the Mineralogical Record

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March–April 2001
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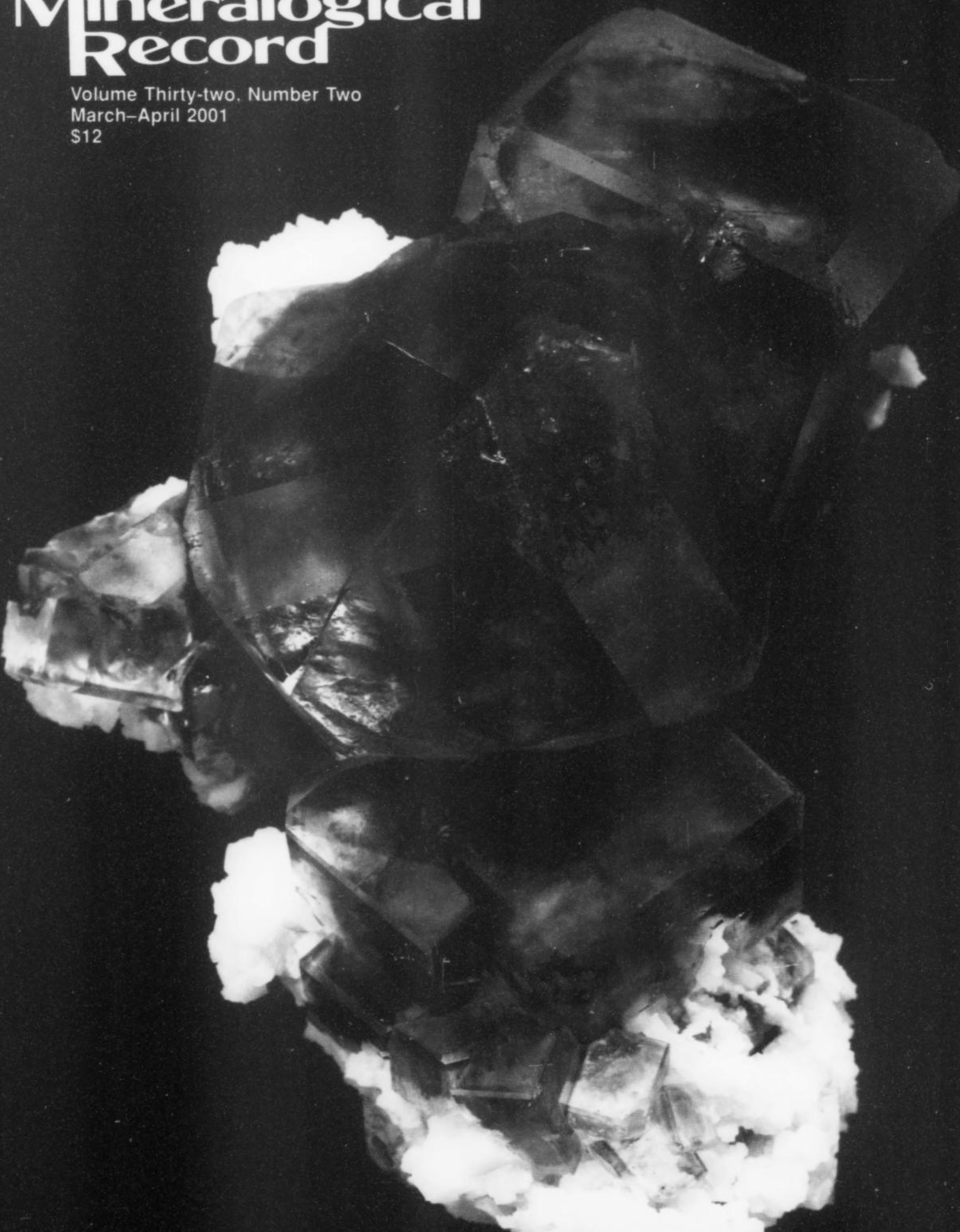

Editing, advertising
4631 Paseo Tubutama
Tucson, AZ 85750
520-299-5274 • FAX: 520-299-5702
E-mail: minrec@earthlink.net

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*Continued on p. 167

THE MINERALOGICAL RECORD

March–April 2001 Volume Thirty-two, Number Two

Articles

Columns

COVER: FLUORITE crystal group, 8.1 cm, from the Shangbao mine, Hunan, China. *Collector's Edge Minerals* specimen; Jeff Scovil photo.

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notes from the EDITOR

FILER COLLECTION

Most people involved in mineral collecting are acquainted with Russell and Alexandra Filer of *Filer's Minerals* in California. Alexandra, now a feisty 85 years old, became the country's first female graduate in Metallurgical Engineering (according to the A.I.M.E.) in 1938. The daughter of a mining family, she has maintained an intense interest in minerals and mining throughout her long life. One of her pursuits in this regard was the collecting of old mining stock certificates, a collection which grew to more than 3,000 items. Last year that extraordinary collection was auctioned off in three parts by *Fred Holabird Americana*, 3555 Airway Dr., #308, Reno, NV 89511 (Ph. 775-852-8822). The three thick auction catalogs illustrate every certificate, some in color, and give a historical background for each mine or mining venture. These catalogs, still available while supplies last at $25 each postpaid, constitute an invaluable reference on mining stock certificates and their current value. We are having our copies hardbound together for the Record Library. If you have an interest in this area, be sure to get copies of the catalogs from Fred Holabird before he runs out.

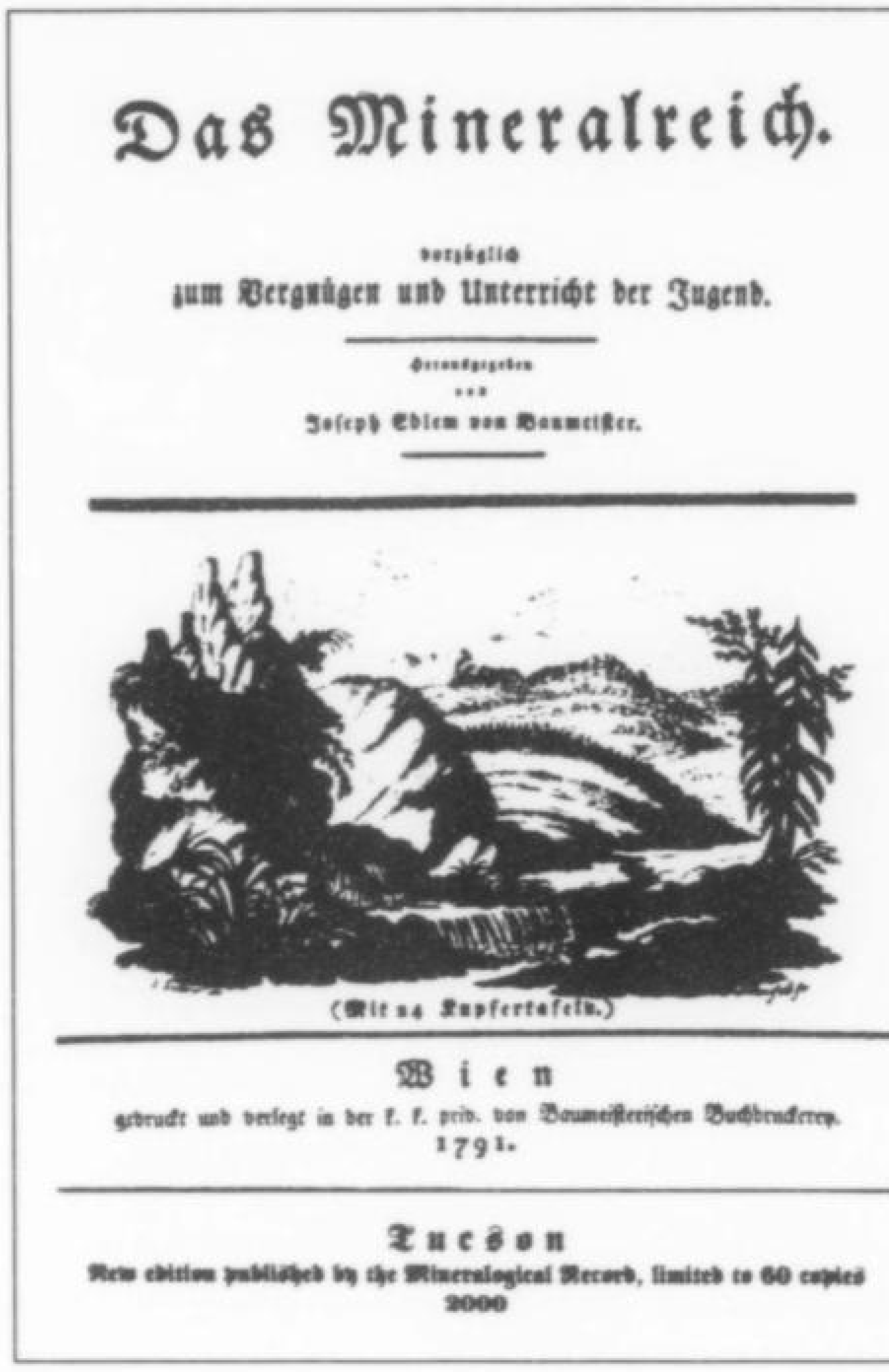
Speaking of stock certificate auctions, Fred Holabird will soon be auctioning off the James Garbani collection of over 1200 Arizona stock certificates plus prospectuses and other ancillary paper, maps, etc. The collection includes many pre-1900 certificates and over a dozen from the critical 1863–1864 period. Once again, if you collect certificates be certain to contact Fred for a catalog, copies of which are *free* (bless him) prior to the auction.

MONT SAINT-HILAIRE

For those who enjoyed our special Mont Saint-Hilaire Issue (vol. 21, no. 4, still available for $12), and are still craving more, the Italian journal *Rivista Mineralogica Italiana* has recently published an entire issue (July-September 2000) devoted to Mont Saint-Hilaire. The new article is by László and Elsa Horváth, who wrote (with Bob Gault) our Mont Saint-Hilaire issue; László ("Les") is also a co-author of the big article on Rudabánya in this issue. Individual copies of the Italian issue, which includes an English summary and many new photos, can be obtained for $15 from Renato Pagano, P.O. Box 37, I-20092, Cinisello, Italy; his E-mail address is renpagan@tin.t. Renato and his wife, Adriana, speak excellent English, and represent the *Mineralogical Record* in our booth each year at the Munich Show. The October-December 2000 issue of *Rivista Mineralogica Italiana* carries an article on the Paganos' superb collection of minerals, antique mineralogical instruments, and antiquarian mineralogy books, some of which were recently exhibited in a special showing at the Municipal Palace in Cremona, Italy.

ANTIQUARIAN REPRINTS

We recently completed publication of the eleventh edition in our Antiquarian Reprint Series, a project aimed at saving from extinction some very rare, old, illustrated mineral books. This time around we reprinted Joseph Baumeister's *Mineralreich* (1791), a work so rare as to be practically unknown.


Das Mineralreich.
vorzüglich
zum Vergnügen und Unterricht der Jugend.
Herausgegeben
von
Joseph Edlem von Baumeister.
(Mit 24 Kupfertafeln.)
Wien
gedruckt und verlegt in der k. k. priv. von Baumeisterischen Buchdruckerey.
1791.
Tucson
New edition published by the Mineralogical Record, limited to 60 copies
2000

Through a stroke of luck we managed to obtain an original copy in which the 24 plates depicting mineral specimens are uncolored; it *also* included, unbound, a set of 24 hand-colored artist's master plates intended to be copied by production-line colorists. Consequently our reprint includes each plate in both colored and uncolored state; also included are (1) a new introduction and biography of Baumeister, in English, (2) translated figure captions for all plates, and (3) a full facsimile reprint of the German text. As usual, it is printed on archival, 100%-cotton, 24-pound paper and bound in bonded leather boards with a calfskin spine. The edition, at $290 per copy, is limited to 60 copies; we *may* have one or two left by press time, but I can't guarantee it. If you would like to be on our advance notification list for the next book in the series, just send your name and address to the editor and ask to be placed on the list.

SMALE MINERALS

In this issue we begin a third year featuring a mineral specimen in each issue from the beautiful collection of Steve and Clara Smale. Some readers are a little confused about these, thinking that he must be selling specimens, but noting that he gives no address or contact information. Steve does indeed pay for each page as if it were an ad, but his main purpose is simply to share with readers some of his specimens; in that respect, his "ads" are unique, more like a serialized photo feature. A biography of Steve, along with photos (by him) of many of his specimens, appeared in vol. 23, no. 5. As of this writing, Steve is still on a multi-year sabbatical teaching mathematics at the City University of Hong Kong, and getting first grab at some truly extraordinary Chinese specimens for his collection. He can be reached by E-mail at masmale@math.cityu.edu.hk.

CORRECTION

In this column in the previous issue we erroneously gave Bill Smith's former title at the National Security Agency as "Deputy Director"; he was, instead, "Office Chief."

The Friends of Mineralogy, Inc.

Who We Are:

Vol 1, No 1, Mineralogical Record, Spring 1970
The *Friends of Mineralogy* was founded in Tucson, Arizona, on February 13, 1970. Its objectives were to promote better mineral appreciation, education and preservation. The chief aims and activities of *FM* include:

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

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

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(302) 731-8407 e-mail: 25628@udel.edu

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Fax: (904) 822-7328
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E-Mail: vwlueth@nmt.edu
Fax: (505) 835-6333
Associate Curator: Robert Eveleth
Tel: (505) 835-5325
E-mail: beveleth@gis.nmt.edu
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Socorro, NM 87801
Hours: 8–5 M–F, 10–3 Sat., Sun
Specialties: New Mexico minerals, mining artifacts, worldwide minerals

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Hours: 8:30-5 Daily (Oct.-Feb.)
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Send vital information, as shown, to the editor. There is a modest annual fee (lower than our regular advertising rates).

Museums listed alphabetically by city

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H-3539 Miskolc - Egyetemváros, Hungary

The only famous classic mineral locality in present-day Hungary, Rudabánya has a long and interesting history. Beginning in the Bronze Age, and for thousands of years after, the deposit was mined for copper, silver, lead and iron. More than 120 minerals have been identified from this mine, but as a mineral locality it is best known for superb crystallized copper, azurite, cuprite and malachite specimens.

INTRODUCTION

The town of Rudabánya is in northeastern Hungary, 35 km north of the city of Miskolc in Borsod-Abaúj-Zemplén county, and approximately 195 km east-northeast of Budapest. This region is characterized by low (200–300 meter-high) rounded hills—the northeastern extension of the Bükk Mountains—and wide valleys. The hills surrounding the town are partially wooded; the gently

Figure 1. **Seal of the town of Rudabánya ca. 1330. The 71-mm diameter silver seal may be the earliest to show the hammer and miner's wedge that eventually became the universal symbol of mining. Nemzeti Múzeum Collection, Budapest.**

Figure 2. **Location map.**

sloping hillsides are a mixture of pasture and farmland, and the southerly slopes are sprinkled with small fruit-orchards and vineyards. Many of these small plots of agricultural land have been worked for centuries and still are by the miners and their families. The current town population is about 3300, and has been declining since 1985 due to lack of employment caused by the closure of the iron ore mine, ore concentration plant, and many small coal mines in the district. During its operation, the mine was the town's main employer, at its peak activity employing more than 1,500 people.

The inactive iron ore mine is an enormous open-pit more than 4 km long, up to 1 km wide and 75–150 m deep, with extensive underground workings which are now inaccessible for safety reasons. The mine is situated immediately northeast of the town, between Rudabánya, the villages of Alsótelekes and Felsőtelekes (alsó = lower, felső = upper) to the north, and Szuhogy to the east. The abandoned ore concentrating plant is located 2.5 km to the east of the mine towards Szuhogy.

LOCALITY NAME

Rudabánya, the name of the town, is constructed from two words, *Ruda* and *bánya*. It simply means *Ruda-mine* [bánya = mine]. Ruda, the original name of the town, first appeared in judicial documents in 1299. It is likely, however, that the name and a settlement of miners existed near the mines long before that date. *Ruda* is of Slavic origin, meaning *ore* in many Slavic languages including Czech, Slovak and Polish. Some historians are of the opinion that the name may have been used before the 9th century, when Northern Hungary was inhabited by Slavic peoples. The most likely hypothesis, however, is that the *Ruda* name was introduced in the 12th or 13th century by transplanted Bohemian (Czech) miners. Many of these miners migrated to Ruda and other mining towns in Hungary from the mining areas of the Erzgebirge in Bohemia, especially after the Mongolian devastation of Hungary in 1241. The Rudabánya name came into use in the 16th century, and appeared on a map in 1556 attributed to a cartographer named Wolfgang Lazius. Both names and their many variants have been used by the ethnically mixed mining population, as well as writers, up to the beginning of the 20th century.

In many old documents and books written in Hungarian, Latin and German, Ruda and Rudabánya appear as *Rudo, Rudobánya, Rudno, Rudnobánya, Rudna* and *Rudnabánya*, with incorrectly placed diacritical marks for added variety. Many of these names also appear on old mineral labels. This can be rather confusing because many of these name-variants do exist as mining towns (mostly inactive) and mineral localities. Therefore it may be worthwhile to review these briefly. A search of the mineralogical and mining literature revealed the following mines and towns that fit these variants: *Ruda*, south-southeast of Brad, Transylvania, Romania (Tóth, 1882); *Ruda* (Tasov) near Brno, Czech Republic; *Ruda* (Vel. Meziříčí), Czech Republic; *Ruda n.* Moravou, Czech Republic (Moravia); *Ruda* u Cachnova, Slovakia; *Rudná*, W. of Rožňava in Slovakia; *Rudná* (Maršikov) Czech Republic (Moravia); *Rudno*, near Banská Štiavnica, Slovakia (all localities in Slovakia and Czech Republic; Bernard, 1981); and *Rudabányácska* (Little Rudabánya) in eastern Hungary. Before 1919, and for most of the previous ten centuries, the Romanian Ruda and most of the listed localities in Slovakia were in the territories of historical Hungary. Furthermore, in the second half of the 19th century, some important descriptive mineralogical references to Rudabánya minerals (as well as old mineral labels) list Telekes (Alsótelekes and Felsőtelekes) rather than Rudabánya as the locality (Tóth, 1882; Schmidt, 1882; and Zepharovich, 1859, 1873 and 1893). Technically this may not be incorrect, because many or perhaps most specimens collected in the late 18th and most of the 19th century originated from the small mines operated at the Telekes end of the Rudabánya deposit. Rudabánya should be the preferred, primary locality name for specimen labeling.

HISTORY

The history of human habitation in the Rudabánya area is inextricably linked with mining. The development of mining there was analogous with the evolution of mining and metallurgy in other parts of Central Europe. Consequently, it is important not only to examine the mining history of the immediate area, but to examine this evolution in a broader context of the historical development of the Carpathian Basin. Most of what is known of the earliest efforts of mining and metallurgy in this area can only be deduced from archeological evidence, most of which was uncovered in the last six decades. The earliest known written records that mention mining and some form of metallurgy in Northern Hungary are from ca. 110 A.D., by the Roman historian Tacitus (55–120), and those only provide scant generalizations (Kalitz, 1957). From the period predating the 13th century, hardly any written historical records are available on Hungarian mining and metallurgy, and even from the 13–17th century, surprisingly few documents survived the many cataclysmic events of history.

Figure 3. **Mining districts of Upper and Lower Hungary in the 14th–16th century.**

Historical Background, and the Earliest Mining

The Carpathian Basin in Central Europe is an oblong-shaped area, defined and largely encircled by the crescent-shaped Carpathian Mountains, one of the major mountain ranges in Europe. Presently the entire land area of Hungary and Slovakia, and parts of Romania, Serbia, Croatia, Ukraine and Poland are within this geographic entity. The Carpathian Basin, with its moderate climate and wealth of natural resources, has been continuously inhabited by humans for about 300,000 years. Many caves in northern Hungary, including some limestone caves near Rudabánya, provided rich archeological evidence, mostly stone tools and pottery, which point to small communities of cave-dwelling hunter-gatherers, who inhabited the region at least as early as 20 thousand years ago. These groups continued to live there through the Mesolithic and Neolithic Ages (8000–3400 B.C.). Many stone tools and fragments of pottery were found and dated from this era. An interesting stone tool dated at ca. 8000 to 10,000 B.C. (early Mesolithic) was recovered near the Rudabánya mine. It is a wedge-shaped, flake-formed tool of a hard, siliceous ankerite rock, undoubtedly originating from the Rudabánya deposit, suggesting that the outcrops of the deposit were explored very early for materials suitable for tool-making (Podányi, 1974).

By ca. 5500 B.C. farming had spread from Greece and the Aegean to the Danube Valley in what is now Hungary, and with the arrival of agriculture small settlements appeared. By 3500 B.C., products of the Copper Age (3500–1900 B.C.) had appeared in many places in Central Europe, including the vicinity of Rudabánya. In a cave near Szendrő, about 7 km from Rudabánya, several copper tools dating from ca. 2000 B.C. were excavated. These tools included two flat axes and a tool resembling a pick (Podányi, 1974). One can only speculate whether or not the copper for these tools was extracted from the nearby Rudabánya deposit, but the probability is very high, considering that this was the only place within a radius of hundreds of kilometers where native copper occurred, possibly exposed in the oxidation-zone outcrops of the deposit. Copper mining evolved throughout Central Europe in the third millennium B.C., followed by the development of gold mining during the second millennium B.C. Historians conclude that by the middle of the 2nd millennium B.C., the mines of Transylvania were quite active, and had become one of the principal sources of gold for the early Mediterranean civilizations of Mycenae, Crete, and later Thrace and Greece.

The use of copper and later bronze and its production technology was introduced to Central Europe by migrating peoples moving up through the Balkan Peninsula (Fülöp, 1984). Historians place the evolution of the Bronze Age in the Carpathian Basin at around 1900–1000 B.C. By the late Bronze Age, we can be reasonably certain that copper mining was in progress in Rudabánya. Evidence for this is provided by the remnants of a sizable bronze foundry dating to ca. 1000–1500 B.C., which was excavated at a site on the Sajó River 9 km south of Rudabánya. From the same find many bronze articles were also recovered including coiled sheets, wires, pins, unfinished decorative articles and round, flat lumps (ingots?) of bronze. The foundry was ideally sited for the proximity of the source of copper and the availability of water and water-borne transportation of tin and antimony, from deposits 50–

70 km east-northeast in the upper Sajó valley. Near Rudabánya many other bronze articles such as pins, bracelets, swords and axes were also found. Speculation by historians places the operation of the bronze foundry to coincide with the presence of the Illyrians ca. 1000 B.C. (Podányi, 1974).

By around 800 B.C., iron mining and metallurgy were well established in Western and Central Europe, especially in the territories inhabited by various groups belonging to the loosely interrelated peoples of the so-called "Urnfield cultures." These tribal groups occupied the valleys of the Rhine, Danube and their tributaries, and from these groups evolved such diverse peoples as the Celts, Illyrians and Slavs. Beginning around 1000 B.C. the Carpathian Basin was inhabited for some periods by Illyrians, Scythians, and by the Celts, who largely displaced all others by about 200 B.C. Scythian and especially Celtic presence in the vicinity of Rudabánya is indicated by the many bronze and iron artifacts found in the area. These artifacts include Scythian beads, Celtic iron arrowheads, pins, swords, scissors and chains, as well as silver and gold chains (Kalitz, 1957). There is some evidence of mining and smelting at Rudabánya during this period, attributed to the highly skilled metal-crafting and mining-oriented Celts (Cotini) who inhabited the area. The evidence includes potsherds of Celtic origin, recovered from layers of ancient slag just outside Rudabánya. By the end of the 1st century A.D. the Celts were displaced in the northern Carpathian Basin by Germanic peoples from the north, and the southern areas came under Roman rule.

West of the Danube was the Roman province of Pannonia, whereas the eastern part covering practically all of Transylvania was the province of Dacia. Roman mining activity in the Carpathian Basin was mainly focused on the gold mining districts of Transylvania, and there is no evidence of Roman-era mining at Rudabánya. While most of the Carpathian basin was nominally under Roman rule from the 1st to the 5th century, the Roman hold on the area became increasingly tenuous from the 3rd century as the Danube Valley became the principal invasion route of successive waves of migrating peoples from the east. Intense migrations continued for the whole of the 1st millennium A.D., and during this time the Carpathian Basin was invaded and inhabited, at least temporarily, by a great variety of migrating peoples. These included the Visigoths, Ostrogoths, Gepids, Avars, Alans, Vandals, Sueves, various Germanic and Slavic tribes, Lombards, Huns, Bulgars, Franks, Moravians and eventually the Magyars.

Magyar (Hungarian) tribes invaded and occupied large parts of the Carpathian Basin from about 890 A.D., displacing the Avars, Bulgars, Franks and Moravians living there. This was a period when the great European migrations of the first millennium A.D. were coming to an end with the increasing trend of permanent settlement and the establishment of strong organized states. By 996 the institutional framework based on Western European models was established, and Hungary became a permanently settled European state occupying almost the entire Carpathian Basin. Christianity was imposed on the population, and the first Christian King, István (Stephen, later St. Stephen) was crowned in 1000. With statehood followed relative stability and safety, which encouraged the development of agriculture, commerce, and eventually mining and metallurgy.

The Beginning of Organized Mining

The recently-settled Magyars possessed considerable metalworking and metallurgical skills (Fettich, 1937), including the utilization of bog-iron for iron production (Heckenast *et al.*, 1968; Zsámboki, 2000). Mining and metallurgy were probably encouraged by the state, due to the great need for their products, mostly tools and weapons. There is evidence that iron production was

Figure 4. **Iron smelting furnace from the 11th or 12th century. Rudabánya Mining Museum collection, Rudabánya.**

established in the Rudabánya region during the 10th century, and some sort of regional control and protection may have been provided from the nearby fortified royal castle, Vasvár ["iron-castle"], which also dates from the 10th century. From this era, archeologists have located and excavated more than 70 sites in the vicinity of Rudabánya, including iron smelting furnaces and extensive slagheaps.

By around 1200, copper mining had risen in importance and iron production almost totally ceased in the district, shifting its focus to the richer iron deposits and the more plentiful supply of wood for the furnaces elsewhere in northern Hungary. Copper mining probably continued until 1240. In 1241 Mongol armies under Batu Khan invaded Hungary, and the Hungarian armies were destroyed in a single major battle. The military defeat was followed by the nearly complete destruction of the country and its population. The devastation and the loss of population were so great that Hungarians consider the subsequent reconstruction to be the second founding of the state. Reconstruction and repopulation of the country involved the invitation of many settlers from other parts of Europe, such as farmers, skilled tradesmen and miners, mostly from Saxony and Bohemia. According to documents surviving from the late 13th century, such as court decrees and deeds, the population of the Rudabánya district consisted mostly of transplanted Bohemian (Czech) miners. This also suggests that copper mining at Ruda was reviving, probably as early as 1260 to 1270.

Medieval Mining in Hungary

The role and the impact of mining cannot be overestimated in the economy and social development of Central Europe in the Middle Ages. Silver and gold were essential for the royal treasuries in order to mint currencies, and the income derived from taxes on metal and salt mining provided the bulk of the royal revenues. This income also provided employment and the development of new skills for many people, not only in mining but also in metal processing, transportation and associated commercial activities. Development of mines and smelters stimulated the parallel development of town and transportation infrastructure (such as a system of roads and bridges). The increasing complexity and sophistica-

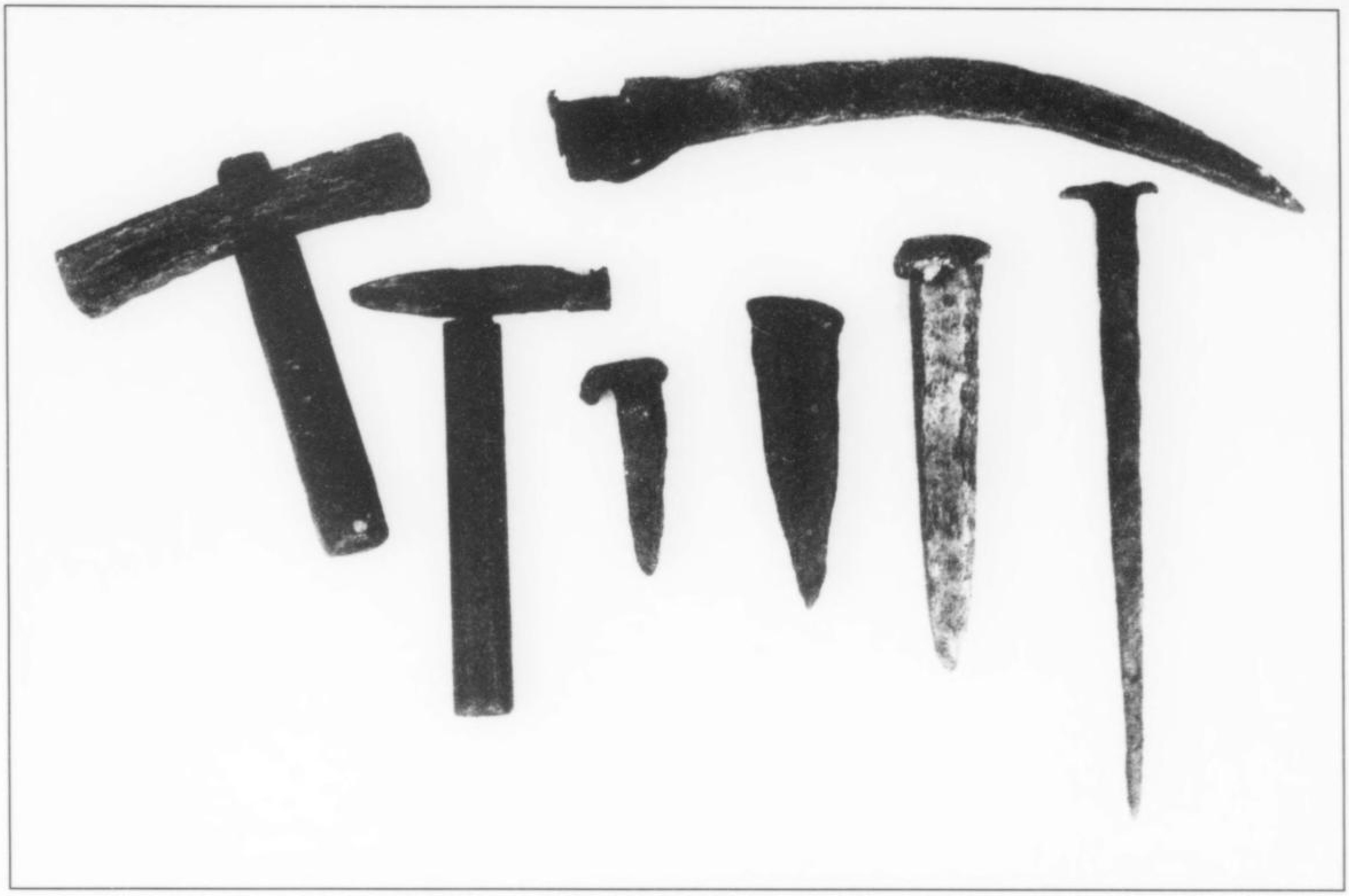


Figure 5. **Mining tools from the Middle Ages. Rudabánya Mining Museum collection, Rudabánya.**

tion of required skills encouraged the establishment of schools and programs of apprenticeship in various trades.

In the late Middle Ages (12th–16th century), Europe had two exceptionally important metal mining regions, the Erzgebirge region straddling the border of Bohemia (present Czech Republic) and Saxony (Germany), and the Transylvanian region in eastern Hungary (now Romania). For several centuries Hungarian mines produced an estimated 30–35% of the world's gold, and 80–85% of Europe's. In the same period the Erzgebirge region accounted for about 60%, and Hungarian mines for about 25%, of the European silver production (Paulinyi, 1933; Zsámboki, 1995 and 2000). The mines of northern Hungary and Tyrol were also the most significant European producers of copper, and important producers of silver, gold and lead. Although diminishing in importance from the late 16th century, with the depletion of reserves and the ever-increasing quantities of imported metals, metal mining continued to be a very important cornerstone of the Central European economy well into the 19th century.

Royal Mining Monopolies in Hungary

Prior to the 10th century, mining in Central Europe was mostly a communal undertaking, with the community (a village or town) exercising joint ownership, and sharing the work and profits from the mines. From the 11th century, with the increasing importance of mining to the state, control and ownership of mines gradually changed, and it appears that, by the 12th century, communal ownership in Hungary had essentially ceased. Through royal decree, the mineral wealth residing in the *womb-of-the-earth* became the exclusive property of the king, regardless of surface property rights. Royal privilege extended over the ownership and administration of mines, and controlled the distribution of gold, silver and salt. Royal control over the mining and smelting of copper, iron and other metals was more relaxed.

Beginning in the middle of the 13th century the administration of mines owned by the crown became increasingly privatized through royal awards and grants given to the church hierarchy (cardinals and bishops), high court officials and loyal nobles. From these privately administered mines an *urbura* [mine tax] was collected on all the production (the *urbura*, for instance, was 1/10 of gold and 1/8 of the silver production). In addition, by law all the gold and silver produced had to be sold at a fixed rate to the *Bányakamara* ["Chamber of Mines"] operated by the royal treasury. The *Bányakamara* was responsible not only for overseeing the collection of the *urbura* and buying the gold and silver production, but also for the minting of currency. Other mined commodities only required the payment of the *urbura* and could be marketed privately without interference from the treasury.

Expanding mining activity and more diversified ownership in Hungary necessitated formalized regulations, and the first mining laws were proclaimed in 1327 by King Charles Robert (1288–1342). These laws were intended to regulate the conflicts of the royal monopolies, and the expropriation rights on newly discovered deposits of gold, silver and salt on private estates. Refinements of the law followed (in 1351 and 1406) to ease royal control and to define or clarify the ground rules for expropriation and compensation (Hóman, 1921; Zsámboki, 1982a). Freedom from royal expropriation was granted in 1523. Liberalizing the law, however, did not affect the royal monopoly on the marketing of gold and silver, which remained with the Chamber of Mines until the 19th century.

Mining, metallurgy and the related commercial activities could only develop and flourish in relative peace and security. Therefore

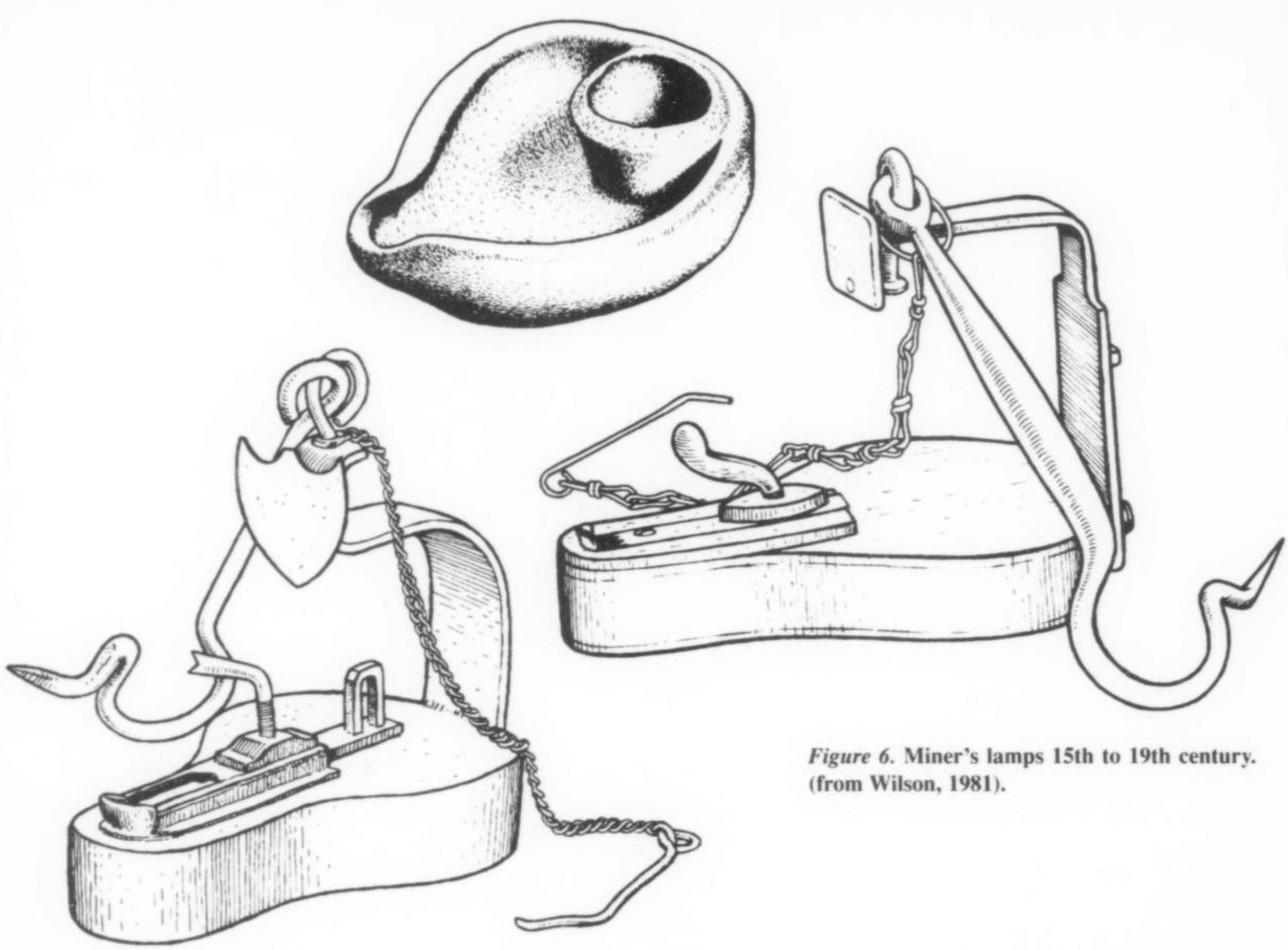


Figure 6. **Miner's lamps 15th to 19th century. (from Wilson, 1981).**

it was in the interest of the King, the primary beneficiary of the revenues from mining, to provide protection and ensure conditions conducive for these activities. Royal protection was granted with the designation of *Royal Mining Town*, and was extended to towns with significant gold and silver mines. Beyond the protection in a military sense, which was frequently very tenuous, these towns were granted self-government and certain privileges. The privileges included tax concessions, freedom from military service, and freedom of movement for all citizens. Miners living in these towns enjoyed an elevated social status, a better standard of living and a greater degree of freedom than the rest of the population (mostly indentured serfs) living in the countryside.

Mining and Metallurgy in Northern Hungary (14th–16th century)

Copper, silver and gold mining and smelting in northern Hungary evolved from primitive, small-scale operations to organized industries by the beginning of the 14th century. Prosperous mining towns developed, and their importance is suggested by the designation of 14 of these towns as *Royal Mining Towns*. These towns were located in two loosely defined geographical groups in northern Hungary. The western group consisted of *Selmecbánya* [Schemnitz] now Banská Štiavnica, *Körmöcbánya* [Kremnitz] now Kremnica, *Besztercebánya* [Neusohl] now Banská Bystrica, *Ujbánya* [Königsberg] now Nova Baňa, *Bélabánya* [Dilln] now Banská Belá, *Bakabánya* [Bugganz] now Pukanec, and *Libetbánya* [Libethen] now L'ubietová. The eastern group consisted of *Szomolnok* [Schmölnitz] now Smolník, *Igló* [Zipser Neudorf] now Špišska Nová Ves, *Gölnicbánya* [Gölnitz] now Gelnica, *Rozsnyó* [Rosenau] now Rožňava, *Jászó* now Jasov, *Rudabánya* and *Telkibánya*. The *Hungarian* names are followed by [German] and current Slovak names (the German names are the best known in the mineralogical literature). With the exception of Rudabánya and Telkibánya, all these towns are now in Slovakia. The largest copper and silver deposits were in the western region, and the most important mining centers were Besztercebánya, Körmöcbánya and Selmecbánya. These mining centers were not only economically important, they were also in the forefront of technological development by the end of the 15th century. They greatly influenced not only the mines in northern Hungary, but also the mines in Transylvania, in Tyrol and elsewhere in Europe. Many of these mining towns retained their prominence into the 19th century, and the *Bergschule* (mining school) established at Selmecbánya in 1735 became the world's first mining academy, the *Bergakademie* in 1762.

Many of the mines in northern Hungary had been actively worked since the 12th century, but by the middle of the 15th century, they were in decline because of two very serious problems. The most important problem was water, which flooded many of the ever deepening mines, often forcing closure. Existing water-lifting techniques were unable to cope with the increasing volumes of water and the depths from which it had to be lifted. Adits for draining, the only known alternatives, were often impractical and beyond the financial resources of mine owners. The other problem that seriously impacted the economy of copper and silver production was smelting technology. Local smelters were unable to fully refine copper produced from sulfide ores, and to separate it from silver. Up to the late 15th century this technology was a jealously guarded secret known to and practiced by very few processing

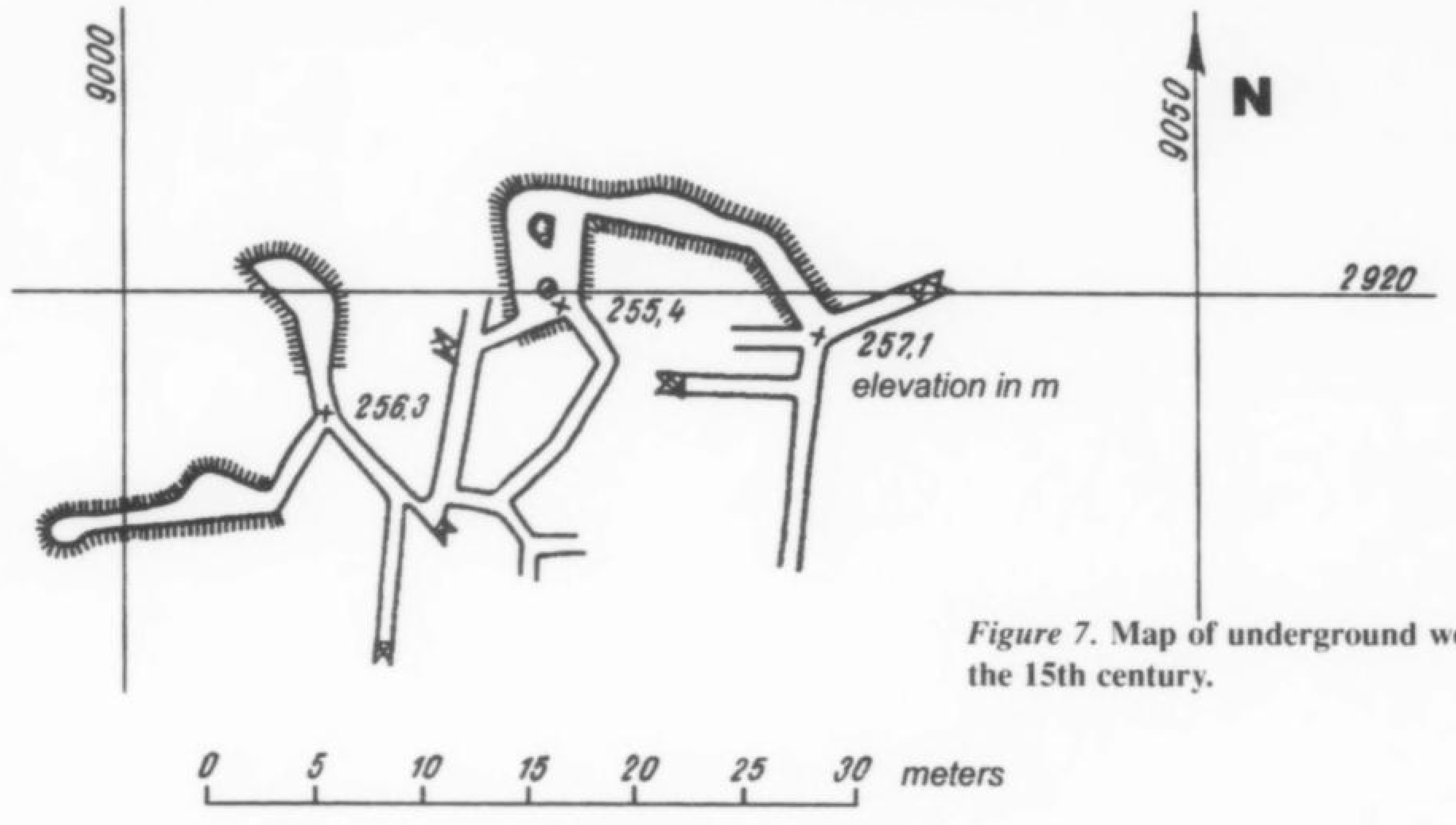


Figure 7. **Map of underground workings from the 15th century.**

centers. Sulfide ores from the mines of northern Hungary were locally roasted, the first step in a multi-stage refinement process, producing a product known as *schwarzkupfer* ["black copper"]. This "black copper," having an exceptionally high silver content, was shipped to technologically more advanced refining centers where the silver was very profitably extracted. Most of the "black-copper" production from the mines of Hungary was, for many years, shipped to Venice (Paulinyi, 1977; Zsámboki, 2000). These problems were awaiting resolution in the second half of the 15th century when two remarkable individuals, János (Johannes) Thurzó, an engineer-entrepreneur, and Jakob Fugger II, an entrepreneur-banker, emerged. Their partnership, which combined technical innovations and entrepreneurship with capital for implementation, had a long-lasting and profound influence on mining, metallurgy and the marketing of metals in Europe.

Fugger-Thurzó Mining Ventures

The Fugger family opened a small weaving business around 1367 in Augsburg, Germany, and eventually developed it into a towering multinational commercial empire of textiles, banking, spices, mining, smelting and the marketing of various commodities. At the height of their power, the Fuggers had branch offices in all the main commercial centers of Europe, and by the 16th century even in the Americas. The Fuggers became involved in mining through their loans to various crowned heads, among them Holy Roman Emperors Maximilian I and Charles V, to finance their various ambitions. To secure their loans, the Fuggers became mortgage holders and partners with the royal treasuries, in lead, copper and silver mines in Tyrol and Carinthia, and the silver and mercury mines in Spain. Income from these mines was applied to the repayment of loans. Around 1490 Jakob Fugger II (1459–1525) met János Thurzó, one of the most interesting mining and metallurgical experts and entrepreneurs of the 15th century, and through him became a partner in the copper and silver mines of northern Hungary.

János (Johannes) Thurzó (1437–1508) was the son of a wealthy Hungarian merchant. After completing his studies at the universities of Rome and Padua, and traveling through Europe, he returned home to join the family business. In 1463 Thurzó moved to Cracow, Poland to head the family business interests which

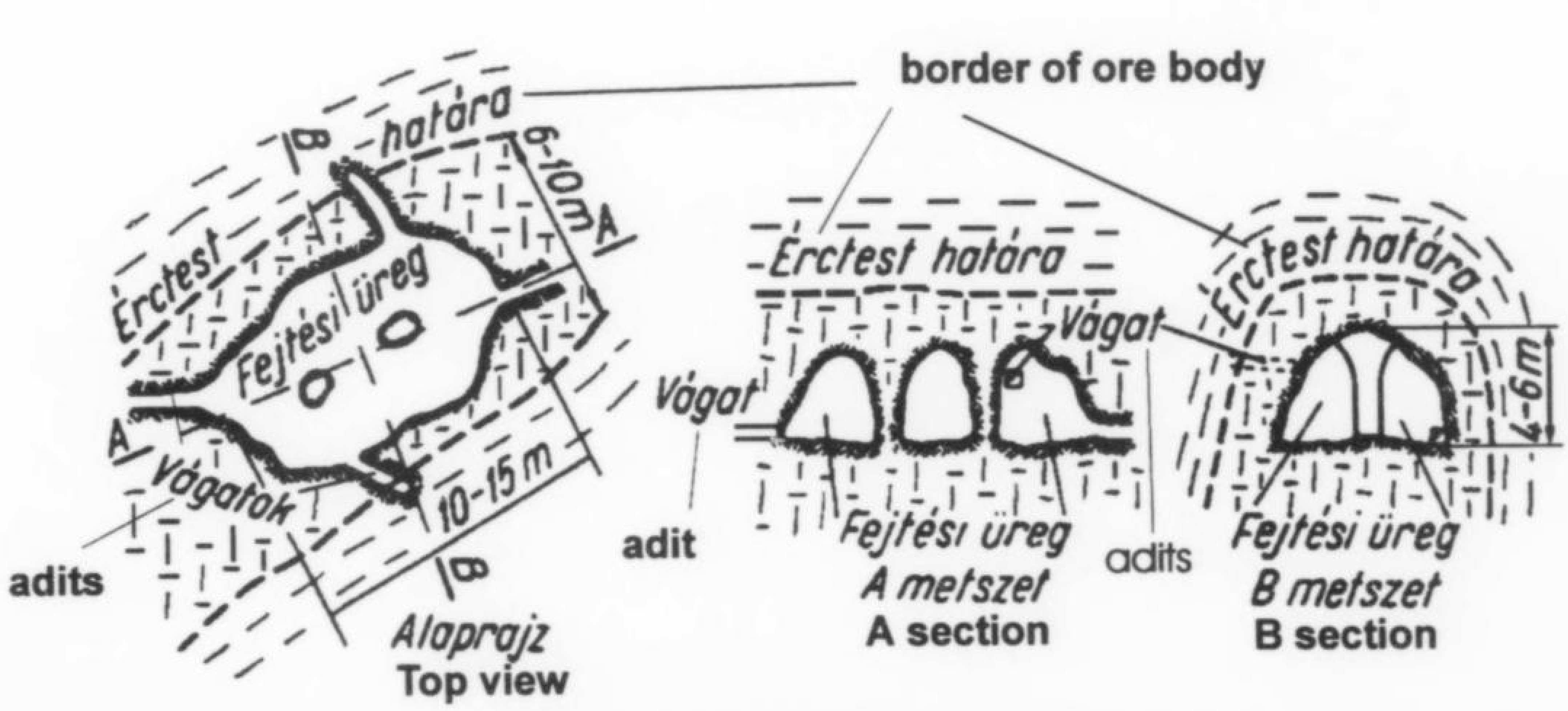


Figure 8. **A map of 15th century underground workings constructed using room-and-pillar method (Pantó *et al.*, 1957).**

Figure 9. **Map of northern Hungary in 1556 by Lazius. Rudabánya, with a figure of a miner, is near the middle of the right margin.**

included a number of copper and lead mines. By 1470 Thurzó had built a copper smelter near Cracow, and in 1478 built another in Goslar in the Harz Mountains. Both facilities utilized the advanced copper refining technology that he either developed on his own or surreptitiously acquired during his travels to Venice (Strieder, 1931). He was also experimenting with and designing new water-raising machinery for the dewatering of mines. Thurzó's devices were successfully introduced into various mines in the Besztercebánya region in northern Hungary and into the Transylvanian gold mines. Through his efforts many mines were drained and reopened. Thurzó collected generous royalties for the use of his machinery, as well as a share of the revenues from the reopened mines (Strieder, 1931; Molnár, 1987). Unfortunately there are no contemporary drawings or descriptions of Thurzó's smelters or water-raising innovations, but some of the devices shown in Agricola's *De re metallica* (1556) may be later derivatives of Thurzó's equipment (Schick, 1957). By 1490 Thurzó bought or leased most of the major gold, copper and silver mines in northern Hungary and built a large copper smelter in Besztercebánya. These ventures required large injections of capital which he was able to secure through a business partnership with the Fuggers. The Fugger-Thurzó Company came into existence in 1495 with the signing of a partnership contract. The Fugger brothers owned 50%, and Thurzó and his son owned the other 50% of the company (Strieder, 1931). Very quickly the Besztercebánya copper-smelter became the largest processing facility in Europe, processing ores from many of the mines in northern Hungary.

The Fugger-Thurzó Company (FTC) was involved only in mining and metal production, with Thurzó and his son Georg managing the operations. Copper was sold to two marketing companies independent of the FTC, one owned by the Fuggers and the other by Thurzó. These two companies marketed the copper through Mediterranean and Hanseatic ports. The Fuggers also owned or had control over the copper production in the Tyrol and, with Thurzó, eventually had a near-monopoly over European copper production (Paulinyi, 1977; Schick, 1957).

A little-known fact about the Fuggers' mining activity was their establishment of a mining school (Bergschule) around 1500, almost certainly the first mining school in the world, in Villach, Austria. The school was established for the technical training of mining officials, assayists and managers employed in the Fugger and Fugger-Thurzó mines. One of the teachers at the school was Wilhelm of Hohenheim (14??–1534), a German physician who is better known as the father of the great physician-philosopher, Paracelsus (Theophrastus Bombastus von Hohenheim, 1493–1541). Wilhelm was appointed as town physician at Villach in 1502, and became the chemistry/alchemy teacher at the mining school, where he remained for over thirty years. Paracelsus attended the school before continuing his education elsewhere. Both father and son had a deep interest in, and extensive knowledge of mining and minerals, and frequently visited nearby Bleiberg to observe the operations of the lead mine (Stoddart, 1911) and possibly to collect minerals. Wilhelm assembled a collection of minerals from the region (Pachter, 1951), possibly to be used for instruction at the mining school. This may be the earliest known mineral collection in Europe. Later, as a doctor, Paracelsus visited many of the Fugger-Thurzó mines in Hungary, where he studied the diseases of the miners, especially respiratory ailments, the causes of which he attributed to their occupation.

Golden-Age of Copper and Silver Mining in Rudabánya (14th–16th century)

Copper and silver mining at Rudabánya developed in parallel with the other mining districts in northern Hungary. During this period Rudabánya reached its Golden Age as a mining town, but by the end of the period it had descended into near-oblivion.

The name of Ruda first appears in official documents in 1299, with brief references to the mining of copper. Around the same time Saxon miners from the Erzgebirge also settled there, probably introducing some of their mining technology. According to historical documents, Ruda was a royal possession in 1351, which suggests that silver mining was already in progress. The town was granted self-government in 1359, and in 1378 became one of 14 privileged *Royal Mining Towns* in northern Hungary.

With increasing mining and commercial activity, a prosperous middle-class of mining officials, merchants and treasury officers emerged in Rudabánya; they built substantial homes and established various civic institutions. The wealthier citizens sent their sons to universities in Germany, Poland and Italy. Indicative of the prosperity of Rudabánya was the building of an elaborate Gothic church, more than 30 meters long. A shortened and reconstructed version with some remarkable frescoes survives to this day.

The importance of the town to the crown is indicated by several royal visits and audiences held there by Sigismund (1368–1437), Holy Roman Emperor and the King of Hungary. On several occasions Rudabánya was also the site of the General Assembly of the counties of Borsod and Gömör, with the Lord Chancellor holding court. From this period (ca. 1330) originates the town's superb silver seal, which is preserved in the Magyar Nemzeti Múzeum ["Hungarian National Museum"] in Budapest. The seal illustrates a bishop, the Gothic church with the Latin inscription *SIGILLUM CIVITATIS RUDAE* ["Seal of the Town of Ruda"], and the hammer and wedge signifying the importance of mining. This appearance of the miner's hammer and wedge may well be the earliest representation of what became (with the crossing of the tools) the universal sign of mining and miners. A new and less impressive brass town seal was introduced in 1786.

Underpinning the prosperity of Rudabánya was the intense mining and smelting of copper and silver. Native copper was the main ore mined, possibly with quantities of copper secondaries, while silver-rich galena and probably acanthite were the primary silver ores. Contemporary production data are not available, but the scale can be judged from the accumulated slag resulting from the processing of copper and silver ores. The modern-day town of Rudabánya is sited on large quantities of slag from this period.

Mining and Metallurgy at Rudabánya

The smelting and water problems affecting the other Hungarian copper mines did not have much impact here. Native copper mined at Rudabánya did not require elaborate smelting technology and was fully processed near the mine. Water was rarely a problem in the mine, as the deposit is exceptionally dry; in fact the problem was the lack of water for the town and for the washing of the ores. Not much is known about the marketing of Rudabánya copper, but it is almost certain that the copper produced there during the existence of the Fugger-Thurzó partnership was distributed through them. Copper and silver mines and smelters at Rudabánya were owned by the Thurzó family for some time. The silver metallurgy was most likely introduced from other smelting centers in northern Hungary. Such technology was transferred through common ownership of mines in different districts and by the mobility of miners, smelter workers and mine officials.

It is likely that most of the mining in Rudabánya up to the 14th century was carried out on the surface, where miners simply dug into the exposures of the oxidation zone and followed the ore concentrations to shallow depths. Even after centuries many small and shallow concavities, probably production or exploratory pits, are still discernible in the hills surrounding the town. In the 14th century the sporadic mining of limonite continued on the surface, while the mining for copper and silver moved underground. Extensive and elaborate underground workings were discovered in the 20th century, during excavation of the open pit and the development of adits and tunnels. Worked-out galleries, chambers and stopes up to 500 cubic meters in volume were found. Some of the ore masses were mined by the room-and-pillar technique, and galleries were connected with wood-lined adits, haulage ways and air shafts. Many old adits and shafts were surprisingly well-preserved, with wooden supports still in place after 400 to 500 years, perhaps preserved by the impregnation of copper solutions. Wooden step-ladders, various miner's tools and clay-lamps were also found. Some of these old workings were mapped before the expanding open pit obliterated them, and many mining implements which were found in them are preserved in the Mining Museum in Rudabánya. Adits were quite small in cross section (as small as 60 x 80 cm), some passable only by crawling. There is evidence that small dog-drawn carts may have been used to transport the ore to the surface. The mines were most likely leased from the landowners during this era and worked independently by individual miners with their family members, or by small work cooperatives.

A rare and interesting glimpse of silver mining and metallurgy at Rudabánya can be seen in a document uncovered in the *Hofkammer Archiv* in Vienna (Vastagh, 1984). According to this document, written in 1528 and attributed to an unnamed visiting Austrian mining expert (probably a graduate of the Bergschule at Villach), seven small silver-smelting furnaces were operating at the time of his visit, but he mentions that as many as 20 had been operating earlier. Silver was refined to approximately 75% purity, requiring additional refinement by the Chamber of Mines. According to the account, the owner of the mine properties, Elek Thurzó, demanded that the furnace operators try to attain a level of purity around 93%. The refinement process required quantities of lead, some of which was produced locally, but most was imported from Poland. He estimated that no more than half the silver produced was actually turned over to the Chamber of Mines, the rest was probably marketed illegally. This estimate was based on his calculations of the ratio of lead used, to the quantities of silver actually delivered to the treasury. The operations were analyzed in financial terms and were considered marginally profitable at the existing exchange rate. According to the document, the population was entirely Hungarian at the time, and because the miners owned agricultural land and vineyards, they were not entirely dependent on their income from mining.

Although silver mining was declining due to the exhaustion of the reserves, copper and, to a lesser extent, lead mining appears to have continued with some interruptions until about 1580. For more than a century after that there is hardly any evidence of mining at Rudabánya. Cessation of mining was the direct result of the invasion and long-term occupation of much of Hungary by the Ottoman Turks, and various internal wars and revolutions. Rudabánya was under nearly permanent Turkish rule from 1564 until about 1660. The heavy taxes imposed by the Turks forced the abandonment of the mines, and the flight of the town's population to safer, unoccupied areas of the country. The population of Rudabánya drastically declined (the population was only 92 in 1664), and the once-prosperous mining town became an impoverished and insignificant village.

Sometime after 1660 Rudabánya became an appendage of the estates of the nearby Szendrő castle and town. Around 1690, copper mining and smelting was reactivated mainly through the efforts of Count Alessandro Gvadagni, later Gvadányi, an Italian noble who settled in Hungary. In 1690 he was the military commander of the district, and the administrator of the Szendrő estates. Copper production continued under the direction of the Count until his death in 1700, and thereafter by his widow, Countess Gvadányi-Forgách until about 1728. There is no mention of silver or lead mining and smelting in contemporary documents; if there was any it would have been insignificant. During this period some native copper specimens were observed and documented in the mineral collection of Countess Gvadányi (Brückmann, 1727). The mines remained in the hands of the Gvadányi family until 1749, but mining had ceased sometime before 1728. From contemporary documents, mostly correspondence pertaining to negotiations on copper prices, applications for loans to the royal treasury, and evaluation reports of mining experts and treasury officials, it is obvious that copper production was only marginally profitable, and declined from about 1700. By 1720 the deposit was depleted in copper, and the Countess was trying (unsuccessfully) to unload an unprofitable enterprise on the royal treasury. With the cessation of mining by the Gvadányi family, centuries of copper, silver and lead mining at Rudabánya finally came to an end.

The Iron Mining Period (1759–1985)

The Rudabánya mine properties changed ownership or were held as collateral for loans by various landowners during the years 1749–1760, but there is no record of mining activity. In the period of 1760–1780, small-scale and somewhat sporadic underground mining of iron ore evolved to supply the furnaces near Diósgyőr, about 30 km south of Rudabánya. Contemporary documents also mention the recovery of copper, presumably as a by-product of iron mining. However, endless disputes between landowners and mine operators, lack of capital, and the high cost of ore transportation to the smelters hindered serious development of the deposit. In 1793 János Csáky, the principal landowner in the area, built a smelter at nearby Szendrő to process Rudabánya iron ores. By 1807 this venture had failed, and for the next 20 years all mining and metallurgical activity ceased. In the period 1826–1841, small-scale mining of iron ore and exploration for copper by individual miner-entrepreneurs and small cooperatives started again. Some attempt was also made to recover copper from the old slagheaps and dumps, but not much is known about these ventures. In 1841 the operators of the Diósgyőr area iron works resumed mining in five small open pits near the town of Telekes, and commenced serious exploration of the deposit by trenching and adits. The company acquired additional new mine properties, and continued mining with some interruption until 1871. In 1871 the assets of the privately owned iron works at Diósgyőr were acquired by the Hungarian state and incorporated into the newly built, modern, state-owned Diósgyőr Metallurgical Works (DMW). With the consolidation of the assets, many of the Rudabánya area mine properties became state property and were operated by the DMW until 1880. Concurrently with the mining of DMW, Count Andrássy, the owner of one of the largest mining and metallurgical firms in northern Hungary, began systematic exploration and mapping of the deposit around 1872. By 1878 he had acquired mining rights to seven mine lots adjacent to the 15 lots owned by the state. Each of

Figure 10. **Seal of the town of Rudabánya, 1786.**

the nearly equal-sized lots were identified by names, many of which survive to this day (i.e. Andrássy I, II & III, Adolf, etc.). Mining, however, was hampered by the lack of a branch line connection from the mines to the nearest railway line about 14 km away, as neither the state nor Andrássy was willing or able to finance it.

The real turning point in the history of Rudabánya occurred in 1880, when Count Andrássy and a large Austrian consortium, the Witkowitzer Bergbau- und Eisenwerks- Aktiengesellschaft (WBEA) (Witkowitz = Vitkovice, Czech Republic), owned mostly by the Austrian Rothschilds, formed a new company to mine the iron ore deposit at Rudabánya. The Borsodi Bányatársulat ["Mining Company of Borsod"] acquired the mining rights to a total of 22 mine-lots, seven held by Andrássy and 15 lots held by the state-owned DMW. Part of the agreement with the state treasury for the mining rights specified the building by the company of a spur line to the main railway line. The 14.1-km-long, narrow-gauge line was opened in the summer of 1881, and that same year the first ore-roasting furnace was built. Roasting was used to reduce the 10–12% moisture content of the limonite ores, resulting in considerable cost savings for long-distance transportation. Production began in 1881 with a rather small 2,000 metric tons, increasing to 100,000 tons by 1884, and 200,000 tons in 1895. Most of the ore production was contracted to WBEA. With increased mechanization, including the use of steam shovels, production increased to

Figure 11. **View of the Rudabánya open pit mine ca. 1900. Rudabánya Mining Museum archives, Rudabánya.**

Figure 12. **Postcard from Rudabánya showing the Adolf mine adit ca. 1900.**

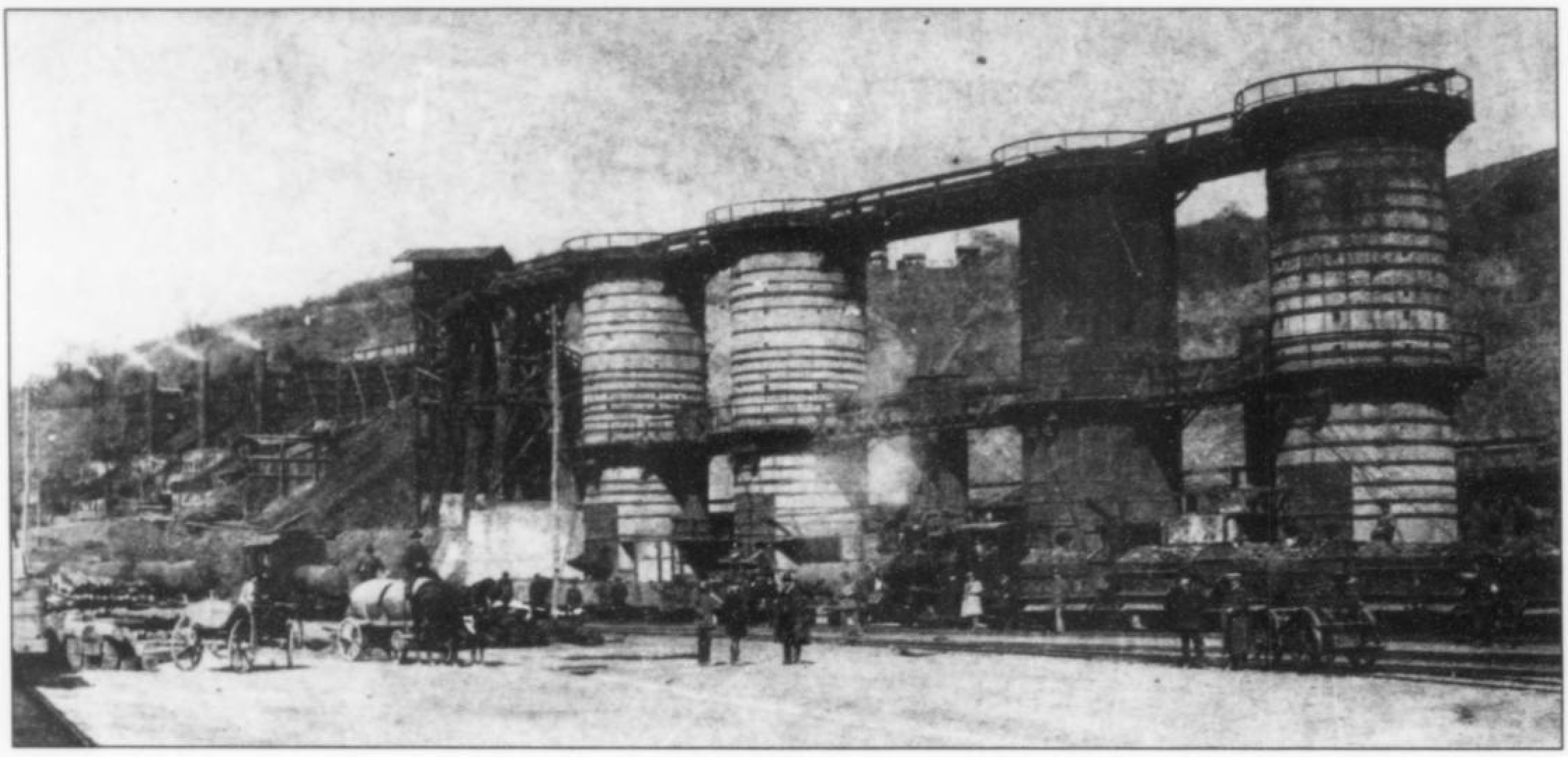
430,000 tons in 1911, and employment peaked at 1,046 in 1910–12. In 1911, the town was completely destroyed by fire, but it was subsequently rebuilt. Production declined sharply with the economic collapse after World War I, but the company continued to operate the mine until 1927, when it was sold to the Rimamurány-Salgótarjáni Vasmű Company (RSVC). During the existence of the Borsodi Bányatársulat, approximately 10 million tons of ore was produced, and a total volume of about 30 million cubic meters of ore and overburden was removed.

RSVC operated the mine from 1927 to the end of World War II in 1945. During this period the production never attained the maximum pre-WWI levels, and in the depression years of 1930–35, production dropped to as low as 43,000 tons per year. Mine production was still mostly by surface excavation, but from 1936 to 1944 underground production increased from about 3% to 25% of the total. In those 17 years of operation, 3.5 million tons of ore was shipped, and a total volume of about 8.5 million cubic meters of ore and overburden was removed.

In the immediate post-WWII years of 1945–46, operations resumed under very difficult conditions, following a short period of inactivity in the last year of the war. From 1949 to the closing of all operations in 1985, Rudabánya was the largest operating iron mine in Hungary, and was owned and operated entirely by the state. During this period the mine equipment was modernized and a new ore-concentrating plant was built in 1953–54, for the treatment of

Figure 13. **Andrássy I mine section in the 1930's. Herman Ottó Museum archives.**

Figure 14. **Ore-roasting furnaces at Rudabánya ca. 1900. Rudabánya Mining Museum archives, Rudabánya.**



siderite ores. To facilitate transportation from the ever deepening open-pit, a haulage tunnel was completed. The 5-km-long tunnel with a double-track, narrow-gauge electric railway line extended for the full length of the deposit, and was accessible from all the actively mined sections of the mine.

Annual production reached 700,000 tons in the 1960–70's, but some of the ore produced was low-grade and scarcely marketable. Without the state subsidies of the postwar socialist economy, the mine would not have been viable. With the depletion of the good-quality ore-reserves, increasing costs and the lack of markets, the long-unprofitable state-subsidized mine finally closed in 1985. Total estimated iron ore production from 1880–1985 was around 45 million tons, and an estimated 120 million cubic meters of ore and overburden was removed. With the closing of the mine the long and colorful history of mining at Rudabánya came to an end, probably never to rise again.

Rudabánya Mining Museum

A small but very interesting mining and mineral museum is located in Rudabánya; it is highly recommended for any visitor interested in mining history or mineralogy. The *Érc és Ásványbányászati Múzeum* ["Ore and Mineral Mining Museum"] of

***Figure 15.* View of the open pit, Andrássy I section in 1995. G. Kulcsár photo.**

Rudabánya, is a member museum in a network of Hungarian mining museums (Molnár, 1980), specializing (as the name implies) in the historical aspects of metalliferous ore mining in Hungary. The idea of the museum originated around 1956 with management and employees of the iron mine who wished to preserve and present memorabilia connected with the history and mining at Rudabánya. Employees and the mining company donated most of the items in the museum's collection, which opened to the public in 1965. Later the museum's mandate was expanded to include collections from other metal mining areas of Hungary.

The most interesting individual exhibits focus on local finds connected with early mining, such as a reconstructed 10th-century iron-smelter, wooden mine supports and step-ladders from the 15th century, mining tools and lamps. There are many items in the museum's collection dating from the 18–20th century, such as tools and implements used in mining, uniforms, mining instruments, maps, models, documents and other memorabilia (Szuromi, 1995). The museum has a small but fine library of old mining, metallurgical and mineralogical books, and it also serves as the historical archive for the town and the mine. Larger pieces of mining equipment from the more recent past are on exhibit in the courtyard of the museum, and in a simulated mine adit with an original mine portal that was transferred from the mine. A separate building houses an exhibit of ores and minerals with an excellent representation of minerals from Rudabánya, and a good selection of minerals from other mining regions in Hungary. Exceptional specimens of azurite, malachite, cuprite, malachite pseudomorphs after azurite, and native copper specimens are the most noteworthy. The museum is open to visitors in the summer months or by appointment.

GEOLOGY

The Rudabánya iron deposit is situated on the margin of the Triassic, sedimentary Aggtelek-Rudabánya Mountains (commonly referred to as Aggtelek karst). The ore deposit, which was exposed by a large open-pit as well as extensive underground workings in a Triassic series, is essentially composed of Lower Triassic (Werfen) marl, limestone and Middle Triassic (Gutenstein) dolomite. This formation was later subject to intense tectonic activity, during which parts of the area were elevated, and the harder and more rigid limestones and dolomites were crushed, fragmented and compressed with the softer, more elastic marl to form a limestone and dolomite breccia. This structural feature was responsible for creating the preconditions for subsequent metasomatic processes that formed the iron deposit. Underlying the deposit are Permian evaporites and Paleozoic black shales; cover formations of the deposit are primarily of Upper Miocene sediments, which occasionally enclose small lignite coal masses. Recent finds of varied fossils of fauna and flora have been described from the cover formations.

In the emplacement of the Rudabánya orebody the following distinct phases have been proposed (Pantó, 1956; Hernyák, 1977). In the first phase, along the main fault-plane, hematite and, to a lesser extent, siderite formed as small lenses and masses. These small bodies of primary origin were considered to be of minor

Figure 16. **Rudabánya Mining Museum, mineral collection building. E. Horváth photo.**

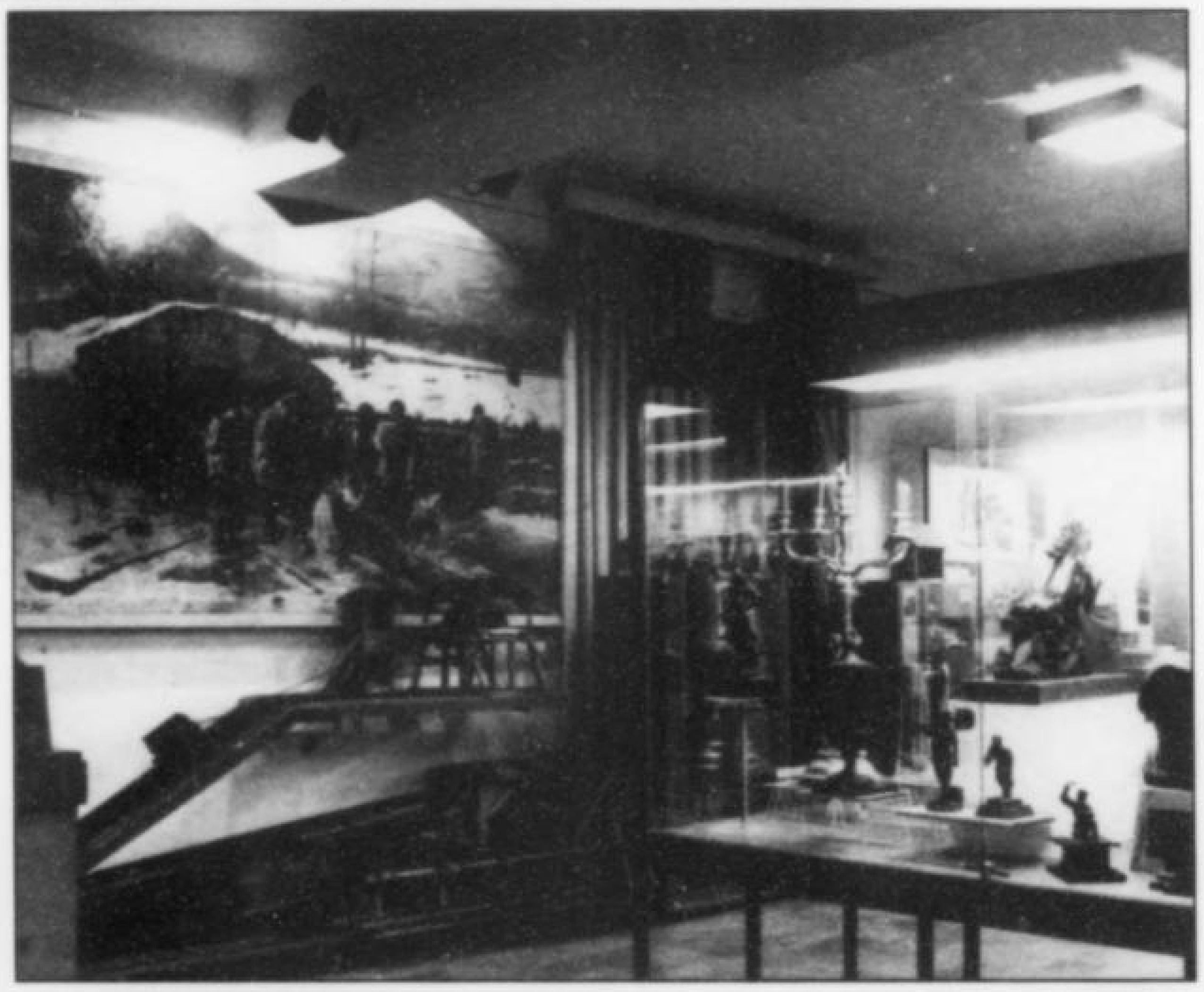


Figure 17. **Interior of the Rudabánya Mining Museum. Herman Ottó Museum archives.**

Figure 18. **Rudabánya Mining Museum, mineral exhibit. L. Horváth photo.**

Figure 19. **Interior of the Rudabánya Mining Museum 1996. L. Horváth photo.**

Figure 20. **Portal of the haulage tunnel in 1994. R. Triebl photo.**

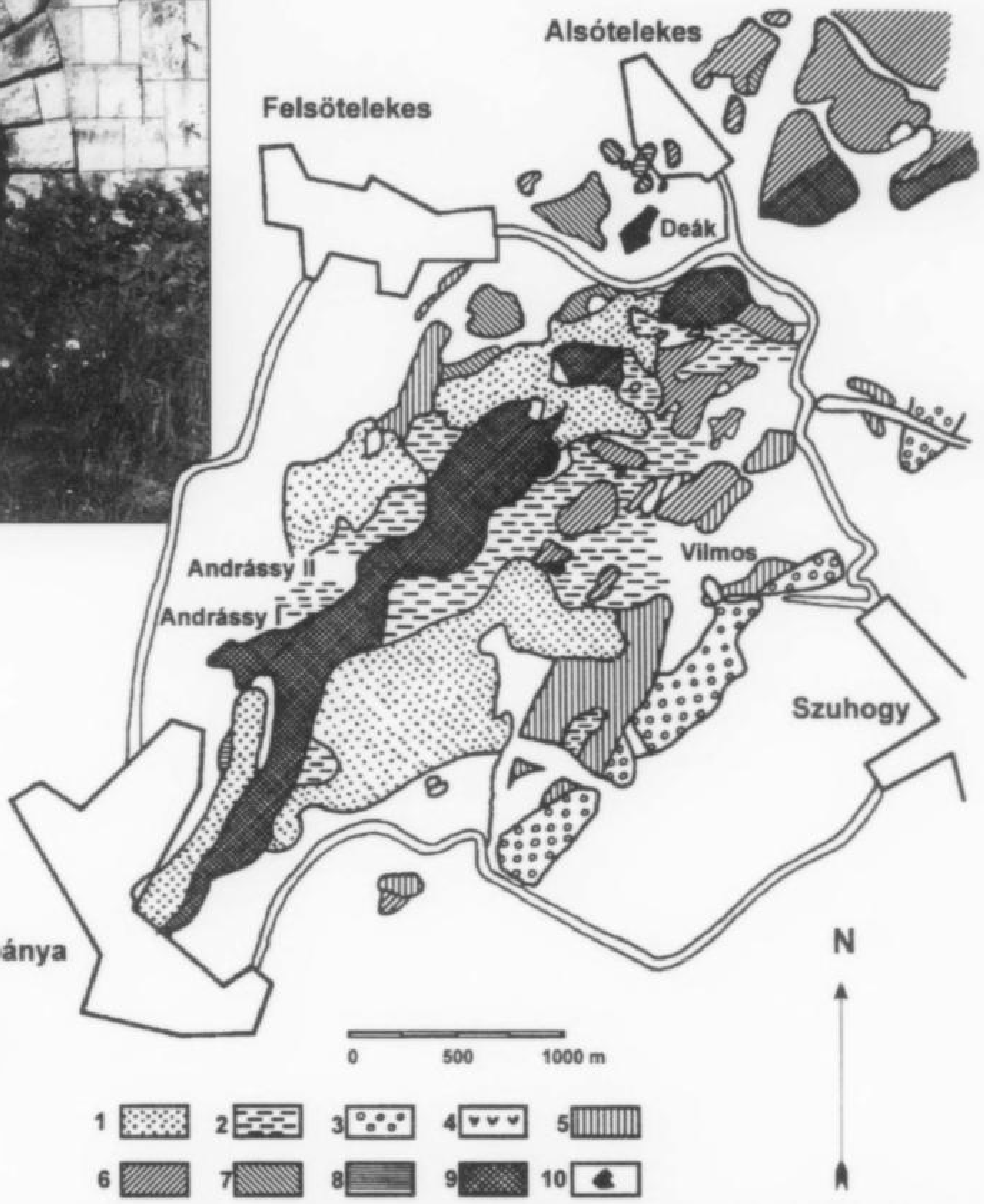


Figure 21. **Geological map of the Rudabánya deposit (after G. Hernyák).**

1. Dumps, 2. Clay and gravel (Pannonian), 3. Conglomerate (Miocene), 4. Limestone (Eocene), 5. Limestone and marl (Ladinian), 6. Dolomite and limestone (Anisian), 7. Limestone and shale (Campilian), 8. Sandstone and shale (Seisian), 9. Limonite, 10. Hematite and siderite (Seisian).

importance, and rarely sufficient for economic exploitation. In the second, the most important ore-forming phase, the brecciated limestone and dolomite were metasomatized by ascending iron-rich solutions, and transformed into large bodies of carbonates consisting mostly of siderite. Siderite ore was economically the most important and intensely mined ore for about 50 years. Other formations of minor economic importance that evolved during this phase are the small hematite bodies which are the result of the metasomatism of the Triassic marl and sandstones. The outward-flowing solution from the metasomatized dolomite masses were blocked by the siderite-marl contacts, forming 0.5–3.0-meter-thick vein-like boundaries or rims, consisting essentially of barite (Pantó, 1956). These barite veins are characterized by fine, banded layering indicating rhythmic deposition. This formation was of considerable importance in early mining, as it gave rise to the most important sulfide concentrations in the deposit.

The sulfide concentration was partially connected to the third phase of the ore-deposition process, during which the already developed metasomatic orebody was probably subjected to hydrothermal action, to which surface alteration and decomposition may have contributed to a considerable degree. Complete or partial dissolution of the siderite and subsequent recrystallization resulted in the formation of isolated bodies consisting of spongy, spheroidal siderite with a radiating structure, locally referred to as *spherosiderite*. Close proximity of the carbonate orebody to the surface for a long period of time permitted considerable surface oxidation and decom-

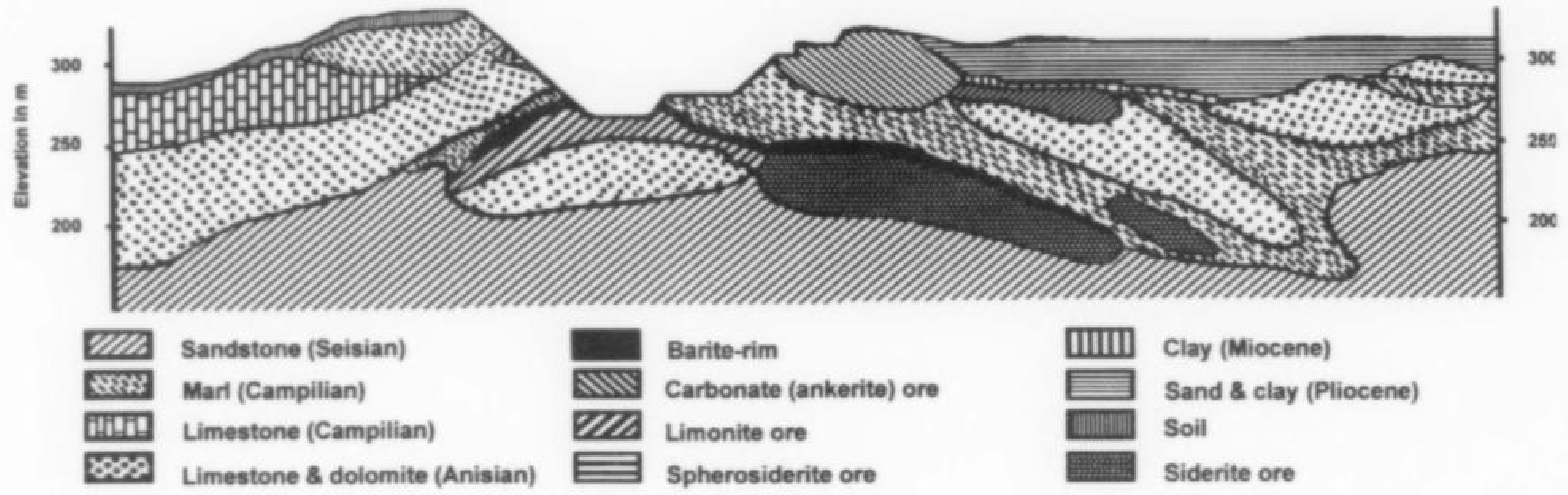


Figure 22. **Geological cross-section of the Rudabánya deposit (after Pantó).**

position to a depth of 40–50 meters. From this zone of decomposition evolved the oxidation and cementation belt of the deposit, the secondary limonite ore, and the siliceous limonite.

There are a number of theories regarding the origin and genesis of the ore mineralization at Rudabánya. The origin of the ore deposit has been considered hydrothermal-metasomatic (Pantó, 1956). According to this theory the metasomatic process was very slow, evolving under low temperatures (and without a significant influence on the evolution of the orebodies) from the various magmatic formations in the mountain range.

Another theory, based on more recent geochemical studies (Csalagovits, 1973a, b and 1974), proposes a non-hydrothermal metasomatic process. Examining the characteristic geothermal indicators of the metasomatized and non-metasomatized Triassic phases, this author pointed out the lack of conclusive evidence that hydrothermal action was involved, or that the ore formation was connected to the regional magmatism. This is also indicated by the low temperatures of formation (max. 150° C) of the ore minerals. Instead, he believes that the orebody resulted from the mixing of fluids from two paleoaquifers combined with disjunctive tectonic activity, which created the specific lithostratigraphic, geotectonic and paleogeographic conditions for the formation of the deposit.

The latest theory is based on the plate tectonic modeling of the area (Less and Szentpetery, 1986). It proposes a definite genetic connection of the orebody to an igneous formation, the Gömör granite, located to the north of the Rudabánya deposit. From the Gömör area the metalliferous formations are said to have been pushed in a southerly direction into an overthrust position during the Cretaceous period, and the orebodies were emplaced in their present location at the beginning of the Miocene period.

MINERALOGY

Minerals such as native copper, azurite, malachite, galena and possibly many others from the Rudabánya deposit were known to the miners for centuries. A number of authors gave brief descriptions of some of the minerals as early as the 18th century (Marsigli, 1726; Brückmann, 1727; Benkő, 1786), but systematic studies only commenced in the latter part of the 19th century (Zepharovich, 1859, 1873 and 1893; Tóth, 1882, and Schmidt, 1882). In the 20th century, researchers such as Schmidt, Kertai, Grasselly and especially Koch have contributed much to the understanding of Rudabánya mineralogy. In recent years (since the closing of the mine) interest in mineralogical investigation was rekindled by a number of mineralogists including one of the authors (S. Sz.), and a growing number of interested amateurs. As a result, many species new for the locality were discovered, and all the minerals reported in the literature have been reinvestigated using modern analytical techniques. Only those species confirmed by X-ray powder diffraction and electron microprobe analyses on multiple specimens, sometimes by multiple investigators, are included in the mineral descriptions. More than half of the species described below have been confirmed in the last 15 years, mostly from recently collected material. Although the mine is inactive, collecting and research on the mineralogy of the deposit continues, and specimen mining

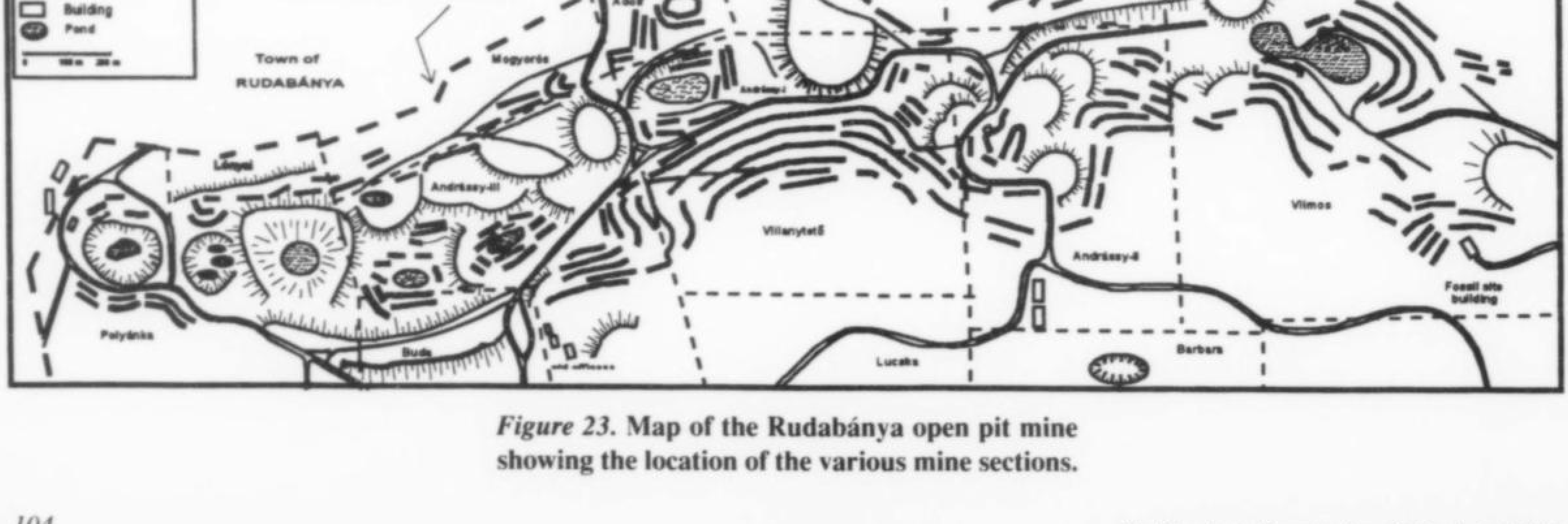


Figure 23. **Map of the Rudabánya open pit mine showing the location of the various mine sections.**

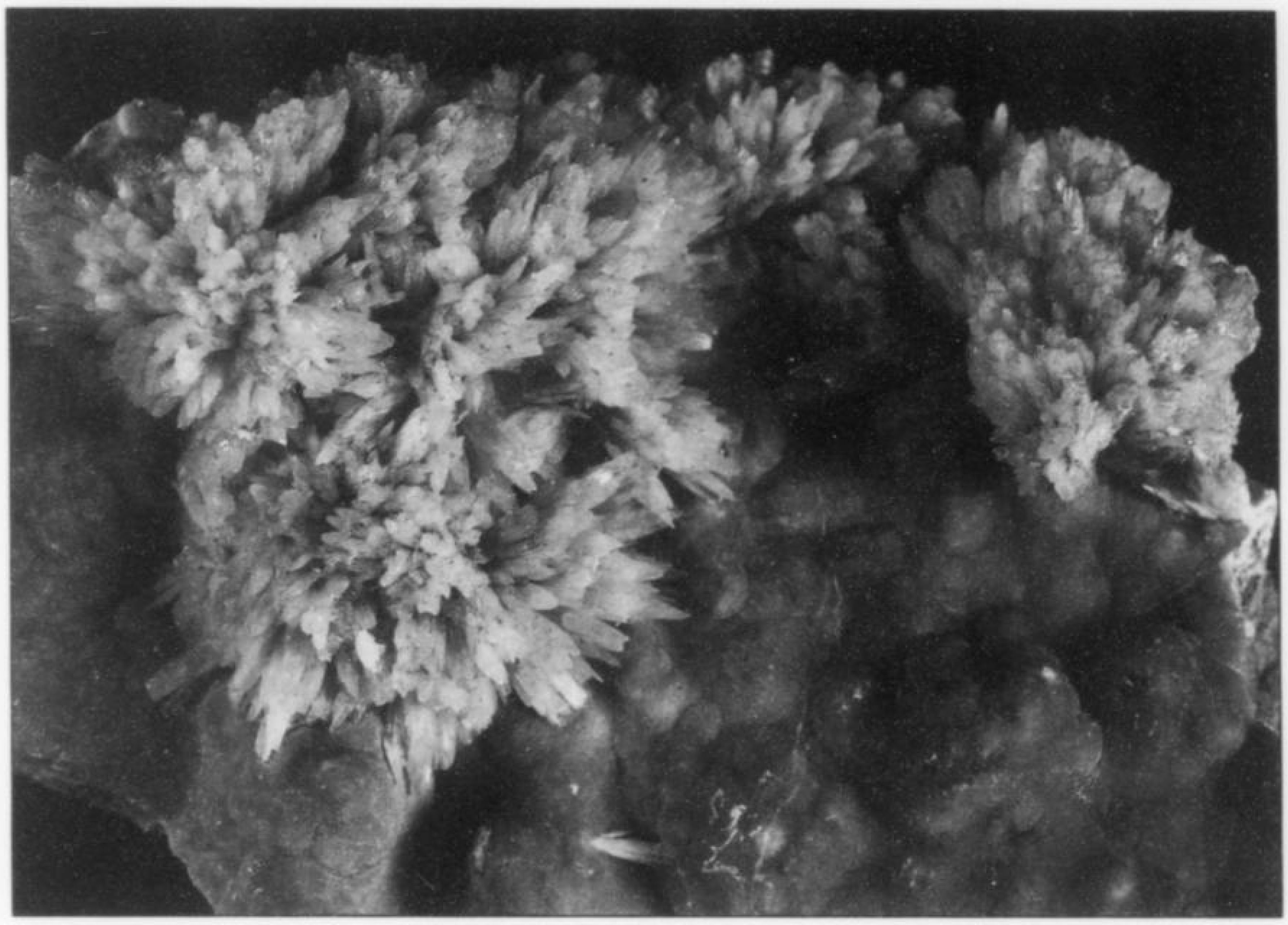


Figure 24. Aragonite, in radiating aggregates on calcite, 9 cm wide, from Rudabánya. Herman Ottó Museum collection, Miskolc; G. Kulcsár photo.

using heavy equipment has resulted in the recovery of some significant specimens in the last two years.

Acanthite Ag_2S

Acanthite is the most common silver mineral at Rudabánya. Although it has rarely been found in recent times, during the silver mining periods it was almost certainly the principal source of silver. Acanthite is widely distributed in small quantities, but is found mainly in the galena concentrations in barite veins. It occurs in the primary ore belt in the Andrássy I and II, the Vilmos and the Polyánka sections as dispersed grains to 0.1 mm across in galena. In the siderite ores it occurs as minute acicular crystals and thin flakes of secondary origin, sprinkled on wire-bundles and granular aggregates of silver. Acanthite is also found in the oxidation zone as lamellar aggregates 1–3 mm across associated with silver, cuprite, malachite, mercury, galena, anglesite and barite (Szakáll and Kovács, 1995).

Aluminite $Al_2(SO_4)(OH)_4 \cdot 7H_2O$

Aluminite is found as white, earthy concretions 3–5 cm in diameter associated with gypsum in the barite-sulfide orebodies (Dobosi, 1978).

Aluminocopiapite (see copiapite)

Anglesite $PbSO_4$

A relatively rare secondary mineral in the deposit, anglesite is found in the limonite ores and in near-surface exposures of galena-enriched barite veins in the Andrássy II and I, and the Vilmos sections. Anglesite occurs mainly in small cavities in the spongy, earthy limonite as colorless to transparent, pale gray, prismatic or tabular crystals 1–2 mm across and in barite veins, as colorless, tabular crystals up to 1 cm across, often on corroded galena crystals. Anglesite is invariably associated with cerussite in both assemblages, but it is considerably rarer than cerussite. On the tabular crystals the following forms have been noted: {100}, {110}, {102} and the dominant {104} (Koch, 1939). Many of the crystals have rounded and partially etched surfaces.

Anhydrite $CaSO_4$

Anhydrite is one of the main constituents in the Permian evaporite beds underlying the ore deposit. It occurs as compact spongy masses in close association with its alteration product, gypsum.

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

Ankerite occurs as xenomorphic grains of microscopic size associated with siderite, calcite and dolomite in carbonate ores (Pantó, 1956), and as idiomorphic crystals in barite veins.

Antlerite $Cu_3^{2+}(SO_4)(OH)_4$

Antlerite, a rare secondary mineral at Rudabánya, occurs in small fractures in the limonite ores as dull, pale green, powdery coatings and thin layers consisting of randomly intergrown, acicular crystals of microscopic size associated with malachite, covellite and chalcanthite (Szakáll *et al.*, 1997).

Aragonite $CaCO_3$

Aragonite is relatively common in fissures and cavities of the limonite-spongy siderite ores, occurring as colorless, white and pale green acicular crystals 1–5 mm long, often forming radiating, spherical groups; as dull, compact white spheres 4–6 cm in diameter; and as solid veins 1–3 cm across. Most of the colorless crystals are twinned on (110) (Koch, 1966).

Aurichalcite $(Zn,Cu^{2+})_5(CO_3)_2(OH)_6$

In limonite ores in the Andrássy I section, aurichalcite is found rarely in small crevices as thin, transparent, pale blue, platy crystals and crystal groups associated with cerussite, brochantite, malachite and zincrosasite (Szakáll, 1992).

Azurite $Cu_3^{2+}(CO_3)_2(OH)_2$

For mineral collectors, some of the most desirable and impressive mineral specimens from Rudabánya are the splendid large azurite crystals. The best examples compare favorably with those of the most famous azurite localities, at least in size. Azurite is a relatively common secondary mineral in cavities and crevices in the limonite ores and in calcite veins of the oxidation zone, commonly associated with or altered to malachite. Azurite occurs as lustrous, complex, transparent to translucent, deep blue, tabular

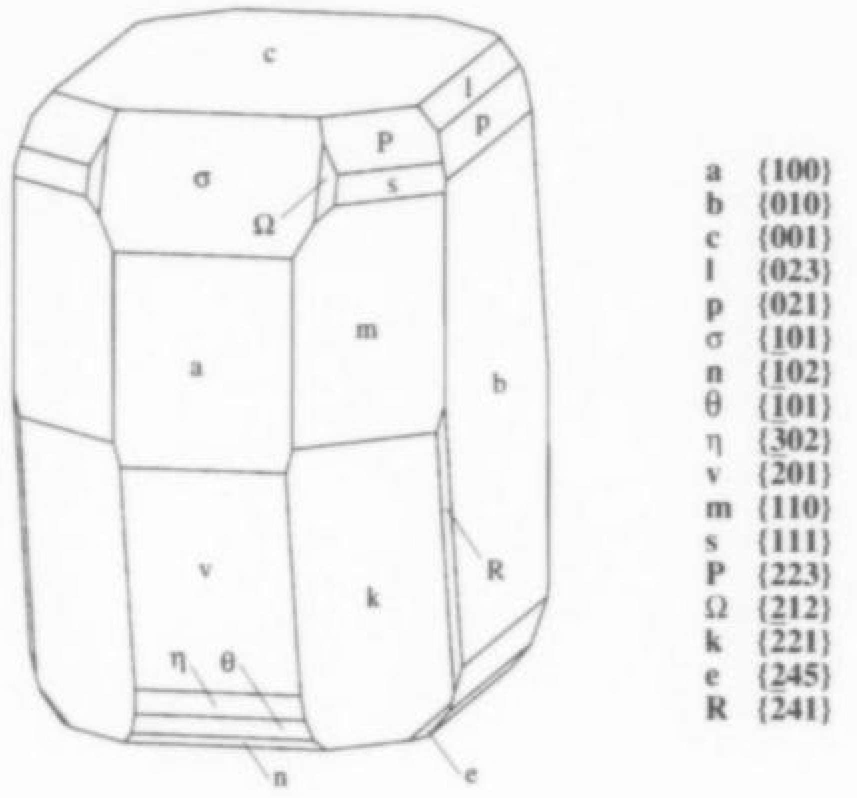


Figure 25. **Azurite crystal drawing, Rudabánya. After L. Tokody, in Koch (1966).**

Figure 27. **Labels of a 19th-century azurite specimen from Rudabánya in the Naturhistorisches Museum collection, Vienna.**

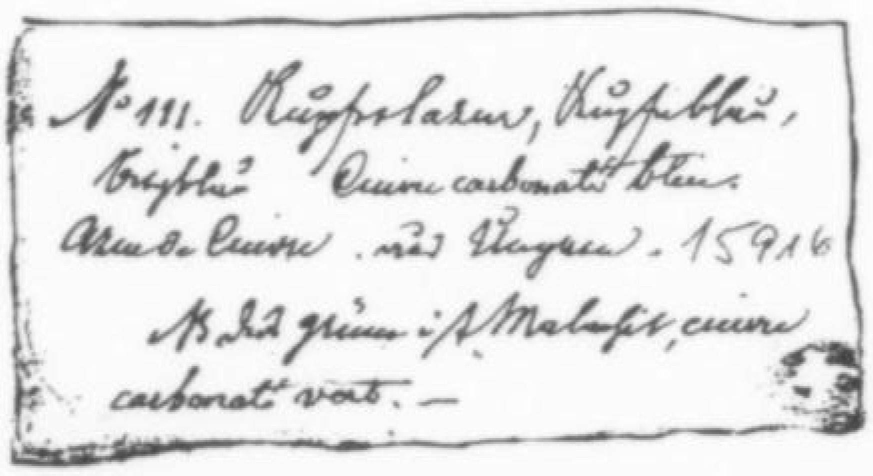


Figure 26. **Labels of a Rudabánya azurite and malachite specimen donated to the Naturhistorisches Museum Basel in 1863.**

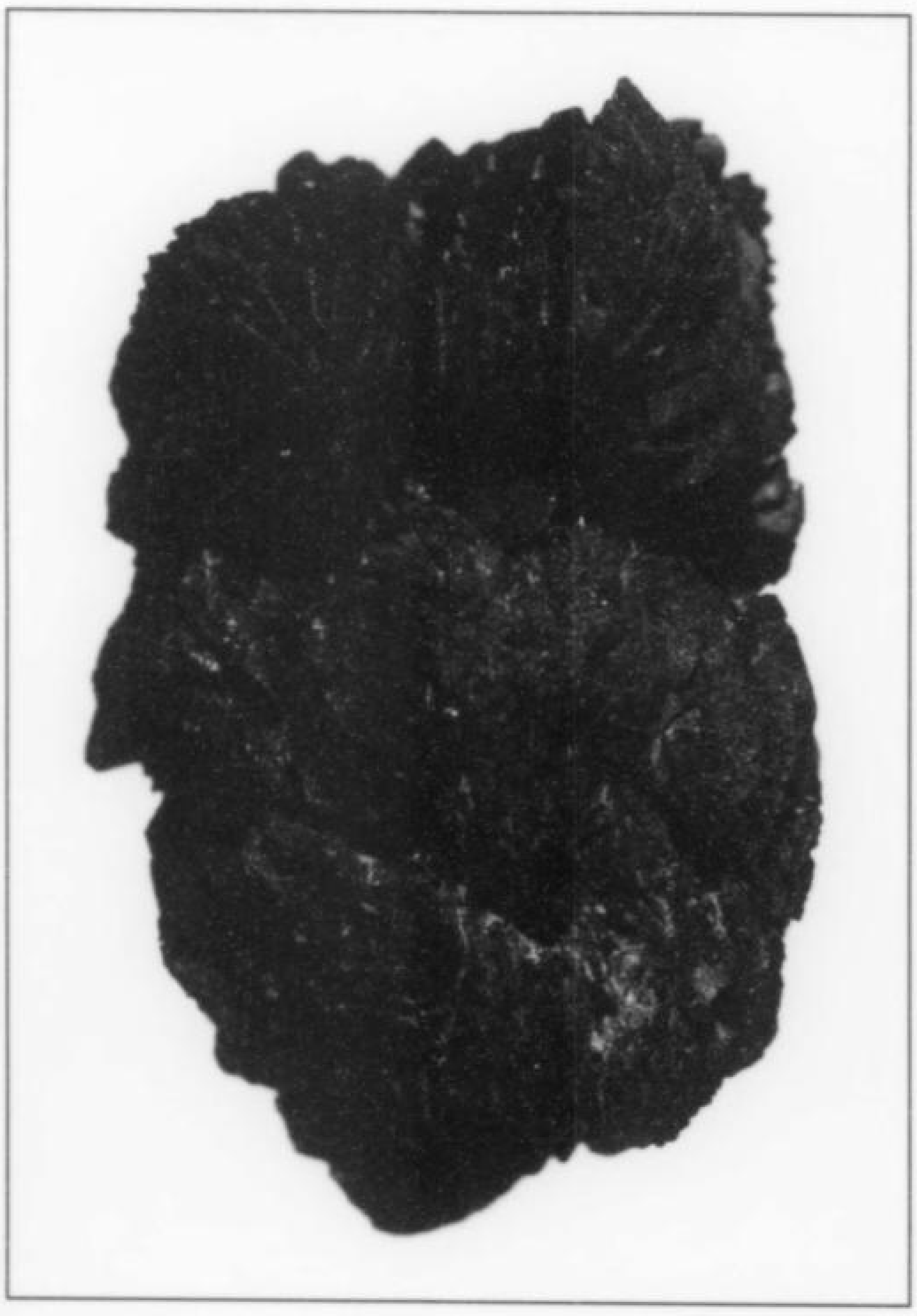


Figure 29. **Azurite, a spherical aggregate partially altered to malachite, 7 cm across, from Rudabánya. Rudabánya Mining Museum collection, Rudabánya; G. Kulcsár photo.**

Figure 28. **Azurite crystal group on calcite, 9 cm wide, from Rudabánya. Rudabánya Mining Museum collection, Rudabánya; G. Kulcsár photo.**

crystals 1–5 mm across; as botryoidal aggregates, consisting of spheres, 2–3 mm in diameter; as thin drusy layers on cuprite crusts covering native copper; as dull, opaque, dark blue, tabular crystals, forming rosette-like, intergrown aggregates 5–15 cm in diameter; as vitreous to dull, thick, opaque, dark blue, tabular crystals up to 16 cm long; and as rosettes and spherical aggregates 1–8 cm in diameter, partially altered to malachite.

The first documented mention of Rudabánya azurite appeared in 1726 (Marsigli, 1726), with etchings of three specimens of native copper, with associated blue (*crusta Vitrioli cœruli*) and green minerals, almost certainly blue azurite and green malachite. The oldest specimens of azurite that we have been able to trace in mineral collections (rather insignificant specimens) are from around 1880. Some fine, large, rosette-like aggregates consisting of bladed

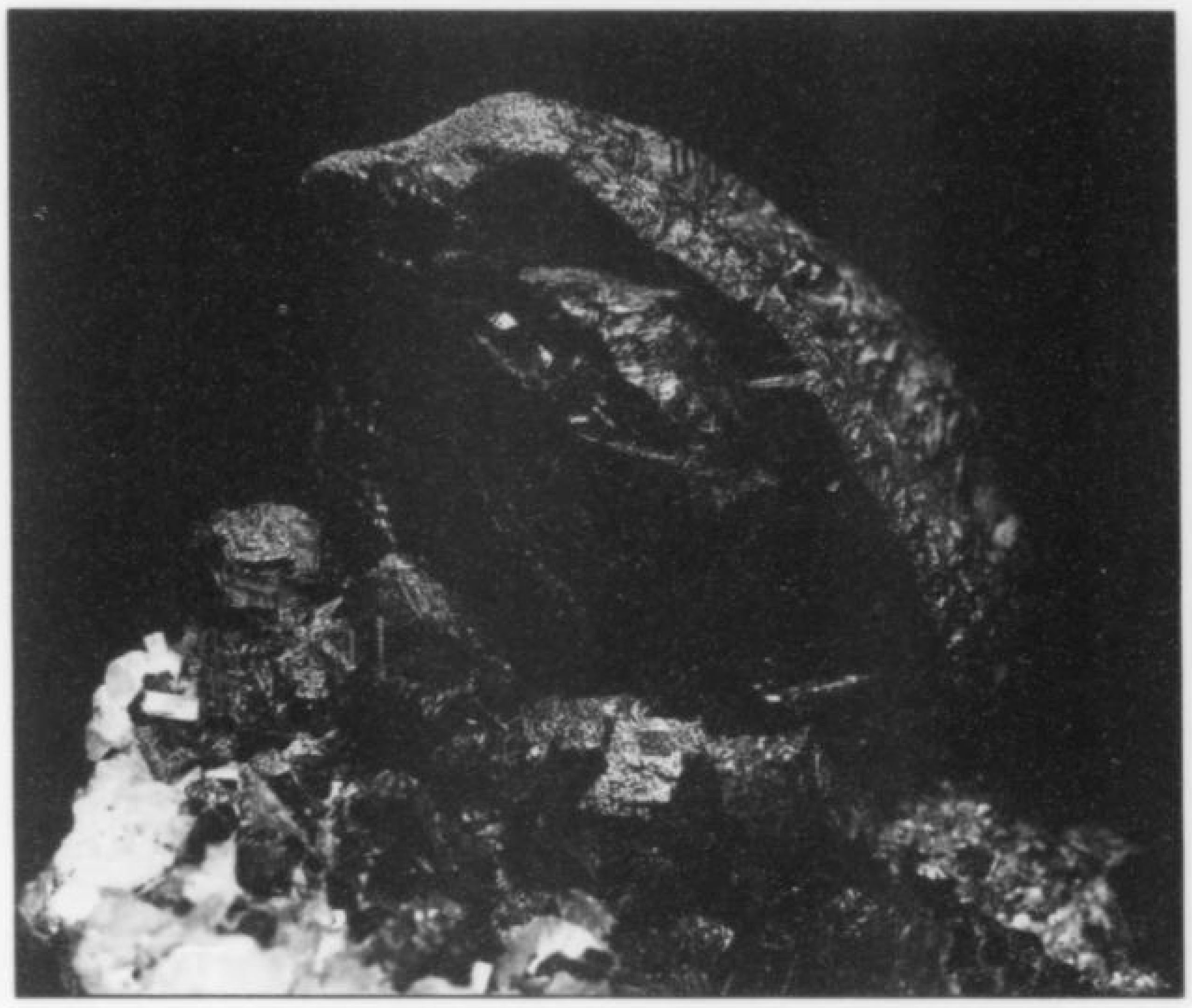


Figure 30. Azurite crystal, 3.5 cm. Herman Ottó Museum specimen; L. Horváth photo.

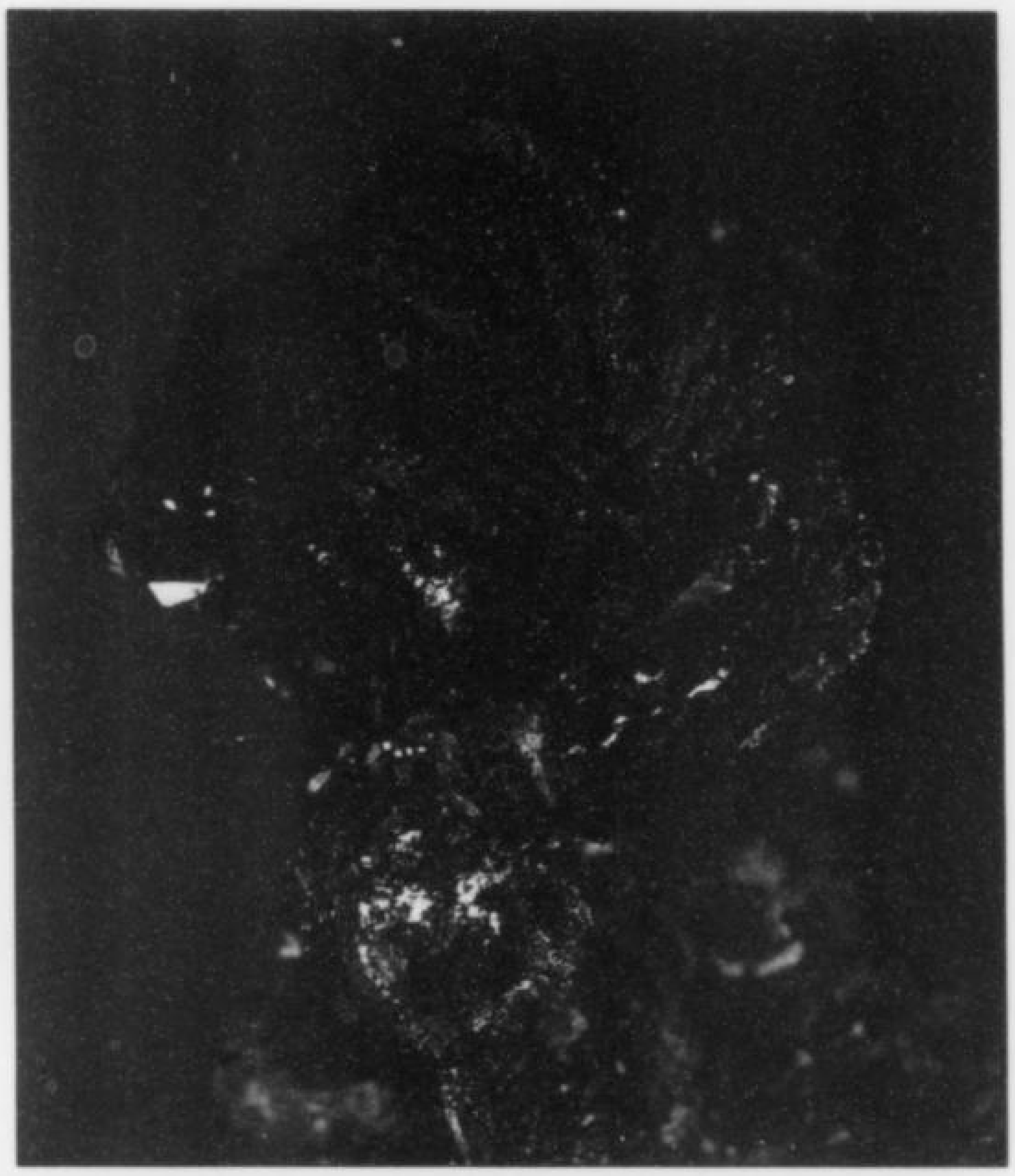


Figure 31. (right) Azurite rosette, 4 cm in diameter, collected in June 2000. Herman Ottó Museum specimen; L. Horváth photo.

Figure 32. Barite rosettes, field of view 3 cm wide. Herman Ottó Museum specimen; L. Horváth photo.

Figure 33. Barite aggregate, 5.5 cm wide. Herman Ottó Museum specimen; L. Horváth photo.

Figure 34. Cerussite crystal in cavity, 6 mm high. Herman Ottó Museum specimen (HOM #35306/2); L. Horváth photo.

crystals were collected around 1900 [or the beginning of the last century]. The largest tabular crystals of unaltered azurite known were collected in the 1950's in the Lónyai section; these are exceptional crystals attaining 10 cm in length. They are characterized by a dominant {001} pinacoid, and most show peculiar, smooth, lustrous to waxy curved surfaces with dull eroded areas. Outstanding specimens of tabular azurite crystals were collected in 1968–69 from an unknown part of the mine. The specimens consist of aggregates of lustrous, sharp, tabular crystals up to 5 cm in diameter and 5–6 mm thick, with the edges of azurite crystals sprinkled with sharp, dark green, prismatic malachite crystals up to 1 cm long. The overgrowth of these malachite (non-pseudomorphic) crystals on unaltered azurite is unique to Rudabánya. Excellent specimens of azurite with cuprite and malachite were also collected in the summer of 2000 from a limonite pod in the Andrássy I section. The specimens consisted of spherical aggregates 4–8 cm in diameter consisting of very dark blue, thin tabular crystals. Many of the azurite crystals found at Rudabánya are rich in forms; morphological studies (Tokody, 1924; Kertai, 1935) have identified 17 forms.

Exceptional specimens of azurite partially or completely altered to malachite were found in the Adolf mine section in 1985. The largest and the best of these is a spectacular matrix specimen consisting of a group of sharp, deep blue crystals, with parts of the crystals altered to bright green malachite in a limonite cavity. The largest crystal in the group is 16 cm long and 8 cm wide while the others 10–12 cm long, and all are totally free of damage. This specimen, along with a number of other significant pieces from the same find, are in a private collection in Miskolc, Hungary. Only a few people (10–12) were allowed to see the best pieces, among them the authors (S. Sz. and L.H.), who were permitted to measure but not to photograph the specimens.

Many of the best specimens of azurite and malachite pseudomorphs after azurite from earlier finds are in the collections of the Magyar Állami Földtani Intézet (MA'FI) [Hungarian Geological Institute] of the Hungarian Geological Survey and the Hungarian Natural History Museum, both in Budapest, the University of Szeged, the Herman Otto Museum in Miskolc, Érc és Ásványbányászati Muzeum [Ore and Mineral Mining Museum] in Rudabánya, and in private collections mostly in Hungary, Austria and Germany.

Barite $BaSO_4$

A widely distributed and very common mineral in many parts of the Rudabánya deposit, barite is found in both the primary and secondary ore belts. Barite is most abundant in the primary belt, where it forms solid rims (up to 3 meters in thickness) on the contact of the siderite masses with marl, and also occurs as vein-fillings in limonite. These primary barite masses contain local concentrations of various sulfides, most commonly galena and

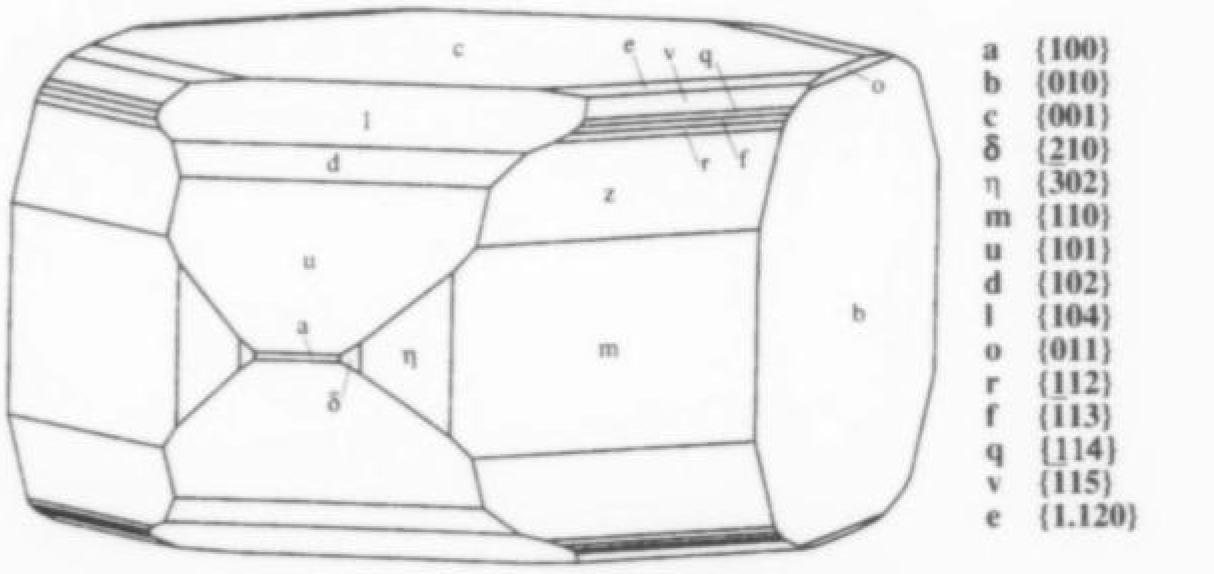


Figure 35. **Barite crystal drawing, Rudabánya (after Schmidt, 1882).**

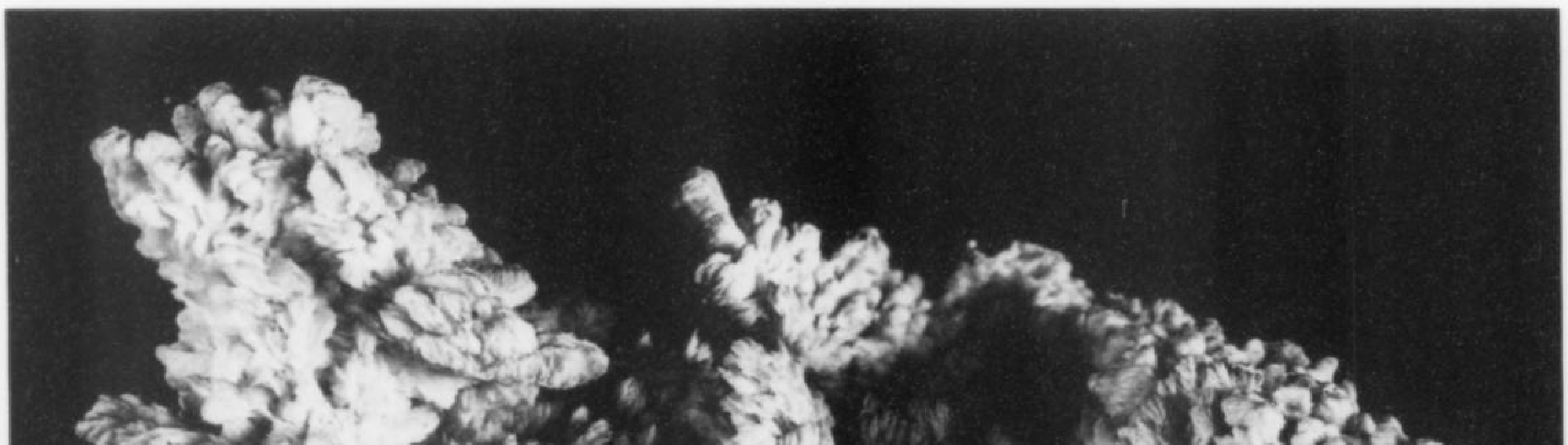


Figure 36. **Barite, an aggregate of sharp, tabular crystals, 18 cm wide, from Rudabánya. Rudabánya Mining Museum collection, Rudabánya; G. Kulcsár photo.**

sphalerite. Most barite masses and veins are solid, but some have cavities which are lined with lustrous, sharp, opaque, white, tabular crystals of barite 1–2 mm across. In the limonite and spongy siderite ores of the secondary belt, barite is found as compact, opaque, white, spherical aggregates up to 3 cm in diameter, covered by small tabular crystals; as irregular, white crusts consisting of small crystals; and as sharp, complex, colorless, tabular crystals dominated by the {001} pinacoid, 5–10 mm across, forming attractive groups and rosettes. Barite was also found in the Upper Miocene clay-sand-lignite layers covering the deposit, as spherical to oblong concretions with concentric, layered ring-structure, 1–7 cm in diameter (Radócz, 1973). Morphological studies of Rudabánya barite (Schmidt, 1882; Kertai, 1935; and Koch *et al.*, 1950) have identified a total of 22 forms.

Beudantite $PbFe_3^{3+}(AsO_4)(SO_4)(OH)_6$

In the siliceous limonite bodies of the Adolf section, beudantite is found finely dispersed as submicroscopic grains enclosed in cerussite. Very rarely, it also occurs in cavities as dull, opaque, greenish yellow, colloform aggregates 1–3 mm in diameter, associated with mimetite (Szakáll *et al.*, 1994), as aggregates of fresh, equant, pale brown, crystals 1–3 mm across, associated with mimetite and malachit, and as green dipyramidal crystals up to 0.2 mm.

Bindheimite $Pb_2Sb_2O_6(O,OH)$

Bindheimite is a relatively rare secondary mineral, an alteration product of boulangerite, found in the barite veins of the Andrássy I and II, and the Vilmos sections. Very rarely it is also found in fissures in the siliceous limonite of the Adolf mine section. Bindheimite occurs as pale yellow to reddish yellow, earthy masses, crusts and thin coatings covering surfaces up to several square centimeters and as masses of acicular to fibrous pseudomorphs after boulangerite.

Bismuth Bi

Bismuth is extremely rare, occurring as microscopic grains in galena associated with barite veins in the primary belt, and very rarely associated with galenobismutite (Nagy and Dobosi, private communications).

Bornite Cu_5FeS_4

Bornite is relatively common in the sulfide-rich parts of the siderite ore, occurring as irregular grains 2–3 mm across, typically associated with chalcopyrite, chalcocite and covellite (Koch *et al.*, 1950). Rarely, bornite has also been found as crystalline masses 4–6 cm across intermixed with chalcocite and chalcopyrite.

Botryogen $MgFe^{3+}(SO_4)_2(OH)\cdot 7H_2O$

A relatively rare secondary mineral, botryogen occurs as thin, orange-yellow crusts up to several square centimeters in area in the Andrássy III section, associated with epsomite, melanterite and copiapite (Szakáll *et al.*, 1997).

Boulangerite $Pb_5Sb_4S_{11}$

Boulangerite is a relatively rare associate of galena in barite veins of the primary zones in the Andrássy I and II, and especially in the Vilmos sections of the mine. It occurs as metallic, opaque, gray, radiating aggregates and irregular matted masses up to 2 cm in diameter, consisting of acicular crystals, invariably intergrown with galena. Typically the boulangerite is coated with pale yellow, powdery bindheimite, and rarely it is found completely altered to bindheimite. It is more than likely that the "fibrous jamesonite" mentioned from the galena of the Andrássy II section (Koch *et al.*, 1950) was boulangerite, as the occurrence of jamesonite has not been confirmed to date.

Bournonite $PbCuSbS_3$

Bournonite occurs very rarely in the primary ore belt, as microscopic inclusions of twinned lamellae in galena (Tokody, 1950).

Brochantite $Cu_4^{2+}(SO_4)(OH)_6$

In the limonite ores of the Andrássy I and the Adolf sections, brochantite is found as a relatively common secondary mineral, typically altered from chalcocite, digenite and covellite. It occurs as translucent, emerald to deep green crusts, as spherical aggregates 1–2 mm in diameter, and very rarely as equant, transparent, deep green crystals up to 1 mm. Associated minerals include calcite, cerussite, aurichalcite and zincrosasite (Szakáll, 1992).

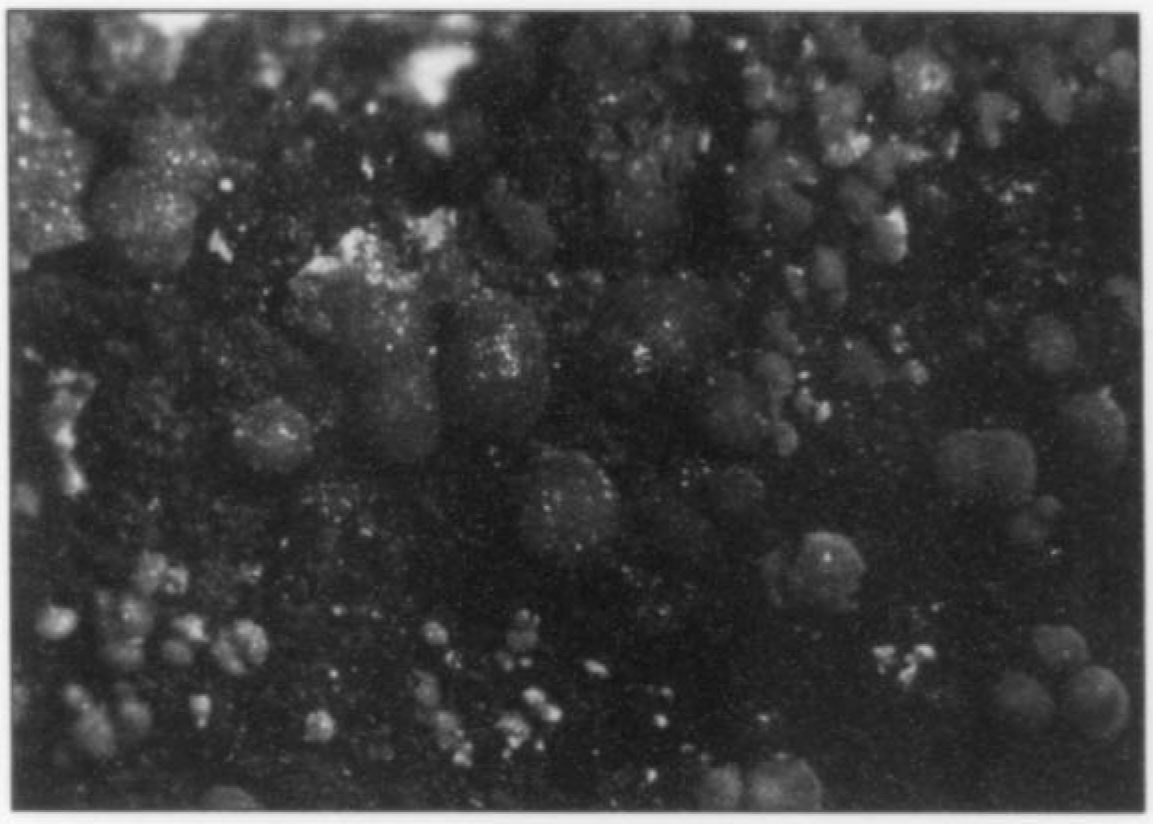


***Figure 37.* Brochantite in spherical aggregates up to 1 mm with malachite, from Rudabánya. Herman Ottó Museum collection; S. Szakáll photo.**

Bromargyrite AgBr

Like other late-stage silver-halides found at Rudabánya, bromargyrite is derived from the alteration of tennantite found in the limonite and siliceous limonite of the Adolf mine section. Bromargyrite is relatively rare, occurring as translucent to opaque, colorless to grayish white crusts, and as aggregates of cuboctahedral crystals up to 1 mm, characteristically associated with chlorargyrite. Electron microprobe analysis of the bromargyrite indicates relatively high Cl content due to intergrowth with chlorargyrite (Szakáll and Kovács, 1995).

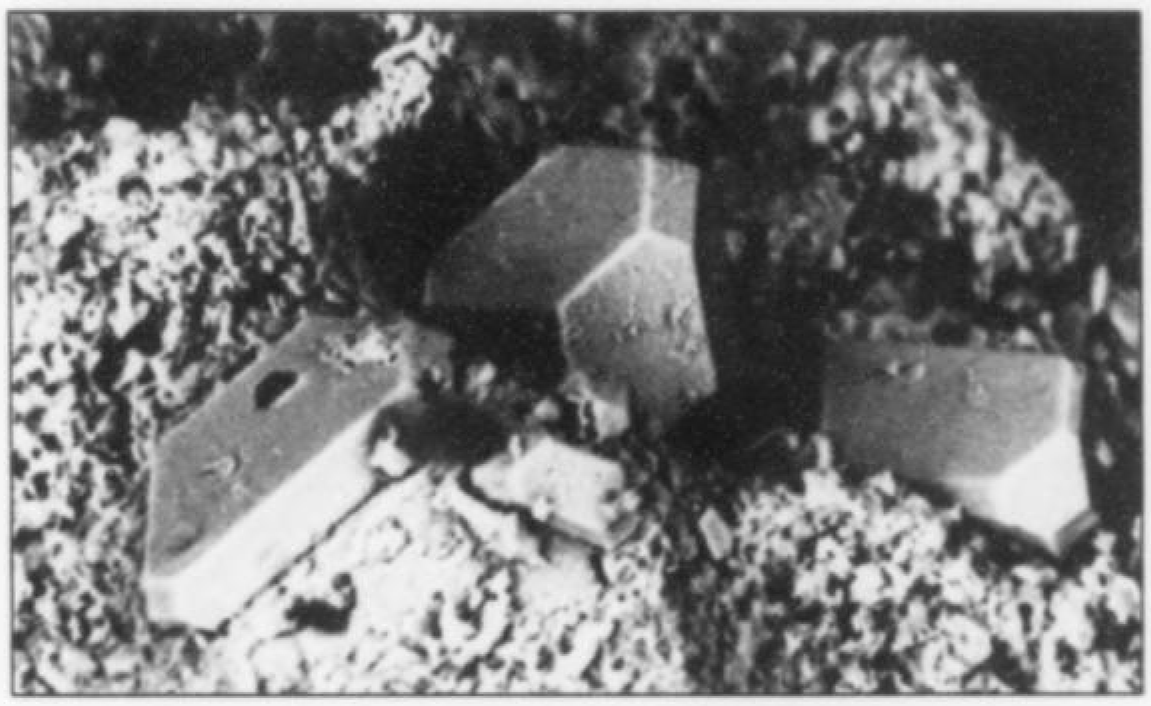


***Figure 38.* Bromargyrite crystals 0.1 mm across, from Rudabánya. Herman Ottó Museum collection.**

Cacoxenite $(Fe^{3+},Al)_{25}(PO_4)_{17}O_6(OH)_{12}\cdot 75H_2O$

Cacoxenite is extremely rare at Rudabánya, found in a single specimen in the Andrássy II section, as greenish yellow, radiating capillary crystals, up to 1 mm long, with indistinct terminations, forming hemispherical aggregates on azurite crystals (Koch *et al.*, 1950).

Calcite $CaCO_3$

Widely distributed in both the primary and secondary ore belts of the deposit, calcite occurs predominantly as massive vein-fillings, and less commonly as well-formed rhombs and elongated hexagonal prisms. Crystals up to 1 cm across are colorless, transparent to translucent, pale yellow, and opaque white grading to gray. Most of the calcites here fluoresce intense red to purplish red under shortwave ultraviolet radiation.

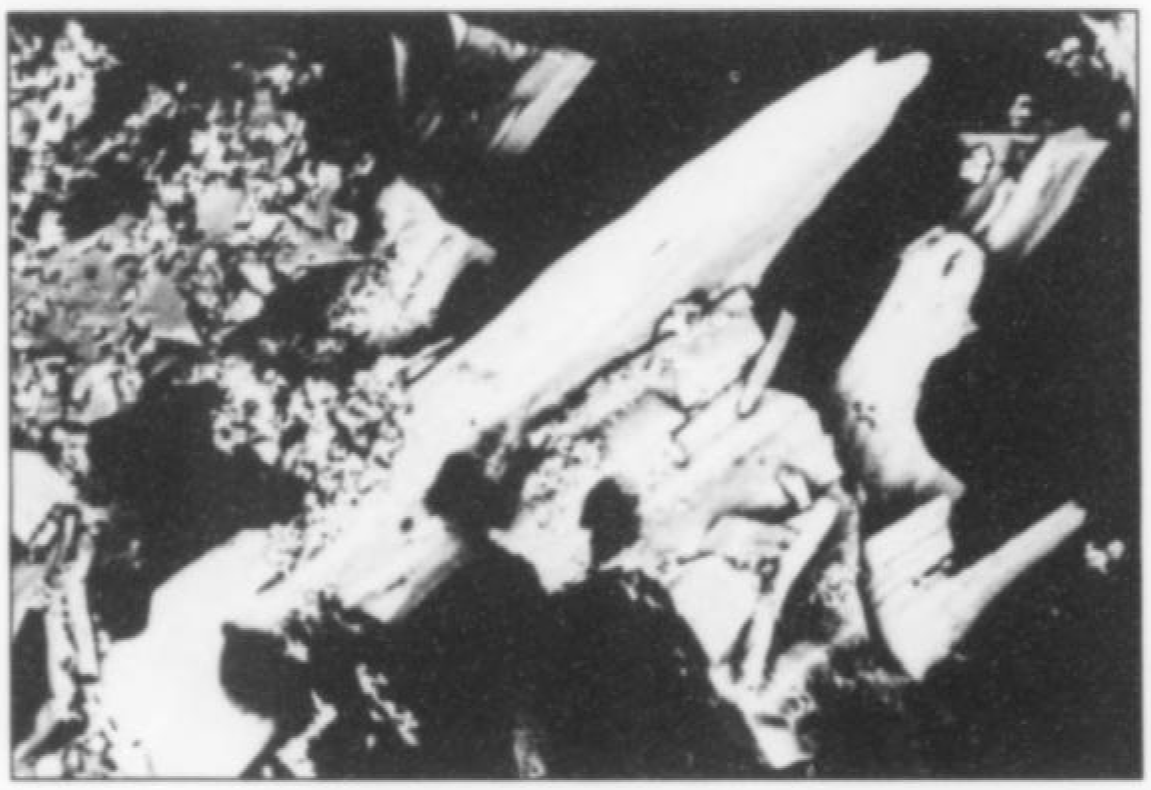


***Figure 39.* Capgaronnite, a crude elongated crystal approximately 0.2 mm long, from Rudabánya. Herman Ottó Museum collection.**

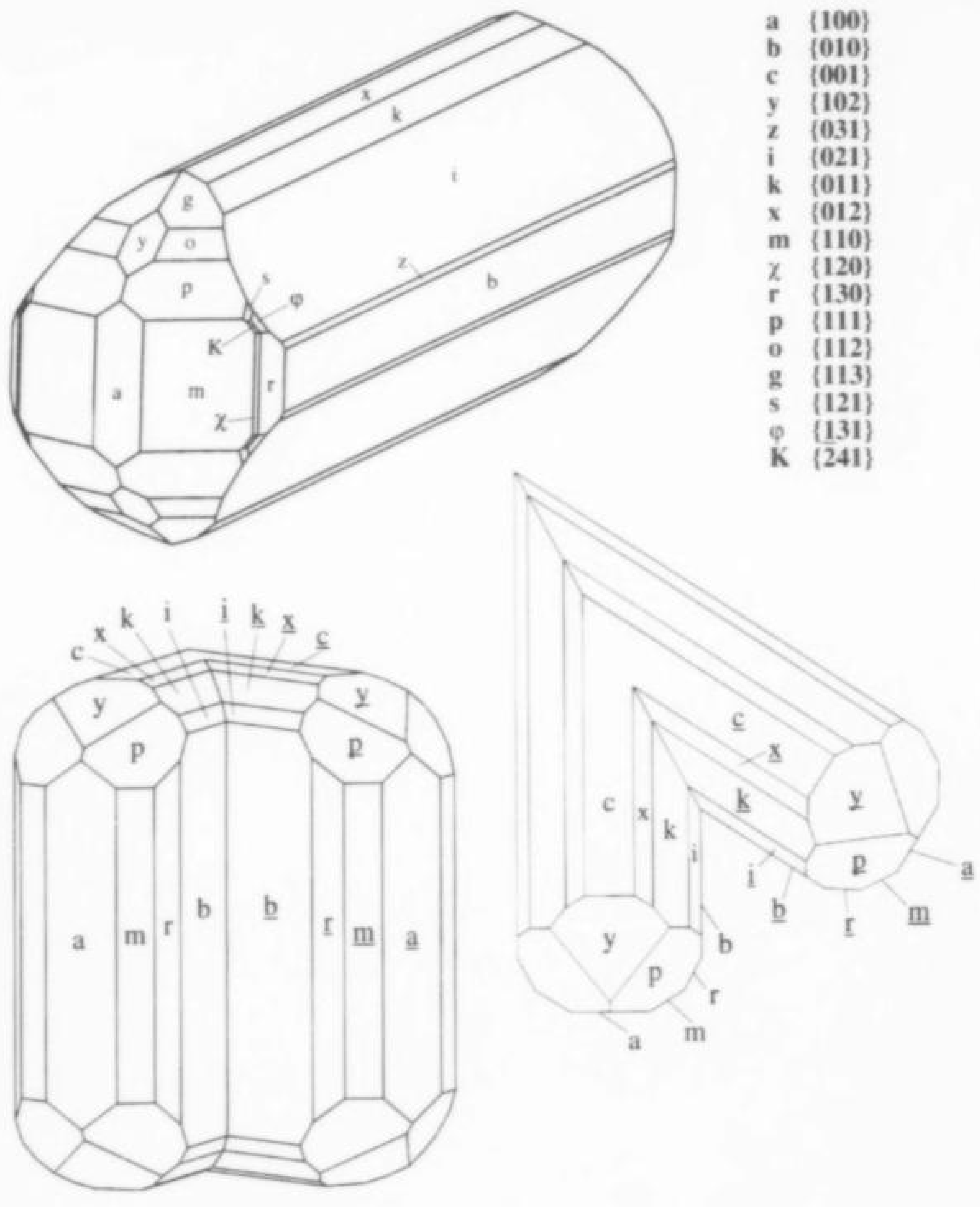


***Figure 40.* Cerussite crystal drawing, Rudabánya (after Schmidt, 1882).**

Capgaronnite $HgS\cdot Ag(Cl,Br,I)$

Capgaronnite, a rare sulfo-halide, was first described from Cap Garonne, Var, France (Mason *et al.*, 1992), where it occurs as minute crystals associated with secondary Cu, Ag and Hg minerals in Triassic conglomerates and sandstones. Rudabánya is the second reported locality for the mineral.

Capgaronnite is extremely rare, found with other late-stage secondary silver and mercury minerals (the alteration products of tennantite) in the siliceous limonite in the Adolf mine section. Capgaronnite occurs as vitreous to adamantine, crude, black, elongated prismatic crystals 0.1–0.2 mm long. Associated minerals are tennantite, moschellandsbergite, cinnabar, mercury, perroudite and iltisite (Szakáll and Sarp, 2000).

Carbonate-cyanotrichite $Cu_4^{2+}Al_2(CO_3,SO_4)(OH)_{12}\cdot 2H_2O$

In the vuggy limonite zone of the Adolf section, carbonate-cyanotrichite was found as radiating aggregates of pale blue acicular crystals 0.1–0.5 mm long.

Cassiterite SnO_2

Cassiterite is a rare associate of the sulfide assemblage consisting mostly of chalcopyrite and bornite in barite veins of the Villanytető mine section. It occurs as microscopic grains and idiomorphic crystals.

Cerussite $PbCO_3$

Cerussite is a very common and widespread alteration product of galena in the secondary ore belts, found most commonly in near-surface exposures of galena-rich ores in the Andrássy I, II, III, the Polyánka and the Vilmos mine sections. Cerussite occurs as well-formed crystals in cavities in barite veins, and in spongy limonite and siliceous limonite. The crystals are adamantine, sharp, complex, colorless (sometimes faintly reddish on the surface due to a finely dispersed dusting of cinnabar), with equant bipyramidal, tabular, and elongated prismatic habits. Crystals are generally 1–3 mm across, with exceptional crystals exceeding 1 cm in length. Morphological studies of the complex crystals by a number of investigators (Schmidt, 1882; Kertai, 1935; Koch, 1939; and Zsivny, 1951) have revealed 23 forms. Many of the crystals are twinned, most commonly on (110) and rarely on (130).

Chalcanthite $Cu^{2+}SO_4\cdot 5H_2O$

As a post-mining deposition in old underground workings, chalcanthite occurs as transparent to translucent blue vein-fillings and crusts with a somewhat coarse, fibrous structure, rarely associated with antlerite.

Chalcocite Cu_2S

In the siderite ores chalcocite is common as crystalline masses up to 1 cm across, and rarely as well-formed crystals. From the underground workings of the Istvántelek section it has been reported as twinned, tabular crystals up to 5 mm across, bounded by the dominant {001} basal pinacoid and the {113} and {023} prisms (Koch, 1966). In thin barite veins intersecting the siderite masses of the Andrássy I and II sections, chalcocite also occurs in narrow fissures as thick, tabular crystals 2–3 mm across. These crystals are partially altered to covellite and digenite, and progressively to cuprite and malachite. In cavities of the limonite and spongy siderite ores, chalcocite also occurs as well-formed, pseudohexagonal tabular crystals 1–3 mm across, and as thin alteration rims on chalcopyrite and bornite intergrown with covellite.

Chalcopyrite $CuFeS_2$

Chalcopyrite is the most abundant copper-bearing sulfide mineral in the deposit, most commonly found in the siderite orebodies as crystalline masses up to 14 cm across, intermixed with bornite and chalcocite. Rarely chalcopyrite also occurs in small cavities in the siderite ore as well-formed disphenoids 1–3 mm across. The attractive copper minerals of the oxidation-cementation zone such as copper, malachite, azurite and cuprite are primarily the alteration products of chalcopyrite.

Chalcostibite $CuSbS_2$

Chalcostibite is rare at Rudabánya, found in small cavities in the spongy siderite ores of the Polyánka, Andrássy I and III sections. Chalcostibite occurs as blocky, opaque, dark gray crystals 1–2 mm across, and dispersed in the ore as anhedral grains to 1 mm in diameter (Szakáll, 1992). Associated minerals include chalcocite (most common), skinnerite, tetrahedrite, digenite and tennantite.

Chlorargyrite AgCl

Chlorargyrite is relatively rare, found in the limonite and siliceous limonite typically associated with the less common bromargyrite. Freshly exposed chlorargyrite is lustrous, transparent, yellowish green and rarely pale magenta in color. It forms octahedra up to 1 mm, sometimes in parallel intergrown crystal groups 1–3 mm across. Chlorargyrite is also found as fine-grained aggregates and thin crusts. On exposure to light chlorargyrite crystals turn gray and black. Associated minerals are bromargyrite, iodargyrite, cuprite, cerussite, malachite, barite and mercury (Szakáll and Kovacs, 1995).

Cinnabar HgS

Cinnabar is relatively common and widely dispersed in small quantities in various orebodies, as a secondary mineral most likely altered from mercury-bearing tennantite (Kertai, 1935; Koch, 1939). Cinnabar occurs most commonly in cavities in limonite and siliceous limonite as dull, opaque, brownish red and red earthy masses and crusts, as a very fine, reddish brown to red dusting on cerussite and sulfur crystals, and very rarely as translucent, red, short prismatic crystals to 1 mm in length. Cinnabar has also been found as a very rare primary mineral in siderite as embedded, dark red anhedral grains of microscopic size (Koch *et al.*, 1950).

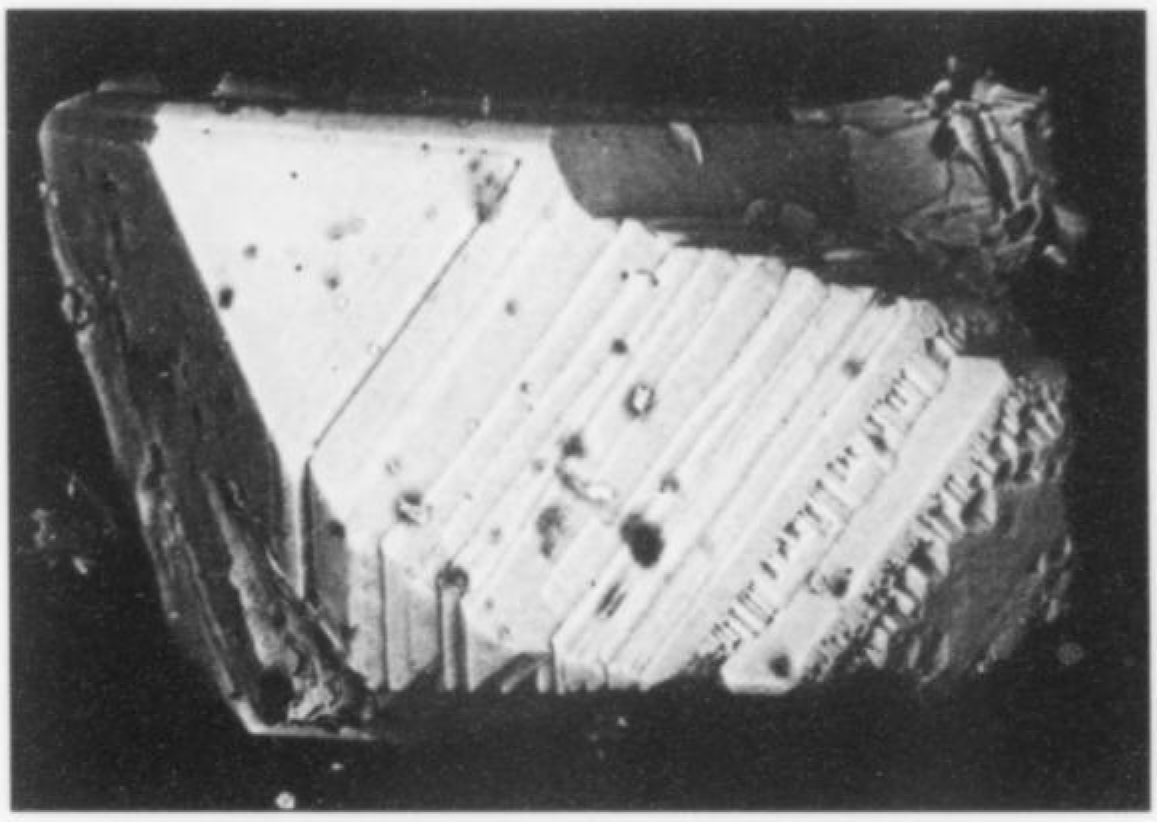


Figure 41. **Chlorargyrite crystal, 0.2 mm across, from Rudabánya. Herman Ottó Museum collection.**

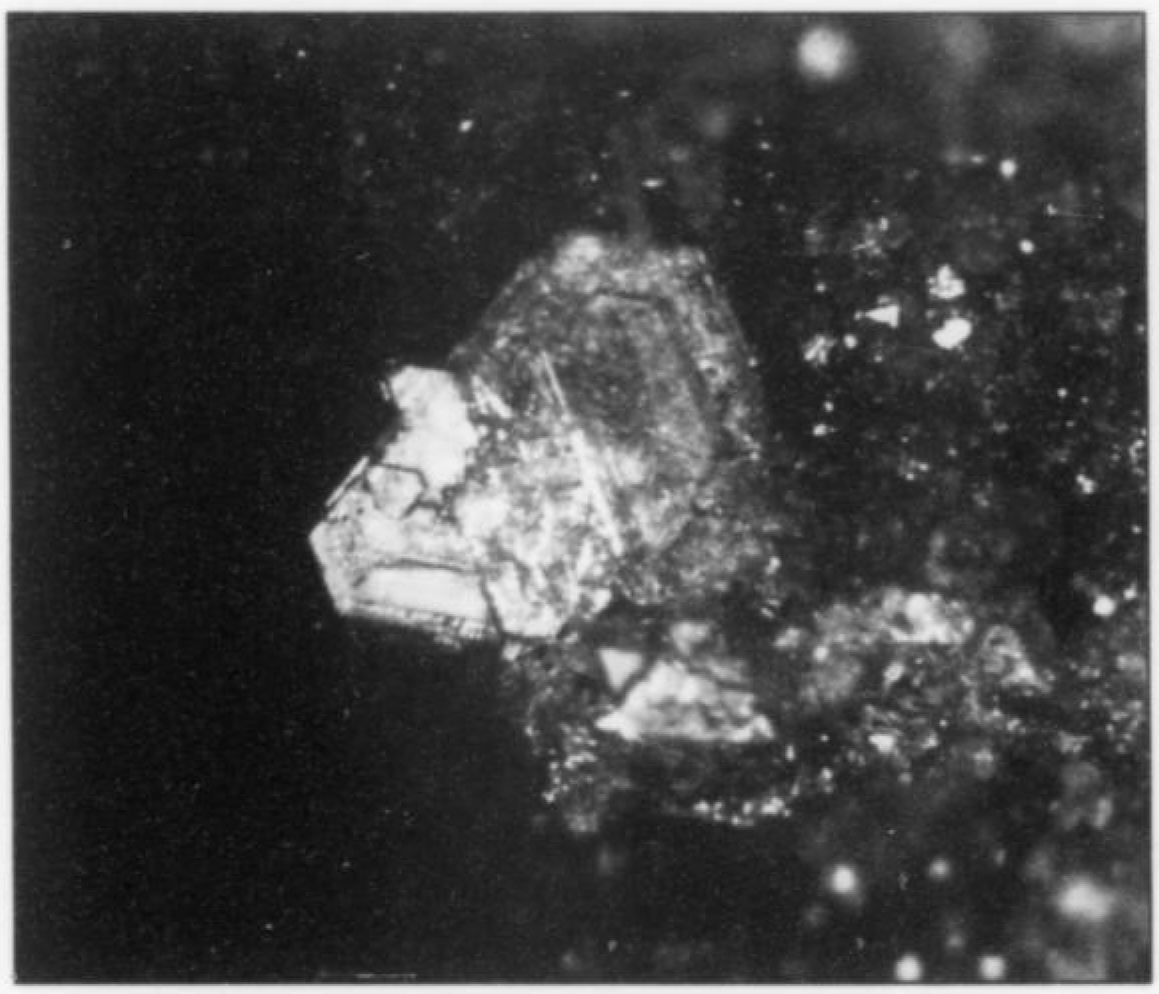


Figure 42. **Chlorargyrite, a 1-mm octahedral crystal, from Rudabánya. Herman Ottó Museum collection; S. Szakáll photo.**

Figure 43. **Claraite, an aggregate of bladed crystals 0.5 mm across, from Rudabánya. Herman Ottó Museum collection.**

Claraite $(Cu,Zn)_3(CO_3)(OH)_4 \cdot 4H_2O$

Claraite was originally described from Grube Clara near Oberwolfach, Schwarzwald, Baden-Württemberg, Germany (Walenta and Dunn, 1982). At Rudabánya, claraite occurs as an extremely rare secondary mineral in cavities of a sulfide-rich barite zone in the Villanytető section, as pale green to greenish blue spherical aggregates consisting of lath-shaped crystals 10–20 μm long. Associated minerals include barite, malachite, devilline, goethite and gypsum (Szakáll *et al.*, 1997).

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

In the quartz-barite veins associated with the marl in the Deák section, clinochlore was identified as finely dispersed microscopic flakes associated with hematite (Pantó, 1956).

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

Conichalcite occurs as thin crusts and spheres 0.1–0.5 mm in diameter consisting of pale green, very fine acicular crystals associated with malachite in the Villanytető mine section.

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

An exceedingly rare species at Rudabánya, connellite was found associated with cuprite as deep blue irregular aggregates up to 0.1 mm in diameter.

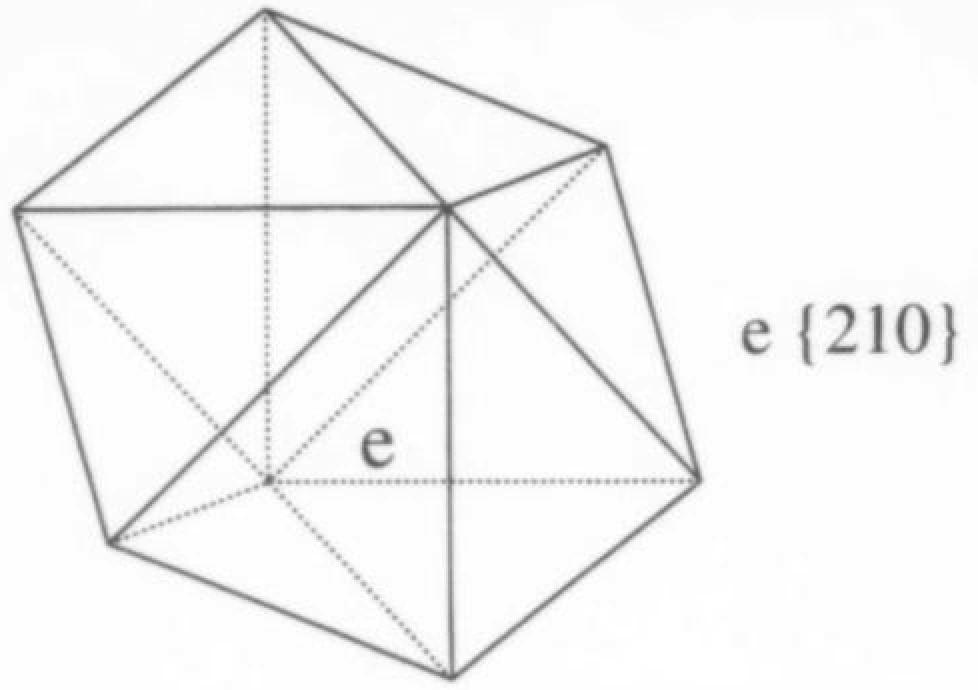


***Figure 44.* Copper, crystal drawing of the pseudohexagonal bipyramidal habit (after Tokody, 1924) (e = {210}).**

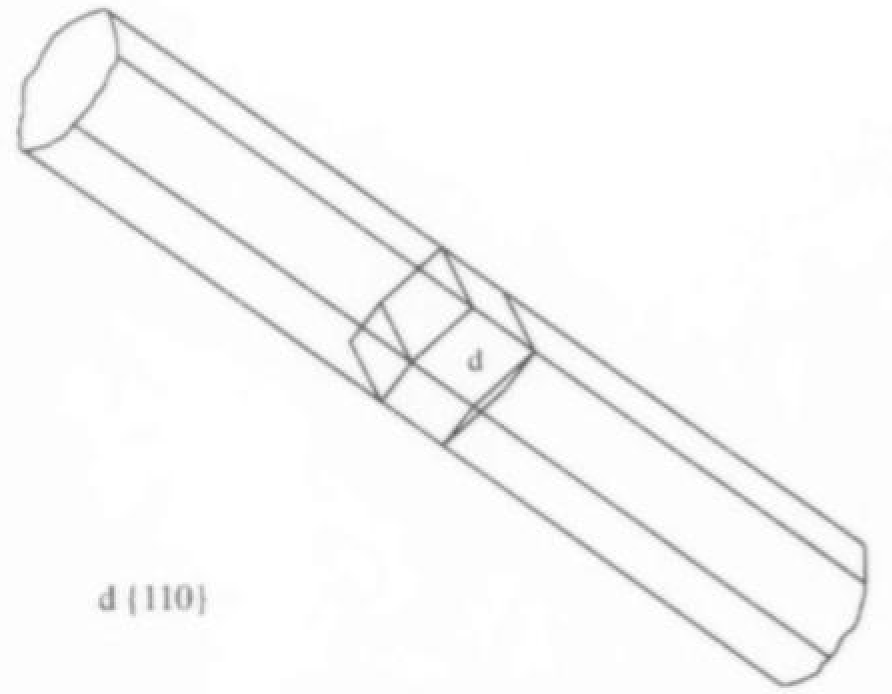


***Figure 45.* Copper crystal drawing depicting a rod with hexagonal cross-section formed by the elongated {110} dodecahedron.**

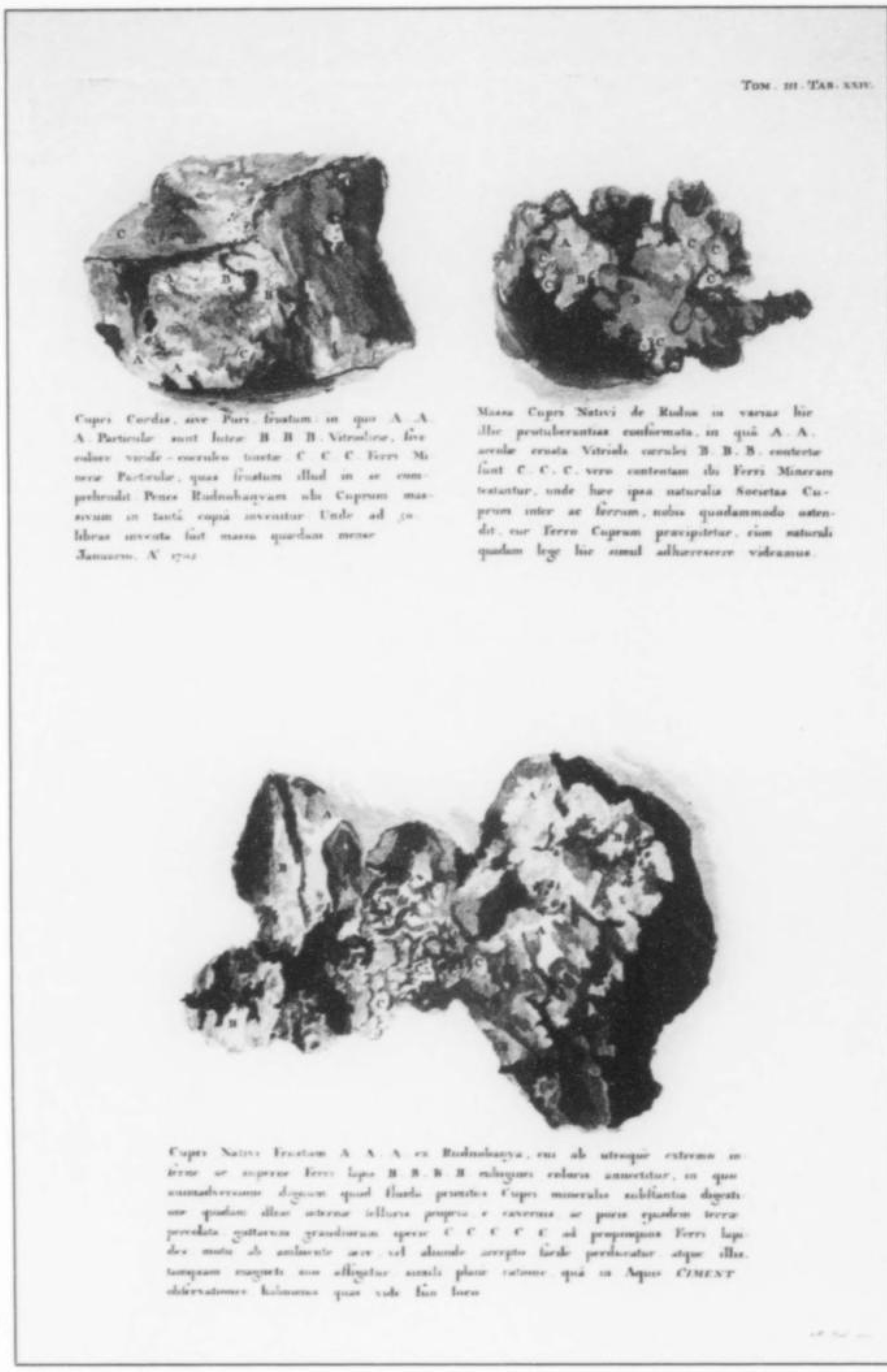


***Figure 46.* Copper specimens from Rudabánya depicted in Marsigli (1726).**

Copiapite $Fe^{2+}Fe_4^{3+}(SO_4)_6(OH)_2 \cdot 20H_2O$

Copiapite and its Al and Mg-analogs, aluminocopiapite and magnesiocopiapite, are relatively common secondary minerals in old workings of the Andrássy I, II and the Vilmos sections. The three species are virtually indistinguishable and occur together as dull, beige, yellow and yellowish white, powdery efflorescences and crusts associated with epsomite, melanterite and fibroferrite.

Copper Cu

For mineral collectors perhaps the best known mineral specimens from Rudabánya are the beautiful native copper specimens of diverse habits, especially the splendid, malachite-coated skeletal crystal specimens. Native copper is found exclusively in the limonite and spongy siderite orebodies of the oxidation zone. Although native copper has been mined and probably collected for centuries, most of the specimens extant in private and institutional collections, were collected from chance exposures in the course of iron ore mining during the last 120 years. The primary source for specimen copper is the Andrássy I mine section, where it is found in complex, interconnected cavities most commonly in limonite, invariably associated with secondary minerals such as cuprite, malachite and azurite.

Native copper occurs in a wide variety of habits: as formless lumps and nuggets, sometimes exceeding 50 kg in weight; as branching, arborescent and dendritic aggregates, up to 30 cm across; as felt-like, mossy, capillary and net-like intertwined wiry masses, up to 10 cm across; as grape-like clusters of solid spheres 5–10 mm in diameter; and as exquisite aggregates up to 30 cm across of intergrown, elongated and distorted skeletal crystals, with a lamellar structure and foil-like hollow shells. Crystals of textbook symmetry are rare at Rudabánya; these are mainly well-formed cubes, octahedra and tetrahexahedra. Asymmetrically developed copper crystals are more common, and the morphology of some of these has been studied in some detail (Tokody, 1924, 1950; Koch, 1939). These include well-crystallized rods with a hexagonal cross section (elongated {110} dodecahedra), pseudohexagonal bipyramids and pseudoscalenohedra (the faces of both correspond to peculiarly developed {210} tetrahexahedra). The most attractive and interesting specimens consist of sharp, elongated, spear-shaped, skeletal crystals, which can attain 15 cm in length. These crystals are formed by the elongation and uneven development of the {111} octahedra, in the direction of the corners and edges. With the exception of some very fine masses of bright, clean, metallic wire-copper, all copper specimens are coated by a thin layer of malachite, or often by a thin layer of cuprite and malachite. Many excellent specimens of native copper are found in institutional collections in Hungary,

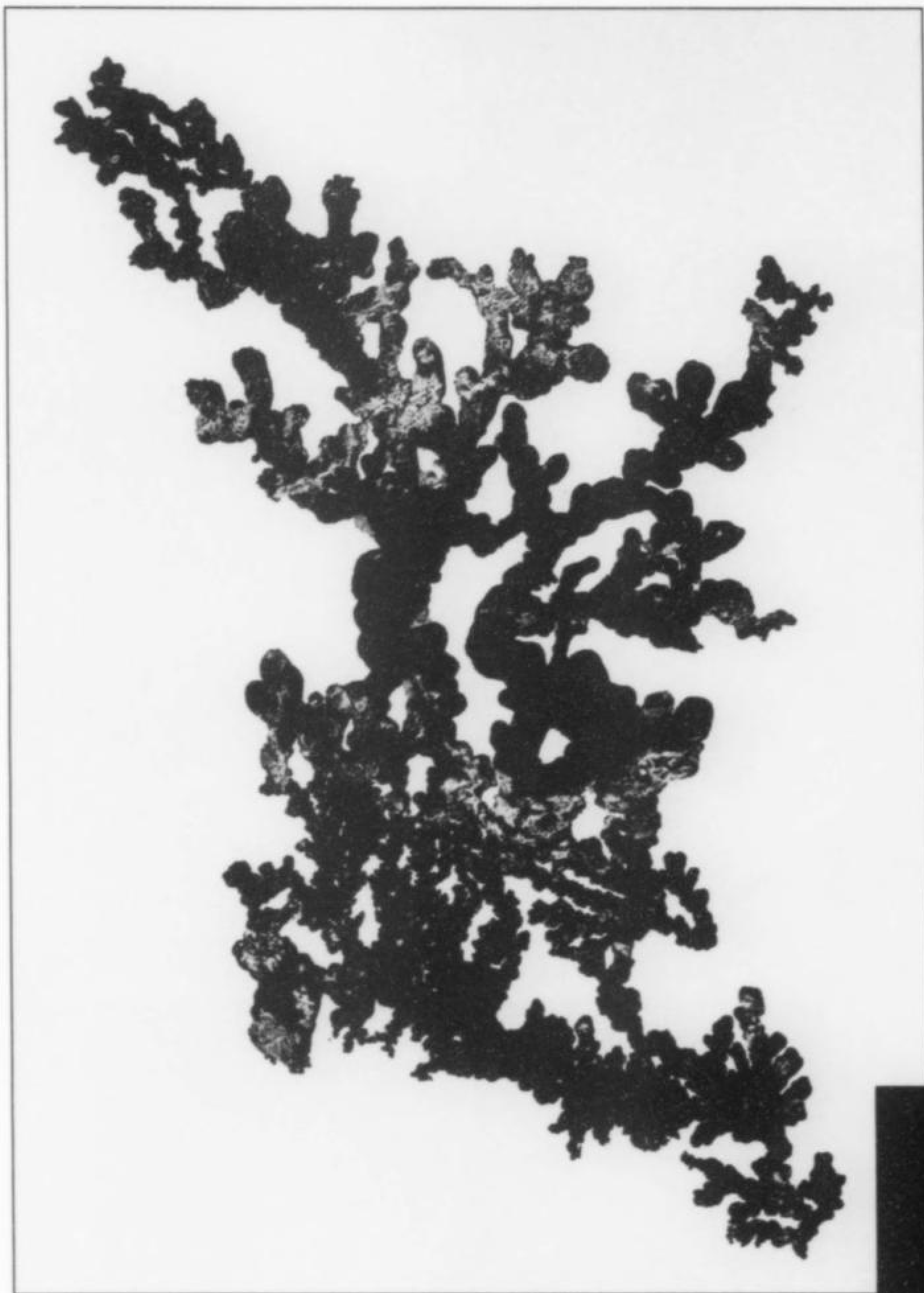


Figure 47. Old label of a copper specimen ca. 1860 from the collection of Eötvös Lóránd University, Budapest.

Figure 48. Copper, an arborescent aggregate, 12 cm high, from Rudabánya. Herman Ottó Museum collection, Miskolc; G. Kulcsár photo.

Figure 50. A group of spear-shaped skeletal copper crystals, 6.5 cm high, from Rudabánya. Hungarian Geological Institute collection; L. Horváth photo.

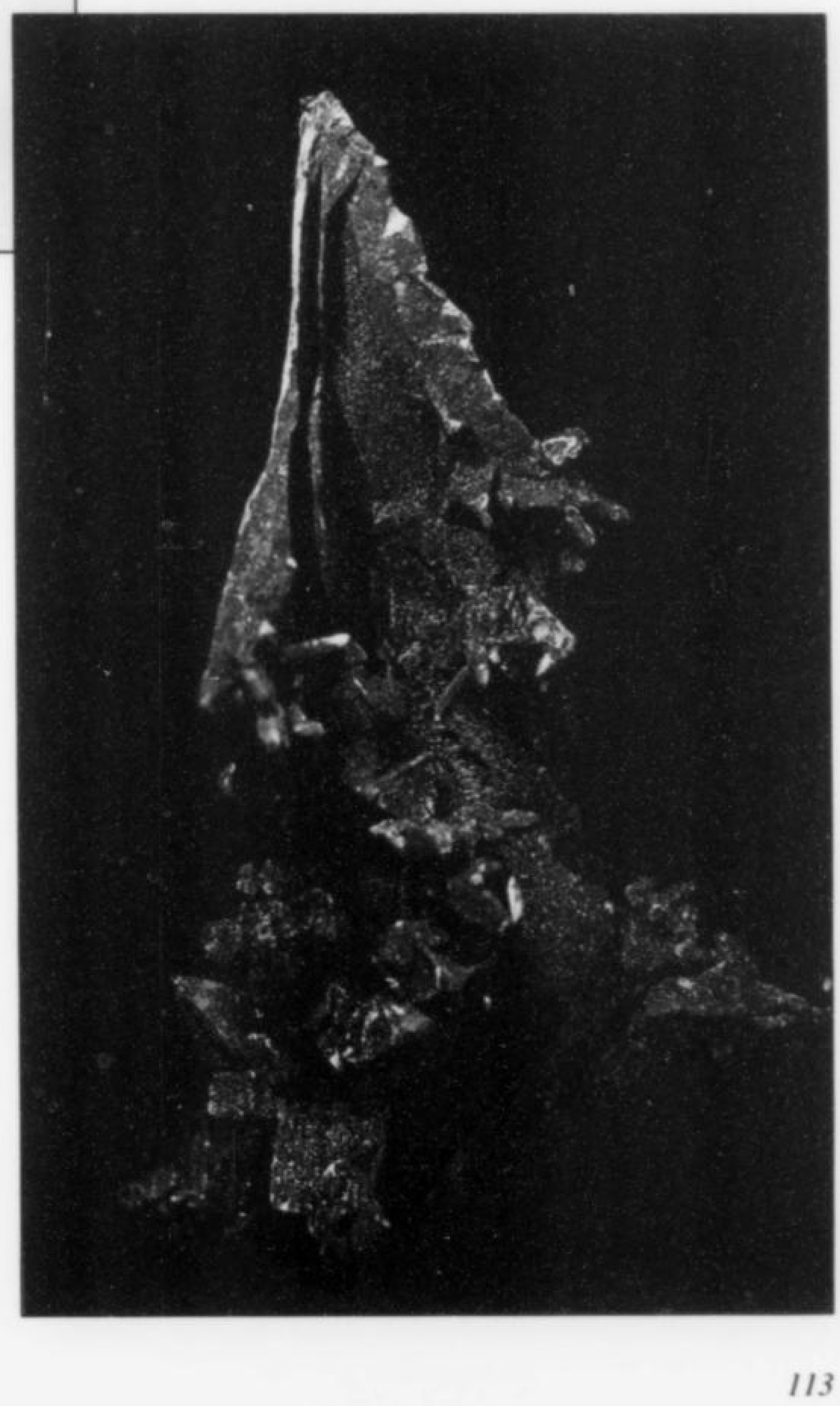


Figure 49. Labels from the oldest Rudabánya specimen known. The oldest is from before 1796, included in the "Catalogus Stützianus" of the Naturhistorisches Museum collection, Vienna.

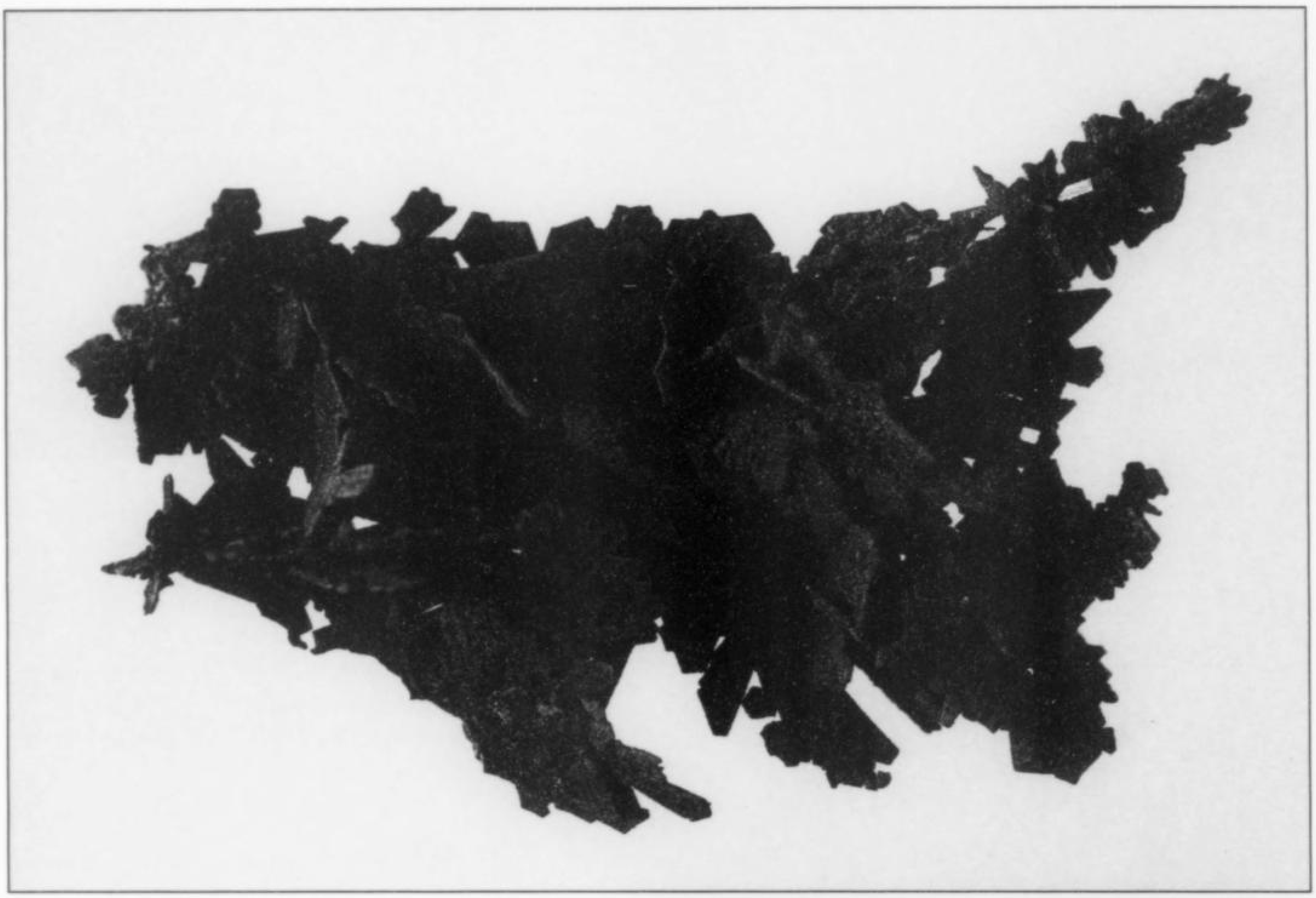


Figure 51. **Copper aggregate of irregular sheets, 6 cm wide, from Rudabánya. József Attila University, Szeged; G. Kulcsár photo.**

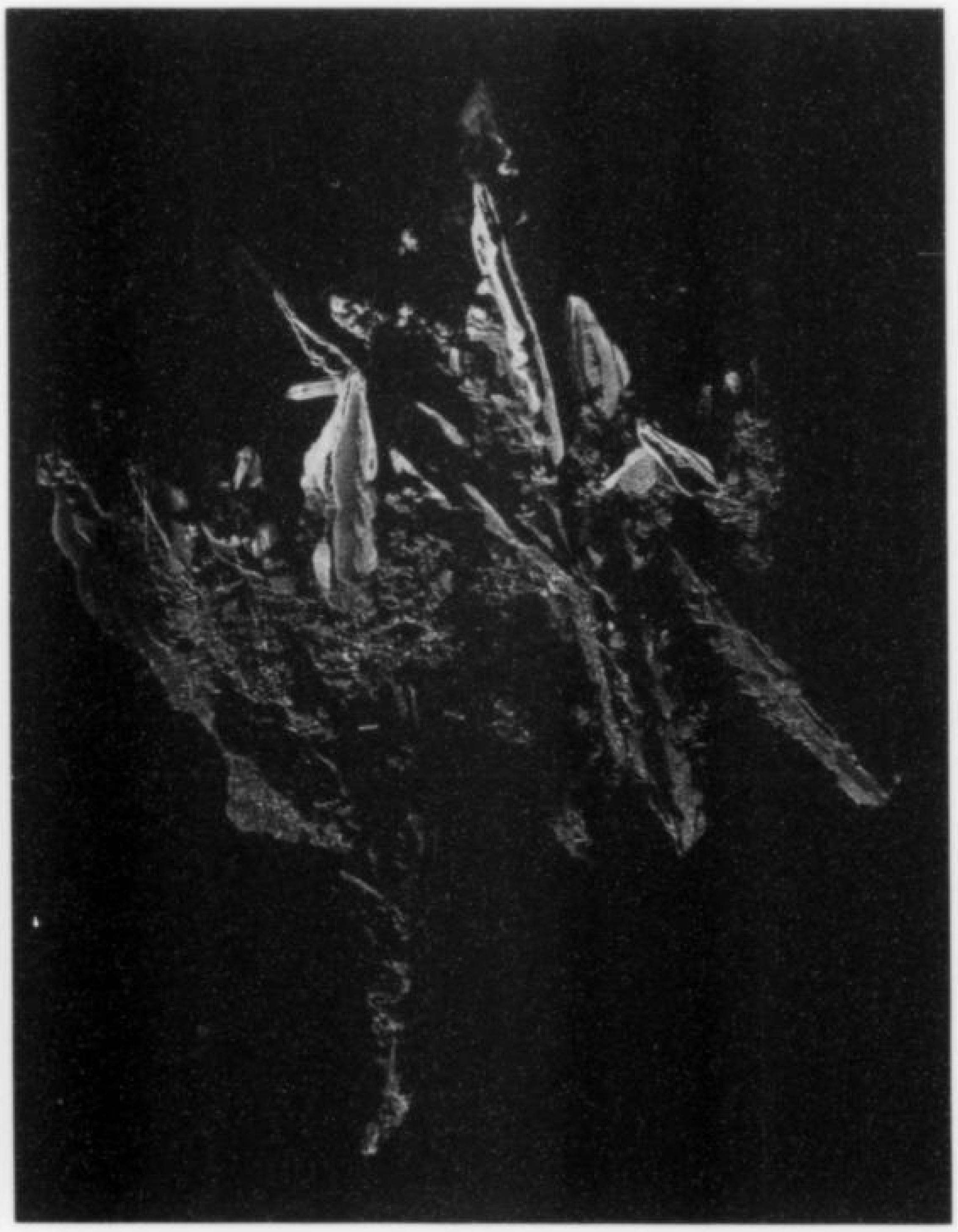


Figure 52. **Superb aggregate of spear-shaped, skeletal copper crystals coated with malachite, 18 cm, from Rudabánya. Hungarian Geological Institute collection; G. Kulcsár photo.**

Figure 53. **Hungarian postage stamp illustrating the Rudabánya specimen of malachite-coated copper shown at right.**

and in private collections in Hungary, Germany and Austria. The best specimens of the spear-shaped, skeletal crystals are in the collections of the Hungarian Geological Institute, Budapest, and the Herman Ottó Museum in Miskolc. One of these specimens appeared on a Hungarian postage stamp in the 1960's.

The earliest mention and illustration of Rudabánya copper specimens in the literature was in 1726, in Marsigli's monumental, six-volume work on the history, geography and natural history of the Danube valley and region (Marsigli, 1726). In this work Marsigli mentions *Penes Rudnobányam: ubi Cuprum massivum in tantâ copiâ invenitur. Unde ad 50. libras inventa fuit massa quœdam mense Januario, Å. 1702*. ["Rudabánya has rich discoveries of massive copper. Here in January of 1702, a mass weighing nearly 50 *libras* (probably the *libres* used in France, 453 g) was

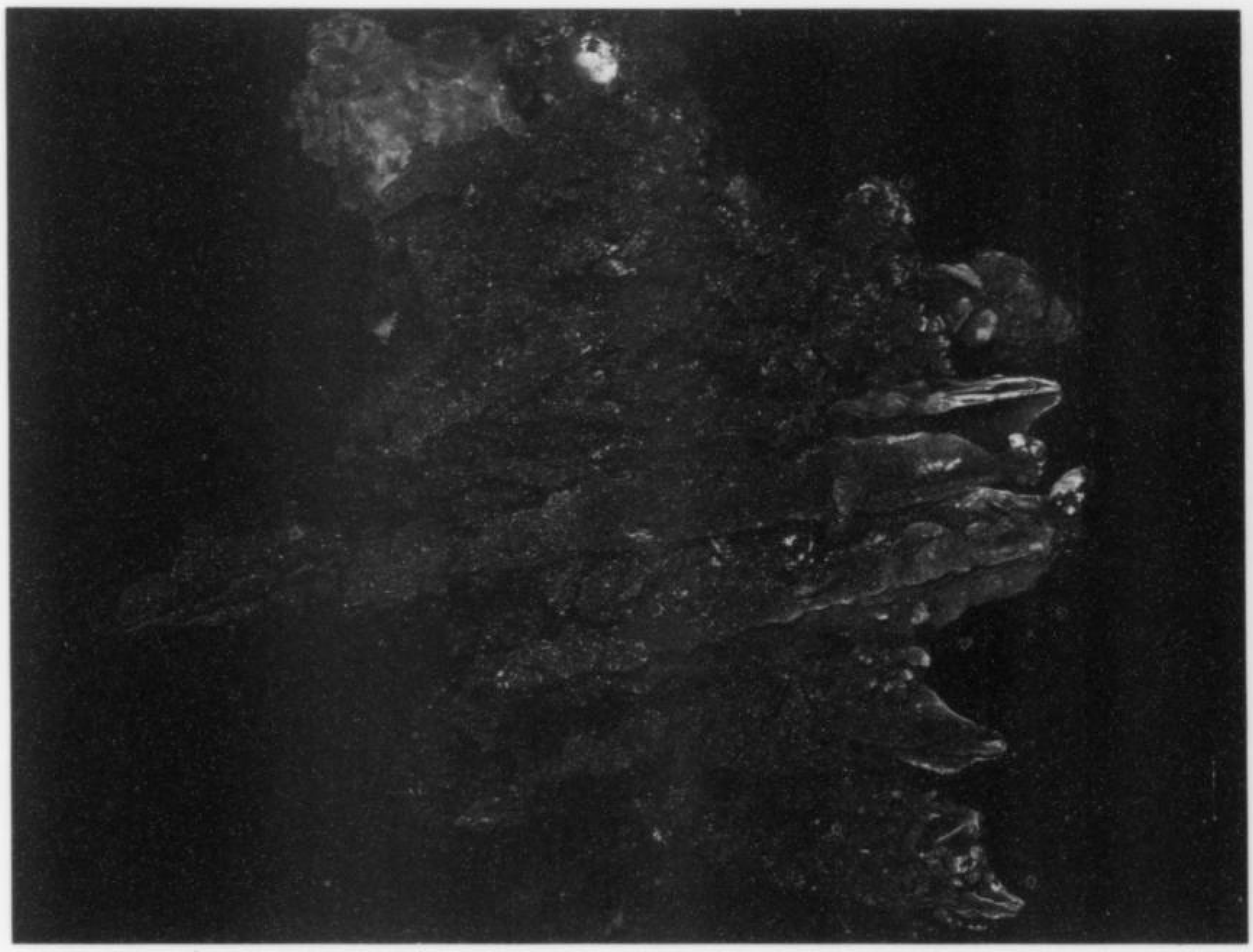


Figure 54. Copper aggregate of malachite coated skeletal crystals, 15 x 15 cm. Herman Ottó Museum specimen; L. Horváth photo.

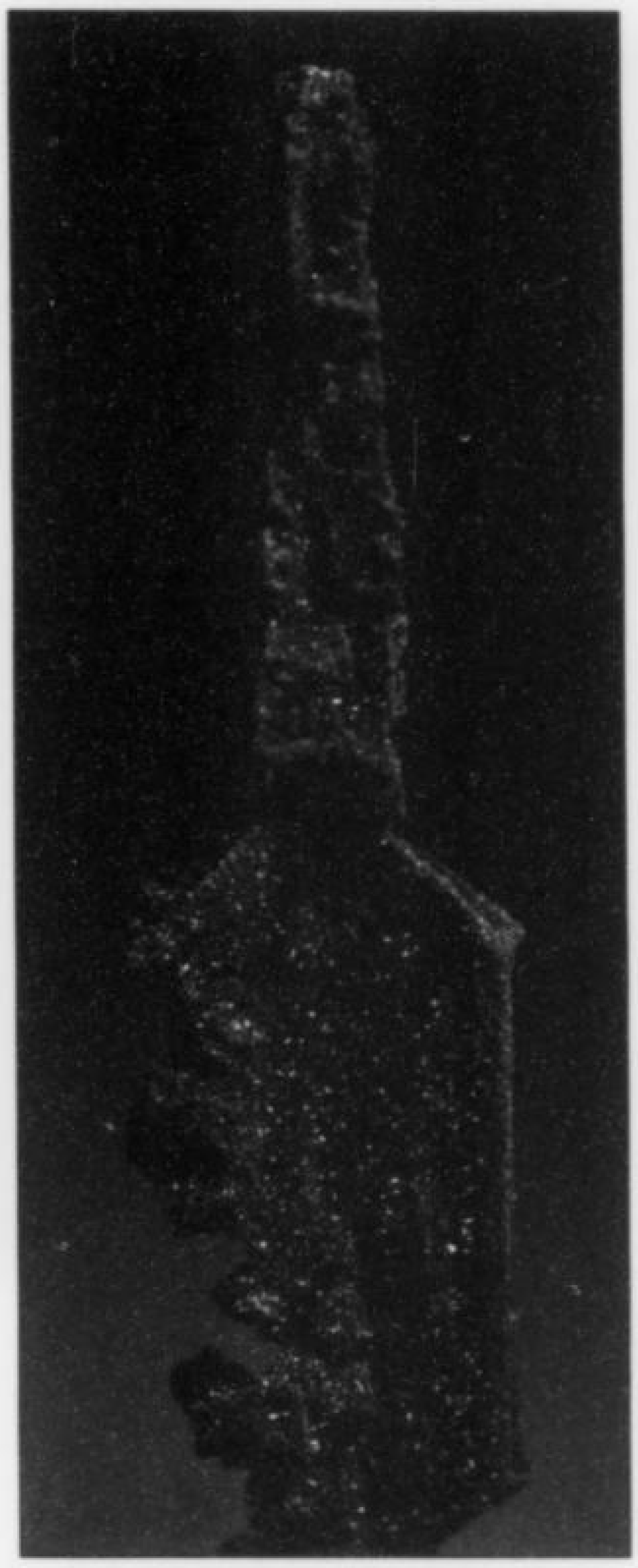


*Figure 55. (right)*Copper crystal, skeletal habit 3.3 cm, with malachite. Herman Ottó Museum specimen (HOM #20496/1); L. Horváth photo.

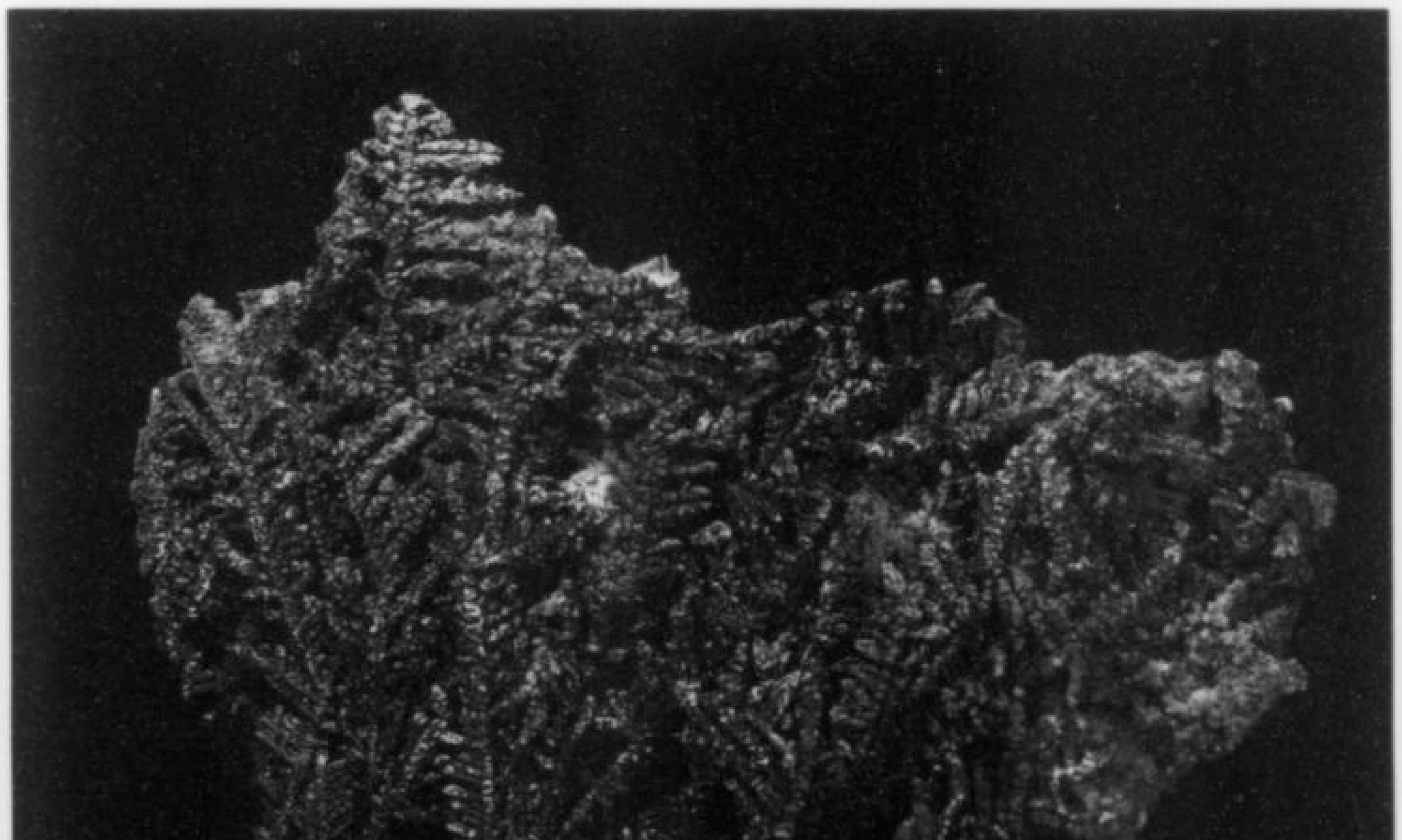


Figure 57. Copper, arborescent aggregate, 12 x 9 cm, on limonite, collected in 1959. Hungarian Geological Institute specimen (MAFI #9919); L. Horváth photo.

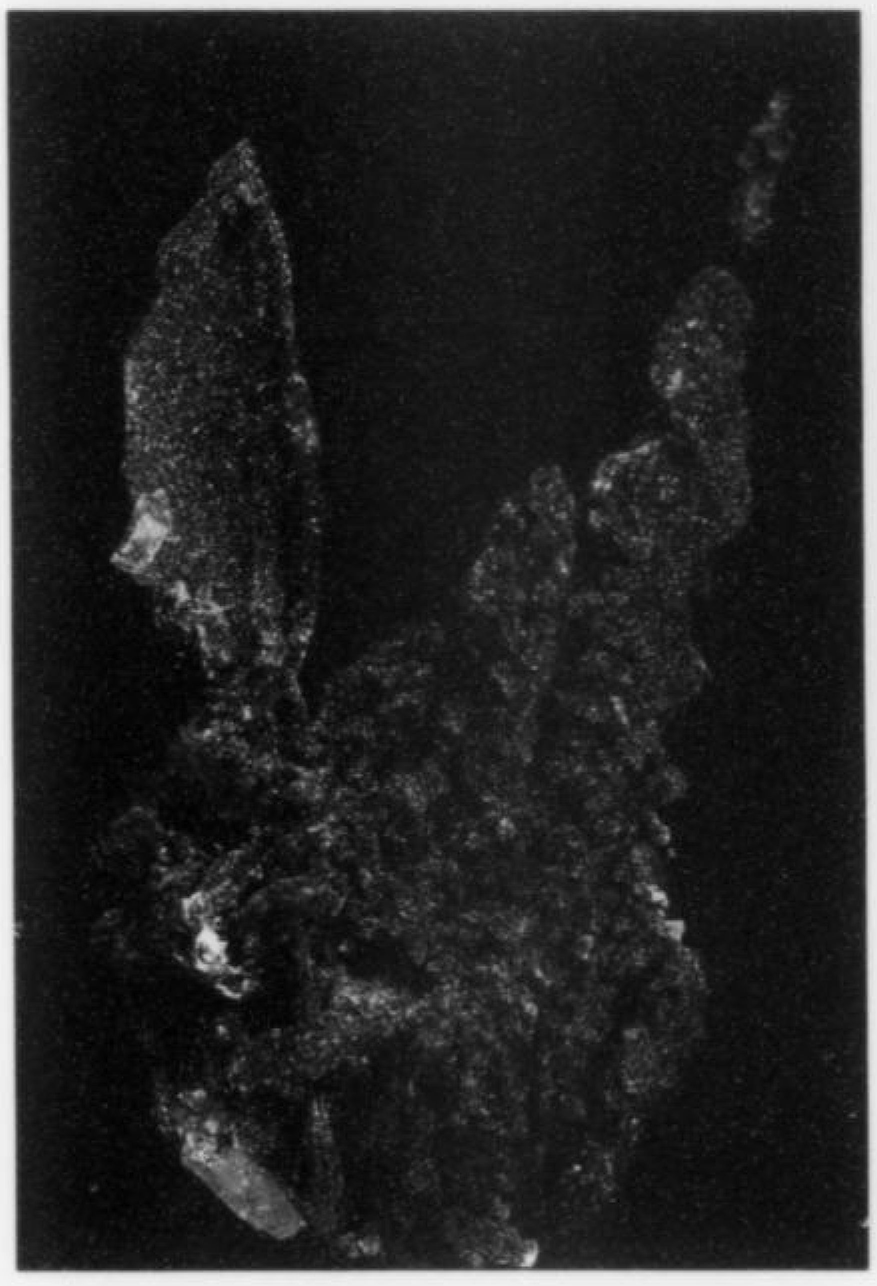


Figure 56. Copper crystal, 7 cm, skeletal habit with malachite coating, collected in 1951. Hungarian Geological Institute specimen (MAFI #2834); L. Horváth photo.

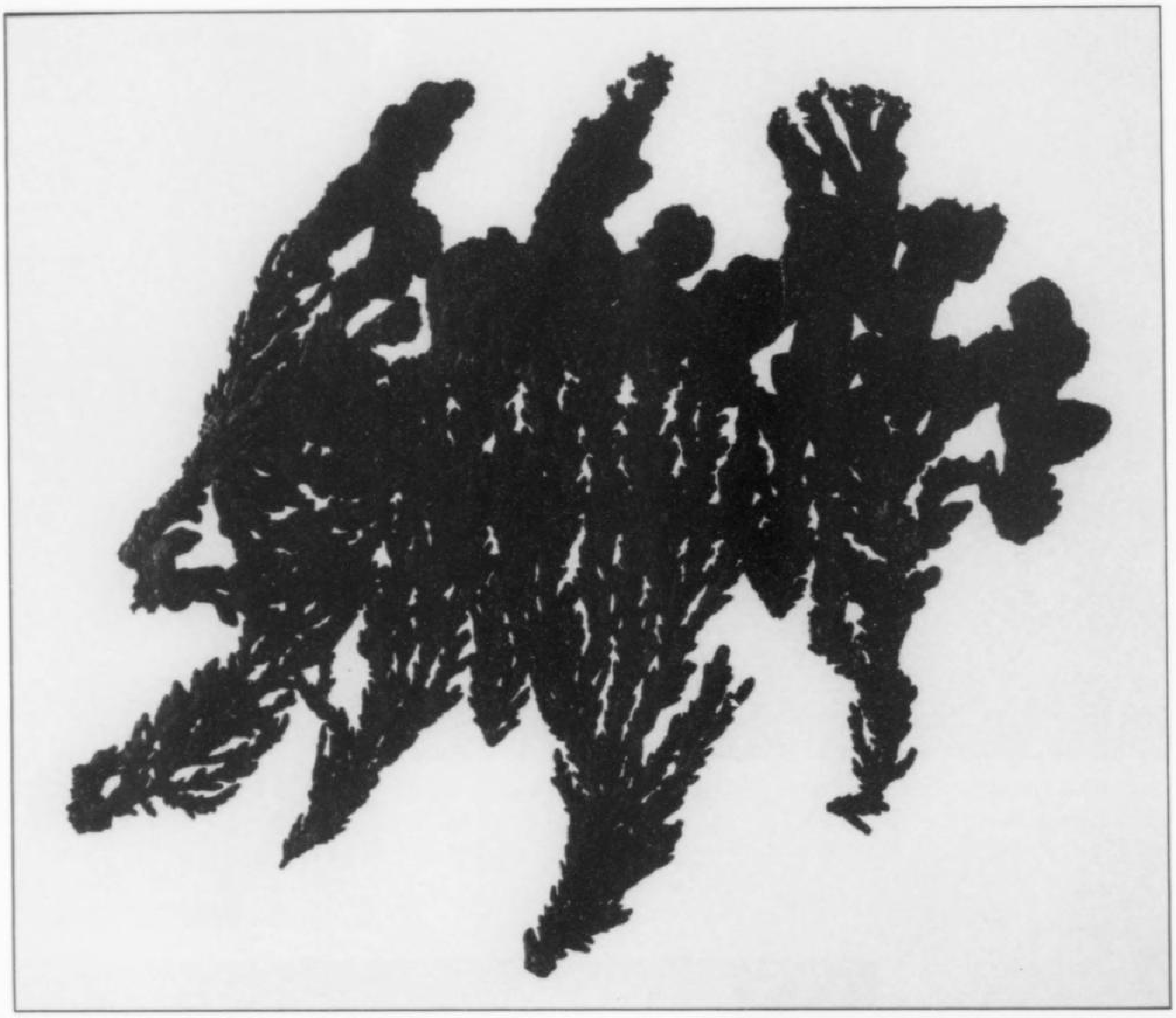


Figure 58. **Copper aggregate, malachite coated, 8 cm high, from Rudabánya. József Attila University, Szeged; G. Kulcsár photo.**

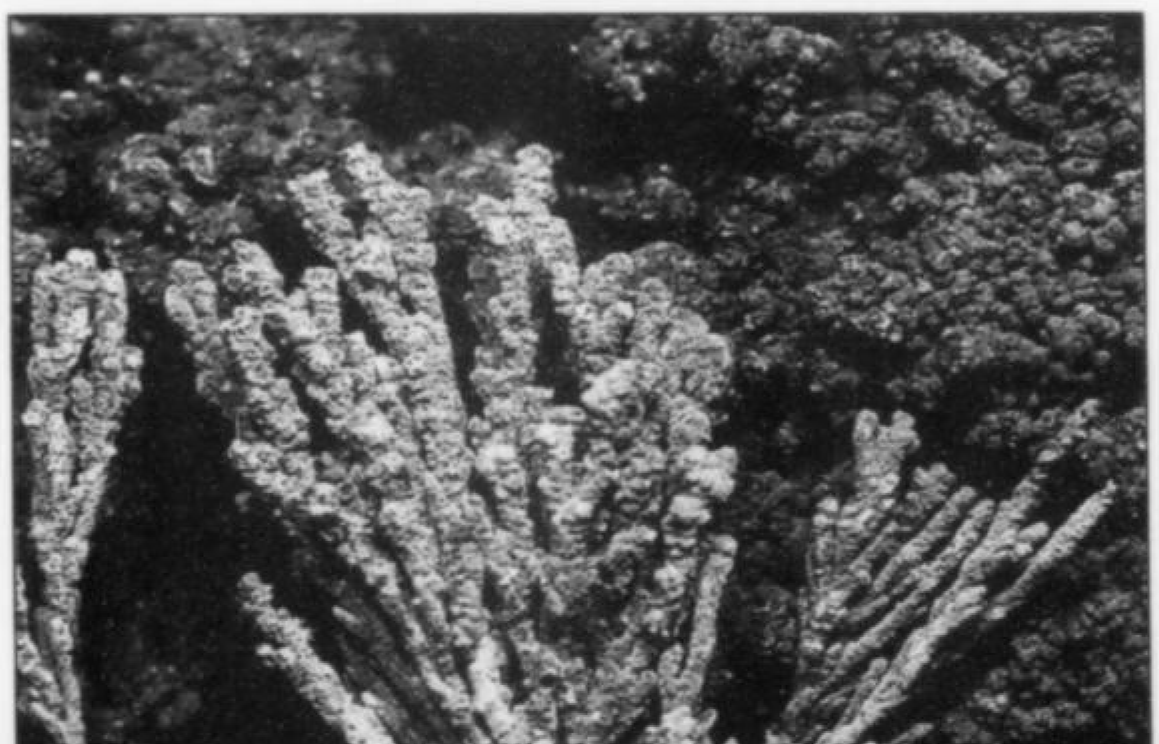


Figure 59. **Malachite-coated copper specimen, 4 cm wide, from Rudabánya. Herman Ottó Museum, Rudabánya; L. Horváth photo.**

found"]. In the same volume appears a fine map showing the mining districts of northern Hungary including Rudabánya, and a full-page illustration of three copper-etchings of Rudabánya native copper specimens, associated with azurite and malachite. The illustrated specimens are unremarkable by current standards, but the observations recorded in the captions on the associated minerals, the limonite matrix, and some speculation regarding the formation of the mineral assemblage is very interesting. From the same period is another mention of a copper specimen, "an extraordinary large and beautiful copper specimen, resembling a bunch of grapes," which was observed in the collection of Countess Dorottya Gvadányi-Forgách, the owner and operator of the Rudabánya mine at the time (Brückmann, 1727). The oldest surviving Rudabánya specimen that we have been able to trace during the preparation of this paper is a native copper specimen in the collection of the Naturhistorisches Museum in Vienna (No. A.b. 2021). This specimen was recorded in the *Catalogus Stützianus* which was compiled between 1797–1806, indicating that the specimen, which is unremarkable in appearance, was acquired before 1796 (G. Niedermayr, personal communications). Many other specimens from the late 1800's are found in various museums in Europe.

Cornubite $Cu^{2+}_5(AsO_4)_2(OH)_4$

Found very rarely in the limonite zone of Villanytető section, cornubite occurs as pale green, porcelaneous, compact masses up to 2 cm in diameter, associated with azurite and malachite.

Covellite CuS

Covellite is relatively common in the chalcopyrite-bornite concentrations of the siderite ores, occurring in small quantities on the margins of the chalcopyrite as thin crusts and as lamellar aggre-

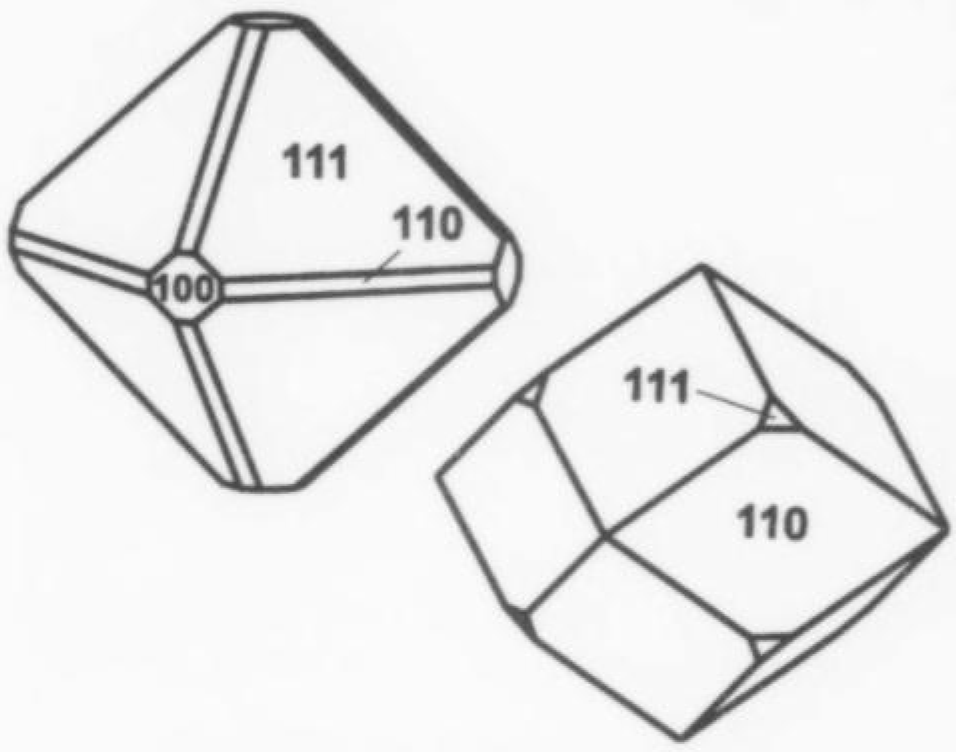


Figure 60. **Cuprite crystal drawing, Rudabánya, showing the most common forms.**

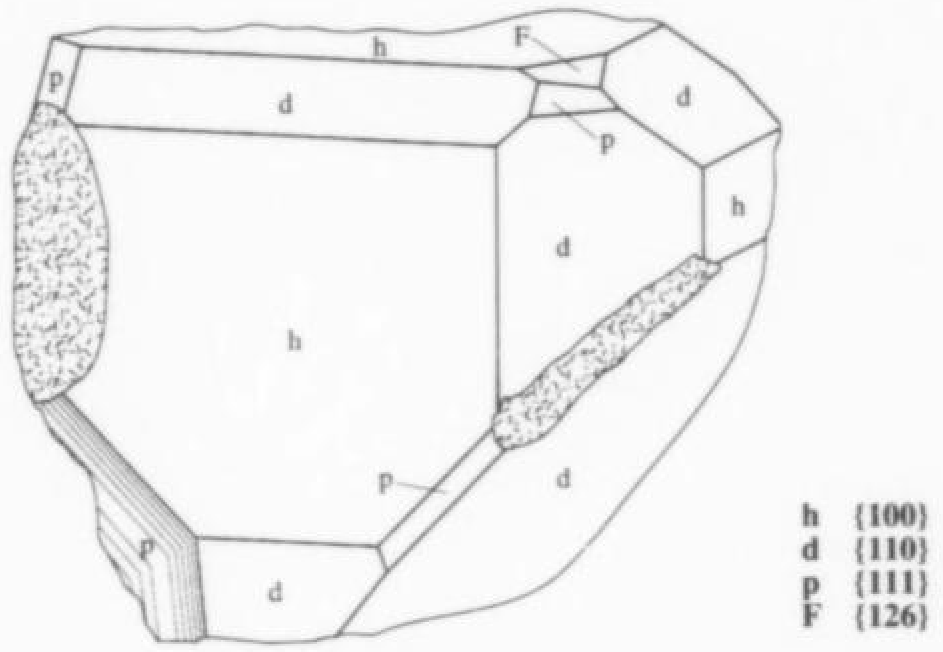


Figure 61. **Cuprite crystal drawing, Rudabánya (after Tokody, 1950).**

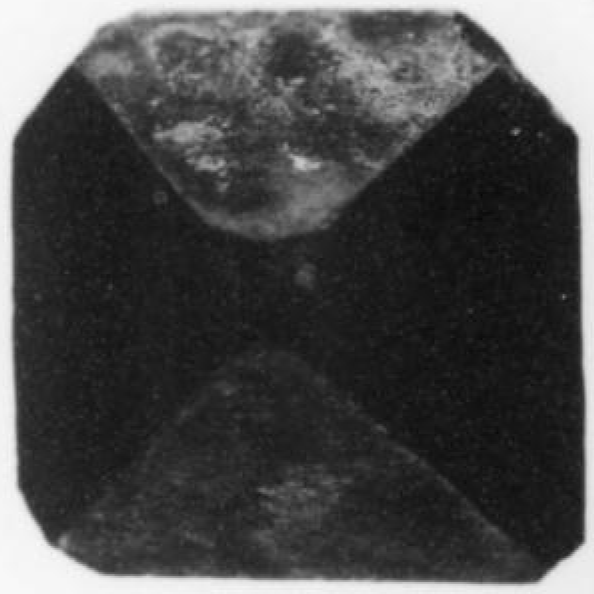


Figure 62. **Malachite-covered cuprite octahedron, 1.5 cm, from Rudabánya. József Attila University, Szeged; G. Kulcsár photo.**

Figure 63. **Cuprite crystals coated with malachite; larger octahedron is 2 cm, from Rudabánya. József Attila University, Szeged; G. Kulcsár photo.**

gates with chalcocite. In the oxidation zone it is found in cavities in the spongy siderite ore, as opaque, black, hexagonal, tabular or short prismatic crystals 1–3 mm across, with bluish iridescence and a submetallic luster; as a crust consisting of masses of thin, bluish lamellae, 0.5–1 mm across, and as pseudohexagonal, tabular pseudomorphs after chalcocite, 0.5–2 mm across, invariably associated with unaltered chalcocite. In the Andrássy II section, it was also found as a 1 to 3-cm-wide vein consisting of massive covellite intersecting a barite vein, and as platy crystals encrusted with a thin layer of cuprite and embedded in a nest of malachite (Koch, 1966).

Cuprite $Cu_2^{1+}O$

Cuprite is a relatively common mineral in the oxidation-cementation belt of the deposit. From the point of view of collectors it is one of the most interesting minerals from Rudabánya, especially when found as well-formed malachite-coated crystals. Cuprite is the product of the oxidation of native copper in the limonite and siderite ores, notably in the Lónyai and Andrássy I sections, occurring most commonly as compact masses up to several kilograms in weight, as pseudomorphs after copper, and relatively rarely as well-formed crystals.

Fresh, uncoated cuprite crystals are found rarely as a drusy cavity lining in massive cuprite. These crystals are adamantine, sharp, transparent to translucent, deep red, cuboctahedral crystals up to 3 mm in diameter. Small cuprite crystals commonly form drusy crusts on native copper but are typically coated with a layer of green malachite. Rarely in cavities of spongy, earthy limonite, cuprite occurs as splendid, sharp, octahedral and dodecahedral crystals 1–4 cm in diameter, with exceptional crystals up to 5 cm. Single crystals are rare whereas attractive, intergrown aggregates are more typical.

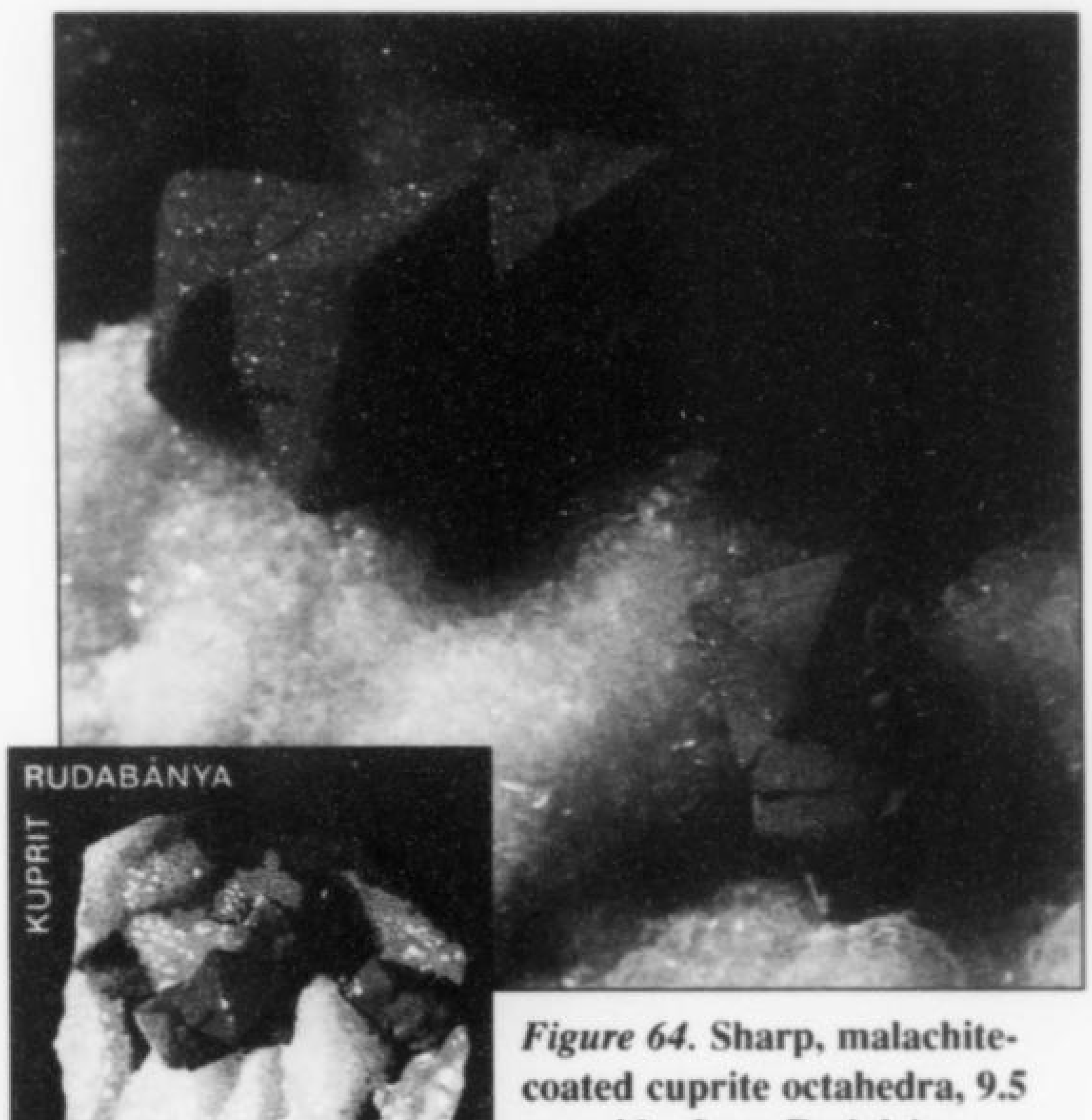


Figure 64. **Sharp, malachite-coated cuprite octahedra, 9.5 cm wide, from Rudabánya. Hungarian Geological Institute collection; G. Kulcsár photo. (*Left:*) Hungarian postage stamp illustrating the same specimen.**

Figure 65. **View of the spring and summer 2000 excavations for the mineral specimens in the Andrássy I section. L. Horváth photo.**

Figure 66. **Excavated limonite pods under gray dolomite-marl breccia in the Andrássy I section. September 2000; L. Horváth photo.**

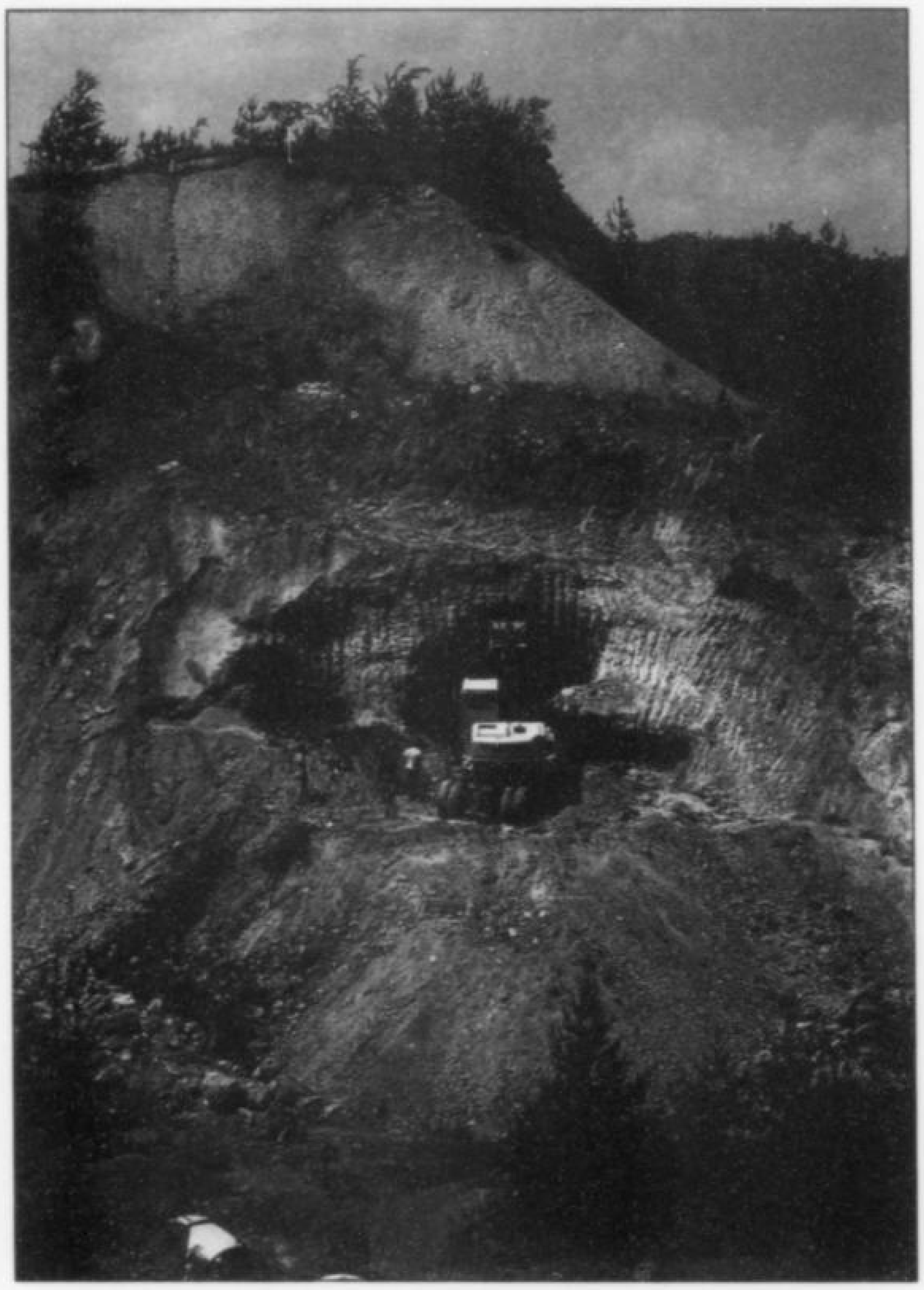


Figure 67. **Excavated for specimens in a liminite pod of the oxidation zone in the Andrássy I section. September 2000; L. Horváth photo.**

These crystals are invariably coated by a thin layer of green malachite reminiscent of the Chessy-les-Mines France, and Onganja, Namibia, cuprite crystals. The most common crystal habit is represented by the dominant {111} octahedron, typically modified by the {110} dodecahedron and the {100} cube; a relatively rare habit is defined by the dominant {110} dodecahedron rarely modified by a small {111} octahedron. Detailed morphological studies (Tokody, 1924; Koch, 1939) have also identified the following rare, subordinate forms on Rudabánya cuprite: {126}, {101}, {211} and {210}.

Excellent specimens of 1-3 cm malachite-coated cuprite crystals were collected in the 1930's and the 1950's in the Lónyai section. The best specimens from these finds are in the collection of the Hungarian Geological Institute in Budapest, and one of the matrix specimens appeared on a Hungarian postage stamp. Similar specimens, collected by the noted mineralogist Sándor Koch, are in the collection of the University of Szeged. Many of these cuprites were partially or completely replaced by malachite and should be considered pseudomorphs; the largest of these, a single 4.5-cm octahedron, is in the collection of the Herman Ottó Museum in Miskolc.

The most outstanding specimens of cuprite crystals however, were collected in the spring and summer of 2000 from the Andrássy I section (Huber and Triebl, 2000). These specimens consist mostly of very sharp, malachite-encrusted dodecahedra with single crystals up to 5 cm in diameter, and crystal groups with 1–2 cm crystals up to 15 cm across. Although the dodecahedral habit is clearly the most abundant in this find, octahedral crystals and crystals with octahedra modified by dodecahedra ({111}, {110}) were also found. The malachite on the crystals varies from a thin coating to a thicker crust which consists of spherical aggregates of tiny malachite crystals. Rarely, under the malachite crust, flakes of silver, lamellar aggregates of acanthite and droplets of native mercury were also found. The largest and best dodecahedral crystals were collected in April, including at least one 5-cm crystal and dozens of crystals in the 3 to 4.5-cm range. Subsequent specimen mining in the summer recovered smaller (1-2 cm) crystals, as well as very good specimens of tabular azurite, copper, malachite and cuprite pseudomorphs after copper. Most specimens were essentially "floaters" found in nests of soft earthy limonite, but a few matrix specimens have also been found. Cuprite dodecahedra of this size are very rare, and to our knowledge these are the largest known of this morphology.

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

A late-stage mineral associated with the alteration of tetrahedrite, devilline is found very rarely in a near-surface barite-zone of

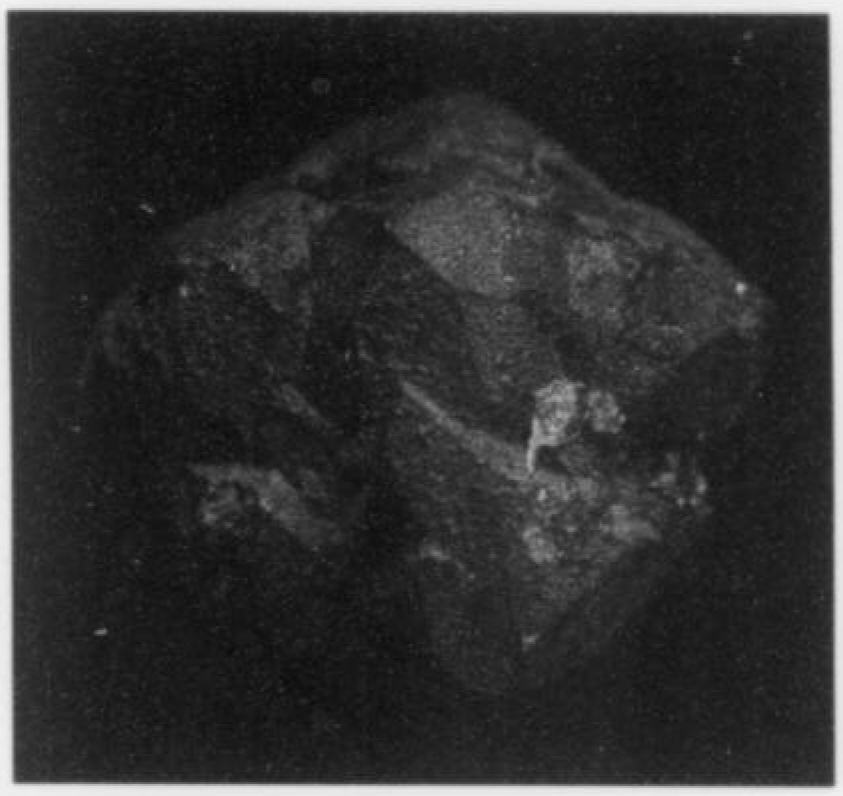


Figure 70. (right) Cuprite crystal group 4 cm wide with malachite coating, collected from the Andrássy I section in April 2000. The main crystal shows the {111} octahedron and the {110} dodecahedron. Herman Ottó Museum specimen (HOM #25533); L. Horváth photo.

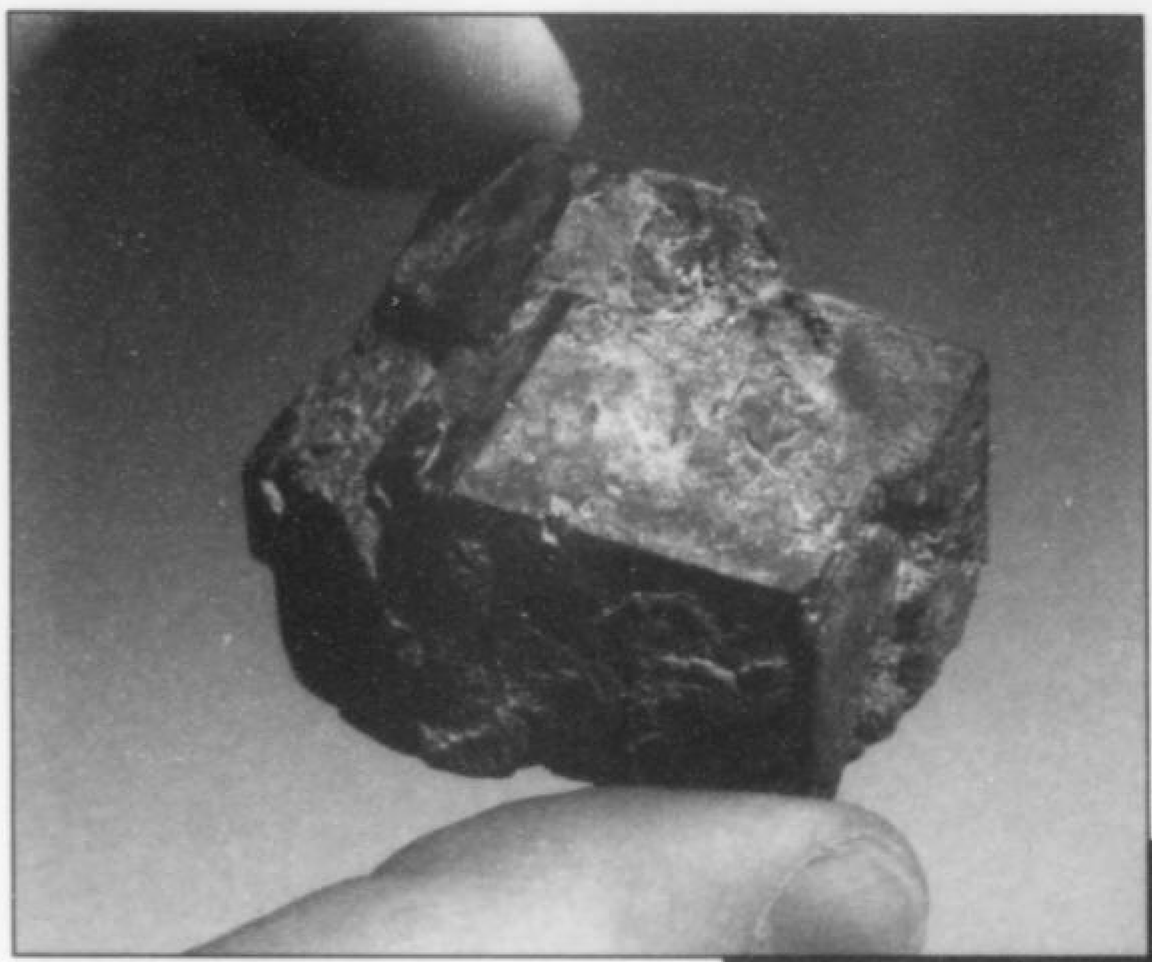


Figure 68. Cuprite crystals to 4 cm. Peter Huber photo.

Figure 69. Cuprite crystals, dodecahedron 4.5 cm. René Triebl collection; Peter Huber photo.

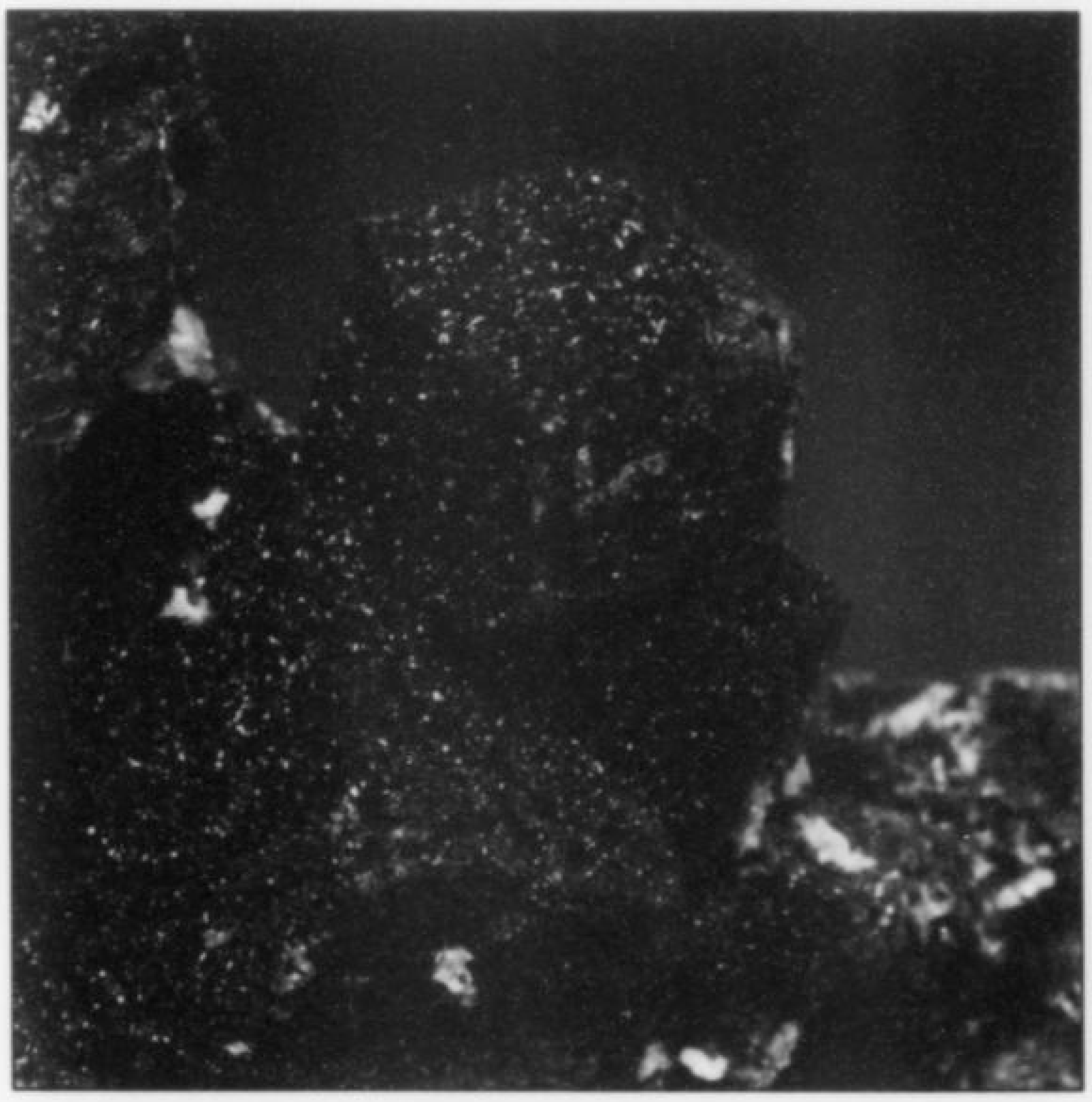
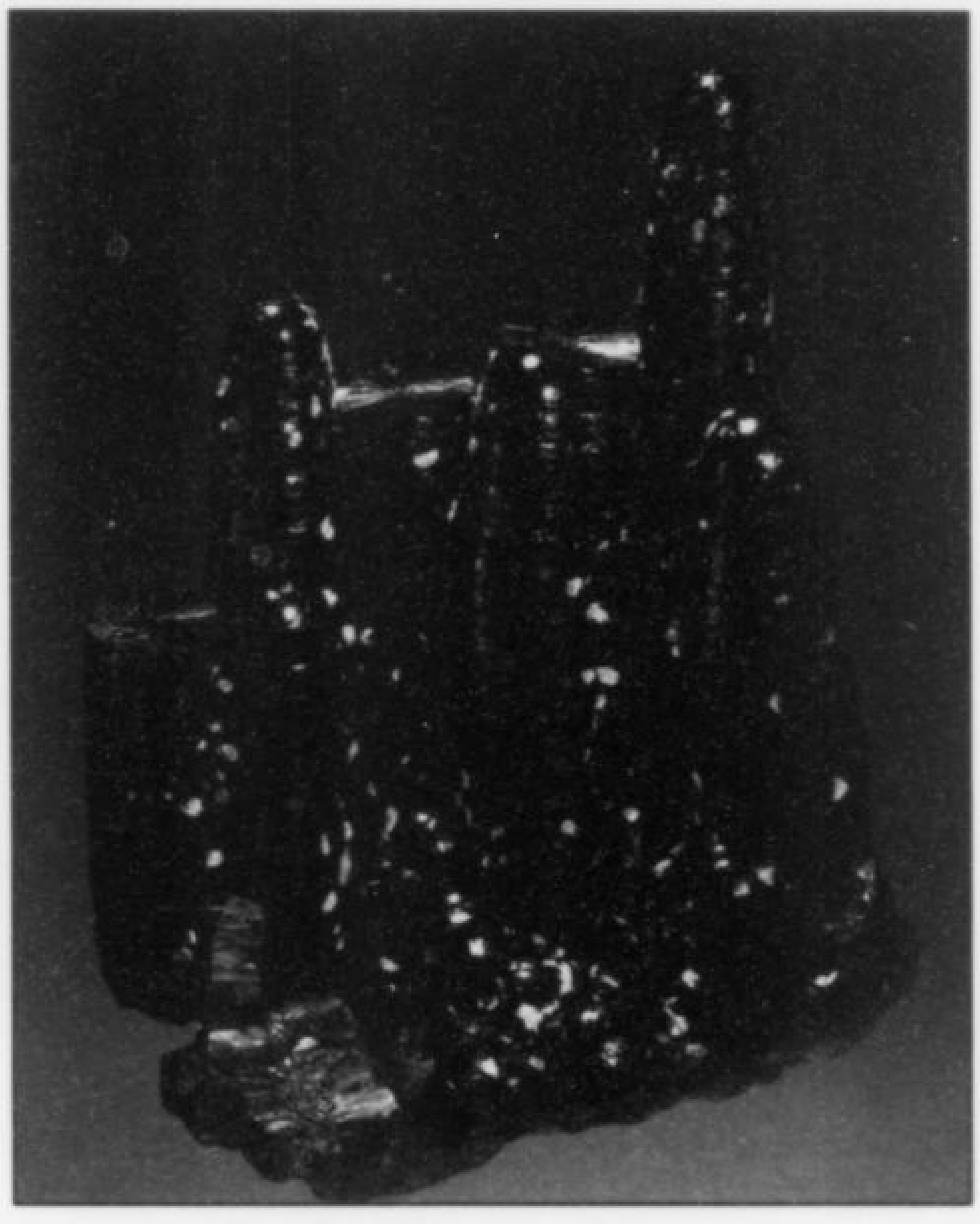


Figure 71. Cuprite dodecahedra coated by a crust of malachite crystals, collected in Andrássy I section in June 2000. The largest crystal is 2 cm. Horváth collection; L. Horváth photo.

Figure 72. (below) Goethite, stalactite aggregate 5 cm high. Herman Ottó Museum specimen (HOM #21852); L. Horváth photo.



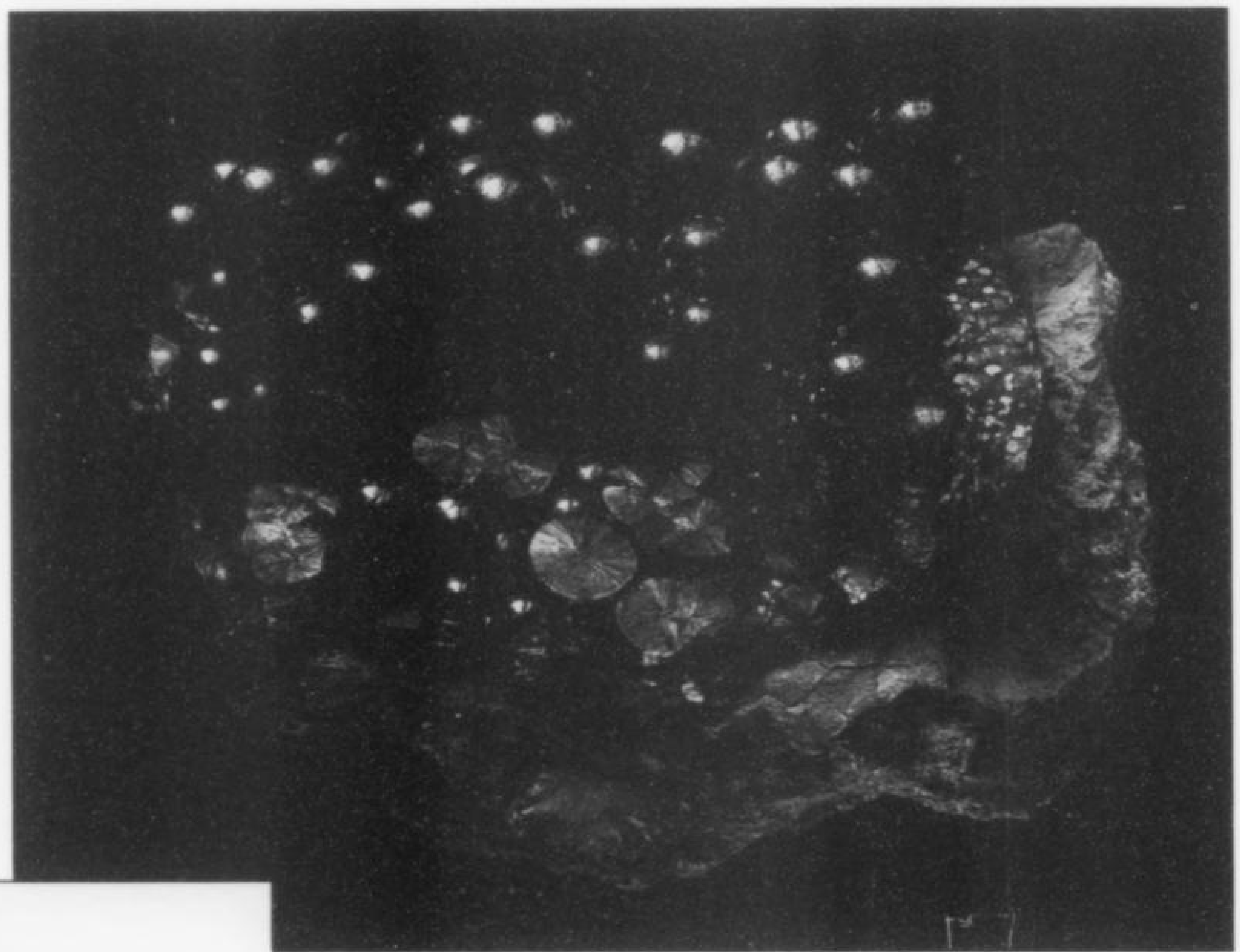


Figure 73. **Goethite stalagmitic group on limonite, 13 cm wide, from Rudabánya. Hungarian Geological Institute collection; G. Kulcsár photo.**

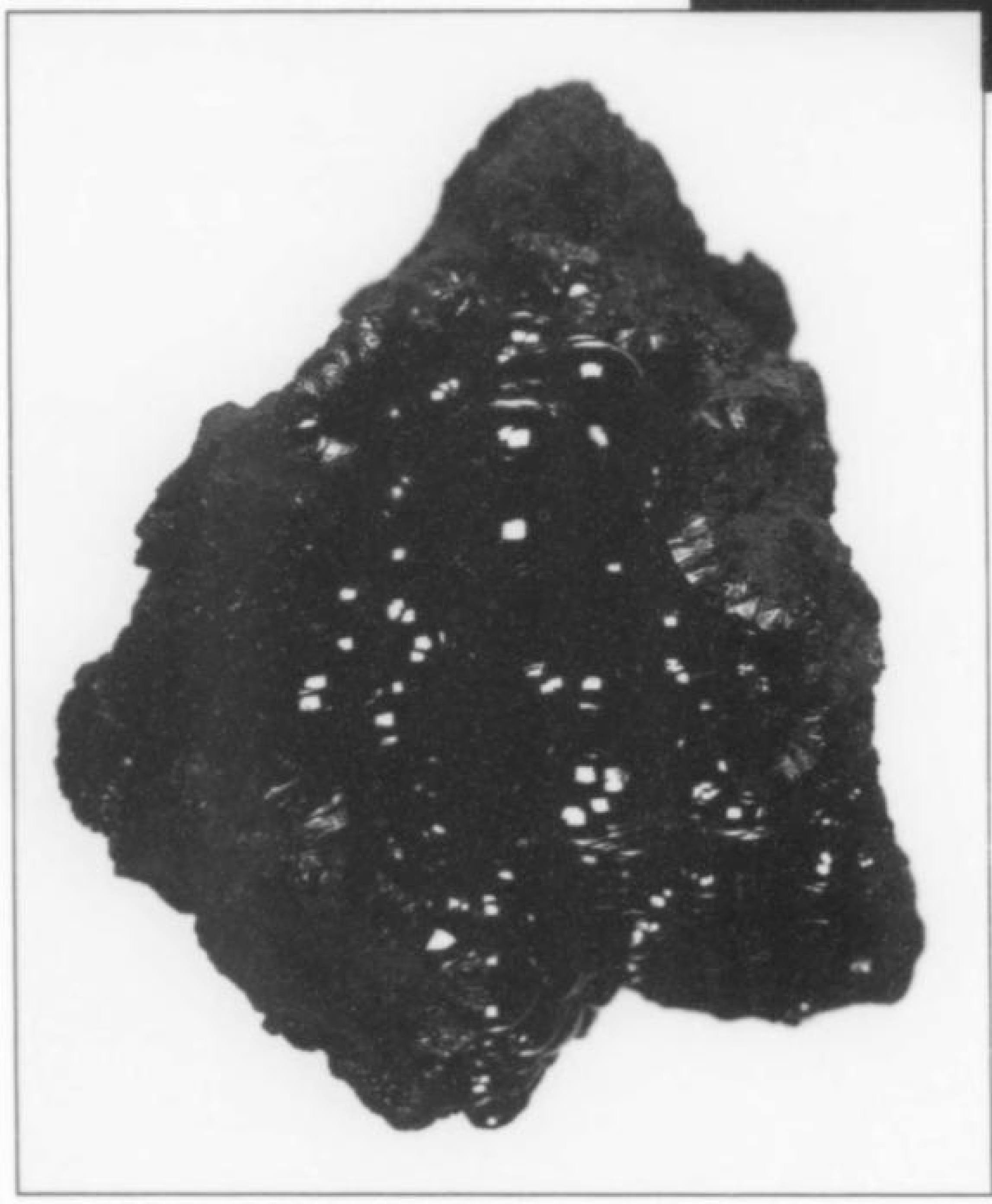


Figure 74. **Goethite spherical aggregates, 11 cm wide, from Rudabánya. Rudabánya Mining Museum, Rudabánya; G. Kulcsár photo.**

the Villanytető mine section. It occurs as dull, translucent, pale blue crusts, and as sheaf-like aggregates of vitreous, sharp, translucent, lath-shaped crystals 0.5–0.8 mm long, associated with malachite, claraite and gypsum (Szakáll *et al.*, 1997).

Digenite Cu_9S_5

A relatively rare alteration product of chalcopyrite, chalcocite and bornite, digenite occurs in spongy siderite as dark bluish gray, metallic grains, lamellar aggregates 1-3 mm across and hexagonal crystals 1-3 mm in diameter, closely associated with djurleite, bornite and chalcopyrite (Pósfai, 1990). It has also been found as pseudomorphs after chalcocite crystals.

Djurleite $Cu_{31}S_{16}$

Djurleite was identified from sulfide pods of the Andrássy I section as opaque, dark gray, microscopic grains, irregular aggregates, and compact masses consisting of digenite and djurleite up to 6 cm in diameter (Pósfai, 1990).

Dolomite $CaMg(CO_3)_2$

A significant component of the siderite ores, dolomite is widely distributed as anhedral grains intermixed with other carbonates. It is also found rarely in cavities in siderite and in barite veins, as well-formed translucent white rhombs 1–3 mm across.

Domeykite Cu_3As

In the Andrássy III section domeykite occurs in small cavities in spongy siderite ore, as opaque, gray coatings, fissure fillings, and as spherical aggregates up to 1 mm in diameter. In an exceptionally rare occurrence it has also been found as crude, distorted octahedra (Szakáll, 1992). Some domeykite aggregates are associated with blue, greenish blue and green, minute, spherical aggregates, powdery coatings and crusts of unidentified Ca-Cu, Cu-Sb, and Cu-arsenate minerals.

Enargite Cu_3AsS_4

Enargite occurs as metallic, black well-formed columnar crystals 1-3 mm long in small fissures in the brecciated dolomite zones of Andrássy II section, associated with tennantite, pyrite and chalcopyrite.

Epsomite $MgSO_4 \cdot 7H_2O$

Epsomite is very common in almost all mine sections, occurring as a white, powdery efflorescence with other sulfates, coating surfaces in old workings (Pantó, 1956).

Famatinite Cu_3SbS_4

In brecciated dolomite-limestone of the Andrássy I section, a mixture of sulfides often encrusts and cements fragments of the carbonate rock. In some of these sulfide crusts, where tetrahedrite predominates, famatinite is found very rarely as dull black, submetallic layers and veinlets up to 0.2 mm across.

Fibroferrite $Fe^{3+}(SO_4)(OH) \cdot 5H_2O$

Fibroferrite is a very rare, recent deposition in old workings of the Vilmos section, occurring as yellow, uneven crusts and aggregates of thin fibers 0.1–0.5 mm long, associated with copiapite, aluminocopiapite and magnesicopiapite (Szakáll *et al.*, 1997).

Galena PbS

Galena is one of most common sulfide minerals in primary zones at Rudabánya. It is associated with the siderite ores, reaching its highest concentrations in barite-rich zones. It is most commonly found as compact masses associated with the other sulfide minerals. Rarely galena has also been found in limonite cavities of the oxidation zone, as aggregates of thin, foil-like sheets. During the medieval silver mining period galena was an important silver-bearing ore mined at Rudabánya.

Galenobismutite $PbBi_2S_4$

Galenobismutite is extremely rare, occurring as microscopic inclusions invariably associated with native bismuth in massive galena in the Andrássy II section of the mine (Nagy and Dobosi, private communication).

Glauconite $(K,Na)(Fe^{3+},Al,Mg)_2(Si,Al)_4O_{10}(OH)_2$

A common rock-forming mineral in the sandstone associated with the Rudabánya deposit, glauconite is found as dispersed greenish micaceous flakes.

Geocronite $Pb_{14}(Sb,As)_6S_{23}$

Geocronite occurs dispersed as metallic, gray, microscopic grains (0.2-0.5 mm) in galena in vuggy siderite in the Andrássy II and Polyánka sections. It is very rare and was identified in thin sections by optics and microprobe analysis.

Goethite $\alpha\text{-}Fe^{3+}O(OH)$

The most common and abundant mineral in the oxidation-cementation belt, goethite was formed by the oxidation of primary siderite. The limonite ore of the deposit consists to a large degree of goethite. Generally this goethite is earthy brown and powdery, but it also forms compact, dark brown, rather dense crusts and masses. In the cavities of the larger masses are found botryoidal, spherical, stalactitic and reniform *glasskopf* aggregates of goethite which make very interesting and attractive specimens. They are dark brown to black with curved, lustrous surfaces, some of which are sprinkled with groups of small, white tabular crystals of barite. Broken surfaces exhibit a marked radial structure, steel-gray color and submetallic luster. Rarely the surfaces of these specimens have a velvety appearance imparted by an overgrowth of minute acicular goethite crystals. Often, goethite is also found as simple, rhombic pseudomorphs after siderite 1–2 mm across, exceptionally up to 3–5 cm across.

Gold Au

Gold is extremely rare in the deposit, occurring as irregular grains and thin flakes up to 1 mm in diameter in malachite and cuprite (Koch, 1939), and as a finely dispersed minor constituent in the copper sulfide concentrations, especially in chalcopyrite and bornite in the oxidation zone in the Lónyai and Andrássy II sections of the mine (Koch, 1966). Gold has also been found as microscopic flakes associated with the primary sulfide masses in the barite veins of the Villanytető section.

Gypsum $CaSO_4\cdot 2H_2O$

A relatively common and widespread late-stage mineral, gypsum occurs as small vein-fillings, crusts, and rarely as colorless, twinned, prismatic crystals up to 5 mm long, typically associated with goethite, melanterite, jarosite and hexahydrite. From the oxidation zone green, spherical aggregates 2–3 mm in diameter, consisting of acicular gypsum crystals enclosing malachite, have been reported (Koch, 1966). Gypsum is also common in the clay layers associated with the cover sediments, as small masses and veinlets, and the Permian evaporite beds under the deposit (Csalagouits, 1974).

Halloysite $Al_2Si_2O_5(OH)_4$

Halloysite is found rarely in the limonite zones in the Andrássy III section as waxy, white, compact aggregates up to 2 cm across.

Halotrichite $Fe^{2+}Al_2(SO_4)_4\cdot 22H_2O$

Silky, white, capillary crystals and fibrous masses of halotrichite coating surfaces in old workings are relatively common (Pantó, 1956).

Hematite $\alpha\text{-}Fe_2O_3$

Hematite, a very common associate of siderite in the primary ore belt, occurs mainly as admixed anhedral grains and rarely in small cavities as thin, platy aggregates (specular hematite) 1–3 mm across. Aggregates of thin, lamellar crystals are also found in fissures of the marl-quartz-barite zones of the primary ore belt. In the oxidation zone, hematite is also very common, occurring mainly as opaque, brown to reddish brown and red earthy masses, and very rarely as compact spherical and reniform ("kidney-ore") aggregates somewhat similar to goethite. Concentrations of primary hematite in the Deák mine section were of sufficient quantity to be mined in the early part of the 20th century.

Hexahydrite $MgSO_4\cdot 6H_2O$

A common post-mining deposition in old workings of the mine, hexahydrite is found as thin, opaque, white crusts and powdery coatings associated with starkeyite and epsomite.

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

In the limonite orebodies of the Andrássy I section, opaque, black, fibrous hollandite fills 0.5-1 cm wide veins.

Idaite Cu_3FeS_4

Idaite is a very rare secondary mineral, occurring as alteration rims on Cu-sulfides, consisting of crusts of minute, oriented lamellae and millimeter-size grains with bornite (Koch, 1966).

Iltisite HgSAg(Cl,Br)

Iltisite, a very rare sulfo-halide, was recently described as a new mineral from the Cap Garonne mine, near Le Pradet, Var, France (Sarp *et al.*, 1997); Rudabánya is the second reported locality for the species (Szakáll and Sarp, 2000). Iltisite is an exceedingly rare, late-stage alteration product of tennantite, found in small fractures in the siliceous limonite of the Adolf mine section. It occurs as

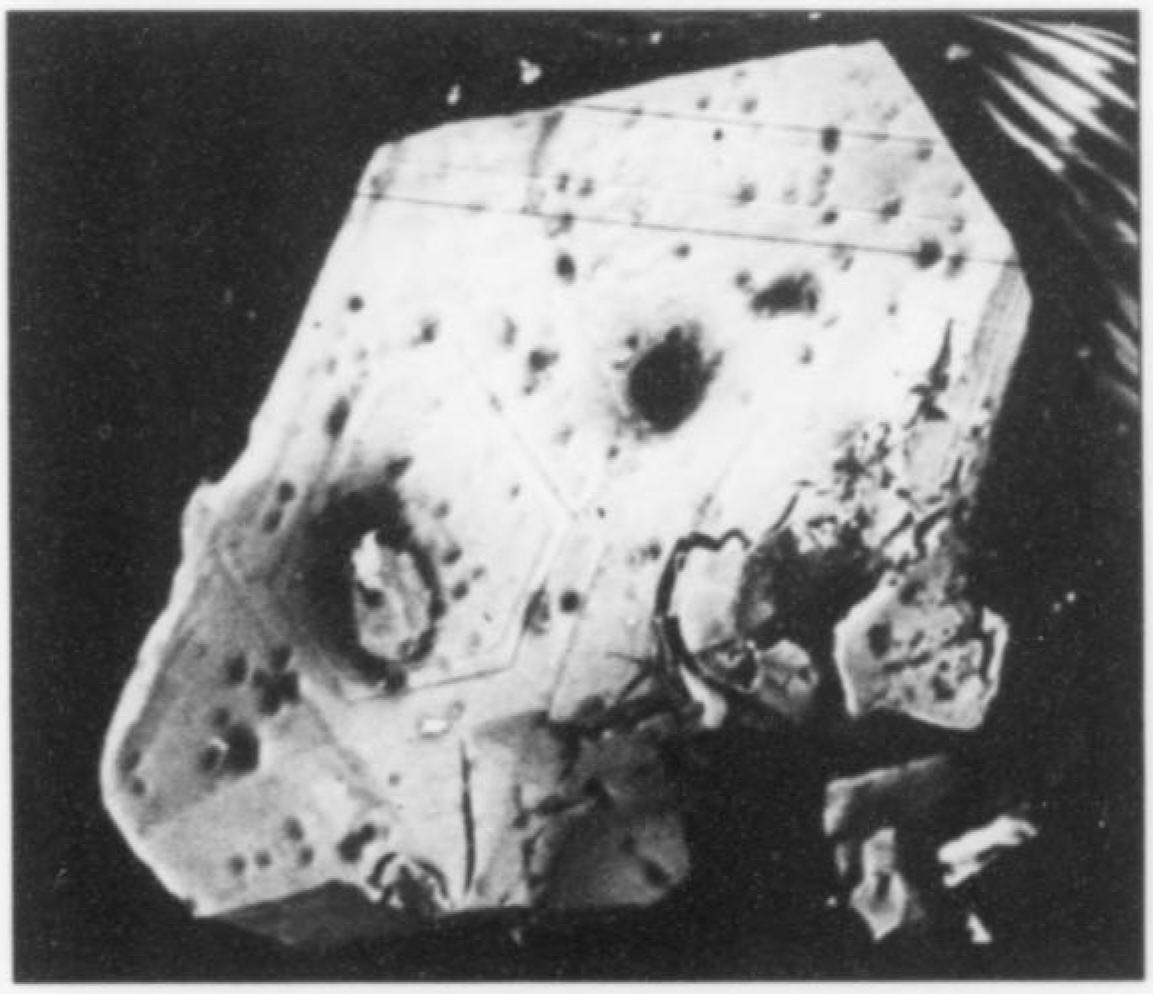


***Figure 75.* Iodargyrite crystal, 0.3 mm long, from Rudabánya. Herman Ottó Museum collection.**

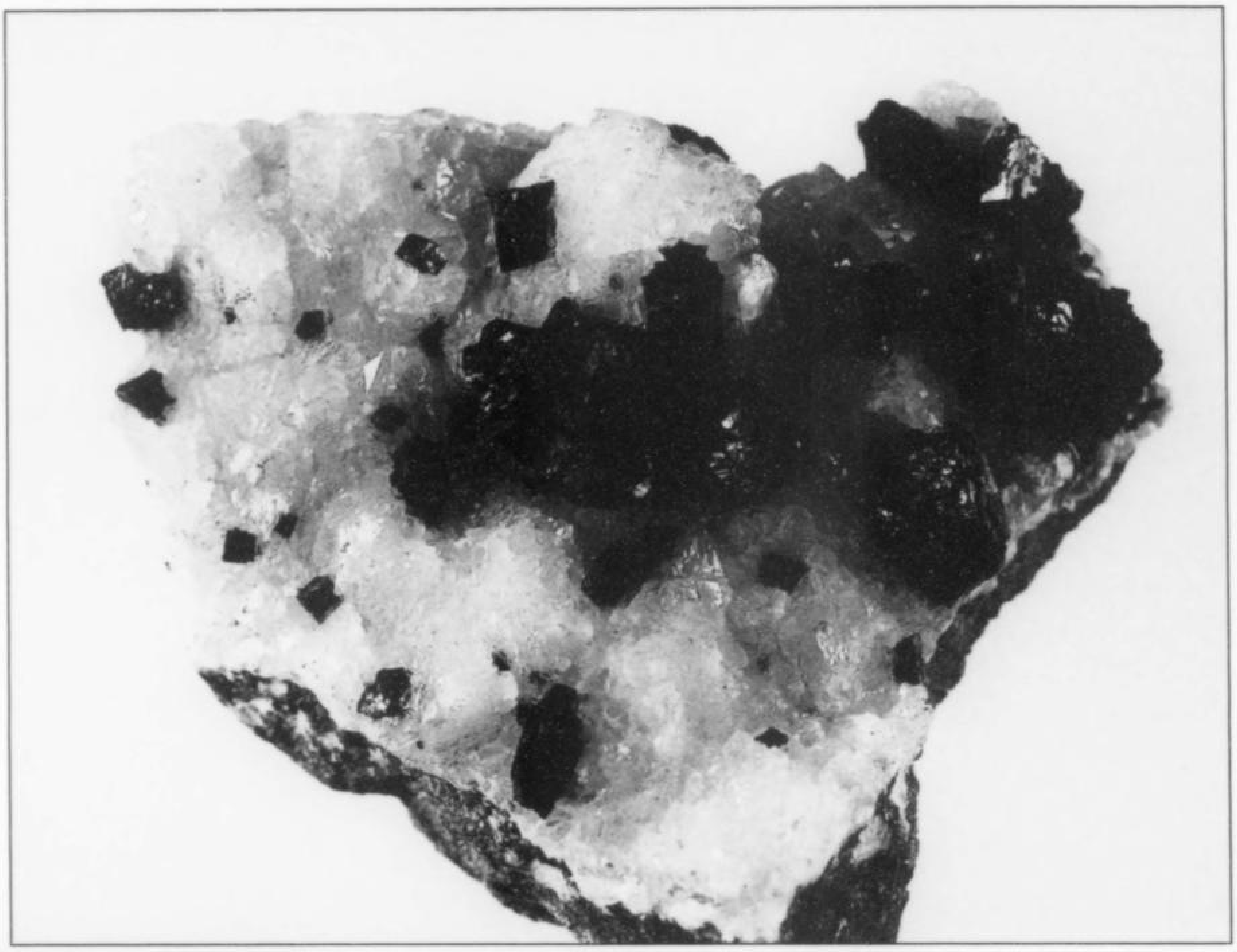
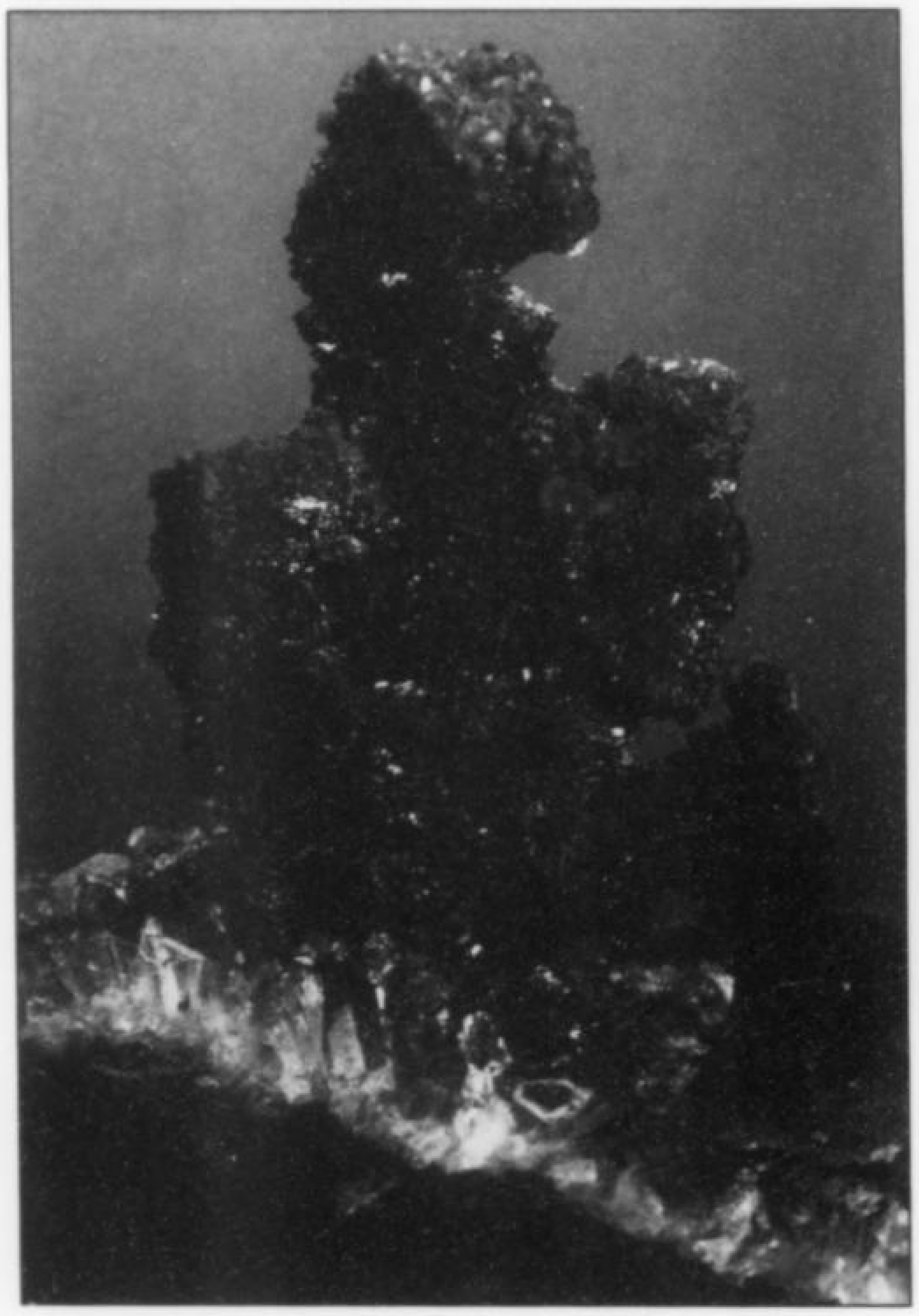


Figure 76. Malachite crystal groups on calcite, 11 cm wide, from Rudabánya. József Attila University, Szeged; G. Kulcsár photo.

Figure 77. Malachite crystal group on calcite, 4 cm wide, from Rudabánya. Herman Ottó Museum collection, Miskolc; G. Kulcsár photo.



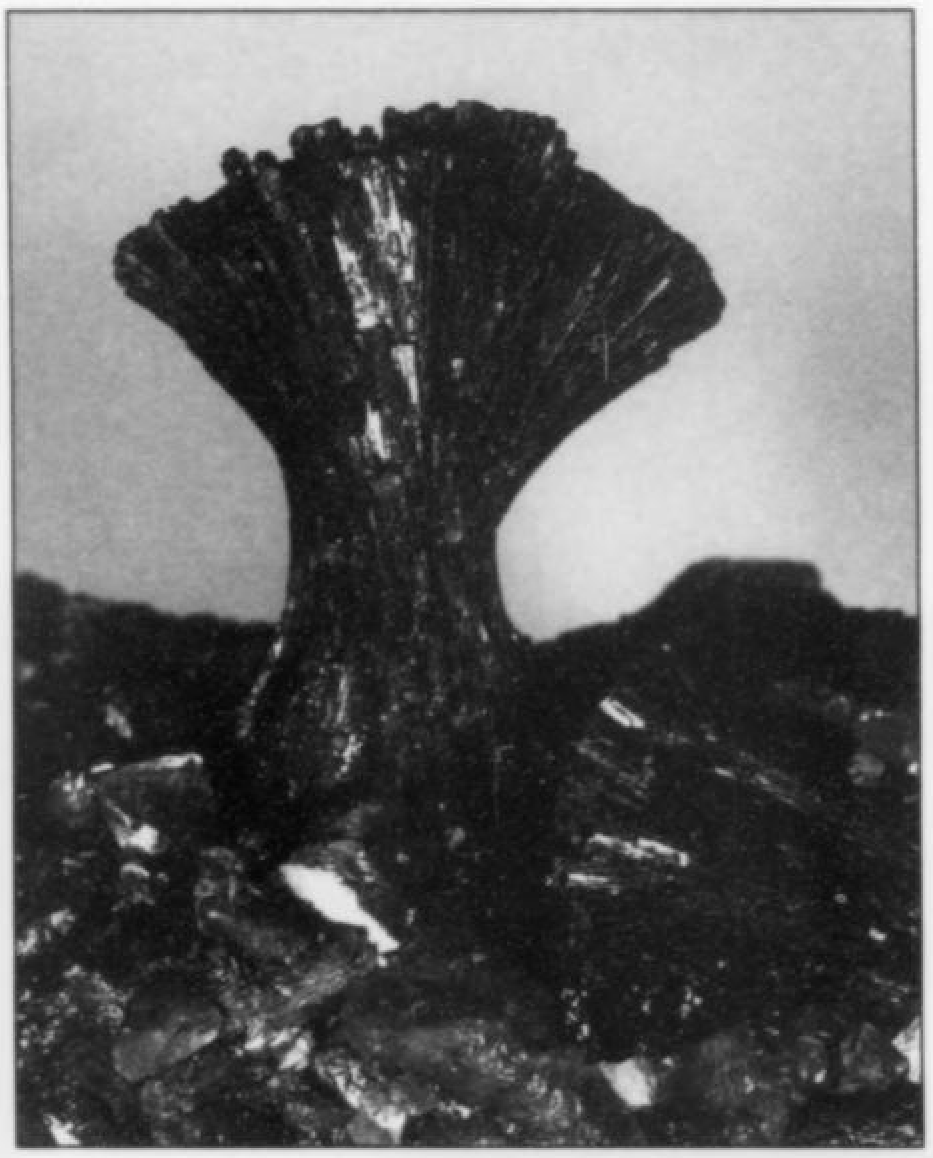
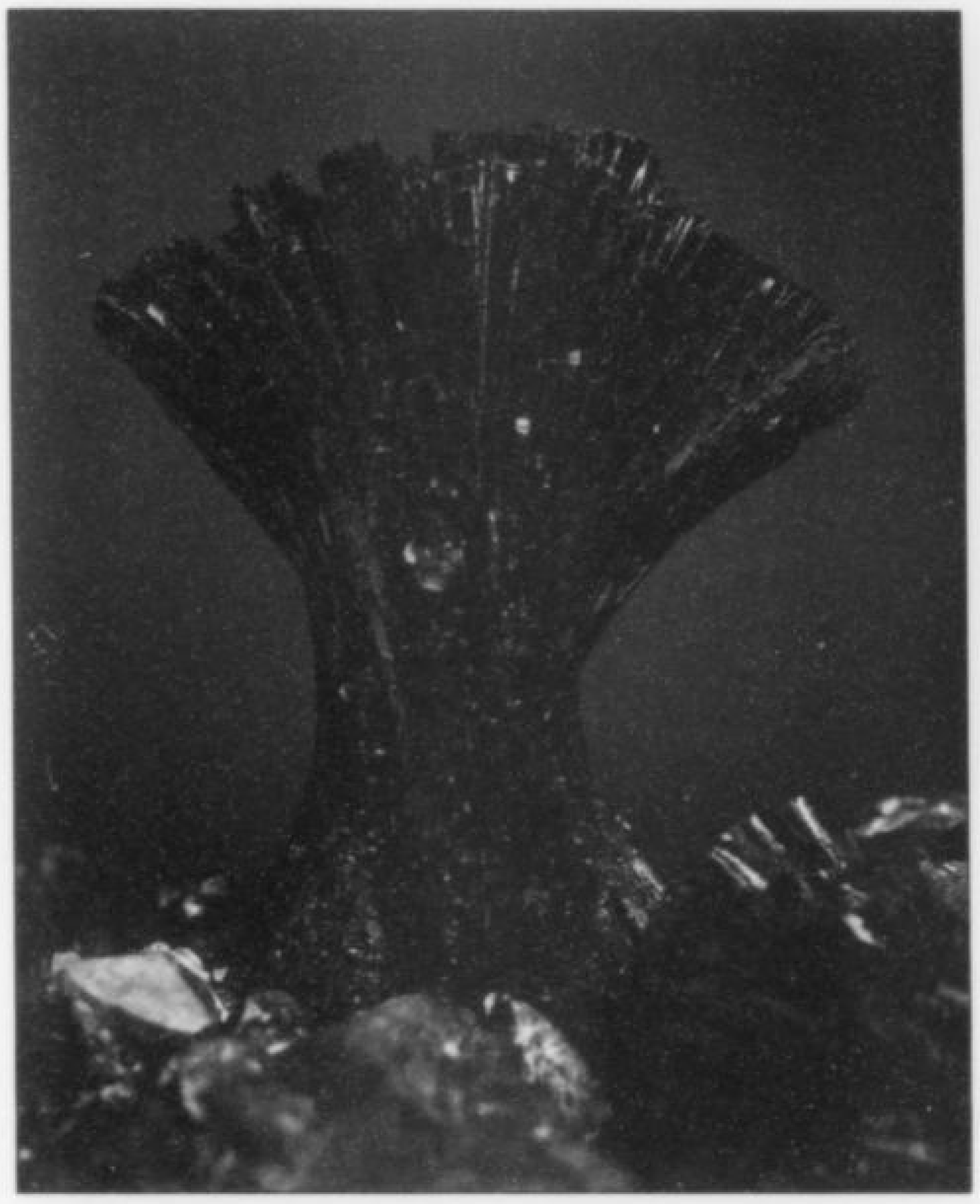


Figure 78. Malachite "bow-tie" crystal group, 3 cm high, from Rudabánya. Herman Ottó Museum collection, Miskolc; G. Kulcsár photo.

Figure 79. Malachite crystal cluster (non-pseudomorphous), 2.5 cm, from Rudabánya. Tom Moore collection; Wendell Wilson photo.



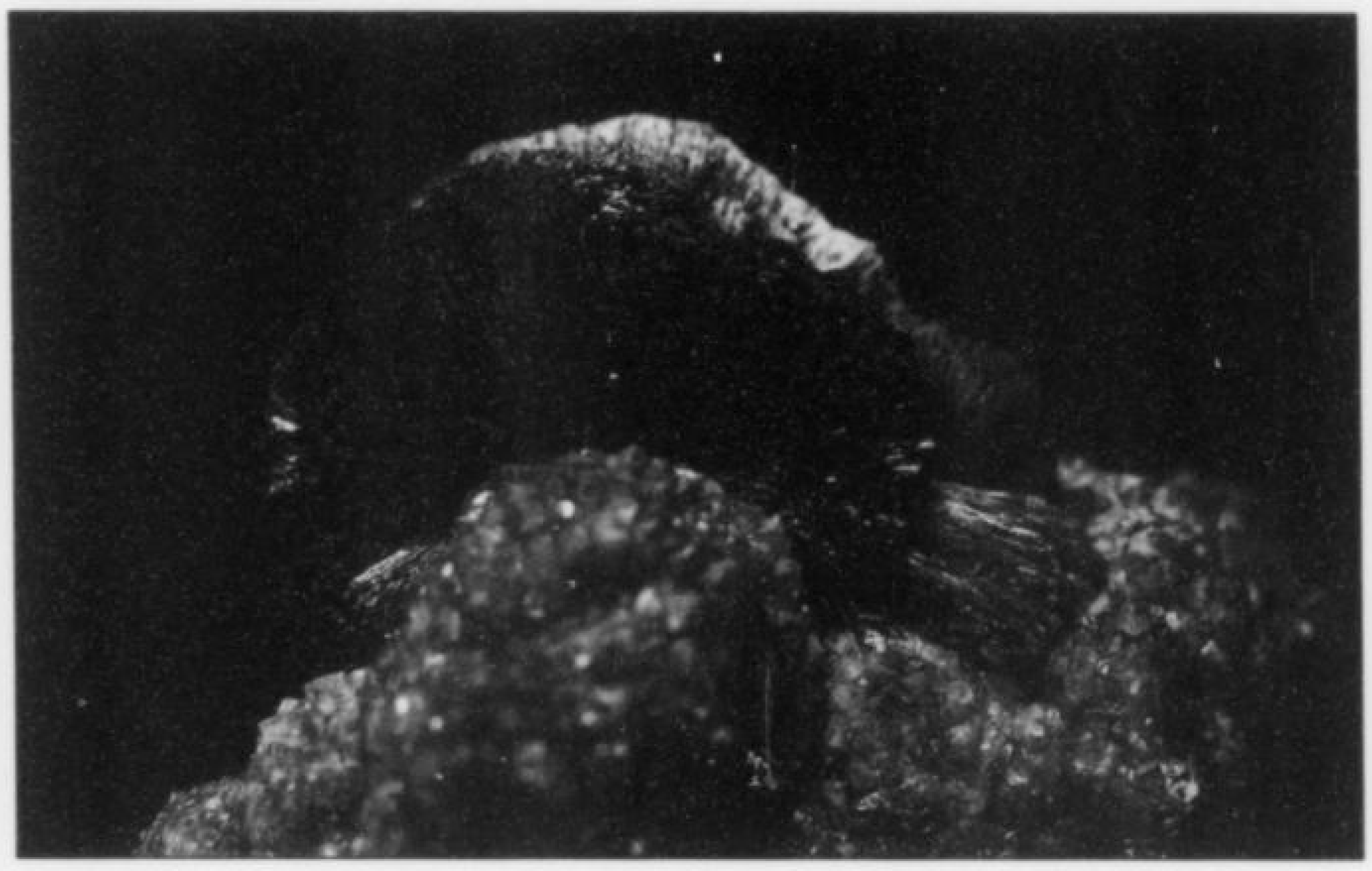


Figure 80. (left) Malachite, Fan-shaped crystal group, on calcite, 2.5 cm high. Herman Ottó Museum specimen (HOM #21247); L. Horváth photo.

Figure 81. Malachite, aggregate of radiating prismatic crystals, 3 cm across. Herman Ottó Museum specimen (HOM #13160); L. Horváth photo.

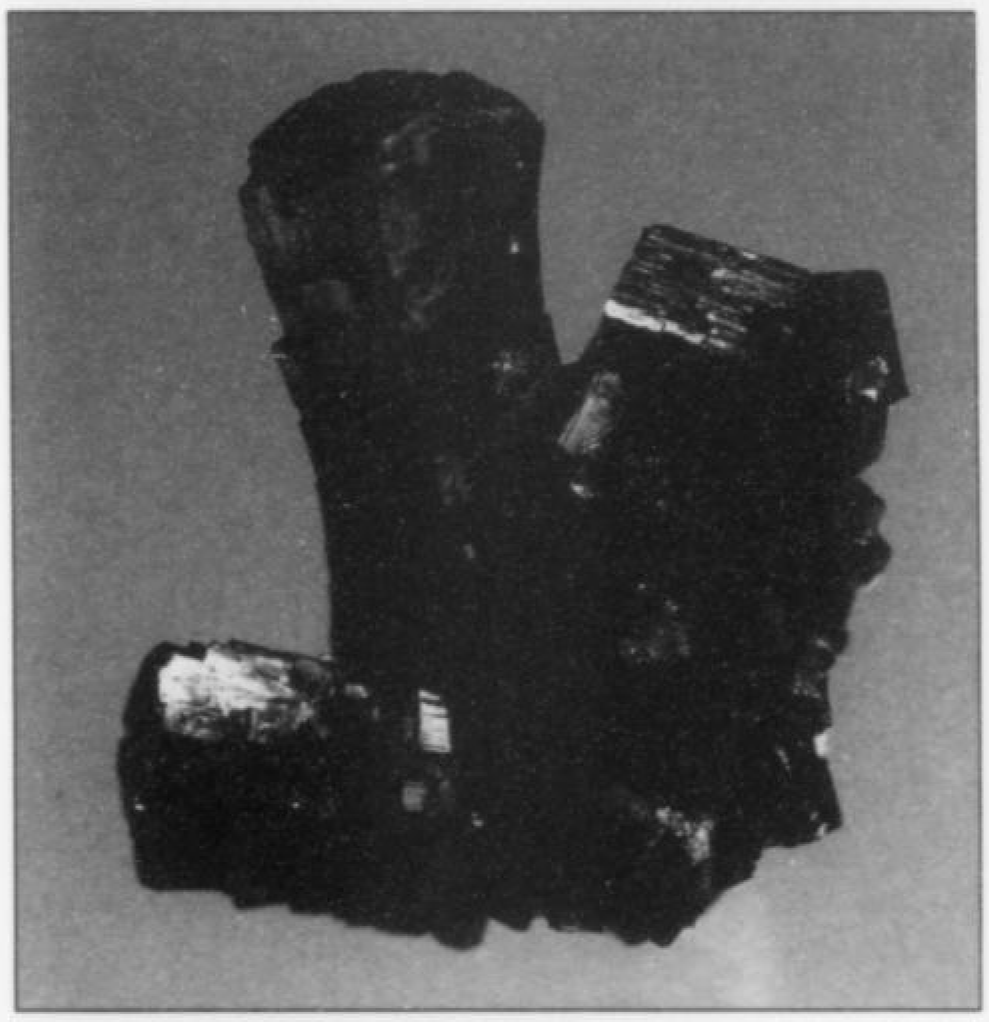


Figure 82. Malachite, a group of prismatic crystals, 2 cm tall. Herman Ottó Museum specimen (HOM #21249); L. Horváth photo.

Figure 83. Skinnerite crystal, 1.5 mm high, from the Andrássy III section. Herman Ottó Museum specimen. S. Szakáll photo.

Figure 85. (below) Valentinite on stibnite spray, 3 mm wide, from the Polyánka section. István Horváth Collection. S. Szakáll photo.

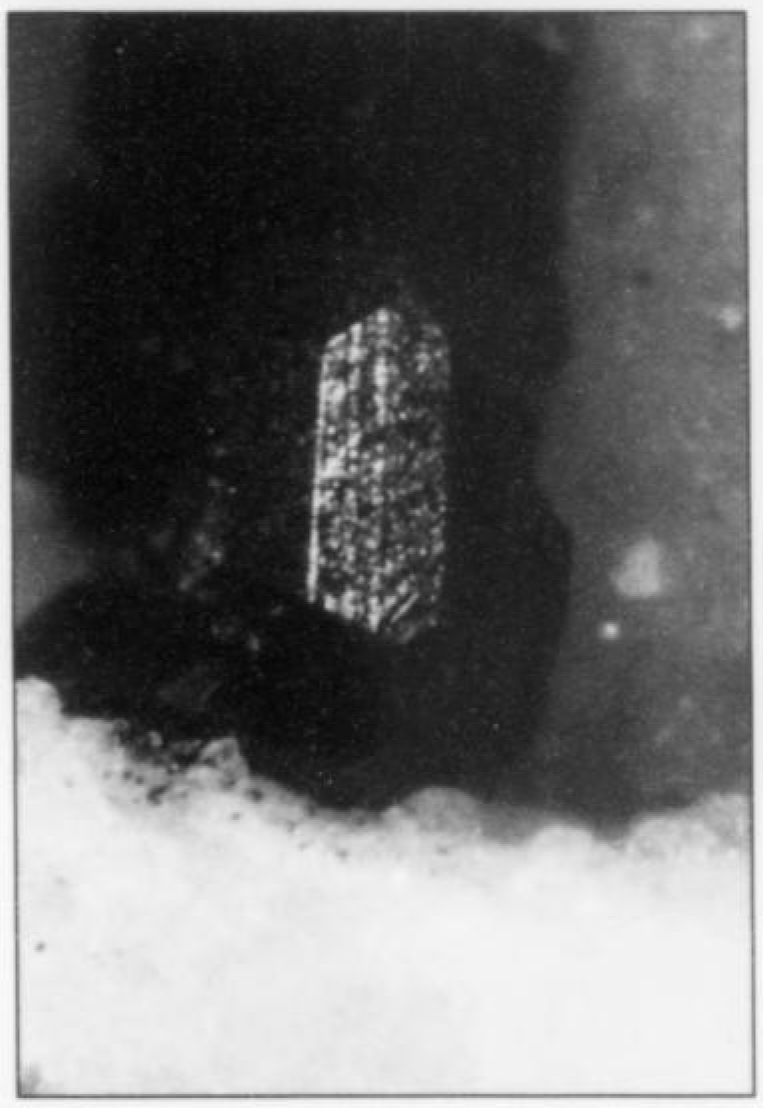


Figure 84. Proustite crystal, 2 mm long, from the Vilmos section. L. Tóth Collection. S. Szakáll photo.

minute (10-30 μm), red, hexagonal tabular crystals very closely associated with capgaronnite and perroudite. Other associated minerals in the assemblage include bromargyrite, chlorargyrite, cinnabar, mimetite, acanthite and mercury.

Iodargyrite AgI

A very rare late-stage associate of bromargyrite and chlorargyrite, iodargyrite occurs as vitreous, transparent, yellow, hexagonal tabular crystals up to 2 mm in diameter, and exceedingly rarely as transparent, lemon-yellow hexagonal prisms 0.2–0.5 mm long (Szakáll and Kovács, 1995).

Jarosite $K_2Fe_6^{3+}(SO_4)_4(OH)_{12}$

Jarosite is a relatively rare alteration product of marcasite or pyrite, found as pale yellow, powdery masses finely dispersed in small quantities in various parts of the deposit.

Kaolinite $Al_2Si_2O_5(OH)_4$

Kaolinite occurs as powdery coatings and small earthy masses in the limonite ores.

K-Feldspar K-feldspar

Identified as microscopic laths, K-feldspar occurs in barite veins and siderite ores associated with various sulfides (Nagy, 1982).

Kolymite Cu_7Hg_6

A rather rare and unusual mineral, kolymite was originally described from the Krokhalin antimony deposit in Yakutia, Russia (Markova *et al*. 1981), and was later reported from Copiapo, Chile. Rudabánya is the third reported locality for the species, where it was found in native copper in a zone of spongy siderite in the Andrássy III section. Kolymite occurs as metallic, silvery xenomorphic grains 10–40 μm across, in copper and closely associated with moschellandsbergite. It was identified in a polished section by microprobe analysis and optical characteristics.

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

A rare, late-stage alteration product of domeykite in the spongy siderite ore in the Andrássy III section, lavendulan occurs as spherical aggregates 0.1-0.5 mm, consisting of turquoise-blue, minute lamellar crystals.

Lepidocrocite γ-$Fe^{3+}O(OH)$

A finely dispersed, relatively rare minor component of the limonite ores, lepidocrocite occurs as yellowish brown aggregates of thin flakes 1–2 mm in diameter. It also occurs in cavities as pale brown druses of densely intergrown, thin lamellar crystals, 1-2 mm across.

Linarite $PbCu^{2+}(SO_4)(OH)_2$

A very rare late-stage mineral, linarite is found in small fractures in a pod of massive smithsonite in the Andrássy I section. It occurs as vitreous to waxy, translucent, pale blue, bladed crystals up to 1 mm long. Associated minerals include cerussite, aurichalcite, brochantite and malachite (Szakáll *et al*., 1997).

Magnesiocopiapite $MgFe_4^{3+}(SO_4)_6(OH)_2\cdot20H_2O$
(see copiapite)

Magnesite $MgCO_3$

Magnesite was identified from dill cores as a relatively common but minor accessory mineral in the Permian evaporites underlying the ore deposit (Csalagovits, 1974).

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

Magnetite is considered a very rare and minor constituent in the siderite ores, occurring as rounded grains up to 1 mm in diameter.

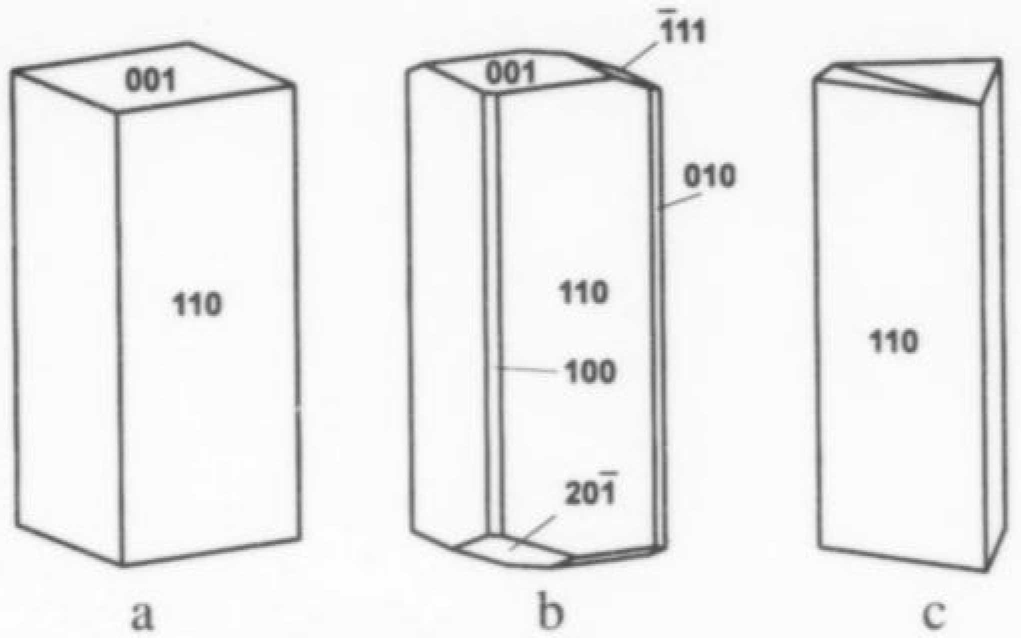


***Figure 86*. Malachite crystal drawings: (a) shows the most common reported and (c) shows contact twinning on (100) reported by Tokody, (1924); and Koch et al., (1950).**

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

The most common secondary copper mineral in the oxidation belt, malachite provides some of the most remarkable and outstanding mineral specimens from Rudabánya, as well as some of the best specimens for the species. Malachite is mainly found in cavities and fissures in the limonite ores most commonly associated with calcite, azurite, cuprite and native copper. The best specimens were collected in the Adolf, Lónyai, Andrássy I and II mine sections.

Malachite occurs mainly as vitreous, transparent to translucent, pale to deep green, acicular to elongated prismatic crystals with the dominant {110} prism up to 1 cm long, typically forming attractive rosettes and fan-shaped, spherical and sheaf-like aggregates up to 6 cm in diameter. The aggregates mainly consist of parallel crystals, intergrown and twinned along the (100) pinacoid (Tokody, 1924; Koch, *et al*., 1950). Some of the best specimens are spherical aggregates of deep green crystals perched on a white calcite crust, found in the 1950's, in the Andrássy II section. However, many excellent specimens have been sporadically found in the last thirty years, mostly in the limonite pods of the Andrássy I section, notably in 1985 and in 2000. Excellent examples are in the collections of the Hungarian Geological Institute and the Hungarian Natural History Museum both in Budapest; the University of Szeged, and the Herman Ottó Museum in Miskolc. Exceptionally well-formed single crystals 1–2 cm long have also been found, but they are uncommon. Blocky, non-pseudomorphic crystals to 1 cm or more resemble the attractive, so-called "primary" malachites from the Onganja mine, Namibia, and the Mashamba-West mine in Zaire. Morphological studies (Tokody, 1924; Koch *et al*., 1950) on single crystals identified the following forms: the {001} basal pinacoid, the {010}, {100} and {$\bar{2}$01} pinacoids, and the {110} prism. Most single crystals have a simple morphology consisting of the dominant {110} prism terminated by the {001} basal pinacoid.

The superb malachite pseudomorphs after azurite and cuprite crystals have already been mentioned earlier. Malachite also forms partial or complete pseudomorphs after native copper.

Marcasite FeS_2

Marcasite is very common in the Rudabánya deposit, found most abundantly in the oxidation zone. Lustrous, brassy crusts, spherical, stalactitic and acicular aggregates, and spear-shaped crystals up to 1 cm in length (Koch, 1966) occur in cavities in spongy siderite ore masses. Crystals are mostly twinned (Tokody, 1924), typically forming groups of cyclic twins. Fresh, bright surfaces often exhibit colorful iridescence which quickly tarnishes, and the specimens disintegrate after a relatively short time. Marcasite has also been found in the marl and clay associated with cover sediments, as spherical concretions 3–10 cm in diameter, and as crusts and stalactitic masses.

Mawsonite $Cu_6^{1+}Fe_2^{3+}Sn^{4+}S_8$

Mawsonite was detected and confirmed by optical and microprobe analysis in a polished section of bornite from the Andrássy II section. It is exceedingly rare, occurring as xenomorphic grains up to 0.1 mm in diameter in bornite.

Melanterite $Fe^{2+}SO_4 \cdot 7H_2O$

A very common post-mining deposition in old workings in many parts of the mine, melanterite is found as greenish crusts and as solid stalactitic formations up to 20 cm across. In the cover sediments it has also been found as pale green, fibrous masses and glaze-like crusts, associated with decomposed marcasite concretions.

Mercury Hg

Mercury is rare at Rudabánya, occurring as minute droplets in cavities in the limonite and siliceous limonite (Guckler, 1882). Very rarely mercury has also been found as inclusions in cuprite, and as microscopic droplets between acicular crystals of malachite lining cavities in massive cuprite, and malachite crusts on cuprite crystals in the Andrássy I and II sections (Koch *et al.*, 1950).

Mimetite $Pb_5(AsO_4)_3Cl$

Mimetite is very rare, occurring in limonite and spongy siderite of the oxidation zone in the Adolf, Andrássy III and Polyánka sections. It is found as sharp, vitreous to dull-lustered, colorless to translucent white hexagonal prisms up to 2 mm long, typically forming radiating and spherical groups. Forms noted are the dominant {10$\bar{1}$0} prism, the {1011} pyramid and the {0001} basal pinacoid. Associated minerals include malachite, cerussite, azurite, olivenite and beudantite (Szakáll and Kovács, 1995).

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

Montmorillonite is found rarely as beige to grayish white earthy masses 1–3 mm across in cavities in limonite masses.

Moschellandsbergite Ag_2Hg_3

Moschellandsbergite is rare, found only in the siliceous limonite in the Adolf mine section. It occurs as irregular grains 1–3 mm in diameter, and very rarely as bright metallic, opaque cubes and diploids 0.1–0.5 mm in diameter. Individual grains and aggregates of moschellandsbergite are sometimes surrounded by a rim of acanthite and malachite. Moschellandsbergite, along with cinnabar, mercury and acanthite, are the alteration products of the mercury-enriched tennantite (Szakáll and Kovács, 1995).

Muscovite $KAl_2(Si_3Al)O_{10}(OH,F)_2$

In the limonite and siderite ores muscovite has been found very rarely, as colorless to golden yellow and silvery white, thin flakes up to 1 mm across (Koch *et al.*, 1950).

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

In the oxidation zone exposures in the Andrássy III and Polyánka sections, olivenite is found very rarely in small cavities with azurite, mimetite and malachite. It occurs as radiating, fan-like and spherical aggregates of vitreous, translucent, pale green, white and rarely olive-green prismatic crystals 1–2 mm long. Crystals are bounded by the dominant {110} prism, and are terminated by the {011} prism (Szakáll and Kovács, 1995).

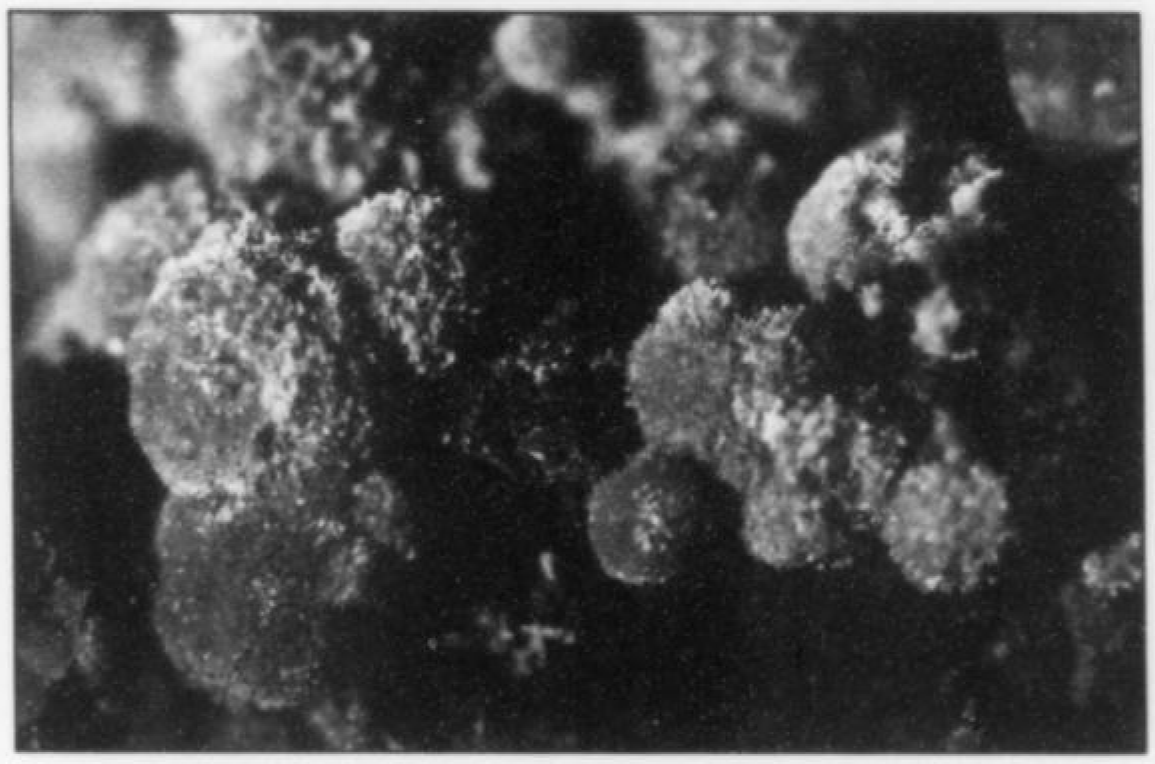


***Figure 87.* Olivenite in spherical aggregates 1–1.5 in diameter, from Rudabánya. Herman Ottó Museum collection; S. Szakáll photo.**

Paratacamite $Cu_2^{2+}Cl(OH)_3$

Paratacamite is very rare, occurring in small fissures in the limonite ores as translucent to opaque, pale green crusts and masses up to 2 cm in diameter. Very rarely it has also been found as pale green tabular crystals 0.1–0.2 mm across (Szakáll, 1992).

Partzite $Cu_2^{2+}Sb^{2+}(O,OH)_7$

In the siderite zone of the Andrássy III section partzite occurs as a rare, late-stage alteration of Cu and Sb sulfides in the form of thin, olive-green coatings and earthy masses 2-3 mm across.

Perroudite $Hg_{5-x}Ag_{4+x}S_{5-x}(Cl,I,Br)_{4+x}$

Perroudite was described simultaneously from Cap Garrone, Var, France (type locality), Broken Hill, New South Wales, and Coppin Pool, Western Australia (Sarp *et al.*, 1987; Mumme and Nickel, 1987). At Rudabánya, perroudite is found as an exceedingly rare secondary mineral, altered from tennantite, in the limonite ores of the Adolf mine section. Perroudite occurs as resinous, somewhat crude, transparent, orange red to red, columnar crystals, 0.1–0.5 mm long, and as thin crusts and coatings, associated with capgarronite, mercury, cinnabar and moschellandsbergite (Szakáll and Sarp, 2000).

Plumbojarosite $PbFe_6^{3+}(SO_4)_4(OH)_{12}$

In the siliceous-limonite of the Adolf and the Audrássy III sections, plumbojarosite has been found as coatings and very rarely in small cavities as pale brown, tabular crystals up to 1 mm forming densely intergrown aggregates.

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

A very rare species in a siderite zone of the Vilmos section, polybasite was found as submetallic, black, hexagonal tabular crystals up to 0.5 mm.

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

Posnjakite is an extremely rare, late-stage mineral found in chalcopyrite-enriched zones of siderite ores, occurring as translucent, pale blue pseudohexagonal tabular crystals 1–3 mm in diameter (Szakáll *et al.*, 1997).

Proustite Ag_3AsS_3

Proustite, rare at Rudabánya, is found exclusively in galena-rich barite of the primary belt in the Vilmos, Andrássy I and II mine sections. In barite veins proustite occurs as embedded, dark red xenomorphic grains up to 1 mm in diameter, and in small cavities as adamantine, transparent to translucent, deep red, short columnar

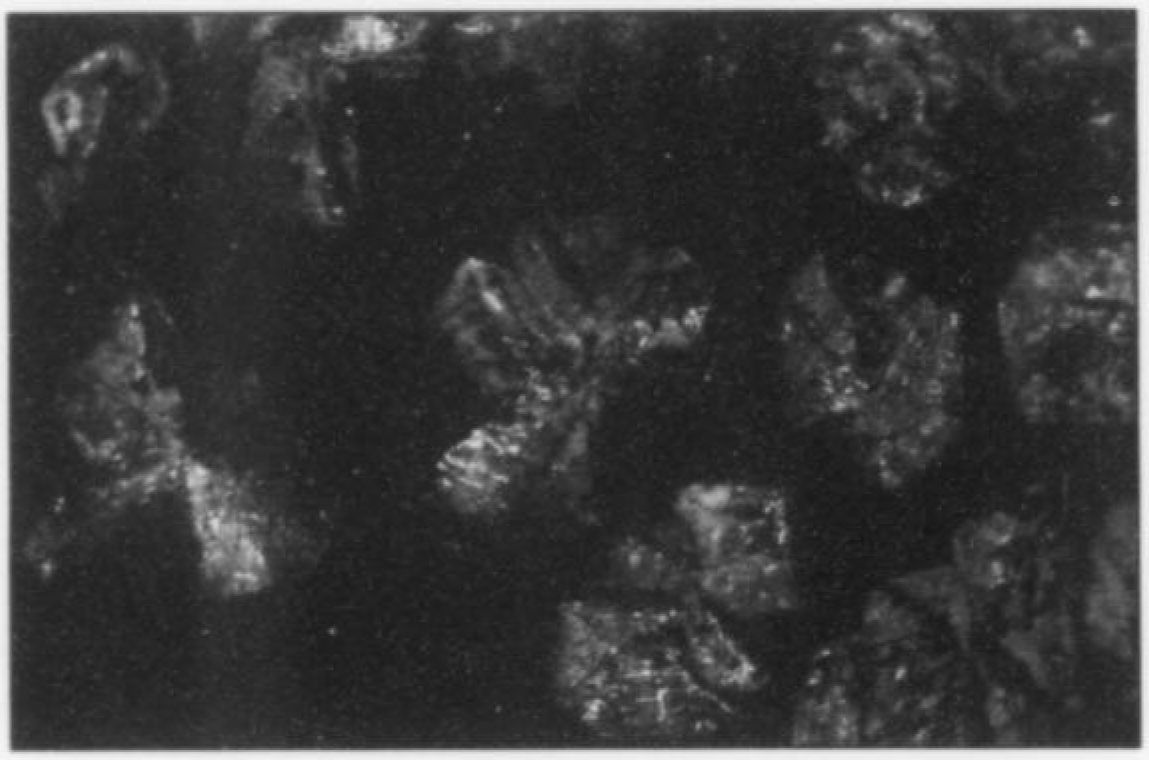


Figure 88. **Posnjakite in groups of pseudohexagonal tabular crystals up to 2 mm across, from Rudabánya. Herman Ottó Museum collection; S. Szakáll photo.**

crystals 1–2 mm in length. The most common forms noted on the crystals are {11$\bar{2}$0} and {0112}. In addition to galena and barite, proustite is usually associated with xanthoconite and pyrargyrite.

Pyrargyrite Ag_3SbS_3

The occurrence of pyrargyrite is rare at Rudabánya and its association is identical to that of proustite. It is found as anhedral grains less than 1 mm in diameter, disseminated in sphalerite, galena and barite (Koch, 1966), and very rarely as adamantine, sharp, translucent, deep red, short columnar crystals 1–3 mm in length.

Pyrite FeS_2

A very common mineral in the primary zone, pyrite is found mostly as compact crystalline masses 5–15 cm across. Pyrite is also abundant in the siderite ores and the barite veins, occurring as widely dispersed grains and masses, and less commonly as well-formed cubes and pyritohedra averaging 1–2 mm in diameter. Morphological studies on single crystals (Köchlin, 1906) identified the following forms: {100}, {110}, {210}, {223} and {211}.

Pyrolusite $Mn^{4+}O_2$

Pyrolusite is a relatively common late-stage alteration product of Mn-bearing primary carbonates in the limonite ores, found mainly as compact masses up to 30 cm in diameter. Rarely it is also found as groups of submetallic, dark gray, hexagonal tabular crystals 2–4 mm in diameter, and as crusts and spherical aggregates of randomly intergrown crystals.

Pyromorphite $Pb_5(PO_4)_3Cl$

Identified from alteration crusts around galena, pyromorphite occurs as opaque, white, hexagonal prisms 0.1 mm long, associated with cerussite, azurite and malachite.

Quartz SiO_2

Quartz is relatively common in small concentrations, occurring principally in the siderite ores of the primary belt as xenomorphic and idiomorphic grains and crystals of microscopic size. It is also found in spongy siderite and siliceous limonite as a drusy cavity lining, and as small aggregates with individual crystals up to 1 cm long.

Ranciéite $(Ca,Mn^{2+})Mn^{4+}_4O_9{\cdot}3H_2O$

In localized Mn-concentrations in the limonite ores, ranciéite is relatively common, occurring in small cavities as aggregates of opaque, black, irregular flakes with a purplish hue (Szakáll, 1992).

Realgar AsS

Realgar is very rare at Rudabánya, found in the spongy siderite ore in small, cellular solution cavities as vitreous, translucent to opaque, red to reddish orange, acicular and short prismatic crystals 1–2 mm in length.

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

Romanechite is a rare associate of other manganese minerals in the limonite ores. It is found as veins to several cm in thickness consisting of opaque, black, compact, banded (rhythmically layered) masses.

Rosasite $(Cu^{2+},Zn)_2(CO_3)(OH)_2$

A very rare secondary mineral found in limonite of the Adolf section, rosasite occurs as green, globular aggregates up to 1 mm in tiny fissures in massive smithsonite.

Rozenite $Fe^{2+}SO_4{\cdot}4H_2O$

Associated with altered marcasite concretions in the cover sediments, rozenite is found as white, fibrous crusts associated with melanterite, szomolnokite and jarosite.

Serpierite $Ca(Cu^{2+},Zn)_4(SO_4)_2(OH)_6{\cdot}3H_2O$

Serpierite is a very rare secondary mineral found in a single specimen as translucent, sky blue radiating aggregates 1–2 mm in diameter, consisting of compact intergrown lath-shaped crystals (Szakáll *et al.*, 1997).

Siderite $Fe^{2+}CO_3$

Siderite, one of the primary iron ore minerals at Rudabánya, is the most abundant species in the deposit. It is also the main component of the carbonate ores in the primary belt, and the spongy siderite ores of the secondary belt of the deposit. The carbonate ores consist of crystalline masses of intimately intergrown siderite, dolomite and calcite, with minor ankerite. In the Andrássy I and III sections there are isolated masses, locally referred to as "spherosiderite" ores, which consist of spongy masses of recrystallized siderite with a radiating spheroidal structure. In cavities of the "spherosiderite" masses, siderite of normal habit also occurs as translucent, pale yellow rhombs 1–2 mm across, commonly forming drusy crusts and spherical aggregates up to 1 cm in diameter.

Siderotil $Fe^{2+}SO_4{\cdot}5H_2O$

A relatively rare post-mining efflorescence, siderotil is found as pale brown, powdery coatings and as porous crusts in old workings of the Andrássy II and Vilmos sections (Szakáll *et al.*, 1997).

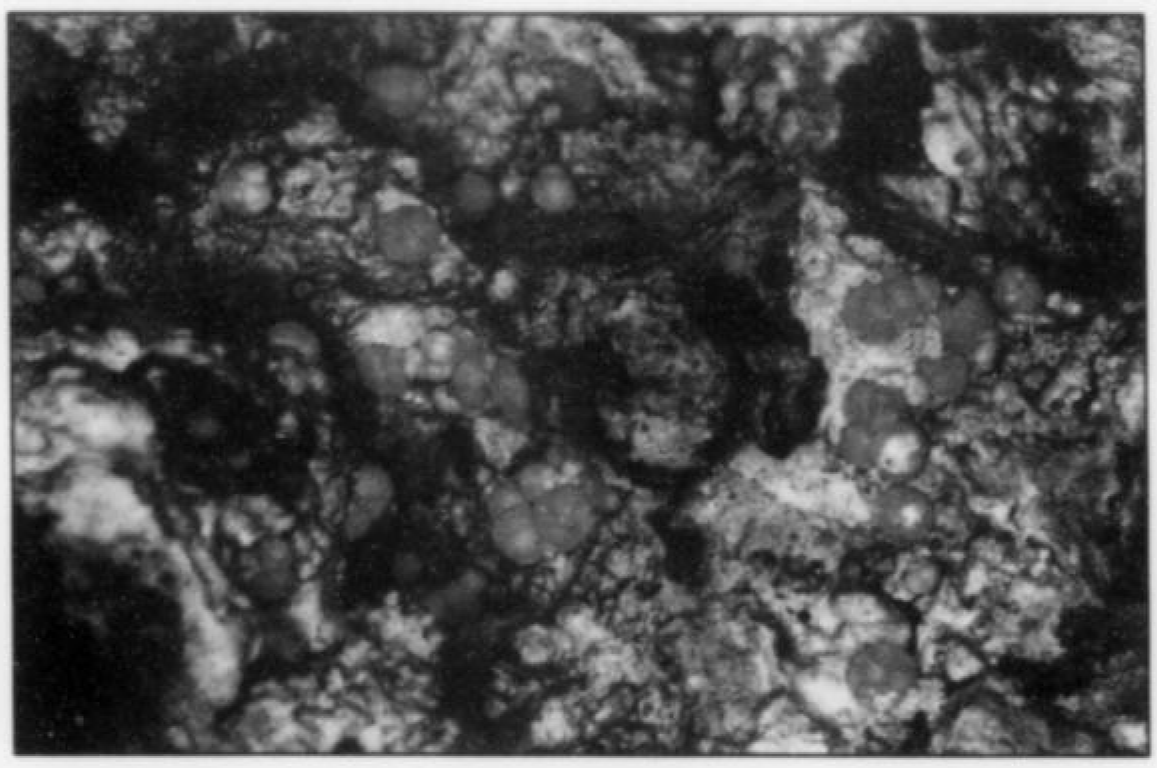


Figure 89. **Zincrosasite spheres, 0.3–0.5 mm in diameter, from Rudabánya. Herman Ottó Museum collection; S. Szakáll photo.**

(continued on p. 155)

Famous Mineral Localities:

THE RIST AND ELLIS TRACTS

HIDDENITE NORTH CAROLINA

Delmer L. Brown
International Geoscience, Inc.
1095 Dudley Street
Lakewood, Colorado 80215

Wendell E. Wilson
The Mineralogical Record
4631 Paseo Tubutama
Tucson, Arizona 85750

The Rist and Ellis properties near Hiddenite, North Carolina, are among the best-known emerald deposits in North America. Many fine gemstones, as well as crystals of monazite-(Ce), xenotime, rutile, tourmaline, quartz and green spodumene ("hiddenite"), have been recovered in the area since the first discovery of emeralds there in 1875.

INTRODUCTION

The Hiddenite area, North Carolina, has long been famous among gemologists and mineral collectors. "Hiddenite," the bright green variety of spodumene, and emerald have been collected from countless pits dug throughout the area. North Carolina is, in fact, the only significant producer of emeralds in North America. Deposits have been found in three general areas: (1) near Shelby in Cleveland County, (2) on Big Crabtree Mountain in Mitchell County, and (3) near the town of Hiddenite in Alexander County. The most famous occurrence is on the old Warren Farm about 1 mile west of Hiddenite, near Salem Church in Sharps Township. J. A. D. Stephenson of Statesville, North Carolina, found an emerald there in 1875, and more crystals were later turned up accidentally by plowing. W. E. Hidden took up the search and, after some months of work in 1880, found a pocket containing good crystals of emerald and a bright green variety of spodumene which was promptly named *hiddenite* in his honor.

In 1881 the Emerald and Hiddenite Mining Company was organized to work the Hiddenite property, and produced many good crystals over the next four years, after which work ceased except for a brief period of renewal in 1926–1927.

Figure 1. **Emerald mining near Hiddenite, North Carolina, in 1888. Photo courtesy of LKA International.**

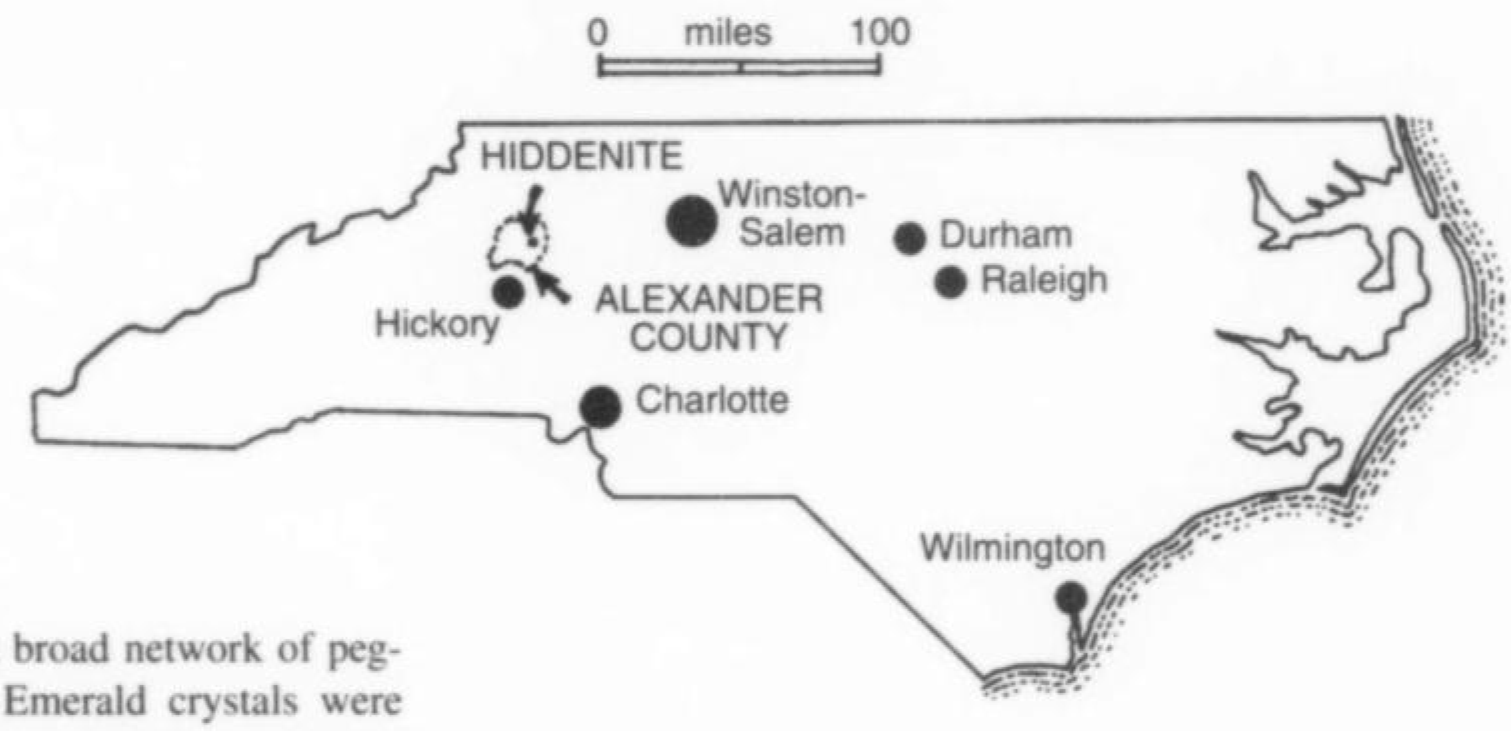


Figure 2. **Locality map: North Carolina.**

Hidden's research eventually revealed a broad network of pegmatite-like veins in the Hiddenite area. Emerald crystals were found on the Osborne-Lackey property about 1000 feet northwest of the Warren Farm site. About 2500 feet west of Hiddenite another prospect yielded both emerald and hiddenite around 1907. A short distance away at the Ellis prospect, due east of Hiddenite, a superb, dark green emerald of 276 carats and about 200 carats of hiddenite crystals were recovered around the same time (Sinkankas, 1959). Many other fine crystals have been found there over the succeeding years.

LOCATION

The Rist and neighboring Ellis properties consist of approximately 200 acres of land located immediately northeast of the small community of Hiddenite, Alexander County, North Carolina.

Alexander County, having an area of 255 square miles, is sparsely populated. Taylorsville is the county seat and largest town; Hiddenite and Stony Point are smaller communities within the county. The area is chiefly agricultural, the main crops being tobacco, corn and cotton. A significant amount of commercial poultry is raised in the rural area. Alexander County also supports an appreciable amount of light industry, consisting chiefly of furniture manufacturing.

The community of Hiddenite is located approximately 5 miles southeast of Taylorsville, at an altitude of 1,140 feet; it is bounded to the north and east by a crescent of low mountains which range from 1,520 feet (Coon Mountain) to 1,851 feet (Rocky Face Mountain) in altitude.

The topography of the area consists of rolling hills. West and north of Taylorsville, higher mountain peaks and ridges are common. The area south and east of Taylorsville is a southeastward-sloping peneplain dissected by a close network of streams. The drainage in the general area northeast of Taylorsville is southeastward to the South Yadkin River. In the remainder of the county the drainage is largely southward toward the Catawba River. The streams are swift and commonly clear—their courses are devious and apparently are not closely related to structural weakness in the underlying rocks.

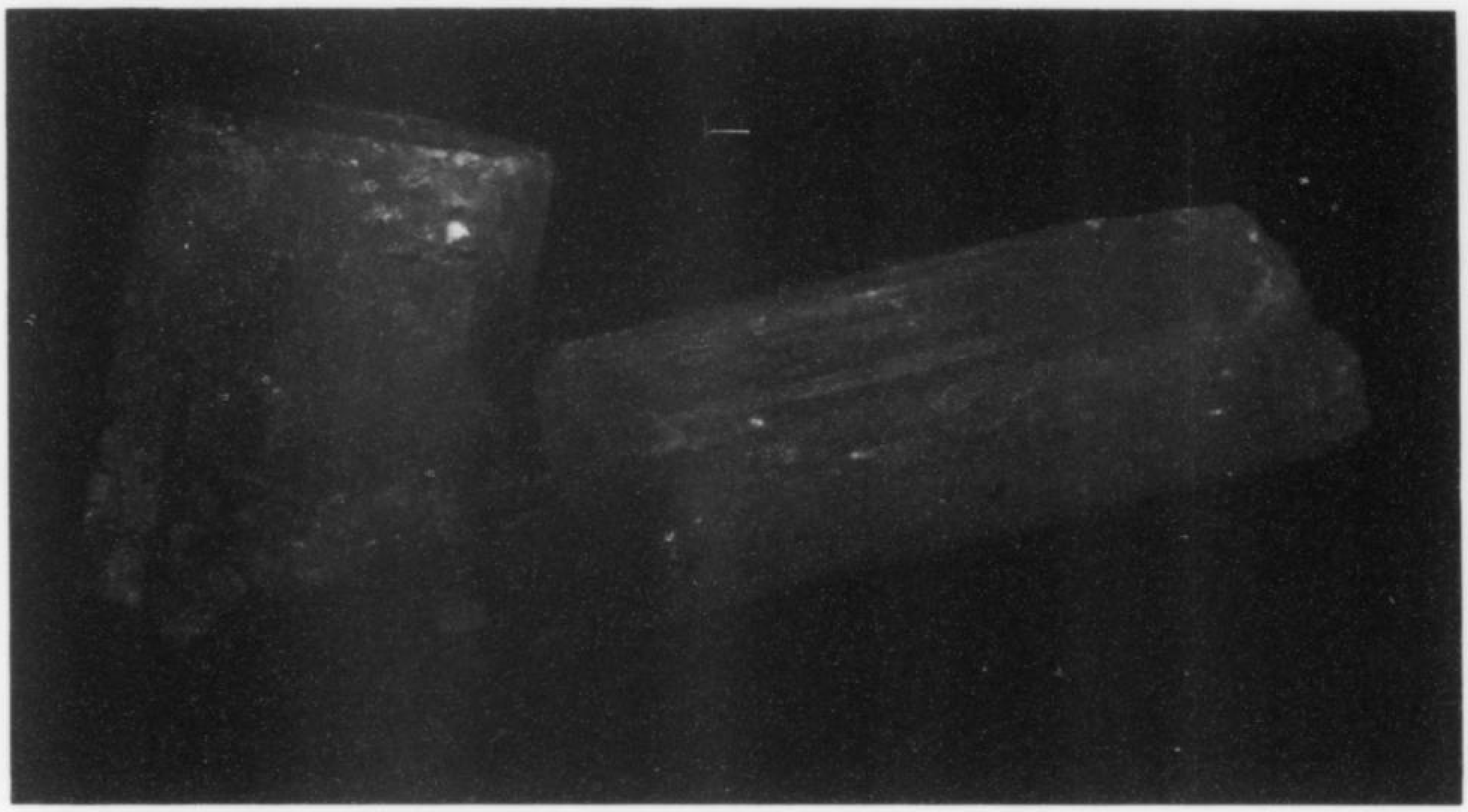


Figure 3. **The "Stephenson" emerald (left, 1,438 carats) was considered to be the largest fine emerald crystal ever found in North America until 1985, when the 1,686-carat crystal at right was found on the Rist property. Photo courtesy of LKA International.**

The area of the Rist and Ellis properties is one of scenic beauty throughout the seasons of the year. The lands are heavily timbered, with black walnut, wild cherry, dogwood, several varieties of yellow pine, red, white, and Spanish oak, sassafras, hickory, poplar, beech, maple, sycamore, cedar and birch being the common species. A great variety of small flowering plants and native grasses are in abundance. Wildlife in the area consists of white-tailed deer, rabbits, squirrels, possums, raccoons, a few black bears, partridges, cranes and migratory ducks.

The eastern limit of the Rist property is bounded by the South Yadkin River, an especially scenic stream. Standing on the Rist property along the stream, one can still see the foundations of Barr's mill, a water-powered grist mill that operated prior to the turn of the century.

HISTORY

Originally the hunting grounds of the Cherokee and Catawba Indian tribes, the area around Alexander County was one of the first areas in colonial America to develop an agricultural industry. Farmers, tilling their fields near present-day Hiddenite, uncovered long green crystals which, because of their vivid color, caught the eye. These green crystals were locally known as "green bolts" owing to their elongate nature. The "green bolts" were later identified as emeralds.

In 1875, an amateur mineralogist, John Adali Stephenson of Statesville, North Carolina, offered to purchase these unusual crystals from the farmers. Reportedly, it was stipulated that to be worthy of purchase, the "green bolts" had to be at least as long as a person's finger, must be dark green, pure, transparent, and with perfect terminal planes and prismatic faces. In spite of these stringent requirements, a surprisingly large number of emerald crystals qualified for purchase by Mr. Stephenson.

In 1879, William Hidden, by profession an engraver for a New York bank, but an ardent devotee of mineralogy, was sent to North Carolina by Thomas A. Edison to search for possible sources of platinum. In this respect, his mission was a failure, but upon learning of the "green bolts" and seeing the emerald crystals in the personal collection of Stephenson, he decided to investigate. Hidden acquired the mineral rights to one of the farms where emerald crystals had been found by plowing. Shortly thereafter, Hidden and some partners hired a crew of workmen, and cross-trenched the ground to a depth of 8 feet, during the course of which a number of emeralds were found. Hidden and his partners continued to mine for emeralds until 1885, at which time their work was abandoned due to legal disputes.

The Ellis property, named after William Ellis, owner of the land at the turn of the century, was the site of early attempts at commercial mining operations. In 1907, the American Gem Mining Syndicate prospected and mined on the Ellis tract, but abandoned work as soon as hard, unweathered rock was encountered.

It was not until 1969 that any excavations were made on the Rist property. In that year, Warren Baltzley of Amelia, Virginia, formed a partnership, American Gems Inc., with Charles Rist, a financier of Fairfield, Pennsylvania. This partnership acquired approximately 200 acres of land east-northeast of the town of Hiddenite, including the Ellis mine and a consolidated tract later to be named the Rist mine. American Gems, Inc. opened portions of the ground on the Rist and Ellis tracts to collecting by tourist "rockhounds," on a daily fee basis, and also developed a campground and souvenir shop complex. Inasmuch as the fee diggers were not required to report any of their finds, no records are available concerning the quantity or gem quality of emeralds or other minerals extracted from the properties, but it is known that a number of fine quality gems were extracted during the periods 1969–1981.

In October of 1982, the Rist and Ellis properties were acquired by LKA International, Inc., headquartered in Seattle, Washington. During the summer of 1983, LKA International, Inc. initiated geological field studies. The Rist property was later acquired by AOKA International, and a portion was sold to the current owners, Gilbert Wooten and Craig Rutledge, in 1994.

An 11.4-acre tract is currently known as the Wooten-Rutledge mine. Wooten and Rutledge have thus far found 30 pockets containing beryl in various colors and five hiddenite veins which have yielded over 800 specimens.

The Yadkin Ripple

A Newspaper With The County In Its Name

The Newspaper With The Most Yadkin Subscribers

ONE HUNDRED & FIFTH YEAR NO. 24 YADKINVILLE, YADKIN COUNTY, N.C. 27055 THURSDAY, APRIL 10, 1997 50¢ A COPY (USPS 694-920)

Ross Fields, who appraises for jewelry stores in five states, talks with Craig Rutledge at the bottom of an excavation where the emerald (below) was found in a vein some 20 feet deep. (Gilbert Wooten Photo.)

Gilbert Wooten, left, and Craig Rutledge stand with the big emerald they found April 3 in their mine at Hiddenite. Beside the emerald is a six-carat emerald crystal. (Ross Fields Photo.)

Hiddenite, Emeralds & Beryl Of All Kinds Are In Their Veins

By CHARLES MATHIS

Forty years ago when he was working at Reynolds Tobacco, Gilbert Wooten was told by a supervisor–who just happened to be an expert on precious and semi-precious stones–not to look to find anything of value in Hiddenite.

"'Don't go up there–you're just wasting your time,'" the supervisor said.

Telling Gilbert Wooten that he could not find any good stones at Hiddenite just made him want to look and see for himself.

"That's what turned me on," said Wooten, who has been mining in Hiddenite since 1957 and, since 1994, has owned with Craig Rutledge an emerald mine on an 11.4-acre site of the property where the famous Carolina Emerald (weighing 13.4 carats and valued at close to half a million dollars) was found in 1971.

"We've found 38 pockets with beryl, plus five hiddenite veins. Beryl can be blue or it can be green. Blue is aquamarine, and green is emerald, but it's all beryl," said Wooten.

"Yellow beryl is heliodor. "I've never found it at Hiddenite, but I have at Spruce Pine.

"Clear beryl is goshenite. We've found some of that, too."

The first big emerald they discovered together was 93 carats, but the biggest Wooten has ever found weighed 270 carats and is now on display in the Greensboro Museum.

This emerald was found about a mile from the location of the Wooten-Rutledge Mine, where the latest find, on April 3, was of a high-quality 175.03-carat emerald.

The emerald–about three and one-half inches long, weighing 175.03 carats, held by Craig Rutledge. (J. E. Brown Photo.)

Cut stones from the emerald could be worth a lot, said Rutledge. "You don't know until you've cut them."

Rutledge, who is owner/publisher of *The Ripple*, added:

"We cut our own stones, and we have several high grade cut stones for sale; they're of the finest quality emerald anywhere.

"Our mine is the only operating mine in the world producing hiddenite," Rutledge said.

"We have found 800 single pieces of hiddenite."

The mine, of course, is at Hiddenite, a town in Alexander County made famous by the semi-precious stone "hiddenite."

Hiddenite is the only place in the world where hiddenite colored by chromium is found.

Said Wooten, retired from Reynolds Tobacco after more than 37 years (he became a supervisor himself–in casing and drying at Whitaker Park):

"North Carolina is the only place in North America that emeralds are found.

"And they are found in only three N.C. counties–Alexander, Cleveland and Mitchell.

"We also find smokey quarts and amethyst quartz.

"We have a big supply, along with other specimen, of quarts with various inclusion–mud, monazite, tourmaline and rutilatted quartz; also ankerite, pyrite, plus inclusions not identified.

"Long ago, when I found out that all precious stones are found in North Carolina–that's what got me

***Figure 4.* Article in *The Yadkin Ripple* detailing the 1997 emerald find made at the Rist mine by Gilbert Wooten and Craig Rutledge.**

GEOLOGY

Regional Geology

Alexander County, North Carolina, is located in the western Appalachian Piedmont province, lying between the Coastal Plain and the Blue Ridge Mountains. The western limit of the Piedmont province is bounded by the Blue Ridge Scarp. This scarp is a prominent topographic feature generally thought to have resulted from fault displacement. Elevations in the Piedmont province range from 300 to 600 feet above sea level along the eastern border and gradually rise to the west to approximately 1,500 feet above sea level at the foot of the Blue Ridge Scarp.

The Piedmont is an ancient erosion surface characterized by gently rolling hills with a few hundred feet of local relief. This rolling topography with well-rounded hills and long, low ridges, for which the Piedmont is noted, is the result of streams eroding rocks of unequal resistance. Standing above this surface are mountainous remnants or monadnocks composed of comparatively more erosion-resistant rock.

Stratigraphically, the Piedmont is underlain mostly by metamorphosed crystalline rocks of late Precambrian to early Paleozoic age. Downfaulted basins filled with Triassic sediments are also present. Locally, these interbedded Triassic sediments have been intruded by mafic dikes and sills of gabbroic composition.

Except along the major stream valleys, the rocks of the Piedmont are almost everywhere covered by a mantle of thoroughly weathered residual material known as "saprolite," which in many places exceeds 150 meters in thickness.

The complex geology of the crystalline rocks of the Piedmont of North Carolina is at best only generally understood at the present time. However, because of similar rock types, structures, and areal distribution, the Piedmont is divisible into parallel geologic belts oriented northeast-southwest. From the southeast to the northwest, these geologic belts are known as the Carolina Slate Belt, the Charlotte Belt, the Kings Mountain Belt, the Inner Piedmont Belt and the Brevard Belt. The latter is a prominent regional structural feature, forming the western boundary of the Inner Piedmont Belt and separating it from the Blue Ridge Mountains.

Local Geology

The emerald deposits of the area are noteworthy, not only because of the fine quality emeralds which have been obtained, but also because of the geology and mode of occurrence, which are in contrast to those of most other emerald deposits of the world.

The bedrock geology of the Rist and Ellis mine area consists of Precambrian quartz-mica schists and gneisses, which constitute

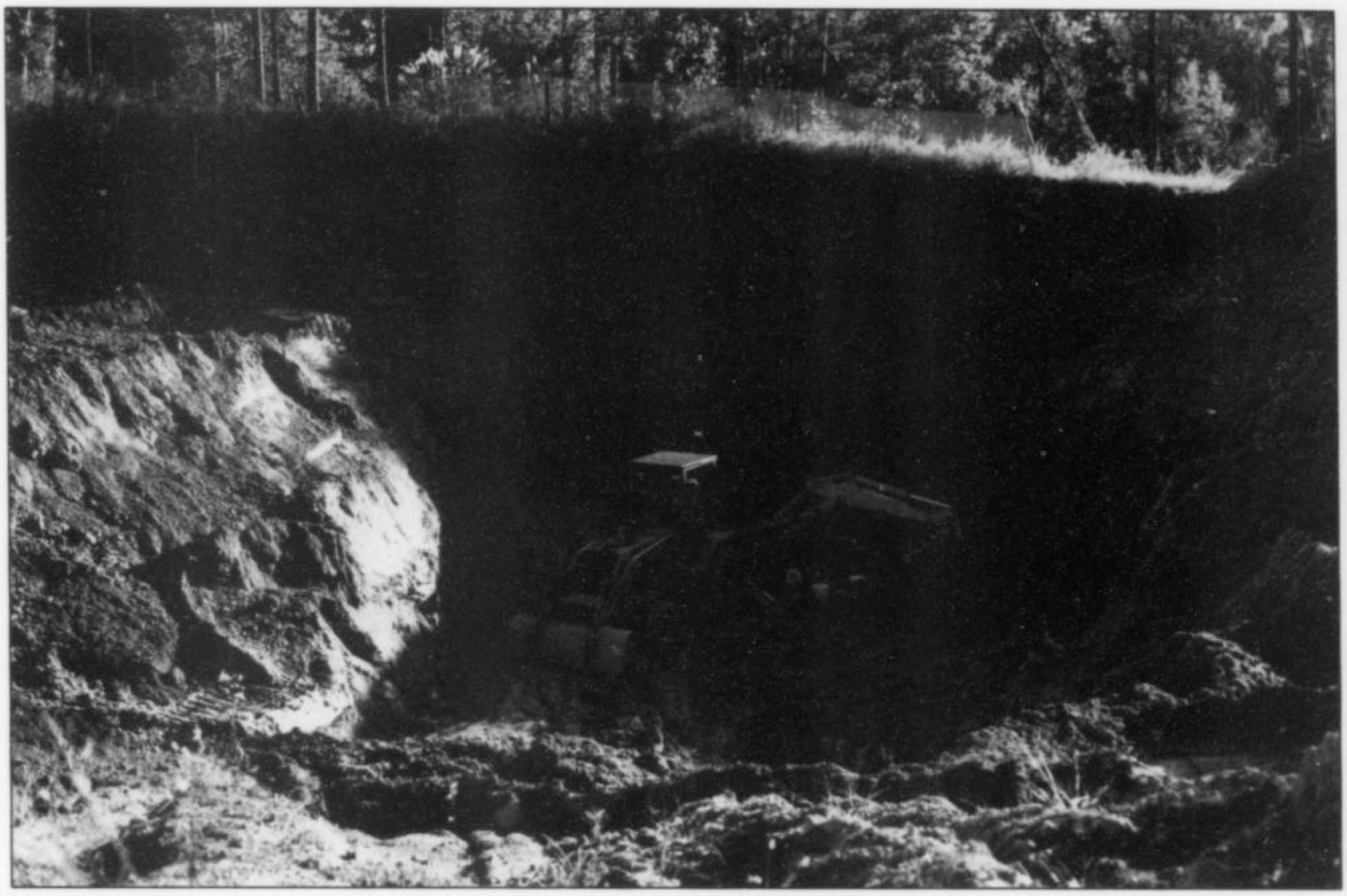


Figure 5. **Excavating at the Rist mine, Hiddenite, North Carolina. Photo by Gilbert Wooten**

part of an immense series of schists in west-central North Carolina. Generally speaking, these schists and gneisses exhibit a northeast-southwest lineation. They have developed an extensive set of steeply-dipping fractures, oriented northeast-southwest, parallel and sub-parallel to the regional structural trends. At some time following the development of these fractures, late-stage pegmatitic fluids penetrated the fractures, with the associated development of quartz and quartz-mica veins. Vugs and pockets along the course of these veins contain emeralds and other associated minerals.

A second set of fractures, oriented in a generalized northwest direction, developed at a later period of time. Fractures of this latter system have been filled with barren "bull" quartz, and are completely devoid of emeralds.

Following the development of the regional peneplain, the area was subjected to prolonged weathering, with the development of a thick residual "saprolite." This saprolite is rich in clays which have developed from the chemical disintegration of the original feldspars within the gneisses and schists; it is brick-red in appearance, owing to the complete oxidation of the original mafic components. The saprolitic zone passes through a transition zone into hard, competent, unweathered schists and gneisses.

Exploration for the emerald-bearing veins has been successfully accomplished in the past by locating the upward reaches of the northeast-trending quartz and quartz mica veins in the saprolitic zones. Not uncommonly, near the surface immediately below the overburden, these veins are only a few inches thick, and consist largely of highly fractured quartz. Followed downward into the highly decomposed saprolite, the quartz becomes more coarsely crystalline, often with the appearance of large crystalline masses (books) of muscovite mica, and not uncommonly, enlarges into a large pocket, some of which are more than 1.5 meters across. These pockets are usually lined with large euhedral quartz crystals and/or large books of muscovite mica, and are commonly partially or completely filled with red clay in which emeralds and other beryls are sometimes embedded.

The emerald-bearing veins are not confined to the upper weathered saprolite zones, but extend downward through the transition zone and into the competent, underlying, unweathered schists and gneisses. However, not all of the veins on the properties, and not all the pockets within a given vein, are emerald-bearing.

On the Rist property, stripping tests have shown that (1) the overburden averages about 1.5 meters thick, (2) a large number of northeast-southwest veins can be revealed by stripping, and are generally vertical or near-vertical in slope, and (3) there is no apparent relationship between vein width and emerald content, emerald crystal size or emerald quality. The upper portions of the veins tend to contain massive quartz and sometimes massive mica, but no emerald. Euhedral quartz and mica crystals predominate immediately above a pocket, and the pockets themselves are usually filled with clays and Fe-Mn oxides.

Mining consists primarily of excavating a trench alongside a vein, then carefully removing and seiving the vein material.

Minerals found in association with the emerald-bearing veins on the Rist and Ellis properties include a number of varieties of quartz (clear quartz and smoky quartz, often occurring in extremely large crystals, as well as rose quartz and amethyst). Other minerals include albite feldspar, muscovite, black to dark green tourmaline, reticulated dark red-brown rutile, and pyrite. Frequently, the quartz contains inclusions of brilliant rutile crystals. Pseudomorphs of goethite after siderite, sometimes more than four inches in diameter, are found in the vugs. In addition to emeralds, the vugs contain green beryl, goshenite, and aquamarine. Monazite crystals, up to 1.9 cm in length, sometimes sufficiently transparent to facet very small gems, have also been found in association with the emeralds. Xenotime has also been noted, although its occurrence on the properties is rare.

Beryl $Be_3Al_2Si_6O_{18}$

Beryl crystals have been found on the properties in a variety of colors, from colorless ("goshenite") to pale green and blue-green

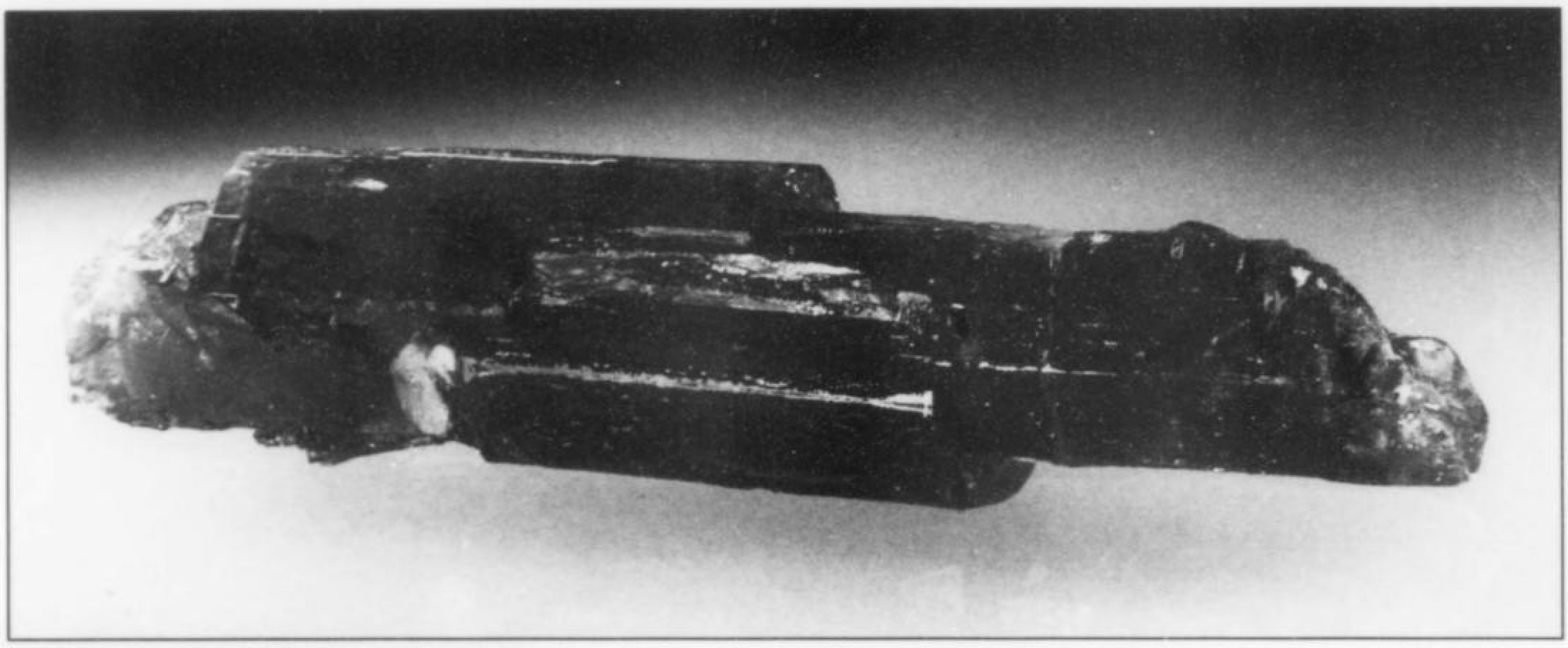


Figure 6. **The 8.4-cm emerald crystal found at the Rist mine in 1997 by Gilbert Wooten and Craig Rutledge. Wendell Wilson photo.**

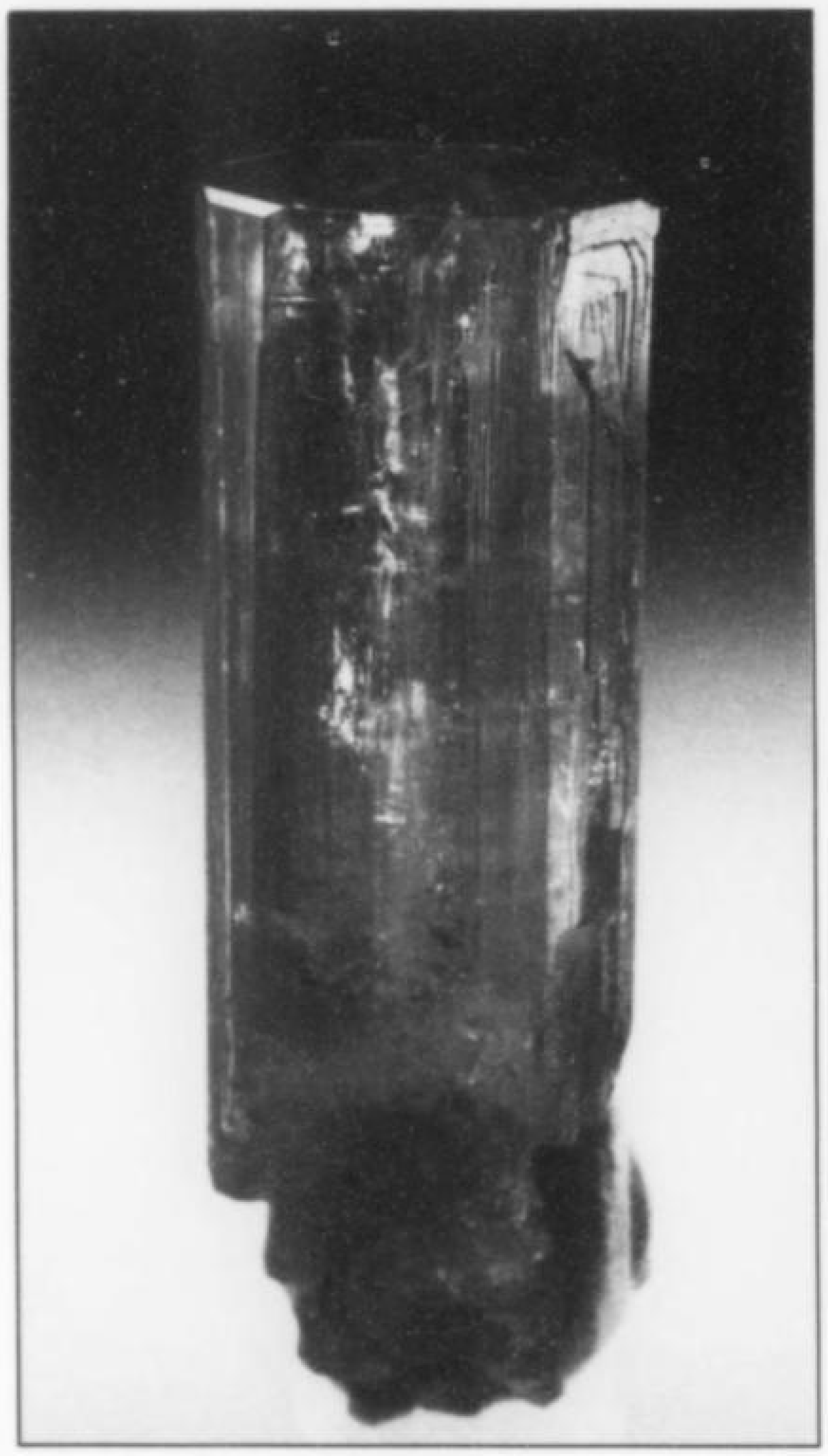


Figure 7. **Thumbnail size crystal (2.5 cm) of emerald found at the Rist mine in 1997 by Gilbert Wooten and Craig Rutledge.**

Figure 8. **Monazite-(Ce) crystal, 5 mm, with rutile, on emerald from the Rist mine. Gilbert Wooten collection; Wendell Wilson photo.**

("aquamarine") to chromium-green ("emerald"). Morphologically the crystals exhibit the first-order prism $\{10\bar{1}0\}$ and basal pinacoid $\{0001\}$ with traces of the second-order prism $\{11\bar{2}0\}$ and second-order dipyramid $\{11\bar{2}1\}$ modifying the dominant forms. Etching of the faces, from mild to severe, is extremely common but some crystals remain bright and unetched. They are generally transparent or nearly so.

Emeralds from the properties often have a colorless core, and in some cases the crystals are darker green on one end than on the other. They have refractive indices of e = 1.580 and o = 1.588, which is somewhat different from those of emeralds from the famous deposit at Muzo, Colombia (1.578, 1.584), as is the birefringence (0.008 vs. 0.006). The measured specific gravity of Hiddenite emeralds (2.73) is also slightly greater than for Muzo emeralds.

When viewed under a Chelsea color filter, the chromium-rich portions of Hiddenite emeralds are a rich blood-red color. The absorption spectrum is normal for chromium-colored beryl (emerald). However, the reddish fluorescence under longwave ultraviolet light is unusual and distinctive. Of further diagnostic value in recognizing Hiddenite emeralds are the peculiar gaseous and liquid inclusions and unusual hollow tubular voids.

There are no records concerning the past production of emeralds from the Rist and Ellis properties, but a number of emeralds are known to have been privately collected from the properties since their being opened to public digging in 1969.

One of the prize emeralds of record from the properties was

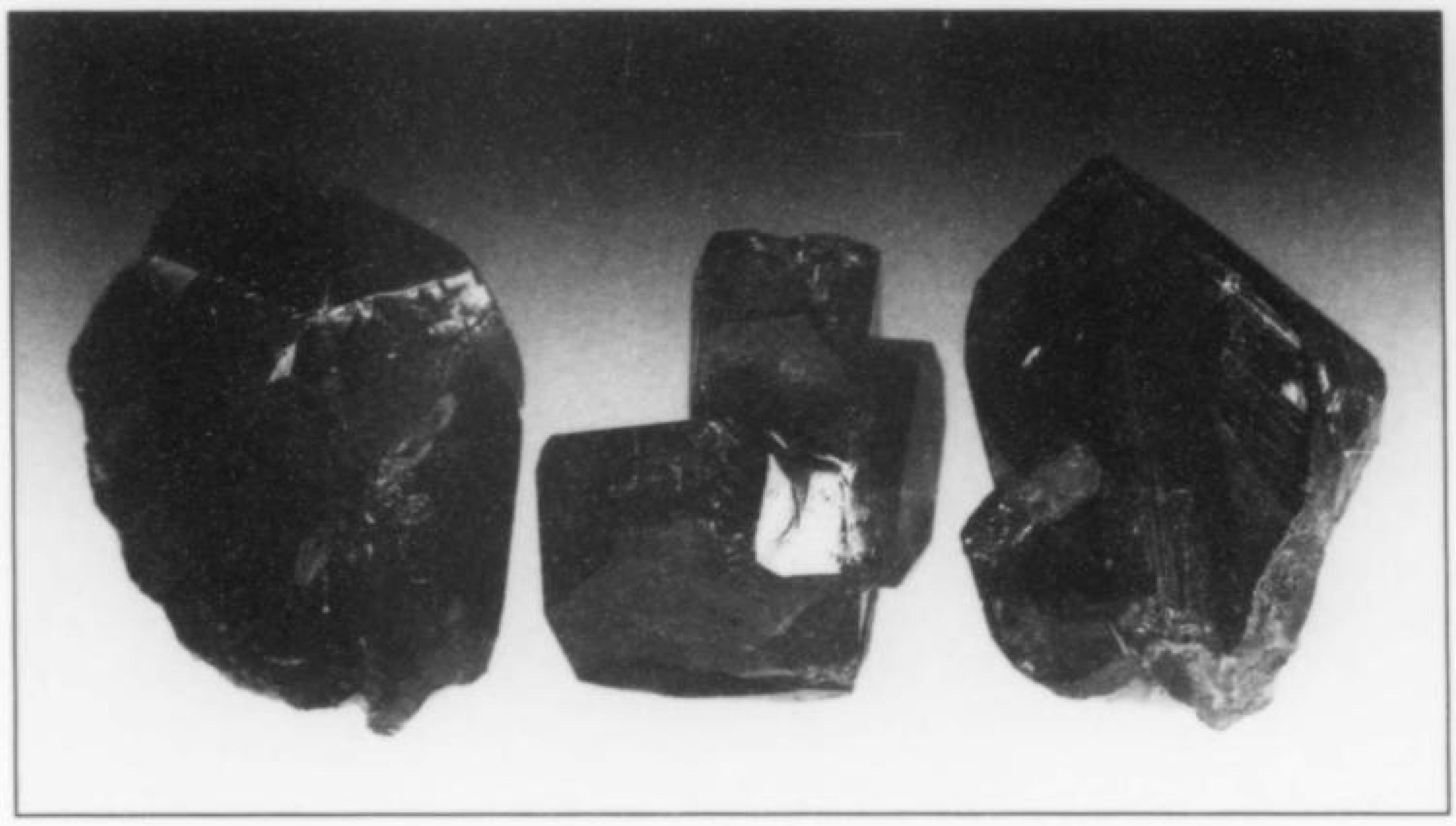


Figure 9. **Monazite-(Ce) crystals up to 1 cm in size, from the Rist mine. Gilbert Wooten collection; Wendell Wilson photo.**

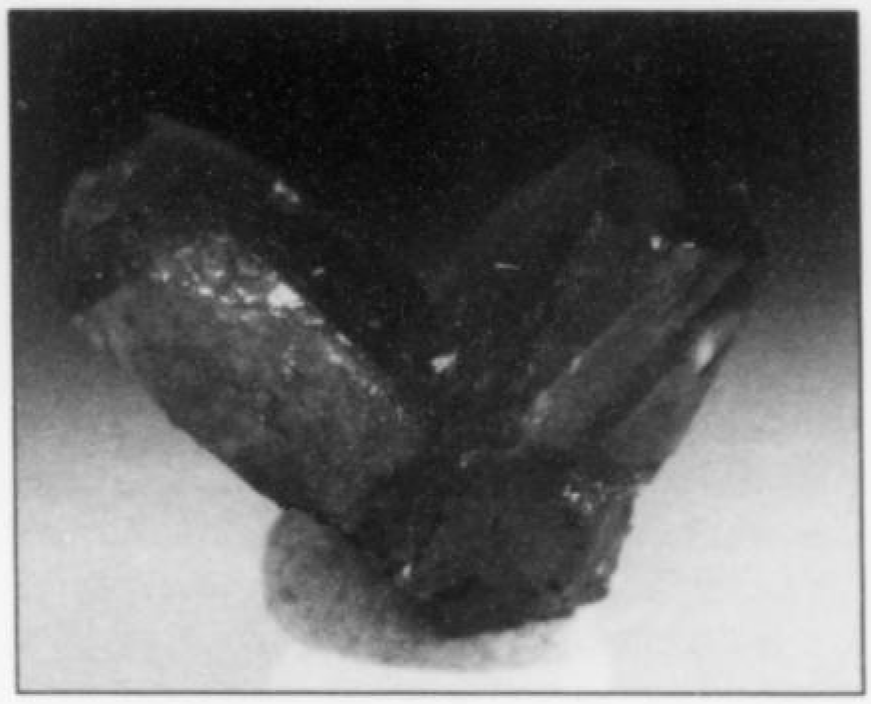


Figure 10. **Monazite-(Ce) twin, 3 mm, from the Rist mine. Russell Elliott collection; Wendell Wilson photo.**

found by Wayne Anthony, a collector from Lincolnton, North Carolina, in 1969. This emerald was found in a small quartz-mica vein in the weathered zone approximately 61 cm below the surface. From an original 1.9 x 2.2-cm crystal (59 carats) was cut a faceted gem weighing 13.14 carats. This emerald, known as the "Carolina Emerald," is now owned by Tiffany's and is on display in their New York showroom.

Another noteworthy recently-found emerald from the Rist property is a 1,438-carat crystal known as the "Stephenson Emerald." This crystal, which remains uncut, measures nearly 7.6 cm (3 inches) in length, slightly more than 5 cm in diameter, and 1,438 carats in weight.

While conducting work on the property in 1984, LKA International discovered the largest emerald ever found in North America. This crystal measures 3.8 cm in diameter, 11.4 cm in length, and weighs 1,686.3 carats. It remains uncut and has not yet been named.

We have seen a number of other fine emerald crystals of unusual merit from the Rist and Ellis properties which are in private collections. One collection of special merit is owned by Mr. Glenn Bolick of Hickory, North Carolina; in a single excavation at the Rist mine, he found a pocket which yielded more than 3,500 carats of emeralds. Mr. Bolick has cut several of these emeralds into magnificent gemstones, including the Marie and the June Culp Zeitner (15.47 carat) emeralds.

During preliminary field studies sponsored by LKA, a number of elongate emeralds and other beryls of varying size were extracted. During some follow-up studies in 1984, a 1,686.3-carat emerald crystal was discovered, the largest emerald crystal ever found in North America!

Other fine specimens of emeralds from the Hiddenite area are on

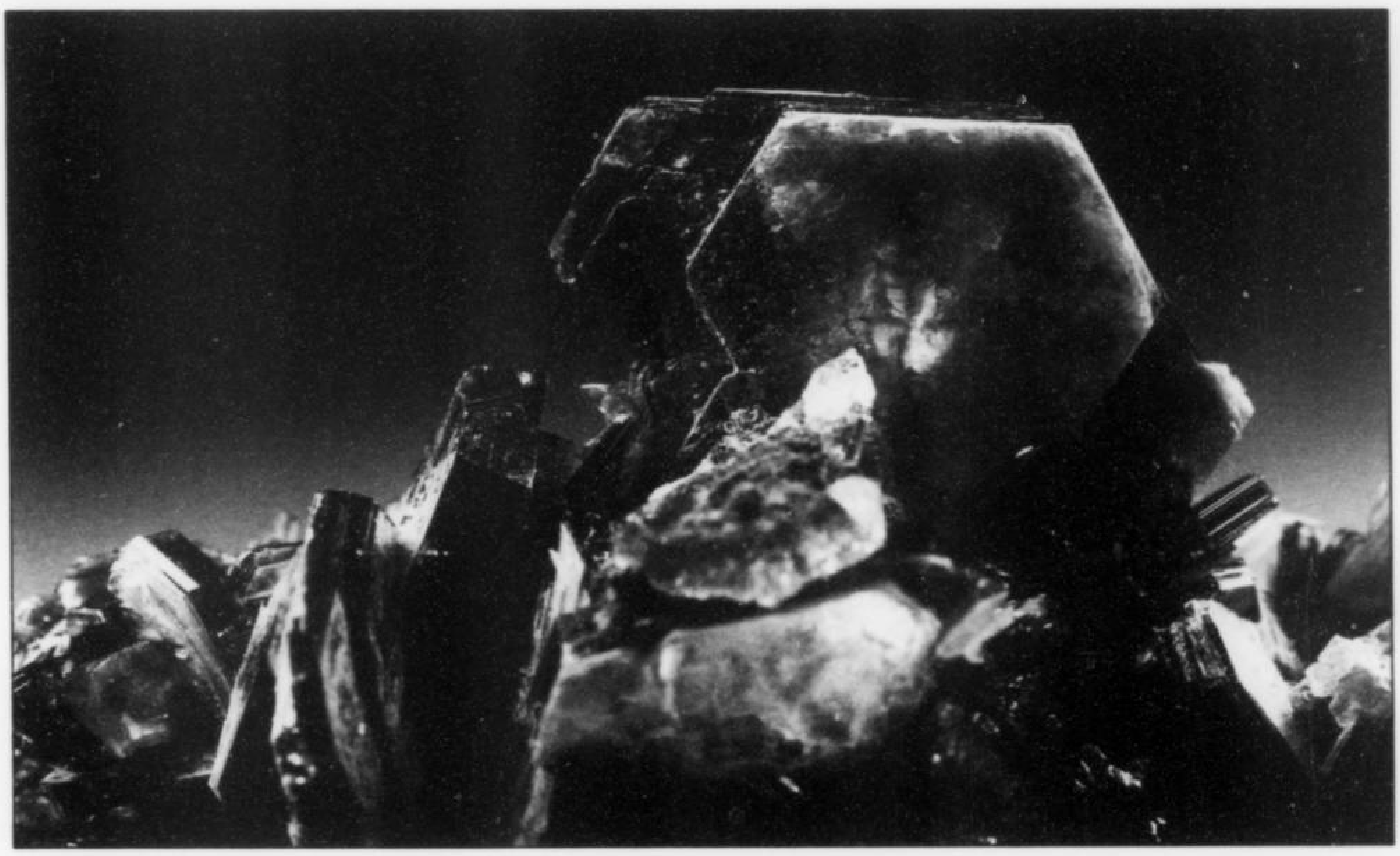


Figure 11. **Muscovite crystals to 1.9 cm, from the Rist mine. Note the gemmy green interiors visible only along the edges. Gilbert Wooten collection; Wendell Wilson photo.**

display in many museums, including the U.S. National Museum and the American Museum of Natural History.

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

Fine, translucent to transparent orange crystals of monazite-(Ce) have been found loose in the soil, or attached to emerald crystals associated with rutile. The crystals range from prismatic to complex equant habits and from a millimeter or two up to 1.9 cm. A few have even been cut as small gemstones. The luster and sharpness are generally excellent. The relative proportions of the rare-earth elements (leading to identification of the species as monazite-*(Ce)*) were determined by Terry Wallace using the electron microprobe at the University of Arizona, Tucson.

Muscovite $KAl_2(Si_3Al)O_{10}(OH,F)_2$

Attractive specimens consisting of lustrous, tabular, pseudohexagonal muscovite crystals to about 2 cm, in clusters, have been recovered from some veins. The crystals are typically white and micaceous in luster on the large *c* faces, but show an inner zone (sandwiched between the two main *c* faces) which is a deep, gemmy green. Considering the association with emeralds, it is possible that this muscovite is also colored green by chromium, but analyses have not been done.

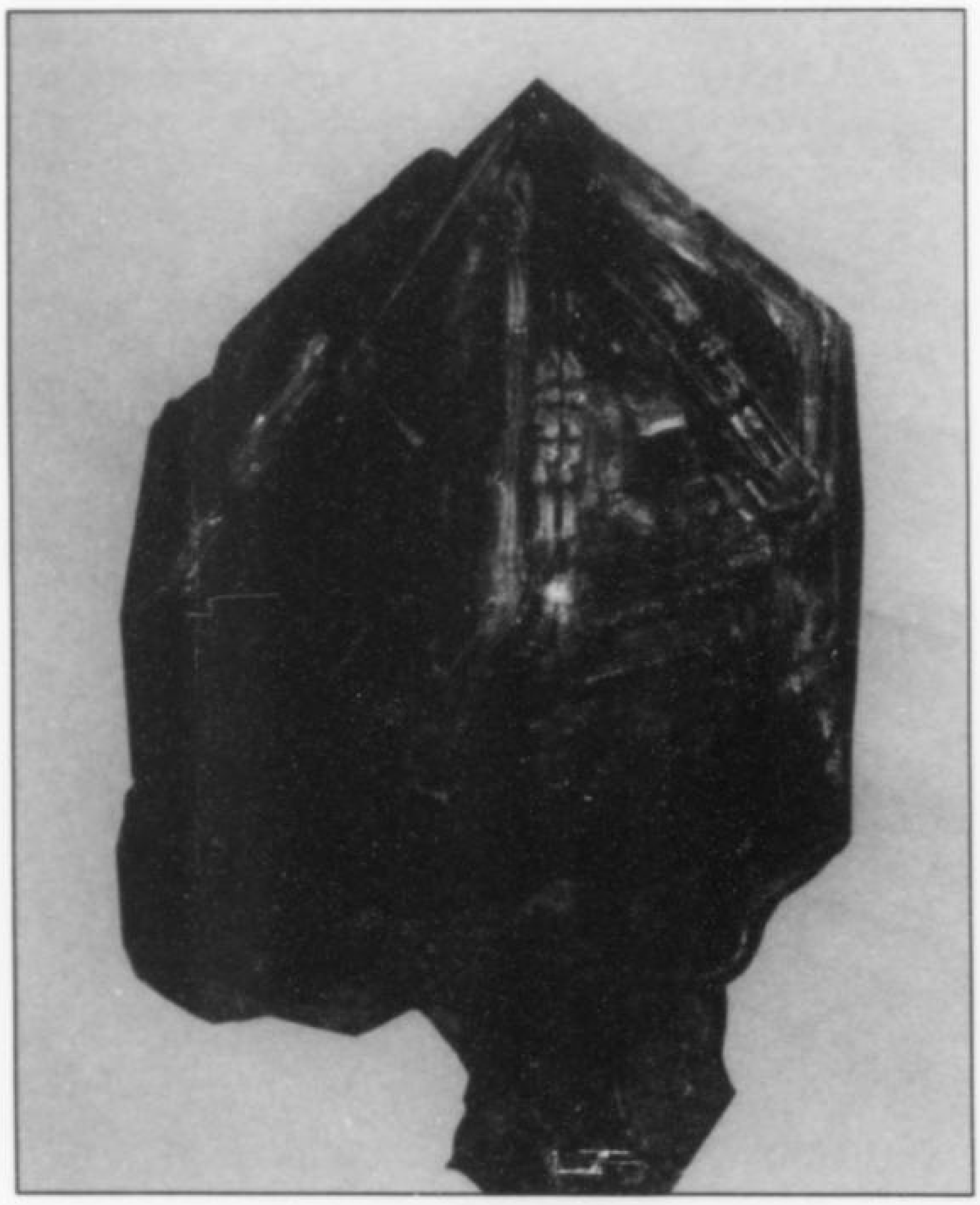


***Figure 12.* Large smoky quartz crystal with clay inclusions, about 20 cm, from the Rist mine. Gilbert Wooten collection and photo.**

Quartz SiO_2

Attractive quartz crystals ranging from colorless to milky, smoky, rose, amethystine and reddish (from inclusions) have been recovered from the veins. Some crystals enclose blocky white albite crystals, and have thereby protected them from weathering and conversion to clays.

Scepter growth is common, the scepter tips often being amethystine or milky and the shafts clear. Large rutile crystals (to several mm thick and over 2 cm long) can occur in association.

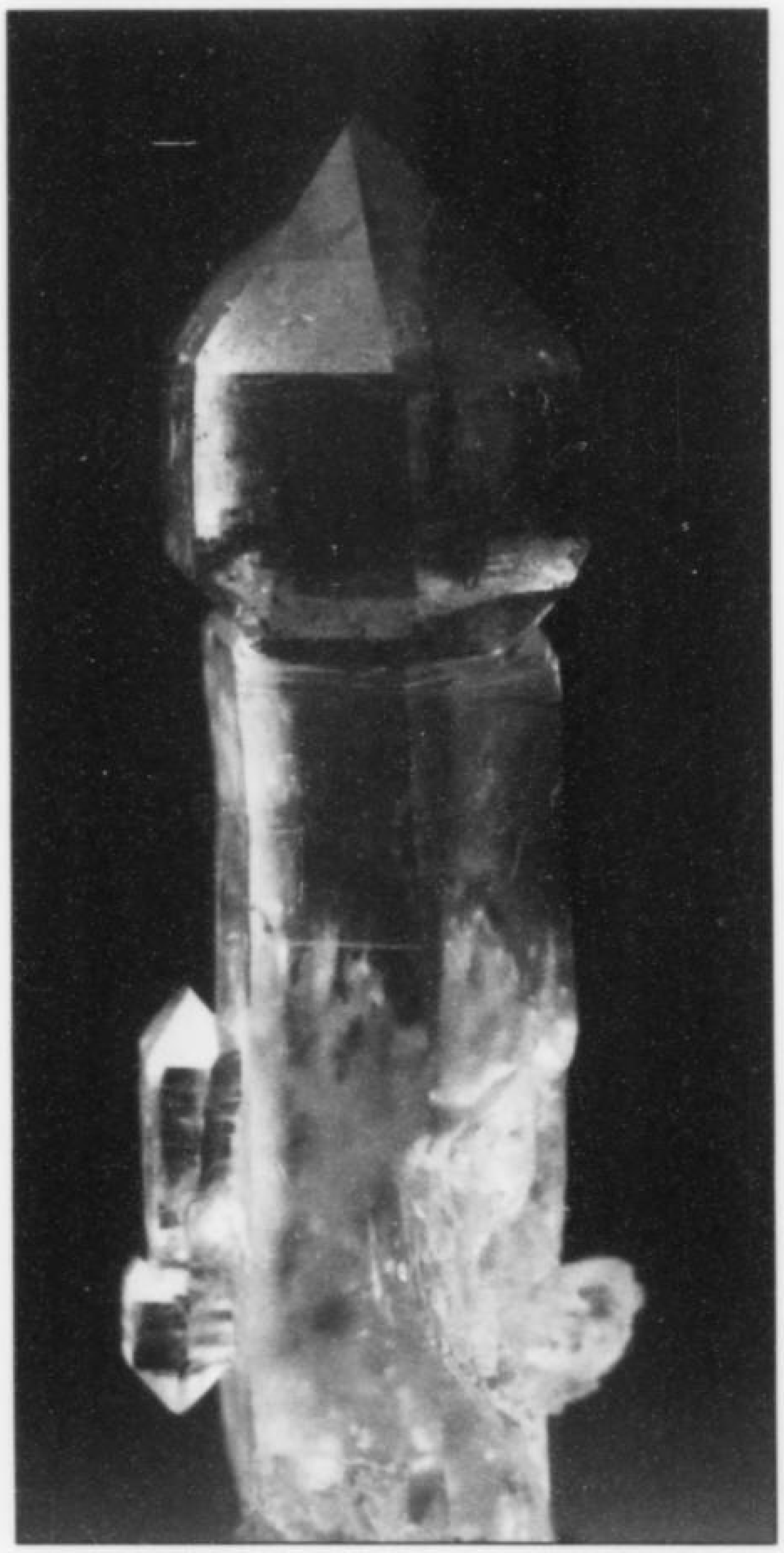


***Figure 13.* Amethyst scepter, 1.1 cm, from the Rist mine. Gilbert Wooten collection; Wendell Wilson photo.**

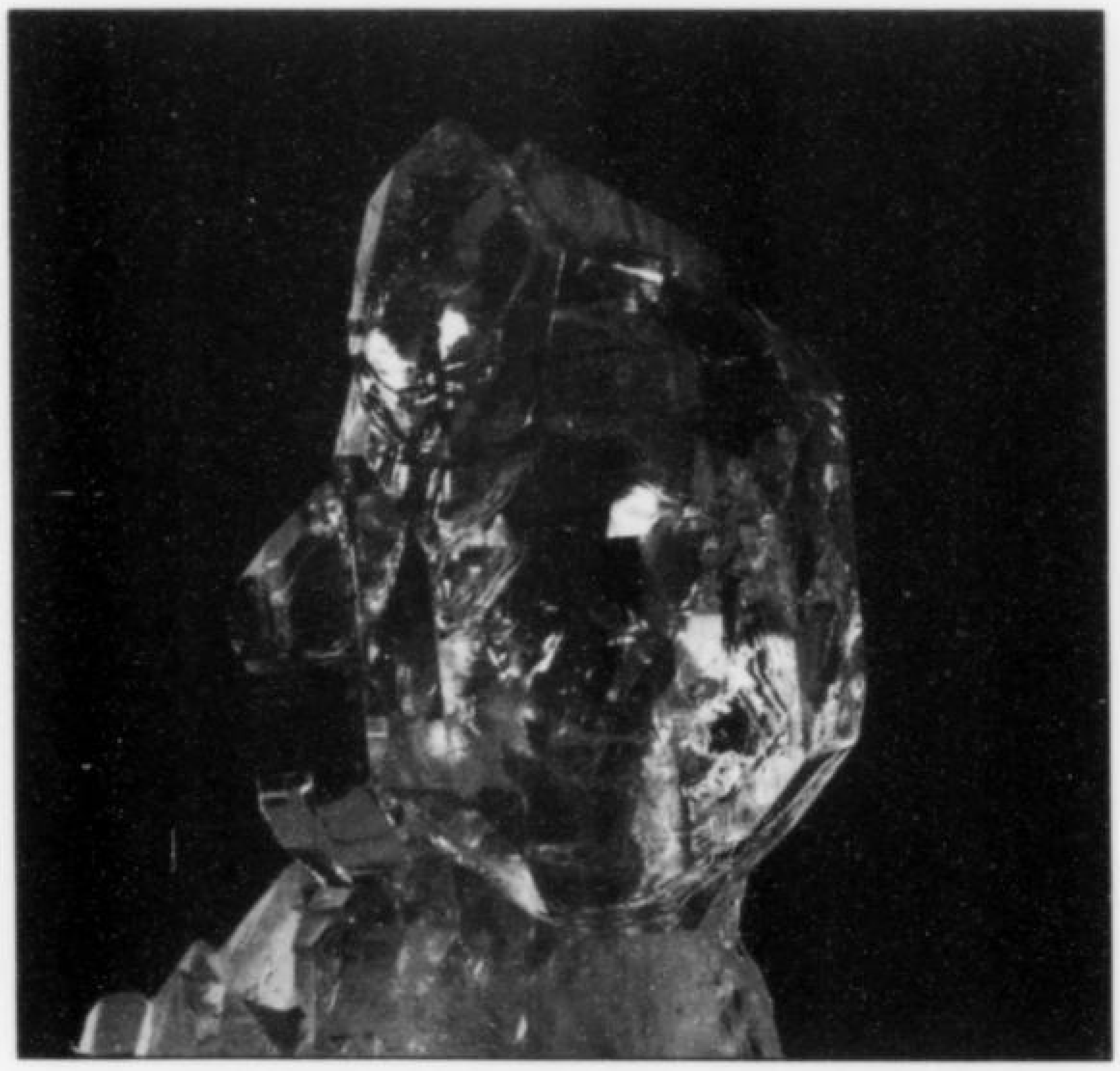


***Figure 14.* Amethyst scepter, 2.4 cm, from the Rist mine. Gilbert Wooten collection; Wendell Wilson photo.**

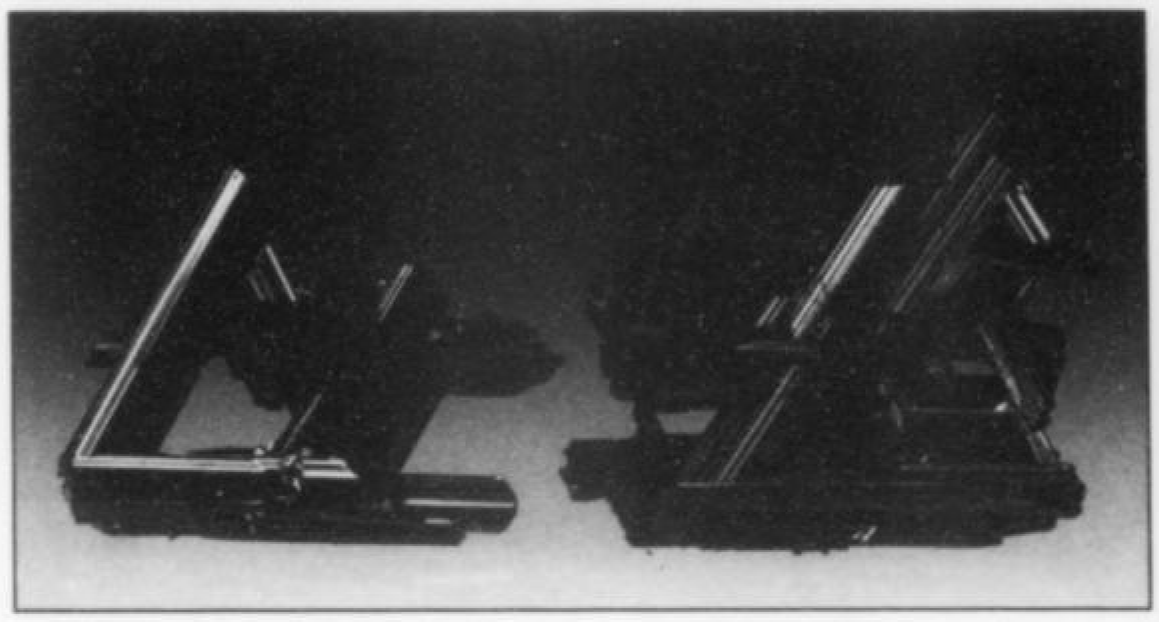


Figure 15. Reticulated rutile crystals to 1.3 cm, from the Rist mine. Gilbert Wooten collection; Wendell Wilson photo.

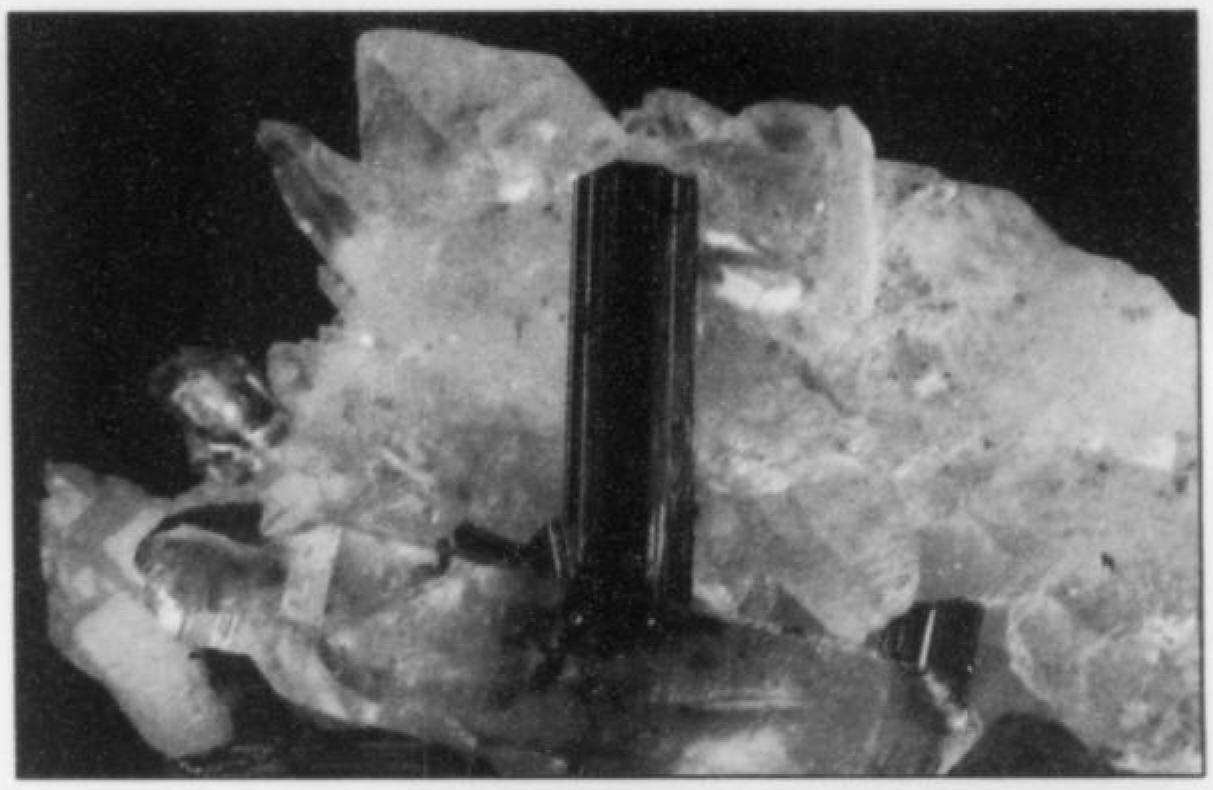


Figure 16. Gemmy red rutile crystal, 1.3 cm, on quartz, from the Rist mine. Gilbert Wooten collection; Wendell Wilson photo.

Figure 17. Large, twinned rutile crystal, 3.6 cm, from the Rist mine. Gilbert Wooten collection; Wendell Wilson photo.

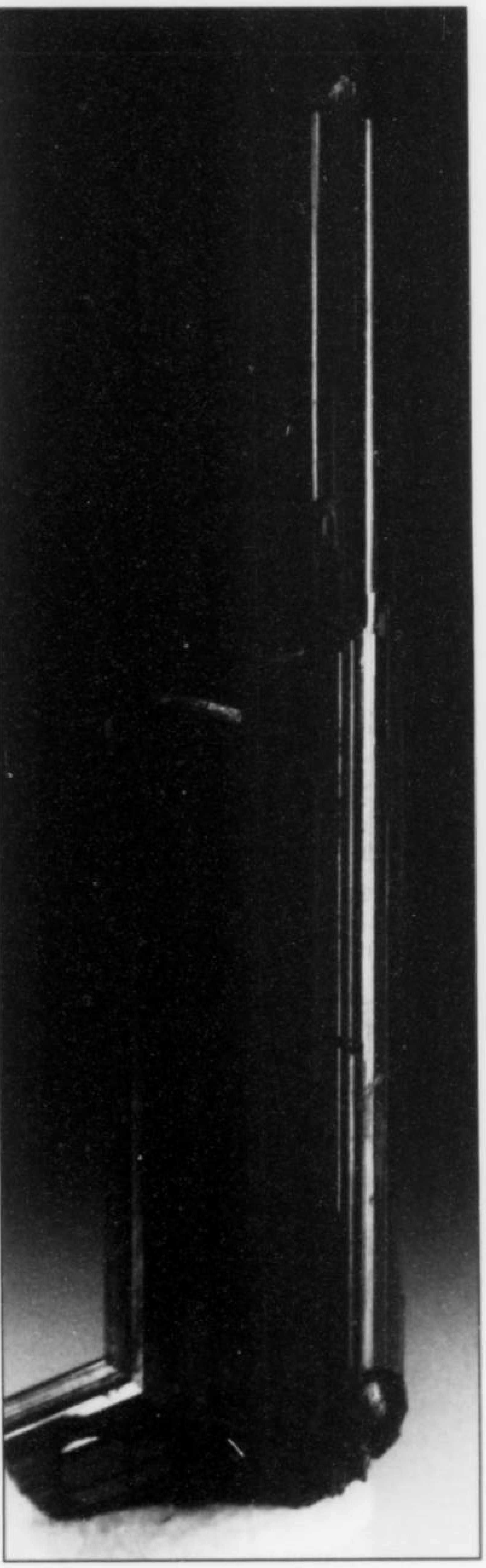
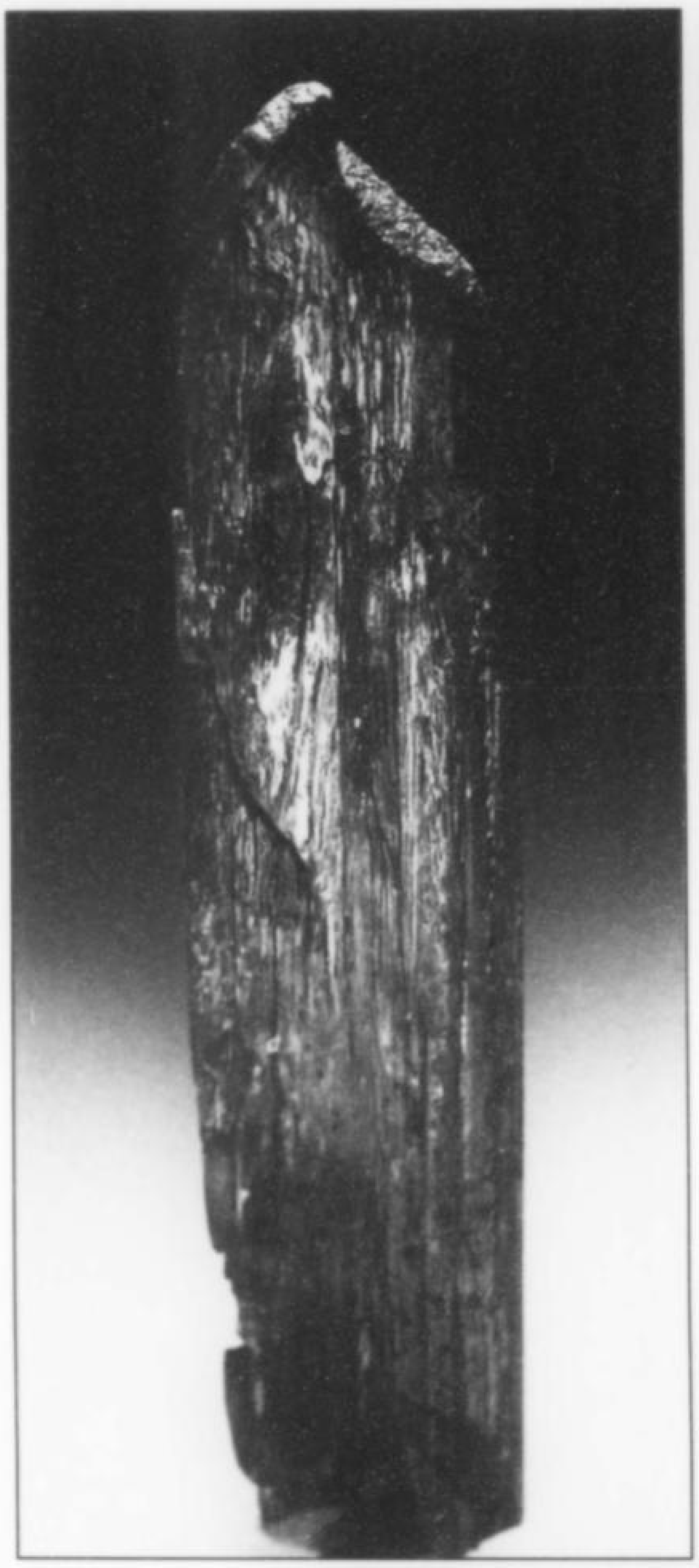


Figure 18. Black schorl crystals to 3 cm from the Rist mine. Gilbert Wooten collection; Wendell Wilson photo.



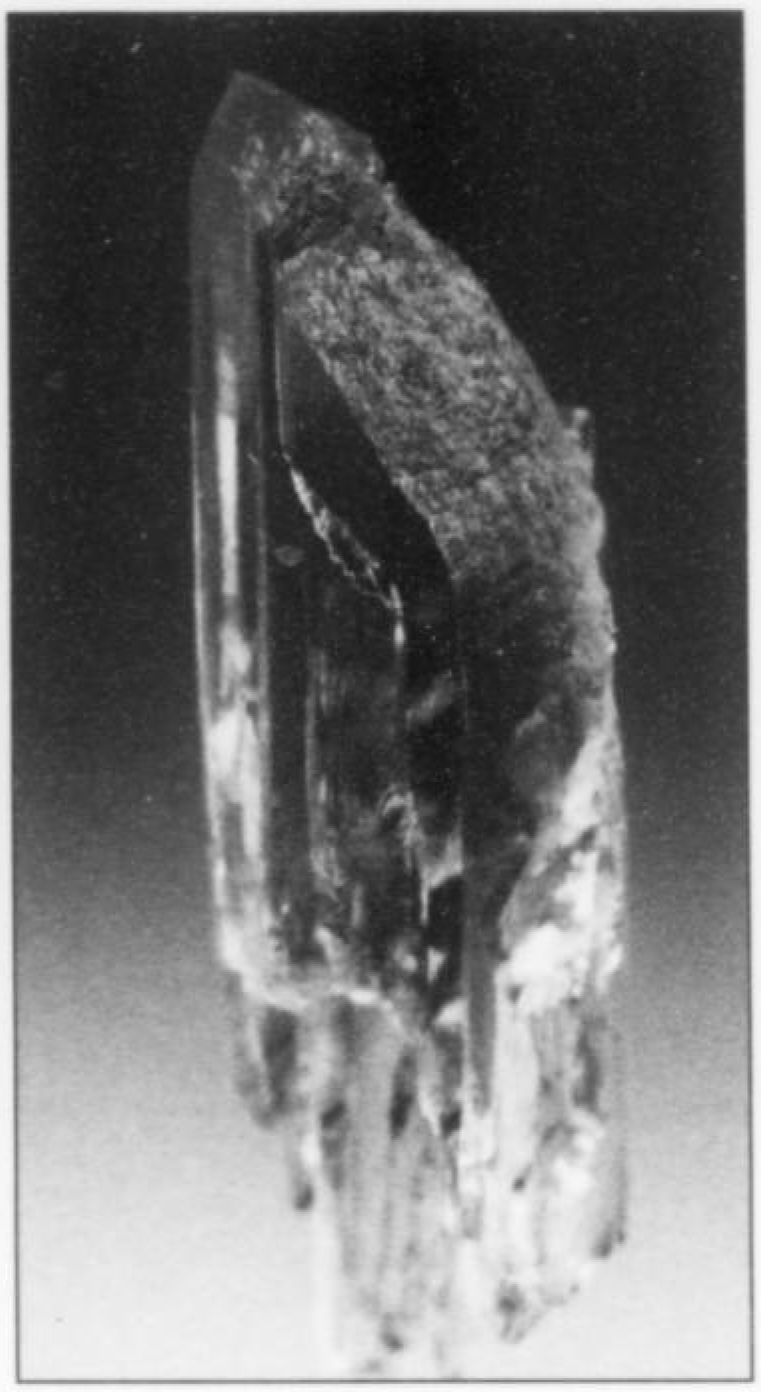


Figure 21. **Green spodumene crystals ("hiddenite") to 2.1 cm, from the Rist mine. Gilbert Wooten collection; Wendell Wilson photo.**

Figure 19. **Green spodumene crystal ("hiddenite"), 7 cm, from the Warren farm in the Hiddenite area. Harvard collection; Wendell Wilson photo.**

Schorl $NaFe^{2+}_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$

Sharp and lustrous crystals of an opaque, jet-black tourmaline, presumably schorl, have been found up to 3 cm or so in length and nearly a centimeter in diameter. They are bounded by striated prism faces capped by the first-order trigonal rhombohedron, with traces of a second order rhombohedron modifying some edges. The overall appearance is remarkably similar to that of neptunite from San Benito County, California. Very dark green tourmaline has also been observed, which may be elbaite or some other tourmaline species.

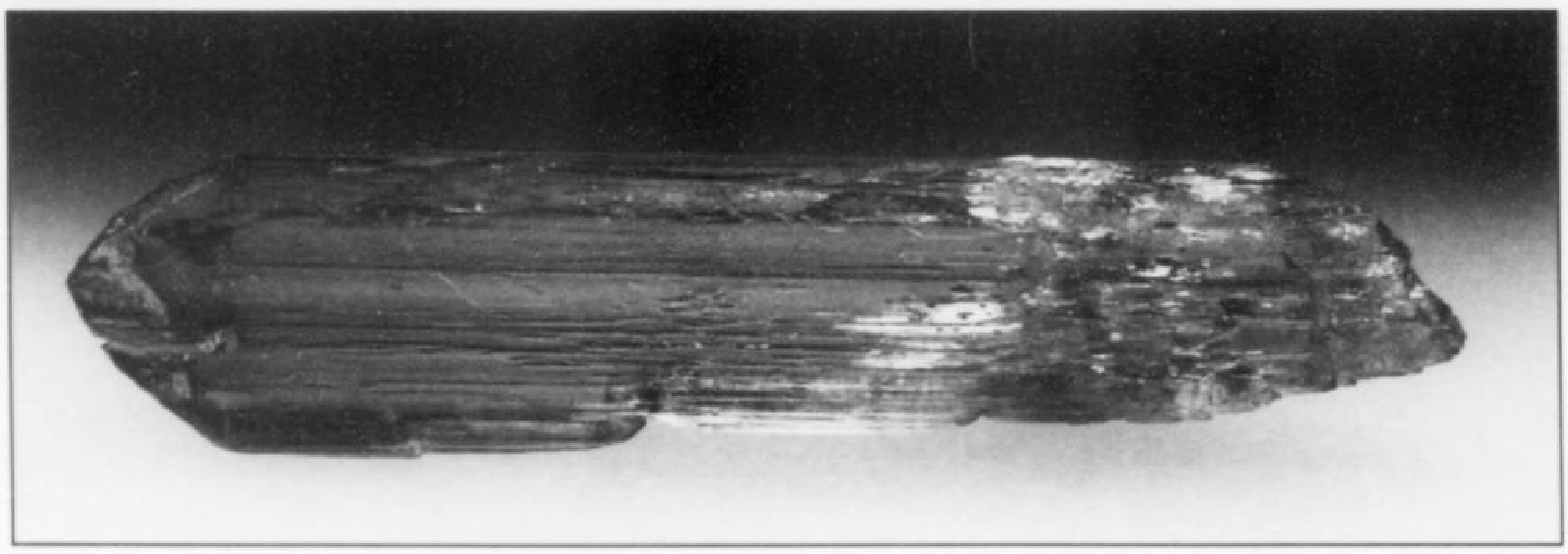


Figure 20. (right) **Green spodumene crystal, 4.8 cm, from the Warren farm in the Hiddenite area. William Larson collection; Wendell Wilson photo.**

Exceptionally large crystals enclosing clay zones and weighing up to 6 kg have also been encountered.

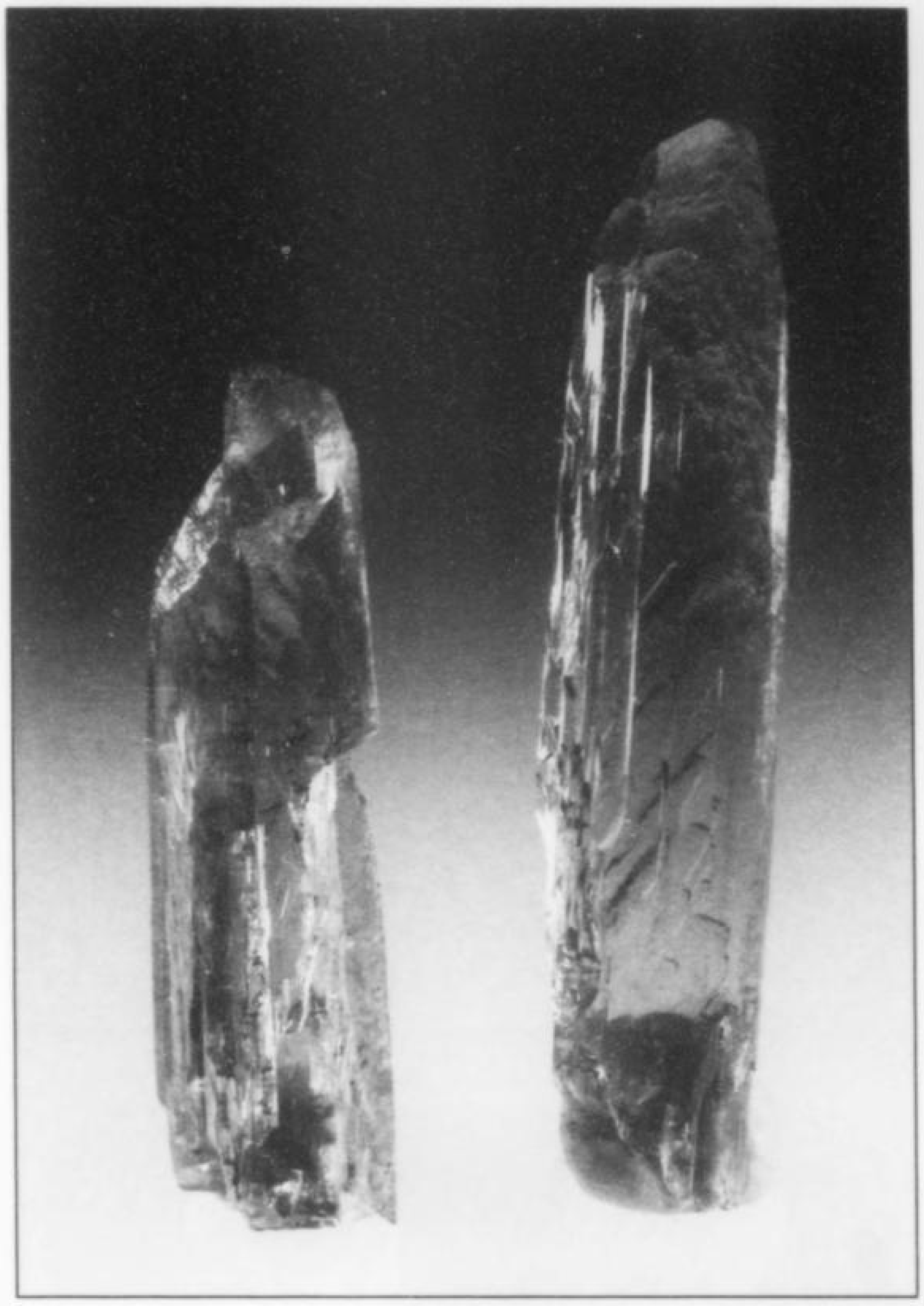
Rutile TiO_2

A substantial number of attractive reticulated rutile thumbnails have been found, most of them under 2 cm in size. The crystals are prismatic and generally 1 to 4 mm thick, with deep red internal reflections. Some crystals have been recovered on quartz crystals; others occur in contact with emerald and monazite-(Ce). Sheets of reticulated rutile sometimes penetrate emerald crystals and facilitate fractures through those zones.

Spodumene $LiAlSi_2O_6$

Spodumene colored green by chromium has been given the varietal gem name "hiddenite," after William E. Hidden. So much of it has been found in this area of North Carolina that the town of Hiddenite was named after the mineral variety.

Crystals are commonly gemmy and elongated, usually etched heavily, and have a termination consisting of rounded corrosion surfaces. Good crystals longer than 4 or 5 cm are rare. The original occurrence on the Warren farm was described in detail by Palache *et al.* (1930).



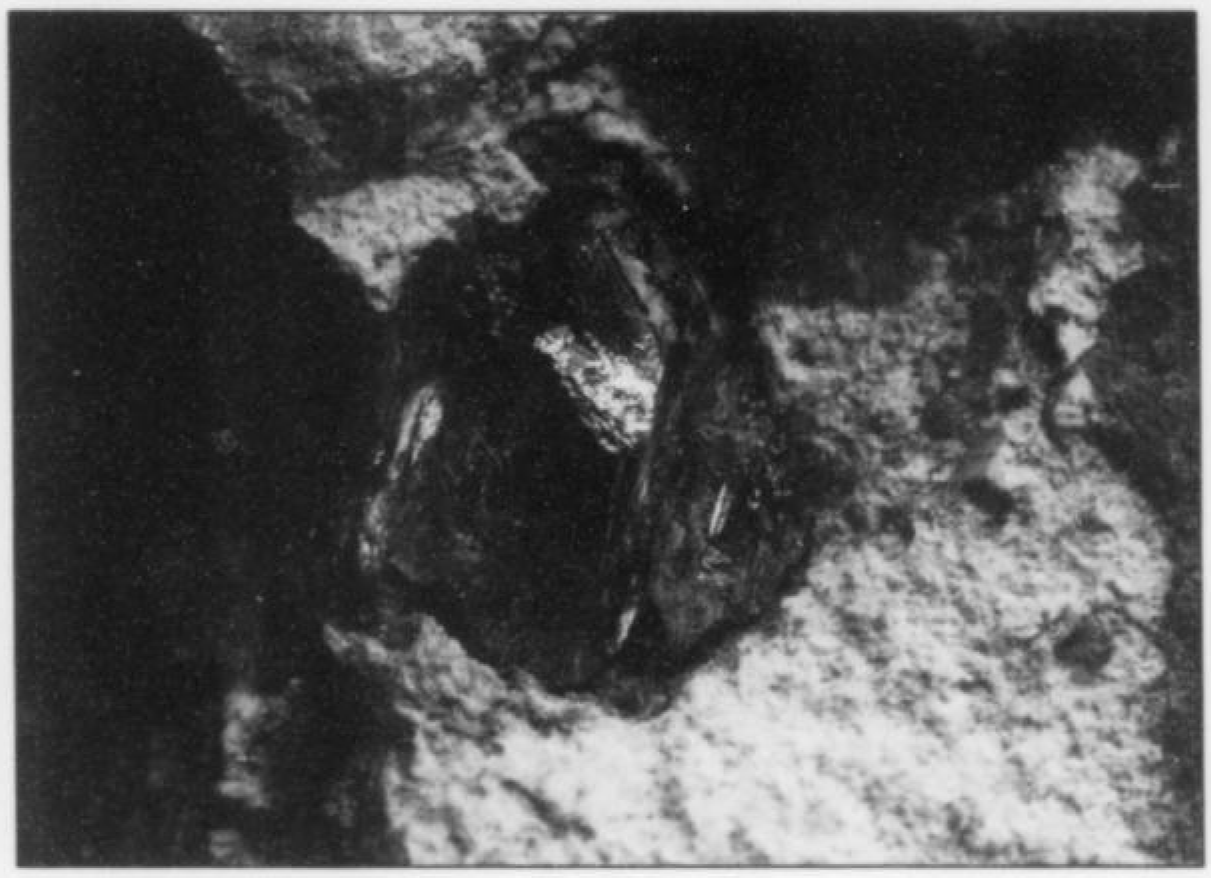


Figure 23. Green spodumene crystal ("hiddenite"), 6 mm, in matrix, from the Rist mine. Russell Elliott collection; Wendell Wilson photo.

Figure 22. Green spodumene crystal ("hiddenite"), 1.6 cm, from the Rist mine. Gilbert Wooten collection; Wendell Wilson photo.

Figure 24. Xenotime crystal, 2 mm, on quartz, from the Rist mine. Gilbert Wooten collection; Wendell Wilson photo.

Xenotime YPO_4

Small, tetragonal prisms of xenotime to a millimeter or two have been found perched on quartz crystals in the veins. The xenotime crystals are very lustrous and sharply formed, with a nondescript, greenish to brownish dark gray color and good transparency. The identification was confirmed recently by Terry Wallace at the University of Arizona, using Raman spectroscopy and xenotime standards drawn from the U. of A. collection.

CONCLUSIONS

The Hiddenite area in general, and the Rist and Ellis tracts in particular, will probably continue to yield fine emeralds and other crystallized minerals for many years to come. The scattered and concealed nature of the veins makes it unlikely that the area can ever be definitively mined out, although it is sometimes years between the finding of good, crystal-producing vein sections. As long as people want to keep digging, they will probably continue to make occasional spectacular discoveries.

ACKNOWLEDGMENTS

Our sincere thanks to Craig Rutledge and Gilbert Wooten, whose enthusiasm inspired the preparation of this article. We also wish to thank Terry Wallace, University of Arizona, for providing analyses of selected specimens.

BIBLIOGRAPHY

BROWN, D. L. (1986) The Rist and Ellis emerald properties, Alexander County, North Carolina. Unpublished report prepared for DiaEm Resources International, 30 p.

HIDDEN, W. E. (1881) Mineral discoveries in Alexander County, North Carolina. *American Journal of Science*, **21**, 159–160.

HIDDEN, W. E. (1882) The discovery of emeralds in North Carolina. *Transactions of the New York Academy of Science*, **24**, 372–374.

HIDDEN, W. E. (1883) The discovery of emeralds in North Carolina. Appendix to Precious Stones chapter in *U.S. Geological Survey, Mineral Resources of the U.S. for 1882*. p. 500–502.

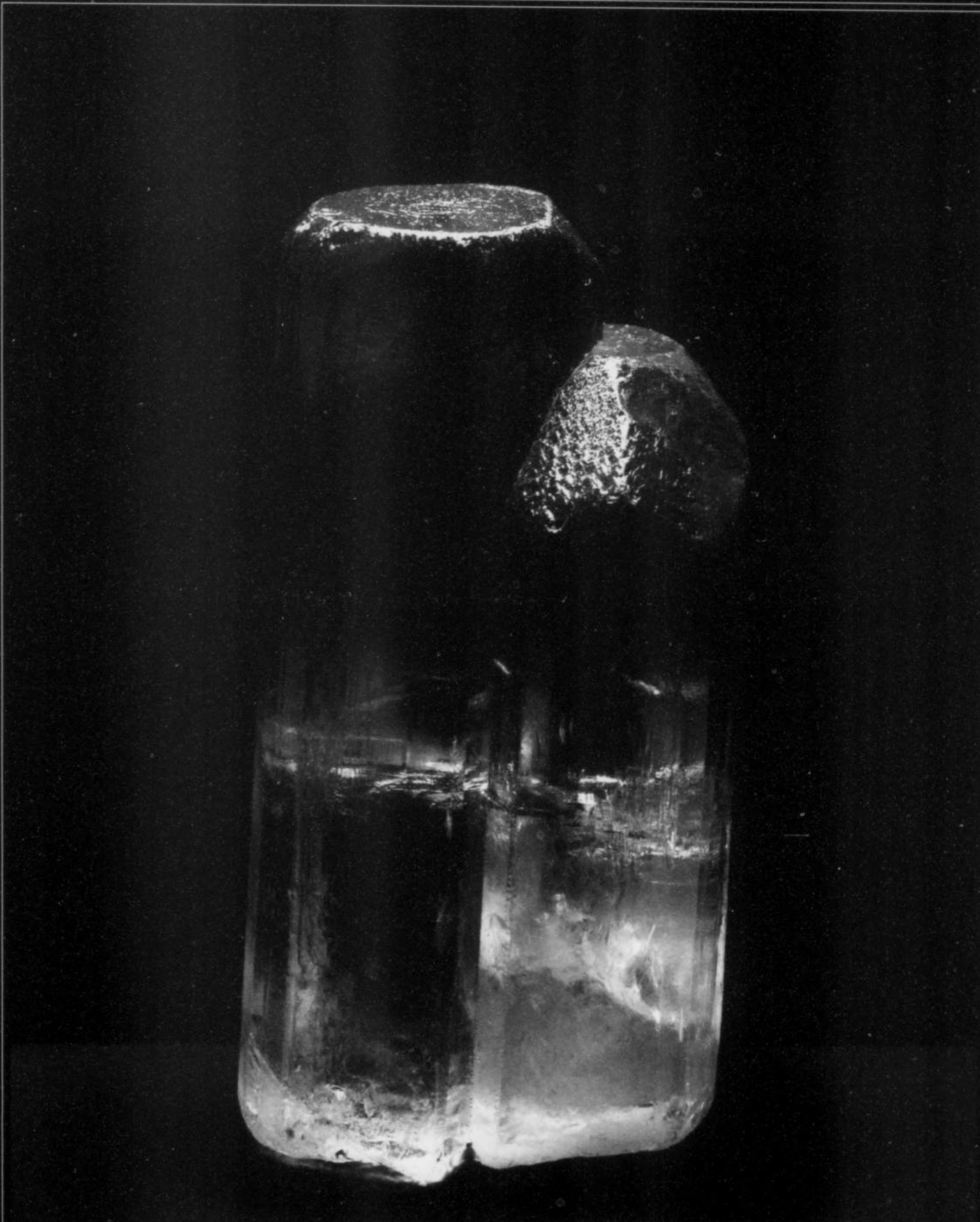
KUNZ, G. F. (1892) *Gems and Precious Stones of North America*. Scientific Publishing Company, New York, p. 87–90, 147–150.

PALACHE, C., DAVIDSON, S. C., and GORANSON, E. A. (1930) The hiddenite deposit in Alexander County, North Carolina. *American Mineralogist*, **15**, 280–302.

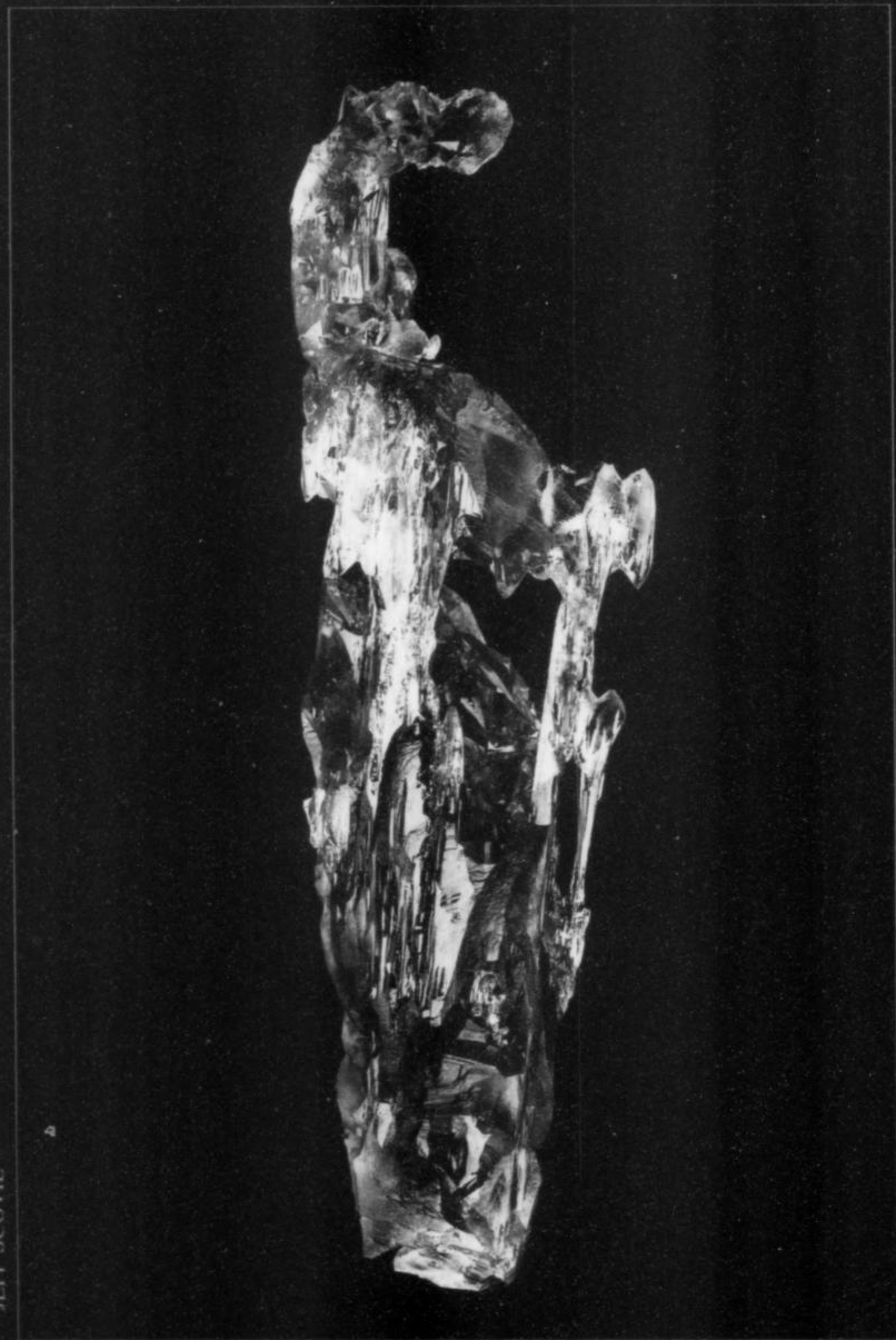
SINKANKAS, J. (1959) *Gemstones of North America*, Vol. 1. Van Nostrand Reinhold, New York, p. 75–81, 155–159.

SINKANKAS, J. (1976) *Gemstones of North America*, Vol. 2. Van Nostrand Reinhold, New York, p. 18–32, 78.

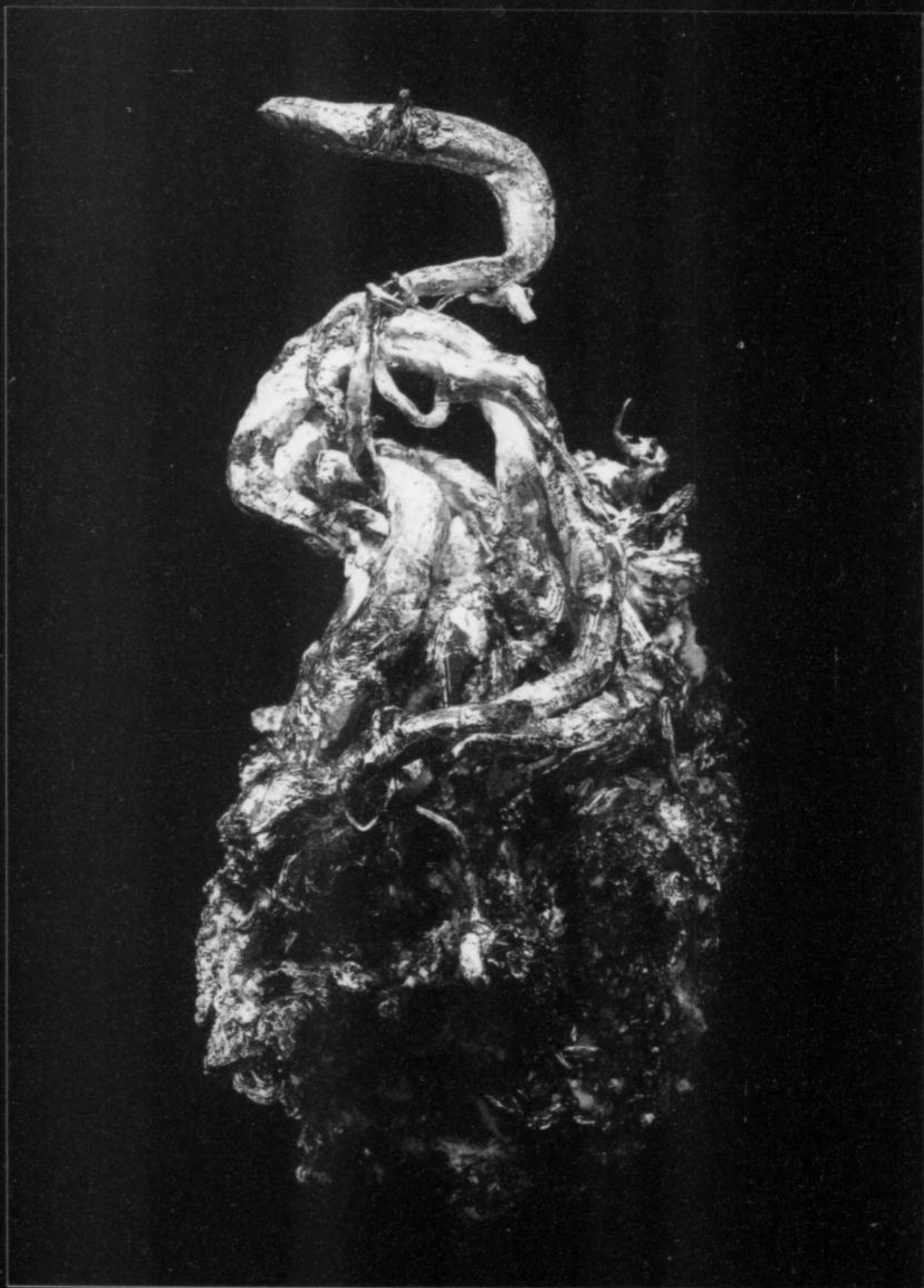
SINKANKAS, J. (1981) *Emerald and Other Beryls*. Chilton, Radnor, Pennsylvania, p. 566–570.



Beryl, 2.25 inches, from Marambaia, Brazil; from Keith Proctor, April, 1991; Illustrated in the Larousse *Encyclopedia of Precious Gems* (Bariand *et al.* 1985), *Pierres Precieuses* (Bariands, 1979), 1993 Mineral Calendar (by Nelly Bariand), *Rocks & Minerals* (Jan. 1988) and *Rock & Gem* (March, 1999).

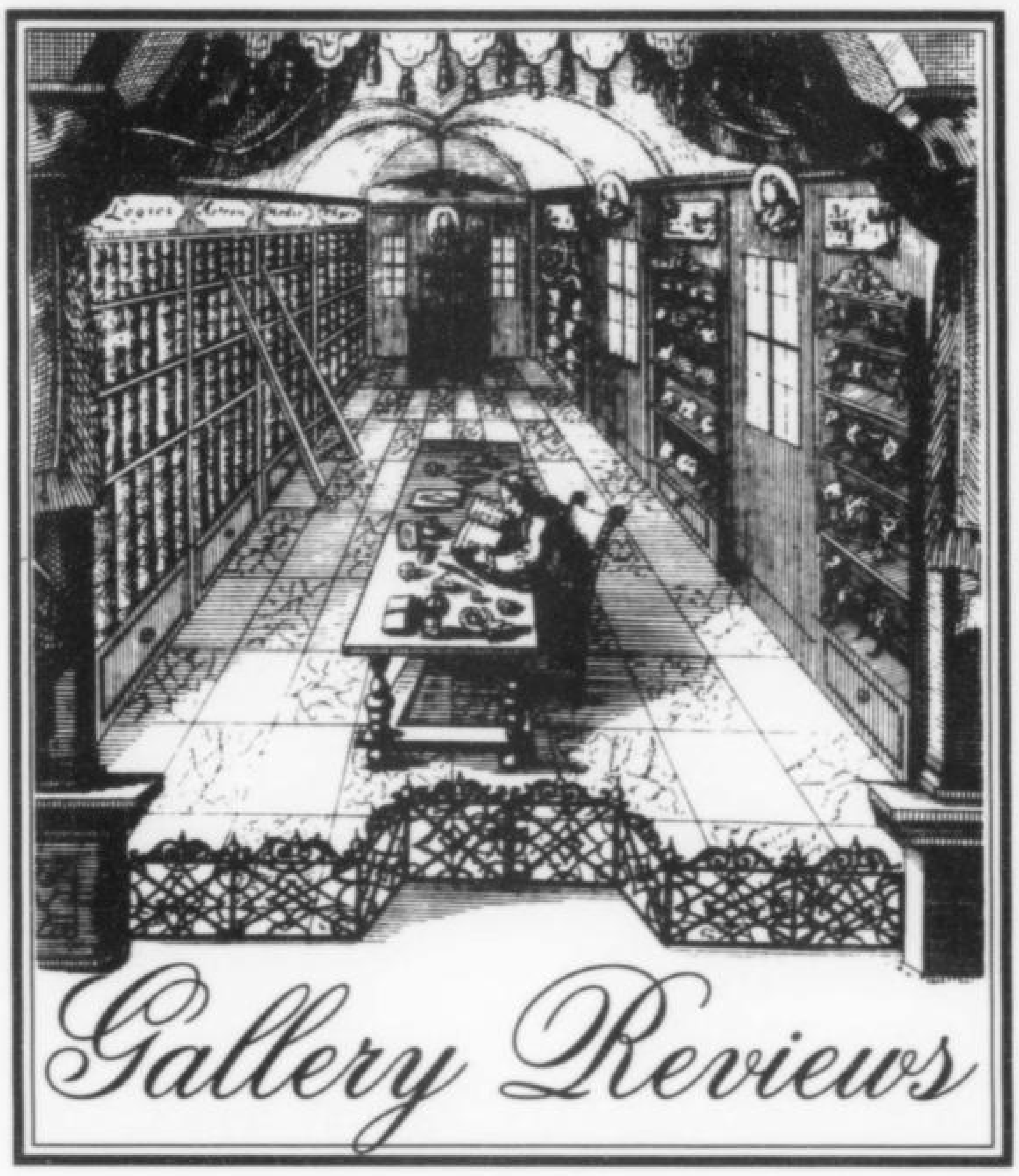


"The Ice Dragon" Aquamarine, Minas Gerais, Brazil, 22.5 cm, Acq., 1999.



JEFF SCOVIL

Silver, 15 cm, Kongsberg, Norway. Acq. 1999



The R. S. McLaughlin Mineral Hall: Royal Ontario Museum

by **John S. White**

When the planning and development of a mineral and gem display stretches out for an unreasonably long period of years such that responsibility for it passes through a succession of hands, unfortunate consequences are almost predictable. So it is with *Treasures of the Earth*, the mineral/gem portion of the new *Dynamic Earth* exhibit at the Royal Ontario Museum in Toronto, Canada. *Treasures of the Earth* is a relatively small gallery comprising perhaps only about 20% of the entire geosciences presentation. As with my other reviews, I will not attempt to describe or evaluate the geological components, but will limit my commentary to the minerals and gems section only. Just the same, it should be said that the two are altogether different in conception, implementation and certainly in overall effectiveness with, unfortunately, the geology portion coming out the big winner in all categories, and definitely worth checking out by anyone visiting the Royal Ontario Museum. In fact, the Museum's Summer 2000 in-house newsletter reports that the *Dynamic Earth* gallery "was a winner at the American Association of Museums' Twelfth Annual Exhibition Competition. The gallery was awarded one of the two top honours at the competition." One suspects that the judges didn't even glance at the mineral and gem section.

Initial planning for the galleries began around 1983, and continued over the next six years. The Mineral Hall was scheduled to open in 1989 but this target date was not met. The *S. R. Perren Gem & Gold Room* opened in 1993. A new proposal for the exhibit was drafted in 1996, projecting a gallery opening in May 1999. The 14,000-square-foot "permanent gallery" opened on May 30, 1999, having cost an estimated $4.25 million (Canadian?). Of the $4.25 million, Inco Limited, a Canadian mining and metal company, contributed $1 million; in recognition of this the new gallery has been named *Dynamic Earth: Inco Limited Gallery of Earth Sciences*. During construction, the *Perren Gem & Gold Room* (which alone had cost just over $1 million) had to be dismantled, then reassembled. Museums these days are so desperate for funding that they must "sell" major blocks of wall space advertising in order to obtain "donations" from corporations and individuals who insist that their names be prominently displayed, not only on the walls of galleries, but in every piece of literature and in every brochure describing the galleries. This is, in my judgment, an unfortunate fact of modern museum life.

FIRST IMPRESSIONS

Upon entering the mineral gallery, its open brightness and the attractiveness of the cases are pleasing, generating a sense of anticipation. What greets the visitor is a long and somewhat narrow corridor, the *R. S. McLaughlin Mineral Hall*, about 120 by 24 feet, which opens upward to skylights in an atrium some 60 feet high. The combination of daylight and case lighting is stimulating. Along and set within the left wall are a series of display cases. Aligned down the center of this corridor are four large free-standing elongated hexagonal cases. These center cases contain minerals that are grouped according to the type of natural processes that are supposed to have produced them; all are accompanied by cutesy-pie case labels, including:

"Chilling Out—Minerals from Molten Rock"
"In and Out of Hot Water—Minerals Formed by Water"
"Changing Identities—Minerals Altered by Chemical Change"
"Under Stress—Minerals Changed by Heat and Pressure"

The recessed cases along the left wall are generally topical ones as well, where mineral specimens are used to illustrate such concepts as mineral color, crystal shapes, inclusions in crystals, chemical classification of minerals, mineral casts, and so on. Halfway along, there is an interactive station with a pair of monitors offering identical programs about gemstones.

On the right side of the corridor are entrances to three rooms, one of which is labeled *Gems & Gold, the S. R. Perren Room*, and houses the gem collection. This is actually a series of four interconnected chambers which are quite dark but nicely furnished, a fitting environment for the display of gemstones plus a couple of cases of native gold. Another small room off of the main corridor, labeled *Minerals that Glow*, is the fluorescent mineral display, and a third room, *Minerals in the Making—The Inside Story*, contains five very striking Brazilian amethyst geodes mounted within the wall, and a pair of video screens which, upon pushing the appropriate button, show a quite good narrated short film about the growth of crystals, in either English or French.

Actually there is another pair of doors on the right side which open into his and hers washrooms. I mention this because between these doors and *inside* each washroom are additional exhibits which attempt to relate minerals to the materials that are used in toiletries and in constructing bathrooms. Not a bad idea. That, apart from a section of wall upon which are mounted a couple of dozen square pieces of Canadian building stones, and lots of large blocks of rocks clustered near the end of the corridor with some along either side, is pretty much it. There are also a few cases out in the immense lobby of the museum that contain some very nice specimens; these are what I call "teaser" cases as they appear designed to entice visitors to enter the gallery. Finally, there is one other additional case just off of the lobby at the entrance to the *Dynamic Earth* galleries, this containing recent acquisitions of minerals and meteorites.

THE GOOD STUFF

Unfortunately, the easier part of this review will be describing the happier aspects of the gallery, because there are relatively few

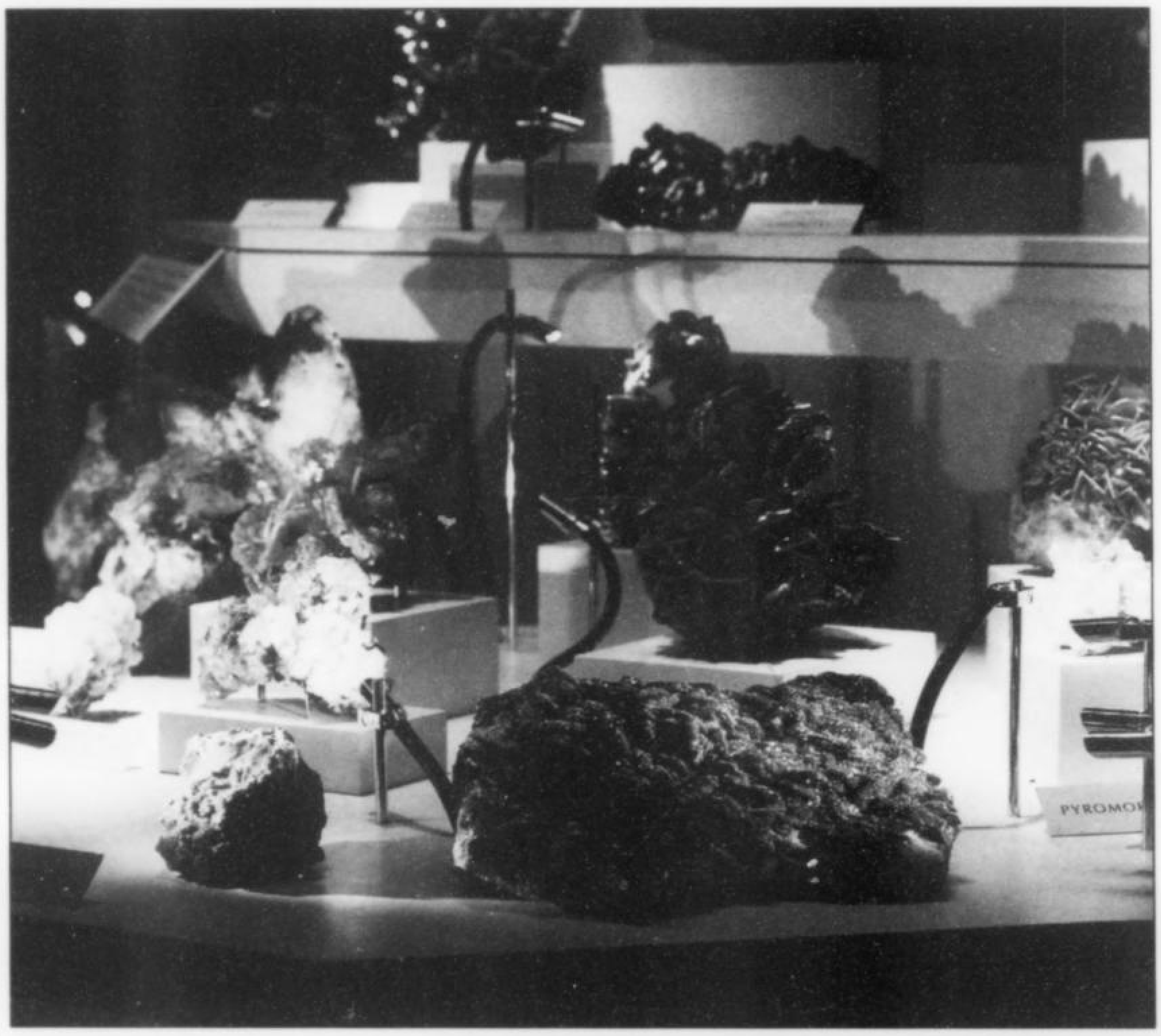


Figure 1. (left) **"Lustrous Lead," and *Figure 2. (below)* "Colours of Copper," two sections of the "Changing Identity" case. Note the total absence of labels for many specimens and only mineral names provided for others. Photographs by Brian Boyle.**

of them. As already mentioned, the openness and brightness of the main corridor make it inviting. The dark elegance of the gems section seems to work well in displaying cut stones, especially, to advantage and this is an approach now used in many newer gem galleries. There is extensive use of fiber optics for lighting the objects, both in the older gem gallery and in the newer mineral gallery. This was done so that the cases could be more or less tightly sealed, thus minimizing the amount of dust entering them. Since the fiber-optic lights in the case do not generate heat, they do not have the diurnal alternate warming and cooling effect that tends

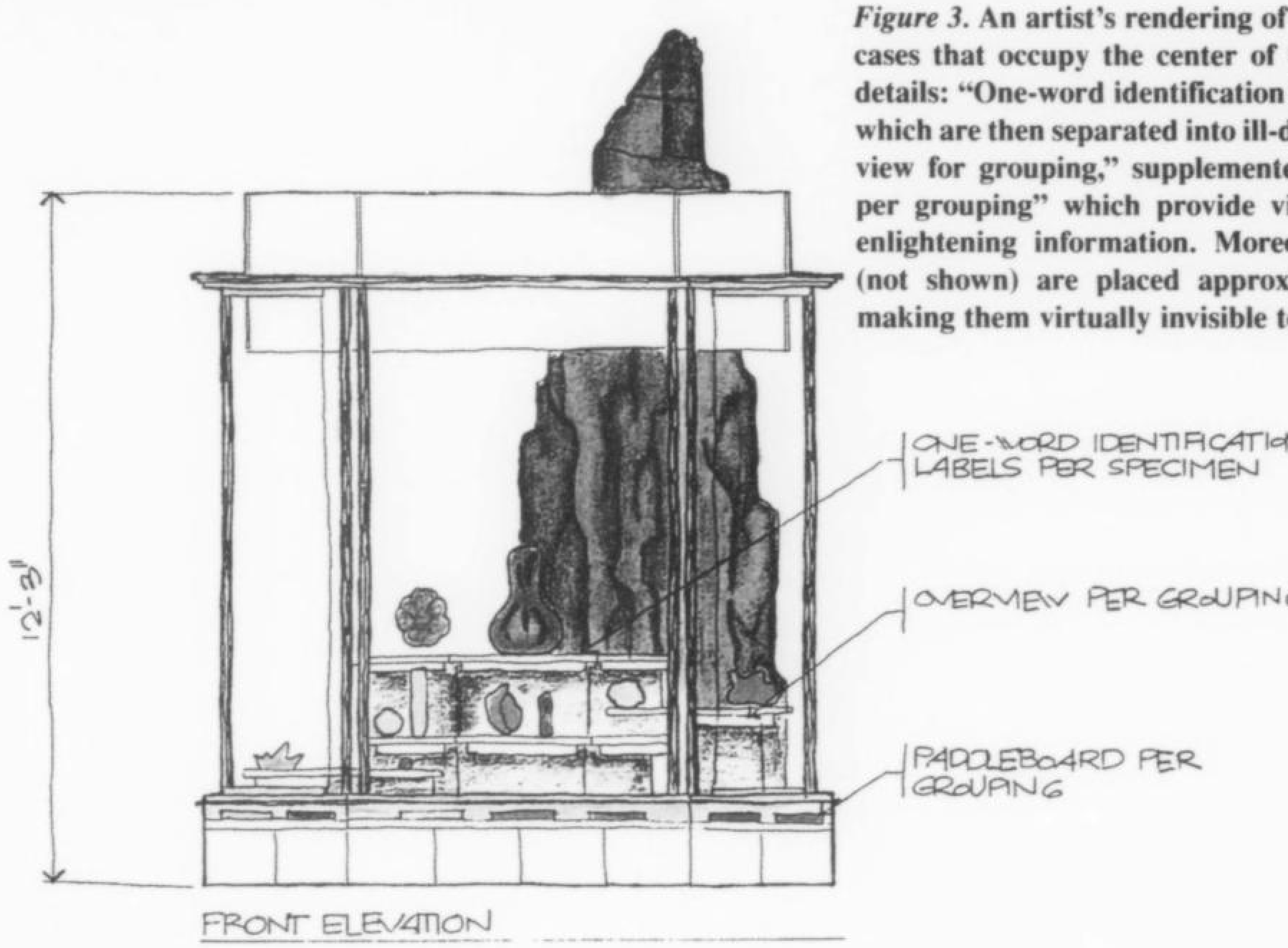


Figure 3. **An artist's rendering of one of the four main cases that occupy the center of the gallery. Note the details: "One-word identification labels for specimen," which are then separated into ill-defined groups "Overview for grouping," supplemented by "Paddleboards per grouping" which provide virtually no useful or enlightening information. Moreover, the case labels (not shown) are placed approximately 8 feet high, making them virtually invisible to most viewers.**

to suck dust into the cases. This appears to be effective, as there was very little evidence of dust in any of the cases, including the "teasers" in the lobby. Another advantage of fiber optics is that there is no light bulb replacement problem because there are no light bulbs, so the cases do not need to be opened frequently.

The exhibited collection of both minerals and gems is a very good one, with enough fine specimens to justify a visit from any serious mineral appreciator. Most are shown to advantage, sufficiently lit to allow one to fully appreciate them. While there are quite a lot of fine specimens from Canada, I expected more and was a little surprised that the representation isn't a lot stronger. By contrast, I have never seen so many fine large amethyst geodes displayed in one museum. There is one large "teaser" case full of them, plus those already mentioned in a side room off of the main gallery. Also, I have never visited a museum where there are so many hands-on specimens. It seems these are scattered about everywhere, and it is clear that children, in particular, really enjoy being able to make direct contact with them, and even crawl all over many of them.

Placing the fluorescent minerals off in a separate room is always a good idea because it minimizes distracting reflections from other cases and it makes the display more effective. One feels more of an aura of mystery upon entering a very dark room like this, which adds to the impact. Here there are two cases of fluorescent minerals all glowing beautifully under ultraviolet light. Upon pressing a hard-to-find button, one of the cases becomes bathed in incandescent light, completely overpowering and washing out the fluorescence. These lights remain on until the button is released. Since no timers are involved, it isn't necessary to wait through a timed cycle, thus allowing visitors to study the minerals under both forms of light as long as they care to. This might be a bit of a problem if the hall were crowded, but it wasn't.

NOT SO GOOD STUFF

There are serious problems with this gallery, from one end to the other. One of them, however, overrides all of the others, and that is the woeful inadequacy of the labeling. I would have to give failing marks in virtually all categories of labeling, but the complete absence of labels in far too many instances is inexcusable. Other label problems include their often being in shadow, some are too high to even be noticed, others are not near enough to the specimens they relate to and, with many, the type size is too small for labels that are far back in the cases, making them very difficult to read.

It is impossible to understand how the absence of labels for so many specimens could have come about. Not only is there virtually nothing about mineral chemistry, there simply are no labels at all for many specimens in many cases! An excuse is that more labeling was to have been included on what are called "paddleboards," which are laminated cards which slip into slots at the base of many of the center cases. Unfortunately, the museum never quite got around to putting this information on the paddleboards. The trivial amount of text that now appears on these boards is so inconsequential that they could be removed altogether and wouldn't be missed. For example, one paddleboard is entitled "Colours of Copper," yet there is nothing on it about the colors of copper. Instead it cites Tsumeb and Bisbee as important copper mines. I visited the gallery for many hours altogether over three days and recall seeing only one person actually lift *and read* one of the paddleboards. I accosted that person and learned that she is a school teacher preparing a lesson plan for her class' upcoming visit to the gallery. A few other visitors lifted a board, glanced at it, and dropped it back into place. Additionally, I could find no signs anywhere in the gallery urging visitors to use the paddleboards.

It might be instructive to examine the entire package critically, beginning with the teaser cases in the main reception hall. These are very large cases with mostly very large and dramatic specimens, mostly adequately lighted. Unaccountable label problems crop up here, however. A wonderful sulfur's label does not say Italy, and another specimen is labeled Tasmania, without Australia being included. A manganite is from Ilefeld [*sic*], Germany. There are labels for nephrite without it being identified as a jade, and rock crystal without it being identified as quartz. These are classic and unfortunate missed opportunities to impart a little learning, but the

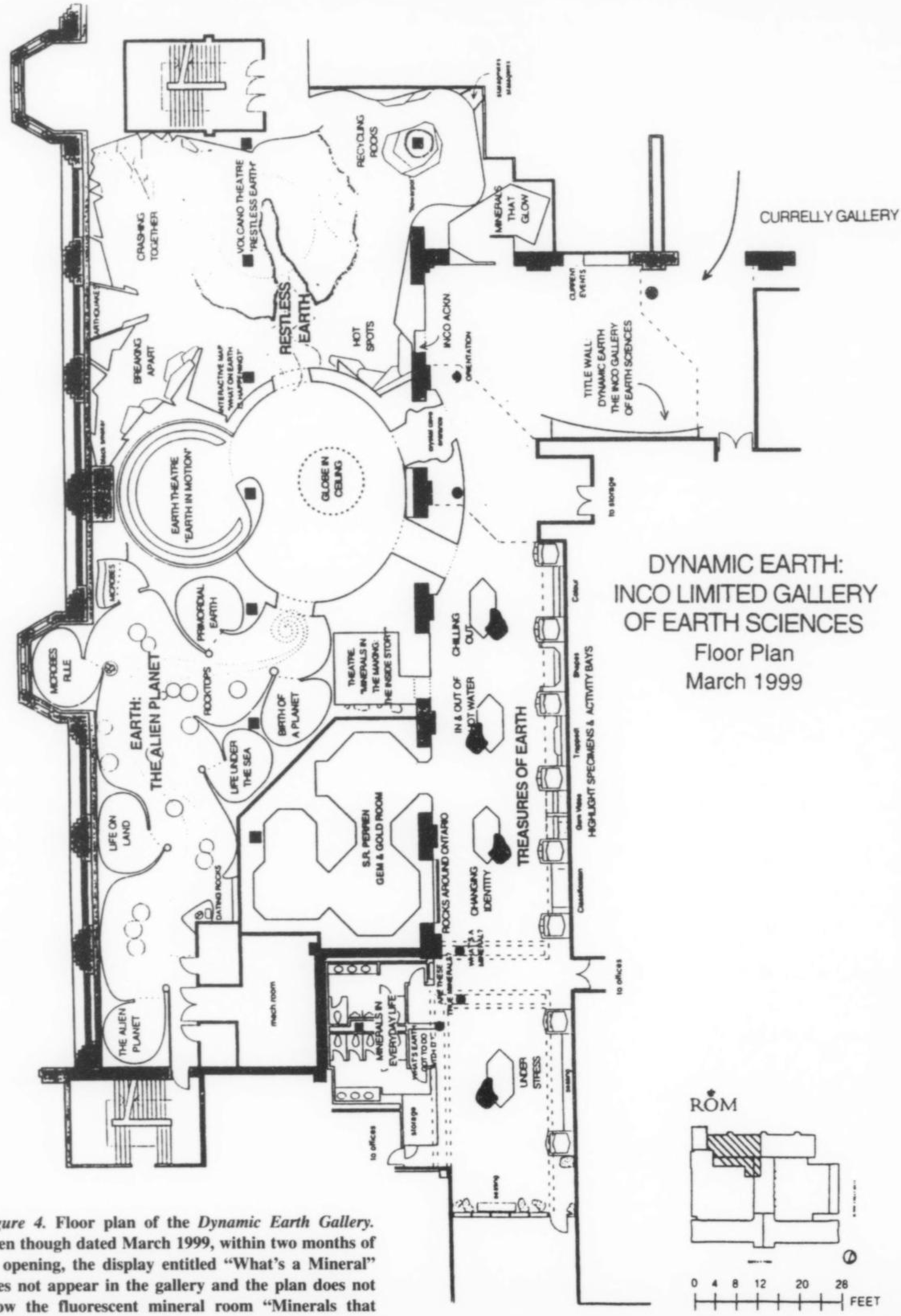


Figure 4. **Floor plan of the *Dynamic Earth Gallery.* Even though dated March 1999, within two months of its opening, the display entitled "What's a Mineral" does not appear in the gallery and the plan does not show the fluorescent mineral room "Minerals that Glow."**

most interesting missed opportunity occurred in the case that contains a wonderful big cleavage of phlogopite. I happened to be standing near this case on two different occasions when family groups approached. In each instance the father (I assume) announced something like "Look at that piece of mica!" Then, when they read the label which identified the specimen only as phlogopite and not a mica, an apology was made along the lines of "Guess I am wrong, it isn't mica." What a terrible unintended consequence.

The next case encountered as one approaches the main gallery is a recent acquisitions case, which sits off to the side and is not particularly well-lit, but then the specimens aren't all that wonderful anyway. Is this the best that the museum can do for new acquisitions?

Upon entering the main gallery things don't get much better. The case labels for the four island cases down the center of the corridor are about 8 feet high and tend to be unseen altogether. The case titles are often grossly misleading. For example, the third case is titled "Changing Identities—Minerals Altered by Chemical Change." The minerals in the case are perfectly fresh; they don't appear altered at all. A better title would have been "Minerals Formed by the Alteration of Other Minerals." The fourth case, "Minerals Changed by Heat and Pressure," should probably have been called "Minerals *Formed* by Heat and Pressure." Most of the specimens in the case show no evidence of having "changed." This division of minerals into those of igneous origin, aqueous origin, chemical changes and metamorphism is forced and unrealistic, especially in light of the absence of explanatory text. In the first case, there are numerous specimens that crystallized from aqueous solutions, not from magma, and in the second case there are those that formed from vapor, not water. The Indian zeolites are in a case which attributes their origin to crystallization from water, yet the Mont St. Hilaire zeolite mineral analcime crystallized from magma!

There are many other problems within the cases as well. Agate is not identified as being a form of quartz. The gypsums are labeled "from the sea," both within the case and on the paddleboard, yet the specimens are mainly from metal mines and amethyst geode localities, not from sedimentary rocks that formed in the sea, and the paddleboard contains photos of metal mines. What association with the sea is illustrated here? There is one group label with two sentences about iron mines, but since there is no chemistry on the specimen labels, what is the visitor to relate this to? Another group label carries text about Mn, Cd, Co and Ni, but the nearby minerals are not identified as containing any of these metals. There is a paddleboard describing erythrite, annabergite and manganite as products of "mixed metals," but without any explanation of what that means, and I am not sure which metals are mixed in manganite.

Along the left wall, the topical cases are better although the messages are not always clear, the sample selection not always supportive of the messages, and the type often too tiny to be readable. The two interactive touch-screen monitors contain identical programs, all about gemstones. These were popular with the few visitors, but one had broken down by Sunday. If such facilities are deemed worthy of inclusion in a museum, I feel that they should be used to help visitors better understand the mineral specimens, not to impart rudimentary gemological lore.

The *S. R. Perren Gem & Gold Room,* of an earlier vintage, fares better although instead of paddleboards the designers elected to slip booklets into slots at the bases of the cases. These were to contain information to supplement the meager information on the labels. Two problems: (1) The design calls for only one book at each station, so multiple visitors must share them, wait for them, or pass them by altogether. And (2) the booklets were missing; they had been removed.

Even though fiber optics is used quite successfully throughout the gem exhibit, lighting is uneven and a number of gems would benefit from more light. Few localities are given for the gems (perhaps these are in the missing booklets?), and the gem labels often do not line up suitably with the gems they relate to. Still, the gem collection is an excellent one and, for the most part, is effectively displayed. The adjoining gold collection is also excellent, but a bit too dark for my taste. Gold looks its best in bright light.

Just a few more comments. There are, mercifully, just a few mechanical exhibit devices used to interpret some optical properties of minerals and these, while I was there at least, were more popular as toys for unsupervised children who did their best to try to destroy them by spinning them as fast as they were able. The "Minerals in the Making" alcove contains five impressive large amethyst geodes set in the wall, and offers a superb short film in English or French to support the topic. One problem is that the two screens are positioned at 45 degrees to each other so that one reflects upon the other, very distracting.

To reiterate, this gallery suffers from three major and related deficiencies: a severe lack of adequate labels, the reliance on paddleboards which could never work effectively even if they contained worthwhile and meaningful information, and an overall organization of the minerals in the center cases that is so inadequately interpreted and arbitrary that it is worse than meaningless, it is confusing to all but a small percent of the visitors. Ironically all of these problems are easily correctable just by redoing the four main cases and doctoring up some of the others. The expense would be nominal, the investment of time more substantial. The paddleboards and the booklets ought to be put in the nearest dumpster.

SOME JUSTIFICATION?

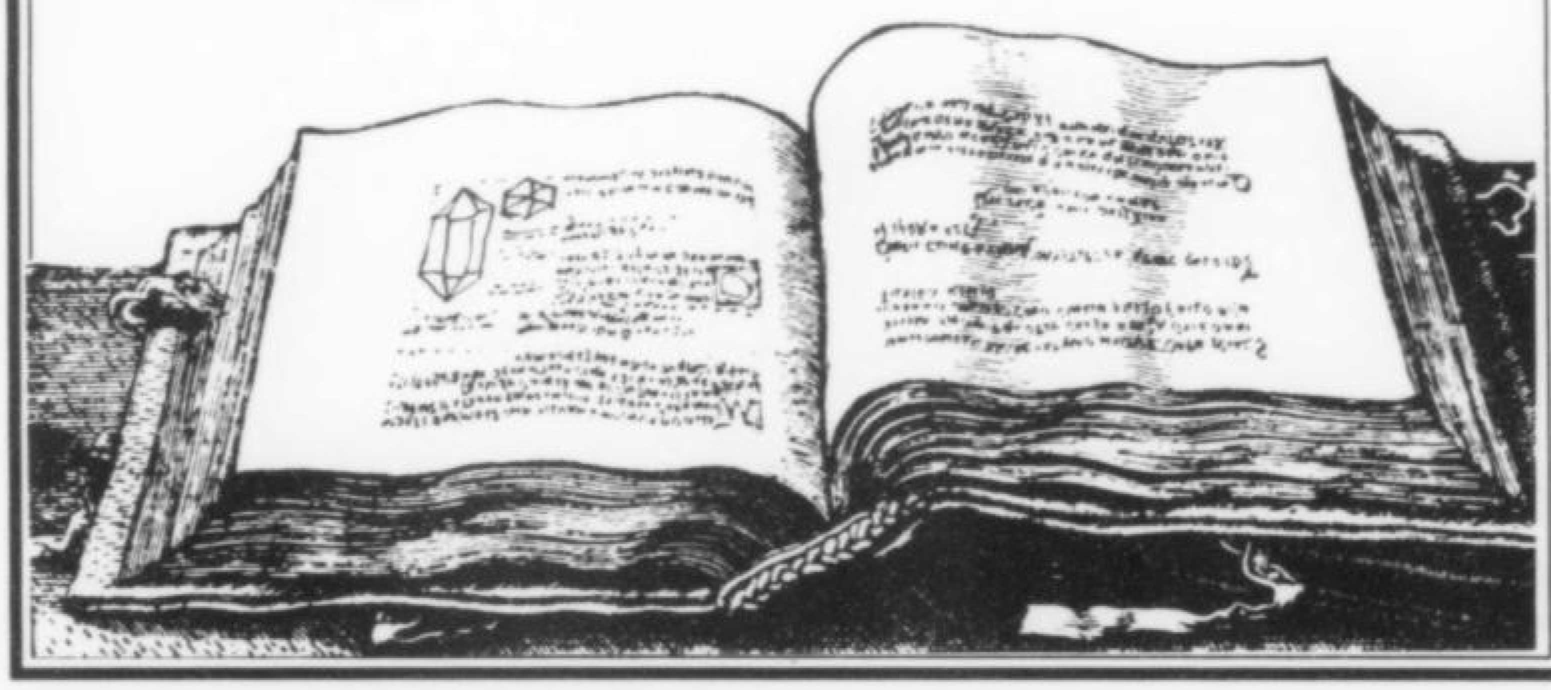
There were at least two conditions forced upon the museum staff which may have foredoomed the success of the mineral gallery. One was a dictate from the director that the text be "dumbed down" to about fifth grade level. For this reason, I assume, the people responsible for the educational content of this hall barely threw it a bone. For example, there is not even an attempt made to define what a mineral is.

Another curse is the bilingualism that Canada allows to be forced upon so many of its governmental productions. The amount of space given over to labels of all kinds is minimal in this hall, but what there is is reduced by half because virtually everything is repeated both in English and French, no matter how obvious the translation. I was told that this was a decision made by the museum, which is a provincial one rather than a national one, and that they were not forced to do this by law.

In closing I should also report that the attendance in the mineral gallery was very light on all three days when I was there (a very nice Friday, Saturday and Sunday in June), seldom more than three or four people in the gallery at one time. This may be due to the very stiff prices charged for admission: adults $12, students $7, and children $6. For a family of four this represents a sizeable investment. I listened in on the comments of one of the museum guides and was surprised to observe that no mention was made of the meanings of the four dominant cases, and even the paddleboards were ignored altogether.

[*Editor's Note:* Interested in reading more reviews of mineral galleries? Look up Peter Leavens' review of the then-new mineral hall in the American Museum of Natural History, New York, in vol. 8, no. 1, p. 28–31 (1977).]

Book Reviews



Minéralogie du Massif du Mont-Blanc

published (1999) as Hors Série V *by* Le Règne Minéral, *L. D. Bayle editor, 1 bis, rue du Piat—43120 Monistrol-sur-Loire, France. Softcover, magazine-format, 21 x 30 cm, 78 pages, $18 plus $3 postage (Visa accepted).*

This beautiful special issue produced by *Le Règne Minéral* magazine is devoted entirely to Mont Blanc, and is highly enjoyable even if one lacks a reading knowledge of French. (Most chapters carry a brief summary in English.) The 180 color photos of superb specimens, mostly pink fluorite and smoky quartz (including gwindels), are worth the price alone.

The issue begins with an introductory discussion about continental drift and the formation of the Alps, peppered with beautiful specimen photos as well as geologic maps and cross-sections. The next section goes into more detail regarding the complex geology of the Alps, with many photos of rugged alpine scenery. This is followed by a chapter discussing the paragenesis of alpine fissures and smoky quartz.

Following the technical background chapters comes an interesting section on the history of mineral collecting at Mont Blanc, with brief biographical data on nine of the most famous field collectors, from Pierre Simond (ca. 1720–1781) to Daniel LaGarde (1948–1999). There is even a little section on local slang terms which is easily understandable (e.g., "Libre = se dit d'un spécimen flottant" . . . a "floater specimen"). Following in the same vein, the next chapter is a biographical sketch of Roger Fournier (1939–1976), the well-known Chamonix mountain climber, guide and collector who died at the age of 37 during a climb, and left behind a superb collection that is still preserved.

Back to mineralogy, the next chapter deals with the topographical mineralogy of the Swiss portion of Mont Blanc, covering 170 species (about 50 of which are aesthetically or scientifically significant). Included is a substantial bibliography and a table showing which environments (skarns, quartz veins, barite veins, Pb-Zn veins, gold veins, etc.) host which minerals. This is followed by an article on the quartz of Mont Blanc, and an important article attempting to explain the cause of gwindel formation (based on Dauphiné twinning and pyroelectrically accelerated growth!).

The issue concludes with articles on the fluorite of Mont Blanc (with dazzling photos), blue beryls of l'Aiguille des Charmoz, a mineralogical inventory arranged alphabetically (by species, with photos), the Argentière Glacier, an interview with Chamonix field-collector Dominique Feray, and an essay, "Réflexions d'une femme de cristallier," by Catherine Feray of Chamonix.

There is a distinct resemblance in this issue (acknowledged by editor Bayle) to the *Mineralogical Record*'s Sweet Home Mine Issue. It is an enjoyable mix of science, history, collecting and beautiful photography. Compliments are due the photographers (L. D. Bayle, Jeff Scovil, E. Moy, B. Poty, J. Von Raumer, S. Ansermet, N. Messier, M. Weibel, A. Bouez, W. Péraud, B. Cochet, C. J. Ducarre, R. Vernay, F. hans, D. Feray and G. Monistier) and the authors (Laurent Gautron, J. C. Goujou, J. Von Raumer, B. Poty, M. Cathelineau, Eric Asselborn, N. Meisser, G. C. Parodi, B. Rondeau, B. Cochet, G. Monistier and C. Feray).

Wendell E. Wilson

Museums, Their History & Their Use

by David Murray. First published in Glasgow in 1904, now reprinted (2000) by Pober Publishing, 35 Stratford Road, Staten Island, NY 10301. Hardcover, three volumes in two, printed on acid-free paper and smythe-sewn, 1057 pages total. ISBN: 1-891396-04-8. Price: $150 plus shipping. (Fax orders: 718-816-9779)

David Murray's classic work on museums is a fascinating though very scarce reference today; thanks to publisher Steven Pober it is now available once again. The new edition carries a new introduction by Paula Findlen of Stanford University (a museologist in her own right), and the entire original text in sharp facsimile reprint. Volume I is the chapterized history of museums from the earliest times, and volumes II and III contain a massive, unique, 700-page catalog of thousands of museums, arranged alphabetically by city. Each museum entry in the catalog lists bibliographical references to published descriptions of the collections, plus, in many cases, paragraphs on the types of items in the collections and the stature of the collections in general, biographical notes on the founders of the collections, and sometimes even the amount of money realized when now-gone collections were sold at auction.

This work is a treasure-trove of highly compact data (over 1000 pages of it!) useful to any student of the history of collecting and museums. In view of the high quality of paper, printing and binding, the price is perfectly reasonable for such a basic reference.

Wendell E. Wilson

Rudabánya *(continued from p. 126)*

Silver Ag

Native silver may have been more common in the early silver mining periods, but it is very rarely encountered at present in the siderite ores of the primary belt, and in the galena associated with the barite veins in the Vilmos and Polyánka sections of the mine. Silver occurs in small fissures as millimeter-size flakes and granular aggregates, and very rarely as random masses and bundles up to 6 mm in diameter, consisting of thin, bent and twisted wires and tufts. The silver is usually covered by minute, acicular acanthite crystals (Szakáll and Kovács, 1995). Silver also occurs as dendritic aggregates 2–3 mm across with malachite and iodargyrite, and with acanthite and mercury under malachite crusts on cuprite crystals in the Andrássy I section.

Skinnerite Cu_3SbS_3

The occurrence of skinnerite is extremely rare in cavities of the spongy siderite ore in the Andrássy III mine section. It is found as submetallic, opaque, gray to brownish gray, tabular crystals to 1 mm across. Skinnerite is closely associated with chalcostibite and chalcocite. Skinnerite crystals are commonly coated with a thin layer of malachite.

Slavíkite $NaMg_2Fe_5^{3+}(SO_4)_7(OH)_6 \cdot 33H_2O$

A very rare secondary mineral found in old workings of the Andrássy III section, slavíkite occurs as yellowish green, hexagonal tabular crystals up to 1 mm in diameter, associated with other sulfate minerals (Szakáll *et al.*, 1997).

Smithsonite $ZnCO_3$

Smithsonite, a relatively rare secondary mineral in the limonite ores of the Adolf and the Andrássy I sections, occurs as dull, crumbly, opaque, pale gray to beige masses up to 10 cm in diameter. It has also been found in small solution cavities in sphalerite as colorless rhombohedra up to 1 mm, and as white irregular aggregates 2-3 mm in diameter.

Sphalerite (Zn,Fe)S

Sphalerite is relatively common in the barite zones of the primary belt where it is closely associated with galena. It is found as finely dispersed, embedded, opaque, pale brown grains in barite, and as rhythmically banded zones with barite and calcite.

Starkeyite $MgSO_4 \cdot 4H_2O$

Found as a relatively common secondary mineral, starkeyite occurs as colorless to white crusts and surface coatings in old workings, commonly associated with hexahydrite (Szakáll *et al.*, 1997).

Stephanite Ag_5SbS_4

In an exceedingly rare occurrence in a barite-sulfide zone of the Vilmos section, stephanite was found as black, irregular aggregates and as twinned, pseudohexagonal crystals up to 2 mm in diameter. Associated minerals include acanthite, pyrargyrite and proustite.

Stibiconite $Sb^{3+}Sb_2^{5+}O_6(OH)$

In small fissures of the siliceous limonite in the Adolf and the Andrássy I sections, stibiconite is found as a relatively rare, late-stage alteration product of stibnite. It occurs as dull, opaque, white to yellowish white groups of divergent prismatic pseudomorphs after stibnite 1–3 mm in length.

Stibnite Sb_2S_3

Stibnite is rare at Rudabánya, found in spongy siderite ore of the Andrássy III section, and in a barite-sulfide-carbonate zone in the Polyánka section. It occurs as bright metallic, opaque, gray,

Table 1. **The minerals of Rudabánya, Hungary.**

Elements
- Bismuth
- Copper
- Gold
- Kolymite
- Mercury
- Moschellandsbergite
- Silver
- Sulfur

Sulfides
- Acanthite
- Bornite
- Boulangerite
- Bournonite
- Capgaronnite
- Chalcocite
- Chalcopyrite
- Chalcostibite
- Cinnabar
- Covellite
- Digenite
- Djurleite
- Domeykite
- Enargite
- Famatinite
- Galena
- Galenobismutite
- Geocronite
- Idaite
- Iltisite
- Marcasite
- Mawsonite
- Perroudite
- Polybasite
- Proustite
- Pyrargyrite
- Pyrite
- Realgar
- Skinnerite
- Sphalerite
- Stephanite
- Stibnite
- Tennantite
- Tetrahedrite
- Xanthoconite

Halides
- Bromargyrite
- Chlorargyrite
- Connellite
- Iodargyrite
- Paratacamite

Oxides
- Bindheimite
- Cassiterite
- Cuprite
- Goethite
- Hematite
- Hollandite
- Lepidocrocite
- Magnetite
- Partzite
- Pyrolusite
- Quartz
- Ranciéite
- Romanechite
- Stibiconite
- Tenorite
- Valentinite

Carbonates
- Ankerite
- Aragonite
- Aurichalcite
- Azurite
- Calcite
- Carbonate-cyanotrichite
- Cerussite
- Claraite
- Dolomite
- Magnesite
- Malachite
- Rosasite
- Siderite
- Smithsonite
- Zincrosasite

Sulfates
- Aluminite
- Aluminocopiapite
- Anglesite
- Anhydrite
- Antlerite
- Barite
- Botryogen
- Brochantite
- Chalcantite
- Copiapite
- Devilline
- Epsomite
- Fibroferrite
- Gypsum
- Halotrichite
- Hexahydrite
- Jarosite
- Linarite
- Magnesiocopiapite
- Melanterite
- Plumbojarosite
- Posnjakite
- Rozenite
- Serpierite
- Siderotil
- Slavíkite
- Starkeyite
- Szomolnokite
- Thenardite

Phosphates and Arsenates
- Beudantite
- Cacoxenite
- Conichalcite
- Cornubite
- Lavendulan
- Mimetite
- Olivenite
- Pyromorphite
- Vivianite

Silicates
- Clinochlore
- Glauconite
- Halloysite
- Kaolinite
- K-feldspar
- Montmorillonite
- Muscovite

Table 2. **Modes of occurrence of Rudabánya minerals.**

1 = siderite ores; 2 = barite-sulfide zones; 3 = limonite ores; 4 = spherosiderite ores; 5 = siliceous-limonite; 6 = cover & lower sediments; 7 = post-mining precipitations

Minerals	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Acanthite		x	x	x	x		
Aluminite							x
Aluminocopiapite							x
Anglesite		x	x				
Anhydrite		x					
Ankerite	x	x					
Antlerite			x				x
Aragonite			x	x	x		
Aurichalcite			x				x
Azurite		x	x	x	x		x
Barite	x	x	x	x	x	x	
Beudantite			x		x		
Bindheimite		x			x		
Bismuth		x					
Bornite	x	x	x				
Botryogen							x
Boulangerite		x					
Bournonite		x					
Brochantite		x	x			x	x
Bromargyrite					x		
Cacoxenite			x				
Calcite		x	x	x	x	x	x
Capgaronnite					x		
Carbonate-cyanotrichite			x				
Cassiterite		x					
Cerussite		x	x		x		
Chalcanthite							x
Chalcocite		x	x	x			
Chalcopyrite	x	x	x	x	x	x	
Chalcostibite				x			
Chlorargyrite			x		x		
Cinnabar	x	x	x	x	x		
Claraite							x
Clinochlore	x						
Conichalcite			x				
Connellite			x				
Copiapite						x	x
Copper			x	x	x		
Cornubite			x				
Covellite		x	x	x			
Cuprite			x	x	x		
Devilline							x
Digenite		x	x	x			
Djurleite		x					
Dolomite	x	x					
Domeykite				x			
Enargite		x		x			
Epsomite						x	x
Famatinite			x				
Fibroferrite							x
Galena		x					
Galenobismutite		x					
Geocronite		x					
Glauconite						x	
Goethite		x	x	x	x	x	x
Gold		x	x				
Gypsum			x			x	x
Halloysite			x				
Halotrichite							x
Hematite	x	x	x	x	x	x	
Hexahydrite						x	x
Hollandite			x				
Idaite		x					
Iltisite					x		
Iodargyrite					x		
Jarosite					x	x	x
Kaolinite			x			x	
K-feldspar	x	x					
Kolymite			x				
Lavendulan				x			
Lepidocrocite			x				
Linarite							x
Magnesiocopiapite							x
Magnesite						x	
Magnetite	x						
Malachite		x	x	x	x	x	x
Marcasite		x	x	x	x	x	
Mawsonite		x					
Melanterite						x	x
Mercury			x		x		
Mimetite			x		x		
Montmorillonite			x			x	
Moschellandsbergite					x		
Muscovite	x	x	x				
Olivenite			x		x		
Paratacamite			x				
Partzite				x			
Perroudite					x		
Plumbojarosite					x		
Polybasite				x			
Posnjakite		x	x				
Proustite		x		x			
Pyrargyrite		x		x			
Pyrite	x	x	x	x		x	
Pyrolusite			x				
Pyromorphite		x					
Quartz	x	x	x	x	x	x	
Ranciéite			x				
Realgar				x	x		
Romanechite			x				
Rosasite							x
Rozenite						x	x
Serpierite			x				
Siderite	x	x		x			
Siderotil							x
Silver		x	x				
Skinnerite				x			
Slavíkite							x
Smithsonite		x	x				x
Sphalerite		x					
Starkeyite							x
Stephanite		x					
Stibiconite					x		
Stibnite		x		x			
Sulfur		x					x
Szomolnokite						x	x
Tennantite		x		x	x		
Tenorite			x	x			
Tetrahedrite		x		x			
Thenardite							x
Valentinite		x					
Vivianite						x	
Xanthoconite			x		x		
Zincrosasite			x				x

prismatic crystals 2–3 mm in length, typically forming radiating, spherical aggregates. Associated minerals include cerussite, anglesite, realgar, barite, galena, mimetite, smithsonite, valentinite and bindheimite.

Sulfur S

Sulfur is a rare late-stage alteration product of various sulfides, characteristically deposited on the walls of small fractures and fissures of the oxidation zone. It occurs as 0.5–1 mm thick crystalline crusts and very rarely as vitreous, transparent, pale yellow bipyramidal crystals 1–2 mm in length, perched on the crust. Sulfur crystals are commonly coated by a very finely dispersed dusting of red cinnabar (Kertai, 1935).

Szomolnokite $Fe^{2+}SO_4 \cdot H_2O$

Associated with altered marcasite concretions in the cover sediments, szomolnokite occurs as a yellow, powdery efflorescence with rozenite (Szakáll *et al.*, 1997).

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

Tennantite is a relatively common component of the sulfide assemblages in both the siderite ores and in barite veins, occurring as crystalline masses invariably admixed with chalcopyrite and other sulfides. Some of the Rudabánya tennantite has an unusually high (up to 10%) mercury content (Nagy, 1982). Native mercury, cinnabar, moschellandsbergite, capgarronite, perroudite, iltisite and an undetermined (Hg-bearing sulfide-halide) mineral are the alteration products of tennantite.

Tenorite $Cu^{2+}O$

Tenorite is an uncommon secondary mineral in the oxidation zone. It is found as opaque, yellowish brown, earthy crusts and coatings, and as black aggregates of spheres consisting of alternating shells of limonite and tenorite. Rarely tenorite is also found as anhedral inclusions in cuprite and malachite (Koch *et al.*, 1950).

Tetrahedrite $(Cu,Fe,Ag,Zn)_{12}Sb_4S_{13}$

Tetrahedrite is relatively common at Rudabánya and some of the splendid copper minerals found in the oxidation zone are the result of its alteration. The largest concentrations of tetrahedrite are found in the barite veins in Andrássy I and II and Vilmos mine sections, where it occurs as compact masses to several cm across. Tetrahedrite is less common in the siderite ores where it is found as finely dispersed grains, and rare in siderite, occurring as bright metallic, well-formed tetrahedra, 1–2 mm.

Thenardite Na_2SO_4

Relatively rare as an efflorescence in abandoned workings, thenardite occurs as white powdery coatings and compact crusts.

Valentinite Sb_2O_3

In the barite-sulfide-carbonate zone of the Polyánka section, valentinite occurs as a late-stage secondary mineral encrusting acicular stibnite crystals. The crusts consist of translucent, yellowish white, short prismatic crystals 0.5–1.5 mm long. Other associated minerals include cerussite, mimetite, smithsonite and bindheimite.

Vivianite $Fe^{2+}_3(PO_4)_2 \cdot 8H_2O$

Vivianite has been identified from clay layers of the cover sediments where it occurs very rarely as powdery masses.

Xanthoconite Ag_3AsS_3

In galena-rich zones of the Vilmos mine section, xanthoconite is found very rarely as honey-yellow irregular aggregates up to 2 mm in diameter.

Zincrosasite $(Zn,Cu^{2+})_2(CO_3)(OH)_2$

Extremely rare in small fissures of limonite in the Andrássy I section, zincrosasite occurs as opaque, pale blue to white spheres 1–2 mm and crusts. Associated minerals include aurichalcite, brochantite, malachite, carbonate-cyanotrichite and cerussite.

Rudabánya fossils

It is rather unusual when a famous mineral locality also becomes a famous fossil locality, as is the case with Rudabánya. In 1967 Gábor Hernyák, the chief geologist of the iron ore mine, discovered a fossil-rich stratum in the Pannonian (Lower Pliocene) cover sediments at the northern edge of the open pit. Among the numerous fossils found by Hernyák were bone fragments that researchers identified as fossils of ape-like early hominids, including *Pliopitheous harnyáki* and *Rudapithecus hungaricus* respectively named after the discoverer and the locality (Kretzoi, 1975; Morbeck, 1983; Gibbons, 1992; Kordos, 2000). The *Rudapithecus* and related fossils recovered at the site appear to represent an early link in human ancestry, and have been the subject of intense study by an international group of investigators. The fossil-bearing strata also yielded fossils of numerous species of flora and fauna (Kretzoi, 1975), and Rudabánya became an important study site not only for paleoanthropologists, but also for paleozoologists and paleobotanists. The site is now covered by a protective roof, and further excavation and investigation is continuing.

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BIBLIOGRAPHY

BALÁZS, E., and SZAKÁLL, S. (1991) *Mineral Rarities of Hungary.* Published by Fine Arts Publishing House, Budapest, 37 p.

BALOGH, K., and PANTÓ, G. (1952) A Rudabányai hegység földtana. [Geology of Rudabánya Mountains] *MÁFI Évi Jelentése*, **1949**, [Hungarian Geological Institute Annual Report for 1949] 135–146. (in Hungarian)

BENKŐ, F. (1786) *Magyar Mineralogia az a' Kövek''s Értzek' Tudománya.* [Hungarian Mineralogy, or the Science of Stones and Ores.] Published at Kolozsvár, 181 p. (in Hungarian) Facsimile reprint published in 1986, Budapest.

BERNARD, J. H. (editor) (1981) *Mineralogie Československa.* [Mineralogy of Czechoslovakia.] Published by Academia, Praha 645 p. (in Czech)

BRÜCKMANN, F. E. (1727) *Magnalia dei in locis subterraneis, Oder Unterirdische Schatz-Cammer Aller Königreiche und Länder.* Published in 4 volumes in Braunschweig. Vol. 1, 383. (in German)

BRUMMER, E. (1938) Kristallisierter Schwerspat und Stilpnosiderit aus Rudabánya. [Crystallized barite and stilpnosiderite from Rudabánya.] *Földtani Közlöny,* **68**, 68–71. (in German with Hungarian abstract)

CSALAGOVITS, I. (1973a) Rudabánya környéki triász összlet geokémiai és ércgenetikai vizsgálatának eredményei. [Results of geochemical and ore genetical investigations, of a Triassic sequence in the Rudabánya area.] *MÁFI Évi Jelentese,* **1971**, 135–146. (in Hungarian with English abstract)

CSALAGOVITS, I. (1973b) Stratigraphically controlled Triassic ore mineralization. A genetic model based on Hungarian geochemical investigations. *Acta Geologica Hungarica,* **17** (1–3), 39–48.

CSALAGOVITS, I. (1974) Besazámoló jelentés a rudabánya-környéki geokémiai vizsgálatokrol. [Report on the geochemical investigation of Rudabánya region] Unpublished manuscript. Archives of the Hungarian Geological Survey (in Hungarian).

DOBOSI, K. (1978) Magyarországi aluminium-szulfátásványok mineralógiai-kristálykémiai vizsgálata. [Mineralogical and crystal-chemical study of Hungarian aluminum sulfate minerals.] Unpublished Thesis, Eötvös Loránd University, Budapest.

FETICH, N. (1937) A honfoglaló magyarság fémmüvészete. [The metalcrafting of the settling Magyars (10th century)] *Archeologica Hungarica,* **21**, 5–303 (in Hungarian).

FÜLÖP, J. (1984) *Az ásványi nyersanyagok története Magyarországon.* [The history of mineral raw-materials in Hungary.] Published by Műszaki Könyvkiadó, Budapest, 179 p. (in Hungarian)

GIBBONS, A. (1992) Hungarian fossils stir debate on ape and human origins. *Science,* **257**, 1864–1865.

GIMESI, I. M. (1994) A Kárpáti-övezet ásványainak magyar bibliográfiája. (1859–1951) [Hungarian language bibliography of minerals of the Carpathian-belt.] Published by Gold Press, Szeged, 2 vols. 318 p. and maps. (in Hungarian)

GRILL, J. (1988) A rudabányai-hegység jura formációi. [Jurassic formations of the Rudabánya Mountains]. *MÁFI Évi Jelentése 1986*, 69–103 (in Hungarian with English abstract).

GRILL, J., KOVACS, S., LESS, G., RÉTI, Zs., RÓTH, L., and SZENTPÉTERY, I. (1984) Az Aggtelek-Rudabányai hegység földtani felépitése és fejlődéstörténete. [Geological constitution and history of evolution of the Aggtelek-Rudabánya Range.] *Földtani Kutatás,* (Hungary) **27**, 49–56. (in Hungarian with English abstract)

GUCKLER, Gy. (1882) Rudabánya vidékének bányászati fejlődése. [Mining development of the Rudabánya region.] *Földtani Értesitő,* **III**, 37. (in Hungarian)

HADOBÁS, S. (1984) *Rudabánya és a Rudabányai-hegység bibliográfiája.* [Bibliography of Rudabánya and the Rudabánya Mountains.] Published in Miskolc, Hungary. 33 p. (in Hungarian)

HANÁK, P. (editor) (1988) *One Thousand Years, a Concise History of Hungary.* Published by Corvina, Budapest, 278 p.

HAHN, A. (1904) A borsodi Bányatársulat vaskőbányászatának monografiája. [Monography of iron-ore mining of the Borsod Mining Company.] *Bányászati és Kohászati Lapok,* **37**, 579–592. (in Hungarian)

HECKENAST, G. (1987) Magyarország vasércbányászata és vastermelése 1526-tól a 18. század végéig. [Hungarian iron ore mining and iron production from 1526 to the end of the 18th Century.] *Közlemények a magyarországi ásványi nyersanyagok történetéből.* **III**, 129–161 published by University of Miskolc (in Hungarian).

HECKENAST, G., NOVÁKI, Gy., VASTAGH, G., and ZOLTAY, E. (1968) A vaskohászat története Magyarországon 1400-ig. [The history of iron-metallugy in Hungary to 1400.] published by Akadémiai Kiadó, Budapest, 249p. (in Hungarian).

HERNYÁK, G. (1977) A rudabányai-hegység szerkezeti elemzése az elmúlt 20 év kutatásai alapján. [Structural analysis of the Rudabánya Mountains, based on the research of the last 20 years.] *Földtani Közlöny,* **107**, 368–374. (in Hungarian)

HERNYÁK, G., HARNOS, J., and BAROSS, G. (1968) Jelentés a rudabányai ritkafém és nyomelemvizsgálatokról. [Report on base-metals and trace-elements studies at Rudabánya]. Unpublished report. Hungarian Geological Survey Archives (in Hungarian).

HERNYÁK, G., HARNOS, J., and BAROSS, G. (1969) Földtani jelentés a rudabányai vasérebánya és annak közvetlen környékén végzett szerkezetkutató mélyfúrásokról [Geological report on the structural studies based on deep-drilling in the immediate area of the Rudabánya iron mine]. Unpublished report. Hungarian Geological Survey Archives (in Hungarian).

HIPS, K. (1969) Stratigraphic and facies evaluation of the Lower Triassic formations in the Aggtelek-Rudabánya Mountains, NE Hungary. *Acta Geologica Hungarica,* **39**, (4), 369-411.

HOFSTRA, A.H., KORPÁS, L., CSALAGOVITS, I., JOHNSON, C.A., and CHRISTIANSEN, W.D. (1999) Stable isotopic study of the Rudabánya iron mine. A carbonate-hosted siderite, barite base-metal sulfide replacement deposit. *Geologica Hungarica Series Geologica,* **24**, 295–302.

HÓMAN, B. (1921) *A magyar királyság pénzügyei és gazdaságpolitikája Károly Róbert korában.* [Financial and economic policies of the Hungarian kingdom during the reign of Charles Robert (1288–1342)] published by Budavári Tudományos Társaság, Budapest, 306 p. (In Hungarian).

HUBER, P., SZOMOR, I., and WIEDEMANN, R. (1988) Rudabánya/Ungarn, Die Mineralien der Eisenerzgrube Rudabánya. *Lapis,* **13**, (11) 11–23. (in German)

HUBER, P. and TRIEBL, R. (2000) Cuprit von Ungarn: Hervorragende Neufunde. *Lapis,* **25**, (6), 50–51 (in German).

KALITZ, N. (1957) Rudabánya őskora. [Ancient history of Rudabánya.] In Pantó *et al.* (1957), 5–6. (in Hungarian)

KERPELY, A, (1877) *Magyarország vaskövei és vasterményei.* [Iron-stones and iron products of Hungary.] Budapest, 83 p. (in Hungarian)

KERTAI, Gy. (1935) Rudabánya oxidációs zónájának új ásványai. [New minerals from the oxidation-zone of Rudabánya.] *Földtani Közlöny,* **65**, 21–30. (in Hungarian with German abstract)

KOCH, A. (1904) A Rudobánya-Szent-Andrási hegyvonulat geológiai viszonyai. [Geological conditions of the Rudobánya-Szent-András mountain range]. *Mathematikai és Természettudományi Értesitő,* **22**, 132–145 (in Hungarian).

KOCH, S. (1939) Adatok Rudabánya oxidációs övének ásványaihoz. [Data on the minerals of the oxidation-zone of Rudabánya.]

Mathematikai és Természettudományi Értesitő, **LVIII**, 868–874. (in Hungarian).

KOCH, S. (1966) *Magyarország ásványai*. [The Minerals of Hungary.] Akadémiai kiadó, Budapest, 419 p. revised and updated in 1985. 562 p. (in Hungarian)

KOCH, S., GRASSELLY, Gy., and DONÁTH, É. (1950) Magyarországi vasércelőfordulások ásványai. [Minerals of the iron-ore occurrences of Hungary.] *Acta Mineralogica-Petrographica, Szeged*, (Hungary) **IV**, 1–41. (in Hungarian)

KÖCHLIN, R. (1906) Über pyrit von Rudobánya. *Tschermaks Mineralogische und Petrologische Mitteilungen*, **25**, 527–531 (in German).

KORDOS, I. (2000) New results of Hominid research in the Carpathian Basin. *Acta Biologica Szegediensis*, **44**, 71–74.

KOVÁCS, S., LESS, Gy., PIROS, O., RÉTI, Zs. and RÓTH, L. (1989) Triassic formations of the Aggtelek-Rudabánya Mountains (North-eastern Hungary). *Acta Geologica Hungarica*, **32**, (1–2), 31–63.

KRETZOI, M. (1975) New ramapithecines and Pliopithecus from the lower Pliocene of Rudabánya in north-eastern Hungary. *Nature*, **257**, 578–581.

LESS, Gy., and SZENTPÉTERY, I. (1986) Az Aggtelek-Rudabányai-hegység földtana. [Geology of the Aggtelek-Rudabánya mountains.] Unpublished manuscript in *Hungarian Geological Institute Archives*. (in Hungarian)

MADERSPACH, L. (1876) Beschreibung der Telekes-Rudóbányaer Eisenstein Lagerstatten. *Österreichische Zeitschrift für Berg und Hüttenwesen*, **XXIV**, 72 p. (in German)

MADERSPACH, L. (1880) *Magyarország vasércfekhelyei*. [Locations of iron-ore deposits in Hungary.] Published by Királyi Természettudományi Társaság, Budapest, 78–81. (in Hungarian)

MARKOVA, E.A., CHERNITSOVA, N.M., BORODAEV, Y.S., DUBAKINA, L.S., and YUSHKO-ZAKHAROVA, O.E. (1980) The new mineral kolymite, Cu_7Hg_6. *Zapiski Vsesoyuznogo Obshehestva*. **109**, 206–211 (in Russian). Abstracted in: *American Mineralogist*, **66**, (1981) 218.

MARSIGLI, L.F. (1726) *Danubius Pannonico-mysicus, observationibus Geographicis, Astronomicis, Hydrographicis, Physicis*. Published in 6 volumes in the Hague, **Vol. III**, (in Latin with French segments).

MASON, B., MUMME, W. G., and SARP, H. (1992) Capgarronite, HgS·Ag(Cl,Br,I), a new sulfide-halide mineral from Var, France. *American Mineralogist*, **77**, 197–200.

MOLNÁR, L. (1980) *Bányászati múzeumok és kiállitóhelyek*. [Mining museums and exhibits (in Hungary)] Guidebook. 31 p. (in Hungarian)

MOLNÁR, L. (1987) 550 éve született Thurzó János, az európai hírű bányavállalkozó. [550th anniversary of the birth of Thurzó János, the renowned European mining-entrepreneur.] *Bányászati és Kohászati Lapok*, **120**, No. 4, 273–276. (in Hungarian)

MORBECK, M. E. (1979) Hominoidea postcranial remains from Rudabánya, Hungary. *American Journal of Physical Anthropology*, **50** (3), 465–466.

MORBECK, M. E. (1983) Miocene hominoid discoveries from Rudabánya, implications from the postcranial skeleton. In: Ciochon, R. L., and Corruccini, R. S. (editors) *New interpretations of ape and human ancestry*. 369–404. Plenum Press, New York, N.Y.

MORVAI, G. (1982) Rudabánya (iron and base metal ore deposit). In: *Mineral Deposits of Europe*. Published by The Mineralogical Society and Institution of Mining and Metallurgy, London. **Vol. 2**, 26–27.

MUMME, W. G., and NICKEL, E. H. (1987) Crystal structure and crystal chemistry of perroudite: A mineral from Coppin Pool, Western Australia. *American Mineralogist*, **72**, 1257–1262.

NAGY, B. (1982) A rudabányai ércesedés összehasonlító ércgenetikai vizsgalata. [Comparative metallogenic analysis of the Rudabánya ore-mineralization.] *MÁFI Évi Jelentése*, **1980**, 45–59. (in Hungarian with English abstract)

PACHTER, H. M. (1951) *Paracelsus Magic into Science*. Published by Henry Schuman, New York, N.Y. 15–24.

PÁLFY, M. (1924) A rudabányai hegység geologiai viszonyai és vaséretelepei. [Geology and iron ore deposits of the Rudabánya Mountains]. *MÁFI Évkönyve*, **26**, (2), 1–24 (in Hungarian).

PANTÓ, G. (1952) Bányaföldtani tanulmány Rudabányán és környékén. [A study of the mine-geology of Rudabánya and vicinity]. *MÁFI Évi jelentése*. **1948**, 127–135 (in Hungarian).

PANTÓ, G. (1956) A rudabányai vasércvonulat földtani felépitése. [Geological structure of the Rudabánya iron-ore range.] *MÁFI Évkönyue*, **XLIV/2**, 327–490. (in Hungarian)

PANTÓ, G. (1957) A rudabányai vasérctelep földtani leirása. [Geological description of Rudabánya iron ore deposit.] In: Pantó *et al*. (1957), 222–275. (in Hungarian)

PANTÓ, G., PODÁNYI, T., PANTÓ, E., and MOSER, K. (editors) (1957) *Rudabánya ércbányászata*. [Ore-mining of Rudabánya.] Published by Országos Magyar Bányászati es Kohászati Egyesület, Budapest, 421 p. (in Hungarian)

PAPP, F. (1933) Ércvizsgálatok hazai előfordulásokon. [Examination of ores from Hungarian occurrences.] *Földtani Közlöny*, **63**, 8–11. (in Hungarian)

PÁKOZDY, V. (1949) Chemical examination of the minerals of the tetrahedrite group. *Acta Mineralogica-Petrographica, Szeged*, (Hungary) **III**, 30–43.

PAULINYI, O. (1933) *A középkori magyar réztermetés gazdasági jelentősége*. [Economic importance of copper production in Middle ages in Hungary.] published by Sarkany-Nyomda, Budapest, (in Hungarian).

PAULINYI, O. (1977) Nemesfém-monopólium és technológia. 1325–1700. [Base metal monopoly and technology.] *MTA II. Osztály Közleményei*, **26**, 251–278 (in Hungarian).

PODÁNYI, T. (1974a) Rudabánya bányásznemzetségei. [National origin of miners at Rudabánya.] *Bányászati és Kohászati Lapok*, **107**, 208–211. (in Hungarian)

PODÁNYI, T. (1974b) Rudabánya und Telkibánya. *Der Anschnitt*, **(1974)** No. 2, 3–9. (in German)

PODÁNYI, T. (1975) A rudabányai bányászat történetének néhány emléke. [Some historical aspects of the mining history of Rudabánya.] *Bányászati és Kohászati Lapok*, **108**, 845–852. (in Hungarian)

PÓSFAI, M. (1989) Bornite from Rudabánya: an electron diffraction study. *Acta Geologica Hungarica*, **32**, 231–240.

PÓSFAI, M. (1990) Rétegződés és kationrendeződés szoros illeszkedésű szulfidásvány szerkezetekben. [Layering and cation-arrangement in the structures of closely-packed sulfide minerals.] Unpublished Ph.D. Thesis, Eötvös Loránd University, Budapest. (in Hungarian)

RADÓCZ, Gy. (1973) Baritkonkréciók a rudabányai pannonból. [Barite concretions from Pannonian sediments at Rudabánya.] *Földtani Közlöny*, **103**, 136–140. (in Hungarian)

SARP, H., BIRCH, W. D., HLAVA, P. F., PRING, A., SEWELL, D. K. B., and NICKEL, E. H. (1987) Perroudite, a new sulfide-halide of Hg and Ag from Cap-Garonne, Var, France, and from

Broken Hill, New South Wales, and Coppin Pool, Western Australia. *American Mineralogist*, **72**, 1251–1256.

SARP, H., SANZ-GYSLER, J., and PERROUD, P. (1997) L'iltisite, Hgsag(Cl, Br), un nouveau minéral de la mine de Cap Garonne, Var (France), polymorph de la capgaronnite. *Archives de Science Genève*, **50** (**1**), 1–5 (in French): Abstracted in *Mineralogical Record*. **29**, 236.

SCHICK, L. (1957) *Un grand homme d'affaires au debut du XVI^e siècle Jacob Fugger*. Published by S.E.V.P.E.N. Paris, 101–271. (in French)

SCHMIDT, S. (1882) Baryt és cerussit Telekesről. [Barite and cerussite from Telekes.] *Értekezések a Természettudományok köréből*, **XII/1**, 1–30. (in Hungarian)

SOÓS, I. (1956) Rudabánya története 1880-ig. [The history of Rudabánya to 1880.] In Pantó *et al*. (1957), 7–47. (in Hungarian)

STODDART, A.M. (1911) *The life of Paracelsus Theophrastus von Hohenheim, 1493–1541*. Published by J. Murray, London 309 p.

STRIEDER, J. (1931) *Jacob Fugger the rich*. The Adelphi Co. New York, N.Y. 227 p. Reprinted in 1966 by Archon Books, 227 p.

SZABÓ, M. (1971) A kelták nyomában Magyarországon. [On the trail of the Celts in Hungary.] published by Hereditas, Corvina, Budapest, 87p. (in Hungarian).

SZAKÁLL, S. (1985) Azurit utáni malachit Rudabányáról. [Malachite after azurite from Rudabánya]. *Ásványgyűjtő Figyelő*, **2** (**3**), 51 (in Hungarian).

SZAKÁLL, S. (1991) Mineral collections of the mining museums in Hungary. In: Vitális and Kecskeméti (eds.), *Museums and Collections in the History of Mineralogy, Geology and Paleontology in Hungary*. Annals of the History of Hungarian Geology Special Issue 3, Hungarian Geological Survey and Hungarian Geological Society, Budapest, 333–338.

SZAKÁLL, S. (2000) Comparison of the Rudabánya (Hungary) and Nižná Slaná (Slovakia) metasomatic iron and hydrothermal sulphide deposits—with special references to the mineral paragenesis of Rudabánya. Ph.D. Thesis, Technical University of Kosice (Slovakia) 156 p.

SZAKÁLL, S., BIRCH, W. D., KOVÁCS, Á., and POSTL, W. (1994) Arsenate minerals from Hungary. *Acta Mineralogica-Petrographica, Szeged*, (Hungary) **XXXV**, 5–25.

SZAKÁLL, S., FÖLDVÁRI, M., PAPP, G., KOVÁCS-PALFFY, P. and KOVACS, A. (1997) Secondary sulfate minerals from Hungary. *Acta Mineralogica-Petrographica, Szeged*, **38**, Supl. 7–63.

SZAKÁLL, S., and GATTER, I. (1993) *Magyarországi ásványfajok*. [Mineral species of Hungary.] Published by Fair System Kft. Miskolc, 255 p. (in Hungarian)

SZAKÁLL, S., and JÁNOSI, M. (1996) *Minerals of Hungary. Topographia Mineralogica Hungariae IV*. Series published by Herman Ottó Múseum, Miskolc, 130 p.

SZAKÁLL, S., and KOVÁCS, Á. (1994) New minerals of Hungary II: Mimetite and olivenite from Rudabánya. *Földtani Közlöny*, **124**, 441–450. (in Hungarian with English abstract)

SZAKÁLL, S., and KOVÁCS, Á. (1995) Silver minerals from Rudabánya. *Acta Mineralogica-Petrographica, Szeged*, (Hungary), **XXXVI**, 5–15.

SZAKÁLL, S. and SARP, H. (2000) Sulpho-halides of Ag-Hg from Rudabánya, Hungary. *Acta Mineralogica-Petrographica, Szeged*, **41**, Sppl. 109.

SZUROMI, B. (1995) Érc és Ásványbányaszati Múzeum. [Ore and Mineral Mining Museum.] *Múzeumi Füzetek (Guidebook) No. 16*. 28 p. (in Hungarian)

TOKODY, L. (1924) Mineralien von Rudabánya. *Zeitschrift für Kristallographie*, **60**, 315–322. (in German)

TOKODY, L. (1950) Ujjab adatok Rudabánya ásványainak ismeretéhez. [New data on the minerals of Rudabánya.] *Földtani Közlöny*, **LXXX**, 156–167. (in Hungarian)

TÓTH, M. (1882) *Magyarország Ásványai*. [The Minerals of Hungary.] Published by Hunyadi Mátyás Press, Budapest, 565 p. Facsimile reprint published by Henman Ottó Múseum 2000, 565 + 49 p. (in Hungarian)

VASTAGH, G. (1984) Ezüstkohászat Rudabányán 1528-ban. [Silver-metallurgy in Rudabánya in 1528.] *Bányászati és Kohászati Lapok*, **117**, 341–342. (in Hungarian)

WALENTA, K., and DUNN, P. J. (1982) Claraite, a new carbonate mineral from the Clara mine (Central Black Forest). *Chemie der Erde*, **41**, 97–102. Abstracted in *American Mineralogist*, **68**, 471.

WENZEL, G. (1880) *Magyarország bányászatának kritikai története*. [Critical review of the history of mining in Hungary.] Published by Magyar Tudományos Akadémia Könyvkiadó-Hivatala, Budapest, 218 p. (in Hungarian)

WILSON, W. E. (1981) *Frog Lamps: A Survey of Examples from 1529 to 1979*. The Rushlight Club, 110 p.

ZEPHAROVICH, V. R. (1859–1893) *Mineralogisches Lexicon für das Kaiserthum Österreich*. Published in 3 volumes. **Vol. I**. 630 p. in 1859, **Vol. II**. 436 p. in 1873 by W. Braumüller, Vienna, and **Vol. III**. 479 p. in 1893 by F. Tempsky, Vienna.

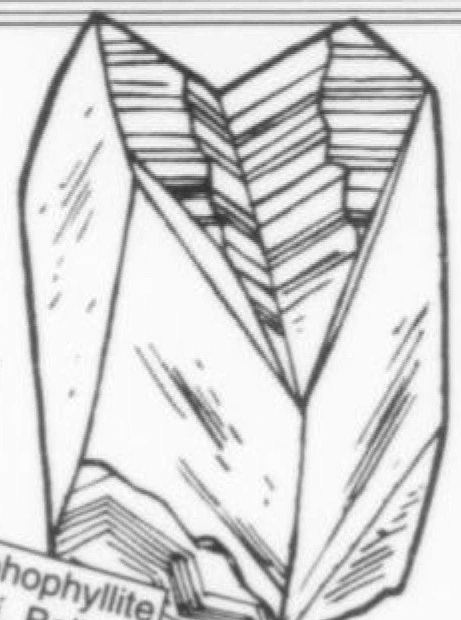
ZSÁMBOKI, L. (1982a) Magyarország érebányászata a honfoglalástól az 1. világháború végéig. [Development of mining laws and mine management in Hungary from settlement (10th Century) to WW II.] in: *Közlemények a magyarországi ásványi nyersanyagok történetéböl*, **I**, 13–48 published by University of Miskole (in Hungarian).

ZSÁMBOKI, L. (1982b) Az országos bányajog és bányaigazgatás fejlődési iránya Magyarországon a honfoglalástól az 1. világháború végéig. [Development of mining laws and mine management in Hungary from settlement (10th Century) to WW II.] In: *Közleménvek a magvarországi ásványi nyersanyagok történetéből*, **I**, 167–196 published by University of Miskole (in Hungarian).

ZSÁMBOKI, L. (1995) One thousand years of mining in Hungary (XI–XIXth century); in Zsámboki (editor), *Hungarian Mining*. Published by University of Miskolc, Hungary, p. 5–20.

ZSÁMBOKI, L. (2000) Articles on the history of Hungarian mining and metallurgy in: *Pannon Enciklopédia, Magyar ipar-és technikatörténet*. [History of Hungarian industry and technical development] Published by Kertek, Budapest. 357 p.

ZSIVNY, V. (1951) Cerusszit Rudabányáról. [Cerussite from Rudabánya.] *Földtani Közlöny*, **LXXXI**, 298–302. (in Hungarian)



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Dudley is currently in Asia, going to the source to locate new and unusual specimens as well as fine examples of those varieties that have become classics. Keep up with his travels on our web site and contact us in early July for the results of his latest trip.

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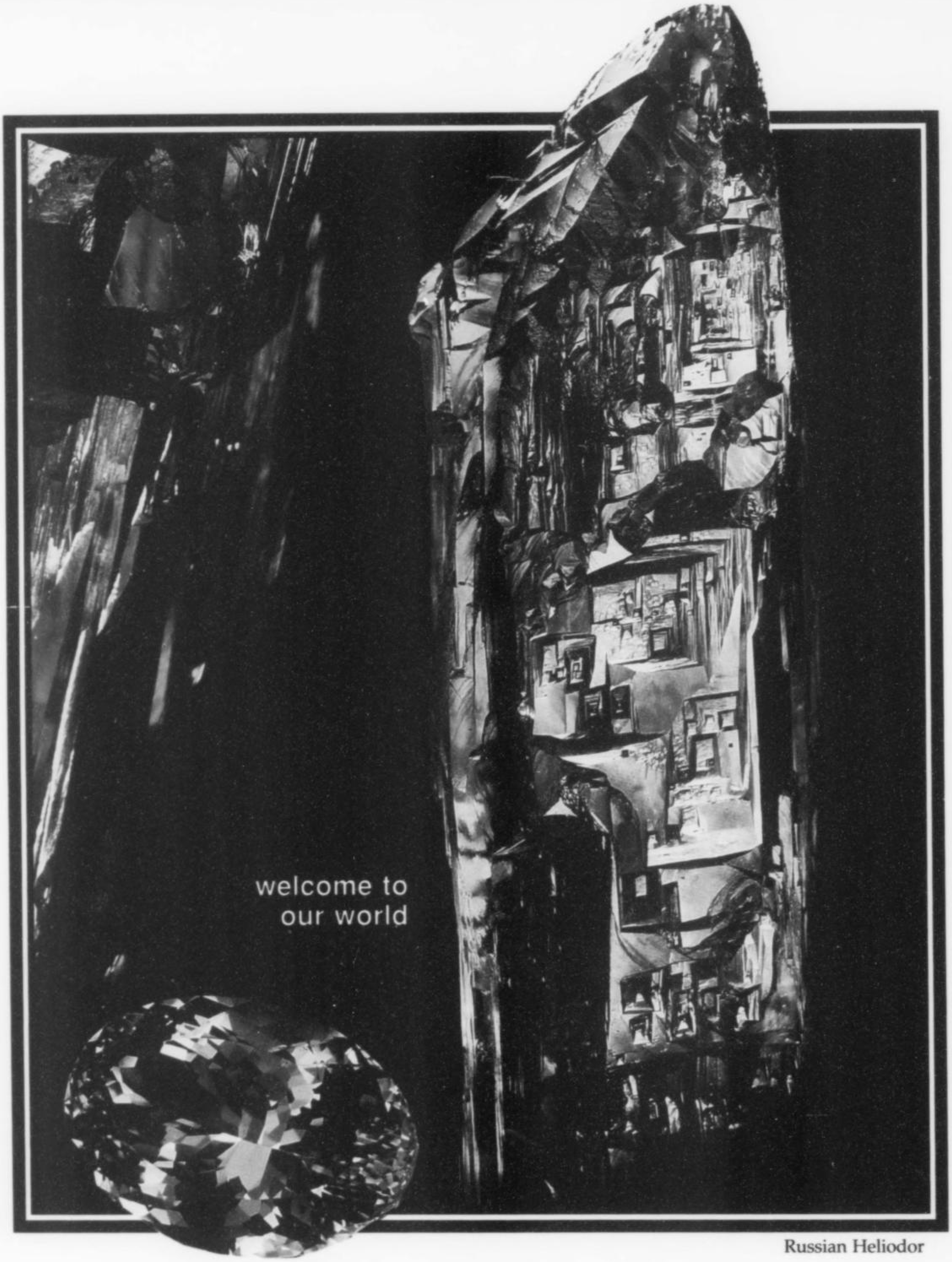

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