THE MINERALOGICAL RECORD

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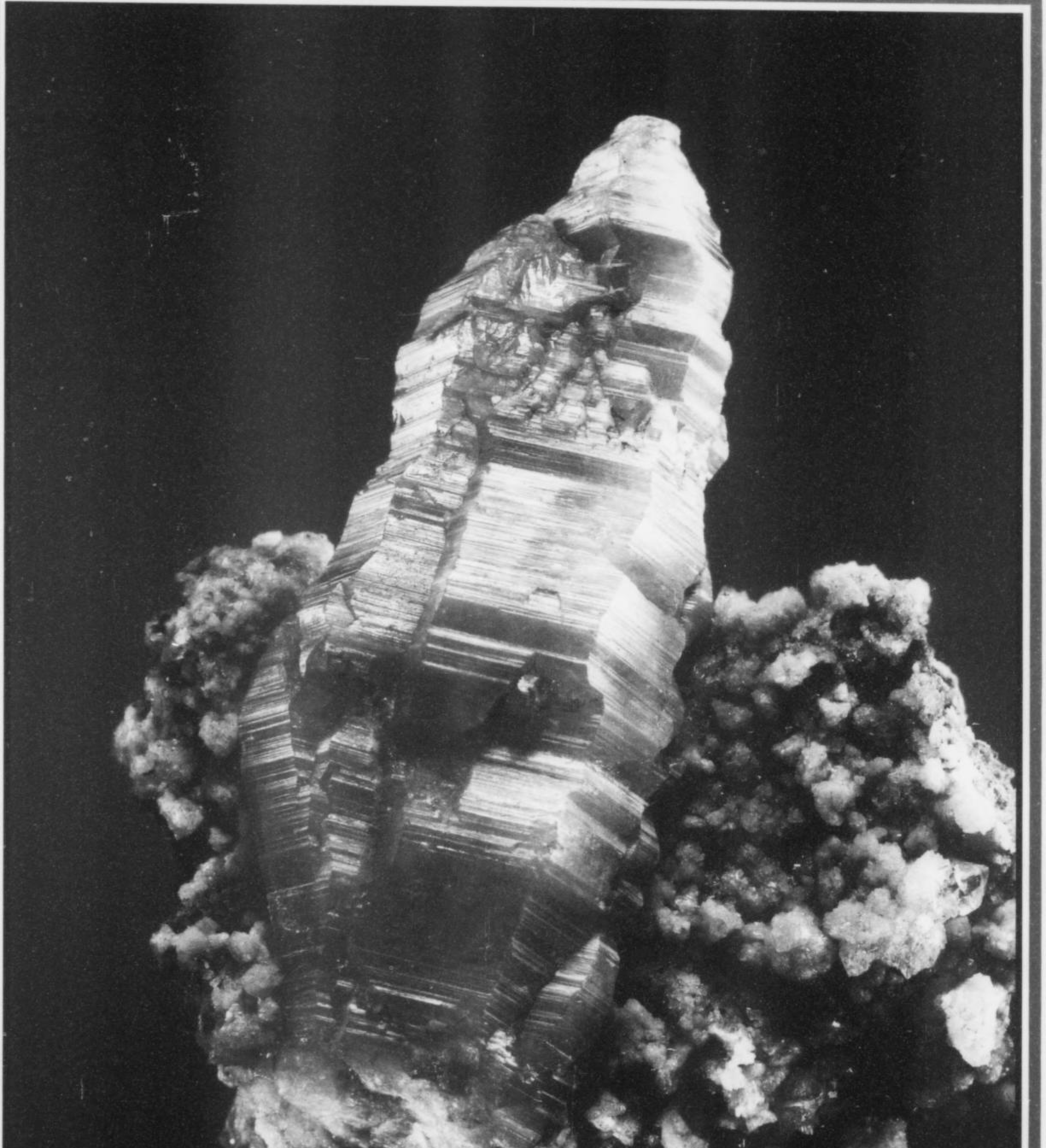

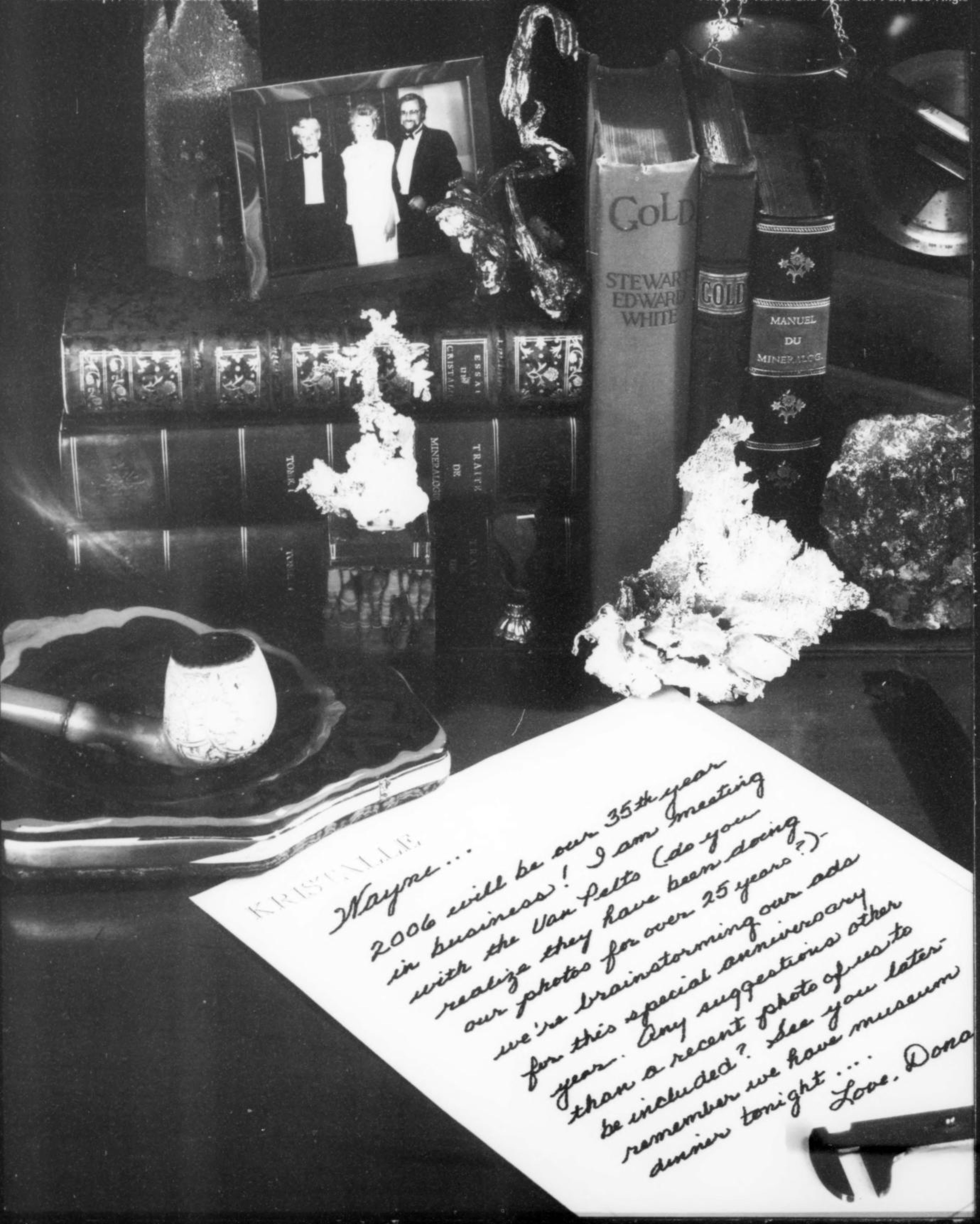
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*Continued on p. 104

THE
MINERALOGICAL
RECORD

January–February 2006 Volume Thirty-seven, Number One

Articles

Columns

Notes from the editors

What's new in minerals

COVER: WELOGANITE crystal, 4 cm, on matrix, from the Francon quarry, Montréal, Québec, Canada. (See the article in this issue on this famous occurrence.) Formerly in the F. John Barlow collection, no. 1531 (obtained from Don Doell in 1977); photo by Harold & Erica Van Pelt.

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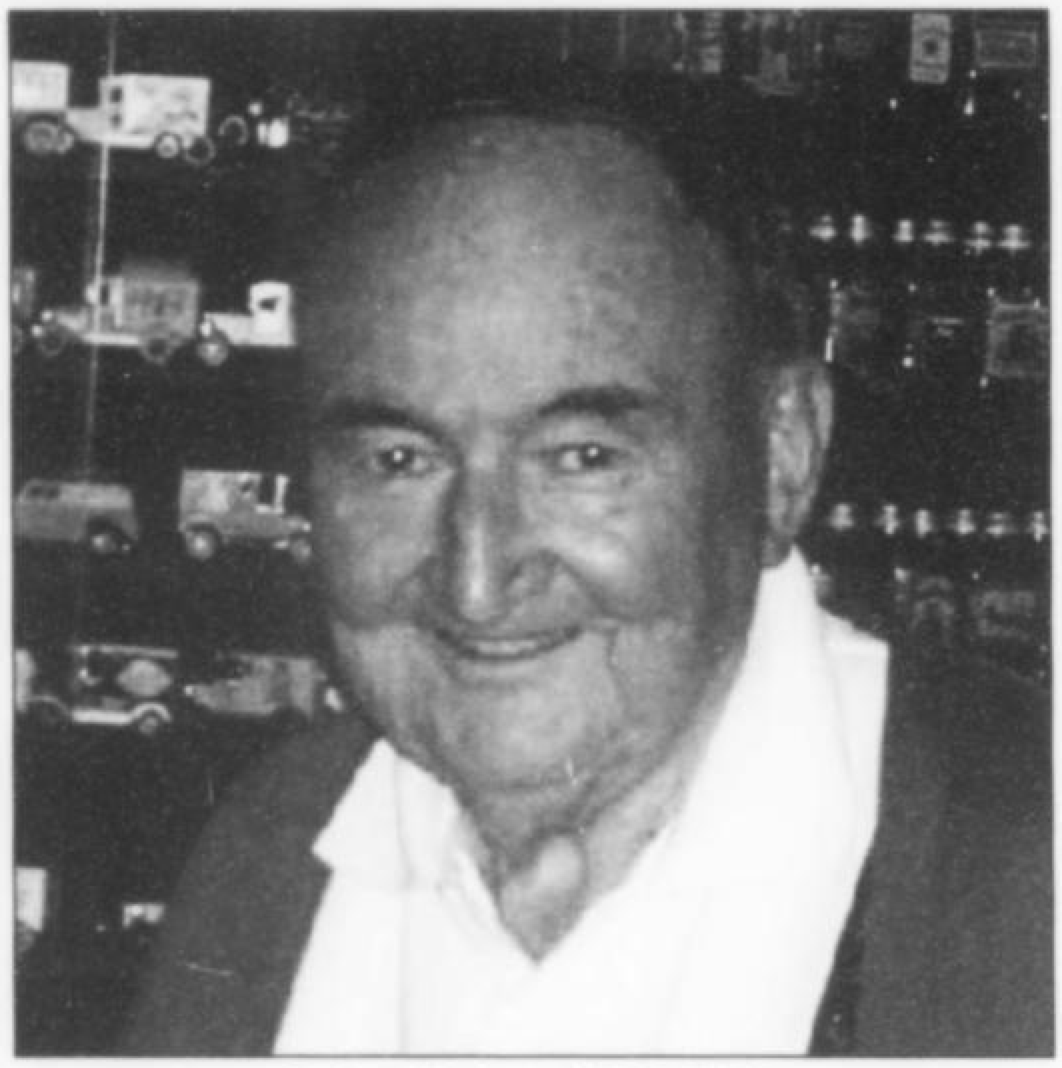
notes from the EDITORS



Brian Shelton (1928-2005)

Died, Brian Shelton, 76

Brian Charles Shelton, a well-known Australian mineral dealer during the 1970's and 1980's, died in hospital in the Victorian town of KooWeeRup on July 21, 2005. Born in the nearby town of Pakenham on November 18, 1928, Brian lived in the area all his life. He left school at an early age and started work on the family farm, but soon commenced a truck-driving business serving the agriculture industry.

What triggered his interest in minerals is not known, but they became a powerful motivator for much of his life. He began buying and selling quality specimens in the early 1970's, taking advantage of the private mineral-collecting boom hitting Australia at the time. He was soon able to build a fine collection, much of which he sold to the then National Museum of Victoria in 1974.

One of Brian's greatest loves was gold, and he was able to establish a network of contacts which enabled him to buy from miners in the Victorian goldfields. By the early 1980's metal detecting had become a popular recreational pastime in Australia and many new nuggets were being found. Brian's role in buying and selling many of the pieces was shrouded in mystery, but somehow he was able to get his hands on some top specimens. The most notable was a 250-ounce nugget uncovered near Wedderburn in central Victoria, which became known as the "Pride of Australia." Trying to find a buyer in Australia for a nugget of this size and value was a challenge, but Brian was determined to give it his best shot. He even took the nugget to the politicians in Canberra, working through his local Member of Parliament, who opened the office doors of the Prime Minister and Treasurer. These attempts to obtain government support failed to gain funds, but eventually a major bank was persuaded to buy the nugget in 1985, as part of Victoria's 150th anniversary celebrations. It disappeared in 1991 during a carefully staged smash-and-grab robbery from its display case in the Museum of Victoria, where it was on loan, and has never been seen since. By then Brian had largely ceased his hectic mineral dealing, but he maintained a personal collection of smaller mineral specimens, and had branched out into collecting miniature model cars and rare whisky bottles (ne'er a drop passed his lips as he was a lifelong teetotaler).

I got to know Brian quite well after negotiating the purchase of his mineral collection by the Museum in 1974. For the next decade or so he visited me regularly. We purchased some excellent specimens from him and did the occasional exchange. He was not a haggler; he had his price and it was take-it-or-leave-it. Looking backwards can be misleading, because although some of his prices appear to have been high by the standards of the time, nowadays they would be bargains, as prices for world-class specimens are now in many cases off the planet.

Like most Australian mineral collectors and dealers, Brian coveted fine pieces from the famous Broken Hill deposits, and by 1984 had put together another specialized collection of about 120 choice specimens. Fortunately, funds to enable the Museum to purchase the collection were forthcoming from the mining company CRA Ltd., as its contribution to Victoria's 150th anniversary. The pieces formed the nucleus of a Broken Hill mineral display between 1985 and 1997, when the Museum was relocated.

It's fair to say that Brian's mineral dealings generated rumors and comments that were not always favorable, but because he never discussed these with me it's very difficult to separate fact from fiction. It's clear there were legal disputes over his gold collection, ultimately purchased by the Perth Mint, and over a magnificent Queensland opal specimen, the "Galaxy," the fate of which remains a mystery. For several years in the 1980's he was a regular visitor to Switzerland, but after he was mugged and robbed in Zürich these visits largely ceased.

Brian was often affable and charming, and he could also be generous, best exemplified by the occasion, after the 1974 sale of his collection, when he took all of the Museum's Natural Sciences staff out for a lavish lunch. Despite his lack of formal education, he had the knack of being able to communicate with people at many levels of society, including politicians, whom he was prepared to approach when he felt it was appropriate, even though he often condemned them collectively as "all the same—bloody hopeless." He had a lifelong association with horse-racing, although I never knew whether he was a big-time bettor or kept within strict limits. He read widely, particularly anything relating to his hobbies, and had strong opinions on many issues, almost always taking a conservative line. This led to our having quite lively discussions on many occasions, to the extent that I got the distinct impression that if something had irked him he'd pay me a visit just to start an argument and let off some steam.

I gradually lost contact with Brian during the 1990's and wasn't aware of his last illness, which saw his health decline over the final year of his life. In many ways I regret that our friendship faded but it was the inevitable outcome of changing attitudes and priorities when it came to mineral collecting. Acquisition funds for the Museum also ran out. Most of my memories of Brian are pleasant ones and we had some good times, especially when we were trying to find someone to buy the "Pride of Australia" nugget. He has left a lasting legacy for our Museum's mineral collections, and no doubt to others around the world. During more nostalgic intervals, I can still picture Brian arriving at my office, with his black brief case loaded with gold or fine crystal specimens worth tens of thousands of dollars, grinning at how he walked all that treasure round the streets with no one knowing.

Bill Birch (with John Bosworth)
Museum Victoria

Charles E. Freed (1930-2005)

Abraham Rosenzweig (1925-2005)

Died, Charles E. Freed, 74

Charlie Freed was born October 20, 1930 and raised in Baltimore, Maryland. Following his stint in the Service he settled in California where he joined the Mineralogical Society of Southern California and eventually served as its President. He was an enthusiastic field collector and a gregarious and much-loved member of the mineral fraternity, regularly hosting parties at his house in conjunction with the Pasadena Show each year. He was fond of recounting the fact that Paul E. Desautels, who later became curator of minerals at the Smithsonian, had been his college chemistry instructor. Charlie was at one time the reigning king of Palos Verdes barite collecting; he had determined the exact times at which the local sheriff made his rounds, so that he would never be caught digging in his favorite hole—in the highway median! Charlie passed away on June 9, 2005, following a sudden illness. [Extracted from BESSE, B. (2005) A PASSING: Charles E. Freed. *Bulletin of the Mineralogical Society of Southern California*, **75**, no. 7, p. 12.] **WEW**

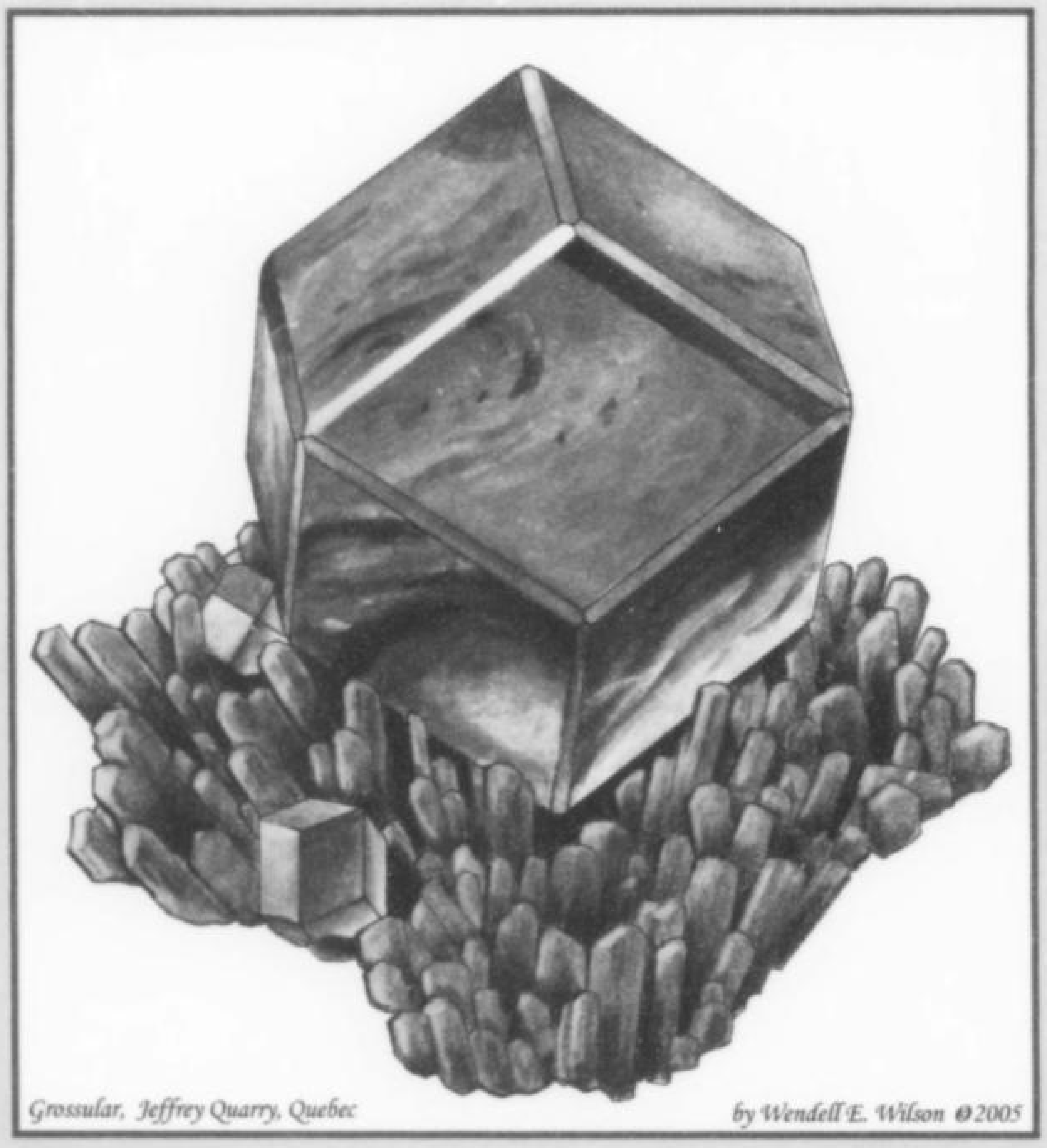
Died, Abraham Rosenzweig, 80

Abe Rosenzweig—mineralogist, crystallographer, author, educator and long-time Associate Editor and Member of the Board of Directors of the *Mineralogical Record*—died October 9, 2005 in Florida. Abe was born June 10, 1925 in Philadelphia and was raised there, and in Vineland, New Jersey, and also in Palestine. He earned his B.S. in Chemistry from the University of Pennsylvania in 1946, and his PhD in Geology and Chemistry from Bryn Mawr College in 1950. While in school in 1945-1946 he worked as a chemist for the Foote Mineral Company, and spent the summers of 1947 and 1948 working for the Pennsylvania Geologic and Topographic Survey. Following his graduation in 1950 he took a position as a mineralogist for the U.S. Atomic Energy Commission, and later worked as a consultant for the Sandia Corporation in Albuquerque and for the Special Weapons Center at Kirtland Air Force Base; he was also a visiting staff member at the Los Alamos National Laboratory from 1957–1984, and served as curatorial consultant for the Romero Mineralogical Museum in Tehuacan, Mexico from 1975–1981. He traveled widely and occasionally dealt in mineral specimens acquired on his many trips, especially those trips which took him to Korea.

Abe had a long career in academic life, teaching and conducting research in mineralogy and geology at Bryn Mawr (1949–1950), the University of Minnesota (Research Associate in Geology, 1953–1954), the University of New Mexico (Assistant Dean and Dean, 1963–1965; Associate Professor 1961–1968; Professor 1968–1973), the University of South Florida (1973–1974), Oberlin College in Ohio (1973–1974), and as Visiting Professor at National Taiwan University (1954–1961). He retired in 1975 to work as a consultant in crystallography, mineralogy, economic geology, appraisals and custom gem cutting, and was co-owner (with his wife Daphne) of Rosenzweig Associates. During that time he also served as Director of Microscopy Services for Thornton Laboratories in Tampa (1988–1993), and as a Technical Expert for the National Institute for Standards and Technology (1988–1995).

Abe self-collected minerals extensively in his younger years, and also purchased specimens, forming a small but choice collection featuring, in particular, a suite of his favorite black minerals. His collection was sold off in large part during the last few years, but a good small collection of micromounts remains, as well as much of his library of mineralogy and crystal structure books. (A decision for their disposal has yet to be made.)

Abe mentored numerous graduate students of many nationalities, and was a stickler for clarity of expression in his editorial function. He read drafts for proposed magazine articles and graduate theses, and pursued gemstone faceting as a hobby, preferring "free forms." He was Past President of the Florida Friends of Mineralogy, loved teaching mineralogy, was generous with his time, shared knowledge willingly, was always ready to learn more about his beloved field, and was a good friend to the *Mineralogical Record.* **WEW**



Grossular, Jeffrey Quarry, Quebec

by Wendell E. Wilson ©2005

FAMOUS MINERAL LOCALITIES:

THE FRANCON QUARRY,

Montréal, Québec

Peter Tarassoff
91 Lakeshore Road
Beaconsfield, Québec, Canada H9W 4H8

László Horváth and **Elsa Pfenninger-Horváth**
594 Main Road
Hudson, Québec, Canada J0P 1H0

The Francon quarry ranks as the second most prolific type locality in Canada after Mont Saint-Hilaire. It has yielded ten new mineral species: weloganite, dresserite, hydrodresserite, strontiodresserite, sabinaite, franconite, doyleite (co-type-locality), hochelagaite (co-type-locality), montroyalite and voggite. Weloganite, described in 1968, established the quarry as a world-famous mineral collecting site. Weloganite was the first known zirconium carbonate, and remarkably, it occurs as attractive, well-formed crystals up to 6 cm in size. Ninety species have been documented from the quarry, mostly from the unique, dawsonite-rich carbonatized phonolite sills which are genetically part of the Monteregian Hills alkaline igneous province.

LOCATION

The Francon quarry is unusual in being located in the midst of a large metropolis, the city of Montréal, on the Island of Montréal. It is situated at latitude 45°34′20″ N, longitude 73°36′50″ W, in what was previously known as the Saint-Michel district, and is now part of the Arrondissement de Villeray—Saint-Michel—Parc-Extension (Borough of Villeray—Saint-Michel—Park-Extension). The quarry is shown on National Topographic System Map 31 H/12. The original entrance to the quarry was at 3701 rue Jarry Est.

Some confusion can arise from the fact that the last operator of the quarry, Francon (1966) Limitée, also worked the former Francon (Montréal-Est) quarry,[1] situated 8 km to the northeast, at latitude 45°37′14″ N, longitude 73°32′06″ W, in the municipality of Montréal-Est. The latter quarry is now called the Lafarge Carrière [= quarry] Montréal-Est. In order to avoid confusion, mineral labels for the Francon quarry should read Francon quarry, Saint-Michel district, Montréal, Québec, Canada. In some publica-

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[1] This quarry is also referred to as the Canada Cement quarry in older literature.

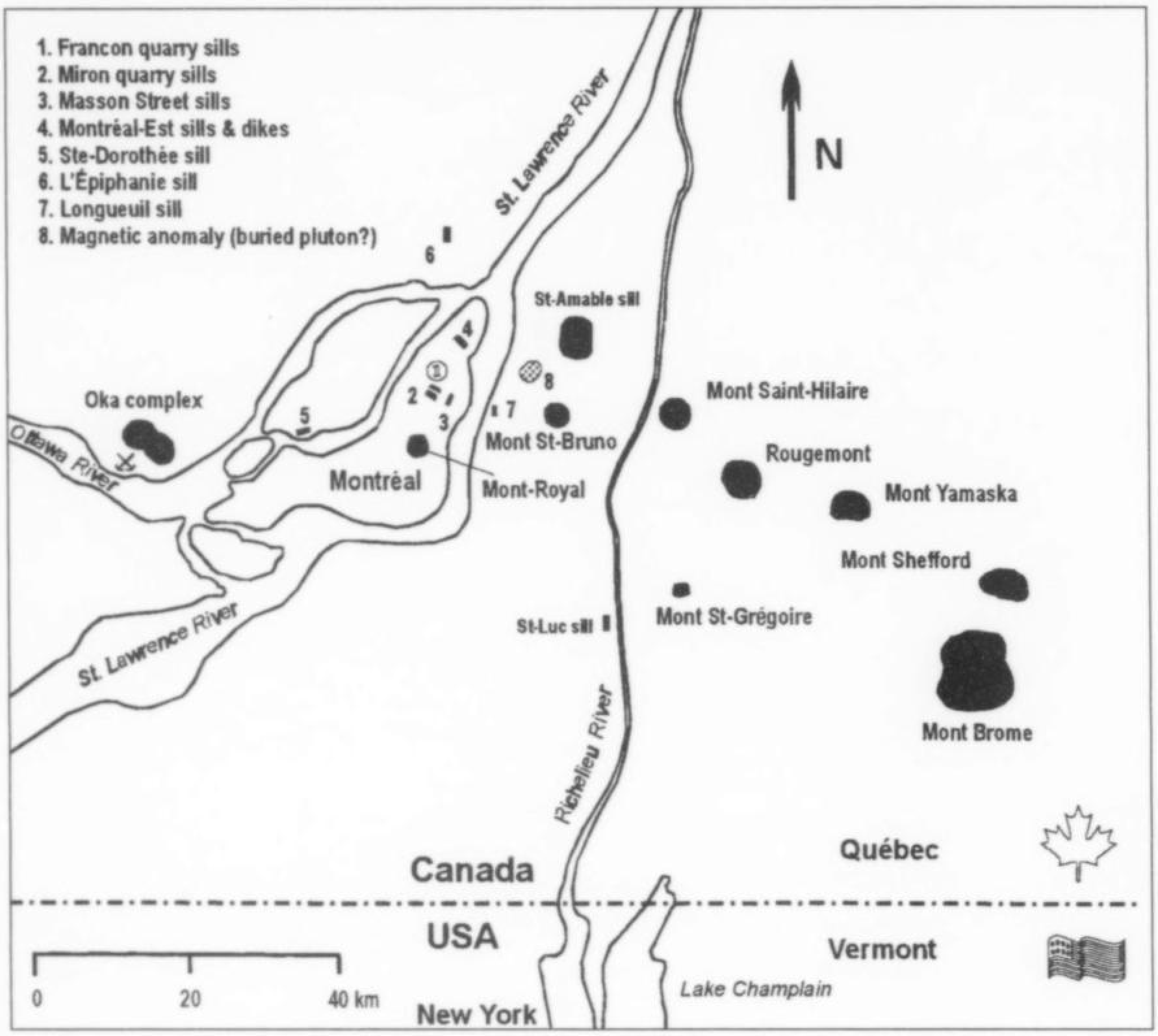

Figure 1. **Map of the Montréal, Québec area showing the location of the Francon quarry in relation to various other Monteregian intrusions and important mineral occurrences.**

tions Montréal Island appears as part of the locality designation. This is redundant and should be avoided.

HISTORY

As early as the 17th century the abundant outcrops of limestone on the Island of Montréal were being used as a source of building material and for the production of lime. By the 19th century, Montréal had become known as "the old gray city" because of the numerous public and private buildings constructed of local limestone (Collard, 1981). Since the end of the 19th century, the island's limestone has been quarried for road material, concrete aggregate, and the manufacture of cement.

Quarrying on the present site of the Francon quarry was begun in 1914 by the Quinlan and Robertson Company (Gauthier, 1919). Subsequent operators included the Arthur Dupré Company (1924–1928), National Quarries Limited (1930–1962), and Highway Paving Company (1963–1965) (Sabina, 1976). In 1966, the quarry was taken over by Francon (1966) Limitée, a division of Canfarge Limited.

Despite its long history, the quarry remained unknown as a mineral locality until 1966. The presence of sills of igneous rocks had been noted by Gauthier (1919) and later by Clark (1952) but nothing was reported on their mineralogy. The limestone on the Island of Montréal was not known as a source of mineral specimens, and like other limestone quarries the Francon quarry was ignored by mineral collectors.

On July 19, 1966, the quarry was visited by Ann P. Sabina of the Geological Survey of Canada (GSC) and a student assistant. The visit was part of a reconnaissance of rock and mineral occurrences of potential interest to collectors. During the visit, Sabina noticed the presence of cavities containing crystallized minerals in a particularly thick sill of igneous rock. Among them was an unusual looking mineral. As described by Sabina (1975) "it was the glow of golden yellow. . . . that caught the eye . . . [and] it captured the attention of the field party." Investigations of the mineral revealed that it was a new species, ultimately named *weloganite* (Sabina *et al.*, 1968). The discovery of weloganite, and the fact that it occurs as attractive, large crystals, captured the attention not only of mineralogists and mineral collectors, but of the press. The *Montreal Star* reported the discovery under the byline "Enter weloganite" (Anonymous, 1968). The *Canadian Magazine* published an article entitled "Another Canadian first! (Yes sir, it's weloganite)" (Alderman, 1968) which described the discovery in a tongue-in-cheek fashion, and profiled the GSC mineralogists who had described the new mineral: John Jambor, George Plant and Ann Sabina. Shortly after, in 1969, another new species, *dresserite*, was published (Jambor *et al.*, 1969). Weloganite and dresserite were the first of the ten new mineral species described from the quarry between 1968 and 1990. All the type specimens, except for voggite, were collected by Sabina, and five were first found in her original investigation of the quarry.

With the publication of weloganite, the quarry quickly became a popular destination for mineral collectors and mineralogists from far and wide. Sabina also continued to routinely visit the quarry. The frequent visits by amateurs and professionals alike in a quarry where new sill sections, and indeed new sills, were being exposed by ongoing operations contributed to a growing list of mineral species. From about 40 minerals in 1976 (Sabina, 1976), the list had increased to about 60 by 1979 (Sabina, 1979), and currently stands at 90. Because the mineralization is not uniformly distributed throughout the sills, regular visits to the quarry were important in documenting unique occurrences, and in preserving many exceptional specimens. Instrumental in this was the continued cooperation of Francon (1966) Limitée in permitting access.

The development of the quarry was carried out along a northwest-southeast axis. The oldest section of the quarry is at the

Figure 2. **The Francon quarry from the top of the northeast wall, showing the vegetation reclaiming the site. L. Horváth photo, July 2003.**

southeast end. When Clark (1952) visited the quarry between 1938 and 1941, quarrying had reached a depth of about 38 meters along the northeast wall. This corresponds to the floor of the present first level. When Francon (1966) Limitée took over the quarry, the first level had been quarried to the northwest property limit, and a second level with a bench height of about 25 meters was being advanced in a northwest direction. Because a crushing plant had been installed on the floor of the first level, the second level was developed some distance in from the southeast end of the quarry and was accessed by a ramp. This level is referred to in the literature as the "upper level." The first of the weloganite-bearing sills, the so-called "upper sill," was encountered when quarrying began on the second level around 1955.

By August of 1968 the second level had been excavated over an area of about 215 × 400 meters, with the sill exposed around the entire perimeter (Steacy and Jambor, 1969). At the bottom of the ramp, the quarry wall angled to the southwest, forming an offset that became known as the "alcove." By 1975, the second level had reached the northwest property limit, and a third level, referred to as the "lower level," was being driven on two sub-levels, from the northwest end of the quarry to the southeast. This revealed a second weloganite-bearing sill, the "lower sill." A third sill, not as well mineralized, was partially exposed at the very bottom of the lower level.

In 1981 the north half of the quarry was taken over by the City of Montréal for use as a snow dump. Quarrying operations continued at the southwest end of the third level for a time, and then moved to the alcove on the second level. The alcove was developed on two sub-levels with the benches being advanced to the southeast. This area became the focus of mineral collecting over the next several years. The alcove produced two new mineral species, *montroyalite* (Roberts *et al.*, 1986) and *voggite* (Roberts *et al.*, 1990).

When quarrying first started, the Francon site was surrounded by farmland. By the 1960's the quarry had been overtaken by urban development, with a residential area along its southwestern and northwestern perimeter and an industrial zone on the northeast side. In 1985, environmental issues and the exhaustion of economic reserves of limestone contributed to a decision by Francon (1966) Limitée to terminate quarry operations. The quarry was sold to the City of Montréal, which has continued to use it as a snow dump and solid-fill site. In recent years, the alcove was still accessible for mineral collecting. One of the last visits by Sabina was in 1992 when she organized a field trip for members of the Geological Survey of Canada as part of the celebration of the Survey's 150th anniversary (Sabina, 1992). Occasional field trips were also organized by the Club de Minéralogie de Montréal up until the end of the 1990's. However, with no fresh exposures of sill rock, collecting had become far less productive than in the heydays of the late 1960's and the 1970's. The quarry is now closed to collecting.

Currently the quarry measures about 2 km along the northwest-southeast axis on the first level, and has a maximum width of about 580 meters over the southern half, narrowing to about 380 meters over the northern half. On the third level the quarry extends about 1.5 km from the northwest to the southeast. The depth of the quarry in this section is about 80 meters.

At present, parts of the quarry are buried under fill and solid residues from melted snow. Much of it is now covered by trees and other vegetation.

Figure 3. **A view of the Francon quarry looking north from the "alcove" area. L. Horváth photo, 1982.**

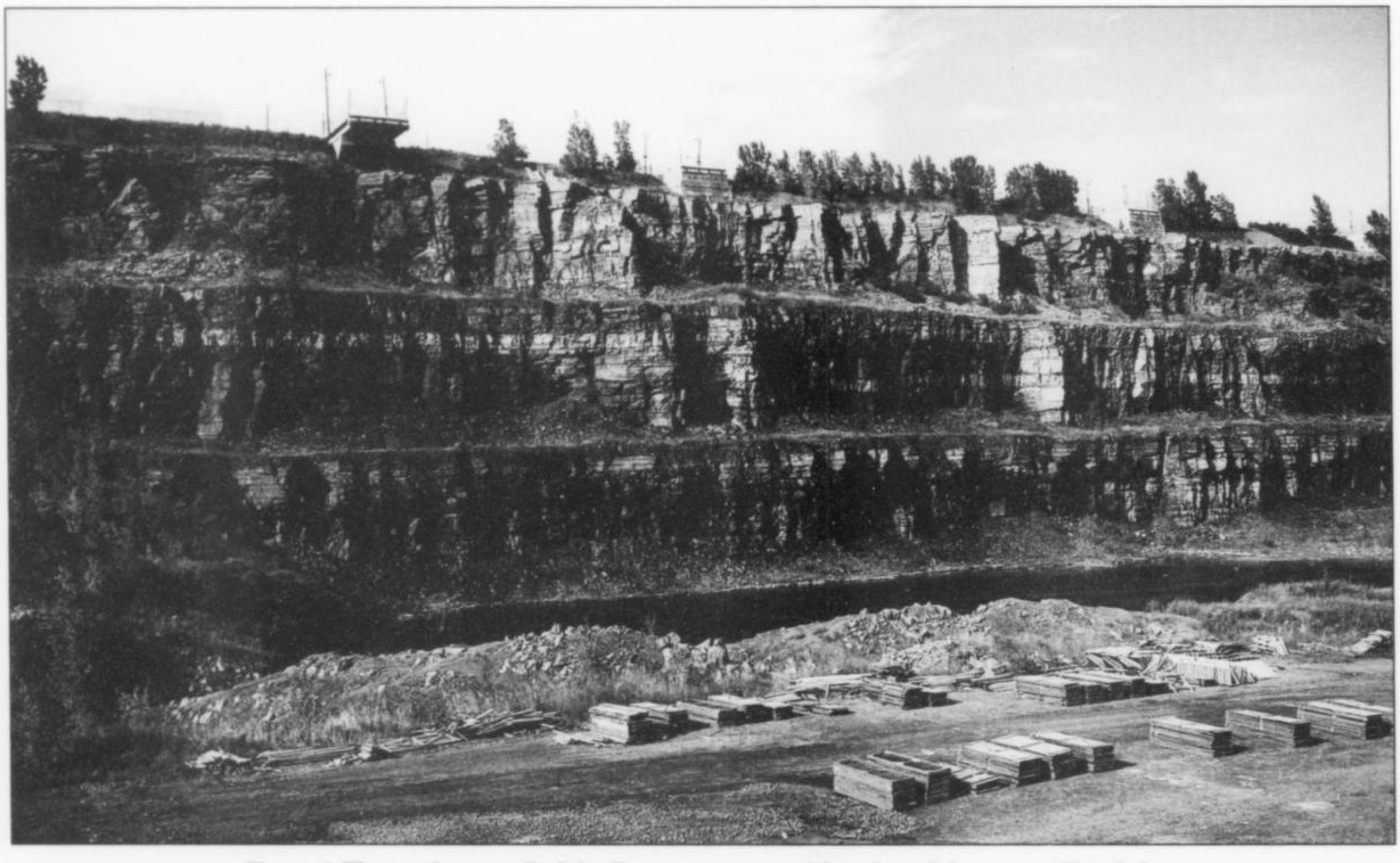

Figure 4. **The northeast wall of the Francon quarry, with a view of the upper sill and the snow-dumping ramps. All three of the main levels and the upper sill are clearly visible. The water is from the previous winter's snowmelt. L. Horváth photo, 1992.**

REGIONAL GEOLOGY

The Island of Montréal is situated within the Saint Lawrence Platform, a thick sequence of Cambro-Ordovician sedimentary rocks resting on a Proterozoic basement. In the Montreal area the platform occupies the junction of the Ottawa-Bonnechère graben and the Saint Lawrence graben (Clark, 1972; Brisebois and Brun, 1994; Brisebois *et al.,* 2003). These grabens were formed as a result of the supercontinental rifting which gave rise to Laurentia (the nucleus of the present North American continent) and to the opening of the Iapetus Ocean during the late Proterozoic (Kumarapeli, 1985; Rocher and Tremblay, 2003). The Saint Lawrence Platform is bounded on the northwest by the Proterozoic Grenville Province, and on the southeast by the Humber Zone of the Appalachian Province.

The sedimentary rocks making up the Saint Lawrence Platform were deposited on the continental shelf of Laurentia over a period of about 100 million years, from the early Cambrian to the late Ordovician. During the middle Ordovician, as the Iapetus Ocean began to contract, an island arc collided with the outer margin of Laurentia, initiating the Taconic Orogeny and the formation of the present Appalachian Mountains. The Humber Zone marks the western edge of the Appalachian Province. In the Montreal area, the Taconic Orogeny is manifested by low open folds in the sedimentary rocks.

By the Permian, Laurentia had become part of the supercontinent of Pangea. Subsequent continental rifting during the middle Mesozoic saw the opening of the present North Atlantic Ocean. In the Montréal area this event is represented by the Saint Lawrence rift system, a series of tensional faults aligned with the older fault zones associated with the Ottawa-Bonechère and Saint Lawrence grabens (Kumarapeli and Saull, 1966; Kumarapeli, 1978). The event also reactivated deep-seated faults extending eastward from the Ottawa-Bonnechère graben across the Appalachian tectonic terranes. These are believed to have provided conduits for the emplacement of the Monteregian Hills igneous intrusions of Cretaceous age.

The most prominent topographical feature on the Island of Montréal is Mont Royal (*Mons Regius* in Latin), the type pluton which gave the Monteregian Hills alkaline igneous province its name (Adams, 1903). The Monteregian Province comprises an east-southeast-trending belt of ten major plutons, and numerous dikes, sills, small plugs and diatreme breccia pipes (Currie, 1976). Their ages range from 107 to 140 million years (Eby, 1987).

The major intrusions include the Oka carbonatite complex (32 km west of Montréal) which intrudes Proterozoic rocks of the Grenville Province; the major plutons Mont Royal, Mont Saint-Bruno, Mont Saint-Hilaire, Rougemont, and Mont Saint-Grégoire, which intrude the Saint-Lawrence Platform; Mont Yamaska at the western edge of the Humber Zone; and Mont Brome, Mont Shefford, and part of Mont Mégantic, in the Appalachian Province. The major intrusions are all zoned, reflecting successive pulses of magma of varying composition and age. They also show a marked change in their overall composition from east to west, becoming progressively more mafic, with a tendency toward agpaicity in late differentiates.

Dikes and sills are more numerous in the western end of the Monteregian Province, and are especially abundant in the Montréal area. They include the Saint-Michel sills and dikes, exposed in the Francon quarry; the sills and dikes in the former Miron quarry (Paré, 1972; Sabina, 1978); the Saint-Amable sill (Clark, 1955; Globensky, 1985; Horváth *et al.,* 1998); the Montréal-Est sills and dikes in the Lafarge (Montréal-Est) quarry; the now-buried Masson Street sill (Adams, 1913; Clark, 1952); the Sainte-Dorothée sill (Howard, 1922: Clark, 1952); the l'Éphiphanie sill (Clark and Globensky, 1977); the Saint-Luc sill (Clark, 1955; Globensky, 1985); and the now-buried Longueuil (Polis quarry) sill (Clark, 1955).

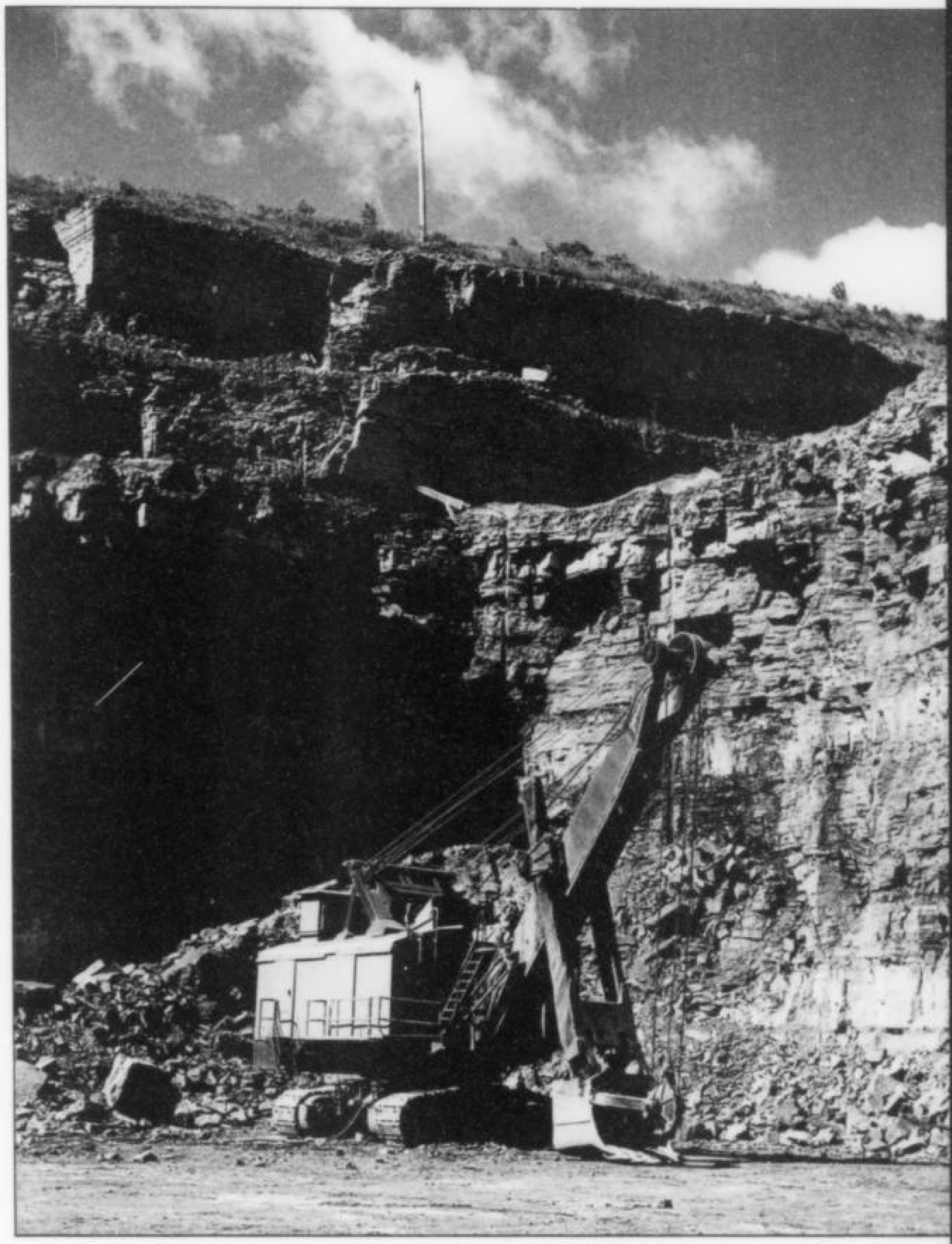

Figure 5. **The west corner of the Francon quarry in 1968, the same year in which weloganite was officially described as a new species. The upper phonolite sill in which it was discovered is exposed in the face on the right. Photo by P. Tarassoff.**

GEOLOGY OF THE FRANCON QUARRY

Exposed in the Francon quarry are about 80 meters of Ordovician-age limestone and interbedded sills. Only the upper 38 meters, on the first level at the southeast end, have been examined in detail (Clark, 1952). The limestone beds in this section are assigned to the Saint-Michel Member of the Montréal Formation of the Trenton Group. Underlying these are Mile End Member limestones, also belonging to the Montréal Formation. Based on the sedimentary succession determined elsewhere in the Montréal area (Clark, 1972), a thickness of about 4 meters can be assigned to the Mile End Member. Below the Trenton Group limestones are about 15 meters of strata comprising the Black River Group. This group includes beds of dolomite and shale in the lowest 2.5 meters. Below the Black River Group and down to the bottom of the quarry are Chazy Group limestones. The quarry is located on the flank of a very shallow anticline with the limestone beds dipping a few degrees to the northwest. In some places the beds are cut by normal faults which have resulted in vertical displacements of up to 2 meters. These faults are related to regional tectonism during the Mesozoic (Rocher and Tremblay, 2003).

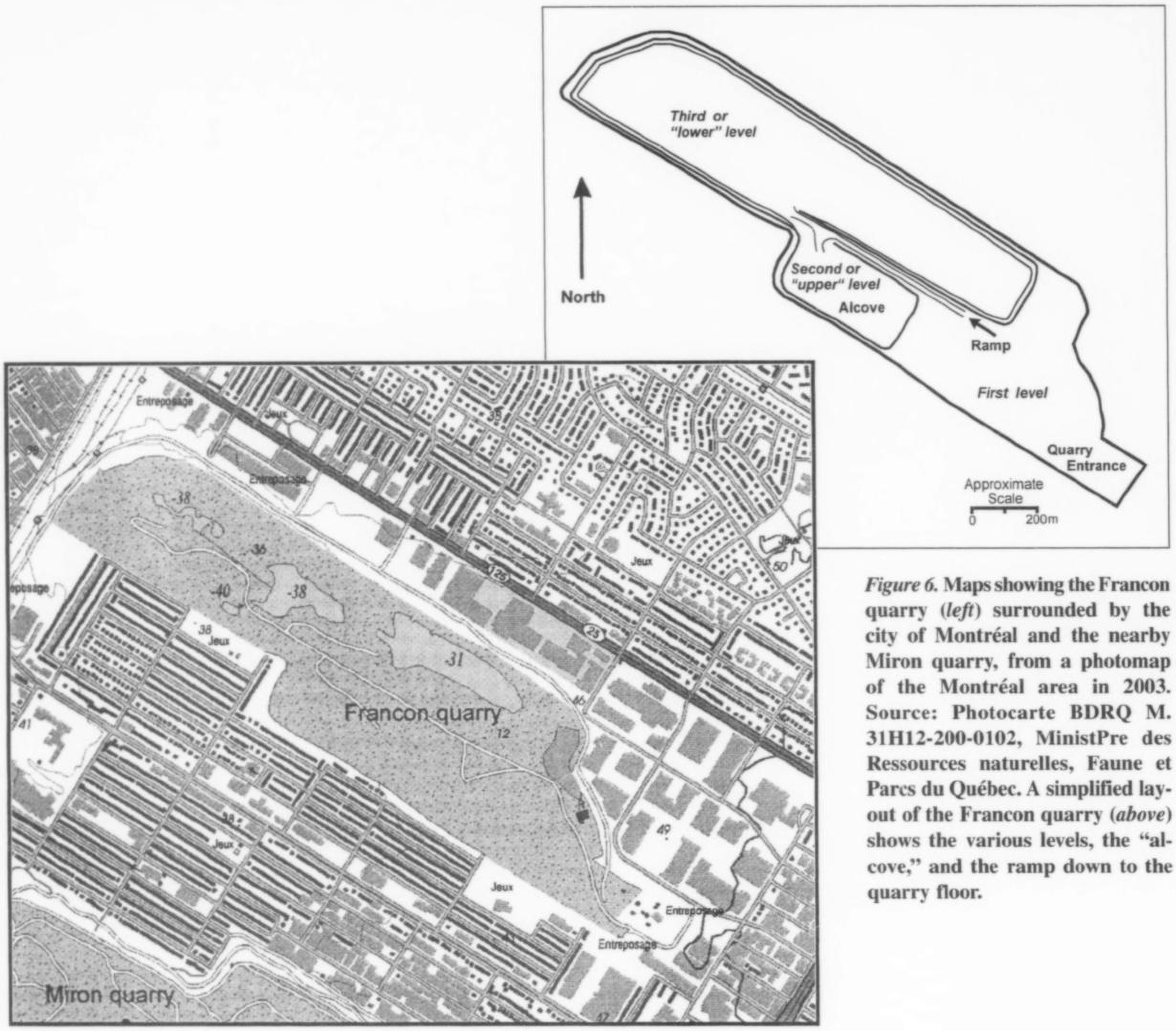

Figure 6. **Maps showing the Francon quarry (*left*) surrounded by the city of Montréal and the nearby Miron quarry, from a photomap of the Montréal area in 2003. Source: Photocarte BDRQ M. 31H12-200-0102, MinistPre des Ressources naturelles, Faune et Parcs du Québec. A simplified layout of the Francon quarry (*above*) shows the various levels, the "alcove," and the ramp down to the quarry floor.**

Although the Saint-Michel carbonatized phonolite sills are the best known feature of the Francon quarry, other sills and dikes are exposed throughout the quarry. Clark (1952) recorded four sills of "basic rock" from 8 cm to just over 1 meter in thickness intruding the Saint-Michel Member beds on the first level. Other sills and dikes, some up to 1.5 meters thick, occur in the lower levels of the quarry. Some of these cut the Saint-Michel sills. They consist of a variety of fine-grained to coarse-grained, often porphyritic, rocks most of which weather to a brown color. In the Montréal area such rocks are mostly alkaline syenite, monzonite, basanite or alkali olivine basalt, and lamprophyre, especially camptonite (Hodgson, 1968; Eby, 1985).

A major lamprophyre sill, over 3 meters thick, is exposed in the nearby Miron limestone quarry (Paré, 1972). A common feature of the lamprophyres noted by Hodgson (1968) is the formation of loose spheroids on weathered surfaces caused by the presence of coarse-grained, feldspar-rich *ocelli* [= eyes in Latin] which are more weather-resistant than the finer-grained matrix. This phenomenon is observed in some of the Francon quarry dikes.

As part of the present study, rock from two different dikes in the Francon quarry was examined in thin section. A very fine-grained rock from one dike was interpreted to be a nepheline microsyenite or micromonzosyenite, and a medium-grained, porphyritic rock was classified as a camptonite (D. Dolejs, personal communication, 2004). Roberts *et al.* (1990) have described one of the dike rocks in the alcove in the quarry as an "altered amygdaloidal basalt." Some of the minor sills in the alcove also appear to be basaltic.

The Saint-Michel Sills

Three major sills, exposed in the Francon quarry, are collectively referred to as the Saint-Michel sills: the weloganite-bearing upper and lower sills, exposed on the second and third levels, respectively, and a third sill that was exposed at the bottom of the third level. Very little information has been recorded about this now-inaccessible third sill.

Petrology and Chemistry

The upper Saint-Michel sill has an average thickness of about 2 meters, thinning from about 2.5 meters in the southeast to 1.2 meters in the northwest (Steacy and Jambor, 1969). It can be traced around the entire perimeter of the quarry, which covers an area of about 0.7 km^2. Exposures in the quarry walls and exploratory drill holes indicate that the sill extends in all directions beyond the present quarry limits. However, it does not appear in the currently exposed section of the southeast wall in the nearby Miron quarry, which is only 750 meters southwest of the Francon quarry.

***Figure 7.* Collecting minerals on the second level, near the northeast wall. Note the progressive reduction in sill thickness. L. Horváth photo, 1974.**

The sill is not a continuous horizontal sheet. In places the sill wedges out and reappears at a different stratigraphic horizon. In other places its emplacement changes abruptly, by up to about 10 meters, from one horizon to another. Sections of the sill have also been faulted, with displacements of several meters.

Steacy and Jambor (1969), Jambor *et al.* (1976), and Simpson (1980) have provided descriptions of the petrology and chemistry of the upper sill. The sill rock is dense, fine-grained, and predominantly pale gray, with darker gray blebs. Locally, it contains mineral-filled amygdules less than 1 cm in diameter. In some areas near its contact with limestone the sill rock has a coarsely mottled texture consisting of dark gray circular patches several centimeters across with pale gray rims set in a medium gray matrix. The contact between the sill and the limestone is sharp, with a thin (about 5 cm) chill zone that varies from greenish gray to dark green and brown. The limestone at the contact shows some discoloration and very minor recrystallization. In a few places, minor brecciation has occurred at the contact.

No detailed investigations have been carried out on the lower sill. It has an average thickness similar to the upper sill, and is also exposed around the entire perimeter of the quarry. The rock in the lower sill is a predominantly greenish gray to pale greenish brown color. Based on a visual examination of samples of the lower sill, Jambor *et al.* (1976) concluded that the upper and lower sills are "similar" and "unquestionably related, and likely derived from a common feeder." The most striking feature of both the upper and lower sills are the numerous, crystal-lined miarolitic cavities which constitute up to several percent of the volume of the sills. These are concentrated in the center to the upper quarter of the sills.

Petrologically, the sills are unique in being carbonate-rich with dawsonite as the main carbonate mineral (Jambor *et al.*, 1976). In thin sections, samples representative of the bulk of the upper sill show phenocrysts up to about 2.5 mm in maximum dimension, in a groundmass with a trachytic texture. The main constituents are dawsonite and fine laths of orthoclase, with minor dolomite and siderite. In some parts of the sill the groundmass contains fine needles of aegirine-augite. Other accessory minerals identified in the groundmass are albite, anatase, apatite group, calcite, magnetite, marcasite, perovskite, pyrite, pyrochlore, quartz, weloganite and zircon (Jambor *et al.*, 1976; Simpson, 1980). The phenocrysts are predominantly dawsonite pseudomorphs after analcime. Minor amounts of unaltered phenocrysts of analcime and lath-like phenocrysts of albite are also present. Some dawsonite has been observed to fill microfractures which cut across both the albite phenocrysts and the groundmass (Stevenson and Stevenson, 1977). No modal analyses of the sill rock are available. The color of the sill rock in the mottled zones near the contacts correlates with variations in the relative proportion of minerals in the groundmass: darker gray areas contain more carbonates whereas paler gray areas contain more orthoclase. The presence of aegirine-augite imparts a greenish color to the rock.

Whole-rock chemical analyses of the upper sill have been reported by Steacy and Jambor (1969), Jambor *et al.* (1976), and Simpson (1980). Steacy and Jambor investigated the horizontal distribution of zirconium, niobium and strontium in the sill by collecting and analyzing single-point samples around its entire perimeter. A selection of these samples representative of different parts of the sill was submitted to a full analysis by Jambor *et al.* Their analyses are reproduced in Table 1, together with averages of the zirconium, niobium and strontium concentrations measured by Steacy and Jambor. Simpson, who sampled the sill across its thickness at two locations, reported similar whole-rock analyses. A compositional profile across the sill at one of the locations is shown in Fig. 8. The results of all three studies demonstrate that the chemical composition of the sill is fairly uniform. Also included in Table 1 are calculated (Na + K)/Al molecular ratios. These indicate that the sill rock is marginally agpaitic (i.e. (Na + K)/Al = 1). Of the complex silicates of Zr, Nb and Ti that normally

Table 1. **Chemical analyses of upper sill rock, Francon quarry.**

	A	*B*	*C*	*D*	*E*	*F*
SiO_2 (%)*	45.50	49.80	44.70	47.90	48.90	—
Al_2O_3	19.70	20.10	18.60	20.20	21.70	—
Na_2O	8.60	8.60	8.40	8.90	9.80	—
K_2O	4.20	3.90	4.10	4.50	3.50	—
CaO	2.50	2.40	2.10	2.10	2.00	—
FeO	2.00	2.40	1.60	1.30	1.00	—
Fe_2O_3	0.20	0.10	0.80	1.00	1.10	—
MgO	0.80	1.00	1.20	0.70	0.90	—
MnO	0.25	0.26	0.24	0.25	0.27	—
SrO	0.05	0.21	0.26	0.17	0.16	0.14
BaO	0.18	0.20	0.21	0.19	0.20	—
TiO_2	0.27	0.35	0.29	0.36	0.26	0.31
ZrO_2	0.06	0.14	0.16	0.10	0.17	0.09
Nb_2O_5	0.12	0.13	0.09	0.14	0.15	—
P_2O_5	0.12	0.14	0.11	0.11	0.10	—
CO_2	11.00	7.80	12.70	6.30	2.90	—
H_2O	3.50	2.00	3.60	4.70	5.30	—
Total	99.05	99.53	99.16	98.92	98.41	—
$\frac{(Na_2O + K_2O)^{**}}{Al_2O_3}$	0.95	0.91	0.98	0.97	0.92	—

*Weight per cent; **Agpaicity index. Molecular ratio.
A—Gray rock, central part of sill, southwest face, near alcove (sample F-9, Jambor *et al.*, 1976).
B—Light part of mottled sill rock near contact, northwest face (sample F-21W, Jambor *et al.*, 1976).
C—Dark part of mottled sill rock near contact, northwest face (sample F-21D, Jambor *et al.*, 1976).
D—Greenish sill rock containing aegirine-augite, northeast face (sample F-32, Jambor *et al.*, 1976).
E—Greenish sill rock containing aegirine-augite, southeast face (sample F-39, Jambor *et al.*, 1976).
F—Average of 39 samples from the entire perimeter of the quarry (Steacy & Jambor, 1969; Jambor *et al.*, 1976).

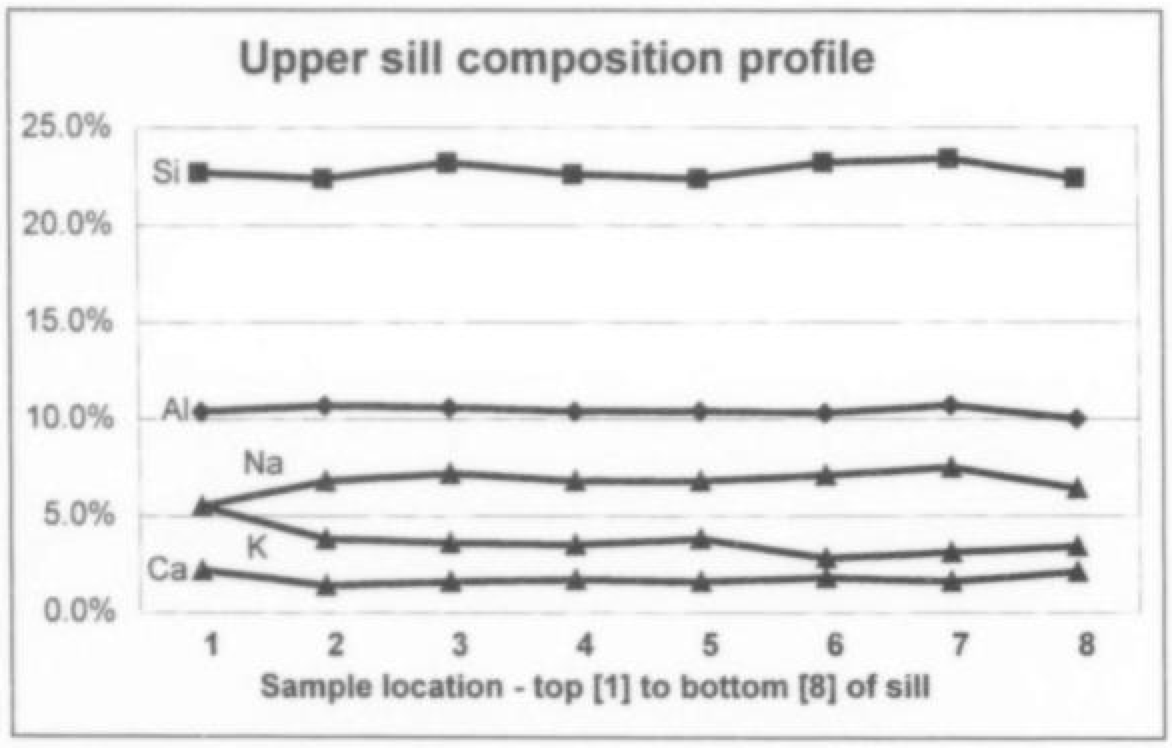

Figure 8. **Upper sill compositional profile, showing that the composition of the sill is relatively uniform (data from Simpson, 1980).**

characterize agpaitic rocks, only minor amounts of elpidite are present. They are replaced by carbonates and oxides of these elements, including weloganite, franconite, sabinaite and hochelagaite.

Based on its relatively high carbonate content, Jambor *et al.* (1976) classified the sill rock as a "silicocarbonatite" but noted that one of their samples (E in Table 1) approached an alkali syenite in composition and mineralogy. However, the sill rock does not meet the more widely accepted definition of a carbonatite as being a magmatic rock containing more than 50 percent by volume of carbonate minerals (Heinrich, 1966; Le Maitre *et al.*, 1989). On the basis of the chemical composition and relict primary mineralogy, Vard and Williams-Jones (1993) concluded that the sill rocks are more appropriately classified as altered agpaitic phonolites.

The origin and age of the Saint-Michel sills have not been investigated.[2] Grice (1989) speculated that the sills and Mont Royal had a common magmatic source. However, in an investigation of the trace-element chemistry and age of four mafic alkaline dikes in and around Mont Royal, Eby (1985, 1987) concluded that the dikes represent two episodes of igneous activity and emanated from a different magma source than the main Mont Royal intrusive mass. Their ages fell within two distinct intervals: 139 to 129 million years, and 121 to 117 million years. Since the Saint-Michel sills are cut by similar mafic alkaline dikes, Eby's data suggest that they have a minimum age of 117 million years. In the absence of trace-element chemistry, the relationship of the sills to the Mont Royal intrusion, if any, and the nature and source of the magma remain unknown.

Genesis of the Sill Rock and Mineralized Cavities

The fact that the Saint-Michel sills and their mineral assemblages are unique not only in the Monteregian province but worldwide, suggests that they formed under very unusual conditions. Fluid inclusions in the cavity minerals can provide some insight into the fluid composition, temperature and pressure that prevailed when the minerals crystallized.

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[2] The age cited by Simpson (1980) is for a carbonatite dike in another quarry also called the Francon quarry and located at Blackburn Hamlet near Ottawa, Ontario (K. L. Currie, personal communication, 2003).

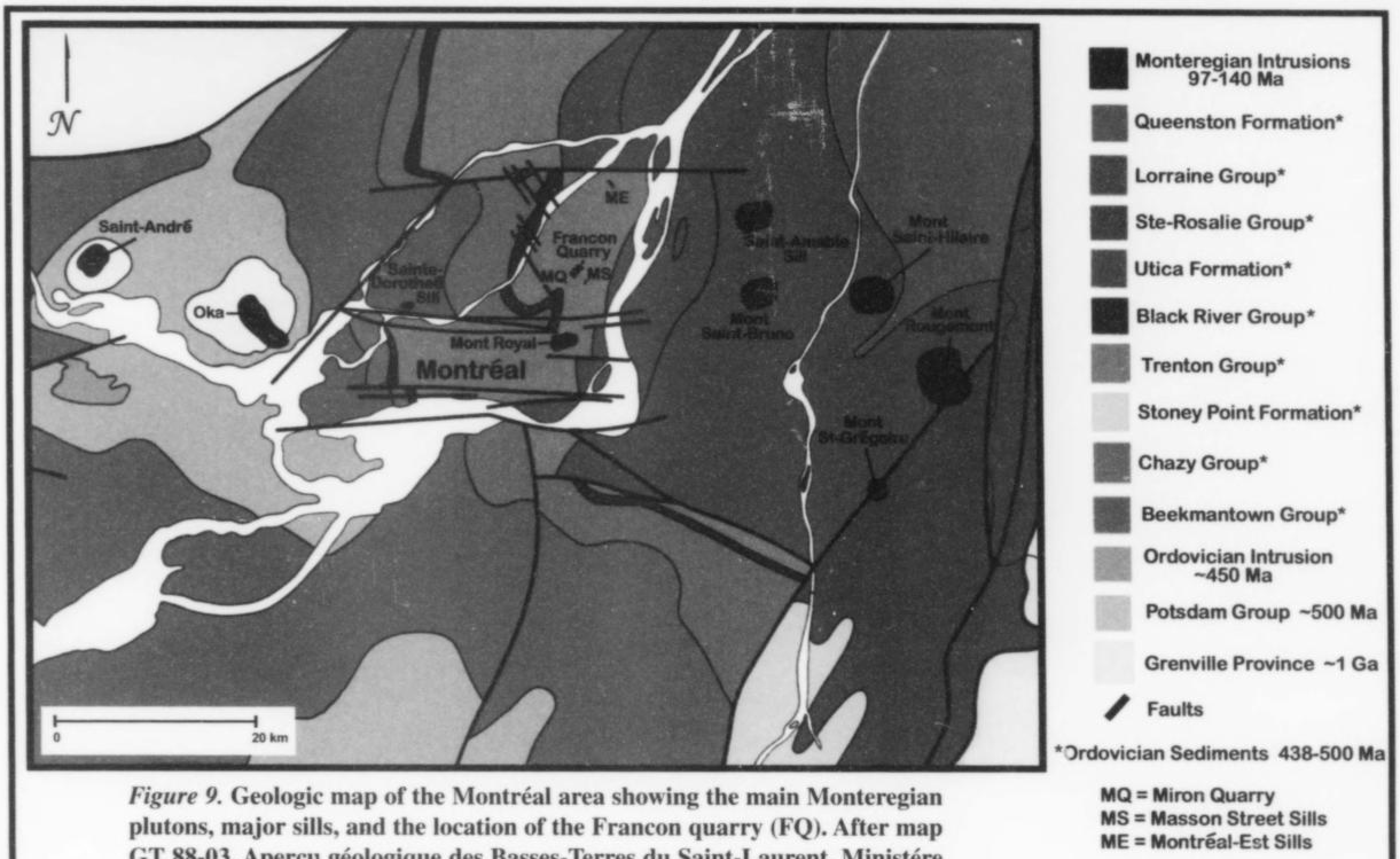

***Figure 9.* Geologic map of the Montréal area showing the main Monteregian plutons, major sills, and the location of the Francon quarry (FQ). After map GT 88-03, Aperçu géologique des Basses-Terres du Saint-Laurent, Ministére de l'Énergie et des Ressources (Mines) du Québec.**

Vard and Williams-Jones (1993) investigated the fluid inclusions in quartz, calcite and weloganite. The inclusions were found to variously contain a saline (NaCl) solution, a carbonic (CO_2) phase, and a solid phase (nahcolite, dawsonite or weloganite). Analyses of the salt residue from decrepitated inclusions showed a relatively high concentration of aluminum and sulfur in addition to sodium and chlorine. Microthermometric measurements on the inclusions indicated that quartz, calcite and possibly weloganite in the sill cavities crystallized at temperatures between 360° and 400°C at a pressure of 450 bars. Dawsonite and probably some of the other minerals crystallized at temperatures between 250° and 300°C, and nahcolite crystallized at temperatures below 120°C.

Jambor *et al.* (1976) and Vard and Williams-Jones (1993) have proposed similar models for the evolution of the phonolite immediately prior to or after it was intruded. As it cooled, the partially crystallized phonolite magma, consisting largely of phenocrysts of analcime and albite in a potassium-rich melt, exsolved a hydrous fluid charged with CO_2. As the fluid degassed, cavities were formed in the solidifying magma. Sodium, aluminum, chlorine, fluorine, sulfur and incompatible elements such as barium, strontium, zirconium, niobium and titanium partitioned into an aqueous phase. With a decrease in temperature, weloganite and other cavity minerals were precipitated from the saturated solution. Emplacement of the magma into the relatively cold limestone resulted in chilled margins that effectively sealed the fluids within the cooling magma under a relatively high lithostatic pressure. This promoted diffusion and infiltration of the fluids throughout the solidifying magma, causing pervasive late-stage alteration of analcime and other primary minerals to dawsonite. The alteration of analcime to dawsonite probably proceeded according to the reaction:

$$Na[AlSi_2O_6]\cdot H_2O + CO_2 = NaAl(CO_3)(OH)_2 + 2SiO_2$$

Vard and Williams-Jones likened the autohydrothermal processes in the sills to the phonolite having "stewed in its own juices." Local variations in temperature and solution chemistry resulted in a highly variable mineral assemblage and an often complex mineral paragenesis in the sill cavities, with crystallization of some minerals in two episodes.

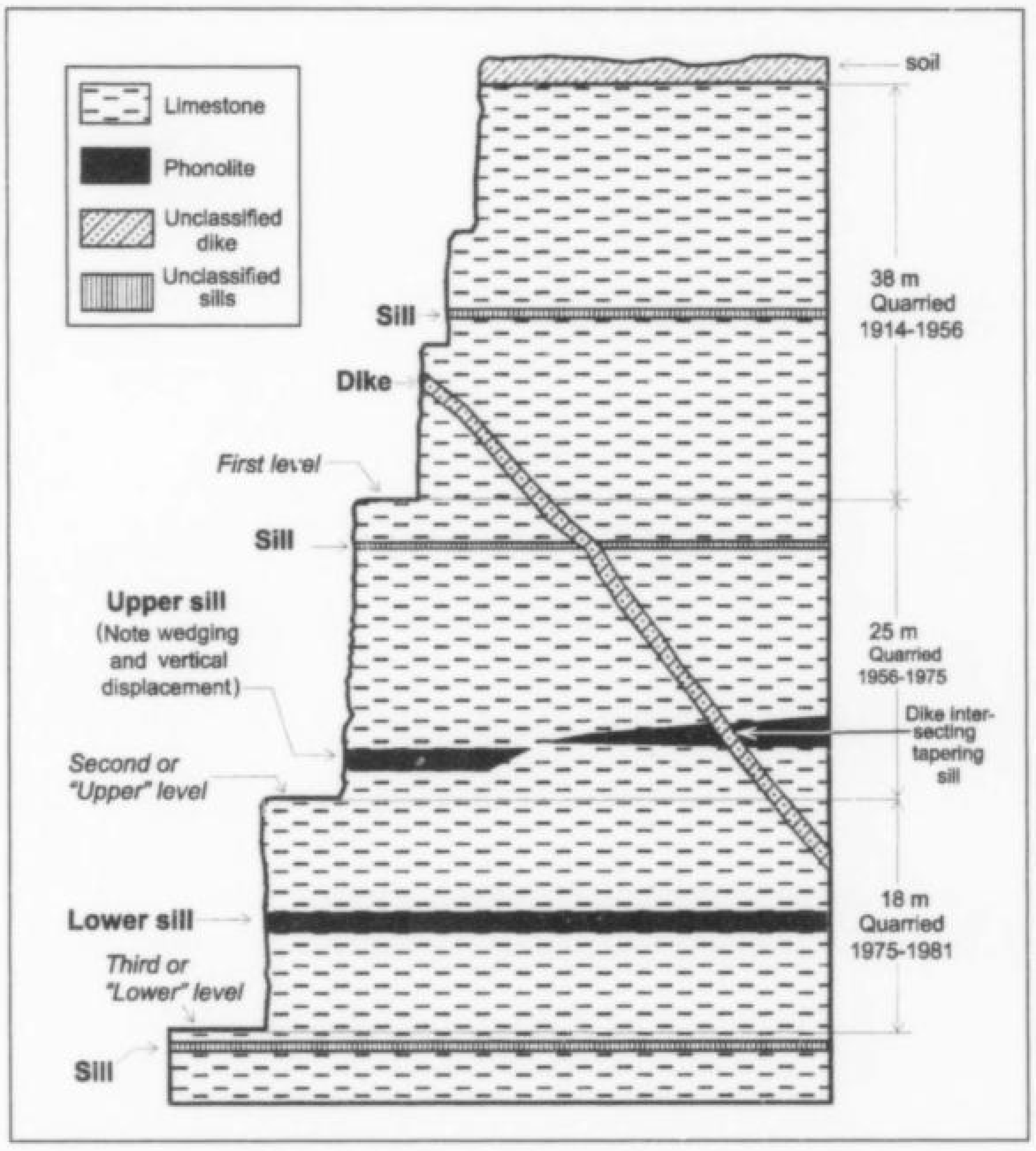

***Figure 10.* Geologic column in the Francon quarry area.**

Dawsonite of hydrothermal origin occurs in other dikes and sills in the Montreal area. At the type locality on the McGill University

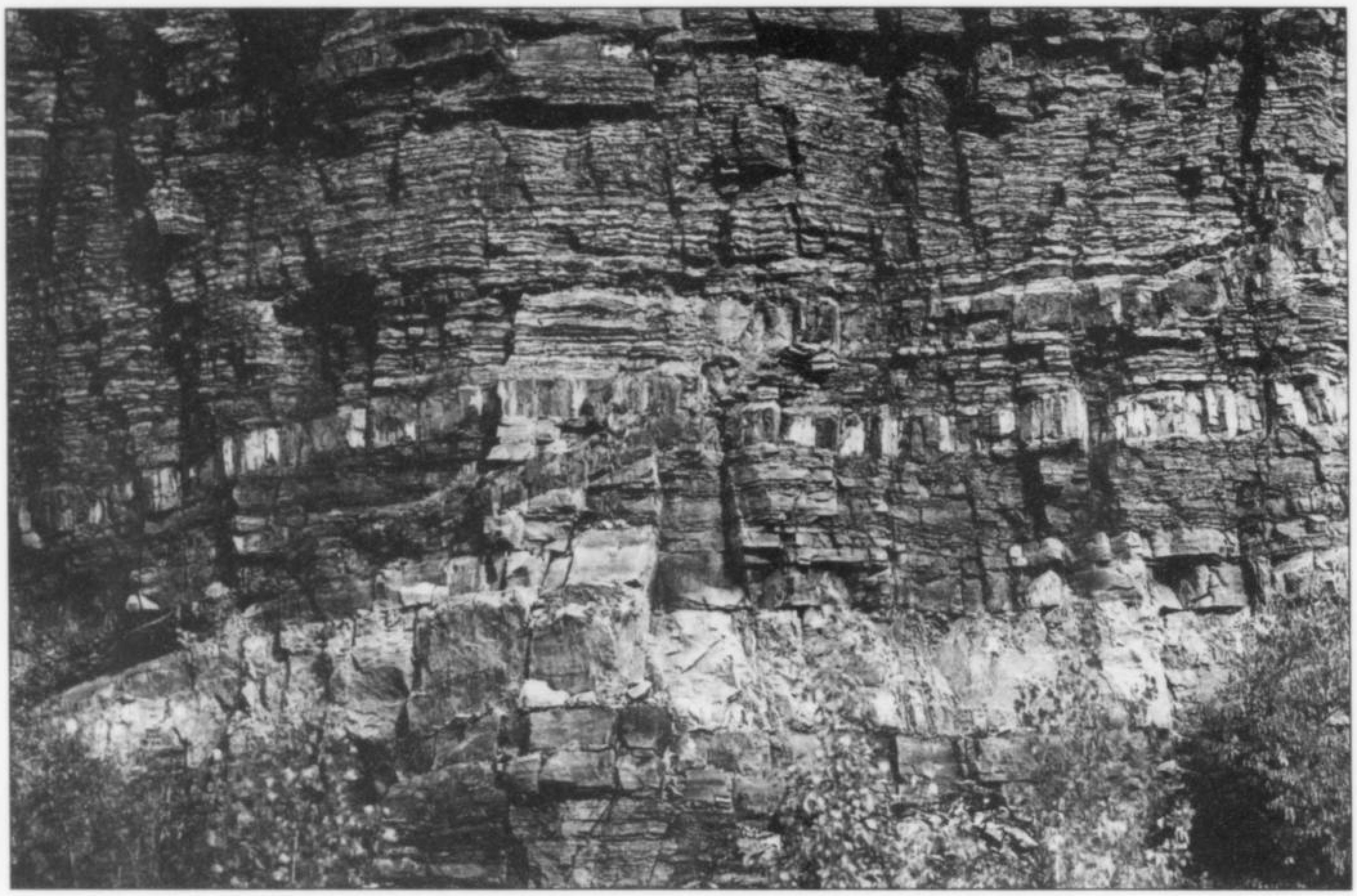

Figure 11. **Dike intersecting a small unclassified sill and the upper phonolite sill (lighter) near the "alcove" area. L. Horváth photo.**

campus, dawsonite is found along joints and as disseminated clusters in a feldspathic dike (Stevenson and Stevenson, 1965). Dawsonite has also been observed as a cavity mineral in feldspathic dikes about 1 km south of the McGill campus (Stevenson and Stevenson, 1977), and at Mont Saint-Bruno (Stevenson and Stevenson, 1978). In the phonolite sill at Saint-Amable, dawsonite is restricted to the hydrothermally altered contact zone and the rare hydrothermal pods (Horváth *et al.*, 1998). Dawsonite has also been found very sparingly in a lamprophyric sill in the Miron quarry (Sabina, 1978) and in the Lafarge Carrière Montréal-Est quarry. The latter sill is also the second of three known weloganite localities but here the mineral is extremely rare. Significantly, none of these occurrences contains a mineral assemblage comparable to that of the Saint-Michel sills, and petrographically they are all different, underlining the uniqueness of the Saint-Michel phonolite sills.

MINERALIZATION

The well-crystallized and rare species for which the Francon quarry is celebrated occur almost exclusively in cavities in the phonolite sills. A small but important suite of minerals is also found in some of the dikes and other sills, and a few common species are encountered in the limestone host rock.

Phonolite Sills

The sill minerals occur in miarolitic cavities, embedded in the sill rock, and in mineral-filled fractures extending into the surrounding limestone.

Miarolitic Cavities

The miarolitic cavities range in size from a few millimeters to more than 30 cm in maximum dimension. Most are in the 5–10 cm range. They vary in shape, from spherical to oblong, lenticular and irregular. Larger cavities are elongated and flattened in the plane of the sills. Often a series of cavities is strung out in groups aligned parallel to the sill contacts. The abundance of the cavities varies in different parts of the sill, and locally they may be almost absent.

An interesting phenomenon sometimes observed, when sill rock is broken up, is the sudden appearance of fluids seeping from newly exposed cavities. Although the fluids probably represent trapped meteoric water, they may also contain components derived from the original hydrothermal fluids. This would account for the occurrence of halite and nahcolite as patches on the surface of sill rock.

There are notable differences in the suite of minerals found in the upper and in the lower sills. Sabina (1979) denoted the minerals in the upper sill as "assemblage A." This assemblage consists of albite, quartz, dawsonite, weloganite and calcite as the principal minerals, with less abundant strontianite, barite, cryolite, fluorite and pyrite. The mineral assemblage in the lower sill, denoted as "assemblage B," consists predominantly of calcite, dawsonite, weloganite, fluorite, quartz, analcime and albite, with fairly abundant strontianite, celestine, barite, montmorillonite, marcasite and hematite. Of the new species first described from the Francon quarry, only weloganite and doyleite are found in both sills, whereas the occurrence of dresserite, hydrodresserite, strontiodresserite, sabinaite and montroyalite is confined to the upper sill. Table 2 lists all the minerals known to occur in the cavities, with an estimate of their relative abundance.

Within the sills, the cavity mineralization is highly variable. The cavities are most commonly lined with crystals of one or more of the following species: quartz, calcite, albite, dawsonite and analcime. Crystals of many other species occur implanted on the cavity linings, following a rather well-defined paragenetic sequence. Some cavities afford clean crystals, whereas in other cavities the crystals are commonly coated or crusted over. Several of the type minerals from the Francon quarry form at least part of these

***Table 2.* Distribution and rarity of minerals in the Francon quarry.**

		Phonolite sills					
		Cavities		Sill	Dikes*		Lime
Mineral	Quarry	Upper	Lower	Rock	Cavities	Rock	stone
Aegirine	R		R				
Albite	C	VC	C				
Almandine	VR			VR			
Amphibole group	C					VC	
Analcime	C	R	VC	VR	R		
Anatase	VR	VR	VR	VR			
Ankerite	C		C		R		
Apatite group	VR			R	VR	R	
Baddeleyite	VR	ER	VR				
Barite	C	R	C				VR
Bastnäsite series	ER		ER				
Biotite group	VR		ER	VR		C	
Brookite	R	R	R				
Calcite	VC	VC	VC	C	R		VC
Celestine	C	R	VC		VR		
Cerussite	ER		ER				
Chromite	ER					ER	
Cristobalite	R		R		VR		
Crocoite	ER		ER				
Cryolite	R	R	R				
Dachiardite-Na	ER		ER		ER		
Dawsonite	VC	VC	VC	VC			VR
Dickite	ER	ER					
Dolomite	R	VR	R		R		C
Doyleite	VR	VR	VR				
Dresserite	C	C					
Elpidite	VR		VR				
Fluorite	VC	C	VC		ER	R	
Franconite	ER	ER					
Galena	R	R	R				
Garronite-like m.	ER				ER		
Gibbsite-like m.	C	C	C				
Gismondine	ER		ER				
Glauconite series	ER			ER			
Gmelinite series	ER	ER					
Goethite	R		C				
Graphite	ER			ER?			
Gypsum	VR				VR		
Halite	ER	?	?	ER			
Halloysite	VR	VR	VR	VR			
Halotrichite	VR	VR	VR				
Harmotome	ER	ER					
Hematite	C		C				
Hochelagaite	ER	ER					
Humboldtine	ER	?	?				
Hydrocerussite	ER		ER				
Hydrodresserite	C	C					
Ilmenorutile	VR	VR	VR				
Kaolinite	R	VR	R				
"K-feldspar"	R		R	C	R		
Magnetite	VR			VR			
Marcasite	VC	VC	VC				C
Molybdenite	ER	ER					
Montmorillonite	R		R				
Montroyalite	ER	ER					
Mordenite	VR		VR		VR		
Nahcolite	ER	?	?	ER			
Natrojarosite	VR		VR				
Natrolite	VR		VR				
Olivine group	VR					C	
Paratacamite	ER	ER					
Phillipsite series	ER				ER		
Phlogopite	VR		ER	VR			
Pseudorutile	VR	VR	VR				
Pyrite	C	C	C	C	C		C
Pyrochlore	VR	ER?	ER?	VR			
Pyrrhotite	VR		VR		VR		VR
Quartz	VC	VC	VC	C	VR		R
Rozenite	VR	VR	VR				
Rutile	ER	?	?				
Sabinaite	VR	VR					
Saponite	ER				ER		
Serpentine series	ER					C	
Siderite	R	VR	R				
Smythite	VR	VR	ER				
Sphalerite	C	C	C	VR			VR
Strontianite	VC	VC	C		VR		C
Strontiodresserite	VR	VR					
Sulfur	VR	VR	VR				
Synchysite-(Ce)	VR	VR	VR		ER		
Talc	ER					VR	
Thaumasite	ER					ER	
Thenardite	ER			ER			ER
Thorbastnäsite	ER		ER				
Viitaniemiite	ER	ER					
Voggite	ER				ER		
Weloganite	VC	VC	VC				
Wurtzite	ER		ER				
Zircon	VR		ER	VR			
"Bitumen"	C	C	?				

Legend: ER = extremely rare; VR = very rare; R = rare; C = common; VC = very common; ? = distribution and/or rarity uncertain;
* includes minor sills

coatings and crusts. Late-stage dissolution and replacement of cavity minerals is also commonly observed.

Certain mineral associations are common and repeatedly found in the cavities. Others have been found on only one or a few occasions.

Fig. 12 summarizes the observed paragenetic sequence of mineralization in the sill cavities for the more common species. Because of the highly variable and sometimes complex cavity mineralization, there is some uncertainty in the paragenetic relationship among some of the species shown, particularly for the lower sill. Nevertheless, fairly consistent trends are observed in the emplacement of minerals which occur in both sills. A notable feature of many cavities is the presence of two generations of the most common minerals.

Sill Rock Minerals

A number of mineral species are found only in the sill rock. Those occurring as embedded euhedral to anhedral grains, such as

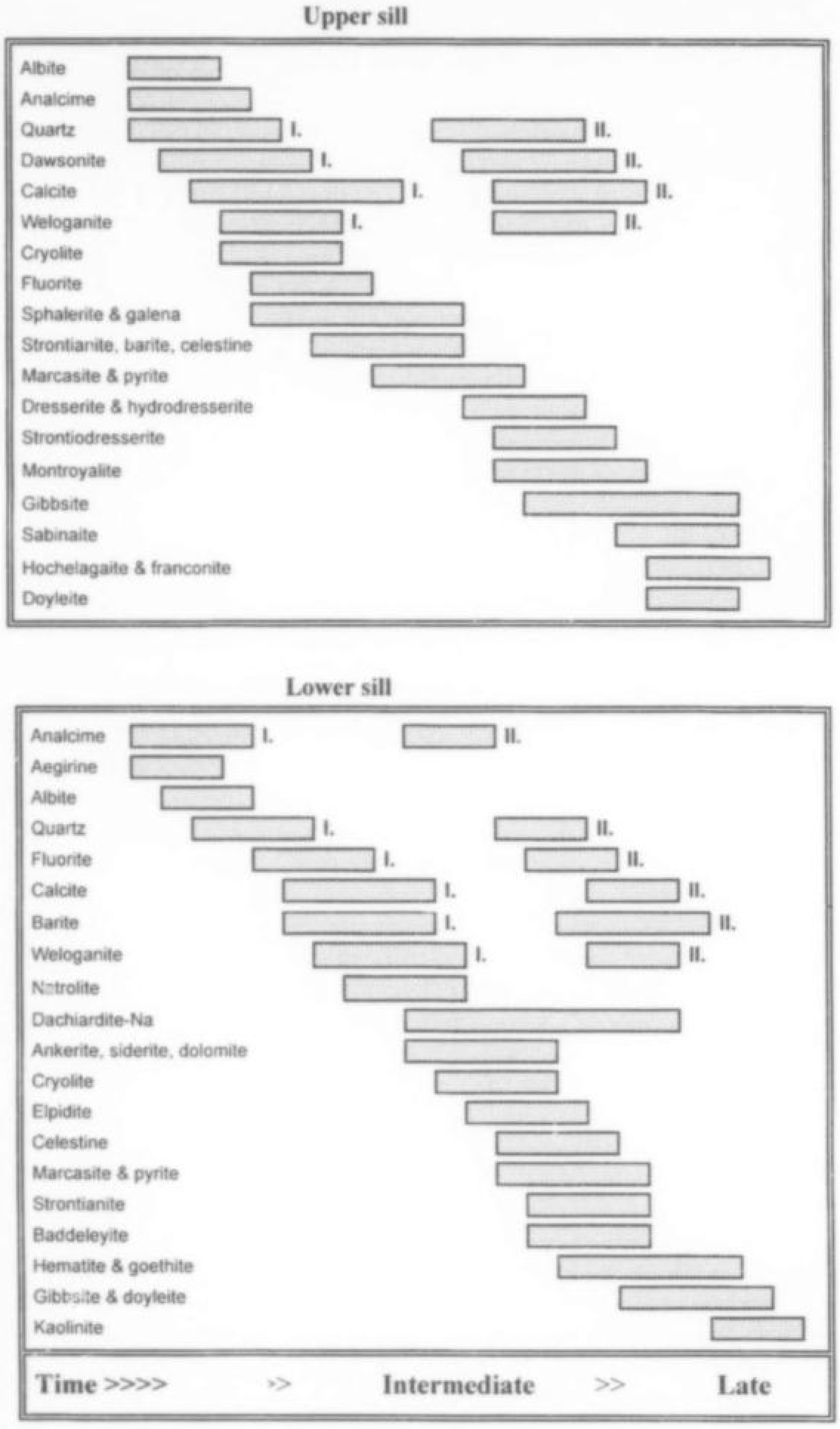

Figure 12. **Composite parageneses of sill cavities.**

apatite, are essentially accessory minerals which are distinguishable because of their size (up to 1 mm) in relation to the fine-grained matrix. The sill rock commonly has a spotted appearance due to the segregation of rock-forming and other minerals into blebs or patches a few millimeters across.

More conspicuous are amygdule-like mineral-filled cavities up to a centimeter in size. They usually contain white carbonate minerals and stand out in contrast to the darker matrix. They tend to be flattened and elongated parallel to the sill contacts. Locally, they can be quite abundant, especially in the lower sill.

Mineralized Fractures

Very rarely encountered are mineralized fractures extending from the sills into the host limestone. Simpson (1980) noted an area below the lower sill where the limestone had been altered by hydrothermal solutions penetrating joint planes. One of the present authors (PT) observed an open fracture containing well-crystallized dawsonite with strontianite and calcite. Chamberlain and Doell (1982) reported similar occurrences of dawsonite, and of strontianite associated with celestine.

Dikes and Minor Sills

With a few notable exceptions, most of the dikes and minor sills in the quarry contain little of real interest to mineral collectors. The new species voggite (Roberts *et al.*, 1990), a sodium-zirconium phosphate-carbonate, was discovered in a dike cutting the upper phonolite sill, and was postulated to have formed by reaction between the intruding dike magma and the zirconium-rich sill. A garronite-like zeolite mineral, a potentially new species, has been found in one of the minor sills.

Conspicuous in some of the porphyritic dikes are large phenocrysts of various ferromagnesian minerals.

Limestone Host Rock

Mineralization in the limestone formations exposed in the Francon quarry is limited to occasional small cavities, veins and solid pods containing common minerals such as calcite, dolomite, strontianite, barite, quartz, pyrite and marcasite.[3]

MINERALOGY

The mineralogy of the Saint-Michel sills in the Francon quarry is unique, not only in the Monteregian Hills alkaline igneous province but also globally. Although some of the type minerals—weloganite, doyleite, franconite, sabinaite, strontiodresserite and hochelagaite—have been found elsewhere, most notably in two other Monteregian province localities (Mont Saint-Hilaire and Saint-Amable), others like dresserite, hydrodresserite, montroyalite and voggite remain unique to the Francon quarry. The abundance of well-crystallized dawsonite in itself makes the quarry an important locality on a worldwide scale. Including what are essentially rock-forming minerals, a total of 90 mineral species have been reported from the quarry (Table 3). They include two native elements, eight sulfides, 18 oxides, 8 sulfates, three halides, 18 carbonates, three phosphates, 28 silicates and two organic minerals.

For the mineral collector, the task of identifying Francon minerals using visual characteristics and simple chemical tests ranges from very easy for such species as weloganite, dawsonite, calcite, quartz and some cryolite, to very difficult or impossible for such species as franconite, hochelagaite, doyleite, sabinaite and montroyalite, which are all white and occur as tiny globules, coatings and encrustations, often as a mixture of two or more species. Minerals in the latter category require instrumental analysis for proper identification, at least X-ray diffraction analysis, and the results can only be applied to the specimen analyzed or at best to identical specimens from a particular cavity. For some minerals the response to ultraviolet radiation (see below) can be helpful in their identification. Certain associations of minerals in which one species is an indicator of the possible presence of another, e.g. hematite and baddeleyite, can also be helpful (Sabina, 1979; Cares, 1993). Various aids to identification have been noted in the mineral descriptions which follow.

Unknown and Undetermined Minerals

From the beginning of her investigation of the Francon quarry minerals, Ann P. Sabina (APS) of the Geological Survey of Canada (GSC), applied consecutive numbers to minerals that instrumental analysis suggested were "unknowns" and possible new species (Sabina, 1976, 1979, 1994). In the mineral descriptions below these appear as APS Nos.1–15. Although the minerals have now all been identified, the numbers are still worth remembering because they appear in various earlier mineral lists and publications.

A number of minerals reported from the locality have not been fully characterized, either as to species within a group, or within a

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[3] Fine specimens of calcite and dolomite have been found in Beekmantown Group dolomitic limestones in quarries off the Island of Montréal. In the stratigraphic column the Beekmantown Group lies below the Chazy Group and is not exposed in the Francon quarry.

Table 3. **Classified list of Francon quarry minerals.**

Elements
Graphite
Sulfur

Sulfides
Galena
Marcasite
Molybdenite
Pyrite
Pyrrhotite
Smythite
Sphalerite
Wurtzite

Halides
Cryolite
Fluorite
Halite

Oxides & hydroxides
Anatase
Baddeleyite
Brookite
Chromite
Cristobalite
DOYLEITE
FRANCONITE
Gibbsite-like mineral
Goethite
Hematite
HOCHELAGAITE
Ilmenorutile
Magnetite
Paratacamite
Pseudorutile
Pyrochlore
Quartz
Rutile

Carbonates
Ankerite
Bastnäsite series
Calcite
Cerussite
Dawsonite
Dolomite
DRESSERITE
Hydrocerussite
HYDRODRESSERITE
MONTROYALITE
Nahcolite
SABINAITE
Siderite
Strontianite
STRONTIODRESSERITE
Synchysite-(Ce)
Thorbastnäsite
WELOGANITE

Sulfates
Barite
Celestine
Crocoite
Gypsum
Halotrichite
Natrojarosite
Rozenite
Thenardite

Phosphates
Apatite group
Viitaniemiite
VOGGITE

Silicates
Aegirine
Albite
Almandine
Amphibole group
Analcime
Biotite series
Dachiardite-Na
Dickite
Elpidite
Garronite-like mineral
Gismondine
Glauconite series
Gmelinite series
Halloysite
Harmotome
Kaolinite
"K-feldspar"
Montmorillonite
Mordenite
Natrolite
Olivine group
Phillipsite series
Phlogopite
Saponite
Serpentine series
Talc
Thaumasite
Zircon

Organic minerals
"Bitumen"
Humboldtine

CAPITALIZED species are type minerals

Table 4. **New species discovered in the Francon quarry.**

Mineral	*Reference*
Weloganite	Sabina *et al.* (1968)
Dresserite	Jambor *et al.* (1969)
Hydrodresserite	Jambor *et al.* (1977)
Strontiodresserite	Jambor *et al.* (1977)
Sabinaite	Jambor *et al.* (1980)
Franconite	Jambor *et al.* (1984)
Doyleite*	Chao *et al.* (1985)
Hochelagaite*	Jambor *et al.* (1986)
Montroyalite	Roberts *et al.* (1986)
Voggite	Roberts *et al.* (1990)

*Co-type locality with Mont Saint-Hilaire

series. In most cases these will require a full chemical analysis, and for some minerals there is currently insufficient material available.

Type Minerals

To date, the Francon quarry is the type locality, or the co-type-locality with Mont Saint-Hilaire, for ten new mineral species. These are listed in Table 4 in chronological order of their description.

Fluorescent Minerals

A number of Francon quarry minerals are fluorescent and/or phosphorescent in response to ultraviolet radiation. Table 5 details the responses observed under shortwave, medium-wave and longwave ultraviolet radiation. Where different specimens of the same species have given different responses, they are listed separately. It should be noted that the responses given here may differ from those reported elsewhere because of the particular specimens investigated or the particular ultraviolet wavelength and power level employed. The equipment used in the present study was manufactured by WTC (Way Too Cool) Inc. The wavelength specifications were 254 nm for shortwave, 312 nm for medium-wave, and 352 and 368 nm (combined in Table 5) for longwave. The ultraviolet radiation sources were rated at 8 W (watts) for the short and medium wavelengths, and 18 W for the 352-nm longwave lamp.

Mineral Descriptions

The following mineral descriptions are based on published descriptions, especially those of Sabina (1976, 1979) and the various papers describing the new species and other minerals from the Francon quarry, on unpublished material provided to the authors, and on the authors' collecting records and the examinations of many hundreds of specimens in private and institutional collections. With a few exceptions, the authors have examined confirmed specimens of all the species described. In the course of this study, several minerals not previously reported from the Francon quarry were identified. A large proportion of the studied specimens are in the collection of the authors, assembled beginning in 1968 but especially during an intense period of collecting in 1973–1980 when the quarry was most active. Most of the very rare and unusual species were examined in the special Francon quarry study collection of analyzed and documented mineral specimens assembled by Sabina and now deposited in the Reference Series of the National Mineral Collection housed at the GSC in Ottawa. Some of these specimens have been referenced in the mineral descriptions with a specimen number and the prefix GSC APS. Other Francon quarry specimens were examined in the Display Series of the National Mineral Collection housed at the Canadian Museum of Nature, Gatineau, Québec, and in the collections of the Redpath Museum, McGill University, Montréal, and Donald V.

Table 5. **Fluorescent minerals of the Francon quarry.**

	Shortwave 254 nm					*Medium-wave 312 nm*					*Longwave 352 nm & 368 nm**					
	Fluorescence		*Phosphorescence*			*Fluorescence*		*Phosphorescence*			*Fluorescence*		*Phosphorescence*			
Minerals	*Color*	*Intensity*	*Color*	*Intensity*	*Duration*	*Color*	*Intensity*	*Color*	*Intensity*	*Duration*	*Color*	*Intensity*	*Color*	*Intensity*	*Duration*	*Comments*
Calcite I.	red	W				red	S									
Calcite II.	pink	S				bright pink	S									
Cryolite I. (yellow)	creamy white	S	white	W	S	greenish yellow	M	white	W	S	brownish yellow	W				
Cryolite II. (colorless)	white	S	white	W	S											
Dachiardite-Na	orangy white	W				orange	W				orangy brown	W				
Dawsonite	pale yellow	M				pale yellow	M				pinkish yellow	M & W*				Very rare reaction
Dresserite I.	yellowish white	S	white	M	S	yellowish white	S	white	M	S	greenish yellow	S	white	M & W*	S	
Dresserite II.	pale yellow-white	M	white	M	S	pale yellow-white	M	white	M	S	pale yellow-white	M	white	M & W*	S	
Elpidite	greenish yellow	M														
Gibbsite-like	whitish yellow	M	white	W	S	yellow	M	white	W	S	whitish yellow	M				
Gypsum I.	orange	M				orange	M				orange	M				
Gypsum II.	whitish yellow	M				whitish yellow	M				whitish yellow	M				
Kaolinite	whitish yellow	M				yellow	M				whitish yellow	M				
Montroyalite	yellow	M				orange-yellow	M				orange-yellow	M				Only one examined
Mordenite	whitish yellow	W				pale yellow	W				pinkish yellow	W				
Natrolite	white	W				white	W				white	W				
Quartz	orange	M				orange	M				orange	M				Rare reaction
Strontianite I.	yellowish white	S	yellowish white	M	M	yellowish white	S	yellowish white	S+	M	yellowish white	S	yellowish white	S	M	
Strontianite II.	pinkish violet	M				pinkish violet	M				greyish white & green	W & M*				
Strontianite III.	greyish white	M	white	M	M	greyish white	M	white	M	M	greyish white	M	white	W	M	
Weloganite I.	pale orange	M														
Weloganite II.	orange	M				greenish yellow	W				orange brown	W				

The above reactions were confirmed by the authors (LH & EPH part time) and J. Poulin, on multiple specimens for most species, using identical techniques and equipment under uniform conditions.

The following reactions were reported (R. A. Ramik, 2004, personal communications) but could not be confirmed by the authors. Fluorescence was not reported in the original species descriptions.

Hydrodresserite											white	W				
Strontio-dresserite	yellowish white	M									yellowish white	M				

Legend: Intensity: S = strong; M = medium; W = weak. Duration: S = short; M = medium; L = long. Minerals: Weloganite I. & II. represent different UV reactions.

Doell of Grafton, Ontario.

Mineralogists from several institutions participated in the characterization and description of the new mineral species from the Francon quarry. Taking a lead role were Sabina and her colleagues at the GSC, especially J. L. Jambor, later with the Canada Centre for Mineral and Energy Technology (CANMET), and A. C. Roberts. Also contributing to the description of the new species were mineralogists from the Royal Ontario Museum, Carleton University, CANMET, and the Canadian Museum of Nature. Their work is referenced throughout. Most of the identifications of the other species described here were also made at the GSC, notably by A. C. Roberts (X-ray diffraction analysis). Other mineral identification work was carried out by G. Y. Chao of Carleton University, Ottawa, and R. A. Gault and R. Rowe of the Canadian Museum of Nature, Gatineau.

MINERALS

Aegirine $NaFe^{3+}Si_2O_6$

Aegirine is a relatively rare cavity mineral in the lower sill, found most commonly in the north corner of the quarry. It occurs as vitreous, transparent, typically bicolored, very sharp, thin bladed crystals, 1–3 mm long. The color grades from pale olive-green in the center of the blades to pale brown at the edges. Aegirine is paragenetically one of the earliest minerals in the cavities, and is associated with analcime (usually as a cavity lining), ankerite, dolomite, quartz (mostly etched crystals), siderite, albite, weloganite, fluorite and, rarely, tiny rosettes of brookite. In some earlier lists of Francon quarry minerals, aegirine is listed as clinopyroxene or acmite.

Albite $NaAlSi_3O_8$

Albite is very common as a drusy cavity lining in both the upper and lower sills. It occurs as vitreous to dull, colorless to opaque white plates up to 3 mm long. The plates consist of individual crystals stacked along [010] with sharply pointed terminations extending from the plates, producing a serrated edge. Some of the colorless plates show a peculiar faden-like effect. Associated minerals include nearly all the cavity minerals. Albite is listed as plagioclase in some earlier publications.

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

Reported by Sabina (1979) as a rare accessory mineral in the sill rock, almandine occurs as pale pinkish, granular aggregates, admixed with gray quartz, in patches up to 1.5 cm in diameter. Visually distinct almandine aggregates are up to 3 mm in diameter. Massive dawsonite is associated with the almandine-quartz patches.

Amphibole group

Amphiboles are common rock-forming minerals in some of the dike rocks in the quarry and may be visible as phenocrysts. A clinoamphibole has been identified by X-ray diffraction as brown laths in a dike in the alcove, and also as black grains and patches in sill rock (Sabina, personal communication, 2004). A chemical analysis would be required to determine the specific member(s) of the amphibole group present.

Analcime $Na[AlSi_2O_6]\cdot H_2O$

A common species in the lower sill, and rarer in the upper sill, analcime occurs as transparent to translucent to opaque, colorless, white, pale brown, yellow brown, orange and pale green crystals with a vitreous to waxy to dull luster. The crystals range in size from a few millimeters to nearly 1 cm in diameter. The predominant form is the {211} trapezohedron, often modified by small

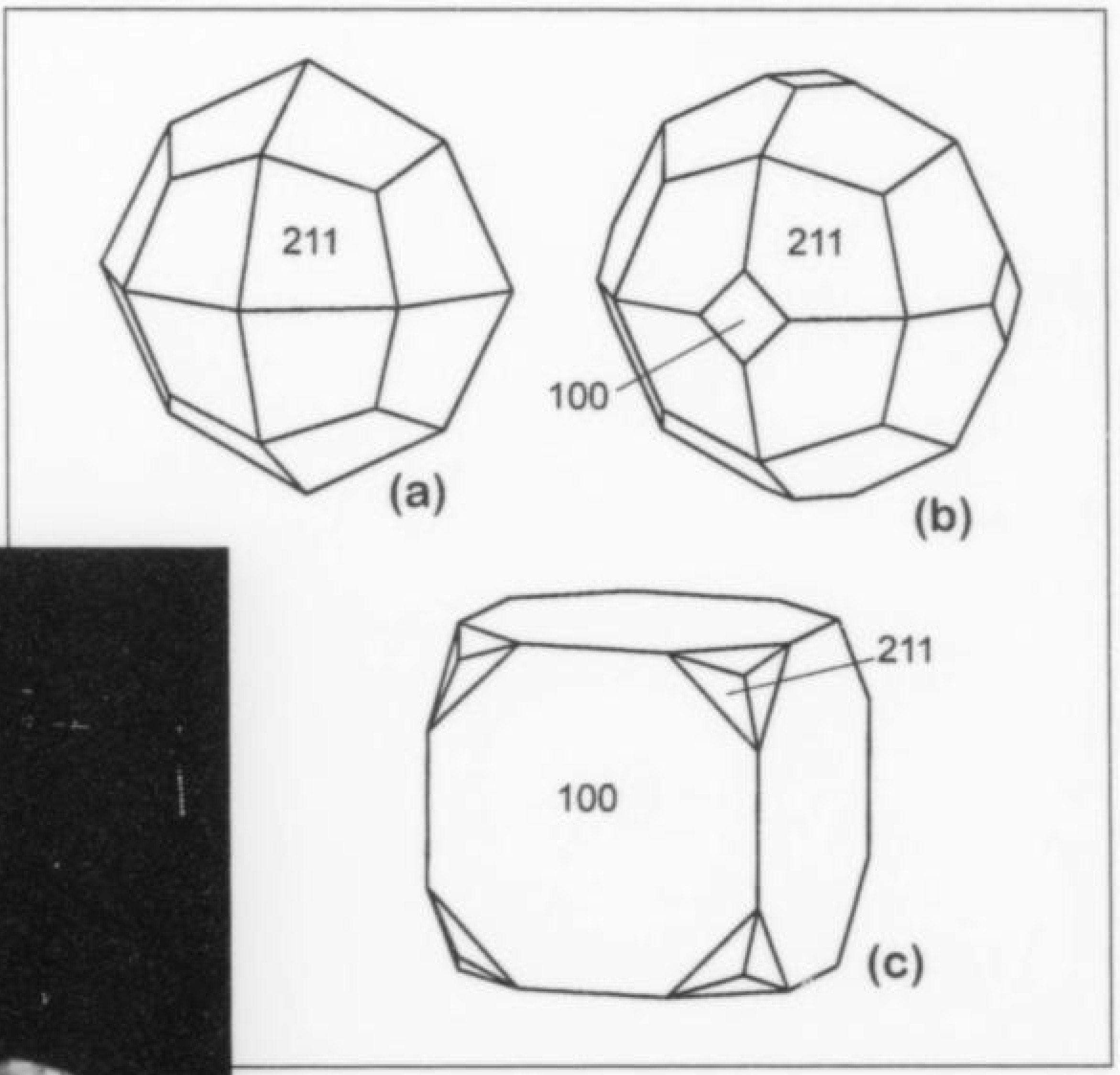


Figure 13. (above) Analcime crystal drawings: (a) the most common habit, defined by the {211} trapezohedron; (b) the {211} trapezohedron modified by small faces of the {100} cube; and (c) the predominantly cubic habit modified by small faces of the {211} trapezohedron.

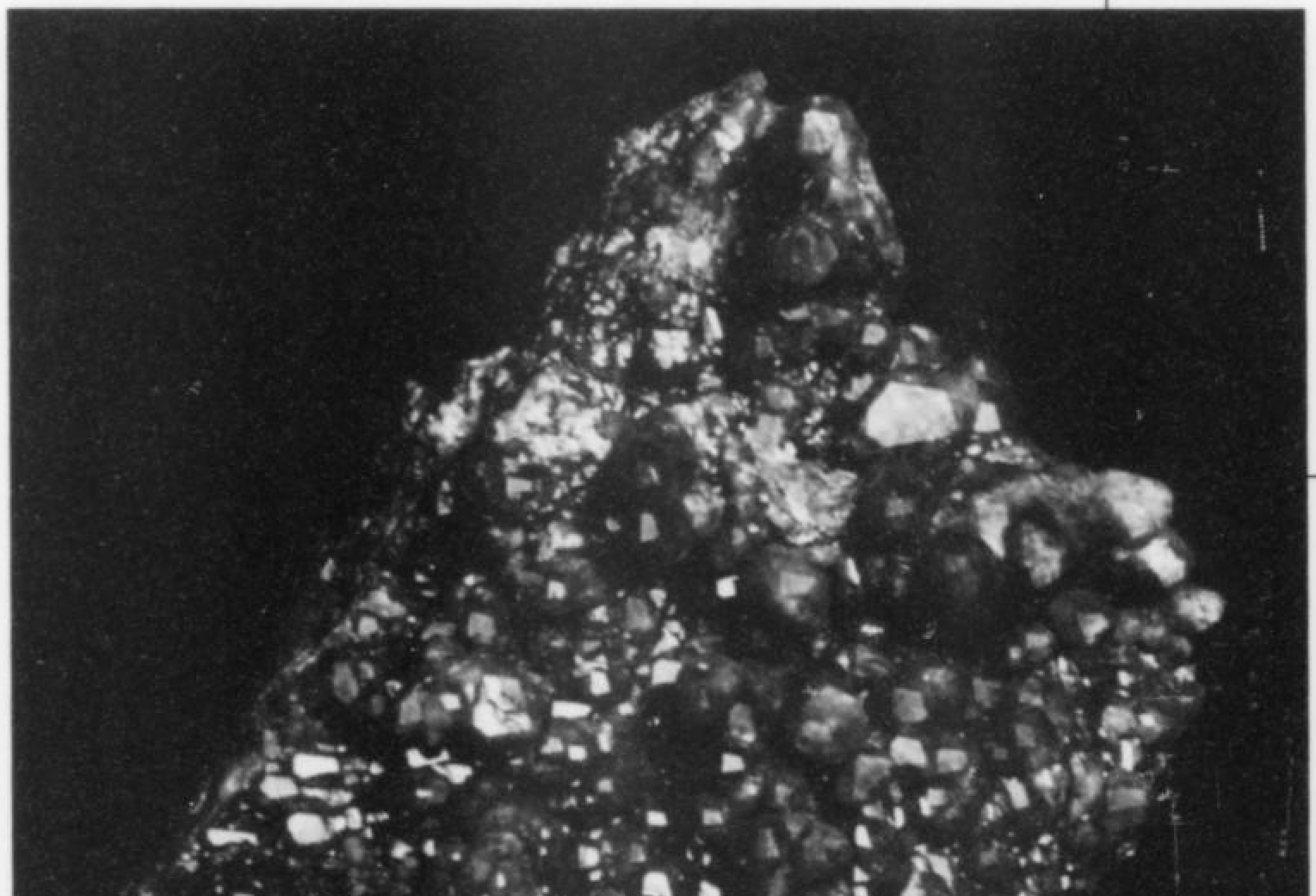


Figure 14. (left) Analcime-lined crystal cavity, 4 × 4.5 cm. Tarassoff collection no. 2390; L. Horváth photo.

cube faces. However, cubic crystals with dominant {100} modified by {211} are not uncommon. In the lower sill, analcime crystals commonly occur as a drusy cavity lining, commonly in parallel growth, and as globular aggregates of colorless to pale brown crystals. Analcime has also been identified as powdery and porcelaneous aggregates, as thin shells of crystals from which most of the mineral has been leached out (Sabina, 1979), and as small crystalline masses in the sill rock. Chamberlain and Doell (1982) have reported the occurrence of analcime pseudomorphs after an unidentified orthorhombic mineral in the lower sill. Analcime is one of the earliest minerals in both the upper and lower sill cavities. It is commonly found completely overgrown by later species such as fluorite, dawsonite and ankerite. Associated minerals include nearly all the cavity minerals.

Analcime has also been found in cavities in a dike in the alcove as hemispherical intergrowths of colorless trapezohedra, and as opaque white cubes modified by small trapezohedral faces, less than 1 mm in size. Associated minerals include dolomite, mordenite, cristobalite and synchysite-(Ce). In other dike occurrences, crystals of analcime colored red by unidentified inclusions line calcite-filled fractures; a cavity lined by analcime crystals was found filled by aggregates of sharp, colorless to pale yellowish gypsum crystals and thin, bladed strontianite crystals.

Anatase TiO_2

Anatase has been identified in sill cavities as tan, powdery coatings, and as gray, submetallic, flaky aggregates associated with siderite and ilmenorutile. It also occurs in the sill rock as embedded, pale brown, flaky aggregates less than 0.5 mm across. It is very rare, and visual identification is unreliable.

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

A very common mineral in the lower sill, ankerite occurs as aggregates of transparent to translucent, predominantly yellow and less commonly beige, greenish yellow, and pale brownish yellow rhombohedra, 1–2 mm in diameter, with a vitreous luster. Some of the crystals appear rounded due to the presence of indistinct second-order rhombohedrons as modifying faces. Mosaic-like growth features are observed on some faces. Ankerite has also been found as spherical aggregates of yellow prismatic crystals; white tabular crystals forming rosettes and curved stacked aggregates; white fibers forming spheres; and yellowish green fibrous and granular masses.

Ankerite is an early to late-stage mineral in the cavities. It is often closely associated with siderite, and is commonly observed in cavities containing a dawsonite-celestine-goethite-hematite assemblage. Other associated minerals include calcite, dolomite, analcime, fluorite and weloganite, and very rarely also baddeleyite, dachiardite-Na, mordenite and bastnäsite. Sight identification of ankerite is not reliable because the associated dolomite and siderite can be quite similar in morphology and physical appearance. Because ankerite forms a solid solution series with dolomite, determining which species is present can be problematic even with X-ray diffraction analysis. For this reason, ankerite appears in some Francon quarry species lists as "dolomite-ankerite series" (Sabina, 1976).

Apatite group $Ca_5(PO_4)_3F$

An apatite group mineral, most likely fluorapatite, was reported to occur in sill rock as "euhedral to anhedral grains of apatite averaging about 0.04 mm" (Jambor *et al.*, 1976), and as "smoky transparent grains" (Sabina, 1979). Colorless grains, and colorless, well-formed, hexagonal prisms up to 3 mm have been observed embedded in dike rock containing phenocrysts of an undetermined amphibole group mineral.

Figure 15. **Baddeleyite pseudomorphous after weloganite (yellow) with fluorite (purple) and dawsonite. The field of view is about 5 mm across. Horváth collection (no. 3867); L. Horváth photo.**

Baddeleyite ZrO_2

The Francon quarry is the second known locality for baddeleyite in Canada. It is a very rare species in cavities in the lower sill at the north end of the quarry, and at least one specimen is known from the upper sill (alcove section). Baddeleyite occurs as vitreous to waxy, tan, pale yellow and yellowish brown, scaly, finely granular, powdery, lamellar and cellular aggregates up to 1 cm across. The aggregates consist of minute spheres, 5–10 µm in diameter. The relict nature of the aggregates, which can form pseudomorphous lamellae, within thin outer shells having the morphology of weloganite (sometimes retaining the characteristic striations of weloganite), suggests that the baddeleyite was derived from the hydrothermal alteration of weloganite. Further evidence of this is seen in the deposition of powdery baddeleyite on the laminar remnants (parallel to {001}) of partially dissolved crystals of weloganite. For this reason the baddeleyite lamellae are preferentially aligned parallel to the {001} pedion of the replaced weloganite crystals. In some specimens baddeleyite is intimately intergrown with grains of zircon (Sabina, 1979).

Baddeleyite is an intermediate to late-stage mineral. Associated minerals include hematite, dawsonite, quartz, calcite, kaolinite, barite, fluorite, ankerite, celestine, rarely weloganite and very rarely paratacamite. Most specimens of baddeleyite were collected in 1975 from cavities very rich in reddish brown globular and powdery hematite that partially (sometimes selectively) coats the cavity minerals. The presence of hematite is a useful indicator of the potential presence of baddeleyite.

Barite $BaSO_4$

Barite is one of the more common cavity minerals that have provided attractive crystallized specimens. It occurs as well-

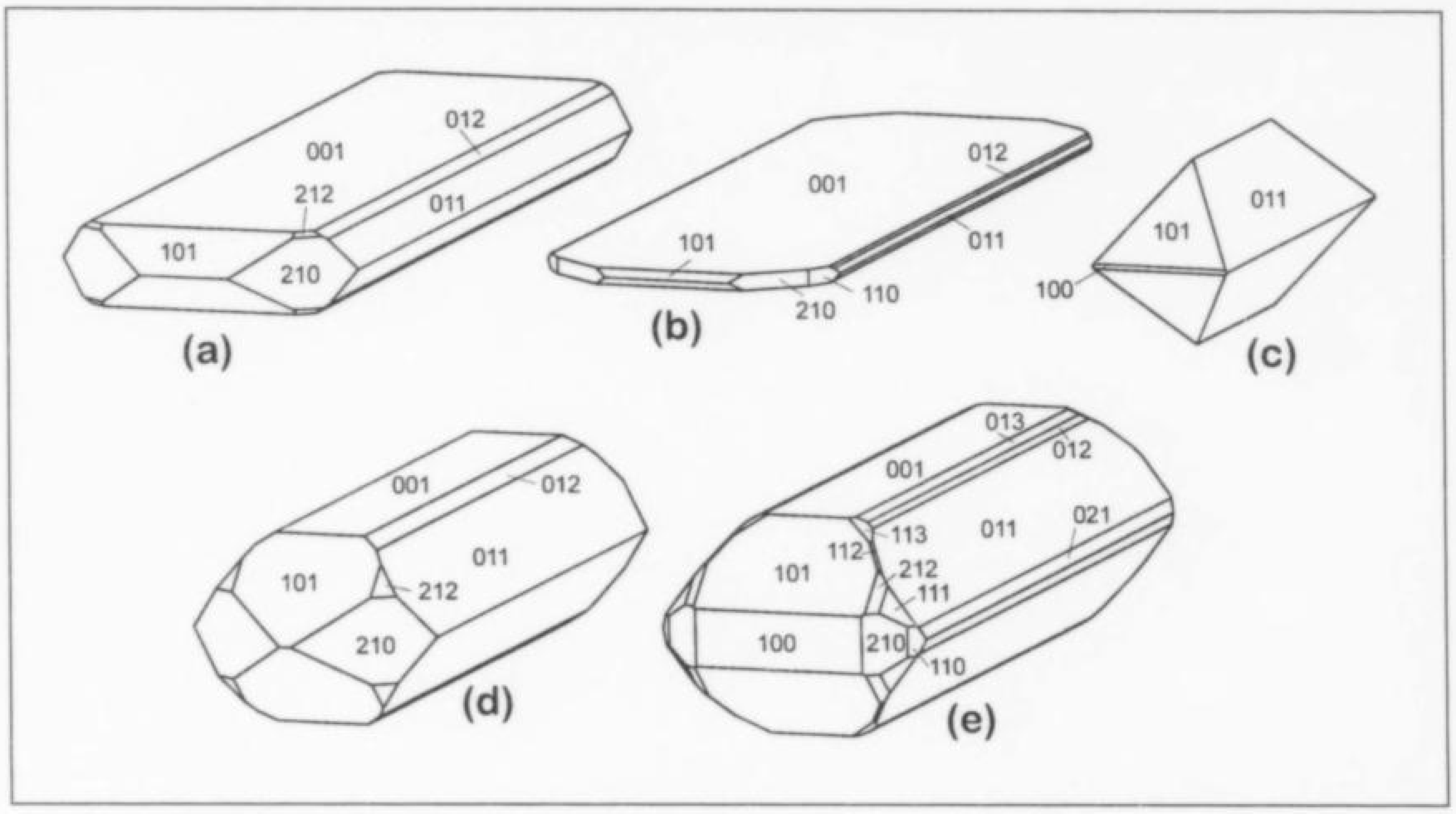


Figure 16. **Barite crystal drawings: (a) blocky tabular with dominant pinacoid, (b) thin platy with dominant pinacoid, (c) simple prismatic with dominant {011} prism, (d) more complex prismatic with dominant {011} prism, and (d) an idealized composite including all observed forms.**

formed crystals of various habits mostly in the lower sill. Barite is uncommon in the upper sill cavities, and rare in small cavities in the limestone near the sill contacts. It is abundant throughout the lower sill, with noted local concentration near the northwestern wall, where some of the largest, exceptionally well-formed crystals were found in 1975. Barite occurs as colorless, pale yellow, pink, white and gray, prismatic to columnar, thick tabular to thin platy single crystals; as aggregates of platy crystals; as granular to powdery masses; and as spheroids, sheets, and slivers. The following crystal habits and morphologies have been observed, practically all in specimens from the lower sill.

Habit A consists of thick tabular crystals, flattened on (001) and elongated on [100]. The crystals are defined by dominant {001} basal pinacoids and prominent {011} prisms, terminated by {101} and {210} prisms, and often modified by minor {012} prism and {212} pyramid. Crystals of this habit and the large crystals of habit C were found exclusively in 1975. The crystals are 1–3 cm long, rarely up to 4.5 cm, and sometimes doubly terminated. The {001} pinacoid faces are translucent and frosty whereas the {011} and most other prisms have a thick, opaque white, pitted, glaze-like layer with a satiny luster; the crystals are transparent, pale yellow internally.

Habit B is characterized by columnar or prismatic crystals in which the {011} prism is prominent and often dominant. This is the most common habit, with crystals ranging from 1 mm to about 2.5 cm in length. The small crystals can be morphologically quite simple, typically defined by the dominant {011} prism and terminated by the {101} prism, with or without a small {100} pinacoid. The small crystals may be colorless to transparent, pale yellow or (rarely) pale pink. The larger columnar crystals are similar to the thick, tabular crystals of habit A, except for the smaller {001} basal pinacoid, giving the crystals a nearly hexagonal cross-section.

Habit C consists of thin, tabular and platy crystals, with the same forms as habit A, but even more dominant {001} pinacoids, all other forms being minor. Nearly all the crystals are colorless, but those in the upper sill commonly have a thin, opaque white outer zone with a silky luster. The crystals range in size from 1 to 6 mm. This is a relatively rare habit.

Habit D crystals are tapering, bladed, often rounded, and sometimes twisted, forming sheaves, spheres, rosette-like and stacked aggregates up to 6 mm in diameter. The crystals are invariably opaque and may be white, pale yellow, orange-red or dark red. The reddish color is imparted by varying amounts of hematite inclusions and coatings.

The most commonly associated minerals include weloganite, cryolite, strontianite, dawsonite, celestine, elpidite, marcasite, gibbsite, quartz, hematite, goethite, siderite, fluorite, analcime, albite, baddeleyite and calcite.

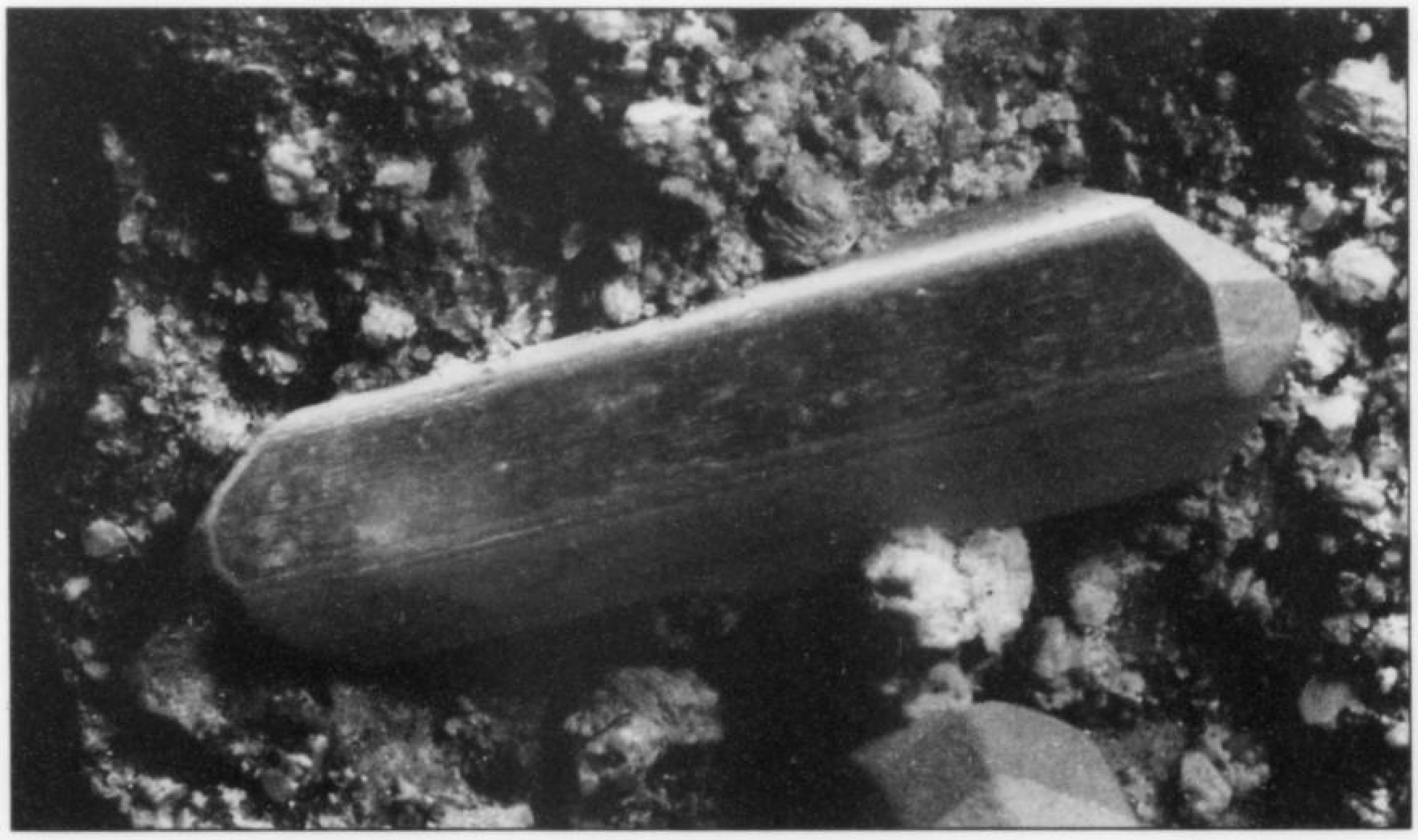


Figure 17. **Doubly terminated barite crystal from the Francon quarry, 2.5 cm. Redpath Museum specimen D5218.01, McGill University; L. Horváth photo.**

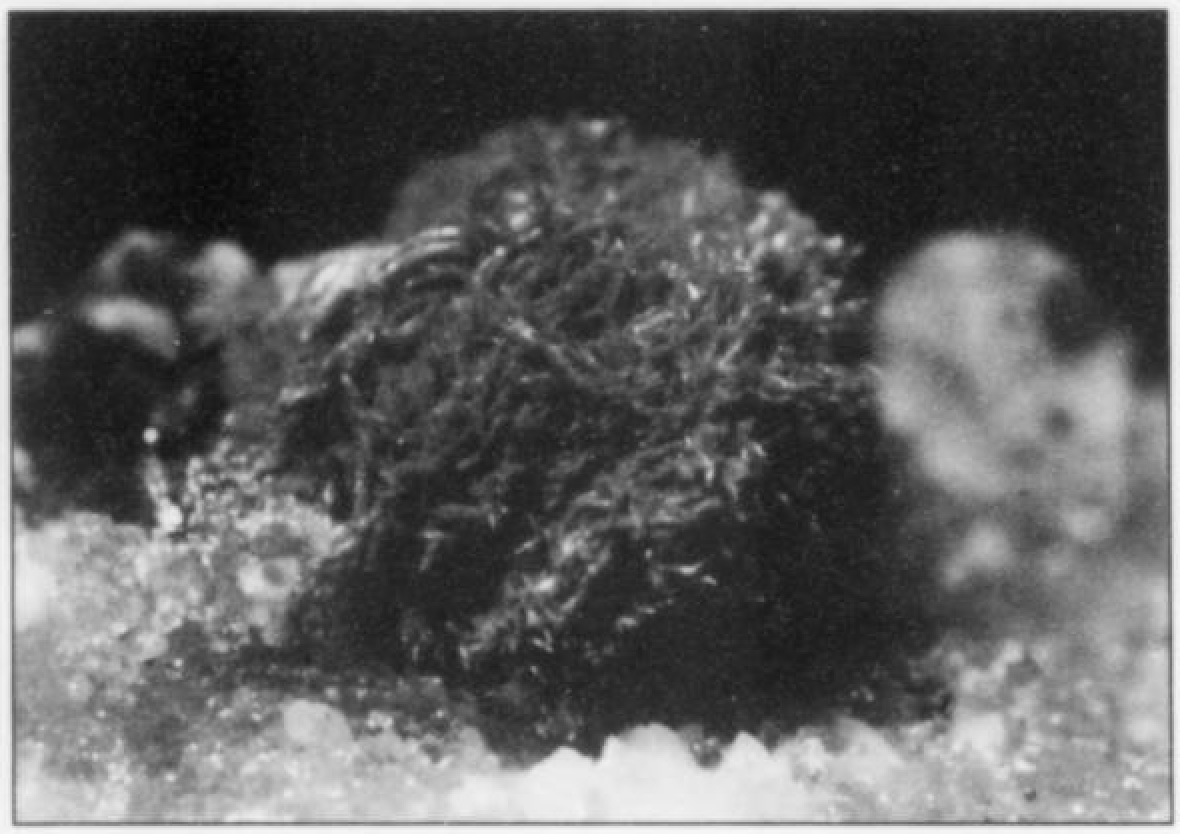


Figure 18. **Platy barite crystals forming a spherical aggregate, 4 mm, colored red by hematite inclusions. Francon quarry; Horváth collection (no. 5145); L. Horváth photo.**

Figure 19. **Barite crystal group, 4 cm, collected at the Francon quarry in 1975. Horváth collection (no. 5514); L. Horváth photo.**

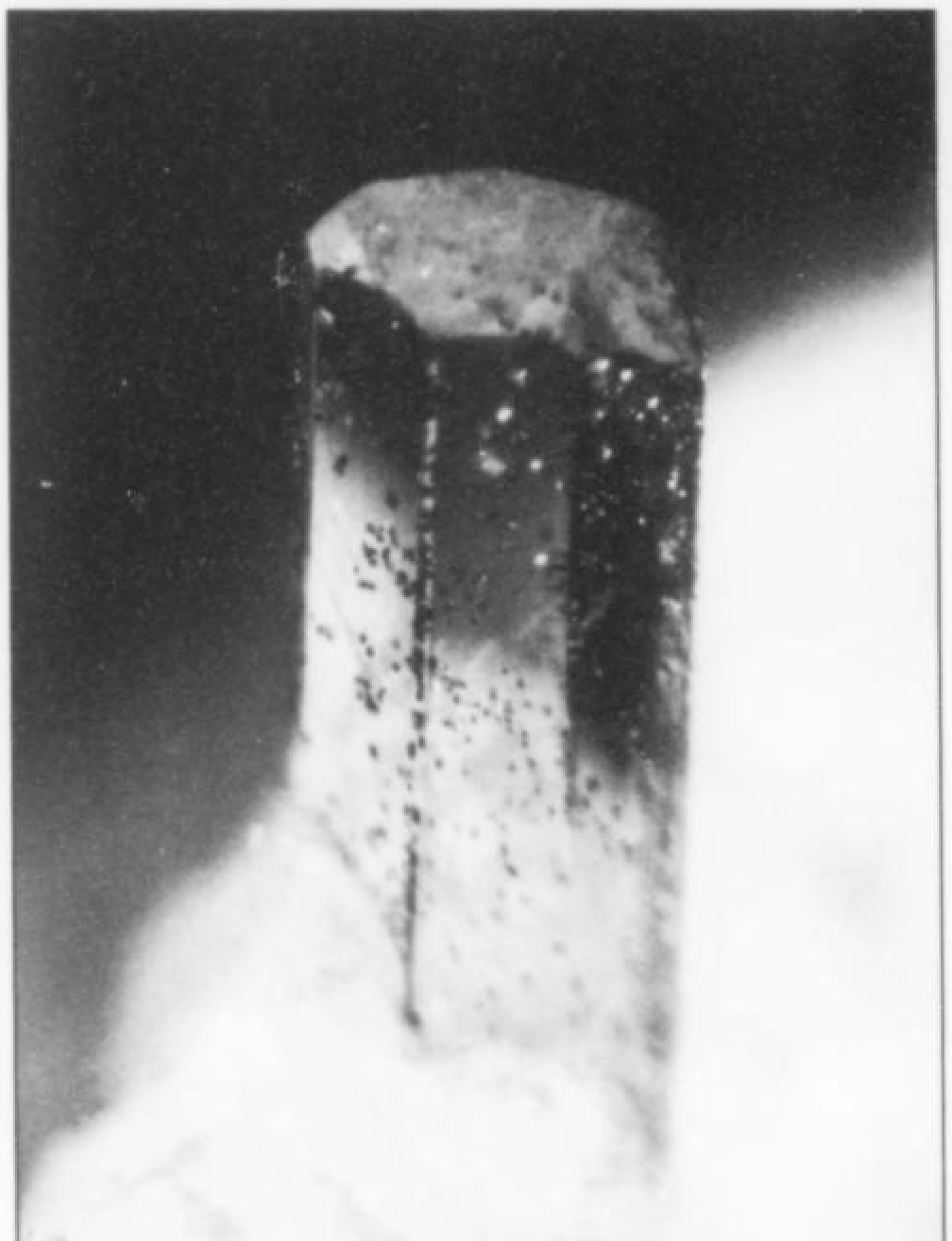


Figure 20. **Colorless barite microcrystals to 4 mm, from the Francon quarry. Horváth collection (no. 5147); L. Horváth photo.**

Figure 21. **Barite microcrystal. 2 mm, with late generation pyrite crystals. Tarassoff collection (no. PT95); Violet Anderson photo (1982) courtesy of the Royal Ontario Museum © ROM.**

Bastnäsite-Hydroxylbastnäsite series

Bastnäsite, probably bastnäsite-(Ce), occurs in the lower sill as dull to chalky white, compact spherules less than 1 mm in diameter associated with ankerite, dawsonite, strontianite, quartz and fluorite, and as silky, tan spherules on ankerite and quartz (A. P. Sabina, personal communication, 2004). A chemical analysis would be needed to determine the exact species.

Biotite series

Jambor *et al.* (1976) reported "rare relict phenocrysts of biotite-phlogopite" in very minor quantities in the upper sill rock. Sabina (1994) also reported "mica-biotite, phlogopite associated with APS No. 9 (= dachiardite-Na)" in the lower sill. A yellow-brown mica has been observed as flakes less than 1 mm in diameter embedded in a dike rock from the alcove. No chemical analyses have been carried out on these micas.

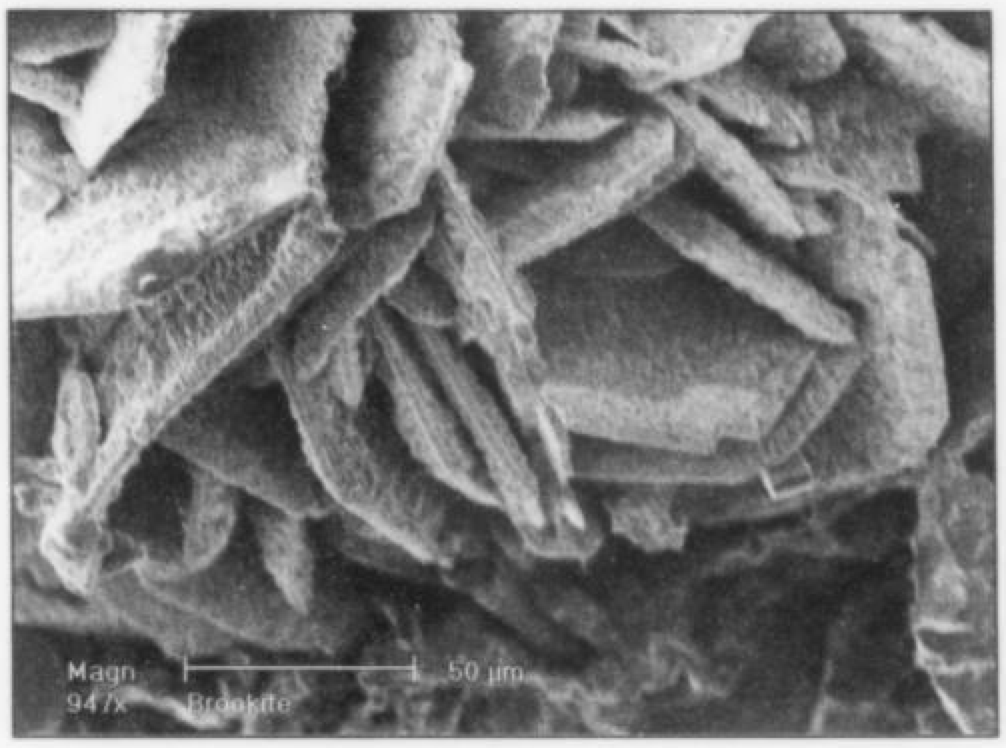


Figure 22. **Platy brookite crystals with irregular surfaces probably caused by a crust of ilmenorutile. Horváth collection; L. Horváth and R. Gault SEM photo.**

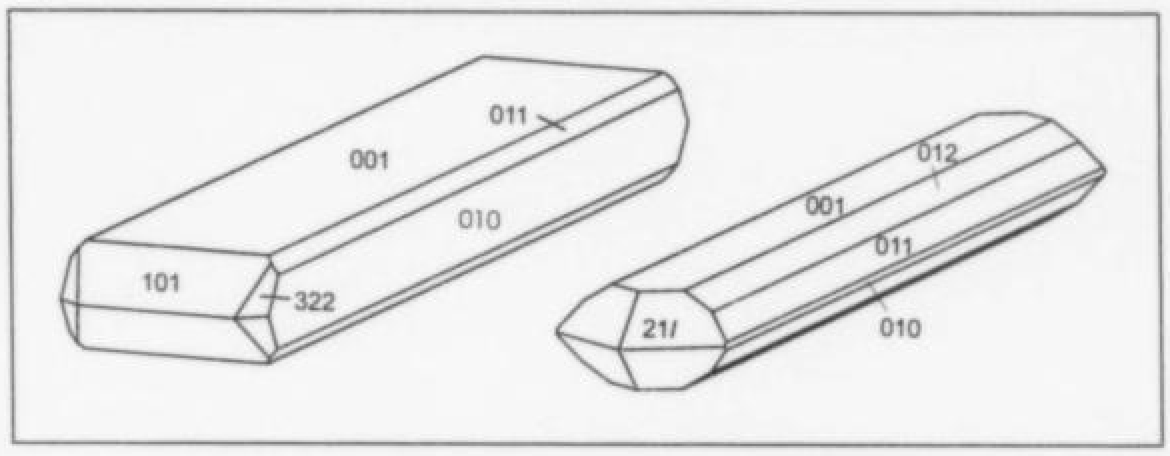


Figure 23. **Celestine crystal drawings: (*left*) blocky tabular habit with dominant {001} and prominent {010} pinacoids, and (*right*) prismatic habit terminated by the {211} pyramid.**

Figure 24. **Celestine crystal cluster, 1 cm, from the Francon quarry. Horváth collection (no. 5522); L. Horváth photo.**

Brookite TiO_2

Brookite is a relatively rare mineral at the Francon quarry, typically found on cavity linings of white albite crystals, in both the upper and lower sills. It occurs as dull black, sub-metallic rosettes, about 1 mm in diameter, consisting of thin plates with a roughly hexagonal outline, and a rough, furrowed surface. Brookite is often coated by a black crust that has been identified in some specimens as ilmenorutile (Sabina, 1979), and may be the reason for the surface roughness. Other associated minerals include dawsonite, barite, elpidite, natrolite and quartz. Visual identification of brookite is unreliable inasmuch as ilmenorutile has also been observed to occur as black rosettes.

Calcite $CaCO_3$

Calcite is a ubiquitous cavity mineral in the upper and lower sills. It occurs as colorless, translucent to transparent, pale yellow, white or beige crystals, and as opaque, white and brown crystals 1–10 mm long. Some crystals are a mottled gray color due to inclusions. The majority of the crystals are either scalenohedral or rhombohedral. The dominant form on the scalenohedral crystals is $\{21\bar{3}1\}$, usually terminated by a $\{10\bar{1}1\}$ rhombohedron, and rarely a {0001} pinacoid. Crystals with acute terminations ("dogtooth" calcite) are uncommon, as are crystals showing the prismatic $\{10\bar{1}0\}$ form. Rhombohedral crystals are predominantly simple $\{10\bar{1}1\}$ rhombohedrons, sometimes with small faces of a negative rhombohedron. Twinning has not been observed. Scalenohedral crystals often have a frosty appearance, with a dull to greasy luster, and many are rounded, or barrel-shaped. Aggregates of crystals in parallel growth are also observed. Rhombohedral crystals tend to be sharper and more lustrous. In an unusual occurrence, calcite has been found as sharp pseudomorphs to 1 cm after an unknown precursor mineral; the crystals have a chalky-white exterior and colorless interior, and an apparently triclinic symmetry.

Calcite commonly occurs as an early mineral in the cavity linings, but quite often a second, late-stage generation of calcite is found in the same cavity. Calcite is associated with practically all the minerals found in the quarry, and it is often found selectively coated by other minerals. Perimorphs after calcite consisting of thin, dull white shells of gibbsite, fluorite and rarely doyleite, have been observed. Some calcite fluoresces very bright red, and sometimes an unusually vivid and intense pink under shortwave and medium-wave ultraviolet radiation. The fluorescence can help to distinguish rhombohedral crystals of calcite from similar-appearing dolomite.

Calcite is also found as small crystalline masses in the sill rock, and as well-formed, colorless crystals in cavities in dikes and in the limestone host rock.

Celestine $SrSO_4$

Celestine is found in both the upper and lower sills, but it is far more abundant in the cavities in the lower sill. It occurs as sharp, colorless, white, yellow and pale blue tabular and prismatic crystals up to 2 cm long, and more commonly as attractive bundles, sheaves and divergent sprays up to 3 cm long, consisting of colorless, and translucent to opaque, white to pink, long prismatic and acicular crystals. Tabular crystals show the following forms, in descending order of dominance: {001} and {010} pinacoids, {101} and {011} prisms, and small {322} dipyramids. Prismatic crystals show major {001} and minor {010} pinacoids, prominent {011} and {012} prisms, terminated by {21*l*} dipyramids (usually etched). Some bladed prismatic crystals have serrated edges caused by reentrant angles formed by opposing faces of {21*l*} prisms.

Celestine has also been found in at least one dike cavity as colorless, very thin, bladed crystals associated with gypsum and analcime. In the presence of hematite, celestine crystals commonly

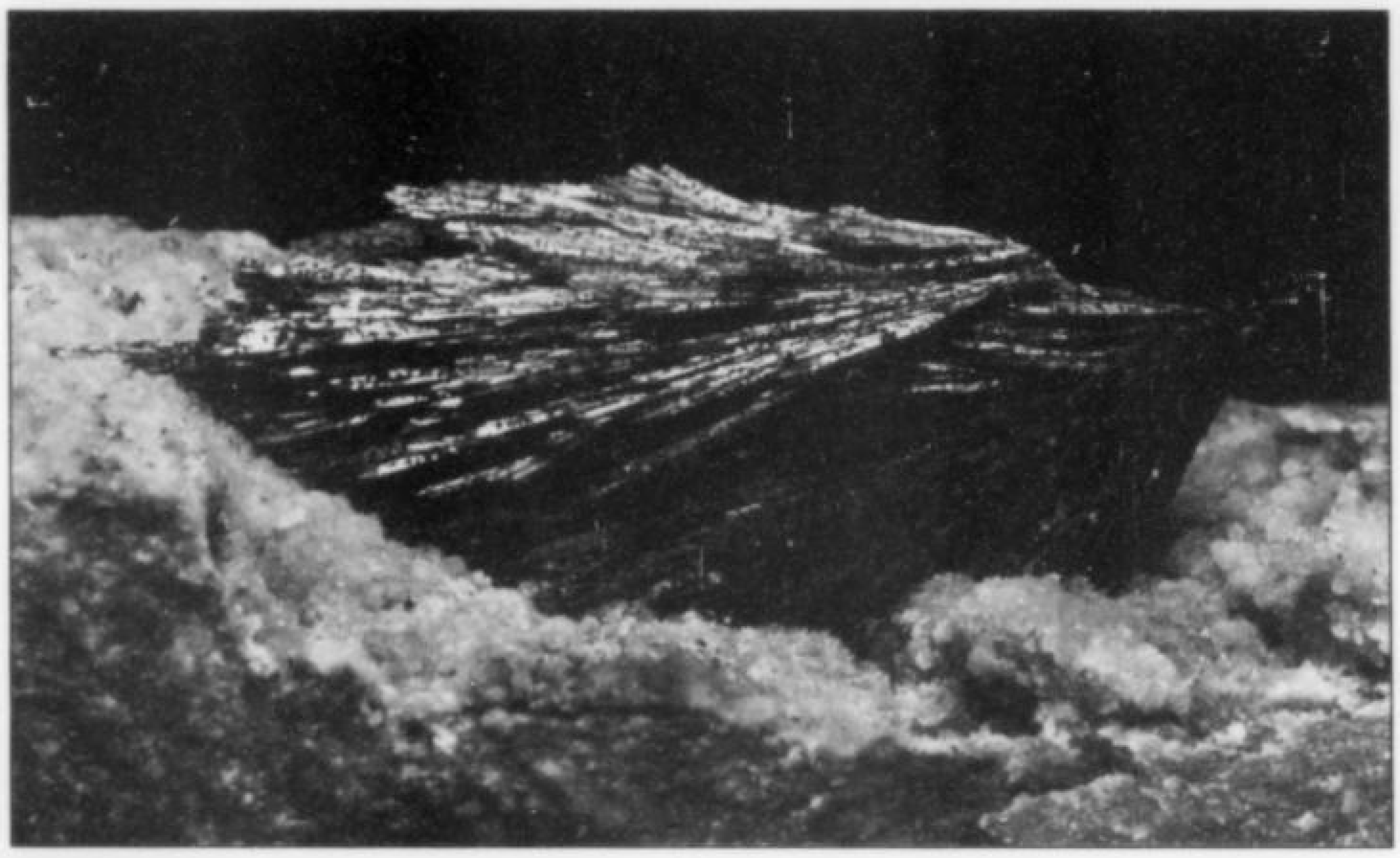
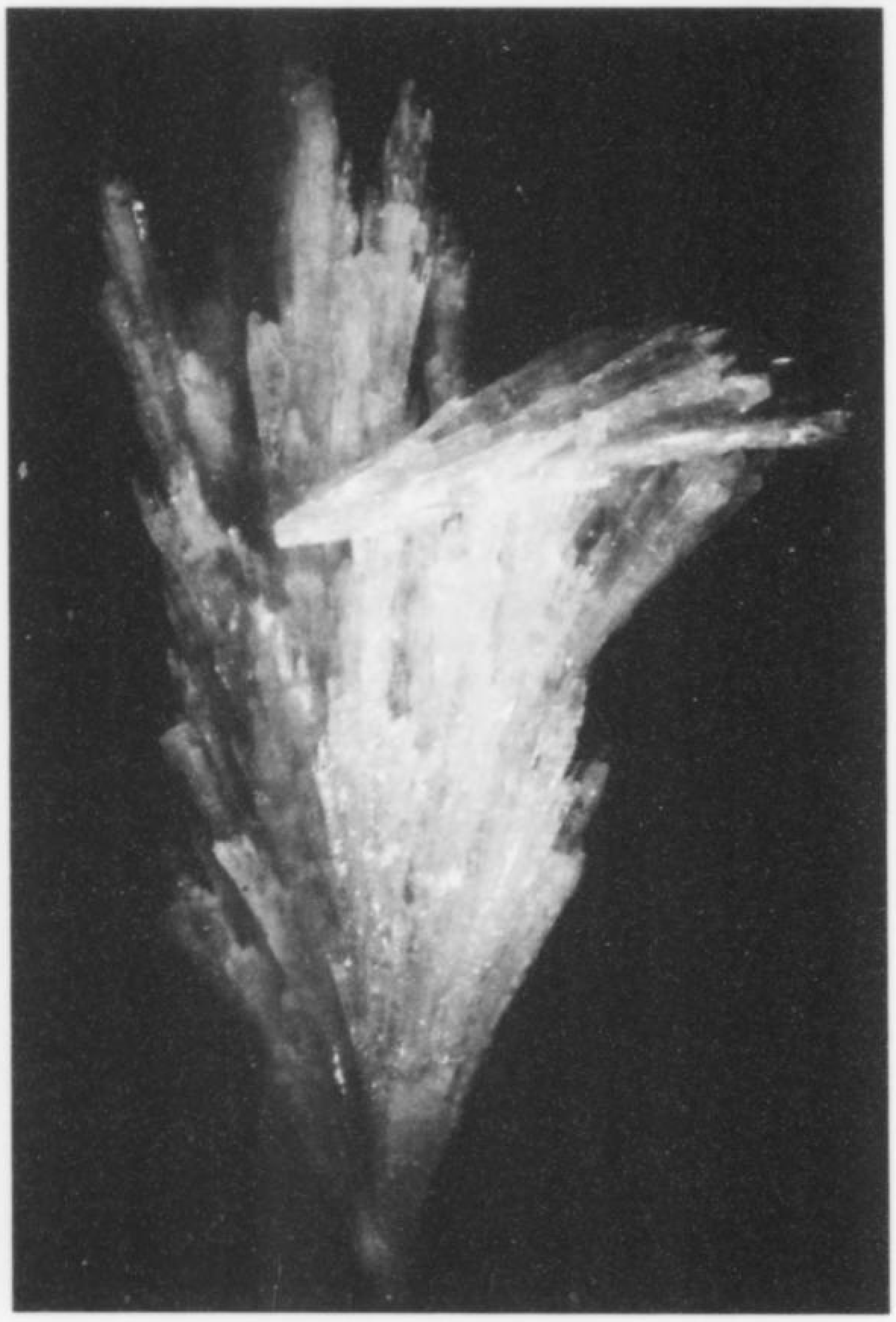


Figure 25. **Celestine crystal spray, 3.5 cm, coated by hematite. Horváth collection (no. 5549); L. Horváth photo.**

Figure 26. **Celestine crystal spray, 1.3 cm, from the Francon quarry. Tarassoff collection (no. PT199); Violet Anderson photo (1982) courtesy of the Royal Ontario Museum © ROM.**



are colored reddish brown or black by hematite inclusions, and in the presence of goethite they are often found coated by a velvety, golden yellow layer of fibrous goethite. The hematite and especially goethite have a marked tendency to selectively coat celestine, but not other associated minerals in the same cavities.

Cerussite $PbCO_3$

Cerussite is an extremely rare, late-stage alteration product, occurring as white powdery coatings or tan crusts, sometimes admixed with hydrocerussite, on galena crystals in the lower sill.

Chromite $Fe^{2+}Cr_2O_4$

Chromite has been identified as black grains in a dike in the alcove (A. P. Sabina, personal communication, 2004).

Cristobalite SiO_2

Cristobalite is a relatively rare accessory in the lower sill cavities, occurring as dull, opaque, white to bluish, rounded and platy aggregates 1–2 mm across, associated with quartz, ankerite, celestine, mordenite and baddeleyite, and as compact, white, matted, fibrous masses up to 3 mm across, associated with calcite, dolomite, pyrite and marcasite (Sabina, 1979). Cristobalite has also been found in cavities in a dike in the alcove as white to pale bluish globules less than 1 mm in diameter, associated with analcime, dolomite, strontianite and mordenite.

Crocoite $PbCrO_4$

Crocoite has been identified as "yellow, waxy patches in microcrystalline intergrowths of dawsonite and "K-feldspar" which also contain pyrochlore, pseudorutile and siderite" (Sabina, 1979). Only one confirmed specimen, from the lower sill, is known (GSC APS 264).

Cryolite Na_3AlF_6

Cryolite is a relatively rare mineral worldwide. It is most commonly associated with granitic rocks (Ivigtut, Greenland; Miask, Russia; St. Peters Dome, Colorado), and rarely with carbonatites (Goldie, Colorado) and sediments (Green River Formation, USA; Lake Magadi, Kenya) (Bailey, 1980). Very rarely, cryolite also occurs in hydrothermally affected zones of agpaitic alkaline rocks in the Lovozero and Khibiny massifs (Semenov, 1972; Khomyakov, 1995), at Mont Saint-Hilaire (Horváth and Gault, 1990), and in the Saint-Amable sill (Horváth *et al.*, 1998). Well-formed crystals of cryolite are exceedingly rare and were essentially known only from a single locality, Ivigtut, in South Greenland (Krenner, 1883; Bøggild, 1953; Petersen, 1993), until their discovery in 1975 in the Francon quarry (Sabina, 1976, 1979). After weloganite, the splendid and exceptionally well-formed yellow cryolite crystals collected in 1975 are arguably the most attractive collectible mineral specimens found in the Francon quarry. At the time, they represented perhaps the largest and the best formed crystals known for this species. In recent years, considerably larger (up to 5 cm) crystals have been found at Mont Saint-Hilaire; however, they are not as well-formed, or colorful, as the Francon specimens.

Cryolite is uncommon in the Francon quarry where it is found as very sharp crystals in both the upper and lower sills. The crystals are transparent to opaque, either colorless or yellow, and typically 1–3 mm in size, with a few exceptional crystals over 1 cm in diameter. Many of the larger yellow crystals have a dull to waxy, grainy or spongy, pseudomorphous or etched appearance. The

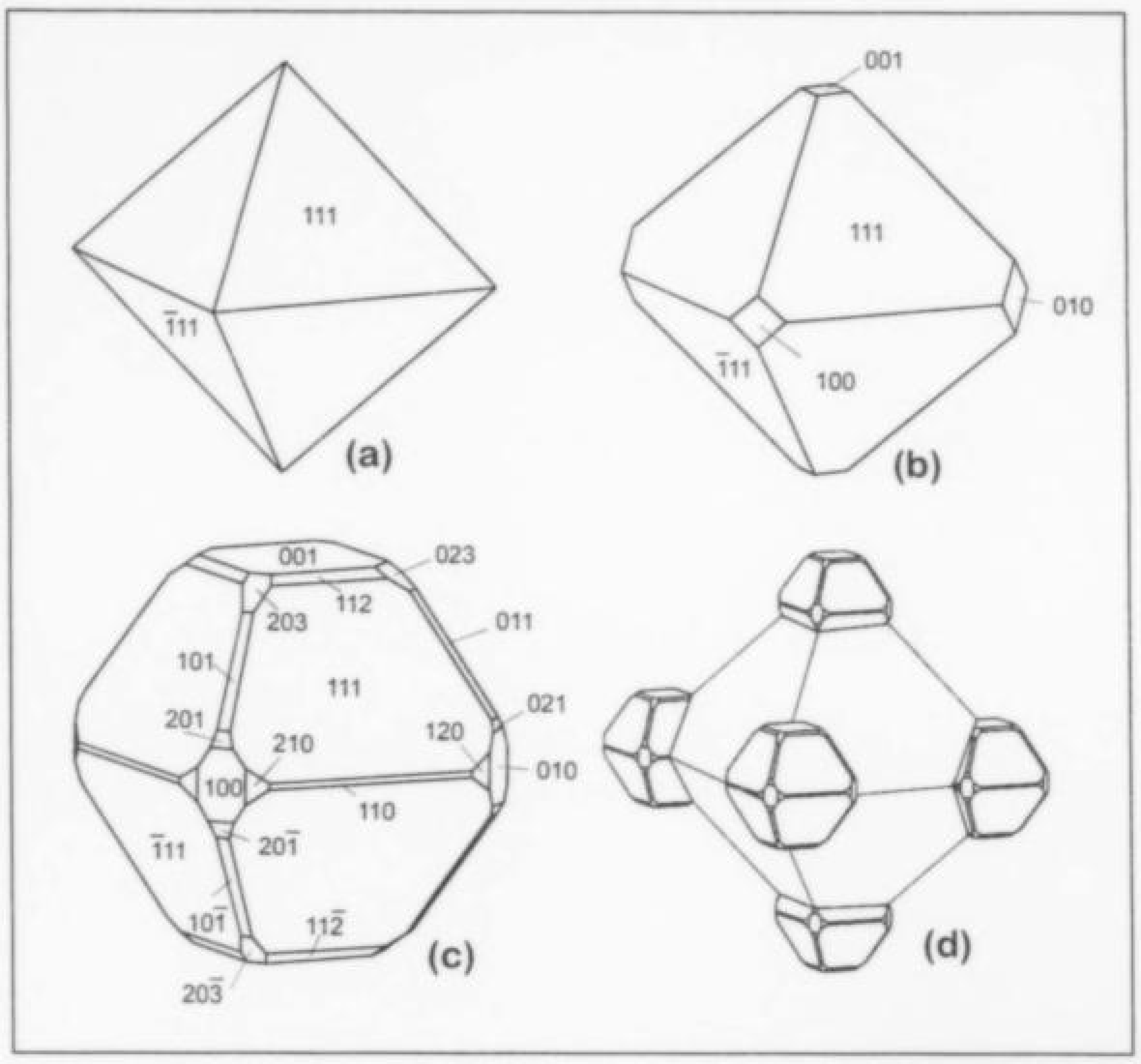


Figure 27. **Cryolite crystal drawings: (a) and (b) show the most commonly observed forms on nearly all crystals; (c) shows an idealized crystal with all observed forms; (d) shows oriented overgrowths of complex, colorless second-generation cryolite on a larger yellow cryolite crystal.**

colorless crystals have a vitreous to adamantine luster. Cryolite is monoclinic but exhibits very pronounced pseudo-cubic symmetry. Unlike the better-known Ivigtut crystals, which appear pseudocubic with dominant $\{110\}$ prisms and well developed $\{001\}$ pinacoids, the only habit of Francon quarry crystals is dipyramidal (pseudo-octahedral). The most common forms are dominant $\{111\}$ and $\{\bar{1}11\}$ bipyramids, modified by minor $\{001\}$, $\{010\}$ and $\{100\}$ pinacoids. These common forms are observed on practically all crystals. Additional, usually minor, forms observed on small colorless crystals are: pyramids $\{112\}$ and $\{11\bar{2}\}$, prisms $\{110\}$, $\{011\}$, $\{210\}$, $\{120\}$, $\{021\}$, $\{023\}$ and pinacoids $\{101\}$, $\{10\bar{1}\}$, $\{201\}$, $\{20\bar{1}\}$, $\{101\}$, $\{10\bar{1}\}$, $\{203\}$ and $\{20\bar{3}\}$. It is interesting to note that the main morphological feature of Francon cryolite crystals, dominant $\{111\}$ and $\{11\bar{1}\}$ bipyramids, is also seen on cryolite crystals from Mont Saint-Hilaire and the Saint-Amable sill. Contact twinning is common in the smaller colorless Francon crystals but the twin laws represented have not been determined.

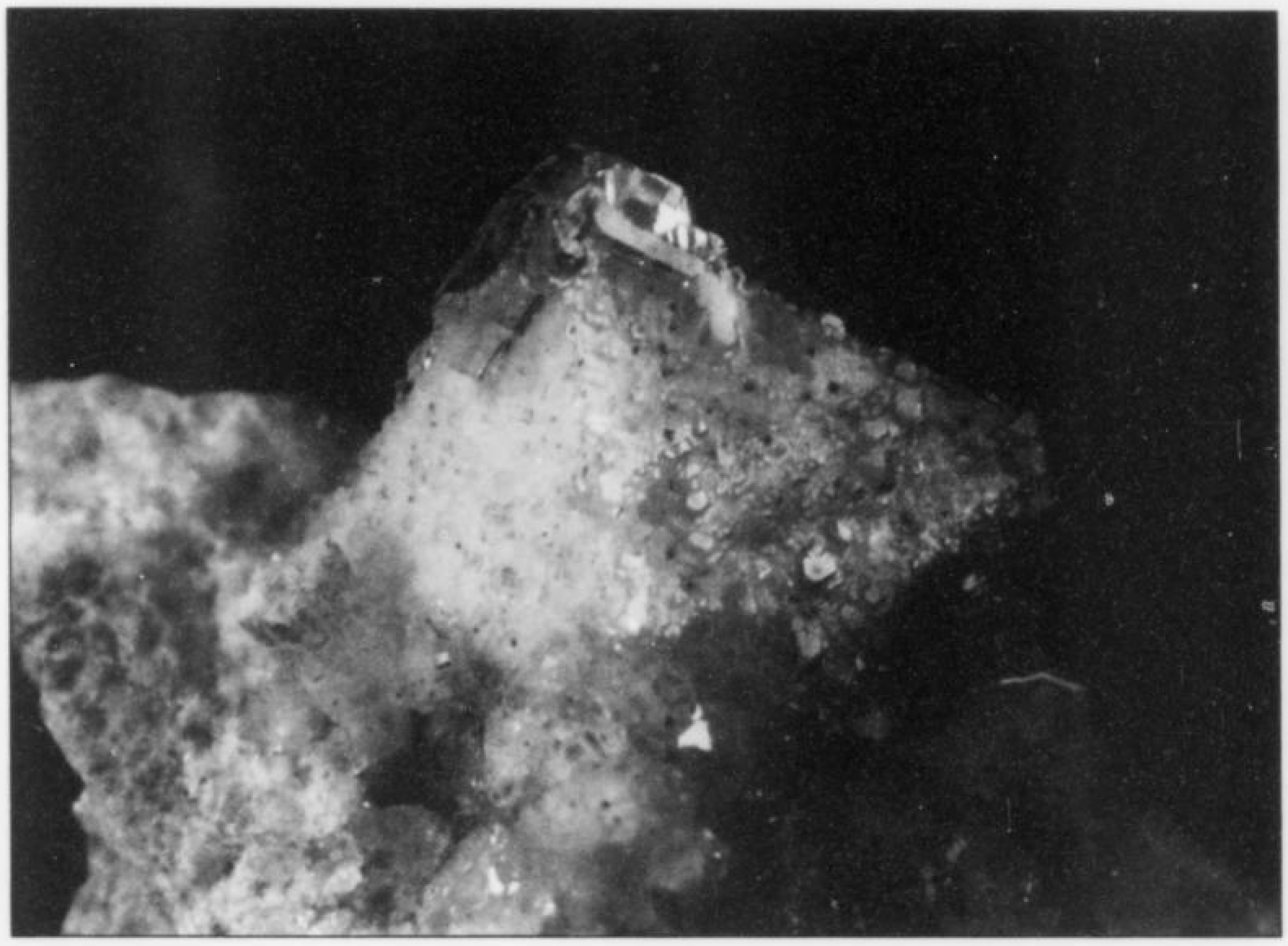


Figure 28. **Yellow dipyramidal cryolite crystal, 1.4 cm, with oriented cryolite overgrowths, from the Francon quarry. Horváth collection (no. 5517); L. Horváth photo.**

Figure 29. **Dipyramidal yellow cryolite crystals to 1.8 cm (one of the largest cryolite crystals ever found at the Francon quarry), with weloganite and strontianite. Horváth collection (no. 5516); L. Horváth photo.**

The colorless crystals are associated with calcite, dresserite, hydrodresserite, dawsonite, and weloganite in the upper sill, and with siderite, calcite, gibbsite, quartz, doyleite and dawsonite in the lower sill. The larger yellow crystals were all found in August 1975 in a unique assemblage in a very small zone of the lower sill near the northwest wall. All the yellow cryolite came from a single blast and specimens were collected over a period of two weeks by two of the authors (LH and EPH) and Donald Doell (Chamberlain and Doell, 1982). The assemblage, in addition to cryolite, included pale gray to white weloganite, including a rare tabular habit, colorless sprays of elpidite, white powdery masses of gibbsite, colorless barite, white strontianite, colorless calcite, and marcasite. The larger opaque, yellow crystals, mostly simple bipyramids, averaged 5–8 mm in diameter with many crystals over 1 cm and a few exceptional ones up to 2.5 cm in diameter. An interesting feature of most of the yellow, bipyramidal cryolite crystals is the conspecific epitactic overgrowth of small, lustrous, colorless cryolite crystals on the corners (represented by the pinacoids $\{001\}$, $\{010\}$ and $\{100\}$) and on the crystal edges of the bipyramids (in the [011] zone). These colorless crystals tend to be morphologically more complex than the larger substrate crystals.

Perimorphs after cryolite have been found in both the upper and lower sills. These consist of dull, frosty white, thin shells, retaining

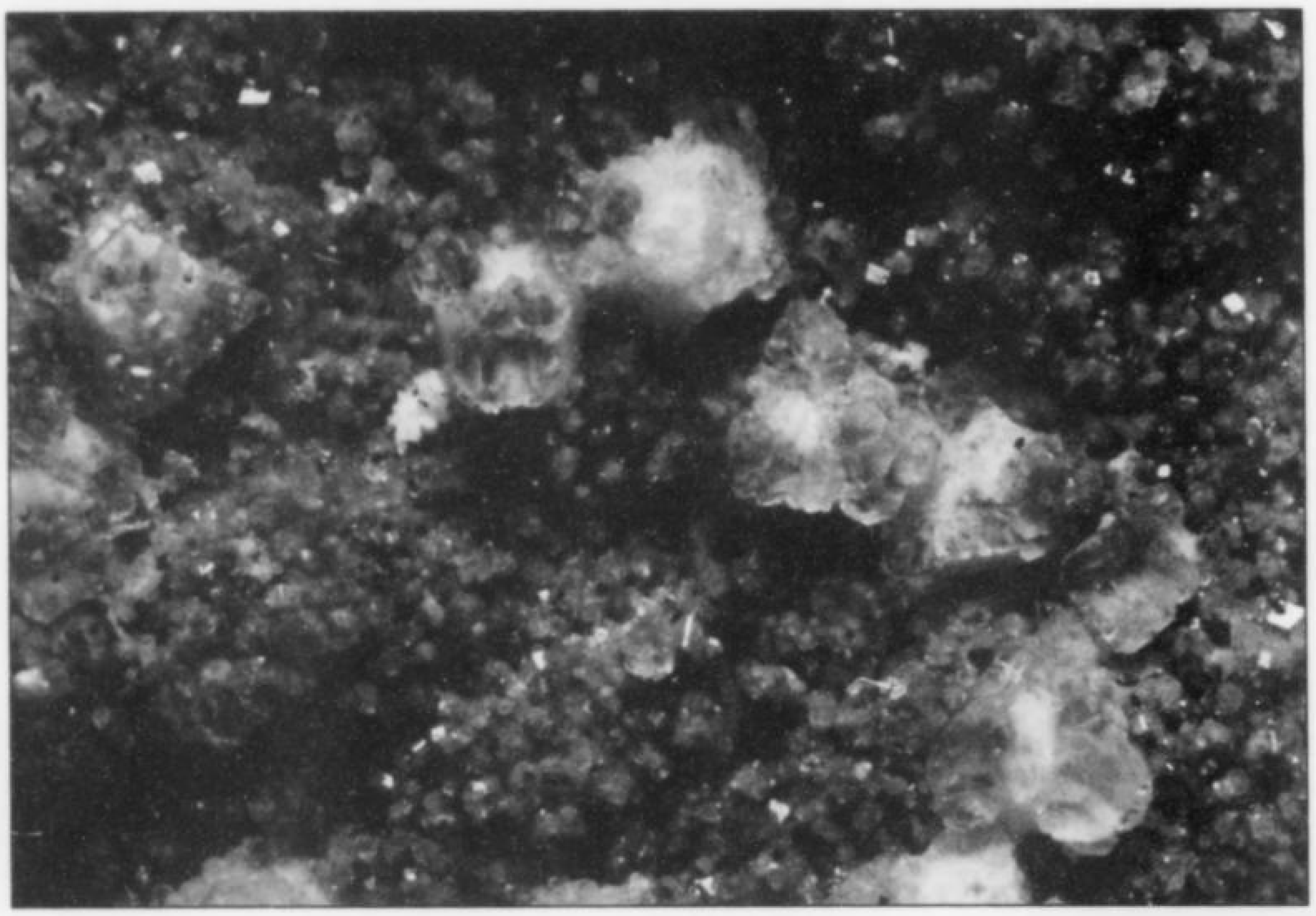
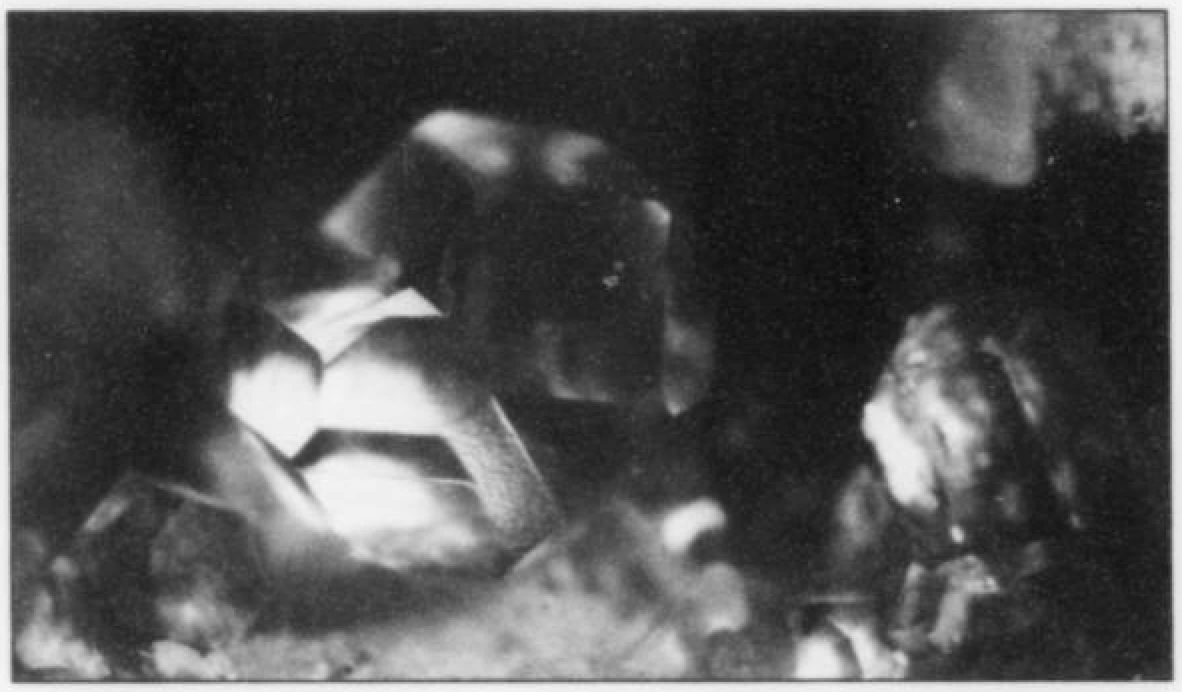


***Figure 30.* Cryolite crystals to 6 mm, on calcite, from the Francon quarry. Horváth collection (no. 5521); L. Horváth photo.**

***Figure 31.* Twinned cryolite microcrystals, about 1 mm, from the Francon quarry. Tarassoff collection (no. 2393); L. Horváth photo.**



the cryolite morphology, composed of gibbsite or fluorite admixed with doyleite. The original cryolite has been partially or completely leached out. A very similar mineral assemblage has been observed at the nearby Saint-Amable sill, except that at Saint-Amable, the gibbsite and doyleite are also closely associated with thomsenolite, a common alteration product of cryolite (Horváth *et al.*, 1998).

Cryolite fluoresces very bright white and creamy white under shortwave ultraviolet radiation, greenish yellow under medium-wave, and brownish yellow under longwave. A weak, white phosphorescence of short duration is observed after exposure to shortwave and medium-wave ultraviolet radiation.

A few gemstones have been faceted from crystals of Francon cryolite. A colorless 0.23-carat, modified kite step-cut stone containing many inclusions is in the collection of the Canadian Museum of Nature (W. Wight, personal communication, 2004).

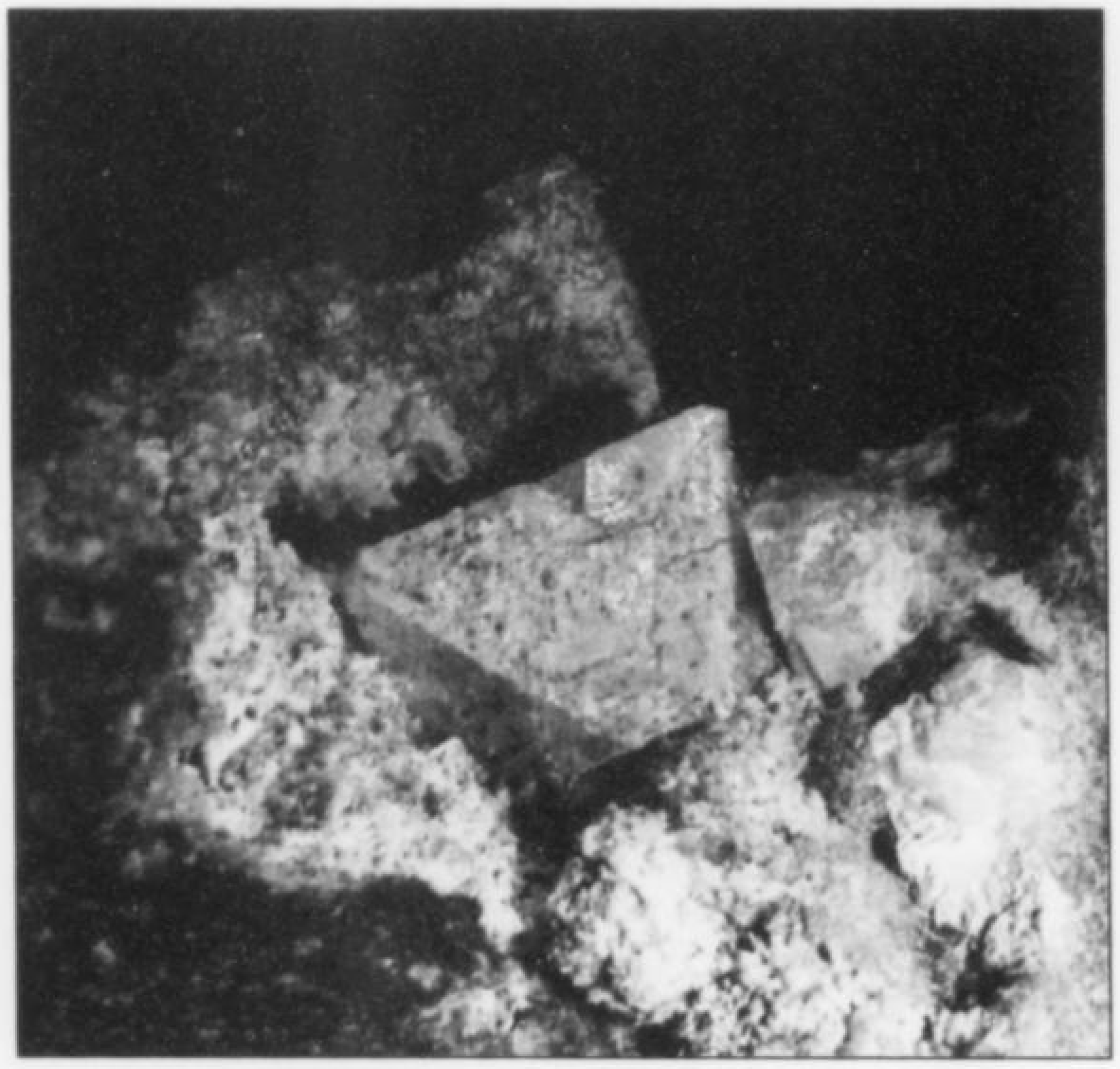


***Figure 32.* Colorless (slightly coated) dipyramidal cryolite crystals to 1.4 cm, among the largest known crystals of colorless Francon quarry cryolite. Doell collection; L. Horváth photo.**

***Figure 33.* Dipyramidal, pale yellow cryolite crystal, 1 cm, with a partial parallel overgrowth of later, darker yellow cryolite, with associated colorless weloganite crystals, from the Francon quarry. Horváth collection (no. 5453); L. Horváth photo.**

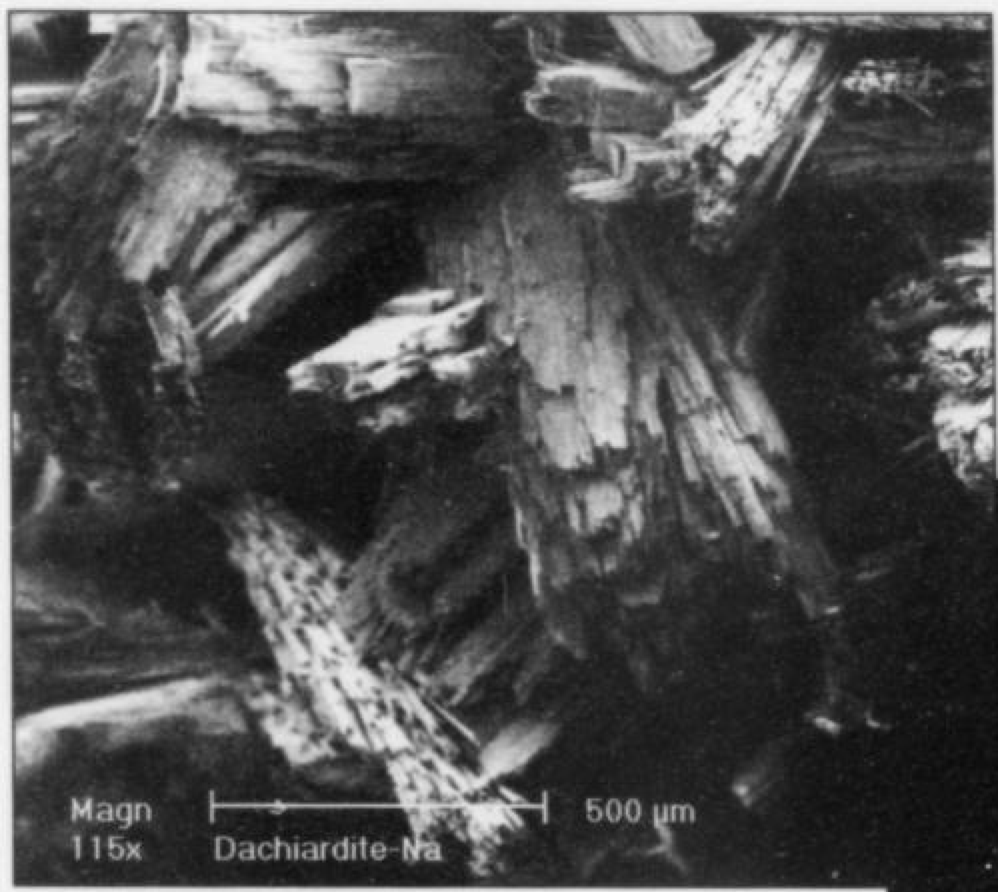


Figure 34. Bundles of acicular dachiardite-Na crystals from the Francon quarry. Horváth collection; L. Horváth and R. Gault SEM photo.

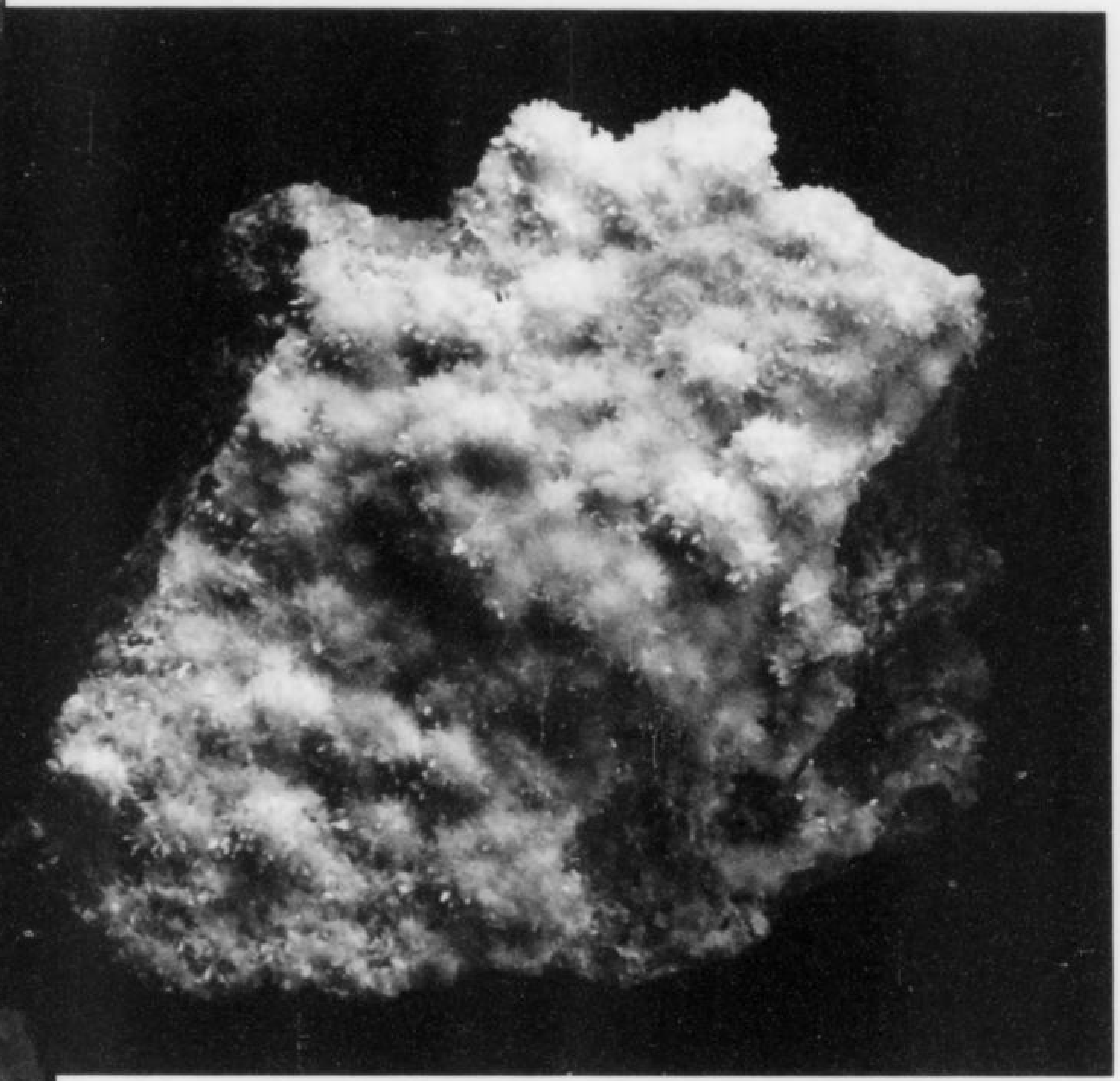
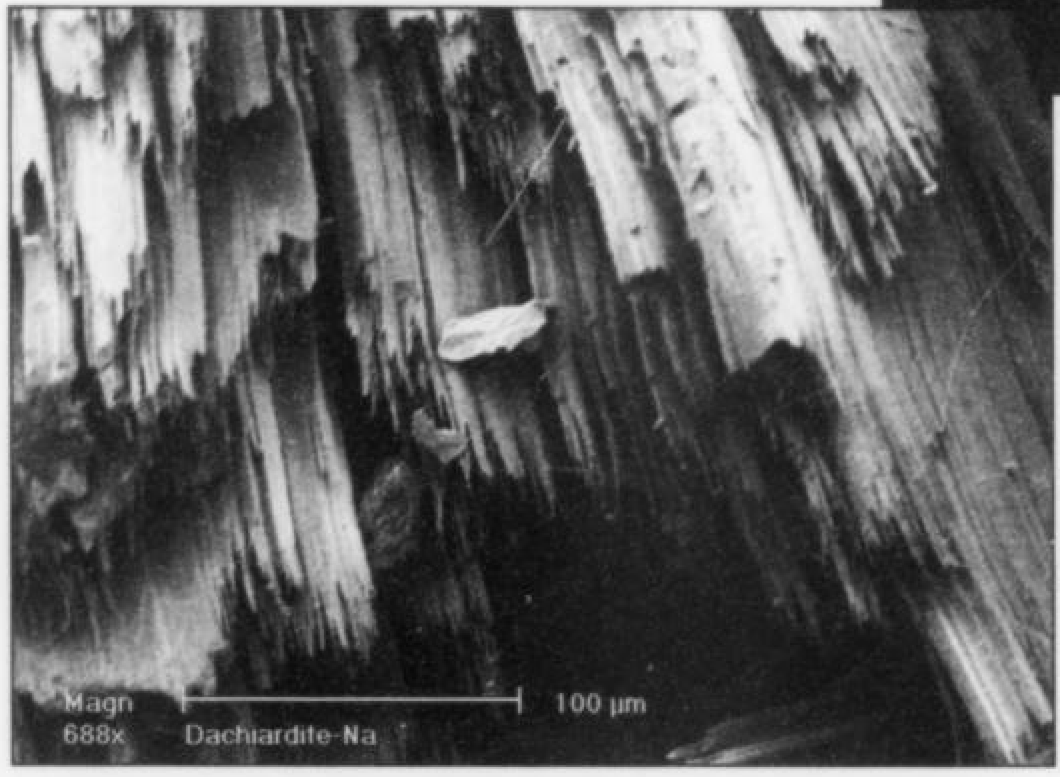


Figure 35. Acicular white dachiardite-Na crystals covering a 5.5 × 6.5-cm matrix, from the Francon quarry. Doell collection; L. Horváth photo.

Figure 36. Fibrous dachiardite-Na crystals from the Francon quarry. Horváth collection; L. Horváth and R. Gault SEM photo.



Dachiardite-Na $Na_{2.5}K_{0.5}Ca_{0.5}[Al_4Si_{20}O_{48}]\cdot 13H_2O$

Dachiardite, a rare zeolite, was first described from San Piero in Campo, Elba, Italy by D'Achiardi in 1906. A sodium-rich variety was first reported from Orli di Fassa, Alpe di Siusi, near Bolzano, Italy by Alberti (1975), and has subsequently been found at several other localities including the Francon quarry (Bonardi *et al.*, 1981). Under the current zeolite nomenclature, dachiardite from the original type locality in Elba is dachiardite-Ca and the sodium analog is dachiardite-Na with Alpe di Siusi as the type locality (Coombs *et al.*, 1997). The Francon quarry is the first and only known locality in Canada.

At Francon, dachiardite-Na is very rare and was first found in the lower sill where its occurrence was restricted to only a few cavities at the north end of the quarry. The mineral was later found in the alcove on the upper level in some minor sills. The material described by Bonardi *et al.* was collected by Donald Doell from the lower sill in 1974; it was originally thought to be a potentially new species and was designated APS No. 9. Further investigations revealed that it was a "sodium-rich dachiardite" (Bonardi *et al.*, 1981), now dachiardite-Na. The composition given by Bonardi *et al.* (1981) is: SiO_2 70.10, Al_2O_3 10.44, CaO 0.02, SrO 0.07, Na_2O 5.18, K_2O 0.98, H_2O 12.76 (by DTA/TGA analysis), total 99.55 weight %, resulting in the empirical formula $(Na_{2.93}K_{0.36}Sr_{0.01}Ca_{0.01})_{\Sigma 3.31}(Si_{20.47}Al_{3.59})_{\Sigma 24.06})O_{48}\cdot 12.48\ H_2O$, based on 48 oxygen atoms. The 5.18% Na_2O content is one of the highest known for the species, and is higher than the 4.47% reported for dachiardite-Na from the type locality (Alberti, 1975).

In the lower sill dachiardite-Na occurs as masses lining cavities (covering many cm²), and as distinct, individual bundles and divergent sprays, up to 5 mm across, of silky to dull, white, beige to pale brownish, acicular to fibrous crystals up to 4 mm long. Individual crystals are bladed and elongated along [010], with poorly defined faces, becoming splintery and fibrous at the terminations. They are transparent to translucent; fragments are colorless. Contrary to Bonardi *et al.* (1981), who reported that the dachiardite-Na occurred in a single cavity, two of the authors (LH and EPH) have found the mineral in at least two others. The Doell specimens are from a cavity (23 cm in maximum dimension) that was lined with colorless analcime, quartz, ankerite and calcite; the cavity walls were entirely covered by a continuous layer of densely intergrown bundles and tufts of white dachiardite-Na crystals. The specimens of dachiardite-Na collected by the authors are significantly different in their paragenesis and even in the physical appearance of the crystals. The specimens are from cavities 5–7 cm in diameter, lined with analcime, mostly covered by a layer of small crystals of beige to pale brown ankerite and pale yellow calcite. From this lining extend small bundles and divergent sprays of beige to pale brownish, acicular crystals up to 4 mm long, invariably associated with small, white, matted masses of finely fibrous mordenite, and colorless weloganite. In the Doell specimens, dachiardite-Na is a very late-stage mineral, whereas in the

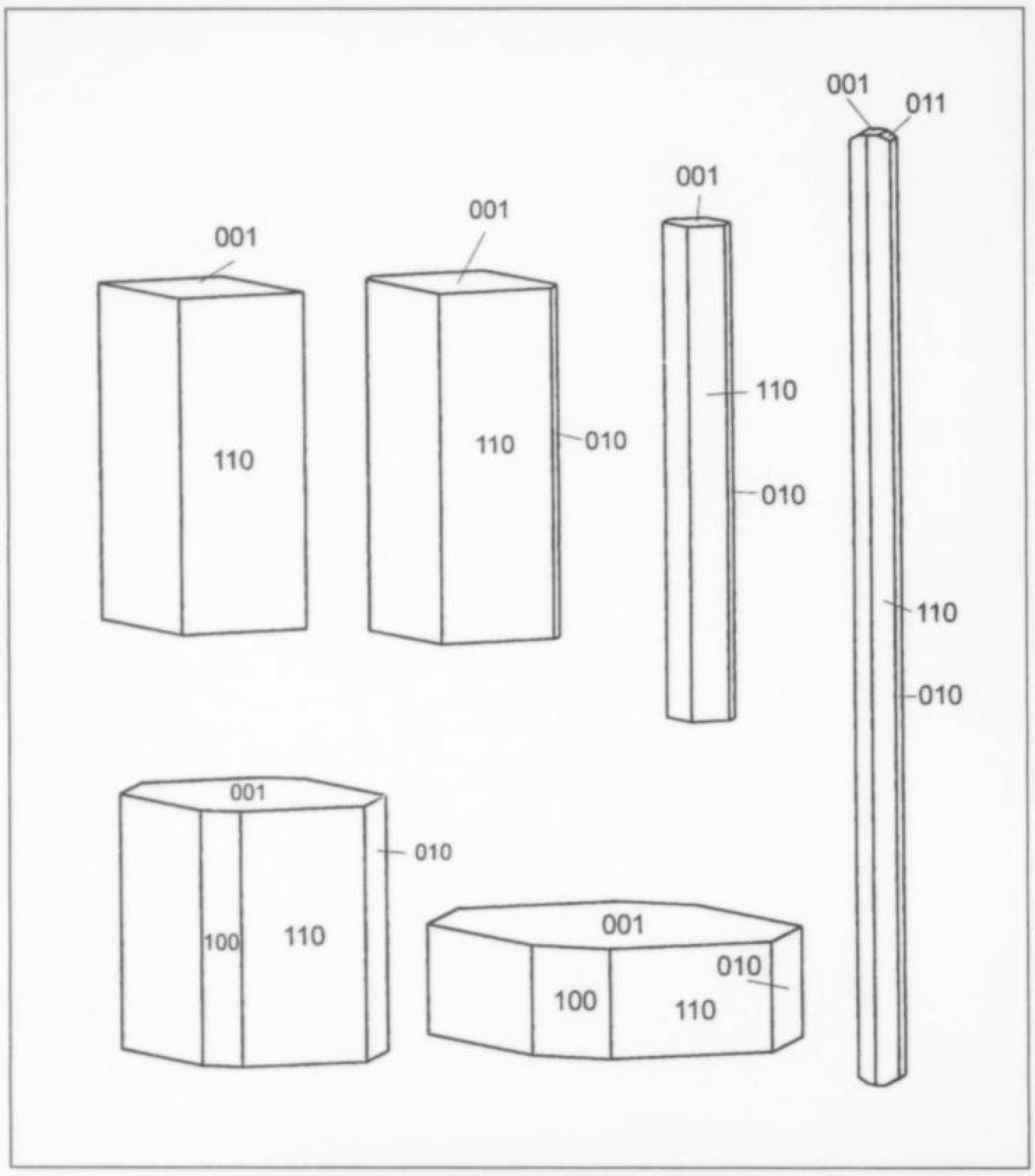


***Figure 37.* Dawsonite crystal, 1 cm, in a cavity from the lower sill, Francon quarry. Doell collection; L. Horváth photo.**

***Figure 38.* Dawsonite crystal drawings: short to long prismatic habits with dominant {110} (*top row*); and blocky to tabular habits (*bottom row*). The slender prism with high aspect ratio (20-30:1) on the right shows the very rare {011} prism.**

***Figure 39.* Dawsonite crystals to nearly 1 cm with celestine sprays in a cavity from the lower sill, Francon quarry. Tarassoff collection (no. 2391); L. Horváth photo.**

authors' specimens it is one of the early minerals in the assemblage, sometimes partially or fully overgrown by ankerite, weloganite and calcite. Other associated minerals include aegirine, albite and marcasite.

In 1982, dachiardite-Na was found in the alcove on the upper level in what appear to be amygdaloidal basaltic sills (A. P. Sabina, personal communication, 2005). The amygdules are generally filled with white minerals, and give the dark, brownish gray rock a spotted appearance. Dachiardite-Na occurs as white, usually radiating, fibrous masses filling amygdules 1–2 mm across. Other minerals in the amygdules include dolomite, feldspar, quartz and

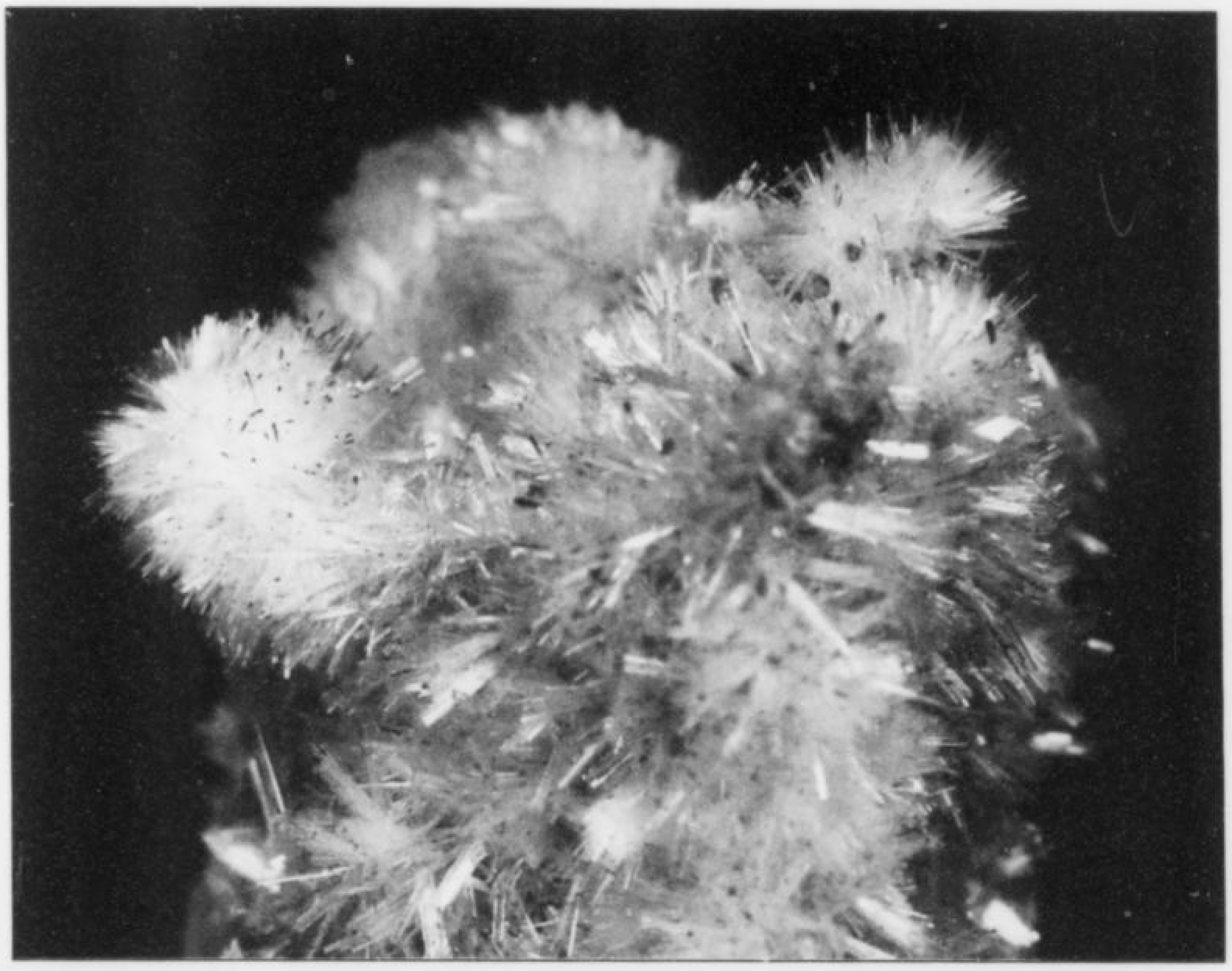
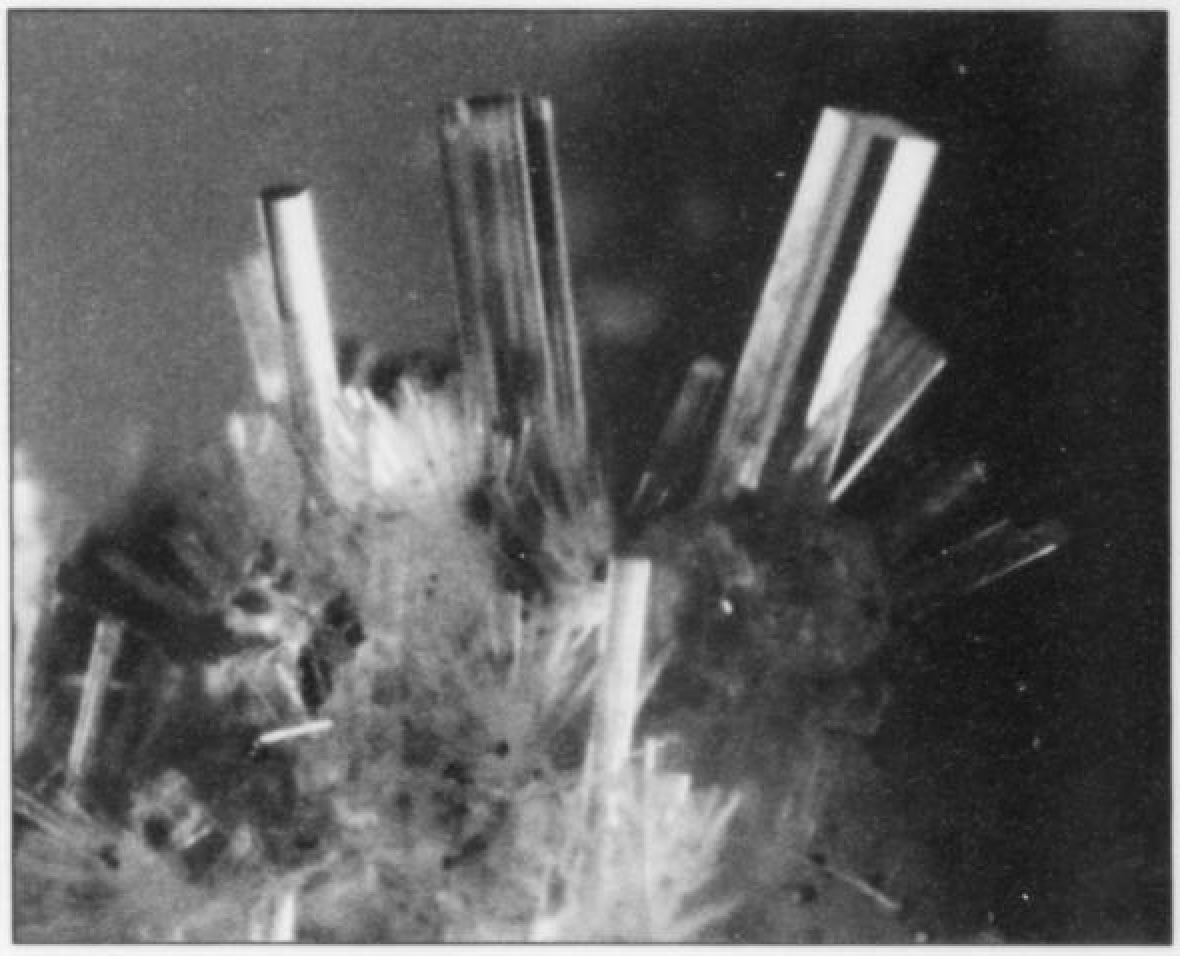


***Figure 40.* Acicular dawsonite covering matrix, about 1.5 cm across, from the upper sill, Francon quarry. Horváth collection (no. 3229); L. Horváth photo.**

***Figure 41.* Dawsonite microcrystals to 1.1 mm from the Francon quarry. Quintin Wight collection and photo.**



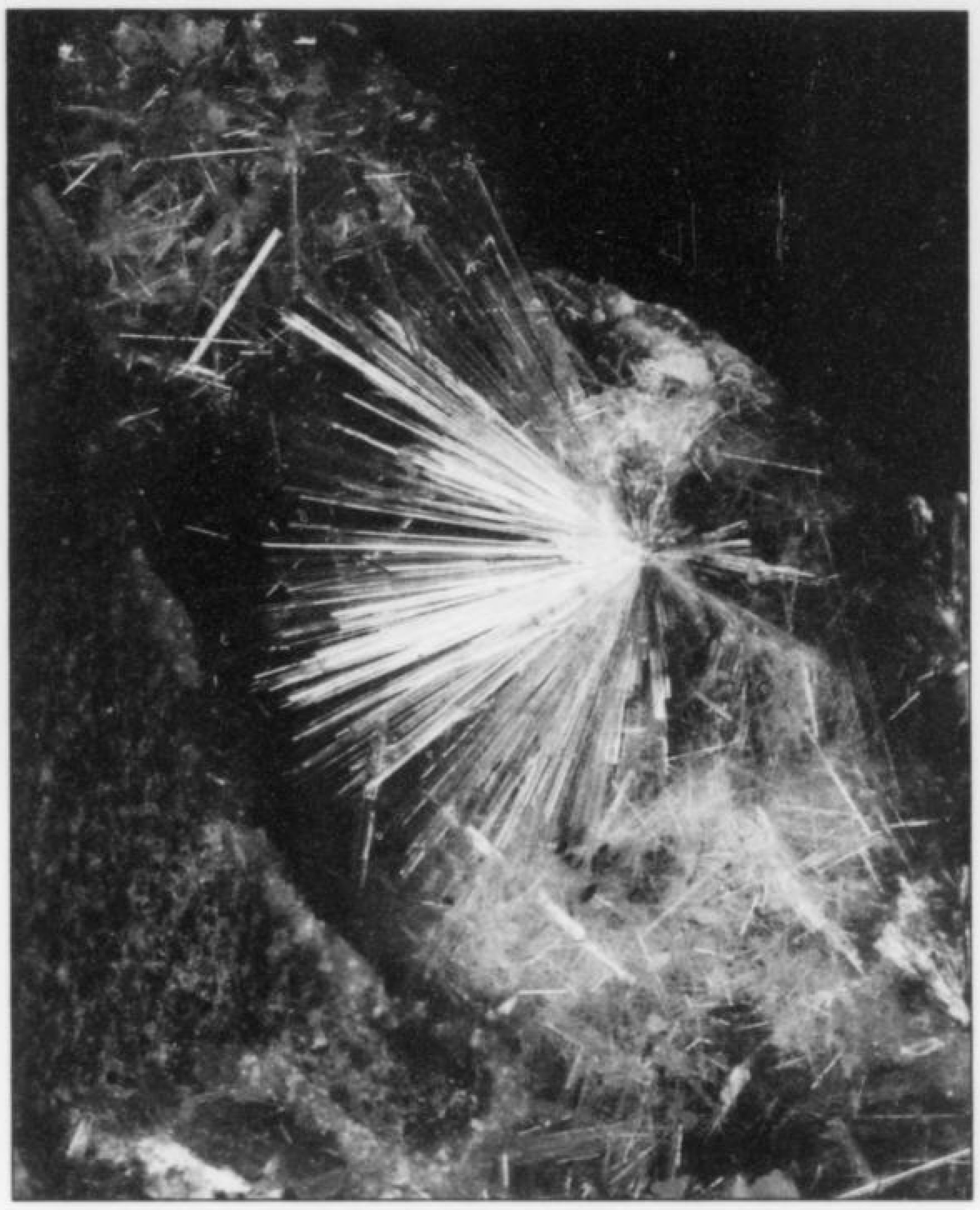


***Figure 42.* Acicular dawsonite crystals to about 1 cm in a cavity; Francon quarry. Doell collection; L. Horváth photo.**

mordenite. Both the mordenite and the dachiardite-Na are white and fibrous, and difficult to distinguish visually.

Dachiardite-Na fluoresces weakly orange-white under shortwave; weakly orange under medium-wave; and weakly brownish orange under longwave ultraviolet radiation. No phosphorescence was observed.

Dawsonite $NaAl(CO_3)(OH)_2$

Dawsonite is a relatively common species in the igneous rocks of the Monteregian alkaline province in the Montréal area. The many occurrences include the type locality on the campus of McGill University (Harrington, 1875, 1878; Graham, 1908; Stevenson and Stevenson, 1965, 1977), Mont Saint-Hilaire (Chao *et al.*, 1967; Horváth and Gault, 1990), Mont Saint-Bruno (Mandarino and Harris, 1965; Stevenson and Stevenson, 1978), the Miron quarry in Montreal (Sabina, 1978), the Saint-Amable sill (Horváth *et al.*, 1998) and several unpublished localities. In the Francon quarry, dawsonite is the most common and abundant mineral. It is a major component of the sill rock (Steacy and Jambor, 1969; Jambor *et al.*, 1976; Vard and Williams-Jones, 1993), and is present in a large proportion of the sill cavities (Sabina, 1976).

In the sill cavities, dawsonite occurs as superb, well-formed, colorless crystals ranging in size from less than 1 mm up to 2 cm long. The crystal morphology is very simple, predominantly defined by only two forms. Several common crystal habits can be recognized:

Habit A consists of short prismatic crystals with a dominant {110} prism, terminated by a {001} basal pinacoid, rarely modified

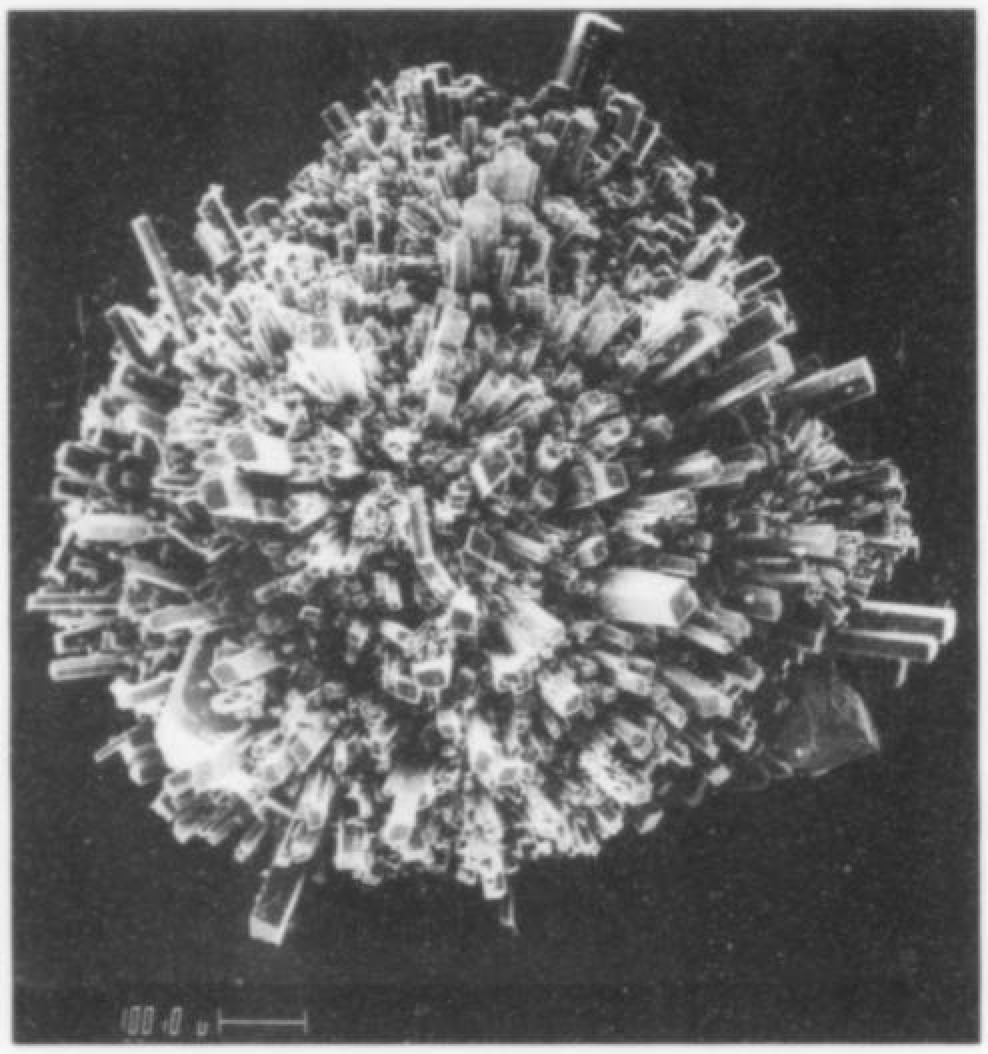


Figure 43. **Spherical aggregate of dawsonite crystals composed of two forms: the {110} prism and the {001} basal pinacoid. Geological Survey of Canada collection and SEM photo.**

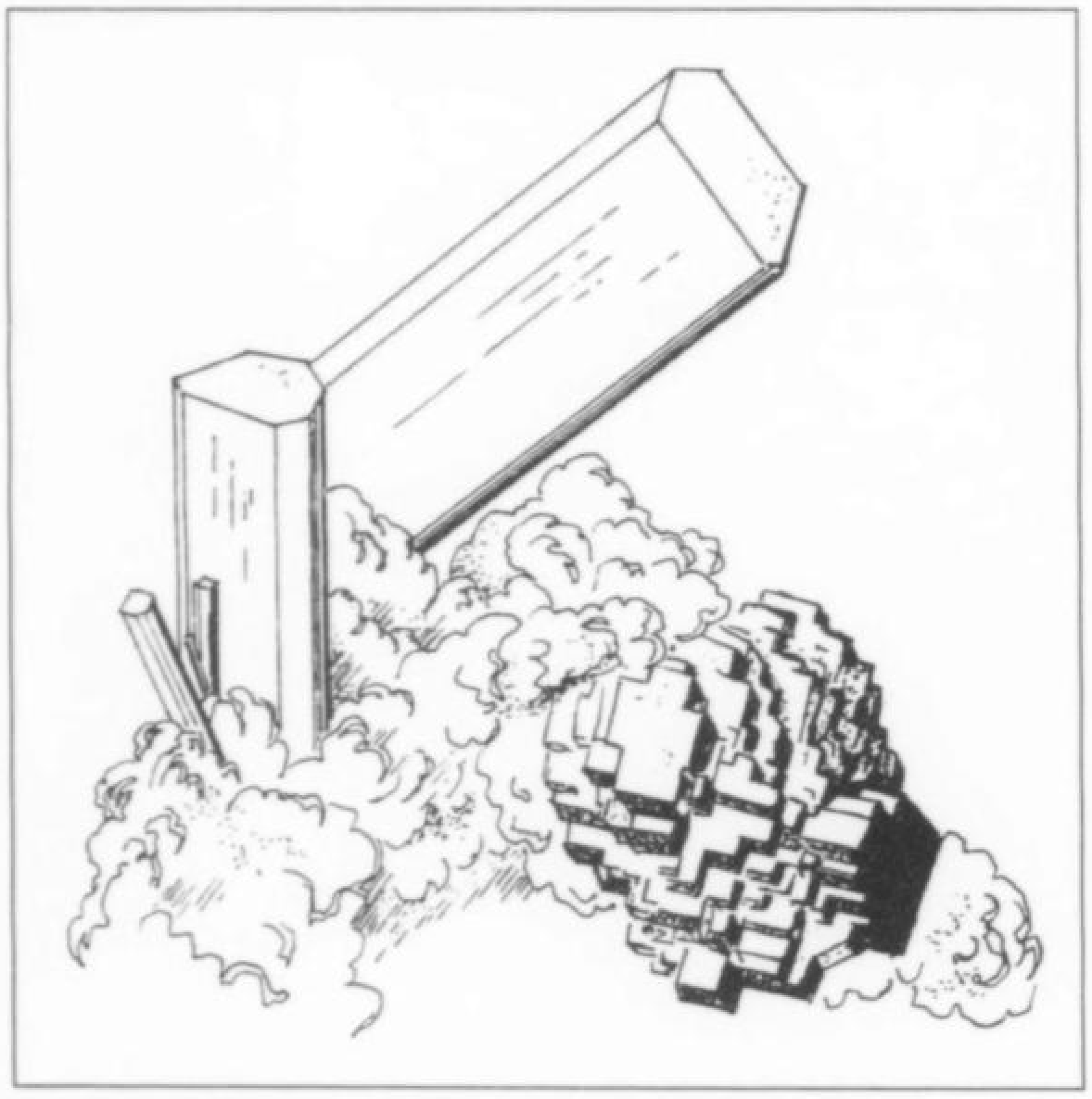


Figure 44. **Prismatic, colorless dawsonite crystals with stepped, pale purple cubic fluorite crystals from the Francon quarry; 3 mm across. Garry Glenn drawing.**

by a small {010} pinacoid. The crystals are 0.2–3 mm in length. In this habit, dawsonite occurs as scattered individual crystals on other minerals, and as compact spherical aggregates and open clusters of radiating crystals. Composite crystals consisting of two or more prisms in parallel to semi-parallel growth are common. This is a very common habit in both the upper and lower sills.

Habit B is characterized by blocky to equant crystals with the same forms as in habit A but with more common and prominent {010} and {100} pinacoids. The crystals are typically 1–3 mm with exceptional crystals up to 1 cm across; the larger crystals sometimes form plate-like, parallel-growth aggregates up to 3 cm across. This is a common habit in both upper and lower sills.

Habit C crystals are tabular, colorless to opaque white, 1–4 mm in diameter, with dominant {001} basal pinacoids. This habit is very rare and localized.

Habit D is characterized by acicular crystals consisting of elongated, slender {110} prisms terminated by the {001} pinacoid, very rarely modified by a {011} prism. Most of these crystals are 6–10 mm long (aspect ratio ~1:10), and rarely up to 2 cm long (aspect ratio of 1:20–30); in the extreme case they are hair-like. Dawsonite with this habit is most common in the upper sill where it occurs as dense masses of radiating and randomly oriented crystals.

Habit E consists of fibrous to capillary crystals in white, matted, cotton-like, and compact fibrous to pulverulent masses. This habit is rare and very localized.

Dawsonite crystals are typically striated parallel to [001] on the prism faces, which imparts a silky luster. In contrast, the luster of the {001} basal pinacoids is vitreous.

Dawsonite has also been reported as white waxy spheres; and as flaky, scaly and botryoidal aggregates (Sabina, 1976, 1979).

Dawsonite is ubiquitous in the sill cavities. It occurs as more than one generation, and is associated with virtually all the minerals known from the quarry. The largest, and undoubtedly the best crystals of dawsonite were the blocky (habit B) crystals found in the lower sill in the northwest end of the quarry in the fall of 1976. The largest single crystals from this find are up to 1 cm long, and some plate-like aggregates are up to 3 cm across. These are characteristically associated with quartz, sprays of pinkish celestine, and goethite. Excellent specimens with cavities several cm across, lined with masses of acicular crystals up to 1 cm long, were common and easy to collect during 1973–1976, from the upper sill at the south end of the quarry near the entrance ramp. Some cavities were lined by dawsonite only and others by dawsonite intergrown with cubes of deep purple fluorite and orange sphalerite. In the same zone, there were very unusual cavities containing only dawsonite and quartz. In some of these, the dawsonite is partially overgrown by bluish gray, drusy quartz, and some fine, acicular, second-generation dawsonite, including exceptionally long acicular crystals (up to 2 cm long). Very late-stage dawsonite in massive form is fairly common in the upper sill. In an occurrence discovered in 1981 in the alcove, white, pulverulent, very finely fibrous masses (habit E) partially filled cavities up to 8 cm across, and encrusted the associated weloganite, quartz, calcite and first-generation dawsonite. The satiny luster and effervescence in dilute HCl helps to distinguish this form of dawsonite from some of the other Francon minerals that occur as white crusts. Although dawsonite is often described as being "soluble in acids with effervescence" (Palache *et al.*, 1951), it should be noted that larger crystals such as those found at Francon display effervescence only in warm or concentrated hydrochloric acid.

Dawsonite has also been found in the limestone adjacent to the lower sill. In 1980, an open fracture yielded randomly oriented acicular crystals up to 1.5 cm in length associated with calcite and strontianite.

Most dawsonite is not fluorescent, but exceptionally, some has been observed to fluoresce pale yellow to pinkish yellow under shortwave, medium-wave and longwave ultraviolet radiation.

Dickite $Al_2Si_2O_5(OH)_4$

Dickite has been identified as a silky white coating on quartz (A. P. Sabina, personal communication, 2004). Dickite is a polymorph of halloysite and kaolinite, which also occur in the quarry.

Dolomite $CaMg(CO_3)_2$

Dolomite is an uncommon cavity mineral in the lower sill, where it occurs as colorless, pale yellow and pale pink rhombohedra less than 1 mm across, often in association with ankerite, calcite and siderite. Visually it is not readily distinguishable from similarly colored associated rhombohedral carbonates. Dolomite has also been found in cavities in the upper sill and in dikes. In an unusual assemblage in a dike in the alcove, dolomite occurred as colorless, saddle-shaped rhombohedra up to 2 mm, occasionally forming drusy cavity linings, in association with analcime, quartz, mordenite and synchysite-(Ce). Dolomite also forms granular patches in the dike rock. Dolomite is common in limestone cavities as translucent, white and brownish, saddle-shaped rhombohedra up to 5 mm across, associated with strontianite, calcite, quartz and, less commonly, pyrrhotite.

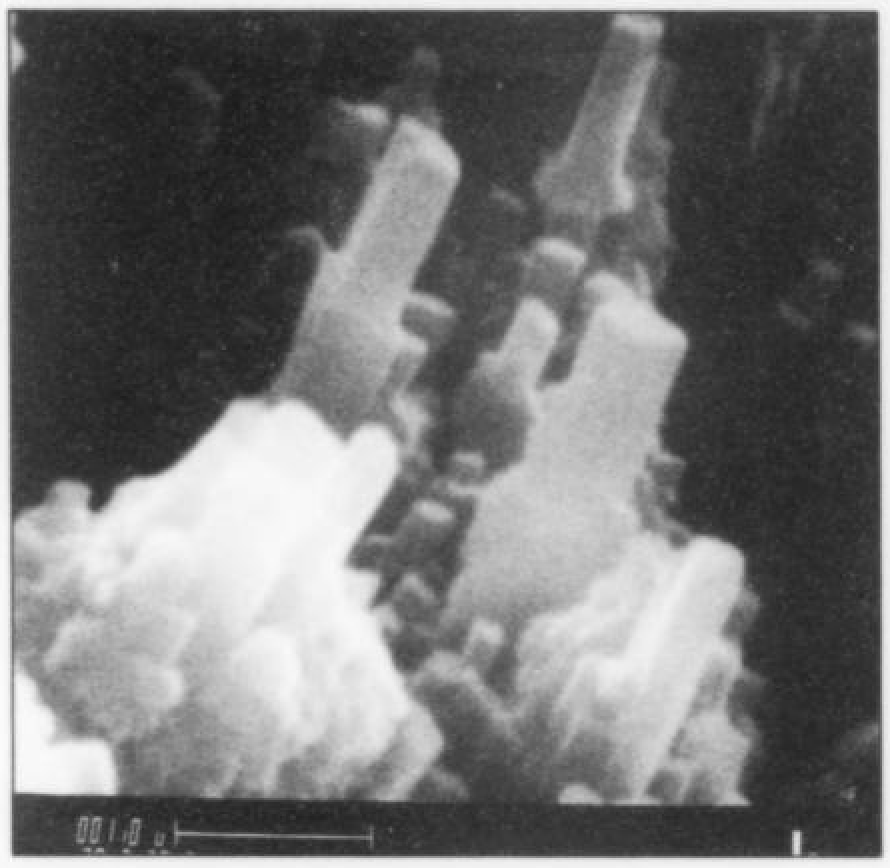


Figure 45. **Aggregate of doyleite crystals; Geological Survey of Canada specimen and SEM photo.**

Doyleite $Al(OH)_3$

Doyleite, a triclinic polymorph of nordstrandite, beyerite and gibbsite, was described as a new species jointly from Mont Saint-Hilaire [type locality 1] and from the Francon quarry [type locality 2] (Chao *et al.,* 1985). The structure was solved by Clark *et al.* (1998) using Mont Saint-Hilaire material, the only known source for well-formed crystals. Since its original description, doyleite has also been reported from Gjerdingen, Nordmarka, Norway (Raade, 1990); Grube Clara, Oberwolfach, Germany (Walenta, 1993); the Coldstones quarry, Pately Bridge, North Yorkshire, England (Young *et al.*, 1997); the Saint-Amable sill, Varennes and Saint-Amable, Québec (Horváth *et al.*, 1998); and the Gold Quarry mine, Eureka County, Nevada (Castor and Ferdock, 2003).

At Mont Saint-Hilaire doyleite was first recognized as a potentially new species in 1974 and was designated as UK45; at the Francon quarry it was first noted in 1977 and was designated as APS No. 11 (Sabina, 1979). The composition given by Chao *et al.* (1985) for Francon quarry doyleite is: Al_2O_3 59.6, SiO_2 3.22, CaO 0.23, MgO 0.96, FeO 0.08, Na_2O 0.35, H_2O 39.56 (calculated by difference), total 100.00 weight %. In contrast, Mont Saint-Hilaire doyleite contains much less Si and no Mg.

At the Francon quarry, doyleite occurs as a late-stage mineral in both the upper and lower sills. It forms dull, translucent to opaque, white, creamy white or bluish white irregular granular or porcelaneous aggregates, compact, botryoidal and spherical aggregates, and thin crusts, commonly on cryolite, weloganite, strontianite and calcite crystals. Other associated minerals include albite, barite, dresserite, hydrodresserite, strontiodresserite, quartz, dawsonite, fluorite, analcime, halloysite and montroyalite. At very high magnification the doyleite aggregates appear to consist of columnar crystals with a roughly square cross-section. Admixed with gibbsite, doyleite commonly forms thin, shell-like perimorphs after cryolite from which the original cryolite has been partially or completely leached out. A similar association of doyleite with cryolite and gibbsite has been noted in the Saint-Amable sill (Horváth *et al.*, 1998). Visual identification of doyleite is unreliable because of its resemblance to other white, powdery aggregates and crusts. Furthermore, although doyleite is not fluorescent under ultraviolet radiation (Chao *et al.*, 1985), its presence is usually masked by the strong fluorescence of admixed gibbsite. For these reasons, its rarity is difficult to assess.

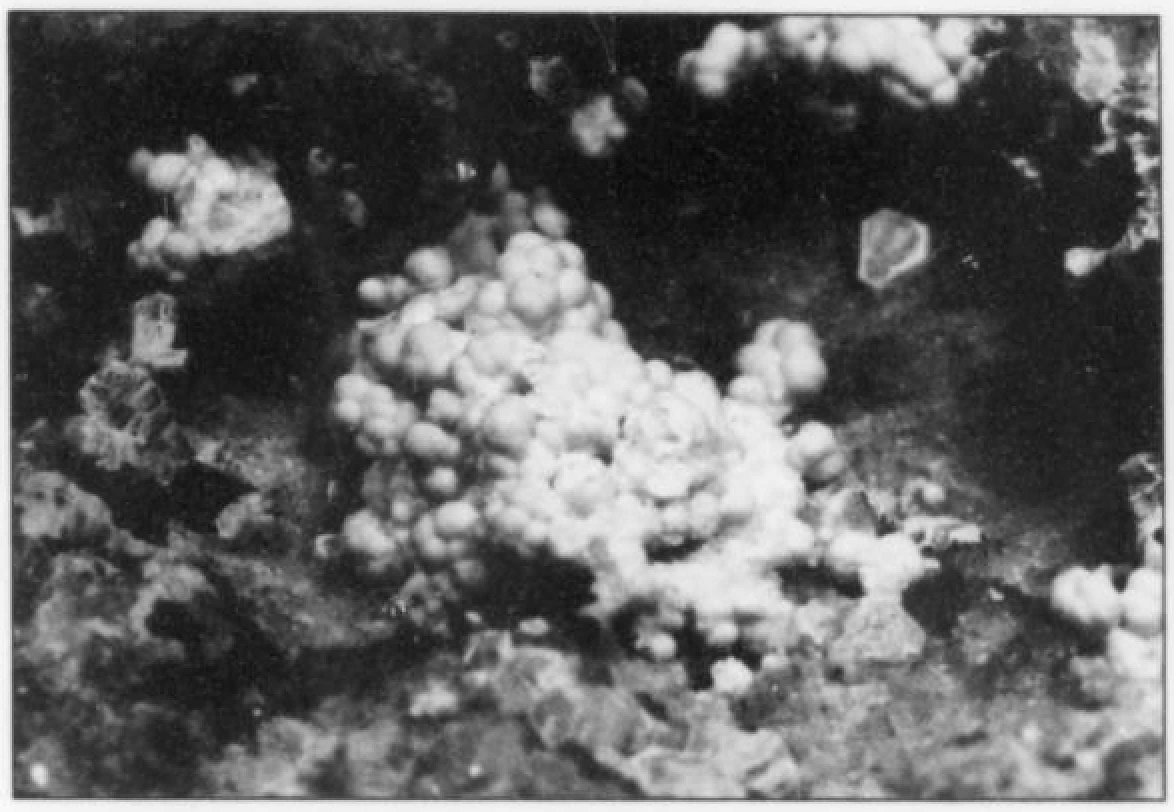


Figure 46. **Dresserite spherules about 1 mm each, on matrix, from the Francon quarry. Tarassoff collection (no. 2395); L. Horváth photo.**

Dresserite $BaAl_2(CO_3)_2(OH)_4 \cdot H_2O$

Dresserite was noted as a potentially new species, along with weloganite, very early in the mineralogical investigation of the quarry, and was designated as APS No. 4. It was first mentioned as a "new barium analog of dundasite" by Sabina *et al.* (1968) and was subsequently described as a new species by Jambor *et al.*(1969). Its infrared characteristics were investigated by Farrell (1977). Although its structure remains undetermined, Jambor *et al.* (1977a) concluded that it was unlikely to be isostructural with its chemical analog, dundasite. The Francon quarry remains the only known locality for dresserite. However, a Ca-analog, from the Mány coal deposit, Tatabánya, Hungary, has recently been approved as a new species (Burke and Ferraris, 2005).

When dresserite was first described, Jambor *et al.* (1969) reported that "another hydrous barium aluminum carbonate, which is not megascopically distinguishable from dresserite" had also been found. This proved to be the new species hydrodresserite (Jambor *et al.*, 1977b). Jambor *et al.* determined that hydrodresserite dehydrates to dresserite, and that some dresserite is in fact pseudomorphous after hydrodresserite. (This is discussed in more detail below, under hydrodresserite.)

Dresserite has been found only in the upper sill, where it is relatively common, and it is especially abundant in the alcove area. It occurs as white to pale cream, compact, spherical aggregates of radiating, colorless, fibrous to thin-bladed crystals. The spheres are 1–6 mm in diameter, with a dull to sub-vitreous luster on the exterior, and a silky luster on freshly broken interior surfaces. They often form botryoidal clusters, rarely up to 2 cm across. The exterior surface of the individual spheres may be smooth, rough due to slightly projecting crystals, or it may have random, colorless bladed crystals extending some distance from the surface. These crystals may be dresserite, hydrodresserite or dresserite pseudo-

Figure 47. **Dresserite spherules on a 1.8-cm smoky quartz crystal aggregate from the Francon quarry. Horváth collection (no. 5524); L. Horváth photo.**

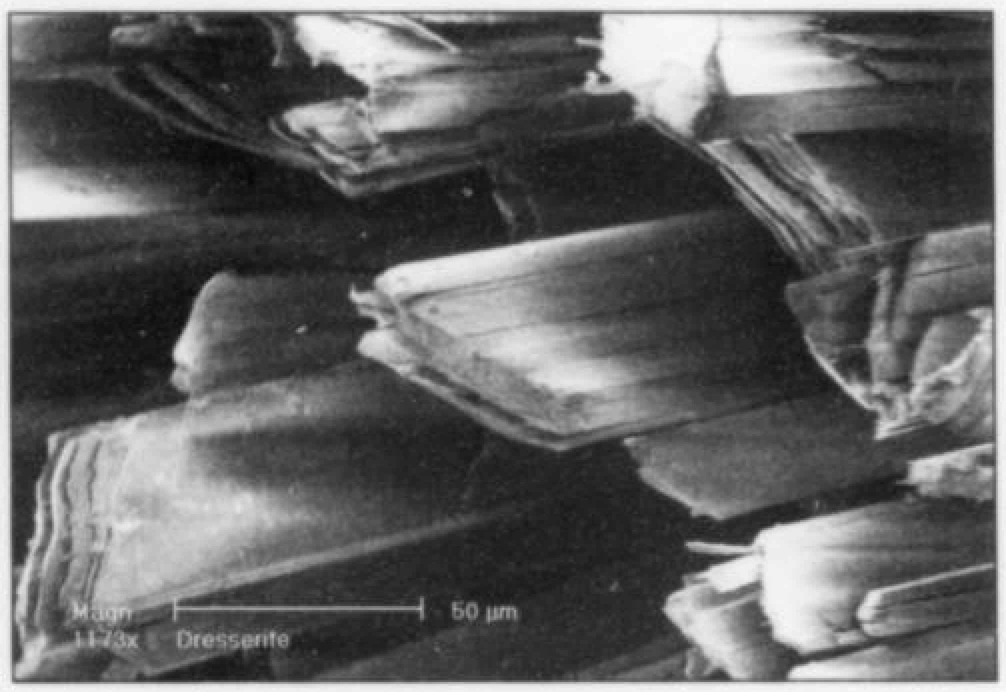


Figure 48. **Dresserite crystal terminations; note possible cleavage or parting and laminations parallel to [010]. Horváth collection; L. Horváth and R. Gault SEM photo.**

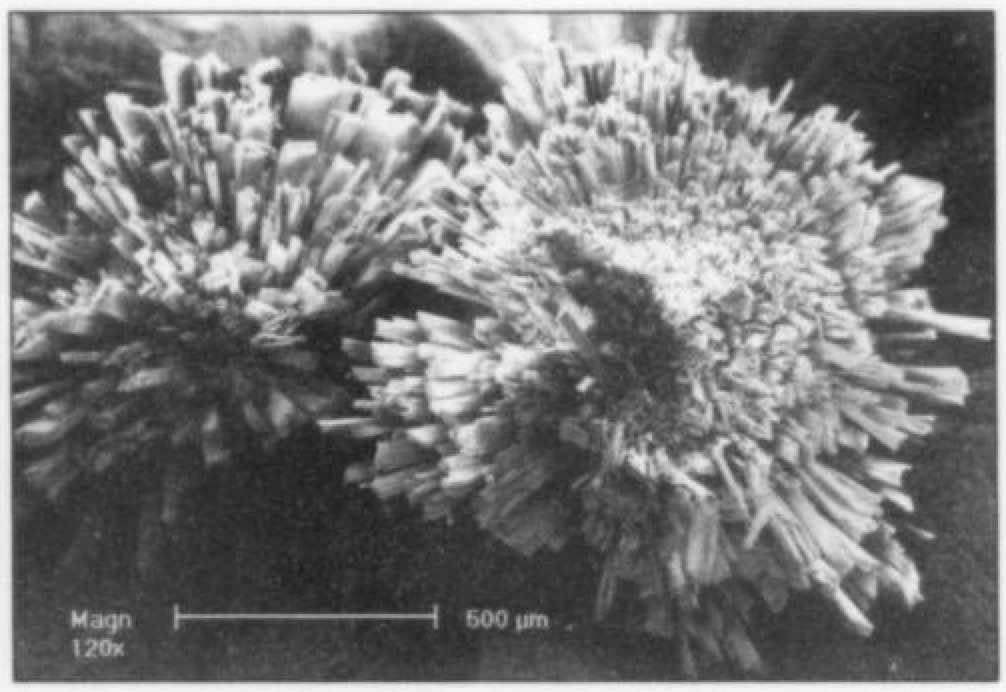


Figure 49. **Dresserite crystals in spherical aggregates. Horváth collection; L. Horváth and R. Gault SEM photo.**

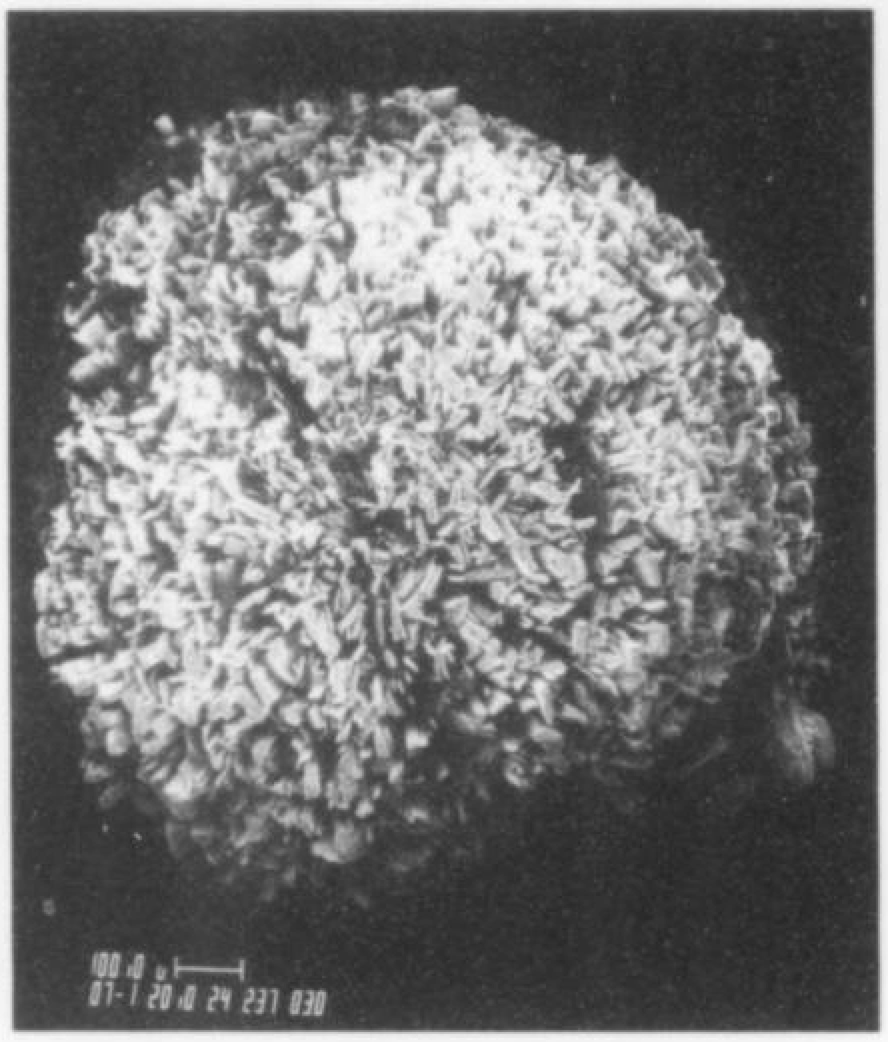


Figure 50. **Dresserite crystals in a compact spherical aggregate. Geological Survey of Canada specimen and SEM photo.**

morphs after hydrodresserite. Dresserite is orthorhombic, with the bladed crystals elongated along [001] and flattened on (010) (Jambor *et al.*, 1969) and "bluntly terminated" (Sabina, 1979) by what is likely a {001} pinacoid. Bladed crystals corresponding to {010}>{100}>{001} forms are visible under the microscope and on SEM photographs. Although cleavage was not reported by Jambor *et al.*, (1969), possible cleavage or parting, and what may be best described as lamination parallel to [010] is apparent in SEM photos. Identical features are observed on hydrodresserite, which has a perfect {010} cleavage. The available evidence suggests that crystals with an orthogonal termination are primary dresserite, and those with the distinct, inclined {102} pinacoid termination are either hydrodresserite or dresserite pseudomorphs after hydrodresserite. In the smooth-surfaced spherules, the two species are indistinguishable.

Associated minerals include practically all the species found in the upper sill, but the invariably and intimately associated species is hydrodresserite. Also very common are weloganite, quartz, calcite and dawsonite. Dresserite is one of the latest minerals in the paragenetic sequence, and is often found perched on quartz and weloganite, resulting in rather attractive specimens.

Dresserite fluoresces strongly yellowish white under shortwave and medium-wave, and greenish yellow under longwave ultraviolet radiation, and gives a medium to weak, white, short-duration phosphorescent response after exposure to all three wavelengths.

Elpidite $Na_2ZrSi_6O_{15}\cdot 3H_2O$

Elpidite, considered to be one of the typical indicator minerals of agpaitic rocks, is relatively rare at Francon. It has been found only in the lower sill, in the northwestern part of the quarry. It occurs as colorless, acicular prismatic crystals, 1–3 mm long, with a vitreous luster. The crystals form sheaves, radiating clusters, random and sub-parallel, stacked aggregates; and sometimes, a crust-like layer several square centimeters in area, commonly on analcime crystals. Elpidite crystals consist of a dominant {110} prism terminated by a {001} basal pinacoid, very rarely modified by a small {011} prism. The only significant concentration of elpidite was found during the summer of 1975, mostly with yellow cryolite. Other minerals in the cryolite assemblage are opaque white weloganite, strontianite, barite and powdery gibbsite. Elpidite was also found in the same area of the quarry with yellow weloganite, analcime, calcite, albite, marcasite, synchysite-(Ce) and brookite. Elpidite fluoresces a medium-intensity greenish yellow under shortwave ultraviolet radiation. The fluorescence, vitreous luster and lack of striations on the prism faces help to distinguish elpidite from superficially similar dawsonite.

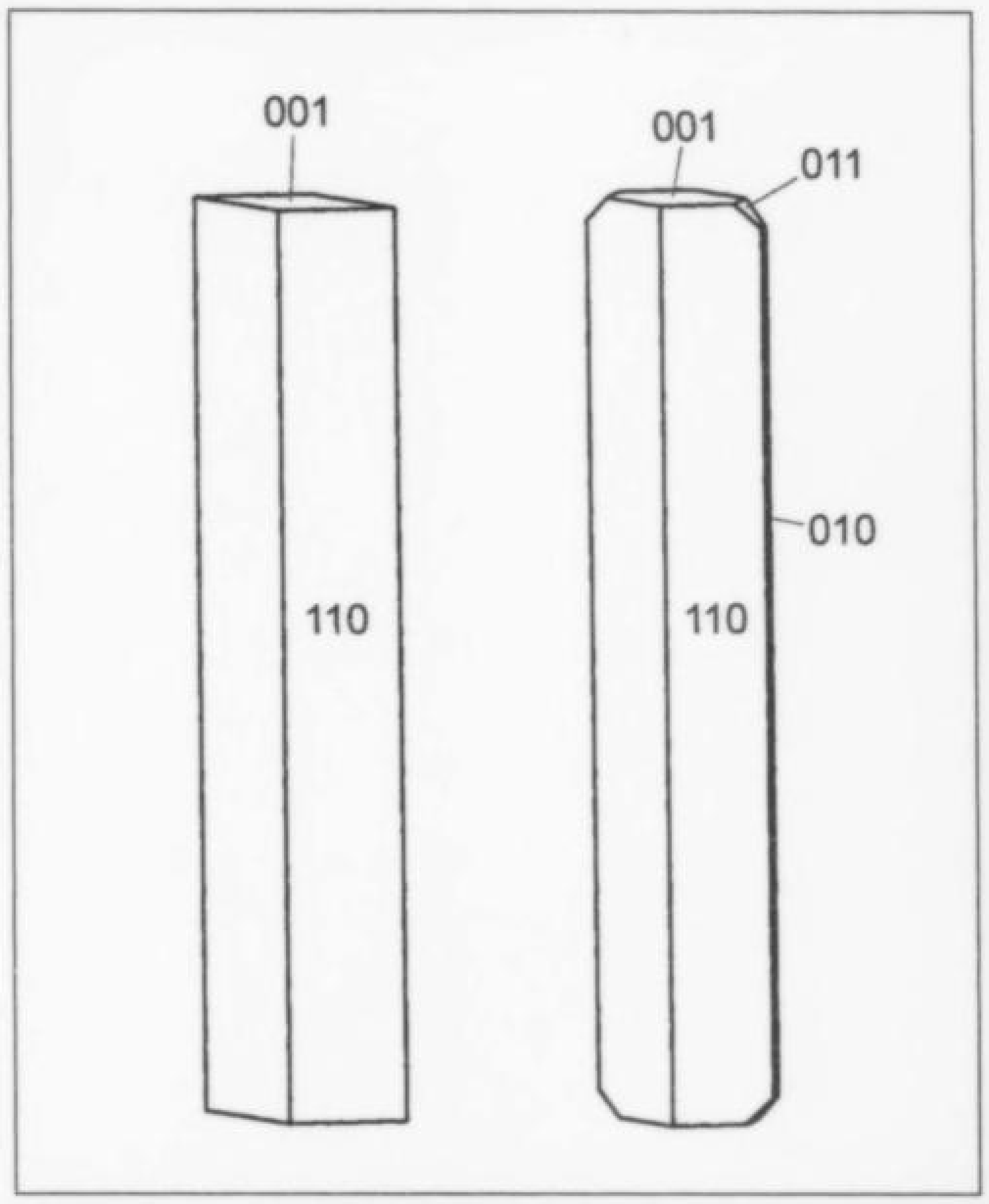


Figure 51. **Elpidite crystal drawings: Nearly all of the observed crystals are of the habit shown on the left, defined only by the two forms {110} and {001}. The drawing on the right shows the addition of the very rare {011} prism and {010} prism.**

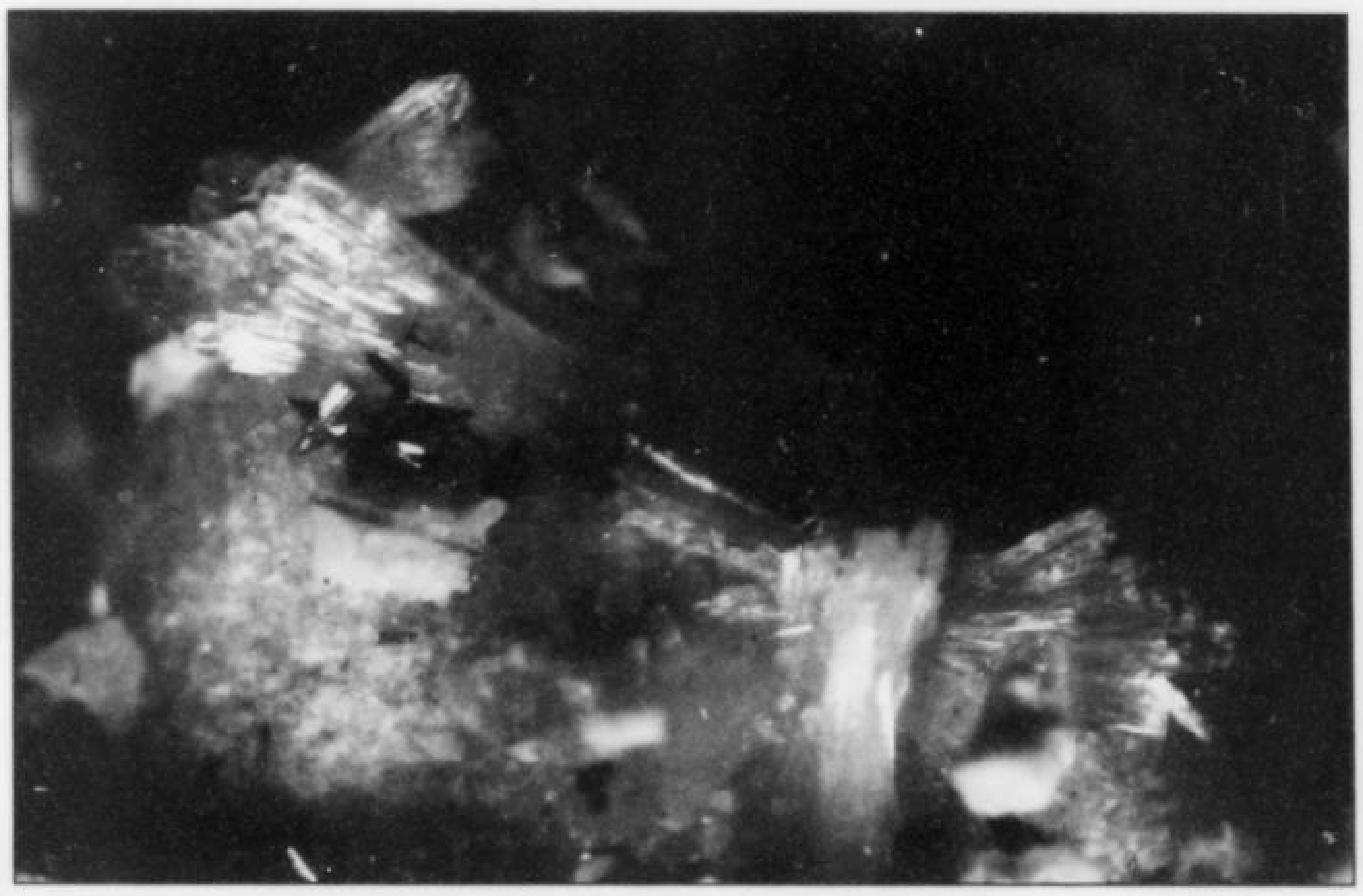


Figure 52. **Elpidite crystal sprays, about 2 mm each, from the Francon quarry. Horváth collection (no. 5240); L. Horváth photo.**

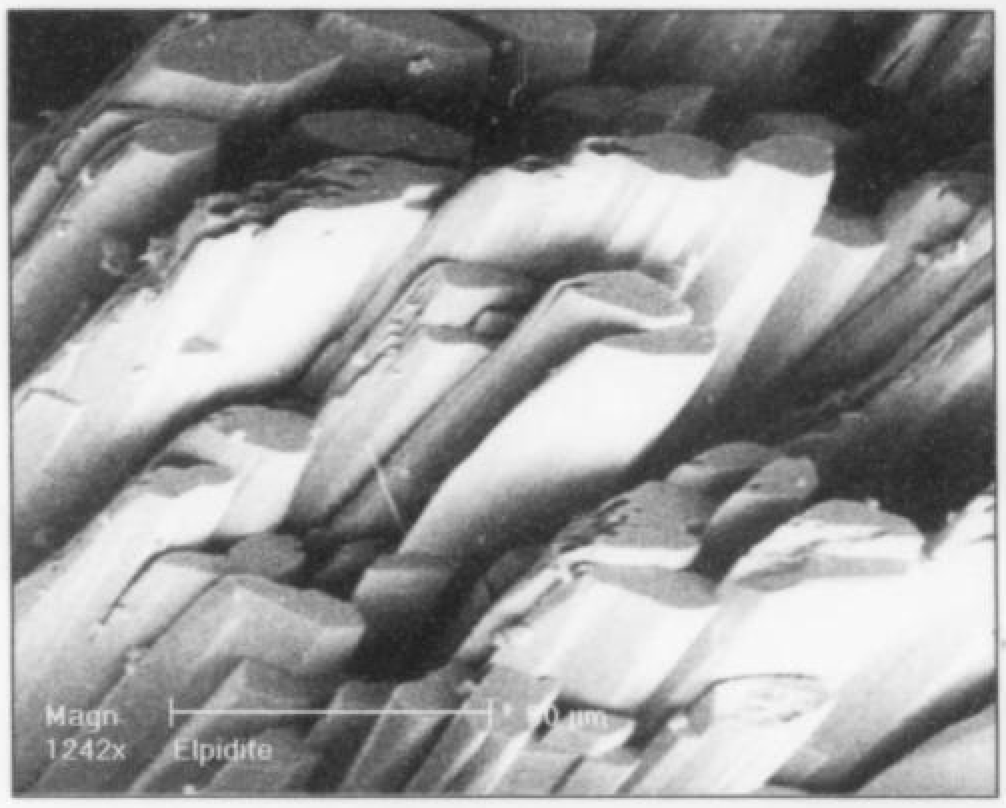


Figure 53. **Elpidite microcrystal terminations; Francon quarry. Horváth collection; L. Horváth and R. Gault SEM photo.**

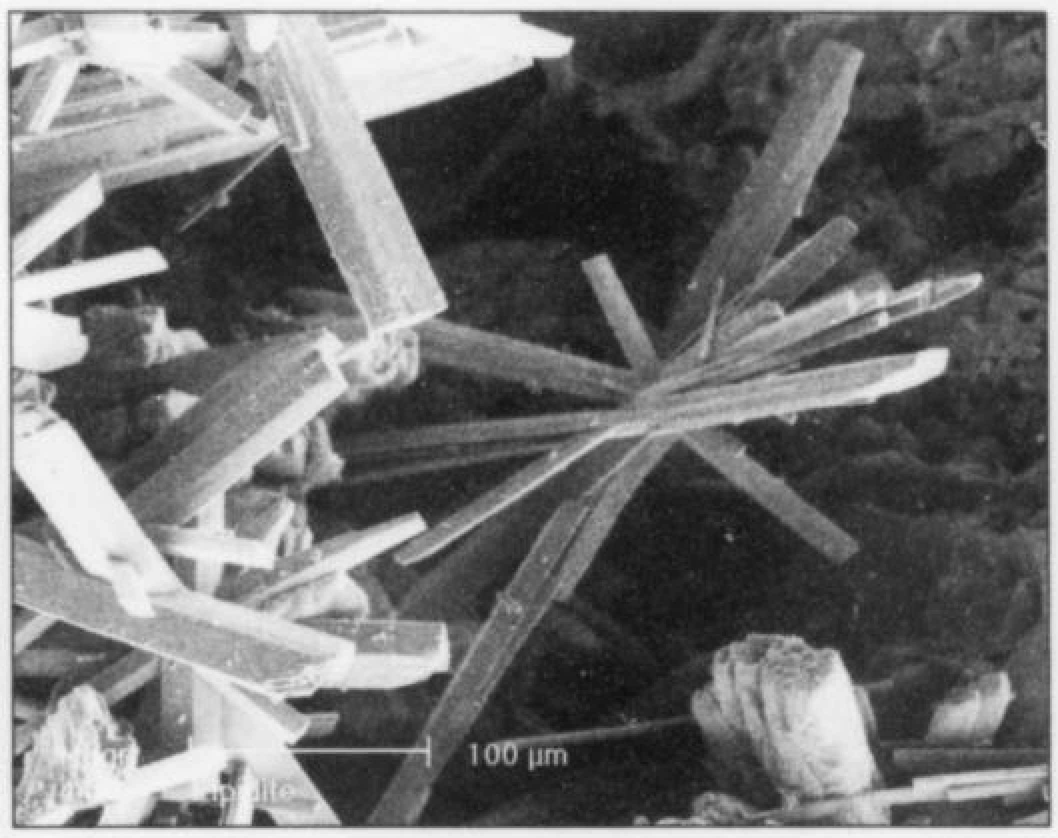


Figure 54. **Elpidite microcrystal clusters and aggregates, from the Francon quarry. Horváth collection; L. Horváth and R. Gault SEM photo.**

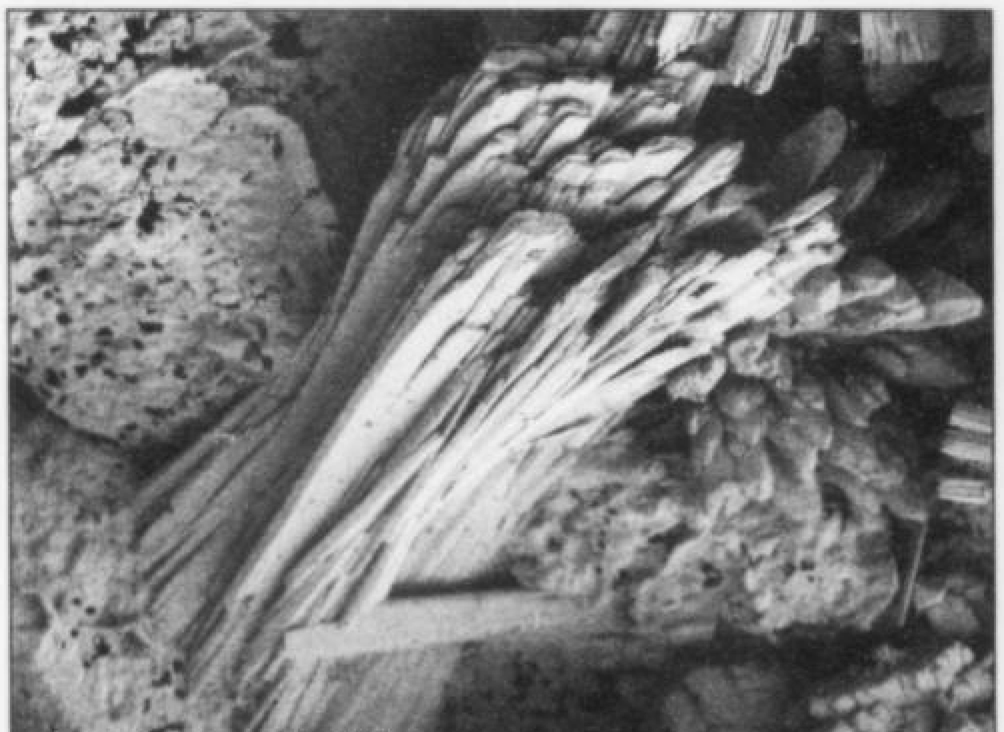


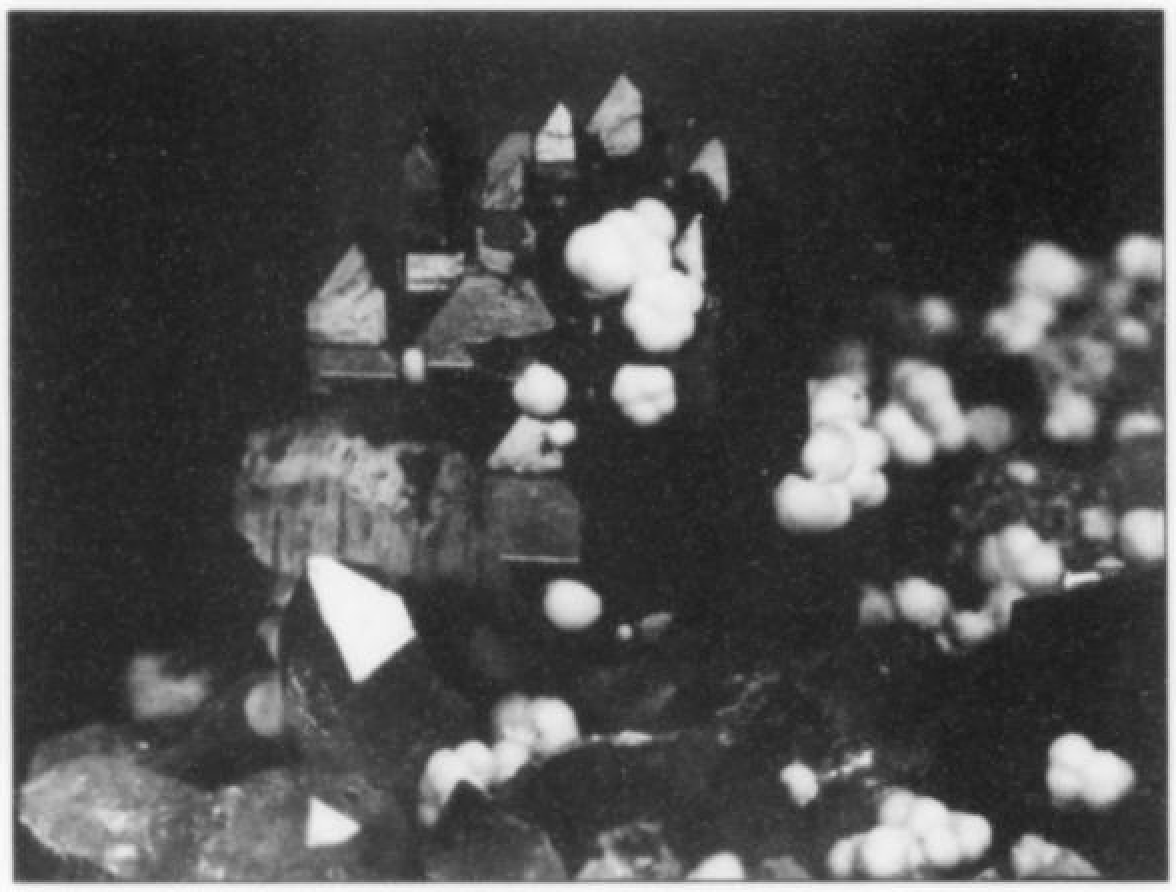
Figure 55. **Elpidite microcrystals in sheaf-like aggregates; Francon quarry. Horváth collection; L. Horváth and R. Gault SEM photo.**

Fluorite CaF_2

Fluorite is one of the more common cavity minerals in the sills. It is somewhat more abundant in the lower sill than in the upper sill. Rarely, it is also found in dike cavities. It occurs as isolated individual crystals 1–5 mm in diameter; as crystal aggregates and drusy cavity linings; as platy, botryoidal, and granular masses; and as finely disseminated inclusions coloring other minerals.

The crystal morphology is simple, with {100} cubes being the most common, and {111} octahedra also quite common; the combination of the two is less common. Another, relatively rare form noted is the typically small {101} dodecahedron. Some crystals display prominent growth offsets on the cube faces.

The color of the most common crystals varies from a transparent and pale to vivid purple, to translucent to opaque and dark purple to almost black. Colorless crystals are less common, and dull, opaque white crystals are rare. Patchy, irregular color zoning, phantoms and color spots (mostly pinkish violet) are relatively



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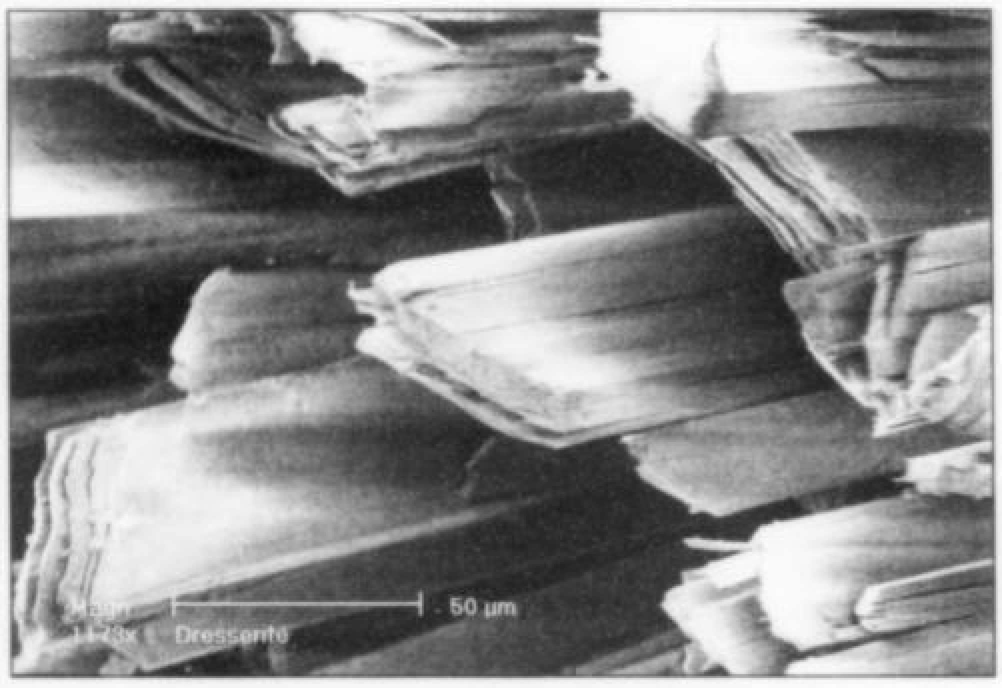

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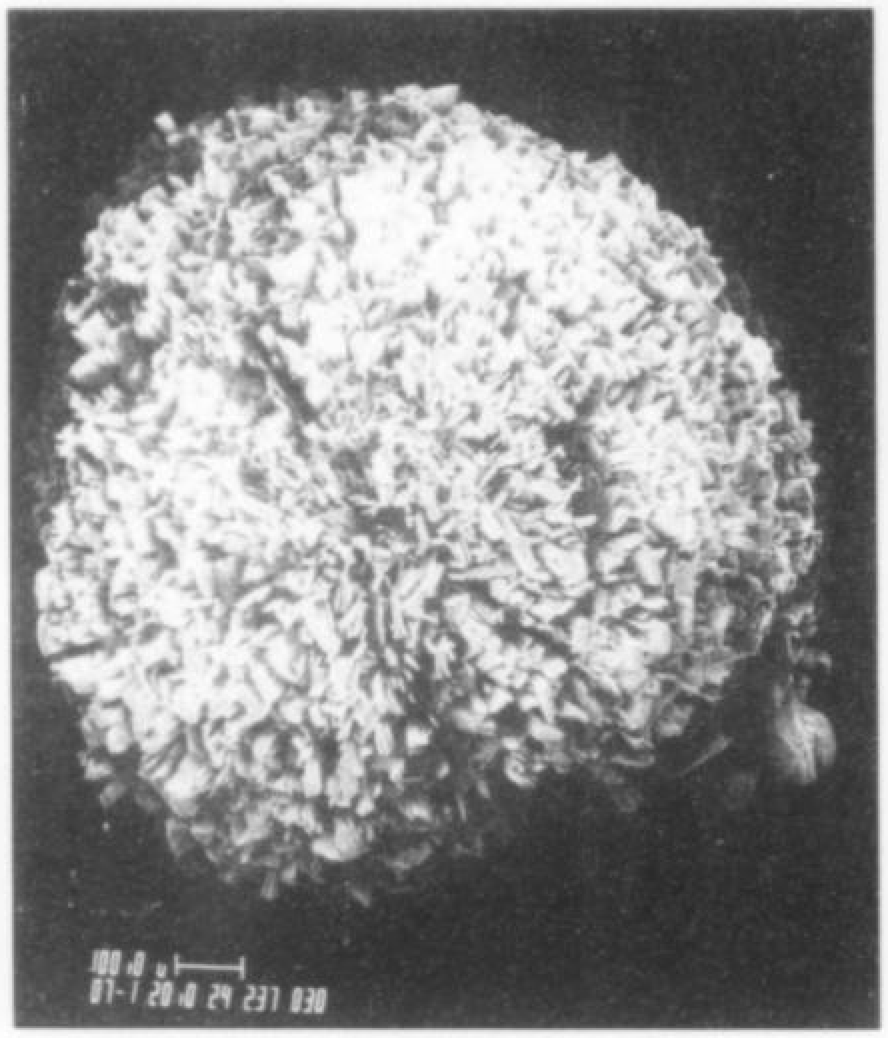
Figure 49. **Dresserite crystals in spherical aggregates. Horváth collection; L. Horváth and R. Gault SEM photo.**



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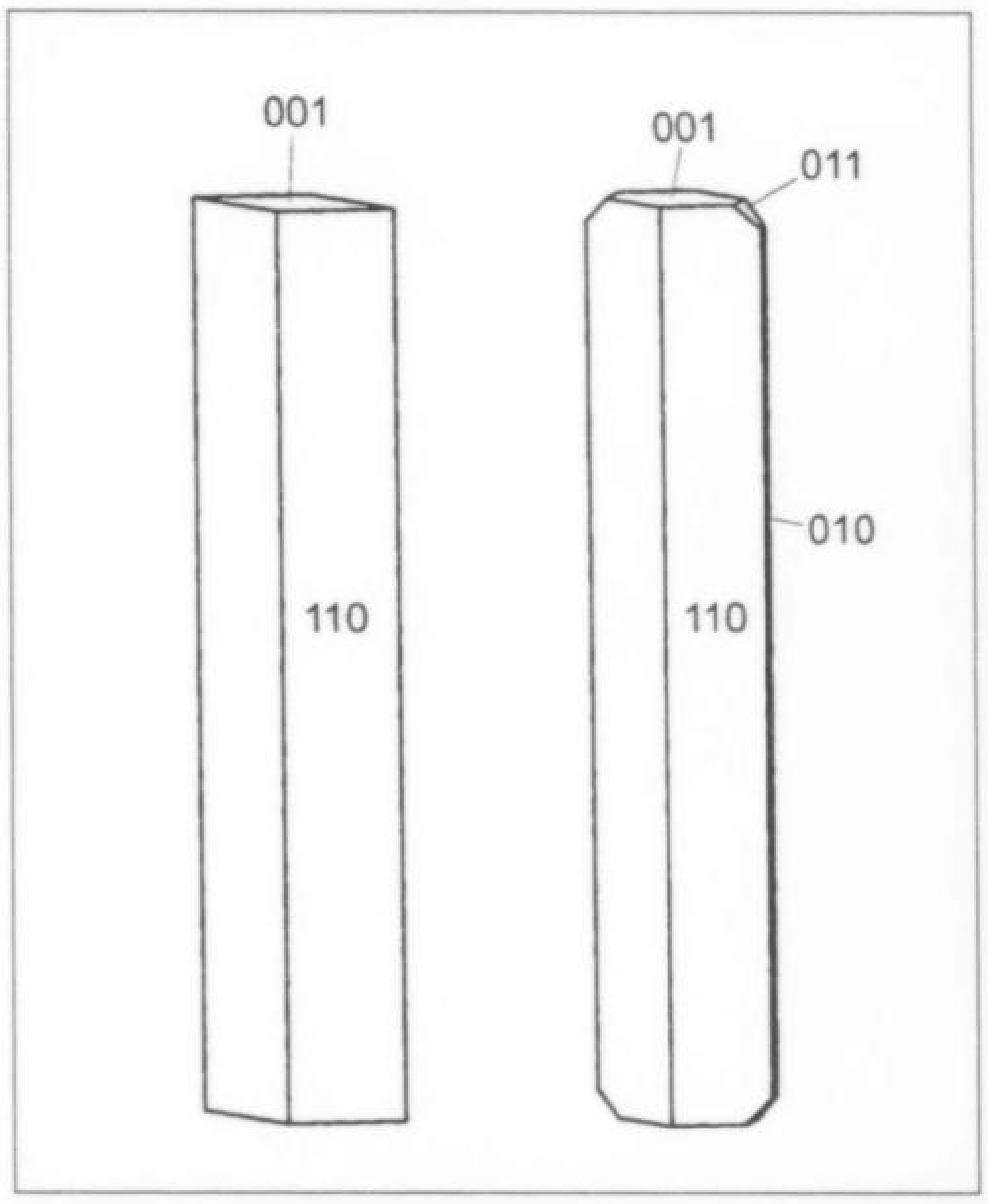

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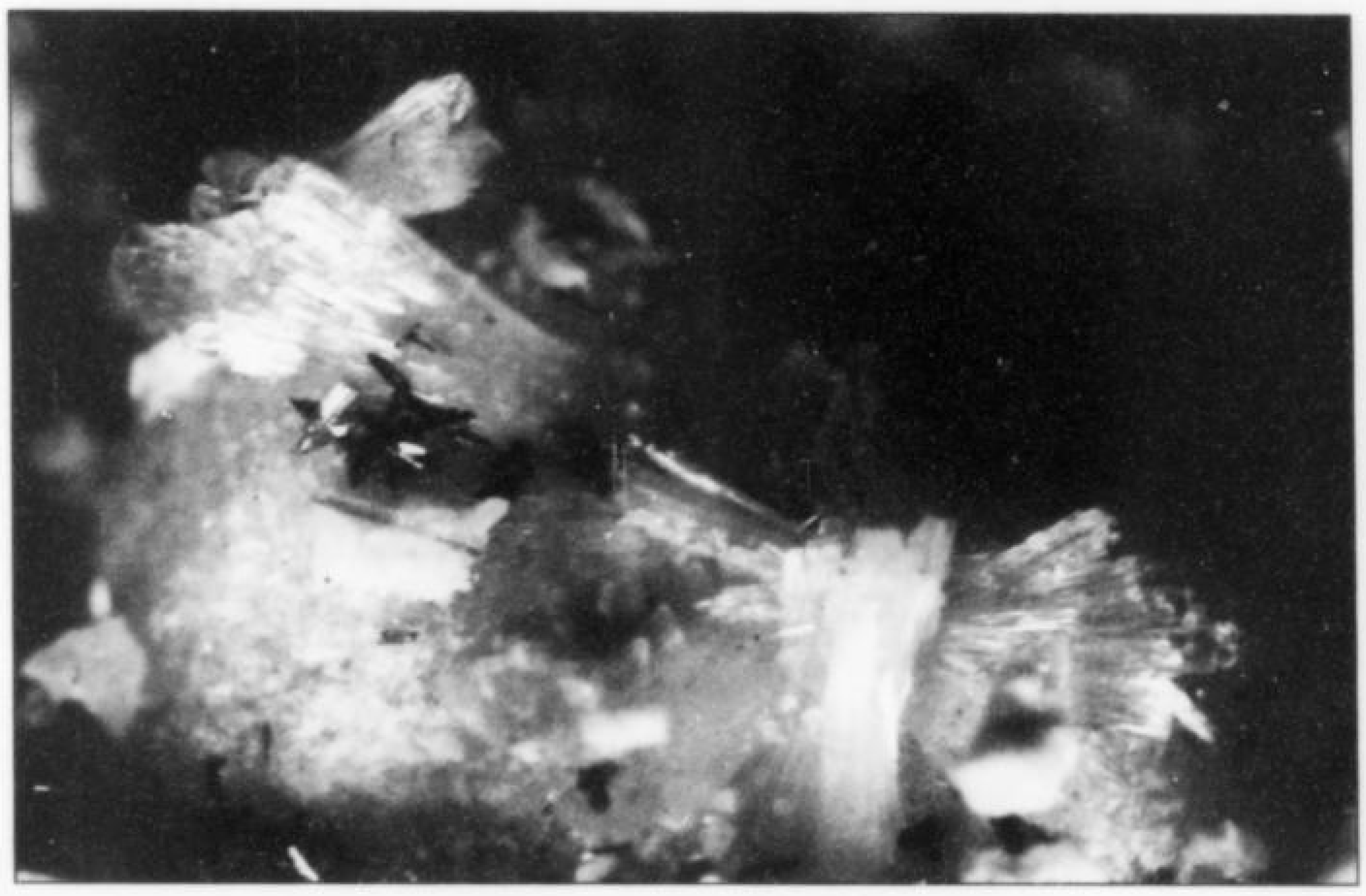

Figure 52. **Elpidite crystal sprays, about 2 mm each, from the Francon quarry. Horváth collection (no. 5240); L. Horváth photo.**

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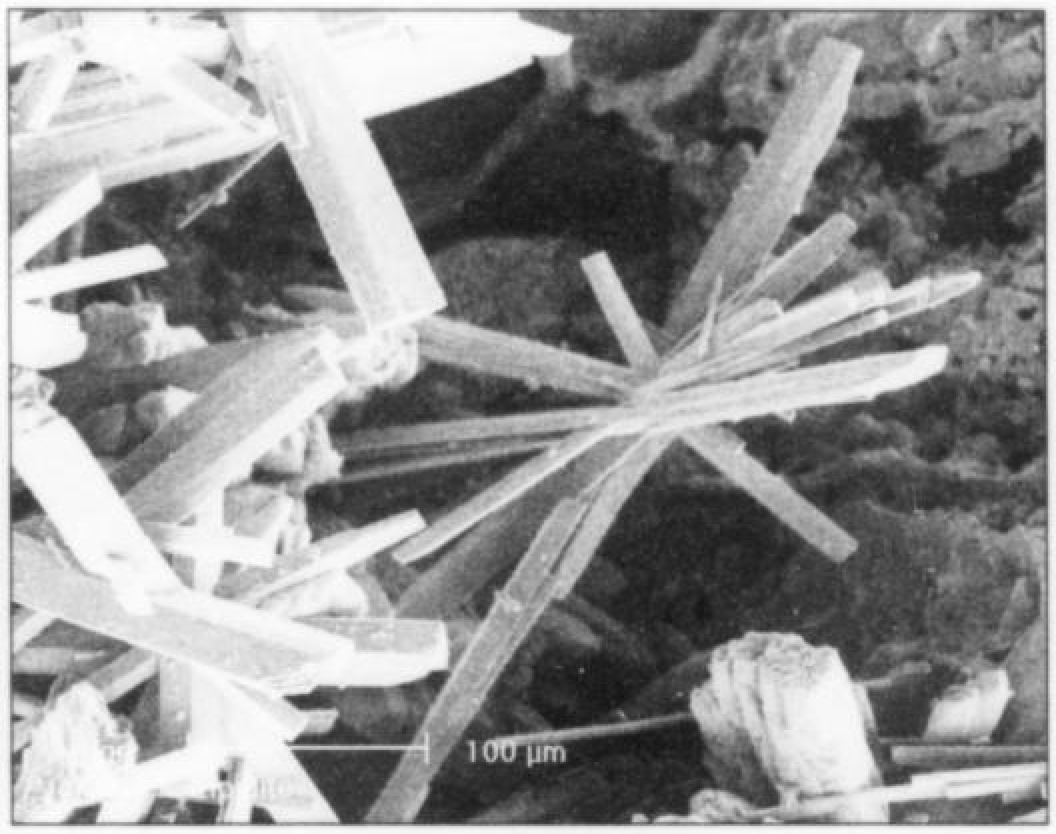

Figure 54. **Elpidite microcrystal clusters and aggregates, from the Francon quarry. Horváth collection; L. Horváth and R. Gault SEM photo.**

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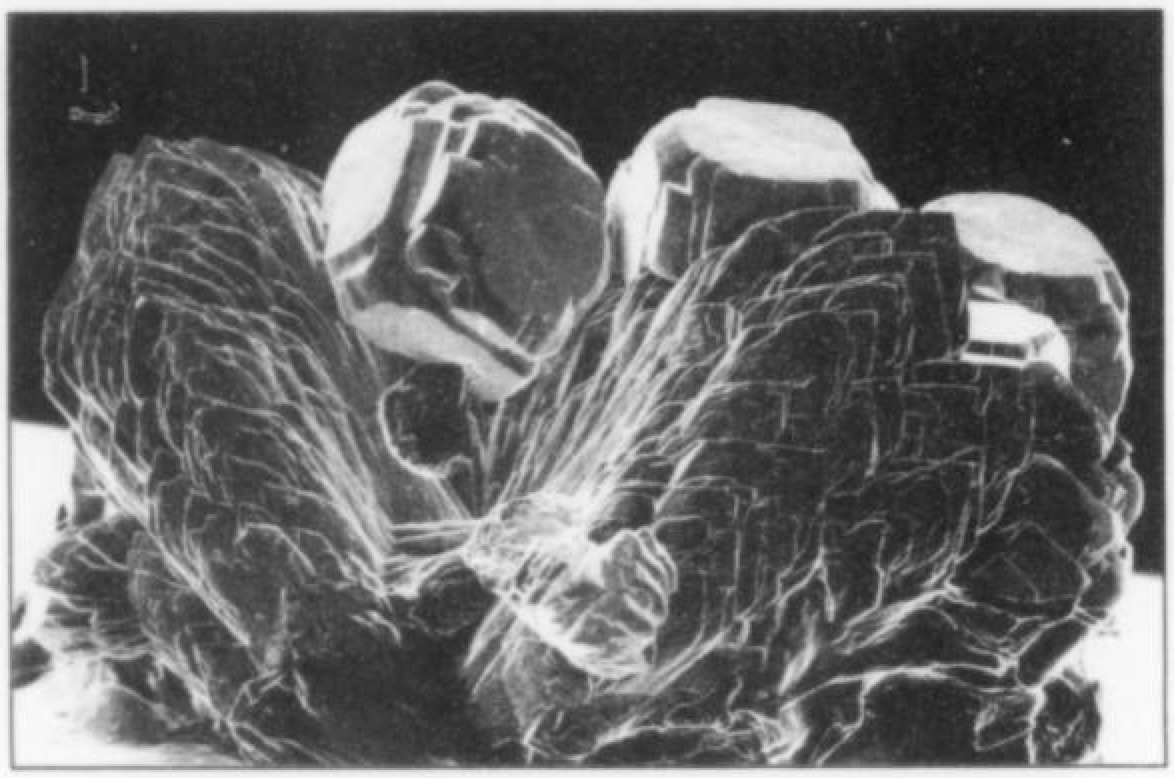

Figure 56. **Fluorite microcrystals (0.5 mm) on "artichoke" quartz, from the Francon quarry. Geological Survey of Canada specimen and SEM photo.**

common. Some crystals are colored reddish by minute hematite inclusions, and hematite sometimes coats the edges of the crystals.

A very rare and unusual variety of fluorite consists of tiny, vitreous, colorless spheroids, forming botryoidal crusts reminiscent of *hyalite* opal. Similar, individual, translucent white spheroids of fluorite have been observed on calcite.

Fluorite is an intermediate to late-stage mineral, sometimes found as two distinct generations in the lower sill, associated with nearly all the cavity minerals in the sills, but most consistently with dawsonite. In dike cavities, colorless fluorite has been found with mordenite, analcime, dolomite, cristobalite and synchysite-(Ce).

Franconite $Na_2Nb_4O_{11}\cdot 9H_2O$

Franconite was first found in the Francon quarry around 1976 and was designated as APS No. 10 (Sabina, 1979). An identical mineral was found at Mont Saint-Hilaire in 1975 by two of the authors (LH and EPH); it was recognized as a potentially new species and designated as UK43 (Chao and Baker, 1979). In 1984, franconite was described as a new species from the Francon quarry by Jambor *et al.* who noted that UK43 from Mont Saint-Hilaire was "probably franconite." Mont Saint-Hilaire then became the second known locality (Wight and Chao, 1986). Franconite has also been reported from the Vishnevye Gory massif, South Urals, Russia (Nikandrov, 1989), the Saint-Amable sill, Varennes and Saint-Amable, Québec (Gault and Horváth, 1994; Horváth *et al.*, 1998), and the Vuoriyarvi massif (Subbotin *et al.*, 1997a and b) and Kukisvumchorr in the Khibiny massif (Pekov and Podlesny, 2004), both in the Kola Peninsula, Russia.

Franconite occurs in cavities in the upper sill as very tiny (up to 250 µm diameter), opaque white globules, commonly forming clusters up to 0.5 mm in diameter (Sabina, 1979; Jambor *et al.*, 1984). At high magnification (SEM), the globules are seen to consist of radiating, elongated bladed crystals with obtuse terminations displaying two faces. The globules have a porcelaneous, relatively smooth surface, and an interior silky luster when split. Their external appearance is quite different from the more open spherical aggregates of radiating fibers found at Mont Saint-Hilaire. However, the individual crystals have the same morphology at both localities; the forms have not been determined. The average chemical composition of franconite from the Francon quarry yields the following empirical formula: $(Na_{1.69}Ca_{0.12}Sr_{0.01})_{\Sigma 1.82}$-$(Nb_{3.81}Ti_{0.09}Al_{0.01}Si_{0.09})_{\Sigma 4.00}O_{10.88}\cdot 9H_2O$ (Jambor *et al.*, 1984). Although not mentioned in the original description, some franconite contains calcium in solid solution, as well as intergrown hochelagaite, as reported by Jambor *et al.* (1986), which would account for the calcium in the above empirical formula. (This is discussed further below, under hochelagaite.)

Jambor *et al.* (1984) reported that franconite from the Francon quarry does not fluoresce under ultraviolet radiation; in contrast, franconite from Mont Saint-Hilaire and the Saint-Amable sill fluoresces under both shortwave and longwave radiation (Horváth and Gault 1990; Horváth *et al.* 1998). The similarity of franconite to other white globular minerals makes its visual identification unreliable. However, the porcelaneous appearance of individual globules, and their tendency to occur isolated on crystals of weloganite (most commonly), calcite, quartz and cryolite are good indicators of its potential presence. Other commonly associated minerals include dawsonite, gibbsite, barite, strontianite and dresserite. In the presence of coatings of bitumen, franconite sometimes occurs on top of the coating (Sabina, 1979).

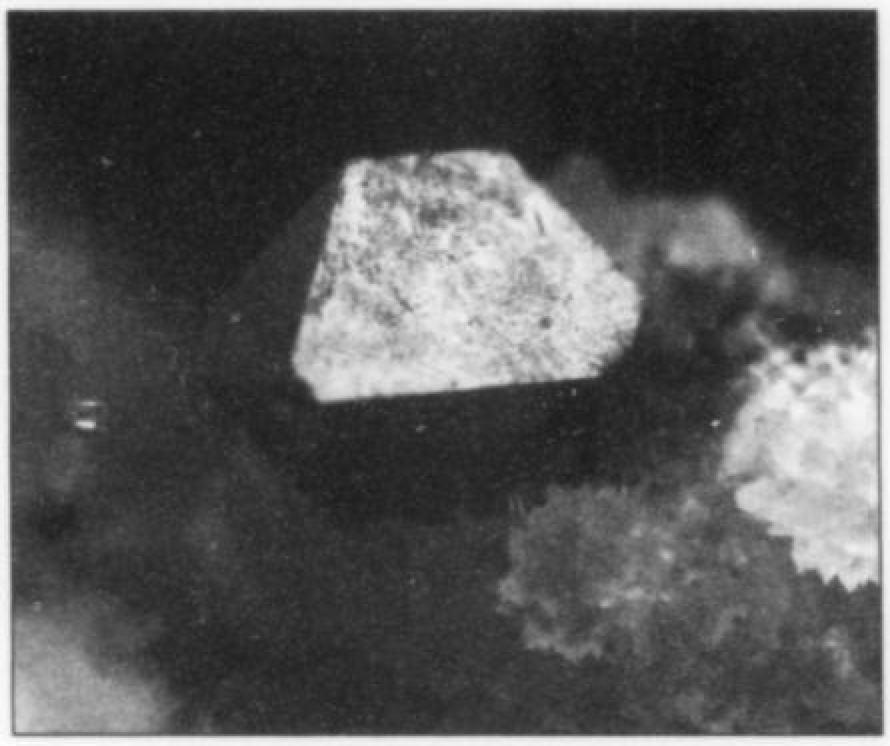

Figure 57. **Octahedral galena microcrystal, 2 mm, with calcite, from the Francon quarry. Horváth collection (no. 5264); E. Offermann photo.**

Galena PbS

Galena at the Francon quarry is relatively common and widespread in very small quantities, especially in the lower sill cavities. It occurs as usually isolated, sharp octahedral crystals generally 1–5 mm in diameter, with exceptional crystals to 1.5 cm in diameter. The morphology is rather consistent, with most crystals exhibiting dominant {111} octahedral faces, sometimes modified by small {100} cube faces. No other forms have been observed. The crystals commonly have a bright metallic luster. Rarely, the crystal faces are coated with pyrite crystals, and very rarely, with thin, film-like alterations of cerussite and hydrocerussite (Sabina, 1979: Sabina, 1992). Galena is most commonly associated with dawsonite, fluorite, marcasite, calcite, quartz, sphalerite, weloganite, celestine, and rarely with barite, cryolite, elpidite and gibbsite.

Garronite-like mineral $NaCa_{2.5}[Al_6Si_{10}]O_{32}\cdot 14H_2O$

A mineral designated as APS No. 14 has been shown to be related to garronite ($NaCa_{2.5}[Al_6Si_{10}]O_{32}\cdot 14H_2O$) but contains very little calcium and may be a new sodium analog. Sabina (1992) lists it as "garronite (Na)." The mineral was found as a transparent, yellow to orange crystalline filling in amygdules 2–5 mm across, in a dark sill rock with a spotted appearance (A. P. Sabina, personal communication, 2005). The sill, about 60 cm thick, was exposed below the upper phonolite sill in the alcove. Rimming the "garronite (Na)" are white, sugary "K-feldspar," and dolomite. Other minerals occurring in the sill were dachiardite-Na, mordenite, calcite, ankerite, and siderite. "Garronite (Na)" was also found in other locations in the alcove, in what may be the same sill.

Work on the mineral has been carried out at the Geological

Survey of Canada by A. C. Roberts who has provided the data reported here. Electron microprobe analyses (WDS) indicate a large variation in the alkali and alkali-earth content, with Na consistently much greater than Ca: Na_2O 4.18–9.58, K_2O 0.39–1.15, MgO 0.19–0.42, CaO 0.05–0.40 weight %. In contrast, garronite *sensu stricto* is commonly Na-poor, with (Na + K) < 0.2 *apfu* (Coombs *et al.*, 1997). APS No. 14 shows a large variation in the Si/Al ratio. A preliminary structure analysis indicates the presence of $(Si,Al)_{16}O_{32}$ groups as in garronite. The mineral has a monoclinic symmetry, space group $I2/m$ or $I2$, a = 9.970, b = 9.968, c = 10.074 Å, β = 90.143°, with V = 1001.2 Å^3. The strongest X-ray powder-diffraction lines are (dÅ(I)): 7.09(90), 4.997(50), 4.095(70), 3.164(100), 2.675(40). The measured density is 2.167 g/cm^3.

Gibbsite-like mineral $Al(OH,F)_3$

The mineral initially designated as APS No. 3 (Sabina, 1976) was later established to be a gibbsite-like mineral containing an unusually high content of fluorine, and differing in other respects from gibbsite (Jambor *et al.*, 1990). It may well be a new species but the available material precludes a structure determination. Three sets of analyses reported by Jambor *et al.* show a wide compositional range: MgO 0.4–0.7, CaO 0.5–0.7, Al_2O_3 52.5–66.1, SiO_2 1.5–10.5, F 4.8–8.3, H_2O 20.9–24.0 weight %. Jambor *et al.* concluded that the high silica content probably represents disseminated amorphous silica.

Fluorine-bearing gibbsite is relatively common at the Francon quarry, in cavities in the upper and lower sills as pure white to pale cream, powdery to granular coatings, porcelaneous and waxy granular aggregates, botryoidal crusts, and globules. It also forms shell-like epimorphs after cryolite crystals, in which the cryolite has been partially or completely leached away. The globules are 0.1–0.2 mm in diameter and consist of radial aggregates of divergent fibers. Under high magnification (SEM) the fibers appear as stepped columns with a pseudo-hexagonal cross-section. Jambor *et al.* reported that the botryoidal crusts generally have an area of no more than 1 to 2 mm^2, but encrustations covering several square centimeters have been observed. In the coatings, aggregates, crusts and epimorphs, F-bearing gibbsite is often found intermixed with its triclinic polymorph, doyleite. F-bearing gibbsite is fluorescent a medium-bright whitish yellow[4] under shortwave, medium-wave and longwave ultraviolet radiation, and displays a weak, white phosphorescence after irradiation with shortwave and medium-wave ultraviolet radiation. Although the fluorescence of F-bearing gibbsite is helpful in distinguishing it from non-fluorescent doyleite, it also masks the presence of intermixed doyleite.

F-bearing gibbsite is a late-stage mineral and has been observed to occur on weloganite, strontianite and calcite, sometimes completely coating the crystals as in the case of the cryolite epimorphs. Other associated minerals include elpidite, barite, dawsonite, fluorite, halloysite and quartz.

Gismondine $Ca_4(Al_8Si_8O_{32})\cdot 16H_2O$

A mineral with an X-ray diffraction pattern closely fitting that of gismondine was found in the lower sill. It is very rare and occurs as irregular aggregates less than 2 mm across, of dull, opaque, pale gray subhedral crystals associated with dull white weloganite (habit G), analcime, albite, marcasite, calcite and dolomite. Chemical analyses are needed to fully confirm this identification.

Glauconite series $K_{0.8}R^{3+}_{1.33}R^{2+}_{0.67}\square Al_{0.13}Si_{3.87}O_{10}(OH)_2$

A member of the glauconite series has been identified on a specimen of sill rock (GSC APS 606). It occurs as velvety black stringers 2–3 mm long. Sabina (1994) has also reported a mineral related to glauconite, or perhaps celadonite, in the sill rock.

Gmelinite series $(Na_2,Ca,K_2)_4[Al_8Si_{16}O_{48}]\cdot 22H_2O$

Gmelinite occurs very rarely in cavities in the upper sill in the alcove as colorless, tabular crystals to 3 mm, associated with quartz and dolomite (A. P. Sabina, personal communication, 2004).The specific member of the gmelinite series under the current zeolite nomenclature has not been determined.

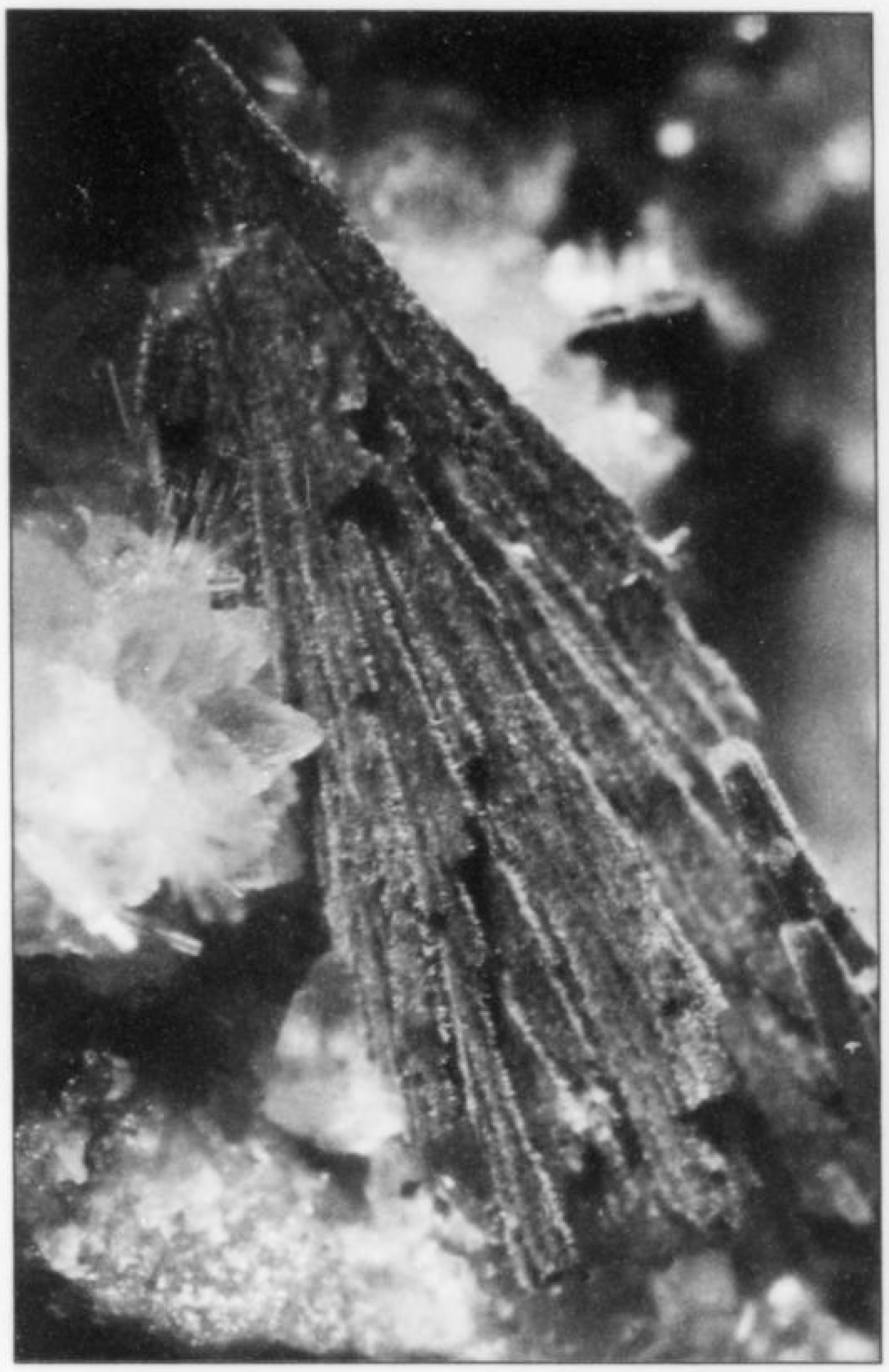

***Figure 58.* Goethite coating a 5-mm spray of celestine crystals. Horváth collection (no. 5269); L. Horváth photo.**

Goethite α-$Fe^{3+}O(OH)$

Goethite is relatively common in some lower sill cavities where it occurs as orange-yellow to brownish yellow, short, fibrous to acicular crystals forming tufts, sprays, spherical aggregates and attractive velvety coatings on other minerals, most notably on celestine and dawsonite. The tendency for goethite to preferentially coat celestine is well illustrated in specimens in which bundles and sprays of celestine crystals are completely encrusted by velvety goethite, whereas other minerals in the same cavity remain totally uncoated or only lightly sprinkled with small tufts. Other commonly associated minerals are calcite, quartz, ankerite, hematite and fluorite.

Graphite C

Small black patches of graphite, less than 5 mm in diameter, consisting of soft, foliated masses of thin, irregular lamellae, occur in the sill rock. Graphite is very rare at the Francon quarry. Associated minerals include dawsonite, almandine, quartz, nahcolite and halite.

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[4] Jambor *et al.* (1980) reported that F-bearing gibbsite fluoresced and phosphoresced "bluish-white ('short' rays) and cream-white ('long' rays)."

Gypsum $CaSO_4 \cdot 2H_2O$

Gypsum is relatively rare at the Francon quarry. Exceptionally large, colorless cleavage masses, up to 10 cm thick and 30 cm across, are in the GSC collection. They were donated by the quarry superintendent, who indicated that they were found at a sill-limestone contact (A. P. Sabina, personal communication, 2005; D. V. Doell, personal communication, 2005). Gray, fine-grained rock attached to one of the specimens has the typical appearance of sill phonolite. Gypsum has also been found in dikes as platy masses up to 5 cm across; as aggregates, several centimeters across, of sharp, colorless, tabular crystals up to 1 cm long in cavities associated with analcime and celestine; and as colorless veins associated with pyrite, dolomite and chalcedonic quartz. Acicular crystals and rosettes associated with natrojarosite, from an unspecified environment, were reported by Sabina (1979). Gypsum fluoresces a medium-bright whitish yellow and orange under shortwave, medium-wave and longwave ultraviolet radiation.

Halite NaCl

In a rare occurrence, halite was found as white stringers of very tiny granules, and irregular, fine powdery patches, admixed with nahcolite, on the surface of broken rock from the lower sill. It may be a residue from the evaporation of the liquid that is commonly released from freshly opened cavities. Halite and nahcolite both occur in inclusions in cavity minerals (Vard and Williams-Jones, 1993).

Halloysite $Al_2Si_2O_5(OH)_4$

Both hydrated (10Å) and dehydrated (7Å) halloysite have been identified by X-ray diffraction (Sabina, 1994). It occurs in cavities in both upper and lower sills as microscopic intergrowths with gibbsite (Jambor *et al.*, 1990); as white globular aggregates associated with pyrrhotite, cryolite, weloganite and quartz; and as chalky white coatings on quartz and albite. Other associated minerals in the upper sill include dresserite, hydrodresserite, strontiodresserite, doyleite and montroyalite. Halloysite has also been observed in sill rock as waxy, amber masses along the margins of a cavity, as embedded, tan, earthy laths associated with kaolinite and analcime, and as bluish-white to white coatings on a fracture surface.

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

Halotrichite occurs very rarely as a white to pale gray, fine, fibrous, supergene efflorescence on altered pyrite and marcasite, typically associated with other alteration products such as rozenite, sulfur and natrojarosite.

Harmotome $(Ba_{0.5},Ca_{0.5},K,Na)_5[Al_5Si_{11}O_{32}] \cdot 12H_2O$

Harmotome is extremely rare at the Francon quarry, known from only a few confirmed specimens. In a specimen (GSC APS F105) found in an upper sill cavity the harmotome occurs as gray, microcrystalline (clay-like) aggregates encrusting quartz and weloganite, and associated with calcite and fluorite. It has also been observed from an unspecified sill cavity as white to beige, felt-like aggregates consisting of minute (< 0.1 mm long) crystals, associated with weloganite (Canadian Museum of Nature specimen CMNMC 49939, identified by X-ray diffraction and EDS).

Hematite α-Fe_2O_3

A relatively common accessory mineral in cavities in the lower sill, hematite is found as minute, waxy to dull, reddish brown and black globules; as botryoidal aggregates and crusts; as red powdery coatings; and as bright red, flaky or powdery inclusions in dawsonite, celestine, calcite and barite. Hematite in a cavity is a useful indicator of the potential presence of baddeleyite, thorbastnäsite and zircon (Sabina, 1979). Other associated minerals include goethite, ankerite, fluorite, marcasite, pyrite, quartz, weloganite and kaolinite.

Hochelagaite $(Ca,Na,Sr)Nb_4O_{11} \cdot 8H_2O$

Hochelagaite, a Ca-dominant analog of franconite (Na-dominant) and ternovite (Mg-dominant), was described as a new species jointly from the Francon quarry and from Mont Saint-Hilaire (Jambor *et al.*, 1986). At the Francon quarry, the mineral was first noted around 1980 and designated as APS No. 13; at Mont Saint-Hilaire it was found in 1979 and recognized as a potentially new species with the designation UK50. Hochelagaite from both localities has a similar overall composition but with a considerable variation in the sodium content. This reflects the presence of sodium in solid solution, and, in the case of Francon hochelagaite, an intergrowth of franconite. In recent years, hochelagaite has also been reported from the nearby Saint-Amable sill, Varennes and Saint-Amable, Québec (Gault and Horváth, 1994; Horváth *et al.*, 1998); Vardeåsen in southern Norway (Andersen *et al.*, 1996); the Vuoriyarvi massif, Kola Peninsula, Russia (Subbotin *et al.*, 1997a and b); the Vishnevye Gory alkaline complex, Russia (Pekov, 2001); and at Kovdor and the Khibiny massif, Kola Peninsula, Russia (I. Pekov, personal communication, 2004).

At the Francon quarry, hochelagaite is considered very rare and is known only from cavities in the upper sill. It is a late-stage mineral like franconite, and occurs as dull to sub-vitreous, white globules, averaging about 150 µm in diameter. The minute globules consist of radiating bladed crystals about 0.03 mm in length, commonly intergrown with thin blades of franconite. Individual crystals are brittle, colorless to translucent white, and have a vitreous luster. Hochelagaite is typically found on crystals of weloganite, calcite and quartz, associated with dawsonite and strontianite. Hochelagaite does not fluoresce under ultraviolet radiation (Jambor *et al.*, 1986), and is visually indistinguishable from franconite and other white globular encrustation minerals.

Humboldtine $Fe^{2+}C_2O_4 \cdot 2H_2O$

Humboldtine is exceedingly rare at the Francon quarry, where it has been found as bright yellow inclusions in quartz (Sabina, 1992, 1994).

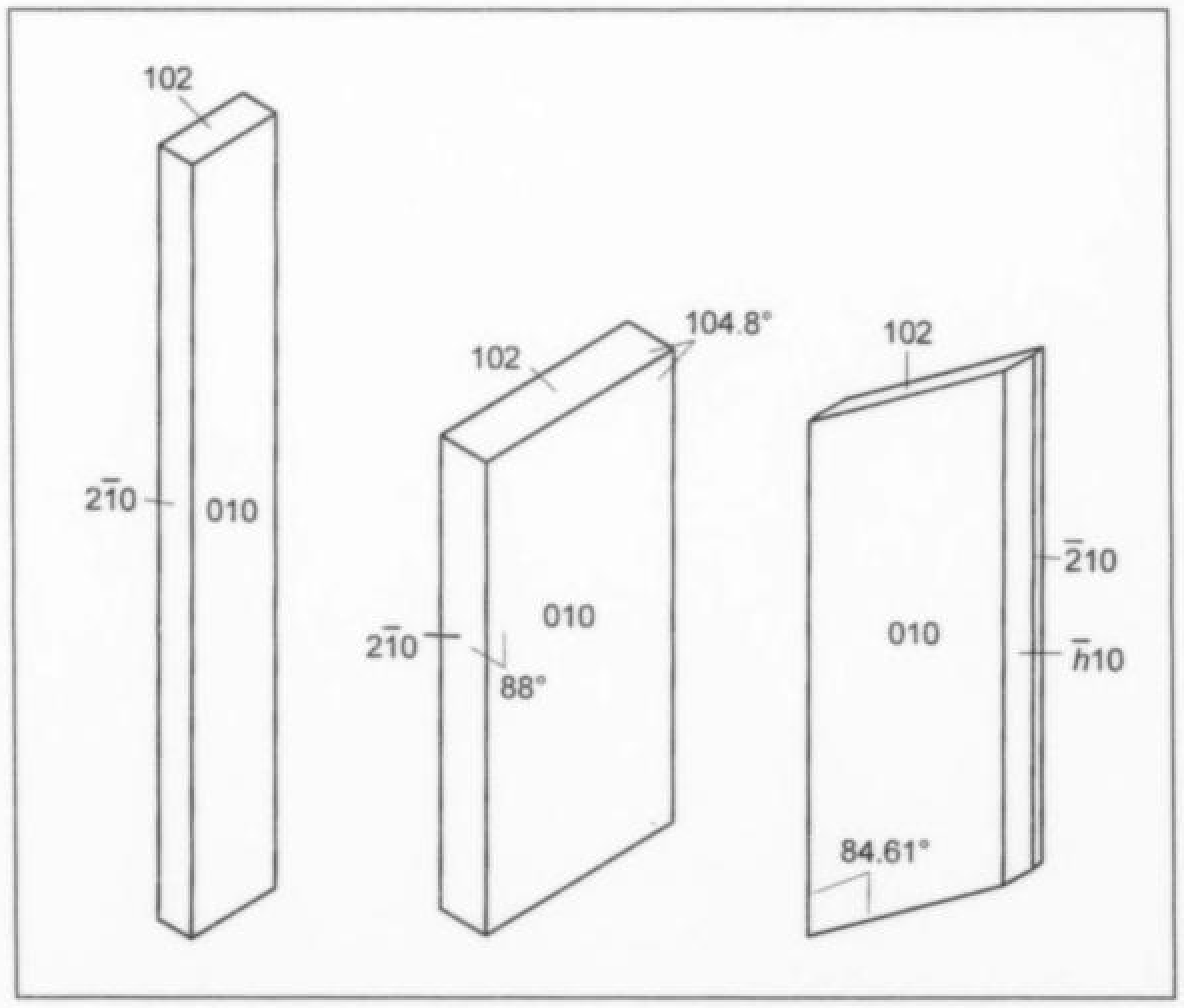


Figure 59. **Hydrodresserite crystal drawings based on Jambor et al. (1977): (*left*) the most common slender bladed habit; (*center*) the less common short tabular habit; (*right*) the short tabular habit rotated to better show the forms including the {$\bar{h}$10} pinacoid observed on SEM photos.**

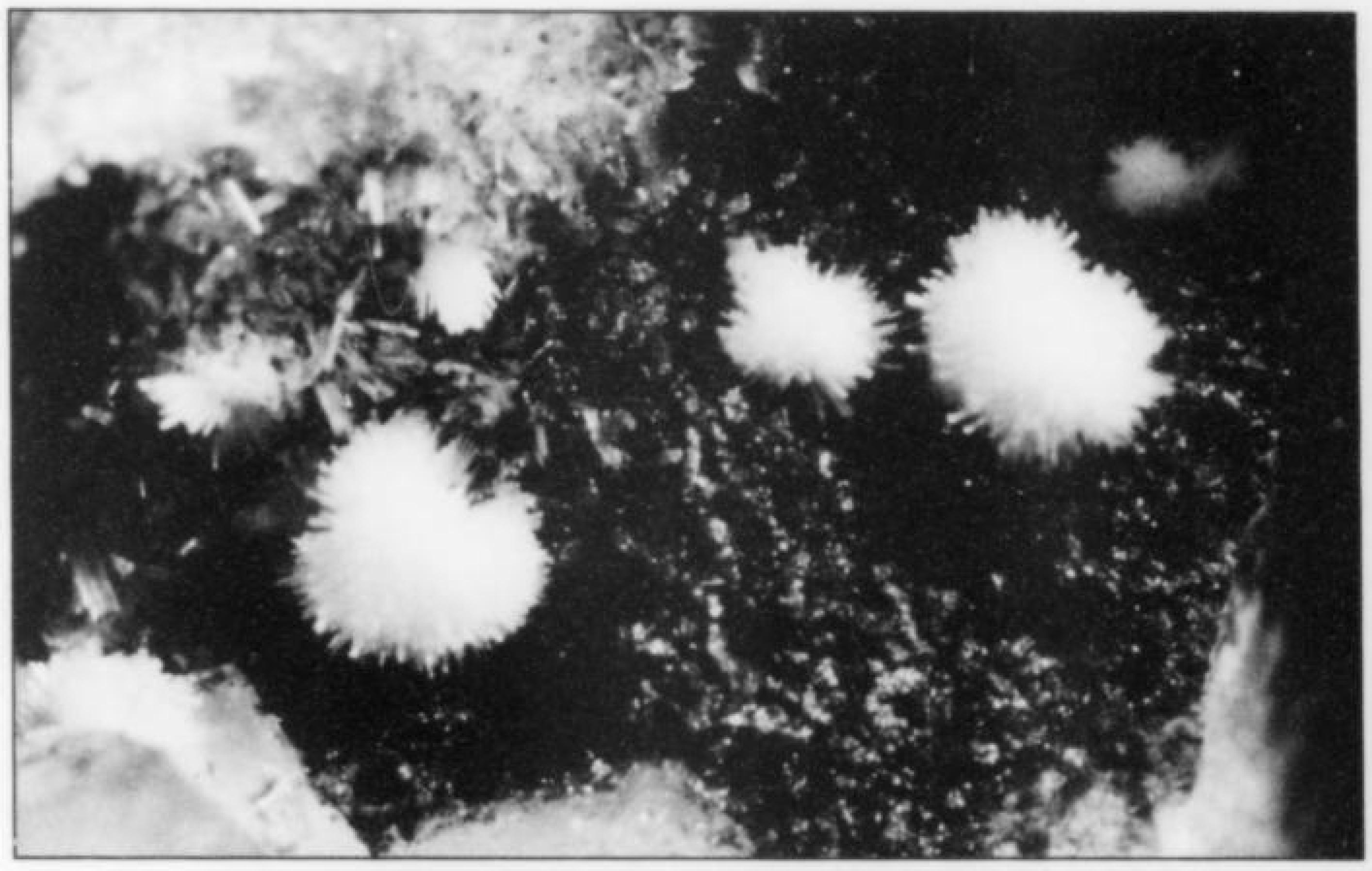


Figure 60. **Spherical aggregates, about 2 mm, of dresserite/hydrodresserite microcrystals on marcasite. Horváth collection (no. 5234); L. Horváth photo.**

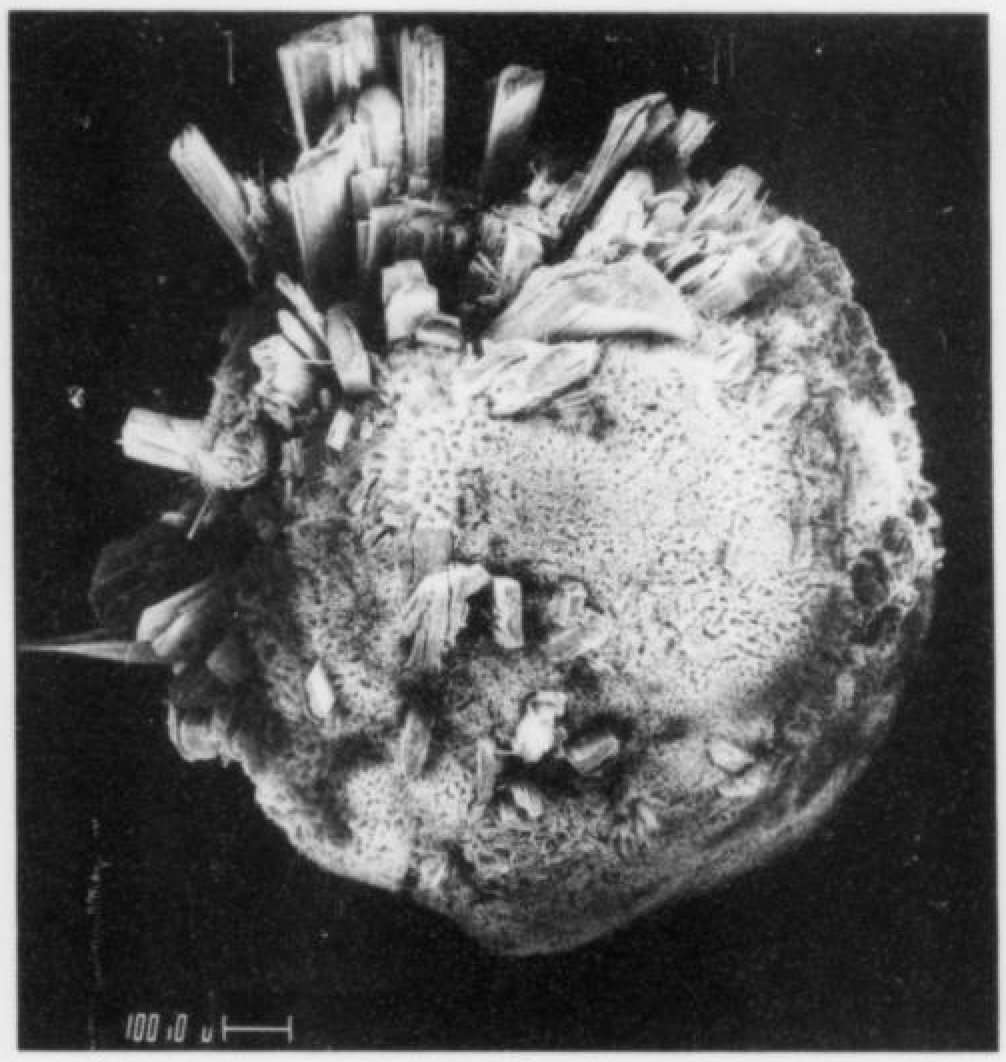


Figure 61. **Compact spherule of fibrous dresserite with larger crystals of dresserite and hydrodresserite protruding from the surface. Geological Survey of Canada specimen and SEM photo.**

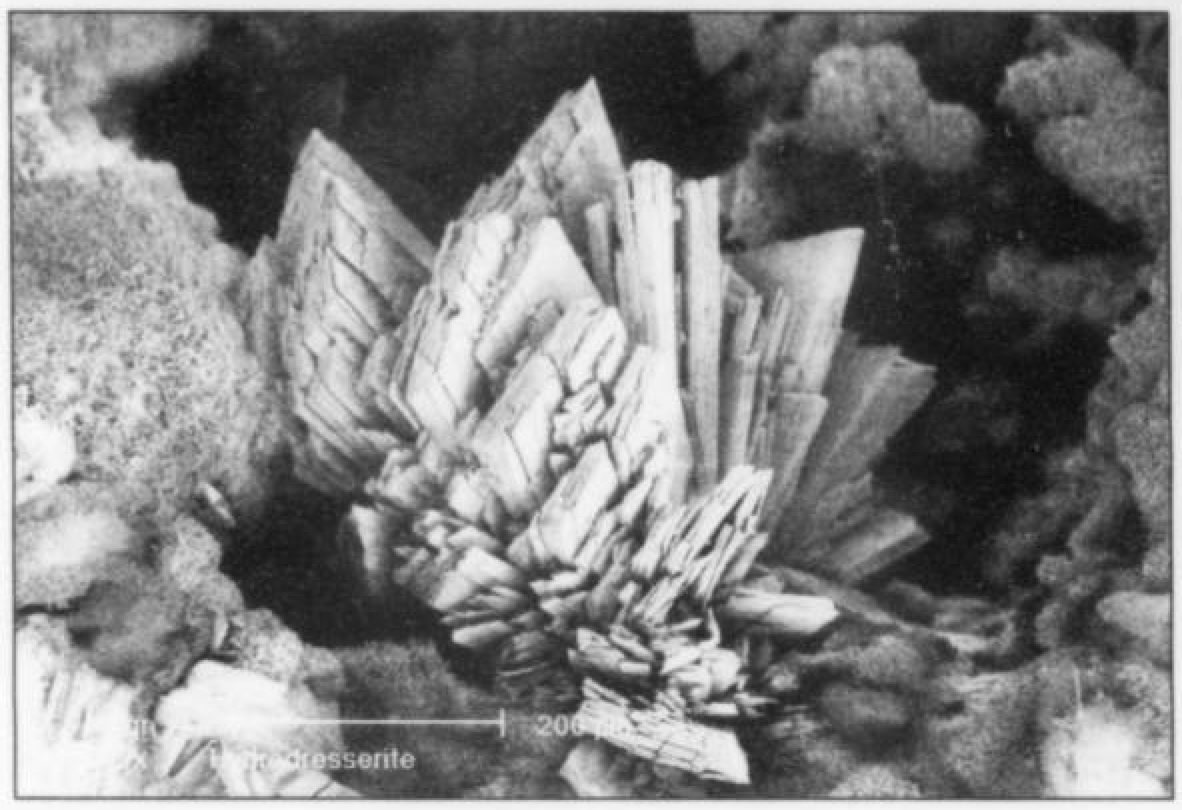


Figure 62. **Radiating cluster of hydrodresserite microcrystals showing the triclinic morphology and the cleavage parallel to [010]. Horváth collection (no. 5234); R. Gault and L. Horváth SEM photo.**

Figure 63. **Spherical aggregates of dresserite and hydrodresserite on albite with siderite and quartz, from the Francon quarry. Robert Fisher sketch.**

Hydrocerussite $Pb_3(CO_3)_2(OH)_2$

A late-stage alteration product, hydrocerussite occurs as white, powdery to granular coatings on galena crystals with cerussite.

Hydrodresserite $BaAl_2(CO_3)_2(OH)_4 \cdot 3H_2O$

Hydrodresserite was described from the Francon quarry as a new species by Jambor *et al.* in 1977. Its infrared characteristics were investigated by Farrell (1977), and its crystal structure was solved by Szymański (1982). The presence of the mineral was noted as early as 1967 when it was designated as APS No. 2. It was first mentioned by Jambor *et al.* (1968) as a "hydrous barium aluminium carbonate." As the name implies, hydrodresserite differs from dresserite in having three water molecules per formula unit compared to one in dresserite. The Francon quarry remains the only known locality for the mineral.

X-ray diffraction studies by Jambor *et al.* (1977b) showed that hydrodresserite is unstable under most atmospheric conditions and dehydrates to dresserite, suggesting that some dresserite is pseudomorphous after hydrodresserite. The dehydration process is particularly sensitive to humidity levels, and Jambor *et al.* found that dehydrated hydrodresserite partially reversed to hydrodresserite after prolonged exposure to a warm water-saturated atmosphere. An infrared analysis of the thermal decomposition of hydrodresserite by Farrell (1977) indicated that, unlike the X-ray diffraction analysis by Jambor *et al.* (1977b), the conversion to dresserite was incomplete. Observations by the authors suggest that the instability of hydrodresserite may not be as general and consistent as reported, and perhaps varies from sample to sample or from zone to zone in the sill. Several specimens collected in 1974–1975 (a few years after the type material) by two of the authors (LH and EPH) and stored in a collection in a normally very dry Canadian home, were analyzed by X-ray diffraction in 1995 and 2003, and were found to be predominantly if not completely hydrodresserite. The colorless, sharp, bladed crystals that were analyzed showed no visible sign of alteration. Silky white, acicular crystals collected by one of us (PT) in 1968 and analyzed by X-ray diffraction in 2004 were also found to be hydrodresserite. However, bladed crystals with the morphology of hydrodresserite that are opaque white and appear to be altered, and may now be dresserite pseudomorphs after hydrodresserite, have been observed.

Hydrodresserite is relatively common in cavities in the upper sill. Two major modes of occurrence are observed: compact spherical aggregates, and open clusters of radiating crystals. The compact spherical aggregates, up to 3 mm in diameter, consist of radiating, fibrous to bladed crystals. The surface of the spherules has a dull to sub-vitreous luster, and at high magnification it appears mosaic-like as if tiled by tiny rectangular terminal faces. The crystals in these spherules radiate from a common center; on broken interior surfaces they have a silky luster. In spherules with a smooth, mosaic-like surface dresserite and hydrodresserite are visually indistinguishable. Some of the compact spherules have sharp, colorless, individual crystals extending from their surface, and in this case hydrodresserite and dresserite pseudomorphs after hydrodresserite can be readily distinguished from dresserite by their distinct triclinic morphology. In the second mode of occurrence, producing the best formed crystals, hydrodresserite occurs as radiating clusters, sheaves and randomly oriented aggregates of well separated, sharp, colorless bladed crystals up to 2 mm long. These crystals are shorter along [001] than those in the compact spherules. This habit is unique to hydrodresserite, and is often observed side-by-side with compact spherules of dresserite. Hydrodresserite crystals are elongated along [001], and are defined by the {010} (dominant), $\{2\bar{1}0\}$ and {102} pinacoids (Jambor *et al.*, 1977). In our investigation of the morphology we also noted another prominent pinacoid on SEM photos, not reported before. The form is $\{\bar{h}10\}$, most likely {110}, but goniometric measurement is needed for confirmation. Some crystals have swallow-tail terminations. Although twinning in hydrodresserite has not been reported, this may represent contact twinning on (010), or perhaps simply parallel growth of crystal pairs. The SEM photos also show splitting and lamination of the crystals parallel to [010], consistent with the perfect {010} cleavage reported by Jambor *et al.* (1977). Hydrodresserite has also been found as silky, white, spherulitic aggregates of divergent, acicular crystals, less than 1 mm in diameter. These form continuous cotton-ball-like crusts to 1 cm or more across.

Unlike dresserite, hydrodresserite is non-fluorescent. Weak white fluorescence under longwave ultraviolet radiation has been observed on the cotype (Royal Ontario Museum specimen ROM M34547; R. A. Ramik, personal communication, 2004), but this may be due to the presence of dresserite. Hydrodresserite is invariably associated with dresserite, and most commonly with weloganite, calcite, quartz, marcasite, strontianite and dawsonite, and rarely with cryolite, gibbsite and doyleite. Since hydrodresserite and dresserite coexist in practically all specimens, labeling them as dresserite/hydrodresserite is recommended in the absence of an instrumental analysis.

Ilmenorutile $(Ti,Nb,Fe^{3+})O_2$

Ilmenorutile is found very rarely in the upper and lower sill cavities and along their margins. It occurs as velvety black, submetallic plates, up to 1 mm in diameter; as black hexagonal plates and rosettes; as dull black, granular patches; and as a dull black, thin coating on small rosettes of brookite. It has been observed on crystals of dawsonite, calcite, quartz, and albite. Other associated minerals include weloganite, analcime and barite.

Kaolinite $Al_2Si_2O_5(OH)_4$

Originally designated as APS No. 7 (Sabina, 1976), kaolinite is a relatively rare late-stage cavity mineral in both the upper and lower sill cavities, and is found as waxy to silky, white to creamy white, powdery, granular, flaky, botryoidal and irregular aggregates and masses up to several centimeters across. Botryoidal aggregates are often seen perched on weloganite and dawsonite crystals. Other associated minerals include analcime, ankerite, baddeleyite, barite, calcite, celestine, goethite, hematite, and quartz. Kaolinite fluoresces a medium-bright whitish yellow under shortwave and yellow under medium-wave ultraviolet radiation.

"K-feldspar" $KAlSi_3O_8$

White to pale pink, platy crystals of "K-feldspar" have been reported from cavities in the lower sill, most commonly associated with analcime, dawsonite and quartz (Sabina,1979). It has not been determined whether the feldspar is microcline, its dimorph orthoclase, or sanidine.

Orthoclase has been identified as a constituent of the sill rock (Jambor *et al.*, 1976).

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

Magnetite occurs in the sill rock as small black grains, and very rarely as black, crude subhedral crystals up to 5 mm in diameter.

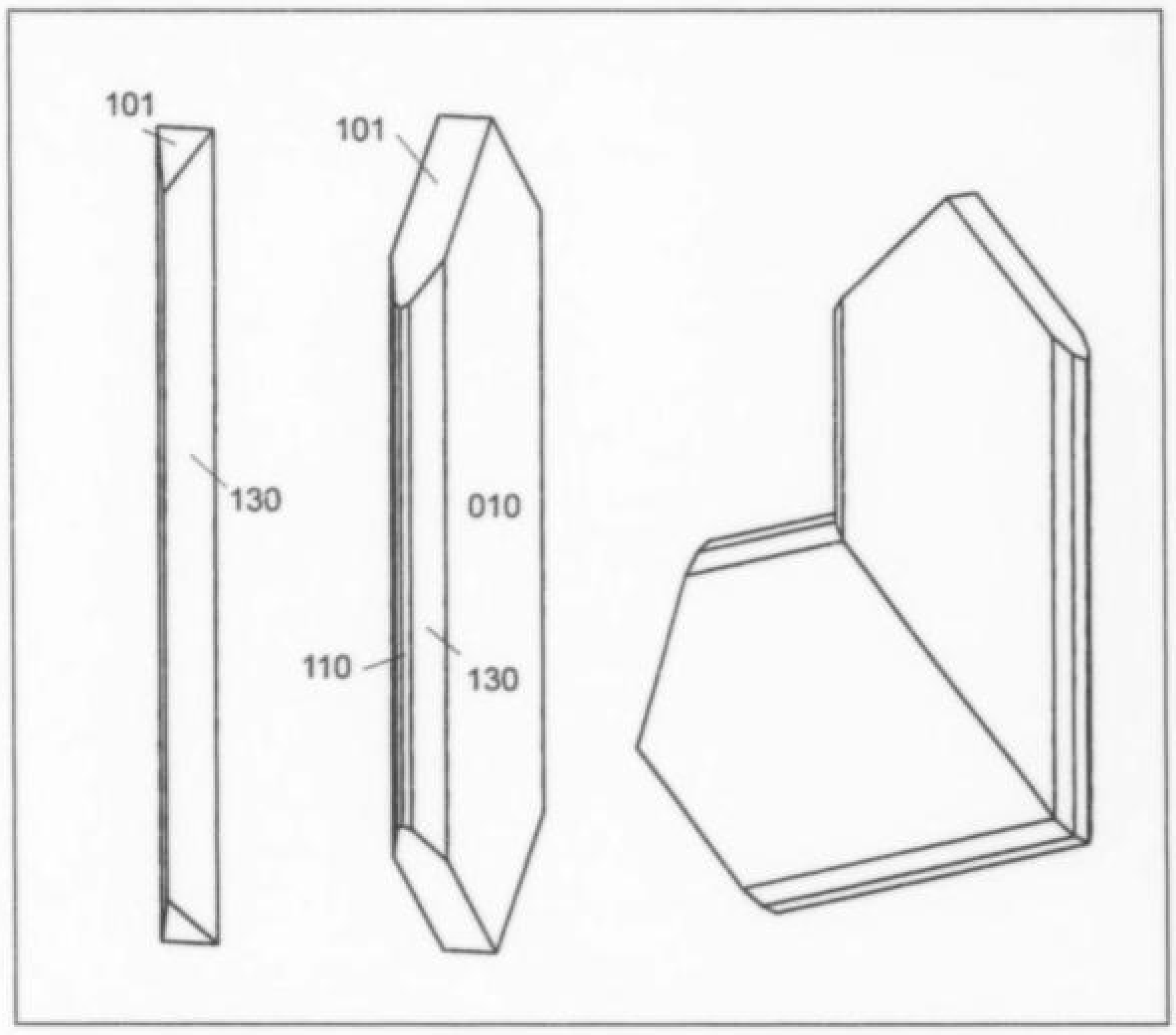
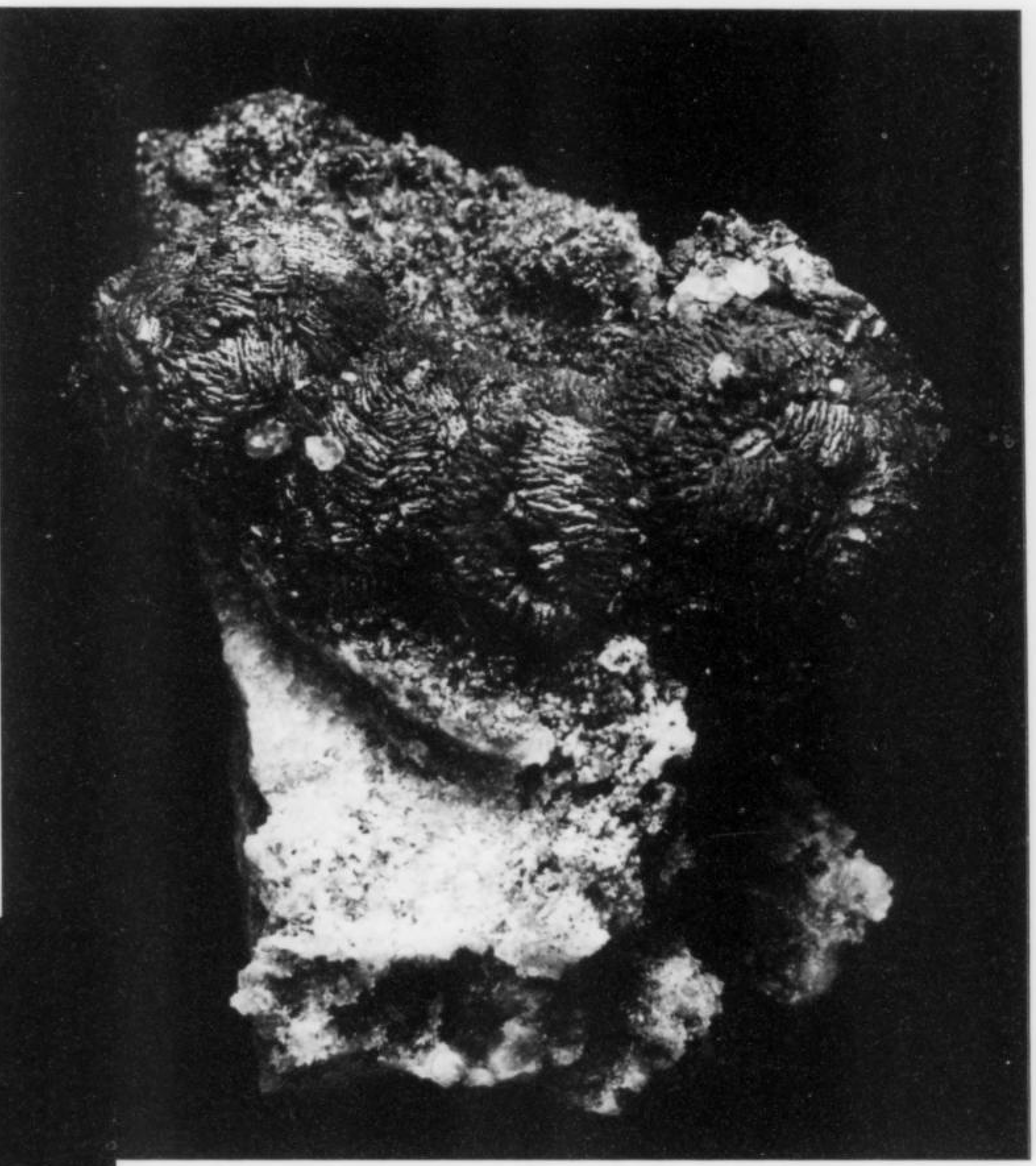


***Figure 64.* Marcasite crystal drawings, Francon quarry: slender prismatic habit (*left*); tabular habit (*center*); and contact twin on (101).**

Marcasite FeS_2

Marcasite is one of the very common species in the Francon quarry, and the most common sulfide. It is found in cavities in both the upper and lower sills and in the limestone, occurring as splendid, acicular, slender prismatic, thin bladed, and thick tabular

Figure 65. **Marcasite crystal aggregates (4.5 cm) on matrix, from the Francon quarry. Horváth collection (no. 5519); L. Horváth photo.**



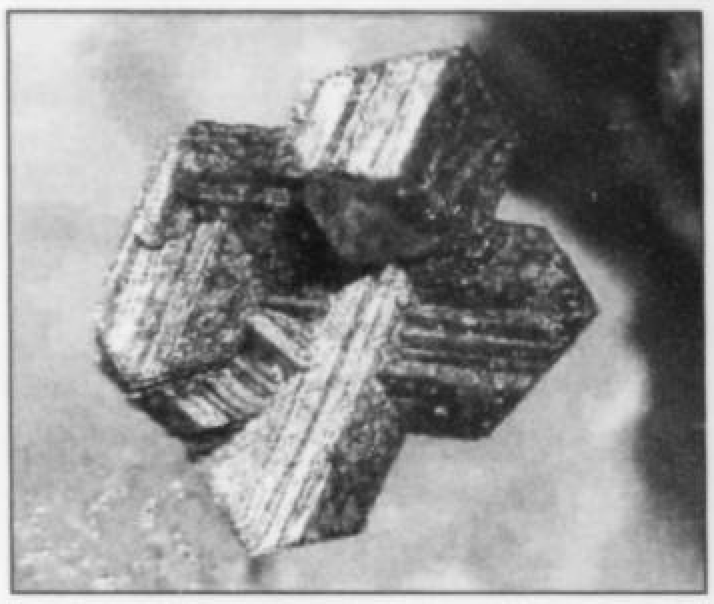
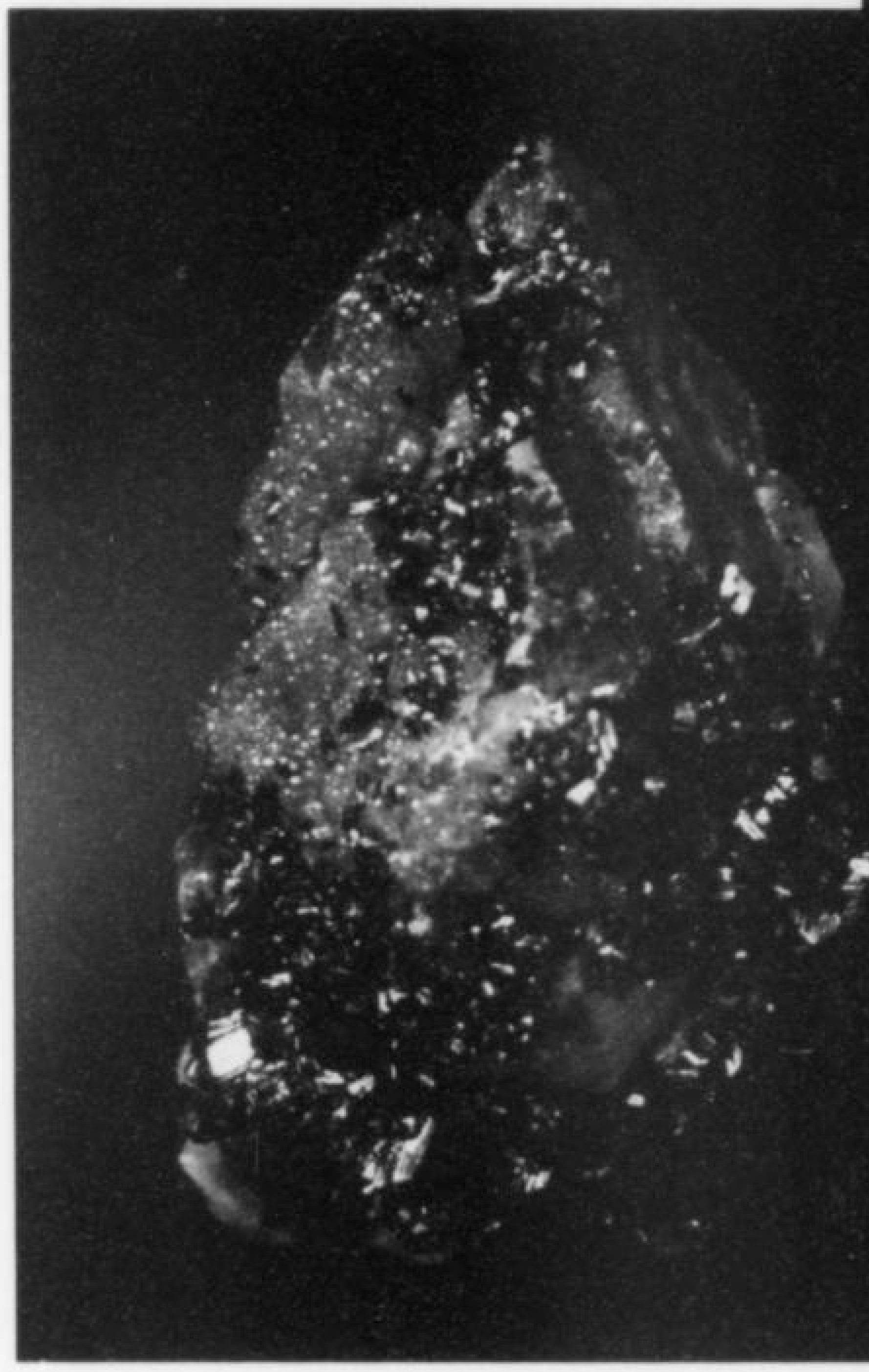


Figure 66. **Twinned marcasite microcrystals, 1.5 mm, from the Francon quarry. Tarassoff collection (no. 2396) and photo.**

Figure 67. **Marcasite crystals partially coating a 3-cm quartz crystal, from the Francon quarry. Horváth collection (no. 3247); L. Horváth photo.**



crystals up to 8 mm, but usually averaging 1–4 mm. The often twinned, bladed crystals form rosettes, fans, v-shaped groups, and stellate aggregates. Crystals are tabular and elongated along [001] with dominant {010} pinacoids, variously developed {110} and {130} prisms, and are invariably terminated by {101} prisms. Contact twinning on {101} is very common. Marcasite is frequently tarnished bluish even in freshly opened cavities. The larger tabular marcasite crystals are sometimes coated with secondary minerals such as natrojarosite, rozenite and halotrichite, and tend to crack after a few years in a collection. However, none has been observed to disintegrate completely, even after 30 years. Thin, bladed crystals show no signs of deterioration, apart from a bluish tarnish. Marcasite is a late-stage mineral and is associated with practically all the species found in the sill cavities. It is often observed as extremely tiny crystals sprinkled on other minerals. Marcasite is much more common than pyrite.

Molybdenite MoS_2

Molybdenite is extremely rare at the Francon quarry. The 2*H* polytype was found as microscopic, thin flakes associated with weloganite (Sabina, 1979). The only known specimen came from a cavity lined with albite, quartz and calcite (A. P. Sabina, personal communication, 2005).

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

Originally designated as APS No. 8 (Sabina, 1976), montmorillonite is a relatively common cavity mineral, concentrated in some zones and almost absent in others, in the lower sill. It occurs as white, compact and waxy spherical aggregates 1–2 mm in diameter; as spheres consisting of white, radiating capillary crystals; as matted, fibrous masses forming sheet-like aggregates; and as white, soft, soap-like masses up to several centimeters across partially filling cavities. When exposed to moisture, montmorillonite readily absorbs water and expands, becoming gelatinous. Soap-like masses have been observed to ooze out of open cavities exposed to rain. Associated minerals include celestine, analcime, ankerite, dawsonite, calcite, fluorite, barite, hematite, and rarely mordenite. The expansion of montmorillonite in water is a useful aid to its identification.

Montroyalite $Sr_4Al_8(CO_3)_3(OH,F)_{26} \cdot 10\text{–}11H_2O$

Montroyalite was first noted in 1979 and designated as APS No.

12. It was later described as a new species (Roberts *et al.*, 1986), and named montroyalite after the nearby landmark, Mont Royal (*Mons Regius* in Latin), from which the Monteregian alkaline province takes its name. The Francon quarry remains the only known locality.

Montroyalite was first found in cavities in the upper sill, near the northwest wall, in the alcove. It occurs as dull, translucent to opaque, white to creamy white, rough-surfaced spherules and hemispheres up to 1 mm in diameter, and as botryoidal, powdery to finely fibrous aggregates. The spherules and hemispheres have a compact porcelaneous interior with a waxy luster, and a knobbly to botryoidal exterior surface. The cavities in which montroyalite was originally found were lined with platy albite crystals and less commonly with aggregates of small colorless quartz crystals. Montroyalite, a late-stage mineral, partially covered the lining, and was associated with strontiodresserite, calcite, dawsonite, ankerite, fluorite, and minor barite, strontianite, smythite, marcasite and pyrite. These minerals were in turn covered by a loose to semi-compact mass of halloysite intermixed with doyleite.

In another occurrence, spherules of montroyalite were scattered in a cream-colored pulverulent crust, possibly strontiodresserite, and associated only with quartz and albite. In all the specimens examined, montroyalite and strontiodresserite are invariably and intimately associated. Both minerals are considered very rare and only a few confirmed specimens are known. Visual identification of montroyalite is unreliable and proper identification requires instrumental analysis. Montroyalite fluoresces a medium-bright yellow under shortwave, and orange-yellow under medium-wave and longwave ultraviolet radiation.

Mordenite $(Na_2,Ca,K_2)_4[Al_8Si_{40}O_{96}]\cdot 28H_2O$

Mordenite, a relatively rare mineral in cavities in the lower sill, is found as silky white tufts, matted felt-like aggregates and compact masses up to several centimeters in diameter, consisting of very fine, capillary crystals up to 1 cm long. Mordenite is often associated with dachiardite-Na, and is sometimes found as inclusions in analcime. Other associated minerals include ankerite, barite, calcite, weloganite, cristobalite, dolomite, quartz, celestine, marcasite, aegirine and pyrite. In 1978, mordenite was found as white, tissue-like aggregates in small cavities in a dike in the alcove area, associated with analcime, dolomite, quartz, strontianite, cristobalite, phillipsite (rare) and synchysite-(Ce). Mordenite is also one of the principal minerals associated with voggite in the type occurrence in a dike in the alcove (Roberts *et al.*, 1990). It has also been observed in one or more minor sills in the alcove associated with dachiardite-Na and a garronite-like mineral.

Mordenite fluoresces weakly pale orange-yellow under shortwave and medium-wave, and a weak pinkish yellow under longwave ultraviolet radiation.

Nahcolite $NaHCO_3$

Nahcolite was identified from the lower sill rock, where it occurs very rarely, admixed with halite, and forming friable, white string-like and irregular, fine powdery patches on the surface of broken rock. It is likely the residue left after the evaporation of the liquid which sometimes spills from freshly opened sill cavities. Nahcolite and halite both occur in fluid inclusions in quartz and other cavity minerals (Vard and Williams-Jones, 1993) and may also be present in the cavity liquid.

Natrojarosite $NaFe^{3+}_3(SO_4)_2(OH)_6$

Natrojarosite is most commonly found in the lower sill as an ochre-yellow to orange and orange-brown, dull to waxy, powdery, granular to glaze-like alteration crust on marcasite crystals and rarely on pyrite. It has also been observed on sphalerite in quartz-lined fractures in the sill rock (Sabina, 1979).

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

Natrolite is very rare at the Francon quarry, occurring in a few cavities in the lower sill as clusters of colorless to translucent, dull white, elongated crystals up 1.5 cm long. The crystal morphology is very simple and consists of a {110} prism terminated by {111} pyramids. Crystals are sometimes flattened along [100]. Some crystals are corroded, hollow and etched, resulting in fibrous terminations. Associated minerals include weloganite, albite, barite, analcime, brookite, calcite and siderite. White, elongated, often partially hollow perimorphs consisting of tiny quartz crystals after natrolite crystals up to 1.5 cm long have also been observed in cavities in the lower sill. Natrolite was recognized by the authors (LH and EPH) and confirmed in the course of the present study on specimens collected in 1975. Natrolite gives a weak, white fluorescent response under shortwave, medium-wave and longwave ultraviolet radiation.

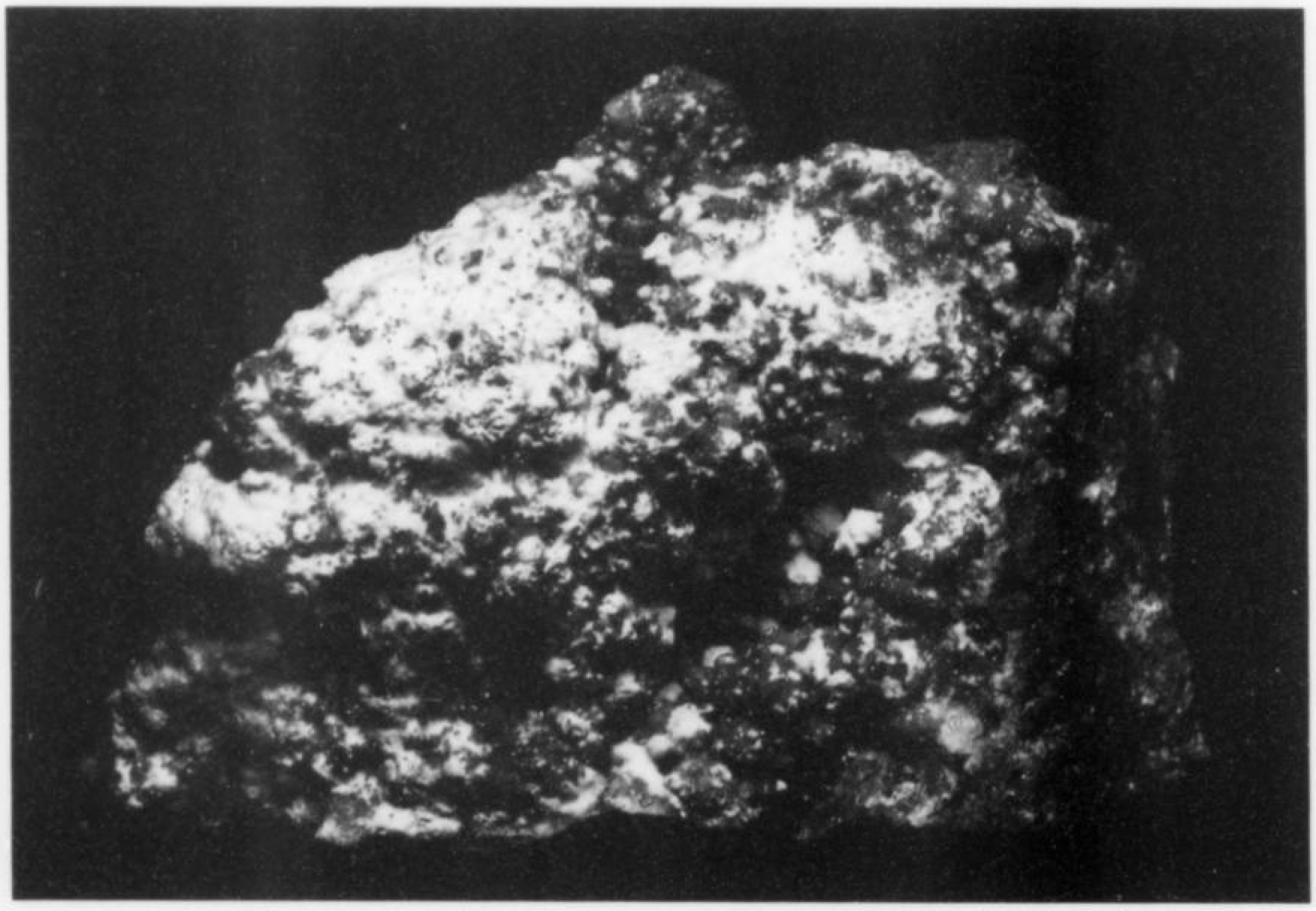


Figure 68. **Fibrous white mordenite on ankerite, 8 cm, from the Francon quarry. Horváth collection (no. 5473); L. Horváth photo.**

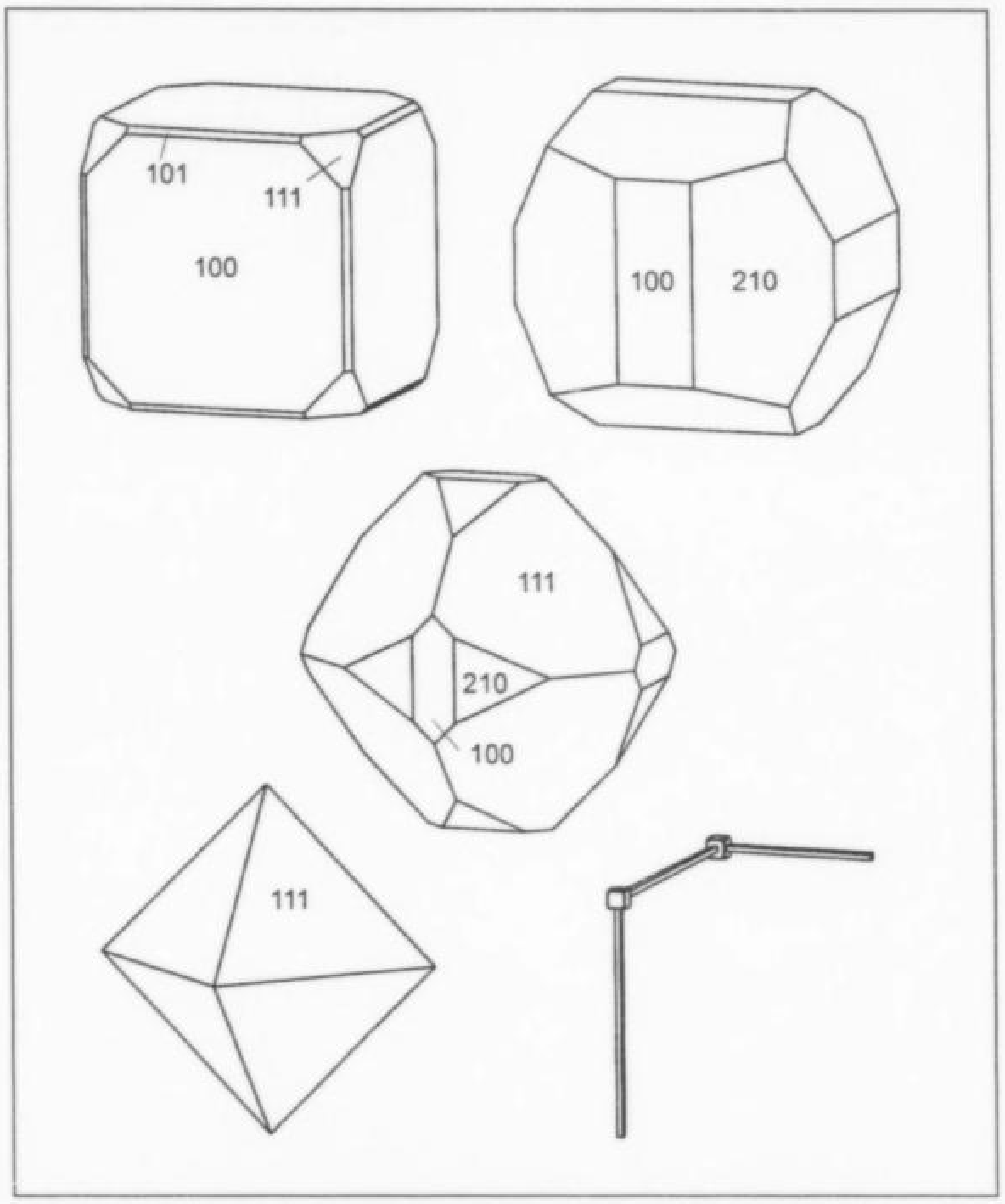


***Figure 69.* Pyrite crystal drawings showing habits in ascending order of rarity, from upper left to lower right.**

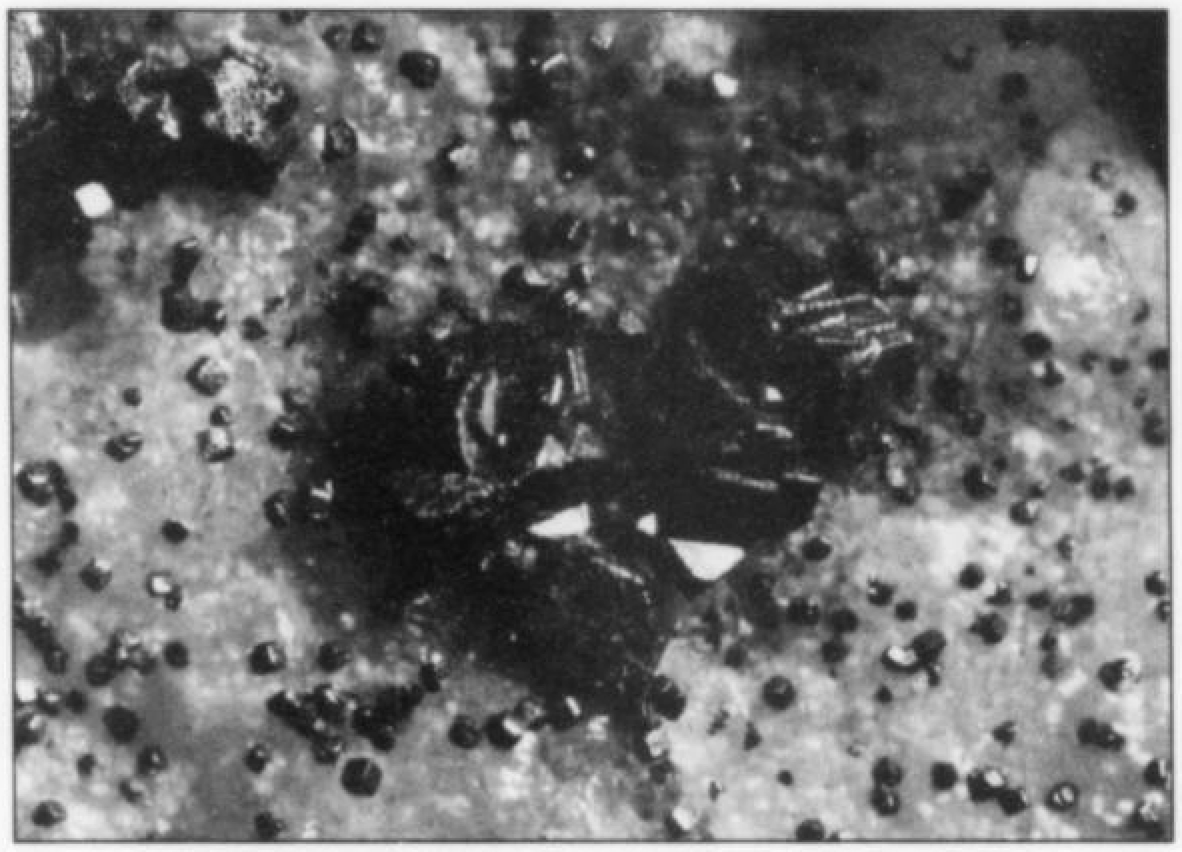


***Figure 70.* Pyrite microcrystal group, 2 mm, on fluorite. Horváth collection (no. 5298); L. Horváth photo.**

Olivine group

Vitreous, reddish to amber, subhedral crystals up to 6 mm in diameter, embedded in a dike rock, have been identified as "olivine" (GSC APS 476). The rock is probably camptonite, which commonly contains phenocrysts of an olivine group mineral.

Paratacamite $Cu^{2+}_2Cl(OH)_3$

Paratacamite was found as green, finely granular aggregates associated with straw-yellow baddeleyite on purple fluorite. The only known specimen (GSC APS 730-8) was collected in 1982 from the west wall of the alcove (A. P. Sabina, personal communication, 2004). This is also the only known occurrence of baddeleyite in the upper sill. To date, no other copper-bearing minerals have been identified from the quarry.

Phillipsite series $(K,Na,Ca_{0.5},Ba_{0.5})_x[Al_xSi_{16-x}O_{32}]\cdot 12H_2O$

An undetermined member of the phillipsite series has been found as very small (less than 0.5 mm) white globules composed of radiating fibers and implanted on dolomite in cavities in a dike (A. P. Sabina, personal communication, 1979). The assemblage, collected in 1978 in the alcove, includes mordenite, analcime and quartz.

Phlogopite $KMg_3AlSi_3O_{10}(OH)_2$

See under **biotite series**.

Pseudorutile $Fe^{3+}_2Ti_3O_9$

Pseudorutile was reported to occur as black, submetallic, granular patches associated with "K-feldspar," brookite and dawsonite (Sabina, 1979).

Pyrite FeS_2

Pyrite, a relatively common sulfide in both upper and lower sill cavities, and in dike and limestone cavities, occurs as crystals 1–3 mm in diameter, with the cube as the dominant form, often modified by the {210} pyritohedron and {111} octahedron. Simple octahedra {111} have been found in the lower sill, but are quite rare. Pyrite also occurs in the sill cavities as spherules up to 3 mm in diameter, with a lustrous, mirror-like surface composed of numerous cubic microcrystals; and very rarely, as small filiform crystals, sometimes displaying single or multiple 90° angular articulations. Pyrite has also been identified as granular crusts, fibrous clusters, and botryoidal aggregates. It is associated with practically all the cavity minerals found in the quarry, and is often observed as microcrystals sprinkled on other minerals.

Pyrochlore $(Ca,Na)_2Nb_2O_6(OH,F)$

Pyrochlore is rare and inconspicuous, occurring as tan-colored octahedra less than 1 mm in diameter disseminated in the upper sill rock (Steacy and Jambor, 1969; Jambor *et al.*, 1976). It has also been reported from unspecified sill rock as orange, granular aggregates associated with barite, pyrite and zircon, and with pseudorutile, siderite and crocoite, in "K-feldspar"-dawsonite intergrowths (Sabina, 1979), and very rarely in sill cavities as orange, resinous aggregates associated with analcime, barite and pyrite (GSC APS 508).

Pyrrhotite $Fe_{1-x}S$ (x = 0.1–0.2)

Pyrrhotite is uncommon in cavities in the lower sill and in dikes. In the sill it is found as bronze-colored metallic, thin tabular, hexagonal crystals and rosette-like aggregates up to 2 mm in diameter, associated with weloganite, dawsonite, fluorite, barite, albite, pyrite, quartz, calcite, cryolite, smythite and doyleite. It has also been found in limestone cavities as plates up to 3 mm in diameter with dolomite, strontianite and calcite. Similarly to marcasite, pyrrhotite crystals typically have a bluish or reddish blue tarnish when collected, or the tarnish may develop after a short period of exposure. Pyrrhotite is similar in appearance to smythite and the two minerals may be difficult to distinguish. Smythite crystals are typically much thinner and foil-like, and are much rarer.

Quartz SiO_2

Quartz is one of the most abundant species at the Francon quarry, especially in the upper sill where it occurs as individual crystals from less than 1 mm to 5 cm long, and more often as intricate intergrown groups. There are two main crystal habits: the common, prismatic habit and the rhombohedral habit with minor prism. Both are composed of the same forms, the $\{10\bar{1}0\}$ prism and the $\{10\bar{1}1\}$ and $\{01\bar{1}1\}$ rhombohedrons. Two additional modifying forms, both very rare, have also been observed: a very small $\{30\bar{3}1\}$ positive rhombohedron, and a minor to well devel-

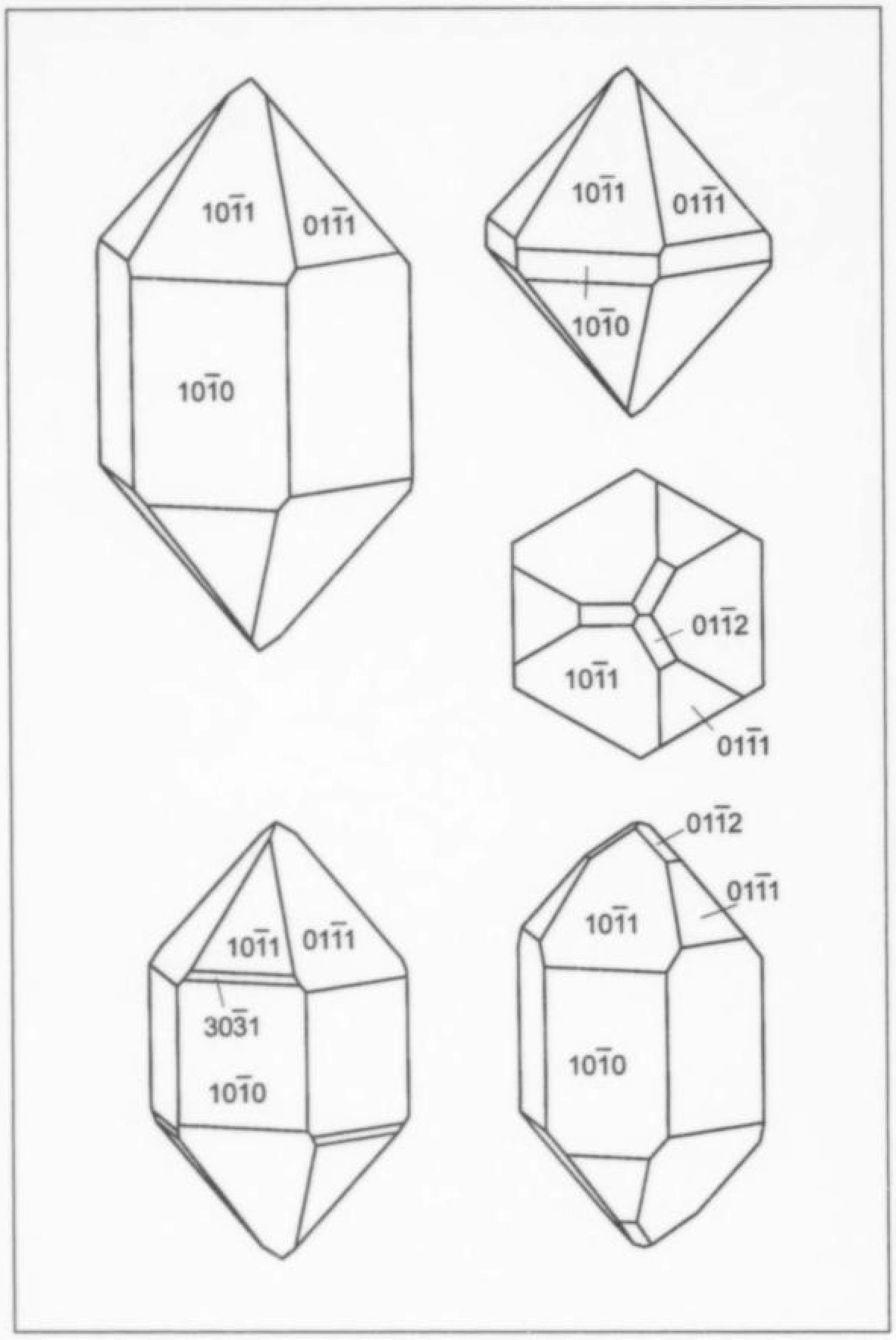


Figure 71. **Quartz crystal drawings, Francon quarry: The most common habit is shown at upper left; less common is the habit with minor prism and dominant rhombohedrons (upper right); the other drawings show habits which include the rare {30$\bar{3}$1} form and the very rare {01$\bar{1}$2} form.**

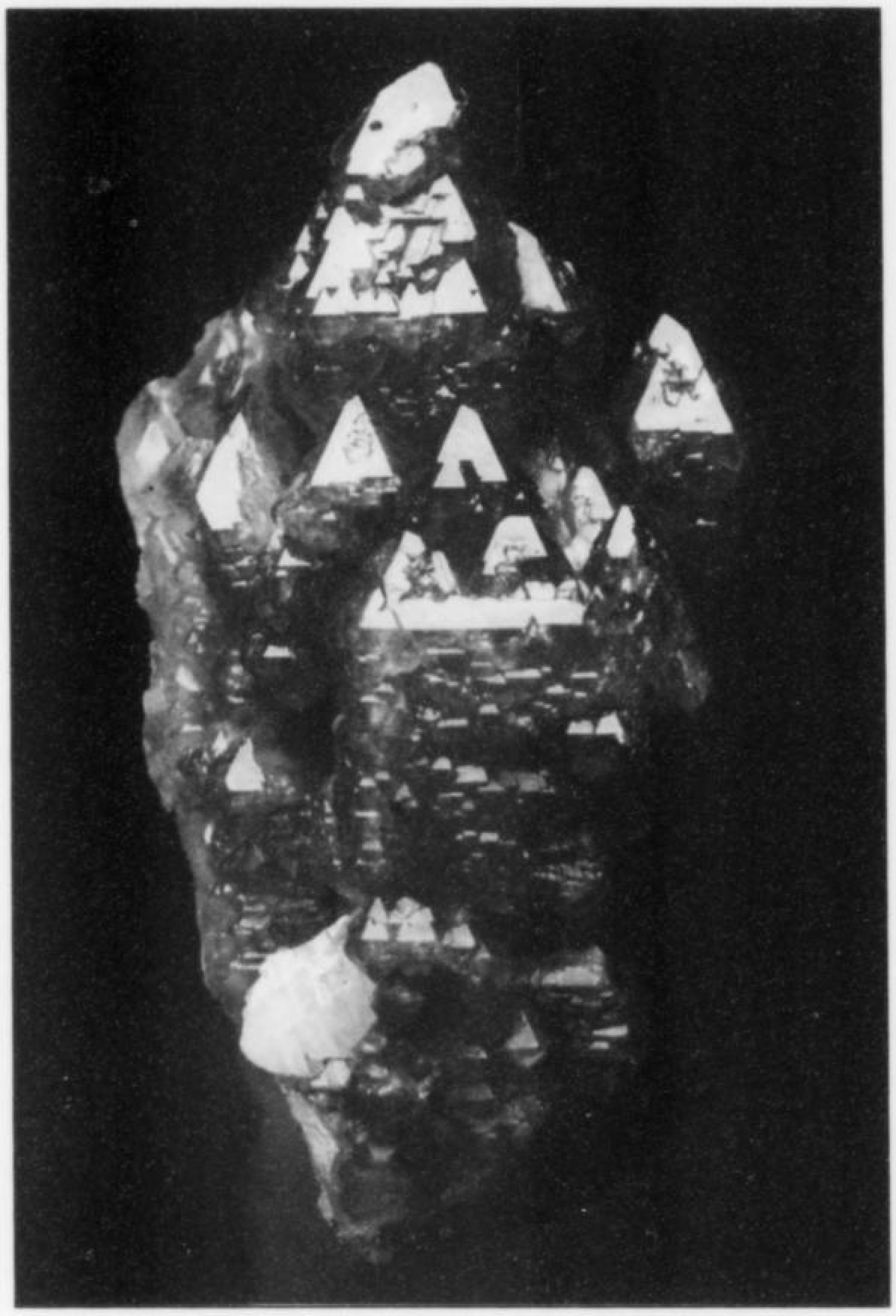


Figure 72. **Smoky quartz crystals in parallel growth, 5 cm. Horváth collection (no. 3890); L. Horváth photo.**

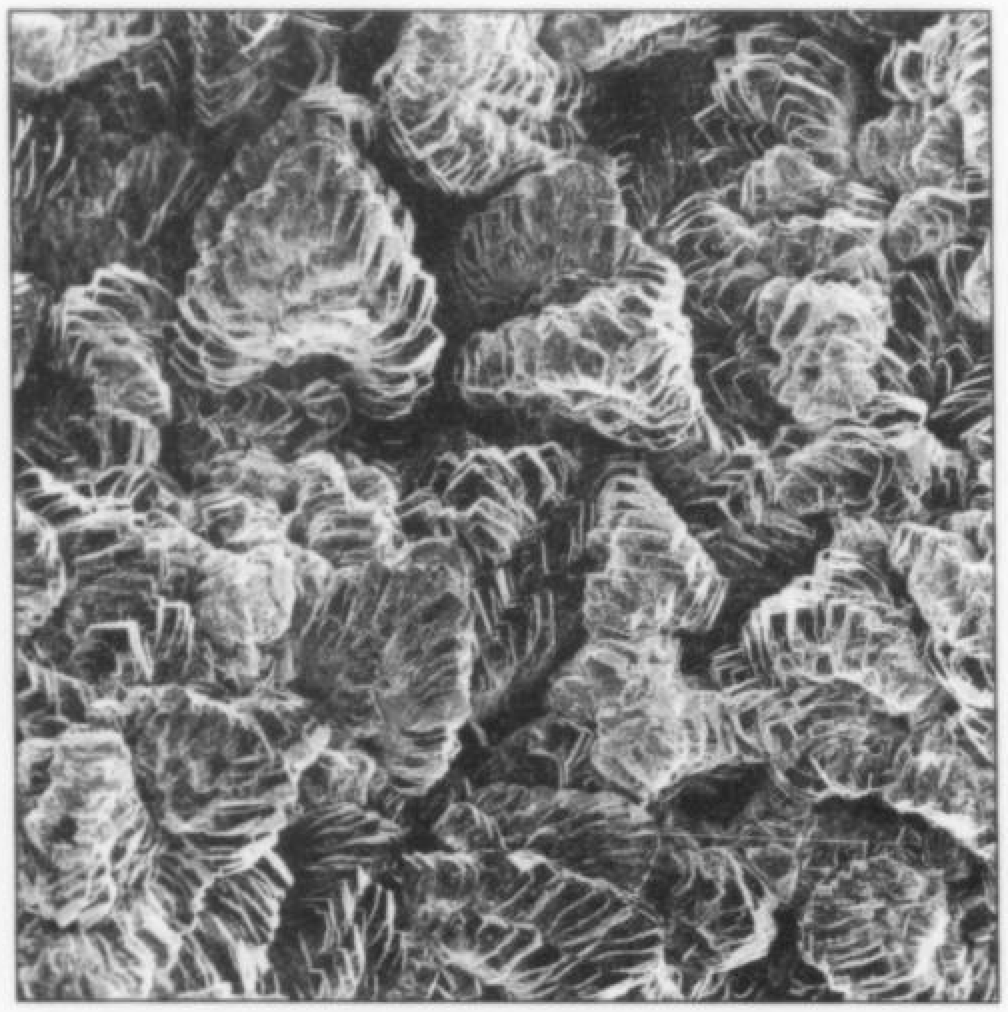


Figure 73. **Quartz microcrystals in fanned, 1-mm clusters called "artichoke" quartz, from the Francon quarry. Geological Survey of Canada collection and SEM photo.**

oped {01$\bar{1}$2} negative rhombohedron. Crystals are transparent to translucent, and colorless to pale gray, and light to dark smoky, some with distinct phantoms, and some appearing almost milky white due to etching. The largest crystals tend to be gray or smoky, and are often skeletal and cavernous due to corrosion.

Some crystals have numerous offsets on the prism faces due to parallel overgrowth. Often the crystals contain inclusions of other minerals, most notably dawsonite, strontianite, marcasite and sphalerite, as well as fluid inclusions (Vard and Williams-Jones, 1993). Colorless small crystals, usually in the 1–3 mm range, often form bow-tie groups, and peculiar artichoke-like aggregates, in which numerous crystals grow from a common center piled on top of and around each other, with terminations pointing in the same direction (Rykart, 1995). The aptly named "artichoke" quartz groups often aggregate into intricately curved and swirling crusts covering cavity walls up to several square centimeters in area. Globular and hemispherical aggregates of very tiny crystals are also observed. Tubular perimorphs of small quartz crystals after natrolite, up to 1.5 cm in length, have been found in the lower sill cavities associated with weloganite, albite, barite, calcite and siderite.

Quartz is an early to late-stage mineral in the cavity paragenesis, and two generations may be observed in the same cavity. In some cavities it forms the wall lining, and it may be the dominant or only mineral present. Quartz also commonly overgrows other minerals including weloganite and dawsonite in the upper sill, and celestine in the lower sill. It can be found with almost any of the cavity minerals in both the upper and lower sills. Very rarely, some quartz found in the upper sill gives a weak orange fluorescent response under shortwave, medium-wave and longwave ultraviolet radiation. This may be caused by inclusions in the quartz.

Chalcedony (cryptocrystalline quartz) has been found in dikes as bluish white masses associated with gypsum, and as bluish white ring-like aggregates on quartz.

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

Rozenite is relatively rare and is found as white powdery coatings and globules on oxidized marcasite and pyrite, occasionally associated with natrojarosite and rarely with halotrichite.

Rutile TiO_2

Rutile has been identified in at least one specimen (from a sill cavity) as black, submetallic plates associated with dawsonite, calcite and quartz (GSC APS 709).

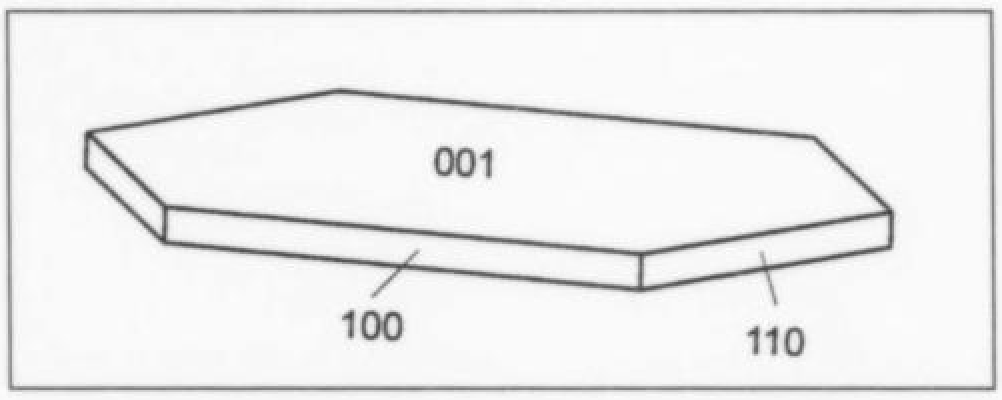


***Figure 74.* Sabinaite crystal drawing, Francon quarry (based on Jambor *et al.*, 1980).**

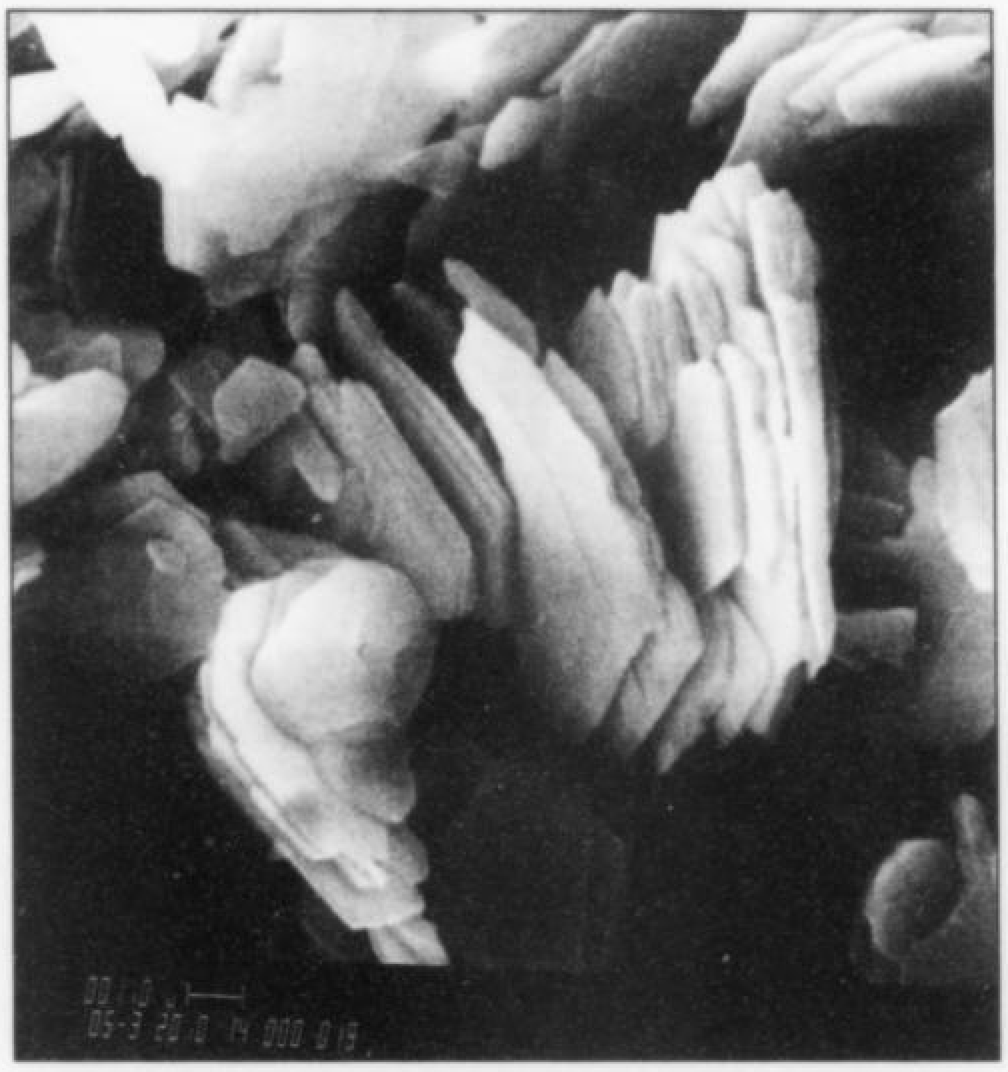


***Figure 75.* Platy sabinaite crystals, Francon quarry. Geological Survey of Canada collection and SEM photo.**

Sabinaite $Na_4Zr_2TiO_4(CO_3)_4$

A mineral first found and recognized as a potentially new species by A. P. Sabina was designated as APS No. 5 (Sabina, 1976, 1979). It was later confirmed to be a new species, and named *sabinaite* after its discoverer (Jambor *et al.*, 1980). It has subsequently also been found at Mont Saint-Hilaire, the only other known locality for the mineral. An investigation of the Mont Saint-Hilaire sabinaite by Chao and Gu (1985) resulted in revised cell parameters, and a revised, currently accepted ideal formula. The structure of sabinaite was solved by McDonald (1996) using crystals from Mont Saint-Hilaire, where sabinaite is found in pegmatites as superb, colorless or transparent, pale yellow, tabular crystals up to 8 mm long, sometimes forming aggregates several centimeters in diameter (Horváth and Gault, 1990; Horváth and Horváth-Pfenninger, 2000).

In the Francon quarry, sabinaite is quite rare, occurring in cavities in the upper sill as white, opaque powdery coatings and crusts on cavity minerals, and as compact, chalky aggregates. The aggregates consist of microscopic flakes and thin, platy crystals with an irregular and roughly hexagonal outline, typically less than 0.01 mm in diameter and 0.001 mm thick (Jambor *et al.*, 1980). The composition of Francon quarry sabinaite reported as Na_2O 20.7, CaO 0.2, ZrO_2 39.1, HfO_2 0.47, TiO_2 12.0, CO_2 27.1, total 99.57 weight %, is not significantly different from the composition of sabinaite from Mont Saint-Hilaire. Sabinaite crystals from the Francon quarry are tabular on (001) with dominant {001} basal pinacoid, bounded by {100} and {110} prisms, similar to sabinaite from Mont Saint-Hilaire. Individual plates are optically colorless and the luster varies from vitreous to silky. No fluorescence is observed under ultraviolet radiation (Jambor *et al.*, 1980). Sabinaite is a late-stage mineral typically associated with calcite, dawsonite, gibbsite, quartz, cryolite, weloganite and many other cavity minerals. Due to its resemblance to other white, powdery coatings and aggregates, there is no reliable way to visually identify sabinaite.

Saponite $(Ca_{0.5}Na)_{0.3}(Mg,Fe^{2+})_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$

Saponite, a member of the smectite group, has been identified at the Canadian Museum of Nature as dull, opaque, beige, spherical aggregates in cavities in a Francon quarry dike. The X-ray diffraction pattern suggests that it is an aluminum-rich variety.

Serpentine series $Mg_3Si_2O_5(OH)_4$

A chrysotile or lizardite member of the serpentine series has been found as a waxy, bluish gray to green, clay-like crust in a weathered dike in the alcove (A. P. Sabina, personal communication, 2004). Serpentine is a common alteration product of olivine in lamprophyric rocks such as camptonite.

Siderite $Fe^{2+}CO_3$

Siderite is a relatively common mineral in the lower sill cavities, and rare in the upper sill. It is found as transparent to translucent and opaque, pale yellow, greenish yellow, amber and brown rhombohedra, 1–2 mm across, sometimes lining cavities, and as botryoidal aggregates, commonly mixed with ankerite and dolomite. It is an intermediate-stage mineral, and has been observed on calcite (sometimes as an epitactic overgrowth), strontianite, dolomite and quartz. Other associated minerals include dawsonite, celestine, analcime, weloganite, cryolite, barite, goethite and hematite. In the upper sill it has been found in association with dresserite. Visual identification of Francon quarry siderite is unreliable because of its resemblance to ankerite and dolomite.

Smythite Fe_9S_{11}

Smythite is very rare in the upper and lower sill cavities as metallic, bronze-yellow to dark brown and almost black, thin, foil-like flakes and hexagonal crystals, typically less than 0.5 mm in diameter, and rosette-like aggregates. Some crystals have a ragged, irregular outline. Smythite is sometimes associated with pyrrhotite from which it is difficult to distinguish visually. Individual crystals of pyrrhotite are typically thicker and better formed. Other associated minerals include albite, analcime, barite, calcite, dawsonite, fluorite, quartz, siderite and strontianite.

Sphalerite (Zn,Fe)S

A relatively common and wide-spread mineral at the Francon quarry, sphalerite is found in very small concentrations, most

Figure 76. **Sphalerite crystals to 1 mm on dawsonite, Francon quarry. Horváth collection (no. 5311); L. Horváth photo.**

Figure 77. **Spherical clusters of sphalerite, 5 mm, with marcasite, Francon quarry. Horváth collection (no. 3832); L. Horváth photo.**

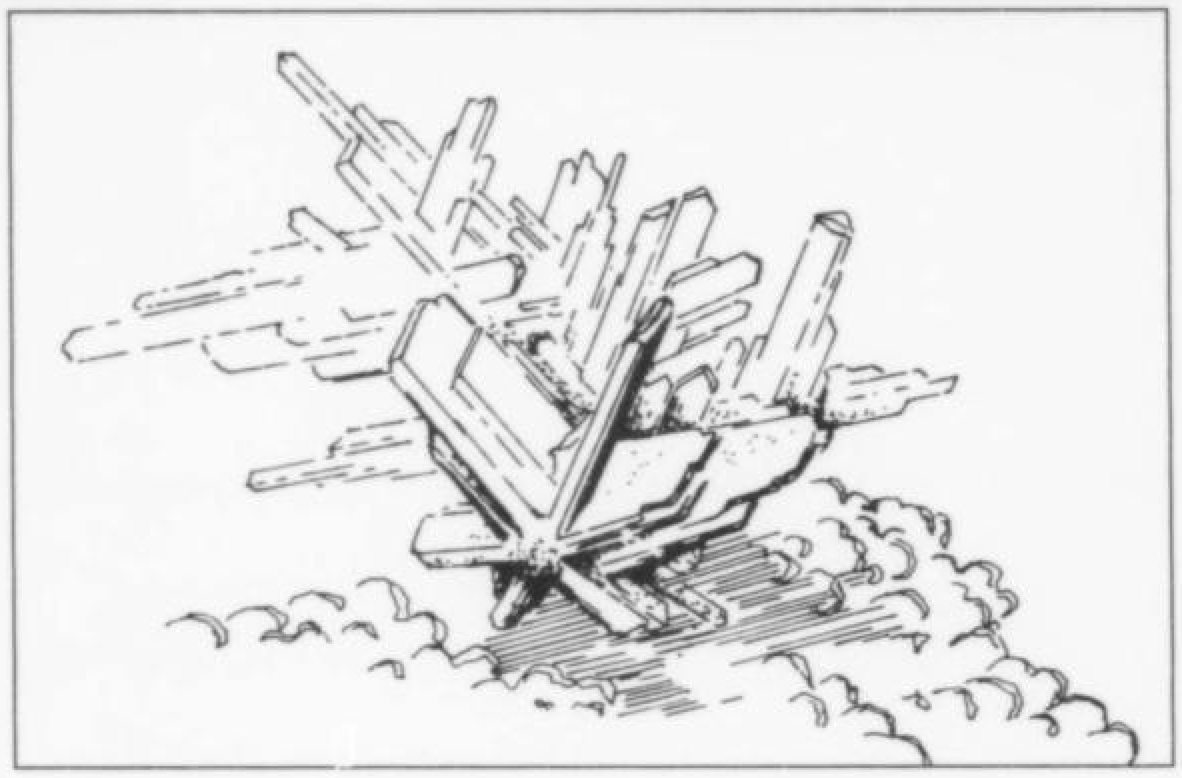


Figure 78. **Reticulated strontianite twins, Francon quarry. Garry Glenn sketch.**

commonly associated with dawsonite and fluorite. It occurs as sharp, vitreous to adamantine, transparent to translucent, orange-yellow, orange, reddish brown, and black crystals, up to 5 mm in diameter. Crystals are modified {111} tetrahedra, almost invariably contact-twinned on (111), and often flattened; some crystal faces are selectively frosted. Sphalerite is also found as yellow, spherical aggregates composed of rounded plates 1–2 mm in diameter, and as orange, platy aggregates of tiny crystals. The latter were found as a second-generation overgrowth on black and brown sphalerite crystals. Sphalerite has also been observed as pink to reddish botryoidal aggregates associated with natrojarosite. After dawsonite and fluorite, the most common associated minerals in the sill cavities are calcite, strontianite, galena, pyrite and marcasite. Sphalerite has also been found as orange-brown granular patches in the sill rock, and as yellow resinous masses in the limestone.

Strontianite $SrCO_3$

Strontianite is very common at the Francon quarry, especially in cavities in the upper sill, and is found in a great variety of crystal habits and aggregate types. It occurs as translucent to opaque, white to pale yellow and beige, generally smooth-surfaced spheroids, hemispheres and compact spherical and botryoidal aggregates up to 10 cm in diameter. It also forms translucent to opaque, white to pale beige spheres consisting of numerous, radiating, acicular crystals with sharp acute terminations, typically 1–10 mm in diameter. It is also found as colorless to white and pale yellow tufts, parallel bundles, and sheaf-like clusters of fibrous to acicular crystals, and as white, finely granular, porcelaneous and waxy globular aggregates.

Strontianite crystals occur in three general habits: tabular, blocky and columnar, all bound by essentially the same forms: the {010} pinacoid, dominant in the tabular and prominent in both the columnar and blocky habits; the {110} prism, dominant in the columnar, prominent in the tabular and minor in the blocky habits; the {001} basal pinacoid is dominant in the blocky and minor in the other habits; and the {011} and {021} prisms and {111} dipyramids are relatively minor forms. Practically all strontianite crystals are contact-twinned on (110), and this results in a variety of interesting twinned groups and aggregates. Particularly attractive are transparent, pale pink, columnar to tabular sixling twins up to 1 cm in diameter, sometimes forming rosette-like groups. Also fairly common are peculiar aggregates of stacked, stellate sixling twins consisting of transparent, pale yellow, tabular crystals. Strontianite has also been found as radiating, spray-like aggregates up to 5 cm long, consisting of colorless to pale yellow, elongated columnar groups, with hexagonal cross-section and shallow grooves parallel to [001] indicative of contact twinning.

Strontianite is a late-stage mineral in the sill cavities, sometimes found as multiple generations. Well-formed individual crystals are

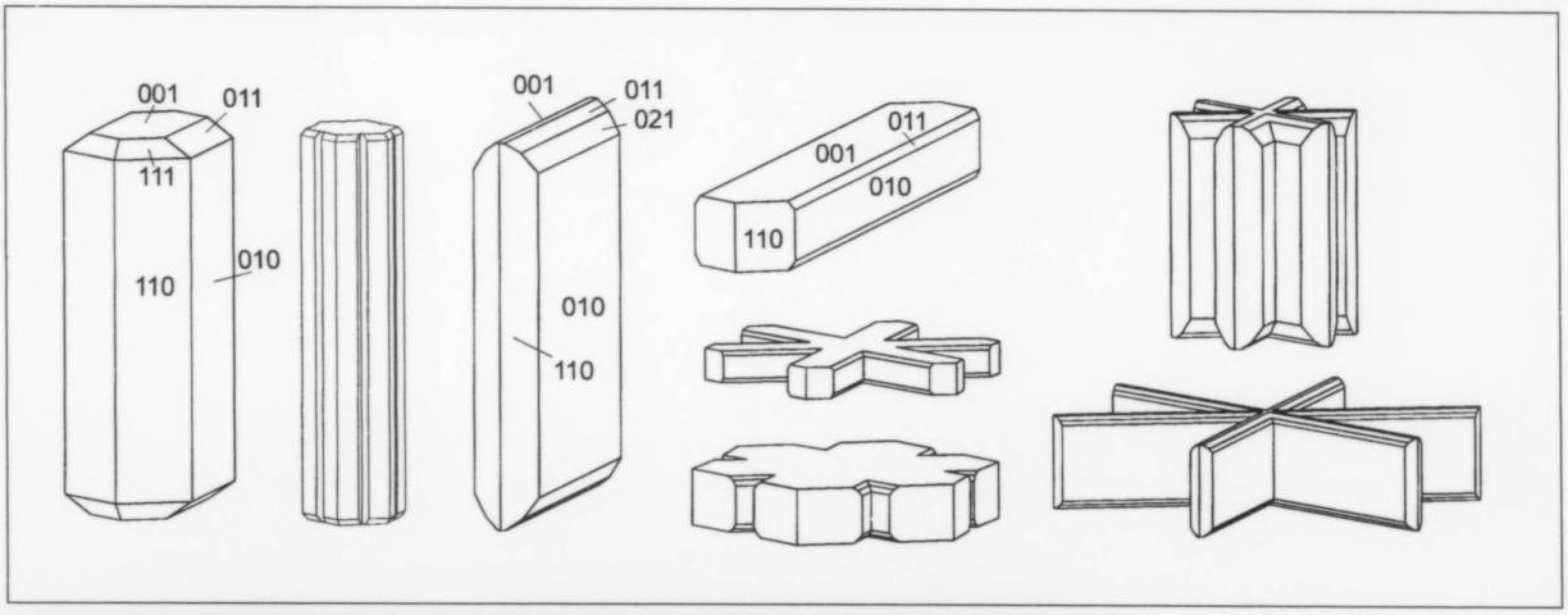
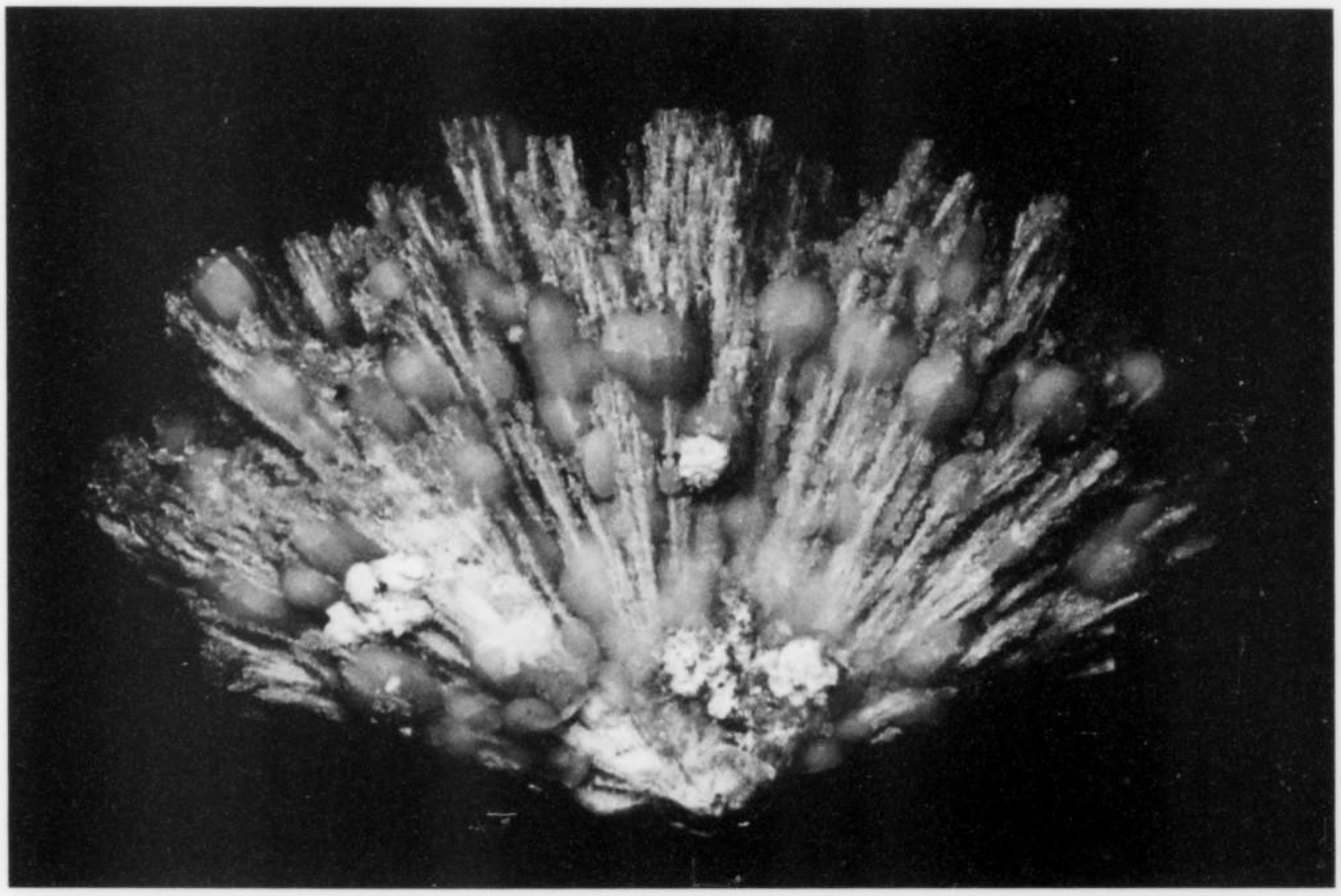


Figure 79. **Strontianite crystal drawings: Idealized single and sixling-twinned crystals.**

Figure 80. **Strontianite crystals to 1 cm, Francon quarry. Horváth collection (no. 3211); L. Horváth photo.**

Figure 81. **Strontianite crystal spray, 8 cm, from the Francon quarry. Redpath Museum collection (no. D2251.2), McGill University; L. Horváth photo.**



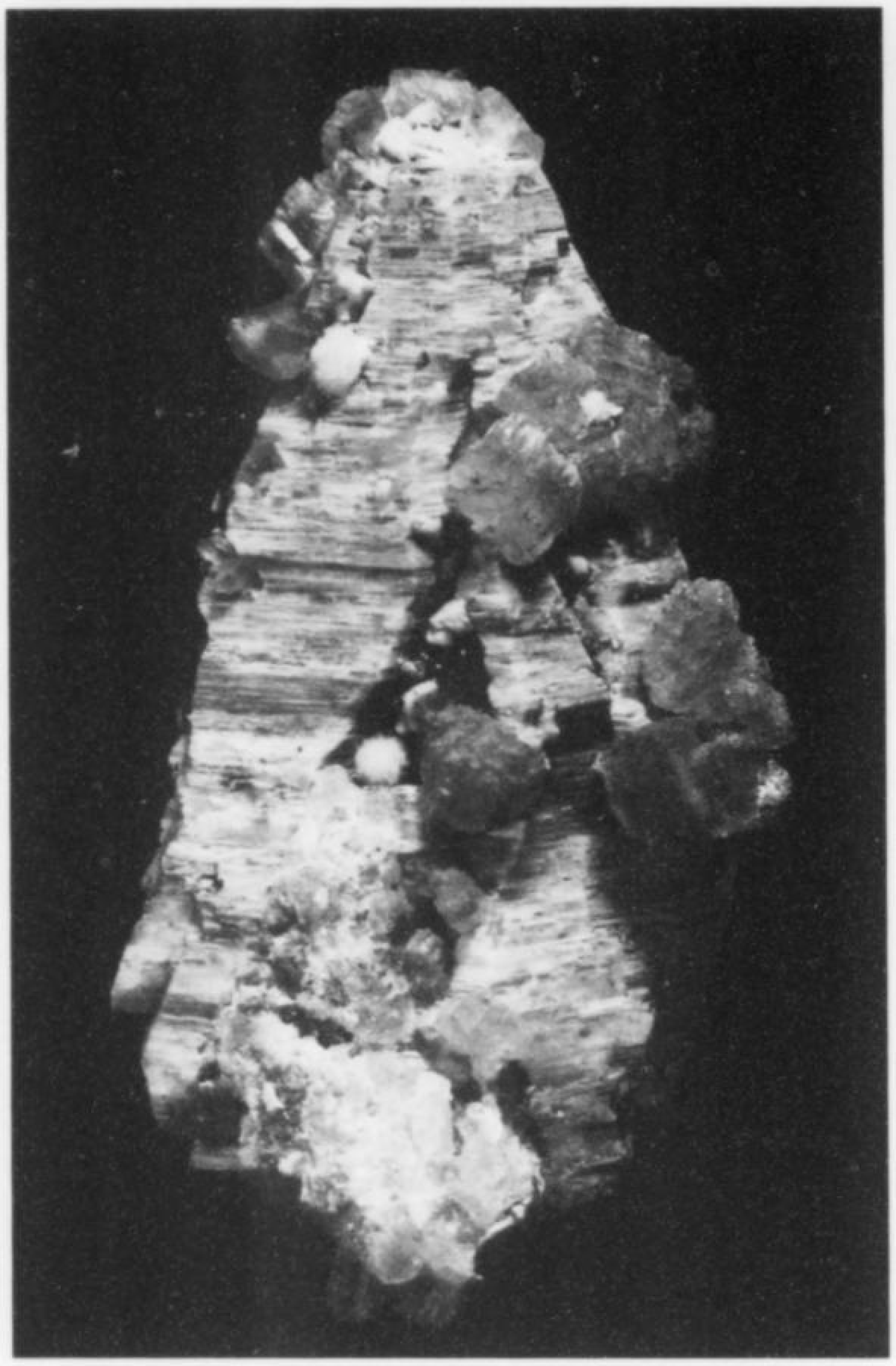


Figure 82. **Pinkish strontianite crystals and white hydrodresserite spheres on a weloganite crystal, 4.5 cm, from the Francon quarry. Horváth collection (no. 5662); L. Horváth photo.**

far less common than the various types of aggregates. The associated minerals include practically all the cavity minerals. Strontianite also occurs as solid masses completely filling small cavities in the sill rock, and as colorless, tabular crystals and spherical groups of acicular crystals in limestone cavities.

Strontianite fluoresces a bright yellowish white under shortwave, medium-wave and longwave ultraviolet radiation, and phosphoresces a strong, medium-duration, yellowish white after exposure to all three wavelengths.

Strontiodresserite $(Sr,Ca)Al_2(CO_3)_2(OH)_4 \cdot H_2O$

Strontiodresserite, the strontium-dominant analog of dresserite with Sr + Ca > Ba, was described from the Francon quarry as a new species in 1977 (Jambor *et al.*, 1977). It was recognized as a potentially new species during the original investigation of Francon quarry minerals and designated as APS No. 6 (Sabina, 1976). The infrared characteristics of strontiodresserite were investigated by Farrell (1977), and the space group was determined by Roberts (1978). Its crystal structure has not been solved to date, nor is there a complete quantitative analysis. The molar proportions of CO_2, H_2O and OH in the theoretical formula are based on the similarity of its X-ray diffraction powder pattern to dundasite, with which it is considered to be isostructural (Roberts, 1978).

Very recently, strontiodresserite has also been found in a marble quarry near Kjøpsvik, Tysfjord, Nordland, Norway, where it occurs as white, fibrous masses of capillary crystals up to 2 cm long (T. Andersen, personal communication, 2004), and in middle Jurassic marl at Condorcet, Drôme, France (Martin *et al.*, 2004). In the latter locality, which has yielded the richest and best specimens, strontiodresserite occurs in fissures as compact, spherical aggregates, less than 2 mm in diameter, of radiating, silky white, fibrous crystals. It is interesting to note that the three known occurrences of strontiodresserite are in totally different geological environments, in igneous rock in the Francon quarry, metamorphic rock in Norway and sedimentary rock in France.

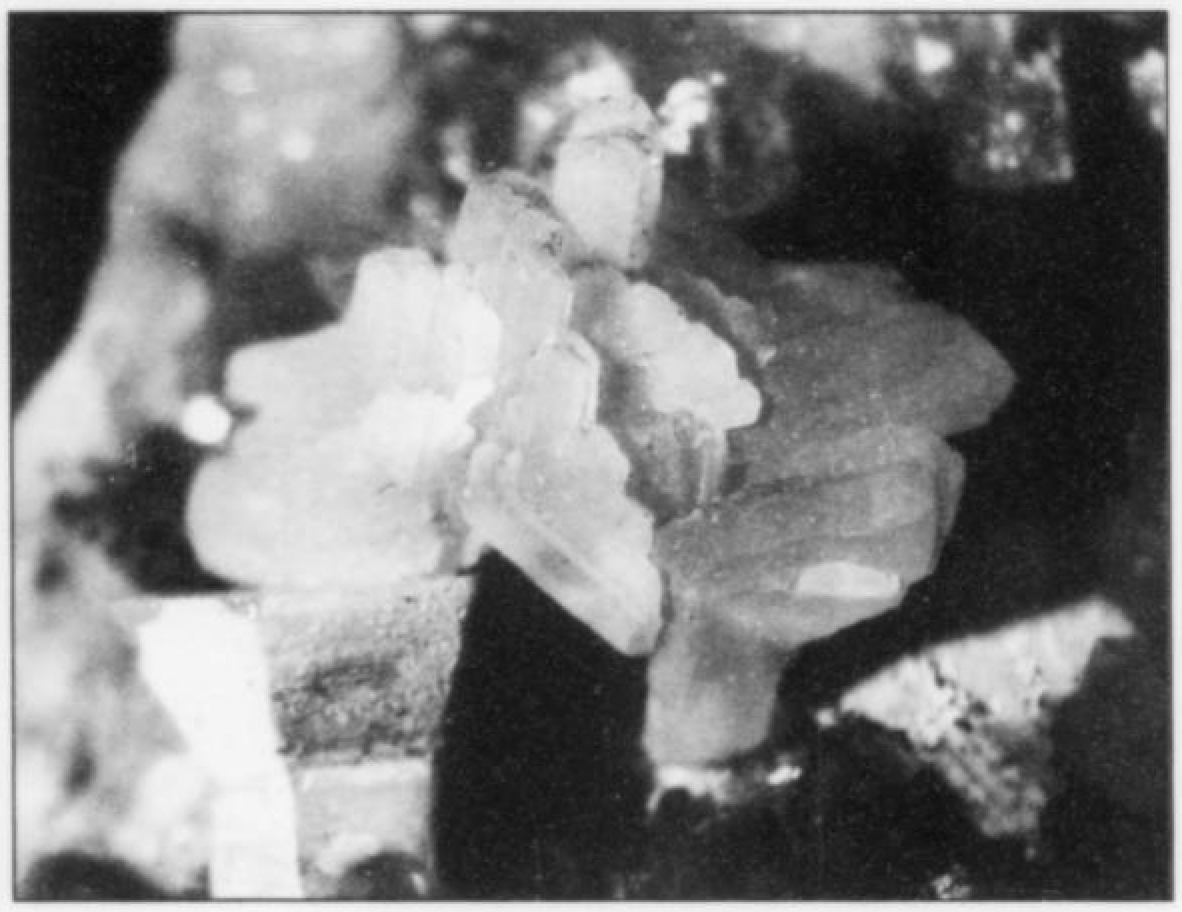


Figure 83. **Twinned cluster of pink strontianite microcrystals, 3 mm, with weloganite, from the Francon quarry. Horváth collection (no. 5357); L. Horváth photo.**

Strontiodresserite is considerably rarer than dresserite or hydrodresserite, and known to occur only in the upper sill, as spherical aggregates up to 1 mm in diameter, consisting of radiating, silky white, flattened fibers, 0.1–0.5 mm long. Some of the larger spheres have a very smooth surface with a waxy to vitreous luster. Jambor *et al.* (1977) described strontiodresserite as occurring as "vitreous to silky white coatings, some of which are atoll-shaped" and "extremely fine-grained lath-like grains of maximum dimensions 0.1 × 0.01 × 0.001 mm." However, later finds revealed larger spheroids. These yielded larger crystal fibers which enabled the determination of the space group (Roberts, 1978). Individual crystals are colorless and morphologically similar to dresserite, very thin and bladed, elongated on [001] and flattened on (010). However, to date, no crystals suitable for goniometric measurements have been found.

In some of the best specimens, strontiodresserite occurs as spherical groups embedded in powdery masses of montroyalite. Other associated minerals are albite, quartz, weloganite and dawsonite. Although the smooth-surfaced spheres are fairly distinctive, visual identification of strontiodresserite is unreliable. Energy-dispersive spectroscopy, however, can readily identify the mineral. Yellowish white fluorescence under both shortwave and longwave ultraviolet radiation is reported for the cotype specimen ROM M344626 (R. A. Ramik, personal communication, 2004), but could not be confirmed by the authors, nor was it reported in the original description by Jambor *et al.* (1977).

Sulfur S

Sulfur is found very rarely as an alteration product of marcasite and pyrite, commonly associated with natrojarosite, rozenite and halotrichite. It forms black, sooty to earthy coatings, and yellow powdery coatings and aggregates on oxidized marcasite and pyrite.

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

Synchysite-(Ce) is the most common of the few known rare-earth element minerals found in the quarry. It occurs very rarely in both the upper and lower sills, and in the dikes, as white, silky spherules up to 1 mm in diameter, and as silky white, gray to tan, fibrous, flaky or powdery aggregates associated with marcasite, celestine and barite (Sabina, 1976). It is also found as gray, greenish gray and brown, sharp hexagonal plates 0.5–1 mm in diameter, forming rosette-like groups; as silvery gray flakes, sometimes stained orange, forming rounded plates and spherules 0.5–1 mm in diameter; and as sprays, 4–5 mm long, composed of aggregates of minute, silvery flakes, that may be pseudomorphs after a fibrous or acicular precursor. Associated minerals include quartz, fluorite, dawsonite, marcasite, pyrite, mordenite and calcite.

Talc $Mg_3Si_4O_{10}(OH)_2$

Talc occurs as white patches associated with a serpentine-series mineral in a highly weathered dike in the alcove (A. P. Sabina, personal communication, 2004).

Thaumasite $Ca_6Si_2(CO_3)_2(SO_4)_2(OH)_{12}\cdot 24H_2O$

Thaumasite has been found as a white, micro-fibrous, crackled crust, several square centimeters in area, on fracture surfaces in a highly weathered serpentine-bearing dike in the alcove (GSC APS 724 and 730).

Thenardite Na_2SO_4

A supergene species, thenardite has been observed as a thin, white, powdery efflorescence on fracture surfaces in sill rock and limestone at the upper sill-limestone contact.

Thorbastnäsite $Th(Ca,Ce)(CO_3)_2F_2\cdot 3H_2O$

Thorbastnäsite occurs, very rarely, in the lower sill cavities as silky to waxy, white spherules and hemispheres to 750 µm in diameter, composed of radiating fibers, and as coatings of fibrous aggregates, associated with baddeleyite and zircon (Sabina, 1979). It has also been found as stringers of very tiny white spherules associated with fluorite, calcite, quartz and dawsonite; as pearly to waxy, opaque white spherules up to 0.5 mm in diameter; and as irregular aggregates up to 5 mm across, composed of minute flakes partially overgrown by hematite and associated with fluorite, dawsonite, ankerite, celestine, goethite and calcite. Thorbastnäsite also occurs admixed with fluorite as velvety black rounded aggregates associated with calcite and dawsonite. Thorbastnäsite is visually indistinguishable from the many other white spherules found in the quarry.

Viitaniemiite $NaCaAl(PO_4)(F,OH)_3$

Viitaniemiite was described as a new species from the Viitaniemi pegmatite, Eräjärvi area, Orivesi, Etelä-Suomen Lääni, Finland, where it occurs as sprays of bladed crystals up to 3 cm long (Lahti, 1981). Its crystal structure was solved by Pajunen and Lahti (1984). The Francon quarry is the second known locality for the species (Ramik *et al.*, 1983). Interestingly, it was collected at Francon in 1976, before its description from Finland, but it was not immediately recognized as a potential new species. Viitaniemiite has also been reported from Paprok, Afghanistan, where outstanding crystals up to 18 cm long have been found (Weerth,1992), and from Greifenstein, Ehrenfriedersdorf, Erzgebirge, Saxony, Germany (Spallek, 1996).

At the Francon quarry, viitaniemiite is exceedingly rare, known only from a few specimens collected in 1976 from a block of rock from the upper sill on the quarry floor near the northeast wall (Ramik, 1992). It was found in cavities as delicate sprays of vitreous, colorless, slightly tapering, bladed crystals, and as solitary crystals up to 2 × 0.5 × 0.2 mm. The crystals are elongated along [010] and flattened on (100), and show dominant {100} and poorly defined {001} faces, with indistinct terminations in the [010] zone. On a microscopic level, the crystals are invariably twinned by reflection on the (100) plane. In contrast to viitaniemiite from the type locality, viitaniemiite from Francon is manganese-free, with the composition Na_2O 11.4, Al_2O_3 23.4, P_2O_5 28.1, CaO 22.3, MgO 0.1, F 14.5, O = F –6.1, total 93.7 weight %, H_2O not determined or calculated, resulting in the empirical formula $Na_{0.91}(Ca_{0.98}Mg_{0.01})_{\Sigma 0.99}Al_{1.13}(P_{0.98}O_4)F_2(OH)$, or ideally $NaCaAl(PO_4)F_2(OH)$. Ramik *et al.* (1983) concluded that the Francon mineral was therefore the Ca end-member in terms of the "Ca-Mn diadochy."

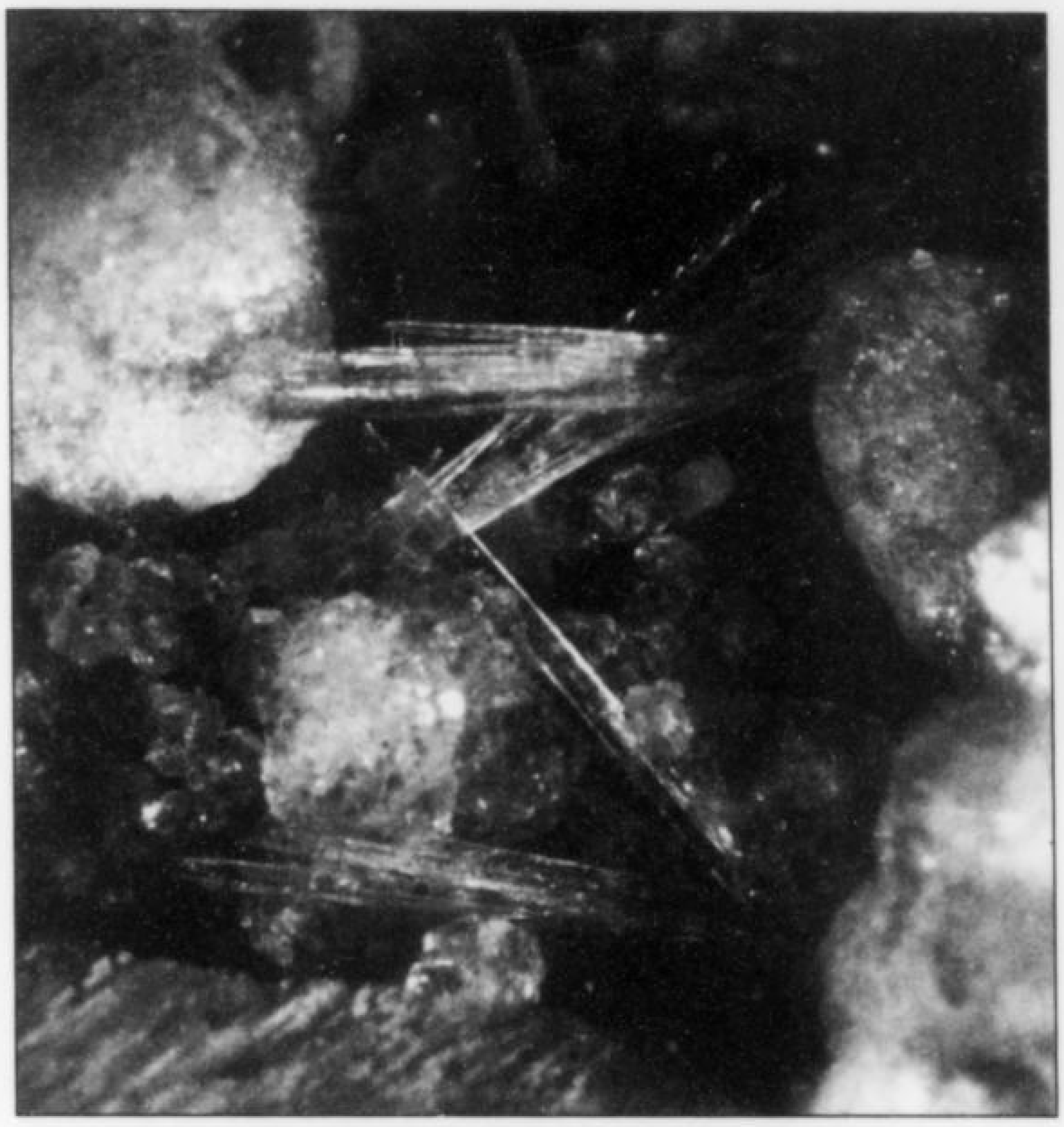


***Figure 84.* Acicular viitaniemiite crystals to 2 mm, with cryolite, calcite and weloganite. Geological Survey of Canada collection and photo.**

Viitaniiemite was the first phosphate mineral reported from the sill cavities. It is associated with colorless cryolite, calcite, weloganite, and minor dawsonite, fluorite, dresserite, pyrite, quartz and galena. Paragenetically, viitaniemiite precedes cryolite, fluorite and pyrite. Although the elongated, tapering crystals of viitaniemiite are distinctive, their small size and transparency make them easy to overlook.

Voggite $Na_2Zr(PO_4)(CO_3)(OH)\cdot 2H_2O$

Voggite is the tenth and most recent new species described from the Francon quarry (Roberts *et al.*, 1990). It was found in amygdaloidal cavities in a basaltic dike that intersects the upper sill in the alcove. The crystal structure was solved by Szymański and Roberts (1990). Because the thin, acicular to fibrous crystals of voggite rapidly decompose under an electron beam, conventional microprobe analysis was only partly successful, and the ideal chemical composition was therefore derived from the crystal structure data: Na_2O 17.95, ZrO_2 35.69, P_2O_5 20.56, CO_2 12.75, H_2O 13.05, total 100.00 weight %. The Francon quarry is currently the only known locality for the species.

Voggite is exceedingly rare and known only from a few specimens collected in 1985, first by Adolf Vogg, a mineral collector for whom the mineral was named. After an initial X-ray diffraction analysis it was immediately recognized as a potentially new

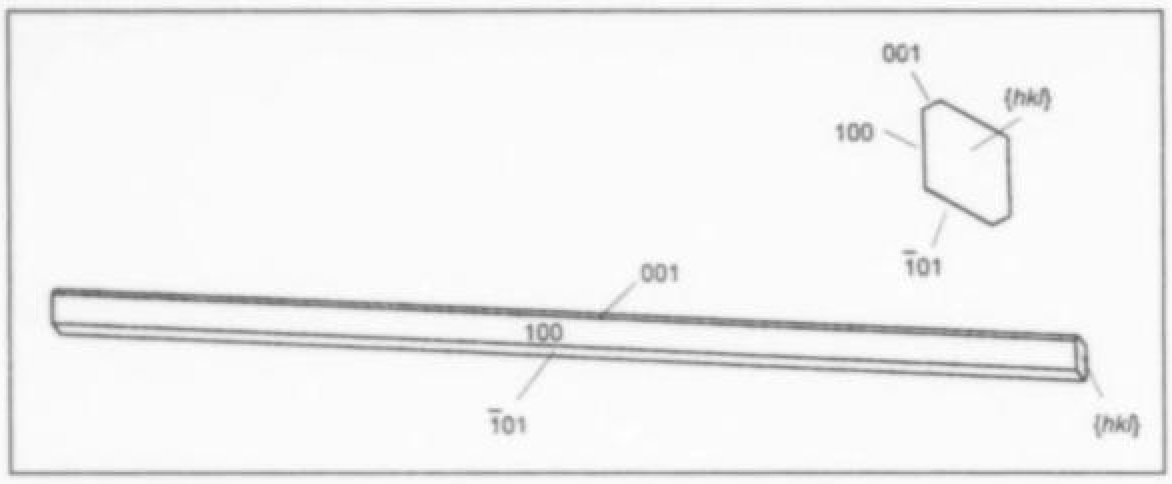


Figure 85. **Voggite crystal drawings based on data given by Roberts *et al.* (1990), except the aspect ratio has been reduced from 100:1 to about 30:1 (terminal faces were not given).**

species and designated as APS No. 15. The voggite-bearing dike, actually an offset of a basaltic sill, was exposed in the northeast face of the alcove near the bottom of the ramp (Ramik, 1992; A. P. Sabina, personal communication, 2005). Although amygdules are distributed throughout the dike, those containing voggite are localized within a few centimeters of the contact between the dike and the phonolite sill. This suggested that the mineral was the result of reaction between the intruding dike magma and the sill which was the source of zirconium (Roberts *et al.*, 1990).

Voggite occurs in cavities within amygdules 1–3 mm across, as matted nests and irregular aggregates of vitreous, colorless to white, acicular capillary crystals rarely exceeding 1 mm in length and 6–8 µm in diameter. The crystals are elongated along [010], with an aspect ratio of about 100:1, and display the following forms: major {100} and $\{\bar{1}01\}$ pinacoids, and minor {001} pinacoid. The terminal faces in the [010] zone are indistinct. It is directly associated with quartz, calcite and dawsonite. Other amygdules in the dike contain mordenite, dachiardite-Na, a garronite-like mineral, analcime, calcite, dolomite, barite and fluorite, often as solid fillings. Voggite superficially resembles the associated fibrous to capillary mordenite, however its brittleness and unbent crystals may be helpful in distinguishing it from the flexible mordenite. Voggite does not fluoresce under ultraviolet radiation.

Weloganite $Sr_3Na_2Zr(CO_3)_6 \cdot 3H_2O$

The discovery of what proved to be a new species, weloganite, by GSC mineralogist Ann Sabina on her first visit to the quarry in 1966, was the pivotal event that established the Francon quarry as a major mineral locality. It is very rare that a new mineral is discovered as large, attractive crystals, as was the case with weloganite. Not only did weloganite occur as multi-centimeter crystals, but it was extraordinarily abundant in the quarry. Fittingly, the mineral honors Sir William E. Logan (1798–1875), the Montréal-born founding director of the Geological Survey of Canada. The Francon quarry is only a few kilometers from the site of the first headquarters of the Geological Survey, and the site of the Logan farm, Sir William's birthplace.

Originally designated as APS No. 1, weloganite was described as a new species, and the first zirconium-bearing carbonate, by Sabina *et al.* in 1968. However, it proved to be a problematic species both structurally and chemically. Sabina *et al.* (1968) concluded that, based on single-crystal X-ray precession photographs, weloganite was trigonal. Subsequently, Gait and Grice (1971) postulated the existence of a monoclinic polytype. Chen and Chao (1975) showed that weloganite was triclinic, with a pronounced rhombohedral sub-cell which resulted in a pseudo-trigonal symmetry. They also showed the existence of a pseudo-monoclinic cell which accounted for the monoclinic symmetry suggested by Gait and Grice (1971). The crystal structure of weloganite was finally solved by Grice and Perrault (1975). They confirmed that weloganite was triclinic and very strongly pseudo-trigonal. As discussed below, the trigonal pseudosymmetry is very

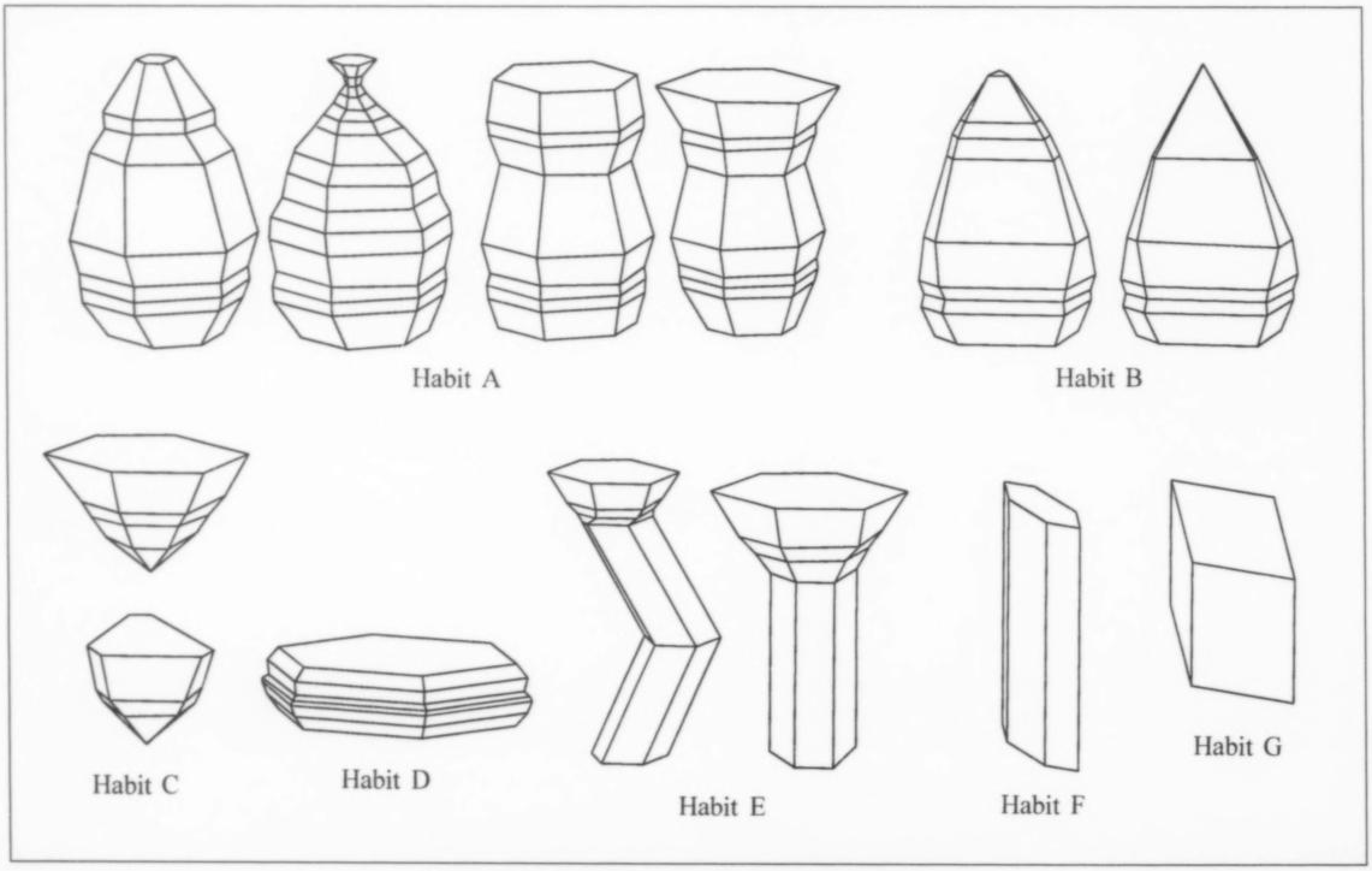


Figure 86. **Weloganite crystal sketches depicting various observed habits described in the text.**

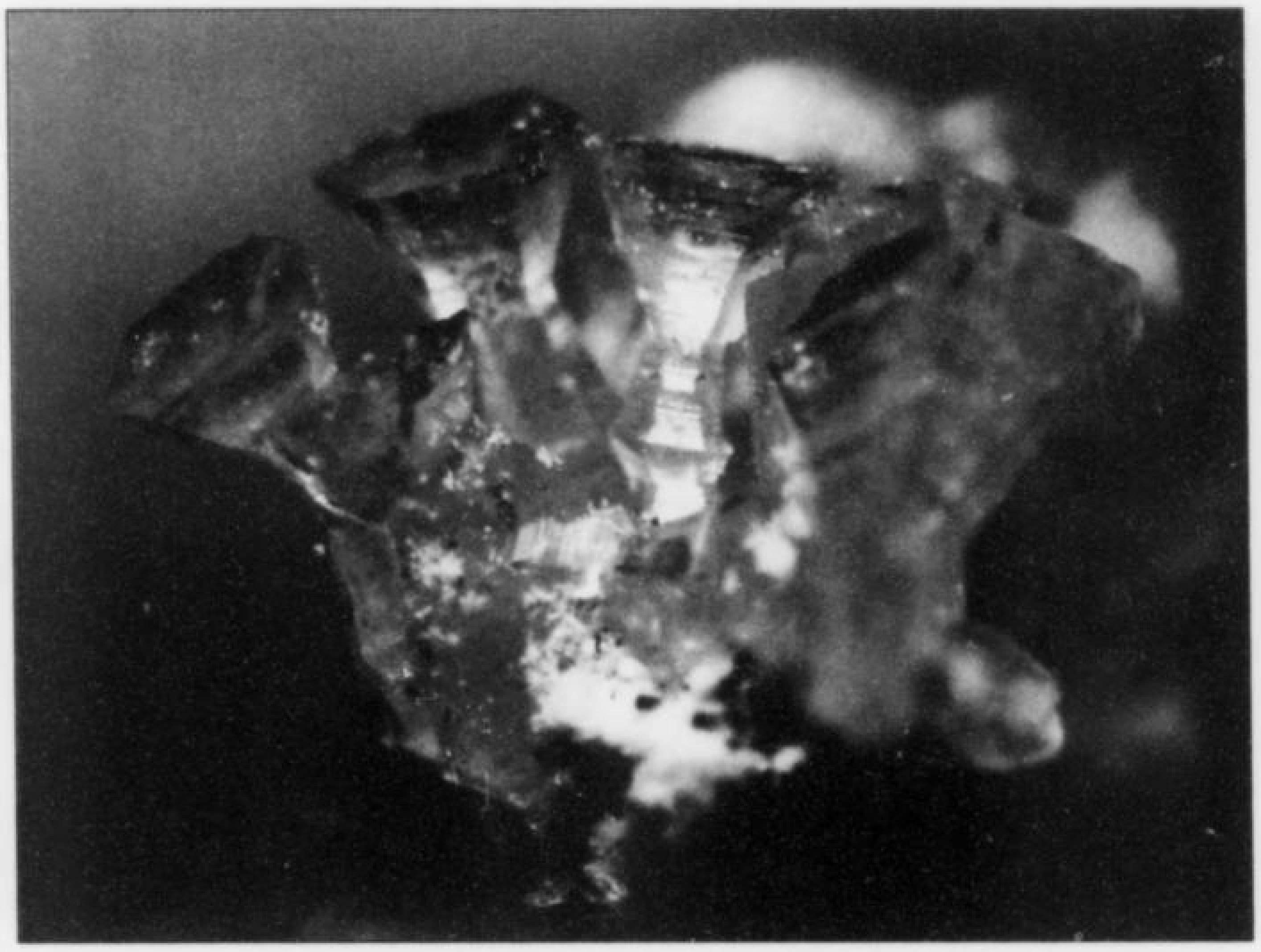


Figure 87. **Weloganite crystal group, 5 mm across, from the Francon quarry. Horváth collection, E. Offermann photo.**

Figure 88. **"Hour-glass" weloganite crystal, 2.5 mm, with marcasite, from the Francon quarry. Tarassoff collection (no. PT156); Violet Anderson photo (1982) courtesy of the Royal Ontario Museum © ROM.**

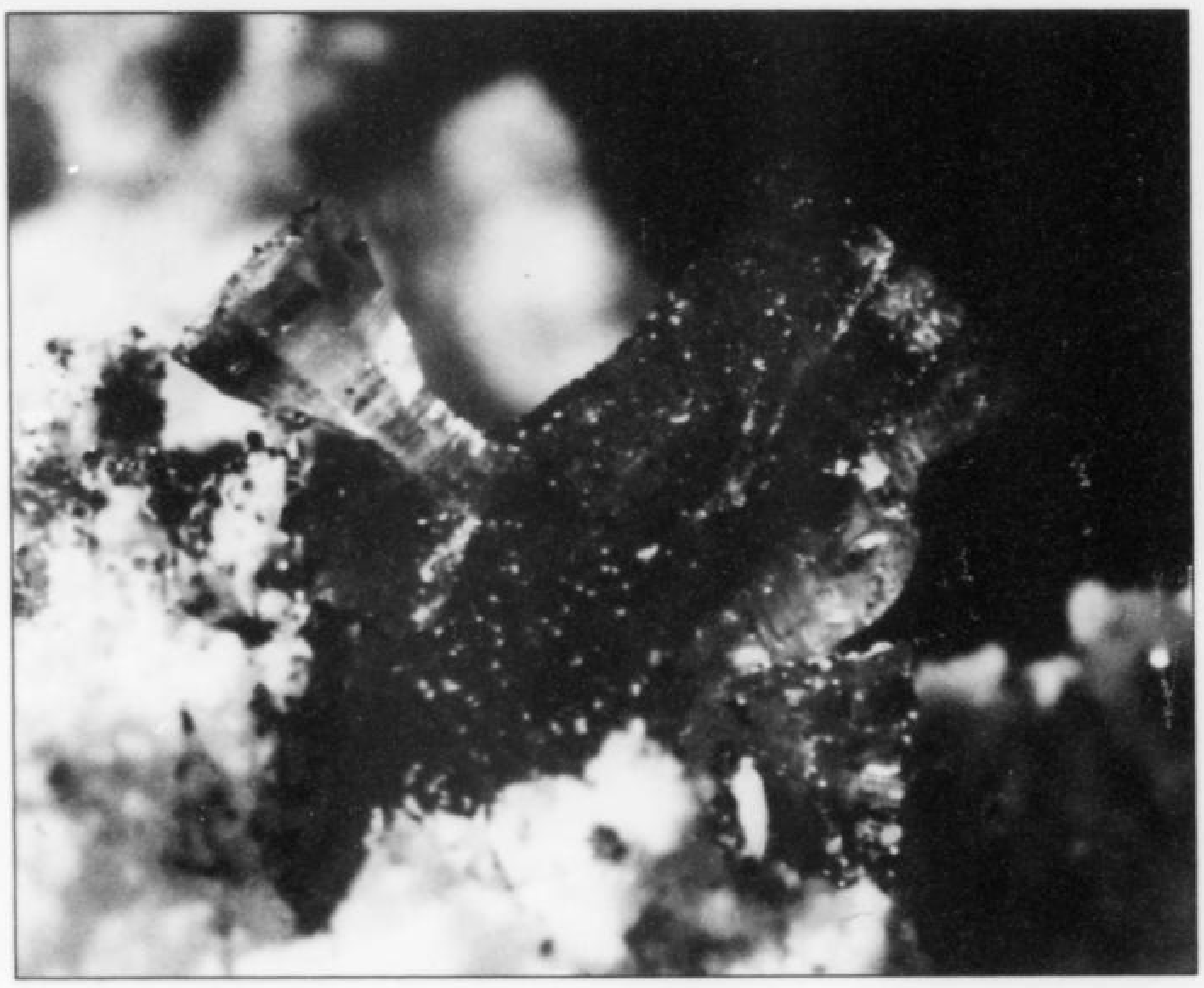


Figure 89. **Weloganite crystals to 4 mm, Francon quarry. Horváth collection (no. 5377); L. Horváth photo.**

apparent in the morphology of weloganite crystals. Weloganite is isostructural with triclinic donnayite-(Y), the Y-analog of weloganite (Chao *et al.,* 1978), which exists as both trigonal and triclinic polytypes (Trinh Thi Le Thu *et al.,* 1992; Khomyakov, 1995). Weloganite is also structurally related to mckelveyite-(Y), ewaldite, and the two unnamed carbonates UK33A and UK37A from Mont Saint-Hilaire (McDonald, 1989; Chao *et al.,* 1990).

The composition of weloganite was originally reported as SrO 41.0, ZrO_2 19.4, CO_2 32.2, H_2O 6.6, total 99.2 weight %, with the theoretical formula $Sr_5Zr_2C_9H_8O_{31}$ (Sabina *et al.,* 1968). Although weloganite was recognized to be a carbonate, the results of infrared and DTA analyses were ambiguous as to the structural units present. Gait and Grice (1971) subsequently showed that weloganite contained very significant amounts of both Na and Ca. The composition reported by Grice and Perrault (1975) and used in their structure determination is SrO 36.18, CaO 1.14, ZrO_2 15.26, Na_2O 7.75, K_2O 0.02, CO_2 30.7, H_2O 7.85, SiO_2 0.25, MgO <0.02, Fe_2O_3 0.03, total 99.2 weight %, resulting in the now accepted formula $Sr_3Na_2Zr(CO_3)_6 \cdot 3H_2O$.

Weloganite has also been found, rarely and in very minor quantities, at two other Monteregian alkaline province localities in the Montréal area. The first of these occurrences is in an alkaline sill in the Lafarge (Montréal-Est) quarry–also known in the past as Francon (Montréal-Est) quarry)—8 km northeast of the Francon quarry. The other is in a nepheline syenite pegmatite in the Poudrette quarry at Mont Saint-Hilaire (Horváth and Gault, 1990).

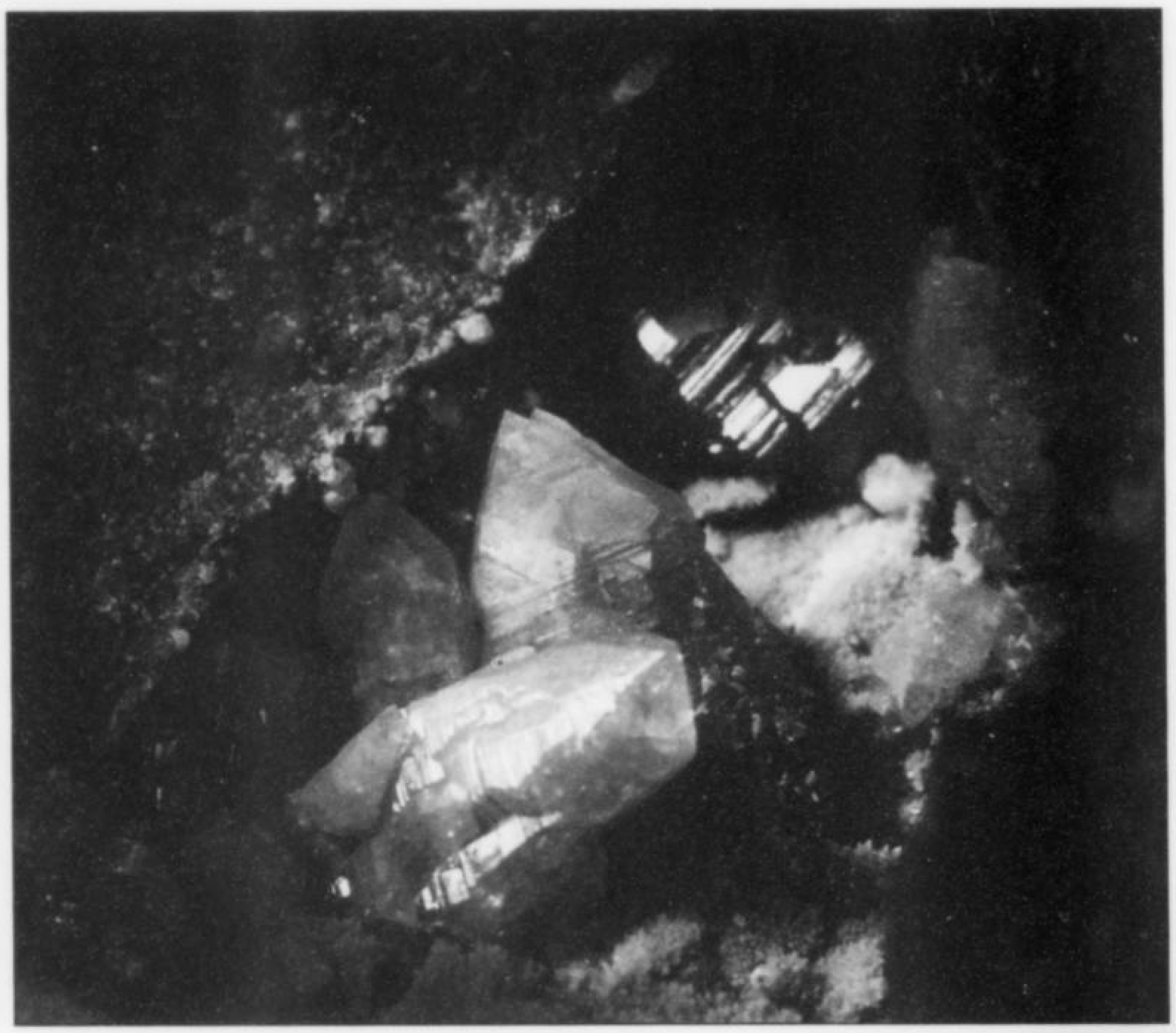


Figure 90. **Weloganite crystals to 1.8 cm (habit B) in a lower sill cavity. Horváth collection (no. 5499); L. Horváth photo.**

Figure 91. **Weloganite crystals to 1.5 cm (habit B) in a cavity from the lower sill. Horváth collection (no. 5501); L. Horváth photo.**

At the Lafarge (Montréal-Est) quarry, weloganite occurs, very rarely, as well-formed, yellow crystals up to 3 mm, and at Mont Saint-Hilaire as 1–2 mm irregular, glassy fragments, in the cores of donnayite-(Y) crystals, intimately associated with UK33A (Chao *et al.*, 1990), an unnamed carbonate which may be the Ce-dominant analog of donnayite-(Y).

In the Francon quarry, weloganite occurs in both the upper and lower sills. The crystals are generally larger, more abundant and more evenly distributed in the upper sill, at least in the zones documented in the period of 1968–1985, whereas in the lower sill the concentration of weloganite is more localized. However, crystals found on the lower level are more varied in habit, generally more transparent, and lack the coatings and encrustations by other minerals that are common in the upper sill.

Weloganite is most often transparent to translucent, pale yellow to lemon-yellow, orange-yellow and amber. Opaque white, gray and greenish gray crystals are also common. Less commonly, weloganite is colorless and, rarely, pale green or pink. The luster ranges from adamantine on some faces, to vitreous, greasy and dull. Color zoning along and transverse to the *c*-axis is quite common, with the zones varying not only in color but also in transparency. Basal sections of larger weloganite crystals may show a yellow, equilateral triangular core, surrounded by a colorless zone followed by concentric, opaque white and colorless, thin hexagonal bands at the outer face. This type of zoning is analogous to that observed in liddicoatite crystals from Madagascar, and reflects a change in crystal growth from a dominant pseudo-trigonal pyramidal form to a prismatic form, perhaps with an interruption as evidenced by the presence of very fine-grained pyrite at the boundary of the triangular core in some crystals (Chen and Chao, 1975). Further evidence of interrupted growth is seen in some larger crystals in which a white outer shell is readily separated, sometimes naturally, to reveal a yellow core crystal with lustrous faces.

The reason for the color change itself is unknown. Sabina *et al.* (1968) conducted an electron microprobe traverse of zoned grains of weloganite and found no variation in the Sr, Zr, Ba and Ca concentrations across the zones. Chen and Chao (1975) noted some differences in optical properties between the core and the rim of a zoned crystal but found that the X-ray powder diffraction patterns were identical.

Weloganite crystals[5] are characteristically strongly striated or grooved due to pronounced oscillatory growth along [001], and

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[5] The morphology of weloganite crystals is described here in pseudo-trigonal rather than triclinic terms.

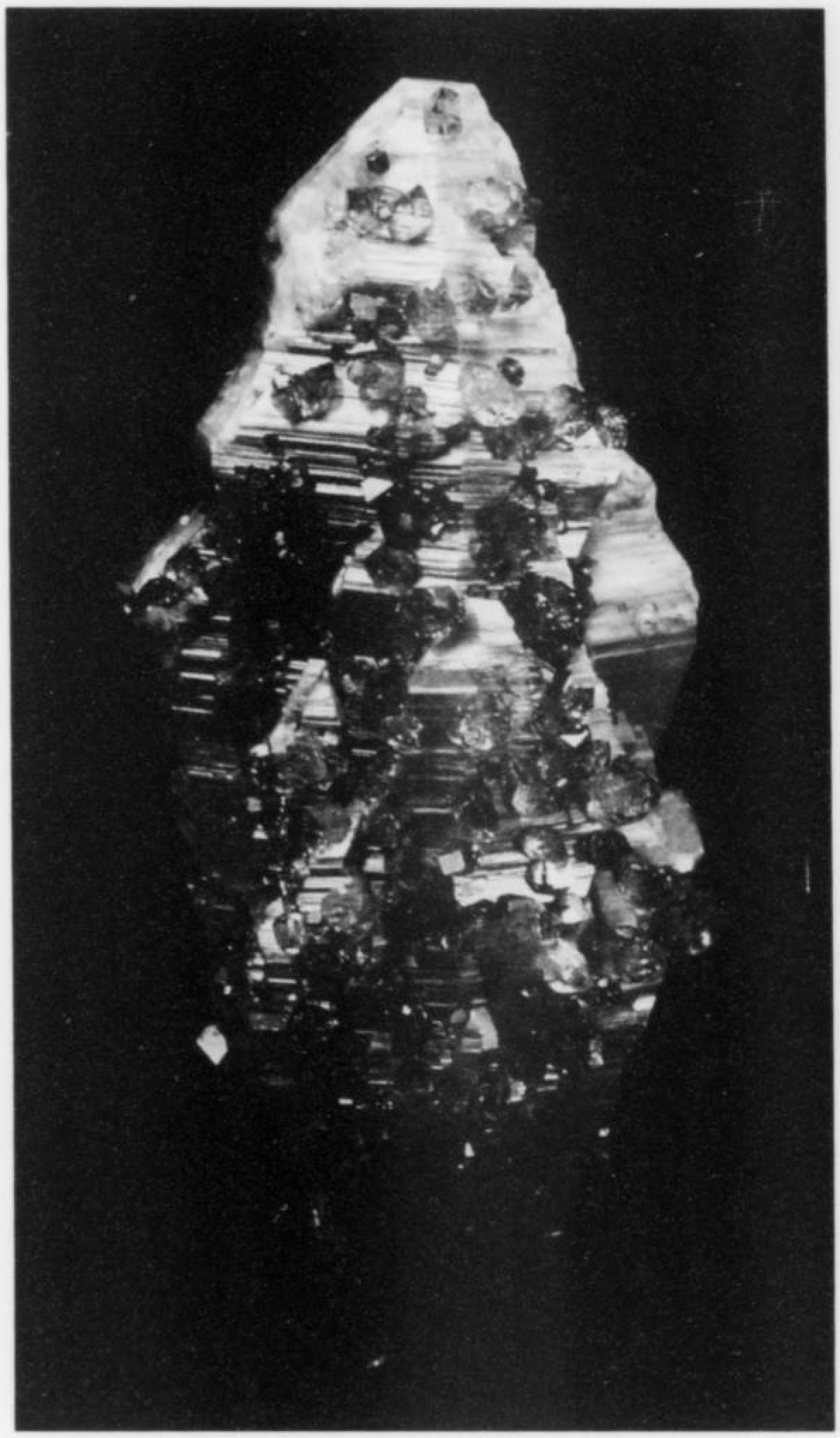

Figure 92. **Doubly terminated "floater" crystal of weloganite, 3.8 cm, studded with small quartz crystals, from the Francon quarry. Doell collection; L. Horváth photo.**

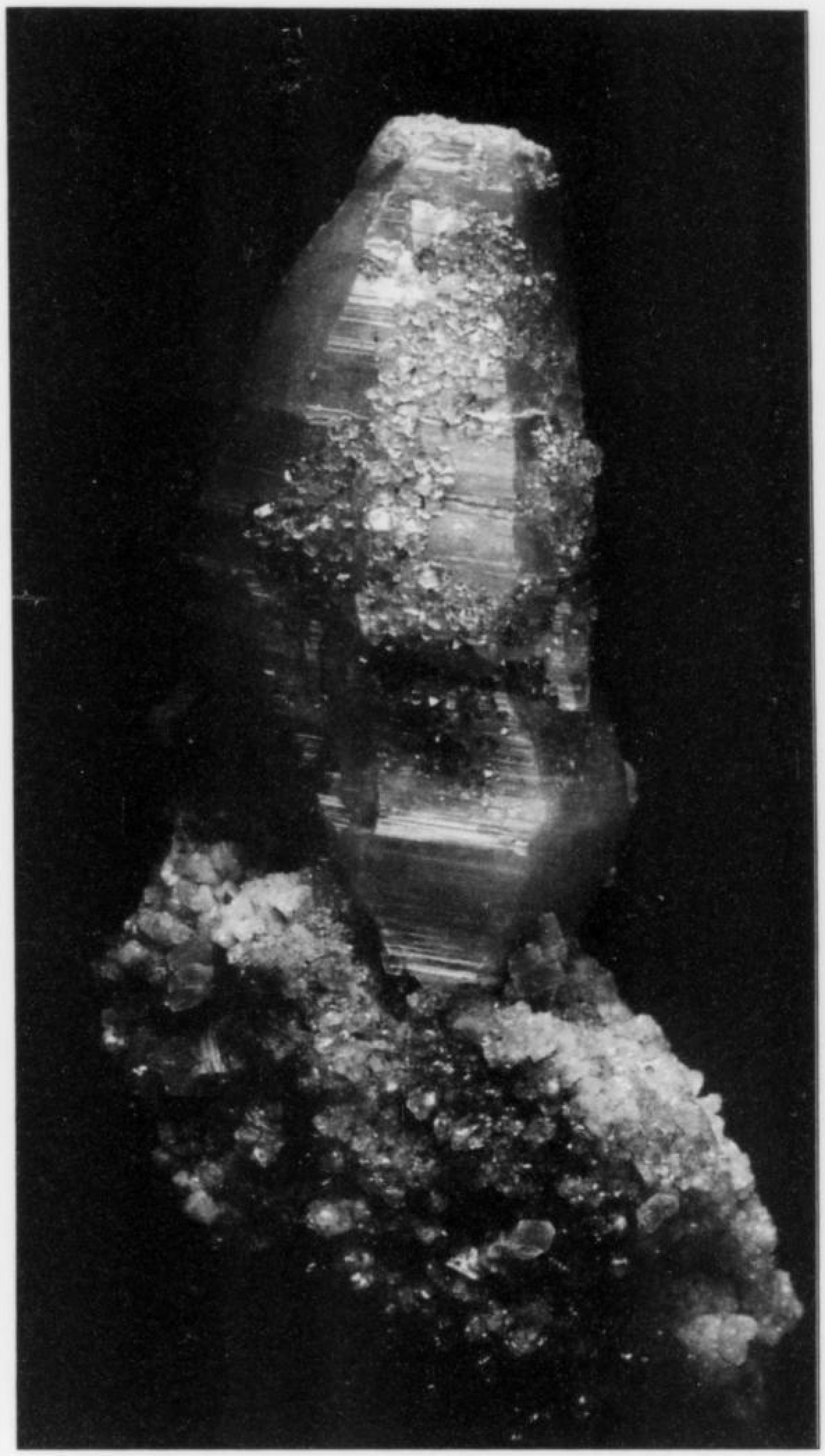

Figure 93. **Yellow weloganite crystal with tiny quartz crystals, on matrix, 3.5 cm, from the Francon quarry. Doell collection; L. Horváth photo.**

most are distinctly hemimorphic. Twinning is common, as evidenced by prominent re-entrant angles along [001], and sharp angular articulations, or kinks, in smaller (less than 1 cm) weloganite crystals. The twin law involved is a 120° rotation about the reciprocal axis [001]* with (001) as the twin plane; or in triclinic terms, a 120° rotation about [103] (Chen and Chao, 1975).

What appear to be conspecific epitactic overgrowths of weloganite on weloganite have been observed, with second-generation small crystals overgrowing larger crystals on the {001} pedion, and more rarely on prism faces, occasionally as belt-like clusters of parallel crystals. The weloganite crystals in some cavities are corroded, with dissolution often having occurred preferentially on {001} and, in color-zoned crystals, along the interface between color zones. On the laminar remnants of the partially dissolved crystals, thin layers of powdery baddeleyite have been observed (see baddeleyite description).

Crystals of weloganite display a remarkable range of habits:

Habit A consists of barrel-shaped or hourglass-shaped, distinctly hemimorphic crystals with a hexagonal cross-section, elongated parallel to the *c*-axis, and ranging from 5 mm to, exceptionally, 6.5 cm in length. Crystal sizes up to 11 cm have been reported, but these were crystal aggregates rather than individual crystals. The crystals are usually terminated by variously developed {001} or $\{00\bar{1}\}$ pedions. In some crystals the pedion termination is the base of what looks like an inverted pyramid (Fig. 86A). The crystals are bounded by pseudo-trigonal pyramids. Sabina *et al.* (1968) described them as {10*l*} and {01*l*} but other forms are plausible based on the strongest X-ray diffraction reflections of weloganite. Faces of the pseudo-trigonal prisms {100} and {010} may also be present. Crystals of habit A are yellow, yellowish white and white, and commonly color-zoned. This is the most common and widespread habit in the upper sill, and has yielded the largest crystals, and spectacular complex aggregates up to 10 cm long. Some of the large crystals were found loose in the cavities, and many were "floaters," some doubly terminated and without any obvious point of attachment. The aggregates consist of many crystals in a parallel or possibly epitactic arrangement on a large core crystal, producing intricate multi-crystal groups. Habit A crystals are commonly coated or encrusted by other minerals, mostly dull white, thin

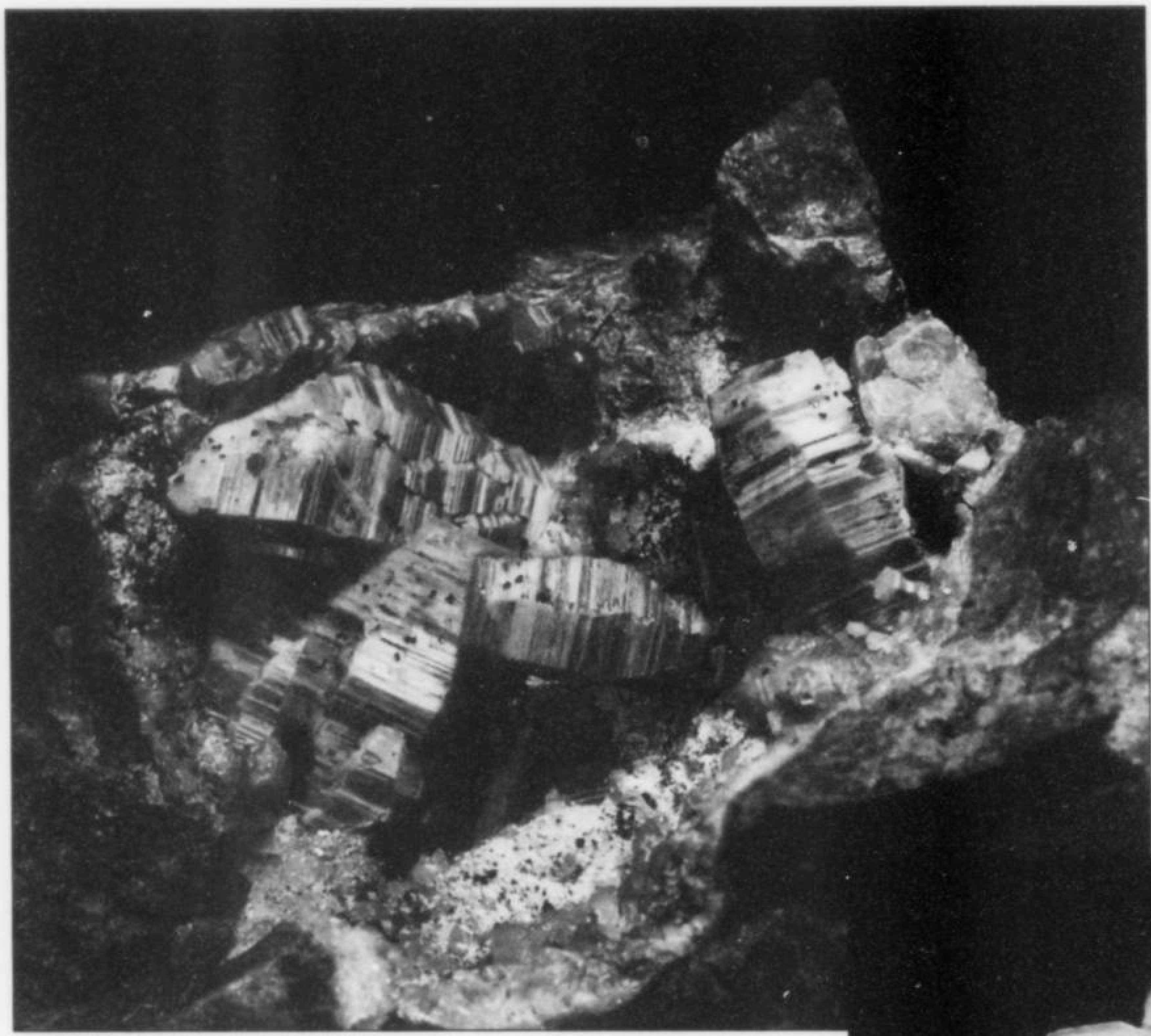

Figure 94. **Weloganite crystals to 2.5 cm in a cavity, from the Francon quarry. Canadian Museum of Nature collection (no. 48628); L. Horváth photo.**

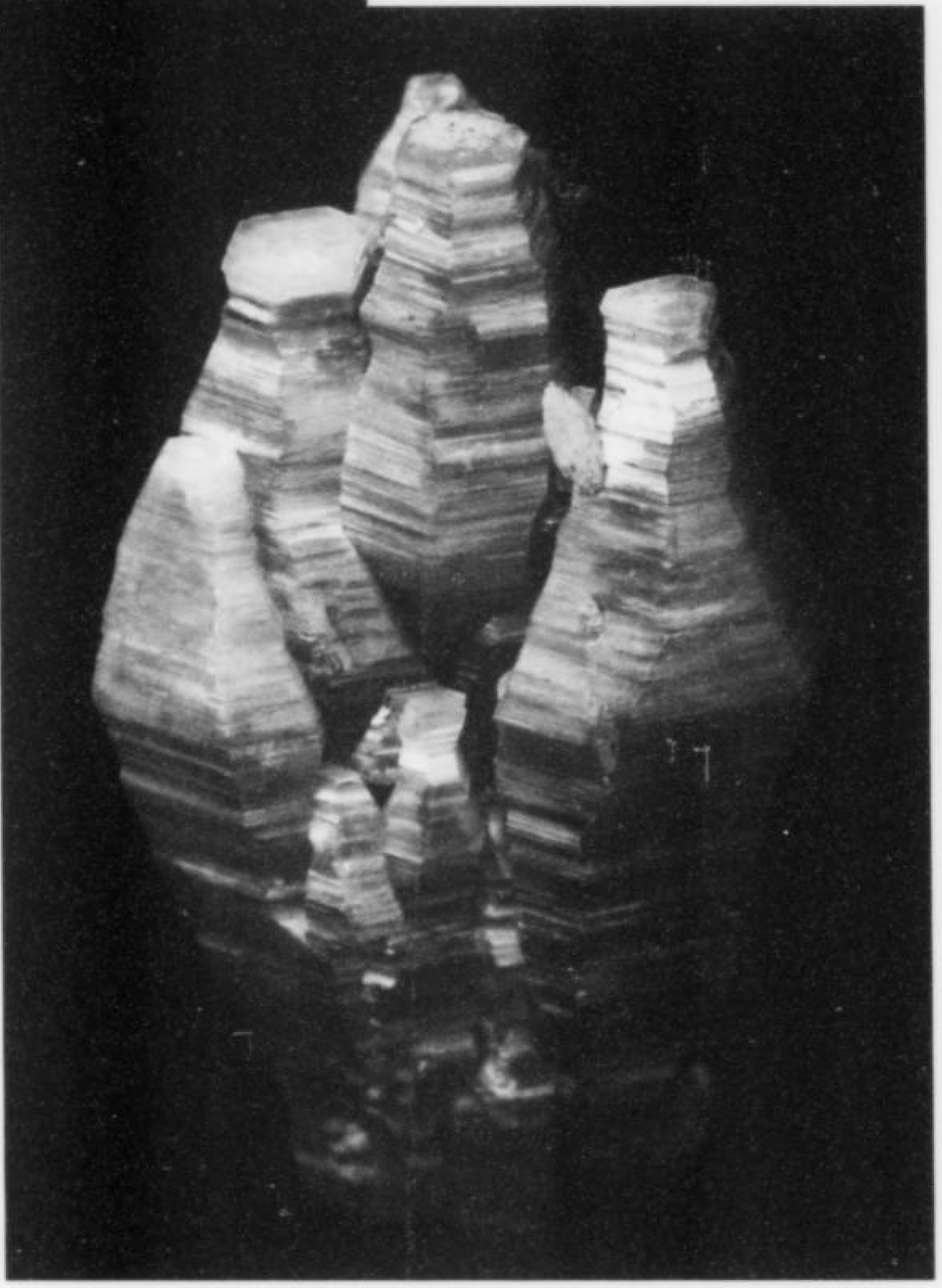

Figure 95. **Weloganite parallel-growth crystal group, 2.6 cm, from the Francon quarry. Horváth collection (no. 5506); L. Horváth photo.**

layers of gibbsite and doyleite, and very rarely spherules of franconite. Associations include dresserite, hydrodresserite, dawsonite, quartz, calcite, strontianite and marcasite.

Habit B is characterized by tapering hemimorphic crystals with a nearly triangular (trigonal) cross-section, with or without a very small triangular {001} pedion. The crystals are transparent to translucent, bright yellow, with a vitreous to adamantine luster, and range from 2 mm up to 2 cm in length. These include some of the sharpest, most transparent and most attractive crystals of weloganite, which were found in the lower sill, in the northern corner in the quarry. In some cavities the crystals show selectively etched zones and some are almost completely dissolved, with only a thin shell or skeletal remnant, some of which is pseudomorphous baddeleyite. Other associated minerals include barite, quartz, fluorite, dolomite, dawsonite, celestine, hematite, goethite and colorless cryolite.

Habit C crystals are hemimorphic and pseudo-trigonal pyramidal with a hexagonal or nearly trigonal cross-section, and dominant {001} pedions. The crystals are colorless, transparent and pale yellow; or translucent greenish gray, with a vitreous luster; or opaque white with a waxy to dull luster. Typically, they form complex cone-shaped aggregates 2–8 mm across consisting of many intergrown crystals. The crystals were found in the lower sill associated with calcite, pyrite, dawsonite and quartz.

Habit D is characterized by tabular crystals with a hexagonal cross-section, and dominant {001} and {00$\bar{1}$} pedions. The crystals are up to 8 mm in diameter. They are translucent to opaque, gray and white. This is a very rare habit, observed only in the lower sill in association with yellow cryolite, barite, elpidite, strontianite and synchysite-(Ce).

Habit E crystals are very sharp, complex and hemimorphic, consisting of a column with hexagonal cross-section, capped by a pyramidal, habit C crystal, often resulting in a funnel-like shape, with a well-developed {001} pedion. In some crystals the columnar sections display peculiar kinks or angular articulations which may be the result of twinning. Other crystals are bifurcated into two individuals. The crystals are colorless to transparent pale yellow, with a vitreous to subadamantine luster, 2–10 mm long, and are found in the lower sill associated with analcime, ankerite, barite, calcite, strontianite and marcasite.

Habit F crystals are columnar, resembling hexagonal prisms, terminated by {001} and {00$\bar{1}$} pedions. The colorless to transparent, pale-yellow crystals, 2–6 mm long, are very sharp, have a vitreous luster and show no striations. These were exclusively

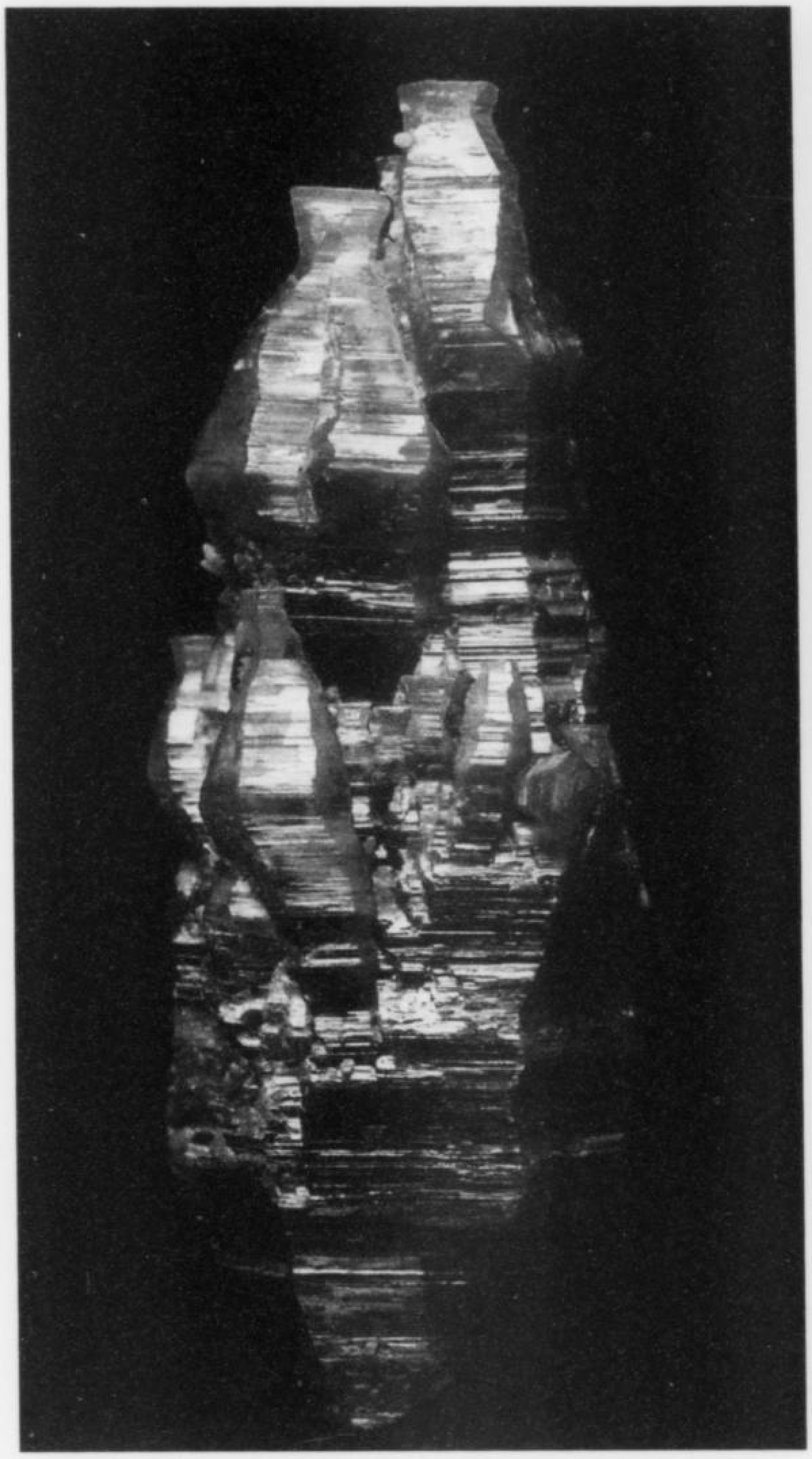

Figure 96. **Weloganite parallel-growth crystal group, 4.5 cm, from the Francon quarry. Horváth collection (no. 5504); L. Horváth photo.**

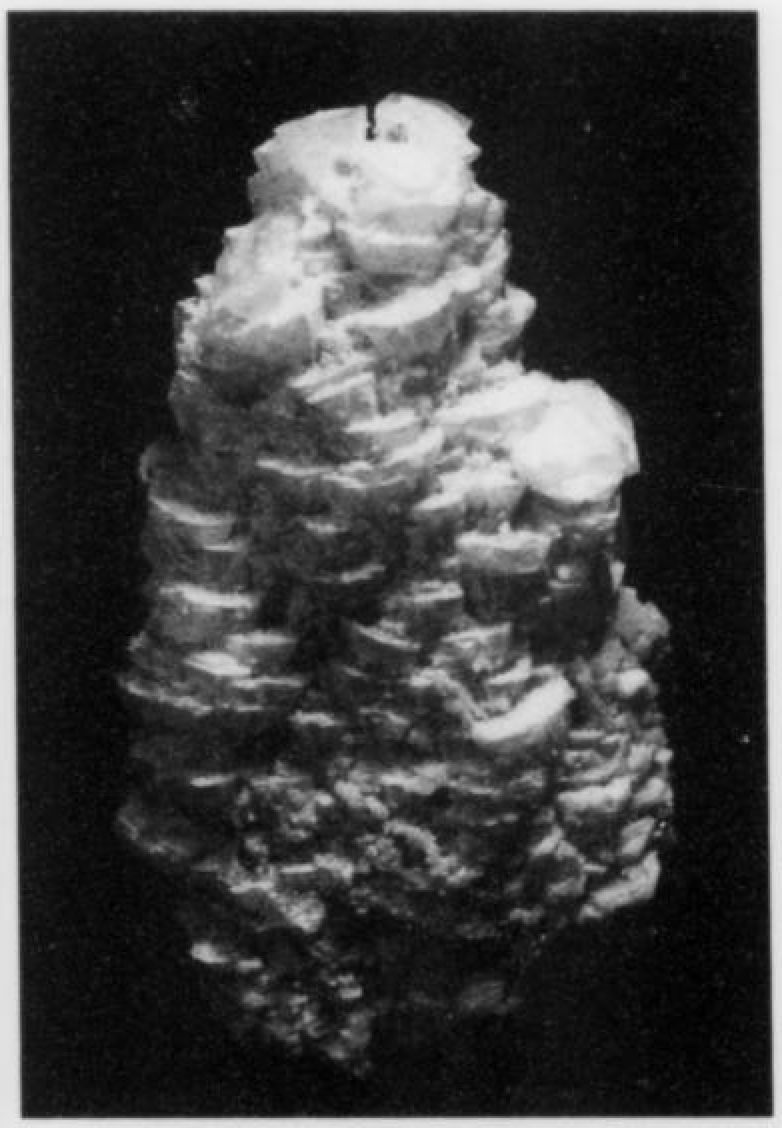

Figure 97. **Stacked weloganite crystal group, 4.8 cm. Doell collection; L. Horváth photo.**

found in the lower sill. Associated minerals include analcime, barite and pyrite. Of all the observed habits, these, and habit G most closely allude to the true triclinic symmetry of weloganite.

Habit G is characterized by short blocky crystals, 2–5 mm across, with a rhombic cross-section, resembling simple rhombohedra. The crystals are opaque white with a dull luster and without striations, and were found only in the lower sill. Associated minerals include albite, brookite, quartz (pseudomorphic after natrolite), cryolite, dawsonite, marcasite and natrolite.

In the paragenetic sequence, two generations of weloganite are observed in the sill cavities: an early to intermediate-stage, and an intermediate to late-stage generation.

Weloganite is fluorescent, giving a medium-intensity, orange response under shortwave radiation, greenish yellow under medium-wave and weak orange-brown under longwave ultraviolet radiation. The mineral is also pyroelectric (R. A. Ramik, personal communication, 2004), and triboluminescent as evidenced by the emission of bluish-white flashes of visible light when crystals are mechanically fractured or crushed (Gait and Grice, 1971).

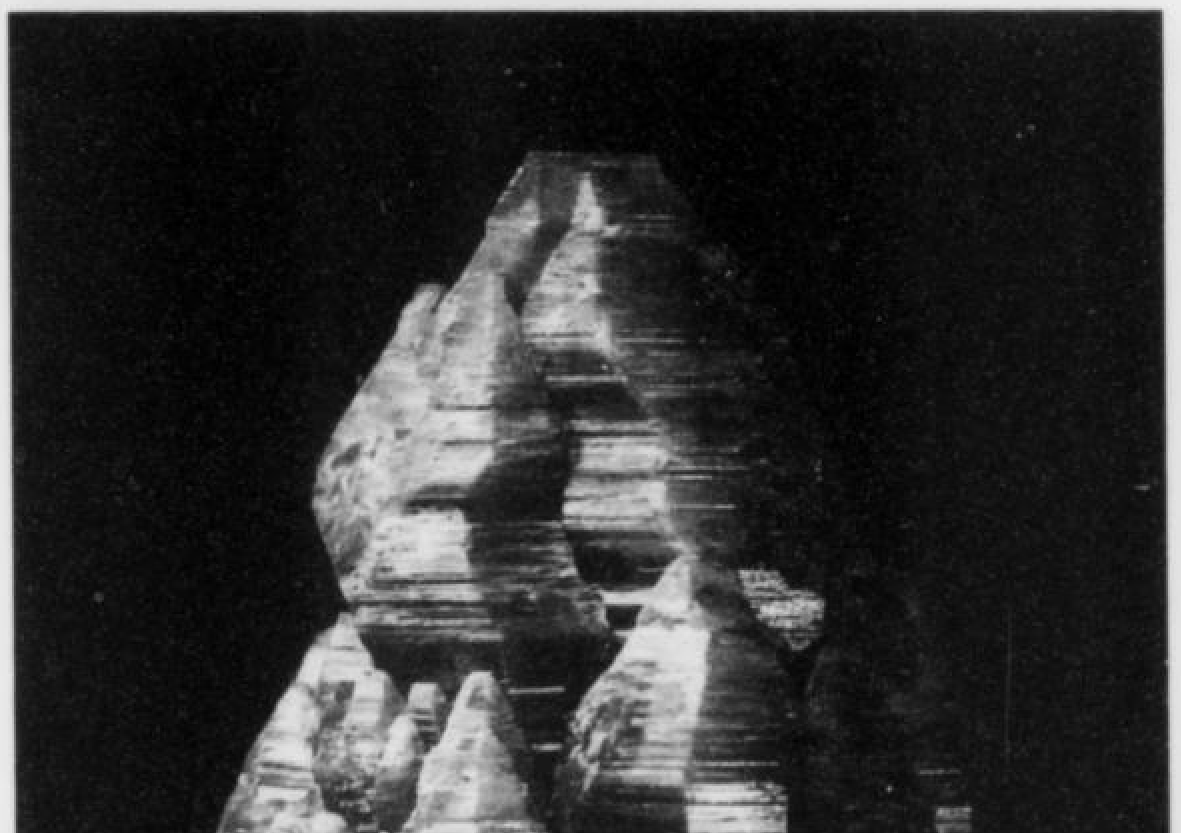

Figure 98. **Parallel-growth cluster of weloganite crystals, 5 cm, from the Francon quarry. Horváth collection (no. 5503); L. Horváth photo.**

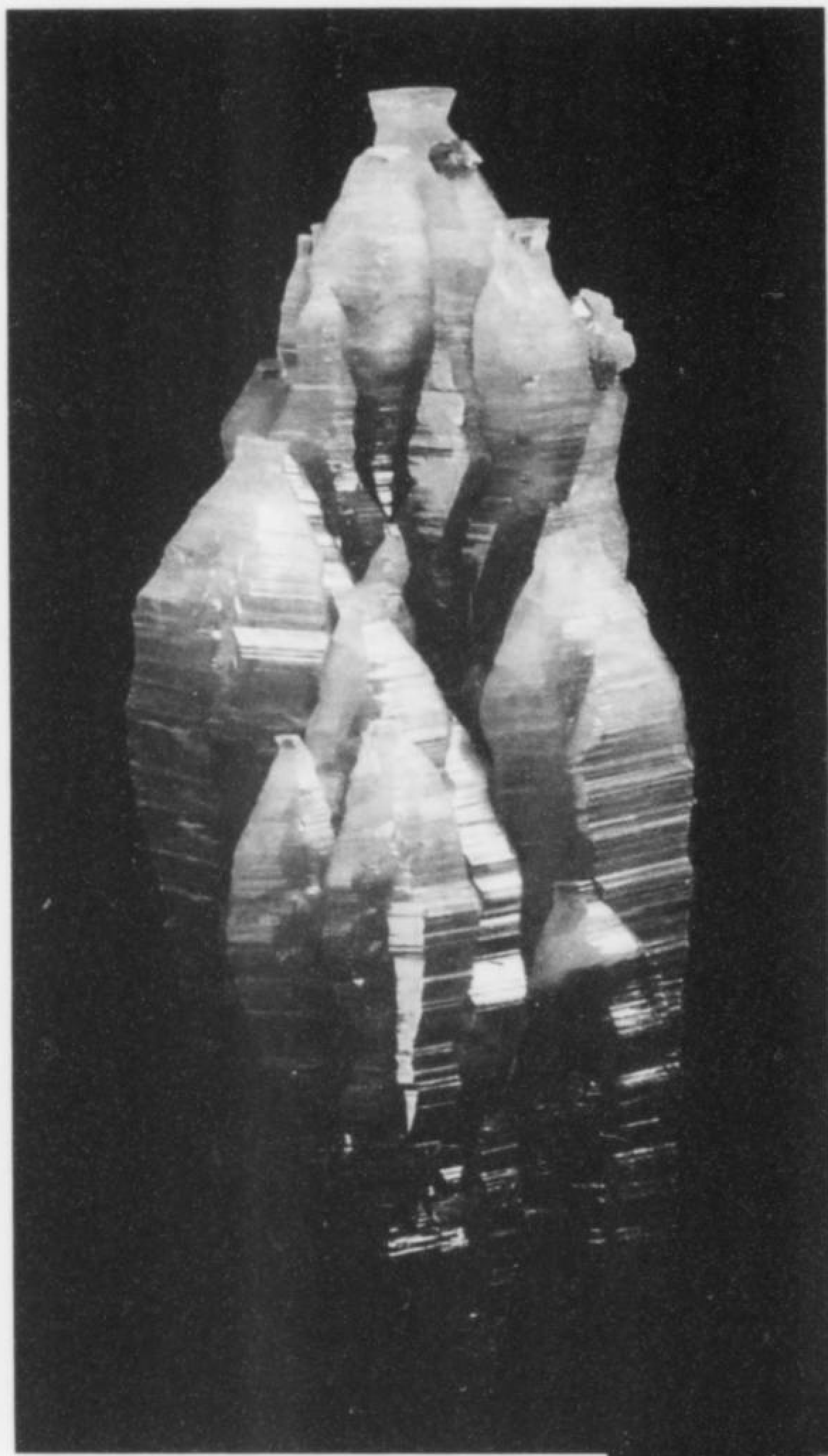

Figure 99. Weloganite crystal group in parallel growth, 3.8 cm, from the Francon quarry. Doell collection; L. Horváth photo.

Figure 101. Doubly terminated "floater" crystal of weloganite, 4.9 cm, from the Francon quarry. Doell collection; L. Horváth photo.

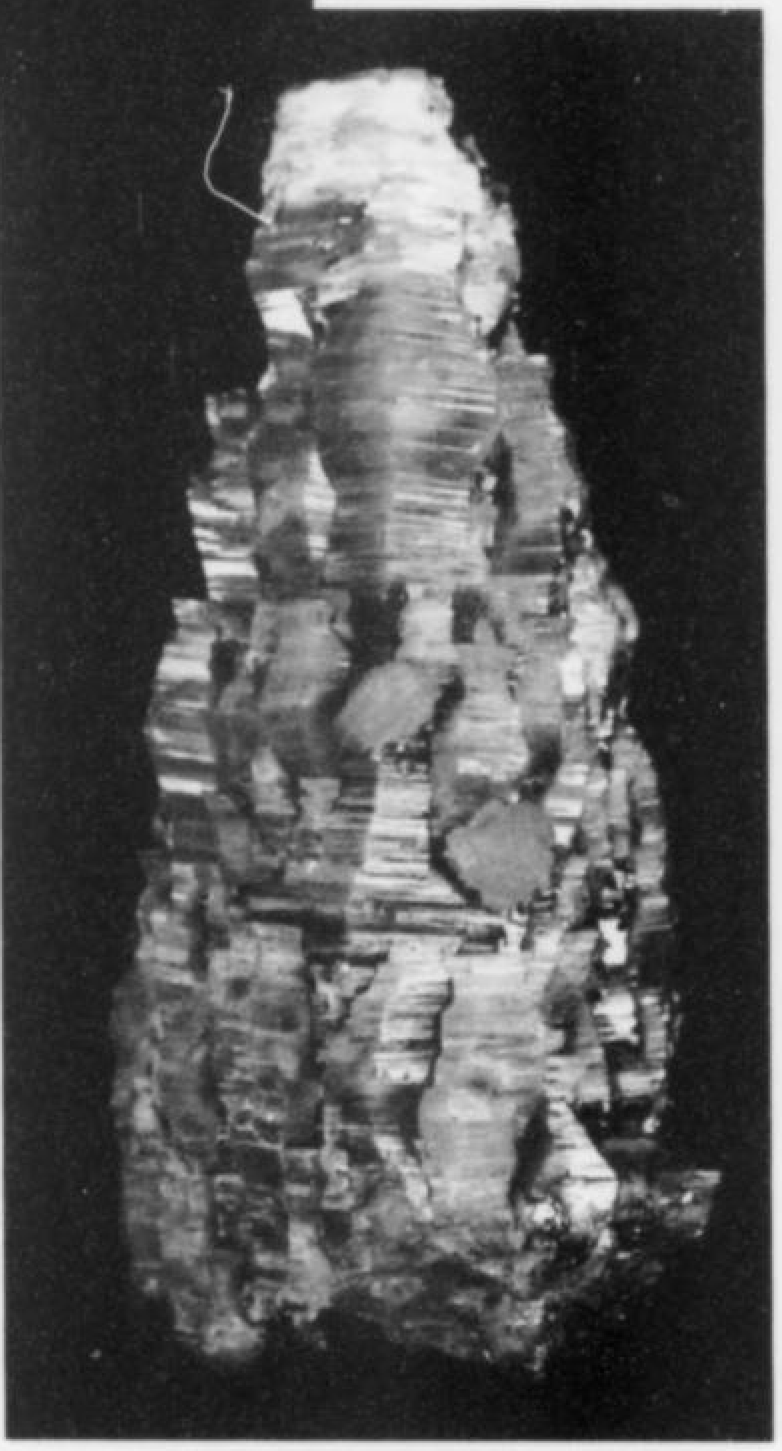

Figure 100. Weloganite crystal aggregate in parallel growth, 5 cm, from the Francon quarry. Redpath Museum collection; L. Horváth photo.

Figure 102. Doubly terminated "floater" group of weloganite crystals in parallel growth, 4 cm, from the Francon quarry. Horváth collection (no. 5508); L. Horváth photo.

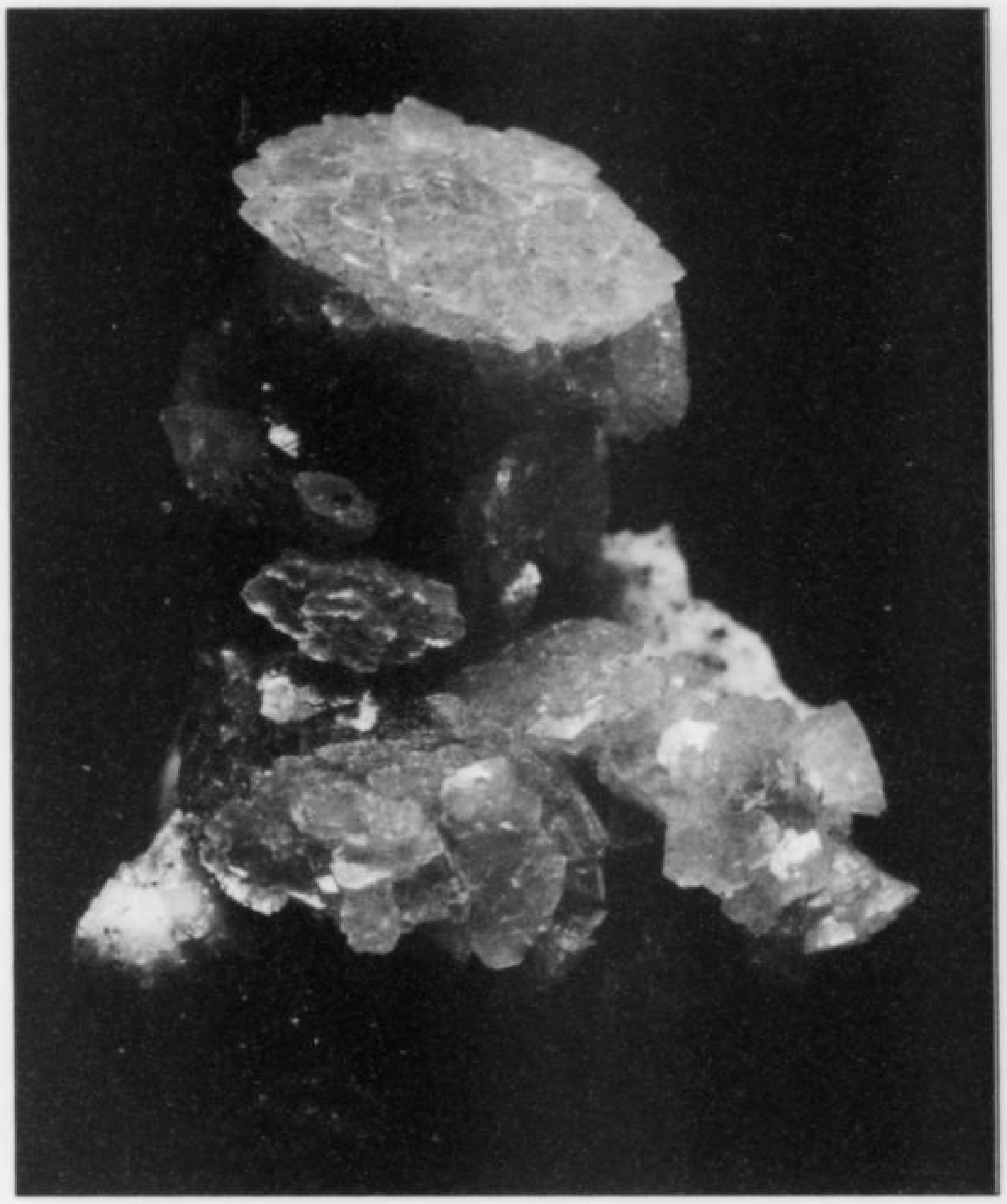

Figure 103. **Hemimorphic gray weloganite crystals (habit C) in a stacked cluster, 2 cm, from the Francon quarry. Doell collection; L. Horváth photo.**

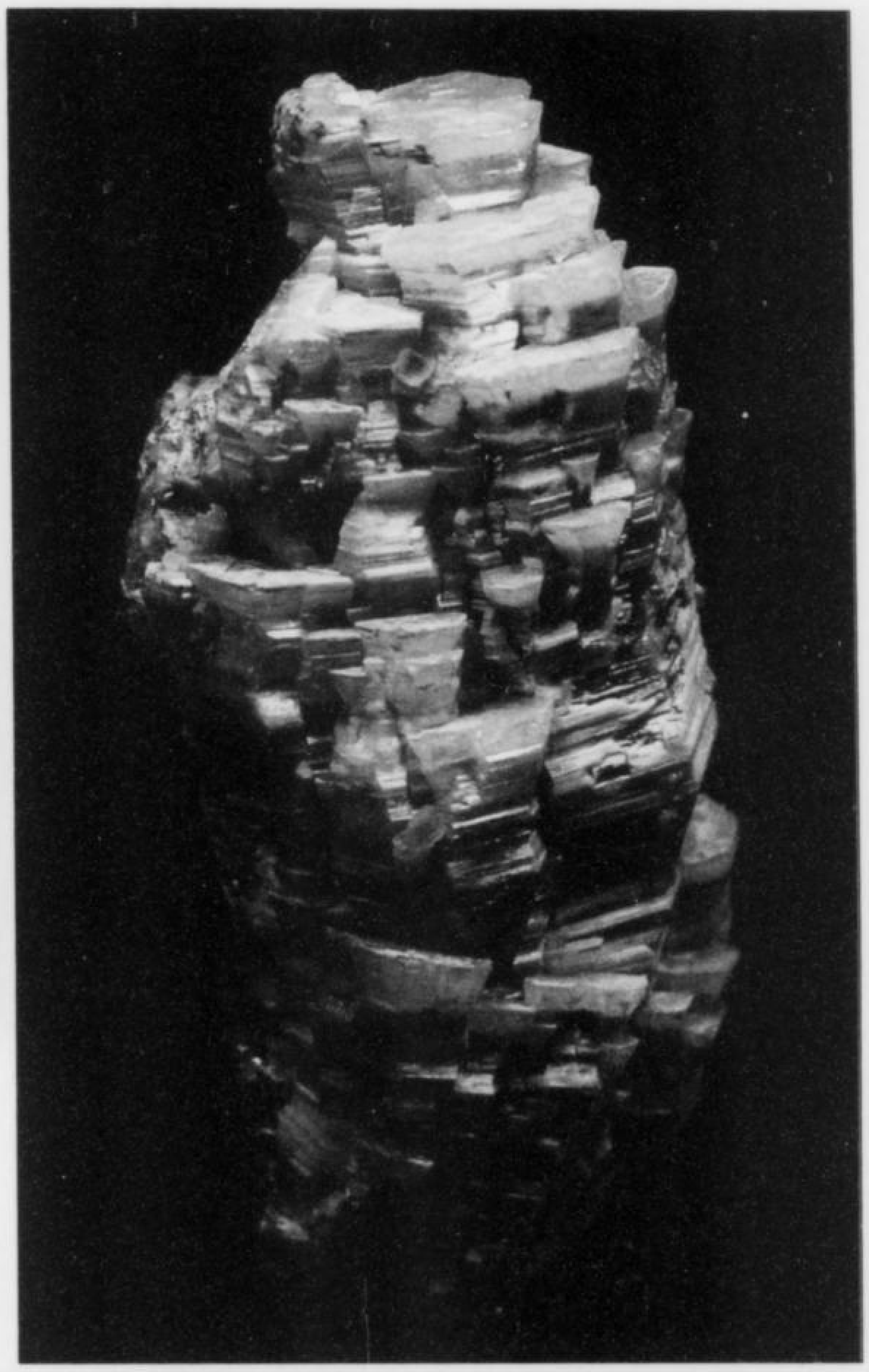

Figure 104. **Weloganite crystal aggregate in parallel growth, 5.5 cm, from the Francon quarry. Canadian Museum of Nature collection (no. 36378); L. Horváth photo.**

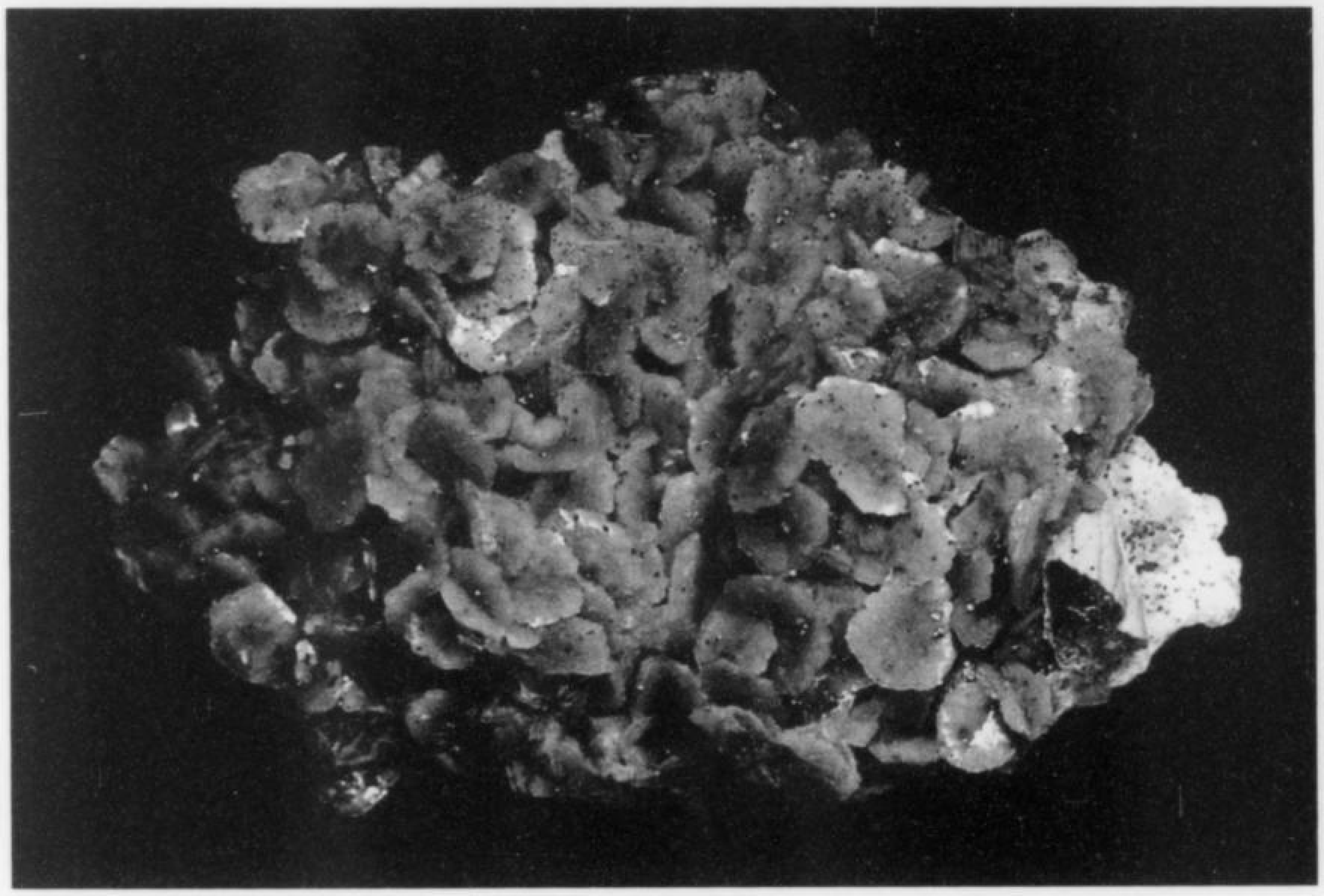

Figure 105. **Gray weloganite cluster of hemimorphic pyramidal crystals (habit C) on matrix, 4 cm, from the Francon quarry. Doell collection; L. Horváth photo.**

A few gemstones have been cut from Francon weloganite. Three pale yellow stones, with inclusions (a 0.52-carat curved rectangular cut, a 0.74-carat oval cut, and a 4.27-carat calf's head cut) and a transparent yellow 0.12-carat tapered baguette are in the collection of the Canadian Museum of Nature (W. Wight, personal communication, 2004).

Wurtzite (Zn,Fe)S

Wurtzite is known from the Francon quarry as a single specimen from the lower sill, with a dark brown, incomplete, hemimorphic crystal less than 2 mm across, associated with quartz, calcite and barite (GSC APS 721–1).

Zircon $ZrSiO_4$

Zircon is a rare accessory mineral in the lower and upper sill rock. It is also found as partially metamict crystals in cavities in the lower sill. Steacy and Jambor (1969) and Jambor *et al.* (1976) reported the presence of zircon "as disseminated, euhedral to subhedral crystals, up to a millimeter in length." In the lower sill cavities it occurs as gray, tan and cream-colored, plate-like and sheet-like granular aggregates (Sabina, 1979), and as vitreous, yellow granular crusts on weloganite (Sabina, 1976); the partially metamict crystals are yellow, tan, amber and gray, dull to waxy, aggregates (Sabina, 1979), and the metamict material also forms a silky, white coating on analcime (GSC APS 559a). From the lower sill rock, Sabina (1979) reported "pink, yellow, amber, brown and gray euhedral grains." The authors have found embedded, vitreous, transparent to translucent, pale pinkish brown and pale brown, sharp to somewhat rounded dipyramidal crystals and short tetragonal prisms up 2 mm long, as well as dull to resinous, opaque, dark brown, elongated crude crystals, exceptionally up to 1 cm long. The crystals have simple morphology, consisting of either the {111} dipyramids only, or the combination of {100} prism and the {111} dipyramids. Well-formed crystals are rare.

Figure 106. **A thin crust of bitumen removed from the surface of a weloganite crystal, Francon quarry. Geological Survey of Canada collection and SEM photo.**

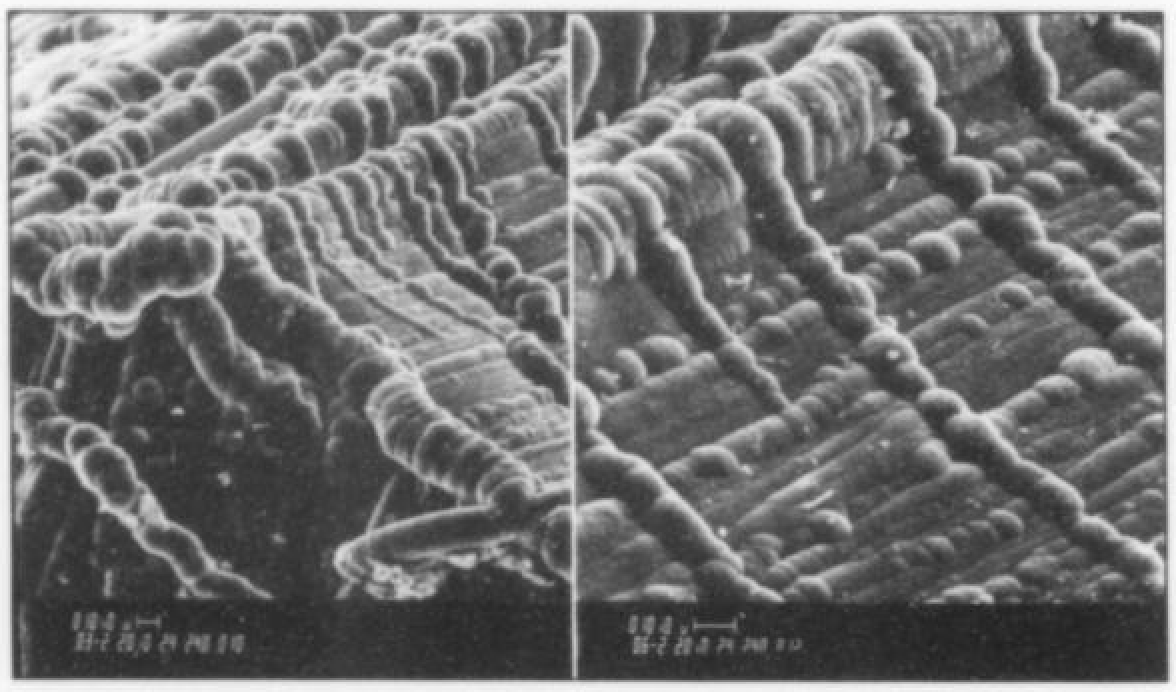

Figure 107. **Surface features of the bitumen crust on a crystal of weloganite, Francon quarry. Geological Survey of Canada collection and SEM photo.**

"Bitumen"

Minerals in the sill cavities, especially in the upper sill, are sometimes partially or wholly coated by a brittle, transparent to opaque, amber to brown or black film or crust of a hydrocarbon of unknown composition (Sabina, 1979). Under high magnification (SEM) the crusts have a ridged and corrugated appearance. The crusts can often be easily removed in order to reveal the underlying minerals.

ACKNOWLEDGMENTS

For most of the specimen-producing life of the Francon quarry, from its discovery as a mineral locality in 1966 to its closing in 1985, the persistence and dedication of one individual, Ann P. Sabina of the Geological Survey of Canada, stands out. We take pleasure in dedicating this paper to her in acknowledgment of her tremendous contribution to the mineralogy of the quarry. We are also grateful for her generous assistance with mineral identifications over a period of many years, for sharing much unpublished information on the quarry and its minerals, and for providing numerous photographs for our use. We also wish to thank Andrew Roberts of the Geological Survey of Canada, Ralph Rowe of the Canadian Museum of Nature, and Dr. George Chao formerly of Carleton University, for X-ray diffraction analyses; Robert Gault of the Canadian Museum of Nature for SEM work and microprobe analyses; Dr. Richard Herd for granting access to the National Mineral Collection at the Geological Survey of Canada and for providing copies of the descriptive lists of the Francon quarry mineral suite assembled by Ann Sabina; Michel Picard of the Canadian Museum of Nature for providing access to the National Mineral Collection at the Canadian Museum of Nature; Dr. Donald Doell for the generous loan of a suite of Francon quarry specimens for study and photography; Jacques Poulin for expert assistance and equipment in investigating the response of Francon quarry minerals to ultraviolet radiation; Dr. David Dolejs, formerly of McGill University, for a petrographic examination of dike rocks from the Francon quarry; Joan Kaylor of the Redpath Museum, McGill University, for the loan of Francon quarry specimens for photography; Dr. Joel Grice of the Canadian Museum of Nature and Dr. Jeanne Paquette of McGill University for helpful discussion on the morphology of weloganite; Robert Ramik of the Royal Ontario Museum for information on the occurrences of voggite and viitaniemiite; Janet and Stephen Cares for information on analyzed Francon quarry specimens in the Cares mineral collection; Willow Wight for information on Francon quarry gemstones; Garry Glenn (now deceased) for permission to reprint his line-drawings of specimens; Dr. Joseph Mandarino for providing draft copies of the Francon quarry type mineral descriptions in *The International Encyclopedia of Minerals*; Dr. Nicolas Meisser of the Musée Cantonal de Géologie, Lausanne, Switzerland for providing data and documentation on the recent find of strontiodresserite in France; and Serge Perreault, géologue résident of the Ministère des Ressources naturelles of Québec for arranging and accompanying the authors on a 2003 geological excursion to the quarry. We also acknowledge the following people who helped in various ways: T. Anderson, Albert Cornu, Donald Doell Jr., Dr. Igor Pekov, and Tony Steede. The manuscript was reviewed by Andrew Roberts and Ann Sabina whom we thank for their helpful comments. Special thanks to Dr. Wendell Wilson for his great editorial work. Finally, on behalf of the mineral collecting community, we wish to express our appreciation to the management of Francon (1966) Limitée, former division of Lafarge Canada Inc., who generously provided access to the Francon quarry over a period of nearly two decades.

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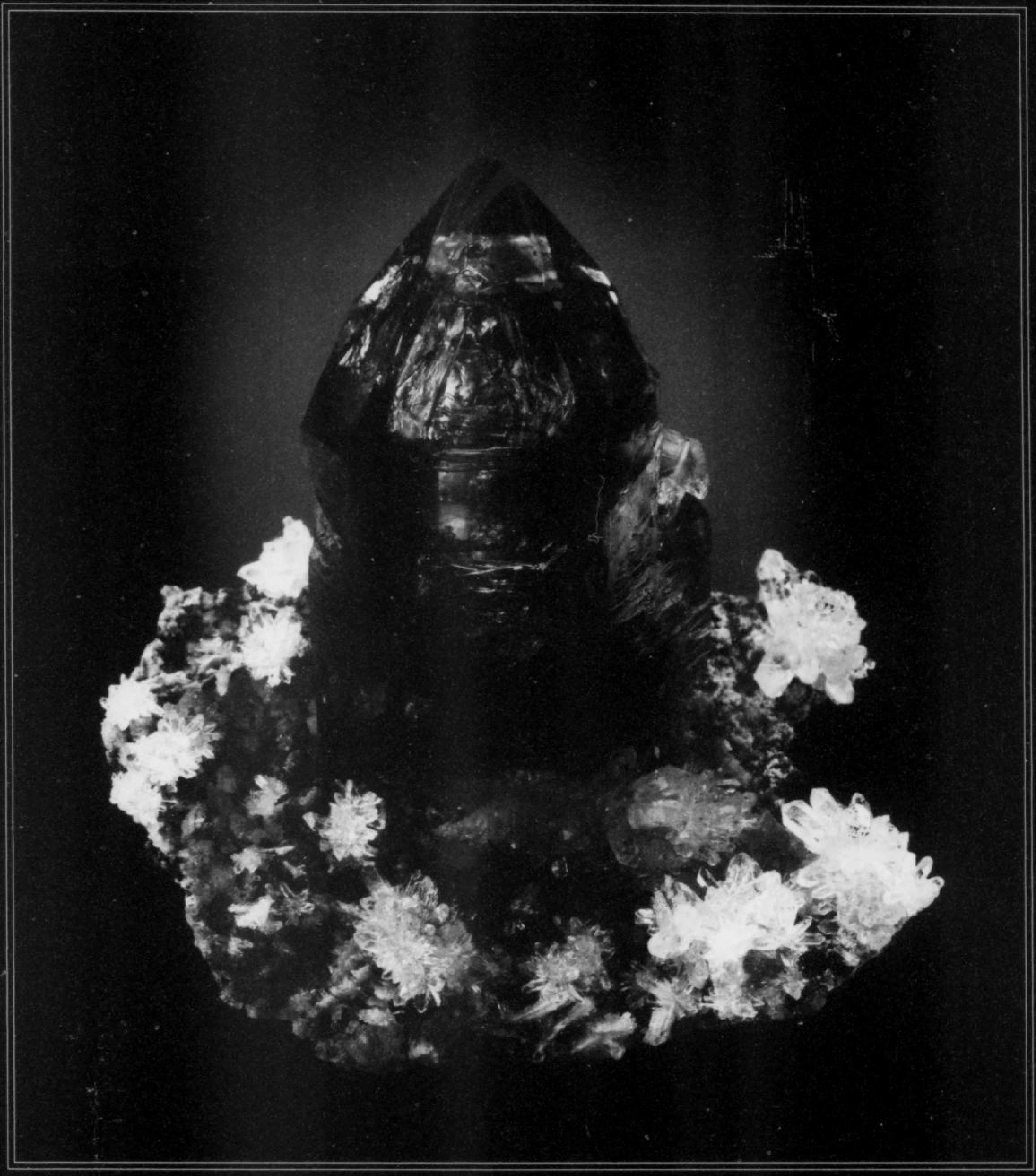
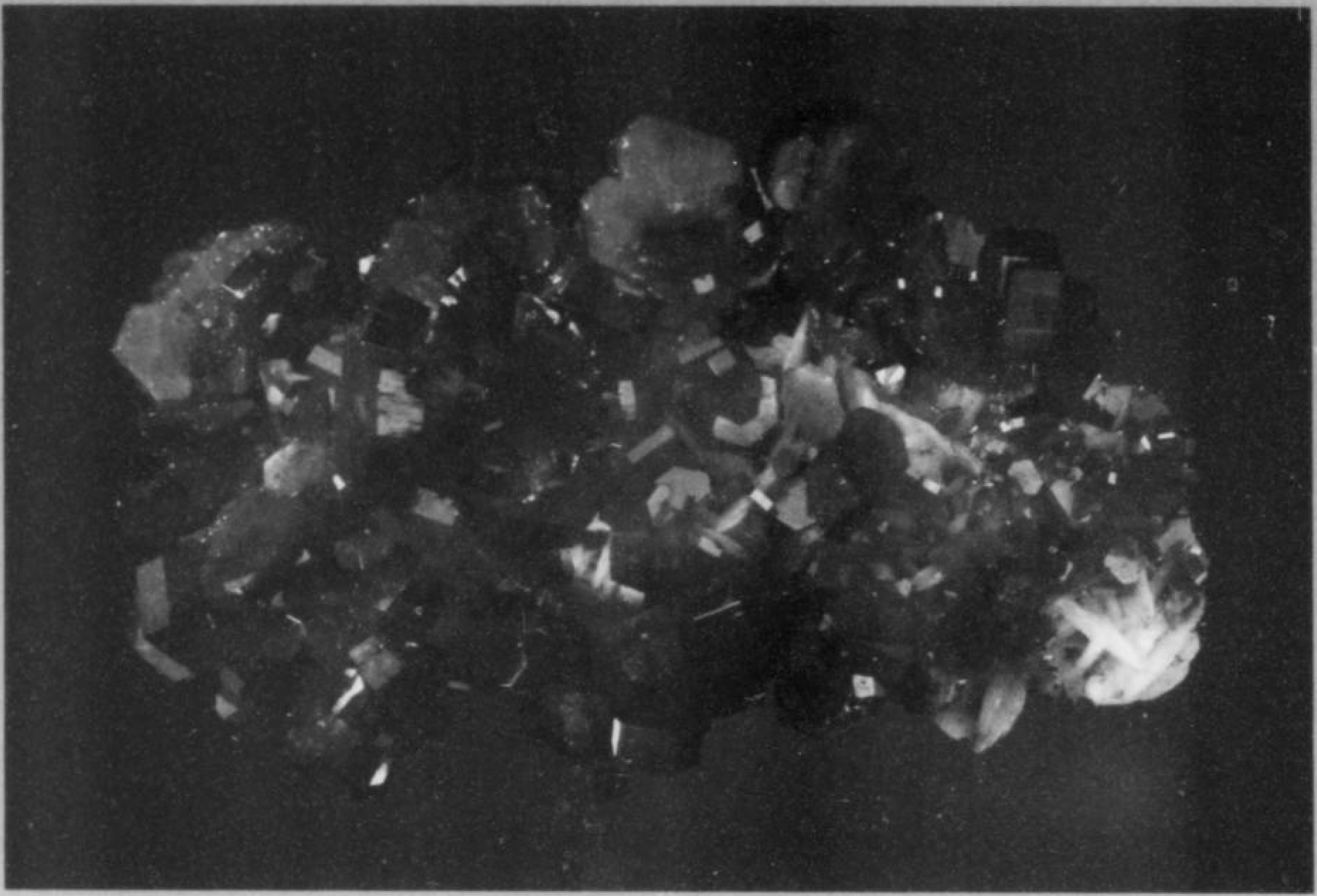
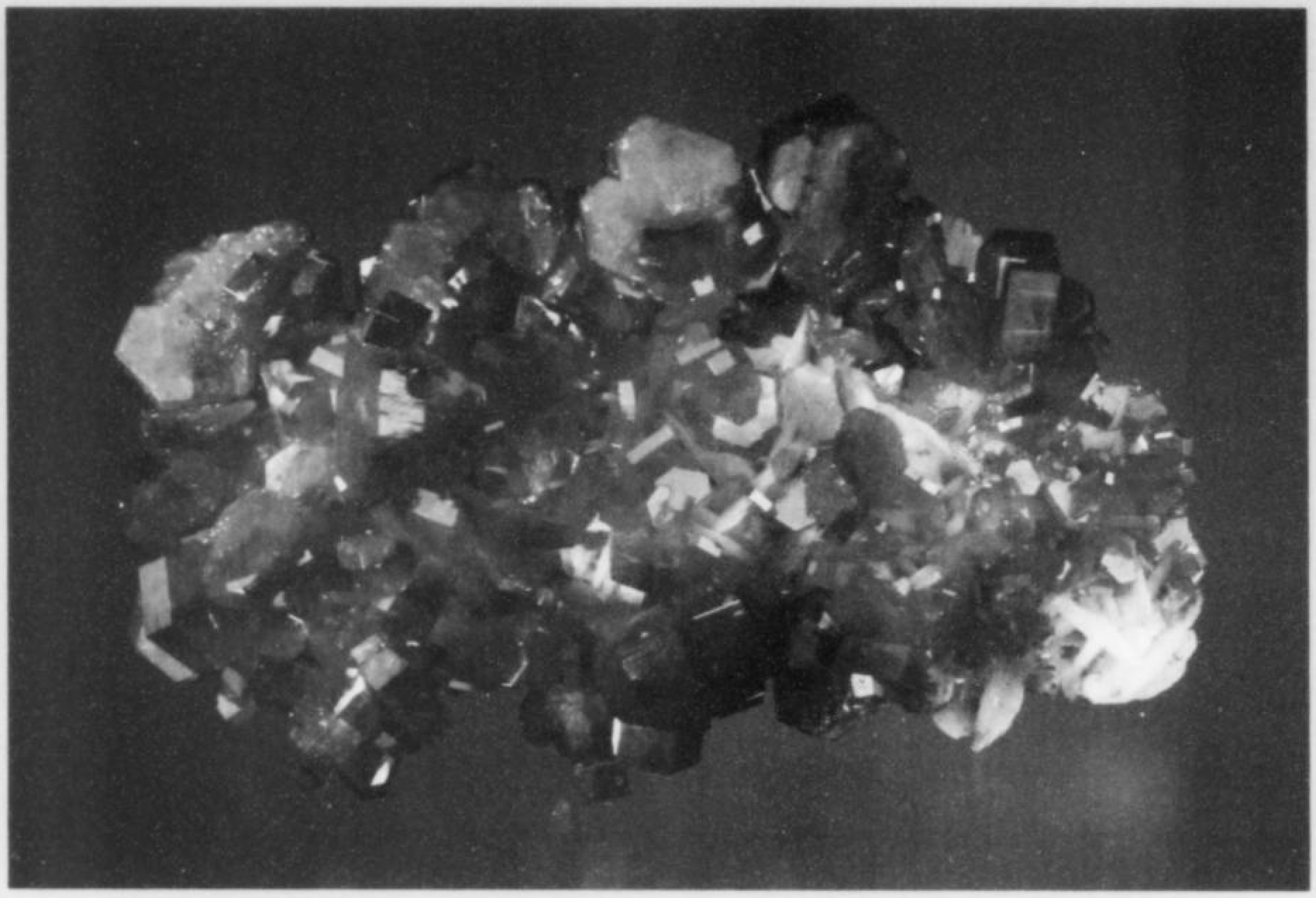




VANADINITE, 10 cm, from Mibladen, Morocco. Jeff Scovil photo.



ABSTRACTS

Of the 27th Annual

FM-MSA-TGMS
TUCSON MINERALOGICAL SYMPOSIUM

CANADA!

SPEAKER SCHEDULE
Saturday, February 11, 2006
Tucson Convention Center

10:00 a.m.	Introductory remarks *Symposium Chairman Robert B. Cook*
10:05	Colored Gemstones from Canada; a Well-Kept Secret *Bradley S. Wilson*
10:25	Recent Gem Discoveries in Canada *Lee A. Groat*
10:45	Diamond in Canada *Andrew Locock*
11:05	Minerals of the Silver Trail, Yukon Territory, Canada *Mark Mauthner*
11:25	Gold in Canada *David K. Joyce*
11:45 a.m.	Chasing Gold Crystals from British Columbia *Mark Mauthner & Carl Francis*

Introduction

Robert B. Cook
Symposium Chairman

The 27th Annual Mineralogical Symposium, sponsored by the Mineralogical Society of America, the Friends of Mineralogy, and the Tucson Gem and Mineral Society, will be held on Saturday, February 11, 2006, at the Tucson Convention Center. Admission is free and everyone is welcome. The symposium coincides with the 52nd Tucson Gem and Mineral show, the theme of which is, of course, Canadian Minerals and Gems.

Figure 1. **Weloganite crystal, 2.6 cm, from the Francon quarry, Quebec, Canada. Tyson's Minerals specimen; Wendell Wilson photo.**

The list of Canada's superlative specimen-producing localities is long and reflects the geologically diverse nature of the country. When one includes significant gemstone localities, the list grows longer and even more geological environments must be considered. There is something for every collector, regardless of specialization. Perhaps such a list would begin with what is Canada's most famous mineralized area, the Monteregian Hills province of Quebec, home to the extraordinary minerals of Mont Saint-Hilaire (*Mineralogical*

Record v.21, n.4), the Saint-Amable sill (v.29, n.2) and the Francon quarry (v.37, n.1), with their incredible array of intrusive-related species. Close on its heels must come a variety of occurrences including garnet and vesuvianite from the Jeffrey mine at Asbestos, Quebec (v.10. n.2; v.35, n.2); the Rapid Creek, Yukon phosphates (v.23, n.4); silver species from Galena Hill-Keno Hill, Yukon Territory; silver and related cobalt and nickel species from Cobalt and Gowganda, Ontario; apatite, titanite, and uranium and thorium minerals from a variety of Ontario localities; zeolites from Nova Scotia; gold from the famous Timmons, Kirkland Lake and Red Lake, Ontario, mining camps; barite and fluorite from the Rock Candy mine, British Columbia (v.12, n.2); calcite and pyrite from the Nanisivik mine on Baffin Island, Nunavut (v.21, n.6); and the many Thunder Bay, Ontario amethyst localities (v.13, n.2).

Clearly Canada is a country rooted in its mineral heritage. However, unlike many other mineral-rich nations, Canada's resources continue to emerge, yielding to modern exploration techniques, changing economies, and the relentless exploration of its northern reaches by an adventuresome breed of men likely not equaled elsewhere. A decade ago few would have dreamed that a significant percentage of the world's diamonds would come from Canada's Northwest Territories, yet with Canadian exploration ingenuity, and the foresight and deep pockets of one of the world's largest mining companies, one can now only guess at what Canada's ultimate position in the world diamond marketplace will be. Similarly, only a few years ago one would have laughed at the idea that the world's highest-grade active gold mine would be discovered in the shadow of one of Ontario's other dominant gold mines, the Campbell mine at Red Lake, and yet it was; again by innovative exploration concepts and dogged determination. This time, however, there was a bonus for collectors—a management that realized the value and importance of the specimen gold and related species its property was producing. There is a great deal more happening, particularly with the price of metals continuing to rise, that will likely impact specimen availability and diversity. There is a new nickel orebody being developed at Voisey Bay, Labrador, and there are new, deep discoveries at Sudbury. Gold and rare metals are hot items and uranium is coming back. Colored gemstones are being developed in the Yukon Territory and on Baffin Island. Provincial governments that were formerly unfriendly to mining have relaxed their anti-mining stances, and exploration and development are taking place like never before. Consequently, one could only predict that the list of exceptional mineral occurrences in the previous paragraph will be considerably longer when Canadian minerals and gems are again the featured topic of the Tucson Gem and Mineral Show some years in the future.

The papers in this year's symposium emphasize the place of Canada not only with respect to its historical mineral and gemstone production, but also its emerging related industries, such as diamond mining in the Northwest Territories and colored gem production in the Yukon Territory and Nunavut. Also on the program is a review of the history of gold mining and gold specimen localities, a discussion of the Keno Hill district, Yukon Territory, and a detailed study of the provenance of a wonderful Canadian gold specimen in the Harvard collection. Speakers range from university professors and museum curators to commercial gem and mineral dealers. Each talk will be illustrated with locality and specimen photographs, many of which have not been shown in previous publications or talks. There is much to be learned from the presentations at this year's symposium, and we encourage audience interaction during the question-and-answer sessions between papers.

Figure 2. **Zircon crystal, 2.5 cm, with faceted stones, from Renfrew, Ontario. Smithsonian Institution specimens; Wendell Wilson photo.**

Colored Gemstones from Canada; a Well-Kept Secret

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Canada is home to a wide array of colored gemstones from a diverse range of geological environments. From amethyst to zircon, and emerald to sapphire, Canada has it all. Yet, for most of its history, Canada has been regarded as a nation devoid of gemstones. Nothing could be farther from the truth. Of the major gem species, Canada lacks only alexandrite and tanzanite.

Some gem localities, such as the amethyst occurrences in Nova Scotia and Ontario, have been known for centuries, although most were discovered much more recently. In the past, there was little, if any, direct exploration for colored gemstones. Until fairly recently most localities were discovered accidentally. Direct exploration for colored gemstones by mining companies and prospectors is a relatively new phenomenon and is responsible for many recent finds. Some of the significant colored gemstones unearthed from Canadian soil include:

(1) Blue, yellow and colorless sapphire from Nunavut (flawless stones up to 2.59 carats).
(2) Emerald from the Yukon (gems up to 2.39 carats).
(3) Demantoid garnet from Quebec (clean, lively gems up to 2.72 carats).
(4) Hessonite garnet from Quebec (lively gems up to 23.94 carats or more).
(5) Amethyst from Ontario (rich purple gems up to 22 carats).
(6) Peridot from British Columbia (bright, lively gems up to 4.52 carats).
(7) Tsavorite garnet from Quebec (bright, lively gems up to 0.76 carats).
(8) Aquamarine from Ontario (flawed stones, with great color, up to 23.91 carats and clean gems possible up to 10 carats).

Although Canada has yet to produce large quantities of transparent colored gemstones, many gem localities are found throughout the country, and new discoveries are constantly being made. Rumors of new gemstone occurrences are coming from every corner of this vast country. Gemstone localities discovered to date probably represent only the tip of an iceberg, with many more waiting to be found. If recent history is any indication, the future of colored gemstones in Canada is bright indeed.

This talk will document some of Canada's finest colored gemstones and the localities from which they come. The focus will be on localities from which transparent faceted gemstones important to the jewelry trade have been recovered.

Recent Gem Discoveries in Canada

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Emerald was discovered at Tsa Da Glisza in the Yukon Territory in 1998. The mineralization there is associated with quartz-tourmaline veins and aplite dikes which intrude metavolcanic rocks. Beryl crystals up to 4 cm in length occur in 12 mineralized zones within a 200–300 × 1000-meter area to a depth of 200–300 meters. Chromium is the predominant chromophore in the emerald. Some of the smaller crystals and sections of larger crystals are gem-quality, and a number of small gems have been fashioned from Tsa Da Glisa crystals.

Gem beryl was discovered at the True Blue property in the Yukon Territory in 2003. The crystals occur in a swarm of quartz-siderite-fluorite-allanite veins that fill tension gashes 5 mm to 20 cm thick in a syenite intrusive body. Over 200 occurrences have been found within an approximately 600-meter radius. Although much of the beryl is dark blue in color, pale blue, green, and even yellow crystals have been found.

In 2002 sapphire was discovered near Kimmirut on Baffin Island, Nunavut. The sapphires are deep blue to yellow in color and range in size up to 2.1 cm. They occur with clinopyroxene, mica, plagioclase, scapolite, nepheline and calcite; petrographic studies suggest that these minerals record a diverse, largely retrograde, progression of assemblages. The sapphires occur near a major terrane boundary within the Paleoproterozoic Trans-Hudson Orogen. The continental collisional setting is analogous to gem provinces within the India-Asia collision zone, such as the Mogok Stone Tract in Burma (Myanmar).

Diamond in Canada

Andrew Locock
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The report in 1991 of diamond-bearing kimberlite at Point Lake in the Northwest Territories sparked the largest staking rush in Canadian history. Although this was not the first discovery of diamond in Canada, or the first report of primary diamond source-rock in North America, it was the first discovery of an economic diamond deposit. Two diamond mines have already opened in Canada, with more on the way. Canada is poised to become the world's third largest producer of diamonds (ahead of South Africa, but behind Russia and Botswana), producing almost 15% of the world's diamonds by value. The future for "ice" in Canada is bright indeed.

Minerals of the Silver Trail, Yukon Territory, Canada

Mark Mauthner
Houston Museum of Natural Science
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Houston, Texas 77030

Placer gold was discovered in the Galena Hill-Keno Hill camp area of the Yukon in 1895, a year before the Carmacks party made their famous discovery on Bonanza Creek in the Klondike. However, despite the presence of gold in payable quantities, the Galena Hill-Keno Hill camp became much better known for its silver mines. The first recorded Ag-Pb-Zn find was that of the Silver King vein on Galena Hill in 1903, a deposit that was worked ten to 12 years later. Prospectors and mining companies took the camp much more seriously after the 1920 establishment of Keno Hill Ltd., a subsidiary of the Yukon Gold Company Ltd., to mine the recently discovered No. 9 vein on Keno Hill. A staking rush ensued, and ultimately the area became one of the major silver producers of the 20th century (over 209 million ounces of silver by December 1986) and Canada's second largest silver camp after Cobalt, Ontario.

More than 65 Ag-Pb-Zn deposits or prospects are known in the camp and about three-quarters of them ended up under the control of United Keno Hill Mines. Several of the mines produced some fine collector-quality mineral specimens, especially silver sulfosalts. Among the best known are the iridescent polybasite and stephanite specimens produced mostly in the 1960's to 1980's, most notably from the Husky mine. Other collectible species include: native silver, pyrargyrite, argentiferous tetrahedrite, freibergite, sphalerite, galena, quartz, siderite, pyrite, marcasite, boulangerite, jamesonite, acanthite, cerussite, hawleyite (type locality), barite and anglesite. The camp is also the type locality for gunningite.

Gold in Canada

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The story of gold mining in Canada is also a study of the recent history of this relatively young country. Although Canada was discovered by Europeans over 500 years ago and exploited immediately for her vast natural resources of fish, timber and game, mining in Canada has been a relatively new activity. Commercial quantities of gold have been mined in Canada only since the mid 1800's and development was modest until the late 1800's. At that time, fabulous deposits of gold were found, first in the Yukon, and then at scattered locations from coast to coast. Three hundred and thirteen million troy ounces of gold, worth around $147 billion (in present-day U.S. dollars), have been extracted from the placer deposits and hard rock mines of Canada in the past 100 years. New deposits, including some of the richest yet discovered, continue to be found and mined.

This presentation will cover the geographical and historical evolution of transportation (foot-canoe-airplane) that affected gold exploration and development; the geological processes and environments (Canadian Shield, placer deposits) that have resulted in and host Canada's gold deposits; and some of the colorful characters (McIntyre, Hollinger, Preston, Oakes, Wright) that seem to be ever-present around gold. Interesting historical anecdotes will be related, particularly the processes of discovery. The important areas and localities that have produced interesting gold specimens and associated minerals, including the Porcupine, Kirkland Lake, Red Lake, Val D'Or and Yellowknife gold camps, will be discussed.

Chasing Gold Crystals from British Columbia

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Carl Francis
Harvard Mineralogical Museum
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Cambridge, Massachusetts 02138

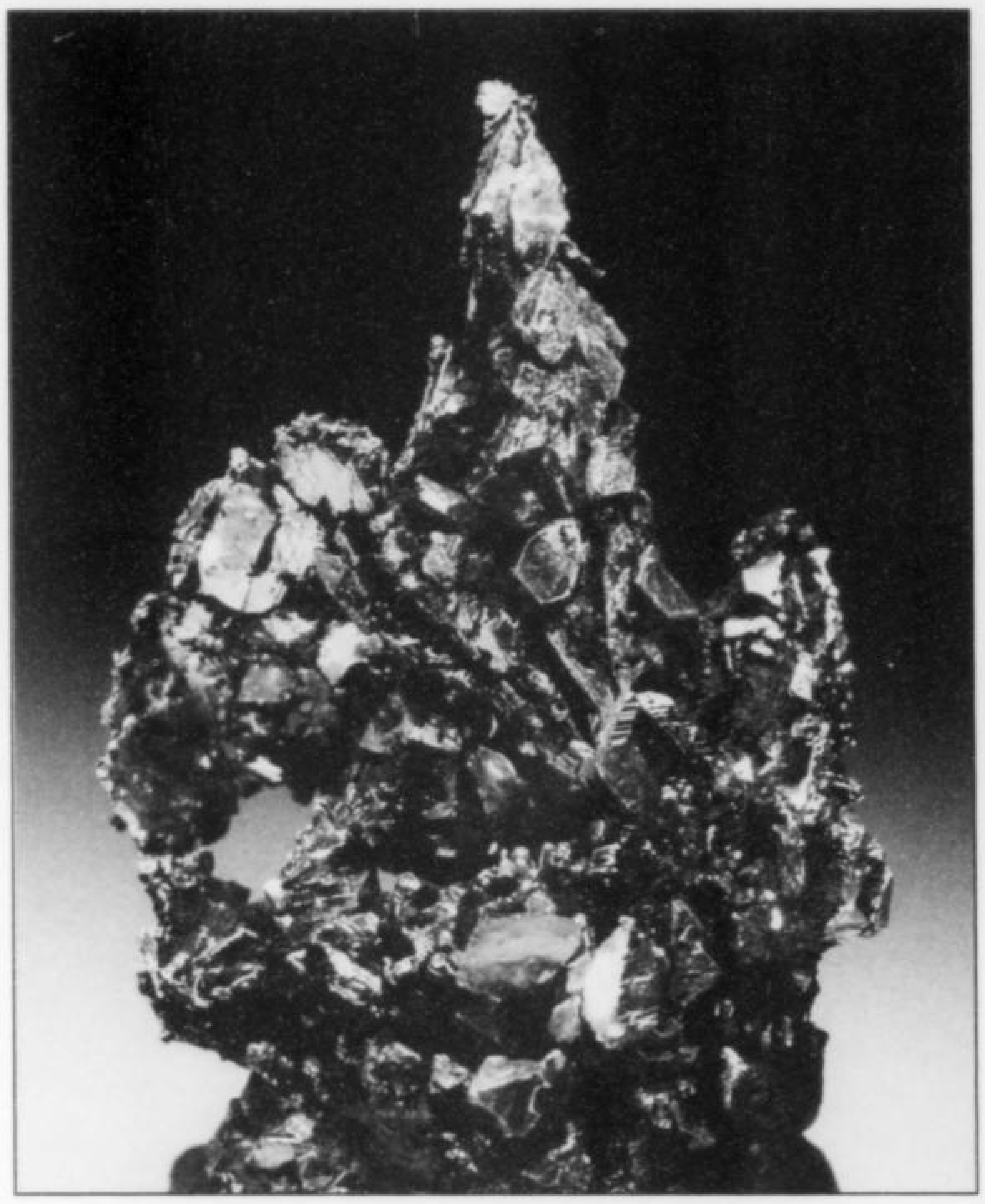
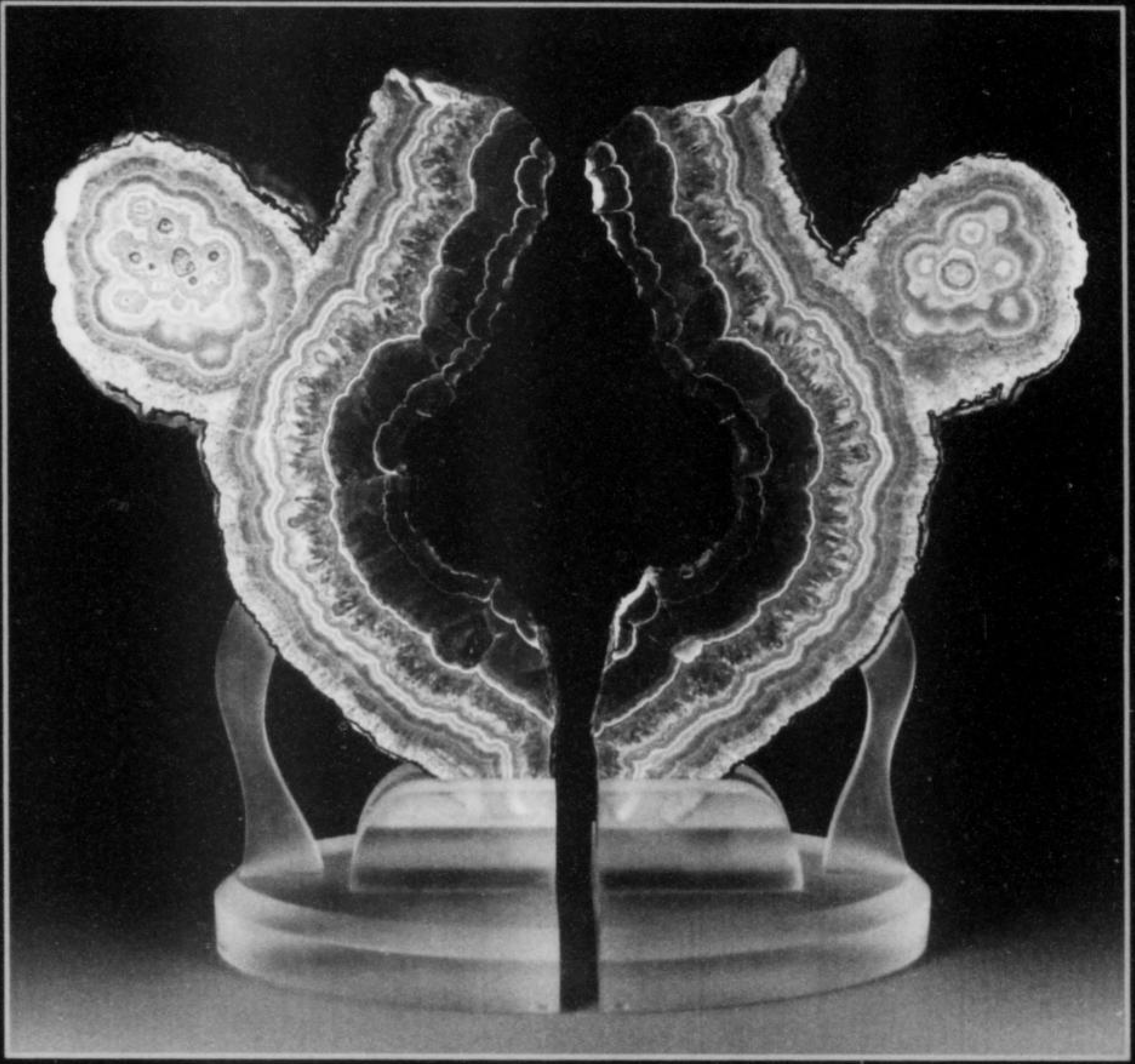


Figure 3. **The Burrage gold from "British Columbia," Canada. Harvard Mineralogical Museum collection; Wendell Wilson photo.**

Much is made of the term "connoisseur" in collecting these days, and all too often only with the implication of "having good taste." The word comes from the French for a "person who knows" . . . someone with an exceptionally well-developed knowledge on a particular subject. The connoisseur is devoted not only to accumulating fine objects for a collection, but also to building knowledge related to those objects.

One of the "gems" of the A.C. Burrage gold collection at the Harvard Mineralogical Museum is a specimen with only the vague locality designation of "British Columbia." In an effort to learn more of the specimen's origin, the authors studied known specimens of crystallized British Columbian gold as well as the chronology of certain gold mining operations. Eighteen localities that have produced well-formed gold crystals have been identified, and although the research is inconclusive regarding the Burrage specimen, the list of possible localities of origin for it has been narrowed. More importantly for the collector community, the beginnings of a useful body of knowledge regarding crystallized gold from the province of British Columbia has been established. ⛏



Mike Bergman Minerals

RHODOCHROSITE
La Capillta Mine
Catamarca, Argentina

The Friends of Mineralogy, Inc.

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

Visit the National Friends of Mineralogy website at
www.friendsofmineralogy.org

Who We Are

The Friends of Mineralogy (FM), formed at Tucson, Arizona on February 13, 1970, operates on a national level and also through regional chapters. It is open to membership by all. (See the FM website for regional chapter information.) FM's objectives are to promote, support, protect and expand the collection of mineral specimens and to further the recognition of the scientific, economic and aesthetic value of minerals and collecting mineral specimens. Our annual meeting is held in conjunction with the February Tucson "TGMS Gem and Mineral Show."

Where You Will Find Us

Through the FM Regional Chapters, FM members are consistently engaged in various activities to bring together people interested in the science of mineralogy and the collection and preservation of mineral specimens.

Annual Symposiums (education)

Local, Regional and National Gem and Mineral Shows (education, membership)

Clean-Up Outings on Public Lands (public relations, education)

Volunteers and Fund Raisers for Earth Science Museums (education, museum support)

State and Local Mineral Locality Indexes (conservation, preservation, education)

Visit Regional Chapter Websites and/or email Contacts for ongoing activities:

Midwest Chapter:
http://www.indiana.edu/~minerals

Pacific Northwest Chapter: http://www.pnwfm.org

Pensylvania Chapter:
http:/www.geocities.com/sajas.geo/FM/index.htm

Southeast Chapter: http://www.southeastfm.org

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email: pmodreski@usgs.gov

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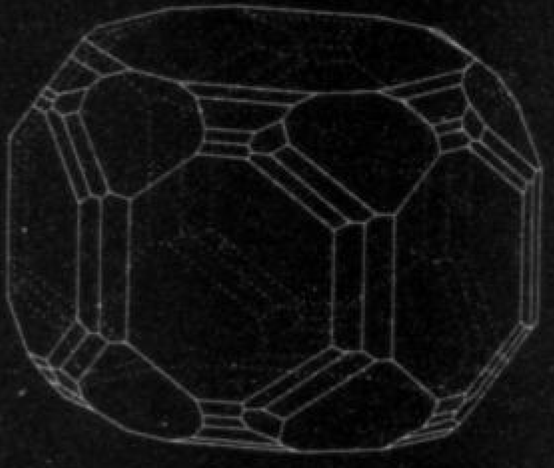

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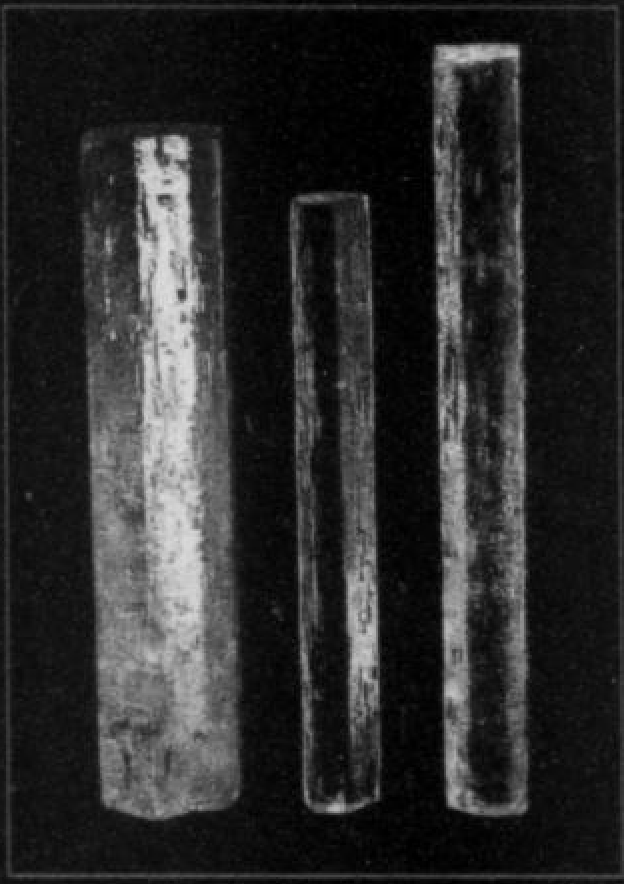
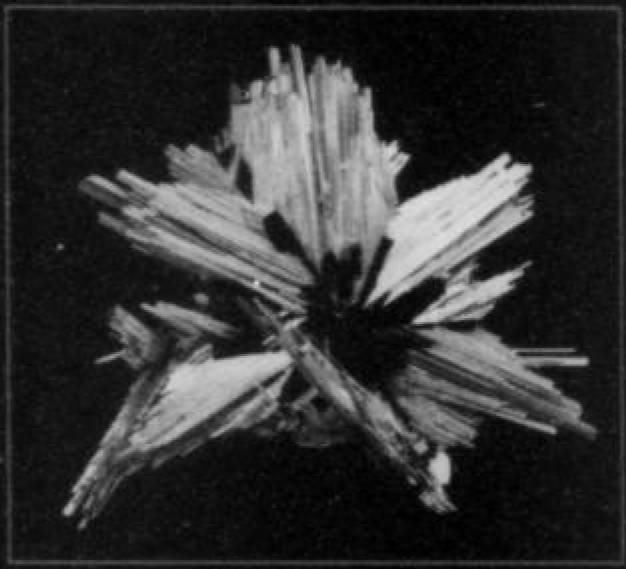
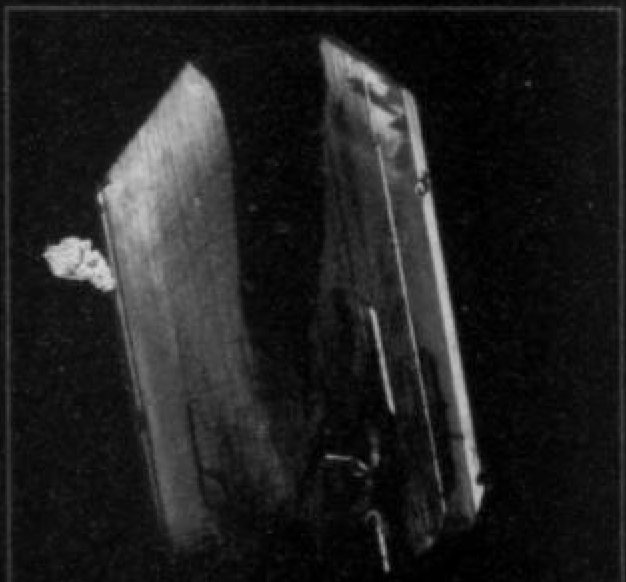


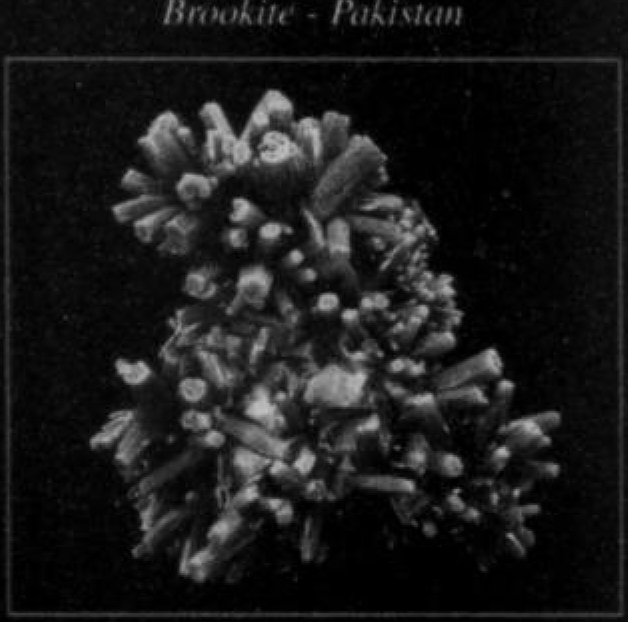
Beryl - Madagascar



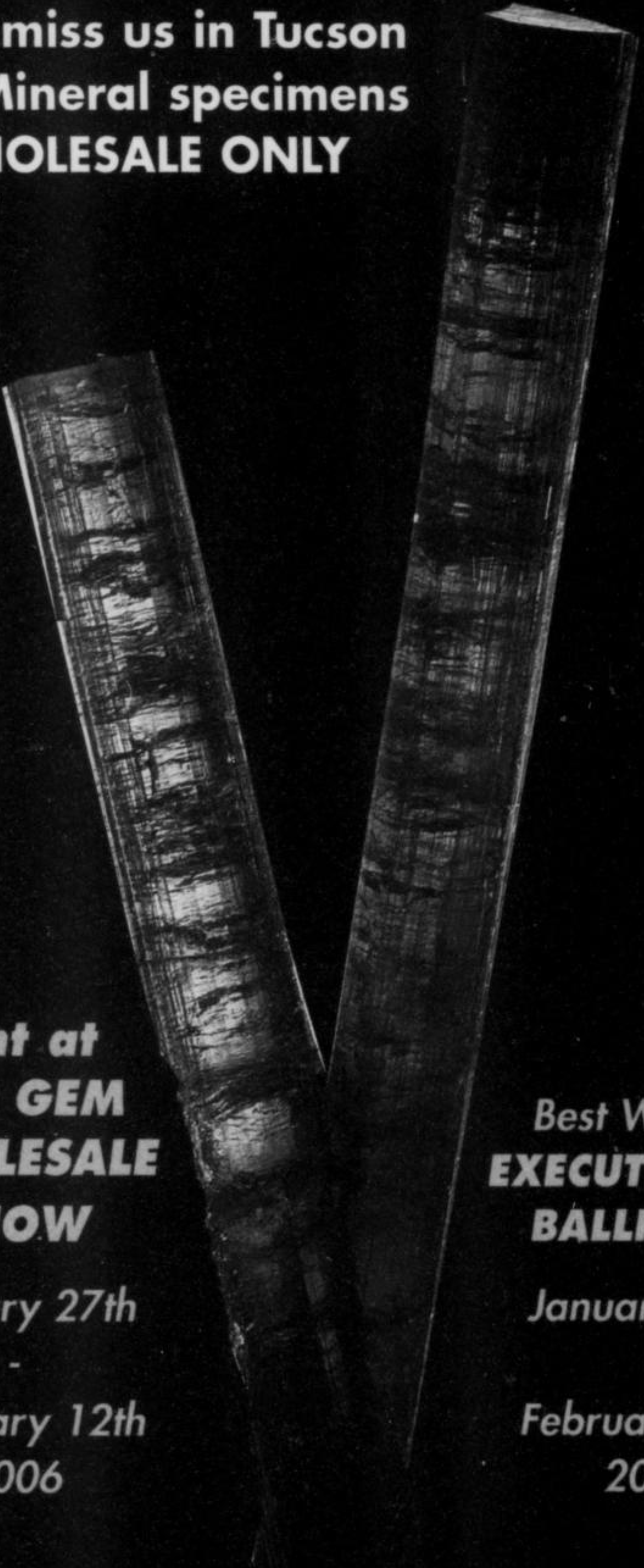
Rutile - Brazil



Brookite - Pakistan



Pyromorphite - France



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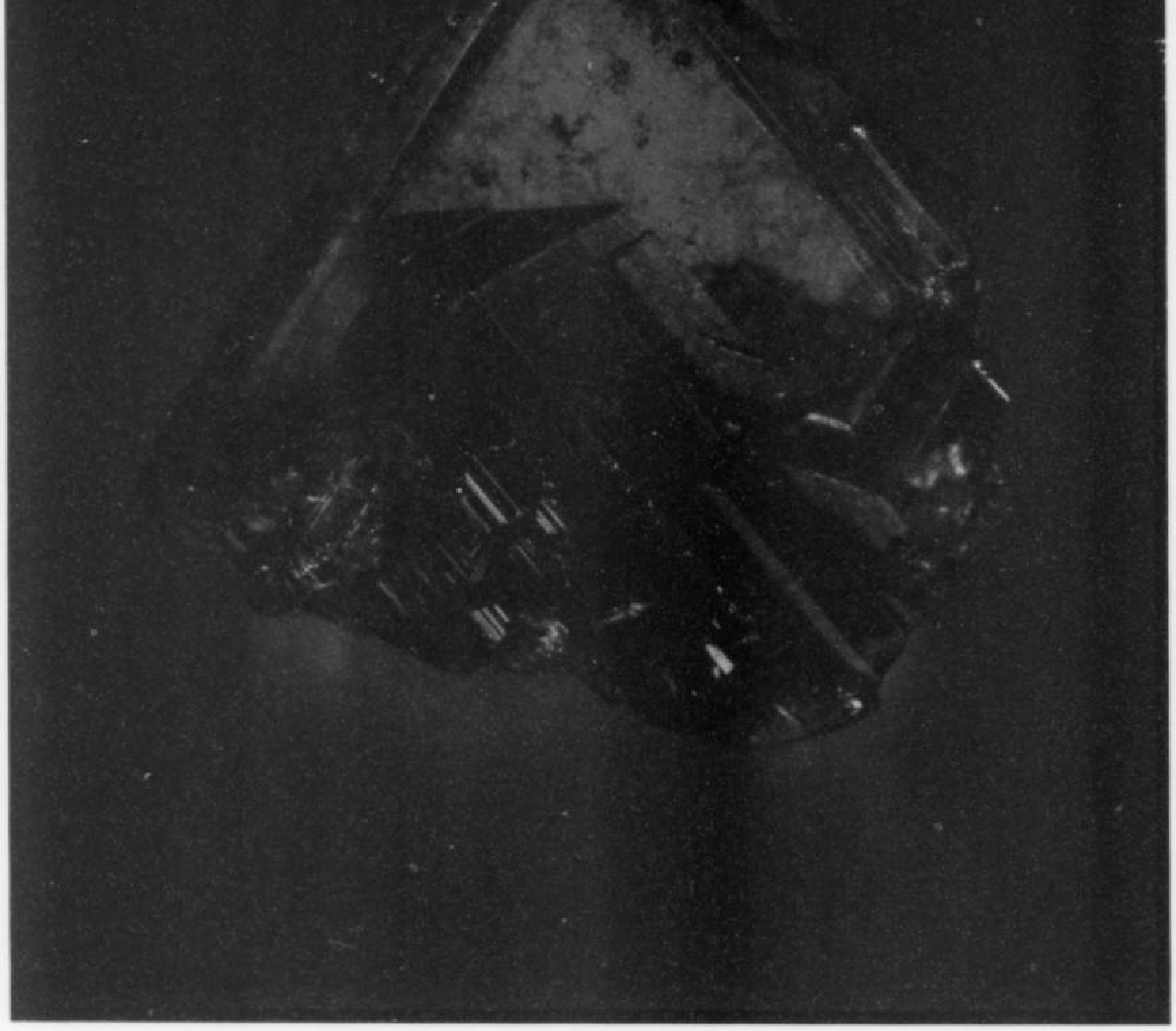


Spessartine, Minas Gerais, Brazil, 3 cm

What's New

in Minerals

Springfield Show 2005

by Joe Polityka

[August 12–14, 2005]

Harvard! Harvard! Harvard! resonated through my mind as I drove from my new home in Macungie (translates to "Bear Swamp" in Native American), Pennsylvania toward the Martin Zinn extravaganza at this year's Springfield, Massachusetts mineral show. No, it was not the Harvard football team's fight song, normally chanted by future corporate lawyers, mineralogists, anthropologists and social scientists. It was my brain anticipating seeing a hoard of fine and fascinating mineral specimens from one of the world's premier mineral collections. Harvard University was exhibiting over 50 cases of prime minerals just for me, and I was willing to drive 500 roundtrip miles to study them! I was not alone in my quest, as I soon discovered when I arrived at the Eastern States Exhibition Center. Quite a few people had the same idea I had: please, Marty, show me the rocks!

This year I arrived on Thursday: set-up day. This gave me more time to inspect dealers' stocks for new specimens before the stampede at the opening bell. Keep in mind that about 180 dealers, both wholesale and retail, were setting up. It takes a concentrated effort to go through so many minerals in so short a time. I was not disappointed because I soon found out there was a lot available both in the "What's New" category and from old collections.

The most prominent minerals for sale at the show were from the world-class collection of Marty Zinn, the show organizer. Many specimens of various (mostly common) species from the Zinn collection were available at the booth of *Kristalle.*

Ross Lillie of *North Star Minerals* had a unique specimen of **bismuth** (silver-colored bladed crystals up to 1 cm in size) on a cabinet-size sulfide matrix. This old-timer is from the famous mines at Schneeberg, Saxony, Germany. Ross also had **amethyst crystals** from the Djurkovo mine, Laki District, Bulgaria. The gemmy crystals, very similar to those from Guanajuato, Mexico, reach about 2.5 cm in size and contain the same type of phantoms. The crystals are found on matrix plates up to 30 cm.

Gold crystals from the Malone mine, Central District, Eugene Mountains, Pershing County, Nevada and from the Majuba Placer, Pershing County, Nevada in thumbnail-size specimens were featured at the booth of *Miner's Lunchbox,* Reno, Nevada. Scott Werschky also had other Nevada gold specimens on miniature-size matrix with interesting massive formations.

Mountain Gems & Minerals of Little Switzerland, North Carolina had about 50 specimens (in cabinet sizes with 5 cm crystals) of those attractive **amethyst** specimens from Jackson's Crossroads, Georgia (featured in the previous issue).

Terry Szenics had his usual array of rare minerals from the mines of Chile. **Molybdofornacite** from the Dulcinea mine, Carrera Pinto, Chile is among those just recently discovered. This mineral is better known as one of the rarities from the famous Tsumeb mine in Namibia. The new Dulcinea molybdofornacite occurs as lovely, platy, bright apple-green microcrystals sprinkled on fracture surfaces of a typical oxidized quartz/hematite vein matrix. These crystals are small and are best seen under 25X power. Coincidentally, several specimens of the same type of material were also found this year at the San Pedro mine, Inca de Oro, not far from Carrera Pinto. In total Terry had about two flats of molybdofornacite available.

Guanacoite from the Soledad mine, Guanaco mining district near Taltal, Chile was also available in Terry's booth. Guanacoite is a copper-magnesium arsenate and occurs with enargite in a hard quartz matrix. The small available lot that Terry had was far superior in quality to previous lots. Some of the crystals are 2 to 3 mm in size and show a deep blue to blue-green metallic color with prominent cleavage. Terry told me that only the guanacoite's prismatic crystal habit distinguishes it visually from spangolite, which can have the same color and cleavage. From the same mine there were also small lots of **arhbarite** and **gilmarite**, both rare copper arsenates. Occasionally in the same matrix there are microcrystals of **clinoclase** peeping out of tiny vugs.

Terry and his miners were busy at the Chapacase mine, near Tocopilla, Chile recently and discovered an interesting pocket of the very rare chromate species **iranite**. Terry had iranite specimens of solid rounded crystal masses up to thumb-size. One could heft one of these small specimens and immediately feel the high specific gravity of this mineral. The heft is not unlike that of anglesite.

Bolivian dealer Alfredo Petrov always has some unusual minerals available. It has been a long time since I had the privilege of examining recently mined **phosphophyllite** from the famous Unificada mine, Cerro Rico de Potosí, Bolivia. The mine is closed now, but that does not deter the intrepid miners who venture into it to dig for phosphophyllite and occasionally find some nice specimens. One of Alfredo's pieces has crystals in excess of 2 cm (!) and several specimens are of miniature size.

K. C. Pandey of *Superb Minerals* had **green calcite** crystals from a new find. These 2.5-cm, pale olive-green crystals are thought to be vanadium-rich. They were found about 3 weeks before the show in a well-digging at Bambori, Ahmednagar, Maharashtra, India. The well diggers of India seem to find a lot of nice minerals while pursuing their trade (remember the fluorapophyllite find of a few years ago?).

Dudley Blauwet recently returned from Pakistan with some gemmy red **chondrodite** from Ladjur Madea, Kokcha Valley, Badakhshan, Afghanistan. The 1-cm crystals in marble matrix are reminiscent of the old-time specimens from the Tilly Foster mine, Brewster, New York.

Luiz Menezes told me of a new mineral species that will bear his name and will be available soon; it is now in the final stages of being described.

Figure 1. **Chondrodite crystal, 3.8 cm, from Badakhshan, Afghanistan.** ***Minerive*** **specimen; Jeff Scovil photo.**

Rocko Rosenblatt had a few specimens of **brucite** from the N'Chwaning mine, South Africa. His specimens (five or six of them) have a pale blue color and a pearly luster. These spherical crystal aggregates are about 2 cm in diameter and are detached from matrix.

Russian dealer Iouri Poustov had many fine specimens of **fluorite** from Dalnegorsk in far-eastern Russia.

New Era Gems of Grass Valley, California had a fine array of loose **alexandrite chrysoberyl** crystals from Lake Manyara in Tanzania.

Phil Scalisi was handling the sale of the late Ken Hollman's collection. Many excellent specimens from classic worldwide locations and self-collected New England minerals were quickly sold. There were quite a few eager hands examining specimens that Ken had personally collected in New Hampshire, Maine, Vermont and Massachusetts. I was told that Ken's personal collection of New York State minerals was donated to the New York State Museum in Albany, New York.

Donald K. Olson had his usual surprise selection of world-wide classics, including about seven specimens in cabinet sizes of **quartz on chrysocolla** from the Manto Tres Gracia mine, Diego de Almagro, Chile. These beautiful, vividly blue specimens, sparkling like millions of stars in the summer sky, are now very difficult to obtain because the mine is exhausted.

At the booth of *Excalibur Mineral Company* I was surprised to find (next to the rare minerals) a flat of classic miniature to small cabinet-size specimens of **golden barite** on a yellow calcite matrix from Elk Creek, South Dakota. The crystals reach about 2.5 cm in size and are quite transparent. Such specimens are getting harder to find, and these were from an old stash, according to Tony.

Ted Johnson of *Yankee Minerals* was selling a portion of his collection which featured mostly minerals from Mexico.

Leonard Himes of *Minerals America* had some beautiful specimens of **brookite** on quartz from Pakistan.

Lambert Minerals–Canada has become a good source of minerals from Russia. They had a nice selection, including a fine matrix specimen of brown **ferro-axinite** from Puiva, Polar Urals, Russia.

Overall, there were quite a few dealers at the show who had desirable things, and the lectures by Rock Currier, Phil Scalisi, Bob Jones and Nancy Millard were filled to capacity and held their audiences spellbound.

At this point you might wonder what ever happened to the Harvard exhibit. I must confess that I visited the exhibit quite a few times during the show. I even took digital photographs for my personal photo album so I could go on what I call "cabin fever field trips" during the winter without leaving my home. As I stated earlier, there were approximately 50 cases of prime minerals on display from the world-renowned collection of the Harvard Mineralogical Museum. The cases were arranged in general categories which included specimens from historic collections such as those of T. A. Garlan (beryl, topaz and spodumene), A. F. Holden (Bingham Canyon, Utah), E. P. Hancock (silver from Kongsberg, Norway, with 2-cm crystals), A. C. Burrage (gold, including the famous "gold horn" specimen from Gilman, Colorado which was featured on the show program) and Franklin, New Jersey. Other cases were dedicated to specimens donated by contemporary collectors such as Terry Szenics, G. D. Elling, Martin Zinn, Gene Meieran and E. L. Collins.

Notable individual specimens included a 25-cm rhombohedron of rhodochrosite with associated quartz, from the Santa Isabella vein, Pasto Bueno, Ancash, Peru. This delicious-looking specimen has a red color that reminded me of raspberry jam. A deep pink, tabular crystal of morganite donated by Bruce Oreck was of top-thumbnail quality, although it is 30 cm wide. There were other cases dedicated to minerals from Namibia, England and other locations. The premier cases, in my opinion, were those that featured exceptional specimens from the northeastern United States. Many locations in New England are past their prime, although much still remains in the ground waiting to be discovered. Exceptional specimens of quartz, beryl, elbaite, fluorapatite and other pegmatite species were obvious proof of a glorious mining history. There was a case of elbaite from the Dunton mine, Newry, Maine; deep purple fluorapatite from the Pulsifer quarry, Auburn, Maine; and lemon-yellow fluorapatite from the Bluestone quarry, Acushnet, Massachusetts. A remarkable 12-cm crystal of smoky quartz with rutile inclusions from Waterbury, Vermont is considered by some to be the high point of Harvard's New England collection. This specimen was collected in the mid-1800's.

An old song by the Rolling Stones exclaims that "Time is on my side." Time has been on Harvard University's side for close to 200 years because of the contributions of so many Harvard alumni. In addition, many geology and mineralogy students from Harvard went on numerous field trips to locations around the United States and many students worked at mines and quarries during their summer breaks. Thanks to these benefactors and former students, attendees at the show were treated to what could be a once in a lifetime show experience. But if you missed it, don't fret; you can always visit the Harvard campus and see the collection there.

In 2006 the special displays will be drawn from the huge and spectacular collection of the Seaman Mineral Museum, Michigan Technological University, Houghton, Michigan. Get ready to see the world's best collection of Michigan copper, silver and calcite!

Denver Show 2005

by Tom Moore

[September 13–18, 2005]

Enacting a ritual as firmly fixed in Nature (or so it can seem to mineral collectors) as the migrations of cranes and salmon, a goodly number of the world's mineral people flocked to Denver again in September. At the Main Show in the Denver Merchandise

Figure 2. **The Denver Merchandise Mart, site of the Denver Gem and Mineral Show.**

Mart there were a few changes in physical layout and in administrative matters, but otherwise the show scene, including the nighttimes' astringent hints of autumn air, were as they have ever been—at least in my own experience, 12 years long now, of this benign rhythm.

A bit challenged this year in the what's-*really*-new department, the show compensated by being unusually rich in older collections being recycled. Easily the most salient offering of this kind was an entire *room* in the Holiday Inn full of nothing but fine specimens from Tsumeb: this was the former collection of **Ulrich (Uli) Bahmann** of Johannesburg, South Africa, lately acquired by Wayne and Dona Leicht of *Kristalle*. The Bahmann collection contained about 4,000 Tsumeb pieces, ranging in size from thumbnail to large cabinet and in quality from very nice to altogether superb. All the major Tsumeb species, plus many rare ones not seen on the market in many long years, were represented in this hoard, and such was the depth of the offerings that individual wall cases could be entirely devoted to one species—say, dioptase, cerussite, or azurite—each in a full complement of styles and habits. Beyond this all-Tsumeb room at the hotel, it should be added, Wayne and Dona also filled their usual large and lavish showroom at the Main Show with its accustomed plethora of major specimens from worldwide localities—including, I hardly need to say, California gold.

Meanwhile, the large and spectacular collection of hotel-show manager **Martin Zinn** was also on the market, with perhaps the best and biggest selection of excellent, almost invariably "aesthetic" pieces being offered by the *Collector's Edge* dealership, while Marty prowled the scene outside, shopping for specimens for his *next* collection. Good pieces from the collection of **Dan Belsher** (1956–2003) were available from several dealers, and in the rooms of *Dave Bunk Minerals* (www.davebunkminerals.com) and Stefan Stolte's *Mineralien & Fossilien Galerie* (min.foss.gal@web.de) one could see hundreds of specimens, including many old European classics, from the collection of **Paul Jung** of Frankfurt, Germany.

Rob Lavinsky of *The Arkenstone* had a surprise for the thumbnail community at the Main Show: about 75 top-quality little specimens from what was until now a "secret" accumulation amassed by **Irv Brown**. Also for thumbnail collectors: **Sam Nasser** (sjnenterprises@hotmail.com) had taken only about six years to build a fine collection in this size range, but decided last year to sell it, and so there was Sam at the Main Show, presiding over several cases stocked with hundreds of fine thumbnails, briskly selling them off one-by-one.

Finally, veteran California dealer John Seibel (johnseibel@hotmail.com) filled a large room at the Main Show with dozens of flats of miscellaneous specimens, in a full range of sizes, once owned by **Donald E. Boydston** (1931–2004) of Los Angeles, a refined and knowledgeable collector (to judge by the stock) who flourished in the 1950's and 1960's. Such was the variety here that no general summary is possible, but I might convey the sense of surprised discovery that awaited the browser by noting that I found a very sharply crystallized, 2.5 × 2.5-cm specimen of **thortveitite** from the classic locality of Iveland, Norway among the Boydston material. In short, this show was a more than usually rigorous test for the quick-scanning eyes and for one's database of mineralogical knowledge, with many entryways to a comforting sense of the intergenerational fellowship of collectors.

Time now, after all, to turn to the major what's-new items on hand at Denver . . .

In earlier years, as one came into the Holiday Inn through the main lobby entrance one passed a little convenience shop on the right, but this year, instead of postcards, cold sodas and bottles of Advil, one saw in the little alcove the setup of a brand-new mineral dealership from Tucson called *The Arizona Company*

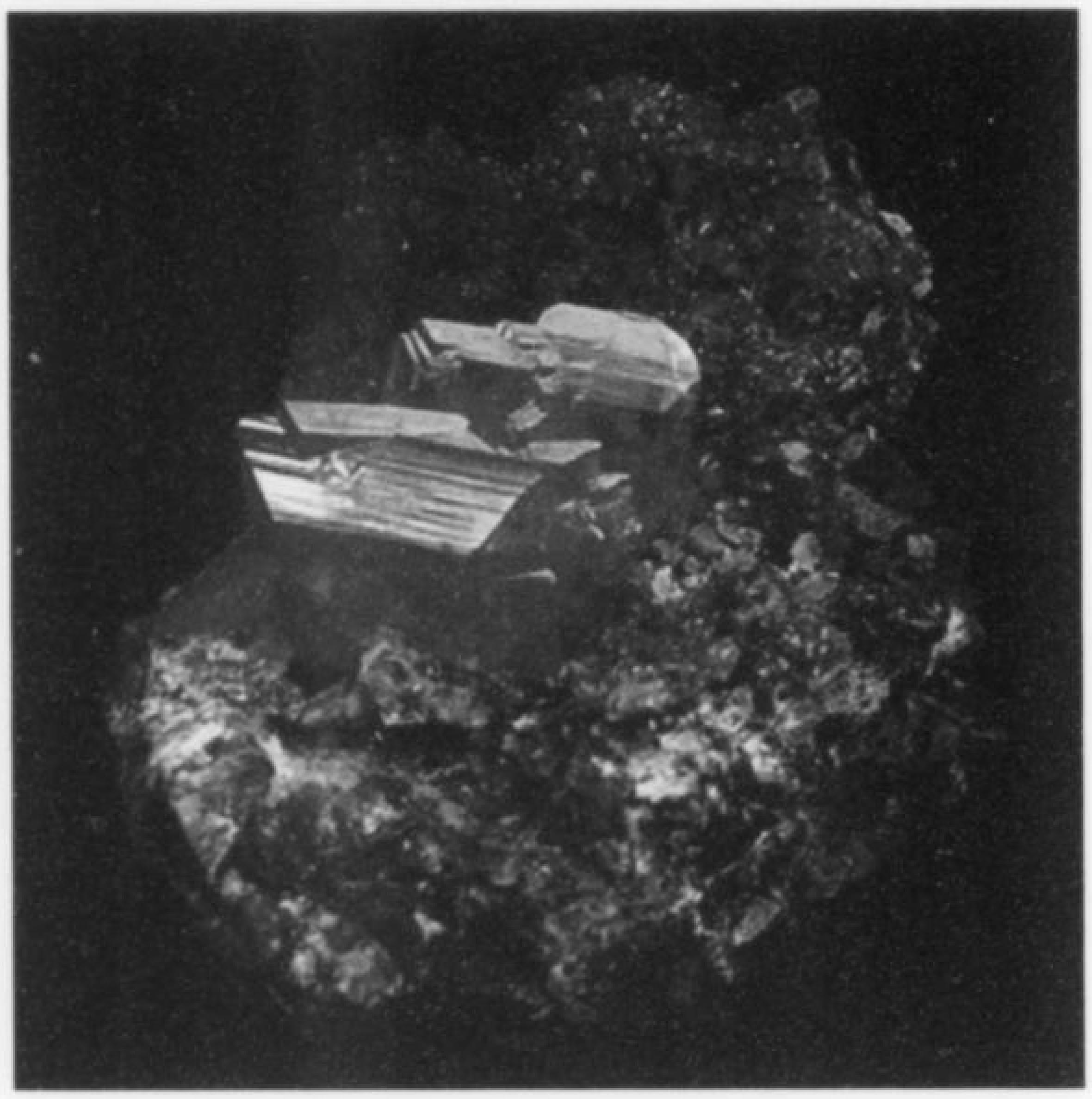


Figure 3. **Brilliant red wulfenite on matrix, 4.5 cm, from the North Geronimo mine, Arizona. The Arizona Company specimen and photo.**

(www.TheArizonaCompany.com), and a lot of bright, twinkling reds and oranges all over the shelves. Jim Ricker, proprietor of the company, was marketing plenty of fine **wulfenite** specimens from the famous Rowley mine near Theba, Maricopa County, Arizona, as well as, more surprisingly, excellent **wulfenite** and **vanadinite** recently dug at the North Geronimo mine, La Paz County, Arizona (see the article by Wilson and Godas in vol. 27, no. 5).

The Rowley mine outpouring began at the end of 2003, when Ed Davis struck a series of loaded pockets on the mine's "Job's Shaft" area; in due course other collectors, including Jim Ricker and his partner Aaron Baukes, took over, and thousands of wulfenite specimens were recovered (Evan Jones also had some last year in Denver). The wulfenite crystals are bright orange, lustrous, transparent "windows" to 3 cm on edge, many standing straight up on small bits of matrix, making for beautiful but excruciatingly delicate thumbnail and miniature specimens. Jim also displayed a hunk of matrix with a 15 × 15-cm vug all toothy with crisp orange wulfenite crystals; he says that some tiny native silver wires (!) had originally been attached to the pocket walls.

More surprising, though, were the results of *The Arizona Company*'s very recent work at the North Geronimo mine (once called the Pure Potential mine), a locality known for its startlingly red wulfenite which may even be superior in color, by just a whisker, to the hallowed wulfenite of the nearby Red Cloud mine. From January through May of 2005, Jim Ricker collected in a 10 × 15-foot zone of pockets extending from earlier workings by George Godas, and took out about 25 superb wulfenite specimens, with crystals to 3 cm on edge, as singles, subparallel groups of two or three, and loosely intergrown clusters, a few of the latter on matrix. The wulfenite is brilliant deep red-orange to red, and although the crystals tend to be thicker than those from the Rowley mine, many are nevertheless transparent—Jim even had a faceted, bright orange gem, the first gem-cut wulfenite I believe I have ever seen. There were also about 20 thumbnail and small miniature-size, color-screaming vanadinite specimens from the same locality: just as in the pictures shown in the Wilson-Godas article, the crystals are very deeply hoppered, some being really only thin shells with stepped inner surfaces, with brilliant luster and a vivid red to red-orange color. Typically the hoppered crystals, which reach 1.5 cm individually, form parallel or subparallel clusters without matrix. Jim says that about 40 flats of vanadinite specimens came from the pocket zone, including about a dozen highest-quality pieces. He also says that the zone is finished, and that these might represent the end of the line for North Geronimo vanadinite. The best of the thumbnail vanadinites topped out at only $100 (the best of the North Geronimo wulfenites, however, topped out at considerably more).

Scott Kleine of *Great Basin Minerals* (scottkleine@greatbasinminerals.com) has been busy field-collecting again in Nevada. In November 2004, at the Lone Tree open pit gold mine in Humboldt County, he found some interestingly formed **pyrite** in crystal clusters encased in gunky-looking iron oxides and siderite; these turned out to be highly lustrous and pretty after Scott cleaned them up. The lightly striated pyrite crystals, reaching 5 cm, are cubes and compound cubes but are complexly twisted and elongated and in some cases slightly hoppered; in overall aspect they are reminiscent of some old French Creek, Pennsylvania pyrite crystals. The groups, from 3 to 8 cm across, have abundant milky grayish quartz crystals, some sceptered, to 1 cm clinging all over them, and dustings of microcrystals of chalcopyrite. About 45 nice miniatures were available in Scott's Holiday Inn room in Denver.

The only other U.S. item noted here comes from an "old" but remarkable and well-respected occurrence, making what will probably be its last market appearance in any significant numbers of specimens. In 1991, on the 2500-foot level of the Zinc Corporation of America's Number-4 mine at Balmat, St. Lawrence County, New York, the late Ken Hollmann collected several hundred specimens of very slightly modified cubic crystals of **magnetite** lining cavities in massive magnetite, with unusual associations including calcite, anhydrite and halite. The magnetite cubes are lustrous black and razor-edged, and reach 2 cm. At Denver this year, Rocko Rosenblatt (Rocko@catskill.net) had about 15 fine miniature to small cabinet-size specimens, released recently from Hollmann's former collection. As always for this material, some of the magnetite crystals are damaged or broken through, but these are still very handsome specimens of magnetite like no other in the world.

For a few months past, the Recuerdo vein of the Huanzala mine, Dos de Mayo province, Huanuco department, Peru has been giving up fine, flashy specimens of **chalcopyrite**, and Dave Bunk had about 30 of these, measuring between 4 and 20+ cm across, in his Holiday Inn room at Denver. Highly lustrous, slightly edge-rounded chalcopyrite crystals to 5 cm form flattish intergrown groups on sulfide matrix coated by drusy pyrite. On most specimens no other associations are visible, but a few show white calcite crystals to 2 cm or so. Dave also offered some good-enough **barite** specimens from the same occurrence, with tabular, coxcomb-shaped, compound smoky brown barite crystals to 4 cm rising from the same sulfide matrix.

Pyrite specimens of varying styles emerge fairly regularly from localities in Peru, of course, but one new find was especially interesting this time around; it was represented at Denver mostly by several flats of wholesale material in Rock Currier's *Jewel Tunnel Imports* tent in the Holiday Inn parking lot, but a few elite miniatures reposed also with John Attard (www.attminerals.com) at the Main Show. The locality is the Canutillos lead-silver mine in Potosí department (the mine near whose portal moonlighting miners have lately been finding wonderful vivianite specimens in outcrops of muddy red sandstone—see my Denver 2004 report).

Canutillos mine pyrite crystals are sharp, highly lustrous octahedrons with gentle roundings of faces caused presumably by the influence of another form, probably the diploid. The slightly curved crystals reach 1.5 cm on edge, and are intergrown in tight groups on matrix of massive pyrite. The specimens range from 2 to 6 cm, and the best of them could make impressive and "different" newcomers to one's pyrite suite.

Once again, the devoted Brazilian-mineralmonger Chris Ehrlich (whose e-mail address says it all: luvquartz@kachina.net) had some nice specimens, this time from the famous epidote/titanite/quartz locality of Capelinha, Minas Gerais, Brazil. About 100 specimens found at Capelinha last May show simple prisms of **quartz** in well-composed clusters to 18 cm across, the crystals all heavily included by, and most of them partly coated with, a sparkling sand of greenish gray chlorite. Uncoated areas of the quartz are creamy white and lustrous, but all of the crystals are rendered opaque by the chlorite inclusions, and bladed, dull-lustered epidote crystals to a few centimeters adhere to some of the groups. Prettier than I'm probably making them sound, the quartz crystals also have come out as loose, doubly terminated, thin-prismatic singles to 7 cm long.

But the stars of the Brazilian troupe which made it to Denver are beautiful gemmy crystals of **elbaite** in a couple of styles from the Pederneira mine, Santa Maria do Sauçui, Minas Gerais, these having been set out alluringly in the Holiday Inn room of Gary Nagin's *Crystal Springs Mining Company* (info@crystalspringsmining.com). These specimens are certainly nothing on the order of the giant, flaring groups of multicolored prisms which came from the Pederneira mine a few years ago; they are single, loose crystals, a few doubly terminated, many with the distinctive (for Pederneira) brushy clusters of purple subhedral lepidolite books around their bases. The crystals range from 1 × 2.5 to 2 × 6 cm, and they are clean, fresh-looking, very sharply terminated either by flat pinacoids or by steep trigonal pyramids, and are totally gemmy. There are a few showing red zones but most are a simple, luscious, rich green with a tincture of blue. A second, intriguing sort of loose Pederneira elbaite crystals, new in my experience, was represented by about a dozen thumbnails and miniatures that Gary set out: they are *hollow* crystals which, when viewed down the *c* axis from the broken-off base-ends, are seen to consist of thin shells with only sparse remnants of fibrous material inside. These shells are presumably the products of differential etching-away of the crystal cores—though some people adhere to a different theory of formation involving a zone of open channels. The hollow shells, only a few millimeters thick, are lightly striated, gemmy blue-green, and terminated by basal pinacoids; they range in size from 1.5 × 3 to 2 × 5 cm.

We are not yet ready to leave the *Crystal Springs Mining* room, for here also were about ten specimens representing a new discovery of **aquamarine beryl** at an unnamed pegmatite prospect near Conselheiro Pena, Minas Gerais. Very pretty, lustrous, pale blue-green, largely gemmy, thick-tabular crystals of beryl to 5 cm tall and 8 cm across the basal face occur as loose singles and parallel groups, some specimens with dense groups of sharp, silvery brown muscovite books adhering. Also, and finally, this dealership had a few loose crystals, to 5 cm, of completely gemmy but heavily etched, pale blue **topaz** newly found at a locality called the Ematita mine (let me guess: an iron mine?) somewhere in Minas Gerais.

European minerals this time will have to be spoken for by only a couple of recent revivals of older localities, both, coincidentally, for gemmy yellow **fluorite**. Among the more famous of the old fluorite-producing mines of north-central England is the Hilton mine, near the village of Appleby in Cumbria (slightly outside the main cluster of "fluorspar" mines just to the west, in Durham). Although the Hilton mine closed commercially in the 1950's, some of its bat-infested underground workings are still theoretically accessible—unfortunately on the edge of a British military installation which makes access, shall we say, "awkward." Don Edwards, "Fossilist & Petrifactioneer" as his card calls him, of *Tideswell Dale Rock Shop* (Commercial Road, Tideswell, Derbyshire, U.K.) showed up in the "International Room" of the Main Show at Denver with a few gorgeous clusters of lustrous, transparent, yellow-orange, cubic fluorite crystals, the individual cubes reaching 5 cm on edge, and the clusters reaching 12 × 12 × 12 cm. These, Don said, were among hundreds of fluorite specimens which have emerged from the Hilton mine's workings during the past three years. Meanwhile, on the main floor of the Main Show, Cal Graeber had about 10 miniature-size clusters of Hilton mine fluorite which, he said, had come recently, not from underground, but from the dumps of the mine: the fluorite cubes here are razor-sharp, lustrous, totally transparent, and of a beautiful orange-yellow color. One thumbnail specimen shows a classic penetration-twinned pair of cubes with regular rows of dark spots of included marcasite crystals.

The Valzergues fluorite mine, Aveyron, France is not well known to American collectors, since its specimens seldom leave Europe; a 1999 book (in French) about the mine was reviewed in vol. 31, no. 4. At the 2004 Ste.-Marie-aux-Mines show, Andy Seibel scored some very nice crystal clusters of Valzergues yellow **fluorite**. The groups, which lack matrix and any associated species, range from 4 to 6.5 cm across, with individual crystals to 2 cm. The handful of specimens which made it to Andy's Holiday Inn room in Denver show very sharp, transparent fluorite cubes, less lustrous than the English ones but otherwise closely resembling them.

Small lots of specimens of **acanthite** from Morocco's Imiter mine—without doubt a major up-and-coming contemporary locality—have been lurking about for a year or so now (see earlier reports by me and by Bill Larson), and modest helpings have been seen here and there on the web. The feeling has been that a large debut of significant specimens is in the offing. In Denver this year, it happened: numerous dealers, prominently including Dave Bunk, Horst Burkard, and Doug Wallace, had Imiter mine acanthite specimens in a wide range of sizes and qualities on hand, although the biggest and best selection was to be found in the Holiday Inn room of Brad and Star van Scriver of *Heliodor*. Now these are peculiar-looking acanthites: the slightly rough-surfaced, in some cases pitted, gray crystals are simple octahedrons, but curved, wavy-edged, and surrealistically distorted to different degrees, although they all seem to gather themselves to very sharp points wherever four octahedral faces meet. Individual crystals reach 3 cm, but generally they are 1 cm on edge or less; they are lightly attached in irregular groups without matrix, in some cases with little dendritic ruffles around the margins. The majority of the groups are thumbnails, but the van Scrivers' hundred or so specimens include perhaps 25 miniatures, and a few clusters reaching 15 cm across. This latest batch reportedly was mined between January and June 2005 and held back in Europe until now, and thanks to the usual *Heliodor* conscientiousness about labeling I can say that the precise locality is the Imiter mine, 7 kilometers from Imiter, 25 km from Boumaine du Dades, and 30 km south of Tinerhir, Ouarzazate province, central Morocco. Differences of opinion concerning the desirability of these acanthite specimens were being verbalized all over Denver. Some collectors maintain that the sharpness of crystallization, the size of the larger crystals, and the "sculptural" quality of the groups place these specimens on

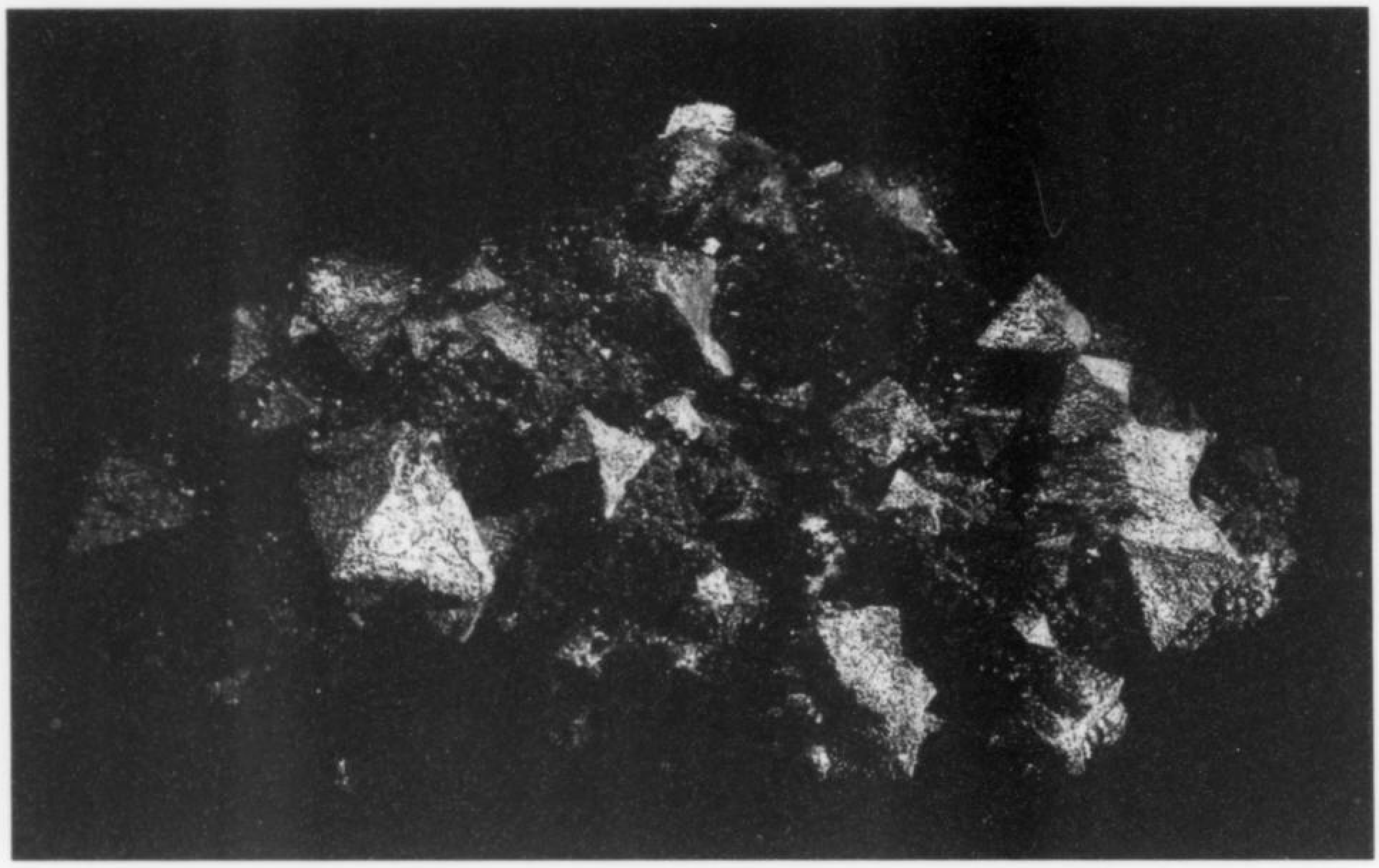


Figure 4. **Acanthite crystal group, 17 cm, from the Imiter mine, Ouarzazate province, Morocco. *Crystal Classics* specimen; Jeff Scovil photo.**

the short list of world-class acanthite occurrences. Others opine that, since the crystal faces on most of these specimens are generally corroded and unappealing, perhaps the crusher would have been the best place for them. Inclining, myself, to the more favorable view, I will point out that while most of the specimens indeed are dull of luster, a few show a fairly nice, satiny-to-matte metallic gray sheen—and a tiny minority of the thumbnails consisting of dendritic growths rather than of large isolated crystals, *are* lustrous, resembling old, bright (untarnished) dendrites of "argentite" from Freiberg. In any case, keep your eye on the Imiter mine, not only for more acanthites, but for wire silver specimens of exceptional quality such as can sometimes be seen on the market even now, and of course for the mine's brilliant red, glittering crusts of proustite microcrystals.

In the *Heliodor* room was also a very small number (about five) of very fine, loose, simple octahedral crystals of **magnetite** from the Imilchil mine, near Midelt, Morocco. The black crystals are perfectly sharp, mirror-faced, and reach 4 cm on edge; they show no associated species, or any hint of matrix. Brad van Scriver says that he picked them up in Ste-Marie last summer from "a Moroccan kid."

Further south in Africa, let us look in on two earlier-reported but still generously productive occurrences. The slightly rough-surfaced spheres of pale green, translucent **prehnite** with (at best) medium luster, associated with (likewise somewhat drab) bladed crystals of epidote, from Bendoukou, Sandare district, Kayes region, Mali are now fairly pouring out: the prehnite spheres reach several centimeters in diameter, and the better specimens show clinging epidote crystals of which a minority are terminated. Many wholesale flats of this material were being offered by *Jewel Tunnel Imports*, and smaller numbers of slightly better specimens came to Denver with Chris Wright of *Wright's Rock Shop*.

In Ethiopia, near the village of Konso, Southern Nations and Nationalities Regional State, some very good **"amazonite" microcline** specimens are being dug. The crude crystals to 30 cm across show a fairly good blue-green color, and the smaller, more elegant crystal clusters are juicily colored indeed. Kevin Dixon of *Alpine Mineral Company* (Kevin@alpineminerals.com) had about ten miniatures of a very pretty bicolored appearance: sharp microcline crystals to 2 cm line open cavities in massive pink microcline, the crystals having very thin blue-green skins (or "caps," like the "whitecap" microclines of Colorado) which contrast prettily with the pink substrate.

Yuri Pustov of Russia (ypoustov@mail.ru) brought in a new and impressive find—from earlier in 2005—of **elbaite** crystals from the Malkhane pegmatite field, Chita Oblast, southern Siberia (the region once called Transbaikalia, as it lies beyond, i.e. east of, Lake Baikal). Single, lightly striated, loose elbaite prisms from 3 to 10 cm long and 1 to 4 cm thick, with complex terminations including both basal and pyramidal faces, are a lush deep red and part-gemmy; some of the crystals have feathery white albite decorating their broken-off bases. Quite pretty . . . but then Yuri led me into his hotel room bathroom to show me the Mother specimen: a fabulous, perfectly terminated, gemmy red compound elbaite prism 22 cm long. A few of the other Russian dealers at Denver had these new crystals too, and all swear that they are elbaite, not liddicoatite (as other tourmaline crystals from the Malkhane field have been shown to be; some are compositionally zoned elbaite-liddicoatite).

Afghanistan came up with something new and interesting this year, by way of who else but the intrepid Dudley Blauwet of *Mountain Minerals International*. A small area in one of Dudley's always-intriguing glass cases at the Main Show harbored about a dozen loose, deep brownish red, part-gemmy crystals and tight crystal groups of **chondrodite** from a site near Ladjuar Madan, Kokcha Valley, Badakhshan. Most of the surfaces of these 1.5 to 2-cm specimens are somewhat rough, and tiny patches of a fine-grained, greenish mica (or possibly talc) can be seen on some, but the crystals are richly colored and lustrous and are of course very fine for a species that has previously been reluctant to appear in visible crystals at all.

After a southeastward passage to India, now, we encounter a few new items, particularly as seen in the Holiday Inn room of K. C. Pandey of *Superb Minerals India*. First, there are not-beautiful but very unusual specimens, found very recently in a well-digging near Aurangabad, of what some dealers at Denver were tentatively calling a mixture of scolecite and mesolite, but which has now been shown to be the zeolite species **thomsonite**. Opaque, pale creamy orange thomsonite spheres and hemispheres rest singly, or are lightly intergrown to form crusts, directly on basalt matrix; the spheres reach 7 cm in diameter, and matrix plates liberally strewn

Figure 5. **Painite crystal, 6 mm, from Mogok, Burma (Myanmar). Mark Kaufman specimen, now in the Natural History Museum of Los Angeles County collection; Anthony Kampf photo.**

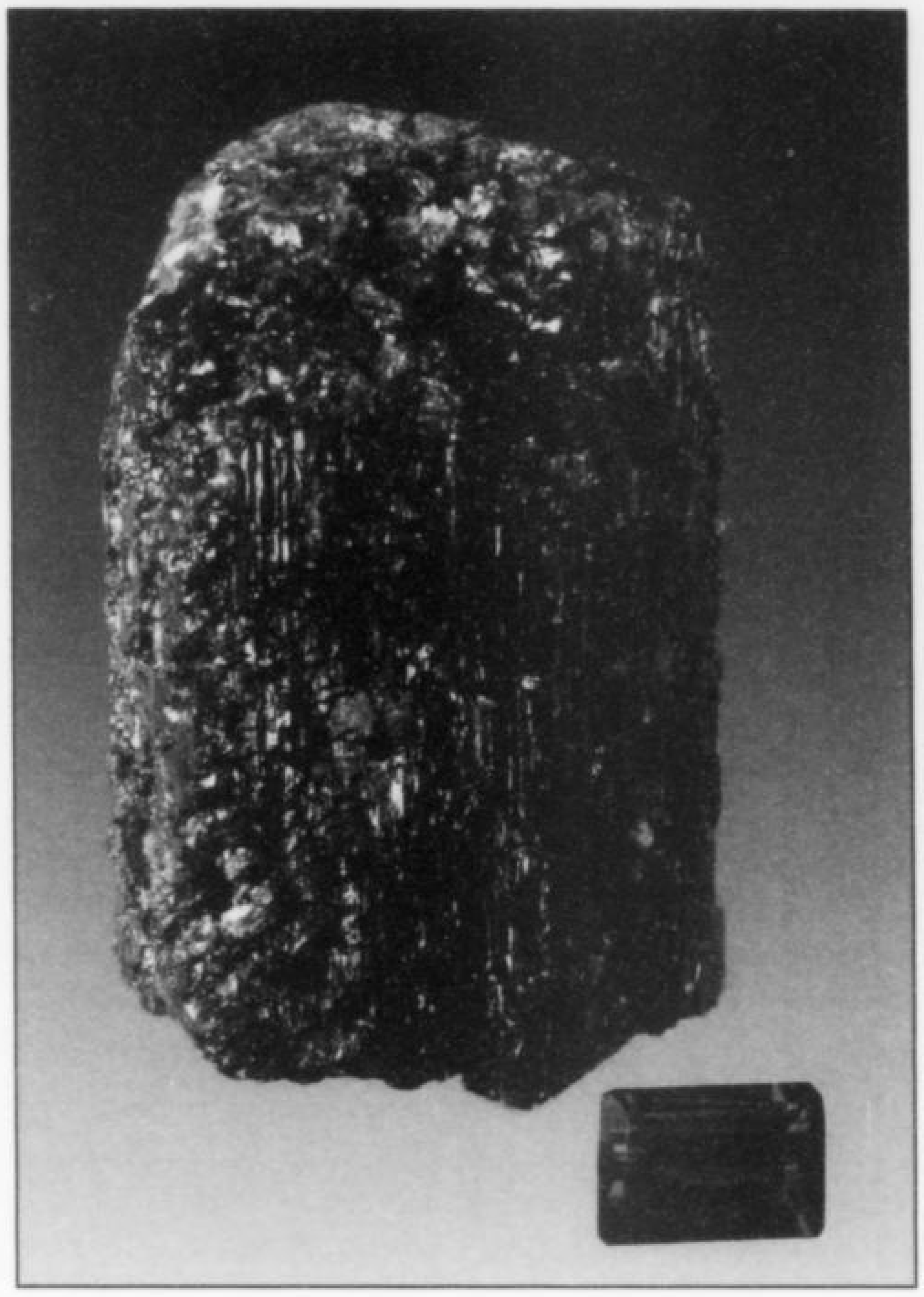


Figure 6. **Painite crystal, 2.1 cm, with drusy pink corundum, from Mogok, Burma (Myanmar); the faceted painite measures 4.9 mm (0.47 carat). Rob Lavinsky specimen, now in the Natural History Museum of Los Angeles County collection; Anthony Kampf photo.**

with spheres reach 30 cm across. The rounded surfaces have a fine-sandpaper texture, and each sphere is composed, of course, of radiating, densely packed acicular crystals. A couple of other Indian dealers besides Mr. Pandey had good specimens of this unusual stuff, and even better ones showed up on Rob Lavinsky's website (www.irocks.com) about two weeks after the show; I owe to Rob, as well as to Berthold Ottens, the assurance that the species in question has been verified analytically as thomsonite.

Mr. Pandey also had lustrous crystal groups of yet *another* new kind of basalt-cavity **fluorapophyllite**, these also from Aurangabad: lustrous, perfect tetragonal prisms with pyramid and basal faces are tinted deep green by included chlorite (*not* celadonite; the celadonite-included heulandite and stilbite crystals from India are paler green and much less lustrous). Individual crystals of fluorapophyllite from the new find reach 2.5 cm, and clusters reach 4 cm.

Next, there were nice **calcite** specimens from a find in July 2005 at Ahmadnagar: translucent, gleaming, pagoda-shaped and trigonally terminated, compound calcite crystals to 6 cm perch on small bits of matrix. The color of these stacks of severely flattened rhombohedrons is a beautiful pale mint-green.

By now you will have seen the November-December 2005 issue of this magazine, and will have read Muhammed Makki's account of the continued gathering of **cavansite** and **pentagonite** at the famous Wagholi quarry near Poona. And yes, specimens are *still* abundant—somehow it seems improbable that anything so dramatically colorful can also be rather common, even at a lone locality—and there were plenty of such specimens at Denver. Special salutes, however, must go to (1) the little loose, delicate sprays of brilliant blue acicular pentagonite crystals (Rob Lavinsky had some of these, as did Mr. Pandey and other Indian dealers), and (2) the lovely specimens, seen but rarely at a few dealerships, on which sharp, transparent, yellow-orange rhombohedral crystals of **calcite** to a few millimeters on edge are impaled on or include blue sprays of cavansite or acicular crystals of pentagonite. As I say, the calcite crystals are very small, but the color-harmony makes for a winning elegance and beauty in these specimens.

Ever heard of the species **painite**? If not, be forgiven, as for many years after its discovery in the early 1950's only two crystals were known to exist. Painite, $CaZrBAl_9O_{18}$ with traces of Cr, V and Fe, is hexagonal and orange-red, crimson, and brownish red, and it occurs, with spinel and corundum, in the contact-metasomatic "dirty" limestones and marbles of the Burmese gem regions; the type locality is a small ruby mine near the village of Ohngaing, Mogok, Burma (Myanmar). From this type locality (and simultaneously from a couple of other Burmese localities) have very recently come painite crystals which, it's an understatement to say, set a new standard for the species. The largest of the new painite crystals are somewhat crude, rough-surfaced prisms to more than 3 cm, while smaller, sharper, gemmier crystals are 1 cm or less; the latter are raspberry-red tinged with brown, and transparent throughout. Rob Lavinsky is offering some of the new painite crystals on his website, and at the Denver show some excellent loose painite crystals to 3 cm were being shown off by Bill Larson of *Pala Properties International*. The gem cutters, of course, have been busy: Rob's site has a picture of a faceted painite whose color resembles that of alexandrite in lamplight.

And so we come to China, and will linger there, as usual, for several robust paragraphs. First up is a new Chinese occurrence producing what are clearly the world's best-so-far specimens of **babingtonite**, in extremely sharp, lightly striated, short-prismatic black crystals exceptionally to 5 centimeters long, associated with colorless-transparent quartz prisms and with pale green, lustrous spheres of prehnite: the assemblage recalls old specimens from the classic Lane quarry, Massachusetts occurrence. In Denver I saw the material only in one hotel room, and showed up too late even there: Mr. Gao Yunfu and Mrs. Nei Qing of the *Hunan Sinophile Mineral Museum* (y.f.gao@public.cs.hn.cn) told me politely that they'd already sold off their best specimens, on which babingtonite crystals to more than 1 cm repose. This dealership gave me "Quying County, Yunnan Province" as a locality, saying that the occurrence had been discovered a few years ago, and that about 100 fine specimens, including those in their Denver room, had been

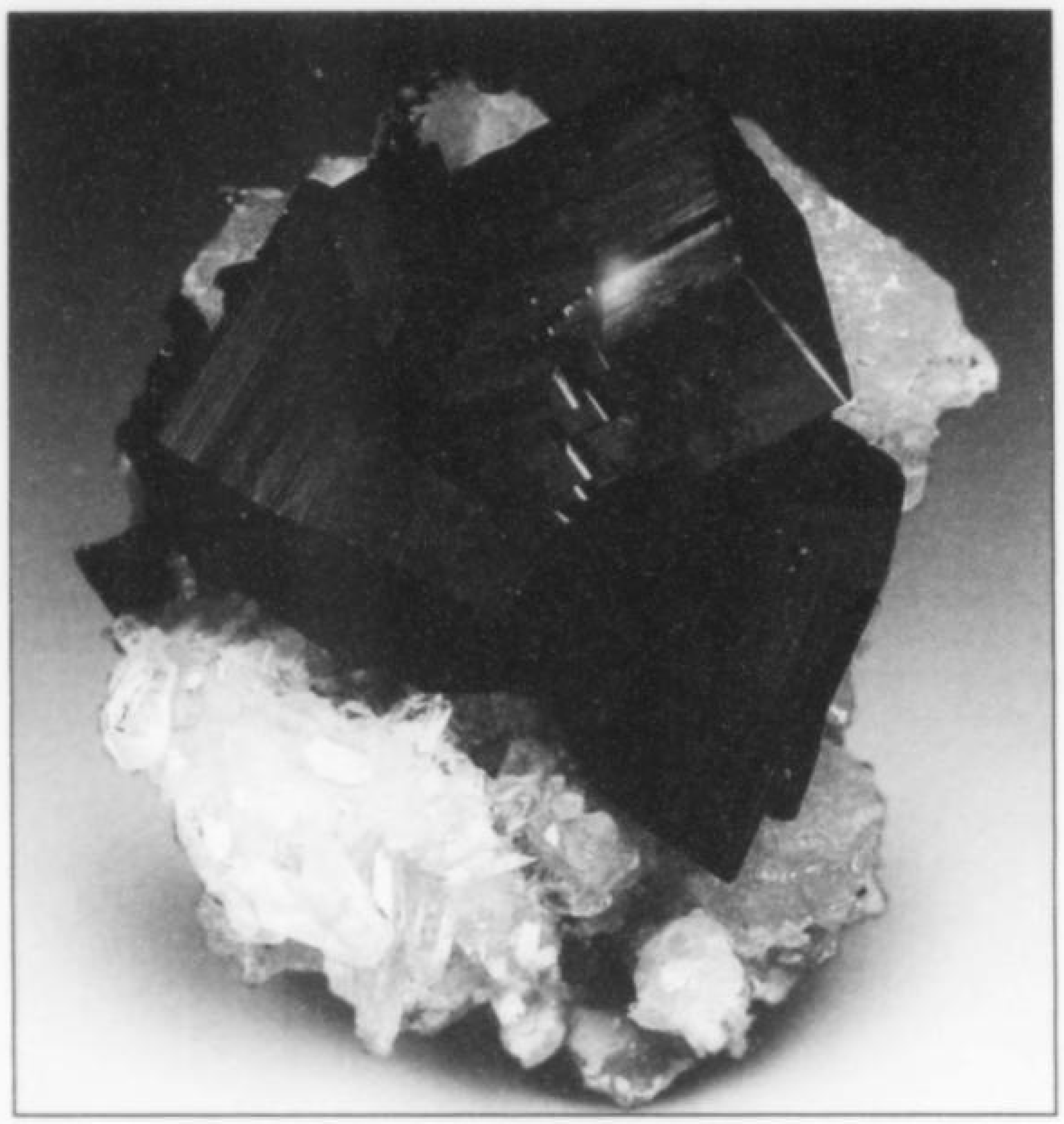


Figure 7. **Babingtonite crystals on matrix, 7.2 cm, from near Meigu, Xichang area, Sichuan province, China. Dan Weinrich specimen, now in the Joan Massague collection; Dan Weinrich photo.**

taken out in April 2005. But now it is early November 2005 (I'm updating this paragraph six weeks after the Denver show and just before galley-proof time), and Dan Weinrich has just returned from one of his Chinese safaris, and on the trip he scored a handful of manganbabingtonite specimens much better even than those I *heard* about in September in Denver. Dan also offers, confidently, a new locality designation, and Bert Ottens, that other tireless Chinese explorer, concurs: the specimens come not from Yunnan but from Sichuan province, specifically from a site near Meigu, in the area of Xichang; and Rob Lavinsky has sources that echo this information and add "Gan Zhi Zhou mine." Both Dan and Rob advertise some specimens showing lustrous black manganbabingtonite crystals in dense groups sharing matrix space with translucent mint-green prehnite spheres and transparent quartz prisms—and these specimens are most impressive (see photo).

Excellent miniature and small cabinet-size specimens of "axinite" (probably the species ferro-axinite) have very recently begun to emerge from a locality designated as either Mian Ning, Sichuan province or Nandan City, Guangxi province. Five fine pieces were on hand at the Main Show stand of James N. Walker and Mary C. Fong/Walker's *IKON* dealership (IkonMining@gmail.com), and Berthold Ottens had a few more a couple of aisles away (and even *he* was unsure about the locality). Lustrous, faintly translucent, deep brown axinite crystals to 3 cm form subparallel clusters without matrix, with associated quartz and calcite, the latter partially etched away. There is a resemblance to old axinite specimens from the Obira mine, Japan, except that the Chinese crystals do not have razor-thin edges like the Japanese "axe blade" crystals, or for that matter the French and Russian ones; rather, they are almost chunky, with thicknesses up to 1 cm. This material is exceptionally promising.

In early 2005, suddenly, fairly good supplies of gem-quality Chinese **topaz** crystals reached the Western market. Bert Ottens had the best specimens at this Denver Show, with lustrous, face-rich, nearly colorless to faintly pink, gemmy crystals on pegmatitic matrix consisting largely of crystals of feldspar and quartz. According to Bert, some Chinese swear that the topaz comes from the Gaoligongshan Mountains in western Yunnan province, near the border with Burma (Myanmar). But the fact is that these specimens look exactly like others which were briefly marketed before the present U.S. embargo on Burmese exports came down, those specimens having been said to come from the Pantaw region near Mogok, Burma. When closely questioned by Bert the Chinese dealers will often admit that they don't really know the source of the topaz crystals, which they obtain through middlemen in Hunan or in large specimen bazaars in Yunnan. Perhaps it is best to believe for now that these "Chinese" topaz crystals are in fact Burmese; according to Bert there is even a possibility that they come from Luc Yen, Vietnam, near the border with Yunnan. In any case, the crystals are limpid, lustrous and sharp, and the ones which have not been deliberately broken off matrix harmonize beautifully with what's around them: absolute colorless transparency against the echoing colorless transparency of quartz crystals, both set against the clean chalk-white of feldspar.

Concerning the specimens of **wire silver** which lately have been emerging from China, and which were quite plentiful at this Denver Show, I am again indebted to Bert Ottens, as well as to Jian-Rong Zhang of Changsha (a regular at major Western shows) for some background information (you may contact Mr. Zhang, of the *Hunan Natural Mineral & Gem Museum*, at dannachina@hotmail.com). Specimens consisting in most cases simply of single, loose corkscrewed wires of blackened, bronze-tinted or bright metallic white silver, these detached wires reaching 20 cm long, began to be seen about two years ago in the West. They come from a small mine near the village of Huangtun, in the Lujiang region of Anhui province, where galena ore with a very significant silver content is exploited. In 2001 and 2002, several pockets in the mine yielded more than 50 kilograms of wire silver, and the miners, unaware of mineral specimen values, simply broke the wires off and kept them as curios. At some point someone recalled or manufactured a folk belief that wearing silver jewelry wards off evil, and most of the wires were then turned into necklaces, bracelets and anklets for children. A few Western visitors to the mine area were startled to see so many otherwise poor-looking village children wearing profuse silver adornments. Only a small portion of the original, large silver find survived unmolested. And there matters stood until some Chinese mineral dealers visiting from Daye, recognizing an opportunity, bought up what they could find of the remainder of the silver hoard, and began introducing the specimens onto the mineral market. Presently the mine is still working, employing only about 20 people; the owners and managers, now sensitized to the commercial value of wire silver specimens, are exploring again in the area which had contained the pockets, but so far there have been no fresh discoveries.

The Chinese wire silver specimens offered at Western mineral shows, including Denver 2005, are thus remnants of the original strike. The great majority of them, as I've said, are simply loose wires, although a few are loose, tangled nests of wires of thumbnail and miniature size. In a few attractive and invariably "full-priced" pieces, the silver wires are intertwined or connected at the base but separate upward so as to "erupt" in every direction. A few other specimens are matrix pieces, with individual wires twisting up from a clayey matrix—but most of these, unfortunately, are fakes. Bert Ottens reports that last August in Changsha a large number of "matrix" specimens consisting of silver wires glued onto galena-

Figure 8. **Proustite crystal cluster, 6.3 cm, from Chañarcillo, Chile. Exhibited by Bill and Carol Smith; Wendell Wilson photo.**

Figure 9. **Wulfenite crystal cluster, 7.6 cm, from Tsumeb, Namibia. Uli Bahmann collection, being offered for sale by Kristalle; Wendell Wilson photo.**

bearing, clay-smeared rock were put onto the market; these of course must be watched for, although there also exist genuine matrix pieces in which the silver wires rest on acanthite. In general we can say that the Huangtun mine is potentially an important new locality for wire silver, and it may yield new specimens at any time . . . watch and wait.

Energy levels at Denver this year seemed high, perhaps even higher than last year, both at the hotel show and at the Main Show, and attendance at both shows looked good. The children brought to the Denver Merchandise Mart by the schoolbus caravans were again eager and wide-eyed, as children should be, even despite the fact that Mr. Bones—the guy in the giant dinosaur skeleton suit who has stalked the floor for several years past—has apparently now gone to the boneyard; anyway I saw no sign of him this time.

The exhibit theme at the Main Show was quartz, and among the display cases which played creatively on it were those by the Cincinnati Museum Center (quartz pseudomorphs); the University of Wollongong, Australia ("Australian Silica"); the Mineral Museum of Bonn (Idar-Oberstein agates); the "Arizona Mineral Minions" (an informal group of seven well-known Arizona collectors who put up quartz specimens); and the American Museum of Natural History, New York (14 super-specimens including a giant Hopkinton, Rhode Island amethyst scepter and a stately, 20 × 20-cm amethyst cluster from Upper Providence Township, Pennsylvania). Other spiffy quartz cases were put in by, among others, the University of Manitoba; the Society of Mineral Museum Professionals; the Arizona-Sonora Desert Museum; the University of Montana; the William Weinman Mineral Museum; the New Mexico Bureau of Geology & Mineral Resources; the California Academy of Sciences; the Royal Ontario Museum; the Denver Museum of Nature and Science; the Colburn Earth Science Museum; the National Museum of Scotland; and the Smithsonian. The large case facing the entrance, put in by the Houston Museum, socked

Figure 10. **Entrance to the Munich Show's large and extraordinary "Agate Dreams" exhibit area. Wendell Wilson photo.**

incoming showgoers with such visions as enormous faceted amethyst and citrine gems, a polished wedge of quartz with a perfect 1.5-cm pyrite crystal included in it, and several *grand prix* specimens including a foot-wide smoky quartz gwindel from the Dodo mine, Russia, and a pristine Japan-law twin whose longer arm measures 10 cm, on matrix of "normal" prismatic quartz crystals, from the Collier Creek mine, Arkansas.

Other cases had other topics. Among the standouts were a beautiful double case of superb Tri-State specimens backed by an enlargement of a 1918 photo of the "Oklahoma-Kansas Lead and Zinc Field" (George Witters); outstanding miscellaneous specimens donated by members of the Mineralogical Association of Dallas; the by-now expected and much-admired spread of colorful wonders from the collection of Keith and Mauna Proctor; terrific Pakistan and Afghanistan specimens representing the best-of-stock from Dudley Blauwet's *Mountain Minerals International*; and four dealers' examples of minerals which, surprisingly but happily, had been purchased for under $100 at last year's Denver Show—demonstrating that it's still possible to collect very nice specimens on a tight budget.

Finally, there were four fine cases on what amounted to a secondary theme topic: silver-bearing minerals. Dave Bunk showed some of the finest extant Colorado specimens of silver species; Wayne and Dona Leicht contributed a sumptuous assortment of large specimens of worldwide silver-bearers; noted silver-species collector Terry Wallace showed off "Spanish Colonial Silver Minerals"; and Bill and Carol Smith repeated the outstanding case on this theme that they've shown before, heavy on great old-timers like German and Chilean proustite, Kongsberg wire silver, Broken Hill chlorargyrite, etc.

Time now for me to leave this and begin to compose the next what's-new-online column—which reminds me to remind everyone to keep checking in on the still-expanding *Mineralogical Record* website, there to shop for books and back issues, browse the Mineral Art Gallery, and check out the ever-growing number of postings on Wendell Wilson's new feature, the Label Archive. Just now, though, it's over and out from Denver.

Munich Show 2005

by Wendell E. Wilson

[October 28–30, 2005]

The Munich Show this year was greeted by spectacularly fine and sunny weather—a nice "welcome back" for my first trip to the Show since 1991. No longer held at the old *Messegelände* ("Fairgrounds") by the Theresian Meadow where Oktoberfest still takes place, the *Mineralientage München* ("Munich Mineral Days") now sets up well out of town at the sprawling new fair complex called the *Neue Messe München*. Big is the word at this facility—16 show halls are available, each of them about as large as the Exhibition Hall at the Tucson Convention Center. The subway provides easy access from the hotels downtown—the two subway stops are named *Messestadt* ("Fairgrounds City") *Ost* ("East") and *West*, the *Ost* being closest to the three halls occupied by the Munich Show, A4, A5 and A6. I'm told that, big as the Munich Show seems, it is nevertheless the *smallest* event held each year at the *Neue Messe*.

Johannes Keilmann, the long-time head honcho of the Munich Show, has passed the administrative reins to his son Christian, retaining for himself what might be termed "creative control"; that is, he still conceives and organizes the thematic aspects (the fun part!). Keilmann has long been famous for his elaborate and beautifully executed theme exhibits which are actually temporary museums in their own right. The main theme of the Show this year was "Agate Dreams," and Keilmann gathered together a museum of worldwide agate specimens that far exceeded, in scope and quality, any such assemblage ever shown anywhere. It occupied a specially constructed multi-room building that by itself took up about a sixth of Hall A6. Individual rooms were devoted to agates from "overseas," agates from the U.S., agates from Germany, agates from Europe, eye agates, agate phenomena, agates from the Edinburgh Museum, master agate-carvers from Idar-Oberstein, *pietre dura* artworks made from agate, and agates from the Museum Schloss Bertholdsburg in Scheusingen/Thuringia, Germany. Dave Wilber's exhibit of beautiful Argentinian "Condor" agates was particularly interesting for a while, inasmuch as he absent-mindedly left a sandwich on display in the locked case, and it was quite some time before he could get officials

***Figure 11.* The Munich Show's "140 Years of Knappenwand" exhibit area, showing many classic and recently collected epidote specimens from the world-famous Austrian locality.**

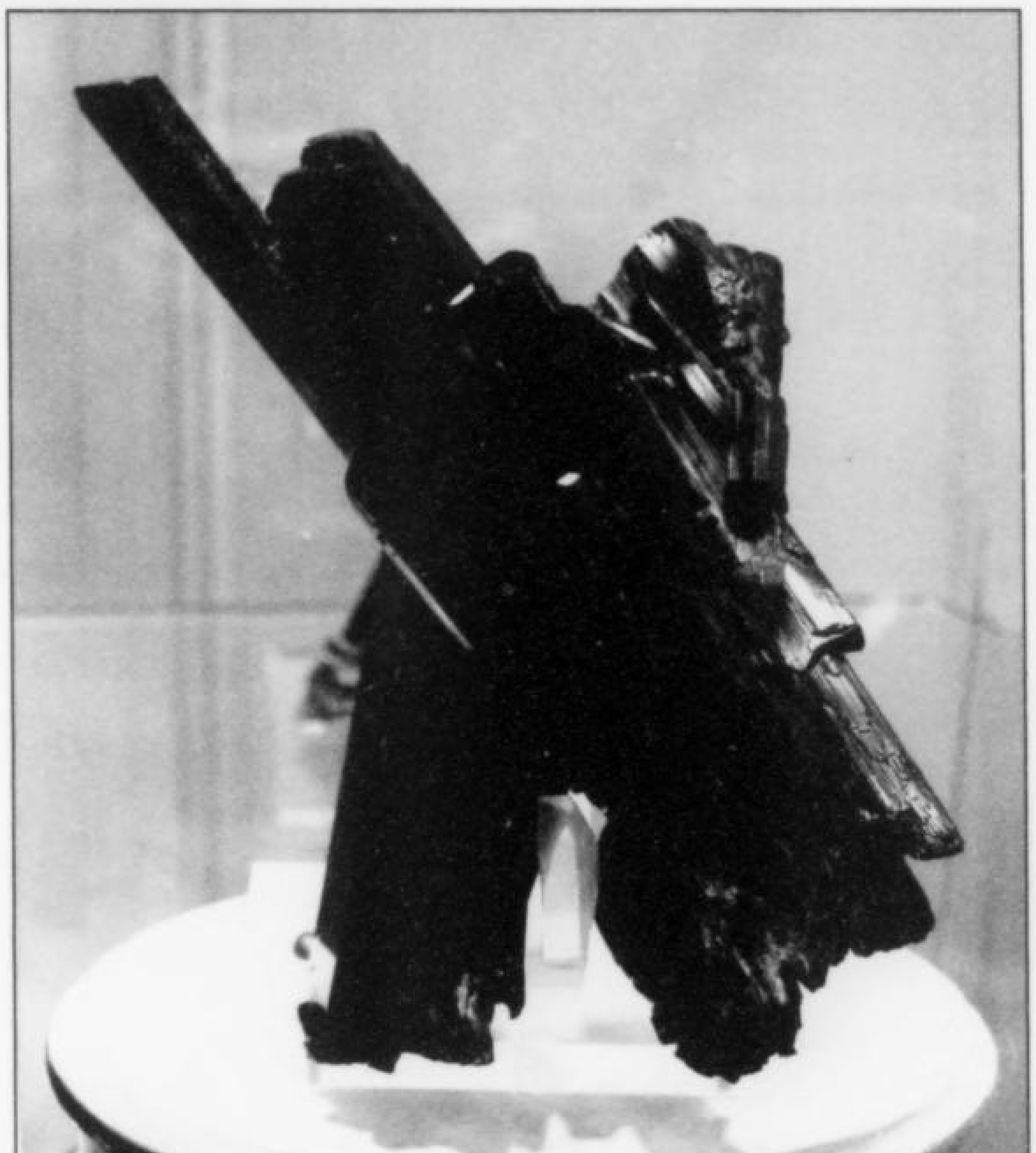


***Figure 12.* One of the large (about 16 cm), recently collected epidote specimens on exhibit from Knappenwand, Untersulzbachtal, Austria. Wendell Wilson photo.**

to re-open the case for him so he could retrieve it. (Of course, this being Dave, you know it was a *world-class* sandwich!)

Slabbed and polished agates are legitimate mineral specimens, of course, but Keilmann well knows that not everyone in the mineral world is interested in cryptocrystalline minerals. So he arranged for a very interesting group of "Collector Cases" in Hall A4. I particularly liked Bernard Sick's historical case about Robert Ferguson (1767–1840) and his collection, the case of Russian gem species put in by Simone and Peter Huber, and the special exhibit cases devoted to the 140-year history of collecting epidote and associated species at Knappenwand, Untersulzbachtal, Austria. Knappenwand must be one of the more labor-intensive localities at which to collect, and yet fine specimens continue to come out periodically, the most recent from a large cleft opened there on February 17, 2004 that yielded crystal clusters up to 22 cm.

Now to the minerals that were actually for sale (in no particular order):

One of the more interesting and voluminous new finds came from the Sapo mine in Minas Gerais, Brazil. Large (to well over 3 cm) discoidal crystals of translucent green **carbonate-fluorapatite** were found in a habit consisting of only the low-angle hexagonal dipyramid. The crystals occur scattered generously over large to very large (over 46 cm) blocky crystals of while feldspar. A preliminary chemical analysis has shown more carbonate than fluorine. Rob Lavinsky had some nice pieces, as did Ricardo Prato (*Preggi Gemme,* pregigemme@iol.it) and Michel and Claudette Cabrol (*Merveilles de la Terre,* michel_cabrol@yahoo.com), among others—reportedly over 3,000 specimens were recovered, so there should be enough to go around!

There was a nice find of pale green, cuboctahedral **fluorite** crystals to 4 cm on matrix from Riemvasmaak near Pela on the Orange River in South Africa. The best one (pictured here, Fig. 16) was being offered by Rob Lavinsky of The Arkenstone. These are attractive specimens, and we can hope that more will be forthcoming.

Rob Lavinsky also had some interesting new **ullmannite** specimens—gray metallic crystals (some of them twinned) to 2 or 3 mm in thick layers on matrix. These were found in September 2005 in the Musaloni mine, Sardinia.

Andreas Weerth (*Weerth Edelsteine und Mineralien,* tel: 08022-4330) had a particularly attractive and interesting (how often do you get both!) lot of colorless **fluorapatite** crystals from the Tormiq area in Pakistan. The crystals are relatively large (to 7 cm), transparent to translucent, stout, blocky hexagonal prisms with pyramidal corner modifications and excellent luster. What makes them unusual is that most of them appear to be *faden* crystals and parallel faden clusters;

Figure 13. **Simone and Peter Huber's exhibit of Russian gem minerals. Wendell Wilson photo.**

Figure 14. **Yellow beryl on smoky quartz, about 6 cm, from Mursinka, Ural Mountains, Russia, exhibited by Simone and Peter Huber. Wendell Wilson photo.**

the milky faden line is clearly discernible in many of them. Faden growth occurs most typically with quartz but can also happen with other rock-forming minerals; it begins with a rock fracture that cuts across individual crystal grains in the rock. The two halves of the crystal re-heal to bridge the gap, and slowly elongate in crystallographic continuity as the fracture gradually widens (see Peter Richards' article on "The origin of faden quartz" in vol. 21, no. 3). About 15 nice specimens of the fluorapatite fadens were recovered.

Much well-justified publicity has surrounded the superb Pakistani brookite crystals that have been coming out in substantial numbers. This time Andreas Weerth and François Lietard (francois .lietard@wanadoo.fr) both had excellent specimens of the brookite polymorph **anatase**, in typical black crystals to 2.5 cm. The habit consists of the tetragonal dipyramid capped by the basal pinacoid, and ranges from rather flattened (dominant *c* face) to steep dipyramids, all with excellent luster and sharpness. Associated minerals include quartz crystals and what appears to be a druse of tiny, tabular, colorless and transparent feldspar crystals. He gave the locality only as "Baluchistan"—a big place! Other dealers are giving the locality as Kharan, Baluchistan, reportedly an Alpine-type cleft occurrence. Last year at Denver a common locality tag given for the presumably closely related brookite occurrence was "near Dalbundi, Baluchistan."

Marcus Budil (*Fine Minerals International,* info@fine-minerals .com) had a good selection of the peculiar raspberry **elbaites** in botryoidal to rounded divergent clusters from Mogok, Burma (Myanmar). These have been seen on the market for several years but this was by far the best bunch to surface, with blobby crystals to 7 cm, on matrix (which is rather rare). Marcus had eight or ten cabinet-size specimens and perhaps 20 smaller ones.

Maurice Eyraud (*Minerama SA,* minerama.fr@wanadoo.fr) had a lot of **elbaite** crystals recently found near Coronel Murta in Minas Gerais, Brazil. These have obviously been well collected

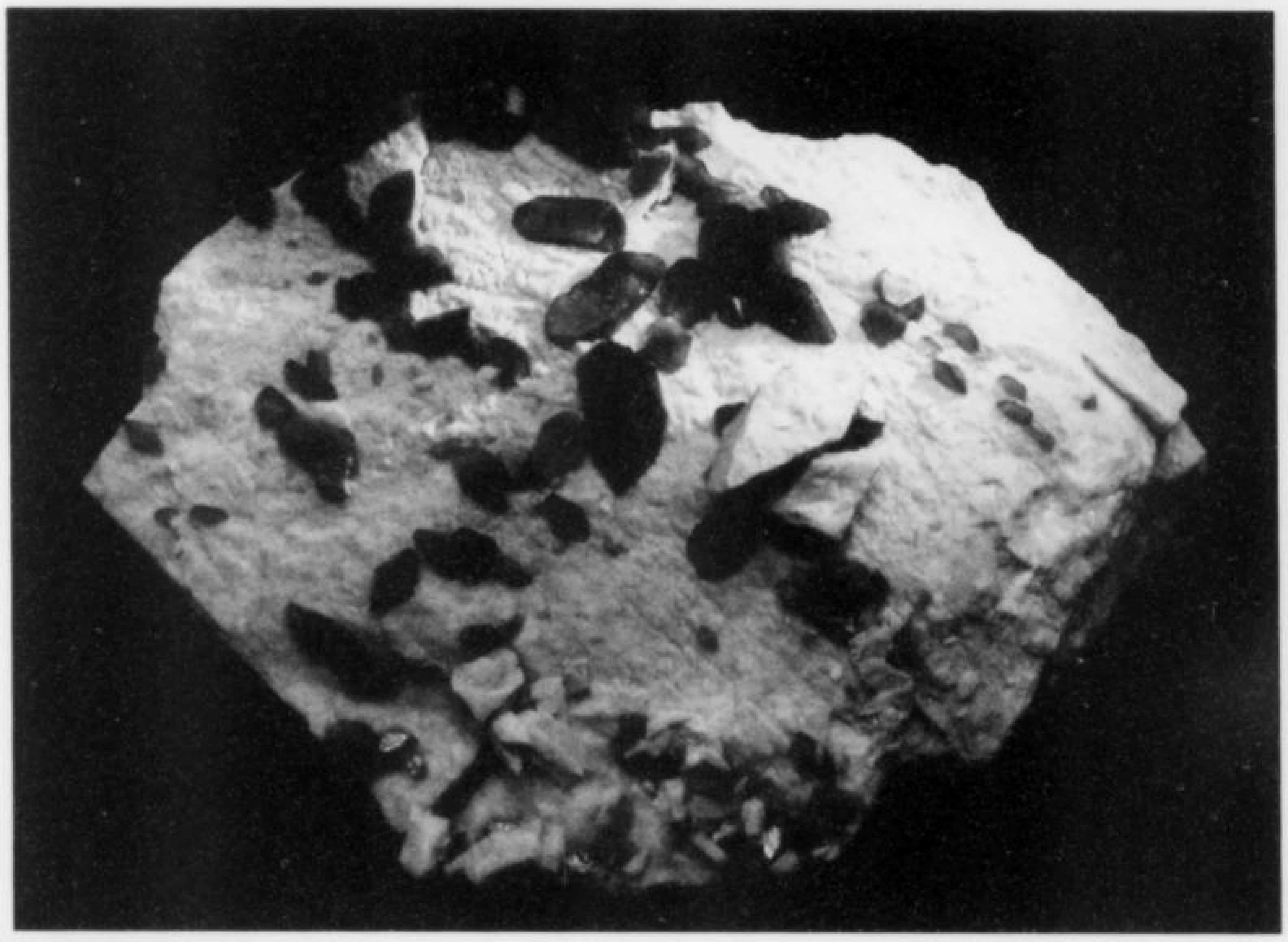
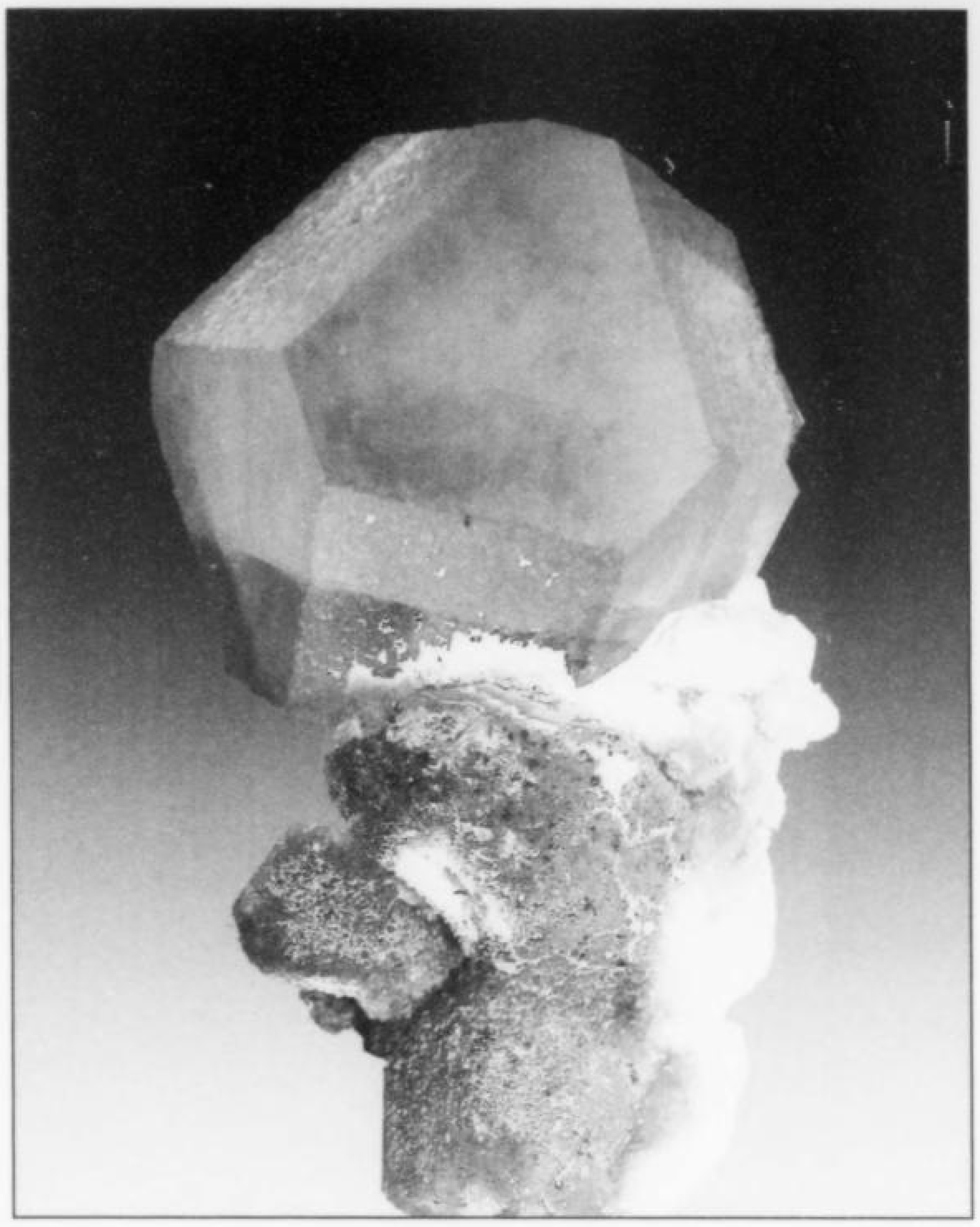


Figure 15. **Carbonate fluorapatite on feldspar, about 46 cm across, from the Sapo mine, Goiabeira, Minas Gerais, Brazil.** ***Preggi Gemme*** **specimen; Wendell Wilson photo.**

Figure 16. **Cuboctahedral green fluorite crystal, 4 cm, on matrix, from Reimvasmaak, on the Orange River, Pela, South Africa. Rob Lavinsky specimen; Wendell Wilson photo.**



and preserved from damage, unlike so many crystals that end up in a bag with many others and have their once-sharp edges reduced to micro-chatter. The crystals are very gemmy and transparent (warning—priced accordingly) and have an appealing greenish brown color in the top half, grading down to brownish green at the base. Nearly a dozen nice examples of loose crystals in the 1.5 to 4-cm range were available, plus a few larger crystals to 5 cm across. Maurice seems to have a corner on these—I didn't see any with other dealers.

Maurizio Casazza (Muzzano, Italy, Maurizio.casazza@tin.it) put out about 15 specimens of **glaucophane** in slabs to 30 cm across, which he personally collected some years ago at Pollone, Piemonte, Italy. Etching away the enclosing dolomite has revealed continuous crusts and masses of lustrous, sharp little blue-black crystals of glaucophane to 5 mm or so. Glaucophane is one of those metamorphic rock-forming minerals that typically is a component of schists but does not form free-growing crystals in cavities, so the occurrence is noteworthy. I'd like to see some good photomicrographs of this material.

As if to underscore Tom Moore's article on "iron roses" in the previous issue, Anton Watzl (Freistadt, Austria; anton.watzl@epnet.at) had a new (2005) find of **hematite "iron roses"** from Mörchnerkar, in the Zillertal Alps, Austria. The rose-like clusters range from 2 to 4 cm or so, on granite. Anton had about 35 specimens available, a substantial lot.

We've all seen the beautiful danburite crystals that have been coming out of Charcas, Mexico for decades, so it was quite a pleasant surprise to see a new lot of specimens that have **amethyst** crystals perched on the danburites in the booth of Matthias Jurgeit (Lampertheim, Germany; tel: 06256-1097). The little blocky amethyst crystals reach 2 cm, and occur singly and in clusters on 5 to 7-cm danburite crystals. These aren't very spectacular specimens—the luster of the amethyst is frosty and the color is pale, but they are still interesting as a hitherto-unknown combination. Several dozen specimens were available.

We have recently reported the discovery of crystals of painite from Mogok, Burma (Myanmar)—notable because previously only a couple of specimens of the mineral were known, making it essentially impossible for collectors to obtain an example until now. At the same time, some interesting little associated crystals of black **baddelyite** to 1 cm or so were recovered, from Wet Loo, Sin Khwar in the Mogok district. These were available in the booth of Patrick de Koenigswarter (*Miner-K*, minerk@club-internet.fe). The lustrous crystals are bladed and appear to be rotation/penetration twins about the long axis.

Yellow to yellow-green, gemmy **fluorapatite** crystals have been coming from the Imilchil area in the Anti-Atlas Mountains of Morocco lately. Several dealers had them at the show (including Jean-François Astier (tel. 0033-61116-5618), typically in stout prismatic crystals 1 to 3 cm across, but occasionally larger. They can be very transparent and lustrous, though they are generally lacking matrix and are often a bit scuffed up. The local collectors may get better at removing them cleanly and preserving them from damage; or this may be a one-shot occurrence. Time will tell.

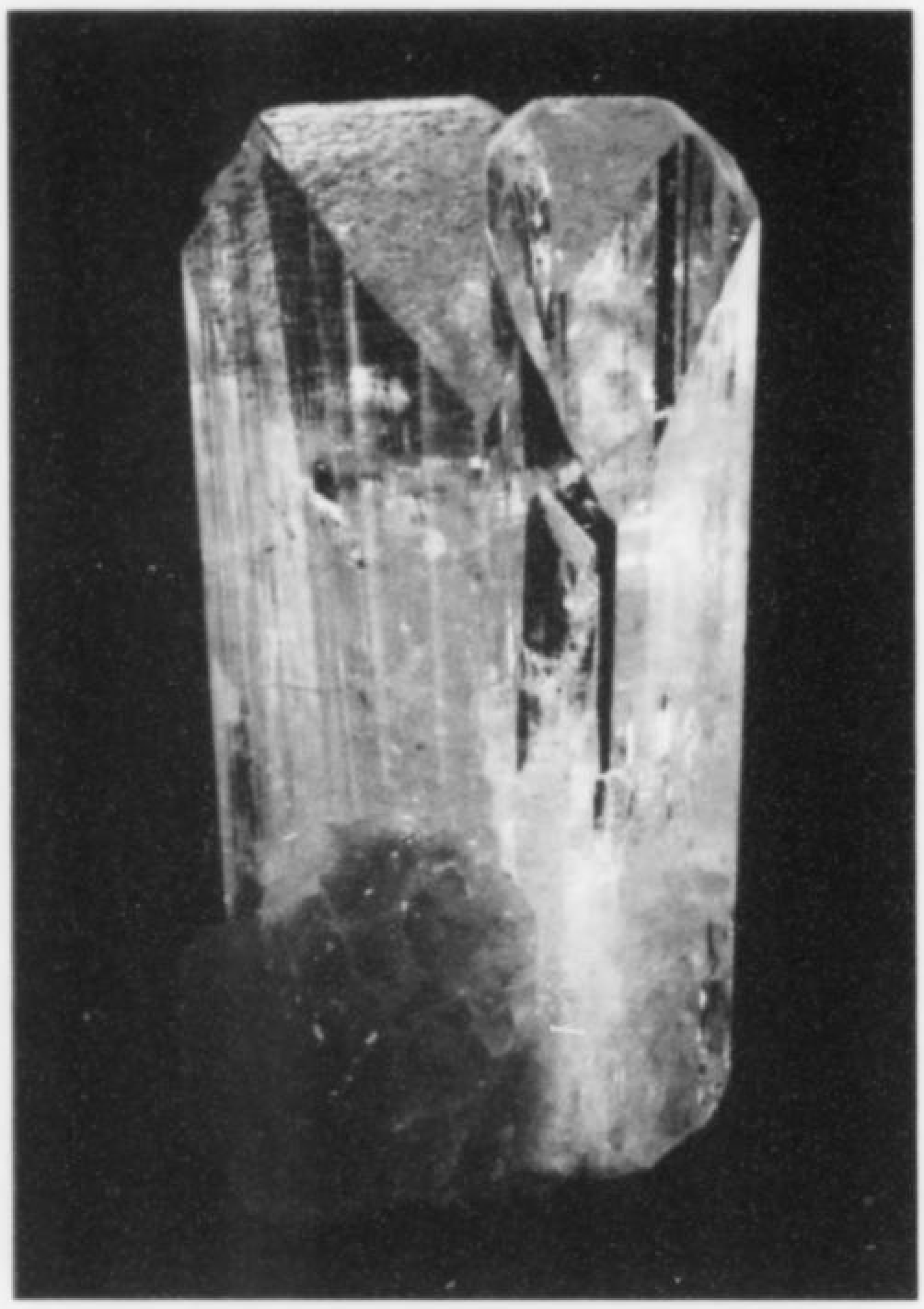


Figure 17. **Amethyst on danburite, 5.3 cm, from Charcas, San Luis Potosi, Mexico. John White specimen; Jeff Scovil photo.**

The *strahlers* of Chamonix in the French Alps are always on the look-out for classic pink octahedral **fluorite** specimens. This year Jean-Franck Charlet (jfkcharlet@hotmail.com) was the lucky one, breaking into a Mont Blanc fluorite/quartz pocket about 30 cm tall and 3 meters wide. The cavity is situated in a vertical cliff-face that can only be reached by rappelling. As if that didn't make collecting sufficiently challenging, the cavity is solidly filled with ice, which must be carefully melted out while the *strahlers* hang precariously from ropes. Those guys sure earn their money. Anyway, thus far, Jean-Franck has removed dozens of cabinet-size pieces as well as smaller ones, enough specimens to cover a couple of eight-foot tables. And he has yet to reach the back end of the cavity, so there may be more glories yet to come. The pink fluorite crystals reach 4 cm across and are generally frosty and rather corroded, with a soft medium-pink color. Fine, lustrous smoky **quartz** is associated, including some well-formed gwindels to perhaps 10 cm across.

The Madagascar dealer Frédéric Gautier (*Little Big Stone,* littlebig.stone@netclub.mg) has been working a pegmatite near Andilamena, Toamasina (Tamatave) Province, Madagascar for about three years now, but only recently encountered a great rarity: white Japan-law quartz twins capped by **amethyst scepters.** The spans across these twins measure from 3 to 12 cm, and many are markedly flattened as is typical for Japan-law twins. Around 60 good to excellent specimens have been recovered, plus another 90 or so second-rate pieces. The luster on the amethyst scepter-ends is very bright and the specimens have been professionally collected, so damage is minimal. Clusters of twins have also been found.

For fans of the radioactive minerals (but how do you get them past Homeland Security?) the Severino/Celmira dealership (severcel.pedras@terra.com.br) had several flats of bright yellow and green

Figure 18. **Jean-Franck Charlet's spread of pink octahedral fluorite on smoky quartz, all from a single, recently discovered (still unfinished!) alpine cleft on Mont Blanc, Chamonix, France. Wendell Wilson photo.**

meta-autunite and uranocircite from Aideia Nova, Satau, Portugal. The thumbnail to cabinet-size specimens are encrusted with brightly colored layers of crystals up to about 3 mm.

Marcus Grossmann (info@the-mineral-web.com) brought six large and attractive **aquamarine** crystals (simple hexagonal prisms) from Taplejung, Nepal. The sharp, gemmy, lustrous crystals are 10 to 15 cm long and perhaps 2.5 to 3 cm across, with a rich blue color (all were purchased by Bill Larson). Marcus also had an extremely fine hamburgite miniature from the old Hyakule mine in Nepal, which has been closed for more than 20 years. The colorless, bladed crystals are sharp and transparent, and reach about 4 cm in length.

The Xianghuapu mine in China has been pouring out green **fluorite** specimens literally by the ton lately, and numerous Chinese dealers had them at the show. Most specimens are big clusters, usually 15 to 30 cm across and sometimes larger, and most are free of matrix. The crystals are cubic with minor edge modifications, have a brilliant luster, a high degree of transparency, and a really beautiful apple-green color—though you might want to give them the sniff test if you suspect oiling. The crystals do tend to be rather intergrown, and it is difficult to find specimens with more individualized crystals. Miniatures are virtually non-existent because the crystal size is so large, typically 4 to 8 cm on edge. The quantity of these available is really overwhelming, but one must remember that that simply means an excellent selection to choose from; in due course these will fade from the market, and the best ones will be treasured, so don't be put off.

We'll conclude the minerals here with an interesting lot of **colemanite** specimens Rob Lavinsky obtained at the show—about ten fine cabinet-size specimens and ten good miniatures, plus around 60 lesser pieces. You would not readily recognize these as the typical California colemanite—they are actually from Mustafakemalpasha in Western Anatolia, Turkey. Unlike the California specimens, these are a very dark, rich, gemmy brown color with what I am tempted to call an adamantine luster, so bright are they. The crystals take the form of slightly distorted pseudo-octahedrons and could almost be mistaken for scheelite. Although the individual crystals rarely exceed about 1 cm across, they solidly cover the cavity linings in a very brilliant show of luster, gemminess and color. Some collectors tend to avoid evaporites, but these are remarkably unusual and attractive specimens. They should be fun for playing the "what is it" game when visiting, supposedly knowledgeable collectors come to see your collection.

For those collectors who also specialize in antique mining lamps and mining memorabilia, there was only one place to visit at the show: the booth of Detlev Seel (www.mininglamps.de). Detlev is one of the major dealers in Europe for such things, and has a large ever-changing stock focusing especially on safety lamps, frog lamps and European carbide lamps. He even had a *Barte*, one of those medieval miner's parade axes with the engraved ivory handle and distinctively shaped blade.

All in all, it was a very easy-going and convivial show. Renato and Adriana Pagano, our Italian representatives from Milan, faithfully manned our *Mineralogical Record* booth (and also had some minerals to sell). The Keilmanns were the perfect hosts as usual. The food and beer were good (not just at the show but, of course, throughout Munich) and, as I said, the weather was blissfully warm and blue-skied. Shopping for souvenirs and clothes in Munich is always enjoyable, and one should always save time for a walk through the long and picturesque *Englischer Garten* (designed by an expatriate Englishman in the 18th century). The 73rd annual Munich art and antique show, a vastly smaller affair than the mineral show but very high-quality, took place the same weekend, as usual (though at a new location, the Paulaner Garten on Nockerburg Strasse). And there are museums galore to visit in Munich—this time we took in the Jagdmuseum (a museum devoted to medieval hunting) and the Alte Pinakothek where the Old Masters reside. All can be reached easily through the clean and efficient subway system.

Next year Keilmann's special theme for the show (November 3–5) will be "Masterpieces," specifically the donation of major private collections of mineral masterpieces to public museums over the centuries—with scads of fine specimens on loan from museums throughout Europe and the United States. Such donations must be encouraged, Keilmann says, because most museums these days can no longer afford to purchase top-quality specimens, and so must depend upon the philanthropic generosity of the wealthy private collectors. It should be a spectacular and historically rich show. ⊠

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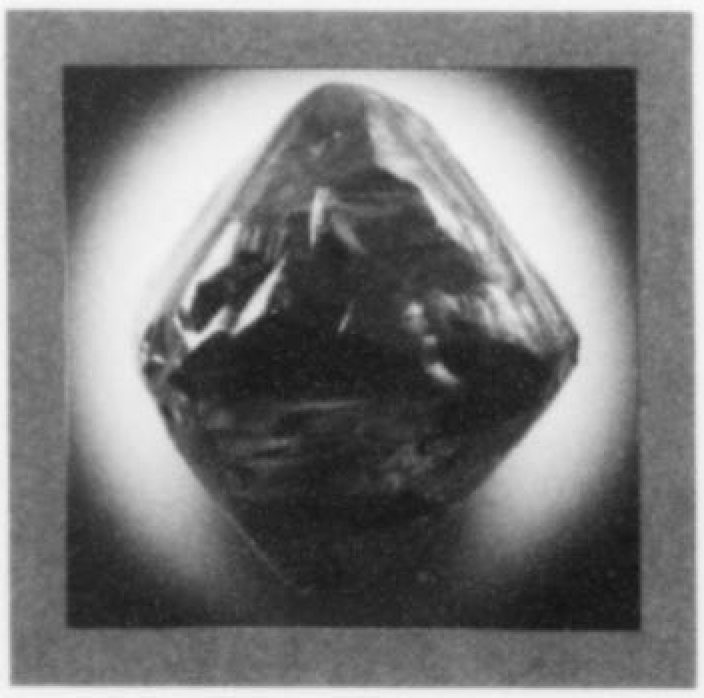

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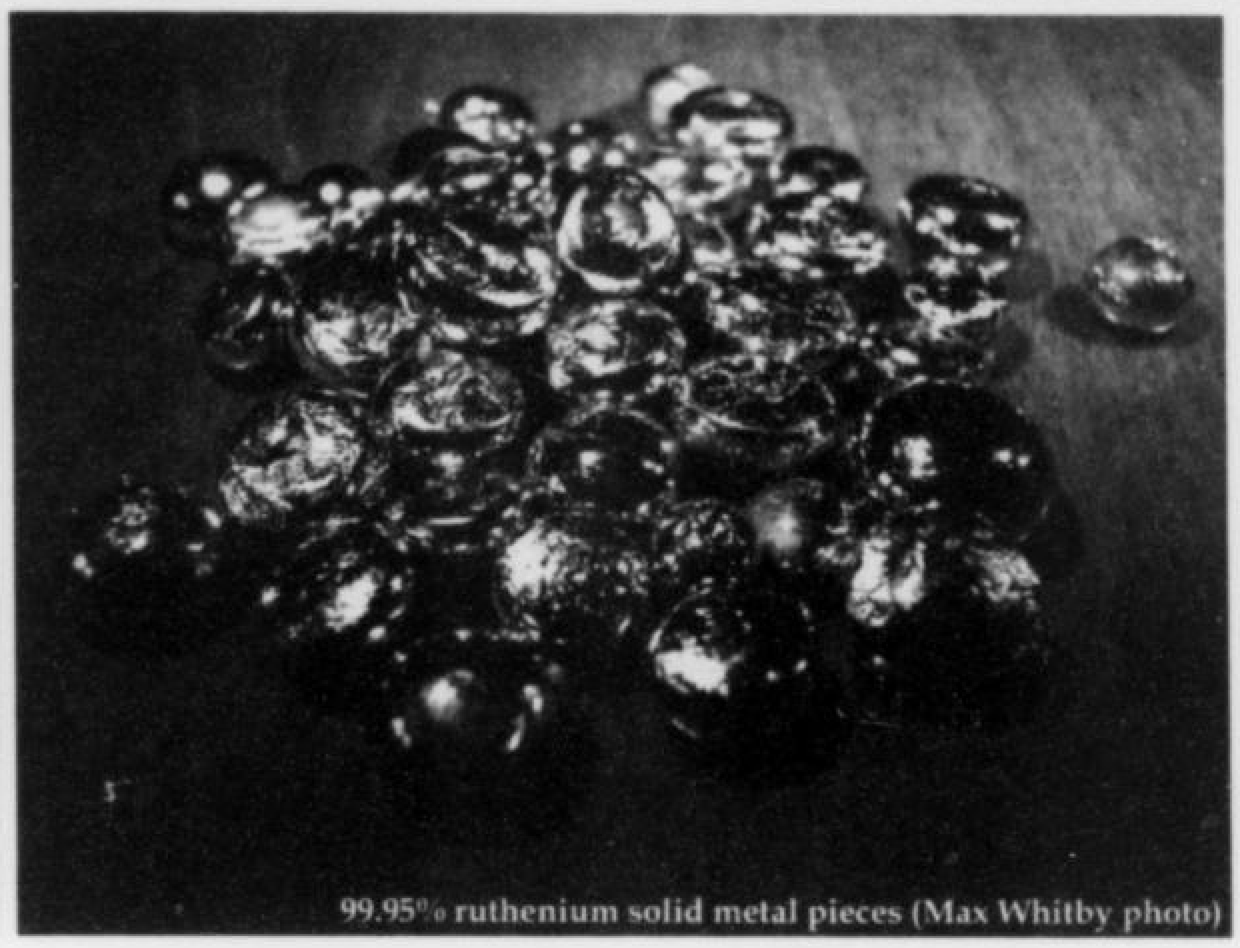

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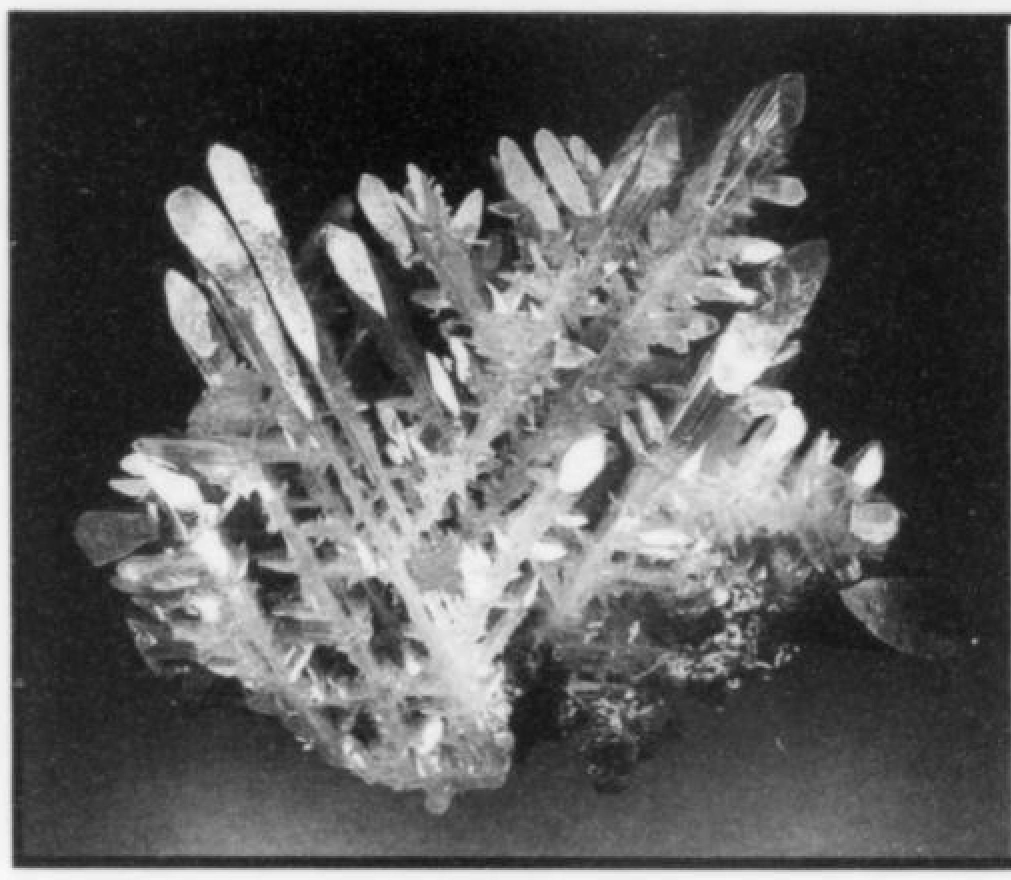

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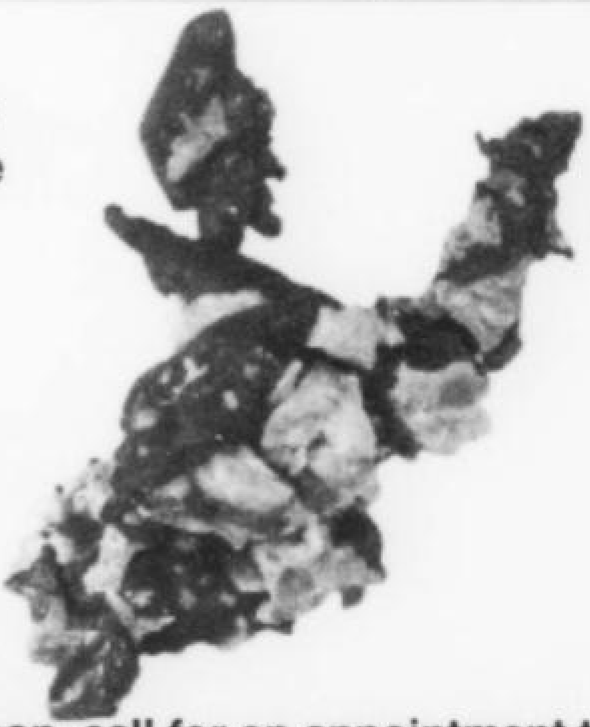

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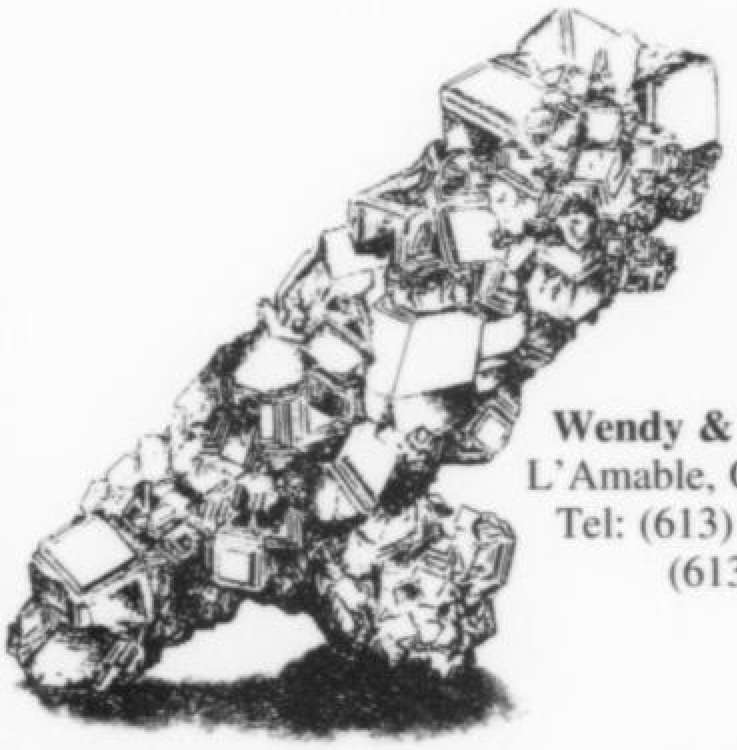

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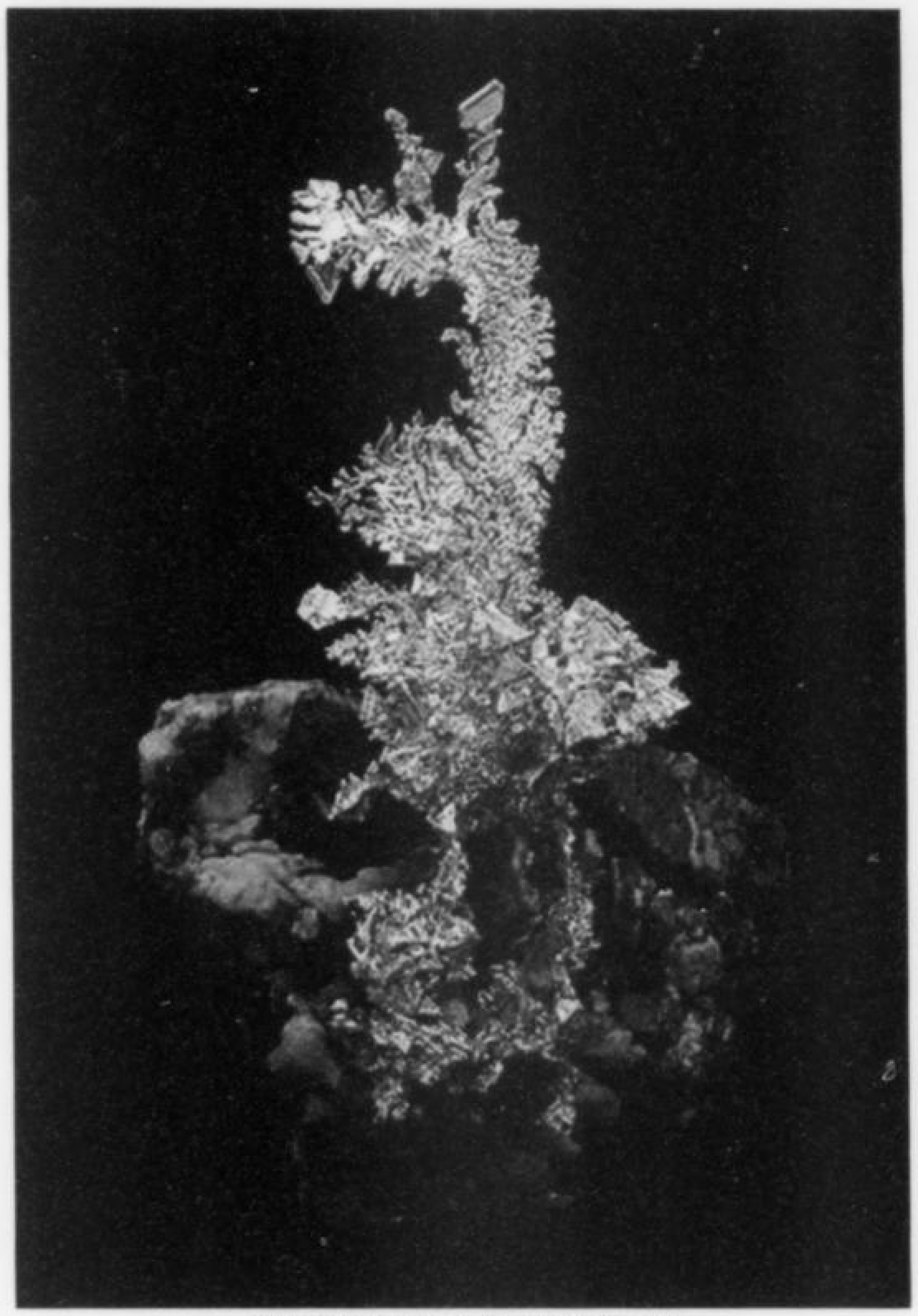

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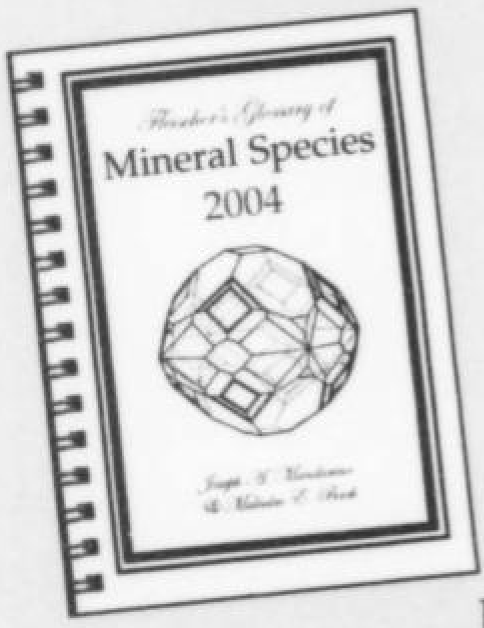

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Masterpieces of the Mineral World

A new book published by the Houston Museum of Natural Science, featuring the treasures of the mineral collection. Distributed by the Mineralogical Record.

Written by **Wendell E. Wilson**, editor-in-chief and publisher of ***The Mineralogical Record***, and **Joel A. Bartsch**, president of the Houston Museum of Natural Science, with **Mark Mauthner**, associate curator of gems and minerals.

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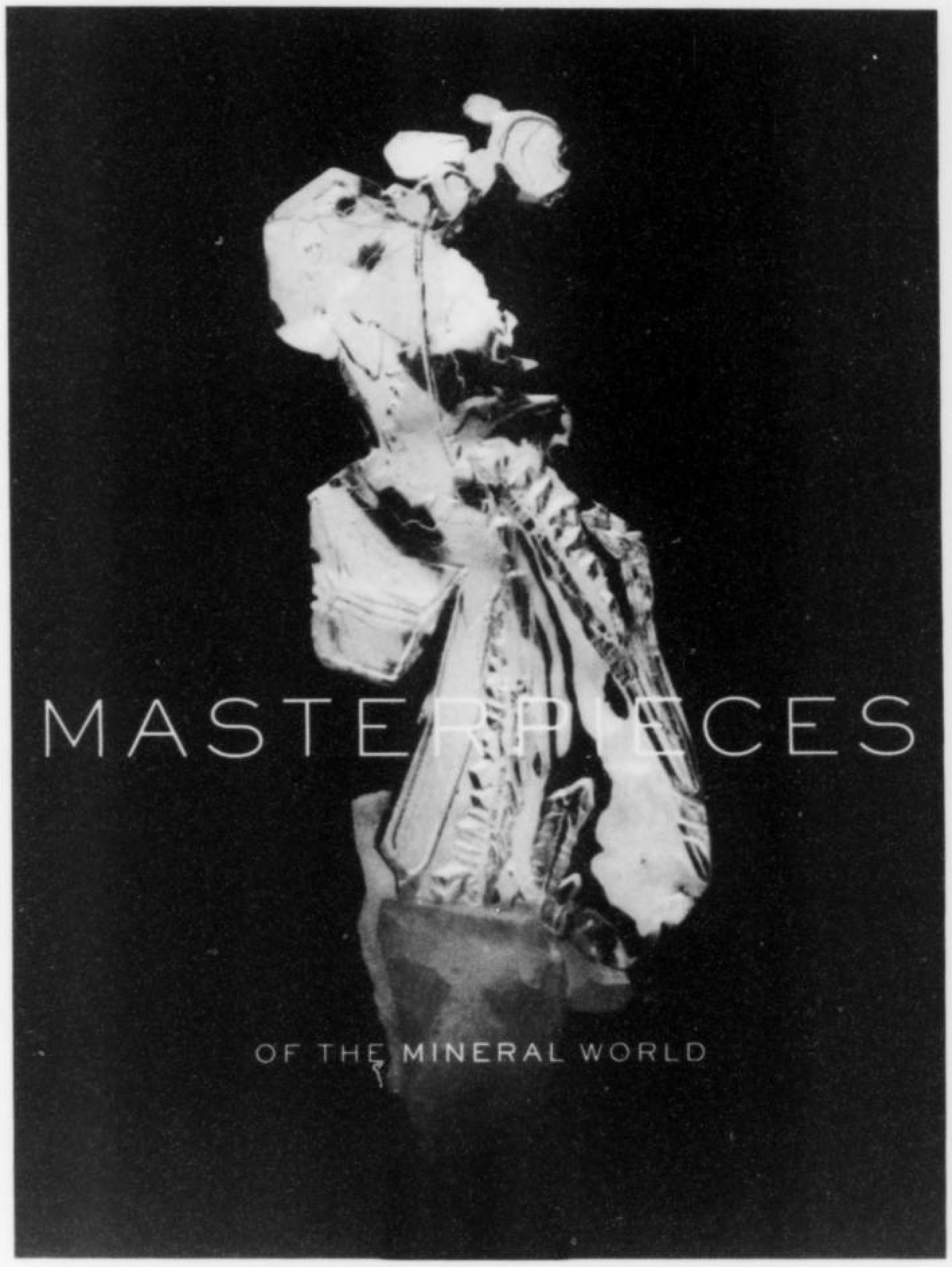

The magnificent mineral collection housed in the Houston Museum of Natural Science is among the finest and best known in the world. Now the treasures of this unique repository are shown in beautiful full-page photographs that will seduce both the connoisseur of beauty and the student of natural history. The spectacular and rare specimens on display here, from a huge imperial topaz weighing more than 2,000 carats to a 6.8-cm phosphophyllite crystal and crystallized gold clusters that are among the most highly coveted objects in the Mineral Kingdom, are true masterpieces, like the Rembrandts and Van Goghs of the natural world. Prized for their rare aesthetic qualities—their highly developed luster, color, size, and sculptural composition—as well as their often exotic provenances, these specimens have come to the museum from elite private collections such as that of Perkins and Ann Sams, and a remarkable, enormously valuable (anonymous) private collection just recently acquired. The majority of the specimens pictured have not been previously published, and many of the others have been rephotographed. All are accompanied by much more background information than was provided in the 1992 Houston Museum Supplement to the *Mineralogical Record.*

An introduction to the museum, its history and its collection is followed by an analysis of connoisseurship ("The Discerning Eye—What makes a mineral collectible?"). The history of aristocratic mineral collecting, from the 16th to the 20th centuries, is recounted ("A Royal Passion"). Eighty full-page color plates show the breathtaking highlights of the museum's collection, with each specimen described in full, its aesthetic qualifications analyzed, and its locality of origin described, often with interesting historical sidelights. Finally, a Selected Bibliography points the reader toward additional reading.

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Letters

Troost's Diamonds

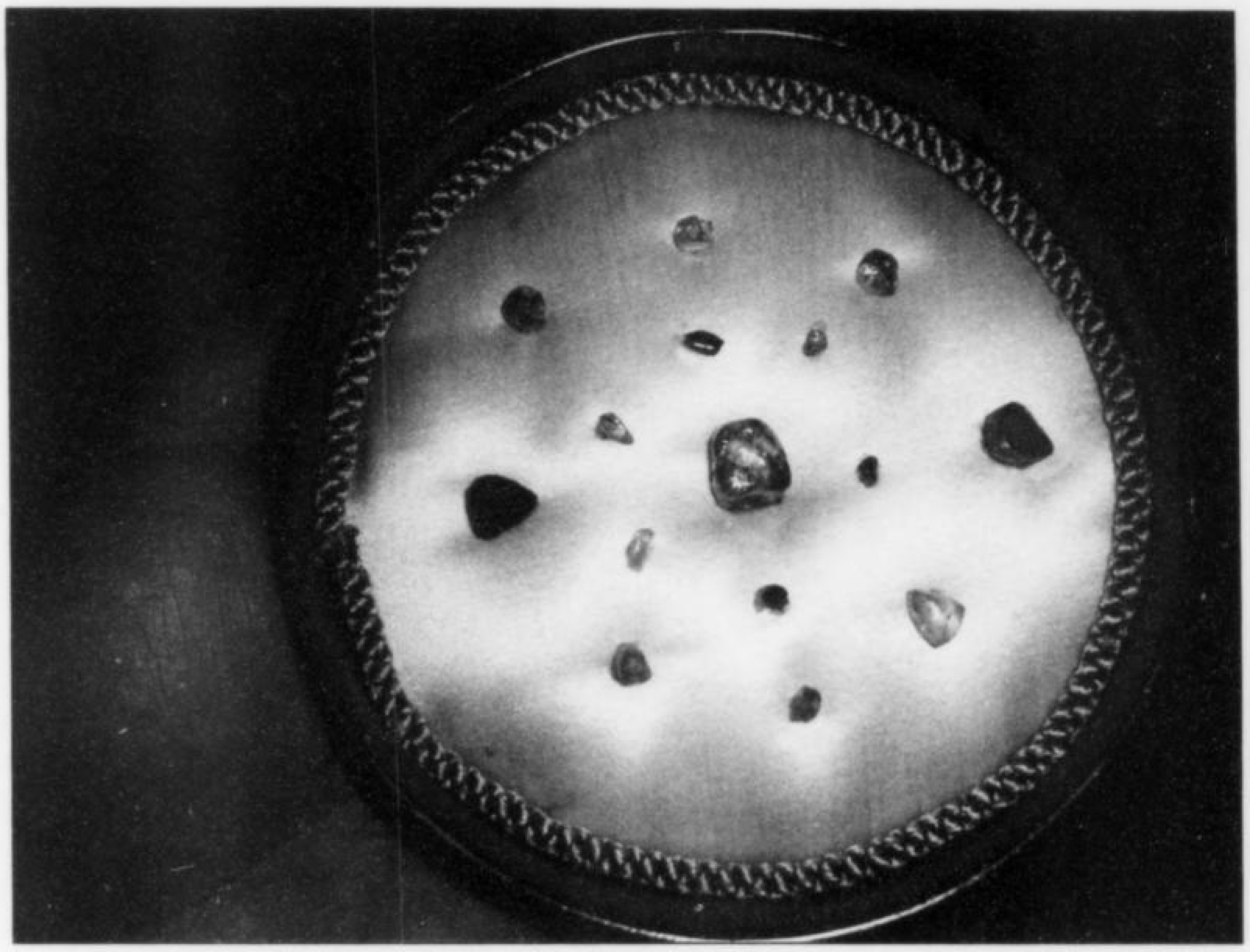
Thomas Moore's article on *Diamond Crystals* (v. 33, no. 1) mentions several historical collections containing diamonds. Gerard Troost (1776–1850), was a prominent early 19th collector in the U.S. His collection has been part of Louisville, Kentucky's history since the 1870's and is now part of the Louisville Science Center's collection. A review of Troost's extensive catalog indicates that he had 13 diamond crystals in his collection—all from Brazil—out of a total of about 13,000 mineral specimens.

About 25 years ago, a small number of Troost's most prized specimens were found locked away in a forgotten safe in the basement of the Louisville Free Public Library. Among the specimens are the best early 19th century gold crystal from Lumpkin County, Georgia and a matrix specimen of Emerald from Columbia that dates back to late 18th century. Both specimens have previously been illustrated in *The Mineralogical Record* (vol. 15, no. 3), in an article I wrote on Gerard Troost and his collection.

A collection of diamond crystals was also found in the safe, and they are most certainly part of the Troost collection as well. The specimens have not yet been studied sufficiently to match them all to specific catalog descriptions. But the largest (in the center of the photo shown here) is probably the 8-carat uncut diamond described by Troost in the following catalog entry:

> 12713 Diamond. It is a modification of the octaedron. Probably a combination of two octaedrons; the faces being convex the precise crystalline form can not be determined. It is a fine colorless diamond. It weighs 8 carats, at $20 pr carat - This diamond, assuming the price for which the diamonds are received by the Brazilian Government would be worth £128 about $640. From Brazils. Heuland $160.

This specimen, along with eight others that follow in the catalog, were probably all purchased from Henry Heuland in the 1840's.



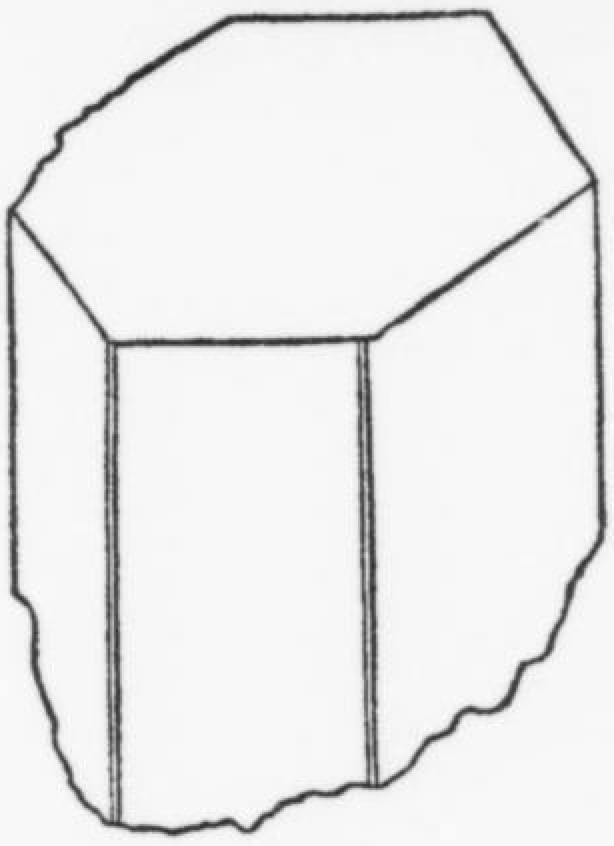
Gerard Troost's diamonds

I thank Scott Alvey of the Louisville Science Center for the photo accompanying this letter.

Alan Goldstein
Louisville, KY

Devonshire Collection

I recently passed a 10-hour journey, in the back of a minivan, that was thoroughly enjoyable because it gave me the opportunity to reread the May-June 2005 issue, particularly the article by Mick Cooper on the Devonshire Mineral Collection. This led to a small discovery of possible interest. I have acquired through E-bay a copy of an old mineral book, *Mineral Riches of the Earth* (1861), "carefully compiled for the American Sunday School Union, and profusely illustrated." As Cooper said, the Duke's Emerald "has been illustrated several times . . ." and one such illustration appears in this book, published four years prior to the earliest reference mentioned in Cooper's article—King (1865). The text reads: "A very large [emerald], weighing eight ounces eighteen pennyweights, is in the possession of the Duke of Devonshire. It came from Granada, and is two inches long and two and a quarter inches in diameter. Here is a drawing of it."



My thanks to the *Mineralogical Record* staff for producing such a wonderful magazine. I tell my family that the day the new *Mineralogical Record* arrives is "the happiest day of the month."

Darryl Powell
Manchester, NY

Correction

In the Clear Creek mine paper, the distance between the upper and lower workings was stated to be 100 meters; that should instead be 1,000 meters.

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