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P O R P H Y R Y D E V E L O P M E N T S

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STORY OF SILVER BELL

A. S. & R. CO.'S NEW ARIZONA COPPER PROJECT

Full-scale production was started on May 1, 1954 by the American Smelting and Refining Company at its Silver Bell Unit, 40 miles northwest of Tucson, Arizona. A successful 30-day trial run was completed in April to qualify the property for production under terms of a government contract.

The Company is mining approximately 7,500 tons of ore daily, with a monthly output of 1,500 tons of refined copper. The ore body is estimated to contain approximately 0.9 percent copper, and at the proposed rate of production will have a life of 12 to 13 years.

The Silver Bell open-pit development was made possible through an agreement with the U. S. Government, which guaranteed the company a market for 177,000,000 pounds of copper out of the first 197,000,000 pounds produced at a floor price of 24.5 cents, plus escalation for higher costs. Increased costs are said to have raised this floor price to a little more than 26 cents a pound. The entire project has been company financed with government assistance limited to rapid amortization of a portion of the investment for tax purposes and the price guarantee for the specified tonnage, this guarantee ending in five and one-half years.

Originally, the total cost of the development was estimated at $17,000,000. Higher costs of labor and supplies during the construction period have increased the investment to approximately $18,000,000. At the end of 1953, American Smelting reported that $14,708,000 had been expended in stripping the ore body and in construction of the mill and townsite. Stripping of the ore body started in December of 1951.

The mine is working two shifts daily and the mill three shifts. Concentrates are trucked a distance of 20 miles to Plata, a siding on the Southern Pacific, then shipped by rail to the El Paso Smelter.

American Smelting and Refining Company has 140 men on its payroll. Mining is handled under contract by a crew of 80 men employed by the Isbell Construction Company.

HISTORY *

Mining in the area dates back to 1865 when the Mammoth mine of the Silver Bell Mining Co., also known as the Boot Mine, was opened. Oxide copper ores containing minor silver-lead values mined from replacement deposits in garnetized limestone were treated in local smelters.

During 1909 the disseminated copper possibilities in igneous rocks were recognized and a three-year campaign of churn-drill exploration followed, leading to the partial delineation of two copper sulphide deposits known today as the Oxide and El Tiro. Low copper content of the ore discouraged exploitation of the deposits at that time, but selective mining of orebodies in the sedimentary rocks continued intermittently until 1930.

* Source: Pay Dirt Dec. 21, 1951, May 21, 1954. E. & M. J. July, 1954

American Smelting and Refining Company first became interested in the Silver Bell district in 1915, through acquisition of the holdings of the Imperial Copper Company. In 1928 the adjoining properties of El Tiro Corporation were acquired.

The Imperial Copper Company, incorporated in 1903, bought the old Silver Bell mine, built the Arizona Southern Railway line from the Southern Pacific to the mine, erected a smelter at Sasco, through a subsidiary, the Southern Arizona Smelting Company, and built a concentrator at the mine. Mining was stopped in 1913 through the loss of a 450-foot shaft by fire and through inability to furnish sufficient tonnage of high-grade ore to make the property pay with copper below 12.5 cents a pound.

The El Tiro Copper Company entered the district in 1907 as a successor to the Cleveland-Arizona Copper Company, and was in turn succeeded by El Tiro Leasing Company and El Tiro Corporation. Its properties were acquired under bond and lease by American Smelting and Refining Company in June 1928.

Production records compiled by the Arizona Bureau of Mines show that the Imperial mine, between 1904 and 1926, produced 64,000,000 pounds of copper, plus some gold and silver, for a total value of $12,125,000. El Tiro, between 1906 and 1927, produced 14,000,000 pounds of copper, 1,000,000 pounds of lead and $20,000 in silver for a total value of $2,150,000. The combined properties produced 5,500,000 pounds of copper between 1927 and 1930 with a total value of $900,000. Total production from the entire Silver Bell District was estimated at $15,746,000.

The railroad connecting the mine with the smelter at Sasco remained in operation until the 1930's, when it was abandoned and the tracks torn up. The smelter was demolished in the late 1920's.

Reactivation of Silver Bellwas considered during World War II, but plans were abandoned when the government lowered its sights on the amount of copper needed for the war effort. The principal reason given for refusal of government support was that it would take too long to get the mine into production.

In 1946, the company began extensive geological exploration and churn drilling at Silver Bell, and in December of 1951, development of the two pits, the Oxide and El Tiro, was started. Since then and up to April 1, 1954, there have been removed from the Oxide pit some 11,800,000 tons of waste, 1,700,000 tons of leach material, and 350,000 tons of ore assaying less than 1% copper. From the El Tiro pit 2 miles distant more than 2,300,000 tons of waste have been stripped during the same period. All stripping and mining is done under contract by Isbell Construction Co., of Reno, Nevada. All ore currently treated at the concentrator is mined from the Oxide pit. Work at the El Tiro pit currently consists of road building and a small amount of stripping.

GEOLOGY AND MINING

The geology of the area and the ore-bodies are described and illustrated in the July, 1954 issue of the Engineering and Mining Journal.

The two porphyry orebodies-developed for exploitation consist of rudely tabular accumulations of chalcocite from 100 to 200 ft. in thickness. Lying beneath about 100 ft. of leached capping, they were formed by two-to three-fold enrichment of copper contained in the primary mineralization.

The Oxide is oval shaped measuring roughly 2,100 ft. by 1,500 ft. Entry is by spiral roadway. Six 40-ft. benches have been established so far, the top bench being known as the 2,908, and the lowest as the 2,780. The present pit floor will ultimately go 160 ft. below the 2,780 horizon.

The major fault traversing the pit in about the center in a northeasterly direction is very noticeable. Of the two types of porphyry occurring in the pit, the dacite is hard and the monzonite is fairly soft, influencing drilling speeds and techniques to some extent.

Blast holes are drilled with churn-drills using 9-in. bits. Broken ore and waste are loaded into 37-ton and 22-ton trucks, by a 5½ yd. electric shovel. Haulage distances to the concentrator average 0.4 mi., and waste haulage about 0.8 mi. Current ore-waste ratio is 1:1. Constant road maintenance has cut equipment repair costs to a minimum. Communication between pit and offices of contractor and company is maintained by a radio-phone short wave FM system.

CONCENTRATOR

Silver Bell's modern concentrator was designed for economical up-keep and low operating costs. Feeders, crushers, vibrating screens, and belts serving them are interlocked both automatic and manual. All plant buildings are equipped with crane installations to speed repairs and handle materials with minimum labor.

Crushing to 1/4 in ball mill feed is accomplished in three stages. A 48-in. gyratory crushes to 6 in., a 7-ft. standard secondary cone crusher, set to 1¼ in., and two 7 ft. tertiary cone crushers with vibrating screens fitted with screens containing 1/2 in. square openings. Two large Roto-Clone units represent the dust collecting system at the crushing plant.

Grinding to about 65% minus 200-mesh is done in four 10½ x 12-ft. ball mills, using 3-and 2-in. balls, operating in closed circuit with 85-in. Akins screw classifiers. The pulp overflowing from the classifiers at 24% solids goes to a central distributor serving four units of rough flotation machines, each made up of two 4-cell-and two 8-cell machines in series. Rougher tailings flow direct to a 275-ft. dewatering thickener, with the overflow going to a 1-million-gal. reservoir, and the underflow via a transite pipe line system to the tailings ponds. The rougher concentrates are pumped to a 26-ft. Hydroseparator. Underflow from this unit is the feed for the regrind section consisting of two 7 x 12-ft. ball mills operating in closed circuit with four DorrClones, and the overflow according to need can either be sent direct to the two 6-cell cleaner machines, or to two 100-ft. middlings thickners.

Concentrates produced by the cleaner machines are re-cleaned in a 6-cell machine, with the final concentrates receiving successive treatment in a 60-ft. thickener and 6-ft. disc filter installed at the shipping plant. Tailings from the final cleaner machine go to the middlings thickeners, as do the concentrates produced by the scavenger flotation unit handling the tailings from the two cleaner machines. The scavenger unit consists of a 4-cell and an 8-cell

flotation machine in series. Underflow from the middlings thickeners is pumped back to the two cleaner machines and the overflow goes to the reservoir mentioned previously.

Re-agents used in the mill circuit include lime, Z-11, Aerofloat 238, pine oil, and Dow froth.

The tailings disposal system operating between the large-de-watering thickener at the foot of the concentrator building and the tailings ponds consists of two 16 in. transite pipe lines set at an 0.8% grade and with concrete drop boxes 8 ft. high placed at strategic points. The main line, 8,100 feet long leads to a large disposal area behind an earth-fill dam 45 ft. high, and the auxiliary line some 1,000 ft. long terminates behind a smaller earth-fill dam 25 ft. high. At the dam sites the pipes are fitted with special valves and rubber distributor pipes. Re-claimed water is pumped back to the large reservoir at the mill.

Water for the camp and plant use is obtained from three wells 200 ft. deep sunk in the valley about 9 miles southeast of the concentrator.

At the townsite there are available 65 modern two-bedroom houses and 35 three-bedroom units, two bunk-houses to accomodate 80 single men, mess hall, 8 apartment buildings. Isbell Construction Company maintains two trailer courts with 90 units near the townsite for its employees.

Arizona Department of Mineral Resources

November, 1954

THE LAVENDER PIT

Another Arizona Copper Mine - the Lavender Pit of Phelps Dodge Corporation - was formally dedicated on August 7th of this year - 1954. A celebration marked the opening of the huge open-pit operation which required the expenditure of more than 25 million dollars to bring the mine to production.

The following statement by Robert G. Page, President of the Phelps Dodge Corporation, gives a good clear picture of the project:

FAITH CAN MOVE MOUNTAINS

The Lavender Pit - the new open-pit copper mine of Phelps Dodge Corporation at Bisbee - was officially opened on August 7. The Lavender Pit is an excellent example of the saying that large mines are made, not found. The presence of copper in the area which is now the Lavender Pit mine was known for many years. But during that long period it was not ore because it could not be mined profitably.

Mineralized rock is ore only when it can be mined and processed at a profit. The Lavender Pit material became ore only after gradual but continuous improvements in the arts of mining, milling and smelting and in the size as well as perfection of modern tools and machinery. It became ore also only when more than $25 million was invested in stripping the mountainous overburden and building the huge industrial facilities.

The nature of the ore deposits in the Bisbee district has required for the most part mining by underground methods for the past 75 years. The underground ore deposits are small, scattered and at considerable depth. Under such conditions only high-grade deposits can be mined commercially.

Once before, in the '20s at Sacramento Hill, Phelps Dodge Corporation undertook to mine a low-grade ore body in the Bisbee district by open-pit methods. That small ore body was near the surface and its comparatively high-grade ore made the project feasible but only slightly profitable because the highly efficient open-pit practices now used had not then been devised.

In developing the Lavender Pit, Phelps Dodge has again tackled the problem of successfully mining a lower grade deposit. For an open-pit mine operation, the deposit is also small, though considerably larger than the Sacramento Hill project. About 3.5 tons of mined rock will produce only one ton of ore yielding metal valued at $3 to $5 depending on the variation in market price. That yield will have to pay for all expenses of mining, milling, smelting, refining, transportation, taxes, so forth; and it is also out of that low gross value that the funds must come to repay the initial cost of the project of over $25 million before a profit can be realized.

Perhaps it is not too much to say that the same kind of courage and vision, and the willingness to take risks, which characterized the Arizona pioneers - whether cattlemen, mining men or farmers - find expression today in this Lavender Pit project. Risk, of course, there is; but, most important, having calculated the risk, we have faith that the risk is worth taking in Bisbee and that another mine - even though mountains have to be moved - may be successfully created in Arizona.

HIGHLIGHTS OF THE PROJECT

Source: Pay Dirt For August 20, 1954

The project cost more than $25 million before a pound of copper was recovered.

It was entirely financed by Phelps Dodge Corporation without one cent of Federal financial aid.

The pit embraces an area of 155 acres.

The ore is low-grade and requires fine grinding.

Ore eventually will be mined from 16 benches 50 feet in height.

The lowest point in the pit will be 1,005 feet below the highest original ground contour.

The first blast to clear the waste material was set off in March, 1951.

First ore was delivered to the concentrator June 24, 1954.

During the preparatory period, 46,000,000 tons of overburden was mined and delivered to waste dumps.

During the life of the pit, 2.62 tons of waste and leach material must be mined to recover one ton of ore that will produce less than 16 pounds of copper.

The 50-foot benches are mined by drilling a series of 7-3/8-inch holes about 60 feet deep and spaced at 14-foot intervals, 15 feet from the edge of the bank.

The holes are loaded with approximately 450 pounds of explosives per hole and shot simultaneously to break about 2,100 tons of rock for each hole.

The broken muck is loaded into 25-ton diesel trucks by five and six-yard electric shovels with six-cubic yard dippers.

At the loading dock, the muck is dumped into 43-cubic yard side-dump railroad cars and transported to a dump by 1,250-horse-power diesel electric locomotives.

In 17 trips to the dump in one eight-hour shift, the locomotive, pulling a 10-car train, will transport 12,000 tons of rock for a distance of 1.25 miles.

Since the ore body was located in the heart of a populated area, it was necessary to remove many businesses and residences, abandon the railroad into Bisbee, relocate U. S. Highway 80 and all utilities.

The construction work included a large crushing plant, concentrator and allied facilities, plus 75 new residences.

An additional 600 jobs have been created.

The Lavender Pit is expected to produce about 76,000,000 pounds of copper annually for a period of 12 years.

PROCESSING THE COPPER FROM THE LAVENDER PIT

(From Arizona Days and Ways, Aug. 8, 1954)

A man presses a dynamite exploder and the earth trembles. A cloud of dust drifts away in the wind and there, among tons of fractured rock, is the set of copper kitchen ware you will give your wife next Christmas. There, too, is the precious copper for wire to carry the messages of the world; copper to make the motor in your car run; copper for ammunition; copper for the thousands of intricate instruments of the atomic age.

The man at the blast control launches the fascinating series of steps that win copper from ore, but it all started countless geologic ages ago when nature laid down a low-grade copper ore deposit in a mountainside.

Today, the mountainside has been gouged into a pit embracing 155 acres. Dynamite and giant shovels will eat into the rock until the pit has reached a point 1,005 feet below the highest original ground level.

This is the great Lavender Pit Project of the Phelps Dodge Corporation, named for the late Harrison M. Lavender, whose vision and engineering skill on a Bisbee mountainside made possible a $25 million project - and all without benefit of Federal financial aid.

Almost four years have passed since the first homes and other buildings were relocated to make way for the new Phelps Dodge project. During the preparatory period, 46 million tons of waste rock were removed to expose benches of copper ore. During the life of the pit, 2 1/3 tons of worthless rock must be removed to reach each ton of ore.

That ton of ore will yield less than 16 pounds of copper by the most advanced technological treatment known in the mining world. Only a short time ago, the low-grade ore such as is found in the Lavender Pit would have been considered commercially worthless.

From the first dynamite blast in the pit to the copper refining, the ore passes through a busy new life on the way to becoming a useful product.

Scooped up in the dippers of 6-cubic-yard shovels, the ore is then trucked, crushed, concentrated and smelted. The chain of operation in the new Phelps Dodge pit mine must run smoothly and efficiently to keep the costs low - for this is low-grade ore.

The ore, with its tiny amount of copper-bearing mineral, is dumped from 25-ton trucks into a large gyratory crusher capable of crushing 3-foot cubes of solid rock, located on the wall of the pit. The product is coarse, broken "muck" which falls from the giant crusher to a conveyer belt. Crossing U. S. Highway 80 for a distance of 975 feet, the belt lifts the roughly crushed ore from the bottom of the pit to a storage bin high on an adjoining mountainside, from which it may be withdrawn as needed for the concentrating operation.

The concentrating operation is one of getting rid of as much waste material aspossible without losing too much of the valuable metals in the ore. The valuable minerals are so minutely distributed through the ore that they must be ground extremely fine in order to make the separation in the concentrator. To do this requires more dry crushing in the concentrator, followed by grinding and re-grinding with water in the ball mills until a pulp of mixed ore and water, fine enough so that most of it will pass through a silk handkerchief, is produced. It is now ready for chemical treatment and more mechanical pushing around.

Additives and re-agents transform the pulp into a soapy froth in flotation cells which act much like an egg beater. This froth attracts to it the tiny copper-bearing particles and carries them over the lip of the cell. This is because chemistry has been busy in this process, and each particle is coated with a substance that makes the copper minerals adhere to the froth bubbles. The waste materials sink to the bottom of the cells and are discharged to large settling basins known as "thickeners" where most of the valuable water is recovered and the solids are conveyed through a pipe line to the tailings disposal area.

The concentrate produced by the froth from the flotation machines also goes to a thickener where much of the water it contains is recovered, and where the concentrate is drawn off as a heavy pulp to filters that further dry it. From the filters, it drops into railroad cars all ready for the trip to the smelter.

The concentrate product travels by railroad to the Phelps Dodge smelter at Douglas, 25 miles from the pit and mill. In the smelting process, which transforms the concentrates into a large amount of slag and a small amount of almost pure copper, large quantities of heat are required.

Here the concentrate, after being mixed with lime and silica, is first passed through roasters at red heat to remove excess sulphur. One thousand tons per day of the roaster product are fed into a reverberatory furnace, the second smelting step required in the process of becoming pure copper.

The copper, combined chemically with iron and sulphur in a substance known as "matte", sinks to the bottom of the furnace where it is drained off. The top layer of the white-hot molten mixture is slag which is drained off, too, and disposed of so colorfully as waste on the slag dump.

From the reverberatory furnaces, the molten matte is transported in huge ladles and poured into a "converter" for more metallurgical treatment, including blowing with air. The product from the converter is "blister" copper which is ladled from the converters to the anode furnace.

Green oak logs at this point are used to stir the molten copper. The excess oxygen in the copper unites with the carbon in the log, forming carbon dioxide gas which passes off. Without the log treatment, excess oxygen would remain in the blister copper as an impurity.

The final product, from the anode furnaces, contains 99.5 per cent copper with minute amounts of gold and silver. The molten copper at this point is poured into revolving molds and then cooled in a water bath.

Each bar of anode copper is about 3 feet square, about 2 inches thick and weighs approximately 700 pounds. The bars are loaded neatly on railroad flat cars for shipment to the refinery at El Paso, Tex. The business of the refinery is to purify these bars by electro-metallurgical treatment to the highest possible degree and to cast into shapes suitable for fabrication. Here too, the small amounts of gold and silver metals are recovered.

From the refinery, the copper goes to various plants throughout the country for fabrication into useful products.

THE SAN MANUEL PROJECT

"When the San Manuel mine, mill and smelter go into full operation, they will employ 1,850 men, with a payroll of $830,000 a month or $10,000,000 a year," according to Wesley P. Goss, Vice-President and General Manager of the Magma Copper Company.

The ore-body being developed is located in the Old Hat Mining District of Pinal County, about seven miles east of Oracle and seven miles south of Mammoth. It is estimated that ten million tons of 0.77% copper ore can be mined annually for the next fifty years. A by-product of molybdenum will also be produced.

The project has been made possible by the development of new scientific techniques in mining. Back in 1915 mining in this area was abandoned because it was not profitable.

Two main shafts for the mine have been sunk, one to a depth of 1,643 feet and the other approximately 2,000 feet. About 25,000 feet of drifting has been done. Water was encountered at 700 feet and 2,500 gallons per minute are being pumped. Hoisting 35,000 tons of ore per day will make the San Manuel the largest underground copper mine in existence.

The company is borrowing $94,000,000 from the government and will pay five percent interest on the money. As the company had already spent 20 million dollars for buildings, equipment and prepaid development, it is estimated that $114,000,000 will have been spent by the time the property goes into production, which should be sometime in 1956.

Under an agreement between Defense Materials Procurement Agency and San Manuel Copper Corp., dated August 29, 1952, the U. S. Government may purchase or be required to purchase all or substantially all of that Corporation's first 5½ years of estimated production of refined copper and molybdenum concentrates.

An agreement was made with private contractors under which they are to finance and build a town suitable for the accommodation of San Manuel's employees. Construction of the town is well under way.

Arizona Department of Mineral Resources November, 1954