

MINERALS OF ARIZONA

Seventeenth Annual Symposium



Sponsored By
Arizona Mineral and Mining Museum Foundation &
Arizona Department of Mines and Mineral Resources

Saturday March 21, 2009

Co-Chairpersons

Jan Rasmussen - Curator, Arizona Mining and Mineral Museum

Ray Grant - Chair, Arizona Mineral and Mining Museum Foundation

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Seventeenth Annual Symposium

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Resources**

**Saturday March 21, 2009
8 AM. to 5 PM.**

**Arizona Mining and Mineral Museum
15th Avenue and Washington
Phoenix, Arizona**

Co-chairpersons:

**Jan Rasmussen - Curator, Arizona Mining and Mineral
Museum**

Ray Grant - Chair, AMMMF

Cover Design by Harvey Jong

Photo credits:

**Top left corner: Fluorite and Quartz, Santa Teresa Mountains,
Graham County, AZ - Harvey Jong photo**

**Top right corner: Mcguinnessite on Chrysocolla, 470 level, 79
mine, Hayden, Gila County, AZ - Paul Harter specimen, Harvey
Jong photo**

**Bottom left corner: Wulfenite, Defiance mine, Gleeson, Cochise
County, AZ - Arizona Mining & Mineral Museum specimen
donated by Les Presmyk, Harvey Jong photo**

**Bottom right corner: Paramelaconite, Copper Queen mine,
Cochise County, AZ - American Museum of Natural History
specimen, Richard Graeme photo**

Program

8:00 - 9:00 - **Coffee Hour**

9:00 - 9:10 - **Welcoming Remarks and Introductions**

Arizona Localities

9:10 - 9:40- **Wulfenite in Arizona - Jan Rasmussen**

9:40 - 10:10 - **Mines and Minerals of the Turquoise district
(Courtland, Gleeson), Cochise County, Arizona -
Anna Domitrovic**

10:10 - 10:50 - **Break, Mineral Silent Auction**

10:50 - 11:20 - **Quartz from the Santa Nino mine area, Santa
Cruz County, Arizona - Barbara Muntyan**

11:20 - 11:50 - **Paramelaconite from Bisbee, Arizona - The Type
Locality - Evan Jones**

11:50 - 1:10 - **Lunch, Mineral Silent Auction**

Other Localities

1:10 - 1:50 - **Solar Wind, Searles Canyon, and Maynard claims,
Utah - Mark Carter**

General Topics

1:50 - 2:30 - **How new Minerals are recognized and
characterized - Marcus Origlieri**

2:30 - 3:10 - **Break, Mineral Silent Auction**

3:10 - 3:50 - **Mineral preparation and cleaning - 101 -
Les Presmyk**

3:50 - 4:20 - **What's New in Arizona Minerals - Harvey Jong
and Ray Grant**

4:20 - **Closing Remarks**

Geologic Settings of Wulfenite in Arizona

by Jan C. Rasmussen
Curator, Arizona Mining and Mineral Museum
March 21, 2009

Arizona is famous for its spectacular wulfenite specimens. The butterscotch-colored, bladed crystals from the Glove Mine in the Santa Rita Mountains south of Tucson and the bright red, chunky blades from the Red Cloud Mine in the Silver district north of Yuma are prized highlights of many mineral collections. Most of these famous mineral localities are no longer available to collectors, making the historic specimens even more valuable.

Outline

- Alkali-calcic Pb-Zn-Ag
 - Laramide (75-65 Ma)
 - Glove, Tyndall, Turquoise, Empire dist.
 - Mid-Tertiary (30-20 Ma)
 - Hilltop, Tonopah, Hull, Red Cloud (Silver dist.), Ripsey, Grand Reef, Purple Passion mines
- Quartz Alkalic Au-base metal
 - Jurassic (180-160 Ma)
 - Bisbee
 - Laramide (75-70 Ma)
 - Old Yuma
 - Mid-Tertiary (28-22 Ma)
 - Tiger, Rowley
- Calc-alkalic porphyry copper stage 4
 - Laramide (68-54 Ma)
 - 79, Chilito, Christmas, Finch, Troy
- Peraluminous Calcic (Au-base metals)
 - Precambrian (~1700 Ma)
 - Cave Creek, Hieroglyphic Mts.
 - Jurassic (~175-150 Ma)
 - Western Arizona deposits
 - Late Laramide (60-45 Ma)
 - Vulture mine
- Peraluminous Calc-alkalic (W-base metals)
 - Precambrian?
 - Tungstona, Picacho View mines
 - Jurassic? (175-160 Ma)
 - Mildren (Cababi district) mine
 - Late Laramide (60-45 Ma)
 - Campo Bonito district, Three Musketeers



Figure 1. Wulfenite from the Glove mine, Santa Rita Mountains

Wulfenite is lead molybdate, PbMoO_4 . It forms in the oxidized zones of lead deposits where the white needle-like crystals of cerussite (PbCO_3) have developed. Surprisingly, the presence of molybdenite is not required. Wulfenite rarely occurs in the same mineral deposits as molybdenite, and then only in the later stages of the deposits. Even there, wulfenite does not occur unless cerussite or mimetite is present. There had to be enough lead in the system in a relatively soluble mineral to allow the molybdenum in the ground water to combine with lead and oxygen as wulfenite.

Most specimens photographed for this article are on display at the Arizona Mining and Mineral Museum. For explanations of the terms used in this article, see articles by Jan C. Wilt that are reproduced on Jan's website at www.janrasmussen.com. Click on Current Research, then on the appropriate article.

ALKALI-CALCIC PB-ZN-AG DISTRICTS

Some of the most stunning collectable specimens of wulfenite occur in lead-zinc-silver districts. These mining districts are associated with igneous rocks whose whole rock chemistry plots in the alkali-calcic field in a diagram of

%K₂O versus %SiO₂. These types of igneous rocks produced hydrothermal fluids that contained lead, zinc, and silver in solution in the hot water. Other metals were sequestered in the mineral structures of the rock-forming minerals. The Pb-Zn-Ag-rich hydrothermal fluids then intruded into veins, stockworks, and fractures, and in some cases replaced limestone formations in the host rocks.

The alkali-calcic districts that contain the most abundant and best specimens of wulfenite were deposited during two time periods: the early Laramide (75-65 million years ago [Ma]) and the mid-Tertiary (25-15 Ma).

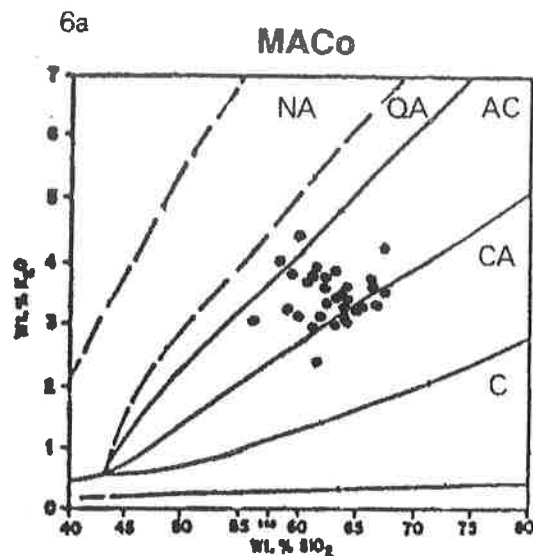
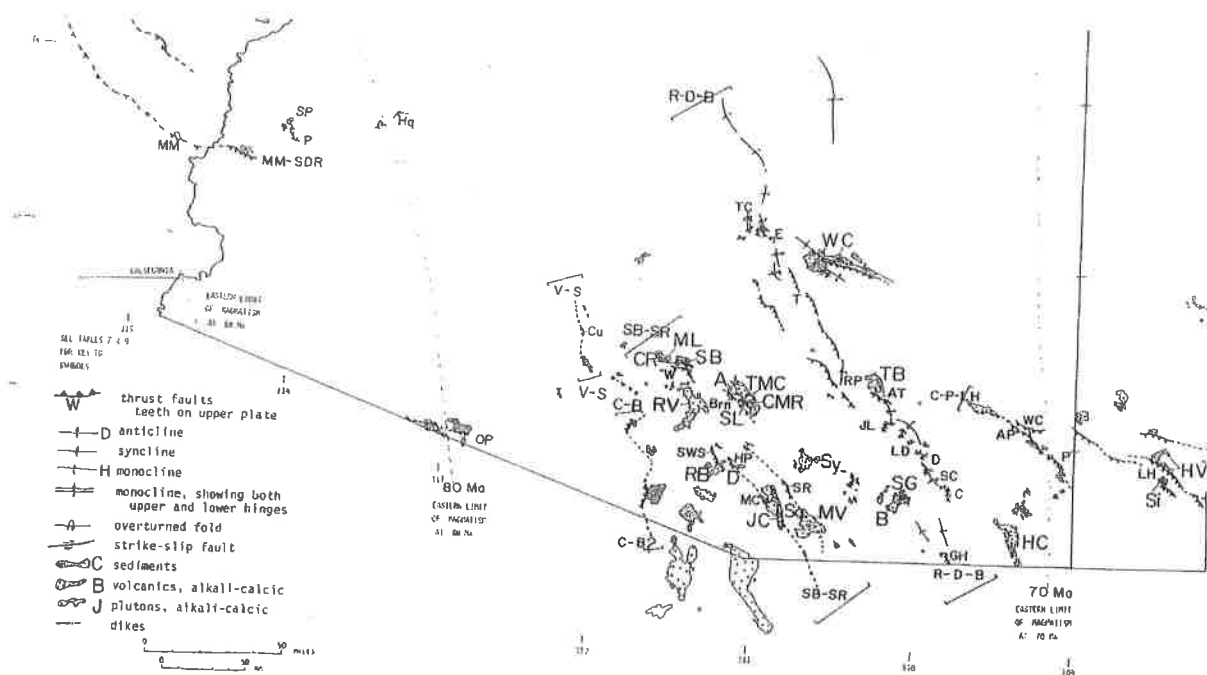


figure 2. Alkali-calcic, oxidized plutons: whole rock chemistry of igneous rocks associated with lead-zinc-silver deposits (Wilt, 1995)



late initial Laramide orogeny

Figure 4. Map of Denver and Tombstone Assemblages of the late initial Laramide orogeny in Arizona and vicinity.

Figure 3. Igneous and sedimentary rocks and structures associated with lead-zinc-silver deposits of Laramide age (from Keith and Wilt, 1986)

Lead-Zinc-Silver Mining Districts of Laramide Age (~75-65 Million Years Ago)

Examples of the alkali-calcic mining districts of early middle Laramide age that contain wulfenite include: the Glove mine in the Tyndall district in the northwestern Santa Rita Mountains, the Emerald-Silver Plume and Toughnut mines in the Tombstone area, the Silver Bill, Defiance, Mystery, and Tom Scott mines in the Turquoise district (Courtland-Gleeson area), and the Total Wreck, Gopher, Prince (Hilton) mines in the Empire Mountains. Other examples, such as the Hardshell and Hermosa mines (Harshaw district), Pomona mine (Vekol district), and Sunset mine (Pajarito district) are listed in Wilt and others (1984).

The wulfenite at the Glove Mine occurs with argentiferous galena, sphalerite, with small amounts of pyrite, chalcopyrite and quartz. The minerals were deposited in permeable zones at the intersection of a bedding plane fault and favorable beds in the Permian Naco Limestone. There was extensive solution of the limestone and the deep oxidation concentrated cerussite, anglesite, wulfenite, and smithsonite in the leached caverns as sand carbonate ore. There were shaft and adit operations, as the mine was worked at various times between 1911 and 1972. The Glove mine produced 29,260 tons of ore averaging about 22% lead, 9% zinc, 0.3% copper, and 7 oz silver per ton, with minor gold (Keith, 1975; Wilt and others, 1984).



Figure 4. Glove mine wulfenite

The Turquoise district in the Courtland Gleeson area of southeastern Arizona produced excellent wulfenite specimens from several mines, such as the Defiance, Mystery, and Silver Bill mines. The Silver Bill mine was a lead-zinc-silver mine that contained irregular small stringers, pockets, and replacement bodies of oxidized base metal sulfides in Pennsylvanian-Permian Naco Group Limestones that is in contact with a Laramide quartz monzonite porphyry. There were large tonnages mined from shaft workings connected to the Mystery mine during the 1800s. In addition, 6,570 tons of ore were produced during 1922-30 and 1938-41 (Keith, 1973).

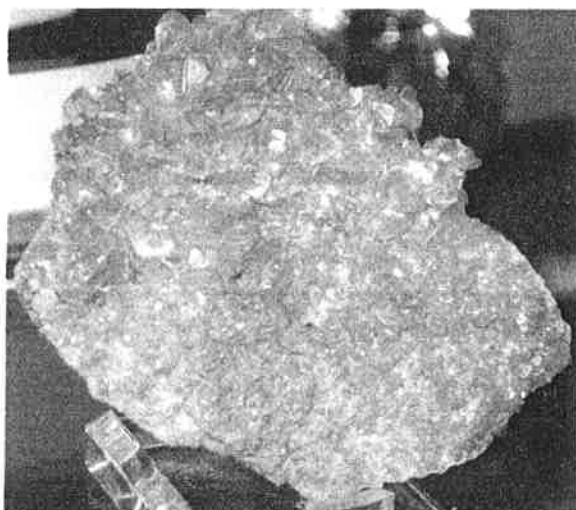


Figure 5. Wulfenite from the Silver Bill Mine, Turquoise district

The Defiance mine, which is also in the Turquoise district, contains large amounts of magnificent wulfenite specimens that line solution cavities and that occur in oxidized lead, manganese, and iron deposits. The wulfenite is associated with cerussite, anglesite, malachite, smithsonite, cerargyrite, and pyrolusite. The lead-zinc-silver orebodies are in Pennsylvanian-Permian Naco Group limestones. They occur where fractures intersect or change dip or they are parallel to bedding. They are associated with aplite dikes related to the Sugarloaf Quartz Latite Porphyry of possible Cretaceous (75 Ma) or Jurassic age (Keith, 1973; Wilt and others, 1984).



Figure 6. Wulfenite from Defiance mine donated by Lorraine Kilpatrick

Wulfenite has also been reported from the Total Wreck Mine in the Empire Mountains southeast of Tucson. The wulfenite is associated with cerussite, vanadinite, cerargyrite, malachite, azurite, chrysocolla and minor copper and lead sulfides. The ore occurs in irregular replacement orebodies in badly faulted Permian limestone beds intruded by Laramide diorite stringers

and dikes. There are shafts and tunnels that were worked from the 1880s to 1940. These produced about 14,000 tons of ore averaging 8% lead, 6 oz silver per ton, and minor gold and copper. Eight tons of molybdenum concentrates were produced for the war effort in 1918 (Keith, 1974; Wilt and others, 1984).

Lead-Zinc-Silver Mining Districts of mid-Tertiary Age (~30-20 Million Years Ago)

Wonderful wulfenite specimens also come from lead-zinc-silver mining districts of mid-Tertiary age. These include the bright red specimens from the Red Cloud mine, and some from the Aravaipa district in the Galiuro Mountains and the Hilltop mine in the Chiricahua Mountains.

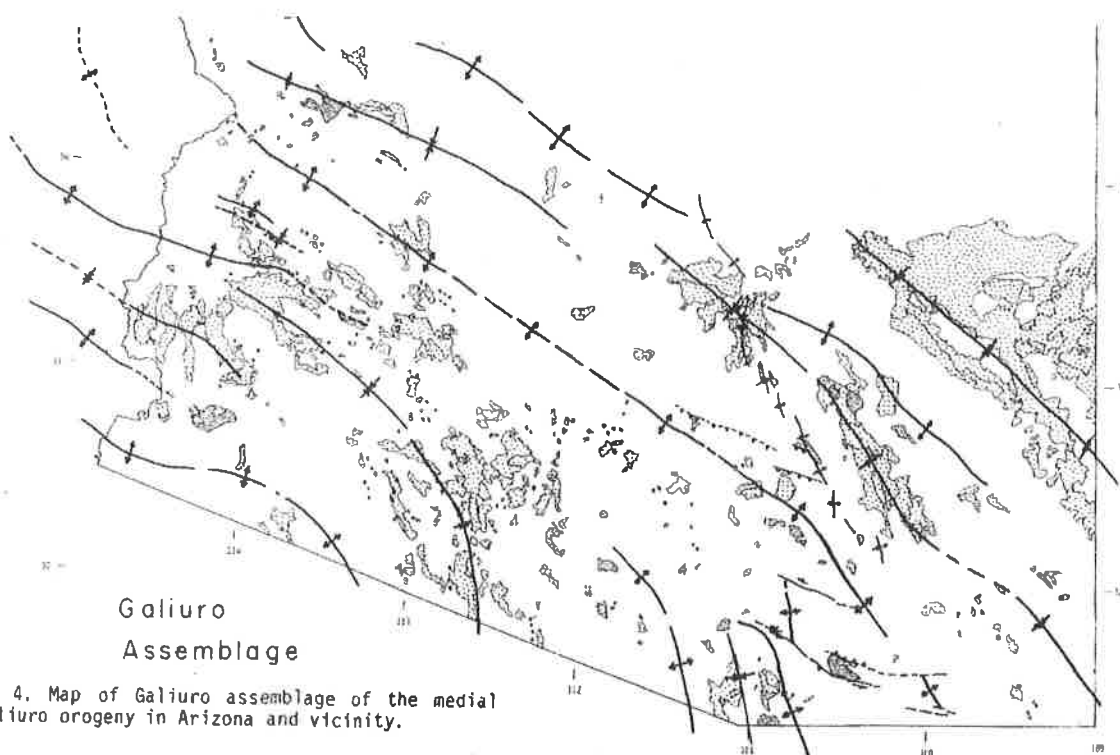


Figure 4. Map of Galiuro assemblage of the medial Galiuro orogeny in Arizona and vicinity.

Figure 7. Outcrops of igneous rocks related to mid-Tertiary lead-zinc-silver districts (from Keith and Wilt, 1985)

The Red Cloud Mine in the Silver mining district of Yuma County is most famous for its barrel-shaped, bright red vanadinite crystals.

But it also contains unusually bright red wulfenite crystals that have a slightly more chunky shape than the usual blades. The

minerals occur in irregular masses and vug linings of argentiferous lead and zinc carbonates with pyrolusite, vanadinite, wulfenite, and minor malachite. Nodules of partly altered argentiferous galena, and disseminated masses of silver chloride and bromide occur in a gangue of iron oxides, quartz, fluorite, calcite, gouge, and brecciated wall rock. The mineralized vein occurs in an irregular fault zone between Tertiary andesite breccia, dacite porphyry, rhyolite to dacitic tuffs and lapilli tuffs that intrude Laramide granodiorite to quartz diorite. The ore had an average grade of 5-6% lead and 10 oz silver per ton. The shaft operations in the 1880s produced a total (until the 1960s) of 21,000 tons of ore averaging 18 oz silver per ton and 5.5% lead and minor gold (Keith, 1978; Wilt and others, 1984).

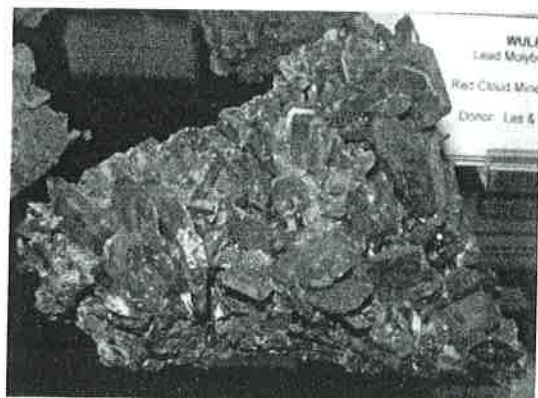


Figure 8. Wulfenite from the Red Cloud mine donated by Les and Paula Presmyk

Specimens of wulfenite from the Hilltop mine in the California district of the Chiricahua Mountains in Cochise County are the more typical butterscotch yellow color. The wulfenite occurs with galena, cerussite, sphalerite, and spotty copper oxides and scheelite. The ore occupies fissure veins and irregular replacement lenses and bodies in banded and tilted, silicified Mississippian to Permian limestones and quartzites. Extensive workings from several tunnels produced a total of 30,000 tons of base metal sulfide ore intermittently from the early 1910s to 1954 (Keith, 1973; Wilt and others, 1984).



Figure 9. Wulfenite from the Hilltop mine in Cochise County

Another possible mid-Tertiary mine with unusual acicular wulfenite crystals and epitaxial needle growth over tabular crystals is the Purple Passion mine in the White Picacho district, also called the Diamond Joe mine, which is near the Great Southern mine. It occurs with fluorite, calcite, galena, anglesite, cerussite, chlorargyrite, smithsonite, willemite, and quartz. In the mid 1920s, about 60 tons of ore per week were being processed for a short time, averaging 12-15% lead, 13.5 oz Ag/ton, and minor gold.

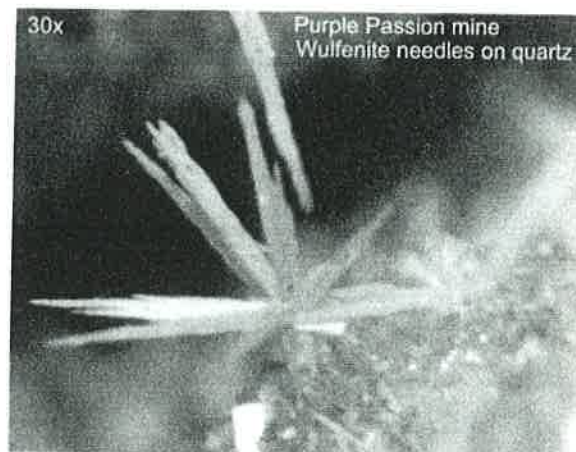


Figure 10. Wulfenite from the Purple Passion mine in Yavapai County (Photos and data from www.fluorescents.com/mr2001.htm).

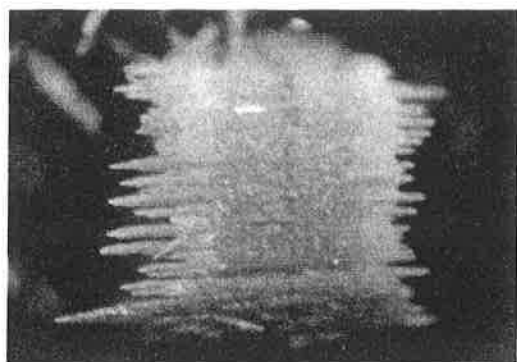


Figure 11. Epitaxial needle growth over tabular crystals of wulfenite, Purple Passion mine, Yavapai County (www.fluorescents.com/mr2001.htm).

QUARTZ ALKALIC GOLD-BASE METAL DISTRICTS

Wulfenite from mining districts associated with quartz alkalic igneous rocks occurs in the lead-zinc-silver zones with mineralization from three different time periods in Arizona: Jurassic, Laramide, and mid-Tertiary.

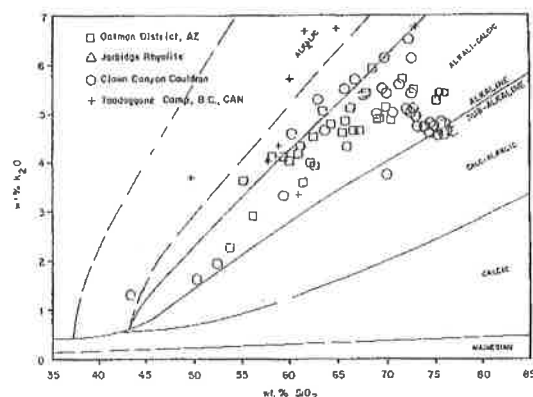


Figure 12. Quartz alkalic, oxidized plutons: whole rock chemistry of igneous rocks associated with gold-base metal (modified from Keith and others, 2005)

Gold-Base Metal Mining Districts of Jurassic Age (~180 Million Years Ago)

Minor occurrences of wulfenite occur in the Campbell orebody at Bisbee in the Warren mining district related to the Jurassic age (186-163 Ma) Juniper Flat Granite. The Campbell orebody contained oxidized base metals (malachite, azurite, cerussite, smithsonite,

mimetite, and wulfenite) on the 1,700 - 2500 level. The minerals were in replacement bodies in lower Paleozoic limestones related to Jurassic porphyry dikes and sills. The shaft workings probably produced several hundred thousand tons of ore (Keith, 1973; Wilt and others, 1984).

Gold-Base Metal Mining Districts of Laramide Age (~75 Million Years Ago)

The Old Yuma mine in the northern Tucson Mountains was primarily a gold mine, previously owned by Richard Bideaux. The mineralization consists of partly oxidized base-metal sulfides with spotty wulfenite and vanadinite, and gangue quartz and calcite. The minerals occurred as a steeply dipping, lensing and faulted orebody along a fracture zone cutting Cretaceous volcanics and associated with a Laramide porphyry intrusive, the Amole Granite. Shaft and underground workings produced ore from 1916-1947, totaling 5,700 tons ore grading 4% lead, 1% copper, 0.6% zinc, 0.3% molybdenum, 1 ounce silver per ton, and 0.1 ounces gold per ton (Keith, 1974; Wilt and others, 1984). The mine is now in Saguaro National Park and is unavailable for collecting.

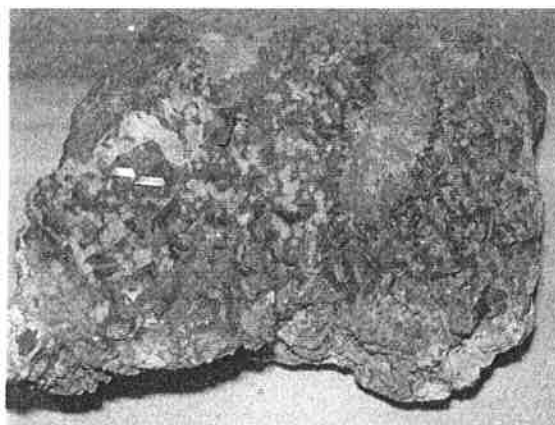


Figure 13. Wulfenite from the Old Yuma mine, Tucson Mountains

Gold-Base Metal Mining Districts of mid-Tertiary Age (~25-15 Million Years Ago)

Some of the most sought after wulfenite are the specimens from the Mammoth-St. Anthony Mine near the Tiger town site. This mine was on the land position of BHP Billiton's now

closed San Manuel mine and the ore was used in the plant as flux in the copper smelting process.



Figure 14. Wulfenite from the Mammoth-St. Anthony mine

The wulfenite occurs with vanadinite, gold in quartz, galena, sphalerite, anglesite, cerussite, and many oxidized minerals. The ore occurs in west-northwest trending shear zones that are intruded by mid-Tertiary (22 Ma) rhyolite. The widest fissure veins occur in Precambrian quartz monzonite (Oracle Granite), which is the most intensely shattered and brecciated host in the mine area. The deposit was oxidized and faulted, and the thin wulfenite and vanadinite mineralization was deposited during the later period of oxidation. About 6.3 million pounds of molybdenum concentrates (MoO_3) were produced between 1881-1947 (Wilt and others, 1984).

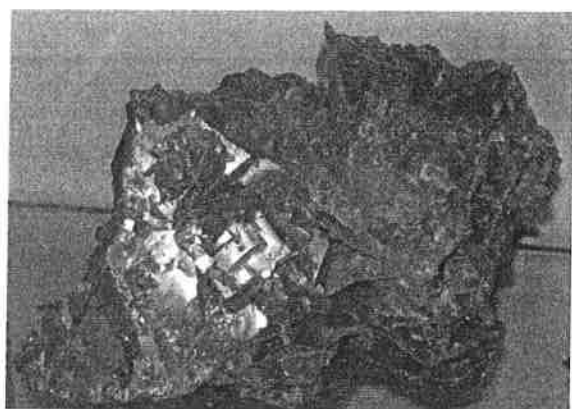


Figure 15. Wulfenite from the Mammoth-St. Anthony mine on loan from the Arizona Mineral and Mining Museum Foundation (AMMMF)

The shafts and adits of the Mammoth-St. Anthony mine were closed in 2005 as part of the closure of the San Manuel mine and are no longer available for collecting. The San Manuel deposit was emplaced during the Laramide, which is typical of most other porphyry copper deposits in Arizona.

The Rowley mine in the Painted Rock district of Maricopa County is also a favorite for mineral collectors. Wulfenite occurs with barite, cerussite, and base-metal sulfides, especially with secondary minerals of a cerussite-anglesite suite, a wulfenite suite, a caledonite suite, and a vanadinite suite. The minerals occur in northwest trending fissure veins in mid-Tertiary andesite and rhyolite flows and dikes. The mine shipped 130 tons of wulfenite concentrate to California (grading 18.26 % MoO_3).



Figure 16. Wulfenite from the Rowley mine, Maricopa County, donated by Floyd and Alice Getsinger

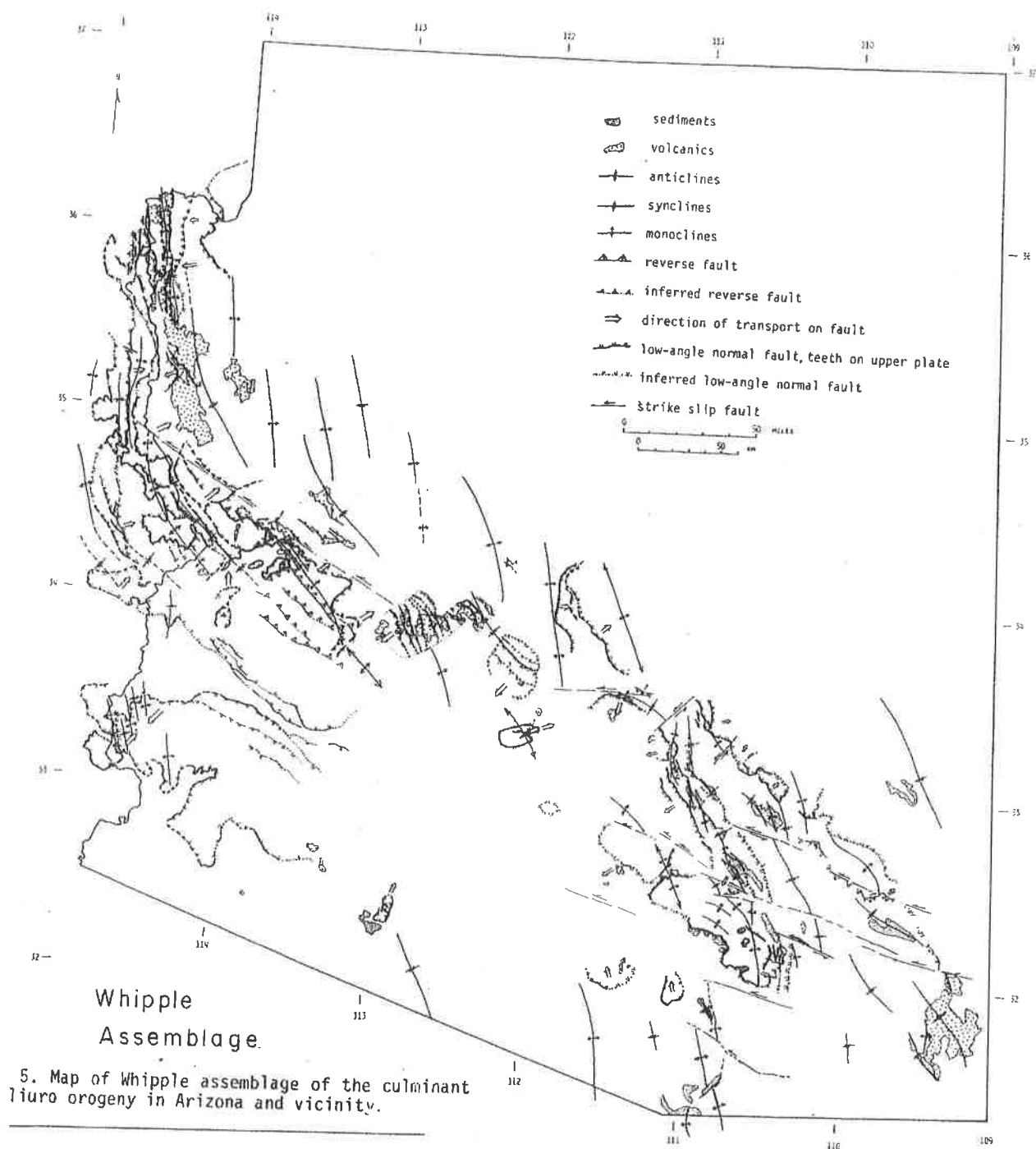


Figure 17. Igneous and sedimentary rocks and structures possibly related to mid-Tertiary gold districts (from Keith and Wilt, 1985)

CALC-ALKALIC PORPHYRY COPPER DEPOSITS

Stage 4 of Porphyry Copper Deposits of Laramide Age (~75-55 Ma)

Minor occurrences of wulfenite have been reported from the Stage 4 zones (later) of porphyry copper mining districts that are associated with igneous rocks of calc-alkalic whole rock chemistry. These Stage 4 deposits are characterized by quartz stockworks and veins associated with quartz-feldspar porphyrys and associated molybdenum-quartz-sericite-pyrite mineralization and minor arsenic (mimetite). Examples of Stage 4 zones in porphyry copper districts reporting wulfenite include the Chilito, Christmas, and 79 mines.

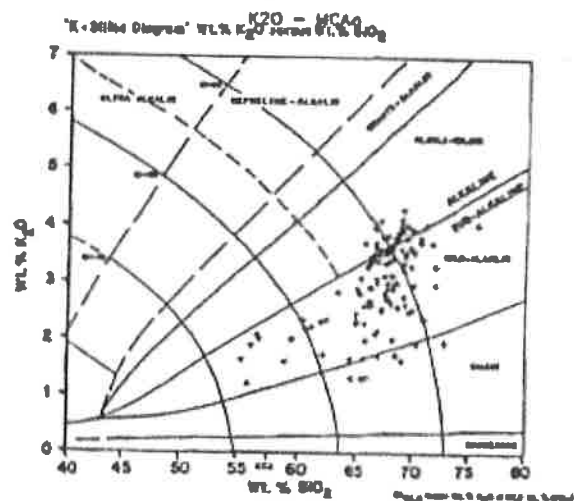


Figure 18. Calc-alkalic, oxidized plutons: whole rock chemistry of igneous rocks associated with porphyry copper deposits (Wilt, 1995)

At the 79 mine near the Ray mine, wulfenite occurs with galena, sphalerite, pyrite, and cerussite, along with a large variety of secondary minerals. The mineralization occurs in permeable zones, such as breccias, fractures, and shear zones, especially as bedded and vein replacements. The mineralization is usually in favorable rock types, such as contact metamorphosed Pennsylvanian Naco Limestone and silicified rhyolite porphyry dikes of probable Laramide age (62 Ma).



Figure 19. Wulfenite from the 79 mine (photo by John Callahan, not in the museum collection)

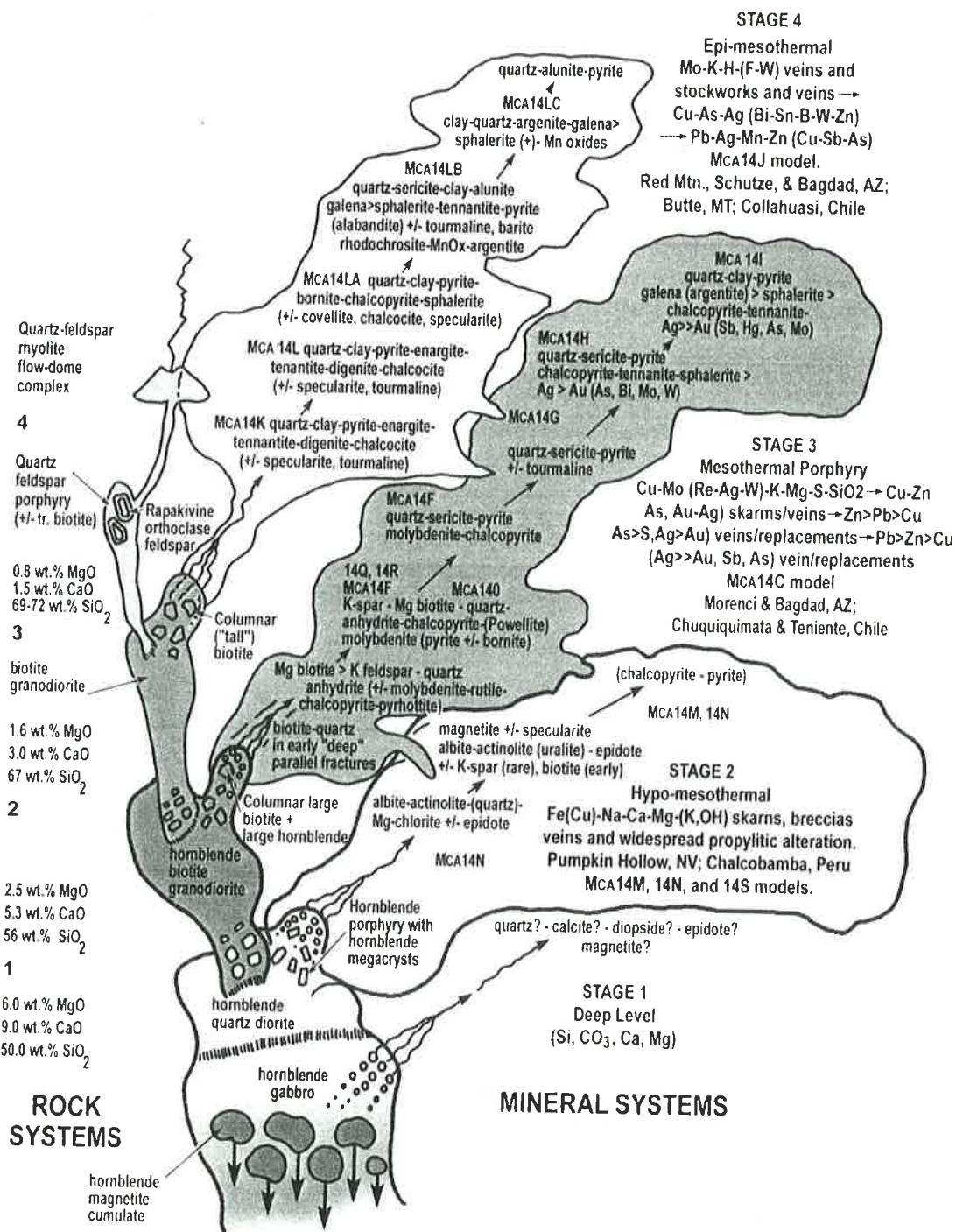


Figure 20. Stages of fluid release and differentiation products of calc-alkalic, oxidized plutons (Keith)

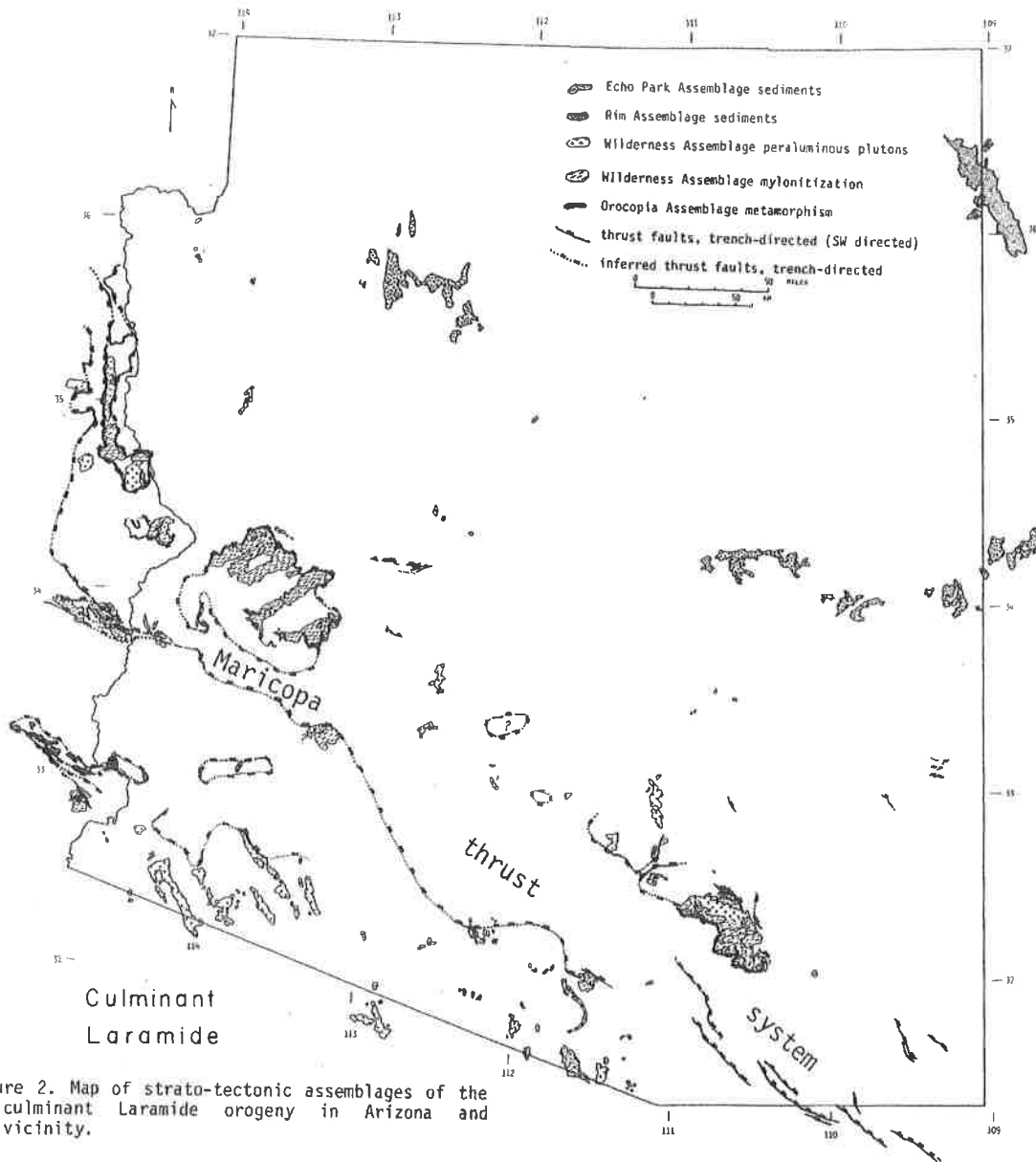


Figure 2. Map of strato-tectonic assemblages of the culminant Laramide orogeny in Arizona and vicinity.

Figure 21. Outcrops of igneous and time-equivalent sedimentary rocks of the Late Laramide peraluminous gold or tungsten districts (from Keith and Wilt, 1985)

PERALUMINOUS

Peraluminous plutonic rocks are commonly termed two-mica granites or "S" granites emplaced during flat subduction in Cordilleran plate tectonic settings. Wulfenite occurs in deposits associated with two types of alkalinity: calcic (gold-base metal related deposits) and

calc-alkalic (tungsten-base metal related deposits). One of the better plots to distinguish between the two types of plutons is the rubidium vs. strontium variation diagram (Figure 22).

Peraluminous plutons have been emplaced in Arizona during several time periods: Precambrian, Jurassic, and Laramide.

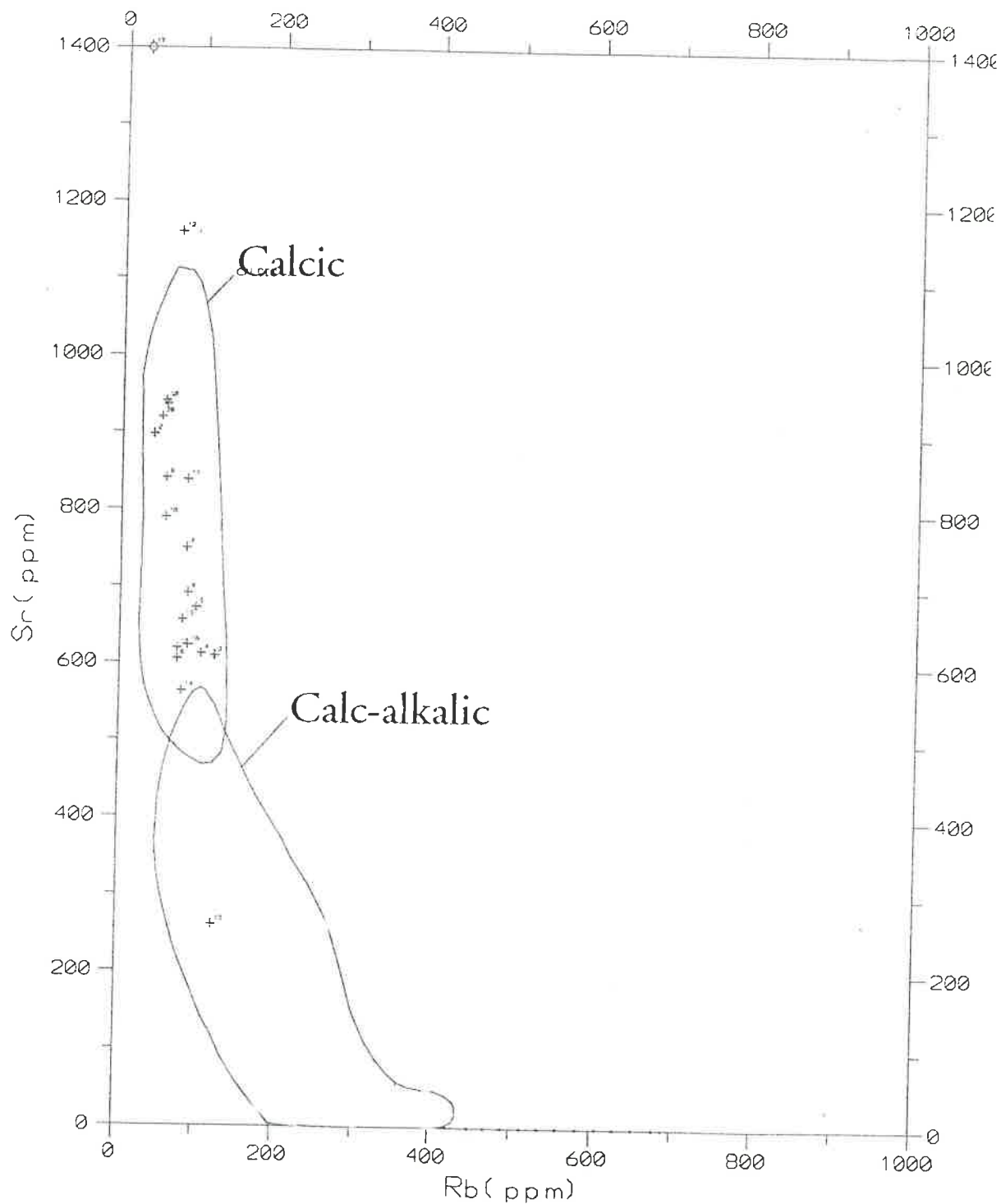


Figure 22. Rubidium vs. strontium plot showing fields of peraluminous calcic and calc-alkalic, oxidized plutons indicating whole rock chemistry of igneous rocks associated with gold (calcic) or tungsten (calc-alkalic) deposits (Keith and others, 1995)

PERALUMINOUS CALCIC AU DEPOSITS

Precambrian? (~1700 Ma) Gold-Base Metal Deposits

Although age dates and whole rock chemistry from the associated stocks are uncertain, it is possible that the Maricopa mine in the Cave Creek district, Prince of Arizona mine in the Hieroglyphic Mountains, and Lucky Strike claim in the White Picacho districts are Precambrian. These mines are hosted in Yavapai Schist and contain gold with oxidized lead minerals in fissure veins in fault zones

Jurassic (~175-150 Ma) Gold Deposits

There are numerous potential candidates for peraluminous calcic deposits of gold-base metal systems in western Arizona. However, age date and whole rock chemistry on such systems is currently lacking. Some of the systems that have been interpreted as mid-Tertiary detachment deposits may have been deposited during the Jurassic (Keith, 2007, SME talk).

Late Laramide (60-45 Ma) Gold Deposits

The culminant stage of the Laramide orogeny experienced flat subduction, which produced two mica granites throughout southern Arizona. Possible representatives of this type are the Kofa and Vulture mines. Characteristics of peraluminous calcic gold-base metal deposits include veins and stockworks or disseminations and breccias. They contain gold, lead, and some arsenic, tellurium, and bismuth. These deposits contain wulfenite and mimetite in the oxidized zones. Another example of this type of deposit is the San Francisco mine in Mexico.

PERALUMINOUS CALC-ALKALIC BASE METAL-TUNGSTEN DEPOSITS

Late stage pegmatite deposits containing boron, lithium, beryllium and minor tantalum, niobium, cesium, bismuth copper, uranium, fluorine,

tungsten, tin, and phosphorous are typical of peraluminous calc-alkalic stocks and dikes related to low-angle subduction zones. This type of pluton is related to tungsten deposits and other rare minerals. They were intruded throughout Arizona during three time periods: Precambrian, Jurassic, and late Laramide.

Precambrian? Pegmatites or Tungsten Mines

Possible peraluminous calc-alkalic stocks and pegmatites of Precambrian age include those related to the Tungstona mine of the Eureka district of Yavapai County, and the Outpost and Picacho View mines of the White Picacho district. Wulfenite is only a minor occurrence in these districts.

Jurassic Tungsten Deposits (175-160 Ma)

The Mildren and nearby mines in the Cababi district of Pima County contains abundant wulfenite associated with vanadinite, cerussite, mimetite, and chrysocolla in brecciated quartz fissure veins in Jurassic amygdaloidal andesite flows.

Late Laramide Tungsten Deposits (60-45 Ma)

Possible peraluminous calc-alkalic districts include the Three Musketeers mine, and the Bear Cat claim of the Campo Bonito (Old Hat) district near Tucson, which may be related to the Wilderness granite suite of stocks and dikes of Laramide age. This district contains tungsten as scheelite and minor wulfenite and vanadinite and pyrite in north-northeast quartz veins in Precambrian granite near Laramide dikes. Without age dates and whole rock geochemistry, these assignments are speculative.

CONCLUSIONS

Minerals associated with wulfenite always include cerussite, and sometimes include vanadinite or mimetite. As the preceding descriptions of the individual mines indicate, wulfenite only occurs in the presence of the lead carbonate, cerussite. Most of the above

wulfenite localities are in lead-zinc-silver mining districts or in the lead-rich zones of other types of deposits. Galena has been oxidized to cerussite by circulating ground water, which may be the most likely source of the molybdenum in the molybdate. None of the mines with good wulfenite specimens contained the molybdenum sulfide, molybdenite (MoS_2).

The best guide to good wulfenite localities is the presence of cerussite in lead-zinc-silver mining districts. A relatively complete description of the occurrences of molybdenum in Arizona is listed in Wilt and others, 1984).

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The articles by Jan C. Wilt are reproduced on Jan's website at www.janrasmussen.com. Click on Current Research, then on the appropriate article in the table.

**The MINES and MINERALS of the
TURQUOISE DISTRICT (COURTLAND, GLEESON)
COCHISE COUNTY, ARIZONA**

Abstract

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The Turquoise Mining District lies in the central part of Cochise County, Arizona, approximately 14 miles east of Tombstone. It includes the ghost town mining camps of Courtland and Gleeson. It gets its name from turquoise deposits, apparently mined prior to the arrival of the Spanish into what is now southern Arizona in the 16th Century. There is some evidence that pre-Colombian native peoples in the area mined the gemstone for trade, ornamental and utilitarian purposes. American mining interests moved into the area in the mid-19th Century when prospectors discovered deposits of silver, lead and copper.

The Turquoise District lies at the southern end of the Dragoon Mountains, 1000' - 1500' above the Sulfur Springs Valley to the east. The Dragoon Mountains are made up of Cambrian to Pennsylvanian age rocks, with decomposing granites in the lower foothills, and quartzite overlain by sedimentary rocks in the steeper hills and on the ridges. These rocks are intruded by ore-bearing porphyries.

The more notable mines in the district include the Copper Belle, Defiance, Maid-of-Sunshine, Mary Shaft, Mystery Tunnel, Silver Bill and Tom Scott Claim. While turquoise drew attention to the area early on, copper, lead and silver kept the mines in operation until the 1950's. Recent "mining" activity appears to be in the hands of specimen and mine dump collectors, although Aurelio Resource Corporation of Denver currently owns property in the Courtland area. Drilling and exploration began in 2006 in the area they refer to as the Hill Copper Project.

Some of the finest wulfenites in institutional and private collections have come from the Defiance and Silver Bill mines. Copper minerals like azurite, brochantite, cyanotrichite and malachite from the Maid-of-Sunshine and Mary Shaft have proven to be worth owning.

Courtland and Gleeson were the two principle camps in the district from the 1880's to the 1950's. Courtland was named after Courtland Young, who was affiliated with the Great Western Mining Company, one of nine that operated in the area. It reached its peak in 1909 with a population of near 5000. But a year later, a 1910 census listed 914 residents. Its post office remained open until 1942. The town boasted the usual assortment of businesses and services. Some noteworthy ones included fresh milk and bakery delivery, an ice cream parlor,

a motion picture theater, five miles of water mains, and both telegraph and telephone service.

Gleeson was originally called Turquoise and located a bit higher in elevation than the current Gleeson ghost town site. As Turquoise, the town came about in 1890 when Tiffany & Company of New York City expressed an interest in turquoise deposits on Turquoise Mountain. This was the first commercial exploitation of the gemstone in the district. The Turquoise post office operated 1890-1893. The townsite was moved to its current location and renamed Gleeson after John Gleeson, an early prospector in the area. As Gleeson, the post office operated 1900-1939. A 1910 census listed 600 residents. By 1920, the combined population of Courtland and Gleeson was about 600 residents.

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Outlaw Mountain, 15 min topographic

Turquoise Mountain, 15 min topographic

THE TURQUOISE DISTRICT: THE MINES

April Fool	Mame
Armstrong	Magnum Claims
Avalon	Mary
Azul Claims	Mason
Barrett Group	Maude Hill Group
Calomel	Miami
Casey Charleston Group	Molke
Copper Belle	Mona
Copper Bug Claim	Muso
Copper Rocks	Mystery - wolf -
Costello Group	Nancy Group
Cyclone Pb-Zn	New York Gift
Defiance	Nightingale Claim
Elgin Claim	Northern Light Claim
Elsie Group	O'Connor
Fortuna	Ontario
George Claim	Outlook
Germania	P & S Claim
Gilbert Silica Quarry	Paramount
Gleeson	Pemberthy
Gold Band	Poor Man
Gold Camp	Pronto
Golden Crown	Sadie Shannon
Goode Workings	Shattuck Workings
Grant Claim	Silver Bill
Grenadier Group	Silverton
Herget-Turquoise	Sycamore
Herron	Tanner Claim
Highland	Tanner Workings
Hill	Tejon
Humbot	Thayer
Johnny Boy	Thelma
King Plomo	Tom Scott
Last Chance	Turquoise Group
Leadville #1, #2	Turquoise King
Leonard	Warnekros
McLendon	
Maid of Sunshine	

Limonite

MINERALS OF THE SANTO NINO MINE AREA, SANTA CRUZ COUNTY

Barbara L. Muntyan

The Santo Nino mine is located about 2.5 miles southwest of Duquesne/ Washington Camp on a northeastern slope of Mt. Washington at the southern end of the Patagonia Mountains. The mine consists of five patented claims, worked by seven levels exploiting a near-vertical ore vein. The quartz veins which contain the sceptered amethyst crystals are found west of the of mine workings on another flank of Mt. Washington.

The mine was located in 1908 by a man named Dennis Coughlin and produced ore from 1912 until 1955. The mine was never a good producer, and it had a succession of owners, including the Havalena [sic.] Mining Company and the Miami Copper Company, as well as at least five others, through 1970.

The geology of the area consists of highly fractured quartz monzonite and a fine to medium-grained granite, probably Laramide in age. The mineralized zones in which amethyst scepters are found consist of pink feldspar crystals and massive "bull" quartz veins containing vugs filled with sericite and terminated quartz crystals.

The mineral collecting areas of the Santo Nino locale are concentrated on a flank of Mt. Washington due west of the mine workings. The diggings thin out the higher up on the hillside one goes, presumably due to the failing stamina of collectors, and not because mineralization peters out. Eddie Granillos, whose father worked at the Santo Nino, and who has collected some major pockets in the area with his brother, says that mineralization occurs across nearly all of Mt. Washington. The hillsides facing north, however, are heavily vegetated with severely limited views, and are extremely steep, thus making it very hard to follow float and locate crystallized pockets.

At least ten mineral species have been reported and verified by the author at the Santo Nino mine and the adjacent ridges of Mt. Washington. These species are as follows:

Anatase – found as tiny, cinnamon-brown bipyramidal crystals under 1mm

Barite – bladed, milk-white barite crystals to 2" have been found sparingly on the upper reaches of the hillside containing the most digging by collectors.

Chalcopyrite – found on the lower dumps of the mine workings in massive chunks.

Microcline – found in fine, large crystals to 2" on edge, sometimes as Manebach twins.

Molybdenite – found on the lower dumps of the mine workings as small blebs.

Muscovite – lovely rosettes of muscovite to ½" across, in groups to 3", often in association with rutile.

Pyrite – found on the lower dumps to the mine workings as small, partially crystallized masses.

Quartz – found as massive milky quartz, as terminated white crystals, and as white to clear crystals topped by bright amethyst scepters more than 2" across.

Rutile – reticulated, cinnamon brown to red-brown bladed crystals to 1½" in length, intergrown with muscovite in masses to 4".

Sericite – pearly flakes often covering everything in the vugs.

In addition to the above species, the Arizona Department of Mines also has reports of silver, copper, gold, galena, and sphalerite occurring at the Santo Nino mine. There is also a report in the literature of akaganeite and chamosite. However, although rutile and anatase are present, there is no report of brookite.

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PARAMELACONITE from BISBEE, ARIZONA - The Type Locality

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WHAT IS PARAMELACONITE?

Before we get to the history of paramelaconite, what is it?

- Very rare secondary copper mineral.
- Cuprous/cupric copper oxide.
- Chemical formula: $\text{Cu}_2(1+)\text{Cu}_2(2+)\text{O}_3$
- Intermediate between cuprite (Cu_2O) and tenorite (CuO).
- Crystal system: tetragonal.
- Color: purplish-black.
- Opaque.
- Luster: brilliant metallic/adamantine.
- Hardness: 4.5.
- Heavily developed striations (oscillatory combination of {100} and {101}).
- Associated minerals: malachite, connellite, goethite, cuprite, copper.

THE DISCOVERY

The story of the paramelaconite discovery begins in 1890, when noted Philadelphia mineral dealer Dr. A. E. Foote was in Arizona Territory during one of his frequent mineral buying trips out west. He had just purchased two unusual specimens from the Copper Queen mine. They looked typical enough, mostly cuprite and goethite. But what Foote couldn't identify were the magnificent, lustrous, and heavily striated black crystals over an inch in length which exhibited obvious tetragonal morphology. The only mineral he could relate them to was anatase. Foote knew enough to realize that titanium dioxide in an oxidized copper deposit made no sense and suspected the crystals might represent a new species.

He didn't know it at the time, but he had just acquired the finest examples of one of the rarest of all copper minerals found in Bisbee, and indeed, the world. To this day, the mineral has never again been encountered at Bisbee.

CLARENCE S. BEMENT ACQUIRES THE SPECIMENS

Not long after Foote returned to Philadelphia, he sold the two specimens with the unknown crystals to pre-eminent American mineral collector Clarence S. Bement for fifty dollars apiece. Bement had made a fortune in his family manufacturing business and had built, between the years 1866 and 1900, the finest private mineral collection in the United States.

KOENIG'S 1891 ANALYSIS

We have no way of knowing, but perhaps at the behest of Dr. Foote, Bement loaned the specimens to Professor George A. Koenig, a mineralogist at the University of Pennsylvania, for examination and analysis. His report was published in the Proceedings of the Academy of Natural Sciences of Philadelphia in 1891. Koenig was so impressed with the unknown mineral he made a line drawing of the best specimen, in its entirety, for inclusion in his report.

He soon discovered that the black crystals, though tetragonal, had different interfacial angles than anatase. This implied that the $c:a$ axial ratio is different for paramelaconite and anatase. In addition, his chemical analysis revealed he was dealing with a copper oxide, similar in composition to tenorite (or melaconite as it was then known). But with obvious morphological differences, in particular the sharp tetragonal crystals, Koenig suspected it was a new species, perhaps a dimorph of melaconite. Thus, he proposed the name "paramelaconite" for the new mineral, "para" being Greek for "like", or "like melaconite".

PARAMELACONITE SPECIMENS ACQUIRED BY THE AMERICAN MUSEUM

In 1900 Clarence S. Bement sold his collection, along with the two paramelaconites, to J. P. Morgan who, in turn, donated it to the American Museum of Natural History in New York. There the specimens remained [eventually one was acquired by the National Museum in Washington, D.C. through exchange] and for many years little work was done on paramelaconite. It still was not officially recognized as a valid species, nor was its crystal system, composition, or structure known for certain.

FRONDEL'S 1941 ANALYSIS

Then, in 1941, Clifford Frondel, a mineralogist at Harvard University, obtained fragments of one of the specimens and did the first modern study of paramelaconite.

Frondel confirmed Koenig's placement of paramelaconite in the tetragonal crystal system. In addition, he determined that paramelaconite was an oxide of copper containing both cuprous (1+) and cupric (2+) copper. Frondel was a proponent of an oxygen-defect structural model, where the omission of oxygen atoms within the crystal lattice results in a loss of negative valence which is compensated for by a change in positive valence of some cupric ions to cuprous.

Paramelaconite was not a dimorph of tenorite, as Koenig had thought, but a species intermediate between cuprite (cuprous copper oxide) and tenorite (cupric copper oxide).

Frondel's study, and a more recent crystal structure report by M. O'Keeffe and J. O. Bovin in 1978 enumerate the properties and crystallography of paramelaconite and are recommended for those who want to learn more about this mineral.

PARAMELACONITE FOUND IN MICHIGAN

For approximately 70 years after the original discovery, it was thought that only two specimens of paramelaconite existed. All that changed in the early 1960's with the discovery of paramelaconite at the Algomah mine, Ontonagan Co., Michigan. The find sent shockwaves through the mineral world.

Paramelaconite crystals from Michigan lack the brilliant luster of the Bisbee examples, and exhibit pitted, rough-looking crystals up to 5 cm. in size. They typically occur locked in a matrix of chrysocolla and are associated with cuprite, tenorite, plancheite, atacamite, and diopside. Many were marketed by Arizona dealer Scott Williams. A second find of this material in 2003 yielded more specimens.

[Recent work has shown that many of the Michigan examples have altered completely to tenorite. In this case, tenorite is the oxidation product of paramelaconite].

Interestingly, the Michigan find in the 1960's led to the discovery of a third fine example from the type locality, Bisbee, Arizona.

SID WILLIAMS FINDS A THIRD SPECIMEN

In 1962, during his study of the Algomah mine material, Sid Williams, then an assistant professor at Michigan Tech, discovered a third fine specimen of paramelaconite from Bisbee in the collection at the A. E. Seaman Mineral Museum in Houghton, Michigan. It had come to the museum prior to 1913 when George A. Koenig donated his collection to the Michigan School of Mines. Koenig had been a professor there from 1892 until his death.

Williams was able to use this specimen for comparison purposes with the Michigan material, and he describes it as "a small, superb group of crystals associated with connellite and malachite". Undoubtedly, this piece represents a co-type specimen, possibly trimmed from one of the others, and was likely used by Koenig during his original analysis in 1891. Unfortunately, the specimen is no longer in the collection at the Seaman Museum and its whereabouts are unknown.

ROCK CURRIER FINDS A FOURTH SPECIMEN

Then in the 1970's, another previously unknown specimen of paramelaconite from Bisbee was discovered. California mineral dealer Rock Currier was perusing the mineral drawers at Bryn Mawr College in Pennsylvania when he noticed a small, nondescript specimen mounted on a wooden stand, tipped over in a box. It was a paramelaconite!

With it was an old handwritten label indicating it had been in the collection of another prominent Philadelphia collector, George Vaux, Jr. (vauxite was named after him), nephew of William Vaux. The Vaux family had donated his collection to the school in 1957. Soon enough, Rock had managed to acquire the specimen, along with other fine specimens, in an exchange.

JIM MINETTE ACQUIRES THE VAUX PARAMELACONITE

In 1978, Rock Currier sold the Vaux specimen to Jim Minette of Boron, California. Jim and his wife Dawn had, over the years, amassed one of the finest private mineral collections in the country and the Vaux paramelaconite remained in their possession for many years. Jim, unfortunately, passed away recently, and the Minette collection was offered for sale at the Tucson Show in 2008. It was there that I was able to acquire the specimen, which subsequently led me to the present study.

WHAT MINE PRODUCED THESE SPECIMENS?

From the beginning, the locality for the paramelaconite has always been given as the Copper Queen mine. But Foote purchased them in 1890, several years after the Copper Queen ceased production. Which mine did they come from?

There were only two operating mines in the district in 1890: the Holbrook, operated by the Holbrook Cave and Mining Co., and the Czar, operated by the Copper Queen Consolidated Mining Co. In those days, all mines operated by the C.Q.C.M.Co. were known as the "Copper Queen". In addition, the Czar was by far the biggest producer and the most efficient mine from 1888 onwards. Therefore it seems likely the specimens originated there.

Not coincidentally, this same period of mining produced the finest known examples of two other rare species for which Bisbee is renowned: connellite (then known as "footeite") and spangolite. Again, the likely source was the Czar Mine [fine connellite crystals are found in close association with paramelaconite on the type specimens].

SO HOW MANY BISBEE PARAMELACONITES ARE OUT THERE?

For many years after the first description of the species, it was thought that only two examples of Bisbee paramelaconite existed. Then two other important specimens surfaced in the 1960's and 1970's. In addition, there are several other examples, mainly small single crystals, in various collections around the world [Michigan Tech, Harvard University, Yale University, the British Museum, and a few private collections]. These are probably trimmings from the type specimens.

But as we saw with the Vaux specimen, discovered in a dusty old drawer at Bryn Mawr College, other fine examples could be out there waiting to be found. How many specimens did A. E. Foote have? Were there others? Where did they go?

These questions are impossible to answer, but an old advertisement from A. E. Foote gives us a clue.

The ad appeared in the American Journal of Science in September 1891. Under the heading "Minerals-New Arrivals", is this offering: "The new species as described by Professor Koenig, Paramelaconite, an oxide of copper, resembling anatase, in large fine crystals".

It has been noted that the two type specimens had been sold to Clarence S. Bement prior to Koenig's analysis and naming of the species. Therefore this ad must be referencing OTHER specimens in "large fine crystals". Either Foote got another batch, or perhaps more likely, he was holding back specimens until after Koenig's analysis, as mineral dealers are wont to do.

Are the Koenig and Vaux specimens from this batch? Perhaps. A notation on the back of the Vaux label accompanying the specimen indicates it was purchased from A. E. Foote in October of 1894, so he had specimens available as late as four years after the initial find. Presumably, there were others. Where are they?

You may be the next lucky collector to find a paramelaconite in an old collection somewhere.

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Thomas Mountain Range, Utah

Solar Wind, Searles Canyon, and Maynard Claims Mark Carter

Much of Utah at one time was the bed of an ancient sea. During a period of volcanic quiescence 19-16 million years ago this area of the United States was undergoing a series of uplift and block faulting. This uplifting resulted in almost a 5000 foot uplift and the development of areas such as the Grand Canyon. When driving in the area one can often make out where the water lines were on some of the mountains in the distance.

At about the 16 million year time range, volcanic activity increased in several areas of western Utah including the Thomas Range (Topaz Mountain), Dugway Range, Drum and Keg Mountains, volcanic elements in the Wah Wah and Needle Ranges, Three Knolls, Twin Peaks, Mineral Mountains, Black Mountains and the Bull Valley Mountains. Lehi Hintze identified the symbol T₂r_f (described as "late Tertiary rhyolite-dactite-quartz latite flows"). The more precise dating of the Thomas Range is more likely about 6 million years ago. There are five separate flows of rhyolite in the Thomas Range with the southern most, Topaz Mountain being the youngest.

The Minerals of the Thomas Range (Collector Interest)

Bixbyite (Dana locality-Maynard pit) $(\text{Mn,Fe})_2\text{O}_3$

Perfect cubes to very modified Dodecahedrons

Named in 1897 by A.E. Foote and S.L. Penfield to honor Maynard Bixby.

Usually occurs implanted on cavity walls but also in combinations with Topaz, highly modified garnets, and red beryl.

Large crystals range from 3mm in the south to almost 20 mm in the north.

Red Beryl (Dana locality-Maynard pit) $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$

Either slender hexagonal prisms or small hexagonal tablets as single crystals or as clusters.

Crystals have been found near Wildhorse Springs in the Thomas Range up to 25mm in length and 15mm in width. Most crystals are less than 6mm.

The tabular crystals are found occasionally perched on topaz.

Originally named for Bixby as Bixbyite but that name is seldom used.

Pseudobrookite $\text{Fe}_2\text{O}_3\text{TiO}_2$

Either as small, elongated striated prisms or as long slender black acicular needles radiating out from a common center.

First noted by Ed Over.

Garnets



Many locations throughout the Thomas Range

From gemmy to highly modified "clinkers"

Crystal shape varies from trapezohedral, dodecahedral and rarely octahedral.

Garnets are defined as Type I and Type II.

Type I are well formed and seldom found with topaz

Type II are modified with hematite and may show some trapezohedral faces or may be just clinkers. Sometimes frozen in rhyolite and sometimes in lithophysal cavities.

At the Maynard Claim Type II may be found with bixbyite crystals perched on them.

Occasionally Type II garnets are found with microscopic topaz orientated along the faces.

TOPAZ



Orthorhombic Crystal

Crystals are elongated prisms, most of which are terminated.

Clusters and even doubly terminated crystals are not uncommon.

Most are less than 1 cm in length.

Three types of topaz:

1. Transparent
2. Rough opaque
3. Smooth opaque

Sherry colored, but the color is unstable.

Will fade to a silver white color.

Color is due to ground radiation

Color is very slow to fade under display type lighting.

In a few areas on the range the sherry color fades to a pale pink.

Crystals form in gas voids and as many as 2000 crystals have come from a single cavity system.

The combinations of multiple mineral species lead to exciting presentations.

Secondary Minerals:

Quartz

Hyalite opal

Sanidine (a potash feldspar)

Fluorite

Hematite

Ilmenite

Durangite

Calcite

Holfortite

Modes of Mineral Formation

Most of the mineralization in the Thomas Range occurred toward the end of volcanism; as the rhyolite began to cool and shrink trapped gases were segregated into distinct layers before complete consolidation occurred. Upon further cooling shrinkage and joints formed extending down several hundred feet to become fluid pathways for mineral rich solutions. These solution incursions were sometimes separate and other times overlapping which explains the mineral combinations seen in the Thomas Range.

There are 3 types of mineral occurrences within the Thomas Ranges.

1. Fluid movement through fractures rise toward the surface filling any voids; as fluids cool, crystals are forming.
2. Mineralizing gases were already trapped in lithophysal cavities during the eruption and as the magma cooled crystal formation occurred.
3. Low temperature events involve late stage cavity filling. Opal, fluorite, calcite, quartz, chalcedony and some uranium minerals are the expected participants.

Thomas Range Mineral Collecting History

The U. S. Army Corp of Engineers was surveying Utah in 1859 for an overland route to California. Captain Harry Engleman reported many shiny gemlike crystals in the area.

The Area remained unexplored till the 1890's when Maynard Bixby (1853-1935) discovered some black, metallic crystal that occurred as perfect cubes along with fine topaz and tabular rose red hexagonal crystals. The dark cubes turned out to be a new species bixbyite and the red crystals turned out to be a beryl, the red color due to manganese during crystallization.

Location was originally listed as the southern end of the Dugway Mountains, 58 kilometers south west of Simpson Springs. Bixby was a dealer so maybe the location was intentionally vague? The year was probably 1896, in 1897 Bixby was exploring the Morenci and Globe Az. area.

Arthur Montgomery (1909-1999) spent the summer of 1934 in the Dugways and explored the eastern edge of the Thomas Range and probably rediscovered Bixby's site. The following year, Montgomery was joined by Ed Over (1905-1963) as they explored the range including the Topaz Mountain Ampitheatre.

Al Buranek (1915-1987) collected the ampitheatre in the 1930's.

Other collectors include but are not limited to Mike and Sandra Sprunger. John Holfert did his masters thesis on the mineralization of the Thomas Range in 1973 and interviewed Art Montgomery to gain more information.

John Holfert and Steve Allred have been very instrumental in helping me with my elementary understanding of the Thomas Range. John and his partners continue to explore the Thomas Range and are often rewarded by exciting new finds.

Collecting the Thomas Range

Equipment-Delta is over 45 miles away, come prepared.
Water, as this is a 5000' elevation desert you need a large amount.
Most everything you would take for any other outdoor outing.
Special things needed for the Thomas Range.

- Screwdrivers (8 inches or longer)
- 2-3 pound hammers
- Chisels
- Pry Bars
- Sledges
- Trenching tool
- Screens (1/4 inch)
- Toilet paper
- Containers (remember the size of your anticipated find)

Collecting Insights - borrowed from John Holfert

Observe the area you are collecting
Study washes for "float" especially after rains.
Although rare, scorpions and rattlesnakes are present.
Vegetation tends to grow along cavity layers in the rhyolite and these areas are more altered.
If a cavity is found remember these are often connected to other cavities and carefully probe the walls for soft spots.
Study the areas of altered rhyolite for the presence of hematite.
Search for areas with drusy quartz, fluorite, and calcite in seams and fractures.
Look for any type of opening in the rocks.
Search mud in pockets as these often contain topaz.
Use screens, they do yield good results.

Thomas Range localities:

Searle Canyon/Starvation Canyon

South west corner of the range.
Red beryl areas with smaller topaz in association.
Lithophyseal Pockets
To the north and west are more type I garnet localities.
Screening is very helpful.
Wind erosion may leave beryl exposed.
This area is a moderate hike with no road so most work is by hand digging.
Very little or NO bixbyite

Recently discovered Holfertite. (A new Hydroxyl-Hydrated Uranium Titanate from Starvation Canyon, Thomas Range, Utah. Mineralogical record 37 (4), 311-317.)

Solar Wind Claim

North end of the Thomas Range

Nice topaz but some of the largest bixbyite ever found on the range.

Bixbyites are highly modified to look like garnets.

Certainly world class bixbyites when accented with topaz and rarely red beryl.

Just 4 miles from the Dugway geode beds.

Some drusy purple fluorite with bixbyite.

For years John Holfert had alluded to large bixbyite but was reluctant to collect it in earnest due to proximity to the Pony Express Trail (road)

Maynard Claim/Pismire Wash

Site of Maynard Bixby's original workings

Midway on the east side of the Thomas Range.

A personal favorite of mine.

White rhyolite facing north.

Now working just west of Maynard's pit

Appears the Maynard pit was a branch off of a vent pipe.

Mining through the 80's left a back wall about 20 feet.

Working down on the vent pipe has now a back wall approaching 40 feet.

Taking down the front lip of the pit yielded moderate topaz numbers but; dramatic numbers of type 2 garnets some with dramatic small (2-4mm) bixbyites.

Clusters are found fairly frequently. Matrix specimens are rare.

Topaz ranges from smooth opaque, rough opaque and gemmy clear.

Some of the largest topaz from the range is from here.

2 km east-northeast is the pink topaz pit.

Worked by hand up to large track hoes.

Sometimes separating rocks reveals crystals hard to visualize in their original site.

Temperatures ranging from 27-95°F.

Altered zones need to be screened.

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How Minerals Are Recognized and Characterized

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The identification of mineral species finds great importance in the academic and collecting communities. The value of a mineral specimen depends greatly upon its identity, and its scientific significance depends fundamentally on its identity. Rare mineral species typify unusual geochemical and geophysical environments.

At the University of Arizona, many methods are available to identify a mineral. For preliminary testing, a form of spectroscopy excites bonds in a sample with a laser, and allows the bonds to relax, emitting energy in the process. A vanishingly small amount of the exciting energy returns shifted both lower and higher in energy from the original exciting energy; this is the Raman shift. Raman spectroscopy affords a rapid tool to distinguish polymorphs, distinguish various tetrahedral chemical groups, and pigeonhole species into classic mineral groups. In the case where rapid Raman spectroscopy does not provide a sufficiently unique answer, X-ray diffraction affords more detailed information. X-ray diffraction data allow a precise unit cell determination, which usually affords a unique identification. In the case of complex minerals, such as members of large mineral groups, chemical analytical data also becomes necessary.

When a unit cell determination does not find a match among the known minerals, a possibility arises that the mineral is new to science. In this case, detailed X-ray data provides information of the relative positioning of atoms in a unit cell, and roughly indicates the atomic number of the atom. In tandem with quantitative microprobe analysis, which identifies the atoms present, and resolves their component ratios, sufficient data are available to form a crystal-chemical model of the mineral. This combination of chemical and structural data is fundamental to submit a mineral, along with a name for approval, to the international mineralogical community for review.

Mineral Preparation and Cleaning 101

By Les Presmyk

All mineral specimens require cleaning. Starting with when they were brought out of the ground to after sitting for years in a display case, they all require some attention. No one has perfected a dust free case, especially in Arizona. With a few basic tools and supplies and a bit of knowledge and common sense, any collector can keep their specimens looking nice. There are additional techniques that an advanced collector can use or should be left to a professional. It depends on the willingness of someone to handle chemicals and more importantly, be able to dispose of them properly when finished.

Trimming is usually best left to someone who has the tools and the experience to do a proper job. Anyone who has field collected has done some trimming, especially to get that 100-pound rock back to the truck so you can get it home. There is way more to trimming than a chisel and a 3-pound sledge hammer, not just in finesse but also in the end result. However, no matter how many years of experience someone has or if they have all of the tools possible, there is always a risk when trimming any specimen. The years of experience and the shop full of tools just help to minimize that risk.

GETTING STARTED

You need some equipment to get started. Nothing fancy but the following list will give you the ability to clean most of your specimens, especially if they were acquired from someone who already performed a professional cleaning. This list will provide you with the basics.

Brushes, ranging from toothbrushes to artists and paintbrushes.

Two plastic wash tubs (three is better)

Several different sizes of "Tupperware" type plastic containers

Dish strainer and newspaper

Tap Water – nature's most powerful solvent (wash water)

Distilled or demineralized water (rinse water)

Liquid dish soap

One or more books – Sinkankas' Gem and Mineral Data Book is my recommendation

Common Sense

When setting up to clean minerals, use two tubs of water, one for the soapy wash water and one for the rinse water. You can even do an intermediate (third) one to save your rinse water by having a post-wash/pre-rinse tub of tap water. The final rinse is done in distilled or demineralized to keep the minerals in our water from leaving any scum on your specimens, much like what builds up on your drinking glasses.

Here are some do's and don't's.

1. Do make sure the mineral(s) is not water-soluble.
2. Keep your water clean. The wash water will get dirtier much faster than the rinse water.
3. Do make your specimens and water about the same temperature. Some minerals, like cerussite and sulfur, are very temperature sensitive. Others, like quartz, are sensitive if the quartz is at 50 degrees and the water is 110 degrees.
4. Don't use your spouse's fancy Tupperware, unless, of course, it is an emergency. There are plenty of good, inexpensive plastic containers at your local grocery or department store.
5. Do make sure your minerals are not sunlight sensitive if you are washing and drying specimens outside. Cinnabar and silver minerals will darken, topaz will lighten.
6. Don't try to wash fuzzy minerals in water without knowing how strong the crystals are. Not all acicular crystals are equally strong and the weight of the water can mash the crystals down. However, if you decide to try it, gently lower the specimen into the water, preferably upside down, don't swish it back and forth, and bring it back out. Continue to hold it upside down until most of the water has drained off.
7. Do understand what dissolves the minerals you are working with. For example, warm water is fine for malachite but warm to hot water can begin to attack azurite and dull bright crystal faces.

8. Don't use drying chemicals, such as acetone or alcohol, without checking out the effects on a poor specimen. These chemicals can pull water out of some minerals and have detrimental effects on the crystals.

Advanced Tools

1. Dental Picks. Don't buy these, just ask your dentist for some he or she is ready to throw away
2. Ultrasonic cleaner. For delicate crystals or dirt in crevasses you cannot reach with brushes.
3. Crock Pots – heat does accelerate chemical processes.
4. Do-it-yourself car wash or high pressure water sprays/guns
5. Acids and bases – from Lime Away to vinegar and citric acid to oxalic acid (very poisonous) to hydrochloric, hydrofluoric, nitric and sulfuric acids. All need to be treated with respect and require personal protective equipment.
 - a. Respirators
 - b. Rubber gloves
 - c. Safety glasses/Face mask
 - d. Apron
 - e. Fan/ventilation

Common sense is truly important when using high-pressure water sprays. On one hand, it is amazing the number of minerals one can use high-pressure water on. On the other hand, it is amazing the number of minerals one should not use high-pressure water on. ALL fuzzy minerals are off-limits unless your intent is to try to blast a bunch of the mineral away from another, more desirable mineral.

Only a few of the acids will be dealt with in this presentation. Vinegar and citric acid, as well as Lime Away, are readily available and can be used to dissolve calcite away from other minerals. Oxalic is easy to use and very effective for removing iron oxide stains from quartz. However, it is very poisonous so care must be taken to keep animals and children away from the tubs. Also, you do not want to use it on calcite or anything with calcium in it

because it will form calcium oxalate, an off-yellow precipitate that is insoluble. Hydrochloric acid is readily available as pool (muriatic) acid and is very effective in removing rust stains. It requires significant time to neutralize to ensure no yellow iron stains precipitate out and sometimes just is not worth the trouble. Strong acids and bases need to be respected and used by those who are experienced. Whenever using acids, let the specimen sit in tap water for several hours before putting the specimen into the acid solution. This allows any fractures or cracks to fill with water. Once the specimen is clean, baking soda is a very good neutralizing agent. Ammonia works well but it can sometimes have interesting side effects on some minerals. Always neutralize the solution before disposing of it.

TRIMMING

The main purpose of trimming is to remove excess matrix so that the prominent mineral and crystals are not overwhelmed by a large amount of extraneous material. Trimming also gets done so a specimen will fit into a certain competition size category. There are some who object to trimming, either because they are afraid to have it done, or because they believe that somehow a specimen should remain just as it came out of the ground. To preserve a specimen just as it came out of the ground makes no sense to me, unless there is something mineralogically significant about the matrix. The matrix that comes out with a specimen is just an accident. Specimens need to be trimmed, if for no other reason, than to decrease the amount of space each collector needs to house and display their collection.

Successful trimming is a matter of three things. First, is the willingness to do it. If you are afraid of breaking something or splitting the specimen, certainly valid reasons for not trimming, then don't. Second, once you get past your fears (some collectors I know swear that a stiff shot of alcohol helps but I do not recommend it), then trimming is like the advice on how to get to Carnegie Hall: Practice, Practice, Practice. If you have the luxury of having purchased a flat of minerals to get the one the dealer made sure was in there so you would buy the entire flat, start with the worst specimen and work your way to the best one. It is all about knowing how the matrix will react when trimmed. For

example, the limestone that surrounds quartz crystals from Diamond Point splits very nicely in a hydraulic trimmer. The New Jersey basalts, while appearing to be just as solid and homogeneous, are actually shot through with fractures and when placed in a trimmer, the break is very unpredictable. Finally, it is a matter of having the right tools, which can be anywhere from tile nippers to diamond saws and micro-abrasion units.

Again, there are some basic tools a person needs to get started.

Tile nippers or horseshoe clippers – available at hardware stores or home improvement stores

Screwdrivers

Screw type trimmer

The more advanced trimmer/preparer will require some or all of the following:

Hydraulic trimmers, preferably the German “Zuber” trimmer

Micro-abrasion units, these require an air compressor

Dremel tools

Air scribes

Diamond saws

What's New in Arizona Minerals

Harvey Jong, Harvey@digipan.com
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Black Copper Wash

Black copper wash located near Kelvin has some present day mineral formation. Orthoserpierite is forming at a seep along the wash. It is found with gypsum and coatings of atacamite. This is second occurrence of orthoserpierite in Arizona, the other being a seep in the Copper Creek district. Also in the wash, there is glaucocerinite as a cement in a recent conglomerate. Opal and black chrysocolla (manganese rich) also occur as cementing agents. (Thanks to Tim Hayes for this information.)

Tiger (Mammoth district)

Joe Ruiz is constantly on the look out for unusual material from Tiger. He has found a couple of interesting minerals. One, a white acicular mineral, was initially identified as mattheddleite, but is now believed to be close to ashburtonite and may be a new mineral. The other has been tentatively identified as munakataite, a rare selenium mineral.

79 mine

Continued work on minerals from the 79 mine has a possible new mineral for Arizona, and several new minerals for the 79 mine list. The new mineral is mcguinnessite and the additional minerals for the list are chalcophanite and manjiroite. Some white smithsonite of really good quality has also been found recently. (Thanks to George Godas and John Callahan for the information.)

Santa Teresa Mountains

Dean Misantoni has been collecting in the Santa Teresa Mountains for the past several years. The locality has produced really good quartz crystals. The quartz occurs as a number of varieties and habits including milky, amethyst, smoky, and clear. Purple fluorite octahedrons and modified octahedrons are outstanding. The most interesting mineral is the blue beryl as terminated single crystals and groups. Other minerals found there include microcline, hematite, epidote, rutile, actinolite, pyrite, ilmenite, bertrandite, and other minerals still to be identified. (Thanks to Dean Misantoni for the information about the minerals.)

Quartzsite

Coloradoite (HgTe) has been found in a placer nugget. The nugget was found at the Middle Camp Placers on a claim operated by the Quartzsite Metal Detecting Club. It occurs as masses 10s of microns across along with pyrite inclusions (Erik Melchiorre, pers. commun., 2009).