Wulfenite in Arizona

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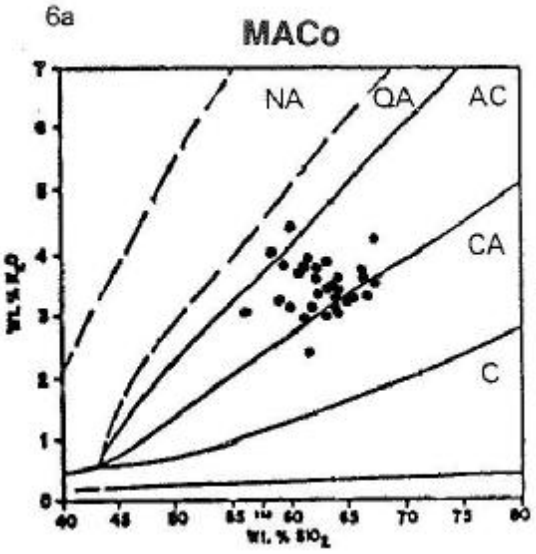
Arizona is famous for its spectacular wulfenite specimens. Specimen photographed for this article are on display at the Arizona Mining and Mineral Museum. The butterscotch-colored, bladed crystals from the Glove Mine in the Santa Rita Mountains south of Tucson and the bright red chunky blades from the 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.

Wulfenite from the Glove mine, Santa Rita Mountains

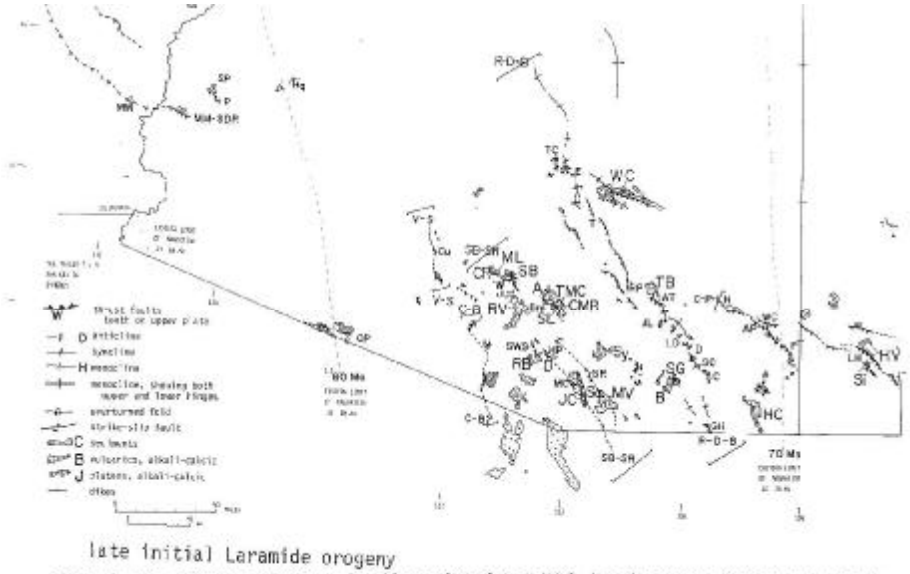
Wulfenite is lead molybdate, $PbMoO_4$, that forms in the oxidized zones of lead deposits where the white needle-like crystals of cerussite ($PbCO_3$) have developed. Surprisingly, the presence of molybdenite is not required. Wulfenite rarely occurs in the same mineral deposits as molybdenite, and then only in the outer lead-zinc-rich fringes of the deposits. Even there, wulfenite does not occur unless cerussite 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.

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

The stunning collectable specimens of wulfenite occur in lead-zinc-silver districts of early Laramide age (75-55 million years ago [Ma]) or of mid-Tertiary (25-15 Ma) age. These mining districts are associated with igneous rocks whose whole rock chemistry plots in the alkali-calcic field in a diagram of K_2O versus SiO_2. These types of igneous rocks produced hydrothermal fluids that contained lead, zinc, and silver in solution in the hot water, rather than being sequestered in the mineral structures of the rock-forming minerals.



Alkali-calcic, whole rock chemistry of igneous rocks associated with lead zinc silver deposits (Wilt, 1995)



Igneous rocks associated with lead-zinc-silver deposits of Laramide age (from Keith and Wilt, 1986, Arizona Geological Society Digest)

Examples of these alkali-calcic mining districts of Laramide age that contain wulfenite include: the Glove mine 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 mine in the Empire Mountains. Many other examples are listed in Wilt and others (1984).

The wulfenite at the Glove Mine occurs with argentiferous galena, sphalerite, 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 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, 7 oz silver per ton, 0.3% copper, with minor gold.

Glove mine wulfenite

The Turquoise district in the Courtland Gleeson area of southeastern Arizona contains several mines, such as the Defiance, Mystery, and Silver Bill mines, that produced excellent wulfenite specimens. 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 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 were produced during 1922-30 and 1938-41.

Wulfenite from the Silver Bill Mine, Turquoise district

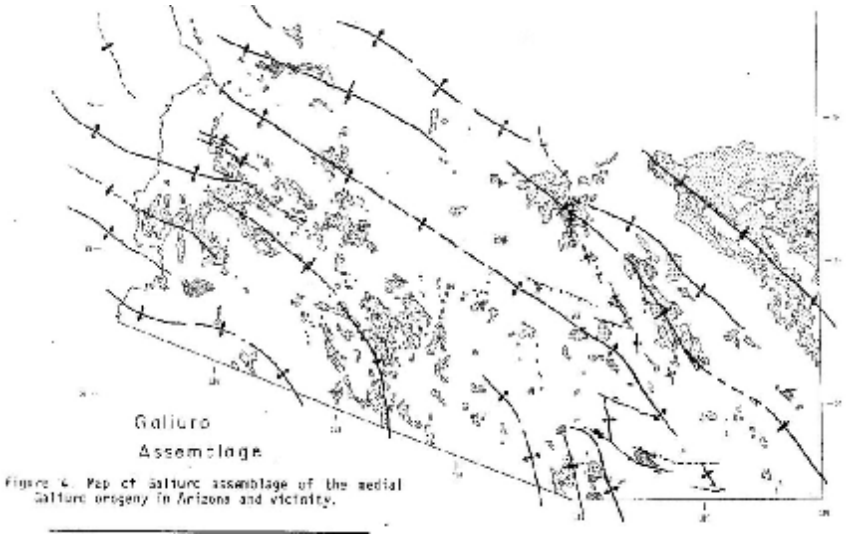
The Defiance mine, also in the Turquoise district, contains large amounts of magnificent wulfenite specimens lining solution cavities and in oxidized lead, manganese, and iron deposits. The wulfenite is associated with cerussite, anglesite, malachite, smithsonite, cerargyrite, and pyrolusite. The lead-zinc-silver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

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 and 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.

Lead-Zinc-Silver Mining Districts of mid-Tertiary Age (~35-20 Million Years Ago)

Also famous for their wonderful wulfenite specimens are the lead-zinc-silver mining districts of mid-Tertiary age. These include the bright red specimens from the Red Cloud mine, as well as smaller specimens of wulfenite from the Aravaipa district in the Galiuro Mountains and the Hilltop mine in the Chiricahua Mountains.



Outcrops of igneous rocks related to 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 intruding Laramide granodiorite to quartz diorite. The ore had an average grade 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 Au.

Wulfenite from the Red Cloud mine donated by Lesand 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 early 1910s to 1954.

Gold-Base Metal Mining Districts (Related to Quartz Alkalic Igneous Rocks)

Wulfenite from mining districts associated with quartz alkali igneous rocks occurs in the lead-zinc-silver zones occurs with mineralization from three different time periods in Arizona: Jurassic, Laramide, and mid-Tertiary. 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. Wulfenite also occurs with the more famous vanadinite in the Old Yuma mine in the northern Tucson Mountains. The most famous localities for wulfenite associated with quartz alkalic igneous rocks are the Mammoth-St. Anthony mine (near the Tiger town site) and the Rowley mine in the Painted Rock district of Maricopa County.

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, most recently 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 volcanic 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. The mine is now in a national park and unavailable for collecting.

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 on the property of BHP Billiton's now closed San Manuel 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 between1881-1947. The shafts and adits were closed in 2005 as part of the closure of the San Manuel mine, which was emplaced during an earlier period of mineralization.

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

Wulfenite from the Mammoth-St. Anthony mine

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).

Wulfenite from the Rowley mine, Maricopa County, donated by Floyd & Alice Getsinger

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Porphyry Copper Mining Districts of Laramide Age (~75-55 Ma)

Minor occurrences of wulfenite have been reported from the outer lead-zinc-silver zones of the porphyry copper mining districts, which are associated with igneous rocks of calc-alkalic whole rock chemistry. However, these are not the spectacular specimens associated with the slightly older alkali-calcic districts that produced lead, zinc and silver from veins and replacement deposits. Examples of porphyry copper districts reporting wulfenite include the Chilito mine, the Christmas mine, and the 79 mine.

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 replacement. 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).

Wulfenite from the 79 mine (photo by John Callahan and not in the museum collection)

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 outer, lead-zinc-silver rich zones of other types of deposits. The 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. For further clarification of the occurrences of molybdenum in Arizona, see the following articles.

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