New methods of working an old mine--Case history of the Eberle Group, Mogollon, New Mexico

Robert W. Eveleth

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Case history of the Eberle Group, Mogollon, NM

by Robert W. Eveleth, Mining Engineer, New Mexico Bureau of Mines & Mineral Resources, Socorro, NM
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Introduction and history

The Cooney (Mogollon) mining district is located in southwest Catron County, western New Mexico. Access to this remote district is via US-180 and NM-78. The area, due to its isolation, has never had rail service although plans were made at various times to construct lines from Silver City, 80 mi south, or Magdalena, 130 mi northeast. During the early days of the district (1880-1900), the raw ore was shipped to a smelter by freight wagon at a cost of $50 per ton (Thompson, 1962), virtually precluding any large-scale production until milling facilities were constructed locally around 1900 (Allen, 1909).

A German itinerant discovered the district in 1870 (Jones, 1904); however, little development occurred until the area was re-discovered in 1875 by James C. Cooney, an army sergeant on a scouting mission from Fort Bayard, New Mexico Territory. In 1876, after retirement from the military, Cooney, for whom the district is named, organized a prospecting party to develop the wide, rich veins he had discovered earlier. But the area was the stronghold of a band of Apaches led by Victorio; constant harassment by the Indians was to prevent full-scale development until the 1880's. Cooney himself was killed during one encounter. The Indian problems were gradually resolved, enabling production to increase rapidly. By 1905, the district had produced a total of $5 million in silver, gold, and copper (Lindgren, 1910).

The introduction of the cyanidation process to the district by Ernestine Mining Company in 1910 (Allen, 1911) along with efficient large-scale mills enabled Mogollon's mines to expand steadily until 1914 when annual production peaked at $1.5 million (Ferguson, 1927). When operations ceased in 1926 due to rising costs and decreasing profits, the Cooney district had produced more than $15 million in silver, gold, and copper at a time when the price of silver averaged less than $1.00 per oz. Operations resumed again in 1931. Because of new orebodies (although lower grade), efficient management, and an increase in metal prices, these operations were successful for another 11 years, during which period an additional $5 million of ore was produced (Thompson, 1962).

The closing of the Fanny Mill on June 18, 1942 forced a shutdown of the entire district because the mill had been processing ore for the local mines including the Last Chance, Pacific, Fanny, Eberle, and others (Weatherly, 1949). Several subsequent attempts were made to revive mining in Mogollon district, but without a mill, ore had to be shipped directly to a smelter. Grades were not then, nor are they now, high enough to sustain such operations. With the exception of a brief period of activity between 1943 and 1946, most such efforts failed and the district has remained virtually dormant. New ideas and modern technology would be required for Mogollon to become an economic mining district once again. The technology was to come in the 1970's in a process known as cyanide heap leaching. A group named Challenge Mining Company would provide the new ideas.

Recovery of precious metals by cyanidation

Although the solubility of gold in cyanide had been known for more than a hundred years, the mining world did not recognize the process until J. H. Rae obtained a patent in 1867 for "an improved method for treating auriferous and argentiferous ores." The process proved impractical until 1891 when a plant constructed in South Africa successfully used a process in which gold dissolved in cyanide was precipitated on zinc dust (Allen, 1911). Today however, the cost of a conventional cyanide mill, which includes crushing and fine-grind circuits, agitation of the fine ore in vats with cyanide, de-aeration and clarification of the leach solutions, and the ultimate precipitation of the precious metal on zinc dust is prohibitive for a small operation that processes low-grade ores.

Cyanide heap leaching, a concept developed as recently as 1967 along with new techniques for recovering gold and silver, however, provides an economically attractive means for the small operator to process such ores. In 1950, the United States Bureau of Mines at Reno, Nevada, demonstrated that a cyanide-leach, carbon-adsorption, electrowinning process could be economically applied to low-grade gold ore. Activated charcoal could be used to extract the gold from unclarified cyanide solutions (Zadra, 1950). Unfortunately, the method was only suited to relatively silver-free ore because the caustic sodium sulphide solution used to leach the gold from the loaded carbon also fixed the silver. In 1952 the process was improved by using hot caustic cyanide solution to strip gold and silver from the loaded charcoal (Zadra and others, 1952). Nevertheless the process remained unattractive to the small operator because stripping was time-consuming, requiring a minimum of 50 hours. Continued research by the Nevada Bureau has developed a process whereby the stripping time has been markedly reduced (Heinen and others, 1976, 1977). This new method allows the small operator to process low-grade ores of the Mogollon district economically.

Eberle mine

In 1967 David Aker collected samples in the Eberle mine but found the ore was too low grade to warrant shipping to a smelter. Nine years later, R. C. Manning visited several successful, small heap-leaching operations in Nevada and familiarized himself with the hydrometallurgical work of the U.S. Bureau of Mines at Reno, Nevada. Manning and his partner at the time, Gene Cook, submitted a sample of Eberle ore to the U.S. Bureau of Mines for testing. Results showed that the ore was amenable to heap leaching (Heinen, 1977). Mr. Cook dropped out of the partnership and was replaced by Aker. Challenge Mining Company was subsequently formed and an assay lab established at Mogollon. Extensive testing has determined that material from some of the mine dumps in the area, particularly the Confidence mine dump, is also economically amenable to the heap-leaching process. Testing has also yielded additional data regarding proper grinding size, reagent consumption, and optimum leach-cycle time. A carbon desorption-electrowinning plant similar in design to the Reno plant built by the U.S. Bureau of Mines has been constructed at Mogollon. A description of the recovery process follows.

Heap-leaching, carbon-adsorption, electrowinning process at Challenge Mining Company

The complete heap-leaching facility and crushing circuit is shown in fig. 1. Ore is crushed to minus ¼ inches and stacked up to 12 ft high on the leach pads. Pad con-

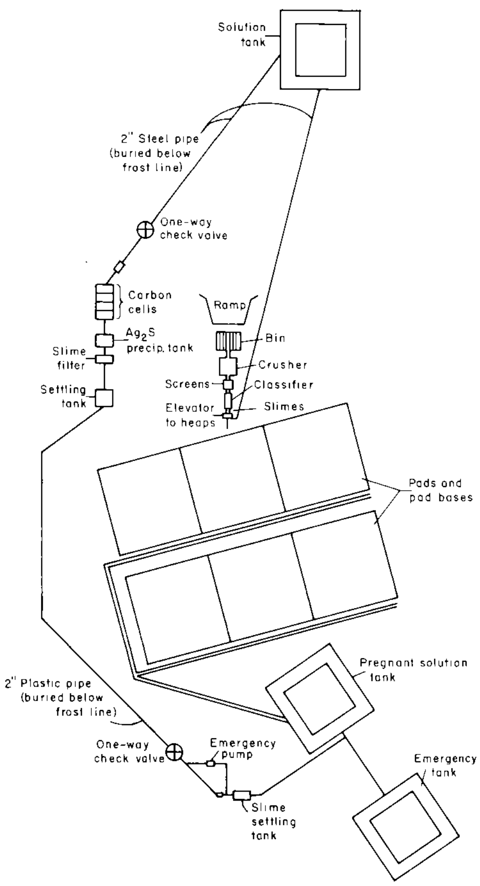

FIGURE 1—LAYOUT OF TANKS, CRUSHER, LEACH PADS, AND CARBON COLUMNS. Courtesy Challenge Mining Company.

struction detail is shown in fig. 2. Cyanide solution (0.5 lb per ton strength) sprinkled over the heap percolates down through the crushed material, dissolving the gold and silver. Leach-cycle time ranges from 40 to 60 days. Tests indicate 50 percent recovery in 19 days; however, the company hopes to attain 70 percent minimum recovery and will allow up to 60 days to achieve it. Washing the spent ore with water requires an additional 20 days—for a total maximum cycle of 80 days. Each of the two pads will hold 3,500 tons—for an annual capacity of 34,000 tons.

The pH is maintained between 10 and 11 by the addition of lime. The pregnant leach solution flows by gravity into the pregnant-solution tank. From there, the solution is pumped first into a slimes settling tank and then into an agitation tank where enough Na_2S (sodium sulphide) is added to precipitate 85 percent of the dissolved silver. The remaining solution, containing 15 percent of the silver and all of the gold is slowing pumped through four columns (each containing 150 lbs of activated charcoal) to remove the remaining silver and gold. The overflow from the first column flows into the second, the second into the third, and the third into the fourth. The nearly barren solution flowing from the fourth column is recycled to the cyanide-solution holding tank. A complete flow diagram is shown in fig. 3. Only 85 percent of the dissolved silver is removed prior to carbon adsorption, thus assuring that excess Na_2S will not be recycled back to the holding tank and the heap where it would prevent the leaching of the silver minerals.

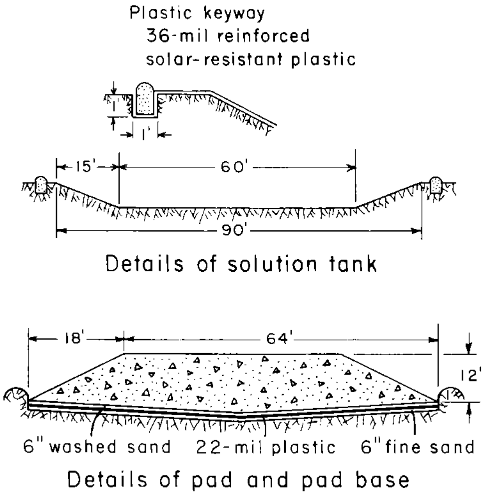

FIGURE 2—DETAILS OF CYANIDE SOLUTION TANKS AND LEACH PADS. Courtesy Challenge Mining Company.

After each day's operation, the loaded carbon from the first column is sent to an electrowinning plant. The carbon in column two is moved up to column one, column three to column two; and column four receives a fresh 150-lb charge of carbon.

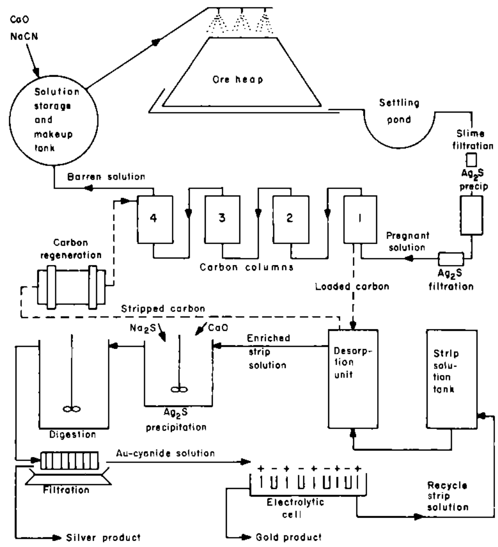

FIGURE 3—FLOW DIAGRAM OF HEAP LEACHING-CARBON ADSORPTION-DESORPTION SYSTEM. Adapted from *Heap leach processing of gold ores* by Heinen, Peterson, and Lindstrom, U.S. Bureau of Mines, Reno, NV, 1977.

In the electrowinning plant, the loaded carbon is placed in the stripping column (fig. 4). A solution containing 1 percent NaOH (sodium hydroxide), 0.1 percent NaCN (sodium cyanide), and 20-volume percent ethanol is heated to 90° C, and pumped upward through the carbon, dissolving the gold and silver. The pregnant solution is cooled and stored in an agitation tank. The silver is precipitated as Ag_2S (silver sulphide) by agitation with Na_2S. Calcium oxide (0.5 lb per ton of solution) is used as a flocculating agent. Precipitation of the silver is complete

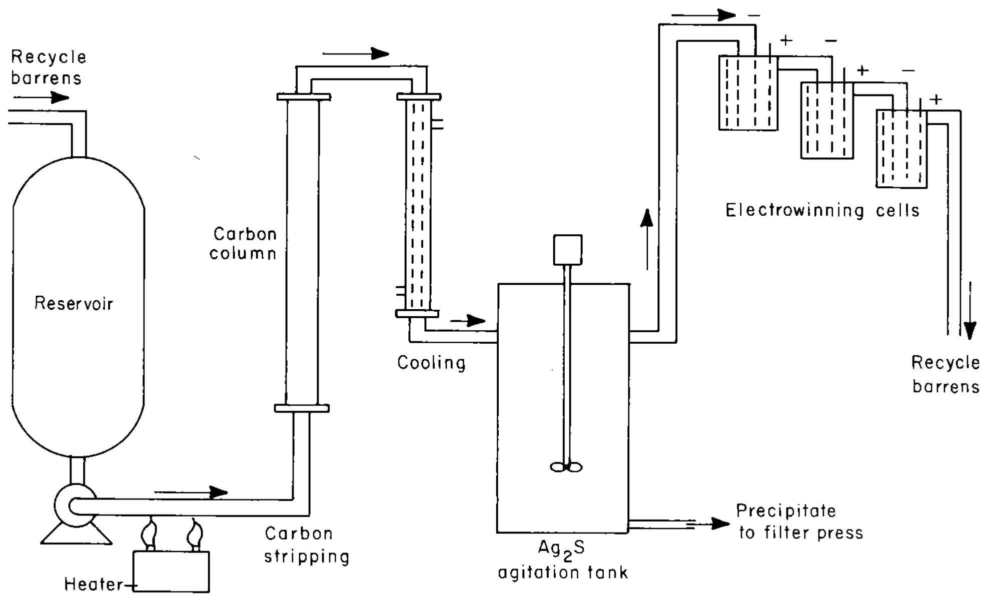

FIGURE 4—FLOW DIAGRAM OF CARBON DESORPTION ELECTROWINNING PLANT. Adapted from *Gold desorption from activated carbon with alkaline alcohol solutions* by Heinen, Peterson, and Lindstrom, U.S. Bureau of Mines, Reno, NV, 1976.

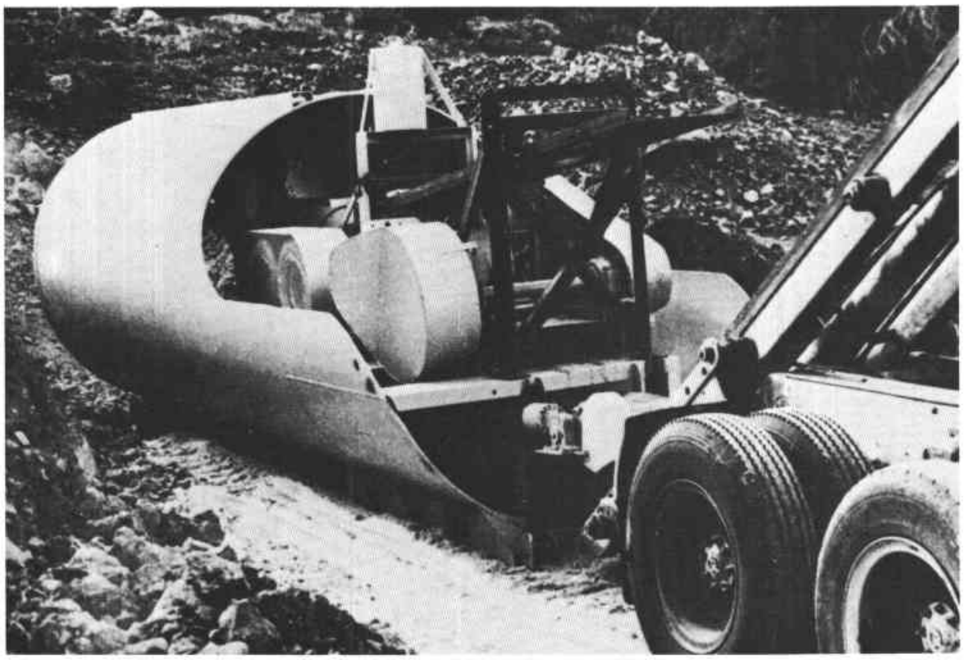

FIGURE 5—TRUCK BACKED UP TO UNIT AND WINCH CABLE ATTACHED TO HOUSING. Courtesy Challenge Mining Company.

after approximately one hour. The Ag_2S slurry is removed in a filter press; the gold in the filtrate is removed by electrowinning on steel wool cathodes. The barren cyanide solution is recyled to the cyanide holding tank.

The advantages of the heap-leaching process that make the method so attractive to the small mine operator follow:

1) Plant costs are about 20 percent of conventional costs.
2) Operating costs are about 40 percent of conventional costs.
3) High recoveries can be obtained with low-grade ores.
4) Environmental damage is minimized.
5) Silver is selectively recovered prior to carbon adsorption, minimizing carbon requirements (the amount of carbon required to absorb Ag is $\approx$30 times that required for Au of equal value).
6) A batch of carbon can be stripped in 6-8 hours instead of $\approx$50 hours.
7) Carbon can be reused, thereby eliminating smelting to recover precious metals.

Unfortunately, not all ores are amenable to the heap-leaching process; only those ores that meet the following basic requirements can be first considered. Ores must be:

1) relatively free from carbonaceous materials that precipitate gold and silver
2) free from cyanide-consuming agents such as sulfides of copper, arsenic, and antimony
3) relatively free of acid-forming agents which consume lime
4) free from excessive fines which will prevent percolation of cyanide solutions through the heap.

Ores that satisfy these conditions may be treated by heap-leaching techniques, but only extensive testing can determine the economics.

In addition to the economics realized from the use of cyanide heap leaching, Challenge Mining Company has designed and fabricated portable equipment—another concept with potential benefit to the small mine operator.

Portable equipment at Challenge Mining Company

R. C. Manning originally conceived the idea of portable milling equipment when he was in the trucking business hauling grain in season and buying, selling, and hauling milling machinery during the off-season. He subsequently rebuilt a 1970 Mack truck and a 1974 Fruehauf trailer and equipped them with hydraulically operated beds fitted with rollers and a 35-ton winch. Steel containers, 8 × 24 ft were designed and built with underframes and rollers to match the truck and trailer beds. The containers are open at the top, have double doors at the rear (which operate similar to those of a semi trailer), and have optional steel bows that can be fitted to the top of the unit and covered with a heavy canvas tarpaulin. These containers are suitable for hauling many materials including grain, ore for small mining operations, and machinery. An empty container is left on location and the full container is hauled to a mill. In the case of a small mining operation, this service eliminates the need of a permanent ore storage facility. The operator is charged only the freight and a nominal rental fee for the container.

While buying and selling machinery and disassembling mills, Manning recognized that once an operation folded, the mill, being too costly to tear down and move, became essentially worthless scrap

FIGURE 6—UNIT IS DRAWN UP ON BED JUST BEYOND CENTER OF GRAVITY. Courtesy Challenge Mining Company.

FIGURE 7—BED IS LOWERED, UNIT ROLLED FORWARD AND LOCKED INTO PLACE. Courtesy Challenge Mining Company.

iron. On the other hand, if the machinery was portable, it would retain some value. He then designed ways to mount various pieces of milling machinery in the containers he had used in his grain-and ore-hauling operations. A set of flotation cells, for example, could be mounted in one container; and a ball mill in another. Larger pieces of equipment could be designed to roll directly onto the bed of the truck or trailer. Putting a mill together with equipment of this sort is just a matter of mechanical ingenuity. These ideas and designs have been refined to the point where all the equipment in use at the Eberle venture today, with the exception of the leach pads and holding tanks, is portable. The equipment includes rolls and classifer, crusher, ore bin, bucket elevator, and power plants. The carbon-desorption and electrowinning plant is built into a semi trailer.

The largest single piece of machinery is the rolls and classifier unit, weighing approximately 40,000 lbs. The Mack truck handles this load with relative ease. First, the truck is backed up to the unit (fig. 5). The rollers on the truck bed and the classifier housing allow the heavy unit to roll easily onto the bed. A winch cable is connected to the classifier housing, and the unit is drawn up on the raised bed to a point just beyond the unit's center of gravity (fig. 6). The bed is then lowered and the unit rolled forward into traveling position and locked into place (fig. 7). Unloading is the reverse of this procedure. The truck or trailer can be loaded in this manner in less than two minutes.

The use of portable equipment has many advantages:

1) Concrete foundations are not needed.
2) Mill setup and disassembly time is held to a minimum.
3) Permanent structures are not abandoned when operations cease.
4) When a property ceases to be economical, the machinery is loaded up and moved to another location—the operator is no longer out of business when the ore is depleted.

Challenge Mining Company is conducting mining and milling operations on lands within the Gila National Forest. The U.S. Forest Service has approved the company's plans mainly because the portable equipment has little impact upon the environment.

Economics

Discussing profitability of a company not yet in production is premature. Many things can go wrong. The ore, however, has been tested by the U.S. Bureau of Mines and repeatedly tested by Challenge Mining Company. Test results have yielded reagent, fuel, and electricity costs from which per-ton costs have been calculated.

Easily mined surface ore on the south end of the Eberle vein and a small quantity of high grade ore underground amounts to approximately 28,000 tons averaging .08 oz gold per ton and 4.5 oz silver per ton. Confidence dump ore amounts to approximately 30,000 tons assaying .045 oz gold per ton and 2.5 oz silver per ton. Other smaller dumps under lease contain a few thousand tons of similar grade material.

The company's two-year plan calls for processing 34,000 tons of vein and dump material per year. Gold recovery is 82.5 percent; silver 69 percent. Profits and costs are outlined below:

ANNUAL PRODUCTION: 34,000 TONS

Eberle ore	14,000 tons per yr.	
Gold per ton	.08 oz	
Total gold	1120 oz	
Production at 82.5% recovery		924 oz
Silver per ton	4.5 oz	
Total silver	63,000 oz	
Production at 69% recovery		43,472 oz
Dump ore	20,000 tons per year	
Gold per ton	.045 oz	
Total gold	900 oz	
Production at 82.5% recovery		743 oz
Silver per ton	2.5 oz	
Total silver	50,000 oz	
Production at 69% recovery		34,500 oz
Total annual production gold:		1,667 oz
silver:		77,972 oz

The economics of the Eberle group venture were originally based upon $150-per-oz gold and $4.50-per-oz silver. These prices will be used here for the purpose of cost/profit projection, for as the price of precious metals increases, operating costs will increase accordingly.

OPERATING COSTS

		Dollars Per Ton
Mining:	Supervision, insurance, labor, fuel, explosives, maintenance, expendables	2.225
Milling:	Supervision	.705
	Labor (mill operation, ore hauling)	.95
	Power (fuel, electricity)	.70
	Reagents (lime, cyanide, sodium hydroxide)	.75
	Water	.10
	Maintenance	.44
	Royalties (leases)	.97
	Ore handling (transportation, loading)	.40
	Carbon adsorption (carbon, lime, sodium sulphide)	.24
	Gold recovery (alcohol, sodium sulphide, steel wool)	.24
	Support facilities (assays)	.12
	Fixed payments on machinery	2.57
	Total	$10.41

PROFIT

Total gold value, 1,667 oz at $150 per oz	$250,050.00
Total silver value, 77,972 oz at $4.50 per oz	350,874.00
Gross value	$600,924.00
Operating costs, 34,000 tons at $10.41 per ton	$353,940.00
Annual profit	$246,984.00

Challenge Mining Company is a partnership owned by three persons. Two are operating partners who entered the venture with approximately $300,000 worth of machinery, supplies, and cash. The third member is a financial partner who matched the operating partners' investment by putting up $300,000 for expenses incurred during construction and start-up. The total investment therefore is $600,000.00. A projected annual profit of $247,000.00 should amortize the investment in less than three years.

Future of Challenge Mining Company

Phase one of Challenge Mining Company's plan of operations provides for processing 34,000 tons of surface vein and dump material per year. Surface material will be depleted in two years. The operation, if it is to survive beyond that point, will have to begin full-scale underground mining. The future for processing underground ores is bright. Production at the time of shutdown in 1942 was mined from a winze sunk from the third level of the mine. Records of ore shipped to the Fanny Mill at this time (138 tons) show 0.17 oz gold per ton and 7.28 oz silver per ton (Weatherby, 1949). The ore left untouched, however, averages 4 oz silver per ton and .08 oz gold per ton. Material of this grade was uneconomical to mine and process by conventional methods and, therefore, was left. Today, a minimum of 300,000 tons of this low-grade material is available for mining.

Summary

Production from the Cooney mining district has been minimal for more than 30 years. Known ore bodies in the area are of insufficient grade and tonnage to attract the interest of a large mining company. Challenge Mining Company, a small operator, is taking advantage of new, low-cost technology and a few novel ideas of its own to treat these low-grade ores.

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