THE MINERALOGICAL RECORD

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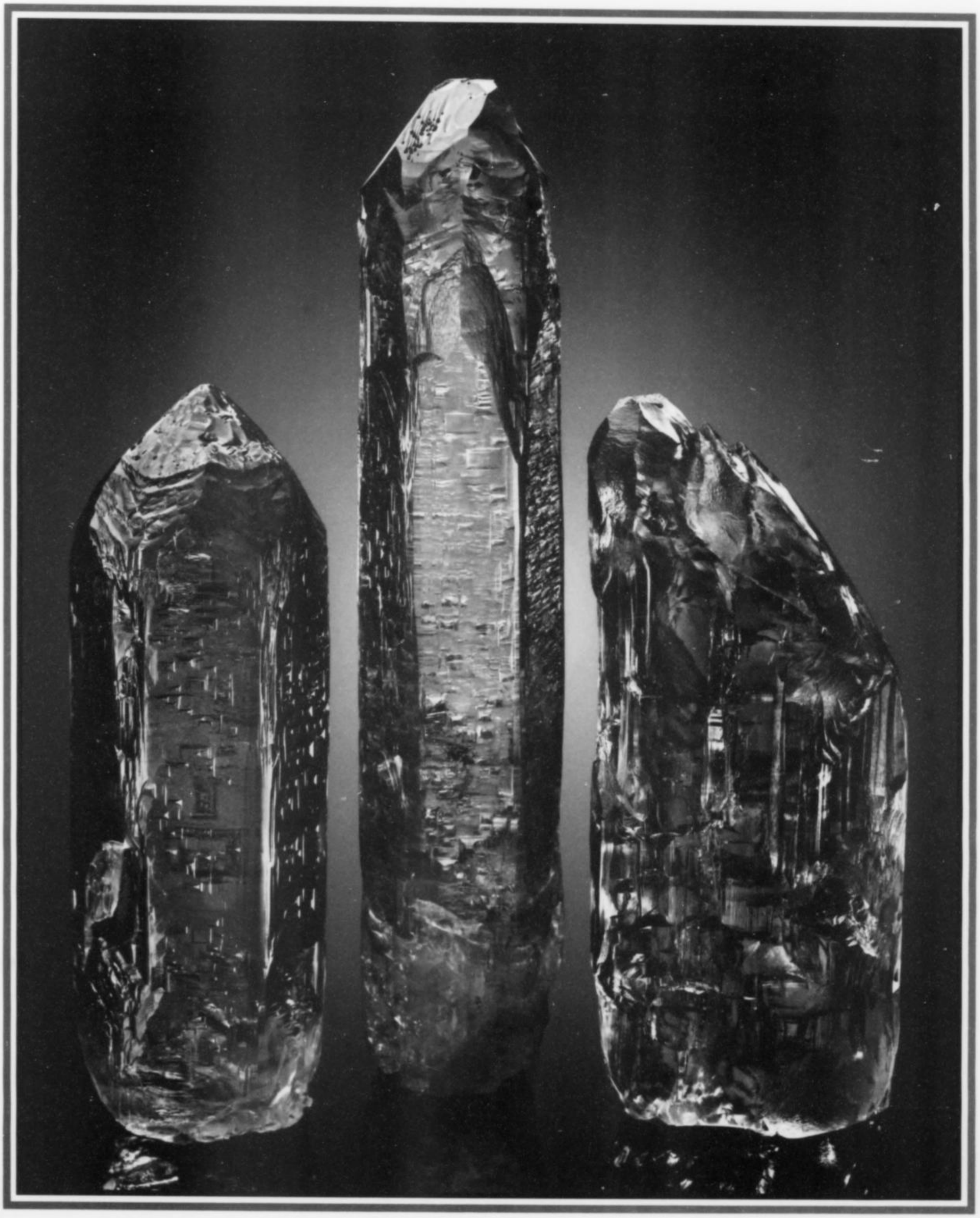

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The
Mineralogical Record

The International Magazine for Mineral Collectors

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Articles

Columns

This issue was made possible in part by contributions from Philip G. Rust and the Endowment Fund of the Fellows of the Mineralogical Record

COVER: BERYL crystals, 14 cm, 20 cm (called the "Dnieper Rocket"), and 14 cm, from Volodarsk-Volynski, Ukraine. See the article on this locality beginning on page 473. The left crystal and the central crystal are from pegmatite no. 576, near shaft 6. The crystal on the right is from a mid-1990s pocket near shaft 2. The central crystal is in the Marco Amabili collection; the other two are from the Daniel Trinchillo collection. James Elliott photo.

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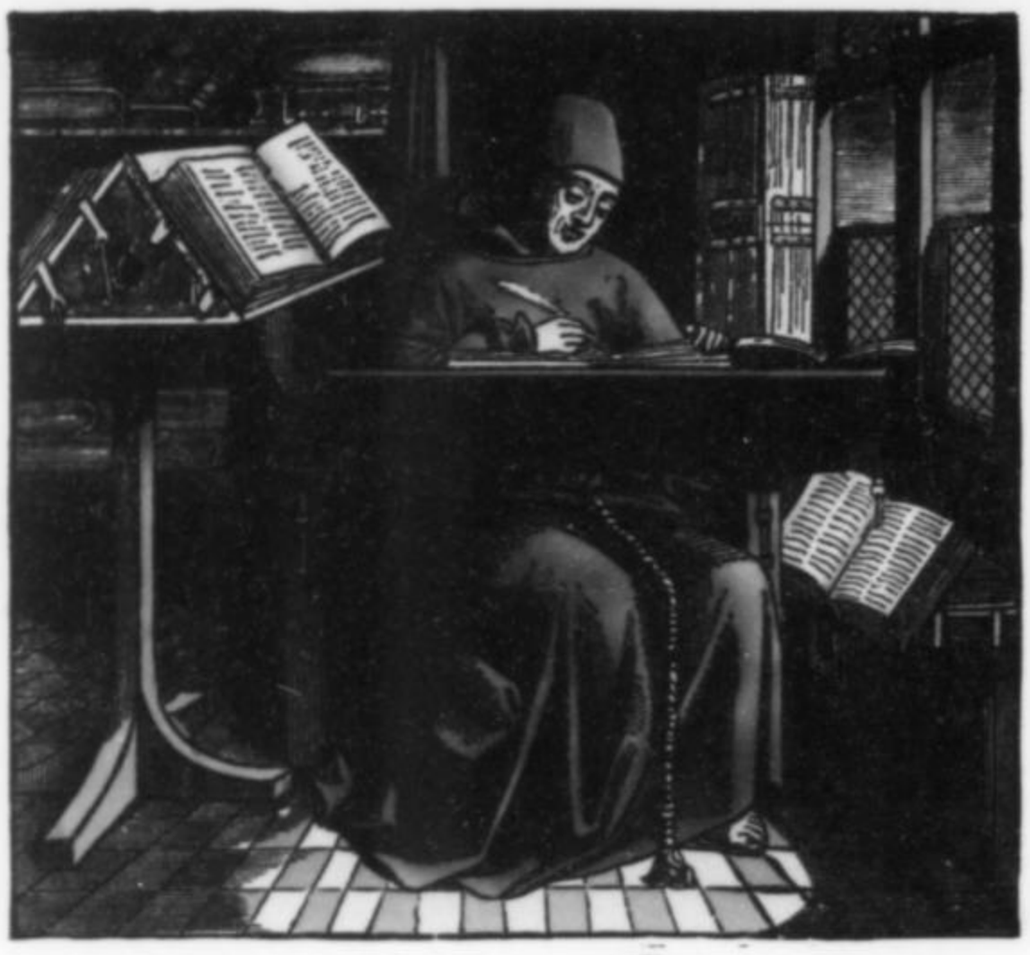


Notes from the Editors

Rocks & Minerals Magazine Sold

Heldref Publications (part of the non-profit Helen Dwight Reed Educational Foundation) has announced that it has sold its entire stable of 37 magazines and journals (including *Rocks & Minerals*) to Taylor & Francis, a for-profit UK-based publishing company. Taylor & Francis currently publishes over 1,500 technical journals. The decision to sell was arrived at "after a long and detailed assessment of industry trends and realities."

Founded in 1926 by Peter Zodac, *Rocks & Minerals* was acquired by Heldref in 1975 following the death of its founder. Current editor and Carnegie Mineralogical Award recipient Marie Huizing joined the magazine in 1978 and is being retained by Taylor & Francis.

The Helen Dwight Reid Educational Foundation (and Heldref Publications) will continue as a non-profit, educational institution. However, it will be restructured and renamed, with a mission that will pay tribute to the work and legacy of two of its founders, former United Nations ambassador Jeane Kirkpatrick (who died in 2006) and her husband Dr. Evron M. Kirkpatrick (who died in 1995), in the areas of public diplomacy, democratic development, and the protection of human rights.

Free Digital Library

An announcement made at the end of the August 3 "what's new in the mineral world" installment on our website is worthy of repetition here. In fact it's worthy of some elaboration, since what is involved is an enormous quantum leap forward in the dissemination of information in our field of interest (and since there is such a sweet deal to be had here by the bibliophiles and scholars among us). Joseph O. Gill, once Director of Jewelry for Sotheby's Auction House, North America, has just finished several years of hard work dedicated to building an electronic "Gem and Mineral Research Library," and now he is making this Library available FREE to anyone who'd like to have it on a hard drive or laptop.

There are two parts to the Library. The gemstone part, 5 gigabytes, contains more than 200 fully scanned books on gemstones with dates from 1652 to 2009, including classic texts by Robert Boyle, John Mawe, and George F. Kunz, and including all of the journal *Gems & Gemology* for the years 1934–1980. The mineral book collection, 3.9 gigabytes, holds about 160 books, from the 1556 first edition (in Latin) of Agricola's *De Re Metallica*, through Sowerby, Agassiz, Dana, Sinkankas, Pough, etc.

The copyrights of most of the Library's PDF text files are held by Microsoft and Google, who only allow FREE distribution: these digital texts are never to be sold, but that's fine with Mr. Gill, whose purpose is to see the Library disseminated as widely, quickly and effortlessly as possible. If those who have it pass it along to others, who pass it to others, etc., the Library soon enough should be living on (as Gill puts it) "over 100,000 laptops." As printed copies, the books in the accumulation would take years of effort and much expertise to collect, and would be worth more than a million dollars. But to get them all FREE in easily readable, searchable, digital form, you can make an appointment to have the Library copied to your computer by Mr. Gill's friend Marc Jobin at mj3inc@aol.com. For other questions, contact Joseph O. Gill by email at gilljoseph1949@yahoo.com; see also the website www .Worldglobetrotters.com.

Why Police Need to Know Mineralogy

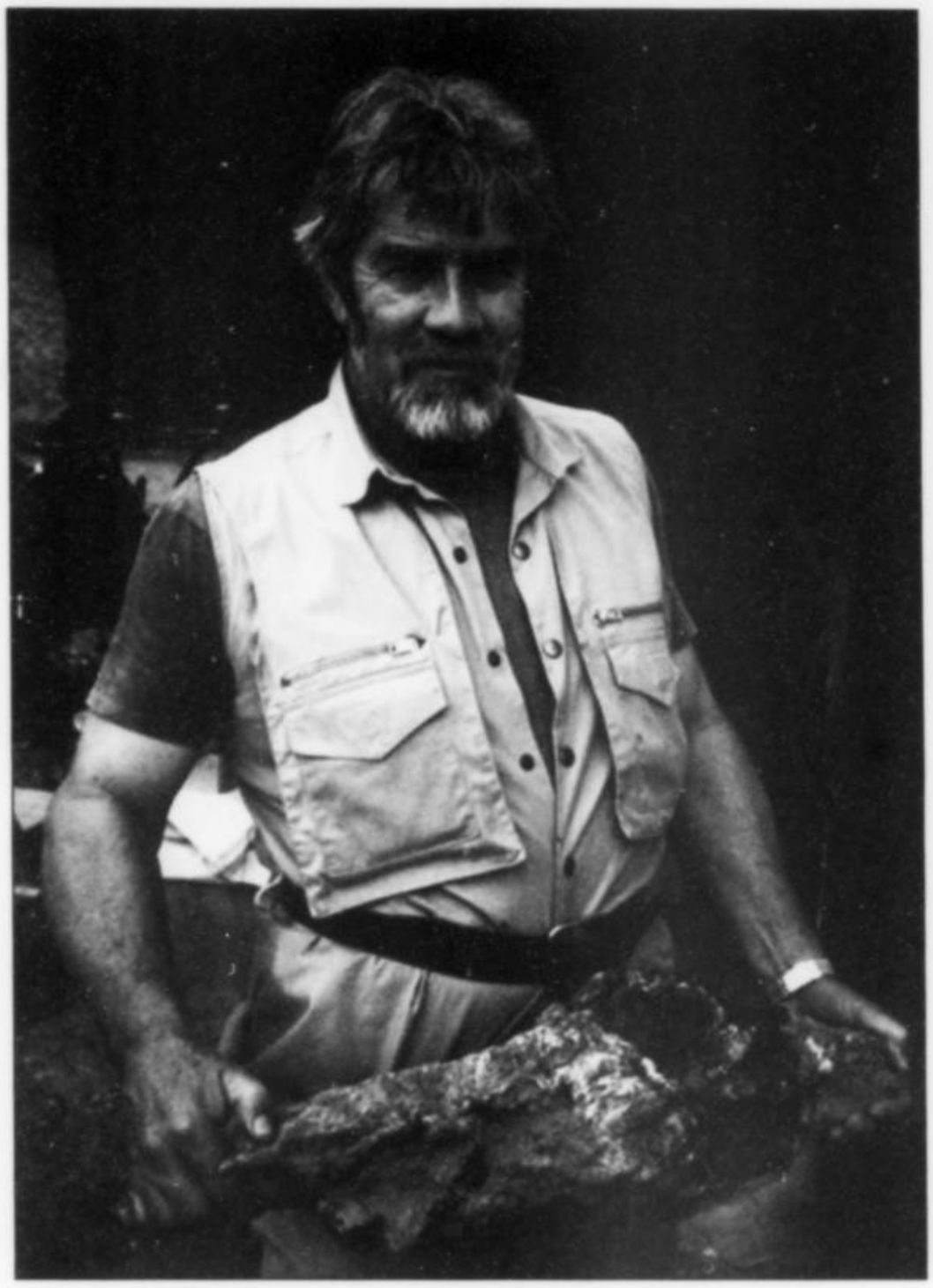
On June 12 Elvira Zatarain, a 49-year-old Tucson mother of two, was stopped for a minor traffic infraction by a Pima County Sheriff's Deputy while driving home from work. The deputy conducted a field sobriety test, but there was no sign of intoxication. He asked if there were any illegal substances in the car, and she said there were not, giving him permission to search her car and purse. In her purse the deputy found a vial of small crystals which he suspected to be methamphetamine ("crystal meth"). So he handcuffed her and placed her in the back of his patrol car while he conducted an on-site test of the crystals. The test proved negative. So you would think that would be the end of the story, but instead the deputy decided he needed to get tough with this woman: he arrested her on suspicion of "possession of an imitation controlled substance"!

Elvira was subsequently offered a deal if she would plead guilty to the charge: she would have to pay a $130 fine and submit to drug counseling. However, she elected to decline this generous offer, saying that there was nothing sinister about the crystals and that she never used drugs. Consequently she was scheduled for a court trial where, if found guilty, she could be subject to a higher fine (not to mention the cost of an attorney to defend her).

Intelligence finally prevailed somewhere in the legal system. The case was dismissed after it was determined that the alleged "imitation controlled substance" was actually tiny quartz crystals (probably "Herkimer diamonds") given to her by a psychic in order to ward off evil. Apparently Elvira had neglected to read the package insert: "Not effective against ignorance." Still, if I were Elvira, I would ask that psychic for a refund.

Died, Campbell R. Bridges, 71

On August 11, 2009 the gem and mineral community lost one of its true legends. Campbell Bridges, pioneer British geologist and gem miner, was ambushed and killed while returning to his mine near Tsavo in Kenya. His son, Bruce Bridges, and two of his



Campbell R. Bridges (1937–2009); Peter Keller photo, 1982. Bridges is holding a rock specimen containing a tsavorite nodule.

employees were wounded in the fight. The attackers, a gang of 20 or more Kenyan bandits allegedly funded by a local politician and organized by gangsters, had been trying to seize control of Bridges' lucrative gem mining concessions. The unlicensed miners had been illegally digging for gems on the family's 6-square-km concession (2–3 km from the Scorpion mine) for the last three years, and had made numerous death threats against Bridges. The identity of the assailants is known, and at least one arrest has been made in connection with the attack.

Campbell Rodney Bridges was born in Kensington, England, on August 25, 1937, the son of Barbara (Carswell) and Rodney Bridges, a British geologist for the Central Mining Investment Corporation in South Africa. Barbara was from the Scottish Highlands; her family was of the Star Shipping Line. Campbell discovered his first amethyst at the age of six, and had an endless love for gemstones and the African continent. He collected minerals and gems throughout his life, and built an extraordinarily fine African gem collection.

Campbell was educated in South Africa, where he attended Hilton College and earned a BSc degree in Geology from the University of Witwatersrand. After working in South Africa and Zimbabwe he began his geological explorations in Tanzania, and gained fame for his discovery of the new gem grossular variety tsavorite in 1967. In 1968 he was among the first to bring tanzanite to the United States for identification by the GIA Gem Trade Lab in New York. When his mines were nationalized by the Tanzanian government, he went looking for similar geology over the border in Kenya, and by 1970 he had discovered and developed his now-famous tsavorite operations in the Taita Hills near the game park for which the gem was named.

Campbell worked very closely with Tiffany & Company, and in 1974 Tiffany's ran a full page ad in *The New Yorker* magazine promoting the new East African gemstone, tsavorite, using Campbell as their focus. He was also featured in *Life* magazine in its article on the discovery of tanzanite in 1969, and, over the years, has been honored internationally for his work. He has held many offices in gem trade organizations: Founding Chairman of the Kenya Chamber of Mines, Vice Chairman of the Kenya Gemstone Dealers Association, and a founding member of the International Colored Gemstone Association, serving on its Board of Directors, as Chairman of Mining Africa. Campbell was generous about sharing his passion for gem mining in Africa. He was frequently on the "speaker circuit" and wrote many articles for the various gem and mineral journals. His publications and lectures around the world are far too numerous to note here (but they are listed on his website, www.tsavorite.com). One of his little known talents, however, was as a composer of songs and lyrics. You never knew just when he might share one with you.

Few of us who were fortunate to spend time with Campbell in his famous tree house overlooking the mining area will ever forget the experience. He was always aware of the dangers, not so much from the lions of Tsavo, but from the many poachers who were constantly after his property, or his gems. He was always trying new defenses and booby traps, including a deadly green mamba that guarded his gem rough. When he wasn't at the mine, he enjoyed telling stories about the leopards that shared his tree house in his absence. He set up very rough sporting games for his guards in order to keep them fit, and made certain that they were proficient with a bow and arrow. In the end, it wasn't enough to defend against the road block that was set up and the large number of attackers that assaulted him.

Campbell was also involved in many types of conservation efforts in Kenya which were rarely publicized; Campbell just "did it" without much fan-fare—his love of Kenya was that great. Here is a quote: "Campbell Bridges is a kindred spirit in conservation!" (Wangari Maathai, 2004, Nobel Peace Prize recipient).

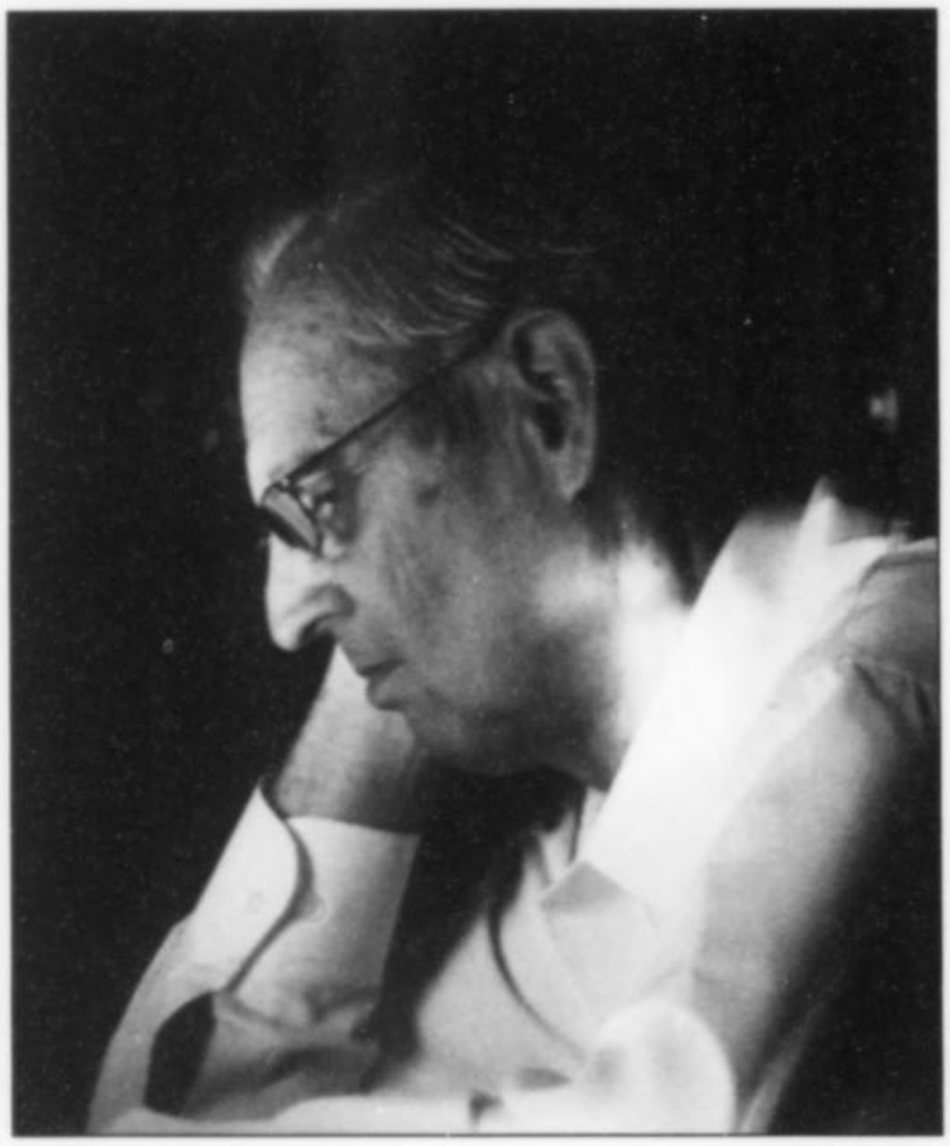
His is survived by his wife, Judith, daughter Laura (a law student in Chicago) and son Bruce. His son has worked side by side with him since graduating from college in the United States. Services were held in Nairobi on August 21st, followed by a good old-fashioned wake hosted by the International Colored Gemstone Association. Campbell Bridges was always, and always will be, larger than life, and we will all be richer for knowing him.

Peter C. Keller
Wendell E. Wilson
Dona Leicht

Died, Harold W. "Hal" Miller, 88

Harold William Miller was born in Walton, New York, in 1920 and died March 19, 2009 in Boulder, Colorado. After high school, he traveled in Germany and enrolled at the University at Marburg. After a year of study, however, he left Germany because of World War II. Hal received his B.S. in Chemistry from the University of Michigan and his M.S. in Chemistry, specializing in organic chemistry, from the University of Colorado. Hal was a member of Sigma Xi and maintained a lifelong friendship with Dr. Stan Cristol, his thesis advisor in the Chemistry Department of the University of Colorado. Hal always enjoyed learning and had a reading knowledge of several languages.

Hal was employed on the Manhattan Project, working in Buffalo, New York, Hanford and, later, at Rocky Flats in Colorado. He took on the task of historian for the group informally known as the "Buffalo 50" and related that up until 2006 only one co-worker had died—and not from a radiation-related cause.



Harold "Hal" Miller (1920–2009)

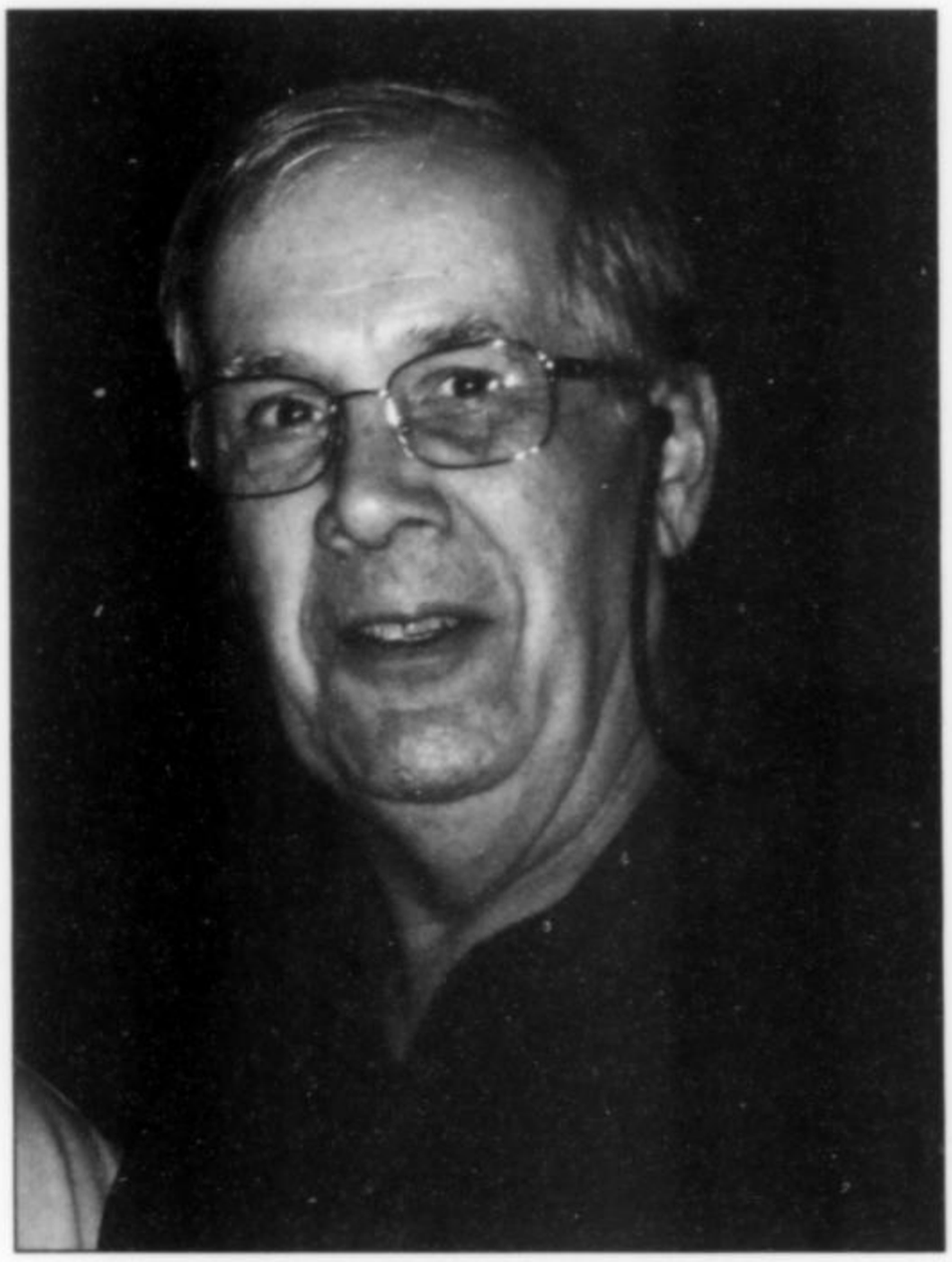
Hal's work focused his fervent interest in the chemistry of, and search for, the super-heavy elements that may be found in nature, an interest he pursued with other scientists for over 30 years. Hal was proud that he was able to furnish Glenn Seaborg with the first significant quantity of the element americium. Hal worked as technical director for several companies involved in the mining of rare-earth minerals and the refining of high purity rare-earth oxides in Wyoming and Colorado.

Hal was a dedicated mineral collector and donated a fine display of cabinet mineral specimens to the Colorado University Geology Department. He contributed two articles to the *Mineralogical Record*: one on rhodochrosite in 1971 and the other (with Richard Kosnar) on the minerals of the Colorado mineral belt in 1976. He cherished classic Colorado and Butte, Montana, mineral specimens. While working on secondary recovery of metals in smelter slag for Anaconda Copper Company in Montana, he befriended local miners and acquired mineral specimens from the local mines. Hal enjoyed telling about an end-of-shift miner finishing off a hearty restaurant meal with an order of apple pie. In loud indignation the miner complained to the server that the "hanging wall was pretty damn thin!" He commented that hard working miners of Butte intimidated restaurateurs sufficiently that their pies were served in quarter-pie cuts. The tradition of serving large slices of pie has continued at Hal's house.

In Buffalo, Hal worked with Charles "Mac" McMullen, and following World War II their travels took them to Colorado. Upon arrival, they climbed to the top of Sugarloaf Mountain, which provided panoramic views east to the Great Plains and west to the Continental Divide. Here Hal chose to locate his home, in the small mining community of Sugarloaf west of Boulder, Colorado. He constructed his south-facing log cabin home on the mountain above 8,200 feet. He hammered in the final nail, exclaiming "I own it!" His cabin home was always welcoming with a fire in the wood stove, large high-altitude cacti framing the view from the south window and a great library to stimulate conversation with his many friends.

Hal's dry sense of humor was a source of delight for many friends, miners and prospectors who enjoyed spending hours in conversations with him, and who valued his suggestions and advice. Hal welcomed everyone, with his German Shepherd always at his side.

Ralph Meyertons
John Muntyan
Burkard Oberle
Carl Swift
Jim A. Paschis



William J. McCarty (1941–2009)

Died, William J. McCarty, 68

There are people who are so special to you and they are always there to help in a quiet and confident way. For over 35 years "Willie" (as I dubbed him long ago) was our "go to" guy for answers, problem solving, computer mishaps and sharing a really fine sip of single-malt scotch. That we won't be able to do these things anymore saddens us deeply. He died suddenly on July 13, 2009.

Not everyone will recognize the name, but they will certainly recognize the extremely fine Arizona minerals that occasionally came out for display at Tucson or Denver. I first met Willie and his wife Roberta when they wandered into our shop in Laguna Beach after a referral from Dr. William Sanborn, from whom Roberta had taken a class while teaching at middle school. It seemed like an easy, instant friendship to develop and it has never wavered all these years later. You will remember they were always in our booth at various shows and it was Willie who had the electrical skills to keep us "lit" throughout the days.

William John McCarty (who always introduced himself and signed correspondence as "Bill") was born in Lakewood, Ohio on February 6, 1941, but raised in California and attended the infamous Hollywood High School. After high school he joined the Air Force and had numerous postings ending in Labrador doing radar and electronics work during his stint.

This was a self-taught man and I don't think there was a scientific subject that you could discuss with him that he didn't understand. Always with a new book doing research on whatever intrigued him at the time, he was our "quiet man" in the background. He was a wiz at computers early on—before they became a household item. It was Willie who got me my first "real" computer—a Lisa by Macintosh. I have been with Mac and Willie since then. He designed many custom programs for us and other friends and I still use them.

He worked in the aerospace industry until his retirement in 1998. He was with Perkin-Elmer, Corning and OCA Optical (basically one and the same company) and developed systems for telescopes, cameras for the first Mars orbiter, optics (think Hubble), color cameras for the space station and some other highly secretive stuff. His co-workers referred him to as "Mr. Wizard." Even after his retirement he still did some consulting work.

Willie always wanted to live in Arizona. A couple of years after retirement he and Roberta moved from Huntington Beach, California to a lovely home at the base of the Superstition Mountains. He was a photographer of great skill and I wish the world could see some of his work. (To that end, we will be posting some of his photos on the Kristalle website from time to time.) When we were on safari together in 2008 it was Willie who did the photography—the albums he put together for us are magnificent, including a very rare *daytime* photo of the elusive aardvark worthy of *National Geographic*.

He had varied interests including astronomy, fossils, photography, Arizona exploration and, of course, the minerals. Before minerals he seriously played with saltwater fish aquariums, and how could I forget my ride up Laguna Canyon with him in his beloved Austin-Healey? And many of you will remember Rufus, the wonderful standard poodle that used to sleep under our tables (hence, Willie's e-mail moniker: "canisrufus").

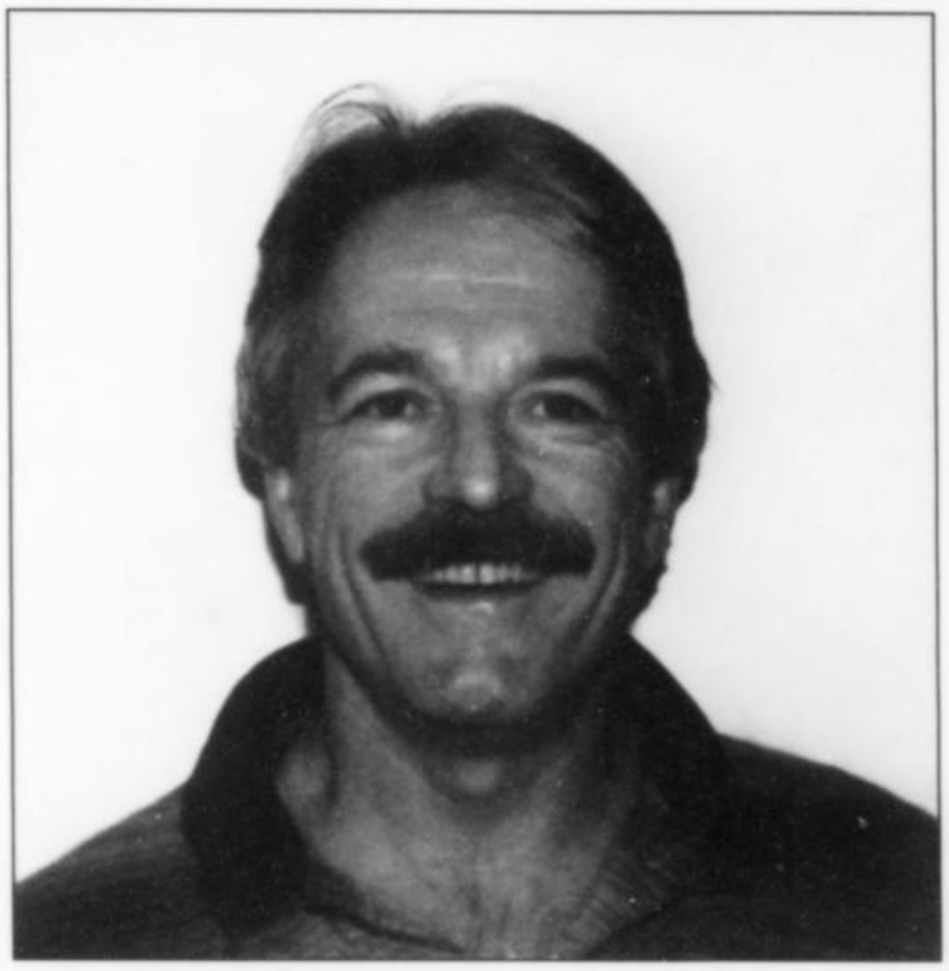
Willie and Roberta loved collecting Arizona minerals (Roberta is almost a native Arizonan) and their acquisition pace picked up after moving to Arizona. The collection consists of miniatures of sheer perfection with an abundance of localities represented. There are also some worldwide specimens; and the Arizona calcite with copper inclusions that was included in an earlier Tucson poster is exceptional.

Years ago, Willie and the late Richard Bideaux formed a wonderful friendship and they were often in the field together until Richard's death in 2004 (tragically, both of these wonderful guys died of cardiac failure). I imagine that Willie and Richard are somewhere together discussing something in depth that none of us would understand—I'll just sit quietly and sip my fine scotch with the greatest of memories.

Dona Lee Leicht

Died, Ken Gochenour, 62

Kenneth Lee "Ken" Gochenour, an adventurous self-reliant spirit with an uncanny ability for prospecting and mining gem pegmatites, succumbed to complications from malaria, leaving a large gap in the ranks of pegmatite miners. But pegmatites occupied his attention for only the last half of a life which reads like a script for an adventure movie. He was an independent scholar with a lifelong interest in Native American culture. He always taught that any field collector should thoroughly research the existing literature before making any serious attempt on a given prospect. He had an almost mystic appreciation of the environment and all its living things, and was known to have carried on a conversation with a rattlesnake in a friendly staredown. Ken was a restless intellect who taught himself the arts of guitar playing, leather crafting, gem cutting, prospecting and mining.



Ken Gochenour (1946–2009)

Ken was born November 9, 1946, the son of Virginia and Glenn Gochenour. Virginia taught elementary school for 35 years, and Glenn operated his own maintenance business. Ken grew up with his six siblings (he was the eldest of three brothers) in Orange County, California, where he was a top track-and-field athlete in high school. He was a Life Scout, a member of the Herpetology Club (he and his brother Dana had their own worldwide zoo in the backyard), the Surf Club, the Drum and Bugle Corps (played two different types of bugles), had his own garage band, and participated in a Native American dance troop for which he made his own dance costumes. He was also very good at sketching nature subjects, including mineral specimens. Restless at the age of 16, he dropped out of school in 1962 and with his guitar headed to Greenwich Village to be a folk singer. He returned soon to Southern California and started his own band, called The Meek. He eventually learned to play the banjo, mandolin, 12-string guitar, electric guitar and glockenspiel.

In 1966 Ken moved to the Haight-Ashbury district of San Francisco, where he continued to perform as a musician, and supported himself as a leather craft artist. In a rescue-and-support role for wayward youth, he distributed food which he solicited from grocery stores and restaurants. This lasted until the district was taken over by the hardcore drug culture, which disgusted him. After several buying trips to Gallup, New Mexico for leather supplies, Ken decided to move there. While in Gallup he learned the art of silversmithing and stone cutting in the Navajo style. His interest in Native American cultures, and their religious beliefs and practices was rekindled and continued throughout his life.

The historic gold rush-era mining town of Central City, Colorado became Ken's next home in 1971. He opened his first retail store there in 1975, called The Blue-Eyed Cherokee, where he produced a line of silver and turquoise jewelry. His brother Dana joined him, having sold his Austin-Healey to buy turquoise rough. Unfortunately the gas crisis of the mid-1970s stalled the retail business of the tiny tourist-dependent town and Ken was forced to close his store. He returned to his Southern California roots in 1976.

His reading of John Sinkankas's *Mineralogy for Amateurs* and other books about gems, minerals and mining inspired him with the idea of actually self-collecting and preparing the gems for his jewelry. In 1979, he leased the Fano-Simmons mine near Anza in

Southern California, and began his prospecting and mining career. His work there, along with the tutelage of his friend Al Ordway (1935–2007), was a lesson in how to mine pegmatites. He discovered new productive pockets yielding several fine 10-cm aquamarines, and his mineral passion was ignited. The Fano experience was the start of a series of successes: Cahuila Mountain in 1981 for beryl, tourmaline, axinite and quartz; the Collier Creek mine in Arkansas for quartz and wavellite; and the Black and Blue mine in 1988 in Harris Park, Colorado for amazonite, smoky quartz and topaz. At first sharing booth space with Bart Cannon in 1981, Ken began selling his mineral specimens in the Tucson shows. In 1999, after searching for five years, he and his brother Dana rediscovered a corundum deposit in the San Jacinto Mountains near Palm Springs, based on an obscure locality reference Ken found during literature research.

Ken married and settled in Healdsburg, California (Sonoma County) and opened a gallery called The Tomb in 1990, where he created and sold a line of Egyptian-revival jewelry. And during their six-year marriage his wife, a caterer, taught him to be an excellent cook.

Ken turned again to prospecting in 1996, and for the next few years he traveled from prospect to prospect, finding herderite in Cooper Canyon in Riverside County; Japan-law quartz twins near Patagonia, Arizona; amethyst in the Kingston Mountains, California; and quartz scepters on Peterson Mountain, Nevada. A dedicated field collector, he mined specimens from many other localities, most of them unknown in today's market. He made three trips to Africa with his partner, Frank Locante, looking for gem rough in Tanzania, South Africa, Namibia and Madagascar. It was in the latter country that he contracted malaria in 1999, a disease which ultimately claimed his life at the young age of 62 on April 24, 2009.

Ken retired periodically to his family ranch near Bly, Oregon on the edge of the Sycan Marsh to recuperate after he contracted malaria, but then returned to Southern California in 2003 when his brother Dana called him to work an important pocket at the Cryo-Genie mine in San Diego County. It was at the Cryo-Genie that Ken applied the techniques of an archeological dig to mining pegmatite pockets, carefully bringing out mapped, sorted and numbered pieces in pails from the pockets in the sheared pegmatite. The little Cryo-Genie team then reconstructed the cleaned pieces from each mapped pocket in their Anza workshops. This resulted in the recovery of two large polychrome tourmaline pockets, with much feldspar and quartz and a host of other minerals, including beryl. After his stint at the Cryo-Genie, he returned to his Oregon ranch where he mapped the archeological evidence of ancient villages and campsites bordering the Sycan Marsh.

In addition to his love of exploring, Ken Gochenour possessed an inquisitive and restless spirit and could easily have been an academic researcher and teacher. He gave many talks to mineral and gem organizations, including the Friends of Mineralogy and the Mineralogical Society of Southern California. His specimens can be found in many private collections and several pieces are on permanent display at the Natural History Museum of Los Angeles County. He left a large volume of notes regarding the many mineral pockets he mined, and also his African journal and his archeological survey of the Sycan Marsh area. His life is a book in itself, and each of his journal themes worthy of publication separately. His life was a series of explorations and adventures woven through with art and music. Farewell, free spirit.

John and Claudia Watson
Dana Gochenour

Died, John E. MacDonald, 75

John Eric MacDonald was born in Jersey City, New Jersey on September 16, 1933. He was a disabled Army veteran who earned his BBA at the University of Miami under the GI Bill. He became an avid mineral collector and mineral dealer, and was well-known at major mineral shows in the 1970s and 1980s; his Franklin, New Jersey mineral collection, totaling 3,500 specimens, was given to the Smithsonian Institution in the 1980s before he and his wife Elaine moved to Tucson. In 1995 they moved to Sun City Vistoso. He died August 12, 2009, at the Veterans' Administration Hospital in Tucson.

The Friends of Mineralogy, Inc.

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New Mexico Bureau of Geology and Mineral Resources
New Mexico Tech, 801 Leroy Place
Socorro, New Mexico 87801
Email: vwlueth@nmt.edu

FM's OBJECTIVES are to promote, support, protect and expand the collecting of mineral specimens and to further the recognition of the scientific, economic, and aesthetic value of minerals, and the collecting of mineral specimens.

The Friends of Mineralogy (FM) was founded in Tucson, Arizona on February 13, 1970. The organization operates on a national level and also through regional chapters. It is open to membership by all. Our annual meeting is held each February in conjunction with the Tucson Gem and Mineral Show.
For further information and a listing of local chapters visit the national Friends of Mineralogy website:
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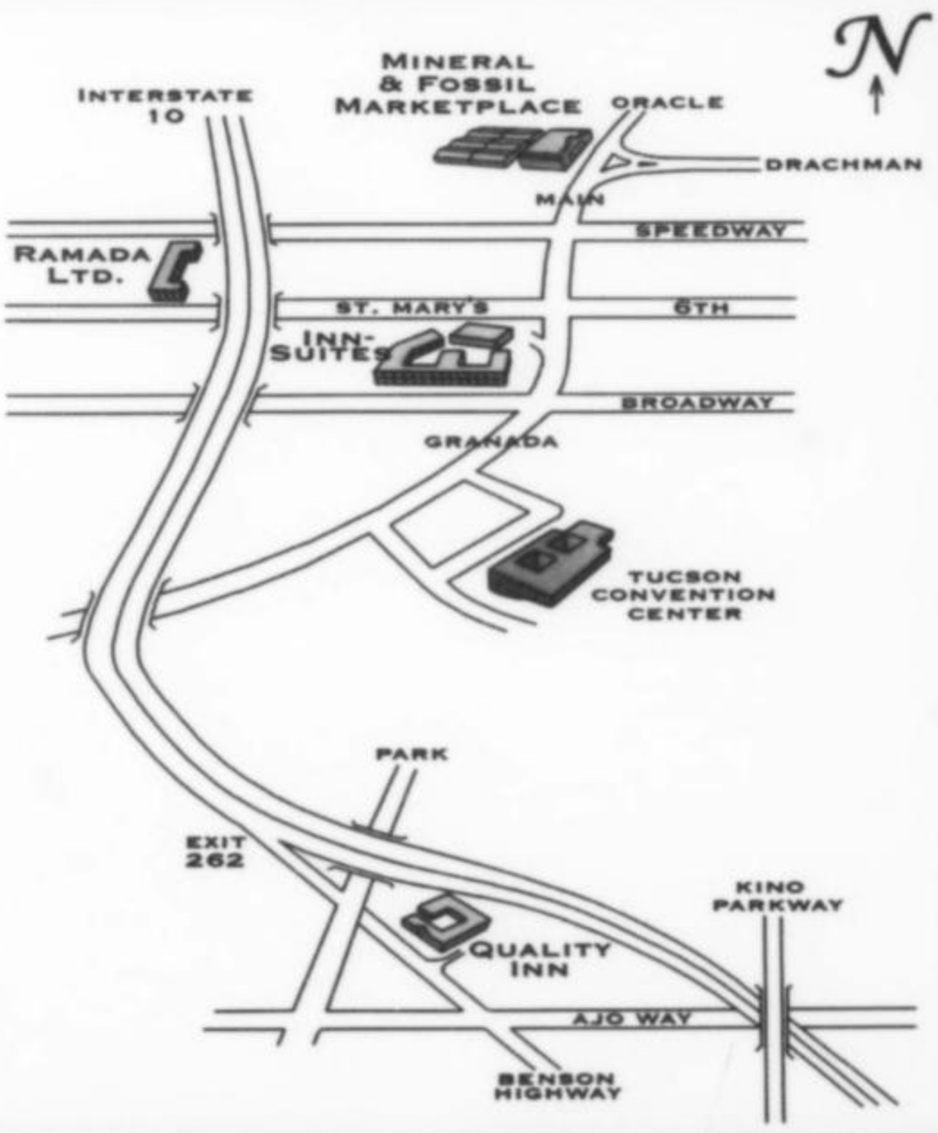

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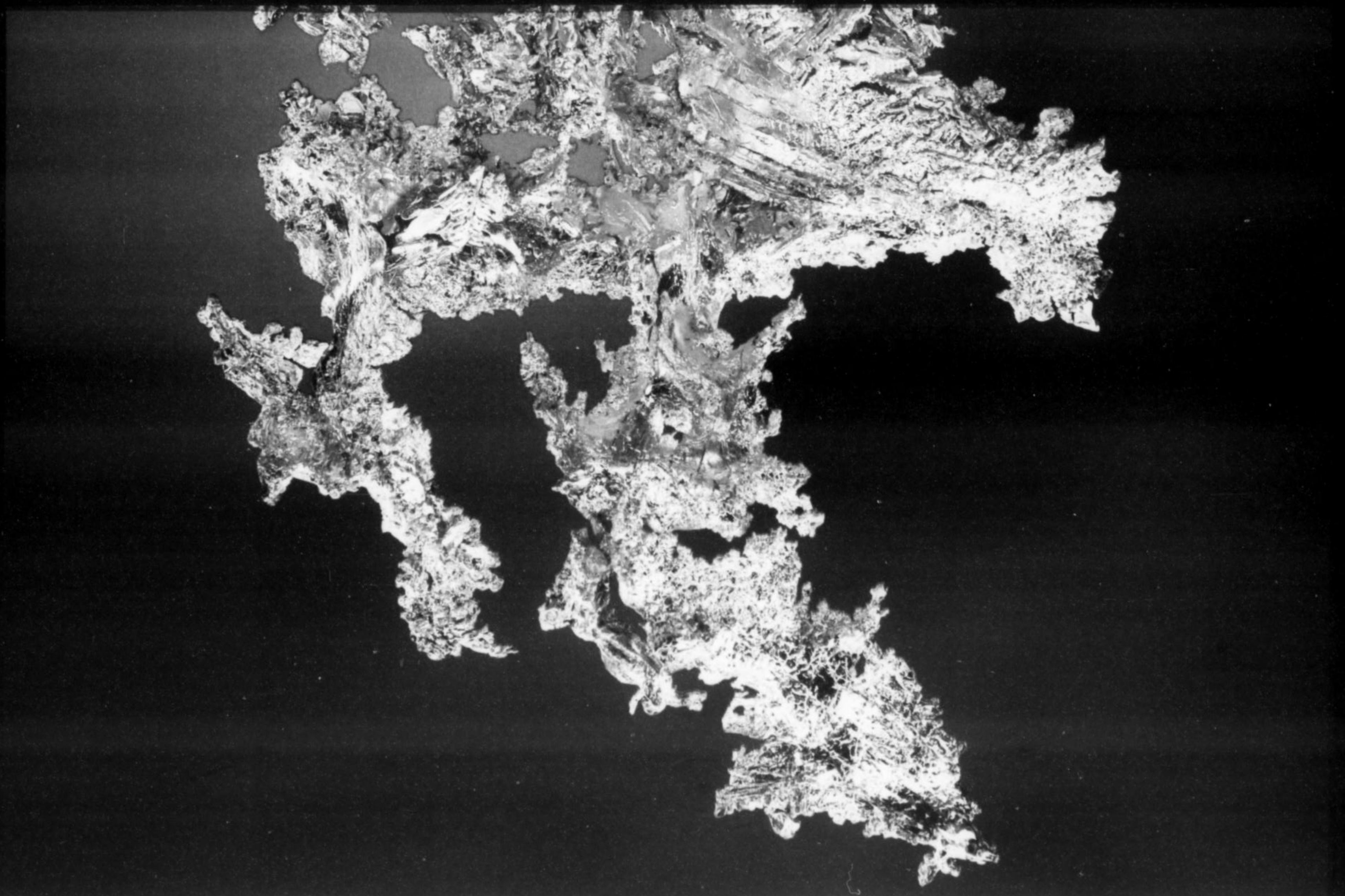

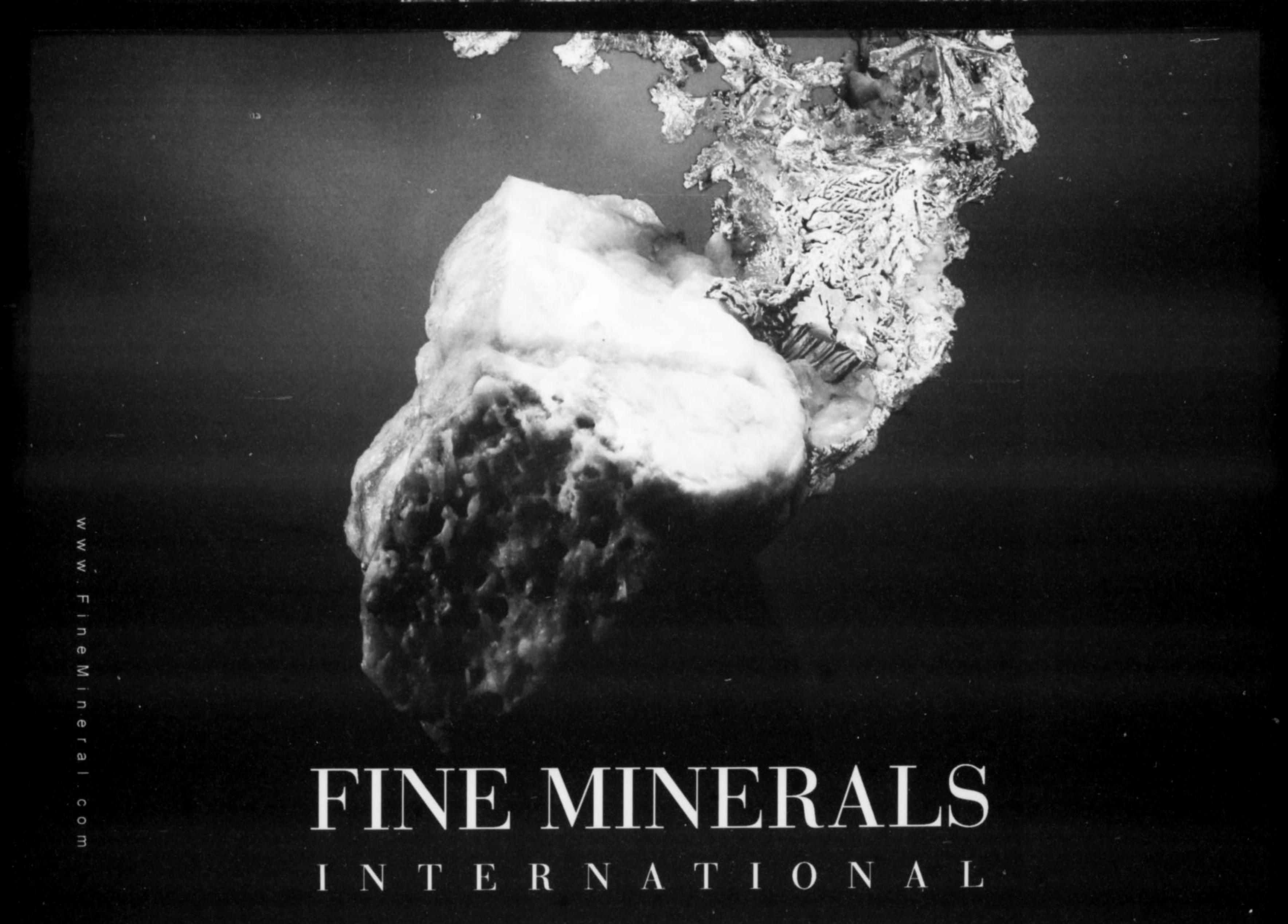

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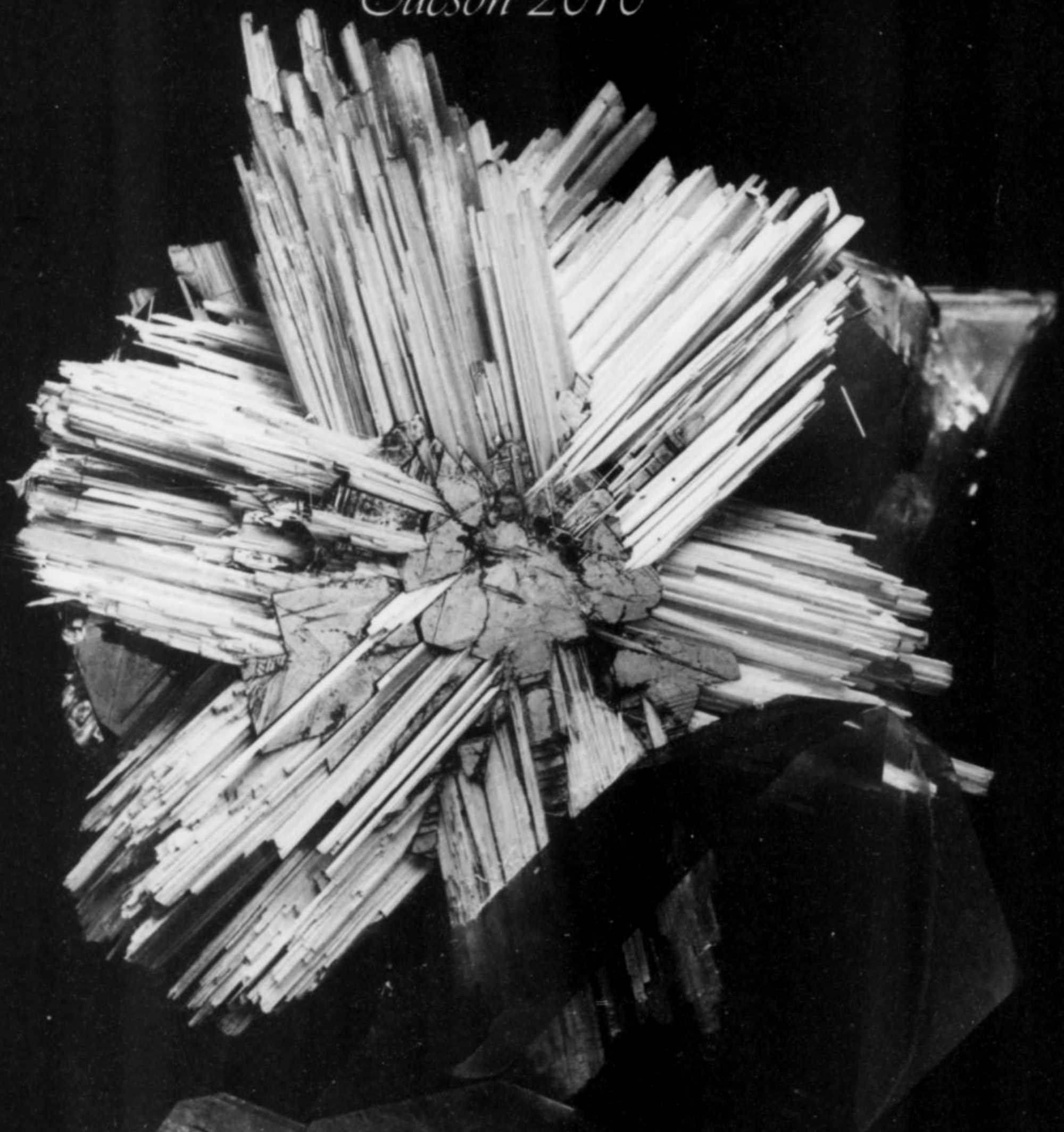

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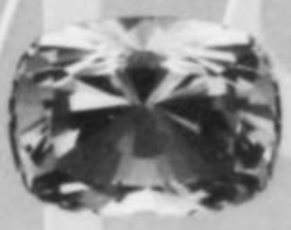

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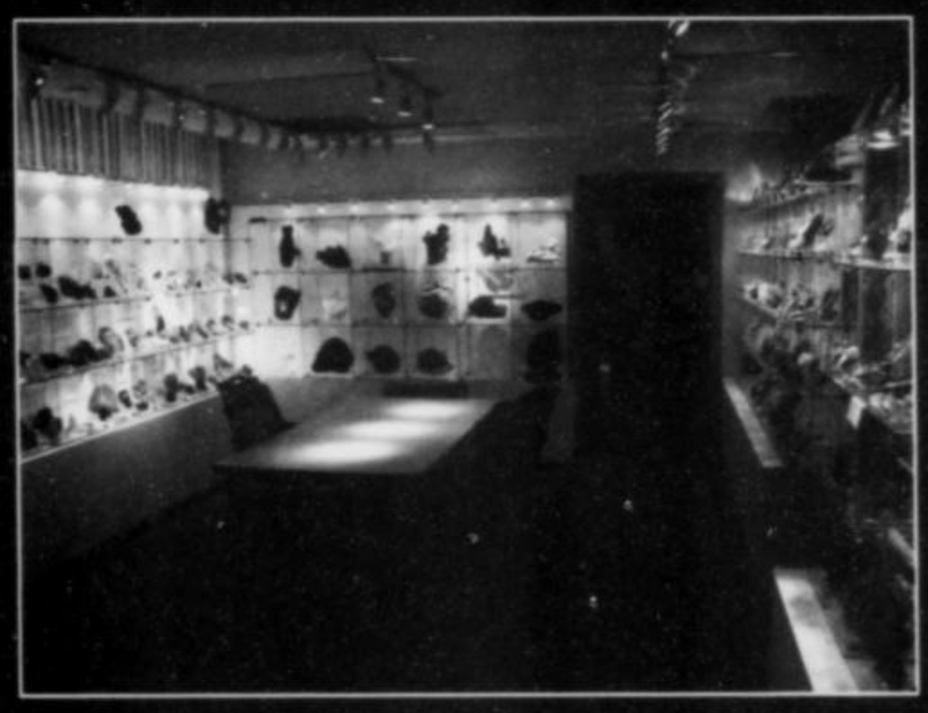

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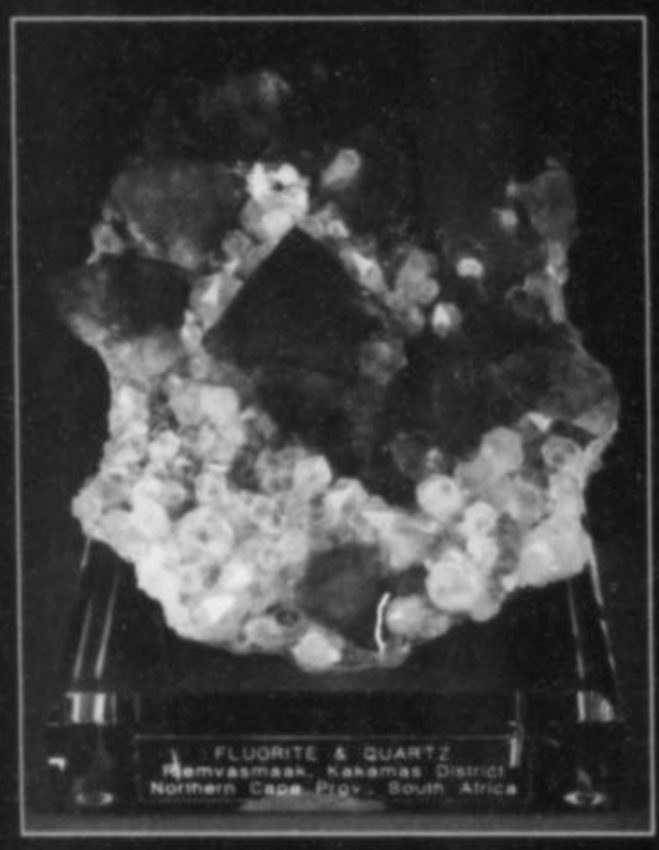
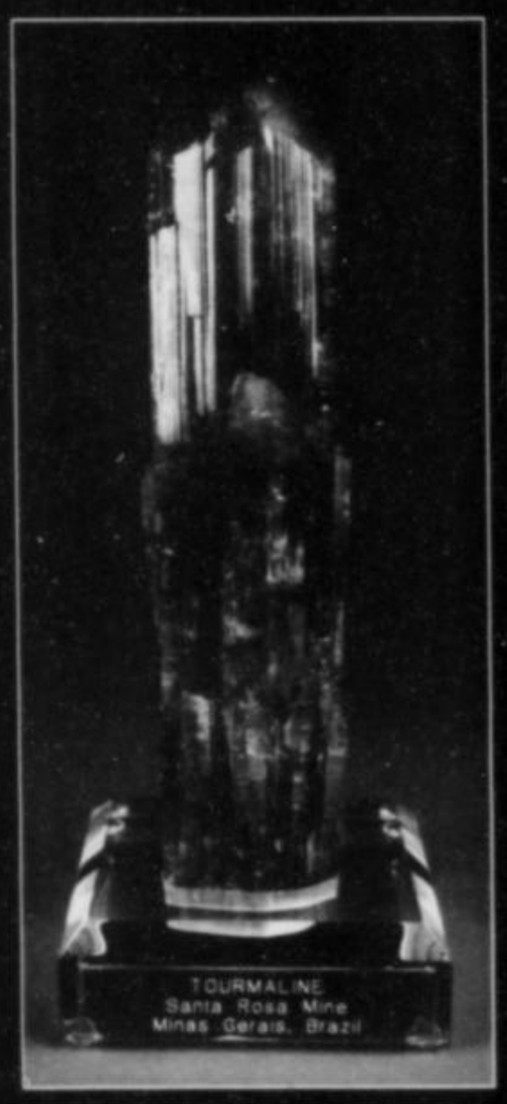




Recent Additions from The Sunnywood Collection

Famous Mineral Dealers:

Bryce McMurdo Wright, Sr.
(1814–1875)

and

Bryce McMurdo Wright, Jr.
(1850–1895)

Michael P. Cooper*
Nottingham, England

Wendell E. Wilson
Mineralogical Record, 4631 Paseo Tubutama
Tucson, Arizona 85750
minrecord@comcast.net

Marc L. Wilson
Head, Section of Minerals
Carnegie Museum of Natural History
4400 Forbes Avenue, Pittsburgh, Pennsylvania 15213
WilsonM@CarnegieMNH.org

Bryce McMurdo Wright Senior and Junior were among the best-known 19th-century mineral dealers in England, specializing in minerals from the famous Lake District. Major museums around the world, and particularly the Carnegie Museum of Natural History in Pittsburgh, contain hundreds of fine specimens that can trace their provenance to the Wrights.

INTRODUCTION

The late Michael P. Cooper (1946–2008), in his remarkable book *Robbing the Sparry Garniture: A 200-Year History of British Mineral Dealers* (2006), wrote as follows of the two mineral dealers named Bryce Wright:

> The name Bryce McMurdo Wright was, and remains, one of the best-known in 19th-century mineral dealing and collecting. Two people bore it, father and son, and between them they dealt in minerals, fossils, shells, rocks, gems, corals, ethnological collectibles, and worked stones old and new for over 50 years. Despite their varied and worldwide stock in trade, it is for the minerals of northern England that their name is best remembered.

*Deceased

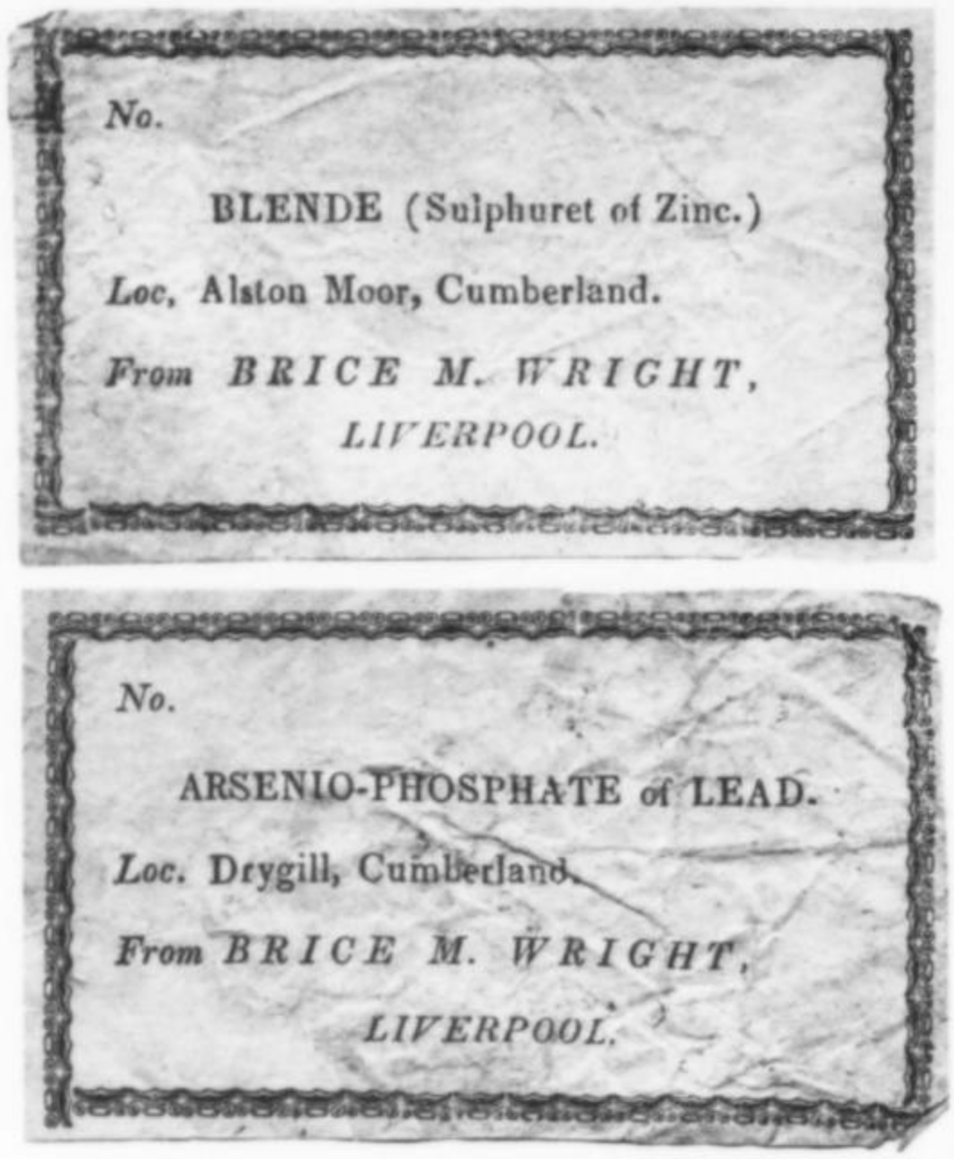


Figure 1. **Rare pre-printed mineral labels from Brice M. Wright Sr.'s earliest days as a mineral dealer in Liverpool, England (1843–1855). He dealt primarily in specimens from northern England, but also handled some Cornish minerals. (Mineralogical Record Label Archive.)**

The lives of the Bryce Wrights are given 33 pages in Cooper's book, and make fascinating reading for any student of the history of mineralogy and mineral dealing. The current article was inspired by a letter (to WEW) from Robert Wright, a descendant of the Bryce Wrights; he brought to our attention a previously unknown oil painting and a photographic portrait of Bryce Wright Jr. that had been passed down through the family. These were unknown to Cooper when he compiled his exhaustive work, and he died just two years after publication. Because his book (published and copyrighted by the Mineralogical Record), which is a superb piece of historical scholarship, has nevertheless sold only a few hundred copies, we thought it would be beneficial to publish an article on the Bryce Wrights drawn largely from Cooper's work, exposing it to a larger audience. Thus most of the biographical data presented here is extracted from that study (which see for detailed references).

But an article on the Bryce Wrights would naturally benefit from color photos of some mineral specimens that had passed through their hands—a luxury which was beyond the budget and scope of Cooper's book. His research revealed that the Bryce Wrights had shipped many specimens to Pennsylvania collector William W. Jefferis (1820–1906), whose collection ultimately ended up with the Carnegie Museum of Natural History in Pittsburgh. An enquiry was sent to the Section of Minerals there, precipitating a massive and gratifyingly successful search for Bryce Wright specimens. Fortunately five bound volumes of Jefferis' correspondence, including those from Wright to Jefferis, had been preserved in the museum archives, including many lists of specimens shipped and their associated label numbers. Ultimately, as a result of that initial query, well over 400 Bryce Wright specimens were identified and correlated with catalog records; many of the best have been photographed especially for this article by Debra Wilson, allowing us to present a more complete picture of one of England's greatest mineral dealing families.

ANCESTRY

Despite extensive research, Cooper was unable to locate any official records regarding the birth of Bryce Wright, Sr., except that his father's name was John, and his first name was initially spelled "Brice." Since Bryce Wright's youngest daughter was named Elizabeth Richardson Wright, Cooper speculated that John was the John Wright who married Elizabeth Richardson, mentioned in an 1816 parish birth record of their son John. This guess has proven to be correct. The Wright family Bible contains detailed information written by Bryce Wright, Jr. himself, a transcript of which has been supplied to us by his great-great grandson, Robert Wright, who is currently living in Germany. The pertinent text is as follows:

> Bryce McMurdo Wright (the author's father) was the 17th child of John Wright (known as "Squire Wright") by his second wife, Elizabeth Richardson, and was born at Dumphries, Scotland at half past 9 a.m. on Friday the 24th of June 1814, and died at Penn Road Villas, Holloway (a house taken for a short period only) on the 19th October 1874, his normal residence being 90, Great Russell Street, WC [London, England].

Bryce McMurdo Wright's Godfather was Lieutenant Colonel Bryce McMurdo from Mavis Grove, Dumfries. It is very probable that John "Squire" Wright and Bryce McMurdo were close friends, hence the latter's selection as Godfather.

Bryce Wright's mother, Elizabeth Richardson, was the daughter of Anne Glaister and Richard Richardson of Stewarts Hill and Egglelonan in Cumberland. The Richardson family was among the wealthiest and most influential in Cumberland, and Elizabeth inherited much of the family holdings. She was "a woman of great beauty," according to Bryce Wright, Jr., and was known locally as "the Egglelonan Beauty."

BRYCE WRIGHT, Sr.

Cooper (2006) wrote that "Nothing certain is known of the first few decades of Wright Senior's life. However, Wright Junior's text in the family Bible sheds some new light:

> It will be seen that the above Bryce Wright was only seven years of age when his father, "Squire" Wright, died on 23rd June 1821. The Squire left a large amount of property to be divided equally amongst his surviving children after the use of it by his wife, who however, becoming very ill, had to leave it to "others," who sold, mortgaged and otherwise scattered the large properties in the most improvident manner. My father, the above BMW, had in his wanderings shown a great adaptability for Natural History and knew every stone, plant and tree in the Lake District whilst yet in his teens.

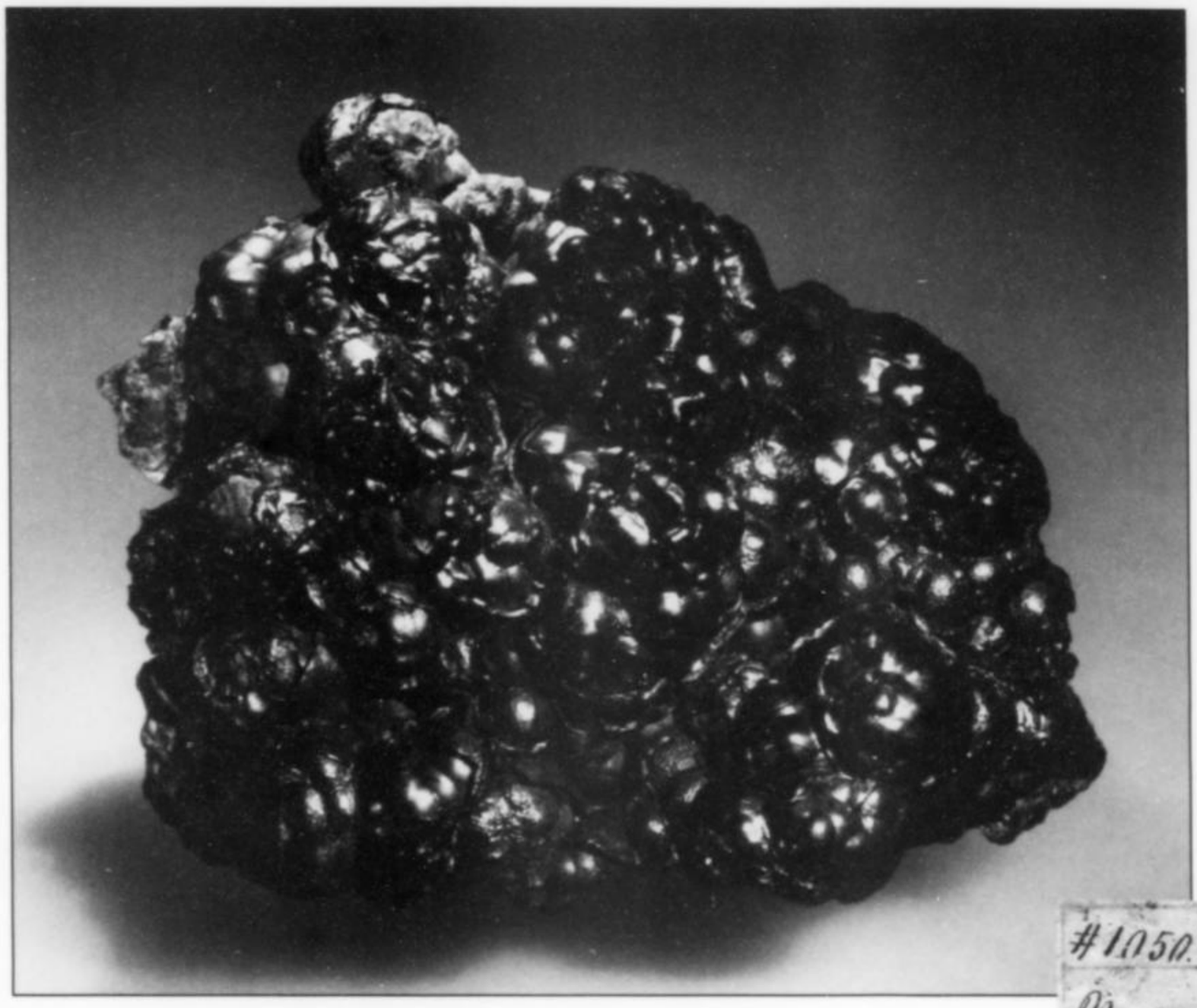
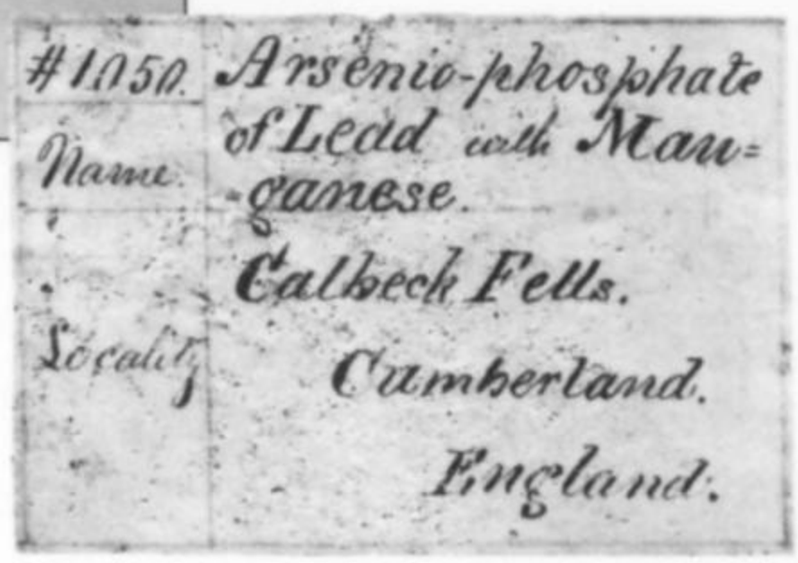


Figure 2. **Romanèchite on mimetite, 10.5 cm, from Caldbeck Fells, Cumbria, England. Obtained by Wm. Jefferis from Bryce Wright in February 1848 (Wright label shown). Debra Wilson photo; Carnegie Museum specimen CM3514.**



According to the American mineral collector Charles H. Pennypacker (1845–1911), Bryce Wright Senior had worked as a miner in Cumberland, probably in the Caldbeck Fells lead mines. His formal education was minimal, but more important to his success were his commercial acumen and tenacity, his capacity for learning and hard work, and above all his good fortune to be in the right place at the right time.

The Move to Liverpool

Bryce Wright Senior grew up in the village of Hesket Newmarket in the Cumbria Lake District, an area rich in mineral deposits. He started collecting (and probably selling) minerals "while yet in his teens," as the family Bible states, and ultimately relocated, at the request of one of his customers, to the big city of Liverpool in order to further his business. Bryce Wright Junior wrote in the family Bible:

> Hesket Newmarket was soon too small to hold him, and he went to Liverpool at the request of the then 14th Earl of Derby [Edward George Geoffrey Smith-Stanley, 1799–1869], to whom he supplied a large quantity of specimens of Natural History to augment the "Knowsley Collection" [at Knowsley Hall, Lancashire] which was later the foundation of the Liverpool Free Museum of Science and Art.

The exact date of his move to Liverpool is unknown, but in 1842 he married Jane Smith there. According to the marriage license, he was at that time working as a painter, when not dealing in minerals. The earliest traceable records of Wright Senior's trade in geological and other natural historical specimens are sales of minerals to the British Museum, made from his home in Liverpool. He was almost thirty in the spring of 1843 when he first made contact with Charles Konig, Keeper of Minerals at the British Museum, bringing specimens from the Caldbeck Fells to London. The museum bought nine specimens for £14 from him, and Konig asked Wright to keep in touch. One of these pieces, a linarite from Roughton Gill mine, Caldbeck, (then a new find) was a sufficiently noteworthy addition to the collection to deserve mention by Lazarus Fletcher in his history of important specimens acquired by the museum.

Wright went on to sell specimens regularly to the British Museum, at first in small lots, but, eventually, once he moved to London, sometimes in groups of over 100 specimens at a time. Whether Wright was selling minerals before 1843 is not known, but it is tempting to conclude that he was most likely the "mineral dealer from Cumberland [who] exposed a collection of North of England minerals for sale" at the 7th meeting of the British Association in Liverpool in 1837. The eminent mineral chemist Thomas Thomson bought a specimen labeled "vanadiate of lead" from "Caldbeck fell" from this dealer and, upon analyzing it, pronounced it a new mineral: a "native diarseniate of lead." It was almost certainly mimetite *var.* campylite from Dry Gill mine, Caldbeck.

In 1845 Wright turned professional mineral dealer, and in 1849 he opened a shop in Liverpool. An idea of the scope of Wright's stock in his early years can be obtained from his advertisements and flyers. A flyer for his Liverpool business, dated to about 1854, mentions his "extensive collection of minerals . . . of upwards of 3,000 specimens" including "many exceedingly rare substances."

The Move to London in 1855

In 1855 Wright moved from Liverpool to London and opened a shop there at 4 Stanley Street, Brompton; two years later he moved to no. 36 Great Russell Street, Bloomsbury, in the heart of London's "natural history district," just across the road from the

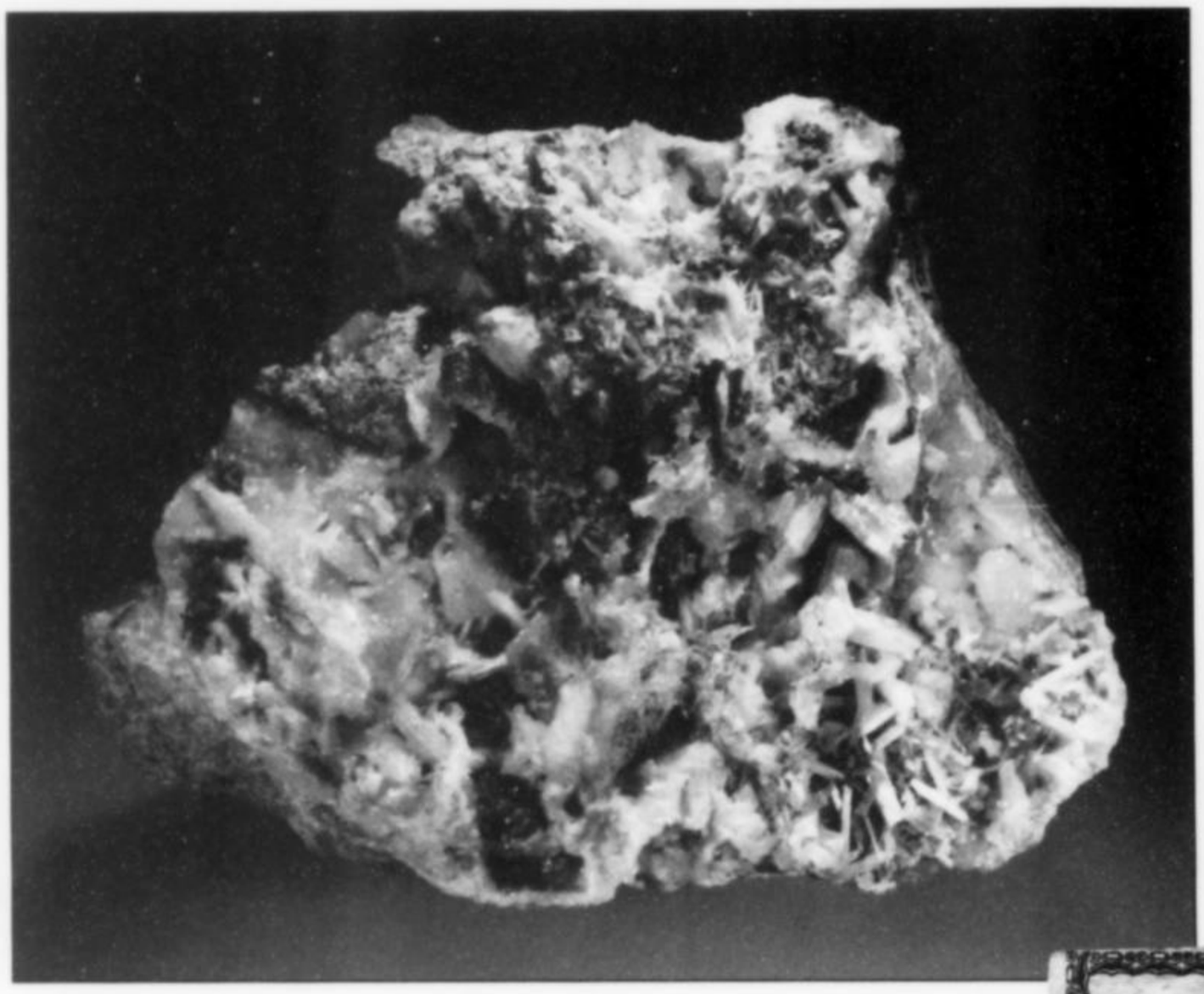
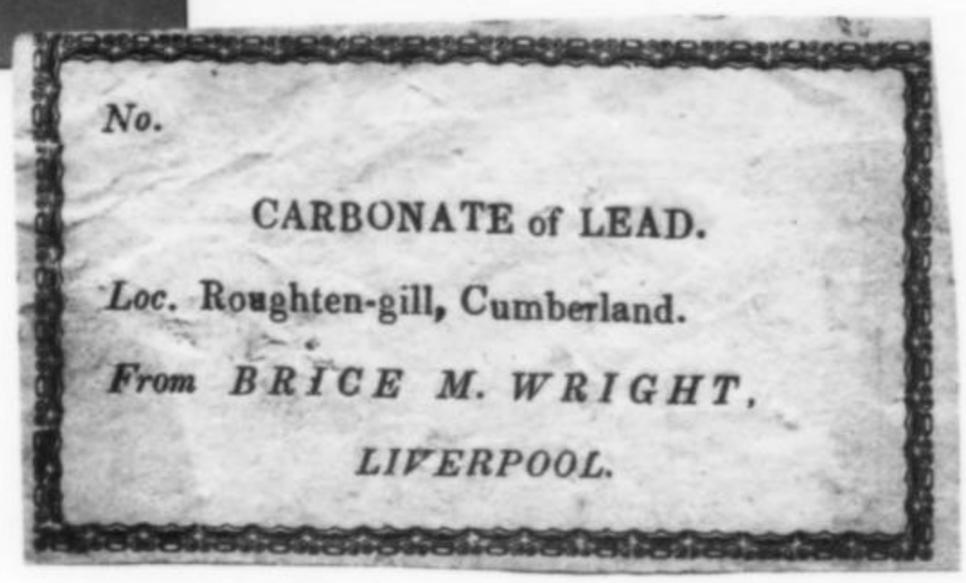


Figure 3. **Cerussite crystals on matrix, 11 cm, from the Roughton Gill mine, Caldbeck Fells, Cumbria, England. Obtained by Wm. Jefferis from Bryce Wright in February 1849 (Wright label shown). Debra Wilson photo; Carnegie Museum specimen CM4760.**



British Museum. By 1857 he was claiming a stock of 7,000 mineral specimens, and by 1860, 10,000 specimens. He moved to No. 90 on the same street in 1866, where he remained until his death eight years later. The business flourished in that neighborhood, Wright becoming the most successful and the best-known London-based mineral and fossil dealer of the mid-nineteenth century. Some of the staff of the British Museum became personal friends and provided him with valuable professional scientific support. In 1868 he claimed to be in "direct communication with the most experienced miners in Cornwall and Cumberland, and also with Collecting Naturalists in Germany, Russia, India, and America."

Wright Senior's 1860 catalog stated:

> B.M.W. has at the present time one of the largest collections in London, from which selections can be made. He has direct communication with the most experienced miners in Cornwall and Cumberland, and also with Collecting Naturalists in Germany, Russia, India, and America, from whom he is constantly receiving fresh supplies of rare and beautiful specimens of every description. B.M.W. begs to call attention to the accompanying List of Minerals; the prices affixed to which will be found lower than those of any other Establishment, and an inspection of his Collection (always open to visitors) will at once attest their superior quality.

The listings of mineral, fossil, and shell species are comprehensive, although Wright points out that the rare species may not be available from stock, though they may be had to order. He also rented out "specimens of all descriptions . . . to decorate soirées and lectures." Evidence of the quality of his stock is everywhere seen in the specimens surviving in the leading mineral museums of the day and in the collections of nineteenth-century connoisseurs such as John Ruskin, Patrick Dudgeon, Clarence Bement, Robert P. Greg and many others.

Wright traveled extensively throughout the country, and occasionally on the continent, in search of minerals. Then, as now, most mining companies were opposed to their workforce wasting company time collecting specimens and Wright had to be circumspect. According to Pennypacker: "by lamp light or by candle light or by the 'dawn's early light' he made his purchases from the miners without illustration on the part of the mining officers." One fragile Cornish calcite which Wright later sent to America was smuggled out of the mine "wrapped in the leg of a pair of trousers which had been discarded for the time being in order to make a safe passage to the surface of the earth." It was wired to a board for its trans-Atlantic journey and arrived in perfect condition.

These collecting trips took up much of Wright's time; he would be away for weeks or months at a time and made half a dozen or more such trips a year. Apart from what he could collect himself, or purchase directly from miners, Wright also obtained specimens from provincial dealers, by exchange with collectors and institutions, and by purchase from travelers, some of whom were journeying on his behalf with instructions to bring back fine specimens. Most of Wright's provincial contacts can only be guessed at, though the Alston mineral dealer and "marine store" owner Patrick Gilmore (1833–1892) notes that he supplied "Mr. Wright" with local specialties like fluorite.

Bryce Wright Senior and William Jefferis

Overseas Wright had valuable exchange arrangements with several important European dealers including Louis Seaman of Paris and Carl Wilhelm Anderberg (1827–1871) of Stockholm, and with various American collectors as well. One of the earliest, perhaps the first, of the latter was William W. Jefferis (1820–1906), a mineral collector from West Chester, Pennsylvania. The two men were put in touch by Thomas Nuttall, who had traveled to England on a buying trip. Pennypacker relates the circumstances:

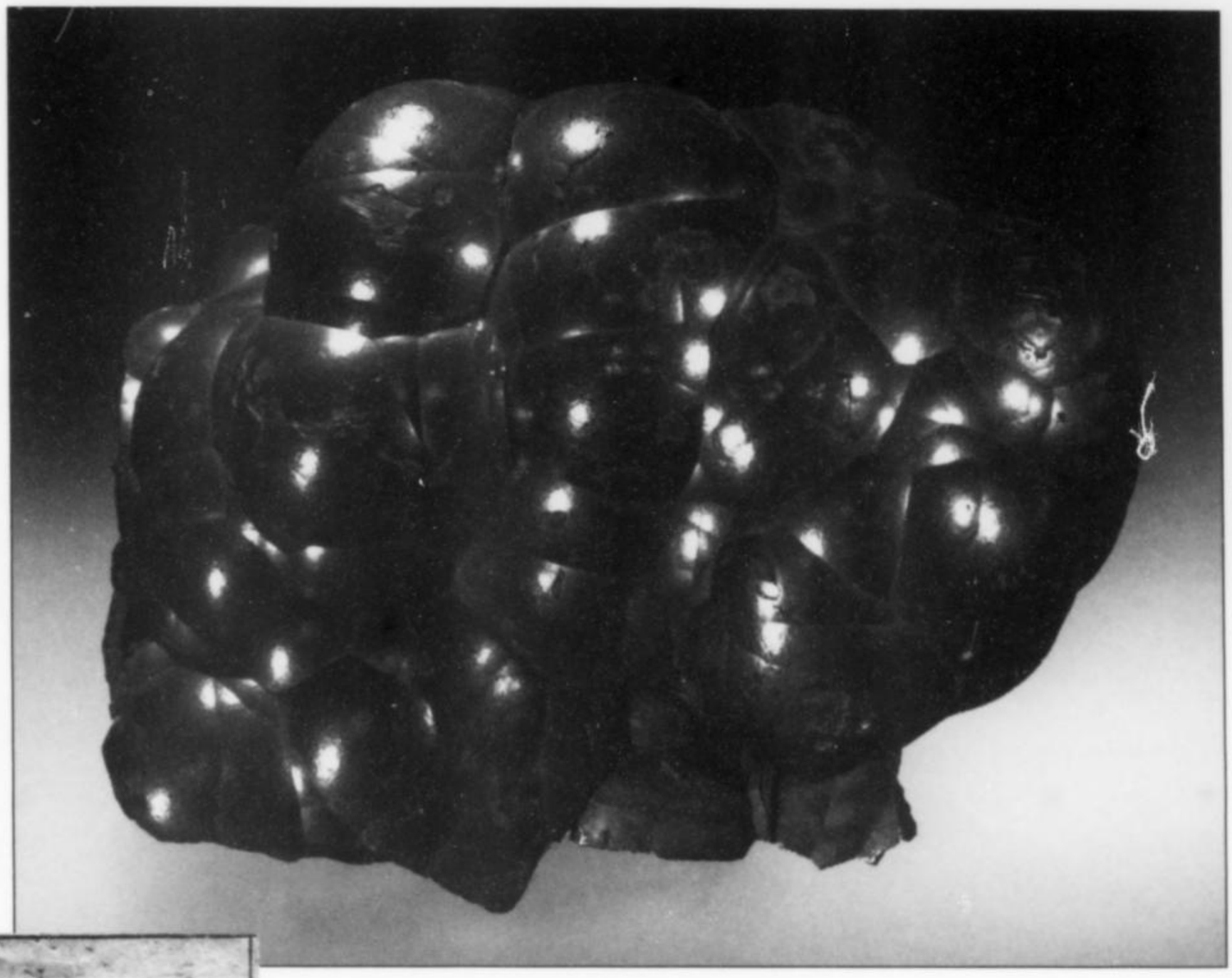


Figure 4. **Hematite "kidney ore," 9.5 cm, from Ulverston, Furness region, Cumbria, England. Purchased by Wm. Jefferis from Bryce Wright in February 1849 (Jefferis label shown). Debra Wilson photo; Carnegie Museum specimen CM2685.**

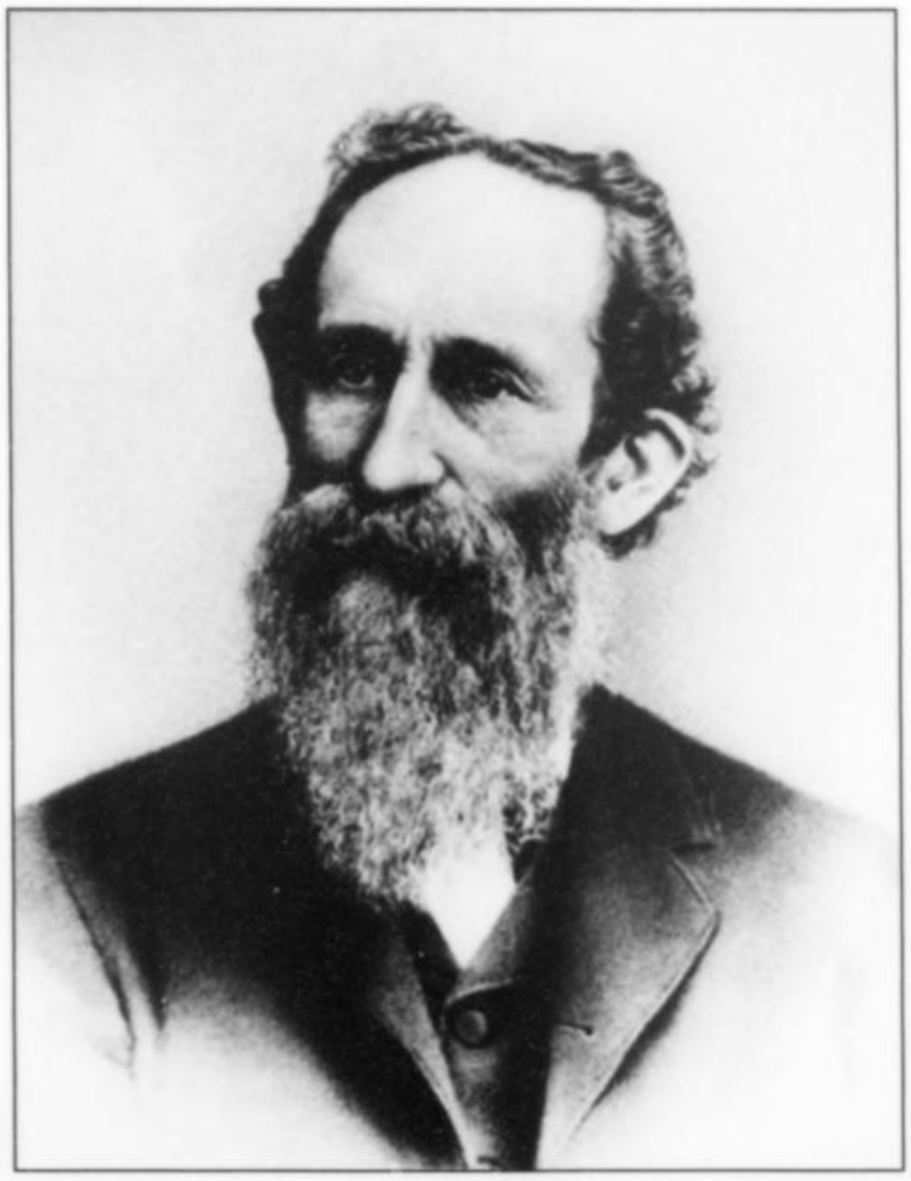


Figure 5. **William W. Jefferis (1820–1906), prosperous banker from West Chester, Pennsylvania, who purchased large numbers of specimens from the Bryce Wrights over the years. His collection was purchased in 1904 by Andrew Carnegie for the Carnegie Museum of Natural History.**

> When Professor Nuttall returned to the 'land of steady habits' [Connecticut] he communicated his English experiences to his friends and correspondents. Among the first to address a letter to the Liverpool dealer was our friend William Jefferis. An exchange was proposed and the suggestion agreeable to Mr. Wright. The Pennsylvanian shipped the minerals of his neighborhood and the Englishman returned an equivalent in the minerals of his native land. It was a fair exchange. Conditions were favorable and the confidence was mutual.

Jefferis, a wealthy banker, began collecting minerals in 1837 and rose rapidly to become one of America's foremost collectors. He had a passion for minerals, "his tenacity of memory of single, extraordinary or rarely beautiful or odd specimens was quite wonderful." In 1883 he retired from the bank to become curator of the William S. Vaux mineral collection in the Academy of Natural Sciences, Philadelphia. His circle of friends in his home town included collector Lewis White Williams, the conchologist and mineralogist William Dell Hartman, paleontologist and gem collector Joseph Leidy (1823–1891), and Charles Pennypacker (1845–1911). All of these men had dealings at some time with Wright. Shortly before his death, Jefferis' collection was bought by Andrew Carnegie for the museum he had recently established in Pittsburgh, where it remains to this day.

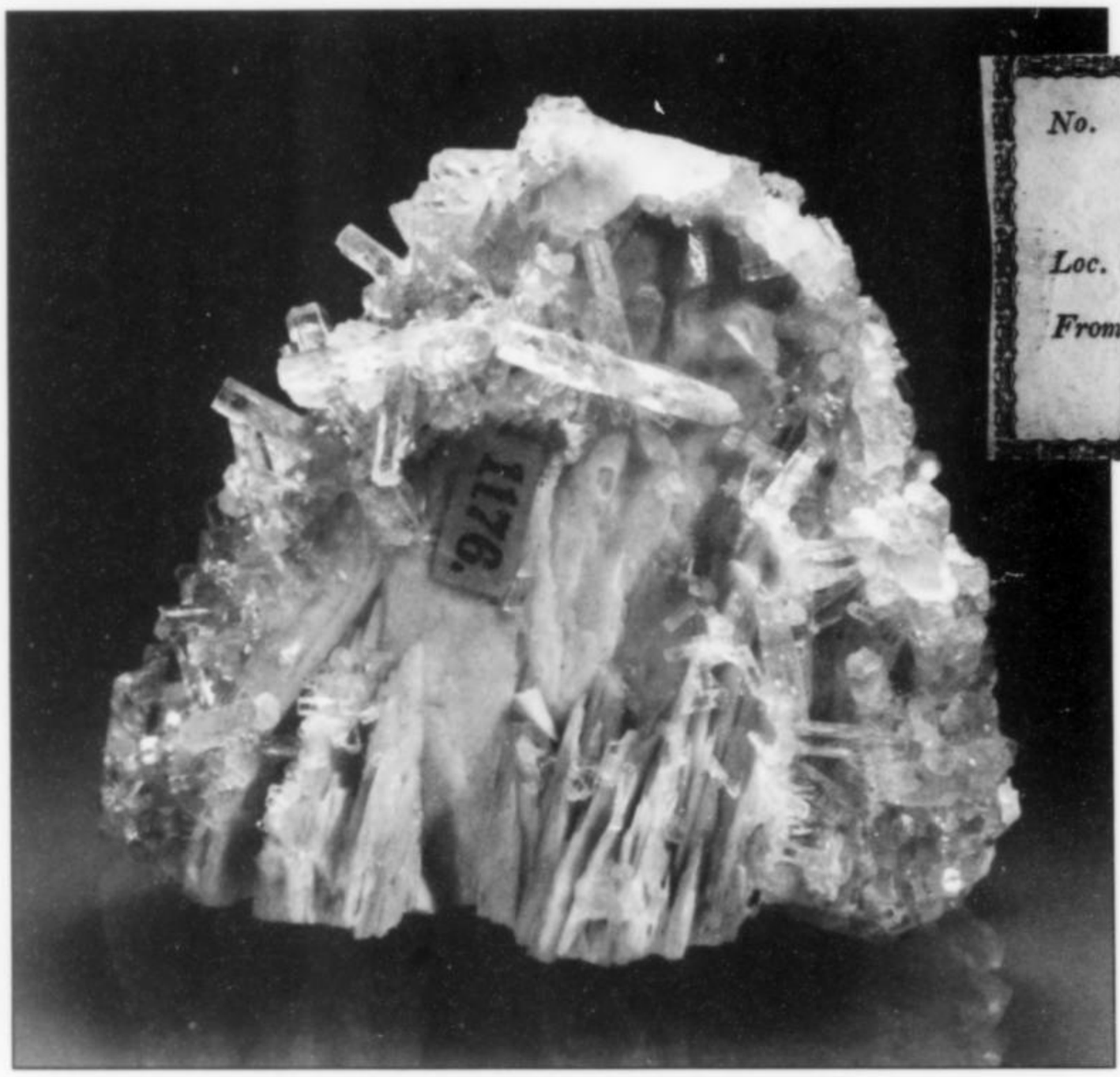


Figure 6. **Calcite crystals on barite, 6.4 cm, from the Greenside mine, Glenridding, Cumbria, England. Obtained by Wm. Jefferis from Bryce Wright in September 1851 (Wright label shown). Debra Wilson photo; Carnegie Museum specimen CM26065.**

From Jefferis's correspondence files we learned that he first contacted Wright in late 1847 or early 1848. Wright's reply to Jefferis's enquiry (no copies of Jefferis's letters to Wright are known) is dated January 28, 1848 from Liverpool and begins: "I received your kind letter & would be glad to exchange for American minerals providing they are good, as inferior minerals are of no value in England. Those which I would send to you would be rare and select." He continues with lists of species he would like from those offered by Jefferis and suggestions as to what he could provide in return: he does not mention localities but the minerals he lists are typical of material from Scotland, Cumberland, and Cornwall. To underline the need to keep the specimen quality high, Wright points out that it costs as much to send good material as bad. He concludes "I would like to have them soon, as many dealers comes here in the spring," thus suggesting that he was already selling minerals wholesale to other dealers in 1848. In the remaining letters (the archive runs until 1867) Wright returns often to the need to maintain standards but there is no indication that he was ever seriously disappointed with Jefferis' offerings, despite occasional problems on both sides in the disposal of some of their exchanged stock.

Jefferis responded quickly to Wright's letter. The receipt of a box of his minerals was acknowledged by Wright in May: he was "very much pleased with many of them." Wright's return box was dispatched in June and contained 110 specimens, including many supergene lead and copper minerals (pyromorphite, mimetite, linarite, caledonite, cerussite, etc.), barite, witherite, fluorite, and the Cornish rarity, fluellite. A return box from Jefferis arrived later that same year. Much excitement was generated among Jefferis's friends by the arrival there of Wright's boxes. Pennypacker recalls one occasion, which must have occurred in the latter half of the 1850s (Pennypacker was ten years old in 1855 when Wright was freshly relocated to London):

> When I was a small boy, small and curious! William W. Jefferis was our nearest neighbor. A box had come from Brice M. Wright, a mineral dealer in London. Doctor William Hartman, brother "Morty," and Lewis White Williams were asked to assist at "the opening." I was there as a handy boy to carry out the packing material and get sandwich glimpses of the offerings from foreign lands. After a while a green encrustation, from Cumberland, England, and labeled "Silicate of Zinc," appeared on the table. The comments were many and favorable. "Lew" thought there was some artificial coloring matter about it, and that the specimen had been "made in Germany." It had the brilliancy of a Venetian bead. "The Doctor" said it was a kidney hepatized, dosed with Paris Green, and then petrified. "Brother Morty" said it was a good thing to have, and had "Hogarth's line of beauty" all about it! I was like "Oliver Twist," I wanted to know if there was anymore. It was the most interesting specimen in the box and the only one of its kind.

The "silicate of zinc" was probably the beautiful (generally blue!) botryoidal hemimorphite from the Roughton Gill mine in Caldbeck. Wright is known to have sent such specimens to Jefferis in 1857: "I have sent you some of my fine silicates of zinc & as they have never been in any hands but mine I have been able to obtain very high prices for them in England as high as 4 pounds a specimen."

Although at first predominantly if not exclusively British minerals, Wright's exchange boxes soon began to include obvious foreign material (foreign to England that is!): in 1849 he sent such things as yttrotantalite (then only known from Sweden) and euchroite (only known from Libethen, Hungary), and in 1852 Wright asked Jefferis if he wanted Norwegian material: "I have purchased 40 boxes." The two men exchanged specimens for several years, sometimes sending nearly 200 at a time, but the flow of minerals seems to have faltered towards the end of the 1850s.

In December 1861, with London's Great International Exhibition of 1862 fast approaching, Wright tried to breathe new life into their exchanges: "It is now a long time since I have heard from

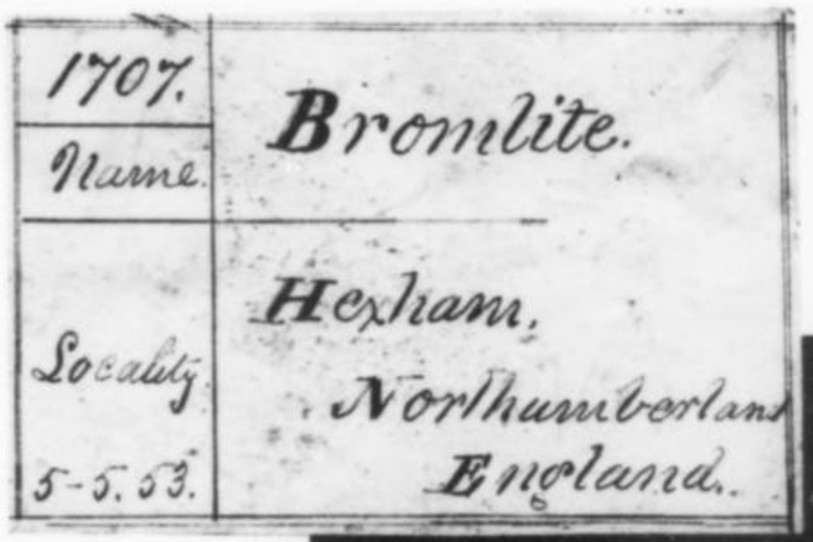
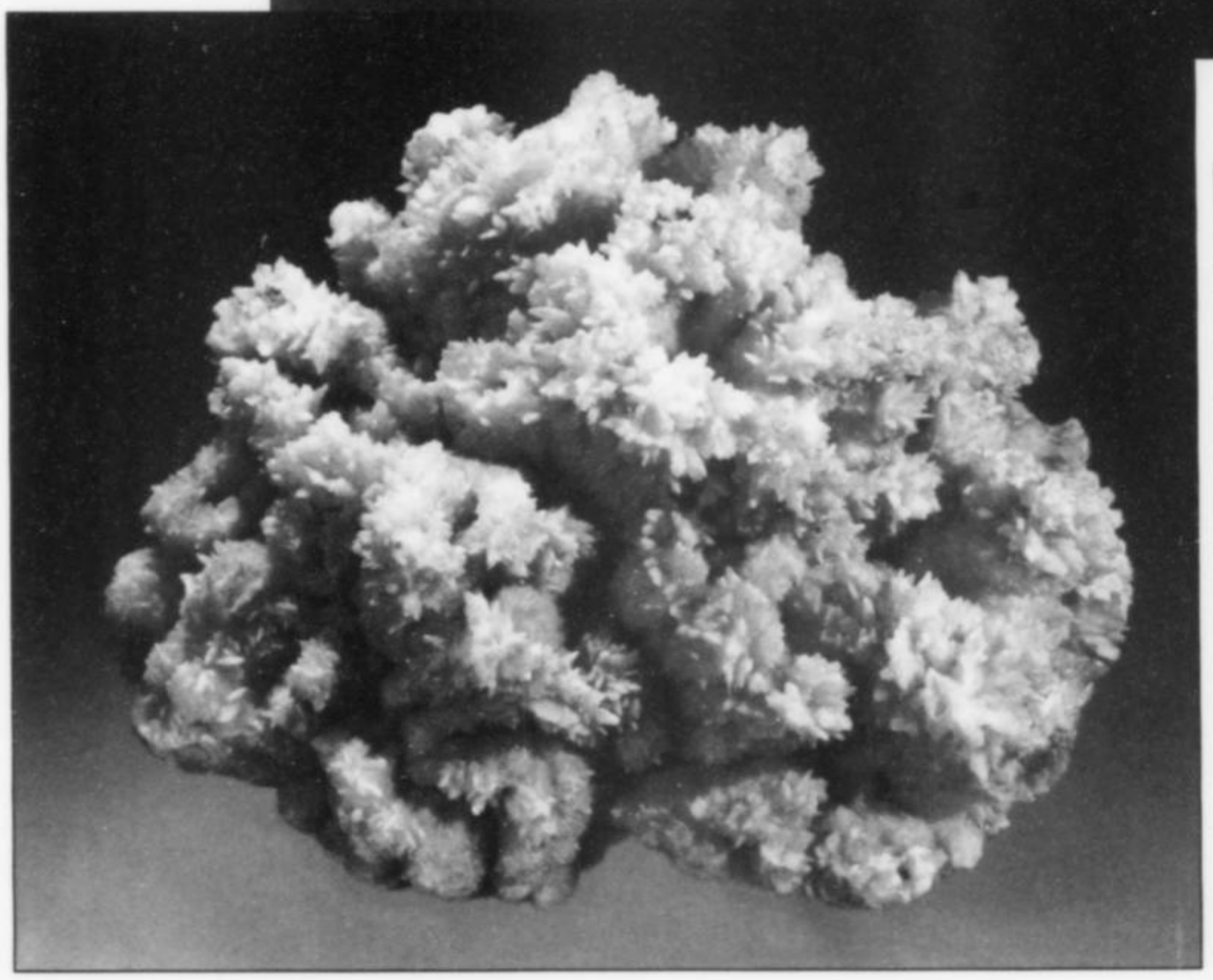


Figure 7. **Witherite crystals to 2.6 cm with drusy barite on matrix, 9.3 cm, from the Fallowfield mine near Hexham, Northumberland, England. The old name "bromlite" refers to the chemically similar mineral alstonite, but was apparently a misidentification. Obtained by Wm. Jefferis from Bryce Wright in January 1853 (Jefferis label shown). Debra Wilson photo; Carnegie Museum specimen CM4695.**



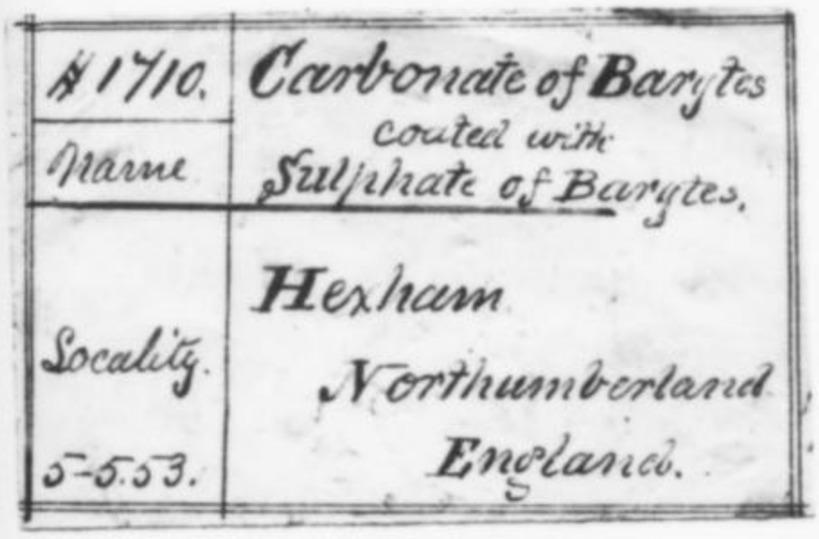


Figure 8. **Barite crystals encrusting witherite crystals, 8.8 cm, from the Fallowfield mine near Hexham, Northumberland, England. Obtained by Wm. Jefferis from Bryce Wright in January 1853 (Jefferis label shown). Debra Wilson photo; Carnegie Museum specimen CM11106.**

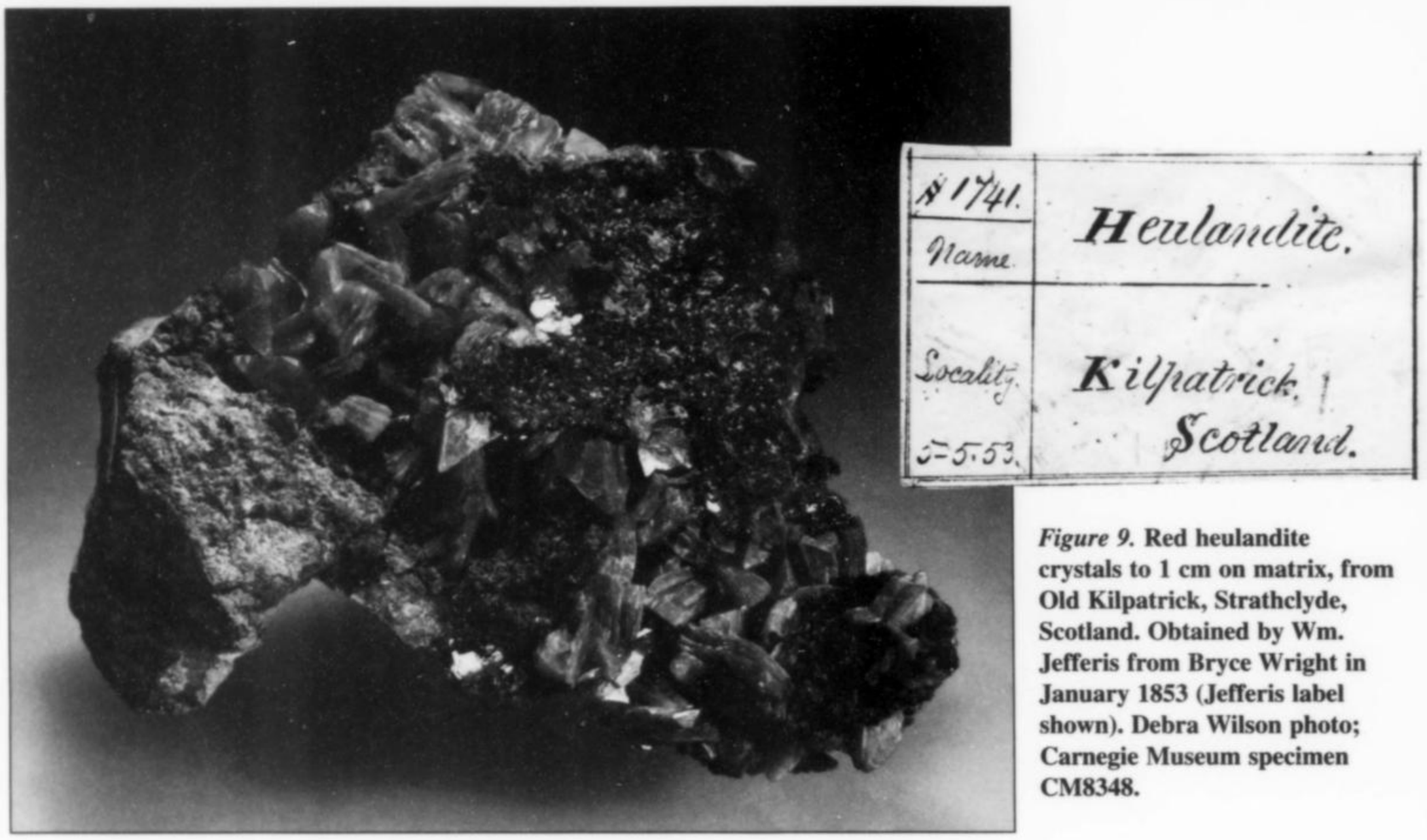


Figure 9. **Red heulandite crystals to 1 cm on matrix, from Old Kilpatrick, Strathclyde, Scotland. Obtained by Wm. Jefferis from Bryce Wright in January 1853 (Jefferis label shown). Debra Wilson photo; Carnegie Museum specimen CM8348.**

you. I should be pleased to know if you have anything good in the mineral way." Despite the outbreak of the Civil War in America, Jefferis responded with a box of 166 specimens. Their exchanges continued at least until 1867; the last letter from Wright in the Jefferis archive is dated February 6th of that year and finds Wright offering yet more material.

Wright was quick to move Jefferis's specimens on. The British Museum bought several American specimens from Wright in June 1848, the first foreign material they had taken from him, and as most were from Pennsylvania and New Jersey they were almost certainly from Jefferis' first consignment. Typical Jefferis specialties (such as magnesium or chromium minerals from mines in Texas, Pennsylvania) are also seen in material bought from Wright by the École des Mines in Paris and other European institutions. Jefferis's specimens were making as much impact in Europe as Wright's were in America, and Wright was jealous of this opportunity to acquire American novelties. Luckily he did not have much competition in London: those dealers most prominent in foreign minerals, such as George Brettingham Sowerby I (1788–1854) or (John) Henry Heuland (1778–1856), were nearing the end of their reigns. Of the remaining serious dealers, Robert Henson (1814–1864) lacked Wright's scope and dynamism and James Tennant (1808–1881) concentrated his considerable efforts and abilities in other fields.

In the correspondence with Jefferis, the only other dealer mentioned by Wright was August Krantz (1809–1872) of Bonn, the leading German mineral and fossil dealer and founder of a company still in business today. He was, rightly, regarded by Wright as a major competitor. Krantz was easily the most important European dealer in minerals and fossils and had a huge international trade. In the first half of the nineteenth century he and Henry Heuland (London-based, but German-born) were the principal suppliers of specimens purchased by the British Museum, perhaps through affinity with the German-born curator Charles Konig. When Nevil Storey-Maskelyne took over in 1857, sources from closer to home quickly began to dominate, partly, perhaps, through increased activity in the British mineral market rather than just the influence of kinship.

Wright/Jefferis Specimens in the Carnegie Collection

The bound volumes of Wright letters in the Carnegie archives end in 1867, although Jefferis continued to purchase and, presumably, trade specimens until at least 1900. Shipments to Jefferis from Wright consisted of both lots for sale and lots for trade. A total of 14 lists detailing lots of specimens sent from 1848 through 1867 have been identified. In addition, there is mention in one of Wright's letters (3-5-1859) to having shipped a lot of specimens purchased on Jefferis' behalf by his brother while on a trip to England.

Wright was not consistent either in numbering the specimens sent or in providing detail of individual specimens. Some lists are complete with numbered specimens identified to species and, rarely, rudimentary locality; some lists were unnumbered with specimens listed by species, with or without rudimentary locality information, and some were just listings of x number of y species with no locality information at all. Of most value in correlating with actual specimens were the few lists that contained numbered specimens with numbers attached to the specimens themselves. In these cases, Wright used uniquely identifiable styles of numbers for each shipment, until latter years when a uniquely Wright style was used for all subsequent shipments that had numbered specimens.

Jefferis handled the shipments he received from Wright as follows: he kept a portion of the best for himself and sold or traded other portions to other notable 19th century eastern US collectors, including (but not limited to) Norman Spang, Gustave Guttenberg, William Vaux and Thomas Hart. He would apparently catalog into his collection blocks of specimens with his labels marked as to the date he received the lot. This allowed us to identify in the Carnegie collection not only the uniquely numbered Bryce Wright specimens, but others of the same lot date that matched the Wright list but which had lost their numbers in the last 150 years. Some Jefferis

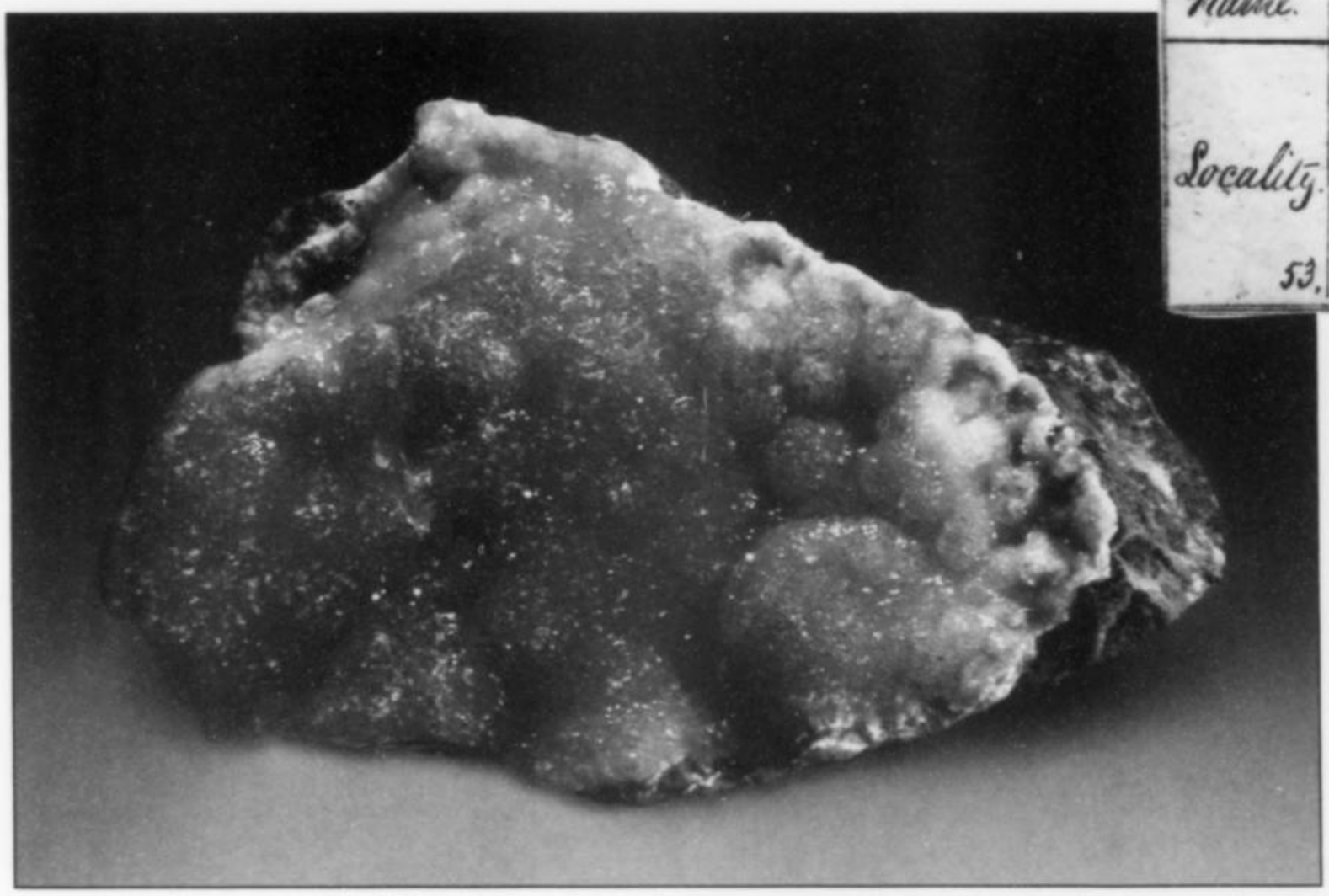


Figure 10. **Blue hemimorphite colored by trace amounts of copper, 5.3 cm, from the Roughton Gill mine, Caldbeck Fells, Cumbria, England. Obtained by Wm. Jefferis from Bryce Wright in January 1853 (Jefferis label shown). Debra Wilson photo; Carnegie Museum specimen CM7843.**

Figure 11. **Siderite crystals on cuboctahedral fluorite crystals to 5 cm, from the Harz Mountains, Germany. Purchased for 8 shillings by Wm. Jefferis from Bryce Wright in December 1862. Debra Wilson photo; Carnegie Museum specimen CM1310.**

specimens were identified from Wright lists that had no numbers attached through this "block of numbers" approach.

To complicate matters further, Jefferis apparently later cataloged into his collection specimens from the Wright lots that he had not been successful in selling or trading. Thus, we have Jefferis labels of a later style assigned to earlier lots with the earlier dates written upon them. Upon occasion, this led to errors on Jefferis' part where he could not remember the exact date and put only a year followed by "?" or an erroneous date confused with a different lot. Only relatively unique specimens of this type could be rectified to the Wright lists.

Jefferis is documented as sending Wright specimens to George Brush for species identification/confirmation and as sending species and locality information to James D. Dana for "the book."

Carnegie Museum holdings of Bryce Wright specimens are further confused by Jefferis' skill at trading. Bryce Wright specimens have been identified amongst the specimens comprising the Spang and Guttenberg (both Pittsburghers) collections by their unique Bryce Wright-style attached numbers. These were probably obtained through trade with Jefferis. Jefferis' correspondence also indicates that Vaux obtained specimens from Jefferis. (At one point

Figure 12. **Anglesite crystals to 1.6 cm on matrix, 13.1 cm, from the Isle of Anglesey, presumably from the type locality, the Parys Mountain mine. Obtained by Wm. Jefferis from Bryce Wright in December 1862 (Jefferis label shown). Debra Wilson photo; Carnegie Museum specimen CM11325.**

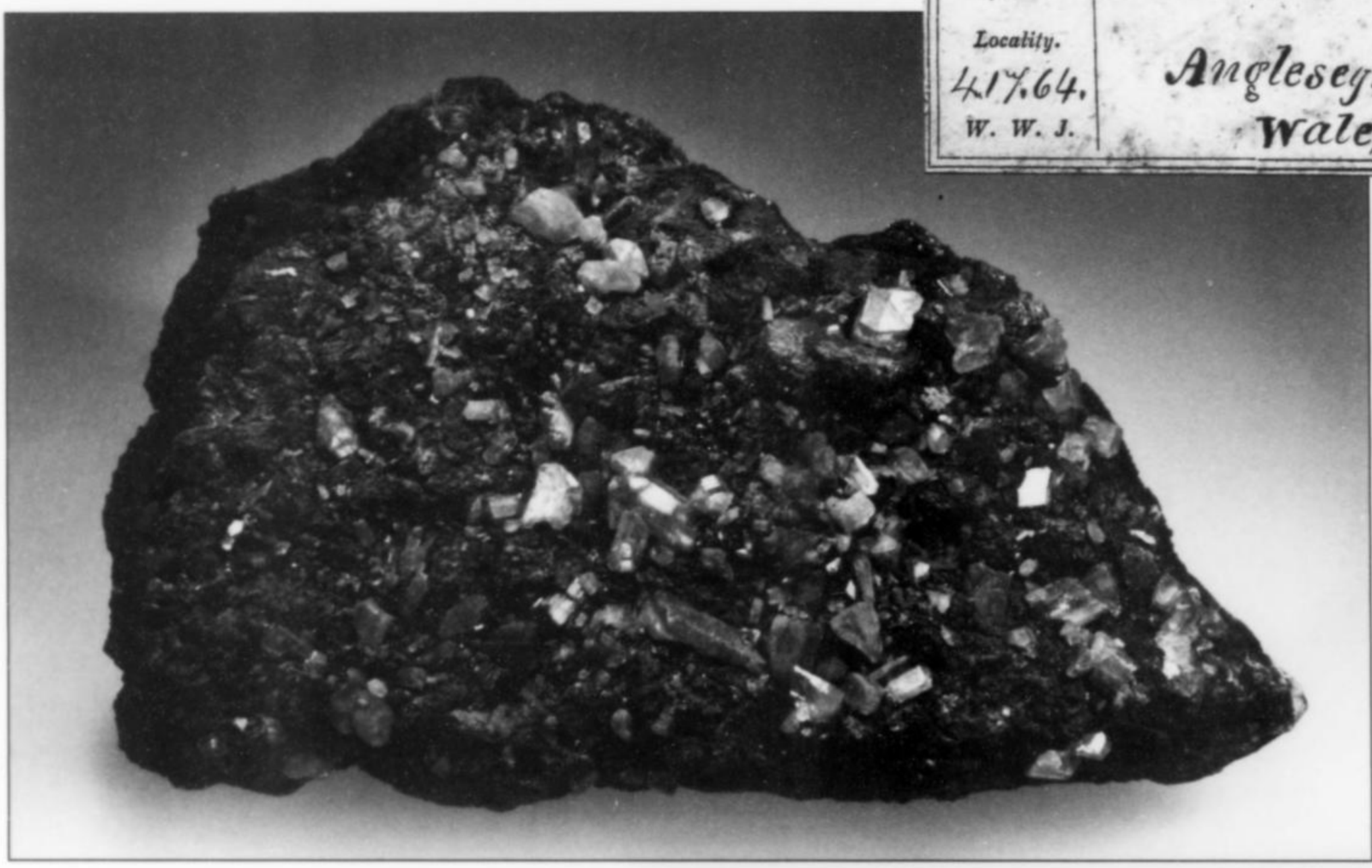
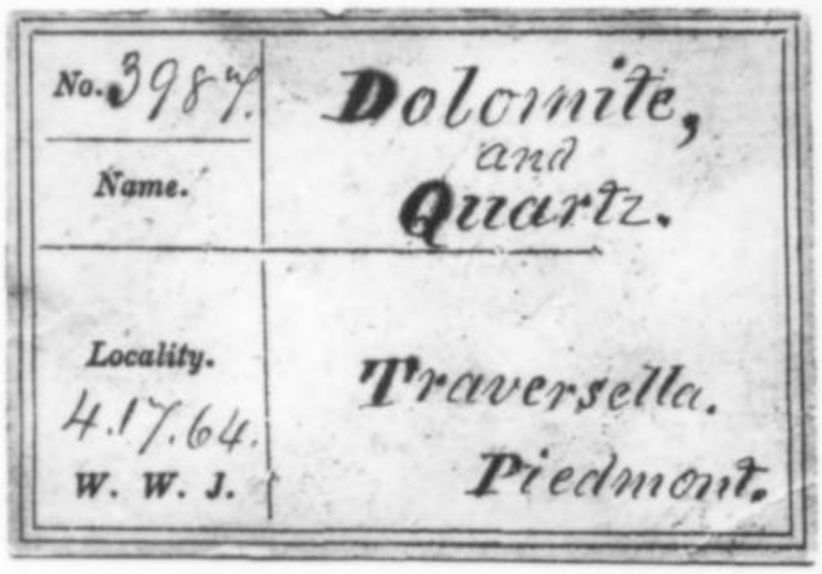
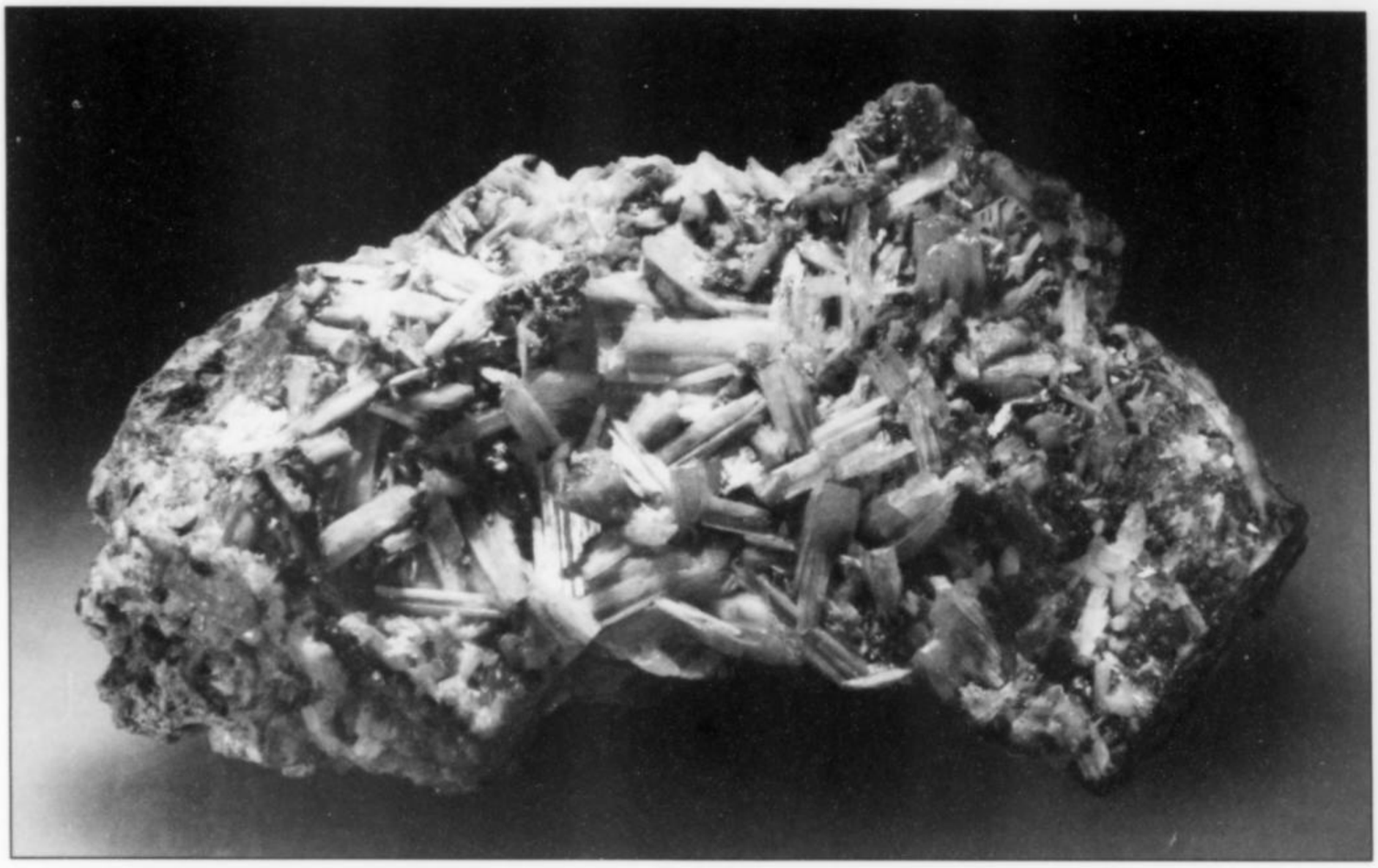
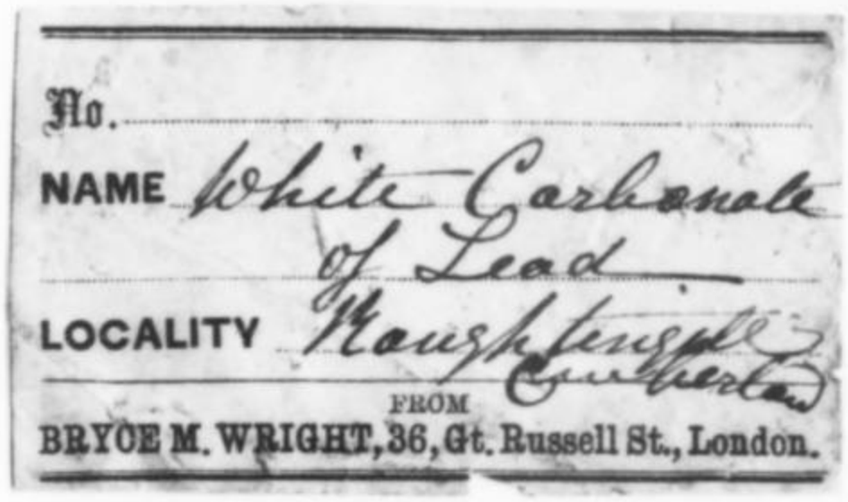


Figure 13. **Siderite crystals to 3.8 cm on quartz crystals, from Traversella, Piemonte, Italy. Purchased for 2 shillings by Wm. Jefferis from Bryce Wright in December 1862 (Jefferis label shown). Debra Wilson photo; Carnegie Museum specimen CM4290.**







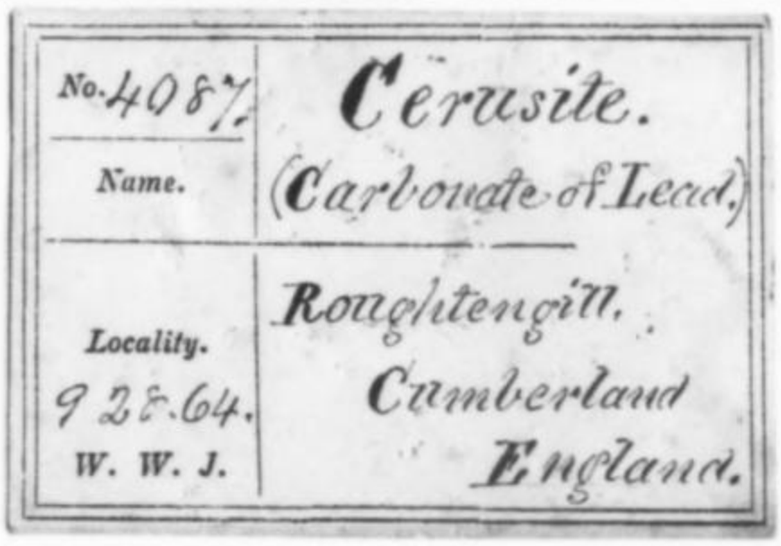


Figure 14. **Cerussite crystals on matrix, 8.7 cm, from the Roughton Gill mine, Cumbria, England. Obtained by Wm. Jefferis from Bryce Wright in July 1864 (Wright and Jefferis labels shown). Debra Wilson photo; Carnegie Museum specimen CM4730.**

he suggests that it would be easier for Jefferis to have the Wright shipments sent directly to Vaux with Vaux's assurance that Jefferis would still get first pick . . . .)

Jefferis specimens with Bryce Wright numbers attached, but that are not included in the documented shipments, indicate that there were four or more additional shipments for which no lists survive. December of 1867, October of 1877, April of 1878 and February of 1879 are the most likely dates for possible undocumented shipments made after January 24, 1867. An additional five Bryce Wright specimens have been identified in the Spang collection, and one in the Guttenberg collection; finally, six miscellaneous specimens are dated 1866, and nine miscellaneous specimens have mixed dates or no dates.

Table 1 lists the tallies for 14 documented and four deduced specimen shipments sent to Jefferis by Bryce Wright., indicating for each shipment:

(1) The total number of specimens shipped (as cited by Bryce Wright).

(2) The total number of specimens cataloged and assigned a number by Jefferis.

(3) The total number of specimens cataloged and assigned a number by CMNH.

(4) The total number of specimens still extant in the Carnegie Museum collection (including eight currently on display in the Hillman Hall of Minerals and Gems).

These statistics should be considered as minima, since only specimens unequivocally identified as Bryce Wright's are included. It is a certainty that many more unidentified Bryce Wright specimens lurk within the Jefferis collection at the Carnegie Museum, but these cannot be proven to our satisfaction to be positively Bryce Wright in origin. Jefferis acquired superb specimens similar to those offered by Wright from August Krantz, Charles Pennypacker, A. E. Foote and George English, and so it would be inappropriate to simply assign a nice English or old European specimen to Wright without compelling evidence of its origin.

Thus a total of 1,804 specimens appear on extant Bryce Wright lists of what was shipped to Jefferis, of which at least 504 were kept by Jefferis and cataloged into his collection (rather than having been sold or traded to other collectors). When the Jefferis collection was acquired by the Carnegie Museum in 1904, at least 339 of these specimens are known to have been present, and of those, 314 can still be found and identified in the collection. At least another 187 specimens are believed to have been subsequently shipped to Jefferis, for which no lists survive; of these, 97 were acquired by the Carnegie Museum with the Jefferis collection in 1904, and 74 can

Table 1. **Bryce Wright Sr. shipping lists of specimens sent to William Jefferis, plus four possible shipments sent after January 1867.**

Shipment Date	*Shipping list total*	*Cataloged by Jefferis*	*Cataloged by CMNH*	*Still in CMNH*
June 29, 1848	110	59	40	37
February 9, 1849	172	63	29	26
March ?, 1850	128	14	6	4
September ?, 1851	213	20	14	12
January 27, 1853	154	76	45	45
September 24, 1853	187	14	12	10
October 29, 1855	133	42	23	20
March 20, 1857	151	14	7	6
December 31, 1862	237	86	76	81
July 23, 1864	186	59	39	29
January 24, 1867	133	57	48	44
SUBTOTAL	1,804	504	339	314
1867 (possible)		49	36	35
1877 (possible)		15	12	10
1878 (possible)		73	24	17
1879 (possible)		50	25	12
SUBTOTAL		187	97	74
Misc. Wright specimens		15	15	15
Non-Jefferis Wright specimens			6	6
GRAND TOTAL	1,804	706	457	409

be found there today, along with 15 other miscellaneous Wright/Jefferis specimens (and six Bryce Wright specimens that came to the Museum from other sources). Thus the minimum number of Bryce Wright specimens cataloged by Jefferis into his collection is 706, of which 403 can still be accounted for. With the addition of the six non-Jefferis Wright specimens, a total of 409 Bryce Wright specimens are currently known in the Carnegie Museum collection.

It is not known how many additional Bryce Wright specimens were in the Jefferis collection at the time of its accessioning by the Carnegie Museum, as an unknown number of Jefferis labels and numbers were lost during or before the original cataloging process. Nor is it known how many others that had lost their Jefferis provenance have left or still remain in the Museum.

Phosgenite and Matlockite

In the 1850s the Caldbeck mines were yielding wonderful lead and copper minerals, and some of the world's finest fluorite and witherite was being found in abundance in the Northern Pennines. Wright was well-connected in these districts and thousands of such pieces must have passed through his hands *en route* to some of the most discerning collectors and museums at home and abroad. He is particularly associated with the world-renowned pyromorphite, mimetite, hemimorphite, and linarite from Caldbeck, and also did a good trade in rare lead minerals from Leadhills and Wanlockhead in Scotland. Some of the finest specimens from these mines were handled by Wright, perhaps with the benefit of personal and family contacts in Cumberland and Scotland. But his British activities were by no means restricted to these mining fields. In 1856 he acquired a fine brookite from Tremadog, Wales and sold it to the British Museum. It has not only been regarded as the world's finest brookite, but also as "one of the finest miniature specimens in

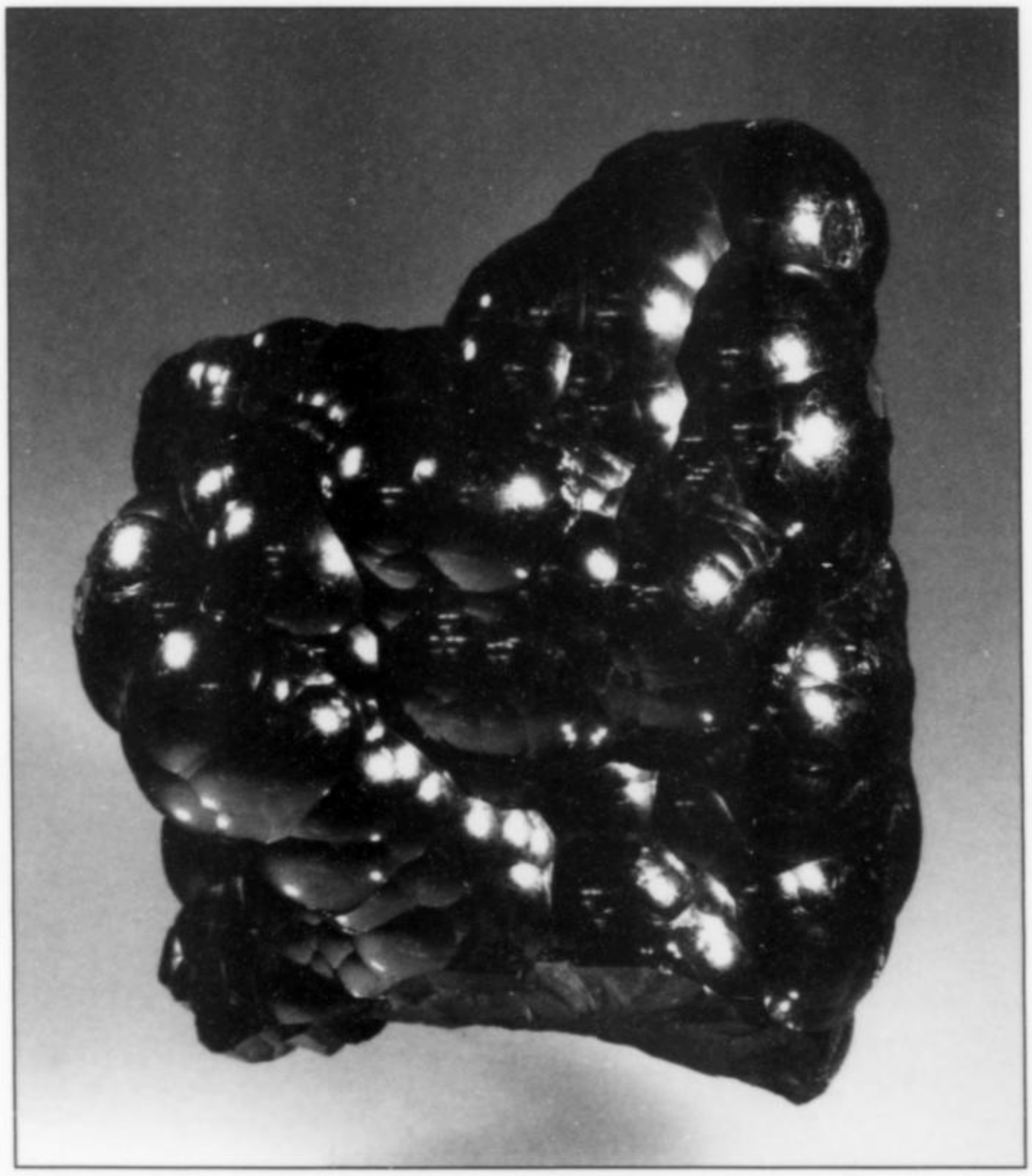


Figure 15. **Hematite "grape ore," 6.3 cm, from Cleator Moor, Cumbria, England. Obtained by Wm. Jefferis from Bryce Wright in July 1864 (Jefferis label shown). Debra Wilson photo; Carnegie Museum specimen CM2631.**

the world." How Wright came by it is, unfortunately, unrecorded. But, notwithstanding the beauty and rarity of the many discoveries he made elsewhere, Wright's finest hour as a collector-dealer was his discovery in 1851 of phosgenite and of the new mineral matlockite in the Bage mine at Cromford in Derbyshire. The latter species was described and named by English collector Roberts Philip Greg (1826–1906), co-author, with William Garrow Lettsom (1805–1887), of the *Manual of Mineralogy of Great Britain and Ireland* (1858). Many of these specimens were of remarkable quality—crystals of both minerals reached over 5 cm across—and were (and remain) much in demand. With such specimens Wright developed other sources by exchange, although, as he says many times in the Jefferis correspondence, he would only part with his best specimens for cash.

Phosgenite was an incredibly rare and highly sought-after mineral in Wright's day. The pre-eminent mineral collector Charles Greville (1749–1809) had been the source of the handful of specimens then in collections, having acquired them around 1785 from Thomas Pearson (*ca.* 1760–*ca.* 1830), a *petrifactionist* (mineral dealer and lapidarist) of Matlock Bath. Greville disposed of a few pieces and kept the best for himself. The mineral was recognized as new in 1800 and named *hornblei*. It was renamed *phosgenite* by Breithaupt in 1841. Greville's collection, including its suite of phosgenites, was bought by the British Government in 1810 for £13,727, the equivalent today of about $2 million, and lodged in the British Museum.

In 1851, William Lettsom obtained by chance a clue to the whereabouts of some old phosgenite specimens in Derbyshire, said to be from the original find, and dispatched Bryce Wright in search of them. Wright obtained five specimens, "among them a very good one," and Lettsom naturally expected first choice, "but no, Mr Greg, who knew of the whole transaction, who knew I had been the means of disinterring these specimens, took the best for himself without saying a word to me." Greg's version of events was slightly different, claiming a hand in the original investigation: "Researches which Mr. Lettsom & I have put on foot in Derbyshire have ended in finding 5 fine cristals of the Murio Carbonate [of] lead of the olden time. They were found in an old basket belonging to an old man living near Matlock. We have also found sulphate tri-carbonate associated with it."

Yet more disappointment awaited Lettsom. Recognizing that an unknown platy mineral was associated with Wright's material, Lettsom sent some to Germany for analysis. This appears to have come from one of the old specimens and was probably the material misidentified by Greg as "sulphate tri-carbonate" (a synonym of leadhillite, another platy lead mineral). Greg also had the mineral analyzed, and published it shortly after as *matlockite*. "He certainly had the legal right to do so," wrote Lettsom from Madrid, "but as he was aware that I had sent some fragments . . . to [Prof. Karl F.] Rammelsberg . . . it was hardly fair of him to take the wind out of the Professor's sails, by employing someone else to analyze this mineral, & publishing the analysis before I received Rammelsberg's. However, legally speaking he has a right to do as he has done, but

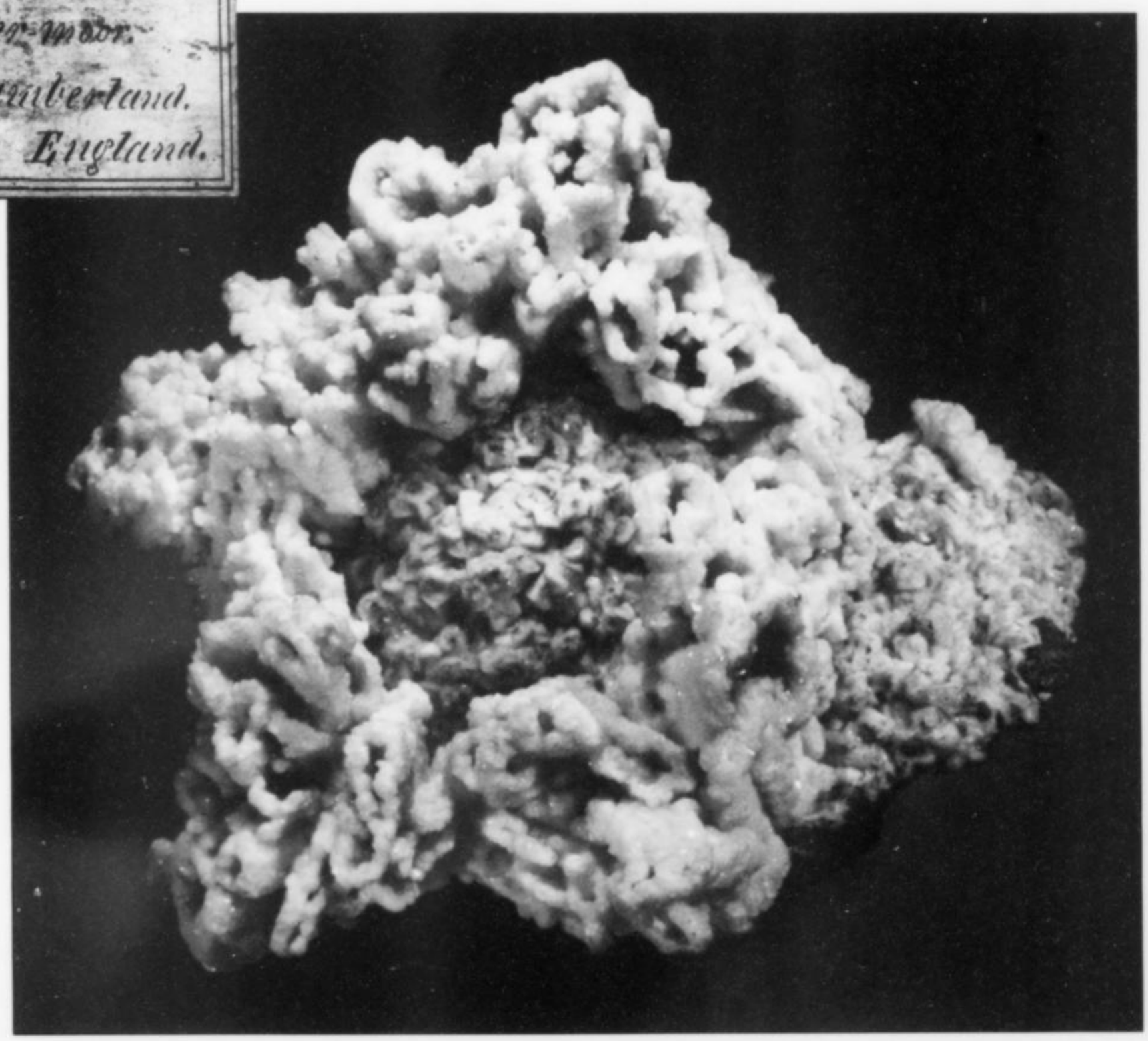


Figure 16. **Aragonite on hematite, 13.5 cm, from Cleator Moor, Cumbria, England. Obtained by Wm. Jefferis from Bryce Wright in July 1864 (Jefferis label shown). Debra Wilson photo; Carnegie Museum specimen CM13210.**

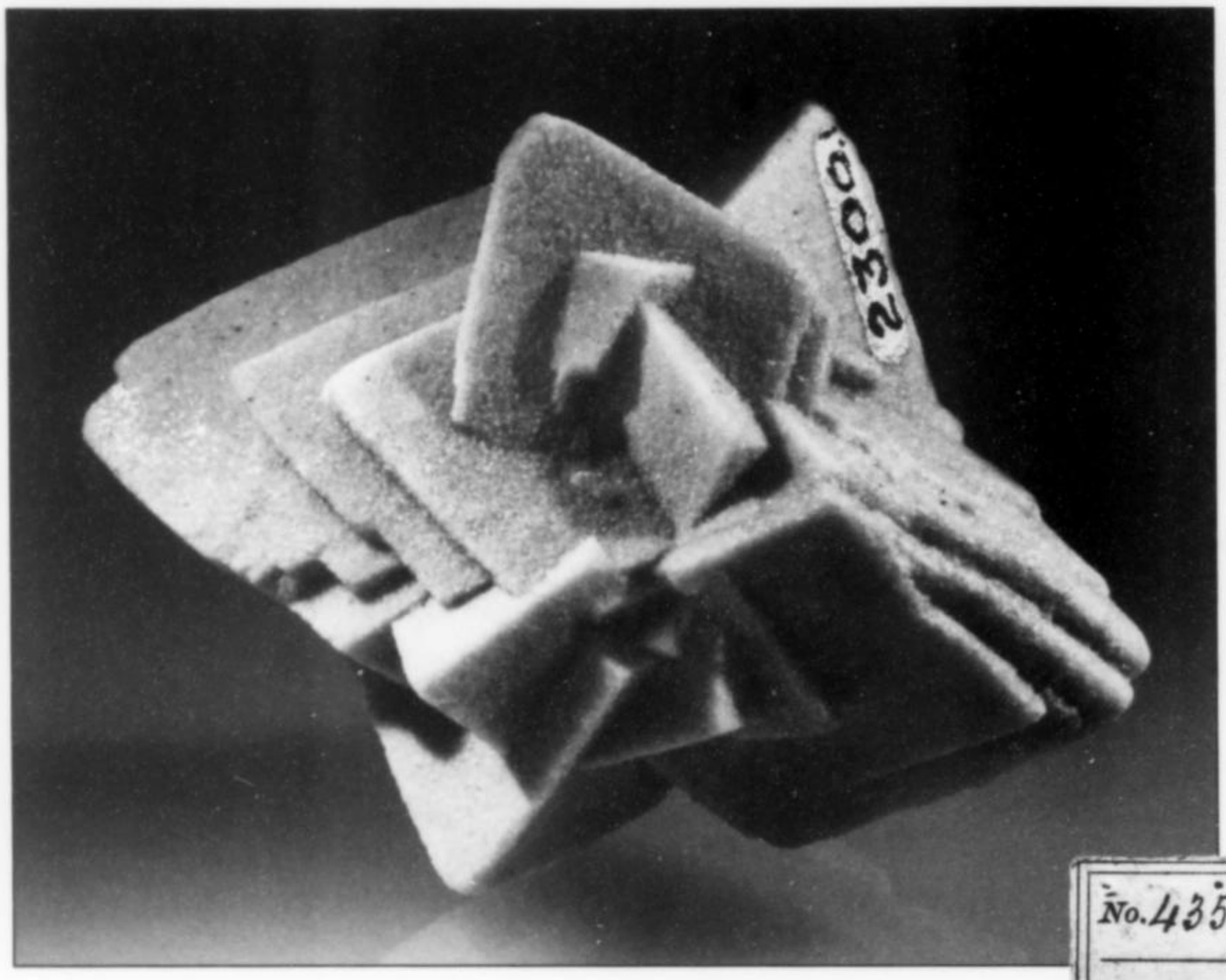
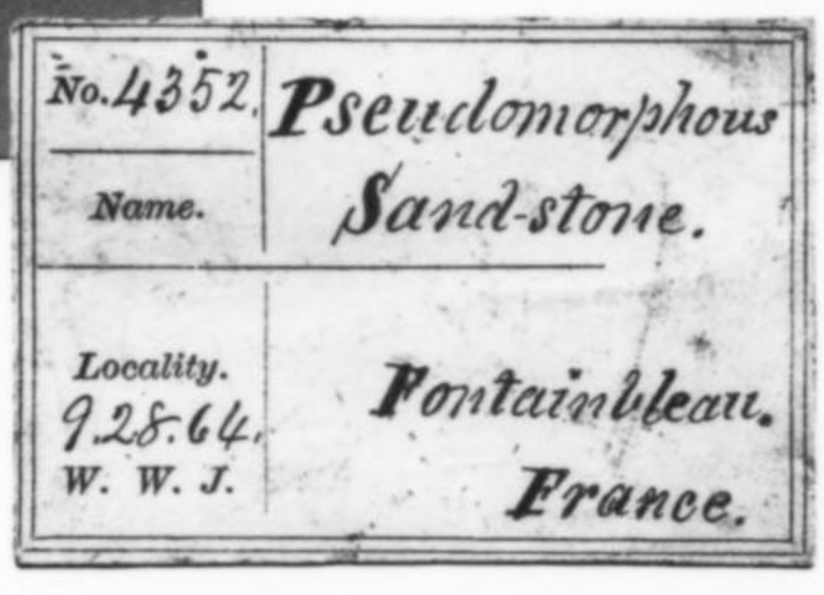


Figure 17. **Calcite "sand crystals," 6 cm, from the classic locality at Fontainbleau near Paris, France. Obtained by Wm. Jefferis from Bryce Wright in July 1864 (Jefferis label shown). Debra Wilson photo; Carnegie Museum specimen CM2300.1.**



his great mineralogical eagerness leads him to do things which I do not think he would approve of in others."

Despite these disappointments, Lettsom concludes—perhaps demonstrating why he chose an overseas diplomatic career rather than remaining a collector (he sold his collection to William Neville before leaving) or becoming Keeper of Minerals at the British Museum (he was offered the job in 1857)—"To a collector all is fair."

Wright must have obtained a lead on the original source during his recovery of the old specimens, and armed with this information he went in search of more. According to Greg (1851) the type matlockite was found on "the old heaps of the level mine at Cromford, near Matlock." This vague information suggests that the first specimens were found in dump material, not in situ. Wright was determined to discover the underground source and after much work his efforts met with great success; over 100 specimens appear to have come his way, either from his own collecting or from miners working the Bage mine. Peter Burr's careful historical research suggests that the precise spot was somewhere on the Wallclose Vein, just below the drainage level. Over the years, the Wrights occasionally sold further Bage mine specimens, but whether these were new finds, old stock, or simply recycled from earlier collections we will probably never know. Further matlockites seem to have come to light in the 1880s, but nothing more has been found since their day.

The Bage mine phosgenite and matlockite specimens were very highly valued by Wright. In 1852 he wrote to William Jefferis: "I have sold specimens in England for 20 pounds each. If I possibly can I will lay a specimen to one side for you as they are very scarce. Mr. Nuttall has not yet [purchased] a specimen [because] the price is so high. I am the discoverer of them & I have served all the leading collectors on the Continent. I will lay to one side for you a small specimen of Matlockite & anything else rare & good. I will not forget to lay a specimen to one side for you."

Wright Senior's Personal Collection

Wright Senior died in London on October 10, 1874. Part of his excellent private mineral collection was auctioned in April 1875 by the J. C. Stevens auction house, amounting to about 1500 fine specimens, and 3,000 more of his specimens were offered for sale in 1881.

Part of Wright's fine private mineral collection was auctioned in April 1875 by J. C. Stevens: 190 lots of minerals, 50 lots of fossils, and a few cabinets of specimens. The minerals were world-wide pieces, mostly offered in lots of six to ten specimens (i.e. around 1,500 pieces); some finer specimens were offered separately, e.g. lot 116, a "very fine specimen of crocoisite, Siberia" which fetched £1.6.0 [£1.30], and lot 136, a "very fine specimen of the rare mineral matlockite" which fetched a remarkably low 17s [85p]. The highest individual price was a mere £3.3.0 [£3.15] for lot 140, "a very fine crystal of green Phosgenite, rare, from Germany."

Several years after this sale, in a catalog published in 1881 (though possibly a reprint of one largely written in 1878), Wright Junior said that he had been:

> . . . instructed by the executors to dispose of his late father's Private Collection of Minerals. When it is mentioned that the Collection has taken thirty years to make, and that the opportunities for procuring the finest examples have been unrivalled, an idea may be obtained of its value and scientific importance. Many of the specimens cannot be equalled. Some of them being of the finest known, whilst the series of rare English Minerals, many procured from mines now closed for twenty years, is of the greatest rarity and beauty . . . . The Fluor-Spars are acknowledged to be the most beautiful series that could be procured . . . in metals the Leads are perhaps

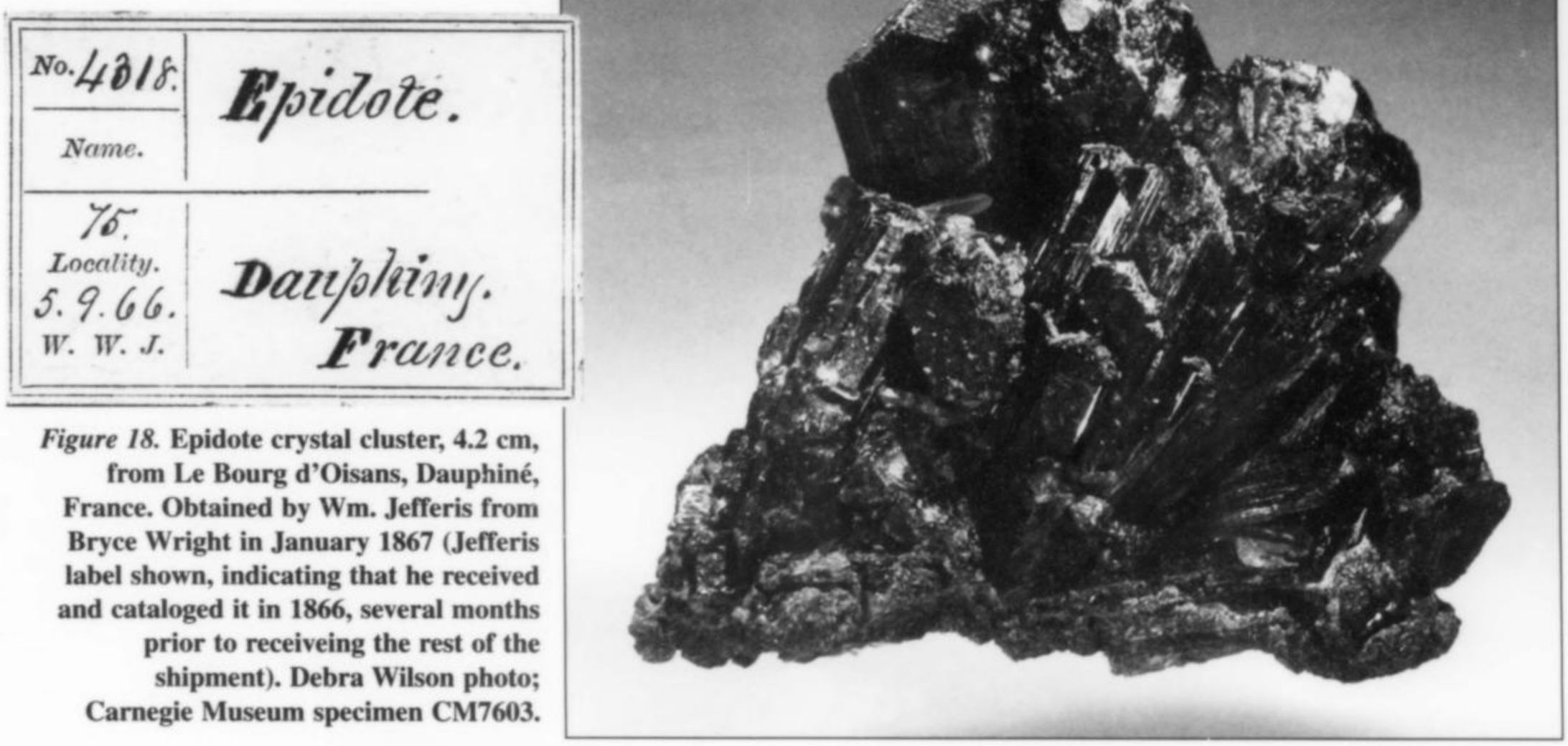
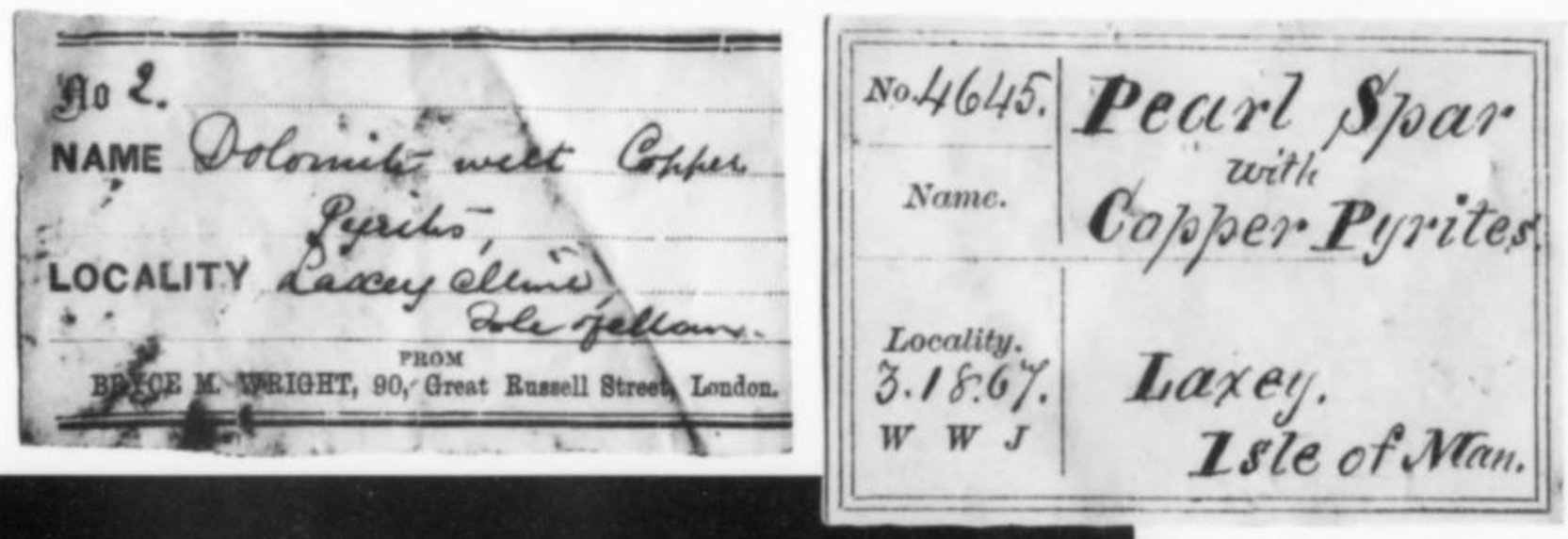


Figure 18. **Epidote crystal cluster, 4.2 cm, from Le Bourg d'Oisans, Dauphiné, France. Obtained by Wm. Jefferis from Bryce Wright in January 1867 (Jefferis label shown, indicating that he received and cataloged it in 1866, several months prior to receiveing the rest of the shipment). Debra Wilson photo; Carnegie Museum specimen CM7603.**



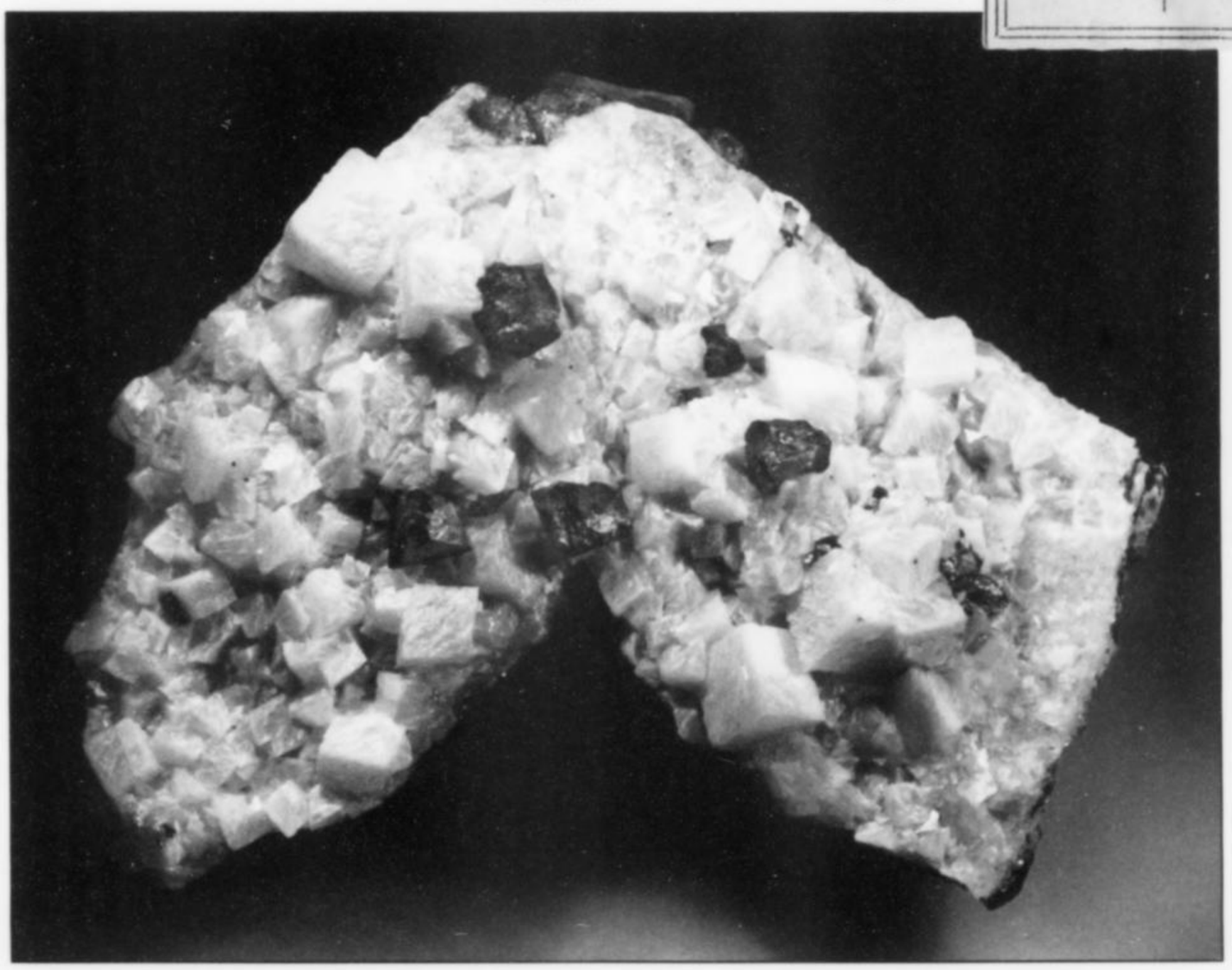


Figure 19. **Dolomite "pearl spar" crystals with chalcopyrite crystals, 11.2 cm, from the Laxey mine, Isle of Man, England. Obtained by Wm. Jefferis from Bryce Wright in January 1867 (Wright and Jefferis labels shown). Debra Wilson photo; Carnegie Museum specimen CM4277.**

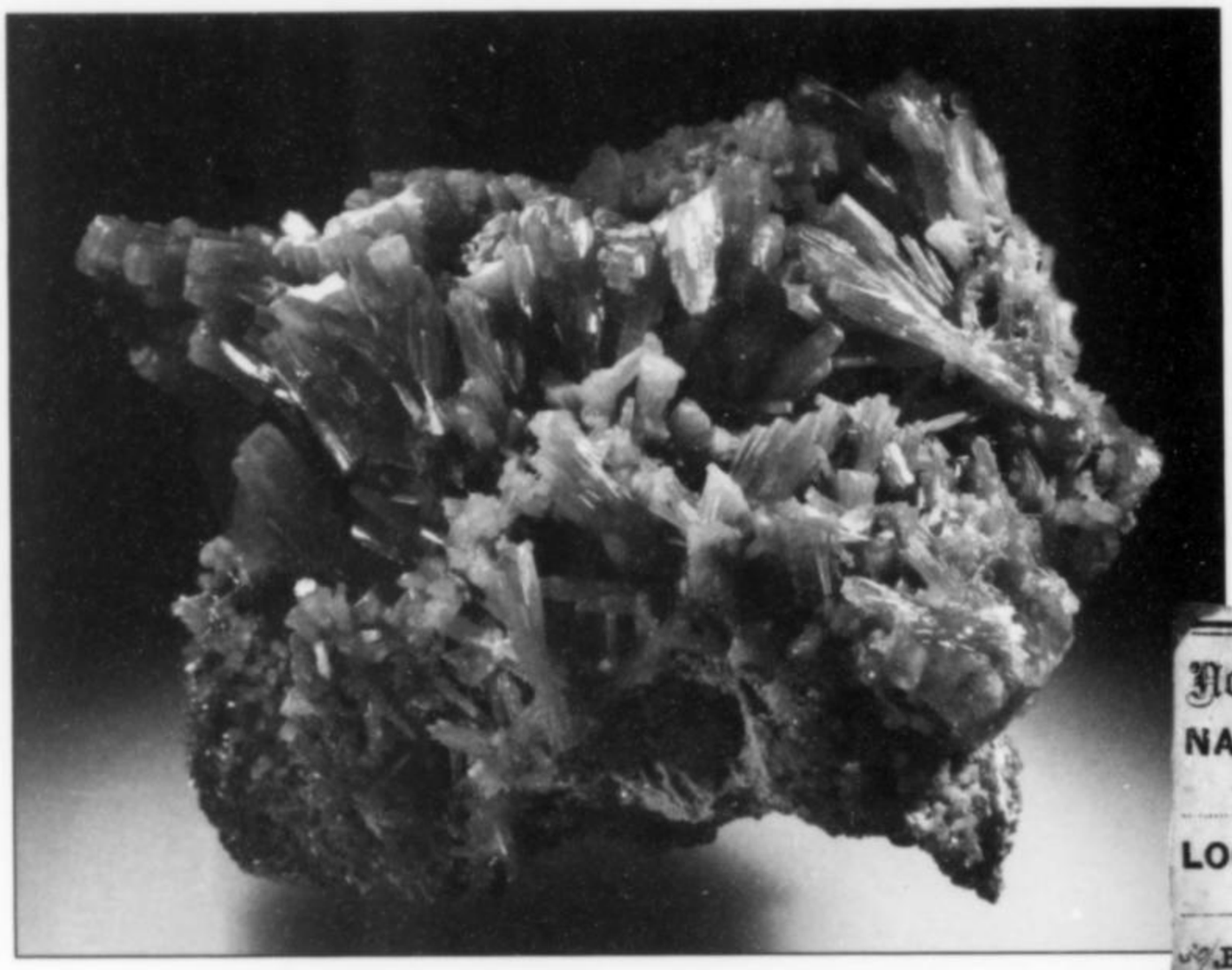
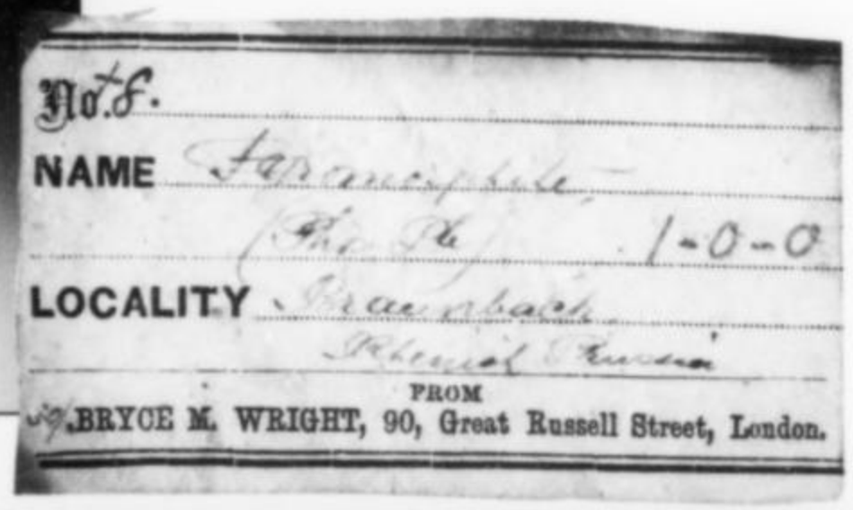


Figure 20. **Pyromorphite crystal cluster, 10.2 cm, from Braubach, Rheinland-Pfalz, Germany. Obtained by Wm. Jefferis from Bryce Wright in February 1868 (Wright label shown). Debra Wilson photo; Carnegie Museum specimen CM10364.**



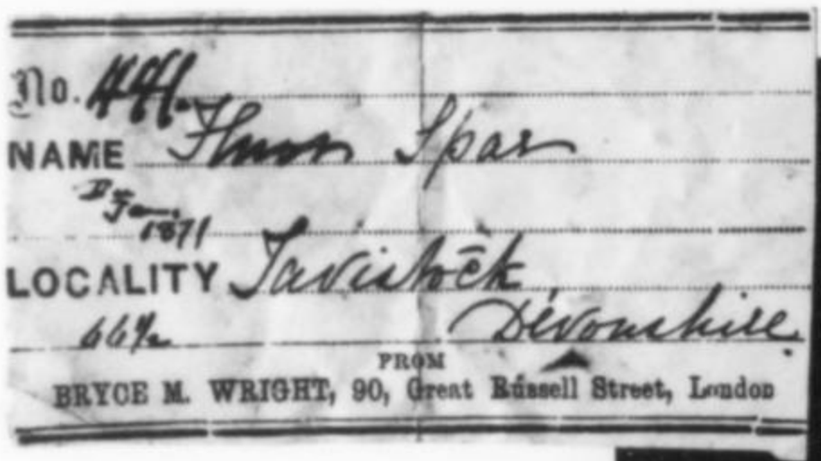


Figure 21. **Fluorite crystals with quartz crystals on matrix, 4.3 cm, from Tavistock, Devonshire, England. Obtained by Norman Spang from William Jefferis (probably in exchange), who had obtained it from Bryce Wright in 1871 (Wright label shown). Debra Wilson photo; Carnegie Museum specimen CM1475.**

the finest known in any private catalogue. Of the following many are specimens that could hardly be equalled: Phosgenites. Matlockites, Suzannites, Leadhillites, Lanarkites, Caledonites, Chromo-phosphates [chromian pyromorphite], Pyromorphites, Kampylites, Vanadinites, Wulfenites, and Linarites. . . . The collection contains about 3,000 specimens, and as a whole offers to an institution or Museum desirous of having a true characteristic working series of Minerals, an unprecedented opportunity of procuring the same. Patrons of Museums are particularly invited to inspect it, which may be done at any time by appointment. The price is fixed at 2,000 guineas."

This collection can no longer be traced and was almost certainly not sold as a unit. Lazarus Fletcher of the British Museum (Natural History) noted that Henry Ludlam and the Museum took specimens from Wright's collection, the latter probably among the 78 mineral

Figure 22. **Drusy malachite with acicular cerussite crystals, 8 cm, from Keswick, Cumbria, England. Purchased by Wm. Jefferis from Bryce Wright Jr. in December 1877 (Wright label shown). Debra Wilson photo; Carnegie Museum specimen CM4853.**

specimens acquired from "Mrs. Wright" in 1875 or the further 40 mineral specimens from Wright's executors in 1876, though there is no positive evidence that these came from Wright's private collection. The museum did not buy specimens from Stevens' sale, and a lack of documentation precludes the identification of Wright specimens in Henry Ludlam's collection (now in the Natural History Museum, London).

Jane Wright kept a few pieces from her husband's collection, but late in life was forced to sell them to make ends meet. In 1890 she begged Thomas Davies of the BM(NH) for help, but Davies was himself seriously ill at the time (he died in 1892) and it would appear that her letter was never passed on. A few months later (on 3 December 1890) Jane died, her daughter Elizabeth at her side.

BRYCE WRIGHT, Jr.

The Wright family Bible supplies biographical notes on Bryce Wright Junior and his descendants as well:

> Bryce McMurdo Wright (Junior) was born on Friday 18th January 1850 in Liverpool and carried on his late Father's (BMW sen) Mineralogical business in the Bloomsbury area of London. On Thursday 17th June 1880 he married Emma Sarah Louisa Crouch, eldest daughter of Edmond Crouch of "The Chase," Clapham, Surrey.
>
> Bryce and Emma had four children: (1) Bryce Walford McMurdo Wright, b. 25 March 1881, d. 5 October 1898 of typhoid at age 17, (2) Clarence Sinclair Darwin Bryce Wright, b. 30 November 1882, d. 20 January 1945, (3) Beryl May Wright, b. 11 August 1885, d. 25 February 1957, and (4) Edith Euclase Winifred Wright, b. 5 February 1888, whose death date is unknown.

Bryce Wright Junior and his sister Elizabeth were actively involved in their parents' business. Elizabeth Wright continued to help her brother in the shop for a short time after their father's demise, but appears to have left soon after her marriage to the paleontologist Robert George Bell (1833–1888) in 1875. Whether Bryce Junior had any formal training in natural history or geology it is impossible to tell; from the style of his publications it appears that he studied the subjects in some detail, although published criticism of his arguments suggests that his grasp of the scientific method was suspect. He claimed to correspond in several languages. Like his father he changed his name from Brice to Bryce, but by the end of 1877 he began to style himself "Mr. Bryce-Wright" and continued with this thereafter. There seems to have been no good reason for this double-barreled style and we can only assume it was an affectation.

Bryce Junior's distinctive hand is first seen on letters, labels, and invoices from the Wright business in the late 1860s, and it may have been the 16-year-old Bryce Junior of whom his father wrote in 1866: "My son is now on the Continent & he has got some fine & rare things from Sweden & Prussia." He also acquired a collection of Elba minerals which arrived in England in 1867. An undated flyer, likely on internal evidence to have been published around 1869-1870, refers to a recent visit by Wright junior to Denmark to procure "Scandinavian Implements." He may have taken over the day-to-day running of the business before his father's death and certainly seems to have had his own customers by the early 1870s: by his own admission he began exchanging minerals with the renowned collector Duke Nicholas of Leuchtenberg as early as 1867, and had dealings with other mineralogists and collectors during this period.

In 1870 he began selling agates to Edward Stanley, 15th Earl of Derby. The collection eventually numbered 779 specimens, all provided by Bryce Wright Junior, of which 695 were cut and polished and the remainder were specimens of minerals, rocks, and meteorites in their natural state. Lord Derby bequeathed his agate collection to the Liverpool Free Museum, which had been founded in 1851 with the zoological collections of his ancestor Edward Smith Stanley the 13th Earl. Wright cataloged the Derby agate collection, and published the results as *Native Silica, a treatise upon a series of specimens of quartz, rock crystal, chalcedony, agates, and jaspers . . . forming the collection of the late . . . Earl of Derby*. Each specimen was described in detail, and each class of the mineral was

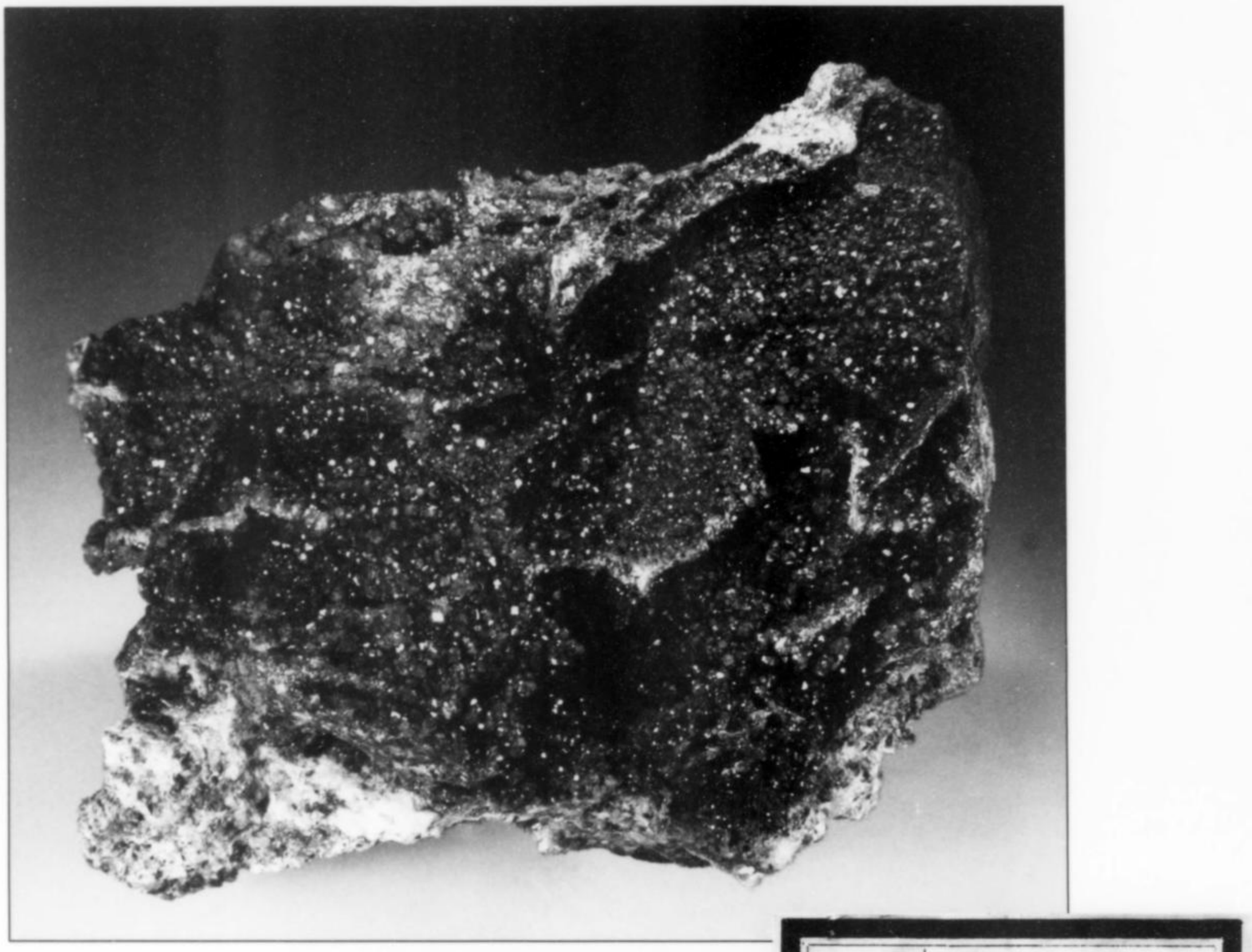


Figure 23. **Pharmacosiderite crystals on matrix, 8.8 cm, from Wheal Gorland, Cornwall, England. Purchased by Wm. Jefferis from Bryce Wright Jr. in May 1879 (Jefferis label shown). Debra Wilson photo; Carnegie Museum specimen CM10758.**

accorded an informative introduction to its sources, history, and origins. Wright's work demonstrates a thorough reading of the subject in hand, interweaving his knowledge of mineralogy, precious stones, ethnology, and archaeology, and quoting a wide and eclectic range of authorities covering the mineralogy of the specimens, theories of their formation, their sources, and associated legends and beliefs from cultures around the world. He concludes the book with a list of collectors from whom he obtained specimens for inclusion in the Derby cabinet. The work has been described by John Sinkankas as "The first major description of the quartz family minerals . . . a most interesting, indeed, in parts, a scholarly work of considerable value . . . and on the whole . . . far more a general treatise on gems than a mere catalog of a collection." Unfortunately, the majority of the collection was destroyed by bombing during World War II, and only 112 specimens survive today.

The situation in the 1870s must have looked promising for the young proprietor. He could boast an aristocratic and influential clientele, an excellent business location, and a fine stock of minerals, gems, fossils, shells, and ethnological artifacts, not to mention the good will and worldwide contacts inherited from his father. On taking over the business, 25-year-old Bryce Junior threw himself into it with gusto, and between 1874 and 1880 invested considerable effort in improving his business and scientific profiles. He advertised regularly, wrote academic papers, popular mineralogies, and collection catalogs and joined many of the most important British and European societies associated with the natural sciences and ethnography. Prominent among these were the prestigious Royal Historical Society (a member 1874–1893) and the Royal Geographical Society (1876–1895), membership of which allowed him to put the letters FRHistS and FRGS after his name. Other societies joined included the Mineralogical Society of Great Britain and Ireland (1878–?) and the Société Minéralogique de France (1878–?). In 1888 he was also styling himself "F.R.S.North.A.," the meaning of which is unknown: it is not an official off-shoot of the Royal Society and is not known in Northern Australia or North America.

He published at least 15 articles, books, and collection catalogs from 1869 to 1894. His first, an introduction to sponges, appeared in the popular natural history magazine the *American Naturalist*

Figure 24. **Painted sketch by the Victorian illustrator and satirist Ernest Griset (1843–1907) depicting a fictitious scene in which Bryce Wright, Jr. (referred to as "Bryce-Wright" in the painting's caption) is presenting a new species of fossil bird to the prominent British Museum paleontologist Prof. Richard Owen in 1873 (note red boutonniere). (Victoria and Albert Museum)**

when he was nineteen. In 1874–1875 he contributed chapters on mineralogy to H. I. Jenkinson's popular series of *Practical guides*: to the *Isle of Man* (1874); the *English Lake District* (1875 and later editions); and *Carlisle, Gilsand, Roman Wall and Neighbourhood* (1875).

In January 1876 Bryce Junior announced in a front page ad in *Nature* his return to his "old and now more extensive Premises [at] 90 Great Russell Street." Presumably the shop had been refurbished in his absence. In a *Nature* ad of 1877, he described his new shop as a "Mineralogical and Geological Museum." Spectacular rarities graced the reopened shop, and were advertised regularly in *Nature*. A suite of ethnographic items from the *Challenger* expedition included "an unique Coat of Armour made of Buffalo Horn and Brass Rings;" impressive fossils such as "one of the largest examples of Teleosaurus Bollensis known . . . nearly 14 feet in length" and a 17-foot-long Plesiosaur dominated the show room.

Just four years later, in 1881, Wright Junior moved from the long-established premises in Great Russell Street to a new shop at 204 Regent Street: "Mr. Bryce Wright's new Show Rooms . . . containing the Finest & Largest Stock of Minerals in Europe." An impression of the interior of the Regent Street shop can be gained from the catalog of Wright Junior's 1888 bankruptcy sale, for included in it was what appears to be the whole of his shop fittings and equipment, from his office desk, lapidarist's benches and books, through the showcases, counters, and gas lights, down to the "extra thick indiarubber doormat." From the sale lots we can calculate that his shop had over 40 feet of wall showcases (including "a very handsome ebonized and bevelled plate-glass wall show-case, 11 feet 4 inches long, 4 feet 6 inches high, 7 inches deep, with mirror back, enclosed by folding doors"), 27 feet of mirrors, two 8-foot-long counters and several free-standing or counter showcases and mahogany mineral cabinets. An eye-catching feature was the "life-size figure of a Japanese soldier, in square glass case, on plinth." The high quality cabinet-making, with the glitter and luster of the myriads of gas-lit crystals, gems, and artifacts reflected in the polished wood and mirrored glass, must have made an impressive sight.

Wright married Emma Sarah Louise Crouch on 17 June 1880. She was the daughter of Edmund William John and Emily Crouch, the former a jeweler and goldsmith of Brixton Road, London and possibly a business associate or client of Wright's. They had four children together (Bryce Walford McMurdo, Clarence Sinclair Darwin Bryce, Beryl May and Edith Euclase Winifred). Emma Wright collected meteorites and shells. *Mitra wrighti* was described by Crosse in 1878 from a specimen in her collection, but the type specimen is now lost. The type specimen of Wright's new species *Murex Huttoniae* resided in her collection at the time of its descrip-

DOUBLE NUMBER.—SECOND EDITION.

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Of Nature trusts the mind which builds for aye."—WORDSWORTH

No. 358, VOL. 14] THURSDAY, SEPTEMBER 7, 1876 [PRICE EIGHTPENCE

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MINERALOGY, GEOLOGY, & CONCHOLOGY.

BRYCE M. WRIGHT, F.R.C.S., F.R.HIST.S.,

(MEMBRE DE LA SOCIÉTÉ MALACOLOGIQUE DE BELGIQUE, &c.)

Mineralogist, Geologist, and Conchologist,

90, GREAT RUSSELL STREET,

BLOOMSBURY, LONDON, W.C.

MINERALS.

MR. BRYCE M. WRIGHT has the honour of calling the attention of Mineralogists and Scientific Gentlemen to his extensive COLLECTION OF MINERALS, now undoubtedly the LARGEST IN EUROPE, from which single specimens may be selected. The latest arrivals are an extremely fine collection of EMERALDS and BERYLS from the River Tokowoia, N. of Katherinenberg, Siberia, formed by an eminent Russian collector; amongst them is probably the LARGEST EMERALD in the matrix KNOWN, measuring 2¾ inches in height, and 1¾ inches in diameter; Crystallised Diamonds from the Cape; Topazes, Phenakites, Alexandrites, from Siberia, &c. Meteoric Stones and Irons of various falls and dates.

FOSSILS.

The GENERAL COLLECTION contains many thousands of specimens from the various formations, being particularly rich in Trilobites, Crinoids, Fish, Brachiopodæ, and Reptiliæ. For Museums and Public Institutions the following on hand at present may be enumerated:—A magnificent complete specimen of the CHELONIA HOFFMANNI, Gray. from the Cretaceous of Maestricht, measuring 4 feet 1 inch in length. One of the largest examples of TELEOSAURUS BOLLENSIS known, measuring nearly 14 feet in length, and a very perfect ICHTHYOSAURUS TENUIROSTRIS, 5 feet in length, both from the Lias of Boll, Wurtemberg. (Sketches and Outlines of the above sent upon application.)

SHELLS.

MARINE, Terrestrial, and Fluviatile Shells from all parts of the world, illustrating many hundred Genera. The latest rarities are the Land Shells from Ecuador, the Spondylus Wrightianus, *Crosse*, from Swan River, Australia, with the rare Voluta thatcheri, V. cymbiola, V. sophia, V. fulgetrum, &c. Conus cedo-nulli, C. Victoriæ, &c.; Cyprœa Scotti and the Cyprœa aurantia (orange Cowry) from the Sandwich Isles.

STONE AND BRONZE IMPLEMENTS.

Implements of every description, illustrating the Palæolithic and Neolithic periods, including Wedges, Flakes, Scrapers, Spear-Heads, Daggers, Hammers, Gouges, Chisels, from Denmark, Sweden, France, Mexico, Ireland, Germany, England, and America. Meri's or Patoo-patoos, Celts in Jade and Greenstone from New Zealand, New Caledonia, and South Sea Islands. Bronze Swords, Palstaves, Celts from France, Ireland, Denmark, &c.

N.B.—Selections of either Minerals, Fossils, Shells, or Stone and Bronze Implements forwarded upon selection.

ELEMENTARY COLLECTIONS.

50	Fossils, stratigraphically arranged, in Case with Lock and Key	...	...	...	...	...	...	£1	0	0	to	£2	0	0
50	Minerals, Earthy and Metalliferous, arranged according to DANA's System of Mineralogy	...	...					1	0	0	to	5	0	0
50	Rocks, Sedimentary and Igneous	...	...	...	...	...	...	1	0	0	to	2	0	0
100	Fossils, stratigraphically arranged, in Case with Lock and Key	...	...	...	...	...	...	1	10	0	to	5	0	0
100	Minerals, Earthy and Metalliferous (Dana's Mineralogy)	...	...	...	...	...	...	1	10	0	to	5	0	0
150	Minerals, Fossils, and Rocks, in one Case	...	...	...	...	...	...	3	10	0	to	7	0	0
200	" "	...	...	...	...	...	...	5	0	0	to	10	0	0

The above Collections obtained the ONLY Prize Medal at the International Exhibition of 1862, and being made under the personal supervision of Mr. Bryce M. Wright, F.R.G.S., &c., the identity and localities are guaranteed.

Superior Collections for Colleges, Institutions, &c., from 10 to 2,000 guineas. Models of Fifteen of the most celebrated Diamonds, in case, £5 5s. Casts of Rare Fossils, including the Head of the Mosasaurus Hoffmanni, Odontopteryx toliapicus, &c. Corals, Sponges (including the Venus's Flower Basket, Euplectella speciosa, price 5s.), Gorgoniæ, Echini, Star Fishes, &c. Round, Square, and Rectangular Glass-capped Boxes (Lithographic Plan on application), Card Trays, Models of Crystals, Charts, Diagrams, Geological Hammers, Blowpipes. Scales of Hardness and Fusibility, and all Mineralogical and Geological Appliances. For latest arrivals, see page clx.

BRYCE M. WRIGHT, F.R.G.S., &c.,

90, GREAT RUSSELL STREET, BLOOMSBURY, LONDON, W.C.

Figure 25. **Bryce Wright advertisement in the September 7, 1876 issue of *Nature*.**

Figure 26. **Bryce Wright Junior's lavish calling card, dated November 27, 1878. His use of the Royal Crest was not officially sanctioned. The card indicates that Bryce Wright (Sr.) had exhibited at the London International Exposition in 1862 and the Paris Exposition Universelle in 1867. It also specifies that Wright (Jr.) was a Fellow of the Royal Geological Society and the Royal Historical Society.**

Figure 27. **Oil painting (unsigned, undated) of Bryce McMurdo Wright, Jr., probably dating to around 1880. Courtesy of Robert Wright.**

tion. She disposed of her meteorites in or before their divorce in 1891. Two months after Wright's death (on 27 July 1895) she married widower George Roberts Minter Frieake (b. 1857), an auctioneer from Harrow.

Early on, Wright Junior began to specialize in rough and cut gemstones, describing himself ever after as "Mineralogist and Expert in Gems and Precious Stones." He offered fine natural crystals in the matrix, spectacular cut stones, and made special collections of gems and gem minerals for sale. In a letter to American gem collector Joseph Leidy in 1880 he says: "My stock of gems is wonderfully increasing & I now have most magnificent specimens of nearly every gem." In his 1881 catalog he claims to have representatives of every known variety. Many of his gem mineral specimens were asserted to be quite exceptional: "Probably the largest emerald in the matrix known, measuring 2⅜ inches in height, and 1¾ inches in diameter" was offered in 1876; "an unique Cat's Eye, being one of the finest, if not the finest known" was advertised in 1880, and in 1881 a "Matchless opal, weighing 34+ carats, one of the finest known." The following year saw a description of a 13th-century engraved diamond in his possession published in the *Times*.

A remarkable rarity was featured in a Wright advertisement in *Nature* in July 1877: "The Scotch Koh-i-Noor," a faceted colorless beryl (goshenite) from Perthshire, Scotland. A short note on the gem appeared in the magazine itself, describing it as "a wonderful white aquamarine . . . found in Perthshire which, when cut, . . . produced one of the most brilliant gems ever seen. It is said by many competent judges to be equal to her Majesty's celebrated Koh-i-Noor [diamond], its refraction being very great both by day and night. It is of a pure pellucid liquid white . . . Mr. Bryce M. Wright, F.R.G.S., is its possessor." This large (85.75 carats) and beautiful stone was bought in 1878 by the British Museum for £65, but although describing it as "unique," Maskelyne's letter to the museum trustees recommending the purchase makes no mention of

Figure 28. **Portrait photo of Bryce McMurdo Wright, Jr. Apparently the red boutonniere was a personal hallmark, as he had it hand-colored on the print. He also appears with a red boutonniere in the Griset cartoon (Fig. 24). Courtesy of Robert Wright.**

its provenance. Its origins were suspect from the beginning: when recorded in the BM register the stone was described as "supposed to be from Perthshire" but nothing remotely like it had ever been reported from Scotland, and in the absence of proof to the contrary it was assumed to be Brazilian. It remains on display in the Natural History Museum mineralogy gallery, labeled "Brazil."

"Now undoubtedly the LARGEST IN EUROPE" said Wright of his stock of minerals in 1876. His regular ads in *Nature* for "Bryce Wright's latest arrivals" often listed minerals, including many rarities, but the best descriptions of his stock are those offered in his 1881 shop catalog and the 1888 bankruptcy sale list. The 1881 overview of his mineral stock mentions species from many of the most important British localities, commenting that the minerals of Leadhills, Scotland "can only be procured through Mr. Bryce-Wright's agency." There is an accompanying engraving of a leadhillite specimen "procured by Mr. Bryce-Wright from the Lead Hills, Scotland, 1873 . . . the finest single crystal known." Wright sold it to the American collector William S. Vaux. The specimen survives, with its Wright label, in the Vaux collection in the Academy of Science, Philadelphia.

He was having trouble making ends meet by 1885, and in a few years was to sink into deep financial trouble. In the summer of 1887

***Table 2.* Addresses appearing on Bryce Wright specimen labels and correspondence, and their corresponding dates.**

Bryce Wright Senior	
Lake District	(no labels)
52 Renshaw St., Liverpool	(<1842–1855)
4 Stanley Street	(1855–1857)
36 Great Russell Street	(1857–1865)
90 Great Russell Street	(1866–1874)
Bryce Wright Junior	
37 Great Russell Street	(1874–1876)
38 Southampton Row	(1874–1876)
90 Great Russell Street	(1876–1881)
204 Regent Street	(1881–1888)
26 Savile Row	(1888–1890)
166 Wardour Street, Soho	(1891)
199 Wardour Street, Soho	(1892?–1895)

his business failed. Following the bankruptcy Wright removed to new premises at "The Museum," Savile Row, in the summer of 1888. He advertised there "larger and more extensive Premises, suitable for his Mineralogical and Natural History Specimens." But he had no capital, and got into trouble pawning jewelry items he didn't own for cash (he was convicted of this crime but received a suspended sentence), and had developed a poor reputation for the manufacture of fake specimens, and the attribution of false localities to specimens. He was forced to file for bankruptcy again in 1890.

Wright Junior was probably partly the victim of bad luck and bad timing. The prosperous mid-Victorian boom was drawing to a close as he attempted to expand his business and the resulting economic decline may have hit him hard. In addition, the increasing professionalization of science was alienating the private amateur or "gentleman" collectors who would have been the mainstay of his geological business, and he would no longer have been capable of acquiring local specimens cheaply, as his father had done, to use as exchange material with overseas suppliers, since many of the classic British mineral occurrences were also waning by the 1880s. He could therefore have been as much a man short-changed by history as a victim of his own shortcomings.

According to Court records, Bryce became extremely abusive toward Emma when his financial and legal troubles were reaching a crisis point, and she divorced him in 1891. He died of heart failure four years later at the age of 45. Most of his collection had already been sold, but according to Robert Wright, Emma sold some of his specimens in order to make ends meet, as did Wright Junior's mother, Jane (Smith) Wright. Thus ended a remarkable half-century of mineral dealing by the Wright family.

ACKNOWLEDGMENTS

We are indebted to Robert Wright (who had not heard of the Cooper book prior to his contact with the *Mineralogical Record* in 2008) for graciously providing copies of the painting and photo of Bryce Wright Junior, transcripts from the Wright family Bible, and copies of Court transcripts. Debra Wilson deserves special acknowledgement for all her hard work assisting in the identification process at the Carnegie Museum, as well as her excellent specimen photography. And the Carnegie Museum library staff was especially helpful in finding and copying the many Jefferis/Wright correspondences preserved in the archives.

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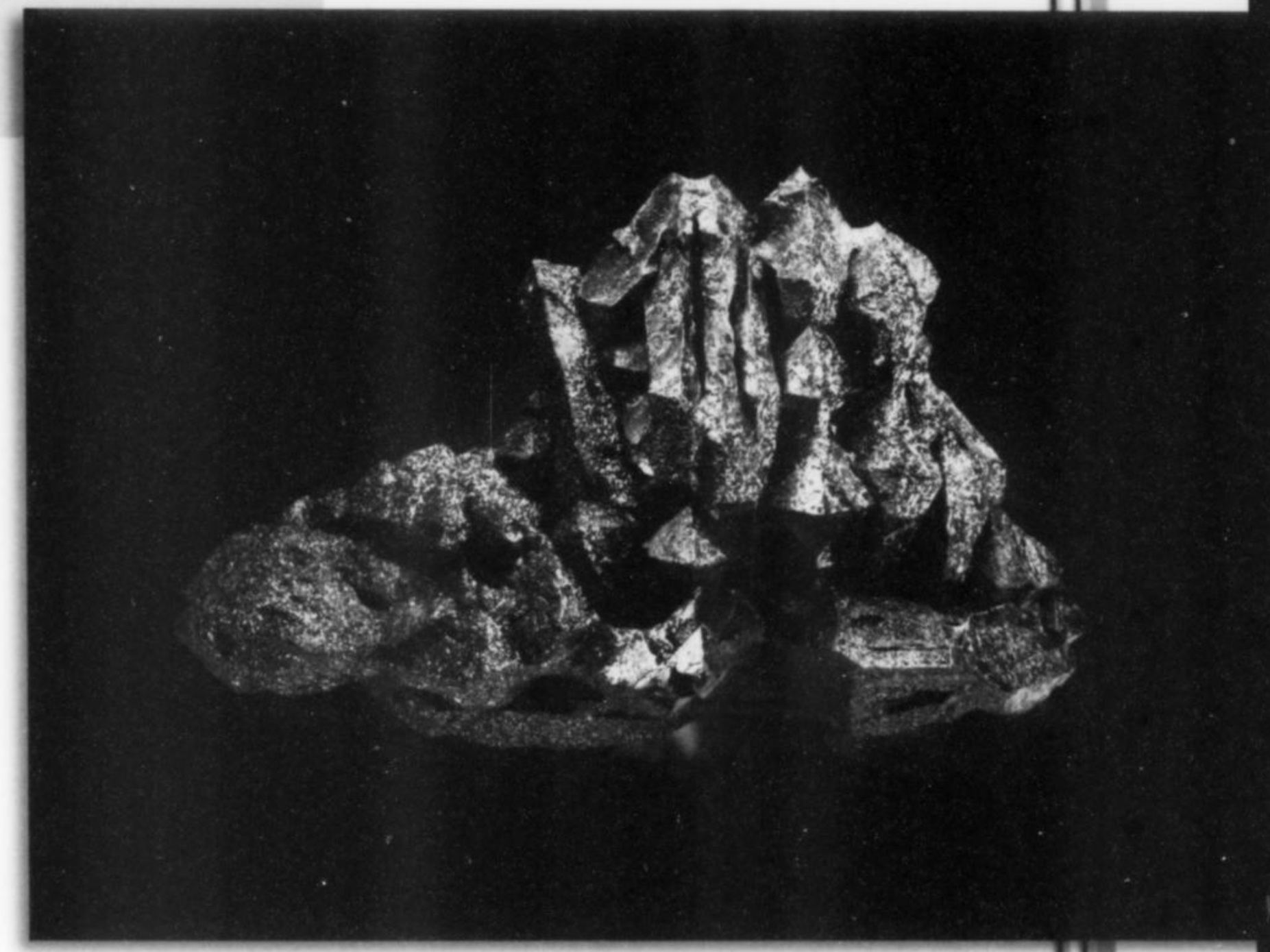

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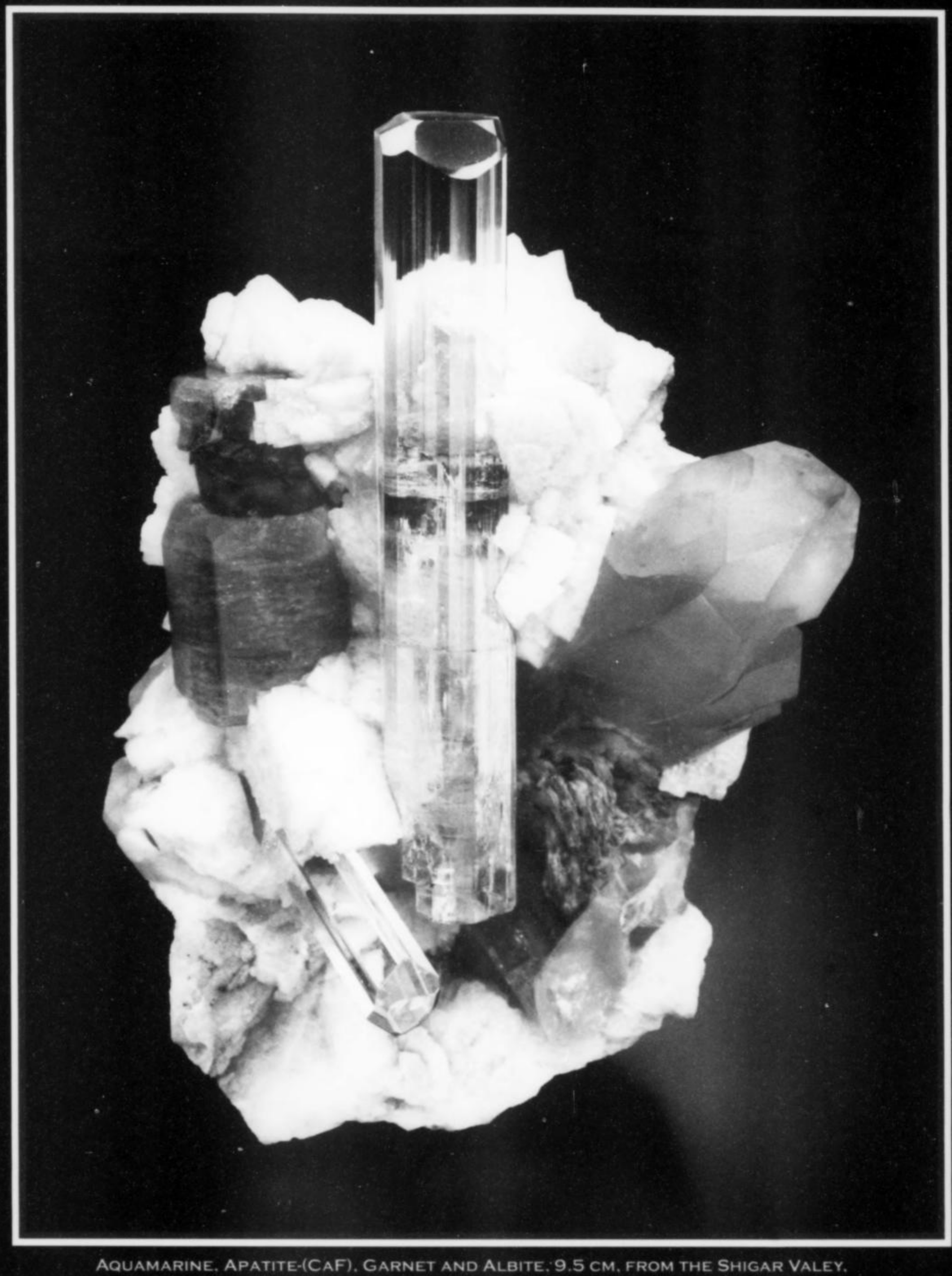

AQUAMARINE, APATITE-(CaF), GARNET AND ALBITE, 9.5 CM, FROM THE SHIGAR VALEY, NORTHERN AREAS, PAKISTAN. ACQUIRED FROM STUART WILENSKY, JUNE 2007

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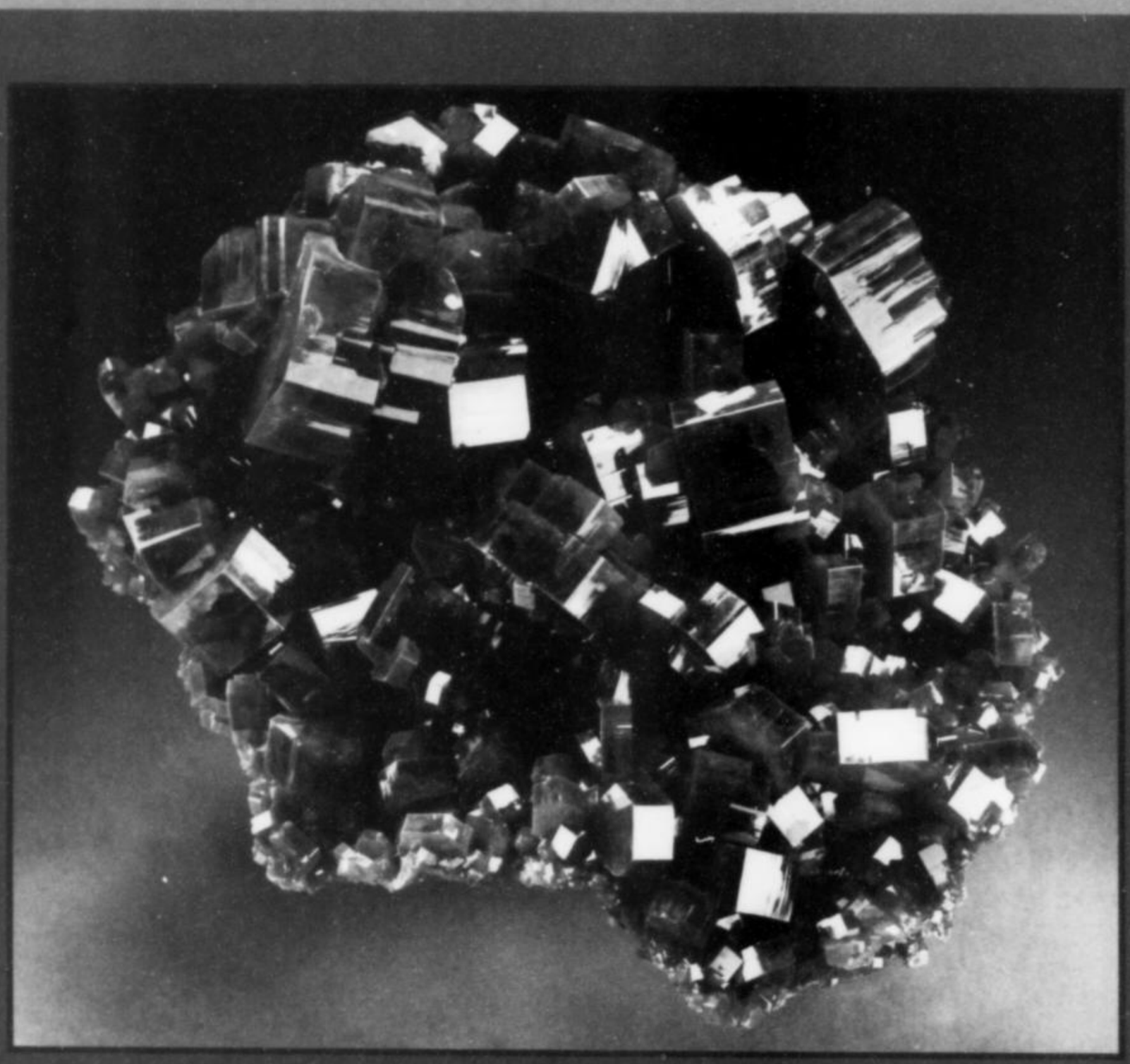

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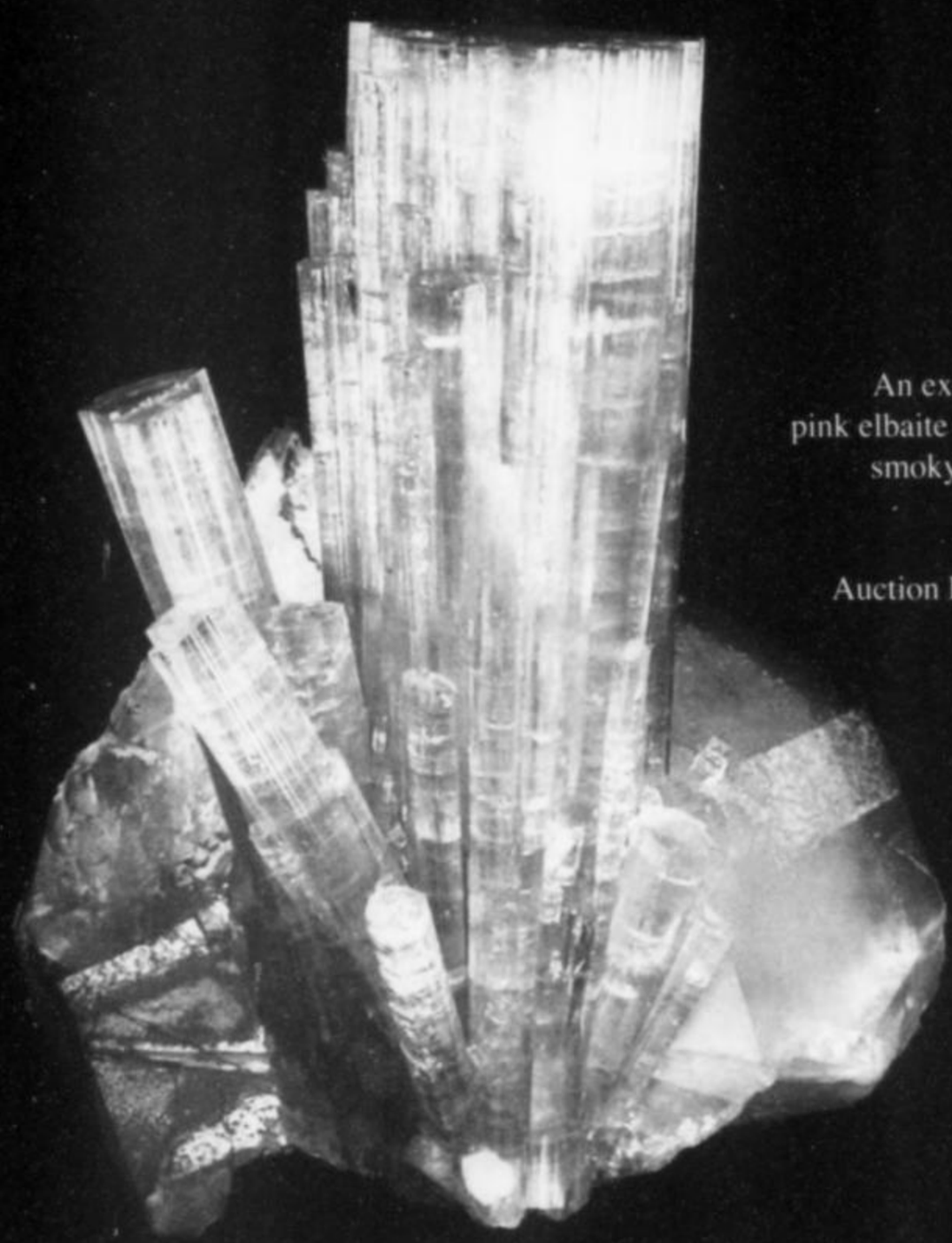

An extremely aesthetic, bubble-gum pink elbaite crystal cluster on a terminated smoky quartz crystal formerly of the Steve Smale Collection

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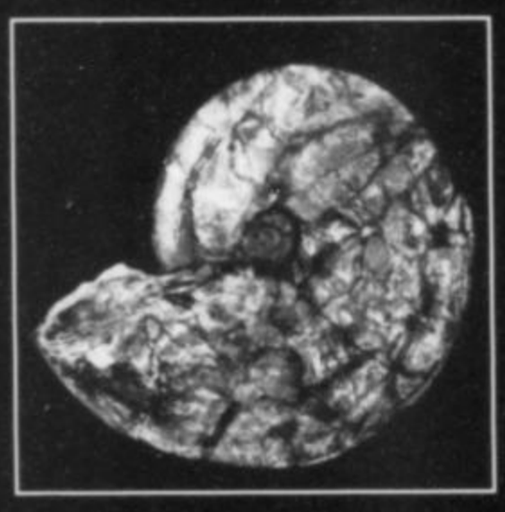
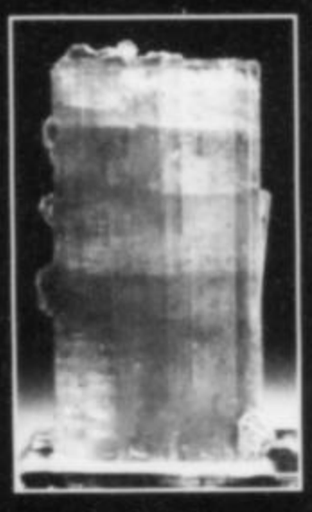


Sold for **$264,000**



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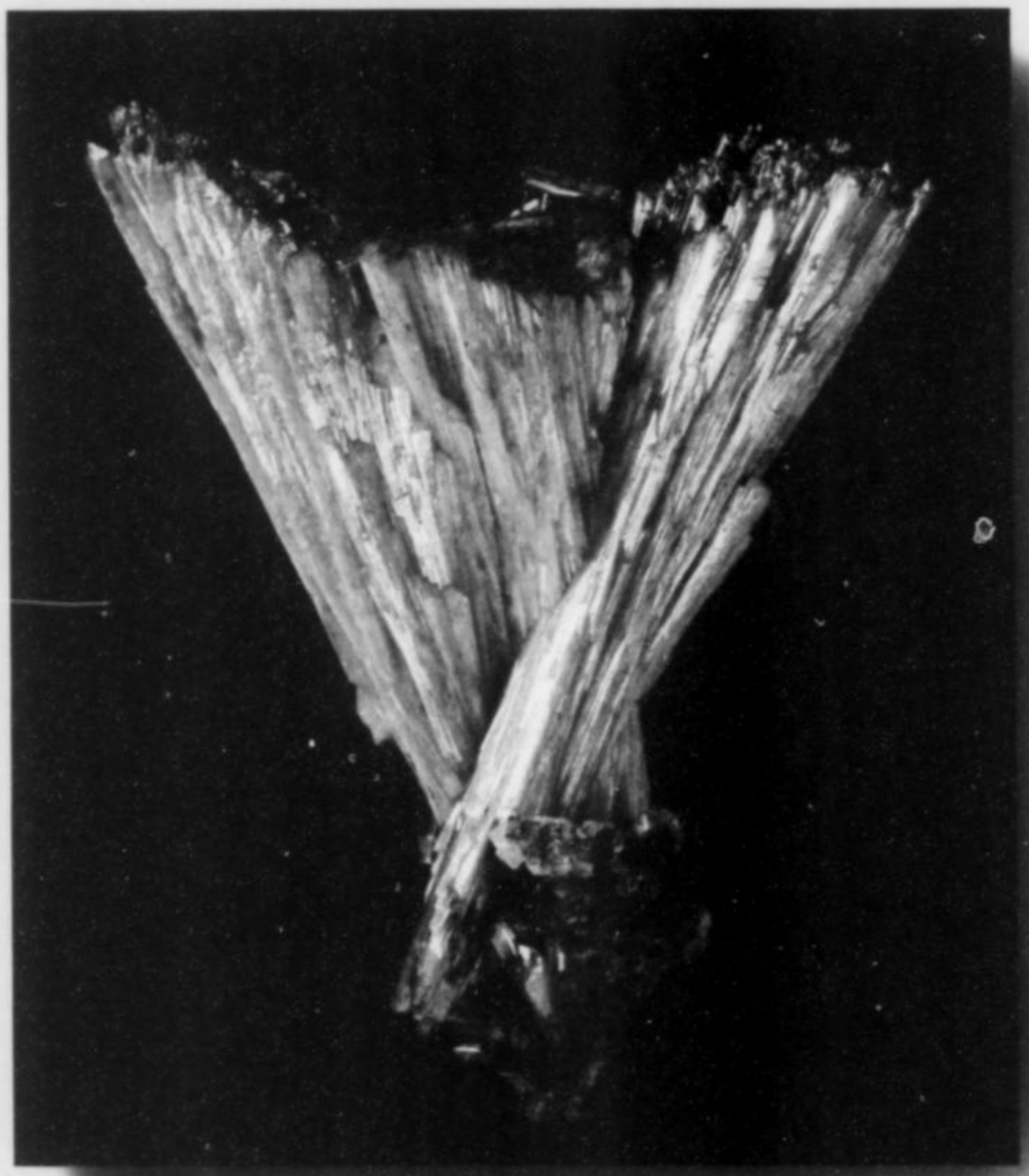

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Pictured above: The "Aztec Sun" legrandite, 18.7 cm, from the Ojuela mine, Mapimí, Durango, Mexico—the centerpiece of the Miguel Romero collection. Jeff Scovil photo.

Famous Mineral Localities:

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lyckberg@pt.lu

Vsevolod Chornousenko
Chief Geologist Volyn Piezoelectric Quartz Deposit
Kvarts Samotsvetny Company
Volodarsk-Volynski, Ukraine

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The Mineralogical Record
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Large, beautiful, deeply etched crystals of yellow-green beryl from the Volodarsk-Volynski pegmatite district first reached the Western mineral market in 1980. The majority of specimen crystals known today were recovered from pockets encountered in 1953, 1973, 1982, 1992 and sporadically since then, continuing after quartz mining ceased there in 1995. The deposits have also yielded large, complex, colorless to orange, blue or bicolored topaz crystals to117 kg, and rare aquamarine, phenakite, fluorite, goethite and other species.

INTRODUCTION

The Volynian[1] pegmatite area is centered a few kilometers west of the town of Volodarsk-Volynski (Володарськ-Волинський) in the Volodarsk[2]-Volynski[3] district of Zhitomir Oblast (Province), north-central Ukraine, on the Irscha River. The pegmatite bodies discovered in the district were found to contain giant crystal pockets with a general structure that had never been seen before. Consequently a new term was coined to describe them: "Volynian chamber pegmatites." Other similar pegmatites have since been found in Finland and Kazakhstan.

The Volodarsk-Volynski district was mined primarily for industrial-grade piezoelectric quartz during the Soviet era, and was

[1]In the literature, "Volynian" is used as an approximate equivalent of the more cumbersome "Volodarsk-Volynskian." The name should not be confused with Volyn Oblast (Province) in northwestern Ukraine.

[2]The Volodarsk name may be in memory of Marxist revolutionary activist V. Volodarsky (1891–1918).

[3]The Volynski name may be in memory of Artemy Petrovich Volynski (1689–1740), a Russian statesman. There is poor agreement in English-language mineralogical and geological literature on the correct spelling of Volynski. Other variations, reflecting various

Figure 2. **Location map.**

Figure 1. **Church on Gorky Street in Volodarsk. Aleksei Beloborodov photo.**

referred to in Soviet literature as the Volynsk Piezoquartz Deposit. Some optical-grade fluorite was found there as well, but more important was the discovery of gem-quality beryl crystals, huge gem topaz crystals and a variety of other species in collector-quality specimens. Information about the pegmatite deposits was treated as a state secret during the Soviet era, but thanks to extensive research over the years by many Russian and Ukrainian investigators, the area now ranks as one of the most widely studied and described pegmatite regions in the world.

HISTORY

Previous Investigations

Quartz and topaz crystals in the Volyn region were first found by farmers in the course of plowing their fields, and were presumed to have been carried down from Scandinavia by glaciation during previous ice ages. It was believed that such exotic gem materials could simply not have originated in the Ukraine!

Konstantin M. Feofilaktov (1818–1901) was the first to describe pegmatite bodies in the Volyn region in 1851. But it was amateur geologist Gottfried I. Ossovskiy (1835–1897) who in 1867 provided more details about the mineralogy. He described large blocks of colorless to smoky quartz and he found cleavages and crystals of topaz.

F. Kreuz (1891) and S. Kreuz (1931) briefly described topaz and a few other minerals from Ossovskiy's personal collection.

Geological-geomorphological research continued for the next few decades, but it was not until the publication of V. I. Vernadskiy's *On the Mineralogy of Volyn* (1911) that mineralogical interest was revived. Much research on the various species and on the genesis of the pocket pegmatites followed. Boris A. Garusevich (1908–1965), in particular, published a series of papers on the mineralogy, proposed a genetic scheme of crystallization, and commented prophetically that "this type of pegmatite is a promising source of interesting minerals, especially of beryl" (1930). The results of many studies were summarized by Ivanov (1936) and Buryanova (1940).

Mining of industrial-grade quartz began in 1931, and production exceeded 10 tons in the first year. Most of the quartz was recovered by open-pit mining of the kaolinized granite and associated pegmatites using primitive methods. Local farmers also dug trenches and

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transliteration conventions and traditions, include Volyn, Volijn, Volynsk, Volynska, Volynsky, Volhynsky, Volynskyi, Volynskiy, Volynskii, Volynskyy and Volynskij. Variations such as Volynskogo, Volynskaya and Volynskoye are grammatically based (in Russian) on the gender of associated nouns, and need not be used in English. German-language versions substitute "W" for "V" to maintain correct pronunciation.

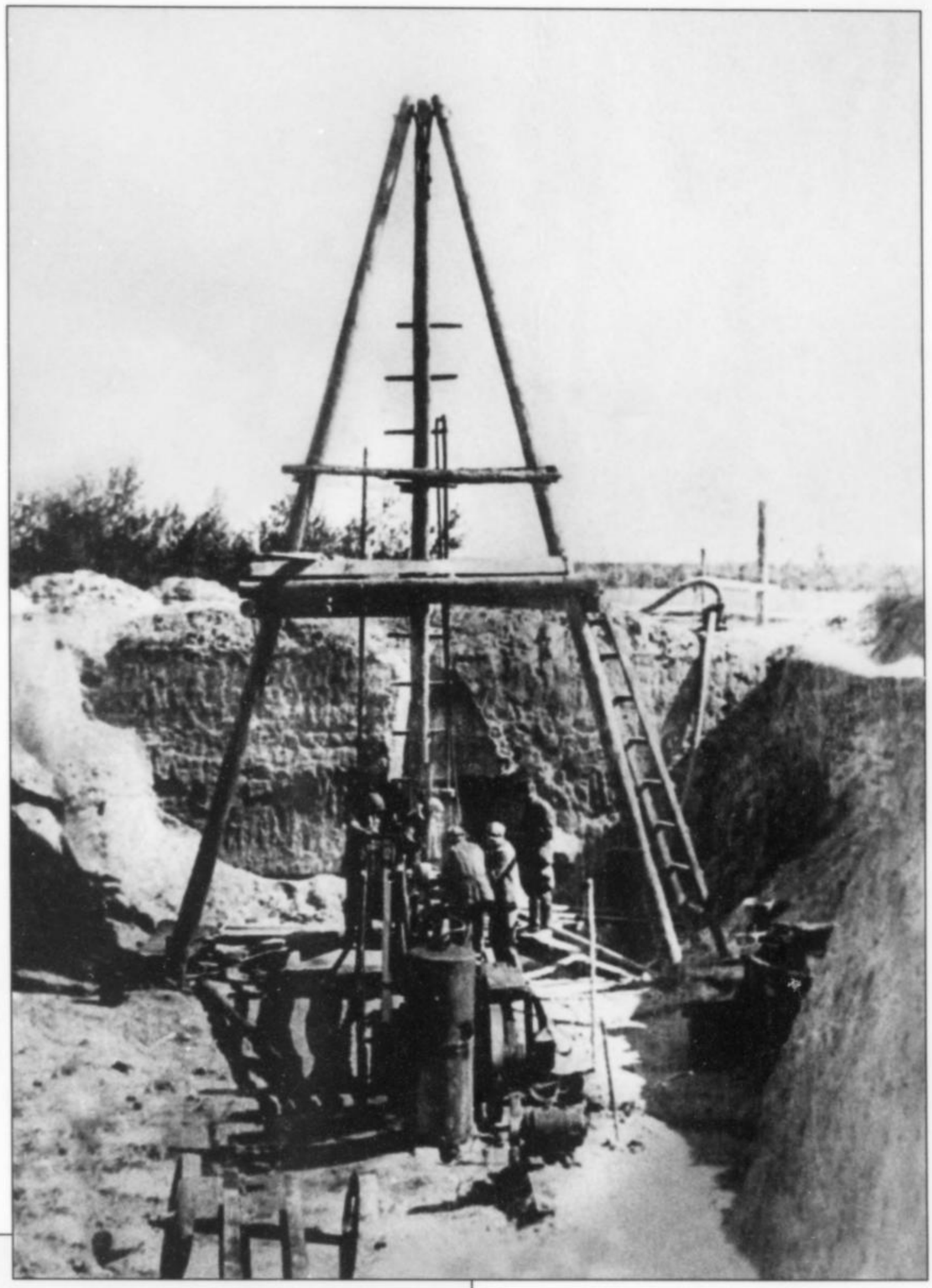


Figure 3. **Exploratory drilling in the deep productive zones at Volodarsk-Volynski. Museum of Precious and Decorative Stones archive.**

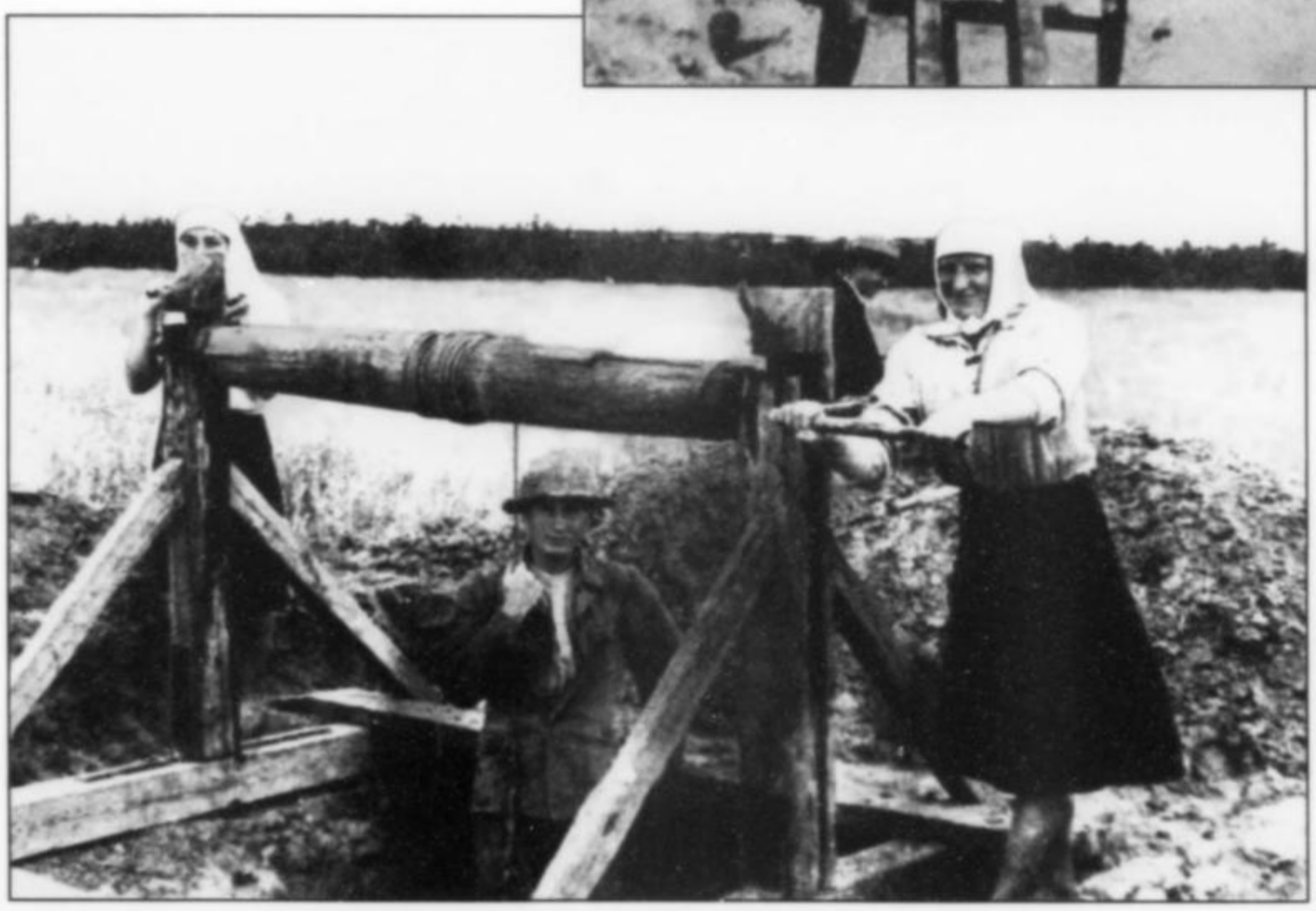


Figure 4. **Windlass for raising miners from a shaft at Volodarsk-Volynski, 1930s. Museum of Precious and Decorative Stones archive.**

Figure 6. **Giant smoky quartz crystal raised from a pegmatite chamber at Volodarsk-Volynski, 1950s. Museum of Precious and Decorative Stones archive.**

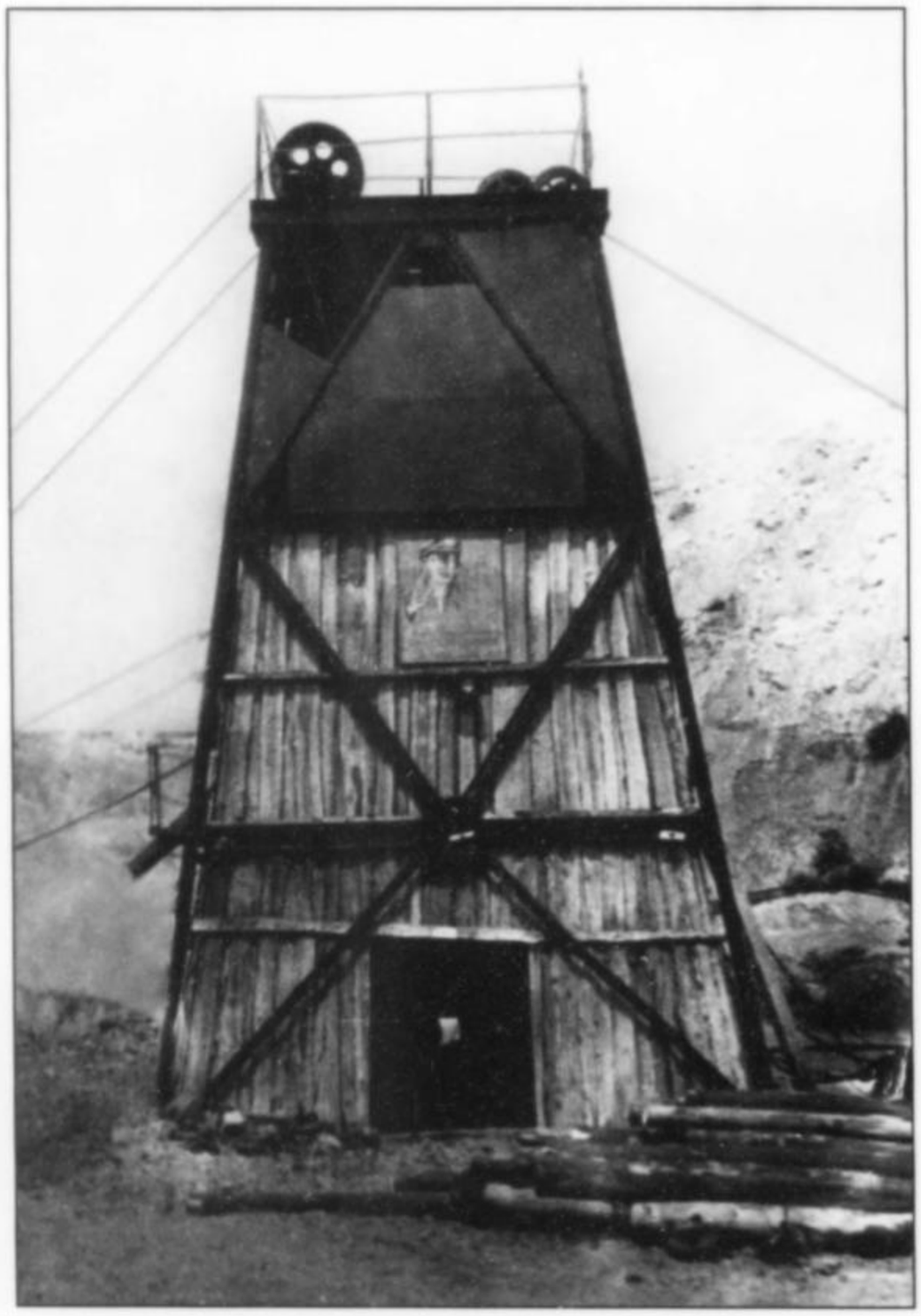


Figure 5. **The first headframe erected at Volodarsk-Volynski. Museum of Precious and Decorative Stones archive.**

sank their own primitive shafts. In 1931–1933 gem-quality topaz was recovered and exported to England for jewelry production.

From December 1941 to December 1943 the area was occupied by the German Army and quartz was flown to Germany in Messerschmidt planes. It is possible that topaz may also have been sought, for use as the outer layer in tank sights, being less vulnerable to scratching from dust in the course of desert warfare. This has not been confirmed. During this time smoky quartz was being mined from other miarolitic pegmatites some kilometers to the east of the Volynsk piezoelectric quartz deposit. In January 1944 the Soviet Army returned, and production came to a halt for the remainder of the war.

In 1945 a 10-ton quartz crystal, the largest ever found at the deposit, was recovered from the soil in an open pit some 200 meters from the future site of shaft 2 (opened in 1975). In 1946 production reached over 100 tons, with one crystal weighing 7.5 tons and five other crystals weighing several tons each. Some individual pockets contained up to 100 tons of quartz crystals; the termination sections were of piezoelectric quality and were sought after by the Soviet Army. Only a few of the pegmatites in the district have yielded the more collectible gem species—seen as a curiosity in the early days.

The pegmatites occur in a 22-km-long, north-south-trending belt that is 500 to 1500 meters wide. These miarolitic pegmatites were located by drilling on a 50-meter grid pattern over an extensive field, generally to depths of 100 to 150 meters but in some cases to 600 meters, resulting in many hundreds of kilometers of drill core at a cost in the hundreds of millions of dollars.

There followed an intense period of research in which literally dozens of mineralogists, geologists and petrologists brought their talents to bear on the Volyn pegmatites, but the two most important summaries in modern times are *Mineralizing fluids and mineral assemblages of the chamber-type pegmatites of the Ukraine* (Kalyu-

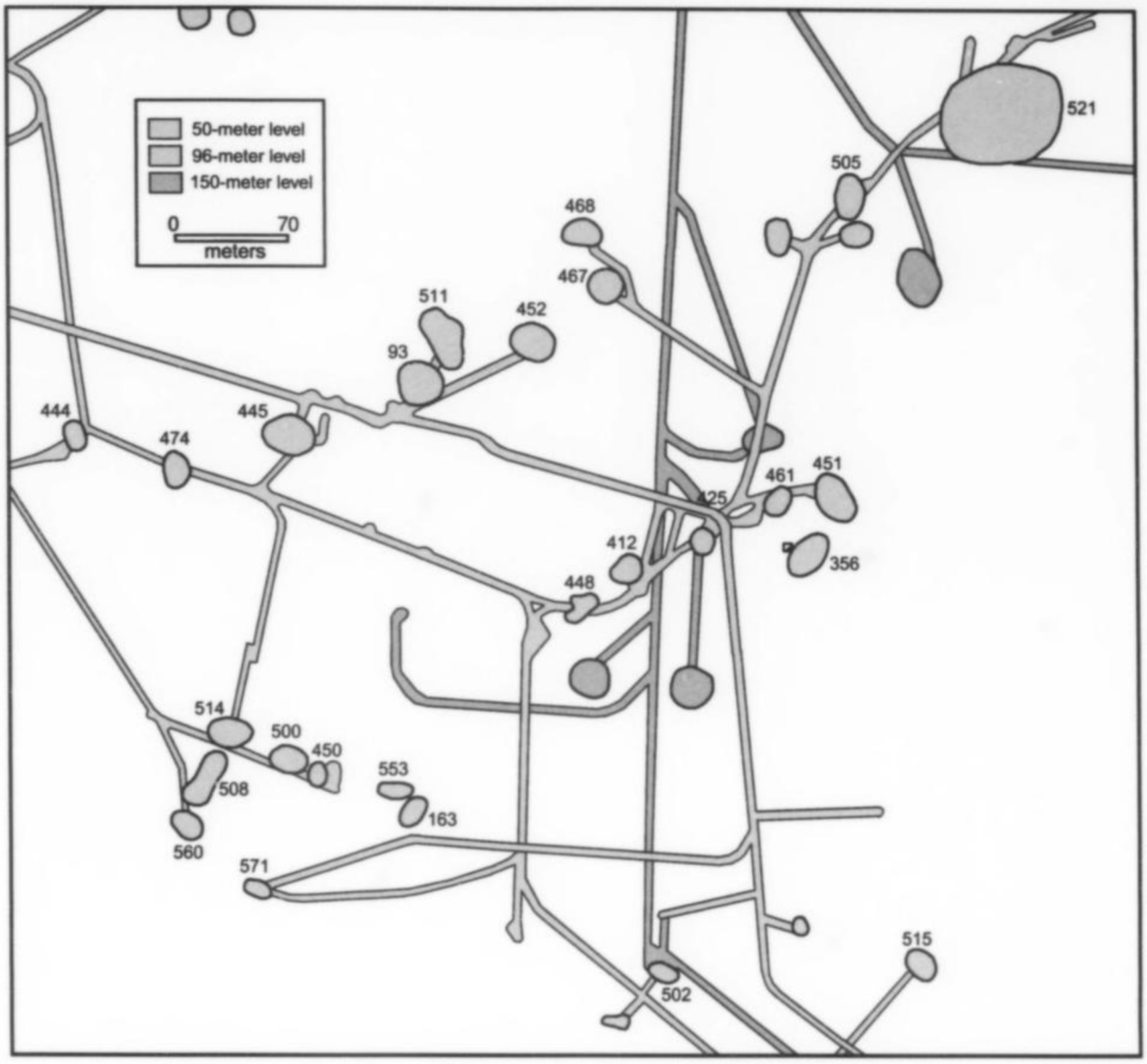


Figure 7. **Plan view showing the distribution and size of some of the pegmatite pockets in the Volodarsk-Volynski pegmatite field (adapted from a Kvarts Samotsvetny company map).**

zhnyi *et al.*, 1971) and *Mineralogy and genesis of Volynian chamber pegmatites* (Lazarenko *et al.*, 1973).

Recent publications include an excellent summary by Pavlishin and Dovgyi (2007), a geological review by Kievlenko (2003), and a specimen-mineralogy review by Koshil *et al.* (1991).

GEOLOGY

The Volyn pegmatites are genetically related to the granitic phases of the Proterozoic Korosten pluton, which crops out over a 110 × 150-km area in the northwestern part of the Ukrainian Shield. Most pegmatite bodies are located in the western margin of the massif. The pluton, dated at around 1.77 billion years old, is a highly complex three-phase intrusion encompassing a number of rock types and including eight major pegmatite areas. Several regions of the world with similar rapakivi-like granites have formed during crustal extension where crustal rocks are believed to have been mixed with magma from below, resulting in the formation of anorthosite and granite (Lyckberg, 2009).

The individual pegmatites and pegmatite clusters (known collectively as the Korosten pegmatite field) are the Guta-Potievskiy, Pikhtenskiy, Ignatopolskiy, Krivotinskiy, Pugachevskiy, Usolusskiy, Radomyshlskiy and Volodarsk-Volynski sites. They are situated in three basic environments: (1) the contact zone of the granite and intruding into adjacent mafic rocks, (2) in fine-grained granite porphyry, and (3) in hornblende-rich granites. Only the syngenetic Volodarsk-Volynski pegmatites, in the contact zone, contain rich chamber-type pegmatites containing giant pockets with quartz, smoky quartz and significant collector-quality crystals. These were formed as water-rich, highly fractionated segregations merged and later crystallized within the cooling and crystallizing granite body. The term "chamber pegmatite" relates more to the structure of the pegmatites having a single large chamber than to the size of the pocket itself (Lyckberg, 2009).

The intensive core-drilling program revealed that the richest zone of pocket pegmatites occurs between the surface and a depth of 100 meters. Many hundreds of pockets were worked between 1931 and 1995 when mining for quartz ceased.

Pegmatites typically occur in groups or swarms of five to a dozen within a distinct area. The pegmatite bodies become progressively less common with depth, at least down to the 622-meter level. The deepest bore hole brought up clear quartz from the bottom. Mining was carried out by the open-pit method, and by large-scale underground mining from levels driven at 50, 96 and 150 meters depth, accessed via six main shafts, several smaller shafts, and drifts extending from the bottoms of the open pits. According to Bulgakov and Panchenko (1981), prospecting extended to a depth of 200 meters.

The chamber pegmatites occur in irregular, blob or loaf-like shapes within the granite, and also as rare pocket-bearing bodies

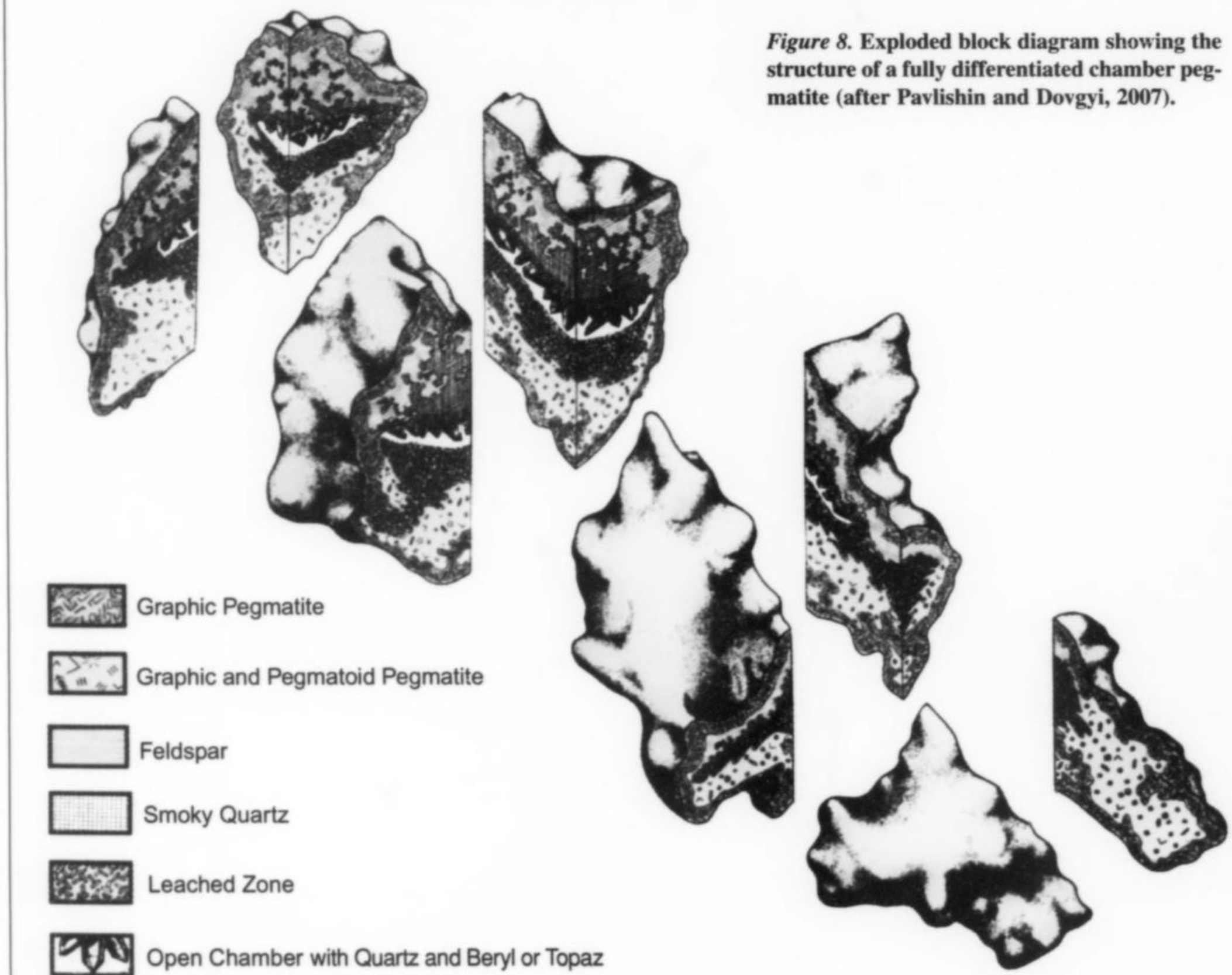


Figure 8. **Exploded block diagram showing the structure of a fully differentiated chamber pegmatite (after Pavlishin and Dovgyi, 2007).**

and veins injected into the nearby country rock. The more fully differentiated pegmatite bodies of roughly equant shape generally contain a single large open chamber with crystals, whereas the irregularly shaped, more attenuated bodies can contain two to five chambers. They are separated into graphic, pegmatitic and blocky microcline zones with typically a single (rarely more than one) gray quartz core forming the roof of the chamber pockets. Typically the internal zoning is asymmetrical. From the chamber roof, fractures having ovoid shapes commonly extend into the surrounding granite, and serve as useful indicators for the location of potential pegmatites and pockets. Pocket zones are characterized by quartz crystals, perthitic microcline, platy albite, orthoclase, biotite, lithium-iron micas and kaolinite.

Open crystal pockets tend to be lenticular in shape, typically measuring around 4 to 6 meters in length, 3 to 4 meters in width, and 1 to 3 meters in height, with a volume of 35 to 40 cubic meters. However, some of the more elongated pegmatite bodies proved to contain chambers over 15 meters long and 250 cubic meters in volume. The largest chamber found thus far, in pegmatite no. 521, measured between 5,000 and 8,000 cubic meters!

The large chambers were generally filled with clay and studded across the roof with downward-pointing quartz crystals interspersed with feldspar crystals. Quartz crystals decrease in size and number down the side walls, as mica and topaz crystals become more common. Most pockets have collapsed and large quartz crystals have fallen down together with platy giant shards of the overlaying quartz cap above the pocket. A space of half a meter to 3 meters commonly opened up in several pockets above the collapsed quartz crystals and shards.

What is usually visible when entering a pocket are the huge meter-size quartz shards that have fallen from the roof and cover the giant quartz crystals from the collapsed ceiling. The ceiling itself consists of the upper part of the quartz core and feldspar-rich pegmatite having a very large grain size. The floors of the chambers are covered with druses of small quartz, microcline, cleavelanditic albite, and rare topaz and mica crystals. The pockets are commonly filled with a breccia of broken quartz and feldspar as well as clay minerals. Only 10% or so of the pockets found have contained topaz crystals, and in most parts of the field only 2% have yielded beryl crystals (Lyckberg, 2008). Because of the large pocket size, each one produced from a few tons to more than 100 tons of quartz, though generally only a small part of the quartz crystal terminations have been of good piezoelectric quality (Lyckberg, 2008).

Beneath the open portion of the chamber is a zone of vuggy rock of comparable volume and up to several meters deep, called the *leached zone*. This zone is the alteration product of the primary pegmatitic and graphic zones and in rare cases the enclosing granite itself (Lyckberg, 2009). The quartz has been dissolved and recrystallized in the roof and wall sections of the pocket, with crystal size decreasing from the top downward. Here a more com-

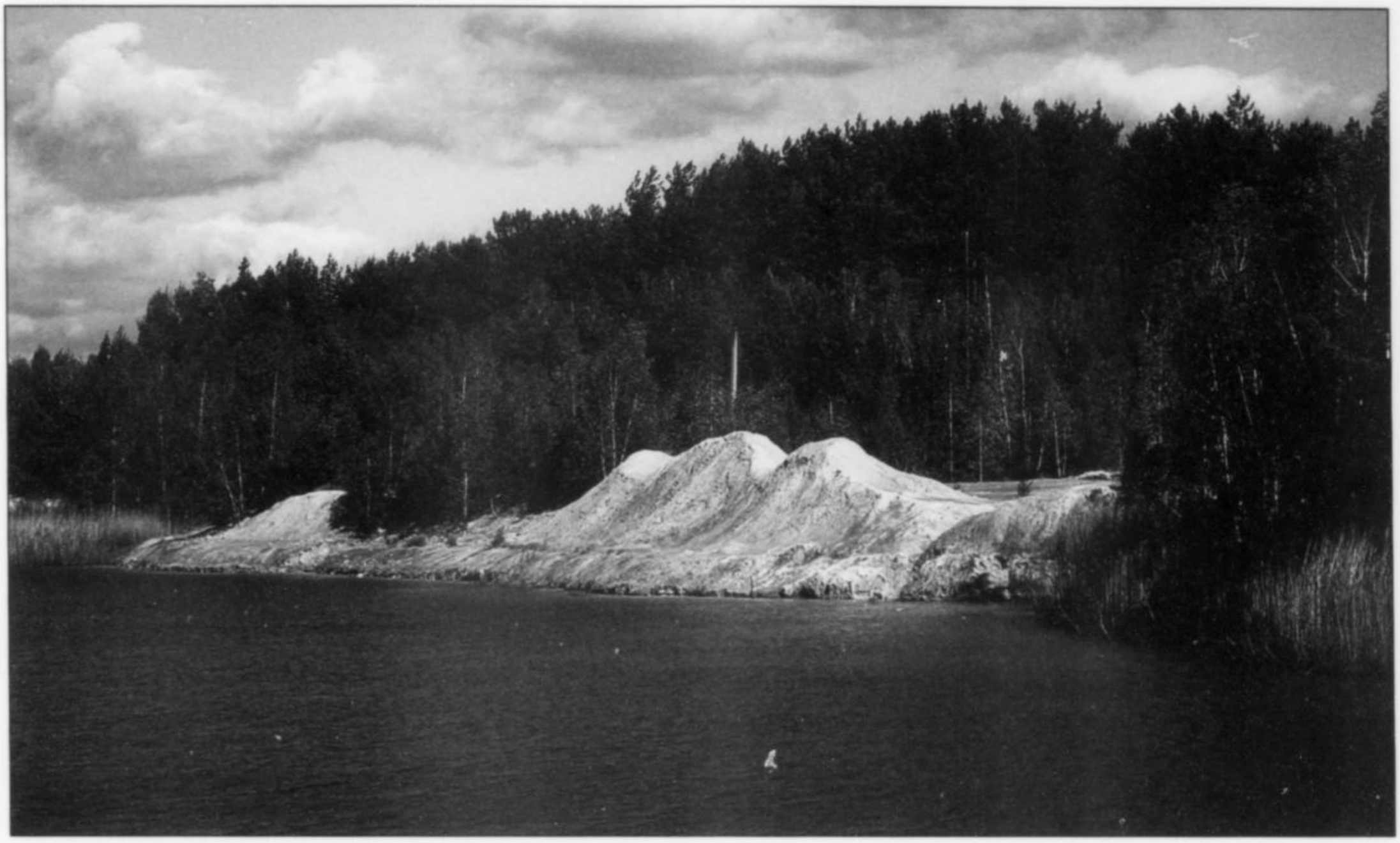


Figure 9. **Old dumps near a flooded pit at Volodarsk-Volynski. E. Y. Pashchenko photo.**

Figure 10. **The Vishnyakovka open pit mined in the 1960s at Volodarsk-Volynski. Adits in the bottom of the pit (now buried) accessed 12 pegmatite chambers. Peter Lyckberg photo, 2007.**

Figure 11. **Collecting beryl crystals in the pocket in pegmatite no. 436. Peter Lyckberg photo.**

Figure 12. **Digging out muck in a 15-meter pocket in pegmatite no. 436. Photo (2007) by Peter Lyckberg.**

plex mineralogy, affected by an intense process of dissolution and recrystallization, includes microcline, albite, albitized microcline, altered hydrous micas, and sometimes small pockets lined with drusy quartz. Relict crystals from the leaching phase and newly grown crystals of other species formed up to 10% of the pocket contents and could include siderite, fluorite, molybdenite, topaz, columbite-(Fe), rutile, pyrite, beryl, very rarely phenakite and other minerals. Most commonly this leached zone consisted of feldspars with small hollows left by dissolved quartz which recrystallized as giant crystals in the ceiling. Spodumene, tourmaline and other minerals occurred in some pegmatites in the frozen sections as tiny crystals that have no value to collectors.

The area richest in beryl-carrying pegmatites is south of the Irscha River, in the Vishnyakovka and Dvorischansky quarries. The surface and underground workings are just to the south of the river, accessed by shafts no. 2 and 6.

In the northern part of the pegmatite field, where the overburden is only 3 to 10 meters thick, much topaz has been found. Further to the south the overburden is between 10 and 40 meters thick, some of it made up of weathered granite now in the form of kaolinite that in some cases contains preserved pockets. Topaz also occurs abundantly in the south-central part of the pegmatite district.

At its peak of operation, the mine employed over 1,000 miners and 60 geologists (Director P. Minko, personal communication, 1995); the quartz processing facilities above ground employed an additional staff and supported around 10,000 inhabitants. Commercial mining for quartz at Volodarsk-Volynski ceased in 1995, and the state-owned mining operation was greatly reduced. In

Figure 13. **Inside the giant pocket in pegmatite no. 364 at Volodarsk-Volynski. Large, heavily etched, gemmy green beryl crystals were recovered from 50 cm to 2 meters under the water level. Peter Lyckberg photo, 2007.**

Soviet times there were no real budget restrictions because the mines were given priority in order to supply the Army with vital piezoelectric quartz. Mining by a limited staff with a limited budget began in later years.

POCKET FORMATION

When the granitic rocks began to crystallize, segregations of enriched solutions became trapped in place and began to form pegmatite bodies. The first pegmatitic structure to form (as the outer shell of the pegmatite) crystallized with a graphic structure at 750° to 760° C in barren pegmatites, and at 700° to 730° C in pocket pegmatites. The latter pegmatites have yielded topaz formed at 620° to 640° C because the fluorine-rich rich solutions functioned as a flux (inducing a lower melting point).

This zone ranges from a few millimeters to several meters thick and is asymmetric. The following crystallization inwards yielded a blocky pegmatitic structure, with larger grains to very large single crystals, and is of the same scale. The zone has complex contacts and gas inclusions (but no melt inclusions).

Giant clear or smoky crystals of quartz hanging from the roof and walls below the gray quartz core crystallized between 600° and 100° C. The core itself formed at the higher temperature, and the lower range represents the primary pegmatite quartz leached at the bottom of the pocket and recrystallized as giant crystals in the ceiling and walls. Analyses suggest that crystallization began from a gaseous phase, followed by boiling of liquids during two acidic periods, separated by an alkaline phase between the two.

When all of the primary pegmatites had crystallized, the alkaline solutions leached quartz from the pegmatite bodies and in rare cases even from the underlying granite and the metasomatically altered feldspars, micas etc. Albitization of microcline took place at around 300° to 400° C, followed by an acidic stage in which crystals of micas, fluorite and thick tabular albite crystallized from weakly enriched CO_2 solutions. Fluorite formed in two main stages: in the first, green fluorite crystallized together with topaz at 400° to 415° C. In the second generation, purple fluorite formed cubic crystals at 340° C and pH of around 6.5. Then followed the deposition of siderite at a pH over 7 and a temperature of 290° to 340° C, after which came molybdenite and rutile.

EARLY GEM CRYSTAL FINDS

Very few people today, even in Volodarsk, are aware of the early discoveries of gem crystals in the district. However, a systematic search during the past 15 years of all old work ledgers, drawings and geological descriptions, as well as interviews with many old geologists and miners, has uncovered some of this lost information, later verified *in situ* and presented here for the first time.

One exceptional pegmatite, no. 206, is located some 400 meters north of the large Vishnyakovka open pit and 300 meters south of the Irscha River. It was mined in 1953 via a 22-meter-deep open pit in kaolinized granite, and proved to contain five large pockets, all filled with gem-grade material. The lower three pockets carried gem beryl crystals up to 5 kg in size, and the upper two carried topaz crystals weighing up to 82 kg. One of the lower pockets contained both topaz and beryl. A total of 460 kg of gem-grade beryl was officially recovered as a byproduct, not counting souvenir specimens kept by the miners. Beryl crystals from this find are the only ones from the chamber pegmatites of Volodarsk to show some similarity in the etching structure to those from the jumbo pocket encountered in pegmatite no. 521 in 1982 (see below).

In 1965 a 117-kg topaz crystal was recovered, along with two additional large crystals weighing over 100 kg together, all from the same pocket.

In 1960 the large Vishnyakovka pit and quarry were opened, first mining a kaolinized pegmatite, and then hard granite enclosing ten additional pegmatite bodies, five of which proved to contain gem-grade beryl. Some of the finest beryl crystals from this find are preserved in the Fersman Mineralogical Museum in Moscow, and date to 1967 and 1968. Other specimens are in the Museum of Precious and Decorative Stones in Volodarsk. Some of them have rounded, cylindrical shapes 12 to 15 cm long that are the result of etching, and show a yellowish green color and flawless transparency (see Fig. 17). In the Volodarsk Museum there is a crystal measuring 30 cm long, with a fantastically etched surface.

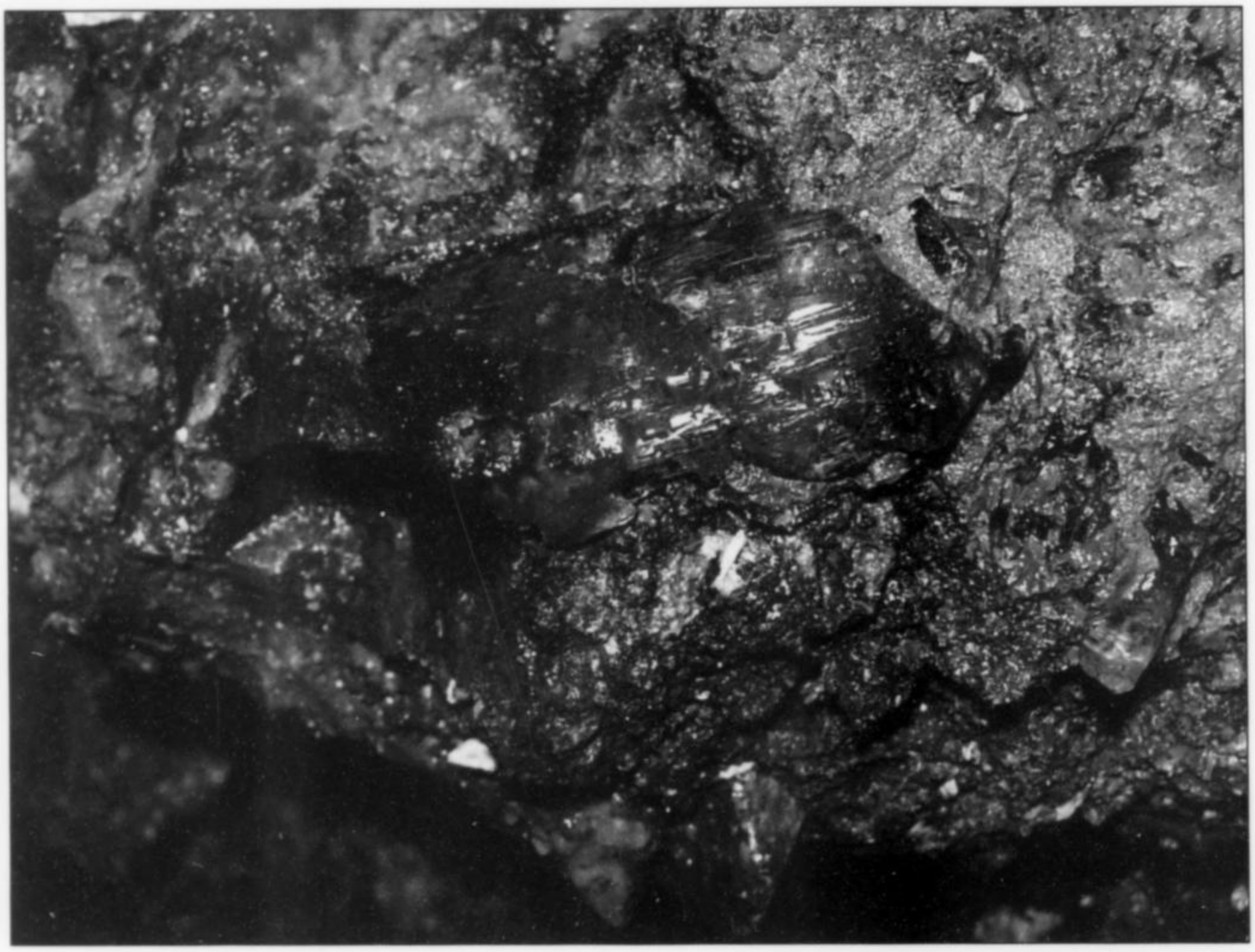


Figure 14. **Beryl crystals to 10 cm *in situ* in the giant pocket in pegmatite no. 364 at Volodarsk-Volynski. Peter Lyckberg photo, 2007.**

At the bottom in the middle of the Vishnyakovka open pit a drift was driven at the 55-meter level, leading 800 meters to the north, to a point under the Irscha River. It passed under pegmatite no. 206 and intersected ten large miarolitic pegmatites that were mined in 1972–73.

The most spectacular pocket produced 260 kg of pale green, hexagonal crystals with well-formed terminations and very light etch patterns on the faces. It was found in 1973, in pegmatite no. 422 on the 55-meter level; 50 tons of quartz were also produced. Some of the beryl crystals reached the Western mineral market in the early days, including a 400-gram crystal that was offered for sale at the 2009 Tucson Show by Scott Werschky (*Miners Lunchbox*).

In 1976–1978 a 15-meter-tall pocket on the 96-meter level in shaft 2 produced 5 tons of topaz!

In the summer of 1983, pegmatite no. 576 was mined. Located between the Vishnyakovka open pit and the Irscha River, it was accessed via shaft no. 6 at a depth of 96 meters.

COLLECTING HISTORY

1950s–1970s

Many heliodor crystals were recovered from pockets found in 1953, in the 1960s and in the 1970s; at least one great beryl discovery took place in each decade. During these years the quartz miners would often put a beautiful beryl specimen in their pocket as a souvenir, as these were not part of the ore being mined. The miners generally had no idea of the monetary value of such crystals as mineralogical specimens or as gem rough, and regarded them only as attractive curiosities. Many of the crystals were given as

Figure 15. **Beryl crystal, 7 cm, in matrix in the wall of the chamber pocket in pegmatite no. 436, Volodarsk-Volynski. Photo (2007) by Peter Lyckberg.**

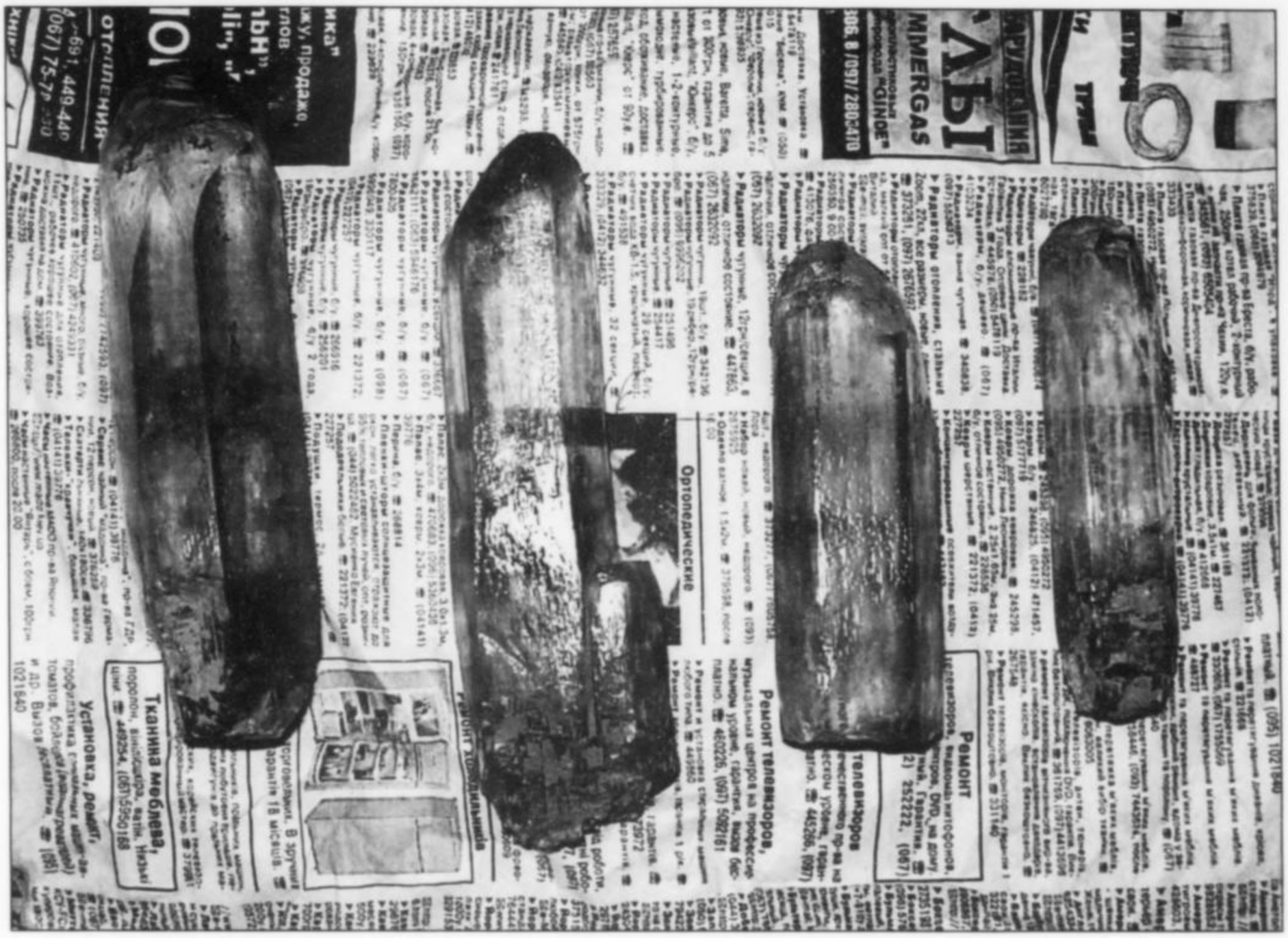


Figure 16. **Beryl crystals freshly collected from pegmatite no. 422 at Volodarsk-Volynski in October 2007. Peter Lyckberg collection and photo.**

gifts to friends or visiting geologists; others were put in windows as ornaments, or were used as doorstops (e.g. large topaz crystals), or were exchanged for bottles of vodka. Some eventually ended up in Russian museums or came to the market in Moscow.

1980s

For many years the Volyn piezoelectric quartz deposits were primarily known and very famous only among scientists in Eastern Europe. Among the first heliodor beryl crystals to reach the Western mineral market were two excellent small gem beryls brought out by Polish dealers Andrei and Anna Chrapowicki in 1980 and sold to Austrian dealer René Triebl. René then obtained a third excellent gem crystal from Igor Bogucki, a young low-level agent for the Soviet heavy metal industry who was working undercover as a mineral dealer. The first time Igor appeared at the Vienna mineral show he had some incredibly fine specimens at very reasonable prices. Three 2.5 × 10-cm gem crystals were sold to Austrian collector Peter Huber. A Nuremberg, Germany gem expert was so sure they were synthetic Russian products that he declined to buy any, a reaction shared by other Western European collectors. The crystals proved to be impossible to sell for a year! (René Triebl, personal communication). Despite being purely natural, they were regarded as too good to be true.

René finally sold them to California mineral dealer Curt van Scriver (1955–1982). Curt brought several beer-can-size crystals of etched but highly gemmy and beautiful yellow crystals, carefully wrapped in towels, to the 1981 Detroit Show and showed them off to a few people; two of the crystals were purchased for the Natural History Museum of Los Angeles County by Hyman Savinar (Brad Van Scriver, personal communication, 2009). Another lot followed shortly thereafter, one specimen from which was acquired by the Harvard Mineralogical Museum. In 1985 René discovered Igor's source in Moscow at the well-known Ptichij Rynok (a Moscow animal flea market where minerals were sometimes sold), thanks to a tip from Leo Bulgak, who was at that time curator of the Fersman Mineralogical Museum. The flea-marker seller was a man belonging to a special police squad charged with combating homosexuality, and he had hundreds of Ukrainian heliodor crystals in stock; he remained the best source for years.

Specimens nevertheless were very scarce until five years later, when a new batch emerged at the 1987 Tucson Show, via dealers Brad van Scriver and the team Andrei and Anna Chrapowicki; heliodor crystals as well as aquamarine beryl were included in the lot (Wilson, 1987). Andrei, who sold the beryl crystals for $34,000, had obtained his crystals in Volodarsk and tried to convince Peter Lyckberg to join him on a visit to the mine, disguised as a Balt (citizen of the Baltic states). The offer to see these interesting mines was exceedingly tempting, but the risk of being arrested and spending an indeterminate amount of time in an unknown "resort in Siberia" was deemed too high.

Andrei was the first person who was able to supply first-hand information on the mines and their interesting geology and mineralogy. Among numerous great specimens, Andrei had a superb, nearly 30-cm crystal for sale at the Sainte Marie-aux-Mines show in the mid-1980s. Unfortunately in the early 1990s he and his wife disappeared from mineral dealing. The years 1988 to 1992 were the very best time for obtaining fine specimens in Russia and the Ukraine; but thereafter many Western dealers began arriving to buy specimens, and consequently supplies diminished and prices increased.

Pegmatite no. 521

Some of the earliest crystals seen at the Detroit Show, and certainly later specimens as well, came out when an access tunnel was driven to exploit a giant pocket in **pegmatite no. 521**. In 1982 the

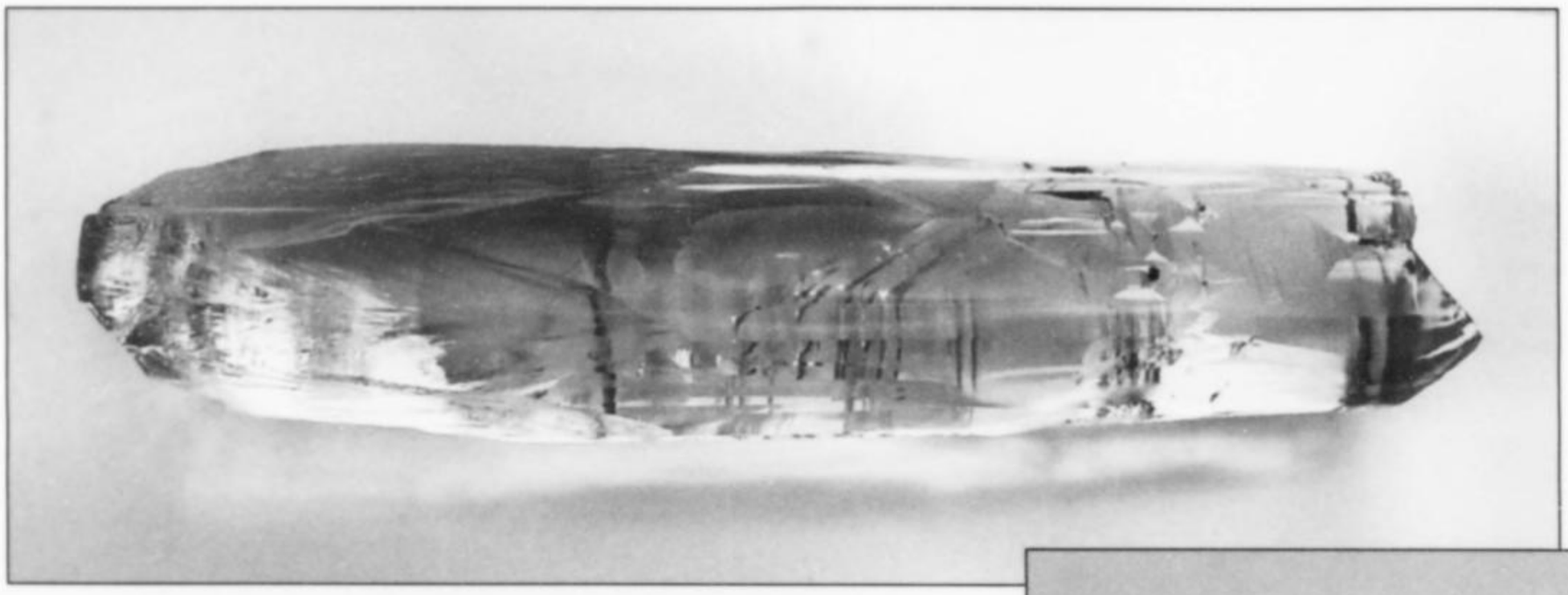


Figure 17. **Beryl crystal, 14 cm, from the Vishnyakovska open pit; found in 1967-68. Peter Lyckberg collection and photo. Two similar crystals are preserved in the Fersman Mineralogical Museum in Moscow.**

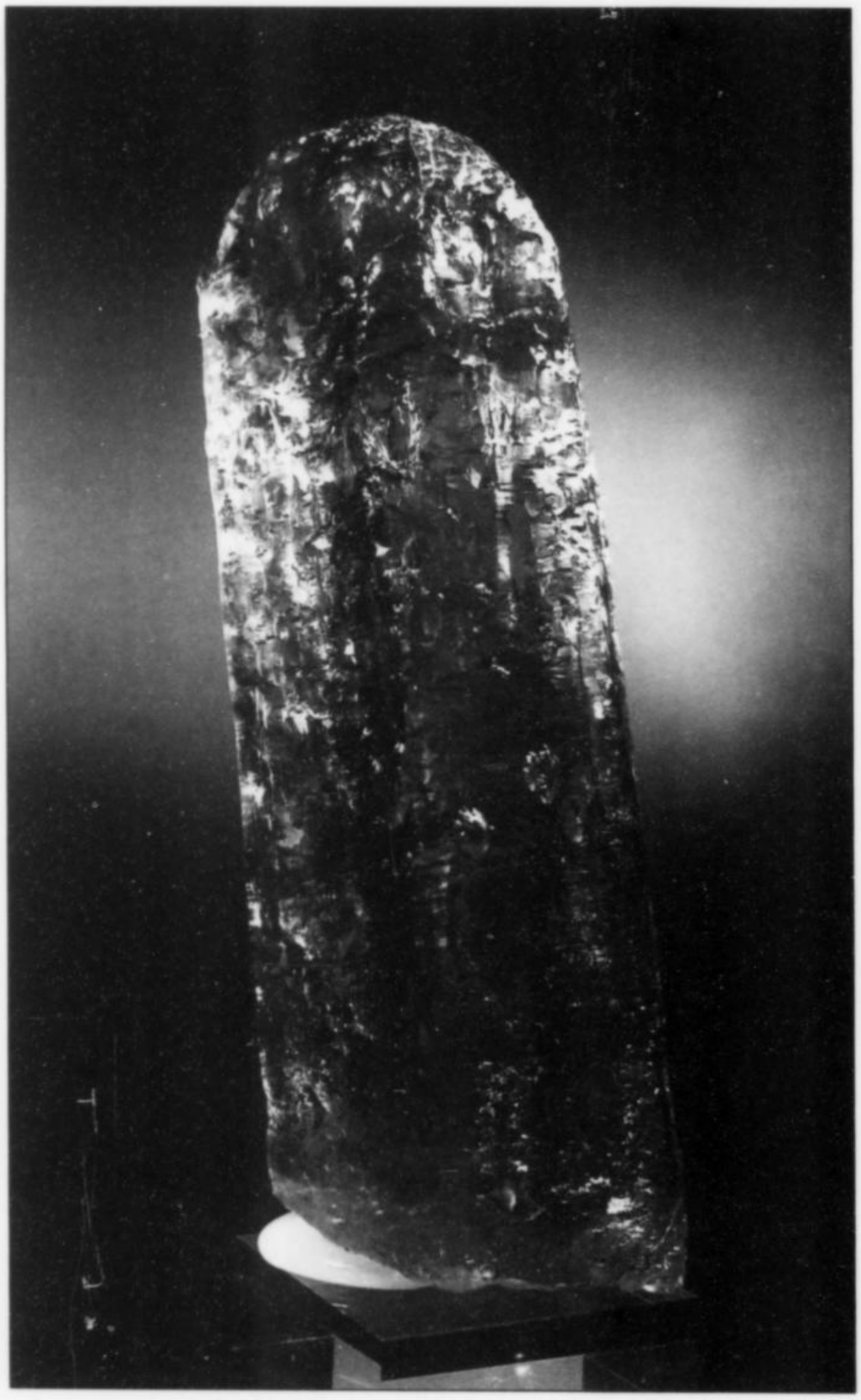


Figure 18. **Beryl crystal, 24 cm, from pegmatite no. 521. Konstantin Buslovich sold many Volodarsk beryls over the years; this is the best one he ever had. Konstantin Buslovich collection and photo.**

Figure 19. **Beryl crystal, 21 cm, found in 1996 in pegmatite no. 445 by Chief Geologist Vsevolod Chornousenko. It was sold to a Kazakhstan collector who in turn sold it to an American collector via a Russian mineral dealer at the 2009 Tucson Show. Konstantin Buslovich photo.**

Figure 20. **A 24-cm beryl crystal from pegmatite no. 521, photographed in the back seat of a car in Volodarsk as it was being offered for sale. Konstantin Buslovich collection and photo.**

Figure 21. **A 1-kg beryl crystal from pegmatite no. 521, photographed in the back seat of a car in Volodarsk as it was being offered for sale. Konstantin Buslovich photo.**

pocket produced about 500 kg to 1 ton of beryl! About 230 kg of gem beryl were officially recorded, 20 kg of which were of pure faceting quality, and another 70 kg were at least partially gem grade. The rest was classified as carving-grade material.

The beautiful beryl crystals recovered from this pocket, showing typical etch features on the faces, made Volodarsk-Volynski world-famous. The pegmatite body, encountered at a depth of 23 meters, measured 60 meters in thickness and 50 × 70 meters horizontally. It contained two huge chambers, accessed from the 96-meter level off of shaft 2. The first was 30 meters long, 12–15 meter high and 15–25 meter wide, totaling 5,000 to 8,000 cubic meters—and has still not been completely emptied of quartz! Around 40 to 45 tons of quartz were recovered, the largest crystals weighing around a ton each.

Beryl specimens were found at the bottom of the first pocket along the sides. Higher up on the upper walls, dark purple to black 2-cm cubic crystals and pods of fluorite were common. The second jumbo pocket, located directly adjacent to the first, produced 80 tons of quartz but contained no beryl. Miners reported finding large hexagonal beryl crystals lying around in the muck on the floor while they were bringing out huge quartz crystals. Occasionally they would put one of the beryls in their pocket and bring it out.

Pegmatite no. 576

In the summer of 1983 a pegmatite chamber (no. 576) was opened a few hundreds meters from shaft no. 6, at a depth of about 90 meters. It yielded particularly sharp and attractive beryl crystals of a yellow to grass-green color, but was rather poor in associated minerals. Besides beryl, only black quartz, gray quartz and orthoclase were found, plus a single crystal of ilmenite, visually identified as an inclusion inside a gemmy 398-gram yellow beryl crystal. The pegmatite chamber was comparatively small, measuring about 1 × 5.5 meters, and contained 43 kg of beryl crystals, only 3 kg of which were gem-quality; 12 kg were partially gemmy and the rest was of poor quality. The largest beryl crystal of gem quality weighed a little under 900 grams and had a grass-green color. Because no buyer was willing to pay the price for preserving it as an uncut crystal—perhaps the finest large, sharp, hexagonal gem beryl crystal ever found at Volodarsk-Volynski—it was cut into a flawless 2,500-carat gemstone.

Some excellent yellow and green crystals weighing up to 540

Figure 22. **Beryl crystal, 13 cm, a heavily etched remnant of a larger crystal from pegmatite no. 364, at edge of the Vishnyakovka open pit. Photo (2007) by Peter Lyckberg.**

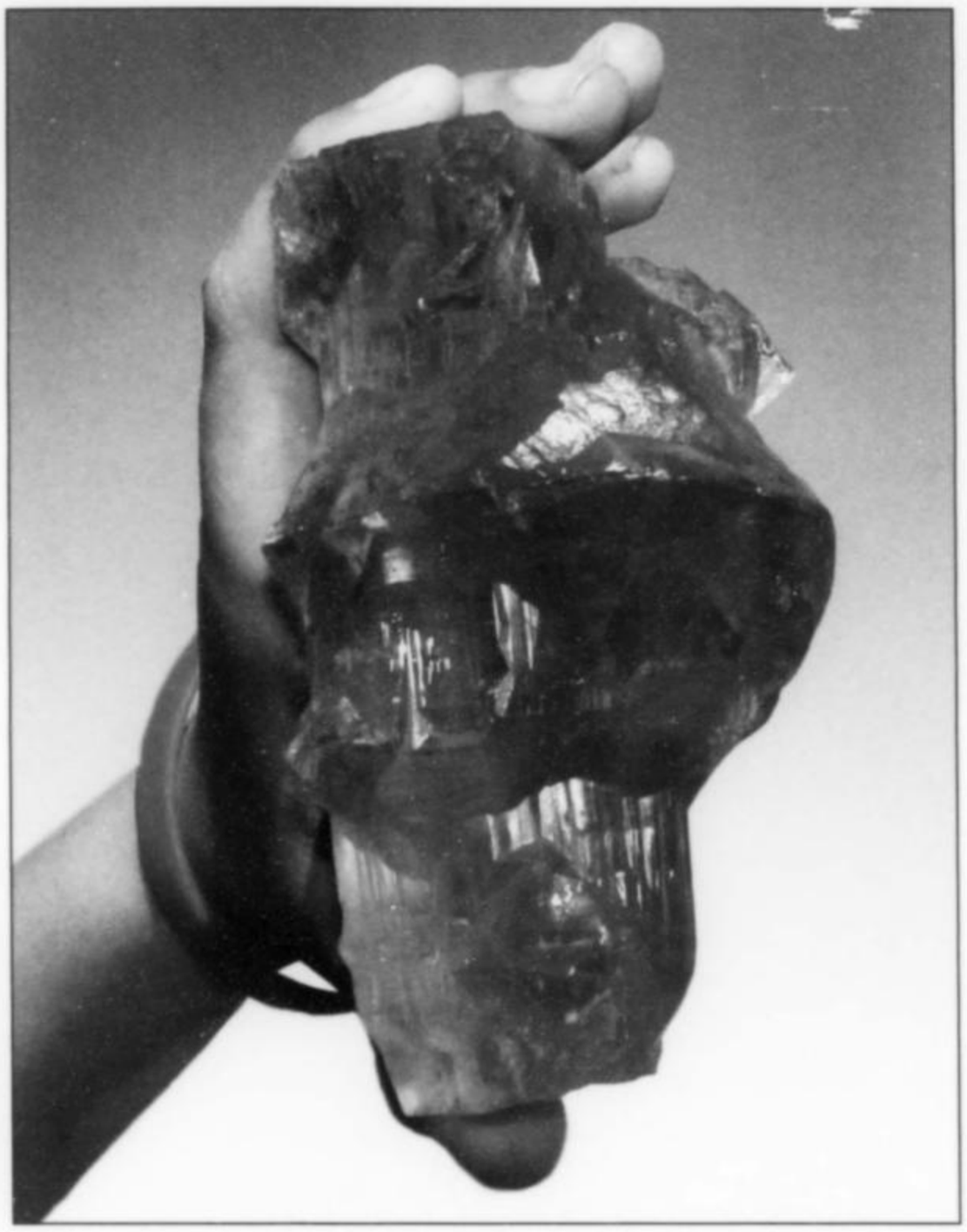


Figure 23. **Beryl crystal, 480 grams, from pegmatite no. 364 at Volodarsk-Volynski, collected in 2008. Vsevolod Chournosenko photo.**

grams have been preserved from this pocket. The best is 20 cm long and weighs about 480 grams. Beryl crystals from pegmatite no. 576 are easy to identify. They are sharper and show less etching than the crystals typical of the workings around shaft no. 2; in general they have better terminations and an extraordinary luster. The crystals are rich in faces (terminated by a combination of two pyramids and a very small pinacoidal face) and are elongated, often resembling a rocket shape.

Beryl crystals from pegmatite no. 576 were unknown to Western collectors until recent years. They first appeared on the market when Mike Bergmann offered a single crystal at the 1993 Tucson Show; in 2005, two fine golden crystals were offered at the Munich Show by the Volhyn Kvarts Samotsvety mining company. At the 2006 Munich show, Marco Amabili purchased three of the crystals. Many other collectors immediately noticed them as well, and they drew the attention of Tom Moore, who wrote about them in his show report in the *Mineralogical Record*. A few months later the best crystal from this discovery was pictured and described by Louis-Dominique Bayle in *Le Règne Minéral* no. 76 (2007), in a report on the 2007 Sainte Marie-aux-Mines show. This crystal has been named the "Dnieper Rocket" because its shape resembles that of a Soviet rocket of the Dnieper class, and because the Irscha River near shaft no. 6 is a tributary of the Dnieper River.

1990s

Beryl crystals from pegmatite no. 521 continued to reach the market occasionally for the next several years. In 1992, as the miners became more aware of the value of beryl specimens and the economies of the former Soviet states deteriorated, miners went back to pegmatite no. 521 specifically in order to recover more beryl crystals. Within a short time about 1,500 kg (3,300 pounds!) of additional gem beryl crystals were recovered from the big pocket, left there during original mining. The largest gem-quality crystal recovered during this period weighed over 22 kg but broke during its extraction into two parts weighing 5 and 17 kg. A little bit turbid at the base but otherwise of faceting quality, it was probably sold to gem-cutters in Idar-Oberstein, Germany or to a buyer in the U.S. Based on interviews with the miners involved, it appears that a total of more than 2.5 tons of beryl were removed from this gigantic pocket.

During the early to mid-1990s it was common for the Volodarsk-Volynski miners (like most workers in the former Soviet states) to not receive their salaries for months. A condition of near-anarchy prevailed, while so-called "businessmen" and organized crime took over parts of the industry—sometimes legally and sometimes not. To avoid starvation, miners in the 1990s began staying after working hours in the mines to dig for beryl and topaz for Kvarts Samotsvetny (the mining company operating the deposit) and also to sell to local dealers.

One miner told of how, for a couple of years, he stayed underground in the mine for a week and sometimes several weeks at a stretch, working for 12 hours and then resting or sleeping for 12 hours, wearing the same clothes. After such a period, having made some extra money, he left by train to visit his girlfriend in Russia. On the way he stopped in Kiev to buy some perfume and jewelry for her, still dressed in his mining clothes, covered with red mud, only his face and hands washed. He was admitted into

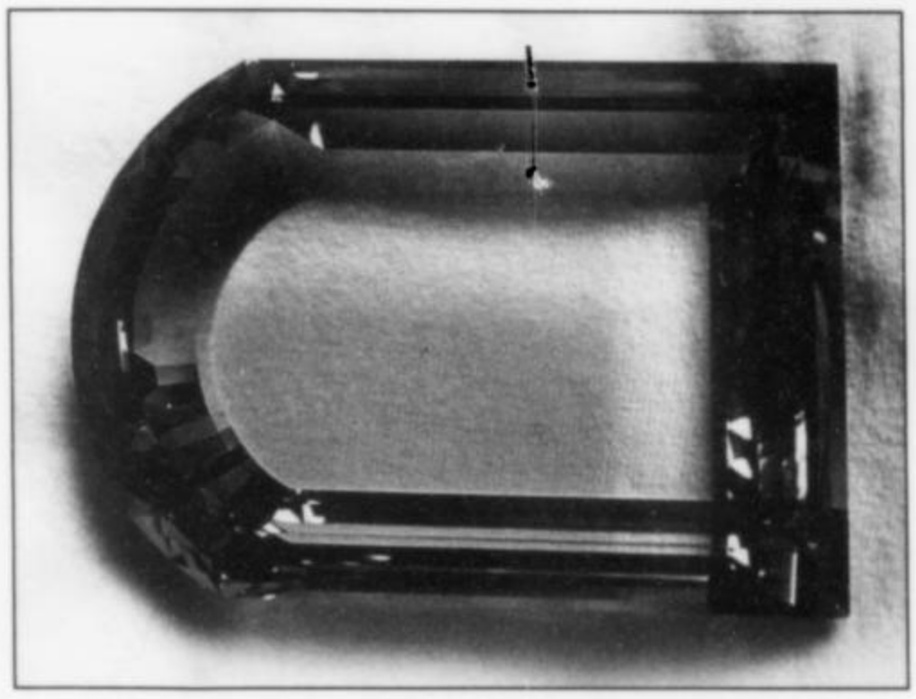


Figure 24. **Faceted Volodarsk beryl, 800 carats. Konstantin Buslovich photo.**

Figure 25. **Beryl crystal, 13 cm, in matrix, from Volodarsk-Volynski. Museum of Precious and Decorative Stones collection; Michael Leybov photo.**

Figure 26. **Beryl crystal (named the "Apostles Peter and Paul"), 25 cm, from Volodarsk-Volynski. Museum of Precious and Decorative Stones collection; Michael Leybov photo.**

a fancy store despite his appearance. The jewelry shop staff knew that miners were among the few people in the early 1990s who had extra money to spend. Their salary ran from $10 to $20 per month between 1990 and 1995, and the sale of gem materials could significantly add to their incomes. In 2005–2008, when the search for gem material was renewed, salaries for miners had increased to between $100 to $400 dollars per month, depending on how much gem material they found.

In 1992 an American dealer, Jim Wills of Wicast Ltd. in Norman, Oklahoma, imported more than a ton of the Volodarsk beryls. He subjected several hundred kilograms of olive-green beryl to heat treatment at 350° C for 12 hours, and succeeded in turning them to a strong blue color. It was found, however, that some heliodor crystals would lose their color entirely if heated above 230–260° C, and others would become colorless above 300–320°.

About 260 kg of Wicast's gem-quality heliodor crystals from pegmatite no. 521 were sold immediately before the Tucson Show to William Larson of Pala International. These were mostly sold as gem rough but a few beautiful crystals were preserved for their specimen value (William Larson, personal communication, 2008).

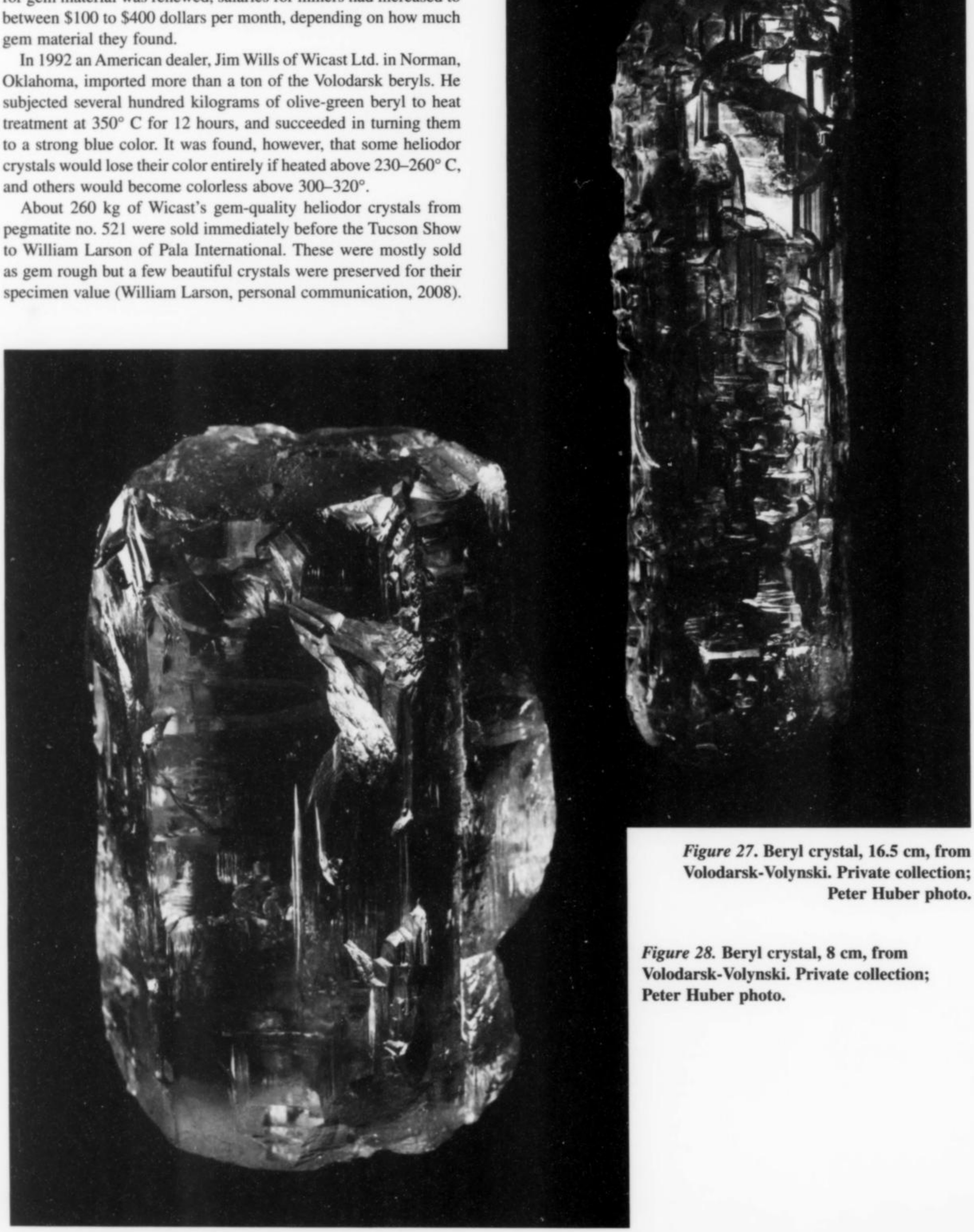


Figure 27. **Beryl crystal, 16.5 cm, from Volodarsk-Volynski. Private collection; Peter Huber photo.**

Figure 28. **Beryl crystal, 8 cm, from Volodarsk-Volynski. Private collection; Peter Huber photo.**

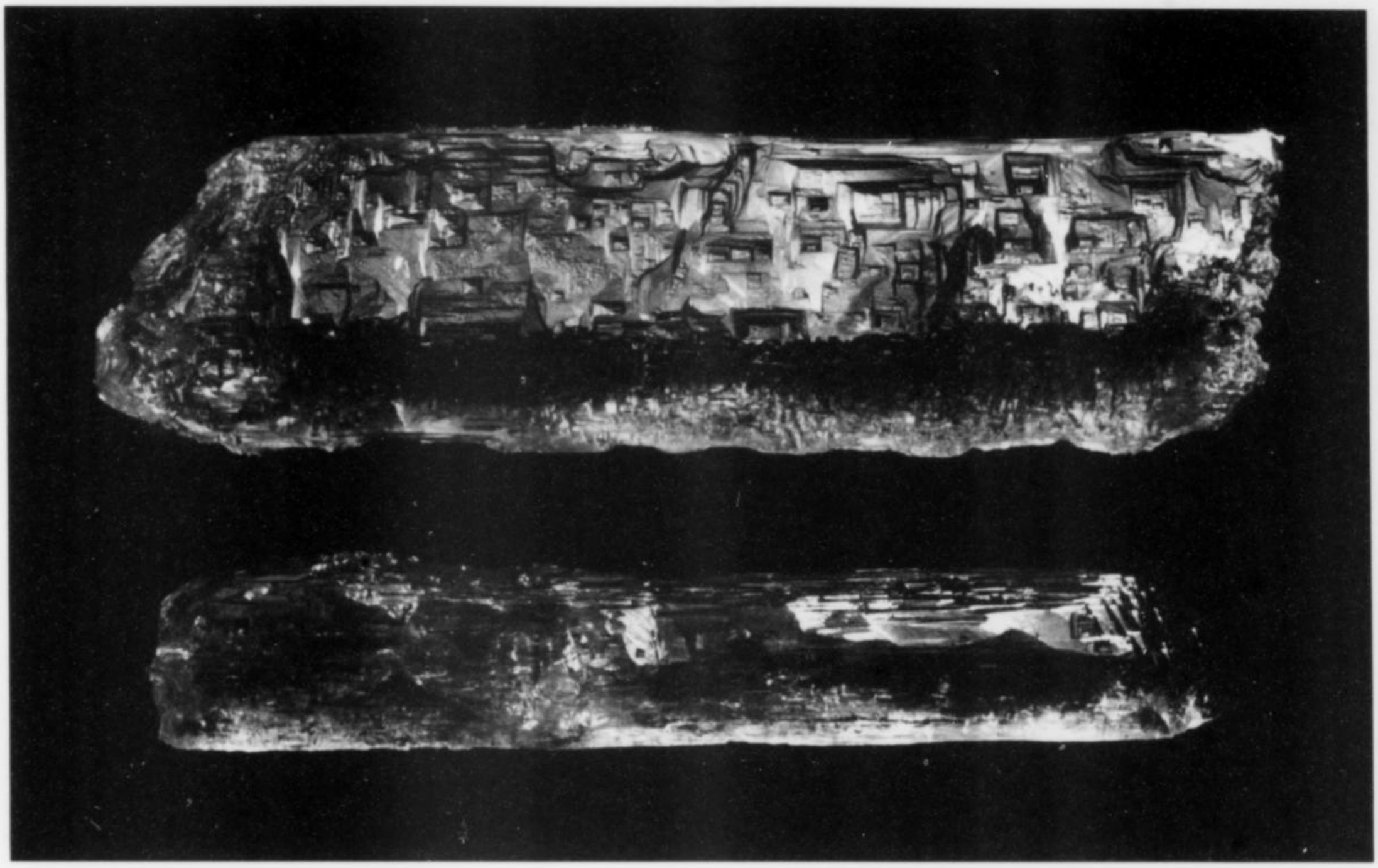


Figure 29. **Beryl crystals, 25 and 28.3 cm, from Volodarsk-Volynski. René Triebl collection (from 1987, third lot), now in a private U.S. collection; Peter Huber photo.**

Figure 30. **Beryl crystal, 14 cm, from Volodarsk-Volynski. Museum of Precious and Decorative Stones archive; Michael Leybov photo.**

The importance of collectors who are willing to pay the gem value of such crystals in order to preserve them for the future cannot be understated.

In 1993 Wicast Ltd. had about 850 kg of Volodarsk beryl for sale at the Tucson Show in a tent (Koivula *et al.,* 1993) and at other Tucson locations. These were mostly giant, carving-grade, heavily etched hexagonal prisms in the 300-gram to 4-kg range, and some even larger, lying on about 10 meters of table space and filling plastic laundry boxes on the floor under the tables. Not a single high-quality crystal was in this remaining lot. The dealer confirmed that all the best specimens had already been sold and he was trying to sell the low-quality "logs" to collectors.

P. Minko, the General Director of the Kvarts Samotsvetny company, reported in 1995 that the mining company had not received any payment for this material from Wicast, Ltd. and had heard nothing from Wicast owner Jim Wills. Several times in Tucson, as late as the 2008 show, two very big Ukrainian men were in town looking for Wills, and there was a reward offered for information that might lead them to him.

A pegmatite worked from Shaft 3 (at a depth of 60 meters) produced some very beautiful optical-quality purple and blue cubic crystals of fluorite 10–20 cm in size.

Since the mid-1990s, small-scale clandestine mining has been carried out by locals going into the old tunnels and shafts before

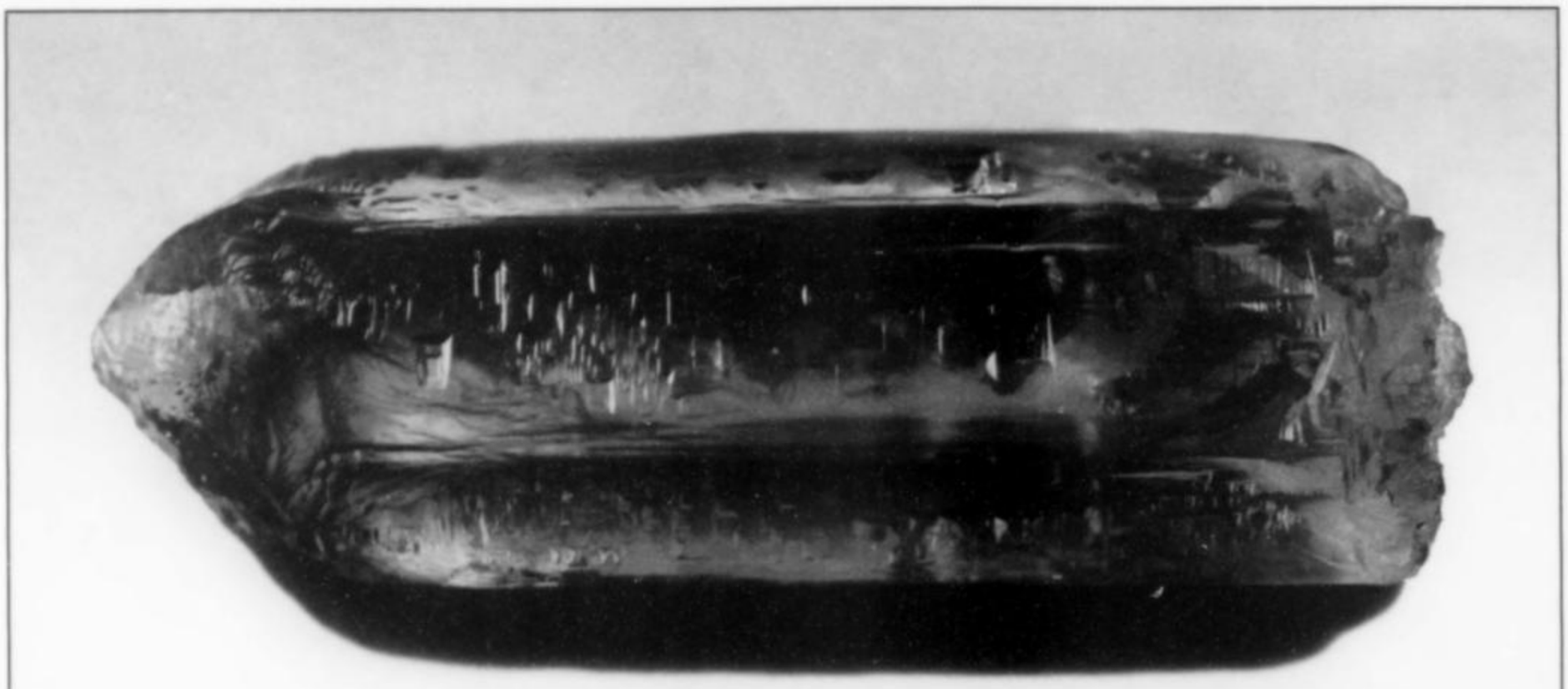


Figure 31. **Beryl crystal, 14 cm, from pegmatite no. 576, Volodarsk-Volynski. Vsevolod Chornousenko photo.**

***Figure 32*. Beryl crystal, 330 grams, found in pegmatite no. 576 at Volodarsk-Volynski in 2004. Peter Lyckberg photo, 2007.**

they became entirely water-filled. Open pits and dumps have been heavily searched since then, and are now pretty well picked over.

One of the cleverest tactics used by the mining company to deter unauthorized collecting during the Soviet era was a barbed-wire enclosure surrounding an open pit, posted with several signs saying "No Trespassing," "Collecting Strictly Forbidden," and "Violators Will Be Prosecuted." This attracted numerous collectors who crawled under the fence after dark and dug frantically for hours looking in vain for beryl crystals. The mining company knew very well that this particular pegmatite contained no beryl or topaz at all, though many unposted pegmatites around it did! (Igor Pekov, personal communication.)

Author's Visit in 1995

Peter Lyckberg (then with Chalmers University of Technology) and Professor William B. "Skip" Simmons (University of New Orleans) were the first foreigners allowed to enter the Volodarsk-Volynski mines in the post-Soviet era—in September 1995, just as the mines were about to be closed. Until that time, secrecy had been rigidly maintained regarding the mines, and it was most difficult if not impossible for anyone, even Russian geologists, not having a special mission at the mine to visit. Secrecy has continued to be maintained in the Ukraine until now regarding the mining of much gem material, as it was during Soviet times.

The water and air temperature in the mine was rather cold, just about 4° C. Our visit was to shaft 2, known for accessing pockets producing not only the largest quantity but also some of the finest beryls. The chief geologist at the time, Mr. Panchenko, and one mine geologist guided our party into the mines. Digging in a pocket in pegmatite no. 445 that was yielding beryl was not allowed, though we were allowed to look into the pocket. In pegmatite no. 452, which was yielding topaz, digging was approved. During work a decade later by the new Chief Geologist, Vsevolod Chornousenko, in pegmatite no. 445, new and very interesting, beautiful beryl specimens were recovered and the features of the occurrence were observed and recorded (see Fig. 19).

The large pockets contain giant quartz crystals, commonly smoky to black quartz, as a main component. Other minerals include mica, kaolin, microcline, albite, orthoclase, broken and re-healed shards of quartz, secondary silica in the form of opal, and a few others.

A great quantity of large beryl crystals was found, some of them weighing 500 grams to several kilograms and measuring up to 10 cm in diameter and 30 cm in length, although most beryl crystals are in the range of 1–3 cm in diameter and 3–10 cm long.

Mining at Volodarsk was conducted from six main shafts connected by drifts at the 50, 96 and 150-meter levels. In addition, several internal shafts (locally called *shurfs*) were sunk down to 70 meters depth in order to reach various pegmatite bodies. During Soviet times the definition of a *shurf* was a shaft not more than 38 meters deep, but in Volodarsk the same term came to be used for internal shafts reaching deeper. Around 500 pegmatite bodies were mined until operations ceased in 1995/1996 for economic reasons.

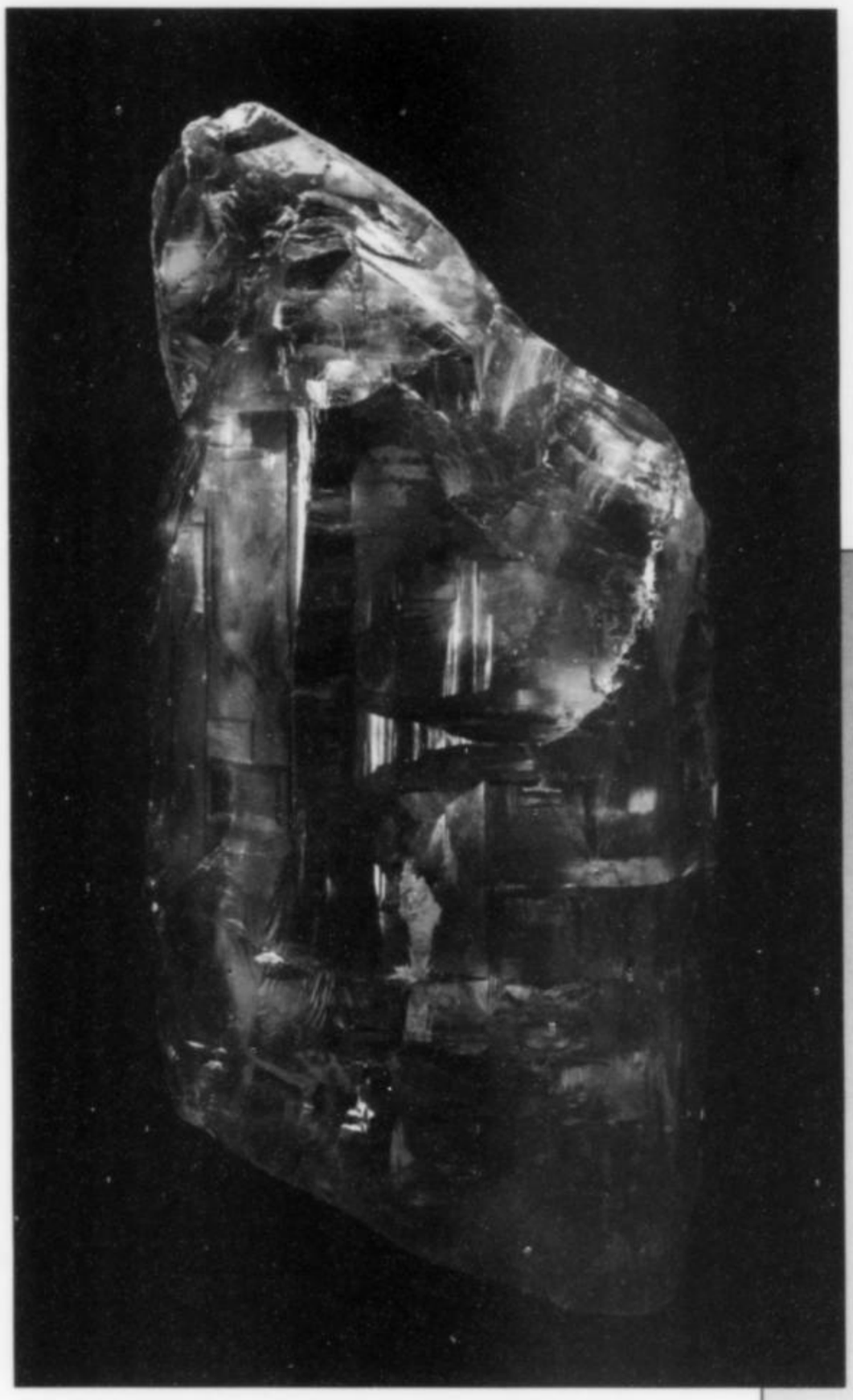


Figure 33. **Beryl crystal, 18 cm, from Volodarsk-Volynski. Museum of Precious and Decorative Stones collection; Michael Leybov photo.**

Figure 34. **Beryl crystal, about 17 cm, from pegmatite no. 576, Volodarsk-Volynski. Museum of Precious and Decorative Stones collection; Michael Leybov photo.**

Figure 35. **Beryl crystal, 12 cm, from Volodarsk-Volynski. Simon and Peter Huber collection; Peter Huber photo.**

Figure 36. **Beryl crystals, 17 cm and 14 cm, from Volodarsk-Volynski. Simon and Peter Huber collection; Peter Huber photo.**

RECENT ACTIVITIES

Shaft 6 Workings

Since the early 1990s the Kvarts Samotsvetny mining company has been studying all the old geological reports from the beginning of mining and has located potential areas of interest where it might still be possible to recover mineral specimens and gem rough. This work has been led by Chief Geologist Vsevolod Chornousenko. As a result, selected workings have been dewatered, beginning with shaft 6 (in 2004) and then shaft 2 (in 2006). Various pockets, including especially those where beryl had been found, were investigated and documented. An exceptional crystal that has been named the "Peter and Pablo Beryl," weighing over 6 kg and measuring 25 cm tall (now in the Museum of Precious and Decorative Stones, catalog no. 476) had been found earlier in one of these pockets. After September 11, 2001, though, all use of explosives was restricted to only one authorized company in every province, thus rendering it much less economical for the Kvarts Samotsvetny company to continue mining using explosives.

In the workings accessed by shaft 6, only two of the 130 pegmatites were known to have yielded beryl in the past, but recent work identified another two pegmatites carrying beryl. New production of gem crystals succeeded in recovering the costs involved in

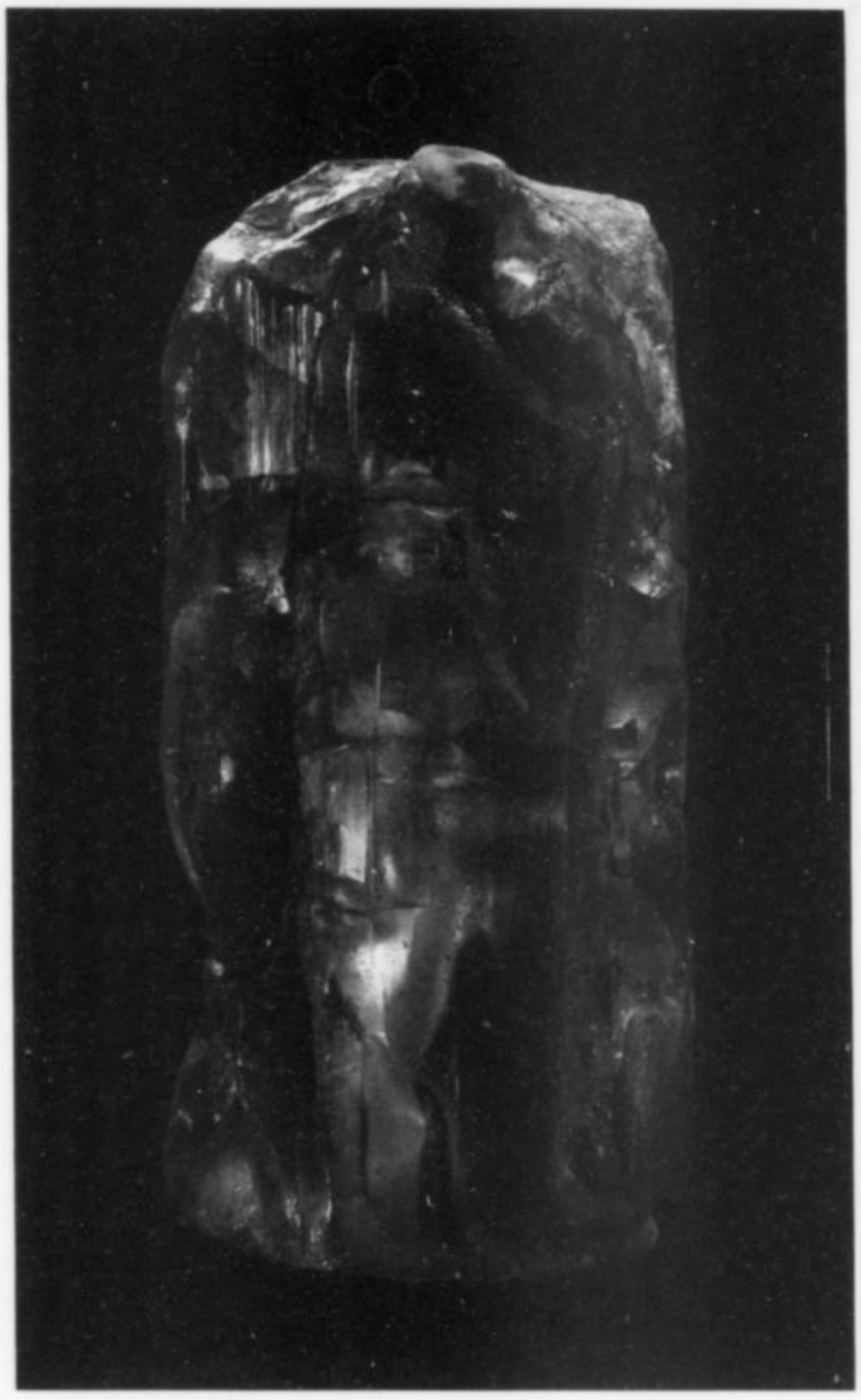


Figure 37. **Beryl (aquamarine) crystal, 5 cm, from the southern area of the Volodarsk-Volynski district. Vernadsky State Geological Museum collection; Michael Leybov photo.**

pumping and mining, and most of the good material has been cut and sold for jewelry in the Ukraine. A few of the crystals that had been offered on the Western mineral market failed to sell immediately, and were then cut within a week and sold in the Ukraine for double the price offered in Western Europe and the U.S. About 56 kg of topaz were also recovered, along with much gem-grade and specimen-quality beryl.

The finest crystals from here were recovered in the same pegmatite (**no. 576**) as produced the lovely 17-cm group in the Volodarsk Museum of Precious and Decorative Stones (catalog no. 534, weighing 718 g), pictured in Pavlishin and Dovgyi (2007, page 62). The renewed mining effort recovered some of the very finest beryls ever found in Volodarsk. These include several deep yellow heliodor crystals and several very fine green crystals. The finest are fairly sharp hexagonal prisms showing good termination faces and only slight etching. This is probably because they were formed within deep, thin fissures 1.5 to 2 meters above the pocket bottom, and were apparently protected from the corrosive solutions that typically leached the beryl crystals in the bottom of the pockets.

Twenty (15%) of the 130 pegmatites accessed by shaft 6 have yielded topaz, though overall only about 10% of the pegmatites of the whole pegmatite field contain topaz.

Recent work in shaft 6 has yielded superb, slightly etched hexagonal yellow and (rarely) green gem-grade beryls. Three superb crystals from 14 to 18 cm tall weighed 334, 400 and 900 grams. The largest one, a flawless, razor-sharp, hexagonal prism, was unfortunately cut into a flawless 2,500-carat gemstone. The other two have been preserved as specimens. The best pure yellow crystals were found in **pegmatite no. 576**, the largest one measuring about 23 cm long and 6 cm thick; but the finest-quality crystals are 1 and 2 cm thick and 8 cm long, flawless, and exceptionally lustrous.

Shaft 2 Workings

Of the seven pegmatites accessed by shaft 2, five have been found to carry beryl. Some of the very finest gem crystals ever found in Volodarsk were also recovered during work in this area, the best ones being sharp, hexagonal, flawless crystals of yellow color found in a thin fissure high above the floor, where they had escaped severe etching. The best were recovered from pegmatite no. 445 off of Shaft 2 at 60 meters depth, only a few hundred meters to the southwest of pegmatite no. 521. About 150 meters to the northeast of pegmatite no. 445 is pegmatite no. 452 at a depth of 50 meters. Here bi-colored blue and salmon-pink topaz was recovered during mining and again in 1995 by one of the authors (PL).

In January 2007, dewatering of the huge old flooded Vishnyakovka open pit originally mined in the 1960s began. By September 2007 it had been emptied and new work was initiated in pockets in the underground workings. Silt covering an access adit to the workings was removed and about 400 meters inside the tunnel a sandbag dam was constructed, measuring a few meters wide and 1.5 meters high. Below this dam, a 400-meter inclined shaft was pumped out. At the bottom of this incline, at a depth of 70 meters, a long side-tunnel led westward to a topaz pocket and a beryl pocket.

Authors Peter Lyckberg and chief geologist Vsevolod Chornousenko visited and participated in the mining of several pockets accessed via this 800-meter-long tunnel. Working conditions in this environment proved difficult, as the oxygen level was low and working efficiency was severely compromised (equivalent to working at more than 5,000 meters altitude). At least one of the authors suffered from a reddened and very swollen face during this work, which Chornousenko himself judged to be very difficult despite having worked in pegmatites at over 5,000 meters in the Pamir Mountains of Tadzhikistan.

The main pegmatites to be reworked were the following:

Pegmatite no. 436, at 55 meters depth, was reworked, including a pocket measuring 3 × 20 × 15 meters that yielded flawless gem beryl crystals to 8 cm in diameter with rounded faces and terminations. A dozen crystals were removed in matrix, which shortly crumbled to gravel after drying out. The largest fragment left from blasting in 1973 was a section of a 10-cm-diameter gemmy green beryl crystal. No other pieces of this crystal could be found.

Crystals recovered ranged primarily from the size of a small finger, i.e. 1 by 4 cm, to 3 or 4 cm thick and 8 to 10 cm tall. These beryls commonly show hundreds of short needle-like microcrystals that can easily be felt along the sides and on the rounded terminations; others show small bubbles within the same faces.

A layer of rubble approximately 1.5 to 2 meters thick in the pocket (see Figs. 11 and 12) was dug through, and along the sides gemmy beryl crystals were mined from *in situ* positions using a small electric jack hammer. Crystals were found in a fine-grained grayish green matrix just below a zone carrying large white feldspar crystals. Surprisingly, no well-formed feldspar crystals were found, and beryl crystals were in most cases broken on the end, possibly as a result of pocket collapse.

A few beryl crystals could be seen to have originally grown on other minerals, and all of them showed a rounded hexagonal to cylindrical shape with highly rounded terminations; a few of them showed remnants of steep termination faces.

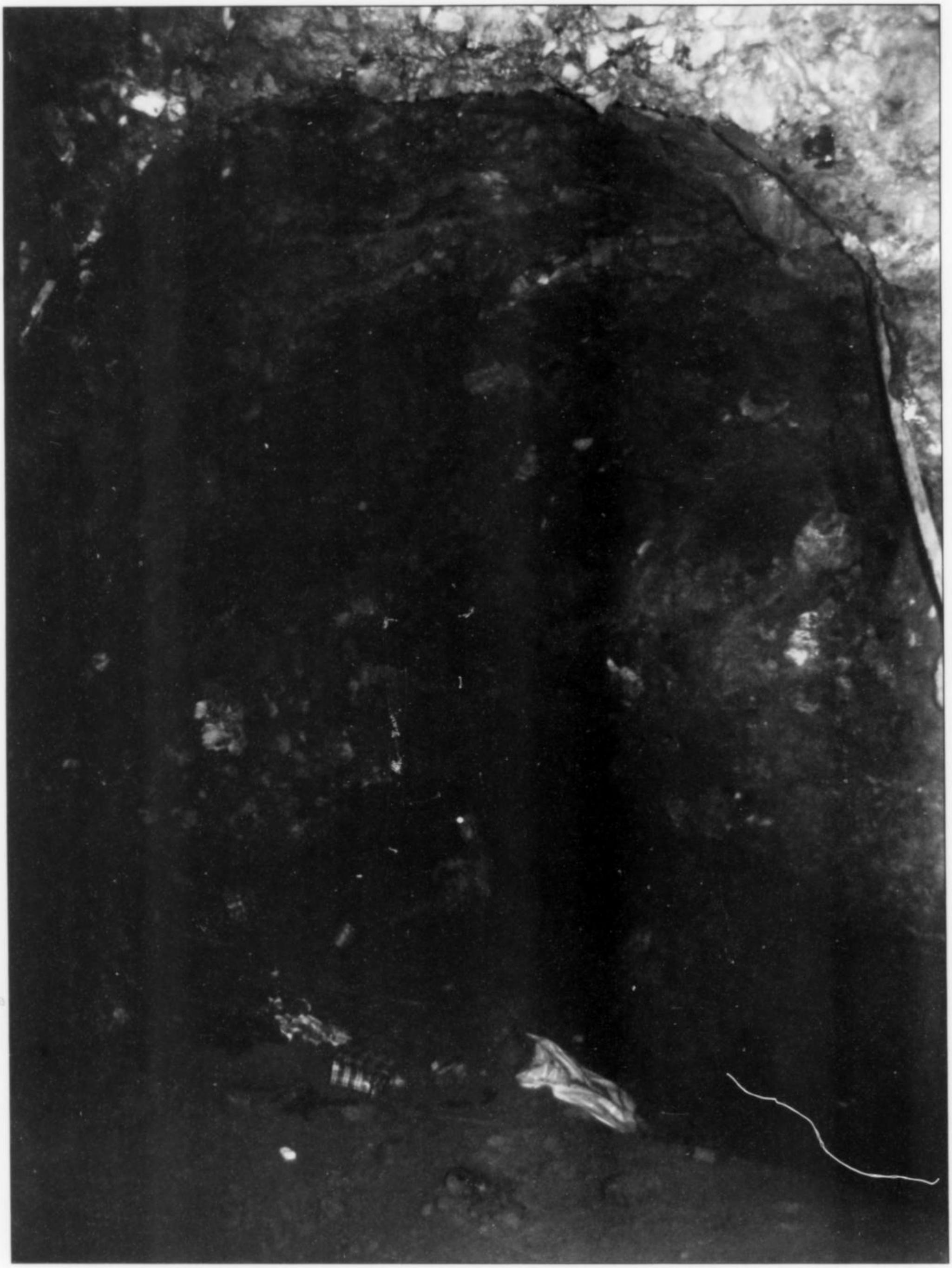


Figure 38. **A miner working in the giant chamber pocket in pegmatite no. 521 at Volodarsk-Volynski. The pocket, which measured 15 meters tall, 30 meters long and 25 meters wide, yielded 2.5 tons of beryl crystals. Vsevolod Chornousenko photo.**

Pegmatite no. 438, 70 meters in depth, measured 3 × 5 × 6 meters and contained lovely feldspar crystals, deep orange topaz chunks up to a kilogram in weight, and small, white, rounded, 2 × 5-cm beryl crystals. In most cases the beryl crystals in pockets where topaz is found have been largely dissolved. Microcline, orthoclase and smoky quartz crystals were found as loose floaters in crystals to 25 cm.

Pegmatite no. 422, at a depth of 55 meters, produced 50 tonnes of quartz and 260 kg of beryl in 1973. Recent finds included giant morion (black quartz) crystals to 4 tons, with large, sharp, slightly etched, hexagonal green to yellowish green gemmy beryl crystals to 793 gram.

Pegmatite no. 434 produced rare, small, 4 to 8-cm cylindrical aquamarine beryl crystals and some topaz.

Off of the same tunnel, **pegmatite no. 428** yielded many wine-yellow topaz crystals and bi-colored topaz in complex crystals to 200 grams (these small ones had been left by previous mining); three more pegmatites were also exploited during our visit. Some of the pegmatites that had been described by geologists in the 1970s as still containing significant amounts of gem beryl crystals (e.g. pegmatite no. 422) had by then proven to be less productive, whereas other pockets that had originally been overlooked were still yielding some beryl crystals.

Pegmatite no. 198, a kaolinized pegmatite at shallow depth (5–10 meters), yielded typical, fantastically etched beryl crystals. In April 2008 a superb, flawless crystal weighing 240 grams was found just before pumping was discontinued and the quarry was allowed to fill with water. The crystal was unfortunately cut within a week.

Pegmatite no. 364, containing a giant, extremely heavily etched pocket, was also among those where two of the authors (VC, PL) participated in mining; we excavated this pocket together with a team of three miners. Access is via a 70-meter vertical shaft that was pumped out in the winter of 2007/2008. Miners desended in a heavy metal bucket hanging on a steel cable, from a temporary crane to an access drift at the bottom. This shaft is located on top of, and at the edge of, the above described open pit, in its southwest corner. The drift leads north under the giant pegmatite no. 206 pocket mined in 1953.

This shaft is located just at the southern edge of the huge Vishnyakovka open pit, where seven major chamber pegmatites and three smaller ones had been mined during 1960–1973. One of them yielded a 12-kg gem beryl crystal. In the Fersman Museum in Moscow, specimens from this open pit which were found in 1967 and 1968 are exhibited. During the earlier mining of this open pit in the 1960s, a flawless elongated gem beryl some 30 cm long and 8 cm in diameter, weighing 2 kg was found (broken off on both ends). This specimen is today exhibited in the Volodarsk museum and was illustrated on page 30 (left image) in Koshil *et al.* (1991).

The large gemmy heliodor crystal illustrated on the same page and the inside front cover of Pavlishin and Dovgyi (2007), named the "Academician Evgeniy Lazarenko" heliodor, measuring 27 cm long and 10 cm in diameter (weight 4.879 kg) was broken in half on purpose because the lower portion was not as transparent and gemmy as the top half. This crystal was found in the 1960s in a pegmatite near shaft 6, in a pocket measuring 12 meters long and 14 meters high. Because the surfaces of the hexagonal crystal are frosted, one face has been polished to show the flawless interior.

In **pegmatite no. 364**, a gushing waterfall was issuing from the shaft wall at 40 meters depth, requiring that a 30-meter-tall rubber curtain be installed to protect us from being completely soaked during our descent. Four big pumps were working continuously, extracting the inflowing water through 20-cm steel pipes to the surface. If the pumps had failed, the workers digging in the pocket (that is, the two of us and three more miners) would have had very little time to get all the way back down the drift to the vertical shaft before it was completely flooded.

Pegmatite no. 364 had originally been located by test-drilling to 70 meters depth on a 50-meter grid pattern; one drill hole happened to hit in the middle of the pocket. As a result, further drilling in a 5-meter grid was carried out in order to delineate the pegmatite pocket. A 4 × 4-meter shaft was sunk and a 100-meter access drift was driven at 70 meters depth. The original mining operation in 1973 had intersected the pocket a bit too high, and the pocket was thought by the mine geologist to be empty. Renewed work revealed a beryl-rich layer only a few centimeters to a couple of meters under the floor of the access drift. Quartz crystals were found *in situ* 5 meters under the floor. Gem beryls were found in a very irregular zone following the top of the leached zone.

Several marvelous, heavily etched beryl crystals were found that had been reduced by dissolution to less than 30% of their original weight. The granite beneath this pocket was leached to a depth of 26 meters, meaning that the quartz had been dissolved and had recrystallized as giant quartz crystals in the upper portion of the pocket. Many of the former giant gem beryl crystals in this pocket had been etched down to a few percent of their original size, a reduction which could easily be determined based on impressions and molds in the surrounding matrix. The largest green gem beryl found in 2007 weighed 4.2 kg and consisted of a pinacoidal termination on the core of a giant, heavily etched crystal estimated to have originally weighed between 15 and 30 kg. This superb crystal would be worthy of any world-class museum. It was sold to a collector in the Ukraine.

Some really unique and atypical beryls were recovered from this pocket, but most of them ended up as cut gemstones. Among the finest deep gemmy green, heavily etched beryl crystals recovered was a crystal weighing 1.75 kg. A superb, highly etched, 1.6-kg specimen named *Svinja* ("The Pig") perfectly resembles a sleeping pig with nose, ears, eyes, and even a perfect tail. The largest crystal found was of superb quality, with a pinacoidal termination modified by a few more termination faces that survived etching, while all prism faces were deeply etched. All of these largest and finest specimens stayed in the Ukraine and Russia, where collectors are willing to pay the faceting rough price in order to save them from being cut. Specimens named "The Fireman's Helmet" (288 grams) and "The Devil's Postpile" (461 grams), both very fine and gemmy crystals, were sold to European collectors at the 2008 Tucson Show and the 2008 Munich Show. David Wilber was extraordinarily excited about these during the filming of "What's Hot in Tucson 2008." He had never seen anything like them, which is not surprising as none had ever been collected until November 2007 to February 2008!

All of these pockets had been mined originally in 1972–1973. When Lyckberg (Lyckberg, 2008) later visited the mines in the spring of 2008, only small-scale digging was taking place, in a single open pit just above the water level. One 14-cm flawless gem crystal weighing 240 grams had just been found, having small knobs on the hexagonal faces (typical for this kaolinized pegmatite). When it was not immediately sold as a specimen it was cut into a flawless, richly colored, 512-carat gemstone and sold for double the original asking price within a week.

During the last few years a strip-search of all miners and geologists exiting the mines, under camera surveillance, was mandatory. All gem material found by miners in the mine was put into a special container that was then removed from the mine only by special guards. Consequently very few matrix specimens were brought out, despite the fact that some wonderful feldspar crystal specimens, topaz and beryl crystals in matrix were found.

MINERALS

Following are the species which occur in the Volyn pegmatite area in collector-quality specimens. These and all other species identified from the area are listed in chemical order in Table 1.

Albite $NaAlSi_3O_8$

Albite occurs in pockets as the platy white cleavelandite variety. Very few specimens with albite and smoky quartz have been preserved because pockets are, in general, collapsed and most specimens have been broken apart; even when intact matrix specimens were found, they were rarely taken out of the mine.

Beryl $Be_3Al_2Si_6O_{18}$

Beryl is understandably the most famous of the Volodarsk minerals because of its occurrence as beautiful, large, gem-quality, typically etched crystals of an unusual yellowish green color. Most collectors are not aware that each beryl-containing pocket yielded characteristic shades, morphologies and grades of etching. The most common are beryls from pegmatite no. 521 near shaft number 6. This pocket was primarily mined in 1982 but specimens that reached the Western market as early as 1981 are likely from this pocket as well.

A ton of beryl crystals was by chance recovered from the sides of the pocket as a by-product of the mining of 80 tons of piezoelectric quartz. In 1992, becoming aware of the value of specimens on the collector market, miners and geologists at the mine went back into this pocket and recovered an additional 1,500 kg. Thus in total about 2,500 kg of beryl were recovered from this jumbo pocket.

Beryl crystals from Volodarsk are commonly heavily etched and range in color from dark olive-green to bright green to the more common yellowish green. Pure yellow crystals are rare but have been found in pegmatite 576, for example. Natural pale blue aquamarine beryl is very rare and was found only in a couple of pegmatites. Colorless, bright lettuce-green and deep green beryl crystals have also been found.

Numerous large beryl crystals have been recovered, some weighing up to several kilograms and measuring 20 centimeters in diameter, although most of the crystals found are between 1 and 3 centimeters in diameter and 3 to 10 centimeters in length. Average-size crystals are 10 to 15 cm tall. Larger crystals can be 15 to 30 cm long. Literally thousands of crystals were found, weighing in total around 3.5 metric tons or more. Of these some 500 kg could be called real gem crystals, and only a few kilograms were of the very best quality, i.e. perfectly formed lustrous gem crystals of green to greenish yellow and rarely pure yellow color.

It must also be noted that even while digging a pocket very carefully, beryl crystals in matrix were found with fresh-looking breaks, and the broken off portions were nowhere to be found. Few beryl crystals have been found where the attachment to other minerals has been preserved. Hexagonal crystals with little etching are the most unusual ones, together with exceptionally etched ones from pegmatite 364.

Beryl typically contains up to 0.3 weight % alkalis (predominantly Na_2O), and between 0.6 and 1.5% Fe_2O_3. Divalent iron occurs in low concentrations or is absent in beryl, a fact which suggests an alkaline environment (pH 8.5 ± 0.2) during crystallization of beryl favoring the oxidation of iron (Kalyuyhnaya and Kalyuzhnyi, 1963)

Precisely where in the pocket beryls crystallized originally is not known, as they are usually found only in a very irregular layer in the pockets. However, in pegmatite no. 422, at a depth of 55 meters, a giant beryl crystal was found growing from a termination face of a giant smoky quartz crystal hanging vertically from the ceiling, the beryl lightly attached horizontally to one of its termination faces.

The largest recorded gem-quality beryl crystal, named "Vladimir," was found in pegmatite no. 521 in 1992. It weighed 22 kg and measured 55 cm long and 16 by 18 cm across. Unfortunately it was broken into two sections while being removed from matrix. The crystal was almost entirely of faceting quality but had some turbidity caused by numerous small three-phase (fluid, gas and solid) inclusions in the lower section.

The largest beryl crystal from the Volodarsk area was found in a kaolinized pegmatite in the Vishnyakovka open pit in 1973. It is a green carving-grade crystal recovered in six pieces which, when reassembled, become a 1.2-meter-long crystal weighing about 66 kg (145 pounds)! It is on exhibit in the Museum of Precious and Decorative Stones in Volodarsk.

Beryl and topaz are antipodal minerals in this type of pegmatite; that is, when one grows, the other dissolves, and consequently only a few pegmatite pockets have been found to contain both minerals together. When they do occur together, one is always heavily etched.

Columbite-(Fe) $Fe^{2+}Nb_2O_6$

Columbite-(Fe) is uncommon but does occur as small crystals in most of the pegmatites in the central part of the pegmatite field. Most crystals are only a few millimeters in size, but crystals up to 2.5 cm have been found in the leached zone at the bottom of some pockets.

Fluorite CaF_2

Fluorite occurs primarily in poorly developed pegmatites, i.e. those without major pockets. One pocket yielded large blue and purple cubes of optical quality and up to 20 cm in size at 60 meters depth near shaft 3. In the largest of two giant chambers of pegmatite no. 521, near shaft 2, dark purple fluorite occurred along the upper walls as small 5-mm chunks. Green octahedral crystals up to 8 cm occur mostly near the chambers. The finest fluorites of Volodarsk are highly desirable collectibles.

Goethite α-$Fe^{3+}O(OH)$

Goethite occurs in some of the pegmatites as large sprays and clusters to 20 cm, with individual acicular crystals to 10 cm. Sometimes the goethite crystal clusters are found growing around smoky quartz crystals. Excellent specimens are preserved in the Gemstone Museum in Volodarsk.

Kerite $C_{491}H_{386}O_{87}S(N)$

Kerite, a rubbery tar-like organic compound, was formed under hydrothermal conditions. It has been found in many pegmatites by Vsevolod Chornousenko as small concentrations and large fibrous masses (up to meter-size lumps) in only a couple of the pegmatite pockets. It has been found also sporadically in pockets yielding topaz and in pockets yielding beryl.

Microcline $KAlSi_3O_8$

Microcline occurs in many pockets in sharp crystals measuring 2 to 30 cm in size, but the crystals generally were not preserved. Sometimes it forms beautiful twins; Manebach twinning is most common, but Carlsbad and Baveno twins also occur. Fine specimens are preserved in the Gems Museum in Volodarsk.

Molybdenite MoS_2

Sharp hexagonal crystals of molybdenite to 15 cm, showing an unusual, dark metallic gray color, were recovered from one of the pegmatites near shaft 2 by Vsevolod Chornousenko. The finest one was donated to the Fersman Museum.

Orthoclase $KAlSi_3O_8$

Lovely crystals of orthoclase in the 2 to 30-cm size range occur in many pockets. Some show sharp twinning. Pegmatite no. 364 (at

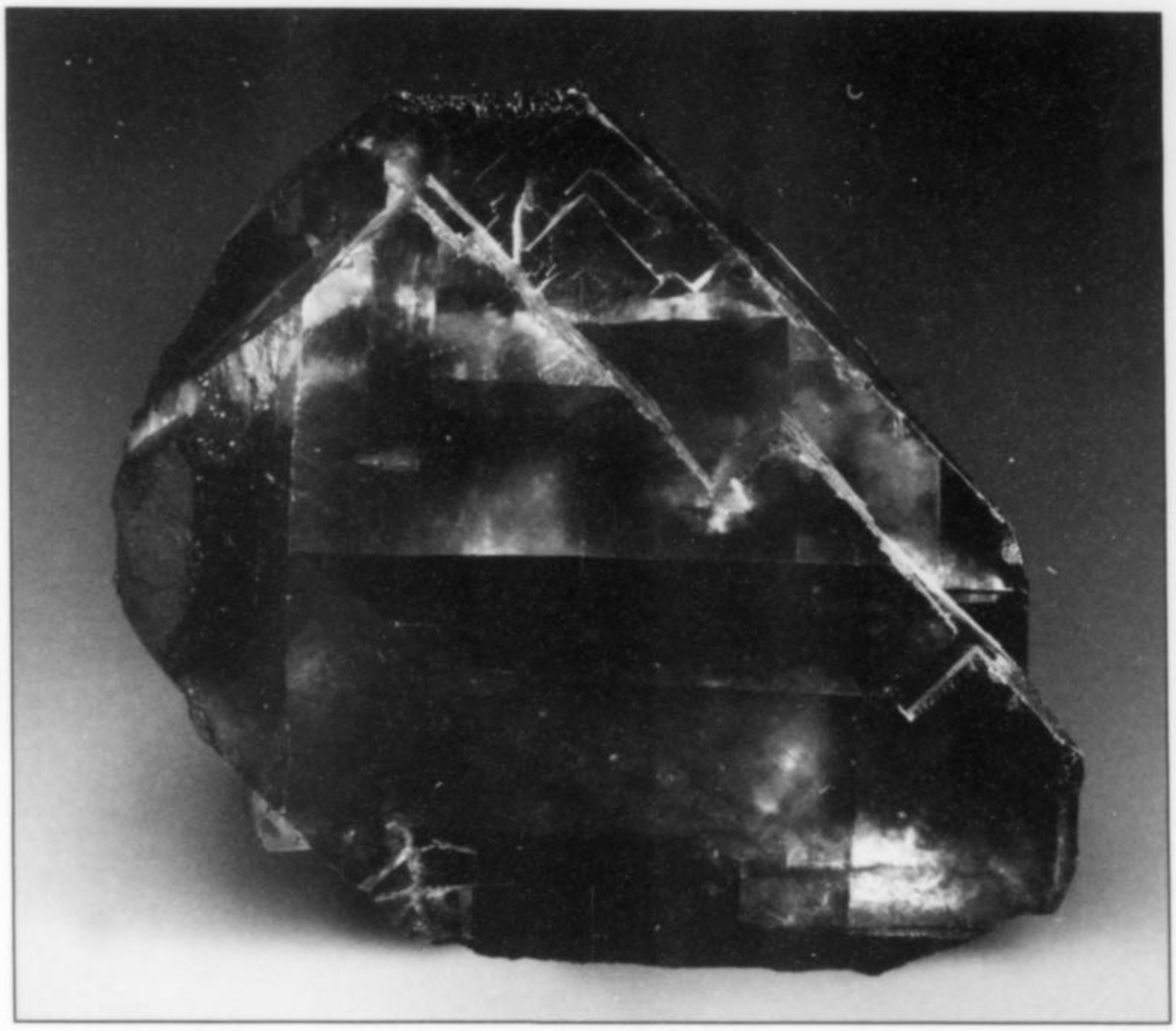


Figure 39. **Fluorite crystal, 8 cm, from Volodarsk-Volynski. Victor Levitskiy collection; Michael Leybov photo.**

Figure 40. **Color-zoned green and purple fluorite penetration twin, 4 cm, from Volodarsk-Volynski. Simon and Peter Huber collection; Peter Huber photo.**

70 meters depth) contained many very sharp groups 5 to 35 cm in size. Pegmatite no. 438 produced some floater crystals to 25 cm.

Phenakite Be_2SiO_4

Completely gemmy phenakite in complex, semi-lustrous crystals to 2 cm occurred with albite on orthoclase in pegmatite no. 373, located in the southern part of the Vichnyakovskovo area. In 1969 this pocket was found and delineated by core-drilling on a 6 by 6-meter grid. The core contained poor quality morion and fragments of blue topaz. In 1972 the pegmatite body was delineated in detail and the study resulted in mining at a depth of 25 to 40 meters. The pegmatite body is 26–30 meters long by 7 to 15 meters wide. These were probably the finest phenakite specimens ever found in Volodarsk. The shape of the crystals is very uncommon for this species (Tomasz Praszkier, personal communication, 2009).

Phenakite crystals have also been found inside large smoky quartz crystals (examples are preserved in the Igor Pekov collection).

Quartz SiO_2

Giant colorless to dark smoky (morion) quartz crystals occur in vugs in the chamber pegmatites. The largest documented crystal weighed 10 tons and was recovered in 1946 from near the surface in an open pit 200 meters from shaft 2. In January 2008 a 4-ton morion crystal was found together with several tons of other giant quartz crystals in a continuation of pegmatite no. 422 (at a depth of 55 meters) which had originally been mined in 1973. Eighty-ton quartz crystals had come from that pocket. The pocket measured about 7 × 15 meters across and 5 meters tall; it was found to continue in one end as a small, 2 × 3 × 3-meter cavity with smoky quartz crystals to 1 meter in length. In the other end it narrowed down to a 10-cm to 40-cm sub-horizontal clay-filled fissure containing hexagonal, pale green gem beryl crystals to 14 cm in length. The fissure then opened up once again into a second giant chamber yielding the second largest quartz crystal with faceting quality termination and large, hexagonal, lightly etched gem beryl crystals to over 1 kg. For the first time in Volodarsk, gem beryl crystals were found in their original positions of attachment, on the termination faces of giant 1.5-meter smoky quartz crystals that had not collapsed into the pocket but were still hanging from the roof of the pocket. The interiors of the quartz terminations were smoky to citrine in color, and a substantial quantity was recovered for faceting.

Unfortunately none of these giant crystals could be brought out intact because of their size, difficult location, and the narrow access to the pocket. The inclined shaft leading to the pocket was several hundred meters long, connecting to a drift that was three-fourths filled with water and was passable only by lying flat on a rubber raft. This drift ended at a small vertical entrance shaft from the Vishnyakovka open pit (Lyckberg visit 2007–2008).

Quartz occurs in well-formed crystals, sometimes of the Tessin habit, often found also as huge clear shards and fragments from

Figure 41. **Goethite, 12 cm, from Volodarsk-Volynski. Vernadsky State Geological Museum collection; Michael Leybov photo.**

Figure 42. **Molybdenite crystal, 4 cm, from Volodarsk-Volynski. S. A. Dovgyi private museum, Kiev; Michael Leybov photo.**

crushed giant quartz crystals. Amethystine quartz is very rare, found only as thin overgrowths on larger smoky quartz crystals.

Perhaps the most expensively obtained smoky quartz group ever to be recovered is a half-meter-size cluster of short, prismatic, dark black crystals preserved in the Gems Museum in Volodarsk. Core drilling to a depth of 70 meters intersected a crystal pocket, and the geologist in charge predicted a 60-ton yield from the pocket. So a shaft was sunk down 70 meters to reach it, but when the pocket was finally entered it proved to contain only the one specimen (shown in Fig. 55).

Volodarsk quartz is commonly in the form of Dauphiné or Brazil-law twins or a combination of both (Leydolt twins). One rare, symmetrically developed Japan-law twin of black quartz 20 cm wide was found in the 1980s and is kept in a private collection.

Rutile TiO_2

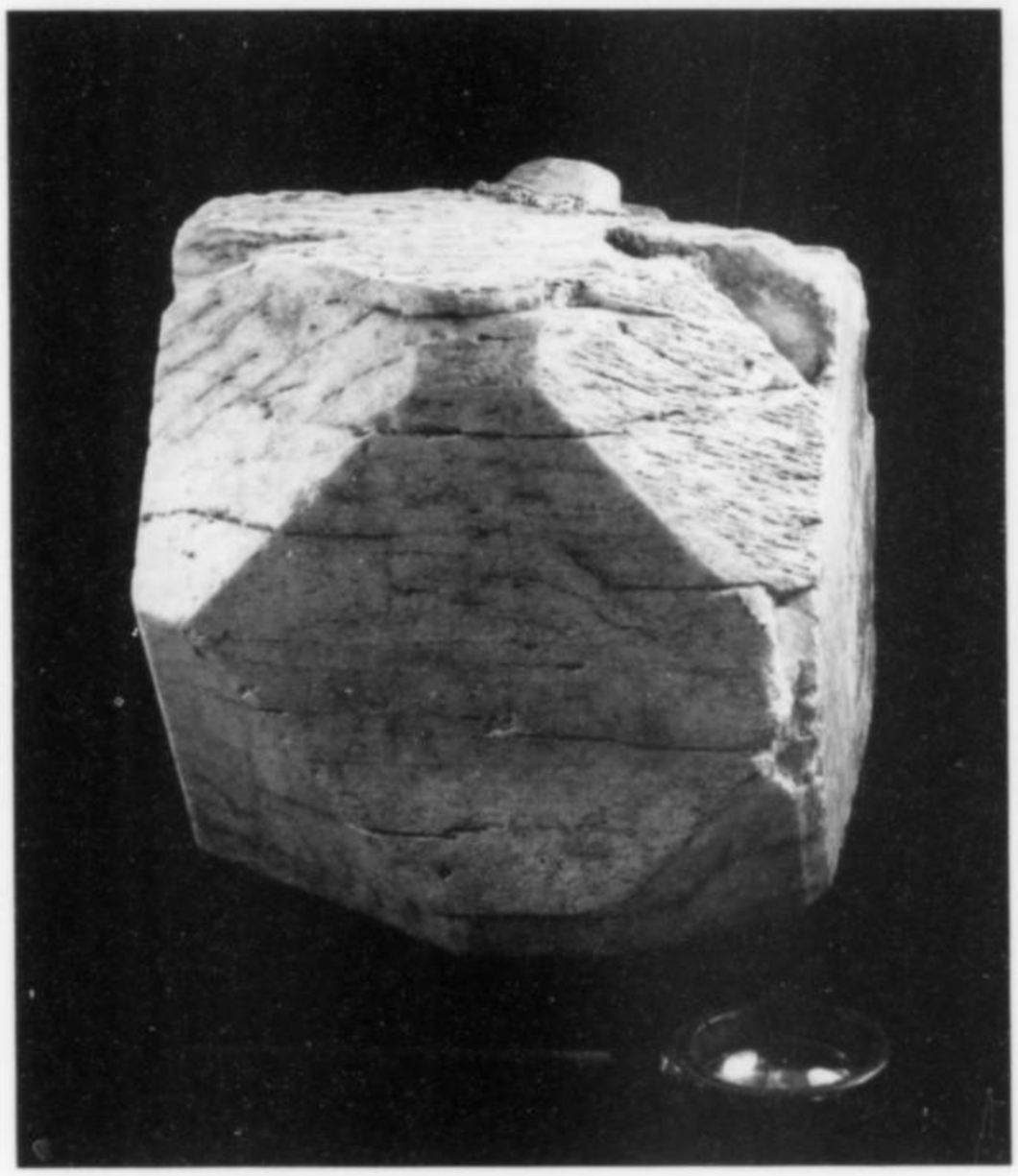
Rutile occurs in the Volodarsk pegmatites as small dipyramidal crystals to 2 cm.

Topaz $Al_2SiO_4(F,OH)_2$

Approximately 10% of all mined chamber pegmatites in Volodarsk contained well-formed, large to very large topaz crystals. The richest find of topaz may have taken place in 1976–1978, when 5 tons of topaz crystals were recovered from a single pegmatite chamber near shaft 2. The crystals generally range from colorless, to dark champagne color, orange, and sky-blue. When faceted the topaz is used only in jewelry intended for evening wear, because the orange and champagne colors fade under the ultraviolet component of sunlight.

Figure 43. **Large feldspar crystals, freshly collected from pegmatite no. 364 at Volodarsk-Volynski. Peter Lyckberg photo, 2007.**

Figure 44. **Orthoclase crystal, 15 cm, from the southern area of the Volodarsk-Volynski district. Vernadsky State Geological Museum collection; Michael Leybov photo.**



In a few pegmatites beautiful bi-colored topaz was found showing a sky-blue and pale pinkish orange color, sometimes with beautiful white "cloudlike" fluorite inclusions. Gray fluorite inclusions have also been found in colorless topaz. The rich colors seen in topaz were induced by natural radiation over the 1.77 billion years since their crystallization.

Studies of two-phase fluid inclusions in topaz indicate an initial crystallization temperature of from 360° to 540° C and the formation of later secondary (rehealing?) inclusions at 180° to 350° C (Kievlenko, 2003). Very few pegmatite pockets carry both beryl and topaz. Beryl crystallizes first, at a higher temperature, and as the temperature falls the acidity of the solutions increases. By the time topaz begins to form, the solutions have become sufficiently acidic

Figure 45. **Phenakite crystals, 3 cm (top) and 1 cm, from Volodarsk-Volynski. Sergei Baskakov collection (top) and Mikhail Anosov collection; Michael Leybov photo.**

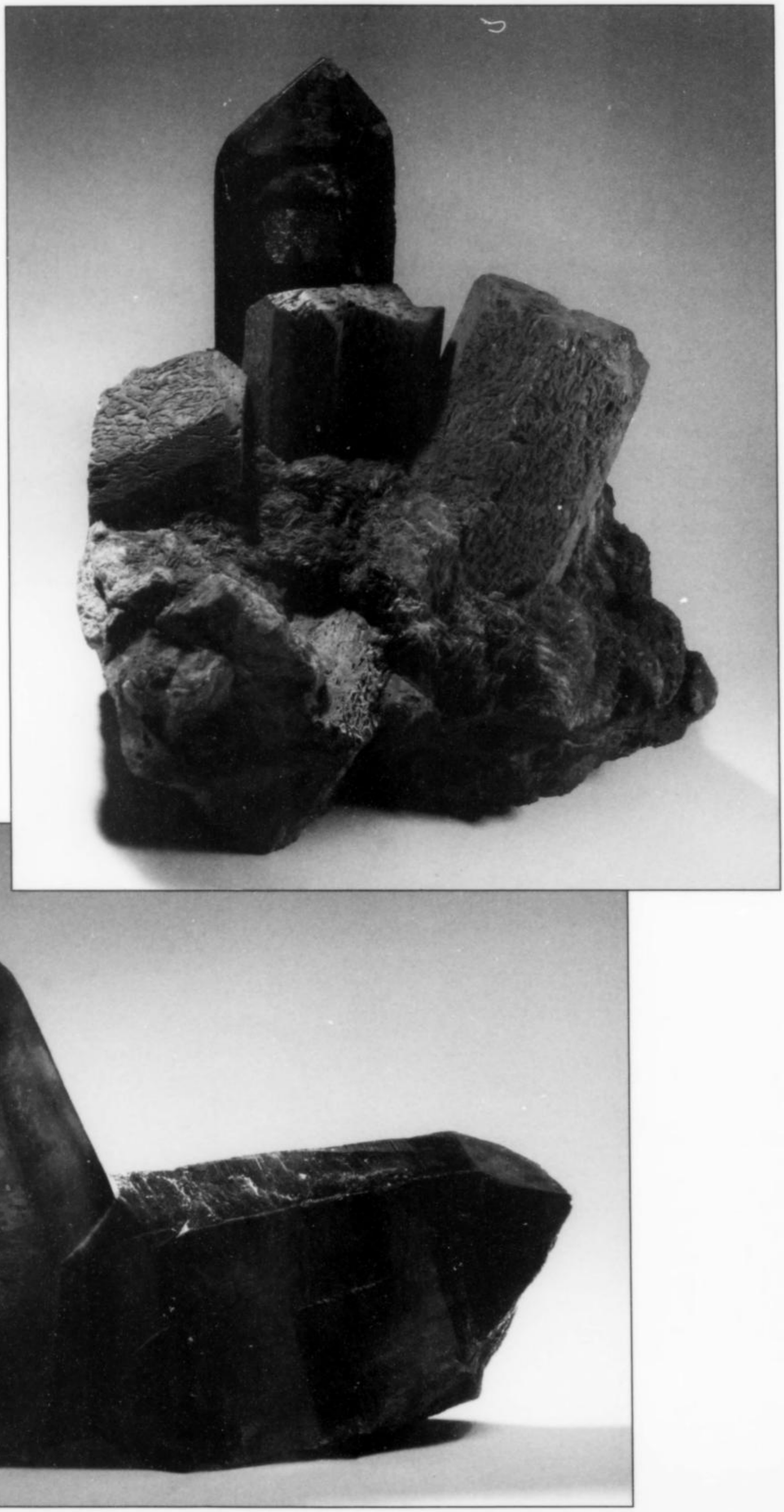


Figure 46. **Smoky quartz with microcline and albite, 26 cm, from Volodarsk-Volynski. Museum of Precious and Decorative Stones archive; Michael Leybov photo.**

Figure 47. **Smoky quartz Japan-law twin, 14 cm, from Volodarsk-Volynski. Museum of Precious and Decorative Stones collection; Michael Leybov photo.**

Figure 48. **Blue topaz crystal, 25 cm, from Volodarsk-Volynski. Fersman Mineralogical Museum collection; Michael Leybov photo.**

Figure 49. **Topaz crystal weighing 3,400 grams, collected at Volodarsk-Volynski in the 1950s and kept by a local geologist; it was sold in 2008. Vsevolod Chournousenko photo.**

to begin dissolving the beryl. Rare matrix specimens containing both species were collected in October 2007 from pegmatite no. 438 at a depth of 70 meters.

In a small pit near shaft 2, sericite pseudomorphs after topaz were found which contain flawless cores of topaz. Topaz occurs as doubly terminated crystals, although because of its prominent cleavage on {001}, crystals are commonly found cleaved into two or more sections. The largest crystal found to date had a wine-yellow color, weighed 117 kg and measured 35 × 37 × 82 cm; it was discovered in 1965, but was not preserved. (This certainly supports the theory that there was some industrial use for gem-grade topaz which was considered more important than preserving the crystal as a specimen.) Other large crystals have also been found, three of which weighed in at 82 kg, 110 kg and 116.5 kg respectively; in addition to these, another 100 smaller crystals were recovered. Huge crystals are preserved in the Fersman Museum and the Vernadsky Lomonosov Moscow State University (a 67.2-kg crystal) in Moscow. Topaz is frequently found as large cleavages in the pockets.

Topaz occurs primarily as large, brown, sharp to rounded or etched crystals which may show numerous small needle-like points on and near the terminations. On rare occasions, blue or blue-peach bi-colored crystals have been found. Minerals besides fluorite that have been found as inclusions in topaz are quartz, feldspar, albite, columbite, elpasolite and smoky quartz.

A display in the Fersman Museum shows several good examples from the Volodarsk deposits. Two particularly well-known topaz specimens in the Fersman Museum are an 8 × 8 × 14-cm blue topaz cleavage containing white cloud-like inclusions of fluorite

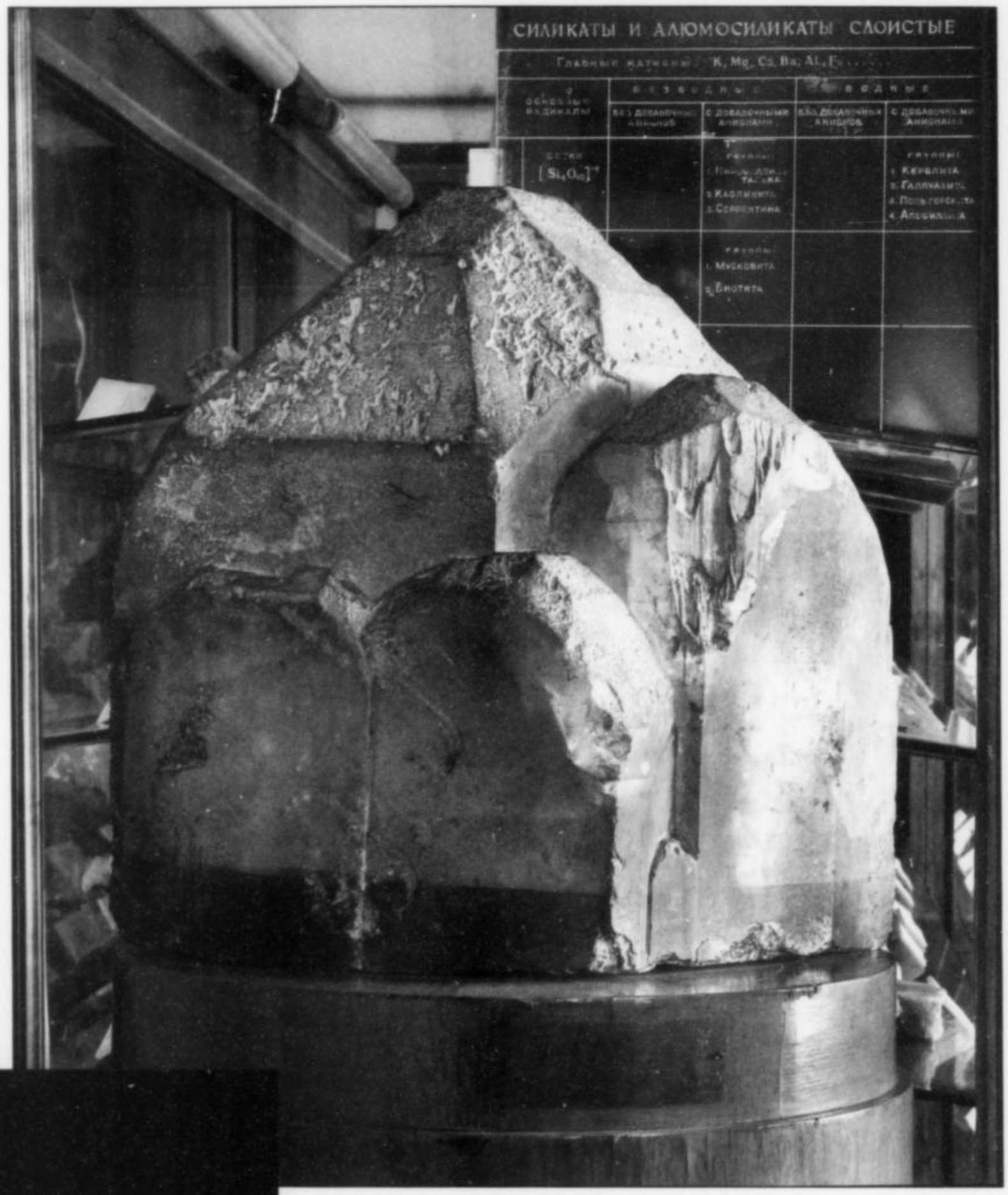


Figure 50. **Large, pale blue topaz, 39 cm, weighing 67.2 kg (148 pounds), from Volodarsk-Volynski. This is the largest known Volynian topaz to have been preserved. Earth Science Museum of the Lomonosov Moscow State University; Michael Leybov photo.**

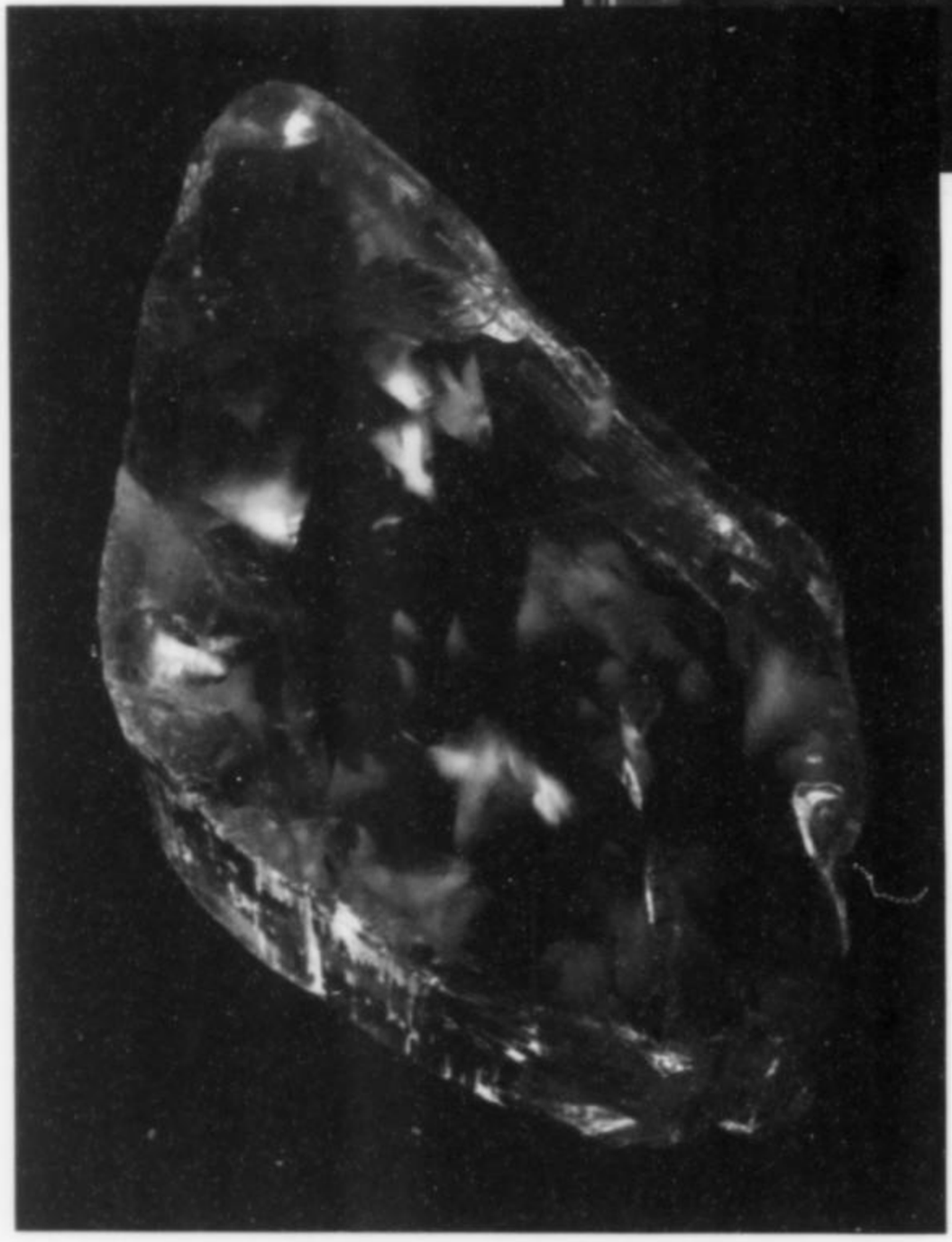


Figure 51. **Blue topaz cleavage (called the "Academician Fersman Topaz") , 14 cm, showing white fluorite inclusions. Museum of Precious and Decorative Stones collection, Volodarsk-Volynski; Michael**

(Fig. 51), and a smaller, flawless, blue and salmon-pink crystal with similar inclusions.

Trilithionite-Polylithionite $KLi_{1.5-2}Al_{1-2.5}Si_{3-4}O_{10}F_2$

Trilithionite-polylithionite occurs in the Volodarsk pegmatites, but is rarely of specimen quality. The mineral forms drum-shaped small crystals in the quartz core near the contact with the blocky feldspar zone, and also cone-shaped inclusions in topaz.

Zinnwaldite series

Zinnwaldite occurs in the Volodarsk pegmatites, and although it is rarely of specimen quality it is a major constituent of the micas in the pegmatite. It occurs most commonly in the central part of the pegmatite field, in the chambers or sub-chambers of the pegmatites, i.e. the more evolved and fractionated areas. In the pockets, zinnwaldite occurs as brown, well-developed crystals associated with cleavelandite and quartz.

CONCLUSIONS

By 1996 the rich mineral specimen output from the former Soviet Union was diminishing and the supply of Ukrainian heliodor crystals had been nearly exhausted, but mining continued on a reduced scale. Open-pit mining was taking place in one pegmatite, yielding bi-colored topaz in late 2008 and the spring of 2009. Investigations

Figure 52. **Topaz crystal, 22 cm, from Volodarsk-Volynski. S. A. Dovgyi private museum, Kiev; Michael Leybov photo.**

Figure 53. **Pale blue topaz crystals, about 19 cm, from Volodarsk-Volynski. Museum of Precious and Decorative Stones collection; Michael Leybov photo.**

aimed at locating previously missed weathered pegmatite bodies in or under the 10 to 40 meters of kaolinized granite overburden continued for a while. But during the summer of 2009, only a little digging took place in the open pits, turning up some small topaz crystals for cutting. By August 2009 all mining in the district had ended.

The exhaustion and closing of such a rich and fascinating group of deposits is a sad development for mineral collectors. But the most important legacy from a scientific standpoint is the fact that the reworking of pockets in the last few years has been conducted carefully, with more documentation than ever before in the mines' history.

ACKNOWLEDGMENTS

We are grateful to director Vasiliy Mihaylovich Batuk, former director P. Minko, and former chief Geologist Dr. V. I. Panchenko of Volhyn Quartz Samotsvety for their hospitality during our first visit to the mine, and to Alexander Hmyz for his help on recent visits. Andrei Chrapowicki provided many interesting discussions in the 1980s. René Trieble provided information in 2009 regarding the first specimens he acquired in 1980–1987, as did Brad Van Scriver. Marco Amabili kindly provided information on discoveries, and James Elliott provided photos of specimens. Thanks also to Professor V. Gordyenko

Figure 54. **Museum of Precious and Decorative Stones in Volodarsk-Volynski. Michael Leybov photo.**

Figure 55. **L. L. Vlasyuk, Curator of the Museum of Precious and Decorative Stones in Volodarsk-Volynski. Michael Leybov photo.**

of St. Petersburg State University for discussions on the geology of the deposit and other pegmatites. And thanks to Prof. William B. "Skip" Simmons, who enthusiastically joined one of us (PL) for a month-long expedition to Transbaikalia, the Ural Mountains, and Volodarsk.

Our special thanks to Michael Leybov, publisher of *Mineralogical Almanac*, for permission to use numerous photos and illustrations, and to Peter Huber and Konstantin Buslovich for specimen photography.

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Table 1. **Minerals identified and confirmed from the Volyn pegmatites (after Pavlishin and Dovgyi, 2007; and Koshil *et al.*, 1991).**

Sulfides	
Arsenopyrite	FeAsS
Bornite	Cu_5FeS_4
Chalcopyrite	$CuFeS_2$
Galena	PbS
Marcasite	FeS_2
Molybdenite	MoS_2
Pyrite	FeS_2
Pyrrhotite	$Fe_{1-x}S$
Sphalerite	ZnS
Oxides and Hydroxides	
Anatase	TiO_2
Brookite	TiO_2
Cassiterite	SnO_2
Columbite-(Fe)	$Fe^{2+}Nb_2O_6$
Corundum	Al_2O_3
Goethite	α-$Fe^{3+}O(OH)$
Hematite	α-Fe_2O_3
Ilmenite	$Fe^{2+}TiO_3$
Ixiolite	$(Ta,Nb,Fe,Mn)O_2$
Magnetite	$Fe^{2+}Fe^{3+}_2O_4$
Rutile	TiO_2
Spinel	$MgAl_2O_4$
Uraninite	UO_2
Wolframite group	
Silicates	
Albite	$NaAlSi_3O_8$
Allanite-(Ce)	$CaCeFe^{2+}Al_2(Si_2O_7)(SiO_4)O(OH)$
Annite	$KFe^{2+}_3AlSi_3O_{10}(OH)_2$
Bertrandite	$Be_4Si_2O_7(OH)_2$
Beryl	$Be_3Al_2Si_6O_{18}$
Buddingtonite	$(NH_4)AlSi_3O_8$
Chamosite	$(Fe,Al,Mg)_6(Si,Al)_4O_{10}(OH)_8$
Cristobalite	SiO_2
Dickite	$Al_2Si_2O_5(OH)_4$
Dumortierite	$Al_7(BO_3)(SiO_4)_3O_3$
Epidote	$Ca_2Al_2(Fe^{3+},Al)Si_3O_{12}(OH)$
Euclase	$BeAlSiO_4(OH)$
Kaolinite	$Al_2Si_2O_5(OH)_4$
Kyanite	Al_2SiO_5
Trilithionite-Polylithionite	$KLi_{1.5-2}Al_{1-2.5}Si_{3-4}O_{10}F_2$
Microcline	$KAlSi_3O_8$
Montmorillonite	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$
Muscovite	$KAl_2\square Al_2Si_3O_{10}(OH)_2$
Natrolite	$Na_2[Al_2Si_3O_{10}] \cdot 2H_2O$
Opal	$SiO_2 \cdot nH2O$
Silicates *(continued)*	
Orthoclase	$KAlSi_3O_8$
Phenakite	Be_2SiO_4
Quartz	SiO_2
Spessartine	$Mn^{2+}_3Al_2(SiO_4)_3$
Spodumene	$LiAlSi_2O_6$
Staurolite	$(Fe,Mg,Zn)_{3-4}(Al,Fe)_{18}(Si,Al)_8O_{48}H_{2-4}$
Thorite	$(Th,U)SiO_4$
Titanite	$CaTiOSiO_4$
Topaz	$Al_2SiO_4(F,OH)_2$
Zircon	$ZrSiO_4$
Zoisite	$Ca_2Al_3Si_3O_{12}(OH)$
Phosphates	
Apatite-(CaF)	$Ca_5(PO_4)_3F$
Monazite-(Ce)	$(Ce,La,Nd)PO_4$
Rhabdophanite-(Ce)	$(Ce,La)PO_4 \cdot H_2O$
Vivianite	$Fe^{2+}_3(PO_4)_2 \cdot 8H_2O$
Xenotime-(Y)	YPO_4
Borate	
Teepleite	$Na_2B(OH)_4Cl$
Carbonates	
Bastnaesite-(Ce)	$(Ce,La)(CO_3)F$
Calcite	$CaCO_3$
Cerussite	$PbCO_3$
Parisite-(Ce)	$Ca(Ce,La)_2(CO_3)_3F_2$
Siderite	$Fe_{2+}CO_3$
Synchysite-(Ce)	$Ca(Ce,La)(CO_3)_2F$
Sulfates	
Anglesite	$PbSO_4$
Anhydrite	$CaSO_4$
Caracolite	$Na_3Pb_2(SO_4)_3Cl$
Gypsum	$CaSO_4 \cdot nH_2O$
Fluorides	
Cryolite	Na_3AlF_6
Elpasolite	K_2NaAlF_6
Fluocerite-(Ce)	$(Ce,La)F_3$
Fluorite	CaF_2
Chlorides	
Halite	NaCl
Rokühnite	$Fe^{2+}Cl_2 \cdot 2H_2O$
Sylvite	KCl
Teepleite	$Na_2B(OH)_4Cl$

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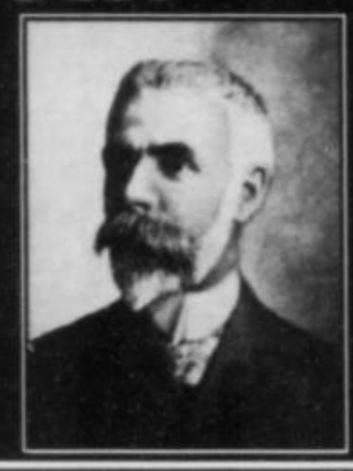

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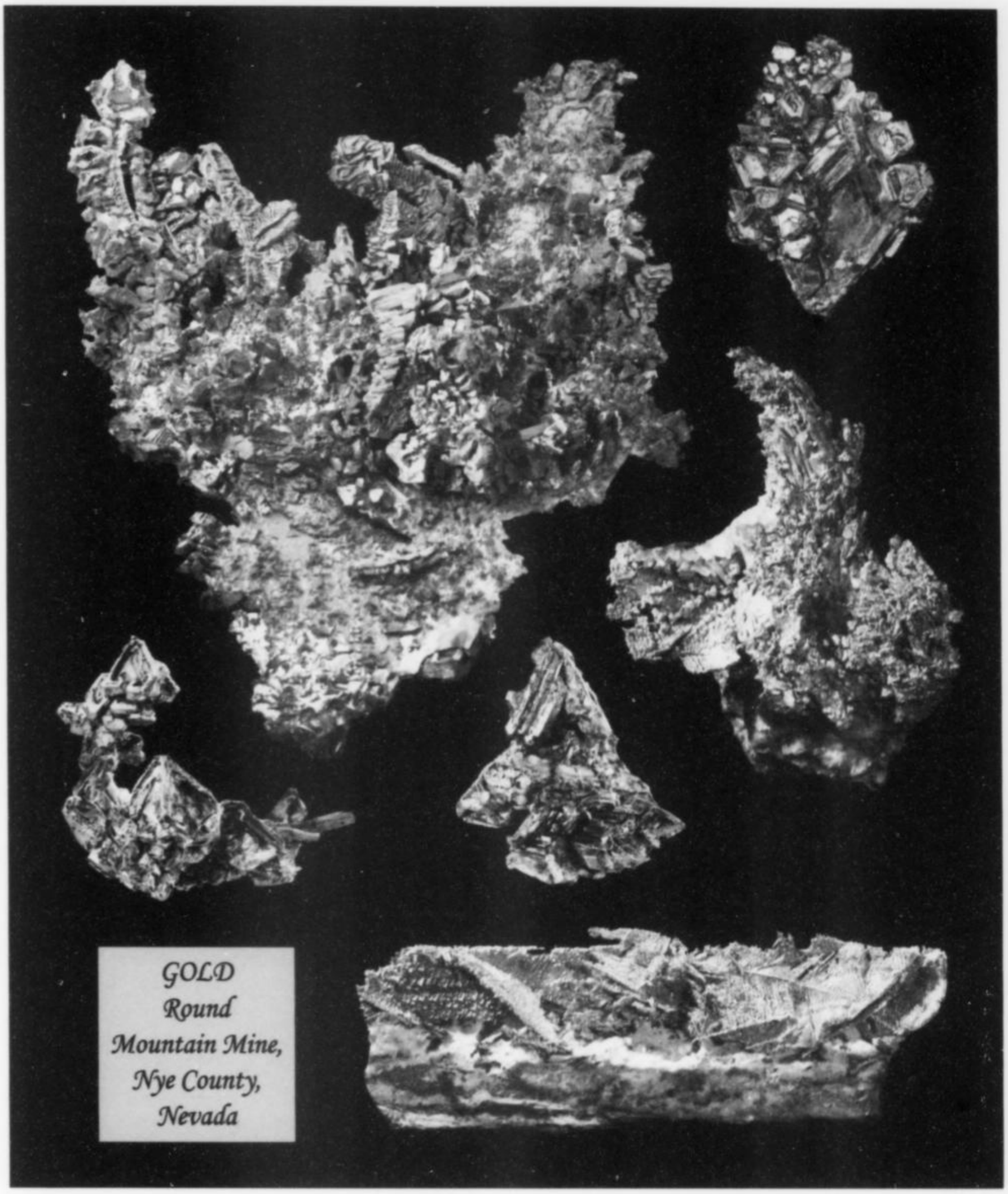

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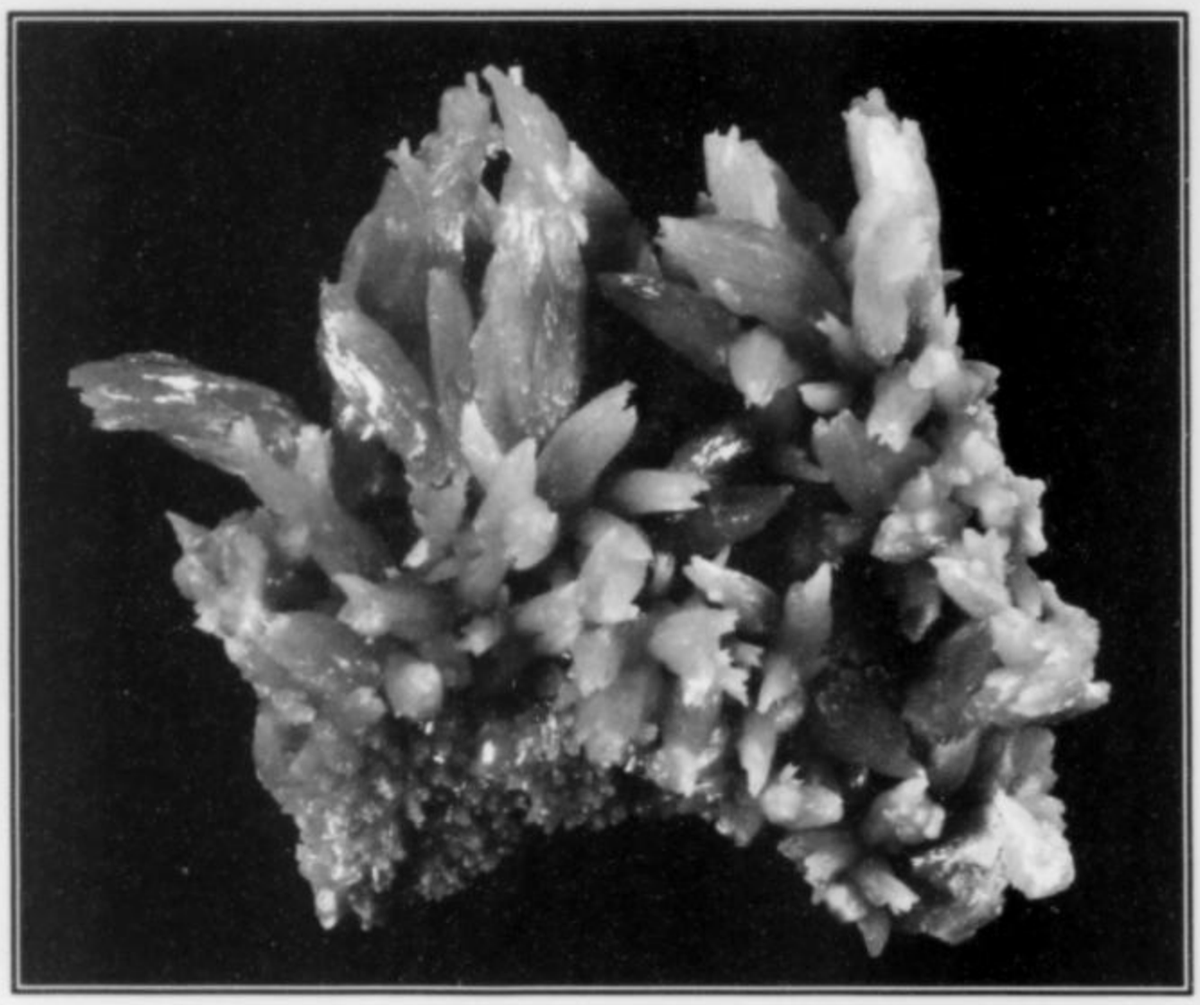

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A huge, transparent Sicilian Sulfur crystal group, 6 inches across, from the Bement Collection at the American Museum of Natural History. Gift of J.P. Morgan in 1900.

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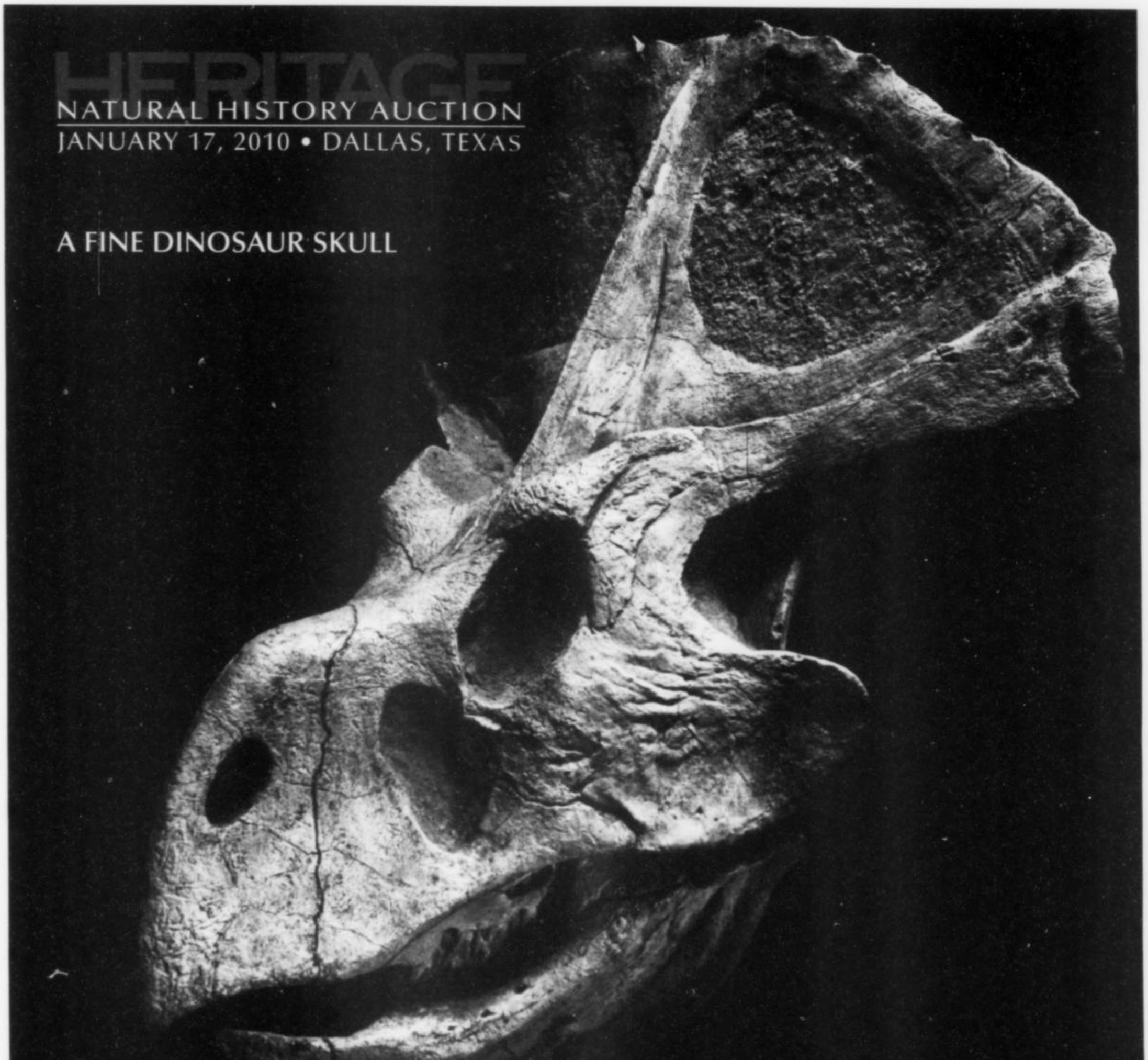

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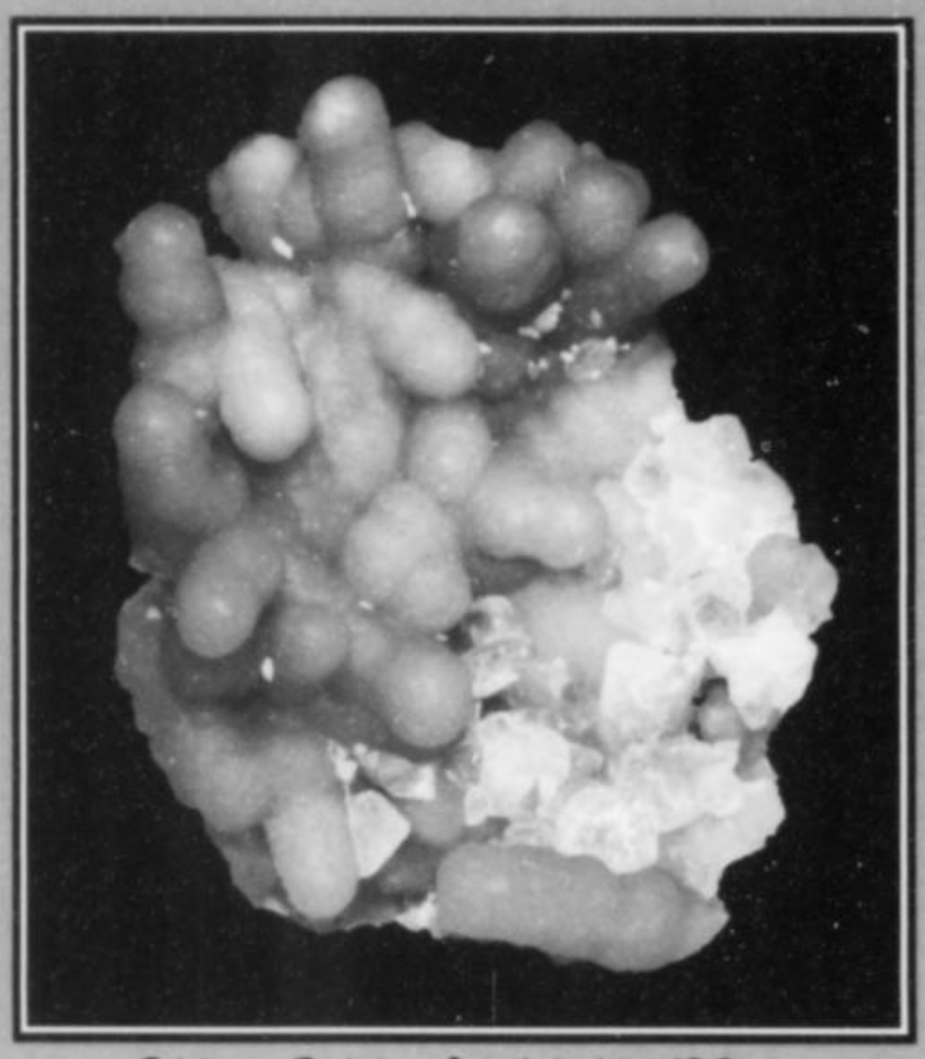
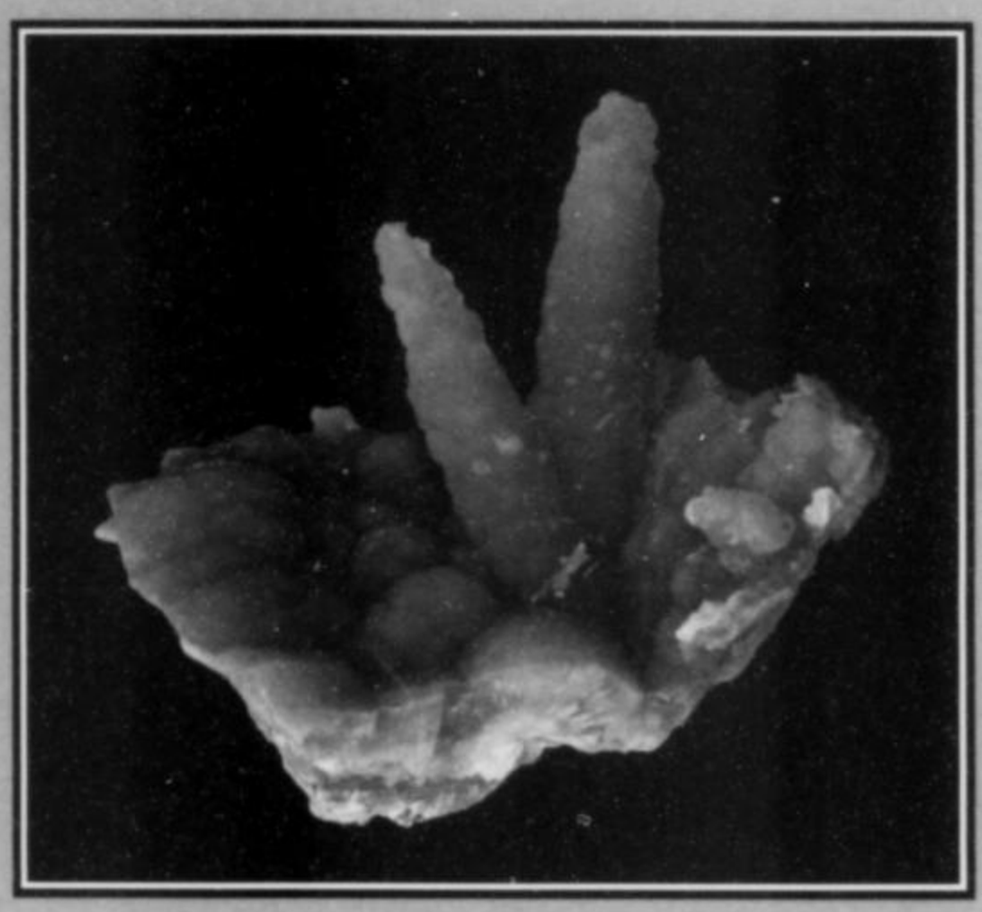
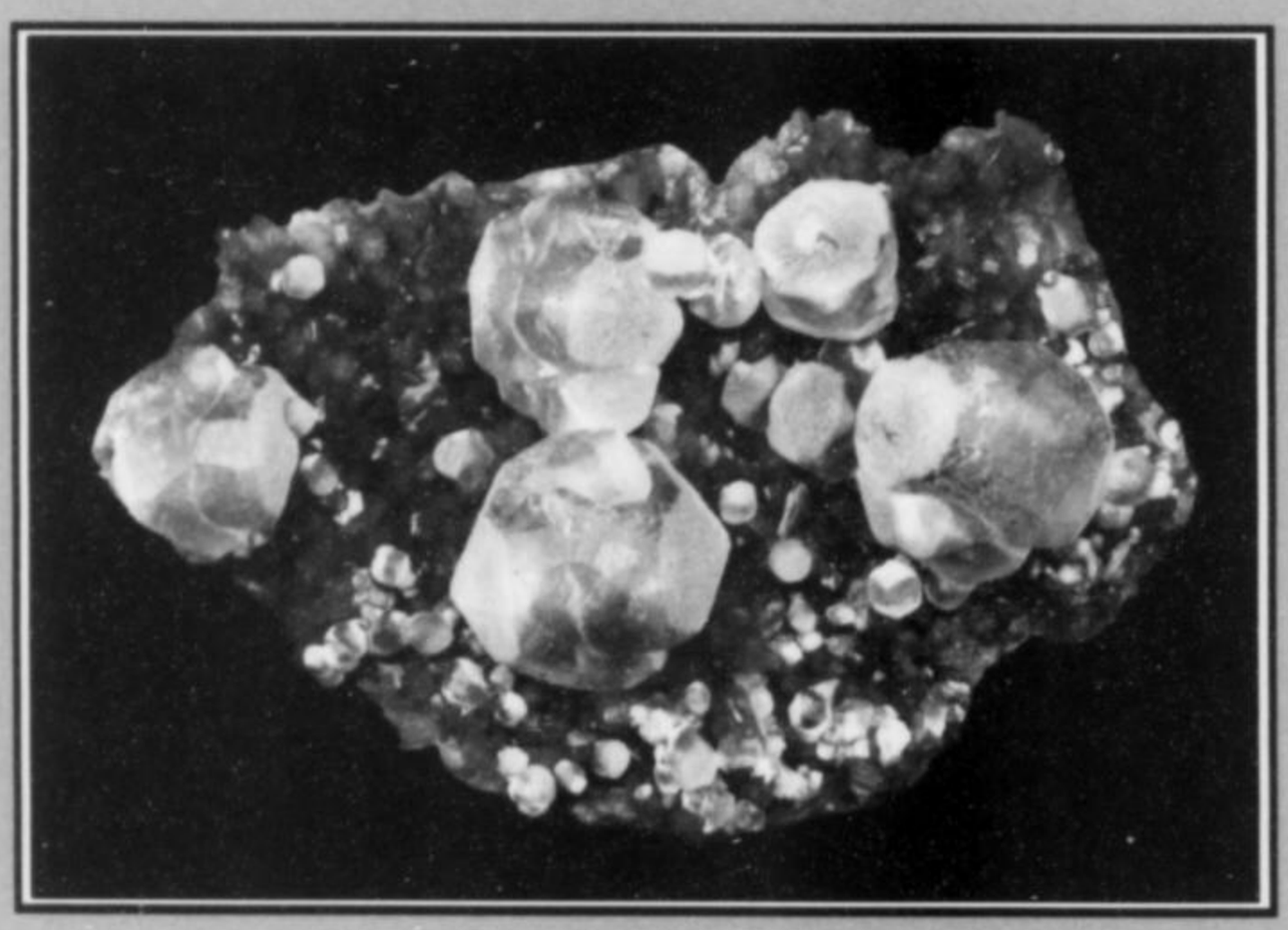


Calcite on Prehnite after Anhydrite, 12.2 cm
McBride Avenue Pumping Station, West Paterson



Prehnite on Pectolite after Anhydrite, 8.4 cm
Millington Quarry, Bernards Township



Calcite on Stilbite, 6.8 cm,
Trap Rock Industries Moore's Station Quarry, Hopewell

Frank A. Imbriacco III

1 Fox Hill Road
Edison, New Jersey 08820
732-548-1796 • fai122@aol.com

The Braen Quarry

Haledon, Passaic County, New Jersey

Frank A. Imbriacco III
1 Fox Hill Road
Edison, New Jersey 08820
fai122@aol.com

New Jersey's Watchung Basalts have been yielding fine zeolites and associated minerals since the late 1800s. The Braen quarry produced attractive specimens during 1999–2003, including the state's finest examples of stellerite. Unfortunately the quarry is now closed to collecting.

INTRODUCTION

The Braen quarry in Haledon, Passaic County, New Jersey has been supplying crushed stone products since 1920. It is presently owned by Braen Stone Industries Inc., which acquired the operation in 1948.

During the quarry's first 78 years of existence, very few collector-quality specimens were gathered by mineral collectors. This was clearly evident from the scarcity of Braen minerals in local trap rock collections. In 1999, word began to spread of a highly mineralized zone having been exposed in the lowest benches of the pit. Within several months of the discovery, material from this section started appearing at area mineral shows.

Around 2000, Kurt Hennig, a New Jersey field collector, decided to visit the quarry office in an attempt to obtain permission to search for minerals. After speaking with management, he was granted access to the property under certain conditions. Collecting was to occur during normal business hours, and the wearing of the proper safety equipment was required to protect against injury. Over the next several years, Kurt and his friend Wes Conahay visited the operation frequently, and were often joined by one of the quarry owners in the hunt for specimens. At times, quarry machinery was utilized to expose mineralized areas and facilitate collecting. Management continued to gather specimen-grade material and set it aside, even when Hennig and Conahay were unable to make the trip. Thousands of specimens entered the mineral market from this prolific zone. Unfortunately, in 2003 specimen production was reduced to a trickle when the company decided that the liabilities associated with collecting were too great.

GEOLOGY

The Braen quarry is situated within the Newark Basin, a half-graben which formed during the late Triassic and early Jurassic periods as the supercontinent of Pangaea began to divide. The basin is approximately 190 km long and 50 km wide, and is filled with sedimentary and volcanic rocks having an estimated thickness of 6.8 km (Schlische, 1992; Olsen *et al.*, 1996). It extends from southern New York through northeastern and central New Jersey and into southeastern Pennsylvania. In its northern portion the Newark Basin is bounded to the northwest by the Ramapo fault, which separates Precambrian rocks from the late Triassic and early Jurassic deposits inside the basin. At its eastern edge the basin is truncated by an erosional surface. The contact between the basal Stockton Formation and the underlying metamorphic rocks of the Piedmont Province is mostly obscured by the Hudson River and the glacial deposits that fill its valley. From Staten Island southwestward, Cretaceous

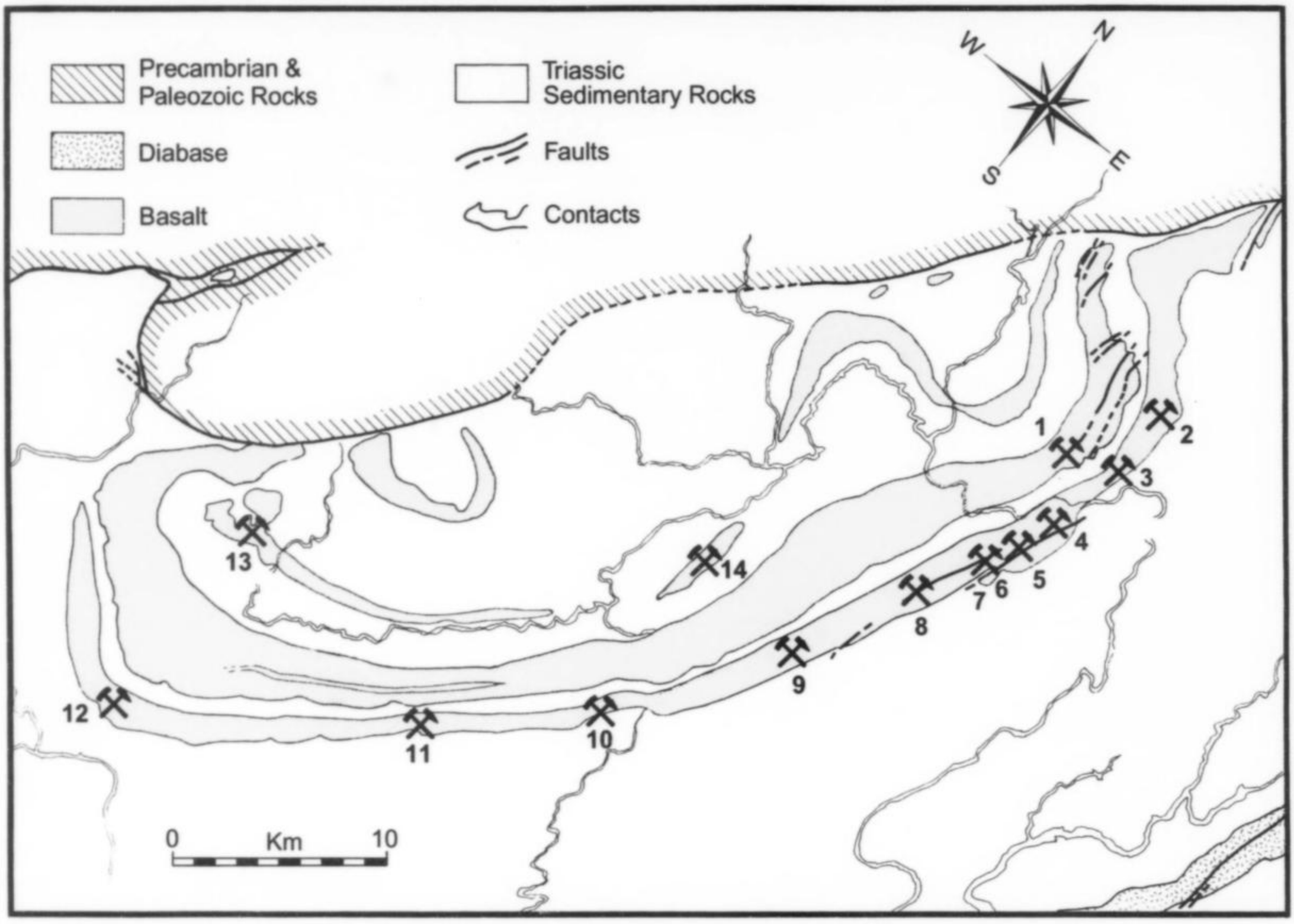


Figure 1. **Location map showing the Braen quarry and other important New Jersey trap rock localities in relation to the Watchung Basalts (modified after Mason, 1960).**

(1) Braen quarry, Haledon
(2) Braen quarry, Hawthorne
(3) Prospect Park quarry, Prospect Park
(4) Union Building and Construction quarry, Clifton & West Paterson
(5) New Street quarries, Paterson
(6) Great Notch quarry, Little Falls
(7) Houdaille quarry, Little Falls
(8) McDowell's quarry, Upper Montclair
(9) Eagle Rock quarry, West Orange
(10) Summit quarry, Springfield
(11) Weldon quarry, Watchung
(12) Chimney Rock quarry, Bridgewater
(13) Millington quarry, Bernards Township
(14) Riker Hill, Livingston

and Tertiary sediments overlap the Newark Basin's southeastern and southern margins (Schlische 1992; Cummings, personal communication, 2007).

Three basalt flows, each separated by sedimentary deposits, lie within the upper third of the stratigraphic section of the Newark Basin. From the oldest to the youngest they are the Orange Mountain Basalt, the Preakness Mountain Basalt and the Hook Mountain Basalt. Jointly the three volcanic ridges are known as the Watchung Mountains. In the Haledon area the basalt flows and the sedimentary beds dip northwest at about 9–10 degrees (Volkert, 2006).

The Braen quarry is within the northern part of the Preakness Basalt outcrop area. The Preakness Basalt is the thickest extrusive body in the Newark Basin, reaching an estimated thickness of 300 meters (Olsen, 1980). Approximately 106 meters of the lower flow and the uppermost beds of the underlying Feltville Formation are exposed within the quarry. The lowermost 8 meters of the basalt contain four types of mineralized structures: (1) pillow lava, (2) scoria (3) amygdaloidal basalt and (4) veins.

The occurrence of pillow basalts (caused by the eruption of basaltic lava into a body of water) seems to have been much more isolated in the basal Preakness Basalt than in the Orange Mountain Basalt and has rarely been reported in the literature. At the basal contact of the Preakness Basalt, exposed in the quarry, the development of pillows is not continuous. In some places, massive, columnar basalt, which is capped by scoria, rests on the underlying Feltville sediments and is flanked laterally by accumulations of pillow lava. The basal contact at Braen is relatively flat, without any down-dropped areas or other indications of a pre-existing pond. This suggests that two separate pulses of lava arrived in rapid succession. The initial tongues of lava that invaded the area altered the local drainage, leading to the formation of ponds. It is in these ponds that the next surge of lava was able to form pillows. The columnar basalt resting directly on the sediments may represent one of the initial tongues (Cummings, personal communication, 2009).

The majority of minerals at the Braen quarry are located within the basal unit of the lower flow. Some mineralization also occurs in the basalt above this horizon, in veins that transect the flows and in vertically bulging, dome-like regions of amygdaloidal basalt, referred to as diapirs by Laskowich and Puffer (1990). Thus far

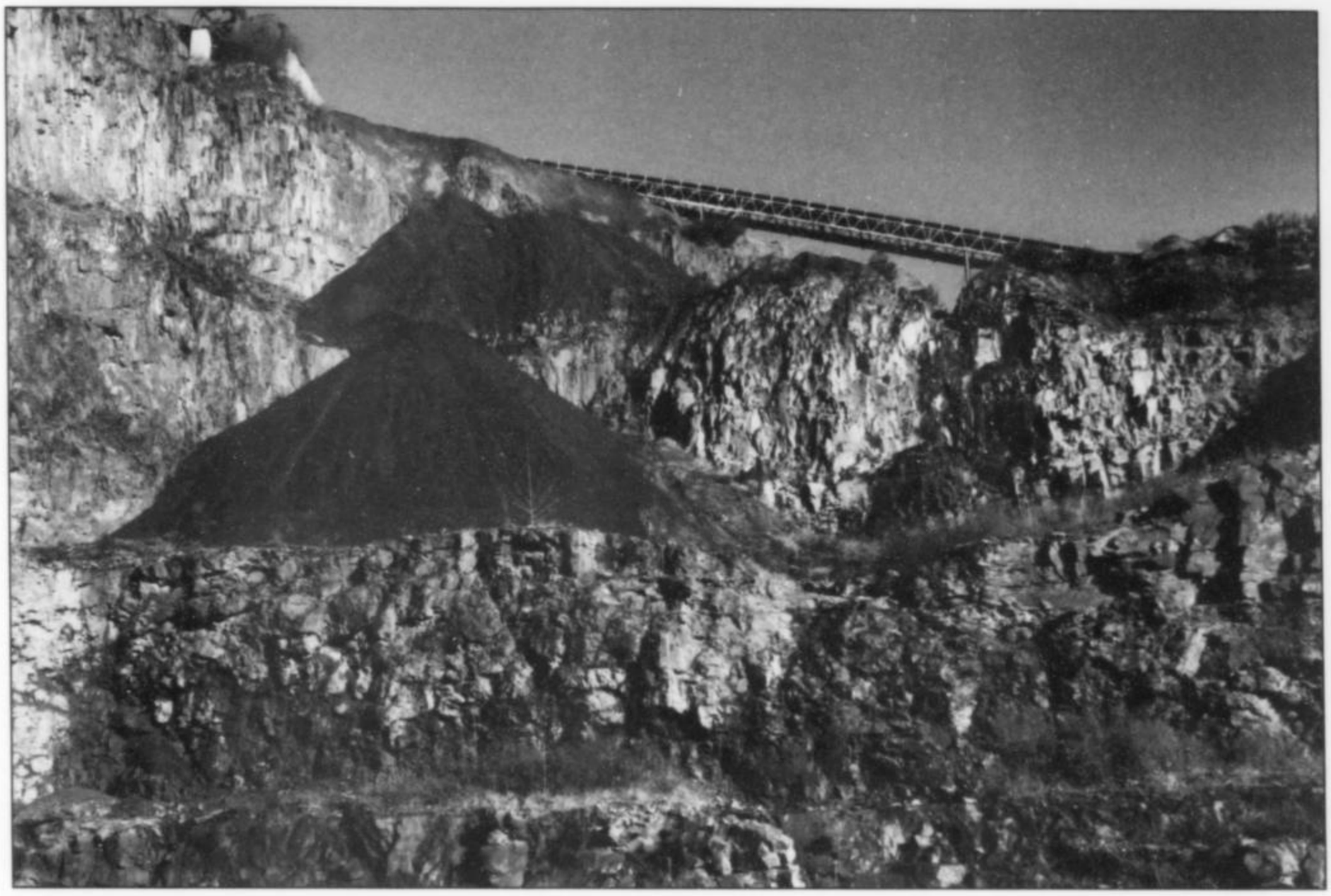


Figure 2. **Massive basalt overlying scoria-capped pillow basalts which rest atop the Feltville sediments as exposed in the Braen quarry. Frank Imbriacco photo.**

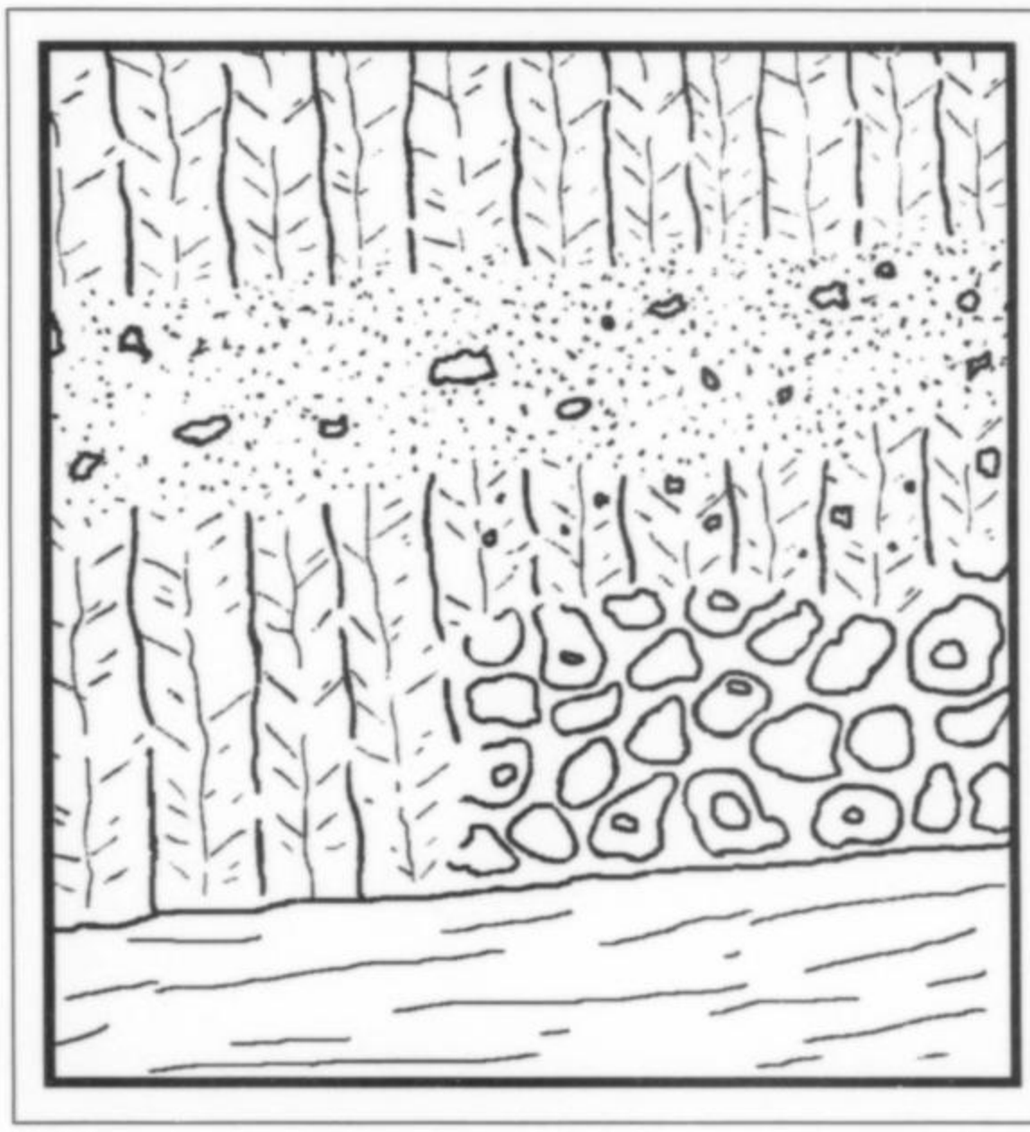


Figure 3. **Mineralized basal zone at the Braen quarry.**

only one diapir has been identified, approximately 9.1 meters high and 7.6 meters wide (Laskowich, personal communication, 2007). Prehnite, calcite and sulfides were the main constituents found within the irregularly shaped vugs of this structure.

Within the mineral-bearing zone at the base of the Preakness, the pillow basalt, averaging 4 meters in thickness, is the most productive of the mineralized structures. Voids generally measure around 18 cm, while the largest can be 1.5 meters across or greater. Quartz, datolite, calcite, anhydrite, hematite, goethite and pyrite are the primary components deposited in these openings. A flow-top amygdaloid of varying thickness rests atop the pillows. Sporadic pockets, between 10 and 60 cm, commonly lined with datolite or prehnite followed by zeolites, calcite and sulfides, are distributed unevenly within this layer. A scoriaceous cap 2.4 to 3.1 meters thick overlies the amygdaloid and includes numerous breccia cavities, some as large as 1.8 meters. These commonly contain well-crystallized zeolites, occasionally in association with datolite, prehnite, calcite and sulfides.

ORIGIN OF SECONDARY MINERALS

The secondary minerals found in the Braen quarry are the result of the hydrothermal alteration of the Preakness Basalt. The

hydrothermal fluids are believed to be saline brines driven out of the lacustrine strata which enclose the Preakness Formation by the increasing depth of burial and the accompanying compaction within the Newark Basin.

The Preakness Formation probably underwent a period of burial and metamorphism prior to the main stage of secondary mineral deposition. In the low-temperature environment, minor alteration of the basalt occurred, producing clay and perhaps zeolites on the walls of the openings in the basalt. The principal phase of mineralization did not begin until some 15 to 20 million years after the basalt flow was extruded and buried. Late in the basin's history, sometime during the early to middle Jurassic period, there was a shift from crustal extension to shortening. This event was accompanied by extensive fracturing which allowed for a period of vigorous fluid circulation and high heat flow (Schlische *et al.*, 2003). The saline formation brines flowed upward into the basal layer of the porous and permeable basalt flow. The presence of pumpellyite and minor epidote suggests that temperatures in the Preakness Basalt were elevated for a brief time to just over 200°C (Kristmannsdottir, 1979; Seki, 1972). As the temperatures rose, the host rock was attacked, broken down and partially replaced.

The formation brines in the sediments of the Newark Basin contained calcium and sodium sulfate. When these sulfate-rich fluids reacted with the basaltic glass and the calcium-rich clays and zeolites that resulted from burial metamorphism, the released calcium and silicon dioxide initially provided for the deposition of anhydrite, accompanied or immediately followed by chalcedony and quartz. Throughout the pillow lava, quartz coated a large percentage of the anhydrite that had developed. Although glauberite normally forms in such a depositional environment, no indications of the mineral have been found at the Braen quarry.

As temperatures increased, alteration of the permeable horizons within the basalt intensified. Not only the glassy part, but the basalt itself, was partially to totally replaced by a very fine-grained mineral assemblage that included chlorite, pumpellyite and epidote. In the permeable and glass-rich regions of the basalt there was an enhanced mix of elements that included components derived from the country rock and introduced by the hydrothermal fluid. In the higher-temperature environment quartz deposition declined markedly as other elements, mainly calcium, aluminum and boron, united with silica to form prehnite, datolite and other silicates. Like quartz, prehnite and datolite also crystallized over anhydrite.

Sulfides also formed during the time of peak temperatures within the Preakness Basalt. Among the sulfides that occur at the Braen quarry are pyrite, galena, wurtzite and sphalerite. The presence of these minerals distinguishes the rocks of the Braen quarry from those in the trap rock quarries within the Orange Mountain Basalt, where pyrite and zinc sulfides are either rare or absent. Their presence suggests that the mineralizing fluid that invaded the basalt at the Braen quarry was more chemically reduced than those responsible for mineralization at most of the region's better known sites. This subtle chemical difference may be due to the influence of the Feltville sediments that underlie the Preakness Basalt, that separate it from Orange Mountain Basalt, and that include a prominent black unit known as the Washington Valley Member. The Newark Basin brines, which migrated upward through this layer and into the Preakness Formation, may have caused a more reducing environment to occur locally, allowing for the deposition of pyrite and the zinc sulfides.

As the crystallization of prehnite and datolite began to wane, anhydrite began to dissolve. It was preserved only where permeability had been reduced to a very low level. The dissolution of anhydrite left the hollow cavities or molds in the quartz, datolite and prehnite that are such a well known feature of mineral specimens from the entire region.

The taking up of silica by later silicates is illustrated by the zeolites found at Braen. Their formation reflects a period of waning temperatures, reaction rates and, perhaps, fluid salinity. The common zeolites, including heulandite and stilbite, are calcium-dominated minerals that are fairly high in silica. Those that are lower in silica, including natrolite and analcime, are sodium-rich minerals that tend to develop in areas of higher fluid flux where more sediment-derived sodium was available.

Calcite precipitated throughout the secondary mineralization in the Preakness Basalt. The mineralizing fluids were in chemical equilibrium with the calcite-containing sediments of the basin. Through most of the paragenetic sequence calcite was locally stable relative to other minerals. At the end of the depositional event, with low temperatures and a thoroughly altered host rock, calcite was dominant among the minerals still being deposited.

MINERALS

The following is a compilation of all the validated species collected at the Braen quarry as of January 1, 2009.

Albite $NaAlSi_3O_8$

Albite is found as elongated microscopic blades on scoriaceous basalt. Albite has also been seen as pseudomorphs after natrolite crystals.

Analcime $NaAlSi_2O_6 \cdot H_2O$

Analcime is a rare zeolite at the Braen quarry. Crystals up to 1.8 cm are found as isolated, opaque white trapezohedrons inside breccia cavities.

Anhydrite $CaSO_4$

Anhydrite forms as blue crystal groups up to 14 cm in quartz and datolite pockets in the pillow basalt. A number of anhydrite specimens have been partially altered to gypsum. Rectangular crystal cavities after anhydrite are often found in quartz, datolite and cal-

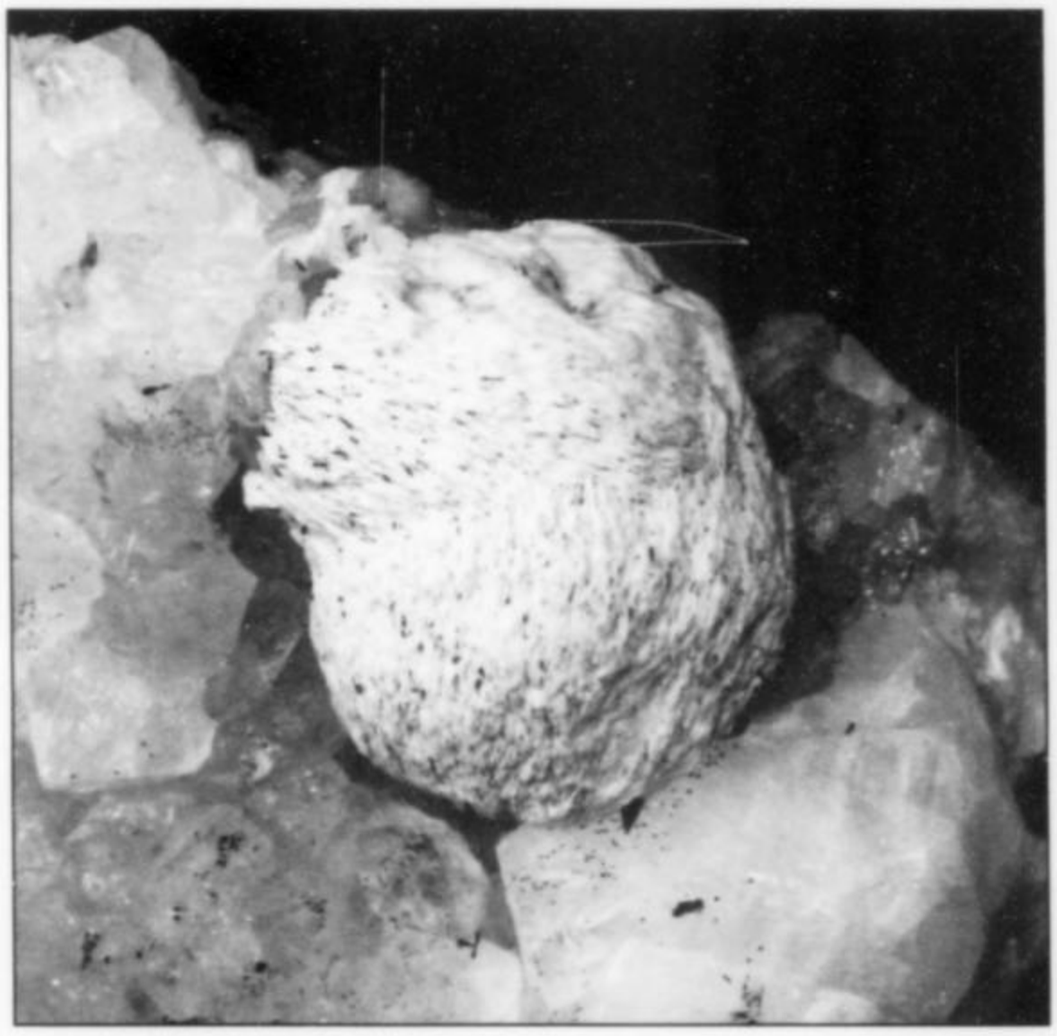


Figure 4. **Barite in a spherical growth, 1.7 cm, on quartz and calcite, from the Braen quarry. Kurt Hennig collection; Frank Imbriacco photo.**

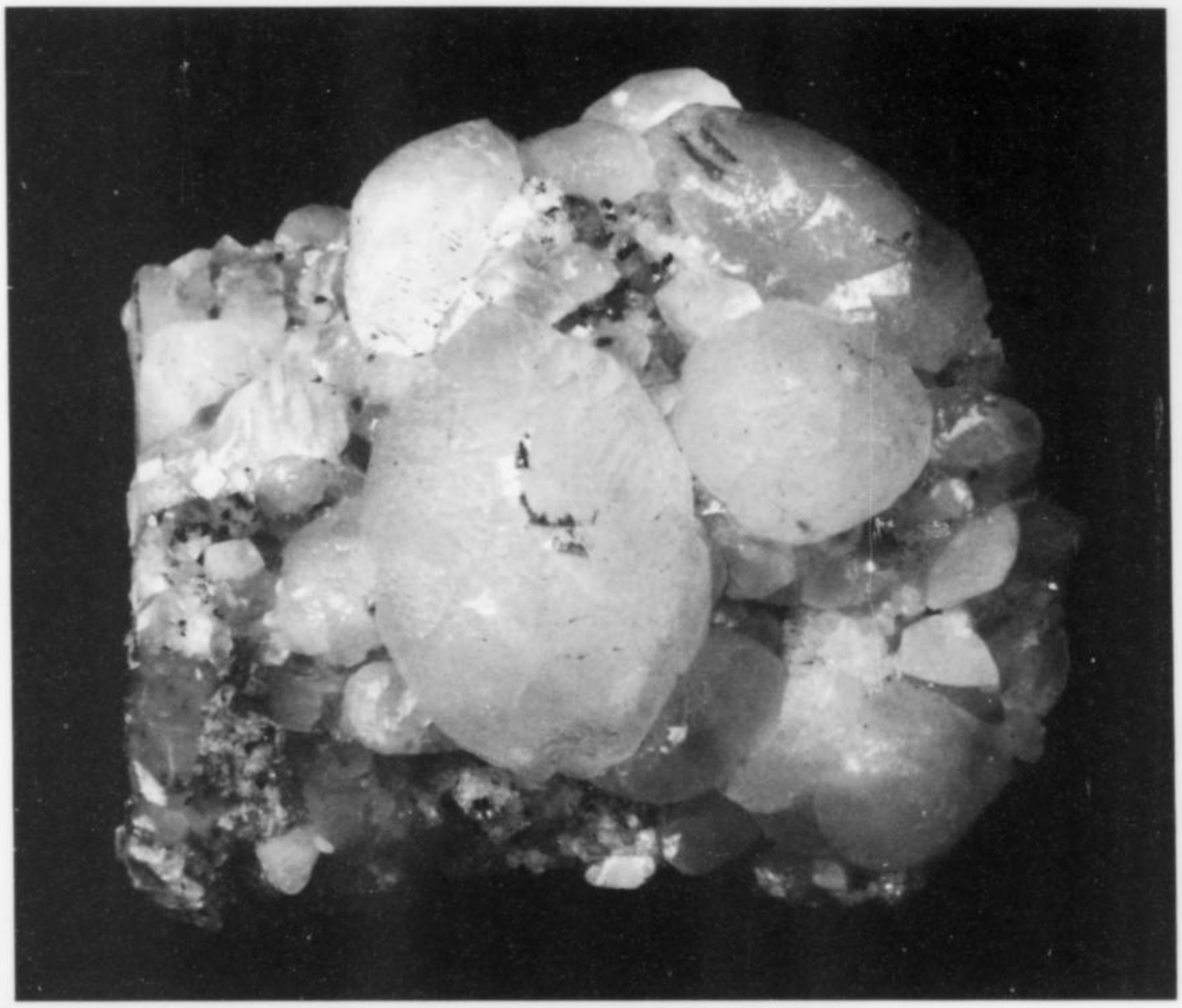
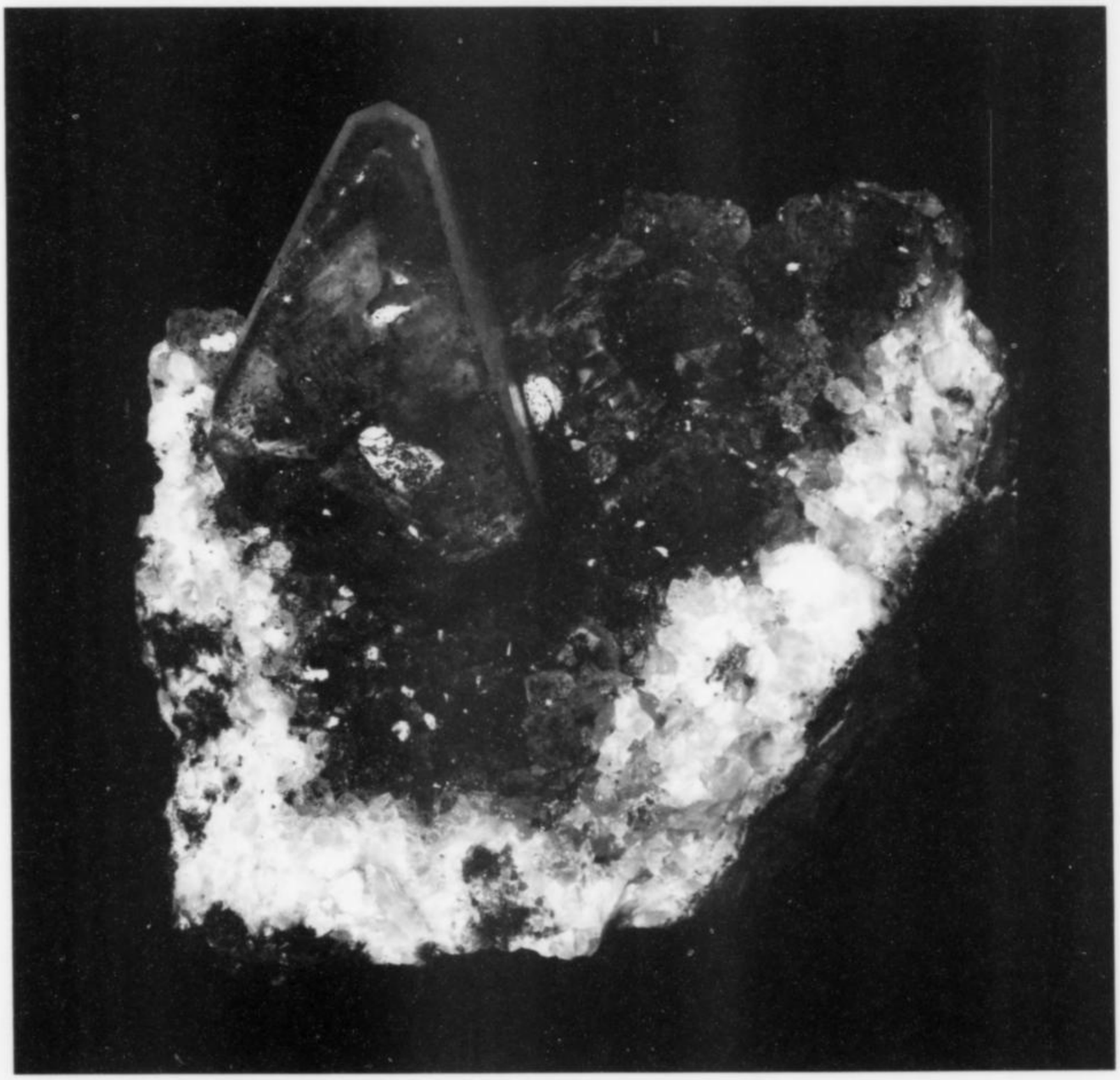


Figure 5. **Calcite crystals with minor hematite, 6.9 cm, from the Braen quarry. Eric Stanchich collection; Frank Imbriacco photo.**

Figure 6. **Calcite scalenohedron, 5.5 cm, on quartz with a sprinkling of hematite microcrystals, from the Braen quarry. Brad Plotkin collection; Frank Imbriacco photo.**



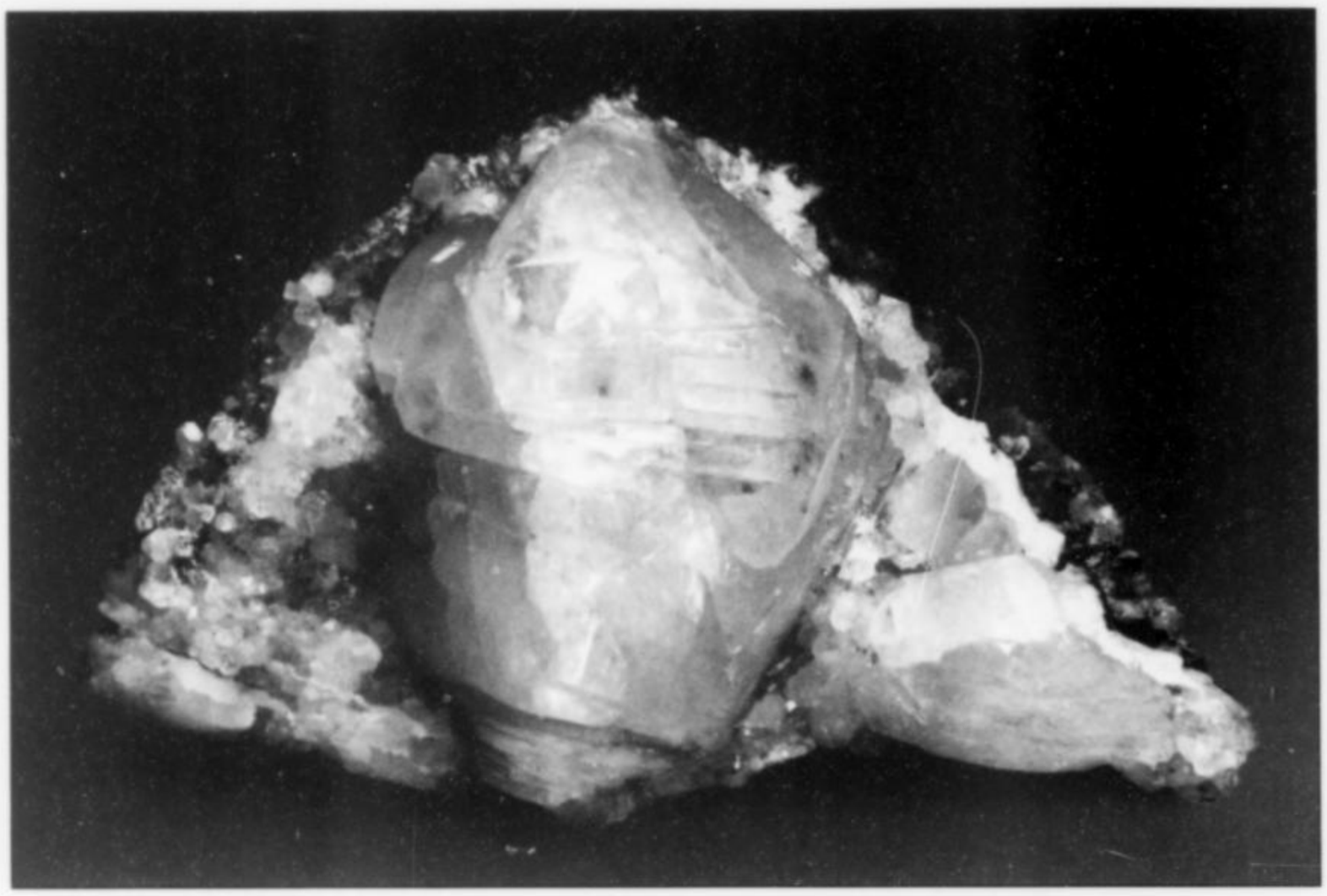


Figure 7. **Calcite pseudomorph after anhydrite, 5.3 cm, on drusy quartz, from the Braen quarry. Steve Huber collection; Frank Imbriacco photo.**

cite. None of New Jersey's former or active trap rock quarries has produced more specimens of anhydrite than the Braen quarry.

Apophyllite-(KF) $KCa_4Si_8O_{20}(F,OH)\cdot 8H_2O$

Apophyllite-(KF) (formerly known as fluorapophyllite) is relatively uncommon at the Braen quarry compared to most other New Jersey basalt quarries. It is collected as isolated crystals on datolite, prehnite or calcite, or directly attached to the walls of breccia cavities. The largest crystal measures 1.8 cm and exhibits a prismatic habit with dipyramidal modifications.

Barite $BaSO_4$

Barite occurs in the quartz-lined openings in the pillow basalt as isolated white crystals and bladed spherical rosettes up to 2 cm. Although small, the crystals and rosettes make for attractive specimens when resting on smoky quartz and amethyst.

Calcite $CaCO_3$

Calcite is ubiquitous in the mineralized areas at the Braen quarry. It occurs in a wide variety of habits, but the scalenohedron and rhombohedron are the most common forms. Colors range from white to golden brown to a pink color caused by hematite on or inside the crystals. Crystals up to 12 cm are known, although most are much smaller. Many specimens display rectangular molds after anhydrite.

Chabazite $Ca(Al_2Si_4)O_{12}\cdot 6H_2O$

Only a few specimens of chabazite are known from the Braen quarry, the largest observed crystal measuring 1 cm. The chabazite crystals are pseudorhombohedral in habit, and very pale pink, white or colorless.

Chalcopyrite CuFeS2

Chalcopyrite is found throughout most of the mineral horizons at the Braen quarry as brassy sphenoidal crystals ranging in size from 1 to 12 mm. Crystals are typically associated with other sulfides, making for showy specimens.

Chamosite $(Fe^{2+},Mg)_5Al(OH)_8AlSi_3O_{10}$

Chamosite forms as platy dark green to black microcrystals inside breccia cavities. This member of the chlorite group has also

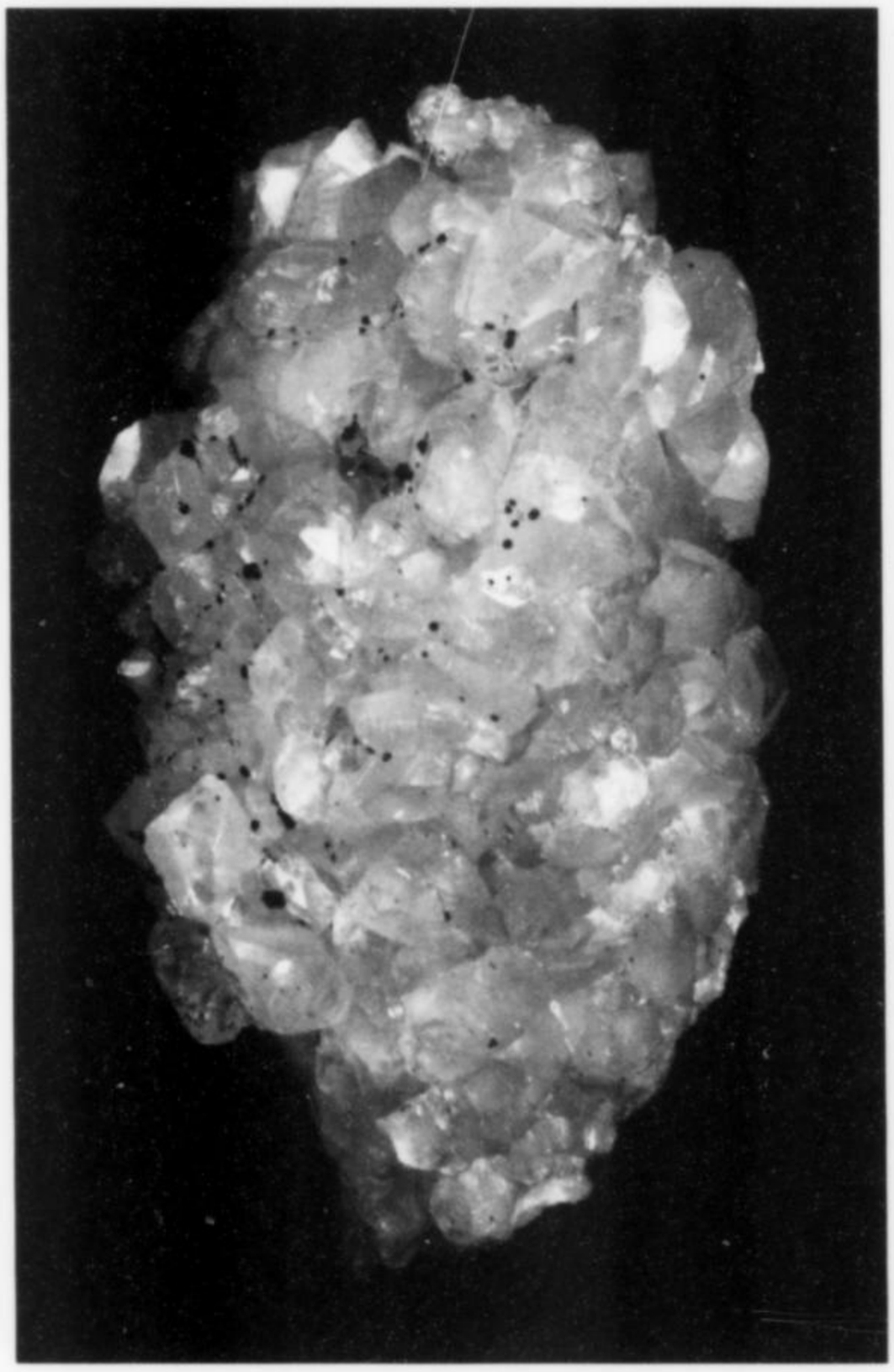


Figure 8. **Datolite crystal cluster, 8.5 cm, with minor hematite, from the Braen quarry. Kurt Hennig collection; Frank Imbriacco photo.**

Figure 9. **Rare galena crystal, 4 mm, on calcite with pyrite and chalcopyrite, from the Braen quarry. Brad Plotkin collection; Frank Imbriacco photo.**

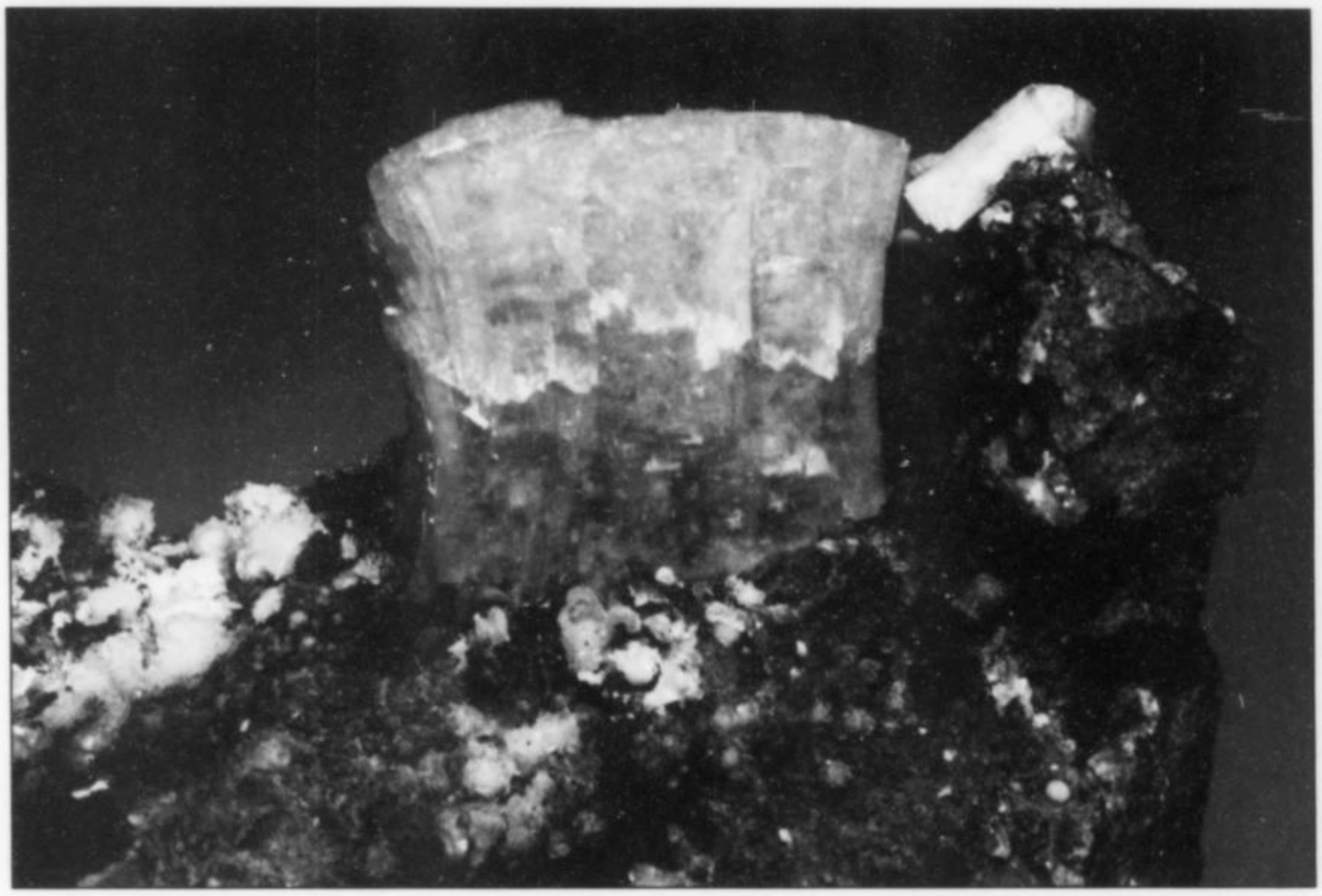


Figure 10. **Heulandite crystal, 2.7 cm, with prehnite, from the Braen quarry. Private collection; Frank Imbriacco photo.**

been collected as earthy brown pseudomorphs after analcime and natrolite. Positive identification was made by chemical analysis (B. Plotkin, personal communication 2007).

Datolite $Ca_2B_2Si_2O_8(OH)_2$

After calcite, datolite is the most common mineral at the Braen quarry. Nearly all datolite specimens are found as drusy plates of whitish to pale green crystals up to 1.3 cm completely lining cavities. Prehnite, apophyllite, calcite, hematite, heulandite and sulfides are known to form on the crystal faces. Datolite epimorphs after anhydrite are often found within crystal aggregates of datolite. Datolite has crystallized in all of the quarry's mineralized areas except in the veins.

Epidote $Ca_2(Al,Fe)_3Si_3O_{12}(OH)$

Microscopic brownish green epidote crystals have been noted from a small vesicle containing pumpellyite in scoria. The tabular crystals, several of which are twinned, have been identified by their crystal morphology and by chemical analysis (B. Plotkin, personal communication 2007).

Galena PbS

Galena is probably the rarest sulfide found in the Braen quarry. It forms sharp cubes up to 4 mm associated with calcite, datolite and other sulfides.

Goethite α-$Fe^{3+}O(OH)$

Acicular red and black goethite microcrystals are frequently found on or included in calcite and quartz within the pillow basalts and in the vesicular basalt cavities of the scoria.

Gypsum $CaSO_4 \cdot 2H_2O$

Transparent gypsum crystals formed as a result of the hydration of anhydrite. Free-standing transparent crystal groups and large crystallized masses are found in the pillow formation on quartz and datolite. Gypsum commonly includes sections which are partially altered to thaumasite. Microcrystals are also found in tiny vesicles of the scoria.

Hematite Fe_2O_3

Hematite occurs in the pillow basalt as 1 to 7-mm black to red platy crystals perched on or included in quartz and calcite; these microcrystals can impart a reddish hue to other minerals.

Hemimorphite $Zn_4(OH)_2Si_2O_7 \cdot H_2O$

Minute yellowish brown hemimorphite overgrowths viewed at 800X magnification have been found on sphalerite in a vesicle containing calcite and pumpellyite. Identification is based on the morphology and on chemical analysis (B. Plotkin, personal communication 2007).

Heulandite $(Na,Ca)_{2-3}Al_3(Al,Si)_2Si_{13}O_{36} \cdot 12H_2O$

Heulandite is found commonly in the breccia cavities of the scoriaceous basalt. It is usually found as pearly coffin-shaped crystals in association with stilbite. The largest crystal found to date measures 2.7 cm, and sits isolated on a vesicular matrix. However,

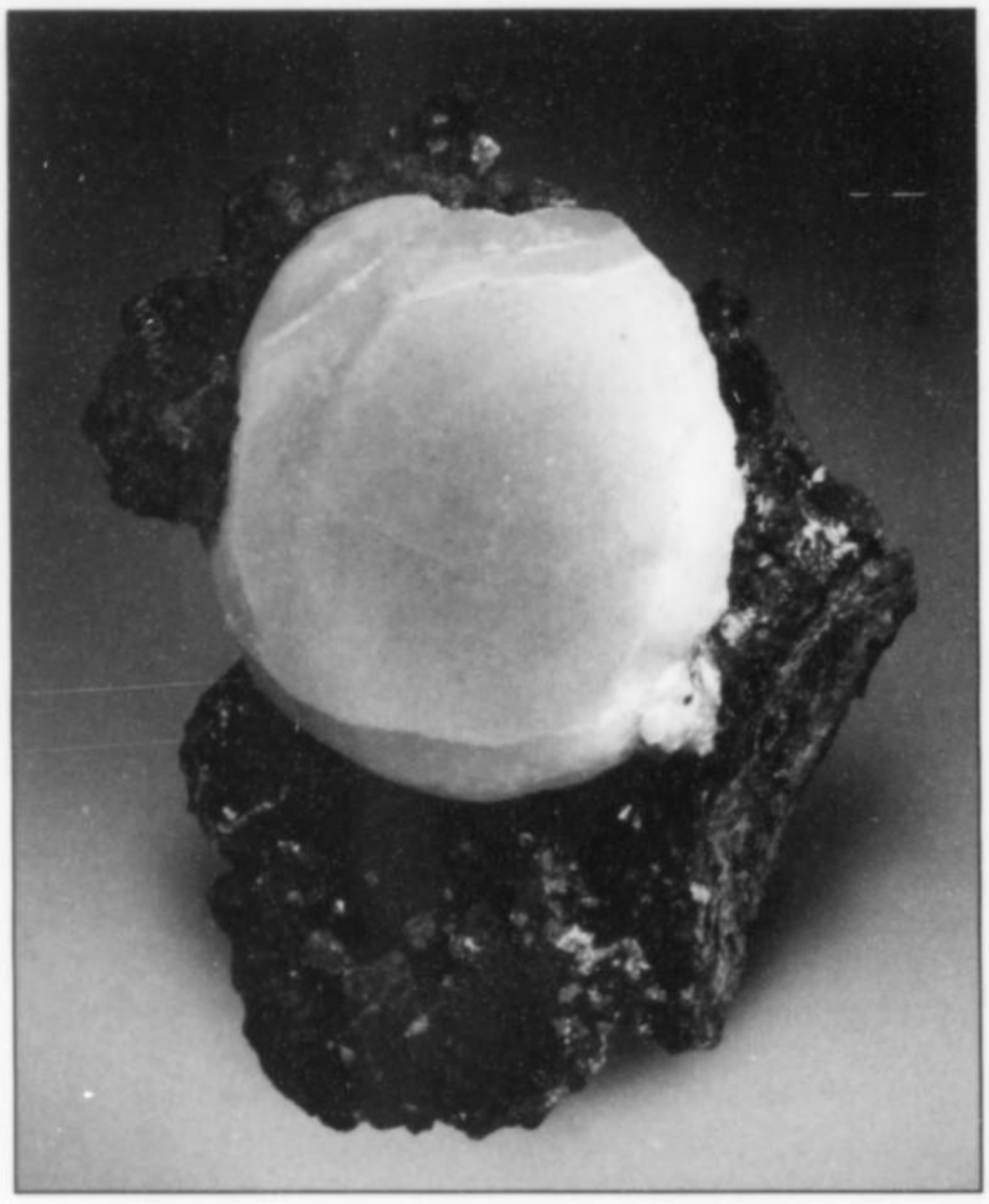


Figure 11. **Prehnite sphere, 2.5 cm, on scoriaceous basalt, from the Braen quarry. Frank Imbriacco collection and photo.**

most crystals are approximately 1 cm and are colored white, golden or honey-brown.

Laumontite $Ca(Al_2Si_4)O_{12}\cdot 4H_2O$

Laumontite is the rarest zeolite to be identified from the quarry. The only known specimen, found in a natrolite vein, shows 4 to 5-mm white prismatic crystals on chabazite.

Mesolite $Na_2Ca_2(Al_6Si_9)O_{30}\cdot 8H_2O$

Clusters of mesolite microcrystals are often found as linings within the smallest vesicles of the scoriaceous basalt. Identification is based on the index of refraction (B. Plotkin, personal communication 2007).

Natrolite $Na_2(Al_2Si_3)O_{10}\cdot 2H_2O$

Natrolite is another rare Braen quarry zeolite often found in seams which transect the columnar basalt, and in breccia pockets

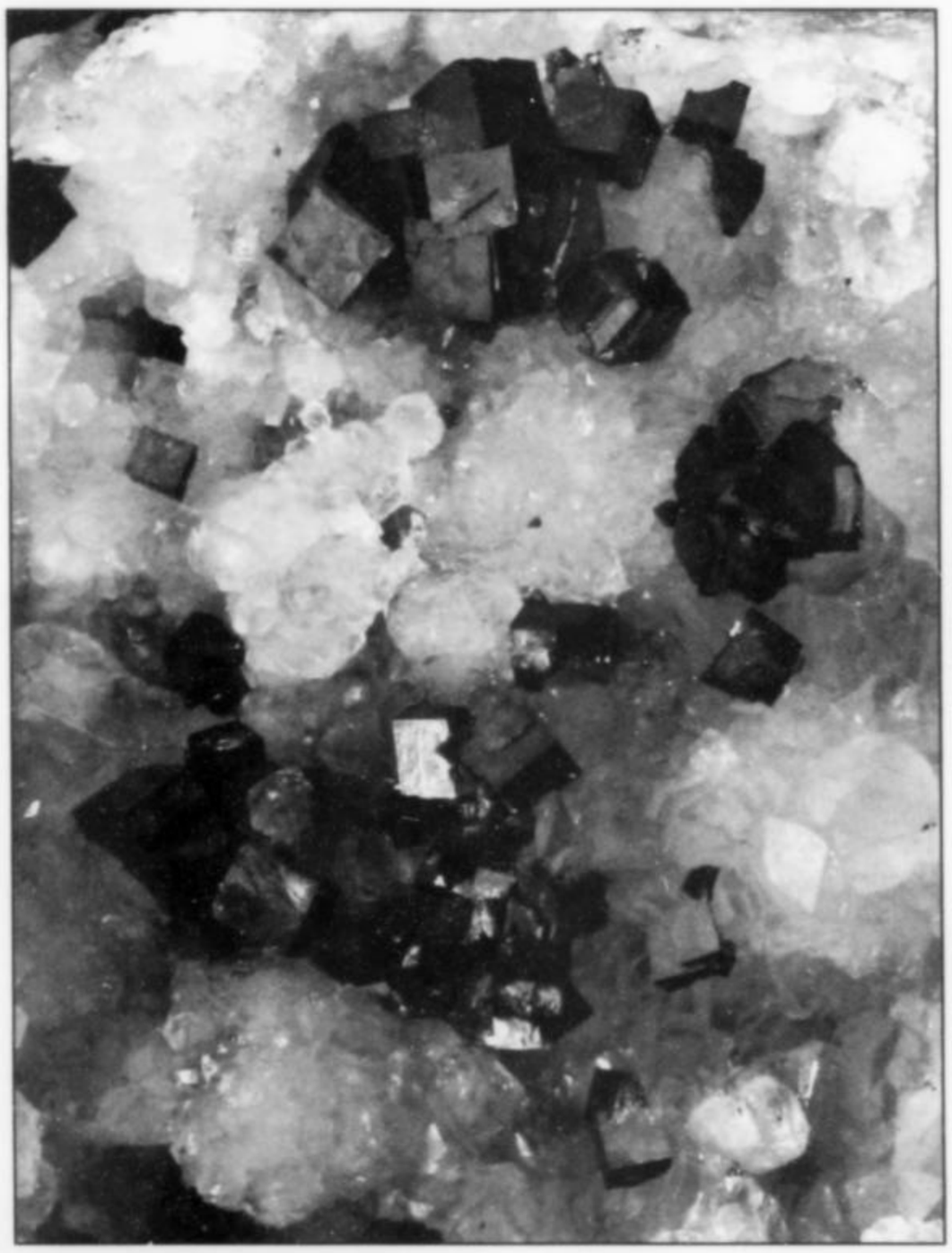


Figure 12. **Cubic pyrite crystals to 3 or 4 mm on datolite, from the Braen quarry. Kurt Hennig collection; Frank Imbriacco photo.**

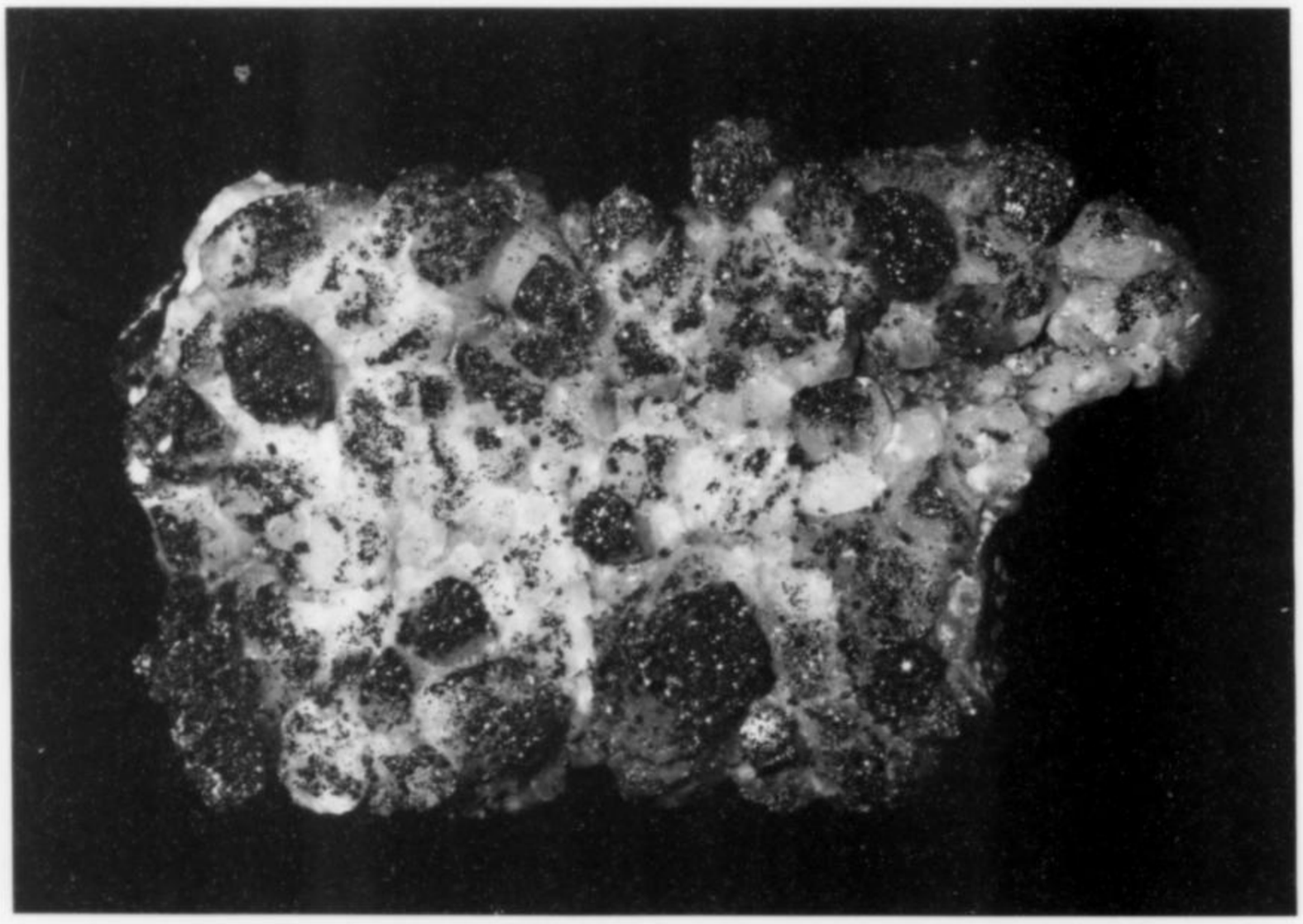


Figure 13. **Pyrite microcrystals partially cover calcite with pinkish zones colored by hematite inclusions, 11 cm, from the Braen quarry. Brad Plotkin collection; Frank Imbriacco photo.**

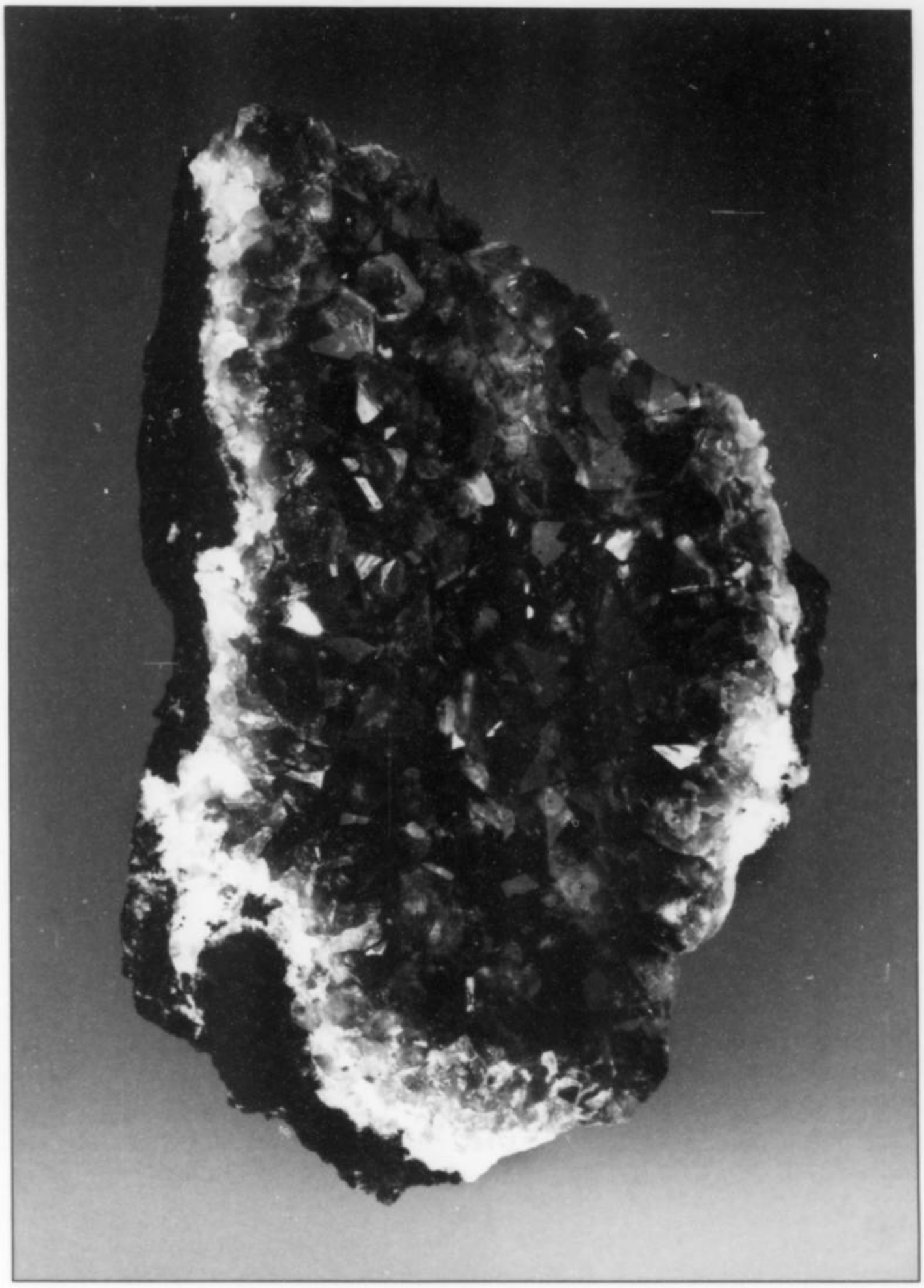


Figure 14. **Smoky quartz lining a vug in basalt, 16 cm, from the Braen quarry. Kurt Hennig collection; Frank Imbriacco photo.**

of the slag-like basalt. Specimens show jumbled acicular crystals up to 1.8 cm with pyramidal terminations.

Prehnite $Ca_2Al_2Si_3O_{10}(OH)_2$

Prehnite occurs as pale green botryoidal coatings, in spherules up to 2.5 cm and in spheroidal clusters. It is commonly associated with calcite, datolite, sulfides and rarely with zeolites. In contrast to most northern New Jersey quarries, prehnite is uncommon at the Braen quarry, and its distribution is limited to the amygdaloidal and scoriaceous basalt overlying the pillow basalt complex; it is also found in the openings in diapirs.

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

Pumpellyite is found as blue-green to black fibrous coatings inside breccia pockets.

Pyrite FeS_2

Pyrite is rare in the New Jersey trap rocks outside of the Millington quarry, but at the Braen quarry it is the most common sulfide. Cubic to octahedral crystals typically occur in clusters and as coatings on earlier minerals. Although most pyrites are microscopic in size, some reach 1.2 cm.

Quartz SiO_2

Quartz lines numerous pockets of the pillow formation as crystals between 5 mm and 2.5 cm. Rectangular quartz molds after anhydrite are also plentiful in these openings. Varieties include colorless, amethystine and smoky quartz. The quartz crystals are usually so densely packed together that only their rhombohedral terminations are visible. It is also found in lavender botryoidal specimens up to 2.5 cm thick. Quartz is not present in the mineral-bearing horizons above the pillow lava.

Sphalerite (Zn,Fe)S

Sphalerite commonly forms on prehnite, datolite, calcite and quartz as sharp, green to reddish brown to black crystals up to 1.9 cm. They are highly prized by local trap rock collectors since they are rarely found outside of the Braen and Millington quarries.

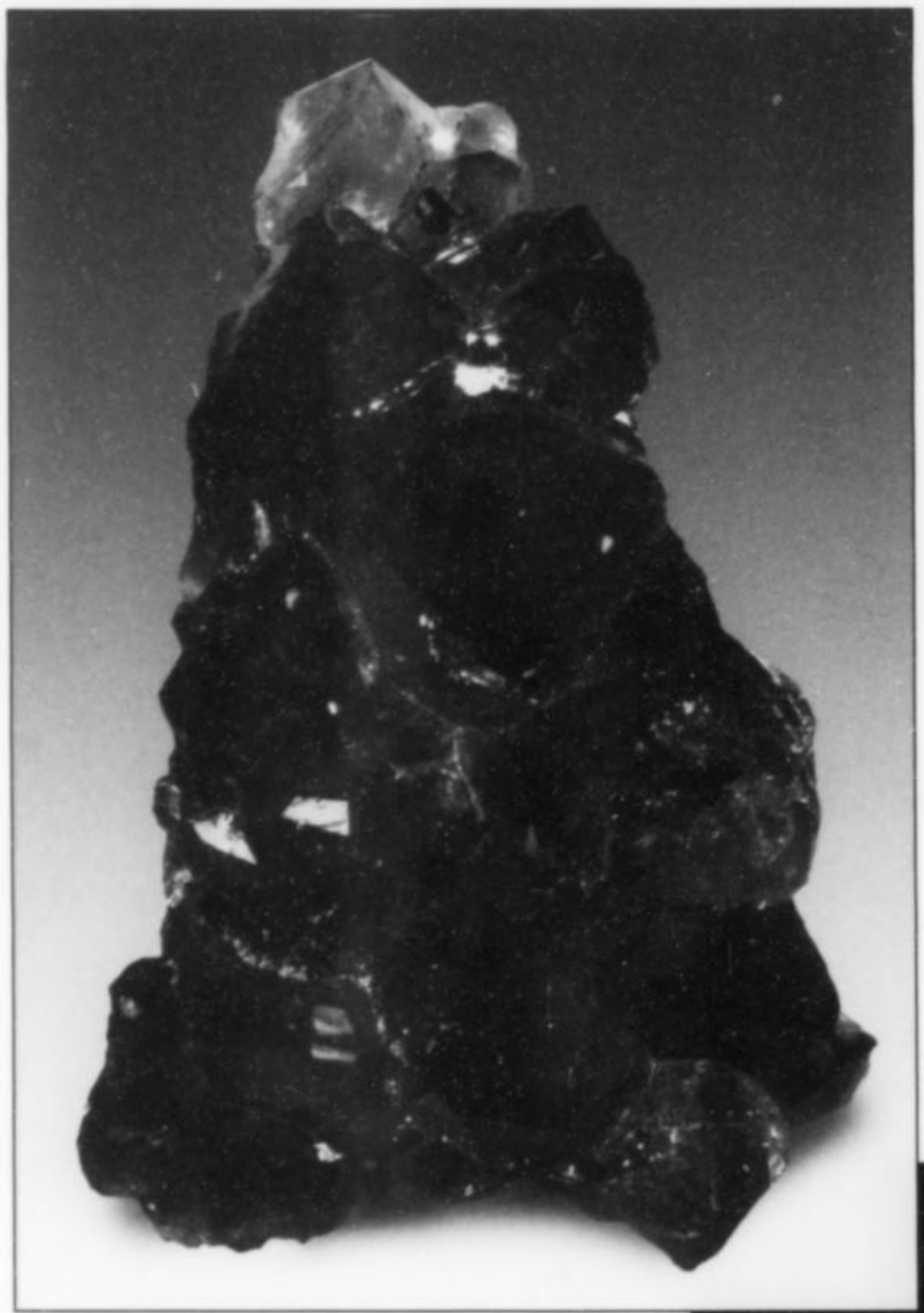


Figure 15. **Smoky quartz crystal cluster with minor goethite, 10 cm, from the Braen quarry. Brad Plotkin collection; Frank Imbriacco photo.**

Stellerite $Ca(Al_2S_7O_{18})\cdot 7H_2O$

Stellerite probably ranks as the Braen quarry zeolite most highly valued by collectors. Initially it was found as small translucent spheres and linings in cavities in the scoriaceous basalt, but large white to gray and cream-colored spheres up to 4 cm are now known. The best pocket produced between 25 and 30 attractive specimens with large, isolated, radiating spheres and spherical groups on drusy stellerite. Several of the spheroids have a ridge running across their midsections. The stellerite identification has been confirmed by chemical analyses (K. Hennig, personal communication 2007).

Stilbite $NaCa_2(Al_5Si_{13})O_{36}\cdot 14H_2O$

Stilbite is the most interesting mineral discovered at the Braen quarry. Crystals occur as half and full bowties and radiating spherical groups in white, brown and tan. The most impressive specimens consist of isolated spheres to 7.5 cm. Stilbite typically forms directly on the walls of the breccia cavities in the scoria.

Thaumasite $Ca_3Si(CO_3)(SO_4)(OH)_6\cdot 12H_2O$

Thaumasite occurs in both datolite and quartz pockets in the pillow basalts as whitish compact masses. On some specimens thaumasite can be seen alongside unaltered gypsum.

Wurtzite (Zn,Fe)S

Wurtzite has not previously been reported from the New Jersey traps. A few examples have been collected at the Braen quarry, the best being a striated black 1.2-cm crystal on datolite, identified by

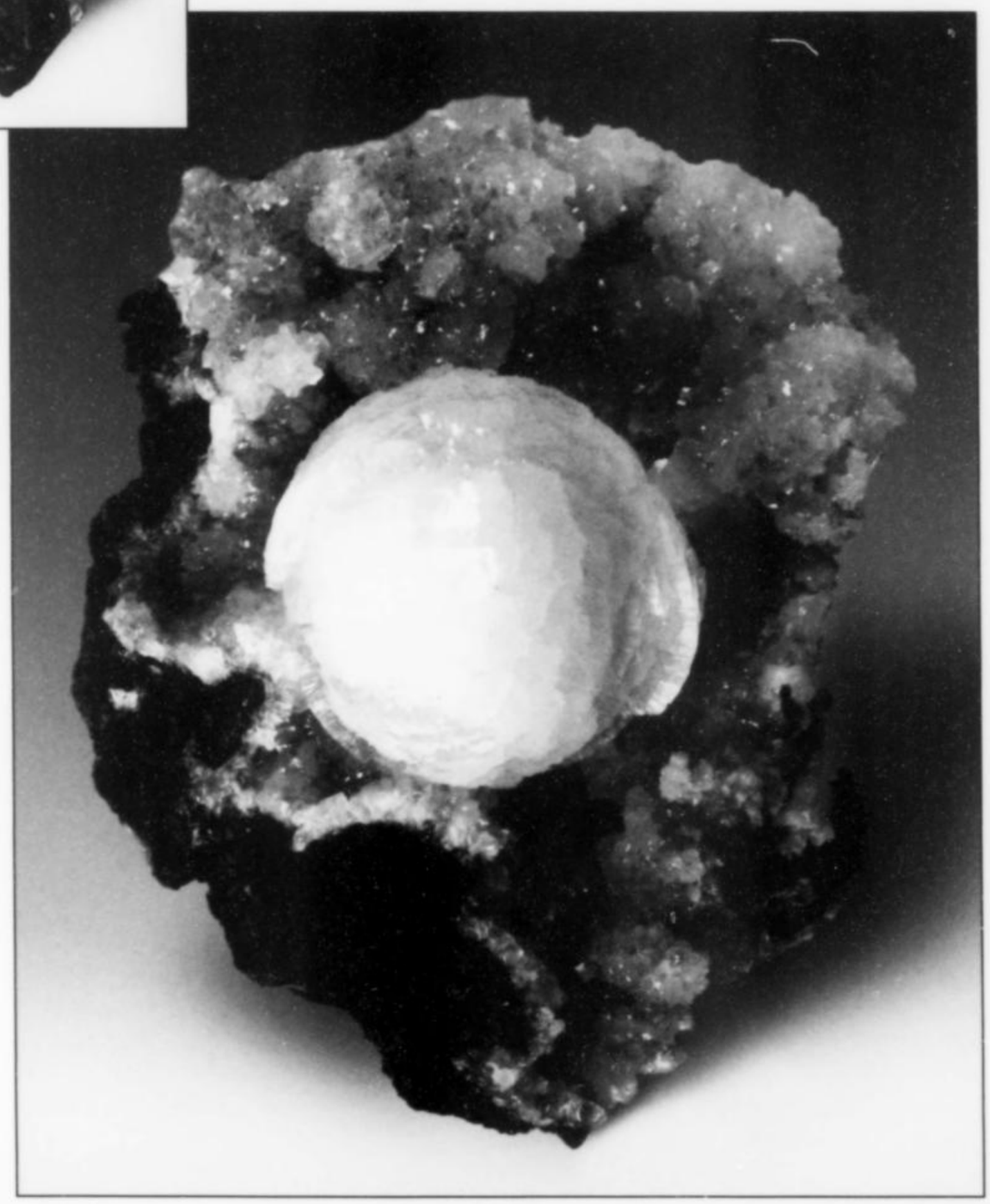


Figure 16. **Stellerite sphere, 3.2 cm, on drusy stellerite, from the Braen quarry. Frank Imbriacco collection; Frank Imbriacco photo.**

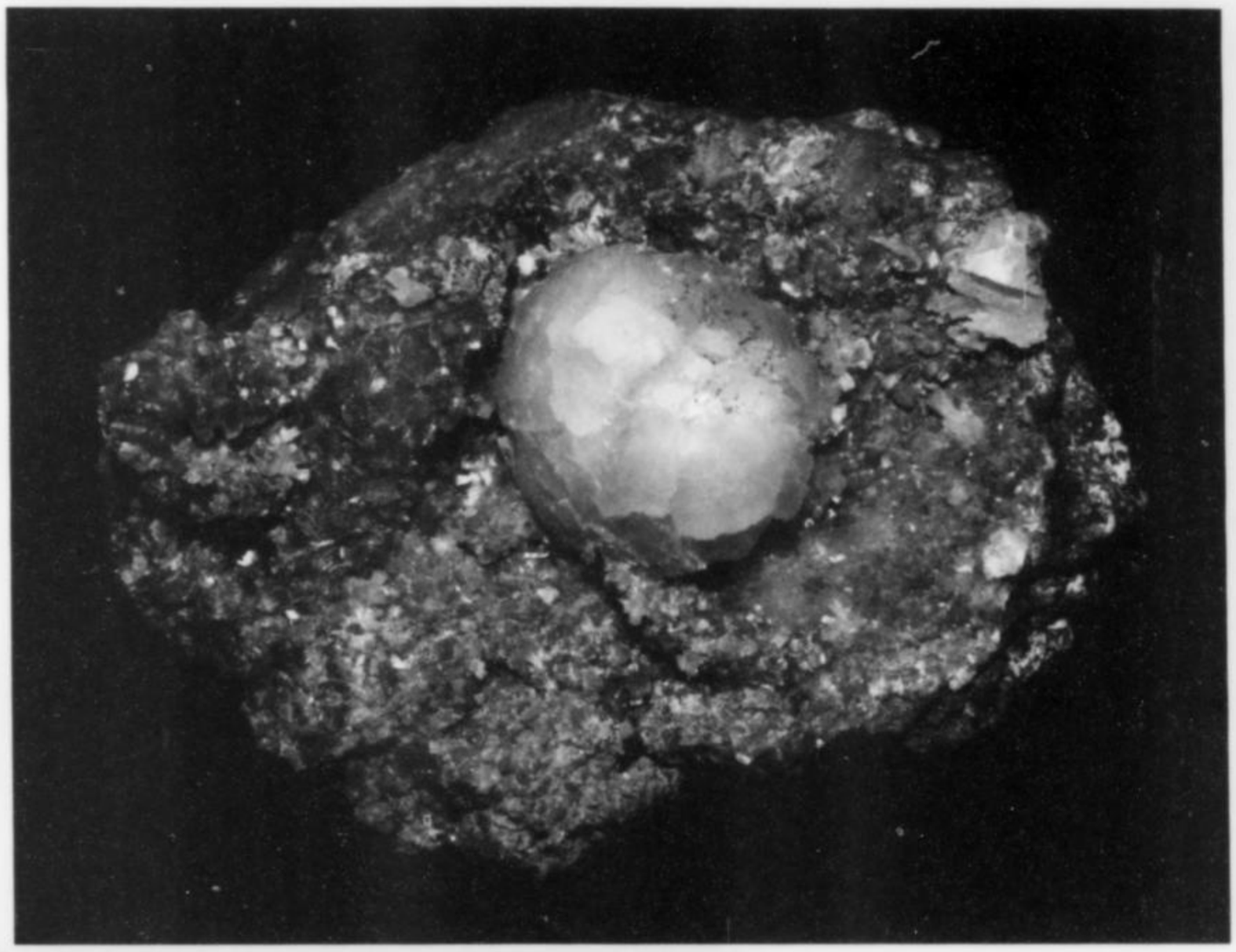


Figure 17. **Stellerite sphere, 4 cm, with datolite on drusy stellerite, from the Braen quarry. Brad Plotkin collection; Frank Imbriacco photo.**

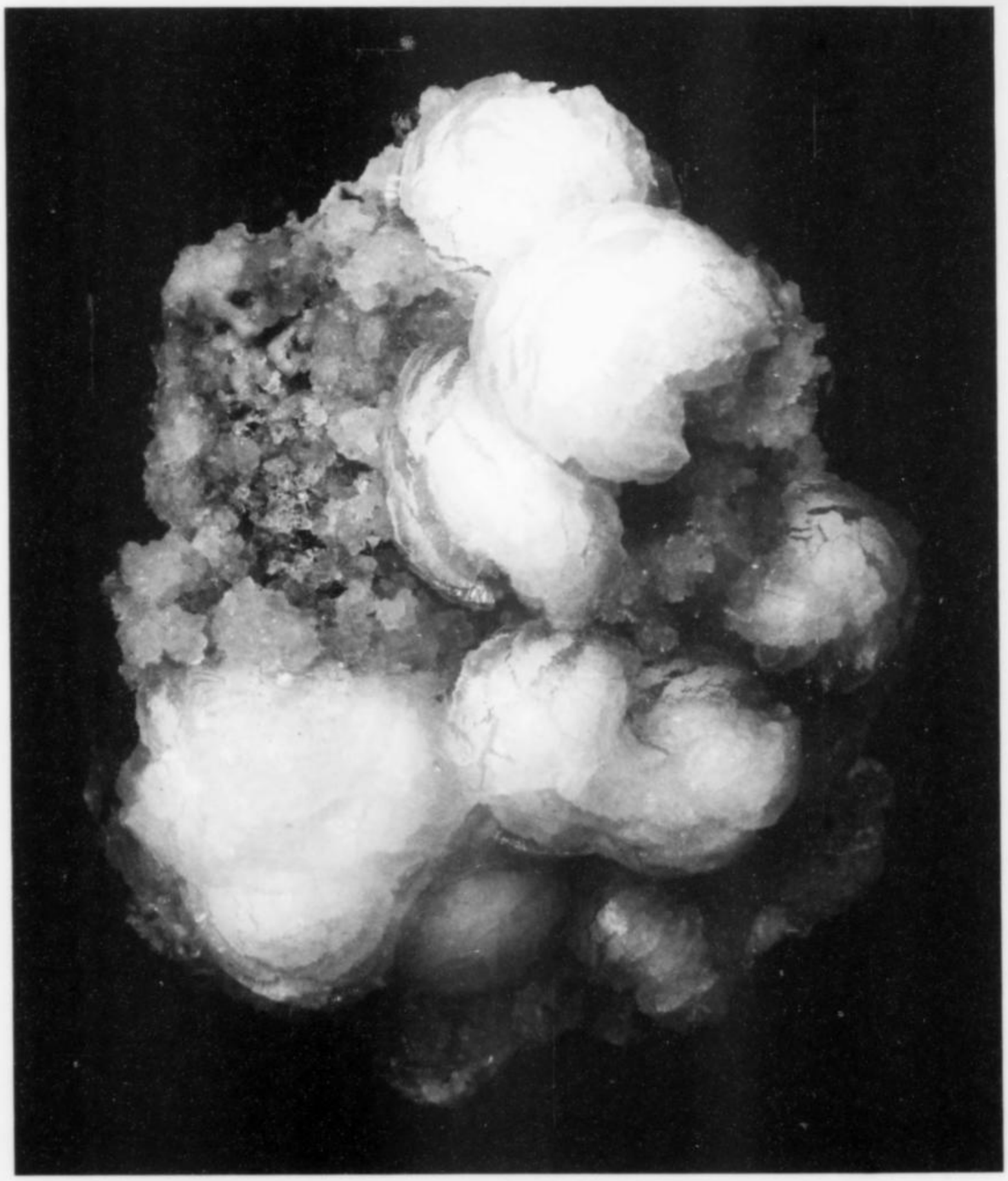


Figure 18. **Stellerite spheres on drusy stellerite, 10.9 cm, from the Braen quarry. Kurt Hennig collection; Frank Imbriacco photo.**

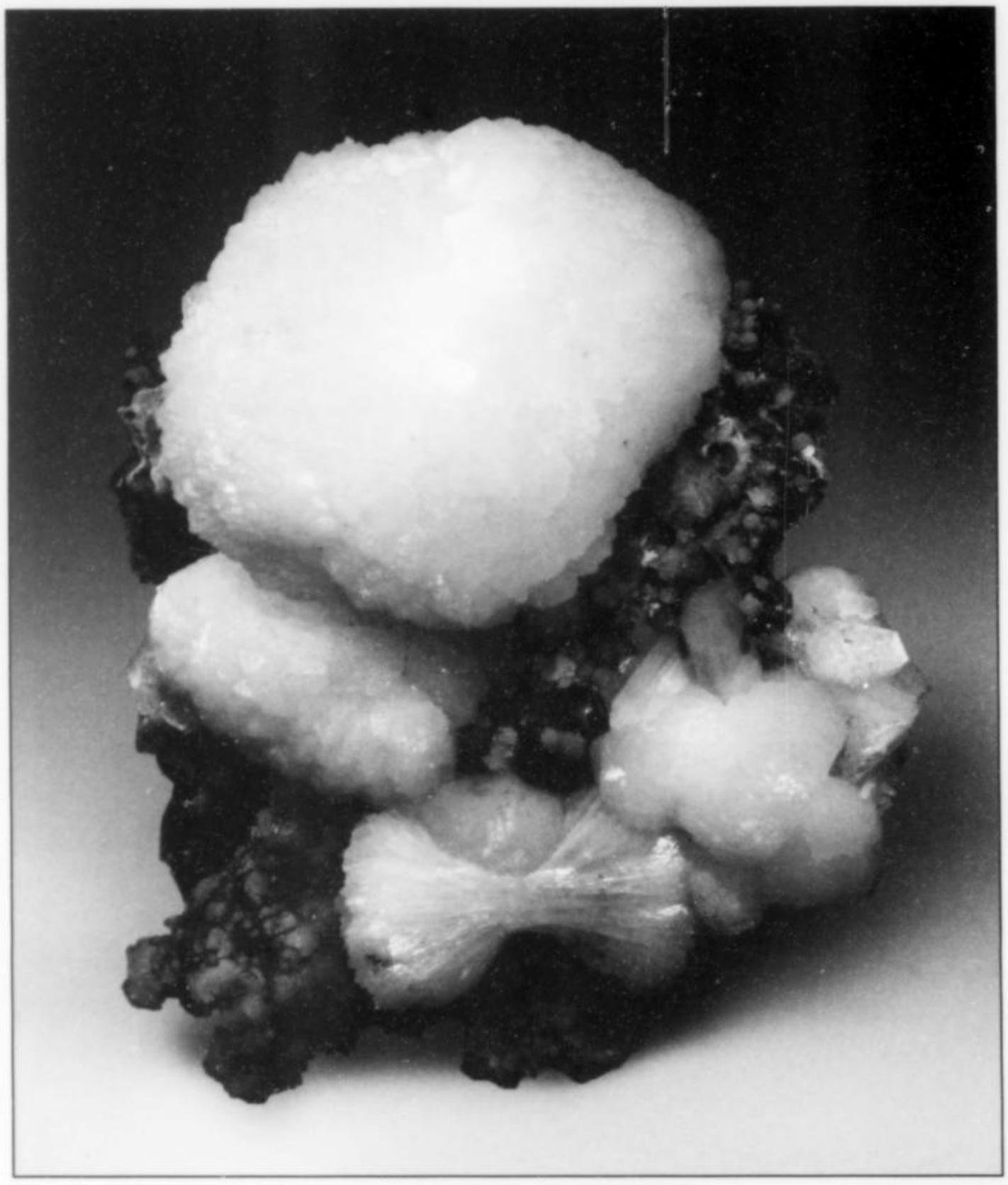


Figure 19. **Stilbite with heulandite, 6.7 cm, from the Braen quarry. Frank Imbriacco specimen and photo.**

Figure 20. **Stilbite with heulandite, 10 cm, from the Braen quarry. Frank Imbriacco specimen and photo.**

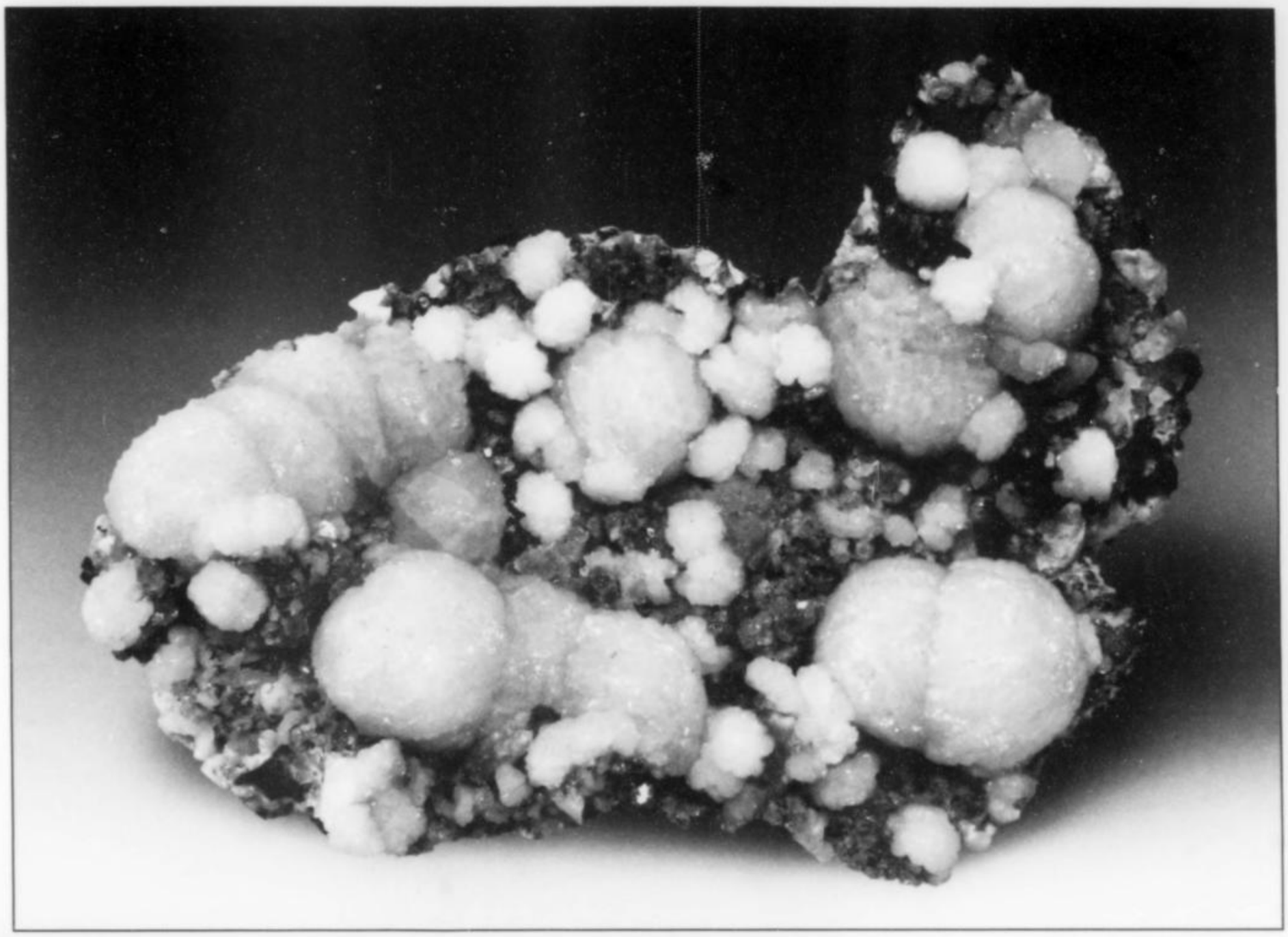


Figure 21. **Stilbite with heulandite, 13.4 cm, from the Braen quarry. Frank Imbriacco specimen and photo.**

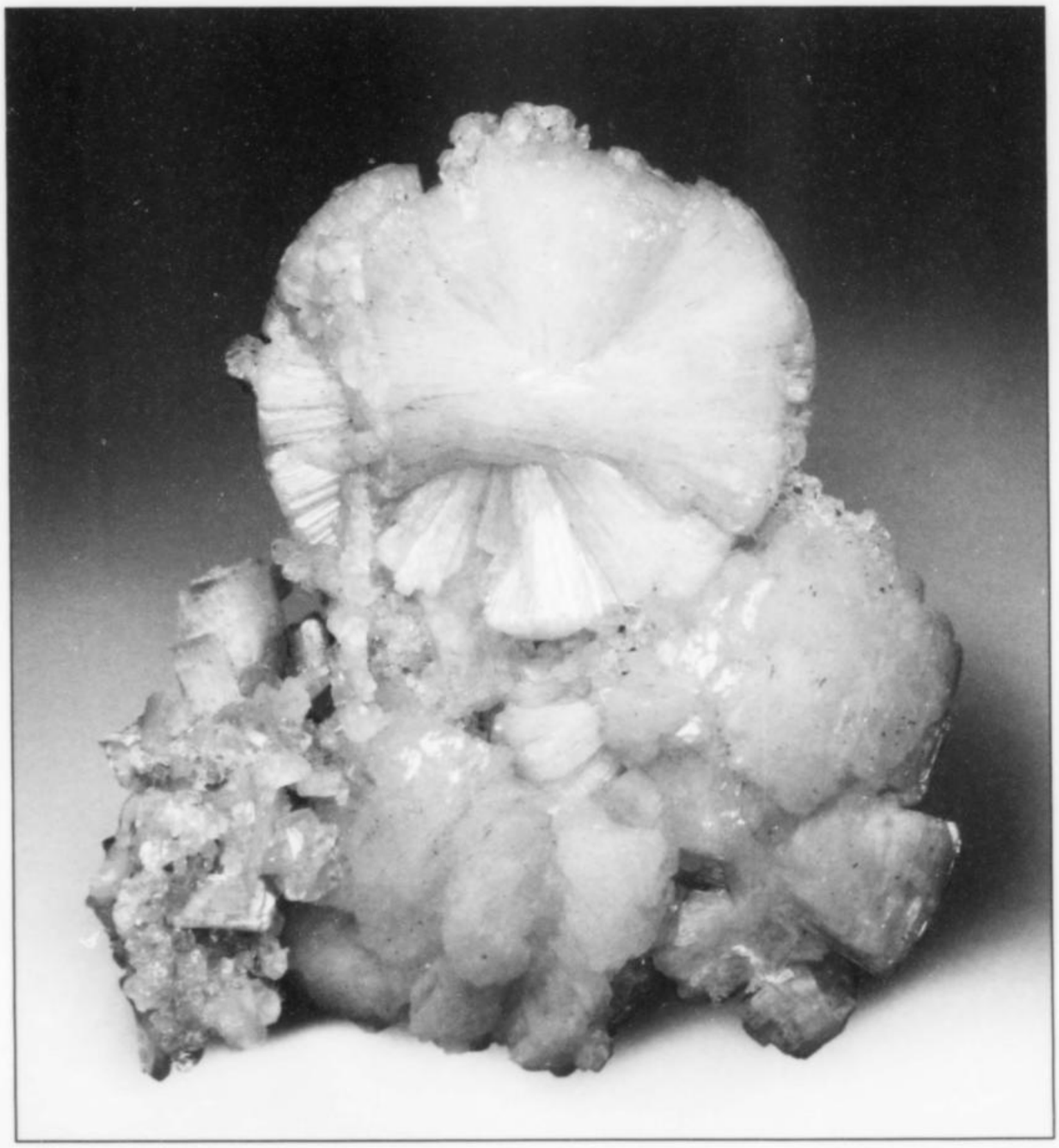


Figure 22. **Stilbite pinwheel with heulandite, 7 cm, from the Braen quarry. Brad Plotkin collection; Frank Imbriacco photo.**

Figure 23. **Wurtzite crystal, 1.2 cm, on datolite, from the Braen quarry. Brad Plotkin collection; Frank Imbriacco photo.**

the morphology and by chemical analysis (B. Plotkin, personal communication 2007).

CONCLUSION

After nearly 80 years in production, the Braen quarry has only recently become known as a source for fine specimens. Some of New Jersey's best quartz, stilbite and anhydrite have been recovered there, as well as the state's best examples of stellerite. Blasting will continue for approximately 14 more years. At present, the operation has moved through the extremely productive areas of the quarry and is excavating mostly barren rock. During the final years of mining, however, several buildings adjacent to the pit are scheduled to be razed to allow the removal of the underlying rock. It is expected that when the basal unit is reached again in this area, an abundance of fine mineral specimens will be uncovered. Whether the company will allow them to be salvaged at that time remains unknown.

Currently, the company does not allow collecting, and all such requests will be refused. In addition, management does not tolerate trespassing, and intends to prosecute any and all trespassers.

ACKNOWLEDGMENTS

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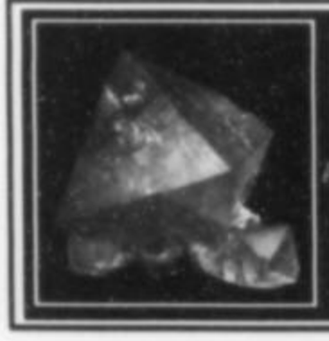

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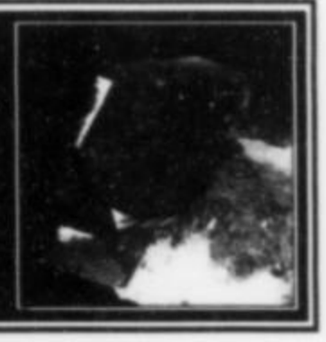

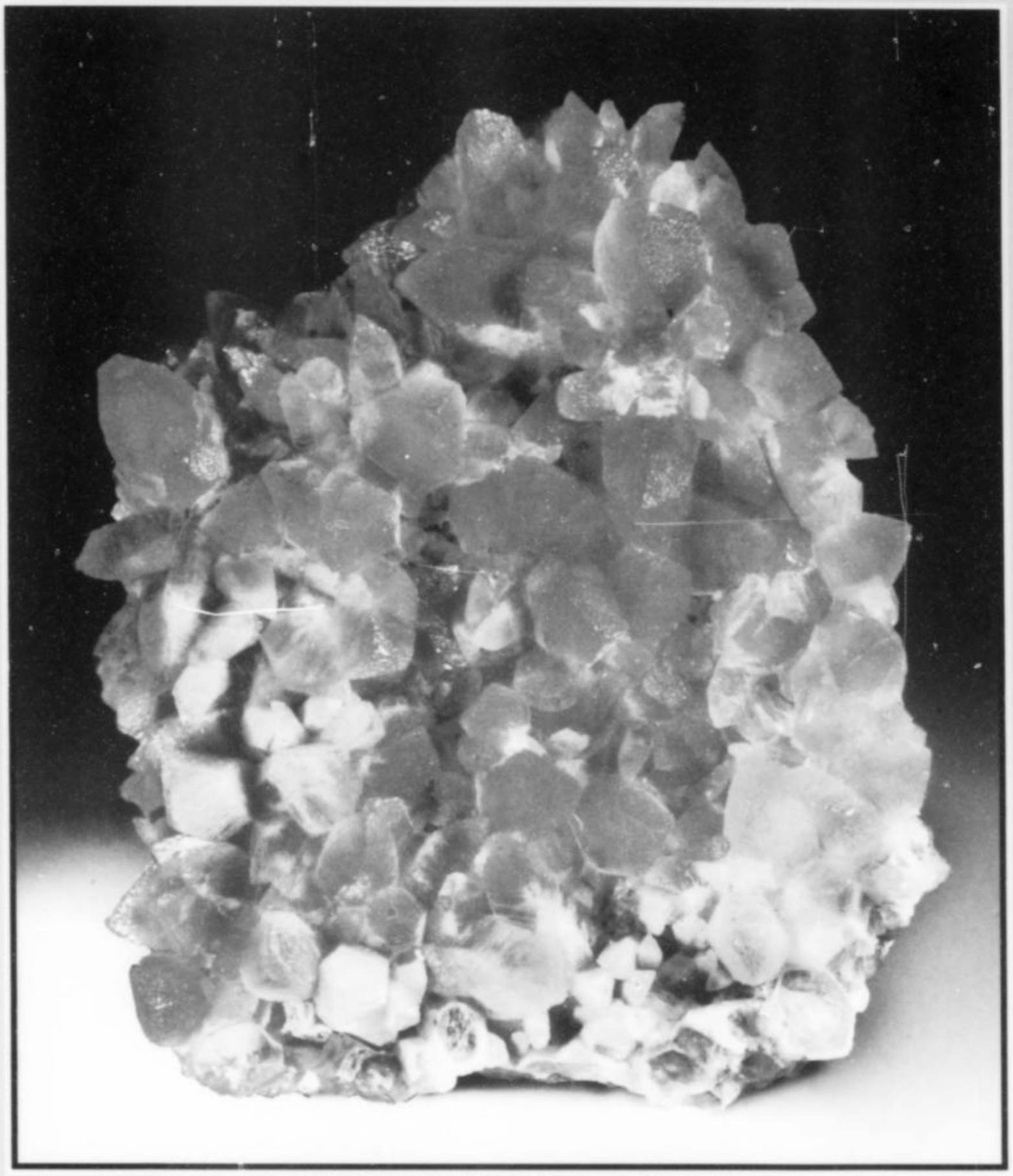

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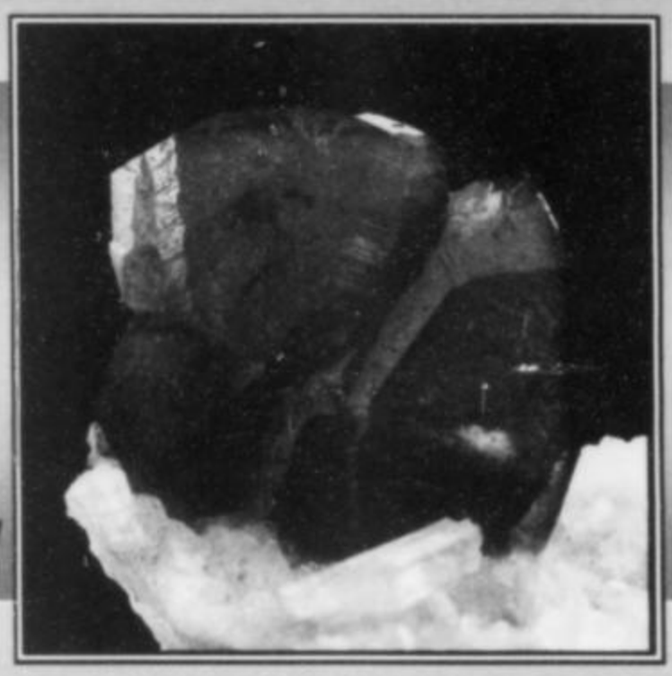

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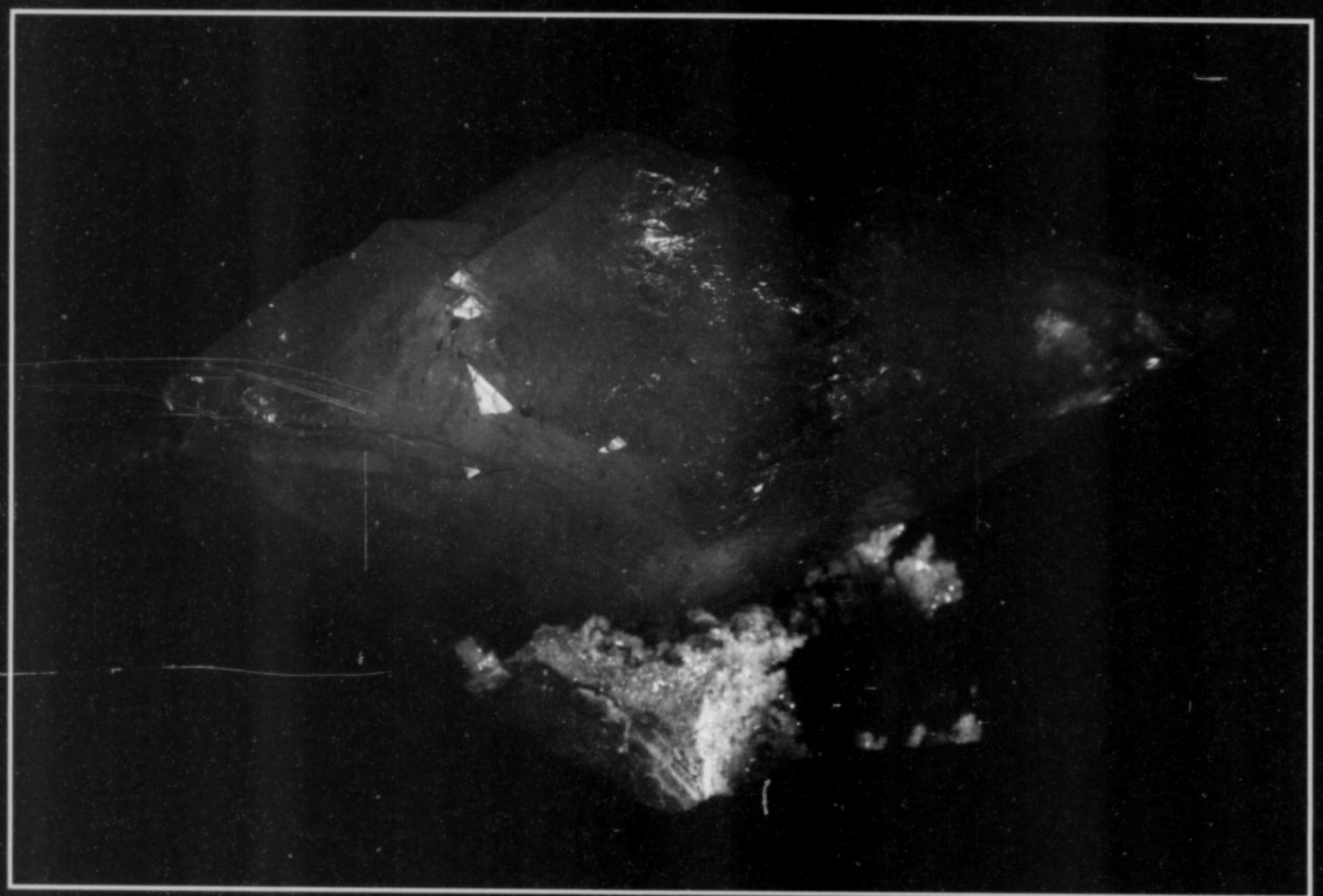

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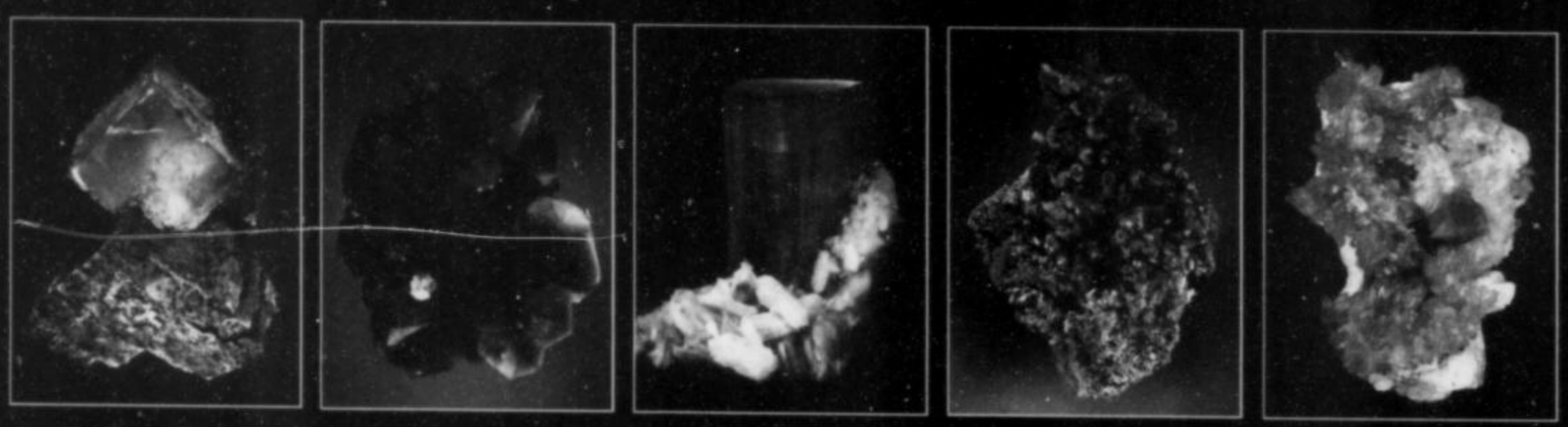

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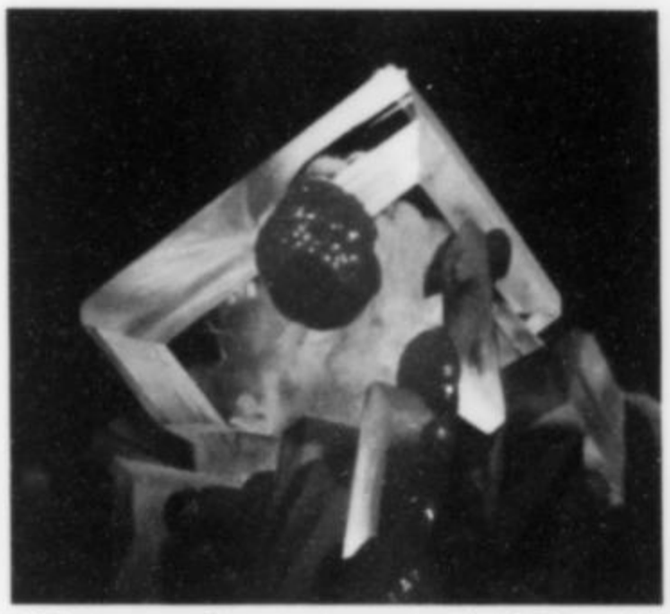

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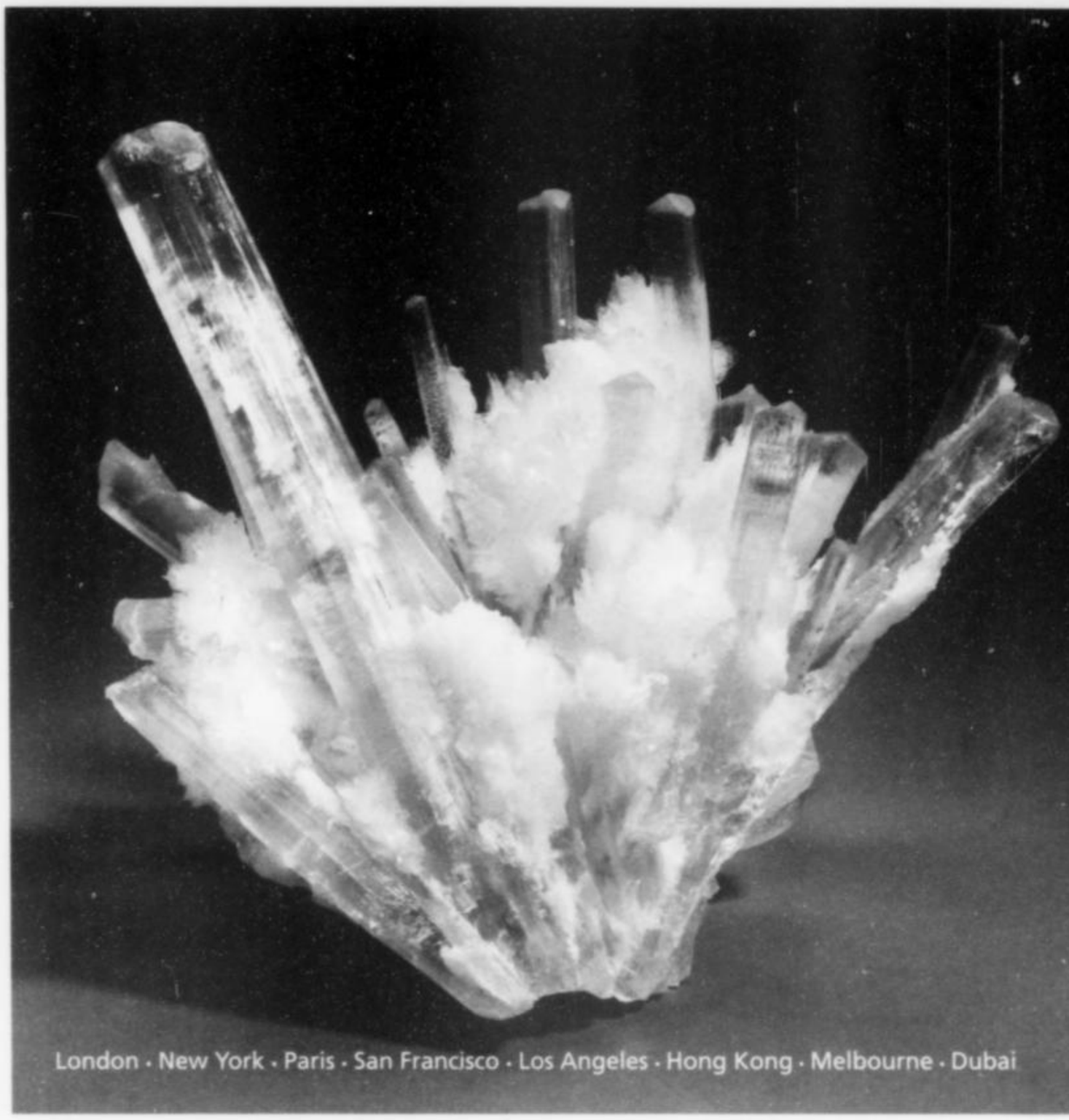

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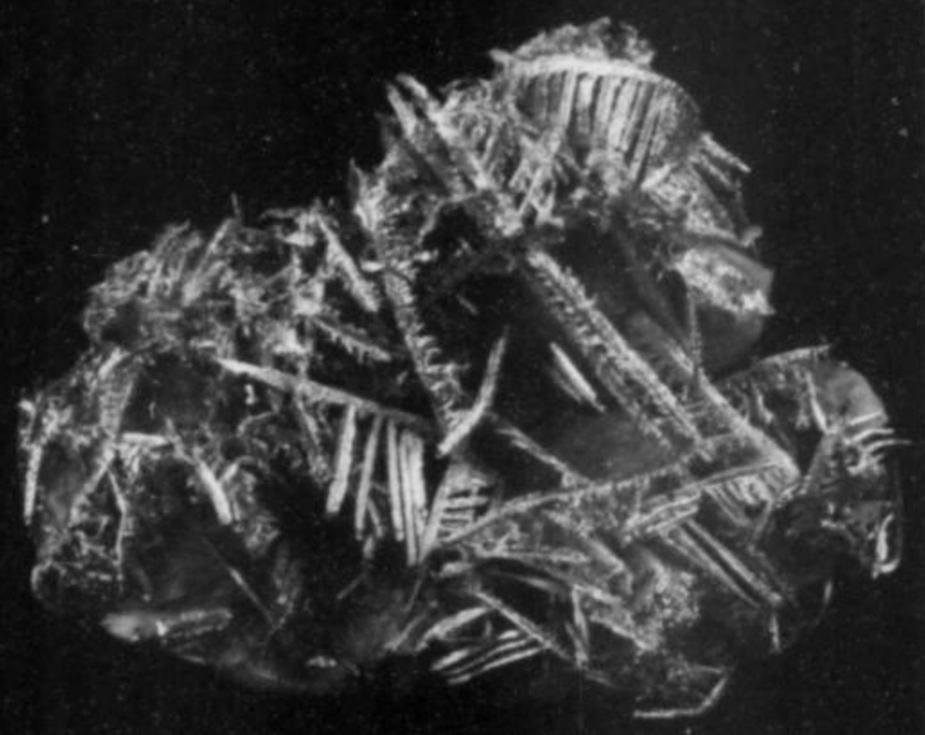

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Fax: (904) 822-7328
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Tel: 775-784-4528, Fax: 775-784-1766
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Mackay School of Earth Science & Engineering
University of Nevada, **Reno,** NV 89557
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Specialty: Comstock ores, worldwide minerals, mining artifacts, Mackay silver

New Mexico Bureau of Mines & Mineral Resources—Mineral Museum

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E-mail: vwlueth@nmt.edu
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Associate Curator: Robert Eveleth
Tel: (505) 835-5325
E-mail: beveleth@gis.nmt.edu
New Mexico Tech,
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Socorro, NM 87801
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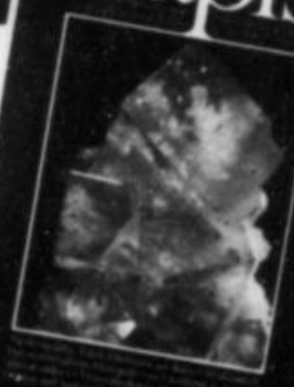

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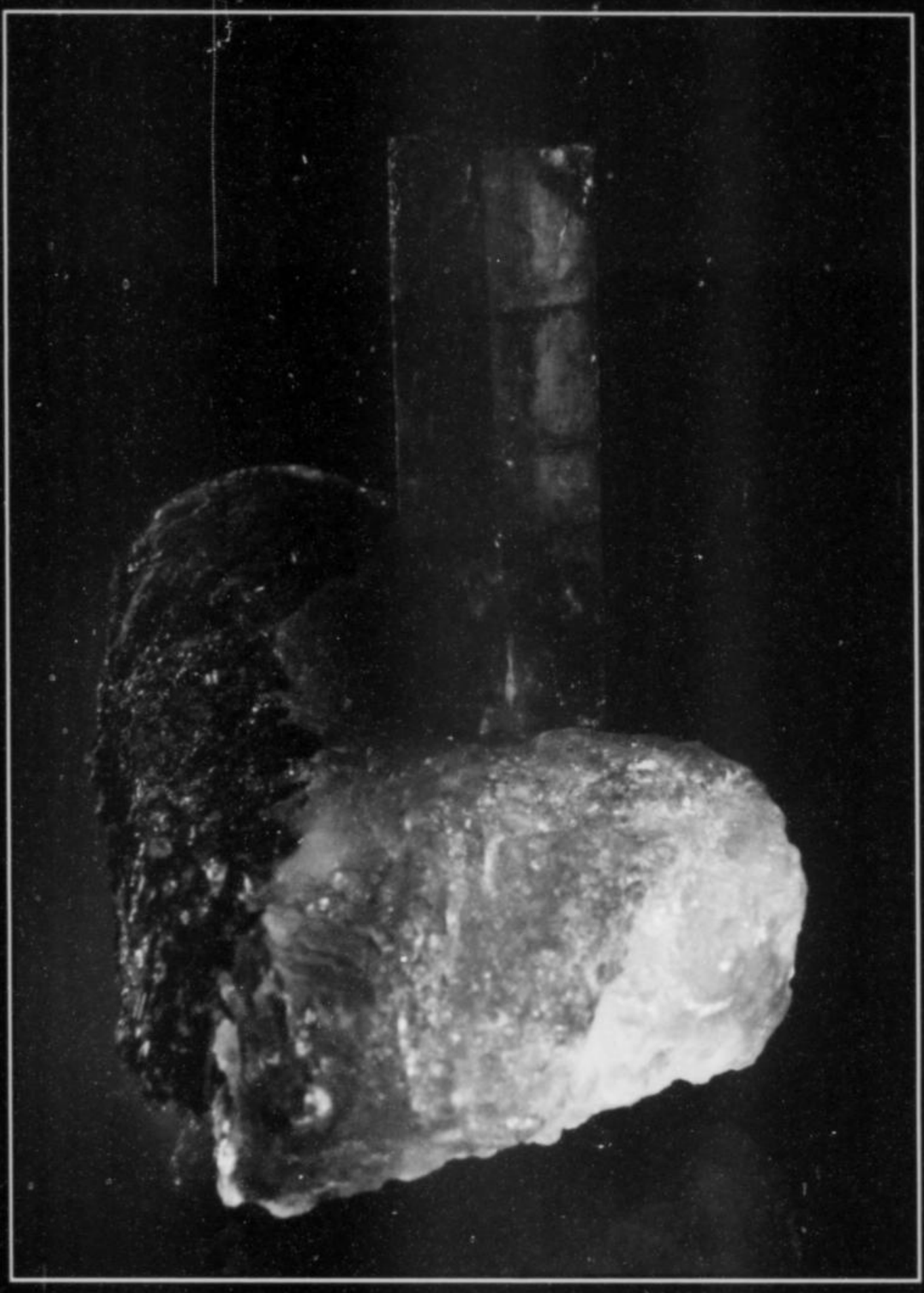

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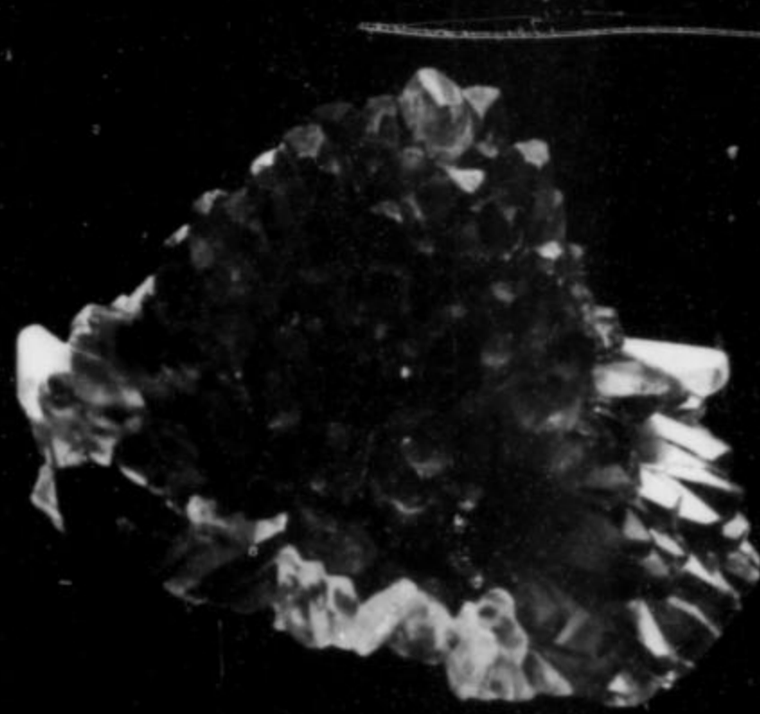
– George F. Kunz
The Curious Lore of Precious Stones, 1915



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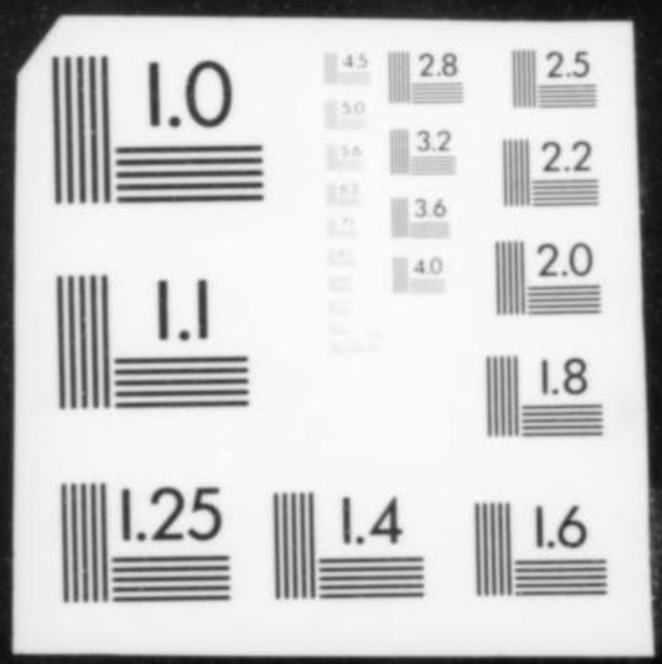
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