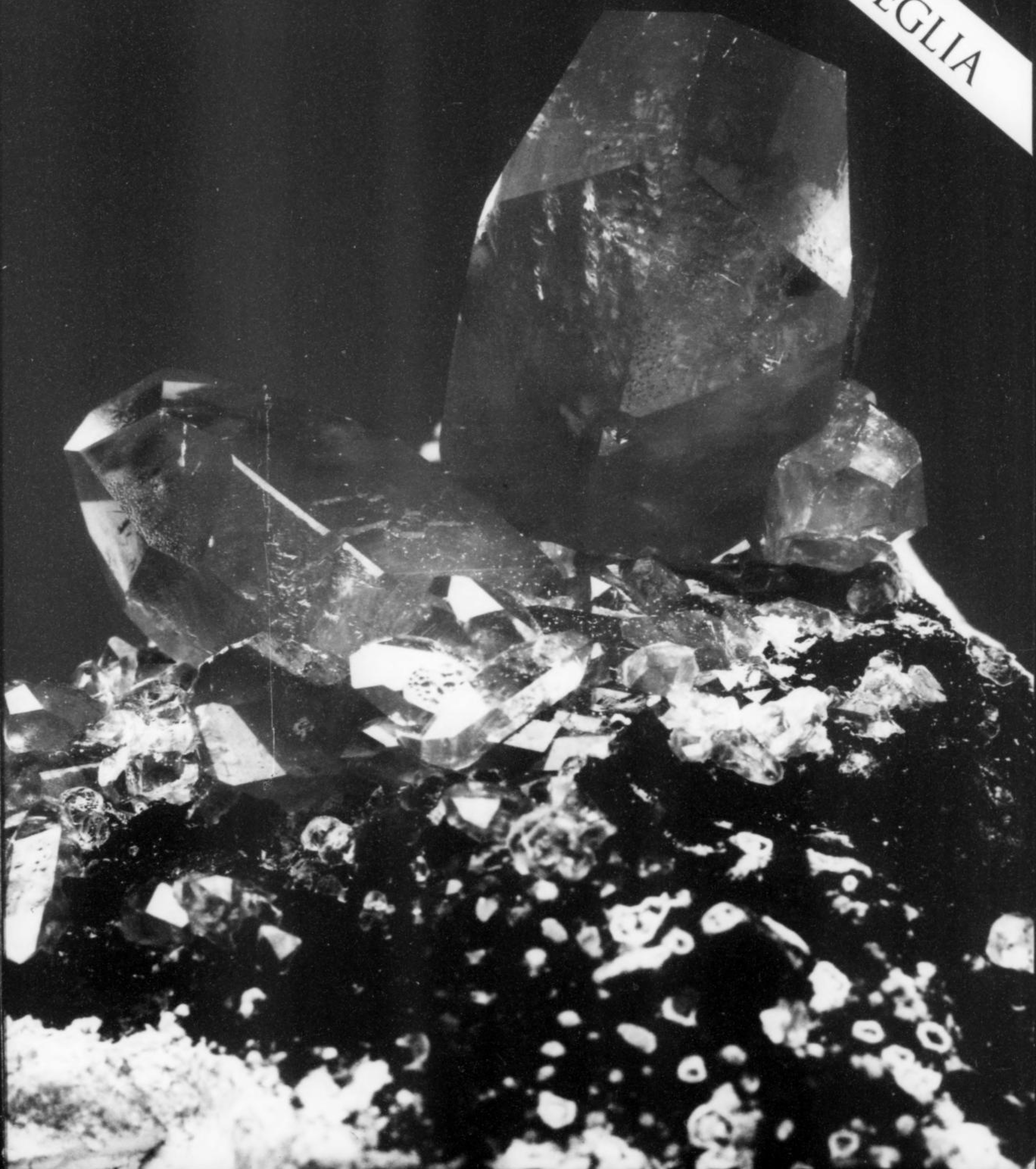
the
Mineralogical Record

Volume Thirty-two, Number Five
September–October 2001
$12

VAL GRAVEGLIA

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THE MINERALOGICAL RECORD

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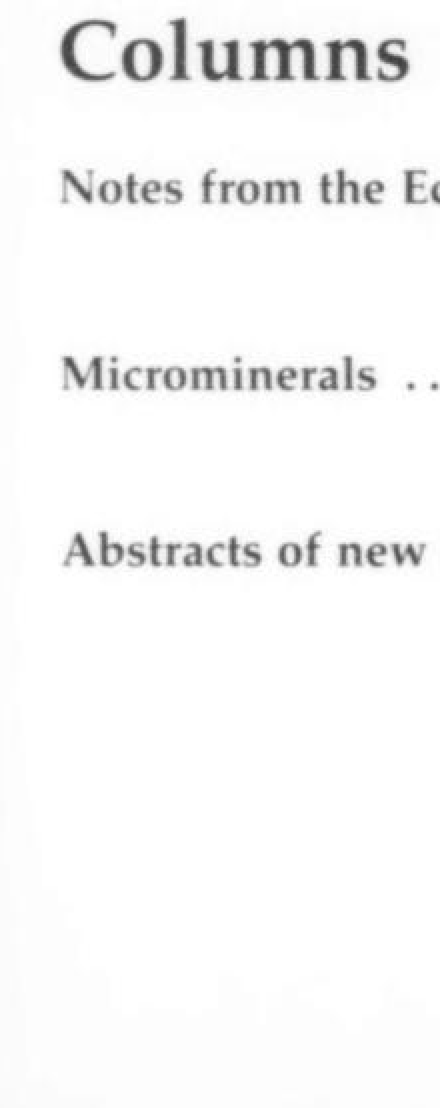
Articles

Columns



COVER: RHODOCHROSITE crystals to 1.6 cm, from the Uchucchacua district, Huanuco department, Peru. (See vol. 28, no. 4, for more on this locality.) Steve Neely collection; Jeff Scovil photo.

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notes from the EDITORS

CONTACTING THE EDITORS

We have telephone, fax and email in the editorial office; and, after much experience with all three, we've concluded that the best route for routine communications with the editorial staff is email. The editorial email address (for both Wendell and Tom) is:

minrec@earthlink.net

Communication by this method will result in the most efficient response, even more so than actual voice communication because we can research our reply thoroughly (without the caller waiting on hold) and send a detailed answer that will not have to be transcribed. Callers from foreign countries can email at any time of the day or night, and can run our reply through one of the free translation websites if English is a problem (try www.babelfish.com).

Email also prevents "telephone tag," that annoying problem of trying to return someone's call to give a response and not finding them in, requiring another recorded voice message. Due to the demands of various duties, we are often not near a phone, not in the office proper, or not able to drop what we are doing when calls arrive; but we do check email several times a day. A query by email can then be forwarded to the best person to deal with your question.

The other email address to have handy is for the Circulation Manager:

minrec@aol.com

Use this one for communications regarding subscriptions, missing or damaged issues, back issues, book sales and wholesale purchases. Here again, the Circulation Manager is often away from her desk, dispatching packages through UPS or the USPS, handling shipments to our warehouse, or transferring books and magazines between the warehouse and the editorial and circulation offices (which are across town from each other). You can leave a verbal recorded message for her by telephone if you wish, but it is so much easier for her to push the print button on your email and have a hard copy of your request or order, especially if a mailing address is involved. Transcription of addresses given verbally is always more prone to errors.

The transmission of short items for publication (Letters to the Editors, Mineral Stories, column installments, book reviews, etc.) is also often easiest by email. However, we do **not** encourage the transmission of full-length articles by this method. There are two reasons for this: (1) We are not set up to forward such submissions electronically to reviewers. Therefore we would have to print off multiple copies of submissions ourselves (at our expense) for forwarding by regular mail. This is an imposition, especially for very lengthy articles, and should instead be done for us by the author submitting the paper. (2) We are **not** set up to handle photos submitted electronically. Some journals are; we are not, especially since we must handle literally thousands of photos and keep them properly filed for examination, layout, color-separation and return. Transparencies are much simpler for us to handle. We also prefer that articles be submitted in complete form, and not in a series of mailings; so it is not a good idea to send text in one shipment and illustrations (later) in another shipment or shipments which must then be reunited with the corresponding text shipment.

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BACK ISSUES

Every once in a while we publish several pages depicting the entire stock of back issues that we have for sale; this is one of those times. Please see pages 381–386. Many of these old issues are still priced at $10 each, which is quite a bargain considering that some of them are over 20 years old! Obviously, sooner or later, we must catch up with the times (and inflation), at least to some extent, and raise these prices. Therefore, as of January 1, 2002, the minimum price for back issues will be $12. You might wish to take this opportunity to fill out your collection at the old price before the increase takes effect. A fax or email to the Circulation Manager listing the issues you want, and your VISA or Mastercard number (e-mailed in two halves separately for best security), will do the trick.

TUCSON COVER SPECIMENS EXHIBIT!

Do you have a specimen once pictured on the cover of the *Mineralogical Record*? If you do, and wouldn't mind exhibiting it at the 2002 Tucson Show in February, contact Gene Meieran at gene.meieran@att.net.

OOPS!

David K. Joyce recently started a new ad and we messed it up. His correct website address is www.davidkjoyceminerals.com (we left out the "k"); his post office box number is 95551 (not 95531); and his postal code is L3Y 8J8 (not L3Y 1N8). At least we spelled his name right! Check out his attractive website for some very interesting specimens.

The Val Graveglia Manganese District, Liguria, Italy

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Val Graveglia is the type locality for eight minerals (gravegliaite, medaite, palenzonaite, reppiaite, saneroite, strontiopiemontite, tiragalloite and vanadomalayaite), and is one of the few reported localities for several other rare species including gamagarite, marsturite, nabiasite, haradaite and pyrobelonite. This deposit has also produced exceptional specimens of tinzenite, sursassite and ganophyllite.

INTRODUCTION

Manganese is the twelfth most abundant element in the earth's crust. Manganese deposits are generally of sedimentary origin, with oxide ore layers interbedded with iron-rich formations, also as carbonate ore in black carbonaceous shales, and as nodular ores. Nodules and crusts can form in soil profiles along weathering surfaces, in shallow marine sediments and on the deep sea floor. Huge concentrations of manganese are often associated with the so-called sea-floor black smokers, which represent the highest part of hydrothermal systems (Bonatti, 1975).

Manganese has been used in small amounts since antiquity, but not until the 1850's were the valuable properties of manganese in iron and steel metallurgy recognized, and the metal finally used in industrial applications. A huge increase in manganese demand occurred in the second half of the 19th century, and many mines were opened. Today's world demand, mainly from the steel industry, is around 25 million tons per year. Most of the present-day production is from Ukraine and Georgia in the Commonwealth of Independent States, China, and from South Africa, Brazil, Australia, India and Gabon. The largest high-grade ore deposits are located in the South African Republic, accounting for about 80% of the world land reserves (Cairncross *et al.*, 1997).

Manganese deposits are often of great interest from a mineralogical point of view: the peculiar electrochemistry of this element and its geochemical association with other elements such as

Figure 1. **The Val Graveglia area, Genoa Province, Northern Italy.**

1—Cassagna mine
2—Gambatesa mine
3—Molana quarry
4—Molinello mine
5—Monte Bardeneto prospect
6—Monte Bianco copper mine
7—Monte Bossea mine
8—Monte Coppello–Reppia prospect
9—Monte Porcile mine
10—Nascio
11—Scrava mine
12—Pontori Prospect

arsenic, barium, iron, lead, vanadium and zinc play an important role in the formation of many interesting and occasionally fine minerals.

The manganese district of Val Graveglia in northern Italy produced over one million tons of high-grade ore in about a century of operation, reaching a maximum production rate of about 50,000 tons per year. The deposits are rather small, but has yielded to date over 125 mineral species, some of which are remarkable for beauty or rarity.

LOCATION

The northern coastal region of the Tyrrenian Sea is called Liguria: the name is from an ancient people known as the Ligures, who lived in a wide area ranging from northern Italy to the southern part of present-day France. Human occupation there dates back to Paleolithic times and is evidenced by many archeological discoveries. The Romans conquered Liguria in the 2nd century BC, and since that time the region has had a complex history.

Genoa is the main city and the main harbor of the region; the eastern Ligurian coast is famous for its beauty and mild climate, including world-famous localities such as Portofino, Rapallo and Santa Margherita. The area surrounding the towns of Chiavari and Lavagna is called Tigullio, after the Latin word *tigellum* (tile) because of the abundance of slates, which are used extensively as roof material (Tiscornia, 1935).

The Graveglia Creek, part of the Entella River Basin, is located in the inland Tigullio area, a few kilometers northeast of Lavagna. The Graveglia Valley (in Italian *Val Graveglia*) covers an area of about 60 square kilometers. The industrial mining of manganese developed there during the 19th century and is continuing today on a very small scale.

HISTORY OF MINING

Human presence in Val Graveglia dates back to the Copper-Bronze Age, as proven by finds of ancient tools at Monte Bardeneto and Monte Zatta (Ministero per i Beni Culturali ed Ambientali—Soprintendenza Archeologica della Liguria, 1998). The mining history of Liguria began much earlier than the Roman conquest. In eastern Liguria, in particular, several ancient mines are known. At Rocche di Lagorara about 3000 years BC jasper chips were quarried to make tools (Maggi *et al.*,1988). In the mining complex of Libiola and in the neighboring Monte Loreto area, about 10 km from Val Graveglia, stone hammers and other primitive wood mining tools were found (Issel, 1879). Recent analyses based on the ^{14}C content on this material have led to the determination of an age of 4580 ± 45 years BP (Maggi and Pearce, 1997).

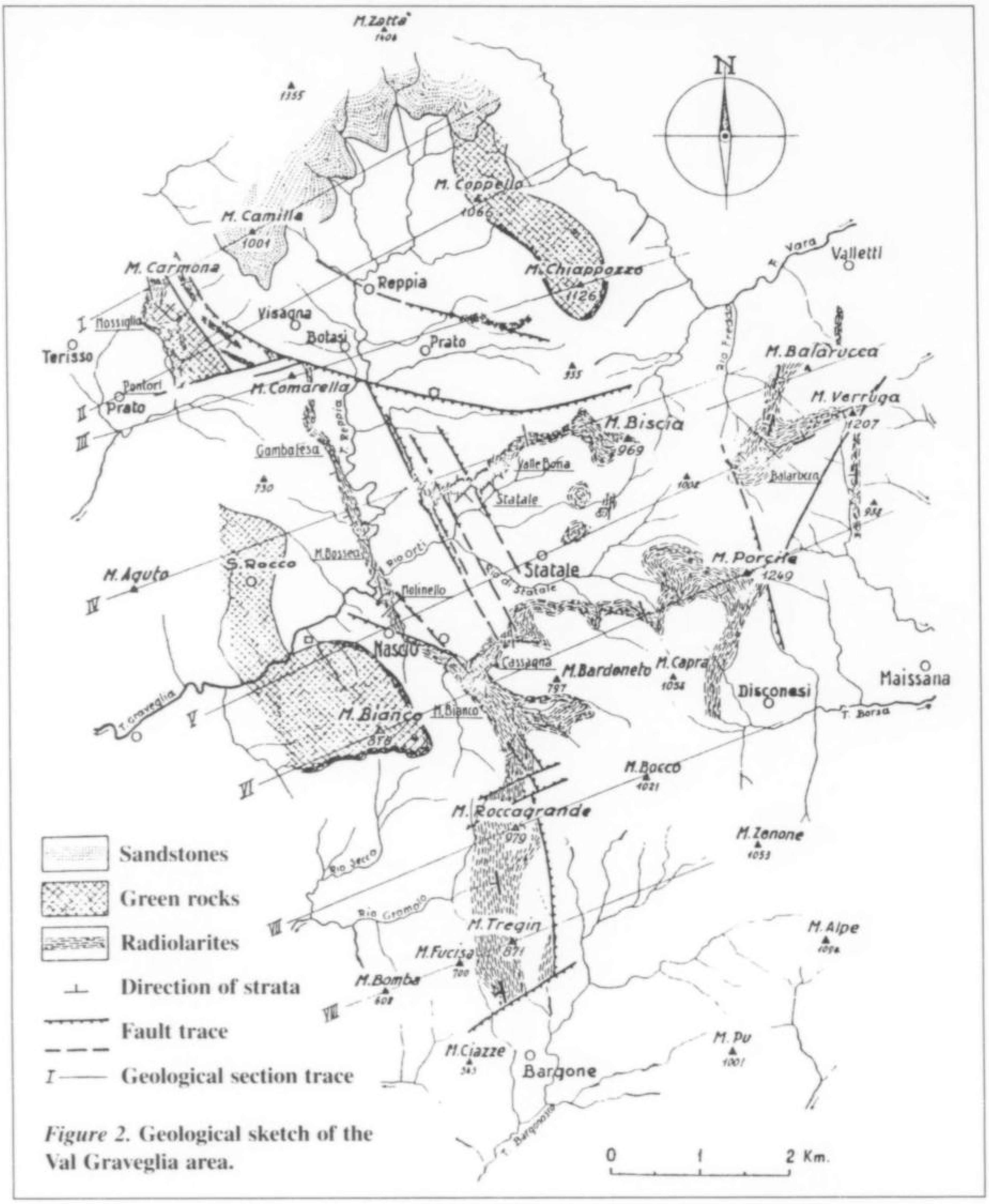


Figure 2. **Geological sketch of the Val Graveglia area.**

In the 7th century BC, Chiavari was the main settlement in a rich mining and quarrying area. Later, during the Roman Empire, the mining activities moved to Gallia and Hispania (for example to the Rio Tinto deposit in present-day Spain). Prospecting for copper, iron, lead, gold and silver resumed on a small scale during the Middle Ages and continued until the 18th century (Pipino, 1984).

In the 18th century the mining operations in Liguria, mainly for copper, grew to industrial scale as a consequence of new technologies, improved communications and new prospecting activity in the area (Issel, 1883). Mining continued, with frequent ups and downs, well into the 1900's. The last workings were closed in the 1950's. The most important mines were located in the Monte Loreto and Libiola areas; in Val Graveglia some copper prospects were opened without leading to any significant mining activity.

During the second half of the 19th century, high manganese prices led to extensive prospecting, and the Val Graveglia deposits were discovered. In 1877 Augusto Fages, a local entrepreneur and pioneer of manganese prospecting, identified the main manganese ore outcrops: Gambatesa, Monte Bossea, Monte Bianco-Cassagna, Molinello near Nascio and Scrava near Statale, all in the Province of Genoa (Tiscornia, 1935). More outcrops were prospected in the Graveglia Valley at Monte Porcile, Balarucca, Nossiglia and Pontori and in some other localities in eastern Liguria as the Tre Monti mining complex, Monte Nero, Cerchiara and Framura.

The ore outcrops in Val Graveglia were the richest and most numerous. Mining began in 1881, and the quantity and quality of ore discovered justified significant industrial investment. During the first years of activity the ore was hand-sorted, mainly by female workers, and carried on mules to the harbor of Lavagna near Chiavari. The high transportation cost hindered the development of mining until 1904 when the mining company built a road from Conscenti to the Pian di Fieno ore treatment plant, aiding the industrial exploitation of the Val Graveglia mines.

Later the mines changed hands and were operated by various companies: from 1919 to 1930 by Società Ferriere di Voltri, then by Ilva (1931–1939), Ferromin (1940–1964) and by the Italsider iron and steel state-controlled industrial group (1965–1974). At that time Italsider also owned the iron mines of Elba and Campiglia in Tuscany and tried, wherever possible, to develop domestic mining resources. The ore production, previously limited to a few hundred to a few thousand tons per year, reached a peak of about 50,000 tons per year in the early 1970's. The manganese ore was used in the iron and steel metallurgy processes at the Italsider Darfo and Lovere plants in Lombardy.

During the Italsider ownership a sink-float ore enrichment plant was built at Pian di Fieno. This plant made it possible to exploit the lower-grade parts of the deposit: the "lean ore," consisting of thin manganese-bearing layers within the jasper. In 1974 Italsider ceased mining operations. The sizable amount of ore in place and the favorable manganese quotations induced some mine employees, including the former mine manager, to establish a new company (Sil.ma.), and in 1976 production was restarted at a reduced rate (a few hundred tons per year) and without using the sink-float technology. During this period most of the rare minerals were collected, including eight new species.

At present all the mines except Gambatesa are closed and the activity there is minimal, but there are plans to transform it into a mining museum.

The total amount of ore mined in the Val Graveglia district is estimated to be over 1,200,000 tons, with a Mn content around 28–30% (Bellini *et al.*, 1984).

VAL GRAVEGLIA TODAY

The Val Graveglia mines left a deep mark on the environment and on the people of the valley. In the villages of the rocky upper valley, where the farm land is limited, almost all families had members working in the mines. Mine workers numbered 50 to 100 in 1937, then grew to 500 in 1938, to 614 in 1942 and then decreased to 110 in 1974, when large-scale mining activity ceased (Galli and Penco, 1997). Many pits, excavations, mine dumps, some remains of cableways, hoppers, ore treatment plants and roads are still visible and testify to the past of a region which hosted an important manganese deposit.

Exceptional mineral specimen discoveries took place during the years of intense mining activity. During that period nice specimens of tinzenite, sursassite and rhodonite were relatively common, and rare species were also found from time to time. Unfortunately, in those days mineral collectors were few, the interest of the scientific community in the locality was low, and analytical tools were not as developed as they are now.

At present good material is hard to find. The open-cuts of the Gambatesa, Cassagna and Scrava mines are partially covered by recent dumps of waste material, the adits of the abandoned tunnels are closed, and the late 1980's underground works of the Molinello mine are flooded. In theory, the Gambatesa mine is still active, but in practice it produces just a few tons per year. The upper levels of the mine are still under maintenance, but they are not accessible to collectors. It must be remembered that most of the orebody consists of massive braunite, and the minerals hosted in veins and cavities can be recovered much more easily from the broken ore brought out of the mine rather than *in situ*. Large-scale resumption of mining activity is unlikely, due to the limited remaining extension of the deposit, to the availability of low-cost manganese ore from several other countries, and to the high cost of local labor.

The dumps, widespread around all the Val Graveglia mines, are only partially covered by vegetation. Although fine minerals are not easy to find, the deposit area is wide and the discovery of significant specimens is not unlikely in the future, both in the field and through the examination of material collected in the past. It is sometimes possible to recognize very good specimens of rare species preserved in old collections and misidentified as common species. One of us, for example, observed a sarkinite crystal over 1 cm long once thought to be the more common tinzenite.

GEOLOGY

An ophiolitic suite consisting of ultramafic rocks, usually highly serpentinized and associated with mafic masses, crops out in the Northern Apennines. The upper part of the complex includes breccias containing fragments of ultrabasic, basic and trodhjemitic rocks, and basalts, often with pillow structures (Decandia and Elter, 1972; Cortesogno *et al.*, 1979; Hoogerduijn Strating and Van Wamer, 1989; Società Geologica Italiana, 1994).

Above the ophiolites is a complex of radiolarian chert and siliceous shale known as the Monte Alpe Chert Formation. The series continues with marls, siliceous shales and pelagic limestone (Calpionella Limestone), and ends with the Palombini Shale and turbiditic units. The ophiolites are believed to be the remnants of some part of the Jurassic oceanic crust, known as the Ligurid Units, which now constitute the structurally highest part of the Apennine chain. Many events leading to the formation of minerals and ores occurred during a geological history of about 100 million years.

The oceanic metamorphic event transformed the gabbros into rodingites, while iron and copper sulfides were deposited by hydrothermal activity. Hot-fluid vents deposited a high concentration of manganese on the Jurassic sea floor, presently appearing as manganese ore deposits within the Monte Alpe Chert formation (Bezzi and Piccardo, 1971).

All the rocks of the series recrystallized under greenschist metamorphic conditions during the alpine orogeny (Cortesogno *et al.*, 1979; Cortesogno and Lucchetti, 1984). The pre-existing sulfides were remobilized and formed Cu-Fe deposits. Moreover, some elements present in low concentrations in the rock mass were concentrated in the rock fractures by fluids (Bonatti *et al.*, 1976). The complexity of the geological and petrologic environment, the abundance of fractures along the shear zones and at the hinge zones of the folds, together with the presence of manganese, vanadium, arsenic and many other elements made possible the formation of many interesting minerals.

In the peridotitic basement rocks a few species are present, such as serpentine-group minerals, magnetite and andradite. In the pillow lava, metamorphosed under greenschist conditions, cavities up to 20 or more centimeters are common, often partially filled by epidote, prehnite and quartz, all of them commonly in good crystals. Calcite, pumpellyite and hematite are also widespread. Along old faulting zones small masses of pyrite (often copper-bearing) are present. These marginal deposits were explored and mined mainly during the 19th century. In the old workings several secondary minerals were found, including nice malachite and allophane.

The radiolarites formation of Monte Alpe is undoubtedly the most mineralogically interesting in the area. In the basal part of the formation the manganese-bearing layers form a banded ore known as "lean manganese ore," which is quite common. The formation of layers of cherts with different silica, iron and manganese contents seems to be related to variations in pH and Eh values at the time of the deposition (De Negri and Rivalenti, 1971; Galli and Penco, 1997). The "lean ore" is sometimes crossed by veins up to 80 cm wide and up to several tens of meters in length; this kind of vein yielded carpholite, native copper, sulfides, and probably the world's best specimens of tinzenite, sursassite and ganophyllite.

The same stratigraphic basal unit of the Monte Alpe Formation also includes the main manganese orebody, formed by braunite layers (Burckhardt and Falini, 1956). The thickest layers, up to 20 meters, are thought to have possibly formed by gravitational accumulation of pre-existing Mn-rich sediments, which were concentrated in paleogeographic depressions. Further increase in thickness occurred in the hinge areas during folding. The braunite ore is relatively rich in veins and vugs containing good specimens

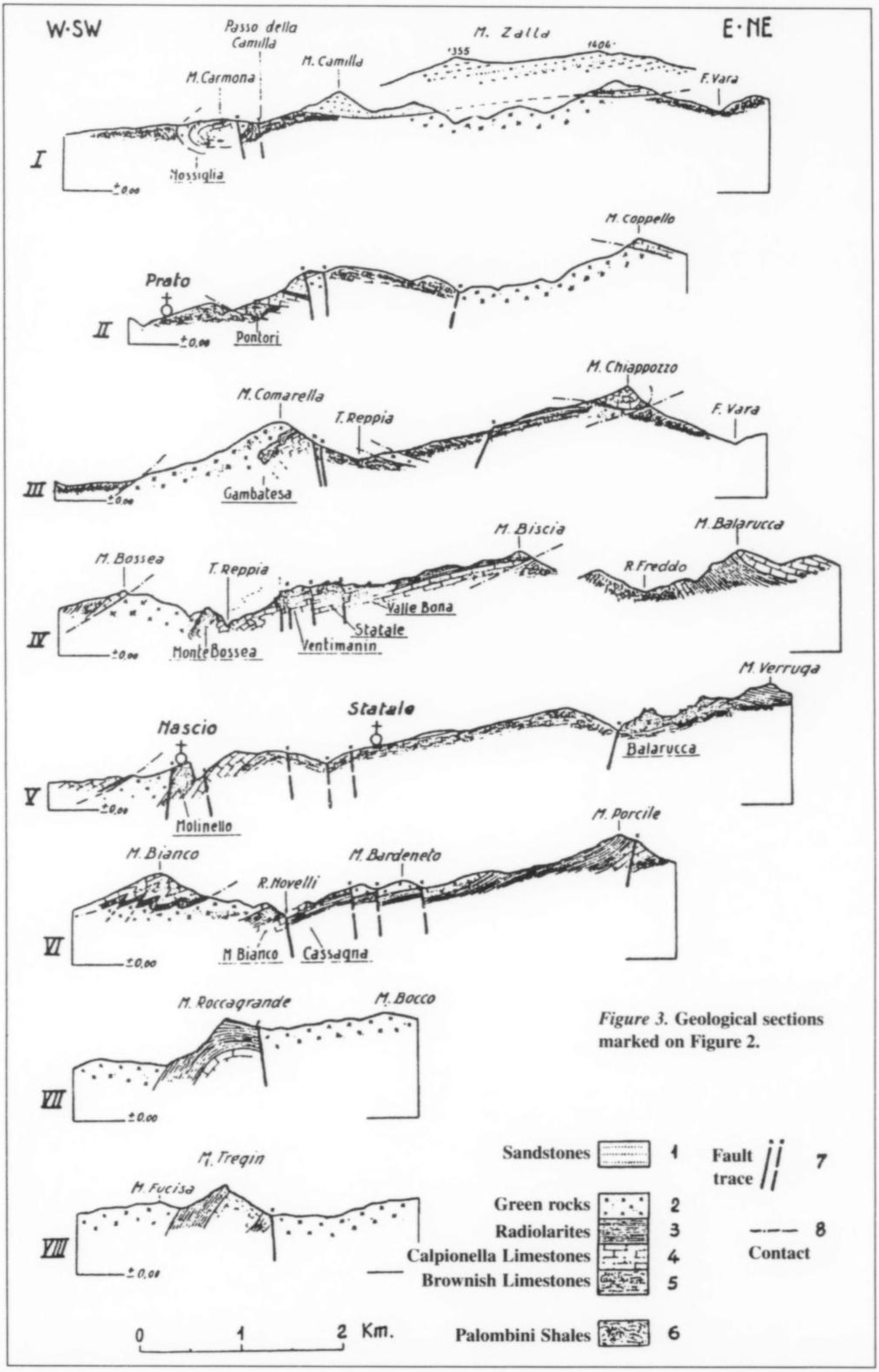


Figure 3. **Geological sections marked on Figure 2.**

Figure 4. **Radiolarite outcrops in the Rio Novelli Valley. In the background is the Cassagna mine open cut, 1995. Marco Marchesini photo.**

of rhodonite, rhodochrosite, tephroite, kutnahorite, pyroxmangite and barite.

In the orebody veins the circulating fluids concentrated elements such as arsenic and vanadium, which formed many minerals, some of which were discovered here for the first time (tiragalloite, medaite, saneroite, palenzonaite, vanadomalayaite, reppiaite) or which are rare or uncommon (haradaite, tangeite, sussexite, gamagarite and goldmanite). The crystallization of the arsenic-bearing and vanadium-bearing minerals could be related to a hydrothermal event taking place under conditions of decreasing temperature with respect to greenschist conditions recognized in the ophiolitic sequence (Basso *et al.*, 1992). The new mineral gravegliaite, a rare natural sulfite, occurs in secondary suites.

A very peculiar occurrence of minerals in Val Graveglia must also be noted: within the Jurassic-age radiolarites it is sometimes possible to find silicified (petrified) woods belonging to trees of the extinct genus *Araucariopitys* (Cortesogno and Galli, 1974; Marchesini, 1999). This is an unexpected occurrence; the radiolarites are considered to be equivalent to the present-day muds in the oceanic or marine sea floor, which was not a likely environment for typical continental plants to grow (Calvert, 1971). According to recent studies (Società Geologica Italiana, 1994; Marescotti, 1993), during the Jurassic period the paleogeography of the area would have been quite complex, and perhaps some islands hosted primitive trees. Some timbers or wood fragments, after floating for some time and distance on the sea surface, may have sunk in the proximity of sea vents, where there was an abundance of dissolved metal ions. This particular environment permitted the preservation of the wood; the pH and Eh conditions caused the partial replacement of the wood material, and in particular the deposition of native copper or chalcocite in the wood microcavities. Later, during the recrystallization of the rock mass, more minerals formed. Finally, secondary minerals formed. In the fossil wood many mineral species have been found, including copper, chalcocite, volborthite, cornubite, chalcophyllite, zeunerite, connellite and many others. It is interesting that significant amounts of Cu, V, As, Cl and even U probably originated from the hot-water sea vents. This occurrence seems to be specific to eastern Liguria and is not known in the very old manganese deposits, which were formed before the development of trees on earth.

MINES, QUARRIES AND OUTCROPS

Cassagna and Monte Bianco Mines

These are the most important mines in the area (together with Gambatesa and Molinello), with extensive underground workings, excavations and a more recent, large open pit. Some exceptional specimens of rhodonite, tinzenite and rhodochrosite have been found here, as well as remarkable volborthite collected in the 1970's. The operation ceased in 1998.

Gambatesa Mine

Discovered in 1877 by A. Fages, the Gambatesa deposit has been the main source of manganese ore and, perhaps, of interesting minerals. In 1885 (Tiscornia, 1935) some chalcopyrite was discovered in the basalts, but prospecting for copper ore did not yield any significant result. The first manganese ore excavations were open cuts; but later some tens of kilometers of tunnels were excavated. Excellent rhodonite and rhodochrosite specimens were collected,

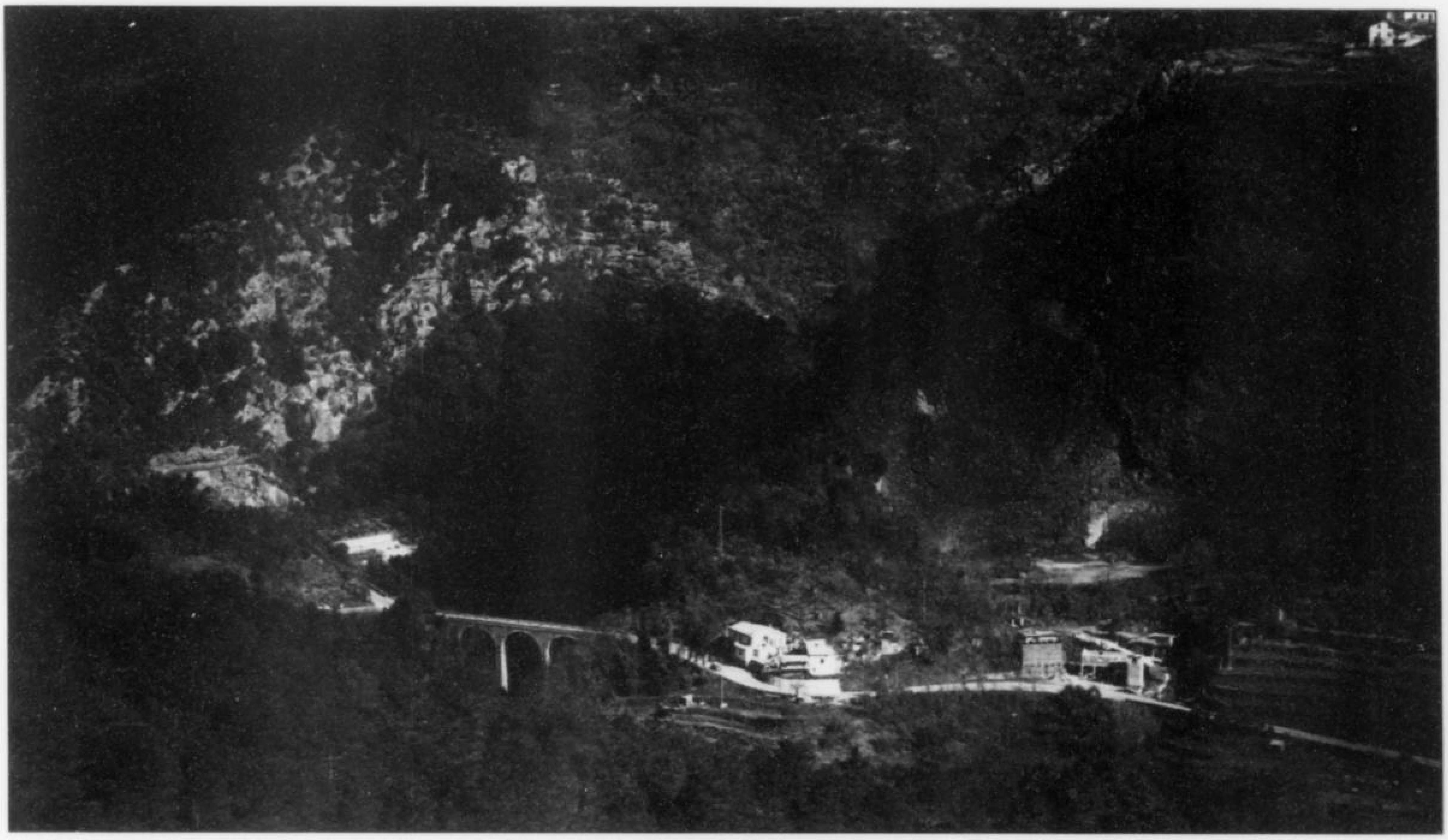


Figure 5. **Ponte Lagoscuro: on the right the Molana quarry operated in a pillow lava outcrop until 1993; on the left the radiolarite outcrops which host the Molinello mine. Molinello is the type locality for medaite, palenzonaite and tiragalloite. Marco Marchesini photo.**

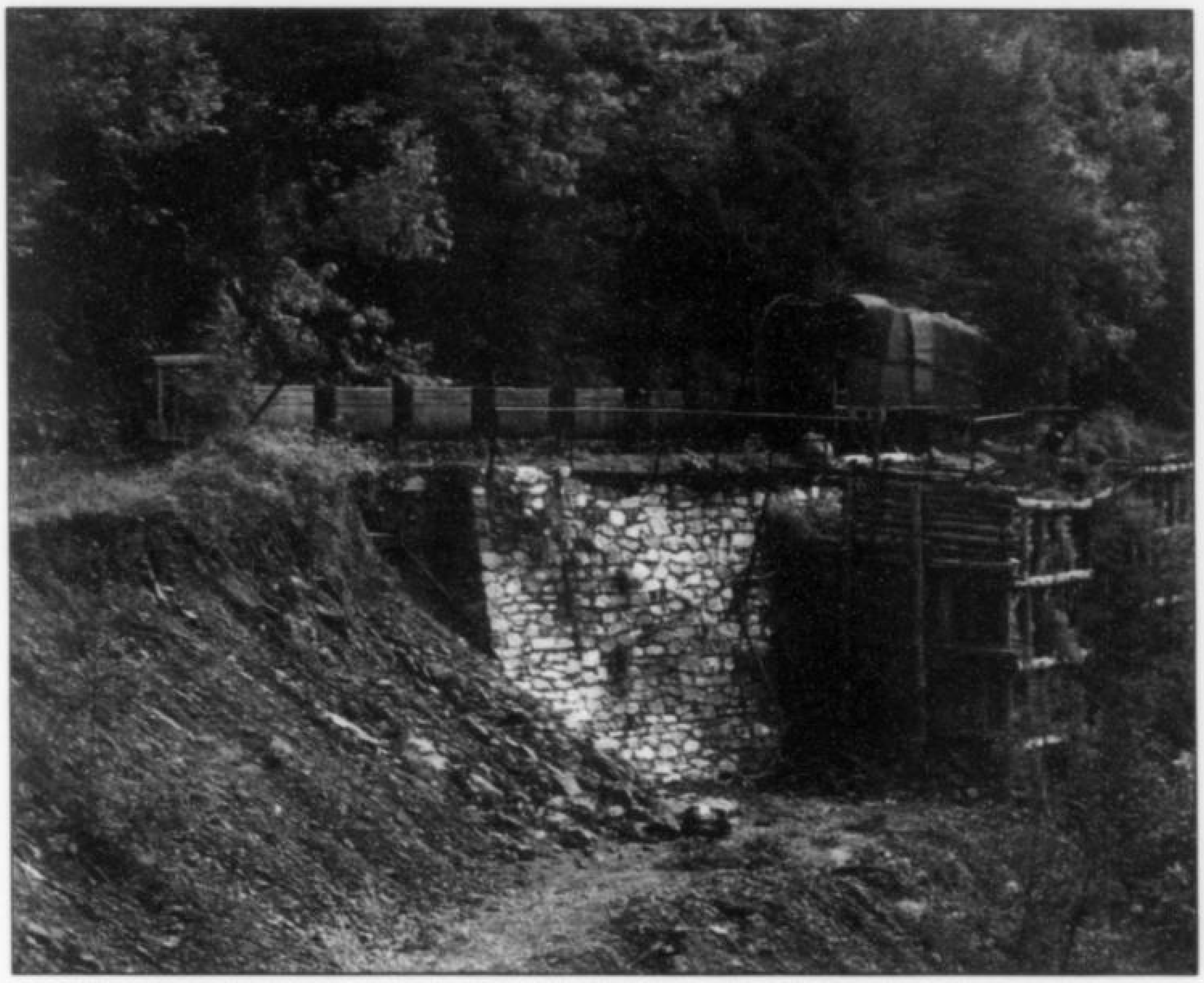


Figure 6. **Mining equipment at the Gambatesa mine main adit in 1998. Gambatesa is the type locality for gravegliaite, reppiaite, saneroite, vanadomalayaite and, together with the Cassagna mine, for strontiopiemontite. Marco Marchesini photo.**

and also very nice sursassite, goldmanite, manganaxinite, tinzenite and neotocite. Gambatesa is the type locality for gravegliaite, saneroite, reppiaite and vanadomalayaite.

Molana Quarry

This stone quarry, presently inactive, was opened in a pillow lava basalt zone near the Molinello mine. Attractive epidote, prehnite and pumpellyite specimens were found during the last years of activity before operations ceased in 1993.

Molinello Mine

The Molinello workings were mainly underground; they yielded fine copper, gamagarite, ganophyllite, rhodochrosite, rhodonite, tangeite and tinzenite specimens. The Molinello mine is the type locality for medaite, palenzonaite and tiragalloite. Operations there ceased in 1996.

Monte Bardeneto-Monte Capra Prospect

Some masses of pyrite and chalcopyrite were mined at this prospect, but with no encouraging results. Some underground workings produced a few hundred tons of ore (Tiscornia, 1935). In the gossan portion of the outcrops nice langite specimens with native copper and cuprite were found. Recent collecting trips to this locality did not yield any good specimens.

Monte Bianco Copper Mine

The Monte Bianco is a small copper mine opened in 1879–80 by the local entrepreneur G. B. Bonelli (Tiscornia, 1935). It produced some pyrite and a few tons of chalcopyrite; no specimens of significance have been collected there to date. On the opposite side of Mount Bianco some native copper, associated with cuprite, connellite and other secondary copper minerals was recently collected in the radiolarites of the Monte Alpe formations.

Monte Bossea Mine

The Monte Bossea is an underground manganese mine whose main adit is near the Molinello mine, on the opposite side of Graveglia Valley. Closed since the end of the Italsider activity, it was not particularly rich in rare species. Good tinzenite veins were encountered in some zones, but vugs were very rare there.

Monte Copello-Reppia Prospect

Along the contact between basalts and serpentinites some small masses of pyrite and chalcopyrite have been found. In the gossan good allophane and malachite specimens were recovered. Mining attempts there have been documented since 1868 (Galli and Penco, 1997; Tiscornia, 1935).

Monte Porcile Mine

Together with the Monte Zenone and Monte Alpe mines, the Monte Porcile mine was included in the so-called Tre Monti manganese claim, filed in 1891 by Augusto Parma. No remarkable mineral finds have been reported to date; nevertheless further investigations might yield results.

Nascio

Nascio is a village near the Molinello mine where some basalt masses crop out. Epidote with orthoclase (adularia variety) and quartz was collected here. Similar specimens were also found at Pontelagoscuro and Zerli though not as abundantly as at Nascio.

Scrava Mine

The Scrava mine consists of extensive, mainly underground manganese mine workings. Generally the ore was rich in carbonates, and calcite and manganoan calcite were common. It yielded good crystals of volborthite, chalcophyllite and other arsenates. In addition, some good pyrolusite crystals were collected there in an oxidized part of the deposit. Operations ceased in 1996.

Pontori Prospect

Some attempts were made to mine manganese ore at the Pontori prospect around 1920. In recent years a few small synchsite-(Ce) and bastnäsite-(Ce) specimens have been collected, in association with anatase, quartz, sulfides and albite.

Other localities

Some manganese outcrops are also known at the Val Graveglia localities of Valle Bona, Balarucca and Nossiglia. No significant mineral finds have been reported from those localities, except for braunite and manganese oxides.

Other small manganese deposits in the same general area, although not included in Val Graveglia, should be mentioned here. The first is the Cerchiara mine, located about 30 km to the southeast. This deposit formed in the same basin and is of similar age but is hosted by a thinner chert sequence. Cerchiara is the type locality for mozartite, caoxite and cerchiaraite. Nearby is another small Mn deposit known as the Monte Nero mine; in recent times (late 1990's) good inesite specimens have been collected there (Marchesini and Palenzona, 1997).

COMPARISONS

The Val Graveglia manganese mines have produced some rare and uncommon species (bementite, ganophyllite, sarkinite, sussexite, tephroite etc.) reported from just a few other famous localities, such as Långban, Sweden, and Franklin and Sterling Hill, New Jersey (Holstam and Langhof, 1999; Frondel and Baum, 1974). A number of other localities around the world are known to have produced some of the minerals typical of Val Graveglia. These include the Kombat mine (Namibia), the Kalahari and the Postmasburg deposits (South Africa), some small Alpine manganese deposits such as Praborna near St. Marcel, Val d'Aosta (in the western Italian Alps) and Scerscen, Val Malenco and Sondrio (Italy), Falotta near Tinizong (formerly Tinzen), and Fianel in Val Ferrera (Switzerland) (Niggli *et al.*, 1940; Weibel, 1996; Brugger, 1996).

A comparison of these mineral occurrences, based on the available literature, is attempted in Table 1, and shows some similarity among the assemblages. This fact might be thought to indicate a similarity between the various manganese deposits. Actually, the similarities are overbalanced by the differences in age, geological history, host rocks and chemistry.

With regard to age, the Val Graveglia deposit and the Western and Central Alps deposits are geologically relatively young. They began to form about 100 million years ago, much more recently than the Franklin and Sterling Hill deposits (about 1000 million years), the Långban deposit (about 1800 million years) and the Kalahari manganese deposit (2200–2300 million years).

Regarding environment, most of the deposits mentioned above were formed in continental or shallow basin environments and are hosted by carbonate rocks. The radiolarite-hosted Apennine deposits of Val Graveglia, however, seem to be related more to oceanic conditions, although the discovery of fossilized land plants could suggest a complex paleogeography or a silica availability not related to deep water but to the chemistry of the environment and to a strong volcanic activity.

Some analogies can be found in Alpine deposits related to radiolarite outcrops such as Parsettens and Falotta or Scerscen which, although smaller, developed in a similar way and have approximately the same age.

The metamorphism at Val Graveglia only reached greenschist facies. The old New Jersey and Swedish deposits reached much higher metamorphic conditions, and the Franklin-Sterling Hill mineral assemblages are proof of sillimanite-facies metamorphism. The South African Kalahari deposit was strongly remobilized by a metamorphic event which happened about 1250 million years ago. Also, the Alpine deposits, such as Praborna and other localities mentioned above, are generally known to have reached higher pressure and/or higher deformation conditions. The Apennine ophiolites are in fact well-preserved in comparison with the Alpine ones.

Chemically the Val Graveglia manganese deposits are silica-hosted and have a low iron content. Other elements like lead, zinc and antimony are either absent or present in very small amounts. The only zinc mineral observed there to date is sphalerite, found only rarely. Lead is also considered rare. Pyrobelonite and even the common (elsewhere) species galena were found in just a few specimens. The Franklin and Sterling Hill zinc-iron-manganese deposits are marble-hosted. The Långban and the Fianel deposits are dolomitic carbonate-hosted and quite rich in carbonate minerals. The Kombat mine deposit is hosted in an iron-manganese silicate-carbonate-oxide unit, associated with a copper-lead-silver sulfide orebody, and it would be difficult to find analogies with the Val Graveglia deposit.

An interesting chemical peculiarity of the Val Graveglia district is the presence of vanadium. Vanadium-bearing species are known, for example, at Franklin (goldmanite, pyrobelonite and descloizite) and in the Postmasburg deposit (gamagarite). But at Val Graveglia a number of minerals with essential vanadium in their structure have been found: gamagarite, haradaite, medaite, palenzonaite,

Table 1. **Occurrences of some rare minerals from Val Graveglia.**

	Bakerite	Bementite	Caryopilite	Crednerite	Gamagarite	Ganophyllite	Goldmanite	Kutnahorite	Marsturite	Neotocite	Palenzonaite	Parsettensite	Pyrobelonite	Pyroxmangite	Saneroite	Sarkinite	Strontiopiemontite	Sussexite	Tephroite
Val Graveglia, Italy	•	•	•	•	•	•	•	•	•	•	TL	•	•	•	TL	•	TL	•	•
Franklin and Sterling Hill, New Jersey	•	TL	•			•	•	•	TL	•			•	•		•		TL	TL
Långban and Pajsbeg, Sweden		•	TL			TL		•		TL			TL	•		TL			•
Kalahari and Postmasburg, RSA		•	•		TL		•					•					•	•	•
Kombat Mine, Namibia				•		•		•					•					•	•
Val Ferrera and Oberhalbstein, Switzerland	•										•	TL	•		•				

TL = Type Locality

pyrobelonite, reppiaite, saneroite, tangeite, vanadomalayaite and volborthite.

According to recent data (Marescotti, 1993; Baroni, 1998), some elements like vanadium and arsenic do not appear to be particularly widespread in the ore or in the rock mass, but form minerals only in this particular environment. From this point of view the closest analogy seems to be with the Fianel deposit, the type locality for fianelite and the second world occurrence of palenzonaite, saneroite and johninnesite.

It may be noted that the dimensions of these manganese deposits are quite different. The Val Graveglia district consists of a group of medium-small deposits, whose cumulative production ranged between 1,000,000 and 1,200,000 tons. These dimensions are comparable with those of the Swedish deposits, while the New Jersey and the South African deposits are much larger. The Alpine manganese occurrences are even smaller and became economical only locally and at times when the manganese prices were high.

Some analogies between the various localities mentioned above can be found in the volcanic-sedimentary origin of manganese in concentrations of economic interest. Manganese often originates from volcanic fumarolic activity or from the upwelling of cold deep ocean water; from this point of view the analogy with the Kalahari manganese deposit is impressive. In both cases the volcanic activity is well represented by the presence of pillow lavas at the base of the sequence, underlying the manganese strata.

The general features of the Val Graveglia geological history, with a metamorphic event followed by an uplift, cannot be considered to be similar to those of the other localities, because of the differences in timing and metamorphic grade. In conclusion, the similarities suggested by the mineral check list in Table 1 are mainly due to the circulation of fluids in fractures, to the abundance of manganese, the availability of arsenic and to the presence of other elements such as copper, calcium, barium, vanadium etc. Consequently the Val Graveglia deposit can be considered essentially unique.

MINERALS

Alabandite $Mn^{2+}S$

Alabandite has been found at the Molinello mine, in the deepest part of the deposit. Not too common there, it was collected in the second half of the 1980's, commonly as green crusts which rapidly turn black (Palenzona, 1996). The crystals, often forming rounded aggregates up to 6 mm, are rare. It is frequently associated with neotocite, manganoan calcite and, sometimes, rhodonite.

Albite $NaAlSi_3O_8$

Albite is common as tiny crystals in the chert veins. Some attractive specimens from the Molinello mine show crystals up to 2 cm, associated with quartz, ganophyllite, kutnahorite and, in places, hematite or sulfides.

Allophane

Allophane, an amorphous hydrous aluminum silicate, was found as a secondary mineral at the Gambatesa, Cassagna and Molinello mines. Some very attractive specimens came from the small copper deposit of Reppia, where nice vugs (up to 12 cm) lined with the copper-bearing variety were found.

Anatase TiO_2

Red to brown anatase crystals up to 1 mm in length have been found in the dump material at the Gambatesa mine, in association with quartz, clinochlore, apatite and sulfides. Anatase is also widespread in radiolarites at Monte Chiappozzo and several other localities.

Andradite $Ca_3Fe^{3+}_2(SiO_4)_3$

Very small yellow to green crystals of andraditic garnets have sometimes been collected in the serpentine outcrops, in particular in the Gambatesa mine area.

Aragonite $CaCO_3$

Aragonite is quite rare in Val Graveglia. Some specimens were found in serpentinite outcrops. Elongated crystals collected at the Gambatesa mine and misidentified as aragonite are actually calcite (Palenzona, 1980).

Arseniosiderite $Ca_2Fe^{3+}_3(AsO_4)_3O_2 \cdot 3H_2O$

Arseniosiderite has recently been found at the Gambatesa mine in fractures in chert, as yellow to brown rosettes up to 2 mm, associated with clinoclase. It has also been collected at the Cassagna mine in fossil wood, with chrysocolla.

Arsenosulvanite $Cu_3(As,V)S_4$

The rare species arsenosulvanite has been found as small bronze-colored masses in association with goldmanite, rhodonite and carbonates. The crystals are very rare and extremely small.

Azurite $Cu^{2+}_3(CO_3)_2(OH)_2$

Azurite is one of the minerals formed by the weathering of copper sulfides. Nice specimens, with prismatic crystals up to 1 cm, were collected in silicified woods at the Cassagna mine and at the Scrava mine. In this last case the association is quite interesting, showing cuprite, volborthite and several arsenates.

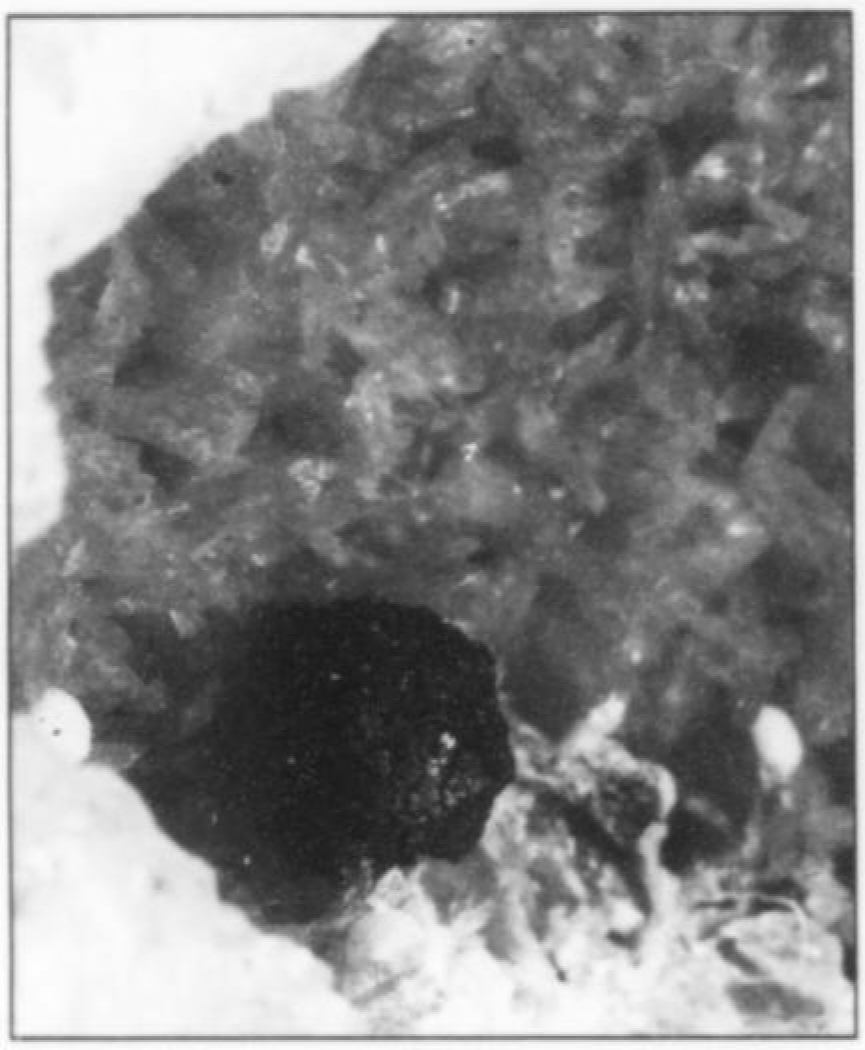


Figure 7. Dark alabandite in spherical aggregate on orange-pink rhodonite crystals, collected in 1986 at the Molinello mine. Diameter of the aggregate: 4 mm. Private collection; Roberto Appiani photo.

Figure 8. Arseniosiderite in radiating aggregates, 2 mm, with chrysocolla in silicified wood, black because of carbon pigmentation, found at the Cassagna mine in 1989. Private collection; Roberto Appiani photo.

Figure 9. Bementite in radiating aggregates, 4 mm, with manganese oxides, from the Gambatesa Mine (found 1999). Private collection; Roberto Appiani photo.

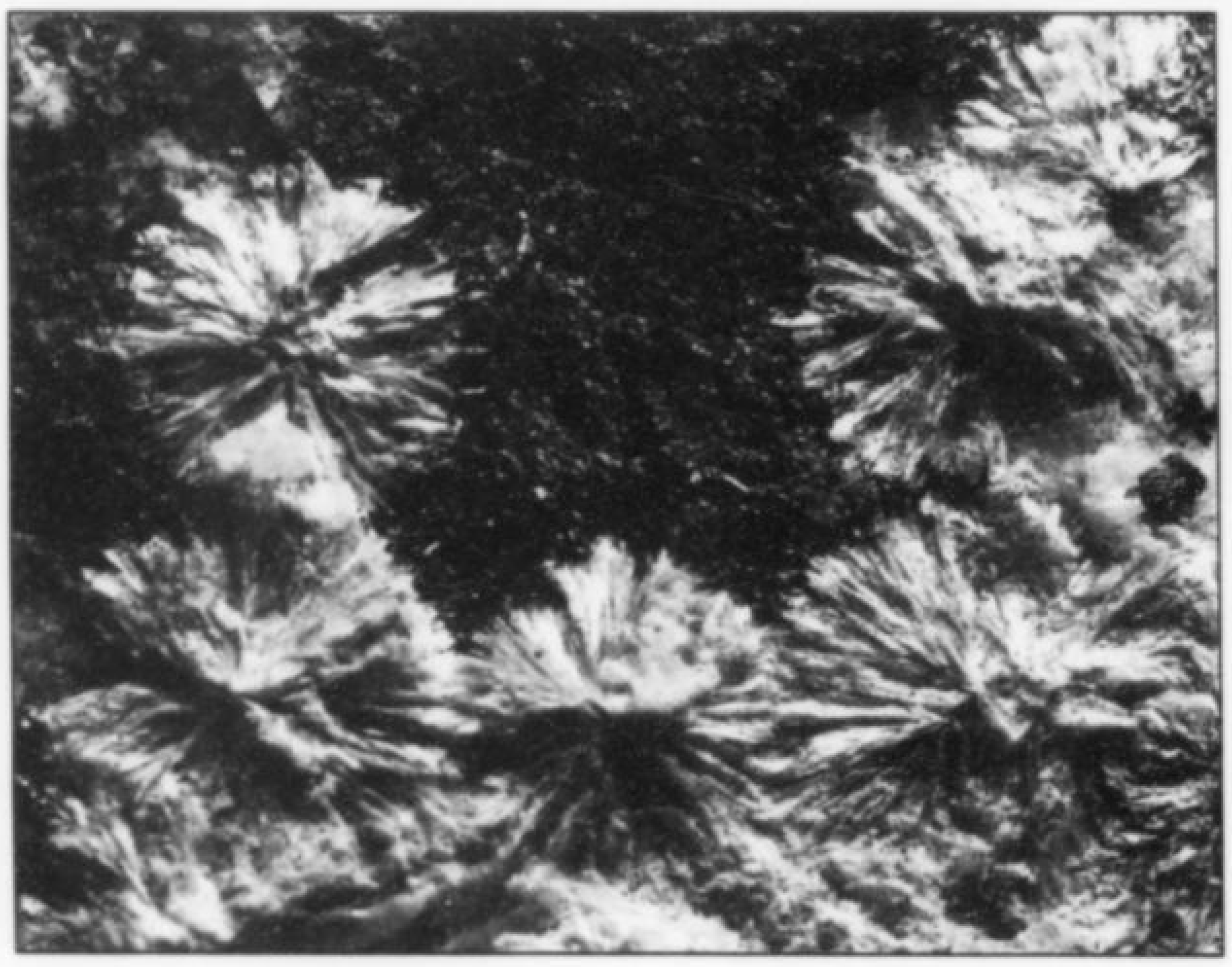


Figure 10. Bakerite in radiating tufts, 1 mm, on weathered rhodonite, from the Gambatesa mine (found late 1980's). Private collection; Roberto Appiani photo.

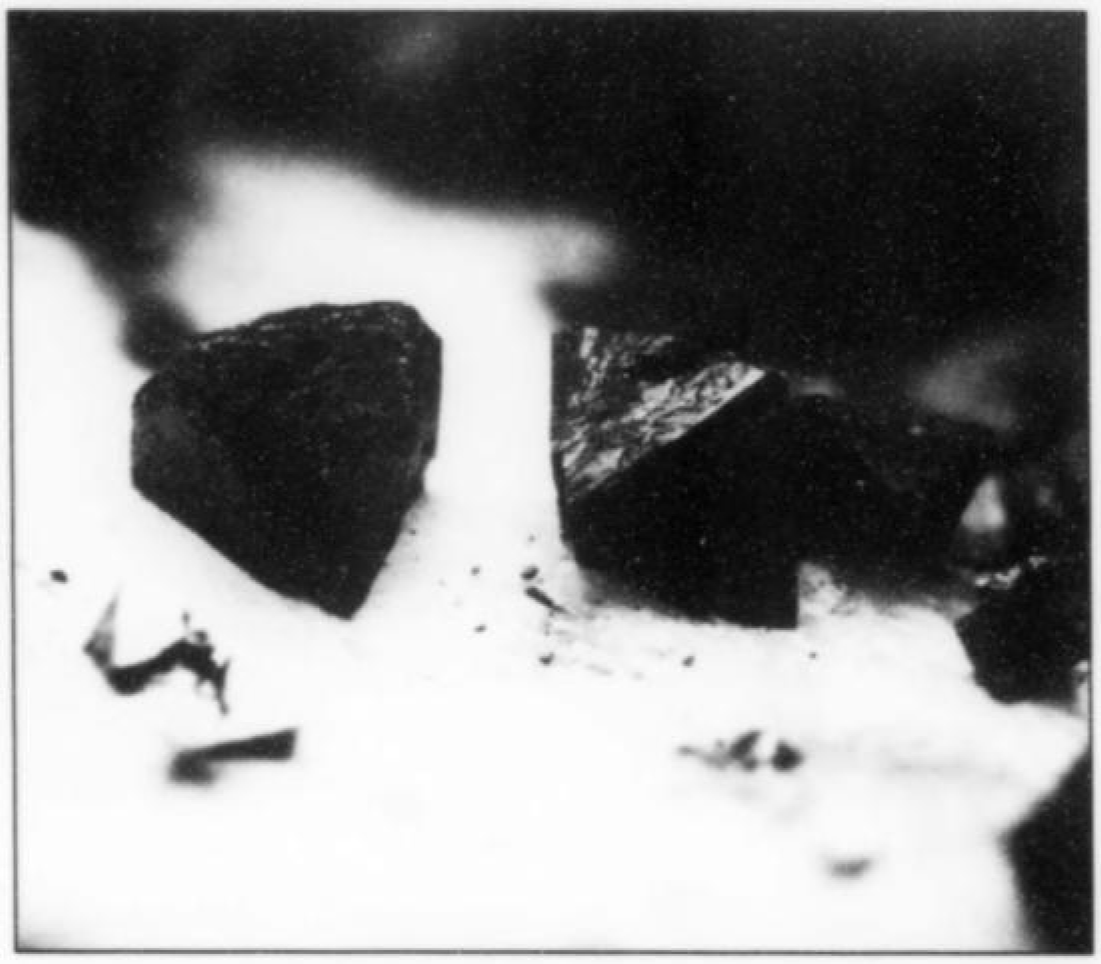


Figure 11. Braunite crystals, 2 mm, from the Gambatesa mine (found 1998). Marco Marchesini collection; Roberto Appiani photo.

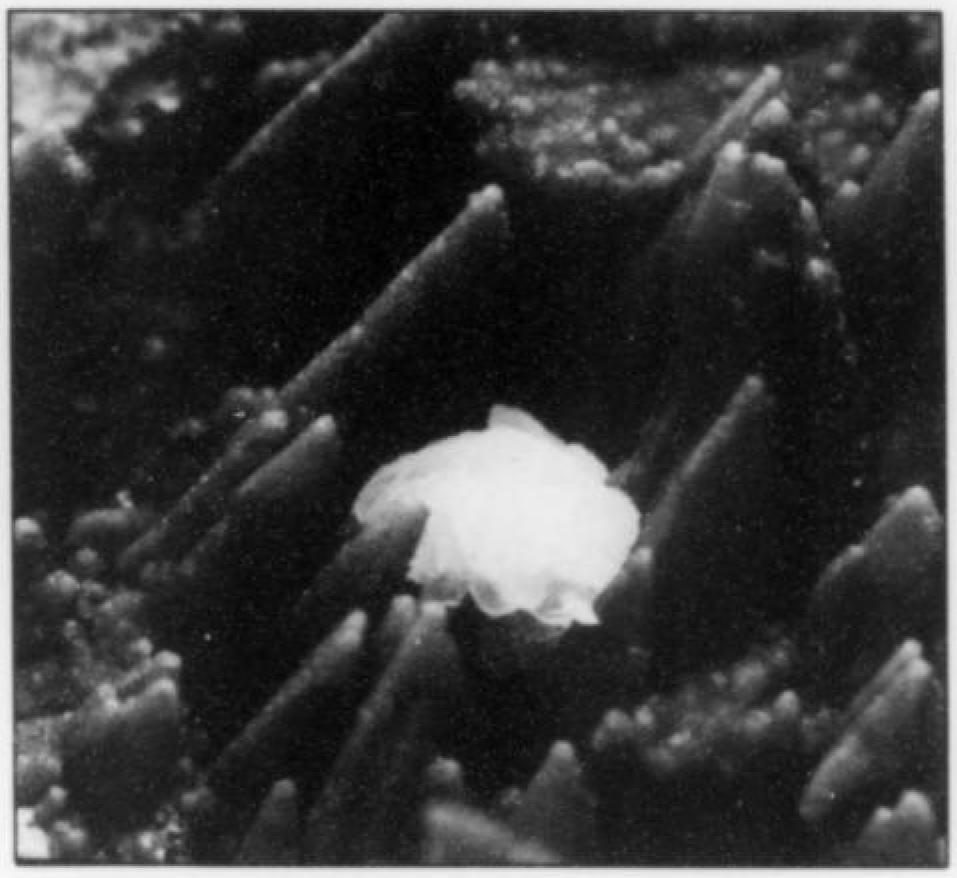


Figure 13. Caryopilite pseudomorphs after 3-mm calcite scalenohedra, from the Cassagna mine (found 1993). Private collection; Roberto Appiani photo.

Figure 12. Calcite scalenohedra to 1.5 cm partially covering a radiolarite fragment. Marco Marchesini collection, Roberto Appiani photo.

Figure 14. Chalcocite crystals, 4 mm, on white quartz and manganaxinite, from the Gambatesa mine (found 1995). Marco Marchesini collection; Roberto Appiani photo.

Figure 15. Blue connellite crystals, 1.5 mm, with volborthite, cuprite and an unknown coralloid mineral. This is an example of the mineral assemblages typical of the silicified wood, from the Cassagna mine (found 1984). Marco Marchesini collection; Roberto Appiani photo.

Figure 16. Copper crystals, 1.5 cm, with black oxide patina, on manganoan calcite. Collected at the Gambatesa mine in 1968. Marco Marchesini collection; Roberto Appiani photo.

Table 2. **Species reported from the Val Graveglia Manganese District.**
VC = very common, C = common, R = rare, VR = very rare, (?) = doubtful, ill-defined, requiring further study etc.

NATIVE ELEMENTS		
Copper	Cu	C
Gold	Au	VR
Selenium	Se	VR
Silver	Ag	VR
Sulfur	S	VR
SULFIDES AND SULFOSALTS		
Alabandite	$Mn^{2+}S$	R
Arsenosulvanite	$Cu_3(AsV)S_4$	VR
Bornite	Cu_5FeS_4	R
Chalcocite	Cu_2S	C
Chalcopyrite	$CuFeS_2$	C
Covellite	CuS	R
Digenite	Cu_9S_5	R
Djurleite	$Cu_{31}S_{16}$	R
Galena	PbS	VR
Marcasite	FeS_2	C
Orpiment	As_2S_3	VR
Pyrite	FeS_2	C
Pyrrhotite	$Fe_{1-x}S$ (x = 0–0.17)	VR
Realgar	AsS	VR
Smythite	$Fe_{13}S_{16}$	VR
Sphalerite	$(Zn,Fe)S$	VR
Tennantite	$(Cu,Ag,Fe,Zn)_{12}As_4S_{13}$	R
OXIDES		
Anatase	TiO_2	VC
Chalcophanite	$(Zn,Fe^{2+},Mn^{2+})Mn^{4+}_3O_7 \cdot 3H_2O$	(?)
Crednerite	$CuMnO_2$	VR
Cuprite	Cu^{1+}_2O	C
Goethite	$\alpha\text{-}Fe^{3+}O(OH)$	VC
Hematite	$\alpha\text{-}Fe_2O_3$	VC
Ilmenite	$Fe^{2+}TiO_3$	R
Magnetite	$Fe^{2+}Fe^{3+}_2O_4$	C
Manganite	$Mn^{3+}O(OH)$	R
Opal	$SiO_2 \cdot nH_2O$	VR
Pyrolusite	$Mn^{4+}O_2$	VC
Pyrophanite	$Mn^{2+}TiO_3$	VR
Quartz	SiO_2	VC
Ranciéite	$(Ca,Mn^{2+})Mn^{4+}_4O_9 \cdot 3H_2O$	C
Romanèchite	$(Ba,H_2O)_2(Mn^{4+},Mn^{3+})_5O_{10}$	C
Todorokite	$(Mn^{2+},Ca,Mg)Mn^{4+}_3O_7 \cdot H_2O$	R
CARBONATES		
Aragonite	$CaCO_3$	R
Azurite	$Cu^{2+}_3(CO_3)_2(OH)_2$	C
Bastnaesite-(Ce)	$(Ce,La)(CO_3)F$	VR
Calcite	$CaCO_3$	VC
Dolomite	$CaMg(CO_3)_2$	C
Kutnahorite	$Ca(Mn^{2+},Mg,Fe^{2+})(CO_3)_2$	C
Malachite	$Cu^{2+}_2(CO_3)(OH)_2$	VC
Rhodochrosite	$Mn^{2+}CO_3$	C
Synchysite-(Ce)	$Ca(Ce,La)(CO_3)_2F$	VR
BORATES		
Sussexite	$Mn^{2+}BO_2(OH)$	VR
SULFATES, SULFITES		
Barite	$BaSO_4$	VC
Brochantite	$Cu^{2+}_4(SO_4)(OH)_6$	C
Connellite	$Cu^{2+}_{19}Cl_4(SO_4)(OH)_{32} \cdot 3H_2O$	VR
Devilline	$CaCu^{2+}_4(SO_4)_2(OH)_6 \cdot 3H_2O$	R
Gravegliaite	$Mn^{2+}(SO_3) \cdot 3H_2O$	VR
Gypsum	$CaSO_4 \cdot 2H_2O$	C
Langite	$Cu^{2+}_4(SO_4)(OH)_6 \cdot 2H_2O$	R
Posnjakite	$Cu^{2+}_4(SO_4)(OH)_6 \cdot H_2O$	R
Spangolite	$Cu^{2+}_6Al(SO_4)(OH)_{12}Cl \cdot 3H_2O$	VR
Wroewolfeite	$Cu^{2+}_4(SO_4)(OH)_6 \cdot 2H_2O$	VR
Wulfenite	$PbMoO^4$	VR
PHOSPHATES, ARSENATES, VANADATES		
Arseniosiderite	$Ca_2Fe^{3+}_3(AsO_4)_3O_2 \cdot 3H_2O$	VR
Chalcophyllite	$Cu^{2+}_{18}Al_2(AsO_4)_3(SO_4)_3(OH)_{27} \cdot 33H_2O$	VR
Chernovite-(Y)	$Y(AsO_4)$	VR
Clinoclase	$Cu^{2+}_3(AsO_4)(OH)_3$	VR
Conichalcite	$CaCu^{2+}(AsO_4)(OH)$	R
Cornubite	$Cu^{2+}_5(AsO_4)_2(OH)_4$	VR
Cornwallite	$Cu^{2+}_5(AsO_4)_2(OH)_4$	VR
Fluorapatite	$Ca_5(PO_4)_3F$	VR
Gamagarite	$Ba_2(Fe^{3+},Mn^{3+})(VO_4)_2(OH)$	R
Lavendulan	$NaCaCu^{2+}_5(AsO_4)_4Cl \cdot 5H_2O$	R
Manganberzeliite	$(Ca,Na)_3(Mn^{2+},Mg)_2(AsO_4)_3$	VR
Nabiasite	$BaMn_9[(V,As)O_4]_6(OH)_2$	VR
Olivenite	$Cu^{2+}_2(AsO_4)(OH)$	R
Palenzonaite	$(Ca_2Na)Mn^{2+}_2(VO_4)_3$	VR
Parnauite	$Cu_9^{2+}(AsO_4)_2(SO_4)(OH)_{10} \cdot 7H_2O$	VR
Pharmacosiderite	$KFe^{3+}_4(AsO_4)_3(OH)_4 \cdot 6\text{–}7H_2O$	VR
Pyrobelonite	$PbMn^{2+}(VO_4)(OH)$	VR
Reppiaite	$Mn^{2+}_5(OH_4)_2(VO_4)_2$	VR
Sarkinite	$Mn^{2+}_2(AsO_4)(OH)$	VR
Tangeite	$CaCuVO_4(OH)$	VR
Tyrolite	$CaCu^{2+}_5(AsO_4)_2(CO_3)(OH)_4 \cdot 6H_2O$	VR
Volborthite	$Cu^{2+}_3V^{5+}_2O_7(OH)_2 \cdot 2H_2O$	R
Zalesiite	$CaCu_6(AsO_4)_2(AsO_3OH)(OH)_6 \cdot 3H_2O$	VR
Zeunerite	$Cu^{2+}(UO_2)_2(AsO_4)_2 \cdot 10\text{–}16H_2O$	VR

Bakerite $Ca_4B_4(BO_4)(SiO_4)_3(OH)_3 \cdot H_2O$

The boron-bearing mineral bakerite was found only once, to date, as small (1–2 mm) white sprays on well-crystallized rhodonite, at the Gambatesa mine (Borgo and Palenzona, 1988; Palenzona, 1996).

Barite $BaSO_4$

It is often present in the veins of the manganese ore, in crystals occasionally reaching 8 cm in length. The barite specimens are quite aesthetic because of their complex habit, luster and association with rare species. Commonly found during only a few periods of mining activity, barite has been collected in all of the manganese mines. Remarkable crystals associated with rhodochrosite came from the Gambatesa and Cassagna mines, and good specimens on rhodonite were collected at the Molinello mine in the 1980's. The larger crystals normally have a simple, tabular habit, while the small ones are often rich in forms.

SILICATES		
Albite	$NaAlSi_3O_8$	VC
Allophane	Amorphous hydrous aluminum silicate	C
Andradite	$Ca_3Fe_2(SiO_4)_3$	R
Bakerite	$Ca_4B_4(BO_4)(SiO_4)_3(OH)_3 \cdot H_2O$	VR
Bementite	$Mn^{2+}_8Si_6O_{15}(OH)_{10}$	C
Braunite	$Mn^{2+}Mn^{3+}_6SiO_{12}$	VC
Carpholite	$Mn^{2+}Al_2Si_2O_6(OH)_4$	R
Caryopilite	$(Mn^{2+},Mg)_3Si_2O_5(OH)_4$	C
Chrysocolla	$(Cu^{2+},Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$	VC
Clinochlore	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$	VC
Clinochrysotile	$Mg_3Si_2O_5(OH)_4$	C
Datolite (?)	$Ca_2B_2Si_2O_8(OH)_2$	(?)
Diopside	$CaMgSi_2O_6$	C
Epidote	$Ca_2(Fe^{3+},Al)_3(SiO_4)_3(OH)$	VC
Fluorapophyllite	$KCa_4Si_8O_{20}(F,OH) \cdot 8H_2O$	VR
Ganophyllite	$(K,Na)_2(Mn,Al,Mg)_8(Si,Al)_{12}O_{29}$-$(OH)_7 \cdot 8$–$9H_2O$	VC
Goldmanite	$Ca_3(V,Al,Fe^{3+})_2(SiO_4)_3$	VR
Haradaite	$Sr_2V^{4+}_2O_2(Si_4O_{12})$	VR
Harmotome	$(Ba_{0.5},Ca_{0.5},K,Na)_5[Al_5Si_{11}O_{32}] \cdot 12H_2O$	C
Hausmannite	$Mn^{2+}Mn^{3+}_2O_4$	C
"Hornblende"		R
Inesite	$Ca_2Mn^{2+}_7Si_{10}O_{28}(OH)_2 \cdot 5H_2O$	VR
Johannsenite	$CaMn^{2+}Si_2O_6$	C
Manganaxinite	$Ca_2Mn^{2+}Al_2BSi_4O_{15}(OH)$	R
Marsturite	$Na_2CaMn^{2+}_3Si_5O_{14}(OH)$	VR
Medaite	$(Mn^{2+},Ca)_6(V^{5+},As^{5+})Si_5O_{18}(OH)$	VR
Montmorillonite	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$	C
Neotocite	$(Mn^{2+},Fe^{2+})SiO_3 \cdot H_2O$ (?)	C
Nimite (?)	$(Ni,Mg,Fe^{2+})_5(Al(Si_3)O_{10}(OH)_8$	R
Orthoclase	$KAlSi_3O_8$	C
Parsettensite	$(K,Na,Ca)(Mn,Al)_7Si_8O_{20}(OH)_8 \cdot 2H_2O$	R?
Pennantite	$Mn^{2+}_5Al(Si_3Al)O_{10}(OH)_8$	R
Piemontite	$Ca_2(Al,Mn^{3+},Fe^{3+})_3(SiO_4)_3(OH)$	C
Prehnite	$Ca_2Al_2Si_3O_{10}(OH)_2$	VC
Pumpellyite-(Mg)	$Ca_2MgAl_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$	C
Pumpellyite-(Mn^{2+})	$Ca_2(Mn^{2+},Mg)(Al,Mn^{3+},Fe)_2(SiO_4)$-$(Si_2O_7)(OH)_2 \cdot H_2O$	VR
Pyroxmangite	$Mn^{2+}SiO_3$	R
Rhodonite	$(Mn^{2+},Fe^{2+},Mg,Ca)SiO_3$	VC
Saneroite	$Na_2(Mn^{2+},Mn^{3+})_{10}Si_{11}VO_{34}(OH)_4$	R
Spessartine (?)	$Mn^{2+}_3Al_2(SiO_4)_3$	(?)
Strontiopiemontite	$CaSr(Al,Mn^{3+},Fe^{3+})_3Si_3O_{11}O(OH)$	R
Sursassite	$Mn^{2+}_2Al_3(SiO)_4(Si_2O_7)(OH)_3$	C
Tephroite	$Mn^{2+}_2SiO_4$	R
Tinzenite	$(Ca,Mn^{2+},Fe^{2+})_3Al_2BSi_4O_{15}(OH)$	C
Tiragalloite	$Mn^{2+}_4As^{5+}Si_3O_{12}(OH)$	VR
Titanite	$CaTiSiO_5$	R
Vanadomalayaite	$CaVOSiO_4$	VR
"Yamatoite" (?)		VR
Zircon	$ZrSiO_4$	R

Bastnaesite-(Ce) $(Ce,La)(CO_3)F$

Bastnaesite-(Ce) has been found in intimate intergrowth with small (less than 1 mm), rare synchysite-(Ce) crystals at Pontori prospect, in veinlets cutting the chert. These crystals are associated with quartz, anatase and clinochlore (Borgo and Palenzona, 1988).

Bementite $Mn^{2+}_8Si_6O_{15}(OH)_{10}$

Bementite has been found in cream-white to violet rosettes up to 2 cm, in association with calcite and hausmannite at the Molinello and Gambatesa mines. Its presence in other Val Graveglia localities is doubtful.

Bornite Cu_5FeS_4

Bornite has been found occasionally at the Gambatesa and Molinello mines in small specimens rarely showing crude crystals (Marescotti, 1993).

Braunite $Mn^{2+}Mn^{3+}_6SiO_{12}$

Braunite forms the main part of the manganese ore in all the Val Graveglia mines, as layers within chert and as large masses up to 20 meters in thickness. In spite of the abundance of massive ore, the crystals are small (1–2 mm) and not very common. They are associated with calcite, ganophyllite and barite. At the Cassagna mine good microcrystals of braunite associated with conichalcite crystals have been collected.

Brochantite $Cu^{2+}_4(SO_4)(OH)_6$

Brochantite has been found as a secondary mineral on copper minerals, both in the copper and in the manganese deposits. Good specimens were found in the fractures of the silicified woods at the Scrava and Cassagna mines.

Calcite $CaCO_3$

Calcite is extremely common in cavities in basalt, in fractures in serpentinite, in fractures and cavities in the Calpionella limestone, and in veins in radiolarite. The best specimens, colorless scalenohedra up to 5 cm, were collected in the 1960's at the Gambatesa mine. Calcite is usually the last vein mineral to have been deposited and commonly fills the vugs. By treatment with diluted acid it is sometimes possible to obtain good specimens of rhodonite and tinzenite with quartz. The acid treatment must be done with caution, as it can destroy or damage carbonates (kutnahorite and rhodochrosite), several silicates (especially phyllosilicates, such as ganophyllite), native copper and some of the rare vanadium minerals, such as palenzonaite and gamagarite.

Calcite forms a series with rhodochrosite and many specimens from the manganese deposit are of the manganoan variety. They often show a pale pink color in natural light and fluoresce bright pink in both longwave and shortwave ultraviolet light.

Carpholite $Mn^{2+}Al_2Si_2O_6(OH)_4$

Carpholite is found as aggregates of yellow fibers in the quartz veins which cut chert. It was one of the first minerals to crystallize, sometimes followed by sursassite, tinzenite and carbonates. Carpholite is commonly enclosed in quartz, and the free crystals, which can reach 1 cm, are very rare, whereas the fibers can be up to 3 cm long. It has been found only a few times at the Gambatesa mine and at the Molinello mine (Antofilli *et al.*, 1983; Palenzona, 1991).

Caryopilite $(Mn^{2+},Mg)_3Si_2O_5(OH)_4$

Caryopilite is not common, although it was collected in some abundance during a few limited periods, mainly at the Gambatesa mine, in association with rhodonite and, sometimes, barite. Caryopilite forms small spheres (1–2 mm) and aggregates of brown to pale brown plates. In places it covers or replaces carbonates to form perimorphs or pseudomorphs.

Chalcocite Cu_2S

Chalcocite is widespread in the quartz veins at the Gambatesa, Molinello and Scrava mines, commonly as massive material but also in beautiful, well-formed crystals, usually a few millimeters across rarely reaching 4 cm. It is associated with quartz, calcite, copper, ganophyllite and other sulfides. Chalcocite associated with native gold was found in the early 1980's at the Gambatesa mine (Pipino, 1983).

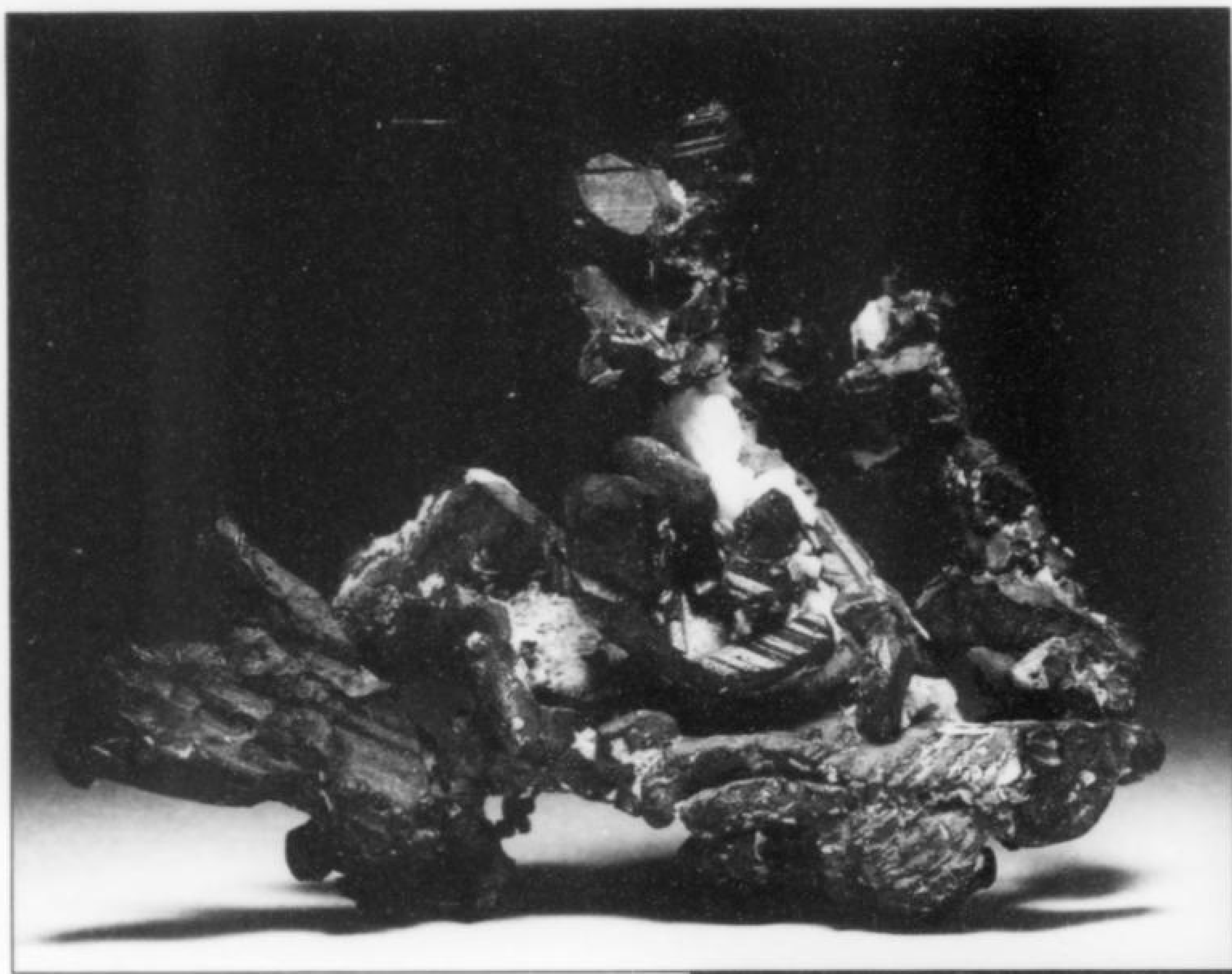


Figure 17. **Aggregate of copper crystals, 5.5 cm, from the Gambatesa mine (found late 1960's). Renato and Adriana Pagano collection; Roberto Appiani photo.**

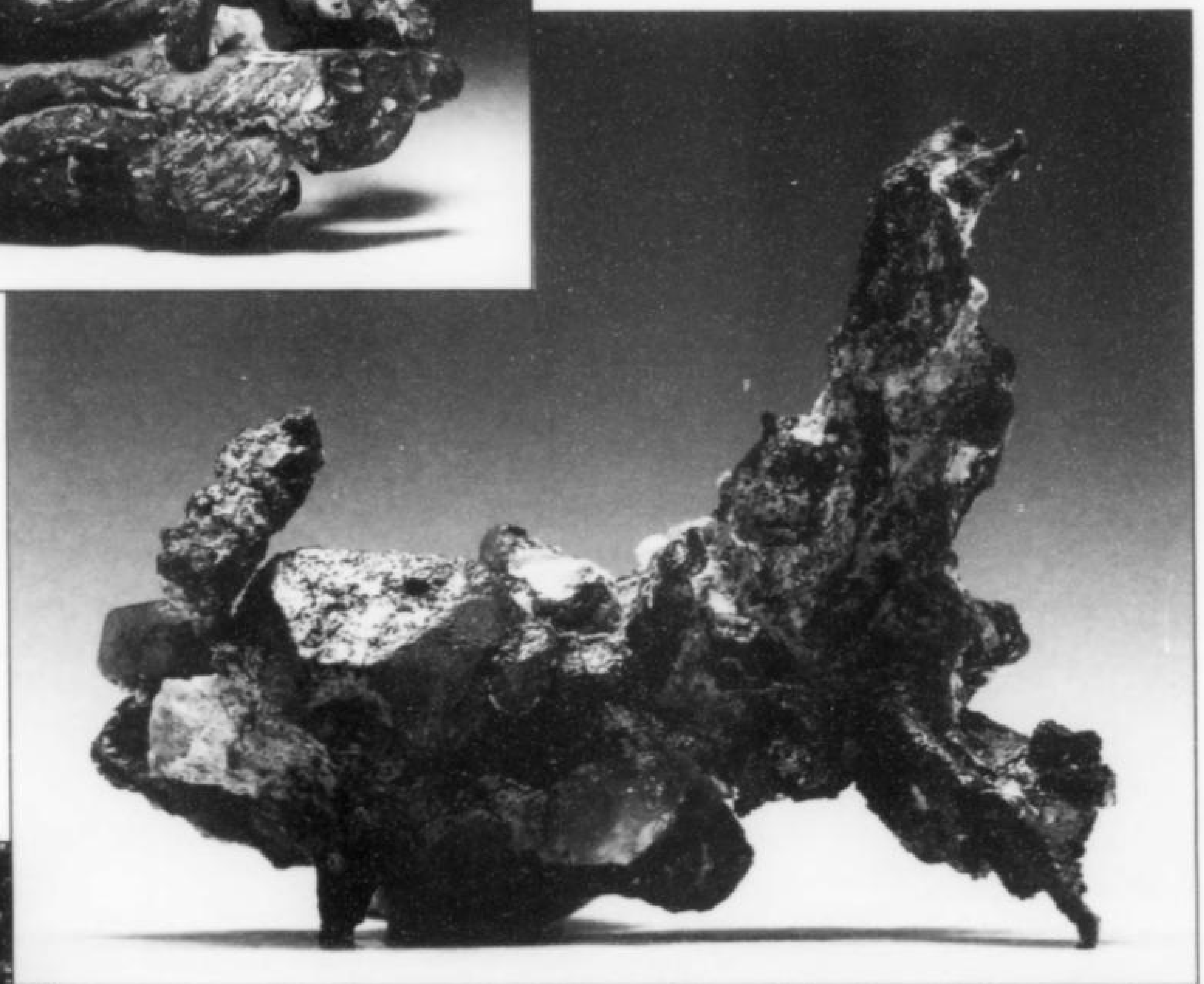


Figure 18. **Copper crystal, 4 mm, with malachite, from the Molinello mine (found late 1980's); found in a rhodonite vein. Private collection; Roberto Appiani photo.**

Figure 19. **Green cornubite spherules, 0.6 mm, on silicified wood, from the Scrava mine (found 1993). Private collection; Roberto Appiani photo.**

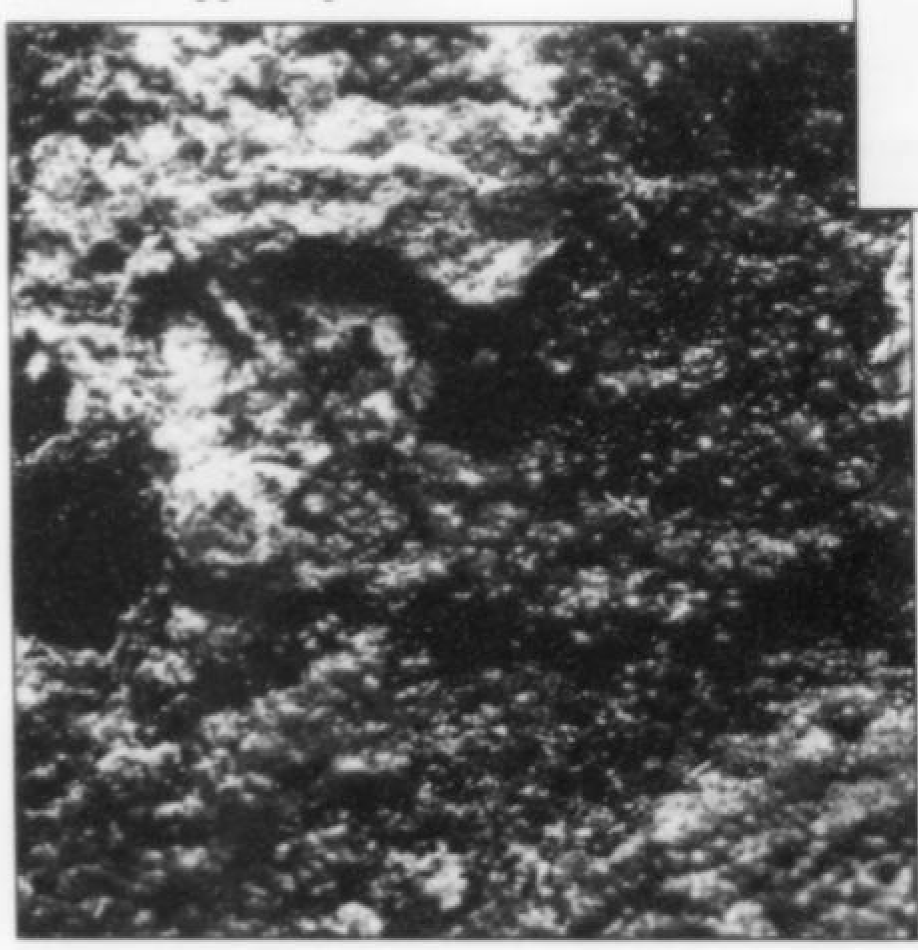


Figure 20. **Cuprite crystals, 1 mm, in a small silicified wood cavity, from the Cassagna mine (found 1993). Marco Marchesini collection; Roberto Appiani photo.**

Figure 21. **Pink rhombohedra of manganoan dolomite, 2.5 mm, from the Gambatesa mine (found 1985). Private collection; Roberto Appiani photo.**

Figure 22. Gamagarite crystals, 3 mm, with rhodonite, quartz and carbonates, from the Molinello mine (found 1987). Renato and Adriana Pagano collection; Roberto Appiani photo.

Figure 23. Brown ganophyllite crystals, 4 mm, from the Gambatesa mine (found 1994). Marco Marchesini collection; Roberto Appiani photo.

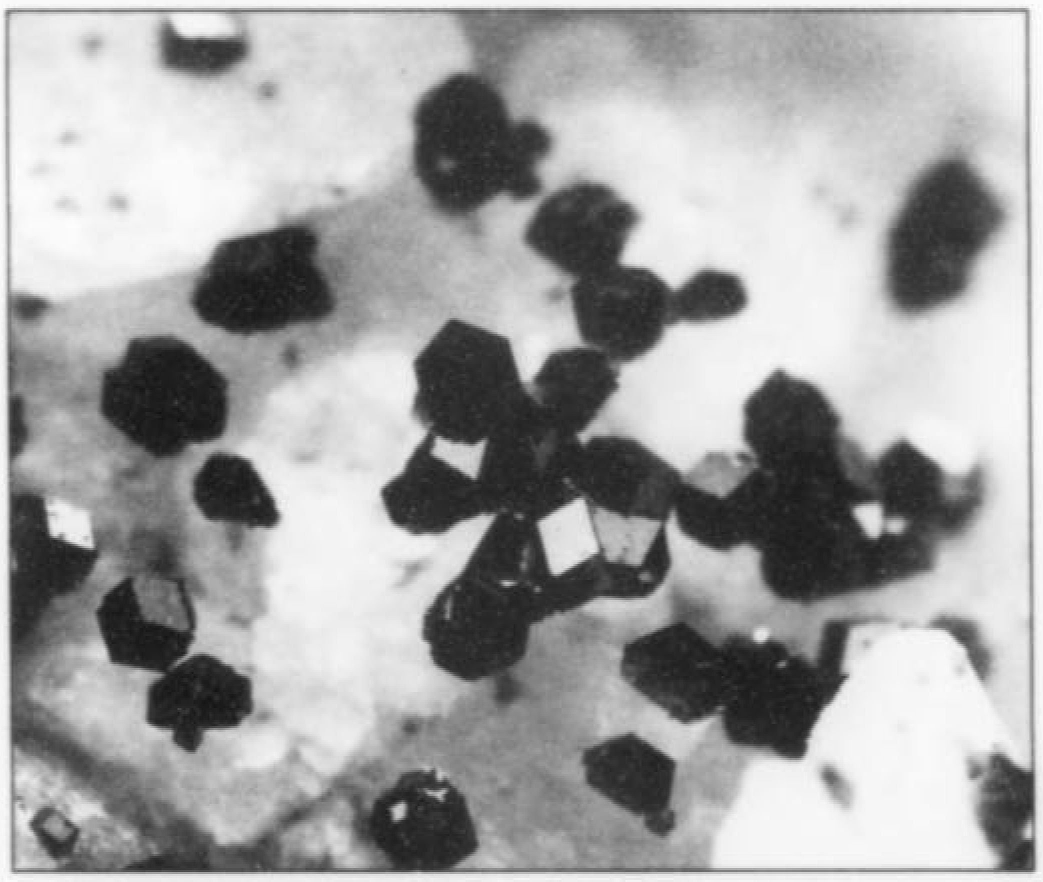
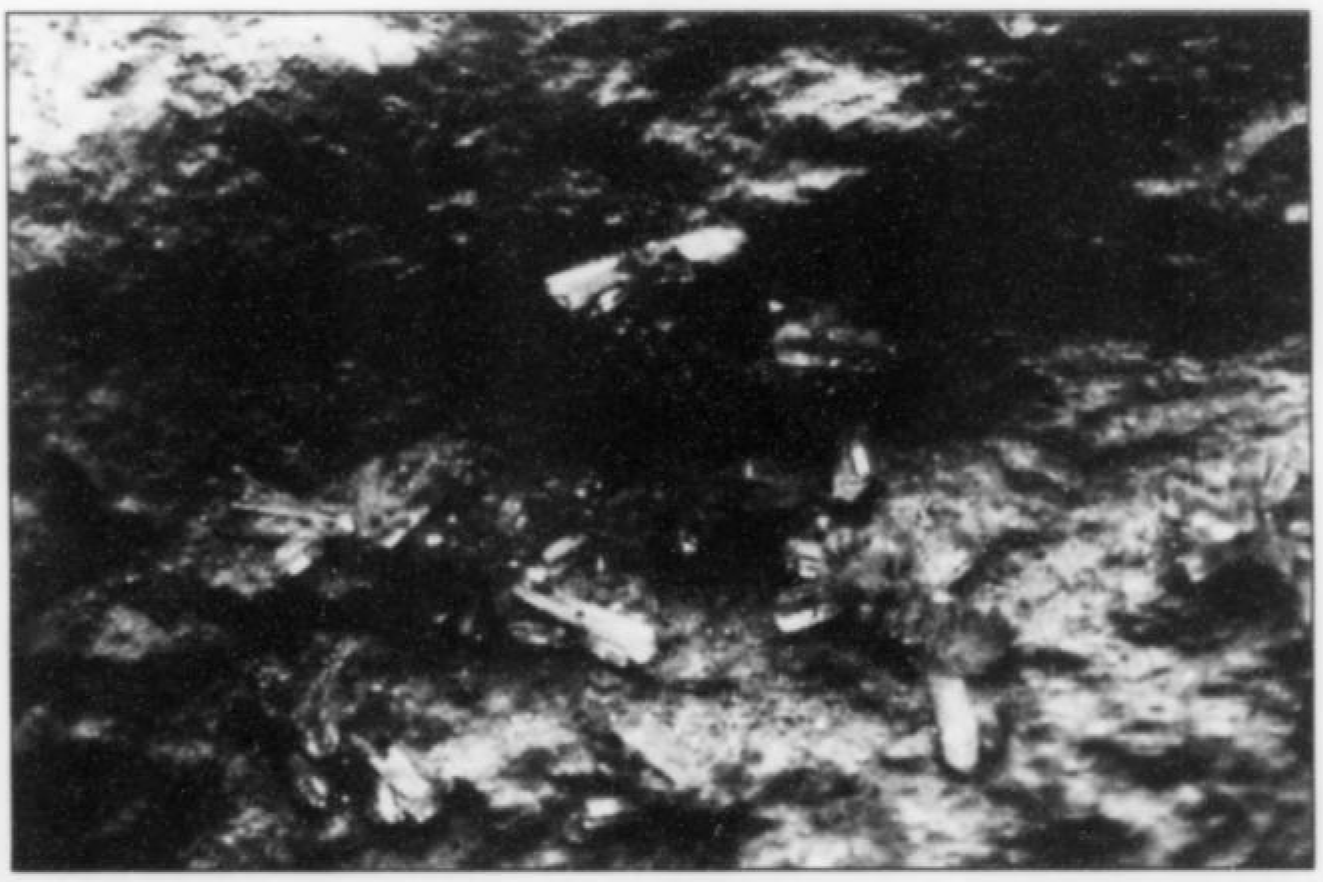


Figure 24. Goldmanite dodecahedra, 1 mm, on white albite crystals, from the Gambatesa mine (found 1992). Marco Marchesini collection; Roberto Appiani photo.

Figure 25. Gravegliaite crystals, 0.5 mm, on black manganese ore, from the Gambatesa mine (found 1997). Private collection; Roberto Appiani photo.



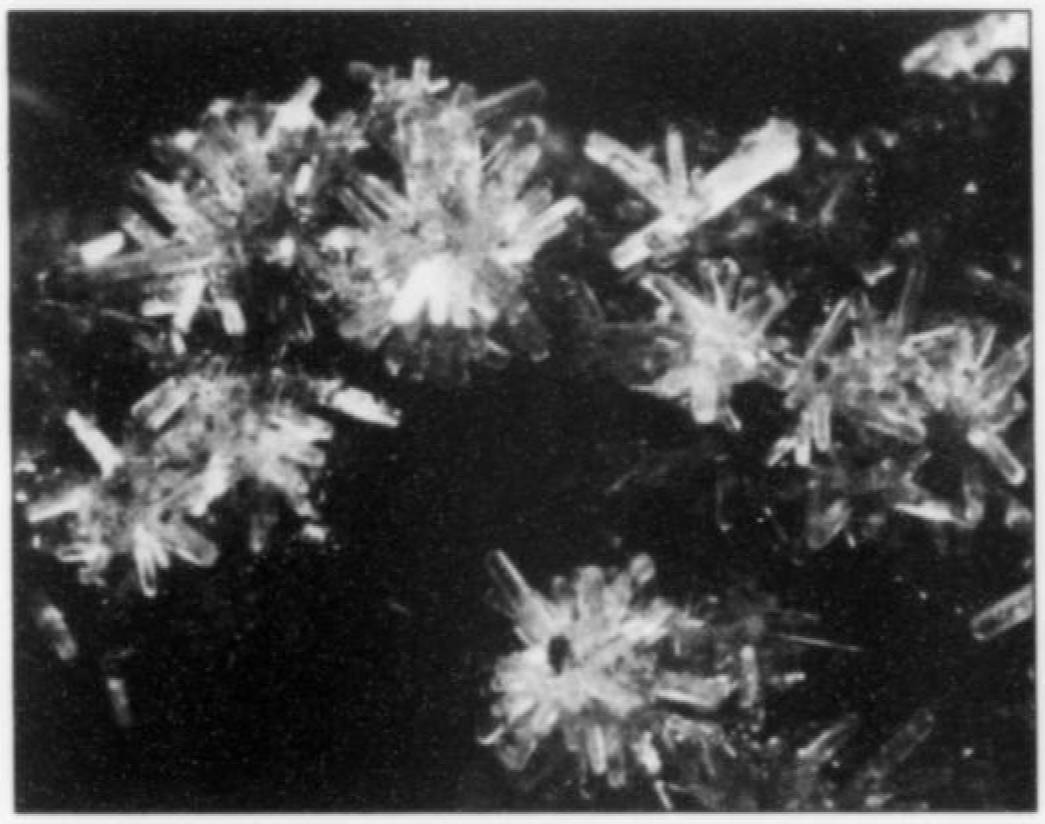


Figure 26. Harmotome crystals, 2 mm, from the Gambatesa mine (found 1993). Private collection; Roberto Appiani photo.

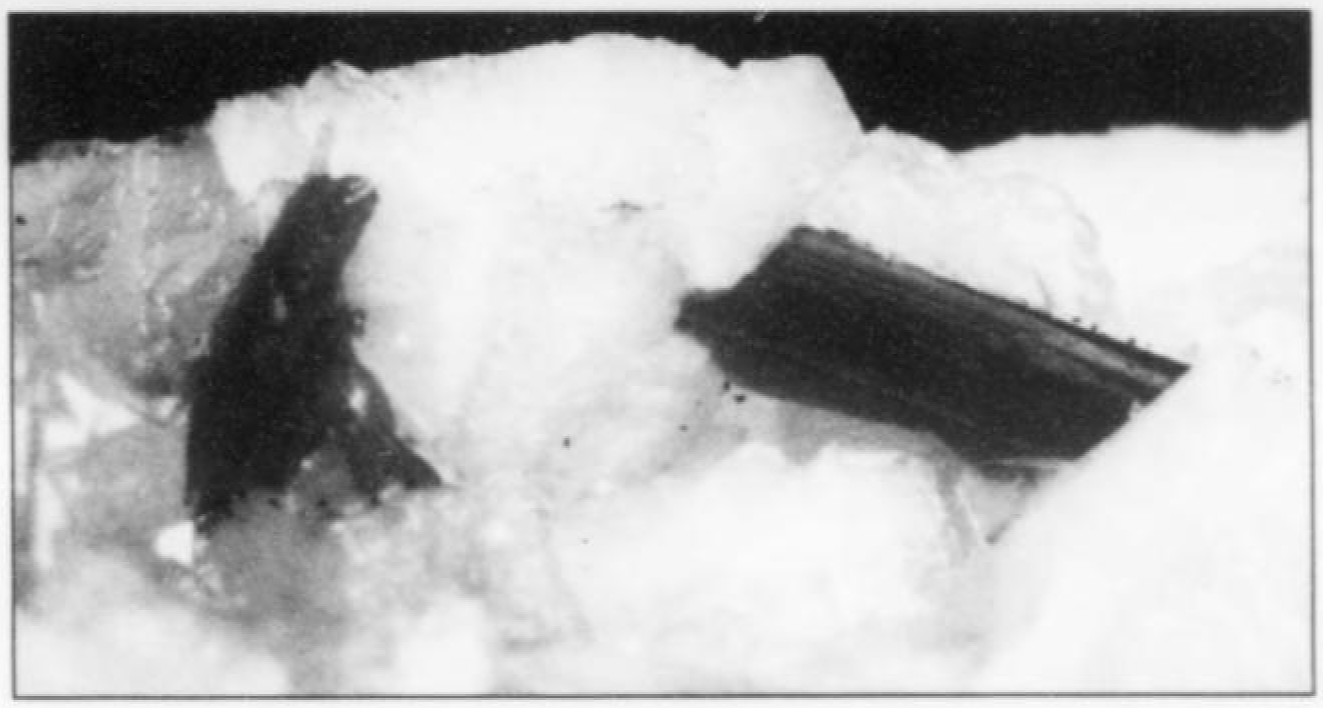


Figure 27. Emerald-green haradaite crystal, 3 mm, on white calcite and quartz, from the Gambatesa mine. Alessandro Pozzi collection; Roberto Appiani photo.

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

The presence of chalcophanite at Val Graveglia, reported as doubtful by Borgo and Palenzona (1988), has not been confirmed by analytical data.

Chalcophyllite $Cu_{18}^{2+}Al_2(AsO_4)_3(SO_4)_3(OH)_{27} \cdot 33H_2O$

Chalcophyllite has been found in good crystals, rarely over 1 cm in diameter, in fractures in fossil wood at the Cassagna mine and especially at the Scrava mine, where the best specimens were found in association with other secondary As and Cu minerals. It has also been found at the Gambatesa mine, as a secondary mineral in tennantite and quartz veins.

Chalcopyrite $CuFeS_2$

Chalcopyrite, widespread in small masses, was found at the Gambatesa mine as crystals up to 5 mm in a quartz vein. Masses up to a few cubic meters were mined from the small sulfide deposits associated with the basalts. In the outcrops it is usually deeply weathered, forming secondary minerals such as malachite and allophane.

Chernovite-(Y) $YAsO_4$

Chernovite-(Y), first described from Russia and later found at Mount Cervandone on the boundary between Italy and Switzerland, is very rare. It was found just once at the Molinello mine, as pink prismatic crystals up to 2 mm in a hematite vein associated with calcite (Borgo and Palenzona, 1988; Palenzona, 1988). The analysis is in good agreement with the available data, 80% of the REE being Y. A specimen from the same locality shows unidentified, very small, greenish yellow prismatic crystals; a microprobe analysis indicates Nd in substitution for Y, suggesting the possibility of a new species. So far further studies have not been possible because of the lack of material (Balestra, personal communication).

Chrysocolla $(Cu^{2+},Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$

Amorphous phases mainly consisting of chrysocolla are common in the copper deposits of Val Graveglia and are widespread as an alteration product of the copper minerals.

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

Clinochlore is rather common, especially in the fractures of chert, in association with quartz, calcite, anatase, orthoclase etc.

Clinochrysotile $Mg_3Si_2O_5(OH)_4$

Chlinochrysotile is known only as a rock-forming mineral in serpentines.

Clinoclase $Cu_3^{2+}(AsO_4)(OH)_3$

Clinoclase has been found as blue crystals up to 3 mm at the Gambatesa mine in association with arseniosiderite in chert fractures. Other finds, such as the ones reported in the fossil woods from the Scrava mine, have not been confirmed by analytical data.

Conichalcite $CaCu^{2+}(AsO_4)(OH)$

Collected since the early 1970's, conichalcite has been found sporadically, mainly at the Cassagna mine and at the Gambatesa mine (both finds are confirmed by analytical data; Antofilli *et al.*, 1983). The better specimens are undoubtedly those from the Cassagna mine, with pale green prismatic crystals up to 2 mm, sometimes associated with braunite, calcite, piemontite and barite crystals. Another commonly associated mineral is botryoidal pyrolusite. Conichalcite was found quite widespread in the early 1980's, but at present well-crystallized specimens are considered uncommon.

Connellite $Cu_{19}^{2+}Cl_4(SO_4)(OH)_{32} \cdot 3H_2O$

Good crystals of connellite up to 2 mm were found in the cavities in silicified wood. It is also present in quartz veins, always associated with cuprite and other copper minerals. The best specimens are from the Cassagna mine, but it has also been found at the Gambatesa mine, the Molinello mine and near Reppia.

Copper Cu

Native copper was found in the gossan of the copper and iron deposits, but the finest specimens were collected in the manganese mines. Spectacular specimens were found during the late 1960's at the Gambatesa mine in a manganoan calcite vein, in association with chalcocite and ganophyllite. In the 1990's a few spectacular specimens in aggregates over 30 cm long were collected again at the Gambatesa mine. Remarkable specimens associated with rhodonite were found at the Molinello mine, especially in 1986; in this case the copper filled rock fractures, forming laminae of several square centimeters up to 1 cm thick and dendritic aggregates with crystals up to 1 cm or more showing dodecahedron, octahedron and cube forms. Those attractive specimens show a rich association, with good crystals of rhodonite, barite, pyrobelonite, chalcocite, quartz, calcite and montmorillonite.

Cornubite $Cu_5^{2+}(AsO_4)_2(OH)_4$

Cornubite has been found at the Cassagna and Scrava mines, as millimetric green spheres in the fractures in fossil wood. It is considered rare in the area. In places it is associated with cornwallite (Balestra, 1992; 1993).

Cornwallite $Cu_5^{2+}(AsO_4)_2(OH)_4$

Cornwallite has been collected a few times at the Cassagna mine as crusts and millimetric spheres in the fractures in fossil wood. It is in places associated with cornubite and other arsenates.

Covellite CuS

Tiny lamellae of covellite on chalcocite have been reported from the Gambatesa mine (Antofilli *et al.*, 1983).

Crednerite $CuMnO_2$

Crednerite is a rare mineral, found for the first time in 1847 at Friedrichroda (Germany) and later in just a few more localities, always in small amounts. Tabular, black and very lustrous crystals were found at the Gambatesa mine in the fractures in braunite and at the Molinello mine in vugs in rhodonite veins (Palenzona, 1987), at the same time that tangeite was collected. It is considered very rare, but accurate analysis of the black minerals occurring in these localities might reveal more specimens.

Cuprite $Cu_2^{1+}O$

Small, nice cubic or octahedral cuprite crystals up to 2 mm were collected both in the copper and in the manganese mines. Probably the most interesting specimens are those found in silicified wood, associated with volborthite, several arsenates and, in places, connellite and spangolite. The acicular variety is also widespread, particularly at the Gambatesa mine.

Datolite (?) $Ca_2B_2Si_2O_8(OH)_2$

The presence of the boron-bearing mineral datolite, reported from Gambatesa by some collectors, has not been confirmed.

Devilline $CaCu_4^{2+}(SO_4)_2(OH)_6 \cdot 3H_2O$

Devilline has been found in radiolarite veinlets with other secondary copper minerals (Palenzona, 1996).

Digenite Cu_9S_5

Specimens with small digenite masses are known from the Gambatesa and the Monte Bardeneto-Monte Capra mines (Antofilli *et al.*, 1983).

Diopside $CaMgSi_2O_6$

Interesting specimens showing brown crystals of a calcium and magnesium pyroxene (manganese and iron-bearing) in association with ganophyllite and calcite came to light in the middle 1980's at the Molinello mine, and were reported as manganoan diopside (Borgo and Palenzona, 1988). Diopside is also common as a rock-forming component in the gabbros of the ophiolitic basement.

Djurleite $Cu_{31}S_{16}$

Djurleite, an example of non-stoichiometric copper sulfide, has been identified just once as small black crystals from the Molinello mine, associated with rhodonite, barite and ganophyllite (Borgo and Palenzona, 1988).

Dolomite $CaMg(CO_3)_2$

Dolomite is found with other carbonates in the veins cutting the main mineralized zone, as rounded rhombohedra and in typical saddle-shape aggregates. The crystals are up to 8 mm in size and range from white to pale pink. It was collected in almost all the manganese mines.

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

Epidote has been found as bright crystals up to 1 cm in cavities in the basalts, at Nascio, at Pontelagoscuro near the Molinello mine, at the Gambatesa mine and at several other localities. When associated with quartz, calcite, orthoclase (var. adularia), pumpellyite and prehnite it forms attractive specimens.

Fluorapatite $Ca_5(PO_4)_3F$

Tabular white crystals of fluorapatite up to 1 cm were found on rhodonite at the Gambatesa mine (Palenzona, 1984). Small "apatite" crystals were also observed in chert fractures with quartz, clinochlore and anatase.

Fluorapophyllite $KCa_4Si_8O_{20}(F,OH)\cdot 8H_2O$

Just a few specimens of fluorapophyllite, in crystals up to 3 mm, have been found with yellow rhodonite crystals in a block of ore at the Molinello mine.

Galena PbS

Galena has been found as small cubic crystals with chalcopyrite in a quartz vein at the Gambatesa mine, and also in the local limestone quarries. Lead is an uncommon element in Val Graveglia and consequently galena is rare.

Gamagarite $Ba_2(Fe^{3+},Mn^{3+})(VO_4)_2(OH)$

One of the most interesting minerals from this area is gamagarite, this being the second occurrence, after the original find in the Postmasburg, South Africa, manganese field, where it forms brown-red veins. It was observed several times at the Molinello mine (Basso and Palenzona, 1988) and, as a rarity, at the Gambatesa mine. The specimens from the Molinello mine, with crystals up to 1 cm, in rhodonite cavities or in the quartz veins that cut the braunite ore, are the best in the world. A possible third occurrence of gamagarite is under study based on material from the Cerchiara mine, about 25 km southeast of Val Graveglia (Balestra and Bracco, personal communication).

Ganophyllite $(K,Na)_2(Mn,Al,Mg)_8(Si,Al)_{12}O_{29}(OH)_7\cdot 8\text{–}9H_2O$

Ganophyllite is a rare species occurring in beautiful specimens at Val Graveglia. The most spectacular ones, from the Molinello mine, show platy, micaceous crystals up to 5 mm forming large druses in the quartz veins crossing chert. Ganophyllite usually lies on hematite and quartz, and is often associated with rhodochrosite or manganoan calcite. The Gambatesa mine also produced good specimens, with single crystals up to 1 cm, and in aggregates lining chert fractures. The color ranges from cream to yellow to brown, and the most common association is with barite, quartz, rhodochrosite and other carbonates. Spherules and platy aggregates of lamellae were also found in relative abundance in some periods in all the manganese mines of the district.

Some of the Molinello and Gambatesa specimens are probably among the best in the world for this species. According to the literature (Cortesogno *et al.*, 1979; Antofilli *et al.*, 1983) the micaceous specimens once labeled as parsettensite are to be considered ganophyllite. However, a later work (Eggleton *et al.*, 1994) indicates that at least some specimens from Gambatesa are indeed parsettensite.

A calcium-rich variety with Ca>Na>>K ("calcio-ganophyllite") is reported from the Molinello mine (Mottana and Della Ventura, 1990).

Goethite α-$Fe^{3+}O(OH)$

Goethite is very common, especially in the gossan of the pyrite deposits, as black, red or yellow masses of "limonite."

Gold Au

Gold is extremely rare in the Val Graveglia district. It was found at the Gambatesa mine in the early 1980's as small dendrites associated with chalcocite in a quartz vein (Pipino, 1983). Another find took place in the 1990's, in aggregates up to 5 mm, with chalcocite, tennantite and quartz.

Goldmanite $Ca_3(V,Al,Fe^{3+})_2(SiO_4)_3$

Another very interesting mineral at Val Graveglia is goldmanite, a vanadium-bearing garnet found in places in 1988, 1992 and 1996 at the Gambatesa mine, as small (about 1 mm) but perfect green to brown-green dodecahedral crystals associated with manganaxinite, albite, calcite, pennantite, and a vanadium-rich pumpellyite (Palenzona, 1991).

Gravegliaite $Mn^{2+}(SO_3)\cdot 3H_2O$

The hydrated manganese sulfite mineral gravegliaite is the third known example of a natural sulfite, after the lead-bearing scotlandite and calcium-bearing hannebachite. It was described as a new species from specimens collected at the Gambatesa mine, where it was found as small (up to 0.5 mm), prismatic, colorless orthorhombic crystals which turn brown-black. The crystals sometimes form sheaf-like or radial aggregates. It occurred very sparingly at the surface of cavities and fractures in a manganese ore containing tephroite, bementite, braunite, hausmannite and hematite. The presence of this phase does not appear to be related to the chemistry of the matrix, which lacks sulfur-bearing minerals. The authors of the article describing it as a new species (Basso *et al.*, 1991) suggested a possible origin involving sulfur from the underlying ophiolitic breccias or from the overlying pelitic layers and suggested precipitation from S^{2-} bearing brines. Gravegliaite is named after the Val Graveglia district.

Gypsum $CaSO_4\cdot 2H_2O$

Gypsum is common in some old workings as an alteration product of the pyrite masses. Colorless crystals were also found in the basalt cavities at the Molana quarry.

Haradaite $Sr_2V_2^{4+}(Si_4O_{12})$

The rare strontium-bearing and vanadium-bearing mineral haradaite, previously reported only from the type locality, the Noda-Tamagawa mine (Iwate, Japan), and from the Yamato mine (Kagoshima, Japan) is one of the most interesting minerals found in the district. It occurred at the Gambatesa mine as attractive small crystals up to 5 mm having a beautiful emerald-green color, in thin veinlets in the red chert, in association with quartz, calcite and the new species vanadomalayaite. Haradaite was collected in just a few specimens; the crystals are elongated parallel to [100] and show good {010} cleavage. The Gambatesa haradaite is of nearly pure

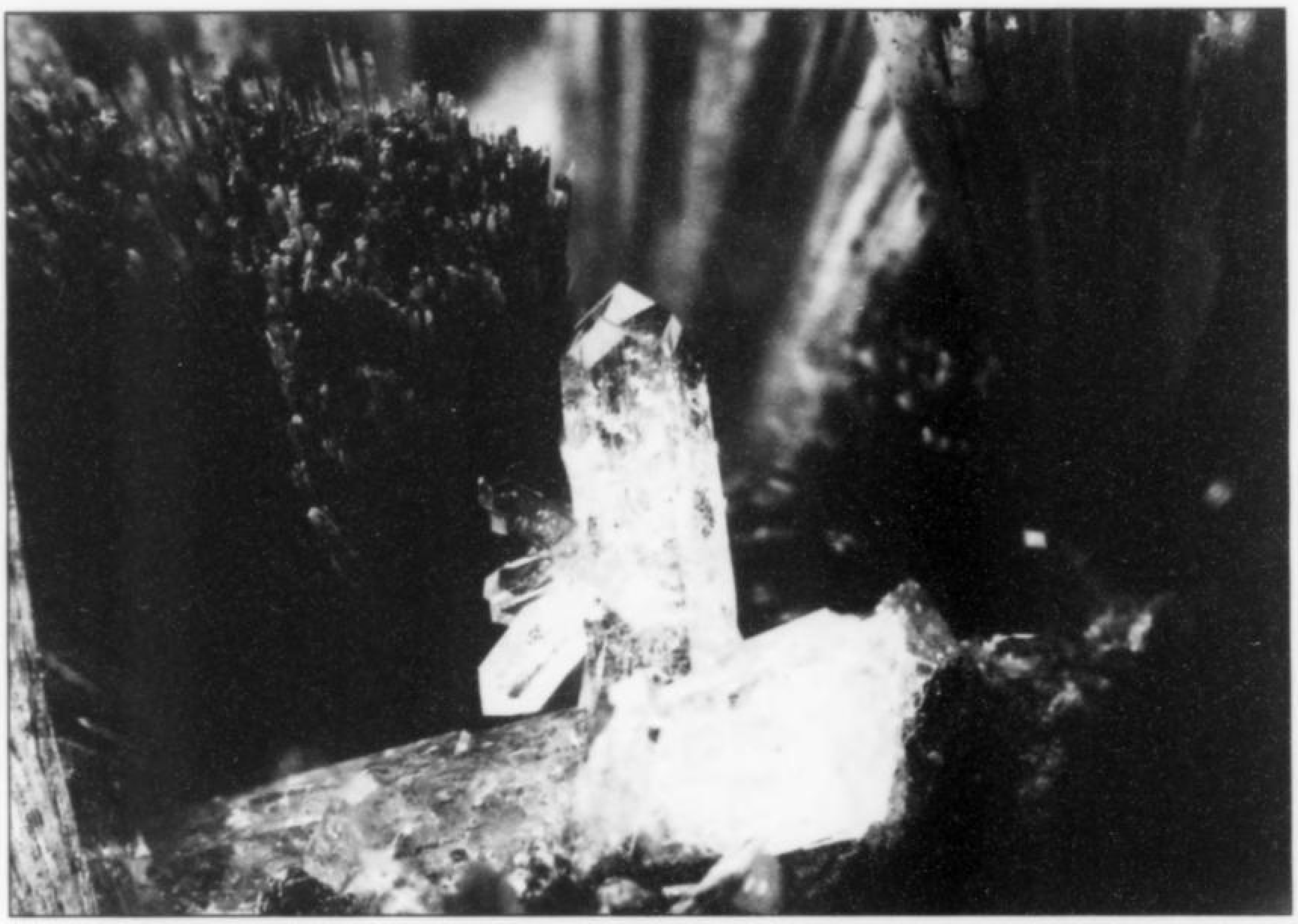
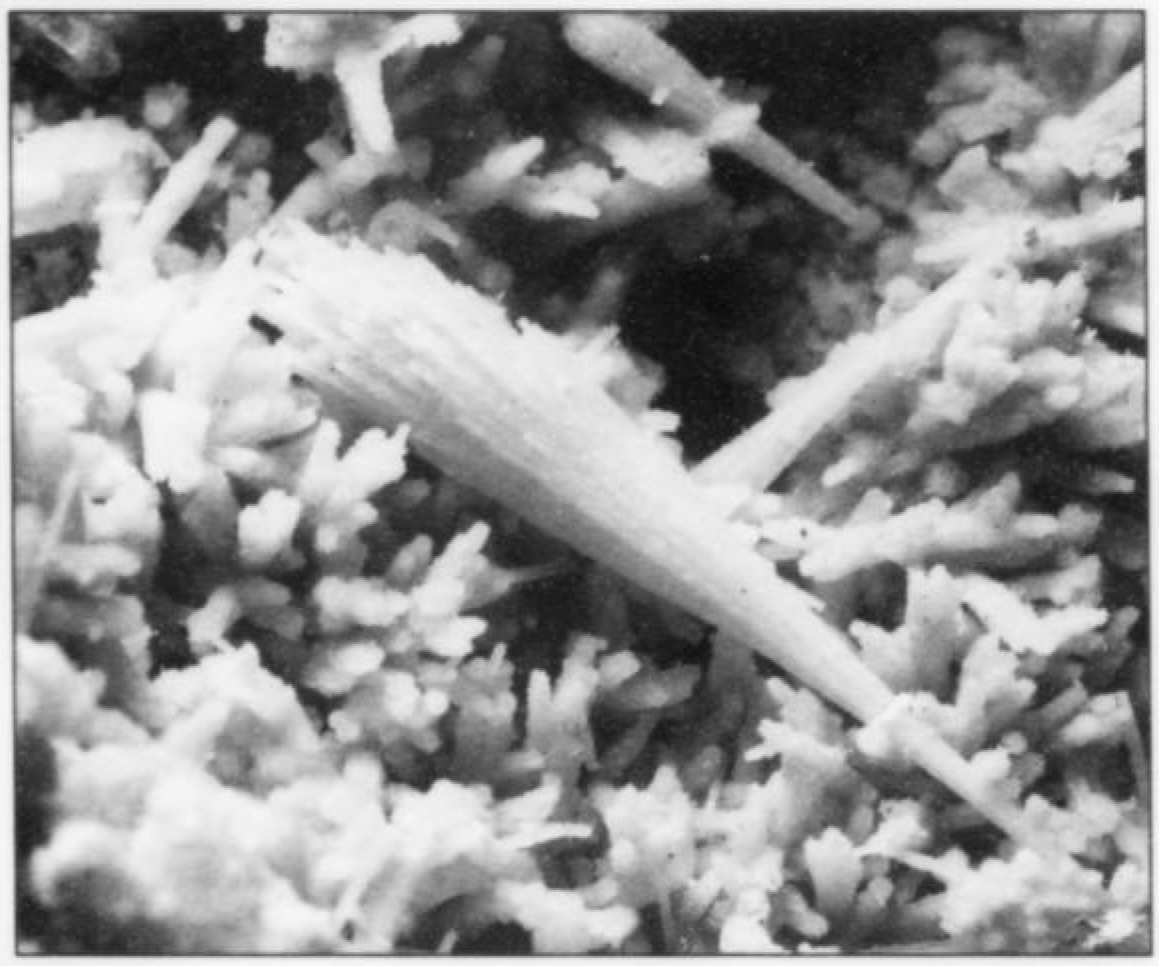


Figure 28. **Harmotome crystals, 2.5 mm, with Ca-rich kutnahorite, from the Gambatesa mine (found 1993). Private collection; Roberto Appiani photo.**

Figure 29. **Kutnahorite, in cream to pink crystal sprays; the longest "club" is 1.2 cm; from the Cassagna mine (found middle 1980's). Private collection; Roberto Appiani photo.**

Figure 30. **Langite crystals to 4 mm, with malachite spherules, in a fracture of the silicified wood, from the Scrava mine (found 1996). Private collection; Roberto Appiani photo.**



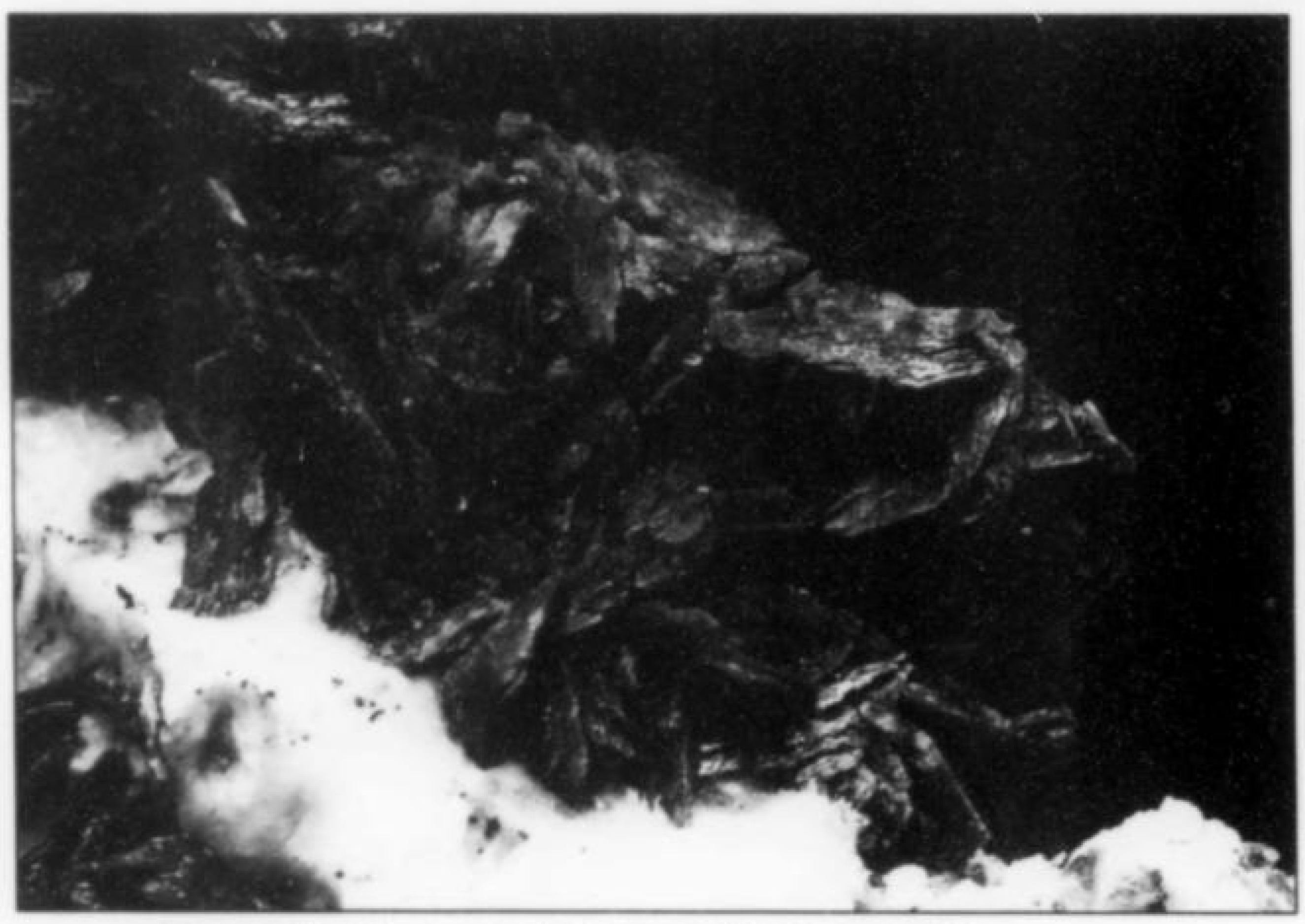


Figure 31. **Manganaxinite crystals, 8 mm, with albite and calcite; from the Gambatesa mine. Marco Marchesini collection; Roberto Appiani photo.**

Figure 32. **Orange marsturite crystals, 1 mm, with white calcite and barite, from the Molinello mine (found 1986). Private collection; Roberto Appiani photo.**

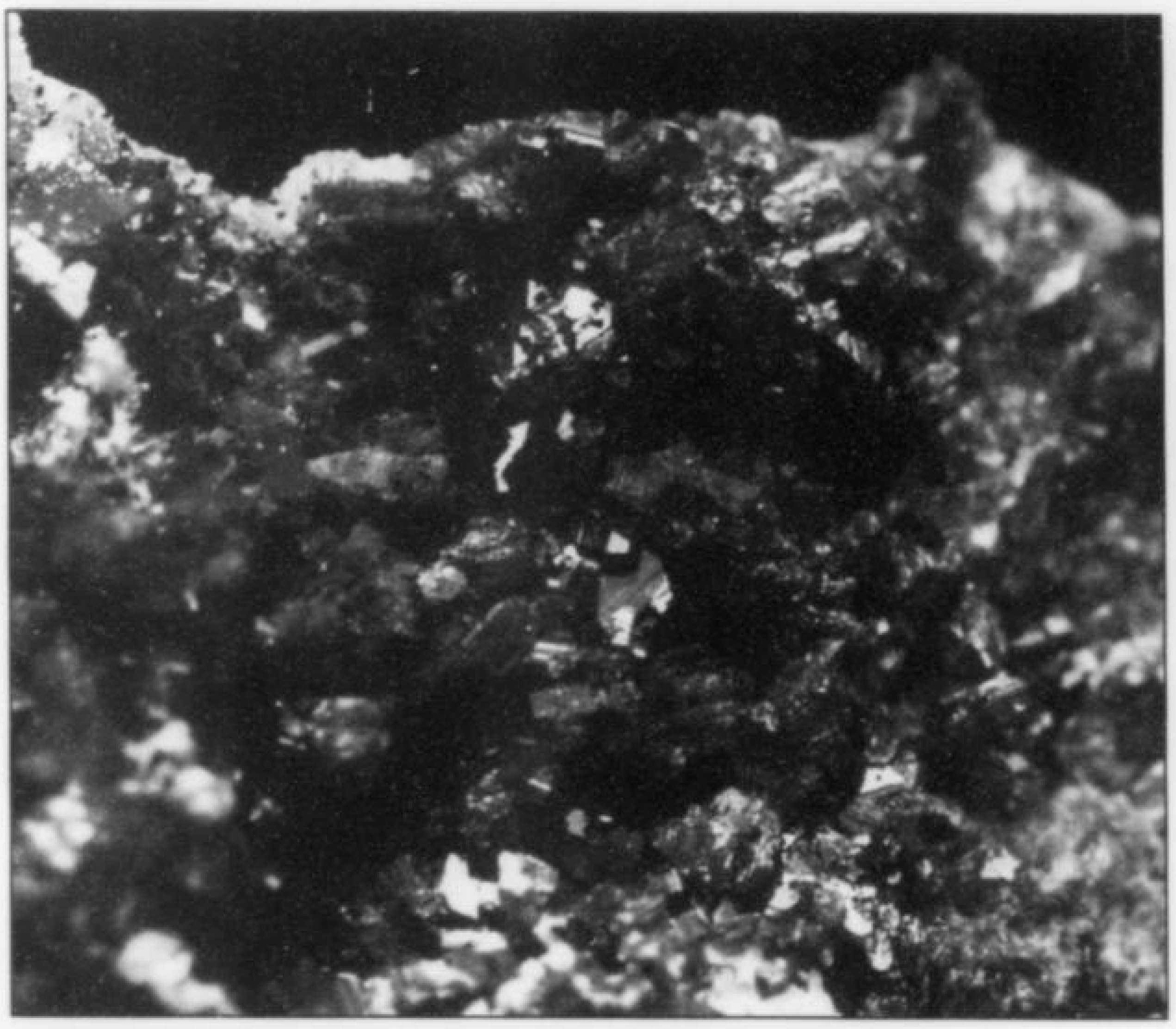


Figure 33. Exceptional druse of red medaite crystals up to 2 mm on white quartz from the Molinello mine (found 1996). Marco Marchesini collection; Roberto Appiani photo.

Figure 34. Well-formed medaite crystal, 0.8 mm, from the Molinello mine (found 1996). Private collection; Roberto Appiani photo.

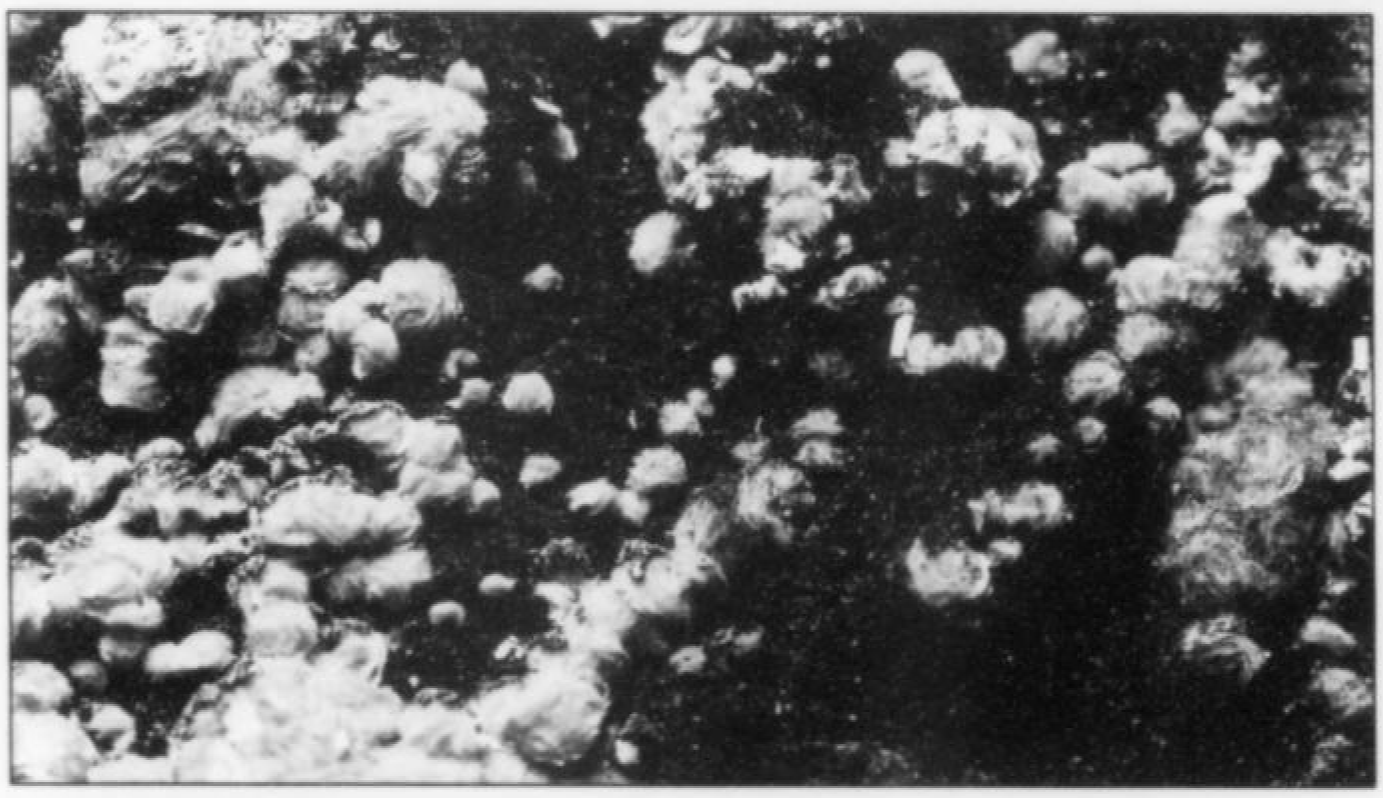


Figure 35. Ganophyllite aggregates of platy crystals, 1 mm, with a dark Mn-bearing mineral similar to nimite. Molinello mine (found 1993). Private collection; Roberto Appiani photo.

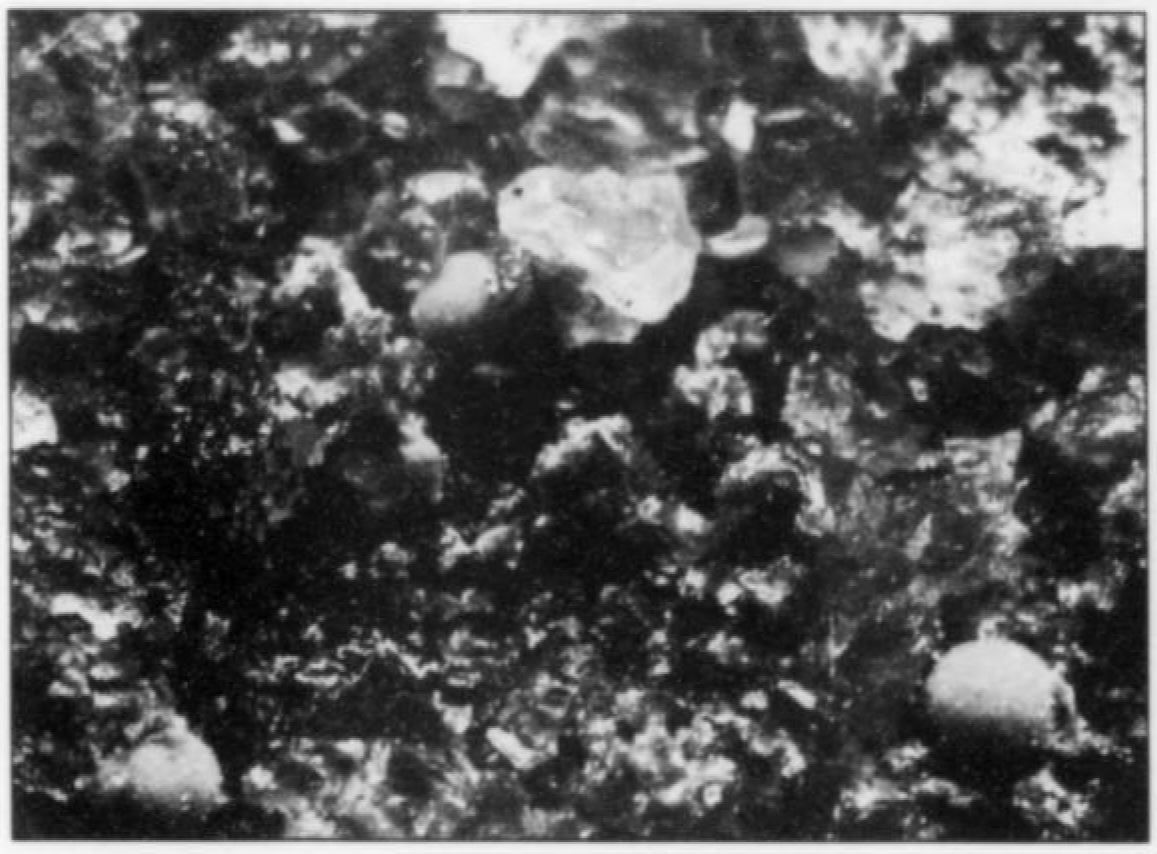


Figure 36. Green parnauite aggregates of tabular crystals, 1.5 mm, with green-yellow volborthite spherules and red cuprite crystals on quartz in silicified wood from the Scrava mine (found 1997). Marco Marchesini collection; Roberto Appiani photo.

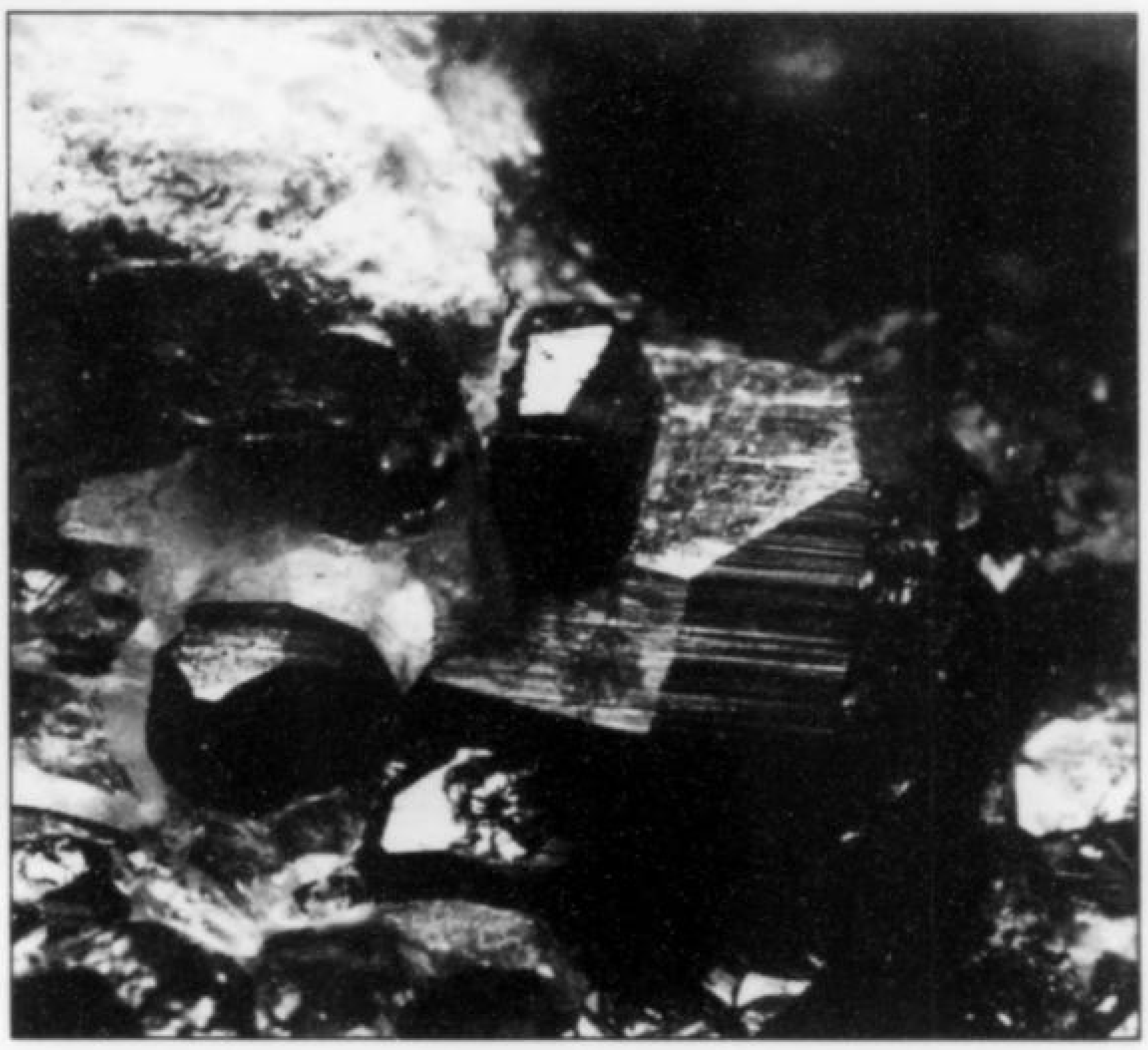


Figure 37. Garnet-like palenzonaite crystals, 3 mm, from the Molinello mine (found 1986). Marco Marchesini collection; Roberto Appiani photo.

end-member composition, with the molar fraction of the Ba analog suzukiite not exceeding 14%. This allowed the accurate refinement of the crystal structure of the mineral (Basso *et al.*, 1995).

Harmotome $(Ba_{0.5},Ca_{0.5},K,Na)_5[Al_5Si_{11}O_{32}]\cdot12H_2O$

Zeolite crystals visually identifiable as phillipsite or harmotome are well-known as last-formed minerals in carbonate veins, braunite fractures and tinzenite druses (Antofilli *et al.*, 1983). Recently microprobe analyses (Balestra, personal communication) have shown that the barium content in these specimens is very high and they should be classified as harmotome. It occurs, associated with carbonates, barite and manganese oxides, at the Gambatesa, Molinello and Cassagna mines.

Hausmannite $Mn^{2+}Mn_2^{3+}O_4$

Hausmannite is a common species, especially at the Gambatesa mine. It is rarely found in crystals and can easily be misidentified as braunite. A close examination of the color can be a clue: usually hausmannite is dark brown while braunite is black. Nevertheless only an accurate analysis can verify the identification.

Hematite $\alpha\text{-}Fe_2O_3$

Hematite is very common, but does not occur in attractive specimens. It was one of the first minerals to crystallize in the chert veins, as lamellae up to 3 mm, sometimes grouped in rosettes. It is frequently followed, and usually covered, by quartz, calcite and ganophyllite.

"Hornblende"

Found as a rock-forming mineral, "hornblende" occurs in small crystals in the diorites of the ophiolitic complex. Some specimens are reported from the Gambatesa mine (Antofilli *et al.*, 1983).

Ilmenite $Fe^{2+}TiO_3$

Ilmenite has been observed in thin section and as small (1–2 mm) concentrations in basic rocks from the Cassagna and Scrava mines (Antofilli *et al.*, 1983).

Inesite $Ca_2Mn_7^{2+}Si_{10}O_{28}(OH)_2\cdot5H_2O$

Inesite has been found just a few times at the Gambatesa mine as pink veinlets in the main orebody, and rarely as crystals up to a few millimeters. Inesite is difficult to identify in the field because of its similarity to the more common fibrous rhodonite and pyroxmangite.

Johannsenite $CaMn^{2+}Si_2O_6$

An uncommon clinopyroxene in the area, johannsenite was occasionally collected at the Molinello mine in veins in the manganese ore, as pale apple-green masses up to several centimeters, and sometimes as well-formed crystals. It is usually associated with calcite.

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

Kutnahorite is a Mn-rich carbonate belonging to the dolomite group. Specimens from Val Graveglia similar to this species have been studied at the University of Genoa (Cortesogno *et al.*, 1979). Their composition showed more calcium than in the theoretical formula, but on the basis of X-ray data they cannot be considered a manganoan calcite. This material, which shows analogies with the Ca-rich kutnahorite found at Långban, Sweden, is not especially rare among the last minerals formed in the veins of the manganese ore. The best specimens are pink to cream-colored elongated aggregates up to 6 cm long that sometimes resemble the shape of a club. It can be associated with barite, tinzenite, caryopilite, zeolites and many other species. Specimens recently collected at the Cassagna mine before the end of the operations show pink clubs up to 2 cm, and are very similar to the kutnahorite from the South African fields (Cairncross, *et al.*, 1997).

Langite $Cu_4^{2+}(SO_4)(OH)_6\cdot2H_2O$

Langite has been found as crystals up to 3 mm in the gossan at the old Bardeneto-Monte Capra excavations, in the manganese mines as an alteration of the copper sulfides, and in fractures in fossil wood. Good specimens of langite were collected at the Scrava mine.

Lavendulan $NaCaCu_5^{2+}(AsO_4)_4Cl\cdot5H_2O$

Lavendulan has been found as spherules up to 2 mm in quartz cavities, in association with chalcocite, tennantite and calcite, only at the Gambatesa mine.

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

Magnetite has been found in serpentinized peridotites and in basalts as small masses and as rare, small (less than 1 mm) subeuhedral crystals.

Malachite $Cu_2^{2+}(CO_3)(OH)_2$

Malachite is very common, in both the copper and manganese mines of Val Graveglia. The most attractive specimens are druses up to 20 by 15 cm with spherules up to 8 mm, which were found in a weathered zone of the small copper deposit at Reppia. It is also common in fossil wood at Gambatesa and at the Scrava mine, and is associated with copper sulfides in many other localities.

Manganaxinite $Ca_2Mn^{2+}Al_2BSi_4O_{15}(OH)$

Manganaxinite was found at the Gambatesa mine in chert veins as good crystals, gray-greenish to violet in color and up to 5 mm in length. Specimens collected in the 1980's show only a few associated species, while the ones found in 1992 are part of a very interesting assemblage with manganaxinite partially covered by albite, goldmanite, ganophyllite, vanadium-rich pumpellyite and calcite.

In the past, some dark-colored specimens of tinzenite were misidentified as manganaxinite (or as ferroaxinite, the presence of which has not been confirmed).

Manganberzeliite $(Ca,Na)_3(Mn^{2+},Mg)_2(AsO_4)_3$

Manganberzeliite has been found only once, on a chert fracture at the Cassagna mine, as very small, yellow aggregates (Palenzona, 1996). Microprobe analysis showed no Mg in this material.

Manganite $Mn^{3+}O(OH)$

Though perhaps not very rare, only a few specimens of manganite have been identified by analysis. At the Cassagna mine specimens with crystals up to 1 cm were collected, while the Molinello mine produced sprays of lustrous crystals in quartz vein (Antofilli *et al.*, 1983; Borgo and Palenzona, 1988).

Marcasite FeS_2

Good marcasite specimens are not very common in Val Graveglia. The best, with sharp, lustrous crystals up to 3 mm, were collected at the beginning of the 1990's in braunite veins, associated with carbonates, barite and, in places, phillipsite.

Marsturite $Na_2CaMn_3^{2+}Si_5O_{14}(OH)$

The rare silicate marsturite, a member of the nambulite group, was originally described from Franklin, New Jersey (Peacor *et al.*, 1978; Dunn and Leavens, 1986), and was also recognized in orange to yellow crystals up to 2 mm from the Molinello mine, associated with braunite, barite and calcite (Palenzona, 1987b). In that period the mine produced large amounts of ore very rich in veins, often containing pink to yellow rhodonite. Examination of those veins led to the discovery of good specimens of marsturite and pyroxmangite. Marsturite is quite rare, and often the so-called "marsturite" specimens turn out to be just rhodonite.

Medaite $(Mn^{2+},Ca)_6(V^{5+},As^{5+})Si_5O_{18}(OH)$

Medaite is a very rare species for which the Molinello mine is the type locality; it has also been reported from Fianel in Val Ferrera, Switzerland. Medaite has a good {100} cleavage, in places occurring as oriented lamellae in tiragalloite or on pyroxmangite crystals, suggesting a syntaxial growth. A characteristic feature of its crystal structure is the presence of a vanadatopentasilicate ion.

This mineral was originally studied in braunite ore collected at the Molinello mine, consisting of veinlets in the braunite ore in which medaite was associated with quartz, calcite, ganophyllite and another new species, tiragalloite. It was named in honor of the Italian mineral collector Francesco Meda (1926–1977) (Gramaccioli *et al.*, 1979; Gramaccioli *et al.*, 1982).

The specimens show brownish red granules up to 1.5 mm. No more were found for several years after the first occurrence. More specimens later collected at the Cassagna mine have a very similar association (Borgo and Palenzona, 1988). In 1988 good prismatic, bright red crystals were found, again at Molinello mine, on braunite in a quartz vein. Other sporadic finds followed until May 1996 when, just a few days before the closing of the Molinello mine, the best specimens of medaite to date were found, with well-formed red to orange crystals up to 2 mm in druses of several square centimeters.

The three minerals, medaite (monoclinic), saneroite (triclinic) and tiragalloite (monoclinic), for which Val Graveglia is the type locality, are not easy to recognize without analytical data, especially if the specimens do not show crystals. The color, usually orange to yellow for tiragalloite, orange to brown for saneroite and orange to brownish red for medaite, may be a clue, but cannot be used to identify those minerals with certainty. The least rare of the three species is saneroite, while the other two are quite scarce.

Montmorillonite $(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$

Montmorillonite occurs in veins in the manganese ore. Nice specimens, with crystals forming rosettes up to 3 mm, were found in association with native copper at the Molinello mine in the middle 1980's (Borgo and Palenzona, 1988).

Nabiasite $BaMn_9[(V,As)O_4]_6(OH)_2$

Nabiasite is a recently described mineral, found in the Pyrenees in just one specimen (Brugger *et al.*, 1999). Some specimens collected in 2000 at the Gambatesa mine were identified as the second world occurrence of nabiasite (Brugger, pers. comm.), and the first occurrence in euhedral cubic crystals. This mineral occurred with quartz in veinlets crossing a braunite-hausmannite ore. It must be considered extremely rare, and difficult to recognize without an analysis, because its red color and general appearance are very similar to those of palenzonaite, gamagarite, pyrobelonite and "yamatoite."

Neotocite $(Mn^{2+},Fe^{2+})SiO_3 \cdot H_2O$ (?)

The brown to black manganese silicate neotocite has a low degree of crystallinity and is not well defined. It was found several times at the Gambatesa mine, as small masses associated with quartz, braunite, calcite and rhodonite. Neotocite often fills little vugs, and sometimes forms transparent brown botryoidal crusts. This mineral was also common at the Molinello mine, with similar associations. Here neotocite pseudomorphs after alabandite crystals, associated with barite, were also found.

Nimite (?) $(Ni,Mg,Fe^{2+})_5(Al(Si_3)O_{10}(OH)_8$

Some brown lamellae were found at the Molinello mine in quartz veins, associated with sursassite and ganophyllite. Similar specimens were also collected at Gambatesa mine. The analysis (Palenzona, 1996) yielded a tentative identification as manganoan nimite.

Olivenite $Cu_2^{2+}(AsO_4)(OH)$

Olivenite was found in the 1990's in the dumps of the Gambatesa mine, in quartz veins with arseniosiderite and in some tinzenite veins, associated with chalcocite and quartz. Other specimens were collected in fossil wood from the Cassagna and Scrava mines. Olivenite forms green crystals and sprays up to 5 mm.

Opal $SiO_2 \cdot nH_2O$

Veinlets in the manganese ore showing the typical opalescence have been found at the Molinello and Gambatesa mines (Borgo and Palenzona, 1988).

Orpiment As_2S_3

Orpiment has been reported as small masses from the Molinello mine (Palenzona, 1996). It is very rare in Val Graveglia.

Orthoclase $KAlSi_3O_8$

The transparent variety of orthoclase was collected several times as crystals up to 1 cm in veins cutting chert, in association with quartz and ganophyllite. It is also commonly associated with epidote in several basalt outcrops, as at Nascio, where the crystals reach 3 cm in length.

Palenzonaite $(Ca_2Na)Mn_2^{2+}(VO_4)_3$

Palenzonaite, a very rare mineral, is cubic with a garnet-type structure in which V (and a small amount of As) replaces Si. It is one of the most interesting minerals at Val Graveglia, described for the first time from material collected at the Molinello mine, and named in honor of Andrea Palenzona (1935–), Professor of Chemistry at the University of Genova (Palenzona, 1986a; Basso, 1987).

This vanadate was found for the first time in the 1980's in a calcite-filled and quartz-filled fracture crosscutting the manganese ore, as wine-red crystals up to 6 mm showing dodecahedral and trapezohedral forms. In 1993 some specimens with cubic crystals up to 7 mm were found, again in a calcite vein in the main ore mass. The occurrence of crystals is rare; most of the palenzonaite specimens are compact masses or veinlets up to 1 cm thick.

The Molinello mine remained the only known locality for palenzonaite for several years, until the discovery of the Val Ferrera, Switzerland, occurrence; nevertheless the Val Graveglia specimens are by far the best.

Parnauite $Cu_9^{2+}(AsO_4)_2(SO_4)(OH)_{10} \cdot 7H_2O$

Parnauite is not common; it was found as nice tabular crystals up to 3 mm in the cavities of fossil wood at the Scrava mine. The associations include quartz, cuprite, azurite, chalcophyllite, volborthite and other secondary As and Cu minerals.

Parsettensite $(K,Na,Ca)(Mn,Al)_7Si_8O_{20}(OH)_8 \cdot 2H_2O$

Parsettensite occurs in platy, micaceous, yellowish to brown crystals on quartz and calcite. It has been verified on some specimens from Gambatesa (Eggleton *et al.*, 1994), and it is probably present at various localities in Val Graveglia. However, it is not easily distinguished, and further study is required.

Pennantite $Mn_5^{2+}Al(Si_3Al)O_{10}(OH)_8$

A vanadium-bearing variety of pennantite, the so-called "grovesite" described in 1955 from the Benallt mine in Wales, has been found at the Gambatesa mine in association with manganaxinite, goldmanite, albite and calcite (Palenzona, 1991).

Pharmacosiderite $KFe_4^{3+}(AsO_4)_3(OH)_4 \cdot 6\text{–}7H_2O$

Pharmacosiderite occurs rarely as small yellow crystals at the Gambatesa mine, found in association with olivenite, and in fossil wood at the Cassagna mine, in association with copper and arsenic minerals (Palenzona, 1991).

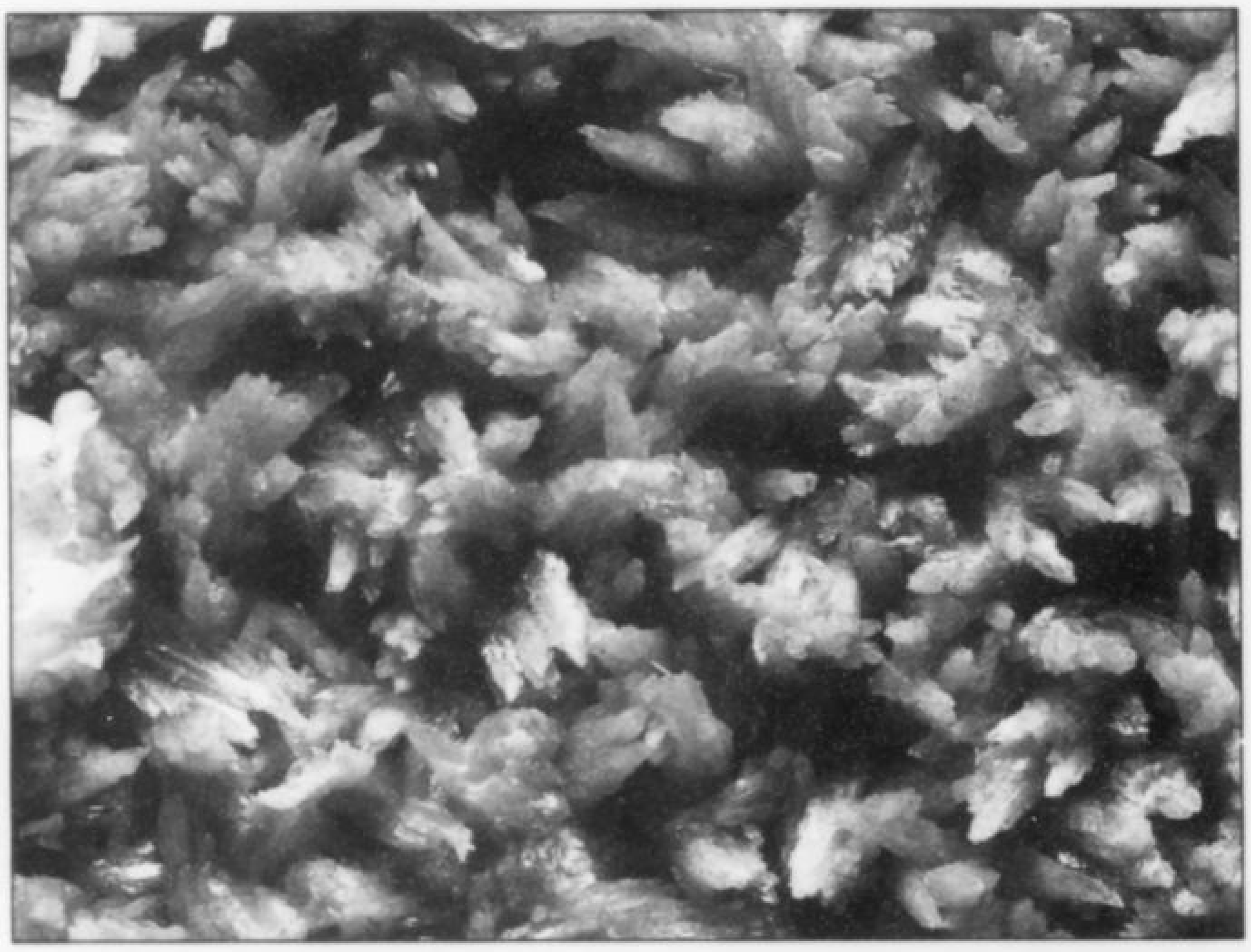


Figure 38. Pyroxmangite crystals up to 2 mm, from the Molinello mine (found 1986). Private collection; Roberto Appiani photo.

Figure 39. Pyroxmangite crystals, 1.5 mm, capped by a secondary growth of medaite, from the Molinello mine (found 1996). Private collection; Roberto Appiani photo.

Figure 40. Pyrolusite crystals, 2 mm, from the Scrava mine. Private collection; Roberto Appiani photo.

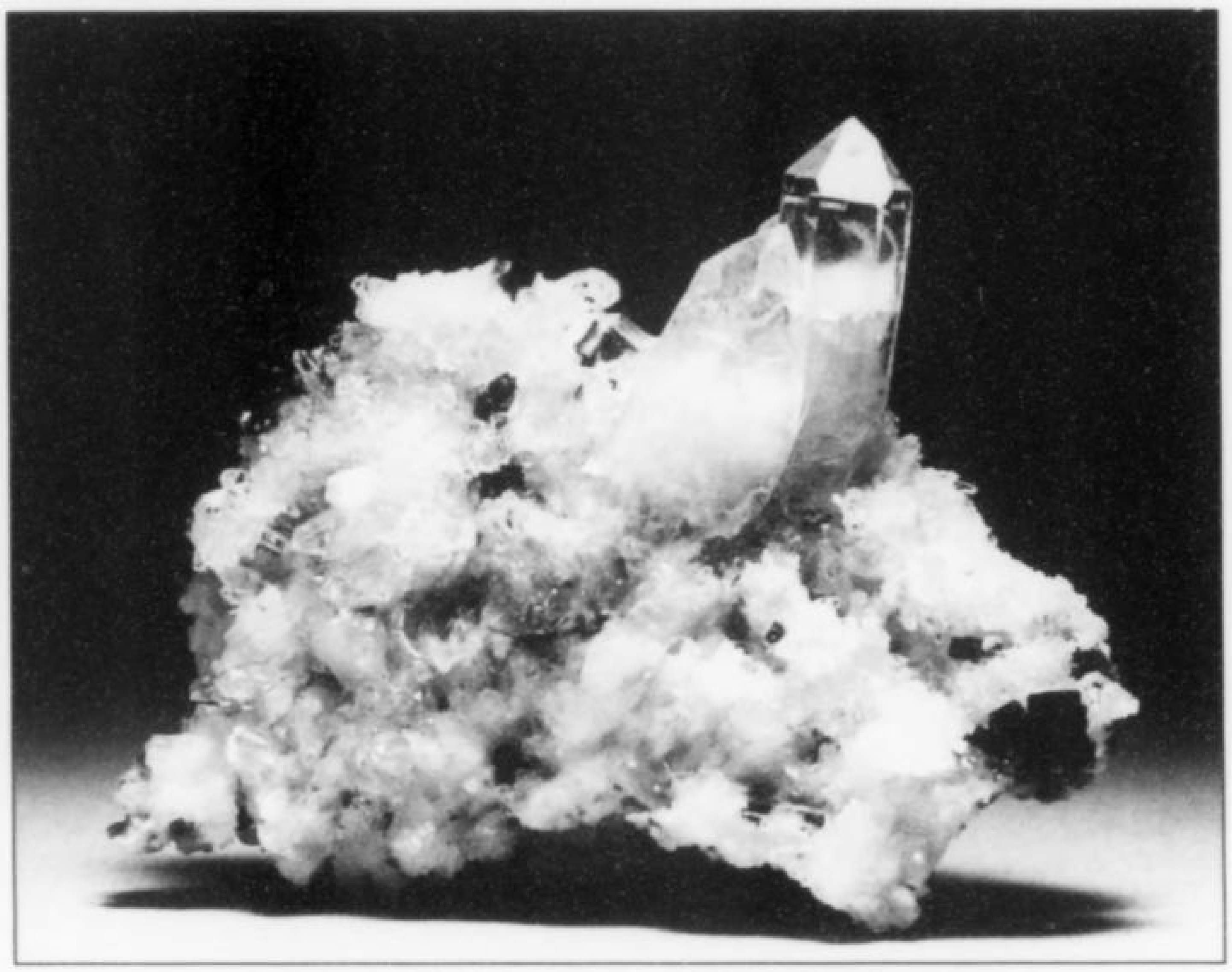


Figure 41. Quartz and epidote crystals with orthoclase (adularia variety), from a cavity in a pillow lava at Nascio (found 1989), 5 cm. Marco Marchesini collection; Roberto Appiani photo.

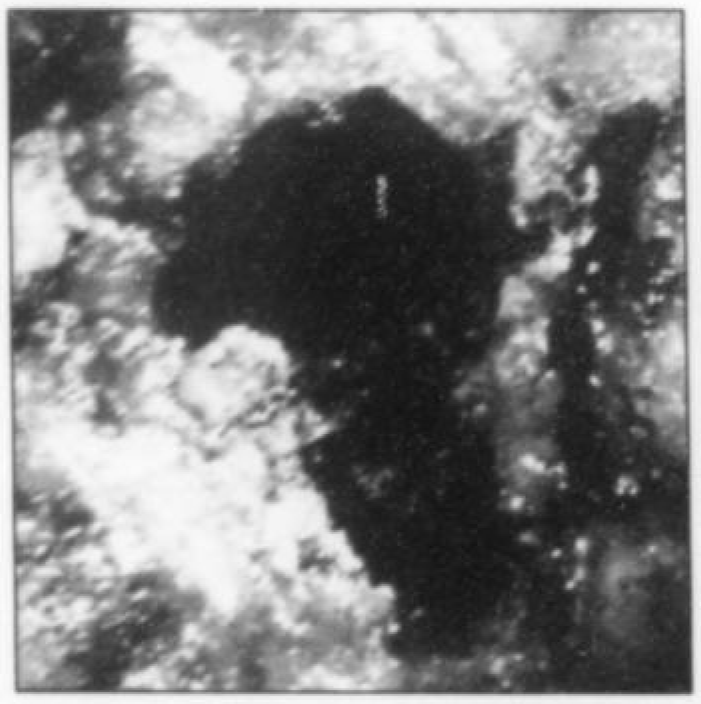


Figure 42. Reppiaite crystals, 0.7 mm, collected at the Gambatesa mine in the late 1980's. Alessandro Pozzi collection; Roberto Appiani photo.

Figure 43. Pink rhodonite crystals with a 3-mm crystal of colorless barite, from the Gambatesa mine (found 1988). Private collection; Roberto Appiani photo.

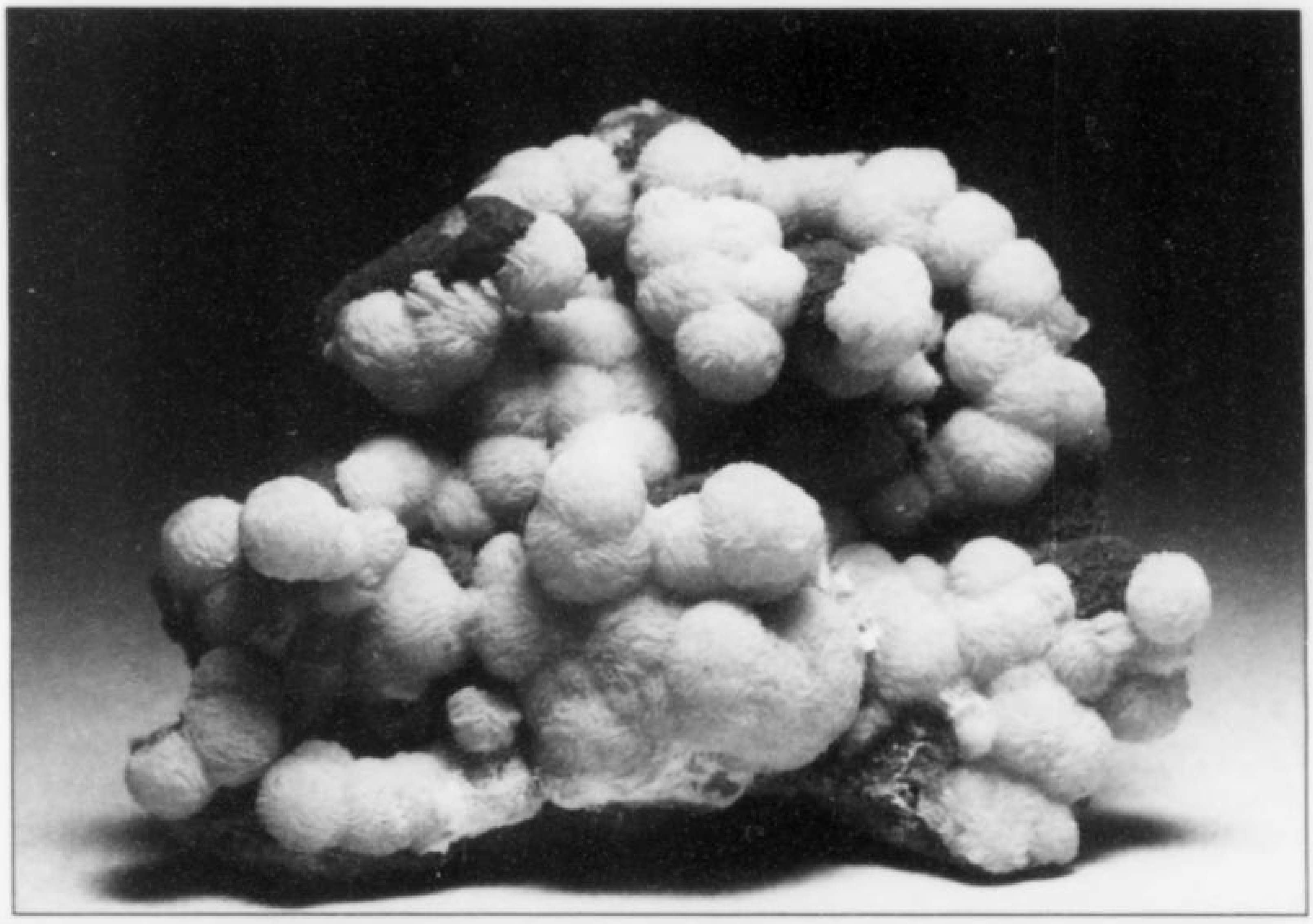
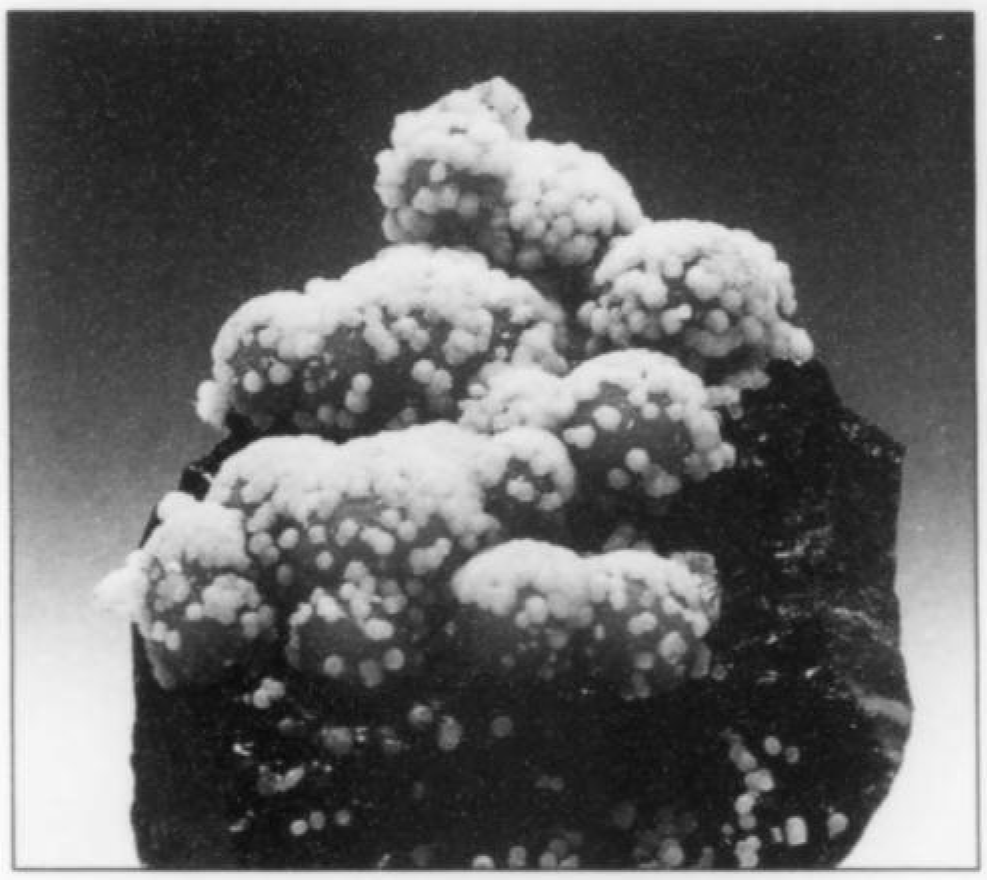


Figure 44. **Pink rhodochrosite spherules on caryopilite; 2.5 cm specimen from the Molinello mine (found 1989). Marco Marchesini collection; Roberto Appiani photo.**

Figure 45. **Two generations of rhodochrosite spherules on dark-brown neotocite, from the Gambatesa mine; 2.5 cm. Private collection; Roberto Appiani photo.**



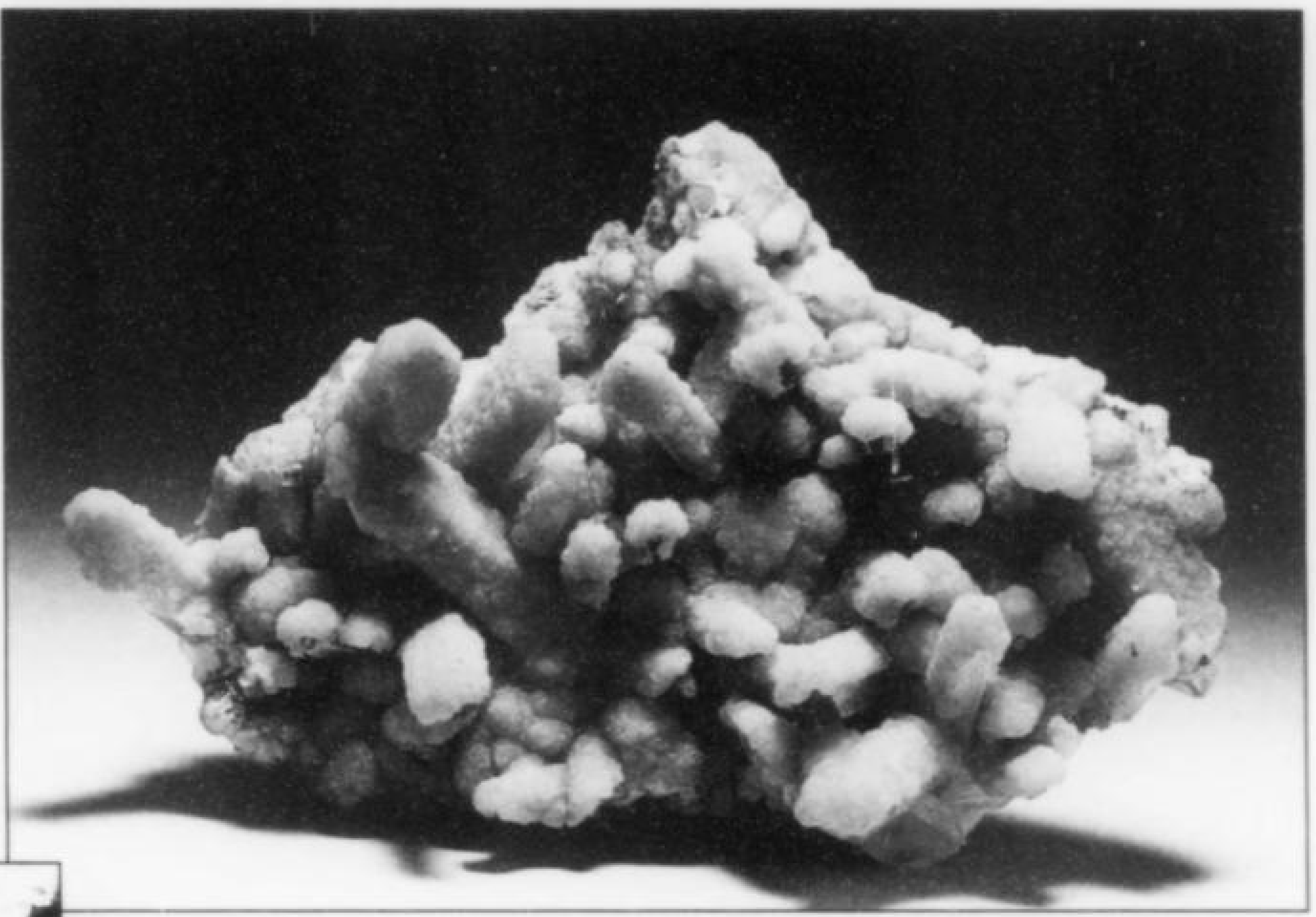


Figure 46. **Rhodochrosite covering quartz crystals, 5 cm, from the Molinello mine (found 1987). Marco Marchesini collection; Roberto Appiani photo.**

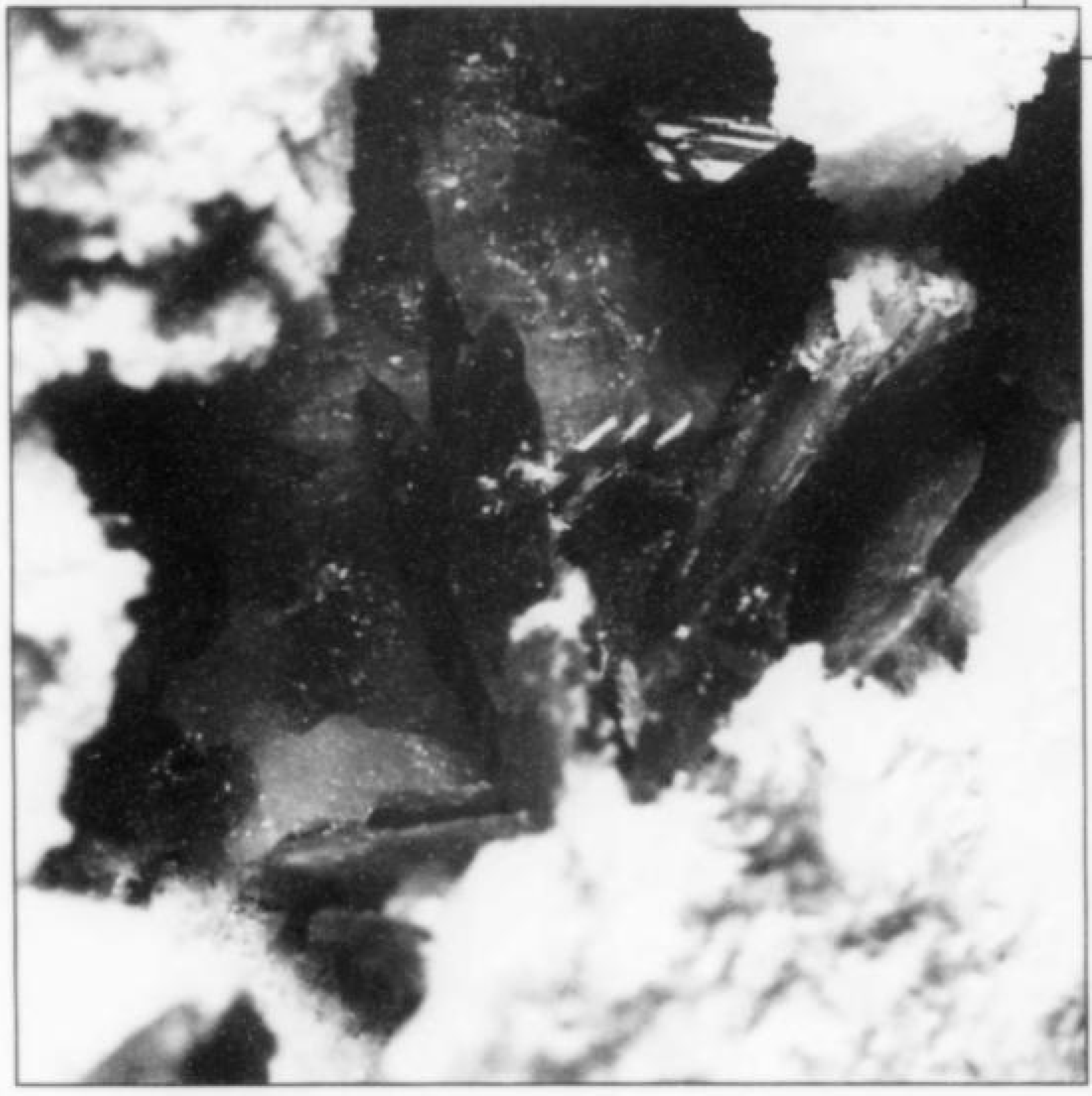


Figure 47. **Saneroite crystals to 5 mm, with calcite and quartz, from the Molinello mine (found 1987). Private collection; Roberto Appiani photo.**

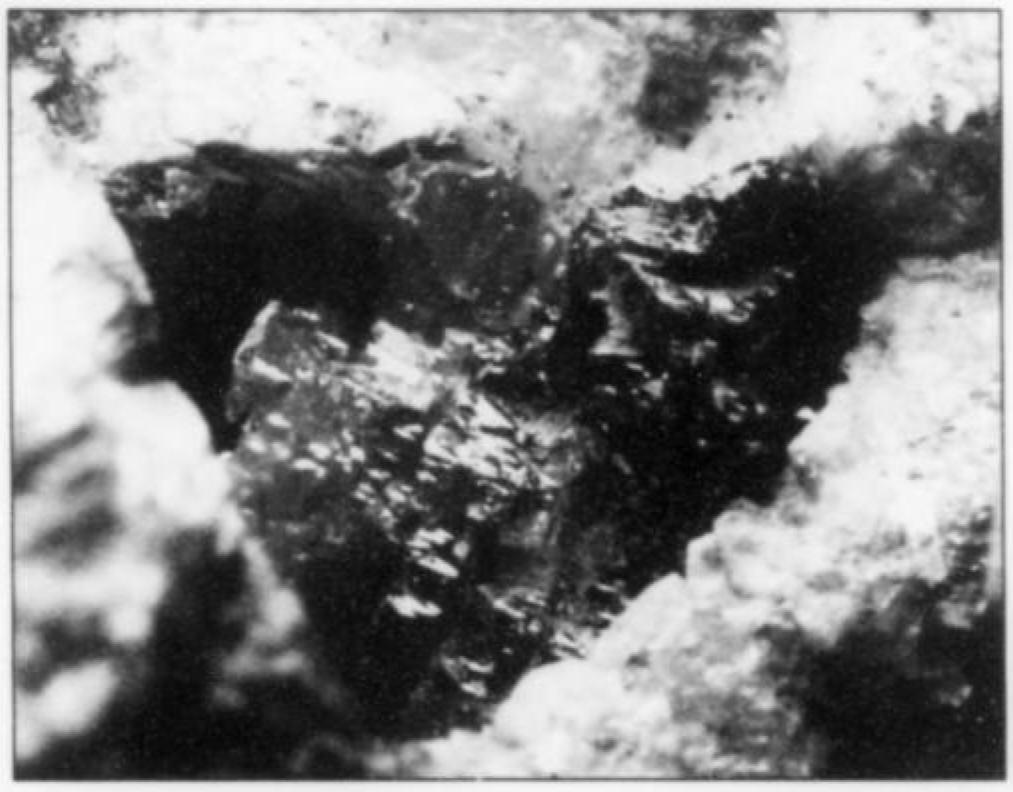


Figure 48. **Orange sarkinite crystal aggregate in bementite-rich Mn ore, from the Gambatesa mine (found 1989); cavity size 4 mm. Private collection; Roberto Appiani photo.**

Piemontite $Ca_2(Al,Mn^{3+},Fe^{3+})_3(SiO_4)_3(OH)$

Piemontite, a manganiferous member of the epidote group, is common as tiny prismatic crystals and crystal sprays in small amounts in the quartz veins, sometimes in association with barite and tinzenite. Well-formed crystals up to 3 mm on chert were recently collected at the Cassagna mine in association with pyrolusite, quartz and an unidentified yellow silicate in small elongated crystals. Piemontite takes its name after the Italian region of Piedmont.

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

A few millimetric posnjakite crystals were found at the Gambatesa mine in a quartz and tinzenite vein, associated with chalcocite and olivenite.

Prehnite $Ca_2Al_2Si_3O_{10}(OH)_2$

Prehnite is common in the basalt at Val Graveglia. Crystals up to 1 cm and globular white to greenish aggregates up to 3 cm were collected at the Molana quarry, in association with epidote, calcite and pumpellyite-(Mg). This association, recognized throughout the Val Graveglia area, attests to metamorphic conditions of low temperature and low pressure (greenschist facies).

Pumpellyite-(Mg) $Ca_2MgAl_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$

Pumpellyite-(Mg) is common as a rock-forming mineral in basalt. Sprays up to 1 cm were observed in cavities in the pillow-lavas, especially near the Molana quarry. A mineral similar to pumpellyite-(Mg) but with a high vanadium content has been collected at the Gambatesa mine, in association with goldmanite, ganophyllite and, in places, manganaxinite and albite. The best crystals from this find are included in calcite and can reach a length of 6 mm.

Pumpellyite-(Mn^{2+}) $Ca_2(Mn^{2+},Mg)(Al,Mn^{3+},Fe)_2(SiO_4)$-$(Si_2O_7)(OH)_2 \cdot H_2O$

Pumpellyite-(Mn^{2+}) has been found in a few specimens at the Gambatesa mine, as thin, yellow to brownish, elongated crystals up to 2 mm, in vugs in a quartz vein. It is probably not very rare, but is difficult to recognize when poorly crystallized.

Pyrite FeS_2

Pyrite masses, sometimes with fairly high copper content, are widespread in the basalt masses in eastern Liguria, and were mined for a long time. In Val Graveglia there are a few small pyrite workings and prospects, mostly near the village of Reppia and in the Monte Capra and Monte Bianco areas. Crystals are not rare in various rock formations (basalts, shales and chert), and usually show a cubic habit. The largest crystals, 4 cm, were collected at the Gambatesa mine. No particularly attractive pyrite specimens are known from these localities.

Pyrobelonite $PbMn^{2+}(VO_4)(OH)$

Pyrobelonite is an orthorhombic lead and manganese vanadate, the analog of descloizite in which manganese substitutes for zinc, originally described from Långban, Sweden. It has been found very rarely at the Molinello mine in rhodonite veins, associated with quartz, calcite, braunite and, sometimes, tangeite. It normally occurs in small masses, but sometimes some small (1–3 mm) crystals are found (Borgo and Palenzona, 1988; Palenzona, 1991).

Recently (1998–1999) some specimens were also collected at the Gambatesa mine, as crystals up to a few millimeters and as vein fillings up to several centimeters, associated with bementite, calcite and braunite. This species is not easy to recognize visually, as the non-crystallized specimens are similar to both palenzonaite (cubic) and gamagarite (orthorhombic). Detailed analysis of dark-colored vanadates could lead to the discovery of more specimens of this mineral.

Pyrolusite $Mn^{4+}O_2$

Most of the manganese crusts and dendrites found in the area are probably pyrolusite. The dendrites are quite common at all the manganese localities, and can be several centimeters wide. In the quarries of the middle part of the valley it is possible to find dendritic manganese oxides on white limestone. Crystals of pyrolusite are rare; the best specimens, with lustrous, well-formed crystals up to 7 mm, were collected at the Scrava mine in 1994 (Palenzona, 1996). Some weathered crystals up to 1 cm were found at the Cassagna mine.

Pyrophanite $Mn^{2+}TiO_3$

Pyrophanite is not very common. Specimens with tiny, tabular, dark red crystals were collected at the Gambatesa mine (Palenzona, 1996).

Pyroxmangite $Mn^{2+}SiO_3$

Observed in thin sections (mainly from the Gambatesa mine; Antofilli *et al.*, 1983), pyroxmangite was collected during the last few years of activity of the Molinello mine in nice specimens. It forms orange to creamy yellow elongated crystals up to 1 cm, sometimes associated with calcite, barite and quartz (Borgo and Palenzona, 1988). Other interesting specimens show epitaxial overgrowth of medaite. Nice specimens were also found at the Gambatesa mine, but not as beautiful as the ones from the Molinello mine.

Pyrrhotite $Fe_{1-x}S$ ($x = 0$–0.17)

Pyrrhotite has been reported as a rare occurrence at the Gambatesa mine (Palenzona, 1991).

Quartz SiO_2

Quartz is very common at almost all of the Val Graveglia localities. The crystals can reach several centimeters in length, but only some particular finds are remarkable. Some crystals not showing the prism form are usually associated with rhodonite or ganophyllite from the Molinello mine. The Gambatesa mine produced some specimens of pale amethyst quartz associated with tephroite and hausmannite. Notable quartz specimens from the Gambatesa and Molinello mines show inclusions of sursassite, copper and piemontite (Antofilli *et al.*, 1983). Nice specimens with crystals to 8 cm were also found in the basalt cavities, associated with epidote and orthoclase, at Nascio and at the Molana quarry.

Rancìéite $(Ca,Mn^{2+})Mn_4^{4+}O_9?3H_2O$

Rancìéite, a hydrated Mn oxide containing Ca, has been found at the Gambatesa mine (Antofilli *et al.*, 1983), and probably is not rare in the other Val Graveglia mines. It forms aggregates of spherules and crusts in fractures in the ore. The color is golden brown in the fresh specimens, and black after weathering; it is often associated with quartz (Antofilli *et al.*, 1983).

Realgar AsS

Realgar has been found in just a few specimens at the Molinello mine as granules and small masses in the veins of chert (Palenzona, 1991).

Reppiaite $Mn_5^{2+}(OH_4)_2(VO_4)_2$

Reppiaite, a monoclinic hydroxyl-vanadate of manganese, was described as a new species from specimens collected at the Gambatesa mine (Basso *et al.*, 1992). It was found in very small amounts as tiny crystals in fractures cross-cutting a hausmannite-tephroite carbonate-bearing assemblage. It is in places associated with native copper and caryopilite, and is related to the hydrothermal circulation of V-enriched and As-enriched fluids. Some specimens collected from the dumps in 2000 also show sussexite crystals. The reppiaite crystals, orange-yellow to red, are minute and tabular, flattened on (100), and with an irregular contour. Their dimensions seldom reach 1 mm. It was named after the village of

Reppia, near the Gambatesa mine, and so far it has not been reported from any other locality.

Rhodochrosite $Mn^{2+}CO_3$

Rhodochrosite is common in the Val Graveglia manganese deposits as small masses and vein filling, and also as fine specimens with crystals up to 8 mm and as spherical aggregates up to 3 cm in diameter, covering fracture walls or crystals of other minerals. Among the best finds are the crystals collected at the Gambatesa mine during the 1960's, many of them associated with barite and ganophyllite. Also of note are the rhodochrosite and ganophyllite specimens collected mainly in the middle 1980's in material from a large quartz vein encountered in the underground workings at the Molinello mine.

Some nice specimens were also collected in 1993 in the Cassagna open pit, when a faulted block of ore rich in cavities was encountered. In this case the mineral formed bright crusts and spherules associated with white barite and neotocite. Rhodochrosite is difficult to find now that mining has ceased because it weathers rather rapidly, turning from pink to black.

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

Rhodonite is one of the most abundant minerals in the district; huge masses were encountered during mining, in particular at the Gambatesa and Cassagna mines during the 1960's and at the Molinello mine in the mid-1980's. Those masses, which have a high manganese content, were often exploited as ore. During the periods of intense activity beautiful specimens were found, with crystals up to 3 cm, in vugs and fractures. The crystals, very different from the large, stout ones from Franklin, usually have a tabular habit, but acicular crystals are also common.

The color is highly variable: commonly pink, but occasionally red, orange, yellow and even purple. For this reason some other manganese silicates were, in the past, assumed to be rhodonite. Analysis led to the recognition of some good specimens of marsturite and pyroxmangite. It is possible that further investigation of rhodonite-like minerals can lead to finds of more uncommon species.

Rhodonite is commonly one of the first minerals formed in the veins, in places followed by calcite, rhodochrosite, barite or copper, and by rare species such as pyrobelonite, tangeite and gamagarite.

Romanèchite $(Ba,H_2O)_2(Mn^{4+},Mn^{3+})_5O_{10}$

This species is often referred to as the so-called "wad" masses, which frequently fill cavities in the manganese ore or in the chert at the borders of the manganese deposits.

Saneroite $Na_2(Mn^{2+},Mn^{3+})_{10}Si_{11}VO_{34}(OH)_4$

Saneroite, a rare sodium and manganese silicate, was found for the first time at the Gambatesa mine as tabular triclinic crystals up to a few millimeters, associated with braunite and barite. The mineral is named after Edoardo Sanero (1901–1983), Professor of Mineralogy at the University of Genoa (Lucchetti *et al.*, 1981; Antofilli *et al.*, 1983). It shows strong pleochroism, color from yellow to deep orange, and easy cleavage.

After the first find at the Gambatesa mine more specimens were collected at the Molinello mine, sometimes even in some quantity, between 1985 and 1989. The crystals reach 1 cm, and are often associated with barite, rhodonite, ganophyllite and barite, and enclosed in calcite. Careful treatment with diluted HCl can expose good crystals.

Saneroite is not easy to distinguish visually from tiragalloite and medaite, which are much rarer.

Sarkinite $Mn^{2+}_2(AsO_4)(OH)$

Sarkinite, a rare arsenate, was originally found in Sweden at Harstigen in Pajsberg, and at Långban, and at Franklin (Dunn, 1995–1996). In Val Graveglia sarkinite has been collected only a few times, first at the Gambatesa mine (Cortesogno *et al.*, 1979) as yellow to orange prismatic crystals up to 1.5 cm long in rhodonite veins, sometimes with bementite and abundant neotocite. Other finds are known from both the Gambatesa and Molinello mines (Borgo *et al.*, 1988) with poorly formed crystals, associated with saneroite and filling thin veinlets. Good specimens were collected in 1999–2000 from the hausmannite ore of the Gambatesa mine. These specimens show 1–2 mm, well formed crystals of sarkinite associated with manganoan calcite crystals.

Selenium Se

Only one specimen of selenium to date has been collected on the dumps of Gambatesa mine; it shows sub-millimetric crystals on white quartz (Palenzona, 1996). The source of the selenium in this specimen is not clear, and could be related to post-mining contamination.

Silver Ag

Silver was recently described in a quartz and native copper vein at the Molinello mine (Borgo and Palenzona, 1988) as arborescent aggregates up to 1 cm.

Smythite $Fe_{13}S_{16}$

Smythite has been found at the Molinello mine, as small metallic crystals, 1 mm or less, in veinlets cutting chert (Palenzona, 1996).

Spangolite $Cu^{2+}_6Al(SO_4)(OH)_{12}Cl\cdot 3H_2O$

Spangolite is known from only one find, as nice sky-blue crystals associated with connellite, cuprite, arsenates and other copper minerals, in the cavities in fossil wood at the Cassagna mine (Palenzona, 1996).

Spessartine (?) $Mn^{2+}_3Al_2(SiO_4)_3$

Spessartine, a Mn-bearing member of the garnet group, was erroneously reported from the Cassagna mine by Pelloux (1919). In 1934 Pelloux himself published a correction of the reported data, identifying as tinzenite the mineral previously believed to be spessartine. Nevertheless this species still appears in some lists of the Val Graveglia minerals (Antofilli *et al.*, 1983). No macroscopic specimens of this species were observed by the authors, but extremely small (10–30 μm) granules, not exhaustively studied, have been reported by Cortesogno *et al.* (1979).

Sphalerite (Zn,Fe)S

Zinc is a rare element in Val Graveglia; apparently sphalerite has been found only a few times at the Gambatesa mine, associated with bornite, chalcopyrite and other sulfides.

Strontiopiemontite $CaSr(Al,Mn^{3+},Fe^{3+})_3Si_3O_{11}O(OH)$

This member of the epidote group is the Sr analog of piemontite, with strontium replacing calcium; it was described for the first time from material found at the Cassagna and Molinello mines, as small (3–4 mm) dark red veins and [010] elongated prismatic crystals, associated with quartz, calcite, rhodochrosite, rhodonite and ganophyllite (Bonazzi *et al.*, 1990). Strontiopiemontite looks like the more common piemontite; only an analysis can confirm the identification of this mineral, which is quite rare in comparison with piemontite.

Sulfur S

Only one specimen of sulfur has been found, in a braunite vein at the Molinello mine in 1986. It shows a 3-mm group of well-

Figure 49. Exceptional acicular sursassite crystals, 3 mm, in a quartz cavity, collected on the dumps of the Gambatesa mine (found 1993). Marco Marchesini collection; Roberto Appiani photo.

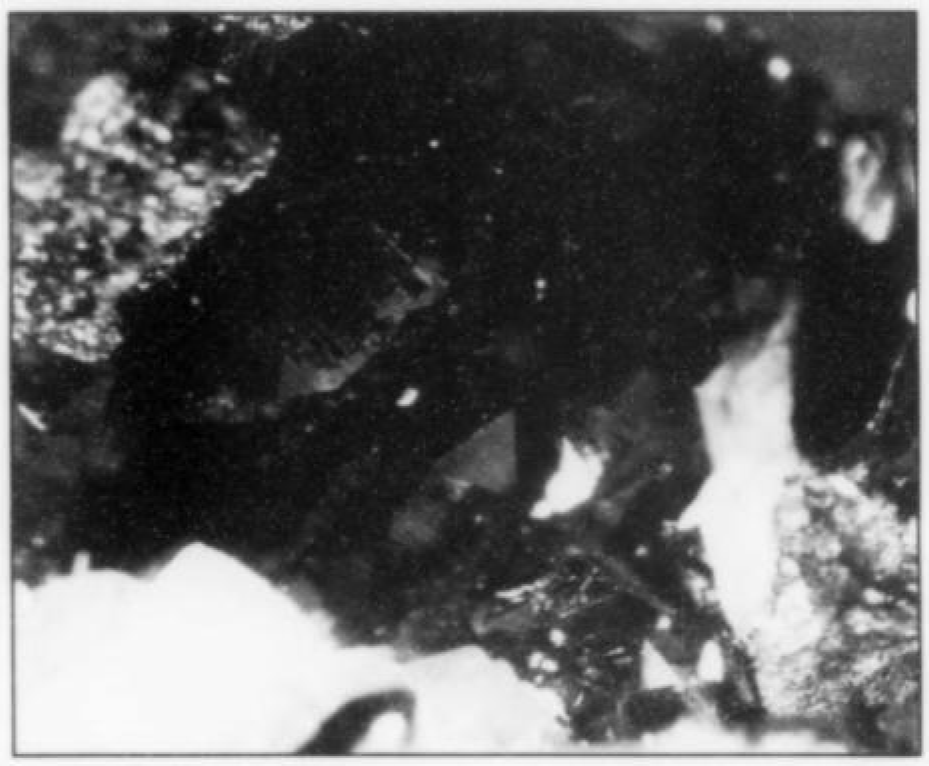


Figure 50. Dark green tangeite crystals from the Molinello mine; 1.5 cm specimen. Andrea Palenzona collection and photo.

Figure 52. Tinzenite crystals up to 5 mm on acicular sursassite crystals, collected at the Molinello mine in 1988. Marco Marchesini collection; Roberto Appiani photo.

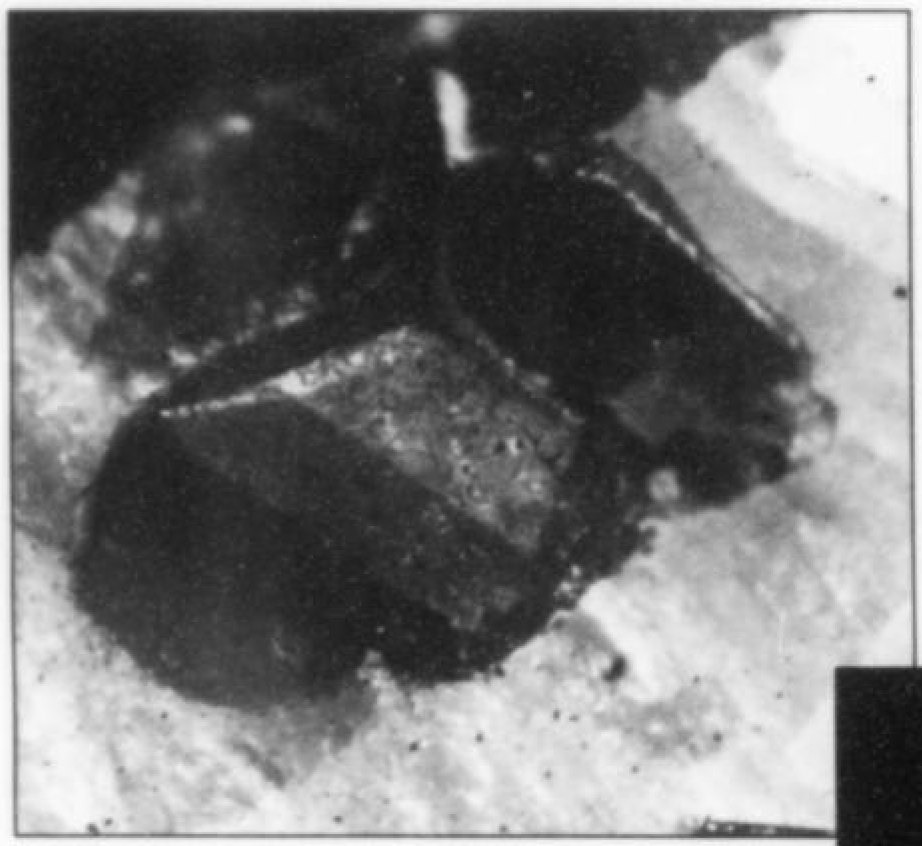


Figure 51. Tephroite crystal, 4 mm, from the Gambatesa mine (found 1980). Alessandro Pozzi collection, Roberto Appiani photo.

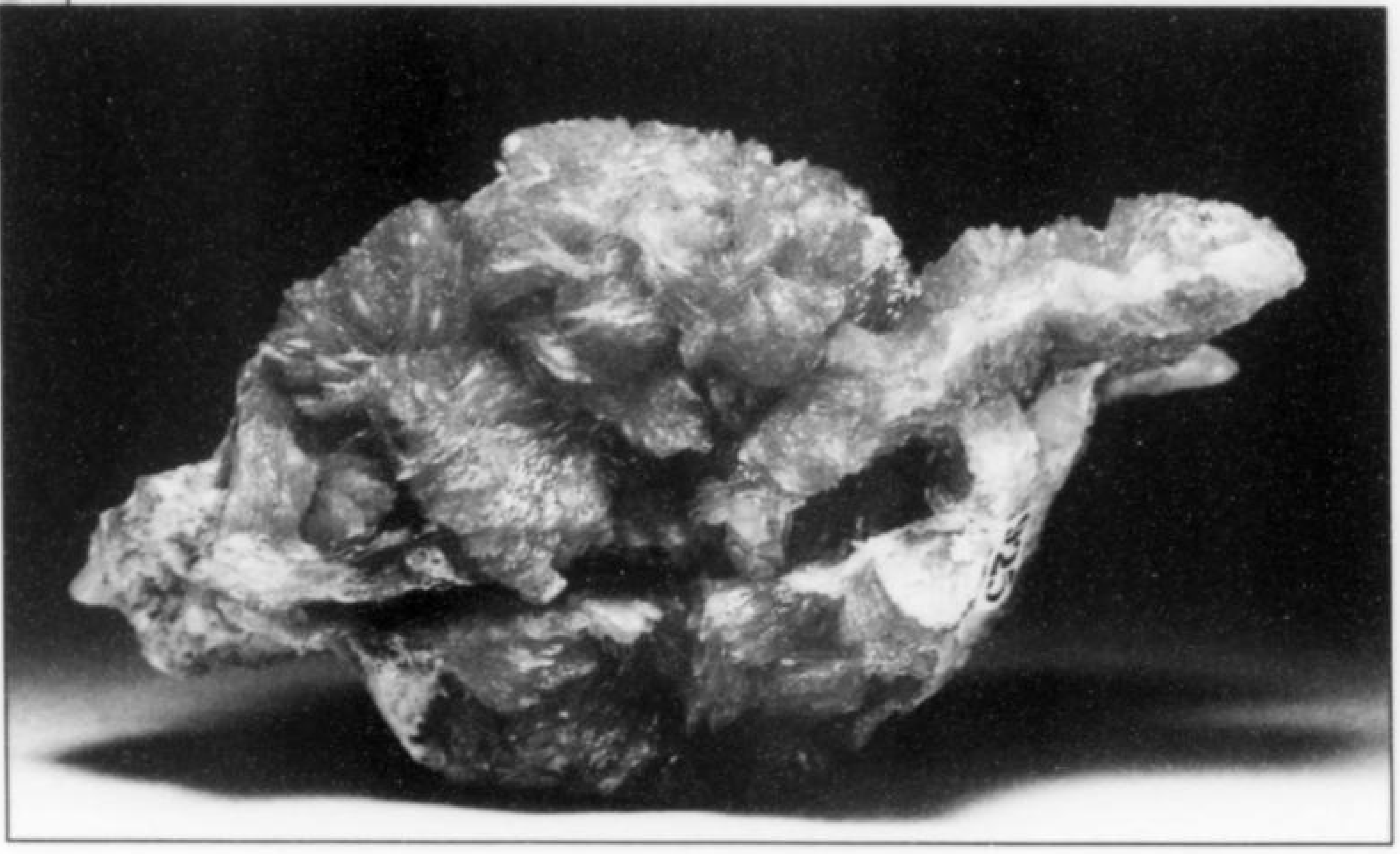


Figure 53. Orange tinzenite crystals. This exceptional specimen, 7 cm, is fractured, recrystallized and cemented by quartz; collected at the Gambatesa mine in the late 1960's. Renato and Adriana Pagano collection; Roberto Appiani photo.

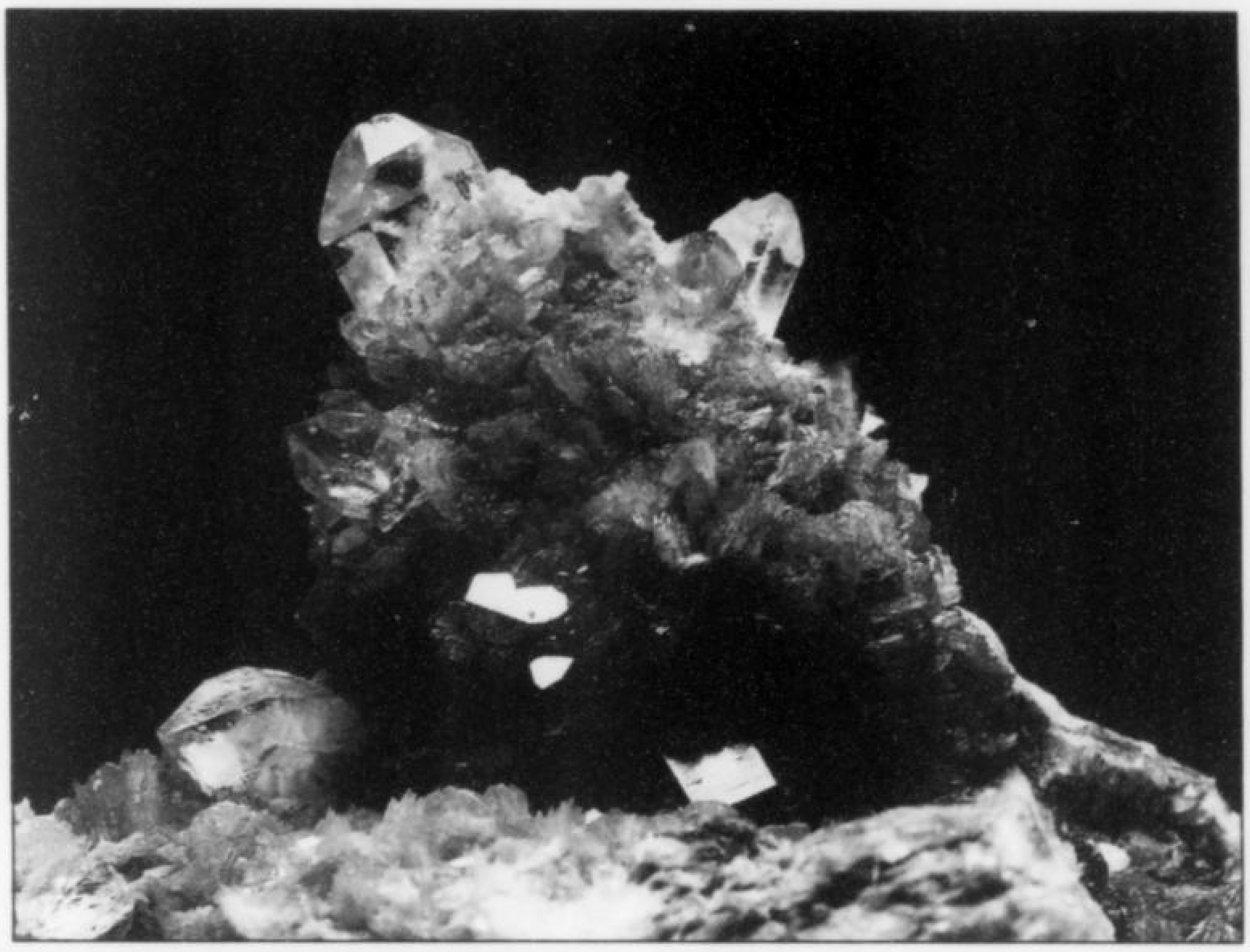


Figure 54. Tinzenite crystals with 6-mm quartz crystals, from the old dumps at the Gambatesa mine (found 1993). Marco Marchesini collection; Roberto Appiani photo.

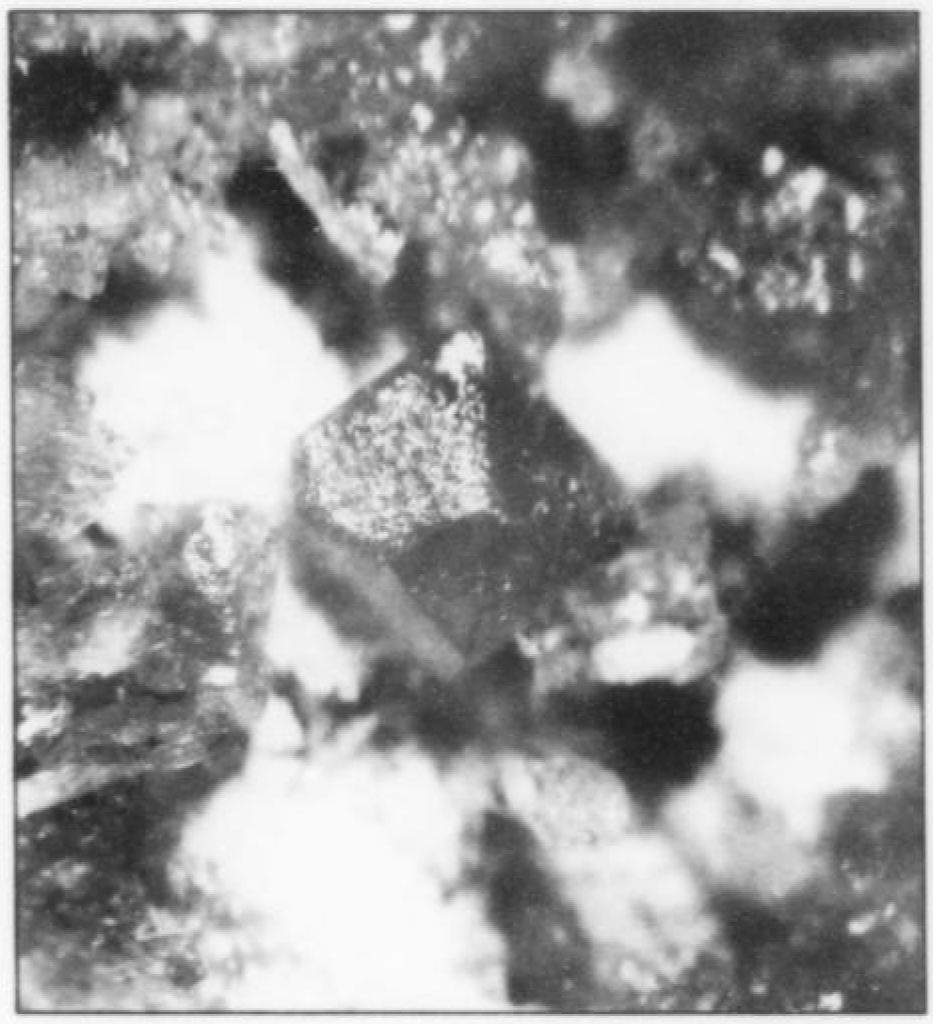


Figure 56. Orange tiragalloite crystals, 2 mm, from the Gambatesa mine (found 1994). Private collection; Roberto Appiani photo.

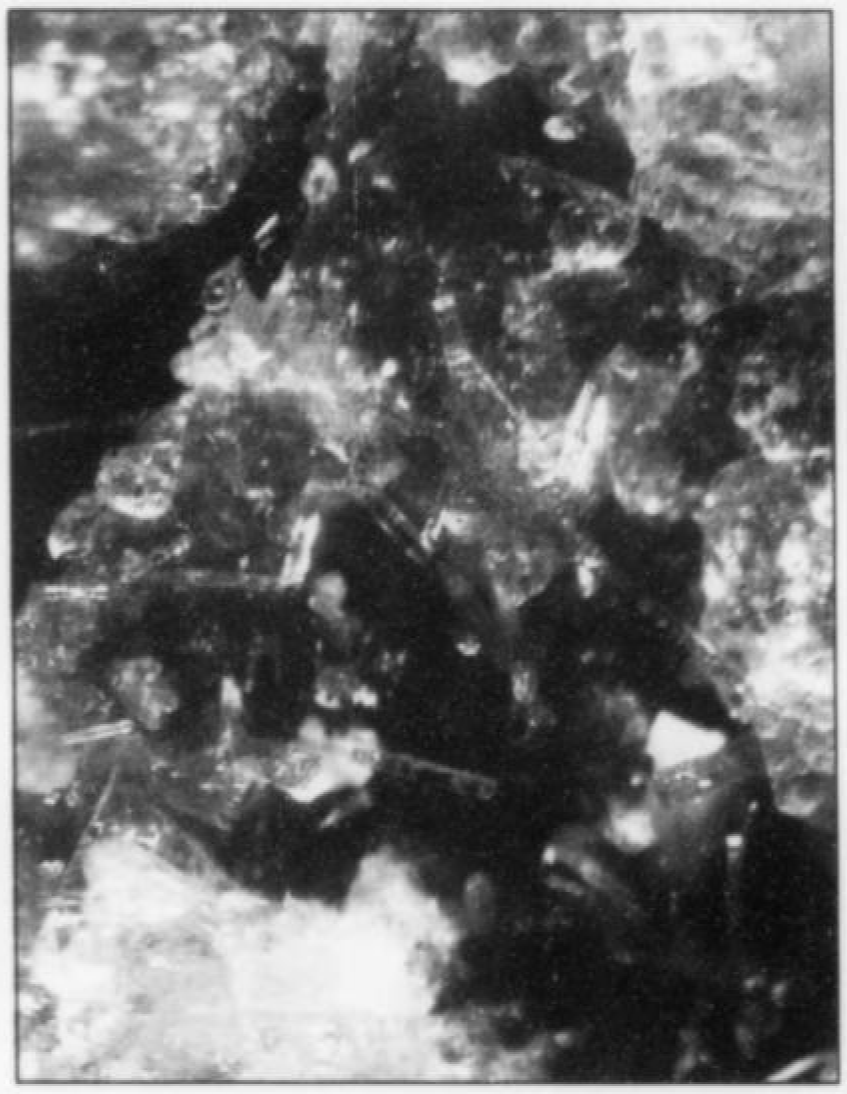


Figure 55. Dark red vanado-malayaite crystal and green haradaite prismatic crystals, Gambatesa mine; 1.5-cm specimen. Giorgio Corallo collection; Andrea Palenzona photo.

Figure 57. Mineral collector Leandro de Magistris and one of the authors (RP) holding a large specimen of crystallized tinzenite; main adit of the Gambatesa mine, 1970.

formed crystals, associated with manganoan calcite, neotocite and weathered alabandite (which is probably the source of this element).

Sursassite $Mn^{2+}_2Al_3(SiO_4)(Si_2O_7)(OH)_3$

The rare silicate sursassite, reported from the Err Valley (Switzerland), New Brunswick (Canada) and some Japanese localities, has been found in quartz veins cutting the "lean ore" at the Molinello mine (Cortesogno *et al.*, 1979; Antofilli *et al.*, 1983), in association with tinzenite, ganophyllite and, in places, manganese oxides. It usually forms veins up to 1 cm thick, with acicular crystals ranging in color from cream to chestnut-brown to reddish brown. Vugs containing good freestanding crystals up to 4 mm, in places forming very elegant sprays, are not easy to find and even more difficult to collect without damaging the crystals, because the matrix, usually crossed by quartz-filled veins, is very hard and tends to break into small pieces. The best specimens were collected in the 1980's mainly from old workings. At the Gambatesa mine, fine sursassite has also been found, and some specimens collected in 1997 are among the best from Val Graveglia.

Sussexite $Mn^{2+}BO_2(OH)$

The manganese pyroborate sussexite was collected at the Gambatesa mine a few times, as pink to violet acicular crystals up to 1 cm long. Sussexite fills thin fractures and is associated with calcite, tephroite, rhodochrosite, sarkinite and reppiaite (Cortesogno *et al.*, 1979).

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

Tiny crystals have been collected at Pontori and Gambatesa, in association with quartz. The specimens from Pontori show an intimate growth of synchysite-(Ce) and bastnaesite-(Ce) (Borgo and Palenzona, 1988; Palenzona, 1996). A few specimens of a mineral containing REE, mainly Ce and Nd, with a very low degree of crystallinity, perhaps pseudomorphs after a monazite-like mineral, were also collected from the Gambatesa dumps.

Tangeite $CaCuVO_4(OH)$

Tangeite, an orthorhombic vanadate of calcium and copper, forms a series with conichalcite. It was found in nice crystals up to 3 mm at the Molinello mine in 1986 (Palenzona, 1987; Basso *et al.*, 1989) and later very rarely, as dark green masses. Associations include pink to salmon-orange rhodonite, quartz, calcite, braunite and in places, brownish red pyrobelonite and lustrous black tabular crystals of crednerite. Dark green crystals of tangite in rhodochrosite and quartz veinlets were collected at the Gambatesa mine in 1999.

Tennantite $(Cu,Ag,Fe,Zn)_{12}As_4S_{13}$

Specimens belonging to the tennantite-tetrahedrite series, with As content largely dominant over Sb, were collected in quartz veins at the Molinello and Gambatesa mines (Antofilli *et al.*, 1983; Borgo and Palenzona, 1988). The crystals are up to 5 mm, with distinct tetrahedral habit. Some small bronze masses associated with goldmanite, originally misidentified as arsenosulvanite, are actually tennantite. Tennantite is often weathered and associated with arsenates such as olivenite and chalcophyllite.

Tephroite $Mn^{2+}_2SiO_4$

Tephroite, the Mn-member of the olivine group, has been collected since 1978 at the Gambatesa mine, as red to brown to greenish brown crystals often included in calcite and associated with rhodonite, rhodochrosite, sussexite and ganophyllite (Cortesogno *et al.*, 1979; Antofilli *et al.*, 1983). More recently, in the early 1990's, several tephroite specimens were found at the Gambatesa mine, as crystals up to 2 cm often included in calcite, associated with bementite. In this case the color can range from red-brown to greenish.

Tinzenite $(Ca,Mn^{2+},Fe^{2+})_3Al_2BSi_4O_{15}(OH)$

Tinzenite, a rare triclinic manganese silicate, was found for the first time in the Swiss Alps (Falotta and Parsettens near Tinzen, Graubunden); it is also known from Akatore, New Zealand (Pelloux, 1934; Hochleitner, 1999) and from South American localities. Tinzenite was found in extraordinary specimens at the Cassagna, Gambatesa, Molinello and Monte Bossea mines, in veins up to 20 cm thick and several meters long in chert (Antofilli *et al.*, 1983). Tinzenite often completely fills the veins, but vugs with crystals were also encountered, especially in the larger veins and in the faulted zones.

The crystals are triclinic and usually form rosettes and botryoidal aggregates. The color varies from creamy yellow to orange-red. Tinzenite from Liguria is probably the best in the world. It is commonly associated with crystals of quartz, sursassite, rhodochrosite, calcite and, in places, with chalcocite, manganese oxides and harmotome.

Tiragalloite $Mn^{2+}_4As^{5+}Si_3O_{12}(OH)$

Another species for which Val Graveglia is the type locality is tiragalloite. The original material was collected in the 1970's at the Molinello mine (Gramaccioli *et al.*, 1979; Gramaccioli *et al.*, 1980) as small orange granules associated with medaite. The main characteristic of the crystal structure of tiragalloite is the presence of the arsenatotrisilicate ion, the first known example of non-isolated AsO_4 groups, with three tetrahedra based on Si and one based on As. This feature implies extreme hydrolysis-preventing physical and chemical conditions, rare in nature and probably related to low temperature and high concentration in solutions. Tiragalloite remained an extremely rare mineral at the Molinello mine which was, for several years, the only known world locality, until the middle 1980's, when good, small (about 1 mm) crystals were found at the Cassagna mine in a vein in the braunite ore, associated with medaite, quartz, calcite and ganophyllite (Borgo and Palenzona, 1988).

Other specimens have been collected, always in very small amounts, again at the Molinello mine, in particular in the last years of operation. At the Gambatesa mine some specimens were also found, in association with rhodonite or calcite. In this case the crystals, orange to yellow in color, are up to 7 mm.

Tiragalloite was later reported from Alpine manganese occurrences (Bedogné *et al.*, 1993), but it is still a very rare speoies. The name of this mineral honors Paolo Onofrio Tiragallo (1905–1987), a well-known mineral collector from Genoa, later curator of the mineral collections at the Mineralogy and Petrography Department of the University of Genoa.

Titanite $CaTiSiO_5$

Titanite has been found in chert fractures as small (less than 1 mm), colorless crystals with quartz, anatase and clinochlore at the Molinello mine.

Todorokite $(Mn^{2+},Ca,Mg)Mn^{4+}_3O_7 \cdot H_2O$

Todorokite is one of the non-crystallized manganese oxides which form "wad" at Val Graveglia (Antofilli *et al.*, 1983).

Tyrolite $CaCu^{2+}_5(AsO_4)_2(CO_3)(OH)_4 \cdot 6H_2O$

Tyrolite has been found rarely at the Cassagna mine, as small rosettes of green-blue crystals, associated with conichalcite, copper, cuprite and secondary copper minerals (Palenzona, 1991).

Vanadomalayaite $CaVOSiO_4$

Vanadomalayaite is an extremely rare mineral for which the Gambatesa mine is the type locality. It occurred in veinlets cutting the chert which hosts the manganese ore. Associated with haradaite, calcite and quartz. It has been found as subhedral isolated crystals rarely exceeding 0.5 mm in size. The habit is prismatic, with a good {110} cleavage. It resembles a dark red titanite, being actually an analog of titanite, with V replacing Ti, and of malayaite, with V replacing Sn (Basso *et al.*, 1994).

Volborthite $Cu_3^{2+}V_2^{5+}O_7(OH)_2 \cdot 2H_2O$

Volborthite was the first vanadium-bearing mineral described from Val Graveglia (Cortesogno and Galli, 1974; Antofilli *et al.*, 1983). Widespread in the fossil woods, in particular at Cassagna mine, it was also found in the quartz veins, especially at the Scrava mine (Basso *et al.*, 1988). It usually forms crusts and thin coatings covering up to several square centimeters on the walls of small fractures. It is also known in tabular crystals up to 2 mm and as rosettes and spherules up to 5 mm. The color ranges from greenish yellow to dark green, suggesting the possibility of variation in composition or of the possible association with other unidentified vanadium species. The presence of volborthite in the fossil wood is an indicator of interesting assemblages of native copper, cuprite, azurite, chalcocite and several arsenates such as arseniosiderite, cornwallite, cornubite and chalcophyllite.

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

Wroewolfeite was found as a secondary mineral at the Gambatesa mine, in a tinzenite vein, associated with chalcocite (C. Balestra, per. comm.).

Wulfenite $PbMoO^4$

Wulfenite has been collected rarely in the mid-valley limestone quarries as tabular, yellow crystals up to 1 mm, associated with calcite and weathered sulfides.

Zalesiite $CaCu_6(AsO_4)_2(AsO_3OH)(OH)_6 \cdot 3H_2O$

A calcium-rich mineral resembling species of the mixite group and orginally designated as "agardite-(Ca)" was found at the Cassagna mine in the chert surrounding fossil wood (Palenzona, 1966). This mineral was later found to be identical to the new species zalesiite.

A neodymium-rich mineral of this type was found in very small aggregates at the Cassagna mine (Balestra, (1996).

Zeunerite $Cu^{2+}(UO_2)_2(AsO_4)_2 \cdot 10\text{–}16H_2O$

Zeunerite has been found just once in fossil wood at the Cassagna mine, as three small (about 1 mm), pale green crystals, two of which were used for analysis. At present just one crystal remains to represent this occurrence. The associations include volborthite, native copper, connellite, arsenates and other copper minerals (Palenzona, 1996).

Zircon $ZrSiO_4$

Pink prismatic crystals of zircon about 1 mm long were recently found as inclusions in trondhjemitic granites found in sedimentary breccia near the village of Arzeno.

Unconfirmed species and unknowns

A mineral found sparingly as dark red, lustrous granules and small (less than 1 mm) cubic crystals has been tentatively described as "yamatoite" (Palenzona, 1991), a hypothetical Mn-end member of the garnet group (not an IMA approved species). This mineral was found at the Gambatesa mine, associated with green goldmanite, in calcite and rhodonite veins.

The names of a few species sometimes circulate among collectors and occasionally are reported in the local literature although they have not been determined with certainty. Among them: tenorite, "illite" and zinnwaldite (from basalt cavities in the Molana quarry), hyalophane (adularia-like crystals associated with barite), marokite and "axinite" (a group name; actually only two members of this group, manganaxinite and tinzenite, are reported from Val Graveglia).

At least a dozen unknown minerals have been found at Val Graveglia. Some of them might someday be recognized as new species, while some others will probably remain unknown, such as the Nd-rich zalesiite-like mineral from the Molinello mine mentioned above, or an Sb-containing acicular sulfosalt found in one specimen at the Gambatesa mine, which was accidentally destroyed during a microprobe analysis.

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DEDICATION

This article is fondly dedicated to the memory of Leandro de Magistris (1906–1990), mineral collector, Honorary Curator of Minerals at the Natural History Museum of Genoa, and acute connoisseur of the Ligurian minerals, a source of encouragement and knowledge to a whole generation of collectors in the Genoa area.

REFERENCES

ANTOFILLI, M. (1982) Le zeoliti della Liguria. *Rivista Mineralogica Italiana*, **1**, 7–14.

ANTOFILLI, M., BORGO, E., and PALENZONA, A. (1983) *I nostri minerali. Geologia e mineralogia in Liguria.* Sagep Editrice, Genova.

BALESTRA, C. (1992) Una paragenesi eccezionale a Cassagna. *Notiziario di Mineralogia del 3M Club Ferrania*, **2**.

BALESTRA, C. (1993) Ancora minerali a Cassagna. *Notiziario di Mineralogia del 3M Club Ferrania*, **2**.

BALESTRA, C. (1996) Le agarditi della Val Graveglia. *Notiziario di Mineralogia del 3M Club Ferrania.*

BARONI, C. (1998) Dispersione degli elementi chimici in aree minerarie: studio geochimico-ambientale del bacino del Torrente Graveglia (Appennino Ligure–Genova). *Unpublished thesis.* Universita' degli Studi di Bologna.

BASSO, R. (1987) The crystal structure of palenzonaite, a new vanadate garnet from Val Graveglia (Northern Apennines, Italy). *Neues Jahrbuch für Mineralogie, Monatshefte*, **3**, 136–144.

BASSO, R., LUCCHETTI, G., and PALENZONA, A. (1991) Gravegliaite: $MnSO_3 \cdot 3H_2O$, a new mineral from Val Graveglia (Northern Apennines, Italy). *Zeitschrift für Kristallographie*, **197**, 97–106.

BASSO, R., LUCCHETTI, G., PALENZONA, A., and ZEFIRO, L.

(1995) Haradaite from the Gambatesa mine, eastern Liguria, Italy. *Neues Jahrbuch für Mineralogie, Monatshefte*, **6**, 282–288.

BASSO, R., LUCCHETTI, G., ZEFIRO, L., and PALENZONA, A. (1992) Reppiaite, $Mn_5(OH)_4(VO_4)_2$, a new mineral from Val Graveglia (Northern Apennines, Italy). *Zeitschrift für Kristallographie*, **201**, 223–234.

BASSO, R., LUCCHETTI, G., ZEFIRO, L., and PALENZONA, A. (1994) Vanadomalayaite, $CaVOSiO_4$, a new mineral vanadium analogue of titanite and malayaite. *Neues Jahrbuch für Mineralogie, Monatshefte*, **11**, 489–498.

BASSO, R., PALENZONA, A., and ZEFIRO, L. (1987) Gamagarite: new occurrence and crystal structure refinement. *Neues Jahrbuch für Mineralogie, Monatshefte*, **7**, 295–304.

BASSO, R., PALENZONA, A., and ZEFIRO, L. (1988) Crystal structure refinement of volborthite from Scrava Mine (Eastern Liguria, Italy). *Neues Jahrbuch für Mineralogie, Monatshefte*, **8**, 385–394.

BASSO, R., PALENZONA, A., and ZEFIRO, L. (1989) Crystal structure refinement of a Sr-bearing term related to copper vanadates and arsenates of adelite and descloizite groups. *Neues Jahrbuch für Mineralogie, Monatshefte*, **7**, 300–308.

BEDOGNE', F., MONTRASIO, E., and SCIESA, E. (1993) *I minerali della Provincia di Sondrio–Val Malenco*–Tip. Bettini, Sondrio.

BELLINI, A., BRANCUCCI, G., and FERRARO, M. L. (1984) *Le miniere di rame e manganese della Liguria Orientale. Proposta di istituzione di un museo minerario*. Lions Club Nervi.

BEZZI, A., and PICCARDO, G. B. (1971) Structural features of the Ligurian ophiolites: petrological evidence for the "oceanic" floor of the northern Apennine geosyncline. *Memorie della Societa' Geologica Italiana*, **10**, 53–63.

BONATTI, E. (1975) Metallogenesis at oceanic spreading centers. *Annual Reviews of Earth and Planetary Sciences*, **3**, 401–431.

BONATTI, E., ZERBI, M., KAY, R., and RYDELL, H. (1976) Metalliferous deposits from the Apennine ophiolites: Mesozoic equivalents of modern deposits from oceanic spreading centers. *Geological Society of America Bulletin*, **87**, 83–94.

BONAZZI, P., MENCHETTI, S., and PALENZONA, A. (1990) Strontiopiemontite, a new member of the epidote group from Val Graveglia. *European Journal of Mineralogy*, **2**, 519–523.

BORGO, E., and PALENZONA, A. (1988) *I nostri minerali. Geologia e mineralogia in Liguria. Aggiornamento 1988*. Sagep Editrice, Genova.

BRUGGER, J. (1996) Fianelite, $Mn_2V(V,As)O_7 \cdot 2H_2O$, a new mineral from Fianel Mine, Val Ferrera (Graubünden, Switzerland). Description and structure determination. *American Mineralogist*, **81**, 1270–1276.

BRUGGER, J., BONIN, M., SCHENK, K. J., MEISSER, N., BERLEPSCH, P., and RAGU, A. (1999) Description and crystal structure of nabiasite, $BaMn_9[(V,As)O_4]_6(OH)_2$, a new mineral from the Central Pyrénées (France). *European Journal of Mineralogy*, **11**, 879–890.

BURCKHARDT, C. E., and FALINI, F. (1956) Memoria sui giacimenti italiani di manganese. I diaspri manganesiferi dell' Appennino ligure. *XX Congreso Geologico International. Symposium sobre yacimientos de manganeso*, **5**, 234–243.

CABONA, A., and CORTESOGNO, L. (1986) *La Val Gromolo e la Val Petronio: le bellezze dell'ambiente naturale e le antiche attività estrattive*. Sagep Editrice, Genova.

CAIRNCROSS, B., BEUKES, N., and GUTZMER, J. (1997) *The Manganese Adventure. The South African Manganese Fields*. The Associated Ore & Metal Corporation Limited.

CALVERT, S. E. (1971) Composition and origin of North Atlantic deep sea cherts. *Contributions to Mineralogy and Petrology*, **33**, 273–288.

CORTESOGNO, L., and GALLI, M. (1974) Tronchi fossili nei diaspri della Liguria Orientale. *Annali del Museo Civico di Storia Naturale di Genova*, **LXXX**, 142–156.

CORTESOGNO, L., and LUCCHETTI, G. (1984) Ocean-floor metamorphism of the volcanic and sedimentary sequences in the Northern Apennine ophiolites: mineralogical and paragenetic features. *Ofioliti*, **9**, 363–400.

CORTESOGNO, L., LUCCHETTI, G., and PENCO, A. M. (1979) Le mineralizzazioni a manganese nei diaspri delle ofioliti liguri: mineralogia e genesi. *Rendiconti S.I.M.P.*, **35**, 151–197.

DECANDIA, F. A., and ELTER, P. (1972) La zona ofiolitifera del Bracco nel settore compreso tra Levanto e la Val Graveglia (Appennino Ligure). *Memorie della Soc. Geologica Italiana*, **11**, 503–530.

DE NEGRI, G., and RIVALENTI, G. (1971) Alcune considerazioni sulla genesi dei giacimenti manganesiferi della Val Graveglia (Liguria). *Atti della Società Toscana di Scienze. Nat. Mem. S. A.*, **78**, 420–437.

DUNN, P. J. (1995–1996) *Franklin and Sterling Hill: The World's Most Magnificent Mineral Deposit*. The Franklin-Ogdensburg Mineralogical Society.

DUNN, P. J., and LEAVENS, P. B. (1986) Marsturite epitaxial on rhodonite from Franklin, New Jersey. *Mineralogical Record*, **17**, 123–125.

EGGLETON, R. A., and GUGGENHEIM, S. (1994) The use of electron optical methods to determine the crystal structure of a modulated phyllosilicate: Parsettensite. *American Mineralogist*, **79**, 426–437.

FRONDEL, C., and BAUM, J. L. (1974) Structure and mineralogy of the Franklin zinc-iron-manganese deposit. *New Jersey Economic Geology*, **69**, 157–180.

GALLI, M., and PENCO, A. M. (1997) Le miniere di rame e di manganese della Liguria Orientale. *Atti dell'Accademia Ligure di Scienze e Lettere, Serie V*, **LIII**, 215–247.

GRAMACCIOLI, C. M., GRIFFIN, W. L., and MOTTANA, A. (1979) Dati preliminari su un probabile nuovo minerale nella miniera di Molinello (Genova). *Rendiconti S.I.M.P.*, **36**, 159–163.

GRAMACCIOLI, C. M., GRIFFIN, W. L., and MOTTANA, A. (1980) The new mineral tiragalloite $Mn_4AsSi_3O_{12}(OH)$, first example of a arsenatotrisilicate. *American Mineralogist*, **65**, 947–952.

GRAMACCIOLI, C. M., GRIFFIN, W. L., and MOTTANA, A. (1982) Medaite, $Mn_6[VSi_5O_{18}(OH)]$, a new mineral and the first example of a vanadatopentasilicate ion. *American Mineralogist*, **67**, 85–89.

HOCHLEITNER, R. (1999) Steckbrief Tinzenit: Die komplette Information über das Mangan-Silicat. *Lapis*, **24** (3), 9–11.

HOLSTAM, D., and LANGHOF, J. [editors] (1999) *Långban: The Mines, their Minerals, Geology and Explorers*. Christian Weise, München, and Swedish Museum of Natural History.

HOOGERDUIJN STRATING, E. H., and VAN WAMEL, W. A. (1989) The structure of the Bracco ophiolite complex (Ligurian Apennines, Italy): a change from Alpine to Apennine polarity. *Journal of the Geological Society*, **146**, 933–945.

ISSEL, A. (1879) Sulle tracce di antichissima lavorazione osservate in alcune miniere della Liguria. *Rassegna settimanale di politica, scienze, lettere ed arti*, **III**, 70, 348–349.

ISSEL, A. (1883) *Cenni sui materiali estrattivi dei monti liguri.* Ricordo della Sezione ligure del Club Alpino Italiano. Genova, Tipografia Sordomuti.

LUCCHETTI, G., PENCO, A. M., and RINALDI, R. (1981) Saneroite, a new mineral hydrate Mn-silicate. *Neues Jahrbuch für Mineralogie, Monatshefte*, **4**, 161–168.

MAGGI, R., CAMPANA, N., and NEGRINO, F. (1988) Valle Lagorara: a quarry of radiolarite (jasper) exploited during the Copper and Early Bronze Age. *Archeologia Polona*, **V**, 33.

MAGGI, R., and PEARCE, M. (1997) Liguria: il rosso metallo delle prime fusioni. *Archeo*, **XIII**, 5.

MANDARINO, J. A. (1999) *Fleischer's Glossary of Mineral Species 1999.* Mineralogical Record, Tucson.

MARCHESINI, M. (1999) Associazioni a Cu-As-V in tronchi silicizzati. *Rivista Mineralogica Italiana*, **2**, 116–122.

MARCHESINI, M., and PALENZONA, A. (1997) Il giacimento Manganesifero di M. Nero (Rocchetta Vara, La Spezia). *Rivista Mineralogica Italiana*, **1**, 51–55.

MARESCOTTI, P. (1993) Le mineralizzazioni a Mn nelle miniere di Molinello e Cerchiara. *Unpublished thesis*. Universita' degli Studi di Genova.

MINISTERO PER I BENI CULTURALI ED AMBIENTALI—Soprintendenza Archeologica della Liguria (1998) *Dal diaspro al bronzo. L' eta'del rame in Liguria: 26 secoli di storia tra il 3600 ed il 1000 avanti Cristo.* Luna Editore (Societa' Editrice Ligure Apuana).

MOTTANA, A., and DELLA VENTURA, G. (1990) A calcian member of the ganophyllite group in the Mn metacherts of Molinello mine. *Rendiconti. Fis. Accademia dei Lincei*, **1**, 313–317.

NIGGLI, P., KOENIGSBERGERGER, J., and PARKER, R. L. (1940) *Die Mineralien der Schweizeralpen.* B. Wepf & Co. Verlag, Basel.

PALENZONA, A. (1980) La calcite di Gambatesa. *Notiziario Ligure di Mineralogia*, **3**, 31.

PALENZONA, A. (1984) L'apatite di Gambatesa. *Notiziario Ligure di Mineralogia*, **1**, 14.

PALENZONA, A. (1986a) Palenzonaite, gamagarite ed haradaite—Val Graveglia, Liguria. *Rivista Mineralogica Italiana*, **1**, 13–16.

PALENZONA, A. (1986b) L'alabandite di Molinello (Val Graveglia). *Rivista Mineralogica Italiana*, **4**, 189–191.

PALENZONA, A. (1987a) La crednerite di Gambatesa (Val Graveglia). *Rivista Mineralogica Italiana*, **2**, 80–81.

PALENZONA, A. (1987b) Tangeite e Marsturite di Molinello. Prima segnalazione. *Rivista Mineralogica Italiana*, **3**, 149–151.

PALENZONA, A. (1987c) La djurleite di Molinello (Val Graveglia). *Rivista Mineralogica Italiana*, **4**, 221–222.

PALENZONA, A. (1988) La chernovite di Molinello (Val Graveglia). *Rivista Mineralogica Italiana*, **3**, 121–122.

PALENZONA, A. (1991) *I nostri minerali. Geologia e mineralogia in Liguria. Aggiornamento 1990.* Gruppo Mineralogico Lombardo, Milano, *et al.*

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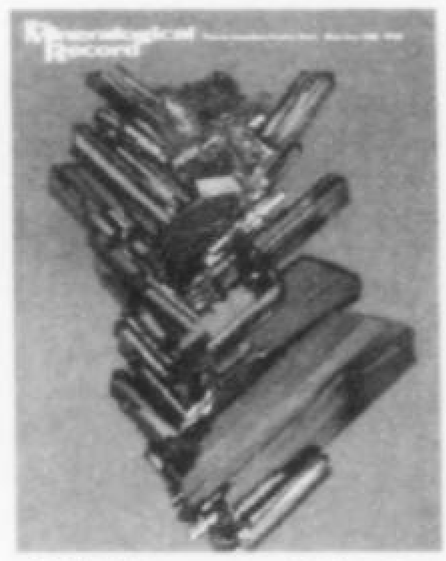

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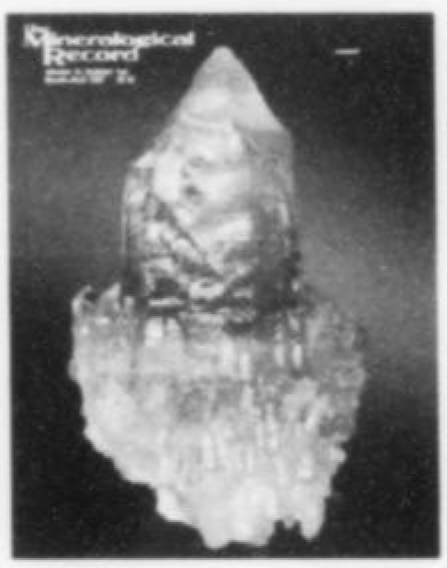

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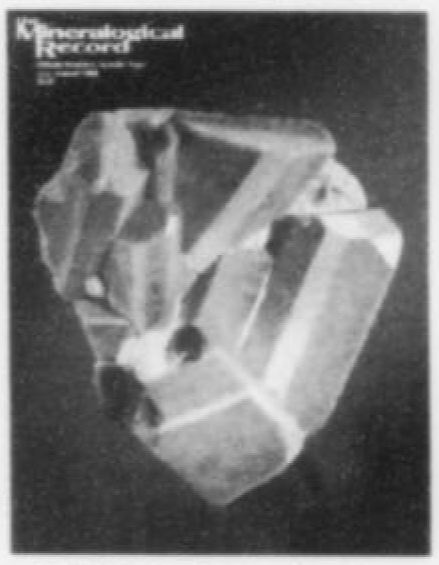

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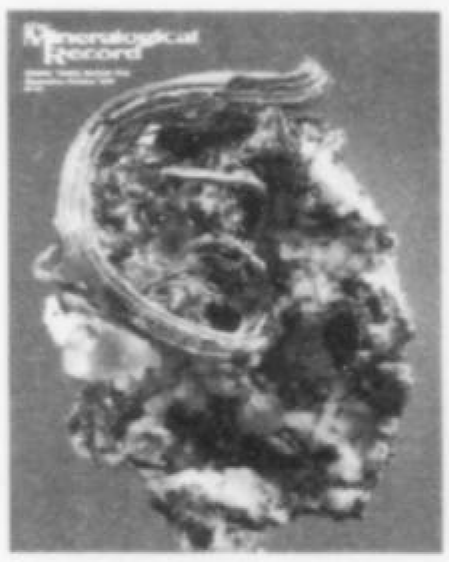

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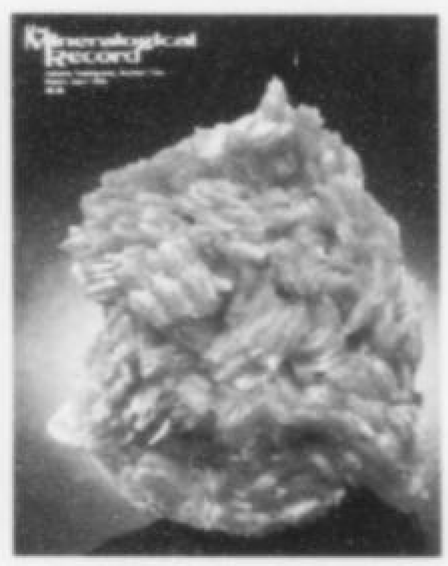

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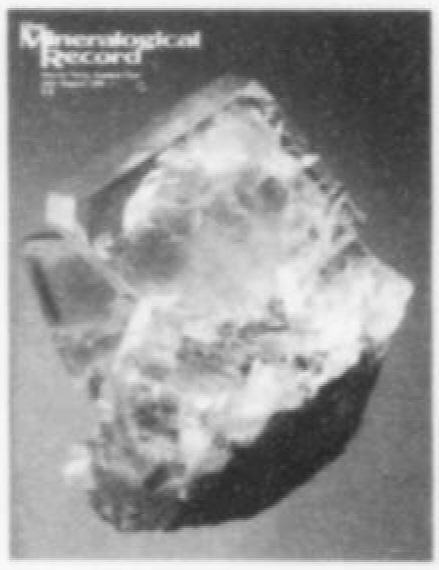

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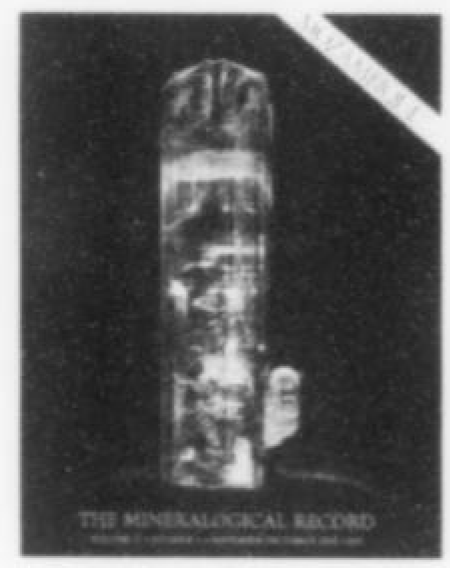

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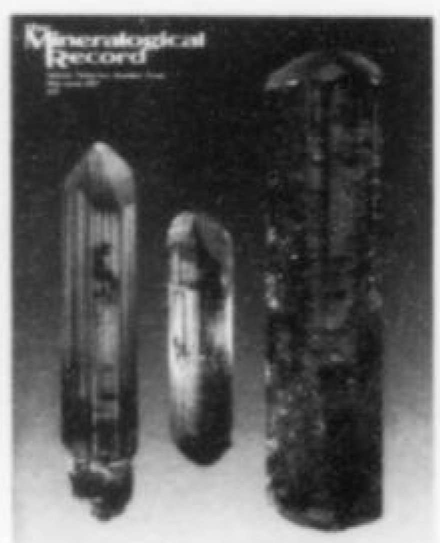

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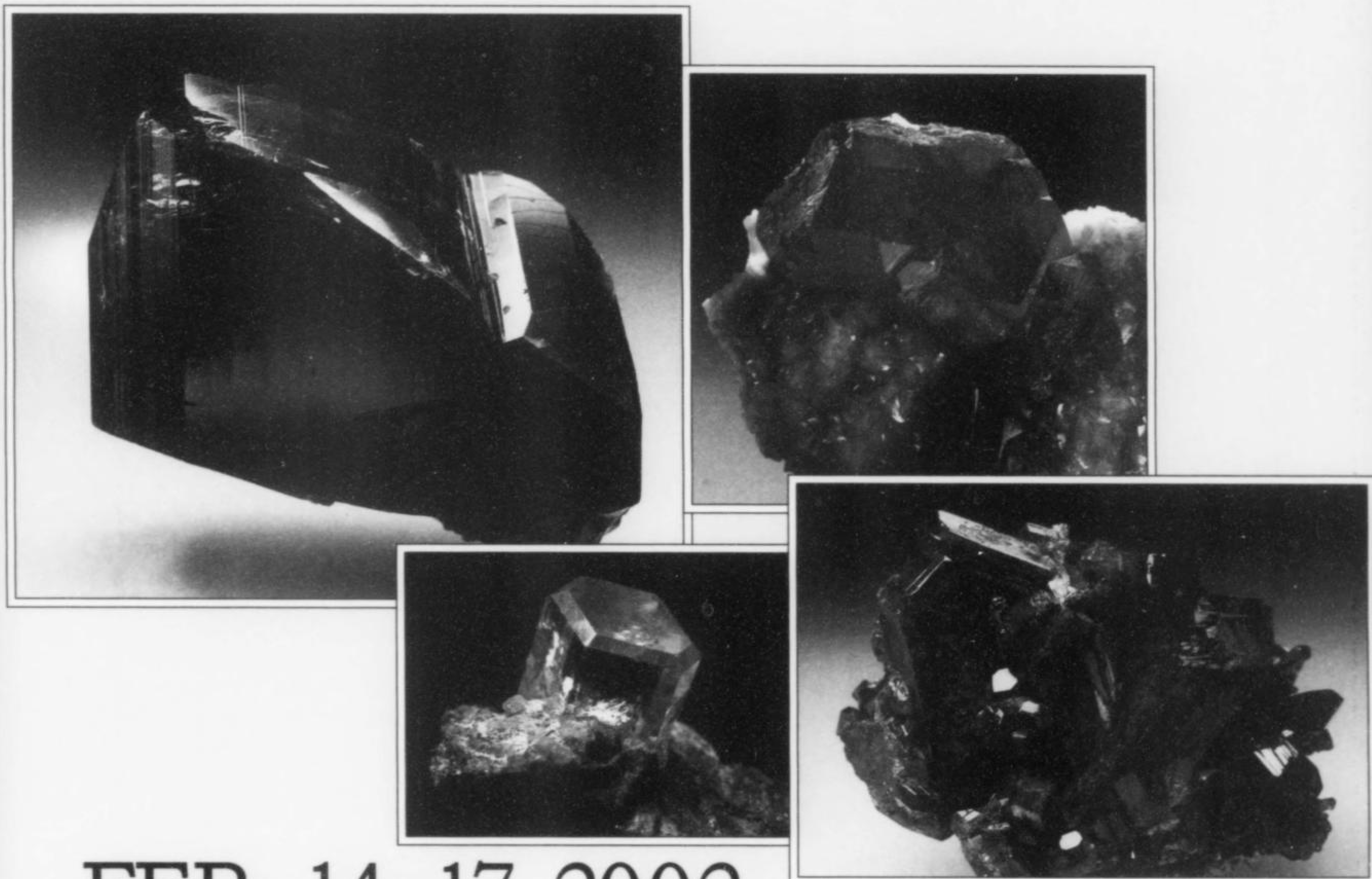

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THE SHIRLEY ANN CLAIM, INYO COUNTY, CALIFORNIA

Paul M. Adams
126 S. Helberta Avenue #2
Redondo Beach, California 90277

The Shirley Ann lead-copper deposit, recently incorporated into the new Death Valley National Park, has produced a suite of well-formed oxidation-zone minerals including a new species: ferrisurite.

INTRODUCTION

While a graduate student in geology at the University of Southern California in the late 1970's, I supplemented my studies with personal mineral collecting trips. In a California Division of Mines report (McAllister, 1955), I came across a reference to wulfenite and cerussite at the Shirley Ann claim, a small oxidized lead-copper deposit near the north end of the Panamint Range, just west of Death Valley National Monument. As everyone knows, it is difficult to find localities with collectable minerals that have not already been over-collected. I had never seen or heard of specimens from this locality, and it certainly seemed remote and obscure enough to have escaped collector notice. I decided that this would be a suitable destination. However, after suffering a variety of scrapes and dents to my car and finally punching a hole in the gas tank, I concluded that my 1975 Plymouth Valiant was not a suitable field vehicle. The Shirley Ann claim would have to wait until this poor student could afford better wheels.

Ten years later, I purchased a four-wheel drive truck, and my mineral collecting trips resumed. While on a collecting trip in the vicinity of the Shirley Ann claim I decided to pay the site a visit. The claim supposedly could be reached via a 3 to 4-km foot trail shown on the topographic map, but considering the very rugged nature of the terrain and the age of the trail, I decided that locating and following the trail would be difficult. After further consideration, I concluded that by following the dry washes I would end up only a short distance from the claim.

The presumably easier course proved to be far from easy. The several kilometer-long hike traversed some nearly impenetrable grapevine jungles growing near springs. Then, the canyon became very narrow and a boulder fall made it impassable. The boulders were too large (the size of cars) to climb over and too tightly packed to crawl between. Sitting there somewhat dejectedly, I consoled myself that I had made a valiant effort. Before starting back, I lingered a bit, staring at the steep canyon walls, when I sensed something unnatural about the rock formations. Someone had built a crude set of switchbacks up and around the boulder fall! The constructed trail led me past this and additional obstacles until, before long, I easily located the claim.

The crystallized minerals that I found on the dumps included wulfenite and mimetite, but they were all of micromount size and not particularly abundant. At the time it didn't seem that my considerable efforts had been adequately rewarded; however, among the material I carried back was a single specimen containing a 3-mm vug with a spray of an unusual, fibrous, olive-brown mineral. An X-ray diffraction (XRD) pattern of the fibrous mineral closely

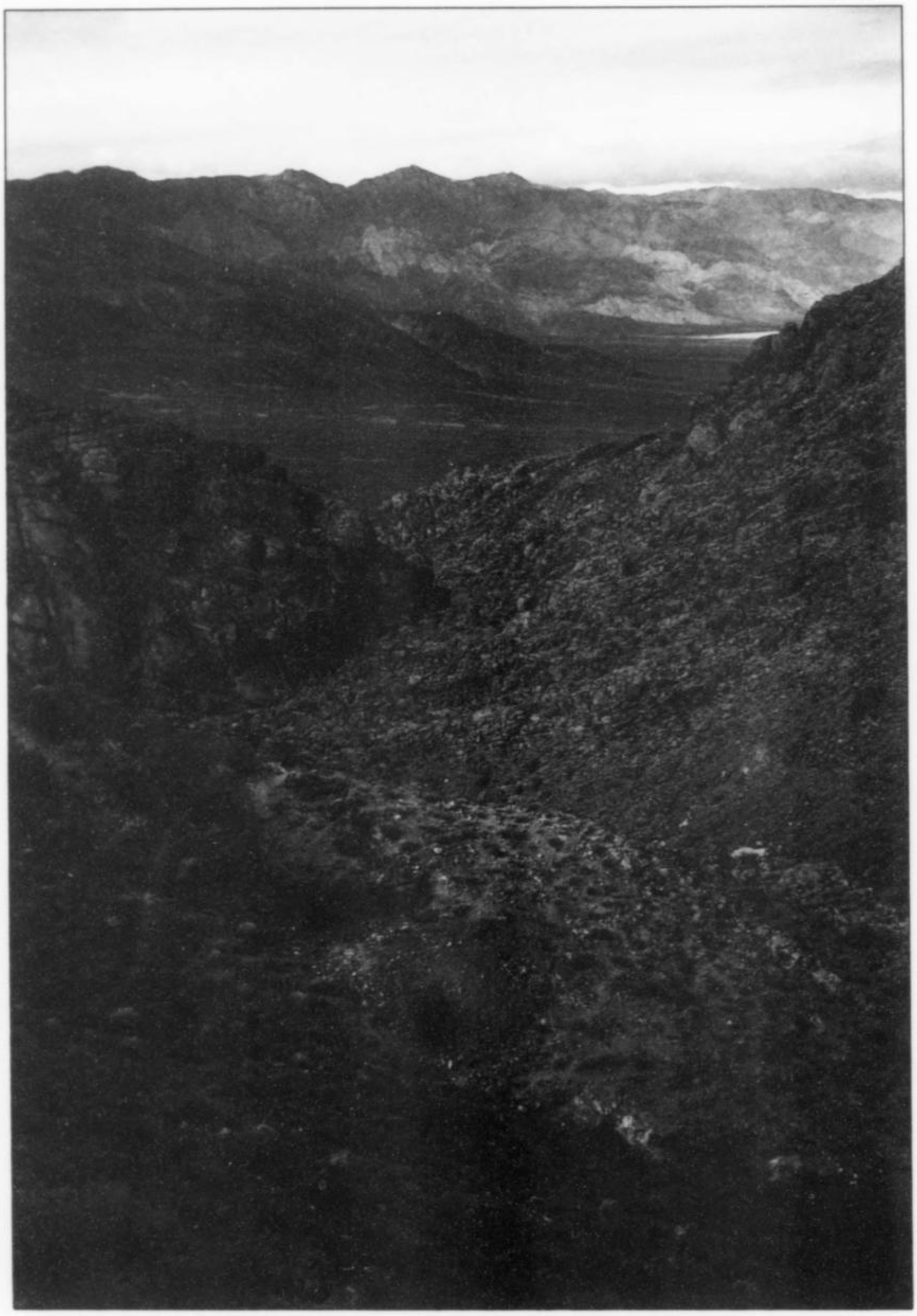


***Figure 1*. View of the Shirley Ann claim with the Nelson Range and Inyo Mountains in the background.**

matched that of *surite,* a silicate related to the smectite group. A qualitative chemical analysis confirmed all of the essential elements in surite, except aluminum, and also indicated the presence of iron. This suggested that the unknown might be an iron analog of surite.

Between the time that the XRD pattern was obtained and the identification was made, the original and only specimen was lost! This prompted a hasty return trip to the Shirley Ann claim and, at that time, I found sufficient material to permit formal description of the new mineral *ferrisurite* (Kampf *et al.,* 1992). Besides ferrisurite, the second visit yielded well-formed microcrystals of wulfenite, cerussite, mimetite, linarite and malachite.

LOCATION

The Shirley Ann claim (elevation 1400 meters) is located about 300 meters southwest of Big Dodd Spring in the Ubehebe mining district, which is about 45 km due east of Lone Pine and 22 km north of Darwin, in Inyo County, California. The claim can only be reached by hiking approximately 4.3 km from the Saline Valley road or 8.5 km from the Lippencot mine.

In 1996 the area surrounding the Shirley Ann claim was incorporated into the newly established Death Valley National Park, and for this reason, mineral collecting is now forbidden there. As a result of the nearby springs, this area has an abundance of interesting wildlife. The juxtaposition of the springs on the desert

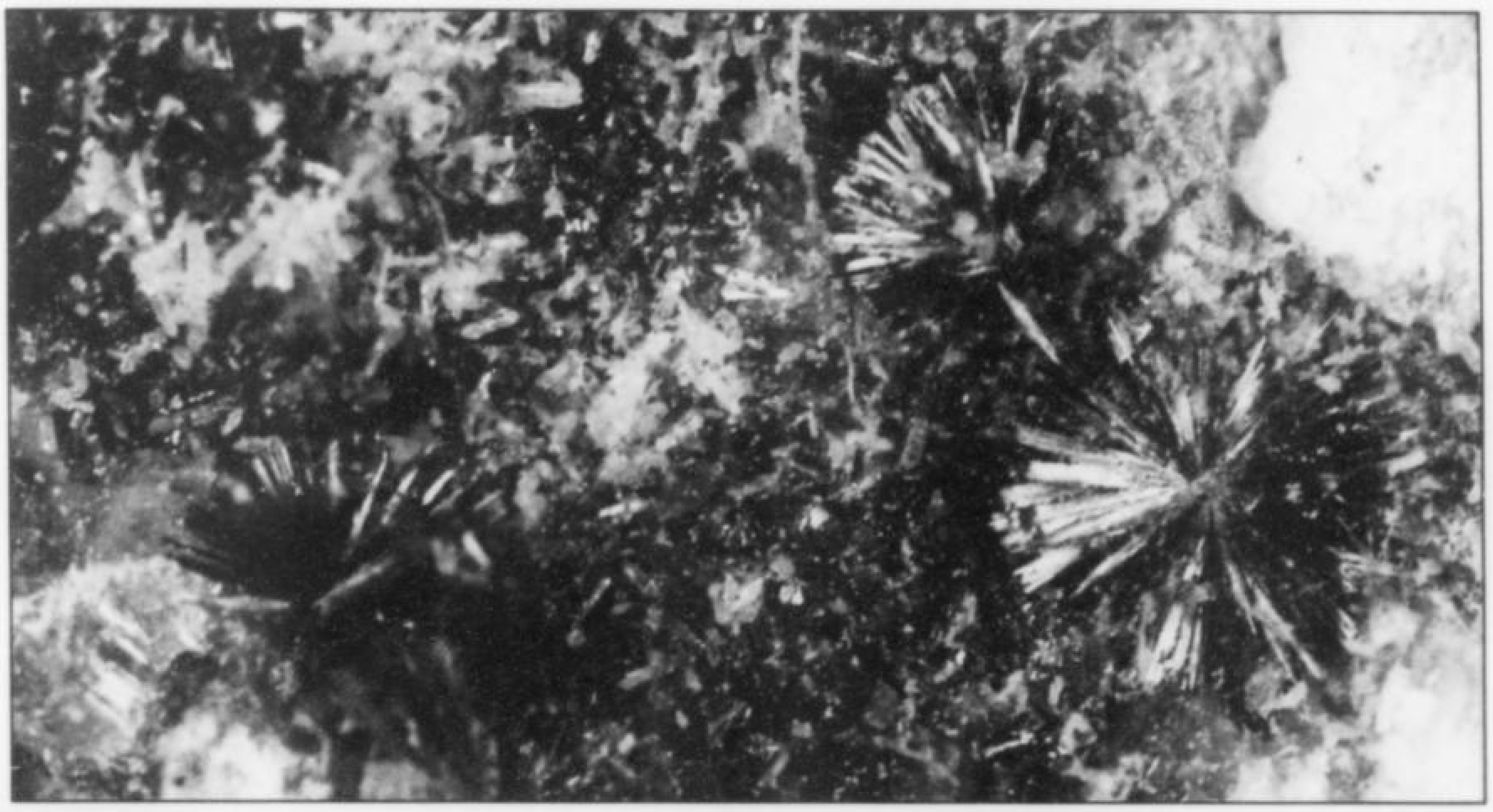


Figure 2. **Free-standing radiating aggregates (to 3 mm) of ferrisurite (habit 1).**

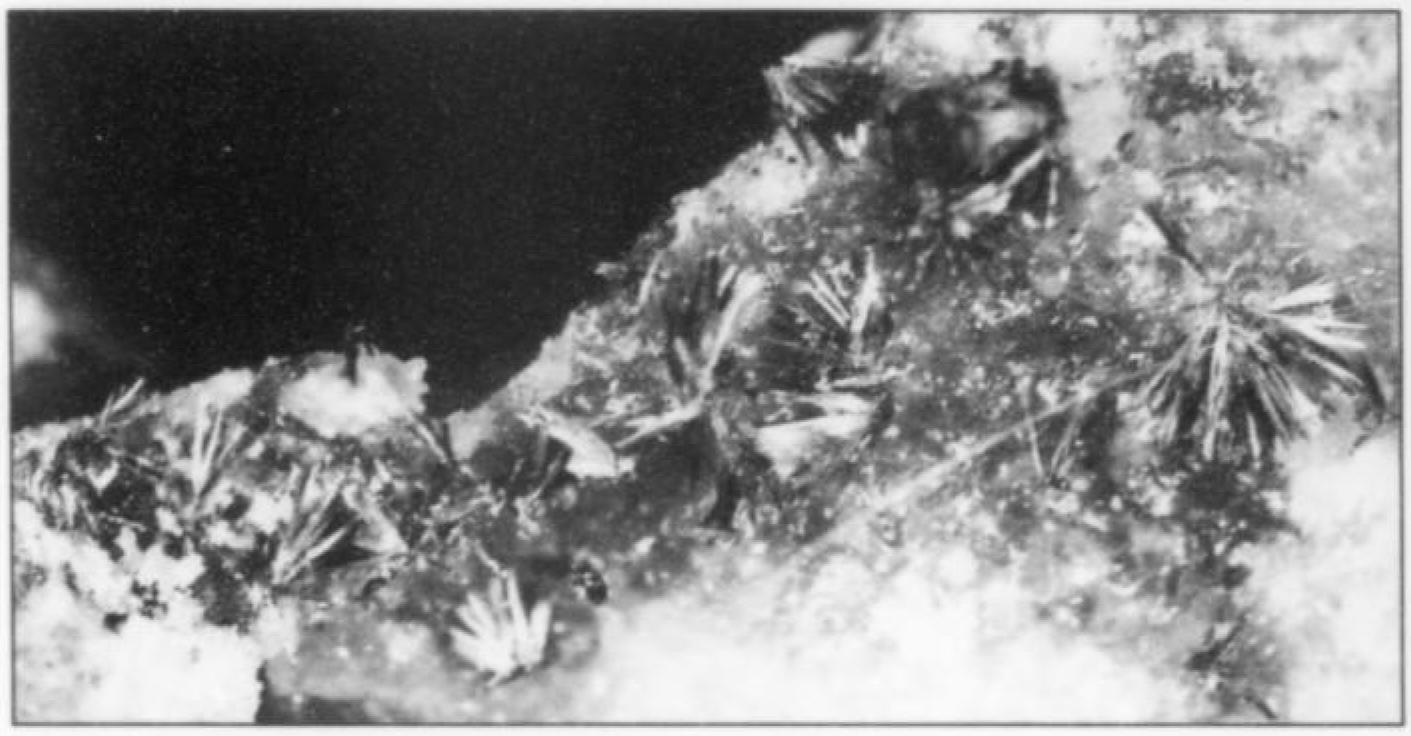


Figure 3. **Free-standing radiating aggregates (to 2 mm) of ferrisurite (habit 1).**

Figure 4. **Radiating aggregates (to 3 mm) of ferrisurite (habit 2).**

environment makes this one of very few places in the desert where one can find grapevine jungles and cat tails in close proximity with cacti. During early collecting trips it was not uncommon to encounter a herd of bighorn sheep and, on one occasion while at the claim, a large ram appeared and vocally protested the presence of an intruder in its territory.

HISTORY

It has been conjectured (McAllister, 1955) that the Shirley Ann claim had been worked as early as 1902 under the name of the Eureka claim, based on limited physical descriptions given in early mining records and mineral reports. Inyo County records indicate that the Shirley Ann claim was located by Earle Carr, Jr. in 1940, and by 1950 it was owned by H. P. Gower. At that time the workings consisted of a 35-meter-long southwest-trending adit with two short adits north and south of the main portal (Fig. 2). About halfway into the main adit a steeply inclined shaft reaches 12 meters to the surface, where it connects with a short (8 meter) adit. In the lower main adit a short drift extends about 8 meters southwestward from the shaft. The southwest extension of veins exposed in the adits are explored by a series of surface trenches that extend for about 80 meters. There is no significant difference in the description of the workings given by McAllister (1955) and the present-day workings, indicating that very little work has been done since that time, probably because of the difficult access.

GEOLOGY

The Shirley Ann claim is situated along the eastern margin of a metamorphosed block of Paleozoic limestone (Pogonip Formation?) that is in contact with a calcic facies of the Cretaceous Hunter Mountain quartz monzonite, that ranges in composition from pyroxene-biotite gabbro to olivine gabbro. The mineral deposits of the Shirley Ann claim were probably controlled by faults in the metamorphosed sedimentary rocks (shaly and silty limestones) (McAllister, 1955). The principal area of mineralization, which contains lead and copper ores, is concentrated along the main adit and extends up the shaft to the connecting small adit. Galena altering to cerussite occurs as veins in calcite and quartz gangue in the lower adit and massive cerussite is common on the dumps. Covellite occurs as rims on partially altered galena and along cleavage faces therein. Minor wulfenite, mimetite, pyrite, chalcocite, chalcopyrite, hematite, chrysocolla, and malachite occur locally, often associated with altered galena veins. In the southwest-trending surface trenches the quartz and calcite veins locally contain minor amounts of chrysocolla and crystallized malachite, galena, cerussite, wulfenite and linarite. The Shirley

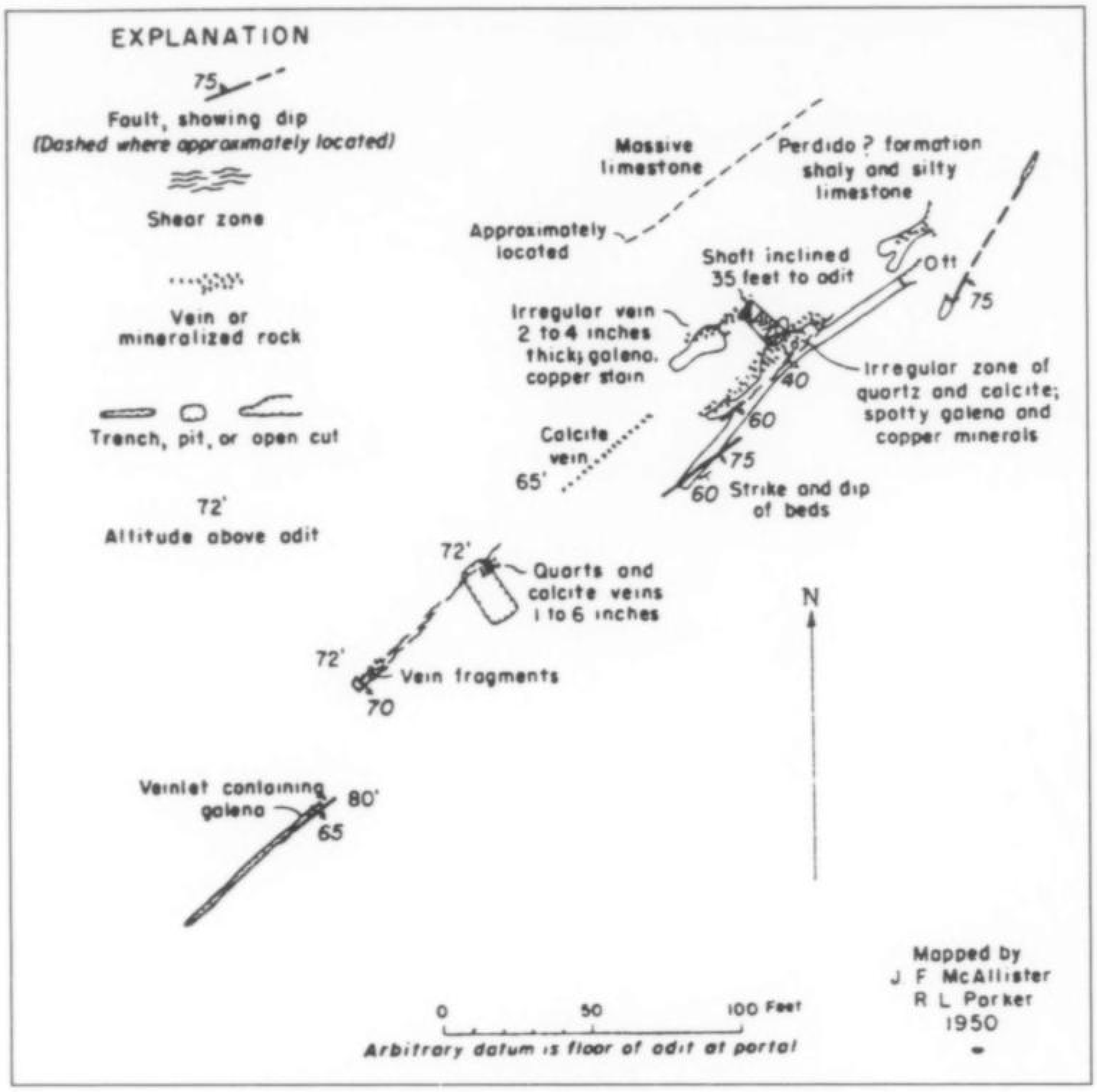


***Figure 5.* Schematic of workings at the Shirley Ann claim (from McAllister, 1955).**

Ann claim differs from the lead deposits at the larger mines in the area in that there is a greater abundance of copper minerals and fewer zinc minerals. Ferrisurite was discovered in calcite and quartz gangue on the dumps, where it is commonly associated with cerussite, galena, wulfenite and mimetite.

MINERALS

The species listed below are those that are most likely to be found as well crystallized microminerals and therefore are more likely to be of interest to collectors. The majority of mineral identifications have been made by X-ray diffraction (XRD) and/or energy dispersive X-ray spectroscopy (EDXS) using a scanning electron microscope (SEM). All figured specimens are in the collection of, and were photographed by, the author (except where noted).

Cerussite $PbCO_3$

Cream to gray, massive cerussite, which formed from the alteration of galena, is common on the dumps and in the underground workings. Minute crystals (<1 mm) tend to be colorless and transparent, while larger (3–4 mm) crystals, which are relatively uncommon, are usually translucent gray. Equant cyclic twins to 4 mm have been found associated with galena bodies in the lower adit. In a surface trench above the upper adit, V-shaped twinned cerussite crystals (to 4 mm) are found associated with milky quartz crystals and malachite. These crystals are typically covered with a thin coating of black plattnerite, but lustrous, unaltered bladed crystals have also been observed.

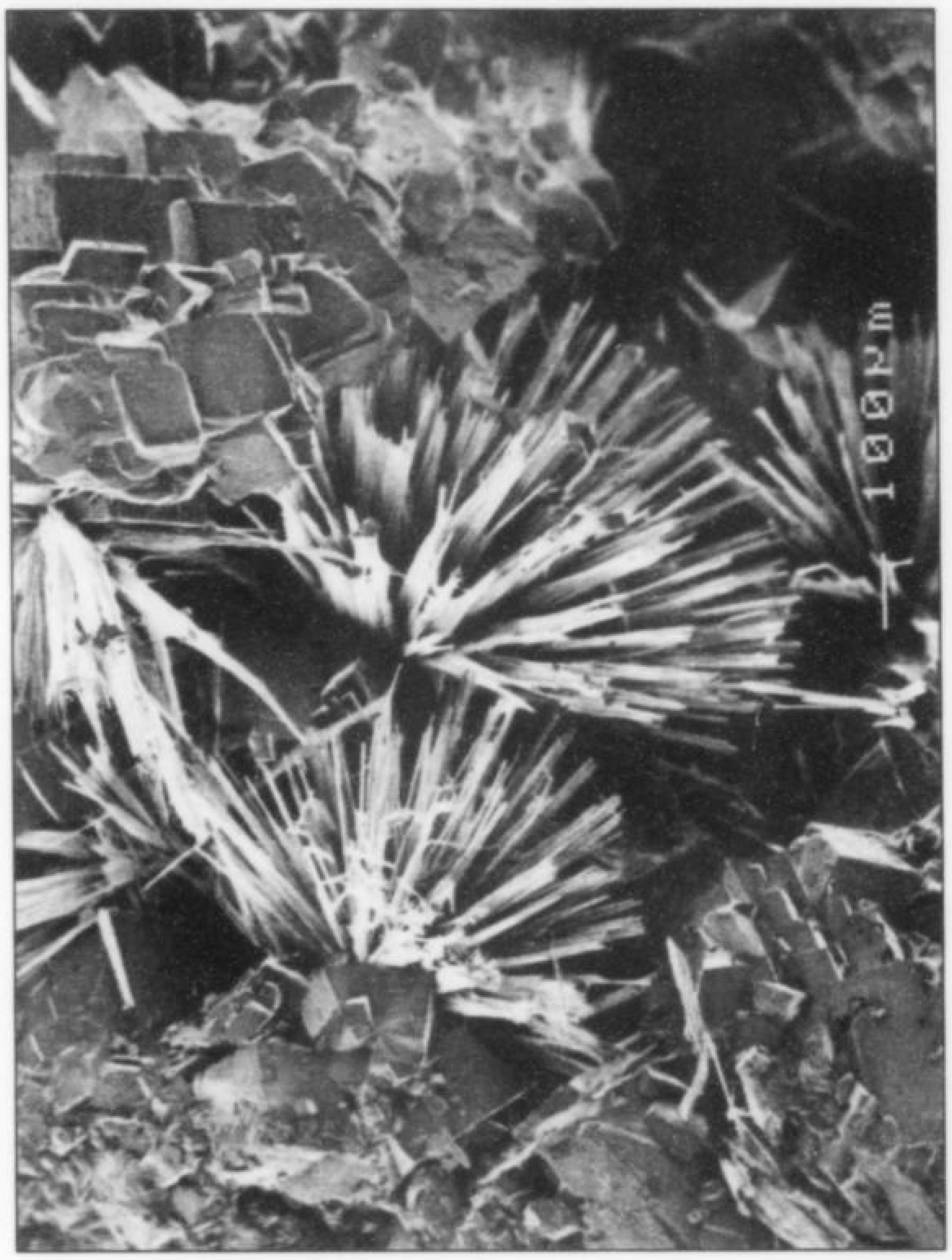
Duftite $PbCu(AsO_4)(OH)$

Small clusters (0.3 mm) of dark red-brown duftite, consisting of minute (0.01 x 0.07 mm) blades, were observed with wulfenite on small milky quartz crystals from a specimen collected in one of the upper trenches.

Ferrisurite $(Pb,Ca)_{2-3}(CO_3)_{1.5-2}(OH,F)_{0.5-1}$-$[(Fe,Al)_2(Si,Al)_4O_{10}(OH)_2]\cdot nH_2O$

Ferrisurite is the ferric iron analog of surite. Surite, which has aluminum in place of iron, was first described as compact aggregates in the oxidation zone of lead-zinc-copper deposits at the Crus del Sur mine in Argentina (Hayase *et al.*, 1978). Additional data on surite have been published by Uehara *et al.* (1997).

The following chemical, structural and physical properties of ferrisurite are summarized from Kampf *et al.* (1992). Ferrisurite crystallizes in the monoclinic system and has pseudo-orthorhombic symmetry ($\beta \approx 90°$). The X-ray powder diffraction patterns of ferrisurite and surite are very similar. The structure of ferrisurite/surite probably consists of cerussite-hydrocerussite layers, represented by the first portion of the above formula, interspersed between smectite layers (second part of formula). Ferrisurite crystals are transparent to translucent with pale yellow-green color and greenish yellow streak. Compact radial aggregates have a medium to dark forest-green color and olive-green streak. Crystals are flattened on (010) and elongate parallel to [100]. The maximum crystal dimensions are 3 mm along [100], 0.01 mm along [010] and 0.04 mm along [001]. Twinning has not been observed. Ferrisurite exhibits silky luster, has perfect {010} cleavage and a Mohs' hardness of approximately 2–2.5. It effervesces in cold 1:1 HCl and leaves a gelatinous residue. Ferrisurite is optically biaxial (+) with refractive indices, measured in white light, of: a = 1.757, b = 1.763, c = 1.773. The optical orientation is X = c, Y = b, Z = a, and the mineral is pleochroic with X = yellow, Y = brown, and Z = light green. No fluorescence under longwave or shortwave ultraviolet radiation has been observed.



occur in bunches up to 1.5 cm. In the second habit, ferrisurite forms olive-brown to dark green radiating fibrous aggregates (to 4 mm) on fracture planes along thin (1 mm) veins in quartz gangue. Fracture surfaces up to 6 x 9 cm covered with radiating ferrisurite have been observed, but are very uncommon. Ferrisurite of the third habit consists of compact olive-green to dark green fibrous aggregates intimately intergrown with coarse-grained quartz and minor, massive, gray cerussite, chrysocolla, mimetite and galena. This material is more disseminated and difficult to isolate from its surroundings.

Occasionally white to cream colored pseudomorphs of a smectite mineral faithfully retain the ferrisurite radiating fibrous morphology. This is not unexpected because it has been shown that surite reacts with acids to produce smectite as a result of dissolution of the interlayer Pb-Ca carbonate (Hayase *et al.*, 1978). More commonly, alterations of ferrisurite are yellowish to brownish in color and less of the radiating fibrous structure is retained.

Fornacite $(Pb,Cu)_3[(Cr,As)O_4]_2(OH)$

Minute (0.25 mm) blades of olive-green fornacite were confirmed on one specimen collected from the dumps.

Galena PbS

Clots and stringers of primary galena up to 10 cm in size are found in some of the underground workings and are surrounded by cerussite and chrysocolla. Thin films of covellite have been observed on some galena cleavages and as thin rims on altered galena clots.

Figure 6. **Scanning electron micrograph (SEM) of ferrisurite (habit 1) on calcite crystals.**

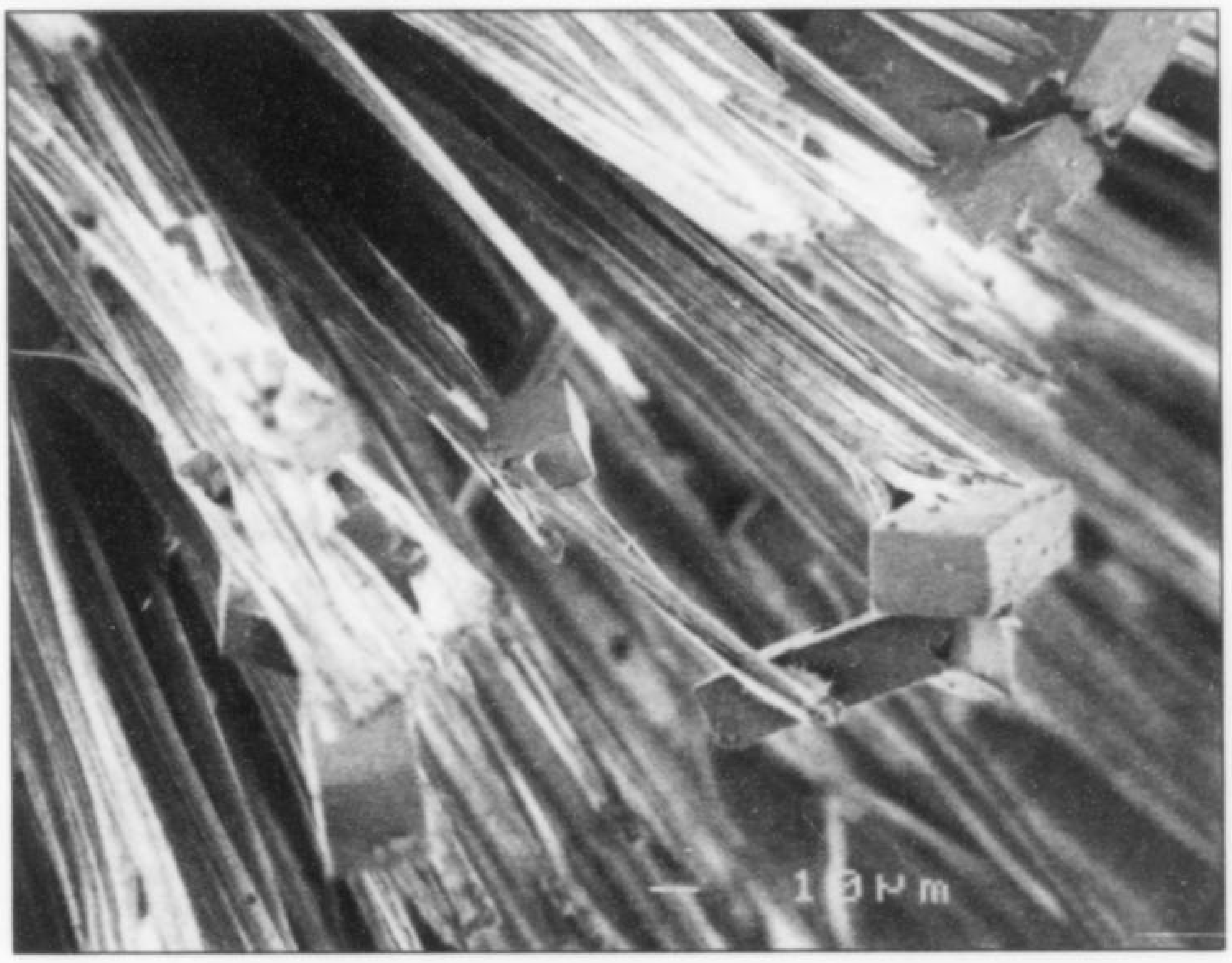


Figure 7. **SEM of calcite crystals impaled on ferrisurite.**

Ferrisurite occurs in three main habits, some of which were not known at the time of its formal description. The first consists of 2–3 mm fibrous olive-green to golden brown aggregates which are found in small, 3–5 mm cavities in coarse-grained brown calcite and fine-grained white to gray quartz gangue. Such aggregates in vugs served as the type specimens for the formal description of ferrisurite. Free-standing, undamaged, radiating fibrous groups (to 3 mm) are exceedingly rare. More typically the ferrisurite crystals are bent or matted. Closely associated minerals include mimetite, calcite and wulfenite, which may or may not be closely associated with altered galena. Occasionally, radiating groups of ferrisurite

Linarite $PbCu(SO_4)(OH)_2$

Bright blue films of linarite (to 4 x 6 cm) have been observed with malachite on the dumps by the upper adit; 1–2 mm crystals on milky quartz crystals have been collected from one of the surface trenches above the upper adit. Associated minerals include malachite, cerussite, galena and chrysocolla.

Malachite $Cu_2(CO_3)(OH)_2$

In one of the surface trenches above the upper adit, 3–4 mm pale green radiating tufts of malachite are found with cerussite, linarite, chrysocolla and galena in milky quartz veins. At the same site,

Figure 8. **Yellow hexagonal prisms of mimetite (to 1 mm) on calcite gangue.**

Figure 9. **Group of equant, cyclic twinned cerussite crystals (3 mm).**

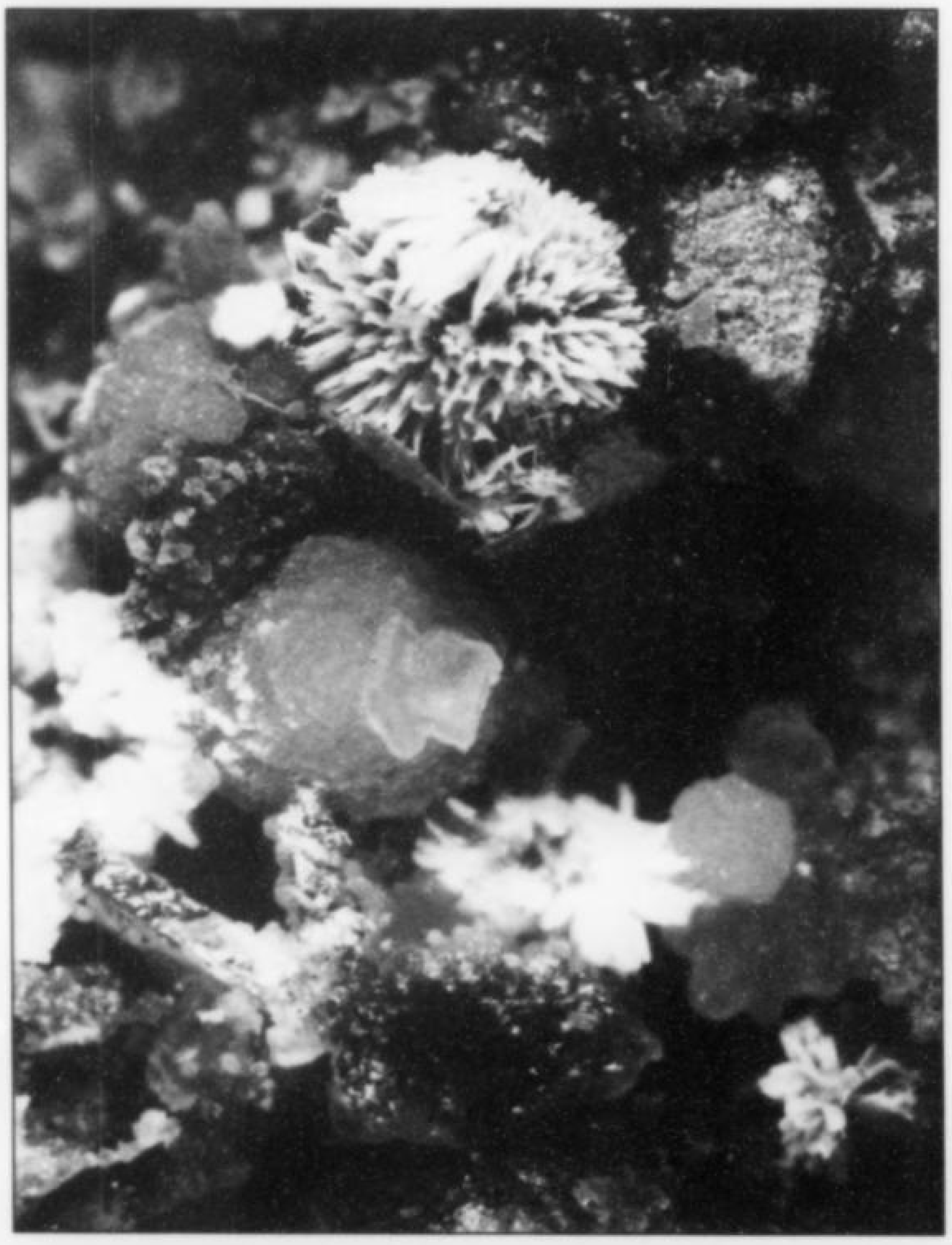


Figure 10. **Smectite pseudomorph (2 mm) after ferrisurite with mimetite and wulfenite.**

Figure 11. **Acicular mimetite crystals (individual crystals to 0.04 mm x 0.5 mm).**

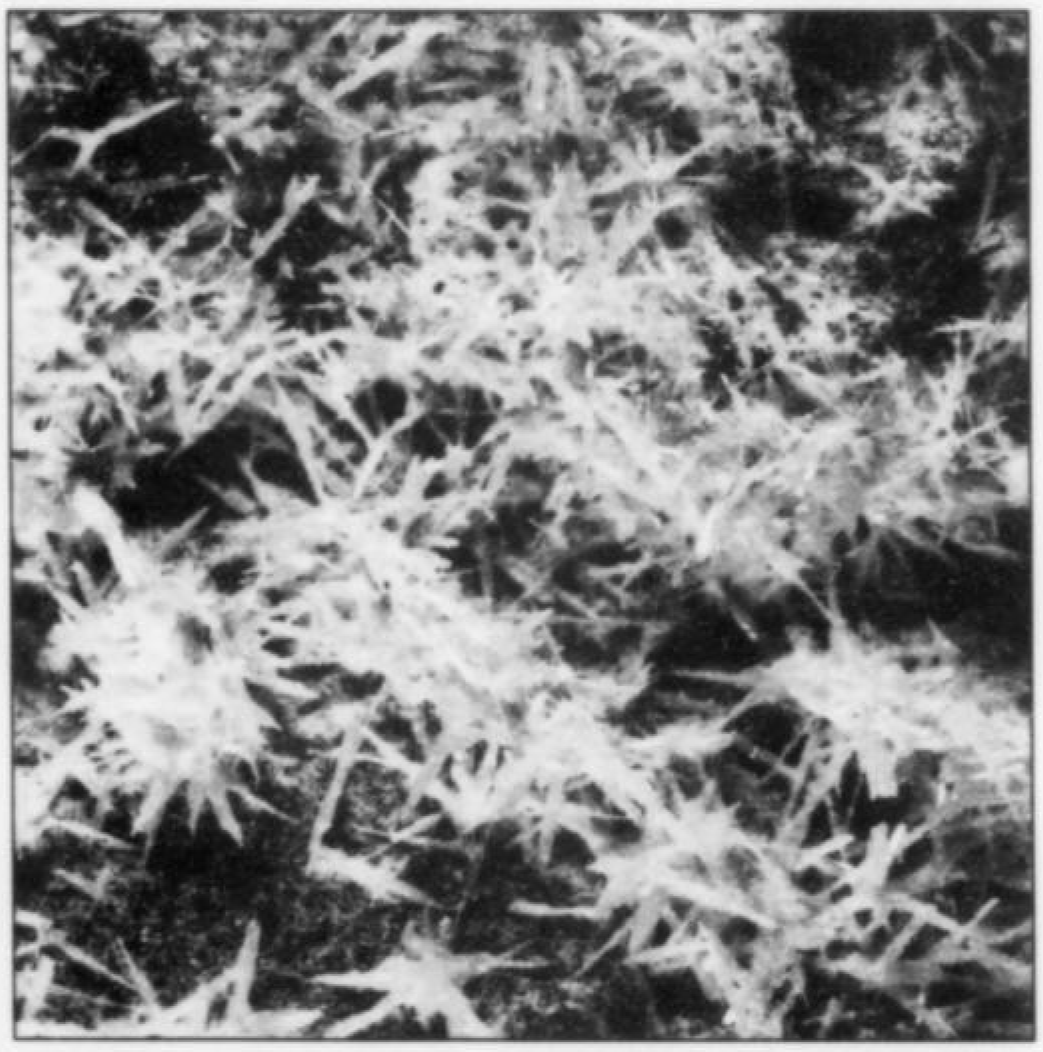


Figure 12. **Radiating acicular malachite (2 mm) with cerussite on quartz from one of the surface trenches.**

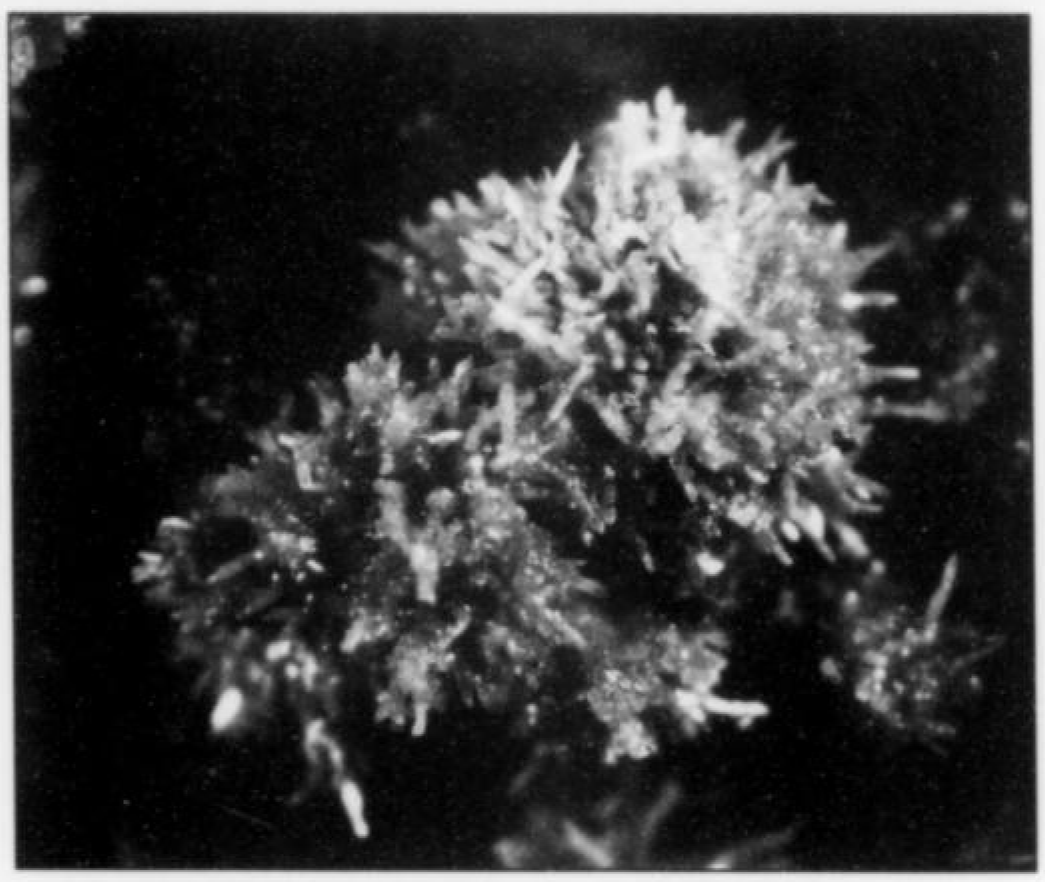


Figure 13. **Radiating aggregate of gray mimetite (2 mm).**

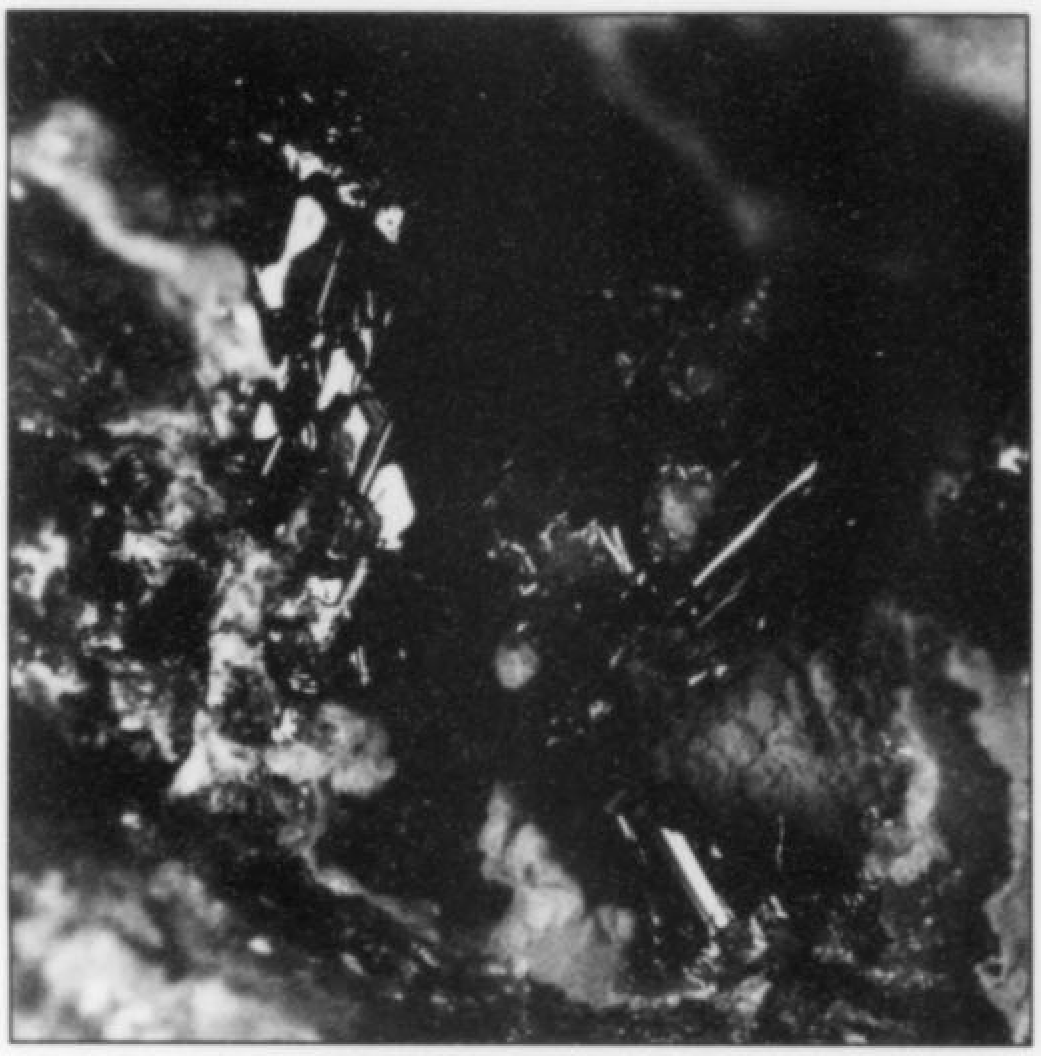


Figure 14. **Linarite crystals (1 mm) from one of the surface trenches.**

Figure 15. **Pyramidal wulfenite crystal group (largest 1 mm).**

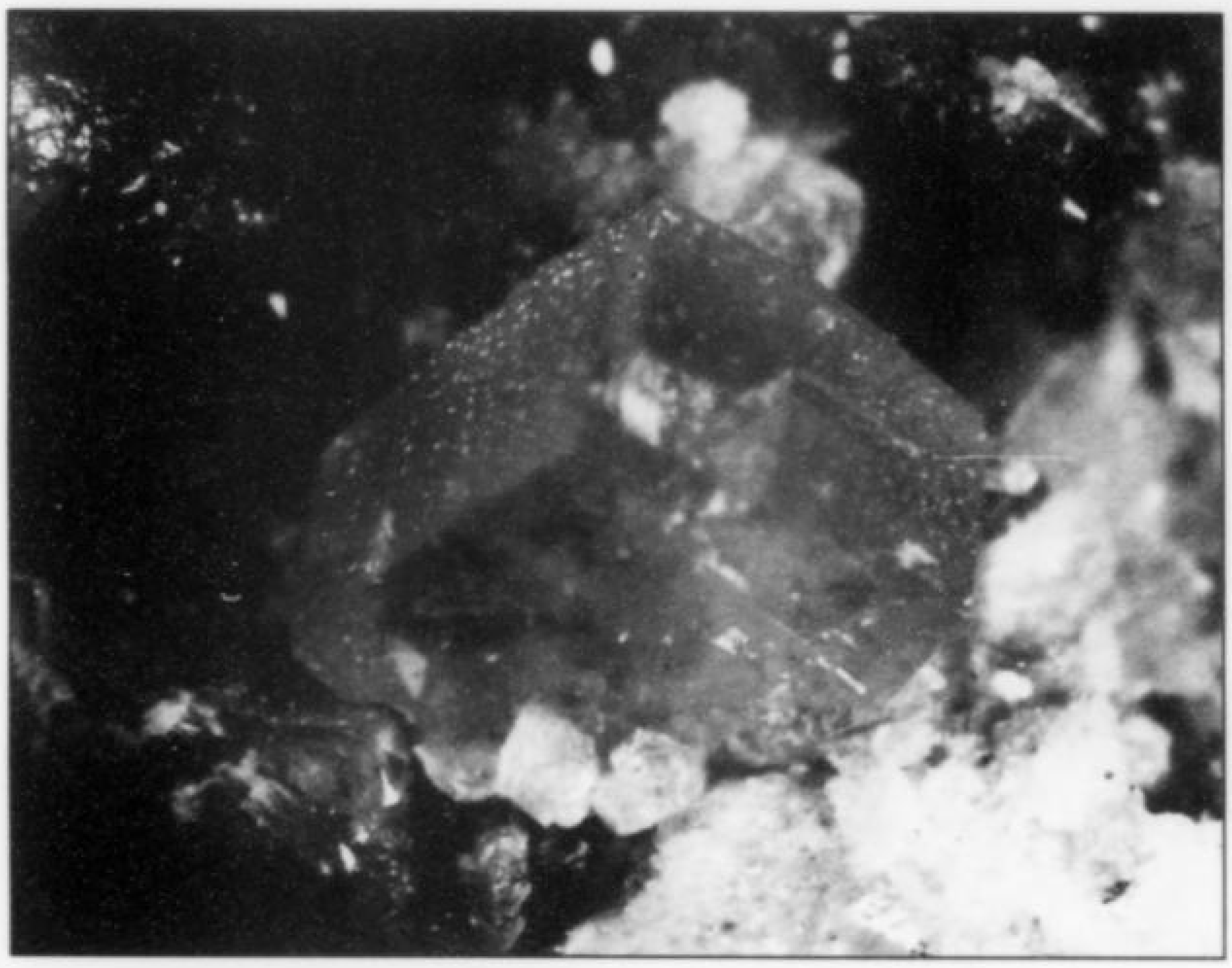


Figure 16. **Equant wulfenite crystal (1.5 mm) on calcite.**

Figure 17. **Tabular wulfenite crystal (1.5 mm) displaying phantom.**

small (1-mm), transparent, dark green flat plates and bladed crystals have also been observed.

Mimetite $Pb_5(AsO_4)_3Cl$

Mimetite is relatively common and displays a wide range of morphologies and colors. Most often it is found as small (to 0.5 mm) white to pale yellow rice-shaped aggregates, which occur with ferrisurite and wulfenite. Less commonly it is found as yellow hexagonal prisms (to 1 mm) and pale gray radial aggregates (to 2 mm) in calcite gangue. Pale gray-green spherical masses (to 6 mm) have also been found in small vugs lined with milky quartz crystals associated with an altered galena body in the lower adit. Acicular, pale orange crystals occur with wulfenite, and matted aggregates of very fine acicular yellow crystals have also been found on milky quartz crystals.

Wulfenite $PbMoO_4$

Wulfenite, while never abundant or very large, is one of the most interesting minerals from the Shirley Ann claim because of the multitude of crystal habits that have been collected. It has been found both in the lower adits and in quartz veins in the upper trenches. Thin tabular crystals to 3 mm occur as solitary individuals in small vugs associated with altered galena bodies. These crystals may be transparent, show signs of phantoms, and range in color from pale yellow to medium or dark orange. Gray nodular or orange semi-acicular mimetite is commonly associated. As crystals become more equant the pyramid faces become more prominent; groups of individual crystals to 2 mm with this mixed morphology have been found coating fracture planes in the rock. The pyramid faces can also become developed to the point where the pinacoid is absent and the crystals are relatively elongated. Homo-epitactic pyramidal overgrowths on tabular crystals have also been observed.

Pale gray tabular crystals (to 1.5 mm) that were suspected of being wulfenite were found to contain appreciable tungsten, in addition to lead and molybdenum. The exact composition was not determined but semi-quantitative analysis indicate that tungsten may be substituting for up to 20% of the molybdenum in these wulfenites. Associated minerals include gray mimetite, orange wulfenite of various habits and cerussite. Gray-blue chrysocolla overgrowths on these tungstenian wulfenites have also been observed.

ACKNOWLEDGMENTS

The author would like to thank A. R. Kampf, L. L. Jackson, G. B. Sidder and E. E. Foord for describing ferrisurite. A. R. Kampf also reviewed this manuscript and provided helpful suggestions. G. W. Stupian provided the SEM photographs of ferrisurite.

REFERENCES

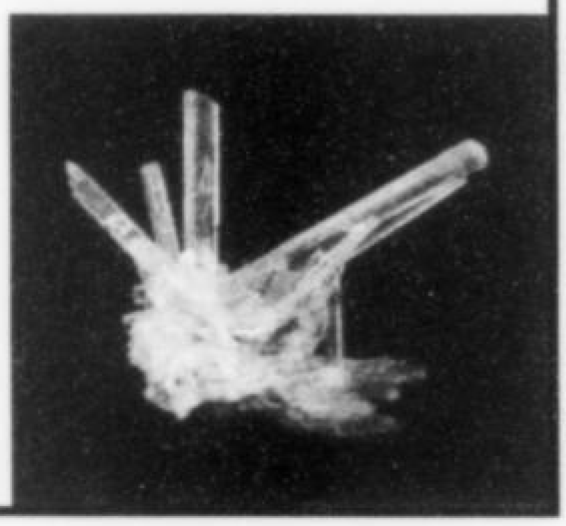
HAYASE, K., DRISTAS, J. A., TSUTSUMI, S., OTSUKA, R., TANABE, S., SUDO, T., and NISHIYAMA, T. (1978) Surite, a new Pb-rich layer silicate mineral. *American Mineralogist*, **63**, 1175–1181.

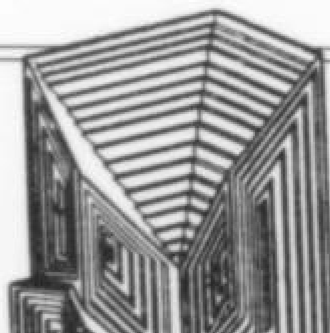
KAMPF, A. R., JACKSON, L. L., SIDDER, G. B., FOORD, E. E., and ADAMS, P. M. (1992) Ferrisurite, the Fe^{3+} analogue of surite, from Inyo County, California. *American Mineralogist*, **77**, 1107–1111.

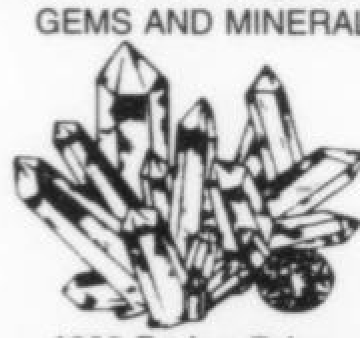
McALLISTER, J. F. (1955) Geology of mineral deposits in the Ubehebe Peak quadrangle, Inyo County, California. *California Division of Mines Special Report* **42**.

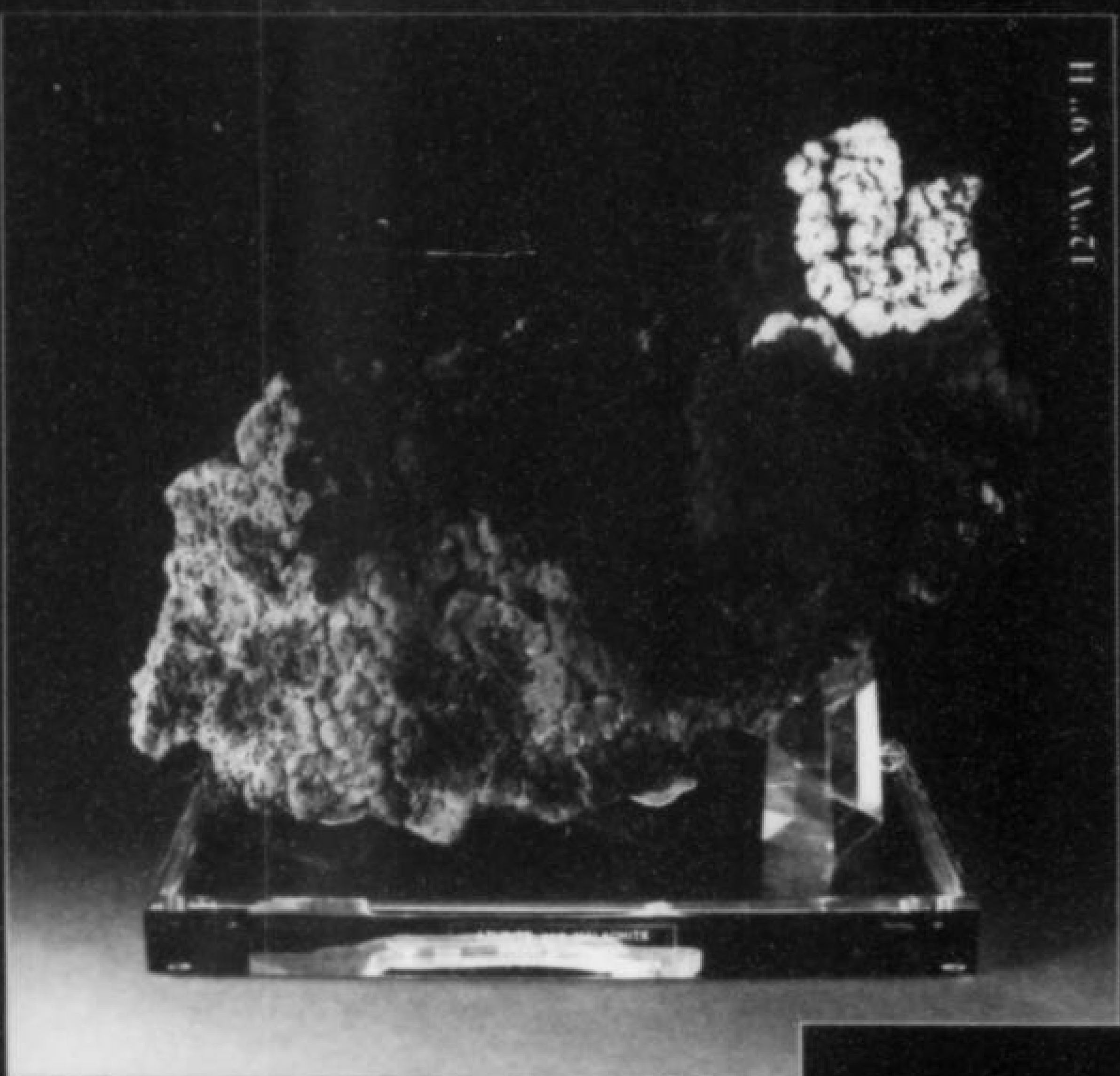
McALLISTER, J. F. (1956) Geology of the Ubehebe Peak quadrangle, California. *U.S. Geological Survey* **GQ-95**.

UEHARA, M., YAMAZAKI, A., and TSUTSUMI, S. (1997) Surite: Its structure and properties. *American Mineralogist*, **82**, 416–422.









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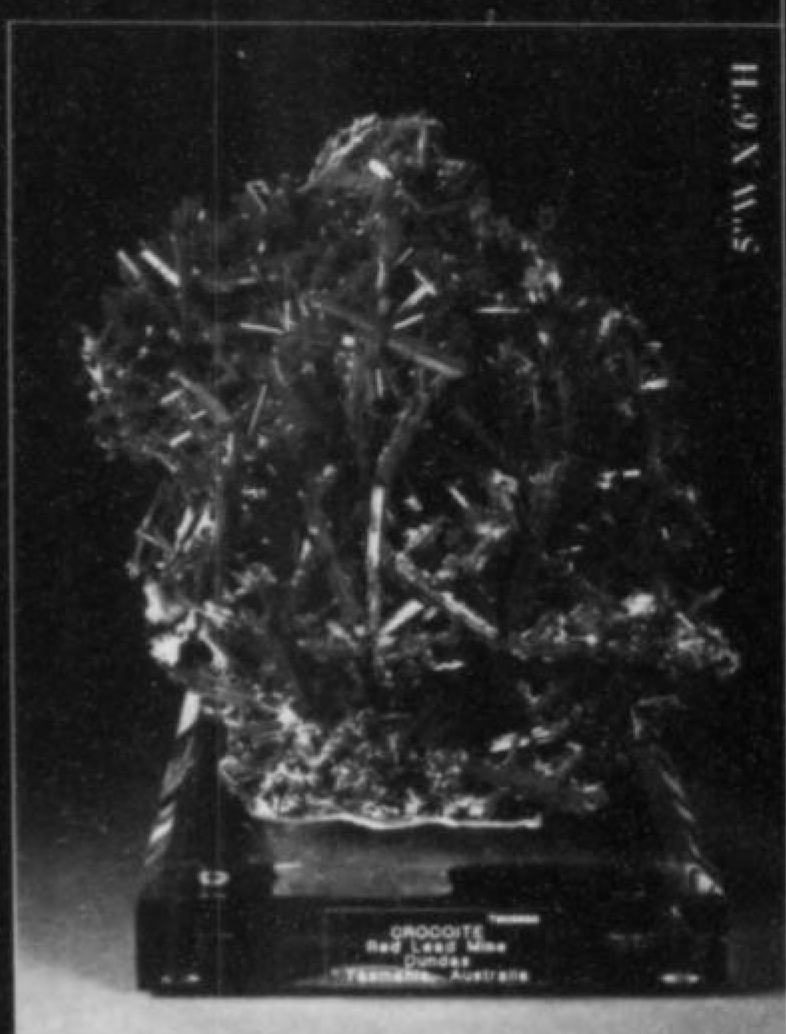

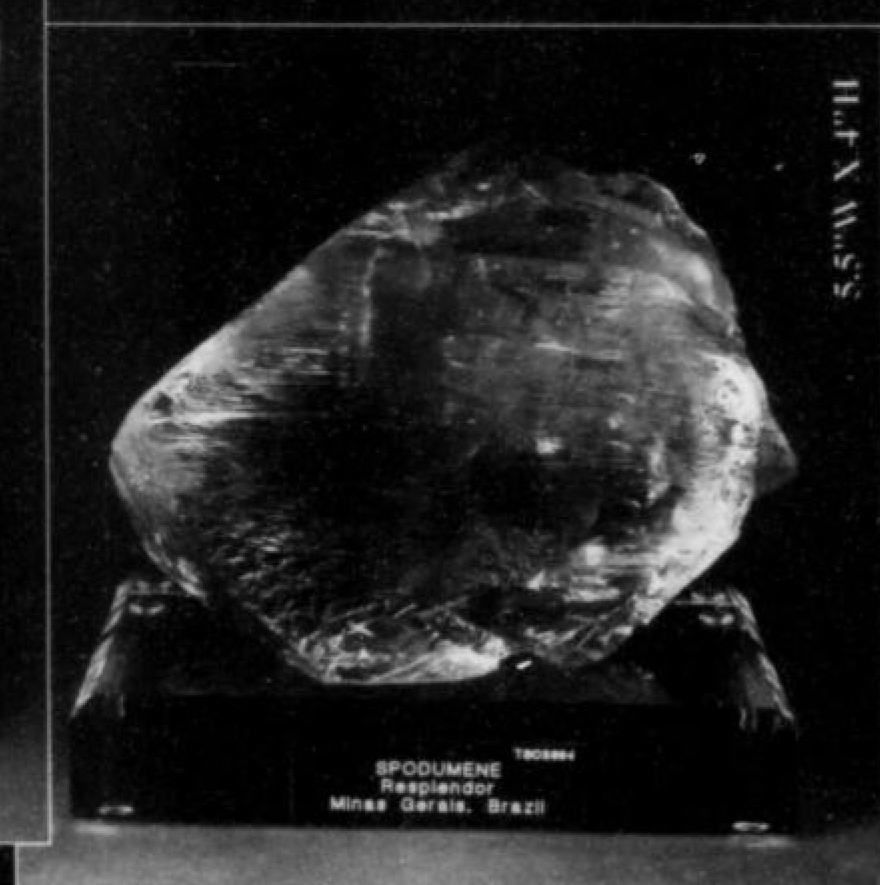

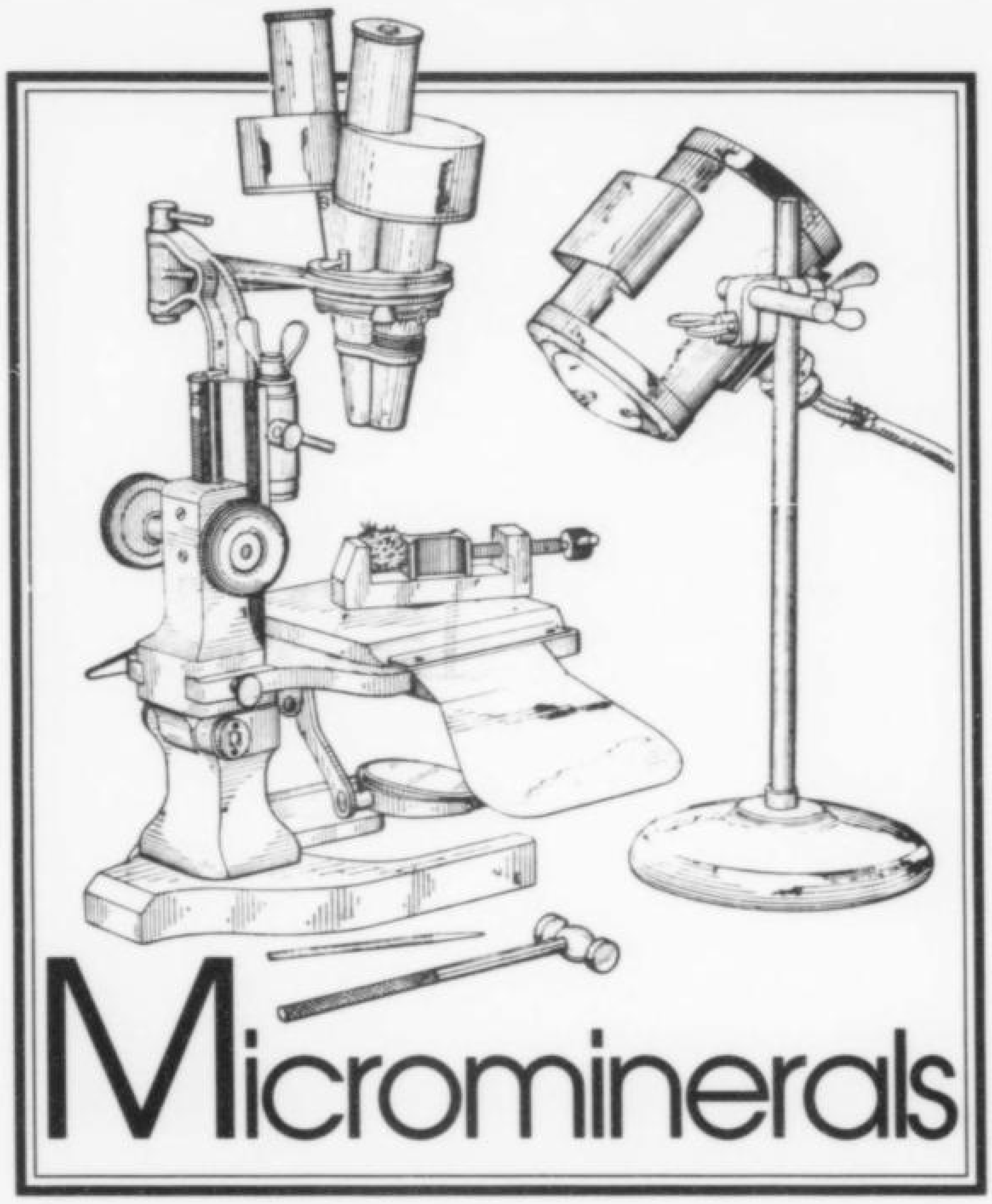

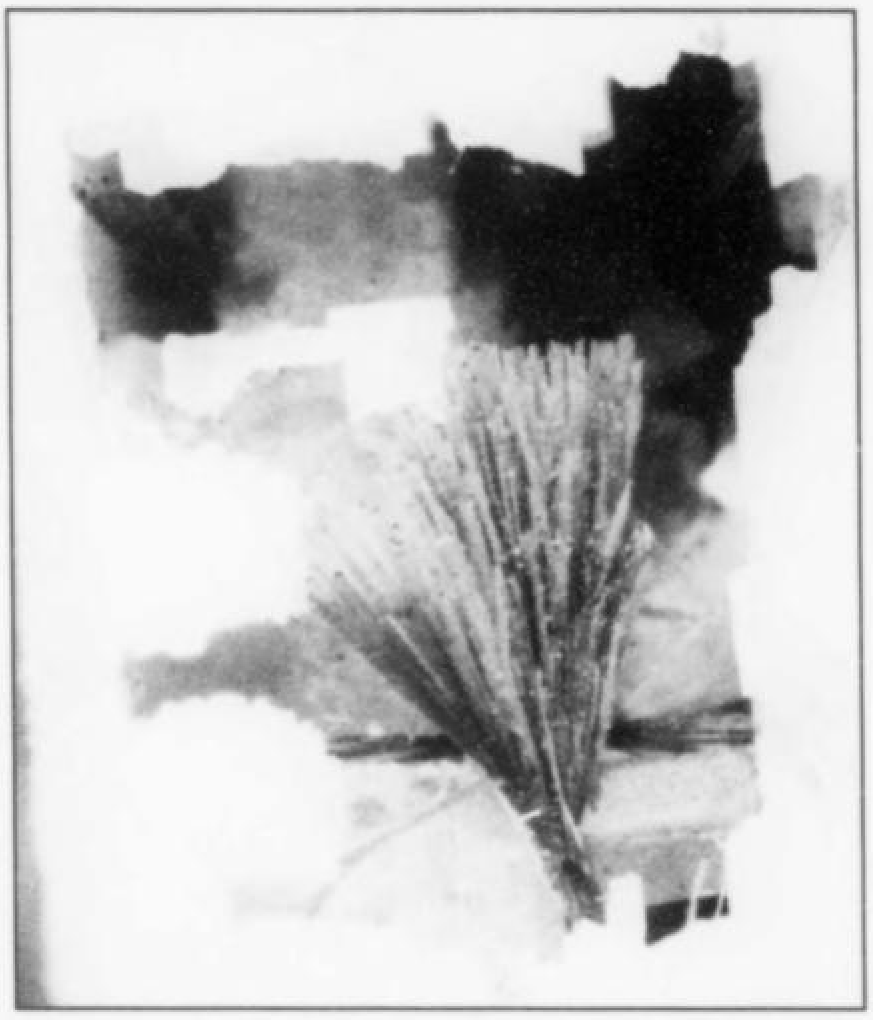

Figure 1. **A single spray of witches' broom habit niobokupletskite from the original vug in the former De-Mix quarry of Mont Saint-Hilaire rests in an etch cavity in white microcline feldspar. Size of spray 1.5 mm. Q. Wight photo.**

by Quintin Wight

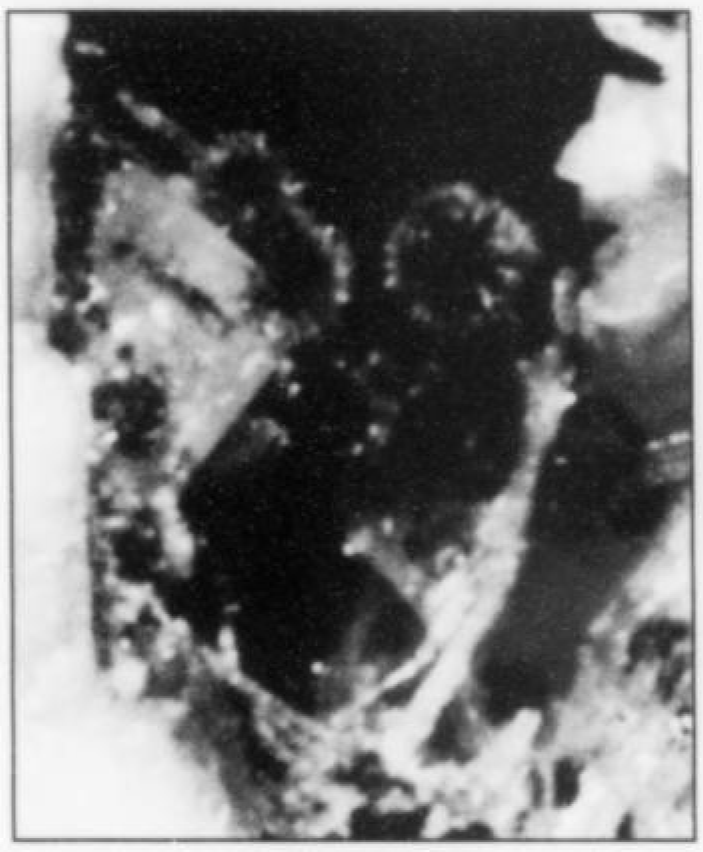

Figure 2. **Extremely rare 0.5-mm balls of dark green ferroceladonite sparkle from this specimen in the collection of the Canadian Museum of Nature. Q. Wight photo.**

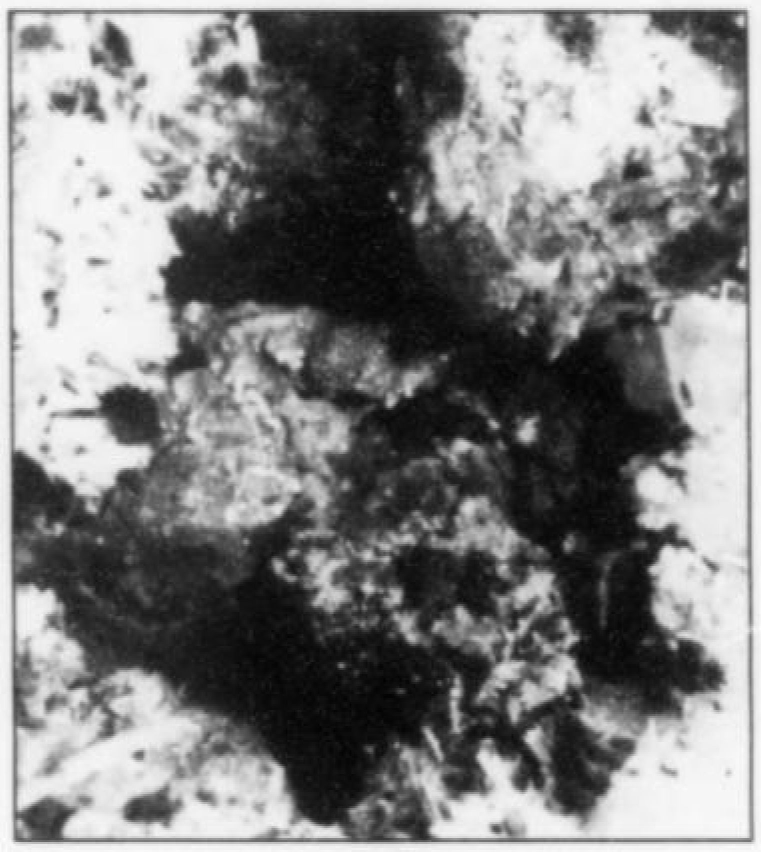

Figure 3. **Green ferroceladonite "mud" packs the interstices of albite crystals in this specimen from the famous "green hole" of 21 May 1972. The white, 0.5-mm sprays are strontium-apatite. Q. Wight photo.**

Figure 4. **Clusters of witches' broom niobokupletskite from the original vug opened by Dr. Peter Tarassoff in 1970. The sprays range from 1 mm to 1.5 mm. Q. Wight photo.**

Sunday, July 12, 1970, was a hot, clear day in the quarries on Mont Saint-Hilaire. There had been a blast in what was then the De-Mix quarry (the center one of the three) on the preceding Friday, and there was a large fan of rubble stretching out on the quarry floor from the back wall. I was sitting half-way up the slope working on a mediocre boulder when I spied a small mobile dot entering the quarry. The dot turned into Dr. Peter Tarassoff, who had been away for several weeks and was on his first visit to the quarry in some time.

Peter climbed up the rubble slope toward me, said "Hi" on the way by, and proceeded to the newly exposed back wall, where he stuck his hand under a rock slab and began hauling out large analcime crystals (up to 10 cm!). He had hit such a bonanza that he had to go find a couple of dynamite boxes left by the workers to pack them out. Aside from drooling a little, there wasn't much I could do at the time, but I did scavenge a bunch of the gravel from the bottom of the vug later on.

On examination, even the gravel proved to be very productive. There were aegirine crystals with oddly clubbed ends; pale pink, blocky ancylite crystals; spiky balls of calcite; very complicated, water-clear crystals of an unknown mineral; tiny, resinous brown crystals of a second mineral showing a hexagonal pyramid termination, and pale brown sprays that were obviously astrophyllite.

At home, a UV lamp gave a nice green glow to the water-clear crystals. Under the microscope, their complicated habit became roughly tetrahedral. That added up to genthelvite. The hexagonal brown crystals turned out to be hemihedral. That suggested wurtzite. The astrophyllite was so characteristic in shape, so much like small twig broom heads, that I called it witches' broom astrophyllite.

A couple of years later, I handed a sample to the staff at the Smithsonian Institution. Dr. Pete Dunn checked the genthelvite, and described it as end-member material, with no iron content. Dr. Arthur Roe mounted a single crystal of the brown material on the Gandolfi camera, and confirmed that it was indeed wurtzite. Other studies later showed the ancylite to be calcioancylite-(Ce).[1] The witches' broom astrophyllite was merely pretty, but nice, so I sent samples to a number of collectors as an item of interest from Mont Saint-Hilaire.

Over the next 30 years, I sent a lot of witches' broom astrophyllite to people in various parts of the world.

Ottawa, Canada's capital city, has two universities and a lot of research capability. One of the researchers, Paula Piilonen, a Ph.D. candidate at the University of Ottawa, was also a member of our micromounting group. A couple of years ago, she mentioned that she intended to do her thesis work on astrophyllite. I showed her my witches' brooms, and gave her some samples, as did Dr. Tarassoff, the original finder of the vug. Shortly thereafter we heard from Paula. The witches' broom astrophyllite proved to be a new species—*niobokupletskite.* To be specific, it's Type III niobokupletskite (see Mandarino, *Mineralogical Record,* vol. 32, no. 3, p. 218).

So—what's the point of this story? There are three points:

(1) In the amateur community, it's usually the micromounters who find the new minerals.

(2) New minerals don't have to come from yesterday's field trip. They could have been in your basement for 30 years.

(3) Everyone who has a specimen labeled "Witches' broom astrophyllite" should change the label to read "Niobokupletskite (Type III)."

Actually, exactly the same thing happened with *ferroceladonite.* It appeared in the late 1960's as the green mud that collectors spent hours washing away from their epididymite and elpidite specimens at Mont Saint-Hilaire. We had it in bucketfuls and paid no attention to it, except as a nuisance. It was described as a new mineral in 1998, using infinitesimal scraps of material from a locality in New Zealand. The lesson is simple: go over your collection again and again, and really pay attention to the accessory minerals.

[1] Personal communication, Dr. Peter Tarassoff.

SOME STATISTICS[2]

Mont Saint-Hilaire is the current Mecca for collectors of microminerals. Glossy magazines print colorful shots of its gorgeous crystals, and collectors salivate at the prospect of the next finds. What people tend to forget, is that the Poudrette quarry (it's all one now) on the Magic Mountain is there for commercial aggregates. The quarry was opened in 1954 to provide roadbuilding material for Autoroute 20 between Montreal and Quebec City. Today, it produces 150,000 metric tons of shingle stone and 500,000 tons of construction aggregates per year, using special techniques to crush and screen on-site.

Shingle stone is the term used for the fine granules stuck to the asphalt shingles on the roof of your house. It is made of crushed hornfels (referred to in the commercial world as "trap rock"). The hornfels is good for this purpose because it is low in iron. That means that it doesn't produce rust streaks down the sides of the house as it weathers. It takes 2.75 tons of hornfels to produce 1.50 tons of shingle stone.

Construction aggregate is made from the syenite bodies. It is crushed to 14–20 mm for asphalt or ready-mix; 5–14 mm for concrete aggregates; 5–10 mm for asphalt stone, and so on. Hornfels is processed from 6 am to 3 pm and syenite from 3 pm to midnight to prevent cross-contamination.

SOME STATIC

Nobody likes minerals with acicular habits. In the first place, they break too easily. In the second, when they do break it's usually because most of the tip has just buried itself in your finger, and you are going to have to spend the rest of the evening digging it out. In

[2] The information was gleaned from *Aggregates & Roadbuilding: Canada's Rock to Roads Magazine,* May/June 2000, pp. 13–14.

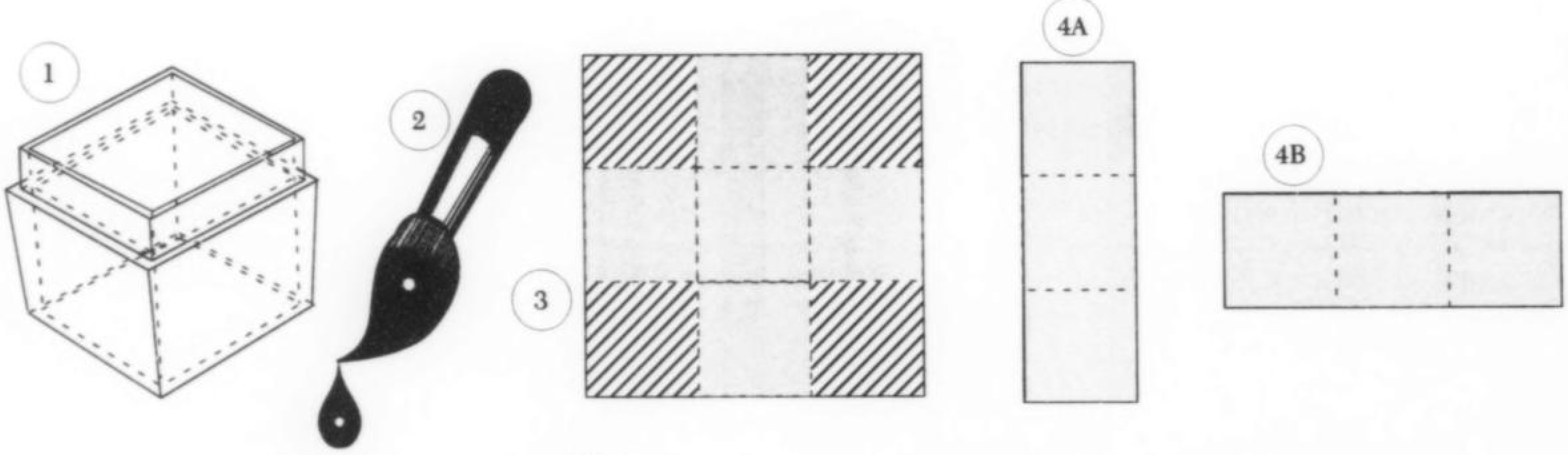

Figure 5. **To darken the bases of clear boxes (1), most collectors use paint (2), or spend time meticulously cutting squares of black paper into cruciform shape (3) to make inserts. Bill Hunt has a much easier idea. Two simple rectangles of black paper of the correct size (4A & B) are much easier to cut and insert. When combined with a piece of folded white paper containing the required information (5), the result is a fine micromount box (6).**

the third, those miniature hedgehogs collect hairs. Take a look at any cluster of acicular crystals under the microscope, and there are usually half a dozen little dust hairs of one kind or another wound between the needles.

Over the years, there has been plenty of depilatory advice given in books on mineral collecting. It has ranged from blasting with compressed air to passing the specimen through an open flame in the hope that the hairs would burn away. None of it worked very well.

Recently, Rodney Lee, owner of *Simkev Minerals*, purchased an old micromount collection in which were several hirsute specimens. He was puzzling over the eternal question of removing remnants of someone's angora sweater from the good bits when he thought of combing them out. A mineral comb would be a great idea if someone could come up with one that would pass neatly between fragile crystals without causing chaos. That probably can't be done, but as he proved, one can use a comb nonetheless.

Rodney took an ordinary plastic comb, rubbed it briskly on his trouser leg for a few seconds, then passed it over the specimen. *Voila!* Those nasty hairs promptly jumped to the electrostatically charged comb, leaving the specimen as hairless as one could wish for.

LINERS

The difficulty with some problems (such as hairy specimens) is that the best solution may be too simple to occur to anyone. We usually go through all the complicated ones until the "Why didn't I think of that!" solution emerges.

Bill Hunt was inducted into the Micromounters Hall of Fame in 1984. He got there by being industrious, inventive, helpful, generous, and smart. He also came up with a simple solution to a long-term problem.

Bill has been micromounting for a long time. In fact, his first micromounts were made using bottle caps (inventive!). When plastic boxes came into general use in the 1950's, Bill switched to those along with everyone else. Plastic boxes brought problems, however. The most appealing mount was obviously in a black box with a clear lid, but boxes came all clear and colorless, or all black. Rich collectors bought equal quantities of each and switched lids. Well-off collectors bought black boxes and extra clear lids. The rest of us bought clear boxes and thought of ways to turn the bottoms black. We used brush-on paint, spray-on paint, sheets of black paper liners die-cut to fit, and even special tools holding scissors to allow cutting the cross-shaped liners from black construction paper. Wooden blocks were carved to fit the liners precisely in the boxes.

A lot of thought went into those liners, but they didn't always work. The boxes vary slightly in size, so there would either be protruding paper edges and crumpled bottoms on small boxes, or wide gaps in the corners of big ones.

Along came Bill Hunt. Bill didn't bother with cruciform liners. He just cut two strips of paper of the right width and length, and folded them into the box at right angles to each other. No fancy tools, no tricky corners, no paint, no die-cut sheets—no problem!

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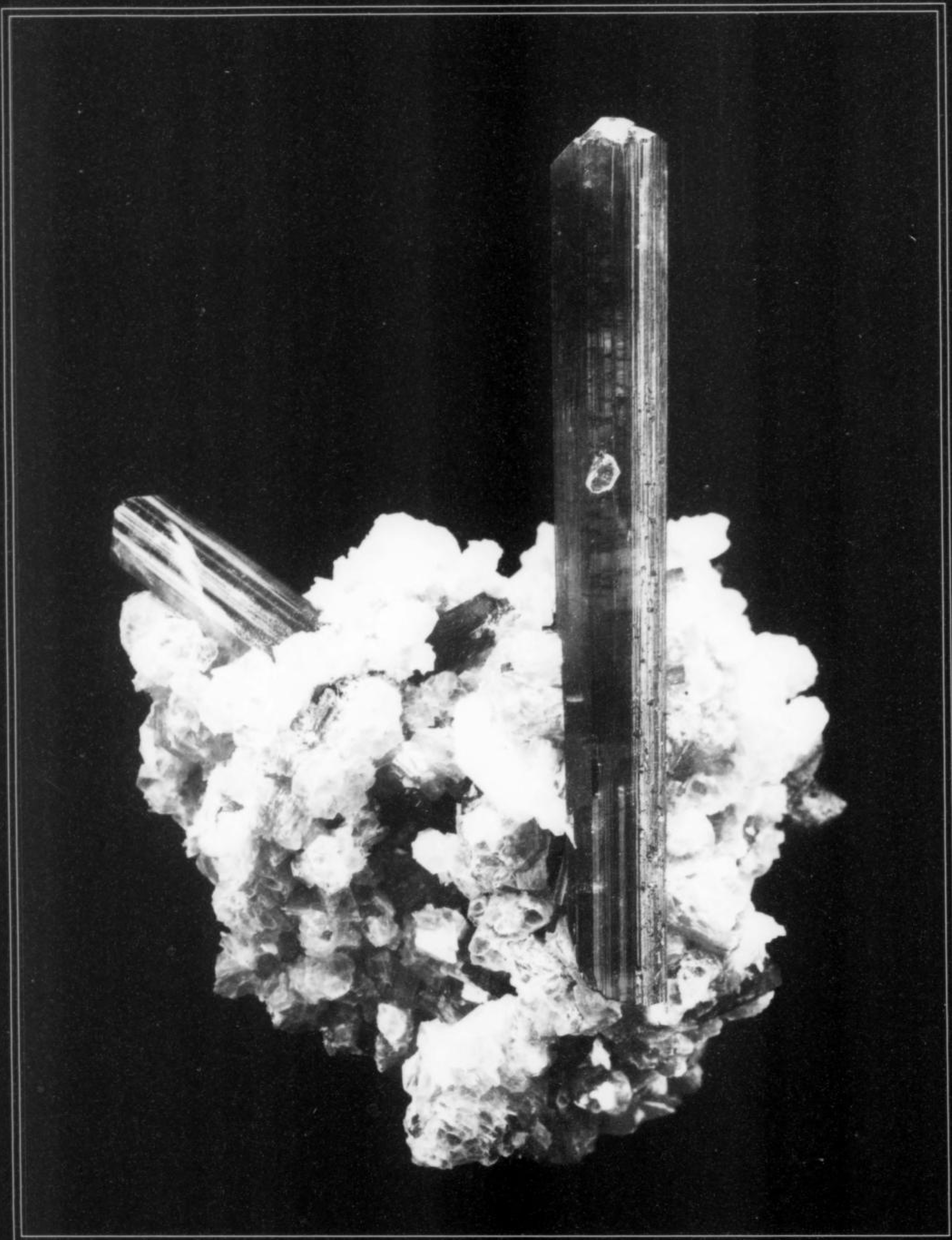
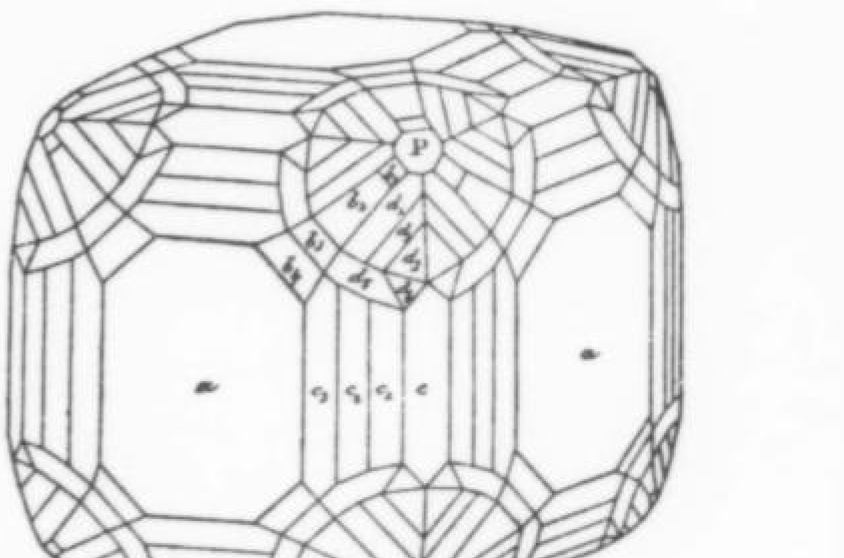


Tourmaline, 12.5 cm, Jonas mine

Calcite, Tsumeb, 5 inches; from Keith Proctor, Feb. 1978

Abstracts of New Mineral Descriptions



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Arakiite — Monoclinic

$(Zn,Mn^{2+})(Mn^{2+},Mg)_{12}(Fe^{3+},Al)_2(As^{3+}O_3)(As^{5+}O_4)_2(OH)_{23}$

Locality: Långban, Värmland, Sweden.

Occurrence: Associated minerals are: hematite (specular), calcite and magnussonite.

General appearance: Aggregates of micaceous plates covering an area of 15 x 10 mm.

Physical, chemical and crystallographic properties: *Luster:* resinous to submetallic. *Diaphaneity:* opaque but translucent on thin edges. *Color:* red-brown to orange-brown. *Streak:* pale brown. *Luminescence:* nonfluorescent. *Hardness:* 3 to 4. *Tenacity:* brittle. *Cleavage:* {001} perfect. *Fracture:* uneven to almost subconchoidal. *Density:* could not be measured because of the small amount of material, 3.41 g/cm³ (calc.). ***Crystallography:*** Monoclinic, *Cc*, *a* 14.248, *b* 8.228, *c* 24.23 Å, β 93.62°, *V* 2843 Å³, Z 4, *a:b:c* = 1.7316:1:2.9448. Morphology: no forms were observed. Twinning: none observed. ***X-ray powder diffraction data:*** 12.07 (100) (002), 6.046 (100) (004), 4.119 (30) (020), 4.040 (90) (006), 3.148 (30) ($\bar{4}04$, $\bar{1}17$), 3.030 (70) (224), 2.411 (40) (424, $\bar{5}15$), 1.552 (70) (640, $\bar{3}51$). ***Optical data:*** Biaxial (−), α 1.723, β 1.744, γ 1.750, 2V(meas.) 40°, 2V(calc.) 56°; dispersion r > v, medium; nonpleochroic; Y = *b*, X ∧ *c* = 4° (in obtuse angle β). ***Chemical analytical data:*** Means of thirteen sets of electron microprobe data: MgO 12.76, MnO 34.32, ZnO 4.48, Al_2O_3 2.25, Fe_2O_3 6.76, As_2O_5 15.84, As_2O_3 6.56, H_2O (13.74), Total (96.71) wt.%. H_2O was calculated assuming stoichiometry. The crystal structure results showed that Mn is Mn^{2+}, Fe is Fe^{3+} and As is present as As^{3+} and As^{5+} in a 1:2 ratio. Empirical formula: $(Zn_{0.83}Mn_{0.17})_{\Sigma 1.00}(Mn_{7.12}Mg_{4.77})_{\Sigma 11.89}(Fe^{3+}_{1.28}Al_{0.67})_{\Sigma 1.95}(As^{3+}O_3)_{1.00}(As^{5+}O_4)_{2.08}(OH)_{22.99}$. ***Relationship to other species:*** The crystal structure resembles that of hematolite.

Name: For Dr. Takaharu Araki (1929–), formerly of the University of Chicago, for his numerous crystal-structure contributions to mineralogy. ***Comments:*** IMA No. 1998-062. Note that the crystal structure has been solved.

ROBERTS, A. C., COOPER, M. A., HAWTHORNE, F. C., GRICE, J. D., and FEINGLOS, M. N. (2000) Arakiite a new As-bearing hematolite-like mineral from Långban, Värmland, Sweden. *Mineralogical Record* **31**, 253–256. COOPER, M. C. and HAWTHORNE, F. C. (1999) The effect of differences in coordination on ordering of polyvalent cations in close-packed structures: the crystal structure of arakiite and comparison with hematolite. *Canadian Mineralogist* **37**, 1471–1482.

Bakhchisaraitsevite — Monoclinic

$Na_2Mg_5[PO_4]_4 \cdot 7H_2O$

Locality: Kovdor massif, southwest Kola Peninsula, Russia (Lat. 67°35′ N, Long. 30°20′ E).

Occurrence: In a mineralized vuggy dolomite carbonatite. Associated minerals are: bobierrite, pyrite, collinsite, "chlorite," nastrophite and juonniite.

General appearance: Fan-shaped aggregates or single bladed tabular crystals (up to 0.5 x 1.5 x 2 mm).

Physical, chemical and crystallographic properties: *Luster:* vitreous. *Diaphaneity:* transparent. *Color:* light yellow, colorless or greenish. *Streak:* white. *Luminescence:* nonfluorescent. *Hardness:* 2 to 2½. *Tenacity:* brittle. *Cleavage:* {001} perfect. *Fracture:* not mentioned. *Density:* 2.50 g/cm³ (meas.), 2.44 g/cm³ (calc.) (given as 2.47 g/cm³). ***Crystallography:*** Monoclinic, $P2_1/c$, *a* 8.324, *b* 12.926, *c* 17.519 Å, β 102.03°, *V* 1844 Å³, Z 4, *a:b:c* = 0.6440:1:1.3553. Morphology: no forms were mentioned. Twinning: none mentioned. ***X-ray powder diffraction data:*** 10.31 (33) (011), 8.56 (100) (002), 3.562 (22) (123), 3.496 (23) ($\bar{1}24$), 3.314 (23) ($\bar{2}04$), 3.020 (28) ($\bar{1}25$), 2.849 (33) (231), 2.675 (25) (125, 232). ***Optical data:*** Biaxial (+), α 1.538, β 1.540, γ 1.543, 2V(meas.) not given, 2V(calc.) 79° (given as 72.5°); X ∧ *c* = 45°, Z = *b*. ***Chemical analytical data:*** Ten sets of electron microprobe data are give. One of these is: Na_2O 9.17, MgO 29.40, CaO 0.07, MnO 0.33, FeO 0.84, P_2O_5 41.57, H_2O (18.62), Total (100.00) wt.%. H_2O was calculated by difference. Empirical formula: $(Na_{2.01}Ca_{0.01})_{\Sigma 2.02}(Mg_{4.95}Fe_{0.08}Mn_{0.03})_{\Sigma 5.06}(PO_4)_{3.97}O_{0.12} \cdot 7.00H_2O$. ***Relationship to other species:*** It is somewhat similar to rimkorolgite, $Mg_5Ba(PO_4)_4 \cdot 8H_2O$.

Name: For Alexander Yu. Bakhchisaraitsev (1947–1998) who studied minerals of the Kola Peninsula for 30 years and discovered eight new mineral species. ***Comments:*** IMA No. 1999-005.

LIFEROVICH, R. P., PAKHOMOVSKY, Ya. A., YAKUBOVICH, O. V., MASSA, W., LAAJOKI, K., GEHÖR, S., BOGDANOVA, A. N., and SOROKHTINA, N. V. (2000) Bakhchisaraitsevite, $Na_2Mg_5[PO_4]_4 \cdot 7H_2O$, a new mineral from hydrothermal assemblages related to phoscorite-carbonatite complex of the Kovdor massif, Russia. *Neues Jahrbuch für Mineralogie, Monatshefte* **2000**, 402–418.

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The Val Graveglia Manganese District *(continued from p. 379)*

PALENZONA, A. (1996) *I nostri minerali. Geologia e mineralogia in Liguria. Aggiornamento 1995. Rivista Mineralogica Italiana*, **2**, 149–172.

PALENZONA, A., GOTELLI, A., and BALESTRA, C. (1990) La tirolite di Cassagna. *Rivista Mineralogica Italiana*, **3**, 151–152.

PALENZONA, A., and ROSSI T. (1991) Goldmanite e yamatoite di Gambatesa. *Rivista Mineralogica Italiana*, **1**, 59–61.

PEACOR, D. R., DUNN, P. J., and STURMAN, B. D. (1978) Marsturite, $Mn_3CaNaHSi_5O_{15}$, a new mineral of the nambulite group from Franklin, New Jersey. *American Mineralogist*, **63**, 1187–1189.

PELLOUX, A. (1919) Appunti di mineralogia ligure. *Mem Soc. Lunigianese G. Cappellini*, La Spezia.

PELLOUX, A. (1934) Tinzenite e parsettensite della miniera di Cassagna (Liguria). *Bollettino della Società Geologica Italiana*, **53**, 235–238.

PIPINO, G. (1983) Ancora oro a Gambatesa. *Rivista Mineralogica Italiana*, **1**, 27–28.

PIPINO, G. (1984) Gambatesa, l'ultima miniera della Liguria. *Rivista Mineralogica Italiana*, **4**, 131–142.

SOCIETA' GEOLOGICA ITALIANA (1994) *Guide Geologiche Regionali: Appennino Ligure-Emiliano*. BEMA Editrice, 240–242.

TISCORNIA, L. B. (1935) *Nel bacino imbrifero dell'Entella. Val di Graveglia. I: Notizie naturali e civili*. Scuola Tipografica Artigianelli, Chiavari.

WEIBEL, M. (1996) *A Guide to the Minerals of Switzerland*. Interscience Publishers/John Wiley & Sons, New York.

Chabazite-Sr — Trigonal

$(Sr,Ca)[Al_2Si_4O_{12}]\cdot 6H_2O$

Locality: Suoluaiv Mountain, Lovozero alkaline massif, Kola Peninsula, Russia.

Occurrence: In a thin aegirine-potassic-feldspar pegmatite cross-cutting nepheline and nosean syenites. Associated minerals are: analcime, gonnardite, vinogradovite, phillipsite, låvenite, seidozerite, fluorapatite, aegirine, potassic feldspar, nepheline, ilmenite, lorenzenite and sodalite.

General appearance: Coarse disk-like crystals (up to 0.3 mm). Open-book-like aggregates are in cavities of corroded analcime crystals.

Physical, chemical and crystallographic properties: *Luster:* vitreous. *Diaphaneity:* transparent. *Color:* colorless or yellowish. *Streak:* white. *Luminescence:* nonfluorescent. *Hardness:* 4 to 4½. *Tenacity:* brittle. *Cleavage:* {101} medium. *Fracture:* rough. *Density:* 2.16 g/cm³ (meas.), 2.25 g/cm³ (calc.). ***Crystallography:*** Trigonal, $R\bar{3}m$, *a* 13.715, *c* 15.09 Å, *V* 2458 Å³, Z 6, *c:a* = 1.1003. Morphology: only {113} was observed. Twinning: on the "phacolite" law. ***X-ray powder diffraction data:*** 9.38 (8) (101), 5.55 (6) (021), 4.34 (7) (211), 2.92 (10) (401), 1.697 (7) (524, 700, 530). ***Optical data:*** Uniaxial (+), ω 1.503, ε 1.507, nonpleochroic. ***Chemical analytical data:*** Electron microprobe data: Na_2O 0.85, K_2O 2.97, CaO 4.79, SrO 10.32, BaO 0.36, Al_2O_3 21.74, SiO_2 40.33, H_2O 18.40, Total 99.76 wt.%. Empirical formula: $(Sr_{0.55}Ca_{0.48}K_{0.35}Na_{.015}Ba_{0.01})_{\Sigma 1.54}(Si_{3.73}Al_{2.37})_{\Sigma 6.10}\cdot 5.68H_2O$. ***Relationship to other species:*** A member of the zeolite group, The Sr-dominant member of the chabazite series.

Name: For the relationship with the chabazite series of zeolites. ***Comments:*** IMA No. 1999-040.

PEKOV, I. V., TURCHKOVA, A. G., CHUKANOV, N. V., ZADOV, A. E., and GRISHIN, V. G. (2000) Chabazite-Sr, (Sr,Ca)-$[Al_2Si_4O_{12}]\cdot 6H_2O$, a new zeolite mineral from Lovozero massif, Kola Peninsula. *Zapiski Vserossiyskogo Mineralogicheskogo Obshchestva* **129(4)**, 54–58.

Dukeite — Trigonal

$Bi^{3+}_{24}Cr^{6+}_8O_{57}(OH)_6\cdot 3H_2O$

Locality: Lavra da Posse, São José de Brejaúba, Conceição do Mato Dentro County, Minas Gerais, Brazil.

Occurrence: Associated minerals are: pucherite, schumacherite, bismutite and hechtsbergite.

General appearance: Tightly bound sheaves of parallel growth acicular crystals (up to 1 mm x 0.3 mm).

Physical, chemical and crystallographic properties: *Luster:* resinous. *Diaphaneity:* translucent (sheaves) to transparent (crystals). *Color:* yellow to dirty yellow-brown. *Streak:* bright yellow. *Luminescence:* nonfluorescent. *Hardness:* 3 to 4 (estimated). *Tenacity:* brittle. *Cleavage:* none observed. *Fracture:* uneven. *Density:* could not be measured, 7.17 g/cm³ (calc.). ***Crystallography:*** Trigonal, *P*31*c*, *a* 15.067, *c* 15.293 Å, *V* 3007 Å³, Z 2, *c:a* = 1.0150. Morphology: no forms were observed; habit acicular. Twinning: none observed. ***X-ray powder diffraction data:*** 7.650 (50) (002), 3.812 (40) (004), 3.382 (100) (222), 2.681 (70) (224), 2.175 (40) (600), 2.106 (40) (226), 1.701 (50) (228). ***Optical data:*** In reflected light: gray to purplish gray with strong yellow internal reflections, anisotropy not observed, bireflectance very weak, nonpleochroic. R_1 & R_2: (17.9, 18.6 %) 470 nm, (16.45, 17.0 %) 546 nm, (16.0, 16.5 %) 589 nm, (15.7, 16.2 %) 650 nm. Calculated indices of refraction are 2.33 and 2.37 at 590 nm. ***Chemical analytical data:*** Means of eight sets of electron microprobe data: Bi_2O_3 85.06, CrO_3 11.65, V_2O_5 0.59, H_2O (1.67), Total (98.97) wt.%. H_2O was calculated assuming the ideal formula. Empirical formula: $Bi^{3+}_{23.95}(Cr^{6+}_{7.64}V^{5+}_{0.43})_{\Sigma 8.07}O_{56.84}(OH)_{6.16}\cdot 3.00H_2O$. ***Relationship to other species:*** None apparent.

Name: For Duke University, Durham, North Carolina, in whose collection the mineral was found and in recognition of the contribution of the Duke family to the advancement of scientific knowledge. ***Comments:*** IMA No. 1999-021.

BURNS, P. C., ROBERTS, A. C., STIRLING, J. A. R., CRIDDLE, A. J., and FEINGLOSS, M. N. (2000) Dukeite, $Bi^{3+}_{24}Cr^{6+}_8O_{57}$-$(OH)_6(H_2O)_3$, a new mineral from Brejaúba, Minas Gerais, Brazil: Description and crystal structure. *American Mineralogist* **85**, 1822–1827.

Ercitite — Monoclinic

$NaMn^{3+}PO_4(OH)\cdot 2H_2O$

Locality: The Tanco pegmatite, Bernic Lake, Manitoba, Canada.

Occurrence: In a lithiophilite nodule embedded in a quartz-spodumene pseudomorph after petalite in the upper intermediate zone (5) of a granitic pegmatite. Associated minerals are: lithiophilite, collinsite-fairfieldite, whitlockite, two unidentified phases, spodumene, quartz, cookeite, rhodochrosite, "apatite" and sphalerite.

General appearance: Irregular aggregates (200 to 400 μm across) of lath-like crystals (generally ≤20 x ≤200 μm).

Physical, chemical and crystallographic properties: *Luster:* vitreous. *Diaphaneity:* transparent. *Color:* pale brown. *Streak:* beige. *Luminescence:* not mentioned. *Hardness:* between 3 and 4. *Tenacity:* brittle. *Cleavage:* {101} and {010} very good. *Fracture:* irregular. *Density:* could not be measured, 2.77 g/cm³ (calc.). ***Crystallography:*** Monoclinic, $P2_1/n$, *a* 5.362, *b* 19.89, *c* 5.362 Å, β 108.97°, *V* 540.8 Å³, Z 4, *a:b:c* = 0.2696:1:0.2696. Morphology: {101}, elongate [$\bar{1}$01] and flattened on {101}. Twinning: none mentioned. ***X-ray powder diffraction data:*** 9.9 (10) (020), 4.92 (5) (011, 110), 3.273 (6) (14$\bar{1}$), 3.126 (6) (150, 051), 2.644 (8) (141), 2.542 (4) (200, 002), 2.376 (4) (17$\bar{1}$). ***Optical data:*** Biaxial (+), α 1.699, β 1.715, γ 1.737, 2V(meas.) 86°, 2V(calc.) 82°; dispersion not mentioned; pleochroism strong X = yellowish green, Y = yellowish brown, Z = very dark brown, absorption Z >> Y > X; X = *b*, Y ∧ *c* = 34° (in acute angle β), Z ∧ *a* = 53° (in obtuse angle β). ***Chemical analytical data:*** Means of four sets of electron microprobe data: Na_2O 12.44, MgO 0.12, CaO 1.09, ZnO 0.08, Al_2O_3 0.34, Fe_2O_3 16.51, Mn_2O_3 18.81, P_2O_5 32.37, H_2O (20.44), Total (102.20) wt.%. H_2O was calculated to give $2H_2O + 1(OH)$ as indicated by the crystal structure results. Empirical formula: $(Na_{0.88}Ca_{0.04})_{\Sigma 0.92}(Mn^{3+}_{0.53}Fe^{3+}_{0.46}Mg_{0.01})_{\Sigma 1.00}(PO_4)_{1.00}(OH)_{1.00}\cdot 2.00H_2O$. ***Relationship to other species:*** It is structurally related to bermanite, $Mn^{2+}Mn^{3+}_2(PO_4)_2(OH)_2\cdot 4H_2O$, and to tsumcorite, $Pb^{2+}(Zn,Fe^{3+})_2(AsO_4)_2(OH,H_2O)$.

Name: For T. Scott Ercit (1957–), Canadian Museum of Nature, an eminent student of the mineralogy of granitic pegmatites. ***Comments:*** IMA No. 1999-036.

FRANSOLET, A.-M., COOPER, M. A., ČERNÝ, P., HAWTHORNE, F. C., CHAPMAN, R., and GRICE, J. D. (2000) The Tanco pegmatite at Bernic Lake, southeastern Manitoba. XV. Ercitite, $NaMn^{3+}PO_4(OH)(H_2O)_2$, a new phosphate mineral species. *Canadian Mineralogist* **38**, 893–898.

Gottlobite — Orthorhombic

$CaMg(VO_4,AsO_4)(OH)$

Locality: On the dump of the long abandoned Glücksstern mine at Gottlob hill, Friedrichroda, Thuringia (Thüringen), Germany.

Occurrence: In hydrothermal barite veins which cut conglomerate. Associated minerals are: hausmannite, barite, vanadian adelite and muscovite.

General appearance: Equant to tabular crystals and equant grains (up to 0.5 mm).

Physical, chemical and crystallographic properties: *Luster:* vitreous to adamantine. *Diaphaneity:* transparent. *Color:* orange to orange-brown. *Streak:* light brownish. *Luminescence:* not mentioned. *Hardness:* 4½. *Tenacity:* brittle. *Cleavage:* none observed. *Fracture:* conchoidal to irregular. *Density:* 3.31 g/cm³ (meas.), 3.40 g/cm³ (calc.) (given as 3.46 g/cm³). ***Crystallography:*** Orthorhombic, $P2_12_12_1$, *a* 7.501, *b* 9.010, *c* 5.941 Å, *V* 401.5 Å³, Z 4, *a:b:c* = 0.8325:1:0.6594. Morphology: {010} dominant, {110}, {011}, {111}, $\{\bar{1}11\}$ and {101}. Twinning: none observed. ***X-ray powder diffraction data:*** 4.496 (72) (020), 4.139 (32) (111), 3.170 (100) (201), 2.785 (30) (130), 2.639 (27) (112), 2.523 (30) (131), 1.614 (41) (332, 133). ***Optical data:*** Biaxial (−) (but the indices indicate +), α 1.797, β 1.805 to 1.815, γ 1.828, 2V(meas.) very large, 2V(calc.) 62° to 80°, dispersion r > v; pleochroism medium strong, X = orange-brown, Y = pale yellowish brown, Z = orange-brown, Z ≥ X > Y; orientation unknown. ***Chemical analytical data:*** Means of nineteen sets of electron microprobe data: CaO 24.98, SrO 0.92, MgO 17.54, MnO 1.50, CuO 1.44, V_2O_5 27.47, As_2O_5 20.32, H_2O 5.40, Total 99.57 wt.%. H_2O by TGA. Empirical formula: $(Ca_{0.92}Sr_{0.02})_{\Sigma 0.94}(Mg_{0.90}Mn_{0.04}Cu_{0.04})_{\Sigma 0.98}[(VO_4)_{0.62}(AsO_4)_{0.36}]_{\Sigma 0.98}[OH)_{0.90}(H_2O)_{0.17}]_{\Sigma 1.07}$. ***Relationship to other species:*** A member of the adelite group.

Name: For the type locality. ***Comments:*** IMA No. 1998-066.

WITZKE, T., STEINS, M., DOERING, T., and KOLITSCH, U. (2000) Gottlobite, $CaMg(VO_4,AsO_4)(OH)$, a new mineral from Friedrichroda, Thuringia, Germany. *Neues Jahrbuch für Mineralogie, Monatshefte* **2000**, 444–454.

Manganonaujakasite — Monoclinic

$Na_6(Mn,Fe)Al_4Si_8O_{26}$

Locality: Lovozero alkaline massif, Kola Peninsula, Russia.

Occurrence: In lovozerite-lomonosovite lujavrites. Associated minerals are: feldspar, sodalite, nepheline, analcime, aegirine, lovozerite, lomonosovite, vuonnemite, lamprophyllite, tisinalite, manaksite, umbozerite, molybdenite and villiaumite.

General appearance: Irregular grains (0.5 to 5 mm across).

Physical, chemical and crystallographic properties: *Luster:* vitreous, pearly on the cleavage. *Diaphaneity:* transparent. *Color:* bright blue. *Streak:* white. *Luminescence:* nonfluorescent. *Hardness:* 5. *Tenacity:* brittle. Cleavage: {001} perfect. *Fracture:* mica-like. *Density:* 2.67 g/cm³ (meas.), 2.71 g/cm³ (calc.). ***Crystallography:*** Monoclinic, *C2/m*, *a* 15.033, *b* 8.001, *c* 10.478 Å, β 113.51°, *V* 1156 Å³, Z 2, *a:b:c* = 1.8789:1:1.3096. Morphology: no forms were mentioned. Twinning: none mentioned. ***X-ray powder diffraction data:*** 3.995 (65) (020, 310), 3.623 (92) (112), 3.552 (56) $(\bar{4}02)$, 3.485 (58) $(\bar{2}03, \bar{2}21)$, 3.362 (33) (202), 3.068 (100) $(022, \bar{3}13, 221)$, 2.613 (39) (420). ***Optical data:*** Biaxial (−), α 1.539, β 1.551, γ 1.554, 2V(meas.) 54°, 2V(calc.) 53°; dispersion r < v, medium; nonpleochroic; Y = b, X ∧ c = 45° (in acute angle β). ***Chemical analytical data:*** Means of five sets of electron microprobe data: Na_2O 19.44, K_2O 0.02, CaO 0.04, SrO 0.01, MnO 3.94, FeO 3.68, Al_2O_3 21.18, TiO_2 0.01, SiO_2 50.76, Total 99.08 wt.%. Empirical formula: $(Na_{5.96}Ca_{0.01})_{\Sigma 5.97}(Mn_{0.53}Fe_{0.49})_{\Sigma 1.02}Al_{3.95}Si_{8.03}O_{26.00}$. ***Relationship to other species:*** The manganese-dominant analogue of naujakasite, $Na_6(Fe,Mn)Al_4Si_8O_{26}$.

Name: For the relationship with naujakasite. ***Comments:*** IMA No. 199-031.

KHOMYAKOV, A. P., NECHELYUSTOV, G. N., FERRARIS, G., and IVALDI, G. (2000) Manganonaujakasite, $Na_6(Mn,Fe)Al_4Si_8O_{26}$, a new mineral from the Lovozero alkaline massif, Kola Peninsula. *Zapiski Vserossiyskogo Mineralogicheskogo Obshchestva* **129(4)**, 48–53.

Paganoite — Triclinic

$NiBi^{3+}As^{5+}O_5$

Locality: Johanngeorgenstadt, Saxony, Germany.

Occurrence: Associated minerals are: quartz, nickeline, bismuth, bunsenite, aerugite, xanthiosite, rooseveltite and two probably new arsenate minerals.

General appearance: Individual crystals (up to 1 mm) and aggregates.

Physical, chemical and crystallographic properties: *Luster:* adamantine. *Diaphaneity:* transparent (crystals) to translucent (aggregates). *Color:* orange-brown to deep golden-brown. *Streak:* very pale orange-brown. *Luminescence:* nonfluorescent. *Hardness:* soft. *Tenacity:* brittle. *Cleavage:* none observed. *Fracture:* uneven. *Density:* could not be measured, 6.71 g/cm³ (calc.). ***Crystallography:*** Triclinic, $P\bar{1}$, *a* 6.7127, *b* 6.8293, *c* 5.2345 Å, α 107.625°, β 95.409°, γ 111.158°, *V* 207.62 Å³, Z 2, *a:b:c* = 0.9829:1:0.7665. Morphology: {100} dominant, {010}, {001} and perhaps {*h*0*l*}. Twinning: none observed. ***X-ray powder diffraction data:*** 3.233 (100) (011), 3.067 (60) $(0\bar{2}1)$, 3.047 (50) (200), 2.116 (50) $(\bar{1}12, 0\bar{3}1, \bar{3}11, \bar{1}\bar{2}2, \bar{2}\bar{3}1)$, 2.095 (40) $(\bar{2}30, 102)$, 1.659 (40) $(\bar{4}20)$. ***Optical data:*** In reflected light, gray with no bireflectance or pleochroism. Under crossed polars the mineral shows dark orange internal reflections. R_1, R_2; ${}^{im}R_1$, ${}^{im}R_2$: (12.85, 13.1; 2.84, 2.99 %) **470** nm, (12.35, 12.6; 2.63, 2.80 %) **546** nm, (12.15, 12.5; 2.57, 2.77 %) **589** nm, (12.0, 12.35; 2.52, 2.73 %) **650** nm. Indices of refraction calculated from the reflectance values in air at 589 nm are 2.07 and 2.09. ***Chemical analytical data:*** Means of two sets of electron microprobe data: NiO 15.37, CoO 2.05, Bi_2O_3 55.06, As_2O_5 28.00, Total 100.48 wt.%. Empirical formula: $(Ni_{0.86}Co_{0.11})_{\Sigma 0.97}Bi_{0.99}As_{1.02}O_{5.00}$. ***Relationship to other species:*** The structure is closely related to that of jagowerite, $BaAl_2P_2O_8(OH)_2$.

Name: For Renato Pagano (1938–) and Adriana Pagano (1939–) of Cinisello, Milan, Lombardy, Italy. This husband and wife team are very competent amateur mineralogists who have made significant contributions to the advancement of specimen mineralogy in Europe for over thirty-five years. ***Comments:*** IMA No. 1999-043. Note that the crystal structure has been solved.

ROBERTS, A. C., BURNS, P. C., GAULT, R. A., CRIDDLE, A. J., FEINGLOS, M. N., and STIRLING, J. A. R. (2001) Paganoite, $NiBi^{3+}As^{5+}O_5$, a new mineral from Johanngeorgenstadt, Saxony, Germany: description and crystal structure. *European Journal of Mineralogy* **13**, 167–175.

Protoferro-anthophyllite Orthorhombic

$(Fe^{2+},Mn^{2+})_2(Fe^{2+},Mg)_5(Si_4O_{11})_2(OH)_2$

Locality: At Hirukawa, Gifu Prefecture, Japan, and in the Cheyenne Mountain area, El Paso County, Colorado, U.S.A.

Occurrence: In pegmatites. Associated minerals are: fayalite, magnetite, quartz, annite, laihunite, and clinoamphiboles (only at the Colorado locality).

General appearance: Acicular crystals up to 3 mm long.

Physical, chemical and crystallographic properties: The usual physical properties (luster, diaphaneity, color, streak, luminescence, hardness, tenacity, cleavage and fracture) are not listed in the paper by Sueno *et al.* (1998). The authors state that another paper by Sueno and Matsuura will be published, but it has not appeared yet. *Density:* 3.54 g/cm^3 (meas.), 3.61 g/cm^3 (calc.) See Comments. ***Crystallography:*** Orthorhombic, Pnmn, a 9.388, b 18.387, c 5.347 Å, V 923.0 Å^3, Z 2, a:b:c = 0.5106:1:0.2908. Morphology: no forms given. Twinning: none mentioned. ***X-ray powder diffraction data:*** None given in the paper by Sueno *et al.* (1998). ***Optical data:*** Biaxial (−), α 1.690, β 1.710, γ 1.726, 2V(meas.) 87°, 2V(calc.) 83°; pleochroism X, Y, Z = pale yellow; orientation, X = a, Y = b, Z = c. ***Chemical analytical data:*** Electron microprobe data (H_2O calculated here to give 2 OH): MgO 0.57, MnO 2.97, FeO 46.63, Al_2O_3 0.33, SiO_2 47.04, H_2O ()1.79, Total (99.33) wt.%. Empirical formula: $(Fe_{1.60}Mn_{0.40})_{\Sigma 2.00}(Fe_{4.90}Mg_{0.10})_{\Sigma 5.00}[(Si_{7.90}Al_{0.07}]_{\Sigma 7.97}O_{22.00}(OH)_{2.00}$. ***Relationship to other species:*** A member of the amphibole group. This amphibole differs from ferro-anthophyllite because it has a different space group.

Name: For the relationship to ferro-anthophyllite. ***Comments:*** IMA No. 86-006. With respect to the densities given above, it is not stated whether the value 3.54 g/cm^3 is the measured or calculated value; it is presumed here that it is the measured value. The 3.61 g/cm^3 value was calculated here from the unit cell parameters and empirical formula.

SUENO, S., MATSUURA, S., GIBBS, G. V., and BOISEN, M. B., Jr. (1998) A crystal chemical study of protoanthophyllite: orthoamphiboles with the protoamphibole structure. *Physics and Chemistry of Minerals* **25**, 366–377.

Protomangano-ferro-anthophyllite Orthorhombic

$(Mn^{2+},Fe^{2+})_2(Fe^{2+},Mg)_5(Si_4O_{11})_2(OH)_2$

Locality: In pegmatites in Suishoyama, Fukushima Prefecture, Japan, and in a manganese mine in Yokoneyama, Tochigi Prefecture, Japan.

Occurrence: Associated minerals are: spessartine, rhodochrosite, pyroxmangite and clinoamphiboles.

General appearance: Prisms and fibrous crystals).

Physical, chemical and crystallographic properties: The usual physical properties (luster, streak, luminescence, hardness, tenacity, cleavage and fracture) are not listed in the paper by Sueno *et al.* (1998) although the color is given as white and the diaphaneity as transparent to opaque. The authors state that another paper by Sueno and Matsuura will be published, but it has not appeared yet. *Density:* 3.44 g/cm^3 (meas.), 3.50 g/cm^3 (calc.). ***Crystallography:*** Orthorhombic, Pnmn, a 9.425, b 18.303, c 5.345 Å, V 922.0 Å^3, Z 2, a:b:c = 0.5149:1:0.2920. Morphology: no forms were observed. Twinning: is not uncommon. ***X-ray powder diffraction data:*** None given in the paper by Sueno *et al.* (1998). ***Optical data:*** Biaxial (−), α 1.695, β 1.714, γ 1.731, 2V(meas.) 76°, 2V(calc.) 86°; pleochroism X, Y, Z = pale yellow; orientation, X = a, Y = b, Z = c. ***Chemical analytical data:*** Electron microprobe data (H_2O calculated here to give 2 OH): MgO 3.69, CaO 0.16, MnO 9.98, FeO 34.44, Al_2O_3 0.17, SiO_2 48.99, H_2O (1.84), Total (99.27) wt.%. Empirical formula: $(Mn_{1.38}Fe_{0.62})_{\Sigma 2.00}(Fe_{4.07}Mg_{0.90}Ca_{0.03})_{\Sigma 5.00}[(Si_{7.98}$-$Al_{0.03}]_{\Sigma 8.01}O_{22.00}(OH)_{2.00}$. ***Relationship to other species:*** A member of the amphibole group. This amphibole differs from members of the anthophyllite series because it has a different space group.

Name: For the relationship to members of the anthophyllite series of the amphibole group. ***Comments:*** IMA No. 86-007.

SUENO, S., MATSUURA, S., GIBBS, G. V., and BOISEN, M. B., Jr. (1998) A crystal chemical study of protoanthophyllite: orthoamphiboles with the protoamphibole structure. *Physics and Chemistry of Minerals* **25**, 366–377.

Rappoldite Triclinic

$Pb(Co,Ni)_2(AsO_4)_2 \cdot 2H_2O$

Locality: The dumps of the Rappold mine near Schneeberg, Saxony, Germany.

Occurrence: On quartz with cobaltlotharmeyerite. Other minerals in the dump material are: cobaltaustinite, scorodite, barium-pharmacosiderite, olivenite, conichalcite, erythrite, arseniosiderite, mimetite, beudantite, silver, bismuth, acanthite, galena, pyrite and skutterudite.

General appearance: Idiomorphic crystals (up to 1 mm long x 0.3 mm in diameter); also as aggregates of tabular crystals.

Physical, chemical and crystallographic properties: *Luster:* given as vitreous but the indices of refraction indicate adamantine. *Diaphaneity:* transparent. *Color:* red to red-brown. *Streak:* light yellow brown. *Luminescence:* nonfluorescent. *Hardness:* 4½. *Tenacity:* brittle. *Cleavage:* none observed. *Fracture:* conchoidal. *Density:* could not be measured, 5.30 g/cm^3 (calc.). ***Crystallography:*** Triclinic, $P\bar{1}$, *a* 11.190, *b* 10.548, *c* 7.593 Å, α 100.38°, β 109.59°, γ 98.96°, *V* 807.6 Å^3, Z 4, *a:b:c* = 1.0609:1:0.7199. Morphology: {210} and {001}, habit prismatic $[\bar{1}20]$. Twinning: none mentioned. ***X-ray powder diffraction data:*** 4.670 (97) $(\bar{2}11)$, 3.256 (100) $(022, \bar{2}12)$, 3.072 (56) (211), 2.890 (40) $(2\bar{3}1, \bar{2}31)$, 2.760 (37) (401, 231), 2.568 (46) $(022, \bar{4}02, 23\bar{2}, 400, 230)$, 1.731 (38) $(0\bar{6}1, 44\bar{1}, 004, 42\bar{4})$. ***Optical data:*** Biaxial (+), α 1.85 (calc.), β 1.87, γ 1.90, 2V(meas.) 85°, dispersion r > v, distinct; nonpleochroic; Y ~ $[\bar{1}20]$, X ~ *c*. ***Chemical analytical data:*** Means of eleven sets of electron microprobe data: PbO 35.27, CaO 0.12, CuO <0.05, ZnO 4.52, CoO 11.60, NiO 7.31, Al_2O_3 <0.05, Fe_2O_3 0.28, Bi_2O_3 0.11, As_2O_5 35.82, SO_3 0.11, H_2O (5.62), Total (100.76) wt.%. Empirical formula: $(Pb_{1.02}Ca_{0.01})_{\Sigma 1.03}(Co_{0.98}Ni_{0.62}Zn_{0.35}$-$Fe_{0.02})_{\Sigma 1.97}[(AsO_4)_{1.98}(SO_4)_{0.01}]_{\Sigma 1.99}[(OH)_{0.06}(H_2O)_{1.96}]_{\Sigma 2.02}$. ***Relationship to other species:*** It is a member of the tsumcorite group, specifically the Co-dominant analogue of helmutwinklerite.

Name: For the locality. ***Comments:*** IMA No. 1998-015. The crystal structure has been solved.

EFFENBERGER, H., KRAUSE, W., BERNHARDT, H.-J., and MARTIN, M. (2000) On the symmetry of tsumcorite group minerals based on the new species rappoldite and zincgartrellite. *Mineralogical Magazine* **64**, 1109–1126.

Tamaite

Monoclinic

$(Ca,K,Ba,Na)_{3-4}Mn_{24}(Si,Al)_{40}(O,OH)_{112} \cdot 21H_2O$

Locality: The Shiromaru mine, Okutama, Tama district, Tokyo, Japan (Lat. 35°48′30″ N, Long. 139°7′30″ E), about 60 km WNW of the center of Tokyo.

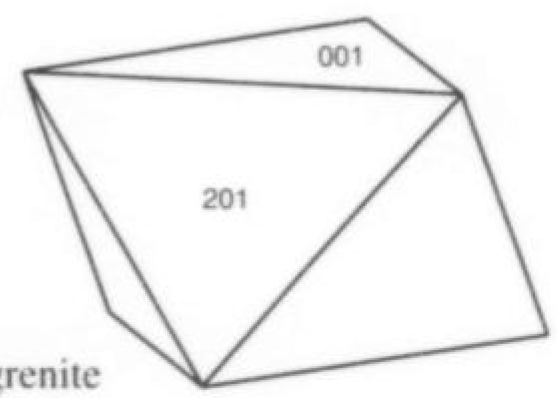
Occurrence: In a weakly metamorphosed manganese ore deposit. Associated minerals are: celsian, barian orthoclase, aegirine, manganoan grossular, native copper, strontiopiemontite, eggletonite and ganophyllite.

General appearance: Veinlets up to 1.5 mm thick composed of micaceous platy crystals less than 0.5 mm in diameter. Also as spotted crystals about 0.1 mm in diameter in veinlets.

Physical, chemical and crystallographic properties: *Luster:* vitreous to pearly. *Diaphaneity:* transparent. *Color:* colorless to pale yellowish brown. *Streak:* white. *Luminescence:* nonfluorescent. *Hardness:* approximately 4 parallel to the cleavage. *Tenacity:* not mentioned. *Cleavage:* {001} perfect. *Fracture:* not mentioned. *Density:* 2.85 g/cm³ (meas.), 2.83 g/cm³ (calc.). ***Crystallography:*** Monoclinic, $P2_1/a$, *a* 16.64, *b* 27.11, *c* 25.35 Å, β 98.47°, *V* 11302.9 Å³, Z 4, *a:b:c* = 0.6138:1:0.9351. Morphology: no forms were observed. Twinning: none mentioned. ***X-ray powder diffraction data:*** 12.6 (vvs) (002), 3.13 (s) (008), 2.84 (s) ($38\bar{2}$), 2.69 (vs) ($38\bar{4}$), 2.60 (s) (602), 2.46 (s) ($60\bar{6}$, $38\bar{6}$). ***Optical data:*** Biaxial (−), β 1.612, 2V(meas.) small. ***Chemical analytical data:*** Means of four sets of electron microprobe data: Na_2O 0.34, K_2O 0.82, MgO 0.23, CaO 1.94, MnO 35.17, FeO 0.16, BaO 2.03, Al_2O_3 7.79, SiO_2 41.23, H_2O 11.07, Total 100.78 wt.%. Empirical formula: $(Ca_{1.65}K_{0.83}Ba_{0.63}Na_{0.52})_{\Sigma 3.63}(Mn_{23.70}Mg_{0.27}Al_{0.12}Fe_{0.11})_{\Sigma 24.20}(Si_{32.81}Al_{7.19})_{\Sigma 40.00}[O_{95.26}(OH)_{16.74}]_{\Sigma 112.00} \cdot 21.00H_2O$. ***Relationship to other species:*** It is the calcium-dominant analogue of ganophyllite, $(K,Na)_6(Mn,Al,Mg)_{24}(Si,Al)_{40}(O,OH)_{112} \cdot 21H_2O$.

Name: For the locality. ***Comments:*** IMA No. 1999-011.

MATSUBARA, S., MIYAWAKI, R., TIBA, T., and IMAI, H. (2000) Tamaite, the Ca-analogue of ganophyllite, from the Shiromaru mine, Okutama, Tokyo, Japan. *Journal of Mineralogical and Petrological Sciences* **95**, 79–83.



Tegengrenite

Tegengrenite

Trigonal

$(Mg,Mn)_2Sb^{5+}_{0.5}(Mn^{3+},Si,Ti)_{0.5}O_4$

Locality: Jakobsberg, Filipstad district, Värmland, Sweden (Lat. 59.83° N, Long. 14.11° E).

Occurrence: In a manganese-iron deposit in marble. Associated minerals are: hausmannite, calcite, brucite, dolomite, clinohumite, kinoshitalite, copper, barytocalcite, bindheimite and cerussite.

General appearance: Euhedral to subhedral crystals (up to 1 mm across).

Physical, chemical and crystallographic properties: *Luster:* subadamantine. *Diaphaneity:* translucent. *Color:* deep ruby red. *Streak:* not given. *Hardness:* not given. *Tenacity:* not given. *Cleavage:* none observed. *Fracture:* conchoidal. *Density:* could not be measured, 4.58 g/cm³ (calc.). ***Crystallography:*** Trigonal, *R*3 or $R\bar{3}$, *a* 16.196, *c* 14.948 Å, *V* 3395.7 Å³, Z 42, *c:a* = 0.9229. Morphology: pseudo-octahedra probably consisting of {001} and {201}. Twinning: the pseudo-octahedra consist of eight twin domains. ***X-ray powder diffraction data:*** 4.98 (20) (211, 003), 3.052 (33) (140, 214), 2.608 (100) (241, 143, 125), 2.162 (28) (244), 1.6652 (30) (363, 075), 1.5313 (26) (820), 1.5273 (29) (428). ***Optical data:*** In reflected light: gray, practically isotropic, orange-red internal reflections sometimes seen. R: (10.4 %) 470nm, (10.0 %) 546nm, (9.9 %) 589nm, (9.8 %) 650nm. ***Chemical analytical data:*** Means of 35 sets of electron microprobe data: MgO 21.83, MnO 25.76, ZnO 2.66, Al_2O_3 0.76, Mn_2O_3 8.12, Fe_2O_3 0.78, SiO_2 1.70, TiO_2 1.40, Sb_2O_5 36.13, Total 99.14 wt.%. Empirical formula: $(Mg_{1.22}Mn^{2+}_{0.82}Zn_{0.07})_{\Sigma 2.11}Sb^{5+}_{0.50}(Mn^{3+}_{0.23}Si_{0.06}Ti_{0.04}Al_{0.03}Fe^{3+}_{0.02})_{\Sigma 0.38}O_{4.00}$. ***Relationship to other species:*** It is chemically related to filipstadite, $Mn_2(Sb^{5+}_{0.05}Fe^{3+}_{0.05})O_4$, and both are structurally related to spinel.

Name: For Felix Tegengren (1884–1980), a renowned Finlandic-Swedish economic geologist who wrote large volumes on the ore deposits of Sweden and China. ***Comments:*** IMA No. 1999-002. The drawing given here is based on the probable forms {001} and {201} which produce a pseudo-octahedron.

HOLTSTAM, D. and LARSSON, A.-K. (2000) Tegengrenite, a new, rhombohedral spinel-related Sb mineral from the Jakobsberg Fe-Mn deposit, Värmland, Sweden. *American Mineralogist* **85**, 1315–1320.

Tumchaite

Monoclinic

$Na_2(Zr,Sn)Si_4O_{11} \cdot 2H_2O$

Locality: The Vuoriyarvi massif on the north shore of Vuoriyarvi Lake, North Karelia, Murmansk Region, Russia.

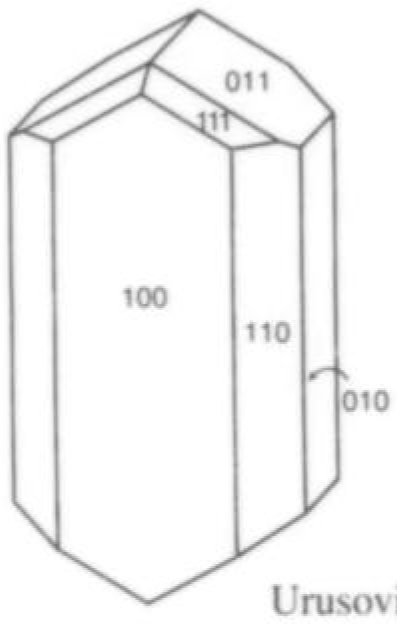
Occurrence: In a sample from a bore hole which crosscuts veined dolomite-calcite carbonatites. Associated minerals are: calcite, dolomite, a serpentine group mineral and pyrite.

General appearance: Tabular crystals (up to 0.2 x 1.2 x 2.5 mm).

Physical, chemical and crystallographic properties: *Luster:* vitreous. *Diaphaneity:* transparent to translucent. *Color:* colorless to white. *Streak:* white. *Luminescence:* nonfluorescent. *Hardness:* VHN_{40} 410 kg/mm², Mohs close to 4½. *Tenacity:* very brittle. *Cleavage:* {100} perfect. *Fracture:* uneven. *Density:* 2.78 g/cm³ (meas.), 2.77 g/cm³ (calc.). ***Crystallography:*** Monoclinic, $P2_1/c$, *a* 9.144, *b* 8.818, *c* 7.537 Å, β 113.22°, *V* 558.49 Å³, Z 2, *a:b:c* = 1.0370:1:0.8547. Morphology: {100}, {h0l}, {hkl}; tabular on {100} and elongated along [001]. Twinning: on {100}. ***X-ray powder diffraction data:*** 8.40 (10) (100), 5.38 (9) ($11\bar{1}$), 4.00 (8) (111), 3.401 (9) ($20\bar{2}$), 2.902 (9) (211), 2.772 (7) ($30\bar{2}$), 2.691 (9) ($13\bar{1}$), 2.190 (7) ($31\bar{3}$, $41\bar{1}$). ***Optical data:*** Biaxial (−), α 1.570, β 1.588, γ 1.594, 2V(meas.) 60°, 2V(calc.) 59°; pleochroism X = greenish gray, Y = Z = colorless; Y = *b*, Z ∧ *c* = 3°. ***Chemical analytical data:*** Six crystals were analyzed by electron microprobe (6 to 10 analyses per crystal). The data from one crystal are: Na_2O 13.72, CaO 0.15, MnO <0.02, FeO <0.02, Y_2O_3 <0.1, SiO_2 52.71, TiO_2 0.35, ZrO_2 20.41, SnO_2 5.73, HfO_2 0.60, Nb_2O_5 <0.05, H_2O (7.86), Total (101.53) wt.%. H_2O was calculated to give $2(H_2O)$. Empirical formula: $(Na_{2.03}Ca_{0.01})_{\Sigma 2.04}(Zr_{0.76}Sn_{0.17}Ti_{0.02}Hf_{0.01})_{\Sigma 0.96}Si_{4.02}O_{11.00} \cdot 2.00H_2O$. ***Relationship to other species:*** Isostructural with penkvilksite-1*M* and is chemically related to vlasovite.

Name: For the Tumcha River, near the Vuoriyarvi massif. ***Comments:*** IMA No. 1999-041.

SUBBOTIN, V. V., MERLINO, S., PUSHCHAROVSKY, D. Yu., PAKHOMOVSKY, Ya. A., FERRO, O., BOGDANOVA, A. N., VOLOSHIN, A. V., SOROKHTINA, N. V., and ZUBKOVA, N. V. (2000) Tumchaite $Na_2(Zr,Sn)Si_4O_{11}\cdot 2H_2O$—A new mineral from carbonatites of the Vuoriyarvi alkali-ultrabasic massif, Murmansk Region, Russia. *American Mineralogist* **85**, 1516–1520.



Urusovite

Urusovite — Monoclinic

$Cu[AlAsO_5]$

Locality: The North Breach of the great fissure Tolbachik eruption (1975-1976), Kamchatka Peninsula, Russia.

Occurrence: A product of fumarolic activity in the second cinder cone of the North Breach. Associated minerals are: ponomarevite, piypite, sylvite and lesser amounts of dolerophanite, euchlorine, tenorite, hematite and two unknown As-bearing minerals.

General appearance: Light green plates (up to 0.4 mm).

Physical, chemical and crystallographic properties: *Luster:* vitreous. *Diaphaneity:* transparent. *Color:* light green. *Streak:* white. *Luminescence:* nonfluorescent. *Hardness:* VHN_{10} 378 kg/mm^2. *Tenacity:* brittle. *Cleavage:* {100} perfect. *Fracture:* not mentioned. *Density:* could not be measured, 3.97 g/cm^3 (calc.). ***Crystallography:*** Monoclinic, $P2_1/c$, *a* 7.314, *b* 10.223, *c* 5.576 Å, β 99.79°, *V* 410.9 Å^3, Z 4, *a:b:c* = 0.7154:1:0.5454. Morphology: {100}, {010}, {110}, {010}, {111}. Twinning: none mentioned. ***X-ray powder diffraction data:*** 7.20 (100) (100), 4.844 (9) (011), 4.327 (23) ($\bar{1}11$), 3.604 (10) (200), 3.174 (10) (121), 3.125 (20) ($\bar{2}11$), 2.458 (8) (221). ***Optical data:*** Biaxial (−), α 1.672, β 1.718, γ 1.722, 2V(meas.) ~30°, 2V(calc.) 32°; slight pleochroism X = colorless, Y = light green, Z = light green; X ~ *c*, Y = *b*, Z ∧ *a* ~ 10°. ***Chemical analytical data:*** Means of fifteen sets of electron microprobe data: CuO 32.23, ZnO 0.25, Al_2O_3 20.89, Fe_2O_3 0.32, As_2O_5 46.02, V_2O_5 0.10, Total 99.81 wt.%. Empirical formula: $(Cu_{1.00}Zn_{0.01})_{\Sigma 1.01}(Al_{1.01}Fe_{0.01})_{\Sigma 1.01}As_{0.98}O_{5.00}$. ***Relationship to other species:*** None apparent.

Name: For Vadim Sergeevich Urusov (1936–), crystal chemist, Corresponding Member of the Russian Academy of Sciences and chair of the Department of Crystallography and Crystal Chemistry of Moscow State University. ***Comments:*** IMA No. 1998-067. Note that the crystal structure has been solved. The crystal drawing produced here is slightly different from that given in the paper which appears to depart slightly from the standard orientation.

VERGASOVA, L. P., FILATOV, S. K., GORSKAYA, M. G., MOLCHANOV, A. A., KRIVOVICHEV, S. V., and ANANIEV, V. V. (2000) Urusovite, $Cu[AlAsO_5]$, a new mineral from the Tolbachik volcano, Kamchatka, Russia. *European Journal of Mineralogy* **12**, 1041–1044. KRIVOVICH, S. V., MOLCHANOV, A. A., and FILATOV, S. K. (2000) The crystal structure of $Cu[AlAsO_5]$: a novel type of aluminoarsenate tetrahedral polyanion. *Crystallographic Reports* (in press).

Vergasovaite — Orthorhombic

$Cu_3O[(Mo,S)O_4](SO_4)$

Locality: The fumarole "Treschina" in the northern part of the central fumarole field of cone II of the Northern Break of the Large Tolbachik Fissure Eruption, Kamchatka Peninsula, Russia.

Occurrence: Formed by sublimation from fumarole gases (temperatures 150 to 170°C). Associated minerals are: chalcocyanite, dolerophanite, euchlorine, fedotovite, tenorite, cuprian anglesite and gold. It forms directly on chalcocyanite and dolerophanite.

General appearance: Rare single crystals (up to 0.3 mm) and as intergrown crystals forming radiating aggregates (up to 0.6 mm).

Physical, chemical and crystallographic properties: *Luster:* given as vitreous, but the optical data indicate adamantine. *Diaphaneity:* transparent. *Color:* olive-green. *Streak:* light yellow. *Luminescence:* non-fluorescent. *Hardness:* VHN_{25} 357 kg/mm^2, Mohs 4 to 5 (measurements subparallel to (010) gave 5 to 5½). *Tenacity:* brittle. *Cleavage:* not observed. *Fracture:* uneven. *Density:* could not be determined, 4.39 g/cm^3 (calc.). ***Crystallography:*** Orthorhombic, *Pnma*, *a* 7.420, *b* 6.741, *c* 13.548 Å, *V* 677.6 Å^3, Z 4, *a:b:c* = 1.1007:1:2.0098. Morphology: the following forms were observed {010}, {110}, {120}, {130}, {111}, {263}, {315}. Twinning: none mentioned. ***X-ray powder diffraction data:*** 3.591 (60) (020), 3.342 (60) (113), 3.077 (100) (104), 2.542 (60) (105, 123), 2.500 (60) (220), 2.275 (60) (124). ***Optical data:*** Optical character unknown, indices of refraction are higher than 1.9; pleochroic with *c* = olive-green and the direction perpendicular to *c* = yellowish to brownish green; orientation not given. In reflected light: gray with ubiquitous light green to colorless internal reflections, anisotropism masked by the internal reflections, bireflectance measurable but not discernible, pleochroism absent. R_1, R_2: (9.85, 11.69) **470** nm, (9.4, 11.01) **546** nm, (9.22, 10.76) **589** nm, (9.00, 10.48) **650** nm. ***Chemical analytical data:*** Means of 18 sets of electron microprobe data (9 for PbO): CuO 49.81, ZnO 1.76, PbO 0.63, SO_3 21.44, MoO_3 25.29, V_2O_5 0.88, Total 99.81 wt.%. Empirical formula:$(Cu_{2.81}Zn_{0.10}Pb_{0.01})_{\Sigma 2.92}O_{1.00}[(Mo_{0.79}S_{0.20}V_{0.04})_{\Sigma 1.03}O_{4.00}](SO_4)$. ***Relationship to other species:*** It is the first known mineral which contains Cu, Mo, S and O as its main elements and it is isotypic with synthetic $Cu_3O(MoO_4)_2$.

Name: For Dr. Lidia Pavlovna Vergasova (1941–), Institute of Volcanology of the Russian Academy of Sciences, Petropavlovsk-Kamchatskii, Russia, in recognition of her contributions to the mineralogy of volcanic exhalates of Kamchatka in general and to the mineralogy of the Tolbachik region in particular. ***Comments:*** IMA No. 98-009.

BYKOVA, E. Y., BERLEPSCH, P., KARTASHOV, P. M., BRUGGER, J., ARMBRUSTER, T., and CRIDDLE, A. J. (1998) Vergasovaite $Cu_3O[(Mo,S)O_4][SO_4]$. *Schweizerische mineralogische und petrographische Mitteilungen* **78**, 479–488.

Wadalite

Cubic

$Ca_6Al_5Si_2O_{16}Cl_3$

Locality: The type locality is at Koriyama, Fukushima Prefecture, Japan, but the complete description of material from that locality has not been published yet. A second locality is La Negra mine, Queretaro, Mexico, and most of the data presented here are from that occurrence.

Occurrence: The mineral occurs at both localities in skarns. Associated minerals are: spurrite, rustumite, hydrogrossular, andradite, calcite, magnetite and perovskite.

General appearance: Granular crystals (less than 200 μm).

Physical, chemical and crystallographic properties: *Luster:* vitreous. *Diaphaneity:* transparent. *Color:* colorless. *Streak:* white. *Luminescence:* not mentioned. *Hardness:* not given. *Tenacity:* not given. *Cleavage:* not given. *Fracture:* not given. *Density:* not measured, 3.08 g/cm^3 (calc.). ***Crystallography:*** Cubic, I43d, a 12.014 Å, V 1734 Å^3, Z 4. Morphology: no forms were observed. Twinning: none mentioned. ***X-ray powder diffraction data:*** 4.903 (16) (211), 3.003 (42) (400), 2.686 (100) (420), 2.452 (39) (422), 2.355 (18) (510), 2.193 (17) (521), 1.665 (25) (640); these data are calculated from single crystal data. ***Optical data:*** Isotropic, n 1.708. ***Chemical analytical data:*** Thirteen sets of electron microprobe data are given; the means of seven sets of the data are: Na_2O 0.04, K_2O 0.00, MgO 3.06, CaO 42.04, MnO 0.03, Al_2O_3 21.08, Fe_2O_3 3.36, TiO_2 0.16, SiO_2 19.87, Cl 12.81, sum 102.45, less O = Cl 2.89, Total 99.56 wt.%. Empirical formula: $Ca_{6.05}(Al_{3.33}Si_{2.67}Mg_{0.61}Fe_{0.34}Ti_{0.02}Na_{0.01})_{\Sigma 6.98}O_{16.09}Cl_{2.91}$. ***Relationship to other species:*** None apparent.

Name: For Tsunashiro Wada (1856–1920), first Director General of the Geological Survey of Japan. ***Comments:*** IMA No. 87-045. The empirical formula and calculated density given here are somewhat different from those given by Kanazawa *et al.* (1997). The published information for this mineral has an interesting history. The crystal structure and some other properties of wadalite were given in the paper by Tsukimura *et al.* (1993). The first formal description of the mineral, from a locality other than the type locality, was published by Kanazawa *et al.* (1997). The following data for type material appears in the paper by Kanazawa *et al.* (1997): a 12.001 Å, V 1729 Å^3, density 3.01 g/cm^3 (meas.), 3.056 g/cm^3 (calc.). Unfortunately, the full description of the type material has not been published.

TSUKIMURA, K., KANAZAWA, Y., AOKI, M., and BUNNO, M. (1993) Structure of Wadalite $Ca_6Al_5Si_2O_{16}Cl_3$. *Acta Crystallographica* **C49**, 205–207. KANAZAWA, Y., AOKI, M., and TAKEDA, H. (1997) Wadalite, rustumite, and spurrite from La Negra mine, Queretaro, Mexico. *Bulletin of the Geological Survey of Japan* **48(7)**, 413–420.

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