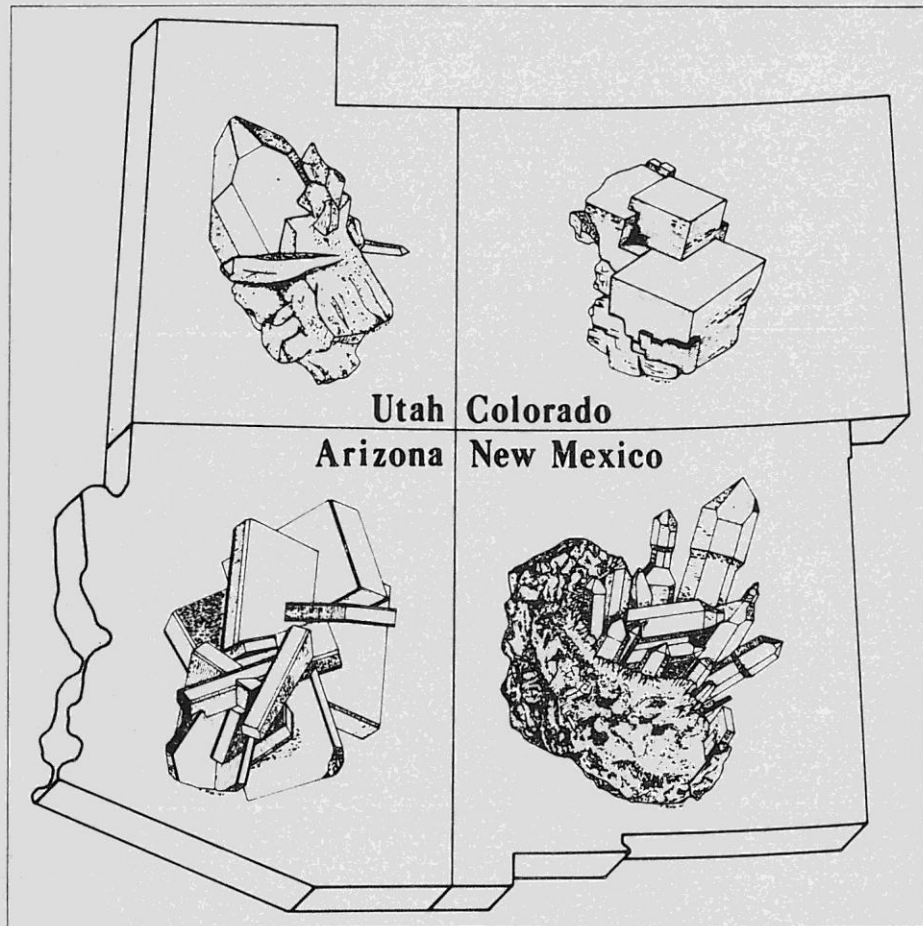




# NEW MEXICO MINERAL SYMPOSIUM

November 12 & 13, 1988



NMIMT Campus, Socorro, New Mexico

Welcome to

**THE NINTH ANNUAL**

**NEW MEXICO MINERAL SYMPOSIUM**

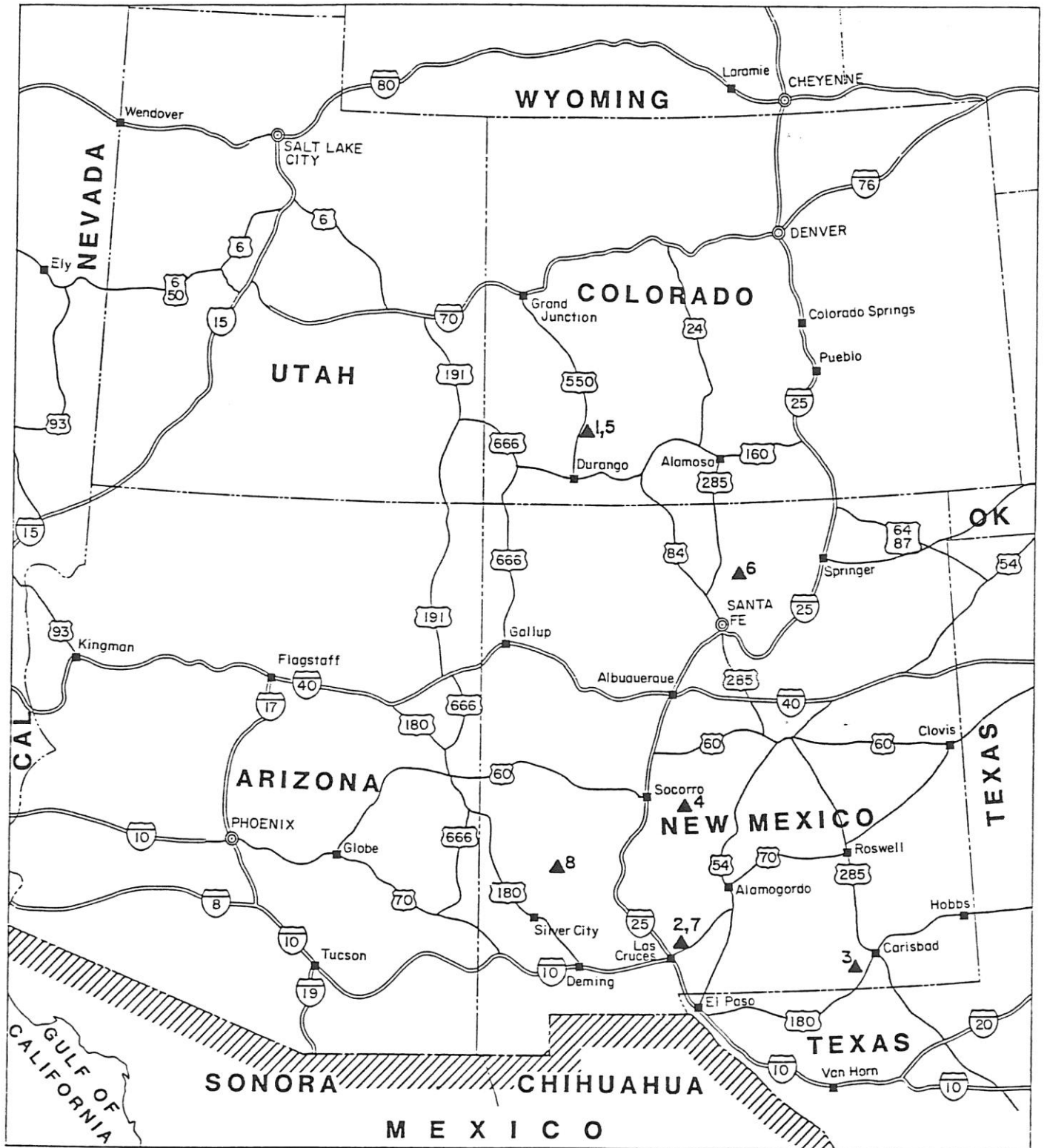
November 12 and 13, 1988

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

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

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

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



Geographic Index Map  
 9th New Mexico Mineral Symposium

## SCHEDULE

Numbers in parentheses refer to geographic location on index map.

### Friday, November 11

6:00 pm Informal tailgating and social hour, individual rooms, El Camino Motel

### Saturday, November 12

8:00 am Registration; coffee and donuts

9:00           Opening Remarks

9:10 (1) Microminerals of the San Juan Mountains, Colorado--  
          Arnold G. Hampson

9:45 (2) The Lost Padre mine: Fact or Fiction?--Russell E. Clemons

10:20           Coffee break

10:45 (3) Mineralogy of Carlsbad Cavern and other caves in the  
          Guadalupe Mountains, New Mexico--Carol A. Hill 11:30 (4)  
          The Blanchard mine: new developments--Ramon S. DeMark

12:00           Lunch

1:30 pm Mines and minerals of the Mapimi district, Durango,  
          Mexico--Mike New

2:00           Zoning in minerals: properties, potentials, and  
          problems--Paul Hlava

2:40           Coffee break

3:00 (5) History and mineralogy of the Sunnyside mine, Eureka  
          mining district, San Juan County, Colorado--Tom  
          Rosemeyer

3:40 (6) Mineral localities in the Picuris Mountains, Taos  
          County, New Mexico--Herbert W. Dick

4:10 (7) Mineral inclusions in galena from the Organ district,  
          Dofia Ana County, New Mexico--Virgil Leuth, Philip  
          Goodell, Ramon Llavona, and Juan Sandoval

5:30           Sarsaparilla and suds: cocktail party, upper lobby,  
          Macey Center

6:30           Dinner, upper lobby, Macey Center, with keynote  
          address, Gem and mineral treasures II, by Dr. Peter  
          Bancroft and an auction to benefit the New Mexico  
          Mineral Symposium

Sunday, November 13

- 9:00 am Mineralogical studies of some caves in Colorado and New Mexico--Peter J. Modreski
- 9:40 (8) Mineralogy of the Black Range tin district, Sierra and Catron Counties, New Mexico--Eugene E. Foord and Charles H. Maxwell
- 10:15 Coffee break
- 10:45 What causes color in minerals?--Robert W. Jones
- 12:00 Lunch
- 1:15 pm Silent auction, sponsored by the Albuquerque Gem and Mineral Club
- 3:00

## MICROMINERALS OF THE SAN JUAN MOUNTAINS, COLORADO

(Location 1 on index map)

Arnold G. Hampson  
1003 Dolores Road  
Cortez, CO 81321

The San Juan Mountains of southwestern Colorado have been an exceptionally productive area for micromineral crystals. Many of the mine dumps, as well as some of the uneconomically mineralized volcanic areas, have provided us with fine crystallized specimens.

In the Summitville district of Rio Grande County, thin hexagonal plates of deep-blue covellite may be found on the dumps of the Reynolds tunnel. Occasionally, these covellite crystals are partially altered to chalcopyrite. The nearby Missionary shaft produces sharp lustrous black crystals of enargite as well as tabular barite.

Careful searching of the dumps of the Bessie G mine in the La Plata district has uncovered several telluride minerals occurring very occasionally as euhedral crystals. Krennerite occurs at the Bessie G as tin-white lath-shaped crystals while sylvanite is found as bladed crystals. Coloradoite, the most common telluride, occurs only rarely as subhedral iron-black crystals having a "melted" surface appearance. Gold, in wire form, has been found with the tellurides. Barite in sharp thin plates has been found at the May Day mine along with sylvanite and sphalerite.

The old dumps of the Longfellow mine on Red Mountain Pass, San Juan County, Colorado, have recently yielded wurtzite, a new species for Colorado, that occurs as dark-brown hexagonal hemimorphic crystals. This locality also produces fine euhedral crystals of tetrahedrite, enargite, and octahedral pyrite. Also in San Juan County in the Silverton district, dumps of the Zuni mine continue to yield well-formed tetrahedrons of zunyite and octahedrons of pyrite. Fine specimens of huebnerite occur on the dumps of the Yukon tunnel located along Cement Creek north of Silverton. The Sunnyside mine, also north of Silverton, has been a noted locality for rhodochrosite, gold, huebnerite, helvite, tetrahedrite, and pyroxmangite.

In nearby Ouray County, the Micky Breen mine has yielded fine euhedral crystals of rhodochrosite and chalcopyrite as well as sphalerite and fluorite. The Zannett tunnel, also in Ouray County, has produced crystals of rhodochrosite, chalcopyrite and huebnerite, as well as sphalerite and fluorite.

Near Ophir in San Miguel County, cassiterite has been found, along with molybdenite and ferrimolybdenite.

At Dunton in Dolores County, nice bladed crystals of stibnite occur.

The volcanics of the Treasure Falls area near Wolf Creek Pass, Mineral County, have yielded some well-crystallized zeolites. Mordenite, heulandite, analcime, and natrolite occur in moderate abundance along with the rarer species new to the area, gmelinite and wellsite. These zeolites are associated in amygdaloidal cavities with celadonite, nontronite, calcite, quartz, and semiopal.

## LOST PADRE MINE: FACT OR FICTION?

(Location 2 on index map)

Russell E. Clemons  
New Mexico State University  
Las Cruces, NM 88003

It is said . . . that Padre La Rue came to Mexico in 1796 and was assigned a small pastorate about 10 days journey south of Paso del Norte. An old soldier told him of a gold prospect in the Sierra Organos near a Spirit Spring. Some years later, after the soldier had died, drought hit the Padre's fields. He and his followers journeyed north and succeeded in finding the gold placers and rich vein(s), but they neglected to report this to the church in Mexico City. A man named Maximo Milliano was sent north to find them. Upon learning of the approaching expedition, the miners hid the gold and the location of the mines. Milliano and his expedition eventually located the Padre and his mining camp but were refused admittance. Allegedly, the Padre and some of his followers were tortured and killed, but none revealed the location of the gold.

Most reports of lost mines are based on some facts. Typically, there are also many variations in background narratives. The Organ Mountain Mining and Smelting Association's 1881-82 prospectus suggested the Padre mine had been worked in Fillmore Canyon on the west side of the Organ Mountains, about 8 mi east of Las Cruces. Sir Kingsley Dunham indicated, in his geologic report on the Organ Mountains published in 1935 by the New Mexico Bureau of Mines and Mineral Resources, that Col. A. J. Fountain may have found the mine shortly before his mysterious disappearance. Dunham also reported that a local goat herder, Tirso Aguirre, was a descendant of one of the original miners. L. H. Davis had written in 1917 that Teso Aguirri (Tirso Aguirre?) had shown a local prospector the cave in which the Padre lived. Henry James in his 1953 book, The Curse of the San Andres, wrote that he had found records in Santa Fe of Padre La Rue. James further wrote that he believed the lost Padre mine was in Hembrillo Canyon of the San Andres Mountains. Frank Kottowski, in a 1966 paper on the lost Padre mine for New Mexico Magazine, quite conclusively pointed out the technical inaccuracies in James' book. Tim Kelly, in an article on the lost Padre mine and the Organ mining district published in the 1975 New Mexico Geological Society Guidebook, indicated that historic and geologic evidence support the likelihood that the mine existed--near the east slope of San Agustin Pass. Kelly also provided the Padre with two names, Philip La Rue. The search continues.



**MINERALOGY OF CARLSBAD CAVERN AND OTHER CAVES IN  
THE GUADALUPE MOUNTAINS**

(Location 3 on index map)

Carol A. Hill  
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A variety of carbonate and sulfate speleothems have formed in Guadalupe caves from dripping, flowing, seeping, pooling, and condensing water. Examples of these are stalactites, stalagmites, columns, draperies, flowstone, coral pipes, coralloids, helictites, shields, cave pearls, brimstone dams, shelfstone, baldachino canopies, rims, frostwork anthodites, moonmilk, selenite needles, cave cotton, and cave rope. Evaporation and carbon dioxide loss have been prime factors in the deposition of the magnesium-carbonate minerals, hydromagnesite, huntite, and dolomite, and in the formation of certain speleothems such as moonmilk and popcorn. Native sulfur and endellite deposits in the caves and the pronounced condensation-corrosion of speleothems are the result of the peculiar  $H_2S-OO_2$ , sulfuric-acid speleogenetic origin of Guadalupe caves.

Guadalupe speleothems are famous for their immensity, profuseness, and beauty. Size and profuseness result from: (a) a sulfuric-acid mode of cave dissolution created huge chambers in which speleothems could grow large; (b) the caves are very old and, therefore, there has been sufficient time for speleothems to grow; (c) wet climatic episodes earlier in the Pleistocene provided the moisture necessary for speleothem growth; and (d) speleothem-depositing solutions easily entered the underground through jointed limestone uncapped by impermeable strata.

## THE BLANCHARD MINE -- NEW DEVELOPMENTS

(Location 4 on index map)

Ramon S. DeMark  
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Albuquerque, NM 87110

Intensive mining for specimens and exploratory activity at the Blanchard mine in 1988 resulted in a number of unexpected, as well as expected, discoveries. Activity was widespread throughout the various tunnels, numerous prospects, and outcrops. In mid-June a backhoe was brought in with three specific goals in mind:

- 1) opening the Sunshine #6 tunnel that had been blasted/bulldozed shut;
- 2) exploratory trenching in the Clarence Barrett workings;
- 3) developing the working area in the vicinity of the ore bin in the Portales/Glory Hole area.

The Sunshine #6 tunnel was closed in 1979 by the operators (Western General Resources) because of hazardous conditions inside the tunnel. Specimens from this particular tunnel were mainly responsible for establishing the reputation of the Blanchard mine as a producer of rare and beautiful minerals. Sprays of delicate brochantite needles, druses of linarite on thin barite blades, and very fine spangolite specimens were all products of this tunnel. Additionally, superb specimens of aurichalcite, murdochite, and platternite were found in this prolific tunnel.

The reopening of the #6 tunnel was accomplished relatively easily. Upon entry, it was obvious that considerable deterioration of the ceiling, walls, and pillars had occurred, and safety was a paramount concern. Several large sections of the ceiling had collapsed onto the floor, and near one of the central pillars, several large boulders had dropped, splintering an 8" x 8" support timber. Most disappointingly, the area that had produced the exceptional spangolite specimens was covered by at least 20 ft of debris deposited when the opening had been bulldozed shut. After minor exploration, the tunnel opening was closed once again.

Exploratory trenching in the Clarence Barrett prospect area revealed extensive cave-type formations in one spot with numerous large selenite crystals as long as 45 cm and sporadic blue fluorite crystals. Farther south, large plates of fluorite-coated rocks were pulled from an outcrop. Fluorite from this location is a lustrous blue with a purple tint, and individual crystals are commonly 2.5 cm on an edge. The final area for

backhoe operations was the outcrop exposed in the trench across from the Portales-era ore bin. For several years this area has produced good-quality blue fluorite cubes about 1-2 cm on an edge. Additional quantities of excellent blue fluorite were recovered from this area. More surprising was the discovery of large numbers of bipyramidal wulfenite crystals coating many of the more lustrous fluorite cubes. These wulfenite crystals are about 1 mm in length, and with their bright luster and orange color they contrast vividly with the blue fluorite.

Sphalerite, the primary sulfide mineral, has always been scarce at the Blanchard mine. The only significant occurrence of in-situ sphalerite has been the Sunshine #4 tunnel where it is found in massive gypsum and often coated with a crust of pyrite crystals and, occasionally, covellite crystals. This past year, the tunnel has been the discovery site of several minerals that had not been reported previously from the Blanchard mine. A 2-m-long seam in the floor at the southern end of the tunnel has produced highly lustrous rosettes and clusters of hemimorphite crystals with an unusual reddish-brown color.' The crystal groups, some of which are stalagmitic, occur in vugs and pockets as large as 0.5 m across. Close examination of these specimens revealed seams and blebs of massive cuprite intergrown with solid masses of cerussite, hemimorphite, and in one case a 2-cm linarite crystal. In many cases, the cuprite is included within the hemimorphite as very fine veils and zones (Hlava, pers. comm. April 1988) accounting for the unusual color. Native copper also has been found in a couple of instances as very minor hackly masses imbedded in the cuprite. Aurichalcite sprays and rosasite balls often accompany the hemimorphite crystal groups, and in one section, groups of 1-2-mm sea-green smithsonite crystals were recovered. Cerussite crystals, some in V-twins more than 1 cm long, were found in an area adjacent to and below the hemimorphite zone. The post-mining minerals, chalcantite and goslarite (Hlava, pers. comm. April 1988), have also been found within and coating massive gypsum at the southern end of the tunnel.

A short west-trending drift near the tunnel entrance has produced a most startling find this-past year. Malachite pseudomorphs after linarite crystals more than 3 cm long have been recovered. In most crystals replacement has been complete, but in some cases a solid core of linarite remains. The crystals are found singly and in radiating groups in 5-20-cm-wide vugs in very tough silicified limestone. Unfortunately, most crystals are detached from the matrix in opening the pockets. The vugs also contain 1-3-mm-long hemimorphite crystals, usually pseudomorphed by chrysocolla, small tufts of malachite, and a white clay-like mineral coating the drusy quartz crystals that usually line the pockets. No unaltered linarite crystals have been recovered to date, but the search continues.

Perhaps the most unexpected new mineral occurrence at the Blanchard mine this past year was that of a mercury sulfide identified (Hlava, pers. comm. April 1988) from locations near

the Portales tunnel (Glory Hole). X-ray diffraction has confirmed this mineral to be cinnabar (Foord, pers. comm. Sept. 1988). The cinnabar occurs as orange-red, pulverulent coatings in small cavities or in roughly square patches in what appears to be relict casts of a completely decomposed mineral. The cinnabar occurs within a very restricted horizon of altered gypsum-bearing punky limestone roughly 10-12 cm thick. It occurs above a zone containing cavities lined with blue fluorite crystals. The cinnabar has been found in the same horizon at two points approximately 50 m apart.

Additional exploratory work at the Blanchard mine is planned for the coming year and very possibly could reveal new and exciting discoveries. The intrigue of minerals is in large part due to our pursuit of them.

**ZONING IN MINERALS:  
PROPERTIES, POTENTIALS, AND PROBLEMS**

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Sandia National Laboratories  
Albuquerque, NM 87185

Most minerals are chemically complex and can exhibit large variations in chemistry. We often see tables of analyses of one mineral or another where the chemistry of the mineral reflects the differences in geochemistry from one locale to another. Therefore most of us are aware of such changes. However, many of us are only vaguely aware that if the chemical and physical conditions change while any one crystal of such a mineral is growing, this individual crystal will show chemical variations within it. This phenomenon is called **zoning** and, while we have all seen this, few of us have thought about what causes it or what it is telling us. In this talk, I plan to remedy that by examining some of the properties of zoning as well as discussing some of the good (potentials) and bad (problems) features of this phenomenon.

In discussing properties I plan to mention phenomena, such as diadochy, that allow zoning to occur as well as discuss the various properties that zoning exhibits. These properties include the fact that some elements can change concentration while others don't. Zoning occurs in various styles or types (normal, reverse, sector, and oscillatory), several of which can be exhibited by any one crystal at the same time. Zoning can be manifested in many different ways (color, birefringence, microprobe analyses, etc.). It is important in discussing zoning to remember that essentially all minerals are zoned, some obviously, some not so obviously.

I will also discuss some of the potentials (benefits) of mineral zoning. For example, zoning helps to simplify the mineral kingdom by making minerals chemically "flexible". Without this flexibility, ordinary rocks might have become amazingly complex--a different mineral for every element in the sample. Zoned minerals aid in our understanding of mineral chemistry and mineral relationships. This understanding has allowed the creation of materials with tailored properties. To the academic geologist, a major benefit of zoning is the easily interpreted record of geochemical history preserved in these minerals. To the hobbyist, a major benefit is the beauty which zoning can create.

I also need to discuss some of the problems that zoning creates. Few people are aware of how difficult it can be to obtain, or manufacture, some materials in pure and/or homogeneous forms. For example, the separation of pure praseodymium from neodymium wasn't possible until the late 1920's when ion exchange techniques were perfected. If one wants to make a

silicon/germanium alloy, one has to expect significant inhomogeneity. Some elements are hard to obtain because zoning has dispersed them in small amounts in some minerals, such as rubidium in feldspar, or has zoned them with elements from which they are difficult to extract, such as tantalum in niobates. Of immediate concern to mineral collectors is how the very wonderful chemical flexibility of zoning can make the naming of a particular specimen frustrating. If the central half of a specimen is nickel-rich skutterudite and the out half is cobalt-rich nickel-skutterudite-- what do I call it?

Examples of zoning in a wide variety of minerals and using a number of techniques will be used to illustrate the talk. Because the electron microprobe was used in many of these examples, a short description of this important instrument and the data it produces will be included.

\*A portion of this work was performed at Sandia National Laboratories and was supported by the U.S. Department of Energy under contract no. DE-AC04-76DP00789.

**HISTORY AND MINERALOGY OF THE SUNNYSIDE MINE,  
EUREKA MINING DISTRICT,  
SAN JUAN COUNTY, COLORADO**

(Location 5 on index map)

Tom Rosemeyer  
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The Sunnyside mine is located 7 air miles northeast of Silverton, Colorado, at an elevation of 12,240 ft. The mine is located on what had been the shore of Lake Emma situated in a beautiful alpine valley.

At the height of mining activity in the late 1800's and early 1900's, the Sunnyside mine complex was a self-contained community complete with offices, boarding houses, hospital, and commissary.

During the 1960's, mining was carried out on the Washington vein above the American Tunnel haulage level. During the next ten years, thousands of mineral specimens were collected, the most famous being the fluorite-rhodochrosite crystal groups. In the 1970's, rich gold veins were discovered and mined below Lake Emma. Many fine gold specimens were collected and found their way into private mineral collections.

There is still confusion among mineral collectors as to the correct mine name, and mislabeling of mineral specimens from the Sunnyside mine is common. This problem has come about in the following manner. The American Tunnel is the lower level of the Gold King mine at Gladstone, Colorado. In 1959, the American Tunnel was extended more than a mile to intersect Sunnyside mine orebodies 600 ft below the old mine workings. Thus, the American Tunnel is not a mine but is the lowest transportation and ore-haulage level of the Sunnyside mine; as such, it should not be used as a separate mine name. All the specimens that are labeled American Tunnel, Gladstone, Colorado and other variations should be labeled as follows: Sunnyside mine, Eureka Mining District, San Juan County, Colorado.

At present, the Sunnyside mine is operated by Alta Bay Mines in a joint venture with Echo Bay Mines, Ltd. The Sunnyside mine produces approximately 700 tons of ore per day and is Colorado's largest underground gold mine.

#### HISTORY

Placer gold was discovered in the San Juan Mountains in 1860 by the Baker Party. In 1871, interest was renewed in the area, but no mining claims were staked because the area still belonged to the Ute Indians. By the summer of 1873, the critical point had been reached between the prospectors and the Indians, and in

September of 1873, the "Burnot Treaty" was signed. The San Juan Mountains were now opened for prospecting and settlement.

The Sunnyside vein was discovered by George Howard and R. J. McNutt in 1873, and valid mining claims were staked in 1874. During the next 24 years, the mine was owned by various individuals. In November 1900, Judge John Terry obtained complete control and ownership of the mine. The American Smelting and Refining Company purchased the mine and mill from the Terry family in 1917. Mine improvements and expansion and the construction of a new selective-flotation system made the Sunnyside mine one of Colorado's largest underground mines. In 1927, the Sunnyside mine was the first Colorado mine to produce 1,000 tons of ore per day with a payroll of more than 500 people.

In 1959, the Sunnyside mine was leased by Standard Metals Corporation and operated through the 1960's and 1970's. In June 1978, the mine broke-into Lake Emma and emptied more than four million tons of water and mud into the workings. The cleanup took two years to complete before the mine was back in operation. In 1985, it was forced into bankruptcy and closed down. Later in 1985, the mine was leased by Echo Bay Mines, Ltd., and put back into production. In 1988, Echo Bay Mines, Ltd., formed a joint venture with Alta Bay Mines, the present operator.

#### GEOLOGY AND ORE DEPOSITS

The San Juan Mountains consist of thick accumulations of middle to late Tertiary lavas and pyroclastic rocks. The volcanic rocks were unconformably deposited on Paleozoic and Mesozoic sediments and on partially eroded Precambrian volcanics, intrusive rocks, and metamorphosed sediments.

During mid-Tertiary time, approximately 32 million years ago, large-scale volcanic eruptions from a series of central-vent volcanoes deposited rhyodacitic ash and lava flows. About 28 million years ago, renewed volcanic activity erupted voluminous amounts of ash that resulted in the formation of the San Juan and Uncompahgre calderas, which are about 12 mi apart. About one-half million years after the formation of the calderas, pyroclastic eruptions within the San Juan caldera formed the ring-faulted Silverton caldera. Resurgence of the magma later domed the overlying sediments and volcanic rocks between the two calderas. A set of major northeast-trending faults was formed by the doming. Further volcanic eruptions caused the dome to collapse and form a trough--the Eureka graben--between the two calderas.

Mineralization occurs in faults and fractures within the northern walls of the Eureka graben, which is made up of quartz latite lavas, flow breccias, and tuffaceous sediments. These volcanic units are the host rock for the orebodies of the Sunnyside mine. The steeply dipping Ross Basin, Sunnyside, Bonita, and Toltec faults and associated fractures were the main



structural control for the localization of the ore shoots and contain the major orebodies of the Eureka mining district. The major ore shoots that make up the Sunnyside mine are along and near the intersection of the Ross Basin and Sunnyside fault zones. The northwest-trending Ross Basin fault zone contains the Mogul, Brenneman, and Belle Creole orebodies, while the northeast-trending Sunnyside fault zone contains the Gold Prince, No Name, Sunnyside, and Spur orebodies. The Washington vein trends roughly east-west and contains the orebodies that are near the intersection of the Ross Basin and Sunnyside fault zone.

The formation of the veins is complex and shows successive fissure reopening and mineral deposition, with each stage having a distinct mineral assemblage. The main ore minerals are sphalerite, galena, chalcopyrite, tetrahedrite, and native gold. The common gangue minerals are quartz, pyroxmangite, pyrite, rhodochrosite, fluorite, and calcite.

#### MINERALOGY

The common ore and gangue minerals that make up the veins of the Sunnyside mine, in decreasing order of abundance, are: quartz, sphalerite, galena, pyroxmangite, pyrite, rhodochrosite, chalcopyrite, tetrahedrite, fluorite, and calcite. The remainder of the vein minerals occur in small to trace amounts.

The following is a list of minerals that occur in the veins. It does not include wall-rock alteration minerals.

|              |             |               |
|--------------|-------------|---------------|
| Aikinite     | Fluorite    | Orthoclase    |
| Alabandite   | Freibergite |               |
| Alleghanyite | Friedelite  | Petzite       |
| Anhydrite    |             | Pyrite        |
|              | Galena      | Pyroxmangite  |
| Barite       | Gold        | Pyrrhotite    |
| Bornite      | Gypsum      |               |
|              |             | Quartz        |
| Calaverite   | Helvite     |               |
| Calcite      | Hematite    | Rhodochrosite |
| Chalcopyrite | Huebnerite  |               |
| Copper       |             | Spessartine   |
|              | Kutnohorite | Sphalerite    |
| Electrum     |             |               |
|              | Molybdenite | Tephroite     |
|              | Muscovite   |               |
|              |             | Tetrahedrite  |

**MINERAL LOCALITIES IN THE PICURIS MOUNTAINS,  
TAOS COUNTY, NEW MEXICO**

(Location 6 on index map)

Herbert W. Dick  
New Mexico Mining and Milling, Inc.  
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The Picuris Range in north-central New Mexico is an isolated mountain range of Precambrian rocks running 16 mi long east and west from the Sangre de Cristo Mountains to the Rio Grande rift; it averages 10 mi wide. The range consists of great masses of quartzite, mica schist, amphibolite, granite, and occasional pegmatites. The total relief in the range is about 4,500 ft, consisting of a maze of high steep ridges and deep canyons. The highest summit is Picuris Peak 10,700 ft above sea level.

There are two major formations: the upper, Vadito Formation with a composite thickness of 4,500 ft subdivided into a schist member and a conglomerate member; and the lower, Ortega formation of 6,650 ft with three members, Pilar Phyllite, Rinconada Schist, and lower quartzite.

The Picuris mining district includes the entire Picuris Range. Many of the minerals are found in quartz veins. Copper Hill, located 4.0 mi west of Peñasco, contains pyrite, gold, silver, chalcocite, cuprite, malachite, chrysocolla, and limonite; argentite and tetrahedrite have been reported.

On Copper Mountain at the Tungsten mine, quartz veins contain brown tourmaline, tabular crystals of wolframite, malachite, and chrysocolla. This is located 1.5 mi north of Copper Hill.

Near the head of Hondo Canyon (south of Taos) are prospects with quartz veins containing silver-bearing galena. These are 4.0 mi east from US-64. Spongy masses of limonite occur along the veins at the surface.

The Harding pegmatite mine located 7.0 mi east of Dixon is the best-known mine in the district. The major crystallization occurred some 7 miles deep and dates 1330 m.y. B.P. The important, extensively mined minerals include lepidolite, spodumene, microlite, and beryl. More than 50 minerals have been recorded from the quarry. Permits to collect can be obtained from the University of New Mexico Geology Department or from Mr. Griego in Dixon.

At present the major mining is for sericite mica with extensive workings about 2.0 mi south of the crest of U.S. Hill. The mill is located near Alcalde between Velarde and San Juan. In localities around the crest are deposits of sericite-mica clay

exploited by the Taos, Picuris, and Apache Indians who make pottery with a distinctly metallic appearance that is a very popular tourist item. A good deal of money is made with this craft. This cookware was made extensively in the late colonial period and was used by the Spanish and Indians alike.

For further information, two publications are:

Montgomery, A., 1953, Pre-Cambrian geology of the Picuris Range, north-central New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 30, 89 pp. (out of print but recorded on microfiche; diazo prints are available)

Schilling, J. H., 1960, Mineral resources of Taos County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 71, 124 pp. (reprinted 1982)

**MINERAL INCLUSIONS IN GALENA FROM THE ORGAN DISTRICT,  
DOSA ANA COUNTY, NEW MEXICO**

(Location 7 on index map)

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and Juan Sandoval  
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Galena mineral separates were collected from 21 mines in the Organ district and analyzed by directly coupled plasma-atomic emission spectrometry (DCP-AES) for the elements: antimony (Sb), bismuth (Bi), silver (Ag), tellurium (Te), and lead (Pb). The purpose of this study was to determine if trace-element substitutions of those elements (except Pb) into galena would be useful for characterizing mineralization when coupled with fluid inclusion, petrologic, and alteration studies. Galena was also analyzed by electron microprobe to determine if trace-element contents of the whole-mineral analyses of galena by DCP-AES were due to discrete mineral inclusions or solid-solution substitution. Both mineral inclusions and coupled semimetal (Sb/Bi)-silver solid solutions were found in the galenas analyzed.

Galena mineral separates that contained tellurium detectable by DCP-AES invariably contained inclusions of both altaite (PbTe) and native tellurium. Altaite replaced galena and native tellurium then replaced altaite. Hessite (Ag<sub>2</sub>Te) was detected by electron microprobe in small grains isolated in galena from the Hilltop and Quickstrike mines in no particular paragenetic relationship with altaite or native tellurium. These samples also had high Ag concentrations as-determined by DCP-AES. No tetradymite (Bi<sub>2</sub>Te<sub>2</sub>S) was detected in any samples from the Organ district, although it had been reported by previous workers.

Detectable silver contents in galenas were accompanied by detectable semimetal (Sb or Bi) concentrations determined by DCP-AES analysis. Very few mineral inclusions were found in these samples, suggesting a coupled solid solution between galena and Ag-Sb(Bi)S<sub>2</sub>. The Ag:Sb(Bi) ratios in these samples were near 1.0 except in samples containing Te (which also contained hessite). The only sulfosalt inclusion detected by electron microprobe was tetrahedrite, from the Hornspoon mine (which had a Ag:(Bi+Sb) ratio of 0.10). No Ag-Bi sulfosalts were detected although samples with the highest silver values were accompanied by high Bi concentrations.

High bismuth and silver concentrations appear to have a weak correlation to higher temperatures determined by fluid-inclusion-homogenization methods. Bismuth-rich galenas also appear to be deposit specific, most common in skarn deposits. However, the exact mechanisms for the distribution of Bi-Sb and Ag in the galenas analyzed are unresolved. The galenas containing tellurium mineral inclusions appear to be the result of a tellurium-rich fluid overprinting of a previously formed sulfide assemblage. The progression of more tellurium-rich mineralogies (galena-altaite-native tellurium) suggests such an overprint at temperatures near 300<sup>0</sup> C (as determined by fluid-inclusionhomogenization temperatures in coexisting quartz).

## MINERALOGICAL STUDIES OF SOME CAVES IN COLORADO AND NEW MEXICO

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Mineralogical and geochemical studies of cave formations (speleothems), bedrock, and cave-filling mud can help us better understand the depositional processes and environments in caves. Samples were sparingly and carefully collected in collaboration with cave owners, members of the Cave Research Foundation (CRF), museum curators, and other USGS scientists. X-ray diffraction (XRD), scanning electron microscopy, electron microprobe analysis, bulk chemical analysis, optical microscopy and petrography, and cathodoluminescence microscopy have been used to examine samples.

Silent Splendor, a chamber within Cave of the Winds (a phreatic cave system developed in Ordovician to Mississippian limestone), Manitou Springs, Colorado, was completely sealed by mud-choked passages until it was first entered by cavers in 1984. This pristine 65-m-long room is noted for a great variety of speleothems (see Hill and Seanor, CRF 1986 Annual Report, p. 2124; Modreski and others, 1987, GSA Abstracts with Programs, v. 19, no. 5, p. 322), particularly its exquisite clusters of beaded helictites up to 30 cm long. Minerals in Silent Splendor include calcite, aragonite, hydromagnesite, gypsum, and "limonite".

Porcupine Cave, noted for a wide variety of Pleistocene fossil vertebrate remains, is developed in the Ordovician Manitou Dolomite at the southwestern edge of South Park, Colorado. In addition to typical carbonate speleothems, mineralized areas within the cave contain barite, calcite, quartz, gypsum, carnotite, a black, botryoidal Ba-Mn oxide that XRD shows to be romanechite, and small (0.1 mm) white sphere-like crystal clusters of dolomite atop the romanechite.

Lechuguilla Cave, in Carlsbad Caverns National Park, New Mexico (Hill, CRF 1986 Annual Report, p. 16-18) has been the subject of extensive recent explorations and discoveries; it is

now the deepest, 457 m (1500 feet) and the longest, 34.3 km (21.3 miles) known cave in the park and in the state. A silvery black, slippery, manganese oxide material that is a corroded limestone residue is composed of rancieite,  $(\text{Ca}, \text{Mn}^{+2})\text{Mn}^{+4}_4\text{O}_9 \cdot 3\text{H}_2\text{O}$ , and todorokite,  $(\text{Mn}^{+2}, \text{Ca}, \text{Mg})\text{Mn}^{+4}_3\text{O}_7 \cdot \text{H}_2\text{O}$ . Associated brown-colored material contains calcite microcrystals plus nearly amorphous FeMn oxides and rare grains of an apparent aluminum hydroxide mineral (gibbsite?).

An unusual cave in Precambrian gneiss was discovered in Clear Creek Canyon, west of Golden, Colorado, during blasting for road construction in May 1988 (Modreski and others, 1988, GSA Abstracts with Programs, v. 20, no. 7, p. A65). A 50-m-long x 10-m-wide x 20-m-high open void formed through collapse, settling, and dissolution of loose rock along a fault zone. The cave contains a spectacular array of carbonate speleothems, including calcite flowstone and draperies, and aragonite stalactites, stalagmites, helictites, and "frostwork" crystal druses. Other minerals identified in the cave include small amounts of hydromagnesite ("moonmilk"); minute blebs of green-luminescent opal as a coating on aragonite crystals; a black BaMn oxide that contains trace Cu, Co, Mo, W, and Pb and gives an XRD pattern of poorly crystalline romanechite; and a poorly crystalline, Mg-rich, Al-poor, layer silicate mineral (a trioctahedral smectite?) with a platy to spheroidal or botryoidal morphology.

The abundance of aragonite vs calcite speleothems, the relationship of speleothem type to water chemistry and evaporation rate, the correlation of luminescence to trace-element chemistry, and the nature and chemistry of Fe-Mn oxide deposits are some of the topics in mineralogy that may help shed light on the mysteries of caves.

**MINERALOGY OF THE BLACK RANGE TIN DISTRICT,  
SIERRA AND CATRON COUNTIES, NEW MEXICO**

(Location 8 on index map)

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Many aspects of the mineralogy of the Black Range tin district (BRTD) have been presented previously (Foord et al., 1985, 1986, 1988; Foord and Maxwell, 1987; Maxwell et al., 1986). We have now identified and/or characterized all of the remaining unknown minerals discussed in earlier communications. Additional unreported species undoubtedly are present and may be characterized in the future.

Table 1 lists the minerals identified from three separate localities and from the rest of the BRTD. Three mineral species new to science have been discovered: squawcreekite,  $(\text{Fe}, \text{Sb}, \text{Sn}, \text{Ti})\text{O}_2$ , a member of the rutile group; maxwellite,  $\text{CaFeAsO}_4\text{F}$ ; and the Ce-analogue of chernovite-(Y),  $\text{CeAsO}_4$ . Species new to the state of New Mexico include: gasparite-(Ce),  $\text{CeAsO}_4$ , chernovite-(Y),  $\text{YAsO}_4$ , and tilasite,  $\text{CaMgAsO}_4\text{F}$ .

Three different members of the durangite group,  $\text{XY}(\text{AsO}_4)\text{F}$ , all having the titanite structure, have been found in the BRTD: durangite ( $X = \text{Na}$ ,  $Y = \text{Al}$ ) (3 localities), tilasite ( $X = \text{Ca}$ ,  $Y = \text{Mg}$ ) (1 locality), and maxwellite ( $X = \text{Ca}$ ,  $Y = \text{Fe}$ ) (2 localities). Solid solution exists between all three members. Tilasite from vapor-phase altered rhyolite at Willow Springs Draw has the following composition:

$(\text{Ca}_{0.55}\text{Na}_{0.47})(\text{Mg}_{0.48}\text{Fe}^{3+}_{0.20}\text{Al}_{0.15}\text{Ti}_{0.14}\text{Mn}_{0.01})(\text{As}_{0.94}\text{P}_{0.02})\text{O}_4\text{F}$

This mineral has been found only at Willow Springs Draw.

Titanite, also found only at Willow Springs Draw, occurs in miarolitic cavities along with diopside (var. salite), pseudo-



brookite, and other minerals. The titanite crystals are euhedral, gem quality, red brown, and range from <0.1 to 1 mm in maximum dimension. Their composition is unusual compared to regular titanite ( $\text{CaTiSiO}_5$ ). The content of Y + REE is about 9 wt. %, with Y being the most abundant single element (about 3%  $\text{Y}_2\text{O}_3$ ). Both LREE and HREE are present. Other elements include (in wt. %):  $\text{Al}_2\text{O}_3$  1.8,  $\text{Mn}_2\text{O}_3$  1.0,  $\text{Fe}_2\text{O}_3$  7.3,  $\text{ZrO}_2$  0.1,  $\text{Nb}_2\text{O}_5$  1.6,  $\text{WO}_3$  0.5,  $\text{ThO}_2$  0.17,  $\text{V}_2\text{O}_3$  0.15,  $\text{Sb}_2\text{O}_3$  0.15,  $\text{Ta}_2\text{O}_5$  0.37, F 2.0. Crystallization of titanite of this unusual composition indicates the abundance of REE's and other incompatible elements in the late-stage vapor phase. This titanite composition (average of three samples) is similar to those reported from complex granitic pegmatites. Titanite in rhyolites is generally sparse because of lack of available Ca and Ti. Calcite has been found only inmiarolitic cavities with the rhyolites.

The diopside occurring with the titanite is yellow orange, and the crystals are usually acicular, transparent, euhedral, and may be several millimeters in length. The composition of the diopside is  $(\text{Ca}_{0.93}\text{Na}_{0.16}) (\text{Mg}_{0.70}\text{Fe}_{0.28}\text{Mn}_{0.06}\text{Ti}_{0.01}) (\text{Si}_{1.92}\text{Al}_{0.05})_6\text{O}_6$ .

Crystallization of tilasite-maxwellite preceded that of titanite and diopside. Crystals of tilasite-maxwellite are etched and corroded to varying extent. The later titanite and diopside may owe their origin, at least in part, to dissolution of the earlier tilasite-maxwellite.

Minor amounts of chevkinite,  $(\text{Ce,Ca,Th})_4(\text{Fe}^{2+},\text{Mg})_2(\text{Ti,Fe}^{3+})_3\text{Si}_4\text{O}_{22}$  or perrierite,  $(\text{Ce,Ca,Th})_4(\text{Fe}^{2+},\text{Mg})_2(\text{Ti,Fe}^{3+})_3\text{Si}_4\text{O}_{22}$ , which are dimorphous, also have been found at Willow Springs Draw. The gray-brown crystals are as much as 0.2 mm in maximum dimension. This particular chevkinite-perrierite is somewhat unusual because of its high  $\text{ZrO}_2$  content (3.04 wt. %). The composition (average of 10 points on one grain) is:

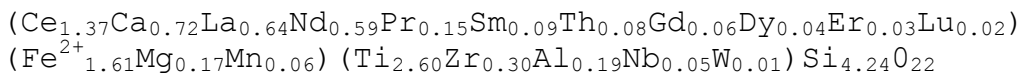


Table 1. List of minerals from rhyolite-hosted tin occurrences in the Black Range Tin District.

| Squaw Creek                 | Paramount Canyon            | Willow Springs Draw   | Rest of BRTD |
|-----------------------------|-----------------------------|-----------------------|--------------|
| squawcreekite*              | beryl                       | diopside              | acmite       |
| maxwellite*                 | bixbyite                    | titanite              | durangite    |
| gasparite-(Ce) <sup>+</sup> | chernovite-(Y) <sup>+</sup> | tilasite <sup>+</sup> | hidalgoite   |
| chernovite-(Y) <sup>+</sup> | Ce-analogue of              | maxwellite*           | beudantite   |
| heulandite                  | chernovite-(Y)*             | chevkinite-           | cryptomelane |
| calcite                     |                             | perrierite            | vanadinite   |
| stilbite                    |                             | calcite               | stolzite     |
| chabazite                   |                             | zircon                | topaz        |
|                             |                             |                       | fluorite     |
|                             |                             |                       | bixbyite     |
|                             |                             |                       | diopside     |
|                             |                             |                       | calcite      |
|                             |                             |                       | todorokite   |
|                             |                             |                       | smectite     |
|                             |                             |                       | opal         |
|                             |                             |                       | kaolinite    |
|                             |                             |                       | pyrite       |
|                             |                             |                       | alunite      |
|                             |                             |                       | jarosite     |
|                             |                             |                       | adularia     |

\* - mineral species new to science

+ - mineral new to state of NM

quartz, sanidine, hematite, and cassiterite are ubiquitous.

crystalite, tridymite, and pseudobrookite are common.

The REE arsenates (REEAsO<sub>4</sub>) occur in the two different structural forms now known in nature: huttonite-monazite type and zircon type. Chernovite-(Y), YAsO<sub>4</sub>, has the tetragonal zircon-type structure while gasparite-(Ce)<sub>t</sub> CeAsO<sub>4</sub>, has the monoclinic huttonite-monazite type structure (Schwartz, 1963; Graeser and Schwander, 1987). Chernovite-(Y) and its Ce-analogue have been found at Paramount Canyon. The Y-analogue of gasparite-(Ce) has not been found and has never been synthesized. The zircon-type structure of the REEAsO<sub>4</sub> is more stable at higher temperatures than the huttonite-monazite-type structure. Significantly, YAsO<sub>4</sub> and CeAsO<sub>4</sub> both occur at Paramount Canyon in the tetragonal (chernovite) form only, while tetragonal chernovite-(Y) and monoclinic gasparite-(Ce) occur at Squaw Creek. Crystallization temperatures of the arsenates at Paramount Canyon are higher

than the temperatures of the arsenates at Squaw Creek. Inversion of tetragonal  $CeAsO_4$  to monoclinic  $CeAsO_4$  has not been achieved experimentally but must occur based on the natural existence of both forms.

The gasparite-(Ce) at Squaw Creek contains about 1.3 wt. % CaO, with 4.3%  $ThO_2$  substituting for the LREEs as well as about 6.1%  $P_2O_5$  substituting for As. Chernovite-(Y) at Squaw Creek contains about 0.6% CaO, 0.3%  $SiO_2$ , 0.2%  $ZrO_2$ , 3.3%  $P_2O_5$ , and 2.8%  $ThO_2$ . The REE arsenates are the only minerals in the rhyolites found to contain major amounts of phosphorus. Apatite, the most common accessory mineral containing major P, is essentially absent.

The assemblages of minerals in the rhyolite-hosted tin occurrences of the BRTD indicate that deposition took place from high-temperature vapor-phase conditions down to ambient conditions with the majority of minerals being deposited from hydrothermal fluids.

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## WHAT CAUSES COLOR IN MINERALS?

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In the last 20 years scientists have been successful in explaining what causes color in a number of minerals and gems.

The results of the work of people like Nassau, Rossman, Fristch, Loeffler, and others reveal that minerals can generally be categorized into five major groups related to their color cause. These groups are:

PHYSICAL OPTICS - minerals whose color is due to physical rather than chemical phenomenon;

DISPERSED METAL IONS - one of the transition metals creates a color condition;

CHARGE TRANSFER - Electrons move from one atom to another by absorbing light energy;

BAND GAP - Metals and some compounds in which energy is absorbed in the gap between a substance's Fermi Surface and absorption band;

COLOR CENTERS - Some external force, such as heat, radiation, etc., disturbs the internal structure creating a condition under which light energy is absorbed.

This talk, supplemented with color slides, will describe the specific causes of color in a number of popular minerals ranging from gold through the rare sulfosalts, quartzes, pegmatite gems, and a host of collected minerals.