ECONOMIC ASPECTS OF COPPER PRODUCTION IN THE UNITED STATES

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Almost ninety percent of United States copper production comes from the large low-grade mines of the west. The developed ore in these mines averages less than twenty pounds of copper to the ton; the average recovery in recent years has been only 18 pounds of copper per ton and about twenty-eight cents in gold and silver.

In each of these large mines, many millions of dollars had to be spent before a profit was returned to the investor. It took vision and courage, as well as capital, to convert these large copper deposits into profitable enterprises. If it had not been for the application of brains and capital to the development of this copper, these properties would be so much worthless rock in mountains of scenic value only. And yet many states are claiming that the mining industry is depleting natural resources originally belonging to the state; and these states have slapped a severance tax upon the industry to recompense them therefor. Although forty years ago the mining industry had created a 20-years' supply of copper ore, it has not only been mining it for forty years, but it still has a 20-years' supply for future use. How this can be called impoverishing the state is difficult to imagine. On the contrary, the big copper producers have taken Federal lands on which no taxes were being paid, and have put them on the tax rolls, thus contributing to State tax revenue.

Before the big copper producing properties were developed, they had been operated as small mines for many years, during which time, the higher grade portions of the ore-bodies near the surface were mined out, leaving the low-grade for science and capital to develop. Large scale operations were necessary to make the ventures profitable. Churn drilling was essential to determine the extent and grade of the ore-body, after which shafts, drifts, cross-cuts and raises had to be driven to block out the ore and prepare it for extraction. This drilling and development usually delimited the ore-body by classifying as ore only that which could be mined, milled and smelted at a profit. Naturally, improvements in mining, milling and smelting as time went on, changed what had been originally classed as waste into profitable ore. In many cases the life of the mine was doubled by the discovery of new technical processes. Hence a mine which had originally a 20-year reserve of copper, remained in business long after the twenty years were past. In some cases additional drilling on the fringes of developed ore-bodies, showed many years' supply of what would have originally been classed as waste, but with new processes, became pay ore.

The element of time enters into the problem of development of copper production, and should be a prime consideration in the argument for protection of the copper industry in the United States. For example, in 1899, Daniel C. Jackling began some pioneer mill testing of a low grade porphyry ore at Bingham, Utah, and it took him until 1905 to prove to the satisfaction of interested capital that by the introduction of large scale open-pit mining, and the erection of a concentrator, he could mine and treat rock containing two percent copper (40 lbs. per ton), recover 25 to 28 lbs. of copper for every ton treated, and concentrate it to a profitable smelting feed. Mr. Jackling's success in Utah started the search for similar large ore-bodies in Arizona. In 1906 Philip Wiseman and Seeley Mudd, under Mr. Jackling's direction, started development of the Ray Orebody. Mr. Louis S. Cates developed the mining system to be used at Ray, and it later became the

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first copper mine in the world to produce 8000 tons or more of ore per day by caving methods. It took until 1912, and the expenditure of fifteen million dollars, before Ray began to produce ore at a profit.

Also, between 1906, (when J. Parks 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 preparation for production. Like Ray, Miami was an underground mining operation, using a caving method which, under the capable management of F. W. Maclennan accomplished the cheapest underground mining in the world. He made a profit in the treatment of 12 to 15 pound ore.

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. Some of the most elaborate pilot-mill testing was done at this plant before the concentrator was finally designed and constructed. The industry at this time was in the stage of evolution from gravity to flotation concentration, and hundreds of thousands of dollars were spent at Inspiration in developing the new process. The brains of Dr. Ricketts directed the successful development of Inspiration. He later was responsible for the change from flotation concentration to the ferric sulphate leaching of the mixed oxide and sulphide ore.

About this time, 1913, diamond-drilling was started at Ajo, but it was not until November, 1918 that New Cornelia paid its first dividend. Doubt as to the possibility of successfully treating the exidized overburden had helped to discourage J. Parke Channing and Seeley W. Mudd when they were considering separate parts of the property in 1909 and 1910. Dr. Ricketts has stated the essence of the problem that faced him and Greenway, in the following short paragraph:

"Greenway drilled the great ore deposit in 200-ft. squares and about 50,000,000 tons of sulphide ore containing about 30 lb. of copper on a 20-lb. minimum were developed. This ore was capped with some 10,000,000 tons of granitic material containing the same amount of copper in the form of malachite and chrysocolla. There was no known method of treating such lean oxidized material. The steam shovel was best adapted to mining the sulphide ore, but even so it was estimated that it would cost, with interest, \$5,000,000 or \$6,000,000 to remove the overburden and throw it away. If, however, a process for treating this oxidized overburden profitably on a large scale could be devised, a large liability would be converted into a much larger asset."

After leaching 16,800,000 tons of oxidized ore, the sulphide zone was attacked, and a modern concentrator was designed and erected to treat the ores by flotation. Many years later, when the freight on the concentrates, which were hauled to Douglas, became excessive, a five million dollar smelter was built at Ajo, and resulted in the saving of hundreds of thousands of dollars annually in railroad freight charges. Cutting corners is a continuing process in a competitive market.

When one considers the many failures in the early attempts to make the Ajo mining district pay, (proving that it was no bonanza in its earlier years) New Cornelia is impressive as another example of how vision and capital have converted a mountain of low-grade copper rock into copper metal. The Morenci enterprise is perhaps the most impressive of all in demonstrating how modern technical and mechanical progress has made it possible to mine and treat successfully enormous tonnages of low-grade ore containing less than 20 pounds of copper to the ton. A total of approximately \$76,500,000 has been expended for the purchase, development, capital additions and improvements on the Morenci property to the end of 1951.

From 1929 to 1942 when regular production from the Morenci open pit commenced in January, Mr. Cates directed a thorough program of testing and development which culminated in the construction of a 25,000 ton concentrator and a smelter to handle its product. A more fortuitous date for starting this operation could not have been chosen, for it was the year of World War II, and Uncle Sam had need for every pound of copper he could get his hands on.

As may well be imagined, the long period of experimentation and planning, between 1929 and 1942, was marked by many failures and changes of plans. While the big problem was the choice of open-pit or underground mining, and leaching or regular concentration methods, there were many other worries facing the company. By no means the least was the uncertain future of the copper industry during the long depression period. Metallurgical problems, involving the choice of the proper equipment to use after the selection of the method of concentration, included the necessity for large-scale practical testing, and the choice was not an easy one. Then there was the smelting problem, for the character of the concentrate made by the mill naturally varied with the modification of the crushing, grinding and concentration processes.

Louis Cates and the Directors of Phelps Dodge had to have courage to launch a \$76,000,000 enterprise, and they made sure that this, the first major copper development in Arizona in 30 years, would be as well planned and well equipped as human ingenuity, experience and determination could make it. Today it is treating 50,000 tons of ore per day.

NOT ALL BEER AND SKITTLES

The record of the development of the large low-grade copper orebodies in the United States was not without its periods of threatened failure. Low market price of copper was one of the hazards the mining industry had to face, a hazard over which the mining companies had no control. The problems were not all geological, metallurgical and mechanical; there were labor and business problems to be met. For example the depression of the thirties caused almost a complete shutdown of two to four years, during which some of the properties came close to complete abandonment. It took large expenditures to keep the underground workings in half-way decent condition for later resumption of operations.

EXPLORATION AND NEW DEVELOPMENTS

All the big mining companies maintain exploration departments which are ever on the look-out for new ore-bodies.

The first big development project to go into production in recent years is Anaconda Copper Mining Company's Greater Butte project. It yielded its first ore through the Kelley shaft on April 26, 1952. It is the industry's answer to charges that America is rapidly becoming a have-not nation in mineral resources, and that the end of some of the famous western mining districts is in sight. Conceived and brought into being by private capital, this new project demonstrates

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that a huge tonnage of low-grade material, once considered waste, can be converted into ore through technological advances applied and directed by capable management and engineering staffs. As a result, 3-billion lbs. of copper reserves have been added to the resources available to industry, and the life of the Butte district will be extended by many decades. A 10,000 ton daily rate of 20-lb. ore is planned. 130 million tons of ore have been blocked out in the project area.

An additional 30,000 tons of copper yearly is expected to be produced from Anaconda's new leaching plant at Yerington, Nevada, by the end of 1953.

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Construction of Copper Range's new White Pine mill and smelter in northern Michigan was well under way at the end of 1952. The White Pine project will add 75 million lbs. of copper to U. S. annual production. It will support a new town of 400 homes and about 2000 people. Total investment will be about 70 million dollars. There will be mined and processed something over 309 million tons of ore running 1.10% cu. Total reserves of ore will run well beyond this figure.

The Magma Copper Company has planned a 120 million-dollar investment for the production of 140 million pounds of copper annually from its San Manuel property near Mammoth, Arizona. The new concentrator will handle 30,000 tons of ore daily, and will make a copper-molybdenum bulk flotation rougher concentrate which will be reground, cleaned, and retreated for production of copper and molybdenum concentrates. Moly concentrates will be shipped, and copper concentrates will be smelted on the site. Over 500 million tons of 0.8% copper ore have been indicated by extensive drilling, and plans are to mine the ore by underground caving methods. A new town of 7000 inhabitants will be created. This property has been under development by the Magma Copper Company since 1944.

Production at the Lavender Pit (Bisbee East Orebody) is scheduled to commence by the end of 1954 or early 1955. On the basis of present estimates, the property is expected to produce 76,000,000 pounds of copper annually for some eleven or twelve years. About 25 million dollars will be spent in bringing this property into production.

Completion of the new Silver Bell mill of A. S. & R. is scheduled for this year, with a capacity of 7500 tons per day of porphyry copper ore. Seventeen million dollars will be spent and production will be about 36 million pounds of copper per year.

Bagdad Copper Corporation will spend about 18 million dollars to double their present production of about 20 million pounds of copper annually. Also some molybdenum will be produced.

The Miami Copper Company is spending 15 millions on its Copper Cities property and plans to produce 45 million pounds of copper annually, starting within the coming year. This however, will not add to the total U. S. production of copper, as it will take the place of the Castle Dome output which will cease in a few months.

Kennecott Copper Corporation is developing a new open-pit copper mine located near its present Nevada operations. The ore-body known as the Veteran is said to be 1400 feet long and 600 feet wide and averages less than one percent copper. Originally an underground mine, it has not been in operation since 1914. This is the second major development undertaken recently by Kennecott in this area. The first involved the moving of an entire town in order to operate new shafts of the so-called Deep Ruth mine, which should be in full operation next year. All of the above means an addition of 240,000 tons of copper to the present annual production of 925,000 tons, making a total of two billion, three hundred and thirty million pounds of copper which will be available annually for domestic consumption by the year 1957.

Aside from the new concentrators being designed or constructed, Utah Copper is modernizing by doing a complete remodeling job on their two mammoth mills which treated 32 million tons of ore in 1952. Indeed all the large companies are spending millions on research in all phases of copper production, for there is a constant need of setting aside a portion of profits in order to keep abreast of technical progress. To do otherwise would be economic suicide.

Exploitation of low-grade disseminated deposits was made commercially possible by technological progress on two fronts: in the development of low-cost techniques for mining and handling large tonnages, and in the perfection of recovery (ore dressing) techniques that extracted the major proportion of a small quantity of valuable metal content from a relatively large proportion of rock.

The open-cut or surface method of operation is the most productive largescale mining technique. In fact, the total proportion of copper produced from surface workings increased from a practically negligible volume in 1905 to almost eighty percent in 1952. The evolution of the large-size electrified power-shovel and associated machinery contributed to the reduction in the cost of mining ore of progressively lowering grade.

Not all of the low-grade ores are close to the surface, and the technologist also made progress in reducing the cost of underground mining. Under a caving system of mining, he employed gravity to produce cheaply large tonnages of low-yielding material. Better knowledge of how to use mining methods for larger results was reinforced by increased mechanization. For example, scraping and loading machinery was utilized; increased capacity and greater speed of mine hoists; electrification of transportation and hoisting facilities; and improved ventilation practice.

The success of technology in improving ore-dressing (concentration) practice was a main factor in making possible the treatment of low-grade ores. The economic aspect of milling progress is seen more clearly from a specific example. In the first decade of the century, mills recovered roughly 60 to 75 percent of the available metal content - usually by the gravity concentration process. To-day, with the froth flotation process, recoveries of 85 to 90 percent or more are the expected performance. Crushing, grinding and classification techniques have made tremendous strides. An extremely low margin of profit has been the incentive for the amazing progress made.

The mining industry should be ever on the alert to prevent the elimination or weakening of two important provisions in the Internal Revenue Code. They have played a most vital part in the development of our natural resources. They are the provision relating to percentage depletion and the provision allowing the taxpayer to deduct as a current expense exploration and development costs. They have acted as a powerful stimulus in providing incentive for the creation of capital to search for minerals. Without them, the mining industry would die of exhaustion, and the nation would perish with it.

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The growth of the aluminum industry should not disturb the copper producers, because the additional aluminum is being consumed in uses that are out of the copper field. Copper will always be in style for the particular uses to which it is especially adapted. For example, copper wire for electric motors is so superior to anything el that it is a field well protected against invasion. The automobile radiator field is another, where copper is well entrenched, though attempts have been made to invade it. In recent testimony military commanders have agreed on the superiority of copper in artillery shells and small calibre ammunition.

The main worry for copper producers is to keep pace with a healthy increase in domestic demand, by the development of more ore to replace its depleting ore-bodies. Present indications are that they are doing just that.

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