

## Abstracts

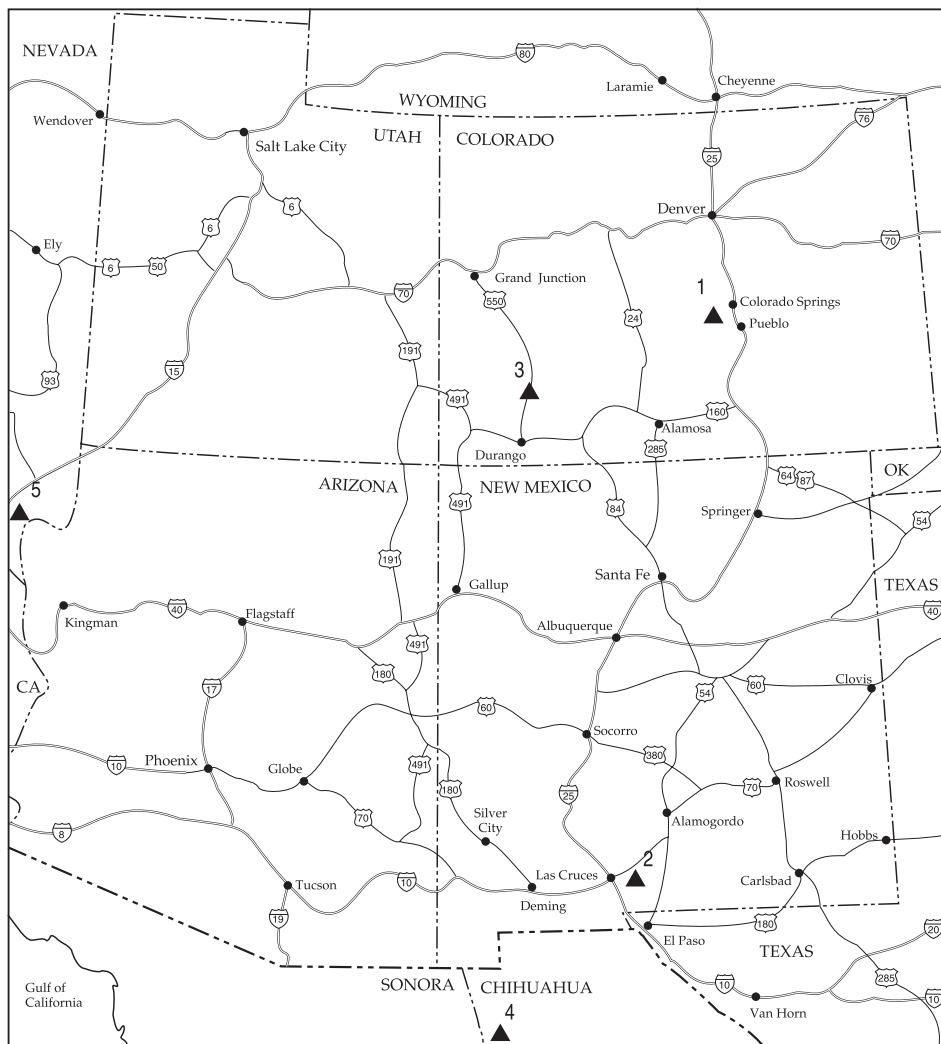
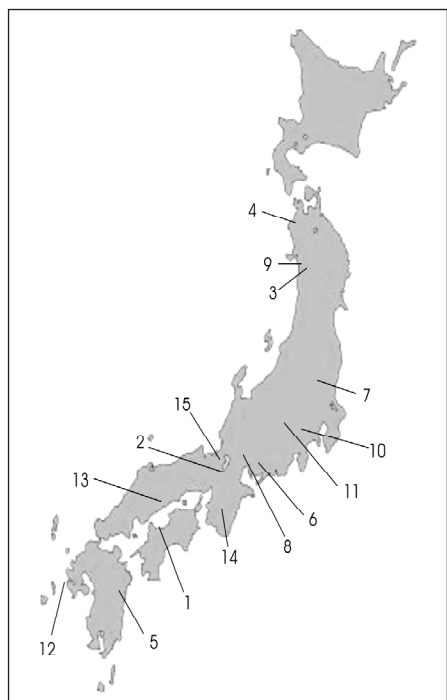
### New Mexico Mineral Symposium

The Twenty-eighth Annual New Mexico Mineral Symposium was held November 10 and 11, 2007, at New Mexico Institute of Mining and Technology, Socorro. Following are abstracts from all talks given at the symposium.

#### MINERALOGICAL MEANDERINGS IN JAPAN, *John Rakovan*, Department of Geology, Miami University, Oxford, Ohio 45056

The geology and mineralogy of Japan are quite diverse, and there are a number of classic mineral locations that are still well known among collectors. Certainly the icon of Japanese minerals is stibnite from the Ichinokawa mine, Ehime Prefecture (1). Other classic locations and their most notable minerals include: topaz, aquamarine, quartz, and microcline, Tanakamiyama, Shiga Prefecture (2); chalcocopyrite, Hisaichi mine, Akita Prefecture (3); rhodochrosite, Oppu mine, Aomori Prefecture (4); axinite and arsenopyrite, Obira mine, Oita Prefecture (5); pyroxmangite, Taguchi mine, Sitara, Aichi Prefecture (6); chalcocopyrite and fluorapatite, Ashio, Tochigi Prefecture (7); topaz, quartz, and microcline, Naegi district, Gifu Prefecture (8); chalcocopyrite, Arakawa mine, Akita Prefecture (9); bournonite, Chichibu mine, Saitama Prefecture (10); Japan-law twinned quartz and ferberite pseudomorphs after scheelite, Otome mine, Yamanashi Prefecture (11); Japan-law twinned quartz, Narushima Island, Nagasaki Prefecture (12).

In recent years it has been unusual for specimens from new mineral finds to make it out of Japan in any quantity. A few exceptions, which have created a lot of interest, include: henmilite, Fuka mine, Okayama Prefecture (13, type location); iridescent andradite, Kouse mine, Yoshino, Nara Prefecture (14); and mica pseudomorphs after cordierite, Yunohana, Kameoka, Kyoto Prefecture (15).



Index map showing the locations referred to in the abstracts.

In the early to middle twentieth century four major mineral collections were assembled that are considered today to be the preeminent collections of Japanese minerals in Japan. These are the Wada (later to become part of the Mitsubishi collection), the Sakurai, the Ko, and the Wakabayashi collections. Each has its own strength, but in terms of specimen quality and quantity the Wada collection is unsurpassed. All of these collections have superlative examples of the minerals listed above as well as many exceptional specimens from locations that are much less familiar to western mineral collectors. In my presentation, *Mineralogical Meanderings in Japan*, I will take the audience on a pictorial tour of these four collections as well as other geographic, cultural, and mineralogical sites.

#### A NEW WAY TO LOOK AT GOLD DEPOSITS IN THE CRIPPLE CREEK MINING DISTRICT: HIGH-RESOLUTION X-RAY COMPUTED TOMOGRAPHY APPLIED TO UNDERSTANDING ORE-FORMING SYSTEMS AND MAXIMIZING PRECIOUS METAL RECOVERY, *Steven Wade Veatch*, Colorado Springs Mineralogical Society, and *Timothy R. Brown*, Cripple Creek & Victor Gold Mining Company

(Location 1 on the index map.)

High-resolution X-ray Computed Tomography

(HRXCT) provides imagery of the interior of rock specimens. This new technique, advanced by researchers at the University of Texas at Austin, has been used to create three-dimensional imagery of ore samples in the Cripple Creek mining district, Colorado, for a variety of studies. HRXCT, unlike conventional medical CAT-scanning, can resolve extremely small details—down to a few tens of microns in size.

The Cripple Creek mining district is centered on a circular-shaped, Oligocene-age, alkaline volcanic complex that covers just over 7 mi<sup>2</sup>. The complex is surrounded by Precambrian rocks (biotite gneiss, granodiorite, quartz monzonite, granite). Regional tectonic extension at the intersection of these four Precambrian rock units localized the volcanic activity. Laccoliths, cryptodomes, dikes, and sills composed of syenites, phonolites, phonotephrites, and lamprophyres were formed at shallow depths.

The mineralization at the Cripple Creek mining district is characterized by high-grade gold-telluride veins and low-grade disseminated gold and gold tellurides. High-grade gold mineralization is associated with major structural zones and also occurs as sheeted vein zones.

Underground mining operated in the district from 1891 until the 1960s. A small amount of underground mining is currently taking place in the district. Small-scale surface mining, using the heap-leach method, started in 1971 and was followed by large-scale, low-grade, surface mining

at Cripple Creek & Victor Gold Mining Company's (CC&V) Cresson project in 1994. The project is expected to continue operating into 2012. CC&V's gold production for 2006 was 283,000 ounces. CC&V reached an important milestone in August 2007 when it passed 3 million ounces of produced gold.

HRXCT technology was applied to samples collected from high-grade gold zones. HRXCT scans sense differences in X-ray absorption due to differences in density within the sample and emphasize these density variations. The digital information is processed from each ore sample, producing a series of two-dimensional images or "slices" of the sample. These series of scans are then stacked in order to generate a three-dimensional data set that will render the rock nearly transparent so that the interior can be seen. These images can be rotated, sliced, and viewed from any angle—allowing a detailed analysis and measurement of internal features. These three-dimensional HRXCT investigations of ore samples examine grain-scale relationships between gold and associated ore minerals, reveal spatial distribution of mineral grains in rocks, and provide insight regarding the nature of structural features and their relationship with gold distribution (preferred mineralization sites). These studies contribute to the understanding of hydrothermal ore-forming systems.

A three-dimensional image was made of an exploration drill core approximately 3.25 inches in diameter and 9 inches long in order to evaluate the economic potential of the exploration target. The image of the opaque rock was nearly transparent with gold-tellurides appearing as red and yellow specks clustered in a single plane. The variation in color of the gold grains is a function of their size and their composition (generally calaverite, sylvanite, or native gold). As a result, the gold content of this piece of drill core is estimated to range between 8 and 23 ounces per ton.

HRXCT technology provides a new way to image rock specimens and has the potential to help understand the emplacement mechanisms that result in high-grade veins and may assist in targeting new resources in ore districts. The evaluation of HRXCT applications in mining, ore studies, and precious metal recovery is continuing.

**AN OVERVIEW OF THE CLOSURES OF ABANDONED MINES IN NEW MEXICO,**  
*Fred Hurd*, 4262 Colt Rd., Las Cruces, New Mexico 88011, and *Chris Cowan*, 1903 Brown Rd., Las Cruces, New Mexico 88005

(Location 2 on the index map.)

This talk reviews closures of abandoned mines during the past decade in New Mexico, and will focus on the mineral-specimen-producing localities. The reasons for the closures and the types of closures will be examined. The localities affected by the closures and the minerals that were produced in these localities will also be highlighted.

New Mexico's mining activities go back more than 900 years, beginning with the prehistoric mining done by the Native Americans, continuing with the mining of the Spanish beginning in the 1600s, and greatly increasing with American miners seeking gold in 1828. Mining in New Mexico has been a major component of the history and growth of the economy of New Mexico for over 175 years and continues to be a vital component of New Mexico's economy today.

The loss of the mining heritage accompanying the mine closures will be discussed.

The goals of the New Mexico Abandoned Mine Land Program will be presented along with a brief explanation of its history and funding status. The past and current closures by the New Mexico Abandoned Mine Land Program will be presented along with the criteria used to select the localities for closure.

A Bureau of Land Management map of the mine closures in New Mexico including the recent mine closures will be presented along with photos of the types of minerals produced in these localities. Historically some of these localities produced museum quality specimens. Additional information provided by current New Mexico collectors concerning other known closures by private and corporate groups is included in this talk.

**CHEMISTRY AND MINERALOGY OF THE TURQUOISE GROUP OF SEMI-PRECIOUS GEM STONES AND THEIR FACSIMILES,**  
*Andrew J. Regis*, Arizona Resources, Pamona, New York

Turquoise is one of those semi-precious gemstones that has never really been explored for, but instead almost always found as a secondary mineral of copper deposits. However, in some cases it occurs by itself for unexplained reasons in a non-copper deposit environment, such as at Cerrillos and Orogrande, New Mexico, northern Nevada, and Cripple Creek, Colorado.

When you look at the mineralogy and chemistry, turquoise becomes a gem stone possessing many properties based mostly on its chemistry, which in turn is responsible for all the varying hues of color that commonly occur in turquoise. The question becomes whether a true turquoise actually exists having a composition of  $\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 4\text{H}_2\text{O}$ .

Turquoise forms a chemical series with the mutual substitution of  $\text{Fe}^{3+}$  for  $\text{Al}^{3+}$  forming chalcosiderite at the far end of the series with a composition of  $\text{CuFe}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 4\text{H}_2\text{O}$ . There are four minerals in the middle of this group that are all hydrated phosphates and vary only by the amounts of Cu,  $\text{Fe}^{2+}$ , Zn, and Ca, which can all substitute for Cu and still produce colors associated with "turquoise."

Most turquoise is deficient in Cu, and only in rare instances do materials called or labeled "turquoise" have Cu as the principal constituent in the divalent state. The x-ray diffraction data for all of the minerals in the turquoise group have almost identical d spacing, which makes identification difficult without corresponding chemical analysis. Because most samples of turquoise are cation deficient, the probability of a true turquoise mineral occurring in the western U.S. is doubtful.

With the popularity of turquoise as a jewelry stone and the lack of any real, untreated natural turquoise, many associated minerals and facsimile materials have entered the market place. Because of this, turquoise has had its mineralogy and popularity undermined by the introduction of treatments, imitations, and synthetics. Some of these facsimiles are difficult to detect even by the experts. Other minerals, which are sometimes called "turquoise," such as chrysocolla, variscite, and gaspeite, are attractive semi-precious stones in their own right. Gaspeite in particular is often more costly than turquoise. Over 60% of all turquoise currently being mined in the U.S. is stabilized to some degree with pricing increasing significantly for untreated natural turquoise.

**EMINENT NEW MEXICO FLUORITES AND COLLECTORS,** *Ramon S. DeMark*, 8240 Eddy Avenue, NE, Albuquerque, New Mexico 87109, and *Michael R. Sanders*, 330 Hastings, NE, Albuquerque, New Mexico 87106

Fluorite is infrequently mentioned in early publications dealing with New Mexico minerals and ore deposits. Fayette Jones (1904) does list fluorite from the Gila River and Sierra Oscura in the census of New Mexico minerals but has little else to say. There is no mention of New Mexico fluorite in *The Mineral Collector* (1894–1909), an early hobbyist magazine, although a number of other New Mexico minerals are mentioned in ads and articles. There is negligible mention of fluorite in Lindgren et al.'s (1910) monumental work on *Ore Deposits of New Mexico*. Fluorite mining, however, was apparently ongoing as early as the 1880s. Rothrock et al. (1946) state that "The first fluorspar mined in New Mexico came from the Foster mine in the Gila area in the 1880s," and Gillerman (1951) reports that fluorspar was first mined from the Burro Chief mine near Tyrone in the 1880s for use as flux.

Interest in fluorite as specimens was to come much later, although a hint of things to come was the mention of fluorite in an 1892 issue of a mining gazette published in El Paso, Texas (*The Bullion* 1892). According to *The Bullion*, "The claims in the main range of the Oscura afford silver-lead mineral (sic), the latter occurring as a sulphide in large cubes, frequently in clusters frosted with a thin crystal coating of fluorspar and calcite, forming the most beautiful cabinet specimens to be found in New Mexico." In recent years fluorite has become one of the most popular minerals sought by collectors. A number of New Mexico locations have produced high quality specimens featuring a wide variety of habits, forms, and colors. Twenty of the state's 33 counties have reported fluorite occurrences (Rothrock et al. 1946). Grant County leads with 30 locations, followed by Sierra County with 16 locations, and Luna County with 14 locations. Fluorite is not reported from virtually any of the eastern counties.

Most of the fluorite on display today in public and private collections in New Mexico has been collected in very recent years by a handful of individuals. These dedicated (obsessed?) collectors and/or dealers have brought forth specimens instantly recognizable by the cognoscenti from London to Tokyo as being from New Mexico. Our presentation will feature some of these fabulous fluorites and their renowned (notorious?) collectors.

#### References

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Lindgren, W., Graton, L. C., and Gordon, C. H., 1910, The ore deposits of New Mexico: U.S. Geological Survey, Professional Paper 68, 361 pp.  
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**HISTORY, GEOLOGY, AND MINERALOGY OF BASE-METAL REPLACEMENT ORE-BODIES, IDARADO AND CAMP BIRD MINES, SAN MIGUEL AND OURAY COUN-**

**TIES, COLORADO**, Tom Rosemeyer, P.O. Box 369, Magdalena, New Mexico 87825

(Location 3 on the index map.)

In 1960 Pb-Cu-Zn replacement ore was discovered in the Eocene Telluride Conglomerate adjacent to the Argentine vein in the Idarado mine, San Miguel County, Colorado. Production of the first replacement ore was from the 2422 stope at the base of the Telluride Conglomerate and continued along the vein until the early 1970s. From 1964 through 1968 additional replacement orebodies were located on the Cross, Basin, Ajax, Black Bear, Pandora, and Subsidiary veins. Production ended in 1978 when the Idarado Mining Company ceased operations. During this period approximately 1,285,000 tons of ore were mined from the replacement orebodies.

In 1968 Camp Bird Colorado, Inc. discovered economic replacement ore along the northwest-trending Orphan vein. Subsequent drilling along the Camp Bird vein from the 14th level disclosed low-grade mineralization but no orebodies of economic importance. Once mining progressed on the 21st level of the Orphan vein, additional ore was discovered adjacent the parallel Gordon vein. The replacement orebodies were mined from 1970 through 1978 and produced 381,589 tons of ore that averaged Au-trace, Ag-0.8 ounces/ton, Pb-4.8%, Cu-0.6%, Zn-6.8%.

During the 1980s when the Revenue mine, located in Yankee Boy Basin, was being operated, the Telluride Conglomerate was diamond drilled and replacement ore was encountered but no mining has taken place.

Most of the orebodies occurred at the base of the Telluride Conglomerate just above the unconformity with the Permian Cutler Shale. The ore boundary was so sharp in the Camp Bird mine that a pencil point could be put on the contact between ore and waste. The replacement ore could range from 10 to 60 feet thick and extend out from the vein for a distance of 40 feet and along the strike of the vein for thousands of feet. The ore from the Idarado and Camp Bird mines is almost identical and cannot be told apart when samples are placed next to each other.

Mineralogically, the main ore minerals were galena, chalcopyrite, and sphalerite. The gangue minerals consisted of green epidote, quartz, and pyrite. The ore minerals replaced the pebbles, cobbles, and boulders and formed pods of ore in the conglomerate. When replacement was not complete, beautiful vugs containing crystals of sphalerite, galena, chalcopyrite, quartz, calcite, pyrite, and barite were encountered in the mining of the orebodies. Probably some of the best mineral specimens that were produced in the 1970s came from these two deposits.

With the price of base metals still rising, there may be renewed mining in the San Juans that will once again supply beautiful mineral specimens to the collector world.

**“DISEASED” MINERALS—MICROBIAL DEGRADATION OF COPPER SULFIDE MUSEUM SPECIMENS**, Mike Spilde, mspilde@unm.edu, Institute of Meteoritics, MSC03-2050, University of New Mexico, Albuquerque, New Mexico 87131; Penelope Boston, pboston@nmt.edu, Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801; and Carl Francis, francis@eps.harvard.edu, Harvard Mineralogical Museum, 24 Oxford Street, Cambridge, Massachusetts 02138

Museum specimens of copper sulfide, notably chalcocite and bornite, sometimes develop brown or black, powdery coatings that degrade their aesthetic quality. Over a period of months to years, a beautiful specimen can develop an unattractive sooty coating that resembles black fungal smut that forms on plants. However, the mineral specimens are typically stored in display cabinets or drawers in ambient humidity and temperature, certainly not the type of environment one associates with fungal infestations. Although the coating can be washed off, it will usually reappear after a few years. Such coatings can raise havoc with museum mineral specimens, particularly in humid localities, where some specimens have to be removed and cleaned on a regular basis.

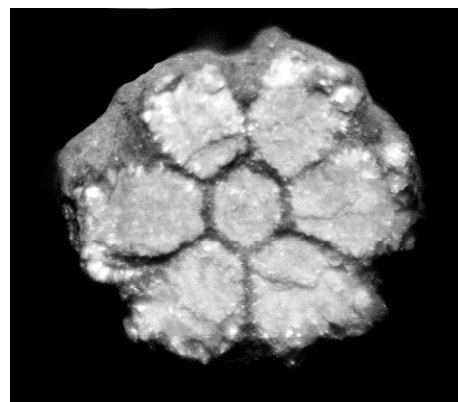
Several afflicted specimens from the Flambeau mine in Wisconsin were originally provided by the Harvard Mineralogical Museum in 2001. Specimens from this locality seem to be especially prone to quickly developing a brown coating while in display cabinets. The specimens were examined by scanning electron microscopy (SEM) and were also used to inoculate enrichment cultures on growth media containing various copper sulfides. Under the SEM, these samples exhibit an abundance of micrometer-sized, arborescent copper oxide growths. This finding led us to examine specimens from other localities and from different storage and display facilities. Many specimens displayed microscopic hyphae, filaments, and visible cells of fungi and bacteria.

The cultures from the original specimens responded slowly, but after several years, developed visible growth of blue-green or brown to black colonies that precipitate brilliant blue and green copper oxide minerals. Samples from the cultures were collected for DNA analysis and examination by SEM and electron microprobe. Several types of microorganisms that may be oxidizing copper and/or sulfur in these specimens have been identified from the cultures.

The level of humidity in certain regions may enhance microorganism growth on copper sulfides. In this case, specimens stored in Boston, on the eastern seaboard of the U.S., exhibit thick powdery coatings, whereas similar specimens from the mineral collection at the University of New Mexico, stored under much lower ambient humidity, display a thin sooty black coating. It is possible that handling the specimens provides a small amount of organic skin oil that may feed some of the organisms. In order to remove the coating, specimens should be cleaned and disinfected, where possible, with a bleach solution to kill the microorganisms. Specimens should also be stored under as dry conditions as possible to prevent growth.

**SAKURA ISHI FROM KAMEOKA, JAPAN: MICA PSEUDOMORPHS OF COMPLEX CORDIERITE-INDIALITE INTERGROWTHS**, John Rakooan, Department of Geology, Miami University, Oxford, Ohio 45056

Cherry blossoms have been revered for more than ten centuries in Japan and have become one of its most recognized icons. In the city of Kameoka, adjacent to Kyoto, mica pseudomorphs after complex cordierite-indialite intergrowths are found. These remarkable pseudomorphs resemble cherry blossoms and are known locally as *sakura ishi*, which means cherry blossom stone in Japanese. As with the real cherry blossoms, *sakura ishi* are also revered by mineralogists and mineral collectors in Japan.



The cordierite-indialite precursors to these pseudomorphs are only found in this unusual intergrowth in central Japan, mostly in Kyoto Prefecture. Kyoto has been the cultural center of Japan for a millennia, and it is fortuitous that this mineral would be from a place so intimately associated with an admiration for cherry blossoms. If the Japanese were inclined to name prefectural minerals, as state minerals are named in the U.S., then *sakura ishi* would be the obvious choice for Kyoto.

To understand how *sakura ishi* form it is necessary to look at the unaltered cordierite-indialite precursors. These can be found elsewhere in Kyoto, including Daimanji, one of the most famous mountains in that city.

The formational history of these unusual crystals includes segregated epitaxial growth of cordierite on indialite, transformation of indialite to cordierite and finally pseudomorphic replacement by mica. An article on the origin of *sakura ishi* was recently published in *Rocks & Minerals*, 2006, v. 81, no. 4, pp. 284–292.

**POSSIBLE CAUSES OF COLOR IN MICHIGAN DATOLITE**, Virgil Lueth, Nelia Dunbar, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801; and Tom Rosemeyer, 506 Pine St., Magdalena, New Mexico 87825

Datolite,  $\text{CaBSiO}_4(\text{OH})$ , is typically colorless to very light green at most localities worldwide. The same mineral from Michigan copper country displays colors ranging from gray to white, red, red-brown, blue-green, green, and yellow. These colors are unusual for a mineral that generally lacks significant substitution of chromophore elements. An electron microprobe and optical study was undertaken to determine if the cause of color in the Michigan samples was due to mineral inclusions or chemical substitutions into the crystal structure.

Optical examination of Michigan datolites reveals a number of interesting color features. Many datolite nodules have a white rim that can vary from hard to chalky. Microprobe analysis of these white rims indicates no chemical differences exist from the main mass of the nodule to the edge; however, empty polygonal pits are more abundant in the white zones. Translucent gray nodules are typically devoid of inclusions and have a consistent chemical composition supported by published data. Some gray specimens do have very small color “spots” of red, usually less than 0.1 mm. When these spots are abundant, the datolite takes on a red coloration. A few microchemical analyses of these spots reveal high iron content, and the spots probably represent hematite inclusions. In some samples these red spots

persist into the white rims. Many of these red spots seem invisible in the microprobe, although readily apparent in the microscope, suggesting many of these red spots are merely a residual iron oxide “dye,” much like that described in agates. The most common red to tan variation in many Michigan datolites appears to be a function of the abundance of these color spots.

Copper was the most abundant mineral inclusion noted in the datolites. In some samples, the copper occupies the same polygonal spaces noted in the white rims. Copper included datolites generally appear tan to red-brown with the intensity of red-brown color proportional to the number of copper inclusions. Brown-yellow datolites also contain fairly abundant inclusions of copper.

The more exotically colored blue and green datolites contain inclusions of secondary copper minerals. The bright blue samples appear to contain inclusions of a Cu-Ca silicate, most likely kinoite, based on stoichiometry. Green hues appear to be due to copper carbonate (malachite) inclusions. Only in light-green specimens are elevated copper concentrations noted in the datolite chemistry. Yellow specimens have many inclusions of an Mg-Ca-Fe silicate, most likely clays. Black veins or rinds on the yellow samples are predominantly iron oxide inclusions.

Based on the consistent chemistry in samples of various colors, it appears the dominant coloring mechanisms in Michigan datolite are inclusions of various types. Copper, secondary iron and copper oxides, and empty space inclusions of variable density impart most of the color observed. Trace element substitution into datolite is very limited, similar to results noted by previous workers, and is unlikely to cause the variations in color observed in these samples.

#### **HISTORICAL MINING, MINERALS, AND RECENT COLLECTING, BATOPILAS, CHIHUAHUA, MEXICO, Jim McGlasson, TheCollectorStope@comcast.net**

(Location 4 on the index map.)

The native silver occurrence at Batopilas, Chihuahua, Mexico, is like very few other deposits in the world. This deposit is grouped in a class of deposits known as “Five-Element Veins” (Lefebvre 1996), characterized by native silver in a calcite host, with associated arsenic, cobalt, nickel, ± bismuth, and uranium. Other examples of this type of silver deposit are: Cobalt, Ontario; Silver Islet, Ontario; Port Radium, Northwest Territories; Black Hawk, New Mexico; Erzgebirge district, Germany; and Kongsberg, Norway.

#### **History**

The name “Batopilas” is most likely derived from the Raramuri (language of the Tarahumara Indians) words *Ba-cho-tigori*, which mean “by the river.” The Tarahumara almost certainly had known of silver in the area for a long time before a Spanish soldier/explorer found silver by the Batopilas River in 1632. The Spanish exploration party took specimens of the silver back to Mexico City and shipped them to the King of Spain.

Only small bits of local records are available from the period before 1845 because of two large fires that ravaged the area—the first in 1740 and the second in 1845. Most of what is known comes from documents in the colonial archives in Madrid.

1730—Rafael Alonzo de Pastrana opened the Nuestra Señora de Pilar mine and is said to have extracted an average of 40,000 pesos of silver per year “for many years.” According to local legend

he invited the bishop of Durango to preside at his daughter’s wedding, and Pastrana had the streets from the hotel to the church paved with silver ingots. The bishop is reported to have been aghast at this display of worldly pride but was quick to thank Pastrana for his “generous donation to the church.” Pastrana died in 1760, by which time the main pocket of silver had been mined out and large portions of the mine were said to have caved.

1775—Cristobal Perez obtained the rights to the San Antonio mine and mined a large pocket of silver, making many millions of dollars over a 14-year period. By the time his son died in 1814 the entire fortune had been squandered.

1790—Angel Bustamante came to Batopilas as a merchant, eventually acquiring the Carmen mine (part of the San Miguel–Santo Domingo vein complex). Angel returned to Spain and “purchased” the title “Marquis de Batopilas” while his employees continued to operate the Carmen until the early 1800s.

In the 1820s the Spanish were expelled from Mexico after the Mexican War of Independence. Following expulsion of the Spanish, many mining districts in Mexico became dormant as no capital was available for operations. In 1820 the San Antonio mine was officially abandoned, leaving the Cata and Martinez mines as the last operations in the district. Some mines at Batopilas must have continued to produce high-grade ore during this difficult period as several excellent native silver specimens from this period survive (see below).

By 1842 Doña Natividad Ortiz, a woman of “strong character,” began acquiring properties and re-opening mines with the help of a Tarahumara Indian associate named “Avila.” In less than 10 years she had acquired and re-opened the Santo Domingo, San Nestor, Animas, Todos Santos, San Pedro, and La Aurora.

Doña Ortiz sold the San Antonio to Manuel Mendozona in 1852, and he proceeded to drive the San Miguel tunnel, near river level, below the San Antonio workings. Mendozona died before the tunnel was completed, and the property was sold to John R. Robinson. Robinson was an American mining engineer who completed the tunnel to the San Antonio vein, encountering a “blind vein” in the process. This structure did not show good indications of silver where it was encountered, but following the weak showings resulted in the discovery of a large bonanza that earned the vein the name “Veta Grande.”

In 1859 Mr. George Le-Brun acquired the Pastrana and Cata mines and started a tunnel below the historic workings of the Pastrana around 1861. In 1866 Koels reported that the lower tunnel was in ore in a structure 17 feet wide and that Le-Brun was negotiating the sale of 50% interest in the mine for \$300,000. Not much else is known except that the mine was abandoned (in ore!) due to flooding. The Le-Brun tunnel has recently been excavated and shown to crosscut approximately 90 meters to the vein, then drift along it for 400 meters. There is a long crosscut to the west, probably exploring for an additional structure, and several stopes above the level, indicating that ore was mined from above this level. A small winze was driven into the vein about midway along the vein, but its depth cannot be determined because it remains flooded.

1880—Alexander Robey Shepherd arrived in Batopilas after leaving Washington D.C. bankrupt and in disgrace after being ousted from being the first, last, and only “Governor” D.C. ever had. Shepherd and associates raised enough funds to pay John Robinson \$600,000 for the San

Miguel in 1880. (Robinson used this money to buy the majority of the Santa Eulalia district outside Chihuahua City, although he never successfully operated there). Through his friendship with Mexican President Porfirio Diaz, Shepherd acquired a government concession that gave him control of most of the open ground in the district and an inside track on controlling/acquiring 350 mining claims covering 31 square kilometers. Shepherd formed the Consolidated Batopilas Mining Company in 1881 and ran the company until his death in 1902. Shepherd returned to Washington in 1887 and commissioned the Gorham Silver Company to produce 15 silver “Batopilas flasks” featuring embossed views of various features of the Batopilas Valley and mines. These were distributed to friends in 1888: Five were given to Mexican government officials, and 10 to Americans. One sold recently for \$12,500. Shepherd died in Batopilas in 1902 and was returned to Washington D.C. for burial. Shepherd’s sons continued to manage the operations in Batopilas until 1913 when Pancho Villa’s soldiers ruined the equipment and ran the gringos out of Mexico. Shepherd’s sons briefly resumed operations late in the teens but ceased mining operations in 1920. They kept control of the claims and again attempted a revival in the mid-1930s, which collapsed in the face of fears of government expropriation of metals following seizure of all petroleum rights in 1936.

Shepherd added about \$2 million in municipal and mine improvements—stamp mills, concentrators, major development tunnels including the 2.14 kilometer Porfirio Diaz tunnel, and a hydroelectric plant. Batopilas was the second city in Mexico to have electricity, following Mexico City. Other improvements included a masonry aqueduct nearly 6 kilometers long, amalgamation and retorting facilities, a foundry capable of making castings up to 2,500 pounds, a hospital, schools, a bridge over the river, and an aerial tram 800 meters long (from the San Miguel mine to the San Antonio hacienda.) During Shepherd’s era the population of Batopilas increased from 400 to 5,000 habitants, and it was considered a fine place to live. The locals still speak of the lost grandeur of Batopilas. The “hacienda” that Shepherd constructed as his residence and beneficiation plant stood until it was stripped for scrap iron in the 1950s. It is now in ruins, but many of the Shepherd-era improvements are still standing, most notably the aqueduct that is still used by the city for water.

The Santo Domingo Silver Company extracted about 800,000 ounces of silver from the Santo Domingo mine from 1922 to 1929. This was one property never controlled by Mr. Shepherd and associates.

During the 1970s a small mill was installed but failed, as it was not appropriate for Batopilas native silver ores. In the 1980s an attempt was made to leach some ore at the Pastrana mine with cyanide, but this too was a failure.

Currently the district is under the control of MAG Silver Corporation (96%), who run an active ongoing exploration program. This exploration program’s target is finding entirely new silver lodes in unexploited parts of the district, not the small amounts of material left by previous operations.

The best estimate for the total district historic production to 1880 is Dahlgren (1883) who indicated that between 200 and 300 million ounces of silver were mined during the first two centuries of operation (1632–1845), but admits that data for the very high grade “bonanza” deposits are grossly incomplete. The best production records

for the district are from the Shepherd era when roughly 1 million ounces a year were produced from ores averaging 30 ounces per ton (Shepherd 1935). This average masks the fact that 75% of this total came from less than 10% of the tonnage produced, in other words ores grading over 200 ounces per ton! It is reported that in the first years after Shepherd began mining \$1 million was paid to investors as dividends, but later correspondence from disgruntled shareholders indicates that most of the profits went to support Shepherd's lavish lifestyle as the "King of Batopilas."

Until 1977 all equipment and supplies to Batopilas arrived by mule train, from Creel, Cuauhtémoc, and Chihuahua City. Likewise, during Shepherd's time all of the bullion was shipped out monthly by mule, with 50–100 bars per month (each bar weighing 60–75 pounds and worth about \$29,000 at today's silver price) going to the Banco Minero in Chihuahua. Production delivered to Chihuahua averaged around 80,000–120,000 ounces per month or around a million ounces a year in the mid-1880s to around 1913. In 1943 a road was built to La Bufa, 12 kilometers upstream from Batopilas, to provide access to the Carmen mine (source of many chalcopryite and copper in calcite specimens); the last 12 kilometers were not built until 1977, but today access to the district is easy for most vehicles.

### Mining

Batopilas has been known for very rich deposits of mainly native silver for considerable time. It is estimated that 75–80% of all silver extracted from the Batopilas district was native silver in very rich pockets or "clavos" (shoots). One example of these comes from the San Miguel group where a "pocket" in the vein measured 1 meter x 8 meters x 12 meters and yielded 2 million ounces of silver. This would represent 5.93 cubic meters of silver—in a mined area of 96 cubic meters or 6.18% silver. Another is from the Santo Domingo mine and represents one of the largest pockets ever recorded in the district at around 100 meters long and up to 3 meters wide.

There are several types of veins described in the Batopilas district (Brodie 1909; Krieger 1935; and Wilkerson 1988):

**Quartz-barite-galena-sphalerite veins** with ± silver usually as acanthite.

**Calcite-silver veins**—These may have minor quartz, galena, and sphalerite but mainly consist of native silver and acanthite in a matrix of highly fluorescent manganoan calcite. There are also trace amounts of nickel-cobalt arsenides in these veins.

**Chlorite-actinolite-silver veins**—These veins contain sheared mafic rocks that have altered to actinolite-chlorite. Silver is present as native silver with minor amounts of galena and sphalerite.

**Quartz-pyrite-molybdenite veins**—These veins contain no silver minerals and only minor galena ± sphalerite.

As the mining developed, large masses of silver were encountered in the calcite-silver veins, and the miners developed terminology to describe the different types of material encountered.

In the mine the silver was described as follows by its physical characteristics related to mining (Koels 1866).

**Massive—Plata Maciza**—This material had to be hammered out or cut by chisels: It would not break.

**Wire—Plata Alambrada**—This material was composed of wires of variable thickness, which separated by pounding; when very fine and near

together it was called *plata broza*, which yields 50–65% silver by weight.

**Nails—Plata de Clavos**—Silver in the shape of nails of variable thickness.

**Leaves—Plata de Hoja**—Silver in the shape of leaves or sheets.

**Lumps—Bolas de Plata**—These are masses of silver that may not show much silver from the outside, but can be essentially solid silver inside.

**Sulphurets—Metal de Azogue**—This material shows small patches of silver usually as sulfosalts. Silver was extracted from this by mercury (*azogue*) amalgamation.

The classes of ore at Batopilas were also determined by mineralogical characteristics as follows (Randolph 1881):

**Bodoque**—Chloride of silver consisting of very rich earths near the surface.

**Plata Negra**—Highly crystallized and very rich "black silver" or acanthite.

**Cardenilla**—Highly crystallized and very rich "ruby silver" or proustite.

**Plata Fuerte**—Massive native silver in pieces commonly weighing several hundred pounds.

**Brosa**—One-third calcite and two-thirds native silver (19,450 ounces per ton); running \$20,000 a ton (\$233,400 at \$12.00 per ounce Ag). Large quantities of this were produced in the 1880s in the San Miguel mines.

**Chispado**—Two-thirds calcite and one-third native silver (9,725 ounces per ton); running \$10,000 a ton (\$116,700 at \$12.00 per ounce Ag). Found accompanying *brosa* silver.

**Plata de Clavos**—Calcite containing scattered nails and ferns of silver; running \$500 to \$5,000 a ton (\$5,800 to \$58,000 at \$12.00 per ounce Ag) and resulting from the hand dressing of *brosa* and *chispado*.

**Azogues**—Amalgamating ores, containing finely disseminated silver, and running \$50 to \$500 a ton (\$580 to \$5,800 at \$12.00 per ounce Ag), in large quantities and containing strings and "bonanzitas" of *brosa* and *chispado* of great value.

Ore grade material was broken by hand with hammers and later by stamp mills. The ores were processed by either direct smelting (very high grade ores) or by mixing with salt and mercury (patio process amalgamation). The metal was formed into bars and shipped to Chihuahua.

Mining started on the vein outcroppings high on the hills both north and south of the Rio Batopilas. As mining proceeded to depth, getting the ore to the surface on workers' backs became too arduous, so some mines installed hoists that were operated by horses or mules. Some still continued human haulage, however. It was not until after Shepherd consolidated the district and started the Porfirio Diaz tunnel that the production from the upper mines (Roncesvalles, Todos Santos, and others) had the opportunity to let gravity work for instead of against them. Shepherd worked on this access tunnel for 14 years commencing in May 1885 and finishing in February 1899. However, plans to continue this tunnel an additional 4 kilometers to the west and access the lower workings of the Camuchin and Descubridora areas never materialized.

### Specimens

Joel Roberts Poinsett, the first American minister to Mexico (and popularizer of the familiar Christmas foliage now known as "poinsettia") acquired several excellent native silver specimens during his 1822–1830 tenure that he gave to the American Philosophical Society. Most are fist-sized pieces of *brosa*, but one example of stout wires to 3 cm long and another of stout elongate

crystals to 5 cm long were included in his gift.

The earliest recorded specimen sales from Batopilas were from an 1886 auction, but Koels (1866) noted, "All of the different classes turn out the most beautiful specimens, which serve to adorn cabinets, and are frequently purchased for more than their intrinsic value." The collection belonging to A. Dohrmann Esq. of San Francisco was auctioned in Philadelphia at the Davis and Harvey Art Gallery on December 13–15, 1886. The collection consisted of 1,867 mineral specimens, of which 212 were silvers, with over 100 from Batopilas. Specimens from the Pastrana mine accounted for 73 of the Batopilas specimens.

A display of specimens from Batopilas was at the 1893 Columbian Exposition (Worlds Fair) in Chicago. The Batopilas Mining Company displayed a 380 pound silver specimen and a primitive voltmeter showing complete connectivity across the specimen. There is no detailed description of this specimen, and it mysteriously vanished after the fair, but it probably came from either the Porfirio Diaz tunnel (Roncesvalles-Todos Santos structures) or the San Miguel mine.

Before the road was completed from La Bufa in 1977 there was a large amount of specimen production by John Whitmire (1972), and these specimens have been disseminated to collectors since that time. During this time specimen production came principally from an orebody in the Nevada Valenciana (New Nevada), discovered by Manuel Limones in the early 1970s. The mine was acquired by a consortium of four local miners—each had a day that they were allowed to work the mine, and keep their finds, without a split to the others. During this time three "pockets" were found ranging from 200 to 450 kilograms each. These specimens are characterized as spiky crystals and herringbone growths, which had to be leached from the calcite vein matrix. There are minor amounts of sphalerite, acanthite, galena, and arsenopyrite on these specimens.

Currently several "gambusinos" are still working the mines, dumps, and the river for specimens. These people then sell the specimens to the tourists or mineral collectors when they come to Batopilas.

During recent exploration activities, MAG Silver discovered a previously undeveloped vein from which 2.7 kilograms of native silver specimens were collected in geological context as part of a vein bulk sample.

Specimen production is likely to continue on a limited scale by the local gambusinos from accessible workings and the river. However, if the exploration program currently being conducted by MAG Silver is successful there is likely to be additional mining in this very productive and historic district. Specimen collecting and marketing rights remain with IMDEX Inc., vendors of the property to MAG Silver.

Mineralization in the district has been described many times in reports and the literature as spotty high-grade silver, confined to structures. Alexander Shepherd Jr. (1935) wrote, "It must be remembered that at Batopilas veins are largely barren except where major pockets occur, and the only way to find these is to mine along the veins." An incident reported by Lamb (1908) concerns a mining engineer who was sampling veins in several points in the mine in order to determine the amount of ore "in sight." Shepherd Sr. admonished him by stating, "We have no ore in sight. Just as soon as it gets in sight, we take it out of sight."

This statement remains as true today. If you think that you can go to Batopilas and get access

List of mineral specimens in the Batopilas district veins

Acanthite	Ag <sub>2</sub> S
Actinolite	Ca <sub>2</sub> (Mg,Fe) <sub>5</sub> Si <sub>8</sub> O <sub>22</sub> (OH) <sub>2</sub>
Arsenic	As
Arsenopyrite	FeAsS
Azurite	Cu <sub>3</sub> (CO <sub>3</sub> ) <sub>2</sub> (OH) <sub>2</sub>
Barite	BaSO <sub>4</sub>
Bromargyrite	AgBr
Calcite	CaCO <sub>3</sub>
Chalcanthite	CuSO <sub>4</sub> ·5H <sub>2</sub> O
Chalcocite	Cu <sub>2</sub> FeS <sub>2</sub>
Chlorargyrite	AgCl
Chlorite group clays	
Dolomite	CaMg(CO <sub>3</sub> ) <sub>2</sub>
Dufrenoyite	Pb <sub>2</sub> As <sub>2</sub> S <sub>5</sub>
Freieslebenite	AgPbSbS <sub>3</sub>
Fluorite	CaF <sub>2</sub>
Galena	PbS
Gypsum	CaSO <sub>4</sub> ·2H <sub>2</sub> O
Harmotone	(Ba,K) <sub>1-2</sub> Al <sub>3</sub> (Al,Si) <sub>2</sub> Si <sub>13</sub> O <sub>16</sub> ·12H <sub>2</sub> O
Heulandite	(Na,Ca) <sub>2-3</sub> Al <sub>3</sub> (Al,Si) <sub>2</sub> Si <sub>13</sub> O <sub>16</sub> ·12H <sub>2</sub> O
Iodargyrite	AgI
Litharge	PbO
Laumontite	CaAl <sub>2</sub> Si <sub>4</sub> O <sub>12</sub> ·4H <sub>2</sub> O
Malachite	Cu <sub>2</sub> (CO <sub>3</sub> )(OH) <sub>2</sub>
Massicot	PbO
Molybdenite	MoS <sub>2</sub>
Polybasite	(Ag,Cu) <sub>16</sub> Sb <sub>2</sub> S <sub>11</sub>
Proustite	Ag <sub>3</sub> AsS <sub>3</sub>
Pyrrargyrite	Ag <sub>3</sub> SbS <sub>3</sub>
Pyrite	FeS <sub>2</sub>
Quartz	SiO <sub>2</sub>
Rammelsburgite	NiAs <sub>2</sub>
Safflorite	CoAs <sub>2</sub>
Silver	Ag
Sphalerite	(Zn,Fe)S
Stephanite	Ag <sub>5</sub> SbS <sub>4</sub>
Xanthoconite	Ag <sub>3</sub> AsS <sub>3</sub>

to the old workings to find some silver you are wasting your time. In the several years that I have been working in Batopilas, there are only a few places that ANY silver could be found exposed in the workings, and this was extremely erratic and small. The best specimens that I have been able to obtain have come from gambusinos where they have "mined" the river following the summer and winter rains. Of course, the exception to this is MAG Silver's native silver discovery, which gives considerable hope for future specimen production from the district.

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The author's extensive bibliography, generated by IMDEX Inc.'s MexBib 3.4©, is available on request.

#### MINERALS OF THE FREDRICKSON MINE GOODSPRINGS DISTRICT, CLARK COUNTY, NEVADA, Patrick E. Haynes, 6468 Jackrabbit Run Ave., Las Vegas, Nevada 89122

(Location 5 on the index map.)

The Fredrickson mine is located in the NW<sup>1</sup>/<sub>4</sub> of sec. 33 T24S R58E in the Goodsprings mining district of Clark County, about 50 mi south-southwest of Las Vegas, Nevada. Hewitt's 1931 paper (pages 147-148) deals with the historical and geological information, which is summarized here. The Fredrickson mine was located in 1897 by Jesse Jones. The mine has a main inclined tunnel with five different levels indicated by Hewitt. Some modifications to the fourth and fifth levels suggest that the mine was producing after Hewitt's report, probably during WWII. From 1909 to 1926 ore from the mine yielded 5,615 ounces of silver, 3,741 pounds of copper, 205,368 pounds of lead, and 559,011 pounds of zinc.

Hewitt reported that the mine workings lie within the Mississippian-age Yellow Pine member of the Monte Cristo limestone. Mineralization occurs in breccias and faults. Sulfide minerals were oxidized resulting in ore that contained mostly hydrozincite, hemimorphite, and residual galena. Collecting specimens can be challenging, as the matrix is sometimes quite crumbly, resulting in a frustratingly high number of damaged specimens. Semi-quantitative EDS and/or powder XRD analysis confirmed the identities of most of these minerals. The wulfenite reported by Hewitt was not found. Only species found by the author are reported here.

**Aurichalcite**, (Zn,Cu)<sub>5</sub>(CO<sub>3</sub>)<sub>2</sub>(OH)<sub>6</sub>, was found on the first, fifth, and sixth levels. It is found as powdery blue films, crystalline aggregates, and as acicular crystals.

**Bromargyrite**, AgBr, was found as small green rounded or curved aggregates on the second level. It is associated with hemimorphite.

**Cerussite**, PbCO<sub>3</sub>, is found on the fifth level associated with rosasite and aurichalcite in a crumbly matrix. Crystals tend to be loosely attached to the matrix and are difficult to recover. The largest crystal recovered was 2.5 mm in size. The translucent colorless to gray crystals are small, and because they occur in a white to off-white matrix, they are difficult to spot. Paying attention to a reflective flash of high luster can give away their location.

**Cinnabar**, HgS, is intergrown with minium and forms red specks and small masses within or adjacent to oxidized galena.

**Descloizite**, PbZnVO<sub>4</sub>(OH), was found on the third level associated with galena and fornacite. It generally forms unattractive brown or orangeish-brown masses, but druses of tiny orange or brown crystals and surfaces with single crystals are also found. It may grade to mottramite as some of the crushed descloizite can locally display a green streak, suggestive of mottramite.

**Dolomite**, CaMg(CO<sub>3</sub>)<sub>2</sub>, is common, both as a coarse-grained gangue mineral and as white opaque rhombohedrons.

**Fornacite**, Pb<sub>2</sub>Cu(AsO<sub>4</sub>)(CrO<sub>4</sub>)(OH), was found on the third and fifth levels. It forms brown crystals up to 0.25 mm in size, which are often twinned. The crystals are lustrous and

transparent. Weathered or smeared fornacite has a pistachio green color, which is a useful hint for looking for microscopic crystals. Another useful clue is its association with galena.

**Galena**, PbS, generally occurs as black grains and masses. The masses can reach several inches in size, especially on the first level, and exhibit shiny cleavage faces. Associated tiny red minium/cinnabar masses or specks are not uncommon.

**Hemimorphite**, Zn<sub>4</sub>Si<sub>2</sub>O<sub>7</sub>(OH)<sub>2</sub>·H<sub>2</sub>O, occurs as transparent, striated colorless crystals.

**Hydrozincite**, Zn<sub>5</sub>(CO<sub>3</sub>)<sub>2</sub>(OH)<sub>6</sub>, is found on all levels of the mine. It is usually found as white or nearly white masses. Using a portable ultraviolet lamp can help locate it. Seams can have coatings of tiny crystals and groups of radiating crystals. The crystals are soft and fragile. Collecting undamaged specimens is challenging.

**Mimetite**, Pb<sub>5</sub>(AsO<sub>4</sub>)<sub>3</sub>Cl, was found on the first and fifth levels. It forms gemmy orange to yellow prisms and also ugly yellow aggregates.

**Minium**, Pb<sub>2</sub>PbO, is intergrown with cinnabar and forms red specks and small masses within or adjacent to oxidized galena.

**Mottramite**, PbCuVO<sub>4</sub>(OH), occurs sparsely with the descloizite on the third level, as indicated by its green streak and green-black drusy crystal coatings.

**Rosasite**, (Cu,Zn)<sub>2</sub>(CO<sub>3</sub>)(OH)<sub>2</sub>, was found on the first and fifth levels and below the fifth level. It forms blue or greenish-blue spherical aggregates and fans of adjacent prisms. Under high magnification individual crystals can be seen.

The mine is not patented but is assumed to be patented, so the owner should be contacted for permission to collect.

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#### EDWIN JENKINS OVER—FIELD COLLECTOR EXTRAORDINAIRE, Ray Berry, Colorado Springs, Colorado

Ed Over, born in 1905, was undoubtedly the premier commercial field collector of the first half of the 20th century. Even by the time of his death in 1963, private mineral collections were very rare. Only a few of the richest people had acquired a "cabinet" of crystals worthy of the name. Museums, however, had long been interested in minerals from the great mines in Europe and America. Over was soon known to museum curators and rich collectors around the world.

He was born in Spokane, Washington, but at age two when his mother died he went to live with his maternal grandparents in Fort Riley, Kansas. His early school years were spent with an aunt in San Francisco, where he became interested in rocks, and attended the Boys Polytechnic High School. As a 16 year old he moved to Colorado Springs, Colorado, to live with his uncle, Loyale Harner, and finished high school, then worked part-time in the Golden Cycle mill where his uncle was superintendent. He met and was influenced by Lazard Cahn, one of the leading mineralogists of the time. He attended the Colorado School of Mines at Golden, Colorado, for two years.

He decided he did not want to become a geologist working for someone else—he wanted to be free to work by himself where and when he liked. He married Louise Tapley and had one daughter, Jean, but married life was not for him! He was already spending most of his time collecting in

the Pikes Peak pegmatites and elsewhere and was divorced by his wife.

1928 saw him spending an entire season on Mt. Antero and Mt. White on the spine of North America. He camped in an old cabin at about 9,000 feet and hiked each day to 14,000 feet. He gained some fame by writing "The Mount Antero aquamarine locality" for *Rocks and Minerals* in December 1928. This was followed a year later with another article in *Rocks and Minerals*, "Some mineral localities of El Paso County, Colorado." He was able to sell his best specimens to various museums, and while at a mineral shop in Florissant, Colorado, he was introduced to Charles Palache of Harvard, probably the second most famous mineralogist of the day. Palache, who had been impressed with Over's collecting techniques and success, became instrumental in introducing him to another young collector and mineralogist, Arthur Montgomery. By 1934 the two had met and entered into a 50-50 partnership that lasted for 8 years and a lifetime friendship. Montgomery, living in New York City, became the sales manager of the team, and opened a shop in New York City that was soon visited by all the leading museum curators and private collectors.

In 1936 the Colorado Springs Mineralogical Society (CSMS) was formed with Lazard Cahn as its founding honorary president. Ed became a charter member, but today few members have heard of Over. But his years of collecting topaz at Devils Head, Colorado, and in the Thomas Range in Utah; epidote from Green Monster Mountain on Prince of Wales Island, Alaska; wulfenite from the Red Cloud mine near Yuma, Arizona; variscite from Clay County, Utah; and many other sites across America made him a collecting icon within the museum curators and private collecting circle.

This PowerPoint program was put together primarily from photos from the CSMS history files held at Penrose Library in Colorado Springs and The Pioneers Museum also in Colorado Springs and from scanned images in various articles in *Rocks and Minerals Magazine*, *The Mineralogical Record*, and *Matrix Magazine*.

Over was not a photographer and this makes it unfortunate for us in that no photos exist of Over's collecting unless Arthur Montgomery was there, and that was only on three of his expeditions. His work was the subject of many articles, and they make very interesting reading

today for those who wish to learn what collecting was like in the 1920s and 30s.

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