THE STORY OF BISBEE

From the time when the Bisbee (or Warren) District began to produce ore (about 1880) until the end of last year (1951), the district had mined almost 55 million tons of ore containing over 5½ billion pounds of copper, 50 million dollars worth of gold, 56½ million dollars worth of silver, over 300 million pounds of lead and over 360 million pounds of zinc, or a grand total of mineral wealth amounting to over one billion dollars. This would indicate an average value of 20 dollars per ton of ore, which puts the district in the bonanza class, as distinguished from the low-grade porphyry copper districts with their three to four dollar ore.

To be sure, the net profit to the operators in producing this mineral wealth is only a small fraction of the gross metal value of over one billion dollars. Such gross value was only attained after many processes outside the State of Arizona were performed and the final product transported to markets.

History*

The discovery of ore in the Bisbee district was made by an American Army Scout named Jack Dunn, in August 1877, when he located a claim called the Rucker, near the Mexican border. Dunn's location was named after J. A. Rucker, an army officer, to whom was given a share in the claim. The Copper Queen deposit was discovered by Hugh Jones in 1877, and a claim named the Mercey was located by George Warren, after whom the district is named, on Dec. 27, 1877. This claim was re-located as the Copper Queen by George Eddlemann and M. A. Herring on Dec. 15, 1878. The original locator, Jones, abandoned his discovery because he saw nothing more than "copper-stained rock". A little copper furnace was erected by Warner Buck on the Robb claim owned by B. D. Rea of Tucson, and some matte was produced unprofitably in 1878. The Copper Queen prospect was purchased by John Ballard and William Martin, of San Francisco. They were successful contractors, but entirely ignorant of mining; they had, however, the advise of two competent men, B en Williams and Lewis Williams, the sons of John Williams of Globe. John Williams had been a Welch miner and was now a partner with Judge Dewitt Bisbee in the noted Brokeage firm of Bisbee, Williams & Co. of San Francisco. Bisbee sponsored the new company of Ballard & Martin, and the town was named in his honor. Under the direction of the Williams Brothers, George Center built a smelting-furnace, a 36-inch water-jacketed cupola, in 1880. This little smelter treated an ore yielding 23 percent of copper, and for a time did well. The fuel was English coke, brought by way of San Francisco.

In 1881, James Douglas came to Bisbee and obtained an option on the Atlanta claim, which was next to the Copper Queen. In developing the Atlanta, Dr. Douglas was unsuccessful at first in finding ore, and after he had spent $70,000 in exploratory work it was proposed by his associates to discontinue

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* James H. McClintock, "Arizona", and Rickard's "History of American Mining."

operations, but on his advise they agreed to advance $15,000 more for development, with the understanding that if this renewed attempt failed to discover sufficient ore, they would abandon the venture. Sinking was resumed, and within a few feet the Atlanta workings penetrated a great orebody, which proved later to be the basis for a magnificant copper enterprise.

Meanwhile, Ballard and Martin had exhausted the ore in the Copper Queen, and in 1884 litigation was threatened between them and the owners of the Atlanta, whereupon the two mines were joined in the name of the Copper Queen Consolidated Mining Company. This was in 1885, and Douglas, who was acting for the firm of Phelps,Dodge & Company, became the moving spirit of this company. In 1890 he engaged Louis D. Ricketts as his assistant, and their association continued for 17 years.

The Copper Queen Company extended its territory by acquiring the Goddard properties and by purchasing outlying claims including the Neptune and Lowell groups. The Irish Mag and one or two other desirable claims, however, were involved in litigation because the owner, an Irishman named James Daley, was a fugitive from justice, and a Mexican wife became claimant to his belongings. Eventually the Supreme Court of the United States recognized her title, which soon afterward passed to Martin Costello of Tombstone. He was willing to sell for $500,000 and Douglas was willing to take a bond at that price provided he could explore the property by extending the underground workings of the Copper Queen mine, whereas Costello insisted that the work be done from the surface of the Irish Mag, so that he could have a shaft in case the deal fell through. When these negotiations failed, in 1901, the Irish Mag was purchased by a group from Michigan and Pennsylvania in the name of the Lake Superior & Western Development Company, which later became the Calumet & Arizona Mining Co., the leaders of which were the Hoatson Brothers, Thomas F. Cole, George E. Tener, Chester A. Corigdon, and Charles Briggs. This company subsequently acquired additional territory and eventually became one of the leading producers of copper in the Southwest. Litigation over apex rights would have ensued between this company and the Copper Queen if Douglas had not possessed the sagacity to arrange with his neighbors to waive any extra-lateral rights in favor of the common law, whereby each company waived any claim to ore in depth that was vertically outside its side and end lines. At the same time an agreement was made giving each company free access, for information, to its neighbor's underground workings. This not only ensured peace but also the opportunity to become informed concerning discoveries of ore, all of which redounded greatly to the prosperity of the district, and to the esteem in which Dr. Douglas was held by his fellow-engineers.

Only oxidized ores were worked by the Copper Queen until 1893, when converters were added to the smelting plant. As early as 1886 a film of matte floated on the bars of copper and the quality of the metal suffered so much that the direct method of smelting had to be abandoned, whereupon matte was made; and reduced in the converter. In 1908 the mine began to produce some lead, and in 1916 some zinc. Since those dates, the district has produced over 312 million pounds of lead and over 366 million pounds of zinc. Gold, amounting to over 1.9 million ounces and silver amounting to almost 81 million ounces, have also been produced by the district since operations began.

* The first smelter of any importance was erected at Fairbanks on the

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* Parsons' "The Porphyry Coppers"

Southern Pacific Railway, 37 miles northwest of Bisbee; and for several years ore was packed thither on mules and burros. In 1888 a railway was built by the mining company from Bisbee to Fairbanks, but in 1900 plans were made for the new reduction works at Douglas, and the El Paso and Southwestern Company, controlled by the Phelps Dodge interests, constructed the necessary railroad. The Copper Queen smelter at Douglas went into operation in 1904, being supplied p rincipally by the Copper Queen mines with rich carbonate ores of smelting grade until 1932.

The blowing-in of the smelter in 1904 was a milestone in the company's history. From a single water-jacketed cupola no higher than a man, its smelting plant had now grown into the most modern structure of its kind in the world. Containing five blast furnaces and four barrel-type acid-lined converters, the new works covered three hundred acres with a fifteen mile network of standard guage railroad tracks connecting smelter, power houses, machine shops and foundry. It was built to handle a production of more than a hundred million pounds per year, but through the years it was constantly enlarged to meet even greater demands upon it. This camp became a thriving town - and in honor of the man who had done so much to develop copper mining in the southwest, it was named Douglas.

In 1917, the name Copper Queen Consolidated Mining Company was changed to the Phelps Dodge Corporation and the assets of Phelps, Dodge & Co., were transferred to the new corporation.

When the other porphyry mines began to cut an important figure in the copper-mining world, the attention of Dr. Douglas and his associates was naturally drawn to the large mass of granite or monzonite porphyry which had intruded into the limestone, in past geologic eras, an with which had been associated the copper-bearing solutions that were responsible for the formation of the rich limestone "replacement" orebodies. As early as 1909 exploration of the porphyry intrusion was undertaken, first by extending the underground workings in the limestone sections of the mines, and later by churn-drilling from the surface. Two orebodies separated by a mass of rock too lean for profitable exploitation, were proven. The so-called West, or Sacramento Hill orebody, was richer, on the average, and the overburden was thinner, ranging from 50 to 350 feet with an average of 250 feet. Steam shovel operations began in 1918.

Sacramento Hill was - before it succumbed largely to the steam shovels - a bold precipitous hump standing in the center of Mule Gulch. Its crest was dark brown from stains of iron; it contrasted sharply with the reddish schist on one side and the gray limestones on the other. The demolition of it was a most spectacular project.

In September, 1929, shovel operations were finally suspended after moving 15,000,000 cu. yd. (equivalent to about 30000,000 tons) including ore and waste. As the ratio of waste to ore was 2.75 to 1, about 8,000,000 tons of ore was shoveled during the period 1923 to 1929. At least three million tons of ore remained to be won. A glory-hole method was developed that recovered this ore economically. In the meantime, mining of the East porphyry orebody was started. In spite of some misgiving on account of the wet and sticky character of the ore, a block-caving method adapted from Morenci practice was put into successful operation, and a substantial part of the ore going to the concentrator in 1930 and 1931 came from this section of the mine.

The old underground sections of the Copper Queen mine have been mined by the use of both square-setting and top-slicing methods, or modifications thereof. The high grade of the ores mined permitted these more expensive mining methods. The Denn Mine, which was taken over by the Phelps Dodge Corporation in March 8, 1947, also used the square-set and pillar system, the pillars being mined by the Mitchell slicing method developed at Bisbee. The Denn Mine had originally been owned by Lem Shattuck and Maurice Denn. In the early days, Lem Shattuck, like almost everyone in the district, picked up a number of claims, including one southwest of the "Copper Queen". When the boom hit Bisbee, he interested some Minnesota investors in helping him sink a shaft on his property. At the three-hundred-and-fifty foot level, the shaft dug into a body of high grade ore which continued all the way down to the eleven-hundred foot level and made the "Shattuck" renowned as the "biggest little mine" in the area. Then with Maurice Denn and others, he owned another group of claims to the northeast where no one expected to find ore; but Shattuck sank a shaft to the seventeen-hundred foot level and again ran into an enormous body of sulphide ore.

Ore Bodies *

The first discovery of copper ore in the district was in the old open cut on the hillside above the Bisbee Post Office. Except at the White Tailed Deer Mine, it was the only copper outcrop in the district. The ore here was malachite and azurite (copper carbonates), which for many years was the only kind of ore found or mined. As work progressed downward and southeastward, secondarily enriched sulphides and finally primary sulphides of mineable grade were found.

The ore bodies of the district are arranged in the semicircle around Sacramento Hill and also radiate outward from this center. A commonly accepted idea about the replacement ore bodies in the limestone is that they are tabular, wider than they are high. The idea originated at a time when mining was done mostly in the western portion of the camp. Here oxidation and erosion shrank and cut down the height of some of the ore bodies of this area. In the extreme eastern ore area, height is generally greater than length or width. Oxidation progresses in intensity from southeast to northwest. In small portions of the Campbell area, however, oxidation has penetrated as deep as the 2,300 level.

Practically all of the ore bodies of the district had a central core of somewhat siliceous pyrite containing small amounts of copper around which sulphides of copper and iron occurred. In the fine grained pyrite core, the pyrite is commonly shattered and becomes ore because of the deposition of small veinlets of copper sulphides in the breaks and cracks. Hematite is frequently associated with the ore along its contact with the limestone. Magnetite is intimately mixed with the pyrite and chalcopyrite in certain areas. In the process of replacement the grain structure, bedding, and the included unreplaced chert lenses of the limestone are frequently beautifully preserved in the resulting sulphide.

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* From Cark Trischha's article in the Arizona Bureau of Mines Bulletin # 145, pages 38-41.

Porphyry Ore Bodies

There was a fairly large mineralized area within the stock of Sacramento Hill. These ore bodies were secondarily enriched by chalcocite and were partly in the porphyry mass of Sacramento Hill and partly in the contact breccia around it. The protore contains less than 0.50 percent copper. The stock of Sacramento Hill was highly silicified, sericitized, and pyritized, and the small amounts of chalcopyrite and bornite in the protore are responsible for the copper of the secondary enrichment.

Ore Guides

Granite-Porphyry dikes and sills are guides to ore; By following them on both sides ore may be encountered in the embayments.

Fracture zones, where they are rather steep and dip more or less normally to the bedding, are well worth following if they are at all mineralized.

Manganese oxides as outcrops or along fracture zones can be used as guides. Silica breccia and hematite, or both, are usually closer to ore than manganese.

Limonitic gossans and calcite-filled cracks in the limestone over oxidized slumped ore bodies are direct guides and point down to the possible ore.

Copper Queen Concentrator *

Because of the sulphide character and the low grade of the ore in Sacramento Hill, a concentrator was deemed necessary. Experiments preliminary to the design of such a plant were commenced as early as 1916 in a small test plant constructed for the purpose near the mine. Early in 1918 H. K. Burch was employed to supervise the design of a 3,000-ton mill to be constructed at a site about two miles south of the mine on the slope of the Mule Mountains. Besides affording gravity flow of the ore through the concentrator, the site was exceptionally well situated with respect to disposal of tailing on the valley floor below.

Many obstacles delayed the completion of the mill until 1923. First, the Government declined to release steel necessary for construction; then in 1919 important changes in the design of the plant were made; in 1920 the strike of railway employees in the United States held up shipment of materials; and finally in 1921 the general curtailment in copper production caused a complete suspension of construction, which remained in force until January 1, 1923. However, on April 1, 1923 the first unit of the plant was put in operation, the nominal capacity having in the meantime been increased to 4,000 tons per day.

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* Parsons "Porphyry Coppers"

At the start the concentrator provided a combination of gravity and flotation treatment, flotation constituting an intermediate process between "roughing" and "finishing" concemtrating tables. Although a number of Porphyry Copper mills had by this time discarded tables, the reason they were retained at the Queen mill was because it was not planned to obtain rich concentrate and a high ratio of concentration. Coarse concentrate was more readily handled at the smelter, and moreover there was the supposed need of iron-bearing minerals at the smelter to flux the large quantities of high-gradeores that were mined from the carbonate orebodies at Bisbee and smelted without concentration. As the minerals of copper and of iron in the sulphide concentrating ore were very intimately associated it would be necessary, if they were to be spparated, to grind exceedingly fine, and fine grinding is a costly operation. Early operation, however, indicated that radical changes were desirable. Within a year, the gravity ta les were discarded, leaving the flotation cells as the only concentrating devices in the plant. The next change was the introduction of finer grinding to permit the removal of more of the gangue constituents of the ore. From these changes came a saving of freight on the concentrate, a reduction in smelting costs, growing out of the treatment of a smaller tonnage, and a reduction of slag losses because of the removal of worthless slag-forming elements in the furnace charge.

The ore mined from the Sacramento Pit increased in grade as the lower horizons of the deposit w ere reached. For example, the first five years of operation produced an average grade of 1.65% copper as compared with 2.04% for the last four years. The concentrate grade was increased from 7 - 8% copper to 13 - 15%. An excellent recovery was made from the start, averaging better than 88%.

Heap Leaching *

In one respect the Sacramento Hill project is unique among the Porphyries, and that is the process of heap-leaching itself consists essentially of: (1) piling run-of-mine ore on a gently sloping hillside to form a bed; (2) "irrigating" this heap with slightly acidulated water; (3) collecting the water (which, in percolating through the heap, has acquired a burden of copper in the form of a solution of copper sulphate) in a pond at the foot of the bed; (4) passing the pregnant solution over scrap iron to precipitate the copper; and (5) collecting and drying the mudlike precipitate of "cement copper" to be fluxed and melted to produce comparatively pure metal. A distinctive feature of the process is that the foregoing sequence of operations is repeated for a particular section of a heap with long intervals intervening during which the sulphide minerals oxidize by contact with atmostpheric oxygen. The consequence is that a period of years is required to effect a satisfactory extraction, a feature that militates against wider utilization of the method.

Ever since early in 1900, experimentation and research have been devoted to the heap-leaching of Bisbee waste dump and low-grade ore piles in the district, and a considerable amount of low-cost copper has been produced by the process.

Zinc-Lead Deposits

Records of the earlier mines of the Bisbee district show that zinc and lead

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* Parsons' "Porphyry Coppers".

occurred throughout the district in areas mined for copper. The zinc and lead production of Bisbee since 1939 has come largely from the Eastern part of the district, particularly the Campbell and Junction areas. Near the borders of the Campbell copper orebody, sphalerite[1] and galena[2] become increasingly abundant.

The deposits vary greatly as to size, shape and mode of occurence, but in general they may be classified as follows:

Deposits along structural breaks.
Deposits peripheral to barren siliceous-pyritic bodies.
Deposits intimately associated with, or peripheral to, rather massive pyrite-copper ore bodies.
Deposits associated with porphyry.

The Phelps Dodge Corporation annual report for 1951 has this to say regarding the lead-zinc ores at Bisbee:

> "During the year, the change-over from lead-zinc ores to the mining of copper ores as the major source of production was brought to completion. This change-over was started in the previous year as a result of the exhaustion of lead-zinc ores of importance. The tonnages mined in 1951 totaled 490, 184 tons of copper ore and 40,426 tons of lead-zinc ore".

Conclusion

For 42 years, until 1932, the Copper Queen Company relied on smelting ores from its carbonate mines to produce its copper, but since 1927, the Porphyry ores- milling and leaching - have contributed the perponderant porportion of the output. The absorption of the Calumet & Arizona Company by Phelps Dodge in 1931 gave the Corporation enormous proved bodies of ore of direct smelting grade, and there is the ever present possibility of finding still further bonanzas in the famous old district.

The latest development is the Lavender Pit, where the Bisbee East Orebody is to be operated as an open-pit mine. It is expected that production will commence by the end of 1954. On the basis of present estimates, the property is expected to produce at a rate of about 76,000,000 pounds of copper annually for a period of some eleven or twelve years. The orebody contains an estimated 41,000,000 tons of concentrating ore, averaging 1.14% copper; 31,000,000 tons of material to be leached, averaging .42% copper; and 70,000,000 tons of waste to be removed. Besides waste removal, the project involves the acquisition of electric shovels and drilling and haulage equipment; the installation and equipment of a concentrator, with a projected capacity of 12,000 tons of ore per day; and other related facilities.

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1 Sphalerite - Zinc Sulphide - 67.1% Zn and 32.9% S.
2 Galena - Lead Sulphide - 86.6% Pb and 13.4% S.

Arizona Department of Mineral Resources

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