

1967

mining in arizona

**ITS PAST
ITS PRESENT
ITS FUTURE**

ARIZONA DEPT. OF MINERAL RESOURCES



DEPARTMENT OF MINERAL RESOURCES
STATE OF ARIZONA
PHOENIX, ARIZONA

FRANK P. KNIGHT, DIRECTOR



MINING IN ARIZONA

Its Past

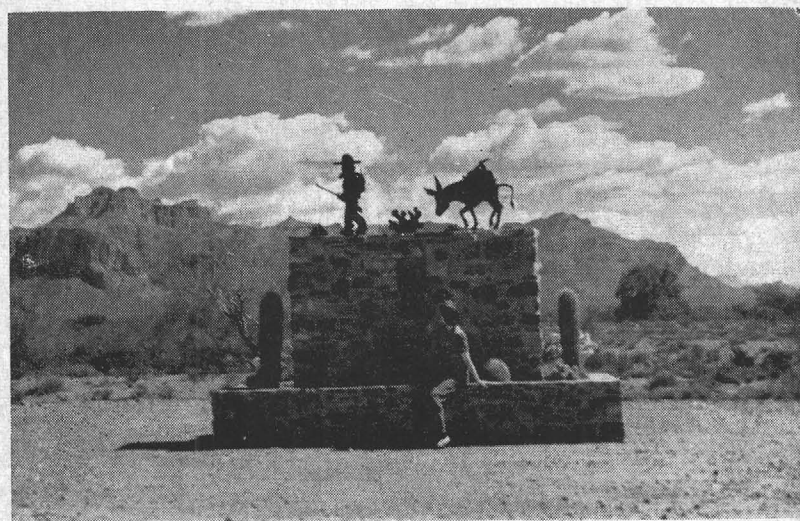
Its Present

Its Future

MAY, 1967



An Open Pit Copper Mine: A Copper Town



Superstition Mountain Monument

TABLE VIII

Mineral Production of Large and Small Producers in Arizona in 1965^{1/}

Source: U.S.B.M. Area Report for Arizona, 1965

LARGE COPPER PRODUCERS:*	PRODUCTION	VALUE
Copper (tons)	697,859	\$494,084,000
Gold (troy ozs.)	133,830	4,684,000
Silver (troy ozs.)	5,352,850	6,921,000
Molybdenum (in concentrates) (lbs.)	9,399,000	15,880,000
		<u>\$521,569,000</u>

SMALL MINERAL PRODUCERS:

Asbestos (short tons)	3,469	441,000
Clays ^{2/} (short tons)	129,000	164,000
Copper (Recoverable) (tons)	5,518	3,907,000
Diatomite (short tons)	295	8,000
Gem Stones 3/		120,000
Gold (Recoverable) (troy ozs.)	16,601	581,000
Gypsum (short tons)	103,000	540,000
Iron Ore (Usable) (long tons)	8,000	51,000
Lead (Recoverable) (short tons)	5,913	1,845,000
Lime (short tons)	204,000	3,543,000
Mercury (76-pound flasks)	158	90,000
Natural Gas (million cubic feet)	3,106	376,000
Petroleum (crude) (42-gallon barrels)	97,000	4/
Pumice (short tons)	1,273,000	1,605,000
Sand and Gravel (short tons)	14,918,000	16,621,000
Silver (Recoverable) (troy ozs.)	742,150	960,000
Stone (short tons)	2,474,000	4,171,000
Tungsten ore (60% WO ₃) (short tons)	3	5,000
Uranium Ore (short tons)	117,898	3,918,000
Vanadium (short tons)	4/	381,000
Zinc (recoverable) (short tons)	21,757	6,353,000
Value of items that cannot be disclosed: Cement, feldspar, helium, mica (scrap), perlite, pyrites, and values indicated by footnotes—2 and 4		5/12,933,000
Small Mine Sub-Total		<u>58,613,000</u>
TOTAL		<u>\$580,182,000</u>
Percentage Due to Small Mines		10.1%

* Phelps Dodge, Kennecott, Inspiration (incl. Christmas), Miami, Magma (incl. San Manuel), Asarco's Silver Bell & Mission units, Pima, Bagdad, Duval's Esperanza and Mineral Park.

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

2/ Excludes bentonite; included with "Value of items that cannot be disclosed."

3/ Weight not recorded.

4/ Withheld to avoid disclosing individual company confidential data.

5/ Value of mineral fuels, \$2,307,000; value of nonmetals, \$10,626,000.

CONTENTS

	Page
MAP OF ARIZONA	4
MINING IN ARIZONA	5
HISTORY — General	5
THE MAJOR METALS	
Copper	10
Molybdenum	18
Gold and Silver	19
Lead and Zinc	22
Manganese	25
Uranium	25
MISCELLANEOUS METALS	
Tungsten	26
Mercury	27
Vanadium	27
Iron	27
Rare Metals	28
NON-METALLIC MINERALS	
Asbestos	29
Cement	30
Clays	30
Diatomaceous Earth	30
Feldspar	30
Gem Stones	31
Gypsum	31
Lime	31
Mica	32
Perlite	32
Pumice	32
Sand and Gravel	33
Stone	33
Miscellaneous	
Barite, Fluorspar, Nitrogen	35
Mineral Fuels — Coal, Gas and Petroleum	35
Helium	36
THE FUTURE AND ARIZONA'S MINERALS	37
ARIZONA DEPARTMENT OF MINERAL RESOURCES	38
"LOST" MINES	39
ARIZONA FACTS	40
TABLES —	
I Annual Production of Five Principal Metals 1954-1966....	6
II Production of Five Principal Metals to end of 1966.....	9
III Major Arizona Copper Mines, 1966	17
IV Molybdenum Production	19
V Lead and Zinc Annual Production Rates	24
VI Manganese Production	25
VII Value of Mineral Production by Counties	41
VIII Mineral Production of Large and Small Producers	42

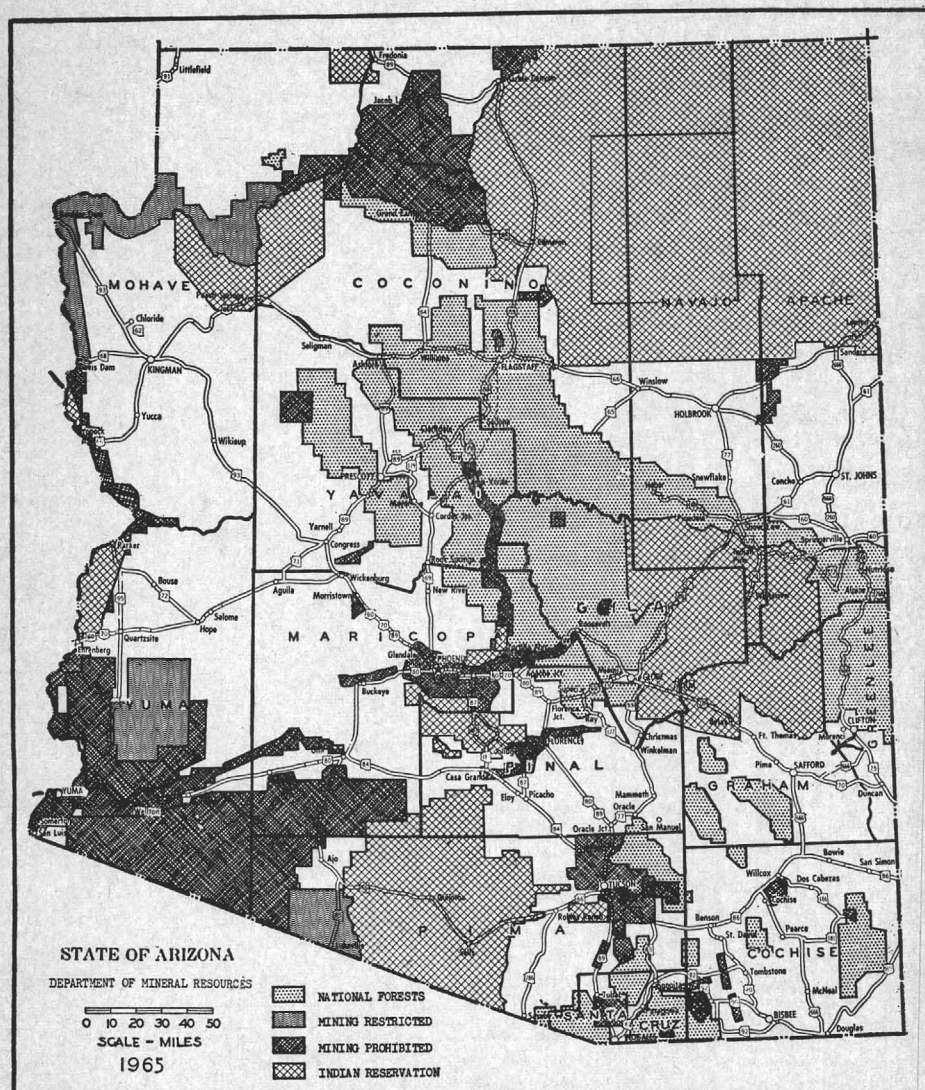


TABLE VII

Value of Mineral Production in Arizona, by Counties
(From U.S. Bureau of Mines Mineral Yearbook)

County	1964	1965	Minerals produced in 1965 in order of value
Apache	\$ 5,483,255	\$ 4,347,106	Helium, uranium ore, natural gas, sand and gravel, vanadium, petroleum, pumice, clays, stone.
Cochise	53,727,756	W ^{2/}	Copper, gold, silver, stone, lime, sand and gravel, zinc, lead.
Coconino	7,367,976	W	Uranium ore, pumice, sand and gravel, copper, stone, silver.
Gila	64,278,510	70,389,453	Copper, lime, molybdenum, asbestos, silver, stone, sand and gravel, gold, mercury, iron ore, clays.
Graham	W	W	Stone, pumice.
Greenlee	87,325,743	93,809,251	Copper, lime, molybdenum, silver, stone, gold, sand and gravel.
Maricopa	9,088,660	6,004,733	Sand and gravel, mercury, mica (scrap), clays, stone, silver, copper, gold.
Mohave	2,092,263	19,586,739	Copper, molybdenum, sand and gravel, silver, stone, feldspar, zinc, gold, lead.
Navajo	1,004,117	1,468,466	Sand and gravel, uranium ore, stone, vanadium.
Pima	148,899,356	149,153,395	Copper, cement, molybdenum, silver, sand and gravel, gold, stone, zinc, clays, tungsten concentrate, lead.
Pinal	119,452,151	141,730,125	Copper, molybdenum, sand and gravel, gold, silver, gypsum, lime, pyrites, perlite, stone, diatomite.
Santa Cruz	356,623	377,323	Zinc, lead, copper, silver, gold, stone.
Yavapai	32,570,543	33,054,812	Copper, zinc, cement, lead, silver, molybdenum, sand and gravel, gold, stone, lime, gypsum, clays, iron ore, pumice.
Yuma	2,428,721	1,290,738	Sand and gravel, stone, lead, gypsum, silver, zinc, gold, copper.
Undistributed ¹	277,271	58,969,629 ²	
Total ..	\$534,353,000	\$580,182,000	

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

¹ Includes gem stones that cannot be assigned to specific counties and values indicated by symbol W.

² \$50,262,936 value of copper, gold, silver, lead and zinc mine production in Cochise County in 1965.

ARIZONA FACTS

The word "Arizona" is believed to have been derived from two Indian languages — Papago and Pima — and means "Little Spring." "Ari" means small and "Zonac" spring.

Arizona is the 48th state admitted to the Union, the seventh largest, and has an area of 113,956 square miles. The State was organized as a territory in 1863, and was admitted to the Union on February 14, 1912.

The State flag represents the copper star of Arizona rising from a blue field in the face of a setting sun. The lower half is a blue field, the upper half is divided into 13 equal rays which start at the center, continue to the edges of the flag and consist of six yellow and seven red rays. A five-pointed copper star is superimposed on the center of the flag.

Arizona's State bird, the tiny cactus wren, likes to build his home in the protection of thorny desert plants. Because of this he often builds his nest in the arms of the giant sahuaro cactus. He builds several nests but lives in only one—the rest are decoys. He is a woody brown bird with a speckled breast.

The State flower is the pure white, waxy flower of the sahuaro cactus, which blooms in the late spring. Blooms are found on the tips of the sahuaro arms. Many sahuaros are more than 100 years old, and some attain a height of 50 feet.

The census of 1960 showed the population of Arizona to be 1,302,161; 74 per cent higher than the census figure for 1950. The population as of July, 1966 has been estimated at 1,655,000. In 1900, it was 122,931. Arizona is the Nation's fastest growing state since the start of the century.

Population figures by counties are as follows:

	1960 ¹	1966 ²		1960 ¹	1966 ²
Apache	30,438	38,000	Mohave	7,736	17,000
Cochise	55,039	61,000	Navajo	37,994	45,000
Coconino	41,857	49,000	Pima	265,660	326,000
Gila	25,745	30,000	Pinal	62,673	64,000
Graham	14,045	16,000	Santa Cruz	10,808	14,000
Greenlee	11,509	12,000	Yavapai	28,912	32,000
Maricopa	663,510	894,000	Yuma	46,235	57,000

1. Census

2. July 1, 1966—Estimate—Valley National Bank

Mining In Arizona

Arizona is by far the greatest producer of non-ferrous, metallic minerals of any state in our Union. In 1964, (the latest year for which Bureau of Mines figures are available) Arizona produced over one-third (34.6%) of the combined dollar value of such metals produced in the entire 50 states.

In 1966, it ranked first in copper production.

It ranked sixth in lead.

It ranked thirteenth in zinc.

It ranked third in silver.

It ranked fourth in gold production.

It ranked third in molybdenum production.

There follows on the next page a tabulation of the annual Arizona production of these metals for the years 1954 to 1966.

HISTORY — GENERAL

In the period from 1858 to 1966 inclusive, Arizona's mines have yielded more than \$11.1 billion, over 94 per cent of which came from its six principal metals; copper, lead, zinc, gold, silver and molybdenum. While all phases of the mining industry contributed to such achievement, it is to the pioneer prospector and miner we of this "machine age" owe an everlasting debt. He blazed the trails, conquered the desert, braved its terrors, bridged the barrenness, scaled its difficulties and, in the end, wrested wealth from its age-long secrets and its hidden hoards.

His search for gold and silver — and later copper, lead and zinc — also resulted in the eventual source of metals so essential to our Nation's defense efforts and space age accomplishments. Molybdenum, now second only to copper in the total value of Arizona's metallic mineral production is recovered as a by-product from the copper ores of ten mines, some of which are so low in

TABLE I

	Gold oz.	Silver oz.	Copper lbs.	Lead lbs.	Zinc lbs.	Molybdenum lbs.
1954	114,809	4,298,811	755,854,000	16,770,000	42,922,000	1,538,000
1955	127,616	4,634,179	908,210,000	19,634,000	45,368,000	1,497,000
1956	146,110	5,179,185	1,011,816,000	23,998,000	51,160,000	2,392,000
1957	152,499	5,279,323	1,031,708,000	24,882,000	67,810,000	2,385,000
1958	142,979	4,684,580	971,678,000	23,780,000	54,064,000	2,320,000
1959	124,627	3,898,336	860,594,000	19,998,000	74,650,000	3,181,000
1960	143,064	4,774,992	1,077,210,000	16,990,000	71,622,000	4,359,000
1961	145,959	5,120,007	1,174,106,000	11,874,000	59,170,000	4,878,000
1962	137,207	5,453,585	1,288,484,000	13,932,000	65,776,000	4,412,000
1963	140,030	5,373,056	1,321,976,000	11,630,000	50,838,000	5,553,000
1964	153,676	5,810,510	1,381,976,000	12,294,000	49,380,000	6,296,000
1965	150,431	6,095,248	1,406,754,000	11,826,000	43,514,000	9,399,000
1966 P	136,100	6,226,000	1,461,400,000	10,340,000	32,760,000	10,240,000

P = Preliminary

many out-of-print U.S. Geological Survey and U.S. Bureau of Mines publications, all very valuable for reference. Technical trade journals, late information on pending legislation, market and price data, mineral rights and other pertinent mining information are on file.

The Mineral Building, finished in 1919, houses a fine collection of minerals. For many years this valuable display was open to the public only during the 10-day period of the Arizona State Fair in November of each year. Early in 1953, the following mining companies provided funds to keep the exhibit open on a year-round basis under the direction of a curator: American Smelting and Refining Company, Inspiration Consolidated Copper Company, Kennecott Copper Corporation, Magma Copper Company, Miami Copper Company, and Phelps-Dodge Corporation. Besides the minerals in the display, there is a fine collection of almost every type of rock found in Arizona. The Museum is valuable for study purposes as well as interesting and informative to visitors, regardless of their interest in mining as an industry.

"LOST" MINES

Arizona is rich in legends of many "lost" mines.

Perhaps 98 per cent of the stories of "lost" mines are pure fiction. The mines exist only in one's imagination. True, the stories are interesting, especially to new-comers, but they are likewise dangerous. Many lives have been lost searching for these mythical mines, and in addition, the communities are put to extra expense for posses and searching parties.

"Don't believe" is sound advice regarding lost mines. Forget the lost mines shown on the "old-map-my-grandfather-bought-from-an-old-Spaniard-he-befriended." It simply doesn't exist. The rich ore that is supposed to have been obtained from a "lost" mine—and some were very rich—in all probability was "high-graded" (stolen) from some of the early-day rich mines then working.

To a tourist in good health, and accompanied by an experienced prospector, the search for a "lost" mine is a healthful and interesting diversion during the winter months. Such trips always have the possibility of discovering some over-looked mineralized out-crop of promise; a neglected, rather than a "lost" mine.

and for new mines to take the place of those becoming depleted. Industrial demands must be met, and the nation's security and economic health must be protected.

Arizona seeks and welcomes new mining venture capital. Investors are cautioned to "investigate before venturing," because mining is a highly specialized industry, requires special know-how, and usually involves more risk than trade or manufacturing. Those entering the mining business need the best available advice about the risks involved and the chances of profit to justify the venture.

Investors in mining now have several advantages over early-day venture capital. Legally, they are much better protected in their investments. Technically, they can enlist the aid of the Arizona Department of Mineral Resources, the Arizona Bureau of Mines, the United States Geological Survey, and the United States Bureau of Mines. These agencies can and will furnish data as to the geology and mining history of Arizona mining districts and of many mining properties. Many valuable bulletins, maps and pamphlets also are available, although a number of them are out of print and must be sought at a library or at such bureaus as the above.

An organization known as the Arizona Small Mine Operators Association, 508 Title and Trust Building, Phoenix, Arizona, furnishes many valuable services. Those interested in mining are advised to join. Dues are only \$2.00 per year, including a subscription to its monthly publication, which disseminates mining news and information.

Mining conditions change. New facts are discovered each day in the advancement of mining and metallurgical technology. Today's waste rocks will be tomorrow's ore, and the demand for the metals will continue to mount.

ARIZONA DEPARTMENT OF MINERAL RESOURCES

This department, with offices in the Mineral Building at the Fairgrounds in Phoenix, is a State agency established to assist the more extensive exploration and development of the mineral resources of the state. The department engineers render assistance within the limitations of their public position. The department's files contain information on many properties, and its library includes

grade that they could not be economically mined, were it not for the value of the molybdenum produced.

Long before the white man had begun settling in America he had explored portions of Arizona. It was the lure of the metals — gold and silver — that prompted Coronado's famous expedition in search of the Seven Cities of Cibola, and in 1540, eighty years before the Mayflower left England, Coronado's Army Captain, Cardenas, stood on the brink of Arizona's Grand Canyon. Coronado, however, wanted his gold and silver already mined, smelted and minted. Consequently, he did no prospecting.

In 1583, thirty-seven years before the landing of the Pilgrim Fathers, a white man, Antonio Espejo, found a deposit thought to be silver ore in what is now Arizona. It was Arizona's first recorded mineral discovery and some believe it was the mineral outcroppings at Jerome. It is known that the Indians did little mining except for coal, turquoise, salt, and possibly iron oxide for paint.

There appears to have been little prospecting following Espejo's discovery until about 1705, when Father Kino did some silver mining. About 1736, the rich silver deposits, Planchas de Plata, in northern Sonora near the site of Nogales, stimulated mining, and in 1769, when Tucson became a Spanish settlement, it is known that the Spaniards mined gold and silver in the region. Gold placers at Quijotoa are said to have been worked in 1774.

From about 1824 to 1842, much of Arizona was covered by American trappers and explorers, among them Bill Williams, Pauline Weaver and Kit Carson. Apache raids prevented settlement and prospecting, however, until well after 1848, when that portion of Arizona north of the Gila River became part of the United States. That was also the year of the California gold rush, and while thousands of emigrants crossed Arizona enroute to the "gold diggins," few stopped to prospect. There are, nevertheless, well authenticated stories that Papago Indians had discovered gold near Gila City, Yuma County, in 1846, or two years prior to the California discovery.

Following the Gadsden Purchase in 1854, southern Arizona was actively prospected. In that year claims were located at Ajo.

Mines were worked at Cerro Colorado, and in the Santa Rita Mountains south of Tucson. A few years later the Mowry mine was shipping rich lead ore. With the outbreak of the Civil War in 1861, and withdrawal of U.S. soldiers, the Apaches "took over" for some 10 years. Nevertheless, in 1862-63 the rich, gold placers of La Paz, Rich Hill and Lynx Creek were found and mined, and soldiers stationed at Fort Mohave discovered gold lodes near what is now Oatman. It was about that time, too, that many famous mines were discovered — Vulture, Planet, Castle Dome, and many of the rich mines of the Prescott region.

The '70's witnessed the discovery and development of many great Arizona mining camps, some of which are still yielding great mineral wealth. Globe-Miami, Silver King, Superior, Bisbee, Jerome, Tombstone, and Clifton-Morenci are among the mining districts founded in that period.

All these camps etched for themselves colorful pages in Arizona's early history, but perhaps the once-riotous Tombstone succeeded in leaving the most indelible impression.

"Instead of a mine, you'll find a tombstone," said a fellow soldier to Ed Schieffelin in 1877 as he set out from Fort Huachuca, near the Mexican border, to "look for stones." Schieffelin recalled the warning, and when he came across some rich-appearing ore, said to himself, "Here is my tombstone." That was how the camp received its name. Since then stories of its development, its frontier sheriffs who brought law and order to one of the wildest mining camps of the then very wild West, and its rugged inhabitants, have been the subject of a number of articles and books.

Untold centuries ago there was locked away in Arizona's mighty mountain vaults, stores of precious metals — an important supply necessary for our increasing commerce, industry and population. The doors of these vaults were fitted with time locks. Those already opened have given the world rich treasures. Others as yet unlocked await but the same combination — need, capital, science, brains, courage, faith and work.

Table II is a summarized tabulation of Arizona's production of its six principal metals.

THE FUTURE AND ARIZONA'S MINERALS

Decades of mining still lie ahead for Arizona. Not all of our ore deposits have as yet been found. In recent years new ore bodies of great promise have been fully investigated and developed under modern exploration, mining and recovery methods. Recent research and exploration results promise further substantial additions to Arizona's copper production.

Only a few per cent of the State's 72,688,000 acres have been fully prospected, or investigated by geophysical methods.

In the older and productive districts large areas of the deposits which were formerly considered to be sub-marginal, are now being worked and are yielding a profit. As rapid advancements are made in the application of new scientific data to methods of proving potential new ore bodies, to the processes whereby the metals are extracted from the host rock, and to the development of larger and more efficient material-handling machines operated more and more by automation displacing common labor, it will be possible to extract more tons of metal from an increasing number of mines, notwithstanding the ever-increasing costs of the elements that enter into production—labor, supplies, transportation, taxes. Similarly many long-shut-down mines may offer renewed productive possibilities.

A number of known oxide and silicate ore bodies until very recently have defied serious consideration of development either because methods of processing had not as yet been perfected or because the complexity of the ore rendered the deposits uneconomical to treat. Also there are undeveloped ore bodies which may not be as rich as those already being mined, but the lower grade may be offset by greater tonnage. With the application of advanced mining and metallurgical practices they should offer rich rewards for venture capital. It should always be borne in mind that as recently as the beginning of this century the porphyry deposits from which our Nation now recovers the bulk of its copper production, were held to be so low in grade and so disseminated that they were considered to be worthless. However, capital requirements have increased and laws, regulations and taxes which tend to repel venture capital should be considered carefully in the light of the need of Arizona and the Nation for maintained mineral production

produced 12,000 barrels of oil. In March 1967, 11 wells produced 72,000 barrels, of which over 80 per cent came from two new wells, and new wells are being driven in the new field. Arizona's cumulative oil production to the end of 1966 is 634,563 barrels.

Production of natural gas increased from 230 million cubic feet in 1962 to 3,106 million in 1965. Total production to the end of 1966 is 6,632,478 million cubic feet. In March 1967 there were 8 producing gas wells.

HELIUM

In the year 1964, 554 million cubic feet of natural gas containing about 9 per cent of helium gas were drawn from ten active wells, and were processed at the plant of Kerr McGee Oil Industries, Inc. located at Navajo, Apache County, near the Pinta Dome and Navajo Springs gas fields.

In the first quarter of 1967, eleven wells in these fields yielded 221,723 million cubic feet of this helium bearing gas, and annual rate of 886,992 million cubic feet. The total yield to the end of 1966 is 2,861,424 million cubic feet.

TABLE II

Production to the end of 1966

21,212,728 tons of copper	worth	\$9,352,052,000
644,854 tons of lead	worth	127,256,000
1,001,580 tons of zinc	worth	244,074,000
13,456,311 ounces of gold	worth	358,467,000
393,420,241 ounces of silver	worth	318,567,000
77,716,523 pounds of molybdenum	worth	96,986,000 (a)

Total Value	\$10,497,402,000
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(a) of this amount 19,639,000 pounds (over 25%) were produced in 1965-1966—valued at \$32,698,000.

And that isn't all of the story. It is estimated that fifty per cent of the value of all these metals has been expended in Arizona for wages, supplies, and state, county, city and school taxes. The balance has gone for out-of-state purchases, refining, marketing, dividends to investors, many of the latter being citizens of Arizona, and federal taxes which reverted to the State's progress in the form of dams, roads, army camps, air fields, and defense plant constructions.

THE MAJOR METALS

The six major metals now being produced in Arizona in order of value are copper, molybdenum, silver, gold, zinc, and lead.

COPPER

For more than 80 years the copper mines of Arizona have poured a ceaseless stream of metal into the nation's industries. The state has for more than 50 years ranked as the leading copper producer in the United States. Its output, up to the end of 1966, amounted to 21,212,728 tons of copper worth \$9,352,052,000. For the past six years Arizona has produced more copper than all the other states combined. There is no reason to believe that she cannot continue as leader for many years to come. Nature has endowed her with one of the world's most important sources of copper.

The record of Arizona's steady growth and progress is closely linked with the development of her copper industry. This development has been achieved through decades of courageous perseverance in the face of repeated discouragements. Thousands have devoted their lifetime to helping in the development of the mines and in the building of the communities with their schools, banks, churches, and public buildings, and the roots of these communities extend down into the earth to the bodies of copper-bearing ore which still continue to nourish them.

From 1880 to 1910 copper mines in Arizona were of the "bonanza" or high-grade type. Such properties as the Old Dominion at Globe, the Copper Queen at Bisbee, the United Verde at Jerome, and those at Clifton-Morenci were the major producers during this period. The Copper Queen is the only one of these which is still a producer of a substantial amount of high-grade copper ores. Morenci now produces low-grade ores from the second largest open pit mine in the United States. Old Dominion and United Verde mines were exhausted more than ten years ago. Beginning about 1910 and through the next 50 years, the low-grade "porphyries" were the chief copper producers. However, the Magma Mine at Superior has been a high-grade producer since 1910, and is still operating as such. The United Verde Extension Mine at Jerome was another high-grade producer that operated from 1916 to 1938.

MISCELLANEOUS NON-METALLICS

Barite, fluorspar and nitrogen compounds have been mined in Arizona, but not in recent years.

MINERAL FUELS

Small amounts of coal were mined, and coal exploration continued in the Black Mesa area of the Navajo and Hopi Indian Reservations in Arizona in 1966.

Early in 1967, the Peabody Coal Company contracted to deliver 117 million tons of coal to a Mohave Power Project in Nevada near Bullhead City, Arizona. The Southern California Edison Company heads a group of utilities which has the project in plan. The coal is to be pumped as slurry 275 miles by pipeline from the Black Mesa area.

Arizona's petroleum discoveries were very disappointing until February 1967 when a new field was found near Red Rock in Apache County. According to figures released by the Oil and Gas Conservation Commission of Arizona, in January 1967, 9 wells



Ore Truck

in Coconino, Maricopa, Pima and Yavapai Counties. Dimension limestone, crushed limestone and very recently some dimension slate also have been produced in Arizona.

Crushed stone, used for concrete, road material, railroad ballast, and smelter flux, has been the chief source of income for Arizona stone producers.

The following production figures tell the story of the phenomenal increase in stone production in Arizona:

	Tons	Value
1889-1948 (Ariz. Bur. Mines)		\$14,234,000
1949-1954 (U.S. Bur. Mines)	2,776,000	3,586,000
1955-1960	13,570,000	19,622,000
1961-66 (1966 Preliminary)	20,051,000	31,174,000
		<hr/>
Total Value 1889-1966		\$68,616,000



Hauling Ore Garfield To Metcalf

In 1965, the copper mining and smelting industry payroll in Arizona amounted to \$135,055,972. This figure includes only about 60 per cent of the total of fringe benefits received by the employees. It is estimated that the total amount of fringe benefits is equivalent to more than 25 per cent of the annual labor cost of the copper mining and smelting industry.

It is calculated that Arizona copper mines spend over \$100,000,000 annually in Arizona for Arizona-grown or manufactured supplies and equipment.

In 1966, over \$33,000,000 was paid to Arizona's various units of government levying property, sales and use, vehicle and state income taxes. Included in this figure are approximately \$7,500,000 paid the state as a "Severance Tax" on copper amounting to 11½ percent of gross at the time the copper contents of mine product are shipped out of state. This, for purposes of taxation, is the "statutory gross sales value of ore, concentrate, or metal at the time it enters interstate commerce."

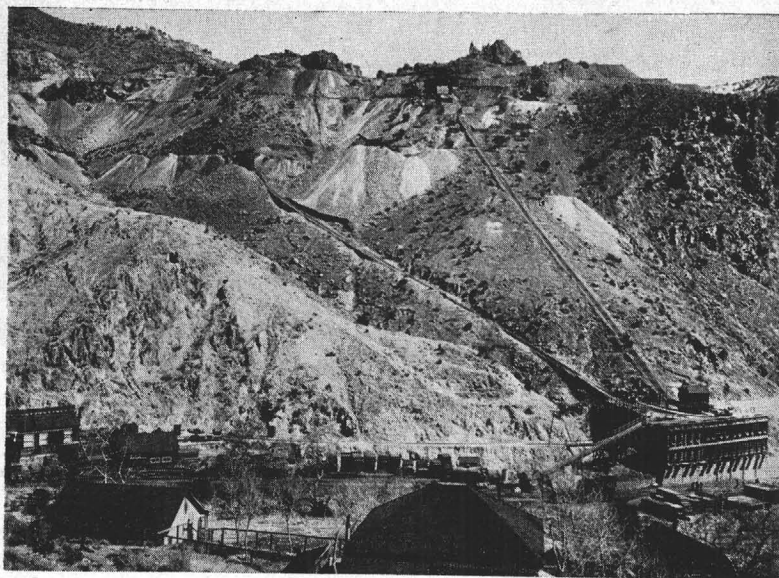
The railroads and truck lines handle a large volume of business through the movement of copper ores and metal as well as supplies and equipment for the mines, mills and smelters. Copper mining brought the railroads to Arizona and continues to furnish much of the freight into and out of the state which has kept them going.

Agricultural, lumber and livestock producers in non-mining portions of Arizona derive a large share of their income from the copper industry through purchases of their products and proration of taxes to counties.

The copper companies are heavy purchasers of electrical power generated at irrigation storage dams. These large power purchases by the copper mining companies make possible the cheaper power and increased water supply for agriculture and industry.

The copper mining industry has a vital and far-reaching effect upon the State's economy. It is one of the few industries which creates new and indestructible wealth. It is most vital to the Nation's security, and it is necessary that this country's domestic mines be kept in operating condition at all times.

Copper ores and minerals are of no practical value until they



Copper Mining About 1900

have been converted into metallic copper. They earn no interest, furnish no employment, produce no benefits to anyone. An active mining industry is the agency which converts them into tangible assets and, in the process of conversion, the benefits derived therefrom are distributed widely among other industries and businesses. The direct and indirect beneficiaries of the copper industry are many; not only the miner and smelterman but also their families, the storekeepers with whom they trade, the truckers who bring the wares to the stores, the professional men whose services they use, doctors, barbers, cleaners, etc. — are all dependent upon the wages of the miner and smelterman. Purchases of supplies and equipment supply the life blood to shops, equipment and auto dealers, doctors, dentists, restaurateurs — namely a healthy cross section of the entire State.

In the past four decades the average grade of copper ore in Arizona has been steadily declining from a content of 50 pounds per ton of ore to less than 16 pounds per ton. This, together with steadily increasing wages, which have more than quadrupled during the same period, naturally leads to higher production costs, in spite

Apache, Coconino, Graham and Yavapai Counties. For the fourteen years preceding 1966, the U.S. Bureau of Mines reported a total Arizona production of 7,900,000 tons of pumice worth \$15,100,000.

SAND AND GRAVEL

Sand and gravel are products of all States in the Union, and Arizona is no exception. Records of Arizona production were first reported statistically in 1917, and the following tabulation shows the tremendous increase since then:

	Tons	Value
1917-1948 (Ariz. Bur. Mines)		\$ 15,668,000
1949-1954 (U.S. Bur. Mines)	15,741,000	12,147,000
1955-1960	66,130,000	57,635,000
1961-1966*	97,237,000	103,234,000
1917-1966 Total Value		\$188,684,000

* 1966 Preliminary

STONE

Commercial stone in Arizona is broadly classified as dimension stone and crushed stone.

Dimension stone is used in buildings, walls, pavements, curbs, flagging and ornaments. Commercial shipments of sandstone have been made from Coconino, Navajo and Yavapai Counties. Coconino sandstone of various colors now is quarried near Ash Fork and Drake. Granite rock for building and monumental purposes has been quarried in several Arizona localities, chiefly near Prescott, Phoenix, Casa Grande and Salome. Volcanic tuff also has been quarried in several counties for buildings.

Marble has been quarried in Cochise County over a period of many years, in the Dragoon Mountains and earlier in the Chiricahua Mountains. In recent years, much of the production has been crushed and sized for roof coatings. Marble also was produced in Pima, Yuma and Yavapai Counties. Onyx marble has been produced

MICA

The Mica produced in Arizona has been of the scrap variety. Four operators in Maricopa, Mohave, Pima and Yuma Counties have accounted for most of it. In recent years, the bulk of the production has been by the Buckeye Mica Co. with mill at Buckeye. Although some mica has been produced for many years, published records are incomplete. It is estimated that for the period 1951-1963 the value of Arizona's mica production exceeds \$600,000.

PERLITE

Perlite deposits near Superior first became of interest in 1924, and commercial production commenced in 1946. Production was small from 1946 to the end of 1948, and was even less in the following years, due to technical problems connected with its use; but beginning with 1951, it started back up. The U.S. Bureau of Mines reported perlite production from 1954 to 1957 inclusive, totaling 42,179 tons valued at \$305,396.

Production dropped in 1958, due largely to the closing of the Superior Industries, Inc., and Lee's Perlite Industries, Inc. operations in Pinal County. Figures have not been published for years after 1957, but there was an increase in 1959 and perlite popping plants were operated at Phoenix by Perlite Industries of Arizona, Inc. and at Tucson by Tucson Perlite, Inc. The same plants operated in 1960.

Since 1960, Arizona Perlite Roofs, Inc. successor to Perlite Industries of Arizona, Inc., and Harborlite Corp. have been the principal producers of Arizona perlite. Expanded perlite was produced from purchased material by Supreme Perlite, Inc., at Phoenix, for use mainly in plaster. Expanded perlite also is used for insulation, concrete aggregate, roof decking and soil conditioning.

Total production of Arizona perlite to the end of 1963 exceeded \$1,000,000 in value.

PUMICE

Arizona in 1965 produced 1,161,000 tons of pumice valued at \$1,515,000. This was 37 per cent of the Nation's output and more than any other state produced. It came from eleven mines in

of technological improvements in mining and metallurgy, which make possible the treatment of larger tonnages and the production from very low grade deposits that were formerly uneconomical to treat. Through the technological improvements, waste dumps are being leached so that high production may be sustained to offset the high wages.

COPPER TARIFF

The copper industry is a world industry and copper is a world commodity. In 1965, 47% of the Free World's copper was produced in countries of Africa and Latin America which are not large consumers of copper. The United States is the largest consumer of copper in the World and Arizona produces more than one-half of U.S. production.

Until 1940, the United States mined more copper than it consumed and was an exporter of copper — except for 1929 and the depression years 1930-1932. At such times as Free World production exceeds consumption which the Free World is called upon to supply, competition develops with foreign producers for part of the United States market.

In order to protect the American industry against competition from the foreign miners who operate their higher grade mines with a much lower per-hour labor cost, it becomes necessary to take steps to prevent the curtailment of United States mine production with the resultant decrease in the labor force.

Therefore, effective June 21, 1932, Congress imposed a 4¢ per pound excise tax on copper imports.

When a great shortage of copper develops in the United States in spite of the operation of our copper mines at capacity, foreign copper is brought in at premium prices and the excise tax is superimposed upon such higher foreign price until pressure from the fabricators on behalf of the consumers results in the suspension of the excise tax.

When copper again becomes plentiful, labor organizations and the domestic mining interests again seek to have the excise tax reimposed by Congress.



Open Pit Copper Mine

The Arizona Bureau of Mines gives the approximate value of feldspar produced in Arizona in the period 1923-1961 at \$4,750,000.

GEM STONES

Turquoise, tourmaline, opal, agate and other gem stones have been produced in Arizona, and all counties have contributed. The value of production through 1966 is approximately \$2,350,000.

GYPSUM

Arizona's gypsum production, which is used mostly in cement, but also in wallboard and soil conditioning, increased from 6,686 tons in 1951 to 96,000 tons in 1956 to a record 147,000 tons in 1964. It was 88,000 tons valued at \$460,000 in 1966. The output comes chiefly from the Arizona Gypsum Corporation's properties near Feldman, Pinal County, and Camp Verde, Yavapai County, and the National Gypsum Company's property near Feldman. The latter company ships to its wallboard plant at Phoenix, built in 1955.

The value of gypsum production in Arizona to the end of 1966 is estimated to be \$7,000,000.

LIME

Lime for building purposes has been produced in Arizona since 1894. The lime plant at Nelson at the northwest corner of Yavapai County, now owned by the U.S. Lime Products Division of Flintkote, is said to have furnished most of the lime used in the rebuilding of San Francisco after the earthquake and fire of 1906. Since 1915, the larger proportion of the lime produced in Arizona has been used in the flotation process at the large copper concentrators, and most of this has come from the Paul Lime Plant at Paul's Spur in Cochise County, and from Hoopes & Company in Gila County. Some copper companies make lime for their mills from limestone quarried at their own properties.

The total value of lime produced in Arizona to date is approximately \$47,000,000.

The Arizona Bureau of Mines estimates the total value of Arizona asbestos produced from 1914 through 1961 at approximately \$15,820,000. Figures are not available for the years, 1962 to 1964 inclusive nor for 1966. In 1965, 3,469 tons valued at \$441,000 were produced.

CEMENT

The first cement plant in Arizona was built by the Arizona Portland Cement Company at Rillito, Pima County. The plant was started up in December, 1949, with a capacity of 2,000 barrels per day. Capacity was increased to 4,000 barrels per day in 1951 and to 7,000 barrels per day in 1955. Present capacity is about 8,000.

The next of the two Arizona cement plants was built by the Phoenix Cement Co. at Clarkdale to meet its commitment to supply 3 million barrels of cement to the Glen Canyon Dam project. The plant was started in operation in the fall of 1959. Its initial capacity was 5,000 barrels per day. An additional kiln installation was completed in mid-1961 to bring plant capacity to about 2,600,000 barrels per year.

CLAYS

Clays have been produced in Arizona since 1894. A white bentonite or bleaching clay from open pits near Sanders, Apache County, has been of chief importance in the past. In recent years clays in Pima County for clay products and in Yavapai County for cement have been of principal value, with lesser amounts from Apache, Gila and Maricopa Counties.

According to the United States Bureau of Mines, the Arizona production of clays (exclusive of bentonite and fire clay) from 1962 through 1966 was 741,000 tons valued at \$945,000.

DIATOMACEOUS EARTH

Diatomaceous earth is mined and processed near San Manuel in Pinal County, for use chiefly in insecticides.

FELDSPAR

High quality potash feldspar is mined and ground near Kingman, Mohave County, by International Minerals and Chemicals Corp., for use in glass and pottery.

The original 4¢ was established for a two-year period and was successively extended until 1949. However, at the end of 1940, the Metals Reserve Company contracted for the full annual production of the principal Latin American countries in order to provide for a stockpile of copper for World War II, and the tax was therefore not operative from 1940 to late 1946.

Impositions and suspensions have been recurrent since, and at trade conferences at Geneva tariffs have been cut with the result that in recent years the copper excise tax has been 1.7¢ instead of 4¢ until June 1966 when Congress again suspended it until June 30, 1968.

World conditions also have changed. The great copper producing countries of South America and Africa are becoming increasingly dependent upon copper as the major source of the National income. They are more and more planning and dictating the amount of copper to be produced from their mines, the price at which the copper is to be sold and the markets to which the copper is to be delivered. They want to sell all they can at the highest price they can get, but if they can't sell their output at the going price, they will go lower. Therefore, there is fear that tariffs may not protect our higher-cost domestic production, and that it may become necessary to impose quotas in order to keep our vital domestic industry and not lower the living standards of its personnel.

Recent Developments

Over the last ten years Arizona has increased its copper production from 500,000 tons to over 700,000 tons of copper per year. Yet the search for new ore bodies and the expansion of operations at existing ore bodies to keep up with the increasing demand for the metal, and for improved methods of extracting copper from their deposits, continues.

New mines which were brought into production during the last ten-year period with an aggregate capacity of 106,500 tons per annum include Asarco's Mission Mine southwest of Tucson, Duval's Esperanza Mine southwest of Tucson and Mineral Park Mine near Kingman, Inspiration's Christmas Mine near Winkelman, and

Rancher's Bluebird Mine near Miami. Expansion of production facilities or improvements in metallurgical processes amounted to an incremental production totalling approximately 101,500 tons per year at the end of the 10-year period at Phelps Dodge's Morenci Mine, Kennecott's Ray Mines Division, Bagdad's Leaching operation, Asarco's Silver Bell Mine, Inspiration's Mine, Magma's San Manuel Mine and Pima's Mine near Tucson.

Between 1967 and 1970, Anaconda's Twin Buttes property will be brought into production with an estimated capacity of 46,000 tons per annum and Asarco is scheduling for production in 1969 on the Papago Indian Reservation a new open-pit mine to be known as the North San Xavier Unit. Further increases in production at presently operating mines totalling 89,500 tons are projected at Kennecott's Ray Mines Division, Bagdad, Asarco's Silver Bell and Mission Units, Pima, Duval's Esperanza Mine and Inspiration. There are other projects under study, both potential new mines and production increases at presently operating mines — so that an additional aggregate of 200,000 tons of production may be anticipated within the next five years.

The tons of ore mined by the major copper-producing mines in Arizona in 1966 are listed in Table III.

NON-METALLIC MINERALS

ASBESTOS

Gila County is the only area in the United States which produces high-grade, low-iron-content, chrysotile asbestos. These Arizona deposits once were the only low-iron chrysotile deposits known in the Western Hemisphere, but now the Cassiar deposit in British Columbia is a strong competitor. The Cassiar asbestos is cheaper to mine, but Arizona has advantageous transportation costs and lower iron content.

The depression picture that gripped this asbestos industry after December 31, 1958, when the U.S. Government stopped purchase of fiber for stockpiling, has changed, and three modern processing mills have been erected as a result of the aggressive leaders of several asbestos companies searching for, and finding, new markets for their products. The asbestos companies which built these modern fiberizing mills were Jaquays Mining Corporation, Metate Asbestos Corporation and Le Tourneau Asbestos Company et al. Rex Town now operates the Le Tourneau, the other two not having changed. The mills are located at Globe.

Most of Arizona asbestos is short fiber, grading through crudes Nos. 3 to 7. Only a very small percentage is longer fiber, high priced crude Nos. 1 and 2 grades for which the market is small. The very low iron content of the Gila County chrysotile makes it eminently suitable for electrical insulation uses. The bulk of the fiber sold is for filter media and of the short fiber grades.

The period of Government purchases from 1952 to 1958 resulted in the opening and reopening of a number of asbestos mines. The largest of these were the Regal, Phillips, Crown, Chrysotile and Rock House. The bulk of the recent Arizona production has come from the Regal and Chrysotile mines of the Jaquays Mining Co.

In the period from 1952 to 1958, the Government purchased 3,240 tons of Nos. 1 and 2 crude asbestos at a cost of \$3,845,314 and 1,897 tons of No. 3 crude costing \$758,424. In 1960, contracts were made for the purchase for the National stockpile of 500 tons of No. 2 crude at \$918.30 per ton.

Counties, have had considerable attention, but production to date has been very small. Claims have been located on large areas of sands containing magnetite in Pinal, Yavapai, Maricopa, Yuma, Mohave and other counties. A deposit of these sands southeast of Florence has been the supplier of magnetite concentrates for a 75-ton sponge iron and steel plant constructed near Coolidge, Arizona in 1960-61. This plant is equipped for use of the Madaras process. Production to date has been small.

Two of the major copper companies have plants for making sponge iron for use in precipitating copper from leach solutions.

There is a large amount of iron in the copper slag dumps in Arizona. This no doubt will be recovered in the future.

RARE METALS

Of the 92 chemical elements of which the earth is composed, 68 may be classed as metals. Perhaps half of these are commercially important, although only about 20 are used now.

It has been said that development of metals got an impetus during the war that would have taken 50 years of peacetime effort to accomplish. Many new uses for metals and new alloys have passed the experimental stage, and many more will be discovered. That statement applies particularly to the more obscure metals, the newcomers to important industrial use, such as selenium, tellurium, germanium, indium, columbium, beryllium, tantalum, thorium, uranium, and, the latest, europium.

The term "rare metals" is often a misnomer insofar as it may imply scarcity. Uranium and lithium are more widespread in the earth's crust than is zinc; thorium than lead; and beryllium and rubidium than tin. Indeed, spectrographic analyses of rocks and minerals are demonstrating that many so-called rare elements are rare only in the sense that they are neither well known or easily recognized. Today's tremendous advances in technology are calling more and more for new substances having special qualities. Singly or in combination, these unfamiliar elements are now important articles in everyday use. Arizona now produces substantial amounts of uranium. Because of its varied and widespread mineralization, this state could easily become an important source for more of these rare elements.

TABLE III
Major Arizona Copper Mines, 1966

Open Pit Mines

Mine	County	Operator	Tons Ore Mined
Morenci	Greenlee	Phelps Dodge Corp.	19,324,691
New Cornelia	Pima	Phelps Dodge Corp.	10,486,937
Ray	Pinal	Kennecott Copper Corp.	8,829,440
Inspiration	Gila	Inspiration Cons. Copper Co.	6,446,836
Lavender Pit	Cochise	Phelps Dodge Corp.	6,107,436
Pima	Pima	Pima Mining Co.	6,024,014
Mission	Pima	Amer. Smelting & Refin. Co.	5,968,600
Mineral Park	Mohave	Duval Corp.	5,559,094
Esperanza	Pima	Duval Corp.	4,384,278
Copper Cities	Gila	Miami Copper Div. Tennessee Corp.	4,353,896
Silver Bell	Pima	Amer. Smelting & Refin. Co.	3,576,600
Bagdad	Yavapai	Bagdad Copper Corp.	2,091,899
Total Tonnage			83,153,721

Underground Mines

San Manuel	Pinal	San Manuel Div. Magma Copper Co.	14,391,335
Christmas	Gila	Inspiration Cons. Copper Co.	934,813
Copper Queen	Cochise	Phelps Dodge Corp.	721,209
Magma	Pinal	Magma Copper Co.	431,913
Total Tonnage			16,479,270
TOTAL			99,632,991

Smelters and Refineries

There are 8 copper smelters, 1 each at Morenci, Ajo, Douglas, San Manuel, Superior and Inspiration, and 2 at Hayden (Kennecott's and Asarco's). Inspiration Consolidated Copper Company operates an electrolytic refinery at Inspiration in addition to its smelter. Bagdad Copper Corporation in a joint venture with Chemetals Corporation has completed construction of a plant to refine

cement copper to copper powder of high purity by a chemical process. The plant will have an estimated capacity of 8,250 tons per year. The product will be used chiefly "for bearings, friction materials, and melting stock briquettes."

MOLYBDENUM

The 1924 Edition of "Mineral Resources of the United States" published by The United States Bureau of Mines lists molybdenum among the "Rare Metals" and reports that it was produced by only two companies. The Yearbook states that the use of molybdenum was "confined to the addition of 0.25 to 0.75 per cent to steel as a toughener taking the place of nickel and possibly vanadium." Molybdenum in ore and concentrates produced in the United States and sold in the 8-year period 1917-1924 totalled only 1,864,504 pounds.

In 1966, the Bureau of Mines reported the production of 89,905,000 pounds of molybdenum contained in concentrates. In spite of this large production molybdenum has been in short supply and great dependency has been placed upon the release of molybdenum from Government stockpiles.

Molybdenum metal and molybdenum-base alloys are virtually indispensable in a wide range of applications in the electronic and electric industries, in missiles and aircraft, in metalworking, in the chemical, glass and metallizing industries, and in nuclear energy applications. The iron and steel industries account for about 85 per cent of the molybdenum consumed, mainly in high speed and tool steels, in stainless steel, in gray and malleable castings, in coating for welding rods and in high temperature alloys. Molybdic oxides and chemical compounds of molybdenum are used in the manufacture of inorganic and organic pigments and catalysts and miscellaneous material such as magnets, friction material, lubricants, pesticides, refractories, packings, etc.

Arizona is the third largest molybdenum producer in the United States, with about 12 per cent of the total production. Second only to copper it yields the State its next largest income from metal mines. In 1966 it amounted to \$16,810,000, greater than that of gold, silver and lead combined. Production comes entirely as a by-

years and the price has risen, in spite of releases of several million pounds from the National stockpile, to a point where interest again is being taken in Arizona tungsten deposits.

MERCURY

Mercury (quicksilver) is the only metal that is liquid at common temperatures. It also has high specific gravity, high electrical conductivity and other valuable properties.

Quicksilver deposits have been worked in the Dome Rock Mountains near the western boundary of Arizona; in Copper Basin, southwest of Prescott; in the Phoenix Mountains; and in the Mazatzal Mountains, north of the Roosevelt Dam. From 1910 to 1928, none of these reported appreciable production. At best, the yield probably did not exceed a few hundred 76-pound flasks, with a total value of perhaps \$25,000. Total Arizona production has been about 9,600 76-pound flasks worth about \$1,500,000.

The period of greatest Arizona production was from 1940-1944 inclusive in World War II. All of these years exceeded the production in 1955 of 477 flasks, the record outside of these World War II years. The year of maximum value of Arizona mercury output, however, is 1966 when 389 76-pound flasks had a value of \$165,000. The record 873 76-pound flasks in 1941 had a value of only \$161,500.

VANADIUM

One of the important uses of vanadium is in the production of high quality steels. The total value of vanadium produced in Arizona through 1947 is estimated at \$460,000. Prior to 1945 it was obtained largely from complex ore operations in the Mammoth District in Pinal County, but more recently it has been recovered from uranium ores of Apache County and to a lesser extent from Navajo County. The U.S. Bureau of Mines has not reported the quantity of Arizona's production from 1947 to 1966. The 1964 and 1965 productions have been valued at \$575,000 and \$381,000 respectively, but no values have been reported for the prior years or for 1966.

IRON

Arizona's iron occurrences are varied. Four areas of hematite-magnetite deposits, in Gila-Navajo, Yavapai, Maricopa and Yuma

all counties of Arizona, but production has come mainly from Apache, Navajo and Coconino Counties. Present production is from mines in northern Apache and Navajo Counties. There is no uranium processing plant in Arizona and the ores are shipped to Mexican Hat and Moab, Utah; Shiprock, New Mexico; and Grand Junction, Colorado.

The former principal producer, the Orphan Mine at Grand Canyon, closed down in 1966. Its ore was the principal feed for an uranium processing plant at Tuba City, Arizona, which not only was closed when the Orphan Mine ore stopped, but was dismantled. However, 1966 saw a rise of several hundred per cent in projects for nuclear power installations, and the Orphan Mine is now being prepared for resumption of production.

The more important of the areas no longer producing are the Cameron in Coconino County, the Globe in Gila County and the Santa Maria in Yavapai and Yuma Counties.

In 1965, uranium ore production was reported from 26 operations, compared with 42 in 1961 and 86 in 1958. The grade of ore produced in 1965 was 0.38 per cent (7.6 pounds per ton) U_3O_8 , or about the same as in the previous two years.

The total value of uranium ore produced in Arizona from 1956-1966 inclusive was \$53,000,000.

MISCELLANEOUS METALS

TUNGSTEN

Tungsten is an important metal with the highest melting point of any metal. Its carbides and alloys are very hard and wear-resistant even at elevated temperatures.

Arizona was a relatively small producer of tungsten from 1910 to 1956, when the government ceased purchases of tungsten for the National stockpile. Since 1956, production of Arizona tungsten ores has practically ceased. The mines are unable to compete with low-priced tungsten imported chiefly from Korea, Portugal, Bolivia, Australia and Peru. Total value of Arizona tungsten ore production from 1910 to date is approximately \$7,000,000.

Demand for tungsten has increased considerably in recent

product of copper ores, and presently it is recovered from nine of the State's copper mines, some of which are so low in copper content of the ores that it would hardly be profitable to operate the mine unless the income were forthcoming from the recovered molybdenum.

It is anticipated that the production of molybdenum in Arizona will increase substantially in the near future due to new production to come from the Twin Buttes' mine of the Anaconda Company, from the new molybdenite plant being built at the Kennecott Ray Mines Division at Hayden, and from the expanded mine production at Silver Bell and Mission Mines of Asarco, the Esperanza mine of Duval and the Inspiration and Pima mines.

The following summary of Arizona's molybdenum production brings out the growing importance of this metal to the economy of the State:

Years	Production (pounds)	Value
1914-1948	13,425,000	\$8,726,000
1949-1954	7,380,000	7,048,000
1955-1959	11,775,000	14,098,000
1960-1964	25,498,000	34,423,000
1965	9,399,000	15,880,000
1966	10,240,000	16,810,000

GOLD AND SILVER

Gold mining in Arizona did not start to any appreciable extent until after the acquisition of the territory by the United States from Mexico in 1848 and 1853.

In 1853, the only accessible parts of the Territory were around Tucson and Tubac, where several silver mines and one copper mine were opened, but little or no mining was done. The outbreak of the Civil War caused the withdrawal of troops and all mining ceased.

During the Civil War, troops came back and prospecting parties were organized. Rich placer gold deposits were found near the Colorado River at Gila City, at La Paz, Quartzsite, and Rich Hill, and along Lynx Creek, Hassayampa River, and Big Bug Creek

in the Bradshaw Mountains of Central Arizona. After the richer parts of the placers were exhausted, gold ledges were located and worked in the crudest manner.¹ The Vulture was the only large mine worked.

After the Civil War, troops were again withdrawn, and with the Apaches again rampant, little mining was done except around Prescott and Wickenburg. Peace was made in 1872, but with commodity prices and mining costs high, gold mining was less attractive than silver and copper. A silver boom followed, and rich mines in the Bradshaws, Silver King, Globe and Tucson areas were discovered. The purchasing power of gold increased during 1884 to 1893 when silver de-monetization stopped practically all silver mining. The silver miners turned to the search for gold, and discovered the Congress and Octave deposits in the Bradshaw Mountains, the Mammoth, north of Tucson, the rich Harqua Hala, La Fortuna, and King of Arizona mines in the desert of Yuma County, and numerous others. Better concentration methods and the cyaniding process encouraged the reopening of old mines.

Commodity prices turned upward near the close of the century, gold mining again became less attractive and, except for short periods, stayed so until the start of the depression in 1929. However, the rich vein deposits of the Gold Road, Tom Reed, United Eastern, and others in the Oatman district and the older mines of the Bradshaw Mountains and Yuma County, were producing—the latter on a reduced scale except for the North Star Mine. The Commonwealth silver mine also produced.

The depression of the Thirties caused a return to active gold prospecting, \$35.00 gold further stimulated the search and there was activity in most of the old gold camps and some new. Activity slowed some, as commodity prices rose following the depression, and stopped with the World War II order L-208 closing all gold mines because of labor shortage.

Before the advent of the big porphyry copper producers in 1912, the gold lode mines and placers were accounting for 75 per cent of gold production in Arizona. From 1912 until 1942, the gold mines and placers still accounted for almost half of Arizona's gold production, but since then, as a result of order L-208, production from gold lode mines and placers has dropped to below 3 per cent

1. J. B. Tenney, Ariz. Bureau of Mines Bull. 137, p16, Aug. 15, 1934.

MANGANESE

Low grade manganese ore occurs in Arizona in a quantity estimated by the United States Geological Survey at 200,000,000 tons with about 4% manganese. It is not visionary to predict utilization of this ore in the future when one remembers that the United States is largely dependent upon foreign sources for its manganese.

Government purchases of manganese ores from 1953 to 1955 resulted in a stockpile at Wenden, Arizona of over 300,000 tons of ore containing less than 20 per cent manganese. This ore will have to be up-graded before it is usable in the steel industry.

Under a later carlot program, additional Government purchases of Arizona manganese ore and concentrates were made until 1959. The quota on the carlot program was reached, and purchase of ore for the Government stockpile was halted on August 5, 1959. Production in 1959 was reported from 82 mines in 9 counties. Yuma and Maricopa counties were the largest producers, followed by Pinal, Pima and Mohave. There were attempts in 1960 and 1961 to continue in business by shipping to steel plants, but they were not successful and no mines have reported production since 1961.

A summary of Arizona production is given in Table V. These figures are approximate.

TABLE VI
Manganese Ore and Concentrates

	Long Tons	Value	Per Ton
Years 1915-1952	75,000	\$ 1,956,000	\$26
Wenden—Years 1953-1954	152,000	10,743,000	70
Carlot— Years 1955-1959	262,000	21,591,000	82
Year 1960	1,626	40,000	25
Years 1961-1966*	-----	-----	-----
	490,626	\$34,330,000	\$70

* Figures not available, small amount in 1961 only.

URANIUM

The use of uranium as a source of atomic energy is well known. Discoveries of uranium-bearing minerals have been made in

TABLE V

	Tons Lead Annual Rate	Tons Zinc Annual Rate
1894-1910	2,075	1,045*
1911-1935	6,376	2,678
1937-1941	12,250	9,900
1942-1946	18,400	30,233
1947-1952	25,388	56,734
1953-1959	10,566	28,145
1960-1965	6,546	28,358
1966 P	5,150	16,380

* Annual Rate from 1905-1910

P—Preliminary



Same Lead-Zinc Mine About 60 Years Later

of the total. By 1944 the annual production from these mines had dropped from 156,000 ounces in 1944 to a mere 10,000 ounces. Although the gold mines were permitted to re-open after World War II, the deterioration of the mines, due to the long shut-down, and the rapid increase in mining costs together with the rapid decline in the purchasing power of the dollar, prevented their doing so. Today there is not one bona fide gold or gold-silver mine in operation in Arizona, except for a few producing siliceous fluxing ores for the copper smelters. With the cost of equipment, supplies and labor being so disproportionate to the price received for gold, there has been no incentive for them to re-open their old gold mines or explore for new ones. The increase in silver price to the statutory value of \$1.293 with the most probable further increase in the price of silver when the government becomes obliged to cease selling silver at the statutory price has stimulated interest in silver and silver-lead mines.

From the average ton of Arizona copper ore mined in 1965, \$0.12 in gold and silver were recovered compared with \$0.354 recovered per ton of ore mined in 1941. The gold and silver content tends to decrease, as does the copper as mines get deeper.

Also contributing to the decrease in the gold-silver value recovered from a ton of copper ore mined is the fact that ore that is leached yields a copper precipitate which contains practically no gold or silver. Gold and silver present in the ore will associate with copper in the concentrates produced by flotation. Therefore the treatment of greater quantities of leaching ore lowers the yield of gold and silver per overall ton of all copper ore treated. Still further contributing to the decreasing yield of gold and silver values per ton of total copper ore treated is the fact that the new mines that have recently been brought into production and those under development contain very little of the precious metals. For each ton of ore mined in 1941, 0.0059 ounces of gold and 0.207 ounces of silver were recovered and in 1965 these figures dropped to 0.0014 ounces and 0.058 ounces, or 76 and 72 per cent respectively.

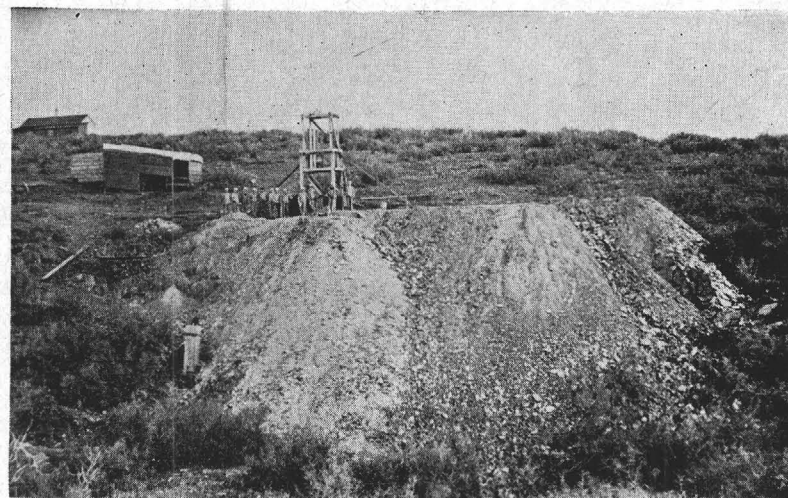
Therefore except for the possibility of new discoveries leading to the development of new gold and silver mines, there is little likelihood of gold and silver recovered from Arizona's mines paralleling the potential increase in copper recovery.

LEAD AND ZINC

The first production of lead in Arizona reported statistically by the Arizona Bureau of Mines, was in 1894, and that of zinc, in 1905. However, there are records of actual production of both metals prior to that time. For example, some lead was mined in the Bisbee or Warren District prior to 1880. Some silver-lead ore was shipped during the period 1882 to 1893 from the San Xavier, Fortuna, Banner, Chloride and other mines of the Pima District. Mineral deposits, including lead carbonate and other silver-lead ores, were discovered in the Aravaipa District before 1880. In the Mammoth (St. Anthony) District, production of lead or zinc was not reported until 1934, though silver and gold had been shipped from the district as early as 1880. The Johnson Camp Area in Cochise County had been worked as a source of copper ores from 1881, but it was not until 1941 that zinc concentrates were produced. Likewise the Magma (Superior) District saw the famous Silver King Mine discovered in 1873, but it wasn't until 1916 that the Magma Mill treated lead-zinc ores. The Big Bug District in Yavapai County had its first production of gold and silver and a little copper in 1906, but did not begin to produce lead and zinc until 1938. The Seventy-Nine lead deposit in the Banner District was first located in 1879, but record of its production of lead and zinc began in 1913.

The Arizona Bureau of Mines reports the production of the Harshaw, Patagonia, Palmetto, Tyndall, Wrightson and Oro Blanco Districts in Santa Cruz County from 1858 to 1933 to have been approximately 19,500 tons of copper, 25,000 tons of lead, \$1,315,000 in gold and \$4,637,000 in silver. The oldest mine is the Mowry. Other notable producers were the Duquesne in the Patagonia District, the Flux, Hardshell and Trench in the Harshaw District and the Montana Mine in the Oro Blanco District. The Montana Mine, operated by the Eagle-Picher Mining Company, ranked as the largest producer of lead and zinc in Arizona from 1935 to 1939 inclusive.

The Iron King Mine in Yavapai County has been the principal producer of lead and zinc since 1951. In 1965 it ranked 10th in lead and 13th in zinc output in the United States. In the first half of



Early Lead-Zinc Mine

1967, it was the only Arizona producer of substantial quantities of these metals. The Old Dick Mine of Cyprus Mines Corporation, next in importance in zinc production, was engaged in sinking its shaft and developing deeper ores.

Low metal prices due to competitive low-cost foreign production, have closed all but these two and a few small producing lead-zinc mines.

Before the year 1947, because of the failure of foreign producers of lead and zinc to furnish our domestic needs, Arizona was encouraged to open up and develop its lead-zinc mines. In 1949 it attained a production of 33,568 tons of lead and 70,658 tons of zinc from a total of 181 mines. A flood of lead and zinc imports from 1952 to 1959 caused metal prices to collapse, and over 100 mines were compelled to shut down. Others have closed since. The Iron King has been the only large lead-zinc mine able to operate continuously since 1952, and it has been kept going only because of its income from gold, silver and copper by-products.