24th Annual
New Mexico
Mineral Symposium

November 8 & 9, 2003

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

Socorro 2003

Welcome to

THE TWENTY—FOURTH ANNUAL
NEW MEXICO MINERAL SYMPOSIUM

November 8 and 9, 2003

Macey Center Auditorium

New Mexico Institute of Mining and Technology

Socorro, New Mexico

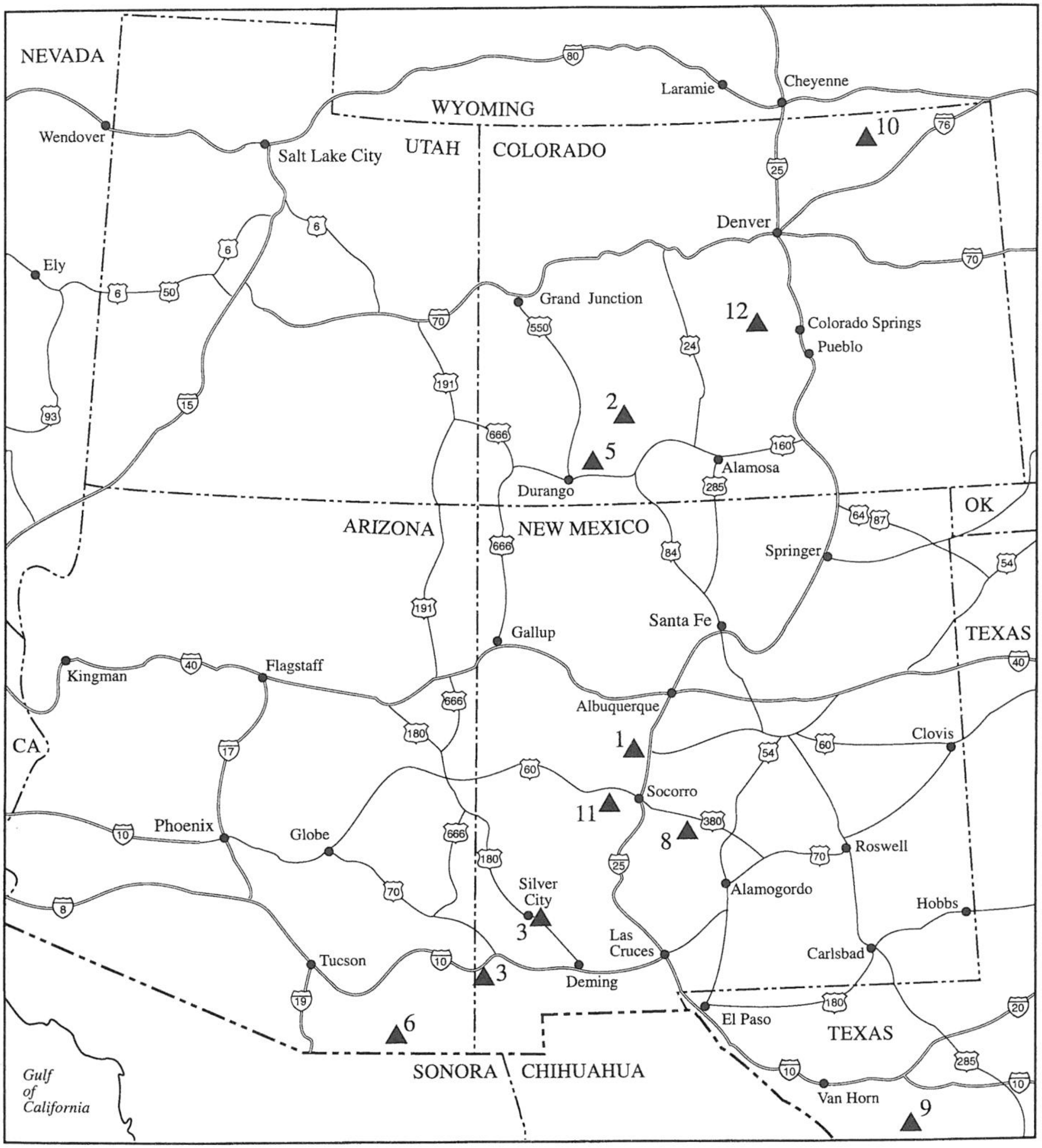
The Mineral Symposium is organized each year by the Mineral Museum
at the New Mexico Bureau of Geology and Mineral Resources.

Sponsors this year include:

Albuquerque Gem and Mineral Club
Chaparral Rockhounds
Los Alamos Geological Society
New Mexico Geological Society

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
24th New Mexico Mineral Symposium

SCHEDULE

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

FRIDAY, NOVEMBER 7, 2003

6:00 p.m. Informal tailgating and social hour individual rooms, Super 8 Motel (free)

SATURDAY, NOVEMBER 8, 2003

8:30 a.m. Registration: Macey Center, continental breakfast

9:20 a.m. *Opening remarks,* main auditorium

9:30 a.m. (1) *Gems of Thief Mountain (amethyst from the Ladrones Mountains, New Mexico)* – Dylan G. Canales and Robert E. Sanders

10:00 a.m. *(2) Wulfenite occurrences in Colorado* – Tom Rosemeyer

10:30 a.m. Coffee break

11:00 a.m. *(3) Wulfenite and associated minerals from the Central and San Simon districts, southwestern New Mexico* – Robert E. Walstrom

11:30 a.m. *An introduction to the Russian genetic mineralogy concept of "minerals ontogeny"* – Carol A. Hill

12:00 p.m. Lunch

1:00 p.m. Museum tours

2:00 p.m. (5) *New process in making meteorite replicas* – Jack Thompson and Jack A. Murphy

2:30 p.m. (6) *Bisbee—Queen of the copper camps* – Les Presmyk

3:00 p.m. Coffee break

3:30 p.m. *Meteorites of New Mexico* – Bill Nash

4:00 p.m. *(8) The cause of color in minerals with special reference to fluorites from Bingham, New Mexico* – John Rakovan, featured speaker

5:30 p.m. Sarsaparilla and suds: cocktail hour, cash bar

6:30 p.m. Dinner followed by an auction to benefit the New Mexico Mineral Symposium

SUNDAY, NOVEMBER 9, 2003

8:15 a.m. Morning social: coffee and donuts

9:00 a.m. *Welcome to the second day of the symposium and follow-up remarks*

9:10 a.m. (9) *Rocks and relics* – Jack W. Burgess

9:40 a.m. *(10) Mining for blue barite at Stoneham, Colorado* – Michael R. Sanders and Frank Bendrick

10:10 a.m. Coffee break

10:40 a.m. *(11) Native silver and wulfenite at the Anchor Mine, Magdalena district, Socorro County, New Mexico* – Ramon S. DeMark

11:10 a.m. (12) *The Godsend claim: a preliminary report, Lake George pegmatite district, Teller County, Colorado* – Steven Wade Veatch, Reinhard A. Wobus, and Richard W. Fretterd

12:00 p.m. Lunch

1:15 p.m. Silent auction, upper lobby,
3:00 p.m. Albuquerque Gem and Mineral Club (free)

Gems of Thief Mountain (amethyst from the Ladrones Mountains, New Mexico)

Dylan G. Canales and Robert E. Sanders
New Mexico Institute of Mining and Technology
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(Location 1 on the index map)

The Sierra Ladrones are situated within the Rio Grande rift and are a basement block uplift formed as a result of the extensional tectonism prevalent in this region for the last 30 m.y. Alteration and mineralization in the region has spanned at least the last 500 m.y. since the intrusion of Cambrian carbonatites into the Precambrian country rock (McMillan and McLemore, 2004). Recent observation suggests that Precambrian basement rocks in the Ladrones Mountains have experienced a much older history of hydrothermal alteration and brittle deformation.

The earliest documentation of mineralization at the Cascabel mine is based on misinterpretation of the local geology and therefore necessitates a contemporary genetic model for the tectonic history and mineral paragenesis. Previous observation attributed fluorite, quartz, and hematite formation to a 1-2-m-wide "diabase dike" that intruded the granitic gneiss country rock. Several factors negate this "intrusion" as the cause of mineralization: 1) Precambrian basement rock throughout the region contains linear amphibolite bodies (not diabase) not associated with country rock alteration; 2) Diabase dikes are water poor and silica poor and would not generate a hydro-thermal system capable of severely altering approximately 2 km^2 of country rock at the Cascabel mine. We prefer a genetic model that relies on circulation of hot, silica-rich fluids that infiltrated and exploited faults and fractures in the country rock. Oxidized iron responsible for the coloration of amethyst implies interaction of meteoric water during the last stage of mineralization. This constrains the depth of the host rock at the time of quartz deposition to several kilometers below the paleosurface. Open voids for quartz mineralization were the result of faulting and/or volumetric loss related to chemical alteration. Goethite pseudomorphs after pyrite show that sulfides were once present in the country rock and were the likely source of acid that caused the locally intense alteration. Following this, silica saturated fluids precipitated large, milky-quartz crystals as much as 6 inches in length. Fluorite crystallized after this. A second episode of mineralization began with deposition of hematite followed by a fluid lightly charged with silica that left a thin coat of dear quartz on the milky crystals. Finally, the amethyst formed as the weak silica solution gained oxidized iron. At least two episodes of mineralization are clearly delineated as nearly all the early quartz crystals were broken, then healed, or in some cases formed "dumbbells" as amethyst grew on both tips.

The age of mineralization has not yet been definitively determined, but several observations suggest a Proterozoic ancestry: 1) host rock for mineralization is Precambrian metamorphic rock; 2) Paleozoic sediments overlying the deposit are unaltered relative to Precambrian rocks. Localized fracturing and dilation within an extensional tectonic regime are conducive to mineralization. Proterozoic extension in the southwestern United States has been documented during two time periods at ca 1000 and 800 Ma (Timmons et al., 2001). ^{40}Ar/^{39}Ar K-feldspar thermochronology of the basement rocks in New Mexico indicates that rocks were at approximately 10-km depth at ca 1000 Ma (Heizler, M.T., pers. comm. 2003), and were likely too deep for the style of mineralization observed at the Cascabel mine. However, by ca 800 Ma the basement over much of the region had been exhumed to a few kilometers depth that places the Precambrian host rocks at the Cascabel mine at shallow crustal levels. Based on this, we believe that - 800 Ma is a good representation for the timing of mineralization and alteration.

References

McMillan, N. J., and McLemore, V. T., 2004, Cambrian-Ordovician magmatism and extension in New Mexico and Colorado: New Mexico Bureau of Geology and Mineral Resources, Bulletin 160, in press.

Timmons, J. M., Karlstrom, K. E., Dehler, C. M., Geissman, **J.** W., Heizler, M. T., 2001, Proterozoic multistage (ca 1.1 and 0.8 Ga) extension recorded in the Grand Canyon Supergroup and establishment of northwest- and north-trending tectonic grains in the southwestern United States; Geological Society of America, Bulletin, v. 113, no. 2, pp. 163-180.

Wulfenite occurrences in Colorado

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(Location 2 on the index map)

Connoisseurs of wulfenite probably do not think of Colorado as a noteworthy state that has produced fine specimens of wulfenite. Surprisingly though, fine microcrystals of wulfenite have been found in a variety of ore deposits throughout the state. A good part of the Colorado wulfenite localities does not compare with those in Arizona and New Mexico, but microcrystals of wulfenite and associated minerals make interesting and rare additions to the micromounter's collection.

The majority of documented wulfenite finds have been made in the last 35 yrs because of new mining operations or as new discoveries in abandoned mines.

The first mention of wulfenite in Colorado was made in 1878 by F.M. Endlich in his mineralogical report in the Tenth Annual Hayden Survey Report. Other early reports of wulfenite in Colorado include the Central City district, the Silver Cliff district, and the Breckenridge district.

The creme de la crème wulfenite locality for Colorado is the Sherman tunnel, located east of Leadville at the base of Iowa Amphitheater at an elevation of 12,200 ft. The deposit was discovered in 1968, and the Sherman tunnel was started in 1970.

Strong oxidation and enrichment in parts of the irregular orebodies in the Leadville Dolomite have formed a large variety of secondary minerals including malachite, azurite, rosasite, aurichalcite, cerussite, smithsonite, hemimorphite, wulfenite, and native silver. All of the minerals occur as microcrystals in various associations.

The mines of the San Juan Mountains of southwestern Colorado have produced some of the best microcrystals of wulfenite that have been found in the last 30 yrs; before that wulfenite was not mentioned as occurring in the San Juans.

Wulfenite and associated minerals from Central and San Simon districts, southwestern New Mexico

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(Location 3 on the index map)

Recent collecting activity in parts of the Central district, Grant County, and San Simon district, Hidalgo County, New Mexico, has revealed an interesting suite of wulfenite in numerous habits and associations. Specimens collected from dumps, pits, cuts, and one underground locality are suitable for micromount and thumbnail presentation. Larger hand specimens are rare.

Central district—Localities covered by this investigation in the Central district include a group of 10 prospects and mines located 1 mi west of Vanadium and 2 mi north of Bayard, Grant County, New Mexico. The area is overshadowed by the large Chino open pit copper operation at Santa Rita located 3 mi north-northeast. The workings investigated include the following mines: Betty Jo, Silver King, Home, Sweeney, Yellowdog Gulch, Lion No. 2, Lion, Tiger, Little Bobs, and the Slate. The area consists of narrow quartz veins striking generally northeast and enclosed for the most part in quartz diorite. Dark resistant altered diorite containing quartz veins is quite noticeable on the gently rolling topography. The veins contain primary sulfides at depth, and near-surface oxidation has produced wulfenite and associated vanadinite, desclozite, willemite, cerussite, smithsonite, and pyromorphite. Wulfenite crystals occur in various habits including pyramidal, square tabular, prismatic, and pseudocubic. One four-wheel drive road remains open to the collecting area.

San Simon district—This district is in the central Peloncillo Mountains, just east of the Arizona border in Hidalgo County, New Mexico. The area, 5 by 10 mi in size, starts at Interstate 10 on the north and extends south to include the mines at Granite Gap. Mineral Mountain is located 2 mi west of Cedar Mountain in the northern part of the district. It is a volcanic-epithermal deposit consisting of steeply dipping quartz veins. The main shaft is reported to be 200 ft deep and is now inaccessible and filled with water to within 50 ft of the surface. Vein matter on the dumps consists of altered galena pods in quartz with associated wulfenite, yellow arsenian vanadinite, zincian mottramite, aurichalcite, fraipontite, and other secondary minerals. Wulfenite forms in various habits, including square tabular, prismatic, pyramidal, acicular, and other modified forms. One mineral, essentially a Pb-Zn-Cu-As vanadate, remains unidentified after analysis using microprobe and X-ray diffraction techniques. A somewhat marginal dirt road, washed out halfway to the workings, provides access to the area.

Granite Gap is located 10 mi south of the Mineral Mountain mine at the southern end of the San Simon district east of Highway 80. The area consists of three main workings: Bob Montgomery group, World's Fair group, and the Vesley mine located on the west slope of Granite Gap Mountain. This area contains carbonate-hosted Pb-Zn replacement deposits. Wulfenite occurs underground at the Bob Montgomery group as square tabular crystals associated with plattnerite. Adamite, agardite-(Y), bromargyrite, carminite, conichalcite, austinite, hemimorphite, mimetite, and other minerals can also be collected elsewhere in the mine. Wulfenite, in association with bromargyrite, has also been collected at an unnamed mine high on the east side of Granite Gap Mountain. The adit is caved, but square tabular wulfenite can be found sparingly on the dumps in gossan material. The Granite Gap mines are all located on private property, and a fee is charged for entry.

References

Beyer, J., and Gibbs, R., 2002, Minerals of the Granite Gap mines, Hidalgo County, New Mexico: Rocks and Minerals, v. 77, no. 5, pp. 298-305.

Gillerman, E., 1958, Geology of the central Peloncillo Mountains, Hidalgo County, New Mexico and Cochise County, Arizona: New Mexico Bureau of Mines and Mineral Resources, Bulletin 57, 152 pp.

Lasky, S. G., 1936, Geology and ore deposits of the Bayard area, Central mining district, New Mexico: U. S. Geological Survey, Bulletin 870, 144 pp.

Northrop, S. A., 1959, Minerals of New Mexico: University of New Mexico Press, Albuquerque, 665 pp.

An introduction to the Russian genetic mineralogy concept of "minerals ontogeny"

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The "ontogeny of minerals" is the study of individual crystals and their aggregates as physical bodies ("minor mineral bodies") rather than as mineral species. The genetic approach to mineralogy has been developed in Russia over the last 80 yrs but is poorly understood (if at all) in the West. Although ontogeny as a subject had its origins in the Russian mining industry, caves prove to be ideal settings for ontogeny studies because, although there are few common mineral species in caves (mainly calcite, aragonite, and gypsum), there is a great variety in the speleothem forms that these minerals can take. This paper introduces the basic principles of minerals ontogeny and explains a hierarchy classification scheme whereby mineral bodies can be studied as crystal *individuals, aggregates* of individuals, association of aggregates (termed *koras* by the Russians), and as sequences of koras *(ensembles).*

Although the discussion will focus on the classification and selection mechanisms of cave minerals and speleothems, these concepts will also be shown to be applicable to non-cave mineralogy subjects: 1) to crystal linings growing into free space within ore cavities (of prime interest to the mineral collector), 2) to the origin of ore veins (not the "traditional" view of druse growth along open spaces within cracked rock), 3) to the concept of "colloidal gels" for substances such as agate (really spherocrystals split down to the molecular level), and 4) to the interpretation of certain diagenetic textures within carbonate rocks (split-crystal growth within bedrock pore spaces due to an evaporative environment). The importance of minerals ontogeny is that, just by looking at a mineral occurrence, its genetic environment of deposition can usually be deduced from ontogenological principles.

New process in making meteorite replicas

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(Location 5 on the index map)

The casting of meteorites to preserve their original character, especially before they are cut, is a well-known procedure. Casting of meteorites has been a part of museum operations through the years; Harvey Nininger, curator of meteorites in the 1930s, made reproductions of several meteorites. In an effort to improve replicas for exhibition, we have used scanned digital images of the meteorites' polished faces on the cut surface of the cast, which give a remarkably realistic appearance. This paper discusses this technique applied to the Rifle iron meteorite and two new stony meteorites from Weld County, Colorado.

The Rifle iron, originally a 226-lb mass, was found in 1948 about 6 mi northwest of Rifle, Colorado. It was sold to Harvey Nininger, and when he divided his collection in the 1950s, it was cut into two almost equal-sized pieces. The Denver Museum's piece weighs 100 lb and is about the size of half a watermelon. Recently we made a replica for the Rifle Creek Museum in Rifle, Colorado, which they placed on display May 28, 2003.

We applied the scanned-image technique to show the dramatic Widmanstatten pattern on the cut and polished face. The procedure for molding and casting the piece was traditional: several layers of latex rubber applied to the original, a plaster support jacket made, then plaster poured into the mold to make the cast. For our 100-lb Rifle meteorite, Chief Prep arator and Curator of Vertebrate Paleontology, Kenneth Carpenter, made the mold and poured the casts. Denver artist Helen Barndt painted the white plaster surface to look like the rusty brown iron meteorite.

Reproducing the beautiful Widmanstatten pattern on the cut and etched surface of the nickel-iron meteorite was a real challenge. Ken Erickson, department volunteer, made a high-quality, flat-field black and white photograph of the meteorite. This was scanned to create a digital image from which an inkjet photo-quality print was made. The gloss of the paper was matched to the gloss of the meteorite's surface.

After sanding and coating the flat surface of the cast with a grout and tile sealer, the image was glued to the cast with super ply-bond cement. The replica was carefully trimmed with a scalpel and touched up with paint.

This technique was also used by Jack Thompson on two other meteorites in the museum collection, both stony meteorites from Weld County, Colorado. One is a fairly fresh (unoxidized) ordinary chondrite found near Stoneham. It had been cut in two directions and shows well-pronounced internal structures including metal veining. The other, found near New Raymer, has a dark-brown oxidized color and an end piece cut off. The usual procedures for molding, casting, and surface painting were used as with the Rifle meteorite. However, these meteorites were small enough to be placed on a flatbed scanner, resulting in digital images for the cut surfaces. The suggestion for this method came from Wilson (2003). The scans were printed on photo-quality paper, and the images were glued to the flat surfaces on the casts, providing realistic exhibit-quality reproductions.

The meteorite from New Raymer was taken one step further because we did not get a chance to cast it before the end piece was cut off. The two ends were reassembled using cardboard shims and molding clay to make up for the space lost during cutting. A latex mold of the whole mass was made, and the casts were painted to look like the original. The final result is one cast with the shape of the original mass and another cast of the existing piece with the digital image of the interior on the cut surface. We believe that these projects are the first to use digital images on meteorite replicas.

Reference

Wilson, W., 2003, Record-keeping for mineral collectors: Mineralogical Record, v. 34, pp. 210-212.

Bisbee—Queen of the copper camps

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(Location 6 on the index map)

Although two other mining districts in Arizona have produced more copper than Bisbee, none have produced such an impressive array of metals or meant so much to the development of Arizona. During its history, Bisbee produced:

- 8 billions lb of copper
- 324 million lb of lead
- 355 million lb of zinc
- 28 million lb of manganese
- 2,792,000 oz of gold
- 102,215,000 oz of silver

As with many of the early mineral discoveries in Arizona, the original location was made when an Army scouting party stopped in the area. John Dunn, a member of that party, discovered lead mineralization in the summer of 1877.

John Dunn then made the mistake of grubstaking George Warren. It was the custom in those days that the prospector would stake claims on an equal basis with the person who grubstaked him. Mr. Warren drank Dunn's money away in Tombstone, then went out, and staked the claims, including the Copper Queen claim, in his name and others he took with him. He ultimately lost his share of the Copper Queen claim by betting he could outrace a horse in a 100 yard race. Unfortunately, he was drunk at the time and misjudged both the distance and his running ability. He died in 1895 as one of the town's drunks, but his name lives on with Warren, Arizona.

Development started on the Copper Queen, and 22 percent oxide copper ore was found. The property was then sold to Lewis and Ben Williams in 1880, and they brought the technical expertise so badly needed to really develop the property (Lewis for his smelting experience and Ben for his mining skills).

In 1882 Dr. James Douglas was sent out by the firm of Phelps, Dodge and Company to examine the adjoining Atlanta claim. They purchased it and spent $80,000 and the next 2 yrs exploring it. No ore was found, but Dr. Douglas made the case for spending another $15,000, which finally paid off with the discovery of a rich oxide orebody.

In 1884, rather than continuing to compete for adjoining properties, the Copper Queen Mining Company and the Atlanta Mining Company merged into a single company. Thus began a lifetime partnership and kinship between James Douglas and the Williams brothers.

Smelting capacity was constantly changing by upgrading and expanding. This was necessary to keep the operations as economic as possible. The Czar mine had the most distinctive smelter stack because it was constructed up the side of the mountain instead of built vertically.

Before 1889 all supplies were hauled into Bisbee with 20 mule teams, and the black matte copper was hauled out. An attempt was made to replace mules with mechanical pulling devices, such as a steam-powered tractor. The tractor worked fine when the roads were dry, but the mule teams could work in all kinds of weather. Once the railroad came to Bisbee in 1889, the cost of moving freight plummeted.

As the sulfide mineralization oxidized, it shrank leaving voids above the now incredibly rich-oxide orebodies. Over the millennium, significant caverns were formed. A high school graduation was held in one of the caverns, and a second cavern hosted a board of directors meeting. The miners learned that the caverns could be used as exploration targets by digging straight down. Fortunately, not all of the orebodies were directly below the caverns, and some of these still exist.

By 1898 Bisbee was a prosperous mining town with the usual collection of bars and saloons and even a photographic business located on Main Street. The Fourth of July celebrations included single and double jack contests—a mining camp knew they had made it if they were around long enough to participate in such contests.

By 1908 there had been three devastating fires in Bisbee. Firebreaks were created when the miners brought dynamite out of the mines and blew up some of the buildings. After 1908 brick replaced wood buildings. Adding insult to injury, the summer monsoon rains came with a vengeance. With the mountainsides stripped of trees that fed the smelters and provided timber to the miners, the rain had no place to go but down through the canyon in Bisbee.

The Calumet and Arizona was the other big mining company in Bisbee. Bill Hoatson, from the Michigan copper country, got a foothold in the district because of a personality conflict between Ben Williams and the owner of the Irish Mag. Pride got the better of the Copper Queen Mining Company that day. Dr. Douglas could have purchased the mine for $10,000 but felt honor bound to the feelings of his general manager and brother-in-law.

The property was ultimately sold to the Lake Superior and Western Development Company for $500,000. This was another Bisbee story of almost running out of money before the ore was hit, but this time Cap'n Jim had to sink to the 1,050-ft level before he struck pay dirt. This 15-acre claim ultimately paid $10,000,000 in dividends. The Calumet and Arizona absorbed the assets of the Lake Superior and Western.

By the early 1900s the Copper Queen controlled the northwest portion of the district, and the Calumet and Arizona held the deeper reserves in the southeast part.

When the great depression hit, the two companies found themselves in opposite positions. The Copper Queen Mining Company, now known as the Copper Queen Branch of Phelps Dodge Corporation, was running out of reserves but had plenty of cash. The Calumet and Arizona had huge reserves but had paid out most of their available cash in dividends. Negotiations were entered into between the two, and Phelps Dodge was the successor.

The Sacramento pit was the first open-pit mine in the Bisbee area. It was started in 1917 and continued through 1929. Low-grade, high-volume mining came to Bisbee in the early 1950s when stripping the Lavender pit began. Art era of Arizona mining came to an end in the mid-1970s when the ore reserves dwindled and the mines at Bisbee were closed, probably for the final time.

Both James Douglas and Ben Williams had an appreciation for mineral specimens. Dr. Douglas' collections in the Smithsonian and the Canadian National Museum include some of the best that Bisbee had to offer. What was not widely known was that Ben Williams not only collected minerals but was also the main seller to dealers, including A.E. Foote. Ben Williams saved hundreds, if not thousands, of Bisbee specimens.

Bisbee is also one of the great mineral localities in the world. As of the printing of Dick Graeme's second article on the minerals of Bisbee in 1993, his list had grown to 285 distinct species, including several that Bisbee is the type locality. We are all familiar with the magnificent azurites, malachites, cuprites, coppers, and calcites that have come from here. These specimens grace collections throughout the world. In addition, some of the rare minerals are attractive and well crystallized, including spangolite, connellite, and even graemite.

Meteorites of New Mexico

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Not all New Mexico visitors from outer space pick Roswell! Many have landed all over the state and continue their visits on a daily basis. However, their trip is one way as avid meteorite collectors of the world refuse to let them return home!

You may question, "Why should meteorites be part of the Mineral Symposium?" Simply put, they are relics of the same material that formed our Earth and solar system eons ago. The materials that formed the minerals we enjoy and collect today were pulled together in the dim past by cosmic forces to create Earth and the other planets in our solar system. This ancient collection of Earth minerals is augmented continually by bombardment with hundreds of tons of "space debris" that settles on our planet daily. There is a size to fit all collecting needs—macro *to micro.*

This eclectic collection of stellar material that continually pelts Earth is a window to the world man has yet to visit and that we are just beginning to visualize and understand. Our first material from the Moon, Mars, and asteroids came from meteorites. Material from the beginning of our solar system, the most ancient there is, is delivered to Earth daily by the cosmic space shuttle.

These visitors, mostly from the asteroid belt between Mars and Jupiter, left over from the creation of our solar system, are controlled by the massive gravity of Jupiter, which acts as Earth's protector. When material does escape and a meteor enters Earth's atmosphere we are entertained with a "shooting star" display and an occasional lucky find. Past visitors have left their mark on Earth in the form of some 150 known impact craters or astroblemes. Some of these like Meteor Crater in Arizona are spectacular, and are great scientific and tourist attractions. Many are old and weathered and hardly recognizable from our terrestrial view. Space views and mapping have helped identify many of these structures, but many event remnants have been completely obliterated by Earth's geologic processes. The cosmic visitor that formed Chicxulub Crater in the Yucatan is thought to be responsible for one of the mass life extinctions on Earth about 65 million years ago. The visitor that created the impact craters at Sikhote-Alain in the USSR in 1947, created affordable and available collecting material that attests to the tremendous forces that accompany our visitors from space.

New Mexico craters are volcanic in origin and are not meteorite impact craters. New Mexico is known, though, for a diverse selection of falls and finds representing the three major classifications of meteorites—stones, irons, and stony-irons. There are about 200 documented New Mexico meteorite falls/finds, each named for a prominent geographic area where it was discovered. Wagon Mound, Chico, Clovis, Glorieta Mountain, Portales, Kenna, Columbus, Socorro, and Oro Grande are a few of the locations represented. Meteorites have been collected in most counties in New Mexico, with a greater representation coming from Roosevelt County. New Mexico ranks above the United States average in material found per million square miles. Several New Mexico pieces can be viewed in the New Mexico Tech Mineral Museum and in the symposium display at Macey Center.

New Mexico is prominently represented in the educational and research arena by the Institute of Meteoritics at the University of New Mexico in Albuquerque. An in depth and quality public museum, publications, research, web page http://eps.unm.edu/iom, authentification service, and noted personalities make this institution one of the highly regarded centers of meteoritic expertise in the world.

Meteorites, impact breccias, shatter cones, tektites, and other meteorite collectibles are available from many sources. Material sells for less than a dollar to several hundred dollars per gram. Moon rocks are not cheap!

What a thrill to hold and own part of the Moon, or Mars, or an asteroid like Vesta, or material from the beginning of the solar system!

The causes of color in minerals with special reference to fluorites from Bingham, New Mexico

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(Location 8 on the index map)

The Hansonburg mining district, Bingham, New Mexico, is famous for its vividly colored fluorite crystals. "Bingham blue" with its characteristic sensitivity to sunlight is the most common and most widely recognized color found at Bingham, but crystals of purple, green, and colorless are also found. Color zoning is also common. Zoning of color between concentric zones from the center of the crystal outward is most commonly seen. Examples include crystals with green cores and blue or violet rims and fine alternating zones of blue and violet. The Mex Tex and Royal Flush mines have produced wonderful examples of sectoral zoning of color. In these samples, symmetrically different crystal faces and the zones beneath them (called sectors) exhibit different colors. For example, cubohexoctahedral crystals have been found with purple hexoctahedral faces (and sectors) and colorless cube faces (and sectors). Figure 1 is a sector zoned cubohexoctahedral crystal.

To understand the origin of color in these fluorites, and in minerals in general, we have to look at how visible light interacts with crystals or individual atoms within crystals. Color is imparted to a material that is illuminated with white light (light that contains all wavelengths in the visible region of the electromagnetic spectrum) when the material absorbs certain wavelengths and other wavelengths are transmitted or reflected so that they reach one's eyes. Color is the physiological response of the human eye to those wavelengths that reach it. For example, if white light enters a transparent crystal and all of the visible wavelengths from red through green (wavelengths roughly from 740 to 500 nm) are absorbed, only the remaining wavelengths of light (wavelengths roughly from 500 to 350 nm) will be transmitted through the crystal and eventually reach your eye. What you perceive as the color of the crystal will be the response of your eyes and brain to the combination of visible wavelengths of light from 500 to 350 nm—a blue or violet color.

Thus the question "What causes color in minerals" can be rephrased as "What causes differential absorption of visible wavelengths of light when white light interacts with a crystal?" Most of the mechanisms of the absorption of light by minerals involve the interaction of light and electrons within crystals. Particles of light are known as photons, and photons not only have the property of a wavelength but also have energy associated with them. The relationship between these two properties, wavelength (λ) and energy (E), is given by the equation:

$$E = \frac{hc}{\lambda}$$

where *hc* is a constant. Electrons in an atom or a crystal also have energy associated with them. Electrons can gain or lose energy by moving from one energy level to another. One of the hallmarks of the nature of matter as described by quantum mechanics is that electrons in an atom or crystal cannot have just any energy, but rather only certain well-defined energy levels are possible. This behavior is ultimately the reason that the absorption of light usually occurs only for certain wavelengths and not others (i.e. differential absorption).

As photons of light move through a crystal, they interact with electrons. If the energy of a given photon is exactly equal to the difference between two possible energy levels of an electron the photon can be absorbed by the electron. The absorbing electron will then undergo a transition to the higher energy level. Thus the specific photon and others with the same energy (or wavelength) will not be transmitted through the crystal and will not reach one's eyes. Photons of other energies that do not match the difference between possible energy levels of electrons in the crystal will not be absorbed but will be transmitted through the crystal and will ultimately reach one's eyes. Again what is perceived as the color of the crystal will be the response of the observers' eyes and brain to the combination of visible wavelengths of light that are transmitted through the crystal.

Electron transitions between energy levels as a result of the absorption of specific energies of visible light can take place on a single atom such as a chromium impurity in beryl (the cause of green in emerald), between atoms such as iron and titanium impurities in corundum (the cause of blue in sapphires), or between energy levels in an electrostatic field where an electron is not associated with a specific atom. The latter type of transitions is associated with defects in crystal. A well-understood type of crystal defect that is commonly found in fluorite is an F-center. An F-center in fluorite is a vacant fluorine site with a trapped electron that is created when a photon of sufficient energy (i.e. and X-ray or gamma ray) knocks a fluorine atom from its original position into an interstitial site in the structure. A free electron can become trapped within the electrostatic field of this vacancy and undergo energy level transitions by the absorption of optical wavelengths of light, thus imparting color to the crystal.

Several studies of the relationship between color, structure, and trace element chemistry of fluorites from Bingham, New Mexico, have been conducted at Miami University (Bosze, 2003; Bosze and Rakovan, 2002; Wright, 2002; Wright and Rakovan, 2001). The results show a complex interplay of color-causing mechanisms in these samples. One mechanism that has been identified is electron transitions on simple F-centers. These are associated with the characteristic "Bingham blue" color. A trait of defects like F-centers is that they can easily be destroyed. If enough energy is imparted to the crystal to move the displaced fluorine atom back to its original site within the crystal structure then the F-center and the color associated with it are lost. This can be done by heating or by exposure to an ultraviolet light source such as the sun. This is exactly the reason that the "Bingham blue" color will fade on exposure to sunlight.

A more complex color center that has been identified is a rare-earth element associated fluorine vacancy. In this case, rare-earth element impurities residing directly adjacent to a fluorine vacancy create a unique electrostatic field by the coupling of the two entities. Two free electrons can become trapped in this field and undergo energy level transitions that absorb light in the visible part of the spectrum, thus imparting color to the crystals.

Color in the sectorally zoned crystals (Fig. 1) is the result of rare-earth element associated fluorine vacancies. During growth of these crystals the rare-earth elements are preferentially incorporated into the (321) crystal faces relative to the (1001 faces. Thus the higher concentration of rare-earth elements in association with defects causes more intense color on the (321) faces and their associated sectors.

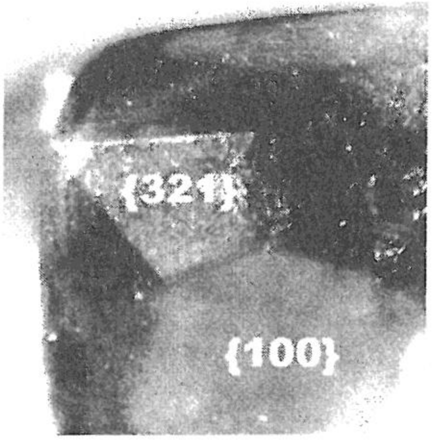

Figure 1—Sector zoned fluorite with purple {321} hexoctahedral faces and colorless (100) cube faces.

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Rocks and relics

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(Location 9 on the index map)

The Chihuahuan Desert Research Institute (CDRI), near Fort Davis, Texas, has a 30-yr history of promoting the Chihuahuan Desert region through research and education. One of the more important historical relationships with the desert has been the pursuit of its mineral wealth. Many historic mines and districts are within a radius of less than 100 mi from the CDRI complex.

The Chihuahuan Desert Mining Heritage Exhibit has been constructed on site to replicate a vibrant and dynamic time in the history of the Southwest. The exhibit includes an 18-ft-high timber head frame and Davis Horse Whim hoisting system; a tramming layout with ore chute, track, battery locomotive, and ore cars; and many smaller relics such as drills, hard hats, carbide lamps, old maps, and vintage photos. Rounding out the exhibit is a variety of rocks containing ores from some of the copper, lead, zinc, silver, gold, manganese, and other mines in the region including Morenci, Santa Rita, Lake Valley, and Shafter.

Today's slide presentation will illustrate this unique exhibit and many of its historical displays.

Mining for blue barite at Stoneham, Colorado

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(Location 10 on the index map)

For one week in July 2002 a mining operation was conducted for blue barite mineral specimens at the famous Stoneham, Colorado, barite locality. The collecting site is about 4 mi northeast of the village of Stoneham in Weld County, Colorado, which is in the high rolling plains about 100 mi northeast of Denver. The collecting site is located on state land and is currently under lease by a local resident.

The barite crystals occur in open pockets developed in the lower most member of the early Oligocene (35-37 million years old) Chadron Formation of the White River Group of sedimentary rocks. This lower most member is a 15-20-ft-thick, tan to cream claystone layer that is rich in volcanic glass shards. The Chadron Formation lies unconformably above the regionally extensive Cretaceous Pierre Shale (Modreski et al., 1990). In the project area, the crystal pockets occurred along two major fault trends, both of which strike northwest-southeast, but one dips southwest and the other dips to the northeast. Dips along the undulating fault planes were highly variable and ranged from about 10 to 45 degrees. The faults were identified in the field by striated slickensided surfaces indicating essentially vertical movement.

Open (and crystal-bearing) pockets occurred predictably in only the flat-dipping part of the faults. Modreski et al. explain that "pull-apart" movement along the flat part of the fault planes created the open pockets. Evidently only the lower most member of the Chadron Formation is sufficiently brittle (rather than plastic) to form open cavities. Pockets were not observed to have developed along the faults in either an overlying siltstone layer, or the underlying Pierre Shale, both of which are apparently more plastic in nature and are not sufficiently brittle to form open pockets when fault movement occurs.

A backhoe was used to uncover cavities as large as 6 inches high, 6 ft long, and 3 ft deep. Some pockets contained abundant free-standing barite crystals, and other cavities were devoid of barite. Individual pale to sky-blue crystals as long as 10 cm were found, and numerous smaller singles and crystal groups were also recovered. Generally, the crystals were either very clean or had only a thin clay coating and were found essentially loose in the cavities. Most crystals from this location were opaque to translucent, but on occasion fairly transparent specimens were also encountered. It was also observed that as the crystal-bearing faults approached the underlying Pierre Shale, the pockets became partially filled with a cream-colored "gooey" clay, and quality of the barite crystals decreased dramatically and became cloudy and broken. This was apparently caused by surface water migrating down the faults and accumulating or pooling in pockets at the top of the Pierre Shale, which acts as a confining layer or barrier to the further downward water migration. It is highly likely that future mining activities at this locality will result in the discovery of new pockets filled with gleaming blue barite crystals.

Reference

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Native silver and wulfenite at the Anchor mine, Magdalena district, Socorro County, New Mexico

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(Location 11 on the index map)

Although native silver is uncommon in the Magdalena mining district of Socorro County, New Mexico, it has nevertheless been reported from several mines. In particular, wire silver reputedly occurred at the Anchor mine in seams and crevices (Loughlin and Koschmann, 1942). This information, coupled with a report of large barite crystals on the dumps (B. D. Huntsman, pers. comm. 2002) inspired Mike Sanders, Chris Cowan, Tom Rosemeyer, and me to investigate the Anchor mine on January 25, 2003. The mine is reached by driving up Anchor Canyon at the north end of the Magdalena district. According to Loughlin and Koschmann (1942), it was opened about 1885 and is said to have produced rich silver ore with a total value of about $60,000, but it was abandoned about 1893 when the price of silver declined. It was reopened in 1924 and operated intermittently until 1926 when all operations ceased. Mine workings consist of an inclined (about 50°) shaft 170 ft deep from which two short levels have been driven and an adit level about 900 ft long. The adit level for most of its length is flooded, but a section at the bottom of the decline remains partially dry.

The average thickness of the vein is about 4 ft and consists primarily of quartz, barite, and calcite with some fluorite. Galena and sphalerite are the primary sulfide ore minerals. The vein exposed on the second level is quite rich in fluorite and galena, and rich ore samples were collected. At the bottom of the shaft (adit level), examination of the vein revealed numerous yellow tabular wulfenite crystals to 6 mm and cerussite crystals to 2.5 cm. Wulfenite in the Magdalena district is quite rare. It was found associated with azurite from the sixth level of the Kelly mine in 1987 by Chris Cowan and at the Mistletoe mine in 1993 by me. Wulfenite has also been found at the Linchburg mine by Brian D. Huntsman.

Following this trip, close inspection of the galena ore with a microscope revealed quartz-lined vugs containing small wires of silver. This discovery led to a second trip on January 30, 2003, by Mike Sanders, John Ottea, and me. A number of wire silver specimens were collected from the vein on the second level along with one specimen of yellow pyramidal wulfenite. The silver wires are mostly coiled and as long as 1 cm. Many of the wires are encrusted with small colorless quartz crystals and are partially altered to acanthite. Acanthite is also found coating sphalerite crystals in the vicinity of the silver. Additional minerals found on the dumps and in the shaft and adit include: pyrite, chalcopyrite, siderite, smithsonite, and hemimorphite. Identification of the acanthite, siderite, and hemimorphite was aided by microprobe analysis (Paul Hlava, pers. comm. 2003). Mine artifacts found at the bottom of the shaft suggest that mineral collectors had not previously visited this mine.

Reference

Loughlin, G. F., and Koschmann, A. H., 1942, Geology and ore deposits of the Magdalena mining district, New Mexico: U. S. Geological Survey, Professional Paper 200, vii, 168 pp.

The Godsend claim: a preliminary report
Lake George pegmatite district
Teller County, Colorado

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(Location 12 on the index map)

The Godsend mining claim, staked by Richard Fretterd in 2001, is in the Crystal Creek area, west of Crystal Peak, in Teller County, Colorado. North of U.S. Highway 24 between the towns of Florissant and Lake George, this famous collecting site spans the Teller–Park county lines. Since the 1870s, some of the world's finest examples of amazonite, smoky quartz, and other minerals have been mined from the Lake George pegmatite district, which includes Crystal Peak and the Crystal Creek area.

The Godsend mining claim is also located within the Hayman fire area where a blaze destroyed more than 138,000 acres of forest during the summer of 2002. Although most of the area is under claim, this part of Pike National Forest is dosed due to the fire.

The geologic setting has many interesting aspects. Pegmatite dikes and lenses in the Pikes Peak batholith may contain miarolitic cavities (crystal pockets). The Godsend claim represents a recently developed, spectacular example of these crystal-bearing pockets found in the Pikes Peak batholith.

The billion-year-old Pikes Peak batholith is the largest pluton in Colorado. Exposed over 3,000 km', it also has been traced geophysically in the subsurface to the east for 129 km (80 mi), and as much as half of the batholith could be buried. The Pikes Peak batholith is unique with no counterparts of that age or composition anywhere in the southern Rocky Mountains. A composite batholith with three major intrusive centers (its principal rock type is classed as an anorogenic A-type granite) is thought to have been generated during a period of continental doming and rifting. Its magmas were likely generated by a combination of processes involving both crustal and mantle melting—evidence suggests a limited amount of mixing of granitic and basaltic magmas. The magma cooled at relatively shallow (epizonal) crustal levels within 5 km of the surface.

Parts of the batholith were exposed by uplift and erosion about 500 Ma, when the Cambrian Sawatch sandstone was deposited unconformably on the granite. Other major periods of uplift and erosion occurred during the creation of the Ancestral Rockies about 250 Ma and during the Laramide orogeny (ca 70 Ma). Major faults that cut the batholith, like the Ute Pass and Rampart fault systems, are largely Laramide features. Parts of the batholith have been segmented by Neogene block faulting, sometimes by re-activating earlier faults.

Late-crystallizing internal and satellitic stocks are of two distinct compositional trends: potassic (granitic) and sodic (syenites and alkali granites). The sodic trend is represented by seven small stocks, six of which are aligned along two northwest-trending linears parallel to major Proterozoic fault orientations.

The 29 km' Lake George intrusive center, which surrounds the Lake George pegmatite district, is actually composite, containing rocks of both the potassic and sodic series in a circular or concentric pattern. Rocks of the sodic series (fayalite granite and quartz syenite) form partial ring dikes around a central stock of dark-green syenite. These sodic rocks were intruded into a late stock of fine-grained granite to fine- to medium-grained porphyritic granite of the potassic series. Most of the productive pegmatite prospects of the Lake George district are in this latter rock unit. The Godsend lies on the edge of the Lake George intrusive center.

The Godsend pegmatites exhibit a gradational pattern with aplite as an outer band abruptly changing to a zone of graphic granite where crystal cavities may occur. The aplite granite has a sugary texture and resembles sandstone. The intergrowth of feldspar and quartz characterize the graphic granite.

While exploring the Godsend, Frettered observed an east-west trending pegmatite dike in contact with a 0.5 m (1.64 ft)-thick quartz vein. Fretterd began work on the quartz-feldspar contact and dug down 1 m (3.28 ft) where he opened a pocket on February 2, 2002. While carefully removing crystals from the first pocket, he encountered a large milky-quartz core. After breaking through the milky-quartz barrier, he discovered another large pocket. By September 6, 2002, Fretterd had opened six pockets, which he named the Holy Moses group. These pockets are very dose together and seem to reflect a high-energy pumping of vapor-rich fluids in pulsating phases. These pulsating phases formed a conduit-like dike that pinched and swelled over short distances, generating this series of en echelon pockets. Richard M. Pearl likened these types of structures to a string of pearls.

Microcline and quartz are the dominant pocket minerals. Buff to cream-colored microcline crystals as long as 3.8 cm (1.5 inches) have been found. A number of feldspar specimens from the claim fluoresce a distinct red under short-wave ultraviolet light. A. F. Wilson in 1950 noted that not all areas of the Pikes Peak batholith contain feldspars that fluoresce.

Several crystal pockets have been opened recently that have yielded some of the largest specimens of smoky quartz ever found in Colorado. The longest crystal measures 1.295 m (4 ft 3 inches) in length and weighs 156.49 kg (345 lb). The heaviest smoky quartz crystal, attached to a microcline plate, weighs 199.1 kg (4391b) and is 1.218 m (4 ft) long. Cubic groups of fluorite have been found in various shades of pale blue. Some cubes exhibit a dark purple along the edges.

The surface features of the area are now easy to observe after the Hayman fire burned all surface vegetation, leaving a vast area to prospect. Pegmatite dikes are slightly more resistant to weathering than the surrounding granite and appear as small ridges. These topographic features, along with graphic granite exposed on the surface, may reveal more pockets. The discovery and development of new pockets and accompanying research will reveal more of the mysteries of the crystal pockets at Lake George—truly a "Godsend."