BATCH TESTING TO PRODUCE A BULK SULPHIDE CONCENTRATE FROM ORE DUMPS OF THE OLD SILVER HILL MINE

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John W. Schlanz
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ABSTRACT

Sulphide ore obtained from ore dumps from the old Silver Hill Mine property was tested to produce a bulk sulfide concentrate. Completed testwork resulted in concentrates from a high grade sample that assayed 1.3 to 2.4 oz/ton Au, 15 to 18 oz/ton Ag, 13 to 18.5% Pb, 31 to 35% Zn and 0.65% Cu. Recoveries of the various elements were 85 to 90% overall with recoveries from rougher flotation averaging +95%.

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BACKGROUND

The Niagara Capital Corporation, based in Vancouver, British Columbia, has been exploring the possibility of re-opening the Silver Hill Mine located near Lexington, N.C. Preliminary flotation work performed in 1986 by the Ontario Research Foundation showed that the ore was amenable to production of a bulk sulfide concentrate. Based on these results Niagara created a $1.2 million budget for exploration of the main ore body.

Niagara's short-term plan is to process material already on the surface and contained in old ore dumps left from previous operations, which has been estimated at 3,000 tons. Processing of this material should create an immediate cash flow to be used for further exploration and definition of the main ore body.

Therefore, at the request of Mr. William Kraigsley, President of Niagara Capital, a state-supported project was conducted at the MRL to assist in evaluating the ore in the

dumps. Working in conjunction with Mr. Sam Phifer, a mining consultant from Monroe, N.C., samples were collected from the dumps and submitted to the Minerals Research Laboratory for bulk sulphide flotation.

Preliminary tests showed that this surface ore was also susceptible to bulk sulphide flotation. More detailed follow-up tests were successful in improving recoveries to more desirable ranges. Limited test results from a high grade ore sample show that a fairly high grade concentrate containing approximately 1.75 oz/ton gold, 16 oz/ton silver, 13 to 14% lead, 31 to 35% zinc and 0.6 to 0.7% copper can be produced at recoveries that are +90%.

TESTING PROCEDURES

Head Feed

Two samples of feed material were received for the testwork and were identified as MRL Lab Nos. 5384A and 5384B. The two samples were obtained from two different ore dumps with Sample A being a high grade material and Sample B consisting of lower grade feed. The majority of the testing was performed on Sample A.

After identification, the samples were stage crushed to 95% passing 8 mesh using laboratory sized jaw and cone crushers. After crushing 500 gram samples were split from the bulk for the batch tests.

Grinding Tests

A grinding series was performed on Sample A in an 8" x 6.25" stainless steel ball mill. Grinds of 5, 10, 15, 20 and 30 minutes were tested. Following each grind the material charge was filtered, dried and subjected to size distribution. This series allowed the determination of the proper grind for the

flotation testing.

Flotation Tests

All flotation tests were performed essentially the same with the exception of the reagent types and dosage. Following grinding, the material was allowed to settle for approximately 15 minutes which allowed clear water to be poured off to obtain 35% solids in a 2000 ml glass beaker. The beaker was placed on a conditioner equipped with a 3.5" impeller and agitated for 15 minutes with the reagents at a speed of 700 R.P.M. A detailed description of the reagents utilized is shown in Table 10.

Following conditioning, the pulp was transferred to a Denver Laboratory Flotation Cell and given a rougher flotation step. The froth product was placed back in the cell and subjected to cleaner flotation. A total of two cleaners were used for each test.

Quality Control

At the completion of each test all products were filtered, dried and weighed to obtain weight balances. Representative samples of each product were obtained and submitted to Bondar-Klegg, Inc., located in Lakewood, Colorado, for the actual assays. Each sample was assayed for Au, Ag, Pb, Zn, Cu and total Fe. It should be noted that for the majority of the tests all middling products were combined for assay purposes.

RESULTS AND DISCUSSION

Head Feed

Feed from each sample was ground and submitted for assay, the results of which are shown in Table 1. This data shows that Sample A was considerably higher grade than Sample B. Because these samples were prepared identically to the flotation samples

the assays shown represent the actual flotation feed.

Specific gravities of each feed sample were also determined. Sample A, being the higher grade sample, averaged 3.298 specific gravity while Sample B averaged slightly lower at 3.015.

Grinding Series

The results of the grinding series are presented in Table 2. This data was generated primarily to obtain a proper grinding period for the flotation testing with the objective of producing a 100 mesh grind. From these results a grind of 30 minutes was selected for use in the batch tests.

Flotation Tests

Results of all flotation tests are detailed in Tables 3 thru 8, including material balances and process parameters. These same results are summarized in Table 9.

Tests 5384A-3 and 4 basically duplicated the process employed by the Ontario Research Foundation, using AERO 350, AEROFLOAT 208, AERO 3501 and MIBC frother. The only marked difference was the MRL's use of two cleaner flotation steps.

Although assays indicate the feeds were slightly different, particularly in gold and silver content, these preliminary results were encouraging as they did show this surface ore to be amenable to bulk sulfide flotation. These tests also defined some areas that needed improvement, specifically recoveries of almost all valuables but in particular the zinc, gold and silver.

Tests 5384A-5 and 6 were conducted with the objective of improving these recoveries. The major change was the addition of copper sulfate as an activator for the zinc minerals as well as increases in the other reagents. In Test 5 the copper sulfate was added with all the other reagents while Test 6 utilized a separate 5 minute conditioning step with the CuSO4 followed by 10 minutes conditioning with the other collectors. Test 5 employed a higher dose of AERO 350 than the preliminary tests while Test 6 utilized higher addition rates of all reagents.

Both tests were successful as substantial increases in recoveries were observed, particularly of the gold, silver and zinc. Although overall recoveries (thru both cleaners) were almost identical between the two tests, Test 6 produced slightly higher recoveries from the rougher step than Test 5. Both tests were fairly successful in maintaining grades along with the improved recoveries although a slight decrease was observed.

Test 5384A-7, shown in Table 7, eliminated the AERO 3501 from the reagent scheme to determine if reagent usage could be minimized. As shown by the results, grades were slightly up but recoveries suffered as compared to the previous tests.

The only test reported for Sample B is presented in Table 8(Test 5384B-2). This particular test did not use copper sulfate or the increased reagent levels utilized on Sample A. However, results are comparable to those obtained on Sample A under similar conditions.

CONCLUSIONS

The following conclusions are based on data collected at the MRL and contained within this report.

1) Head feed assays did show that the two samples submitted were substantially different in feed grades with Sample A designated high grade and Sample B the lower grade.

2) Both samples did show susceptibility to bulk sulfide concentration although limited work was performed on Sample B.

3) Respectful grades and recoveries were achieved in the limited testwork performed.

4) The addition of copper sulfate in the conditioning phase improved recoveries substantially, particularly from the zinc minerals. Higher reagent additions than those reported by the Ontario Research Foundation was also responsible for substantial

increases in recoveries.

RECOMMENDATIONS/REMARKS

Overall the testwork proved extremely successful. Although the testing completed is considered limited, recoveries were improved to more desirable levels while maintaining good grades. However, additional testing has to be recommended in order to optimize any eventual flowsheet. Areas that should be further investigated include fineness of grind, reagent optimization, total flotation steps necessary, possible leaching of flotation tailings to recover additional gold and silver and testing of additional samples to further define the variability of the ore.

The grind utilized in the batch testing was very fine and, because grinding will ultimately be a major cost item, batch testing is needed to further define the optimum grind needed to achieve liberation and maintain recoveries.

The batch testing also indicated improved results with higher reagent additions although testing in this area was extremely limited. Therefore additional testing should be performed in this area to determine if any reagents could be minimized or eliminated entirely, which would be another cost reduction.

Some concern was expressed over the grades obtained. In all of the batch testing only two cleaners were utilized and use of multiple cleaner flotation could improve upon these results.

Some gold particulation was observed by the assayers which created very high tailings assays on one test. This ties in with the previous statement of testing additional samples to further define any variability. In addition, even when high gold and silver recoveries were obtained, tailings still contained leachable quantities of these valuables. Therefore, if it is

felt that the eventual tonnage will justify and if gold particulation is widespread, leaching tests should be conducted on the tailings as a means of further increasing the recovery of the gold and silver.

It is realized that time may be a factor in following up on many of the above recommendations, particularly since all assay work must be performed by an outside laboratory, which has proved to be very time consuming. However, these recommendations could result in substantial savings in capital and operating costs. Therefore, at the very least, pilot plant testing should be conducted which would allow the investigation of some of the above on a more realistic level.

Table 1. Chemical Analysis of Ground Head Feeds

Feed	Oz/Ton Au	Oz/Ton Ag	% Pb	% Zn	% Fe	% Cu
5384A	0.794	6.90	6.78	16.00	5.55	0.28
5384B	0.061	1.06	2.75	8.00	6.16	0.10

Note: Feed samples were wet ground in laboratory ball mill prior to assay. Grind used was equivalent to that utilized in all flotation tests. Therefore, the above assays represent flotation feed.

Specific Gravities of Feed Samples

Sample	Graduate	Pycnometer	Average
5384A	3.21	3.38	3.298
5384B	3.01	3.02	3.015

Table 2. Results of Grinding Series

Screen size	5 Minutes Wt.%	5 Minutes Cum Wt.%	10 Minutes Wt.%	10 Minutes Cum Wt.%	15 Minutes Wt.%	15 Minutes Cum Wt.%
+50	23.4	23.4	6.0	6.0	1.0	1.0
50x70	5.6	29.0	2.2	8.2	0.3	1.3
70x100	6.5	35.5	4.1	12.3	0.9	2.2
100x200	17.2	52.7	19.5	31.8	12.4	14.6
200x325	20.8	73.5	41.5	73.3	59.9	74.5
325x400	7.5	81.0	10.7	84.0	13.0	87.5
-400	19.0	100.0	16.0	100.0	12.5	100.0
Total	100.0	-	100.0	-	100.0	-

Screen Size	20 Minutes Wt.%	20 Minutes Cum Wt.%	30 Minutes Wt.%	30 Minutes Cum Wt.%
+50	0.4	0.4	0.0	0.0
50x70	0.1	0.5	0.0	0.0
70x100	0.2	0.7	0.0	0.0
100x200	6.2	6.9	2.0	2.0
200x325	66.5	73.4	75.4	77.4
325x400	14.6	88.0	13.9	91.3
-400	12.0	100.0	8.7	100.0
Total	100.0	-	100.0	-

Note: All grinding performed in laboratory ball mill at 65% solids on Dump A sample.

Table 3. Results of Flotation Test 5384A-3

MATERIAL BALANCE

Product Grades

Product	Wt%	Au	Ag	Pb	Zn	Fe	Cu
Tails	38.6	2.95*	0.93	1.22	4.33	4.60	0.015
#1 Mids	19.4	0.128	1.47	2.08	10.30	5.00	0.017
#2 Mids	12.1	0.154	3.39	3.03	21.60	6.77	0.025
Conc	29.9	2.400	18.00	18.60	33.10	6.01	0.248
Total	100.0	1.90	6.44	6.80	16.18	4.76	0.31

% Distribution of Elements

Product	Au	Ag	Pb	Zn	Fe	Cu
Tails	59.9	5.6	6.9	10.3	24.7	4.9
#1 Mids	1.3	4.4	5.9	12.4	20.4	5.6
#2 Mids	1.0	6.4	5.4	16.1	17.2	8.2
Conc	37.8	83.6	81.8	61.2	37.7	81.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

TEST PROCEDURE

Process	Time	pH	% Solids	Reagents(lb/ton of Feed) 350	208	3501	MIBC
Ball Mill	30	-	65	-	-	-	-
Condition	15	6.6	30	0.2	0.1	0.1	0.08
R. Float	11	6.8	25	-	-	-	-
#1 C. Float	10	-	18.5	-	-	-	-
#2 C. Float	10	-	9.0	-	-	-	-

(*) - Denotes gold particulation observed in assay.
Note: All gold and silver assays are oz/ton. Other elements reported in %.

Table 4. Results of Flotation Test 5384A-4

MATERIAL BALANCE

Product Grades

Product	Wt%	Au	Ag	Pb	Zn	Fe	Cu
Tails	36.2	0.470	1.28	1.30	5.60	5.33	0.022
#1 Mids	22.5	0.282	2.07	2.17	11.95	5.75	0.025
#2 Mids	10.3	0.242	3.05	3.49	17.50	5.98	0.021
Conc	31.0	2.250	20.00	17.30	33.30	5.11	0.251
Total	100.0	0.96	7.44	6.68	16.84	5.42	0.319

% Distribution of Elements

Product	Au	Ag	Pb	Zn	Fe	Cu
Tails	17.8	6.2	7.0	12.0	35.6	6.9
#1 Mids	6.6	6.3	7.3	16.0	23.9	7.8
#2 Mids	2.6	4.2	5.4	10.7	11.3	6.6
Conc	73.0	83.3	80.3	61.3	29.2	78.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

TEST PROCEDURE

Process	Time	pH	% Solids	Reagents(lb/ton of Feed) 350	208	3501	MIBC
Ball Mill	30	-	65	-	-	-	-
Condition	15	6.8	35	0.2	0.2	0.2	0.08
R. Float	12	6.8	30	-	-	-	0.08
#1 C. Float	10	-	19.2	-	-	-	-
#2 C. Float	10	-	12.4	-	-	-	-

Note: All gold and silver assays are in oz/ton. Other elements reported in %.

Table 5. Results of Flotation Test 5384A-5

MATERIAL BALANCE

Product Grades

Product	Wt%	Au	Ag	Pb	Zn	Fe	Cu
Tails	35.0	0.023	0.80	1.14	1.58	5.19	0.04
Mids*	22.7	0.094	2.04	2.69	3.10	5.52	0.12
Conc	42.3	1.470	15.61	13.00	31.80	5.34	0.61
Total	100.0	0.65	7.35	6.51	14.71	5.33	0.30

% Distribution of Elements

Product	Au	Ag	Pb	Zn	Fe	Cu
Tails	1.2	3.8	6.1	3.8	34.1	4.7
Mids*	3.3	6.3	9.4	4.8	23.5	9.0
Conc	95.5	89.9	84.5	91.4	42.4	86.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

TEST PROCEDURE

Process	Time	% Solids	Reagents(lb/ton of Feed) CuSO4	350	208	3501	MIBC
Ball Mill	30	65	-	-	-	-	-
Condition	15	35	0.5	0.5	0.2	0.2	0.08
R. Float	11	30	-	-	-	-	0.08
#1 C. Float	10	-	-	-	-	-	-
#2 C. Float	10	-	-	-	-	-	-

(*) - Combined the two middling products for assay purposes.
Note: All gold and silver assays are in oz/ton. Other elements reported in %.

Table 6. Results of Flotation Test 5384A-6

MATERIAL BALANCE

Product Grades

Product	Wt%	Au	Ag	Pb	Zn	Fe	Cu
Tails	26.4	0.037	0.66	0.95	1.40	4.84	0.03
Mids*	31.1	0.216	1.94	2.44	2.79	5.40	0.10
Conc	42.5	1.344	14.99	12.90	31.60	5.70	0.66
Total	100.0	0.65	7.15	6.49	14.67	5.38	0.32

% Distribution of Elements

Product	Au	Ag	Pb	Zn	Fe	Cu
Tails	1.5	2.4	3.9	2.5	23.8	2.5
Mids*	10.3	8.4	11.7	5.9	31.2	9.7
Conc	88.1	89.2	84.4	91.6	45.0	87.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

TEST PROCEDURE

Process	Time	% Solids	Reagents(lb/ton of Feed) CuSO4	350	208	3501	MIBC
Ball Mill	30	65	-	-	-	-	-
Condition	5	35	0.5	-	-	-	-
Condition	10	35	-	0.5	0.4	0.4	0.08
R. Float	10	30	-	-	-	-	0.08
#1 C. Float	8	-	-	-	-	-	-
#2 C. Float	7	-	-	-	-	-	-

(*) - Combined the two middling products for assay purposes.
Note: All gold and silver assays are oz/ton. Other elements reported in %.

Table 7. Results of Flotation Test 5384A-7

MATERIAL BALANCE

Product Grades

Product	Wt%	Au	Ag	Pb	Zn	Fe	Cu
Tails	35.4	0.091	0.93	1.38	1.85	5.34	0.06
Mids*	26.2	0.441	2.52	2.88	3.70	5.96	0.17
Conc	38.4	1.729	16.26	14.10	35.00	5.02	0.67
Total	100.0	0.81	7.23	6.66	15.06	5.38	0.32

% Distribution of Elements

Product	Au	Ag	Pb	Zn	Fe	Cu
Tails	3.9	4.5	7.3	4.4	35.1	6.5
Mids*	14.2	9.1	11.4	6.4	29.0	13.9
Conc	81.9	86.4	81.3	89.2	35.9	79.6
Total	100.0	100.0	100.0	100.0	100.0	100.0

TEST PROCEDURE

Process	Time	% Solids	Reagents(lb/ton of Feed) CuSO4	350	208	3501	MIBC
Ball Mill	30	65	-	-	-	-	-
Condition	5	35	0.5	-	-	-	-
Condition	10	35	-	0.5	0.4	-	0.08
R. Float	10	30	-	-	-	-	0.08
#1 C. Float	8	-	-	-	-	-	-
#2 C. Float	7	-	-	-	-	-	-

(*) - Combined the two middling products for assay purposes.
Note: All gold and silver assays are in oz/ton. Other assays reported in %.

Table 8. Results of Flotation Test 5384B-2

MATERIAL BALANCE

Product Grade

Product	Wt%	Au	Ag	Pb	Zn	Fe	Cu
Tails	49.5	0.002	0.12	0.26	1.28	6.13	0.01
Mids*	29.5	0.018	0.36	0.76	4.19	6.36	0.03
Conc	21.0	0.214	3.91	11.50	27.60	5.90	0.46
Total	100.0	0.051	0.99	2.77	7.66	6.15	0.11

% Distribution of Elements

Product	Au	Ag	Pb	Zn	Fe	Cu
Tails	2.0	6.0	4.7	8.2	49.3	4.5
Mids*	9.8	10.8	8.1	16.1	30.5	8.1
Conc	88.2	83.3	87.2	75.7	20.2	87.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

TEST PROCEDURE

Process	Time	% Solids	Reagents(lb/ton of Feed) CuSO4	350	208	3501	MIBC
Ball Mill	30	65	-	-	-	-	-
Condition	15	35	-	0.2	0.2	0.2	0.08
R. Float	10	30	-	-	-	-	0.08
#1 C. Float	7	-	-	-	-	-	-
#2 C. Float	7	-	-	-	-	-	-

(*) - Combined the two middling products for assay purposes.
Note: All gold and silver assays are oz/ton. Other elements reported in %.

Table 9. Summary of Completed Tests

Test 5384A-3

	Au	Ag	Pb	Zn	Fe	Cu
Conc Grade	2.40	18.00	18.60	33.10	6.01	0.248
O'all Recovery	37.8	83.6	81.8	61.2	37.7	81.3
Rougher Recovery	40.1	94.4	93.1	89.7	75.3	95.1

Test 5384A-4

	Au	Ag	Pb	Zn	Fe	Cu
Conc Grade	2.250	20.00	17.30	33.30	5.11	0.251
O'all Recovery	73.0	83.3	80.3	61.3	29.2	78.7
Rougher Recovery	82.2	93.8	93.0	88.0	64.4	93.1

Test 5384A-5

	Au	Ag	Pb	Zn	Fe	Cu
Conc Grade	1.470	15.61	13.00	31.80	5.34	0.61
O'all Recovery	95.5	89.9	84.5	91.4	42.4	86.3
Rougher Recovery	98.8	96.2	93.9	96.2	65.9	95.3

Test 5384A-6

	Au	Ag	Pb	Zn	Fe	Cu
Conc Grade	1.344	14.99	12.90	31.60	5.70	0.66
O'all Recovery	88.1	89.2	84.4	91.6	45.0	87.8
Rougher Recovery	98.4	97.6	96.1	97.5	76.2	97.5

Test 5384A-7

	Au	Ag	Pb	Zn	Fe	Cu
Conc Grade	1.729	16.26	14.10	35.00	5.02	0.67
O'all Recovery	81.9	86.4	81.3	89.2	35.9	79.6
Rougher Recovery	96.1	95.5	92.7	95.6	64.9	93.5

Test 5384B-2

	Au	Ag	Pb	Zn	Fe	Cu
Conc Grade	0.214	3.91	11.50	27.60	5.90	0.46
O'all Recovery	88.2	83.3	87.2	75.7	20.2	87.4
Rougher Recovery	98.0	94.1	95.3	91.8	50.7	95.5

Table 10. Description of Reagents

Copper Sulfate (CuSO4) - No particular brand utilized. Added either in the conditioning step or in a pre-conditioning step as an activator for the zinc sulfides.

AERO 350 xanthate (350) - Cyanamid's potassium amyl xanthate. Added in conditioning step as a collector for all sulfides. Classified as the most powerful but least selective of the xanthate collectors.

AEROFLOAT 208 promoter (208) - Cyanamid's R = ethyl + sec. butyl promotor. Added in conditioning step as a collector for copper. Also an excellent collector for native gold and silver.

AERO 3501 promotor (3501) - Cyanamid's R = isoamyl promotor. Added in conditioning step as a collector for copper and activated zinc minerals.

Methyl Isobutanol Carbonal (MIBC) - No particular brand utilized. Added to both the conditioning step and the flotation step as the frothing agent for the flotation. Can be stage added in the various flotation stages as needed.