History of the Ajo Mining District, Pima County, Arizona

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Aerial photograph of Ajo mining complex, 1956; courtesy of Freeport-McMoRan Inc.

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The hostile environment of southwestern Arizona’s low desert presented many challenges to those who sought to discover and exploit the mineral wealth of the region. Ajo’s remote location combined with hot summer days and scarce water created a number of obstacles that needed to be overcome. Despite these impediments, the district’s wealth was mined by Native Americans long before the arrival of first Spanish explorers, who recognized its potential soon after establishing outposts in this region.

Many years passed before mining professionals with the knowledge, skills and financial backing achieved commercially viable copper operations at Ajo. Application of new technologies and mining practices enabled them to develop Arizona’s first large copper operation to successfully employ open pit methods.

Early History (Prior to 1899)

Tohono O’odham Indians and their ancestors mined hematite from the hills around present day Ajo for many centuries prior to the arrival of the first Spanish explorers during the 1530s. Used as body paint, hematite was dug from shallow pits at a site known to the Indians as “au àuho,” which means paint. Later explorers used a similar sounding Spanish word, “Ajo”, meaning garlic, as the name of this site (Greeley, 1987).

During the late 1600s, Jesuit missionaries established numerous missions in northern Sonora and southern Arizona, including a mission at Sonoyta in 1693. These early settlements served as bases for early prospectors, who intermittently explored and developed primitive mining operations in the surrounding mountains. As more settlers arrived, there were episodic conflicts with the Indians, including the Pima Revolt of 1751. These uprisings disrupted mining activities at the remote sites. This unrest led to the establishment of a number of presidios - fortified bases - including Santa Gertrudis de Altar (1755) in northern Sonora and San Ignacio de Tubac (1752) and San Augustín de Tucson (1775) in southern Arizona. At the outset of the Mexican Revolution (1810-1821), the withdrawal of Spanish troops from the region left many of the settlements, missions and mines vulnerable to Indian raids and outlaw depredations. Although protection was gradually reestablished following the revolution, significant mineral exploration and development did not resume until the mid-1850’s (Greeley, 1987).

In 1847, Tom Childs, a member of a group of 19 prospectors exploring the Cubabi Mountains southeast of Sonoyta, Sonora, heard rumors of a copper prospect at three little peaks north of the town of Sonoyta at a site named Ajo. On their return to Tucson, the prospecting party found evidence of this early mining activity in the area that would become the Ajo mining district, including shallow open cuts in the hillside and a 60-foot inclined shaft that was accessed by ladders made from notched mesquite logs. They also found buckets fashioned from rawhide that were used to extract the mined material by hand (Greeley, 1987).

With the signing of the Treaty of Guadalupe Hidalgo at the end of the Mexican American War on February 2, 1848, the United States acquired California, Nevada, Utah and portions of Colorado, Wyoming, New Mexico and Arizona. Unknown to both governments, gold had been discovered by James W. Marshall at Sutter’s sawmill in Coloma, California on January 24, 1848, nine days prior to the signing of this treaty. As news of this discovery became known, prospectors from northern Sonora used El Camino del Diablo (aka the Devils Highway) to reach the California goldfields. Connecting Altar, Sonora and Yuma, Arizona, this trail passes very close to Ajo (Greeley, 1987).

A portion of southwestern New Mexico and Arizona south of the Gila River was purchased from Mexico for $10 million through the successful completion of the Gadsden Purchase in June 1854. This acquisition resolved outstanding border issues with Mexico following the end of the Mexican American War and provided a favorable terrain to construct a transcontinental railroad along a southern route.

Returning to Texas from the California goldfields in 1850, Peter Rainsford Brady met Tom Childs in Tucson, who told him about his prospecting trip to Ajo several years earlier. In 1853, Peter Brady joined the survey party led by Colonel Andrew B. Gray, who
had been assigned the task of finding a suitable route for the southern transcontinental railroad, connecting Indianola, Texas with San Diego, California. While on this expedition, the survey party passed through the town of Sonoyta, Sonora. With the help of a Seri Indian guide, Brady visited the Ajo site, where he gathered a number of rich ore samples. After completing this survey project, Peter Brady went to San Francisco, where he established the Arizona Mining and Trading Company in August 1854. Other notable shareholders of this business venture included Robert Allen, Tom Childs, Colonel Andrew Gray, Granville Oury and Frederick Ronstadt (Greeley, 1987).

Shortly after the Arizona Mining and Trading Company began prospecting the area in October 1854, several wealthy citizens of Sonora claimed Ajo was located in Mexico. In March 1855, a company of Mexican cavalry was sent to Ajo to arrest Americans working at the site. This confrontation produced a skirmish that resulted in the Mexican cavalry returning to Sonora empty handed. By September 1855, an official survey of the United States-Mexico boundary had been completed, with Ajo being located approximately 40 miles north of the border (Gilluly, 1946).

By the end of 1855, 17 mining claims had been located near Ajo, a wagon road constructed to Petato (now known as Gila Bend) and local Tohono O’odham Indians were hired to help mine the ore. Approximately 10 tons of hand-sorted, high-grade ore, consisting mostly of cuprite and native copper was transported 300 miles by ox-drawn wagons through Fort Yuma to the port of San Diego and shipped by boat around Cape Horn to Swansea, Wales for smelting. Later ore shipments were transferred to barges at Fort Yuma and floated down the Colorado River to the port of Guaymas, Sonora on the Gulf of California for trans-shipment to Swansea, Wales. (Greeley, 1987).

With the viability of this business venture threatened by high transportation costs, a reverberatory furnace was erected at Ajo in 1856 at a cost of $30,000. However, this alternative failed due to a lack of a suitable flux and the high cost of coke or charcoal to fuel the smelter. Unable to make this business venture profitable due to its remote location, high freight costs, low grade of the ores and the lack of water, the Arizona Mining and Trading Company ceased operations by 1859 (Greeley, 1987).

Little further activity occurred at Ajo until 1884, when Tom Childs formed a partnership with Washington M. Jacobs, who established an assay office in Tucson, Arizona in March 1880 and had previously worked for the Arizona Mining and Trading Company (Anonymous, 2016). Jacobs established a permanent camp at Ajo and over the next 14 years intermittently transported high-grade ore via wagon to a Southern Pacific rail siding at Gila Bend from which it was shipped to the Selby Smelting Company in San Francisco (Greeley, 1987). They also erected a small mill at the site in 1897 (Anonymous, 2016).

As an important side note, Washington Jacobs’ descendants remained in the assaying business, running the family assay office in Tucson until July 2011, when his great grandson Michael Jacobs retired. At the time of its closure, the 131-year old Jacobs family business was the oldest assay office in the United States (Anonymous, 2016).

Promoters and Fraudulent Mining Schemes (1898-1908)

With the sale of Childs’ and Jacobs’ holdings to a mining promoter named A. J. Shotwell during the fall of 1898 for $200,000, the history of the Ajo mining district took a decidedly negative turn. Shotwell, with the financial assistance of John Boddie, a successful dry goods salesman from St. Louis, Missouri, organized the St. Louis Copper Company to finance the construction of a 10-stamp mill. Producing only $36,000 of concentrates at a cost of $45,000, this business venture ended in bankruptcy. Undaunted by the previous failure, Shotwell formed the Rescue Copper Company as a way to salvage its predecessor’s assets. This company subsequently sold a portion of its holdings to the Cornelia Copper Company, another firm based in St. Louis, Missouri, which was organized by John Boddie, Captain Huie, W. W. Brown and C. E. Neely in May 1900 (Gilluly, 1946). About the same time, other claims controlled by Shotwell were transferred to the Shotwell Tri-Mountain Copper Company and San Francisco-based Ajo Copper Mountain Mines Company (Gilluly, 1946). In February 1907, Cornelia Copper Company absorbed the Shotwell Tri-Mountain Copper Company and Rescue Copper Company, after it was discovered that Shotwell was misappropriating company funds (Anonymous 1981). The Cornelia Copper Company was subsequently reorganized as the New Cornelia Copper Company in September 1909 (Stevens, 1911).
Unable to successfully treat the copper-bearing rock by conventional methods, the management of the Cornelia Copper Company sought ways to resolve these issues. However, their inexperience in the mining industry made them vulnerable to fraudulent schemes to profitably recover copper from “hard-to-treat ores.”

During early 1906 the Cornelia Copper Company enlisted assistance from Professor Fred L. McGahan, who claimed to have invented a process to recover copper using a “vacuum smelter” (Figure 1). This facility prevented nitrogen in the air from coming in contact with the ore, reportedly eliminating all slag and the need for fluxing agents (Stevens, 1907). Once the air had been pumped out of the device, the ore could be fed into it along with a small amount of fuel oil and enough oxygen to get the smelting process started. McGahan claimed the temperature within the furnace could be regulated so precisely that all of the elements could be melted one at a time. Gold would melt first and accumulate at the bottom of the furnace, where it could be drawn off by the bottom spigot. The next higher spigot was for silver and so on. The oxygen and hydrogen gas collected from the top spigots could be used to fuel the furnace indefinitely, eliminating the need for an outside fuel source (Rickard, 1987).

The Cornelia Copper Company invested $30,000 to build McGahan’s vacuum smelter at Ajo. However, before construction of the Ajo facility was completed, a similar facility in California was tested and failed to live up to expectations. Professor McGahan skipped town, but not before leaving a note demanding an additional $50,000 to reveal the secret of its operation. On learning of the events in California, management of Cornelia Copper immediately halted construction on the Ajo facility (Anonymous, 1981a). McGahan was subsequently arrested, sued for damages and criminally indicted in May 1907 on three counts of obtaining money under false pretenses (Stevens, 1908).

Another of the notorious scams in the Ajo mining District involved the Rendall Ore Reduction Company, which acquired the property held by the Ajo Copper Mountain Mines Company in January 1907 (Stevens, 1909). They erected a 50-ton/day plant at the site, which reportedly could treat all types of copper ores...
at a cost of $1/ton, recovering 95 to 98% of metal content. This facility consisted of a special upright furnace, which was practically air-tight with a suction draft operating above the charge. Low incandescence by gases from wood, coal or oil were used to treat the ores, which were fluxed with a special fluxing gas that prevented oxidation, carbonization or chlorination. The charge was then quickly quenched in a vat of water to break up the gangue and passed through a set of rolls, finely crushed and the copper recovered by concentration (Stevens, 1909). The Rendall Process ultimately treated all ore types with great difficulty and was a complete failure (Anonymous, 1981a). The Rendall Ore Reduction property was subsequently acquired by the Ajo Copper Company in 1909 (Stevens, 1911).

Undaunted by losses resulting from the McGahan fiasco, the Cornelia Copper Company turned to another new and untested process in 1907, known as the “Anderson Process,” which was initially touted to produce copper at a cost of less than 3 cents per pound. Cost estimates were later increased to 8 cents per pound. It employed hydrofluorsilic acid, which was reported to be made from approximately equal amounts of sulfuric acid, quartz and fluorspar with the addition of a secret ingredient. Used to leach siliceous oxide ores, this facility employed three 5-ton leaching tanks, followed by settling tanks and 52 square electrolytic tanks placed in four rows for the circulation of electrolyte (Stevens, 1909).

An Anderson electrolytic reduction plant was erected at Cornelia Copper’s mine site during 1907. However before testing of this new facility had been completed, financial instability during the Panic of 1907 resulted in the suspension of all mining activities at Ajo in October 1907. Prior to its closure, its best daily production amounted to 600 pounds of copper, only 6% of its rated daily capacity of 10,000 pounds, making its commercial feasibility highly questionable (Stevens, 1909).

An Elusive Exploration Target (1909-1910)

Three short-lived exploration ventures evaluated the copper potential of the Ajo mining district during the winter of 1909-1910.

The General Development Company, a holding company controlled by the Lewisohn financial interests, acquired an option to purchase the controlling interest in the New Cornelia Copper Company. Consulting engineer, J. Parke Channing directed their $20,000 diamond drilling and underground exploration program. Five diamond drill holes were completed with the deepest being 188 feet. It showed the ground to be oxidized to a depth of 30 feet, below which occurred an unoxidized zone containing 2 to 2.75% copper (Stevens, 1911). The remaining 4 holes were barren (Anonymous, 1981a).

Seeley W. Mudd and associates acquired an option on the Rendall Ore Reduction property (Gilluly, 1946) from the Ajo Copper Company (Stevens, 1911). Their exploration effort consisted of a six-hole churn drilling and underground program, which was conducted along the southern edge of the Ajo Basin (Anonymous, 1981a). Four of the holes failed to encounter mineralization, while the other two encountered mineralized material that averaged 1.25% copper (Ingham and Barr, 1932).

A group of English capitalists backed by the Tharsis-York Company acquired an option on claims held by Tom Childs, where they sank an exploration shaft in an outlying area (Gilluly, 1946).

Failing to find sufficient evidence to warrant additional development, each of these exploration ventures allowed its option to lapse during 1910. It is interesting to note that each of these efforts had its own theory of where the ore body was located. Nearly all of this activity was conducted on lower ground surrounding the three small hills composed of hard, silicified outcrops that would eventually be found to overlie the Ajo copper deposit (Joralemon, 1914).

Calumet and Arizona Mining Company (1911-1931)

After assuming the job of general manager of Calumet and Arizona’s Bisbee operation in July 1910, John C. Greenway began looking for opportunities where copper could be mined by open pit methods. In a discussion on potential exploration opportunities with Ira Joralemon in January 1911, the Ajo mining district was mentioned as a possible candidate for open pit mining (Coggin, 1999). After a short visit to Ajo, Joralemon reported the mining district had an estimated potential resource of 40 million tons,
averaging approximately 2% copper, consisting of sub-equal amounts of oxide and sulfide material. A preliminary metallurgical examination by Louis Ricketts showed both oxide and sulfide resources required the development of a new metallurgical process to economically recover the copper. Despite these challenges, it was decided that further work was warranted (Anonymous, 1981a).

The Calumet and Arizona Mining Company acquired an option on the Childs claim group, which lies east of the New Cornelia holdings and in part between the New Cornelia and Rendall Ore Reduction properties (Parsons, 1933). After exploring their holdings with a few churn drill holes, they allowed their option to lapse. The Childs property was subsequently acquired by the New Cornelia Copper Company (Gilluly, 1946).

Calumet and Arizona began a diamond drilling program at Ajo in December 1911, using the E. J. Longyear Company as the drilling contractor. This program employed holes drilled on 200-foot centers with intermediate holes drilled in areas where the tenor of the mineralization appeared uneven. Early results from this effort were so discouraging Calumet and Arizona decided against making a $50,000 payment required by their option agreement with Ajo Copper, pre-maturely terminating their agreement on the Rendall Ore Reduction property (Gilluly, 1946).
Not long after the option expired, James Philips, Jr., former president of the Butte & Boston Consolidated Mining Company, purchased the Rendall Ore Reduction property from Ajo Copper Company for $200,000. Philips organized the Ajo Consolidated Copper Company in December 1912 and commenced an exploration program at the site. Over the next four and half years, they completed sixty-four diamond drill holes, averaging 445 feet in depth as well as a substantial amount of underground development (Weed, 1918).

After a discouraging start, Calumet and Arizona’s exploration efforts soon confirmed the presence of a large copper sulfide resource at New Cornelia’s Ajo property. Following the completion of the initial drilling program in May 1913, bulk metallurgical tests were conducted on approximately one-half of the drill holes, through the excavation of four-by-six-foot test pits to depths of 50 to 150 feet (Anonymous, 1981a).

The large sulfide resource was overlain by a carbonate oxide cap that was not amenable to treatment, due to its low copper content. Calumet and Arizona’s management realized that developing a process to make it profitable to recover copper from this oxide resource would substantially improve the bottom line of this business venture (Gilluly, 1946). Other challenges included establishing a rail connection with the outside world and finding a sufficient water supply. The Calumet and Arizona Mining Company successfully exercised its option to acquire a controlling interest in the New Cornelia Copper Company during 1913.

A survey of the railroad right-of-way was made during 1913 (Figure 3). The Tucson, Cornelia and Gila Bend Railroad was incorporated in May 1915 and commenced construction of a standard gauge line in August 1915 (Irwin, 1987). This rail line was completed in February 1916, connecting Ajo with the Southern Pacific rail line at Gila Bend. This permitted high-grade, siliceous, direct smelting ores (2.5% copper) to be shipped to Calumet and Arizona’s Douglas smelter (Gilluly, 1946).

The search for a reliable water supply began during the spring of 1913 with the drilling of four deep water wells in the valley north of Ajo. The most promising of these wells was located at Childs Siding, located approximately 6 miles north of the mine site. Drilled to a depth of 1,348 feet through alluvium, lava and interbedded gravels, this well tapped a productive aquifer at a depth of 645 to 664 feet. A 6-mile water pipeline was constructed to a 500,000-gallon storage tank located on Reservoir Hill (Gilluly, 1946).

Figure 3. Ajo location map showing railroad infrastructure, ca. 1913.
As drilling defined the ore body and mine plans were developed, it was found the old town of Ajo was located too close to the proposed open pit. The New Cornelia Copper Company relocated the town site approximately one mile north of the original community. New Ajo was a planned community with a plaza, hotels, stores, hospital, bank, paved streets, water supply and sewage system. Competing communities of Clarkstown and Gibson were established immediately east of the leach plant site and northwest of the new Ajo town site, respectively (Gilluly, 1946). Like most southwestern communities of the time, the towns were segregated with Mexicans residing in Mexican Town, which was located between Ajo and mine (Coggin, 1999). Much of Clarkstown was destroyed by a fire in 1931.

After several years of research led by Dr. Louis Ricketts, Calumet and Arizona was ready to test a process designed to recover copper from approximately 12 million tons of highly siliceous, oxidized, copper-bearing material that occurred above the sulfide ore body at Ajo. Commissioned in January 1915, this 40-ton/day pilot leach plant treated 12,222 tons of oxidized material by the end of 1915 (Gilluly, 1946). Recovering 74 to 79% of the copper from oxidized material, these tests demonstrated it was economically feasible to recover copper from oxidized rock capping the Ajo ore body (Weed, 1916).

By the end of 1915, the Calumet and Arizona Company completed eighty-four diamond drill holes averaging 300 feet in depth at Ajo. More than 5,000 feet of underground development was also conducted to recoverable gold and silver values of $0.30 to $0.50 per ton (Weed, 1916).

The management of New Cornelia Copper Company decided to proceed with the development of the Ajo open pit project on September 1, 1915. Financing for this project was made through the issuance of $4 million of 6%, sinking fund gold bonds that matured on September 1, 1927, which were convertible into stock at $10/share (Weed, 1918).

Construction of a 5,000-ton/day oxide leach plant commenced in early 1916. It was commissioned in April 1917 at a cost of $7.5 million. A supply of sulfuric acid was secured from an acid plant constructed at Calumet and Arizona’s Douglas smelter (Tenney, 1927-1929). Its first shipment of electrolytic copper was made on June 18, 1917 (Tobelmann and Potter, 1919).

New Cornelia Copper’s Ajo project was Arizona’s first large porphyry copper deposit to be mined by open pit mining methods. Initial mining of three steep-sloped hills ranging from 115 to 165 feet above the general surface proved to be most challenging part of the mining operation (Figure 4). It was finally decided to remove the hills with a single lift, rather than establishing benches between their base and crests. (Ingham and Barr, 1932).

Early blasthole drilling demonstrated that air drills were better suited than churn drills at Ajo. The original air drills were piston machines with tripod mountings, which averaged about 24 feet per shift. Transitioning from piston drills to the more efficient hammer machines began in 1923 and was completed by 1930. The hammer drills averaged about 80 feet per shift (Ingham and Barr, 1932).

Figure 4. Commencement of mining operations on the Three Green Hills that capped the Ajo Ore Body (circa 1917). (Photo provided by Freeport-McMoRan, Inc.)
The New Cornelia mine initially employed three 105-ton railroad type, oil-fired, 4-cubic yd. steam shovels, which loaded the ore into five to six car trains consisting of 20-cubic yard, side-dump rail cars that were hauled over standard gauge tracks by oil-fired, steam-powered locomotives (Ingham and Barr, 1932).

The ores were transported to a three-stage crushing circuit located approximately one mile northeast of the pit, where it was reduced to 1/4-inch. The crushed ore was delivered via conveyor to one of eleven leach tanks, each designed to hold 5,000 tons of ore. Each charge was leached with sulfuric acid and ferric sulfate for eight days, before being disposed of. The resulting pregnant solution was treated by four sulfur dioxide gas towers, where ferrous iron was converted to ferric iron prior to reporting to 152 electrolytic tanks, each holding 77 cathodes (Figure 5). An electric current was used to precipitate copper onto cathodes, producing a finished cathode product averaging more than 99.4% copper (Weed, 1918). Any copper remaining in the discarded solutions was precipitated onto scrap iron, which was recycled to the leach circuit or shipped to the smelter for further processing (Tobelmann and Potter, 1919).

The New Cornelia Copper Company purchased the Rendall Ore Reduction property from Ajo Consolidated Copper Company for nearly $4 million in July 1917 (Gilluly, 1946). At the time of its purchase, Ajo Consolidated Copper’s ore reserves were reported to be 846,100 tons of oxidized carbonate ore, carrying 1.96% copper and 11,998,800 tons of sulfide ore averaging 1.79% copper (Weed, 1918).

Despite the reduced demand for copper following the end of World War I, the New Cornelia Copper Company continued production, although at reduced levels during 1921, when the price of copper bottomed out at 12.7 cents/lb (Jenison, 1924).

Knowing the oxide carbonate ores would be exhausted after several years of production, a pilot plant designed to test the underlying sulfide ores was commissioned in September 1919. Operated until February 1920, this pilot mill demonstrated that copper could be economically recovered from the sulfide ores using existing flotation technology. Construction of a 5,000-ton/day sulfide concentrator began in October 1922. The first sulfide ore was delivered to the crusher on December 26, 1923 and the concentrator was fully commissioned on January 8, 1924 (Gilluly, 1946).
The sulfide concentrator employed a three-stage crushing circuit, followed by a two-stage grinding circuit with the copper-bearing concentrates being recovered by Callow-type flotation cells (Barker, 1939). The addition of three new 2,000-ton production lines and modifications to the five older lines at the Ajo sulfide concentrator increased its production capacity to 16,000-tons/day in 1929 (Parsons, 1957). These modifications also improved overall copper recoveries from 87-89% to approximately 93% (Anonymous, 1930).

Both leaching and sulfide process facilities at Ajo operated until early July 1930, when the oxide leaching plant was closed after processing 16.34 million tons of oxidized carbonate ore, averaging 1.36% copper (Gilluly, 1946).

The Calumet and Arizona Copper Company merged with the New Cornelia Copper Company in April 1929 (Gerry and Miller, 1932). Although the Calumet and Arizona Mining Company transformed the problem-plagued Ajo property into a real money-maker, it also owned successful underground mining and smelting operations at Bisbee and Douglas, respectively. Its, historically generous dividend policy however had depleted much of its cash reserve. Falling copper prices following the crash of the stock market in October 1929 left the Calumet and Arizona Mining Company without the cash flow it required to remain competitive (Anonymous 1981b).

Conversely, Phelps Dodge Corporation’s more conservative management policies had accumulated a huge cash reserve, which could be used to acquire additional ore reserves it required to achieve its long range production goals (Anonymous, 1981b).

Realizing a merger would benefit both companies, negotiations began in April 1930. Although a minority of shareholders from Calumet and Arizona delayed a decision for many months, shareholders from both firms voted in favor of the merger on September 21, 1931. This allowed Phelps Dodge to acquire Calumet and Arizona’s assets by increasing its capitalization from 3 million to 6 million shares (Anonymous, 1981a). Calumet and Arizona’s New Cornelia project became the New Cornelia Branch of the Phelps Dodge Corporation.

**Phelps Dodge (1931-2007)**

Following Phelps Dodge’s merger with Calumet and Arizona Mining Company, the price of copper continued to fall, reaching a low of 4.8 cents/pound by December 1932 (Julihn and Meyer, 1934). This resulted in the suspension of all mining and milling operations at Ajo from April 1932 until July 1934 (Gilluly, 1946). Due to the prolonged shutdown of the operation, much work was required to return the mine and concentrator to full production. Figure 6 shows a panorama of the Ajo pit in early 1934. Conversion of the railroad-mounted steam shovels to caterpillar mounts greatly improved the efficiency of the mining operations (Gerry and Luff, 1936).

Concentrator capacity was increased from 16,000 to 20,000 tons/day in 1937 with the replacement of the older pneumatic flotation cells by newer trough-type flotation machines and the addition of three new cone crushers (Barker, 1939). Processing capacity was further expanded to 25,000-tons/day during 1941-42 with further modifications to the grinding circuit and to 30,000-tons/day in 1953 with the addition of two new ball mills (Luff, 1956).

The older steam shovels were replaced by 4.5-cubic yd. electric shovels around 1936. In April 1937, the New Cornelia mine became one of the first open pit...
copper mines to use off-highway, end-dump haul trucks, when it became necessary to strip a portion of Arkansas Mountain that rose approximately 500 feet above the south rim of the open pit. Four 22.5-cubic yd. end-dump haul trucks were employed to perform this task (Figure 7). Successful use of these trucks led to their use in performing other tasks, where track haulage was impractical or not cost effective (Angst, 1941).

Prior to 1945, all of the main haulage track at Ajo was laid out on a 2 percent or less grade. About that time a decision was made to abandon steam haulage and increase the main-line grade to 3 percent (Hardwick, 1960). Transition from steam haulage to electric haulage was completed in 1947, resulting in a marked improvement in pit efficiency and substantially lower haulage costs (Needham and Luff, 1949). The main haulage tracks were electrified, but loading tracks were not. Trolley-type electric locomotives with two auxiliary 235-hp diesel generators were employed. Power was supplied to these locomotives by a pantograph (a jointed framework conveying an electric current) on the main-line tracks or by the two auxiliary diesel-electric generators, when the locomotives were on loading tracks. Larger 1,750-hp diesel-electric locomotives that were capable of handling the 3 percent grade were introduced in 1955 (Hardwick, 1960). Installation of remote controls in the locomotives during 1965 permitted the trains to be operated by one-man instead of two-man crews (Figure 8).

Site preparation and preliminary work on the Ajo smelter began during 1948. The Ajo smelter was commissioned in July 1950 at a cost of $8 million, eliminating the need of hauling 700 tons of concentrate/day to the Douglas smelter, a distance of 300 miles (Parsons, 1957). This facility employed a 30- by 100-foot reverberatory furnace, which produced a matte product that was upgraded by two 13- by 30-foot Peirce-Smith converters. The blister copper product from the converters was further upgraded by a 13- by 30-foot anode furnace and cast into 700-pound anodes that were shipped to the Phelps Dodge’s copper refinery at El Paso (Hardwick, 1960). This facility benefitted from a ready source of silica flux provided from the tailings derived from the siliceous oxide ores that were treated by the oxide leach plant between 1917 and 1930 (Parsons, 1957).

The layout of the operation is shown in Figure 9.
Labor union contracts with most U.S. copper producers expired on June 30, 1967. Allied with twelve smaller unions, the United Steelworkers of America and the International Union of Mine, Mill and Smelter Workers took the lead in negotiating new contracts. Although usual issues such as wages, pensions and working conditions were discussed, the unions focused much of their efforts on establishing bargaining procedures that required company-wide bargaining and company-wide contracts. The management of the major copper producers was uniformly opposed to this demand (Rowland and Greenspoon, 1968).

Despite a two week extension, efforts to resolve their differences failed. Workers at all plants without binding contracts, including Phelps Dodge's Ajo operation, went on strike on July 15, 1967 (Larson and Henkes, 1968). On February 28, 1968, the National Labor Relations Board ruled company-wide negotiations were illegal, because it amounted to an unlawful “refusal to bargain” (Stucki, 2009). Seeing that government opinion was turning against them as well as support from the local striking miners, the unions settled one of the longest copper strikes in history. Workers at Ajo returned to work on March 19, 1968 (Larson and Henkes, 1970).

In May 1970, the Arizona Department of Health established air-quality standards, which required sulfur emissions from smelters not to exceed 6,500 pounds per hour and contain no more than 10 percent of the sulfur in the smelter feed. Arizona's standards required compliance by May 1973. In January 1971, the newly established Federal Environmental Protection Agency (EPA) issued guideline standards that permitted higher allowable sulfur dioxide concentrations with no limit on total sulfur discharged to a proportion of sulfur in the smelter feed (Moore, 1973).

As studies were conducted on how to meet these standards, it became apparent the cost of bringing some of the older smelters into compliance with Arizona's standards was not feasible. In October 1971, Phelps Dodge petitioned the Arizona State Board of Health to lower state standards to those suggested by the EPA, estimating the costs of bringing its Douglas, Ajo and Morenci smelters into compliance would be $112 million under Federal standards as opposed to $400 million to meet Arizona's standards. Furthermore, if state standards were imposed, the Douglas smelter would be forced to close (Moore, 1973).

In May 1972, the Arizona State Board of Health revised its sulfur emissions standards to bring them into compliance with the Clean Air Act of 1970. The new standards required an annual average sulfur dioxide content of air surrounding smelters to be less than 80 micrograms per cubic meter by January 1974 and 50 micrograms per cubic meter by July 1975. Higher concentrations were permitted for short periods. Smelting facilities could also control emissions by curtailing operations during periods of air stagnation. The revised standards also required all smelters to remove at least 90% of the feed sulfur from their atmospheric exhaust by December 31, 1980. However, the EPA refused to approve Arizona regulations, because the proposed intermittent production curtailment method of controlling sulfur dioxide emissions was deemed to be inadequate and unenforceable. They wanted to limit smelter emissions by reducing the amount of sulfur in the feed to a point that atmospheric pollution did not occur (Moore, 1974).
In September 1973, the EPA approved the use of meteorological stations for continuous monitoring of smelter emissions, existing ambient air quality, and meteorological conditions. This made it possible to adjust production rates to ensure permissible pollution levels were not exceeded. This action brought the EPA’s regulations into substantial agreement with those of the Arizona Department of Health (Greenspoon and Schroeder, 1976). However, problems continued to plague the facility requiring an additional $3.6 million for two mist precipitators at the acid plant during 1974, bringing the total cost (1971-1974) of the smelter refit to $31.3 million (Everett, 1977).

Sulfuric acid by-product was sold to markets in Arizona and California.

In mid-1979, Phelps Dodge announced plans to expand the Ajo pit, which required the relocation of the mine office building, change room, and most of the mechanical shops as well as 135 privately owned homes. Phelps Dodge purchased employee owned homes that were located in the affected areas and made arrangements for the resettlement of the occupants. By the end of December 1980, site preparation was underway for relocating the mining engineering office and locomotive maintenance shop and for construction of the new office and change room building, and mine garage (Burgin, 1982). Much of this work was completed during 1981, allowing pre-production stripping for open pit expansion to continue on schedule.

Construction of a molybdenum recovery circuit at the New Cornelia concentrator began in February 1980. The molybdenum flotation circuit was completed in November 1980 at a cost of $3 million (Burgin 1982). The first moly concentrate shipment was made on January 26, 1981 (Burgin, 1983).

A consent decree negotiated with the EPA on the Ajo smelter air quality compliance programs was approved by the Federal District Court in October 1981 and amended in 1984 (Burgin, 1983). Deferred compliance orders required Phelps Dodge to bring the Ajo smelter into compliance with the Federal Clean Act by reducing sulfur dioxide emissions and particulate matter to acceptable levels by the end of 1984 and the end of 1985, respectively (Burgin, 1986).
Declining copper prices during the early 1980s resulted in Phelps Dodge’s decision to temporarily suspend mining, milling and smelting operations at Ajo on April 17, 1982 (Burgin, 1984). Of the normal workforce of 1,100 employees, 800 were laid off. Meanwhile in an effort to reduce costs, engineering studies focused on methods of increasing production capacity. Approximately 525 workers were recalled when mining and milling operations resumed on February 28, 1983. Ajo’s copper concentrates were shipped to the Douglas and Hidalgo smelters. On July 1, 1983, Ajo workers went on strike. As with other Phelps Dodge operations, supervisory personnel, non-striking employees and newly hired workers kept operations going. By September 1983, Ajo had been returned to full production. Preparations for resuming operations at the Ajo smelter began in October 1983 with repairs to the acid plant (Burgin, 1985). This allowed the smelter to resume operations in May 1984. However, all mining and milling operations at Ajo were indefinitely suspended in August 1984, due to the low price of copper and high mining costs (Burgin, 1986).

Unwilling to spend the $45 million required to bring the Ajo smelter into compliance with the Federal Clean Air Act, Phelps Dodge closed the facility in April 1985 (Beard, 1986). Over its 86-year life (1899-1985), approximately 445.9 million tons of ore were mined at Ajo, yielding 3,085,390 tons of copper, 463 tons of molybdenum, 1.56 million ounces of gold and 19.7 million ounces of silver (modified from Keith et al, 1983). The operation remained on a care and maintenance status until 1989, when corporate management decided not to resume production for the foreseeable future.

The Tucson, Cornelia and Gila Bend rail line was briefly re-opened during 1995-1998, allowing the concentrator and smelter to be dismantled and removed (Anonymous, 2016b). The 360-foot smelter stack at Ajo was toppled by a controlled blast on November 29, 1995. Demolition was completed in February 1996. In May 1997, Phelps Dodge announced plans to resume production at Ajo. Scheduled to begin in early 1998, this $238 million project was indefinitely shelved pending improvement of the price of copper (Schwantes, 2000).

Freeport-McMoRan, Inc. (2007-present)

Freeport-McMoRan Copper and Gold Inc. (renamed Freeport-McMoRan, Inc. in July 2014) acquired the Ajo project through its merger with the Phelps Dodge Corporation in March 2007 (Freeport-McMoRan Copper and Gold, Inc., 2008).

In an effort to reduce America’s dependence on fossil fuels, Freeport-McMoran leased a portion of its Ajo property to Recurrent Energy LLC (acquired by Duke Energy Renewables in August 2011). Construction of Recurrent Energy’s 5-MW Ajo solar energy project began in January 2011 (Figure 10). This facility achieved commercial operations in September 2011 (Anonymous, 2011a and Anonymous, 2011b).

Figure 10. Ajo Solar Energy Project, looking east (Photo Google Earth).

Phelps Dodge’s successor, Freeport-McMoRan continues to periodically assess the economic feasibility of returning the Ajo project to production (Figure 11). As of December 31, 2015, this project is estimated to contain a sulfide resource of 482 million short tons, averaging 0.40% copper, 0.010% molybdenum, 0.002 oz. of gold/ton and 0.023 oz. of silver/ton (Freeport-McMoRan, 2016).
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References


