CYANIDATION OF GOLD-SILVER ORE FROM MANHATTAN, NEV.

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INTRODUCTION

A representative sample of gold-silver ore from the Keystone mine, Manhattan, Nye County, Nev., was submitted for these tests. The ore was an altered diorite rock with very small amounts of sulfide minerals of copper, lead, zinc, antimony, and arsenic disseminated in fine grains throughout. As indicated by test results, much of the silver content of the ore apparently was associated with these sulfide minerals. The gold probably occurred with iron oxides in the ore. Assays showed 0.16 ounce of gold and 2.8 ounces of silver per ton of ore.

This investigation was made to study application of activated carbon in the cyanidation treatment of the ore. The treatment proposed for use at the mill is as follows: The ore is crushed to minus-10-mesh size and separated into plus- and minus- 65-mesh portions. The minus-10, plus 65-mesh sands are cyanided by leaching and the minus- 65-mesh slimes by agitating. After 48 hours of agitation the slime pulp is thickened to about 1:1 water:solid ratio, and part of the pregnant solution is recovered. The pulp is then diluted to a 2:1 ratio, and the remaining dissolved values are extracted with the activated carbon. The barren pulp then can be discarded. This procedure eliminates the necessity for further washing the slime pulp and also recovers most of the excess sodium cyanide required for extracting the optimum amount of silver from this portion of the ore.

ACKNOWLEDGMENTS

The work described in this report was done under the general supervision of J. B. Zadra, chief of the Hydrometallurgical and Ore-Dressing Branch, Metallurgical Division, Region III, Reno, Nev.

The information concerning the proposed treatment of the ore was received from Pierce C. Walker, superintendent of the Bradshaw mill, Manhattan, Nev.

CRUSHING AND SCREENING

The sample was crushed in the laboratory rolls to pass a 10-mesh screen and the minus-65-mesh portion was separated by further screening.

Assays showed the plus-65-mesh portion contained 0.09 ounce of gold and 2.46 ounces of silver per ton, which represented about 50 percent of the gold and 70 percent of the total silver in 81 percent of the original weight of ore. This was the portion to be cyanided by percolation leaching.

The minus-65-mesh portion amounted to about 19 percent of the original weight and contained 0.4 ounce of gold and 4.0 ounces of silver per ton, representing about 50 percent of the gold and 30 percent of the silver in the

entire ore. This portion was to be cyanided by agitation and given additional treatment with activated carbon to recover part of the dissolved values.

PRELIMINARY STANDARD CYANIDATION TESTS

Standard cyanidation tests were made on both the plus- and minus-65-mesh portions of the sample. In each test 200 grams of ore, with 600 ml. of H_2O, 0.9 gram of NaCN, and 0.6 gram of CaO were agitated in a 2-liter bottle on the laboratory rolling machine. The reagents used corresponded to 9.0 pounds of NaCN and 6.0 pounds of CaO per ton of ore or 3.0 pounds of NaCN and 2.0 pounds of CaO per ton of solution. This standard laboratory cyanidation test has been found to indicate very closely the extractions that may be expected, whether leaching by percolation or straight agitation of slimes is proposed for a given ore.

After 24 hours treatment 89 percent of the gold and 49 percent of the silver were extracted from the plus-65-mesh portion of the ore. Consumption of cyanide was 0.9 pound per ton of feed, and lime consumption was 5.8 pounds. The cyanidation residue assayed 0.015 ounce of gold and 1.40 ounces of silver per ton.

A parallel test on the minus-65-mesh portion showed about 94 percent extraction of gold and 59 percent extraction of silver in 24 hours. Reagent consumption was 2.3 pounds of cyanide and 4.5 pounds of lime per ton of feed. The cyanidation residue assayed 0.02 ounce of gold and 1.86 ounces of silver per ton.

Calculated over-all extractions were 91.8 percent of the gold in the whole ore and 51.8 percent of the silver. Combined reagent consumption was 1.1 pounds of cyanide and 5.9 pounds of lime per ton of ore. Combined residue assays were calculated at 0.016 ounce of gold and 1.49 ounces of silver per ton. Further tests for longer periods of treatment showed no appreciable increases in extractions of gold and silver but resulted in higher consumptions of both cyanide and lime.

In treatment of most ores containing silver, it is necessary to use an excess amount of cyanide during leaching and agitation to extract the silver satisfactorily. On the other hand, gold can be extracted satisfactorily by using only the amount of cyanide actually consumed during treatment.

A further test was made on the minus-65-mesh portion of the ore. Using only the amounts of cyanide and lime shown to have been consumed in the standard test, which was 2.5 pounds of NaCN and 4.5 pounds of CaO per ton of solids. This provided only a very slight excess of cyanide. The pulp was agitated for 24 hours as before. Gold extraction was about the same, 95.5 percent, but silver extraction dropped to 27.8 percent. The residue assayed 0.02 ounce gold and 3.15 ounces of silver per ton.

ACTIVATED CARBON TESTS

In other investigations where activated carbon was used in simultaneous leaching and extraction of dissolved values, the use of excess cyanide and lime adversely affected extractions. When the use of excess cyanide to extract silver was necessary, better results were achieved by applying the activated carbon to the pregnant pulp after cyanidation was completed than by conducting simultaneous leaching and extracting operations during cyanidation.

In the present investigation it was proposed to apply the activated carbon to the pregnant pulp after most of the pregnant solution had been removed and the remaining portion had been diluted. This converted the use of the carbon to a clean-up function and eliminated the use of equipment for filtering and washing the pulp. It also permitted recovery and re-use of most of the excess cyanide and lime present in the pregnant solution that was removed.

A charge of the minus-65-mesh portion of the ore was agitated for 24 hours and allowed to settle briefly; about half of the clear pregnant soultion was then decanted. The same amount of water was replaced, enough lime and cyanide were added to maintain a slight excess of each, and agitation was continued for another 24-hour period. The pulp was settled again, and enough pregnant solution decanted to reduce the water:solids ratio to 1:1. The pulp was then diluted with plain water to 2:1 water:solids ratio. A charge of activated fruit-pit carbon was added, and the pulp was agitated for 24 hours more. The carbon was then removed, and the several test products were assayed.

In the first 24 hours agitation, 93.3 percent of the gold and 17.3 percent of the silver were dissolved. In the second 24 hours agitation, only 0.7 percent of the gold and 5.7 percent of the silver were dissolved. In the third 24-hour treatment, 0.3 percent of the gold and 7.6 percent of the silver were dissolved. The total gold dissolved from this minus-65-mesh portion was 94.3 percent, and the total silver dissolved was 30.6 percent.

The same results, expressed in another manner, show that 46.2 percent of the gold and 8.5 percent of the silver were removed in the first pregnant solution, and 32.0 percent of the gold and 9.6 percent of the silver were removed in the second pregnant solution. The activated carbon extracted 16.0 percent of the gold and 11.7 percent of the silver, 0.3 percent of the gold and 0.7 percent of the silver remained in the barren solution after treatment with the carbon, and 1.9 percent of the gold and 69.5 percent of silver remained in the tailings, which assayed 0.016 ounce per ton of gold, and 2.20 ounces per ton of silver.

The calculated over-all extractions from both plus- and minus-65-mesh portions of the ore were 91.7 percent of the gold and 43.7 percent of the silver. Data of the activated carbon test are also shown in the following tables:

Cyanidation of minus-65-mesh ore including use of activated carbon

Extraction, percent		Time of agitation, hours
Gold	Silver	
93.3	17.3	24
.7	5.7	48
.3	7.6	72
94.3	30.6	

Product	Distribution, percent	
	Gold	Silver
First pregnant solution	46.2	8.5
Second pregnant solution	32.0	9.6
Loaded carbon	16.0	11.7
Total values recovered	94.2	29.8
Barren solution	.3	.7
Tailings	5.5	69.5
	100.0	100.0

The preceding test was made as follows: A charge of 200 grams of the minus-65-mesh portion of the ore was pulped with 600 ml. of H_2O containing 0.25 gram of sodium cyanide, corresponding to 2.5 pounds per ton of ore, and 0.45 gram of lime, or 4.5 pounds per ton of ore. The pulp was rolled in a 2-liter bottle on the laboratory rolling machine for 24 hours and 295 ml. of pregnant solution was removed. Titrations for lime and cyanide showed that 2.0 pounds of NaCN and 4.0 pounds of CaO had been consumed.

The pulp was brought back to the original volume by adding 295 ml. of H_2O and 0.05 gram each of NaCN and CaO were added to retain a slight excess of each in the pulp. It was then rolled for another 24-hour period. At this point, 400 ml. of pregnant solution was removed. Titrations for lime and cyanide showed that 0.25 pound of NaCN and 0.6 pound of CaO had been consumed.

The pulp was then diluted with 200 ml. H_2O, and a charge of 2.0 grams of activated carbon was added. This carbon, which was manufactured from fruit pits and crushed and sized between 10- and 24-mesh screens, is usually referred as 10X24 carbon. No more lime or cyanide was added to the pulp, but it was again rolled for 24 hours.

The carbon was then removed by screening and was washed, dried, and assayed. The barren solution was titrated for lime and cyanide and showed traces of each. The total consumption of reagents was 2.25 pounds of NaCN and 2.6 pounds of CaO per ton of ore.

Calculated consumption of reagents for both plus- and minus-65-mesh portions of the ore was 1.2 pounds of NaCN and 4.0 pounds of CaO per ton of ore.

GRAVITY CONCENTRATION OF MINUS-65-MESH CYANIDATION TAILINGS

The tailings from the cyanidation of the minus-65-mesh portion of the ore were panned, and small amounts of heavy minerals were recovered. These were examined with the binocular microscope, and some sulfide minerals were seen, including some comparatively coarse grains of jamesonite. Analyses of the pan concentrates showed:

Gold	oz. per ton	0.268
Silver	do.	16.30
Arsenic	percent	1.18
Zinc	do.	.9
Lead	do.	.7
Antimony	do.	.33
Copper	do.	.25

These concentrates represented 1.9 percent of the gold and 13.1 percent of the silver in the minus-65-mesh portion of the ore. This corresponds to 1.0 percent of the total gold and 3.6 percent of the total silver in the whole ore.

Apparently, additional small amounts of gold and silver could be recovered by passing the minus-65-mesh cyanidation tailings over shaking tables. The same results might be achieved by use of a gold-type jig in the grinding circuit before the ore was separated into plus- and minus-65-mesh portions.

SIMULTANEOUS LEACHING AND EXTRACTION OF GOLD AND SILVER FROM MINUS-65-MESH ORE WITH ACTIVATED CARBON

A comparison test was made in which carbon was used during a 24-hour treatment period. The carbon extracted the dissolved values during simultaneous leaching and extraction. The procedure was as follows: A charge of 200 grams of the minus-65-mesh portion of the ore was pulped with 600 ml. H_2O, and 0.25 gram of NaCN, 0.45 gram of CaO, and 2.0 grams of activated 10X24 carbon were added. The pulp was rolled for 24 hours. The carbon then was removed and all products assayed.

The carbon this time extracted 91.5 percent of the gold and 27.5 percent of the silver contained in the ore. The barren solution, however, carried 2.1 percent of the gold and 6.6 percent of the silver, which had been dissolved from the ore but not absorbed by the carbon. The tailings retained 6.4 percent of the original gold and 65.9 percent of the silver.

Cyanide consumption during this test was 2.1 pounds per ton of ore and lime consumption was 4.1 pounds.

The calculated over-all extractions on the whole ore were 90.3 percent of the gold and 43.1 percent of the silver. These figures do not include the values remaining in the barren solution after the carbon treatment of the minus-65-mesh portion of the ore.

The results of this test indicate lower extractions of gold and silver than the results of the method proposed for the plant, which was previously described. However, certain advantages should be considered that may offset the lower recoveries, particularly when construction or alteration of a treatment plant is being considered.

These advantages are (1) that only 24 hours agitation is necessary, and, consequently, the number of agitation tanks can be reduced to half, for any given tonnage being treated; and (2) there is no necessity for thickening and subsequent dilution of the pulp, as in the other treatment, and, thus, equipment for this purpose is not needed.

SUMMARY

Tests were made to investigate a proposed treatment method for gold and silver ore from the Keystone mine, Manhattan, Nye County, Nev. The ore was crushed to minus-10-mesh and separated into plus- and minus-65-mesh portions. The plus-65-mesh portion is cyanided by leaching. Laboratory tests indicated that 89 percent of the gold and 49 percent of the silver could be extracted from this portion in 24 hours with a consumption of 0.9 pound of cyanide and 3.8 pounds of lime per ton of ore.

The minus-65-mesh portion was cyanided by agitation for 48 hours, in a standard manner, given what amounted to a wash by decanting the pregnant solution to reduce the water:solid ratio from 3:1 to 1:1, diluted to 2:1, and agitated for 24 hours with activated carbon. The carbon extracted virtually all the remaining dissolved values from the pulp. This combination treatment resulted in 94.2 percent extraction of gold and 29.8 percent extraction of silver from this portion of the ore. Cyanide consumption was 2.25 pounds per ton of ore, and lime consumption was 2.6 pounds.

Calculated over-all extractions were 91.7 percent of the gold and 43.7 percent of the silver in the entire ore. Calculated consumption of reagent for treatment of the entire ore was 1.2 pounds of cyanide and 4.0 pounds of lime.

These data compare favorably with the results of standard cyanidation tests on the ore, which indicated 91.8 percent extraction of the gold and 51.8 percent extraction of the silver in the entire ore and reagent consumption of 1.1 pounds of cyanide and 3.9 pounds of lime. The elimination of equipment for filtering and washing the slime pulp would more than offset the difference in silver extraction. The other differences were negligible.

The use of activated carbon in simultaneous leaching and extraction of dissolved values from the minus-65-mesh portion of the ore was also tested for comparison purpose. Calculated extractions from the entire ore were 90.3 percent of the gold and 43.1 percent of the silver. Reagent consumption was about the same as in the other tests. These extractions of gold and silver were lower than when carbon was used for clean-up purposes only, but the use of still less equipment and the shorter time required for such treatment might prove advantageous when new plant design or alterations were being considered.

Laboratory tests indicated the possibility of small increases in recoveries when some sulfide minerals were concentrated by gravity from the minus-65-mesh tailings.

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