

Arizona's Mineral Industry - 1997 and 1998

As it has for nine of the last ten years, Arizona led the Nation in total nonfuel mineral production in 1997. Arizona's production exceeded \$3.5 billion, a 17 percent decrease from 1996. Arizona also leads the Nation in copper production, accounting for 65 percent of the total U.S. copper mine production. In addition, Arizona is among the leaders in the production of gemstones, molybdenum, silver, perlite, and sand and gravel. Excluding sand and gravel operations, there are 65 mining companies operating 126 mines. There are 71 sand and gravel producers in the state. More than 18,000 people are directly employed by the mining industry.

Arizona Mineral Production - 1997¹

(thousand of tons unless otherwise noted)

Commodity	Quantity	Value
Clay	withheld	withheld
Copper	1,360	\$2,930,000,000
Gemstones	na	3,220
Gold	withheld	withheld
Sand and Gravel	44,500	200,220,000
Silver (troy ounces)	5635,000	22,300,000
Stone - crushed	6,700	38,000,000
Coal ²	11,723	279,000,000
Other ³	na	325,000,000
Total	--	\$3,797,740,000

¹ USGS Preliminary figures

² DMMR estimate for value

³ Includes cement, gypsum, lime, molybdenum, salt, dimension stone, and withheld values.

Copper

Despite a continued high demand for copper, the industry suffered wide-spread losses in the first three quarters of 1998 because of an 11-year low in copper prices. The Asian economic troubles and heavy production from South America are being blamed for the price drop. In the first nine months of 1998 copper was 32 cents lower than in the first nine months of 1997. Despite this, it should be noted that 1997 production from Arizona copper mines was near an all-time high of 2.7 billion pounds with a value of \$2.93 billion.

Copper and its by-products represents over 80 percent of Arizona's nonfuel mineral value. Production comes primarily from four major companies, but strong demand for copper is encouraging other companies to pursue exploration and development in Arizona. The Western Economic Analysis Center reports that Arizona's economy received more than \$10.4 billion and

nearly 82,000 Arizona residents had jobs in 1997 as a result of the direct and indirect contributions of the copper industry.

1997 Copper Mine Production¹

Mine/Company	Production (lbs)
Morenci/Phelps Dodge	1,084,000,000
Ray/Asarco	304,000,000
Mission/Asarco	252,000,000
San Manuel/BHP*	251,000,000
Sierrita/Cyprus	246,000,000
Bagdad/Cyprus	246,000,000
Pinto Valley/BHP	157,000,000
Miami/Cyprus	156,000,000

¹Company Annual Reports and Form 10-K's

Asarco Incorporated

Asarco's world-wide copper production was 977 million pounds in 1997. The company's Arizona operations consist of the open-pit mines of Ray and Silver Bell, an open-pit and underground operation at Mission, the Hayden copper smelter, and the Santa Cruz experimental copper mine. Ray and Mission are the second and third largest copper mines in Arizona.

Copper output at the Ray mine was down from 1996 to 304 million pounds largely due to a 43 million pound decrease in concentrate production. Operation of the Hayden concentrator was curtailed from the fourth quarter of 1996 until May, 1997 to reduce concentrate inventory. The Ray mine replaced its remaining eleven 170-ton capacity haul trucks with five 240-ton capacity trucks in late 1997.

Ray consists of an open-pit mine, dump and heap leach operations, a 80 million pounds-per-year SX-EW plant at Ray, and two mills - a 28,000 ton-per-day concentrator at Hayden and a 32,000 ton-per-day concentrator at Ray. At the end of 1997 Ray had reserves of 969 million tons grading 0.6 percent sulfide copper and 189 million tons of leachable copper.

The leaching process at Ray was changed to use higher acid concentrations to increase recovery rates. A \$10 million EW tankhouse expansion is underway that will add an additional 12 million pounds of capacity. When completed in mid-1999 total SX-EW capacity will be 102 million pounds annually with a projected cash production cost of less than 50 cents per pound. As part of a negotiated settlement with EPA and State agencies to resolve environmental issues Asarco will extend the Mineral Creek diversion tunnel around the Ray mine workings at a cost of \$55 million.

Mission copper production declined slightly in 1997 as harder ore was milled. Offsetting this however, average ore grade increased as the underground mine contributed higher grade material

for all of 1997. Production totaled 252 million pounds of copper. Accounting for 37 percent of Arizona's silver production, Mission was Arizona's largest silver producer with 2.17 million ounces recovered as a by-product. The Mission complex consists of the underground mine and two pits, Mission and the smaller, but separate, San Xavier North. Sulfide ore is treated at two mills, Mission and South with a combined capacity to process 63,000 tons of ore daily.

Development drilling during 1996 increased copper reserves and also identified long-term stripping requirements. This led Asarco to purchase a conveyor system and two new 60 cubic-yard shovels. Installation of the conveyor system was completed in the third quarter of 1997 and will lower waste removal costs eight cents per ton or \$9.5 million per year. During late summer 1998 Asarco was considering buying seven new 320 ton capacity trucks. Mission's reserves at end of 1997 exceeded 500 million tons grading 0.7 percent.

The Hayden smelter, an INCO flash furnace rated at 720,000 tons of charge per year, processed a record amount of concentrates during 1997 producing 423.9 million pounds of copper. Improvements to the smelter's gas handling and process controls began during 1997. They are expected to lower operating costs and increase throughput upon completion in 1998. A scheduled maintenance shutdown reduced smelter output during March and April of 1998.

Asarco began mining the Silver Bell North deposit, part of the Silver Bell complex near Tucson, and dedicated the mine and new processing facility on July 16, 1997. The facility's new \$70 million SX-EW plant was developed as a joint venture with Mitsui & Co. U.S.A. (25 percent share) and has produced at its design rate of 36 million pounds-per-year since start up. Rubblization and leaching of material in the El Tiro and Oxide pits also provides solution to the SX-EW plant. Asarco reports cash costs to be 50 cents per pound. Utilizing six 170-ton trucks from Ray and three 15 cubic-yard shovels from Mission reduced startup capital costs.

President Clinton vetoed funding in October, 1997 to continue the experimental in-situ leach research project at Santa Cruz. Instead, funds were provided for closure of the ongoing test. Injection of leach solutions ceased after 22 months with many technical and environmental goals achieved along with the recovery of 35,000 pounds of copper. The final year of the project was to provide data on economic feasibility but that goal will not be achieved. All results obtained to date will be released. The joint venture partners have applied for permits for additional testing (without federal funds) at another site about one mile south of the initial test site. Information gathered there will provide data on the economics of in-situ leaching the deposit.

BHP Copper

San Manuel and Pinto Valley are the company's two active mining divisions in Arizona. BHP is also developing the Poston Butte deposit, an in-situ leach property that, when fully operational, will be the world's first stand-alone in-situ copper mine.

San Manuel is the largest underground operation in the United States and one of the largest underground copper mines in the world. San Manuel consists of a block-caving underground copper mine, a 62,000 ton-per-day concentrator, in-situ leach, a 60,000 ton-per-year SX-EW plant, a 1,300,000 ton-per-year smelter with a 3,000 ton-per-day acid plant, a 690 million

pounds-per-year electrolytic refinery, and a 180,000 ton-per-year rod plant. San Manuel produced 252 million pounds of copper in the fiscal year that ended May 1, 1998.

BHP's San Manuel smelter accounts for about 25 percent of U.S. copper smelting capacity. The Outokumpu flash smelting furnace is the largest single furnace smelter in the industry. The smelter may be shut down for 45 days in early 1999 for rebuilding. It has been operating since 1988 without a shutdown.

The Lower Kalamazoo orebody has estimated ore reserves of 2.5 billion pounds of contained copper that will add 12 years to the San Manuel underground mine. Production commenced in January, 1997 and is being phased in with the depletion of the San Manuel orebody over the next few years. San Manuel's and Lower Kalamazoo's estimated proven and probable ore reserves are 226 million tons of sulfide ore at an estimated grade of 0.62 percent copper.

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 16 million pound-per-year SX-EW plant. In February of 1998 the sulfide portion of Pinto Valley's operation was shut down and 447 employees were laid off. When copper prices recover sufficiently the sulfide operation will recommence. Pinto Valley's estimated recoverable proved and probable ore reserves are 613 million tons of sulfide ore at an average grade of 0.17 percent copper.

Miami's operations recover copper from in-situ leaching of the old Miami mine block cave area and by hydraulic mining and leaching of the Miami No. 2 Tailings pile. The resulting pregnant leach solutions are processed through Miami's 20 million pound-per-year SX-EW plant. The Miami in-situ project contains an additional 172 million tons at an average grade of 0.40 percent copper, while 9 million tons at 0.40 percent remain to be processed at the No. 2 Tailings pile. In 1997, Pinto Valley produced 136 million pounds of copper in concentrate and 36 million pounds of electrowon copper cathode.

BHP's Florence in-situ leach project has completed permitting, but will not go into full production until copper prices are improved. Oxide resources for the project are 321 million tons averaging 0.34 percent copper that are expected to produce 72 million pounds of cathode copper per year for 15 years.

BHP reported discovery of the Magma Porphyry near Superior in mid-1998. It is the first major copper discovery announced in Arizona in many years. The deposit, deeply buried under post-mineral rocks, was first intersected by drill holes from the underground workings of the Magma mine in 1995. Assays from the bottom 1,004 feet of intercept yielded arithmetic mean grades of 1.75 percent copper and 0.029 percent molybdenum. The last 619 feet assayed 2.18 percent copper and 0.028 percent molybdenum! The dimensions of the Magma Porphyry deposit are still incompletely defined, but it is at least 1,500 feet high, 2,100 feet long, and 600 feet wide. The top of the deposit is approximately one mile beneath the surface. BHP is evaluating options for future exploration.

Cyprus Climax Metals Company

In 1997 the Cyprus Climax Metals division of Cyprus Amax produced over 1 billion pounds of copper and 63 million pounds of molybdenum. Two thirds of the copper and over 40 percent of the molybdenum were produced from their Arizona operations. Cyprus is Arizona's second largest producer of copper and the world's largest producer of molybdenum. Cyprus Climax maintains headquarters in Tempe, Arizona and operates four copper mines in the State: Bagdad, Tohono, Miami, and Sierrita. In September of 1997 Cyprus sold their Mineral Park property to Equatorial Mining N.L. of Australia.

The Sierrita property consists of three open-pit copper-molybdenum mines, a 115,000 ton-per-day concentrator, two molybdenum roasting plants, a ferromolybdenum plant, a rhenium plant, and an oxide and low grade sulfide dump leaching operation with SX-EW plant. In 1996 Sierrita started mining a 70-million-ton oxide deposit that has led to increased output. Cathode production during 1997 totaled 39 million pounds.

Cyprus completed construction of two new in-pit crushers and a conveyor system to reduce haulage costs. Sierrita, recognized as one of the most efficient mines in the world, operates with the lowest average copper grade, 0.27 percent, of any milling operation. A contributing factor to this success is the mine's by-product molybdenum credit of 20 million pounds. That makes Sierrita the largest molybdenum mine in Arizona. Sierrita contains proven and probable copper reserves of 837 million tons.

The Bagdad mine in Yavapai County produced 246 million pounds of copper in 1997, a new production record. This resulted from mining higher grade sulfide ore, improved recovery and increased equipment availability. The operation consists of an open-pit copper-molybdenum mine, a 85,000 ton-per-day concentrator, an oxide dump leach operation, and an 30 million pound-per-year SX-EW plant. Cyprus reports that Bagdad has nearly a billion ton proven and probable ore reserve of 0.38 percent copper and 0.021 percent molybdenum.

In response to low copper prices during 1998, Cyprus is reducing copper production by 60 million pounds from Bagdad and Sierrita. These cutbacks are being made by reducing the use one of their highest cost equipment. Additionally expenditures are being reduced by \$10 million by deferring equipment purchases and holding other expenses to sustaining levels.

The Miami mine consists of an open-pit copper mine, an SX-EW plant, a 650,000 ton-per-year capacity smelter with acid plant, a 380 million-pound-annual capacity electrolytic refinery, and a 135,000 ton-per-year rod plant. The mine and SX-EW plant produced a record 156 million pounds of copper in 1997. The smelter processed 633,000 tons of copper concentrates from other Cyprus operations, five percent less than in 1996. The Miami rod plant produced 294 million pounds of copper rod, a seven percent increase over 1996 and a production record.

Cyprus' Tohono operations, located on land leased from the Tohono O'Odham Nation, consists of an SX-EW plant fed by a newly developed test open pit and heap leach. Although mining was suspended in July 1997, leaching of existing heaps continued. Production at Tohono totaled 27 million pounds of copper during 1997.

Phelps Dodge Corporation

Phelps Dodge's Morenci mine in Greenlee County, the largest copper mine in North America, again had an annual production of over 1 billion pounds of copper in 1997. Phelps Dodge Corporation, headquartered in Phoenix, is the world's largest producer of SX-EW cathode copper. Its mining division, Phelps Dodge Mining Company, produces about one-third of the U.S.'s mined copper at its properties in southeastern Arizona and southwestern New Mexico. In Arizona, in addition to Morenci, Phelps Dodge operates the Copper Queen in Bisbee, and controls significant undeveloped copper resources throughout the state, including the New Cornelia mine at Ajo and several deposits near Safford. Phelps Dodge owns an 85 percent interest in the Morenci mine; the remaining 15 percent is owned by Sumitomo Metal Mining Company, Ltd.

Morenci produced 1.1 billion pounds of copper in 1997. The Morenci operation consists of the Morenci, Metcalf, and Northwest Extension open-pit copper mines, the 100,000 ton-per-day Morenci concentrator with a molybdenum circuit, the 40,000 ton-per-day Metcalf concentrator, four dump leaches with three SX plants, the new Southside EW plant with an annual capacity of 130 million pounds, and Morenci, with an annual capacity of 370 million pounds, the world's largest EW plant.

Morenci's milling and leaching reserves totaled over 1.7 billion tons at the end of 1996. Additional resources include: Coronado with 180 million tons of sulfide with an average grade of 0.69 and 310 million tons of oxide mineralization with an average grade of 0.29; Western Copper with an estimated 530 million tons of milling material at a grade of 0.55 percent copper, and 500 million tons of leach material at a grade of 0.31 percent copper; Garfield, containing 1 billion tons grading 0.27 percent copper; and American Mountain, containing 140 million tons of leach material grading 0.25 percent copper.

The company's Copper Queen mine consists of a small dump leaching and precipitation operation at the depleted Lavender pit. No decision has been made as to when to bring the adjacent Cochise deposit, containing 210 million tons of 0.4 percent leach material, to production.

Phelps Dodge opened a district office in Safford where feasibility studies and environmental permitting were initiated in 1996 for the Lone Star, Dos Pobres, and San Juan deposits. The draft EIS was released in mid-1998. The Dos Pobres and San Juan deposits contain 555 million tons of leachable material and 330 million tons of sulfide material with a grade of 0.65 percent copper. The acquisition of the Sanchez deposit in 1995 increased the company's open pit, leachable copper resources in the district, including Lone Star, to nearly 2.4 billion tons.

In 1997 Phelps Dodge announced that a \$238 million construction project is planned for the New Cornelia mine at Ajo. The project, scheduled to include a new concentrator and mining equipment, will allow resumption of mining the deposit that last operated in 1983. The sulfide resource there is 150 million tons grading 0.56 percent copper. The New Cornelia operation, which will employ about 400 people, is expected to produce 135 million pounds of copper and 25,000 ounces of gold annually.

Phelps Dodge and Cominco continue a joint venture exploration agreement on the United Verde massive sulfide deposit at Jerome. The property, one of the largest zinc resources in the U.S., contains 21 million tons grading 6.6 percent zinc, plus copper and precious metals.

Other Copper Companies

Carlota Copper Company, a subsidiary of Cambior U.S.A., received their Plan of Operation from the Forest Service on September 30, 1998 and began preliminary construction of road access and monitoring facilities. Efforts continue to obtain all remaining permits to operate their Carlota Mine in Gila County. When startup is achieved Carlota will be the first new, major mine in Arizona in many years.

The property consists of four oxide ore bodies, Carlota, Cactus, and North and South Eder. Mineable reserves total 96 million tons grading 0.44 percent copper. Production is planned at a rate of 30,000 tons of copper per year for the first 10 years via open-pit mining, heap leaching, and SX-EW. Capital costs are estimated at \$100 million. The project will employ 300 workers when in full operation.

Equatorial Mining exercised their option to purchase Mineral Park from Cyprus Climax Metals Company on October 1, 1997. Mineral Park is an open-pit copper-molybdenum mine located in Mohave County. Production currently comes from a combination of dump and bench leaching. Equatorial plans to double production of the SX-EW operation that produced 3 million pounds of copper for Cyprus in 1997.

In 1995 AMT International Mining Corporation acquired the Copper Creek Deposit, located 45 miles northeast of Tucson. By October of 1997 they had completed a feasibility study of the property. The project includes the Old Reliable, Child Aldwinkle, and Copper Prince mines.

On July 1, 1998 the company announced they will purchase BHP's 50 percent interest in a portion of the project. AMT has also purchased several other properties in the district, including the 37,000 acre Mercer Ranch adjacent to the project.

Summo Minerals purchased Johnson Camp in Cochise County from bankrupt Arimetco Inc. The open-pit, heap leach SX-EW operation produced cathode copper from the Burro Pit with an estimated 10 million tons reserves, while another estimated 17.8 million tons await development at the near-by Copper Chief orebody and additional resources outside the reserve area.

The U.S. Bankruptcy Court approved the transaction by Summo Minerals that involves a provision for a due diligence program and a \$2.9 million payment.

Coal

Peabody Group, parent company of Arizona's Peabody Western Coal Company, completed restructuring its U.S. operations this summer. Peabody Group became an independent, privately held company when it was acquired by Lehman Merchant Banking Partners. The sale made

Peabody Group the world's largest private sector coal company. The Flagstaff office was closed and management of the company's two Arizona properties was relocated to St. Louis, Missouri.

Coal ranks second only to copper in economic importance in the State. In 1997 Arizona's coal production was 11,723,000 short tons, having an estimated value of \$279 million. All production is from land leased from the Navajo and Hopi Nations by Peabody Western Group. Royalties from coal production total \$30 million annually.

High-quality coal is strip mined from the Kayenta and Black Mesa mines in central Navajo County. The coal is subbituminous with an average quality of 11,000 Btu, 0.5 percent sulfur, and 10 percent ash. Both mines are now using 300-ton capacity tractor trailer bottom-dump trucks to transport coal from the mine to the conveyors and pipeline feed plants.

Kayenta Mine's production was 7,089,532 tons in 1997. The coal from the mine is carried by a conveyor system 17 miles to storage silos. From there it is transported by the electric-powered trains of the Black Mesa & Lake Powell Railroad to the Salt River Project Navajo Generating Plant 78 miles away.

Black Mesa produced 4,633,735 tons in 1997. At Black Mesa the coal is powdered and mixed with water prior to transport by the world's longest coal-slurry pipeline. The 273-mile journey to the Mohave Generating Station at Laughlin, Nevada takes three days.

Peabody's 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 And Silver

Arizona's 1997 gold production was not reported by the Department of Interior (either USGS or former USBM) for the first time since reporting began in 1880! Arizona's only operating primary gold mine, Gold Road, produced 35,098 troy ounces in 1997 according to Addwest Mineral's annual report. DMMR estimates by-product recovery of gold from the sulfide operations of the copper mines would be at least 50,000 ounces. Silver production totaled 5.6 million ounces, recovered as a by-product of copper mining.

The gold price declined \$35 during the first nine months of 1998. It averaged \$294 per ounce, compared with \$331 per troy ounce in 1997. During the second quarter sub-ore grade material was encountered underground in a projected mineable block at the Gold Road mine. These conditions combined with lack of capital for continued development forced Addwest to cease mining and milling in June, 1998. Despite the mine closure and lower gold prices, Addwest continued to add to its holdings in the Oatman district, acquiring rights to the United Western and United Eastern mines. These deposits are located adjacent to the Gold Road and thus ore from them could be treated by the company's 500 TPD CIP mill. Addwest also controls and has been conducting exploration on the nearby Moss mine.

The Bureau of Land Management released the Yarnell gold project's draft Environmental Impact Statement in June, 1998. BEMA Gold, doing business in Arizona as Yarnell Mining Company, anticipates that construction could begin by mid-1999 if the record of decision and other permits are received. The mine will be operated as an open pit utilizing a closed-loop, heap-leach system.

Industrial Minerals

Although the mining of copper and its by-products accounts for 80 percent of the State's mineral production by value, mining in Arizona continues to be a diversified activity. Coal, industrial minerals, and gold largely account for the remaining 20 percent. Sand and gravel for construction aggregates, cement, and lime for chemical and construction material uses make up the majority of industrial mineral value. In 1998 Salt River Sand & Rock, located in Maricopa County, again operated the second largest sand and gravel plant in the U.S.

Other industrial minerals mined in the state are more interesting in terms of their variety than their dollar value. These include limestone and marble, bentonite, diatomite, common clays, salt, cinders, smelter slag, pumice, zeolites, crushed stone, decomposed granite, perlite, gypsum, silica flux, hematite, sandstone, dimension stone, industrial sand, and mine tailings.

Calcium carbonate is mined as limestone and marble for mineral filler and as raw material for lime and cement plants. The zeolite minerals, chabazite and mordenite, are mined for processing into molecular sieves and for waste treatment. Diatomite is produced for metallurgical process insulation. Salt is crystallized by solar evaporation from brines produced by solution mining for use in food processing, livestock feed, and chemicals. Perlite is mined for processing into filter media, fillers, and carriers. Quartz and quartzite is mined for use as silica flux in copper concentrate smelting. Industrial sand is produced for use as hydrafrac sand used in petroleum production. Mill tailings from a zinc mine are processed for fertilizer. Processing is done so that the contained iron pyrite can provide available iron and sulfur and so that other trace minerals in the tailings and added nitrogen can be used by plants. Bentonite is mined for out-of-state processing into desiccants and for bleaching and clarifying of edible oils.

Common clays are mined to manufacture tile, pipe, and bricks and to provide an aluminum source for the manufacture of cement. Volcanic cinders are mined for aggregates, landscaping, and road deicing. Slag from a copper smelter is processed for roofing granules and abrasives. Pumice is used for fabric treatment and light-weight aggregate. Stone is quarried and crushed for aggregates and landscaping. Decomposed granite is used for landscaping. Gypsum is mined and processed for wall board manufacture, cement manufacture, and agriculture. Hematite is mined for color and barrier pigments. Sandstone is quarried and worked for flagstone. Schist, limestone, marble, rhyolite, gneiss, and granite are quarried for decorative stone.

Omya (Pluess Stauffer) of Lucern Valley, California is continuing work on their plans and permits for a calcium carbonate processing plant at Superior in Pinal County. Their Queen Creek Limestone mine is continuing to supply mine run white marble to Mineral Development Inc.'s crushing and screening plant at Queen Creek in Maricopa County.

Arizona Portland Cement together with their parent company, California Portland Cement and their corporate owner, Onoda has received permits to expand their Rillito plant's capacity in phases. Over the next five years the Arizona plant's capacity will be increased to 2,300,000 tons of cement per year. The initial phase will increase capacity to 1,560,000 tons per year and involves installing a new raw feed roller mill and converting the existing raw feed mill into a finish mill. The second phase, planned for completion in 2003, requires installing a second pre-calcining tower.

Phoenix Cement Company has announced they have entered the planning stage for plant modernization at their Clarkdale operation. Plans include an increase in plant capacity from the current 630,000 tons of cement per year to 1,100,000 tons per year. Phoenix Cement Company is wholly owned by the Salt River Pima - Maricopa Indian Community.

Adit Canyon L.L.C. acquired the White Cliffs Diatomite mine from Arimetco and plans to reopen the operation by December 1998.

The corporate merger and acquisition fervor has hit Arizona's flagstone stone industry in a small way. The Drake and Ashfork sandstone quarries and processing plant of Western States Stone were acquired by American Sandstone. Western States' schist quarries in the Mayer area were acquired by Apache Stone and their marketing and stone yards were combined into Garden State Stone.

The Department of Mines and Mineral Resources has noted interest in deposits of numerous industrial mineral commodities. These include perlite, clays, industrial sand, mica, limestone, vermiculite, specialty aggregates, and the raw materials containing iron, aluminum, and silica for cement manufacture. Arizona's two cement plants currently source these raw materials from clay, shale, or volcanic zones in their own limestone quarries, from other quarries they own, importers, and waste products from secondary metal processors.

A robust economy with an attendant high level of new residential, commercial, institutional, and industrial construction continues to spur interest in developing additional sources of sand and gravel for construction aggregate.

Gemstones

Arizona is a leading state in the value of mined gemstones in the United States. Approximately \$4 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, and fire agate 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 Native American jewelry. It is mined as a by-product by contractors 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. By-product turquoise is produced by Sleeping Beauty Turquoise from the Sleeping Beauty Mine at Pinto Valley. Colbaugh Processing terminated their turquoise

mining agreement at the Mineral Park Mine in June and processes only purchased material. Although long known for their turquoise, the Morenci Mine and the deposits at Bisbee are currently yielding very little.

Peridot is the gem variety of the mineral olivine. The translucent green material comes from the Peridot Mesa area of the San Carlos Apache Reservation east of Globe. Arizona material is suitable for faceting and is the finest quality in the world. This deposit accounts for approximately 90 percent of the world's production.

Amethyst from the Four Peaks mine in Maricopa County has been coveted by lapidaries and collectors since the turn of the century. The best quality Four Peaks material is as good as any in the world. The mine, inactive for over 10 years, was purchased in late 1997 by Kurt Cavano and Jim Machlan. They plan to secure the mine and begin production. The amethyst will be mined by hand, flown by helicopter to Phoenix (the property is surrounded by the Four Peaks Wilderness Area), and shipped to Bangkok for faceting.

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 supplies nearly all of the gem market. Commercial production comes only from private lands.

Government News

Mine fraud is of increasing concern to stock exchanges and government security regulators. Although Bre-X, and its Indonesian property Busang, may be the most infamous of recent scandals, others have had connections to Arizona. Additional scandals reported in *Setting New Standards*, by the Toronto Stock Exchange and the Ontario Securities Commission, include International Platinum (IP), Delgratia and Naxos. In early 1998 International Precious Metals (successor to IP who was delisted by the Toronto Stock Exchange), was delisted by the NASDAQ stock exchange. The Arizona Corporation Commission issued a cease and desist order to Black Diamond Mining.

These and other companies' activities were the impetus for the Ontario Securities Commission and the TSE to form the mining standards task force to review standards governing the conduct of mineral exploration programs and reporting of results. The task force's interim report, *Setting New Standards*, made four key recommendations: 1) designate a qualified person to sign off on exploration disclosures, 2) establish best exploration and field practices to ensure integrity of results, 3) raise disclosure standards, and 4) improve regulatory oversight.

An all too common occurrence is the reporting of gold or other precious metals where none exists. Investors seem vulnerable to promotions that claim to be able to detect or recover gold that reputable laboratories cannot detect. Despite regulatory agencies investigations and shutdowns, investors should remain wary as the proposed improvements are expected to discourage, but not stop, mine fraud.

Recreational Mining

Gem material, mineral specimens, and fossils collected by the rockhound and small contractors at the mines are not generally included in the reported gemstone production. It is likely that the value of this production is higher than that officially reported for gemstone production. Some portion of rockhound-collected material goes directly into collections, however, much of it and most of the other material collected is sold privately or at gem shows. 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 dealers and buyers from around the world. More than 25 additional gem shows are held in the state annually and 37 organized earth science clubs are currently active.

Another important segment of recreational mining in Arizona includes gold-panners and operators of small hobby-type suction dredges. Although gold is likely recovered by nearly all who participate in this form of recreation, the recreational value is undoubtedly greater than the value of gold produced. Economic data for recreational mining is difficult to quantify, but the impact on the Arizona tourism industry is significant.