

THE STORY OF THE MIAMI - INSPIRATION COPPER DISTRICT

The Miami-Inspiration Copper District attained a production of 181 million pounds of copper in 1951. Three large mines were responsible for practically all of it. They are the Inspiration, the Miami and the Castle Dome. The latter is a wholly owned subsidiary of the Miami Copper Company, and altho the Castle Dome ore-body is located miles away from the Inspiration-Miami ore system, its mineralization is related to that of the other low-grade copper deposits in the area, the generally accepted theory being that the older formations were intruded by the Schultze granite, providing an avenue for secondary enrichment along the contact.

History *

The major developments in the Miami-Inspiration district have all happened in the twentieth century. At the beginning of the century, chrysocolla, a blue-green copper silicate mineral containing when pure about 36 percent copper, had been mined at the Keystone Mine, and soon after, a vein of chrysocolla was stoped at the Live Oak. Both of the veins were in granite porphyry and did not extend into the schist. Several years later the Woodson tunnel was driven in the north side of Inspiration Ridge. This tunnel cut disseminated chalcocite, a black-grey copper sulphide mineral containing when pure about 80 percent copper, and some crude ore was mined from a zone of stringers in the schist. In 1906 the General Development Company sank a shaft on the Captain claim and another on the Red Rock, the latter striking ore at a depth of 220 feet. The Miami Copper Company was organized in November of that year and development work was actively undertaken. By 1909 the railroad had been extended to Miami from Globe, and in 1911 the first concentrates were produced after an intensive construction period which saw the completion of a mill, power plant, and other surface equipment.

During this period the Inspiration Copper Company and the Live Oak Development Company were also engaged in development work. At Inspiration active development by shafts, drifts, and crosscuts, as well as churn drilling, was begun in 1909. Two years later, 21,000,000 tons of ore had been outlined. The Live Oak had by 1912 developed 15 million tons of ore despite the fact that much of the ore body lies deeper than at either Miami or Inspiration and is covered by porphyry and Gila conglomerate. The Live Oak and Inspiration merged in January, 1912 as the Inspiration Consolidated Copper Company with ore reserves of 45,300,000 tons averaging 2 percent copper.

Further developments and refinements in mining and milling methods have greatly increased the ore reserves of both major companies.

Between 1906, when J. Parke Channing examined the deposits at Miami and exploratory shafts were started, and 1911, when the Miami Copper Company began to produce concentrates, almost ten million dollars had been expended in the preparation for production.

Development of the Inspiration ore-bodies began in 1909 and about fifteen millions had been spent before the production of copper in 1915. In 1915 the International Smelting Company erected a three million dollar smelter at Miami.

* From a paper presented by G. R. Rubley to the A.I.M. & M.E. at Tucson, Nov. 1938.

The third big producer, the Castle Dome mine, is located about nine miles by highway west of Miami and some three miles north of Pinto Creek. The first systematic exploration work was initiated in the early twenties by the Pinto Valley Mining Company. Jackson Hoagland has written a good description of the Castle Dome operations and much of this history of the Castle Dome area has been taken from his description, written in 1946. The churn drilling conducted from 1924 until 1931 proved the existence of the deposit - and provided valuable information as to its size and grade. Subsequent mining operations by Castle Dome Mining Company have verified the accuracy of the earlier determination.

Miami Copper first became interested in the region when it acquired the Continental group of claims adjoining the Castle Dome group through its purchase of the Old Dominion Company. Because the surface geology indicated the possibility of copper values underlying a considerable area, an option was acquired on the Pinto Valley Mining Company holdings and extensive surveys and churn drilling were undertaken to determine the extent and grade of the deposit.

Miami Copper had considered the property as a possible future reserve, but about that time the government became vitally interested in increasing copper output. Consequently, arrangements were completed for the RFC subsidiary, Defense Plant Corporation, to provide the funds necessary to equip the property, and, late in 1941, Miami Copper exercised its option on the Pinto Valley holdings. These claims, together with the Continental group, were then deeded to Castle Dome Copper Company.

One of the most remarkable achievements of the entire operation was the speed with which the property was brought into production once the decision to go ahead was reached. The project was granted top priority by the government and the W. A. Bechtel Company commenced preliminary work early in January of 1942 as engineer-contractor. Seventeen months later copper concentrates started moving from the company's mill to the International smelter at Miami.

Castle Dome took the mine over from the contractor on April 19, 1943, and accepted the concentrator on June 10 of that same year. By this time the Bechtel Company had stripped the orebody of nearly 14,000,000 tons of waste, stockpiled 473,000 tons of ore, constructed a 10,000-ton flotation plant and built a $4\frac{1}{2}$ -mile paved highway to the property.

To provide the necessary water, a 16" combination steel and wood stave pipe line was laid a distance of over 11 miles from the Old Dominion mine at Globe to Castle Dome and a 3,563,000-gallon reservoir was built. A power line was erected to connect the property with the Salt River Valley Water Users Association system.

The most remarkable achievement of this operation has been the fact that though the ore mined has contained only twelve to sixteen pounds of copper per ton, the Castle Dome Mining Company has paid in rental to the Defense Corporation a total of approximately sixteen million dollars, and has had net earnings of almost ten million dollars before depreciation and depletion.

Geology of the Miami-Inspiration District

The Pinal Range, which covers an area about 16 miles long and 12 miles wide, is made up largely of Pinal schist with considerable irregularly intruded quartz diorite and granite and also a younger intrusive, the Schultze granite. The disseminated copper deposits of Miami occur in the northeast corner of this area.

Probably the most important rock associated with the copper deposits of Inspiration, Miami and Castle Dome is the Schultze granite. This has been minutely fissured and the cracks have been filled with quartz and to a less extent with sulphides. The result is a very brittle and fragile mass that, with the crumbly character of the Pinal schist, is so essential to successful block-caving methods of mining.

The Miami district contains numerous faults¹ which have played an important part in the mineralization of the district. The metallic minerals of interest are native copper, native silver, molybdenite, galena², chalcocite³, covellite⁴, chalcopyrite⁵, pyrite⁶, cuprite⁷, malachite⁸, azurite⁹, and chrysocolla¹⁰.

The bodies of disseminated copper ore of Miami, Castle Dome and Inspiration may be characterized generally as undulating, flat-lying masses of irregular horizontal outline and variable thickness. As a rule these masses lack definite boundaries. Closely placed sampling and assays indicate a gradational passage from ore to country rock. The depth to the ore ranges greatly from place to place, as in many places the leached rock itself is overlain by dacite or Gila conglomerate.

In a general way the Miami ore-body is chiefly in schist, although a granite-porphyry dike cutting the schist has likewise been metallized. The Inspiration ore-body is also mainly in the schist, although in places this schist occurs beneath an intrusive sheet of the porphyry. The predominant feature of the Castle Dome orebody is the Dome or Turtleback fault which divides it into two parts. To the east of this fault the ore is largely of a soft nature with chalcocite the predominant copper-bearing mineral. To the west is a harder ore in which chalcopyrite is the principal source of copper.

Operations at Miami

The Miami Copper Company's property has been an underground mining operation with a block-caving system of mining to take out the ore. When the 6,000 ton mill was ready to start in 1911, gravity concentration was standard practice, and the mill was equipped with chilean mills for fine-crushing, and tables for concentration. The chilean mills were soon replaced by Hardinge ball and pebble mills, and a short time later steel balls replaced the pebbles. These

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1. Fault - a fracture in the earth's crust accompanied by displacement of one side of the fracture with reference to the other.
 2. Galena - Lead sulphide - 87% lead, 13% sulphur.
 3. Chalcocite - Copper sulphide - 80% copper, 20% sulphur.
 4. Covellite - Copper sulphide - 66.5% copper, 33.5% sulphur.
 5. Chalcopyrite - Copper Iron Sulphide - 35% copper, 30% iron, 35% sulphur.
 6. Pyrite - Iron Sulphide - 47% iron; 53% sulphur.
 7. Cuprite - Copper Oxide - 89% copper, 11% oxygen
 8. Malachite - Copper Carbonate - Green - 57.5% copper.
 9. Azurite - Copper Carbonate - Blue - 55.0% copper.
 10. Chrysocolla - Copper Silicate - Green - 36.2% copper.

technical improvements continued with the adoption of flotation. Indeed, the Miami Copper Company, like the other big copper companies, was continually spending money to enable it to profitably treat a gradually lowering grade of ore. In recent years it is now possible to make money in the treatment of ore containing as low as .75% copper (15 lbs. per ton). When the grade of ore dropped below 1 percent, milling capacity was increased to 17,500 tons per day.

It was necessary to do this or suspend operations entirely. A plan of mining operations was worked out on paper by Mr. MacLennan and his associates. They showed the directors of the Miami Company that it would be possible to mine this low-grade ore at a cost well below 50 cents per ton, and the directors authorized the expenditure of almost four million dollars to effect the expansion in plant capacity from 6600 to 17,500 tons daily.

The production of copper at a cost of 10 cents per pound from an ore giving a net yield of only 10.55 lbs per ton had never been achieved before. Economies effected both in mining and in concentrating as between 1923 and the later dates are due in part to the increased tonnage, but improved efficiency in many directions likewise is a factor. It is difficult to refrain from using extravagant adjectives to describe such figures as 35.7 cents per ton for mining and 24.9 cents for concentrating. The tailings discarded from the concentrator during the first three years of operation averaged 14.52 lb. of copper per ton. In November, 1930, the ore as mined and treated contained less copper than the ton of tailing rejected 15 years earlier.

The Miami ores contain very little gold and silver but since 1938, commercial quantities of molybdenum have been recovered from the copper ores, and have been a factor in keeping the mine in the profitable class. Leaching of the oxidized portion of the mixed ores produced by the mine, has also been employed by the Company in attaining the economic success of its operations. The Miami Copper Company has been a shining example of how a combination of capital, progressive business acumen and technical brains has converted common rock into useful metal.

Up to January 1, 1952, the Miami mine has produced over 140 million tons of ore from which have been recovered over 2100 million pounds of copper, which together with small values of gold, silver and molybdenum had an estimated total value of \$330,000,000.

Operations at Inspiration

The Inspiration Consolidated Copper Company's plant at Miami, Arizona, was designed and built to make possible the profitable working of a low grade, finely disseminated copper deposit containing 100 million tons of ore averaging 1.54% copper.

From the beginning it was evident that the plant could not be kept integral but that a break would have to be made somewhere in the flow-sheet, removing at least the concentrator to a site more suitable than any available near the mine. It was finally decided to do the coarse crushing at the mine, to store the crushed rock in a bin from which it could be loaded into railroad cars and to haul it to the concentrator, an excellent site for which was available about 1-3/4 miles from the mine.

The original intention was to equip a plant to treat 7500 tons of ore per day, but through the acquisition and proving up of additional ore reserves, the introduction of the Ohio caving system, and the excellent results in the test mill (which made it possible to treat a lower-grade ore than had been thought possible) it was evident that a plant of much greater capacity should be

supplied. It was, therefore, decided to treat approximately 15,000 tons of ore per day.

A gravity test mill was erected and placed in operation near the Joe Bush shaft in November 1910, and its operation was continued until August, 1911. Soon after, flotation began to attract considerable attention, and a 600-ton test mill was designed and erected in 1913. That the large-scale test-mill method for working out flow-sheets for large plants is the only logical method, is evidenced by the fact that in nearly every stage of treatment either an entirely new machine has been adopted or a new application has been made of a standard machine; the result in each case being increased efficiency or a more economical arrangement. It may be interesting to note that six complete designs for the concentrator were executed, the idea being to keep this work abreast of the developments brought out by the test-mill.

The concentrator was no sooner erected than very marked changes in grinding machinery began to develop, the ultimate result of which was another altogether new arrangement for the entire mill.

As a result of preliminary studies, a dual arrangement of the mine plant was evolved. To insure continuity of service two shafts were used, and the whole mine plant was made duplicate in arrangement. A water supply for the concentrator was developed at Wheatfields, about 12 miles from the mill site, and later, wells were sunk on the flat below the tailing storage site. The best location was determined to be about $2\frac{1}{2}$ miles from the mill, at the junction of two fair-sized drainage channels receiving their supply from the Pinal Mountains about 10 miles away and 4000 ft. higher.

Electric power was obtained from two sources. The Reclamation Service of U. S. Government at Roosevelt Dam, 40 miles away, furnished some of the power, and in conjunction with the International Smelting Co., the Inspiration built a power house that utilized reverberatory waste heat and also produced power from oil-fired boilers (later gas-fired).

Throughout the early years of mill operation, research and experimentation developed improvements, until in the early twenties, when the Inspiration ore being mined at that time, began to show larger proportions of non-sulphide copper which was not amenable to efficient treatment by flotation. A search was made for a process that would successfully treat such mixed ores. The main sulphide copper mineral was chalcocite and the principal non-sulphide, chrysocolla. Laboratory and test-plant investigations conducted by G. D. Van Arsdale, together with the Inspiration staff, proved that such mixed ores could be successfully treated by leaching with ferric sulphate. Many millions of dollars were expended in these tests and in the construction of a suitable leaching and precipitating plant. And since 1926, this method of treating the Inspiration ore has been standard practice.

An open-pit development and construction program was completed in March, 1948, and since that time almost half of the ore mined has come from the open pit. In 1949 all necessary work underground was completed for leaching in place certain mined out and caved areas in the mine to recover part of the remaining copper. Production from this source began in 1950.

By January 1, 1952, the Inspiration mine had produced over 130 million tons of ore, from which had been recovered 2500 million pounds of copper worth about 400 millions of dollars.

Castle-Dome Operations

Castle Dome Copper Company mines and mills over 12,000 tons of ore daily. The mine is a typical open-pit operation with the latest and most modern equipment known to the industry. Electric churn drills, electric shovels, and diesel trucks are used. The concentrator is also one of the most modern and efficient in the industry. Its simplicity of design and operation has permitted the use of women as operators, which is one reason why this property was not as seriously affected as others by the labor shortage problems during the war. Automatic feed control, first conceived by F. W. MacLennan, and worked out by Miami and Castle Dome staffs together with Westinghouse Electric and Mfg., Co., has increased the plant's efficiency both as to tonnage and metallurgy. Tied in with the feed control is a water control which adjusts the flow of water into the mill, maintaining a constant density. The importance of this control to an operation like Castle Dome becomes apparent when it is realized that no attempt is made to control the hardness and grindability of the ore mined and delivered to the concentrator for treatment. The ore is dumped into the coarse ore pocket as it best suits the mining operation. At times it may carry 1 percent copper and other 0.4 per cent. Moreover, on one day it may come from the eastern portion of the ore body where the ore is softer, and the next from the western side where it is harder.

By January 1, 1952, the Castle Dome mine had produced over 33 million tons of ore from which had been recovered over 420 million pounds of copper, over five hundred thousand ounces of silver and over eight thousand ounces of gold, with an estimated value of 66 million dollars.

The Castle Dome mine is approaching exhaustion of its orebody, but the owners are already making preparations to open up a new mine in the Miami area. The Miami Copper Co's wholly owned subsidiary "The Copper Cities Mining Co", will utilize the mining and milling equipment of the Castle Dome Copper Co. when the latter has ended its operation.

Conclusion

The above facts tell the story of how intelligent observation and scientific reasoning can be brought to bear even on the exploratory phase of mining which has seemed usually so haphazard. In the case of the Miami mine the sum of \$400,000 was risked to ascertain whether there was enough ore to constitute a profitable mine; after that point was passed, the further development underground served merely to emphasize the bigness of the orebody and the consequent need of making financial provisions for operations on a big scale. The story of the Miami and the Inspiration suggests also that the successful exploitation of an orebody may involve operations on a scale so big as to require the expenditure of sums of money that make the original purchase of the bare ground seem very cheap; it indicates that a mining claim without the intelligent use of capital is only second-rate scenery.

In connection with the early development of the Miami-Inspiration district, the names of "Black Jack Newman", F. C. Alsdorf and F. J. Elliott, the latter a Phoenix attorney, should be mentioned as responsible for Mr. Channing becoming interested in the Miami property. Henry Krumb, W. B. Thompson and Dr. Ricketts were the men chiefly responsible for the development of the Inspiration. Needless to say the managers and staffs of the two companies furnished the brains which brought about the success of both ventures.

The three mines have been the producers of over 300 million tons of ore, from which have been recovered a total of 5 billion pounds of copper with a value of over 800 million dollars. A result far beyond the dreams of Parke Channing and Henry Krumb!

Most of the eight hundred million dollars benefitted the State of Arizona in the form of wages for its citizens, education for its children, a market for its farmers, and a higher standard of living for everyone. It has been determined that "for every man engaged in mining and allied industries, 2-1/3 jobs were created in service industries and (on the basis of average family size) a total of 12 local persons are thereby supported." Every miner, every millman and every smelter man who has taken part in this creation of wealth may take just pride in his share of such constructive work.

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