# 26TH ANNUAL MINERALS OF ARIZONA SYMPOSIUM


## APRIL 13TH, 14TH and 15TH 2018
## DRURY INN - TEMPE

**CHAIRPERSONS:**
Phil Richardson
Ray Grant

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# Minerals of Arizona

## Twenty-sixth Annual Symposium
## Sponsored by the
## Flagg Mineral Foundation

**Friday, April 13, Saturday, April 14 and Sunday April 15 at the Drury Inn**
**Tempe, Arizona**

**Co-chairpersons**
**Phil Richardson**
**Ray Grant**

Cover Design by Don Boushelle

From Top going Clockwise

Red Cloud Mine, Trigo Mountains, La Paz Co., Arizona - Evan Jones Collection, Jeff Scovil photo

79 Mine, Dripping Spring Mountains, Gila Co., Arizona - Mark Hay Collection, Chris Whitney Smith photo

Defiance Mine, Gleeson, Dragoon Mountains, Cochise Co., Arizona - Allminerals.com, John Betts Fine Minerals photo

Rowley Mine, Theba, Painted Rock Mountains, Maricopa Co., Arizona - The Arkenstone, Joe Budd photo

## Saturday, April 14 - Symposium Program

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| 8:00 - 9:15 - | **Coffee Hour** |
| 9:15 – 9:30 - | **Welcoming Remarks and Introductions** |
| 9:30 – 10:10 - | Arizona Pseudomorphs – Barbara Muntyan |
| 10:10 – 10:40 - | **Break** |
| 10:40 – 11:20 - | How Wulfenite Became the Official State Mineral of Arizona– Evan Jones |
| 11:20 – 12:00 – | The Cause of Color of Wulfenite – Dick Zimmerman |
| 12:00 – 1:00 - | **Lunch** |
| 1:00 – 1:40 – | The Pioneer Mining District, Pinal County, Arizona - Les Presmyk |
| 1:40 – 2:20 – | Remembering Dr. Arthur Steadman Roe - Anna Domitrovic |
| 2:20 – 2:40 - | **Break** |
| 2:40 – 3:20 - | Heavy Metal: Gold, Silver, and Tungsten Mineral Collecting Opportunities around Quartzsite, Arizona – Erik Melchiorre |
| 3:20 – 4:00 - | The University of Arizona Gem and Mineral Museum |
| 4:00 - | Visit Dealers at the Drury Inn meeting room |

6:00 - Mexican Dinner Banquet at the Drury Inn, speaker Catie Carter, Museum Curator: The Arizona Mining, Mineral and Natural Resources Education (MMNRE) Museum: A rebirth of the Arizona Mining and Mineral Museum under the University of Arizona.

# Twenty-sixth Minerals of Arizona Symposium

## Introduction

This is a year to celebrate Arizona minerals and mineral collecting. We have an official state mineral, wulfenite. See Evan Jones abstract in this volume. (Dick Zimmerman asked a simple question: What causes the color of wulfenite? And he will share hundreds of hours of research on the answer.)

The mineral museums in both Tucson and Phoenix are moving forward. We will have presentations today about both projects. Twenty-six years ago at the first symposium we had the morning session devoted to the mineral collections in Arizona. The program consisted of:

Terry Wallace – University of Arizona Mineral Collection

Anna Domitrovic – Arizona-Sonora Desert Museum Mineral Collections

Glen Miller – Arizona Mining and Mineral Museum Mineral Collection

Bob Jones – Private Mineral Collections in Arizona

This year Anna Domitrovic will have her 26th presentation at a symposium, followed by Les Presmyk giving his 23rd talk and Barbara Muntyan trying to catch them with her 11th talk. The regulars are great, but we are always looking for new speakers, so if you have an idea, talk to Phil or Ray.

# ARIZONA PSEUDOMORPHS

Barbara L. Muntyan

Pseudomorphs (Latin for "false form") are a varied and interesting group of mineral specimens appreciated by many collectors. Surprisingly, little has been written on pseudomorphs, especially on places and conditions where they form. Arizona has many localities which have produced pseudo-morphs. The most common are the result of alteration in carbonate deposits – azurite to malachite or chrysocholla. Indeed, virtually all of the porphyry copper deposits in the State have produced noteworthy examples of pseudomorphs. Perhaps the best-known are the "Roman sword" malachite @ azurite clusters from several mines in Bisbee, notably the Junction and the Cole. A close second are the velvet malachite pseudo-rhombic crystals on tenorite matrix from the New Cornelia mine in Ajo. But there are also numerous examples of azurite altering to malachite from Morenci, from the Silver Hill mine, and many other locales thru out the state.

Chrysocolla pseudomorphs after azurite or malachite are also found in copper deposits in Arizona. Some of the best have been found in the oxide zone at Bagdad as the open pit was being developed. These specimens are after azurite crystals up to 4" in length. Excellent examples of chrysocholla @ malachite or azurite are also found in Globe-Miami, especially from the Old Dominion mine.

Alteration pseudomorphs can be found in many granitic deposits. Sharply defined specimens of limonite @ pyrite have been found at the Belmont mine in Washington Camp/Duquesne, at the Fat Jack mine, at the Willow Springs locale, and many other locales around the State. The Willow Springs deposit is also well-known for alteration of schorl crystals to micaceous pseudomorphs, some to 6" in length. Some pseudomorphs after pyrite are not limonitic, but rather are hissingerite (iron silicate). No testing has been done, but a casual field observation by the author suggests that hissingerite is fairly common throughout Arizona and is often mistakenly identified as limonite.

Pseudomorphs often form as a result of weathering processes. Perhaps the best-known and most prolific locality is the salt mine near Camp Verde, AZ, which has produced replacement pseudomorhs of calcite @ glauberite. These have formed crystals up to 3" monoclinic crystals in cream, milk-white, tan, or grey color as single, sharp crystals or clusters without matrix. A lesser amount of selenite @ glauberite have been found at this locale. Since these pseudomorphs form as a result of evaporation, it is likely that this locality will keep on producing pseudomorphs for many years to come.

Arizona also boasts a wide selection of encrustation pseudomorphs, or "perimorphs". Some purists do not recognize these as true pseudomorphs because they do not fit the classical definition of a pseudomorph, namely a molecule-by-molecule replacement of one mineral by another, exactly filling the same volume as the original crystal. Encrustation pseudomorphs are more like icing on a cake: taking the form of the underlying material but being slightly larger than the original. Quartz perimorphs are found in a number of localities in Arizona, with the original crystal form easily identifiable.

One of the finest localities for quartz perimorphs is found in the South Comobabi Mountains in Pima County. Calcite schalenohedra to 4"tall are replaced by a fine-grained quartz druse coating. Each of the ridges in one area of the South Comobabis has a characteristic appearance of differing quartz pseudomorphs. While most are white or pale amethystine crusts after scalenohedra, white quartz druses after calcite forming sharp rhombs have also been found. Rarely, quartz casts of cubic fluorite, often forming on top of quartz @ calcite specimens are also found.

Another important locality for quartz pseudomorphs was a find made in Duquesne on the ridge between the North and South Belmont mines in 2001 by Paul Harter, Gene Schlepp and Jim Bleess. They were looking for Japan-law twins of quartz when they hit a chain of three large, cave-like vugs. While there were a few quartz twins, the really noteworthy find was a series of quartz clusters with quartz @ calcite shoveled onto the dump and abandoned. Following directions from Paul Harter, Don Belsher of Colorado and I located the dig and sifted the extensive dumps. We were able to recover over two flats of pseudomorph specimens.

Perhaps the most alluring find of quartz pseudomorphs has been found at the Piedmont Mine in Yavapai County. These are quartz coatings over pseudo-rhombic malachite @ azurite specimens. The crystal surfaces range from fine-grained milky quartz to gemmy quartz points over emerald-green, light green-to-whitish, or dark green, large crystals. Although the legend is that these specimens were out of a single pocket, it is fairly clear to any knowledgeable field collector that several vugs produced the variety of specimens. They are an icon of Arizona pseudomorphs, and perhaps the rarest.

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# Wulfenite – The Official State Mineral of Arizona

Evan A. Jones

For mineral collectors, perhaps no other mineral species is more closely associated with the state of Arizona than wulfenite. The reasons for this are many. Chief among them: Arizona has arguably produced the finest examples of the species in the world. Wulfenite specimens from Arizona can be found in mineral collections and museums the world over.

In addition, the sheer number of different locations in Arizona where high quality collectible wulfenite specimens can be found is unlike any other region in the world. Numerous weathered and oxidized hydrothermal lead deposits in the state have produced tremendous volumes of specimen material in a wide variety of crystal forms, habits, colors and mineral associations.

Several years ago a group of determined and enterprising collectors and mineral groups decided to spearhead a movement to make wulfenite the official state mineral of Arizona, joining turquoise as the official state gemstone, petrified wood as the state fossil, and copper as the state metal.

Due to their efforts and together with support from members of the Arizona State Legislature, this culminated in the passing of HB 2092 in March 2017 establishing wulfenite as the official state mineral of Arizona much to the delight of local collectors. This presentation is the story of how HB 2092 came to be.

## The Causes of Color in Wulfenite

Dick Zimmermann

The many colors and habits of wulfenite (lead molybdate) crystals make them desirable collector specimens. Various specimens have been described as yellow, bright yellow, wax-yellow, honey-yellow, grey yellow, yellow-orange, bright orange, reddish-orange, pink, bright red, brown, reddish brown, orange brown, greenish brown, yellowish grey, gray, grayish white, white (rarely), colorless (rarely) green, siskin-green, olive-green, blue, pale to dark blue, and even black. Yet pure lead molybdate is colorless. Natural, colorless samples are rare, but they do exist. Specimens have been collected at the San Rafael Mine in Nevada, the Tsumeb mine is Namibia, and the Ojuela Mine in Mexico.

In an attempt to determine the causes of color in natural wulfenite crystals, over 200 technical and scientific papers were reviewed, as well as over 120 additional abstracts. Unfortunately, the large amount of information gathered and reviewed did not provide a straightforward answer to the question. The color of wulfenite, a structurally simple mineral, is determined by a variety of different variables, many of which are not well identified. In general, the colors are caused when impurities or structural defects cause selective light absorption (if the crystal absorbs blue and green light, then it appears yellow or red). However, the specific impurities and defects causing color in wulfenite are not, according to the literature reviewed in this survey, well understood.

The large volume of literature related to wulfenite consists of two groups. The first was published by mineralogists and chemists over the last 150 years. The second, and much larger group, was published by engineers and material scientists over the last 50 years. Interest in commercially grown wulfenite crystals blossomed when it was discovered that it has unique properties making it useful for special semiconductor applications. Current uses include sensors for radiation measurement, electro-optical devices for telecommunications, specialty lasers, and even as catalytic material to harvest energy from sunlight and produce hydrogen. The engineering literature does not use mineral names. Wulfenite references can only be found by searching for lead molybdate.

In the late 1800s, bright red wulfenite crystals from various locations attracted particular interest. Various chemists analyzing wulfenite crystals attributed the color to Cr and V. Thereafter, some publications cite Cr, and some cite V. It was not until the mid-1900s that some controlled experiments were conducted to prove that Cr can make wulfenite yellow or red, depending upon concentration. No references with any controlled experiments with V were found. So, while it has been established that small percentages of Cr can make wulfenite red, the possibility of other impurities also making it red has not been eliminated.

No impurity is even required to cause color. Crystal defects that have been attributed to color in wulfenite include excess Pb, excess Mo, $O_2$ vacancies, and free electrons trapped in the molybdate tetrahedrons.

While pure lead molybdate is colorless, it is surprisingly difficult to grow colorless crystals in the laboratory. Whether grown from a solution or from a melt, they are usually light yellow. Since pure crystals are required for commercial applications, many studies have been performed to identify the cause of the yellow color. They have produced a dozen different explanations, none of which have been established as a common cause. Through trial and error, painstaking procedures for growing colorless crystals have been established without proving the causes(s) of the yellow color.

A number of studies have established a correlation between morphology and color in natural crystals. Pyramidal crystals tend to be red while platelet crystals tend to be yellow. Exactly what factors in the growth environment causes that have not been established. There appear to be too many variables to permit conclusive identification of cause and effect.

The reports on the causes of unusual colors such as black, blue, and green are particularly fragmented. Black has been attributed to inclusions, to pseudomorphing by another mineral, and even to gold inclusions. Blue has been attributed to Mo with a valence of 5 rather than 6, and green has been attributed to Cu. There is probably not a common cause for these colors in natural crystals.

Determining the cause of color in crystal can be extremely difficult. Analysis indicating the presence of a trace element does not establish that trace element is responsible for the color. The next logical step is synthesis. Growing crystal from high purity constituents with the trace element added can prove the trace element is a possible cause of the color, but is not conclusive. It just proves that the trace element may be the cause of a similar color in a natural mineral specimen. Conclusive proof requires eliminating other possible causes, not an easy task.

An extensive body of knowledge has been developed for the cause of color in gemstones. Much of that knowledge has been gained through synthesis. Because of the market for gems with desirable colors, there is financial support for supporting experimentation. Because wulfenite is too soft for a gemstone, a similar body of experimental information has not been developed for it.

Further complicating the identification of the cause of color in wulfenite is the incredibly small traces of impurities that can cause intense color. Cr, a common suspect of color in wulfenite crystal, need be present in only fractions of a percent or less. One paper claims that only a few ppm of Cr can color wulfenite. Often, the amounts of trace elements involved may have been within the margin of error of the analytical process used to detect them. Reports of the effect of 0.1 % Cr from work done 150 years ago in a wet chemistry lab may not be consistent with modern reports of 0.1 % Cr determined by microprobe analysis. Some papers claim that microbe analysis is less accurate (for *quantitative* evaluation of trace elements) than classical wet chemistry techniques.

Another complication is that natural crystals tend to be very nonhomogeneous. The exact composition, and the color, varies as growing conditions change. The crystals are often zoned, and analysis of one portion of the crystal may be representative of another portion of the crystal.

In spite of the large body of literature that was reviewed, firm evidence for the specific causes of color in natural wulfenite specimens was not found. Chemists and mineralogists were interested in explaining it in the late 1800s, but were frustrated by very low concentrations of trace elements and contradictory results. Some concluded that organic dyes must be involved. Laboratory evidence later proved that very low levels of Cr can cause yellow or red, but other possible causes were not eliminated. In particular, early claims that V colors wulfenite red were never disproved. There is little to no scientific support for the many and varied claims for other colors, including blue, green, and black.

The many engineering papers on lead molybdate provide a very detailed understanding of the structure and physical properties. However, engineering applications of laboratory grown lead molybdate involve wavelengths above and below the visual range. In particular, extensive studies have been conducted in the ultraviolet and infrared. The color of lead molybdate under white light is of no interest for engineering applications, and is usually not even reported.in the literature.

Acknowledgement: Dr. Jan Rasmussen provided the literature reviewed in this survey

Note: A far more detailed paper containing information gathered during the survey (by Zimmermann and Rasmussen) is available, see Dick for more information.

The references and bibliography also follow for anyone looking to find more information.

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**Additional abstracts:**

An additional 120 abstracts were reviewed but the papers were not. Full copies of the papers were not obtained because the abstract did not suggest there might be any information about color.

The Pioneer District, Pinal County, Arizona
Arizona Mineral Symposium – April 14, 2018

Les Presmyk

The discovery of the Silver Queen and Silver King mines in 1874 and 1875 and their development from 1875 to 1890 brought capital and settlers into the area that would ultimately help the construction of the railroads to make the rich and large copper deposits profitable. This was expecially true for the Silver Queen (now Magma) Mine. Specimen production of Arizona's finest silvers and some of the nation's best silver specimens occurred from 1875 to 1885. The Magma Mine would become known for its fine barites, pyrites and calcites.

## Mining History

### The Silver King Mine

In 1870, Colonel George Stoneman was given command of the newly established Military Department of Arizona and the project to build a military road connecting posts and forts in the southeastern part of the territory with those in the northern and central areas. He established Camp Pinal in May 1871, at the base of what we now know as Picket Post Mountain, a few miles west of Superior.

The army troops then set about building a road over and through the imposing escarpment known as Apache Leap. This road, later named the Stoneman Grade, would connect the farming and ranching community of Florence to the potential mining area of Globe. During the construction, one of the troops, by the name of Sullivan, found some chunks of heavy black rock. Although he was not educated in geology or mineralogy, he hoped he had found something potentially valuable. Sullivan gathered up several of the black rocks and told no one about his discovery.

After leaving the Army he found work at one of the ranches in the Florence area, about 20 miles to the southwest. At one point, he shared his discovery with his boss, a Charles Mason. He did not share the exact location of the find but gave Mason enough information to spark his interest. Not long after this conversation, Sullivan disappeared from the ranch.

In 1874, Mason and three fellow ranchers, Benjamin Reagan, William Long and Isaac Copeland, decided to start prospecting in the area. Once the crops were brought in, the winter months gave them plenty of time to do other things. They headed towards the Stoneman Grade, with the goal of prospecting in the Globe area and hoping to find Sullivan's outcrop. They discovered one promising outcrop, east of the original military camp of Pinal and named it the Silver Queen. Based on what Mason had seen of Sullivan's samples, he knew this was not the one they were looking for. They continued east up the Stoneman Grade to the Globe area, and were able to locate another prospect, which they named the Globe. This was part of what would become the Old Dominion complex.

The four men headed home to tend to their farms and ranches and decided to try it again in 1875. In March, they set off with a fifth friend, to bring samples back from their Globe claim. While returning, they were attacked by Apaches and one of the five was killed. As they escaped down the Stoneman Grade, they halted near the bottom of the steep grade and Copeland found Sullivan's original discovery. They continued on to the safety of Florence. The next day, March 22, 1875, they returned and laid out the Silver King claim. Along with their Silver Queen claim, they established the Pioneer Mining District.

Starting the next year, they began digging out material from the small hill. What they lacked in real mining and geologic knowledge, they made up for in effort. Their first shipment of "ore" to the Selby smelter in San Francisco cost them $1200. At that time, everything had to be hauled by wagon to the port of Yuma, placed on a ship, and taken around the Baja California peninsula and up the California coast to San Francisco, a total of over 1000 miles. These four ranchers had very carefully hand sorted the shiniest of the mineral chunks and shipped those, which was almost entirely galena and almost devoid of silver. Fortunately for them, four miners from the Comstock Lode in Nevada happened onto the site. The miners negotiated a 50/50 split agreement and proceeded to sort through the "waste" dump, this time hand selecting all of the truly rich silver ore. This shipment to the Selby Smelter resulted in a check for $50,000.

By the end of 1876, they had abandoned the open pit method and had sunk a shaft to a depth of 42 feet. In the meantime, two of the original discoverers sold out to Mason and Reagan. Mason sold out in January 1877 James Barney, a merchant from Yuma. At the same time, notice was taken of these rich concentrates coming into San Francisco and a group of San Francisco and Comstock interests established the Silver King Mining Company on May 5, 1877, with a capitalization of $10,000,000. Barney and Reagan signed over their interests four days later and became part of the company. Barney was named general manager and Reagan sold out his interest.

In December 1878, the main shaft had been deepened to 110 feet deep and a five stamp mill was constructed along Queen Creek, the closest source of water, near where Colonel Stoneman had established the Pinal military post. A steam hoist was installed, towns established as Silver King and Pinal and the mill was doubled in size to 10 stamps. Further expansions of the mill continued along with the main shaft reaching a depth of 830 feet by 1883. Silver ore was being extracted from seven levels and the mill was running 24 hours a day.

The teamsters driving the twenty-mule teams pulling four wagons, each carrying 11 tons of ore, customarily used whips to spur their teams to haul the ore. Then they discovered they could use chunks of rock from the ore wagon to do the same thing. They did not throw just any chunk of rock, only the richest pieces of silver would do for their fine mules. They had confederates who would follow along and pick up these high-grade chunks, not to throw back in the wagons but to apply to their own accounts. It was said the road ran between $5 and $10 in silver per ton.

The Silver King was able to continue production until 1891, with the last profitable year occurring in 1887.

The LS&A and Arizona Hancock Mines

Other mines in the immediate area included the LS&A and the Arizona Hancock. The LS&A (Lake Superior and Arizona) was discovered in 1885 and produced intermittently until purchased by Michigan copper interests in 1902. The Lake Superior & Arizona Mining Company was organized in Calumet, Michigan. The LS&A produced oxide copper ore for about 15 years. Magma Copper Company acquired the property in 1920. All of ore occurred along the quartzite/limestone contact where 50 years later the same horizon would produce the fine barites and pyrite at much greater depth. So, unlike the Magma vein this horizon experienced significant oxidation. The only known specimens are two gold specimens from here and are portions of the same specimen. In the late 1970s, Magma geologists spent some time in here and encountered a pocket of white calcite crystals. The mine operated for gold starting in 1932 for several years and once it shut down it has never reopened.

The Arizona Hancock (Black Prince) consists of a short adit. While it was not economically important, it has provided some interesting vanadinite specimens to the collector willing to spend time there. The specimens consist of scattered red vanadinite crystals up to 2mm on a grayish white calcite matrix. Unfortunately, it has become more of a place for the local youth to hold their parties.

The Magma Mine

Meanwhile work had begun on the Silver Queen, located just a few miles south, with indications and the hope it would be another rich silver mine. The first Silver Queen Company was organized in San Francisco by 1875 by the owners of the Silver King. However, all of their efforts were directed towards the Silver King and in 1880, a second company was organized by Philip Swain and associates in New York to buy out the San Francisco firm. Two years later, the shaft was 400 feet deep with most of the rich silver ore extracted in the first 200 feet. High grade copper mineralization replaced silver below the 200 foot level. In 1882, there was not any copper rich enough to support a mining operation in this remote part of the Arizona Territory. One specimen dates from this period, a small dioptase collected on the surface near the main shaft. No further work took place at the Silver Queen until around 1910 when the mine was bought by Boyce Thompson who renamed it the Magma Mine.

Located at the town of Superior, Arizona, about 60 miles east of Phoenix, the Magma Mine has been the main employer for this community since 1910. The history of the Magma Mine dates back to the same period as Bisbee and Morenci and concurrently with the Silver King, but its productive history as a mainstay of supporting a town and several generations of miners really begins around 1910. As rich as the ores were, its specimen production really only encompasses a quarter of a century, from 1959 to 1984. Although the Magma Vein extended over 4000 feet deep, the oxidation zone was no deeper than than 100 feet or so. It would prove to be barite and pyrite that finally awakened both the collector and the capitalist in the miners to start saving and selling specimens. Today, the Magma Mine remains Arizona's premier locality for barite and pyrite specimens and ranks among its top two or three localities for calcites.

Thompson and his engineers liked what they saw in the Silver Queen, and after purchasing the property he renamed it the Magma mine and established the Magma Copper Company. They deepened the existing shaft and drove additional drifts to explore the vein. More times than not, it is always better to be lucky than good, and the history of the Magma mine is no exception. They ultimately broke into a rich and large vein of high grade copper, enough to start making plans for the future. A mill was constructed in 1914, the first railroad in 1915 and the smelter in 1923 The future of the mine looked good and the town of Superior started to build and grow up around the mine.

In 1909, there was only one shaft that had been sunk directly on the vein. This was designated as number 1 shaft by Thompson. Once the extent of the vein was located down to the 800 foot level, #2 and #3 shafts were sunk, north and south of the Magma vein, respectively, to provide better access and ventilation for the mine. Although the initial ore was hoisted up to the collar of #2 shaft and brought down to the mill utilizing an aerial tramway, it was determined that a haulage adit on the 500 level was a better choice and was driven to both #2 and #3 shafts. These two shafts were used to move men, supplies and hoist ore and #3 shaft was utilized by Magma through its final closing in the 1990's, as was the 500 level adit. As mining progressed these shafts were deepened, ultimately attaining depths over 3600 feet. Shaft #4 through #8 were sunk for access, production hoisting and ventilation.

Specimens from this period are rare. While there almost certainly were pockets and openings in the veins, the mineralization just did not produce many attractive specimens. This was certainly the case in the replacement beds that will be described in the next few paragraphs.

Mining continued on the Magma vein through the 1960's. In addition, a smaller parallel vein called the Koerner was discovered and mined. During World War II, several zinc stopes were mined to support the war effort, much like what occurred in Bisbee. Once the government supported prices were removed, this mining stopped. In the 1950's, drilling discovered manto replacement beds in the limestones far to the east. These beds outcrop at the surface in Superior, starting with the basement quartzite with the Martin, Escabrosa and Naco limestones placed on top. At extreme depth and with solutions fed from the south along the North Boundary Vein of a conglomerate graben, massive beds of hematite, bornite, chalcocite and chalcopyrite had formed.

As mining began near #6 shaft in the uppermost of these beds, known as the A-beds, the richness and quantity of the ores gave the Magma Mine a new lease on life. As drilling continued, even larger orebodies were discovered to the east. The decision was made to sink #9 shaft on the far east side of these beds. In addition, the mill was expanded and a 7500 foot haulage adit was driven using a tunnel boring machine.

The Magma mine operated almost continuously from 1909 through 1984. The mine was one of the richest copper mines in the state, producing 8,000,000 pounds of copper, 50,000 ounces of silver and 2000 ounces of gold per month from 5% rock. It closed in 1984 due to high costs and the low selling price of 75 cents per pound for copper. The mine was shut down but not for long. bed material. With the exhaustion of these ores, the Magma mine shut down for what appeared to be the final time in 1995.

Minerals

As a general rule the mineralogy of the Magma Mine is relatively simple. Since there was little oxidation of the veins and manto replacements there was no opportunity for the various elements to mix and blend and develop the variety of minerals like at Bisbee or Tiger.

Barite

Barite is the mineral the Magma mine is most famous for, having produced crystals with a wide range of colors and sizes. The first best specimens were recovered in the A-bed stope from the 3000 to 2800 levels. As the mine was developing the additional replacement orebodies down to the 3600, the first to be encountered were these A-bed replacements at the quartzite/limestone contact.

As the mining progressed up dip in this area, the miners encountered a series of pockets, the likes of which had not been seen in this mine. Every blast seemed to open additional pockets. Barite crystals up to 3" long and ½" thick and in clusters up to 8" were collected, along with associated calcite crystals. The crystals ranged from clear golden to reddish to gray-green and to black. The reddish color is due to included hematite. The gray-green is due to included clay and possibly pyrite and the black crystals are due to either hematite or pyrite. Some of the crystals exhibit a rootbeer brown color with golden edges. Some barite crystals, generally black, occur with calcite crystals.

From about 1974 to the mine closing in 1984, a number of smaller pockets were encountered in various stopes and drifts throughout the mine. This collecting was due to a group of geologists and mining engineers employed at the mine who were also dedicated mineral collectors. A frothy pyrite zone in one of the drifts on the 3900 level was dug for a period of time by the geologists with some success but the barite crystals were few and far between. The most notable pocket was encountered in the 3600-4D stope about a week before Thanksgiving in 1982. Most of the specimens were under 2" in size but a few clusters up to 4" were found. Gypsum crystals up to 2" were found in clusters up to 5" across. The crystals were a light brown and were about ¼" across.

Calcite

Calcite is the most widespread mineral in the mine and not surprising considering that the mining from the late 1950's was in limestone replacement beds. Pockets of various sizes were occasionally encountered in the development drifts, since virtually all of the drifting was done in limestone. Even in the drifts that headed south into the conglomerate, crystals would be discovered in cracks and fractures. The crystals varied from ice clear rhombs to scalenohedrons to curved rhombohedrons. In numerous pockets, two and three types of crystallization might be evident.

Chalcocite

Chalcocite was one of the more common ore minerals but the veins either rarely produced crystals or because they were black and looked like hematite and so were rarely collected. One specimen exhibits typical bladed crystals up to ½" across in a 1.5" cluster. The most notable pocket came out of the 3200-5E stope in a vuggy face of hematite. The crystals were initially thought to be hematite until the assays came back showing the ore ran 20% copper.

Chalcopyrite

Chalcopyrite specimens were occasionally collected at the mine. Again, like chalcocite, bornite and hematite in the replacement beds, the orebodies did not lend themselves to providing vugs and openings in which crystals could occur. One pocket in the upper A-bed produced botryoidal chalcopyrite with a purple bornite surface, very reminiscent of the famous English material. One pocket of chalcopyrite crystals on white quartz crystals was collected by Reg Barnes in 1976. Chalcopyrite crystals up to ½" across and crystalline masses up to 3" long were found in association with sphalerite crystals in one of the early replacement bed stopes.

Copper.

Although copper is normally associated with oxidation zones within a copper orebody, native copper was found rarely and sporadically throughout the mine. The most notable occurrence was on the 2800 level, D bed stope where a small ledge of almost Michigan-like copper crystals were found.

Dioptase

Dioptase occurred at the collar of #1 shaft, the original shaft sunk on the Magma vein. Local collectors accessed the area starting in the 1980s and collected many flats of this material. The specimens were fairly uniform and while not spectacular, were nice commercial material. The crystals are less than 1/8" on matrix but occur in specimens up to 4" across.

Gypsum

Gypsum crystals up to 4" have been recovered but most are under 2". Clear and colorless crystals were found in the 3000 A-bed stope along with barite crystals, but usually not in association with the barites. The one occurrence with barites was on the 3600-4D stope where one particularly notable specimen has a 2" bow-tie of gypsum crystals placed on the face of a 1" black barite crystal.

Pyrite

Pyrite is one of the most well-known minerals from the Magma mine. The best of the pyrites were collected in the same A-bed replacement beds as the barites. Small white quartz crystals do occur with and on the pyrite crystals. The crystals are generally pyritohedrons and rarely octahedrons. The crystals can also exhibit highly lustrous smooth faces.

Sphalerite

Sphalerite was produced in one of the zinc orebodies during World War II. Black crystals up to ½" across were recovered, usually on massive or crystalline chalcopyrite. Smaller red crystals were also recovered. In 1982, in the 3600-4D stope, and in association with the barite and gypsum, several specimens with botryoidal, yellowish-green sphalerite were collected.

# REMEMBERING DR. ARTHUR STEADMAN ROE

**1912 – 1993**

**Anna M. Domitrovic**

**Arizona-Sonora Desert Museum**

**Tucson, Arizona**

Art Roe is one of our own. He may have spent the majority of his life living and working outside of the western states, but he was born in Victor, Colorado on August 22, 1912 and retired to Tucson in 1971 to live out his days, passing away on April 27, 1993.

Art's education at Oberlin College in Oberlin, Ohio (an AB degree), at Colorado College in Colorado Springs (a MA) and at Northwestern University in Evanston, Illinois (his PhD in chemistry) provided the background he used for his work in the field of chemistry. After receiving his doctorate, he taught chemistry for eight years at colleges and universities in Colorado Springs, Evanston, Chicago, Norman, Urbana-Champaign and finally at the University of North Carolina in Chapel Hill. He remained at UNC for 30 years from 1941-1971, advancing his positions from full professor to director of the radio-isotopic lab to chairman of the natural sciences and chemistry departments. Even with all his responsibilities at UNC, he managed to serve on several committees for the National Science Foundation in Washington, D.C. from 1959 – 1971.

Retirement brought Art, and his wife Barbara of more than 30 years at the time, back to the West and Tucson. But retirement was not in the cards for Art. With his experience in the mineralogical world, he volunteered his time at the University of Arizona (UA) Mineral Museum and the mineral department at the Arizona-Sonora Desert Museum (ASDM).

Art's interest in minerals began at an early age while he was still in Colorado. Some are only interested in minerals that they "can see from across a room", but Art was drawn to the microscopic minerals. His time spent with Colorado Springs micromounters Lazard Cahn, Cecil Graves and Willet Willis laid the foundation for Art's future in the world of micro minerals. He was a member of and officer in the Micromineralogists of the National Capital Area and the Baltimore Mineral Society, and volunteered at the Smithsonian while in D.C. Once in Tucson in the early 1970's, he volunteered tirelessly at the UA Mineral Museum and the ASDM. He was a lifetime member of the Tucson Gem & Mineral Society (TGMS) and volunteered his time for the society and its annual mineral show in February. An annual event at the Show is a micromount symposium focusing on the Show's theme, which Art initiated and is now named in his honor and memory.

During his tenure at Tucson's mineral museums, he built their micromount collections by encouraging donations and laboring over microscopes to add his own micromount donations to each museum's collections. Art was responsible for acquiring several notable micromount collections at the ASDM, including those of Edna Andregg, Marvin Deshler, Bill Hunt and Francis Sanders.

Arthur Roe may have earned degrees to lead him to a career as a chemist, but his association with the mineral world earned him lifetime recognition as a micromineralogist. His legacy lives on at the ASDM and the UA Mineral Museum with his contributions and work with their micromineral collections. And he will be memorialized forever in the Micromounters Hall of Fame with his induction in 1983.


## ACKNOWLEDGMENTS

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# Heavy Metal: Gold, Silver, and Tungsten Mineral Collecting Opportunities Around Quartzsite, Arizona

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Abstract

The mining districts of the Greater Quartzsite area (i.e. La Paz, La Cholla, Plomosa, and Bouse) are best known for placer gold. Yet there is far more in this area for collectors who wish to scratch a bit deeper. Crystalline gold, including unusual pyritohedrons, occur within the La Cholla placers. These gold crystals are secondary, having formed through recrystallization of placer gold when a hot spring emerged along the range front and through the pre-existing placers. Placer gold with typical forms, ranging from dust to large multi-ounce nuggets is also found throughout all of the Quartzsite districts. The shape and character of this placer gold indicates that most was transported in flash floods as "pulse placers," while less commonly wind has played a role creating desert pavement with "sunbaker" gold occurring on the deflation surface. Native gold occurs in several deposits as attractive masses on chocolate-hued siderite and white quartz, a nice sample of which is in the former AZDMMR collections. Silver is also a major resource in the Quartzsite area. The Ramsey Mine is perhaps the most famous of these deposits, hosting chlorargyrite and vanadinite. But the copper deposits of the La Cholla and Plomosa districts also contain abundant silver, with typical cuprite/chalcocite rich rock running 50 to 175 ounces of silver per ton. The speciation of the silver is microscopic inclusions of silver-rich jarosite, stromeyerite (CuAgS), and polybasite ($(Cu(Ag,Cu)_6Ag_9Sb_2S_{11})$). In the Plomosa district at the Humdinger Mine, and other localities, slugs of galena with a white cerussite coating are common in the placers. These lumps of galena typically contain 100 ounces of silver per ton, identical to the local galena lode veins. The silver mineral(s) in these slugs have not yet been identified. Tungsten has also been produced from the Quartzsite area, with the Tungsten Hill and Livingston Mines being the most significant producers. In both cases, the deposits were worked originally as a placer gold operation. However, the operations were confounded by abundant "heavy quartz" sands which were later determined to be scheelite. The scheelite has a distinctive light blue under shortwave UV light, and is now used as an indicator for richer placer gold paystreaks. "Dog-tooth" crystals up to 2 cm (about an inch) have been confirmed from both sites, though anhedral masses predominate.

**The University of Arizona**
**Gem and Mineral Museum**

**Go to gemandmineralmuseum.arizona.edu for more information.**

**Global Significance**

**Tucson's Gem & Mineral Shows are a huge draw for hundreds of thousands of collectors, jewelers, manufacturers and dealers from all over the world. And, Earth scientists come to Tucson all year long, as well. Until now, people who followed their passions and professions didn't have one place to explore both the art and science of gemology and mineralogy.**

**A Science Center**

**The UA Geosciences Department will have expansive laboratories and expanded programs on-site at the new museum. Gemologists and mineral collectors will be able to access the latest technologies, including Raman analysis, X-ray diffraction, and mass spectroscopy to further their studies.**

**Gemology Degree Program**

**Jewelers and other industry professionals will be offered a four-year degree-granting program in gemology, the first in the United States. These courses will be taught in the lower level classrooms as well as on the main UA campus. And, naturally, students will have access to a wealth of scientific resources and lab equipment.**

**Deeper Resources**

**Expanded laboratories and satellite office space will bring the world's scientific community and major collectors to Tucson. We are literally creating a global destination for the Earth sciences. Gemologists and collectors will have access to the best in technologies, including Raman analysis, X-ray diffraction and mass spectroscopy. These precision tools allow for Earth scientists to determine mineral species and their characteristics. New data will be added to the RRUFF Project, which has had over 600 million "hits" to date.**

**Historic Beauty, Repurposed**

**The University of Arizona Gem & Mineral Museum will occupy one of the most historic and iconic buildings in all of Arizona. By June of 2018, Pima County will complete an $11 million renovation of the exterior, restoring its architectural glory. The new museum will be an anchor tenant, placing the new museum, front and center.**

**Rock-Solid Destination**

**While the museum will draw the scientific and professional communities, tourists will also be attracted to the museum as a year-round destination. Visitors of all kinds will have abundant opportunities to be inspired and astonished by what they see here. Exhibitions will extend to the outdoor areas on the plaza, offering space for relaxing and deciding where to go next.**

# The Arizona Mining, Mineral and Natural Resources Education (MMNRE) Museum: A rebirth of the Arizona Mining and Mineral Museum under the University of Arizona

Catie Carter

2018 is an exciting time for the Arizona mineral community as the University of Arizona works to establish two new state-of-the-art museums: the Arizona Mining, Mineral and Natural Resources Education (MMNRE) Museum in Phoenix, a natural resource-centered rebirth of the former Arizona Mining and Mineral Museum, and the UA Gem and Mineral Museum in Tucson, currently relocating from the Flandrau Center on UA's campus to the historic Pima County Courthouse. This talk will focus specifically on the MMNRE Museum – its history, establishment, current updates, and our plans for the next few months.

The Arizona Mining and Mineral Museum was a beloved fixture in Phoenix for decades[1]. The diverse mineral collection dates back to 1884 with an exhibit at the first Arizona Territorial Fair. In 1917, the Arizona State Legislature appropriated $30,000 to build an exhibit hall on the Arizona State Fairgrounds in Phoenix, bolstered by funds from major mining companies of the day. In 1947, the Arizona Department of Mines and Mineral Resources (ADMMR) moved to the Gem and Mineral Building and in 1953, a permanent museum was established. The first curator was Arthur L. Flagg, who held the position until his death in 1961.

In July of 1991, with financial support from Arizona's mining community, the Mining and Mineral Museum and the ADMMR offices were moved from the Fairgrounds to the El Zaribah Shrine Building (renamed the Polly Rosenbaum Building) at 1502 W. Washington St. on the Government mall. From 1991 to 2011, the Mining and Mineral Museum displayed thousands of minerals to tens of thousands of visitors and schoolchildren each year. They also hosted local clubs and groups, logged thousands of volunteer hours, and ran a lapidary shop. The outdoor mining exhibits, including a baby-gauge steam locomotive from Morenci, fully-reassembled Boras headframe, and working Swallow Mine stamp mill, were particularly popular as well.

In 2010 the Department of Mines and Mineral Resources was discontinued and the museum was transferred to the Arizona Historical Society (AHS). In 2011 the museum was closed to make way for the Centennial Museum, which was ultimately not established. After many attempts to reopen the museum through state legislation, Senate Bill 1530 passed in 2016, championed by Sen. Gail Griffin. The bill transferred the collection, curator position, and custodianship of the building to the Arizona Geological Survey (AZGS), under the University of Arizona. AZGS was charged with developing and operating a new natural resources museum called the Mining, Mineral

[1] For a full history of the museum, photos, and further details, see Rasmussen, Jan, "Arizona Mining and Mineral Museum – History" http://www.miningmineralmuseum.com/history

and Natural Resources Education (MMNRE) Museum, with the project was headed by Chief of Geologic Extension Service Mike Conway. In 2017, Senate Bill 1415 moved responsibility from AZGS directly to the University of Arizona under the office of Research, Discovery and Innovation, with VP for Research R. Brooks Jeffery as project leader. Most notably, the bill permanently transferred full ownership of the building and collection from the state to the University.

The 20,000+ specimen mineral collection is at the heart of the MMNRE Museum. The collection includes spectacular specimens from Arizona's mines and mineral localities, as well as rocks, ores, industrial minerals, gemstones, mining artifacts, and Native American artifacts. While the minerals will be on display, state statute designates that the museum will have a broader scope, exploring the sustainable science of Arizona's other natural resources – agriculture, livestock, forestry, and tourism. In addition, we will showcase innovative technologies from UA's College of Engineering and College of Agriculture & Life Sciences. Early efforts to fundraise, identify industry partners, and develop our mission will be led by the Governor-appointed Advisory Board, consisting of members from each industry and legislators Sen. Griffin and Rep. Leach. As of April 2018, half of the board members have been officially appointed.

Right now, we push forward with building renovations and explore our options to engage the public in a phased approach. We have cleared out the building, cleaned the grounds and exterior, installed a new pigeon mitigation system, and begun the process of installing a new security system. Charlie Connell and the Monday Crew volunteers have devoted countless hours servicing the outdoor equipment, and we hope to hold a community event within the next few months. We will also undertake the daunting endeavor of moving the mineral collection from AHS back into the museum building once security and environmental controls are established. In the meantime, we are installing small displays at local museums, conducting outreach, and planning a revamped exhibit at the Arizona Capitol Museum down the street.

None of our current progress could be possible without the steadfast support system of our volunteers and stakeholders, including the Flagg Mineral Foundation. We are eternally grateful for the hours of work and limitless patience over the past two years. UA has big plans for this museum and will continue these partnerships in the future. Thanks to everyone for your help and support, and stay tuned for more developments later this year.