

# THE MINERAL INDUSTRY OF ARIZONA

**This chapter has been prepared under a Memorandum of Understanding between the U.S. Geological Survey and the Arizona Department of Mines and Mineral Resources for collecting information on all nonfuel minerals.**

In 1997, for the ninth time in the past 10 years, Arizona led the Nation in total nonfuel mineral production value,<sup>1</sup> according to the U.S. Geological Survey (USGS). Arizona's mineral production had an estimated value of \$3.52 billion, a 1.7% decrease from the \$3.58 billion of 1996; following a 14.6% decrease from 1995 to 1996 (based on final 1996 data). The State accounted for about 9% of the value of U.S. total nonfuel mineral production.

Arizona continued as the top copper-producing State, accounting for 64% of total U.S. copper mine production and value. Copper was the State's leading nonfuel mineral, representing 83% of the total value. Most of the State's decrease in value resulted from decreases in copper, gold, and silver. Compared with that of 1996, the values of all other nonfuel minerals increased with the exception of those of construction sand and gravel, crude gypsum, and crushed stone.

The State's 1996 decrease in total nonfuel mineral production value mainly resulted from declines in average copper and molybdenum prices. Copper mine production increased by 6% in 1996, but its value decreased by about 18%. In 1995, both production and price increased resulting in a 30% increase in value.

Based on USGS estimates of the quantities produced in the United States during 1997, Arizona remained first in the production of molybdenum, second in perlite, fourth in silver, and fifth in pumice and pumicite. The State climbed from fifth to third in gemstones (by value) and dropped from fifth to sixth in construction sand and gravel. Additionally, Arizona was a significant producer of portland and masonry cement, gypsum, lime, and dimension stone.

The following narrative information was provided by the Arizona Department of Mines and Mineral Resources<sup>2</sup> (ADMMR). ASARCO Incorporated began mining the Silver Bell North copper oxide deposit and dedicated the solvent extraction-electrowinning (SX-EW) facility in July 1997. The joint venture with Mitsui & Co. U.S.A. (25% share) is expected to produce

<sup>1</sup>The terms "nonfuel mineral production" and related "values" encompass variations in meaning, depending on the minerals or mineral products. Production may be measured by mine shipments, mineral commodity sales, or marketable production (including consumption by producers) as is applicable to the individual mineral commodity.

All 1997 USGS mineral production data published in this chapter are estimates as of January 1998. For some commodities (for example, construction sand and gravel, crushed stone, and portland cement), estimates are updated periodically. To obtain the most current information, please contact the appropriate USGS mineral commodity specialist. Call MINES FaxBack at (703) 648-4999 from a fax machine with a touch-tone handset, and request Document # 1000 for a telephone listing of all mineral commodity specialists, or call USGS information at (703) 648-4000 for the specialist's name and number. This telephone listing may also be retrieved over the Internet at <http://minerals.er.usgs.gov/minerals/contacts/comdir.html>.

<sup>2</sup>Nyal J. Niemuth, Mining Engineer, authored the text of State minerals information provided by the Arizona Department of Mines and Mineral Resources.

16,000 metric tons of copper annually. Much of the oxide ore will come from the new pit, Silver Bell North, with reserves of 179 million tons grading 0.39% copper. Rubblization and leaching of material in the El Tiro and Oxide pits will also provide solution to the SX-EW plant. Capital costs were reduced by using mining equipment from the Ray and Mission Mines.

Copper production at the Ray Mine was up from 1995, to 156,000 tons, because of increased ore production as a result of improved efficiency and access to high-grade ore following completion of a stripping program. Efficiency was increased, in part, by adding three new 218-ton capacity trucks and a new 43-cubic-meter shovel. Late in 1996 the mine began testing a prototype truck, the Haulpak 930E Komatsu with a capacity of 281 tons. Six smaller 154-ton capacity trucks were freed for use at the Silver Bell Mine. By yearend, the Ray Mine had reserves of 897 million tons grading 0.6% copper (ASARCO Incorporated, Form 10-K405, accessed March 17, 1998, at URL <http://www.sec.gov/Archives/edgar/data/7649/0000007649-97-000003.txt>).

At the Mission Mine, ore production and average grade increased as the underground mine came on-line, supplying high-grade ore. In 1996, production totaled 118,000 tons of copper and 363 tons of molybdenum. The Mission Mine was Arizona's largest silver producer with 61 tons recovered as a byproduct. Developmental drilling increased copper reserves to 485 million tons containing 3.4 million tons of copper. The drilling also identified long-term stripping requirements that led Asarco to install a conveyor system to move 53 million tons of waste per year and purchase two new 46-cubic-meter capacity shovels. These actions allowed three 11-cubic-meter capacity shovels to be moved to the Silver Bell Mine.

Broken Hill Proprietary (BHP) Copper Co.'s San Manuel Mine, the largest underground operation in the United States, produced 107,000 tons of copper for the fiscal year ending May 1, 1997. The Lower Kalamazoo ore body commenced production in January 1997. Production from the Lower Kalamazoo ore body will increase as the San Manuel ore body is depleted over the next few years. According to BHP's Report to Shareholders and the ADMMR, the ore reserves of the two deposits are 222 million tons of sulfide ore at 0.62% copper.

BHP's Florence insitu leach project has completed permitting and is scheduled to begin production in 1998. The operation is anticipated to produce 32,000 tons of cathode copper per year for 15 years. The project is in a testing phase that includes a pilot insitu leach and SX-EW plant. Oxide resources for the project are 291 million tons averaging 0.34% copper.

In 1996 Cyprus Sierrita Corp. started mining a 63-million-ton oxide deposit that has led to an increase in cathode output, according to the company's 1996 Annual Report. Construction has begun on a new in-pit crusher and conveyor system to reduce

haulage costs. A major contribution to the mine's success is a byproduct molybdenum credit of 8,600 tons, valued at \$100 million in 1996. Sierrita is the largest producer of molybdenum in Arizona.

Equatorial Mining N.L. of Australia exercised their option to purchase the Mineral Park Mine from Cyprus on October 1, 1997. The company plans to double production of the SX-EW operation that produced 2,300 tons of copper for Cyprus in 1996. Cyprus' Tohono operations, located on land leased from the Tohono O'Odham Nation, consists of an SX-EW plant fed by an experimental open pit and heap leach. In 1996 Tohono produced 18,000 tons of copper, however Cyprus suspended mining in July 1997.

Investments in the smelter and refinery at Miami have made Cyprus more efficient and self-sufficient in domestic copper smelting and refining. The smelter processed a record 574,000 tons of copper concentrates in 1996.

Phelps Dodge Corp.'s Morenci Mine in Greenlee County, the largest copper mine in North America, produced over 454,000 tons of copper in 1996. The Morenci Mine produces about 25% of the U.S. copper production and 5% of the world's production. The Morenci operation consists of the Morenci, Metcalf, and Northwest Extension open pit copper mines, the 91,000-ton-per-day Morenci concentrator with a molybdenum recovery circuit, the 36,000-ton-per-day Metcalf concentrator, and four dump leaches with three SX plants. The Morenci operation also includes the new Southside EW plant, with a 59,000-ton capacity, and Morenci, with an annual capacity of 168,000 tons, the world's largest EW plant. Following testing of the Haulpack 930 E 290-ton capacity trucks at Phelps Dodge's Chino Mine in New Mexico, the company purchased a fleet of 39 of the new large haulers, 28 of which are scheduled for service at Morenci in 1997.

In 1997 Phelps Dodge announced that a \$238 million construction project is planned for the New Cornelia Mine at Ajo. The New Cornelia operation, which will employ about 400 people, is expected to produce 61,000 tons of copper and 780 kilograms of gold per year, perhaps as early as 2000. The project is scheduled to include a new concentrator and used mining equipment, allowing resumption of mining of the deposit that last operated in 1983. The sulfide resource is 136 million tons grading 0.56% copper. Novel features of the planned concentrator include the largest semiautogenous grinding (SAG) mill in Arizona, which is 10 meters in diameter by 5 meters wide and powered by an 11 meter in diameter wrap around drive motor. This 15,000 horsepower electric motor will also be the largest in Arizona. After screening, the feed will be supplied to the world's largest ball mill measuring 7 meters in diameter by 12 meters long.

Carlota Copper Co., subsidiary of Cambior U.S.A., was granted their long awaited Environmental Impact Statement and Record of Decision in July 1997 from the Tonto National Forest for their Carlota project. The company still awaits approval from the Environmental Protection Agency and the Bureau of Reclamation. The delays and lower copper prices caused Cambior to schedule

the close of their construction office for January 1998.

In October 1997, AMT International Mining Corp. announced the completion of a feasibility study on their Copper Creek deposits located 45 miles northeast of Tucson. The exploration project includes the Old Reliable, Child Aldwinkle, and Copper Prince breccia pipes and encompasses joint venture property with BHP and Phelps Dodge.

According to ADMMR, Arizona's 1996 gold production exceeded 3,100 kilograms. Addwest Minerals Inc.'s Gold Road Mine in Mohave County added over 1,200 kilograms to the approximately 1,900 kilograms of byproduct production from its copper mines. According to the company, as of January 1997 the underground Gold Road Mine had about 3 years of reserves totaling 475,000 tons at 7.9 grams per ton. Addwest conducted exploration drilling on the nearby Moss Mine that contains a 6.7-million-ton resource grading 1.16 grams per ton. Addwest's parent company, Addwest Minerals International Ltd., became a publicly traded company in early 1997. The Bureau of Land Management's publishing of the draft Environmental Impact Statement for Bema Gold Corp.'s proposed open pit heap leach Yarnell project has been delayed and is now expected to be released in early 1998. Royal Oak Mines, Inc. reported promising intercepts as it continued drilling the Copperstone gold deposit for a possible underground mine.

In 1996, Salt River Sand & Rock Co., in Maricopa County, continued to operate the second largest sand and gravel plant in the United States. Acquisitions, mergers, and dissolutions have changed the corporate structure of Arizona's industrial mineral mining industry. Omya (Arizona) Inc. [Pluess Staufer] acquired the Queen Creek Limestone deposit previously operated by Mineral Development Inc. Omya has announced plans to construct a marble grinding mill near Superior in Pinal County. Minerals Development Inc., in agreement with Omya, will continue to supply the market with crushed and screened marble products of a particle size greater than 200 mesh. Georgia Marble Co. acquired the Santa Rita quarry and plant in Pima County from Specialty Minerals Inc. under a long-term lease and announced plans to concentrate their Arizona operations at the newly leased location. Superior Companies, Inc. sold its Camp Verde Gypsum Mine to Phoenix Cement Co. and sold its other mines including the Verde Valley sand and gravel operation, Winkleman Gypsum, and the idle St. Johns limestone mine to United Metro. Pioneer Concrete of America, through its Pioneer Concrete of Arizona subsidiary, acquired Cashway Concrete and Materials Co. in Phoenix. Pioneer of Australia is the parent company of Pioneer Concrete and is reported to be the second largest sand and gravel producer in the world.

The Salt River Project's Navajo Power Plant at Page began receiving limestone from Chemical Lime Co. in Nevada for a new flue gas desulfurization plant. At full capacity, approximately 163,000 tons of limestone will be received annually from the Nevada quarry 402 kilometers away. The desulfurization produces gypsum as a waste product.

TABLE 1  
NONFUEL RAW MINERAL PRODUCTION IN ARIZONA 1/ 2/

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	1995		1996		1997 p/	
	Quantity	Value	Quantity	Value	Quantity	Value
Clays:						
Bentonite	21	W	W	W	W	W
Common	98	449	104	W	91	W
Copper 3/	1,170	3,560,000	1,240	2,980,000	1,230	2,930,000
Gemstones	NA	3,230	NA	2,360	NA	3,220
Gold 3/ kilograms	1,920	23,900	1,740	21,800	W	W
Iron oxide pigments, crude metric tons	68	90	W	W	W	W
Sand and gravel:						
Construction	40,100	201,000	41,900	199,000	40,400	197,000
Industrial	334	2,910	323	2,890	319	3,220
Silver 3/ metric tons	220	36,400	188	31,300	159	22,300
Stone, crushed	5,520	32,600	6,800	40,600	6,100	38,000
Combined value of cement, gypsum (crude), lime, molybdenum, perlite (crude), pumice and pumicite, salt, stone (dimension sandstone), and values indicated by symbol W	XX	331,000	XX	308,000	XX	325,000
Total	XX	4,190,000	XX	3,580,000	XX	3,520,000

p/ Preliminary. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.

1/ Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

2/ Data are rounded to three significant digits; may not add to totals shown.

3/ Recoverable content of ores, etc.

TABLE 2  
ARIZONA: CRUSHED STONE SOLD OR USED, BY KIND 1/

Kind	1995				1996			
	Number of quarries	Quantity (thousand metric tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand metric tons)	Value (thousands)	Unit value
Limestone	4	2,550	\$14,000	\$5.48	6	4,110	\$23,000	\$5.60
Granite	11 r/	1,940 r/	10,800 r/	5.56 r/	12	1,540	8,580	5.57
Marble	3	W	W	6.09	3	W	W	8.24
Sandstone and quartzite	2	W	W	14.62	2	W	W	12.58
Volcanic cinder and scoria	4	135	416	3.08	5	238	W	W
Miscellaneous stone	2	W	W	8.88 r/	2	W	W	9.04
Total	XX	5,520	32,600	5.91	XX	6,800	40,600	5.97

r/ Revised. W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.

1/ Data are rounded to three significant digits; may not add to totals shown

TABLE 3  
ARIZONA: CRUSHED STONE SOLD OR USED BY PRODUCERS  
IN 1996, BY USE 1/ 2/ 3/

Use	Quantity (thousand metric tons)	Value (thousands)	Unit value
Coarse aggregate (+1 1/2 inch); riprap and jetty stone	41	\$123	\$3.00
Coarse and fine aggregates:			
Graded road base or subbase	56	96	1.71
Unpaved road surfacing	105	158	1.50
Terrazzo and exposed aggregate	616	4,480	7.27
Other construction materials 4/	34	176	5.18
Agricultural: poultry grit and mineral food	(5/)	(5/)	10.75
Chemical and metallurgical:			
Cement manufacture	(5/)	(5/)	6.61
Lime manufacture	(5/)	(5/)	5.51
Special:			
Whiting or whiting substitute	(5/)	(5/)	10.96
Other specified uses not listed	2,630	15,800	6.00
Unspecified: 6/			
Actual	222	1,790	8.07
Estimated	3,100	18,000	5.82
Total	6,800	40,600	5.97

1/ To avoid disclosing company proprietary data; "District tables were not produced in 1996."

2/ Includes granite, limestone, marble, miscellaneous stone, sandstone and quartzite, and volcanic cinder and scoria.

3/ Data are rounded to three significant digits; may not add to totals shown.

4/ Includes screening (undesignated).

5/ Withheld to avoid disclosing company proprietary data; included with "Other specified uses not listed."

6/ Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 4  
ARIZONA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1996,  
BY MAJOR USE CATEGORY 1/

Use	Quantity (thousand metric tons)	Value (thousands)	Value per ton
Concrete aggregate (including concrete sand)	13,700	\$73,000	\$5.34
Plaster and gunite sands	674	3,140	4.66
Concrete products (blocks, bricks, pipe, decorative, etc.)	247	1,180	4.78
Asphaltic concrete aggregates and other bituminous mixtures	4,650	27,200	5.85
Road base and coverings 2/	7,830	29,600	3.79
Fill	956	3,330	3.49
Other miscellaneous uses 3/	591	2,660	4.51
Unspecified: 4/			
Actual	7,050	32,100	4.55
Estimated	6,250	26,900	4.30
Total or average	41,900	199,000	4.75

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes road and other stabilization (cement).

3/ Includes filtration and snow and ice control.

4/ Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 5  
 ARIZONA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1996,  
 BY USE AND DISTRICT 1/

(Thousand metric tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregate and concrete products 2/	284	1,960	172	955	14,100	74,400
Asphaltic concrete aggregates and road base materials 3/	507	3,710	398	2,290	12,500 4/	54,200 4/
Other miscellaneous uses 5/	8	41	11	117	572	2,510
Unspecified: 6/						
Actual	368	1,320	--	--	6,680	30,800
Estimated	2,410	10,900	1,110	4,260	2,740	11,700
Total	3,570	17,900	1,690	7,620	36,600 4/	174,000 4/

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes plaster and gunite sands.

3/ Includes fill and road and other stabilization (cement).

4/ Includes unspecified within all districts.

5/ Includes filtration and snow and ice control.

6/ Includes production reported without a breakdown by end use and estimates for nonrespondents.