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OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 67-55

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**RECOVERY OF SILVER AND ZINC FROM
TWO ORE SAMPLES FROM
CRESWELL MINES LIMITED
PORT ARTHUR, ONTARIO**

by

G. I. MATHIEU

MINERAL PROCESSING DIVISION

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RECOVERY OF SILVER AND ZINC FROM TWO ORE SAMPLES
FROM CRESWELL MINES LIMITED,
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SUMMARY OF RESULTS

The two ore samples received were mineralogically similar, but one designated as "low grade" contained 9.7 oz Ag/ton and 0.94% Zn, while the other "high grade" assayed 160.9 oz Ag/ton and 4.75% Zn. Gold was present only in trace amounts in both samples.

Silver extraction by straight cyanidation fell short of the desired recovery even with 72-hour contact time. This was attributed to the presence of coarse flakes which could not be reduced by grinding to a size suitable for rapid dissolution in cyanide solution. This difficulty, which is particularly noticeable in the "high grade" ore, is illustrated by the following silver extractions obtained by straight cyanidation:

Extraction after:	(48 hrs)	(72 hrs)	(96 hrs)
Low grade ore	87.4 %	93.7 %	95.9 %
High grade ore	65.1 %	75.0 %	89.6 %

However, it was possible to reduce the contact period without impairing the recovery by cyaniding after removal of "metallics" by jigging and screening. With this technique, the "metallics" fraction produced was of direct smelting grade (20,000 oz Ag/ton), while the silver extraction from the residual ore attained 96% after 48 hours of cyanidation.

Tests showed that the feed to cyanidation could be considerably reduced by prior concentration of the silver by flotation. The best overall silver recoveries were 94% with the "low grade" ore and 97% with the "high grade" when the jig undersize was combined with the silver flotation concentrate and cyanided.

Finally, zinc concentrates were scavenged from the cyanidation residues. The grade varied from 55% to 65% Zn with recoveries in the order of 90%. This operation also added 2% to the overall silver recovery.

Integrated tests to simulate plant practices, using the best conditions previously found, confirmed the above results.

* Research Scientist, Mineral Processing Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

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INTRODUCTION

Property

Creswell Mines Limited holds a silver property consisting of 28 claims and 4 lots located in Gillies and O'Connor townships, 25 miles southwest of Port Arthur, Ontario. Underground development by means of adits was made by previous owners and further exploration, mapping and sampling was undertaken by the present owners in 1966.

Shipments

Two shipments of ore were received, one on October 20, 1966, (730 lb designated as "low grade" ore) the other on December 13, 1966, (104 lb described as "high grade"). The shipments were made under instructions of the company's mining consultant, Mr. A.C.A. Howe, P.Eng. A.C.A. Howe and Associates Ltd, Mining and Geology Consultants, Suite 824-826, 159 Bay Street, Toronto, Ontario.

Purpose of Investigation

The company's main interest was in the possibility of recovering silver by direct cyanidation of the ore; failing this, by standard gravity, flotation and cyanidation processes. The appreciable zinc content in the ore prompted a few tests aimed at recovering a marketable grade of zinc concentrate.

Sampling and Analysis

The two lots of lump ore were crushed to -1 in. and a few pieces were selected from each sample for mineralogical examination. Half of the remainder was then reduced to -20 mesh, from which separate head samples were riffled out for chemical and spectrographic analyses.

TABLE 1

Chemical Analysis* of Head Samples

<u>Element</u>	<u>Low Grade Ore</u>	<u>High Grade Ore</u>
Silver (Ag)	9.66 oz/ton	160.9 oz/ton
Gold (Au)	Traces	Traces
Zinc (Zn)	0.94 %	4.75 %
Lead (Pb)	0.07 "	0.06 "
Copper (Cu)	0.01 "	0.01 "
Iron (Fe)	2.67 "	1.29 "
Sulphur (S)	0.67 "	2.12 "
Insoluble	60.30 "	34.53 "

* From Internal Reports MS -AC- 66-1056 and 67-118.

A spectrographic analysis on a portion of the head samples indicated the presence of the elements listed below in their approximate order of decreasing abundance.

TABLE 2

Spectrographic Analysis* of Head Samples

I - Si, Ca, Mg, Ba.
 II - Fe, Zn, Al, Pb.
 III- Cr, Ti, Ni, Mn.
 IV - Mo, Sn, Zr, Cu, Ag.

* From Internal Report MS -AC - 66-137.

Mineralogical Examination*

The hand specimens selected from the ore shipments and a portion of -20 mesh head samples were submitted to the Mineralogy Section of the Mineral Sciences Division for identification of the constituents.

Polished sections were prepared from each sample and examined microscopically. The mineralogy of the "low grade" ore and of the "high grade" ore was similar and is summarized below.

TABLE 3

Mineral Content of Head Samples

Metallic		Non-Metallic
Acanthite	Galena	Quartz
Native silver	Chalcopyrite	Calcite
Sphalerite	Niccolite	Dolomite
Pyrite	Gersdorffite	Fluorite
Marcasite	Native bismuth	Feldspar
Pyrrhotite	Bismuthinite	Chlorite

Note: Calcite and particularly dolomite were more abundant in the "high grade" ore.

The acanthite and native silver occur as separate grains near the sphalerite masses, as inclusions in sphalerite, as intergrowths with galena, and as veinlets along sphalerite -- calcite grain boundaries. The separate grains are up to 15 mm in size; the inclusions and intergrowths vary from 1 to 100 microns in size; and the veinlets are up to 5 microns wide.

The pyrite and marcasite occur as intergrowths, and are

* From Internal Report MS - 66-110, by W. Petruk.

present as separate grains up to 5 mm in size. They contain small irregular grains of pyrrhotite, galena, chalcopyrite and sphalerite. Some of the pyrrhotite also occur as separate grains in gangue.

The galena and chalcopyrite are present as minute grains in sphalerite, pyrite and gangue, and as veinlets along sphalerite-calcite grain boundaries.

The niccolite, gersdorffite, native bismuth and bismuthinite were found only as separate grains in gangue.

OUTLINE OF INVESTIGATION

The investigation was divided into four main sections which can be summarized as follows:

1. Straight cyanidation of the ore for various periods at increasing degrees of fineness.
2. Removal of coarse silver or "metallics" by jigging, grinding and screening, followed by:
 - (i) cyanidation of the residual ore;
 - (ii) flotation of the silver from the jig tailing and cyanidation of the flotation concentrate along with jig under-size.
3. Zinc flotation and silver scavenging from cyanidation residues.
4. Simulation of two possible plant flowsheets for recovering both silver and zinc minerals.

DETAILS OF INVESTIGATION

Straight Cyanidation, Tests 1 to 9

Nine 1000 g samples, cut from each of the two lots of ore, were ground and cyanided for various periods at solution strengths of 2.0 lb NaCN and 1.0 lb CaO per ton. The other conditions for cyanidation and the results obtained are shown in Tables 4 and 5.

TABLE 4
Conditions for Cyanidation

Test	Grinding Time min	Cyanidation Time hrs	LOW GRADE ORE		HIGH GRADE ORE	
			Fineness % - 200m	Dilution Liquid: Solid	Fineness % - 200m	Dilution Liquid: Solid
1	20	48	71.5	2:1	74.9	3:1
2	30	"	85.4	"	86.7	3:1
3	40	"	94.9	"	96.1	3:1 & 2:1
4	20	72	71.5	2:1	74.9	3:1
5	30	"	85.4	"	86.7	3:1
6	40	"	94.9	"	96.1	3:1 & 2:1
7	20	96	71.5	2:1	74.9	3:1
8	30	"	85.4	"	86.7	3:1
9	40	"	94.9	"	96.1	3:1 & 2:1

TABLE 5

Results of Straight Cyanidation

Test	LOW GRADE ORE				HIGH GRADE ORE			
	Reagents Consumed lb/ton of ore		Residue Assay * oz Ag/ton	Extraction** % Ag	Reagents Consumed lb/ton of ore		Residue Assay * oz Ag/ton	Extraction** % Ag
	NaCN	CaO			NaCN	CaO		
1	2.1	6.0	1.45	85.0	11.2	5.0	70.25	56.3
2	2.4	6.0	1.22	87.4	11.6	5.2	56.15	65.1
3	2.4	6.5	0.61	93.7	12.1	5.3	54.47 (60.67)	66.1 (62.3)
4	2.2	6.0	1.03	89.3	13.3	5.8	42.08	73.9
5	2.4	6.0	0.61	93.7	13.7	5.9	40.18	75.0
6	2.3	6.6	0.35	96.4	14.0	6.1	38.68 (58.19)	76.0 (63.8)
7	2.5	6.1	1.01	89.5	15.7	6.6	19.86	87.7
8	2.5	6.3	0.40	95.9	15.9	6.5	16.72	89.6
9	2.3	6.7	0.29	97.0	15.9	6.6	14.03 (45.71)	91.3 (71.6)

* From Internal Reports MS-AC- 66-1073, 67-60, 140 and 154.

** Calculated by difference.

() Similar tests made at a dilution of 2:1.

Remarks:

Long agitation was necessary to extract the silver because of the coarse flakes of acanthite and native silver. Therefore, prior removal of these flakes ("metallics") by jigging and screening should reduce the cyanidation period without impairing the recovery.

Separation of "Metallics" Prior to Cyanidation, Tests 10 to 13

A lot of 20,000 g of ore was cut from each sample and jigged. The jig concentrates were ground separately for 30 minutes and screened on a 100 mesh sieve with the following results:

TABLE 6

Results of Jigging and Screening

Test	Product	LOW GRADE ORE			HIGH GRADE ORE		
		Weight %	Assay* oz Ag/ton	Dist'n %	Weight %	Assay* oz Ag/ton	Dist'n %
10	"Metallics"	0.01	21,501.	20.4	0.2	23,295.	29.7
	Screen u'size	4.20	103.4	41.1	10.2	426.6	27.7
	Jig tailing	95.79	4.25	38.5	89.6	74.5	42.6
	Feed (calcd)	100.00	10.56	100.0	100.0	156.9	100.0

* From Internal Reports MS-AC- 66-1084, 67-60 and 94.

A few 1000 g samples, cut proportionally from the screen-undersize product and the jig tailing, were ground for 30 minutes and cyanided in a solution maintained at about 2.0 lb NaCN/ton and 1.0 lb Ca/ton. Cyanidation conditions and results obtained are shown in Tables 7 and 8.

TABLE 7

Conditions for Cyanidation

Test	Cyanidation Time hrs.	LOW GRADE ORE		HIGH GRADE ORE	
		Fineness % -200m	Dilution Liquid: Solid	Fineness % -200m	Dilution Liquid: Solid
11	48	86.5	2:1	88.7	3:1
12	72	86.5	2:1	88.7	3:1

TABLE 8

Results of Cyanidation After Separation of "Metallics"

Test	LOW GRADE ORE				HIGH GRADE ORE			
	Reagents Consumed lb/ton		Residue Assay* oz Ag/ton	Extraction % Ag	Reagents Consumed lb/ton		Residue Assay* oz Ag/ton	Extraction % Ag
	NaCN	CaO			NaCN	CaO		
11	2.0	5.8	0.37	95.7	14.9	4.3	4.23	96.0
12	2.2	6.2	0.30	96.2	16.0	4.4	2.93	97.2

* From Internal Reports MS-AC- 67-60, 89 and 154.

Note: Extraction calculated by difference.

Silver Concentration and Cyanidation, Tests 13 to 18

This series of tests was aimed at reducing the weight of the cyanidation feed. The technique consisted of complementing the jig treatment and "metallics" removal by (1) flotation of the silver from the jig tailing and (2) cyanidation of the flotation concentrate along with the undersize fraction from screening the reground jig concentrate.

The flotation tests were made on 2000 g samples cut from the jig tailings of Test 10, and using the procedure shown in Table 9.

TABLE 9

Reagents and Conditions for Silver Flotation

Test	Grinding		Flotation Time min	Reagents (lb/ton of ore)			
	Time min	Size % -200m		Copper Sulphate	Xanthate 301	Aerofloat 25	Dowfroth 250
13	20	74.7	25	1.5	0.15	0.05	0.10
14			30	1.8	0.18	0.06	0.12
15			35	2.1	0.21	0.07	0.14
16	30	87.1	25	1.5	0.15	0.05	0.10
17			30	1.8	0.18	0.06	0.12
18			35	2.1	0.21	0.07	0.14

Note: The reagents were added by stages at 5 min intervals.

TABLE 10

Results of Silver Flotation

Test	Products	LOW GRADE ORE			HIGH GRADE ORE		
		Weight %	Assay oz Ag/ton	Dist'n % Ag	Weight %	Assay oz Ag/ton	Dist'n % Ag
13	Conc	8.3	41.7	81.4	26.2	279.5	98.3
	Tailing	91.7	0.86	18.6	73.8	1.71	1.7
	Feed	100.0	4.25	100.0	100.0	74.5	100.0
14	Conc	10.1	38.0	90.3	32.0	231.6	99.5
	Tailing	89.9	0.46	9.7	68.0	0.57	0.5
	Feed	100.0	4.25	100.0	100.0	74.5	100.0
15	Conc	16.2	23.7	90.5	35.4	209.5	99.6
	Tailing	83.8	0.48	9.5	64.6	0.52	0.4
	Feed	100.0	4.25	100.0	100.0	74.5	100.0
16	Conc	10.9	32.5	83.4	25.7	285.1	98.4
	Tailing	89.1	0.79	16.6	74.3	1.65	1.6
	Feed	100.0	4.25	100.0	100.0	74.5	100.0
17	Conc	15.7	23.8	87.9	30.2	245.1	99.3
	Tailing	84.3	0.61	12.1	69.8	0.70	0.7
	Feed	100.0	4.25	100.0	100.0	74.5	100.0
18	Conc	18.6	32.5	91.4	34.1	217.3	99.5
	Tailing	81.4	0.45	8.6	65.9	0.56	0.5
	Feed	100.0	4.25	100.0	100.0	74.5	100.0

Note: The tailing assays were from Internal Reports MS-AC- 67-39, 60, 94 and 140; the concentrates assays were calculated by difference.

The flotation concentrates were mixed with proportional amounts of their respective jig-undersize products. A few 200 g samples were then cut and cyanided in solution strengths of 2.0 lbs NaCN and 1.0 lb CaO per ton under the following conditions.

TABLE 11

Conditions for Cyanidation

Test	LOW GRADE ORE			HIGH GRADE ORE		
	Time hrs	Fineness % -200m	Dilution Liquid:Solid	Time hrs	Fineness % -200m	Dilution Liquid:Solid
19	48	95.6	3:1	72	96.7	5:1
20	48	"	5:1	72	"	7:1
21	72	"	"	96	"	"
22	72*	"	"	96**	"	"

* Filter and repulp after 36 hours.

** Filter and repulp after 48 hours.

TABLE 12

Results of Cyanidation of Jig Undersize and Flotation Concentrate

Test	LOW GRADE ORE				HIGH GRADE ORE			
	Reagents Consumed lb/ton		Residue Assay* oz Ag/ton	Extraction % Ag	Reagents Consumed lb/ton		Residue Assay* oz Ag/ton	Extraction % Ag
	NaCN	CaO			NaCN	CaO		
19	0.9	1.0	3.18	92.5	5.6	1.7	130.6	55.2
20	1.4	1.7	2.84	93.3	6.8	1.9	87.5	70.0
21	1.5	1.9	1.58	96.3	8.1	2.5	13.8	95.3
22	1.8	2.0	0.83	98.0	9.2	3.2	9.8	96.6

* From Internal Reports MS-AC 67-89-140, and 154.

Note: Extraction calculated by difference.

A few supplementary tests were made after regrinding the cyanidation feed and at higher concentration of sodium cyanide. However, none of these techniques significantly improved the silver extraction by cyanidation.

Flotation of Zinc Minerals

Because sphalerite occurs in quantity of economic interest in both types of ore and particularly in the "high grade", a few tests were made to concentrate this mineral to marketable grade. In addition to zinc recovery, the tests also aimed at scavenging the residual silver and, therefore, were made on mixture of cyanidation residues from previous tests.

The feed to each test and the flotation procedure are shown in Table 13.

TABLE 13

Reagents and Conditions for Zinc Flotation

Test	Operation	Time min	Reagents	lb /ton of ore	pH
23 (Res- idues from Tests 11-12)	Rougher flotation	15	Copper sulphate Sodium silicate Xanthate Z-6 Dowfroth 250	1.50 0.50 0.15 0.08	10.1-10.4
	Cleaner flotation	6	Copper sulphate Sodium silicate Xanthate Z-6 Dowfroth 250	0.10 0.10 0.01 0.01	9.2-9.6
	Recleaner flotation	4	Sodium silicate	0.02	9.1-9.4
24 (Res- idues from Tests 19-22)	Rougher flotation	10	Copper sulphate Sodium silicate Xanthate Z-6 Dowfroth 250	0.50 0.20 0.05 0.04	10.4-10.7
	Cleaner flotation	5	Copper sulphate Sodium silicate Xanthate Z-6 Dowfroth 250	0.10 0.10 0.01 0.01	10.1-10.3
	Recleaner flotation	3	Sodium silicate	0.02	9.7-10.1

Note: The reagents additions were made in stages.

TABLE 14
Results of Zinc Flotation

Test	Product	LOW GRADE ORE					HIGH GRADE ORE				
		Weight %	Analysis*		Dist'n		Weight %	Analysis*		Dist'n	
			%	oz/ton	%	%		%	oz/ton	%	%
			Zn	Ag	Zn	Ag		Zn	Ag	Zn	Ag
23	Zn recl conc	1.3	60.0	14.73	89.7	60.5	6.8	61.2	39.10	88.2	79.7
	Zn recl tailing	5.6	0.60	0.61	3.9	10.8	3.1	3.89	3.50	2.6	3.3
	Zn cl tailing	16.7	0.15	0.13	2.9	6.9	28.2	1.20	1.46	7.2	12.4
	Flot tailing	76.4	0.04	0.09	3.5	21.8	61.9	0.15	0.25	2.0	4.6
	Feed (calcd)	100.0	0.87	0.32	100.0	100.0	100.0	4.71	3.33	100.0	100.0
24	Zn recl conc	9.3	56.0	18.88	91.8	61.4	20.0	55.0	108.20	95.1	76.7
	Zn recl tailing	13.5	1.85	3.23	4.6	15.3	4.2	3.10	21.51	1.1	3.2
	Zn cl tailing	15.2	0.50	1.01	1.4	5.3	6.0	1.81	13.69	1.0	2.9
	Flot tailing	62.0	0.20	0.83	2.2	18.0	69.8	0.47	6.98	2.8	17.2
	Feed (calcd)	100.0	5.46	2.88	100.0	100.0	100.0	11.57	28.21	100.0	100.0

* From Internal Reports MS-AC- 67-190, 205 and 334.

Simulation of Plant Flowsheet

For the treatment of the samples of Creswell ore, initial testwork indicated two main procedures. Outlines of these, along with flowsheets and results of confirmatory tests, are as follows:

1. Separation of "Metallics", Cyanidation of Residual Ore and Zinc Flotation

Procedure:

- a) Jigging of crushed ore at -20 mesh.
- b) Grinding of jig concentrate to 99.9+ % -100 mesh.
- c) Screening of "metallics" on 100-mesh sieve.
- d) Grinding of jig tailing to 87% -200 mesh.
- e) Cyanidation of residual ore for 48 hrs in solution strengths of 2.0 lb NaCN and 1.0 lb CaO per ton at liquid:solid ratios of 2:1 for the "low grade ore" and 3:1 for the "high grade ore".
- f) Zinc flotation from cyanidation residues, as in Test 23 (Table 12).

Flowsheet I

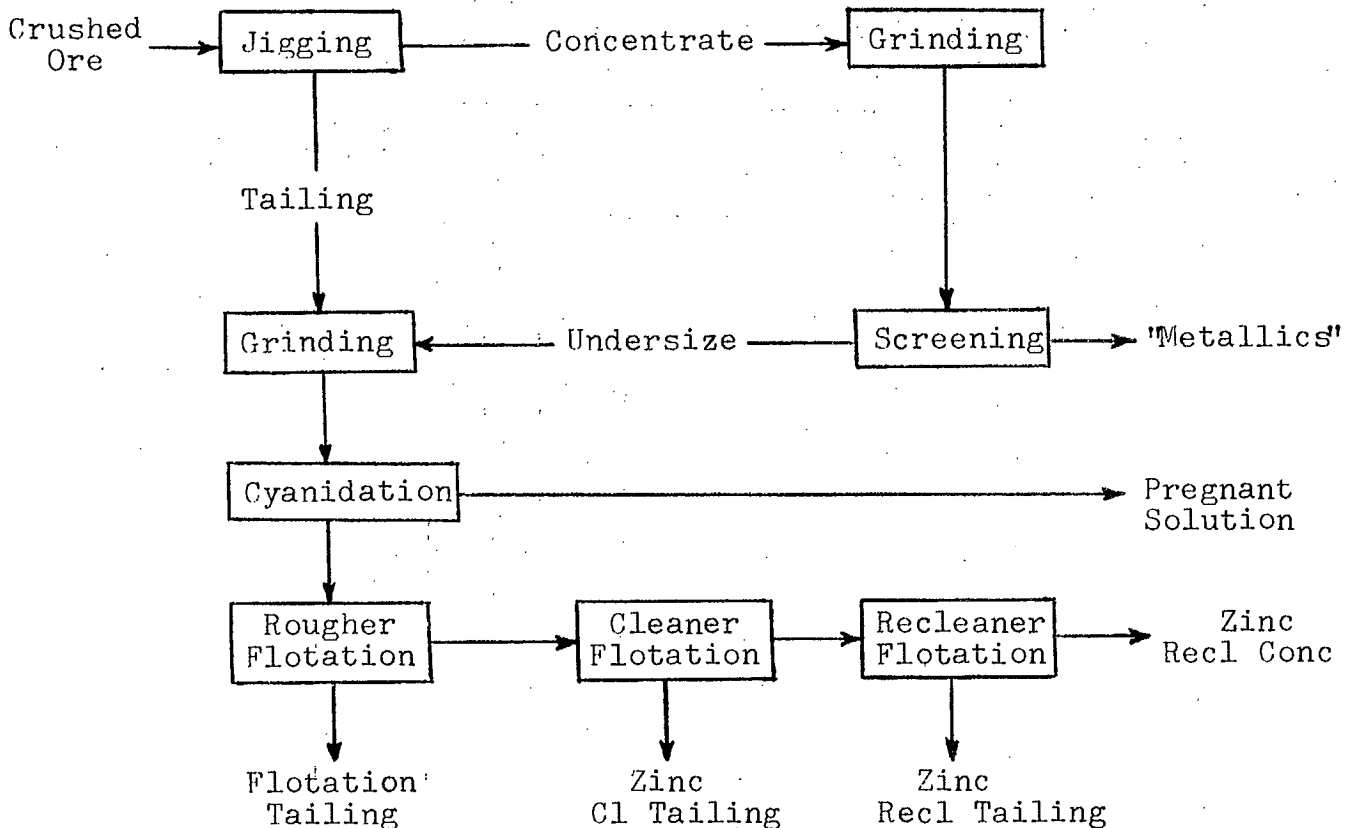


TABLE 15

Test Results with Flowsheet I

Product	LOW GRADE ORE					HIGH GRADE ORE				
	Weight %	Analysis*		Dist'n %		Weight %	Analysis*		Dist'n %	
		oz Ag/ton	% Zn	Ag	Zn		oz Ag/ton	% Zn	Ag	Zn
"Metallics"	0.01	20485.	—	19.7	—	0.2	23246.	—	29.8	—
Pregnant sol'n	—	8.04	—	77.5	—	—	106.4	—	68.0	—
Zn recl conc	1.2	14.98	65.8	1.7	91.1	7.1	39.44	60.0	1.8	89.0
Zn recl tailing	7.0	0.50	0.45	0.4	3.6	2.2	4.54	4.22	0.1	2.0
Zn cl tailing	15.3	0.11	0.10	0.2	1.8	29.9	1.33	1.18	0.2	7.3
Flot tailing	76.49	0.07	0.04	0.5	3.5	60.6	0.19	0.13	0.1	1.7
Feed (calcd)	100.00	10.37	0.87	100.0	100.0	100.0	156.1	4.78	100.0	100.0

* From Internal Reports MS-AC- 67-190, 205 and 334.

Note: The solution assays are expressed on the basis of cyanidation feed. The reagent consumption during cyanidation was 1.9 lb NaCN and 6.0 CaO/ton of ore, and 15.1 lb NaCN and 4.6 lb CaO/ton of ore for the "low grade" ore and the "high grade" ore respectively.

2. Separation of "Metallics", Flotation of Silver, Cyanida- tion of Concentrate and 2 inc Flotation

Procedure

- a) Jigging of crushed ore at -20 mesh.
- b) Grinding of jig concentrate to 99.9+% -100 mesh.
- c) Screening of "metallics" on 100-mesh sieve.
- d) Grinding of jig tailing to 77% -200 mesh.
- e) Silver flotation for 30 min with copper sulphate (1.8 lb/ton), xanthate 301 (0.18 lb/ton), Aerofloat 25 (0.06 lb/ton) and Dowfroth 250 (0.12 lb/ton).
- f) Cyanidation of the concentrates for 72 hrs in solution strengths of 2.0 lb NaCN and 1.0 lb CaO per ton at liquid:solid ratios of 5:1 for the "low grade" ore and 7:1 for the "high grade" ore. The latter was filtered and repulped after 36 hours.
- g) Zinc flotation from cyanidation residue, as in Test 24 (Table 12).

Flowsheet II

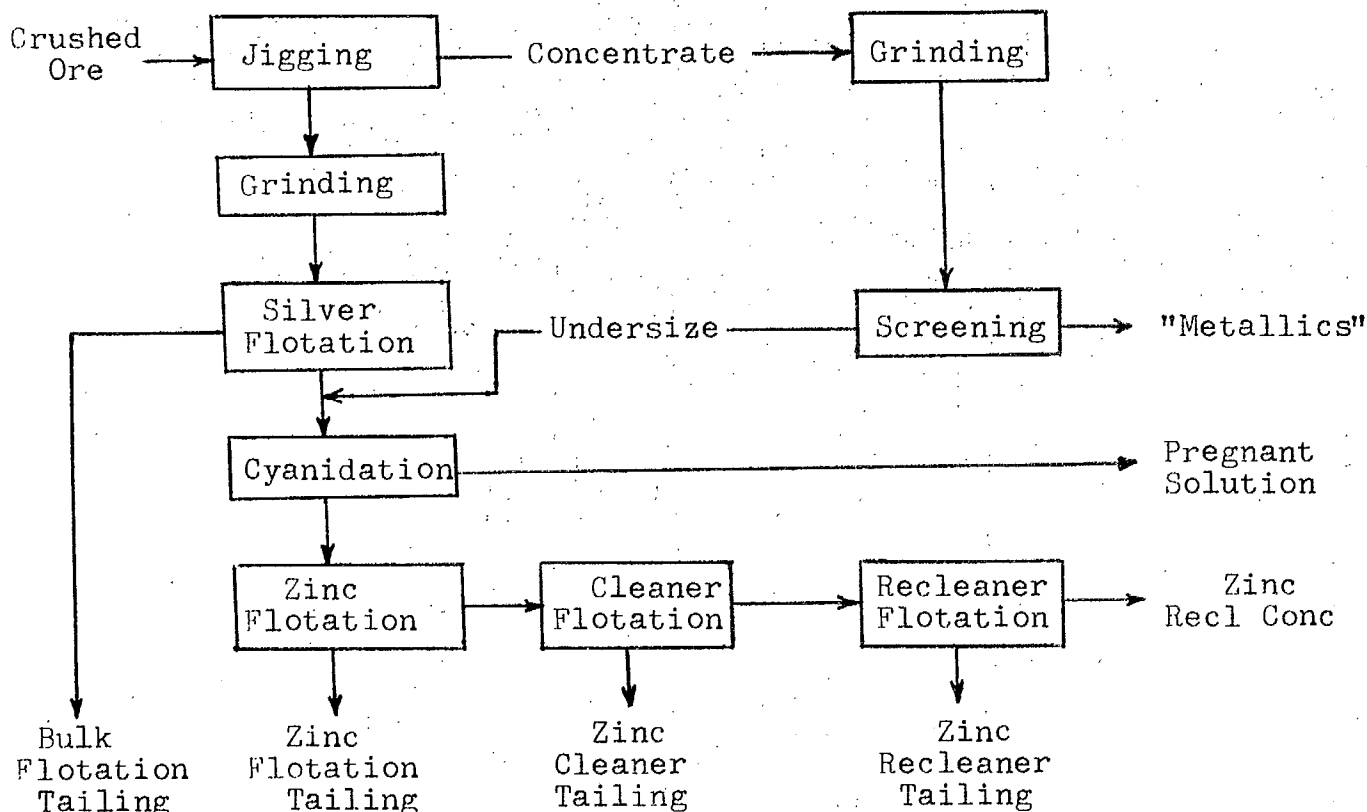


TABLE 16

Test Results with Flowsheet II

Product	LOW GRADE ORE					HIGH GRADE ORE				
	Weight %	Analysis*		Dist'n %		Weight %	Analysis*		Dist'n %	
		oz Ag/ton	% Zn	Ag	Zn		oz Ag/ton	% Zn	Ag	Zn
"Metallics"	0.01	22491.	—	22.2	—	0.02	23216.	—	30.1	—
Pregnant sol'n	—	51.94	—	71.2	—	—	309.1	—	67.5	—
Zn recl conc	1.4	12.87	56.0	1.8	89.8	6.8	39.64	69.0	1.7	95.2
Zn recl tailing	0.6	0.91	1.00	0.1	0.8	2.7	3.19	1.50	0.1	0.9
Zn cl tailing	2.2	0.69	0.60	0.2	1.5	4.5	2.65	1.20	0.1	1.2
Zn flot tailing	9.7	0.59	0.28	0.5	3.0	19.7	1.55	0.42	0.2	1.9
Bulk flot tailing	86.09	0.48	0.05	4.0	4.9	66.28	0.70	0.05	0.3	0.8
Feed (calcd)	100.00	10.14	0.88	100.0	100.0	100.00	154.3	4.43	100.0	100.0

* From Internal Report MS-AC- 190, 198, 205 and 334.

Note: The solution assays are expressed on the basis of cyanidation feed. The reagent consumption during cyanidation was 1.2 lb NaCN and 2.0 lb CaO per ton of ore, and 8.7 lb NaCN and 2.9 lb CaO/ton of ore for the "low grade" ore and the "high grade" ore respectively.

SUMMARY AND CONCLUSIONS

The ore samples received from Creswell Mines contained the following valuable constituents:

"Low grade" ore — 9.6 oz Ag/ton and 0.94 % Zn
 "High grade" ore — 160.9 " " " " 4.75 " "

About 25% of the silver was present as coarse flakes of acanthite and native silver; the remainder was of smaller grain size. The zinc occurred mostly as masses of sphalerite.

As requested by the company, a first series of tests was made to determine if direct cyanidation could effectively recover the silver. However, this method was precluded because of the slow dissolution rate of the large silver flakes resulting in unsatisfactory extraction after normal cyanidation periods (48 to 72 hours). Therefore, any flowsheet for the treatment of this ore should include a method for recovering the coarse silver prior to cyanidation. This was effectively done by jigging, grinding and screening on a 100-mesh sieve. Laboratory tests made along these lines indicated that 20% to 30% of the silver could be recovered in the form of "metallics" concentrates assaying more than 20,000 oz/ton, suitable for direct silver smelting.

Treatment of the residual ore was attempted by cyanidation with and without preconcentration. When cyaniding the ore directly after "metallics" separation, the extraction attained 95.7% with the "low grade" ore and 96.0% with the "high grade", after a 48-hour contact time. Cyanidation without such a separation extracted only 93.7% and 75.0% of the silver, respectively.

Flotation of the jig tailing recovered 90% of the residual silver in the "low grade" ore and 99% of the silver in the "high grade" ore. The flotation concentrates were then mixed with their respective jig-undersize products and cyanided. Although this process reduced the cyanidation feed by three to five times, this advantage might be offset by slightly lower silver recoveries and by the necessity of higher dilution and longer contact time in order to obtain satisfactory extraction from the enriched concentrates. "Metallics" separation with silver concentration and cyanidation resulted in overall recovery of 94% with the "low grade" ore and 97% with the "high grade" ore.

Finally, the cyanidation residues of previous tests were treated by flotation for zinc recovery. This operation also permitted scavenging the undissolved silver. Typical tests on both type of ores produced concentrates assaying 55% to 65% Zn with recoveries of 90% of the zinc and 70% of the silver contained in the residues.

To confirm the previous results and to complete the in-

vestigation, integrated tests (see Flowsheet I and II) were made using the two best procedures found for the treatment of the Creswell ore, namely, separation of "metallics" by jigging and screening followed by (I) cyanidation of the residual ore and zinc flotation, and (II) flotation of the silver, cyanidation of both flotation concentrate and jig undersize, and zinc flotation from the residue. The results of these tests are summarized in the following table:

TABLE 17
Comparative Results with Flowsheet I and II

Flow-Sheet	Product	LOW GRADE ORE		HIGH GRADE ORE	
		Analysis oz/ton	Cumulative Recovery%	Analysis oz/ton	Cumulative Recovery%
I	"Metallics"	Ag 20,485	19.7	23246	29.8
	Pregnant sol'n	Ag 8	97.2	106	97.8
		Ag 15	98.2	39	99.6
	Zn recl conc	Zn 56%	Zn 91.1	Zn 60%	Zn 89.0
II	"Metallics"	Ag 22,491	22.2	23216	30.1
	Pregnant sol'n	Ag 52	93.4	309	97.6
		Ag 13	95.2	40	99.3
	Zn recl conc	Zn 56%	Zn 89.8	Zn 62%	Zn 95.2

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