Mining Hall of Fame Awards

The 26th annual American Mining Hall of Fame Awards Banquet and fundraiser sponsored by the Mining Foundation of the southwest will be held at the Marriott University Park Hotel in Tucson of December 6, 2008.

This year's inductee, guest of honor, and featured speaker at the banquet will be Timothy Snider, who as President and Chief Operating Officer of Phelps Dodge Corporation, led the operational and technical integration of Phelps Dodge's Cyprus-AMAX acquisition and helped to establish Phelps Dodge as one of the industry leaders in technology development and operational excellence.

As representatives of mining heritage, the Hall of Fame will induct R.A.F. Penrose and Samuel Heintzelman into the American Mining Hall of Fame. Medals of Merit will be awarded to Paul Hodges and Barbara Filas. The Industry Partnership Award will be presented to Atlas Copco.

Arizona Department of Mines & Mineral Resources
1502 West Washington Street
Phoenix, AZ 85007

Address Correction Requested

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Mineral Resource

Status of Mining in Arizona

by Dr. Madan M. Singh, Director

Need for Mining

There is a perception among a vociferous minority in Arizona that mining merely mars the landscape and causes environmental damage. These people have little comprehension of the fact that our standard of living depends on mined materials. Everything around us is made of minerals that are obtained from the earth. There is an old axiom that states "if it can't be grown, it has to be mined." Actually even crops and trees need minerals for fertilizers (for example potash, phosphates, and nitrates) which are mined.

Every person in the United States uses 3.6 million pounds of minerals in their lifetime – including over 1.6 million pounds of stone, sand and gravel. 82,000 gallons of petroleum, 5.7 million cubic feet of natural gas, 65, 000 pounds of cement, nearly 20,000 pounds of phosphate, more than 587,000 pounds of coal, almost 30,000 pounds of iron ore, over 28,000 pounds of salt, more than 19,000 pounds of clays, in excess of 1,300 pounds of copper, 5,600 pounds of bauxite, and the list goes on. Automobiles, appliances, televisions, telephones, houses, roads, and bridges, play an essential role in modern society. Where do the raw materials for these come from? Without these and other amenities life would become primitive!

The first steps towards civilization were when man fashioned crude tools and weapons from rocks and used flint to start fires. The metallurgy of copper led to the civilization along the Nile and the Tigris-Euphrates area. The discovery of the effects of adding tin to the copper led to the Bronze Age. When iron was found, the Iron Age began. These metals resulted in trade between countries. After Columbus stumbled on America, the Spanish came looking for gold and other riches.

The Spanish expeditions into lands that later became the State of Arizona in the mid-sixteenth century were in search of precious metals. After the Gadsden Purchase in 1853 many companies were formed to explore for minerals in the region. The census after the creation of the Arizona Territory in 1863 showed that nearly one quarter of the population declared their occupation as miner or prospector. Twelve members (44 %) of the first Territorial Legislature were miners; there were two farmers and two ranchers. This is an excellent indication of the role of mining in the formation of the State.

Economic Contributions

The mining industry is not as dominant as it was earlier. However, its contributions to the state's economy are underestimated. In fiscal year (FY) 2008, which ended on June 30, 2008, the mining industry contributed $43.7 million in severance taxes and $6.8 million in Transaction Privilege Taxes (TPT) to the state, giving a total of $50.5 million. In FY 2007 the total was $51.5 million; but since construction has been affected by the mortgage crisis in FY 2008 the aggregate (including sand and gravel) mining was down by 15 percent even though the severance taxes were 0.5 percent higher. The total sales from metal mines in Arizona were $1.75 billion and from non-metal mines (including oil and gas) were $217 million.

In addition the companies paid corporate income taxes, property taxes, payroll taxes, sales taxes, rents and royalties for use of the State lands, and a host of other taxes and fees. The operating companies also make payments to counties, local municipalities, school districts, and other local organizations.

The Arizona Mining Association (AMA) publishes an annual report on "The Economic Impact of the Arizona Copper Industry." This is based on data from three major mining companies. Estimates are included for the copper being produced in Mineral Park and in the future also for Carlota and Johnson Camp. The direct impact of copper mining in calendar year (CY) 2007 was $3.3 billion and the total impact, direct and indirect, was $6.8 billion. No other metal or non-metal industries are included. Also the contributions of the considerable exploration and development work being done by various companies are not taken into account. In the recent past there has been significant drilling in the Arizona Strip and other areas for uranium. Some companies have been exploring for gold, both placers and lode. There are economic benefits to the state from the development work that companies perform to open up the mines, which is regarded as construction, but should correctly be attributed to mining. Even the recent housing construction in communities such as Globe-Miami-Superior and Safford would not have occurred if it were not for the new mines being developed. During exploration the expenditures for motel rooms and subsistence for drilling crews and geologists are routinely credited to tourism, not mining.

The Gem and Mineral Show in Tucson is the second largest in the world. Its contribution to the economy of Pima County is over $80 million, and attracts visitors and vendors from countries all across the planet. This is the result of the innate mining industry in Arizona. There are similar exhibits in Bisbee, Cottonwood, Globe, Green Valley, Kingman, Lake Havasu City, Mesa, Phoenix, Prescott, Quartzite, Sedona, Sierra Vista, Tombstone, and Wickenburg, albeit on a smaller scale. All attract visitors

from far and wide. The economic benefits are ascribed to tourism, but should be attributed to the mining industry.

If we take Tucson as an example of the economic impact of mining, one out of five workers in the Arizona copper industry lives in that metropolitan area. Mining provides $117 million in personal income, whereas tourism contributes $342 million. However, remember that the latter figure includes significant income from the mineral shows, exploration, and visitors that come to conduct business with mining related entities. Mining consultants that reside in Tucson but provide services outside Pima County are classified as "Exported Business Services," not mining. Thus, their income is not included in the mining category. The contributions to the local economies of Globe, Miami, Safford, Bagdad, Superior and other towns near mines are even more important.

The Arizona Rock Products Association (ARPA) funds a study of the aggregate, sand and gravel, cement and asphalt industries. In CY 2007 the direct impact of these industries was $2.8 billion. The combined direct and indirect impact was $5.8 billion. The industry directly employed over 11,000 persons, but the total number of jobs was 34,500. It should be borne in mind that the construction industry depends on the materials produced by the rock products industry.

The contributions of coal, gemstones, gypsum, mica, perlite, pumice, salt, dimension stone, uranium and zeolites are omitted in these figures. Individually these may not have a significant impact but combined the effect is substantial. For instance, turquoise to fabricate jewelry is noteworthy in Arizona.

If the combined impacts on Arizona for copper and the rock products industries are added together the total is $12.6 billion. If the economic contributions of all the other mining activities are included the total exceeds $15 billion. This compares with tourism that has an impact of $19.3 billion, and agriculture which has a contribution of $9.2 billion.

Copper and Uranium

During CY 2007 Arizona produced 62 percent of the copper mined in the United States. The nation still needed to import 37 percent of its needs from abroad. There is currently an emphasis on generating non-polluting energy. A wind farm, for instance, requires 4.5 times the amount of copper per megawatt of electricity of a conventional power plant. Copper use in cars ranges from 45 pounds for the smaller vehicles to 100 pounds for luxury and hybrid automobiles. At this time there is a high demand for hybrids and this is expected to increase in the near future. High-speed trains utilize 2 to 4.5 tons of copper compared to 1 to 2.5 tons for traditional electric trains. Large electric locomotives have nearly 8 tons of the red metal. A Boeing 747-200 has copper components (including 120 miles of wire) of about 4.5 tons. A Triton submarine contains 100 tons of copper. Copper and its alloys have antimicrobial properties and kill bacteria deposited on them; many doorknobs and other frequently-touched surfaces, especially at healthcare facilities, are made of such materials. Copper is the most recycled metal, and nearly half the metal in use is obtained from scrap; this reflects positively on the current focus on "green." In CY 2007 the copper industry contributed more than $53.5 million directly to various school districts in the state.

Uranium may resume being mined in Arizona; the state was the second largest producer of the mineral during World War II. It is anticipated that uranium production may start here, especially with the increasing demand for nuclear power throughout the world. Nuclear power is clean and does not introduce greenhouse gases into the atmosphere. The U.S. Geological Survey estimates that there are 375 million pounds of uranium oxide (equivalent to 13.3 billion barrels of oil) in the part of the Arizona Strip suggested to be withdrawn from mining. The deposits in this area lie 1,000 feet above any aquifer, and there is little precipitation to carry any dissolved or suspended material into any waterways. The mines must meet strict regulatory requirements to be permitted. Normally mines that operate in the area occupy less than 20 acres of land. Some mines that operated during the 1980s have been so competently reclaimed so that it is challenging to discern that mines existed there. Examples of these include the Hack complex (1, 2, and 3), Hermit, and Pigeon mines. Two decades have passed since these operations, and there are no known ill effects on the miners or surrounding community. Owing to limited milling capacity it is expected only a few mines can operate economically at any one time.

Impact on Environment and Safety

There is a legacy from mines that were left with little effort towards restoration in the past. There was a poor understanding of the environmental damage that these abandoned mines could cause, not only by the mining companies but also the local communities in which the mines were located. Now mining is one of the most regulated industries in the United States. There is an abandoned mine program managed by the Arizona State Mine Inspector's (ASMI) office, which has been in operation since April 1997. The Hardrock Reclamation Rules in 1994 exempted aggregate mines from having to reclaim the land. However, as a result of a new law initiated in 2005, effective January 2007 the aggregate (including sand and gravel) mines have to present formal reclamation programs approved by the ASMI (Arizona Revised Statutes 27-441 through 47-448). Individual mining companies have reclaimed the land even before the law. The Cotton Center at Broadway and 48th Street in Phoenix and the Pines of Marana golf course, just north of Tucson, are outstanding examples of such reclamation work.

The copper mining industry has taken major steps towards restoring mined lands. BHP Billiton has reclaimed the San Manuel mine and millsite at a cost of over $120 million. The company has also reclaimed the Old Dominion Copper mine. Resolution Copper has committed to an expenditure of $50 million over a 10-year period to the restoration of the West Plant site at Superior. Richard C. Adkerson, CEO of Freeport-McMoRan Copper and

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. They are associated with aplite dikes related to the Sugarloaf Quartz Latite Porphyry of possible Cretaceous (75 Ma) or Jurassic age.

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

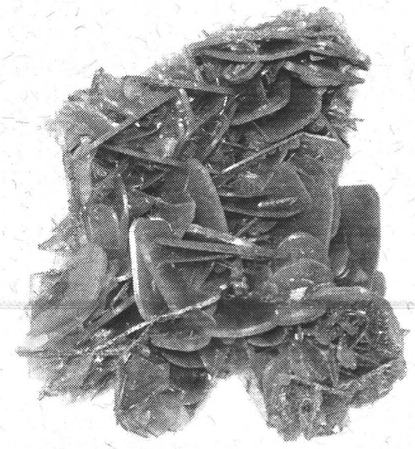
Also famous for their wonderful wulfenite specimens are the lead-zinc-silver mining districts of mid-Tertiary age. These include the bright red specimens from the Red Cloud mine, as well as smaller specimens of wulfenite from the Aravaipa district in the Galiuro Mountains and the Hilltop mine in the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

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.

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 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),



Glove mine, Santa Cruz County

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. 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.

Wilt, Jan C., Keith, S.B., and Theodore, T.G., 1984, A listing and map showing molybdenum occurrences in Arizona: U.S. Geological Survey Open-File Report 84-830, 62 p., scale 1:1,100,000

(The complete text of *Wulfenite in Arizona*, Mineral Report 9, will be available as a download from the Department website)

Outreach Program Grant

The Mining Foundation of the Southwest (MFSW) and the Arizona Department of Mines and Mineral Resources (DMMR) jointly announce that MFSW will fund an Outreach Program for the Department's Mining and Mineral Museum located in Phoenix. This grant will include funding for an Education Curator for a period of three years, based on the assumption that DMMR will be able to secure funding from the State or other sources for that position before the end of that term. The MFSW Education Curator will conduct classes on minerals and mining in schools and community colleges throughout Arizona. The agency plans to enlist local volunteers in various parts of the State to help with this program.

The Mining Foundation of the Southwest, based in Tucson, is a non-profit organization, working to educate the public about the mineral industries, and reporting on outstanding accomplishments in the fields of Earth Science.

The Museum will also host a Hall of Fame, as an extension of the American Mining Hall of Fame located in Tucson, for the men and women who have made outstanding contributions to the minerals and mining industry. This will entail photographs of those honored by MFSW, with brief descriptions of their contributions to the industry.

In addition to the MFSW/DMMR Outreach Program and Hall of Fame, a private philanthropic foundation has funded the Department to build a mine display in the Museum portraying current copper mining practices for the citizens and school children to see and comprehend the various processes involved.

Both of these grants and the Hall of Fame will be beneficial in educating the public about the role of minerals in Arizona.

For more information on this program, please contact: Jean Austin at the Mining Foundation of the Southwest at 520/577-7519, admin@miningfoundationsw.org, or Diane Bain at the Department of Mines and Mineral Resources at 602/771-1605, dianebain@hotmail.com

Gold, has stated "We acknowledge our obligation to address the environmental legacy from past eras. Standards, practices and knowledge about impacts were not the same as they are today. Our Reclamation Services unit is busy at various sites around the state and the southwest region restoring lands, protecting groundwater and creating wildlife habitat." Even the effects of climate change have been recognized. Chip Goodyear, CEO of BHP Billiton, has enunciated a policy that BHP, "...will take action within our own businesses and work with governments, industry and other stakeholders to address this global challenge and find lasting solutions consistent with our goal of zero harm."

Peabody Energy has long been a leader in reclamation of the lands where it mines coal. The company has won several awards for its efforts in Arizona. At the encouragement of the Department of Mines and Mineral Resources Peabody entered the competition for the Energy Globe Awards in 2006 and received top honors among nearly 100 nations in Belgium. The awards resulted from a reclamation program that generated up to 20 times more forage for sheep and cattle than native range, introducing a project for restoring cultural plants used by the Navajo and Hopi Nations for medicines and ceremonies, and instituting a managed grazing program on reclaimed lands under control by the company.

Many examples, such as the saving of bighorn sheep from disease at ASARCO's Silver Bell mine, the protection of the Hedgehog cactus plants by moving them into a sanctuary prior to mining at Quadra's Carlota operation, the rehabilitation of the uranium mines in the Arizona Strip mentioned above, reclamation of the Cove Abandoned Mine lands, and many others may be cited. Use of water in the desert landscape of Arizona is leading to instituting dry tailing technologies and other means of reducing usage. Data on water used by mining need to be collected; comparison with other industries would put this in perspective.

National Security Considerations

The dependence of the United States on minerals from other countries has made the nation very vulnerable. The "addiction" to oil has now created a sense of alarm and frustration in the public, and impressed upon them the urgency to develop energy sources within the country. A recent study by The National Academies entitled "*Managing Materials for a Twentieth Century Military*," (for which the current author was a committee member) recognizes that "owing to changes in the global threat environment and changes in the U.S. industrial base, the emergence of new demands on material supplies, the ineffectiveness of the National Defense Stockpile, and resultant potential for new disruptions to the supply chains for defense-critical materials, the committee believes there is a need for a new approach in the form of a national defense-materials management system." Similar remarks may be applied to homeland security. In this context, minerals and metals mined within the boundaries of the U.S., when these are accessible and economical to extract, deserve special priority. The nation can no longer subscribe to the NIMBY (Not In My Back Yard) attitude.

Wulfenite in Arizona

By Dr. Jan C. Rasmussen, Curator

Excerpted from Mineral Report 9

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.

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.

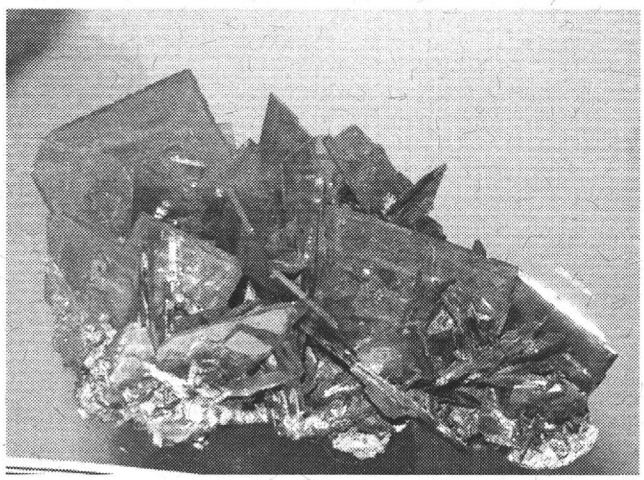
Lead-Zinc-Silver Mining Districts of Laramide Age (~75-65 Million Years Ago)

The stunning collectable specimens of wulfenite occur in lead-zinc-silver districts of early Laramide age (75-65 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.

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. 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.

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.



The famous and stunning "Tiger" wulfenite from the Mammoth-St. Anthony mine, Pinal County.