



# Department of Mines and Mineral Resources

1502 West Washington

Phoenix, Arizona 85007

(602) 255-3791 Toll free in Arizona 1-800-446-4259

---

## ARIZONA MINING UPDATE - 1994

Circular No. 55, April, 1994

by K.A. Phillips, N.J. Niemuth, and D. Bain

*Arizona continues to rank as the nation's leading mineral producer. The value of mineral production in the state last year was in excess of \$3.44 billion (see table, p. A2). As it has since 1910, Arizona leads the nation in copper production. A total of 2.542 billion pounds of copper was produced in 1992, 65% of the U.S. total. Arizona also ranks first in the nation in mined gemstone production and is among the leaders in the production of molybdenum, silver, pyrite, and perlite. There are over 104 mines active, excluding sand and gravel operations, producing the above mentioned metals plus 18 industrial mineral commodities. The mining industry directly employs more than 16,000 people.*

### COPPER

The copper mines produced a record amount of copper in 1992! This was the third year of record production. Completion of expansion projects along with good market prices and operating conditions contributed to higher levels of production. Leach solvent extraction electrowinning (SX-EW) production reached 30% of total production, an all time high, despite flotation concentrate production being up 10.5%, reaching 1.767 billion pounds. Record rainfall during December, 1992 through February, 1993 hampered operations with flooding occurring in open pits and lowering copper concentrations in leach solutions.

Copper value reached \$2.731 billion as copper prices were nearly unchanged in 1992 down only \$0.02 averaging \$1.07/pound. The slow world economy and growing copper inventories in commodity warehouses have resulted in prices dropping to \$0.74 in December 1993. Producers have been cutting costs and attempting to preserve corporate earnings by hedging and forward selling portions of their 1993 production. The outlook looks grim for 1994 unless demand increases significantly.

Byproduct production and value from copper mining for 1992 was as follows: molybdenum - 30.8 million pounds, \$61 million; silver - 5,015,702 ounces, \$19.8 million and gold - 60,089 ounces, \$20.6 million.

### **Arimetco Incorporated**

Arimetco produced copper from the Emerald Isle and Johnson Camp mines, while development continued at the Van Dyke and Zonia copper properties. The two properties combined to produce 8.7 million pounds in 1992. The

company also operates the Yerrington copper mine in Nevada.

Johnson Camp's 8.2 million pounds of copper accounted for over 45% of the company's production in 1992. This was the first full year of mining at the property by Arimetco. Additional reserves of 4 million tons were identified by drilling in the producing Burro pit. These extend its life further and will allow postponement of development of the Copper Chief ore body.

The Emerald Isle open pit mine produced in 1992 from heap leach pads and an 8,000 pounds per day SX-EW facility. Heavy 92-93 winter rains flooding the pit have forced this operation to assume a care and maintenance status.

Arimetco reports that good progress was made during 1992 in rehabilitating the Van Dyke shaft. Plans are to inject acid into previously mined underground areas and treat recovered solutions in an SX-EW plant. Use of the shaft is planned to access workings and serve as a collection point for injected leach solutions. Unfortunately, flooding caused by winter rains in Magma's adjacent Miami mine has caused operations to be suspended. The two mines are connected by a bulkhead and high water levels in the Miami mine pose a safety hazard to underground miners at Van Dyke.

Premine-planning drilling was completed at Zonia in 1993. Reserves totaling 30 million tons have been identified with additional tonnage possible. Engineering, permitting and planning efforts are under way for an open pit mine and construction of an SX-EW plant.

## Asarco Inc.

Asarco's Arizona operations consist of the Hayden copper smelter, two major open-pit mines, Mission and Ray, and a dump leaching/cementation operation at the Silver Bell mine. The mines' production was 544 million pounds of copper in 1992. Asarco, along with joint venture partner Freeport, continue the in-situ leach research at the Santa Cruz property in cooperation with the U.S. Bureau of Mines. Asarco also holds major reserves at the Chilito north of Hayden, at Helvetia, east of the Mission Complex, and at Sacaton East.

The Hayden Smelter consists of an INCO flash furnace rated at 720,000 tons of charge per year for an estimated production of 175,000 tons of blister copper. An acid plant rated at 1,600 tons of sulfuric acid per day controls sulfur dioxide emissions.

The company's Mission Complex is a consolidation of the Mission, Eisenhower, San Xavier South, and Pima open-pit mines. The smaller but separate San Xavier North pit is also included. Sulfide ore is treated at two mills, Mission and South. They have the capacity to process 59,000 tons of ore daily resulting in an annual capacity of 124,000 tons of copper in concentrates.

The Ray Mine consists of an open-pit mine, two mills, a 26,000 ton per day concentrator at Hayden and a newly commissioned 30,000 ton per day concentrator at Ray, dump and heap leach operations, and a 40,000 ton per year SX-EW plant at Ray. Output from the new mill made Ray the second largest producer in the state in 1992. The new mill allowed lowering of the cut-off grade to 0.3% that resulted in nearly a doubling of the reserves to 1.1 billion tons. This puts the Ray mine in an elite group of three deposits in the U.S. with reserves in excess of 1 billion tons. Rainfall totaling 22 inches in December 1992 and January 1993 (average annual rainfall is 17.5 inches) hurt 4th and 1st quarter production.

Asarco's Silver Bell mine produces copper by dump leach precipitation. The open-pit mine and mill remained on stand-by status. Permitting for a new SX-EW plant continues. The new facility when completed is expected to produce 18,000 tons of refined cathode copper annually at substantially lower cost. Oxide ore is expected to come from a new area of the property known as Silver Bell North.

## Cyprus Climax Metals Company

Late in 1993 Cyprus Minerals Company and AMAX Inc. merged to create Cyprus Amax Minerals Inc. and formed a new subsidiary known as Cyprus Climax Minerals Company.

## MINERAL PRODUCTION IN ARIZONA - 1992

[(np), no production]

COMMODITY	QUANTITY	VALUE
<b>Nonfuel<sup>1</sup></b>		
Clay (tons)	112,808	\$463,000
Copper (tons)	1,271,220	2,731,152,000
Gemstones		5,416,000
Gold (troy ounces)	213,995	73,818,000
Sand & gravel(tons)	33,842,000	123,517,000
Silver (troy ounces)	5,304,865	20,873,000
Stone-crushed(tons)	5,500,000	26,300,000
Pigments (tons)	85	62,000
Other <sup>2</sup>		184,337,000
<b>Fuel</b>		
Coal (tons)	12,500,000	275,000,000
Uranium (pounds)	np	np
<b>TOTAL</b>		<b>\$3,440,938,000</b>

1/ Nonfuel figures from U.S. Bureau of Mines.

2/ Cement, clays (bentonite), gypsum, lime, molybdenum, perlite, pumice, pyrite, salt, sand & gravel (industrial), dimension stone, lead, tin.

Cyprus was Arizona's second largest producer of copper in 1992 and continues to be the largest producer of molybdenum. Totals for the year were 647 million pounds of copper and 25 million pounds of molybdenum. Cyprus Climax Minerals Company maintains corporate headquarters in Tempe, Arizona and operates five copper producing operations in the State: Bagdad, Casa Grande, Miami, Mineral Park, and Sierrita.

The Bagdad operation consists of an open-pit copper-molybdenum mine, a 75,000 ton per day concentrator, a dump leach operation, and an SX-EW plant. The mill was being expanded to increase capacity by 10% in 1993.

The Casa Grande operation consists of an in-situ leaching operation, an SX-EW plant, and a roast-leach-electrowinning (RLE) plant that is treating approximately 160,000 tons of copper concentrates from other Cyprus properties. Acid produced from the RLE gases is used for the leaching operations. The block caved stopes in the oxide ore body are being leached and development of a leaching operation in virgin ground is under way using high pressure

ing 15 percent is owned by Sumitomo Metal Mining Company, Ltd. Morenci employees more than 2,000 people.

The Morenci operation consists of the Morenci, Metcalf, and Northwest Extension open pit copper mines, the 60,000 ton per day Morenci concentrator with a molybdenum circuit, the 40,000 ton per day Metcalf concentrator, three dump leaches with SX plants and at a capacity of 170,000 tons annually, the worlds largest EW plant. The 650,000 ton per year smelter with a 2,400-ton-per-day acid plant remains inactive. The feasibility of adding a fourth open pit, Coronado, to the mining operation is under way. It hosts 480 million tons of sulfide and oxide ore.

The company's Copper Queen mine consists of a dump leaching and precipitation operation at the depleted Lavender pit. The New Cornelia mine consists of an open-pit copper mine, a 30,000-ton-per-day concentrator with a molybdenum circuit, and a 190,000-ton-per-year smelter with an acid plant. The mine has been inactive since August, 1984 and the smelter was shut down in April, 1985.

Evaluation of the Lone Star and Dos Pobres deposits near Safford continues. These deposits, estimated to contain nearly 2 billion tons of open pitable material are being evaluated as heap leach SX-EW operations. Phelps Dodge has been rehabilitating underground workings at the United Verde mine at Jerome to sample and evaluate a high grade zinc resource.

## **COAL**

---

Low sulfur coal ranks second to copper in economic importance in the State. In 1992 Arizona coal production was 12,513,000 short tons with an estimated value of \$275 million. Coal is mined from the Kayenta and Black Mesa mines in central Navajo County. Surface mining is done on reservation land leased from the Navajo and Hopi Tribes in the 1960's by Peabody Coal Company. Peabody is the Nation's largest coal producer and the Kayenta mine in northeastern Arizona is their largest operation.

The coal from the Black Mesa and Kayenta Mines is subbituminous with an average quality of 11,000 Btu, 0.5% sulfur, and 10% ash. The coal complies with the Clean Air Act Amendments of 1990 emission standard of 1.2 pounds of sulfur dioxide per one million Btu. Kayenta coal, which is burned in Arizona, is blended with other coals at the power plant to meet the more stringent Arizona emissions limit of 1.0 pounds of sulfur dioxide per one million Btu.

The leases from the Navajo's and the Hopi's were renegotiated in 1987. In addition to the 400 million tons of coal covered by the original leases, an additional 270 million tons was acquired in the renegotiated leases. The 670

million tons of coal lie beneath 17,000 acres of the 64,858 acre lease.

The Kayenta mine employs more than 500 people and produces about 8 million tons annually. The coal from the Kayenta mine is carried by a conveyer system 17 miles to storage silos. From there it is transported by automated trains to the Salt River Project's Navajo Generating Plant 78 miles away. The Black Mesa mine produces about 4.5 million tons annually. Here, the coal is powdered and mixed with water prior to transport by the world's longest, and the Nation's only, coal-slurry pipeline. The 273-mile journey to the Mohave Generating Station at Laughlin, Nevada takes, three days.

The Peabody operations at Black Mesa are model reclamation programs. Mining and reclamation proceed at the same rate of approximately 500 acres annually. As an area is mined, the topsoil is removed and stored. After mining is completed, the topsoil is returned and the surface is contoured. The resultant reclaimed land, used for grazing, is more productive than the original land.

## **GOLD**

---

Lower gold prices in 1993 had a negative effect on Arizona's gold producers.

The Cyprus Copperstone open pit, for many years the state's largest producer, exhausted its reserves but continued to mill stockpiled ore through April. Verdestone Gold shipped about 25,000 tons of ore from the Oakland mine in northern Yuma county for processing at Copperstone's mill under a toll agreement before it shut down. The mill and other surface facilities are now being dismantled as part of the mine's reclamation.

Magma Copper Company depleted reserves at the McCabe underground mine in March and closed the operation. Workings have been capped and the flotation mill dismantled. During its year and a half of operation the McCabe mine produced 28,405 ounces of gold, 113,116 ounces of silver and 473,946 pounds of copper.

The Mystic Mine, north of Phoenix, operated for part of 1993 by Mystic Mining LLC, Inc. Ore was trucked to a gravity mill located near Wickenburg for processing. The company reported recovering \$1 million of gold (2,750 ounces) before mining was suspended due to depletion of reserves.

On a positive, note Western States Minerals Corp. returned the Gold Prince, located near Willcox, to production shipping, gold-bearing silica flux to Phelps Dodge's Hidalgo smelter in Playas, New Mexico. During 1994, a

pumps to inject sulfuric acid solution into holes drilled from the old underground workings. Evaluation of open pit mining and heap leaching a portion of the oxide ore body was underway during 1993.

The Miami property consists of three open pit copper mines formerly known as Inspiration, Bluebird, and Ox Hide, an SX-EW plant, a smelter recently expanded to a capacity of 650,000 tons per year, an acid plant, SX-EW plant, electrolytic refinery, a 135,000 ton per year rod plant, and a 24,000 ton per day concentrator that is currently on standby status.

Cyprus operates a dump and in-pit leaching operation and precipitation plant at Mineral Park. The Mineral Park open-pit copper-molybdenum mine and its 15,000 ton per day concentrator are on stand-by status.

The Cyprus Sierrita property consists of an open-pit copper-molybdenum mine, a 95,000-ton-per-day concentrator, two molybdenum roasting plants, a ferromolybdenum plant, a rhenium plant, a dump leaching operation, and an SX-EW plant. An expansion of mill capacity by 10% was being undertaken in 1993. More than three quarters of Cyprus' molybdenum concentrate from their Thompson Creek (Idaho), Bagdad, and Sierrita operations is processed at Sierrita through on-site roasters to produce molybdenum oxide and ferromolybdenum.

Twin Buttes contributed over 40% of the copper produced at the Sierrita concentrator in 1992. Sulfide ore is transported to the Sierrita concentrator by a 6.8 mile conveyor. The agitation leach/SX-EW plant at Twin Buttes was closed in December of 1992 when oxide ore was depleted.

### **Magma Copper Company**

Magma Copper Company's corporate headquarters are located in Tucson and the company operates three mining divisions in Arizona — San Manuel, Pinto Valley, and Superior. In 1992 they produced 554 million pounds of copper, making the company the third largest producer in the state. Magma also holds significant undeveloped reserves in the Florence and Copper Creek deposits. In addition to the divisions, the company operates a 29-mile railroad from San Manuel and a 28-mile railroad from Superior, both connecting to the Santa Fe Southern Pacific's railways.

The San Manuel Division consists of a block-caving underground copper mine, a 62,000 ton per day concentrator, an open pit oxide copper mine and heap leach, in-situ leach, SX-EW plant, a 1,000,000 ton per year smelter with a 3,000 ton per day acid plant and a 310,000 ton per year electrolytic refinery, and a 180,000 ton per year rod plant. The underground mine is the largest underground

operation in the United States and the largest underground copper mine in the world. During 1993 Magma Copper decided to proceed with a \$135 million development of the downfaulted Kalamazoo ore body that will add twelve years to the San Manuel underground mine. Magma's San Manuel smelter accounts for about 25 percent of U.S. copper smelting capacity. Even though the Outokumpu flash smelting furnace, at a design capacity of 3,000 tons of concentrate per day, is the largest single furnace smelter in the industry, an expansion of its capacity by 20% was announced in 1993.

The Pinto Valley division includes the Pinto Valley mine and the Miami in-situ and Miami No. 2 tailings leach operations. The Pinto Valley mine consists of an open pit mine, a 63,000-ton-per-day concentrator, dump leach and 8000 ton per year SX-EW plant. Miami's leach operations recover copper from in-situ leaching of the old Miami mine block cave area and by hydraulic mining and leaching of the old Miami tailings. The resulting pregnant leach solutions are processed through Miami's 10,000 ton per year SX-EW plant.

The Superior division consists of the company's namesake, Magma underground mine. This mine overcomes the difficult mining challenges of being hot, wet, and deep. That it remains in production is credited to its high grade ore averaging 5.56% copper in 1992, ten times the average content of Arizona copper ore.

### **Oracle Ridge Mining Partners**

The Oracle Ridge Mining Partnership consists of South Atlantic Ventures Ltd., who hold a 70% interest and operate the mine and Continental Materials with the remaining 30%. The underground Oracle Ridge mine produced concentrates containing 6.9 million pounds of copper in 1992.

### **Phelps Dodge Corporation**

Phelps Dodge Corporation, headquartered in Phoenix, is the nation's largest copper producer. Its mining division, Phelps Dodge Mining Company produces about one-third of the U.S.'s new copper at its mines in southeastern Arizona and southwestern New Mexico. In conjunction with its Arizona operations, Morenci and Copper Queen, Phelps Dodge operates the Hidalgo and Chino smelters and the Tyrone and Chico mines in New Mexico, and a 420,000 ton per year refinery at El Paso Texas.

Phelps Dodge's Morenci mine is the largest copper producer in North America and the second largest copper mine in the world. In 1992, Morenci produced a record 778.6 million pounds of copper! Phelps Dodge owns an 85 percent undivided interest in the Morenci Mine; the remain-

drilling program to confirm reserves, followed by development of the lower mine levels is planned.

Gold continues to be produced as a by-product of the copper industry in Arizona. Last year the major copper mines produced approximately 60,000 ounces of gold. Listed in order of production, San Manuel, Magma, Morenci, Ray, Mission, Sierrita, Pinto Valley, and Oracle Ridge all produced significant quantities of gold.

## **URANIUM**

---

Low uranium prices (NUEXCO spot price \$6.90/lb. as of 12-92) continue to negatively influence this industry segment. While waiting for price and demand to improve, Energy Fuels Nuclear Inc.'s mines are on care-and-maintenance basis. Developed deposits include Arizona One, Hermit, Kanab North, and Pine Nut. Development of the Canyon Mine awaits regulatory approval.

## **INDUSTRIAL MINERALS**

---

Although copper accounts for two-thirds of the State's mineral production by value, mining in Arizona continues to be a diversified activity. Industrial minerals mined in the state last year include calcium carbonate as limestone and marble for mineral filler and as raw material for lime and cement plants, bentonite for desiccants and for bleaching and clarifying of edible oils, sand and gravel for construction aggregate, diatomite, tile and brick clay, salt, cinders, pumice for laundry uses and light-weight aggregate, zeolites for molecular sieves, stone, perlite for filters, gypsum for wall board and agriculture, silica flux, pyrite and micaceous hematite for pigment, quarried flagstone, and hydrafrac sand. Construction aggregates in the form of sand and gravel lead this industrial mineral group, both in volume and value of production. Salt River Sand & Rock operated the fourth largest sand and gravel plant in the nation in 1992.

Many market niches exist for the specialized industrial mineral producer. The tremendous range in employee and capital requirements for the industrial minerals commodities vary widely enough to accommodate a family-run operation as well as large corporate producers. The increase in the number of family run decorative and dimension stone producers is an indication of this condition.

Arizona Portland Cement's cement plant at Rillito has completed a \$14,000,000 cement kiln efficiency improvement project. The project included a number of modifications to the large kiln that was installed in the 1970's. The improvements made a slight throughput increase and a major improvement in energy efficiency.

Arizona's two new mineral pigment mining and processing operations have been added to the directory. Arizona Oxides mines a natural red iron oxide pigment from their Iron Chancellor Mine and Swansea Minerals produces a micaceous hematite pigment for anticorrosive paints.

The Arizona Department of Mines and Mineral Resources' project to survey and quantify consumption of industrial minerals in Arizona's market area continues. The object of this project is to encourage exploration, development, and production of industrial mineral deposits in Arizona that can supply southwestern United States and northern Mexico markets.

## **GEMSTONES**

---

Arizona is the leading state in the value of mined gemstones in the United States. Approximately \$3.2 million worth of commercial gemstone production is reported for Arizona annually. Turquoise, peridot, and petrified wood account for most of the value, with amethyst, chrysocolla, azurite, malachite, fire agate, and apache tears making up the remainder.

Turquoise, a hydrous phosphate of aluminum and copper, is the leading gemstone produced in Arizona. Prized for its color, turquoise is the traditional gemstone used in Southwestern American Indian jewelry. It is mined as a by-product at a number of Arizona porphyry copper deposits. The best quality material is sold by the piece, and the remainder sold or processed for sale by weight.

Peridot is the gem variety of the mineral olivine. The translucent green material comes from the Peridot Mesa area of the San Carlos Apache Indian Reservation east of Globe. Arizona material is suitable for faceting and is of the finest quality in the world. Occurring in Quaternary basalt, the olivine is mined by shallow drilling and blasting of productive zones followed by hand breaking, screening, and sorting.

Petrified wood, although occurring in nearly every state, is best known as an Arizona gem material. Petrified wood is a fossil in which a mineral material, usually silica, has replaced the original cellular structure of the wood. Petrified wood occurs in all Arizona counties, but that occurring in Navajo and Apache counties in the Triassic Chinle Formation of northeastern Arizona supplies nearly all of the gem market. Commercial production comes only from private lands.

## RECREATIONAL PROSPECTING

Rockhounding continues to be a popular recreational activity in the state. The resultant impact on the Arizona tourism industry is hard to determine, but undoubtedly is significant. The gem show in Quartzsite, for example, is the largest in the world, drawing in excess of 100,000 visitors. The prestigious Tucson Gem And Mineral Show attracts visitors and dealers from around the world. More than 20 additional gem shows are held in the state annually and 61 organized earth science clubs are currently active.

Gem material collected by the rockhound hobbyist is not included in the official reported gemstone production, but it is likely that rockhound production is higher than the reported mine production. A portion of rockhound-collected material goes directly into collections, but much of it is sold privately or at gem shows.

Gold panning as a recreational activity has seen increased interest in the last few years. Perhaps this can be linked to interest generated by tourists and the current popularity of outdoor recreational activities. A Department publication, *Gold Panning in Arizona*, is available to provide information to the general public on this subject.