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Testing and Concentration of a Low Grade Gold Ore from Marysville, Montana

John B. White, Jr.

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TESTING AND CONCENTRATION OF A LOW GRADE GOLD ORE FROM
MARYSVILLE, MONTANA

By
John B. White, Jr.

A Thesis

Submitted to the Department of Mineral Dressing
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Metallurgical Engineering

MONTANA SCHOOL OF MINES

BUTTE, MONTANA

MAY, 1942

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TESTING AND CONCENTRATION OF A LOW GRADE GOLD TAILING FROM
MARYSVILLE, MONTANA

Introduction

The purpose of this investigation was to investigate and attempt to concentrate low grade cyanided tailings rejected from the old Montana Mining and Milling Company's mill situated 4 miles below the town of Marysville, Montana.

The majority of the tailings came from the old Drumlummon mills situated in the town of Marysville, Montana. These mills were straight amalgamating plants consisting of stamps and amalgamating plates. The mill feed as it came from the mine averaged in the neighborhood of \$23.00 gold and silver value per ton. Approximately \$15.00 per ton was recovered from these ores. The tailings were impounded in dams four miles below the mills.

In 1897, a few years after satisfactory methods of leaching gold and silver ores had been perfected, the Montana Mining and Milling Company decided to erect a 300-ton leaching plant. This plant was erected and put into operation in the spring of 1898. The majority of the mill tailings, 1,000,000 tons in all, were cyanided, and they were not reground prior to treatment. After leaching they were impounded in a huge dam. These are the sands that the writer of this report has investigated.

A fairly representative grab sample was taken from various faces and cuts situated around the dam. This was done due to the great expense of adequately sampling a tailings deposit of this size. The material had been

thoroughly sampled at previous dates, and the tailings collected by the writer are, he believes, fairly representative, because the assay value checks with the known values of the more exhaustive surveys.

Testing Procedure

Head Assay of Ore:

About 250 pounds of tailings were secured as mentioned above. The complete sample was transported to the Montana School of Mines mineral dressing laboratory where it was accurately coned and quartered and a representative sample taken for assay. The remaining sand was stored away for subsequent testing. Table I presents the gold and silver assays of the head sample.

Table I

Head Assay of Ore

Gold	0.035 oz. per ton
Silver	0.935 oz. per ton
Total value @ \$33.50 Au and 70¢ Ag..	\$1.82

Screen Analysis:

880 grams of minus 14-mesh material was taken for screen analysis. The test was run on the Tyler Automatic Ro-tap apparatus. The tailings are quite free from wood, trash, and small stream gravel. 0.5 per cent of the material is plus 14-mesh. It is believed that inside the dam proper this figure would be lower. Tables II and III show the tabulated results of this test together with the assay values of the various sizes.

Table II

Screen Analysis of Ore

Mesh screen size	Weight gms.,	Weight per cent	Cumulative, Wt., per cent.	Gold oz. per ton	Silver oz. per ton
- 14 + 20	1.8	.20	.20	} Combined 0.075	} Combined 1.59
- 20 + 28	7.6	.86	1.06		
- 28 + 35	10.6	1.20	2.26		
- 35 + 48	52.3	5.95	8.21		
- 48 + 65	88.8	10.01	18.22	0.105	1.220
- 65 +100	85.8	9.75	27.97	0.030	0.930
-100 +150	66.6	7.57	35.54	0.025	0.685
-150 +200	65.9	7.49	43.03	0.005	0.570
- 200	500.4	56.97	100.00	0.005	0.850
Composite	880.0	100.00		0.025	0.922
Actual Assay, Head Sample - - - - -				0.028	0.900

Table III

Screen Analysis of Ore

Mesh screen size	Value per ton \$33.50 Au & 70¢ Ag	Wt. x Assay val.		Val./ton x Wt.	Val. %	Cum. Val. %
		Gold	Silver			
- 14 + 20	} \$3.63					
- 20 + 28		.006158	.130539	.2980	20.2	20.2
- 28 + 35						
- 35 + 48						
- 48 + 65	\$4.37	.010511	.122122	.4374	29.7	49.9
- 65 +100	\$1.66	.002925	.090675	.1619	11.0	60.9
-100 +150	\$1.32	.001893	.051855	.0999	6.8	67.7
-150 +200	\$.57	.000375	.042693	.0427	2.9	70.6
-200	\$.76	.002849	.484245	.4330	29.4	100.0
Composite Values		.024711	.922129	\$1.4729		
Actual Value, Head Sample				\$1.57		

It can readily be seen that there is a difference of \$0.25 per ton between the unscreened head sample and the minus 14-mesh material taken for screen analysis. This plainly shows that the fine wood intermixed with the sands has been impregnated with gold and silver values. A sample of this material was taken for assay, but unfortunately only the combined gold and silver was weighed. When the parted gold bead was ready for weighing it was accidentally lost. There was no further sample to be re-assayed, because of the small amount of minus 14-mesh material sands. The combined gold and silver weighed 6.310 ounces per ton.

Knowing that the plus 14-mesh material is 0.5 per cent of the total and that the assay difference is \$0.25 per ton, it was estimated that the plus 14-mesh material should assay fifty dollars per ton. Taking into account the average ratio of gold and silver in the other assays, this value more or less checks with the combined gold and silver bead that was obtained. This point, however, should be checked, and if found to be substantially correct the values could be easily recovered in any method found necessary to extract the values in the sands.

Test For Soluble Gold and Silver Salts:

In any cyanide leaching operation the pulp is subjected to treatment until all the recoverable gold and silver is in solution. The sands are then washed with water until the wash solutions show no value in gold and silver. In many of the first cyanide leaching plants the pulp was not thoroughly washed and some gold and silver in the form of cyanide salts

was left in the sands. The following test was applied to ascertain if this was the case for these particular tailings.

Approximately 100 grams of the sand was mixed with water. The pulp was thoroughly heated and agitated for about ten minutes, filtered and thoroughly washed with water. The sands residue was dried and a representative sample cut for assay. Table IV shows the assay results.

Table IV

Assay of Leached Sands

Gold	.025 oz. per ton
Silver	.89 oz. per ton
Value @ \$33.50 Au and 70¢ Ag	\$1.46

The head assay shows \$1.82 per ton. The difference would therefore be \$0.36 per ton, indicating that some, at least, of the gold and silver is in soluble form. However part of this value might be in the wood chips and a more careful analysis should be undertaken along this line. If thought advisable, this gold and silver could be recovered by precipitation with zinc dust.

Spectrographic and Microscopic Examination of Ore:

The tailings proved to be very siliceous. The silica content ranges between 60 and 70 per cent. A portion of the ore was carefully panned, and the results showed that the amount of sulphides present was very small, and representing not more than an estimated 0.3 per cent of the ore. This figure was verified by later flotation tests. Pyrite and chalcopryrite are the principle sulphide minerals. Spectrographic analysis of concentrates

secured from flotation testing showed an abundance of iron, some copper and silver, and less amounts of lead and zinc.

No visible gold or silver could be seen upon examining the concentrates under the microscope. It is difficult to say just how the gold and silver occur, but in part they are probably intimately associated with the sulphides, and in part finely disseminated in the free state in the quartz itself.

Preliminary Hydraulic Classification:

About 26 pounds of the representative sample were taken for analysis. A constriction-plate classifier was used. The tailings were placed in the classifier and sufficient water was admitted to remove minus 150-mesh material at the overflow discharge. After the overflow was clear and all of this particular size had been removed, the remaining sand was put in teeter. The sands that then overflowed the discharge were the medium-sized particles ranging between 65 and 150-mesh. The remaining portion was the coarse sands and ranged in size from 8-mesh to 65-mesh. Table V gives the tabulated results of this test together with the assays.

Table V

Hydraulic Classification Analysis

Product	Per cent weight	Assay		Value per ton @\$33.50 Au & 70% Ag	Val./ton x wt. %	% Val.	Cum.% value
		Gold	Silver				
Spigot 1 (coarse mat.)	20	.085	1.60	\$3.97	.794	47	47
Spigot 2 (medium mat.)	28	.030	.945	\$1.66	.465	27	74
Slimes (minus 150)	52	.01	.750	\$.87	.442	26	100
Composite					\$ 1.701	100	

Tables II, III, and V should be carefully scrutinized. Screen analysis has shown that the majority of the values are concentrated in the coarser sizes. This fact has been exemplified by hydraulic classification. As will be shown by flotation tests, some of the values that are combined with the slime material can be saved. Hydraulic classification or a de-sliming operation offers a very satisfactory method for grading up the value of the ore.

pH of the pulped Ore:

Usually in any cyanide operation the pH is maintained slightly on the alkaline side. The ore under investigation was no exception, the alkalinity of the pulp having been maintained by the addition of lime. In a leaching operation quite a large percentage of the lime is washed out during the percolation treatment, prior to discharging the sand from the tanks. This would tend to bring the pH back to nearly neutral.

The following procedure was employed to test the alkalinity of the pulped ore:

Ore diluted with distilled water to 25 per cent solids was heated and agitated for a few minutes. The pulp was filtered and the filtrate tested by use of the LaMotte Roulette comparator. The pH was found to be 7.3; or nearly neutral.

Preliminary Flotation Tests:

It is a known fact that lime is a specific depressant for pyrite, but the writer did not believe that a pH of 7.3 was too alkaline for the successful flotation of this sulphide. After each flotation test a portion of the tailings was very carefully vanned. In the most successful tests on

the unground flotation tailings there was no evidence of free sulphides. Numerous flotation tests were run on the unground ore, and many combinations of reagents were used, but none of the tests was very successful from the standpoint of a good recovery of all the economic minerals. Table VI gives the tabulated results of one of the most successful tests on the unground ore.

Table VI

Flotation Results on Unground Ore

Ore	Minus 8-mesh tailings
Grind	None
Water	Distilled
Per cent solids	23%
Head assay	{ Gold 0.025 oz. per ton
	{ Silver .. 0.890 oz. per ton
Tails assay	{ Gold 0.02 oz. per ton
	{ Silver .. 0.63 oz. per ton
Per cent recovery of combined values	25%
Reagents Used	
American Cyanamid reagent No. 30110 lb. per ton
" " " No. 20810 lb. " "
Pine oil10 lb. " "
Barrett No. 410 lb. " "
Remarks: Other tests showed that a preliminary grind of 1 or 2 minutes to brighten the sulphides did not improve the recovery.	

Preliminary Flotation Tests of Products From Hydraulic Classification:

No attempt was made to regrind and float the intermediate products (spigot 2), obtained from hydraulic classification. Spigot 1 or the coarse sands were reground and the results of the flotation test are tabulated in Tables VII and VIII.

Table VII

Minus 65-mesh Grind Float Results; Coarse Hydraulic Classification Sands

Ore	Coarse sands from hydraulic classification		
Grind:	Primary <u>None</u>	Final: <u>MillAbbe'</u>	Mesh <u>-65</u> Time <u>15-15-10</u> min.
Water: Grind <u>Distilled</u>	Flotation <u>Distilled</u>		
Per cent Solids <u>23</u>	Flotation machine used <u>Fagergren 600 gram cell</u>		
Head Assay	}	Gold	0.085 oz. per ton
		Silver	1.60 oz. per ton
Tails Assay	}	Gold	0.033 oz. per ton
		Silver	0.74 oz. per ton
Per cent recovery of combined values	59%		
Reagents Used			
American Cyanamid reagent No. 301	.10	lb.	per ton
" " " No. 208	.10	lb.	" "
Pine Oil	.10	lb.	" "
Barrett No. 4	.10	lb.	" "
Remarks:	The pH was 7.5. This material did not grind with ease as is indicated by the grinding time. The ore after grinding was very free from material coarser than 65-mesh.		

Table VIII

Minus 100-mesh Grind Float Results; Coarse Hydraulic Classification Sands

Ore		Coarse hydraulic classification sands	
Grind:			
Primary	<u>None</u>	Final: Mill	<u>Abbe'</u> Mesh <u>-100</u> Time <u>15-15-15-10</u> min.
Water: Grind <u>Distilled</u>		Flotation <u>Distilled</u>	
Per cent solids	<u>23</u>	Flotation machine used <u>Fagergren 600 gram cell</u>	
Head Assay.....	{	Gold	0.085 oz. per ton
		Silver	1.60 oz. per ton
Tails Assay	{	Gold	0.03 oz. per ton
		Silver	0.65 oz. per ton
Per cent recovery of combined values			63%
Reagents Used			
American Cyanamid reagent No. 301	.10 lb.	per ton	
" " " No. 208	.10 lb.	" "	" "
Pine Oil	.10 lb.	" "	" "
Barrett No. 4	.10 lb.	" "	" "
Remarks: The pH was 7.5. Grinding the ore to minus 100-mesh did not give a much greater recovery than the minus 65-mesh grind. In both of these tests a portion of the tailings from the float test was carefully vanned and no visible concentrates were seen.			

Large Scale Classification and Lock Flotation Test:

Approximately 10,000 grams of the ore was screened through minus 14-mesh. This was accomplished by first screening the material dry. The lumpy oversize was then wet screened, the undersize dried and combined

with the minus 14-mesh material. The two minus 14-mesh were thoroughly mixed and a representative head sample was obtained. The residual material was then divided into five equal portions. Each portion was floated in a 2000 gram Denver laboratory flotation machine. The concentrates from these tests were combined. The flotation tailings were also combined, then classified into three products by means of the constriction plate classifier. The three products, spigot 1, spigot 2, and the slimes were dried, weighed and assayed. Representative samples of spigot 1 (coarse sands) were ground in an Abbe' mill and floated in a Fagergren flotation cell.

The detailed flow-sheet on the following page fully explains the test.

Flow Sheet

Classification and Flotation

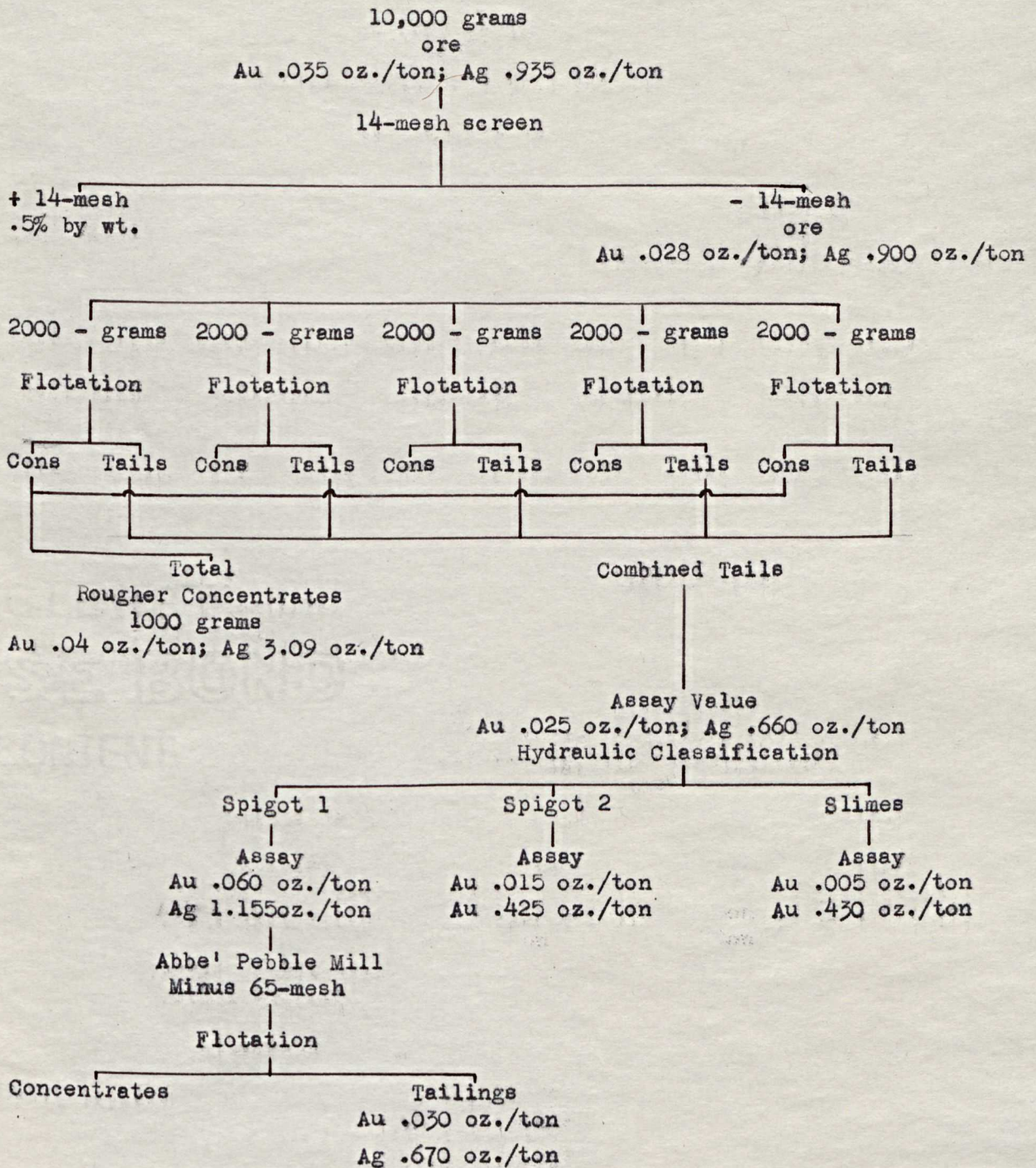


Table IX tabulates the flotation results of the minus 14-mesh ore in the large scale classification and flotation test.

Table IX

Flotation of Minus 14-mesh Unground Ore

Ore	Minus 14-mesh unground ore
Grind: <u>None</u>	Water for flotation <u>City of Butte Tap</u>
Per cent Solids <u>23</u>	Flotation cell used <u>Denver 2000 gram</u>
Head Assay.....	{ Gold..... 0.028 oz. per ton
	{ Silver 0.900 oz. per ton
Tails Assay	{ Gold 0.025 oz. per ton
	{ Silver..... 0.660 oz. per ton
Per cent recovery of combined heads	17
Reagents Used	
American Cyanamid reagent No. 301	.10 lb. per ton
" " " No. 208	.10 lb. " "
Pine Oil	.10 lb. " "
Barrett No. 4	.10 lb. " "
Remarks: The pH was 7.4. The froth from this test was very dirty. Some fine concentrates were observed in the tailings. The rougher concentrates were 10 per cent by weight of the total heads.	

Table X gives the results of hydraulic classification which followed the flotation on the minus 14-mesh ore.

Table X

Hydraulic Classification of Flotation Tails

Product	% Wt.	Assay		Value per ton @\$33.50 Au; 70¢Ag	Val./ton x Wt. %	% Val.	Cum. % Value
		Au	Ag				
Spigot 1 (coarse mat.)	30	.060	1.155	\$2.82	.85	67.5	67.5
Spigot 2 (medium mat.)	36	.015	.425	\$.70	.25	20.0	87.5
Slimes (minus 150)	34	.005	.430	\$.47	.16	12.5	100.0
Composite				\$1.26		100.0	
Actual head sample hydr. class.				\$1.30			

The weights per cent of the spigot products of Table X do not check with those of Table V. This is caused by slime recovered in the flotation test that preceded hydraulic classification. The remaining discrepancy is probably caused by the variation of water that entered the classifier. Tables V and X should be compared for comparison of values. It plainly can be seen that the flotation test lowered the value, somewhat, of the fine material and therefore most of the remaining values are in the coarser sands.

Table XI, on the forthcoming page, gives the results of the flotation of spigot 1 (coarse material) indicated in the previous flowsheet. The sands were ground to minus 65-mesh.

Table XI

Flotation of Spigot 1 as of Flowsheet

Ore	Spigot 1 (coarse material)		
Grind:	Primary <u>None</u>	Final <u>Abbe'</u>	Mesh <u>-65</u> Time <u>15-15-10 min.</u>
Water: Grind <u>Butte tap</u>	Flotation <u>Butte tap</u>		
Per cent Solids <u>23</u>	Flotation machine used <u>Fagergren 600 gram</u>		
Head Assay	{ Gold	0.06	oz. per ton
	{ Silver	1.155	oz. per ton
Tails Assay	{ Gold	0.030	oz. per ton
	{ Silver.....	0.670	oz. per ton
Per cent recovery of combined values	48		
	Reagents Used		
American Cyanamid reagent No. 301	.10	lb.	per ton
" " " No. 208	.10	lb.	" "
Pine Oil	.10	lb.	" "
Barrett No 4	.10	lb.	" "
Remarks: The pH was 7.4. The concentrates from this test were fairly clean.			

Summary

1. Screen analysis show that 67 per cent of the total values in the ore are concentrated in the plus 150-mesh sands, and that these sands represent 35 per cent of the total weight of the ore. See Tables II and III.
2. 0.5 per cent of the sands are coarser than 14-mesh. This material is composed of wood chips and fine gravel, and assayed approximately \$50.00

per ton. Leaching tests showed that approximately \$.36 of the gold and silver per ton of 14-mesh material were water soluble. Further testing should be done along this line, because a part of these values might be in the fine wood chips which were not washed free of pregnant solution in the previous cyanide operation. See Table IV.

3. Hydraulic classification reasonably substantiated the screen analysis. Classification showed that the plus 150-mesh ore, and representing roughly 48 per cent of the total sands, carried 74 per cent of the values.

4. The flotation tests, as a whole, were not very successful. The best recovery on the unground ore was 25 per cent. On the 10,000 gram batch test the recovery on the unground ore was 17 per cent. No attempt was made to float the medium sands from hydraulic classification. The coarse hydraulic classification product (spigot 1) was ground to pass 65-mesh. Flotation of this product gave a gold and silver recovery of 59 per cent. Another 600 gram sample was ground to pass 100-mesh and the flotation recovery was 63 per cent of the combined gold and silver values. In the more successful flotation tests no sulphides were visible in the tailings. The economic size of liberation for the gold and silver interlocked with the sulphides seems to be in the vicinity of 65-mesh.

Conclusions

The tests seem to show conclusively that the ore is not amenable to flotation. It is difficult to calculate the actual recovery of gold and silver, because there is still the unknown factor of the gold and silver in the wood chips and in the soluble form. In the continuous classification

and flotation test the net recovery was 43 per cent. This does not include the values interlocked with the wood chips and those in solution.

It is very doubtful if it would be worthwhile to try and save the values in the slime material. The writer believes if a satisfactory method of recovering a major amount of the values in the ore can be devised, the slime material could be discarded. Of course the material has to be handled prior to de-sliming, but it is hardly possible to devise a treatment that will make a profit on such a low grade product as the slimes. By de-sliming, the heads to a treatment plant would run approximately \$2.80 per ton. For example, if 500 tons of ore were handled in twenty four hours approximately 250 tons with a value of \$2.80 per ton would be treated and the other 250 tons, the slimes, would go to waste.

It was the intention of the writer to make cyanidation tests after completion of the flotation testing, but because of inadequate time these investigations could not be pursued. Successful all-slime counter-current decantation cyanide plants have operated on other portions of this same type of ore.

The writer believes that further tests should be run, especially cyanide. A regrind would be necessary and a good place to start would be on the de-slimes portion of the ore.

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