31ST ANNUAL

Minerals of Arizona
SYMPOSIUM

Celebrating the Field Collector, Part 2
As a Tribute to Bob Jones!

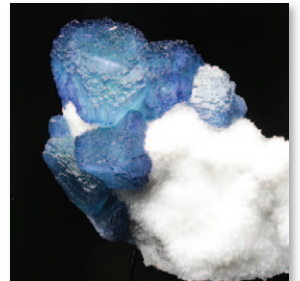APRIL 13th, 2024 | GILBERT, ARIZONA

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Epidote ps. Orthoclase - Orogrande Dist., Otero Co., New Mexico
Philip Simmons specimens. Photo: Erin Delventhal & Philip Simmons.

Pyrite, Bingham Canyon open pit copper mine
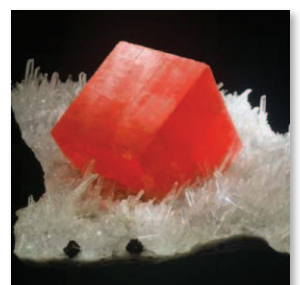Salt Lake County, Utah, Jared Judd collection

Fluorite on Quartz, Blanchard mine.
17 cm upper left to bottom right. Sanders photo

Quartz structure, 1.5 cm tall, inside a Trancas Station geode,
ID No. JRS-T359A. Jeff Smith photo and specimen.

Fluorite - Homestake Mine
Mark Hay Specimen - Jeff Scovil Photo

Rhodochrosite on quartz, 10.4 cm, Blueberry Pocket
found through GPR exploration work - Photo by Jeff Scovil.

Chairperson
Les Presmyk

Co-Chairperson
Catie Sandoval

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Titles	Presenter(s)	Times		Page
Registration		8:00 AM	8:45 PM	
Opening Remarks	Les Presmyk, and Catie Sandoval	8:30 PM	8:45 PM	
Collecting in Contemporary Utah	Phil Richardson	8:45 PM	9:25 PM	5
Field Collecting and Collectors at the Desert Museum	Anna Domitrovic	9:25 PM	10:05 PM	9
Break and mineral sales		10:05 PM	10:40 PM	
A rediscovery of epidote pseudomorphs after orthoclase from the Orogrande district, Otero County, New Mexico	Erin Delventhal	10:40 AM	11:20 AM	11
The Sweet Home mine, Alma, Colorado	Karen Wenrich, Ph.D.	11:20 AM	NOON	15
Lunch and mineral sales		NOON	1:30 PM	
Fluorite from the Oatman District, Mohave Co., AZ	Mark Hay	1:30 AM	2:10 AM	25
Where did that turquoise come from? A case study of the turquoise deposit from Bisbee, Arizona	Mark Pecha	2:10 AM	2:50 PM	29
Break and mineral sales		2:50 PM	3:40 PM	
The Peculiar Geodes of the Trancas Station, Chihuahua, Mexico	Jeff Smith	3:40 PM	4:20 PM	31
Three Decades of Collecting at the Hansonburg Mining District, Otero County, New Mexico	Mike Sanders	4:20 PM	5:00 PM	35
Closing Remarks and Adjournment		5:00 PM	5:05 PM	
Mineral Sales and Light Buffet		5:05 PM	9:00 PM	

Shannon Minerals
Lucky Muckers
Others to be announced for evening sales

Dealers List
Shannon Minerals – Michael Shannon
Lucky Muckers – Joe Philpott, Jr.
Ray Grant, Ph.D.

Flagg Mineral Foundation
Jim McGlasson
Dan Fortunato
ASE Minerals
Headframe Minerals - Don Bouschelle
Boris Dimov
Jan Rasmussen, Ph.D.

The 31st Arizona Mineral Symposium, a Tribute to Bob Jones

by Evan Jones and Les Presmyk

Bob Jones' interest in minerals started in 1936 at age 10 during a school field trip to the Peabody Museum in New Haven, CT where he was fascinated by the fluorescent mineral display. After serving in the Army Air Corp in 1946 and marrying his beloved wife Alicia in 1953, he went on to write his master's thesis "Luminescent Minerals of Connecticut" in 1956. Then in 1959, the Jones family moved to Scottsdale, Arizona where Bob's interest in mineral collecting blossomed under the guidance of such Arizona luminaries as mineralogist Scott Williams, who owned a mineral shop near the Jones family residence, and Arthur Flagg, curator of the Arizona Mineral Museum.

In 1961, his book on the fluorescent minerals of Franklin, New Jersey, titled "Nature's Hidden Rainbows", was published which is still a classic among fluorescent mineral collectors. That same year Bob was enlisted by Peter Zodac to write a monthly column on fluorescent minerals in Rocks & Minerals magazine which marked the beginning of his lifelong interest in writing magazine articles. However, he is most recognized as the premier author for Rock & Gem magazine, having published well over 1000 articles in the magazine starting in 1971 until the present day. He also wrote articles published in Lapidary Journal, Arizona

Bob mineral collecting in Arizona mid 1960's

Highways and The Mineralogical Record, including both the 25th and 50th History of the Tucson Show publications as well as editing or authoring other mineral books including "The F. John Barlow Collection" and "The Frugal Collector".

Bob Jones is also well known as the host of several videos on gemstone localities across the globe including "Gemstones of America" and "Russian Gem Treasures" and as host of dozens of episodes of the "What's Hot in Tucson" videos for Blue Cap Productions. He has made countless presentations over his lifetime on subjects ranging from the miners and minerals of Cornwall, England to Russia's fabulous works of lapidary art to the emerald mines of Colombia and numerous other mineral and lapidary topics. For these and

Bob Jones with mineral cabinet clate 1960's

his many other achievements he received the prestigious Carnegie Mineralogical Award in 1998, is a member of the Rockhound Hall of Fame, and has received numerous other honors and awards over the years in the fields of mineralogy and lapidary.

During filiming of Gemstones of America video, 1980's

Bob is the only remaining member of the group that established the A.L. Flagg Foundation for the Advancement of the Earth Sciences, honoring Arthur L. Flagg, in 1963. Mr. Flagg had been the long-time curator of the mineral collection at the Arizona Mineral Museum and was responsible for many new collectors in the 1940s through the early 1960s. Bob served on the Flagg Foundation Board for many years, and has passed this responsibility onto his youngest son, Evan. Bob is also the only living member of the original "Scottsdale Gang" of mineral collectors, the precursor to the Arizona Mineral Minions group.

Les Presmyk recalls that he first met Bob as a junior member of the Mineralogical Society of Arizona when he was 12. Bob, along with Bill Panczner, the Fosters and other adults involved with MSA who took an interest in a group of kids, helped generate Presmyk's lifelong passion for minerals and this hobby. Probably because he was an 8th grade science teacher, Bob became a mentor to Presmyk, Wayne Thompson and others and quickly made them feel like fellow mineral collectors, not just the kids that they were. As Presmyk grew into adulthood, Bob became a dear and cherished friend to him and when he received his Carnegie Award, he could not upstage Bob by proposing to Paula like Bob did with his now wife Carol. However, he highlighted the contributions three people had made in life: Marcella "Marc" Watson, Bob Jones and his wife of 47 years, Paula.

Senior Editor, Rock & Gem

Presmyk continues, "In our world Bob is one of the giants or, put another way, he has achieved the status that Gene Meieran, Steve Smale or Jack Nicholson have in their respective fields. But he will always be Bob to me, a long-time mentor and most importantly someone I consider to be a dear friend. After all, he is the one who consistently derides and denigrates my sphalerite collection. When he does, I'm just reminded of a quote from a well-known author, 'you can tell a true mineral collector if they like black minerals'. Yes, those wise words were written by Bob Jones himself".

COLLECTING CONTEMPORARY UTAH
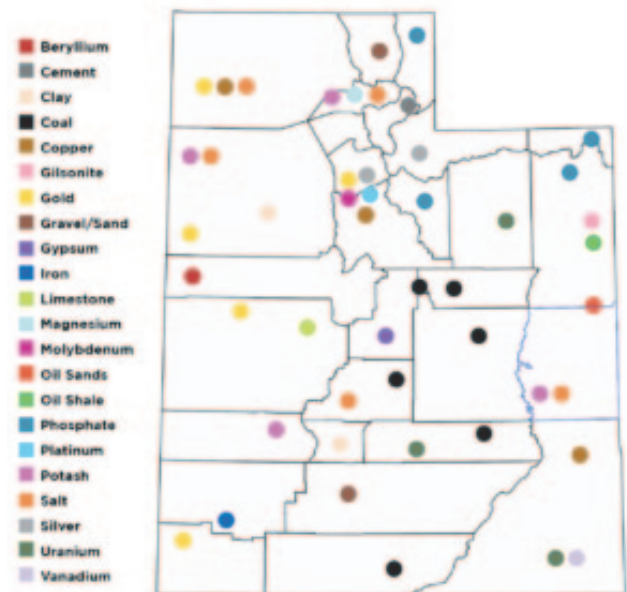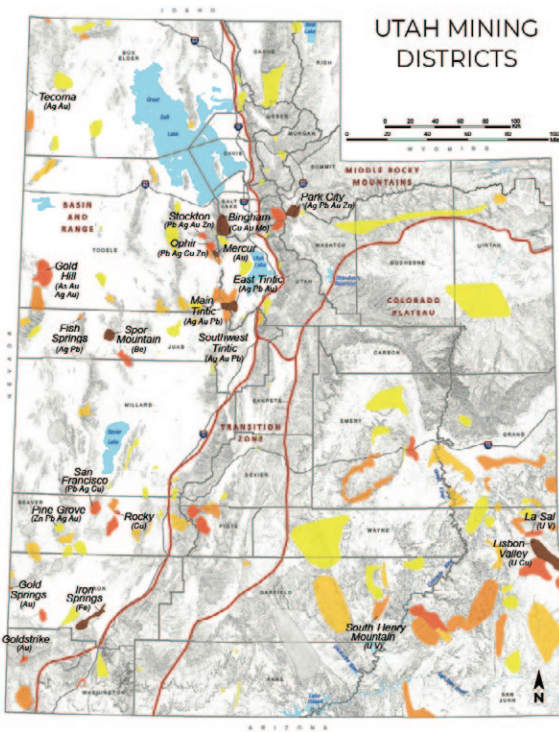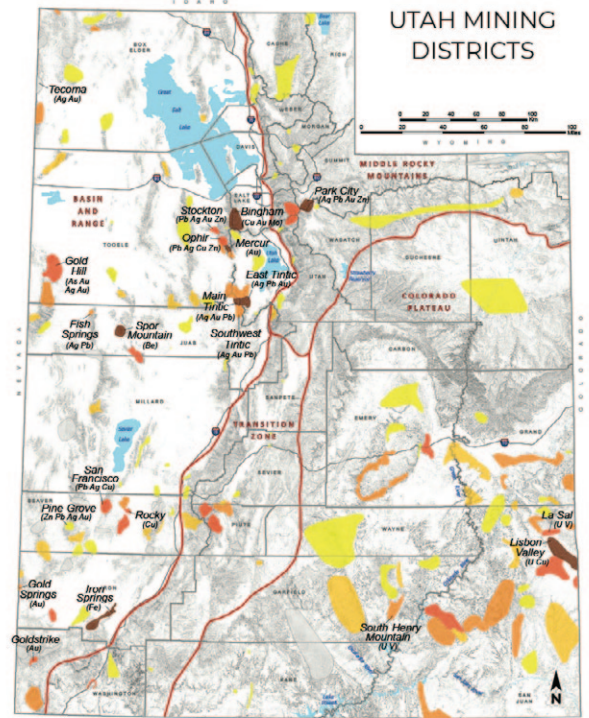
by Phil Richardson (richardsonutaz@gmail.com)

Utah, our neighbor to the North, is an interesting and varied land comprised of three distinctive geographical regions; the Northwestern portion is Basin and Range, which does extend all the way down to the southwest corner, the vast Southeastern portion is Colorado Plateau, and the Central Western area is the land of volcanics. All three present different collecting opportunities and a variety of mineral species. What is most notable about this state of 85,000 square miles, and only 3.4 million people, is that it is somewhat sparsely populated, has a lot of open public lands, and in general, due to it being mostly high desert, a lot of the rocks are exposed. These circumstances allow for the possibility of new discoveries even today. With over 150 distinct designated Mining Districts, and the majority of them considered inactive, these mines, adits, shafts, open pits, cuts, and quarries may present their own collecting opportunities and rediscovery. Do your due diligence to access any of these properties legally and exercise caution when encountering hazards. Collecting opportunities abound to this day!
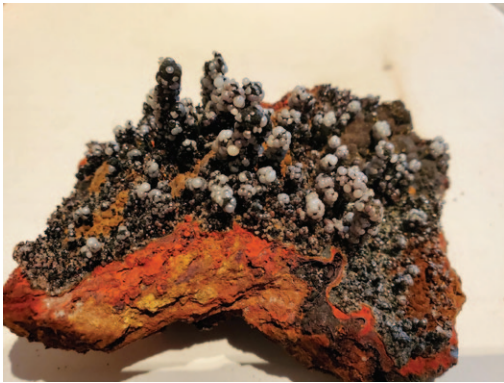
As a very general characterization of these distinct regions, the Basin and Range contains the metalliferous deposit minerals, the Colorado Plateau the uranium and vanadium mineralization hosted in sandstone, and the Central land of volcanoes with its vapor emplaced mineralization mainly in rhyolites. Interspersed in this unique and interesting geography we also see evaporites in the Great Salt Lake, a variety of phosphates in three distinct areas, producing world renowned variscite, and several anomalies such as the vertical breccia pipe near St. George, Utah, the Apex mine, and the copper deposits of the La Sal area of San Juan County. Adding to all this interesting mineralogy, the entire Southern portion of the State of Utah is graced with an otherworldly landscape of wind and water carved and sculpted sedimentary rock creating buttressed cliffs, flat topped buttes, deep slot canyons, tall slender pinnacles, and long spanning arches; Grand Staircase-Escalante, Zion, Bryce Canyon, Capitol Reef, Canyonland, Monument Valley, and Arches.

This presentation will address a broad survey across the majority of the State of Utah highlighting minerals collected contemporaneously from around 1980 until today. I will also feature a few minerals sought from historic sites, which often come into the marketplace when older collections are recycled. All the minerals shown are of thumbnail size and larger, with most being small cabinet pieces. The Colorado Plateau is not as evenly represented, although it is responsible for over 120 new species described over the last ten years. 30 alone from the Blue Lizard mine, Red Canyon Mining District, San Juan County. (Personal communication with Joe Marty, 2024) As most of these minerals are considered as micro mounts, they should be covered in their own presentation.
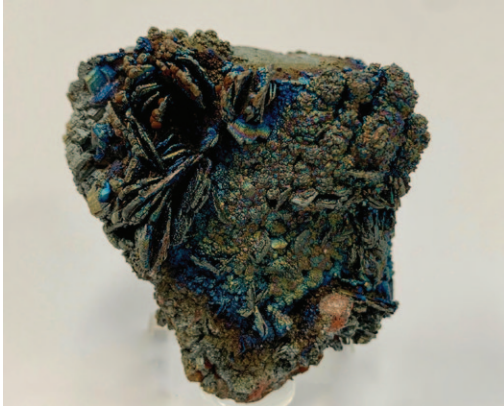
Location of Selected Mining Districts of Utah

UTAH MINING DISTRICTS

District Total Production Value

Geologic Province Boundary | No Production | < $1,000,000 | $1,000,000 – $10,000,000 | $10,000,000 – $100,000,000 | $100,000,000 – $1,000,000,000 | >$1,000,000,000

UTAH MINING DISTRICTS

District Total Production Value

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- Beryllium
- Cement
- Clay
- Coal
- Copper
- Gilsonite
- Gold
- Gravel/Sand
- Gypsum
- Iron
- Limestone
- Magnesium
- Molybdenum
- Oil Sands
- Oil Shale
- Phosphate
- Platinum
- Potash
- Salt
- Silver
- Uranium
- Vanadium

Smithsonite on coronadite, Burgin mine, East Tintic, Utah County, Utah, PR collection

Goethite after barite, Colorado mine, Tintic District, Juab county, Utah, PR collection

Gypsum, Salt Wash, near Hanksville, Wayne County, Utah, PR collection

Okenite, Bingham Canyon open pit copper mine, Salt Lake County, Utah, PR collection

Pyrite, Bingham Canyon open pit copper mine, Salt Lake County, Utah, Jared Judd collection

Calcite grouping, Ophir Canyon, Oquirrh Mountains, Tooele county, Utah, PR collection

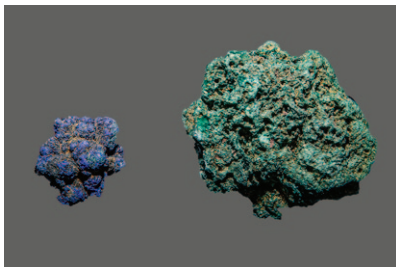Galena, Bingham Canyon open pit copper mine, Salt Lake County, Utah, PR collection

Celestine geode, Greasewood Draw area, Emery County, Utah, PR collection

FIELD COLLECTING & COLLECTORS: ARIZONA-SONORA DESERT MUSEUM, Tucson, Arizona

by Anna M Domitrovic, Curator, Mineralogist Emerita

Field collecting for the Earth Sciences Center at the Arizona-Sonora Desert Museum goes back to the 1980's. To maintain the Museum's simulated Mine Dump, annual trips were made to various southwestern U. S. mines to collect miscellaneous minerals

Azurite, Malachite
Santa Rosalía, Baja California Sur, Mexico

and rocks to salt the dump. Visitors were encouraged to hand-dig and collect a sample or two to take home with them. To this day, the Mine Dump and fossil dig blocks at Ancient Arizona are the only places on the Desert Museum grounds where visitors are permitted to pick up and take home a remembrance of their visit at the Museum.
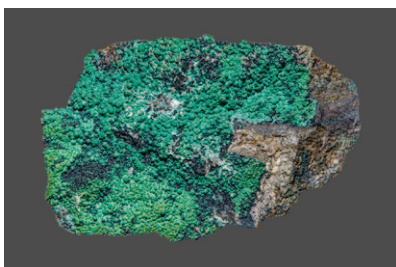
In the mid-1990's, the Mission Mine south of Tucson generously donated boulders which we installed, with the mine's help and equipment, at the Museum entrance. We were invited to the mine to select the types and number of boulders we needed. And in 2016, when the Museum was in need of limestone rocks for an agave garden, the Portland Cement Plant quarry allowed us to collect what we needed.
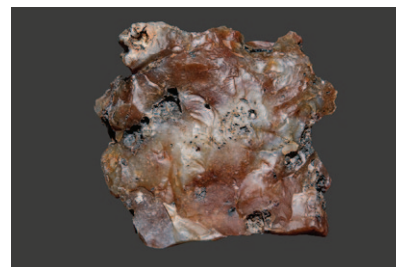
Agate
Anderson Mountain, Yavapai Co., AZ

Field collecting since 2000 is primarily done by ES Curatorial Assistant Penny Savoie and this author Anna Domitrovic. While the majority of our collecting is to replenish give-away minerals for the Museum's Mine Dump, representative specimens from the Sonoran Desert Region of Arizona, Baja California, Sonora and southeastern California have

Malachite
Silver Bell Mine, Pima Co., AZ

made their way into the Museum's Permanent Mineral Collection (PMC). Field trips sponsored by the Arizona Geological Society, the Tucson Gem & Mineral Society and the Desert Museum which we participated in, allowed us to collect and enter specimens into the PMC. Catalogued specimens came from sites in Graham, Pima, Pinal and Yavapai counties as well as the Baja Peninsula.

Several self-collected specimens from Australia, New Mexico and sites in southern Arizona remain in private collections.

Bio: Anna M. Domitrovic

With the exception of a brief hiatus when she volunteered from 2006 – 2016, Anna has been with the Arizona-Sonora Desert Museum in Tucson as an employee and volunteer in the Earth Sciences Center from 1977 – present, with the current title of Earth Sciences Curator Emerita & Mineralogist. Coming from coal mining country in southwestern PA, it's logical that her background and education is in geology with an emphasis on mineralogy. She received her Bachelor's Degree in Geology from Edinboro University of Pennsylvania in 1973. She is especially interested in pseudomorphs, a mineral form in which the original mineral's chemistry is replaced with another but retains the crystal form of the original, thus the term pseudomorph, which means false form. Anna also has a special interest in mining history and is an active collector of mining artifacts from the 19th & 20th centuries.

A rediscovery of epidote pseudomorphs after orthoclase from the Orogrande District, Otero County, New Mexico

by Erin Delventhal and Phillip Simmons

New discoveries, or rediscoveries of old localities, are very often some of the most challenging objectives within the field collecting world. Sparse information along with vague references or landmarks often lead to frustration in locating these areas, and more often than not result in many hours, if not days, of fruitless exploration. In this particular venture, we were fortunate to have at least a distinct starting location from which we could base all of our further exploration. This led to a wonderful find of pseudomorphs that, as far as we can determine, are unique in the mineral collecting world.

The Discovery
This adventure started with research for the New Mexico Pseudomorphs presentation given at the New Mexico Mineral Symposium in 2019. As Phil browsed the Ray Demark collection to find interesting pseudomorphs for the talk, Ray pointed out a couple of specimens that were easily overlooked. They were the typical sharp phenocrysts of orthoclase common from porphyries found at several localities across the state, but in this case they were green! Closer inspection revealed that the orthoclase had been fully replaced by epidote, a pseudomorph Phil had never seen before. An excited phone call to Erin was all that was needed to prompt us to ask Ray if he would be willing to tell us from where he had collected the specimens. Ray graciously agreed. Although the specimens observed in Ray's collection were found by an individual from Alamogordo years back, Ray had gone looking for the locality. The trip only resulted in a few crude crystals that were nowhere near the quality of the ones found previously. However, with the knowledge of where Ray had collected, we were able to pinpoint other promising targets that eventually led to the discovery (or possible rediscovery) of the premier zone that produced the sharp pseudomorphs in November of 2020.

Geology
Although the mineralogy is more complex in the parts of the Orogrande district that contain base and precious metal contact metasomatic deposits and hydrothermal turquoise deposits, the local geology of the pseudomorph locality is relatively simple. The collecting area is composed of a monzonite porphyry stock containing large, sharp phenocrysts of potassium feldspar reaching sizes of 6 cm. Late-stage mineralizing fluids, rich in iron and magnesium (known as propylitic alteration) worked their way through zones of the

monzonite with higher permeability, resulting in an alteration mineral assemblage of epidote and albite with minor chlorite and calcite. This alteration targeted the feldspar, resulting in pseudomorphs of epidote/albite after orthoclase. However, the replacement is most often observed in fracture fillings and rounded "pods" up to about 20 cm in diameter. Most feldspar phenocrysts within these zones are replaced, while the effects of the replacement outside of the zone are sporadic.

Minerals and Mineralogy

XRD analysis of unaltered potassium feldspar failed to distinguish the species. XRD analysis of the replacement mineral matched clinozoisite; however, because of the pistachio green color, we assume the mineral is the isostructural epidote. Further analysis is needed for both the precursor feldspar species and the replacement species to determine the identity unequivocally. Small albite crystals form a replacement texture on the outside of the phenocrysts; some replaced by epidote and some unreplaced. Based on the replacement, it appears that the rind of the phenocrysts was less susceptible to epidote alteration. Replacement is variable within the phenocrysts, although the majority of crystals are fully replaced. Surficial replacement often consists of albite, and the crystals can exhibit cracks as a result of the volumetric change during pseudomorphism or later weathering. A mix of single crystals and Carlsbad-law twinned crystals are found at the locality. The twins are both morphologically left- and right-handed pairs. Only two Baveno twins have been found, making them the rarest type of crystal growth. Coveted groups of intergrown crystals are found occasionally, as well as parallel growth crystals. Matrix specimens are occasionally found, and are some of the more desirable specimens from the locality. Since the crystals are found as phenocrysts, they have no point of attachment, and are fully complete all around when not broken by the weathering process.

Fig. 1 Caption: A comparison of an unaltered (4.2 x 3.1 cm) and an altered twin (4.1 x 3.1 cm). Note that the unaltered crystal still shows signs of surficial pitting, demonstrating that many of the defects of the pseudomorphs may have been defects in the original feldspar. The orthoclase twin is also one of the very few relatively complete crystals found on the mountain. Philip Simmons specimens. Photo by Erin Delventhal and Philip Simmons.
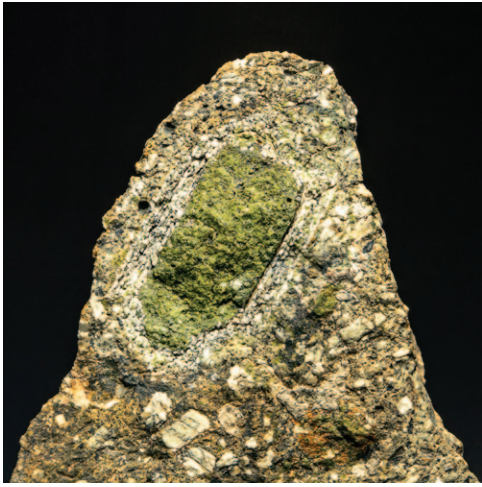
Fig. 2 Caption: A cross-section of a broken epidote pseudomorph exhibiting a rind of concentric layers of flattened albite crystals, crystal is 3.0 cm long. Also of note are the other feldspar phenocrysts that, even in close proximity, show little sign of epidote alteration. Mike Sanders specimen. Photo by Erin Delventhal and Philip Simmons.

Bio: Erin Delventhal

Erin Delventhal grew up collecting minerals with her family – long road trips were punctuated with detours where she and her brothers could get dirty (and very tired) while collecting minerals. Photography and design took precedence as a hobby and a profession for many years, but a visit to the Tucson Gem & Mineral Show rekindled her love for minerals. She rejoined the mineral community with enthusiasm and has since been an active member in several organizations ranging from local to international, has been involved in mineral museums, symposia, and other educational programs, and has joyously returned to a life punctuated by getting dirty (and very tired) while collecting minerals. Among other things, Erin works as a freelance photographer, photo editor, and graphic designer.

The Sweet Home Mine—Silver to Rhodochrosite

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INTRODUCTION

The Sweet Home Mine is nestled at timberline (11,600') near the head of Buckskin Gulch in the Alma Mining District in the Mosquito Range, central Colorado. The mine's veins lie within Precambrian granite gneiss intruded by Tertiary monzonite porphyry. Paleozoic formations, mostly limestone/dolomite, have hosted most of the precious and base-metal production from the Alma district. However, the Sweet Home mine vein system is not in Paleozoic formations. "A possibility exists that this vein system continues updip into the Paleozoic units capping Mount Bross above the mine and to the east." (Misantoni & others, 1998).

Pb-Ag mining began in 1872--the mine holds U.S. Patent #106--one of the 1872 Mining Law's oldest. Like so many of Colorado's old silver mines, the Ag-bearing veins were elusive and yielded no bonanza. "As silver mines go, the Sweet Home mine was a failure. It was a hole in the ground that devoured hopes and money, and gave very little in return. Based solely on its unimpressive silver output, the Sweet Home should have faded into obscurity and abandonment a century ago, joining many others that became nothing more than collapsed portals and flooded workings" (Voynick, 1998). However, the tenacity of miners allowed this mine to operate intermittently for over 120 years. From the 1870's to the 1890's, the silver miners also mined rhodochrosite specimens, which were sold to museums in the United States and Europe. Rugged topography, extreme elevation, poor roads, and long, bitter winters finally put the end to the marginal silver mining. The last Ag mining occurred in 1966, when a specimen of rhodochrosite ($MnCO_3$) was sold by miners for $2500; that specimen, now in the Houston Museum of Natural Science, was estimated to have a value of $250,000 in 1998. Far more money has been made from Sweet Home rhodochrosite than was ever made from silver. Early production records for silver at the Sweet Home Mine have not been located. This was not the case for some of the other mines on the side of Mt. Bross and Mt. Lincoln, which by 1878 had produced more than $3 million in silver (Voynick, 1998). Beeler (1933) estimated the extent of the original 5 tunnels of the Sweet Home Mine at 1,040 feet and that "these ores were sometimes almost unbelievably rich, there can be no doubt, and there is no doubt as to the haphazard manner in which they were mined and the product scattered, often leaving no record except a local legend of what had been found."

In 1991, with an investment capital of $300,000, the mine was reopened by Sweet Home Rhodo, Inc., but silver was hardly the target; instead, cherry-pink, gemmy rhodochrosite was the commodity of interest. Like most mining, times got rough and Sweet Home Rhodo, Inc. went broke after 1.5 years, just as they hit a pocket of gemmy rhodochrosite. Borrowing more money, they were able to mine the material, which included
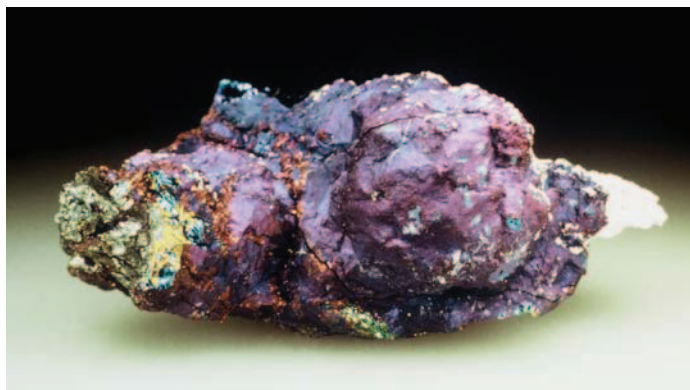

Figure 1. Bornite in association with chalcopyrite and pyrite from the Tetrahedrite Pocket. This is the environment in which Ag-rich digenite, stromeyerite, and spionkopite formed. Crystal group is 7.6 cm in length. Sweet Home Rhodo, Inc. collection; photo by Jeff Scovill.

"museum grade" rhodochrosite along with fluorite, tetrahedrite, sphalerite, and hübnerite. The Coors Foundation bought the biggest of these specimens, the Alma King, and donated it to the Denver Museum of Nature and Science.

SILVER

For over a century silver was believed to occur in argentiferous galena (Patton, 1912). However, in 1998, microprobe analyses (Wenrich, 1998) showed little Ag in the galena. Rather it occurs in small crystals of the Ag-Cu-sulfide, stromeyerite, and in Cu-sulfides, such as digenite, bornite, and tetrahedrite (Table 1, Fig. 1). Had previous miners been privy to this information they might have been more successful in their quest for silver.

RHODOCHROSITE

Although the early Sweet Home miners failed to find a silver bonanza, they did find well-developed, deeply colored, euhedral crystals of rhodochrosite as early as the 1870's (Voynick, 1998). 100 years later in the 1970's, Leonard Beach, the owner at that time, realized that if the Sweet Home Mine was to have a future it was in rhodochrosite, not silver. Over the past 100 years the Sweet Home Mine has produced rhodochrosite of extraordinary beauty--it is unrivaled in its striking color by rhodochrosite from any other locality in the world (Fig. 2).
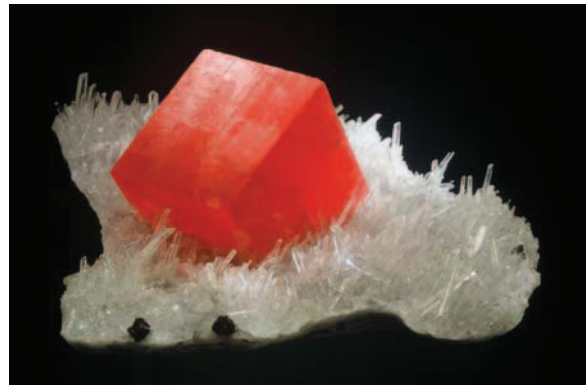

Figure 2. Rhodochrosite on quartz, 10.4 cm, from the Blueberry Pocket, found through GPR exploration work. Photo by Jeffrey Scovil.

An ambitious petrographic/electron microprobe study was undertaken at the Sweet Home Mine, supported by Sweet Home Rhodo, Inc. Analyses of 127 rhodochrosites containing 28 elements each were completed from 13 pockets in the Sweet Home Mine. Likewise, extensive analyses of the associated sulfides were completed. Geochemical halos and geographic trends in the mineral chemistry were helpful for rhodochrosite exploration. Although tetrahedrite (high Sb) is higher in silver than is tennantite (high As -- Table 1), high quality cherry red rhodochrosite tends to be associated more with tennantite (Wenrich, 1998).

SULFIDES—Ag-bearing
Tetrahedrite/Tennantite $(Cu,Fe,Ag,Zn)_{12}(Sb,As)_4S_{13}$

Tetrahedrite/tennantite is closely associated with rhodochrosite at the Sweet Home Mine. Tetrahedrite is more common at the Sweet Home Mine than tennantite. An almost complete solid solution exists between tennantite (100% arsenic) and tetrahedrite (100% antimony) at the Sweet Home Mine. Forty-nine analyses show the tetrahedrite/tennantite spans a range from $Sb_{02}As_{98}$ to $Sb_{91}As_{09}$ (Table 1, Fig. 3). Such compositional variation occurs not only on a large scale throughout the mine, but also on a small scale as well; individual crystal clusters vary through as much as 60% of the solid solution series.
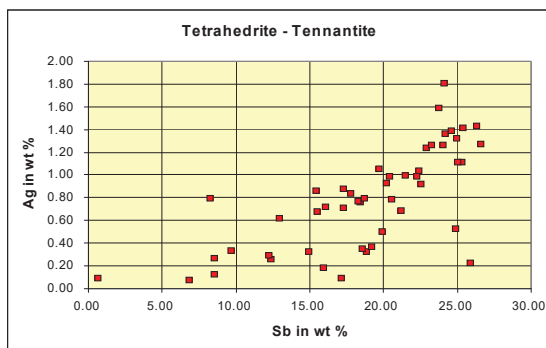
Figure 3. The concentration of silver increases with increasing antimony in the zincian tetrahedrite/tennantite series. Electron microprobe chemical analyses of 49 tennantite/tetrahedrite crystals from samples collected throughout the Sweet Home Mine.

Some of the silver mined from the Sweet Home Mine from 1872 until 1966 undoubtedly was extracted from the tetrahedrite (Fig. 3). A direct linear correlation exists between the concentration of silver and that of antimony in tetrahedrite/ tennantite (Fig. 3) because Ag

substitutes for Cu more readily in Sb-rich tetrahedrite than in the As-rich members of the tetrahedrite/tennantite series. The concentration varies from 1.8 wt. % (18,000 ppm) Ag in Sb-rich tetrahedrite down to 0.08 wt. % (800 ppm) in As-rich tennantite.

An average of 15 atomic % of the copper in the tennantite/tetrahedrite structure is replaced by Zn. Few samples contain Zn concentrations that deviate more than 2% from this 15% substitution for copper. Therefore, this sulfosalt series at the Sweet Home Mine is most properly named zincian tetrahedrite or zincian tennantite.

Bornite (Cu_5FeS_4), Digenite (Cu_9S_5), Spionkopite ($Cu_{39}S_{28}$), Stromeyerite (AgCuS), and Jalpaite(?) (Ag_3CuS_2)

All five of these copper sulfides contain silver at the Sweet Home Mine and were probably the major source of silver for the mining operations from 1872 to 1966, although the early miners may have thought it was coming from the associated "argentiferous" galena (see Table 1 and Fig 4 for galena/copper sulfide associations). Stromeyerite is sparse, but where present, it is a major silver mineral (Table 1) and would have contributed significantly to the Ag ore. Four analyses were made of a Ag-rich copper sulfide that was very fine grained (2 microns); the electron microprobe results for all 4 analyses gave low totals, which was probably a result of the very small size of the grains and the minerals slightly oxidized nature. The stoichiometry of this phase is not clear because of the poor totals and partial oxidation, but it is not stromeyerite. It has tentatively been identified as jalpaite(?)--Ag_3CuS_2--(Table 1), but the stoichiometry works out to an oxidized jalpaite(?)--$Ag_{1.56}Cu_{0.41}S_{1.36}O_{0.62}$.

Figure 4. Reflected light photomicrograph of pyrite (Py-yellow), chalcopyrite (Ccp-gold), galena (Gn-light gray), digenite (surrounding Stro-blue-gray), bornite (Bn-maroon), stromeyerite (Stro-purplish pink—small grain in center of photo). Sample from the Main Stope. Horizontal field of view is 0.24mm. Photo by Karen Wenrich.

A bluish copper sulfide that petrographically used to be called blaubleibender covellite was described in 1981 as spionkopite ($Cu_{39}S_{28}$). Covellite was identified petrographically by Honea (1992), and a bluish mineral from the Main Stope that appears to be covellite was also observed petrographically during this study. However, this "covellite" was analyzed on the microprobe (4 analyses) and all results closely calculate stoichiometrically to $(Cu,Ag,Fe)_{39}S_{28}$. They are therefore referred to here as spionkopite (Table 1). They contain significant amounts of silver, 23-38% (weight percent).

No native silver was observed during these petrographic and electron microprobe studies. All of these copper sulfides have anomalous Hg concentrations, which in one case is over 4 wt.%. None of these copper sulfides are as common at the Sweet Home as sulfides such as pyrite, galena, sphalerite, or chalcopyrite. However, some nice samples have been discovered in the mine (Fig. 1). Figure 4 shows the association of all of these copper sulfides plus galena, pyrite, and chalcopyrite.

A graph of silver versus copper in bornite (Fig. 208, Wenrich and Modreski, 1998) illustrates a direct inverse correlation between the two elements, indicating that silver has substituted for copper in the crystal lattice. These copper sulfides occur late in the paragenetic sequence and have apparently replaced earlier sulfides (Fig. 209, Wenrich and Modreski, 1998). Locally they fill skeletal tetrahedrite crystals, and, as also shown in Fig 209, Wenrich and Modreski (1998), wormy galena can be observed to lie within bornite that has partially replaced the galena.

Chalcopyrite $CuFeS_2$

The chalcopyrite formed distinctly later than the pyrite as can be seen in Figure 201, Wenrich and Modreski (1998), where the chalcopyrite fills fractures in the pyrite. A significant amount of Zn and Ag have substituted into the chalcopyrite structure in a few samples (Table 1), although in general, the chalcopyrite is
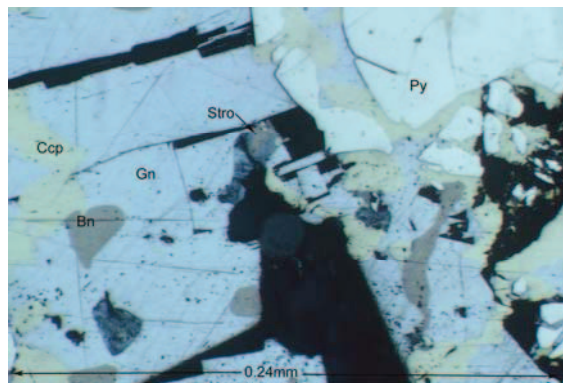
pure $FeCuS_2$ for most of the 32 analyses (Wenrich and Modreski, 1998).

Galena   PbS

    Galena forms cubes and octahedrons (Fig. 5) at the Sweet Home Mine, and is associated with copper sulfides, particularly chalcopyrite, bornite, and the sulfosalt tetrahedrite/tennantite. Although most of the 31 galena analyses show pure PbS, a few contain over a percent Zn. According to Patton and others (1912, pp. 226-227) "argentiferous galena is the principal mineral mined where the ore is unoxidized." Although electron microprobe analyses show that some galenas from the Tetrahedrite Stope, Main Stope, and Red and Blue Pocket do contain silver, galenas from other areas of the mine contain little to no silver (Table 1). Even where the galena is "argentiferous", the concentration of silver is <0.45 wt.%--significantly lower than that contained in most of the copper sulfides, bornite, digenite, and tetrahedrite (Table 1), and certainly less than in the Ag-Cu-sulfides, stromeyerite, spionkopite, and jalpaite(?). Modreski (1988) analyzed several galena crystals from the Sweet Home Mine on the scanning electron microscope and found no samples with Ag >0.48%.
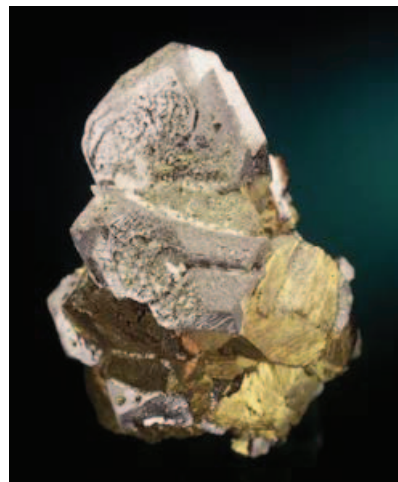
Figure 5. Galena octahedron coated with later chalcopyrite. Galena crystal, from the Rainbow Pocket, is 3.1 cm high. Photo by Jeff Scovil.

SULFIDES—Non-Ag-bearing
Pyrite FeS_2

    Pyrite is by far the most common of the sulfides and also the earliest formed. The crystals are generally euhedral and associated with quartz or other sulfides. The pyrite is surprisingly pure FeS_2 with little substitution of other elements. Electron microprobe analyses of 31 pyrite crystals indicate the concentrations of As, Ni, Pb, Cd, Sb, Ca, Mn, Mg, P, Ba, V, Si, Al, K, Ti, Se, and W are <0.02.

Sphalerite   ZnS

    The sphalerite is moderately pure ZnS in all 56 sphalerite analyses, except for very minor substitution of Cd and Fe for Zn (Table 1). The compositionally pure sphalerite commonly formed gemmy golden orange (Fig. 6) to gemmy golden yellow crystals. Amazingly, only a very small amount of Fe replacing the Zn caused the sphalerite to be opaque (Fig. 202, Wenrich and Modreski, 1998). Zones of submicroscopic (<1 micron) opaque needles are aligned within some sphalerite. Other sphalerite is clear and colorless, with wispy golden patches. Electron microprobe analyses did not detect any compositional differences (Table 1) between the clear inclusion-free sphalerite and the golden sphalerite.

    Minor increases in Fe in sphalerite occur in areas where the rhodochrosite is likewise contaminated by Fe, such as in the Tetrahedrite Stope, whereas the Main Stope, where some of the purest rhodochrosite resides, contains some of the purest sphalerite.

Figure 6. Golden orange sphalerite crystal, 9 mm, intergrown with quartz crystals. Photo by Jeff Scovil.

OXIDES, FLUORIDES, and PHOSPHATES
Hübnerite $MnWO_4$

    The hübnerite from the Sweet Home Mine is very close to the pure end member of the hübnerite-ferberite solid solution, so much so that in thin section the color is a gemmy orange. This orange translucent color is visible along the thin edges of large hübnerite blades (Fig. 7). When a thin slice of the crystal is cut and the slice is viewed with transmitted light in a microscope, distinct compositional banding is obvious (Fig. 7). The

gemmy orange bands are essentially pure $MnWO_4$. Only a very small amount of iron (around 0.35 weight percent) substituting for the Mn is required to turn the orange hübnerite into black bands. The hübnerite in several samples is associated with muscovite and with chalcopyrite (Fig. 8).

Figure 7. Transmitted plane light photomicrograph of a single gemmy orange hübnerite blade from the Coors Pocket. Note the compositional banding. Gemmy orange bands are essentially pure $MnWO_4$. Only a very small amount of iron (<0.35 wt. %) substituting for the Mn is required to turn the orange hübnerite into the black bands. Horizontal field of view is 1.05 mm. Photo by Karen Wenrich.

Figure 8. Large single blade of hübnerite associated with chalcopyrite from the Rainbow Pocket, 2.5 cm. Photo by Jeff Scovil.

Fluorite CaF_2

Fluorite formed during two distinct separate stages: (1) an early green fluorite, and (2) a later purple fluorite. Electron microprobe analyses of the fluorite indicate that these minerals are very pure and stoichiometric. As is normally the case, the color in fluorite is not due to any detectable changes in trace element impurities. The late stage purple fluorite is wispy in places, but microprobe analyses do not show any compositional variations between the purple wisps in and the colorless wisps. This is not surprising, because the color in fluorite has generally been attributed to physical properties other than compositional variation. However, extensive studies on the color in fluorite indicate that some colors appear to be attributable to trace concentrations of rare-earth-elements well below the lower detection limit of these elements on the electron microprobe.

Fluorapatite $Ca_5(PO_4)_3F$

Elongate doubly terminated apatite grains were found as inclusions within the rhodochrosite in samples from both the Empty and Red & Blue Pockets. Electron microprobe analyses indicate that they are fluorapatite (Table 14, Wenrich and Modreski, 1998).

Triplite $(Mn,Fe,Mg,Ca)_2(PO_4)(F,OH)$

Three grains of triplite occur as small inclusions (about 20 microns each) in fluorapatite that rims a large rhodochrosite crystal from the Empty Pocket. The electron microprobe analyses of the triplite were very stoichiometric considering the size of the grains that were analyzed (Table 14, Wenrich and Modreski, 1998)

SILICATES

Muscovite $KAl_2(Si_3Al)O_{10}(OH,F)_2$

Muscovite books are not uncommon in the Sweet Home Mine. Electron microprobe analyses were made of muscovite from the Corner Pocket, Coors Pocket, Watercourse Drift, and the Red and Blue Pocket (Table 15, Wenrich and Modreski, 1998). The most common occurrence of the muscovite is in radiating aggregates in association with hübnerite (Fig. 213, Wenrich and Modreski, 1998).

Topaz $Al_2SiO_4(F,OH)_2$

Topaz inclusions are very common in the quartz crystals associated with rhodochrosite, fluorite,

sphalerite, and tetrahedrite/tennantite. Electron microprobe analyses of two topaz crystals indicate that the mineral is stoichiometric and has almost no detectable trace elements.

Quartz SiO_2

    Quartz was the earliest formed mineral in the Sweet Home Mine suite and formed well-developed terminated crystals onto which many of the subsequent minerals grew. Large quartz crystals are commonly surrounded by sulfides, particularly tetrahedrite, chalcopyrite, and sphalerite.

Dickite $Al_2Si_2O_5(OH)_4$

    Very fine-grained clusters of greenish crystals of dickite were found and analyzed on the electron microprobe (Table 16, Wenrich and Modreski, 1998).

CARBONATES

Rhodochrosite $MnCO_3$

    Rhodochrosite commonly occurs as a gangue mineral in mines throughout the world. However, it rarely occurs in a gemmy, lustrous red form like that from the Sweet Home Mine in the Mosquito Range. Unfortunately, not all rhodochrosite that comes from the Sweet Home Mine is as red and gemmy as those in the Good Luck Pocket and Watercourse Drift, because a rind of lighter pink rhodochrosite coats the gorgeous cherry-red interior of many specimens from the Sweet Home Mine. The lower quality rhodochrosite fills fractures in the cherry rhodochrosite, and forms rinds around many crystals, demonstrating that it is clearly later than the cherry rhodo (Fig. 9). This indicates that rhodochrosite in the Sweet Home Mine formed in two
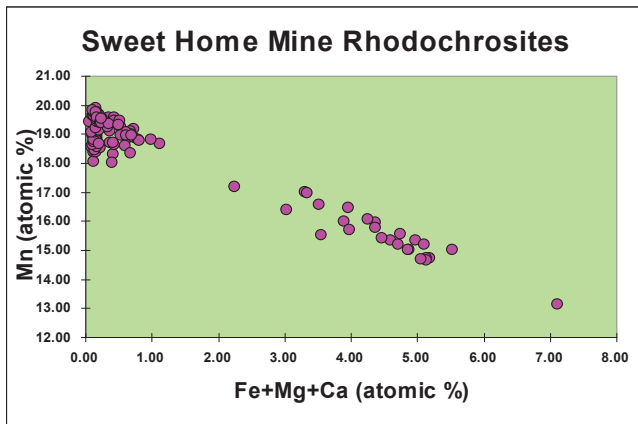

Figure 10. Summary of 127 electron microprobe results showing Mn versus Mg+Fe+Ca in atomic percent. There is a distinct break in composition between the two stages of rhodochrosite. The gemmy, cherry-red rhodochrosite consistently has Mg+Fe+Ca contents that are <1%, whereas the lower quality pink rhodochrosite has >2% up to 7% Mg+Fe+Ca. Fig. 9 shows color result of impurities.

Figure 9. The gemmy rhodochrosite in the center of the specimen formed earlier at a higher temperature and is essentially pure $MnCO_3$, whereas the later, lower-temperature, lighter pink rhodochrosite contains several percent Ca+Fe+Mg in substitution for Mn in the rhodochrosite structure. Sweet Home Rhodo, Inc. collection.

distinctly different stages of mineralization. Pink material contains as much as 7% (atomic) Fe+Mg+Ca replacing Mn in the rhodochrosite structure, whereas the cherry-red gemmy material is consistently <1% total Fe+Mg+Ca (Fig. 11). Such pure $MnCO_3$ is rare in nature and relatively unique to the Sweet Home Mine. It is clear that there are areas within the mine that consistently show the low Fe+Mg+Ca signatures in rhodochrosite. The low Fe:Mg:Ca signatures signify areas where higher temperature and higher value, cherry-red rhodo may be found (Fig. 10).

CRYSTAL CHEMICAL ZONING IN THE SWEET HOME MINE

Most minerals in the Sweet Home Mine are relatively pure stoichiometric end members. However, tetrahedrite/tennantite and rhodochrosite are not. Tetrahedrite/tennantite spans most of the solid solution series between the two end members - from $Sb_{02}As_{98}$ to $Sb_{91}As_{09}$. Although rhodochrosite does not have such extensive solid solution, the content of Fe+Ca+Mg substitutes significantly for Mn, such that the color of rhodo is dramatically altered (Fig. 11) (Wenrich, 1998). Likewise, sphalerite shows very minor enrichment of Fe.

Coincidentally the "contamination" of rhodochrosite, tetrahedrite, and sphalerite generally occur within the same areas of the Sweet Home Mine. High antimony tetrahedrite/tennantite, higher-Fe+Ca+Mg rhodochrosite, and higher-iron sphalerite all occur in the Tetrahedrite Stope whereas these same minerals in the Main Stope remain relatively pure. The Coors Pocket and the Watercourse Raise contain some low and some moderate trace-element substitution in their crystals.

Higher As tetrahedrite/tennantite and low Fe sphalerite correlate nicely with the areas of the highest quality, gemmy cherry-red rhodochrosite. The best comes from the Main Stope, and if these four areas are ranked, the Tetrahedrite Stope is fourth in quality. Figure 214 in Wenrich and Modreski (1998) shows mine drift cross sections; if these cross sections are studied, one can see that the purer material comes from pockets along 2 parallel structural trends.

Figure 11. Cherry rhodochrosite is transparent in thin section whereas the lower-quality pink rhodochrosite forms rims and fills fractures that are dark and cloudy. Electron backscatter image; horizontal field of view is 250 μm. A traverse of spot chemical analyses was made across this sample, providing an excellent demonstration of the substantial variation in Fe, Ca, and Mg content between the cherry and pink rhodochrosite. The spots are recorded by number on the photograph and correspond to the sample numbers in the following table of Fe, Ca, and Mg contents in weight percent. Note the low Fe content for spots 4-7 and the associated clear purity in the backscatter image.

	1	2	3	4	5	6	7	8	9
Fe	8.8	8.6	9.2	1.2	1.2	1.3	1.3	9.1	9.0
Ca	0.7	0.6	0.7	0.1	0.1	0.1	0.1	1.1	1.1
Mg	0.6	0.6	0.7	0.1	0.1	0.1	0.1	0.8	0.8

PARAGENESIS

The most prominent minerals at the Sweet Home Mine have been placed into a paragenetic sequence of formation based on their interrelationships as observed in hand specimen, and their decreasing temperature of formation measured by T. James Reynolds (1998). Minerals that can have their temperature of formation calculated from fluid inclusions, such as rhodochrosite, fluorite, topaz, quartz, and sphalerite can be placed into such a diagram as shown in Fig. 12 with a fair degree of accuracy. However, the opaque minerals such as pyrite, galena, chalcopyrite, and tetrahedrite/tennantite had to be worked into the paragenetic sequence based on their interrelationships as observed in hand specimen, and with those minerals that have measured fluid-inclusion filling temperatures.

Fluid inclusion temperatures determined by Reynolds (1998) indicate that the early cherry stage of rhodochrosite formed at about 325°C, whereas the later, lower-quality pink stage formed at temperatures <200°C.

CONCLUSIONS

The electron microprobe has provided quantitative chemical analyses of most mineral phases known to be present in the Sweet Home Mine, including some that are a mere 2-3 microns in size. Owners of Sweet Home sulfide specimens can feel more confident in the mineral identifications put on the labels for their specimens than is often possible from other mines where no specimens have been chemically analyzed.

Overall, the samples analyzed during this study indicate that there is twice as much tetrahedrite as tennantite and that the two phases are intricately intergrown in many samples.
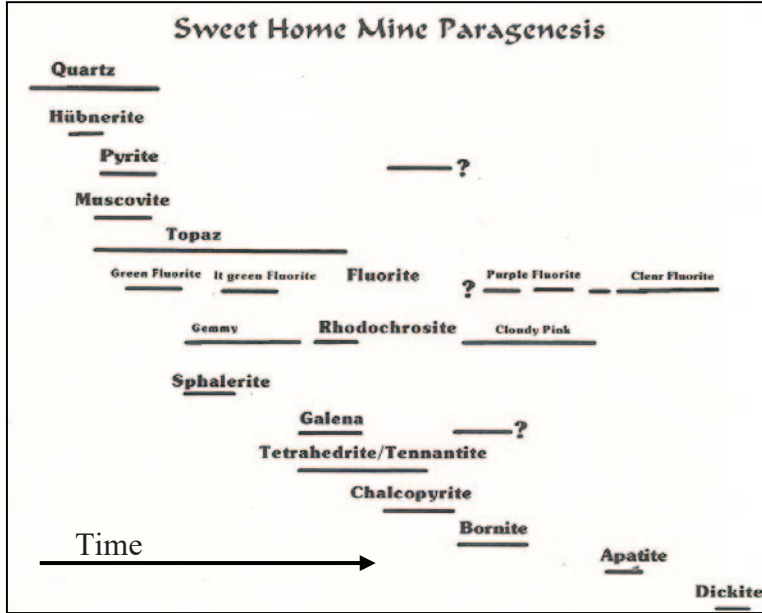

Figure 12. Graph showing the paragenetic sequence for the dominant minerals found at the Sweet Home Mine. Note that quartz and pyrite are the earliest-formed minerals, while rhodochrosite and fluorite appear to have formed over a longer period of time and at much lower temperatures. Fluid inclusion filling-temperatures were determined for rhodochrosite, fluorite, quartz, and sphalerite (see Reynolds, 1998); hence, these minerals are more firmly established on the paragenesis sequence than are the remainder of the minerals.

Analyzed veins and pockets that show elevated iron contamination in the sphalerite and high antimony to arsenic ratios in the tetrahedrite/tennantite (toward the tetrahedrite end member) match up with the same veins and pockets that contain Fe+Ca+Mg contamination in the rhodochrosite.

Areas that contain such trace-element contamination of sphalerite, tetrahedrite, and rhodochrosite have historically produced lower quality rhodochrosite. The cherry-red rhodochrosites were deposited early from moderately high temperature Mn-rich fluids that were very different from the late, low-temperature, Mn+Fe+Ca+Mg-rich fluids that deposited the pink rhodochrosites.

Sweet Home Rhodo, Inc. used this information successfully as an exploration tool. When a sulfide vein was encountered and contained higher As tetrahedrite/tennantite and low Fe sphalerite, it was explored further, because the probability of discovering a pocket with high quality, gemmy cherry rhodochrosite is much greater than with high Sb and Fe sulfides veins, which were avoided.

Alteration ages of 28-31 Ma were determined by K-Ar dating of sericite vein selvages adjacent to quartz-pyrite-hübnerite veins and polymetallic, base-metal, rhodochrosite veins (Missantoni & others, 1998). These ages are similar to mineralization ages at the Climax Mine, <7 km to the NW. Lüders and others (2009) believe that "mineralization at the Sweet Home Mine occurred coeval with the final stage of magmatic activity and ore formation at the nearby world-class Climax molybdenum deposit about 26 to 25 m.y. ago." The abundant sulfide mineralization associated with fluorite and rhodochrosite as gangue minerals, and occasional quartz-pyrite molybdenite veins, are similar to peripheral epithermal mineralization at the Climax and Henderson Mo deposits. So, it is possible that the Sweet Home Mine mineralization is the uppermost expression of a deeper-seated molybdenum deposit. Stable isotopes and fluid inclusion results suggest early stages of alteration/mineralization took place in a high temperature, magmatic-dominated hydrothermal system at 375-400°C (Reynolds, 1998). These fluids later cooled and became increasingly meteoric in origin. No phase separations (boiling, etc.) occurred and no high-salinity fluids were present (Reynolds, 1998). Open-space euhedral quartz began growing at 350-375°C (Reynolds, 1998), followed by topaz, muscovite, hübnerite, tetrahedrite/tennantite, fluorite, sphalerite, and rhodochrosite. Rhodochrosite formed in two stages: (1) The earliest at about 325°C resulting in a pure, gemmy, cherry-colored $MnCO_3$, and (2) A later <200°C impure stage that has up to 16% Fe+Mg+Ca replacing Mn. This cation substitution significantly reduces the value of the specimens. The Sweet Home Mine has produced millions of dollars in mineral specimens between 1991 and 2004--a far better bonanza than was ever reaped by silver production.`

Table 1. Selected electron microprobe chemical analyses of Sweet Home sulfides. Values are in weight percent. Al, Ca, Cd, Co, K, Mg, Mn, Ni, P, Se, Si, Ti, V, and W were also determined, but all were less than 0.03%.

A. Sample Location	Ag	As	Sb	Cu	Zn	Fe	Pb	Ba	Hg	S	Total
Tennantite-Good Luck Pocket	0.09	19.8	0.6	43.9	8.7	0.2	<.03	<.03	<.03	28.6	102.2
Tennantite-Main Stope	0.13	13.3	8.6	41.0	7.8	0.2	0.12	<.03	<.03	26.9	98.0
Tetrahedrite-Watercourse Vein	0.68	9.2	15.5	40.4	7.2	0.6	<.03	<.03	<.03	26.9	100.6
Tetrahedrite-Watercourse Vein	1.43	1.9	26.3	37.8	7.0	0.2	<.03	<.03	<.03	25.3	97.7
Tetrahedrite-Coors Pocket	0.51	5.5	19.9	39.5	7.8	0.4	<.03	<.03	<.03	26.2	99.8
Tetrahedrite-Museum Pocket	1.81	2.7	24.1	38.2	7.7	0.1	<.03	<.03	<.03	25.2	101.8
Tetrahedrite-Empty Pocket	0.88	3.7	17.3	38.0	7.8	0.1	<.03	<.03	<.03	26.1	98.7
Bornite--Good Luck Pocket	1.6	<.03	<.01	58.5	0.09	12.9	<.01	0.17	0.41	25.9	99.7
Bornite--Main Stope	5.2	<.03	<.01	55.9	0.05	10.7	<.01	0.24	0.43	24.5	97.1
Digenite--Empty Pocket	0.2	<.03	0.10	75.3	0.04	3.3	<.01	0.14	0.65	22.1	101.9
Jalpaite(?)--Museum Pocket	65.7	<.03	<.01	9.8	<.01	0.2	0.06	<.01	--	8.4	86.6
Jalpaite(?)--Museum Pocket	65.2	<.03	0.12	9.9	<.01	0.2	<.01	0.12	--	8.5	87.0
Spionkopite--Main Stope	23.6	<.03	<.01	46.4	0.04	5.4	0.21	0.21	0.16	24.0	100.1
Spionkopite--Main Stope	25.1	<.03	0.03	47.6	0.02	1.1	0.14	0.11	<.01	24.5	98.7
Stromeyerite--Main Stope	50.7	<.03	<.01	29.8	0.04	0.01	<.01	0.22	4.13	16.1	101.1
Stromeyerite--Main Stope	52.0	<.03	<.01	33.6	0.10	0.09	<.01	<.01	0.49	19.1	105.5
Chalcopyrite-Coors Pocket	<.01	<.03	<.03	33.7	3.0`	29.5	<.03	<.03	<.03	34.8	100.1
Chalcopyrite-Museum Pocket	1.39	<.03	<.03	34.5	0.2	29.8	<.03	<.03	<.03	34.4	100.6
Chalcopyrite-Red+Blue Pocket	<.01	<.03	<.03	33.4	<.01	30.5	<.03	<.03	<.03	35.0	99.3
Galena-Corner Pocket	<.01	<.03	<.01	0.01	0.03	<.01	86.4	<.03	<.03	13.3	100.0
Galena-Coors Pocket	<.01	<.03	<.01	0.24	0.78	0.23	85.7	<.03	<.03	13.7	101.0
Galena-Museum Pocket	0.02	<.03	<.01	0.07	<.01	0.04	87.1	<.03	<.03	13.5	100.8
Galena-Pyrite Pocket	0.32	<.03	0.03	<.01	0.70	0.06	84.5	<.03	<.03	13.6	99.55
Galena-Red & Blue Pocket	0.44	<.03	0.06	0.03	0.02	0.06	84.9	<.03	<.03	13.6	99.76

*Jalpaite(?): This mineral identification is very tenuous. The analysis is suspect because of the low totals. However, the approximate proportion of silver to copper should be reasonably accurate, roughly 3:1. The mineral is partially oxidized--the samples contain 1.56% and 1.98% oxygen respectively, and the totals are very low indicating an unreliable analysis. Such oxygen concentrations calculate to about 8.5 atomic % oxygen. Both samples also contain Al: 0.53% and 0.71%, respectively.

EPILOGUE

In late 2016, following a lengthy permitting and approval process with state and federal agencies, initial work began creating an access road to the site of the new Detroit City Mine entrance; work trailers and heavy equipment were brought in. By 2019, two lovely pockets had been discovered. Since 2019, some rhodochrosite has been discovered, but generally occurs in massive veins with no vugs for large crystal growth. In the Sweet Home Mine most of the crystals were attached to quartz, which provided a firm matrix for the cherry pink rhodochrosite crystals. In contrast, the Detroit City Mine rhodochrosite crystals lie on sulfides, which commonly crumble, leaving the crystals with little to no matrix.

After two dry years, 2022 brought good production from 2 major pockets in the Detroit City Portal. Beautiful rhombs of rhodochrosite, some with gorgeous fluorite dusted on their surface, range in size from small rhomb clusters to specimens almost 2" across.

Running a mine at 12,000' is expensive and challenging, especially during winter months. Keeping the road passable is difficult, and even with backup equipment, there are constant setbacks. Although progress at the mine is slow, it is steady, and beautiful specimens will continue to come out of the Detroit City Portal.

Figure 13. Detroit City Mine Rhodochrosite with Fluorite, 10.8cm wide, 6.4cm high. Mined in 2019 Pocket 19-02.

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Fluorite from the Oatman District, Mohave Co., Arizona

by Mark Hay

Introduction

The quaint and colorful mining town of Oatman lies in the northwest corner of Arizona, nestled among the dramatic volcanic spires and cliffs of the Black Mountains. Like many western mining towns, its heyday was a long time ago. Early in the last century, Oatman was a bustling mining center known for rich gold deposits. Names like the Tom Reed, Gold Road and the United Eastern mines commanded respect in mining circles and created excitement with investors. Between the years 1907 and 1932 these mines yielded over $36,000,000 in gold bullion.

The big gold mines may have quickened the pulse of mining men and investors but they offered virtually nothing to the mineral collector. For that we must look to the small outlying mines to the north along the sides of Hardy Mountain and Silver Creek. With few exceptions, veins in that area, though a bust financially often carry fluorite as a gangue mineral and to the good fortune of mineral collectors, the veins are vuggy and the fluorite is crystallized.

Geology

The geology can be summarized as a depositional sequence of tertiary volcanic units that have been locally intruded by volcanic necks, porphyry stocks and dikes. The volcanic units consist of basalts, tuffs, trachytes, latites, dacites, andesites and rhyolites that dip from zero to 35 degrees to the east. They have been cut by numerous high angle faults and fractures trending west-northwest. The ore deposits of the district including those hosting fluorite invariably occur in these high angle structures. Fluorite is widespread in west-northwest trending veins cutting the plutonic porphyritic stocks in the northern part of the district – especially the Moss and Times porphyrys.

Fluorite

Fluorite occurs in a range of colors and forms. The most common color is green but it can range from colorless to rich lime green to dark purple. In some rare cases bi- and tri-colored crystals have been found.

Crystals are commonly octahedral with silky to rough composite faces. Under a hand lens or microscope they are seen to be formed by many tiny cubic crystals arranged in classic fashion to form the octahedron. In most instances, the crystals are an inch or less in size though crystals to four inches on an edge have been found at the Homestake mine. Cubic and cuboctrahedral crystals do occur but are rare. When found they are invariably small,

a half inch or less, and very pale to colorless. An unnamed prospect north of Silver Creek yielded a small number of dodecahedral crystals to just over an inch with frosted faces.

Throughout the area, the fluorite occurs on massive, white, vein quartz and matrix pieces are the rule. Pockets in the quartz are often coated by drusy quartz which makes an attractive backdrop for the fluorite crystals. In many instances the quartz will form a partial to complete secondary overgrowth on top of the fluorite of small gemmy crystals. Rarely quartz will occur as slender, prismatic, milky crystals to four inches or more. Occasionally the large quartz crystals will have fluorite crystals along their sides.

Collecting History

The first recorded visit to the district by a mineral collector was the well known 19th century Yale University mineralogist, Benjamin Silliman, Jr. In 1866, Silliman authored a tantalizing report describing "beautiful octahedral crystals of green, white, and purple" coming from the Skinner lode and other properties.

It appears the next time the district would be visited by serious field collectors would not occur for over a hundred years. In the early 1980s, brothers Brad and Jeff Archer were successful in collecting fluorite specimens from a mine in the Silver Creek area. Specimens from their discovery can be found in several local collections including that of Les and Paula Presmyk (Gilbert, AZ) and the Flagg Foundation (Phoenix, AZ).

Then in 1993, the author and Dick Morris visited the district in search of fluorite. They explored the area for over thirteen years and made numerous fluorite discoveries. They enlisted local residents and part time miners, Randy McIntosh and Mike Van Stratten, in their search for fluorite. Randy and Mike made numerous fluorite discoveries on their own starting in about 2000.

The mines that were the most productive to collectors have been those along the north and east sides of Hardy Mountain. Specifically the Oregon, Homestake, Jackpot, Hardy and Skinner Lode.

The Mines

Oregon Mine (Navy Group) – The Oregon Mine is located in T19N, R20W, Section 6, on the western end of the east-west trending Hardy vein. Fluorite occurs sporadically in the first several hundred feet of the main tunnel as pale to medium green octahedral crystals to one inch on quartz. Based on discussions with Brad Archer and the physical appearance of the specimens they recovered, the Oregon is likely the source of the specimens he and his brother Jeff found.

Homestake Mine – The Homestake Mine is on the Hardy vein about 2,400 feet east of the Oregon. The workings consist of three tunnels driven into the vein, one above the other. The middle tunnel, though only twenty five feet long, was the source of the greatest number of high quality specimens. Crystals occur as pale to lime green octahedrons, many exceeding an inch in size. Rarely crystals to four inches or larger have been found. Larger crystals often exhibit intense color but are usually more rounded, without the crisp octahedral form of the smaller crystals. Cubic crystals occur but are rare and invariably small, a quarter inch or less.

The fluorite occurs on massive milky quartz coated with milky to clear drusy quartz crystals. Occasionally larger single and groups of quartz crystals are found but they rarely exceed two inches in length.

Jackpot Mine – The Jackpot Mine, also on the Hardy vein, is about 1,000 feet east of the Homestake. The mine consists of several small tunnels and shafts. Fluorite occurs sporadically inside the mine and in some of the small surface pits and cuts. The most notable specimens were found circa 2003 by Randy McIntosh and Mike Van Stratten. They consist of watery green octahedral crystals to an inch with ghostly pale purple edges on quartz matrix.

Hardy Mine – The Hardy Mine is one of the larger and older mines in the district. It's named for William Harrison Hardy, a pioneer active in local commerce and territorial politics in the 1860s. He laid out the community of Hardyville near present day Bullhead City where he established a post office and a ferry connecting Arizona and California. At the time, Hardyville was the northern most navigable point on the Colorado River.

The Hardy Mine is on the eastern end of the Hardy vein where it intersects Silver Creek. It consists of numerous tunnels and shafts almost all of which contain abundant fluorite. The crystals occur as attractive blue-green octahedrons and modified cubes to an inch or less on quartz matrix. The quartz is often spongy, highly etched and massive but occasionally it occurs as well formed, milky crystals to an inch or more.

Skinner Lode – The Skinner Lode, as mentioned earlier, was one of the properties Benjamin Silliman visited in 1866. The Skinner, as well as the other mines that he noted, were subsequently lost. However, thanks to the diligent efforts of Randy McIntosh and Mike Van Stratten, the Skinner Lode was rediscovered in 2005.

The Skinner Lode is not on the Hardy Vein. It is on a separate, parallel structure about a third of a mile to the north. Fluorite from the Skinner Lode is very similar to that from other area mines except for color. Rather than various shades of green, they are predominately purple and occasionally bi- and even tri-color. The bi- and tri-color crystals show alternating layers of light to dark purple, light to dark green and occasionally colorless fluorite. Some of the most striking specimens have quartz crystals to four inches that are partially to completely encrusted with purple fluorite octahedrons.

Conclusion

The Oatman district is the most prolific locality in Arizona for high quality fluorite, the finest of which are comparable to octahedral fluorite from any locality in the US. The chances of additional collector grade fluorite being discovered in the area are excellent as many of the mines are still accessible and contain abundant fluorite. However, the mines discussed above, including the Skinner Lode, are currently under claim and access is denied without permission from the owners.

Bio: Mark Hay

Long version (153 words):

Mark grew up in southwest Colorado where he developed a love of mountains, rocks and nature. His family moved to Scottsdale, Arizona when he was in high school. After graduating from Arizona State University with a degree in geology, he worked at the Magma Mine in Superior, Arizona. Magma was an underground, hardrock copper mine known to mineral collectors for its beautifully crystallized of barite, calcite and pyrite. It was there that his interest in mineral collecting began. That was almost 45 years ago. Today, he specializes in Arizona minerals but also has small suites from other US localities. He and Dick Morris, his long-time partner, did extensive field collecting in Arizona starting in the mid-1980s. This led to Minerals of Arizona, a retail mineral business he ran with Dick until they closed it in 2021. Mark has authored or co-authored over ten articles on collecting and Arizona localities for the Mineralogical Record.

Where did that Turquoise come from?
A case study of the turquoise deposit from Bisbee, Arizona

by Dr. Mark Pecha

It is often possible to determine the geographical origin (aka provenance) of gemstones/gemstone material due to the innate relationship between the physical and chemical characteristics of certain minerals and the geological environment in which they formed. This provenance determination is often achieved through trace and rare Earth elemental analysis using either laser induced breakdown spectroscopy (LIBS) or laser-ablation inductively coupled plasma mass spectrometry (LA-ICPMS). In the case of turquoise, both archaeological and geological studies have primarily focused on trace element geochemistry (concentrations and/or isotopic ratios) of the turquoise itself.   However, due to the complex nature of most turquoise, these studies have often been met with limited success. To avoid these complexities, we have developed a novel approach to turquoise provenance assessment by characterizing the host rocks of the turquoise for their detrital zircon age signature, coupled with U-Pb isotopic age determinations of the actual turquoise. These techniques provide two independent lines of evidence, thereby enhancing the possibility of a robust provenance assignment. A total of 695 U-Pb laser analyses have been completed on three host rock samples of the basal Glance conglomerate, yielding a complex age spectrum with 7 prominent age peaks. We have also conducted U-Pb raster analyses on the turquoise which yield a Tera-Wasserburg intercept age of 11.3 ± 1.5 Ma (1-sigma). This age is indistinguishable from the U-Pb age (12.04 ± 0.13 Ma, 1-sigma) that we obtained from another supergene phosphate mineral, metavariscite, which also came from the Lavender Pit. The analyses indicate that supergene mineralization was taking place in this part of the district along the Dividend Fault, ca. ~12.8 to 9.8 Ma. These results provide the basic groundwork for future isotopic analysis and comparisons with other turquoise and secondary phosphate minerals from Bisbee or around the world.

Bio: Dr. Mark Pecha
Dr. Mark Pecha received his BS (2008), MS (2013), and Ph.D. (2019), all from the University of Arizona. For the past 14+ years he has been the research manager for the Arizona LaserChron Center (ALC), which is a National Science Foundation Community Facility designed to address problems in Earth science through the generation of geochronologic and geochemical data using laser ablation ICP mass spectrometry. Mark's research is primarily focused on the geologic and tectonic history of the North American Cordillera, but he also has a keen interest in the geology of ore deposits, and their associated minerals. He is an avid Arizona mineral collector but specializes in Bisbee specimens which tell an interesting geologic story.

The Peculiar World Inside the Geodes From Trancas Station, Aldama Municipality, Chihuahua Mexico

by Jeffrey R. Smith

Google Trancas Station geodes and you will quickly discover numerous individuals and mineral dealers offering the geodes for sale. Attend a mineral show and you will likely see vendors offering Trancas Station geodes for cracking. In fact, the Google search will reveal that Trancas Station geodes are being offered by dealers overseas. Even though these geodes have been on the market for over 50 years, there is very little site-specific information regarding their origin.

As I prepared for this presentation, I performed a literature search from various sources, and found general information that the geodes occurred in rhyolite, are mined at the surface, have unusual quartz crystals and contain fluorescent chalcedony. In conjunction with my 19 trips to the Las Choyas geode mine over the past 24 years, I have had the opportunity to investigate and field collect at the Trancas Station geode deposit three times - in 2002, 2013 and 2014. In the past 6 months, in preparation for this presentation, I have photographed and cataloged over 900 Trancas Station specimens from my collection. The geode deposit appears to be far more complex in its origin and mineralization than what was found in my literature search.

In the early 1970's a rancher found pieces of sparkling rock on the ground while herding his cattle. As he investigated the area he realized he had discovered a new geode deposit. The Trancas Station geode deposit is located approximately 15 miles northeast of the town of Aldama. The Trancas Station geode deposit is so named because it is adjacent to an old railway line and train stop (Trancas Station) along the route from Chihuahua City to Ojinada. Before it was known as Trancas Station, the area was called Piedras Negras (Black Rock), and was originally settled as a "colonia" or colony in the early 1900's, when a group of Mexican citizens purchased approximately 80,000 acres of land from the government to establish a community with it's own leaders and governing body. The geode deposit was discovered on a portion of the original colonia.

 Geologically, the geodes occur in rocks within the Chihuahua Tectonic Belt. This belt is a northwest-trending fold-and-thrust fault zone that extends through eastern Chihuahua, Mexico. From the Paleozoic through the Cenozoic, thousands of feet of marine limestone were deposited. During the Tertiary, volcanic activity occurred at the site, depositing rhyolite with void spaces unconformably on top of the limestone. Meteoric water with dissolved minerals percolated through the preserved voids to form the geodes.

Since the geode-bearing rock is flat-lying and exposed at the surface, a variety of mining equipment and techniques have been employed. Surface mining has been the primary mining method, with a few shallow underground tunnels.

Quartz is the primary mineral in the geodes, occurring in crystals with fascinating shapes and designs. The geochemical conditions are not completely understood; however, conditions must have been changing rapidly during crystallization to create these complex forms. Typical hexagonal quartz crystals are rare in Trancas geodes. Chalcedony is fairly common in botryoidal form and fluoresces green under short-wave UV light. A high percentage of individual clear quartz crystals contain white cylindrical cores of chalcedony. Calcite is the main secondary mineral and occurs in a variety of morphologies. Microminerals occur and SEM analysis was performed on several of my geodes in 2003. The analysis suggests the presence of hollandite, romanechite, and psilomelane. In specimens I've collected since then, I've observed what appear to be cryptomelane micros, and further examination may identify other microminerals as well. As a side note, around the edge of the deposit where the underlying limestone is exposed, various marine fossils can also be found. As mining continues at the deposit, additional specimens will be available for continued study.

This presentation seeks to contribute to the ongoing scientific research on the geodes from Trancas Station in an effort to begin developing a model for origin of their unique crystallization.

Bio: Jeff Smith

Jeff Smith field collected his first geode in a creek bed in Tunnelton, Indiana in 1974. He earned an MS in Geology from West Virginia University. Jeff worked as a PA Licensed Professional Geologist (retired) with the Department of Environmental Protection in Pittsburgh for 30 years. Since 1999 Jeff has also owned Jeff's Geodes, offering unique presentations and sales of geodes from Indiana and Mexico. He has made 19 field collecting trips to the Las Choyas geode deposit, and 3 field collecting trips to the Trancas Station geode deposit in Chihuahua, Mexico in the last 24 years. During one collecting adventure, Jeff cracked open a rare Las Choyas geode containing mordenite which now resides in the Carnegie Museum in Pittsburgh. Jeff has authored 3 articles on geodes for Rocks and Minerals magazine (2007, 2010, 2023). He is a mineral photographer with published photos in Rocks and Minerals magazine and the book "Geodes, Earth's Treasures." In 2005 one of Jeff's photos of a quartz formation inside a Trancas Station geode won 3rd place in the Macro Division at the Tucson Gem and Mineral Show Mineral Slide Competition.

Figure 1. Jeff Smith in the mining pit at the Trancas Station geode deposit in 2014. Hector Carrillo photo.

Figure 2. Sue Smith "waiting for the train" at the Trancas Station geode deposit in 2002. Jeff Smith photo.

Figure 3. Quartz cluster, 1 cm wide, in a Trancas Station geode, ID No. JRS-T144A. Jeff Smith photo and specimen.

Figure 4. Quartz structure, 1.5 cm tall, inside a Trancas Station geode, ID No. JRS-T359A. Jeff Smith photo and specimen.

Figure 5. Quartz group, .75 cm tall, inside a Trancas Station geode, ID No. JRS-T187A. Jeff Smith photo and specimen.

Three Decades of Collecting Adventures in the Hansonburg Mining District, Socorro County, NM

by Mike Sanders

The Hansonburg mining district is located in central New Mexico (NM) and is approximately 34 miles southeast of Socorro, NM. The district can be reached by driving 30 miles east on U.S. Route 380 to the tiny community of Bingham. Mines in the district are then accessed by turning south on dirt roads and traveling approximately 3 to 5 miles to the various mines in the district. The district is located just north of the northern boundary of White Sands Missile Range. The Blanchard mine in the southern part of the district is approximately 11 miles as the crow flies from the Trinity Site where the first atomic bomb was detonated in 1945.

The Hansonburg district is located on the west side of the Sierra Oscura range. The deposits are hosted in Pennsylvanian-age marine limestones. Estimated age of these deposits range from 6.1 to 8 Ma. Mineralization is controlled by north-south striking, deep seated faults on the east side of the Rio Grande rift, a tensional geologic structure that spans the entire north-south length of NM. Mineral specimens occur in numerous crystal-lined vugs that are mainly found in the 4.5 to 6 meter thick Council Springs formation of the Madera group.

The main mines in the district include the Royal Flush, Mex-Tex and Blanchard mines in the northern, central and southern parts of the district respectively. The deposits were discovered by non-native prospectors in about 1881 and commercial mining and milling activities occurred sporadically from about 1916 to 1979. Attempts to mine potentially economically viable ore (barite and lead) from these deposits by various operators through the decades have likely been marginal at best.

Notable mineral specimens from this district were recovered starting in the 1950s. The earliest Hansonburg district specimens in the NM Bureau of Geology and Mineral Resources Mineral Museum in Socorro are from the Mex-Tex mine, and were donated at that time. Apparently very little effort was made to save and preserve

Figure 1. Western General Resources mill constructed late 1970's at the Blanchard mine. DeMark photo, 1987.

mineral specimens by commercial operators prior to the 1950s. From a mineral collector perspective, it is difficult to envision the number of extraordinary crystal specimen vugs that

were mined, crushed and destroyed during early ore production operations in the district! Mineral specimen collecting activities gradually increased starting in the 1960s by local mineral dealers, students from various NM universities (primarily NM Tech in Socorro) and many other visitors to the district.

Figure 2. Specimen mining operation by Sam Jones at the Blanchard mine, 1973.

In 1987 it was determined that the previous claims on the Blanchard, Mex-Tex and Royal Flush mines had lapsed, and they were immediately re-staked by Ray DeMark, Brian Huntsman, Robert Dickie and Tom Massis. I started collecting with the above individuals in district mines in the late 1980's and then had the good fortune to become a Blanchard mine claim owner along with Ray and Brian in 1994 when I purchased Robert's share in the claims. It is the sole intention and focus of current claimants to work these deposits strictly for the production and preservation of fine mineral specimens for current and future generations. When our tenure is done at these properties, it also our intent to transfer these claims to those who would continue to preserve the mineral specimen legacy from this marvelous district.

Hansonburg district mines are renowned for countless numbers of high-quality mineral specimens of fluorite, galena, barite and notable secondary copper and lead sulfate and carbonate minerals including linarite, brochantite, cerussite and others. To date, over 80 individual mineral species have been identified from this famous mineral specimen locality. This talk will focus on and will summarize our major discoveries and mineral specimen recovery operations since our claims were staked in 1987. Since 1987, mineral specimens have been recovered by hand-digging methods and heavy equipment including backhoes at first, and then seven projects using track-mounted excavators (trackhoes). Most (but not all) of the operations were successful and resulted in thousands of mineral specimens produced

from the various mines in the district from 1987 to the present using these methods.

Figure 3. Specimen mining and reclamation operation at the Blanchard mine, summer 2013. Sanders photo.

In addition, three formal social events called "An Evening at the Blanchard" were held starting in 2001.
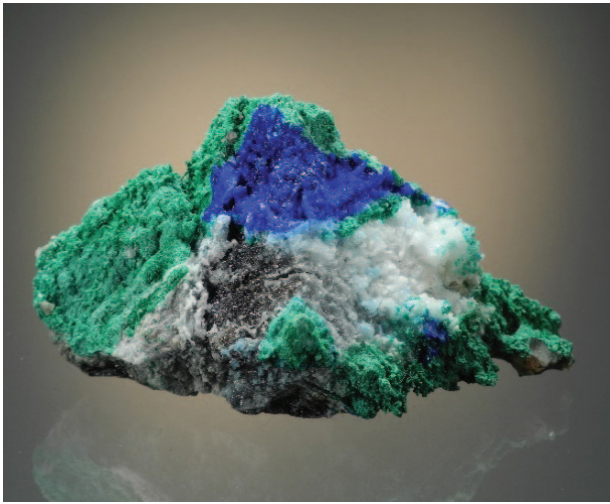
Figure 4. Linarite, Brochantite, Cerussite, Anglesite on Galena, Blanchard mine. 9 cm wide. Sanders photo.

Figure 7. Fluorite with Quartz on Galena, Blanchard mine. 17 cm. wide. Sanders photo.
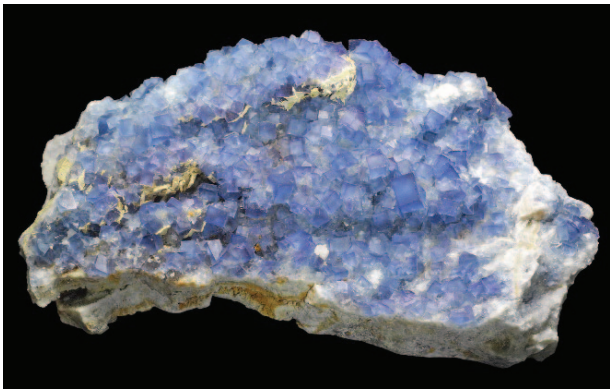

Figure 5. Fluorite on Quartz, Blanchard mine. 30 cm wide. Sanders photo.

Figure 8. Fluorite with Quartz on Galena, Blanchard mine. 75 cm. wide. NM Bureau of Geology and Mineral Resources Mineral Museum specimen, Mark Mauthner photo, 2024.

Figure 6. Fluorite on Quartz, Blanchard mine. 17 cm upper left to bottom right. Sanders photo.