



# NEW MEXICO MINERAL SYMPOSIUM

November 8 & 9, 1997



NMIMT Campus, Socorro, New Mexico

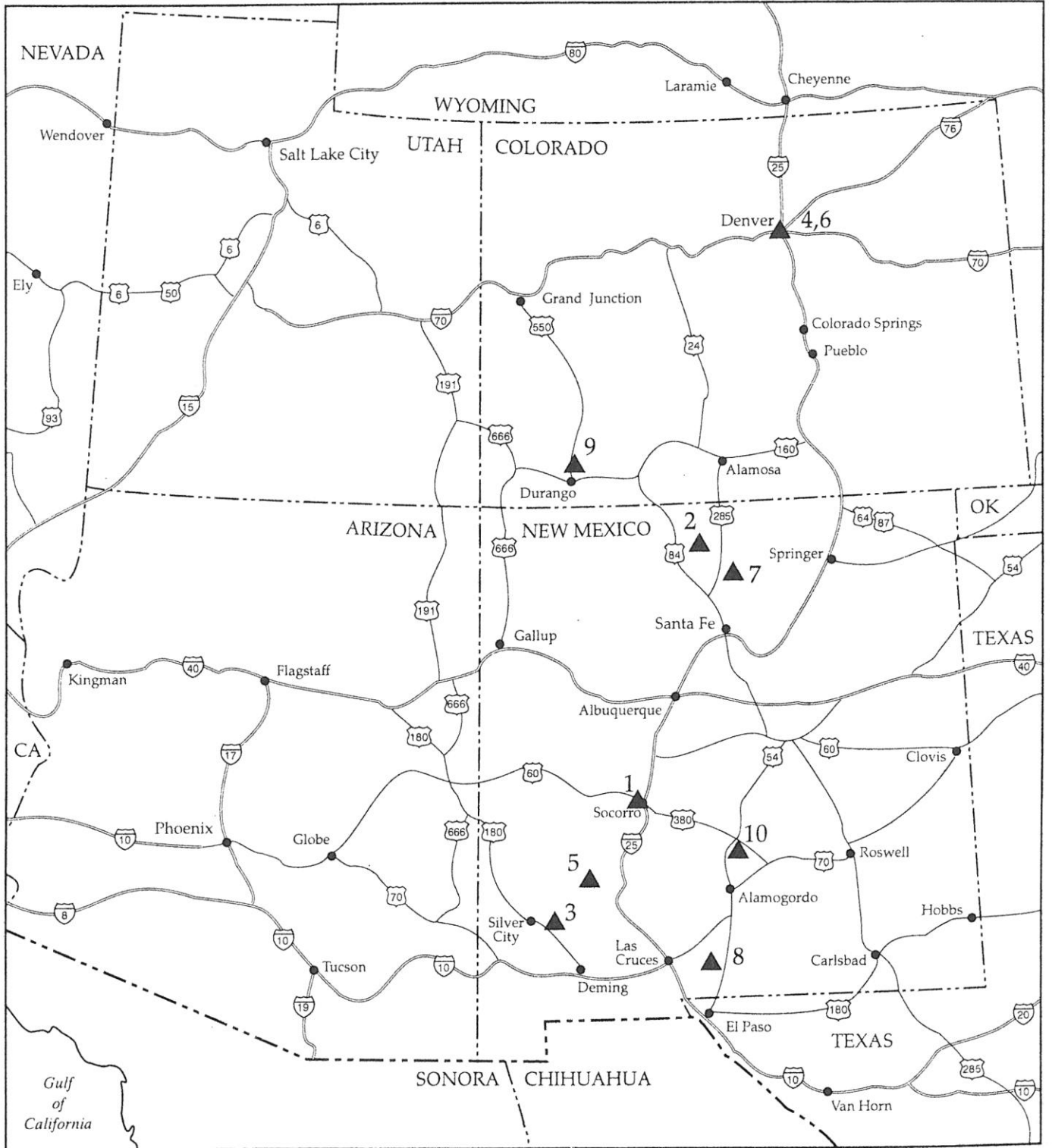
Welcome to  
THE EIGHTEENTH ANNUAL  
NEW MEXICO MINERAL SYMPOSIUM  
NOVEMBER 8 AND 9, 1997

Macey Center Auditorium  
New Mexico Institute of Mining and Technology  
Socorro, New Mexico

Sponsored by  
New Mexico Bureau of Mines and Mineral Resources  
Albuquerque Gem and Mineral Club  
Los Alamos Geological Society  
New Mexico Geological Society  
Chaparral Rockhounds

The purpose of the New Mexico Mineral Symposium is to bring together for an exchange of ideas both professionals and amateurs interested in mineralogy. The sponsors hope that the Eighteenth New Mexico Mineral Symposium will give both groups a forum to present their cumulative knowledge of mineral occurrences in the state. In addition to the formal papers, informal discussions among mineralogists, geologists, and hobbyists should benefit all.

COVER—MINERALS OF THE FOUR-CORNERS STATES. Scepter quartz from Kingston, New Mexico; rhodochrosite from Silverton, Colorado; topaz from the Thomas Mountains, Utah; and barite from Superior, Arizona represent the four-corners states in the cover design by Teresa Mueller.



Geographic Index Map  
 18th New Mexico Mineral Symposium

## SCHEDULE

Numbers in parentheses refer to geographic location on map.

	<b>Friday, November 7</b>	4:00	<i>(7) A fourth world occurrence of foitite at Copper Mountain, Taos County, New Mexico</i> —Dr. Carl A Francis, featured speaker
6:00 pm	Informal tailgating and social hour, individual rooms, Super 8 Motel		
	<b>Saturday, November 8</b>		
8:30 am	Registration, Macey Center; coffee and donuts	5:30	Sarsaparilla and suds: cocktail hour, cash bar
9:20	<i>Opening remarks</i> , main auditorium	6:30	Dinner followed by an auction to benefit the New Mexico Mineral Symposium and a brief presentation by Dr. Carl A. Francis
9:30	<i>(1) History of the New Mexico Bureau of Mines &amp; Mineral Resources Mineral Museum</i> —Robert W. Eveleth & Virgil W. Lueth		<b>Sunday, November 9</b>
10:00	<i>(2) Mineral collecting in northern New Mexico</i> —Ramon DeMark	8:15 am	Morning social, coffee and donuts
10:30	Coffee break	9:00	Welcome to the second day of the symposium and follow-up remarks
11:00	<i>(3) Geology and mineralogy of the Chino mine, formerly at Santa Rita, New Mexico</i> —Robert M. North	9:10	<i>(8) Two diverse origins for turquoise at the Orogrande mining district, Otero County, New Mexico</i> —Virgil W. Lueth
11:30	<i>(4) The Wall—a mine and its minerals preserved for the future</i> —Jack Murphy & Jack Thompson	9:40	<i>(9) Update on the mineralogy of the San Juan Mountains, southwestern Colorado</i> —Tom Rosemeyer
12:00 pm	Lunch	10:10	Coffee break
1:00	Museum tours	10:40	<i>(10) Lazulite occurrences in southern New Mexico</i> —Phillip C. Goodell, Virgil W. Lueth & Mark Gresock
2:00	<i>(5) Quartz epimorphs from the Hermosa district, Sierra County, New Mexico</i> —Virginia T. McLemore, Joe Glines & Virgil W. Lueth	11:10	<i>Open forum on minerals and collecting in the four-corners states</i>
2:30	<i>Industrial minerals of New Mexico from A to Z</i> —George Austin	12:00 pm	Lunch
3:00	Coffee break	1:15-3:00	Silent auction, upper lobby, Macey Center, sponsored by the Albuquerque Gem and Mineral Club
3:30	<i>(6) Micromount minerals of the Denver Museum of Natural History</i> —Jim Hurlbut & Jack Thompson		

## **A rocky history - The first 100 years of the Mineral Museum in Socorro, New Mexico, USA**

(Location 1 on index map)

Robert W. Eveleth & Virgil W. Lueth  
New Mexico Bureau of Mines & Mineral Resources  
Socorro, New Mexico 87801

A little over 100 years ago the New Mexico Territorial Legislature established the New Mexico School of Mines (now New Mexico Institute of Mining and Technology). The charge to the school was to provide for higher education in the earth and related sciences. The school's board of trustees (now "Regents") was assigned the responsibility of prescribing the various courses of study, of equipping laboratories and classrooms in a manner appropriate for instruction, and of assembling (for educational purposes) a geological and mineralogical cabinet. President Fayette A. Jones carefully selected and acquired many specimens during his travels for the fledgling school and to him must go the credit for creating, in 1899, the first collection. With little or no fanfare, Socorro's first museum of any kind was born. Nurtured by dozens of earth scientists over the years, the collection has steadily evolved through prosperity and depression, fame and tragedy, to a superb assemblage of more than 10,000 pieces today. The museum is maintained by the New Mexico Bureau of Mines and Mineral Resources, and its staff routinely draws on this mineralogical legacy to participate in educational events and gem and mineral shows throughout New Mexico and the United States. In addition, the collection provides ongoing aesthetic, scientific, and research benefits for all of society.

## Mineral collecting in northern New Mexico

(Location 2 on index map)

Ramon S. DeMark  
530 East Arch Street  
Marquette, MI 49855

For years mineral collectors have passed many unique collecting sites in northern New Mexico en route to better-known locations in the south. Perhaps now is the time to explore this region.

An overview of the area presents missed opportunities, favorable current prospects, and future potential. Certainly, the collecting scene has diminished in some areas, for example, the uranium belt of northwestern New Mexico. During the active mining era from the 1950s until the early 1980s, specimens of uranophane, tyuyamunite, and other rarer species were easily obtained from the poor rock dumps of Todilto limestone at the Poison Canyon mines. Now, very little remains. Active mining at the San Pedro and Ortiz gold mines in Santa Fe County presented opportunities for collectors to obtain excellent scheelite crystals, Japan-law quartz crystals, superb large chalcopyrite crystals, and wonderful specimens of wire and crystallized gold. These mines are now closed.

Rather than dwelling on what has been lost, I would like to emphasize what is now available in northern New Mexico to the energetic field collector. Outstanding finds have recently come to light in the cliffs near Pilar and in the Harding mine area as a result of the efforts of Jesse Kline from Taos. Chrysoberyl, previously only reported from an obscure, small pegmatite just south of Colorado, and microcrystals from La Madera have been found in large numbers of excellent crystals as much as 2 cm across associated with euhedral beryl crystals more than 10 cm long from small pegmatites just northwest of the Harding mine. Gahnite and zoisite crystals have also been found in this area as well as specimens of margarite (see 1996 New Mexico Mineral Symposium abstract by DeMark and Kline; *New Mexico Geology*, v. 19, no. 1, p. 28 [1997]).

The Pilar cliffs are not recommended for collectors afraid of heights or out of shape; however, the area has recently revealed opportunities for the hardy collector. Jesse Kline has found highly lustrous schorl crystals high up the cliffs associated with garnets that have been altered to the iron silicate hisingerite. Attractive blades of an unusual gold kyanite in quartz and kyanite altered to andalusite have been collected recently. Some of the andalusite is the green variety viridine. Dravite, purple muscovite, and the chromian variety of muscovite, fuchsite, can also be found in these cliffs.

The Harding mine remains open to collecting with some limitations and prior approval from the Department of Earth and Planetary Sciences of the University of New Mexico. Excellent specimens of pink muscovite and purple lepidolite along with spodumene laths are easily found. Massive beryl is common although difficult to recognize. The rare brittle mica, bityite, and the lithium amphibole, holmquistite, can also be found in the area. Microcrystals of microlite and zircon are common and, rarely, thorite, pucherite, bertrandite, and even elbaite do occur here.

Other northern mining districts have produced specimens in the past and offer opportunities even today. The Petaca district is well known for museum-quality columbite, manganocolumbite, monazite, and beryl. Although mining has ceased, the dumps of the Nacimiento mine near Cuba still contain specimens of fossil wood replaced by chalcocite and azurite balls. Although currently restricted to active mining exploration, the Tungsten (Wichita) mine and Copper Hill in the Picuris district are worthy of collecting. It was determined recently that the brown, silky tourmaline found at the Tungsten mine is

foitite, a recently described species. Wolframite, scheelite microcrystals, and conichalcite can also be found there. Coarsely bladed blue kyanite is common just east of the Tungsten mine on Copper Mountain.

The Rociada, Hopewell, Elk Mountain, and Tecolote districts along with the Valle Grande area are potential producers of high-quality specimens and minerals that would add to the mineralogical knowledge of the region. Approval to collect can be a problem, however. The owners of the Valle Grande in the Jemez Mountains have totally restricted access to the obsidian/cristobalite location once accessible with prior permission.

Notwithstanding the prohibitions on collecting, there are vast areas in northern New Mexico open to the individual who will hike, climb, and persevere. Many significant discoveries have been made in the last couple of years and the next find is just over that far ridge.

## Geology and mineralogy of the Chino mine, Grant County, New Mexico

(Location 3 on index map)

Robert M. North  
Phelps Dodge Chino Mines Company  
PO Box 7, Hurley, NM 88043

The Chino (Santa Rita) deposit is a porphyry copper ore body that includes intrusive and skarn-hosted copper mineralization. The largest copper-producing mine in New Mexico, and among the oldest in the United States, Chino is set in a complex geological setting in the transition zone between the Colorado Plateau and Basin and Range physiographic provinces. Early Tertiary mineralization is associated with a generally porphyritic composite intrusive, varying in composition from granodiorite to quartz monzonite, that has intruded and domed surrounding Paleozoic and Cretaceous sedimentary rocks. Sedimentary rocks in the district include Paleozoic sandstone, limestone, dolomite, and shale. The upper Cretaceous rocks include sandstone, siltstone, shale, and minor shaly limestone of the Colorado and Beartooth Formations. The sedimentary section was also intruded by Late Cretaceous quartz diorite sills that predate the main stock intrusive but are not believed to be associated with mineralization. Three ages and compositions of dikes cut the intrusive, including granodiorite, quartz monzonite, and quartz latite. The granodiorite may occasionally be mineralized, while the latite is unmineralized and the quartz monzonite only rarely, but is seldom of ore grade. Post-mineral (mid-Tertiary) volcanic rocks overlie the southern and southeastern part of the deposit. These rocks, extruded about 35 m.y. ago, include the Sugarlump and Kneeling Nun tuffs, and probably initially overlaid the entire deposit. The tuffs are overlain, in places, by basaltic andesite flows.

Hydrothermal alteration and mineralization is associated with the intrusion of the Santa Rita composite stock, which has been dated by  $^{40}\text{Ar}/^{39}\text{Ar}$  methods at between 58.1 and 59 m.y. The stock was intruded at the junction of three sets of faults including pronounced northwest and northeast sets and a less prominent easterly set. The intrusion is elongate in a northwest-southeast direction. Abundant mineralized fractures show the stock was intensively fractured closely following solidification and attending hydrothermal alteration. Non-skarn alteration includes k-spar, biotite, quartz-sericite-pyrite, and argillic alteration. Pennsylvanian and Mississippian sedimentary rocks, primarily limestone, that were invaded by the magma were completely altered and replaced by calc-silicates and associated contact metasomatic minerals. Common skarn minerals include magnetite, pyrite, quartz, garnet, epidote, actinolite, chalcopyrite, and others in lesser amounts. The alteration minerals are generally controlled by their proximity to the stock. However, some, such as magnetite, are also controlled laterally by the composition of the Paleozoic host rocks.

Chalcopyrite is the primary hypogene copper mineral in both skarn and unenriched intrusive rocks. Without secondary chalcocite enrichment, however, little other than the skarns would be of ore grade. Cretaceous elastic sedimentary rocks, and the quartz diorite porphyry sills within surrounding sedimentary rocks, are also secondarily enriched, frequently to ore grade. The upper Paleozoic rocks, though extensively altered, were typically reactive to descending supergene solutions and, consequently, were not greatly susceptible to secondary enrichment. Subsequent oxidation of the chalcocite enrichment blanket has resulted in the formation of some of the better-known secondary copper minerals in the deposit, including native copper, cuprite, libethenite, and turquoise (see list). Specimen-grade native copper and cuprite were extensively collected in late 1993 and early 1994, when numerous samples of coarsely crystalline copper with coatings of cubic cuprite crystals were found during mining in the East Pit area of the mine.



## Minerals Reported from the Santa Rita District, Grant County, New Mexico

### Native Elements

Copper	Cu
Gold	Au
Silver	Ag

### Sulfides and Sulfosalts

Bornite	$\text{Cu}_5\text{FeS}_4$
Chalcocite	$\text{Cu}_2\text{S}$
Chalcopyrite	$\text{CuFeS}_2$
Covellite	$\text{CuS}$
Digenite	$\text{Cu}_9\text{S}_5$
Djurleite	$\text{Cu}_{31}\text{S}_{16}$
Galena	$\text{PbS}$
Idaite	$\text{Cu}_3\text{FeS}_4$
Molybdenite	$\text{MoS}_2$
Pyrite	$\text{FeS}_2$
Pyrrhotite	$\text{Fe}_{1-x}\text{S}$
Stibnite	$\text{Sb}_2\text{S}_3$
Tetrahedrite	$(\text{Cu,Fe})_{12}\text{Sb}_4\text{S}_{13}$

### Oxides

Cuprite	$\text{Cu}_2\text{O}$
Goethite	$\alpha\text{-Fe}^{+3}\text{O}(\text{OH})$
Hematite	$\alpha\text{-Fe}_2\text{O}_3$
Ilmenite	$\text{FeTiO}_3$
Ilsemanite	$\text{Mo}_3\text{O}_8 \cdot n\text{H}_2\text{O}$
Magnetite	$\text{Fe}_3\text{O}_4$
Pyrolusite	$\text{MnO}_2$
Rutile	$\text{TiO}_2$
Tenorite	$\text{CuO}$

### Carbonates

Azurite	$\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$
Calcite	$\text{CaCO}_3$
Cerussite	$\text{PbCO}_3$
Malachite	$\text{Cu}_2\text{CO}_3(\text{OH})_2$
Rhodochrosite	$\text{MnCO}_3$
Siderite	$\text{FeCO}_3$

### Sulfates

Alunite	$\text{KAl}_3(\text{SO}_4)_2(\text{OH})_6$
Brochantite	$\text{Cu}_4(\text{SO}_4)(\text{OH})_6$
Chalcanthite	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
Gypsum	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
Jarosite	$\text{KFe}^{+3}_3(\text{SO}_4)_2(\text{OH})_6$
Siderotil	$\text{FeSO}_4 \cdot 5\text{H}_2\text{O}$
Zinc-melanterite	$(\text{Zn,Cu,Fe})\text{SO}_4 \cdot 7\text{H}_2\text{O}$

### Phosphates/Nanadates

Apatite	$\text{Ca}_5(\text{PO}_4)_3(\text{F,OH,Cl})$
Beraunite	$\text{Fe}^{+2}\text{Fe}^{+3}_5(\text{PO}_4)_4(\text{OH})_5 \cdot 4\text{H}_2\text{O}$
Dufrenite	$\text{Fe}^{+2}\text{Fe}^{+3}_2(\text{PO}_4)_3(\text{OH})_5 \cdot 2\text{H}_2\text{O}$
Leucophosphite	$\text{KFe}_2^{+3}(\text{PO}_4)_2(\text{OH}) \cdot 2\text{H}_2\text{O}$
Libethenite	$\text{Cu}_2\text{PO}_4(\text{OH})$
Meurigitte	$\text{KFe}_7^{+3}(\text{PO}_4)_5(\text{OH})_7 \cdot 8\text{H}_2\text{O}$
Mottramite	$\text{Pb}(\text{Cu,Zn})\text{VO}_4(\text{OH})$
Phosphofibrite	$\text{KCuFe}^{+3}_{15}(\text{PO}_4)_{12}(\text{OH})_{12} \cdot 12\text{H}_2\text{O}$
Pseudomalachite	$\text{Cu}_5(\text{PO}_4)_2(\text{OH})_4$

### Silicates

Actinolite	$\text{Ca}_2(\text{Mg,Fe})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$
Allanite	$(\text{CaCeY})_2(\text{Al,Fe})_3(\text{SiO}_4)_3(\text{OH})$
Biotite	$\text{K}(\text{Mg,Fe})_3(\text{Al,Fe})\text{Si}_3\text{O}_{10}(\text{OH,F})_2$
Chlorite	$(\text{Fe,Mg,Al})_6(\text{Si,Al})_4\text{O}_{10}(\text{OH},\text{O})_8$
Chrysocolla	$(\text{Cu,Al})_2\text{H}_2\text{Si}_2\text{O}_5(\text{OH})_4 \cdot n\text{H}_2\text{O}$
Cristobalite	$\text{SiO}_2$
Diopside	$\text{Ca}(\text{Mg,Fe})\text{Si}_2\text{O}_6$
Dioptase	$\text{CuSiO}_2(\text{OH})_2$
Epidote	$\text{Ca}_2(\text{Al,Fe}^{+3})_3(\text{SiO}_4)_3(\text{OH})$
Garnet	$(\text{Ca,Fe}^{+2})_3(\text{Al,Fe}^{+3})_2(\text{SiO}_4)_3$
Halloysite	$\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$
Hornblende	$\text{Ca}_2(\text{Mg,Fe,Al})_5(\text{Si,Al})_8\text{O}_{22}(\text{OH})_2$
Illite	$(\text{K,H}_3\text{O})(\text{Al})_2(\text{Si,Al})_4\text{O}_{10}[(\text{OH})_2\text{H}_2\text{O}]$
Ilvaite	$\text{Ca Fe}^{+2}_2 \text{Fe}^{+3}(\text{SiO}_4)_2(\text{OH})$
Kaolinite	$\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$
Montmorillonite	$(\text{Na,Ca})_{0.3}(\text{Al,Mg})_2\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot n\text{H}_2\text{O}$
Muscovite	$\text{KAl}_2(\text{Si}_3\text{Al})\text{O}_{10}(\text{OH})_2$
Nontronite	$\text{Na}_{0.3}\text{Fe}_2(\text{Si,Al})_4\text{O}_{10}(\text{OH})_2 \cdot n\text{H}_2\text{O}$
Opal	$\text{SiO}_2 \cdot n\text{H}_2\text{O}$
Orthoclase	$\text{KAlSi}_3\text{O}_8$
Pigeonite	$(\text{Mg,Fe}^{2+})_2\text{CaSi}_2\text{O}_6$
Plagioclase	$(\text{Na,Ca})\text{Al}(\text{Al,Si})\text{Si}_2\text{O}_8$
Quartz	$\text{SiO}_2$
Sanidine	$(\text{K,Na})(\text{Al,Si})_4\text{O}_8$
Shattuckite	$\text{Cu}_5(\text{SiO}_3)_4(\text{OH})_2$
Talc	$\text{Mg}_3\text{Si}_4\text{O}_{10}(\text{OH})_2$
Titanite	$\text{CaTiSiO}_5$
Torbernite	$\text{Cu}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 8\text{-}12\text{H}_2\text{O}$
Tremolite	$\text{Ca}_2(\text{Mg,Fe}^{+2})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$
Turquoise	$\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 4\text{H}_2\text{O}$
Wollastonite	$\text{CaSiO}_3$
Zircon	$\text{ZrSiO}_4$

**The Wall**  
**A mine and its minerals preserved for the future**

(Location 4 on index map)

Jack A. Murphy  
Geology Curator  
Denver Museum of Natural History  
Denver, CO 80205

Jack D. Thompson  
Voluntary Geology Associate  
Denver Museum of Natural History  
Denver, CO 80205

High in the Colorado Mosquito Mountain range, near Alma, in Park County is located the Sweet Home mine. The Sweet Home, while a very poor silver producer, has produced the largest and finest rhodochrosite crystals, as well as some 30 other minerals.

When Bryan Lees of Collector's Edge reopened the old mine in 1991, Jack Murphy said he wished for and dreamed of a rhodochrosite vug, or pocket, recreated in the museum. This came closer to reality in September 1994, when we received telephone calls to come take a look, as well as take some photos.

Three years later, made possible by a grant from the Adolph Coors Foundation, the pocket stands as "The Wall" in the Mineral Hall's mine tunnel.

The slide presentation will show photos of mining and specimen removal, cleaning and layout, reconstitution and assembly, remodeling and installation. It will also show photos of other minerals found in the Sweet Home mine. From 11,000 ft high and thousands of feet under Mt. Cross, the Sweet Home mine and "The Wall" have become a collector's and curator's dream.

## Quartz epimorphs from the Hermosa district, Sierra County, New Mexico

(Location 5 on index map)

Virginia T. McLemore  
NMBMMR  
Socorro, NM 87801

Joe Glines  
Albuquerque, NM

Virgil Lueth  
NMBMMR  
Socorro, NM 87801

The Hermosa or Palomas district is in western Sierra County and includes part of the eastern foothills of the Black Range. Harry W. Elliott discovered silver deposits in 1879 at the American Flag and Flagstaff areas, and by 1904 the areas had produced approximately \$1.25 million. By 1885, Hermosa was booming and boasted of a 20-tpd concentrator and a 1-tpd adobe smelter. Mining in the district nearly ceased in 1891 with the drop in silver prices. Sporadic activity continued into the 1900s, but never at previous production levels. Last known exploration activity occurred in 1980-81 by Brass Ring Resources, Ltd., followed by Triple S Development Co. in 1981-83. Total production from 1879 to 1957 is approximately 1.25 million oz Ag, 47,600 lbs Pb, 8,000 lbs Zn, 1,850 lbs Cu, and 3 oz of Au worth approximately \$2 million from carbonate-hosted Ag-Mn replacement deposits. Much of the early silver production probably was never reported.

Palomas Creek has exposed more than 1,000 ft of Ordovician through Mississippian limestones and dolomites of the Aleman, Cutter, Fusselman, and Oilate Formations that strike N60°E and dip 20-30° NE. Locally Tertiary latite and andesite flows, breccias, and tuffs overlie the sedimentary rocks. Mineralized zones are restricted to three stratigraphic horizons: 1) Upper Ordovician—Silurian Upham, Aleman, Cutter, and Fusselman dolomites, 2) the Lake Valley and Kelly Limestones, and 3) Madera limestone. Two steeply dipping (N38°W and N60-70°E) normal fault systems offset the stratigraphic section and provided conduits for mineralizing fluids.

Mineralized zones occur along or adjacent to the faults as manto-like replacement bodies, fissure veins, and breccia fillings in limestone. Deposits in the Ordovician—Silurian dolomites typically lie beneath the Percha Shale. Individual orebodies range in size from a few short tons to as much as 5,000 short tons. Primary ore minerals include argentite, galena, sphalerite, chalcopryrite, bornite, pyrite, and gold in a gangue of calcite, barite, quartz, clay, and talc. Talc generally surrounds most orebodies. Secondary minerals include azurite, cerussite, chalcocite, chrysocolla, cuprite, descloizite, malachite, mimetite (Pbs(As04)3C1), smithsonite, vanadinite, and wulfenite. Wulfenite is locally present as small cubes. Silver is the predominant metal, although lead and zinc occur locally in significant quantities (as much as 40% combined Pb and Zn). Gold rarely exceeds 0.05 oz Au/ton. Silicification is common, especially along faults. Fluid-inclusion and stable-isotopic studies indicate that the mineralization occurred at 220-300°C from low salinity (0-9 eq. wt.% NaCl) meteoric fluids with local magmatic input (Bazrafshan, 1989). Fluid-inclusion studies (Bazrafshan, 1989), alteration assemblages, and textural features (V. T. McLemore, unpublished field notes, December 29, 1995) indicate that boiling probably occurred and may have been a mechanism of deposition.

Shepard (1984) reported quartz pseudomorphs after galena in the American Flag—Flagstaff area. The "pseudomorphs" occur within silicified zones in and near the American Flag, Flagstaff, and Pelican mines. Clusters of pseudocubic to pseudo-octahedral "crystals" as large as 2-4 inches across occur in vugs and solution cavities. The morphological resemblance to galena led Shepard (1984) to believe that they were pseudomorphs after galena. Crystallographic and petrographic analyses of the "pseudomorphs" indicate that they are actually calcite crystals

overgrown or replaced by quartz. The thin coating of quartz and subsequent dissolution of the calcite produced the epimorphs ("over forms"). The epimorphs are typically hollow inside and consist of successive layers of chalcedony (initially amorphous silica?) and very fine grained quartz crystals with a final coating of sugary quartz. Freshly broken epimorphs locally contain calcite. "Fossilized" rhombohedral cleavage traces are also preserved by the quartz in some samples. Goniometric measurements of the crystal faces preserved by the epimorphs are consistent for rhombohedral crystals. Interfacial angles measured from complexly twinned galena from the district do not match those of the epimorphs.

One mechanism proposed for the origin of the quartz epimorphs is boiling. Fluid inclusion data are consistent with boiling at the American Flag—Flagstaff mines (Bazrafshan, 1989). In most natural waters, cooling without boiling causes calcite to dissolve. However, when an ascending carbonate-rich fluid boils as a result of cooling adiabatically, then calcite will precipitate as a result of a loss of CO<sub>2</sub>. Once CO<sub>2</sub> is lost, boiling stops but the cooler water continues to ascend and dissolves the calcite. On the other hand, quartz is deposited as a result of cooling of hydrothermal waters and therefore, quartz simultaneously replaces the calcite. The deposition of chalcedony (amorphous silica?) prior to drusy quartz is consistent with this interpretation. The rising fluids begin to boil again and the process is repeated until CO<sub>2</sub> is completely removed from the system.

#### References

- Bazrafshan, K., 1989, Geology and geochemistry of the Hermosa mining district, Sierra County, New Mexico: Ph.D. dissertation, New Mexico Institute of Mining and Technology, Socorro, 470 pp.
- Shepard, M. D., 1984, Geology and ore deposits of the Hermosa mining district, Sierra County, New Mexico: Unpublished M. S. thesis, University of Texas (El Paso), 215 pp.

## New Mexico's industrial minerals from A to Z

George Austin

New Mexico Bureau of Mines and Minerals Resources  
New Mexico Institute of Mining and Technology  
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Industrial minerals consist of a large number of nonmetallic, nonfuel, nongem materials that can be solid, liquid, or gas; that can be natural or man-made; and that are used for their physical and/or chemical properties. The list stretches literally from A (aggregates) to Z (zeolites). In New Mexico, the value of industrial minerals ranks a distant third behind oil and gas and copper, but still accounts for about 8-10% of the value of the state's natural resource production, which is currently about \$5-6 billion annually.

**Aggregate** (both sand and gravel and crushed stone) continues to be New Mexico's largest-volume industrial mineral product. Pits and quarries are present in all of the state's counties but Harding County. In value, it follows potash. In 1996, the average cost of a ton of gravel purchases at an Albuquerque quarry was \$2.65. Because transport is a major cost of aggregate that same ton of gravel delivered to a site 50 miles away was \$6.55.

**Cement** is produced at the state's only cement plant at Tijeras east of Albuquerque. The limestone is quarried locally. Alumina is supplied from bottom ash generated at the Prewitt power plant near Grants. Iron comes from byproduct magnetite produced by copper mills in Grant County. Gypsum comes from White Mesa near San Ysidro northwest of Bernalillo.

Although **gypsum** is exposed in many places in New Mexico, sizeable production is limited to White Mesa near San Ysidro in Sandoval County. This mine principally supplies a wallboard plant near Bernalillo, in addition to the cement plant at Tijeras.

**Humates** are humic acid-rich carbonaceous shales, claystones, or weathered coal. In New Mexico, humate is mined from Cretaceous coal-bearing sedimentary rocks in the northwest part of the state. It is processed in state and shipped mostly out of state and used principally to replenish impoverished organic-poor soils.

Muscovite **mica** is produced from Precambrian mica schist in the Picuris Range about 20 mi south of Taos. This is the only mica mine east of the Appalachian Mountains. White muscovite mica is used in joint compounds, paint, oil well drilling muds, roofing, rubber, and cosmetics.

With three very large **perlite** mines and one small one, New Mexico ranks first nationally in perlite production. Two mines are in north-central part of the state at No Agua Peaks about 20 mi south of the Colorado border, one is about 8 mi northeast of Grants, and the last is about 1 mi southwest of Socorro. Together these mines quarry about 80% of the nation's production of perlite. All production is shipped out of state and expanded into a lightweight, nonflammable, cellular aggregate that is chemically inert and has high-insulating ability.

New Mexico, the leading domestic producer of **potash**, is responsible for about 85% of the total national output. Three different products are produced by the two remaining operations east of Carlsbad. The main product is sylvite (KCl), which contains about 63% **K<sub>2</sub>O** by weight, followed by langbeinite (K<sub>2</sub>SO<sub>4</sub>\*2MgSO<sub>4</sub>) with about 23% K<sub>2</sub>O, and by an artificial potassium sulfate product (K<sub>2</sub>SO<sub>4</sub>) with about 54% K<sub>2</sub>O. In 1995, the average price for a short ton of potash product was \$173.49.

New Mexico ranks second in the nation in the production of pumice. Mines are on the east and south flanks of the Jemez Mountains in the north-central part of the state. Premium-grade pumice (lumps greater than 1.9 cm) demands higher prices and is used to prepare stonewashed fabrics. Smaller-lump ore is used as lightweight aggregate in concrete blocks and other building products, abrasives, absorbents in potting soils, loose-fill insulation, fillers, and filter media.

Zeolite is produced at a mine south of the old mining district of Winston, about 30 mi west of Truth or Consequences. Ore with 50-85% clinoptilolite is quarried, crushed, and screened for use as animal bedding and in feed, in water-filtration systems, and environmental cleanup products.

New Mexico produces many other industrial minerals, but of smaller value and/or in smaller volumes. They include brick, clay, lime, shale, salt, silica flux, and stone. Still others, notably barite, feldspar, and fluorite, are not produced now but were in the past.

## **The micromount minerals of the Denver Museum of Natural History**

(Location 6 on index map)

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Some statistics on the Paul Seel micromount collection in the Denver Museum are:

301 quartz crystals, many showing unusual crystal faces;  
198 topaz crystals, many crystal forms shown;  
12,000+ specimens of which 11,142 are currently cataloged;  
803 species;  
98 countries represented;  
367 specimens from type localities;  
110 minerals from type localities;  
1,518 Specimens in rakestraw boxes with an age of 50+ yrs;  
5,000+ diamond crystals showing many crystal forms; and  
98 unknowns.

In the Denver Museum of Natural History there are three other micromount collections, Zimmerman, Anderson, and Withers collections containing 3,669 specimens; 729 species, 188 of which are not duplicated in the Paul Seel collection; and 76 unknowns.

From Arizona there are 822 specimens from 42 localities representing 88 species.  
From Colorado there are 345 specimens from 50 localities representing 75 species.  
From New Mexico there are 273 specimens from 26 localities representing 65 species.  
From Texas there are 30 specimens from 8 localities representing 10 species.  
From Utah there are 423 specimens from 33 localities representing 68 species.

In 1992, Paul and Hilde Seel's mineralogic friends, P. Barand, B. Bachet, and C. Brassy of the University Pierre and Marie Curie in Paris, France, named a new mineral in their honor, seelite. Paul and Hilde were very much a part of the mineral-collecting hobby. They traveled all over the world attending meetings, giving lectures, collecting and trading specimens while making friends. Paul and Hilde were a warm, generous couple and it was always a pleasure to be with them. Paul died in 1982 and Hilde died in 1987. His micromount collection of more than 12,000 specimens was donated to the Denver Museum of Natural History and is the largest part of the museum micromount collection. This is one of the largest cataloged micromount collections in a United States museum that is documented and available for research.

Selected slides of some of the unusual specimens will be shown.

## A fourth world occurrence of foitite at Copper Mountain, Taos County, New Mexico

(Location 7 on index map)

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Foitite, the newest member of the tourmaline group, is the alkali-deficient and aluminous analog of schorl. It was originally described from two isolated crystals labeled merely "southern California" and has since been recognized as zones in hairlike fibers in cavities in pegmatite at the classic Elba locality of Filone della Speranza. A new foitite occurrence (third world occurrence) was identified at the Tungsten or Wichita mine on Copper Mountain, in the Picuris Range, Taos County, New Mexico, which is about 21/2 mi northeast of the famous Harding mine. This is a wolframite deposit mentioned briefly by Hess in *Tungsten mineials and deposits* (U.S.G.S. Bulletin 652). Here foitite is found as brown, cross-fiber veins 2 cm wide in quartz. It was analyzed as part of a larger study by Dyar et al. (submitted to the *American Mineralogist*) by a combination of modern techniques to provide a thorough characterization of its chemistry. Methods included electron microprobe analysis for the major elements, proton-induced gamma-ray emission analysis (PIGE) for lithium, boron, and fluorine, Mossbauer spectroscopy for the ferrous/ferric ratio, and uranium extraction for hydrogen. The results yield a formula with no ferric iron, only 0.35 sodium atoms in the X site, ferrous iron and aluminum dominating the Y site, and a deficiency of 1.37 protons. This is an unusual tourmaline, clearly a foitite, and the data suggests that both the alkali-defect and dehydroxylation substitution mechanisms identified by Foit and Rosenberg (1977) are operative in this sample.



## Two diverse origins for turquoise at the Orogrande mining district, Otero County, New Mexico

(Location 8 on index map)

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Turquoise,  $\text{Cu}^{+2}\text{Al}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 4\text{H}_2\text{O}$ , occurs in two distinctly different geological environments in the Orogrande district, Otero County, New Mexico. The two deposits are hosted in different rock types. Associated vein mineral and gangue assemblages are also variable between the deposits. Turquoise also has distinctly different physical character at each deposit. The individual features at each deposit suggest a different model origin for the turquoise.

**Providence (a.k.a. DeMueles) mine area**—The Providence mine is near the terminus of an old railroad grade near the Cinco de Mayo and Iron Duke iron skarn deposits. The turquoise is hosted by altered quartz monzonite. The quartz monzonite represents the main-stage plutonism in the district. Alteration assemblages typical of porphyry copper systems are present. The dominant hydrothermal alteration stage is quartz-sericite with a superimposed weathering assemblage of kaolinite and limonite (jarosite). The turquoise occurs as vein fillings and nodules in veins. Most of the material on the surface of the dumps is faded. Freshly broken fractures containing turquoise and unfaded material on the dump are deep sky blue. The material tends to be thin but hard. Associated minerals are limited and consist mainly of kaolinite and mixed iron oxides (limonite) with minor gypsum. On the margins of mineralization the turquoise grades into jarosite veins. This feature is similar to the reported turquoise occurrences at Hatchita, New Mexico.

**Iron Mask mine area**—The Iron Mask mine approximately halfway between the Lucky and the Cinco de Mayo mines. Most of the mining in this area was for iron, hosted in skarn and as large magnetite blocks cemented by caliche. The turquoise deposits are immediately southwest of the Iron Mask workings. Turquoise occurs as vein fillings and nodules in a 7-meter-thick shale unit in the Laborcita Formation (upper Pennsylvanian to lower Permian). The most unusual feature of this deposit is the association of abundant gypsum and halite with the turquoise. Most of the turquoise is chalky and light colored. Occasional hard nuggets or veins are encountered but it is uncommon. The material tends to be lighter blue than that from the Providence mine. No turquoise was observed in rocks outside the shale formation. Jarosite and copiapite are found on the margins of turquoise mineralization as replacement masses.

Three models for the origin of turquoise have been presented by previous investigators. These models include (1) magmatic-related processes, e.g. hydrothermal alteration; (2) contact metasomatic processes; and (3) weathering-related (supergene) processes. The geologic relationships and mineral assemblages suggest a weathering mode of formation for the turquoise at both deposits at Orogrande.

At the Providence mine, weathering of disseminated pyrite and chalcopyrite in the monzonite porphyry led to the formation of acid waters and provided a source of copper. Percolating acid waters altered feldspar to kaolin and dissolved some aluminum. The same acid waters weathered disseminated apatite as a source for phosphorous. The solutions were

concentrated along fractures where the turquoise precipitated. "Spent" solutions (lacking copper and phosphorus) precipitated jarosite and gypsum-goethite on the margins of the turquoise-mineralized area.

A different weathering model is required for the turquoise deposits at the Iron Mask locality. Pyrite replacement deposits occur above and in the upper portions of the host shale. The oxidation of these pyrite deposits (which show copper staining) led to the formation of acid sulfate waters. The acid sulfate waters percolated along fractures and through the shale and reacted with colophane-rich (probably carbonate-hydroxylapatite,  $\text{Ca}_5(\text{PO}_4, \text{CO}_3)_3(\text{OH})$ , because fluorite was not observed) zones to form the turquoise. The abundance of gypsum is an artifact of the acid sulfate alteration. The presence of jarosite and copiapite on the margins of the shale are also reaction products of the pyrite oxidation.

## Update on the mineralogy of the San Juan Mountains, southwestern Colorado

(Location 9 on index map)

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Mining in the San Juan Mountains is history, with all major mines shut down and little hope of any new operations starting up. Reclamation of mining sites is in progress along with an active program of permanently closing the mine openings.

Usually, mine-land reclamation projects destroy or severely hamper collecting at mine sites, but the reverse is true at the National Belle mine. Removal of the dump for stream diversion exposed low-grade ore mined in the 1880s that produced many fine specimens of barite, covellite, enargite, pyrite, tennantite, and sulfur.

Underground collecting at the Pilot mine before the adits were sealed produced fine specimens of scepter quartz, kutnohorite with calcite, and pyrite epitaxially oriented on marcasite.

Anatase, brookite, and rutile continue to be found at new localities throughout the San Juan Mountains. Probably the best locality is the Silver Mountain and Indiana mines, which are located on the same vein. The anatase occurs as beautiful blue-black microcrystals on clear quartz crystals. Brookite occurs as honey-yellow to medium-brown tabular crystals that range to 0.5 mm long. Rutile occurs as lathlike pale-brown crystals to 0.1 mm that are crystallized on either brookite or quartz.

The Oyama mine, near the top of Stony Pass, has produced beautiful groups of iridescent amber to dark-brown siderite that occurs as single crystals and as groups of stacked parallel-growth crystals. This locality has also produced scepter amethyst crystals to 2 cm long.

The Grizzly Bear mine, in addition to beautiful rhodochrosite crystal groups, has produced rare crystallized minerals including brookite, anatase, and bismuthinite.

Continued collecting at accessible mine dumps and remote localities should produce new finds in future years. Because mining seems to be an industry of the past, we can now sit down and write our memoirs before they fade from memory.

## Lazulite occurrences in southern New Mexico

(Location 10 on index map)

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At the end of the last century, a time of intense exploration in New Mexico, remote areas of the territory were reached by prospectors, and more exotic resources were found. One of these was recorded by Carrera (in Prince, 1891): "There is said to exist up in the craggy peaks of the eastern slopes of the Organ Mountains large bands of lapis lazuli, a very valuable stone, made so both by its extreme rarity and matchless beauty." Farther east, in the Sacramento Mountains around 1904, an unusual blue-banded stone was quarried for building stone. The rock did not hold up to weathering and quarrying was halted. In both cases the blue mineral was misidentified and its significance unexplored.

The location of the lapis lazuli (lazurite  $(\text{Na,Ca})_{7-8}(\text{Al,Si})_{12}(\text{O,S})_{24}[(\text{SO}_4)_2(\text{Cl})_2(\text{OH})_2]$ ) in the Organs was never properly reported in Prince (1891) and was repeated by Northrop (1944). When the area was mapped in some detail, Seager (1981) reported azurite present near the contact of the granite of Granite Peak with a roof pendant. Suspicious of these early reports, the area was explored and lazulite  $\text{MgAl}_2(\text{PO}_4)_2(\text{OH})_2$ , not lazurite or azurite, was found. The lazulite occurrence in the Sacramento Mountains was mapped in detail by the United States Geological Survey during the White Mountain Wilderness study, but lazulite was not identified. It was recently recognized during a reconnaissance geological trip.

In the Organ Mountains lazulite occurs in veins with muscovite (occasionally a dense blue-green variety), quartz, hematite, and jarosite hosted by a sericitized tuffaceous sandstone. The lazulite occurs in a roof pendant in close proximity to a pyritized zone in the granite of Granite Peak, the latest stage of granitic plutonism recognized in the Organ batholith. A red *unidentified* mineral is also associated with the lazulite.

At the Sacramento Mountains occurrence in Bluefront Canyon, the lazulite occurs in an altered quartzite. The rock contains corundum (v. sapphire) and alunite in addition to the quartz. The lazulite and corundum occur in bands that appear blue. The light-colored bands consist mostly of quartz. The blue bands of lazulite have reaction rims on their margins.

The origin of the lazulite is still under study. The geologic and mineralogic relationships suggest phosphate metasomatism associated with late-stage crystallization of a granitic magma gave rise to the lazulite veins. However, alteration of a phosphate-rich host rock is also possible. Porphyry-type molybdenum mineralization is in close proximity in both instances.

### References

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