



CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
520-770-3500
<http://www.azgs.az.gov>
inquiries@azgs.az.gov

The following file is part of the
James Doyle Sell Mining Collection

ACCESS STATEMENT

These digitized collections are accessible for purposes of education and research. We have indicated what we know about copyright and rights of privacy, publicity, or trademark. Due to the nature of archival collections, we are not always able to identify this information. We are eager to hear from any rights owners, so that we may obtain accurate information. Upon request, we will remove material from public view while we address a rights issue.

CONSTRAINTS STATEMENT

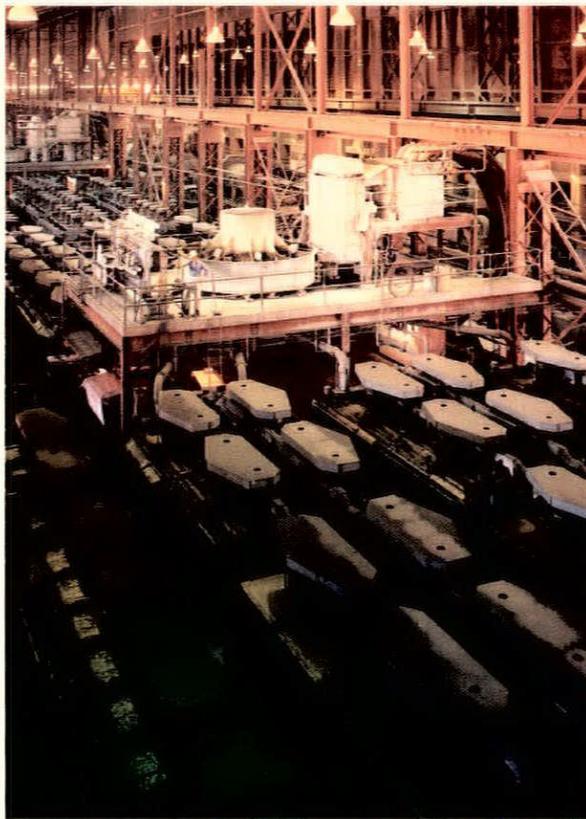
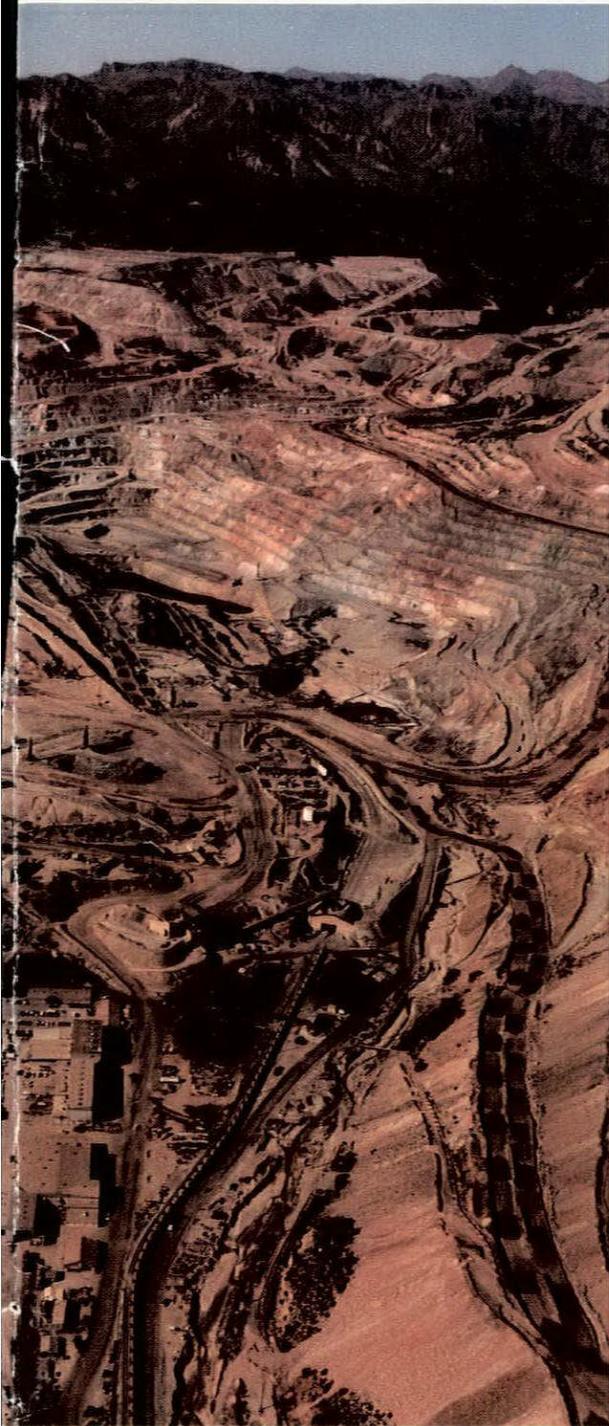
The Arizona Geological Survey does not claim to control all rights for all materials in its collection. These rights include, but are not limited to: copyright, privacy rights, and cultural protection rights. The User hereby assumes all responsibility for obtaining any rights to use the material in excess of "fair use."

The Survey makes no intellectual property claims to the products created by individual authors in the manuscript collections, except when the author deeded those rights to the Survey or when those authors were employed by the State of Arizona and created intellectual products as a function of their official duties. The Survey does maintain property rights to the physical and digital representations of the works.

QUALITY STATEMENT

The Arizona Geological Survey is not responsible for the accuracy of the records, information, or opinions that may be contained in the files. The Survey collects, catalogs, and archives data on mineral properties regardless of its views of the veracity or accuracy of those data.

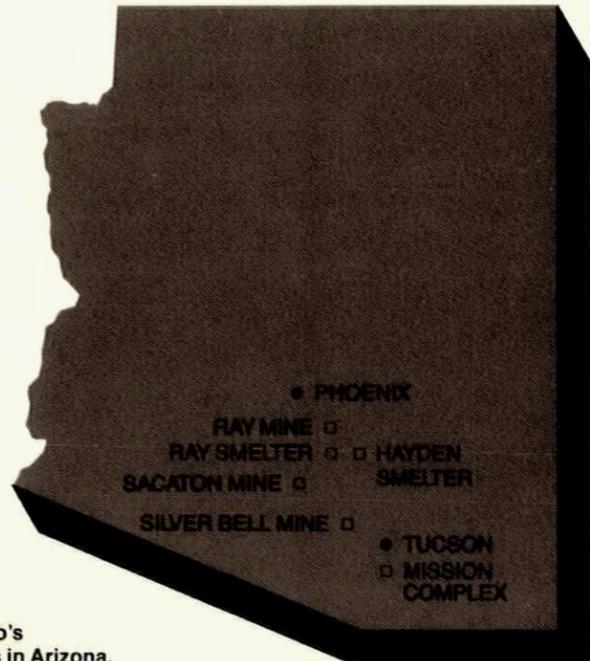
Asarco
in
Arizona



ASARCO



Excavation and construction of the Hayden smelter was started in September of 1911 and completed in spring of 1912.



Location of Asarco's copper operations in Arizona.

ASARCO Incorporated has contributed to Arizona's growth and prosperity since 1911 when it began construction of a copper smelter at Hayden to process ores from the nearby Ray mine operated by another company. In 1912, the year Arizona became the forty-eighth state, Asarco's Hayden Plant poured its first copper. Since then the plant has been enlarged and modernized several times, most recently in 1983.

Asarco entered copper mining in Arizona in 1915 through the acquisition of properties in the Silver Bell district. After operating intermittently as an underground mine, Silver Bell commenced production as an open-pit copper mine in 1954. The rapid advances in open-pit technology after World War II made the mining of lower grade ore economical and were largely responsible for the great expansion of copper mining at Silver Bell and elsewhere in Arizona. Today, Arizona produces two-thirds of the copper mined in the United States.

In 1953, Asarco's geologists discovered copper by drilling through valley gravels southwest of

Tucson, and by 1961 Asarco had constructed a major new open-pit mine and mill at the site. The new operation was named the Mission mine after the historic Mission San Xavier del Bac, the famous "white dove of the desert," located not far away. Also, Asarco developed the San Xavier mine adjacent to the Mission mine, beginning production at the San Xavier North pit in 1967 and at the San Xavier South pit in 1972.

Separating the Mission and San Xavier mines is the Palo Verde copper deposit. Eisenhower Mining Company, in which Asarco held a 50 percent interest, began stripping overburden from this deposit in 1976 and started production in 1979. As mining progressed, the Mission and San Xavier South pits were joined, and together with the Eisenhower mine formed one large open pit. Occupying the opposite end of this pit is the Pima mine which was developed by another mining company. Asarco acquired the Pima mine in 1985 and the contiguous, undeveloped Mineral Hill deposit in 1987. Also in 1987, Asarco acquired its partner's 50 percent interest in the Eisenhower mine, thus consolidating all mineral

interests in the Mission copper mining complex under Asarco's control. These additional copper and water reserves enabled Asarco to expand annual capacity at the Mission Complex by 46%, or 27,000 tons of contained copper, in 1988.

In 1986, Asarco more than doubled its copper-mining capacity in Arizona by purchasing the Ray mine from Kennecott Corporation. The purchase also included the Ray copper smelter which suspended operations in 1982. Although Asarco's Hayden smelter had originally been built to process Ray mine concentrates, it ceased to do so after the Ray smelter started up in 1958. Since 1983, Ray mine concentrates have again been processed at Asarco's Hayden copper smelter.

In 1974 Asarco started up the Sacaton open-pit copper mine near Casa Grande and operated it until 1984 when ore reserves near the surface were exhausted. There is also an underground copper deposit at Sacaton which may become economical to mine in the future.

Asarco's operations provide hundreds of jobs for Arizonans and pay millions of dollars in taxes to state and local governments. Asarco also pays royalties on minerals mined from state leases which benefit primarily Arizona's educational system. Asarco's purchases of materials and supplies required to keep its operations going are made locally, as far as possible. Asarco employees, in turn, buy goods, pay taxes, and create additional jobs. During 75 years of involvement in the copper industry in the state, through periods of both boom and bust, Asarco has developed a strong commitment to copper and to Arizona.

Asarco's Arizona Properties

	PRODUCTS	CAPACITY (tons/year)	RESERVES (tons)
MINES			
Mission Complex	Copper Concentrates	87,000*	367,000,000 (0.64% copper)
Ray	Copper Concentrates	75,000*	677,000,000 (0.70% copper)
Silver Bell	Copper Cathodes	40,000	21,000,000 (0.68% copper)
	Copper Concentrates**	15,000*	
	Copper Precipitates	5,000	
SMELTERS			
Hayden	Copper Anodes	175,000	
Ray**	Copper Anodes	110,000	

*Contained copper **On standby

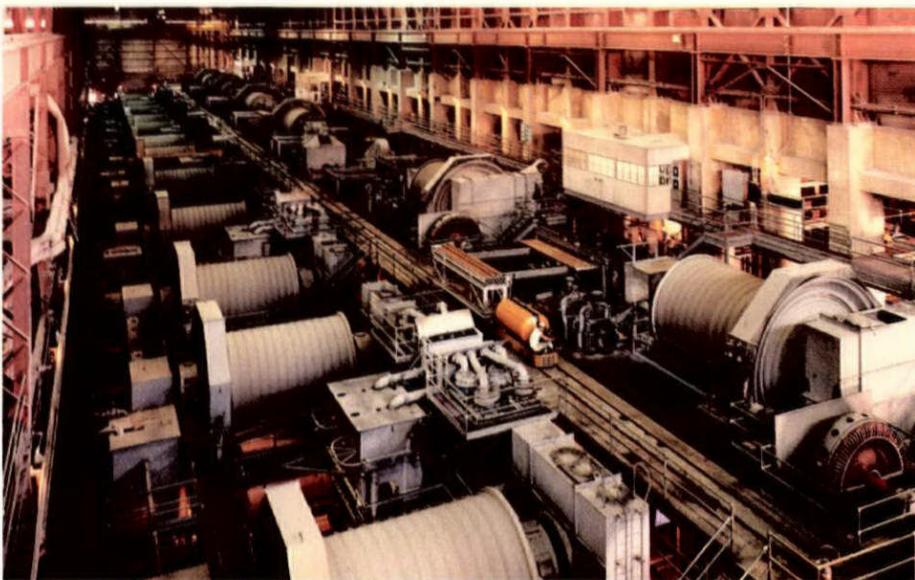
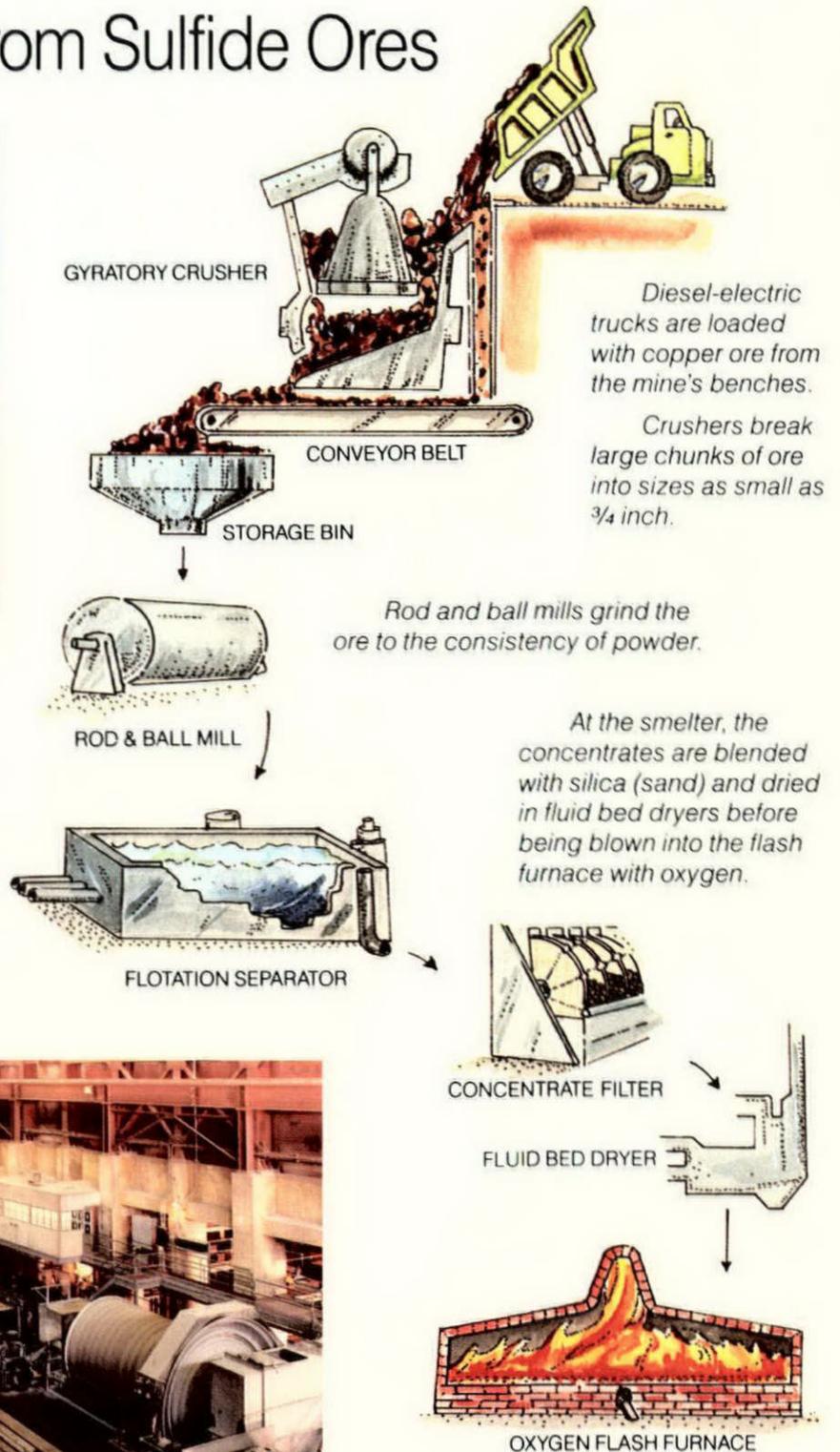
From Rock to Metal

Producing Copper from Sulfide Ores



170-ton truck is loaded with ore.

The finely ground ore is agitated in a water and chemical solution and pumped as a slurry to the flotation cells. The solution is then aerated causing a froth which carries the copper minerals, but not the waste rock. The froth is skimmed off and filtered to remove the copper concentrates. The concentrates are shipped to the Hayden smelter.



Rod and ball mills in concentrator building.

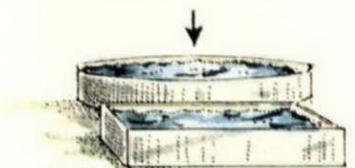
The concentrates ignite and melt in the flash furnace producing "matte," containing approximately 55 percent copper, and slag, containing iron and other impurities. Sulfur is oxidized to sulfur dioxide gas.

Producing Copper from Oxide Ores

Oxide ore is leached to dissolve the copper. Then solvent extraction/electrowinning technology is employed to produce copper cathodes directly from the leach solution. This method is employed at Asarco's Ray mine.



HEAP LEACHING



SOLVENT EXTRACTION PROCESS



ELECTROWINNING PLANT



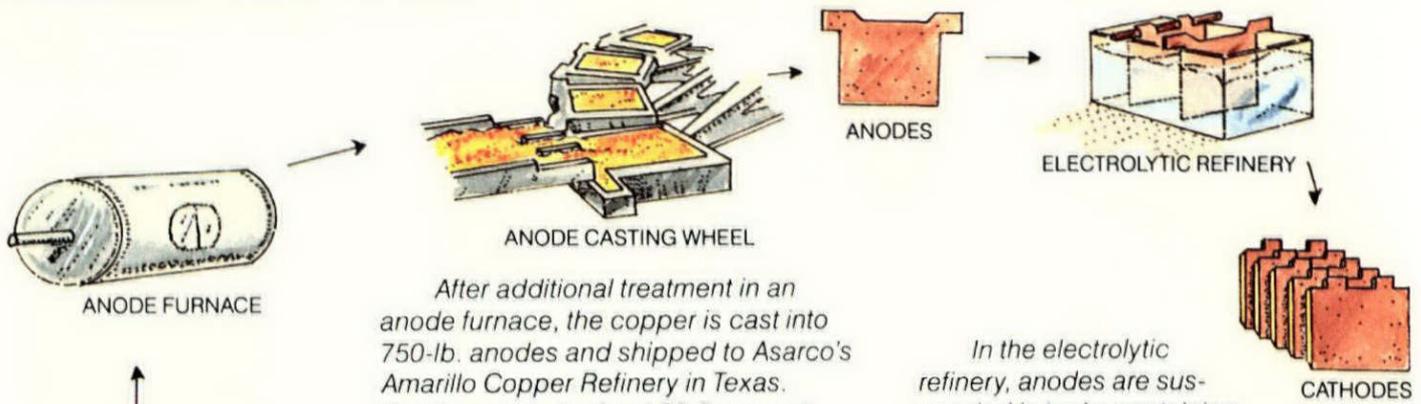
CATHODES



Blister copper is poured from the converter furnace.



Anodes await shipment to refinery.



After additional treatment in an anode furnace, the copper is cast into 750-lb. anodes and shipped to Asarco's Amarillo Copper Refinery in Texas. Anode copper is about 99.0 percent pure.

In a converter furnace more iron and sulfur is removed, producing blister copper which is about 98.5 percent copper.

In the electrolytic refinery, anodes are suspended in tanks containing sulfuric acid and copper sulfate. An electrical current is passed through the anodes and chemical solution, producing cathodes of 99.9 percent pure copper. Other impurities (including gold and silver) settle on the bottom of the tank as sludge.

Blasting is necessary to loosen the rock ► and ore.



Large flotation cells increase efficiency. ▼



Mission Complex

The Mission Complex is composed of five open-pit copper properties. Of these, Mission, Eisenhower, Pima, and San Xavier South began as separate mines but now form one giant pit.

The pits are laid out in 40-foot-high "benches" which allow for selective mining and easy transporting of ore.

The ore is fragmented by blasting and loaded by electric shovels into 170-ton haulage trucks

which transport the ore to the Mission mill.

At the mill, primary, secondary and tertiary crushers reduce the ore from rocks of up to five feet in size to less than an inch. The ore is then combined with water and ground to the consistency of powder by a series of rod and ball mills. The resulting slurry is transferred to flotation cells where it is combined with biodegradable additives and aerated. The additives coat the copper minerals causing them to cling to the air

bubbles and float to the top where they are skimmed off. Waste particles sink to the bottom and are discarded.

The collected froth is filtered to remove the copper concentrate, which at this point contains 30 percent copper. The concentrate is shipped to a smelter. Seventy percent of the water used in the process is recycled and reclaimed.



Mission Complex includes (from left to right) the Pima, Mission, Eisenhower and San Xavier South mines, which comprise the large open pit. Not visible is the San Xavier North pit. ▶

Ray Mine

The Ray Unit consists of an open-pit mine containing both copper sulfide and copper oxide ores, a mill to produce concentrates from the sulfide ores, and a leaching and solvent extraction/electrowinning plant to produce refined copper cathodes from both the oxide ore and low-grade sulfide/oxide ore dumps. The sulfide ore mined at Ray is

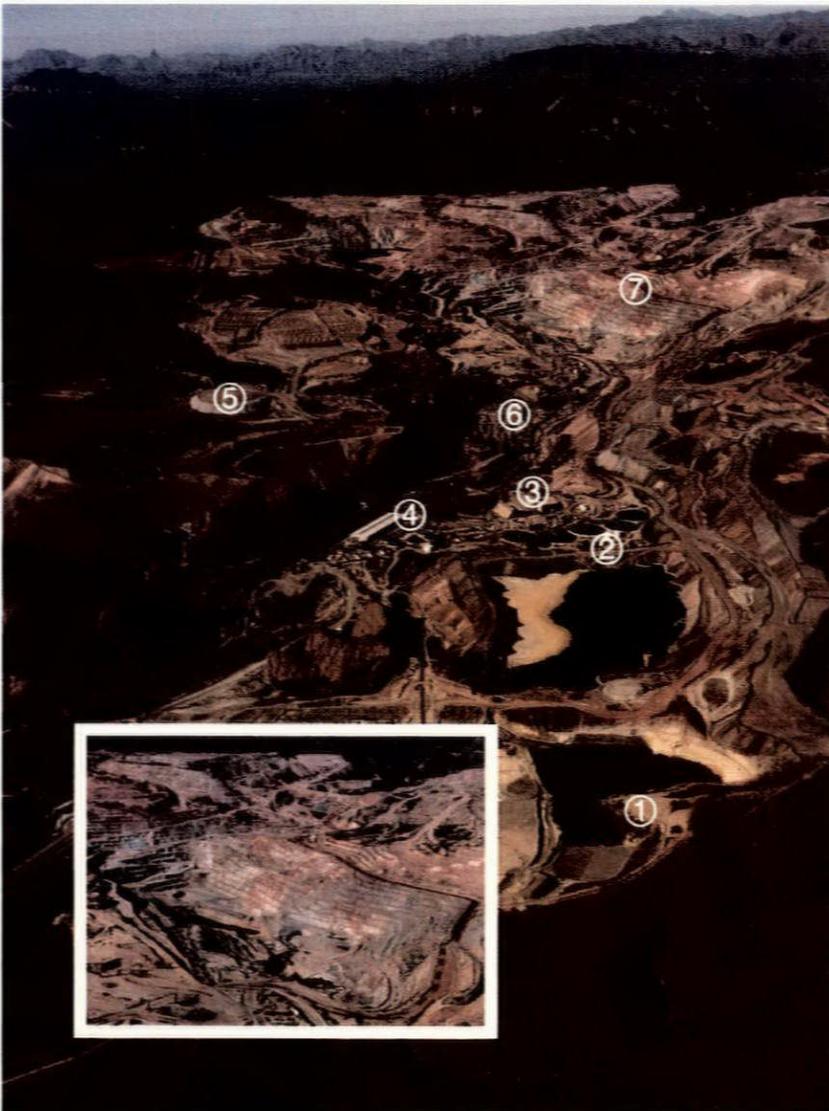
processed in the same manner as at the Mission Complex.

The Ray Unit also includes a modern copper smelter capable of processing 400,000 tons per year of copper concentrates, but which is on standby. Ray concentrates are smelted at Asarco's nearby Hayden Plant.

The technology of producing copper by leaching of ore with dilute sulfuric acid and precipitating out the dissolved copper by

galvanic action on scrap cans has existed for many years. This method has been used on oxide ore at Asarco's Silver Bell mine since 1960. The precipitate is sent to a smelter.

In recent years, however, a superior method of recovering the copper from the leaching solution has been perfected called solvent extraction. In this method, the dilute acid copper solution from the leaching operation is agitated



◀ The entire Ray mine facility is visible in this aerial including the heap leaching field (1), solution storage area (2), solvent extraction unit (3), electrowinning plant (4), sulfide leaching area (5), mine administration and shop buildings (6), and the open pit (7), also shown in inset. The pit and dumps occupy an area 3 miles by 1½ miles wide and the pit is 1,000 feet deep.

▼ A front-end loader with a 17-cubic-yard bucket loads ore from stockpiles into a 170-ton truck.



vigorously with a solvent containing chemical additives which attract copper ions. Since the solvent, like oil, is lighter than water and does not mix with water, it rises to the top carrying the copper with it and is skimmed off. The solvent is then agitated with a relatively strong acid solution which releases the copper from the solvent.

The resulting strong acid copper solution is then transferred to electrowinning tanks where the copper is plated out on cathodes just as in electrolytic refining. Thus the solvent extraction/electrowinning process (SX/EW) produces copper cathodes ready for sale without any milling, concentrating,

smelting and refining of the ore.

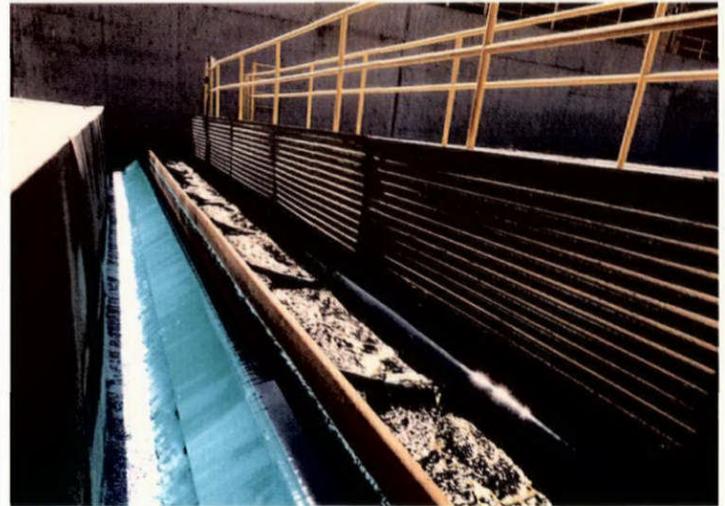
In 1987, the SX/EW plant at the Ray mine was modified to increase its capacity by one-third to 40,000 tons per year of electrowon cathodes. Solutions from the leaching of both newly mined oxide ore and low-grade ore dumps can now be processed by the SX/EW plant. Previously, the dump solutions had been processed at a precipitation plant.

IN SITU MINING

Elsewhere in Arizona, Asarco, in conjunction with the U.S. Bureau of Mines, is researching a new extractive technique called *in situ* mining. Dilute acid solutions are injected into previously undisturbed copper oxide deposits to dissolve the copper. The solution is then pumped to the surface and treated to remove the copper. If successful, *in situ* mining could recover copper from numerous oxide deposits in Arizona which are not economical to mine by conventional means.



▲ Sprinklers spray solution onto oxide ore in the heap leaching process.



▼ Copper cathodes are produced in Ray's electrowinning plant and shipped directly to the consumer.



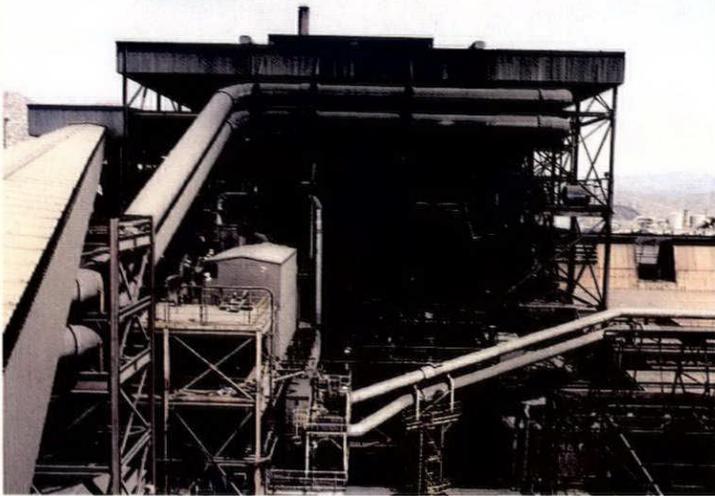
▲ Copper in leaching solution is captured by an oil and reagent solution in the solvent extraction process.

Leaching dissolves remaining copper from previously mined low-grade ore at Silver Bell mine. ◀



◀ Hayden Plant's 1,000-foot stack dominates the 200-acre site in this aerial overview.

▼ 750-lb. anodes containing 99.0 percent copper are cast in molds and cooled for shipment to the refinery.



▲ A state-of-the-art oxygen flash smelting furnace is housed in this 11-story structure.



▶ Plant operations are monitored in the central computer room. ▶

Hayden Plant

Since its initial construction in 1912, the Hayden Plant has been enlarged and improved repeatedly. A major modernization was completed in 1983 at a cost of \$132 million. Major components of the project included an oxygen flash smelting furnace to replace the roasters and reverberatory furnaces previously used, an oxygen plant to produce oxygen for the new furnace, a second sulfuric acid plant to recover the sulfur dioxide produced during smelting, and a water treatment plant to recover process water from the acid plant for reuse. Upon completion of the project, the Hayden Plant met all federal and state regulations governing emissions of sulfur dioxide and dust particles, and was once again able to operate at rated capacity without the need to curtail operations for environmental reasons.

Copper concentrates arrive at the smelter by rail and samples are assayed for metallurgical value. The concentrates are unloaded and blended with fluxes, then

transferred by conveyor to the fluid bed dryers where they are dried and stored before being introduced into the flash furnace. The "flashing" process produces "matte" which is then transferred to the converter furnaces where iron and sulfur are removed, leaving blister copper which is 98.5 percent pure. The blister copper then goes to the anode furnaces for additional treatment. The resulting anode copper, which is 99.0 percent pure, is cast into 750-lb. anodes. These anodes are then shipped to Asarco's refinery at Amarillo, Texas, to be refined into 99.9 percent pure copper.

In the flash furnace and converter processes, sulfur dioxide (SO_2) is produced. Hayden's acid plant processes the gas into sulfuric acid. This co-product of copper smelting is then sold and used for numerous applications, including the production of fertilizer and the leaching of copper ore.

Other air pollution controls, including hooding and ventilating systems, baghouses and electrostatic precipitators (Cottrells), remove solid dust particles

produced in the smelting process before emissions are released into the atmosphere through a 1,000-foot stack.

A central process control computer controls flash furnace feed, acid plant gas flow, oxygen production, sulfur dioxide emissions and other processes.

A water treatment plant recycles water from the acid plant. Approximately 95 percent of the water received from the acid plant is recovered and reused.

Additional facilities located on the 200-acre site are: a powerhouse, maintenance and repair shops, a warehouse, an acid storage and loading facility, a business office, a safety and personnel office, employee change facilities and a medical clinic.



At Hayden, as well as all other Asarco properties, numerous health and safety practices are observed during all phases of production. ▶

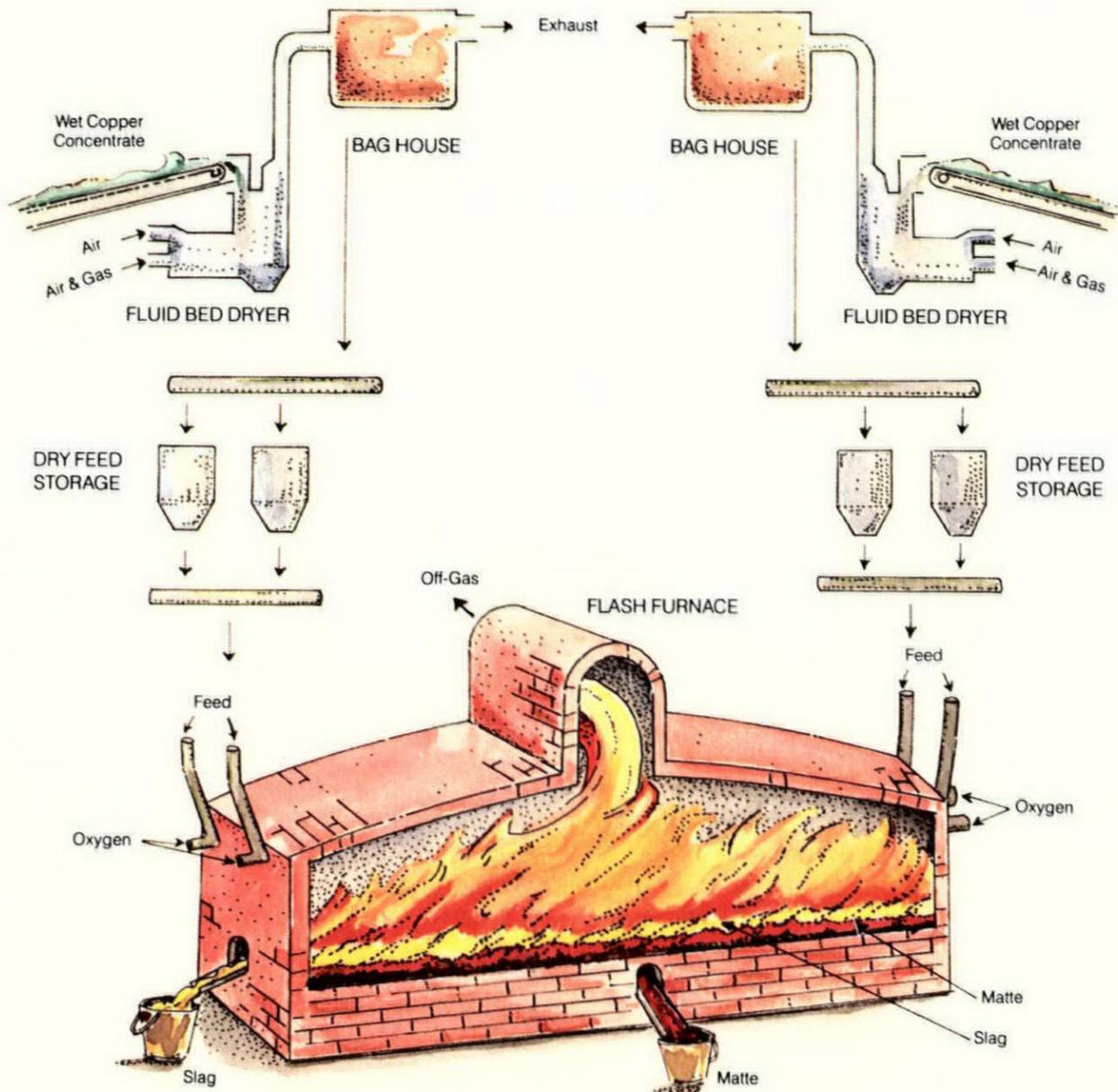
Oxygen Flash Furnace

The heart of Hayden's state-of-the-art smelting system is the oxygen flash furnace. Copper concentrates from the fluid bed dryers are fed into the furnace through four dry-feed storage units. Oxygen of 95 percent purity is simultaneously introduced,

causing instantaneous ignition or "flashing." A molten rain is produced and the sulfur in the concentrates burns in the oxygen providing heat to keep the process going. Off-gases are collected and sent to the acid plant.

Meanwhile, the molten concentrate in the bottom of the furnace has separated into two

layers. The top layer, "slag" (composed of iron, silica and limestone), is tapped off and discarded. The remaining layer, matte, containing 55 percent copper plus iron and sulfur is tapped into 20-ton matte ladles. It is then transferred to the converters for further processing.



Revegetation and reclamation at Asarco's Silver Bell mine restored the area to a state suitable for recreational uses. ►



Helping Arizona remain beautiful

Arizona is world-famous for bright blue skies, clean air and panoramic views. If there was a way to mine and smelt copper without disturbing its magnificent landscape, Asarco would most certainly do so. Unfortunately, the earth doesn't give up its treasures easily. Penetrating the earth's surface, separating the copper from other metallic compounds, protecting the environment—doing it all simultaneously is a difficult task. But it is one Asarco has undertaken voluntarily from the very beginning.

DUST CONTROL

Dust, even in areas not mined, is as normal to Arizona as sand is to beaches! Automatic sprinkler systems, water trucks plus a series of both wet and dry dust collectors are used at Asarco's open-pit mines to protect the environment.

WATER CONSERVATION

Just as too much dust is a constant concern in Arizona, so is too little water! Believing strongly in the conservation and recycling of the Southwest's limited water resources, Asarco recycles and reclaims 70 percent of the water used in its Arizona mines. The remainder is lost to evaporation. As mining progresses deeper into the pits, ground water appears, providing another source of process water.

REVEGETATION

Asarco's goal is to revegetate mining-disturbed areas with species that will survive and flourish on natural rainfall. Since no two mining sites are exactly alike, no one reclamation system works for all. There are problems of soils, climate, plant materials, topography and wildlife. At one site, just as desert grasses and plants became established, jackrabbits returned and ate the fresh growth. Soon, however, coyotes came back as well! Today, there is a relative natural balance among plant life, rabbits and coyotes on that particular mine site. Results at other reclaimed mines have been different, but equally gratifying.

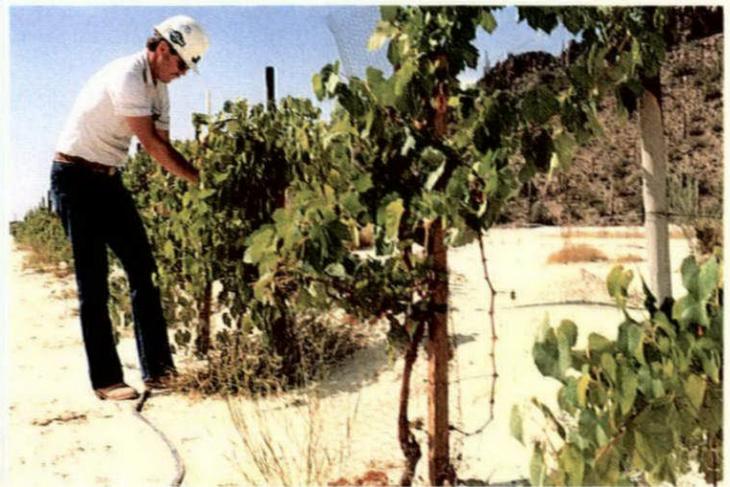
AIR AND WATER

Asarco has invested millions of dollars in environmental protection measures. As a result, Asarco's mines and its operating smelter in Arizona are ranked among the best in the world!

PHOTO LEFT:
Sulfur dioxide is converted into sulfuric acid in Hayden's new acid plant.

RIGHT TOP:
An Asarco agronomist tests the soil in a reclaimed area.

RIGHT BOTTOM:
Livestock herds can now take advantage of Asarco's revegetated areas.



Metal Maker for the World

ASARCO Incorporated is one of the world's leading producers of nonferrous metals, principally silver, copper, lead and zinc. The Company was organized in 1899 as American Smelting and Refining Company and the current name was adopted in 1975. Asarco operates or has interests in mines in the United States, Australia, Peru, Mexico, and Canada.

In addition to mining and treating ore from its own mines, Asarco is a custom smelter and refiner of nonferrous metal ores mined by others.

Asarco also produces nonmetallic minerals. Coal, limestone, sand, and gravel are mined in the United States, and the Company has an indirect interest in asbestos mines in Canada.

Asarco is a major producer of sulfuric acid which is produced as a by-product of the environmental control systems at its smelters. The Company also produces zinc oxide, an important raw material in the manufacture of rubber tires and paint. Other subsidiaries and affiliated companies produce specialty chemicals and manufacture alloys, electronic solders, fluxes, cathodic protection anodes, other metal products and asbestos-cement and PVC pipe.

Since its inception, Asarco has been involved in mining ventures outside the United States. Today it has substantial interests in three of the world's great mining companies: Southern Peru Copper Corporation, M.I.M. Holdings Limited in Australia, and Mexico Desarrollo Industrial Minero, S.A. Each of these companies is a leading world producer of nonferrous metals and one of the major industrial enterprises in the country where it is located.

Asarco and its associated companies together normally account for about 10 percent of Free World mine production of copper, 15 percent of silver, 12 percent of lead, and 9 percent of zinc.

MISSION COMPLEX

P.O. Box 111
Sahuarita, Arizona 85629

HAYDEN PLANT

Box 98
Hayden, Arizona 85235

RAY MINE

Box 8
Hayden, Arizona 85235

The ASARCO logo consists of the word "ASARCO" in a bold, white, sans-serif font, centered within a dark blue rectangular background.

