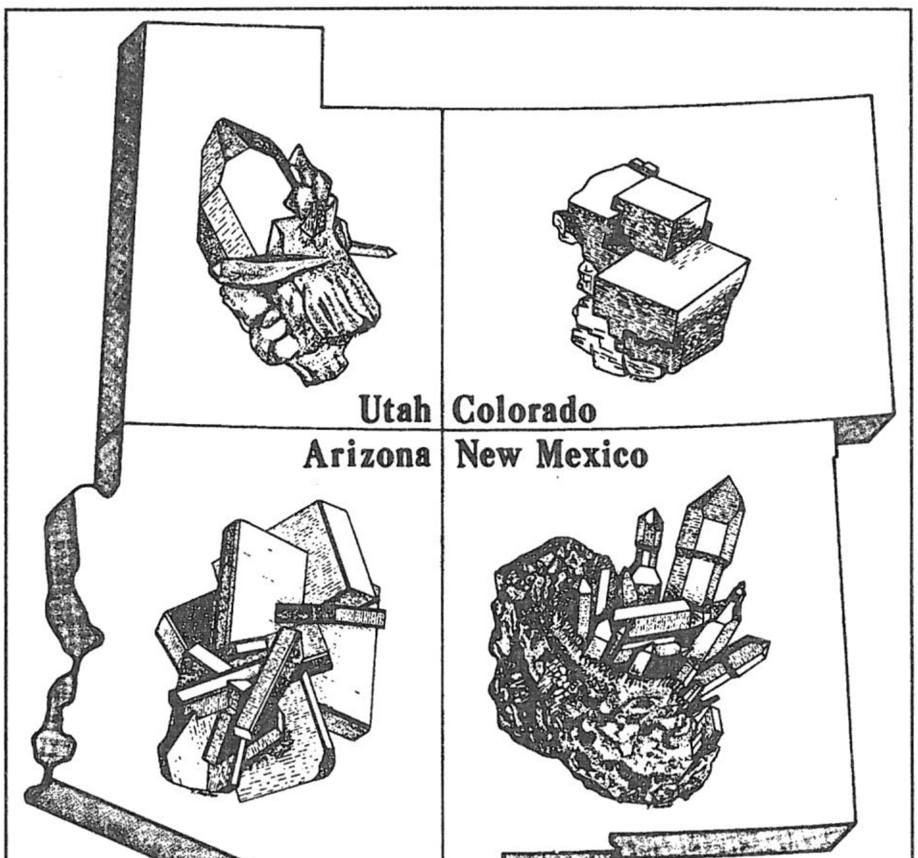
22nd annual

NEW MEXICO MINERAL SYMPOSIUM

November 10 & 11, 2001



New Mexico Tech Campus, Socorro, New Mexico

Welcome to

THE TWENTY—SECOND ANNUAL

NEW MEXICO MINERAL SYMPOSIUM

November 10 and 11, 2001

Macey Center Auditorium

New Mexico Institute of Mining and Technology

Socorro, New Mexico

Sponsored by

New Mexico Bureau of Geology and Mineral Resources

Albuquerque Gem and Mineral Club

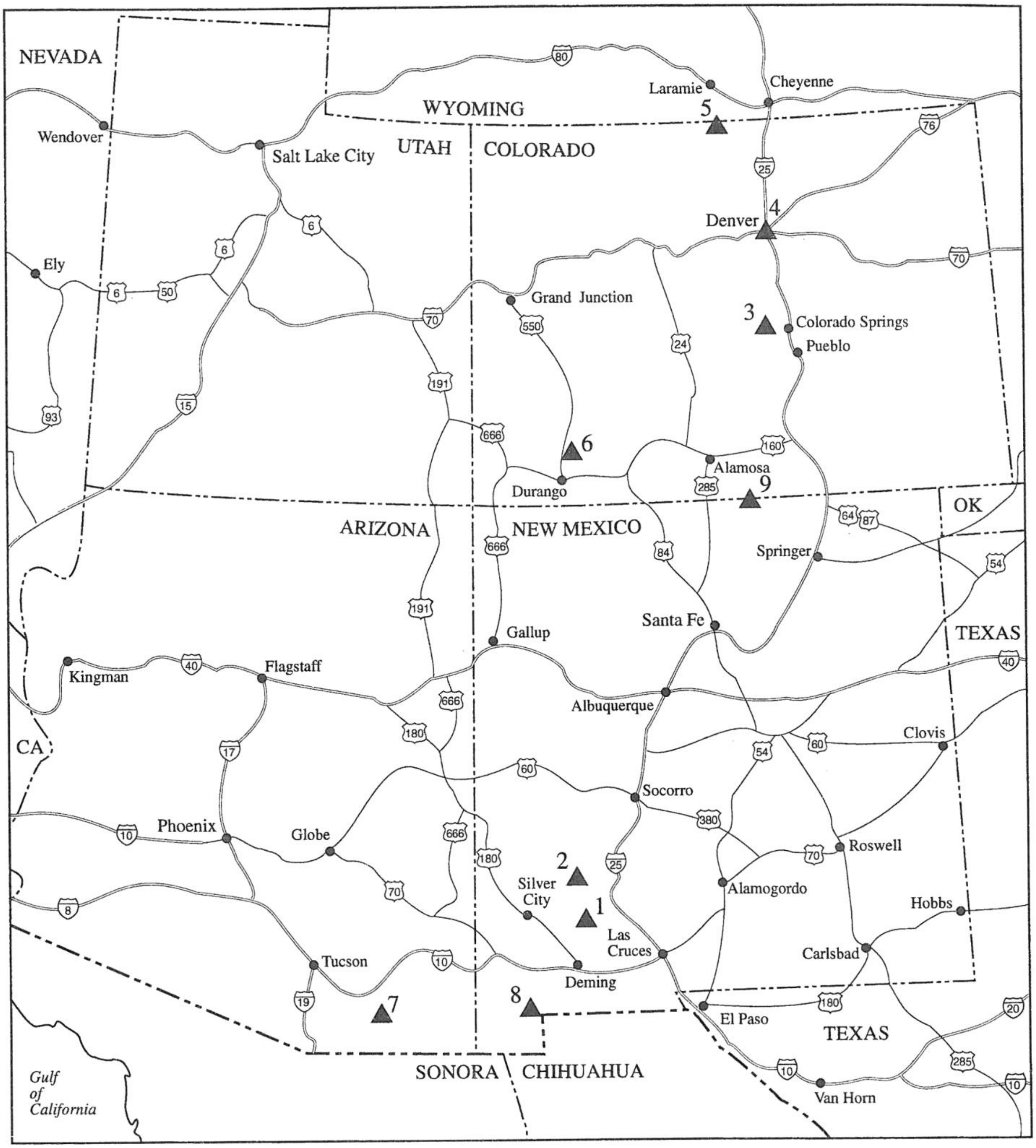
Los Alamos Geological Society

New Mexico Geological Society

Chaparral Rockhounds

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 Twenty-second 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
22nd New Mexico Mineral Symposium

SCHEDULE

Numbers in parentheses refer to geographic location on index map.

FRIDAY, NOVEMBER 9

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

SATURDAY, NOVEMBER 10

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

9:20 *Opening remarks*, main auditorium

9:30 (1) *Minerals of the Macy mine and other selected mines near Hillsboro, New Mexico*
—Ramon S. DeMark

10:00 (2) *Octahedral fluorite from the Chise fluorite deposit, Sierra County, New Mexico*
—Ed Huskinson

10:30 Coffee break

11:00 (3) *Quartz with goethite inclusions (onegite) from the Pikes Peak Granite—Ray* Berry

11:30 (4) *Diamonds in the Denver Museum of Nature and Science*
—James F. Hurlbut and Jack Thompson

12:00 p.m. Lunch

1:00 Museum tours

2:00 (5) *Minerals of the diamond-bearing kimberlites of Colorado and* Wyoming—Peter Modreski

2:30 (6) *Thirty years of mineral collecting in the San Juan Mountains, Colorado*
—Tom Rosemeyer

3:00 Coffee break

3:30 (7) *Tellurium oxysalts from Tombstone , Arizona*
—Peter K. M. Megaw

4:00 *Sampling the finest*
—Jeff Scovil, featured speaker

5:30 Sarsaparilla and suds: cocktail hour, cash bar

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

SUNDAY, NOVEMBER 11

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

9:00 Welcome to the second day of the symposium and follow-up remarks

9:10 *Four faces of gold*
—Harry Covey

9:40 (8) *Turquoise at Turquoise Mountain, Old Hachita, New Mexico—Robert* D. Beard

10:10 Coffee break

10:40 (9) *Wulfenite in the Tusas and fluorite in Amalia: new mineral stories in New Mexico*
—Jesse M. Kline

11:10 *OPEN FORUM*

12:00 p.m. Lunch

1:15-3:00 Silent auction, upper lobby, Macey Center, sponsored by the Albuquerque Gem and Mineral Club—FREE

Minerals of the Macy mine and other selected mines near Hillsboro, New Mexico

Ramon S. DeMark
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(Location 1 on index map)

Hillsboro and the Las Animas mining district in Sierra County, New Mexico, evoke images of a sleepy town with a history of gold mining. Before the turn of the twentieth century, however, prospectors also turned an eye to the southern part of the district along Ready Pay Gulch and Percha Creek. It was called the "lead-carbonate belt" in early reports.[1] Prospectors located deposits of vanadium, manganese, and secondary lead minerals and filed numerous claims in the area.

Sierra County residents were so proud of the mines and minerals of Hillsboro and surrounding mining districts that they sent 12 tons of ore specimens to the 1893 World's Columbian Exposition in Chicago![2] The minerals were used to cover a miner's cabin that was constructed in the Mines and Mining Building. Specimens from the Percha, Big Chief, and other mines in the area were used in the exhibit.[3]

In recent years, mineral collectors have focused on a mine generally known as the Macy mine on the south side of Percha Creek near the spot where Ready Pay Gulch enters the Percha. Although known as the Macy mine, a search of Sierra County mining claim records reveals that the mine was first located on June 14, 1892, by George E. Robin, Steve J. Macy, and Ed Strickland and was named the Percha mine.[4] This mine was never named the Macy mine but should probably best be called Macy's mine in recognition of long-standing usage and the fact that Steven Macy was one of the original claim owners. This misnomer most likely resulted from Fayette Jones' reference to the area in 1904 as follows: "It is said that this is the largest body of vanadium ore known in the world. The property is known as the S. J. Macy lode."[5] Minerals identified from this mine include vanadinite, endlichite, mimetite, wulfenite, descloizite, galena, cerussite, fluorite, and heulandite.

In May 1981, lustrous, small-black crystals were found by the author on the dumps of what, at that time, was an unknown mine on the north bank of Percha Creek across from Macy's mine. In September 1981, Paul Hlava[6] confirmed by microprobe analysis that these crystals were kentrolite, the lead manganese silicate that forms a series with melanotekite, the lead iron silicate. A search of the Sierra County claim records determined that this mine was originally located as the Big Chief mine and was filed on October 25,1892.[7] Vanadinite, which is present in association with kentrolite and wulfenite, has been reported but not confirmed.

Melanotekite from New Mexico was first described by C. H. Warren in 1898.[8] The material was provided by W. M. Foote of Philadelphia and J. H. Porter of Denver. They obtained the material from George E. Robin (one of the first claim owners of the Percha (Macy's) mine and several other mines in the area). The material was described as coming from the Rex and Smuggler mines at Hillsboro. George Robin was claim owner of the Rex mine along with Steven Macy and two others. The mine was located on March 10, 1892[9] The Smuggler mine was not under claim by Robin or Macy and was outside the "lead-carbonate belt." The precise location of the Rex mine remains unclear, and melanotekite has not been recovered from the Hillsboro area for over 100 yrs.

The Petroglyph mine (west of Ready Pay Gulch and just south of New Mexico 152) was located as the Miners Dream mine in May 1916[10] and relocated as the Petroglyph mine on September 3, 1962.[11] Specimens of wulfenite, vanadinite, descloizite, willemite, and hemimorphite have been recovered from this mine. Heulandite and possibly mordenite have been found at a small mine just south of Ready Pay Gulch about 0.5 mi south of New Mexico 152. It has been called the Rex mine, but this identification remains uncertain. Cryptomelane has been identifie[12] by microprobe analysis from the Trojan mine on the east side of Ready Pay Gulch about 0.5 mi north of Macy's mine.

A search of Sierra County claim records (from 1884 up to the present, in the area of the Percha Creek box, north up Ready Pay Gulch to the intersection with New Mexico 152) reveals intense claim activity starting in 1892 (Percha, Big Chief, Whaleback, Flora Temple, Animas, Sarnia, and others). Many of these claims were filed again in the early 1900s by William F. Hall under such names as the Endlichite, Melanotickite *[sic]*, Pyromorphite, and Wulfenite. Much later, the original Percha (Macy's mine) claim was filed again as the Barking Frog by Dick Jones and others in 1980[13] and as the Bobbi Dee in 1983.[14] The latest attempt at filing on this site by Mike Sanders and Tom Massis in 1996 resulted in a rejection by the Bureau of Land Management with the stated reason that the mineral rights were not federal leasable nor subject to claim.[15]

Around 1897, William F. Hall of Hillsboro shipped 1,250 lb of vanadium minerals to the A. E. Foote Mineral Company of Philadelphia. These specimens were distributed as rare mineral specimens to various public and private collectors throughout Europe and America.[16] Where are these specimens today? George Robin, in his letter of February 24, 1893, states that "we are now collecting and will have within 30 days from 1,800 to 2,000 lb of choice mineral specimens to fill the eight show cases" (at the 1893 Columbian Exposition).[17] No trace of these specimens exists today. Let us hope our generation of mineral collectors will better document the provenance of our treasured mineral specimens and preserve them for future generations to enjoy.

Endnotes

1. Sierra County Advocate, May 5, 1893, (ZIM Mfilm AN2 552 January 6, 1893–December 16, 1898) Mines, Mills, & Smelter Column, UNM Zimmerman Library
2. Letter dated February 24, 1893 from Geo. E. Robin to W. H. H. Llewellyn, Esq. 1893 World's Columbian Exposition file. Archives & Historical Services Division, State of New Mexico.
3. Sierra County Advocate, June 30, 1893 (ZIM Mfilm AN2 552 January 6, 1893–December 16, 1898) Mines, Mills, & Smelter Column, UNM Zimmerman Library
4. Sierra County Courthouse, claim records, book D, p. 795.
5. F. A. Jones (1904) New Mexico mines and minerals (World's Fair edition, 1904), p. 83.
6. Pers. comm., Paul Hlava, September 1981.
7. Sierra County Courthouse, claim records, book E, p. 103.
8. C. H. Warren (1898) Mineralogical notes: 1—On the occurrence of melanotekite at Hillsboro, New Mexico and on the chemical composition of melanotekite and kentrolite, American Journal of Science (4) v. 6., p. 116.
9. Sierra County Courthouse, claim records, book F, p. 537.
10. Sierra County Courthouse, claim records, book K, p. 681.
11. Sierra County Courthouse, claim records, book 29, p. 27.
12. Pers. comm., Paul Hlava, September 2001.
13. Sierra County Courthouse, claim records, book 54, p. 794.
14. Sierra County Courthouse, claim records, book 66, p. 387.
15. Pers. comm., Mike Sanders, September 2001.
16. Brigham Leatherbee (1910) Sierra County, New Mexico, vanadium deposits, Min. World, v. 33, p. 799.
17. Letter dated February 24, 1893 from Geo. E. Robin to W. H. H. Llewellyn, Esq. 1893 World's Columbian Exposition file. Archives & Historical Services Division, State of New Mexico.

Octahedral fluorite from the Chise fluorite deposit, Sierra County, New Mexico

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(Location 2 on index map)

Fluorspar deposits occur on and near Cross Mountain, near Chise, Sierra County, New Mexico. The Chise fluorspar district lies within an inlier of upper Paleozoic rocks nearly surrounded by Tertiary extrusive rocks, composed primarily of flows and tuffs.

The bulk of the sedimentary rocks exposed in the area are Pennsylvanian limestones of the Magdalena Group and Permian sandstones, limestones, and shales of the Abo and Yeso Formations. Pliocene and Pleistocene fluviatile deposits have also been mapped in the area. Igneous rocks include Tertiary intrusive diabase, monzonite, and syenite, as well as late Tertiary andesites, flows, and tuffs.

Cross Mountain is a horst, which has been elevated by movement along two north-trending faults. The easternmost fault (Montoya fault) is more mineralized, and several springs issue along it. There probably were several periods of movement along these faults.

Fluorspar occurrences in the Chise district include jasperoid veins and mantos in Pennsylvanian limestones, open-space filling in brecciated zones along faults and near intrusive contacts, and replacement mantos in Permian rocks. It is postulated that the basement rocks along the eastern margin of the Cordillera have a high fluorine content and that Tertiary vulcanism initiated hydrothermal fluids, which rose along Basin and Range fractures parallel to the Rio Grande rift system. The Chise district is believed to be such an occurrence.

Prospecting guides in the area include the presence of jasperoid, fluorite casts, caliche horizons, and certain shale marker beds.

Quartz with goethite inclusions (onegite) from the Pikes Peak Granite

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(Location 3 on index map)

Edward S. Dana (1892) first described onegite thus: "onegite is acicular goethite penetrating quartz, like rutile, from an island in Lake Onega, Russia." The term "onegite" has fallen into disuse because it is not a mineral name but is descriptive of an inclusion of one mineral within another.

The term "onegite" is still used by many collectors in Colorado, probably because it is easier to say "onegite" than "quartz with goethite inclusions." This combination of minerals has been found in the Pikes Peak Granite pegmatites since the late 1800s, but little has been written about it, and few specimens are found in museums or other major collections. Over the past 30 yrs, I have found many pockets containing onegite, including particularly fine material on the Second Mesabi Claim, located in the southern edge of the Lake George intrusive center near Lake George, Colorado.

Peter Modreski (1996) of the U.S. Geological Survey in Denver gave a presentation at the Seventeenth New Mexico Mineral Symposium, titled *Onegite (amethyst with goethite inclusions) from the Pikes Peak batholith, Colorado.* His presentation covered what was then known about the material, including his own estimation of the paragenetic sequence and temperatures of crystallization. My presentation will review Modreski's description and photos of onegite, and then, present new findings from fluid-inclusion testing on the minerals.

In conjunction with the recent publication of a description of the occurrence of onegite (Berry, 2001), I had fluid-inclusion testing done by Virgil Lueth at the New Mexico Bureau of Geology and Mineral Resources in Socorro.

The fluid inclusions showed that the primary quartz formed at a temperature of 360° C, indicating that this pocket, at least, formed after the granite magma had cooled and crystallized—not as part of the magma, but as truly hydrothermal in nature (crystallizing from water carrying elements through cracks and crevices in the now cooled granite.)

The fluid inclusions in the quartz with goethite inclusions had temperatures much lower than expected. They were found to be a single-phase growth of 40° C or less. Using the known temperature gradient (the natural increase in temperature with depth) for the Pikes Peak Granite, which is approximately 25° C/km, and by subtracting the average ambient temperature of 3.4° C at the Lake George U.S. Weather Station (Normals and extremes, 2001), one finds that a temperature of 36.6°C divided by the 25° C/km temperature gradient yields a crystallization depth minimum of 1.4 km.

The Pikes Peak pluton was emplaced at a depth of approximately 4-5 km, 1.06-1.09 b.y. before present (Unruh et al., 1995). It is also generally accepted that the Laramide orogeny (present Rocky Mountain uplift) began about 60-70 m.y. ago and continued rather slowly until about 10 m.y. ago, when rapid uplift began. I reached the conclusion that the pegmatites yielding the onegite could not have reached a depth of 1.4 km until sometime during the last 10 m.y.

Knowing that there were two other ancestral Rocky Mountains, one may rightly question why formation of the onegite could not have occurred earlier. I further postulate that during those periods, which were at times of a more tropical climate (dinosaurs, etc.), ambient temperatures were probably higher than 40° C.

Photos from this presentation show that there were several variations in deposition, particularly of goethite growth under and on top of the onegite, proving that goethite can also crystallize at very low temperatures and pressures. Also, after the publication of the *Rocks & Minerals* article (Berry, 2001), I corresponded with a collector in Montana who has found quartz with goethite inclusions (some amethyst) in the Montana batholith in at least two different locations (Van Laer, pers. comm. 2001). Photos of the material show that it is similar to the Pikes Peak material, with the possible exception of euhedral growths of goethite. The onegite in Montana appears to have been deposited directly on the quartz. I have found the underlying goethite depositions are often missing when euhedral amethyst crystals with goethite inclusions are found, and when goethite sub-strata is present, the onegite is very heavily included making it opaque.

Little other modem scientific investigation of the paragenesis of the miarolitic cavities in the Pikes Peak Granite has been done. It would be of great interest to expand this investigation to other pockets within the batholith, extending the testing to other species. I extend an offer to take a professional mineralogist to a variety of pockets I have collected, securing from the dumps: quartz and microcline; from the walls: fluorite, amazonite, and smoky quartz; and other minerals that might be present. This investigation should be able to show if the occurrences noted in this paper are different from those in other areas or those lacking onegite. It would even be valuable to know if there is a difference in crystallization temperature from the base of a quartz crystal to the termination.

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Diamonds in the collections of the Denver Museum of Nature and Science

James F. Hurlbut and Jack Thompson

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(Location 4 on index map)

The first diamond donated to the museum was in 1922. It was a 1.5-carat stone from Brazil. Since then, the collection has grown to over 7,000 stones; of those, 6,500 are natural, ranging in size from 2 to 3 mm. The Paul Seel micromount collection consists of 3,000 mounted micromounts and 3,500 unmounted stones.

The collection also contains 150 diamonds from the kimberlites of northern Colorado and southern Wyoming donated by exploration mining companies. The Geology Department has also used funds donated by Paul Seel to purchase several larger crystals and cut stones from Colorado deposits. The most recent addition was a donation of two, small, natural diamonds from the current northern Canadian explorations.

The extent and variety of these collections will be illustrated. Paul Seel studied the nature of diamond crystals and their growth using his micromounts. The collection contains crystals from all diamond producing areas before 1970. He also made drawings of some of the unique features of diamond growth.

Mineralogy of the State Line kimberlite district, Colorado and Wyoming

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(Location 5 on index map)

Kimberlite, the igneous rock from the Earth's mantle that hosts most diamond deposits worldwide, was recognized in 1964 to be present in northern Colorado and adjacent Wyoming. Diamonds were first reported from one of the pipes in 1975, and diamonds are now known to occur in most of the —35 kimberlite pipes and dikes in the State Line district of Larimer County, Colorado, and Albany County, Wyoming. Additional kimberlites, which however are not known to be diamond-bearing, occur to the north in the Laramie Mountains of Wyoming (Iron Mountain and other areas), and to the south near Estes Park, Rocky Mountain National Park (Isolation Peak and Hayden Gorge kimberlites), and Boulder, Colorado (Green Mountain kimberlite pipe). The State Line kimberlites include pipes (circular, elliptical, or elongate intrusions), dikes, and diatremes (pipes which have a very fragmental texture, indicating eruption as a "blowout" to the surface). The State Line kimberlites intrude 1.4 and 1.7 Ma Proterozoic granite, and most have been found to be of Early Devonian age, about 390 Ma, but some are reported to be older, of latest Proterozoic age (-600 Ma).

A related rock type, lamproite, occurs in the Leucite Hills of southwest Wyoming. Lamproites host diamond deposits elsewhere in the world, including Western Australia and Prairie Creek (Crater of Diamonds), Arkansas. The igneous rocks of the Leucite Hills are not diamond bearing, but a few diamonds have been reported from not far to the southwest at Cedar Mountain and vicinity in the Green River basin, Wyoming. Igneous rocks with some affinities to kimberlite and lamproite are also known from several other localities in Colorado, Utah, Arizona, New Mexico, and adjacent states, but none are known to be diamond bearing.

The Sloan kimberlite in Colorado was mined on a trial basis in 1994, and some 9,034 diamonds weighing a total of 342 carats were recovered from 3,300 tons of rock excavated from a 614-ft adit. The largest diamond recovered from the Sloan kimberlite was 5.14 carats and was of partial gem quality. A full-scale open pit diamond mine was operated from 1996-1998 at the Kelsey Lake kimberlite group, on the Colorado—Wyoming border. During this mining, two large diamonds were found, and by coincidence both were 28.18 and 28.3 carats, yellow, and cut into 16.8 and 5.39 carat faceted stones. The 16.8-carat stone is currently the largest faceted diamond in existence from North America. Other diamonds found at Kelsey Lake have included stones of 16.9, 14.2 (a colorless, gem-quality octahedron), 11.85, 10.48, 9.4, and 6.2 carats, and many of 1 carat or more in weight. Mining has been inactive at Kelsey Lake for the last several years but is expected to resume.

In addition to diamond itself, classic kimberlite "indicator minerals" are found at all pipes in the State Line district: emerald-green chromian diopside ("chrome diopside"), pyrope garnet (typically red but ranging in color from orange to purple), and metallic-black magnesian ilmenite. Since these minerals (along with diamond) were plucked out of the mantle host rocks from which the kimberlites were derived, and did not crystallize from the kimberlite magma itself, the crystals are termed "megacrysts" (large crystals) or "xenocrysts" (foreign crystals); most have been rounded by abrasion or solution in the kimberlite pipes. A pyrope megacryst exceeding 2 lb in weight has been reported from the Schaffer kimberlite, Colorado, but most of the indicator minerals range from a few millimeters to a few centimeters in size. Some pyrope from the Sloan kimberlite exhibits an alexandrite-like color change from red to green, but only when observed in small thin fragments. Chrome diopside megacrysts as large as 9 cm have been observed in the Sloan kimberlite. Flakes of brown phlogopite (magnesium-rich mica) are common.

Xenoliths ("foreign rocks") found in the kimberlites, typically as rounded nodules from several centimeters to a foot or more in size, include rocks from the mantle (garnet, peridotite, and eclogite) and the crust (granite, gneiss, schist, granulite, limestone, and sandstone). Olivine is a common mineral in the State Line kimberlites, but most grains are rounded and have been altered to serpentine minerals. A wide variety of other minerals have been reported from the kimberlites, including megacrysts of other pyroxene group minerals, and various layer silicates, carbonates, and oxides as constituents of the groundmass of the kimberlites. Reported minerals include: antigorite, apatite, aragonite, barite, biotite, calcite, chlorite, chromite, diopside, dolomite, enstatite, graphite, hematite, ilrnenite, iron, lizardite, magnetite, nickel, omphacite, perovskite, pyrite, rutile, sanidine, spinel, talc, xenotime, and zircon. Many of these minerals, as well as coesite, corundum, pyrrhotite, pentlandite, periclase, acmite, richterite, hornblende, titanite, and wollastonite, have been reported as inclusions in diamonds from the district.

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Thirty years of mineral collecting in the San Juan Mountains, southwestern Colorado, 1970-2000

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(Location 6 on index map)

Now that mining has virtually ended in the San Juan Mountains in southwestern Colorado, it is a good time to look back over the last 30 yrs of mining and mineral collecting. I came to the area in August 1970, after serving in the U.S. Army for 2 yrs. At that time, mining was booming in the San Juans, with almost 800 people employed in the mining industry. Jobs were not hard to find, and I landed a position as mine engineer at the Camp Bird mine located 6 mi southwest of Ouray.

Mining of the lead-copper-zinc replacement orebody at the base of the Telluride Conglomerate had just started, and I was there from start to finish. Over the next 8 yrs hundreds of fine specimens of galena, sphalerite, chalcopyrite, pyrite, calcite, and quartz were collected. The orebody was mined out by December 1978, which put about 100 people out of work. The mine was put on a caretaker basis until 1986 when another round of mining took place until 1990. During this short span, some of the finest scheelite crystals to be found in the United States were recovered from the Camp Bird vein.

The Idarado mine, with access from Red Mountain and Telluride, had a payroll of about 300 and was mining both replacement orebodies and fissure vein deposits. The minerals from the replacement orebodies were very similar to those of the Camp Bird mine, whereas the veins yielded gold and base metal sulfides. The Idarado mine ceased operations in November 1978, and 150 hands were laid off.

The Sunnyside mine, which is located in Sunnyside Basin, was being mined through the American tunnel located at Gladstone, San Juan County During the 1970s and 1980s the mine was the largest gold producer, and hundreds of fine specimens of gold were high-graded by the miners. In the 1980s the mine was in serious financial condition and went through a series of owners. It finally ceased operations in July 1991, with a layoff of the last 150 people. With the shut down of the Sunnyside mine, the industry came to a halt—never again to recover. The golden years were over for mining and mineral specimen recovery in the active mines.

During the 1980s and 1990s sporadic small-scale mining continued, with the recovery of some very fine mineral specimens. Mineral collecting turned from recovering specimens in active mines to field collecting on mine dumps and underground in abandoned mines. In the early 1990s the Mined Land Reclamation Division of the Colorado Bureau of Mines initiated a program of sealing all mine openings, and it then became a race against time to collect and preserve minerals that would never again see the light of day.

By the mid-1990s most of the abandoned mines were inaccessible, and collecting turned to out-crops of fissure veins. Some of the best milky quartz crystals to be found in the world were collected from solution cavities and vugs in fissure veins in the Leadville Limestone, which crops out in and around Ouray.

Field collecting continues in the San Juans, and important discoveries are still being made by diligent collectors willing to hike to the more inaccessible areas.

Tellurium oxysalts from Tombstone, Arizona

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Tucson, Arizona 85728

(Location 7 on index map)

The mention of the Tombstone district of southeastern Arizona conjures up romantic images of the old West including prospectors braving hostile Apaches to make the initial discovery, the Earp brothers and the "Shoot out at the OK Corral," and enough wealth pouring out of the mines to support a non-stop 24/7 poker game...with a $1,000 buy-in for 5 yrs! Of course the prospector sold out cheap and died penniless, the Earp brothers' reputation has tarnished with time, and the fabulous ores played out long ago. Today, the Tombstone district is a world-renowned tourist trap, and the mines are largely inaccessible. However, the Tombstone district has produced a number of rare tellurium oxysalts, is type locality for nine such species, and a number of unknowns are awaiting description.

Tombstone mining commenced about 1881 on high-grade ores that cropped out on the surface. These bonanza oxide ores were rapidly followed to the water table, about 150 m below the surface. Massive pumps were installed to allow following the rich underlying sulfide ores to depths ultimately reaching over 350 m. The pumps were unable to hold back the water influx, and when one pump failed in the 1890s, the entire district flooded rapidly to the water table. One later attempt was made in 1912 to dewater the mines and pursue deep ores, but except for this, all twentieth century mining was focused on scavenging remnants and lower-grade ores bypassed in the rush to follow bonanzas to depth. Total district production is estimated to be 2,700,000 tons, grading: 1.53 grams per ton Au; 372 grams per ton Ag; 0.8% Pb; 0.02% Zn; and 0.13% Cu (Titley, 1993). These are average grade figures and do not begin to reflect the extremely high gold and silver grades found in the enriched upper parts of the system.

Tombstone mineralization is hosted in a thick sequence of Paleozoic carbonate rocks unconformably overlain by Cretaceous shales, sandstones, and limestones. Structurally, the Tombstone district is folded into a series of northwest-trending folds cut by northeast-trending faults. A large granitic porphyry stock with related rhyolitic volcanic rocks abuts the Tombstone district to the west. Bimodal, rhyolite-lamprophyre dikes are emplaced along several of the northeast-trending faults. Mineralization consists of gold-silver-tellurium veins developed along the northeast-trending faults and associated lead-zinc-copper-silver replacement mantos or saddle reefs (rolls) that lie along the crests of the tight northwest-trending folds—immediately below shale beds. The crosscutting relationships between these two are unclear, but the veins are probably younger. Alteration includes pervasive argillic alteration of the igneous rocks and marbelization, skarn, and silicification of the sedimentary rocks. The Tombstone district is zoned from a copper-zinc-gold center to lead-zinc-silver to peripheral manganese-silver over about 6 km. The primary vein mineralogy includes: empressite, hessite, krennerite, tellurium, rickardite, and altaite (probably) with quartz, calcite, fluorite, and adularia gangue. Replacement bodies were dominantly composed of galena, sphalerite, pyrite, chalcopyrite, tetrahedrite, and alabandite with similar gangue. The distal manganese mineralization is dominated by soft manganese oxides. Oxidation is nearly complete to the water table except for some silica-armored zones.

Tellurium species

The distinctive green colors of the secondary tellurium species are almost infallibly associated with native gold and silver halides, and their utility as a guide to riches was clearly recognized early in the Tombstone district. Stopes in the highest-grade zones have literally been scraped to the limestone walls by armies of miners working with single jacks and hand chisels. Emmonsite, recognized as unusual, described as a new species in 1885, is the oldest type species from the Tombstone district, and probably came from a high-graded underground ore sample. The remainders of the species are micro-minerals described in the late 1970s and early 1980s by Sid Williams, working from dump samples. Most of the dumps were lost to early 1980s open-pit, heap-leaching operations, and the thoroughness of underground mining makes it very difficult to find more than scraps of overlooked tellurium-bearing materials. Nonetheless, a late 1980s exploration program that included systematic underground mapping resulted in the location of a few small areas of rich tellurium-oxysalt mineralization and the discovery of many district type species in situ. This has also resulted in the recognition of several attractive, although as yet, undescribed species.

It is worth emphasizing that the underground workings are in very poor condition and extremely hazardous. Most underground access is sealed, and residents living near the mine entrances do not hesitate to call the police when they see unauthorized activity.

Secondary tellurium species*
Tombstone district, Cochise County

(*type locality species in bold)

Compiled from:
Anthony et al., 1990, Handbook of Mineralogy
Anthony et al., 1995, Mineralogy of Arizona
Gaines et al., 1997, Dana's New Mineralogy
Mandarino, 1999, Fleischer's Glossary of Mineral Species

Cesbronite—$Cu^{2+}{}_5(Te^{4+}0_3)2\ (OH)_6{*}2H_20$, orthorhombic, reported by Anthony et al., 1995.
Choloalite—$Cu^2Pb(Te^4{+}0_3)_2$, cubic, dump between Grand Central and Little Joe shafts.
Dugganite—$Pb_3Zn_3T^{6+}As_20_{14}$, hexagonal, Emerald mine dumps (Little Joe, Old Guard), 1978, named for Marjorie Duggan who performed the analyses.
Emmonsite--$Fe^{3+}{}_2Te^{4+}{}_30_9{*}2H_20$, triclinic, unknown locality (Emerald mine dumps, Little Joe shaft dump, Grand Central dump, Empire mine, underground), 1885, named for Samuel Franklin Emmons, economic geologist with USGS. Original type material almost certainly rodalquilarite!
Fairbankite--$PbTe^{4+}0_3$, triclinic, Grand Central mine dumps, 1979, named for Nathaniel Kellog Fairbank, an important entrepreneur in early Tombstone.
Frohbergite—$FeTe_2$, orthorhombic, Joe shaft dump.
Girdite—$Pb_3H_2(Te^{4+}0_3)(Te^{6+}0_6)$, monoclinic, Grand Central mine dumps, 1979, named for Richard Gird (1836-1910), mining engineer and assayer who made the first rich silver assays from the Tombstone district.
Graemite—$Cu^{2+}Te^{4+}0_3{\bullet}H_20$, orthorhombic, district (Gaines et al., 1997).
Khinite—$PbCu^{2+}{}_3Te^{6+}0_4(OH)_6$, orthorhombic, Old Guard mine dumps (Empire, underground), 1978, named for Ba Saw Khin, petrographer; compare to hexagonal-trigonal for parakhinite.
Mackayite—$Fe^{3+}Te_20_5(OH)$, tetragonal, Toughnut-Empire mine.
Mroseite—$CaTe^{4+}(CO_3)0_2$, orthorhombic, Tombstone Exploration Incorporated pit (=Contention-Tranquility Zone).

Oboyerite—$Pb_6H_6(Te^{4+}O_3)_3 (Te^{6+}O_6)_2*2H_2O$, triclinic, Grand Central mine dumps, 1979, named for **O.** (Oliver) Boyer, one of the first stakers of the Grand Central claim. Parakhinite—$Cu^{2+}{}_3PbTe^{6+}O_6(OH)_2$, hexagonal-trigonal, Emerald mine dumps (Empire underground), 1978, named in allusion to its dimorphous relationship to khinite.

Paratellurite—TeO_2, tetragonal, Little Joe mine dump.

Quetzalcoatlite—$Zn_8Cu^{2+}{}_4(Te^{4+}O_3)_3(OH)_{18}$, hexagonal, Empire mine.

Rodalquilarite--$H_3Fe^{3+}{}_2(Te^{4+}O_3)_4C1$, triclinic, Grand Central mine dump.

Schieffelinite—$Pb(Te^{6+}, S)O_4{\bullet}H_2O$, orthorhombic, Little Joe and Grand Central mine dumps, 1980, named for Ed Schieffelin, stagecoach driver and prospector who "found his tombstone" and is credited with discovering the Tombstone district.

Sonoraite--$Fe^{3+}Te^{4+}O_3(OH){\bullet}H_2O$, monoclinic, Little Joe shaft dump.

Tlapallite—$H_6(Ca,Pb)_2(Cu^{2+}, Zn)3(SO)_4(Te^{4+}O_3)4 (Te^{6+}O_6)$, monoclinic, Lucky Cuss mine dump.

Winstanleyite–$TiTe^{4+}{}_3O_8$, cubic, Grand Central mine dump, 1979, named for Betty Joe Winstanley, finder of first specimen

Xocomecatlite—$Cu^{2+}{}_3Te^{6+}O_4(OH)_4$, orthorhombic, Emerald mine dump.

Yafsoanite—$Ca_3Zn_3(Te^{6+}O_6)_2$, isometric, Empire Mine underground; this is the material used to determine the garnet structure of yafsoanite.

Reference

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Sampling the finest

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An aspect of my job as a mineral and jewelry photographer is a great deal of travel, both in the United States and Europe. I photograph for museums, dealers, collectors, and publishers. I see everything from the most mundane pieces to the best—those pieces that are drooled over in museum display cases and at mineral shows. This presentation for the New Mexico Mineral Symposium will be a sampling of some of the finest that I have seen. Many will be well-known species that we see at every show, and others will be rarities that are, nevertheless, some of the best of their kind.

There are a number of questions that are sure to be on some of your minds. No, I do not shoot yet with digital cameras, but I know that someday I will—when the prices come down and the quality goes up. I am also not involved in the digital manipulation of my images (i.e., Adobe Photoshop), but I will be shortly. All of my 35-mm work is done with one of three Canon Fl cameras. I shoot both with tungsten light (with Kodak Ektachrome 64T film) and with daylight studio flash using Fuji Velvia (ISO 50). I use either a 50-mm or a 100-mm Canon macro lens with these cameras. I also do a great deal of work with a large format (4x5 inch) Sinar F camera.

Four faces of gold

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To most gold seekers, gold prospecting means getting out the shovel, gold pan, sluice box, and plastic buckets, but this is not really gold mining. Placer mining is the recovery of gold after mother nature has done the mining, milling, and concentrating of the heavy minerals, including gold. Yellow gold is only a small part of the gold story. The four faces of gold are the four ways gold exists, and all should be considered by any prospector seeking a productive venture into the world of gold.

Face one, *crystalline gold—This* face of gold is the most common form that weekend prospectors seek. It includes flakes and nuggets of the yellow metal. Free gold is formed in a crystal pattern (though often distorted by impact) and is identified by its crystalline lattice framework of gold molecules, orderly arrayed as the crystal grew naturally. Errant molecules of the other elements, such as silver, are commonly present. This is the gold of the Mother Lode, the Klondike of Canada, and of Breckenridge, Colorado.

Face two, *refined gold or melted gold—This* face of gold is represented by the fact that the gold is not crystalline but rather a solid solution or an alloy with other metals. This is the gold of jewelry and coinage. Also, it is the gold of Fort Knox and the melted bubbles of gold that result from roasting the minerals of gold. The only difference between this face of gold and crystalline gold is that it is not naturally occurring and is a solid solution. The gold of Fort Knox is neither a solid solution nor an alloy; it is elemental gold (99.999% pure or 24K).

Face three, *complex gold minerals—This* face of gold is the gold of Cripple Creek and Boulder, Colorado, Romania, and the Carlin Trend of Nevada, and all of the other areas that produce refractory gold ore. These are the complex minerals of gold. Gold combines chemically as a compound and forms crystals with a lattice pattern. It differs profoundly from crystalline gold because the elements that comprise the anion in the mineral affect the structure of the crystal. This face of gold includes the tellurides and pyritic minerals such as pyrrhotite, arsenopyrite, marcasite, and pyrite often referred to as auriferous pyrite where molecules of gold are included in the crystal structure. The telluride minerals include sylvanite, krennerite, calaverite, muthmanite, nagyagite, etc.

Face four, *the pseudomorphs of gold—This* face of gold is present only in the supergene or oxidized area of a rich telluride vein or orebody. It is residual gold that results from the leaching action of ground water in the process of erosion. Pseudomorphs of gold after sylvanite are known as "rusty gold," and after calavarite and krennerite are known as "mustard gold" or "sponge gold." These are the rarest forms of gold and are so rare that most people do not recognize them or know of their existence. They are not spectacular or beautiful like crystalline gold, in fact, they are somewhat ugly. The rareness stems from the fact that they exist only in the upper part (5-10 ft) of an oxidized telluride vein. They were the first gold to be sent to the smelter to put beans and bacon on a starving prospector's table. The pseudomorphs retain the lattice pattern of the original telluride crystal but have voids that are left when ground water leaches away the tellurium. Thus, a porous and fragile framework of gold remains with no definite reflective crystal surface. The structure resembles rotten wood.

As with most things, the more you know about a subject, the more you realize how little you know. Knowledge provokes questions, and knowledge of gold is no exception.

Turquoise at Turquoise Mountain, Old Hachita, New Mexico

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(Location 8 on index map)

Turquoise Mountain is in the Eureka mining district in the Little Hatchet Mountains, Grant County, New Mexico. It is immediately west of the ghost town of Old Hachita. Turquoise Mountain is on Bureau of Land Management land, and New Mexico State land is present to the south and east. Access to the area is good, but four-wheel drive vehicles are recommended as sections of the road are not maintained.

Indians first worked the deposits for turquoise hundreds of years ago. In the 1880s mines in the district were worked for gold, silver, and copper, but none of these deposits proved of great economic importance. In 1885 miners began working the district for turquoise. Mining lasted until 1888 and was restarted in 1892 but with little result. In 1908 extensive mining started, but it only lasted a few years. Fine sky-blue material was reported to have come from a number of claims (Carter, 1965).

The turquoise deposits in the Little Hatchet Mountains have reportedly produced some large pieces of turquoise. Sinkankas (1997) described a 160 lb piece that was extracted in 1926 from a mine in the Hachita Mountains. This piece was carved into a scene depicting a pueblo and its occupants and was exhibited at the Tucson Gem and Mineral show in 2001 by Freedland's Jewelry of Tucson, Arizona. The piece weighed 121 lb after carving and was considered to be the largest in the world (Tucson Show Web site, 2001).

Carson (1975) described the area in detail from a collector's standpoint. Whereas Turquoise Mountain has been the focus of turquoise activity in the Eureka mining district, showings that are not profitable for large-scale commercial mining yet attractive to collectors, surround the area around Turquoise Mountain. The Azure mine, which is not to be confused with the Azure mine in the Burro Mountains turquoise district, is located on top of Turquoise Mountain and has produced high-grade material. The Cameo mine, about 1 mi northwest of the northeast end of Turquoise Mountain, was developed by a vertical shaft. The Cameo mine is one of the oldest in the region based on the number of stone tools found, and the material is similar to that of the Azure mine. The Galilee mine, about 0.5 mi southwest of Turquoise Mountain, was worked by a large pit and produced from two prominent veins. The Aztec mine, named because of its prehistoric workings, is about 1.5 mi southwest of Turquoise Mountain. The Aztec mine was worked by an adit, and the turquoise is present in seams as nuggets scattered throughout the rock. The turquoise here is soft and pale and sometimes fades under exposure. Darker blue turquoise is reported to occur in the American Turquoise mine, which is a few hundred yards west of the Cameo mine. This claim was worked from both an open pit and a shaft. The turquoise here is quite hard and is predominantly pure turquoise. Carson (1975) noted that these sites and most of the other claims in the area are patented, but that collectors would encounter no entry problems as long as property rights are respected. During a site visit in August of 2000, no indications of claims stakes or indications of other restrictions to collecting for personal collections were observed in the area of Turquoise Mountain.

Geologic mapping by Zeller (1970) indicates that Turquoise Mountain consists of a hydrothermally altered monzonite stock and andesite and andesite breccia of the Hidalgo volcanics. The Hidalgo volcanics are believed to be early Tertiary in age, indicating that the monzonite stock may also be early Tertiary. Where exposed, the stock is generally iron stained due to the abundance of disseminated pyrite in the unweathered rock. Much of the rock has been altered to clay minerals, and this is immediately apparent from the fine-grained, white character of the rock. Turquoise is present in altered rocks along the borders of the stock.

Collecting of turquoise at Turquoise Mountain is relatively easy, and loose pieces can be found on the surface of trench floors and in piles along the sides of old equipment trenches and cuts. Most of the turquoise in the walls of trenches and cuts is present as veinlets and along fracture fillings. Color ranges from sky blue to light green. A breaker bar is useful for breaking out large slabs, and a flat chisel with a hammer can be used to split apart smaller pieces. Areas with veinlets on the surface should be explored deeper with a breaker bar, as collecting in the district has undoubtedly removed the bulk of the loose turquoise on the surface.

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Wulfenite in the Tusas and fluorite in Amalia—new mineral stories in New Mexico

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(Location 9 on index map)

In late summer of the year 2000, two mineral specimens came into my possession that have haunted and driven my field collection ever since. One is an astonishing plate, 20 cm in length, of skarnlike material sprinkled with simple rectangular crystals of amber-colored wulfenites (as much as 5 mm in length). The other is a single, loose, very pale purple octahedron of fluorite containing small crystals of chalcopyrite—measuring 2 cm tip to tip.

It is the story of their origin that intrigued me. There is no known record of wulfenite in the north-central Tusas Mountains; there is no known record of fluorite in the extreme northern part of Taos County.

My presentation is a recollection of events in my investigation of these two specimens—attempting to reconcile the oral historical record with the geological model in order to find the source. My documentation of said investigation has taken on overtones of "something funny happened to me on the way to the symposium." But it makes for a fine "fishing" tale in the annals of New Mexico minerals.