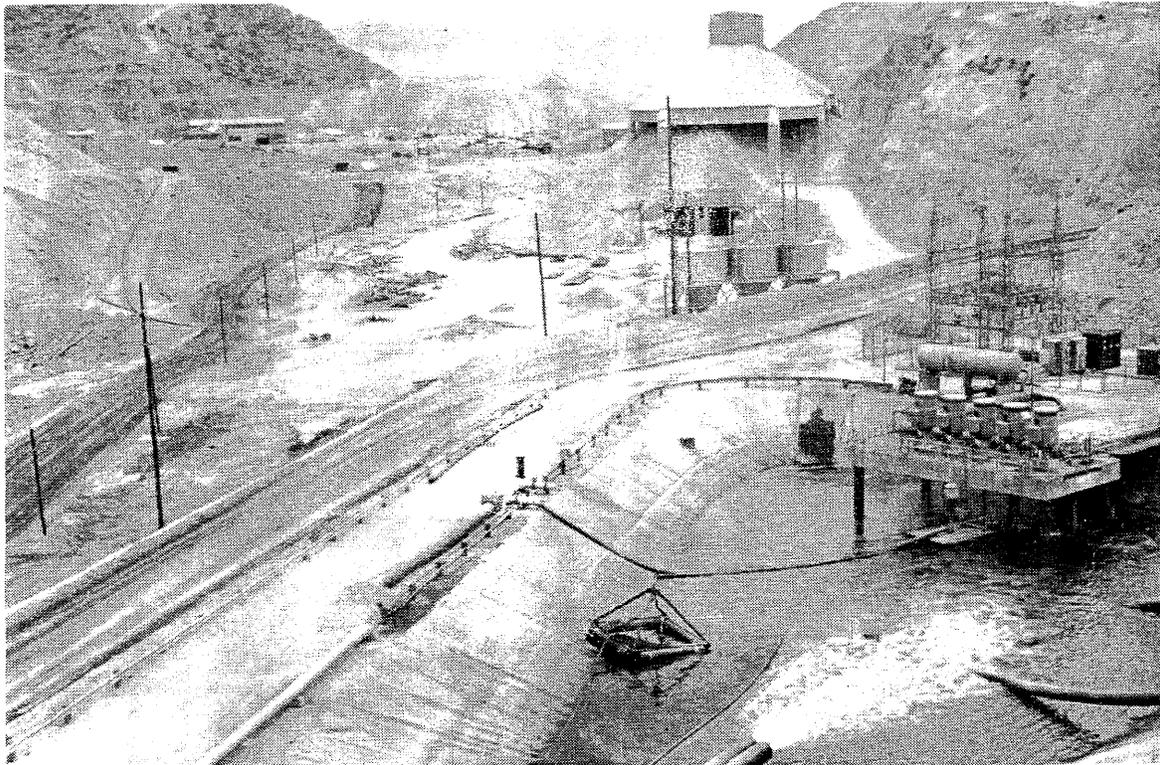


# **THE PRIMARY COPPER INDUSTRY OF ARIZONA IN 1991**



**DEPARTMENT OF MINES AND MINERAL RESOURCES**

**BY K. A. Phillips and N. J. Niemuth**

**ARIZONA DEPARTMENT OF MINES  
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# THE PRIMARY COPPER INDUSTRY OF ARIZONA

by K.A. Phillips and N.J. Niemuth

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Department of Mines and Mineral Resources

Special Report No. 18



State of Arizona  
Fife Symington, Governor

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## INTRODUCTION

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The Arizona Department of Mines and Mineral Resources presents herein a report covering activity in Arizona's copper industry in the calendar year 1991. A brief review of operational highlights reported by the major producers and developers in the State, market and price developments that affected copper production, and discussions of Arizona severance taxes on metalliferous minerals are included.

The contained statistical tables include various production, employment, inventory, import/export, prices, costs, and ore reserve numbers for 1991. Production of recoverable copper is given for individual mines and by company. Figures showing the importance of copper in the mining industry are provided, as are data on the by-products of copper mining; gold, silver, and molybdenum. In addition, historical compilations are included for leach copper, average grade of ore produced, percent copper recovered, stripping ratios, and employment and earnings. Additional compilations indicating refined copper inventories in and out of the United States and average copper prices by month from 1982 through 1991 are provided. Also included are tables showing designed mine capacity and copper reserve base in Arizona plus cash production costs for the United States, 1983-1990.

The Department maintains an extensive reference library concerning the copper industry in Arizona. This repository includes information on individual mines and mining companies, United States Bureau of Mines and United States Geological Survey publications, other professional publications, periodicals, and earlier editions of this report. Additionally, experienced mining engineers are available for consultation, at no charge, on matters germane to the minerals industry.

The authors wish to express their sincere appreciation to the management and staff of each of Arizona's mining companies for graciously devoting time and effort to provide information for this report. Michael Greeley of the U.S. Bureau of Mines, Dr. George Learning of the Western Economic Analysis Center of Marana, Arizona, and the American Bureau of Metal Statistics, Inc. of Secaucus, New Jersey also provided vital information.

Thanks are also due to the Arizona Department of Economic Security, the Arizona Department of Revenue, and the staff of the Joint Legislative Budget Committee for providing statistics and data.

A special gratitude is felt toward the preceding authors for providing the format and sources of statistical information and to Leroy E. Kissinger, Director of the Department of Mines and Mineral Resources, for providing the opportunity to author this report.

Stripping of waste, including some leachable material, was accomplished at the 10 operating open pit mines during 1991. The weighted average of the stripping ratios - waste to ore - was 1.49 to 1 (Table 8). This is comparable to the 1.57 to 1 in 1990 which probably indicates continued normal long-range mine planning.

The weighted average grade of sulfide ore mined in 1991 was 0.57 percent copper (Table 6).

The estimated capacity to produce copper at each of Arizona's principal operations totals 1.316 million tons annually (Table 11). By this estimate the mines, concentrators, and leach facilities operated at 86.1 percent of capacity in 1991.

The copper reserve base in Arizona is estimated to be over 13 billion tons containing over 67 million tons of copper (Table 22). At present mining rates, this amount, if economic, would represent 50 years of reserves.

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### 1991 OPERATIONS SUMMARY

Operating properties	18
Operating companies	6
Operating smelters	3
Ore mined (including some oxide)	258,646,597 tons
Ore milled (sulfides)	171,221,185 tons
Waste/overburden removed (includes some leach material)	357,729,604 tons
Average stripping ratio	1.49:1 (waste:ore)
Copper produced	1,132,536 tons - 63.0% of U.S.
From sulfide ores	798,693 tons - 70.5% of AZ
Average sulfide grade	0.57% copper
From leaching	333,843 tons - 29.5% of AZ
By SX-EW	326,773 tons - 97.9% of leached
Molybdenum produced	35,050,734 pounds
Silver produced	4,651,000 troy ounces
Gold produced	51,248 troy ounces
Average employment	12,369
Average annual wage	\$37,418
Productivity (production workers)	115.6 pounds of copper per man-hour 13.2 tons of ore per man-hour

## **CONCENTRATION**

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The majority of copper mineralization in Arizona is of the sulfide type and is not amenable to leaching without extraordinary means. Inspiration had success with its heap leach-ferric cure process on mixed oxide-sulfide ores and Kennecott pioneered the use of bacteria to convert sulfides to oxides in low-grade dumps. However, as shown in the 1991 Operations Summary, about 70.5 percent of the copper was produced by the flotation method of concentration. In addition much of the leached copper produced is from dumps of "waste" that was stripped from open pit mines to provide access to sulfide ore. Another aspect of the flotation process that makes it viable at some properties is the recovery of molybdenum by selective flotation. Molybdenum provides a significant portion of the revenues from some properties. Also, any precious metals in the ore follow the copper through the flotation process and smelting to the electrolytic refinery where they can be recovered from the anode slimes.

There are currently 9 flotation concentrators in operation in Arizona. Asarco is operating 3 - 1 at Ray and 2 at Mission, Cyprus is operating 2 - Bagdad and Sierrita, Magma is operating 3 - San Manuel, Pinto Valley, and Superior, and Phelps Dodge 2 at Morenci-Metcalf. A new 30,000 ton per day mill is being constructed at Ray.

Although efficiency is constantly being improved, the flotation process is not cheap. It requires crushing and grinding the ore, separation of the ore minerals from the gangue minerals in the flotation cells, smelting the concentrate, and refining the copper anodes from the smelter. The most significant recent advance in flotation is the improved recoveries resulting from the use of column flotation cells that have been installed in most concentrators.

## **SMELTING**

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Of the 7 smelters remaining in Arizona in 1991 only 3 operated. Asarco's Hayden smelter and Cyprus' smelter at Miami have been brought into compliance with air pollution constraints and Magma's smelter at San Manuel has been retrofitted with an Outokumpu flash furnace to bring it into compliance. The smelter at Hayden that Asarco acquired from Kennecott met all significant environmental constraints when last operated in 1982. Magma's smelter at Superior and Phelps Dodge's smelters at Ajo and Morenci will require extensive retrofitting before they can be operated. Phelps Dodge is shipping concentrates to its Hidalgo smelter at Playas, New Mexico and to the Chino smelter at Hurley, New Mexico.

As an alternative to smelting, Cyprus Casa Grande has reactivated the roast leach electrowinning (RLE) plant built by Hecla. In this process a portion of the flotation concentrates from Sierrita are roasted to make them acid soluble and then leached with sulfuric acid. Soluble cathode copper is extracted from the leach solution by electrowinning. Cyprus upgrades the leach solutions in the solvent extraction plant before electrowinning. Acid is produced from the roaster gases and the process is essentially pollution free.

Planned upgrading and expansion of the Miami smelter will make Cyprus self-sufficient in the smelting of their own sulfide production. A fire at the smelter in early November moved the beginning of the upgrade and expansion of the facility from March 1992. The Isasmelt technology developed by Mount Isa Mining Company in Australia will be installed at Cyprus-Miami.

## **PROGNOSTICATION**

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Prognosticators of gloom and doom for the mining industry continue to be less than accurate in their predictions of a glut of copper in warehouse inventories, in the resultant drop in price, and ultimately reduction in the production of copper. The boom expected by the development of Eastern Europe and the Third World continues to be slow in arriving, and may never take on giant proportions. However, industry optimists still believe growth of that magnitude will take place in those areas. The resultant demand for copper in the construction of new plants and infrastructure will be important to the red metal into the 21st century. That the copper price continues to be relatively strong in the face of lingering recession and growing inventories, indicates market strength that belies the normal analysis used by most prognosticators.

On the down side, the threat of increased environmental regulatory pressures, and the development of large high-grade copper deposits outside the United States, will keep severe pressure on the domestic copper industry to remain competitive.

section of the pit late in 1987 increased reserves and facilitated 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.

## **Ray**

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**P.O. Box 9, Hayden, Arizona 85235  
Phone (602) 356-7811**

The Ray operation 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.

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 was delayed until 1992. Copper output 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.

## **Silver Bell**

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**Marana, Arizona 85653  
Phone (602) 622-6551**

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

## **CYPRUS COPPER COMPANY**

**Corporate Headquarters - 1501 W. Fountainhead  
Parkway, Tempe, Arizona 85282  
Phone (602) 929-4400**

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 5 copper producing mine complexes in the State: Bagdad, Casa Grande, Miami, Mineral Park and Sierrita. In addition to its copper-molybdenum properties, Cyprus operates Arizona's largest gold mine, the Copperstone north of Quartzsite.

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 operation at Miami, including the mines, concentrator (inactive), SX-EW plant, smelter, acid plant, electrolytic refinery, and rod plant.

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 SX-EW 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 mil-

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 the Thompson Creek (Idaho), Bagdad, and Sierrita operations is processed at Sierrita's roasters to produce molybdenum oxide and ferromolybdenum that are shipped to customers worldwide.

### **MAGMA COPPER COMPANY**

**Corporate Headquarters - 7400 N. Oracle Road,  
Tucson, Arizona 85704  
Phone (602)575-5600**

In 1987, after nearly 20 years as a wholly owned subsidiary of Newmont Mining Corporation, Magma once again became an independent corporation. Magma embarked on and continues an extensive expansion and modernization program to become competitive in the copper market and meet environmental constraints.

Magma's Arizona operations include the San Manuel, Pinto Valley, Miami, and Superior mines. The company also operates the McCabe gold mine near Mayer and a railroad. The McCabe Mine produces gold-copper concentrates that are shipped to the San Manuel smelter for treatment. The railroad operation consists of 2 segments, a 29-mile line from San Manuel, and a 28-mile line from Superior, that both connect to the Santa Fe Southern Pacific system.

Magma reports that production, cost reduction, and productivity have all 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.

### **San Manuel**

**P.O. Box M, San Manuel, Arizona 85631  
Phone (602) 385-3100**

San Manuel consists of a underground copper-molybdenum mine, a 62,000 ton-per-day concentrator, an open-pit oxide copper mine, a heap leach, an in situ leach, an SX-EW plant, a 1,000,000 ton-per-year smelter, a 3,000 ton-per-day acid plant, a 300,000 ton-per-year electrolytic refinery, and a 180,000 ton-per-year rod plant.

Mining at San Manuel uses the block-caving method. 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 about 8 miles 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. Preliminary results indicate that the development of the ore body could extend the San Manuel underground mine's life by 11 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.

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

## **PHELPS DODGE CORPORATION**

**Corporate Headquarters - 2600 North Central Avenue, Phoenix, Arizona 85004- 3015  
Phone (602) 234-8100**

Phelps Dodge is the nation's largest copper producer, accounting for about 33 percent of the nation's production from its mines in southeastern Arizona and southwestern New Mexico. Facilities in Arizona consist of the 2 operating properties Morenci and Copper Queen, along with New Cornelia, a closed open-pit mine, mill, and smelter complex located at Ajo. In conjunction with its Arizona operations, it operates 2 mines, Tyrone and Chino, near Silver City, New Mexico, 2 smelters, Hidalgo and Chino, both in New Mexico, and a 420,000 ton-per-year refinery located at El Paso, Texas.

In 1991 Phelps Dodge's U.S. mines and 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's total production in 1991, compared with 31 percent in 1990. Soon, SX-EW is expected to contribute nearly 50 percent, or about 250,000 tons, of annual production.

### **Morenci**

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**Morenci, Arizona 85540  
Phone (602) 865-4521**

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 2 open pits, 2 concentrators, and an SX-EW plant. The 2 pits, Morenci and Metcalf, are located on portions of the same deposit. Phelps Dodge owns an 85 percent interest in the Morenci Mine; the remaining 15 percent is owned by Sumitomo Metal Mining Company, Ltd. and Sumitomo Corporation. Morenci employs 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, 3 SX plants, and an EW tankhouse. 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 system eliminated rail haulage completely. The trucks dump into the 2 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 3 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 facilities 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.

### **Copper Queen**

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**Highway 92, Bisbee, Arizona 85603  
Phone (602) 432-3621**

The company's Copper Queen facility consists of a dump leaching and precipitation operation at the mined-out Lavender pit. Additional copper resources are available in the adjacent 210-million-ton Cochise deposit. Although metallurgical work has been done, it is unlikely to be developed without construction of a new SX-EW facility that would require improvement in the copper market.

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## PROPERTY TAX

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The following has been excerpted from *Appraisal Manual for Mines and Natural Resources* by Donald E. Ross of the Arizona Department of Revenue which was effective as of January 1, 1988 and is revised annually.

The Natural Resource Unit of the Division of Property Valuation and Equalization is assigned the responsibility of valuing producing and nonproducing mines and oil, gas, and geothermal interests. Arizona Department of Revenue mine valuation regulations R15-4-201 through R15-4-206 are incorporated into this manual.

Arizona Revised Statutes (ARS Section 42-201.8) states:

*"Producing mine or mining claim" means any mine or mining claim from which any coal, mineral or mineral substance, other than clay, sand, gravel, building stone or any mineral substance normally processed into artificial stone, has been extracted for commercial purposes at any time during a period of one year prior to the first Monday in January of the tax year."*

A producing mine includes the land utilized for mining purposes together with structures and facilities necessary to sustain mining operations. It also includes equipment used directly in the process of extracting ores or minerals from the earth for commercial purposes, including equipment required to prepare the materials for extraction and the handling, loading or transportation of such extracted material to the surface. Mining includes underground, surface and open-pit operations for the extraction of ores and minerals.

If mining operations cease, real and personal property associated with a mining operation will continue to be valued by Centrally Valued Properties for a period of three years. The nonoperating mine will be retained in the legal class 1 for the first year after mining operations are terminated. The legal class designation used for the next two years will depend on the use of the property, which could be class 4 if the property remains idle.

Three years after mining operations have ceased, the valuation of the nonproducing mining property will be transferred from the Centrally Valued Properties' jurisdiction to the Locally Valued Properties' jurisdiction. From this point on, the county assessor is responsible for classifying and valuing the subject property. Such property will be classified according to its current use. If the real and/or personal property is idle at the expiration of the three-year period, it normally will be classified legal Class Four property.

The Natural Resource Unit of the Centrally Valued Properties Section of the Arizona Department of Revenue is responsible for determining annually the

value of all producing mines as of the first day of January of the tax year. Property within the context of a producing mine excludes manufacturing operations such as a rod plant. In summary, the value of taxable producing mine property for Arizona property tax purposes includes land, supplies inventories, ore reserves, construction work in progress, personal property and improvements.

### Summary of Procedures

Producing mines are taxed on the basis of their assessed value multiplied by the local tax rate which produces the tax due. The assessment ratio for 1988 is 28% of the full cash value or market value. The full cash value is determined by the mineral property appraiser after correlating the three approaches to value, namely the income, cost and market approaches.

The income approach consists of discounting two different future income streams as developed by (1) the mining company and (2) by the Department utilizing a single rate factor. The Department has developed a method in which a five-year history, expressed as a profit margin, is combined with the future production schedule to produce a future income stream. The historical data are expressed on a production basis, not on a sales basis. This five-year margin method avoids the problems of predicting the future price of copper and other metals. It is supported in the literature and has been approved by the Arizona Supreme Court. The past is only a valid indicator of the performance level of a relatively stable operation and should not be used for new or dying mines. The historical data are averaged to flatten the effects of the peaks and it is generally accepted as standard for financial reporting, and the Securities and Exchange Commission reports.

Cost approach values are determined by computing the reproduction cost new less depreciation for the physical assets. Straight line depreciation is utilized along with appreciation or inflation factors as developed by the Department. Economic and functional obsolescence can be allowed for by the appraiser if warranted.

Comprehensive field notes are written for each mine annually. Contacts with the mining industry are maintained in order to keep abreast of development in technology and discount rates. Technical papers and literature are collected, indexed, and placed in the listing of references for each mine appraisal report. Detailed production statistics are maintained in order to analyze the historical performance for the mine.

**Table 1. Copper and molybdenum production in 1991, by mine and company — continued**

Company Mine Ore/process type	Copper ore mined (tons)	Copper ore milled (tons)	Recoverable copper (pounds)	Recoverable molybdenum (pounds)	Waste removed (tons)
<b>San Manuel</b>					
Underground sulfide	18,753,661	18,761,357	221,861,238	4,023,734	--
In-situ/SX-EW	--	--	24,674,000	--	--
Open Pit-Sulfide	47,644	7,220	113,710	--	--
Open Pit-Oxide	13,076,711	--	--	--	15,048,633
Heap leach/SX-EW	--	--	66,888,000	--	--
<b>Superior</b>					
Sulfide	250,500	250,500	25,167,574	--	--
<b>Company total</b>	<b>54,787,855</b>	<b>41,678,416</b>	<b>519,500,694</b>	<b>5,411,734</b>	<b>48,024,704</b>
<b>Oracle Ridge Mining</b>					
<b>Oracle Ridge</b>					
Sulfide	171,792	192,969	4,483,042	--	4,200
<b>Company total</b>	<b>171,792</b>	<b>192,969</b>	<b>4,483,042</b>	<b>--</b>	<b>4,200</b>
<b>Phelps Dodge Corp.</b>					
<b>Copper Queen</b>					
Dump leach/cement.	--	--	2,280,000	--	--
<b>Morenci (4)</b>					
Sulfide	44,500,000	43,100,000	445,500,000	1,000,000	107,000,000
Oxide	27,000,000	--	--	--	19,500,000
Dump leach/SX-EW	--	--	238,900,000	--	--
<b>Company total</b>	<b>71,500,000</b>	<b>43,100,000</b>	<b>686,680,000</b>	<b>1,000,000</b>	<b>126,500,000</b>
<b>Subtotals by process type</b>					
Flotation	177,893,736	171,221,185	1,597,386,245	35,050,734	308,113,971
Leach	80,752,861	xx	667,685,358	--	49,615,633
Dump/SX-EW	xx	xx	317,629,000	--	xx
Heap leach/SX-EW	xx	xx	256,285,741	--	xx
In-situ/SX-EW	xx	xx	42,034,000	--	xx
Vat agitation/SX-EW	1,789,000	xx	37,597,000	--	xx
SX-EW total	xx	xx	653,545,741	--	xx
Dump/cementation	xx	xx	13,139,617	--	xx
In-situ/cementation	xx	xx	1,000,000	--	xx
Cementation total	xx	xx	14,139,617	--	xx
<b>Arizona total</b>	<b>258,646,597</b>	<b>171,221,185</b>	<b>2,265,071,603</b>	<b>35,050,734</b>	<b>357,729,604</b>

(1 Although some of this production is from old dumps, it is undifferentiated and reported as heap leach.

(2 Sulfide ore is concentrated at Sierrita.

(3 Includes production from ore stockpiles, reclaimed sulfide tailings, and newly mined ore.

(4 Includes Sumitomo's 15%. All waste is low-grade material that is dump leached.

Table 2. Leach copper production, by mine — continued

Company/Mine	1988	1989	1990	1991
<b>Arimetco International Inc.</b>				
Emerald Isle	--	48	26	--
Johnson (2)	--	--	2,852	5,898
Van Dyke (3)	67	654	--	--
<b>Asarco Inc.</b>				
Ray (4)	76,966	79,933	81,797	85,238
Silver Bell	8,660	10,017	8,480	8,059
<b>Cyprus Copper Co.</b>				
Bagdad	19,100	22,262	23,419	22,391
Casa Grande (5)	4,300	5,000	2,500	6,864
Miami (6)	115,293	124,367	121,702	121,224
Mineral Park (7)	4,500	3,338	4,000	3,800
Ox Hide (6)	--	--	--	--
Sierrita/Esperanza (7)	8,556	8,400	9,383	9,337
Twin Buttes (8)	--	18,800	30,919	37,597
<b>Magma Copper Co.</b>				
Copper Cities	--	--	--	--
Pinto Valley/Miami	23,413	21,013	31,955	34,535
San Manuel (9)	62,956	68,855	80,400	91,562
<b>Phelps Dodge Corp.</b>				
Copper Queen	2,700	4,762	3,100	2,280
Morenci	108,426	133,221	200,823	238,900
New Cornelia	--	--	--	--
<b>Total</b>	<b>434,937</b>	<b>500,622</b>	<b>601,356</b>	<b>667,685</b>
<b>Percent of primary copper produced (9)</b>	<b>23.1</b>	<b>24.9</b>	<b>27.7</b>	<b>29.5</b>

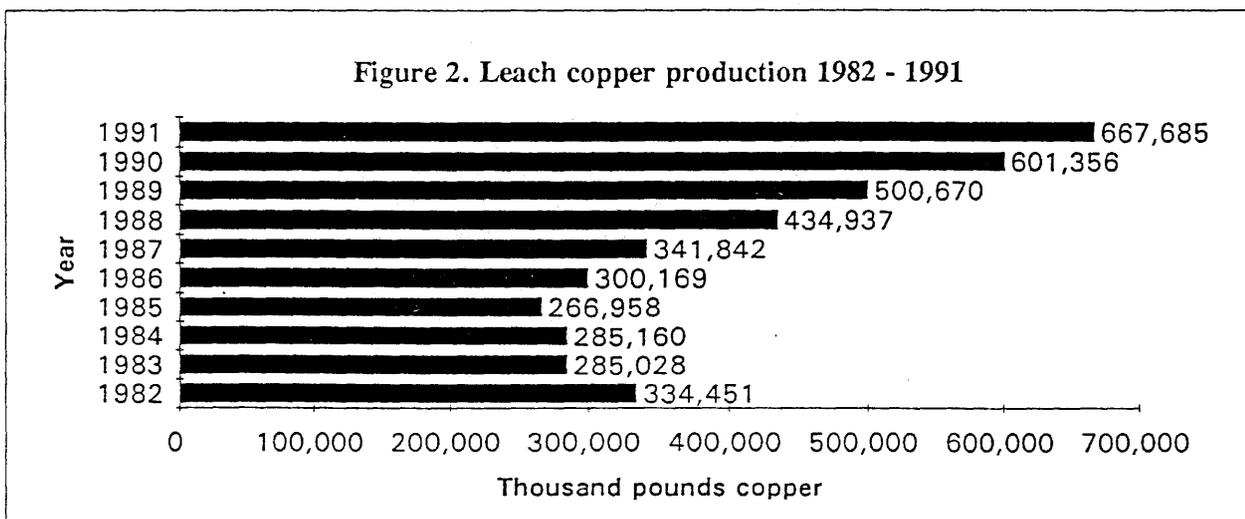


Table 4. Mine rank in 1991, by copper and molybdenum production

Rank	Mine/Company	Production (pounds)	% of total
<b>Copper</b>			
1	Morenci/Phelps Dodge Corp.	684,400,000	30.2
2	San Manuel/Magma Copper Co.	313,536,948	13.8
3	Ray/Asarco Inc.	234,691,000	10.4
4	Bagdad/Cyprus Copper Co.	219,243,000	9.7
5	Mission/Asarco Inc.	172,042,541	7.6
6	Pinto Valley/Magma Copper Co.	161,450,172	7.1
7	Sierrita/Cyprus Copper Co.	143,351,000	6.3
8	Twin Buttes/Cyprus Copper Co.	134,371,000	5.9
9	Miami/Cyprus Copper Co.	121,224,000	5.4
10	Superior/Magma Copper Co.	25,167,574	1.1
11	Miami/Magma Copper Co.	19,346,000	0.9
12	Silver Bell/Asarco Inc.	8,059,617	0.4
13	Casa Grande/Cyprus Copper Co.	6,864,000	0.3
14	Johnson/Arimetco International Inc.	5,897,741	0.3
15	San Xavier North/Asarco Inc.	4,863,968	0.2
16	Oracle Ridge/Oracle Ridge Mining	4,483,042	0.2
17	Mineral Park/Cyprus Copper Co.	3,800,000	0.2
18	Copper Queen/Phelps Dodge Corp.	2,280,000	0.1
<b>Total</b>		<b>2,265,071,603</b>	<b>100.0</b>
<b>Molybdenum</b>			
1	Sierrita/Cyprus Copper Co.	15,532,000	44.3
2	Bagdad/Cyprus Copper Co.	11,679,000	33.3
3	San Manuel/Magma Copper Co.	4,023,734	11.5
4	Twin Buttes/Cyprus Copper Co.	1,428,000	4.1
5	Pinto Valley/Magma Copper Co.	1,388,000	4.0
6	Morenci/Phelps Dodge Corp.	1,000,000	2.9
<b>Total</b>		<b>35,050,734</b>	<b>100.0</b>

**Table 6. Average copper content of ore produced**

[Copper content reported as percent of total copper. Percentage in parenthesis is approximate and not used to calculate weighted average. Leaders (--), no production. (UG), underground. (OP), open pit. (do.) ditto]

Company/Mine	Ore type	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
<b>Arimetco International Inc.</b>											
Johnson (1)	Oxide	0.40	0.40	0.71	--	--	--	--	--	--	0.40
<b>Asarco Inc.</b>											
Mission (2)	Sulfide	(0.75)	(0.75)	(0.75)	0.65	0.70	0.67	0.73	0.70	0.72	0.72
Pima (2)	do.	0.48	--	--	--	--	--	--	--	--	--
Ray (3 (4	do.	0.80	1.19	1.13	0.99	0.99	0.89	1.00	0.97	0.88	0.84
do.	Oxide	--	--	--	1.17	1.23	1.15	1.11	1.13	1.05	0.95
San Xavier (2)	Sulfide	(0.65)	(0.51)	(0.51)	(5	(5	(5	(5	0.55	0.54	0.67
<b>Cyprus Copper Co.</b>											
Bagdad	do.	0.50	0.50	0.45	0.44	0.45	0.48	0.45	0.49	0.53	0.44
Esperanza (7	do.	0.29	--	--	--	--	--	--	--	--	--
Lakeshore	Oxide	1.00	(1.00)	(1.00)	--	--	--	--	--	--	--
Miami (6	Sulfide	0.58	0.53	0.55	0.60	0.54	--	--	--	--	--
do.	Oxide	--	--	0.50	0.49	0.57	0.59	0.52	0.49	0.44	0.48
Mineral Park (7	Sulfide	--	--	--	--	--	--	--	--	--	--
Sierrita (7	do.	0.30	(0.30)	0.34	0.33	0.34	0.33	0.30	0.31	0.31	0.28
do.	Oxide	--	--	--	--	--	--	--	--	--	0.15
Twin Buttes (8	Sulfide	0.78	0.57	--	--	--	--	3.39	1.90	0.99	0.99
	Oxide	1.06	0.93	0.86	0.84	--	--	1.22	1.13	0.99	0.90
<b>Magma Copper Co.</b>											
Pinto Valley	Sulfide	0.46	--	0.44	0.45	0.45	0.36	0.37	0.46	0.44	0.40
San Manuel UG	do.	0.66	0.64	0.64	0.61	0.62	0.62	0.63	0.64	0.65	0.69
San Manuel OP	do.	--	--	--	--	--	--	--	--	--	1.08
do.	Oxide	--	--	--	--	0.58	0.64	0.61	0.56	0.55	0.59
Superior	Sulfide	4.32	--	--	--	--	--	--	--	5.26	5.44
<b>Oracle Ridge Mining Partners</b>											
Oracle Ridge	do.	--	--	--	--	--	--	--	--	--	1.79
<b>Phelps Dodge Corp.</b>											
Morenci/Metcalf	do.	0.71	0.73	0.81	0.86	0.84	0.82	0.88	0.79	0.74	0.78
do.	Oxide	--	--	--	--	--	--	--	--	--	0.46
New Cornelia	Sulfide	0.64	0.60	0.55	--	--	--	--	--	--	--
<b>Weighted average (9</b>		<b>0.59</b>	<b>0.65</b>	<b>0.70</b>	<b>0.62</b>	<b>0.61</b>	<b>0.58</b>	<b>0.60</b>	<b>0.62</b>	<b>0.58</b>	<b>0.57</b>

(1 Arimetco acquired Johnson from Cyprus in August, 1989.

(2 Combined as Mission complex in 1985.

(3 Ray acquired from Kennecott, November 18, 1986.

(4 Grade reported for Ray is an average of oxide and sulfide together for 1982.

(5 Data for San Xavier included with Mission for 1985-1988.

(6 Acquired from Inspiration, July 1, 1988.

(7 Acquired from Duval, April 1, 1986.

(8 Includes Amax's share of Palo Verde deposit for 1979-1982. Acquired by Cyprus, March 1988.

(9 Weighted average grade of ore based generally on assay of total copper.

**Table 8. Stripping ratios of open pit mines**

[Waste:ore. Leachable rock included with waste at some mines. Leaders (--), no data]

Company/Mine	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
<b>Arimetco International Inc.</b>										
Johnson (1)	--	0.03:1	--	--	--	--	--	--	--	--
<b>Asarco Inc.</b>										
Eisenhower (2 (3	0.67:1	0.57:1	1.26:1	--	--	--	--	--	--	--
Mission (3	1.62:1	2.52:1	1.32:1	0.74:1	0.84:1	1.05:1	2.02:1	1.41:1	2.87:1	3.92:1
Pima (3	1.42:1	--	--	--	--	--	--	--	--	--
Ray (4	2.30:1	2.72:1	2.11:1	2.27:1	2.12:1	1.99:1	2.10:1	1.70:1	1.90:1	3.18:1
Sacaton	0.70:1	0.35:1	0.10:1	--	--	--	--	--	--	--
San Xavier (3	2.90:1	0.96:1	1.97:1	(5	(5	(5	(5	6.72:1	6.05:1	1.82:1
Silver Bell	--	1.09:1	1.17:1	--	--	--	--	--	--	--
<b>Cyprus Copper Co.</b>										
Bagdad	1.45:1	1.53:1	0.94:1	0.42:1	0.54:1	0.77:1	1.96:1	1.23:1	1.17:1	0.80:1
Miami (6	1.42:1	0.27:1	1.72:1	1.50:1	1.82:1	2.04:1	2.01:1	0.96:1	0.55:1	0.57:1
Mineral Park (7	--	--	--	--	--	--	--	--	--	--
Sierrita (7	0.55:1	0.33:1	0.76:1	0.55:1	0.19:1	0.40:1	0.67:1	0.77:1	0.79:1	0.91:1
Twin Buttes (8	2.05:1	1.14:1	--	--	--	--	34.60:1	8.37:1	4.38:1	2.15:1
<b>Magma Copper Co.</b>										
San Manuel	--	--	--	--	1.70:1	2.46:1	2.32:1	2.45:1	1.80:1	1.20:1
Pinto Valley	1.80:1	--	0.79:1	1.01:1	1.21:1	1.32:1	1.39:1	1.53:1	1.27:1	1.46:1
<b>Phelps Dodge Corp.</b>										
Morenci/Metcalf	0.79:1	0.64:1	0.90:1	0.68:1	0.76:1	1.10:1	1.13:1	1.22:1	1.81:1	1.78:1
New Cornelia	1.21:1	0.30:1	0.58:1	--	--	--	--	--	--	--
<b>Weighted average</b>	<b>1.31:1</b>	<b>0.57:1</b>	<b>1.10:1</b>	<b>0.88:1</b>	<b>0.96:1</b>	<b>1.21:1</b>	<b>1.49:1</b>	<b>1.46:1</b>	<b>1.57:1</b>	<b>1.49:1</b>

(1 Arimetco acquired Johnson from Cyprus in August, 1989.

(2 Mining was done by Asarco, includes ANAMAX's share of ore.

(3 Combined as Mission Complex in 1985.

(4 Ray Unit acquired from Kennecott, November 18, 1986.

(5 Data for San Xavier included with Mission.

(6 Acquired from Inspiration July 1, 1988.

(7 Sierrita, Esperanza, and Mineral Park acquired from Duval April 1, 1986.

(8 Acquired by Cyprus March, 1988.

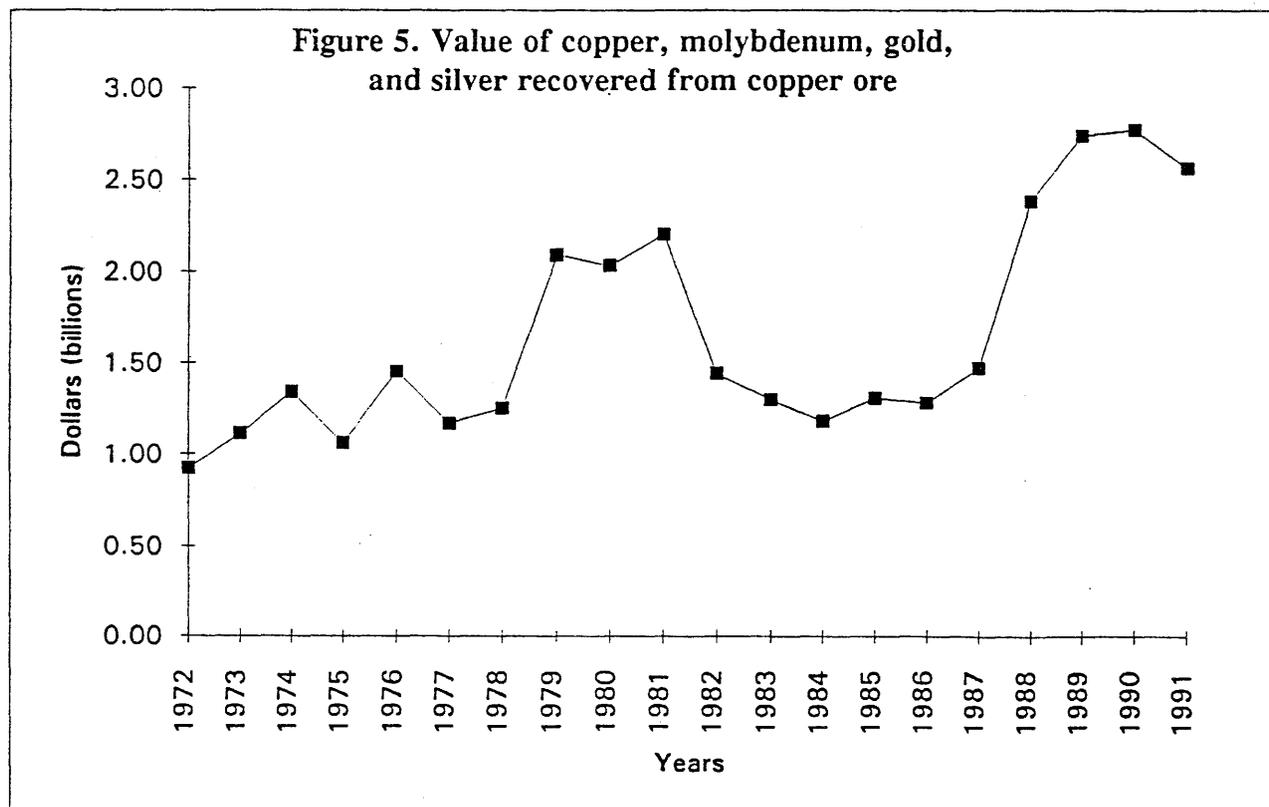
Source: "Minerals Yearbook - Area Reports: Domestic," U.S. Bureau of Mines; companies' annual reports; "E&MJ International Directory of Mining and Mineral Processing Operations;" Arizona Department of Mines and Mineral Resources; company submitted data beginning in 1985.

**Table 9. Production and value of copper, molybdenum, gold, and silver recovered from copper ore — continued**

Year	Copper ore (tons)	Copper (1) (lb./ton ore) (cents/lb.)	Copper (1) (pounds) Value (2) (\$)	Molybdenum (1,000 lbs.) Value (\$1000)	Gold (troy ounces) Value (3) (\$)	Silver (troy ounces) Value (4) (\$)	Value of copper, gold, silver, and molybdenum (\$)
1988	175,261,000	10.76	1,885,112,000	29,132	60,981	4,766,000	2,379,486,000
		119.00	2,243,283,000	78,074	26,972,000	31,157,000	
1989	196,684,000	10.22	2,009,782,000	29,795	44,959	5,312,000	2,738,918,000
		129.01	2,592,723,000	99,545	17,283,000	29,367,000	
1990	213,168,000	10.20	2,174,574,000	29,334	36,041	5,272,184	2,771,711,000
		121.80	2,648,631,000	82,429	13,842,000	26,809,000	
1991	258,646,597	8.76	2,265,071,603	35,051	51,248	4,651,017	2,564,406,000
		107.93	2,444,692,000	82,370	18,554,000	18,790,000	

- (1 Excludes precipitate copper from dump and in-place leaching prior to 1982.  
 (2 E&MJ average annual price, U.S. producer cathode for 1972-88. Metals Week annual average price, U.S. producer refiner for 1989 - 1991.  
 (3 Handy and Harmon average annual gold price.  
 (4 E&MJ average annual N.Y. market price for .999 fine silver for 1972-88. Metals Week's Handy and Harmon annual average quotation for 1989-1991.

Source: Table 1, this publication; "State Mineral Summaries," U.S. Bureau of Mines.



**Table 11. Copper mine capacity in 1991**

[Figures generally represent a current estimate of the production capacity of primary recoverable copper in concentrates, precipitates, and cathodes. Figures do not represent smelter or refinery capacity. Capacities for closed operations are historic and not necessarily immediately available]

Mine/Company	Annual capacity (tons copper)	Basis
Morenci/Phelps DodgeCorp.	342,000	Recent production figure
Ray/Asarco Inc.	182,000	Design capacity & ore grade
San Manuel/Magma Copper Co.	157,000	Recent production figure
Sierrita & Twin Buttes/Cyprus Copper Co.	138,000	Recent production figure
Mission/Asarco Inc.	120,000	Design capacity & ore grade
Bagdad/Cyprus Copper Co.	110,000	Recent production figure
Pinto Valley/Magma Copper Co.	88,000	Recent production figure
Miami/Cyprus Copper Co.	61,000	Recent production figure
New Cornelia/Phelps Dodge Corp.	40,000	Historic data
Superior/Magma Copper Co.	20,000	Company annual report and/or 10K
Mineral Park/Cyprus Copper Co.	17,000	Historic data
Miami & No. 2 tailings/Magma Copper Co.	10,000	Recent production figure
Christmas/Cyprus Copper Co.	8,000	Historic data
Oracle Ridge/Oracle Ridge Mining	6,000	Design capacity & ore grade
Johnson/Arimetco International Inc.	5,000	Design capacity & ore grade
Silver Bell/Asarco Inc.	4,000	Leaching only
Van Dyke/Arimetco International Inc.	3,000	Design capacity & ore grade
Casa Grande/Cyprus Copper Co.	3,000	Recent production figure
Copper Queen/Phelps Dodge Corp.	2,000	Leaching only
<b>Total</b>	<b>1,316,000</b>	

Source: Arizona Department of Mines & Mineral Resources' file data; companies' annual reports and form 10-Ks; professional publications.

**Table 13. United States copper production, by company**

[Copper content (tons) of mine production unless otherwise noted.

Leaders (--), no production. (na), not available]

Company	1987	1988	1989	1990	1991
Arimetco International Inc. (1)	--	--	--	2,254	4,858
Asarco Inc.	194,800	206,000	235,700	266,400	279,900
Cominco American Inc./Dresser Minerals (2)	1,925	1,671	1,489	1,586	1,385
Copper Range Co. (3)	53,053	45,802	52,061	51,104	59,498
Cyprus Copper Co.	173,537	233,242	293,451	312,102	313,498
The Doe Run Company	13,018	22,936	20,220	13,261	10,894
Hecla Mining Co. (4)	289	481	460	250	423
Apex Mine	--	--	--	45	na
Coeur Mine (5)	58	47	50	43	na
Galena Mine (6)	121	125	129	113	248
Lucky Friday Mine	110	309	281	49	175
Inspiration Consolidated Copper Co. (2)	35,582	(7)	(7)	(7)	(7)
Kennecott Corp. (8)	60,000	245,000	244,000	251,000	251,000
Magma Copper Co. (9)	197,013	200,753	214,388	232,458	262,000
Montana Resources	30,856	53,155	39,634	37,245	47,421
Noranda Lakeshore Mines, Inc. (10)	1,152	--	--	--	--
Oracle Ridge Mining (11)	--	--	--	--	2,241
Phelps Dodge Corp.(U.S. mines) (10)	468,900	494,500	500,500	548,400	518,100
Tennessee Chemical Co.	4,560	--	--	--	--
Refiners (12)					
Asarco Inc.	447,700	484,700	492,800	482,400	492,800

(1) Data from Arimetco International Inc. 1991 annual report.

(2) Refined production.

(3) Magmont mine.

(4) Includes Hecla's share of production from each mining property.

(5) Operated by Asarco. Shows Hecla's share of 5%.

(6) Operated by Asarco. Shows Hecla's share of 25%.

(7) Starting in 1988, Cyprus Miami Mining.

(8) Reported production of refined copper plus unrefined copper sales. Includes only Kennecott's share from jointly owned properties.

(9) Refined copper contained in concentrates produced and SX-EW production. 1991 data from company form 10-K.

(10) Includes copper produced from purchased ores.

(11) Data reported by company to Arizona Department of Mines and Mineral Resources.

(12) The total for this concern is to a large extent a duplication of the reports of other producers.

Source: "Non-ferrous Metal Data 1991," American Bureau of Metal Statistics Inc., Arizona Department of Mines and Mineral Resources file data.

Table 14. Copper imports of the United States, by country — continued

[Copper content in short tons. Leaders (--), no data]

	1987	1988	1989	1990	1991
Yugoslavia	4,629	2,199	--	--	--
China	165	845	71	153	--
Hong Kong	--	711	--	--	--
Japan	661	--	3	--	4,957
Syria	--	--	--	20	--
Taiwan	300	--	--	--	--
Niger	--	--	912	--	--
South Africa	5,046	1,985	1,193	830	165
Zaire	26,446	35,143	12,607	3,469	--
Zambia	21,834	--	--	689	--
Other Countries	154	62	15	--	2
<b>Copper Waste &amp; Scrap</b>	<b>36,510</b>	<b>40,952</b>	<b>34,808</b>	<b>39,579</b>	<b>31,685</b>
Canada	28,302	28,860	21,350	25,723	21,591
Bahamas	23	37	17	22	--
Barbados	67	72	56	80	43
Costa Rica	214	224	594	582	896
Dominican Republic	592	648	515	450	377
El Salvador	167	--	--	106	303
Guatemala	94	205	267	491	242
Haiti	--	--	49	41	62
Honduras	41	53	38	57	203
Jamaica	62	194	207	363	621
Mexico	5,890	8,036	3,933	4,013	3,590
Netherlands Antilles	94	139	31	109	36
Panama	431	977	703	655	433
St. Vincent	--	--	14	33	--
Trinidad	93	209	336	151	187
Brazil	--	--	--	194	--
Chile	--	79	5,296	4,024	1,111
Surinam	--	48	--	15	--
Venezuela	--	628	648	1,661	1,177
Finland	--	--	--	--	64
France	24	119	--	11	--
Germany	--	111	325	--	--
Netherlands	--	--	304	466	85
United Kingdom	24	42	1	58	112
Japan	--	--	--	79	--
South Korea	124	48	7	28	--
Malaysia	30	--	--	61	22
Singapore	79	--	--	--	--
Taiwan	25	27	--	--	--
Ghana	--	--	--	23	--
Other Countries	134	196	117	159	530
<b>Copper Alloy Waste &amp; Scrap (1</b>	<b>48,703</b>	<b>55,146</b>	<b>87,435</b>	<b>108,809</b>	<b>107,100</b>
Canada	32,661	31,120	42,720	69,333	60,439
Bahamas	37	--	67	--	--
Barbados	41	--	35	--	--
Costa Rica	40	--	146	168	119
Dominican Republic	464	962	1,177	1,174	1,515
Guatemala	82	137	346	290	319

**Table 14. Copper imports of the United States, by country — continued**  
 [Copper content in short tons. Leaders (--), no data]

	1987	1988	1989	1990	1991
<b>Wire</b>					
Copper Alloy	23,833	25,028	22,143	22,353	18,661
<b>Rod, Bar, &amp; Other</b>					
Copper	31,391	31,474	29,617	31,155	25,580
Copper Alloy	64,579	74,634	75,622	61,137	44,345
<b>Tube &amp; Pipe</b>					
Copper	100,021	91,924	72,896	46,565	28,822
Copper Alloy	57,224	59,493	66,882	57,430	51,209

(1 Copper alloy content.

(2 Thousands of pounds.

Source: "Non-ferrous Metal Data 1991," American Bureau of Metal Statistics, Inc.

**Table 15. Copper exports of the United States, by country — continued**

[Copper content in short tons. Leaders (--), no data. (na), not available at time of publication]

	1987	1988	1989	1990	1991
El Salvador	--	--	108	129	265
Honduras	--	--	291	75	5
Mexico	4,674	9,409	8,097	6,214	7,939
Brazil	501	56	19	80	--
Chile	--	--	70	--	--
Venezuela	134	--	1,429	5,216	2,359
Belgium	391	234	21	2,442	337
France	535	1,660	760	1,567	1,316
Germany	514	1,456	1,430	1,068	2,043
Italy	218	4,984	652	748	1,306
Netherlands	276	9,583	731	3,714	3,416
Switzerland	49	137	249	115	81
United Kingdom	1,185	2,729	1,197	1,090	1,937
China	--	3,905	15,727	3,911	15,278
Hong Kong	458	592	644	1,580	2,923
Indonesia	--	--	--	2,088	773
Japan	3,036	14,877	53,374	113,720	143,635
Korea, South	2,063	6,755	1,374	8,668	13,326
Malaysia	--	512	--	2	880
Philippines	--	106	2	21	--
Singapore	2	1,410	1,328	1,580	4,070
Taiwan	1,178	1,776	53,729	72,930	87,425
Thailand	--	--	--	2,376	5,541
Egypt	--	--	--	168	--
Other Countries	101	155	130	268	310
<b>Copper Waste &amp; Scrap</b>	<b>119,776</b>	<b>132,025</b>	<b>170,789</b>	<b>153,907</b>	<b>144,749</b>
Canada	12,273	32,159	41,956	55,651	36,363
Jamaica					44
Mexico	13,533	12,672	8,639	9,789	8,264
Brazil	3,326	655	892	846	400
Chile	--	--	140	--	--
Venezuela	217	337	20	39	--
Belgium	2,154	3,100	3,991	403	103
Finland	97	--	--	--	--
France	--	--	59	436	--
Germany	4,774	10,748	14,570	6,294	572
Italy	6,769	920	280	1,080	22
Netherlands	406	1,019	3,779	793	174
Norway	--	118	245	289	107
Spain	8,877	3,725	958	168	22
Switzerland	--	17	122	--	--
United Kingdom	822	2,547	1,354	969	91
China	210	470	6,666	8,592	25,213
Hong Kong	3,656	1,579	1,242	1,003	6,045
India	545	2,222	1,203	434	652
Indonesia	--	--	456	39	313
Japan	17,141	17,780	22,411	19,622	26,149
Korea, South	10,650	21,540	35,936	35,584	32,506
Malaysia	--	--	--	--	96
Pakistan	--	--	--	--	96
Philippines	1,045	--	133	44	25

**Table 15. Copper exports of the United States, by country — continued**  
 [Copper content in short tons. Leaders (--), no data. (na), not available at time of publication]

	1987	1988	1989	1990	1991
<b>Wire</b>					
Copper Alloy	14,556	16,725	8,592	14,454	19,283
<b>Rod, Bar &amp; Other</b>					
Copper	8,204	5,183	34,603	27,846	24,130
Copper Alloy	16,703	24,480	50,430	54,171	44,416
<b>Tube &amp; Pipe</b>					
Copper Alloy	14,218	17,078	44,702	35,270	43,053
Copper Alloy	12,917	20,618	9,436	11,163	12,431
<b>Copper Exports Of Copper Imports Of The United States (4</b>					
Blister & Anodes	--	10	--	2	--
Refined Cathodes & Shapes	11	2,261	13,291	1,714	692
Copper Waste & Scrap	218	523	286	431	336
Copper Alloy Waste & Scrap (1	8,772	609	2,184	1,054	806

(1) Copper alloy content.

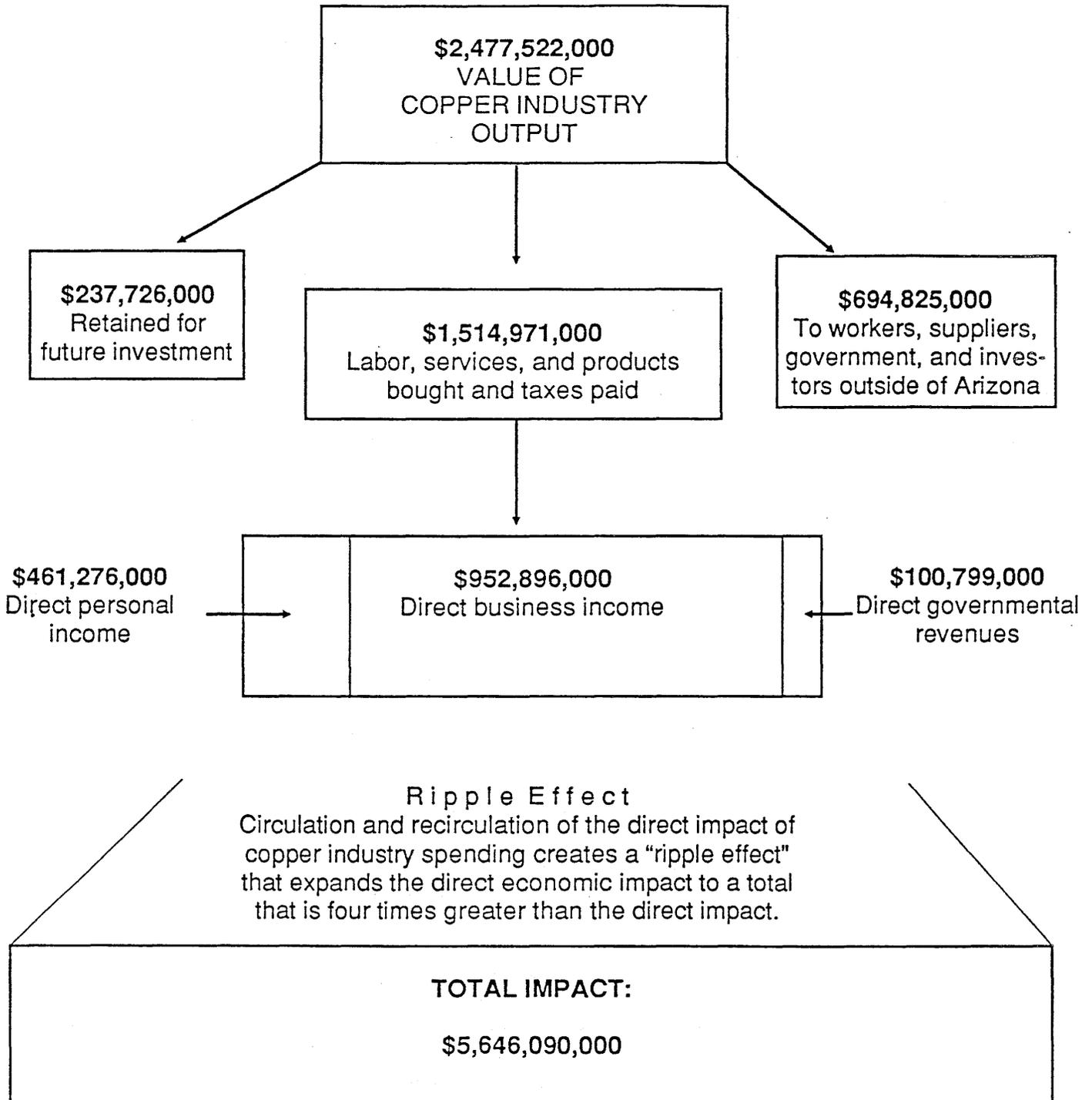
(2) Thousands of pounds.

(3) 1988 data combines copper and copper alloys as well as not backed and backed.  
 1989 separates copper alloys and includes only not backed.

(4) Copper content.

Source: "Non-ferrous Metal Data 1991," American Bureau of Metal Statistics Inc.

**Figure 6. Direct and indirect impact of the copper industry on the Arizona economy - 1991**



Source: Leaming, G.F., 1992, "The copper industry's impact on the Arizona economy"

**Table 18. Employment, earnings, and hours in copper mining  
in the United States and Arizona**

[These statistics do not reflect workers in copper smelting, refining, and rod fabrication]

Year	All employees		Production workers							
	Average number (thousands)		Average number (thousands)		Weekly earnings (4 (average)		Weekly hours (average)		Hourly earnings (5 (average)	
	AZ (1	U.S. (2	AZ (3	U.S. (2	AZ	U.S.	AZ	U.S.	AZ	U.S.
1970	18.8	37.0	14.9	29.5	173.01	175.67	43.8	44.7	3.95	3.93
1971	18.9	34.7	14.9	26.8	178.50	178.46	42.4	42.9	4.21	4.16
1972	20.5	38.9	16.1	30.7	194.69	192.19	41.6	41.6	4.68	4.62
1973	21.5	42.3	17.6	33.7	206.75	206.42	41.6	42.3	4.97	4.88
1974	24.0	42.8	19.1	33.8	222.16	226.46	39.6	41.1	5.61	5.51
1975	22.5	37.1	17.9	28.4	247.43	247.14	38.6	39.2	6.41	6.33
1976	21.7	35.5	17.2	27.0	286.31	280.70	40.1	40.1	7.14	7.00
1977	19.3	35.1	15.3	26.9	302.99	288.73	39.4	38.6	7.69	7.48
1978	17.2	35.2	13.7	26.9	344.76	338.40	40.8	40.0	8.45	8.46
1979	19.3	31.9	15.3	24.6	404.81	405.03	42.3	42.5	9.57	9.53
1980	17.7	29.4	14.0	22.6	446.19	435.01	41.7	41.0	10.70	10.61
1981	21.9	36.2	17.4	27.9	497.28	492.54	41.2	41.6	12.07	11.84
1982	15.2	25.3	12.1	18.5	495.60	484.91	38.3	38.7	12.94	12.53
1983	11.3	18.9	9.0	13.5	519.25	522.69	39.1	39.9	13.28	13.10
1984	10.5	16.3	8.2	11.4	553.83	562.74	41.3	41.5	13.41	13.56
1985	9.4	13.1	7.5	9.4	573.80	574.76	41.4	42.2	13.86	13.62
1986	8.7	11.4	6.9	8.8	582.38	507.99	40.4	41.3	14.42	12.30
1987	8.6	13.5	6.9	10.7	556.65	492.20	40.1	43.1	13.88	11.42
1988	8.8	14.4	7.0	11.2	517.74	510.12	41.3	43.9	12.53	11.62
1989	9.5	14.1	7.5	11.2	561.26	540.44	43.4	45.8	12.94	11.80
1990	10.0	15.1	7.9	12.3	599.84	569.09	43.7	45.6	13.72	12.48
1991	11.1	15.8	8.6	13.0	648.68	610.55	43.8	45.7	14.81	13.36

(1) These figures are estimates made by the Arizona Department of Economic Security in cooperation with the U.S. Bureau of Labor Statistics, and they include all full-time and part-time wage and salary workers who are employed in copper mining in any part of the pay period that included the 12th of each month of the year.

(2) Estimates made by the U.S. Bureau of Labor Statistics in cooperation with the 50 states, and based upon monthly samplings similar to those in (1) above, adjusted periodically to census benchmark.

(3) Estimates of production (non-supervisory) workers based upon samplings as in (2) above. Since 1975 figures have been calculated by the Arizona Department of Mines and Mineral Resources dividing the annual number of "All Employees in Arizona" by a factor of 1.26. This factor was derived by comparing the annual number of "All Employees-Arizona" with "Production Workers - Arizona" from 1970 to 1974.

(4) Weekly earnings figures are the product of hourly earnings and weekly hours for that year.

(5) Gross payroll aggregates, exclusive of irregular bonuses and other pay not earned in a sample pay period, are divided by gross man-hour aggregates of production and related workers for the period in order to determine hourly earnings.

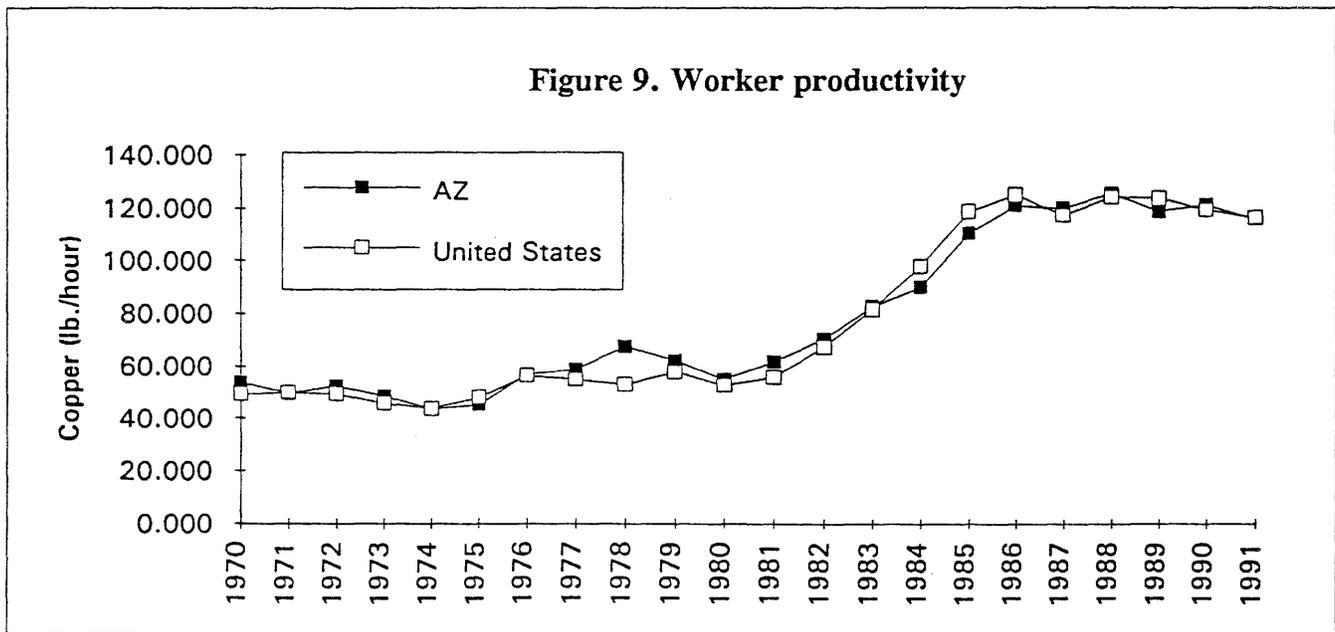
(6) Weekly earnings times 52 weeks.

(7) Product of the number of production workers, weekly hours, and 52 weeks.

Source: Table 1 this publication, American Bureau of Metal Statistics Unit, Arizona Department of Economic Security, Mineral Yearbook - Metals, Minerals," U.S. Bureau of Mines. "Employment and Earnings", U.S. Dept. of Labor, Bureau of Labor Statistics, March issues, U.S. Dept. of Interior.

Table 18. Employment, earnings, and hours in copper mining  
in the United States and Arizona — continued

Year	Worker productivity			
	Ore mined/hour (tons)		Copper produced/hour (pounds)	
	AZ	U.S.	AZ	U.S.
1970	4.427	3.759	53.829	49.132
1971	4.544	4.059	49.725	49.996
1972	4.761	4.017	52.161	49.151
1973	4.872	3.912	48.530	45.683
1974	4.547	4.062	43.496	43.539
1975	4.694	4.543	45.076	47.885
1976	5.410	5.040	56.968	56.250
1977	5.379	4.815	58.824	54.905
1978	6.131	4.713	67.607	52.817
1979	6.061	5.369	61.971	57.759
1980	5.588	5.004	54.994	52.465
1981	5.815	5.072	61.549	55.582
1982	6.064	5.388	70.442	67.342
1983	8.356	7.005	82.766	81.707
1984	8.250	7.703	89.921	97.795
1985	10.790	11.606	110.141	118.470
1986	11.576	9.847	120.897	124.934
1987	11.545	9.155	119.827	117.189
1988	11.658	9.637	125.398	123.918
1989	11.620	9.805	118.739	123.828
1990	11.874	9.430	121.133	119.245
1991	13.205	9.880	115.642	116.400

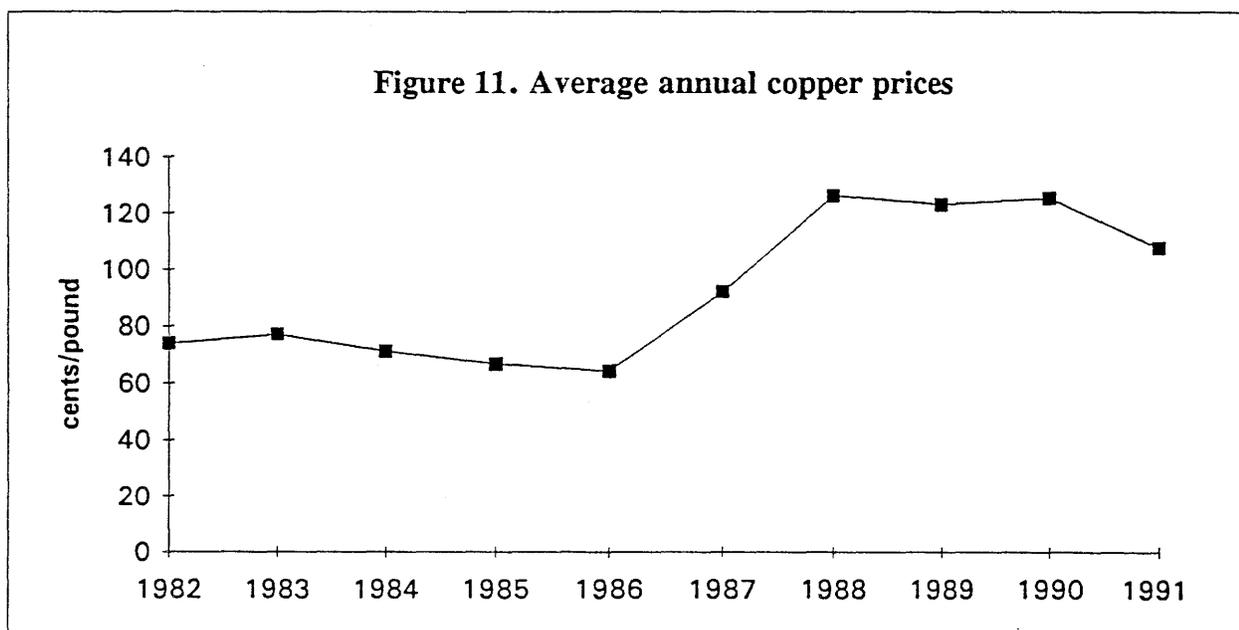


**Table 20. Average monthly price of cathode copper**

[All prices are Metals Week U.S. producer delivered cents/lb.]

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
January	78.634	80.219	68.792	64.487	69.881	64.986	132.496	152.770	108.644	114.614
February	78.779	84.024	70.748	66.446	68.253	65.525	105.025	140.211	111.260	115.012
March	75.862	82.072	75.311	65.547	70.144	68.071	109.720	148.492	128.414	113.953
April	76.273	83.493	77.388	70.318	68.801	67.129	103.641	143.486	126.936	113.127
May	77.948	85.634	72.229	69.864	67.082	70.985	104.373	127.146	124.574	105.574
June	71.488	81.836	69.849	67.094	67.471	74.346	114.275	115.901	117.346	103.877
July	71.053	82.947	64.402	66.773	63.815	80.419	104.848	113.487	126.115	104.344
August	70.999	80.542	64.535	66.284	62.374	82.183	101.451	127.430	134.960	105.969
September	71.065	77.587	63.408	65.716	64.844	85.607	116.120	138.439	134.215	111.109
October	72.413	73.392	62.039	66.680	63.464	88.253	138.048	131.659	130.182	111.336
November	72.968	69.581	65.650	66.294	62.855	108.528	152.320	118.109	119.762	110.034
December	74.230	70.805	63.538	68.025	63.630	133.339	161.270	109.216	115.611	102.972
Annual average.	74.309	79.344	68.157	66.961	66.051	82.448	120.299	130.529	123.168	109.327

Source: Metals Week.



**Table 22. Copper reserve base in 1991**

[Reserve base is that part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth. The reserve base is the in-place demonstrated (measured plus indicated) resource from which reserves are estimated. It may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. The reserve base includes those resources that are currently economic (reserves), marginally economic (marginal reserves), and some of those that are currently subeconomic (subeconomic resources). Definition from "Mineral Facts and Problems" 1985 edition, U.S. Bureau of Mines, Bulletin 675, page 3]

Deposit Location	Company	Mineral type	Million tons	% Cu	Source/comments
Antler T17N R16W S. 4	Standard Metals Corp.	Sulfide	5.0	1.95	Annual report & form 10-K, 1987. With 4.13% Zn, 0.94% Pb, and 1.05 Ag oz/ton. An additional 2.5 million tons reported in 1979 annual report.
Atlas T11S R8E S. 32	Asarco Inc.	Sulfide	5.0	0.64	"Report on the BS&K Project" by Buchella, F.
		Acid Soluble	5.0	0.4	Sulfide cutoff 0.40%. Acid Soluble cutoff 0.20%.
		Sulfide	19.0	0.7	Asarco property adjacent to Atlas.
		Acid Soluble	12.0	0.4	Asarco property adjacent to Atlas.
Bagdad T14N R9W S. 4	Cyprus Copper Co.	Sulfide	741.4	0.40	Cyprus Minerals form 10K, 1991. With 0.022% Mo. Sulfide includes acid soluble.
Buckeye East T3S R12E S. 26	Asarco Inc.	Acid Soluble	20.0	0.65	"Arizona Wilderness 1988", Arizona Mining Association, Report A-23. 40 million possible.
Carlota T1N R13E S. 36	Cambior USA Inc.	Acid Soluble	92.0	0.44	Reported by Cambior. Includes Cactus and Eder deposits.
Casa Grande T6S R5E S. 18	Asarco & Freeport McMoran JV.	Mixed	352.0	1.00	Getty Oil Co. annual report, 1980. With 0.01% Mo. Cutoff at 0.5% Cu.
Casa Grande (Lakeshore) T10S R4E S. 25	Cyprus Copper Co.	Sulfide	41.0	0.71	Porphyry - Noranda annual report, 1984.
		Sulfide	9.0	1.35	Tactite - Noranda annual report, 1984.
		Acid Soluble	15.5	0.76	Cyprus Minerals form 10-K, 1991.
Chilito T4S R15E S. 22	Asarco Inc.	Mixed	75.0	0.51	Chilito Mines Report. With 0.01% Mo, and 0.04 oz/ton Ag.
Christmas T4S R16E S. 30	Cyprus Copper Co.	Sulfide	7.0	0.63	Inspiration Resources form 10-K, 1983. Open pit.
		Sulfide	20.0	1.82	Underground.
Cochise T23S R24E S. 9	Phelps Dodge Corp.	Acid Soluble	210.0	0.40	Phelps Dodge form 10K 1991.
Copper Basin T13N R3W S. 20	Phelps Dodge Corp.	Sulfide	70.0	0.5	Phelps Dodge form 10K 1991. With 0.021% Mo.
Copper Butte T3S R13E S. 30	Asarco Inc.	Acid Soluble	22.0	1.1	"Arizona Wilderness 1988", Arizona Mining Association, Report A-23.
Copper Creek T8S R18E S. 11	Magma Copper Co.	Sulfide	80.0	0.55	Unpublished estimate.

Table 22. Copper reserve base in 1991 — continued

Deposit Location	Company	Mineral type	Million tons	% Cu	Source/comments
Mame T19S R25E S. 20	Hope Mining & Milling Co.	Acid Soluble	1.0	1.10	Unpublished estimate.
Miami T1N R14E S. 25	Cyprus Copper Co.	Acid Soluble	213.0	0.45	Cyprus Minerals form 10K, 1991. Acquired from Inspiration July, 1988.
Miami East T1N R15E S. 19	Magma Copper Co.	Sulfide Sulfide	6.0 50.0	3.14 1.95	Newmont Mining annual report, 1985. USBM Minerals Yearbook 1973, Area Reports.
Miami Tailings T1N R15E S. 30	Magma Copper Co.	Acid Soluble	29.0	0.3	Magma form 10-K, 1991. 54% recovery expected.
Mineral Butte T4S R7E S. 1	U.S. Government	Mixed	15.0	0.4	Withdrawn from mineral entry.
Mineral Park T23N R17W S. 19	Cyprus Copper Co.	Acid Soluble	11.0	0.27	Cyprus Minerals form 10-k, 1991.
Mission T16S R12E S. 31	Asarco Inc.	Sulfide	584.0	0.67	Asarco annual report, 1991. With 0.16 oz/ton Ag.
Morenci T4S R29E S. 16	Phelps Dodge (85%) and Sumitomo (15%)	Sulfide Acid Soluble Sulfide Mixed	665.0 922.4 150.0 180.0	0.79 0.3 0.72 0.71	Phelps Dodge form 10K, 1991. Milling reserves. Leaching reserves. Western Copper. Coronado deposit.
New Cornelia T12S R6W S. 27	Phelps Dodge Corp.	Sulfide	160.0	0.56	Phelps Dodge form 10-K, 1991.
Oracle Ridge T11S R16E S. 16	Oracle Ridge Mining Partners	Mixed	4.0	2.23	E&MJ June 1989. With 0.67 oz/ton Ag. Additional 4.4 million tons possible.
Peach Elgin T18S R15E S. 15	Asarco Inc.	Sulfide Acid Soluble	14.0 10.0	0.8 0.8	West, Barbara J. report, January 1980.
Pinto Valley T1N R14E S. 2	Magma Copper Co.	Sulfide Sulfide Sulfide Sulfide	177.0 495.0 146.0 49.0	0.37 0.14 0.42 0.20	Magma form 10-K, 1991. Milling reserve. Dump leach reserve. Milling resource. Dump leach resource.
Poston Butte T4S R9E S. 33	Magma Copper Co.	Sulfide Acid Soluble	500.0 300.0	0.39 0.4	Magma "Copper Sense", August, 1992.
Ray T3S R13E S. 10	Asarco Inc.	Sulfide	1100.0	0.63	Asarco 1992 2nd quarter investor meeting.
Red Mountain T22S R16E S. 20	Kerr McGee Corp.	Sulfide	100.0	0.71	Tucson Daily Citizen, Sept. 23, 1970.
Sacaton East T5S R5E S. 26	Asarco Inc.	Sulfide	15.0	1.3	Asarco form 10K, 1979. Underground.

Table 22. Copper reserve base in 1991 — continued

Deposit Location	Company	Mineral type	Million tons	% Cu	Source/comments
Van Dyke T1N R15E S. 30	Arimetco International Inc.	Acid Soluble	100.0	0.53	Arimetco annual report, 1990.
Vekol hills T10S R3E S. 4	Tohono O'odham Tribe	Sulfide	105.0	0.56	Vekol Hills Project EIS, U.S. Interior Dept. 1988. With 0.014% Mo, 16 million tons acid soluble.
Ventura T23S R15E S. 1	Cyprus Copper Co.	Sulfide	6.0	0.26	Iso Mines Ltd. annual report, 1965. With 0.28% MoS <sub>2</sub> , 6 million additional tons possible.
White Mesa T38N R9E S. 29	Navajo Tribe & private party.	Acid Soluble	2.0	0.75	Mayo, E.B., 1955 report. Additional tonnage likely.
Zonia T11N R4W S. 12	Arimetco International Inc.	Acid Soluble	35.0	0.31	Lundin, Richard J. et.al. Feb. 1985 report.
<b>Total copper reserve base in Arizona</b>					
		Sulfide	7,146.7	0.56	contains 39.863 million tons of copper
		Acid Soluble	3,369.9	0.40	contains 13.463 million tons of copper
		Mixed	2,658.0	0.52	contains 13.709 million tons of copper
<b>Total</b>			<b>13,174.6</b>	<b>0.51</b>	<b>contains 67.035 million tons of copper</b>

Company index to copper reserve base

Company	Deposit	Company	Deposit
Arimetco International	Emerald Isle	Keystone Minerals	Korn Kob
Arimetco International	Johnson	Lodestar Minerals	Gibson
Arimetco International	Van Dyke	Magma Copper	Copper Creek
Arimetco International	Zonia	Magma Copper	Kalamazoo
Asarco & Freeport	Casa Grande	Magma Copper	Miami East
Asarco & Freeport	Santa Cruz	Magma Copper	Miami Tailings
Asarco Inc.	Atlas	Magma Copper	Pinto Valley
Asarco Inc.	Buckeye East	Magma Copper	Poston Butte
Asarco Inc.	Chilito	Magma Copper	San Manuel OP
Asarco Inc.	Copper Butte	Magma Copper	San Manuel UG
Asarco Inc.	Helvetia	Magma Copper	Superior
Asarco Inc.	Mission	Navajo Tribe	White Mesa
Asarco Inc.	Peach Elgin	Oracle Ridge	Oracle Ridge
Asarco Inc.	Ray	Orcana Resources	Sheep Mtn.
Asarco Inc.	Sacaton East	Phelps Dodge	Copper Basin
Asarco Inc.	Silver Bell	Phelps Dodge	Copper Queen
AZCO Mining Inc.	Sanchez	Phelps Dodge	Dos Pobres
AZCO Mining Inc.	Strong & Harris	Phelps Dodge	Lone Star
Cambior USA Inc.	Carlota	Phelps Dodge	New Cornelia
Corn, Russ	Lonesome Pine	Phelps Dodge	San Juan
Cyprus Copper	Bagdad	Phelps Dodge	United Verde
Cyprus Copper	Casa Grande	Phelps Dodge	Cochise
Cyprus Copper	Christmas	Phelps Dodge	Morenci
Cyprus Copper	Esperanza	Rayrock Mines	Kay Copper
Cyprus Copper	Miami	Santa Fe Pacific	Turquoise
Cyprus Copper	Mineral Park	Smith, Addison	Dynamite
Cyprus Copper	Sierrita	Squaw Peak	Squaw Peak
Cyprus Copper	Twin Buttes	Standard Metals	Antler
Cyprus Copper	Ventura	Sullivan, James	Dragoon
Duerr & Prochnav	Four Metals	Sullivan, James	I-10
Dugan Production	Two Peaks	Tohono O'odham	Vekol hills
Heinrichs GEO	Stray Elephant	U.S. Government	Mineral Butte
Hope Mining	Mame	Unknown	Iron Door
Kerr McGee Corp.	Red Mountain		

## **THE ARIZONA DEPARTMENT OF MINES AND MINERAL RESOURCES**

The objective of the Department is to promote the development of Arizona's mineral resources. This is accomplished through technical research, field investigations, compilation of information into a mineral occurrence data base and disseminating information through publications, personal contacts and seminars.

The Department's mining engineers and geologists assist mining and exploration companies, prospectors and others interested in Arizona's minerals with mineral processing, mineral land acquisition, exploration, mine development, financing, government regulations and marketing.

The Department is a service agency and does not regulate, tax, or require any type of registration. The agency provides assistance that is tailored to meet the differing needs of the public. The following is a partial list of services which the Department offers:

- Maintain a site specific data base of unpublished reports and maps which includes 5,000 mine files and indexes of 10,000 computerized Arizona
- Maintain an information bank and library of mineral and mining information including a mine map library (hard copy and microfilm), government publications, periodicals, and unpublished master and doctorate theses.
- Gather and disseminate information on commodities and markets.
- Suggest target areas for possible exploration activity.
- Suggest prospects and individual properties for study and acquisition.
- Assist individuals and companies in their dealings with State regulatory agencies to facilitate their mining and exploration activity.
- Produce publications in the form of mineral reports, annual directories, technical reports, annual mineral industry surveys and information circulars. These include Laws and Regulations Governing Mineral Rights in Arizona, Directory of Active Mines in Arizona, Manual for Determination of Status and Ownership of Arizona Mineral and Water Rights, and others. A current listing of the Department publications is available upon request.