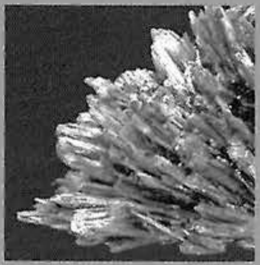
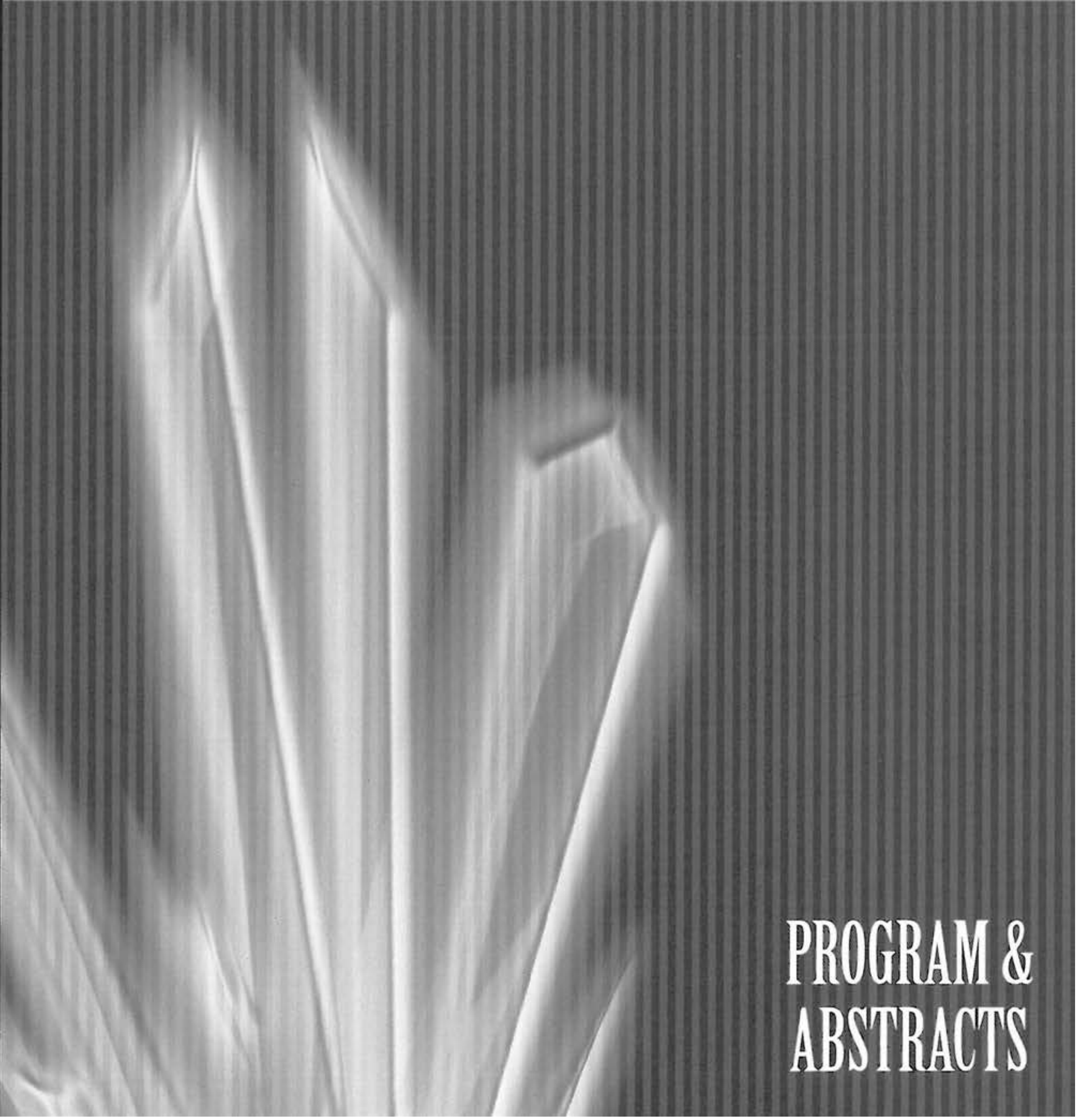
ANNUAL NEW MEXICO MINERAL SYMPOSIUM

27th Annual
New Mexico
Mineral Symposium

November 11 & 12, 2006





PROGRAM &
ABSTRACTS

27th Annual
New Mexico
Mineral Symposium

November 11 & 12, 2006

New Mexico Bureau of Geology and Mineral Resources
A Division of New Mexico Institute of Mining and Technology

Socorro 2006

Welcome to

THE TWENTY-SEVENTH ANNUAL

NEW MEXICO MINERAL SYMPOSIUM

November 11 and 12, 2006

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

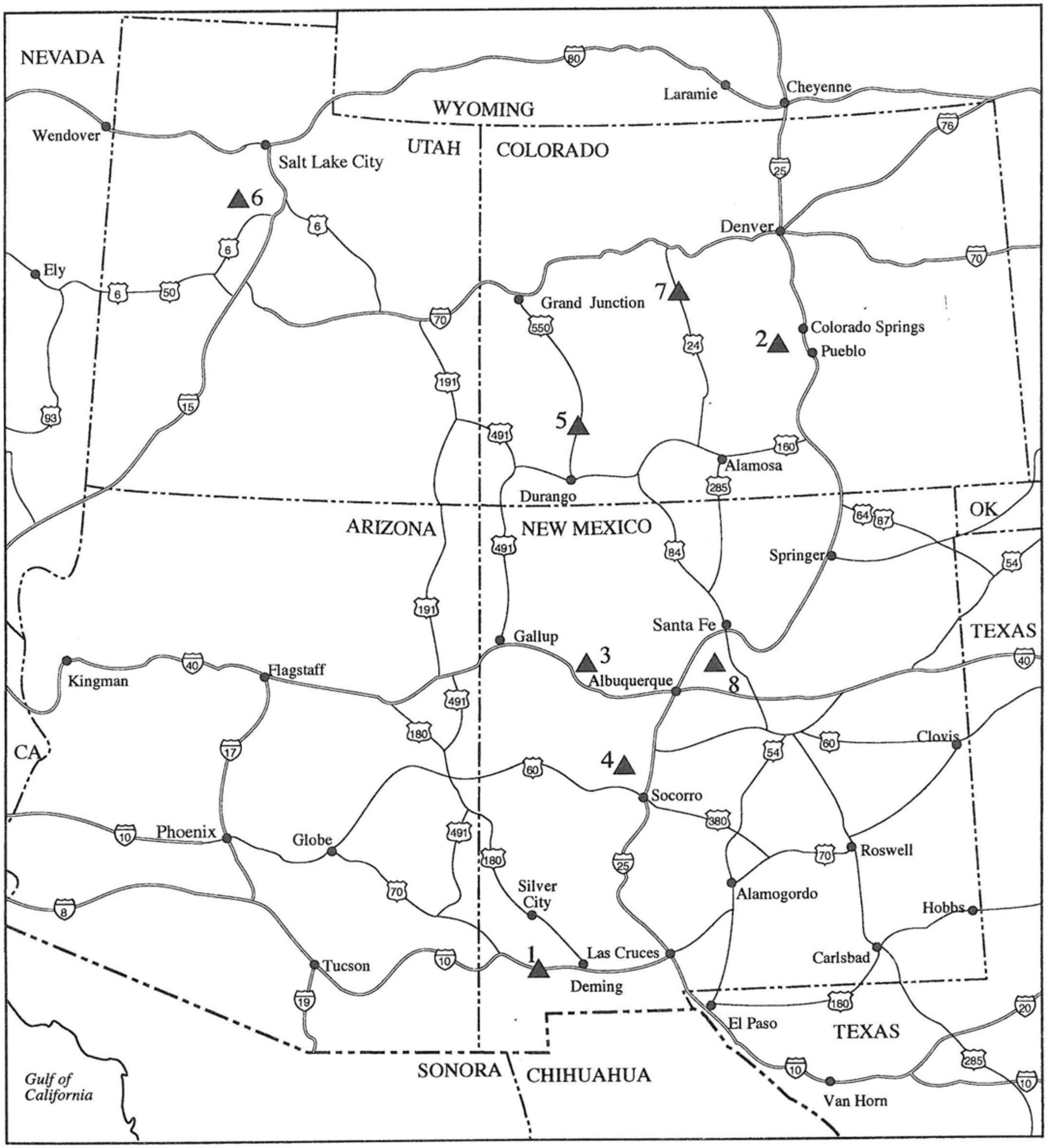
The Mineral Symposium is organized each year by the Mineral Museum at the New Mexico Bureau of Geology and Mineral Resources.

Sponsors this year include:

Albuquerque Gem and Mineral Club
Chaparral Rockhounds
Los Alamos Geological Society
New Mexico Geological Society Foundation
Friends of Mineralogy

The New Mexico Mineral Symposium provides a forum for both professionals and amateurs interested in mineralogy. The meeting allows all to share their cumulative knowledge of mineral occurrences and provides stimulus for mineralogical studies and new mineral discoveries. In addition, the informal atmosphere allows for intimate discussions among all interested in mineralogy and associated fields.

New Mexico minerals on the cover: top left - pyrolusite, top right - halite, bottom left - malachite pseudomorph of linarite, and bottom right - magnetite.



Geographic Index Map
27th New Mexico Mineral Symposium

27th Annual New Mexico Mineral Symposium
11-12 November 2006

Schedule

Numbers in parentheses refer to geographic location on the index map.

Friday, November 10, 2006

6:00 pm Informal tailgating and social hour, individual rooms, Super 8 Motel (# 1 on map)
FREE

Saturday, November 11, 2006

8:30 am Registration, Macey Center; continental breakfast
9:20 *Opening remarks,* main auditorium
9:30 *Chasing the Green Goddess: Dioptase in New Mexico—Bob* Walstrom (1)
10:00 *The Cross and Penrose rock collection of Cripple Creek: The foundation of fortunes and GSA's inheritance—Steve* Veatch (2)
10:30 Coffee break
11:00 *Selected minerals from the Grants uranium district—Ray* DeMark (3)
11:30 *A new zeolite occurrence in the Bear Mountains, Socorro County, New Mexico—*
Dylan Canales and Robert Sanders (4)

12:00 pm Lunch

1:00 Museum tours
2:00 *Basal (c) face quartz, its history and occurrences—Jim* Hurbut
2:30 *Sneffels mining district, Ouray County, Colorado—Tom* Rosemeyer (5)
3:00 Coffee break
3:30 *The Hidden Treasure mine, a mineral collector's paradise—Joe* Marty (6)
4:00 *The Leadville silver deposit—Ed* Raines, featured speaker (7)
5:30 Sarsaparilla and suds: cocktail hour, cash bar
6:30 Dinner followed by an auction to benefit the New Mexico Mineral Symposium

Sunday, November 12, 2006

8:15 am Morning social, coffee and donuts
9:15 *Welcome to the second day of the symposium and follow-up remarks*
9:25 *Unusual quartz crystal growth habits—Jack* Thompson
9:55 *Pegmatites and pegmatite districts of New Mexico—Peter* Modreski
10:25 Coffee break
10:55 *Scheelites of the Old and New Placers—Jerry* and Philip Simmons (8)
11:25 *Extraterrestrial mineralogy—An update on Martian minerals—Virgil* W. Lueth

12:00 pm Lunch

1:15- Silent auction, upper lobby, Macey Center, sponsored by the Albuquerque Gem
3:00 and Mineral Club for the benefit of the Mineral Museum (FREE)

Chasing the green goddess: Dioptase in New Mexico

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Nature provides a wide variety of green minerals for collectors to choose from: epidote, beryl, uvarovite, microcline, fluorite, brochantite, malachite, and a host of others. However, there is one mineral that seems to stand out in this group: dioptase. The type locality for dioptase is the Altyn-Tyube deposit in Kazakhstan. Worldwide localities include Argentina, Australia, Congo (Zaire), Germany, Mexico, Namibia, New Zealand, Peru, and other countries. In the United States, with one or two exceptions, dioptase is found in the more arid regions of southern California, Nevada, Arizona, and New Mexico. Arizona is the most prolific with approximately 30 localities. Next is Nevada with five and California with three. Dioptase possesses a very distinctive color and crystal form, which, once observed, is usually easy to recognize in the field. Although locations are not numerous around the world, specimens are available through a wide price range, from inexpensive to "off the chart." Most general collections usually contain at least one or two specimens of dioptase.

New Mexico seemingly has been left out of the dioptase picture even though the chemistry of deposits is sometimes similar to localities in other states. In Northrop, *Minerals of New Mexico,* 3rd rev. ed., 1996, there are two references to dioptase: F. Jones, 1904, at Orogrande, Otero County, and Thorne, 1931, at Santa Rita, Grant County. Both references merely list dioptase as a component in a brief general list of minerals at those mining areas. A check of the collections at New Mexico Tech as well as several private collections of New Mexico collectors fails to turn up specimens from these two localities. In the summer of 2003, in the course of preparing a report on the Old Hadley district, Cookes Peak, Luna County, dioptase was discovered at the Copper mine. This mine also produced the first New Mexico locality for creaseyite in addition to plancheite/shattuckite, fornacite, murdochite, and other species. In September of 2005, dioptase was found on a dump at the Independence lode, Victorio district, Luna County. Dump material produced excellent specimens of dioptase, and subsequent exploration of underground drifts produced three separate areas for additional recovery. Extensive sampling of the underground system produced the following list of minerals: bind- heimite, cerussite, chrysocolla, dioptase, dolomite, duftite, goethite, hematite, hemimorphite, jarosite, malachite, mimetite, mottramite, pyromorphite, quartz, rosasite, smithsonite, stibnite, and willemite. A number of these minerals are new to the Victorio district. The narrow vein of the Independence, completely enclosed in dolomitic rocks, strikes northeast-southwest and dips very steeply to the northwest. The primary ore is, for the most part, completely oxidized. A few remnants of stibnite can still be found in the vein quartz. The ore occurred as irregular pods of dense pale-yellow and blue oxidized stibnite and galena containing values of gold and silver. Secondary minerals such as bindheimite, willemite, pyromorphite, and dioptase are locally abundant, but other minerals are sparse and scattered throughout the mine.

New Mexico is a prime candidate for additional dioptase discoveries. There are several areas in particular that have possibilities. The Florida, Tres Hermanas, and Peloncillo Mountains contain oxidized lead-zinc-copper deposits associated with carbonate rocks necessary for buffering aqueous solutions that provide a favorable environment for the deposition of dioptase. There are certainly many secondary silicate minerals present in the deposits of southern New Mexico. For instance the author has in his collection willemite, a secondary zinc silicate, from 27 localities in Hidalgo, Luna, and

Grant Counties. So, keep your eyes open, and you might be the one to discover the next dioptase locality in New Mexico. And that will happen only if you are willing to chase the elusive green goddess.

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The Cross and Penrose rock collection of Cripple Creek: **The foundation of fortunes and** GSA's inheritance

Steven Wade Veatch', James Aber', Timothy R. Brown'
'Earth Science Department, Emporia State University
'Cripple Creek and Victor Gold Mining Company

On the western side of Pikes Peak in Colorado, at a site that was once a remote cattle operation known as the Broken Box Ranch, a cowboy named Bob Womack discovered gold in 1891. A gold rush was soon underway: The Cripple Creek mining district was established while local mines began regular gold shipments. The gold mining district, known as "The World's Greatest Gold Camp," grew from a few prospectors after Womack's initial discovery to a peak population of more than 60,000 people. By 1900 the district had more than 500 active mines.

Since 1891 more than 23 million ounces of gold have been produced—making Cripple Creek the third largest gold mining district in the United States and one of the largest gold-telluride districts in the world.

The gold deposits occur within a 7-mi^2, Oligocene (- 30 Ma) alkaline diatreme complex emplaced at the junction of four Precambrian units along the western margin of the Pikes Peak batholith. The complex consists of an upward-flaring volcanic neck filled by heterolithic volcanic breccia with evidence for significant vertical transport during magmatism such as carbonized wood more than 3,000 ft below the current surface. A complex series of alkaline intrusions are found within the diatreme that form composite flows, dikes, sills, laccoliths, and dome-shaped features intruding diatremal breccias and the surrounding Precambrian rocks.

A process of mineralization, spanning about 2 m.y., closely followed the emplacement of the volcanic complex, with most of the gold localized along major structural zones (north-northwest and northeast) within the volcanic complex. The orebodies occur as (1) deposits of rich, narrow gold-telluride veins with quartz, pyrite, rutile, and fluorite and (2) deposits of low-grade, disseminated, microcrystalline, native gold attached to pyrite. Most of the gold mined in the early days of the district came from the high-grade gold-telluride veins.

Cripple Creek had grown rapidly to about 10,000 people by 1894 when the United States Geological Survey (USGS) sent Whitman Cross and Richard A. F. Penrose, Jr., to conduct field work and to prepare a report on the geology and mining of the Cripple Creek goldfields. Richard Penrose's younger brother Spencer was already at the mining camp.

Whitman Cross (1854-1949) was a prominent field geologist who had done most of his field work in the Colorado Rockies where he mapped more than 9,842 km^2 (3,800 mi^2) of southwestern and central Colorado. Much of his mapping was in extremely rugged country that required travel on foot, horseback, and pack train. His major field areas were related to new mining districts and included Cripple Creek, Crested Butte, Telluride, Rico, and the San Juan Mountains. His field parties were recognized as excellent training for young geologists.

Richard Alexander Fullerton Penrose, Jr. (1863-1931), was a mining geologist and an investor who had accumulated great wealth through shrewd investments in mining stocks. He received a Ph.D. degree at the young age of 23. He worked in Texas, Arkansas, Arizona, and Colorado, where he pursued mapping assignments with the USGS and acted as a private consultant.

As part of their geologic investigations of the Cripple Creek mining district, Cross and Penrose made a collection of representative rocks (which still exists today in the Cripple Creek Museum) in 1894 with a particular emphasis on the breccias associated with the

Cripple Creek diatreme complex. The breccias are an important host for gold mineralization in the district.

The Cross and Penrose specimens were carefully prepared in a standard size, measuring approximately 7 x 8 cm each. The specimens were stored in boxes with a label in the bottom of each. Today many of the specimens are either not in boxes or are missing labels. The Cross and Penrose rock collection was recently rediscovered in the Cripple Creek Museum by S. W. Veatch who cleaned, arranged, and photographed the specimens. This collection represented the petrology of the mining district and became the foundation of the USGS report Cross and Penrose made on the Cripple Creek mining district in 1895. This report was important for two reasons: (1) this was the first scientific report on the district and (2) mine owners used this report to raise capital and expand their mines. Spencer Penrose's mine, the C.O.D., was featured in the report and soon sold for $250,000—the largest amount ever paid for mining property at that time in the district.

Not only was this rock collection the basis of the report and the geologic mapping of the district, but it also brought together in Cripple Creek the principal investors of what would become the Utah Copper Company and the inventor of the technique that made the processing of low-grade copper ore profitable—Daniel Jackling (1869-1956). While working in a Cripple Creek mill from 1894 to 1895, Jackling developed relationships with the Penrose brothers and others who would later provide funds for the Utah Copper Company.

Daniel Jackling had been working on new mining and milling methods that would transform mining. His new process included mining with large open pits, using huge mechanical shovels, and having steam locomotives haul ore cars to the mill. A number of mining magnates had turned down Jackling's proposal to mine low-grade copper ore; the problem was that a great amount of capital was needed to get the project going. Spencer Penrose had money to invest and began to listen in earnest to Daniel Jackling. Richard Penrose, who also had the funds to invest, carefully evaluated the project and thought it would work. Richard Penrose also knew that with the dawn of the age of electricity there would be enormous demand for copper.

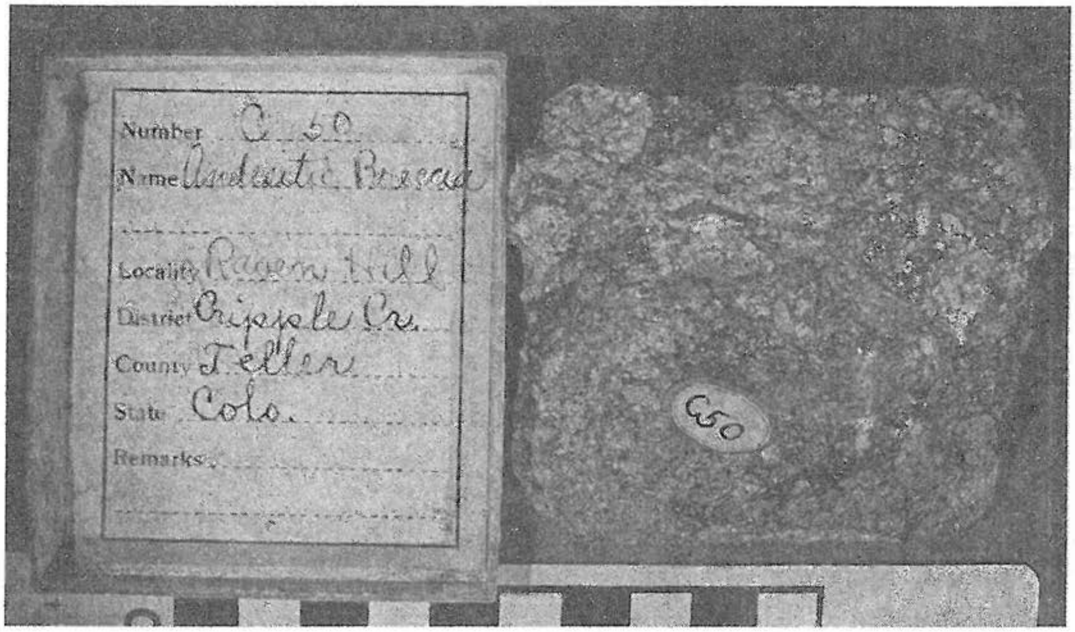
In 1903 Richard Penrose co-founded the Utah Copper Company, the predecessor of Kennecott Copper, in order to develop the rich Bingham Canyon copper deposit in Utah. Although no one in mining circles believed the process would be profitable, the project at Bingham Canyon, called "Jackling's Folly" by its critics, was started. The process turned out to be profitable, and over time the Bingham Canyon ore values became greater than the worth of the Comstock lode, the California and Klondike gold rushes combined, and eventually made the Utah mining operation the richest hole on Earth.

Richard Penrose's interest in the Utah Copper Company brought him considerable wealth. Daniel Jackling also benefited financially from his involvement with the Utah Copper Corporation and was a millionaire by his fortieth birthday. Spencer Penrose, who profited from the Cross and Penrose rock collection and from the Utah Copper Company, established the El Pomar Foundation upon his death to benefit people of the Pikes Peak region and Colorado.

Because of shrewd investing and his interest in the Utah Copper Company, Richard Penrose was able to make a large fortune. At his death (1931), few suspected his true wealth or knew of his will. Penrose had no children or other heirs who could benefit. Most of his estate was equally divided between two scientific organizations, the American Philosophical Society of Philadelphia and the Geological Society of America (GSA).

GSA was founded in 1888 for the purpose of *"the promotion of the science of geology by the issuance of scholarly publications, the holding of meetings, the provision of assistance to research, and other appropriate means."* The organization experienced steady but unremarkable growth to around 600 members by 1930. The single most important event since its founding occurred in 1931, when GSA inherited an endowment of nearly $4 million from the estate of R. A. F. Penrose, Jr.

The Penrose legacy has benefited GSA greatly. His endowment transformed a small unremarkable, scientific society into a world leader in geologic science. Membership has grown to more than 10,000 fellows, professionals, and students. GSA is without question among the largest and most productive geological organizations today. Its success mirrors the diverse and dynamic nature of geology as a key component in global environmental and resource issues that face modern society.



Number C 50
Name Andesitic Breccia
Locality Raven Hill
District Cripple Cr.
County Teller
State Colo.
Remarks

This breccia sample is representative of the Cross and Penrose collection in the Cripple Creek Museum. Photo by S. Veatch.

Selected minerals of the Grants uranium region

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Interest in uranium minerals has substantially waned along with uranium mining in New Mexico during the last 25 yrs. The uranium industry was very active in New Mexico from the early 1950s until 1980 and provided much of the fuel that propelled nuclear power plant development in this country. This industrial development was also accompanied by a tremendous expansion of the study of uranium minerals, particularly in the sedimentary environments that exist in New Mexico. Thirty different uranium minerals have been reported from the Grants uranium region (comprising several districts), along with five uranium/vanadium minerals and 13 vanadium minerals. (Berglof and McLemore 1995; Brookins 1979; Granger 1963; Kittel et al. 1967; Northrop 1996; Rosenzweig 1961). Many of these minerals, particularly the unoxidized species, are black and not noteworthy as specimens. The oxidized species, however, are often brightly colored (yellow and orange) and in some cases have produced exceptional specimens. Uranophane is perhaps the most important of the specimen minerals in the region. Specimens are best developed in the Jurassic Todilto limestone. Bright yellow jackstraw crystals of uranophane in vugs to 10 cm and even larger are some of the finest examples of this mineral in North America. Tyuyamunite and, to a much lesser extent, carnotite are found in well-developed microcrystals in association with uranophane and the common gangue minerals calcite and barite. Three new vanadium minerals were first described from locations in the Grants uranium region. Goldmanite, a vanadium member of the garnet group, was described by Moench and Meyrowitz (1964), Grantsite, a hydrated sodium calcium vanadium mineral described by Weeks et al. (1964), and Santafeite, a complex hydrated vanadate described by Sun and Weber (1958).

Specimens of a bright yellow mineral on coffinite from the Jackpile mine near Laguna were commonly available in the 1970s. This mineral was generally thought to be zippeite [$K_4 (UO_2)_6(SO_4)_3(OH)_{10} \cdot 4H_20$]. Recent microprobe analysis (Hlava, pers. comm. 2006) has determined that this mineral does not contain potassium. Granger (1963) writes that "Most zippeite is nonfluorescent or has a weak yellow fluorescence." The material from the Jackpile mine has a strong green fluorescence. Chemistry and the strong fluorescence of the mineral suggest that it may be uranopilite [$(UO_2)_6(SO_4)(OH)_{10} \cdot 12H_20$]. Positive identification awaits XRD analysis.

East Grants Ridge is a portion of the late Tertiary Mount Taylor volcanic field, which lies southwest of the main peak. Although not geologically connected with the uranium region, it is flanked by uranium districts and is thus included in this paper. The ridge is partially composed of a lithophysal rhyolite that hosts microcrystals of topaz and spessartine. Transparent, colorless to amber-colored topaz crystals to 1 cm are abundant, and transparent, crimson-red crystals of spessartine generally less than 1 mm can be found in the vugs. Some of the spessartine crystals are coated with a drusy layer of bixbyite /hematite crystals (Hlava, pers. comm. 2006).

During the active mining years, many samples of oxidized, post-mining uranium minerals such as andersonite, bayleyite, and zippeite were collected by miners from efflorescents on the walls of the underground mines. Additionally, large numbers of specimens of uranophane, tyuyamunite, and other species were collected from the dumps and stockpiles of Todilto limestone ore in the Poison Canyon area. Active uranium mining in this region is now over. The underground mines have been sealed, and the surface mines and pits have been bulldozed, reseeded, and reclaimed to the extent that specimens are no longer available. With the current resurgent interest in nuclear power as an energy source here in the United States and around the world, perhaps one day uranium mining will re-emerge in New Mexico and fascinating uranium minerals will once again be available.

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Minerals reported from the Grants uranium region

Uranium minerals

Andersonite
Autunite
Bayleyite
Becquerelite
Chernikovite
Coffinite
Cuprosklodowskite
Curite
Johannite
Liebigite
Meta-autunite
Metatorbernite
Novacekite
Phosphuranylite
Rutherfordine
Sabugalite
Saleeite
Schoepite
Schrockingerite
Sklodowskite
Soddyite
Sodium-zippeite
Torbernite
Uraninite
Uranophane
Uranophane-beta
Uranopilite
Weeksite
Zellerite
Zippeite

Vanadium minerals

Barnesite
Corvusite
Doloresite
Goldmanite
Grantsite
Haggite
Hewettite
Metahewettite
Montroseite
Paramontroseite
Pascoite
Roscoelite
Santafeite

Uranium/vanadium minerals

Carnotite
Metatyuyamunite
*Rauvite
Tyuyamunite
*Uvanite

Other minerals

Barite
Calcite
Chalcopyrite
Cryptomelane
Ferroselite
Fluorite
Galena
Goethite
Gypsum
Hematite
Ilsemannite
Jarosite
Jordisite
Kaolinite
Lepidocrocite
Marcasite
Microcline
Molybdenite
Montmorillonite
Muscovite
Nontronite
Prehnite
Psilomelane
Pyrite
Pyrolusite
Quartz
Selenium
Sphalerite
Stibnite
Thenardite
Thermonatrite
Todorokite
Wollastonite
Wurtzite

* ID not confirmed

A new zeolite occurrence in the Bear Mountains, Socorro County, New Mexico

Dylan Canales[1] and *Rob Sanders*[2]

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Chabazite, $(Ca,K,Na)_4(A1_4Si_80_{24})\cdot 12H_20$, occurs as large, well-formed crystals in gas cavities in moderately altered basaltic andesite in the Bear Mountains, New Mexico. Crystals as large as 1.5 inches in diameter line cavities and are also associated with minor scalenohedral calcite and acicular, radiating mesolite, $Na_2Ca_2(A1_6Si_90_{30})\cdot 8H_20$. Other large crystals from this locality have a crystal morphology similar to analcime, $NaAlSi_20_6\cdot H_20$. A single x-ray diffraction analysis indicated a crystal structure of chabazite, but the analcime has not been confirmed.

The zeolite-bearing units are exposed in steep arroyos that have incised the Tertiary volcanic sequences in the area. The economic feasibility of the deposit is currently being evaluated although the size of the deposit appears small and significant tonnages are not expected.

Basal (c) face quartz, its history and occurrences

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As man became interested in minerals and curious about them he gathered and shared information. A major publication by Dr. Victor Goldschmidt, *Atlas der Krystallformen* (1917) depicted several occurrences of quartz crystals showing the basal or c face. Of the publications that Goldschmidt cited as sources of his information, I have only been able to locate one in the library of the Technische Universitat Berlin, a paper by Maskelyne (1877). This paper describes five amethyst quartz crystals showing the c face. A detailed study of the faces on these crystals leads to the conclusion that they all are fourling twins. All were crystals showing no prism faces and suspected of occurring in a geode.

In *Les mineraux de la Belgique* (Buttgenbach 1938), in the chapter on quartz, page 208, the author mentions that in the collection of the University of Liege there is a crystal terminated with the basal plane (0001). This is specimen number 11026 and is still in the collection. The specimen is from Nil-Saint-Vincent.

I have obtained four macro-size crystals showing the basal pinacoid: one amethyst from Bolivia, one amethyst from the Four Peaks mine in Arizona, one smoky crystal from Hidden, North Carolina, and one from the CF&I marble quarry near Monarch Pass, Colorado.

In the micromount collection of the Denver Museum of Nature and Science there are 14 quartz crystals showing the c face. Several occurred in rhyolites, several are from the Amethyst mine at Creede, Colorado, several are from the Olsen ranch, Park County, Montana, and several are from the Ellis Emerald mine, North Carolina. These crystals showing the basal face were popular with micromount collectors, and most museums that have micromount collections will have some in their collections.

The Sneffels mining district, Ouray County, Colorado

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The Sneffels mining district is located approximately 8 mi south of Ouray, Colorado, in Imogene, Sidney, Silver Lake, and Yankee Boy Basins. The district is situated in the heart of the San Juan Mountains and in rugged and beautiful mountainous terrain at elevations over 13,000 ft.

In the 1870s and 1880s, the basins were the scene of intense mining activity and promotions, both miners and promoters hoping to make a fortune on the newly discovered silver deposits. Mines named the Minne B, Circassian, Eldorado, Ruby Trust, Yankee Boy, and Black Diamond sprang to life. Most of these mines were short-lived, lasting only a few years, but a few lingered on until the silver panic of 1893 shut down the remaining mines.

Thomas Walsh discovered rich gold ore in a quartz-sulfide vein in Imogene Basin in 1896. The operation was named the Camp Bird mine and made Walsh a millionaire many times over. The mine operated for almost 100 yrs and produced more than 1.5 million ounces of gold.

Leasers again resumed sporadic activity on the silver veins in the 1920s and 1930s, but production was small. In 1986 a Utah mining group leased the Eldorado group of claims, and an exploration drift was driven on the Eldorado vein. The drift encountered two small silver-bearing orebodies that were mined and produced a variety of fine crystallized minerals.

The silver-bearing veins of the basins occur in Tertiary-age San Juan tuff and the Stony Mountain gabbro-granodiorite intrusion. The veins can be as much as 5 ft wide, and most have a general northwest trend.

Of interest to the mineral collector are a number of mineral species found as well-crystallized microcrystals to thumbnail specimens. Ore minerals found to date include native gold, native silver, polybasite, acanthite, pyrargyrite, tetrahedrite, galena, sphalerite, and chalcopyrite. The gangue minerals in the veins include pyrite, marcasite, arsenopyrite, quartz, barite, rhodochrosite, kutnohorite, dolomite, siderite, and calcite. Of special interest are the globular inclusions of pyrargyrite and tetrahedrite in clear crystals of quartz and barite.

The Hidden Treasure mine: A mineral collector's paradise, Tooele County, Utah

Joe Marty
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The Hidden Treasure mine sits at the top of Dry Canyon in the Oquirrh Mountains with spectacular views of the Stansbury Mountains and Rush Valley to the west. Many world-class specimens of aurichalcite, suites of beautiful secondary copper-zinc minerals, and the rare and spectacular cadmium sulfate mineral niedermayrite were collected there. Ore was first discovered in the Ophir mining district in 1864. During the last 20 yrs, the mines in Dry Canyon were some of the more prolific mineral specimen-producing areas in Utah. Many enthusiasts avidly collected there, especially at the Hidden Treasure mine. Most of the specimens were gathered from oxide zones.

Mineralization occurred in pipes, fissures, and blanket replacement deposits in the Madison Limestone that lies beneath the Deseret Limestone. Values from lead, silver, zinc, copper, and gold were obtained in both oxide and sulfide ores. The oxide ores were mainly lead, copper, and zinc carbonates with chlorargyrite. In places the orebodies were 100 ft high and 50 ft wide. Galena and sphalerite were the main sulfide ores with pyrite and chalcopyrite. However, very few aesthetic sulfide specimens have been preserved or collected.

In 1989 a boy scout became lost in the Hidden Treasure mine. Due to the adverse publicity the mine entrance was sealed shut with cement, rebar, and rubble. The mine was repeatedly reopened, but in 2000 all of the mines in the area were reclaimed by the state of Utah. The Hidden Treasure mine is located about a 90-min drive from Salt Lake City, Utah. The mine is south and west of the town of Stockton.

The Leadville silver deposits

Ed Raines

History of the silver boom

In the spring of 1860, the Slater party discovered placer gold deposits in California Gulch on the western slopes of the Mosquito Range in Lake County. The gulch was divided into three placer districts:

Arkansas Independent-8,200 ft long (82 claims, beginning at the mouth of the gulch)
Sacramento-19,000 ft long (190 claims, in the mid-portion of the gulch)
California-6,700 ft long (67 claims, in the upper portion of the gulch)

By early summer, 5,000 people had migrated into the gulch. Some mined, some were involved in commerce, and some tried to relieve others of their hard-earned gold through various predatory practices. They occupied crude log cabins, tents, lean-to shelters, or wagons that were strung up and down the length of the gulch. Oro City became the name that was applied to the portions of the gulch in which the Sacramento and California placer districts were located. Placer mining continued through the summer of 1861, when the gold-bearing gravels of the gulch began to be mined out. By the winter of 1862-63 only a handful of prospectors remained, the rest having left to seek other opportunities.

Placer gold production during these years is estimated to have been between 170,000 and 250,000 ounces. Production from several small gold veins on Printer Boy Hill kept mining alive (barely) during the rest of the 1860s and early 70s.

To the east and across the Mosquito Range in Park County, similar placer gold camps at Buckskin Joe and Montgomery went through the same boom-bust cycle. But here a different kind of discovery kept mining alive following the bust in placer gold operations. At altitudes of 13,600 to 13,700 ft on Mt. Bross, Daniel Plummer and Joseph Myers found lead-silver replacement deposits in the Leadville Limestone—the Dwight was located in 1869 and the Moose in 1871. Assays ran from 265 ounces to 879 ounces of silver per ton. Forty tons of ore were shipped to Swansea, Wales, and even with freight charges of $70 per ton, the miners netted a nice profit. The Moose paid from the "grass roots."

During that summer of 1871, several more prospectors made their way to the new Park County silver fields, among them were Sullivan D. Breece and William H. Stephens. A 51-yr-old veteran of mining in the Lake Superior copper country, Stevens plunged into silver mining, learning as he went. Over the next few years he formed a business alliance with several prominent financiers and politicians, a smelter owner, a smelter manager, and a metallurgist. When the alliance soured in 1873, Stevens teamed up with Breece (who had operated a California Gulch placer during the 1860s boom) in several Mt. Bross silver prospects. Breece told Stevens of his continuing belief in the California Gulch placers, provided that a water shortage problem could be overcome. During this time, Stevens convinced Alvinus B. Wood, a former associate from his Michigan mining days, to join him in Colorado.

California Gulch is, at best, an intermittent stream carrying a very low water volume. In fact, it has no flow during much of the year. So, Stephens and Wood (with Breece as a partner) formed the Oro Mining Ditch and Fluming Company. Stevens then traveled back east during the winter of 1873-74 where he raised $50,000 for a California Gulch placer mining venture. The men used the money to dig an 11-mi ditch from the Arkansas River to provide water for hydraulic giants like those that had proven so successful (and environmentally destructive) in California. Having gained control of the old gulch claims, they began placer operations. It was a limited success. There was gold aplenty, but they had to spend an inordinate amount of time cleaning out the heavy brown sands that clogged their sluices. This was not a new problem in California Gulch; those same sands had plagued the placer operations of the early 1860s.

As it turned out, the much-cursed dark sand was composed of the lead carbonate mineral cerussite combined with various iron and manganese oxides. The material was too heavy to wash through the sluices with the "ordinary" sands; instead it filled the spaces between the gold-catching riffles (small strips of wood nailed to the bottom of the sluice box every few inches). With those spaces between the riffles filled, the gold-trapping mechanism of the sluice was negated and the sluice failed to trap gold.

Stevens recognized the cerussite because that mineral was the primary ore in the oxidized portion of Park County silver mines—the cerussite carried significant amounts of silver as a contaminant. Assays soon confirmed that this California Gulch cerussite also carried silver, and in 1874 the partners began a prospecting effort that continued into 1876. They discovered lead-silver replacement deposits in the Leadville Limestone cropping out around the western and southern slopes of Iron Hill. They staked a series of claims on these mineralized outcrops and founded the Iron Silver Mining Company. This was the beginning of the Leadville silver boom.

For a time the local populace did not catch on to the significance of the Stevens-Wood discoveries, but then three emigrant Irish brothers, John, Charles, and Patrick Gallagher, staked the Camp Bird and Keystone claims on near-surface mineralization on the north slope of Iron Hill. Lore has it that they dug where Stevens told them to dig. According to that local lore, Stevens was more concerned with getting the brothers out from underfoot than with passing on a useful prospecting tip. No matter Stevens' motives, the Gallaghers struck ore very near the surface and had soon staked their claims.

Although completely ignorant of "proper" mining techniques, the Gallaghers soon mined out enough ore to raise their standard of living by several orders of magnitude. They then sold their entire group of claims to the Argentine Silver Mining Company (founded by Edwin Harrison of the St. Louis Smelting and Refining Co.) for $225,000. The Gallaghers split the purchase price and went their separate ways to see the world, and enjoy the seeing. The story of how three poor Irish emigrants had struck it rich was the stuff of fairy tales. Accordingly, it received a great deal of attention from the newspapers of the day, and this publicity did as much to fan the flames of the Leadville silver boom as any other single occurrence.

More discoveries followed, first at other locations on Iron Hill, and then on Carbonate Hill, just to the west. On Carbonate Hill, the original discovery was the Carbonate, located in June 1877 by Nelson Hallock and Albert Cooper. The Yankee Doodle, Crescent, Catalpa, and Morning Star were staked soon thereafter. The Morning Star was the real prize among them. It was sold to Governor John L. Routt in October 1877. After faithfully working the property for 2 yrs, an immense orebody was found. Production during the last half of 1879 was $290,491, and averaged $70,000 per month for the first 3 mos of 1880. The holdings of the Morning Star Consolidated Mining Company were sold for $1,000,000.

The climax of the Leadville silver boom arrived with the discoveries on Fryer Hill. George Fryer and John Borden filed on the New Discovery on April 4, 1878. Borden sold out to Foss Bissell and A.V. Hunter, and Fryer sold out to Jerome Chaffee for $50,000. On April 15 August Rische and George Hook got a grubstake from Horace Tabor and began prospecting near the New Discovery. They had to go back for two more grubstakes before finding ore at 28 ft in their prospect shaft. They named the claim Little Pittsburg in honor of Hook's hometown. When the two reported to the Tabors that the assay ran $200 per ton, Augusta replied, "Rische, when you bring me money instead of rocks, then I'll believe you." Hook sold out to Rische and Tabor for $90,000; Rische sold out to Tabor and David Moffat for $265,000. The Little Pittsburg Consolidated Mining Company was incorporated with Chaffee as President, Moffat as Vice President; and Tabor and Borden on the Board of Directors. Tabor sold out for $1,000,000.

By February 1880 the Little Pittsburg high grade ore was nearly exhausted. Chaffee and Moffat dumped 51,000 shares of stock before the bottom fell out in mid-March. The stock fell from $34 a share to $7.50. Those were different days. New York stockbrokers praised Moffat for his "superior shrewdness in standing from under," meaning that he had been able to dump his shares (undetected) before the price crashed.

The Chrysolite was located on May 3, 1878, by "Chicken" Bill Lovell, with Fryer and Borden each owning one quarter. Lovell salted the prospect shaft with ore from the Little Pittsburg and sold one-quarter interest to Tabor for $10,000 on July 13. The rest of the transaction was not recorded, but the Chrysolite Silver Mining Company, Inc., produced more than $1,700,000 before its stock crashed in 1880.

Tabor purchased the Matchless mine outright for $117,000. It produced $2,000 per day for a considerable period of time. The property became famous as the final home for Tabor's second wife, "Baby Doe," in the poverty-stricken years of her widowhood.

Many believed the Robert E. Lee to be the richest Fryer Hill mine of all. Located in June 1878 the mine passed through many hands during the boom years. Over $250,000 was produced during a 39-day period in 1879. Another orebody produced $118,500 in a 17-hr mining effort.

Geology and mineralogy of the Leadville silver deposits

The Leadville district is located on the eastern limb of the Sawatch uplift in the central portion of the Colorado mineral belt. Paleozoic sedimentary rocks lie unconformably atop Precambrian metamorphic and igneous rocks. The Mississippian Leadville Formation (which is composed of the lower Redcliff Member and the upper Castle Butte Member) is the major host rock for the rich lead/silver manto orebodies mined during the years of the silver boom.

The carbonate sediments of the Leadville Formation were dolomitized during diagenesis. A Late Mississippian global sea-level drop exposed the Leadville Formation to erosion. Over time, a karst erosion surface developed, complete with caves, sinkholes, solution breccias, and solution enlarged joints. Both dolomitization and karstification enhanced the porosity and permeability of the Leadville Formation, and may have influenced the path that migrating fluids followed.

Ore-forming solutions generated during intrusion and emplacement of stocks at Printer Boy and Breece Hills traveled through the permeable beds at about 39.6 m.y. ago (± 1.7 m.y.), depositing a suite of primary sulfide minerals. Orebodies are mostly confined to the more permeable beds of the dolomite. Primary minerals containing silver are galena (as a contaminant), and, to a lesser extent, argentite/ acanthite and tetrahedrite.

Following uplift and erosion, prolonged weathering oxidized the upper portion of many orebodies in the district, producing supergene cerussite and anglesite (containing silver as a contaminant), chlorargyrite, chlorargyrite variety embolite, silver, and argentojarosite.

Production of these supergene minerals accounts for the great Leadville silver boom of the 1870s and 80s.

Unusual quartz crystal growth habits

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The first unusual crystal to look at is "pagoda" quartz from Young's River, Astoria, Clatsop County, Oregon. This is part of the Columbia Plateau basalt flow. Pagoda quartz was formed by calcite oriented on the original quartz crystal; then at a later date these calcite crystals became pseudomorphs of quartz after calcite. The girdling bands of quartz have no relationship to the original crystal.

The next crystal to look at, very closely related to the first, is "cut quartz" from Dalnegorsk, Russia. Here the quartz and calcite formed at the same time; later the calcite was dissolved away leaving only the quartz. Another locality where "cut quartz" was collected by the author in May 2005 is near Story, Montgomery County, Arkansas. This is a pay-to-dig open pit claim of G. W. Johnson. The cut quartz crystals are found in clay between sandstone layers.

Faden quartz is another unusual crystal to look at; *faden* is German for "thread," which appears to run through the crystal. This faden is formed by a tectonic fracture of a quartz crystal and the subsequent widening of the fracture. During this time just enough quartz-forming solution entered the fracture to form the faden. This consists of tiny oriented crystals of quartz that appear white because of water and gas inclusions. Some noted localities for faden quartz are Waziristan, Pakistan; Saline County, Arkansas; Graubunden, Switzerland; and Quebec, Canada. Another locality that was brought to my attention in 2002 by Dwaine Edington is Chihuahua, Mexico. These crystals are micros seldom more than 2 or 3 mm in size. They formed in the confines of small quartz-lined geodes; much more work needs to be done on this occurrence of faden quartz.

Gwindel or twisted quartz crystals are one of the more unusual quartz. They are one of the most studied without any conclusion as to how they were formed. There are as many hypotheses as authors on this subject. We know something kicked the crystal normal growth pattern out of whack. Normal growth pattern for quartz is a spiral around the "c" axis, with rhomb growth 3-5 times that of the outer faces. However, the spiral growth of a gwindel is around one of the "a" axes; latest hypothesis is it is due to the chemistry of impurities. Noted localities for gwindels are the Dodo mine, Tyumen Oblast, Russia, and the northern part of the Alps, Switzerland.

Pegmatites and pegmatite districts of New Mexico

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The best known pegmatite in New Mexico is the Harding pegmatite dike, well exposed in mine workings east of Dixon, Taos County. Once owned by Dr. Arthur Montgomery and subsequently donated to the University of New Mexico, it was mined over the years for lithium (lepidolite and spodumene), tantalum (microlite and columbite-tantalite), and beryl, (some of which is pink beryl rich in alkali metals and H_20). Other distinctive minerals found at the Harding mine include manganese-bearing "rose" muscovite, albite variety cleavelandite, fluorapatite, eucryptite, bityite, holmquistite, and many more. Montgomery (1951) gave an interesting and classic account of the beryl mining, in which three men and a mule produced several hundred tons of hand-sorted beryl per year. Good summaries of the geology and mineralogy of the pegmatite were published by Jahns and Ewing (1976, 1977) and Brookins et al. (1979). Spilde (1999) described its bismuth carbonate and related minerals; see also Northrop (1959), Hlava (1979), and Modreski (1991). A comprehensive web page about the Harding pegmatite, including a complete bibliography and instructions for visiting the mine, is on the University of New Mexico Web site at http://epswww.unm.edu/harding/harding.htm .

West of the Rio Grande, the Petaca and Ojo Caliente pegmatite districts have been mined for muscovite mica and niobium-tantalum minerals (Jahns 1946, 1974; Holmquist 1947). The Globe pegmatite (Wright 1948) is one of the best known. Mangancolumbite at the Globe mine occurs in two forms, large blocky crystals and dendritic "feather" columbite, latter having formed within replacement pods of lamellar white albite (variety cleavelandite); other minerals include monazite as large brown crystals, green fluorite (with distinct white fluorescence under shortwave ultraviolet due to its high rare-earth content), and beryl (Jahns 1946; Northrop 1959; Hlava 1979). Similar minerals have been found at the Apache, Coats, Cribbenville, Fridlund, Star, and other pegmatite mines in these districts.

Several pegmatite districts on the east side of the Sangre de Cristo Mountains, including the Rociada, South Mora, Old Priest, and Elk Mountain districts, have been mined for mica, beryl, and tantalum (Redmon 1961; Holmquist 1946; Jahns 1946). The Rociada district is probably the best known of these to collectors, for its lepidolite, topaz, microlite, beryl, and other minerals (Sheffer and Goldsmith 1969; Jacobson 1987).

In recent years a number of other pegmatites occurring locally in northern New Mexico have produced minerals, often in well-crystallized form, including beryl, chrysoberyl, gahnite, titanite, epidote, margarite, and schorl, thanks to the diligent efforts of astute and observant collectors such as Ramon DeMark, Jesse Kline, and others.

An unusual pegmatite occurrence is the moonstone deposit at Rabb Park, Grant County, New Mexico. The moonstone (sanidine) occurs in pegmatite with associated aplite that is interpreted to have been partially crystallized pegmatite magma that was erupted and rapidly cooled (O'Brient 1986; see also Kelley and Branson 1947; Beard 2001).

Pegmatites in Rock Springs Canyon in the Organ Mountains have been mined in recent years for their minerals of interest to collectors, including orthoclase, albite, fluorapatite, smoky quartz, and titanite (Cowan 1994). Perhaps the most distinctive specimens from this area have been large crystals of orthoclase with oriented overgrowths of snow-white albite crystals. The large and euhedral, prismatic, fluorapatite crystals, as well as the associated titanite, greatly resemble the mineral assemblage found at the Crystal Lode pegmatite in Eagle County, Colorado (Young and Munson 1966).

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Comparison study of scheelite from two locations in the southwestern sector of Santa Fe County, New Mexico: The Old Placers and New Placers mining districts

Jerry and *Philip Simmons*

This presentation is a comparison of one of the rarer minerals, scheelite, found at the Cunningham Hill mine in the old Placers mining district and the Copper Belle mine in the New Placers mining district. The Cunningham Hill mine is a part of the Ortiz mine area, and the Copper Belle is part of the San Pedro mine area.

The objectives of this study were to compare the geochemical make up of the scheelite crystals being found at both sites and to get a better understanding of the sequence of mineral formation from the minerals closely associated with the_ scheelite. A series of SEM (scanning electron microprobe) tests were run on fragments of scheelite for the geochemical comparison, and field collecting of minerals in association with the scheelite was also done. Photographs were made of all quality specimens for review and record purposes. Information from the fieldwork, SEM data, and the mineral associations was then used to determine a paragenetic sequence model for both scheelite localities.

Symposium attendees will enjoy the pictures and find the presentation informative. In particular, the pictures of the Copper Belle mine specimens may give evidence of the best scheelite and amethyst quartz scepters to be found in the state to this date.

Extraterrestrial mineralogy—an update on Martian minerals

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Different landing vehicles have explored five locations on the Martian surface in situ in addition to five surface mapping missions via satellite. Unlike mineralogical studies on Earth, determinative mineralogy on Mars has been limited to only a few analytical methods that were mounted on the probes. The most detailed studies of Martian mineralogy have been accomplished by studying Martian meteorites that were collected on Earth. This abstract reports on the proceedings of the "Workshop on Martian Sulfates as Recorders of Atmospheric-Fluid-Rock Interactions" held in Houston, Texas, on October 22-24, 2006, and will provide a comprehensive review of Martian mineralogy.

Analysis of meteorites and some limited spectral analysis indicate typical igneous rocks on Mars appear to be basalts and gabbros composed predominantly of olivine, pyroxene, chromite, magnetite, and plagioclase. Some feldspathoidal rocks may exist in the Columbia Hills region and include feldspathoid minerals and potentially assorted zeolites, although the direct mineralogy is not yet confirmed.

Analysis of Martian meteorites and limited compositional determinations using remote instruments (spectral analysis) indicate that Mars contains approximately 10 times greater amount of sulfur compared to crustal rocks of Earth. This high sulfur content appears to have allowed for the development of a wide suite of sulfate minerals on the surface. In contrast, the carbon cycle is much greater than the sulfur cycle on Earth, and carbonate minerals predominate in the surface environment. Table 1 summarizes the identified minerals from the Martian surface.

The origin of this sulfate is the subject of intense discussion and four models for sulfate formation have been proposed: (1) sulfates represent "gossans" formed by subareal weathering of sulfides; (2) impact excavation of sulfides and subsequent weathering; (3) volcanogenic mists; and (4) sulfuric-acid ground water. Regardless of the model, the presence of sulfate on the surface of Mars suggests the presence of water at some time in its history.

Table 1—List of minerals reported from Mars and their primary mode of occurrence on Earth.

Mineral	Formula	Occurrence on earth
Silicates		
Olivine	(Mg,Fe)2SiO4	Mafic igneous rocks, metamorphosed dolomite
Pyroxene Group	(Ca,Na)(Mg,Fe,A1,Ti)(Si,A1)206	Mafic igneous rocks
Plagioclase Series	(Na,Ca)(Al,Si)308	Mafic igneous rocks, metamorphic rocks
Cristobalite	Si02	Volcanic rocks, hydrothermal alteration
Mica/Clay Group	Al2Si05•H20	Sedimentary rocks, hydrothermal alteration
Oxides		
Magnetite	Fe3O4	Igneous rocks
Hematite	Fe203	Igneous, sedimentary, metamorphic rocks
Goethite	FeO(OH)	Sedimentary rocks
Chromite	FeCr2O4	Mafic igneous rocks
Halides		
Halite	NaC1	Salt deposits
Sulfates		
Gypsum	CaSO4•nH20	Sedimentary rocks, hydrothermal deposits, weathered ore deposits
Bassanite	2CaSO4•H20	Fumaroles, dry lake beds (alteration of gypsum)
Kieserite	MgSO4	Marine salt deposits, fumaroles
Starkeyite	MgSO4•4H20	Weathered ore deposits, evaporation of surface or ground waters
Thenardite	Na2SO4	Continental salt deposits, fumaroles
Rozenite	FeSO4•4H20	Weathered ore deposits, lake beds
Melanterite	FeS07•7H20	Weathered ore deposits
Fibroferrite	Fe(SO4)(OH)•5H20	Weathered ore deposits
Coquimbite	Fe2(SO4)3•9H20	Weathered ore deposits, fumaroles
Kornelite	Fe2SO4)3•7H20	Weathered ore deposits
Yavapaiite	KFe(SO4)2	Weathered ore deposits, fumaroles
Copiapite	Fe5(SO4)6(OH)2•20H20	Weathered ore deposits,fumaroles
Jarosite	KFe3(SO4)2(OH)	Weathered ore deposits, hydrothermal deposits