

ANNUAL NEW MEXICO MINERAL SYMPOSIUM

32nd Annual
New Mexico
Mineral Symposium

November 12 & 13, 2011



PROGRAM &
ABSTRACTS

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

Socorro 2011

Welcome to

The Thirty-Second Annual

New Mexico Mineral Symposium

and

Third Mining Artifact Collectors Association Symposium

November 12 and 13, 2011

Joseph A. Fidel Center
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.

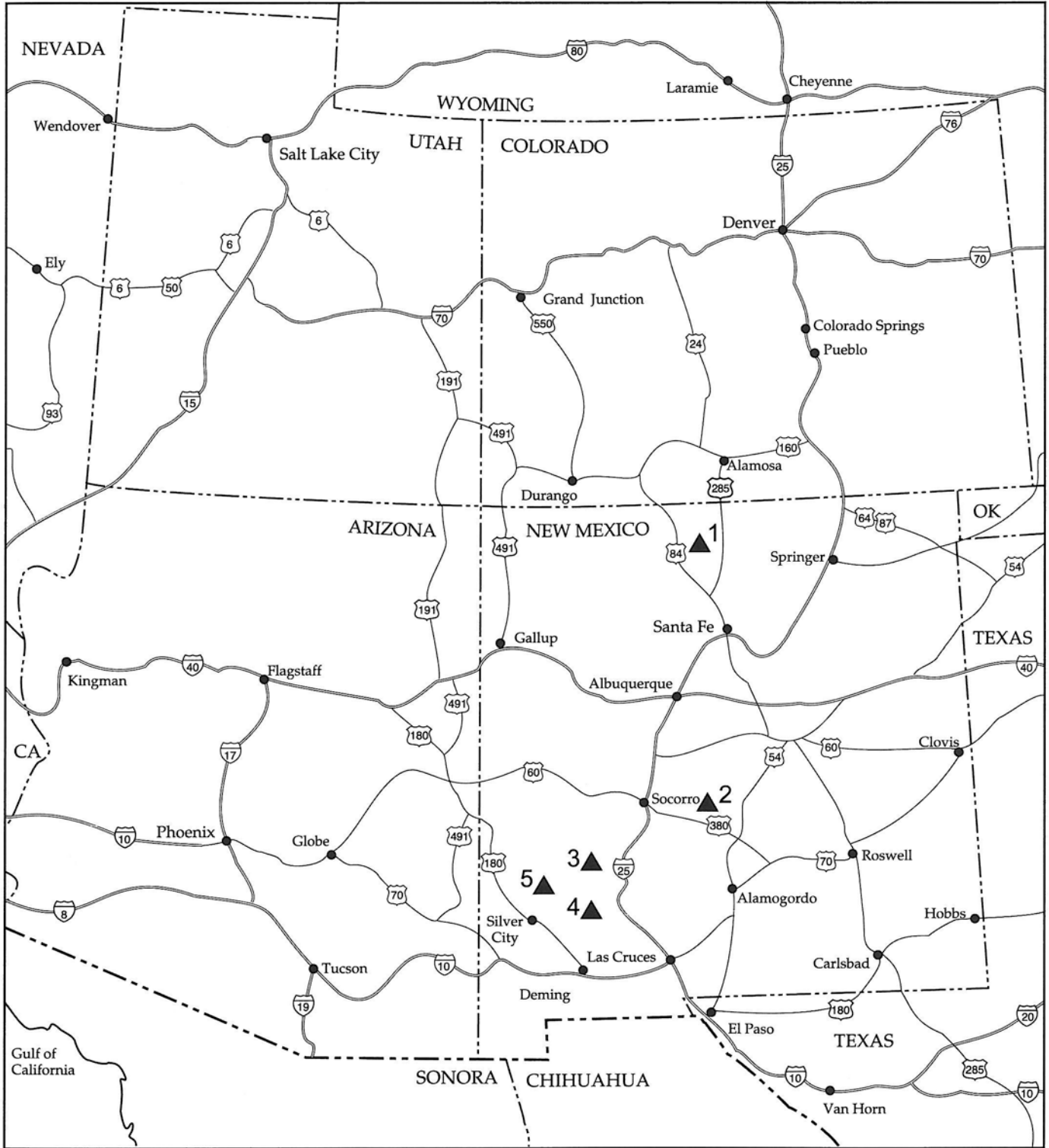
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The New Mexico Mineral Symposium provides a forum for both professionals and amateurs interested in mineralogy. The meeting allows all to share their cumulative knowledge of mineral occurrences and provides stimulus for mineralogical studies and new 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
32nd New Mexico Mineral Symposium**

32nd Annual New Mexico Mineral Symposium 2011

SCHEDULE

Friday, November 11

6:00 pm Informal tailgating and social hour, individual rooms, Comfort Inn & Suites (# 1 on
map—
FREE

Saturday, November 12

8:00 am Registration, Joseph A. Fidel Center; continental breakfast
8:50 *Opening remarks*, Ballroom B and C
9:00 *Rare and unusual minerals from the Petaca Pegmatite district of New Mexico—*
Michael N. Spilde, Brian Salem, Steve Dubyk, and William P. Moats (1)
9:30 *Arizona-100 years of statehood, 130 years of mineral collecting—Les Presmyk*
10:00 *The arsenate minerals of the Sterling Hill mine, Ogdensburg, New Jersey—Fred J. Parker*
10:30 Coffee break
11:00 *Mineralogy of a supergene enriched volcanogenic massive sulfide deposit, Flambeau mine,*
Rusk County, Wisconsin—Tom Rosemeyer
11:30 *Microminerals from the Jones camp district, Socorro County, New Mexico—Ron Gibbs (2)*
12:00 pm Lunch and Museum tours
1:30* *Postcards from southwestern New Mexico mining towns—Jane Bardal*
2:00* *Frontier mining methods—Ed Raines, MACA featured speaker*
3:00 Coffee break
3:30 *Crunchy on the outside, tender on the inside: the giant crystals and tiny microbes of the*
Naica caves—Penelope J. Boston, Michael N. Spilde, Diana E. Northup, and
Cameron McMillan
4:00 *Solving mineral mysteries—Dr. Anthony Kampf, featured speaker*
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 13

8:00 am Morning social, coffee and donuts
8:50 *Welcome to the second day of the symposium and follow-up remarks*
9:00 *Fluorite from the Blizzard prospect, Sierra Cuchillo Mountains, Sierra County,*
New Mexico—Travis Cato (3)
9:30 *The melanotekite/kentrolite story—Ramon S. DeMark and R. Peter Richards (4)*
10:00 *Zeolites and associated minerals from the Gila Cliff Dwellings area, Catron and Grant Counties,*
New Mexico—Patrick E. Haynes (5)
10:30 Coffee break
11:00 *Vignettes of four Montana mineral localities (Crazy Sphinx mine, Sourdough mine, Bald*
Mountain, and PC mine)—Peter Knudsen
11:30 *Twenty-three pegmatites in five days, a Colorado field trip saga—Peter Modreski and*
Luis Sanchez-Munoz
12:00 pm Lunch
1:15- Silent auction, third floor, Joseph A. Fidel Center, sponsored by the Albuquerque Gem
3:00 and Mineral Club for the benefit of the Mineral Museum (FREE)

*denotes Mining Artifact Collectors Association talk.

Rare and unusual minerals from the Petaca pegmatite district of New Mexico

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The Petaca district, located in north-central New Mexico in Rio Arriba County, lies within rugged, forested country that is a part of the Carson National Forest. The district is accessed by unpaved roads extending from New Mexico state highways 111 and 519. Granitic pegmatites in the Petaca district were mined for sheet and scrap mica from about 1870 through the end of World War II (1945), and perhaps as late as 1965. Mica may have been recovered from mines at the Cribberville town site (abandoned) as early as the 17th century, which may represent the earliest systematic effort to recover sheet mica in the United States (Jahns 1946). Although mica (muscovite) was the chief commodity produced, small amounts of beryl, monazite, columbite-tantalite, and rare-earth-element (REE) bearing niobium (Nb)- tantalum (Ta) minerals were also recovered. The Petaca district offers the collector the opportunity to find minerals in which REE, as well as uranium and thorium, are essential constituents. The acquisition of such rare and unusual minerals is becoming increasingly popular among mineral enthusiasts.

The Petaca pegmatites are classified as rare element pegmatites and are found in an area about 1 to 4.5 mi wide by 15 mi long. The pegmatites form dikes, sills, pods, and irregular bodies that intrude Paleoproterozoic metasedimentary and metavolcanic rocks of the Vadito Group and were emplaced approximately 1400 Ma. The Precambrian terrane hosting the pegmatites is surrounded and locally covered by volcanic and volcanoclastic rocks of Cenozoic age. The Petaca pegmatites, with their high Y- and Nb-bearing minerals, amazonitic potassium-feldspar, and common occurrence of fluorite as an accessory mineral, fall within the NYF type.

In general, a border zone, wall zone, usually one or more intermediate zones, and a core zone generally comprise the pegmatites. Replacement bodies of albite ± muscovite and fracture fillings of quartz ± albite are common. The pegmatites are composed chiefly of microcline (perthite), quartz, albite, and muscovite, which occur as medium- to coarse-grained aggregates with granitoid textures in wall zones, and as large or giant anhedral to euhedral crystals in intermediate zones. The intermediate zones are usually dominated by only one or two minerals, whereas the pegmatite cores are usually composed of quartz, or less commonly quartz + microcline. The common accessory minerals are spessartine, fluorite, columbite-tantalite, monazite-(Ce), beryl, ilmenite, and bismutite.

REE-bearing Nb-Ta oxides are among the more interesting minerals that occur in the Petaca pegmatites; such minerals previously reported from the district include those from the euxenite, gadolinite, aeschynite, fergusonite, and samarskite groups. However, the identities of many of these minerals or mineral groups are tentative, and most are unsupported by published data. For convenience and for practical reasons, Jahns (1946) simply classified all black, metamict minerals he observed as "samarskite" in his classic study of the geology and the economic potential of the Petaca pegmatites.

Due to the uncertainty of which REE-bearing Nb-Ta oxides actually occur in the Petaca district, a number of pegmatites were examined and suspect samples of REE-bearing Nb-Ta minerals collected. Such samples were rare and were found at only a few of the deposits. The suspect samples were analyzed by electron microprobe to identify composition and mineral type and to determine the relative abundances of REE. Of the pegmatites sampled, REE-Ta-Nb

minerals were found in six of them, but only the Bluebird, Fridlund, and La Paloma pegmatites provided coarse specimens, where they occurred as masses of dark-brown to black, glassy minerals up to several centimeters in diameter. Minute inclusions of REE-Ta-Nb minerals were found in columbite and other minerals at the Alma, Nambe, and North Star pegmatites.

Based on the results of our microprobe study, several new minerals were identified or confirmed for the district, including euxenite-(Y), samarskite-(Y), polycrase-(Y), xenotime-(Y), and microlite. However, yttrotantalite, fergusonite, gadolinite, and aeschynite were not found, and thus, could not be confirmed. Polycrase-Y is a new mineral for the state, and was collected in situ at the Bluebird mine in the central part of the district.

Samples of other minerals, including monazite, columbite-tantalite, and fluorite, were also subjected to electron microprobe analysis. Monazite-(Ce) was found as reddish-brown or salmon-colored, blocky masses and crystals weighing up to a half kilogram, and is probably the most abundant of the REE-bearing minerals in the Petaca district. Xenotime-(Y) was observed as vein-like alterations of monazite and as sub-millimeter inclusions in monazite and Y-rich fluorite. Inclusions of pyrochlore were found at the Fridlund pegmatite and microlite at Nambe and La Paloma pegmatites.

A kilogram mass of yellowish-brown, pulverulent (i.e., powdery) thorite, containing significant phosphate, was found at the Coats mine. The PO₄-rich material occurs in veinlets scattered throughout the larger thorite sample. Thorite also occurs as inclusions in monazite at the Coats, Fridlund, La Paloma, and North Star deposits, where the inclusions range from individual millimeter size to swarms of micrometer-sized masses. Zircon was found at La Paloma as millimeter-sized black crystals in quartz, associated with samarskite and bismutite. All specimens of columbite-tantalite analyzed in our study were found to be columbite-Mn.

Specimens of columbite-tantalite and bismutite continue to be found by collectors at many of the pegmatites, including a recently collected partial crystal of columbite-tantalite weighing in excess of 3.6 kilograms. Microcline, variety amazonite, is locally common at several pegmatites near and at the Mica Lode and Vestegard mines. Galena, associated with fluorite, was found loose in soil at the North Star mine.

Additional investigation of the mineralogy of the Petaca pegmatites is ongoing, with emphasis on the REE-bearing mineral species.

References

- Jahns, R. H., 1946, Mica deposits of the Petaca district, Rio Arriba County, New Mexico: New Mexico Bureau Mines and Mineral Resources, Bulletin 25, 294 pp.

Arizona-100 years of statehood, 130 years of mineral collecting

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Summary

Arizona became the 48th state of the United States of America on 14 February 1912. Its history as a territory and state is intimately tied to that of New Mexico. In fact, the two states were originally considered the New Mexico Territory with about a half dozen counties stretching from its eastern border with Texas and its western border at the Colorado River. In 1864, Congress divided it into the New Mexico and Arizona Territories. Had it not been for the framers of the Arizona Constitution insisting on including provisions for the recall of judges, Arizona would have been the 47th state.

Arizona's modern mining history began in the early 1850s as unsuccessful adventurers began returning from the California gold rush of 1849. The western side of the Arizona Territory was the least inviting for settlement because of its arid nature. The eastern half had a more hospitable climate, and more water, but because of the various native tribes, especially the Apaches, and other lawless individuals roaming these areas until the mid-1870s, exploration for natural resources was limited. It is tough to look at the ground for gold, silver, or whatever, when the main concern was staying alive! With the end of the Civil War and the re-establishment of numerous army forts in the territory, these unfriendly elements began to be subdued. The army soldiers also became some of the first prospectors in these areas. Soldiers were not the only ones interested in searching for mineral treasures. The western and central portions of Arizona had started to be populated by ranchers and farmers, some with this interest and certainly the time to start the search.

The collecting of mineral specimens was entirely mine and ore related until the early 1880s. Heintzleman and others shipped and displayed specimens back in St. Louis, Chicago, and points farther east, mainly to entice capital investment in this last American frontier. The early interest was in silver and gold. Silver mining began to take hold before the Civil War, at the Ruby and the Mowry mines. In fact, silver from Ruby was fashioned into an inkwell set presented to President Lincoln. The Mowry mine was confiscated by the Union army because Sylvester Mowry was suspected to be a southern sympathizer.

The Colorado River provided a means of travel along the western border of the territory. A number of mines, including the Red Cloud and within 2 mi of the Colorado River, was located in the 1860s. It was named for a nearby Indian trail near the Colorado River, not the red crystals found lying about on the top of the vein, and mining started in 1880. This silver mine would become more famous for its wulfenite crystals, even attracting the attention of the territorial governor and mention in one of his reports to Congress.

Toward the middle of the territory, several rich but short-lived silver deposits, all in the Superior to Globe area, were discovered, and mining started in the late 1870s and early 1880s. The Silver King mine was originally found by a member of the army while building a road over the mountains. It was relocated by a small group of farmers from the Florence area in 1875, just a few miles north of where the town of Superior is today. The Stonewall Jackson mine was also located about this time, east of Globe. Both were rich enough that crystallized specimens were saved and found their way into the inventories of mineral dealers of the time.

Most of these early mines and mining camps were short lived, usually less than 10 yrs. The copper mines would bring stability and longevity to Arizona's towns and economy but these required the railroads for cheap and reliable transportation. Without the railroads, even the

richest copper mineralization (20% plus) was barely profitable. Bisbee was the first to have rail access, followed by Morenci and Globe-Miami. Along with this prosperity and ease of travel, specimens were saved to a much greater degree. Once a person no longer feared for their life, and more importantly, dealers could travel into these areas and safely transport specimens back to their eastern markets, did the normal economic drivers take hold of having miners collect specimens knowing they could supplement their incomes by filling their lunch boxes.

The beauty of some of these mineral finds, such as the caverns at Bisbee and the rich copper oxide orebodies at Morenci, inspired both miners and management to preserve these specimens. Ben Williams and Dr. James Douglas of the Copper Queen Mining Company appreciated the beauty of the calcites, azurites, malachites, and cuprites, the likes of which had not been seen before. They even employed miners to collect for their collections and the company account. Bisbee would remain Arizona's premier producer of specimens for 90 yrs while various mines operated and even some clandestine efforts since 1975. When the Lavender pit was extended into the old Copper Queen and Holbrook workings, Phelps-Dodge arranged to have specimens saved and sold. Phelps-Dodge's legacy of saving specimens continues to this day through the efforts of Freeport McMoran Copper and Gold, mainly at Morenci, but also continuing to maintain the corporate mineral collection in Phoenix, Arizona, which was started back in the 1880s.

Other mines, like the Live Oak and Old Dominion in the Miami and Globe, produced azurite, malachite, cuprite, and chrysocolla specimens and gem materials recognized for their beauty and value even in 1900. The Magma mine at Superior was one of Arizona's richest copper mines and produced its finest barite and pyrite specimens, along with calcites only second to Bisbee. Halfway between Globe and Tucson, the Mammoth and Collins mines had enough wulfenite that it was produced as an ore of molybdenum before and during World War I. While it is fun to speculate how many specimens went to the crusher, most of the wulfenite filled the vein openings and was tightly crystallized enough to truly constitute ore. In its final mining phase, mine management recognized the value of its mineral suite and employed one or two full-time miners to collect specimens for sale.

Arizona's mineral collecting legacy the amateur and week-end collector began its rise in the 1940s and continues today. Like New Mexico, amateur and professional collectors have scoured and rescoured its abandoned mines and surface localities for the past seven decades, bringing to light hundreds of discoveries of specimens for collectors and museums throughout the world. Minerals from aurichalcite to zunyite and every letter in between have been found. Arizona is home to world class and type localities including Tiger, Jerome, and the Grand Reef. Arizona's mineralogy is as diverse as any state or country. Names like the Glove, the Apache, the Old Yuma, the Homestake, the 79 mine, the Rowley, the Red Cloud, the Portland, the Western Union, the Grandview, the Defiance, the Silver Bill, Silver Bell, and Silver Hill all form part of Arizona's mineral heritage and legacy, due to the efforts of amateur collectors.

While the next century will probably not be as exciting as its first 130 yrs, new deposits and finds still await those who are willing to put in the time and sweat necessary to hike the hills, explore the old mines, and then dig out those treasures still awaiting discovery.

About the author

Les is an Arizona native and a mineral collector for almost 50 yrs, specializing in Arizona minerals for more than 30 yrs. He is an Arizona native and a graduate of the University of Arizona, with a degree in mining engineer. He spent the first 11 yrs of his career in underground copper mining and the past 25 yrs dealing with coal and uranium fuel procurement for the second largest utility in Arizona. He has also been a member of the Tucson Show committee for 28 yrs.

The arsenate minerals of the Sterling Hill mine, Ogdensburg, New Jersey

Fred J. Parker, parkermineral@comcast.net, Catonsville, Maryland

The famous zinc deposits of Franklin—Ogdensburg, Sussex County, New Jersey, are uniquely composed of willemite, zincite, and franklinite as the primary ore minerals. The deposits are world renowned for the large number of outstanding fluorescent minerals and complex, rare mineral assemblages. One of these assemblages is the arsenate minerals found between about 1972 and 1985 from the Sterling Hill mine. Many new species were found including sterlinghillite, parabrandsite, kraisslite, and kolicite, as well as superb examples of known arsenates such as sarkinite, allactite, chlorophoenicite, koettigite, brandsite, legrandite, and holdenite. It was observed that the arsenates of Sterling Hill were found in substantially separate distributions, depending on whether they were in red ore, black ore, or adjacent marble. A summary of these observations will be presented, along with slide images of some of the Sterling Hill arsenates and associated minerals.

Mineralogy of a supergene enriched volcanogenic massive sulfide deposit, Flambeau mine, Rusk County, Wisconsin

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The Flambeau mine was located about 1.25 mi southwest of the town of Ladysmith, Rusk County, northwestern Wisconsin. The mine site is at an elevation of 1,130 ft above sea level and only 140 ft from the Flambeau River, which the mine takes its name from. The general topography of this glaciated region is low rolling countryside with numerous lakes and rivers. The picturesque scenery of the area is agricultural, with dairy farms interspaced with timbered lands.

The open pit Flambeau mine was a supergene enriched deposit that contained a high-grade copper orebody that was mined from May 1993 to March 1997. During the short life span of the mine, 1.9 million tons of ore was extracted that averaged 10% copper and 0.18 ounce of gold per ton. The deposit was located in a belt of Precambrian sedimentary and volcanic rocks known as the Wisconsin magmatic terranes, which are located on the southern margin of the Canadian Shield. The orebody was a volcanogenic massive sulfide deposit similar to other deposits that occur over the length of the volcanic belt in northern Wisconsin. The primary ore consisted of poorly layered, fine-grained chalcopyrite, sphalerite, pyrrhotite, pyrite, and minor galena.

Extensive folding and faulting during the period of Penokean Mountain building about 1.85 b.y. ago tilted the volcanic rocks to a vertical position. A long period of erosion followed that reduced the mountains to low rolling hills. An Upper Cambrian sea covered the area about 520 m.y. ago and deposited a layer of sandstone that covered the deposit. During relatively recent times part of this sandstone was removed by glaciation. The original deposit was extensively altered and enriched by chemical weathering that formed a supergene high-grade chalcocite orebody. An iron-rich cap (gossan) formed in the sandstone over the orebody that also contained appreciable fine-grained native gold, which was mined and paid for most of the development costs.

Chalcocite was the dominant supergene ore mineral and occurred as granular and massive material. It also occurred as fine crystals that rival those found at Cornwall, England, and Bristol, Connecticut. The crystals also made the mine world famous in mineralogical circles for the size, crystallization, and number of specimens produced. Other minerals that occurred in the supergene zone and were of interest to collectors were native copper along with gold and silver. Many stunning specimens of microcrystals were also recovered, which included complex crystals of chalcocite along with colorful groups of cuprite, malachite, and azurite crystals.

The Flambeau mine will be remembered as a source of fine chalcocite specimens mainly due to the efforts of Casey Jones who collected on site the majority of specimens produced from the short-lived mining operation. Today, reclamation has been completed and wetlands have been created from the back-filled open pit.

Microminerals of the Jones Camp district, Socorro County, New Mexico

Ron Gibbs

The Jones district, also known as Jones camp, is located about 15 mi east of Bingham in eastern Socorro County. The district was established around a small iron deposit and is named after Fayette Jones, who was an early promoter of the district. Fayette Jones is well known for his 1906 publication, *Mines of New Mexico*. Claims were located in the late 1880s and actively promoted in the early 1900s to iron and steel companies in New Mexico and Colorado. Many investigations and reports have centered on the district, but mining has been as sporadic and small scale as the iron deposits themselves.

The most prominent feature of the district is the Jones dike that cuts a significant east-west swath through Chupadera Mesa and is clearly visible in satellite photos. The dike is one of a swarm of radial dikes focused on the Socorro-Magdalena caldera of the early Rio Grande rift. The dike has been dated at 28.9 Ma placing it in the Oligocene. The dike has a multi-phase syenodiorite composition. Small, scattered skarn deposits were formed along its margins in the adjoining Chupadera formation. These skarns host the iron deposits that are dominantly composed of magnetite.

The various phases of the dike occasionally have miarolitic cavities containing well-formed microcrystals of several minerals of interest to mineral collectors. These include titanite, actinolite-tremolite, apatite, and zircon. The skarn deposits have produced nice specimens of magnetite with crystals to about 1/2 inch in size.

The locality is easy to get to by following the directions in *Field Trip Guide to the Jones Camp Mining District* by Bob North.

Postcards from southwestern New Mexico mining towns

Jane Bardal, jbardal@q.com, Albuquerque, New Mexico

Spanish and American prospectors discovered gold, silver, and copper mines in southwestern New Mexico in the 1800s. This talk describes the further development of these mining operations into the early 1900s. During this time period improvements in technology made mining profitable and eastern corporations invested in New Mexico mines. This era saw the development of paternalistic company towns. Miners faced difficult and dangerous working conditions, but their lives improved compared to previous generations. This presentation tells the stories of the towns and the people in southwestern New Mexico that owed their livelihood, in whole or in part, to mining.

This talk will also discuss collecting mining postcards. Postcards with pictures came into existence in 1901 with a change in postal regulations. A mining camp of any size at all would have a post office, and people wrote each other more frequently than today. People wanted to show off signs of development and progress in their towns, such as tree-lined main streets and substantial buildings. They were also proud of industrial developments, such as the mining operations shown in this talk. Postcards showed the day-to-day operations, such as steam shovels, trains, freight teams, and concentration mills.

The focus of this talk is on mining between 1908 and the 1920s, because this was the "golden age" of postcards. The best postcards were printed in Germany. With the advent of World War I, Americans cut their ties with many German businesses, and that was the end of these beautiful postcards in the U.S. Local publishers printed many postcards as well. Real photo postcards were created by individuals with cameras. These one of a kind images are often quite valuable. The golden age of postcards coincides with the beginning of several large-scale industrial mining operations in New Mexico.

Warning: collecting postcards can be as habit-forming as collecting minerals!

Frontier mining methods

Ed Raines

The California gold rush introduced the idea of mining to America. Discoveries of more mineral deposits created an industry that thrived on the western frontier using "older" technologies. Following the introduction of explosives to mining in the 17th century, mining and ore processing had become a six step process: (1) drilling holes in rock, (2) filling the holes with explosives, (3) blasting down rock, (4) loading and hauling the rock to the surface, (5) separating ore from waste rock, and (6) extracting metals from the ore. The first four steps are the basic underground mining operations that have been used since that time, but through the years, technology has modified the manner of accomplishing each of these tasks.

During the latter half of the 19th century the industrial revolution brought a plethora of technological innovations to the underground world of hardrock mining. New inventions and methods changed the tasks of drilling and blasting; mucking and haulage; and hoisting and lifting. As the task of mining went deeper underground, new conditions demanded new technologies such as timbering, ventilation, and pumping and drainage. Even the most basic of tasks—providing light to work underground—went through four major technological developments during the frontier days. By the outbreak of World War I, hardrock mining had entered the modern age, and the frontier technology of the Colorado gold rush had become a relic of the past.

Crunchy on the outside, tender on the inside: the giant crystals and tiny microbes of the Naica Caves

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Introduction

Gypsum crystals of extraordinary size were discovered a decade ago in cave chambers intersected by mining activity at the Naica mine (*Industrias Peñoles*) in Chihuahua, Mexico (Garcia-Ruiz et al. 2007). The cave chambers are genetically associated with a hydrothermal base metal deposit that is the source of the ore. The system is hot, ranging from — 40-60°C (104-140°F) in the accessible areas. Large volumes of water are continually pumped out of the mine to facilitate zinc, lead, silver, and minor copper extraction.

Inclusions are numerous within the giant selenite crystals. Most contain solid materials, fluids, and sometimes gas, but microbial microfossils are visible in scanning electron micrographs of some of the inclusions. In addition, highly colored orange and black deposits on the chamber walls exhibit microbial biofabrics. Copper seams in some of the mine passages also exhibit mineral deposits reminiscent of biofabrics that we have observed in copper-bearing study sites around the world.

During February 2008 and December 2009, we collected fluid and solid samples from a wide variety of mineralogical settings within the caves and elsewhere in the mine. These samples have been analyzed with direct microscopic inspection (optical and electron), bulk chemical analysis, live microbiological culturing, and molecular DNA analysis.

Microscopy

Scanning electron microscopy was employed to examine the contents of inclusions, iron- and manganese-rich wall materials, unusual blue copper stalactites, and other deposits from the mine. Both live and fossilized materials were present in inclusions within the selenite crystals, and microbial filaments and cell bodies were observed in many of the other materials.

Molecular analysis

Samples were taken from a variety of sites at Naica for molecular analysis. These samples yielded a number of mostly uncultivated and novel microorganisms. While many of the organisms are unknown to science, we can infer clues about their metabolic capabilities and adaptations by comparing them to known genetically close relatives. Many of the closest relatives to the Naica clones are high-temperature organisms, yet others are soil organisms. Several come from high CO₂ environments and some from volcanic environments. Interestingly, several strains come from other caves in far distant parts of the world. Although these are the closest known relatives to our strains, the genetic distance is still great, so the environmental characteristics of the relatives may or may not be shared by our strains.

Live cultures

Approximately 30 cultures of live organisms were isolated from the environments studied in Naica. Characterization of these slow-growing organisms is currently underway. Mineral precipitation, catalyzed by organism cell surfaces, has been observed. Work by other colleagues on Naica samples collected at the same time as ours, have shown large viral loads (Suttle et al., pers. comm.). Viruses live only as infective agents on other organisms, so their presence is another corroboration that there is a well-developed microbial subsurface ecosystem in the Naica caves.

Crystal ages

The age of the crystals provides a constraint on the time elapsed since the microorganisms were trapped in the crystal fluid inclusions. The age of the crystals in Cueva de los Cristales, the cavern with the largest crystals, were dated by Sanna et al. (2010) at 106-260 k.y. However, the crystals may be much older than the U/Th dates indicate, due to uncertainties in the location of broken crystal sampled for that analysis. Indeed, crystal growth experiments in the mine produced calculated ages of ~ 400 k.y. (Sanna et al. 2010). The deepest fluid inclusion that we sampled was at a crystal depth of ~ 3-4 cm, which yields an approximate age of 50 k.y. since entombment. This is based on a growth rate of 1.45 mm per 1 k.y. (Lauritzen et al. 2008).

Discussion and conclusions

Live organisms and analyzable DNA have been recovered from all of the sites sampled. Preliminary microscopic examination shows a variety of microbial forms growing in close association with minerals at the wall surfaces. Fossilized biomineral-encrusted microbial forms are also present within some inclusions in the giant selenite crystals. Live cultures from the fluid inclusions suggest that the organisms have survived significant periods of time in a crystalline time-capsule and remain viable and have extractable DNA. Live organisms still growing in the wall material resemble some of the preserved inclusion organisms and presumably constitute the microbial community that was trapped during crystal growth. Trapped pollen and soil microorganisms indicate at least intermittent connectivity with the surface. Thus, organisms may serve as tracers to understand the hydrologic circulation and mixing of meteoric and deep geologic waters. Such apparent long-term persistence of microorganisms in geological materials can be useful in understanding the history and connectivity of hydrogeological systems, the potential for long duration survival of organisms, and the potential for minerals and rocks to act as repositories of biodiversity.

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Solving mineral mysteries

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The identification of new mineral species requires careful, detailed, and insightful scientific detective work. The two crucial defining characteristics of a mineral species are its chemistry and its crystal structure. In the absence of a crystal structure determination, the powder X-ray diffraction (PXRD) pattern, which depends upon the structure, is a strong indication of whether the mineral has the same structure as another. The powder pattern, coupled with at least semi-quantitative chemical analysis, generally allows one to determine whether an unknown phase is, in fact, a new mineral.

Unfortunately, the identification of minerals relies upon existing chemical and crystallographic data that, in some cases, are not as accurate or unambiguous as they should be. That is when the mineral researcher must become a sleuth, searching for clues in the literature and often examining the primary evidence—type specimens. Three recent mineralogical projects serve to illustrate mineralogical detective work in action.

More than 5 yrs ago, Bob Jenkins submitted a green tabular mineral from the Lomas Bayas mine, Antofagasta, Chile, for identification. Chemical and crystal structure analyses determined it to be a new Na-Cu molybdophosphate, essentially isostructural with betpakdalite. This led us to conduct a detailed study of other molybdophosphate and molybdoarsenate minerals in an effort to elucidate their interrelationships. The other existing species examined were natrobetpakdalite, melkovite, mendozavilite, paramendozavilite, and obradovicite. For each species, type material was studied. Unfortunately, these minerals are typically fine-grained and, when well-formed crystals do occur, they are often complexly twinned. Nevertheless, we were able to obtain several structure refinements for species with the betpakdalite structure-type, to solve the structure of obradovicite, and to refine additional structures of new obradovicite analogues. Comparative PXRD proved effective in demonstrating structural relationships for those species for which single crystal studies could not be conducted. Electron microprobe analyses (EMPA) were performed for all species studied, including those for which analyses had been previously published. The final results of this study, which are yet to be published, include the establishment of a new mineral family, referred to as the heteropolymolybdates, the establishment of the betpakdalite, mendozavilite and obradovicite groups, the creation of a suffix-based naming scheme for the species in these groups, and the descriptions of a total (so far) of six new species in these groups. In addition, examination of the type specimen of paramendozavilite has revealed another new heteropolymolybdate mineral (but no paramendozavilite).

In recent years, Joe Marty's collecting efforts in the U-V mines of the Uravan mineral belt along the Colorado-Utah border, have so far resulted in the discovery of at least nine new vanadium minerals (some still under study), seven of which contain the decavanadate anion, $(V_{10}O_{28})^{6-}$ a distinctive cluster of 10 VO_6 octahedra. The decavanadate minerals are remarkable, not only because they contain the decavanadate anion, but because they readily form at room temperature from acidic mine waters and contain very high contents of water. During the course of our investigations, Joe Marty submitted well-formed orange crystals of a Na-Mg decavanadate. Their chemistry fit that of the existing species huemulite; however, our single-crystal and powder X-ray diffraction data differed significantly from those published in 1966 for the species. The only existing type specimen of huemulite in the Smithsonian Institution proved instead to be the recently described decavanadate mineral lasalite, rather than huemulite. We finally located the PXRD slides used in the original description in the collection at Yale University. Tests on this material, including

recrystallization, and dehydration tests on the newly collected crystals, led us to the conclusion that the new material is huemulite and that the discrepancies between the sets of XRD data were the result of dehydration of the original material (and therefore modification in its crystal structure) prior to the recording of the original published XRD data.

We recently described two new hydrous aluminum phosphates: kobokoboite, $\text{Al}_3(\text{PO}_4)_2(\text{OH})_3 \cdot 9\text{H}_2\text{O}$, from the Kobokobo pegmatite in the Democratic Republic of Congo and afmite, $\text{Al}_3(\text{OH})_4(\text{H}_2\text{O})_3(\text{PO}_4)(\text{PO}_3\text{OH}) \cdot \text{H}_2\text{O}$, from Fumade, France. Both of these minerals occur in clusters of thin flaky white crystals. During our study of afmite, based upon specimens provided by Georges Favreau, we encountered tiny colorless crystals of another phase that we thought might be new. It provided a PXRD pattern and single-crystal cell similar to those of matulaite, $\text{CaAl}_{18}(\text{PO}_4)_{12}(\text{OH})_{20} \cdot 28\text{H}_2\text{O}$; however, EMPA and crystal structure analysis showed our mineral to have the ideal formula $\text{Fe}^{3+}\text{Al}_7(\text{PO}_4)_4(\text{PO}_3\text{OH})_2(\text{OH})_8(\text{H}_2\text{O})_8 \cdot 8\text{H}_2\text{O}$. To clarify the chemistry of matulaite, we investigated type specimens deposited in the Smithsonian Institution and in The Natural History Museum, London, as well as additional material identified as matulaite from the type locality, the Bachmann iron mine, Hellertown, Pennsylvania. Interestingly, neither matulaite type specimen was found to contain any matulaite. Instead, they contained afmite, kobokoboite, and crandallite. Some non-type specimens examined from the Bachmann mine contained radial sprays of distinct blades, which fit the crystallographic characteristics of matulaite (and of the unknown from Fumade). These provided an excellent crystal structure refinement and EMPA consistent with the ideal formula $\text{Fe}^{3+}\text{Al}_7(\text{PO}_4)_4(\text{PO}_3\text{OH})_2(\text{OH})_8(\text{H}_2\text{O})_8 \cdot 8\text{H}_2\text{O}$. Our conclusion is that the original published chemical composition of matulaite, which was determined using wet chemical techniques, was most likely conducted on a mixture of kobokoboite, afmite, and crandallite using material removed from the specimens that were deposited as the types for matulaite. The PXRD and single-crystal cell reported in the original description were clearly obtained from crystals that came from one of more different specimens that were not preserved as types.

I have had many collaborators in these projects. Besides Georges Favreau, Bob Jenkins, and Joe Marty, mentioned above, Stuart Mills, Fernando Colombo, John Hughes, and Mike Rumsey deserve particular recognition. Other collaborators include Ricardo Baggio, Maurizio Dini, Mickey Gunter, Barbara Nash, William Pinch, George Rossman, and Ian Steele.

Fluorite from the Blizzard prospect, Sierra Cuchillo Mountains, Sierra County, New Mexico

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During the mid-1980s, I was coming back from Iron Mountain (looking for helvite) and needed to stop for a bush break. There was a road leading toward the Cuchillos. Went about a mile or so, and found some jasper with quartz pockets. In this material, there were some large drusy quartz casts after octahedral and dodecahedral fluorite, about an inch in size. I looked toward the Cuchillos and saw mine dumps, thinking these might prove interesting to track down. I made quite a few trips looking for the fluorite, and finally in 1992, I started finding some. In 1993, a friend from Maryland came out to collect. After we set up the tent, a blizzard hit. There was four inches of snow, 70 mph winds, the poles from the tent broke, we took everything out of the Ford Expedition and slept. Next morning, it was 20°. Hence, the name the Blizzard prospect. We found what I was looking for in 1993.

The geology of the area consists of Magdalena limestone, which has been intruded by Tertiary age volcanics, consisting of monozite and latite porphyrys, andesite and rhyolite dikes and plugs. The mines and prospects of the area are along the contact skarns with the limestones. Most of the fluorite is found along a silicified fault zone(?) showing stalactitic structures.

Crystals of fluorite to about an inch are found coated with an attractive drusy quartz. These are simple octahedrons. The only dodecahedrons were seen in an andasite plug to the northwest of the Blizzard prospect.

Some stripping tests were done with hydrofluoric acid, the fluorite is badly etched under the quartz. Small pockets with uncoated fluorite do form and the crystals are very bright. Colors are usually pastel, green, and purple, though in one spot, a very bright grass-green was found. And in another, small pink crystals were found.

Other minerals: quartz-drusy, jasper, and scepters to $\frac{3}{4}$ of an inch. Small wulfenite crystals in one pocket, and several unknowns.

The melanotekite/kentrolite story

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The rare lead-iron silicate melanotekite was first found in Langban, Sweden, and described by G. Lindstrom (1880). C. H. Warren (1898) described melanotekite chemically and crystallographically from material that had been provided by George E. Robin from Hillsboro, New Mexico. The material was reported to have been from the Rex and Smuggler mines near Hillsboro. In November 1898, A. E. Foote of Philadelphia was offering melanotekite as "distinct crystals with massive material" for sale in the *The Mineral Collector* (1898). Subsequent to A. E. Foote's offering, early mineral dealers Otto Kuntze, Ray Hopping, and Lazard Cahn were also offering melanotekite from Hillsboro for sale in *The Mineral Collector*.

In May 1981, one of the authors (R. S. DeMark) collected some lustrous, black crystals from what was at that time an unknown mine, high on a bluff on the north side of Percha Creek, across from the Percha (S. J. Macy) mine. These crystals were identified as kentrolite by microprobe analysis by Paul Hlava (pers. comm. 1981). Paul gave a presentation on this material at the Third New Mexico Mineral Symposium in November 1982. The mine name still was unknown at that time.

In 1987, Vandal King gave the author (R. S. DeMark) a specimen with an old label that identified the material as melanotekite from Hillsboro, New Mexico. It was massive material in ferruginous jasperoid. A chip from this specimen was provided to Paul Hlava for microprobe analysis. It was confirmed to be melanotekite (Hlava, pers. comm. 1987). The specimen came from stock in Ward's Natural Science Establishment and was quite likely from George English's material that was sold to Ward's in 1905. A thorough search of the mine on the north bluff of Percha Creek provided material identical in appearance to the specimen provided by Vandal King.

According to Paul Pohwat (pers. comm. 2001), the national (Smithsonian) collection contains seven melanotekite specimens from Hillsboro, three from the Bosch collection (1880s-1920s), one from Frederick Canfield (1926), one from the Roebbling collection (1926), and two others. Two specimens were X-rayed and two were micro-probed to establish identification. The Smithsonian collection also contains two kentrolite specimens, one was purchased from Arthur Montgomery in 1938 (not X-rayed), and one specimen from Howard Belsky, in 1938, also not X-rayed.

A search of historical claim records at the Sierra County courthouse in 2001 provided a wealth of information regarding claim ownership, and location of mines in the Las Animas district near Hillsboro. The unknown mine on the north bluff of Percha Creek was determined to be the Big Chief mine. It was located in June 1892 by three men (T. Nolan, D. Chandler, and E. H. Welch) and witnessed by Stephan Macy (2001). The mines from which melanotekite was first identified by Warren in 1898, were the Rex and Smuggler. The Rex mine was located in December 1896, and two of the claim owners were George Robin and S. J. Macy (2001). The Rex mine was partly located by a bearing line of N70° 55' to the highest peak of the Caballo Mountains. The Rex mine is positioned about 1 mi northwest of the Big Chief mine on Ready Pay gulch.

A thorough search of the dumps and the underground workings of the Rex mine did not turn up any material resembling the material (crystals or massive) of the identified melanotekite specimens provided by Vandal King or the kentrolite crystals identified by Paul Hlava from the Big Chief mine. The Smuggler mine is about 3 mi northeast of Hillsboro and is not considered a viable location for the melanotekite/kentrolite. Specimens collected from the dumps of the Big Chief mine by the authors in November 2010 were examined by (R. P.

Richards) using EDS on a JEOL scanning electron microscope with INCA software. A few grains from the massive material and rare euhedral crystals were found to be Fe-dominant (melanotekite), whereas most of the black and reddish crystals were Mn-dominant (kentrolite). In one case, both minerals were found on the same crystal! There seems to be no physical characteristic that would allow visually distinguishing melanotekite from kentrolite.

One hundred thirteen years ago, C. H. Warren described melanotekite provided by George Robin reputedly from the Rex and Smuggler mines. The mineralogy of these two mines does not support this contention. Material from the Big Chief mine matches chemically and crystallographically the material that Warren studied. We suggest that the original location of the Rex and Smuggler for melanotekite was a "red herring" to obfuscate the true Big Chief mine location, which was not under claim by George Robin. End of story?

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Zeolites and associated minerals from the Gila Cliff Dwellings area, Catron and Grant Counties, New Mexico

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Most New Mexican mineral collectors familiar with the zeolite minerals found in basaltic andesites near the Gila Cliff Dwellings can name several species easily. However, the exact species names were disrupted about 20 yrs ago when the zeolite group minerals received some serious nomenclature changes. For instance, "chabazite" is now divided into "chabazite-Ca," "chabazite-K," "chabazite-Na," and even "chabazite-Sr." Similarly, five species ending with Ba, Ca, K, Na, and Sr, depending upon the dominant cation, now represent "heulandite." This nomenclature change has left many a collector and museum curator in the lurch, not knowing what species they might have and causing headaches regarding analyzing, labeling, cataloging, etc. The identification of Gila zeolites also presented this challenge.

Zeolites found at the Grapevine campground on the East Fork of the Gila River, Grant County, recently analyzed by Tony Kampf using powder diffraction and EDS (on two specimens) have been further delineated. All of the tested East Fork zeolites have been Ca dominant. These include chabazite-Ca, heulandite-Ca, phillipsite-Ca, and lévyne-Ca. Note that lévyne, both Ca and Na, had an additional nomenclature change after the above mentioned zeolite nomenclature changes. Lévyne now has an accent! Stilbite, observed but not tested, could easily be assumed to be Ca-dominant as well. Other observed East Fork minerals are analcime, mesolite, calcite (rounded/weathered crystals up to 2 inches), quartz (usually as microscopic crystals showing multiple tapers, reverse scepters, and pagodas), a tiny late brown/black dendritic mineral (probably goethite) and late crusts and acicular crystals of a carbonate (perhaps aragonite). Of note were chabazite-Ca crystals reaching 1 inch.

Zeolites collected on the Middle Fork of the Gila River in Catron County have not been tested. Hopefully, they will have been analyzed by the 2011 New Mexico Mineral Symposium. If so, the results will be presented at that time. Minerals observed from the Middle Fork include "chabazite" (including variety phacolite), "heulandite," "stilbite," quartz, calcite, and a tiny fibrous, silky-lustered mineral with curved crystals resembling mordenite. The Middle Fork zeolites should be Ca-dominant. This is logical as Ca-dominant zeolites appear to be the most common worldwide.

Zeolites, quartz, and other species also occur on the trails leading to the Gila Cliff Dwellings.

The most common zeolites in the Gila area are heulandite-Ca and chabazite-Ca. Analcime and stilbite-Ca are also easily found, although the stilbite-Ca appears to be more localized. Mesolite, although a bit more rare, is locally common. Lévyne-Ca appears sparsely as white hexagonal wafers up to 1/4 inch, and one boulder had common colorless, gemmy, stubby, microscopic crystals. Notably, the same boulder contained a few phillipsite-Ca crystals.

The areas investigated for specimens were limited to the vicinity of the Grapevine campground (where the East Fork of the Gila River joins the West Fork), the adjacent SA Canyon and the Middle Fork area within 1 mi of the trailhead. Certainly, numerous other less accessible areas will likely produce interesting zeolites in the future.

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Vignettes of four Montana mineral localities (Crazy Sphinx mine, Sourdough mine, Bald Mountain, PC mine)

Peter Knudsen

Montana hosts a fairly large number of mineral localities where hobbyists can collect nice specimens. Today's presentation will highlight four localities that are not world class, not well known to hobbyists outside of Montana, but are localities where hobbyists can find some very nice specimens.

The Crazy Sphinx mine is near Helena, Montana. The name "Crazy Sphinx" was coined by Bart Cannon who briefly had a claim on the deposit in the 1980s. Mineral collecting at the deposit dates back to at least 1930 and probably much earlier. The mineralogy of the deposit was first described by Knopf in his article describing clintonite from this deposit.

Knopf describes this deposit as a xenolith of limestone enclosed in granodiorite of the Boulder batholith. The skarn is composed predominantly of massive vesuvianite, grossular, and calcite. The most striking feature of this deposit is the blue spinel that is found here. The spinel occurs as octahedrons up to 1.5 inches and are almost always embedded in grossularite or vesuvianite. Careful preparation (or luck) is required to expose the crystals. Other collectible minerals are grossular, vesuvianite, stilbite, and clintonite. The grossular occurs as white to slightly yellowish crystals up to 9 cm. Vesuvianite crystals occur up to 9 cm, but are not common. Stilbite occurs as spherules up to 8 mm and as crusts. Clintonite occurs as snow white fans with a pearly luster.

The Sourdough mine is on the west side of Elkhorn, Montana. Elkhorn Goldfields LLC is presently developing the property. At this property the gold is hosted in skarn related to the Boulder batholith. In 2009, the Montana Crystal Collectors had a field trip to the mine site to collect vesuvianite from a roadcut near the mine. The rock at this roadcut is basically massive vesuvianite with small zones that have well-crystallized vesuvianite. Crystals can reach 2.5 inches in size. During the field trip, Lanny Ream found a number of small red grossular crystals in one small area. A feeding frenzy ensued by the 15 collectors in attendance, and many nice specimens of grossular and anorthite were found in the zone, which measured only 5 x 6 x 5 ft deep. There are vast areas of skarn exposed in the Elkhorn mining district. Surely there should be additional sites that afford excellent specimen collecting.

Bald Mountain is a skarn deposit located in Jefferson County, Montana, and about 25 mi southeast of Butte. The mineralogy of Bald Mountain has been described by Reuss. Minerals of interest are diopside, grossular, vesuvianite, apatite, spinel (black), and blue calcite. Massive fine-grained diopside forms a zone perhaps 100 ft thick and several thousand feet in length. A thick unit of massive white calcite underlies the diopside bed. Within the massive diopside are areas where the diopside is coarsely crystalline and cavities have formed. These cavities are filled by blue calcite that must be dissolved to expose the diopside crystals. The diopside forms excellent crystals up to 1 inch. Much of the diopside is twinned. A bright blue calcite fills the cavities. Grossular is sparingly found in the cavities. The grossular forms excellent crystals up to 1.5 inches. The color ranges from a brownish red to almost an orange color. The garnets occur in combination with diopside and can be very showy. Vesuvianite is fairly rare. It occurs as crystals up to 1/2 inch. Light-yellow apatite (calcium) is also found in the diopside zone, but is rare. Crystals are opaque and light yellow in color and are up to 1 inch. The spinel occurs as shiny black octahedrons up to 5 mm and is very rare.

The PC mine is a specimen mine located about 7 mi from Basin, Montana, and was mined by the author from 1989 to 2005. The deposit is an epithermal deposit hosted in Elkhorn volcanics. The deposit is highly brecciated and has (had) countless "pockets" or "vugs" that were filled with quartz crystals. The site produced a large number of Japan law twins and many tons of quartz crystals, singles and groups. Other minerals produced include pyrite, galena, and sphalerite. Sulfides were very rare in the pockets, but the crystal size was impressive. The sphalerite occurred in crystals up to 9 inches and the galena up to 5 inches. The sphalerite was green to brown, and flawless gems up to 99 carats have been cut.

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Twenty three pegmatites in five Days, a Colorado field trip saga

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During five days in August of 2010, the authors visited numerous pegmatites in northern and central Colorado in pursuit of samples of microcline feldspar to add to the worldwide suite of samples that had already been studied by Munoz. The focus of his work has been the study of microstructures—exsolution and twinning—in potassium feldspar, and interpretation of what these can tell about the cooling history of pegmatites. His goal was to collect clean, large, orientable cleavage samples of microcline, free of hydrothermal alteration effects, which would preserve a record of the original crystallization conditions and subsequent cooling history of the feldspar.

Aside from the Tertiary-age pegmatites in the Mount Antero granite, most Colorado pegmatites are related to Precambrian granitic rocks. Best known are the amazonite-bearing miarolitic pegmatites in the ~1.1 Ga (1.1 b.y. old) anorogenic Pikes Peak granite, but in the northern part of the Pikes Peak batholith a swarm of vertical, pipe-like, concentrically zoned pegmatites also occurs that constitute the South Platte pegmatite district. These have an NYF (niobium-yttrium-fluorine) geochemical affinity and are enriched in those elements, often containing large masses of fluorite.

Older pegmatites in Colorado are associated with the synorogenic ~1.7 Ga suite of granite, granodiorite, and other igneous rocks known as the Routt (Boulder Creek) plutonic suite. These pegmatites typically occur as contorted bodies within high-grade metamorphic rocks that surround the plutons. The pegmatites have an LCT (lithium-cesium-tantalum) geochemical affinity; several contain lithium minerals (lepidolite, colored tourmaline, spodumene), and many contain beryl, black tourmaline (schorl), and phosphate minerals, all of which are rare in the Pikes Peak batholith. The actual age of most of the pre-Pikes Peak pegmatites has not been directly determined, and although most of the larger pegmatites are believed to be genetically related to the 1.7 Ga plutons, the affiliation of many is in doubt and it remains uncertain how many pegmatites are instead related to the granitic intrusives of the dominantly anorogenic ~1.4 Ga Berthoud (Silver Plume) plutonic suite. Our goal was to visit and sample as many different types of pegmatites as possible during Munoz' visit to Colorado.

The field work took us to pegmatites near Denver, Golden, and Evergreen (the "Denver Mountain Parks area"), the Crystal Mountain pegmatite district of Larimer County, the Eight Mile Park, Micanite, and Texas Creek pegmatite districts north of the Arkansas River, to Trout Creek Pass, and to the South Platte pegmatite district of the Pikes Peak batholith. Luis had already obtained samples of microcline from amazonite-bearing miarolitic cavity pegmatites on a previous visit to Colorado. Pegmatites we visited, with some of the notable minerals occurring in them, were:

1. Unnamed, simple pegmatite dike in Golden Gate Canyon, near the Golden Gate grange.
2. Unnamed simple pegmatite dike in Golden Gate Canyon, east of Mt. Galbraith Park trailhead.
3. Roscoe pegmatite dike, Clear Creek Canyon (biotite, magnetite, rare-earth minerals).
4. Unnamed garnet-bearing pegmatite dike near the top of Douglas Mountain Road.
5. Evans Ranch (Bald Mountain) lithium-bearing pegmatite (lepidolite, dark blue-green elbaite).

6. Lesser White Cloud pegmatite, South Platte pegmatite district.
7. White Cloud pegmatite, South Platte district (fluorite, gadolinite, synchysite).
8. Unnamed small pegmatite north of Raleigh Peak, South Platte district.
9. Oregon No. 3 pegmatite, South Platte district.
10. Oregon No. 21/2 pegmatite, South Platte district.
11. Oregon No. 11/2 pegmatite, South Platte district.
12. Oregon No. 1 (?) pegmatite, South Platte district.
13. Devils Hole pegmatite, Texas Creek area, Fremont County (beryl, columbite, rose quartz).
14. Chief lithium pegmatite, Texas Creek area, Fremont County (lepidolite, dark green elbaite).
15. Mica Lode pegmatite, Eight Mile Park district, Fremont County.
16. Climax mica mine pegmatite, Micanite district, Park County (abundant muscovite).
17. Rose Dawn pegmatite, Micanite district, Fremont County (beryl, fluorapatite, columbite).
18. Clora May pegmatite, Trout Creek Pass, Chaffee County (aeschnite).
19. Unnamed quartz-microcline pegmatite knob north of Clora May pegmatite, Trout Creek Pass.
20. McGuire (Lone Lode) pegmatite, South Platte district, Park County (ilmenite, fluorite, topaz).
21. Hyatt (Big Beryl) pegmatite, Crystal Mountain district, Larimer County (beryl).
22. Tourmaline Prospect pegmatite, Crystal Mountain district, Larimer County (schorl).
23. Bull Elk Beryl Crystal No. 1 pegmatite, Crystal Mountain district, Larimer County.
24. Big Boulder pegmatite, Crystal Mountain district, Larimer County (spodumene, schorl).

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