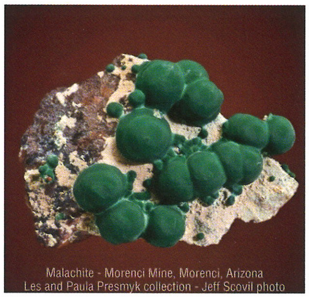
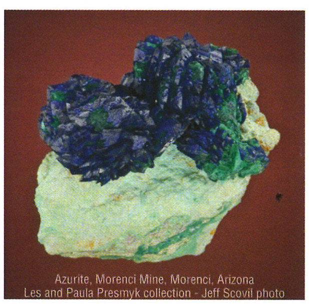
Prehnite - Gila Co., Arizona
Barbara Muntyan collection - Jeff Scovil photo

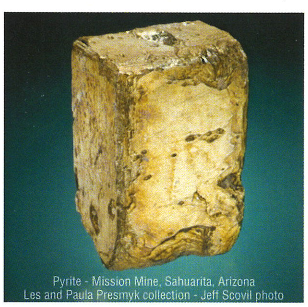


Malachite - Morenci Mine, Morenci, Arizona
Les and Paula Presmyk collection - Jeff Scovil photo

Quartz on Chrysocolla - San Manuel Mine, San Manuel, Arizona - Les and Paula Presmyk collection - Jeff Scovil photo



Azurite, Morenci Mine, Morenci, Arizona
Les and Paula Presmyk collection - Jeff Scovil photo



Pyrite - Mission Mine, Sahuarita, Arizona
Les and Paula Presmyk collection - Jeff Scovil photo

Copper in Gypsum - Mission Mine, Sahuarita, Arizona
Les and Paula Presmyk collection - Jeff Scovil photo

27TH ANNUAL

MINERALS OF ARIZONA SYMPOSIUM

Chairperson
Les Presmyk

Co-Chair
Phil Richardson

Chairman Emeritus
Ray Grant

APRIL 5TH, 6TH, and 7TH, 2019

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SPONSORED BY FLAGG MINERAL FOUNDATION

TWENTY-SEVENTH ANNUAL

MINERALS OF ARIZONA SYMPOSIUM

Sponsored by
Flagg Mineral Foundation

Friday, April 5 | Saturday, April 6 | Sunday, April 7, 2019
Drury Inn - Chandler, Arizona

Chairman Les Presmyk
Co-Chairman Phil Richardson
Chairman Emeritus Dr. Ray Grant
Cover Design by Don Boushelle
Mineral photos by Jeff Scovil

Cover Minerals, Top to Bottom

PREHNITE, Gila County, Barbara Muntyan collection
MALACHITE, Northwest Extension, Morenci mine, Morenci, Les and Paula Presmyk collection
QUARTZ on CHRYSOCOLLA, San Manuel mine, San Manuel, Les and Paula Presmyk collection
AZURITE, Northwest Extension, Morenci mine, Morenci, Les and Paula Presmyk collection
PYRITE, Mission mine, Sahuarita, Les and Paula Presmyk collection
COPPER in GYPSUM, Mission mine, Sahuarita, Les and Paula Presmyk collection
COVER PHOTO, Morenci mine, Morenci, Photo by Dawn Boushelle

Saturday, April 6 - Symposium Program

8:00 to 9:00am	**Coffee Hour**
9:00 to 9:15am	**Welcoming Remarks and Introductions** - Phil Richardson and Les Presmyk
9:15 to 9:30am	**An Update on UofA's Two Mineral Museums -** Les Presmyk
9:30 to 10:10am	**Stan Keith** – *"Mineralogy of a Giant Graphene Deposit in West-Central AZ"*
10:10 to 10:40am	**Break and Mineral Sales**
10:40 to 11:20am	**Barbara Muntyan** – *"Arizona Prehnite"*
11:20 to 12:00pm	**Mark Hay** – *"Minerals of the San Manuel Mine, Pinal County, Arizona"*
12:00 to 1:00pm	**Lunch**
1:00 to 1:40pm	**Anna Domitrovic** – *"Minerals with Stories to Tell"*
1:40 to 2:20pm	**Dick Zimmerman** – *"Collecting Radioactive Minerals"*
2:20 to 2:40pm	**Break**
2:40 to 3:20pm	**Guenther Neumeier** – *"Playing in the Big Boys' Sandbox - ASARCO's Mission Mining Complex"* by Bill Williams
3:20 to 4:00pm	**Bob Jones** – *"Color in Minerals"*
4:00 to 6:00pm	**Visit Dealers at the Drury Inn conference room**
6:00 to 9:00pm	**Mexican Dinner catered by Macayo's at the Drury Inn** - **Silent Auction** - **Erik Melchiorre** – *"Morenci Mineral Mayhem:* *Where Exactly is Morenci and Why Does It Have So Many Names?"*

Twenty-Seventh Annual Minerals of Arizona Symposium

Introduction

There is a lot of activity in Arizona these days regarding its museums. Dr. Ray Grant is actively working to expand his museum in Coolidge, both its displays and programming. The UofA "Alfie Norville" Gem and Mineral Museum in Tucson is moving forward both with its museum planning and construction and fundraising. Finally after almost ten years, the light is becoming brighter at the end of the tunnel regarding the reopening of the now Arizona Mining, Mineral and Natural Resource Museum in Phoenix.

The Flagg Mineral Foundation has been a long-time supporter of the museum in Phoenix and has continued that legacy with support for the museum in Coolidge as well as the one at the University of Arizona. The Foundation will continue that support as part of its on-going goal of promoting the earth sciences and providing educational opportunities for as many people as possible.

We hope you enjoy this year's symposium. Friday afternoon we start with the micromount workshop and then at 5pm mineral sales in a separate conference room and on the second floor. Dr. Erik Melchiorre, will work his magic with mineral identification on Sunday morning. The Saturday programs will concentrate on Arizona localities as usual and in addition, Dick Zimmermann will explain why it is okay to have a few radioactive minerals in your collection.

With the new venue, we know there have been a few glitches in the process. Please let us know how we can make the symposium even better for you next year.

Thank you for attending.

Les Presmyk, Phil Richardson and Dr. Ray Grant

The University of Arizona's Two Museums – One in Phoenix and One in Tucson

Les Presmyk

Nine years ago, the Arizona Mining and Mineral Museum was closed to prepare it for remodeling and reopening as the Arizona Centennial Museum, under the responsibility of the Arizona Historical Society (AHS). Unfortunately, this did not happen and ultimately, the Historical Society dedicated an area at its Tempe museum to display part of the collection. Work continued by concerned Phoenix collectors and through legislative action led by Senator Gail Griffin, responsibility for the museum and its collections were moved to the Arizona Geological Survey and ultimately to the University of Arizona. Catie Carter was originally hired by AHS and continues as the collection curator and point person for the museum. The entire collection is currently stored in secure rooms at the Arizona Historical Society.

As defined by the legislation, the new museum will be known as the Arizona Mining, Mineral and Natural Resource Museum, with an advisory board appointed by the Governor. Currently there are a quorum of members in place with others waiting to be selected. Responsibility for this museum now resides with the UofA's vice president of research, R. Brooks Jeffries, who also oversees the other three museums, the State Museum, the Art Museum and the Photographic Museum. The University's facilities group has begun its review and analysis of the building and once the necessary improvements are completed work can proceed on displays and programming. The University has also started the process of hiring an executive director to head up this project and initiate the significant fundraising effort to build out the museum's displays. An initial meeting was held in January with the various interested parties in the Phoenix area and it was well attended.

When the museum was functioning prior to 2010, there was a dedicated group of volunteers, known as the Monday crew and led by Charlie Connell, who spent countless hours building, rebuilding and maintaining the outdoor displays at the museum, along with the interior of the museum. They have started this work again and have the outdoor displays, including the stamp mill, back in operating condition. When the building is ready to be moved back into, this group and other volunteers will be called upon to move the collection back from Tempe and start the process of redoing the museum and its displays.

The University of Arizona "Alfie Norville" Gem and Mineral Museum is currently housed in the basement of the Flandrau Planetarium and will be moving to the south half of the historic Pima County courthouse in downtown Tucson. Alan Norville has provided a significant gift to honor his late wife, Alfie, and has continued to support the fundraising efforts. The projected "soft" opening date is probably the fall of 2020 with a grand opening ceremony to coincide with the 2021 Tucson Gem and Mineral Show®. Pima County has renovated the building and has loaned the funds to the University of Arizona to complete the build-out of the museum. A significant fundraising campaign was started in 2018 and will continue until all of the funds to repay Pima County are raised as well as an endowment fund to support the museum and its collections is completed. This goal is $20 million and we still have a long way to go.

Design of the museum includes three main halls, Mineral Evolution, the Southwest and Gems. Mineral Evolution will encompass the geologic and mineralogic history of the earth. For example, with the formation of the earth there were probably around 50 mineral species, based on the analysis of meteorites. Today, there are well over 4000 species with new ones described on an on-going basis. Dr. Bob Downs, museum curator, is a co-author with Robert Hazen, of the seminal work regarding mineral evolution. This will be the first museum telling this story of the earth and Arizona's geologic history from this basis.

The Southwest Hall will start with prehistoric use of turquoise and current research regarding sources and uses of turquoise. Then the story of early gold and silver mining along with the importance of mining at Bisbee will be told, with a stope recreation at the end of this hallway. Then a cross-section and description of a porphyry copper deposit will be displayed. Visitors will then walk into the main portion of this hall where displays of Mexican minerals, Arizona's state mineral Wulfenite, and Arizona's mining and specimen producing districts, including Globe-Miami, Clifton-Morenci, Ray, Ajo, and others will be highlighted. Additional displays will tell the story of Rockhounding in Arizona along with some of the clubs like the Mineralogical Society of Arizona, the Tucson Gem & Mineral Society, the Flagg Mineral Foundation, along with the Maricopa Lapidary Society and the Old Pueblo Lapidary Club. There will be a special area for rotating exhibits of private collections including collectors under the age of 18. As one continues through the hall there will be a significant display about the importance of mining, not just to the State of Arizona but to modern society in general. Then the story of space exploration to Mars and the asteroid, Osiris Rex, will be told. These projects have significant involvement and leadership by UofA researchers and professors.

Then, the "Crystal Palace" will contain a number of hands-on type displays and activities where visitors will learn about rocks and minerals and how crystals grow. As one moves from the Southwest Hall to the Gem Hall there will be a display of fluorescent minerals and gems, allowing visitors the opportunity to experience the wonder of what some minerals look like when viewed under ultraviolet light.

The Gem Hall will be the third hall and as its name suggests, this is where natural gem minerals and polished and faceted stones will be displayed. The UofA has received funding to establish the first undergraduate and graduate degree program in gemology in the United States. In addition, this is where the golds, silvers, coppers and platinum will be displayed.

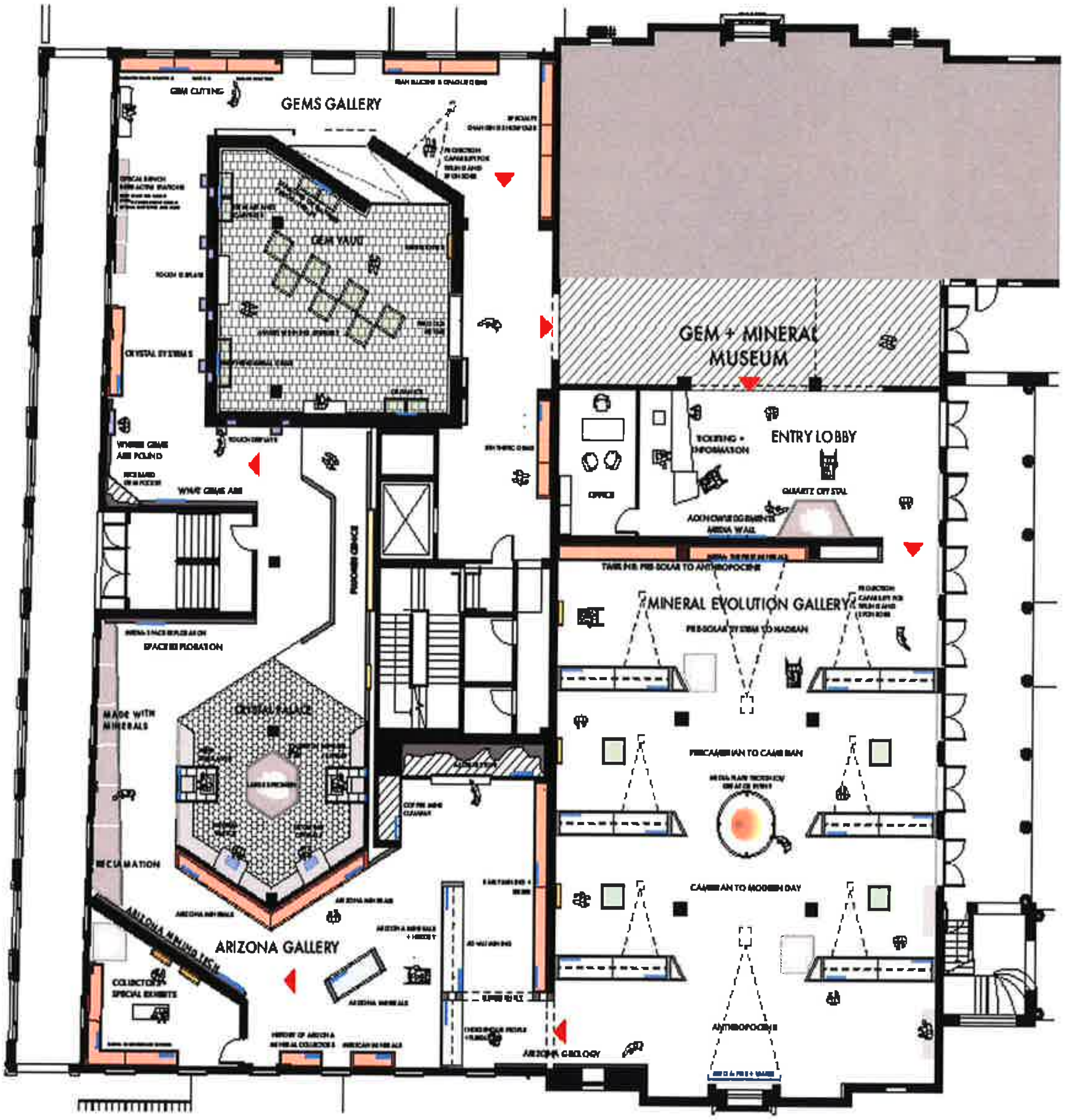
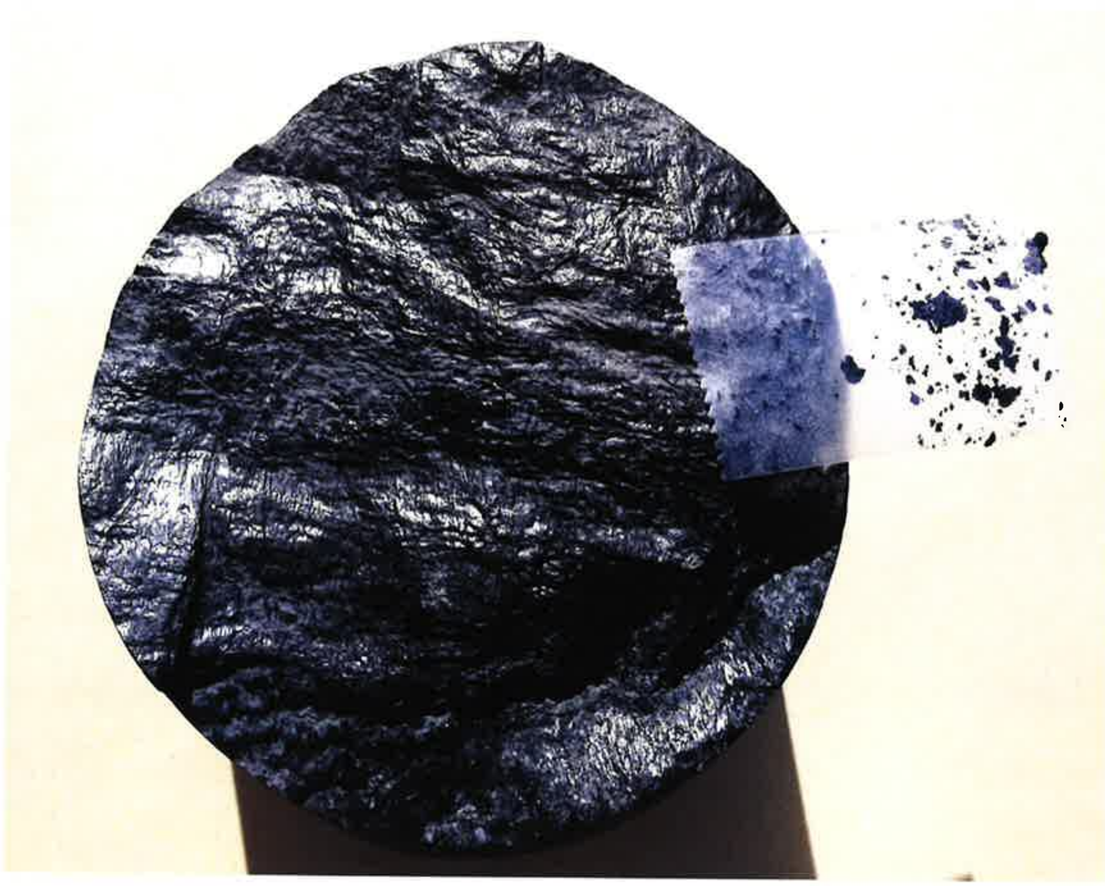


EXHIBIT KEY LEGEND

- WALL DISPLAY CASE
- TALL 2 SIDE DISPLAY CASE
- LOW DISPLAY CASE
- THUMB/MINI/FLUOR DISPLAY CASE
- DISPLAY PLATFORM
- MEDIA
- TOUCH SPECIMEN

Mineralogy of a Giant Graphene Deposit at Yellowbird, West-Central Arizona

Stanley Keith, Tillmann Viefhaus,
Jan Rasmussen, Volker Spieth,
and Merrill Palmer



CAP

In April of 2011, a drillhole by VANE exploring for porphyry copper mineralization serendipitously discovered what has turned out to be a giant graphene deposit. The presence of the obvious 'graphite' mineralogy was extensively investigated by Raman Spectrometry, X-Ray Diffraction and was characterized electrically and magnetically. Reconnaissance drilling of the electrical anomaly has resulted in the identification of a giant graphene deposit which crops out on the surface south of the Yuma Mine (Figure 1). In this communication we present the mineralogical aspects of the Yellowbird deposit and develop a model for carbon metamorphism at Yellowbird that explains how this unique graphene mineralogy happened.

Figure 1. Location Map

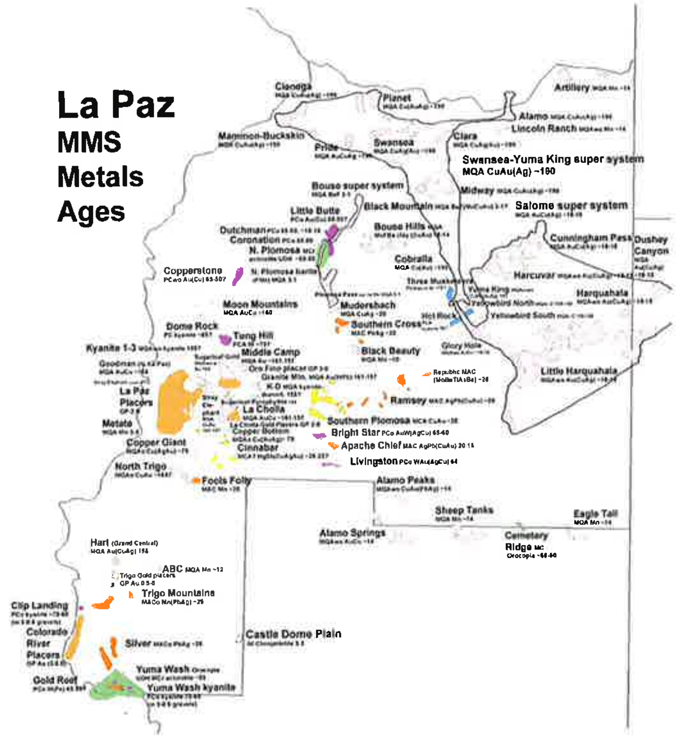
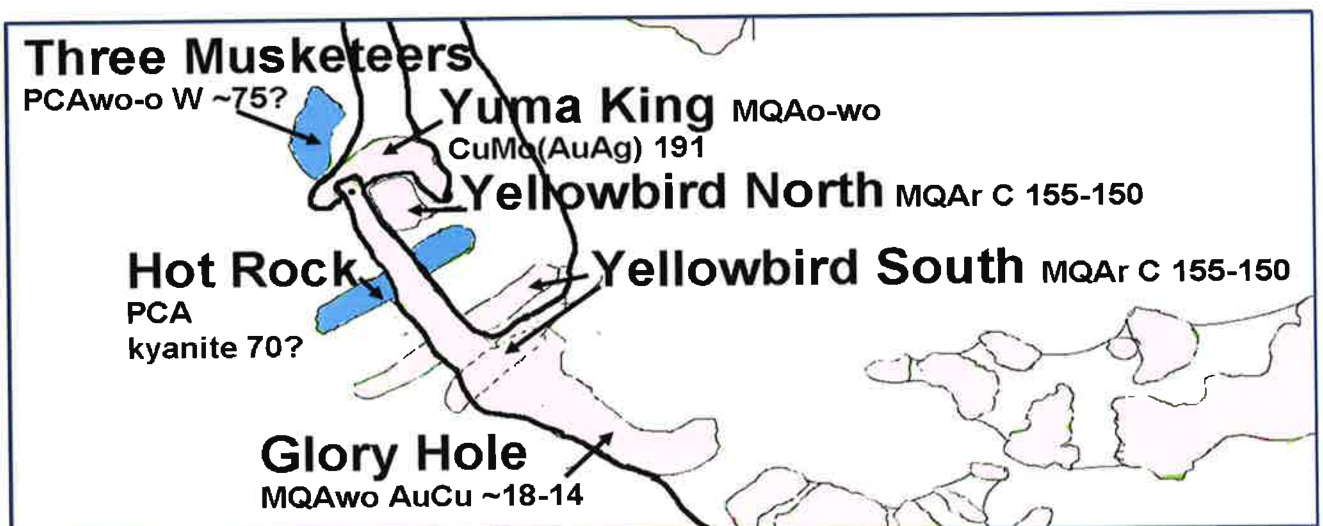


Figure 2. La Paz County mineral districts



From Rasmussen and Keith chapter In preparation for Mineralogy of Arizona, 4th Edition by Grant and others

- At least 4 episodes of mineral systems were developed in the Granite Wash Mountains from about 200 to 15 Ma.
- Five types of metallogeny are featured and overprint each other on a district scale but not at the deposit scale.

Figure 3. Mineral Systems in the Granite Wash Mountains

Table 1. Mineral Evolution of the Granite Wash Mountains

Glory Hole
Au (Ag,Cu,Pb [Bi])
~ 18 – 15 Ma
Mafic dikes and intrusions
Primary Minerals
Gold
Specular Hematite*
Chalcopyrite
Unidentified Cu-Bi sulfosalt(s) ?
Galena
Quartz
Muscovite
Fluorite
Calcite
Chlorite
Epidote
Secondary Minerals
Chrysocolla
Malachite
Dioptase
Plancheite
15 Minerals

Three Muskateers
W (Cu, Ag. Bi, Pb, Mo)
~75-65 Ma
Muscovite aplogranites and pegmatites
Primary Minerals
Scheelite*
Bismuthinite
Molybdenite
Quartz
Microcline
Albite
Chalcopyrite
Galena
Pyrite
Muscovite
Calcite
Chlorite
Secondary Minerals
Goethite
Chrysocolla
Malachite
Bismite
Kettnerite*
Wulfenite*
18 Minerals

Hot Rock
Al-Si (P,Ti,B,Sr)
~75-65 Ma
Muscovite aplogranites and pegmatites
Primary Minerals
Kyanite*
Pyrophyllite
Staurolite
Quartz
Microcline
Albite
Magnetite
Hematite
Ilmenite
Rutile
Pyrite
Covellite
Bornite
Calcite
Schorl Tourmaline
Dumortierite
Lazulite
Svanbergite
Secondary Minerals
Goethite
19 Minerals

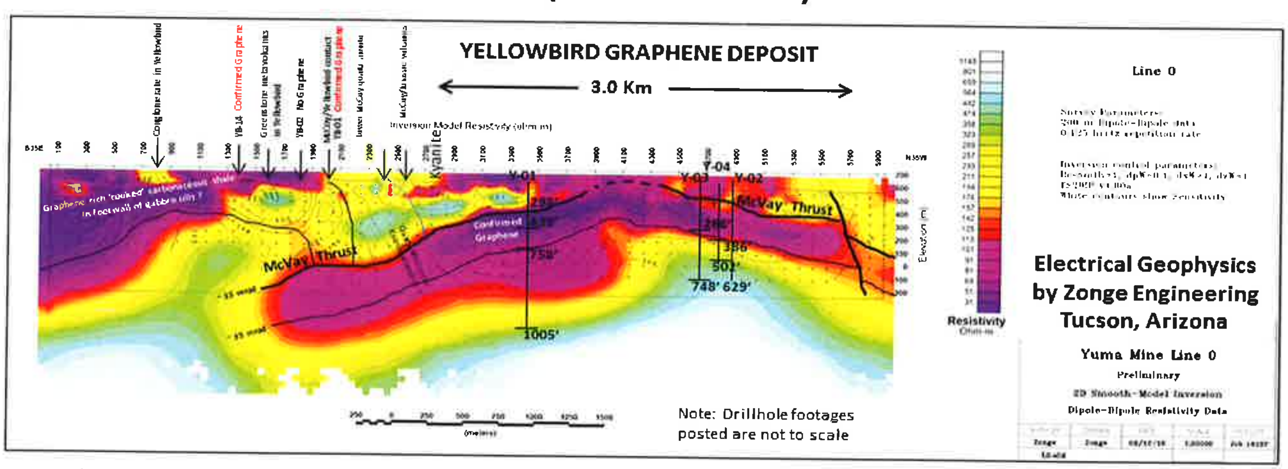
Yellowbird
C (K,Al,Ti,Cu)
160-150 &~75-65 Ma
Carbonaceous Mud Volcanism followed by Regional Metamorphism
Primary/Metamorphic Minerals
Kerogen
Graphane
Graphene*
Graphite*
Muscovite
Chlorite
Clinochlore
Chamosite
Anatase
Brookite
Rutile
Ilmenite
Pyrite
Calcite
Dolomite
Chalcocite
Feldspar
Quartz
Supergene Minerals
Goethite
18 Minerals

Yuma King
Cu, Mo (Fe,F, Au, Ag,Re)
195-190 Ma
Hornblende Syenodiorite (Fe [Cu])
Biotite Quartz Monzonite (Cu,Mo)
Biotite latite Mo (Cu,Re)
Primary Minerals
Chalcopyrite*
Molybdenite (rhenium rich)*
Magnetite*
Specular Hematite*
Bornite
Pyrite
Rutile
Galena
Sphalerite
Quartz
Muscovite
Fluorite
Calcite
Dolomite
Diopside
Grossular
Andradite
Epidote
Lizardite (in verde antique)*
Tremolite (in verde antique)*
Actinolite*
Metamorphic Minerals
Sillimanite*
Rutile
Orthoclase
Plagioclase
Supergene Minerals
Chrysocolla*
Malachite
Aurichalcite*
Azurite*
Turquoise*
Tenorite-Melaconite
Goethite-red hematite
Chloragyrite
34 Minerals

*** Specimen quality**

- Mineral evolution in the Granite Wash Mountains featured at least 62 mineral species deposited in 5 mineral system types formed between about 195 and 15 million years ago during 4 orogenies and one rifting event.

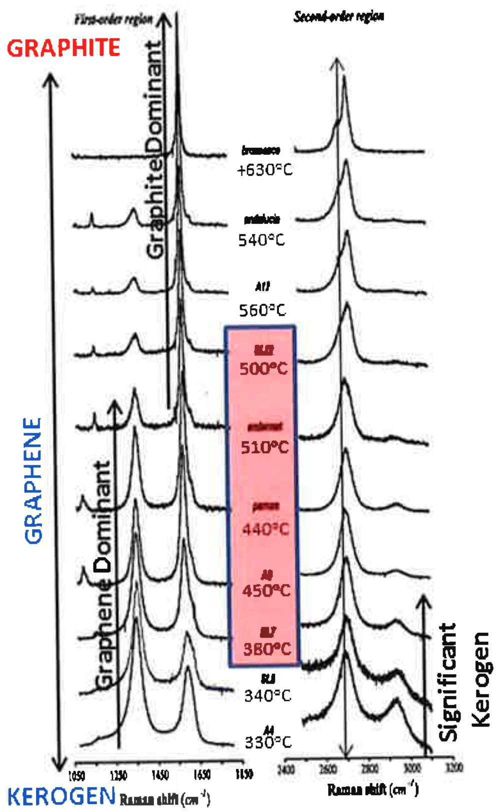
CONDUCTIVITY SIGNATURE OF THE YELLOWBIRD GRAPHENE (GRAPHITE) DEPOSIT



- The new higher resolution resistivity data (based on full frequency IP geophysics developed by Zonge Engineering in Tucson, Arizona) shows a less 'balloony' more continuous sheet like pattern that appears more geological.
- The more continuous pattern allows the inference that the Yellowbird Graphene Deposit is 3 km long (vs. 2.7 km in the less resolved older data).
- The more resolved resistivity data also allows a more confident assessment of the bottom of the strongly conductive units which are moved to a shallower level and are more strongly conductive.
- The position of the new samples taken in the upper plate Yellowbird section that have yielded confirmed graphene-graphite are also shown.

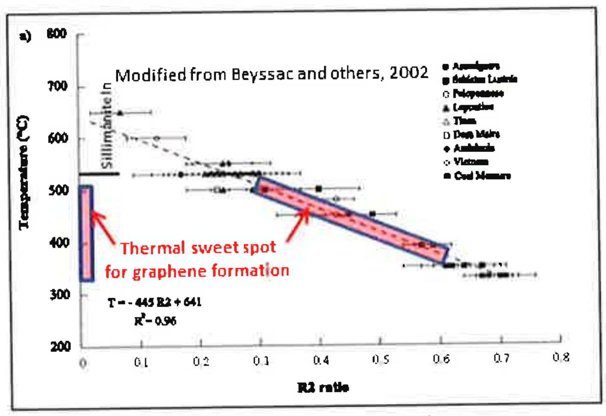
Figure 4. Geophysical cross section of Yellowbird graphene deposit

The Yellowbird giant graphene deposit (Figure 4) was created initially as a carbonaceous, kerogen-rich black shale deposit that was the product of deep, possibly serpentinite-sourced carbonaceous mud volcanism deposited in a rift trough at the end of Jurassic time circa 160 to 150 million years ago. The initial carbon material was a hydrocarbon material called kerogen (the starting material for oil generation. Beginning about 85 million years ago, the region was subjected to two major episodes of orogenesis during the Sevier and Laramide orogenies. At this time, the Yellowbird deposit 'to be' was buried beneath a thrust-thickened crust where temperatures reached at least 550°C at depths of about 15 kilometers based on graphite geothermometry and metamorphic mineral assemblages (specifically kyanite-sillimanite geobarometry and graphite geothermometry; Figure 5).



Selected samples represent first and second order regions of Raman spectra from various graphite-graphene bearing schists in northern Italy. Visually determined temperatures for each sample are also posted together with the position of Yuma King graphene-graphite samples (red box). Modified from Beyssac and others, 2002.

GEOTHERMOMETRY OF YELLOWBIRD GRAPHENE DEPOSIT BASED ON RAMAN SPECTROSCOPY



R2 ratio (D/G+D-D2) versus peak metamorphic temperatures for graphite-graphene bearing schist samples in northern Italy

- As shown by Beyssac and others, 2002, the conversion of kerogen to graphite via graphene is temperature controlled in the 330-650° C range.
- Application of the kerogen-graphite geothermometer to the Yellowbird samples yielded temperatures in the 415-545° C temperature range (red bars).
- These temperatures were attended by SW directed thrust shear strain in the immediate lower plate of the McVay SW directed thrust at depth of 12 km (4 kb) or more (lower sillimanite stability).
- The conjunction of thrust tectonics overprinted on a former large body of carbonaceous black shale provided a unique situation for the creation of a potentially major graphene deposit.

Figure 5. Graphite geothermometry applied to Yellowbird graphene deposit

The metamorphism led to a systematic carbon metamorphic series that followed the sequence kerogen → graphane → graphene → graphite → graphene-graphite (Figures 6 and 7). The last step (graphene-graphite) resulted in an upgrade of the graphene content to large flake 'graphite' deposited in late retrograde shear fabric (Figure 7) in SW-directed thrusting during culminate stage Laramide flat subduction.

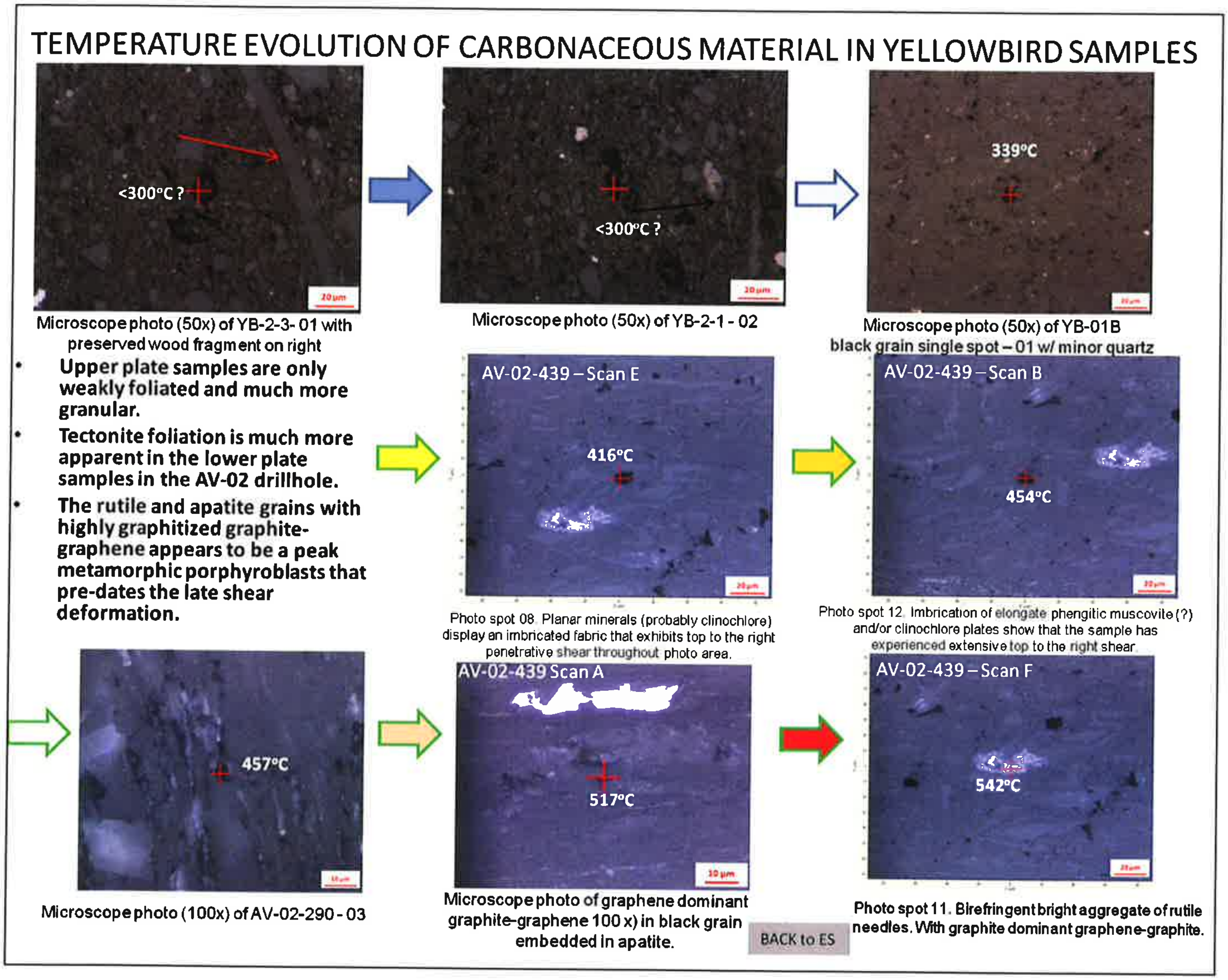


Figure 6. Photomicrographs showing textural aspects of carbon metamorphism in the Yellowbird carbonaceous muds. The first three photomicrographs (top row) are from three relatively unmetamorphosed Yellowbird sequence in the upper plate of the McVay Thrust. The lower two rows show progressively metamorphosed carbon grains constrained by the graphite geothermometer in the lower plate of the McVay Thrust. Corresponding Raman spectra for each sample are shown in Figure 7.

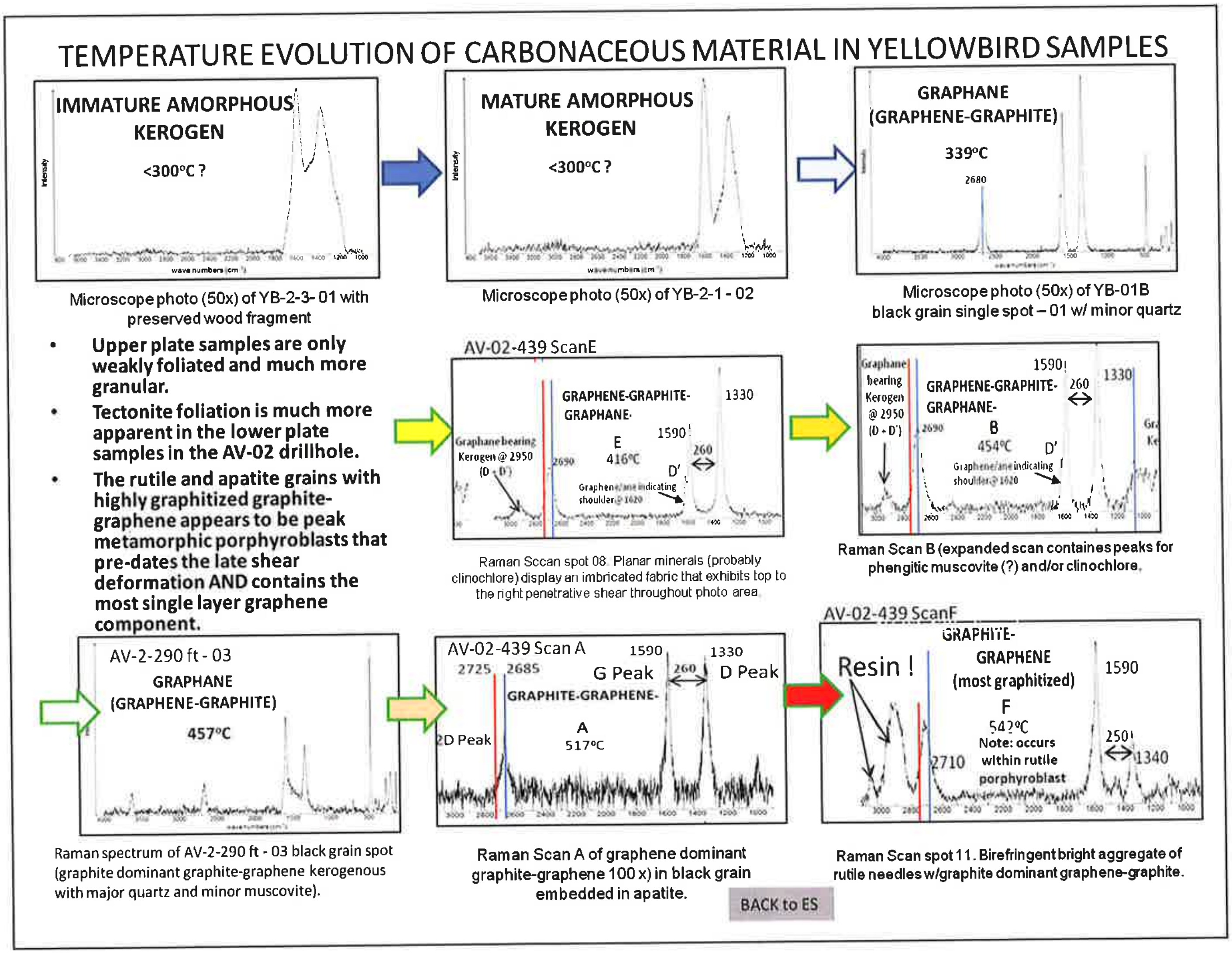


Figure 7. Raman spectra showing temperature evolution of Yellowbird samples constrained by the graphite geothermometer. Each panel corresponds with those shown in Figure 6. Note that the highest temperatures are recorded in a graphite inclusion in a rutile porphyroblast embedded in graphite schist of Scan F at the lower right of the figure.

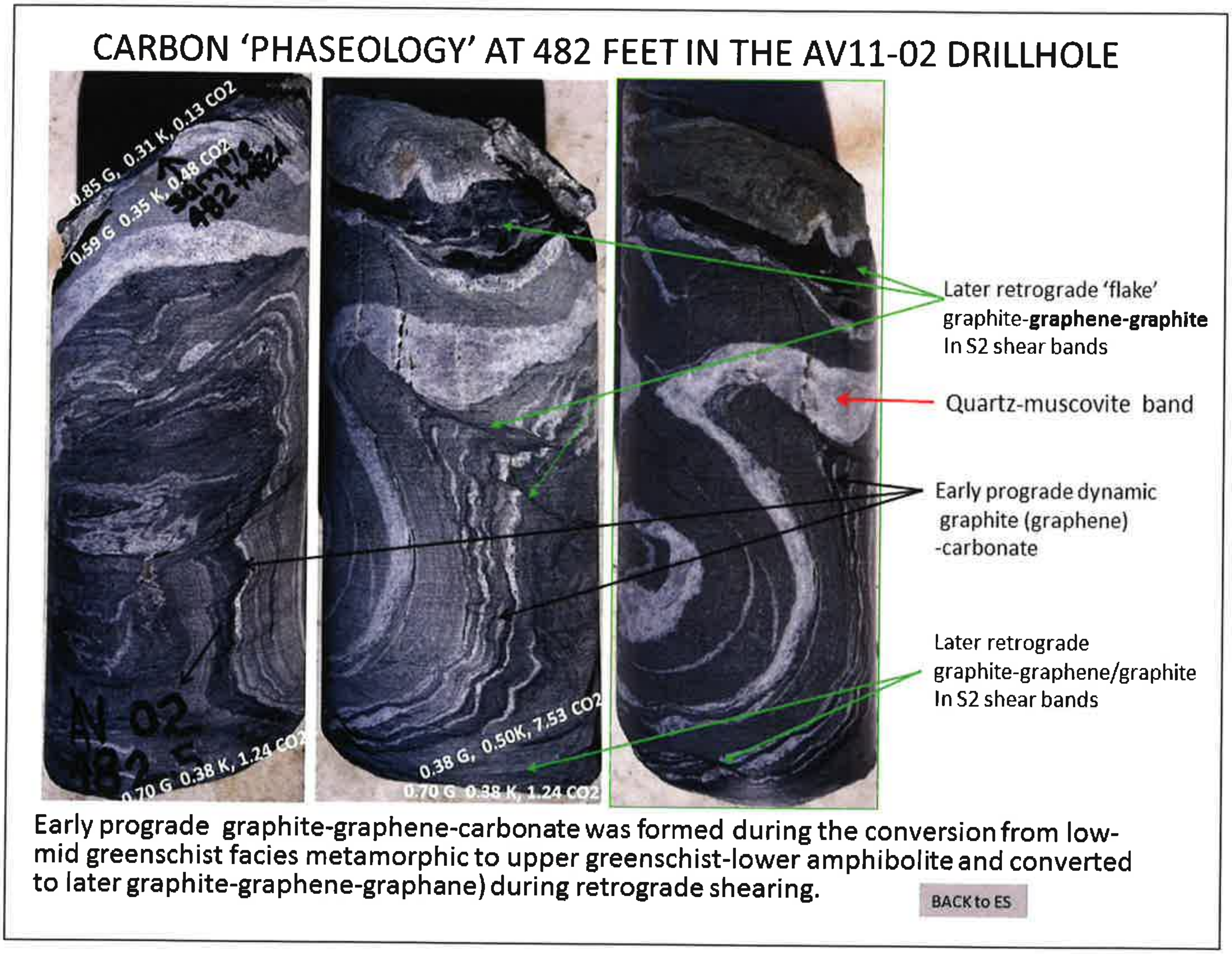
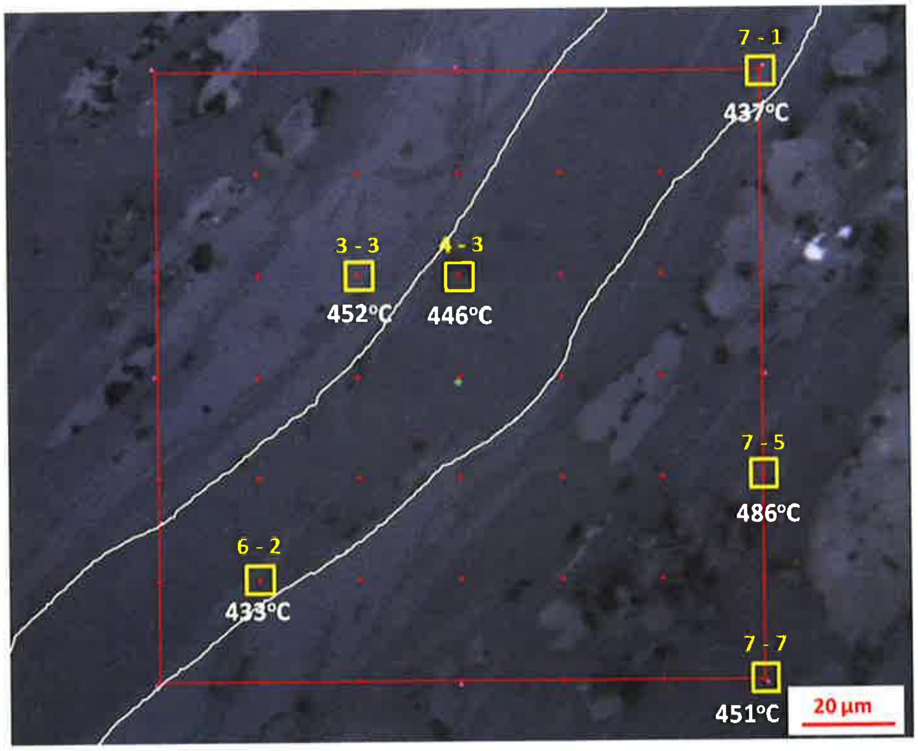


Figure 8. Textural aspects of the carbon metamorphic sequence in the Yellowbird graphene deposit.

RAMAN BASED GRAPHITE GEOTHERMOMETER FOR GRAPHITE IN A LATE S2 SHEAR PLANE VS. MATRIX GRAPHITE

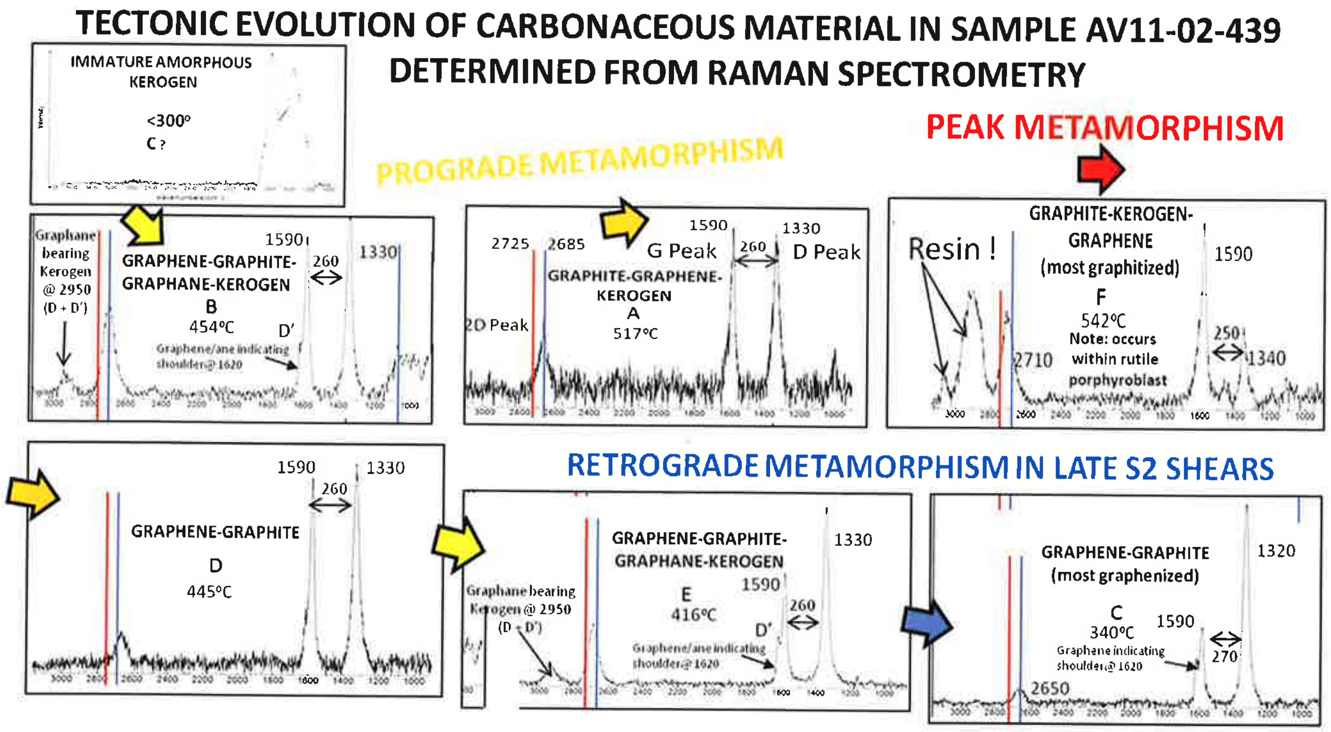


Microscope photo (50x) of AV-2-436 ft - mapping. Calculated conversion temperatures are 485.54°C for 7-5 (spectrum 8), 433.32°C for 6-2 (spectrum 10), 437.36°C for 7-1 (spectrum 6), 450.59°C for 7-7 (spectrum 11), 452.40°C for 3-3 (spectrum 9), 446.41°C for 4-3 (spectrum 7)

The graphene enriched shear plane developed at lower transformation temperatures (433-446°C) during late retrograde shearing associated with the McVay D2 SW-directed thrust event circa 80 Ma. In contrast the slightly graphite enriched matrix developed at higher prograde metamorphic temperatures between 451 and 486°C

Figure 9. Raman spectra from late shear band showing temperature data obtained from the graphite geothermometer. Three samples from within the band range from 433-446oC compared to those obtained from the matrix which range from 451oC to 486oC consistent with the inference of lower temperature retrograde metamorphism following higher temperature peak metamorphism in the lower plate Yellowbird rocks.

Integrated tectono-thermal models for the Yellowbird graphene system are shown in Figure 10. The tectono-thermal model is consistent with a carbon metamorphic series that is temperature driven from low temperature kerogen to lower greenschist grade graphene rich carbon to middle greenschist graphene enriched carbon to upper greenschist graphite-graphene carbon to lower-mid amphibolite graphite carbon. The decrease in temperature during the retrograde shearing leads to a reformation of a graphene rich flake graphene based on a slight hydrogenation of graphite. The above carbon mineral series could be analogized to the plagioclase series with albite appearing at the low temperature end and anorthite presenting at the high temperature end. The status of kerogen as a discreet mineral at the low temperature end is of course debatable, but the mineral status of graphane and graphene as two-dimensional mineral species formed later in sequence under more crystallographically structured conditions stands on firmer ground. To our current knowledge, this specific sequence of carbon metamorphism produced a giant graphene-dominant carbon deposit that is to date unique and reflects a unique geologic sequencing. However, the presence of graphene deposits in other orogenic settings is certainly permissive and should be evaluated where orogenesis overprints carbonaceous shale mud volcanism that formed in earlier rift geotectonic settings.



- One of the very striking and provocative aspects of the AV11-02-439 sample of graphite bearing phyllonite schist is that it apparently contains an almost complete record of carbon metamorphism from strong graphene bearing graphite formed at lower temperatures to graphite-dominated kerogenous/graphane reduced carbons at higher temperatures.
- The occurrence of the most graphenized sample with rutile which locally co-exists with kyanite in the area and is thus consistent with this part of the sample experiencing a higher metamorphic grade. Also the rutile aggregate exhibits a prograde texture that pre-dates the shearing.
- Upon cooling and late brittle fracturing graphene-graphite formed with high total carbon contents in late brittle S2 shear planes.

Figure 10. Thermal evolution of Yellowbird carbonaceous metamuds based on graphite geothermometry.

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Arizona Prehnite: A New Find

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Prehnite, hydrated calcium aluminosilicate, is not a common species in Arizona. Indeed, Mindat (as of March, 2019), lists only six locations, and all but one of these are for massive veinlets of the species. Recently, a newly-reported Arizona find of this mineral has produced attractive, pale green- to cream-color prehnite in well-crystallized specimens up to 15 cm across. The story of the discovery makes an intriguing addition to Arizona collecting history.

I first saw examples of these prehnite specimens at a small meeting of Arizona collectors at our monthly luncheon in Phoenix several years ago. One of the group, Dick Morris (then a Phoenix resident, now living in Pinetop, AZ) had brought a couple of pieces in for "Show-and-Tell". He had acquired them at the Copper City Rock Shop in Globe, Arizona. While these first specimens were modest, it nevertheless aroused my interest as a specialist in Arizona minerals. Within a short time, I took a trip from Tucson to Globe to find out more.

I have known the proprietor of the Copper Rock Shop for many years, and always have found John Mediz to be knowledgeable and willing to share locality information. When I asked about the prehnite find, he told me it was found by two brothers from Globe, and he put me in touch with them. Their story of the prehnite find is most interesting.

John and Roy Trobaugh, who have the deposit under claim, have lived and worked in Globe for most of their lives. Both love the outdoors and spent many hours in the Tonto National Forest, hiking, picnicking with family and friends, and looking for mineral specimens. They were not avid field collectors, but they had knowledge of many species, particularly material from the Globe area suitable for slabbing and polishing.

Many years ago, the brothers attended a mineral show in Phoenix and saw so-called "Desert Roses" for sale. These were not typical desert roses, which are normally either gypsum or chalcedony. These specimens came from the Tonto Forest north of Globe, and were eventually identified as being prehnite. The brothers were intrigued, but did not pursue the find for several years.

In the early 1970s, the Trobaugh brothers and two friends decided to go camping and mineral collecting in the area where the prehnite desert roses had been found. They made camp near a huge tree. One cowboy friend, the late Samuel R. Ellison (nicknamed "Slim," because he was seriously overweight!) was in charge of the cooking, while the other three men reconnoitered the surrounding hills. They found the prehnite seam up on the ridge above the camp and picked up several samples, but did not purse extensive collecting at that time.

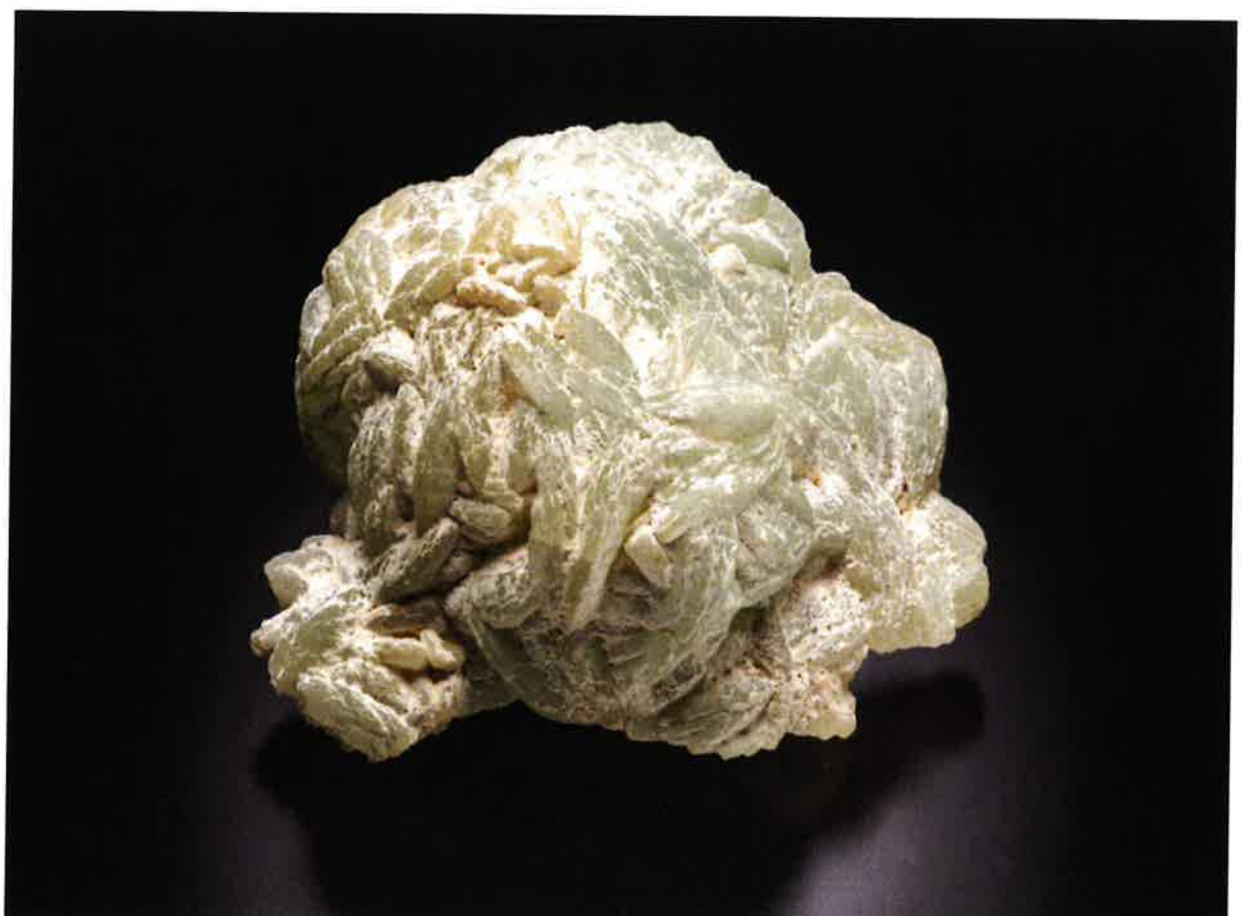
Time passed before the brothers decided to reexamine the prehnite deposit. Roy Troubaugh says that a number of Globe residents also knew about the odd "desert roses" and that it was considered merely an interesting deposit (personal communication, March, 2019). The brothers set out to revisit the area where the prehnite was found, looking for the huge tree where they had camped with the two cowboy friends years earlier. They could not find it, and thus spent the next dozen years periodically revisiting the general area and trying to find the exact spot. It became a mild obsession. Finally, in 2013, the brothers took yet another foray to seek the prehnite deposit. This time they found the landmark tree and the prehnite at the top of the ridge. And this time, the brothers filed lode claims on the outcrop.

Prehnite is a secondary or hydrothermal mineral, forming in veins and cavities in mafic volcanic rocks and less-commonly in granitic gneiss. The mountains of the Tonto Forest north of Globe are rugged and sparsely populated. Mountain peaks rise above 6,000 ft., with deep canyons between. The area bordering the Salt River to the north is wilderness area; the San Carlos Apache reservation lies east of the area. A few large ranches run cattle in the area and there are a few Forest Service roads. There are no towns between Globe and Show Low.

The prehnite deposit extends approximately 1,000 ft. along a contact between basalt and granite. It formed in veins ranging from 2.5 cm to 30 cm which pinch and swell. The prehnite forms pale-green massive material, but in the wider pods, have had enough room to form specimens which are found loose in decomposed vugs. Color ranges from off-white to pale sea-green to a medium sea green. Specimens have formed fan-like groups found in clusters looking like roses or perhaps pale green "brains." A second habit forms tighter fans looking a bit like rice grains.

While researching prehnite, I came across the sole image on Mindat of a crystallized prehnite from Arizona. It had the famous Rock Currier brass bar at the bottom and, indeed, the specimen was his. The notes said the specimen was from the "Coolidge Dam, Stanley Butte mining district" and that the specimen was obtained from Les Presmyk, noted Gilbert mineral collector and dealer. When I contacted Les for more information, he told me he had two specimens and both were obtained from Fred and Sammy Jones of Globe. They had gotten them from Harold Maryett. Doing some further research, it turned out that the Jones were lifelong residents of Globe. Harold Maryett was the Chief Mine Engineer at Magma from 1939 to 1946, and also a longtime resident of the Globe-Miami area.

My interest in the Currier prehnite specimen and the people surrounding it was due to the fact that the pale-green prehnite shown on Mindat was a dead ringer for the specimens which come from the Tonto Forest north of Globe. Subsequently, I have examined Les Presmyk's remaining specimen. And the similarity to my specimens is remarkable. It has been my experience as a field collector that specimens from two different places are almost never identical. Moreover, Mr. Maryett and the Jones were all from Globe, and (according to Roy Trobaugh) the Jones family ranch was located next to the ranch where the "Desert Roses" occurred. It is quite possible that either Maryett or the Jones suggested the Coolidge Dam locality in an effort to keep other collectors off their neighbors' land. Perhaps we will never know for certain.



JOHN ALVIN TROBAUGH

1941- 2015

Minerals of the San Manuel Mine, Pinal County, Arizona

Mark Hay

The San Manuel Mine got off to a very late start compared to most large copper mines in Arizona. The first shaft that would give access to the deep copper ores was not completed until 1953. Even so, it soon developed into the largest underground mine in North America. Over its 44 year history it produced over 4.6 million tons of copper and 73 tons of molybdenum. It provided high paying jobs to 3,400 people at its peak and made a major economic contribution to southern Arizona and the Tucson area.

San Manuel had several significant "firsts" in its history. There was no town of San Manuel before the mine. Magma Copper Company, the mine's owner, did not want the town to grow piece-meal. To avoid this they contracted with Del E. Webb to design a comprehensive community from the ground up. Webb's design included homes, recreational facilities, shopping, parks, schools and a hospital. San Manuel was the first master planned community Del Webb built but certainly not his last. He went on to build master planned communities all across the American sun-belt from Florida to California.

San Manuel was also the inspiration for a new geologic understanding of porphyry copper deposits. The complex mineral assemblages and alteration patterns in the orebody led an independent geologist in Tucson, J. David Lowell, to develop a new geologic model that helped to locate buried deposits. Today, almost 50 years later, his model still stands as the gold standard for exploration and research into porphyry copper deposits worldwide.

San Manuel has never received much attention from mineral collectors primarily because it never produced a large number of specimens. However, forty-nine species have been identified from the mine and at least nineteen of them occur in sufficient quality to be of interest to collectors. The most common of these are calcite and pyrite. In fact, San Manuel arguably produced the finest pyrite crystals in Arizona. Although unknown to many collectors, it also produced a small number of superb specimens of azurite and copper.

Mining ended at San Manuel in January of 2002 and by 2007 all surface facilities had been removed and the site reclaimed. It is an example that full restoration of a large scale copper mining, milling and refining project is possible once operations have ceased.

San Manuel should be remembered as a significant Arizona locality that inspired multiple innovative and historical firsts with far reaching consequences. Though largely under appreciated by collectors, it produced a wide variety of beautiful minerals. And in a few instances, it produced specimens that are extraordinary by any measure including azurite, native copper and pyrite.

MINERALS WITH STORIES TO TELL

Anna M. Domitrovic
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Mineral specimens, whether in institutional collections like the Desert Museum's or in private collections, have a value associated with each one. We ask questions and use certain criteria to determine those values. Is the mineral rare? Is it one-of-a-kind? Is the location notable and/or inaccessible? Is there something about the mineral that makes it unusual, that makes it stand out?

When labelling mineral specimens, cards or labels are generally displayed with the specimen. These cards or labels may include the mineral name and the location (mine, prospect, claim, road cut), along with country, state, county and nearest geographic location (city, town, ghost town), where it was found. In some cases involving private collections, additional information may be handwritten on the back of the specimen's label. Institutional collections may include labels from previous owners or collections. As for the Desert Museum, any detailed information that came with the specimen is kept in a separate file, both hard copy and electronic.

Another tidbit of information that may increase the value of a mineral specimen is the story that goes along with it. Was it collected in a rain or snow storm? Did the collector break a leg or have a stand-off with a rattlesnake to collect it? Stories such as these help to personalize the specimen and the one who went to the trouble to bring it to the light of day. And these kinds of stories help to make connections between inanimate, inorganic objects like minerals and those people seeing them close-up-and-personal, whether they be amateur collectors or experienced ones, or those who just enjoy looking at minerals.

COLLECTING RADIOACTIVE MINERALS

Dick Zimmermann

Hundreds of different radioactive minerals are found in the earth's crust. Some collectors specifically seek a collection of radioactive minerals, while others may have radioactive minerals without being aware of it. Therefore, some familiarity with radioactive minerals is of value for all mineral collectors. No natural mineral is so highly radioactive that it cannot be included in a mineral collection. However, some health risk is possible if they are not handled and stored appropriately.

Human senses cannot detect radioactivity. It was unknown until, in 1896, a mineralogist noticed that some uranium minerals caused exposure on a photographic plate in the dark. Subsequently, Marie Curie studied the phenomenon for her PhD thesis and went on to discover the elements polonium and radium. Next, Rutherford discovered alpha and beta particles in 1899, and Villard discovered gamma rays in 1900. Thus, it was not until the very beginning of the 20^{th} century that there was any fundamental understanding or even any awareness of radioactivity.

Crude instruments capable of detecting radiation were developed at the Cavendish Laboratory in 1908, but it was not until the Geiger Muller tube was invented in 1928 that there was a practical way for mineralogists to detect radiation. Mineral collectors need a Geiger counter, or some modern equivalent, to effectively collect radioactive minerals or to scan their mineral collection for material that warrants special handling and storage.

Radioactivity is caused by a breakdown of isotopes of elements which are unstable due to excess neutrons. Isotopes of many elements are possible; however, there are only about 15 elements in the earth's crust that have at least one naturally occurring isotope. These include uranium, thorium, potassium, vanadium, platinum, tellurium, zirconium, samarium osmium, neodymium, indium, gadolinium, rubidium, rhenium, and lithium. Of those, the first three are the ones the mineral collectors are likely to encounter. The others are extremely rare, have very short half-lives, or do not form any natural minerals.

There are natural potassium minerals, and potassium is actually the most common radioactive element. However, potassium is thoroughly distributed in the earth's crust and does not provide many collectible specimens. Ores of potassium that are found in sedimentary deposits are carnallite ($KMgCl_3 \cdot 6(H_2O)$, langbeinite ($K_2Mg_2(SO_4)_3$), polyhalite ($K_2Ca_2Mg(SO_4)_4 \cdot 2H_2O$), and sylvite (KCl). Only 0.01% of potassium is radioactive and it has an extremely long half-life (decay rate). Therefore, potassium minerals do not produce much detectable radioactivity.

Highly radioactive minerals the collector is likely to encounter will be compounds of thorium and uranium. There are not nearly as many thorium minerals as uranium minerals because thorium does not form secondary minerals. Primary thorium minerals are found mostly in granites, pegmatites, and hydrothermal vein deposits. The most common minerals are thorianite (ThO_2), thorite ($ThUSiO_4$), huttonite (ThSiO4), and cheralite ($CaTh(PO_4)_2$).

Uranium is rather plentiful in the earth's crust and is as common as tin, tungsten, and molybdenum. It occurs naturally at a few ppm in soil, rock, and water all over the globe. Ore is concentrated in granitic deposits and by sedimentation. Since uranium readily forms secondary minerals, there are hundreds of different uranium minerals and more are still being discovered.

Many uranium minerals remain in the Southwestern (USA) mines and prospects developed during the uranium boom of the 1950s. While some are highly radioactive, none are particularly attractive. However, different locations around the globe have produced uranium mineral specimens of great beauty and unique crystal form.

Thus, there is an opportunity to assemble a radioactive mineral collection of considerable variety and great beauty, even though it will be based on a small number of radioactive elements. Self-collected specimens, however, may be highly radioactive but will not be particularly attractive in terms of crystal form. They can be colorful, because uranium minerals appear in many hues of yellow and green.

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Playing in a Big Boy's Sandbox: Bill William's book about Asarco's Mission Complex

Guenther Neumeier

According to the USGS Mineral Yearbook, the Mission Complex was the 3rd largest copper producer by output in 2015 in Arizona after the Morenci and Ray mines. The open pit mine south of Tucson is an important copper producer, but it is not necessarily known as a producer of mineral specimens.

The Mission Complex, Pima County south of Tucson. Bill Besse map.

Bill William's book takes us on a tour through the history of the Mission copper deposit, how the mining ventures—some more, others less successful— developed over almost 150 years.

The use of copper and copper mineralizations goes back to the Native Americans living in the area where they worked mostly surface outcrops. In the 16th and 17th century soldiers and missionaries were early prospectors in the region for silver and gold. Copper had been known but it was not until 1876, when the Southern Pacific Railroad was completed and it became economical to extract and ship copper ore.

The first mining claim was the San Xavier Mining Claim, filed in 1872, and in 1882, the Mineral Hill claims were filed. Many of these early claims changed hands over time. New owners renamed claims and mines and it can be sometimes confusing to have numerous names for one mine or claim to quantify the sporadic production of copper, and lead-zinc ores from primitive underground operations, the preferred method until the early 20th century.

In the early 1950s the district saw the discovery of enormous low-grade copper ore reserves through modern geophysical methods. Two enterprises, Banner Mining Company and United Geophysical Company can be credited with setting in motion what would eventually develop into the Mission Complex eventually operated by American Smelting & Refining Company (Asarco). Asarco, organized in 1899 and started up the Mission Mine in 1961. Over the decades, mergers and acquisitions consolidated the individual operations into what is today's Mission Integrated Pit operated by Asarco, a wholly owned subsidiary of Grupo México.

Bill's book is an important contribution to the preservation of mining history of the Southwest. The book covers Asarco's history at the Mission Mine, Arizona's history, local history, mining history, geology, mineralogy and mining artifacts. I am proud to have been part of this project.

Aerial view of the Mission Complex. Bill Williams photo.

Color in Minerals

Bob Jones

Color in minerals is the most obvious property and the most appealing. Scientists have identified a number of reasons why minerals have color. Some minerals self-coloring like azurite and malachite. Others owe their color to their physical structure like precious opal. But the majority, of minerals owe their color due to included trace element metallic impurities such as the chromium Red Cloud wulfenite. This talk will highlight some of those causes.

Morenci Mineral Mayhem: Where exactly is Morenci, AZ, and why does it have so many names?

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A bewildering array of names are associated with mineral specimens that have come from the Morenci District of Arizona. These may be divided into three main categories:

1) ***Historical Names***- These are names that are no longer used for new specimens, as these mines have been consumed by the present Morenci Open Pit, or lie beneath 100s to 1000s of feet (30 to 300 m) of low-grade stockpile material. These include the Longfellow Mine, Metcalf Mine, Yankie Mine, Dover Mine, Stargo Mine, Ryerson Mine, Copper Cliff Mine, and many more (Figure 1). To further confuse the issue, some of the old Morenci mines shared names that are associated with other, now more prominent mines, located elsewhere in the state (e.g., Mammoth Mine, Yavapai Mine, and Silver King Mine). There are also a range of names associated with specific mine workings, such as the Pelican Tunnel, Horse Shoe Shaft, Joy Shaft, Manganese Blue Shaft, Humboldt Tunnel and Arizona Central Tunnel. And finally, there are old names which have been superseded by new names. For example, Joy's Camp became Morenci, which was ultimately consumed by the expanding open pit. The town was moved far down Chase Creek during the late 1970s and early 1980s to the site of what had been known as Plantsite and East Plantsite, which is known today as Morenci. The county name has also changed over the years. In 1872 it was part of Yavapai County. Later, it became part of Apache County, and in 1881 it was ceded to form part of Graham County. In 1909 it became Greenlee County. Similarly, the Copper Mountain Mining District of the 1800s was later known as the Clifton-Morenci Mining District, and finally as the Morenci Mining District. Historical names should be used for samples collected between 1872 and 1937.

2) ***Sub-District Names-*** The modern Morenci Mine is sub-divided into at least 11 main areas, and as the pit expands there are new ones being added. These names are shown on Figure 2. These official names, used by the mine for logistical purposes for many years, are derived from historical names. The actual Morenci Pit locality only covers about 9% of the total district, with the remainder divided between the other 10 sub-localities. These sub-district names have been adopted following the start of open pit mining in 1937, and constitute the "modern" Morenci era.

3) ***Incorrect names-*** These are names that include areas near Morenci, but are incorrectly attributed to the mine. For example, many older collections list samples as being from "Clifton, AZ." Clifton was for years the site of smelters and shipping facilities for the mines that were located 3.2 miles (5.2 km) above the town of Clifton along Chase Creek. Clifton is located in barren

unmineralized Gila Conglomerate, and was never the site of copper mining activity. Yet visitors in the late 1800s and early 1900s would often be presented with or purchase samples of ore and minerals from the mines while staying in Clifton. In later years, it was often possible to procure good specimens from the site of these processing and shipping facilities, where coarse ore storage bins were located. The author collected several fine specimens as recently as 1993 by walking the old railroad grade near the former smelter in Clifton. But attribution of these samples to Clifton is incorrect. Similarly, some old specimens are labeled with the name of the company that ran the mine from which the samples came (e.g., Arizona Copper Company, Detroit Copper Company). And lastly, there are many mines located near the Morenci Mine that are often miss-attributed to Morenci. Examples include the Polaris Mine 3.1 miles/5 km northeast), and Clifton Manganese Deposits (2.5 miles, 4km east).

Deciphering Morenci Names

Faced with the range of names over time, here are some suggestions for deciphering sample names. Most samples which collectors will have in their collections will be more modern and best cataloged by one of the 11 sub-district names. Companies such as Southwest Minerals had contracts for years, extracting samples from a range of sub- localities at Morenci. Other samples have been obtained during tours of the mine. If self-collected, you may consult Figure 2 to determine a proper name. Otherwise, it is often useful to consult with collectors who specialize in Morenci, or the employees of companies that mined specimens. Many times, the specific mineral (e.g., smithsonite was almost exclusively from Southside), or the physical appearance and matrix (e.g., massive blue veins and breccias of azurite with white porphyry clasts and abundant red clay characteristic of Northwest Extension) can provide key clues. It is suggested that labeling for samples from the modern open pit era include the bench/level (if known), sub-district name (followed by a "?" if uncertain but likely), Morenci District, Greenlee County, Arizona. For any sample, it is wise to include details on who collected the sample, when it was collected, and any specific site names (e.g., Southside Expansion, 1998, John Doe, near foundations from old townsite).

For historical samples, it becomes a lot trickier. If a historical label does exist, one should never discard it, even if it has errors. The original labels should be amended with a separate new label that corrects any error(s). It is often useful to have such a label, especially for valuable specimens. For example, a historical label that lists "Clifton, Graham County, AZ" could be amended with a supplemental label "Morenci District (pre- 1909), Greenlee County, AZ." Preservation of these samples and their pedigree is especially important as they represent the fragments of mining history that has often been consumed by the Morenci Pit.

Notes on the History of the Morenci Mine

Copper was found on Chase Creek as early as the late 1860s, and by 1872 mining of high-grade copper oxide ore (averaging 20% Cu) was booming. The Detroit Copper Company formed in this period, followed by the Longfellow Mining Company in 1874, when a smelter was built in Clifton. By 1879, the Coronado Railroad connected the mines with the smelter. In 1882 the Arizona Copper Company acquired these resources and expanded the rail lines and built a new smelter and concentrator in Clifton by 1886. As mining extended to "refractory" sulfide ores, the company was required to update and build new concentrators in 1895, 1906, and a new smelter in Clifton in 1913. During the same period (1880-1897) the Detroit Copper Company received major capitol for new infrastructure from Phelps, Dodge, and Company of New York. In 1897 Phelps, Dodge, and Company bought the remaining interest in the Detroit Copper Company, and in 1908 became Phelps Dodge Corporation. By 1922, Phelps Dodge Corporation had control of the entire district. A massive exploration program in 1928-1930 delineated the large disseminated "low-grade" deposit that is now being mined by open pit. Underground mining ended in 1932, and stripping of overburden began in 1937. A modern concentrator and smelter was built as part of a federal war production effort in 1942, far south of town, and christened "Plantsite." Pit expansion eventually consumed the towns of Morenci, Stargo, and the old ghost town of Metcalf, producing one "super-pit" by 1981. In 1987 the mine expanded to include Solution-Extraction/Electrowinning plants to process low-grade leachable ores. Since 2007, the mine has been owned and operated by Freeport-McMoRan Copper and Gold. In 2017, the mine produced 737 million pounds of copper and employed over 3000 workers.

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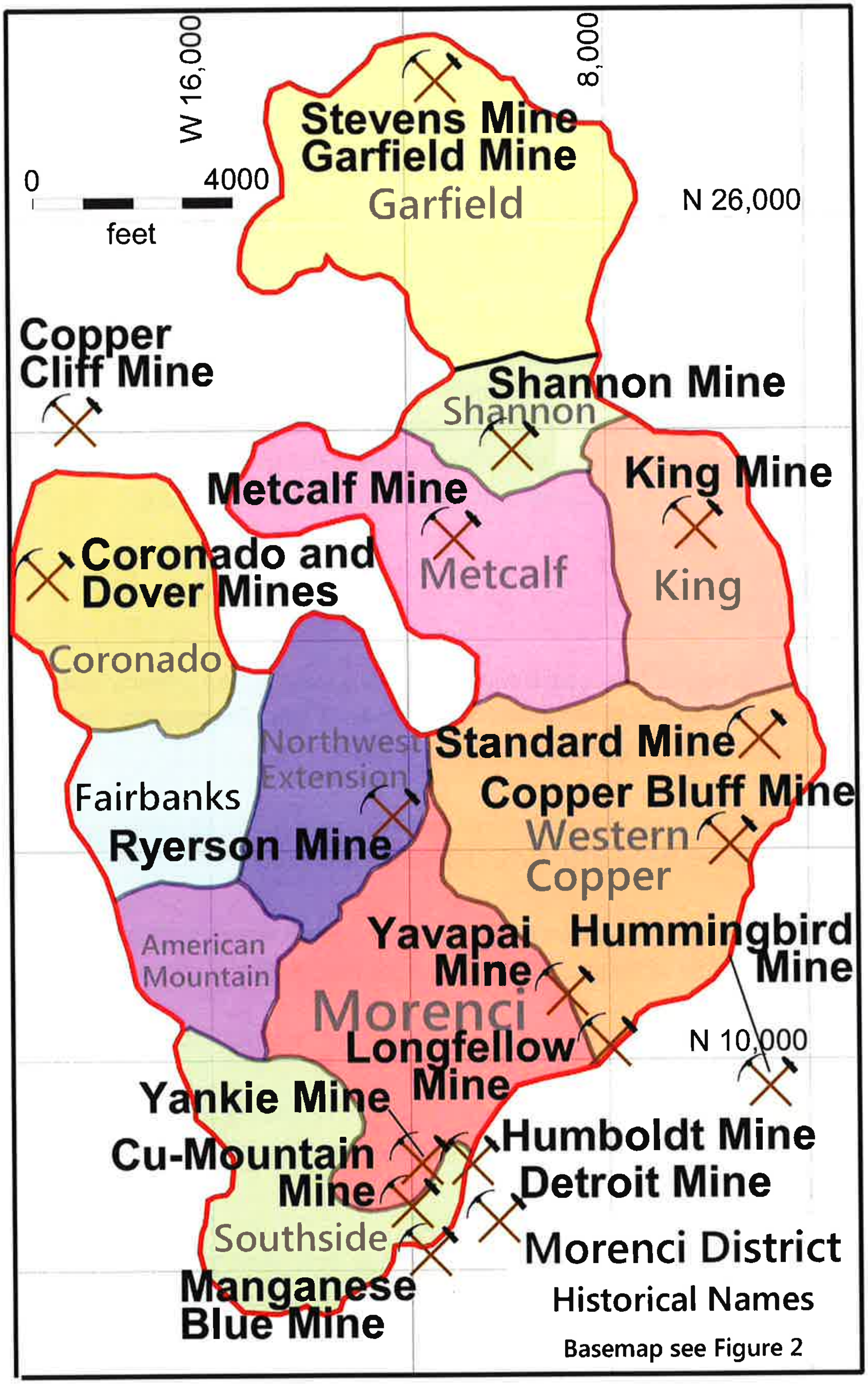

Figure 1. Morenci District map, showing historical mine names and locations (1872-1937) against the modern pit outline and the location of major sub-districts (see Fig 2).

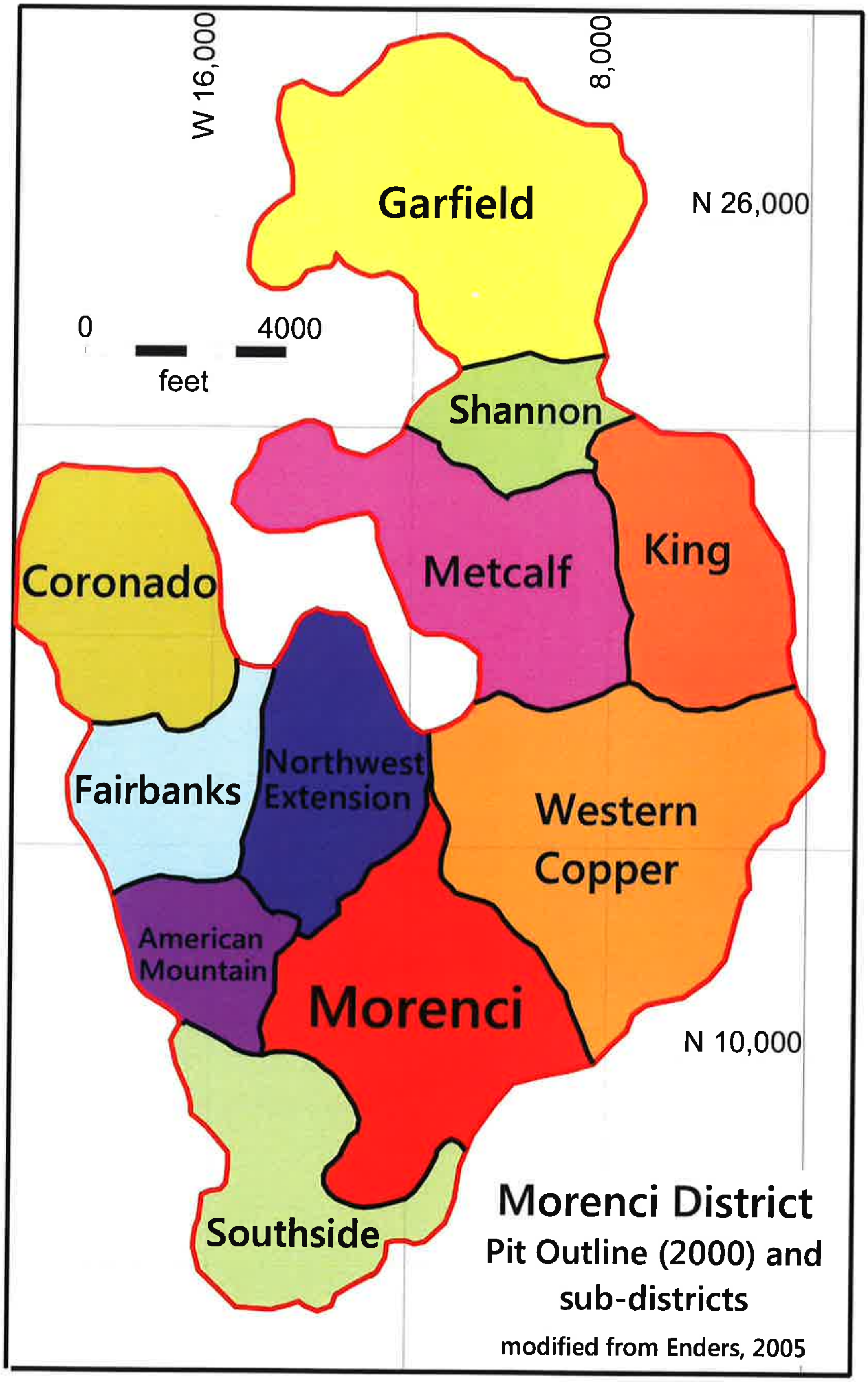

Figure 2. Morenci District map, showing pit outline (red line), and the location of major sub-districts (colored areas with black names).