FIFTY YEARS OF MINING IN THE STATE OF ARIZONA

1912-1962



by FRANK J. TUCK

ARIZONA DEPARTMENT OF MINERAL RESOURCES,

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FEBRUARY 14, 1962

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1912 - 1962

Fifty years of Statehood for Arizona have witnessed an amazing growth of the mining industry, with copper playing the leading role. In 1855 the first copper ore was hauled from Ajo to San Diego for shipment to Swansea, Wales. However it was not until 1874 that records were kept of copper production in Arizona. The first year of record reported a production of 400 tons of copper. In 1961, the annual production has exceeded 538,000 tons! Records of gold and silver production go back to 1858; of lead to 1894; and of zinc to 1905.

Prior to Statehood in 1912, Arizona had produced 3,822,046 troy ounces of gold, which, at 20.67 per ounce was worth \$79,009,000; 89,663,960 ounces of silver, which, at \$0.8287 per ounce, was worth \$74,307,000; 1,755,052 short tons of copper, which, at \$0.14424 per pound, was worth \$506,283,000; 40,419 short tons of lead, which, at \$0.0433 per pound, was worth \$3,501,000; 8,551 short tons of zinc, which, at \$0.0545 per pound was worth \$933,000.

In the fifty years of Statehood, 1912-1961, Arizona has produced 8,878,292 troy ounces of gold, which, at \$28.65 per ounce, was valued at \$254,398,000; 274,789,689 ounces of silver, which at \$0.7566 per ounce, was worth \$207,911,000; 16,027,939 short tons of copper, at \$0.2049 per pound, worth \$6,567,926,000; 574,192 tons of lead, at \$0.1012 per pound, worth \$116,184,000; 871,349 tons of zinc, at \$0.1214 per pound, worth \$211,582,000. See Table I.

The total value of the five principal metals produced in Arizona prior to Statehood, is estimated at \$664,033,000, while for the fifty years of Statehood, it amounted to \$7,358,001,000.

In 1911, the last year prior to Statehood, Arizona had produced $4\frac{1}{2}$ million tons of ore, while in the year 1961, Arizona has produced an estimated 68 to 70 million tons of ore, in addition to stripping tremendous tonnages of waste overlying the open-pit ores.

Statehood for Arizona was coincidental with the development of the flotation process for the treatment of metallic sulphide ores. The big low-grade copper mines began to experiment with this process which was successful in increasing recovery of copper from the low-grade ores over the old gravity methods of extraction, by several percent. As time went on, this improved recovery became of increasing importance, as the grade of ore in all the big mines tended to become lower as the mines became deeper.

Prior to Statehood and the Flotation Process, only the mines with rich ores were profitable. Bisbee's Copper Queen Mine, the United Verde Mine at Jerome, Globe's Old Dominion Mine, and the Clifton and Morenci Mines were among these. There have been only two "bonanzas" discovered since that time: the Magma Mine at Superior (1912), and the United Verde Extension at Jerome (1916). The development of the caving system of mining was responsible for the exploitation of the Ray, Miami and Inspiration mines in the early years. The Ray and Inspiration mines became open pit mines in the "fifties" Operations at the Miami underground mine have recently been converted to leaching in place. Magma Copper Company's San Manuel Mine is now the only large low-grade underground copper mine in Arizona. It started production in 1956, mining ore averaging less than 15 pounds of copper to the ton. The open-pit copper mines now operating are the Inspiration, the Copper Cities, the Ray, the Morenci, the New Cornelia, the Lavender Pit, the Silver Bell, the Pima, the Bagdad, the Esperanza and the Mission Unit. The high-grade underground mines are the Copper Queen at Bisbee, the Magma at Superior. The biggest lead-zinc underground mine is the Iron King at Humboldt.

Before the advent of the big porphyry copper producers in 1912, the gold lode mines and placers were accounting for 75 percent 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, production from gold lode mines and placers has dropped to below 3 percent of the total. In 1942 the annual production from these mines had dropped from 156,000 ounces to a mere trickle of 1,000 ounces, a loss of 155,000 ounces, or almost five and one-half million dollars. The loss in silver was over 1,050,000 ounces, which had a value (including seignorage) of almost one and one-half million dollars. 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 the few producing siliceous fluxing ores for the copper smelters. Because of the federal government's control of both gold and silver prices, the producers have not enjoyed the inflationary benefits which other commodities have enjoyed. Result, there has been no incentive for them to re-open open their old gold mines or explore for new ones. The high rate of out-flow of gold from the United States in 1960 raised the hopes of gold miners that there would be an early return to economic conditions favoring gold mining.

For each ton of Arizona copper ore mined in 1959, \$0.109 in gold and silver were recovered. This gold and silver content tends to decrease, as does the copper, with deeper ores. For example, the value of the gold and silver recovered from copper ores in 1941 was \$0.354 per ton of ore mined. For each ton of copper ore mined in 1941, 0.0059 ounces of gold and 0.207 ounces of silver were recovered, and in 1959 these figures dropped to 0.0018 ounces and 0.051 ounces respectively.

Mineral Fuels

Coal production to the amount of 5,000 to 10,000 short tons annually has been coming for several years from 2 mines in the Indian Reservation, in Coconino and Navajo Counties.

The year 1959 was probably the most significant in the history of oil and gas in Arizona. Twenty-seven wells were completed compared with 19 in 1958. Of the 27 completed wells, 25 were exploratory and 2 were development. Two exploratory wells, both in Apache County were listed as discoveries, one an oil well and the other gas. The oil discovery, 8 miles south of the Boundary Butte field in Utah, produced 240 barrels of oil a day from Mississippian formations at a depth of 5,566-5,589 feet. One successful development well, an extension of the East Boundary Butte field, was completed in Pennsylvanian formations and produced 104 barrels of oil and 774 thousand cubic feet of gas a day. The gas well was 4 miles west of the Bita Peak field and flowed at 4 million cubic feet a day from the Hermosa(Pennsylvanian) formation at a depth of 4,999-5,071 feet.

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Production of crude petroleum, all from Apache County, increased in 1960 more than threefold over 1959. Drilling activity increased with 32 wells completed in the first 10 months compared with 24 for the same period in 1959. At the end of October two rotary drills were active compared with one in 1959.

The Kaibab National Forest was opened to oil and gas exploration. As of June 12, 1961, lease applications for 400,000 acres had been filed and were awaiting action by the Bureau of Land Management.

Helium

Interest in the helium wells in northeastern Apache County was heightened by passage by the 86th Congress of the helium conservation bill. The measure encourages production of helium from natural gas by private industry. A number of wells drilled in recent years in the Pinta Dome field contain significant quantities of helium.

Production of helium from the Nation's first privately owned helium plant, owned and operated by Kerr-McGee Oil Industries, Inc., was scheduled to start November 1, 1961. Availability of salable quantities of Grade A helium was expected December 1. The raw gas, from the Pinta Dome field in Apache County, contained 8 percent helium, 90 percent nitrogen, 1 percent argon, and 1 percent carbon dioxide. The helium, the only gas recovered, was valued at \$35 per thousand cubic feet.

COPPER PRODUCTION RECORD AND OUTLOOK

Throughout the fifty years of Statehood, Arizona has not only retained its number one position in copper production in the United States, but has reached the point where it is producing more copper than all the other states combined.

Since 1958, for four years, Arizona's production of copper has amounted to 2,042,341 tons, which is 50.8 percent of the reported U. S. production of 4,020,344 tons. In the first year of Statehood (1912), Arizona produced 182,519 tons of copper, which was only 29.3 percent of the U. S. production of 621,634 tons. Yet Arizona's production has ranked first in the United States for more than fifty years.

This amazing increase in copper production in recent years has been due to exploration activity by several large companies, which are continuing their search for new deposits, and presently show promise of further expansion of the copper industry as future growth in consumption expands.

Note: A booklet "Mining in Arizona, Its Past, Its Present, Its Future" published by this Department in April, 1961, accompanies this commemorative pamphlet, because it has considerable detail not covered in the pamphlet.

TABLE I

ARIZONA METAL PRODUCTION

REPORTED PRODUCTION AND VALUE OF FIVE MAJOR METALS (000 omitted)

PERIOD 1858-1911

GOLD	SILVER	COPPER	LEAD	ZINC
Ounces Value	Ounces Value	Tons Value	Tons Value	Tons Value
3,822 \$79,009 \$20.67/oz	89,664 \$74,307 \$0,8287/oz	1,755 \$506,283 \$0.14424/1ъ	40 \$3,501 \$0.0433/1b	9 \$ 933 \$0.0545/1b

50-YEAR PERIOD 1912-1961

" GC	DLD	SI	LVER	C	OPPER]	LEAD	2	LINC
Ounces	Value	Ounces	Value	Tons	Value	Tons	Value	Tons	Value
8,878 \$28,	\$254 , 398 65/oz	274,790 \$0.7	\$207,911 566/oz	16,028 \$0.2	\$6,567,926 2049/1b	574 \$0.1	\$116,184 L012/1b	871 \$0.]	\$211,582 L214/1b

First year of reported production: gold & silver 1858; copper-1874; lead-1894; zinc-1905.

Tota Tota	al Valu al Valu	e of e of	Five Five	Major Major	Metal Metal	s - s -	Period 50 Yr.	1858- Perio	1911 d 1912-	1961	-	\$ 7	664,033, ,358,001,	,000
GRAND	TOTAL	VALUE	OFI	FIVE M	AJOR M	ETAI	LS 1858.	-1961	INCL.	-		\$8	022,034	,000

MINERAL PRODUCTION OTHER THAN THE FIVE MAJOR METALS

No significant amount of minerals other than copper, lead, zinc, gold and silver was reported during Arizona territorial days. The Arizona Bureau of Mines and the United States Bureau of Mines have both made rough estimates of the value of the production since Statehood, of the following miscellaneous minerals which have been produced in Arizona since 1911:

Metals: Beryllium, manganese, mercury, molybdenum, tungsten, uranium, vanadium and rare metals.

Non-Metallics: Asbestos, cement, clays (bentonite), gypsum, lime, mica, perlite, pumice, sand & gravel, stone, and such miscellaneous non-metallics as barite, coal, diatomaceous earth, feldspar, fluorspar, nitrogen compounds, and gem-stones.

The total estimated value of the miscellaneous metals and non-metallics up to and including 1961 was \$445,990,000.

TERRITORIAL AND STATE HISTORY OF MINING IN ARIZONA

Period 1854 - 1870

In 1854, one year after the Gadsden Purchase from Mexico, Charles D. Poston began the search for gold and silver near Tubac. In the following year, rich copper ore was hauled from Ajo to San Diego for shipment to Swansea, Wales. In 1856 the Santa Rita silver mine near Tubac was opened. In 1857, prospectors began to enter Arizona in numbers, and gold ore was found in Mohave County near the Colorado River. In 1858 came the discovery of the Mowry lead-silver mine in the Patagonia Mountains; also discovery of the Gila City or Dome placers near Yuma.

In 1859 rich silver ore was mined at Heintzelman Mine in Cerro Colorado Mountains.

In 1861 came the Civil War with withdrawal of troops, followed by Apache depredations. In 1862 Confederate troops occupied Tucson. They were driven out by California Column under General A. M. Carleton who established posts at Camp Verde, Fort McDowell, and Fort Whipple. Also in this year, the La Paz gold placers were discovered by Pauline Weaver.

In 1863, the Castle Dome district, near Yuma, became known. Discovery of many placer and lode deposits was made in the Prescott region. The Moss Mine, Oatman District, Vulture Mine near Wickenburg and Planet Mine, near the Williams River, were discovered. The Moss and Vulture were gold mines, the Planet was copper. Many lode deposits were discovered in Mohave County.

Arizona was made a Territory, chiefly because of the many gold discoveries, but also because of the influence of that indefatigable explorer, Charles D. Poston, who was the first individual to present an organized plan for the Territory of Arizona to Congress, in December, 1862. The Congress provided for a temporary government for the Territory of Arizona, approved February 24, 1863; but it was not until December 27, 1863 that the Territorial officers appointed by Lincoln arrived in Arizona. Attended by a military escort to protect them from Indians, they set up the Territorial government on December 29 in a snow storm at Navajo Springs. John Gurley of Maine, had been named by President Lincoln as Arizona's first Governor, but Mr. Gurley died before assuming the office. John Goodwin was named by Lincoln to assume the office of first Territorial Governor of Arizona in 1863. The Capital was moved from Prescott to Tucson, November 1, 1867. It was relocated in Prescott in 1877, and remained there until it was moved to Phoenix on February 4, 1889.

CHRONOLOGY Period 1871 - 1911

- 1871 The Federal Government sends a large number of troops to end the Apache problem, which is finally settled with the surrender of Geronimo in 1886.
- 1872 The Town of Clifton founded by Metcalf and Stevens.
- 1873 The U. S. Mint, by Act of Congress, discontinues the coinage of silver dollars. Great financial and industrial panic.

- 1874 Globe becomes a booming silver camp. Railroad built from Clifton to Metcalf, the first in Arizona. McCracken silver-lead mine discovered in Mohave County. Richmond Basin Silver district northeast of Globe is opened.
- 1875 Silver King Mine in Superior district is discovered by Mason and Copeland. Silver Queen (Magma) also discovered. The Lesinsky brothers build a copper furnace of one ton daily capacity at Clifton. Detroit Copper Company founded, and mining started at Morenci.
- 1876 Southern Pacific Railway reaches Gila Bend from California. United Verde ore body discovered at Jerome by M. A. Ruffner. Activity at Mineral Park district, Mohave County.
- 1877 John Dunn, Army Scout, makes first location in Warren district. Ed Schieffelin begins his hunt for his "tombstone".
- 1878 First shipment of matte from Copper Queen claim. First locations made at Tombstone recorded. Act of Congress makes silver legal tender.
- 1879 Boom started at Tombstone.
- 1880 Lesinsky sells out to Arizona Copper Company at Clifton after making \$2,000,000. Phelps Dodge, on advice of Dr. James Douglas, buys half interest in Detroit Copper and builds a small smelter at Morenci. Dr. Douglas makes first visit to Bisbee. Silver-copper ore is mined from Silver Queen (now the Magma) at Superior.
- 1881 Railroad reaches Lordsburg. Old Dominion Copper and Smelting Company starts operations at Globe. Phelps Dodge acquires Atlanta claim at Bisbee. Mammoth district opened. A small copper furnace goes into operation at the present site of Miami.
- 1882 United Verde Copper Company is organized. Atlantic and Pacific Railroad crosses northern Arizona.
- 1883 Some copper mining is undertaken at Ray. A small smelter is built at Jerome.
- 1885 Copper Queen Consolidated Mining Company is formed. Territorial Legislature creates the University of Arizona.
- 1886 Bonanza ores become exhausted at Morenci and a concentrator is built by William Church to treat oxidized ore that averaged 6.5 percent copper. Six furnaces in operation at Globe.
- 1887 Dennis May discovers Congress gold mine.
- 1888 Dr. James Douglas turns down United Verde because of inaccessibility. Old Dominion Company reorganized at Globe. First building to house the School of Mines at University of Arizona is completed at Tucson. Harquahala gold deposit is discovered.
- 1889 Territorial Capital is moved from Tucson to Phoenix on February 4th. Senator W. A. Clark obtains control of the United Verde mine, which resumes operations.

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- 1890 Sherman silver purchase bill is enacted by Congress. Louis D. Ricketts becomes assistant to Dr. Douglas.
- 1891 The cyanide process, after years of experimenting, becomes a success in South Africa and revolutionizes gold mining.
- 1892 Phelps Dodge Corporation purchases United Globe Mines at Globe, and also certain claims in the Miami district.
- 1893 Silver is demonetized. Disastrous panic. Prospectors turn from silver to gold. Copper Queen begins working sulphides.
- 1894 Rail connection completed to Jerome. An unsuccessful attempt is made to work the Ajo deposit.
- 1895 Cyanide process is introduced at Congress Mine, one of the first installations of its kind in this country. Fortuna Mine southeast of Yuma is discovered.
- 1896 King of Arizona Mine, northeast of Yuma is discovered by Chas. E. Eichelberger. McKinley elected President, and gold standard assured. First disseminated copper ore is treated at Clifton by James Colquhoun, but this was relatively high-grade ore.
- 1898 War with Spain.
- 1899 Daniel C. Jackling pioneered treatment of low-grade porphyry ore at Bingham, Utah. United Verde Extension Mining Company formed. An English Company, Ray Copper Mines, Ltd., unsuccessfully attempts to work Ray deposit.
- 1900 A smelter is built at Douglas by Phelps Dodge Corporation. Rich gold ore is found in Oatman district. John R. Boddie, Captain Huie, and several others organize the Cornelia Copper Company to work the Ajo deposit.
- 1902 Calumet and Arizona Company is organized.
- 1903 Phelps Dodge obtains control of the Old Dominion at Globe. Gold Road Mine is discovered in Oatman district.
- 1904 F. L. Ransome, of the U. S. Geological Survey, prepares report on the Bisbee district.
- 1905 Waldemar Lindgren writes report on Morenci for the U. S. Geological Survey.
- 1906 Philip Wiseman and Seeley Mudd obtain options at Ray. J. Parke Channing examines the copper deposits at Miami, and exploratory shafts are started. The famous McGahan vacuum smelter is built at Ajo, the most fantastic metallurgical scheme ever devised. First low-grade porphyry copper production at Morenci.
- 1907 Daniel C. Jackling undertakes extensive development work at Ray. John Lawler owns eight claims at Bagdad. Panic of 1907.
- <u>1907-1908</u> Arizona passes Montana in copper production and becomes the No. 1 copper producer in the U.S.

- 1908 Miami Copper Company and Inspiration Copper Company are organized. Tom Reed Gold Mines Company starts intensive operations on the Tom Reed vein in the Oatman district.
- 1909 Sacramento Hill at Bisbee is drilled. J. Parke Channing and Seeley Mudd drill at Ajo and reject property. Cornelia Copper Company reorganized as New Cornelia Copper Company. Louis S. Cates is placed in active charge at Ray. Arizona loses its No. 1 position in copper production.
- 1910 Magma Copper Company at Superior organized. Arizona regains the No. 1 position in copper production. A gravity test mill is erected and placed in operation by Inspiration Copper Company.
- 1911 Production starts at Miami Copper Company. American Smelting and Refining Company builds smelter at Hayden. Ray production starts on large scale. General John C. Greenway becomes interested in Ajo, and the New Cornelia property is drilled by the Calumet and Arizona Company. Production starts at Magma.

CHRONOLOGY Period 1912-1961

- 1912 Town of Oatman is started. Arizona is admitted to the Union as fortyeighth state. James S. Douglas becomes interested in United Verde Extension, and development work there is begun.
- 1913 A Flotation test mill is erected and placed in operation at Inspiration.
- 1914 World War I starts.
- 1915 Large gold ore body is developed in United Eastern Mine at Oatman. Metal prices start to boom. International Smelting Company erects smelter at Miami. Flotation introduced at Inspiration, the first large-scale copper flotation plant in this country. Legislature creates Arizona Bureau of Mines.
- 1916 United Verde Extension mines bonanza ore body at Jerome.
- 1917 United Eastern purchases Big Jim at Oatman. Production starts at New Cornelia with leaching ore. War prices for metals. Extensive working of small high-cost copper, manganese, and tungsten deposits. New Cornelia buys property of Ajo Consolidated Company.
- 1918 Steam shovel operations start at Sacramento Hill at Bisbee.
- 1919 Experimental flotation plant is installed at Ajo.
- 1921 Postwar depression and shut down of copper properties. Entire Morenci district now controlled by Phelps Dodge.
- 1922 End of postwar depression.
- 1923 Copper Queen mill south of Bisbee is placed in operation.

- 1924 Ray and Chino merge. Concentrator at Ajo put into operation, and treatment of sulphide ore commences. Smelter is completed at Magma.
- <u>1925</u> End of high-grade ore at Miami in sight. Company plans for working low grade
- <u>1926</u> Ray Consolidated is absorbed by Nevada Consolidated. Large-scale leaching operations started at Inspiration.
- <u>1928</u> Drilling program started on Clay ore body at Morenci. Extensive addition to concentrator at Ajo.
- 1929 Climax of boom and start of the great depression. Sacramento Hill open pit operations are discontinued. Miami Copper mining low-grade ore body successfully.
- <u>1930</u> Copper price collapses from 18 to under 10 cents a pound. Louis S. Cates becomes president of Phelps Dodge.
- 1931 Phelps Dodge absorbs Calumet and Arizona. Great Britain abandons gold standard.
- 1932 Curtailed copper operations. Extensive reworking of gold placer deposits. Four-cent tariff is placed on copper imports. Copper price declines to under 5 cents a pound.
- 1933 Price of gold is raised to \$25.56. Silver legislation.
- 1934 Price of gold is raised to \$34.95 per ounce with subsequent boom in small gold properties.
- 1935 Price for newly mined domestic silver is raised to 77.57 cents.
- 1936 Period of general recovery.
- 1937 Business pick up, high copper prices and subsequent collapse in summer and fall. Extensive development of Clay ore body (Morenci Open Pit Mine) is started.
- 1938 Partial or complete shutdown of copper properties and re-opening in late summer. Price for newly mined domestic silver is reduced to 64.64 cents. War scares. United Verde Extension finishes ore body, and smelter is dis-mantled and sold. Arizona Small Mine Operators Association is formed.
- 1939 Arizona Department of Mineral Resources is created by Legislature. World War II begins. Mineral industries geared to high production. Copper, lead and zinc prices begin long climb upward.
- 1940 U. S. copper imports exceed exports: government stock-piling stimulates entry of Latin American and African copper into United States. Zinc output largest in Arizona's history.
- 1941 Pearl Harbor. United States declares war on Axis nations. Copper price under voluntary control.

- 1942 Morenci begins large-scale, open-pit production. Record zinc output. Government premium prices inauguarated February, 1942. Most gold mines closed by government order L-208, October, 1942.
- 1943 Open pit production at Castle Dome mine commences in April. Arizona's metal output greatest since 1929. Severe labor shortages. Zinc output establishes new record. U. S. Bureau of Mines starts exploratory drilling at San Manuel copper deposit after recommendation by B. S. Butler and N. P. Peterson, of University of Arizona and U. S. Geological Survey.
- 1944 Magma Copper Company becomes interested in San Manuel mine near Mammoth. Seven percent decrease in Arizona metal production owing in part to labor shortage. Increase from 25,000 to 45,000 tons of ore per day at Morenci copper concentrator. Lead and zinc output highest in State's history.
- 1945 Cessation of hostilities with Axis. Zinc production makes new record, 38 percent greater than 1944. Lead also sets new record, 37 percent greater than 1944.
- 1946 San Manuel exploration continues: 211,500,000 tons of ore proved up. Lead and zinc production continues upward trend, exceeding 1945. Stimulation of interest in non-metallics owing to building boom.
- 1947 San Manuel Copper Company reports a total of 462,784,500 tons of copper ore proved. Government premium prices expire in June.
- 1948 Copper excise tax is reduced from 4 cents to 2. (Tax had been suspended during the war, and suspension continued to March 31, 1949.) High metal prices continue to stimulate mining industry. The output of copper ore and zinc-lead ore is the highest of any year in the history of the State. Open-pit development is completed at Inspiration and in progress at Ray. Underground exploration begins at San Manuel.
- 1949 Copper import tax is again suspended in March to June 30, 1950. Owing to a drop in base-metal prices in March and April and subsequent reduction of the work-week to 40 hours, copper production is curtailed by 5 percent under the output of 1948. Production of zinc and lead, however, reaches a new high.
- 1950 Production of copper, gold, and silver increases while the output of zinc and lead decreases. Interest in tungsten, manganese, and other critical metals and minerals is stimulated by world conditions. 2-cent copper tax resumes July 1st. Open-pit production commences at Ray. Phelps Dodge begins development of Lavender Pit. New copper smelter blows in at Ajo.
- 1951 The 2-cent copper tax is suspended April 1st, with provision for resumption of the tax if copper drops to 24 cents.
- <u>1951-1953</u> Flood of imports of lead and zinc causes shut-down of many lead and zinc mines.
- <u>1952-1954</u> Banner Mining Company and Pima Copper Mining Company appear among notable producers of copper in the Pima Mining District south of Tucson.

1953 Castle Dome ore reserves are exhausted. Operations cease at United Verde in March. Development of Miami's low grade ore starts. Manganese ore purchasing depot opens at Wenden, January 26th. Copper price decontrolled May 1st. Asbestos purchase depot is opened by U. S. Government at Globe. Copper tax suspension is continued to June 30, 1954.

<u>1954</u> Castle Dome's mill building is moved to Copper Cities, and production is begun at the latter mine in August. Miami begins production from low-grade ore-body. Inspiration takes option on Christmas mine.
A. S. & R. Company begins production from Silver Bell mine in Pima County in March. Phelps Dodge begins production at Lavender Pit (Bisbee), August 7th. Copper tax suspension is extended to June 30, 1955. Wenden Depot closed after purchase of 6,000,000 recoverable long-ton units of manganese. Duval Sulphur & Potash Company begins development of Esperanza Mine.

- 1955 Trial runs on stockpiled ore are made by San Manuel Mining Co. Carlot purchases of +35% manganese ore and concentrates to be continued until 1959.
- 1956 Underground mining, flotation concentration and smelting of concentrates begin at San Manuel. Tremendous demand for copper both here and abroad, causes price to rise to over 50 cents. U. S. average for year 41.8 cents.
- 1957 Construction of 12,000 tons per day concentrator begun by Duval.
- 1958 First commercial oil producer in State drilled by Humble Oil & Refinery Co. in Apache County. Excise tax of 1.7 cents per 1b. placed on copper imports July 1, 1958.
- 1959 Two exploratory wells in Apache County listed as discoveries, one an oil well, the other gas. Asarco's Mission Mine's pre-stripping and construction of 15,000 tons per day capacity concentrator commenced in August, 1959. Operation of Duval's mine & mill begun in March, 1959. Kennecott Copper Corporation purchases 120 claims in a copper mineralized area northeast of Safford.
- 1960 Phelps Dodge Corporation also exercises options to buy 300 mining claims 10 miles north of Safford. Bagdad Copper Corporation starts leaching its immense stock-pile of oxidized copper. Pima Mining Company reaches agreement to mine and mill a large tonnage of Banner Mining Company's ore, and is increasing its mill capacity from 3,000 to 3,800 tons per day.
- 1961 Asarco's Mission Unit starts its new mill, August 1, 1961, handling 15,000 tons copper ore per day.

MINING IN ARIZONA

Its Past - Its Present - Its Future

ARIZONA DEPARTMENT OF MINERAL RESOURCES



DEPARTMENT OF MINERAL RESOURCES STATE OF ARIZONA PHOENIX, ARIZONA

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FRANK P. KNIGHT, DIRECTOR FRANK J. TUCK, STATISTICAL ENGINEER



MINING IN ARIZONA

Its Past Its Present Its Juture

APRIL, 1961

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Superstition Mountain Monument

PALMER PRTG. CO., PHOENIX, ARIZ.

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MINERAL PRODUCTION OF LARGE AND SMALL PRODUCERS IN ARIZONA IN 1959*

LARGE COPPER PRODUCERS1	PRODUCTION	VALUE
Copper (lbs.)	841,153,000	\$258,234,000
Gold (ozs.)	100,000	3,500,000
Silver (ozs.)	2,850,000	2,579,000
Molvbdenum (lbs.) (content of concentrate)	3,181,000	4,019,000
Total Value of Large Mine Production in 1959		\$268,332,000
SMALL MINERAL PRODUCERS:	120.000	★ 170.000
Clays ² (short tons)	120,000	\$ 179,000
Coal (short tons)	7,000	63,000
Copper (recoverable content of ores, etc.) (lbs.)	19,441,000	5,968,000
Gem stones	(4)	88,000
Gold (recoverable content of ores, etc.)		
(troy ozs.)	24,627	862,000
Lead (recoverable content of ores, etc.) (lbs.)	19,998,000	2,300,000
Lime (short tons)	123,000	1,666,000
Manganese ore and concentrate (35% or more Mn)	
(gross wt.) (short tons)	68,183	5,727,000
Manganiferous ore and concentrates (5-35% Mn)		
(gross short tons)	10,693	234,000
Mercury (76-lb. flasks)	(3)	(3)
Mica (scrap) (short tons)	3,069	55,000
Pumice (short tons)	487,000	1,153,000
Sand and Gravel (short tons)	13,458,000	11,966,000
Silver (recoverable content of ores, etc.)		
(troy ozs.)	1,048,000	949,000
Stone (short tons)	2,468,000	3,998,000
Uranium Ore (short tons)	253,390	6,309,000
Zinc (recoverable content of ores, etc.) (lbs.)	74,650,000	8,585,000
Value of items that cannot be disclosed:		
Asbestos, cement, clays (bentonite), feldspar		
gypsum, perlite, pyrites, petroleum, vanadium,		
and values indicated by footnote 3		9,837,000
Total Value of Small Mine Production ³		\$ 58,556,000
GRAND TOTAL VALUE OF		
MINERAL PRODUCTION		\$326,888,000
PERCENTAGE DUE TO SMALL MINES		17.91%

FOOTNOTES:

Proof Notes:
Phelps Dodge, Kennecott, Inspiration, Miami, Magma, A.S.&R.Co's Silver Bell, Pima, Bagdad and Duval's Esperanza.
Excludes bentonite; value included with "Items that cannot be disclosed."
Figure withheld to avoid disclosing individual company confidential data; value included with "Items that cannot be disclosed".

Weight not recorded. Total has been adjusted to eliminate duplication in the value of raw materials used in 5. the manufacture of cement and lime. *Compiled from U. S. B. M. Area Report D-106, July 1960—Final Figures 1959.

Mining In Arizona

Arizona is by far the greatest producer of non-ferrous, metallic minerals of any state in our Union. In 1960,

It ranked first in the combined dollar value of such metals.

It ranked first in copper production.

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It ranked fourth among western states in lead.

It ranked second among western states in zinc.

It ranked second among all states in silver.

It ranked fourth among all states, including Alaska, in gold.

The following is a tabulation of the total Arizona production of these metals.

			TABLE I		
	Gold oz.	Silver oz.	Copper Ibs.	Lead Ibs.	Zinc Ibs.
1950	118,313	5,325,441	806,602,000	52,766,000	120,960,000
1951	116,093	5,120,985	831,740,000	34,788,000	105,998,000
1952	112,355	4,701,330	791,438,000	33,040,000	94,286,000
1953	112,824	4,351,429	787,050,000	18,856,000	55,060,000
1954	114,809	4,298,811	755,854,000	16,770,000	42,922,000
1955	127,616	4,634,179	908,210,000	19,634,000	45,368,000
1956	146,110	5,179,185	1,011,816,000	23,998,000	51,160,000
1957	152,499	5,279,323	1,031,708,000	24,882,000	67,810,000
1958	142,979	4,684,580	971,678,000	23,780,000	57,064,000
1959	124,627	3,898,336	860,594,000	19,998,000	74,650,000
$1960 \\ P = P$	P 145,600 reliminary	4,751,000	1,080,000,000	17,200,000	72,600,000

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HISTORY — General

In the period from 1858 to 1960 inclusive, Arizona's mines have yielded more than \$8 billion, over 95% of which came from its five principal metals: copper, lead, zinc, gold and silver. 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 first found the veins and the orebodies. 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.

Long before the white man had set foot on much of this nation's area 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 silver ore in what is now Arizona. It was Arizona's first recorded mineral discovery. It is known that the Indians did little mining except for 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, Planches de Plata, 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 The preliminary population figures by Counties, for 1960, were as follows:

Apache	30,438	Mohave	7,736
Cochise	55,039	Navajo	37,994
Coconino	41,857	Pima	265,660
Gila	25,745	Pinal	62,673
Graham	14,045	Santa Cruz	10,808
Greenlee	11,509	Yavapai	28,912
Maricopa	663,510	Yuma	46,235

TABLE VIII

VALUE OF MINERAL PRODUCTION IN ARIZONA, BY COUNTIES

YE	ARS 1955-56-	57-58-59	Source: U.S.E	B.M. YEARBOO	K
County Apache	1955 ¹ \$ 731,066	1956 \$ 3,691,829	1957 \$ 3,164,474	1958 \$ 4,324,954	1959 \$ 4,233,943
Cochise	49,677,664	68,344,376	50,474,007	38,065,293	31,963,199
Coconino	64,045	1,884,705	2,864,384	4,394,124	4,884,107
Gila	66,684,347	76,785,677	50,935,723	43,124,640	50,239,827
Graham	674,745	531,609	290,079	20,402	153,582
Greenlee	95,328,130	111,374,672	67,052,744	53,073,897	48,084,455
Maricopa	3,315,210	3,959,377	6,206,000	5,370,894	6,698,542
Mohave	427,067	1,873,189	911,628	950,678	982,759
Navajo	104,443	793,823	1,495,443	2,253,126	3,170,572
Pima	82,748,688	91,431,712	75,739,870	66,089,879	91,324,508
Pinal -	56,209,900	101,723,680	87,710,021	78,450,806	61,236,788
Santa Cruz	2,324,005	2,929,900	2,491,068	1,266,720	1,130,477
Yavapai	16,510,609	16,064,018	18,254,158	16,399,450	21,643,699
Yuma	99,088	331,363	1,117,509	1,652,166	1,794,254
Undistributed ²	4,332,066	4,344,641	5,230,422	288,528	682,697
TOTAL ³	\$378,277,000	\$484,959,000	\$372,641,000	\$314,520,000	\$326,888,000

1. Excludes value of manganese ore sold and blended at Gov't low-grade stockpiles for future beneficiation.

2. Includes sand and gravel, vanadium, stone, gemstones, natural gas and uranium.

3. Total has been adjusted to eliminate duplication in the value of raw materials used in the manufacture of cement and lime.

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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 overlooked mineralized out-crop of promise; a neglected, rather than a "lost" mine.

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 sixth largest, and has an area of 113,956 square miles. The State was organized as a territory in 1863, and was admited 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 and continue to the edges of the flag, consisting 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 they often attain a height of 50 feet.

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Arizona population in 1960 was reported to be 1,302,161, 73.7 percent higher than the census figure for 1950. It is the nation's fastest growing state since the start of the century. In 1900, Arizona's population was 122,931.

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 Arizona mining camps that 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.

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Untold centuries ago there was locked away in Arizona's mighty mountain vaults, stores of precious metals; a supply sufficient and necessary for our increased 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 five principal metals to the end of 1960:

TABLE II

17,197,000	tons of copper	worth	\$6,721,464,000
609,000	tons of lead	worth	118,526,000
851,000	tons of zinc	worth	205,998,000
12,596,000	ounces of gold	worth	328,365,000
359,290,000	ounces of silver	worth	277,543,000
	Total Value		\$7 651 896 000

And that isn't all of the story. It is estimated that fifty percent of the value of all of 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, and dividends to investors, many of the latter being citizens of Arizona.

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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, 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 with a curator and assistant: American Smelting and Refining Company, Inspiration Consolidated Copper Company, Kennecott Copper Corporation, Magma Copper Company, Miami Copper Company, and Phelps-Dodge Corporation. The Mineral Museum is under the direction of the Department. 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 percent of the "lost" mines are pure fiction. They exist only in 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-froman-old-Spaniard-he-befriended." It simply doesn't exist. The map is probably a fake, regardless of crude lettering, old and soiled paper, or other details which would seem to lend authenticity.

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.

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geology and mining history of most Arizona mining districts. Many valuable bulletins, maps and pamphlets may be obtained free of charge.

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 \$1.00 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



Mineral Building, Fairground

THE MAJOR METALS

The five major metals being produced in Arizona are gold, silver, copper, lead and zinc.

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, 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 high, gold 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,

1. J. B. Tenney, Ariz. Bureau of Mines Bull. 137. p. 16, Aug. 15, 1934.

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 in 1933 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 percent 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, production from gold lode mines and placers has dropped to below 3 percent of the total. In 1942 the annual production from these mines had dropped from 156,000 ounces to a mere trickle of 1,000 ounces, a loss of 155,000 ounces, or almost five and one-half million dollars. The loss in silver was over 1,050,000 ounces, which had a value (including seignorage) of almost one and one-half million dollars. 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 the few producing siliceous fluxing ores for the copper smelters. Because of the federal government's control of both gold and silver prices, the producers have not enjoyed the inflationary

THE FUTURE AND ARIZONA'S MINERALS

Arizona is not a "mined-out state". Not all of our ore deposits have been found. In recent years some 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 4 percent of the State's 72,688,000 acres have been intensively prospected, and perhaps less than 1 percent have been investigated by geophysical methods. In addition, many marginal areas in the older and productive districts will yield mineral wealth in the future. There still are productive possibilities in many long-shutdown mines; and many oxide ores not now economical will become so when ways to treat them are found.

The undeveloped ore bodies may not be as rich as those already mined, but the lower grade may be offset by greater tonnage. And with the application of advanced mining and metallurgical practices they may offer rich rewards for venture capital. However, laws, regulations and taxes should be considered carefully in the light of the need of Arizona and the Nation for maintained production 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. To investors we say, "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 earlyday venture capital. Legally, they are much better protected in their investments. Technically, they can enlist the aid of the Arizona State Department of Mineral Resources, the Arizona Bureau of Mines, the United States Geological Survey, and the Federal Bureau of Mines. These agencies can and will furnish data as to the

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A large cement plant near Tucson has manufactured cement for many years, and until 1959 was the only cement company operating in Arizona. Recently, however, a large plant has been located at Clarkdale, and it is now engaged in shipping enormous quantities of cement to the new Glen Canyon Dam being built on the Colorado River at Page.

MINERAL FUELS

Coal production to the amount of 5,000 to 10,000 short tons annually has been coming for several years from 2 mines in the Indian Reservation, in Coconino and Navajo Counties.

The year 1959 was probably the most significant in the history of oil and gas in Arizona. Twenty-seven wells were completed compared with 19 in 1958. Of the 27 completed wells, 25 were exploratory and 2 were development. Two exploratory wells, both in Apache County, were listed as discoveries, one an oil well and the other gas. The oil discovery, 8 miles south of the Boundary Butte field in Utah, produced 240 barrels of oil a day from Mississippian formations at a depth of 5,566-5,589 feet. One successful development well, an extension of the East Boundary Butte field, was completed in Pennsylvanian formations and produced 104 barrels of oil and 774 thousand cubic feet of gas a day. The gas well was 4 miles west of the Bita Peak field and flowed at 4 million cubic feet a day from the Hermosa (Pennsylvanian) formation at a depth of 4,999-5,071 feet.

Production of crude petroleum, all from Apache County, increased in 1960 more than threefold over 1959. Drilling activity increased with 32 wells completed in the first 10 months compared with 24 for the same period in 1959. At the end of October two rotary drills were active compared with one in 1959.

HELIUM

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Interest in the helium wells in northeastern Apache County was heightened by passage by the 86th Congress of the helium conservation bill. The measure encourages production of helium from natural gas by private industry. A number of wells drilled in recent years in the Pinta Dome field contain significant quantities of helium. All have been shut in. benefits which other commodities have enjoyed. Result, there has been no incentive for them to re-open their old gold mines or explore for new ones. The high rate of out-flow of gold from the United States in 1960 raised the hopes of gold miners that there would be an early return to economic conditions favoring gold mining.

For each ton of Arizona copper ore mined in 1959, \$0.109 in gold and silver were recovered. This gold and silver content tends to decrease, as does the copper, with deeper ores. For example, the value of the gold and silver recovered from copper ores in 1941 was \$0.354 per ton of ore mined. For each ton of copper ore mined in 1941, 0.0059 ounces of gold and 0.207 ounces of silver were recovered, and in 1959 these figures dropped to 0.0018 ounces and 0.051 ounces respectively.

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 50 years ranked as the leading copper producer in the United States, its output, up to the end of 1960, amounting to 17,197,000 tons of copper worth \$6,721,464,000. There is no reason to believe that she cannot continue as the leader for many years to come. Nature has made her 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 spent a lifetime in helping to develop the mines and to build the communities with their schools, banks, churches, public buildings, and their roots extend down into the earth, to the bodies of copperbearing ore which 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



Copper Mining About 1900

period. Beginning about 1910 and through the next 50 years, the low-grade "porphyries" were the chief copper producers. 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. The Copper Queen at Bisbee is still producing a sizable amount of copper. The United Verde at Jerome was exhausted in 1952.

In 1959, the copper mining and smelting industry payroll in Arizona amounted to \$80,534,236, in a year which saw over half the industry shut down by a strike that lasted throughout the last five months. The average weekly earnings of those employed in the Arizona copper mines and smelters were higher than the national average for non-ferrous mines and higher than for any other industry in the state. These statistics do not include fringe benefits which are adding over 25 percent to the annual labor cost of the copper mining and smelting industry.

Arizona copper mines spent over \$30,000,000 in Arizona for

in the following years, due to technical problems connected with its use, but for three years beginning with 1951, production averaged 2,000 tons annually with a value of \$13,000. The U. S. Bureau of Mines reported perlite production from 1954 to 1957 inclusive, totalling 42,179 tons valued at \$305,396.

Production was not reported in 1958 and 1959, but the 1958 production dropped below the 1957 value of \$114,000. This was due largely to the closing of the Superior Industries, Inc., and Lee's Perlite Industries, Inc. operations in Pinal County. The principal producer in 1958 was Perlite Industries, Inc., which shipped crude perlite to Sil-Flo Corporation, Fort Worth, Texas, and also consumed 600 tons at its Phoenix expanding plant.

Production increased in 1959 and perlite popping plants were operated at Phoenix (Perlite Industries) and at Tucson by Tucson Perlite, Inc.

PUMICE

Pumice and pumicite (volcanic ash), used mainly as an aggregate for making concrete blocks, have come into prominence only since 1951. For the last seven years, the U. S. Bureau of Mines reported a production of 1,700,000 tons worth \$4,100,000.

Material classified as pumice in 1959 consisted entirely of volcanic cinder (scoria) and total output reached 487,000 tons with a value of \$1,153,000. The use of scoria as railroad ballast accounted for 57 percent of the total, followed closely by concrete aggregate (42 percent). The Santa Fe Railroad operated its cinder pit in Coconino County and was the principal producer. San Xavier Rock & Sand Company in Cochise County, Harenburg Block Company, Inc., Superlite Builders Supply Company in Coconino County, and Gila Cinder Company, in Graham County were the other operators.

MISCELLANEOUS NON-METALLICS

Barite, diatomaceous earth, feldspar, fluorspar, gypsum, nitrogen compounds, and silica have been or are being produced in commercial quantities in Arizona. Also gem stones.

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various colors is quarried near Ash Fork, Seligman 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 is a popular building stone and has been quarried in Cochise, Gila, Maricopa, Mohave, Pima and Yavapai Counties.

Marble was quarried many years ago in the Chiricahua Mountains of Cochise County. Onyx Marble has been produced in Coconino, Maricopa, Pima and Yavapai Counties.

No slate has been produced commercially 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 Arizona Bureau of Mines estimates the value of stone produced in Arizona from 1889-1948 to be \$14,234,000. From 1949 to the end of 1954, Arizona produced 1,493,323 tons of stone worth \$1,764,958, and from 1955 to 1959 production totalled 9,321,000 tons valued at \$14,514,000. This tremendous increase continued in 1960 with preliminary U. S. Bureau of Mines production figures of 2,500,000 tons valued at \$4,000,000. The total recorded value (1889-1960) is \$34,513,000.

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. Although some mica has been produced for many years, no published records were available before 1953. Arizona mica production from 1953 to 1959 inclusive, according to U. S. Bureau of Mines reports, was 13,192 tons valued at \$238,385.

PERLITE

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Perlite deposits near Superior first became of interest in 1924, and commercial production commenced in 1946. The production from 1946 to the end of 1948 was estimated by the Arizona Bureau of Mines to be worth \$65,000. There was a decline in production Arizona grown or manufactured supplies and equipment in 1960, thus contributing substantially to the larger cities where supply and machinery headquarters are located.

The mining industry is Arizona's largest taxpayer. An annual average of \$20,046,000 was paid for property and production (sales) taxes within the state during the six year period, 1955 to 1960. No other industry contributes nearly as much in taxes. Mining alone carries about 19.0 percent of the State property and sales tax load.

The railroads and truck lines receive a large volume of business through the movement of copper ores and metal as well as supplies and equipment. Copper mining brought the railroads to Arizona and has furnished the bulk of the freight which has kept them going and expanding.

Agricultural, lumber and livestock producers in non-mining portions of Arizona derive a large share of their income from the copper industry.

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

The copper mining industry has a vital and far reaching effect on the State's economy and is one of the few industries which create new and indestructible wealth. It is equally vital to the nation's security, and it is necessary that this country keep its domestic mines in operating condition at all times.

Copper ores and minerals are of no practical value until they 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 countless. It has been estimated that an average of 13.5 persons (including the miner himself) is dependent upon each mine and smelter employee's wages.

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has been used in the flotation process at 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 mills have been making their lime from limestone quarried at their copper properties.

The Arizona Bureau of Mines has estimated the value of lime produced in Arizona from 1894-1948 to be \$12,046,000. From 1949 to the end of 1960, the value of lime produced was \$15,859,000, making the total value since the beginning of production 28 million dollars.

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. Other bentonite clays have been marketed and bricks and miscellaneous clay products have been produced in Maricopa and Pima Counties.

Production value to the end of 1960 is estimated to have been over \$22 million.

SAND AND GRAVEL

Sand and gravel are products of all States in the Union and Arizona is no exception. Records of production were first reported statistically in 1917, and the Arizona Bureau of Mines reports the production from 1917 to 1948 inclusive to have been worth \$15,668,000. The U. S. Bureau of Mines reports the Arizona production for the period 1949 to 1954 inclusive to have been 15,423,000 tons worth \$11,770,532, and for 1955 to 1959, 61,640,000 tons with a value of \$43,400,000, an increase of nearly 400 percent. Preliminary figures for 1960 are 12,135,000 tons with a value of \$11,183,000, making the total for 1917 to 1960, \$82,021,000.

STONE

Commercial stone is broadly classified as dimension stone, slate, 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 of several asbestos companies searching for, and finding, new markets for their products. Most Arizona asbestos is short fiber, grading through crudes No.'s 4 to 7. Only a very small percentage is longer fiber, high priced No.'s 1, 2 and 3. The very low iron content of the Gila County chrysotile makes it eminently suitable for electrical insulation uses.

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. It is cheaper to mine but Arizona has advantageous transportation cost and lower iron content.

The asbestos companies who now have modern fiberizing mills are Metate Asbestos Corporation, Jaquays Mining Corporation and Le Tourneau Asbestos Company. Other active mills are those of Roger Kyle and Guy Phillips. All of these mills are at Globe, except the Phillips which is near Seneca.

Total production in Arizona is roughly estimated at 39,000 tons with a value of \$10,600,000.

Since 1944, production figures have been confidential excepting data regarding Government Purchases from 1952 to 1958. In October, 1952, the General Services Administration opened an asbestos purchasing depot at Globe, and this resulted in the opening and re-opening of a number of asbestos properties. The largest of these were the Regal, Phillips, Crown, Chrysotile and Rock House.

The total asbestos purchases by the General Services Administration from 1952 to 1958 were:

	Tons	Value
Nos. 1 and 2 Crude	3,240	\$3,845,314
No. 3 Crude	1,897	758,424

In 1960, G.S.A. contracted for purchase of 500 tons of No. 2 Crude for the National Stockpile at \$918.30 per ton.

LIME

Lime for building purposes has been produced in Arizona since 1894. Since 1915, the larger proportion of the lime produced 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 18 to 20 pounds per ton. This, together with steadily increasing wages, which have quadrupled during the same period, naturally leads to higher production costs, in spite of technological improvements in mining and metallurgy.

Threat of Imports

From 1932 to 1940, Congress imposed and re-imposed a 4-cent copper tariff every two years. The price of copper averaged 10.11 cents per pound in this period, so that on an ad valorem basis the duty was roughly 40 percent. Cutting the ad valorem tax from 40 percent to 12½ percent would still permit a 4-cent tariff in a 32-cent copper market. This 68.75 percent tariff reduction should satisfy the low-tariff advocates. Nevertheless, the present tax is only 1.7 cents per pound of copper, which means that the ad valorem tax is only 5.3 percent of a 32-cent copper price, and amounts to an 86.75 percent cut.

New Developments

Arizona has attained a copper production capacity of over 600,000 tons of copper per year, but the producers are continuing the search for new ore-bodies to keep up with the expanding demand for the metal and for improved methods of extracting copper from their deposits. Kennecott Copper Corporation has recently expended over forty-million dollars in increasing their ore production at Ray by fifty percent. The company has also purchased 120 claims north and east of Safford where drilling has discovered a large copper mineralized area. Phelps Dodge Corporation has been exploring and acquiring property nearby.

The American Smelting & Refining Company has completed a 5-year exploration program at its Mission Project, 15 miles southwest of Tucson, and is spending \$43.5 million in order to mine and process 15,000 tons of ore per day. An annual output of 45,000 tons of copper is expected after 1961.

Inspiration Consolidated Copper Company plans to be producing at the rate of 18,000 tons of copper annually from its Christmas property in Gila County by 1962. Additional output of copper is expected soon from the Banner and Pima companies in Pima County.

Duval's Esperanza Mine in Pima County began production of copper in March, 1959, treating 12,000 tons of ore a day, a rate expected to yield an annual output of about 25,000 tons of copper.

The major copper producing mines and smelters in Arizona in 1960 are listed in Table III.

TABLE III MAJOR ARIZONA COPPER MINES, 1960

Open Pit

Mine	County	Operator	Tons Ore Mined
Morenci	Greenlee	Phelps Dodge Corp.	14,499,800
New Cornelia	Pima	Phelps Dodge Corp.	9,065,600
Ray	Pinal	Kennecott Copper Corp.	6,526,814
Inspiration	Gila	Inspiration Cons. Copper Co.	5,314,770
Esperanza	Pima	Duval Sulphur & Potash Co.	4,245,762
Lavender Pit	Cochise	Phelps Dodge Corp.	4,248,400
Copper Cities	Gila	Miami Copper Co.	3,058,372
Silver Bell	Pima	Amer. Smelting & Refining Co.	2,718,700
Bagdad	Yavapai	Bagdad Copper Corp.	1,828,055
Pima	Pima	Pima Mining Co.	1,327,473
		Total Tonnage	52,833,746
		Underground	
San Manuel	Pinal	San Manuel Mining Co.	12,261,220
Magma	Pinal	Magma Copper Co.	386,636
Copper Queen	Cochise	Phelps Dodge Corp.	509,700
Mineral Hill		이 같은 것 같은 것 같은 것 같아요.	1
& Daisy	Pima	Banner Mining Co.	48,872
Miami	Gila	Miami Copper Co.	*
		Total Tonnage	13,206,428

There are 8 copper smelters, 1 each at Morenci, Ajo, Douglas, San Manuel, Superior and Miami, and 2 at Hayden (Kennecott's and Asarco's). Inspiration Consolidated Copper Company operates an electrolytic refinery at Inspiration, in addition to its smelter at Miami.

*Underground mining discontinued June 26, 1959.

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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. Among these are lithium, germanium, indium, columbium, beryllium, tantalum, thorium and uranium.

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, spectographic 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 nor 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 every day 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.

NON-METALLIC MINERALS

ASBESTOS

Today the asbestos producers of Central Arizona are again producing the high grade, low-iron content fiber for which they are famous.¹ The depression picture that gripped the Arizona asbestoc industry after December 31, 1958, when the U. S. Government stopped purchases of fiber under Public Law 733, has changed to one of new activity. Three new processing mills, with new equipment, have been erected as a result of the aggressive leaders 1. Mining World, September, 1960, pages 44-45.

MERCURY

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. Up to 1928, none of these had reported appreciable production. At best, the yield to then probably had not exceeded a few hundred 75 pound flasks, (say 500 with a value of \$37,500). U.S.B.M. records from 1928 through 1946 indicate a production of 9,000-76 pound flasks worth about \$1,200,000. The production from 1947 through 1953 was practically nil. From 1954 through 1960, mercury production in Arizona amounted to about 1,500-76 pound flasks worth about \$400,000. This makes a total Arizona production of about 10,500 75-76 pound flasks worth about \$1,500,000.

VANADIUM

One of the important uses of vanadium is in the production of high quality steels. The total value of vanadium that has been produced in Arizona is estimated at one million dollars. 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 the northeastern part of the State. The U.S. Bureau of Mines does not report the quantity or the value of Arizona's production.

IRON

The development of iron ore in Arizona is a long-range prospect, with many problems to solve. However, the production of metallic iron from copper slag dumps is well within the range of early development.

Exploration by the Colorado Fuel and Iron Company in the Apache Reservation gives promise of developing iron ore in commercial quantities in the near future.

A small 75-ton steel plant, developed by J. D. Madaras has been constructed near Coolidge, Arizona, and will be used to treat concentrate from a black sand (magnetic iron) deposit located between Florence and Oracle Junction.

LEAD AND ZINC

The production of lead in Arizona was first reported statistically by the Arizona Bureau of Mines 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 from 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 1942 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 it 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 the 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, which from 1858-1930 produced 5,000 tons of lead and \$500,000 in silver. Another property was the Duquesne, which from 1899-1925 produced 7,500 tons of copper, 6,000 tons of lead, and \$350,000 in silver.

Three mines in the Harshaw District, the Flux, Hardshell and Trench produced from 1880-1925 a total of 5,500 tons of lead and \$430,000 in silver. The Montana Mine (Goldfield Cons. 1917-18) (Eagle Picher, 1927-30) in the Oro Blanco District produced 3,900 tons of lead and \$393,000 in gold and silver. 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.

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Early Lead-Zinc Mine

The Iron King Mine (Yavapai County) has been the principal lead and zinc producer in recent years, with an output in 1959 of 7,251 tons of lead and 17,419 tons of zinc. The Flux and the Glove Mines in Santa Cruz County and the San Xavier in Pima County, supplied most of the remaining lead output. The Old Dick Mine was reopened by Cyprus Mines Corporation at the beginning of 1959 after a year of inactivity. It operated throughout the year, and became the State's second largest zinc producer. Other major zinc-producing mines, in order of descending 1959 output, were the Atlas, Flux, San Xavier and Johnson Camp (Moore Shaft). The San Xavier and Glove Mines are now idle.

Arizona's average annual production of lead and zinc is shown in Table IV.

TABLE	IV

	Tons Lead Produced Annual Rate	Tons Zinc Produced Annual Rat	
894-1910	2,075	1,045*	
911-1935	6,376	2,678	
937-1941	12,520	9,900	
942-1946	18,400	30,233	
947-1952	25,388	56,734	
953-1959	10,566	28,145	

*Annual Rate from 1905-1910.

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0.35 percent (7.0 pounds per ton) U₃O₈ compared to a similar estimate of Dec. 31, 1958, of 1.4 million tons averaging 0.34 percent (6.8 pounds per ton) U₃O₈.

Uranium production from July 1, 1955 to the end of the year 1959, totalled 6,473,000 pounds of U₃O₈ obtained from 1,164,000 tons of ore and valued at \$27 million. Production figures for 1958 and 1959 are given in Table VII.

TABLE VII

URANIUM PRODUCTION IN ARIZONA IN 1958 AND 1959

1.	1958			1959				
County	No. of Properties	Ore (Short s Tons)	Lbs. U ₃ O ₈ (1000's)	F.O.B. Mine Value (1000's)	No. of Properties	Ore (Short Tons)	Lbs. U ₃ O ₈ (1000's)	F.O.B. Mine Value (1000's)
Apache	30	112,364	650.0	\$2,723	16	85,384	446	\$1,846
Navajo	6	75,434	484.4	2,076	11	114,028	661	2,707
Coconino	46	69,222	510.3	2,234	37	53,956	406	1,756
Gila			1997 - <u>19</u> 1			486 -	· · · · ·	-
Undistributed	4	736	3.9	16	2	22	0	0
TOTAL	86	257,756	1,648.6	\$7,049	66	253,390	1,513	\$6,309

MISCELLANEOUS METALS

TUNGSTEN

Arizona has been producing a small amount of tungsten ore since 1910. The total ore production for the years 1910 to 1959 was 4,581 short tons with total value of \$6,337,000.

Tungsten mining has received little encouragment from the government since 1956. The base price paid by the government, under the Defense Production Act of 1950, for concentrate produced in the United States was \$63 per short-ton unit of WO₃ until about June 1, 1956, when purchase of the authorized 3 million short ton units was virtually completed. Public Law 733, passed by the 84th Congress in July 1956 authorized the purchase of an additional 1,250,000 units at \$55. However the appropriated \$15 million was exhausted by early December, 1956. Congress has refused to appropriate more and the complete shut-down of Arizona tungsten mines in middle 1957 still continues.

Mexican manganese ore and concentrates to the Kaiser Steel Corporation plant at Fontana, California, under a contract negotiated in 1958.

The recorded Arizona production of 35 percent or better manganese ore prior to the establishment of the Wenden Depot in 1953, as reported by the U.S. Bureau of Mines, totals 75,000 long tons with a value of \$1,956,000. Practically all of this was produced during World Wars I and II.

A summary of Arizona production is given in Table VI. TABLE VI

			Manganese Ore and Concentrates		
			Long Tons (Approx.)	Value (Approx.)	Per Ton (Approx.)
	Years	1915-1952	75,000	\$ 1,956,000	\$26.00
Wenden-	-Years	1953-1954	152,000	10,743,000	70.00
Carlot—	Years	1955-1959	262,000	21,591,000	82.25
	Total		489,000	\$34,290,000	\$70.12

URANIUM

Considerable prospecting has been done in Arizona for uranium during the last ten years, and discoveries of uranium bearing minerals have been made in all fourteen counties of Arizona. With few exceptions, operating mines are located in the Colorado Plateau in the northeast section of the State. By far the greater number of deposits are in the Mesozoic sedimentary formations. Properties in the Globe area, in Yavapai County, and in Yuma County near the Bill Williams River, are not producing. Ores in the Globe area are refractory and from these last three regions transportation to the nearest, and only Arizona uranium plant, at Tuba City, is costly.

In 1959, uranium-ore production was reported from 66 operations compared with 86 in 1958. The grade of ore produced declined from 0.32 percent (6.4 pounds) to 0.30 percent (6.0 pounds) U_3O_8 per ton.

The uranium-ore reserve as determined by the Atomic Energy Commission (AEC) on Dec. 31, 1959 was 1.2 million tons averaging



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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. Only one large lead-zinc mine (the Iron King) was able to operate continuously from 1952 through 1959, and this mine had been kept going only because of its income from gold, silver and copper by-products.

Table V compares the two periods, 1947-1952 and 1953-1959.

IABLE V		
	1947-1952	1953-1959
Avg. tons lead produced per year (Ariz.)	25,388	10,566
Avg. tons zinc produced per year (Ariz.)	56,734	28,145
Avg. price of lead (U.S.) (c per lb.)	15.891	13.953
Avg. price of zinc (U.S.) (c per lb.)	14.052	11.498
Avg. tons lead imported per year (U.S.)	400,391	415,769
Avg. tons zinc imported per year (U.S.)	493,892	701,409
Avg. number Arizona lead-zinc mines	155	39

MOLYBDENUM

The metal molybdenum, used as an alloying metal in the steel industry, is beginning to rank with gold and silver as a valuable by-product of Arizona copper ores. The chief mineral of molybdenum is molybdenite (MoS_2). The Miami Copper Company has been a regular producer of molybdenum concentrates since 1938. They are recovered as a by-product at Miami, Arizona, and are converted to molybdic oxide at the same location.

Wulfenite (lead molybdate, PbMoO₄) was mined from 1916 to 1944, in the Mammoth District in Pinal County.

The metal molybdenum was in short supply in 1951, and the Government took steps to increase production. In addition to Miami, the Morenci and Bagdad mines developed a method of recovering the mineral from their copper ores in 1951. The Silver Bell, San Manuel and Esperanza mines also have become important producers of molybdenite.

Arizona's recorded production of molybdenum from 1916 to 1959 inclusive is 33,456,000 pounds with a value of \$31,038,000. In 1951 the production was 1,173,000 pounds, more than the entire period from 1916 to 1934. 1960 preliminary molybdenum production was 4,314,000 pounds valued at \$5,413,000, and was 80 percent above the previous high year of 1956.

MANGANESE

Low grade manganese ore occurs in Arizona in a tonnage estimated by the United States Geological Survey at 200,000,000 tons of 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 purchase of manganese ore from 1953 to 1955 resulted in the stockpile at Wenden, Arizona of ores contaiinng 6,108,316 long-ton units of recoverable manganese. The cost to the Government was \$10,743,179. This ore will have to be up-graded before it is usable in the steel industry. It now contains less than 20 percent manganese.

Under a later carlot program, additional Government purchases of Arizona manganese ore and concentrates totalled 262,205 long tons with a value of \$21,591,410. For 1959, the United States Bureau of Mines reported that Arizona production of manganese ore and concentrates totalled 78,876 long tons with a value of \$5,961,000. Production was reported from 82 mines in 9 counties. Yuma and Maricopa counties were the largest producers, followed by Pinal, Pima, and Mohave. The quota on the carlot program was reached, and purchase of ore for the Government stockpile was halted on August 5, 1959. Arizona's manganese industry came to a near standstill. Mohave Mining and Milling Company, the State's largest producer and operator of a manganese mill and sintering plant at Wickenburg announced its decision to liquidate the company. Throughout the year, this company supplied domestic and