UTILIZATION OF BALD MOUNTAIN MINE TAILINGS TROJAN, SOUTH DAKOTA

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ABSTRACT

The Engineering and Mining Experiment Station conducted a utilization study of the Bald Mountain Mine tailings between June 1967 and March 1968 to evaluate the additional values contained in the mine waste and to investigate recovery methods.

Thirty-one composite drill-hole samples were recovered and analyzed. Analytical results indicated potentially economic values of gold and silver. Silver values were determined by fire assay, and gold values were determined by atomic absorption and fire assay methods. Both gold and silver concentrations were mapped for the upper and lower tailings ponds.

The upper tailings pond, containing an estimated 1,137,400 tons, was found to average 0.0275 oz gold per ton by atomic absorption methods and 0.0289 oz gold per ton by fire assay methods. The silver content was found to average 0.494 oz per ton by fire assay methods.

The lower tailings pond, containing an estimated 1,969,700 tons, was found to average 0.0153 oz gold per ton by atomic absorption methods and 0.0183 oz gold per ton by fire assay methods. The silver content was found to average 0.576 oz per ton by fire assay methods.

Associative elements were identified by X-ray and emission spectroscopy. Elemental concentrations other than gold and silver were found to be uneconomical.

Extractive methods for the recovery of gold and silver appear to be confined to chemical leaching. The feasibility of this method will depend upon the efficiency of recovery versus the installation and operating costs.

INTRODUCTION

The Engineering and Mining Experiment Station of the South Dakota School of Mines and Technology has completed its research on the utilization of mine dump tailings at the Bald Mountain gold mine at Trojan, South Dakota. This investigation was conducted as part of a research program sponsored by a U. S. Bureau of Mines grant under the provisions of the Solid Waste Disposal Act of 1965. This program, entitled "Utilization of Mine Dumps in the Black Hills," began in September of 1966 and is currently being conducted on other Black Hills mine dumps.

Research of the Bald Mountain tailings was designed to investigate the feasibility of economic utilization of the waste material by extensive sampling, thorough analyses, and a consideration of possible recovery methods.

Tailings from the Bald Mountain mine are contained in two main dams situated immediately northeast of the mill. The upper pond is located in the NE¼ of Section 35 and portions of the lower tailings pond are located in Sections 25, 26, 35, and 36 of T5N, R2E of the Black Hills Meridian. The ponds occupy a valley at the headwaters of False Bottom Creek in mountainous terrain at an elevation of approximately 6,000 feet.

Climatic conditions are seasonal with warm summers and cold winters with temperatures often below zero. Annual precipitation of 23.81 inches has been recorded at Lead about three miles to the east.

Access to the tailings ponds may be had by traveling one mile southwest on highway 85 from Lead, then 2½ miles west on the chair lift road to a junction near the top of the hill, then ¾ mile north on the right fork of the road.

This research project was co-ordinated by Director J. H. Cope, principal investigator, and W. L. Roberts, associate investigator. Research assistance was provided by D. A. Fredlund and student assistance was provided by Olav Hatlegjerde, Joseph Kovarik, and John Steichen. The field drilling and sample recovery program was contracted to Earth Science Consulting of Rapid City.

The Experiment Station gratefully acknowledges the right of free access and sample removal granted by War Bonnet, Inc., present controller of the mining property.

HISTORY

Early day history of the individual properties located in the Bald Mountain Mining District is very fragmentary; however, records show that many of the claims were located and worked as early as 1877. The Bald Mountain Mining Company, which went into production in 1922, was formed in 1928 as a reorganization of the old Trojan Mining Company which operated in the district from 1911 to 1923. The Portland Mining Company was formed in 1880 and operated continuously until 1911 when it was absorbed, together with several other companies, to form the Trojan Mining Company.

The Bald Mountain Mining Company owns approximately 2,250 acres of mining claims in the district which include the following mines: Portland, Trojan, Decorah, Clinton, Folger, Two Johns, Juno, Gunnison and Vulcan, Snowstorm, Dividend, Crown Hill, Empire State, Mark Twain, Monday Group, Perseverance, Burlington and Golden Sands, Alameda, Ben Hur, Baltimore and Chance, Baltimore and Richmond, Segregated Burlington, Northerly, Apex, and American Eagle. The Bald Mountain mining property is presently under option to War Bonnet, Inc., of Pierre, South Dakota.

The American Eagle mill, constructed in 1908, forms the nucleus of the present 325 t.p.d. Bald Mountain cyanide mill. The Bald Mountain Mining Company operated the mill continuously from 1933 until operations were shut down on July 25, 1959, due to increased labor costs and fixed price for gold, except for a War Production Board shut down between June 8, 1943, and July 1, 1945.

MINERAL DEPOSITS AND PRODUCTION

Allsman (1) estimated the total production, through 1937, from holdings of the Bald Mountain Mining Company at about $12,000,000 in gold and silver. Production averaged about $1,000,000 annually before the wartime shut-down in 1943 and somewhat less subsequent to reopening in 1945 to final shut-down in 1959.

All ore milled has been mined from two horizons within the flat-lying Deadwood formation, with mineralization controlled by vertical fractures. The ore is usually a replacement spreading out into dolomitic members of the formation.

Minerals identified from the Bald Mountain deposits are: altaite, arsenopyrite, atacamite, autunite, azurite, barite, calcite, cerargyrite, chrysocolla, dolomite, emmonsite, fluorite, galena, glauconite, gold, gypsum, jarosite, kaolin, limonite, malachite, microcline, orthoclase, pyrite, pyrolusite, pyromorphite, quartz, rhodochrosite, silver, sphalerite, stibnite, sylvanite, uraninite, and wulfenite.

METHODS

A preliminary study was made to determine the most advantageous sampling and analytical methods necessary to insure accurate results.

The sampling procedures—consisting of a site survey, tailings mapping, locating proposed drillholes, drilling, and sample recovery techniques—were established. Analytical methods by x-ray and emission spectroscopy, atomic absorption, fire assay, and wet chemical analyses were established.

Brunton compass and tape methods were used to establish the configuration of the tailings ponds. The drill-hole pattern was layed out in 200-feet center equilateral triangles wherever possible and located by transit and tape methods. Twelve drill-holes were located on the upper tailings pond and nineteen drill-holes were located on the lower pond.

A mobile three-inch diameter auger drilling rig was used in the program. The maximum depth drilled was 50 feet except where the tailings thickness was less. The cuttings augered up by the drill stem were quartered, and a composite 20-pound sample was collected from each hole. Each sample was placed in a canvas bag and labeled with the drill hole number. The samples were then taken to the Experiment Station for analyses.

The samples were prepared for analyses by room drying, splitting, and sizing to minus 200 mesh. The laboratory samples were stored in pint-sized ice cream cartons until analyzed.

Preliminary x-ray spectrographic analyses were made of each sample to determine qualitative constituents. Emission spectrographic analyses were also run on a few of the samples to determine relative amounts of some elements.

Silver analyses were made by fire assay, and gold analyses were made by fire assay and atomic absorption methods.

The tailings volume and weight were estimated and compared to production records. Estimates of contained values were then calculated, and recovery methods of extracting potentially economic products were considered.

DISCUSSION

Preliminary qualitative x-ray spectrographic analyses were made and provided essentially identical results for all 31 samples. Iron, calcium, arsenic, lead, strontium, barium, rubidium, and zinc were identified by this method. Semi-quantitative emission spectrographic analyses were then conducted to determine relative concentrations of the elements present.

The results of emission spectroscopy were identical for all samples and are listed in Table I.

TABLE I

Semi-Quantitative Elemental Concentration Results Obtained by Emission Spectroscopy

Element	Per Cent
Silicon	more than 10
Iron	approximately 5
Magnesium	approximately 5
Aluminum	approximately 1-5
Calcium	approximately 1-5
Manganese	approximately 0.5
Arsenic	approximately 0.1
Lead	approximately 0.1
Titanium	approximately 0.1
Zinc	approximately 0.1
Nickel	approximately 0.05
Copper	approximately 0.01
Sodium	approximately 0.01
Silver	approximately 0.001
Antimony	trace
Germanium	trace
Beryllium	trace

Analytical results indicating potentially economic values of gold and silver were obtained by fire assay of the 31 drill-hole samples. The silver content was sufficiently high to be within the accuracy limits of the fire assay method to provide reliable results. The gold content, however, was low; and fire assay determinations are greatly affected by weighing errors for low-grade ores. Shepard and Dietrich (12) state, "For example, a weighing error of 0.003 mg represents an error of five per cent in a one-assay-ton of a low-grade ore containing 0.006 oz per ton." Subsequent gold assays made by atomic absorption methods provide more accurate results.

The assay results obtained for the 31 samples are shown in Table II.

Concentration maps showing the gold content (from atomic absorption assays) and silver content (from fire assays) for both upper and lower tailings ponds are included as Figures 1 and 2.

The gold concentration is very probably a function of gravity separation. The area of highest gold content is located in the vicinity of drill-hole no. 5 which is immediately north of the mill tailing discharge. The gold concentration diminishes away from the discharge. The gold concentration in the lower pond decreases to the north and away from the point where the tailings were introduced.

The silver concentration appears to be a function of natural leaching by meteoric and mill discharge waters. The silver content is less in the vicinity of the mill tailing discharge and increases somewhat to the sides away from the major course of flow. An increased silver concentration near the tail-end of the lower pond may be due to precipitation from solutions derived from the upper pond tailings.

The silver content of the lower tailings pond is lowest in the vicinity of drill-holes no. 15, 16, and 17 where increased leaching may have been active. The silver content is also lower in the vicinity of drill-holes 27 and 28 where water has been observed on the tailings pond during periods of sustained rainfall.

Volume estimates of the tailings contained in both tailings ponds were computed from drill-hole depth and surface measurements. Density measurements of dried tailing samples were applied to volume estimates and used to determine the contained tonnage. Total tonnage estimates obtained by this method compare favorably with existing production records.

The upper tailings pond is estimated to contain 1,137,400 tons and the lower tailings pond is estimated to contain 1,969,700 tons.

TABLE II
Assay Results

Drill-Hole Number	Depth Drilled	Fire Assay Ag oz/ton	Fire Assay Au oz/ton	Atomic Absorption Au/oz ton
1	38′	0.52	0.00	0.010
2	45′	0.62	0.02	0.007
3	50′	0.54	0.02	0.010
4	46′	0.50	0.02	0.007
5	50′	0.48	0.06	0.067
6	35′	0.56	0.04	0.031
7	40′	0.54	0.02	0.018
8	50′	0.42	0.04	0.043
9	50′	0.44	0.02	0.018
10	50′	0.50	0.02	0.029
11	49′	0.58	0.02	0.012
12	50′	0.58	0.02	0.018
13	39′	0.92	0.02	0.015
14	50′	0.54	0.02	0.018
15	50′	0.40	0.02	0.015
16	50′	0.40	0.04	0.015
17	50′	0.36	0.02	0.015
18	49′	0.74	0.02	0.018
19	50′	0.74	0.02	0.015
20	50′	0.58	0.00	0.015
21	50′	0.58	0.02	0.018
22	50′	0.60	0.02	0.018
23	50′	0.60	0.02	0.015
24	50′	0.54	0.02	0.012
25	50′	0.62	0.02	0.012
26	31′	0.62	0.02	0.012
27	50′	0.54	0.00	0.010
28	50′	0.56	0.00	0.012
29	36′	0.70	0.02	0.026
30	50′	0.62	0.02	0.021
31	50′	0.40	0.02	0.021

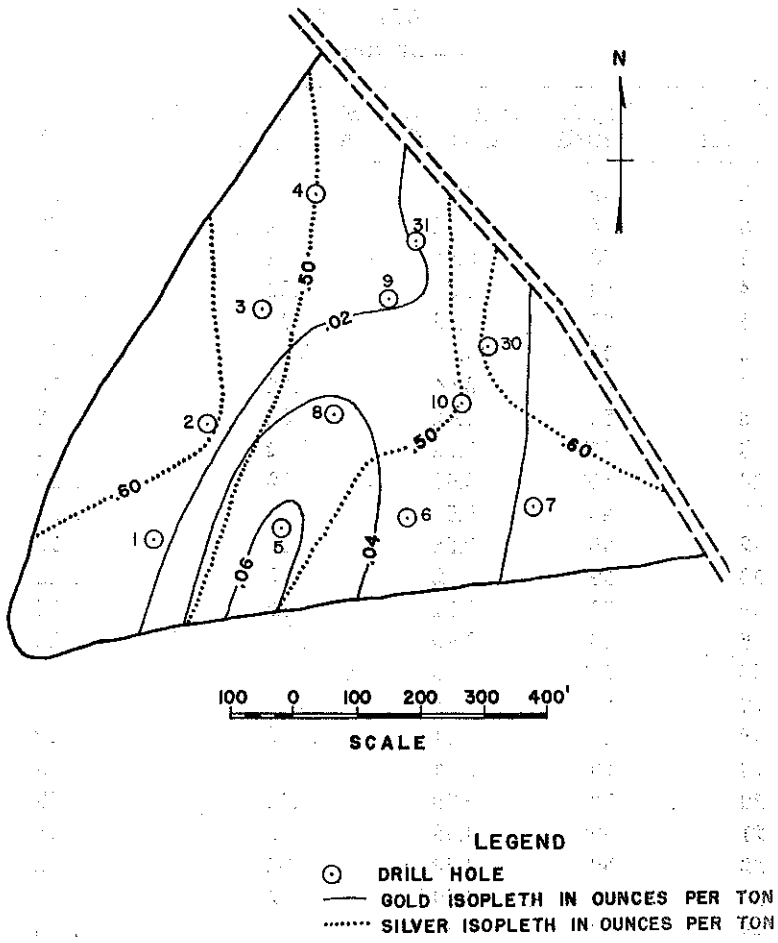

FIGURE 1. GOLD AND SILVER CONCENTRATION MAP OF THE UPPER TAILINGS POND AT THE BALD MOUNTAIN MINE.

Average gold and silver contents were calculated as a function of drill-hole depth and the volume of tailings contained within the triangular prisms defined by the drill-hole configuration. The accuracy of the average is proportional to the number of samples assayed. Shepard and Dietrich (12) state that "The reliability of the average of a number of samples increases as the square root of the number of samples included in the average."

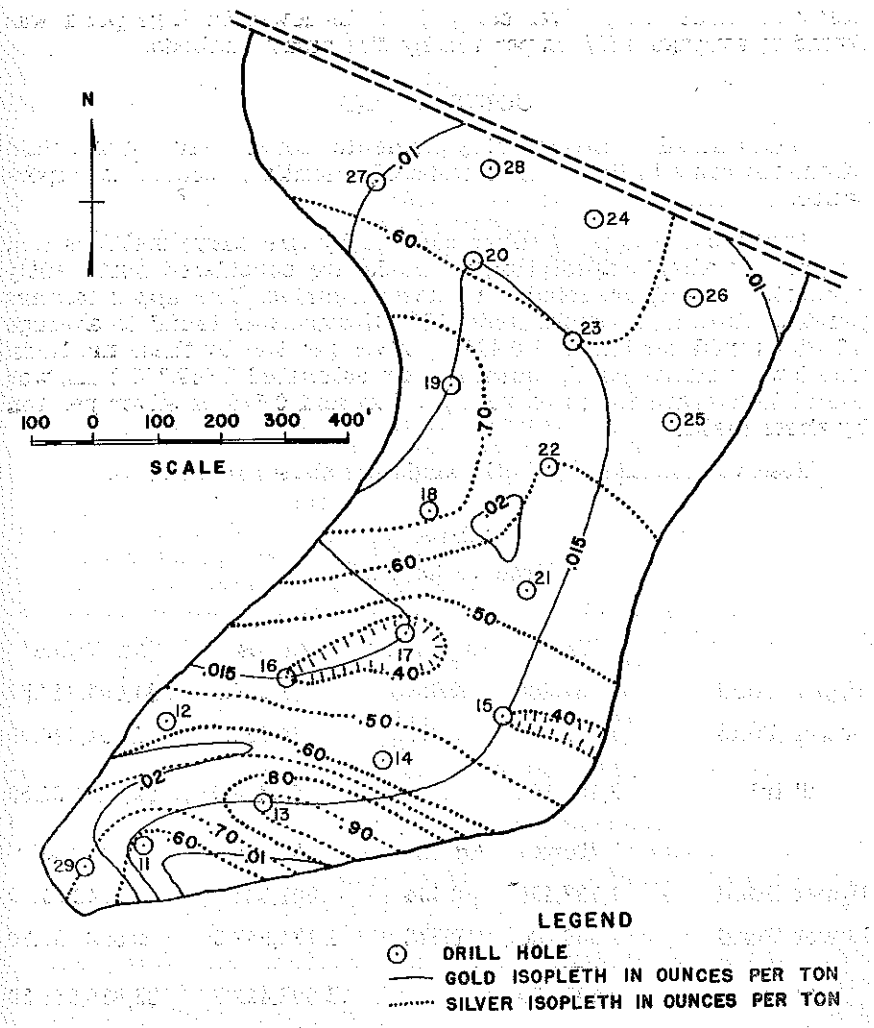

FIGURE 2. GOLD AND SILVER CONCENTRATION MAP OF THE LOWER TAILINGS POND AT THE BALD MOUNTAIN MINE.

The upper tailings pond was found to average 0.0275 oz gold per ton by atomic absorption methods and 0.0289 oz gold per ton by fire assay methods. The silver content of the upper tailings pond was found to average 0.494 oz per ton by fire assay methods.

The lower tailings pond was found to average 0.0153 oz gold per ton by atomic absorption methods and 0.0183 oz per ton by fire

assay methods. The silver content of the lower tailings pond was found to average 0.576 oz per ton by fire assay methods.

CONCLUSIONS

Gold and silver are the only elemental constituents of the Bald Mountain mine tailings found to be of potentially economic importance.

Analytical results of silver content by fire assay methods and of gold by atomic absorption methods are considered sufficiently accurate to establish reliable reserve estimates. The upper tailings pond, containing an estimated 1,137,400 tons, was found to average 0.0275 oz gold per ton and 0.494 oz silver per ton by these methods. The lower tailings pond, containing an estimated 1,969,700 tons, was found to average 0.0153 oz gold per ton and 0.576 oz silver per ton by these methods.

Reserve estimates for both ponds are shown in Table 3.

TABLE III
Reserve Estimates

	Tons	Au oz/ton	Au oz	Au Value*
Upper Pond	1,137,400	0.0275	31,278.5	$1,094,747.50
Lower Pond	1,969,700	0.0153	30,136.4	1,054,774.00
Total	3,107,100	.....	61,414.9	$2,149,521.50
	Tons	Ag oz/ton	Ag oz	Ag Value**
Upper Pond	1,137,400	0.494	561,875.6	$1,264,220.10
Lower Pond	1,969,700	0.576	1,134,547.2	2,552,731.20
Total	3,107,100	.....	1,696,422.8	$3,816,951.30

*Gold @ $35.00/oz
**Silver @ $2.25/oz

Total contained gold and silver values $5,966,472.80

Gravity separation of gold near the mill tailings discharge is responsible for the higher concentration of gold in the upper tailings pond. The higher concentration of silver in the lower tailings pond may be due to more extensive leaching of the upper pond and redeposition in the lower pond, or to differences in ore being milled at the respective times of pond filling.

Mechanical removal and transportation of the tailings to an existing mill for treatment has been considered and, although cost and recovery information is inadequate, it is doubtful that this method would be practical.

Economic recovery of the low-grade gold and silver may be possible by in situ leaching. Extensive leaching and cost studies would be required to determine the feasibility. Depending upon installation and operating costs and the efficiency of recovery, cyanide, chloride, and/or nitrate leaching may be feasible.

It is possible that only one of the ponds may be susceptible to economic recovery due to the differences in precious metal content.

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