

NEW MEXICO MINERAL SYMPOSIUM

November 8 & 9, 1986



NMIMT Campus, Socorro, New Mexico

Welcome to
THE SEVENTH ANNUAL
NEW MEXICO MINERAL SYMPOSIUM

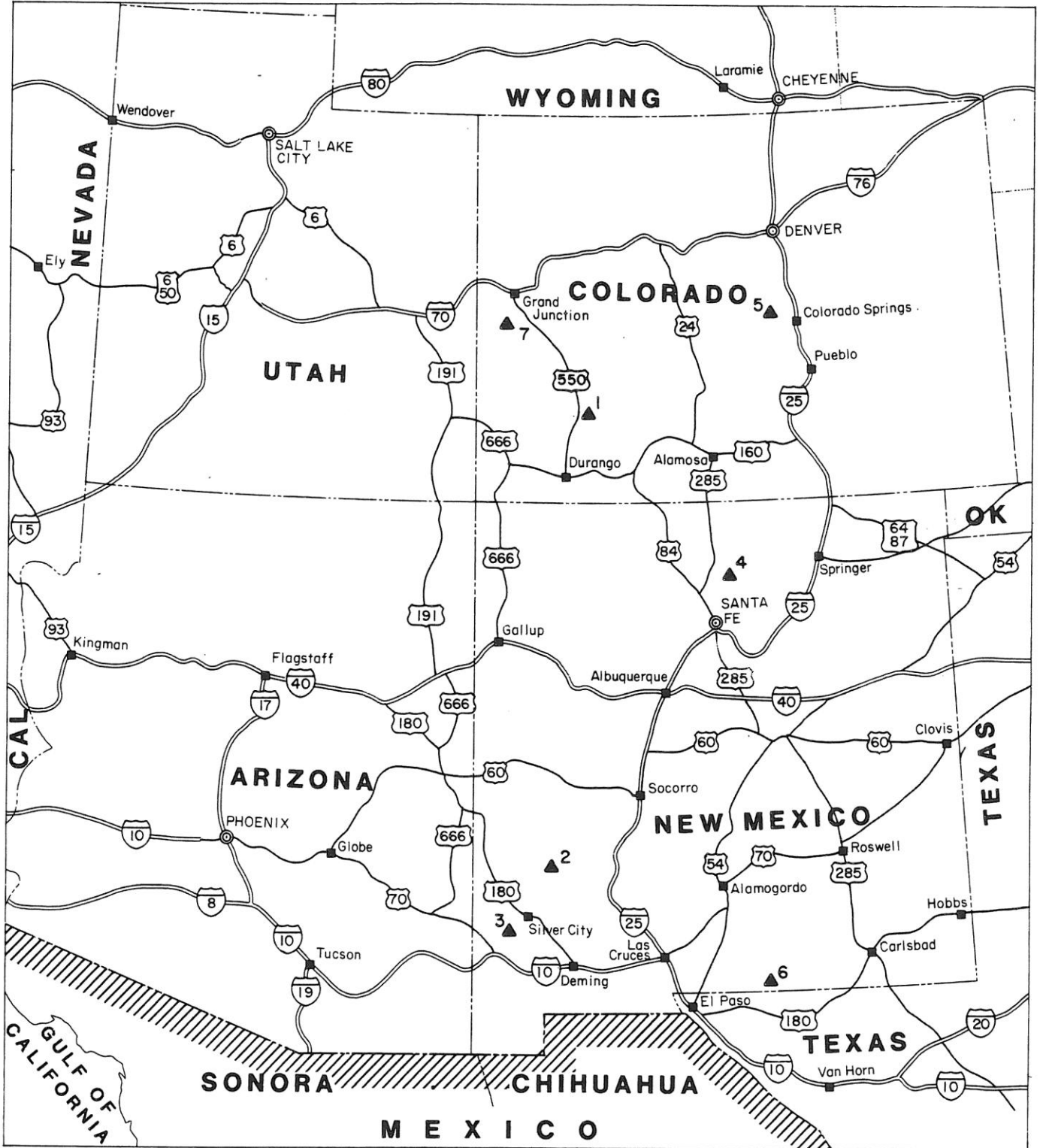
November 8 and 9, 1986

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

sponsored by
New Mexico Bureau of Mines and Mineral Resources
New Mexico Tech Mineralogical Society
Albuquerque Gem and Mineral Club

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 Seventh 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

7th New Mexico Mineral Symposium

SCHEDULE

Numbers in parentheses refer to geographic location on index map.

Friday, November 7

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

Saturday, November 8

7:45 am Registration and coffee and donuts
9:00 Opening remarks
9:05 (1) Gold mineralization in the San Juan Mountains,
southwestern Colorado--Tom Rosemeyer
9:40 (2) Mineralogy of the Black Range tin district, Sierra and
Catron Counties, New Mexico--Eugene E. Foord and
Charles H. Maxwell
10:15 Unusual zoning patterns in two secondary minerals from
New Mexico--Paul F. Hlava
10:45 Coffee break
11:15 Butte, Montana, the richest hill on earth--Michael J. Goble
12:00 Lunch
1:30 (3) Phosphate mineralization at the Tyrone mine, Grant
County, New Mexico--Ron B. Gibbs
2:00 (4) A new occurrence of cyprine (blue idocrase) in New
Mexico--Ramon S. DeMark and Paul F. Hlava
2:30 Great mineral hoaxes of the Southwest--Robert W.
Eveleth
3:00 Coffee break
3:30 (5) The "key-hole vug," Ten-percenter mine, Teller County,
Colorado--Don L. Smith, Sr., and Tom Rosemeyer
4:15 Sulfosalt and semimetal sulfide distribution in the .
southwestern United States--Virgil W. Lueth,
Phillip C. Goodell, and Diedrich A. Kropp
6:00 Sarsaparilla and suds: cocktail party, upper
lobby,
Macey Center
7:00 Dinner, upper lobby, Macey Center, with keynote address
by Vandall T. King

Sunday, November 9

9:00 am Fluorescent minerals from New Mexico--Peter J. Modreski
9:45 (6) Mineralogy and textures of a eudialyte-bearing dike,
Wind Mountain, Otero County, New Mexico--Russell
C. Boggs
10:15 Coffee break
10:45 (7) Amethyst from Unaweep Canyon, Colorado--Richard
Dayvault and Michael E. Madson
11:30 Newly discovered minerals from New Mexico, 1959-1986:
Northrop + 27 years--round table discussion, all
welcome
12:30 Lunch
2:00- Silent auction, sponsored by the New Mexico Tech
3:30 Cooney Mining Club

GOLD MINERALIZATION IN THE SAN JUAN MOUNTAINS
SOUTHWESTERN COLORADO
(Location 1 on index map)
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The San Juan Mountains encompass a large area of southwestern Colorado and part of northern New Mexico. The rugged mountain range is very scenic and has been called the "Alps of North America."

The mountains consist of a base of eroded Precambrian igneous and metamorphic rocks overlain by Mesozoic and Paleozoic continental and marine sediments. These sediments are overlain with thick accumulations of Late Cretaceous and Tertiary volcanics that are associated with Laramide tectonics. During mid-Tertiary times renewed eruptions from vent volcanoes formed the widespread San Juan Formation, which consists of lavas, breccias, and mudflows. Volcanic activity created widespread ash-flow tuff deposits and formed at least fifteen calderas. Large-scale subsidence following evacuation of magma chambers formed landslide formations from the collapse of the caldera walls. Later eruptions resulted in thick accumulations of the Burns and Henson Formations, the host rock for the veins in the Eureka mining district. Subsequent uplift and stress due to the renewed tectonic activity created major fractures that were filled by the hydrothermal solutions that formed the Smuggler-Union, Tomboy, and other rich gold-based metal veins.

The area discussed in the slide presentation is the Ouray-Silverton-Telluride triangle. This area is intensely mineralized and contains major Au-Ag-Pb-Cu-Zn deposits.

Gold was discovered in 1860 in the San Juan Mountains by some of the first prospectors to venture into the rugged range. Charles Baker is credited with making the original placer-gold discovery in Eureka Gulch, three miles north of Howardsville. The news of this discovery brought hundreds of prospectors into the area. However, the placer deposits did not "pan out," and the area was abandoned after 1861. Because the region was inaccessible and the territory was controlled by the Ute Indians, mining and settlement were not established until the 1870's. Lode gold was discovered in 1872 at the Little Giant mine in Arrastra Gulch. Discovery of the Belle Creole, Washington, and Sunnyside veins in the Lake Emma area followed. In 1873 a treaty was signed with the Ute Indians that opened up the San Juan Mountains for mining and settlement.

By 1876 Silverton was well established as a mining and railroad center serving the mines of the southern San Juan Mountains. Major gold mines in the area were the Gold Prince mine at Animas Forks, the Sunnyside mine at Eureka, and the Gold King mine at Gladstone. Telluride, on the western edge of the San Juan Mountains, was the main settlement serving the mines in this area. In 1875 John Fallon discovered gold in Marshall Basin and developed the Sheridan mine. Later the Sheridan, Mendota, Union, and Smuggler mines were consolidated by English bankers into the Smuggler-Union mine, one of the largest producers in the area. Other major discoveries that resulted in profitable operations were the Liberty Bell mine, discovered in 1876, and the Tomboy mine, discovered in 1880. Ouray, on the northern edge of the San Juan Mountains, was the main supply point for the mines of Yankee Boy and Imogene Basins, the Engineer Mountain area, and Poughkeepsie Gulch. The dominant gold producers were the American Nettie mine, discovered in 1889, and the Camp Bird mine, discovered by Tom Walsh in 1896.

By 1956 all major mining properties had been consolidated into one large mining operation, The Idarado Mining Company. Extensive development was completed, and the area was mined profitably until 1976 when operations ceased. Native gold is the primary gold-bearing mineral in the region and occurs with base-metal sulfides and numerous, mostly quartz, gangue minerals. Petzite and krennerite occur rarely with the gold ore in some of the veins. The mines of the area have produced millions of dollars in precious and base metals and have supplied the mineral collector with thousands of fine specimens.

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

(Location 2 on index map)

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Recent geologic studies of the Black Range tin district have indicated that there are several different types of cassiterite occurrences that are associated with the Taylor Creek peraluminous rhyolite. Four types have been distinguished, from early to late: I. high-temperature vapor dominated; II. high-temperature hydrothermal fluid dominated; III. low-temperature hydrothermal fluid dominated; and IV. supergene(?). Type I deposits consist of sparse amounts of cassiterite occurring in lithophysae, miarolytic cavities, and tiny gash veins. Type II deposits consist of well-defined gash veins and anastomosing systems of veinlets that vary widely in orientation and size (1-10 cm thick and 1-8 m long). Type III deposits consist of veins and stockwork-like areas of reticulate veinlets in the distal edges of rhyolite flow domes and in the underlying tuffs and ash-flow tuffs. Some veins are as much as 30-40 cm wide and 100+ m long. The exposed surface area of the veins may encompass several thousand square meters. Type IV deposits consist of supergene accumulations of wood-tin and stannic acid, $\text{SnO}_2 \cdot x\text{H}_2\text{O}$, occurring in porous zones in sandstone, conglomerate, and tuff. They also occur in subsurface pockets of intensely altered or weathered rock, most commonly in pockets filled with red clay. Thus, deposition of cassiterite and associated minerals occurred over a wide range of conditions. Some of the tin mineralization (Type I) is derived from the host Taylor Creek Rhyolite, but most of the tin mineralization (Type III) is characterized by colloform (wood-tin) cassiterite and is derived from a source outside of the rhyolite flow domes. Most of the tin was deposited in vein systems after the host rocks had solidified, cooled, and fractured.

A list of the minerals identified from each of the four types of deposits is tabulated on the next page.

Type I	Type II	Type III	Type IV
High-temperature vapor dominated	High-temperature hydrothermal fluid dominated	Low-temperature hydrothermal fluid dominated	Supergene (?)
specular hematite beryl pseudobrookite bixbyite topaz cassiterite quartz sanidine titanite (sphene) clinopyroxene calcite	quartz specular hematite cassiterite cristobalite fluorite sanidine zeolites Sb-Sn-Ti-Fe-oxide Na-Ca-Fe-Ti-Mg-Mn fluoro-arsenate Ce-group arsenate or fluoro-arsenate	hematite quartz cassiterite (var. wood-tin) durangite tridymite cristobalite chalcedony hyaline opal fluorite beudantite hidalgoite jarosite smectite cryptomelane todorokite	cassiterite (var. wood-tin) stannic acid disordered smectite

Electron microprobe and emission spectrographic analyses of cassiterite from all four types of deposits indicate that there is substantial variation in the chemical composition. The earliest formed (Types I and II) cassiterite is characterized by the presence of minor to major amounts of Sb, Fe, ± Ti. Essentially pure cassiterite is a paragenetically intermediate product, followed by the most abundant type of cassiterite, wood-tin, in Type III deposits. Cassiterite from Type III deposits generally contains as much as 1 wt. % or more of all or some of the following metals: In, As, Si, Pb, Fe, Zn, and Sb.

Mineralogical investigations have shown that a monoclinic(?) derivative of cassiterite, amber to caramel colored, most likely related to the trirutile structure, and containing major amounts of Sb, Sn, Fe, and Ti, exists in rhyolite at Squaw Creek. Some of the material has epitaxial overgrowths of cassiterite. Crystals are all small, usually less than 100 microns long and 10-20 microns wide. Detailed microprobe studies of this material have been done by Paul Hlava of Sandia National Laboratories.

Hematite, particularly high-temperature varieties, may contain as much as 1% Ti, 1.5% Mn, 0.07% Nb, 0.15% Zn, and 0.7% Sn (based on emission spectrographic analyses).

To date, three fluoroarsenates (and/or arsenates) have been found at multiple localities. Durangite, $\text{NaAlAsO}_4\text{F}$, has been found at two different localities (the Clearing and 74-draw) and has been described in detail in the Canadian Mineralogist (1985, vol. 23, pp. 241-246). A new red to red-orange Na-Ca-Fe-Mn-Ti-Al-Mg fluoroarsenate occurs at Squaw Creek and Willow Creek. At Squaw Creek, very small amounts of a new bright yellow Ce-group fluoroarsenate or arsenate, with minor amounts of Ca and Th, coexist with the red fluoroarsenate. Maximum dimensions of crystals of the red fluoroarsenate are as much as 0.5 mm, and those of the yellow REE fluoroarsenate (or arsenate) are about 0.25 mm.

Clinopyroxene, ranging in color from orange to red brown to amber, occurs at several localities (Willow Creek, Squaw Creek, 74-draw, and Lookout Mountain Road). Material from the Lookout Mountain Road locality shows the alexandrite effect, being violet-purplish red under tungsten light and green under natural light. Crystals are typically 0.5-1 mm in mean dimension.

Some of the titanite from Willow Creek, east of the Black Range, has a very unusual composition. It may contain as much as several percent or more of REE, Pb, Nb, F, and other elements. The color is very similar to that of the clinopyroxene from the same locality. Mean dimension is approximately 0.5 mm.

Single-phase high sanidine adularia with the unusual composition $(\text{K}_{0.51}\text{Na}_{0.45}\text{Rb}_{0.004}) \sum 0.964 (\text{Al}_{.98} \text{Fe}_{.01}) \sum 0.99 \text{Si}_{3.0108}$ occurs at Alexander along with Sb-Fe-bearing cassiterite. The adularia coats fracture and/or vein surfaces, and individual euhedral colorless to white crystals are as much as several mm across.

A continuous progression from high- to low-temperature minerals is present, and the occurrence of typically hydrothermal elements, such as Zn, Sb, Pb, and As, along with the geologic observations points toward a principally hydrothermal origin for the deposits.

UNUSUAL ZONING PATTERNS IN
TWO SECONDARY MINERALS FROM NEW MEXICO

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Solid solutions between end members of isomorphous series are responsible for most of the variations seen in mineral compositions and are useful for recording genetic conditions. Indeed, by determining the exact composition of a specimen the mineralogist may be able to tell much about the temperature, pressure, and chemical conditions present when the mineral formed. In the case of zoned crystals the varying compositions also indicate the trends in conditions with time. Recent microprobe examinations of two specimens from different places in New Mexico not only revealed some interesting and unusual zoning patterns but also identified four uncommon mineral species and gave information about the solid solubilities of the mineral pairs.

The first specimen of interest came from a cavity in altered andesite found in some old mine workings in the Bear Mountains north and a bit west of Magdalena. These crystals are bright, lustrous tablets with a rhombic outline and vary from a bright emerald-green to a very dark green color. Microprobe analyses of the crystal surfaces indicated major amounts of Cu, Ca, V, and As, a composition not represented by any known mineral species. In cross section, the zoned nature of the crystals became obvious; bands rich in either As or V alternated with constant amounts of Ca and Cu. Quantitative analyses confirmed that the crystals were intermediate between conichalcite $\text{CaCu}(\text{AsO}_4)\text{OH}$ and calciovolborthite $\text{CaCu}(\text{VO}_4)\text{OH}$. The oscillatory- and sector-zoning records repeated major changes in the chemistry of the fluids from which the crystals formed. These may represent influxes of fresh As-rich fluid from the weathering of primary minerals. Continuous zoning within each sector or band indicates that the As-rich species is less soluble than the V-rich and that there is complete solid solubility between the two even if they do occur in different crystallographic space groups.

The other specimen comes from the Tyrone mine of Phelps Dodge Corp. near Silver City. These crystals are modified rhombohedra with a poor luster and a strange whitish-yellow color. Analyses of the surfaces indicated a confusing mix of Ca, Al, Si, P, and S--again not easily recognizable as any known species. Analyses of a cross-sectioned crystal revealed the outer layer to be quite different from the bulk, which turned out to be the mineral corkite $\text{PbFe}_3(\text{PO}_4)(\text{SO}_4)(\text{OH})_6$. Corkite is one member of a large family of isomorphous minerals that also contains a Ca-Al-P-S member, woodhouseite, and a third member in

which Si is substituted for P. By integrating all of this information it appears that this specimen consists of a thin layer of siliceous woodhouseite on a core of corkite. These crystals contain minor amounts of K and Ba that, together with the major elements, create a complex pattern showing (again) oscillatory, sector, and continuous zoning. In this material the oscillations are mainly between Pb and K + Ba. Continuous zoning involves the enrichment from core to rim of P, Al, Pb, and Ca at the expense of S, Fe, and K. Sector zoning is exhibited by the sudden disappearance of Pb and Fe, the appearance of Si, and the abrupt enrichment in Ca and Al. The suddenness of the change suggests that the two minerals do not form a continuous solid solution even though they are isomorphous. Another interesting observation is that the corkite seldom contains S and P in a perfect one-to-one ratio indicating that the formula ratios are somewhat flexible and not rigid. In fact, these non-stoichiometric ratios in the corkite seem to indicate that there may be solid solutions between the three groups.

*This work was performed at Sandia National Laboratories supported by the U.S. Department of Energy under Contract #DE-AC04-76DP00789.

BUTTE, MONTANA
THE RICHEST HILL ON EARTH

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Gold was discovered on the Original claim in July 1864 by G. O. Humphreys and William Allison. The site was chosen because a small pit had been found along with some worn elk horns used for digging by unknown miners years before. In August Humphreys and Allison located the Missoula and Buffalo claims. W. L. Farlin located the first lode claim called the Asteroid. By the end of 1864 more than one thousand men were placering for gold. The shaft in the Original mine reached 80 ft and the weathered ore was taken down to Silver Bow Creek for panning.

In 1865 a copper-silver brick was smelted in New Jersey from ore taken from Joseph Ramsdell's Parrot No. 2 mine. In 1866 copper ore from William Park's Parrot No. 3 claim was shipped to Swansea, Wales for refining but high shipping costs took most of the profit from the enterprise. In 1867 Dennis Learly, who had located the Parrot No. 1 claim, erected Butte's first smelter. However, the gold placers began to give out, and most of the miners rushed to new strikes in Idaho. By 1868 it was evident that the attempts at smelting the copper ores had failed. The population of Butte was less than one hundred men.

In 1872 W. L. Farlin returned from Idaho after having a rock from Butte assayed. Farlin relocated the Asteroid as the Travonia and this became Butte's first successful silver mine. A new rush was on. By the end of the 1870's Butte was Montana's largest city and was known as the world's leading silver producer. Among the rich silver mines of the period were the Original, Parrot Colusa, Ramsdell's Parrot, Mountain Consolidated, Leonard, Alice, Moulton, Lexington, Bluebird, Silverbow, and Acquisition.

During the 1880's the ore that was mined changed from being rich in silver minerals to rich in copper. Many mines were closed. The experience of the previous years showed that only the richest copper mines could overcome the high shipping costs to make a profit. Marcus Daly was among the few who had faith in copper. He purchased the Anaconda claim for \$30,000. At the 300-ft level of this claim a crosscut disclosed a huge vein of nearly pure chalcocite. The ore assayed 45% copper and the vein was 30 to 100 ft thick. Shipments of ore from the Anaconda to Swansea began. The metallurgists in Wales wrote to Butte asking if the material came from a new metallurgical process. Daly assured them that the ore was entirely natural. The copper ore mined previously in Butte had consisted of bornite and

chalcopyrite. Chalcocite had been known only as a mineralogical curiosity. Daly moved ahead and purchased the St. Lawrence and Never Sweat claims. In 1883 he constructed a smelter at what would become the town of Anaconda. He realized that if the ores could be smelted locally the profits would be greatly increased.

In 1880 Edison patented the incandescent lamp; in 1882 New York City built an electric generating plant for its street lights. Daly had anticipated that a great change would occur in the demand for copper. In 1882 the U.S. consumed 91 million pounds of copper, of which Butte supplied 9 million pounds. Soon Butte gave competition to the Michigan copper mines as the demand for the red metal grew. By 1884 Butte produced over 14 million ounces of silver and 26 million pounds of copper. In 1887 Butte's production of almost 79 million pounds surpassed that of Michigan; the total U.S. consumption of copper was 184 million pounds. A few years later Butte became known throughout the world as "The Richest Hill on Earth."

For many years to follow Butte's copper production would exceed 100 million pounds per year. In October 1978 the Anaconda Company announced that it had produced its 20 billionth pound of copper from the Butte district. The district also has produced almost 5 billion pounds of zinc, 4 billion pounds of manganese, 850 million pounds of lead, 700 million ounces of silver, 3 million ounces of gold, 300 million pounds of arsenic compounds, 4 million pounds of cadmium, 4 million pounds of bismuth, 10 million tons of sulfuric acid, 300 thousand pounds of selenium, and 250 thousand pounds of tellurium.

In 1981 Anaconda added a molybdenum circuit to its mill. Mining activity shifted from the Berkeley pit to the eastern part of the district. There was more than 20 years left for copper mining by open-pit methods and at least 20 more years of underground reserves were available. The Weed concentrator was built over the top of a recently discovered copper-molybdenum orebody. The size of this orebody is not fully known but it may well be the largest molybdenum deposit in the world. The expense of drilling exploration holes 7,000 ft deep through hard rock has discouraged a full assessment. Low metal prices coupled with higher operating costs led Anaconda to close the Berkeley pit in 1983. Many people predicted that this meant the end of mining in Butte. However, the purchase of the properties by Washington Corp. of Missoula, Montana, in 1985 has given the Butte district a brighter future.

The talk features the mines and minerals of the district. More than one hundred forty minerals have been identified. Butte is world famous for its crystals of covellite, enargite, bornite, pyrite, and rhodochrosite.

PHOSPHATE MINERALIZATION AT THE TYRONE MINE
GRANT COUNTY, NEW MEXICO

(Location 3 on index map)

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Phosphate mineralization has been known in the Tyrone area since 1871. Small pits and stone tools are evidence of earlier mining by Indians. The Azure mine was opened in 1891 and became one of the largest turquoise mines in the country. Turquoise mining declined as copper mining became prominent. Small underground mines gave way to the opening of the Tyrone open-pit mine in 1967, and more phosphates came to light. Today, 16 species have been recognized, some rarely found in New Mexico. They include turquoise, libethenite, torbernite, autunite, lead-meta-autunite(?), pseudomalachite, cornetite, chalcocyanite, apatite, wavellite, plumbogummite, woodhouseite, corkite, strengite, cacoxenite, and pyromorphite.

A NEW OCCURRENCE OF CYPRINE (BLUE IDOCRASE)
IN NEW MEXICO

(Location 4 on index map)

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The Picuris Range of the Sangre de Cristo Mountains has long been known for producing bright red piemontite crystals. Piemontite is a major constituent of the upper portion of the Vadito Formation, a Precambrian muscovite-quartz schist and quartzite that is exposed extensively on the west slopes of the range near Pilar, New Mexico. The piemontite in stratified layers within the quartzite occurs as individual crystals in quartz stringers and as eyes in the quartzite. While the quartzite in this area is generally compact, separation along seams in the layers has allowed, in some cases, the growth of free-standing crystals.

One such seam that is exposed on the west slope of the Picuris Range approximately 300 ft above NM-68 and roughly one-half mi south of Pilar has revealed the occurrence of cyprine, the rare blue variety of idocrase, in direct association with free-standing crystals of zoisite (thulite), piemontite, and grossular. The seam is restricted laterally to approximately 3 m and is from 1 cm to 5 cm thick. This seam is composed of disintegrated rock that is predominantly zoisite (thulite), piemontite, and grossular in the core whereas the idocrase is restricted to the surface. Most of the idocrase is opaque, but a small percentage of the crystals are transparent and sapphire blue. Crystals range in size from 2 to 8 mm and are heavily striated. Many crystals are zoned with the blue color abruptly changing to gray. Microprobe analyses reveal almost identical chemical compositions in the blue and the gray zones. There are only subtle variations in the minor-element contents; the blue zone is richer in Cu and Ti whereas the gray is richer in Mn and Fe. Weathering along the seam has destroyed the integrity of most crystals so that freestanding, terminated crystals on matrix are scarce. Minor seams located stratigraphically above and below the described seam show minor evidence of idocrase, but the thinness of the seams has precluded the growth of free-standing crystals.

In addition to the occurrence of attractive specimens of cyprine, thulite, and piemontite, several other minerals of interest can be found as float in the arroyos and on the talus slopes. Dravite has been identified as the brown tourmaline that is found quite commonly in the schistose rocks of the Vadito Formation. Andalusite and its green Mn-rich variety viridine are also common. The other aluminosilicate polymorphs, kyanite and

sillimanite, occur, although not in noteworthy specimens. Finally, a muscovite of unusual appearance has been found in a canyon directly south of the idocrase area. It is found in a seam similar to that in which the idocrase occurs although the maximum seam width is only 4-5 mm. The muscovite at this location occurs in distinct but somewhat rounded crystal aggregates about 1 mm in size with a distinctive lilac to purple color. They are found in association with free-standing crystals of piemontite and, to a minor extent, grossular. We feel that this assemblage of unusual minerals and mineral varieties in such a restricted area is noteworthy but not unique. We expect that diligent searching of the appropriate stratigraphic horizons will reveal other occurrences of these minerals in the metamorphic rocks of northern New Mexico.

GREAT MINERAL HOAXES OF THE SOUTHWEST

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Throughout New Mexico's long history of mineral production thousands of mining companies, some successful, many otherwise, have come and gone. Regardless of their success or failure, the majority were aboveboard operations with noble intentions. A small portion, however, were based upon shaky foundations; a few of the more notorious were carefully planned, outright frauds.

In general the creators of these hoaxes were men of some intelligence with a flair for telling a good story. Armed with the knowledge that few of us are capable of resisting our gambling instincts, particularly when confronted with the vision of sudden wealth so vividly painted, the con artist/mineral promoter lines up the suckers as easily today as did his predecessors from the previous century.

This presentation focuses on a few of the more sensational promotions from the Ralston diamond hoax to the multimillion-dollar platinum-gold scams of the 1980's.

THE "KEY-HOLE VUG"
TEN-PERCENTER MINE
TELLER COUNTY, COLORADO

(Location 5 on index map)

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The term amazonite or amazonstone as used in this article refers to the light to dark green variety of microcline feldspar. Amazonite and smoky quartz crystal groups have been collected in the Crystal Peak area since the 1800's. Crystal Peak, elevation 9637 ft, is located approximately 3 mi north of the Lake George-Florissant area in Teller County, Colorado. In 1867 Ovander J. Hollister referred to the location in his book, The Mines of Colorado. Since then the area has been collected extensively and is world famous for amazonite-smoky quartz crystal groups and associated minerals.

The amazonite and associated minerals occur in pockets in pegmatite lenses and dikes that are classified as the simple type. The pegmatites were emplaced at a shallow depth in the Pikes Peak batholith and surrounding metamorphic rocks. The contact between the pegmatites and the surrounding rocks is usually sharp.

The Ten-percenter mine is located on the northeast side of Hackett Mountain just northwest of Crystal Peak. The mine has been worked from upper, middle, and lower excavations. The upper level has yielded fluorite on smoky quartz, amazonite, and columbite-tantalite. The middle level has produced amazonite, smoky quartz, and small fluorite cubes. Good smoky quartz and amazonite crystal groups have come from the lower level.

The Ten-percenter mine has produced the following minerals from the pegmatite pockets.

APATITE occurs as cream to dark green crystals up to 4 inches. The crystals occur as singles and groups and most are untwinned.

BASTNAESITE is thought to occur as microcrystals but it has not been positively identified.

CLEVELANDITE (ALBITE) occurs as white- to cream-colored crystal rosettes associated with amazonite.

COLUMBITE-TANTALITE is found as black terminated crystals up to 1 inch.

FLUORITE occurs as purple cubes up to 1 inch in groups and on smoky quartz.

GALENA is found as blue-gray metallic masses with amazonite. PHENAKITE occurs as small colorless crystals.

QUARTZ occurs as clear to smoky crystal shards, doubly terminated crystals up to 14 inches, and as crystal groups.

TOPAZ occurs as colorless to brownish-red, euhedral crystals that sometimes show slight etching.

Don Smith recounts the discovery of the "key-hole vug."

Having spent the first seven weeks of the 1986 mining season following numerous small pegmatite lenses in the center cut of the mine, I decided to give this area a rest and prepared to move my operation back to the originally discovered lower cut. On Monday, 9 June, I fired up the dozer, walked it down to the lower cut, and after a short lunch break was ready to begin exploration work. This cut has been a good producer of smoky quartz and amazonite specimens in both singles and combinations every season since 1972. It has good exposures of pegmatites and has been used as a study area for geologic mapping during the summer.

I started working my way towards the apex of a small, uplifted, dome-like structure that to me was not normal to the slope of the hill above the cut. It was around three o'clock in the afternoon, and I had just completed a final cut and back-drag of decomposed plates of diorite and granite from the west face of the cut. As I was backing up, I spotted a long thin quartz vein in contact with a six- to eight-inch vein of Pikes Peak pegmatite.

Shutting down the dozer, I gathered up some hand tools and started to expose the two veins. After a few minutes work I had exposed an eight-inch quartz vein contacting a twelve-inch pegmatite vein. The quartz vein was pinched off just shy of the diorite, but the pegmatite vein swelled in width and was arching down under the diorite on a 30 dip striking southwest.

In order to get through the quartz vein, I had been using a long steel drill bit. All of a sudden the point broke through into open space. I moved about twelve inches to the right and started another hole so that I could use a bar to remove a section of the quartz vein. Once more I broke into open space. I asked Dean, a friend helping me, to get a small mirror from the tool box in the jeep so he could reflect the sun into one hole while I peered into the other. As I looked through the hole, I could hardly believe what I was seeing in the reflected sunlight. I was looking inside what appeared to be a large hollow hemispherical cavern. I was unable to make out the top of the

ceiling but was able to see a washed level of fill with several large, red iron-stained, quartz shards lying on top.

Using a chisel, hammer, and pry bar we enlarged the first hole so that I was able to get my hand and arm through it. Putting my arm in up to my shoulder I felt around in the loose clean fill, recognizing by touch the shape of a quartz shard. In order to get rid of some large blocks of granite at the bottom of the cut, I made up one stick of powder and packed it into the base of the granite. After the shot went off, we found that it had gassed through cracks in the granite plates such that the plates were readily pried loose. In a short time we had them rolled into the dozer bucket and quickly had the cleanup work completed.

Enlarging the small hole we had made in the quartz vein, we soon had a small door opening into a large igloo-shaped open vug. Inside, lying on top of very clean washed fill was a six-inch-diameter smoky quartz crystal, tens of other quartz crystals, shards, and one large plate of amazonite that we later found weighed 45 lbs. By enlarging the door opening a little more, I was able to crawl inside and sit upright on top of the fill. The north half of the ceiling was composed of Pikes Peak pegmatite and in the center was a six-inch-wide quartz vein striking northeast and dipping 75. Because it was getting late, we removed a few more quartz crystals and shards, sealed the door with the dozer blade, and called it a day.

Returning early next morning we started the recovery work. I thought we had 12 inches of fill to remove, 15 at the most, before we reached the final bottom of the pocket. It would take another 5 days to find out how wrong I was about the final depth to the pocket floor.

The first really full day's work on the recovery produced over 200 smoky quartz crystals of which 80% were doubly terminated. Numerous singles and twins of amazonite were recovered; a good share of these had rosettes of clevelandite on them. All the amazonite was a good deep-green color, sharply terminated, and fracture free. Two more large ceiling plates of amazonite with clevelandite were recovered; one weighed 65 lbs and the other 192 lbs. Thirteen ceiling plates in all were recovered, the largest weighing 300 lbs. Three large floor plates were recovered, averaging almost 200 lbs each. At the end of the week, working 12- to 15-hour days, we finally reached the floor of the vug. The distance from the apex of the ceiling to the floor was 92 inches. After all the fill material had been removed from the "key-hole vug," the empty vug measured 92 inches high, 7 ft wide, and 6 1/2 ft long. Almost 1800 pounds of choice specimens were recovered.

On site during recovery work were Reinhard A. (Bud) Wobus,

professor of geology at Williams College in Massachusetts, Miss Sara Finnemore, undergraduate student, and Eric Wobus, son of R. A. Wobus. I was honored by having Eugene E. Foord, geologist-mineralogist at the USGS Denver branch, and John S. White, Smithsonian Institution, Washington D. C., on the site during recovery work. Gene: "Only once in fifty years is such a vug found." John: "The material recovered from the vug was just phenomenal". All excavation and recovery of the vug's contents were documented on tape, with photographs, and by measurements.

SULFOSALT AND SEMIMETAL SULFIDE DISTRIBUTION
IN THE SOUTHWESTERN UNITED STATES

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The use of semimetal-bearing sulfides as petrologic tools has not yet been applied in most ore-deposit studies although ore deposits containing sulfosalts or semimetal sulfides have been located and symbolized by deposit type. This compilation of sulfosalt localities and the plotting of relative abundances of arsenic, antimony, and bismuth have been done to test the usefulness of these minerals and elements as ore-deposit and metallogenic indicators.

Gross distribution of the semimetals follows closely the general distribution of metallic ore deposits related to Laramide and Cenozoic volcanism. However, certain semimetal elements appear confined to particular tectonic environments. Bismuth displays an affinity for continental crust areas, especially in spacial relation to exposed Precambrian rocks. Antimony, although widely distributed, is concentrated in areas of crustal thinning (i.e., the Great Basin and Rio Grande rift). Arsenic is the most widely distributed semimetal element, but interestingly occurs in high crustal deposits not necessarily related to magmatism (e.g., sandstone uranium deposits of the Colorado Plateau).

Semimetal distribution in particular ore-deposit environments is fairly consistent and often zoned, indicating possible geochemical factors unique to each deposit type. Bismuth is most commonly found in pegmatites (bismuthinite), porphyry coppers, and skarns (Pb-Ag-Bi sulfosalts). Bismuthinite also is found in epithermal gold veins, usually with other semimetal phases absent. Antimony is most often associated with epithermal veins (tetrahedrite and polybasite) and hot-spring deposits (pyrargyrite and stibnite) and in massive sulfides (tetrahedrite). Arsenic species are found in skarns (arsenopyrite), veins (arsenopyrite, pearceite, and proustite), stratabound deposits (arsenopyrite and tennantite), and the upper zones of porphyry coppers (enargite).

The details of sulfosalt geochemistry and tectonics are still poorly known and are subject to continuing study. This relatively simple treatment of the data does reveal potential in the field of semimetal geochemistry, perhaps converting sulfosalts from mineralogic curiosities to interpretive tools.

FLUORESCENT MINERALS OF NEW MEXICO

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Minerals that fluoresce under ultraviolet (UV) light are of interest for several reasons. They are a curiosity and an aesthetic attraction to collectors. The fluorescence can be a useful aid in recognizing and identifying minerals; it may provide otherwise hidden information about a mineral's trace-element content and crystal chemistry. Finally, the existence or distribution of fluorescent minerals in a given area may provide clues to the presence, size, zoning, composition, and genetic history of a mineral deposit.

Fluorescent minerals in New Mexico can be grouped by occurrence: 1) minerals in igneous rocks, especially pegmatites; 2) ore and gangue minerals in base- and precious-metal deposits, including skarns; 3) secondary uranium minerals from the Grants mineral belt-Colorado Plateau area; and 4) low-temperature carbonate, sulfate, and silica minerals that occur as nodules, veins, or coatings in sedimentary and volcanic rocks.

Many of the pale-colored, largely iron-free minerals of igneous rocks fluoresce, though often weakly; these include sodium and potassium feldspars, sodalite, zircon, and apatite. Fluorapatite from the Harding pegmatite, Taos County, is notable for its yellow fluorescence (due to manganese, Mn^{+2}) under shortwave (SW) UV, which is brightest in pale gray to tan apatite but nearly absent in darker, blue apatite. Eucryptite, an uncommon and inconspicuous mineral at the Harding pegmatite, is most easily located by its crimson fluorescence. At the Globe pegmatite near Petaca, Rio Arriba County, pods of green fluorite fluoresce pale violet under long-wave (LW) UV but strong greenish white SW. This differs from the typical europium (Eu^{+2})-activated fluorescence (violet LW, weak violet SW) seen in most fluorite and is due to the greater abundance of rare-earth elements (REE) in addition to Eu in fluorite from the Globe pegmatite (about 1 wt. % Y and about 0.1 wt. % or more each of several other REEs).

Ore minerals that fluoresce include scheelite (blue to yellowish white SW) from numerous localities, such as the Ortiz gold mine, Santa Fe County; the Dalton Canyon area, Santa Fe County (northwest of Pecos); Iron Mountain, Sierra County; and the Victorio district, Luna County. Powellite (yellow SW) is also reported from Iron Mountain. Yellow, cadmium-bearing "turkey-fat" smithsonite from the Empire mine, Grant County, fluoresces orange to red (LW and SW) as described by R. W. and D.

L. Graeme at the 1984 New Mexico Mineral Symposium. Pale-colored, iron-poor sphalerite from many worldwide localities fluoresces orange (LW); such sphalerite is uncommon in New Mexico though Northrop (Minerals of New Mexico, 1959) noted "museum specimens of fluorescent sphalerite" from the Black Range. Willemite, common in the oxidation zone of zinc-bearing ore deposits in the southwestern United States, is sometimes fluorescent (green, SW). Occurrences of green-fluorescent willemite include Iron Mountain, Socorro Peak, the Tres Hermanas Mountains, and Hillsboro and elsewhere in the Black Range. Other secondary ore minerals that commonly fluoresce include hydrozincite (blue SW) and cerussite (yellow white, strongest LW); they occur at the Blanchard and Kelly mines, Socorro County, and elsewhere. Hemimorphite commonly fluoresces faintly or not at all, but some (verified by XRD from the Carnahan mine, Santa Fe County, and the Waldo mine, Socorro County) does fluoresce fairly bright blue white (SW). Coarsely crystalline fluorapatite intergrown with quartz, biotite, chalcopryrite, and potassium feldspar in a mineralized quartz-monzonite breccia pipe at the Copper Flat deposit, Sierra County, fluoresces pinkish white SW, indicative of a high REE content. Fluorite, abundant in many districts throughout the southern half of New Mexico, often has a strong violet fluorescence (LW); generally, the darker the color of the fluorite, the weaker the fluorescence. Calcite is a common fluorescent gangue mineral in many mining districts--Magdalena, Kingston, Tres Hermanas, and Luis Lopez, to name a few. Calcite most commonly fluoresces red (SW) due to Mn+2 but may range to blue, yellow, or white (activators unknown).

Fluorescent uranium minerals reported from the state include uranyl phosphates and sulfates (such as autunite or metaautunite, and zippeite) that fluoresce yellow green (strongest SW), and uranyl carbonates (such as andersonite and liebigite) in which the color of luminescence is shifted to bluish green. Many other uranium minerals (carnotite, torbernite, uranophane) are essentially nonfluorescent.

Other minerals of low-temperature origin include many occurrences of green-fluorescent, slightly uraniferous chalcedony (including agate and silicified wood) and opal. Pink chalcedony "roses," which weather out of rhyolite in the Apache Creek area of Catron County, have a particularly bright green fluorescence (strongest SW). Calcite in sedimentary rocks may fluoresce red, white, or other hues, or not at all. Hot-spring or cave calcite deposits (travertine) commonly fluoresce and phosphoresce white or near white (LW and SW). Aragonite or calcite (such as that from the Tres Hermanas Mountains, Luna County) may fluoresce green, but in many (most?) cases, the fluorescence is due to an otherwise imperceptibly thin layer of opal deposited atop the carbonate minerals. Thin coatings of green-fluorescent opal on fracture surfaces are common in many kinds of rock and in many ore deposits. Calcite as caliche, deposited by rising capillary

water on loose, fractured, or porous rock in or below the soil, is one of the most widely distributed fluorescent minerals. It forms chalky-white crusts that may fluoresce various shades of orange, yellow, or white; this luminescence is controlled by mechanisms that so far remain a mystery. Other fluorescent minerals of sedimentary or diagenetic origin reported from New Mexico include barite, gypsum, langbeinite, thenardite, and trona.

One example of a locality only recently examined for fluorescent minerals is the Point of Rocks phonolite sill in Colfax County. Fluorescent minerals discovered here include villiaumite (dark red to orange and yellow, SW and LW); sanidine (violet red SW); sodalite (orange LW); polyolithionite (dull yellow SW); searlesite (green SW); cancrinite (green, white, violet, or pale orange SW and LW, probably due sometimes to inclusions or coatings); lovdarite (newly identified by XRD and microprobe; brilliant green SW, weaker LW); coatings of green-fluorescent opal on fracture surfaces and in vesicles; secondary calcite and aragonite (blue white to violet white SW and LW); and several additional minerals, recognizable because of their fluorescence but as yet unidentified. A brownish-orange hydrocarbon film, which coats crystals in some vugs, fluoresces orange LW and SW. This locality--as yet only incompletely examined--is an example of an area where close scrutiny of mineralized rock under ultraviolet light is likely to lead to the recognition of additional minerals.

MINERALOGY AND TEXTURES OF A EUDIALYTE-BEARING DIKE
WIND MOUNTAIN, OTERO COUNTY, NEW MEXICO

(Location 6 on index map)

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A eudialyte-bearing dike approximately 1 m thick by 100 m long has intruded the surrounding country rocks near the western edge of the Wind Mountain laccolith. The dike consists predominantly of albite, potassium feldspar, nepheline, and acmite. The main accessory mineral is eudialyte. The eudialyte makes up about 5% of the rock although it is irregularly distributed in the dike and locally makes up 20% of the rock. The dike shows interesting textures with margins consisting of large crystals of acmite up to 4 cm long arranged perpendicular to the walls. The spaces between these crystals and the center of the dike consist of smaller (1-2 mm) crystals of feldspars, nepheline, acmite, and eudialyte. Quartz is found locally very near the margins of the dike and has presumably formed by assimilation of silica from the country rock, which is a marly shale to impure silty limestone. Eudialyte is concentrated toward the center of the dike. In thin section many of the eudialyte crystals show color zoning with a pink to brown pleochroic rim and a colorless core.

Compositionally the acmites are close to pure $\text{NaAlSi}_2\text{O}_6$ with minor amounts of CaO , Al_2O_3 , ZrO_2 , and TiO_2 the main other oxides present. CaO ranges from 0.7 to 4.6 wt. %. The larger crystals near the margin of the dike show Ca-rich cores (up to 1.7 wt. % CaO) and Ca-poor rims (0.7 to 0.8 wt. % CaO). The cores of smaller crystals appear to be richer in Ca with some as high as 4.6 wt. % CaO . The acmites also show uncommonly high contents of ZrO_2 of from 0.8 to 3.4 wt. %. The eudialytes tend to be quite uniform in composition with little core to rim variation. Apparently the variation that accounts for the color zoning is an increase in MnO (from 3-4 wt. % in the core to 5 wt. % at the rim) and a corresponding decrease in FeO (from 3.5-4 wt. % in the core to 2.7-3 wt. % at the rim). A typical analysis of the eudialyte yields the following results expressed as percentages: SiO_2 , 47.07; ZrO_2 , 13.39; TiO_2 , 0.18; Al_2O_3 , 0.01; La_2O_3 , 1.22; Ce_2O_3 , 2.05; Pr_2O_3 , 0.30; Nd_2O_3 , 0.37; Sm_2O_3 , 0.05; Eu_2O_3 , 0.74; Gd_2O_3 , 0.46; CaO , 3.69; FeO , 2.71; MnO , 5.12; MgO , 0.21; Na_2O , 13.22; K_2O , 0.40; F, 0.59; Cl, 2.71 (estimated); total 92.16. The albites range from Ab_{98} to Ab_{99} and the potassium feldspars range from Or_{64} to Or_{94} . Both feldspars contain less than 0.5% of the anorthite end member. The nephelines show considerable silica in solid solution and approach the maximum silica content

that can occur in nepheline ($\text{Ne}_{85} \text{Qz}_{15}$).

The dike can be traced into the main body of the Wind Mountain laccolith (an analcime-nepheline syenite) where it appears to grade into a zone of poorly defined dike-like bodies. The dike is interpreted to have formed from a late-stage Zr-rich pegmatitic magma that was injected into the surrounding country rock from the laccolith, possibly along a fracture formed during the doming of the overlying sediments. The dike began to crystallize under water-rich conditions that lead to the formation of the large acmite crystals. Before crystallization was complete, however, the system lost water pressure (presumably by further fracturing and venting to the surface), and the remaining magma was pressure quenched, producing the fine-grained center of the dike. The quenching was due to the shallow level of emplacement of the laccolith, which has been estimated to have been less than 1 km. The center of the dike is enriched in eudialyte because of further concentration of Zr in the remaining magma during crystallization of the acmite.

AMETHYST FROM UNAWEEP CANYON, COLORADO

(Location 7 on index map)

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Gemstone and specimen-grade amethyst occur along faults in Unawep Canyon located approximately 20 mi southwest of Grand Junction, Colorado. A series of faults, ranging from N50W to N80W and mineralized with minor amounts of copper and silver, also carry fluorite, amethyst, and calcite. The Amethyst Queen mine is located along a vertical brecciated fault zone in a Precambrian biotite-muscovite granitic rock. The amethyst vein has been traced on the surface for more than 100 ft at an average width of 1.5 ft and is known to extend 22 ft downward. Amethyst crystals, which occur as broken plates and loose crystals in a calcite cement, rarely exceed 1 inch in diameter and exhibit pronounced color zonation as reflected by Brazil Law twinning. Only about 1 percent of the crystals are gemmy; however, Siberian-grade faceted stones of several carats have been produced. Gemstone mining has continued intermittently for the past 8 years.

In the fall of 1985 a new occurrence of amethyst on fluorite was found approximately 0.75 mi from the Amethyst Queen mine along the same fault system. Amethyst crystals, averaging 0.25 inch across and coating apple-green fluorite octahedra, occur in mineralized Wingate Sandstone. Fluorite octahedra are the most common habit and typically exhibit small cube-faced step growths; however, other more complex habits occur. Colorless quartz associated with this occurrence exhibits quartzoid and rarely pseudo-cubic habits that have been of considerable interest to collectors of micromount specimens. The potential for gemstone and specimen-grade amethyst from this area is good.

NEWLY DISCOVERED MINERALS FROM NEW MEXICO, 1959-1986:
NORTHROP + 27 YEARS

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In 1959 the University of New Mexico Press published the second edition of Minerals of New Mexico by Dr. Stuart A. Northrop. This book was a remarkably complete compilation of the minerals then known to occur in the state. In the 27 years that have elapsed, however, many discoveries have been made that would greatly expand Northrop's book. The following list represents some of the minerals that could be added to a third edition. This list does not include new localities for minerals that Northrop listed in the second edition, but only new mineral entries. The list is certainly not comprehensive, and it is hoped that all of the attendees at the Seventh New Mexico Mineral Symposium will help to complete it.

Tentative identifications are starred. Numbers in the reference column are keyed to numbered citations in the reference list.

Mineral	Formula	Locality	Reference
Andersonite	$\text{Na}_2\text{CaUO}_2(\text{CO}_3)_3 \cdot 6\text{H}_2\text{O}$	Grants uranium dist.	6
Agardite	$(\text{Y}, \text{Ca})\text{Cu}_6(\text{AsO}_4)_3(\text{OH})_6 \cdot 3\text{H}_2\text{O}$	Copper Hill	2
		Red Cloud mine	2
*Apachite	$\text{Cu}_9\text{Si}_{10}\text{O}_{29} \cdot 11\text{H}_2\text{O}$	Bear Mountains	P. Hlava, pers. comm.
Bayleyite	$\text{Mg}_2\text{UO}_2(\text{CO}_3)_3 \cdot 18\text{H}_2\text{O}$	Grants uranium dist.	6
Bertrandite	$\text{Be}_4\text{Si}_2\text{O}_7(\text{OH})_2$	Harding mine	8
Betekhtinite	$\text{Cu}_{13}(\text{Pb}, \text{Fe}, \text{Ag})_2\text{S}_9$	St. Cloud mine	10
Beudantite	$\text{PbFe}_3\text{AsO}_4\text{SO}_4(\text{OH})_4$	Black Range	
Beyerite	$(\text{Ca}, \text{Pb})\text{Bi}_2(\text{CO}_3)_2\text{O}_2$	Taos(?)	F. Cureton, pers. comm.
*Birnessite	$\text{Na}_4\text{Mn}_{14}\text{O}_{27} \cdot 9\text{H}_2\text{O}$	Point of Rocks Mesa	9
Bismutotantalite	$\text{Bi}(\text{Ta}, \text{Nb})\text{O}_4$	Harding mine	11
*Brenkite	$\text{Ca}_2\text{CO}_3\text{F}_2$	Point of Rocks Mesa	9
Brockite	$(\text{Ca}, \text{Th}, \text{Ce})\text{PO}_4 \cdot \text{H}_2\text{O}$	Laughlin Peak area	15
Catapleiite	$\text{Na}_2\text{ZrSi}_3\text{O}_9 \cdot 2\text{H}_2\text{O}$	Wind Mountain	1
Chalcosiderite	$\text{CuFe}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 4\text{H}_2\text{O}$	Tyrone mine	A. Tlush, pers. comm.
Conicalcite	$\text{CaCuAsO}_4\text{OH}$	Red Cloud mine	2
Crandallite	$\text{CaAl}_3(\text{PO}_4)_2(\text{OH})_5 \cdot \text{H}_2\text{O}$	Laughlin Peak area	15

Duftite	$\text{PbCuAsO}_4\text{OH}$	Silver Hill area	12
Dundasite	$\text{Pb}_2\text{Al}_4(\text{CO}_3)_4(\text{OH})_8 \cdot 3\text{H}_2\text{O}$	Juanita mine	17
Durangite	$\text{NaAlAsO}_4\text{F}$	Black Range	4
Ferroselite	FeSe_2	Grants uranium dist.	6
Fornacite	$(\text{Pb}, \text{Cu})_3[(\text{Cr}, \text{As})\text{O}_4]_2\text{OH}$	Silver Hill	12
Geerite	Cu_8S_5	St. Cloud mine	F. Cureton, pers. comm.
Georgechaoite	$\text{NaKZrSi}_3\text{O}_9 \cdot 2\text{H}_2\text{O}$	Wind Mountain	1
*Glaucodot	$(\text{Co}, \text{Fe})\text{AsS}$	E-Town-Baldy dist.	North, unpublished
Gonnardite	$\text{Na}_2\text{CaAl}_4\text{Si}_6\text{O}_{20} \cdot 7\text{H}_2\text{O}$	Gila Cliff Dwellings area	13
Holmquistite	$\text{Li}_2(\text{Mg}, \text{Fe})_3\text{Al}_2\text{Si}_8\text{O}_{22}(\text{OH})_2$	Harding mine	11
Kettnerite	CaBiCO_3OF	Victorio(?)	F. Cureton, pers. comm.
Kupletskite	$(\text{K}, \text{Na})_3(\text{Mn}, \text{Fe})_7(\text{Ti}, \text{Nb})_2$ $\text{Si}_8\text{O}_{24}(\text{O}, \text{OH})_7$	Point of Rocks Mesa	8
Khademite	$\text{AlSO}_4\text{F} \cdot 5\text{H}_2\text{O}$	Lone Pine mine,	19
Lannonite	$\text{HCa}_4\text{Mg}_2\text{Al}_4(\text{SO}_4)_8\text{F}_9 \cdot 32\text{H}_2\text{O}$	Lone Pine mine,	19
Levyne	$(\text{Ca}, \text{Na}_2, \text{K}_2)_3\text{Al}_6\text{Si}_{12}\text{O}_{36} \cdot$ $18\text{H}_2\text{O}$	Gila Cliff Dwellings area	7
Lorenzenite	$\text{Na}_2\text{Ti}_2\text{Si}_2\text{O}_9$	Point of Rocks Mesa	3
Mackayite	$\text{FeTe}_2\text{O}_5\text{OH}$	Lone Pine mine	18
Mangan-neptunite	$\text{KNa}_2\text{Li}(\text{Mn}, \text{Fe})_2\text{Ti}_2\text{Si}_8\text{O}_{24}$	Point of Rocks Mesa	3
Mckinstryite	$(\text{Ag}, \text{Cu})_2\text{S}$	Mogollon	F. Cureton, pers. comm.
Mesolite	$\text{Na}_2\text{Ca}_2\text{Al}_5\text{Si}_9\text{O}_{30} \cdot 8\text{H}_2\text{O}$	Gila Cliff Dwellings area	7
Montroseite	$(\text{V}, \text{Fe})\text{O}(\text{OH})$	Grants uranium dist.	6
Nacrite	$\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$	Laughlin Peak area	15
Neptunite	$\text{KNa}_2\text{Li}(\text{Fe}, \text{Mn})_2\text{Ti}_2\text{Si}_8\text{O}_{24}$	Point of Rocks Mesa	3
Paragonite	$\text{NaAl}_2(\text{Si}_3\text{Al})\text{O}_{10}(\text{OH})_2$	Truchas Range	5
Paranatroilite	$\text{Na}_2\text{Al}_2\text{Si}_3\text{O}_{10} \cdot 3\text{H}_2\text{O}$	Point of Rocks Mesa	9
Polyolithionite	$\text{KLi}_2\text{AlSi}_4\text{O}_{10}(\text{F}, \text{OH})_2$	Point of Rocks Mesa	3
Poughite	$\text{Fe}_2(\text{TeO}_3)_2\text{SO}_4 \cdot 3\text{H}_2\text{O}$	Lone Pine mine	R.DeMark, pers. comm.
Rajite	CuTe_2O_5	Lone Pine mine	18
*Rosenbuschite	$(\text{Ca}, \text{Na})_3(\text{Zr}, \text{Ti})\text{Si}_2\text{O}_8\text{F}$	Point of Rocks Mesa	9
Searlesite	$\text{NaBSi}_2\text{O}_5(\text{OH})_2$	Point of Rocks Mesa	3
Selenium	Se	Grants uranium dist.	6
Serandite	$\text{Na}(\text{Mn}, \text{Ca})_2\text{Si}_3\text{O}_8\text{OH}$	Point of Rocks Mesa	16

Strengite	$\text{FePO}_4 \cdot 2\text{H}_2\text{O}$	Tyrone mine	A. Tlush, pers. comm.
Tetranatrolite	$\text{Na}_2\text{Al}_2\text{Si}_3\text{O}_{10} \cdot 2\text{H}_2\text{O}$	Point of Rocks Mesa	3
Thermonatrite	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$	Grants uranium dist.	6
*Thorbastnaesite	$\text{Th}(\text{Ca}, \text{Ce})(\text{CO}_3)_2\text{F}_2 \cdot 3\text{H}_2\text{O}$	Point of Rocks Mesa	9
Todorokite	$(\text{Mn}, \text{Ca}, \text{Mg})\text{Mn}_3\text{O}_7 \cdot \text{H}_2\text{O}$	Black Range	4
		Grants uranium dist.	6
Treasureite	$\text{Ag}_7\text{Pb}_6\text{Bi}_{15}\text{S}_{32}$	Tyrone mine	F. Cureton, pers. comm.
Tripuhyite	FeSb_2O_6	Bear Mountains	14
*Tundrite	$\text{Na}_3(\text{Ce}, \text{La})_4(\text{Ti}, \text{Nb})_2(\text{SiO}_4)_2$ $(\text{CO}_3)_3\text{O}_4(\text{OH}) \cdot 2\text{H}_2\text{O}$	Point of Rocks Mesa	9
Villiaumite	NaF	Point of Rocks Mesa	16
Vishnevite	$(\text{Na}, \text{Ca}, \text{K})_6(\text{Si}, \text{Al})_{12}[(\text{SO}_4),$ $(\text{CO}_3), \text{Cl}_2]_{2-4} \cdot n\text{H}_2\text{O}$	Point of Rocks Mesa	9
Weissite	Cu_5Te_3	Winston(?)	F. Curton, pers. comm.
Wilcoxite	$\text{MgAl}(\text{SO}_4)_2\text{F} \cdot 32\text{H}_2\text{O}$	Lone Pine mine	19
Xenotime	YPO_4	Laughlin Peak area	15

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