Copper Chronicle: Magma Mine, Superior Arizona

Douglas E. Kupel

Mining is a boom and bust activity. Good economic times and high demand lead to new discoveries and increased production. Poor economic times result in mine closures and layoffs. The copper chronicle of the Magma mine near Superior, Arizona, is representative of the boom and bust cycle of the copper industry in Arizona. Its story illustrates the economic impact copper mining had, and continues to have, on Arizona.

In 1996, the Australian corporation Broken Hill Proprietary Limited (BHP) purchased the Magma holdings at Superior and San Manuel. That year miners extracted 1,356,000 tons of copper from mines with a value of $2.930 billion. Copper sold for $1.20 per pound when BHP paid $2.4 billion for the Magma operations. Today, with copper trading at only 63 cents per pound, BHP has closed its mine at Superior and its mine and smelter at San Manuel.

While the future of Arizona's copper properties looks bleak today, locations such as the Magma Mine in Superior have a rich history of previous cycles of economic ebb and flow. Because Magma is an underground, hard rock copper mine, many of its historic support facilities have remained intact on the surface. In most other locations in Arizona, the construction of large open-pit copper mines resulted in the destruction of historic mining facilities as the pits grew ever wider. In contrast, the deep ore body at Magma remained an underground mine with the subsequent preservation of its surface facilities.

When BHP purchased the Magma Mine in 1996, its managers undertook a complete examination of the environmental conditions at the site. This included an evaluation of historic and archaeological features. These studies revealed a fascinating story of hard rock copper mining in Arizona. While the original study had as its goal the identification and survey of historic properties that were significant enough to be preserved, the research involved has left mining historians with a rare insight into a significant and unique property.[1]

Although the history of the Magma mine must be understood in terms of hard rock mining, the many activities involved at the property to mine, concentrate, refine, and transport the metal expand the depths of its history. In addition, providing for the needs of the workers at the site also comprise a major portion of the Magma mine story. This article examines the history of the property with an emphasis on standing surface structures. Those structures can be categorized by which particular part of the mining process they were associated with: extraction, concentration, smelting, transportation, or personnel needs.[2]

Physical Setting of the Magma Mine

As with many mining histories, location proved to be the key factor in the establishment of the Magma mine. The mine is located in northeastern Pinal County and in what was first known as the Pioneer mining district. It is more commonly referred to as the Superior mining area. The town of Superior, located in close proximity to the Magma mine, is situated at the eastern edge of a basin between the Superstition and Pinal mountain ranges. Immediately east of the town and mine the high escarpment of the Apache Leap rises to form a mesa rim of the Pinal Mountains.[3]

Doug Kupel is a historian for the City of Phoenix. He received his Ph.D. from Arizona State University in 1995. An earlier version of this article was presented at the Mining History Association's 1998 conference in Bisbee.

The Superior area is the location of a highly mineralized district. Here, millions of years in the past, geologic forces concentrated massive amounts of precious minerals in varying degrees of strength. Some of the minerals were tightly localized and easy for the early miners to discover. Other minerals were dispersed in small percentages over large areas and required careful study and experimentation to find and exploit them. These deposits were large lenses of ore, formed in limestone, often containing high grade concentrations of ore. These same geologic forces concentrated minerals in other areas of Arizona as well, in addition to the Magma mine, at Clifton-Morenci, Globe, Bisbee, Ajo, and Jerome, making the state the largest copper producer in the nation. The discovery of these deposits between 1870 and 1880 came at a time when the development of electricity and telephones created an insatiable demand for copper.[4]

Discovery and Early Growth of the Silver Queen Mine and the Superior District, 1875-1910

The initial discovery of mineral resources at the Magma mine is veiled by time and by the secrecy of the miners themselves, but there is no question that the initial identification came during the early years of the Territory when the first prospectors began to fan out across Arizona. Prospectors discovered two significant silver properties in central Arizona in 1875: the Silver King and the Silver Queen mines. The Silver Queen mine shaft later became the No. I shaft of the Magma mine. On March 29, 1875, W. Tuttle located the Hub claim centered on the Silver Queen mine. One year later, on September 1, 1876, Irene Vail located the Irene claim adjacent to the Hub claim. These two claims formed the heart of the Silver Queen property.[5]

In 1880, Phillip S. Swain organized the Silver Queen Mining Company to secure financing for the operation. By 1882 the Silver Queen shaft reached a depth of 400 feet, with short crosscuts on the 100, 200, 300, and 400 levels. The Federal government granted a patent for the Irene claim on October 31, 1885, and for the Hub claim on November 3, 1886. Miners concentrated on the rich silver deposits, leaving the copper ore behind. Mining continued until 1893, when depressed economic conditions and low prices for silver rendered the operation unprofitable.

Another mine in the area was the Golden Eagle. In 1902 it was acquired by the Lake Superior and Arizona Mining Company which had been organized by Michigan businessmen. This group understood the prospects for copper mining in the area. The original claims for the Golden Eagle had been located by George Lobb.

During the remaining years of the nineteenth century, George Lobb served as a caretaker for the Silver Queen. He occasionally sorted silver ore from the dump and shipped it for smelting. Activity resumed in 1906 when George Andrus evaluated the property for copper deposits. His positive report encouraged the formation of the Queen Copper Mining Company, which leased the property from Swain. This activity was short lived. The depression of 1907 put an end to operations. William D. Fisk, an officer in the Queen Copper Company, purchased controlling stock in the Silver Queen property after operations shut down in 1907.

Poor economic conditions kept Fisk from developing the property. By 1910, a new player arrived on the scene. William Boyce Thompson was in the process of developing the Inspiration Copper mine in Miami. Thompson engaged Fred Flindt to examine properties in the Superior area. Flindt looked favorably at the area, and requested that consulting mining engineer Henry Krumb undertake a detailed examination of the old Silver Queen mine. Krumb issued a favorable report in 1910.[6]

In June of 1910 Thompson organized the Magma Copper Company on the basis of the Krumb report. Magma took an option on the Silver Queen mine and began exploratory work to develop the property. This included driving a tunnel from the surface to connect with the Silver Queen shaft at the 215 level. Known as the Flindt Adit after Fred Flindt, this tunnel opened access to the mine. By the middle of 1911 the shaft had been deepened to 650 feet.

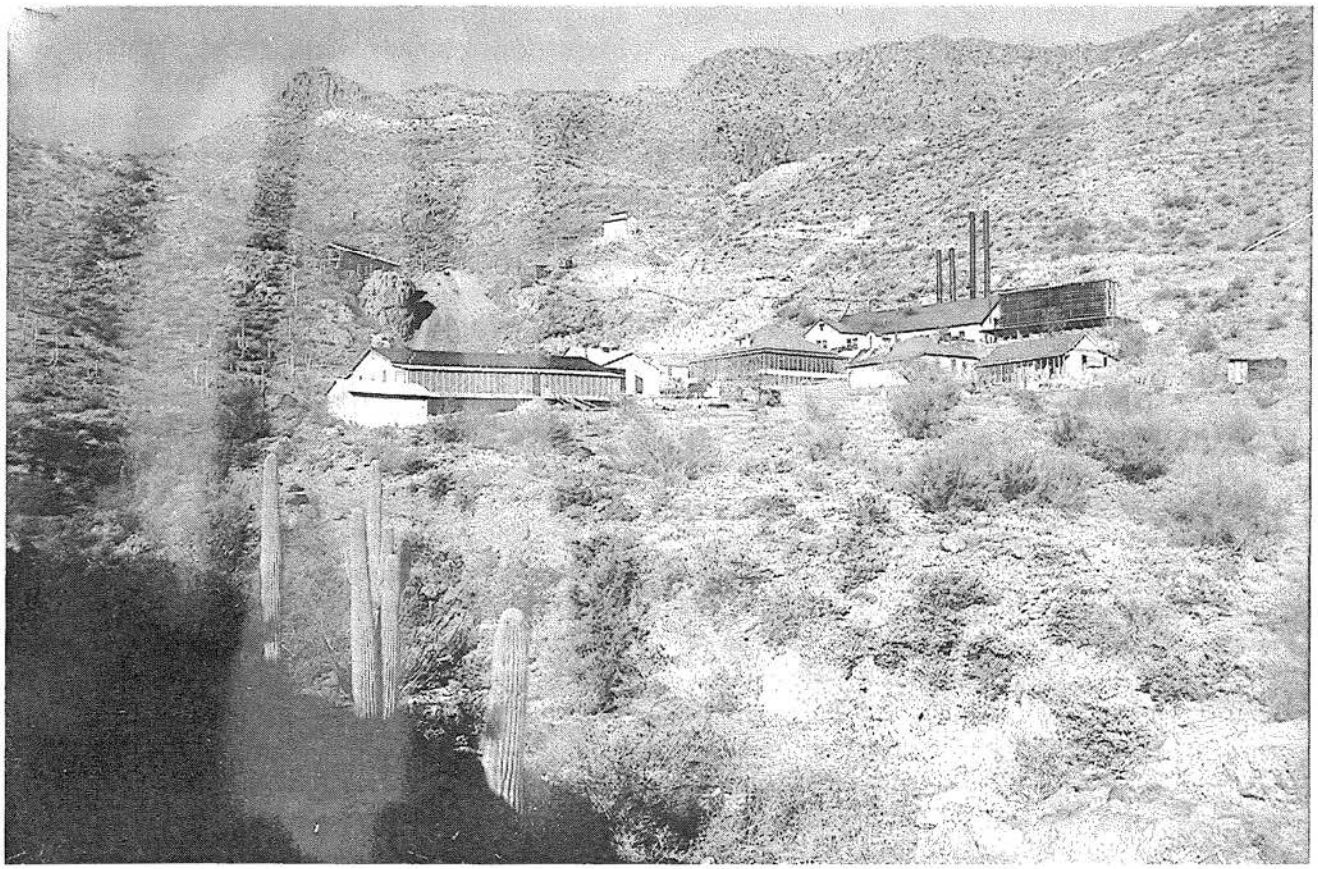
Few men understood copper mining as well as William Boyce Thompson. The son of William Thompson, once the mayor of Butte, Montana, and an active developer of property that evolved into cop-

per giant Anaconda, Boyce Thompson went east for his education to Exeter Academy and the Columbia School of Mines. His mining interests took him around the world, from diamond mines in South Africa to copper mines in Peru. A man of eclectic interests, he founded the Boyce Thompson Southwestern Arboretum on Queen Creek near Superior and the Boyce Thompson Institute for Plant Research in Yonkers, New York. In Arizona, Thompson had strong interests in the Inspiration Mine near Miami as well as the Magma Mine near Superior.[7]

Copper and the Magma Mine, 1910-1921

The organization of the Magma Copper Company and the opening of the old Silver Queen to copper production in 1910 signaled the beginning of one of Arizona's most productive mining properties. Over the next decade Thompson's Magma Copper Co. worked to develop the mine into a very profitable enterprise. The decade from 1910 to 1920 was an auspicious one to start a mine. High copper prices generated by World War I led to increased production. The demand for the red metal to be used in armaments for the European War caused prices to rise and Arizona copper companies took advantage of the situation.

In 1912 the shaft had been deepened to the 800 level and crosscuts on the 500, 600, and 800 levels were being actively mined. Thompson transferred a number of officials from the Inspiration mine to Magma. These included General Manager W. C. Browning, Mine Superintendent E. H. Lundquist, and Chief Engineer I.A. Ettlinger. By August of 1912 a number of associated buildings arose in close proximity to the opening of the Flindt Adit. These included a blacksmith shop, carpenter shop, and change room. At a distance of one-quarter mile from the shaft, Magma constructed a power house and machine shop, general office building, two worker's



Magma mine c. 1920. Dane Coolidge photograph. Courtesy, Arizona Historical Foundation, Tempe.

dwellings, mess hall, assay office, warehouse, two coal bins, and a corral. In January of 1913 magma employed fifty men at the mine.[8]

The work in 1912 located a productive structure of copper ore on the 600 and 800 levels. This encouraged company officials to expand operations. Construction of a concentrator at the property began early in 1914. By August of 1914 workers put the finishing touches on the new concentrator. This first concentrator carried a rated capacity of 150 tons. It used gravity and flotation concentration to prepare the ore for smelting. The concentrator took advantage of topography and was constructed along the back edge of a small hill on the property (a hogback). The concentrator used Wilfley tables and Callow cells. It also contained the first Marcy mill installed for commercial use.

To power the concentrator, Magma officials extended a power line fifteen miles to the Inspiration mine. Here it connected with a government-owned power line that originated at Roosevelt Dam. At magma, officials constructed a transformer house in 1914 near the concentrator to transfer the power from the line to the mill.[9]

To get the ore from the opening of the Flindt Adit to the concentrator, Magma constructed a 2,600 long aerial tramway. At the mine, ore was first stored in bins in preparation for loading onto the tram. A second set of bins at the concentrator (terminal bins) received the ore from the tram in preparation for concentrating.

After the ore had been concentrated, it was dewatered in preparation for shipping. The concentrated materials were hauled by wagons to Florence. Here it was loaded onto cars of the Arizona Eastern Railroad for shipment to a smelter in Hayden.

The increased production from the concentrator soon rendered this method of transportation obsolete. In November of 1914 construction began an a narrow-gauge railroad to connect with the Arizona Eastern. Workers finished the project in May of 1915 at a cost of $160,000.

The total expenditures for the concentrator, aerial tram, and narrow-gauge railroad reached nearly one million dollars in 1914. other facilities constructed during the year included a mill office and store house, a blueprint room, a mine manager's dwelling, and a dwelling for the master mechanic.[10]

In 1915 construction started on a new shaft. Called shaft No. 2, this shaft dropped from the 215 level at the end of the Flindt Adit. This replaced the No. 1 shaft as the main working shaft of the mine. The No. 2 shaft reached the 1,200 level in 1915. To bring added power to the operation, Magma constructed a transformer house at the opening of the Flindt Adit in 1915.

The expansion of the mine following construction of the concentrator resulted in several other improvements in 1915. These included the construction of a wood-frame hospital building, a club house, new mine assay office, and dormitory. Another section was added to the concentrator in 1915, a 50-ton capacity unit for treating lead-zinc ore.[11]

In 1916 the No. 2 shaft reached the 1,500 level. Here, "the Magma vein was found to be mineralized from wall to wall." This vein was 34 feet thick and rich in copper. This discovery provided an ample reward for the tremendous expenditures made by Magma officials over the past two years. To meet the anticipated demand for additional milling capacity, Magma enlarged the concentrator to 300 ton capacity in 1916.[12]

The discovery of the Magma vein at the 1,500 level taxed the hoisting capabilities of the No. 2 shaft, which terminated at the Flindt Adit on the 215 level. As the No. 2 shaft was deepened to the 1,800 level in 1917, Magma official realized the improvements had to be made in order to fully tap the possibilities of the Magma vein. Late in 1917, mine workers opened the No. 3 shaft. The collar of the No. 3 shaft reached the surface 400 feet south of the No. 1 shaft, reflecting the southward trend of the deposits. A tunnel connected the No. 3 shaft with the ore bins at the Flindt Adit.

Other improvements in 1917 included the construction of a mine foreman's house, the construction of five three-room cottages for married employees, a machine shop near the concentrator, and several changes to the concentrating process. Late in the year, plans were made to extend the narrow gauge railroad to the 500 level. Construction of a railroad roundhouse began late in the year. Plans were also made to begin construction of a new power line to supply the mine. Originating at Goldfield on the Salt

River, the new line would have a capacity of 600 kW.[13]

Magma officials completed the Goldfield power line in 1918. This additional power was needed as the No. 3 shaft reached the 1,600 level. The No. 3 hoist house and was completed in 1918 and the hoist and generators installed. The railroad roundhouse was completed early in the year. A major addition in 1918 was the construction of a two-story warehouse of concrete and steel. This mine warehouse served as the main distribution point for supplies entering the property.[14]

Following the Armistice which ended World War I in 1918, tough times descended on the Arizona copper industry. Reduced copper prices and stockpiled bullion left from the years of high production meant reduced demand for the red metal. Despite the reduction in the price of copper, Magma's rich deposits continued to provide a steady income. However, profits had declined from over $1 million in 1917 to $178,000 in 1919.[15]

Despite the set-back in copper prices, Magma officials continued to finish plans drafted during the war. In 1919 both the No. 2 and No. 3 shafts reached the 2,000 level. To reduce costs, Magma officials drove a new adit to the surface at the 500 level. Called the lower main tunnel, this improvement reduced the expense of hauling ore to the Flindt Adit, 300 feet higher in elevation. Buildings completed in 1919 included a new mine office and a new main office. Construction was started that year on a new change house and a timber framing shed. This new construction represented the creation of the 500-level yard and a gradual shift of support operations from the higher elevations of the property. The new buildings were located along the narrow-gauge tracks near the opening of the lower main tunnel which reduced transportation costs.

The low price of copper resulted in curtailed operations in 1920. Development work continued, particularly on the 1,600 and 1,800 levels. To further reduce costs, Magma officials instituted electric haulage at the 500 and 200 levels within the mine. This necessitated the construction of a battery storage house. The change house and the timber framing shed were completed in 1920. The company added a tube mill and blower to the concentrator that year.[16]

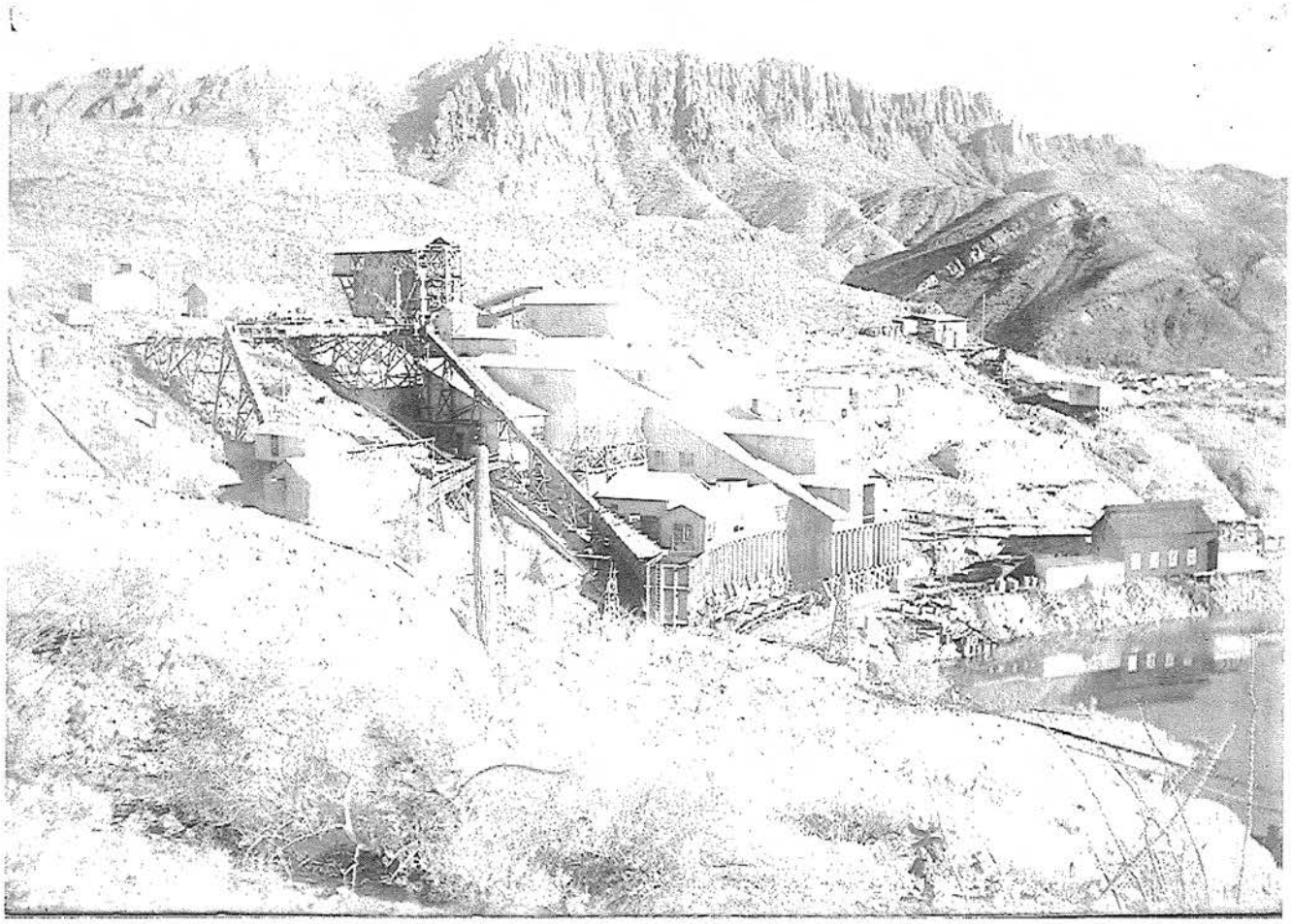
Also in 1920, construction began on the No. 4 shaft. This shaft was located to the east of the property and served as an air shaft to improve ventilation in the mine. As the workings reached greater and greater depths, the temperature of the rock increased. Although the name of the mine originated from the igneous rock that was plentiful in the area, as mining continued deeper and deeper it became apparent that the name Magma was appropriate for another reason. The Magma mine was the hottest in Arizona.

As for every copper property in Arizona, 1921 represented a low point. Copper prices had not risen from the post-war slump. The net average price for producing copper was 14.9 cents, compared with an average net selling price of 14.7 cents. By the end of the year producers had accumulated nearly 8 million pounds of unsold copper. At Magma, workers mined ore for the first three months of the year only. Officials shut down the concentrator at the end of March. Development work continued, with the No. 2 shaft reaching a depth of 2,450 feet. The results were gratifying. High grade copper ore continued as the shaft deepened.[17]

Magma officials faced some hard decisions in 1921. High production costs and low copper prices had curtailed mining. Development work showed that the mine had large amounts of high grade copper ore. To combat the cost issue, officials decided to embark on another improvement program that would allow for continued mining. The expansion of the railroad to standard-gauge and the erection of a smelter on site would reduce the costs associated with sending the ore to Hayden for smelting. Despite the severe slump in the copper industry, Magma officials decided to go ahead with a massive expansion of operations at Superior.

The Smelter Era, 1922-1929

In 1922, the Magma Copper Company issued $3.6 million in bonds to construct a standard-gauge railroad and smelter at Superior. The company engaged the Toohy Brothers Construction Company to construct the standard-gauge railroad and the engineering firm of Bradley, Bruff & Labarth of San Francisco to prepare the smelter plans. In anticipation of construction, the company opened a brick



Magma concentration mill ca. 1920. Dane Coolildge photograph. Courtesy, Arizona Historical Foundation, Tempe.

plant on the property. In preparation for the larger quantities of ore that the smelter would require, Magma enlarged the concentrator to a capacity of 600 tons. The concentrator was closed during the upgrade, and no new ore was stoped or shipped during 1922.

Construction of the new project began late in 1922. Two of the first buildings completed were the metallurgy building (assay office) and its associated grinding room or "bucking room." The company broke ground for the smelter itself in February of 1923. The smelter office was the first building completed.[18]

The smelter consisted of six coarse ore bins where the material received direct from the mine arrived. Larger-sized ore passed through a crushing plant to reduce the size of the material. Concentrates from the mill, after being filtered and thickened at the filter plant, joined the flow at the end of the crusher. The ability to pump concentrates from the mill to the smelter was a major improvement. From the end of the crusher and the filter plant, the material passed by conveyor belts to the bedding bins. The material then traveled to one of five Herreshcoff roasters. Fumes from the roasting process passed through a Cottrell plant to recover copper-laden dust and smoke. The remaining exhaust passed to the smelter stack. The roasted ore passed from the roaster to the reverbatory furnace where it melted. Here the slag was removed and the matte transferred to the convertor for conversion to blister copper. The finished blister copper was then ready for shipment off-site.[19]

In addition to the smelter itself, Magma constructed several ancillary structures at the smelter complex. These included a power house, boiler and machine shop, warehouse, smelter change house, and oil reservoir. The power house generated electricity with two steam turbines and contained a blowing

engine to provide air used in the smelting process. Steam for the power plant was generated in the boiler room which also contained steam-powered machine tools. Incoming materials for the smelter were stored in the warehouse. The smelter change house provided a location for smelter employees to change their clothes when going on or off shift. The oil reservoir consisted of a 20,000 BBL oil storage tank from which fuel oil was pumped through a pump house to the furnaces in the boiler room.

The construction of the standard-gauge railroad resulted in the completion of additional facilities in the vicinity of the smelter. These included the railroad engine house, the railroad machine shop, the locomotive shop restroom, and the speeder house for the gasoline-powered railroad engine. Other buildings associated with the railroad, constructed outside of the smelter area, included the railroad depot and scale house.[20]

The smelter construction brought a large number of new employees to the property. Starting in 1923, Magma constructed a number of "cottages" for senior-level workers. A series of houses along both sides of Smelter Road for the smelter superintendent and foreman became known as "Smelter Row. The company constructed four houses in smelter row during 1923 and added seven more in 1924. These houses included detached garages. Other additions in 1923 for personnel needs included the expansion of the mess house and the construction of a guest house for mine visitors.[21]

Activity in the mine itself during 1923 was limited to putting it into condition to resume heavy production once the smelter was completed. The No. 4 shaft reached the 1,500 level and a large fan was installed at the collar of the shaft for ventilation. The result of these improvements was that the mine was ready for several years of production.

The Magma smelter commenced operations on March 29, 1924. The completion of the smelter and the resumption of mine production began to give Magma officials a return on their investment. After losses in 1922 and 1923, the mine returned to making a profit in 1924.[22]

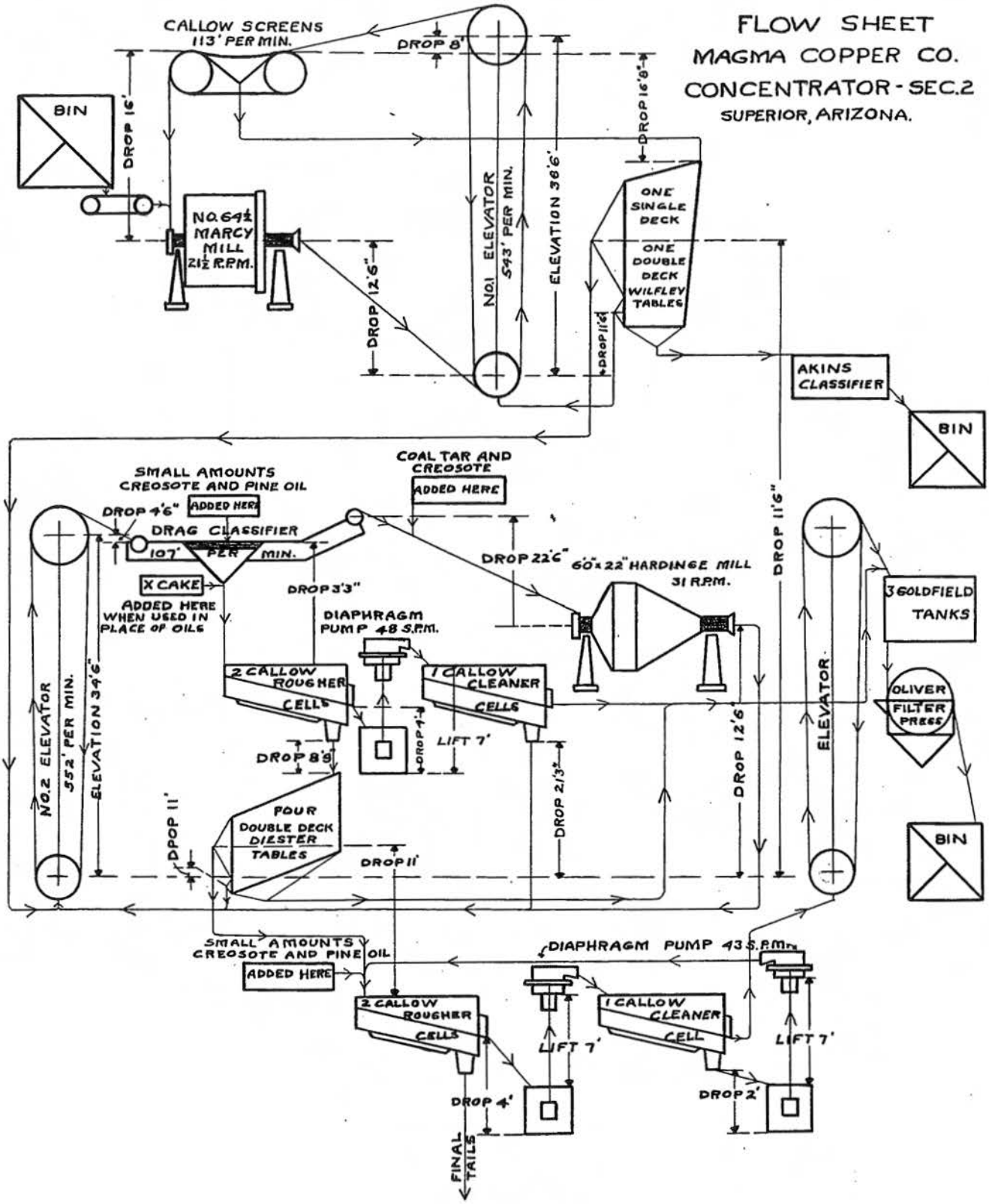
In 1925 the company began to make plans for the elimination of the aerial tram. It would be replaced by a surface tram system. The new system operated on electricity. It connected the mill with the 500-level portal and improved the speed with which materials could be delivered to the concentrator. The old aerial tram was abandoned in 1926. As part of the change, new receiving bins were constructed at the mill. The elimination of the aerial tram reduced the time for ore delivery to the concentrator from two 8-hour shifts to one 8-hour shift.[23]

Long-time manager E.C. Browning retired in 1925. One of the original managers brought from the Inspiration Mine by Boyce Thompson, Browning oversaw the transformation of the Magma property from a small single-shaft operation to a fully integrated mining, milling, and smelting operation. Thompson appointed William Koerner to succeed Browning.

Mine officials began the construction of a new shaft in 1926. Located at a distance 2,400 feet southwest from the No. 3 shaft, the No. 5 shaft reached a depth of 650 feet that year. Engineers designed the No. 5 shaft to follow the ore body which was trending west as the mine reached deeper and deeper depths. The construction of shaft No. 5 resulted in the discovery of the west ore body in 1927 as the shaft reached the 2,550 level. From 1927 onward, the company distinguished the main ore body and the west ore body as the two productive areas of the mine. The No. 5 shaft connected to the 500 level yard through a short adit.[24]

Tragedy struck the Magma mine in 1927. On November 24 a fire in shaft No. 2 claimed seven lives. Three days later, on November 27, a fire broke out in shaft No. 1. The fires heavily damaged both shafts. As shaft No. 1 had been all but abandoned, it was not repaired after it caved in due to the fire. Shaft No. 2 was repaired and put back into service. Construction work in 1928 was limited to the repair of shaft No. 2, the extension of shaft No. 5 to the 2,960 level, and the replacement of the disc crusher at the mill with a cone crusher.[25]

The catastrophic events of 1927 convinced mine officials that improvements in ventilation were needed. As the mine reached further and further into the earth, the temperature of the rock continued to increase. The construction of shaft No. 5 had opened a large new area to mining and taxed the existing ventilation system. To rectify the situation, in 1929



Magna Mill flow sheet.

Magma began construction on two new shafts. Shaft No. 6 was started early in the year, 4,500 feet east of shaft No. 3. Shaft No. 7 was started later in the year, 500 feet west of the concentrator and 8,350 feet west of shaft No. 6. The addition of these two new shafts, essentially "bracketing" the mining operation, improved the ventilation in the mine considerably.[26]

Other improvements in 1929 included an addition to the power house for a turbine generator, and a new stack and boiler house that were erected for the new boiler. To accommodate this change, company officials doubled the size of the power house cooling pond. Toward the end of the year, construction began on a new brick hospital building and a change house for the No. 5 shaft.

Dealing with the Depression, 1930-1939

The condition of the copper market after 1929 precluded any hasty decisions regarding further improvements. In April of 1930 the price of copper dropped to fourteen cents per pound, after staying at eighteen cents for more than a year. By October the price reached ten cents per pound, the lowest figure in thirty years. The Magma mine went on a reduced production schedule as copper prices refused to rebound during the depression. The concentrator operated for 330 days in 1930 and the smelter for 319 days.[27]

By May of 1931 the price of copper dipped near eight cents, the lowest in forty years. The company responded by shutting down operations during the heat of the summer. Officials discontinued stoping from June 13 to September 16, the concentrator was closed from June 16 to September 16, and the smelter shut down from June 22 to October 1.[28]

The company resumed development work on June 27. It also continued to improve ventilation. A crosscut at the 2,000 level extending to the No. 6 shaft greatly improved conditions in the eastern portion of the mine. In the western portion of the mine, a crosscut at the 2,550 level extending to the No. 7 shaft from the No. 5 shaft improved conditions. The No. 5 shaft had reached the 3,200 level where the temperature of the rock topped 126 degrees.

In 1931 the old hospital burned. After the construction of the brick hospital in 1929, the old wooden building had been used as a nurse's home. It was replaced by a brick building in 1931. It was linked to the hospital, and in later years was known as the clinic.

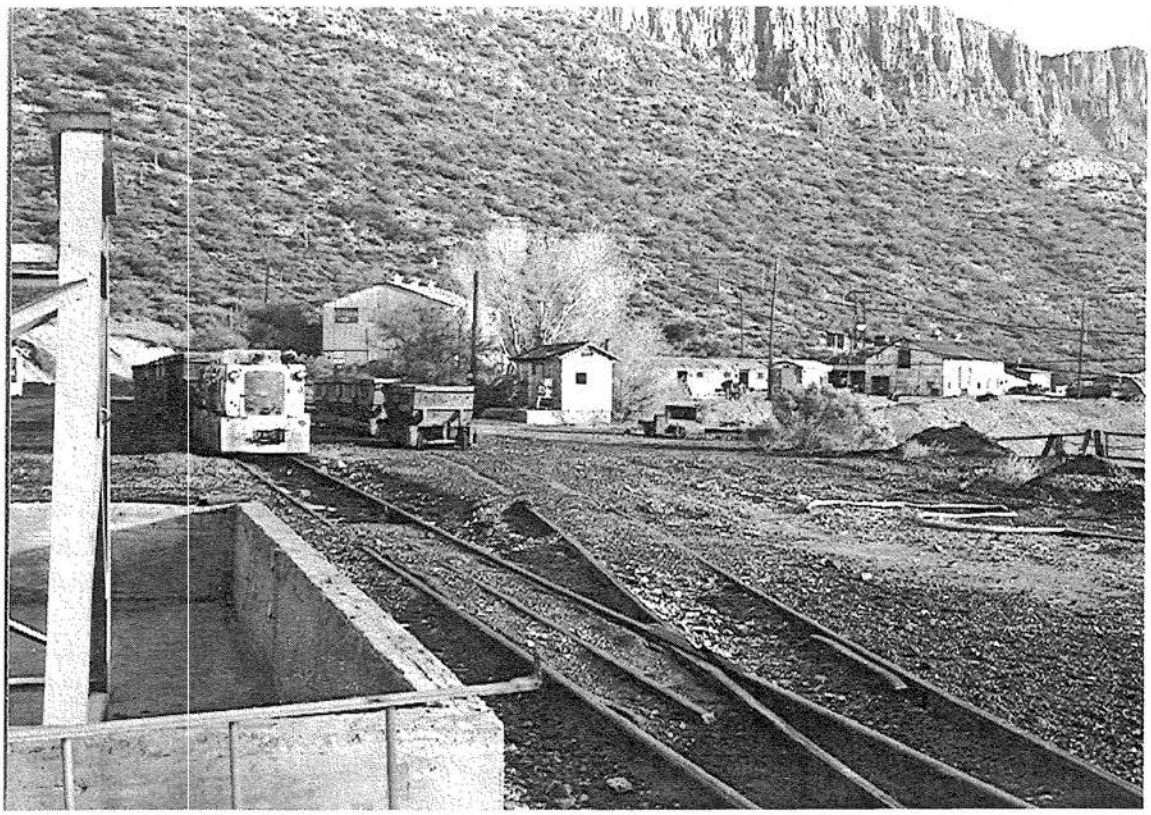
Conditions remained much the same in 1932 and the company operated at a loss. Instead of a summer shut down, the mine and plant stood idle for nearly half the year. Stoping was discontinued from June 12 to December 5, the concentrator was closed from June 10 to December 15, and the smelter closed on June 30 and did not resume operations for the rest of the year.[29]

The same general pattern extended over the next four years. Copper continued to sell for less than eight cents per pound. As conditions gradually began to improve after Franklin D. Roosevelt assumed the office of President, the summer shut-down was reduced in length. By 1936 the shut-down had been reduced to a single month during the summer. The company completed some minor improvements during this period. In 1935, Magma began construction of shaft No. 8, an air shaft between shafts 3 and 5. In 1936 natural gas replaced fuel oil at the smelter.[30]

In 1937 the copper industry finally began to shake off the effects of the prolonged depression. Prices for copper reached thirteen cents that year, and Magma began plans to exploit the west ore body. A key to the continued expansion of the mine was a means to cool the working area.[31]

Temperatures of the rock at the 4,000 level had reached 140 degrees. It took several years of ventilation to cool the working areas. For example, the 3,200 level took about three years to cool to a point where it could be worked effectively. In 1937 Magma officials contracted with Willis H. Carrier to install air conditioning units in the mine. The first unit was placed in operation on July 19 and the second on August 3. These units were placed at the lowest working levels of the mine — the 3,600 level. The units cooled the air temperature of the mine from 101 degrees to 93 degrees after a month of operation, and to 80 degrees after four months.[32]

All of the air conditioning equipment was located deep in the mine. At the time, engineers considered the installation as a giant advance in technology. Over time, professionals in the field of mechanical engineering recognized the significance of the



Idle surface tram with Apache Leap in distance. Douglas Kupel photograph.

achievement. The American Society of Mechanical Engineers declared the cooling system of the Magma mine a National Historic Mechanical Engineering Landmark. In addition to the equipment deep in the mine, improvements included a regenerative cooling tower. This unit was installed on the surface in 1947. M.L. Thornburg of the Mechanical Engineering Department at the University of Arizona designed this improvement.[33]

Other improvements in 1937 included the addition of a 250-ton capacity unit at the mill for concentrating zinc. This all-flotation unit operated with minimal success. A more satisfactory improvement was the completion of a new transmission line and the addition of a new substation at the mill. In 1938 the old roasting plant at the smelter was replaced by a wet concentrate bin. From this time forward, all material was "wet charged" into the furnace.[34]

The remaining years of the decade saw few changes. The copper market fluctuated erratically. The property continued to operate with a summer shut-down. Additional improvements were made to the air conditioning system. In 1939 the hoist for the No. 3 shaft was rebuilt to accommodate lifting from the 5,000 level.[35]

Although war clouds had begun to gather in Europe, the daily operation of the Magma mine in 1940 changed little. But a chance discovery that year would result in extending the life of the property for many more years. Workers at the 4,000 level were drilling a cross-cut to improve the water supply at the lower levels of the mine. They encountered a new vein of copper. Magma officials called it the Koerner vein, after long-time General Manager William Koerner, who had died on June 30, 1940.[36]

Many felt this tribute fit Koerner's achievements in the mining field. Recognized as one of the nation's top mining engineers, Koerner served Arizona as a member of the Copper Tariff Board. He began his career as an engineer for the Ray Consolidated Copper Company, then transferred to the Inspiration Copper Company. He left Arizona for the next fifteen years, returning to manage the Magma property in 1925. Miners remember Koerner as kind and sympathetic. He inaugurated a system of vacation pay and protected his workers through a system of group insurance. The introduction of air conditioning came during his leadership. Although introduced as a

means to improve production, workers appreciated the salutary effects of the system as much (or more) than the accountants did.[37]

World War II

In 1941 the US government approached Magma officials and asked the company to expand its production. To prepare for the heavy demand, scheduled to begin in September, the company began a major overhaul of the property during its summer shut-down.[38]

World War II generated a tremendous demand for copper. The Magma mine operated at full capacity during the war effort. Changes in the operation of the property were few during this era. In 1943 six additional flotation cells for zinc were added at the zinc concentrator. By the end of the war the old crushing plant and concentrator were in their final days. Although the original 1914 concentrator had been constantly modified and improved over the years, it was essentially the same plant as had been originally installed. In 1945 Magma officials planned the construction of a new crushing plant and mill.[39]

Another war-time development that would have significant post-war implications was the purchase of mining properties at San Manuel. In 1944 Magma exercised an option on a new mining site at San Manuel. The owners had been trying to get someone interested in the property for years, and Magma finally decided to pursue the venture.

Post-War Era to 1982

The period from the completion of the new concentrator in 1946 until the closure of the Magma mine in 1982 is that of sustained growth. Copper prices had their ups and downs during this forty year period, but the massive investment of Magma in the mine and the sheer amount of copper to be withdrawn had a stabilizing effect on the economy of the Superior area. Continued demand for copper generated by Cold War defense spending meant that the "bust" cycles of the mining economy during this period were minor and short-lived.

In 1946, construction started on a new crushing plant and mill. Officials also updated the cooling system during this time, resulting in the construction of the above-ground cooling tower. With the completion of the modifications, the mill was capable of handling up to 1,500 tons of ore per day and was sectioned to treat copper ore and copper-zinc ore separately.[40]

The high levels of demand for copper during the Cold War led Magma to explore other mining properties in the Superior area and elsewhere. This included exploration in what became known as the far east area. Development began with the identification of this area in 1949, known as the "A bed" and located far to the east of the other mining areas at Superior. Following the discovery of this new area, containing primarily copper-zinc ore, the Magma mine consisted of three ore bodies: main, west, and east.[41]

During the 1950s the San Manuel property was extensively developed by Magma. It included the construction of a railroad, townsite, concentrator, and smelter in addition to the mine itself. The concentrator at San Manuel was completed in September of 1955 and the smelter opened in January of 1956.[42]

The rise of San Manuel gradually eclipsed Superior in the books of the Magma Copper Company. The western portion of the Magma mine had been mined extensively, and production gradually decreased. The Koerner vein was depleted by 1957 and was shut down. Production in the west area accessed by the No. 5 shaft ceased in 1961. The heaviest production continued to be in the far east area. The discovery of three additional copper bearing strata in 1965, (B, C, and D beds) in the far east area reinforced the decision to concentrate work to the east. Mining in the main Magma vein was abandoned in 1966.

Mining in the far east area was high in cost due to the difficulty of transferring the ore across great distances underground to reach the mill. Continuing high prices for copper in the 1960s allowed for the utilization of high cost production methods. The Vietnam War meant a continued demand for copper. This allowed for ongoing development of the far east area.

In 1968 the Newmont Mining Corporation acquired the Magma mine. Newmont was another creation of William Boyce Thompson, established in 1920. Newmont officials undertook a complete study

of the Magma operation. The investigation revealed that the east ore body had many years of production remaining and would continue to be profitable if costs could be reduced.[43]

In 1969 Newmont began a major construction effort at Magma. This included a large expansion of the mine into the far east area Construction of a new shaft, No. 9, was begun that year and the area surrounding it became known as the east plant site. To connect with the concentrator, Newmont officials used a tunnel-boring machine to drive a tunnel from far east area to the 500 level yard. Called the "Never Sweat Tunnel," this 9,700-foot tunnel reduced transportation costs.[44]

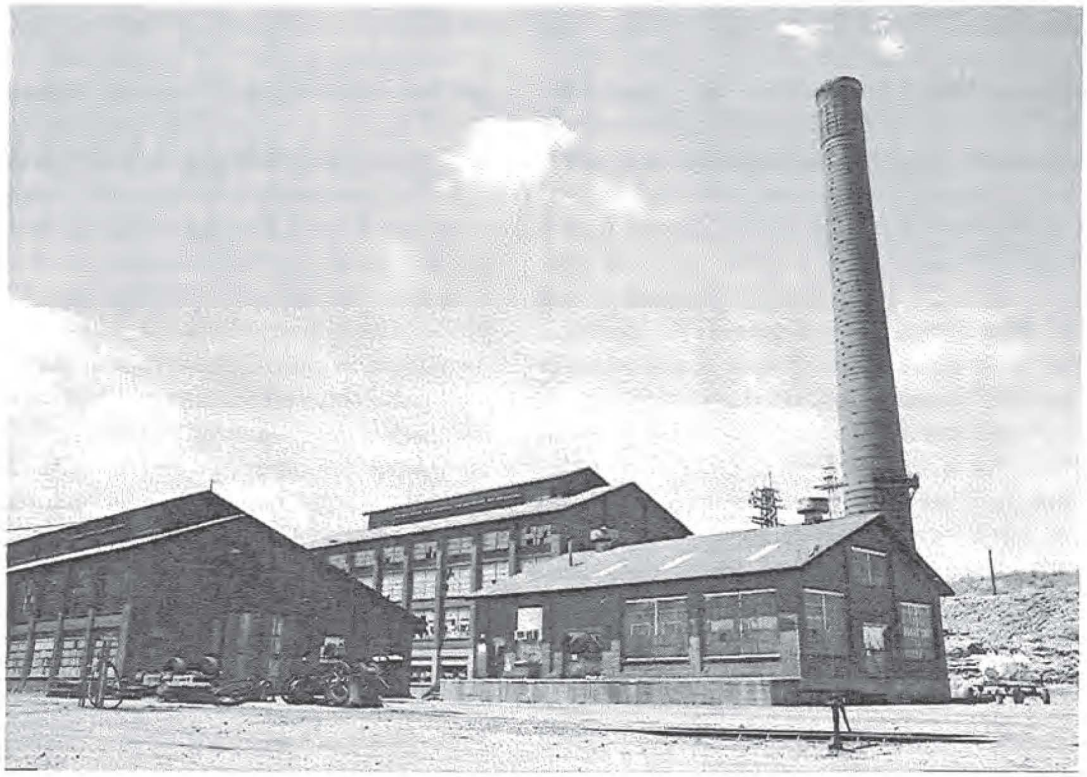
The decision to expand operation from the east plant site required a major expansion of the concentrator. This resulted in the construction of many new facilities in the vicinity of the concentrator. This mill expansion was completed in 1971. The capacity of the new mill was 3,500 tons, up from the expansion to 1,500 tons in 1946.

Concurrent with the decision to expand the concentrator was the idea to abandon the old smelter, completed in 1924. Newmont officials determined that it would be more cost effective to ship the concentrates to its new smelter at San Manuel, opened in 1956. It took four years to complete the entire improvement program. In the summer of 1973, the No. 9 shaft went into full operation and production jumped to 3,000 tons per day.

The additional production coincided with the end of US involvement in the Vietnam War in 1975. Saigon fell to the North Vietnamese in 1975. The end of the war resulted in a long, slow decline in copper prices and reduced profits for Newmont. In 1982 Newmont closed the Magma mine. This was a dark year for the copper industry in Arizona, not only for Magma but for every property in the state.

Recent Years: 1982-Present

Newmont officials kept the groundwater pumps running at the closed Magma mine for four years, but by 1986 financial difficulties caused the company to shut the pumps down. In 1987, Newmont spun the Magma operation off to form an independent corporation once again. Faced with the prospect of building a new flash furnace at the San Manuel



The smelter at Superior. Douglas Kupel photograph.

smelter, Magma officials could not justify the $1 million yearly expense to keep the mine dry. Water quickly rose to the 3,000 level where it stabilized.[45]

The shut-down gave Magma officials the opportunity to re-examine the mining operations at the site. The studies determined that high production costs were the results of flawed mining methods and low productivity. Officials predicted that a revision in mining methods and the establishment of new management strategies would result in improved production. The first step was to prepare the mine by pumping out the water that had accumulated over the past few years.[46]

Magma began the dewatering program late in 1989. By February of 1990 the mine had been dewatered to the 3,400 level. Rehabilitation reached the 3,600 level by July of 1990. Production began on September 1, 1990, when the first concentrate was produced for shipment to the smelter at San Manuel.[47]

Mining at Magma continued for the next six years, meeting the expected life of the operation. In 1996, Broken Hill Proprietary Company Limited, an Australian corporation, purchased Magma's assets. This included the Magma mine, and the open pit mine and smelter at San Manuel. The purchase coincided with record high prices for copper. Since the BHP purchase, the economies of Thailand, China, and Brazil failed. A general downturn in many Asian economies resulted in a world oversupply of copper. Prices plummeted, and for the fiscal year ending May 31, 1999, BHP announced it had lost $2.3 billion Australian dollars.[48]

BHP closed its operations at Magma and San Manuel on June 24, 1999. Despite the hard times, BHP had completed a $54 million upgrade of the San Manuel smelter, including construction of a new flash furnace, installation of new conveyor systems, and air pollution upgrades. Residents of Superior and San Manuel are confident that prices will rebound someday, and the attractive qualities of the Magma mine and San Manuel facilities will lead to another upturn in the copper economy. In the meantime, the history of the Magma mine remains, providing today's miner and history buff with some insight into past cycles of boom and bust.

An original 1996 inventory of surface buildings and structures at Magma noted 165 properties that appeared to meet age and condition criteria for historic designation. As a result of the 1998 survey, the consultants concluded that 65 properties could be eligible for listing on the National Register of Historic Places as part of two potential historic districts and thirty-one properties appeared eligible for individual historic designation.[49]

The large number of intact buildings and structures at the Magma mine make it unique in Arizona. Most other copper properties have been severely altered during the conversion to open pit mining. The continuation of underground hard rock mining at Magma has resulted in an extraordinary level of preservation for its surface features.

Notes

1. The original report is Alliance Architects, "Historic Resources Survey of BHP Superior West Plant Site, Superior, Arizona," Phoenix: Alliance Architects, 1998. A synopsis of the research is Douglas E. Kupel, "Magma Mine: Preservation Challenges and Prospects," paper presented at the Ninth Annual Meeting of the Mining History Association, Bisbee, Arizona, June 5, 1998.
2. The best overall history of mining in the Superior area is by M.N. Short, et al, "Geology and Ore Deposits of the Superior Mining Area, Arizona," *Arizona Bureau of Mines Bulletin* No. 151; (October 1943); For mining techniques, see Fred W. Snow, "Mining Methods and Costs at the Magma Mine, Superior, Arizona," *US Bureau of Mines Information Circular* No. 6168 (September, 1929); Milling methods are described by J.H. Rose and J.C. McNabb in "Milling Methods and Costs at the Concentrator of the Magma Copper Co., Superior, Arizona," *US Bureau of Mine Information* Circula No. 6319 (August, 1930); Smelting operations are summarized by Edward J. Caldwell in "Milling and Smelting Operations of the Magma Copper Co., Superior, Arizona," *US Bureau of Mines Information* Circula No. 7300 (December, 1944); The transportation history of the Magma Mine is thoroughly detailed by Gordon Chappell in *Rails to Carry Copper: A History of the Magma Arizona Railroad* (Boulder: Pruett Publishing, 1973).
3. For a description of the town of Superior, see Bernard Deustch, *Superior, Arizona: Historical Resources Survey* (Phoenix: Bernard Deustch & Associates, 1988) and Betty Garrido, ed., *Superior, Arizona Centennial, 1883-1982*

(Superior; Superior Historical Society, 1982).

4. Ira B. Joralemon, *Copper: The Encompassing Story of Mankind's First Metal* (Berkeley: Howell-North Books, 1973; first published New York: D. Appleton-Century, 1934), pp. 202- 203.
5. Short, et al, pp. 59-60. For the Silver King mine, see William P. Blake, "The Silver King Mine of Arizona," typescript copy of 1883 original, 1934, University of Arizona Special Collections, Tucson.
6. For William Boyce Thompson, see Hermann Hagedorn, *The Magnate, William Boyce Thompson and His Times* (New York: Reynal & Hitchcock, 1935); See also Robert H. Ramsey, *Men and Mines of Newmont: A Fifty-Year History* (New York: Octagon Books, 1973).
7. For a brief biography of Thompson, see his obituary in the *Arizona Republic*, June 28, 1930.
8. "The Mining News," *Engineering and Mining Journal* 95: 4 (January 25, 1913): 251; Magma Copper Company Insurance Map, August 1, 1912, Magma Archives.
9. Rose and McNabb, p. 2.
10. Magma Copper Company, "Report to Stockholders," May 27, 1915; Magma Copper Company, "Annual Report," December 31, 1915.
11. Magma Copper Company, "Annual Report," December 31, 1916.
12. Short, et at, p. 65; Magma Copper Company, "Annual Report," December 31, 1916.
13. Magma Copper Company, "Annual Report," December 31, 1917.
14. Magma Copper Company, "Annual Report," December 31, 1918.
15. Magma Copper Company, "Annual Report," December 31, 1919.
16. Magma Copper Company, "Annual Report," December 31, 1920.
17. Magma Copper Company, "Annual Report," December 31, 1921.
18. Magma Copper Company, "Annual Report," December 31, 1922.
19. For a description of the smelter, see Joseph Irving and Charles F. Willis, "Magma Copper Company New Smelter Started," *Arizona Mining Journal* 8: 2 (June 15, 1924).
20. For the railroad, see Chappell, pp. 89-96.
21. Magma Copper Company, "Annual Report," December 31, 1923.
22. Magma Copper Company, "Annual Report," December 31, 1924.
23. For the aerial tramway, see Rose and McNabb, p. 2; Magma Copper Company, "Annual Report," December 31, 1925.
24. Magma Copper Company, "Annual Report," December 31, 1926.
25. Magma Copper Company, "Annual Report," December 31, 1927; Magma Copper Company, "Annual Report," December 31, 1928.
26. Magma Copper Company, "Annual Report," December 31, 1929.
27. Magma Copper Company, "Annual Report," December 31, 1930.
28. Magma Copper Company, "Annual Report," December 31, 1931.
29. Magma Copper Company, "Annual Report," December 31, 1932.
30. Magma Copper Company, "Annual Reports," for the years 1933, 1933, 1934, 1935, and 1936.
31. Magma Copper Company, "Annual Report," December 31, 1937.
32. For the air conditioning system see Walter A. Biddle, *National Historic Mechanical Engineering Landmark: The First Air Conditioning of the Magma Copper Co. Mine Superior, Arizona, 1937* (Washington: American Society of Mechanical Engineers, 1976).
33. The cooling system of the Magma mine was declared a National Historic Mechanical Engineering Landmark in 1976.
34. Magma Copper Company, "Annual Report," December 31, 1938.
35. Magma Copper Company, "Annual Report," December 31, 1939.
36. Magma Copper Company, "Annual Report," December 31, 1940.
37. For a brief biography of William Koerner, see his obituary in the Arizona Republic, July 4, 1940.
38. Magma Copper Company, "Annual Report," December 31, 1941.
39. Magma Copper Company, "Annual Reports" for the years 1942, 1943, 1944, and 1945.
40. Magma Copper Company, "Annual Report," December 31, 1946 and December 31, 1947.
41. Magma Copper Company, "Annual Report, " December 31, 1948 and December 31, 1949.
42. Magma Copper Company, "Annual Reports" for the years 1950, 1951, 1952, 1953, 1954, 1955, and 1956.
43. For the acquisition by Newmont, see Ramsey, pp. 146-156.
44. Bruce Johnson, "A Brief History of the Pioneer Mining District and the Magma Mine, paper presented to a meeting of the Arizona chapter of the AIME, May 11, 1974, updated May 22, 1990.
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47. Bill Epler, "Magma Restarts Mine After Eight-Year Hiatus," *Southwestern Pay Dirt* (November, 1990).
48. Matthew Doig, "Boomerang Bust," *Phoenix New Times* (August 26 - September 1, 1999): 24-36.
49. Alliance Architects, *Superior West*, p. 6.