its bluish gray color, its metallic luster and its perfect cubic cleavage.

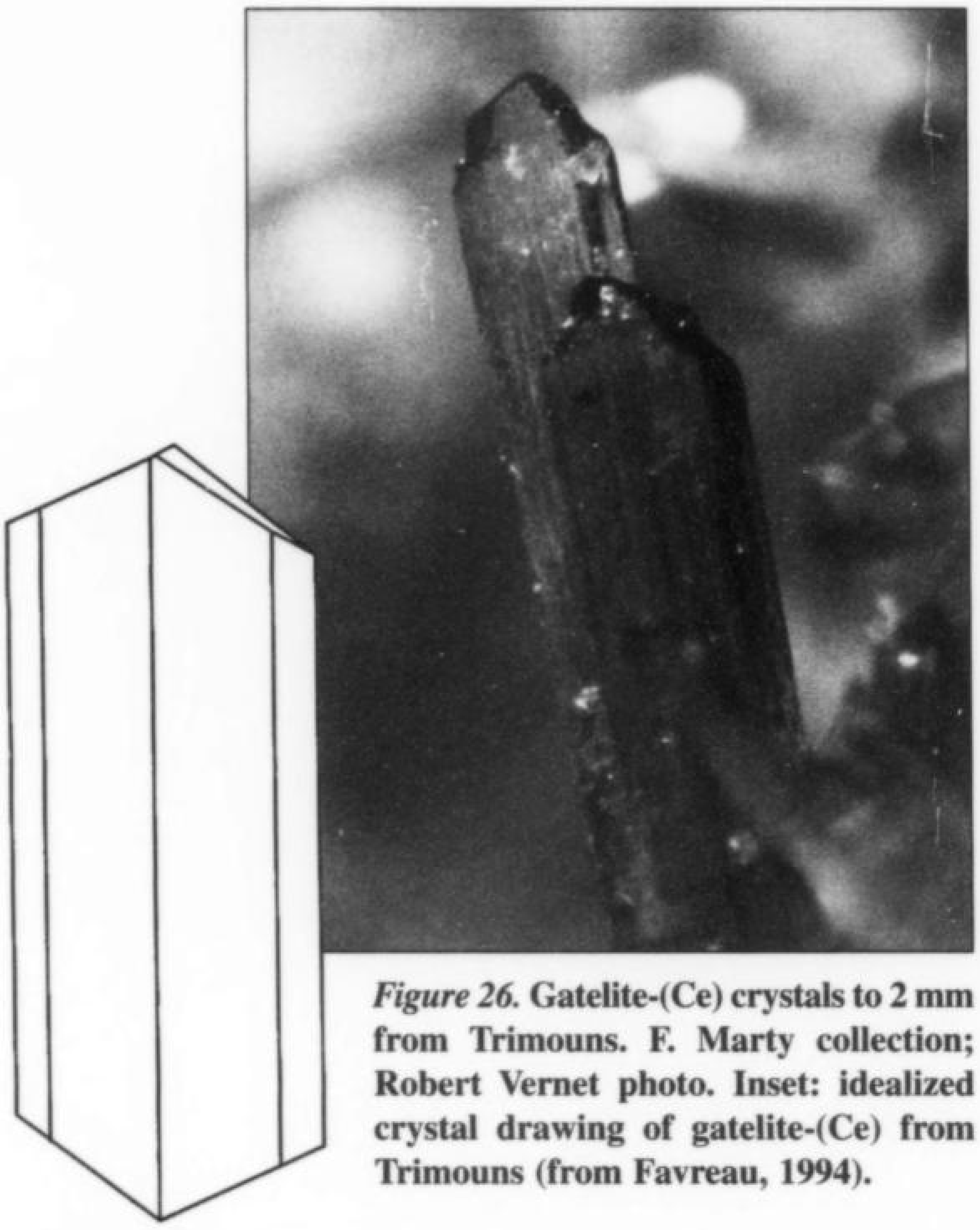


Figure 26. **Gatelite-(Ce) crystals to 2 mm from Trimouns. F. Marty collection; Robert Vernet photo. Inset: idealized crystal drawing of gatelite-(Ce) from Trimouns (from Favreau, 1994).**

Gatelite-(Ce) $(Ca,REE_3)_4[Al_2(Al,Mg)(Mg,Fe,Al)]_4[Si_2O_7]$-$[SiO_4]_3(O,F)(OH,O)_3$

Gatelite-(Ce) is a new mineral species described by Guy Bernadi and Freddy Marty in 1998, and named for M. Gatel, a French amateur mineralogist (AFM).

The mineral, which has not yet been found *in situ*, comes from vuggy blocks of pale crystalline saddle-shaped dolomite, and forms groups of crystals up to 1.6 mm in size. The crystals are colorless to whitish, resembling very pale dissakisite, and display longitudinal striations. The samples appear to come from the upper part of the hydrothermally altered lens in the hanging wall of the talc-chorite structure.

Some crystals are found in association with chlorite. These are easily confused with crystals of clinozoisite, but do not occur in the same paragenesis.

Goethite α-$Fe^{3+}O(OH)$

Goethite is found in massive, locally earthy aggregates near the talc lens.

Graphite C

Graphite is abundant in the quarry, particularly in the hanging wall of the talc-chlorite structure. It forms millimeter-thick, black, amorphous layers interbedded with very pale crystalline dolomite, imparting a banded or striped appearance. It also occurs as shiny black 10-cm amygdules. More rarely, isolated flat fibers of graphite several millimeters long have been reported.

Gypsum $CaSO_4 \cdot 2H_2O$

Massive gypsum, a byproduct of the decomposition of pyrite, occurs intermixed with calcite and talc; colorless, millimeter-size crystals have also been found. Species determination was made by analysis with the scanning electron microprobe (SEM) (G. C. Parodi, pers. comm.).

Halite NaCl

Halite, as granular aggregates included in quartz, was identified by electron microprobe (Parodi, pers. comm., 1998).

Hellandite-(Y) $(Y,Ca)_6(Al,Fe^{3+})Si_4B_4O_{20}(OH)_4$

Hellandite forms pale pink, tabular hexagonal crystals less than 1 mm in size, with a pronounced nacreous luster. It is very rare in the deposit, having been identified by X-ray diffraction on a few samples from the quarry dump. It is not thus far been seen *in situ*. The mineral was reportedly found only once, and its authenticity appears doubtful.

Hematite α-Fe_2O_3

Hematite is found very rarely as millimeter-size euhedral crystals forming rosettes and pseudomorphs after pyrite associated with saddle-shaped dolomite crystals.

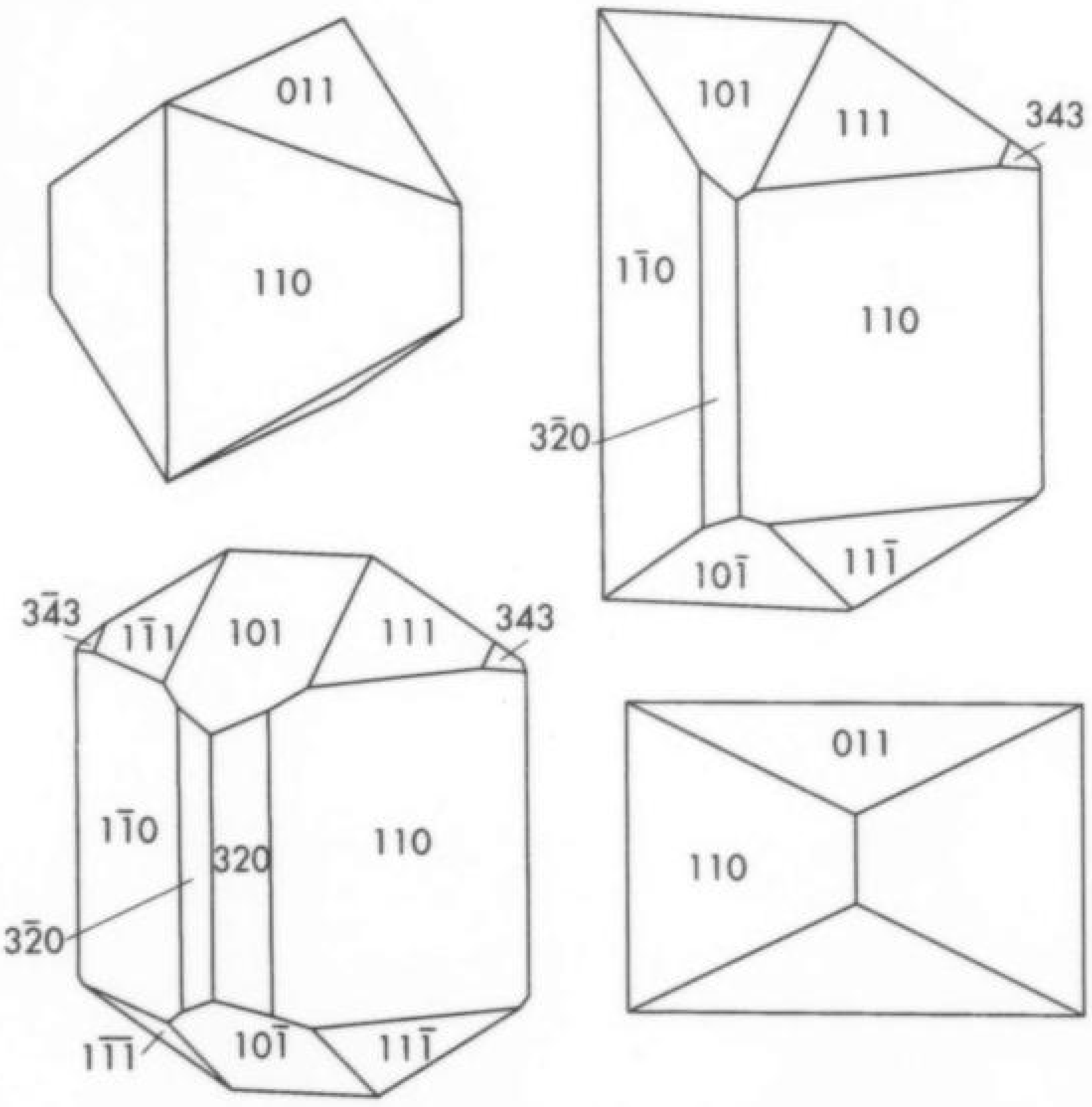


***Figure 27.* Hingganite-(Y) crystal drawings, Trimouns (from Gatel *et al.*, 2002).**

Hingganite-(Y) $(Y,Yb,Er)_2Be_2Si_2O_8(OH)_2$

Hingganite occurs as isolated, prismatic, translucent crystals and also as fan-shaped groups from a few millimeters to 1 cm long, with a pale-green to pale-yellow color (Voloshin *et al.*, 1983; Miyawaki *et al.*, 1984, 1990). The samples were found between 1990 and 1993.

Crystals ranging in color from greenish to yellowish to pale beige or pale gray-green were discovered in 1986 in vugs in

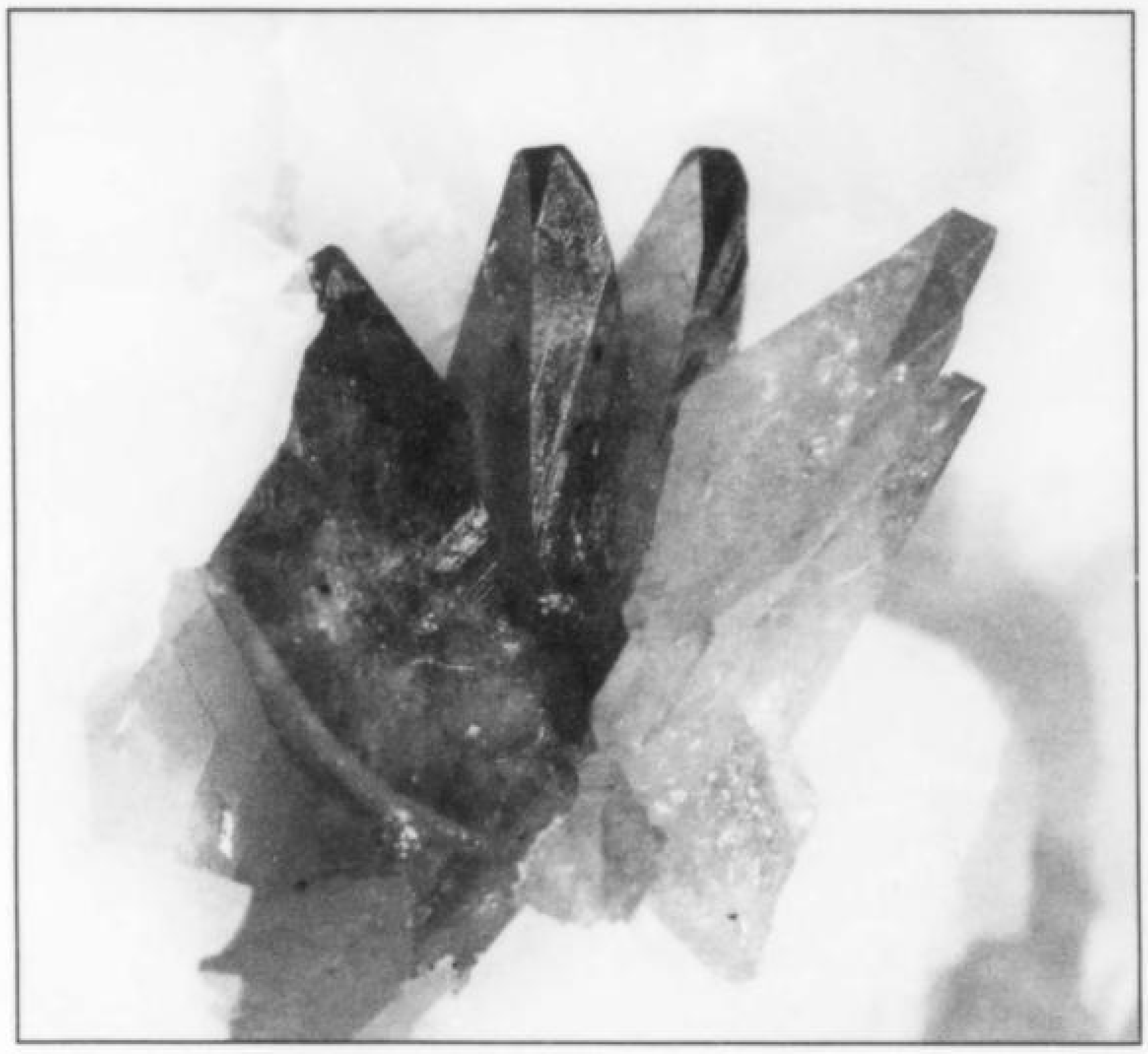


***Figure 28.* Hingganite-(Y) crystal cluster, 3.3 mm, from Trimouns. Robert Vernet photo.**

***Figure 29.* Hingganite-(Y) crystal cluster, 6 mm, from Trimouns. Robert Vernet photo.**

***Figure 30.* Hingganite-(Y) crystal cluster, 5.3 mm, from Trimouns. G. Bernadi collection; Robert Vernet photo.**

Figure 31. **Iimoriite-(Y) crystal, 4 mm, in dolomite from Trimouns. Jordi Fabre specimen; Jeff Scovil photo.**

Figure 33. **Iimoriite-(Y) crystal, 2 mm, in dolomite from Trimouns. F. Marty collection; Robert Vernet photo.**

crystalline dolomite. Some crystals show bevelled terminations as well as truncations on the top faces of the crystals, i.e. the basal pinacoid faces. Rare in the deposit, hingganite-(Y) is part of the dolomitic metasomatic suite from the hanging wall of the talc structure. It is found in the same environment as iimoriite. This hingganite has a very low iron content (analysis by Dr G. Parodi).

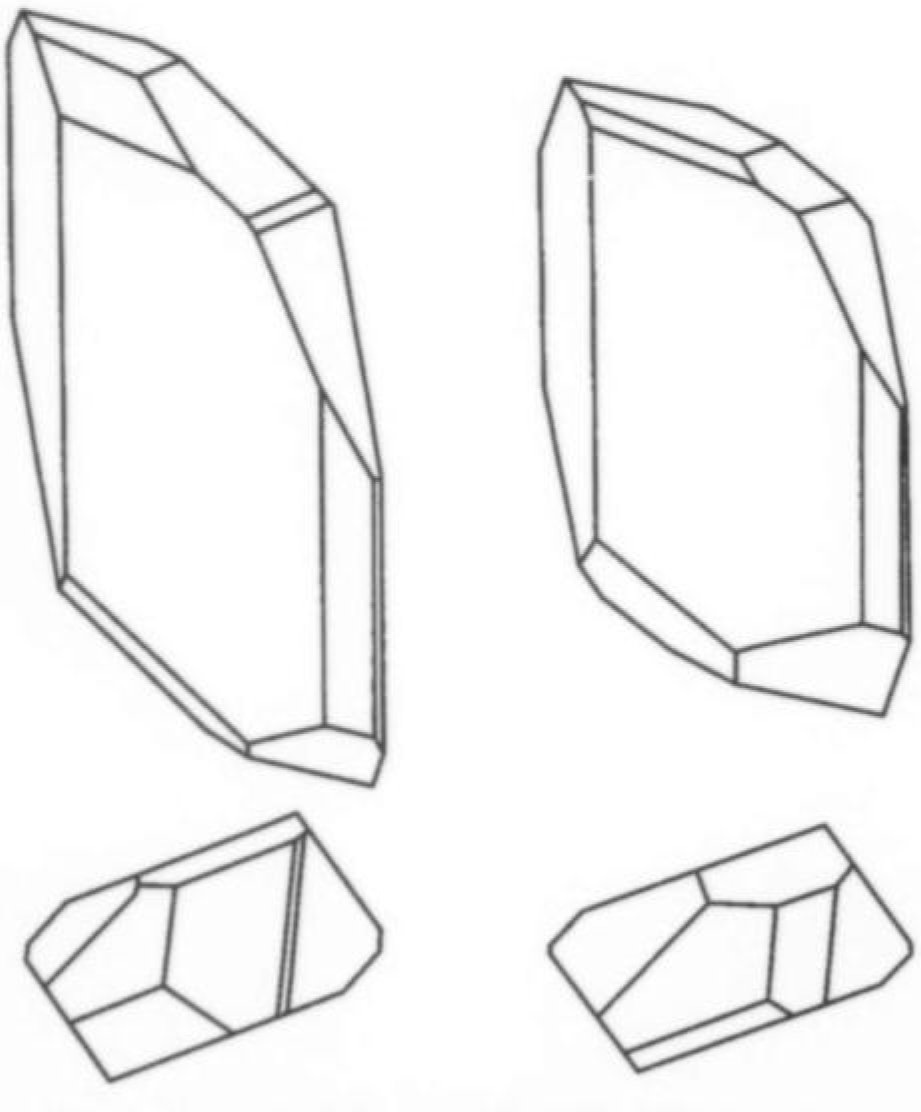


Figure 32. **Iimoriite-(Y) idealized crystal drawings, Trimouns (from Favreau, 1994).**

Iimoriite (Y) $Y_2(SiO_4)(CO_3)$

Iimoriite was previously only known as 3-cm crystalline masses in a pegmatite at Kawatamanachi, Fukushima Prefecture, Japan (Kato and Nagashima, 1970) and in a granite massif at Bokan Mountain, Prince of Wales, Island, Alaska (Foord *et al.*, 1984).

At Trimouns iimoriite generally occurs as pink to colorless, 2 to 3-mm, pink to colorless crystals, some showing gemmy areas, in crystalline dolomite. The crystals are tabular, slightly curved, and longitudinally striated; they occur in matrix of white saccharoidal or saddle-shaped dolomite, most commonly as isolated singles, but occasionally in small groups. Some doubly terminated "floater" crystals of iimoriite-(Y) up to 1 cm in size have been found in vugs in crystalline talc; in rare cases crystals to 1 mm are twinned. X-ray determination of the internal structure of iimoriite gives the following unit cell parameters: $a = 6.573$ $b = 6.651$ $c = 6.454$.

Figure 34. **Iimoriite-(Y) crystal, 1.7 cm, from Trimouns. F. Marty collection; Jeff Scovil photo.**

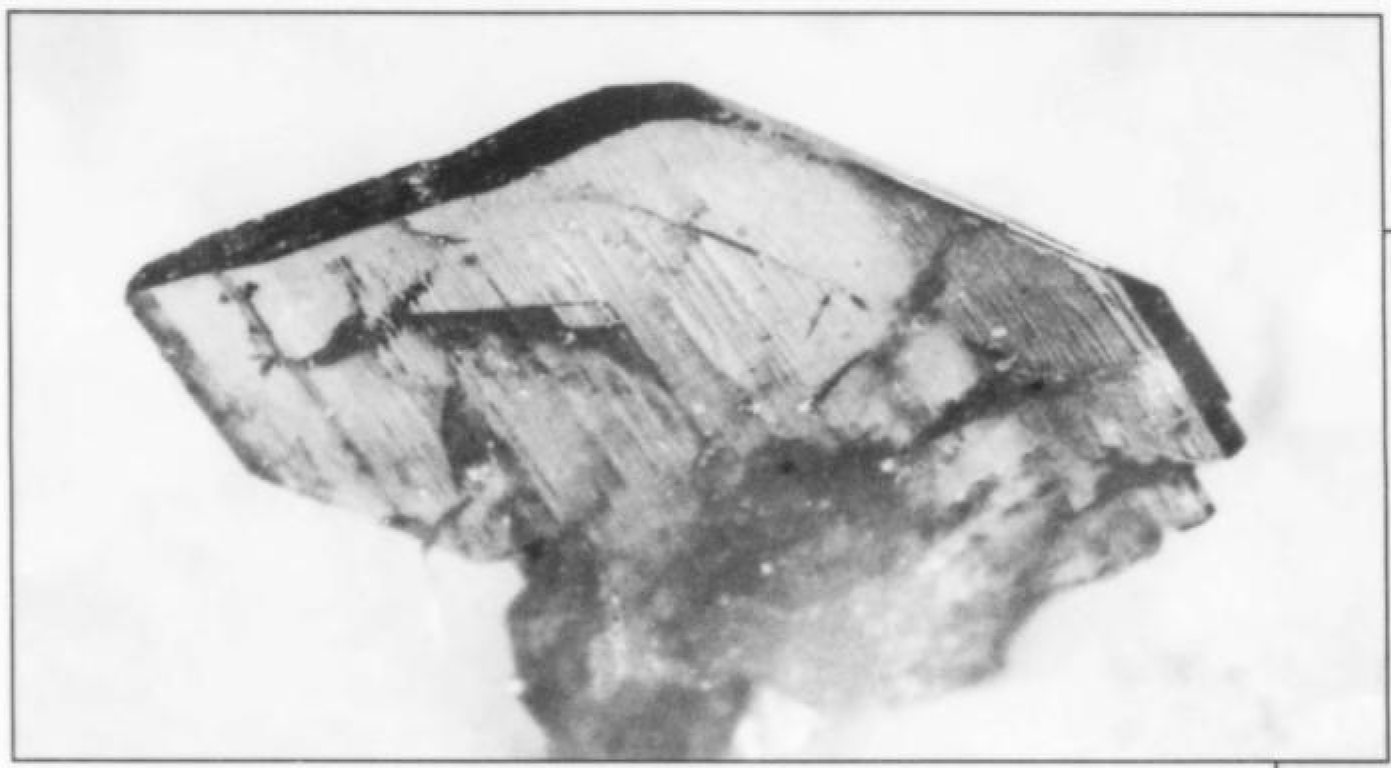


Figure 35. **Iimoriite-(Y) crystal, 4 mm, in dolomite from Trimouns. Robert Vernet photo.**

Figure 36. **Iimoriite-(Y) crystal, 2.5 mm, in dolomite from Trimouns. Robert Vernet photo.**

Iimoriite is farly rare in the deposit. Well-formed crystals are found in the hanging wall, in fissures in banded dolomite of the upper part of the carbonate lenses. It is commonly associated with thortveitite and is found in the same environment as hingganite.

The medium to dark pink color of certain iimoriite crystals does not show up well in photographs and becomes greenish on printing (luminescence and probable radioactivity).

The best known crystal measures 1.7 cm long. It is doubly terminated, and was found loose in a vug in talc in 1997. It is extraordinary, and no comparable crystal has been found since.

"Limonite" mixture of hydrous iron oxides

Limonite results from the alteration of pyrite, after which it forms pseudomorphs. These pseudomorphs occur as isolated crystals ranging up to 10 cm in size, and as groups of subhedral crystals associated with allanite and/or dissakisite, aeschynite, synchisite, parisite, bastnäsite and, more rarely, cassiterite.

The iron hydroxides and oxides, with their ocher to brown color, commonly contrast with the white or gray dolomite, locally imparting touches of bright color that seem to spread out over the exposures in the hanging wall of the talc structure.

Malachite $Cu_2(OH)_2CO_3$

Early in the history of the quarry, malachite was reported as forming millimeter-size encrustations and films in joints in the beige dolomite of the hanging wall of the talc-chlorite mineralization. The mineral has not been seen in the deposit since 1903.

Microcline $KAlSi_3O_8$

Microcline has been reported in the pegmatite zone of the footwall of the talc-chlorite structure, where it forms masses of several millimeters, in places associated with chlorite, quartz and titanite.

Monazite-(Ce) $(Ce,La,Nd)PO_4$

Monazite is present as isolated crystals from several millimeters to 1 cm in size, and more rarely as groups of crystals, in fine-grained white or graphitic dolomite of the hanging wall of the talc structure. It is orange to reddish brown, and the translucent crystals very commonly contain reddish inclusions. A few millimeter-size gem crystals with {100} and {111} terminations were found in 1987. The crystals are implanted on whitish dolomite in small vugs or microfissures, occasionally associated with rutile. Some monazite crystals, several millimeters in size, are sprinkled with 1-mm crystals of limonitized pyrite. Analyses give an age for the monazite of 99 ± 1 Ma (Schärer *et al.*,1999).

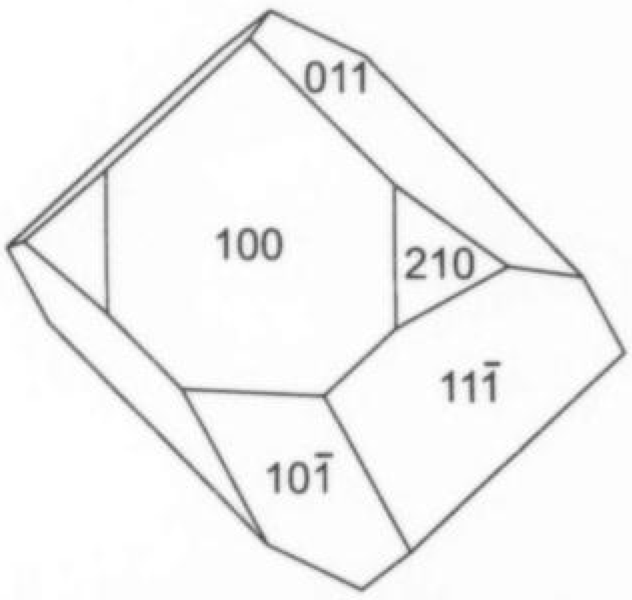


Figure 37. **Monazite, idealized crystal drawing, from Trimouns (Favreau, 1994).**

Figure 38. **Monazite-(Ce) crystal, 1.5 mm, from Trimouns. Robert Vernet photo.**

Muscovite $KAl_2\square AlSi_3O_{10}(OH)$

A few lamellar crystals of muscovite several millimeters in size were collected in 1983 in the pegmatite zone of the hanging wall. Sharp pseudohexagonal prisms to 2 mm have been found in fissures in the mica schist.

Natrolite $Na_2[Al_2Si_3O_{10}]\cdot 2H_2O$

Natrolite forms white sprays of acicular crystals to 1 mm, the individual crystals having a square cross-section. It was discovered in 1985 in the mine dumps, in association with calcite. It has never been found *in situ* in the deposit.

Palygorskite $(Mg,Al)_2Si_4O_{10}(OH)\cdot 4H_2O$

Palygorskite is found in dolomite joints as millimeter-size, white, silky fibers arising from the alteration of the phyllosilicates. The samples are all very fragile. They may be assocaited with allanite or bastnäsite.

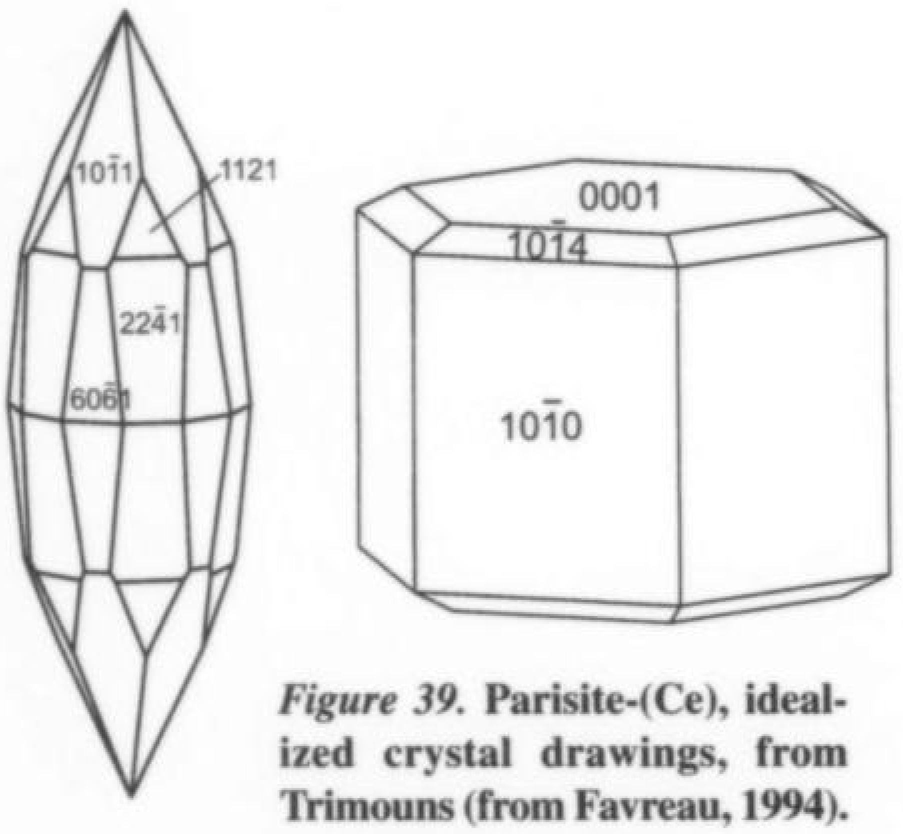


Figure 39. **Parisite-(Ce), idealized crystal drawings, from Trimouns (from Favreau, 1994).**

Figure 40. **Parisite-(Ce) crystals to 6 mm from Trimouns. F. Marty collection: Robert Vernet photo.**

Figure 41. **Parisite-(Ce) crystal, 5.2 mm, from Trimouns. Robert Vernet photo.**

Figure 42. **Parisite-(Ce) crystal, 5.5 mm, from Trimouns. F. Marty colllection; Robert Vernet photo.**

Figure 43. **Parisite-(Ce) crystals to 3 mm from Trimouns. Robert Vernet photo.**

Parisite-(Ce) $Ca(Ce,La)_2(CO_3)_3F_2$

Parisite forms reddish brown to orange, hexagonal crystals tapering upwards; some crystals are horizontally striated, and some are translucent with gemmy areas. The crystals can be as much as 2.8 cm long and several millimeters thick. Parisite is found in the same environment as bastnäsite, in units of crystalline dolomite interbedded with dark green to black shale a few hundred meters from the main contact. Parisite is very similar chemically to synchisite, and distinguishing them analytically is difficult (Lasmanis, 1977); however, parisite crystals characteristically taper to a point and synchisite crystals do not.

Very rarely, parisite crystals to several milimeters long are found to be terminated by {10$\bar{1}$4} faces; these could be confused with squat crystals of bastnäsite.

Phlogopite $KMg_3AlSi_3O_{10}(OH)_2$

Phlogopite is found as crystalline masses and as variably distinct aggregates at the contact with aplites in the footwall of the talc-chlorite structure, and also as palm-shaped crystals, several millimeters in size, in the marble limestone of the hanging wall.

Pyrite FeS_2

It is pyrite that made the Trimouns deposit famous at the beginning of the 20th century, after Lacroix (1896) reported the presence of curved-faced octahedral crystals several centimeters in size. The talc structure in the deposit commonly contains pyrite as very shiny, euhedral cubic crystals to 1 cm within the white massive talc. These crystals are often oriented in parallel within the massive talc, thus marking and emphasizing tectonic movements.

The largest pyrite crystals, with edges to 15 cm, were found in the 1960's. They came from the hanging wall of the talc-chlorite structure, in the dolomite that the local quarry workers call "little granite." This type of dolomite is formed of equidimensional grains, 1 to 5 mm in size, that resemble agglomerated salt crystals with faces {210}, {100} and {211}. The same environment also contains (1) octahedral pyrite crystals of several centimeters, locally associated with calcite, (2) exceptional dodecahedral pyrite crystals, commonly "limonitized" (supergene alteration), and (3) flat crystals elongated along the two-fold axis (pseudo-rhombic) or, more rarely, elongated along the three-fold axis (pseudo-rhombohedral). From these pyrite crystals we can see the influence of the enclosing matrix on the crystal form. Other form combinations encountered in the commonly "limonitized" crystals, several centimeters in size, are the cuboctahedron, the cubo-dodecahedron, the pyritohedron/dodecahedron and the pyritohedron/octahedron (Gatel, 1990).

Pyrrhotite $Fe_{1-x}S$

Pyrrhotite nodules weighing several kilograms were reported at the beginning of the 1900's. The pyrrhotite came from the hanging wall of the deposit in highly metamorphosed, crystalline limestone beds, where it forms diffuse aggregates and rare millimeter-size gray-brown to black hexagonal crystals associated with milky white quartz (Lacroix, 1962). The mineral has since only been found as inclusions in calcite.

Quartz SiO_2

In the hanging wall of the talc-chlorite structure, the best quartz crystals, generally isolated, are found in vugs, several tens of centimeters to more than a meter in size, in white, coarsely crystallized dolomite (Auriol, 1987). The crystals have a Bambauer (lamellar) structure and can reach 35 cm in length. Commonly they are transparent and colorless, and as beautiful as any quartz crystals from Brazil or from the La Gardette mine or other Alpine localities. In addition to the classical prismatic habit, some crystals display a typical pyramidal "Muzo habit," or are Dauphiné twins.

A few centimeter-size clusters of quartz crystals were found in 1989, and some very good crystals were collected in 1994 at the contact of a talc lens with white crystalline dolomite.

Good doubly terminated "floater" crystals to several centimeters have also been reported, and, very rarely, some Japan-law twins, also to several centimeters.

Many quartz crystals from the deposit are curved, having been tectonically deformed (Lacroix, 1891). Growth phantoms outlined by whitish inclusions have been seen in some crystals.

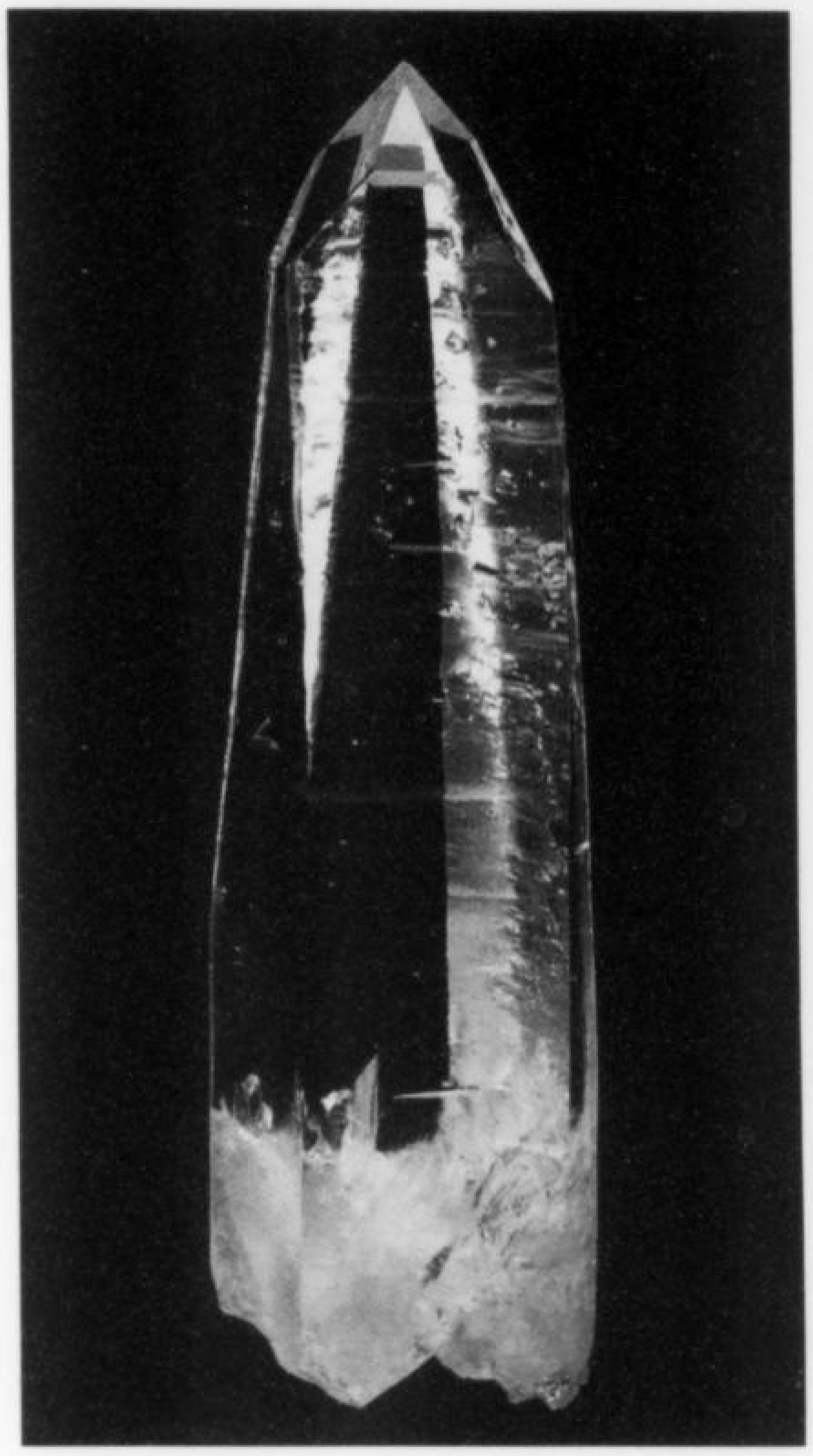


Figure 44. **Quartz crystal, 12.5 cm, from Trimouns. F. Marty collection; Jeff Scovil photo.**

The quartz can be associated with crystals of purplish calcite (to several centimeters), dolomite, allanite, bastnäsite, synchisite, rutile and very rarely hingganite. A few patches of smoky quartz associated with crystals of albite several millimeters in size were found in 1997 in the footwall pegmatite zone of the talc-chlorite structure.

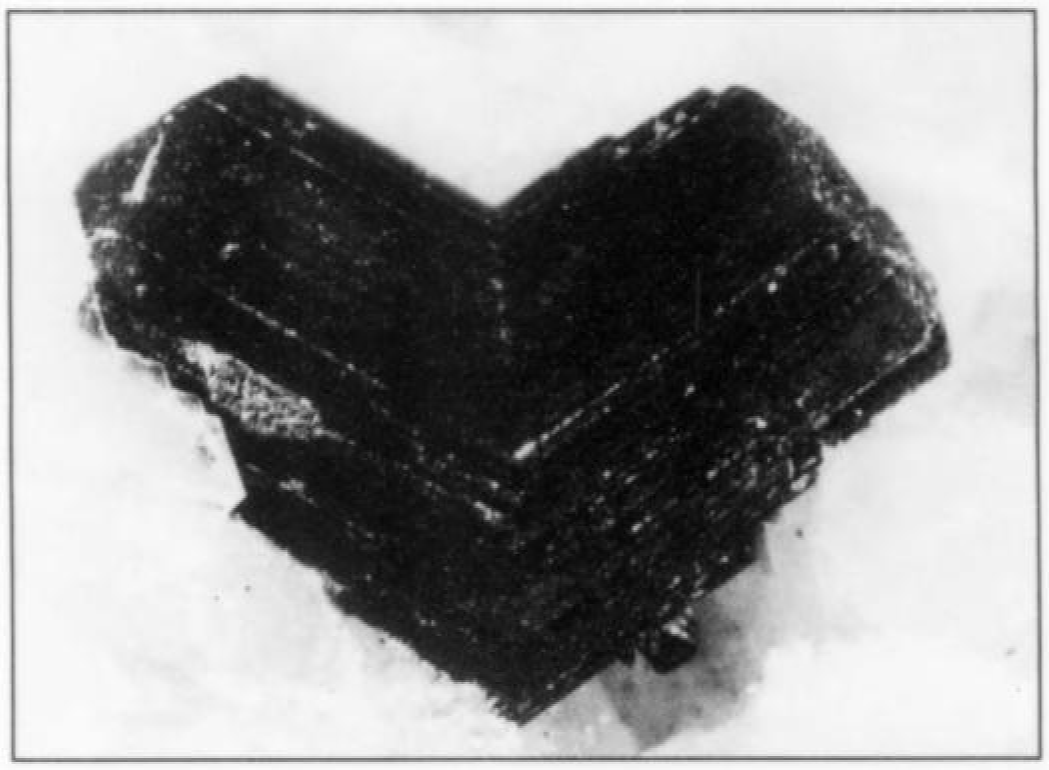


Figure 45. **Rutile twin, 4 mm, from Trimouns. Robert Vernet photo.**

Rutile TiO_2

Rutile, as prismatic-acicular crystals from a few millimeters to 3 cm long and a few microns thick, and as black, centimeter-size sheaflike crystal aggregates, is found in the hanging wall of the talc-chlorite structure.

More rarely, rutile occurs as squat crystals to several millimeters, twinned on (011) (Bariand *et al.*, 1978); these dark brown crystals are longitudinally striated, and the twins are of characteristic geniculate form. This species occurs in the same environment, and belongs to the same paragenesis, as its dimorphs, brookite and anatase.

Commonly, long, needlelike rutile crystals pierce dolomite and calcite crystals, and are seen as inclusions in quartz. A few rare specimens show rutile in association with hingganite or monazite. In 1994, in the footwall of the talc structure, a few isolated, red crystals of the "sagenite" type of rutile (to 1 mm) were found with calcite in the chloritization zone (Favreau, 1994).

Schorl $NaFe_3^{3+}Al_6(BO_3)3[Si_6O_{18}](OH)_4$

Schorl, as poorly formed, millimeter-size crystals with vertical striations, is found embedded in the pegmatites of the footwall of the talc mineralization zone. Sharply terminated schorl crystals to several centimeters were found in 1998 in a pegmatitic zone about 100 meters to the west of the talc-chlorite structure.

Stellerite $Ca_4(Al_8Si_{28}O_{72})\cdot 28H_2O$

Morphologically similar to stilbite, stellerite forms white, rectangular, millimeter-size crystals in the dumps at the footwall of the talc-chlorite mineralization zone. It may be accompanied by quartz and epidote (Favreau, 1994). This mineral has thus far not been found *in situ*, and has only been identified visually.

Stibnite Sb_2S_3

Stibnite comes from the footwall pegmatites of the talc-chlorite structure. A few specimens were reported at the end of 1985 and in the beginning of 1986; they show millimeter-size, striated acicular crystals, some of them bent, associated with calcite (Favreau, 1994).

The mineral was analyzed, but has not been found again since 1986.

Stilbite-Ca $(Ca_{0.5},K,Na)_9[Al_9Si_{27}O_{72}]\cdot 28H_2O$

Stilbite is found as vitreous white, opaque to transparent, millimeter-size radial aggregates. Rare millimeter-size crystals, variably elongated, some of them lozenge-shaped, came from the hydrothermally altered zone near the contact with the talc-chlorite lens in the same environment as the scolecite and chabazite found in the footwall of the talc-chlorite deposit (Favreau, 1994). The identification was visual, and has not been analytically confirmed. The mineral has not been found since 1994.

Sulfur S

Sulfur results from the decomposition of pyrite in the hanging wall of the talc-chlorite mineralization zone. It forms lemon-yellow coatings to 1 cm across in microfissures, and as powdery films, and, more rarely, subhedral crystals to 1 mm.

Synchisite-(Ce) $Ca(Ce,La)(CO_3)_2F$

Synchisite-(Ce) is chemically very similar to parisite-Ce, but probably more common in the deposit It occurs as orange to reddish brown prismatic crystals in the same environment as the parisite. The prisms are always truncated at both ends, enabling synchisite to be distinguished from parisite, which forms pointed crystals. The synchisite crystals are opaque to translucent, and rarely gemmy; the largest observed are 2.2 cm long and less than 1 cm thick (Boggild, 1953). Allanite is a common association and xenotime a very rare one; synchisite may also form syntaxic intergrowths with bastnäsite (Parker and Brandenberger, 1946; Donnay *et al.*, 1953).

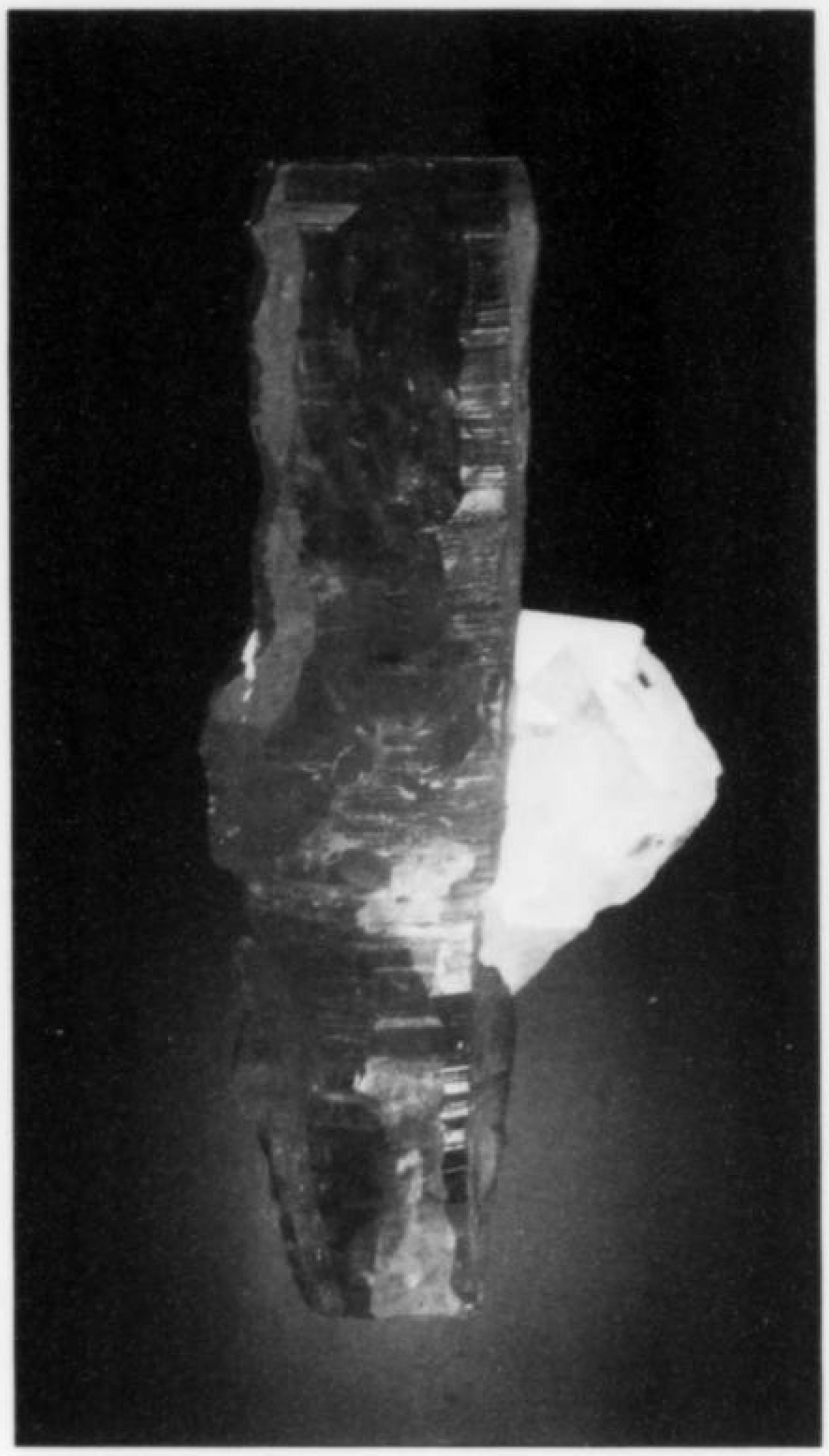


Figure 46. **Synchisite-(Ce) crystal, 1.7 cm, with dolomite from Trimouns. F. Marty collection; Jeff Scovil photo.**

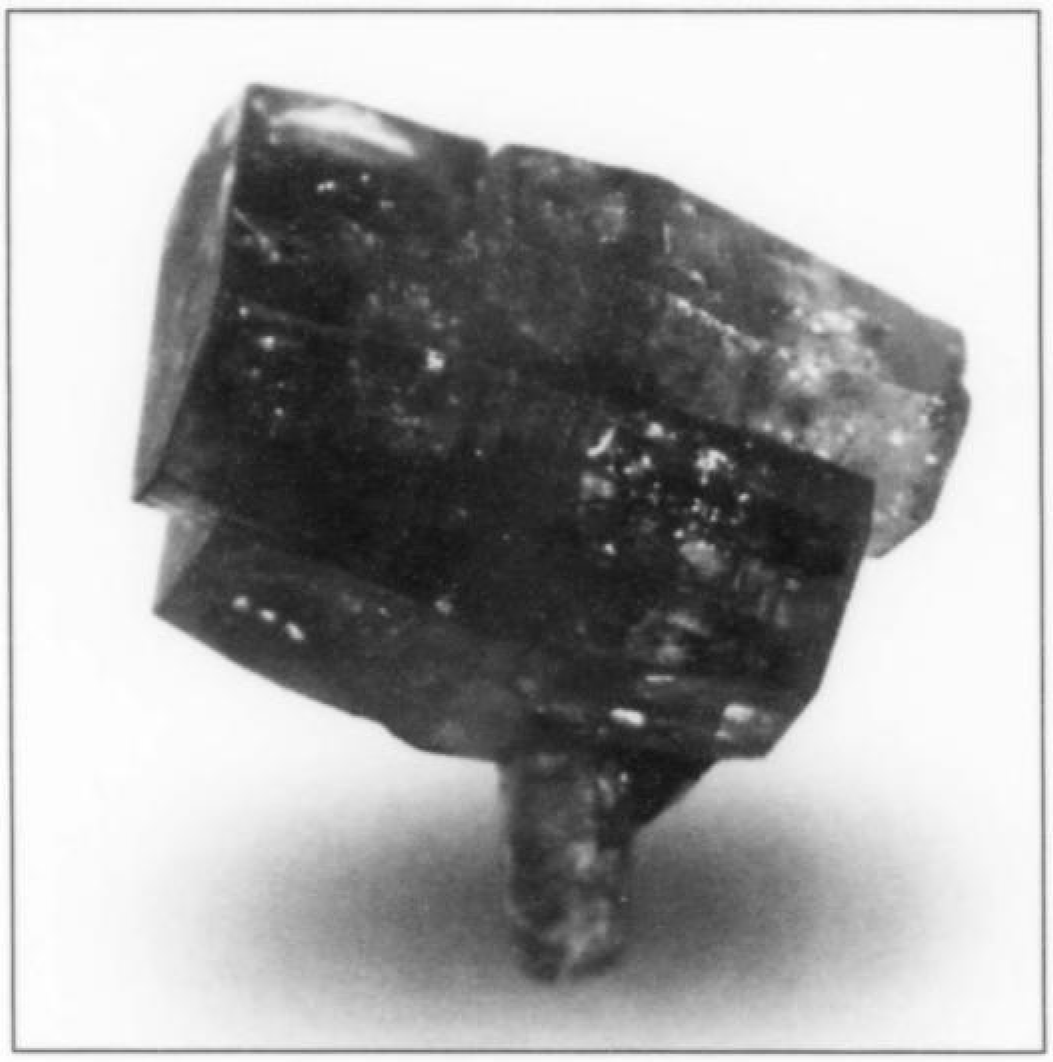


Figure 47. **Synchisite-(Ce) crystal, 5 mm, with dolomite from Trimouns. Robert Vernet photo.**

Talc $Mg_3Si_4O_{10}(OH)_2$

The talc of the Trimouns deposit is mainly amorphous and of varied colors, ranging from white through green to black. Eighteen varieties or quality grades are distinguished according to two criteria: chemical composition and whiteness.

For the mineralogist, crystalline talc is, of course, the most interesting form of the mineral. It is found in the hanging wall of

Figure 48. **Synchisite-(Ce) crystal, 1.8 cm, with dolomite from Trimouns. F. Marty collection; Jeff Scovil photo.**

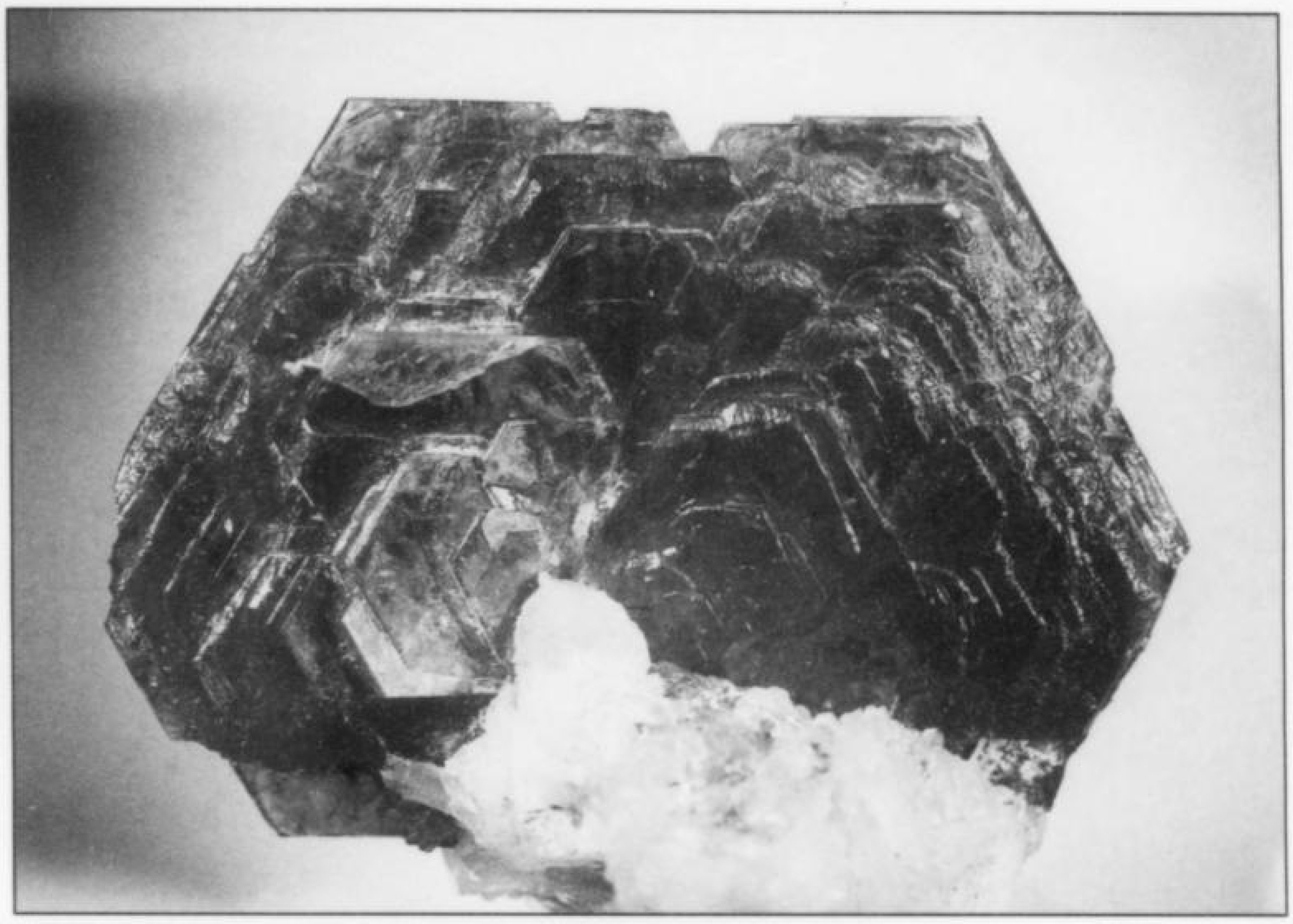


Figure 49. **Synchisite-(Ce) crystal, 2.7 cm, with dolomite from Trimouns. Robert Vernet photo.**

Figure 50. **Synchisite-(Ce) crystal, 1 cm, with dolomite from Trimouns. Robert Vernet photo.**

Figure 51. **Synchisite-(Ce) crystals to 1.4 cm, with dolomite from Trimouns. F. Marty collection; Jeff Scovil photo.**

the talc-chlorite mineralization zone in geodes and vugs in dolomite (some to 10 cm across), and in microfractures. It forms very thin, transparent, nacreous white to yellowish hexagonal sheets, fragile intergrown leaves, and clusters of spherules lining the vugs.

Thorite $(Th,U)SiO_4$

Very rarely, thorite is found as subhedral crystals in aggregates to several millimeters, black to brown with a greasy luster and an imperfect cleavage along {110}. Specimens of this description were collected in 1985 in the mica schist of the pegmatite zone in the footwall of the talc-chlorite structure.

Thortveitite $(Sc,Y)_2Si_2O_7$

A handful of specimens of thortveitite was found in the hanging wall of the talc structure; the specimens came from the top part of the dolomite lenses, in the same environment as iimoriite, associated with banded dolomite. Some very rare, yellowish white, acicular thortveitite crystals to 1 mm, associated with pale dolomite, were collected from fissures in 1997, as were a few millimeter-size thortveitite crystals perched on crystals of bastnäsite with calcite and clinochlore (Bianchi and Pilati, 1988; Schetelig, 1912, 1922).

The identification was made by G. C. Parodi of the Natural History Museum in Paris.

Titanite $CaTiSiO_4$

Crystals of pink, opaque titanite, from a few millimeters to 3.5 cm in size, were found in the chlorite zone of the footwall of the talc structure in 1994.

Törnebohmite-(Ce) $(Ce,La)_2Al(SiO_4)_2(OH)$

A few crystals of törnebohmite, dark green with a yellow play of color, from several millimeters to 1 cm in size and striated longitudinally, were found in the summer of 1997. They are associated with crystallized calcite in the immediate vicinity of the allanite/dissakisite occurrence in the hanging wall of the talc mineralization zone (Shen *et al.*, 1982). The analyses and determinations were made by G. C. Parodi (University Paul Sabatier Toulouse).

Tremolite $\square Ca_2Mg_5Si_8O_{22}(OH)_2$

Tremolite was reported as soon as the mining started in the 1900's, as whitish fibers up to several centimeters long, as well as a pseudomorph after talc.

The mineral has not been found *in situ* since the time of Lacroix (1896).

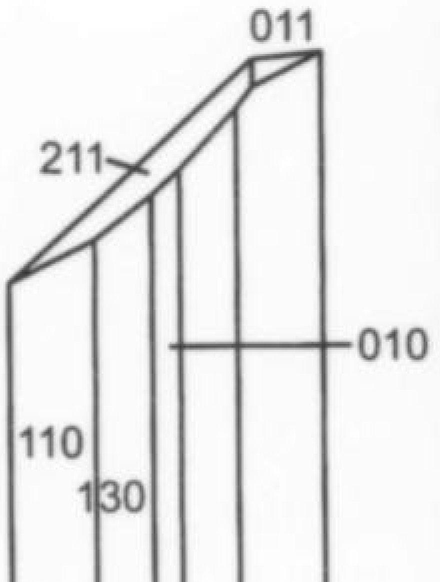


***Figure 52.* Trimounsite-(Y), idealized crystal drawing, Trimouns (from Favreau, 1994).**

***Figure 53.* Trimounsite-(Y) crystal, 7 mm, from Trimouns. F. Marty collection; Robert Vernet photo.**

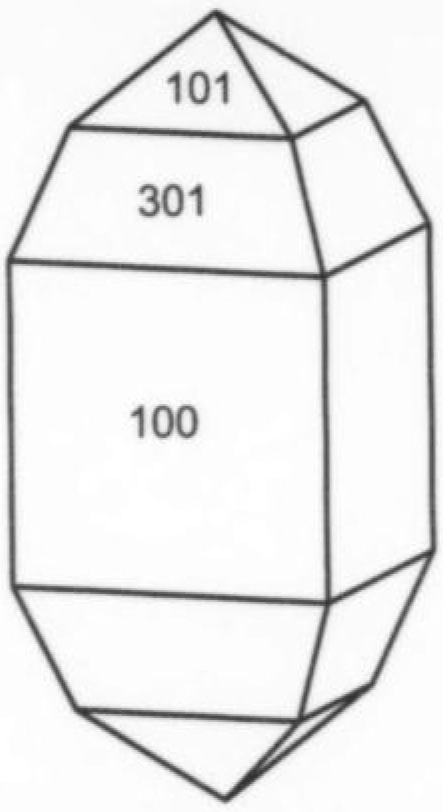


***Figure 54.* Xenotime-(Y), idealized crystal drawing, Trimouns (from Favreau, 1994).**

***Figure 55 (right).* Xenotime-(Y) crystal, 3 mm, from Trimouns. Robert Vernet photo.**

***Figure 56.* Xenotime-(Y) crystal, 2.7 mm, from Trimouns. Robert Vernet photo.**

Trimounsite-(Y) $Y_2Ti_2SiO_9$

Trimounsite-(Y), named after the Trimouns locality by Piret *et al.* (1990), occurs as brown acicular prisms and pale brown, translucent to slightly smoky, flattened rod-like crystals with longitudinal striations. It is found in vugs to several centimeters across, in gray and white dolomite in the hanging wall of the talc structure.

The crystals are elongated parallel to [001], and display the forms {110}, {130}, {211}, {121} and {011}. Forms {110} and {130} alternate, and the resultant faces appear striated. Trimounsite-(Y) crystals reach only 1 mm long and a few microns thick, and are easily confused with allanite. The only distinction is that allanite crystals have a characteristic termination that is oblique to the prism. Trimounsite-(Y) is monoclinic with a unit cell of a = 12.299, b = 11.120, c = 4.858. Also to be noted is its intense blue luminescence under the microprobe beam.

Since the collection of a very few specimens in 1989, all searches for further samples have been unfruitful.

Xenotime -(Y) YPO_4

Honey-yellow to brown, translucent crystals of xenotime to several millimeters have been found in the hanging wall of the talc structure. Most are isolated, doubly terminated crystals and some are twinned. Clusters of crystals are found rarely in small vugs of crystallized dolomite and calcite. Isotopic dating gives an average age 110 Ma (De Parseval, 1992), the same as for the monazite (see above).

Zircon $ZrSiO_4$

A few brown, vitreous crystals of zircon to several millimeters in size, have been found in the pegmatite zone close to the hanging wall of the talc-chlorite structure.

CONCLUSION

The identification of certain rare earth element-bearing minerals from Trimouns, both carbonates and silicates, proved to be very difficult, because the minerals are chemically complex. Only by employing a variety of analytical methods including X-ray diffraction, scanning electron microscopy and electron probe microanalysis, has it been possible to identify them.

Today, the zone containing the rare earth minerals in the hanging wall of the talc-chlorite structure is very nearly exhausted. This zone is, economically speaking, a barren part of the deposit, and nearly all of it now has been stripped, dumped as spoil and covered with earth. In fact, under current French environmental law, the area must now be reclaimed for sustainable development, and the present dump material replanted with trees (Höffler *et al.*, 2000).

The Trimouns quarry has already acquired an international mineralogical reputation, both for its exotic species and for the quality of its crystals. It will probably figure among the great classic localities of tomorrow, comparable to the fabulous Mont Saint Hilaire deposit in Canada (although not equalling it in the diversity of species found).

Although only very small numbers of specimens of some of its rare minerals, e.g. trimounsite and gatelite, have been discovered, the Trimouns deposit may yet provide more surprises, most likely in the quarry's northern extension, where overburden is now being stripped away. Systematic exploration of the Trimouns area may well locate additional interesting mineral occurrences. Detailed quantitative analyses should enable other unusual species, perhaps including new ones, to be found, as well as illuminating the origin of these species.

All of the pictured minerals are from the collection of F. Marty, except as noted.

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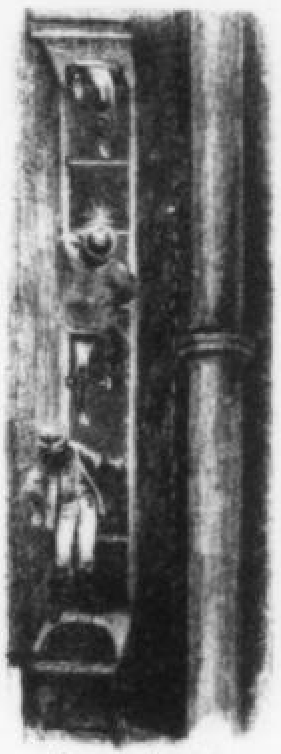


ARAGONITE, 3 inches, from Sicily. From Herb Obodda in May 1995; ex Fred Cassirer collection

Clara and Steve Smale

COLLECTORS

PHOTO BY STEVE SMALE

What's New in Minerals

Tucson Show 2004

by Tom Moore

[January 31–February 15]

Omne ignotum pro magnifico est

The Latin motto above means "Anything we haven't seen before is marvelous." This is apt for the "What's New" column, of course, and also as advice for those showgoers who are prone to complaining that "there's nothing new at this show." Such chronically woebegone folks lament the lack of any major debuts of new occurrences (1) totally unheard-of before, and (2) productive of a large quantity of specimens of (3) very high quality and/or rarity. This indeed happened to be the case at the 2004 Tucson Show: there was no new serendipity this time to rival, say, last year's Chinese mimetite, or the Idaho pyromorphite, Sweet Home rhodochrosite, Ojuela purple adamite, etc., of various yesteryears. But I've never sympathized much with those who would demand mega-surprises each magical February. Just look around you alertly, don't ignore the small lots, the out-of-the-way, the strong revivals of older items—even, sometimes, the *ugly*—and you will have yourself a *good* Tucson time, every time. Witness, this year, the new blue Romanian scheelite, the Spanish torbernite, the Bolivian bournonite and ferberite, the new Imperial topaz from Zambia, the lilac gem scapolite from Afghanistan . . . all to be expounded upon shortly. Any show this large will have plenty of minerals which fit at least one of the three criteria for greatness listed above. So be of good cheer, and keep up those Latin studies.

This was the fiftieth anniversary year of the Tucson Gem and Mineral Show, i.e. the "Main Show," the huge center-ring event which the Tucson Gem and Mineral Society stages so expertly each year at the Tucson Convention Center. The golden-anniversary theme, naturally, was gold, and consequently the long row of display cases harbored what was doubtless the greatest assemblage of world-class crystallized gold specimens ever brought together in one place. Additionally, this was the 150th anniversary of the Gadsden Purchase, which in 1854 added to the U.S. that mineral-juicy strip of southern Arizona which today includes virtually all of the state's most famous localities. Thus there was a strong secondary show-theme, expressed not only by a special exhibit of the original Gadsden Purchase treaty, but by case after case of dazzlements of "Gadsden" minerals, especially those of Bisbee.

On opening day at the Main Show, Arizona governor Janet Napolitano visited, made an appreciative speech over the public address system, and then was toured around the show floor by TGMS Show Chairman Bob Jones. Bob himself had an exceptional show experience, resulting, however, in cramps of the right hand, as he cruised continually about autographing countless copies of the softcover and hardcover editions of his just-published *A Fifty-Year History of the Tucson Show,* which were being sold at the *Mineralogical Record* booth and by the TGMS folks in the upstairs lobby (*Mineralogical Record* subscribers will by now have received their own free softcover copies).

As for *Mineralogical Record* news, well, we had a table at Marty Zinn's Executive Inn show for the first time, and here, as well as at the Main Show, we found ourselves frenetically selling the show-anniversary book, as well as the new, 2004 edition of *Fleischer's Glossary of Mineral Species*, the January/February special issue on diamonds and gold, and the new *ExtraLapis English* booklet on gold. I know sales were brisk because Adrianna Pagano (our tireless Italian representative) and I had to keep the hotel and show tables going by ourselves for two solid weeks in the absence of longtime Circulation Manager Mary Lynn Michela, who had come down with double pneumonia just before showtime! Thanks to massive slugs of antibiotics she's feeling better now, and we very much hope she will be fully recovered by the time you read this. Come to think of it, by that time *I* might even be fully recovered from hauling and selling all those books, whilst also monitoring the hotel show's "What's New in Minerals" case (see description in last year's Tucson report), taking the usual What's New notes, and doing the (indispensable, mandatory) personal specimen shopping. That combat ribbon ought to look good on my Tucson Show T-shirt.

So, by the way (you might wonder), what *is* new in minerals? Since you asked. . . .

Dick Morris and Mark Hay (for the latter, phone 602-952-2445) have shifted their Arizona field-collecting attentions from the Oatman district (although they still have some nice green fluorites from there) to a fine, heretofore little-known **calcite** locality: the Portland mine, Black Mountains, Mohave County. From this old open-pit gold mine—which was commercially active from the mid-1970's to the mid-1980's—come beautiful colorless, transparent calcite crystals on gray, weathered volcanic rock matrix. Except for that matrix, these strongly resemble old-time English calcite specimens. The waterclear, silky-lustered crystals are lightly modified hexagonal prisms, most with trigonal terminations, plus a few modified scalenohedrons, to about 5 cm long. Specimens have appeared sporadically before, but the newest batch, consisting of about 100 top-quality pieces of miniature to cabinet size, was collected by Dick and Mark just a few months ago.

The calcium-aluminum silicate **lawsonite** was originally described from a crystalline schist which is associated with serpentine on the Tiburon Peninsula, Marin County, California. This occurrence turns out to be an outcrop of serpentinite and eclogite along Reed Ranch Road on the Tiburon Peninsula, to date one of the world's very few localities for crystallized lawsonite. Specimens were collected as early as the turn of the 20th century, but most were found in the mid-1950's, then stored by the collector at his home somewhere near San Francisco, except for a few pieces which reached local collectors. The field collector died in 1970, his wife died this past April, and at this point the couple's children

Figure 1. **Lawsonite crystals to 1 cm from Reed Ranch Road, Tiburon Peninsula, Marin County, California. John Veevaert specimen and photo.**

called California dealer Steve Perry, inviting him to come and see what was wrapped in some old newspapers in the family garage . . . and thus it was that at the Main Show this year *Steve Perry Minerals* (P.O. Box 136, Davis, CA 95617) was offering about 200 specimens, in widely varying sizes, of what is undoubtedly the world's best lawsonite, and the last likely ever to come on the market from the classic California locality. Translucent, medium-lustrous, blue-white lawsonite crystals of complex wedge-like aspect compose tight clusters in shallow seams in hard, gray-green, igneous matrix. The crystals reach 8 cm individually, although the really sharp ones max out at 2 cm, and most are less than 1 cm. Matrix specimens, with fairly liberal showings of lawsonite crystals, are up to 15 cm across, and actually are fairly attractive. You can't complain when an attractive, well crystallized, translucent blue best-of-species turns up on the market.

Surprisingly, there were no major mineral scoops from Colorado this time, but collecting is *still* going on in the Sweet Home mine, and, at the Main Show, Bryan Lees of *Collector's Edge* was debuting a lavish video he has just had made (and will be selling to the general public this summer) telling the Sweet Home story since the modern mining effort began in 1991. Prospecting, drilling, blasting and the original collecting-out of some of the great pockets are all caught in action, and the cover of the *Mineralogical Record*'s Sweet Home Special Issue is seductively flashed on-screen as well. At the *Collector's Edge* booth at the Main Show a preview showing of this video ran constantly on a big plasma screen, and it was nice to see that another documentary effort for this great locality has shaped up so well.

Joe Polityka wrote from Springfield on the new—I repeat, *new*—gem-quality crystals of **spodumene variety hiddenite** which have emerged very lately from the classic locality for the material: the Adams (or Warren) Farm, Alexander County, North Carolina. Terry and Jean Ledford of *Mountain Gems & Minerals* (P.O. Box 239, Little Switzerland, NC 28749), assisted by W. Renn Adams, hit two superloaded hiddenite pockets in late March and early April 2003, taking out about 1,200 loose, gemmy green crystals, ranging from tiny to 9 cm long, and many of these crystals were for sale (even small thumbnails sporting 4-figure prices) in the Executive Inn at Tucson. The crystals are brightly lustrous and lightly striated; most are of a very intense green at the tips, grading to somewhat paler farther down. The bottoms of the same two pockets also harbored about a dozen loose **emerald** crystals: semi-gemmy, medium-green, thin to medium-fat simple hexagonal prisms to 3 cm.

Last issue's article by Amabili *et al.* on new discoveries at the famous Jeffrey mine, Asbestos, Quebec sets us up nicely for the next item: a small number of remarkable **diopside** crystals and crystal clusters collected at the Jeffrey quarry in 2003. Their handler in the Executive Inn was the ever-affable Giuseppe Agozzino, working out of the room of *Geofil* (Alto da Bela Vista, 2-A, 2750 Cascais, Portugal). Four days into the show I got to help Giuseppe unpack a small flat which had just arrived, containing about 20 beautiful specimens, thumbnails and small miniatures, showing sharp, highly lustrous, transparent diopside crystals to 2 cm; in habit they are wide, very thin blades, and in color they are a subtle, very pale greenish brown. The crystals are either loose singles or lightly intergrown, sparkling groups without matrix, and tiny green crystals of vesuvianite decorate a few of the diopside crystal faces. These gemmy beauties represent, as far as I know, a new kind of diopside, and they certainly set beauty records for the species. A very small number of newly found, rich emerald-green **vesuvianite** crystal clusters from the Jeffrey mine, most of them of thumbnail size, were also to be spotted with various dealers around the show. As the recent article points out, the demise of the Jeffrey mine as a collecting locality is imminent (perhaps already "official") and, sad as such demises are, it's good to see this one occur with a bit of a bang, not a whimper.

Until a couple of years ago I looked forward to getting the Mont Saint-Hilaire news in the really fun way, i.e. by visiting the Executive Inn room of full-time Saint-Hilaire collector Gilles Haineault, but Gilles regrettably no longer comes to Tucson. This year a number of Gilles' latest discoveries were being marketed at the Main Show by *Tyson's Minerals* and by Rob Lavinsky (of *The Arkenstone*, P.O. Box 450788, Garland, TX 75045-0788). Last summer at Saint-Hilaire, Gilles collected about 100 thumbnail and small-miniature crystal groups of the very rare **epididymite**, most of which specimens were for sale at low three-figure prices with both dealerships in Tucson. The special Mont Saint-Hilaire issue of 1990 reports that epididymite from this locality occurs as tiny acicular, long-prismatic or bladed crystals, or very rarely as colorless, lustrous, stellate twins to 2 cm. The new specimens, though, are entirely different: they consist of sharp, simple hexagonal-tabular epididymite crystals to 6 mm across, attached loosely in sugary white, jumbled groups, or skewered in neat little rows on black needle-crystals of aegirine, or draped over crystals of albite and/or serandite.

Gilles' next find was gemmy, pale green **sphalerite** crystals to 2 cm in loose clusters and on matrix of albite and polylithionite; the specimens suggest the now very rare and very attractive green sphalerite found about 12 years ago at Thomasville, Pennsylvania, and they surely represent Saint-Hilaire's best sphalerite to date. The new, mostly thumbnail specimens of **catapleiite pseudomorphs after fluorite** are quite unusual as well: pale brown, slightly rough-faced dodecahedral crystals to 1.5 cm, with smaller crystals of epididymite, serandite, and mangan-neptunite. Then there was the small hoard (at Tyson's) of opaque, bright pink **rhodochrosite** in thumbnail groups of sharp rhombohedrons to 2 cm with nicely stepped faces; and there were super-sharp, colorless, absolutely transparent, well terminated loose prisms of **natrolite** to 7 cm long (also at Tyson's). Some newly collected groups, to 10 cm across, of **polylithionite** in sharp, silvery books were interesting as well . . . a good summer's haul for Gilles, and another impressive What's New scoop from Saint-Hilaire.

Before leaving Quebec (and North America), I'll mention that John Medici (5280 Stover Rd., Ostrander, OH 43061) has lately

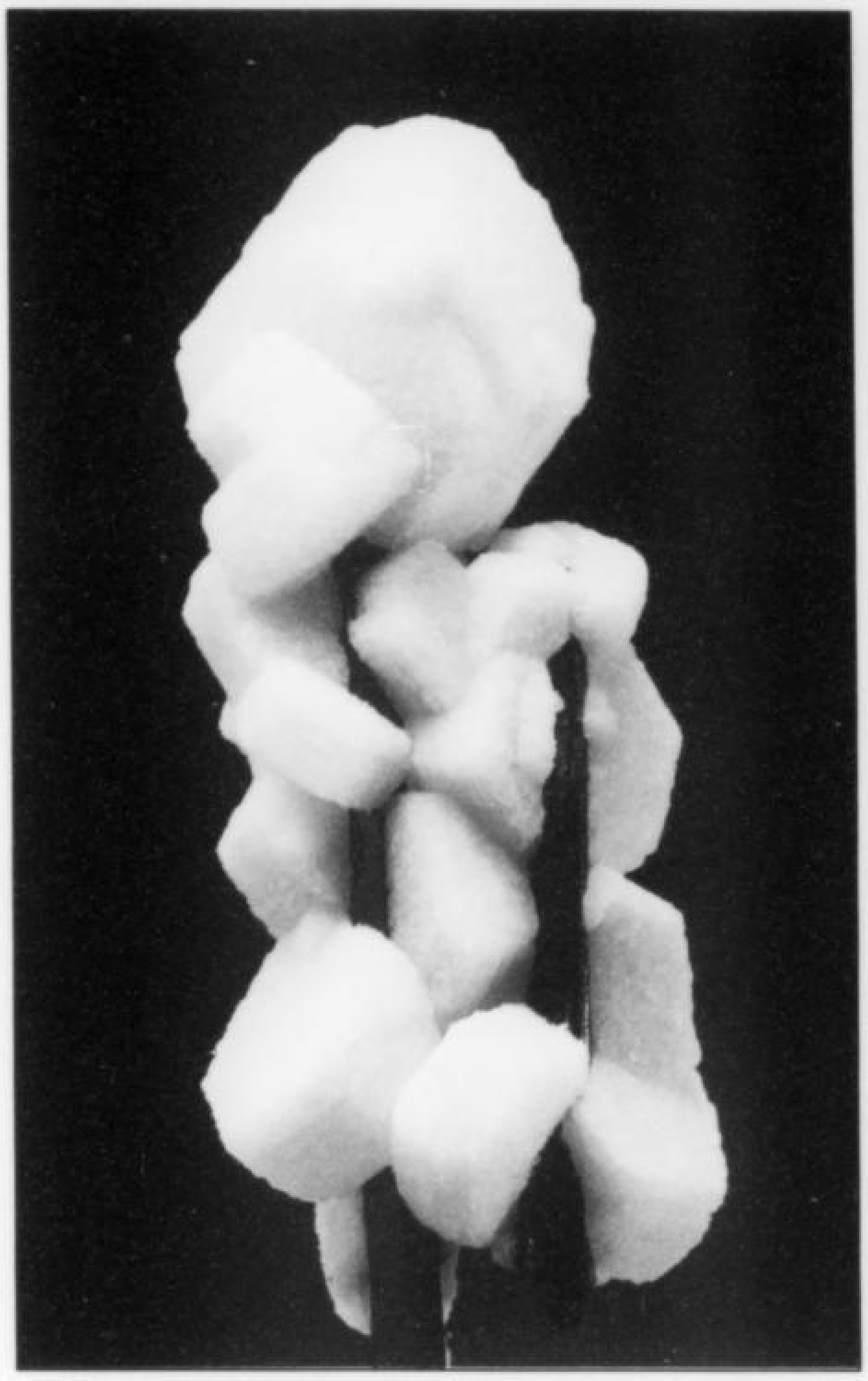


Figure 2. **Epididymite crystals on aegirine, 2.3 cm, from Mont Saint-Hilaire, Quebec. Arkenstone specimen; Jeff Scovil photo.**

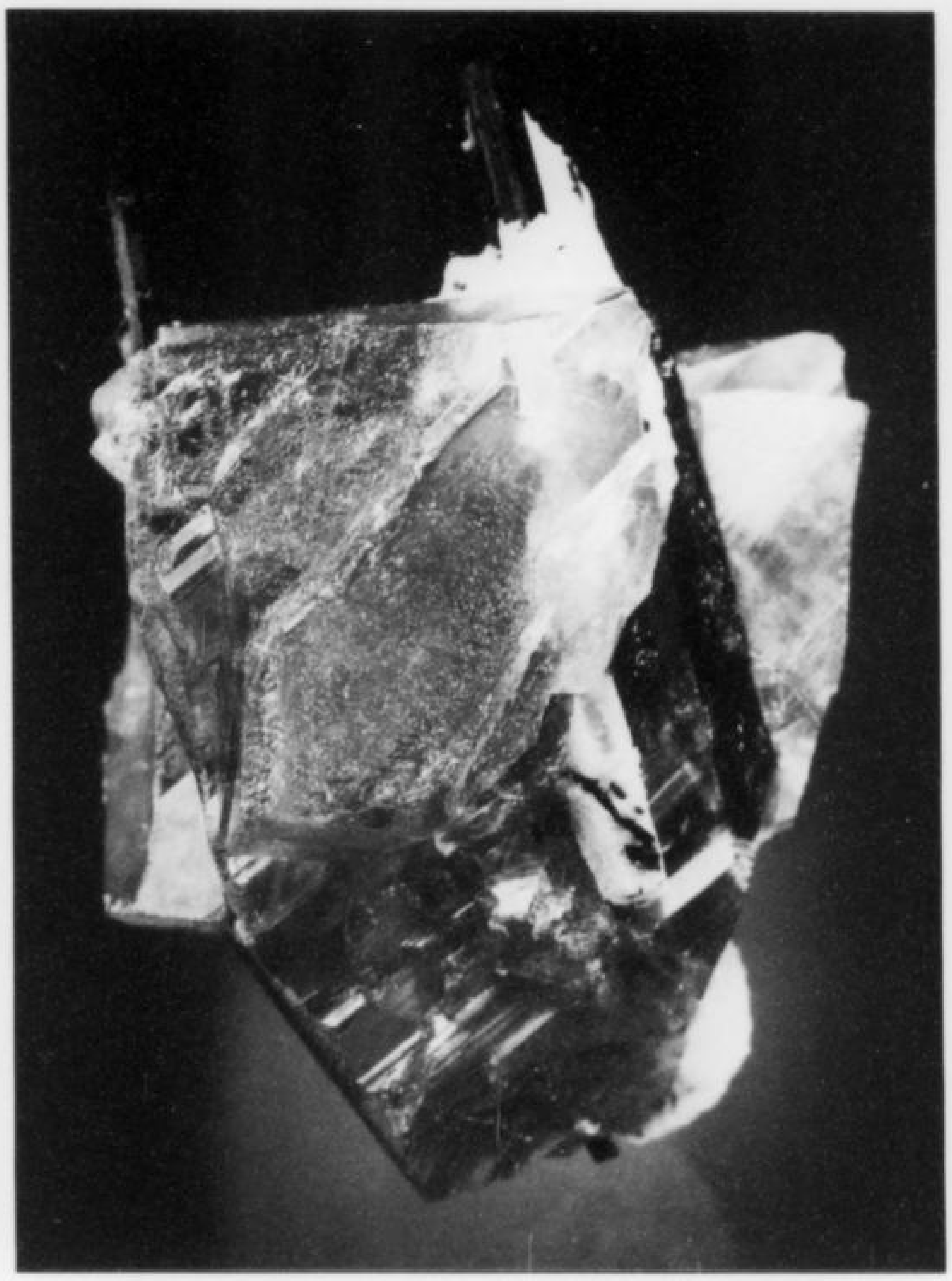


Figure 3. **Sphalerite with aegirine, 2.3 cm, from Mont Saint-Hilaire, Quebec. Arkenstone specimen; Jeff Scovil photo.**

been doing some fairly major trenching in the rubble at the Parker mine, Notre Dame du Laus (see the article in vol. 24, no. 5), and has recovered many very sharp, very lustrous black octahedral crystals of **spinel** to 2.5 cm, together with interesting **forsterite** crystals to about the same size; he had pieces for sale at the Main Show.

Mineralogical Mexico pretty much took a *siesta* this time—not so, though, the fabled emerald fields of Colombia. In a room at the Inn Suites, Swiss dealer Pierre Vuillet of *Samargand Resources Ltd.* (samress@yahoo.com) was offering a little hoard of lustrous, bright pink **fluorapatite** specimens from Boyaca: pretty, translucent hexagonal-tabular crystals in groups to 3 cm without matrix or associations, collected sometime last year. Also, from the La Pita mines in the Occidental district, he had fine, gemmy, deep green **emerald** crystals to 2 cm embedded, or even free-standing, in gray calcite (this mine, Pierre says, is now even more productive of gem emeralds than the much better-known Musquiz and Chivor mines). On the same matrix from the same locality, in a very few specimens, one espies very sharp, barrel-shaped crystals of **parisite** to 1 cm, these crystals being a rich orange-brown in lamplight and fluorescent yellow-green in shortwave ultraviolet light.

The Executive Inn room of the new Spanish dealer Luis Miguel Fernández Burillo (Urb. Pinar Canal, 24, 50007 Zaragoza, Spain) was very well stocked this year, as last year, with interesting things (see later under torbernite). Among these was a noteworthy Peruvian item consisting of about 20 miniature **quartz/epidote** specimens recently found at Huaytara, Huancavelica. On lustrous, doubly terminated "floater" crystals, to 5 cm, of transparent quartz with heavy inclusions of green chlorite perch lustrous sprays, brushes and bowties, to 3 cm, of acicular epidote crystals. The contrast between the bright pistachio-green of the epidote bundles

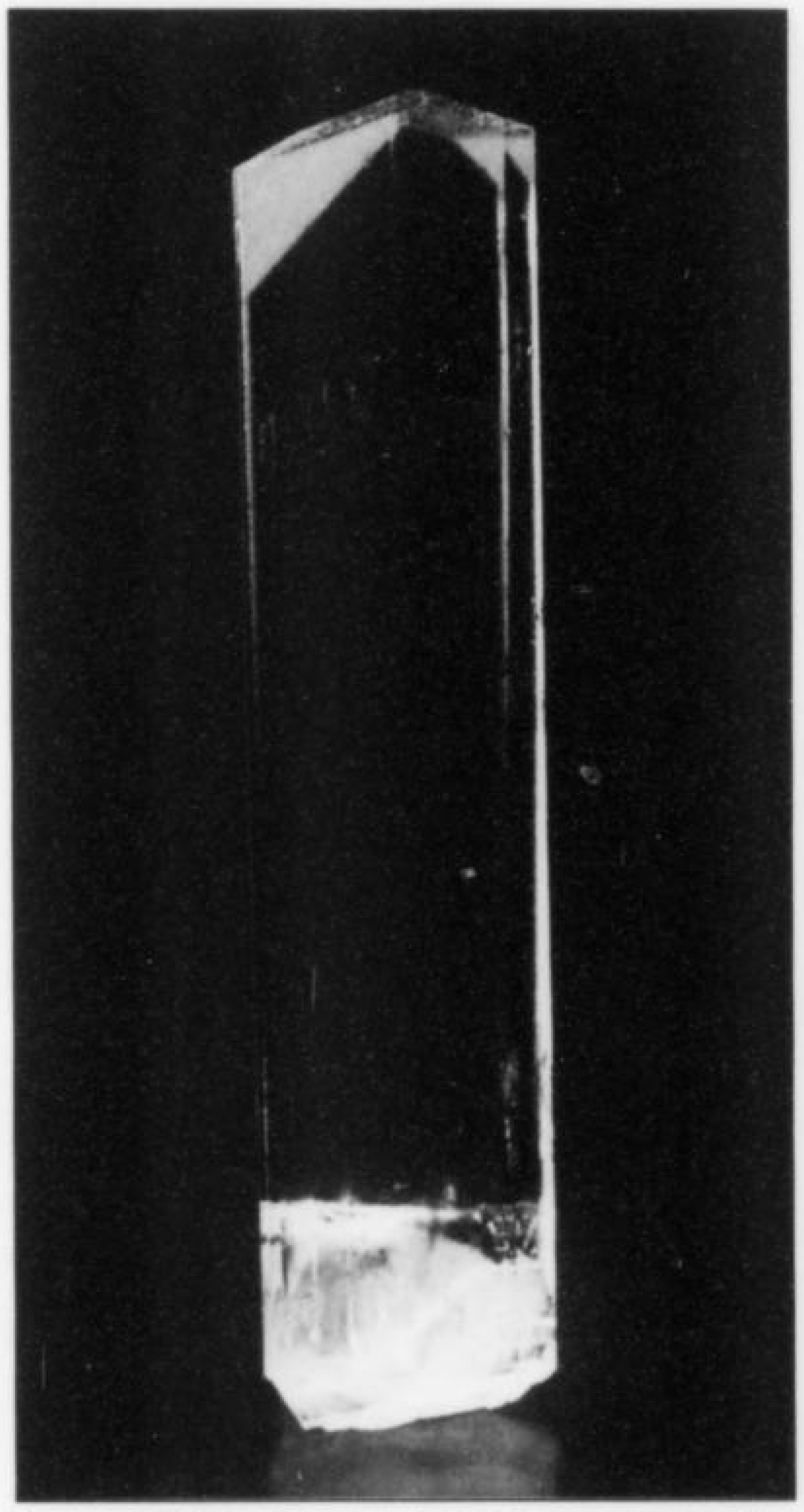


Figure 4. **Natrolite crystal, 3.9 cm, from Mont Saint-Hilaire, Quebec. Arkenstone specimen; Jeff Scovil photo.**

outside and the foggy green of the included chlorite inside is quite a pretty thing to behold. This is the same locality, by the way, which lately has been producing small, bright yellow-brown groups of sharp **clinozoisite** crystals, a few of which Luis offered also.

Bolivia is very big in the news this year. We'll begin with the hundreds and hundreds of bright **sulfur** specimens from the locality written about recently in a lively, humor-blessed way by Alfredo Petrov (Vol. 34, No. 4): the El Desierto mine, Potosí, a desolate salt flat whose western edge is mere hundreds of meters from the Chilean border, and where one breathes salt, volcanic dust, and sulfur fumes while digging for sulfur specimens. Alfredo Petrov himself (531 N. James St., Peekskill, NY 10566-2401) had about 50 toenail-to-miniature sulfur crystals and crystal clusters to sell, and *Red Metal Minerals* (109 N. Steel St., Ontonagon, MI 49953) had several flats in another room just down the hall in the Executive Inn. The sulfur crystals are elongated, skeletal, and misshapen in tortured-looking ways, but are very lustrous, and many are part-gemmy. The great majority of specimens are loose single crystals and loose subparallel groups, though a handful of small-cabinet matrix pieces were to be found in the Red Metal room.

Last year a silver/tin deposit worked by co-operative miners in the vicinity of Oruro, Oruro Department, Bolivia produced some unknown number of what are surely the world's finest known specimens of **metastibnite**. Don't get too excited by "world's finest"—metastibnite (an amorphous phase of Sb_2S_3) has only been seen before now as red or reddish gray smears, stains and areas of alteration in antimony deposits, and these new specimens aren't pretty either, although they do feature *solid* metastibnite, in botryoidal crusts on massive pyrite. The metallic gray (though inwardly reddish) metastibnite coatings are finely bubbly and look "cooked out," but for all their slaggy appearance they are excellent specimens of a very rare species. Alfredo Petrov had a few, and Jaroslav Hyrsl (Heverova 222, 280 00 Kolin, Czech Republic) had dozens more small pieces and five larger ones (to 10 cm across).

The superstar metallic mineral from Bolivia this year, though, was **bournonite**, in about 40 fine specimens of various sizes, from the Viboras vein of the Machacamarca mine near Colavi, Potosí. These specimens were being proudly offered at the Main Show by Brian Kosnar of *Mineral Classics* (P.O. Box 2, Black Hawk, CO 80422), though a few were scattered elsewhere as well. Some years ago, you may recall, a number of very large, very sharp, unusually thin bournonite "cogwheels" emerged from this same place; they reach 10 cm across, but the trouble is that they are dull black, i.e. entirely lacking in any metallic-luster pizazz. The new specimens, by contrast, while they also feature flat cogwheels with twinning notches all around their perimeters, are highly lustrous, resembling the best of the old Cornwall bournonites (but thinner). The compound crystals reach 5 cm across, and sit up, in some cases edgewise, on matrix consisting of intergrown octahedral pyrite crystals to 1 cm, with minor sphalerite and tetrahedrite. These first-class bournonite specimens were reportedly found in the summer of 2003.

A just-as-major new Bolivian item is the 25 or so exceptional specimens of **ferberite** found last May in the hallowed Tasna mine, Nor Chichas Province, Potosí Department. Mike Bergmann brought these to the Westward Look show, and by Main Show time he had sold almost all of them, and no wonder: the sharp, jet-black, mirror-faced, bladed ferberite crystals reach 7 cm across individually, and their clusters, lacking matrix and devoid of associated species, range from 5 to 15 cm across. The minor edge-chipping on some of the large crystals, and stumps of broken-off crystals in a few of the large groups, did not dampen the feeding frenzy brought on in Mike's room by these magnificent specimens of ferberite.

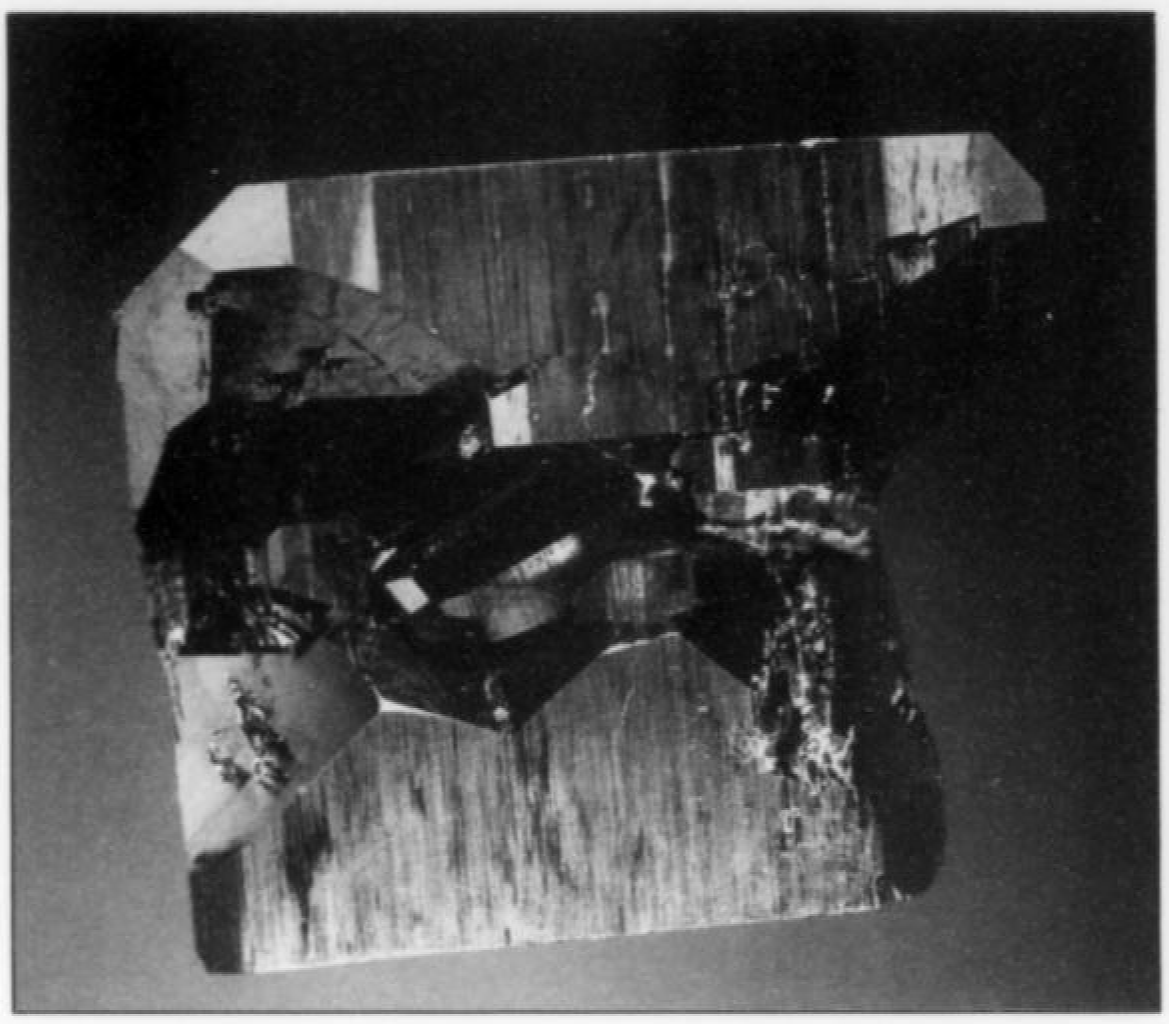


***Figure 5.* Ferberite, 7 cm, from Tasna, Potosí Department, Bolivia. Carolyn Manchester collection; Jeff Scovil photo.**

Finally from Bolivia, there is a new occurrence of **vivianite**, very different from the old ones, discovered in June 2003 at the Tomokoni mine, Colavi district, Potosí Department (just 200 meters from the Canutillos silver/tin mine, incorrectly shown on some labels as the source of the specimens). The vivianite crystals are of typical canted-wedge shape (think of playing-card diamonds), most of them fairly thick, reaching 9 cm; they are of good sea-green transparency, and more lustrous on the side faces than on the wide front faces. The only associated species are barite and siderite, in sparse patches of microcrystals. What's so unusual is that the matrix is a simple, brick-red, muddy-looking sandstone—not the metallic ore masses rich in secondary phosphates which we are used to seeing from the Huanuni and other Bolivian mines. Several hundred specimens of this material, it's said, came out, and at Tucson the greatest number were with Brian Kosnar, although Alfredo Petrov and Rob Lavinsky were well stocked as well.

Brazil also had new **vivianite** to offer—from the Cigana (also called the Jocão) mine, near Galiléia, Minas Gerais. This is the material found in October/November of 2003 and mentioned, while it was still "newborn," by Bill Larson in his Munich report. In Tucson, Luis Menezes in the Executive Inn had the goods, i.e. about 20 nice miniature to cabinet matrix pieces and about 100 thumbnails. Thin, typically wedge-shaped crystals of vivianite to 11 cm across, of only medium luster but of good smoke-blue color and satisfying transparency, sit up on busy matrix of sharp, silvery muscovite plates, some with druses of pyrite microcrystals; and there are floater "flowers" of vivianite, consisting of offset crystals, with slightly curved faces, to 7 cm across. At the same occurrence, highly lustrous, transparent, very faintly smoky prisms of **quartz** to 25 cm were extracted. The best and the brightest of these, however, do not show vivianite in association.

While we're in Luis Menezes' room, let's admire his new stash of bright brown, lustrous **monazite** twins from Buenopolis, Minas Gerais: an old locality once worked by Ed Swoboda, who dug about 2,000 loose specimens from the topsoil there in the late 1970's. Luis' new specimens, like Ed's old ones, are thumbnails, with slightly rough-faced monazite crystals grown right through each other, in wing-shaped twins. There are also (while we're still

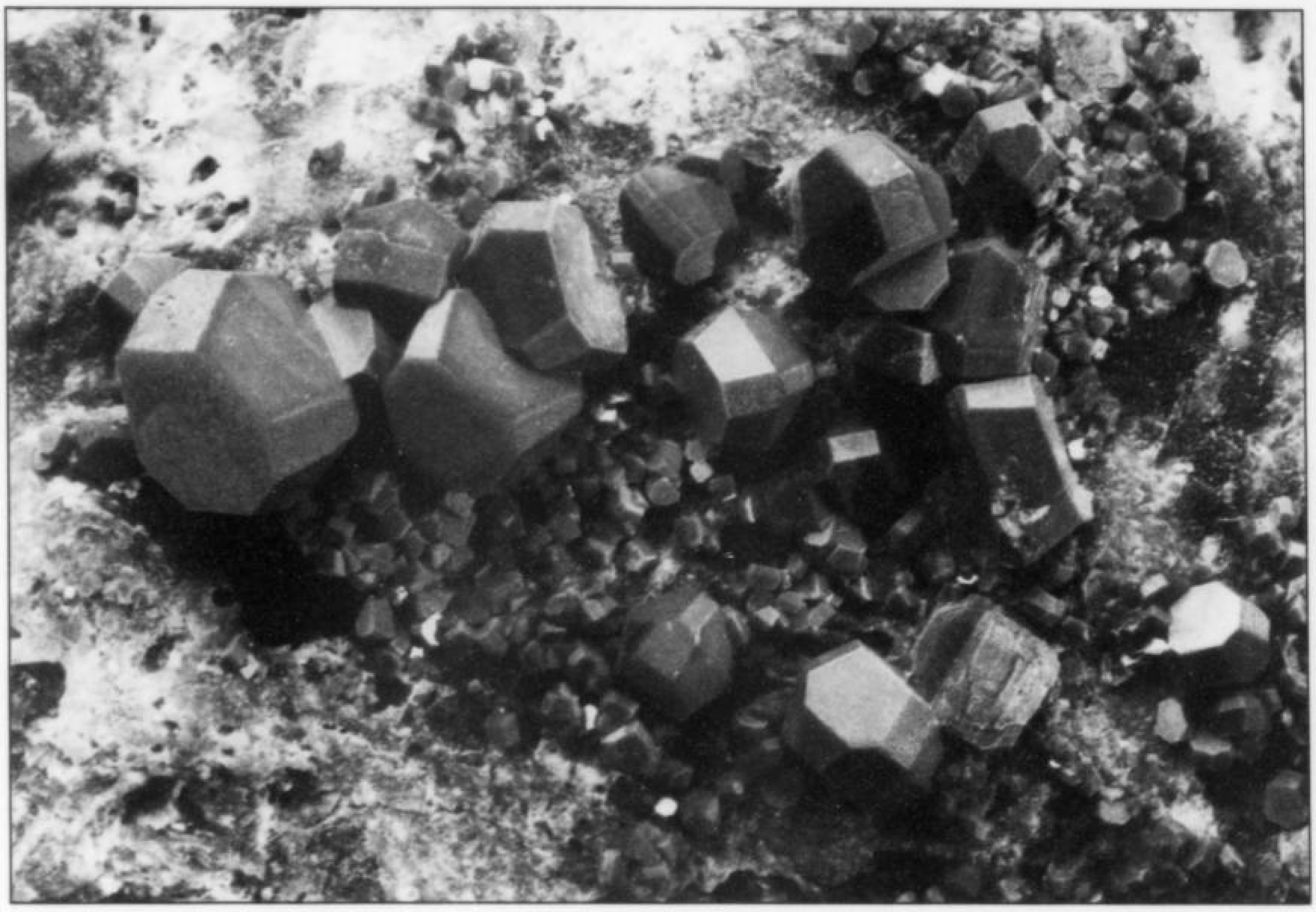


Figure 6. **Metatorbernite crystals to 4 mm from Calo, Soneira La Coruña, Spain. Luis Miguel Fernandez collection; Jeff Scovil photo.**

with Luis) a couple of flats of very bright red-brown **rutile** thumbnail specimens from Diamantina, each one a floater consisting of stubby crystals in reticulated intergrowths, all artful angles and elbows.

Meanwhile, elsewhere in the Executive Inn, Carlos Vasconcelos (Rua Afonso Pena, 3035, 35010-001 Governador Valadares, Minas Gerais, Brazil) was showing off about 25 gorgeous new **elbaite** specimens, from a pocket hit just this past January in the Aricanga pegmatite, Cruzeiro area, Minas Gerais. The crystals are a deep, lush, subtly yellowish green, lightly striated, very lustrous and totally gemmy. Most of them are terminated, which is remarkable, seeing as how they are all very thin, clustering loosely in delicate jackstraw groups. Individual thin-prismatic elbaite crystals reach 9 cm long, and the biggest jackstraw cluster is a dramatic 12 x 12 x 25 cm. This last specimen includes also a colorless prism of **quartz**, and large, hunky, faintly smoky quartz crystals are also found at the locality in sizes to 15 x 15 x 20 cm, most of them showing the thin, gemmy green elbaites as inclusions or half-embedded in surfaces. Brazilian tourmaline strikes again!

More modest, but very pretty, are the loose butterfly-twin specimens of **calcite** which began to emerge two years ago from Nonoaî, Rio Grande do Sul, Brazil. In the ballroom of the Executive Inn, Maurice Eyraud of *Minerama S.A.* (49, Rue de la Republique, 42800 Rive De Gier, France) offered about a hundred loose twins—flattened and very thin, with shallow re-entrant angles—from 1 to 4 cm across the wingtips, of this milky white to colorless, lustrous calcite; there were also a very few matrix plates of cabinet size with butterflies perching all over them. The smaller frozen flutters of cute individual twins were priced at $10 to $100.

In the mineral world we generally don't hear much from Argentina, but possibly that's beginning to change. The odd pseudomorphs of hematite after magnetite from some desolate cinder-pit in Patagonia ("Mendoza" is the locality usually given) are still plentiful around the market, and now, from the same region ("in the middle of nothing," to quote the dealer's characterization) we have abundant, reasonably attractive specimens of **andradite**. The source is a skarn around an iron deposit once worked by an iron mine (closed since about 1940) at La Valenciana, Mendoza. The dealer in question, Jorge Raúl Dascal of *Patagonia Minerals* (Mansilla 3511, 1425 - Buenos Aires, Argentina), says that about 150 andradite specimens in all sizes were dug here in January 2004. Most of these were laid out on a table—unlabeled and roughly size-sorted, after the fashion of the magnetite offering of two years ago—in this dealership's Executive Inn room. Sharp, honey-brown to yellow-green dodecahedrons of andradite reaching 1.5 cm individually form clusters to 12 cm across, some on matrix of massive black hematite. The general resemblance is to the andradite crystals of Stanley Butte, Arizona, except that an elite few of the Argentinian specimens show lustrous, *gemmy* andradite crystals to 1 cm.

On, now, to the Old World. Earlier (apropos epidote/quartz from Peru) I mentioned that the Executive Inn room of Luis Miguel Fernández Burillo was full of interesting things. Among these the most interesting were a handful of excellent **torbernite** specimens which, Luis said, had been found in July 2003 in an outcrop of kaolin and quartz at Calo, Soneira, La Coruña, Spain. This is a brand-new locality for torbernite, and, from the looks of these specimens, a significant and highly promising one. The very sharp torbernite crystals individually reach about 3 mm across; they are tabular and square-profiled although some are modified by secondary faces on and around the corners. They are a rich medium green and opaque (presumably partly dehydrated to meta-torbernite), and they form dense clusters on the chalky white matrix, some druses of smaller crystals filling cast-cavities in the punky quartz. Specimen sizes range from thumbnail to large miniature. Luis says that about 300 good pieces were found in all, covering a wide range of matrix sizes.

But the champion "classic" specimens of **torbernite** in recent years are surely the magnificent crystal groups from the Margabal mine, Entraygues, Aveyron, France: the old locality that was reborn very dramatically in the 1990's, when hundreds of world-class specimens hit the market (see the Denver report in March/April 1998, and Eric Asselborn's letter in Sept./Oct. 1998). Very recently, Daniel Trinchillo of *DeTrin Minerals* acquired about 50 superlative specimens of Margabal mine torbernite from a French collector, and in Tucson he marketed the stash. Thumbnail to small-cabinet crystal clusters display very sharp, blocky, well individualized torbernite crystals to 2.5 cm, some specimens showing interesting crests and coxcomb-growths of subparallel crystals; a first-rate thumbnail could be had for around $200. It is quite possible that this offering represents the last large market appearance of French torbernite at its best.

The Trinchillo dealership and the Van Scrivers of *Heliodor* operate out of a quite elegant venue at the Tucson Show: a big white house adjacent to the InnSuites, with three spacious rooms lined with glass cases, all chocked with outstanding specimens. Outside and behind the house, an open courtyard and big white tent contained more tempting selections of specimens, and the centerpiece of the area under the tent was a Chinese stibnite cluster measuring about 3 x 3 *feet*: the most absurdly gigantic stibnite I never could have imagined.

Bright, sharp, *blue*, tetragonal-bipyramidal crystals of **scheelite** from the very old mines of Baia Sprie (Felsöbánya), Romania have been known for an indefinitely long time, but have always been very sparse on the modern market—this distinctive scheelite occurrence is, in my opinion at least, the most "elite" one for the species. Well, blue Romanian scheelite is *still* very rare (especially compared to the recent floods of gemmy orange crystals from China, Pakistan and Peru); however, a pocket found about a year ago at Baia Sprie produced about 40 fine specimens, a few of which were beguilingly scattered about the Tucson Show, most residing with Luis Burillo and (at the Main Show) with Ross Lillie of *North Star Minerals*. Mirror-faced and brilliantly lustrous, smoky blue to maroonish gray scheelite bipyramids rest lightly on a pristine white matrix of drusy dolomite. The scheelite crystals reach 3 cm, but the most brilliant among the larger ones average about 1.5 cm. These exquisite thumbnail specimens represent perhaps the best-yet expression of blue Romanian scheelite, and both dealers were pricing them in the low three figures.

Having mentioned those elegant display rooms in the old white house by the InnSuites where both the *DeTrin* and the *Heliodor* dealerships were holding court, I must also say that Brad Van Scriver of *Heliodor* filled a couple of shelves of one of the cases with a knockout batch of **vanadinite** specimens collected some years ago from prospects near the ACF mine, Mibladen, Morocco. Decades ago now, vanadinite-aficionado Wendell Wilson wrote a show report in which, concerning Moroccan vanadinite, he happily asked "will it *ever* end?" . . . and still the answer is no, it hasn't ended, it's only continuing to get even better, and top specimens seem to be more abundant each year. Brad's specimens, collected in 1999/2000, range in size from 4 to 15 cm, and show amazingly sharp and brilliant hexagonal-tabular vanadinite crystals to 3.5 cm across sitting up perfectly on white barite matrix. Horst Burkard, François Lietard and Jordi Fabre were among many other dealers around the show who had almost-as-good Moroccan vanadinite specimens on hand.

Like Agatha Christie's Inspector Poirot, Gilbert Gauthier likes to remind people that he is Belgian, not French; but no one who

Figure 7. **Blue scheelite crystals to 1.6 cm from Baia Sprie (formerly Felsöbánya), Maramures, Romania. Ross Lillie specimen, now in the Tom Moore collection; scanner photo by Wendell Wilson.**

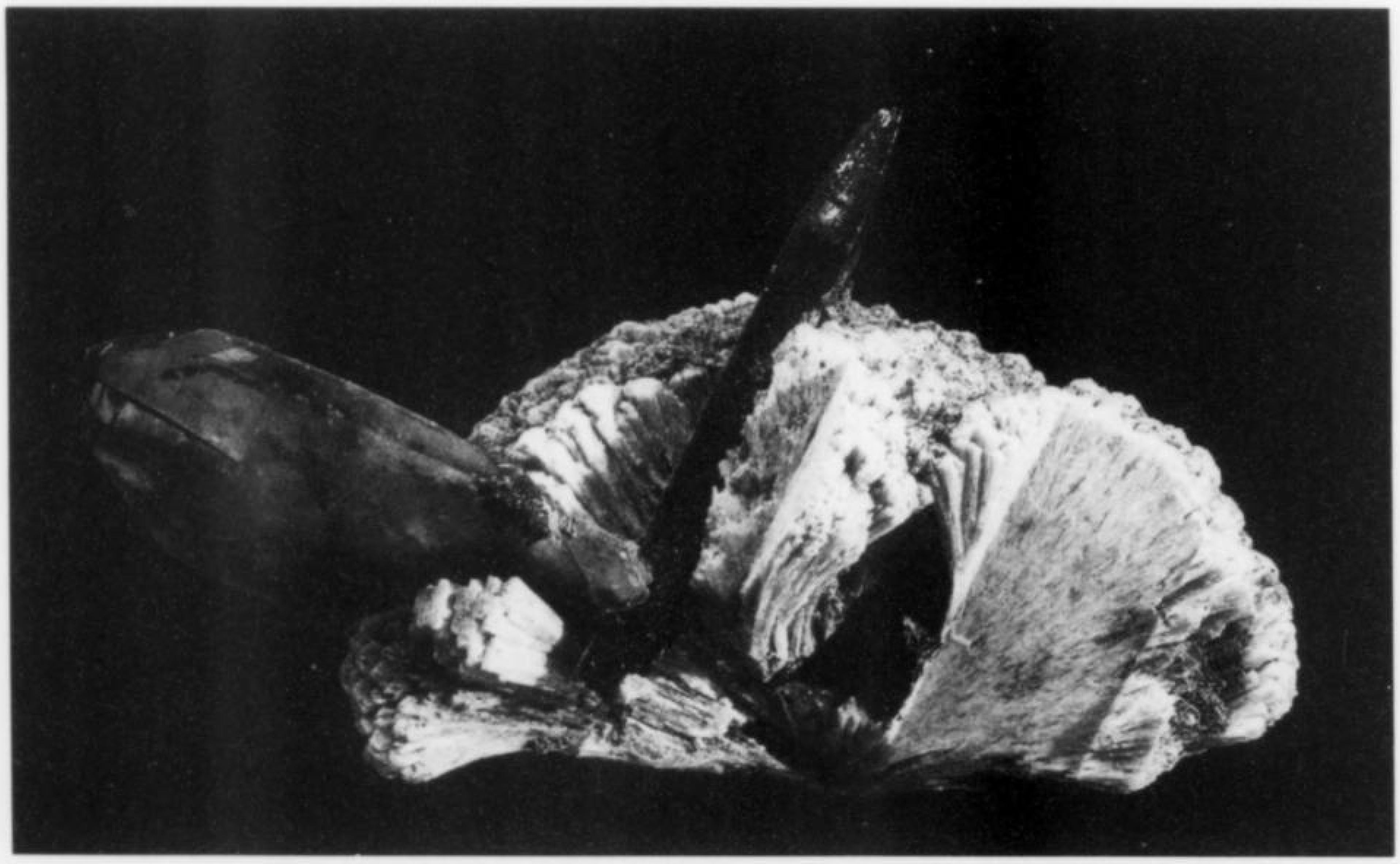


Figure 8. **Kainosite-(Y) with black aegirine and smoky quartz, 4.7 cm, from the Zomba district, Malawi. Paul Botha specimen; Jeff Scovil photo.**

knows the ever-bustling Gilbert needs reminding that he is always apt to come up with something exciting from central Africa. This year, at his stand in the ballroom of the Executive Inn, it was about a hundred very good, all-sized specimens of **dioptase** from the Tartara mine, Shinkolobwe, Katanga, Congo (Zaire). This old copper mine, 10 kilometers west-southwest of the town of Shinkolobwe, was worked in the early 20th century, closing before World War II, but the new specimens were gathered from the old workings by native diggers about two years ago. Medium-sharp, lustrous, deep green dioptase crystals to 2 cm line seams in white dolomite; some specimens also show massive bright blue chrysocolla, patches of drusy quartz, and tiny spheres of pale blue shattuckite. Large miniature and small cabinet specimens of this attractive (and "new") dioptase were priced by Gilbert up to $1,000.

Kainosite-(Y) is a very rare carbonate/silicate of calcium and the rare-earth elements, of which the best specimens heretofore have been very small, gemmy crystals from Swiss and Austrian Alpine pockets. But in mid-2003 the complex, rare earths-rich alkaline pegmatite at Mt. Malosa in the Zomba district, Malawi (see the article in vol. 25, no. 1) produced about 15 specimens with kainosite-(Y) crystals to 4 cm growing in subparallel fan-shaped groups on a matrix of feldspar and aegirine. The opaque, dull, brownish yellow crystal fans are not pretty, but represent a giant quality-leap for the species (and their identity has been verified by Dr. Bruce Cairncross). Paul Botha of *Southern Africa Minerals* (P.O. Box 12027, Vorna Valley, 1686 South Africa) brought a very few specimens to Tucson, and promises (well, semi-promises) that more will be coming soon.

An altogether more beautiful new item from Africa is the orange ("Imperial") **topaz** now being dug from an undisclosed site in northern Zambia, so near the Congo border that the nearest identifiable entity is the town of Kolwezi, in Katanga, Congo. The loose topaz crystals, ranging from 1 to 8 cm long, are brilliantly lustrous and gemmy, and of a very rich orange (some slightly pinkish) color, very closely resembling their cousins from Ouro Preto, Minas Gerais, Brazil, except that they have busier, more complex systems of secondary faces around the wedge terminations. Reportedly they are found loose in sand near some deeply weathered, presumably granitic, rock unit. Bill Larson mentioned these lovely crystals in his Munich report. In Tucson it was Brice and Christophe Gobin who brought about 20 crystals, first to the InnSuites, then to the Main Show, selling them for low three-figure prices.

Safari-ing on now into Asia, we make a quick stop in Kazakhstan to note that the famous **dioptase** specimens from Altyn-Tube are still appearing, as they did last year, and are continuing to improve. According to Ivo Szegeny of the KARP dealership (P.O. Box 54, 272 80 Kladno, Czech Republic), a Kazakhstan company is now systematically mining the Altyn-Tube limestone for specimens. Although these pieces were scattered widely about the show, the most and the best of them were in the KARP room at the Executive Inn: the dioptase crystals are deepest green, quite sharp, and reach 1.5 cm, occurring as loose groups or as generous strewings over white chunks of matrix to medium-cabinet size.

At the Westward Look show, Mike Bergmann flashed at me some loose rosette-clusters of **azurite** crystals. The rosettes are uniformly between 3 and 4 cm in diameter, not particularly lustrous but well composed, with small azurite blades all around 360° of each sphere. The surprising locality is the Itauz mine near Dzhezkazgan, Kazakhstan (a site which lately has been excelling in native copper specimens), situated in a large district of copper mines known primarily heretofore for its fine specimens of metallic minerals (Dzhezkazgan silver, copper, bornite, chalcocite, betekhtinite, etc.). It is stimulating to see, at last, presentable specimens of secondary copper minerals from this region—especially in quantities such as the 15 full flats offered by Mike.

I am tired by now, I confess, of writing about the wonders that have been pouring forth for about 15 years now from Dal'negorsk, Primorskiy Kraj, Russia—"will it *ever* end?"—but cannot refrain from mentioning this time an extremely nifty new habit of **fluorite** found there within the past year. Like the famous "ice cubes" and "invisible fluorites" of earlier times, these new crystals are absolutely transparent and colorless, but their faces are adorned with intricate, etched-looking ridges and swirls. Furthermore, instead of simple cubes they are cubo-dodecahedrons, of which a few pairs are spinel-law twinned in cozy offsets. The crystals reach 3 cm, and sit up well on a typical "Dal'negorsk" matrix of quartz crystals coated by dull greenish chlorite or clay. Several Russian dealers, plus KARP and Heliodor, had appealing small specimens—and *my* thumbnail cost only $20.

About a year ago a chromium mine near Gulbahar, Ghazni Province, Afghanistan produced generous numbers of matrix garnet specimens sporting bright apple-green, in some cases gemmy dodecahedral crystals of a garnet species which some dealers in Tucson were calling pyrope. However, according to François Lietard, who has had specimens tested at the Smithsonian and in Europe, the mineral is **andradite**. The crystals reach 2 cm across, and are thickly scattered (in the best specimens) on white matrix. Specimens were brought to Tucson by several wholesalers and other outdoor tent-type dealers, but the best I saw were with François in the Executive Inn and at the Main Show. Also, François offered about 100 miniature and small-cabinet specimens of a new, fairly attractive **vesuvianite** from the Siro Mountains, Khak district, Zabul Province, Afghanistan. The blocky, medium-lustrous crystals, individually reaching 5 cm, are intergrown as cavity-fillings in massive pale blue calcite: this makes for a nice, offbeat color effect, as the vesuvianite itself is orange-brown with green overtones.

But for my money, the most exciting new item from Afghanistan this time was the new, very pale, gemmy, lilac-colored **scapolite** in sharp, well terminated, beautiful crystals in matrix. These were collected at (or somewhere near) the classic Sar-e-Sang, Badakhshan locality revered for centuries for its lazurite crystals. Not many of these lilac gem scapolites were around, and the great majority of them are loose, generally rather rough single crystals measuring from less than 1 cm to 7 cm. The very rare specimens in which the gem crystals stand upright in a mottled brown/white matrix are of exceptional beauty, and surely represent a world-class occurrence of scapolite (usually so opaquely dull white and uninteresting). Brice and Christophe Gobin of the *Gobin Sarl* dealership had a couple of premium matrix pieces, and more liberal numbers of specimens (nearly all just loose crystals, however) were found in the Executive Inn room of Jamal Ul Hasnain Gillani (No. 1, 2nd Floor, Al-Jalil Market, Namak Mandi, Peshawar, Pakistan).

Late November/early December of 2003 saw a discovery of world-beating crystals of **xenotime** at Torghar, Kyber Agency, Pakistan—about 10 km from the earlier-known Zagi Mountain locality which has also lately produced exceptional specimens of xenotime (see the full article on Zagi Mountain elsewhere in this issue). The Torghar xenotime specimens are loose, parallel-growth crystal clusters of thumbnail and small miniature size, and the sharp, lustrous, pale brown, blocky to elongated xenotime prisms reach 4 cm. About a dozen specimens were with Dudley Blauwet (of *Mountain Minerals International*) at the Main Show.

Then there are the very nice, petite specimens of lustrous black **magnetite** in sharp, lightly striated dodecahedrons to 2 cm or so, from the Laila Base Camp, Haramosh Mountains north of Dusso,

Figure 9. **Scapolite crystals to 1.5 cm from Badakhshan, Afghanistan. Gobin Sarl specimen, now in the Tom Moore collection; scanner photo by Wendell Wilson.**

Gilgit Division, Pakistan. At the Main Show, François Lietard had a whole flat of these, with the floater singles and two or three-crystal clusters, mostly of thumbnail size, priced around $15 apiece.

India checked in this year, as usual, with a few new discoveries made recently in the Deccan zeolite province (see the January-February 2003 Special Issue for abundant background). **Stilbite** in big, thick, lustrous, creamy white to pale orange bowtie aggregates was found at two different sites last year, 250 kilometers apart in Maharashtra state: Sangamner, Ahmednagar, and a well-digging in the Aurangabad district. At the former place, the sharp bowties reach 15 cm across; most are loose, having been found as floaters in the soil, but there are a few specimens with the stilbite resting on large matrix plates of weathered basalt. Specimens from the Aurangabad locality are similar, but do an interesting color-change trick: pure white when they emerged, they have since acquired a distinct orange tint from exposure to sunlight. The Aurangabad site also yielded about 500 fair-to-good specimens of **powellite**, with translucent white to pale orange, rounded clusters of powellite "points" to 8 cm across with the stilbite. Next we come to the famous Malad quarry complex near Mumbai (Bombay), from whence have lately emerged about 20 winsome thumbnail specimens of lustrous pinkish orange **stilbite** (or stellerite—no species-determination has yet been made), as spherical 2-cm clusters to which adhere patches of chalky white zeolitic material. Finally, from Savda, near Jalgaon, there are about 35 miniature specimens of stilbite heavily coated and included by dull greenish black **julgoldite** in microcrystals and brushy sprays to 2 cm—the sprays being quite a remarkable performance for this rare, albeit unpretty, species. All these Indian goodies were being offered in the Executive Inn by K. C. Pandey of *Superb Minerals India.*

From China this year, once again, calcite and fluorite showed up from (it seems) hundreds of places, in hundreds of habits and associations; and what man or woman presumeth to name and number them all? Well, actually, in the case of the calcite, a good start has been made by Dr. Guanghua Liu, in his chapter on Chinese calcite in the recent *ExtraLapis English* on Calcite—check it out. Meanwhile I'll only mention the 15 or so outstanding **calcite** specimens, said to have been collected last year at an unnamed metal mine near the village of Lian Xian, in Guangdong Province, which were brought to Tucson by the *Bear Connections* dealership. I learned of these specimens from ogling the best one of the lot, a spectacular double-fist-sized piece acquired by calcite collector Terry Huizing and placed by him, lovingly, in the What's New case in the lobby of the Executive Inn. A first generation of calcite growth expresses itself in sharp, perfect scalenohedrons to 7 cm, uniformly coated by sparkling drusy quartz; on these crystals grows a second generation of calcite of radically different aspect—perfect, creamy white and uncoated, tabular "poker chip" crystals to 4 cm across. Terry's big specimen, with both habits excellently developed, is a dramatic contrast-in-sameness viewing experience.

Perhaps the most buzzworthy of Chinese **fluorite** this year was the new group of cabinet specimens (some to 25 cm across) found late in 2003 at the De An mine, Jian Jiang, Jiangxi Province. Supersharp, simple octahedrons of fluorite to 4 cm on edge are intergrown in flattish clusters without matrix, and on thin white quartz plates—having been etched away from the masses of quartz in which they grew as seam-fillings. The fluorite crystals are quite beautiful: translucent, with frosted faces, a dim sea-green in lamplight, a very bright green in sunlight, with thin purplish zones along crystal edges. Spectacular specimens were being offered by Chris Wright, Jordi Fabre, Daniel Trinchillo, Rob Lavinsky and a few Chinese dealers.

For several years now we've seen, sparingly, specimens of the lovely deep brown to pale brown, transparent **cassiterite** crystals which come from the Amo mine, Ximeng, Yunnan Province. No new, spectacular lots of these specimens appeared in any one place at Tucson, but it seems well to mention that quite a few dealers, including Dr. Liu of *AAA Liu's Minerals* (Französische Allee 24, D-72072, Tübingen, Germany) brought modest supplies, and some of the smaller specimens are impressive indeed: some of the gemmy cassiterite crystals are butterfly-twinned, while others are oddly flattened, appearing as squarish tablets to 4 cm in tight intergrowths. The Amo is a tin mine, still active, although no new cassiterite specimens of any importance have emerged from it, according to Dr. Liu, since about 1997.

A *really* new Chinese occurrence is of **wire silver**, with lustrous, slightly iridescent, curling wires to 2 mm thick, in loose snarls and nests, from Kunming, Yunnan Province. The rumor (already!) is that the gold mine in which the silver occurs is mined out, and no new specimens will appear. The ones seen in Tucson were found, reportedly, in summer 2003. Loose nests of this fine wire silver from thumbnail size to 15 cm across were offered in the InnSuites by Casey Jones of *Geoprime Minerals*, and in the ballroom of the Executive Inn by Georg Gebhard.

On the China Section's back page it should be mentioned that the specimens of **cuprite variety chalcotrichite** from the Daye mining area, seen very sparingly around the show, give promise of things to come that might rival Bisbee's achievement in the chalcotrichite line. And many dealerships still offered fair-to-good specimens of the sensational **mimetite** from the Pingtouling mine, Guangdong, which wowed us last year. One rumor has it that "several" new mimetite pockets have been found recently in the mine, although, for what it's worth, none of this year's specimens seemed to me to differ in any essential way from last year's. They *could* have come from a different pocket (some are now available on a limonite matrix), but need not have.

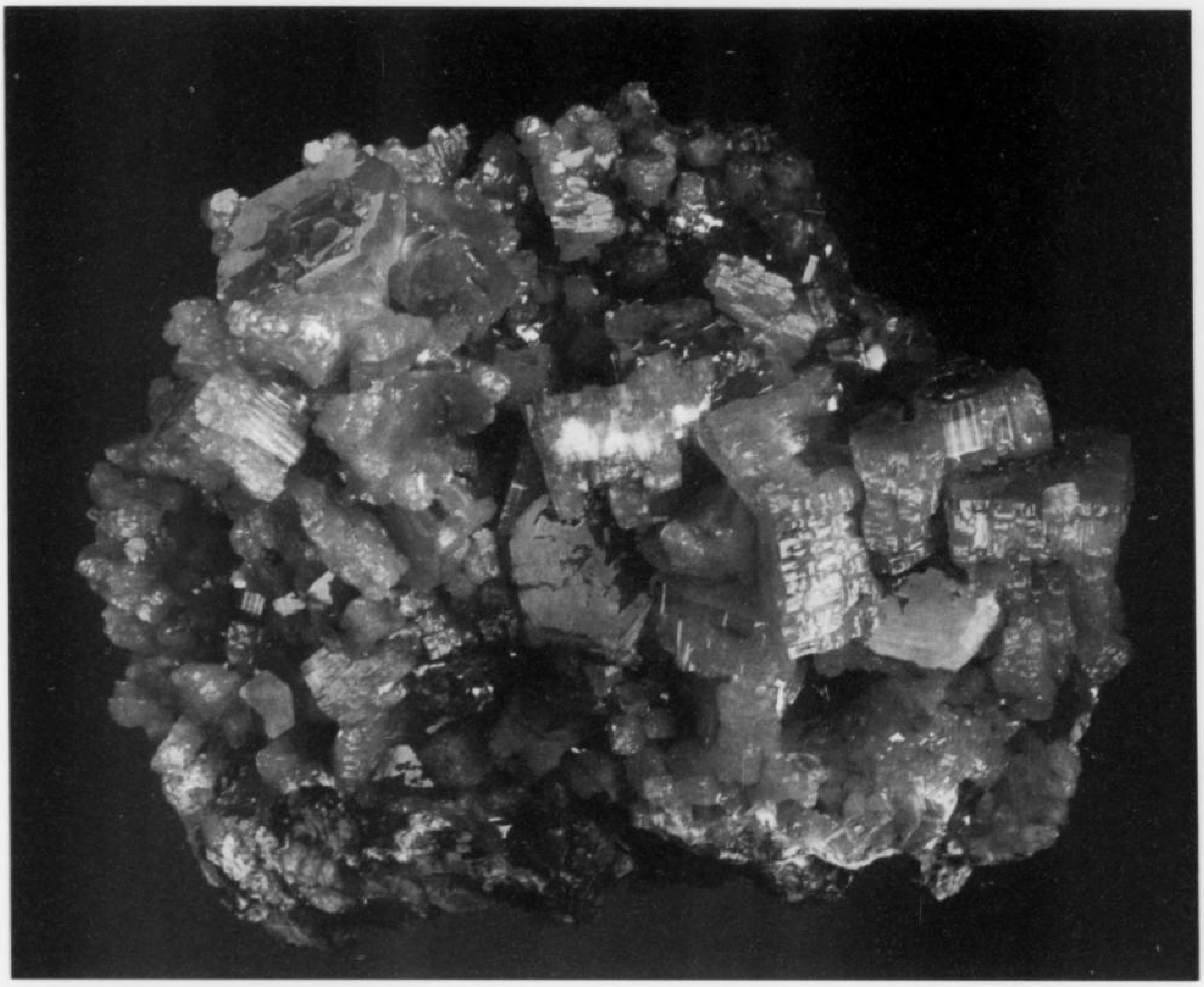


Figure 10. **Mimetite crystals on limonite matrix, 8.7 cm, from the second pocket at Pingtouling mine, Guangdong, China. Ken Roberts specimen; Jeff Scovil photo.**

Figure 11. **Mimetite crystal cluster, 4.6 cm, from the second pocket at Pingtouling mine, Guangdong, China. Ken Roberts specimen; Jeff Scovil photo.**

Down-under at the bottom of this tour/report there are three items from Australia. In one earlier report I mentioned seeing some middling specimens of the **ferrocolumbite** which is intermittently collected from the dumps of the Giles pegmatite prospect, Spargoville, Western Australia, where active questing for columbium and tantalum (and for aquamarine crystals) ceased in the late 1970's. Last year at Spargoville, Ben Nicholson found about 130 good ferrocolumbite specimens, including perhaps 10 which far exceed any taken out earlier, and quite a few of these were being sold in the InnSuites by *New Find Minerals* (P.O. Box 1096, Dickson, ACT 2602, Australia). The sharp, black prismatic crystals reach 6 cm; all possess a decent submetallic luster, and a very few are doubly terminated. Most of the crystals are loose and from less than 50% to more than 90% complete, in sizes from 1.5 to 5 cm, but the really impressive pieces are the matrix specimens, with the stately-looking, no-nonsense ferrocolumbite crystals resting, more than half exposed, in quartz/albite/microcline. The very best piece was purchased by Carolyn Manchester, and reposed for a few days in the What's New case in the Executive Inn.

The Red Dome mine, Chillagoe, Queensland has recently become known as the source of clusters of gemmy, deep red, cubic cuprite crystals. There were no new lots of these on hand in Tucson, but, at the Westward Look show, *Miner's Lunchbox* displayed about 30 cabinet specimens (and more than that number of thumbnails and miniatures) of beautiful **calcite** found in solution cavities in the open pit last November—by far the best calcite I have yet seen from this locality. Rounded, extremely complex crystals showing many forms, but scalenohedral in general aspect, reach 12 cm; they are colorless, transparent, and highly lustrous, and occur as large singles, as groups of two or three crystals without matrix, and (rarely) as crystals resting on pieces of a grayish corroded limestone.

A great and august classic locality is last of all. At the Broken Hill mine in New South Wales about 10 years ago, a couple of hundred fine specimens of **smithsonite** were collected, and nearly all were being marketed this year in the InnSuites and at the Main

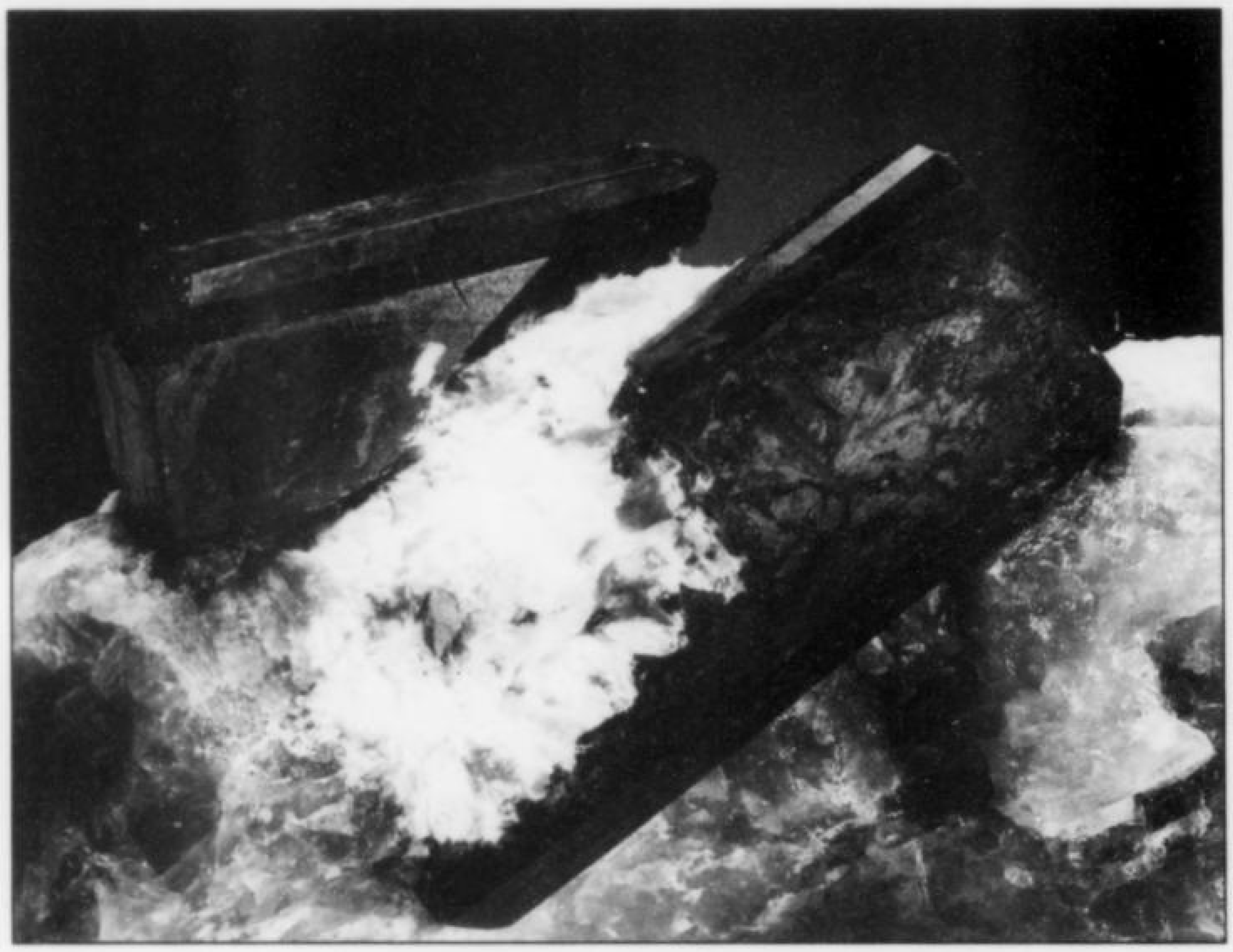


Figure 12. **Ferrocolumbite crystals to 6.1 cm from Giles prospect, Spargoville, Western Australia. Carolyn Manchester collection; Jeff Scovil photo.**

Figure 13. **Copper crystal cluster, 2.6 cm, from the Etauz mine, Dzezkazgan, Kazakhstan. Fabri Minerals specimen; Jeff Scovil photo.**

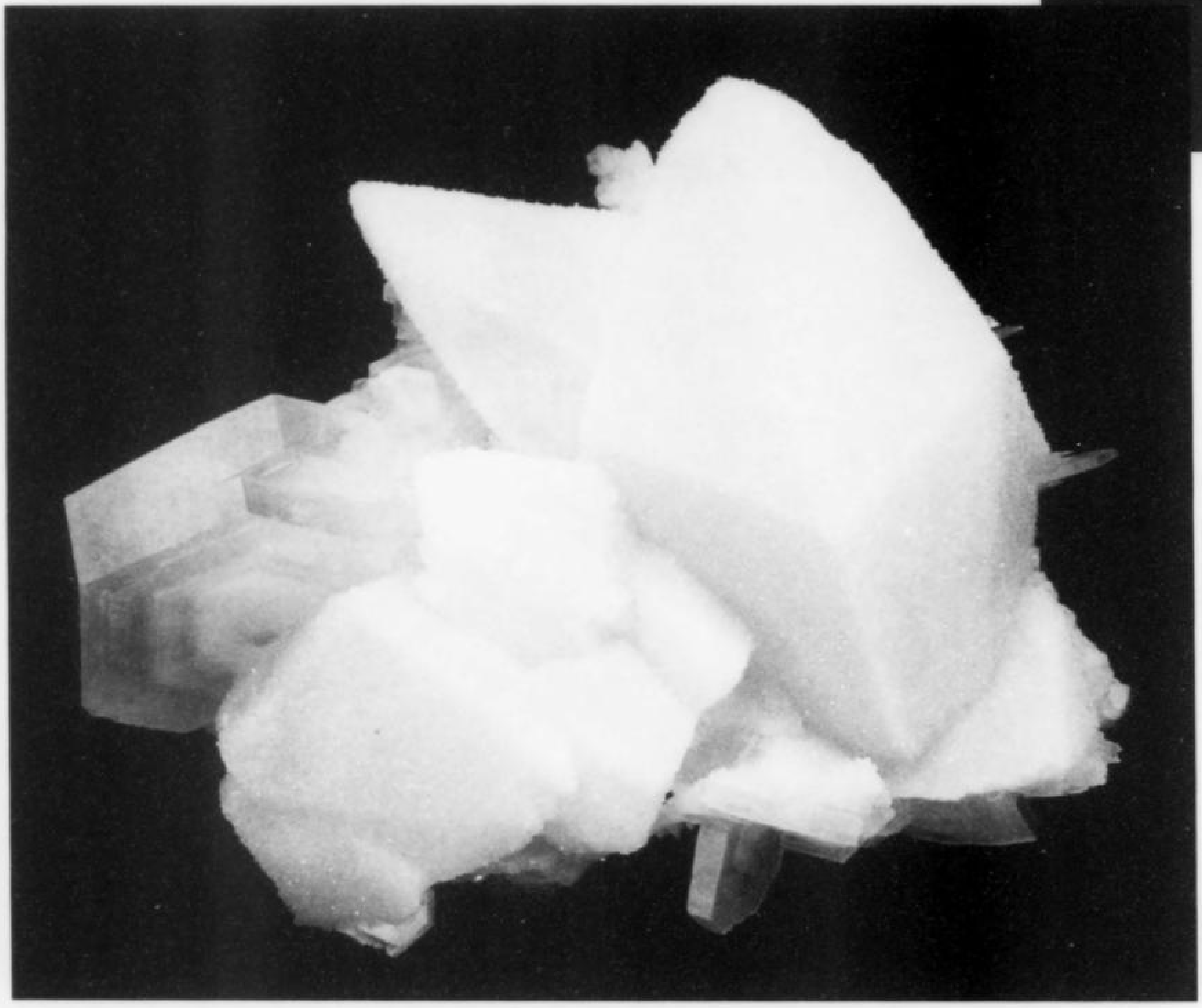


Figure 14. **Calcite crystals coated with drusy quartz, 10 cm, from Lian Xian, Guangdong, China. Terry Huizing collection; Jeff Scovil photo.**

Show by Tom Kapitany of *Crystal World* (1672 Princes Hwy, Oakleigh East 3166, Melbourne, Australia). The smithsonite appears as lustrous gray-white translucent "dewdrops" strewn all over thin spikes and laths of dull black coronadoite. The individual dewdrops are never larger than 5 mm, but they hang richly and ornamentally on the black floater shards of manganese oxide. Specimen sizes range from 1.5 to about 8 cm, and good thumbnails run around $50. This is the classic Broken Hill smithsonite you've read about (a good picture appears on p. 232 of Bill Birch's *Minerals of Broken Hill*, 1999), and this was your chance to get a fine one—if, of course, you were there, as you know you should have been.

I have already tried to communicate something of the extra-special excitement at the Main Show this year, because of the show's fiftieth anniversary and because of all that **GOLD** which was brought to town for the occasion. The general hue and cry and the expressions of worshipful awe around those gold cases were just what one would expect, and so, instead of running superlatives predictably around the old track, I will simply say that the major gold cases included the following: Gold Mines of Transylvania

Figure 15. **Sphalerite with galena and quartz, 4.9 cm, from Shui, Koushan, Hunan, China. Stuart Wilensky and Irv Brown specimen; Jeff Scovil photo.**

(with specimens showing visible crystals of petzite, hessite and alabandite)—Bill Pinch; a gorgeous case with gold coins, assay scales, books, pictures, etc., and superb specimens including the famous "tree root" California gold—Wayne and Dona Leicht; twelve tremendous old golds from the Burrage collection—Harvard; Native Elements of the Gold Group—A. E. Seaman Mineral Museum; a small but densely packed, luscious case of miscellaneous gold specimens—Keith and Mauna Proctor; Gold of Papua New Guinea—Larry and Bec Queen and Larry Queen, Sr.; Gold From the Western U.S.—Natural History Museum of Los Angeles County; Australian Gold—Penny Williamson and Paul Carr of the University of Wollongong; the "Boot of Cortez," a 32.5-pound nugget found with a metal detector in the Sonoran Desert in 1989—St. Troy Consolidated Mines, Ltd.; golds from the Smithsonian, including the great, famous, foot-high "Seaweed"; The Literature of Crystallized Gold (with fine old crystal models and drawings)—Geo-Literary Society and the Gemological Institute of America; Gold Mining Memorabilia—Herb and Monika Obodda; Gold From Unusual Places, and Gold Fakes (including a really quite handsome specimen of gold-plated pyrite, with perfect 2-cm pyritohedrons)—Society of Mineral Museum Professionals; the Fricot nugget (really a brilliant crystal specimen about 45 cm wide, found in California in 1865—it is shown on the front and back cover of the second Gold Issue, vol. 18, no. 1)—California State Mining and Mineral Museum; Famous Collectors and Their Gold Specimens, 1500–1900 (a fascinating historical case with antique Transylvanian golds, old labels, title pages of books back to Cronstedt (1770), pictures of old, dagger-moustachioed European aristocrats who collected gold, etc.)—Christel Gebhard-Giesen. And there were other sumptuous cases of just plain great gold specimens put in by, among others, the Houston Museum of Natural Science, the American Museum of Natural History, the Carnegie Museum, the Arizona-Sonora Desert Museum, the Royal Ontario Museum, the Rice Northwest Museum, and several private collectors. Oh yes, and at one end of the hall was the traveling exhibit of the "Ship of Gold" (see the article by Q. David Bowers in the January-February 2004 issue), where crowds kept lining up all day to see the gold coins and ingots retrieved almost mint-fresh from the seabed where they had rested since 1857.

On the "Gadsden Purchase" theme there were many displays making clear why the U.S. made a good buy 150 years ago, especially as measured by treasures in secondary mineral species from weathered metallic deposits. Two magisterial cases on Bisbee, with specimens and memorabilia, were put in by Evan Jones, and two others, just as beautiful, by Richard Graeme III and his two sons (possessors of the world's best private collection of Bisbee minerals, to which Dick seems entitled enough, since he wrote the special Bisbee issue of September-October 1981). Dawn Minette let us see again the accumulation of exquisite Bisbee azurite roses which her husband Jim came onto not too long before his death: the now famous "Shoebox" hoard of small specimens mined in the late 1890's. John C. McClean, Tony Potucek and the Bisbee Mining and Historical Museum also displayed rich arrays of Bisbee specimens. More broadly, there were two large, geologically erudite cases on Minerals of the Gadsden Purchase, respectively by the Arizona-Sonora Desert Museum and the University of Arizona

Figure 16. **Gene and Roz Meieran's incredible Colombian euclase crystal, about 18 cm, in their exhibit case (which won the Desautels Trophy). Wendell Wilson photo.**

Figure 17. **The Lidstrom Award Memorial case assembled by Gene Meieran (both photos this page) showing nearly all of the specimens that have won the Lidstrom Award over the years. Wendell Wilson photo.**

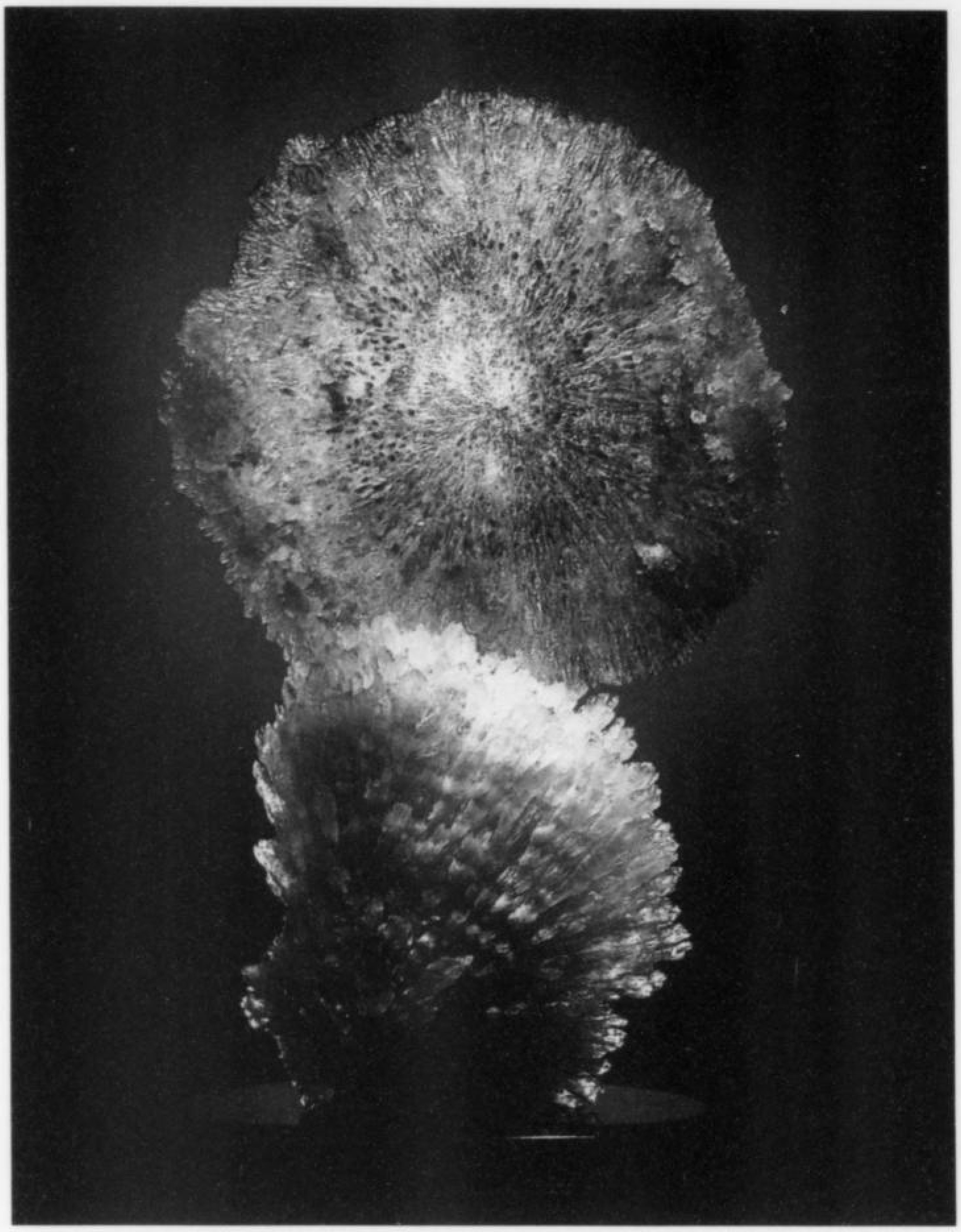


***Figure 18.* Amethyst "flower," perhaps the largest known, measuring near a meter (35 inches), from Irai, Rio Grande do Sul, Brazil. Andreas Guhr (*Mineralien* Zerntrum) specimen.**

Mineral Museum; still more fine cases on the Gadsden theme were put in by the Arizona Mineral & Mining Museum Foundation, Bob and Susan Weaver, Dick Morris, Mark Hay, Les and Paula Presmyk, Ed and Aleta Huskinson, Mike and Mary Jaworski, David A. Witwer, John and Karen Cesar, and Robbie and Bill McCarty. And special cheers go to Sam Elbin, whose case showed Arizona specimens resting on photocopies of the appropriate articles from the Arizona special issues of the *Mineralogical Record.*

But even *two* charismatic show themes did not fully embrace all the wonderful things to be seen in that long, long row of showcases laid grandly down the middle of the Convention Center floor. Let's see, now: there was the majestic 198.6-carat "Bismarck sapphire" set in a diamond and platinum necklace—Smithsonian; two sprawling Elmwood mine, Tennessee cases full of large, melodramatically gorgeous calcites—one case by Dennis Fischer, the other from the Joe Kielbaso and Bryan Brookmyer collections; a case showing most of the Lidstrom Trophy-winning specimens from between 1978 and 2003—organized by Gene Meieran; a big end case loaded with stunners from the Deccan Plateau, India—Steve and Clara Smale; another end case with very large, assorted drop-dead pieces, include the "dinner plate" or "fruit basket" Sweet Home rhodochrosite—Keith and Mauna Proctor; a case of quartz from Brandberg, Namibia, including fantastic amethyst and other scepter specimens—Charlotte and Marshall Sussman; a case of elegant thumbnails and miniatures—Wendell Wilson; fine "general" specimens—Matilda Pfeiffer; a case on the minerals of the Apuan Alps, Tuscany, with background pictures showing everything from specimen photomicrographs to sweaty marble-quarriers—Paolo Orlandi, Giovanni Bracci, Renato and Adriana Pagano; and a first-in-Tucson general display of fine specimens by the Natural History Museum of Luxembourg. Other cases did good jobs of addressing other specialty themes: prehnite—Henry and Patsy Schmidt; Russian alexandrite—Ural Gemological Association; twinned quartz—Si and Ann Frazier; the Kladno coal deposit, Czech Republic—KARP; inclusions in quartz—Jaroslav Hyrsl; native silver—Al and Sue Liebetrau; and Himalayan minerals—Mineralogical Association of Dallas.

However, among the non-gold and non-Gadsden cases the one which impressed me most and held me longest was a fairly small, inconspicuously situated case put in by some very hard-working people (as they must have been) from the Natural History Museum of London: "Mineral Classics From Cornwall and Devon." Here, just about every one of the 22 antique specimens was an education in mineral history and mineral "classicism"; most of these pieces once belonged to the pioneering Cornwall collector Philip Rashleigh (1729–1811) and, in the case, many of these had accompanying colorplates reproduced from Sowerby's *British Mineralogy* (1804–1817). A 12-cm specimen of chalcophyllite from Wheal Gorland, collected ca. 1792, shows vugs with rich blue-green platy crystals to 1 cm. A sparkling 10-cm specimen of galena pseudomorphs

Figure 19. **The "Ship of Gold" exhibit, probably the last time it will be shown in public. It commemorates the discovery of the wreck of the *S.S. Central America*, with its Gold Rush load of gold coins, gold bars and gold specimens. Through portholes could be seen piles of gold bars and stacks of gold coins just as they were found on the ocean floor (see the article in the January-February issue). Wendell Wilson photo.**

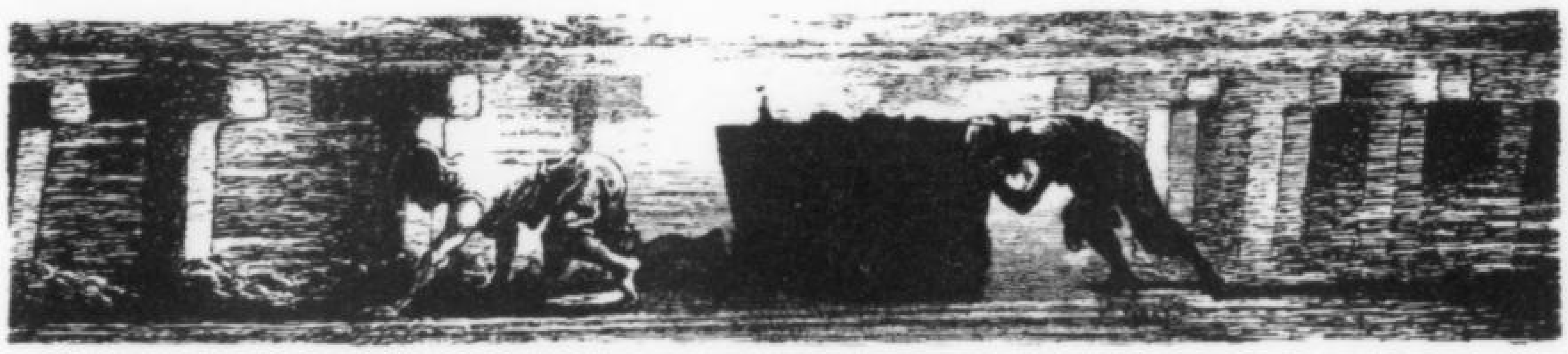
Figure 20. **The Carnegie Museum of Natural Science exhibit of gold specimens. Wendell Wilson photo.**

after pyromorphite from Wheal Hope dates to ca. 1822. Two vivid liroconite miniatures sport sharp crystals to 2 cm. Here also were a giant Herodsfoot mine bournonite; the famous, big siderite epimorph after fluorite from the Virtuous Lady mine in Devon; an astonishing (for Cornwall) acanthite from Wheal Newton with sharp, stacked octahedrons to 2 cm; and a magnificent (more modern) specimen of gold from Hope's Nose, Devon, with delicate ferny growths all over its 10 x 10-cm surface.

The Saturday night awards ceremony led off with a zippy Bob Jones talk about the show's 50-year history, then morphed into an auction (Terry Wallace, esteemed auctioneer) highlighted by the sale of a "Martian meteorite," a gray-painted lump of styrofoam two feet tall, which went for, I think, $100 to some ironic bidder. Then, rather more seriously, came the awards. The Lidstrom Trophy for best single specimen in the show was won by Allan Young for his astonishing thumbnail specimen of Magnet Cove, Arkansas brookite (illustrated in the What's New column in March-April 2004). The Friends of Mineralogy award for the best article in the *Mineralogical Record* was a dead-heat tie between Berthold Ottens' "Indian Zeolites" (the January-February Special Issue) and, well, my own article (with Peter Megaw) on the Ojuela mine, Mexico (the September-October Special Issue); consequently both articles received the award. Awards for competitive gold specimens were won by Ann Frazier (thumbnail), Dawn Minette (toenail), Von Ceil Bleess (miniature), Paul Harter (small cabinet), and Francis Sousa (Arizona gold). The Miguel Romero Award for the best single Mexican specimen in the show was taken (again!) by Kerith Graeber. And Gene and Roz Meieran took the Desautels Trophy for the show's best case of specimens, and Gene himself was this year's recipient of the Carnegie Mineralogical Award in recognition of outstanding contributions to the field of mineralogy and mineral collecting.

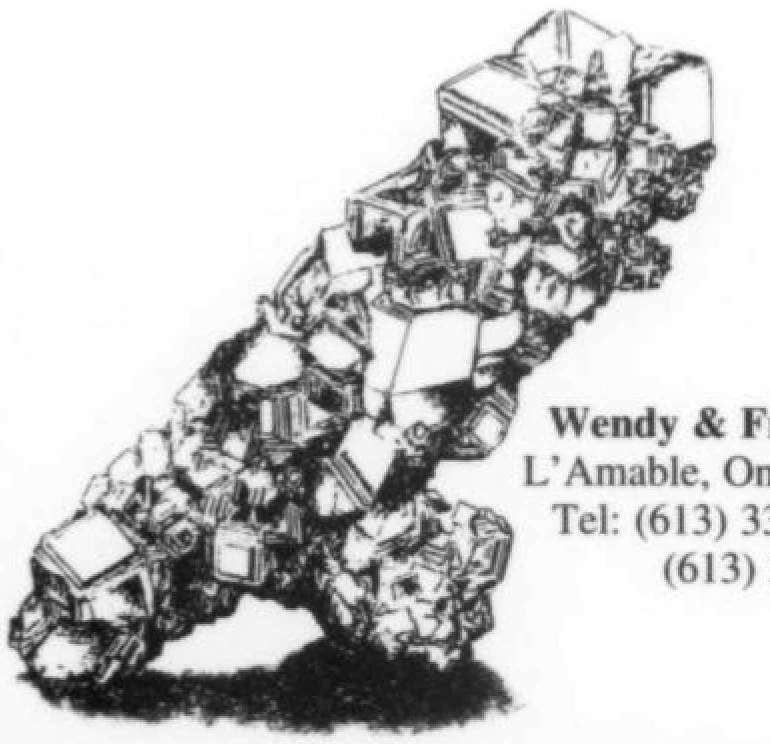
Figure 21. **Keith and Mauna Proctor's exhibit of colorful, mostly gem minerals. Wendell Wilson photo.**

Some big changes in the hotel-show scene are afoot for next year—Marty Zinn will be pulling his Arizona Mineral and Fossil Show out of the aging Executive Inn and resettling it at the Smuggler's Inn at 6350 E. Speedway (about 15 or 20 minutes due east of the Executive Inn). The Executive Inn management intends to promote its own show in the wake of Marty's departure, but we suspect the mineral dealers will want to stick with Marty and stay together. In any case, *that* Tucson Experience is still a long way off . . . I hope you've enjoyed, if only vicariously, the remarkable one that was offered this year. ⊠



DANBURITE – Aurora Mine,
Charcas, SanLuis Potosi, Mexico


ALCOHOL
ACIDS



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

National Organization Website: http://www.friendsofmineralogy.org

Who We Are

The Friends of Mineralogy (FM), formed at Tucson, Arizona on February 13, 1970, operates on a national level and also through regional chapters. It is open to membership by all. FM's objectives are to promote, support, protect and expand the collection of mineral specimens and to further the recognition of the scientific, economic and aesthetic value of minerals and collecting mineral specimens.

FM helps produce locality indexes for specimen mineral localities and is co-sponsor, with the Tucson Gem & Mineral Society (TGMS) and the Mineralogical Society of America (MSA), of the annual Tucson Mineralogical Symposia. Among its activities it also sponsors awards for best articles each calendar year in *the Mineralogical Record*, *Rocks & Minerals* and *extraLapis English* and gives special recognition at the February Tucson Gem and Mineral Show for cases which help explain an aspect of mineralogy.

The Friends of Mineralogy is affiliated with the *American Geological Institute* and the *Mineralogical Society of America,* as well as with *Rocks & Minerals* and *the Mineralogical Record.* Both of these magazines provide FM space and publish news of its activities from time-to-time. FM in turn supports these magazines in various endeavors.

FM Awards

The Friends of Mineralogy annually presents awards at the Saturday night banquet of the Tucson Gem and Mineral Show. There was a tie this year for the best article in *the Mineralogical Record*. The winners at the 2004 Tucson Show were:

Best Article 2003, ***The Mineralogical Record,*** Thomas P. Moore and Peter K.M. Megaw

Best Article 2003, ***The Mineralogical Record,*** Berthold Ottens

Best Article 2003, ***Rocks & Minerals***, Tom Rosemeyer

Best Article 2003, *extraLapis English*, Rupert Hochleitner & Terry Huizing

Best Educational Case, TGMS, 2004 – Individual, Jesse Fisher & Joan Kureczka

Best Educational Case, TGMS, 2004 – Institutional, Houston Museum of Natural Science

In conjunction with the Best Article awards, FM presents a check for $200 to *Rocks & Minerals, the Mineralogical Record* and *extraLapis English.*

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812-855-2687; E-mail: shaffern@indiana.edu

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For Chapter information contact Mark Sherwood, President,
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Southeast Chapter
For Chapter information contact Julian Gray, President,
524 Robin Lane, Marietta, GA 30067; Tel: 770-973-3632;
E-mail: jcgray@gsu.edu

Southern California Chapter
For Chapter information, contact Bob Reynolds, President,
220 South Buena Vista St., Redlands, CA; Tel. 909-781-9310;
E-mail Jreynold@empirenet.com or Bob.Reynolds@Lsa-assoc.com
Visit our website at www.mineralsocal.org/scfm

National Officers

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

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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: Phillip M. Potter
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.
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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
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William Metropolis
Tel: (617) 495-4758
24 Oxford Street
Cambridge, Mass. 02138
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Specialties: Systematic Mineral Coll'n

Western Museum of Mining & Industry

Curator: Terry A. Girouard
Tel: (719) 495-2182
email: wmmicurator@aol.com
Dir. of Educ.: Scott Wright
Tel: (719) 488-0880
Fax: (719) 488-9261
www.wmmi.org
1025 North Gate Road
Colorado Springs, CO 80921
Hours: 9–4 M-Sat.
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The Gillespie Museum of Minerals, Stetson University

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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
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Adjunct Curator: Dr. John A. Jaszczak
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Houghton, Michigan 49931
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Fax: (713) 523-4125
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Houston, Texas 77030
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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

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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.
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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.)
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Arizona Mining & Mineral Museum

Department Director: Doug Sawyer
Curator: Sue Celestian
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Specialty: Arizona minerals

Gargoti Mineral Museum

Director: K. C. Pandey
Tel: ++91 2551 230528
Fax: ++91 2551 230866
D-59 MIDC, Malegaon, **Sinnar**, Nashik 422 103 India
Specialty: Minerals of India

Matilda and Karl Pfeiffer Foundation Museum

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Tel: (870) 598-3228
E-Mail: execdir@ pfeifferfoundation.org
P.O. Box 66
1071 Heritage Park Drive
Piggott, AR 72454
Hours: 9–4 Thurs.–Sat.,
9–5 Thurs.–Sat. (Daylight Savings Time)
Specialties: Fine collection of geodes from Keokuk, Iowa, area; worldwide collection of 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

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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-Sonora Desert 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.)
7:30-5 Daily (Mar.-Sept.)
Specialty: Arizona minerals

Pacific Museum of the Earth

Curator: Kirsten Parker
Tel: (604) 822-6992
E-mail: kparker@ubc.ca
Dept. of Earth and Ocean Sciences
Univ. of British Columbia
6339 Stores Rd.
Vancouver, BC, Canada V6T 1Z4
Hours: 9–4, M–F
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

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51 Mineral Museum Dr.
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Letters

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Sports are the Culprit!

I thoroughly enjoy reading the *Mineralogical Record*, front to back. After having read in your "Notes from the Editors" column about slipping subscriptions I had to comment:

I used to belong to a gem and mineral club here in Texarkana, but due to "lack of members" or just plain lack of interest, the said club finally folded in 2000. I now realize that this is a real problem in other areas as well. And part of the problem is not just the diminishing number of open collecting sites. The problem starts in our homes and in our schools, where children are pressured (by coaches, teachers, parents and by other students who buy into the sports culture) to spend all of their free time playing sports, whether they have a real interest in sports or not. It is unfortunate that the Arts and Sciences suffer because the emphasis in our society so strongly favors youth sports. Our youth are being turned away from the more intellectual pleasures, including activities like mineral collecting.

William K. Hunt
Fouke, AR

We agree that you have a point. Sports can be extremely beneficial to young people, but balance between physical and intellectual pursuits is also essential and is often overlooked or disregarded. The anti-science bias in certain segments of our society may also contribute to this problem, as does, no doubt, the strong emphasis on competitive viability in American culture.

We suspect that there is an additional cultural component keeping young people from becoming mineral collectors. Most mineral collectors are male, strongly suggesting a hormonal relationship in some way. Males are biologically inclined to be hunter-gatherers (ideal for making a mineral collector) but also fighter-defenders (sports). In modern culture those impulses seem to be siphoned off to a large extent, not only by organized sports but also by the massive popularity of addictive video games. Young boys who used to spend their free time outdoors gathering collections of butterflies, plants, minerals, rocks or anything else collectible (as we did in our youth) now burn off their energy playing video games. After the time spent on sports and video games, there may be little time, energy or desire to enjoy the outdoors and the wonders of nature as much as in earlier generations. That's our theory anyway. Does anyone else have any thoughts on this subject?
Eds.

Microscope Supplement

Just wanted to let you know that the supplement on petrographic microscopes was superb. As a long-time optical mineralogist, I was delighted to see the wealth of information made available. While such techniques may be waning in the geosciences, they are still highly useful to those of us trained back in the "Paleozoic."

Henry Barwood
Troy, Alabama 36082

I was pleasantly surprised and excited when I received the microscope supplement to my Mineralogical Record subscription.

In the 1980's my interest and enthusiasm in microscopy were ignited by Walter McCrone as he preached about the polarizing microscope. I had the pleasure of taking a few McCrone courses, and utilized that knowledge in my work in industry. Actually, it was my love for microscopy that got me interested in the hobby of rock and mineral collecting, because I could apply my knowledge of microscopy to an enjoyable hobby.

Nice publication.

Mike Cibulsky
Forest, Virginia

Huanzala Fluorite

In the Peruvian update (May-June), Jaroslav Hyrsl wrote that there have been no new finds of pink octahedral fluorite from Huanzala. However, during my trip to Peru in May of 2002 I purchased a pink, modified cube of fluorite on matrix that was said to have been mined in March or April 2002.

Also, Scott Werschky of *Miner's Lunchbox* advised me that he purchased an octahedral pink fluorite at the mine site around that same time. So it appears that Huanzala is still producing these highly prized specimens, albeit only very sporadically.

Bob Schreiber
Akron, Ohio

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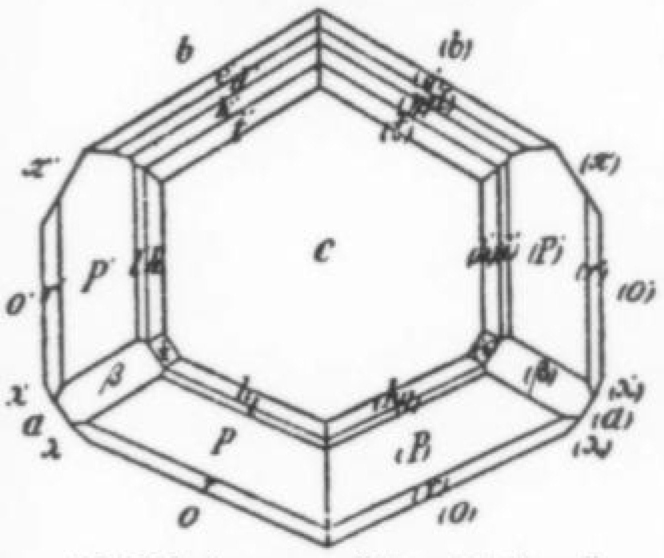

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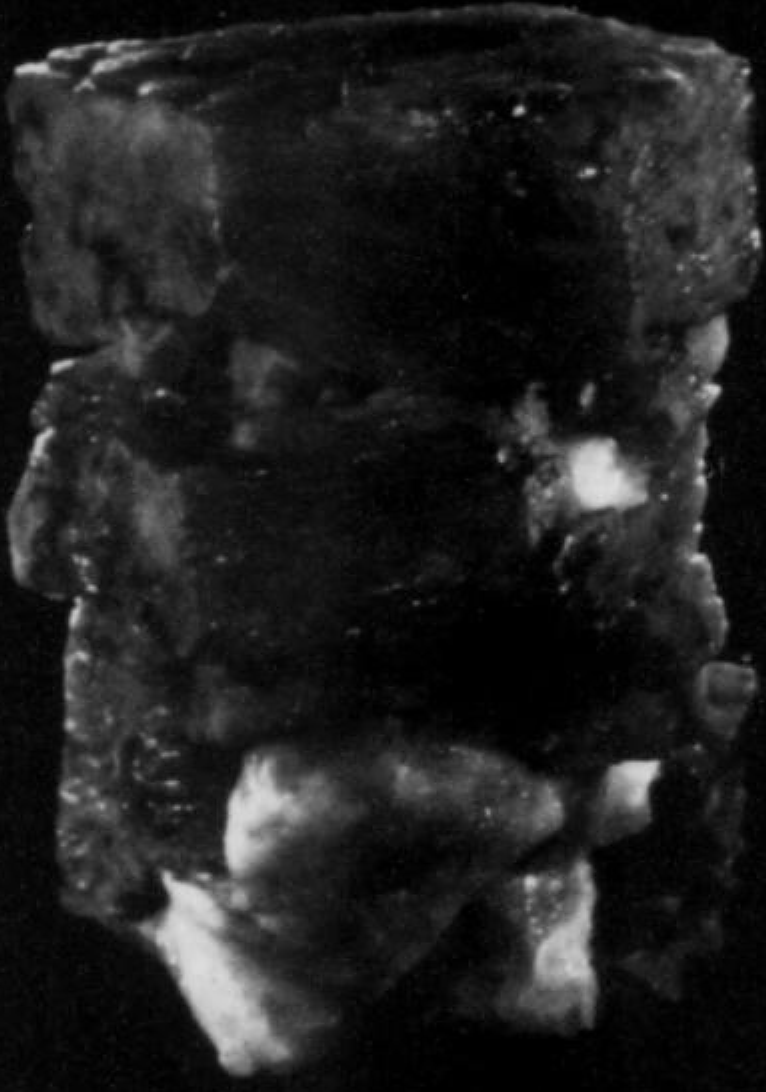

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Ralph Waldo Emerson