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ARIZONA MINING UPDATE - 1993

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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 \$3.1 billion (see table, p. A2). As it has since 1910, Arizona leads the Nation in copper production. A total of 2.233 billion pounds of copper was produced in 1991, 62% 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 102 mines active, excluding sand and gravel operations, producing the above mentioned metals plus 18 industrial mineral commodities. The mining industry directly employs over 14,000 people. Estimates of development expenditures exceeded \$100 million.

COPPER

The dominant trend in the State's copper industry is the continued modernization of the industry's infrastructure in order to lower production costs and expand production capacity. An important part of this process has been the widespread deployment of solvent extraction electrowinning (SX-EW) technology. This process produces cathode grade copper, which is directly marketable, from low cost leach solutions obtained from oxide ores or mine dumps. Some companies have acquired ore reserves and formulated development plans for leach only deposits.

Copper prices declined 13 cents to \$1.09/lb in 1991, but this price decrease was partially offset by a 4.6 percent increase in production that lessened the drop in value of the year's production.

Arimetco Incorporated

Arimetco owns and/or operates the Emerald Isle, Johnson Camp, Van Dyke, and Zonia copper properties and also has industrial mineral interests in Arizona.

Their Emerald Isle mine, which consists of in-situ leaching and a precipitation plant, was shut down in the first quarter of 1990. Planning and permitting for an 8,000 pounds per day SX-EW facility and associated components began in mid-1991. The plant is expected to be operational in the spring of 1992. The SX-EW plant will be fed by a combination of solutions from a leach pad and an in-situ leach of the pit bottom.

The Johnson Camp mine contributed in excess of 60 percent of the company's production during 1991 and is expected to produce over 9 million pounds of copper during 1992. The addition of a second train in the solvent extraction plant has increased the flexibility and overall operational efficiency of the mine.

Until mid-year, production was entirely dependent on the leaching of copper from existing heaps. Mine planning to produce new ore began early in 1991 and development began in May of 1991. The first fresh ore was placed on the dumps in July. Mining at the rate of 10,000 tons per day is expected to continue from the Burro Pit and adjacent areas until the end of 1993.

Arimetco reports that good progress has been made during the year in formulating a development plan for its Van Dyke ore body, partially located under the town of Miami. Copper will be produced by injecting acid into mined out areas and treating recovered solutions in an SX-EW plant.

They have examined the possibility of initially using the existing Van Dyke shaft, which accesses the entire ore body and connects with all workings, as an extraction well. The advantage of using the shaft as a collection point for the injected fluids are many. The eventual access to the ore body through the shaft is viewed as a major advantage.

Asarco Inc.

Asarco's Arizona operation consists of a major copper smelter at the Hayden Unit, major open-pit mines at the Mission and Ray Units, and a dump leaching/cementation operation at the Silver Bell Unit. With the increased production at the Mission Complex, Asarco is able to produce 76 percent of the copper concentrate feed to its smelters. Asarco continued its \$375 million program to become self-sufficient in concentrates to feed its smelters.

Asarco, along with joint venture partner Freeport, continued the in-situ leach research at the Santa Cruz property in cooperation with the U.S. Bureau of Mines. Part of the study consists of injection of saline solution to determine the hydrology of the deposit. The results are being evaluated.

Asarco also holds major reserves at the Chilito north of Hayden, at Helvetica east of the Mission Complex, and at Sacaton East.

The Asarco Hayden Unit consists of an INCO flash furnace smelter 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 keeps sulfur dioxide emissions within air quality restraints.

The company's Mission Unit consists of the consolidation of the Mission, Eisenhower, San Xavier, and Pima open-pit mines into one large open-pit referred to as the Mission Complex. Also included is the smaller San Xavier North pit. The acquisition of the rest of the Eisenhower in April and of the Mineral Hill deposit adjacent to the Pima section of the pit late in 1987 increased reserves and facilitates further efficiencies in pit design and mine planning.

Mining at Mission is conducted by electric shovels with truck haulage to the primary crusher and waste dumps. Some areas of the pit are back to final limits allowing some waste dumping in the pit. The stripping ratio in 1991 was 3.92:1, waste to ore; a high ratio that reflects removal of large amounts of waste related to expansion.

The expansion of the Mission Mine was completed in the fourth quarter of 1991, more than doubling production capacity from mid-1980's levels, to 124,000 tons of contained copper per year. The addition of the refurbished Pima Mill, now called the South Mill, increased concentrator capacity to a total of 59,000 tons per day.

Their Ray Unit consists of an open-pit mine, dump leach and heap leach operations, and a 40,000 ton per year SX-EW plant at Ray and a 26,000 ton per day concentrator at Hayden.

MINERAL PRODUCTION IN ARIZONA - 1991

[(np), no production]

COMMODITY	QUANTITY	VALUE
Nonfuel¹		
Clay (tons)	251,781	\$3,830,000
Copper (tons)	1,128,845	2,468,255,000
Gemstones ²		3,173,000
Gold (troy ounces) ²	181,748	67,247,000
Sand & gravel(tons) ^e	22,500,000	79,400,000
Silver (troy ounces)	4,758,304	19,212,000
Stone-crushed(tons)	7,060,000	32,842,000
Pigments (tons)	20	22,000
Other ³		198,230,000
Fuel		
Coal (tons) ⁴	11,695,00	230,000,000
Uranium (pounds) ⁵	np	np
TOTAL		\$3,102,211,000

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

2/ ADMMR estimate.

3/ Cement, gypsum, lime, molybdenum, perlite, pumice, pyrite, salt, sand & gravel (industrial), dimension & specialty stone.

4/ Source: Coal production - DOE/EIA's "Weekly Coal Production," Value - ADMMR estimate.

5/ Source: Energy Fuels.

e/ U.S. Bureau of Mines estimate.

Mining is conducted by electric shovels supplemented by front-end loaders utilizing truck haulage. The production rate is 100,000 tons per day of which 26,000 tons are sulfide ore sent to the mill, and 10,000 tons are silicate ore that is crushed and sent to the leach heaps. The remainder is low grade sent to leach dumps or waste sent to waste dumps. The stripping ratio in 1991 was 3.18:1, waste to ore, a high ratio that reflects mine development ahead of increased production. The mine plans are predicated on the sulfide operation and therefore silicate ore is stockpiled when in excess and fed from the stockpile to the crushers when short.

Sulfide ore is hauled by truck to the primary crusher at Ray where it is crushed and transferred to trains for the 20 mile haul to the mill.

Silicate ore is hauled to the primary crusher, then further reduced to minus 3/4 inch by secondary and tertiary crushers. It is then transported by conveyor where it is agglomerated with sulfuric acid while in transit to the heap leach area. Final haulage and placement on the heaps is by end-dump trucks.

Low grade muck is hauled to prepared leaching areas and non-mineral muck is hauled to waste dumps by end dump trucks. All leach solution are now fed to the SX-EW plant. Previously stockpiled native copper ore is being reclaimed and fed to the mill in small proportions as is smelter slag.

A \$12 million project was started in 1988 to maintain production capacity as the hardness of the ore increases as the pit deepens. A 60,000 ton per day portable in-pit crusher and conveying system will replace the 30,000 ton per day primary crusher at the pit and a 20,000 ton per day concentrator will be built at the mine site. Concentrates will be hauled by rail to the smelter at Hayden.

The difficult permitting process for the Ray Mine expansion was satisfactorily concluded in late 1991. Scheduled start up of the new mill had been delayed until 1992. The Ray Mine output of copper will increase by 58 percent to 182,000 tons per year as a result of this expansion. The project is scheduled for completion in 1992.

Asarco's Silver Bell Unit consists of an open-pit copper mine on stand-by status. Mining was stopped in 1984 because of high operating costs and plans to build a new solvent extraction/electrowinning plant. The new facility when complete in 1994 will produce 18,000 tons of refined cathode copper per year at substantially lower cost. In late 1991, the company began the permitting process for reactivation of the mine and construction of the SX-EW plant. The dump leaching operation and precipitation plant have continued in operation.

Cyprus Minerals Company

Cyprus was Arizona's second largest producer of copper in 1991 and continues to be the largest producer of molybdenum.

Cyprus Copper Company maintains its corporate headquarters in Arizona and operates four copper producing mine complexes in the State: Cyprus Bagdad, Cyprus Casa Grande, Cyprus Miami, and Cyprus Sierrita. Additionally, they operate 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 both on stand-by status.

In March, 1988, through a 15-year lease, Cyprus acquired the Twin Buttes property formerly operated by Anamax. In July, 1988 they acquired the entire Inspiration property at Miami, including the mines, concentrator (inactive), SX-EW plant, smelter, acid plant, electrolytic refinery, and rod plant.

In addition to its copper-molybdenum properties, Cyprus operates Arizona's largest gold mine, the Copperstone north of Quartzsite.

Cyprus continues to increase its copper leaching capabilities with the expansion of leaching operations at Bagdad, Mineral Park, and Sierrita. Cyprus had the second copper solvent extraction - electrowinning unit in the world at Bagdad and produced the first cathodes to meet the stringent specifications for trading on the London Metal Exchange and COMEX. The company currently produces 210 million pounds, or approximately 33 percent of normal annual copper production, from leach solvent extraction-electrowinning technology.

Their Cyprus 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. Mining is conducted by electric shovels using truck haulage to the primary crusher and dumps. The stripping ratio in 1991 was 0.80: 1, waste to ore.

The sulfide ore is transported from the primary crusher at the mine, a distance of 6,400 feet to the coarse ore stockpile at the concentrator, by conveyor belts. There it is crushed further, ground by autogenous and ball mills, and copper and molybdenum concentrates are produced. Column cells are utilized in the molybdenum flotation circuit.

Dual process ore (sulfide ore with an unusually high oxide content) is placed in heaps and leached for 60 days before being sent to the concentrator.

Pregnant solutions from the leach dumps are collected behind dams and pumped to the SX-EW plant at approximately 1.8 grams of copper per liter. The barren solutions are returned to the dumps after the copper has been extracted.

Their Cyprus Casa Grande operation consist of the refurbished Hecla Lakeshore Roast-Leach-Electrowinning (RLE) plant that is treating concentrates from other Cyprus properties.

The Casa Grande operation consists of an in-situ leaching operation and an SX-EW plant. The block caved stopes in the oxide ore body are being leached and development of a leaching operation in virgin ground is underway using

high pressure pumps to inject sulfuric acid solution into holes drilled from the old underground workings. Pregnant solutions are collected in sumps underground and pumped to the SX-EW plant.

The roasters and acid plant of the RLE plant originally built by Hecla and refurbished by Cyprus are treating approximately 160,000 tons of copper concentrates from other Cyprus operations yearly. The pregnant solutions go to the SX-EW plant and the acid produced from the roaster gases is used for the leaching operations.

The Cyprus Miami properties consist of three open pit copper mines formerly called Inspiration Mines, a 24,000 ton per day concentrator that is currently on standby status, a smelter soon to have an expanded capacity of 650,000 tons per year, an acid plant, SX-EW plant, electrolytic refinery, and a 135,000 ton per year rod plant.

The ore is mined at the rate of 50,000 tons per day with electric shovels and hauled by truck to high grade, low grade, and waste dumps. The stripping ratio in 1991 was 0.57:1, waste to ore. Soon after Cyprus acquired the property the construction of the second, nearly identical, solvent extraction train was completed, increasing the capacity of the plant to 8,000 gallons per minute. The cathodes from both the electrowinning and electrorefining sections are fed to the continuous cast rod plant to produce 5/16 inch copper rod on reels holding three and one-third miles of rod each. In 1991 the Miami rod mill produced 252 million pounds of copper rod, approximately 93 percent of capacity, mostly from Cyprus-produced cathode.

A 3-year pilot project with Arizona Ranch Management has been underway to test and evaluate the use of cattle as a tool to promote vegetative growth, to control dust, and curtail erosion on tailings at the Miami operation. Costs of reclamation were substantially reduced by the use of livestock in a reclamation process. Cattle are used on bare tailing material to prepare a base to stabilize the tailings and to promote plant growth.

A project to make Cyprus independent of outside smelting continued in 1992. An increase in capacity from 450,000 tons to 650,000 tons of concentrate per year was completed in July, 1992 at the Miami Smelter. The \$106-million project increased smelting capacity by about 50 percent. Their new ISASMELT furnace began operation with production planned to gradually increase until full annual capacity of 650,000 tons is reached in 1993.

The Cyprus Sierrita property consists of an open-pit copper-molybdenum mine, a 95,000 ton per day concentrator, a ferromolybdenum plant, a rhenium plant, a dump leaching operation, and an SX-EW plant. Mining is conducted using electric shovels and truck haulage to the

crushers and dumps. The stripping ratio in 1991 was 0.91:1, waste to ore.

Production was started at the Twin Buttes mine in 1988 providing additional feed to the Sierrita Mill. The stripping ratio in 1991 was reduced significantly to 2.15:1. Sulfide ore is transported to the Sierrita concentrator by a 6.8 mile conveyor. Twin Buttes contributed over 40 percent of the copper produced at the Sierrita concentrator in 1991. The SX-EW plant at Twin Buttes is fed with solutions from leaching tailings.

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 that are shipped to customers worldwide.

Magma Copper Company

In March, 1987, after nearly 20 years as a wholly owned subsidiary of Newmont Mining Corporation, Magma once again became an independent corporation. As such it has continued implementing an extensive expansion and modernization program to meet environmental constraints and to become competitive in the copper market.

Magma's Arizona operations are divided into the San Manuel Division and the Pinto Valley Division that includes the Pinto Valley Unit and the Miami Units, and the original Magma Mine at Superior.

Magma also operates the McCabe gold mine near Mayer and a railroad. The McCabe gold mine started production with concentrates being shipped to the San Manuel Smelter for treatment. The railroad operation consists of a 29-mile railroad from San Manuel and a 28-mile railroad from Superior. Both connect to the Santa Fe Southern Pacific system.

Magma reports that production, cost reduction, and productivity have improved dramatically since Magma became an independent company in 1988. New development projects and purchase of a major high quality ore body have supplemented Magma's reserves to ensure copper production into the next century.

Company highlights for 1991 include the achievement of record operating performance, the signing of a historic fifteen-year labor contract, the implementation of employee gainsharing programs, the refinancing of the company's debt, and the reorganization of its balance sheet.

The expansion and modernization program that began in 1987 included a major expansion of the San Manuel smelter and refinery as well as several different leaching, solvent extraction, and electrowinning projects. These

projects suffered a series of technical start-up problems that resulted in initial production and cost disappointments.

An innovative 15-year labor contract was signed in October, 1991. The contract is tailored to the needs of the company, unions, employees, and management, and is dedicated to employee involvement, high productivity, low production cost, and greater employment security.

The San Manuel Division consists of a block-caving underground copper-molybdenum mine, a 62,000 ton per day concentrator, an open pit oxide copper mine, pad 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 300,000 ton per year electrolytic refinery, and a 180,000 ton per year rod plant.

After development of the grizzly and haulage levels, caving is initiated by undercutting the ore block. The caved ore is drawn through the grizzlies to the haulage level. Haulage to the production shafts is by 23-ton trolley locomotives pulling ten 15-17 ton ASEA cars or fifteen 12-13 ton rotary dump cars. After hoisting to the surface the ore is hauled by rail to the mill in 100 ton cars in groups of 35 to 40 pulled by 125 ton diesel-electric locomotives.

Three years ago Magma was facing the planned closure of the San Manuel underground mine. Currently, a feasibility study is underway to assess the financial viability of mining the nearby Kalamazoo ore body. The study will be completed by the end of 1992. Preliminary results indicate that the development of the ore body could extend the San Manuel underground mine's life by eleven years - from 1997 to 2008.

Utilization of high performance production techniques developed in the Kalamazoo ore body pilot production project have helped increase the San Manuel underground production by 22 percent from 184 million pounds in 1988 to 222 million pounds in 1991, while reducing net cash operation cost by \$ 0.24 per pound from \$1.06 in 1988 to \$0.82 in 1991.

In 1991 the smelter processed over 1 one million tons of new concentrate, 42 percent more than in 1988. Magma's San Manuel smelter accounts for about 25 percent of U.S. copper smelter capacity.

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 oxygen plant and modifications to the acid plant were a part of the modernization. The smelter has attained full design capacity production. The technical problems associated with the smelter were resolved by mid-1990 and the facility has operated consistently above design capacity ever since.

In the spring of 1992 Magma announced plans to increase its smelter capacity by up to 20 percent to take advantage of a growing worldwide "smelter bottleneck." Attempts to build new smelters have been thwarted by environmental concerns. Both Mitsubishi Materials and Outokumpu have given up on plans to build new smelters after years of attempting to get approval. As a result, copper smelting charges are skyrocketing. In early 1990, the average smelting and refining charge was 15 cents per pound. By spring of 1992 smelters were charging about 35 cents per pound for custom processing.

To take advantage of this trend, Magma hopes to increase its smelting capacity by 5 percent, or 30 million pounds of copper, in 1992. They are also examining the feasibility of constructing a new acid plant that could increase smelting capacity by another 15 percent. Magma reports that more than one quarter of Magma's copper throughput is derived from custom smelting and refining.

Mining at the open-pit oxide mine is accomplished with front-end loaders with truck haulage at the rate of 28,000 tons of ore and 65,000 tons of waste per day. Ore is placed on the polyethylene-lined leach pads and some of the waste is dumped in the subsidence area. Any sulfide ore encountered is hauled to a railroad siding and added to the feed going to the concentrator. Copper is recovered from the leach solutions at the SX-EW plant that uses the ISA process of plating the copper on stainless steel sheets rather than on copper starter sheets. The solutions from the in-situ leaching are also fed to this plant that was expanded to a capacity of 75,000 tons of copper per year.

Electrowon cathode production has increased considerably since 1988. In 1991, 130 million pounds were produced, 51 percent above the 86 million pounds produced in 1988. This increase is partly attributable to increased production at San Manuel's in-situ leaching operations that employ well-to-well leaching. Cathodes from the electrolytic refinery and the SX-EW plant are melted and cast into continuous rods at the rod plant.

The Pinto Valley Division consists of the Pinto Valley Unit and the Miami Unit. At the Pinto Valley Unit mining is accomplished with electric shovels and truck haulage to the 63,000 ton per day concentrator. A dump leaching and an 8000 tons per year SX-EW plant are also in operation. The concentrates and cathodes are shipped to San Manuel.

At Pinto Valley 14 haulage trucks were replaced with larger units to provide additional feed to the concentrator. Mill capacity was expanded in 1989.

The management team at Pinto Valley has been restructured and a new mine plan has been developed to address declining ore grades. The new plan theoretically

reduces the mine life, but is economically more attractive. Opportunities to exploit additional oxide ore zones are being studied to increase production of electrowon copper.

In April of 1988, following favorable metallurgical tests, a feasibility study, and permitting, the company began a project for the reclamation and leaching of mill tailings associated with the old Miami underground mine. The tailings are reclaimed using hydraulic mining methods to produce a slurry of tailings and water. Sulfuric acid is added to slurry to dissolve the contained copper and the resulting pregnant leach solution is processed through the Miami Unit's SX-EW plant. The remaining tailings are transported for disposal through an overland pipe to an abandoned Miami Unit pit. During 1991, approximately 3.9 million tons of tailings were mined, producing nearly 9 million pounds of copper. Production from the project is expected to continue until 1998.

The Magma underground mine at Superior was closed in 1982 due to high operating costs and low productivity. The company reopened this deep, high-grade mine in 1990 with an expected production rate of 1500 tons of ore per day. This ore body produced 25 million pounds of copper in 1991. The work force has operated at productivity levels higher than before closure. A fire in the fourth quarter of 1991 resulted in lower operating performance than was expected.

Phelps Dodge Corporation

Phelps Dodge Mining Company was formed in September, 1988 as one of two operating divisions of Phelps Dodge Corporation. It is the nation's largest copper producer and accounts for about one-third of the nation's copper production at its mines in southeastern Arizona and southwestern New Mexico. In conjunction with its Arizona operations, Phelps Dodge operates the Hidalgo Smelter near Playas, New Mexico, a 420,000 ton per year refinery at El Paso Texas, and two mines in New Mexico, the Tyrone and the Chino Mine near Silver City.

In 1991 Phelps Dodge Mining Company's U.S. mines and related facilities produced 621,800 tons of copper, 518,100 tons for the company and the balance for the accounts of minority interest owners. This production included a record 234,100 tons of copper from SX-EW plants, approximately 197,800 tons of which were for the company's account.

Copper produced by SX-EW accounted for 37 percent of Phelps Dodge Mining Company's total production in 1991, compared with 31 percent in 1990. The company expects SX-EW eventually to contribute nearly 50 percent, or about 250,000 tons, of annual production.

Phelps Dodge's Morenci mine is the largest copper producer in North America and the second largest copper producer in the world. The operation consists of two open pits, two concentrators, and an SX-EW plant. The two pits, Morenci and Metcalf, are located on two sections of the same deposit. Phelps Dodge owns an 85 percent undivided interest in the Morenci Mine; the remaining 15 percent is owned by Sumitomo Metal Mining Company, Ltd. and Sumitomo Corporation. Morenci employees nearly 2,000 people. During 1991 Morenci produced a record 342,000 tons of copper, accounting for more than half of all copper produced by Phelps Dodge in the United States.

The operation consists of the combined Morenci-Metcalf open pit copper mine, the 60,000 ton per day Morenci concentrator with a molybdenum circuit, the 40,000 ton per day Metcalf concentrator, and a dump leach - SX-EW operation. The 650,000 ton per year smelter with a 2,400 ton per day acid plant remain inactive and will require extensive modifications to meet air quality restraints if ever reactivated.

Mining is conducted with electric shovels and truck haulage utilizing a computer controlled Modular Mining Truck Dispatching System for maximum efficiency. During 1989 the completion of the in-pit crushing and conveying (IPCC) system eliminated rail haulage completely. The trucks dump into the two semi-mobile primary crushers in the pit and the crushed ore is conveyed to the coarse ore stockpile by conveyor belt. Each concentrator is fed by conveyors running under the stockpile. Both concentrators are standard flotation mills except that column flotation cells have been installed in the cleaner circuit of each.

All mined material other than ore is classified as leach material and is taken to one of several leach dumps. There are three widely spaced solvent extraction plants to upgrade the solutions before they are pumped to the centrally located tank house for electrowinning.

Construction continued on the \$112 million Northwest Extension project, which will add 70,000 tons of SX-EW production per year. Upon completion of this project in 1992, the Morenci SX-EW plant will be the largest in the world, with an annual production capacity of 170,000 tons of high cathode copper.

Two other substantial capital programs at Morenci that continued during 1991 included reentry into the Metcalf pit and extension of the ore crushing and conveying systems.

The company's Copper Queen facility consists of a dump leaching and precipitation operation at the mined out Lavender pit.

Their New Cornelia Branch 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. There are no immediate plans to reactivate the operation.

The Hidalgo smelter near Playas, New Mexico is an Outokumpo flash furnace rated at 500,000 tons per year. During 1986 the oxygen enrichment plant from the Morenci smelter was installed to increase capacity and efficiency. The resulting increase in sulfur dioxide concentration of the gases improved the operation of the acid plant as well.

COAL

Coal ranks second to copper in economic importance in the State. In 1991 Arizona coal production was 11,695,000 short tons with an estimated value of \$230 million. Coal is mined from the Kayenta and Black Mesa mines. Surface mining is done on reservation land leased from the Navajo and Hopi Tribes by Peabody Coal. Peabody is the Nation's largest coal producer and the Kayenta mine in northeastern Arizona is their largest operation.

The coal deposits occur on Black Mesa, a prominent structural basin feature of the Colorado Plateau, in the Cretaceous Wepo Formation. Peabody Coal has 35-year leases on 64,858 acres. Mining and reclamation proceed at the same rate; approximately 500 acres annually.

The Kayenta mine, employing over 700 people, is located in central Navajo County. The coal from the Kayenta mine is carried by conveyor belt 15 miles to storage silos. From there it is transported by automated trains to the Salt River Project's Navajo Generating Plant 80 miles away. The Black Mesa mine produces about 4.5 million tons annually. Here, coal is powdered and mixed with water prior to transport by the world's longest, and the Nation's only, coal slurry pipeline. The 272-mile journey to the power plant at Laughlin, Nevada takes three days.

The Peabody operations at Black Mesa are model reclamation programs. 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

A six-year low in gold prices has adversely impacted new gold projects.

Republic Goldfields' Congress Mine shut down operation during 1992. The mine and mill are being held on a care-and-maintenance basis by a small staff. Both reopening the mine and/or operating just the mill on a custom basis are being considered under possible new financial arrangements.

The Cyprus Copperstone open pit mine remained Arizona's largest gold producer with production of over 100,000 ounces. Copperstone's reserves are expected to be depleted by early April, 1993 and mill and heap leach production will cease. Some production will occur as the heap leach and tailings are washed and neutralized. The mill and surface plant will be dismantled as part of the surface reclamation.

Magma Copper Company continued operating the underground McCabe Mine. Ore is hoisted to the surface and concentrated by flotation. The resulting sulfide concentrate containing gold and copper is processed at the San Manuel smelter.

URANIUM

Lower uranium prices (NUEXCO spot price \$7.50/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, 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 hydrofract sand. Although sand and gravel lead this industrial mineral group, both in volume and value of production, 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.

Pfizer Minerals division, which acquired Calcium Products of Arizona's Santa Rita Quarry and marble filler mill in late 1991, has gone through a corporate adjustment and now operate the mine and plant as Specialty Minerals Incorporated, a subsidiary of Minerals Technologies Incorporated.

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 a hundred thousand 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.