Mineral Sciences

CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 73-52

A STUDY OF CONCENTRATING TECHNIQUES ON A COMPLEX, FINE-GRAINED Cu-Pb-Zn-Ag ORE FROM NADINA EXPLORATIONS LIMITED, OWEN LAKE AREA, BRITISH COLUMBIA.

by

A. STEMEROWICZ AND R.W. BRUCE

MINERAL PROCESSING DIVISION

NOTE: THIS REPORT RELATES ESSENTIALLY TO THE SAMPLES AS RECEIVED. THE REPORT AND ANY CORRESPONDENCE CONNECTED THEREWITH SHALL NOT BE USED IN FULL OR IN PART AS PUBLICITY OR ADVERTISING MATTER.

COPY NO. 9

JULY 1973

Mines Branch Investigation Report IR 73-52

A STUDY OF CONCENTRATING TECHNIQUES ON A COMPLEX, FINE-GRAINED Cu-Pb-Zn-Ag ORE FROM NADINA EXPLORATIONS LIMITED, OWEN LAKE AREA, BRITISH COLUMBIA.

by

A. Stemerowicz* and R. W. Bruce**

SUMMARY OF RESULTS

The two samples investigated assayed as follows:

Sample No.	% Cu	% Pb	% Zn	oz/ton Ag	oz/ton Au
No. 1	1.17	2.18	8.74	13.98	0.17
No. 2	0.72	1.90	9.75	8.37	0.10

Mineralization consisted mainly of pyrite and sphalerite with lesser amounts of galena, chalcopyrite, and silver-bearing tennantite. Other important economic minerals identified in the ore were argentiferous tetrahedrite and native gold. Most of the tennanite was intimately associated with pyrite and chalcopyrite. Other significant associations were silver-bearing minerals with galena and galena with pyrite.

The best results obtained for copper and lead concentration were as follows:

Analyses

	No. 1 Sample			No. 2. Sample		
	Cu %	Pb %	Ag oz/ton	Cu %	Pb %	Ag oz/ton
Cu conc	23.25	4.20	99.13	27.08	4.45	163.36
Pb conc	1.05	59.00	122.14	0.69	70.45	43.71
Tailing	0.36	0.41	7.10	0.21	0.39	3.98

---

*Research Scientist and **Head, Non-Ferrous Minerals Section, Mineral Processing Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

Distribution, %

	No. 1 Sample			No. 2 Sample		
	Cu	Pb	Ag	Cu	Pb	Ag
Cu conc	53.2	5.6	18.4	44.7	3.0	21.4
Pb conc	1.8	58.4	16.9	1.0	42.6	5.1
Middlings	16.2	19.1	18.2	26.1	32.6	30.0
Tailing	28.8	16.9	46.5	28.2	21.8	43.5

These results were achieved on the No. 1 Sample by selectively floating copper and lead concentrates directly from the ore and on the No. 2 Sample by separating the copper from a bulk copper-lead concentrate by means of the sulphur dioxide-starch method and floating the lead from the reground separation tailing.

The recovery of silver from the ore could be increased by as much as 14% by floating a pyrite concentrate, followed by roasting it and then cyaniding the calcines to recover the associated silver.

The flotation of zinc from the copper-lead rougher tailings gave a cleaner concentrate assaying 64 to 65% zinc with rougher recoveries of 82 to 87%.

CONTENTS

CONTENTS Continued

CONTENTS Continued

Flotation Test Reports

CONTENTS Continued

Page

Flotation Test Reports

Cyanidation Test Reports

CONTENTS Continued

Cyanidation Test Reports

FIGURES

INTRODUCTION

Location of Property

The property is located at Owen Lake, 27 miles south of Houston, B. C.

Shipment:

Two ore Samples were received as follows:

Sample No.	Date received	Weight, lb.
1	December 29, 1969	140
2	December 16, 1970	200

Nature of Investigation Requested

In a letter dated December 16, 1969, Mr. H. B. Johnston, Manager of Nadina Explorations Limited (N.P.L.) P.O. Box 489, Houston, B.C. requested a metallurgical investigation of the ore. In answer to a request for further information, it was stated that the potential of the orebody was greater than a million tons and that production at 500 tpd was being contemplated.

Sampling and Analysis

The ore samples were stage-crushed to minus 10 mesh and riffled into portions. One of these portions was chosen as the head sample, the remaining portions, after adjustment to 2000 grams, made up the charges to individual tests. In order to minimize oxidation of sulphide minerals, the crushed material was stored in a freezer.

TABLE 1

Head Sample Analyses*

Constituent	Sample No. 1	Sample No. 2
Copper %	1.17	0.72
Lead "	2.18	1.90
Zinc "	8.74	9.75
Gold oz/ton	0.17	0.103
Silver " "	13.98	8.37
Cadmium %	0.07	
Soluble iron "	12.83	12.51
Sulphur "	16.41	16.04
Insolubles "	40.18	41.00
Arsenic "	0.36	
Antimony "	0.17	

*From Internal Reports 70-139, 147, 745 and 71-79, 86.

TABLE 2

Semi-Quantitative Spectrochemical Analysis of Head Sample No. 1*

Elements	Range %
Si, Fe, Zn	Principal constituents
Pb, Ba	0.5 to 0.7
Mn, Al, Cu, Ni, Ca	0.1 to 0.3
Mg, Sr, Cr, In	0.04 to 0.09
Ti, Bi, Ag, Mo, Zr	0.01 to 0.03
V	< 0.01
Be, Sb, As, W, Sn, Nb	Not detectable
Ta, Ga, Ge, Na, Co, Cd	

*From Internal Report SL 70-12

Mineralogical Examination

A comprehensive mineralogical examination* was carried out on No. 1 Sample by the Mineral Sciences Division. This showed that the ore was composed essentially of small masses and disseminations of various sulphide minerals in a siliceous and carbonaceous matrix. The zinc content of the ore was largely accounted for by sphalerite, the lead by galena, and the copper by chalcopyrite, tennantite, and tetrahedrite. Most of the silver in the ore was present as a constituent of tennantite and tetrahedrite. Electron microprobe analyses gave a silver content of 1.5 to 4.0% in the tennantite and 8.0 to 17% in the tetrahedrite. Other silver minerals present in the sample were stephanite(?), pyrargyrite(?), matildite ($AgBiS_2$) and berryite $6(Pb_2(Cu, Ag)_3\ Bi_5S_{11})$. Gold occurred in trace amounts as the native metal. Other minerals identified in the ore were pyrite, marcasite, aikinite (Pb Bi Cu S_3), hematite, magnetite, ilmenite, goethite, rutile, anatase, quartz, manganiferous siderite, dolomite, apatite, mica, and barite.

The sphalerite, which contains an average of 0.3% cadmium and less than 1% iron, is essentially coarse-grained and should largely be liberated by normal grinding methods. It is expected that traces of silver (as tennantite) and lead as galena will be retained by the sphalerite as very small inclusions.

Most of the galena is quite coarse-grained. However, difficulty can be expected in liberating the very small grains of galena that occur in the pyrite, and to a lesser extent, in the sphalerite and tennantite.

---

*Mines Branch Investigation Report IR 70-47 by D. Owens

The silver in the ore will be distributed chiefly between the lead and copper concentrates, in the former as inclusions of pyrargyrite, stephanite, and tetrahedrite in the galena and in the latter as a constituent of the tennantite and tetrahedrite.

Liberation of the copper minerals from other minerals in the ore should generally be effective. However, some copper will occur in the lead concentrate as inclusions of tetrahedrite in galena. Most of these are very small and will be difficult to free. In addition, it is expected that some of the tennantite in association with pyrite and, to a lesser degree with sphalerite will be difficult to liberate because many of these inclusions are very small.

OUTLINE OF INVESTIGATION

The aim of the investigation was to produce copper, lead, and zinc concentrates from the ore by flotation, with the optimum amount of gold and silver to be recovered in the copper and lead concentrates. Two techniques were developed for producing copper and lead concentrates, viz; flotation of a bulk copper-lead concentrate followed by copper-lead separation of the bulk concentrate and selective flotation of copper and lead concentrates directly from the ore. After flotation of the copper and lead minerals, a zinc concentrate was floated from the tailing using standard procedure.

Copper-Lead Separation of Bulk Concentrate

The copper, lead, and silver minerals were floated together into a bulk concentrate. The bulk rougher concentrate was upgraded by cleaning and then subjected to copper-lead separation either by (1) depressing the copper minerals with cyanide and floating off the galena or (2) depressing the

galena with either dichromate or sulphur dioxide and starch and floating off the copper minerals.

Before attempting copper-lead separation of the bulk concentrate, reagents and conditions for bulk flotation were investigated as follows:

(1) Alkalinity regulator and depressants:

(a) Soda ash + sodium sulphite + cyanide, pH 7.6 to 8.4
(b) Lime + zinc sulphate + cyanide, pH 10.5 to 10.9
(c) Lime + sodium sulphite + cyanide, pH 10.0 to 10.2

(2) Grind:

(a) 80.6% minus 200 mesh
(b) 92.3% " " "

(3) Collectors:

(a) amyl xanthate
(b) Aerofloat 208 + Z-200
(c) Aerofloat 208 + Aerofloat 242

(4) Conditioning:

(a) with aeration in an aerator
(b) without aeration in a laboratory flotation cell.

After determining which set of reagents and conditions gave optimum results for bulk flotation, 8 copper-lead separation tests were carried out; 3 on bulk concentrate produced from No. 1 Sample and 5 on bulk concentrate produced from No. 2 Sample.

In addition to the standard separation methods, other schemes were developed in which selective flotation techniques were employed in conjunction with regrinding. The purpose of regrinding was to improve separation efficiency by liberating the copper, lead, and silver minerals that were intimately associated with pyrite.

In the initial test (20), the bulk rougher concentrate was reground before cleaning. Soda ash, sodium sulphite, and cyanide were added to the regrind mill; the former for alkalinity control and the latter two reagents to depress sphalerite and pyrite. The depressants added to the regrind mill had such a severe depressing action on the copper minerals that most of the copper-lead separation occurred during cleaning instead of in the subsequent separation step as was intended. The enhanced effect of the depressants in regrinding was used to advantage in Test 21 in which a lead concentrate was floated from the reground bulk rougher concentrate followed by the addition of copper sulphate and copper flotation. This scheme had the disadvantage that the sphalerite was reactivated with copper sulphate along with the copper minerals. Then a new approach was adopted. It consisted of regrinding the bulk rougher concentrate with sulphur dioxide and starch followed by the selective flotation of copper, lead, and zinc concentrates from the reground material (Test 24). It was hoped that the zinc concentrate produced would be high enough in grade to be included with the primary zinc concentrate floated from the ore and that the tailing would be low enough in metal values so that it could be rejected to waste. When this method gave disappointing results further modifications were made. These were to subject the bulk rougher concentrate to copper-lead separation using the sulphur dioxide-starch method followed by lead flotation from the regound separation tailing. Soda ash, sodium sulphite and cyanide were added to the regrinding step.

A flowsheet for bulk flotation with copper-lead separation of the bulk concentrate is given in Figure 1, while Figures 2 to 5 give flowsheets and other pertinent data for the more complex separation techniques described above.

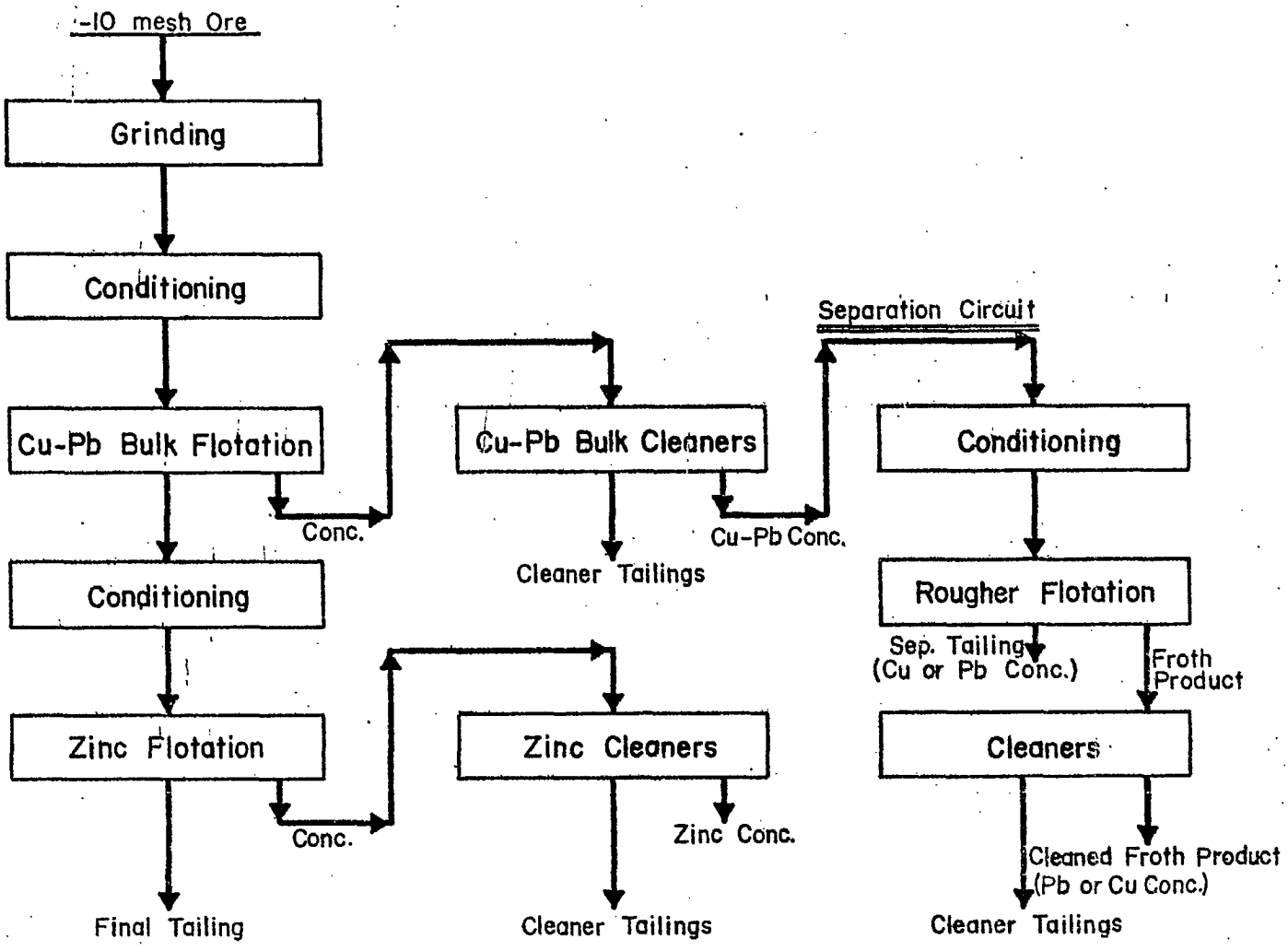

Figure I FLOWSHEET No.I – BULK FLOTATION FOLLOWED BY COPPER LEAD SEPARATION OF BULK CONCENTRATE

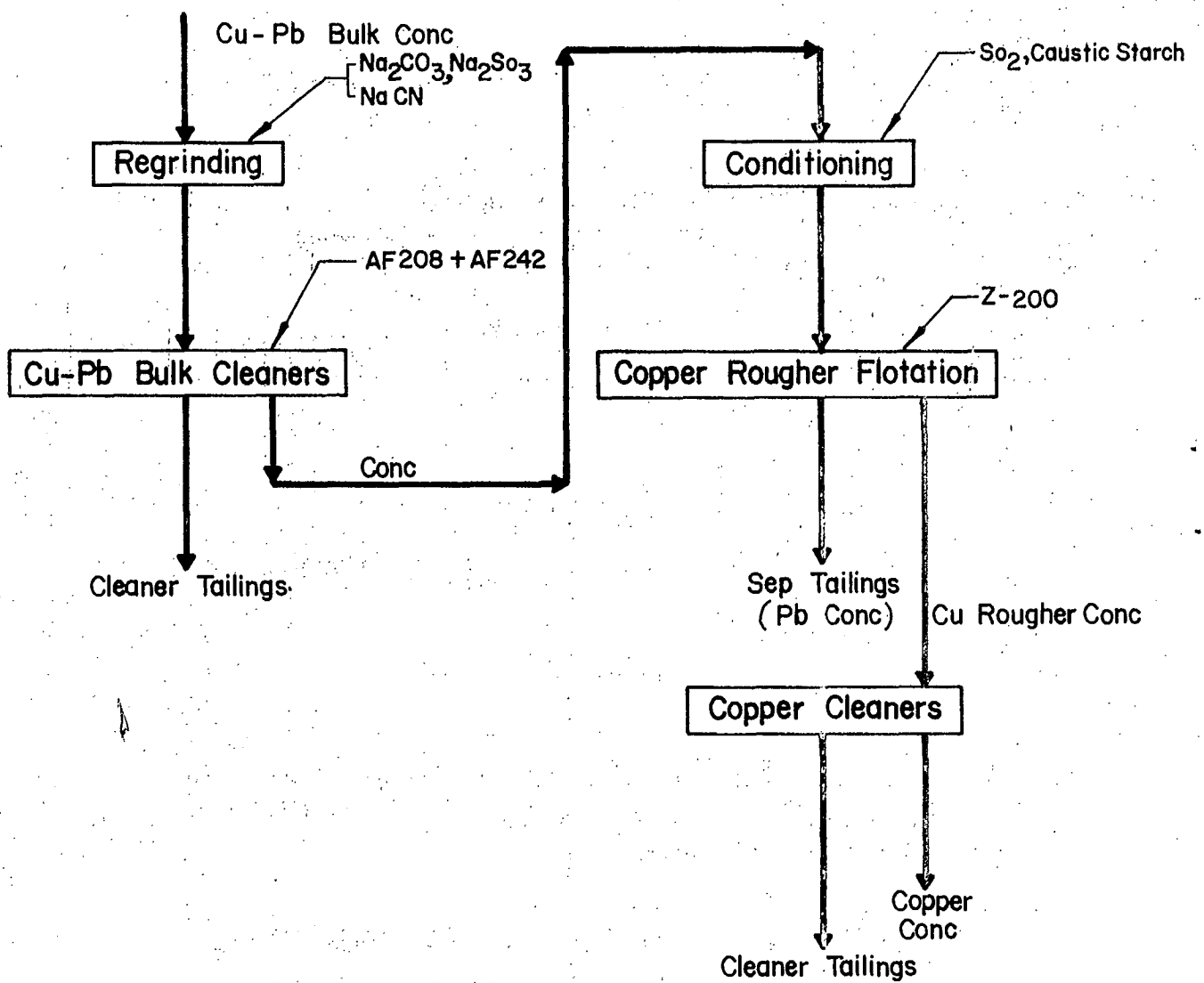

Figure 2 - MODIFIED COPPER-LEAD SEPARATION, BULK CONCENTRATE REGROUND BEFORE CLEANING

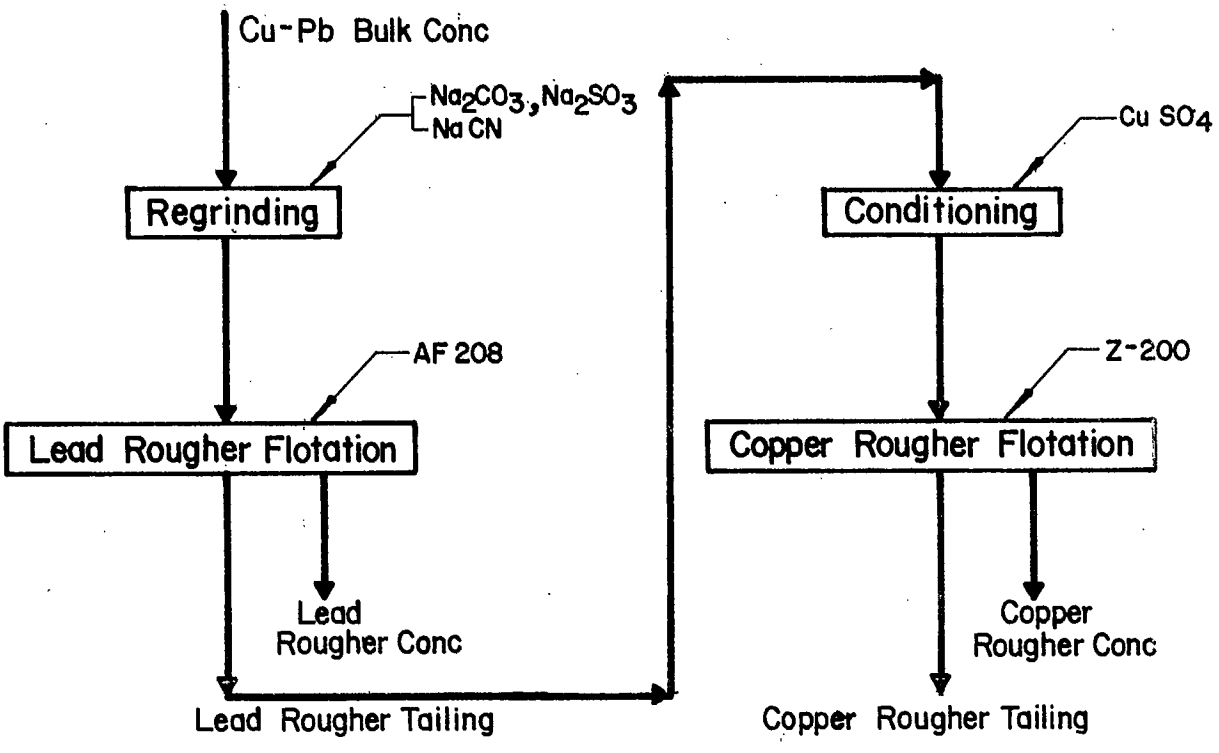

Figure 3 - MODIFIED COPPER-LEAD SEPARATION, SELECTIVE FLOTATION OF LEAD AND COPPER CONCENTRATES FROM REGROUND BULK CONCENTRATE

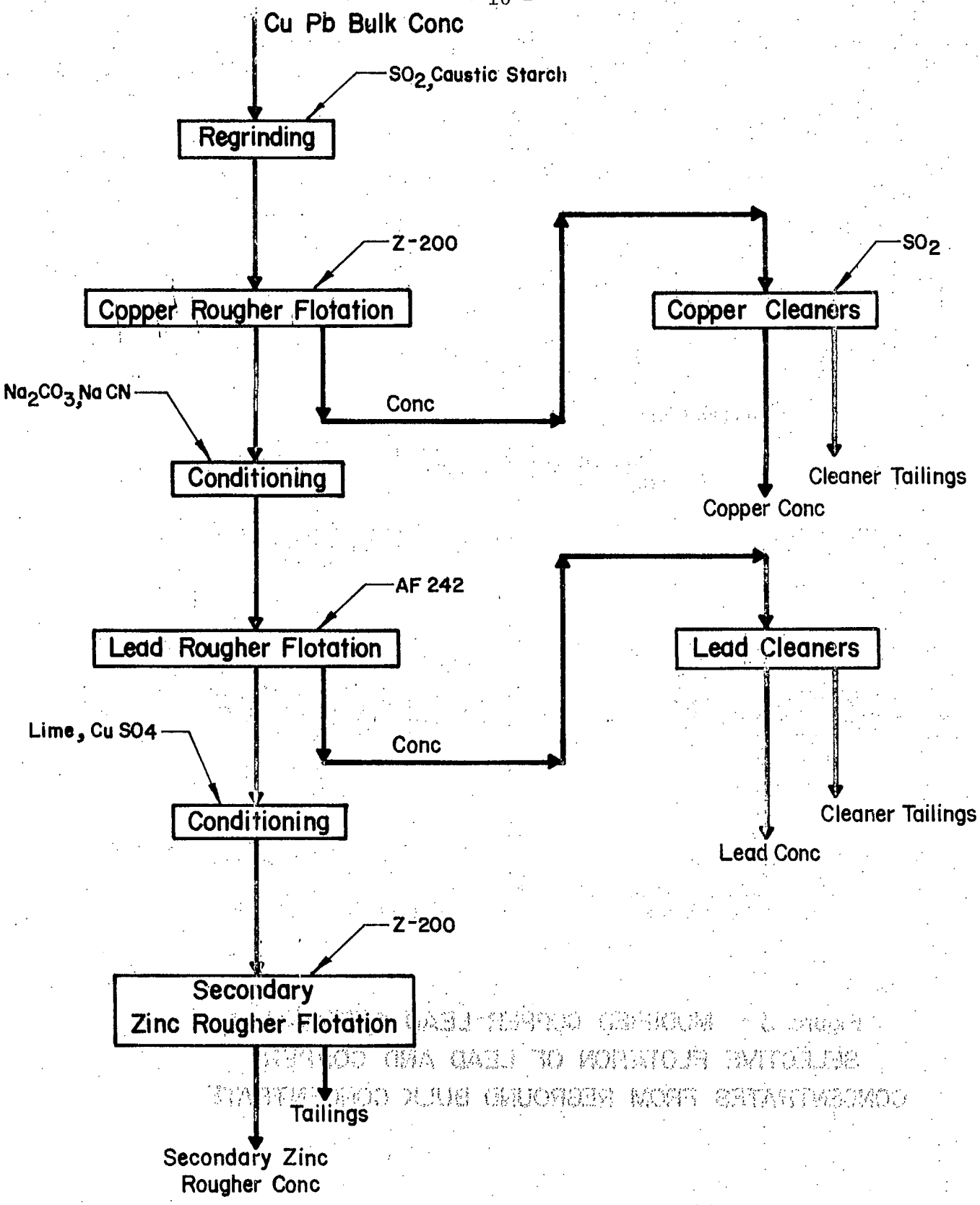

Figure 4- MODIFIED COPPER-LEAD SEPARATION, SELECTIVE FLOTATION OF COPPER, LEAD AND ZINC CONCENTRATES FROM REGROUND BULK CONCENTRATE

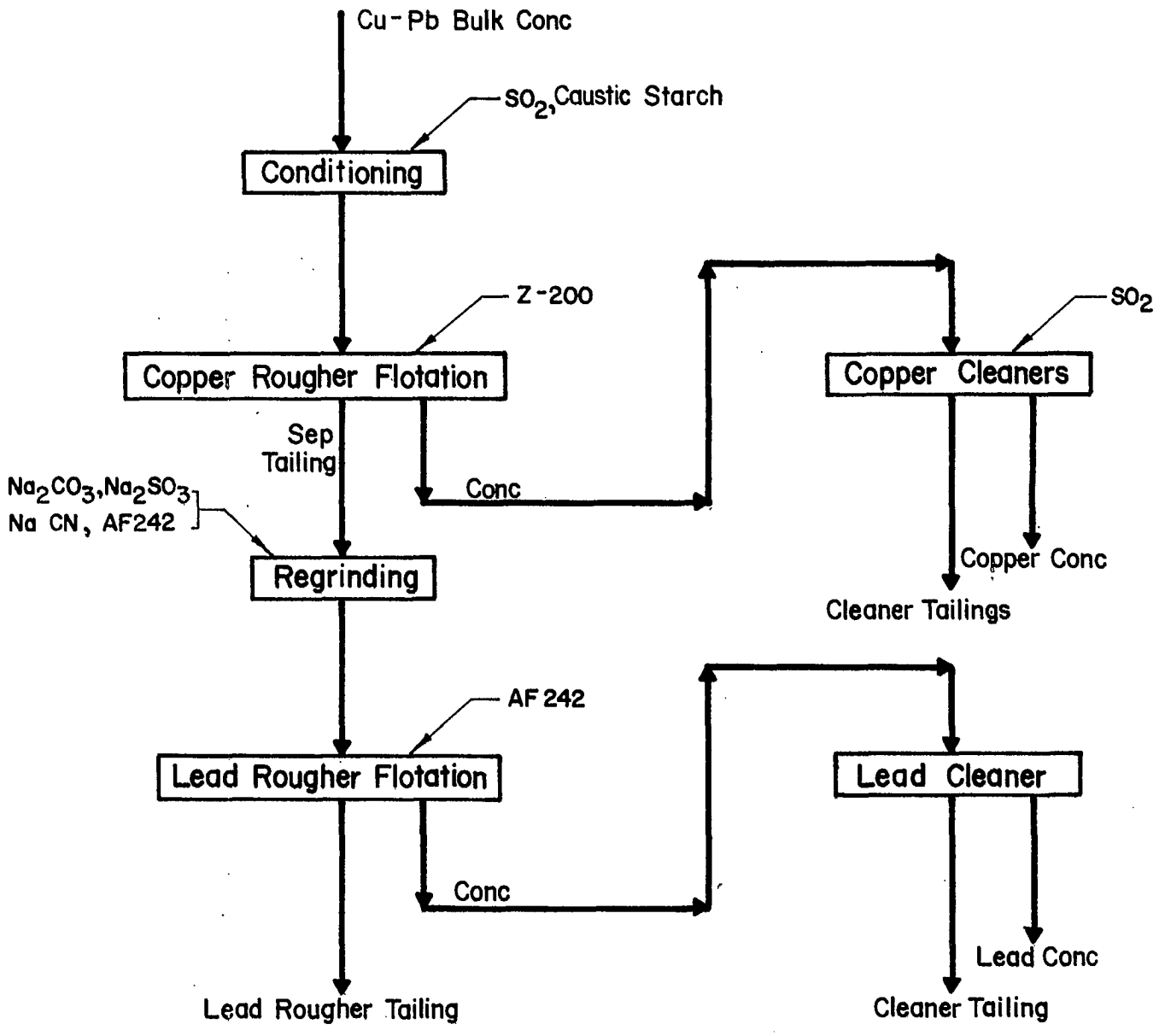

Figure 5- MODIFIED COPPER-LEAD SEPARATION, SO_2-STARCH SEPARATION ON Cu-Pb BULK ROUGHER CONC FOLLOWED BY LEAD FLOTATION FROM REGROUND SEPARATION TAILING

Selective Flotation Directly from the Ore

A copper concentrate was selectively floated from the ore by employing sulphur dioxide as a galena depressant. The galena was then reactivated by adding lime and cyanide, and a lead concentrate was floated off. It was anticipated that the liberated, argentiferous tetrahedrite and tennantite would be unaffected by sulphur dioxide and would therefore float with chalcopyrite while the balance of the silver minerals intimately associated with galena would be recovered in the lead concentrate.

Five selective flotation tests were done, all on the No. 1 Sample. In the first two tests potassium amyl xanthate was employed as collector for both lead and copper. In the remaining tests it was replaced by the more selective copper and lead collectors, Z-200 and Aerofloat 242. Other variables investigated were aeration of the pulp before copper flotation and very fine grinding (Test 16). Figure 6 gives the flowsheet for selective flotation.

Dolmage Campbell Flowsheet

In addition to the schemes described above, a third flowsheet was tried on No. 2 Sample at the request of Mr. J. D. Gunn of Dolmage Campbell and Associates Ltd., who had been retained as consulting engineers by Nadina Explorations and were carrying out a concurrent metallurgical investigation. This flowsheet, which was developed by Mr. Gunn, employed a combination of selective flotation and copper-lead separation techniques as follows:

(1) The ore was ground with sodium sulphite and zinc sulphate added as sphalerite and pyrite depressants.

(2) A low-lead bulk concentrate was floated off (pH < 7) with Aerofloat 208 as collector.

(3) The pulp was conditioned with lime and cyanide (pH c.8) and a scavenger concentrate was floated off using ethyl xanthate as collector.

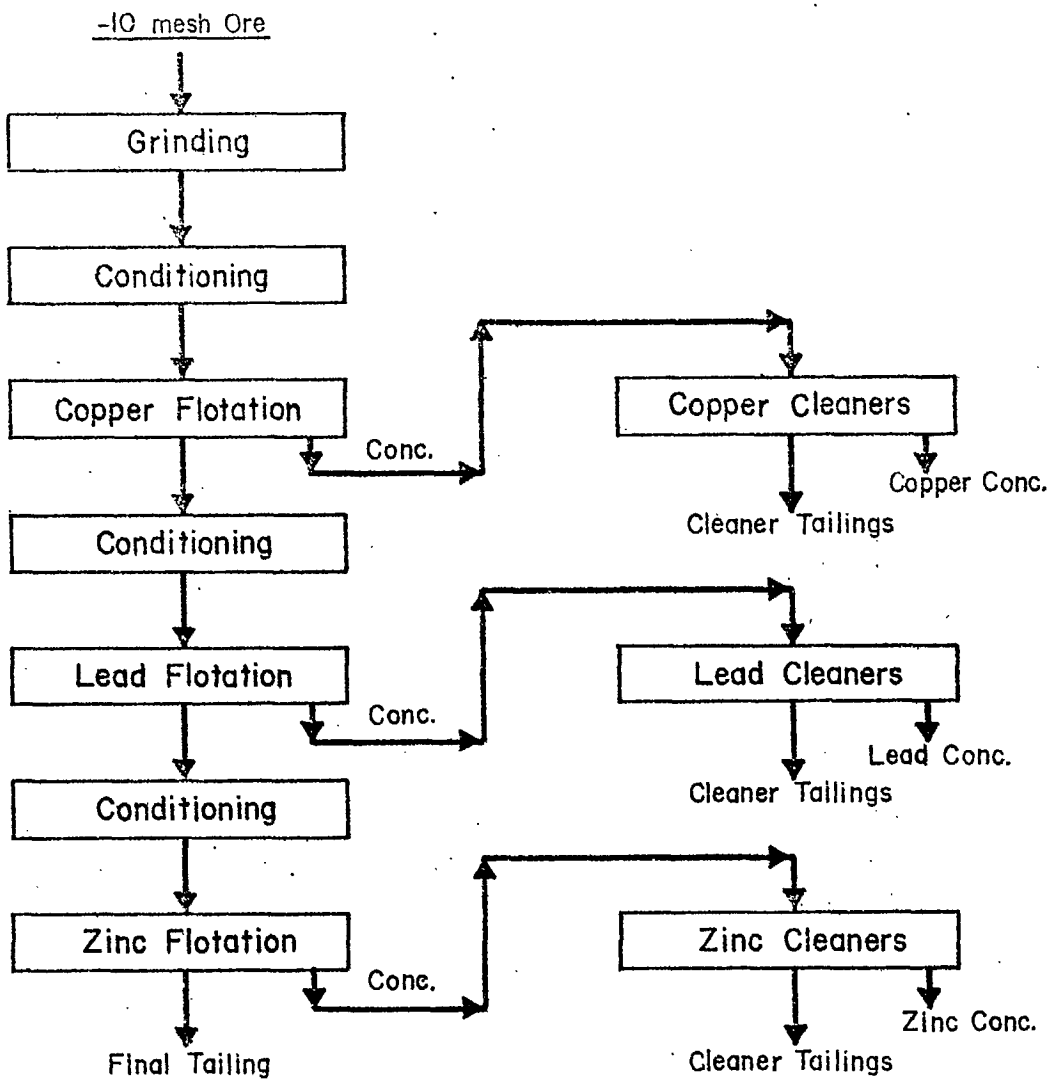

Figure 6 FLOWSHEET No. 2 — SELECTIVE FLOTATION OF COPPER AND LEAD CONCENTRATES DIRECTLY FROM THE ORE

(4) The scavenger concentrate was reground and subjected to a series of selective flotation techniques to produce a secondary copper-lead concentrate and a secondary lead concentrate.

(5) The secondary copper-lead concentrate was combined with the cleaned bulk concentrate from (1) and the resultant product was subjected to copper-lead separation using the sulphur dioxide-starch method.

The flowsheet was designated by Mr. Gunn, as the "Nadina Flowsheet, October 1970" but will be referred to in this report as the Dolmage Campbell flowsheet. The flowsheet, which is shown in Figure 7, without zinc flotation which was omitted, was tried in two tests on the No. 2 Sample (22 and 23). In Test 22, the object was to ascertain the make-up of the intermediate products, therefore copper-lead separation and lead flotation from the secondary copper-lead rougher and cleaner tailings was not done. In Test 23, the flowsheet was tried in its entirety.

Modified Dolmage Campbell Flowsheet

A study of the reagent scheme employed in the Dolmage Campbell flowsheet along with the results obtained indicated that it could be modified to serve as a method for selectively floating copper and lead concentrates directly from the ore. What was designated as the copper-lead rougher concentrate and the copper-lead scavenger concentrate would then become the copper and lead rougher concentrates respectively. A modified version, as shown in Figure 8 was tried on No. 2 Sample in Test 25. Modifications were as follows:

(1) Z-200, a more selective copper promoter, was substituted for Aerofloat 208 in the copper rougher float.

(2) Sulphur dioxide was added to the copper cleaners for lead depression.

(3) After regrinding the lead rougher concentrate was upgraded by simple cleaning.

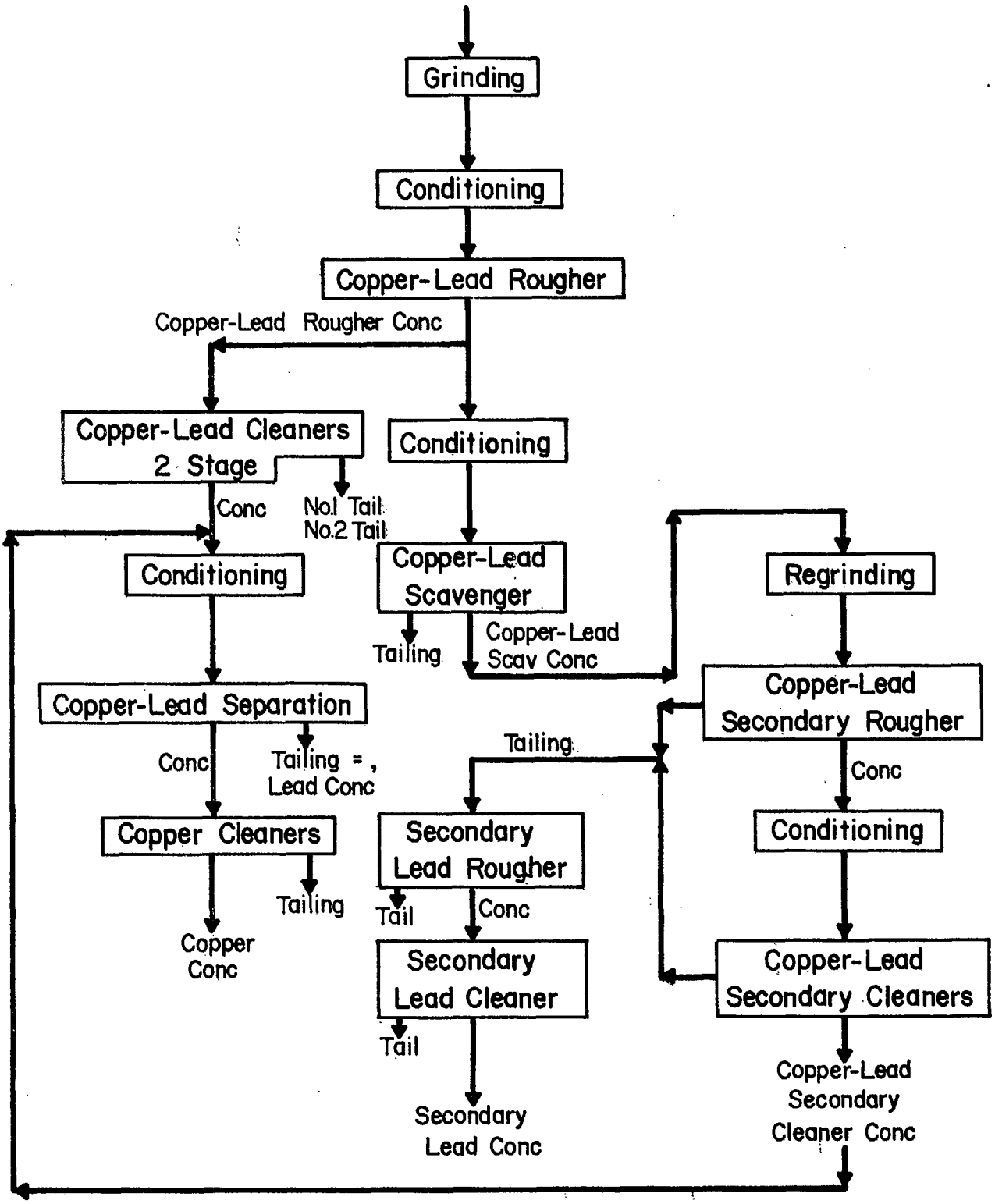

Figure 7- DOLMAGE CAMPBELL FLOWSHEET

Zinc Flotation

In most tests (16 out of 26), a zinc concentrate was floated from either the copper-lead rougher tailing or, in the case of selective flotation, from the lead rougher tailing. The sphalerite floated readily to give excellent concentrate grades accompanied by high recoveries. Sodium aerofloat was employed as the main zinc collector augmented by smaller additions of either amyl xanthate or Z-200. A high pH (11-12) was maintained in the roughers and cleaners to ensure maximum selectivity between sphalerite and pyrite.

Silver Recovery from Pyrite Concentrate

The main problem encountered in concentrating the ore was the high loss of silver in the tailing. Mineralogical examination showed that this was due mainly to the interlocking of silver minerals with pyrite. As a first step in recovering this silver, a pyrite concentrate was floated from the zinc rougher tailing.

Two silver recovery methods were tried on the pyrite concentrate as follows:

(1) Flotation of Silver from the Pyrite Concentrate

The pyrite concentrate was reground to liberate the interlocked silver minerals and a silver concentrate was selectively floated away from the pyrite. This was accomplished by employing lime and cyanide as pyrite depressants and Aerofloat 208 and 242 as collectors for the silver minerals.

(2) Cyanidation

Silver recovery by cyanidation was tried in nine tests on pyrite concentrate floated from both the No. 1 and No. 2 Samples. In most tests, the pyrite concentrate was roasted prior to cyanidation but cyanidation of the finely reground, raw concentrate was also tried. Roasting temperature and length of roast were varied; also the effect of adding lime to the charge was investigated.

Test Data

Screen analyses of grinds employed, detailed test procedure, and metallurgical balances for all flotation and cyanide tests are given in Appendix A.

EVALUATION AND DISCUSSION OF RESULTS

Best Copper and Lead Results

Tables 3 and 4 compare the best results obtained for copper and lead concentration by various flotation techniques.

TABLE 3

Best Copper and Lead Flotation Results Obtained on No. 1 Sample

Test No. and Method	Product	Wt %	Analysis*				Distribution %			
			Cu	Pb	Zn	Ag	Cu	Pb	Zn	Ag
16 Selective flotation	Copper conc	2.45	23.25	4.20	4.29	99.13	53.2	5.6	1.1	18.4
	Copper cl tail	2.54	4.94	5.39	9.12	51.72	11.7	7.4	2.4	10.0
	Lead conc	1.82	1.05	59.00	4.67	122.14	1.8	58.4	0.9	16.9
	Lead cl tail	7.29	0.66	2.39	8.68	14.76	4.5	9.5	6.6	8.2
	Lead ro tail	85.90	0.36	0.41	9.90	7.10	28.8	19.1	89.0	46.5
	Feed (calcd)	100.00	1.06	1.84	9.56	13.14	100.0	100.0	100.0	100.0
18 Copper-lead Separation (SO_2-starch method)	Copper conc	2.67	23.68	12.98	3.43	130.70	56.5	17.8	1.0	26.5
	Copper cl tail**	1.08	7.12	19.31	3.98	108.15	6.9	10.8	0.5	8.9
	Lead conc	2.45	2.66	34.08	5.49	87.88	5.8	43.0	1.5	16.3
	Cu-Pb cl tail**	5.43	2.13	6.21	11.50	33.67	10.4	17.4	7.0	13.9
	Cu-Pb ro tail	88.37	0.26	0.24	9.07	5.14	20.4	11.0	90.0	34.4
	Feed (calcd)	100.00	1.12	1.94	8.90	13.18	100.0	100.0	100.0	100.0

* Analysis in this and all subsequent tables is given in per cent except silver which is in oz per ton.

** Combined

As can be seen from Table 3 the best copper and lead concentrate grades obtained on No. 1 Sample were produced by selective flotation directly from the ore. However, copper, lead, and silver losses in the rougher tailing were higher than the losses in the tailing from bulk flotation. None of the copper-lead separation methods tried on the bulk concentrate were effective in producing a copper concentrate low enough in lead to be acceptable to a copper smelter.

TABLE 4

Best Copper and Lead Flotation Results Obtained on No. 2 Sample

Test No. and Method	Product	Wt %	Analysis				Distribution %			
			Cu	Pb	Zn	Ag	Cu	Pb	Zn	Ag
23 Dolmage-Campbell Flowsheet	Copper conc	2.45	12.50	2.12	3.10	75.57	48.9	3.0	0.8	21.1
	Copper cl tail	0.52	4.84	17.90	4.17	70.60	4.0	5.4	0.2	4.2
	Lead conc	2.74	2.85	32.17	4.68	59.47	12.4	51.0	1.4	18.5
	Sec lead tail	2.44	0.68	9.24	12.24	15.36	2.7	13.0	3.4	4.2
	Cu-Pb cl tail	3.57	2.13	7.15	10.09	32.37	12.2	14.8	4.0	13.2
	Cu-Pb ro tail	88.28	0.14	0.25	9.20	3.86	19.8	12.8	90.2	38.8
	Feed (calcd)	100.00	0.63	1.73	9.01	8.79	100.0	100.0	100.0	100.0
25 Modified Dolmage-Campbell Flowsheet (Figure 8)	Copper conc	1.02	17.86	2.74	3.06	70.94	26.8	1.6	0.4	8.1
	Copper cl tail	4.85	4.74	3.68	5.70	40.74	33.7	10.8	3.2	22.3
	Lead conc	0.70	1.25	67.70	2.50	94.92	1.3	27.7	0.2	7.5
	Lead cl tail	2.58	1.90	24.79	9.10	48.28	7.2	37.4	2.7	14.0
	Lead ro tail	90.85	0.23	0.43	9.04	4.70	31.0	22.5	93.5	48.1
	Feed (calcd)	100.00	0.68	1.71	8.77	8.88	100.0	100.0	100.0	100.0
26 Modified Copper-lead Separation (Figure 5)	Copper conc	1.11	27.08	4.45	5.15	163.36	44.7	3.0	0.6	21.4
	Copper cl tail	1.42	7.51	14.85	5.14	108.79	15.9	12.8	0.7	18.3
	Lead	0.99	0.69	70.45	3.00	43.71	1.0	42.6	0.3	5.1
	Lead cl tail	0.48	2.21	25.43	10.00	43.33	1.6	7.5	0.5	2.5
	Sec lead ro tail	3.23	1.80	6.22	10.41	24.33	8.6	12.3	3.6	9.2
	Cu-Pb ro tail	92.77	0.21	0.39	9.44	3.98	28.2	21.8	94.3	43.5
	Feed (calcd)	100.00	0.67	1.64	9.30	8.47	100.0	100.0	100.0	100.0

Of the schemes tried on No. 2 Sample the modified copper-lead separation method employed in Test 26 gave the best set of copper and lead results. This method which is outlined in Figure 5 consisted of using the SO_2 - starch separation method on the copper-lead rougher concentrate to produce a copper concentrate followed by the flotation of a lead concentrate from the reground separation tailing. The Dolmage-Campbell flowsheet (Test 23) gave low-grade concentrates attributable to a high pyrite content, whereas the modified form of this flowsheet (Test 25) gave improved cleaner concentrate grades but with excessive amounts of copper and lead rejected to the cleaner tailings.

Best Zinc Results

Table 5 gives a summary of the best zinc results obtained on the two ore samples. The feed given in this table is the feed to zinc flotation, i.e., either the copper-lead rougher tailing or the lead rougher tailing.

TABLE 5

Summary of Best Zinc Results Obtained on No. 1 and No. 2 Samples

Sample No.	Test No.	Product	Wt %	Analysis % Zn	Analysis % Fe	Distn % Zn	Overall Zn Distn %	Flotation Method for Copper and Lead
1	6	Zinc ro conc	13.50	57.63	2.82	94.4	81.9	Bulk Flotation
		Zinc ro tail	86.50	0.54		5.6	4.9	
		Feed (calcd)	100.00	8.74		100.0	86.8	
		Zinc cl conc	9.43	64.24	1.22	73.5	63.8	
1	12	Zinc ro conc	15.23	49.19	4.64	94.9	79.6	Selective Flotation
		Zinc ro tail	84.77	0.48		5.1	4.3	
		Feed (calcd)	100.00	7.90		100.0	83.9	
2	21	Zinc ro conc	16.83	52.76	3.83	96.1	87.4	Bulk Flotation
		Zinc ro tail	83.17	0.43		3.9	3.5	
		Feed (calcd)	100.00	9.23		100.0	90.9	
		Zinc cl conc	12.92	65.44	1.39	91.5	83.2	
2	25	Zinc ro conc	14.69	50.00	4.19	81.3	76.0	Modified Dolmage-Campbell Flowsheet
		Zinc ro tail	85.31	1.99		18.7	17.5	
		Feed (calcd)	100.00	9.04		100.0	93.5	

Excellent zinc concentrate grades and recoveries were obtained for both samples when copper-lead bulk flotation was employed in the preceding step (Tests 6 and 21). When copper-lead selective flotation was employed (Tests 12 and 25), subsequent zinc flotation resulted in a significantly lower, but still satisfactory grade of rougher concentrate. Also, in Test 25 the zinc loss in the tailing was inexplicably higher.

Nature of Metal Losses in Zinc Rougher Tailing

In order to determine the nature of the metal losses in the zinc rougher tailing a sample from Test 12 was separated into sized fractions by screening through 200 and 270 mesh screens and then running the minus 270 mesh material through a Warman Cyclosizer. Each size fraction was assayed and submitted for mineralogical examination to determine the mode of occurrence of the metallic minerals and their textural relationships. Assays and metal distribution in the various size fractions of the tailing are given in Table 6.

TABLE 6

Assays and Metal Distribution in Various Size Fractions of Zinc Rougher Tailing from Test 12

Size Fraction	Wt %	Assays					Distribution %				
		Cu	Pb	Zn	Au	Ag	Cu	Pb	Zn	Au	Ag
+ 200 mesh	10.3	0.14	0.19	0.29	0.13	5.54	12.8	11.9	15.5	14.0	13.8
+ 270 "	8.7	0.11	0.16	0.21	0.113	4.96	8.5	8.4	9.5	10.3	10.4
+ 41 microns*	14.3	0.15	0.17	0.20	0.156	6.72	19.1	14.7	14.8	23.3	23.2
+ 31 "	13.3	0.08	0.09	0.13	0.096	3.74	9.4	7.3	9.0	13.3	12.0
+ 23 "	11.4	0.06	0.08	0.10	0.072	3.00	6.0	5.5	5.9	8.6	8.3
+ 12 "	16.0	0.05	0.10	0.09	0.062	2.40	7.1	9.7	7.5	10.4	9.3
- 12 "	26.0	0.16	0.27	0.28	0.074	3.68	37.1	42.5	37.8	20.1	23.0
Total (calcd)	100.0	0.11	0.17	0.19	0.10	4.14	100.0	100.0	100.0	100.0	100.0
Total (assay)		0.13	0.22	0.22	0.11	3.80					

*Quartz particle size in cyclosizer fractions

As can be seen, the coarse fractions generally had a higher metal content than did the finer fractions. This was especially true for gold and silver. Mineralogical examination (see report in Appendix A) showed that in every case the metal losses were due mainly to interlocking of the various minerals with pyrite. Silver was present entirely as a constituent of tetrahedrite and tennantite. These two minerals also accounted for most of the copper loss.

Results of Silver Flotation from Pyrite Concentrate

Results of pyrite flotation from the zinc rougher tailing are given in Table 7 followed by Table 8 which gives the results of silver flotation from the reground pyrite concentrate.

TABLE 7

Results of Pyrite Flotation from Zinc Rougher Tailing (Test 13)

Product	Wt %	Analysis %			Distribution %		
		Ag	Au	S	Ag	Au	S
Pyrite rougher conc	25.15	9.96	0.28	39.10	76.5	82.4	87.8
Final tailing	74.85	1.03	0.02	1.82	23.5	17.6	12.2
Feed (calcd)	100.00	3.28	0.085	11.20	100.0	100.0	100.0

TABLE 8

Results of Silver Flotation from Pyrite Rougher Concentrate (Test 13)

Product	Wt %	Analysis %		Distribution %	
		Ag	Au	Ag	Au
Silver cleaner conc	3.71	29.01	0.80	10.8	10.7
Silver cleaner tail	8.98	13.44	0.32	12.1	10.4
Silver rougher tail	87.31	8.79	0.25	77.1	78.9
Feed (calcd)	100.00	9.96	0.28	100.0	100.0

Most of the precious metals present in the zinc rougher tailing were recovered in the pyrite concentrate. However, only about 23% of the contained silver and 21% of the gold were subsequently recovered in the silver concentrate floated from the reground pyrite concentrate. During cleaning, about half of the recovered precious metals were rejected to the cleaner tailing.

Results of Cyanidation of Pyrite Concentrate

Table 9 compares the results of cyaniding a sample of pyrite concentrate in the raw state and after roasting.

TABLE 9

Results of Cyanidation of Pyrite Concentrate

Test No.	Cyanidation Feed	Product	Wt	Assays, oz/ton		Distribution %	
				Au	Ag	Au	Ag
1	Raw pyrite conc reground to 91% -500 mesh	Pregnant soln	-	0.07	4.06	25.0	37.3
		Residue	100.0	0.21	6.84	75.0	62.7
		Feed (assay)	100.0	0.28	10.90	100.0	100.0
4	Calcines from 3-hour low-temp (475°C) roast with lime	Loss in roasting	14.36	0.01	0.80	3.5	7.4
		Loss in calcine wash	18.81	-	0.04	--	0.4
		Pregnant soln	-	0.20	7.45	71.1	68.6
		Residue	66.83	0.11	3.83	25.4	23.6
		Feed (assay)	100.00	0.28	10.86	100.0	100.0

Notes:

(1) Assays for pregnant solution and roasting loss expressed as oz/ton feed and obtained by difference.

(2) Loss in calcine wash determined as mg/liter and converted to oz/ton feed.

As can be seen from the comparison of results in Table 9, there was a very sharp increase in precious metal extraction by cyanidation when the pyrite concentrate was subjected to a low-temperature roast with lime added to the charge. Cyanidation of the raw pyrite concentrate was not too effective even though the concentrate was very finely reground.

Bulk Flotation

A comparison of results for bulk rougher flotation obtained by employing various reagent conbinations is given in Table 10, whereas Table 11 gives reagents and conditions for these tests.

Effect of Aeration

The employment of a soda ash - aeration scheme along with xanthate as collector (Test 2) resulted in the flotation of excessive amounts of pyrite. Zinc depression using this scheme, however, was very good. In a comparison test without aeration (Test 9), a similar concentrate grade was obtained and was accompanied by similar copper and silver recoveries but lead recovery was significantly lower. The essential difference between the two tests was the high flotation rate of the copper, lead, and silver minerals obtained when aeration was employed. Note that it required a skimming time of 6 minutes in Test 9 to achieve the same level of copper and silver recoveries obtained after only $1\frac{1}{2}$ minutes of skimming in Test 2.

Lime vs Soda Ash

The use of lime as an alkalinity regulator (pH 10 +) in place of soda ash (Tests 4, 5, 6, and 8) resulted in much improved pyrite depression but zinc depression was much poorer - the amount reporting in the bulk rougher concentrate increased by about 3 times. In Test 8, about half of the zinc was recovered in the bulk rougher concentrate despite the increase in cyanide addition to 0.15 lb/ton. In this test, the original intent was to use Aerofloat 242 and Z-200 as collectors. When these appeared to be ineffective, some amyl xanthate was added. A light, foamy froth was obtained which carried excessive amounts of fine sphalerite.

Unexpected were the high lead recoveries obtained in Tests 5, 6, and 8. Generally, lime has a detrimental effect on the flotation of galena.

TABLE 10

Comparison of Results for Bulk Rougher Flotation

Test No.	Product	Wt %	Assays					Distribution %			
			Cu	Pb	Zn	Fe	Ag	Cu	Pb	Zn	Ag
2	Ro conc	9.89	8.74	12.08	3.41	29.25	64.74	78.7	60.6	3.9	49.5
	Ro tail	90.11	0.26	0.86	9.18		7.25	21.3	39.4	96.1	50.5
4	Ro conc	8.16	4.76	16.20	12.26	12.39	69.28	33.7	72.8	12.1	42.7
	Ro tail	91.84	0.83	0.54	7.92		8.25	66.3	27.2	87.9	57.3
5	Ro conc	7.17	10.49	23.94	15.70	14.99	104.22	67.5	85.7	12.8	59.1
	Ro tail	92.83	0.39	0.31	8.32		5.57	32.5	14.3	87.2	40.9
6	Ro conc	7.98	9.90	22.10	14.43	13.41	97.84	70.3	89.6	13.2	60.7
	Ro tail	92.02	0.36	0.22	8.24		5.50	29.7	10.4	86.8	39.3
8	Ro conc	15.75	5.32	10.08	26.40	9.77	54.51	76.5	85.0	49.4	66.1
	Ro tail	84.25	0.31	0.33	5.07		5.23	23.5	15.0	50.6	33.9
9	Ro conc*	9.64	8.87	10.77	4.51	26.93	71.75	82.1	51.7	5.3	53.5
	Ro tail	90.36	0.21	1.07	8.63		6.67	17.9	48.3	94.7	46.5
13	Ro conc	13.92	6.98	13.08	6.59	24.76	64.60	89.5	89.0	10.7	69.9
	Ro tail	86.08	0.13	0.26	8.88		4.50	10.5	11.0	89.3	30.1
19	Ro conc	11.52	7.58	14.29	8.15	18.15	74.27	79.3	86.1	11.2	65.5
	Ro tail	88.48	0.26	0.30	8.33		5.10	20.7	13.9	88.8	34.5
20	Ro conc	8.04	6.55	18.24	9.18	14.19	65.25	80.5	83.7	8.2	59.0
	Ro tail	91.96	0.14	0.31	9.18		3.98	19.5	16.3	91.8	41.0

*Rougher conc after 6 minutes skimming (see Appendix A page16)

TABLE 11

Reagents and Conditions for Bulk Rougher Flotation

Test No.	Grind %-200m	Reagents to grind lb/ton			Conditioning		Collectors	Skimming time min.
					Aeration	pH		
2	80.6	3.0 Na_2CO_3	1.0 Na_2SO_3	0.10 NaCN	Yes	8.1	CX51	$1\frac{1}{2}$
4	"	3.5 lime	0.5 Zn SO_4	" "	No	10.9	AF 242+Z-200	3
5	"	" "	" "	" "	No	10.5	CX51	4
6	"	3.0 lime	1.0 Na_2SO_3	" "	No	10.2	" "	4
8	92.3	" "	" "	0.15 NaCN	No	10.0	CX51+AF 242 + Z-200	$2\frac{1}{2}$
9	"	3.0 Na_2CO_3	1.0 Na_2SO_3	0.10 NaCN	No	8.2	CX51	10*
13	"	" "	" "	" "	No	7.8	AF242+AF208	4
19	"	3.5 Na_2CO_3	" "	" "	No	8.3	" "	4
20	87.6	3.0 Na_2CO_3	" "	" "	No	7.6	" "	3

*Floated in 5 increments.

Most Effective Reagent Combination

The combination of soda ash, sodium sulphite and cyanide with non-aerative conditioning and Aerofloat 242 and 208 as collectors proved to be effective and was adopted as the standard method for bulk flotation. Generally, it gave good copper, lead, and silver recoveries accompanied by reasonably good pyrite and zinc depression.

Effect of Grind

Generally, higher copper and silver recoveries were obtained at the finer grind (92.3% minus 200 mesh) but there was no appreciable change in lead recovery. However the higher recoveries obtained may have been caused by other changes in reagents and conditions. None of the tests were specifically designed to test the effect of varying the fineness of grind.

Copper-Lead Separation

Standard Methods

Table 12 gives a comparison of the results obtained for copper-lead separation using the three standard methods on cleaned bulk concentrate produced from No. 1 Sample. Included in the comparison are the results of a sulphur dioxide-starch separation test on bulk rougher concentrate from No. 2 Sample (Test 26). The criterion used in evaluating these tests is the separation efficiency* which is a quantitative measure of the extent of separation between the copper and lead minerals. It is calculated by subtracting the per cent distribution of the unwanted metal in the concentrate from the per cent distribution of the metal concentrated.

---

* "Separation Efficiency" by N.F. Schultz, SME Transactions, Vol. 247, March 1970.

TABLE 12

Comparison of Results for Copper-Lead Separation Using Standard Methods

Test No	Separation Method	Product	Wt %	Analysis			Distribution			Sepn* Eff %
				Cu	Pb	Ag	Cu	Pb	Ag	
17	Dichromate	Copper conc	43.41	23.22	17.36	175.36	75.4	32.5	56.1	
		Copper cl tail	25.37	10.53	29.91	158.21	19.9	32.7	29.6	
		Lead conc	31.22	2.00	25.84	61.89	4.7	34.8	14.3	30.1
		Feed (calcd)	100.00	13.38	23.19	135.58	100.0	100.0	100.0	
		Copper ro conc	68.78	18.54	21.99	169.03	95.3	65.2	85.7	
18	SO_2-Starch	Copper conc	43.06	23.68	12.98	130.70	81.6	24.9	51.2	
		Copper cl tail	17.42	7.12	19.31	108.15	9.9	15.0	17.2	
		Lead conc	39.52	2.66	34.08	87.88	8.5	60.1	31.6	51.6
		Feed (calcd)	100.00	12.49	22.42	109.85	100.0	100.0	100.0	
		Copper ro conc	60.48	18.91	14.80	124.21	91.5	39.9	68.4	
19	Cyanide	Lead conc	15.44	9.34	46.20	140.40	9.6	30.4	16.7	
		Lead cl tail	18.76	17.38	20.45	133.27	21.5	16.4	19.2	
		Copper conc	65.80	15.80	18.96	126.70	68.9	53.2	64.1	15.7
		Feed (calcd)	100.00	15.10	23.45	130.05	100.0	100.0	100.0	
		Lead ro conc	34.20	13.75	32.08	136.49	31.1	46.8	35.9	
26	SO_2-Starch	Copper conc	15.38	27.08	4.45	163.36	62.3	3.9	38.0	
		Copper cl tail	19.57	7.51	14.85	108.72	22.0	16.4	32.2	
		Sep tailing	65.05	1.61	21.71	30.28	15.7	79.7	29.8	64.0
		Feed (calcd)	100.00	6.68	17.71	66.10	100.0	100.0	100.0	
		Copper ro conc	34.95	16.12	10.28	132.76	84.3	20.3	70.2	

* For initial rougher flotation.

None of the three separation methods employed on the No. 1 Sample bulk concentrate (Tests 17, 18 and 19) gave satisfactory results. In each case the copper content in the lead concentrate was excessively high. A comparison of the separation efficiencies indicates that the sulphur dioxide-starch method was the most effective. When tried on the No. 2 Sample bulk concentrate (Test 26), it gave much more acceptable results probably because of the more favourable ratio of copper to lead in the separation feed.

Modified Methods

Table 13 gives a comparison of the results obtained for copper-lead separation using the modified methods as outlined on pages 5 and 6. All of these tests were done on bulk concentrate produced from No. 2 Sample.

From a comparison of separation efficiencies it can be seen that the method employed in Test 26 was much superior to all the other methods. In this test, the bulk rougher concentrate was subjected to sulphur dioxide-starch separation followed by lead flotation from the reground separation tailing. However, when tried in conjunction with regrinding of the bulk rougher concentrate in Test 24, sulphur dioxide-starch did not effectively depress galena.

In Test 20 the cyanide added to the regrinding step had a severe depressing effect on the copper minerals (presumably chalcopyrite was affected to the greatest degree) such that about 53% of the copper present in the reground rougher concentrate was rejected to the cleaner tailings. Because of this, a greater degree of separation between the lead and copper minerals took place during cleaning (separation efficiency, 38.2%) than in the subsequent sulphur dioxide-starch separation of the copper-lead cleaner concentrate (separation efficiency 20.3%). However, when the enhanced depressing effect of cyanide in the regrind was taken advantage of in Test 21, it depressed

only about 2/3 of the copper. This could have been due to the ineffectiveness of cyanide as a depressant for the copper-bearing minerals, tennantite, and tetrahedrite.

TABLE 13

Comparison of Results for Copper-Lead Separation Using Modified Methods

Test No.	Separation Method	Product	Wt %	Analysis			Distribution			Sep Eff %
				Cu	Pb	Ag	Cu	Pb	Ag	
20	Flowsheet 2 Modified SO_2-Starch	Copper conc	10.24	19.48	33.03	142.26	21.0	7.1	12.3	
		Copper cl tail	22.75	12.09	47.30	134.46	29.0	22.6	25.9	
		Lead conc	67.01	7.06	50.00	109.19	50.0	70.3	61.8	
		Feed (calcd)	100.00	9.48	47.65	118.33	100.0	100.0	100.0	
		Copper ro conc	32.99	14.38	42.87	136.88	50.0	29.7	38.2	20.3
21	Flowsheet 3 Selective flotation of lead and copper from reground bulk conc	Lead conc	26.42	7.02	46.60	112.65	33.1	77.5	50.3	44.4
		Copper conc	17.52	10.00	13.72	75.65	31.2	15.1	22.4	
		Copper ro tail	56.06	3.57	2.11	28.75	35.7	7.4	27.3	
		Feed (calcd)	100.00	5.61	15.90	59.13	100.0	100.0	100.0	
		Lead ro tail	73.58	5.10	4.87	39.92	66.9	22.5	49.7	
24	Flowsheet 4 Selective flotation of copper lead and zinc from reground bulk conc	Copper conc	11.01	21.94	21.18	178.90	52.1	16.9	39.4	
		Copper cl tail	9.48	7.33	28.30	89.06	15.0	19.4	16.9	
		Lead conc	10.54	3.79	51.82	72.00	8.6	39.6	15.2	
		Lead cl tail	17.60	2.99	8.86	37.78	11.3	11.3	13.2	
		Sec Zn ro conc*	5.29	2.21	5.63	26.56	2.5	2.2	2.8	
		Sec Cu-Pb ro tail	46.08	1.05	3.15	13.60	10.5	10.6	12.5	
		Feed (calcd)	100.00	4.64	13.79	50.05	100.0	100.0	100.0	
		Copper ro conc	20.49	15.18	24.47	137.33	67.1	36.3	56.3	30.8
26	Flowsheet 5 SO_2-starch with lead Flotation from reground Sep tailing	Copper conc	15.38	27.08	4.45	163.36	62.3	3.9	38.0	
		Copper cl tail	19.57	7.51	14.85	108.79	22.0	16.4	32.2	
		Lead conc	13.68	0.69	70.45	43.71	1.4	54.4	9.0	
		Lead cl tail	6.69	2.21	25.43	43.33	2.2	9.6	4.4	
		Sec Cu-Pb ro tail	44.68	1.80	6.22	24.23	12.1	15.7	16.4	
		Feed (calcd)	100.00	6.68	17.71	66.12	100.0	100.0	100.0	
		Copper ro conc	34.95	16.12	10.28	132.76	84.3	20.3	70.2	64.0
		Lead ro conc	20.37	1.19	55.68	43.59	3.6	64.0	13.4	

*11.29% zinc with recovery of 22.9%

Selective Flotation Directly from the Ore

The results for selective flotation directly from the ore are compared in Table 15, while reagents and conditions for these tests are given in Table 14.

TABLE 14

Reagents and Conditions for
Selective Flotation Directly from the Ore

Test No.	Grind %-325m	Conditioning		Collectors, lb/ton	
		Aeration	pH	Copper	Lead
11	85.0	No	6.6	CX51, 0.03	CX51, 0.005
12	"	Yes	5.7	CX51, 0.04	CX51, 0.02
15	"	Yes	5.7	Z-200, 0.03	AF 242, 0.06
16	97.3	Yes	5.8	Z-200, 0.06	AF 242, 0.05

From Table 15, it can be seen that the best results were achieved by aerating the pulp prior to copper flotation and by employing Z-200 and Aerofloat 242 as copper and lead promoters respectively. The very fine grind employed in Test 16 did not bring about any significant changes in results.

TABLE 15

Comparison of Results for Selective Flotation Directly from the Ore

Test No	Product	Wt %	Assays					Distribution %				Sep Eff %
			Cu	Pb	Zn	Fe	Ag	Cu	Pb	Zn	Ag	
11	Copper ro conc	3.03	19.00	3.00	6.60	16.30	105.39	53.6	4.8	2.4	24.0	48.8
	Lead ro conc	3.77	6.00	25.53	5.93	6.11	85.33	21.0	50.5	2.6	23.8	
	Lead ro tail	93.20	0.29	0.91	8.55		7.46	25.4	44.7	95.0	52.2	
	Feed (calcd)	100.00	1.07	1.91	8.39		13.31	100.0	100.0	100.0	100.0	
12	Copper ro conc	6.18	12.11	9.21	6.70	24.03	68.64	68.0	29.2	5.0	33.1	38.8
	Lead ro conc	5.25	2.83	21.66	17.59	11.16	73.01	13.5	58.5	11.1	30.0	
	Lead ro tail	88.57	0.23	0.27	7.90		5.35	18.5	12.3	83.9	36.9	
	Feed (calcd)	100.00	1.10	1.94	8.33		12.81	100.0	100.0	100.0	100.0	
15	Copper ro conc	4.23	19.37	6.00	6.40	20.22	88.78	68.0	13.0	3.1	26.9	55.0
	Lead ro conc	5.96	1.65	23.11	9.45	9.50	71.80	8.2	70.8	6.5	30.7	
	Lead ro tail	89.81	0.32	0.35	8.70		6.59	23.8	16.2	90.4	42.4	
	Feed (calcd)	100.00	1.21	1.95	8.65		13.95	100.0	100.0	100.0	100.0	
	Copper cl conc	2.94	25.00	5.52	4.82	21.75	101.17	61.0	8.3	1.6	21.3	
	Lead cl conc	2.24	2.26	55.13	6.58	6.57	149.45	4.2	63.5	1.7	24.0	
16	Copper ro conc	4.99	13.93	4.81	6.75	19.41	75.00	64.9	13.0	3.5	28.4	51.9
	Lead ro conc	9.11	0.74	13.70	7.88	10.56	36.21	6.3	67.9	7.5	25.1	
	Lead ro tail	85.90	0.36	0.41	9.90		7.10	28.8	19.1	89.0	46.5	
	Feed (calcd)	100.00	1.07	1.84	9.56		13.14	100.0	100.0	100.0	100.0	
	Copper cl conc	2.45	23.25	4.20	4.29	22.73	99.13	53.2	5.6	1.1	18.4	
	Lead cl conc	1.82	1.05	59.00	4.67	5.90	122.14	1.8	58.4	0.9	16.9	

Dolmage Campbell Flowsheet

Table 16 gives a metallurgical balance for Test 2 which, as was mentioned previously, was done to ascertain the make-up of the intermediate products initially produced using the Dolmage Campbell flowsheet.

TABLE 16

Metallurgical Balance for Test 22

Product	Wt %	Assays				Distribution %			
		Cu	Pb	Zn	Ag	Cu	Pb	Zn	Ag
Copper-lead cleaner conc	2.79	12.85	5.39	7.63	102.28	58.6	9.7	2.1	33.0
Copper-lead cleaner tail	1.50	2.32	11.57	9.08	22.64	5.7	11.2	1.4	3.9
Sec Cu-Pb cleaner conc	1.37	3.06	59.81	4.41	64.44	6.9	52.8	0.6	10.2
Sec Cu-Pb cleaner tail	1.13	0.74	18.30	12.03	43.28	1.4	13.3	1.4	5.7
Sec Cu-Pb rougher tail	3.64	0.43	2.55	11.27	8.95	2.6	6.0	4.1	3.8
Copper-lead rougher tail	89.57	0.17	0.12	10.00	4.20	24.8	7.0	90.4	43.4
Feed (calcd)	100.00	0.61	1.55	9.91	8.65	100.0	100.0	100.0	100.0
Copper-lead rougher conc	4.29	9.17	7.55	8.14	74.43	64.3	20.9	3.5	36.9
Copper-lead scav conc	6.14	1.07	18.22	9.88	27.65	10.9	72.1	6.1	19.7

The results in Table 16 indicate that the greatest proportion of the copper floats in the copper-lead rougher, whereas most of the lead is recovered in the subsequent copper-lead scavenger float. Also, the galena that floats in the copper-lead rougher tends to be depressed during the cleaning operation. The so-called secondary copper-lead cleaner concentrate which is floated from the scavenger concentrate (see Figure 7) is actually a finished lead concentrate. From this test, therefore, it can be concluded that, other than additional cleaning of the copper-lead concentrate, further treatment as outlined in Figure 7 is unnecessary and that, in effect the initial portion of the flowsheet is equivalent to selective flotation directly from the ore.

Roasting and Cyanidation of Pyrite Concentrate

Table 17 compares results obtained for cyanidation of raw and roasted pyrite concentrates.

TABLE 17

Comparison of results for Cyanidation of Raw and Roasted Pyrite Concentrates

Test No.	Cyanidation feed	Roasting conditions			S content in calcines, %		Extraction by Cyanidation,%		Reagents consumed lb/ton pyrite conc		
		Temp °C	Time hr	Lime added	Total	Sulphide	Au	Ag	Lime-1*	Lime-2**	NaCN
1	Raw pyrite conc						25.0	37.2		8.5	15.4
2	Calcines	450 to 700	5	No	1.13	0.09	58.4	28.5		1.0	4.8
3	Calcines	475	0.8	Yes	12.71	2.04	64.5	55.9	102	9.7	14.0
4	Calcines	475	3	Yes	1.31	0.67	71.1	68.6	104	10.6	3.8
5	Raw pyrite conc						28.1	40.8		10.2	16.4
6	Calcines	475	3	Yes	16.71	1.54	66.2	57.1	80	6.9	14.7
7	Calcines	475	3	No	13.48	1.52	60.4	58.7		7.1	13.4
8	Calcines	475	4	Yes	5.05	0.86	72.1	55.7	71	3.9	11.1
9	Calcines	475	4	No	4.30	0.78	70.8	61.0		3.9	11.1

* Consumed in roast
** Consumed in cyanidation.

Cyanidation of the raw pyrite concentrate (Tests 1 and 5) was not effective in extracting the precious metals. When the pyrite concentrate was subjected to a complete roast at a high temperature prior to cyanidation (Test 2), gold recovery more than doubled but there was a decrease in silver recovery.

In an investigation on gold and silver ores carried out by the U.S. Bureau of Mines (Technical Paper 423, 1928), it was found that, when sulphosalts such as tennantite or tetrahedrite were roasted at a high temperature, they

were converted to base metal arsenates and antimonates. These compounds contained the silver originally present in the sulphosalts and were insoluble in cyanide solution. It was found that by subjecting these minerals to a low-temperature roast (450°C) in the presence of lime, calcium arsenate and antimonate were formed in preference to the corresponding base metal compounds. These calcium conpounds gave up their silver more readily to dissolution by cyanide.

A number of tests were tried in which the pyrite concentrate was roasted at a low-temperature for varying periods. In some of these tests, 20 grams of lime were mixed with the roasting charge. In every test, there was at least a doubling of silver extraction by cyanidation over that obtained on calcines from the high-temperature roast thus confirming the findings of the U.S. Bureau of Mines investigation. However, it was found that the addition of lime to the roasting charge was not essential (compare results of Tests 6 and 7 and 8 and 9). The best results (Test 4) could be related to the lowest sulphur content in the calcines of any of the low-temperature roasts. Cyanide consumption in this test was also very much lower.

CONCLUSIONS

Marketable grades of copper, lead, and zinc concentrates can be produced from this ore by differential flotation techniques. On No. 1 Sample, the only successful technique for copper and lead concentration was selective flotation directly from the ore (Test 16), whereas on the lower-grade No. 2 Sample the best results were achieved by floating a copper-lead bulk concentrate, subjecting it to the sulphur dioxide-starch separation method to produce a copper concentrate followed by reactivation and flotation of a lead concentrate from the reground separation tailing (Test 26).

In order to maintain satisfactory copper and lead concentrate grades, recoveries would have to be compromised. This is because of the intimate association of some of the lead and copper minerals with pyrite.

An appreciable portion of the silver is also intimately associated with the pyrite in the form of tiny inclusions of silver-bearing tennantite-tetrahedrite. In order to recover this silver, it is necessary to float a pyrite concentrate from the zinc tailing, roast the concentrate and cyanide the calcines. A significant amount of gold is also recovered by this scheme. Precious metal extraction by cyanidation in the best test (4) expressed as oz/ton flotation feed was 1.82 oz/ton for silver and 0.05 oz/ton for gold which represent additional recoveries of 14% and 30% respectively.

In contrast to the difficulty experienced in concentrating the copper, lead and silver minerals the sphalerite in the ore floated readily to give an exceptionally high grade zinc concentrate accompanied by good zinc recovery.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of the following persons who made important contributions to this investigation:

Messrs. J.C. Banks and M. Raicevic of the Mineral Processing Division who did the cyanidation tests.

Mr. D.R. Owens of the Mineral Sciences Division who did the mineralogical studies on the ore and on the zinc rougher tailing.

Messrs. J. Cloutier, D. Cumming, C.A. Derry, R. Donahoe, J. Graham, J. Hole, B. Kobus, P. Lanthier, H. Lauder, P.E. Moloughney, E. Nadeau and Miss C. Smith all of the Mineral Sciences Division who carried out the many analytical determinations required.

A.S.,R.W.B:ec

APPENDIX A

Screen Analyses of Primary Grinds

45-Minute Rod Mill Grind		
Tyler Mesh	Wt %	Cumulative Wt %
+100	0.3	0.3
+150	2.5	2.8
+200	16.6	19.4
+270	14.3	33.7
+325	11.7	45.4
+400	3.5	48.9
-400	51.1	100.0
Total	100.0	
30-Minute Ball Mill Grind		
+100	0.2	0.2
+150	1.7	1.9
+200	5.8	7.7
+270	7.2	14.9
+325	8.7	23.6
+400	3.9	27.5
-400	72.5	100.0
Total	100.0	
60-Minute Ball Mill Grind*		
+150	0.2	0.2
+200	0.7	0.9
+270	1.8	2.7
+325	4.5	7.2
+400	1.1	8.3
+500	14.2	22.5
-500	77.5	100.0
Total	100.0	

*Screen analysis of lead rougher tailing.

Classification of Tests

According to Flowsheet Employed

Flowsheet No.	Description	Test No
1	Bulk flotation only.	1,2,3,4,5,6,7, 8,9,13,14.
1	Bulk flotation followed by copper-lead separation.	17,18,19.
2	Modified copper-lead sepn, bulk conc reground before cleaning.	20
3	Modified copper-lead sepn, selective flotation of lead and copper conc from reground bulk conc.	21
4	Modified copper-lead sepn, selective flotation of copper, lead and zinc conc from reground bulk conc.	24
5	Modified copper-lead sepn, SO_2-starch sepn on Cu-Pb bulk rougher conc followed by Pb flotn from reground separation tailing.	26
6	Selective flotation of copper and lead conc directly from the ore.	10,11,12,15,16
7	Dolmage Campbell flowsheet	22,23

Abbreviations Used in Flotation Test Reports

RM	Rod mill
BM	Ball mill
CX51	Potassium amyl xanthate
DF 250	Dowfroth 250
NaAF	Sodium aerofloat
PO	Pine oil
Fe/FeS	Iron present as iron sulphides
Z-200	Trade name for selective copper collector
AF 242	Aerofloat 242
AF 238	Aerofloat 238
AF 208	Aerofloat 208
Dich	Sodium dichromate
CS	Caustic starch
MIBC	Methyl isobutyl carbinol
ZnCN	$Na_2Zn\ (CN)_4$
Z-3	Potassium ethyl xanthate

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 1	SAMPLE: Nadina Explorations Limited	DATE: Feb. 9, 1970
OBJECT OF TEST:	Copper-lead bulk flotation using lime + $ZnSO_4$ + NaCN followed by zinc flotation.	CHARGE: 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Lime	$ZnSO_4$	NaCN	CX51	DF250	$CuSO_4$	NaAF			
Grinding	45	65	6.8*	7 x 14 RM	1.0	0.5	0.05							
Conditioning	10		8.1	1000-g cell	0.5			0.02						
Copper-lead rougher														
Stage 1	½								0.02					
" 2	1							0.01						
Copper scavenger	1													
Conditioning	10		11.1		3.0			0.01	0.01	1.0				
Zinc rougher														
Stage 1	1							0.02			0.10			
" 2	1								0.02		0.05			
" 3	2										0.05			

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
TEST PRODUCTS													
DISCARDED													

REMARKS: Excessive amounts of pyrite appeared to float especially in copper scavenger, pH too low?, not enough NaCN?
* after dilution with water.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 2 | SAMPLE: Nadina Explorations Limited | DATE: Feb. 9, 1970

OBJECT OF TEST: As in Test 1 but used Na_2CO_3 + Na_2SO_3 + NaCN along with aerative conditioning prior to copper-lead float | CHARGE: 2000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Na_2SO_3	NaCN	CX51	PO	$CuSO_4$	Lime	NaAF	DF250	
Grinding	45	65	7.2*	7 x 14 RM	2.0	1.0	0.10							
Conditioning	20		8.1**	Aerator	1.0			0.02						
Copper-lead rougher				1000-g cell										
Stage 1	1								0.02					
" 2	½							0.01						
Conditioning	10		11.4							1.0	4.0			
Zinc rougher														
Stage 1	1							0.02				0.10		
" 2	1											0.05	0.02	
" 3	2											0.05		

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Insol	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper-lead conc	7.78	10.55	13.09	2.96	29.31	2.60	0.57	73.33	74.8	51.6	2.7	28.1	44.1
Copper-lead cl tail No.1	0.92	2.86	9.60	4.13	31.48	7.52	0.53	43.26	2.4	4.5	0.4	3.1	3.1
" " " " No.2	1.19	1.42	7.43	5.76	27.14	16.58	0.34	25.17	1.5	4.5	0.8	2.5	2.3
Zinc conc	6.81	0.87	1.13	63.40	1.44	0.76	0.12	16.64	5.4	3.9	50.2	5.2	8.8
Zinc cl tail No.2	2.72	1.11	2.08	56.00	2.68	3.36	0.17	17.98	2.8	2.9	17.7	2.9	3.8
" " " No.1	5.48	1.11	3.14	32.00	9.08	1.22	0.23	22.40	5.5	8.7	20.4	8.0	9.5
Zinc rougher tail	75.10	0.11	0.63	0.90			0.11	4.90	7.6	23.9	7.8	50.2	28.4
Feed (Calcd)	100.00	1.10	1.97	8.61			0.16	12.93	100.0	100.0	100.0	100.0	100.0

REMARKS: Fe/FeS in copper-lead conc 20.0%, in copper-lead rougher conc 21.6%.

Copper-lead float - coppery froth in first rougher but excessive amounts of pyrite floated in second rougher; therefore, cut off float at 1½ min.

* after dilution with water ** at end and after dilution in cell.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 2 | SAMPLE: Nadina Explorations Limited | DATE: Feb. 9, 1970

OBJECT OF TEST: | CHARGE: | TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton								
											Lime		DF250
Copper-lead cleaners													
No. 1	1½			250-g cell									0.005
No. 2	1			" "									
Zinc cleaners													
No. 1	2		11.7	500-g cell							1.0		
No. 2	1½		11.7	" "							0.25		

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Insol	Au	Ag	Cu	Pb	Zn	Au	Ag
Calculated assays													
1st Stage copper-lead Cleaner conc	8.70	9.74	12.72	3.08	29.54	5.65	0.56	70.15	77.2	56.1	3.1	31.2	47.2
Copper-lead rougher conc	9.89	8.74	12.08	3.41	29.25	6.97	0.54	64.74	78.7	60.6	3.9	33.7	49.5
Copper-lead rougher tail	90.11	0.26	0.86	9.18			0.12	7.25	21.3	39.4	96.1	66.3	50.5
1st stage zinc cl conc	9.53	0.94	1.40	61.29	1.79	1.50	0.13	17.02	8.2	6.8	67.9	8.1	12.6
Zinc rougher conc	15.01	1.00	2.04	50.59	4.45	1.40	0.17	18.99	13.7	15.5	88.3	16.1	22.1

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 3	SAMPLE: Nadina Explorations Limited	DATE: Feb. 17, 1970
OBJECT OF TEST: Repeat of Test 1 but with increase in lime and cyanide		CHARGE: 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Lime	$ZnSO_4$	NaCN	CX51	DF250	$CuSO_4$	NaAF			
Grinding	45	65	9.8*	7 x 14 RM	3.0	0.5	0.10							
Conditioning	10		ca 10**	1000-g cell	0.5			0.02						
Copper-lead rougher	1		10.6		0.5			0.01	0.02					
" " scavenger	1		10.7					0.02						
Conditioning	10		11.3		1.0					1.0				
Zinc rougher														
Stage 1	1							0.02			0.10			
" 2	1								0.02		0.05			
" 3	2										0.05			

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
Copper-lead ro conc	4.4												
" " scav conc	4.0												
Zinc rougher conc	14.7												
Zinc rougher tail	76.9												
Feed	100.0												

TEST PRODUCTS
NOT ASSAYED
BECAUSE OF UNSTABLE pH

REMARKS: Light, leady froth in copper-lead rougher, pyrite came up quickly in scavenger.
*after dilution in cell.
**unstable pH, started at about 10.5 and then began to drop.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 4	SAMPLE: Nadina Explorations Limited	DATE: Feb. 17, 1970
OBJECT OF TEST: Copper-lead bulk flotation using lime + $ZnSO_4$ + NaCN but with Z-200 and AF 242 as copper and lead promoters in place of CX 51.		CHARGE: 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Lime	$ZnSO_4$	NaCN	AF242	Z-200	$CuSO_4$	DF250	NaAF		
Grinding	45	65	10.0*	7 x 14 RM	3.0	0.5	0.10							
Conditioning	10		10.9	1000-g cell	0.5			0.02	0.02					
Copper-lead rougher														
Stage 1	1		10.7					0.02						
" 2	1							0.02						
" 3	1							0.01						
Conditioning	10		11.6		1.5					1.0				
Zinc rougher														
Stage 1	1										0.02			
" 2	1											0.05		
" 3	1											0.05		

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag		Cu	Pb	Zn	Au	Ag
Copper-lead ro conc	8.16	4.76	16.20	12.26	12.39	0.65	69.28		33.7	72.8	12.1	30.6	42.7
Zinc rougher conc	13.40	1.91	1.00	48.92	4.31	0.13	18.41		22.2	7.4	79.2	10.1	18.7
Zinc rougher tail	78.44	0.65	0.46	0.92		0.13	6.51		44.1	19.8	8.7	59.3	38.6
Feed (calcd)	100.00	1.15	1.82	8.28		0.17	13.23		100.0	100.0	100.0	100.0	100.0
Copper-lead ro tail	91.84	0.83	0.54	7.92		0.13	8.25		66.3	27.2	87.9	69.4	57.3

REMARKS: Foamy, fine-grained, "depressed" froth in copper-lead rougher.

*after dilution in cell.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 5 | SAMPLE: Nadina Explorations Limited | DATE: Feb. 18, 1970

OBJECT OF TEST: Repeat of Test 3 | CHARGE: 2000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Lime	$ZnSO_4$	NaCN	CX51	DF250	$CuSO_4$	NaAF			
Grinding	45	65		7 x 14 RM	3.5	0.5	0.10							
Conditioning	10		10.5*					0.02						
Copper-lead rougher														
Stage 1	1							0.01	0.02					
" 2	½								0.01					
" 3	½							0.004						
Copper-lead scavenger	2		10.0**					0.004						
Conditioning	10		11.6		1.5					1.0				
Zinc rougher														
Stage 1	1							0.02			0.10			
" 2	1										0.05			
" 3	2										0.05			

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Insol	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper-lead conc	2.60	10.68	40.60	4.36	12.90	1.76	1.18	137.05	24.9	52.7	1.3	19.4	28.2
Copper-lead cl tail No.2	2.76	9.63	22.42	22.63	14.55	12.72	0.38	96.67	23.9	30.9	7.1	6.6	21.1
" " " " No.1													
Copper-lead scav conc	1.81	11.52	2.33	21.43	18.68	12.56	0.36	68.57	18.7	2.1	4.4	4.1	9.8
Zinc conc	7.50	0.38	0.33	64.15	1.24	1.02	0.10	9.63	2.6	1.2	54.4	4.7	5.7
Zinc cleaner tail No. 2	2.73	1.22	0.64	55.65	3.40	5.46	0.15	15.67	3.0	0.8	17.2	2.6	3.4
" " " No. 1	2.60	2.93	1.15	36.88	8.05	19.38	0.17	21.36	6.8	1.5	10.8	2.8	4.4
Zinc rougher tail	80.00	0.28	0.27	0.54			0.12	4.33	20.1	10.8	4.8	59.8	27.4
Feed (calcd)	100.00	1.11	2.00	8.85			0.16	12.64	100.0	100.0	100.0	100.0	100.0

REMARKS: Clean, leady froth in copper-lead rougher.

* at start

** at end

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 5 | SAMPLE: Nadina Explorations Limited | DATE: Feb. 18, 1970

OBJECT OF TEST: | CHARGE: | TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Lime				DF 250					
Copper-lead cleaners														
No. 1	1½			500-g cell					0.02					
No. 2	1			250-g cell										
Zinc cleaners														
No. 1	1½		12.1	500-g cell	1.0				0.02					
No. 2	1½		12.1	" " "	0.5									

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Insol	Au	Ag	Cu	Pb	Zn	Au	Ag
Calculated assays													
Cu-Pb rougher conc	5.36	10.14	31.24	13.77	13.75	7.40	0.77	116.26	48.8	83.6	8.4	26.6	49.3
" " ro + scav conc	7.17	10.49	23.94	15.70	14.99	8.71	0.67	104.22	67.5	85.7	12.8	30.1	59.1
" " rougher tail	92.83	0.39	0.31	8.32			0.12	5.57	32.5	14.3	87.2	69.9	40.9
1st stage Zn cleaner conc	10.23	0.60	0.41	61.88	1.82	2.21	0.11	11.24	5.6	2.0	71.6	7.3	9.1
Zn rougher conc	12.83	1.08	0.56	56.82	3.08	5.69	0.13	13.29	12.4	3.5	82.4	10.1	3.5

REMARKS

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 6 | SAMPLE: Nadina Explorations Limited | DATE: February 18, 1970

OBJECT OF TEST: To try the combination lime + Na_2SO_3 + NaCN in bulk copper-lead flotation | CHARGE: 2000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Lime	Na_2SO_3	NaCN	CX51	DF250	$CuSO_4$	NaAF			
Grinding	45			7 x 14 RM	3.0	1.0	0.10							
Conditioning	10		10.2*	1000-g cell				0.02						
Copper-lead rougher														
Stage 1	½								0.02					
" 2	1½							0.01	0.01					
Copper-lead scavenger														
Stage 1	1							0.002						
" 2	1							0.002						

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Insol	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper-lead conc	3.44	15.08	31.00	6.85	13.34	3.74	1.02	143.63	46.1	54.2	2.7	22.6	38.4
Copper-lead cl tail	2.71	4.92	21.05	20.53	11.91	9.90	0.34	70.77	11.9	29.0	6.4	5.9	14.9
Copper-lead scav conc	1.83	7.54	6.91	19.63	15.78	15.34	0.34	51.85	12.3	6.4	4.1	4.0	7.4
Zinc conc	8.68	0.33	0.33	64.24	1.22	1.42	0.085	11.02	2.5	1.5	63.8	4.8	7.4
Zinc cl tail No. 2	1.91	0.87	0.86	52.60	3.92	8.24	0.15	16.08	1.5	0.8	11.5	1.9	2.4
" " " No. 1	1.83	1.89	0.82	31.50	9.27	27.18	0.18	17.56	3.1	0.8	6.6	2.1	2.5
Zinc rougher tail	79.60	0.32	0.18	0.54			0.12	4.37	22.6	7.3	4.9	58.7	27.0
Feed (calcd)	100.00	1.12	1.97	8.74			0.16	12.87	100.0	100.0	100.0	100.0	100.0

REMARKS: * at start. Fe/FeS in copper-lead conc, 0.1%, in copper-lead rougher conc, 3.4%, in copper-lead rougher + scav conc, 4.7%.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 6 | SAMPLE: Nadina Explorations Limited | DATE: February 18, 1970

OBJECT OF TEST: | CHARGE: | TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Lime			CX 51	DF 250	$CuSO_4$	NaAF			
Conditioning	10		11.8	1000-g cell	2.0					1.0				
Zn rougher														
Stage 1	1							0.02			0.10			
" 2	1										0.05			
" 3	2								0.01		0.05			
Copper-lead cleaner	1 ½			250-g cell					0.006					
Zinc cleaners														
No. 1	1 ½		~12	500-g cell	1.0				0.02					
No. 2	1 ½		~12	" "	0.5									

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Insol	Au	Ag	Cu	Pb	Zn	Au	Ag
Calculated assays													
Copper-lead ro conc	6.15	10.60	26.62	12.87	12.71	6.46	0.72	111.52	58.0	83.2	9.1	28.5	53.3
Copper-lead ro+scav conc	7.98	9.90	22.10	14.43	13.41	8.49	0.63	97.84	70.3	89.6	13.2	32.5	60.7
Copper-lead ro tail	92.02	0.36	0.22	8.24			0.11	5.50	29.7	10.4	86.8	67.5	39.3
1st stage zinc cl conc	10.59	0.43	0.42	62.14	1.71	2.65	0.10	11.93	4.0	2.3	75.3	6.7	9.8
Zinc rougher conc	12.42	0.64	0.48	57.63	2.82	6.26	0.11	12.76	7.1	3.1	81.9	8.8	12.3

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 7 | SAMPLE: Nadina Explorations Limited | DATE: April 7, 1970

OBJECT OF TEST: To try the combination Na_2CO_3 + Na_2SO_3 + NaCN in bulk copper-lead flotation with AF242 and AF 238 as collectors. | CHARGE: 2000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Na_2SO_3	NaCN	AF242	AF238	DF250				
Grinding	30	65	8.2	12 in. BM	3.0	1.0	0.10	0.04						
Conditioning	20			Aerator	1.0				0.02					
Copper-lead rougher				1000-g cell										
Stage 1	1		8.0					0.02	0.02					
" 2	½									0.02				
" 3	1							0.02						

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
Copper-lead ro conc	15.18												
" " ro tail	84.82												
Feed	100.00												

TEST PRODUCTS NOT ASSAYED

REMARKS: Dirty, non-selective float, excessive amounts of pyrite floated.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 8 | SAMPLE: Nadina Explorations Limited | DATE: April 7, 1970

OBJECT OF TEST: Repeat of Test 6, but employed AF242 and Z-200 as collectors in conjunction with CX51*. | CHARGE: 2000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Lime	Na_2SO_3	NaCN	AF242	Z-200	CX51	DF250	$CuSO_4$	NaAF	
Grinding	30	65		12 in. B.M.	3.0	1.0	0.15	0.04						
Conditioning	10		10.0	1000-g cell					0.02	0.01				
Copper-lead rougher														
Stage 1	½										0.02			
" 2	1									0.01				
" 3	1									0.01				
Conditioning	10		11.6		2.0							1.0		
Zinc rougher														
Stage 1	½									0.02				
" 2	1										0.02		0.10	
" 3	1												0.05	
" 4	½												0.05	

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	S	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper-lead ro conc	15.75	5.32	10.08	26.40	9.77		0.40	54.51	76.5	85.0	49.4	38.9	66.1
Zinc ro conc	10.07	1.47	1.00	40.40	7.42		0.15	14.92	13.5	5.4	48.3	9.3	11.6
Pyrite ro conc	23.70	0.36	0.42	0.54	34.92	39.58	0.29	10.43	8.1	5.3	1.6	42.4	19.0
Final tailing	50.48	0.04	0.16	0.13	4.84	1.83	0.30	0.86	1.9	4.3	0.7	9.4	3.3
Feed (calcd)	100.00	1.10	1.87	8.43	14.50		0.16	12.90	100.0	100.0	100.0	100.0	100.0
Copper-lead ro tail	84.25	0.31	0.33	5.07			0.12	5.23					
Zinc ro tail	74.18	0.15	0.24	0.27			0.11	3.91					

REMARKS: Copper-lead float - Light, foamy froth to give high weight of conc.
*Had intended to use AF242 and Z-200 only but these were ineffective by themselves.

MINES BRANCH FLOTATION TEST REPORT

TEST NO: 8	SAMPLE: Nadina Explorations Limited	DATE: April 7, 1970
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
										CX51				H_2SO_4
Conditioning	10		8.7							0.10				2.9
Pyrite rougher														
Stage 1	1/2													
" 2	1									0.05				
" 3	1									0.05				
" 4	1 1/2									0.05				

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO: 9 | SAMPLE: Nadina Explorations Limited | DATE: April 8, 1973

OBJECT OF TEST: Repeat of Test 2 but without aeration | CHARGE:

TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton				
					Na_2CO_3	Na_2SO_3	NaCN	CX 51	DF 250
Grinding	30	65		12 in. BM	3.0	1.0	0.10	0.01	
Conditioning	10		8.2	1000-g cell				0.01	0.02
Copper-lead rougher									
Stage 1								0.005	
" 2								0.005	0.008
" 3								0.0025	0.004
" 4								0.0025	
" 5								0.0025	0.004

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Fe/FeS	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper-lead ro conc No.1	1.68	14.51	11.94	6.32	16.72	3.97	1.20	128.40	23.4	10.0	1.3	12.0	16.7
" " " " No.2	3.65	11.16	10.73	4.46	27.24	17.43	0.65	81.79	39.1	19.5	2.0	14.1	23.1
" " " " No.3	4.31	4.74	10.35	3.84	30.65	26.49	0.40	41.17	19.6	22.2	2.0	10.2	13.7
" " " " No.4	2.71	2.23	8.00	4.17	33.85	31.89	0.35	28.35	5.8	10.8	1.4	5.6	5.9
" " " " No.5	2.50	0.96	6.24	6.43	29.41	28.57	0.34	27.09	2.3	7.8	1.9	5.0	5.2
Copper-lead ro tail	85.15	0.12	0.70	8.84	10.08		0.11	5.38	9.8	29.7	91.4	53.1	35.4
Feed (calcd)	100.00	1.04	2.01	8.24	12.83		0.17	12.94	100.0	100.0	100.0	100.0	100.0

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 9	SAMPLE: Nadina Explorations Limited	DATE: April 8, 1970
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Fe/FeS	Au	Ag	Cu	Pb	Zn	Au	Ag
Calculated assays of combined copper-lead ro conc													
No. 1 + 2	5.33	12.22	11.10	5.05	23.92	13.19	0.82	96.48	62.5	29.5	3.3	26.1	39.8
No. 1 + 2 + 3	9.64	8.87	10.77	4.51	26.93	19.13	0.63	71.75	82.1	51.7	5.3	36.3	53.5
No. 1 + 2 + 3 + 4	12.35	7.42	10.16	4.43	28.45	21.93	0.57	62.23	87.9	62.5	6.7	41.9	59.4
No. 1 + 2 + 3 + 4 + 5	14.85	6.33	9.50	4.77	28.61	23.05	0.53	56.31	90.2	70.3	8.6	46.9	64.6

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 10	SAMPLE: Nadina Explorations Limited	DATE: April 8, 1970
OBJECT OF TEST: To try copper-lead selective flotation directly from the ore using sulphur dioxide for galena depression.		CHARGE: 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton SO_2	Z-200
Grinding	30	65		12 in. BM		
Conditioning	5		6.7	1000-g cell	3.0	
"	5					0.04

PRODUCT	WT %	ANALYSIS %	DISTRIBUTION %
TEST PRODUCTS DISCARDED			

REMARKS: Z-200 did not appear to promote chalcopyrite effectively, obtained a depressed, slimy, and fine-grained froth.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 11	SAMPLE: Nadina Explorations Limited	DATE: April 11, 1970
OBJECT OF TEST:	Copper - lead selective flotation as in Test 10 but used Xanthate as copper promoter in place of Z-200	CHARGE: 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SO_2	CX51	DF250	Lime	NaCN					
Grinding	30	65	7.2	12-in. B.M.										
Conditioning No. 1	5		6.6	1000-g cell	4.0									
" No. 2	5					0.02	0.02							
Copper rougher														
Stage 1	1					0.005								
" 2	1					0.005								
" 3	2						0.01							
Conditioning	5		9.2					4.0	0.10					
Lead roughers														
No. 1	1					0.005								
No. 2	4						0.02							

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Fe/FeS	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper rougher conc	3.03	19.00	3.00	6.60	16.30	-	0.67	105.39	53.6	4.8	2.4	12.1	24.0
Lead rougher conc No. 1	1.62	1.28	52.50	4.25	6.11	4.99	1.19	85.33	1.9	44.6	0.8	11.5	10.4
" " " No. 2	2.15	9.56	5.20	7.20	14.68	6.28	0.44	82.97	19.1	5.9	1.8	5.6	13.4
Zinc rougher conc	15.85	1.08	2.30	47.60	4.76	3.81	0.14	18.29	16.0	19.1	89.9	13.2	21.8
Zinc rougher tail	77.35	0.13	0.63	0.55			0.13	5.24	9.4	25.6	5.1	57.6	30.4
Feed (calcd)	100.00	1.07	1.91	8.39			0.17	13.31	100.0	100.0	100.0	100.0	100.0
Calculated assays													
Lead rougher conc 1 + 2	3.77	6.00	25.53	5.93	11.00	5.73	0.76	83.98	21.0	50.5	2.6	17.1	23.8
Lead ro tail	93.20	0.29	0.91				0.13	7.46	25.4	44.7		70.8	52.2

REMARKS: Copper rougher - light froth, mixed leady + coppery colour
Lead roughers - No. 1, leady froth
No. 2, bright coppery coloured froth
Zinc rougher - light voluminous froth, short of $CuSO_4$?

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 11	SAMPLE: Nadina Explorations Limited	DATE: April 11, 1970
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton			
					CX51	Lime	$CuSO_4$	NaAF
Conditioning	10		11.3			3.0	1.0	
Zinc rougher								
Stage 1	½				0.02			0.10
" 2	1				0.01			
" 3	2				0.01			0.05

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 12 | SAMPLE: Nadina Explorations Limited | DATE: April 10, 1970

OBJECT OF TEST: Copper-lead selective flotation as in Test 11 but employed aerative conditioning prior to copper float. | CHARGE: 2000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SO_2	CX51	DF250	Lime	NaCN	AF242				
Grinding	30	65		12 in. BM										
Conditioning	30		5.7	Aerator	4.0	0.02								
Copper rougher No. 1														
Stage 1	½					0.005	0.02							
" 2	1					0.005								
Copper rougher No. 2														
Stage 1	1					0.005								
" 2	1					0.005								
Conditioning	5		11.0					5.0	0.10					
Lead rougher No. 1														
Stage 1	1									0.01				
" 2	1					0.005				0.01				

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Fe/FeS	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper ro conc No. 1		16.57	7.74	6.59	23.43	8.87	0.51	78.99	43.7	11.5	2.3	9.0	17.9
" " " No. 2		8.16	10.51	6.79	24.56	17.39	0.45	59.49	24.3	17.7	2.7	9.0	15.2
Lead ro conc No. 1		1.29	38.71	7.01	10.63	9.50	1.02	98.46	3.2	54.6	2.3	17.0	21.1
" " " No. 2		4.51	3.04	29.13	11.74	7.78	0.26	45.23	10.3	3.9	8.8	4.0	8.9
Zinc rougher conc		0.78	0.54	49.19	4.64	3.96	0.13	13.99	9.6	3.7	79.6	10.7	14.7
Zinc rougher tail		0.13	0.22	0.49	14.04		0.11	3.80	8.9	8.6	4.3	50.3	22.2
Feed (calcd)		1.10	1.94	8.33	13.24		0.16	12.81	100.0	100.0	100.0	100.0	100.0

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 12 | SAMPLE: Nadina Explorations Limited | DATE: April 10, 1970

OBJECT OF TEST: | CHARGE:

TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton							
						CX41	DF250	Lime		AF242	$CuSO_4$	NaAF
Lead rougher No. 2												
Stage 1	1					0.01						
" 2	1					0.005				0.01		
Conditioning	10		11.5					2.0			2.0	
Zinc rougher												
Stage 1	1					0.02						0.10
" 2	1					0.01	0.02					0.05
Zinc rougher conc 3	3											0.05

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Fe/FeS	Au	Ag	Cu	Pb	Zn	Au	Ag
Calculated assays													
Combined Cu ro conc	6.18	12.11	9.21	6.70	24.03	13.39	0.48	68.64	68.0	29.2	5.0	18.0	33.1
Combined Pb ro conc	5.25	2.83	21.66	17.59	11.16	8.67	0.66	73.01	13.5	58.5	11.1	21.0	30.0
Lead rougher tail	88.57	0.23	0.27			0.002	0.11	5.35	18.5	12.3		61.0	36.9

REMARKS: OBJECT OF TEST: Copper-lead selective flotation as in Test 11 but sample

MINES BRANCH FLOTATION TEST REPORT

TEST NO: 13 | SAMPLE: Nadina Explorations Limited | DATE: June 15, 1970

OBJECT OF TEST: To selectively float a silver conc away from the pyrite conc after regrinding. | CHARGE: 2000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	NaCN	Na_2SO_3	AF208	AF242	DF250	Lime	$CuSO_4$	CX51	NaAF
Grinding	30	65		12-in. B.M.	3.0	0.1	1.0	0.02	0.035					
Conditioning	5	7.8						0.02	0.02	0.02				
Copper-lead rougher				1000-g cell										
Stage 1	1													
" 2	1							0.02	0.02					
" 3	2							0.02	0.02					
Conditioning	10	10.8									4.0	1.0		
Zinc rougher														
Stage 1	½												0.02	
" 2	1									0.02				0.05
" 3	1									0.02				0.05
" 4	1½													

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	S	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper-lead ro conc	13.92	6.98	13.08	6.59	24.76		0.53	64.60	89.5	89.0	10.7	50.8	69.9
Zinc rougher conc	13.07	0.35	0.40	55.45	3.30		0.075	11.34	4.2	2.6	84.6	6.7	11.4
Silver cleaner conc	0.68	1.15	2.95	18.54	22.91		0.80	29.01	0.7	1.0	1.5	3.7	1.5
" " tail	1.65	0.42	0.84	2.63	32.30		0.32	13.44	0.6	0.7	0.5	3.6	1.7
Silver rougher tail	16.03	0.20	0.32	0.96	35.60	39.10	0.25	8.79	3.0	2.5	1.8	27.6	11.0
Final tailing	54.65	0.04	0.16	0.14	5.37	1.82	0.02	1.03	2.0	4.2	0.9	7.6	4.5
Feed (calcd)	100.00	1.09	2.05	8.56	13.21		0.15	12.87	100.0	100.0	100.0	100.0	100.0
Calculated Assays													
Copper-lead ro tail	86.08	0.13	0.26				0.083	4.50	10.5	11.0		49.2	30.1
Zinc rougher tail	73.01	0.10	0.24	0.55			0.085	3.28	6.3	8.4	4.7	42.5	18.7

REMARKS: Copper-lead rougher - light, leady froth
Zinc rougher - gummy froth, "weeping" at end of float
Pyrite rougher - bright, active pyrite float

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 13	SAMPLE: Nadina Explorations Limited	DATE: June 15, 1970
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
						NaCN		AF208	AF 242		Lime	H_2SO_4	CX51	
Conditioning	5		7.8									1.5		
Pyrite rougher														
Stage 1	1												0.05	
" 2	1												0.05	
" 3	1												0.05	
Pyrite conc regrinding	15			8-in. B.M.		0.1					1.0			
Conditioning	5		11.2	500-g cell				0.02	0.02					
Silver rougher														
Stage 1	1													
" 2	1							0.02	0.02					
Silver cleaner	1			250-g cell										

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag		Cu	Pb	Zn	Au	Ag
Metallurgical Balance for Pyrite Rougher													
Pyrite rougher conc*	25.15	0.26	0.46	1.76		0.28	9.96		68.6	49.1	80.9	82.4	76.5
Final tailing	74.85	0.04	0.16	0.14		0.02	1.03		31.4	50.9	19.1	17.6	23.5
Feed (zinc rougher tail)*	100.00	0.10	0.24	0.55		0.085	3.28		100.0	100.0	100.0	100.0	100.0
Metallurgical Balance for Silver Flotation													
Silver cleaner conc	3.71	1.15	2.95	18.54	22.91	0.80	29.07		16.7	23.6	39.0	10.7	10.8
" tail	8.98	0.42	0.84	2.63	32.30	0.32	13.44		14.8	16.2	13.4	10.4	12.1
Silver rougher tail	87.31	0.20	0.32	0.96	35.60	0.25	8.79		68.5	60.2	47.6	78.9	77.1
Feed (pyrite ro conc)	100.00	0.26	0.46	1.76	34.83	0.28	9.96		100.0	100.0	100.0	100.0	100.0

REMARKS: Silver flotation - foamy, fine-grained froth in both rougher and cleaner

*Calculated assays

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 14	SAMPLE: Nadina Explorations Limited	DATE: June 15, 1970
OBJECT OF TEST:	Repeat of Test 13 but with regrinding time for pyrite conc increased from 15 to 30 min.	CHARGE: 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
Procedure identical														
to Test 13 except														
as noted above														

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	S	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper-lead ro conc	13.76	7.20	12.54	6.23	22.88		0.53	64.59	87.3	89.5	10.5	47.6	69.5
Zinc rougher conc	13.66	0.61	0.42	50.64	4.36		0.11	12.16	7.3	3.0	84.3	9.8	13.0
Silver cleaner conc	0.63	1.18	2.44	16.46	23.46		0.96	32.93	0.7	0.8	1.3	3.9	1.6
" " tail	1.72	0.36	0.65	3.20	33.52	36.55	0.34	12.54	0.5	0.6	0.7	3.8	1.7
Silver rougher tail	16.05	0.19	0.26	1.13	36.11	1.64	0.25	8.50	2.7	2.2	2.2	26.2	10.7
Final tailing	54.18	0.03	0.14	0.16	5.24		0.03	0.85	1.5	3.9	1.0	8.7	3.5
Feed (calcd)	100.00	1.13	1.93	8.20	13.10		0.15	12.80	100.0	100.0	100.0	100.0	100.0
Calculated assays													
Copper-lead ro tail	86.24	0.17	0.23	8.52			0.093	4.53	12.7	10.5	89.5	52.4	30.5
Zinc rougher tail	72.58	0.08	0.20	0.59			0.09	3.10	5.4	7.5	5.2	42.6	17.5

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 14	SAMPLE: Nadina Explorations Limited	DATE: June 15, 1970
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe		Au	Ag	Cu	Pb	Zn	Au	Ag
Metallurgical Balance for Pyrite Rougher													
Pyrite rougher conc	25.36	0.24	0.37	1.85	35.43		0.28	9.72	73.1	47.3	79.7	79.2	79.5
Final tailing	74.64	0.03	0.14	0.16	5.24		0.025	0.85	26.9	52.7	20.3	20.8	20.5
Feed (zinc rougher tail)	100.00	0.08	0.20	0.59	12.90		0.09	3.10	100.0	100.0	100.0	100.0	100.0
Metallurgical Balance for Silver Flotation													
Silver cleaner conc	3.44	1.18	2.44	16.46	23.46		0.96	32.93	16.9	22.6	30.6	11.7	11.7
" cleaner tail	9.37	0.36	0.65	3.20	33.52		0.34	12.54	14.0	16.4	16.2	11.3	12.1
" rougher tail	87.19	0.19	0.26	1.13	36.11		0.25	8.50	69.1	61.0	53.2	77.0	76.2
Feed (pyrite ro conc)	100.00	0.24	0.37	1.85	35.43		0.28	9.73	100.0	100.0	100.0	100.0	100.0

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 15	SAMPLE: Nadina Explorations Limited	DATE: June 17, 1970
OBJECT OF TEST: Copper and lead selective flotation directly on the ore using Z-200 as copper promoter as in Test 10, but 1/3 of Z-200 was added to grinding.		CHARGE: 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Z-200	SO_2	DF 250	Lime	NaCN	AF242				
Grinding	30	65		12-in. B.M.	0.01									
Conditioning	20		5.7	Aerator	0.01	4.0								
Copper rougher, stage 1	1			1000-g cell			0.02							
" " " 2	1				0.01									
Conditioning	10		9.7					4.5	0.1					
"										0.02				
Lead rougher, stage 1	1													
" " " 2	1									0.02				
" " " 3	1									0.02				
Copper cleaner	1			250-g cell										
Lead cleaner No. 1	1			" " "										
" " " 2	1			" " "										

PRODUCT	WT %	ANALYSIS %						DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper conc	2.94	25.00	5.52	4.82	21.75	0.64	101.17	61.0	8.3	1.6	12.3	21.3
Copper cleaner tail	1.29	6.55	7.11	10.00	16.72	0.40	60.56	7.0	4.7	1.5	3.4	5.6
Lead conc	2.24	2.26	55.13	6.58	6.57	1.18	149.45	4.2	63.5	1.7	17.3	24.0
Lead cleaner tail No. 2	0.77	2.04	7.90	13.58	11.53	0.28	43.74	1.3	3.1	1.2	1.4	2.4
" " " No. 1	2.95	1.09	2.76	10.53	11.20	0.185	20.16	2.7	4.2	3.6	3.6	4.3
Lead rougher tail	89.81	0.32	0.35	8.70		0.105	6.59	23.8	16.2	90.4	62.0	42.4
Feed (calcd)	100.00	1.21	1.95	8.65		0.15	13.59	100.0	100.0	100.0	100.0	100.0
Calculated Assays												
Copper rougher conc	4.23	19.37	6.00	6.40	20.22	0.57	88.78	68.0	13.0	3.1	15.7	26.0
Lead rougher conc	5.96	1.65	23.11	9.45	9.50	0.57	71.80	8.2	70.8	6.5	22.3	30.7

REMARKS:
Clean and bright froth in both copper and lead roughers.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 16 | SAMPLE: Nadina Explorations Limited | DATE: June 17, 1970

OBJECT OF TEST: Similar to Test 15 but grinding time increased from 30 to 60 min. | CHARGE: 2000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Z-200	SO_2	DF250	Lime	NaCN	AF242				
Grinding	60	65		12 in. BM	0.02									
Conditioning	20		5.8	Aerator	0.02	4.0								
Copper rougher	2			1000-g cell	0.02		0.02							
Conditioning 1	5		9.6					4.5	0.1					
" 2	5								0.1*	0.05				
Lead rougher	2													
Copper cleaner	1			250-g cell										
Lead cleaner	1			500-g cell										

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe		Au	Ag	Cu	Pb	Zn	Au	Ag
Copper conc	2.45	23.25	4.20	4.29	22.73		0.77	99.13	53.2	5.6	1.1	11.8	18.4
Copper cleaner tail	2.54	4.94	5.39	9.12	16.21		0.40	51.72	11.7	7.4	2.4	6.3	10.0
Lead conc	1.82	1.05	59.00	4.67	5.90		1.04	122.14	1.8	58.4	0.9	11.9	16.9
Lead cleaner tail	7.29	0.66	2.39	8.68	11.72		0.13	14.76	4.5	9.5	6.6	5.9	8.2
Lead rougher tail	85.90	0.36	0.41	9.90			0.12	7.10	28.8	19.1	89.0	64.1	46.5
Feed (calcd)	100.00	1.07	1.84	9.56			0.16	13.14	100.0	100.0	100.0	100.0	100.0
Calculated assays													
Copper rougher conc	4.99	13.93	4.81	6.75	19.41		0.58	75.00	64.9	13.0	3.5	18.1	28.4
Lead rougher conc	9.11	0.74	13.70	7.88	10.56		0.31	36.21	6.3	67.9	7.5	17.8	25.1

REMARKS: Copper float - similar to Test 15.
Lead float - light, foamy froth

*Additional NaCN added to depress pyrite which appeared in froth.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 17	SAMPLE: Nadina Explorations Limited	DATE: Aug. 25, 1970
OBJECT OF TEST:	To try copper-lead separation using the dichromate method (copper-lead rougher flotation similar to Test 13).	CHARGE: 2 x 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	NaCN	Na_2SO_3	AF208	AF242	DF250	Lime	$CuSO_4$	CX51	NaAF
Grinding	30	65		12 in. -BM	3.5	0.1	1.0	0.02	0.025					
Conditioning	5		8.4	1000-g cell				0.02	0.02	0.02				
Copper-lead rougher														
Stage 1	1													
" 2	1							0.02	0.02					
" 3	2							0.02	0.02					
Conditioning	10		11.4								4.5	1.0		
Zinc roughers														
Stage 1	½		11.4							0.02	1.0		0.02	
" 2	1													0.05
" 3	2½													0.05

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag		Cu	Pb	Zn	Au	Ag
Copper conc	2.22	23.22	17.36	4.49	16.50	1.28	175.36		50.8	19.1	1.1	16.8	28.0
Lead conc	1.60	2.00	25.84	3.00	26.64	0.54	61.89		3.1	20.5	0.5	5.1	7.1
Copper cleaner tail No.2	0.60	12.94	29.16	4.49	15.90	1.20	231.46		7.6	8.7	0.3	4.3	10.0
" " " No.1	0.70	8.50	30.55	4.26	19.08	0.54	95.42		5.9	10.6	0.3	2.2	4.8
Copper-lead cl tail No.3	1.12	3.27	19.40	10.30	20.87	0.50	59.51		3.6	10.8	1.3	3.3	4.8
" " " " No.2	1.05	2.86	9.85	12.59	19.48	0.44	48.25		3.0	5.1	1.5	2.7	3.6
" " " " No.1	4.79	1.22	5.04	10.00	17.89	0.29	25.40		5.8	12.0	5.4	8.2	8.8
Zinc rougher conc No. 1	8.29	0.70	0.64	41.53	7.16	0.14	11.72		5.7	2.6	38.8	6.8	7.0
" " " No. 2	9.09	0.70	0.47	33.88	16.70	0.20	10.45		6.3	2.1	34.8	10.5	6.8
Pyrite rougher conc No.1	9.69	0.30	0.55	2.90	36.58	0.31	11.50		2.9	2.7	3.2	17.7	8.0
" " " No.2	9.19	0.37	0.58	11.52	27.43	0.28	11.44		3.3	2.7	11.9	15.2	7.6
Final tailing No.1	26.34	0.04	0.12	0.16		0.027	0.94		1.0	1.6	0.5	4.2	1.8
" " No.2	25.32	0.04	0.12	0.15		0.02	0.92		1.0	1.5	0.4	3.0	1.7
Feed (calcd)	100.00	1.01	2.01	8.87		0.17	13.90		100.0	100.0	100.0	100.0	100.0

REMARKS: Two 2000-gram batches ground and floated separately - copper-lead rougher concentrates combined for cleaning and copper-lead separation.
Pyrite appeared in zinc froth upon addition of CX 51, therefore added extra lime -effect of oxidation?

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 17 | SAMPLE: Nadina Explorations Limited | DATE: Aug. 25, 1970

OBJECT OF TEST: | CHARGE: | TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Dich*					DF250			CX51	H_2SO_4
Conditioning	5		8.7											1.5
Pyrite ro, Stage 1	1												0.05	
" " " 2	1												0.05	
" " " 3	1												0.05	
" " " 4	1												0.05	
Copper-lead cl No. 1	3			1000-g cell						0.02				
" " " No. 2	1½			500-g cell										
" " " No. 3	1½			" " "										
Copper-lead separation														
Conditioning	5			250-g cell	4.0									
Copper rougher	1½													
Copper cleaner #1 &2	1			250-g cell										

PRODUCT	WT %	ANALYSIS %						DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag	Cu	Pb	Zn	Au	Ag
Metallurgical Balance for Copper-Lead Separation												
Copper conc	43.41	23.22	17.36	4.49	16.50	1.28	175.36	75.4	32.5	48.8	59.2	56.1
Copper cleaner tail No.2	11.71	12.94	29.16	4.49	15.90	1.20	231.46	11.3	14.7	13.2	15.0	20.0
" " " No.1	13.66	8.50	30.55	4.26	19.08	0.54	95.42	8.6	18.0	14.5	7.8	9.6
Lead conc	31.22	2.00	25.84	3.00	28.64	0.54	61.89	4.7	34.8	23.5	18.0	14.3
Feed (calcd)**	100.00	13.38	23.19	3.99	19.95	0.94	135.58	100.0	100.0	100.0	100.0	100.0
Calculated Assays												
1st Stage copper cl conc	55.12	21.03	19.87	4.49	16.37	1.26	187.28	86.7	47.2	62.0	74.2	76.1
Copper rougher conc	68.78	18.54	21.99	4.44	16.91	1.12	169.03	95.3	65.2	76.5	82.0	85.7

REMARKS:
* Sodium dichromate
** Copper-lead cleaner concentreate

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 18 | SAMPLE: Nadina Explorations Limited | DATE: Aug. 26, 1970

OBJECT OF TEST: To try copper-lead separation using the sulphur dioxide-starch method (copper-lead rougher flotation as in Test 17) | CHARGE: 2 x 2000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
Grinding as														
Copper lead ro in														
Zinc rougher Test														
Pyrite rougher 17*														

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag	S	Cu	Pb	Zn	Au	Ag
Copper conc	2.67	23.68	12.98	3.43	19.58	0.98	130.70		56.5	17.8	1.0	15.6	26.5
Copper cleaner tail No.2	0.34	8.85	21.58	4.17	24.05	0.94	130.67		2.7	3.8	0.2	1.9	3.4
" " " No.1	0.74	6.33	18.26	3.89	27.83	0.74	97.80		4.2	7.0	0.3	3.3	5.5
Lead conc	2.45	2.66	34.08	5.49	20.48	0.56	87.88		5.8	43.0	1.5	8.2	16.3
Copper-lead cl tail No.3	1.05	3.82	11.43	12.79	24.05	0.57	50.08		3.6	6.2	1.5	3.6	4.0
" " " " No.2	1.12	2.30	7.76	13.90	21.47	0.53	45.02		2.3	4.5	1.7	3.5	3.8
" " " " No.1	3.26	1.53	4.00	10.26	17.20	0.28	24.49		4.5	6.7	3.8	5.4	6.1
Zinc rougher conc No. 1	9.45	0.91	0.53	46.18	15.75	0.15	12.16		7.7	2.6	49.0	8.5	8.7
" " " No. 2	9.70	0.74	0.55	33.89	11.88	0.15	11.56		6.4	2.7	37.0	8.7	8.5
Pyrite rougher conc No.1	8.35	0.30	0.58	1.42	34.89	0.34	11.10	38.02	2.2	2.5	1.3	16.9	7.0
" " " No.2	9.03	0.24	0.48	1.95	33.80	0.31	10.14	36.52	1.9	2.2	2.0	16.7	6.9
Final tailing No. 1	26.63	0.05	0.05	0.13		0.02	0.90		1.2	0.7	0.4	3.2	1.8
" " No. 2	25.21	0.04	0.02	0.12		0.03	0.75		1.0	0.3	0.3	4.5	1.5
Feed (calcd)	100.00	1.12	1.94	8.90		0.17	13.18		100.0	100.0	100.0	100.0	100.0

REMARKS: *Except that Z-200 was added to the first stage of the zinc rougher in place of the CX51 added in Test 17.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 18	SAMPLE: Nadina Explorations Limited	DATE: Aug. 26, 1970
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					AF242	DF250	SO_2	CS*						
Copper-lead cleaners														
No. 1	3			1000-g cell	0.01	0.02								
No. 2	1½			500-g cell										
No. 3	1½			" " "		0.004								
Copper-lead separation							0.25	0.05						
Conditioning	5		5.3	250-g cell										
Copper rougher	2					0.004								
Copper cleaner No. 1	1½			250-g cell		0.004								
" " No. 2	1			" " "		0.004								

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag		Cu	Pb	Zn	Au	Ag
Metallurgical Balance for Copper-Lead Separation													
Copper conc	43.06	23.68	12.98	3.43	19.58	0.98	130.70		81.6	24.9	34.0	53.9	51.2
Copper cleaner tail No.2	5.50	8.85	21.58	4.17	24.05	0.94	130.67		3.9	5.3	5.3	6.6	6.5
" " " No.1	11.90	6.33	18.26	3.89	27.83	0.74	97.80		6.0	9.7	10.7	11.3	10.6
Lead conc	39.52	2.66	34.08	5.49	20.48	0.56	87.88		8.5	60.1	50.0	28.2	31.6
Feed (calcd)	100.00	12.49	22.42	4.34	21.16	0.78	109.85		100.0	100.0	100.0	100.0	100.0
Calculated Assays													
1st stage Copper cl conc	48.56	22.00	13.95	3.51	19.98	0.97	130.70		85.5	30.2	39.3	60.5	57.7
Copper rougher conc	60.48	18.91	14.80	3.59	21.61	0.93	124.21		91.5	39.9	50.0	71.8	68.3

REMARKS:

* Caustic Starch - an aqueous solution of starch and caustic starch in the ratio 2:1

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 19 | SAMPLE: Nadina Explorations Limited | DATE: Nov. 10, 1970

OBJECT OF TEST: To try copper-lead separation using the cyanide method (copper-lead rougher flotation as in Test 17). | CHARGE: 2 x 2000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Lime	$CuSO_4$	DF250	MIBC	Z-200	NaAF	CX51			
Grinding } as														
Conditioning } in														
Copper-lead ro } Test 17														
Conditioning	10		11.2	1000-g cell	6.0	2.0								
Zinc rougher														
Stage 1	1						0.02		0.02					
" 2	1									0.05				
" 3	2							0.02						
" 4	3									0.05				

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Au	Ag			Cu	Pb	Zn	Au	Ag
Metallurgical Balance for Copper-Lead Sepn													
Copper conc	65.80	15.80	18.96	4.78	0.86	126.70			68.9	53.2	62.3	69.6	64.1
Lead conc	15.44	9.34	46.20	6.70	0.79	140.40			9.6	30.4	20.5	15.0	16.7
Lead cleaner tail No. 2	7.36	17.50	19.92	5.37	0.69	131.56			8.5	6.3	7.8	6.3	7.4
" " " No. 1	11.40	17.30	20.80	4.15	0.65	134.38			13.0	10.1	9.4	9.1	11.8
Feed (calcd)	100.00	15.10	23.45	5.05	0.81	130.05			100.0	100.0	100.0	100.0	100.0
Lead ro conc (calcd)	34.20	13.75	32.08	5.56	0.72	136.49			31.1	46.8	37.7	30.4	35.9

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 19 | SAMPLE: Nadina Explorations Limited | DATE: Nov. 10, 1970

OBJECT OF TEST: | CHARGE: | TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
									DF250	CX51	H_2SO_4	ZnCN	AF242	NaCN
Conditioning	5		8.7								3.0			
Pyrite rougher, Stage 1	1								0.02	0.05				
" " " 2	1									0.05				
" " " 3	1									0.05				
" " " 4	1									0.05				
Cu-Pb cleaners (as in Test 17)														
Copper-lead separation														
Conditioning	5		11.6	250-g cell								0.87		
Lead rougher	1½												0.01	
Lead cleaner														
No. 1	1½			250-g cell									0.005	0.10
No. 2	1			" " "									0.01	

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	S	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper conc	3.18	15.80	18.96	4.78	19.57		0.86	126.70	45.7	31.5	1.8	17.0	30.8
Lead conc	0.75	9.34	46.20	6.70	7.35		0.79	140.40	6.4	18.1	0.6	3.7	8.1
Lead cleaner tail No. 2	0.36	17.50	19.92	5.37	17.43		0.69	131.56	5.7	3.8	0.2	1.6	3.6
" " " No. 1	0.55	17.30	20.80	4.15	18.82		0.65	134.38	8.6	6.0	0.3	2.2	5.7
Copper-lead cl tail No.3	1.05	3.88	17.44	12.57	19.49		0.49	56.19	3.7	9.6	1.6	3.2	4.5
" " " " No.2	1.04	3.31	9.92	12.37	18.69		0.42	48.45	3.1	5.4	1.5	2.7	3.9
" " " " No.1	4.59	1.46	4.88	9.44	18.48		0.31	25.43	6.1	11.7	5.2	8.8	8.9
Zinc rougher conc	13.33	0.44	0.33	50.35	5.04		0.11	10.42	5.3	2.3	80.9	9.1	10.6
Pyrite rougher conc	23.23	0.60	0.59	2.46	33.71	38.47	0.29	11.41	12.6	7.2	6.9	41.9	20.3
Final tailing	51.92	0.06	0.16	0.16	4.94		0.03	0.91	2.8	4.4	1.0	9.8	3.6
Feed (calcd)	100.00	1.10	1.91	8.30	13.16		0.16	13.07	100.0	100.0	100.0	100.0	100.0

REMARKS: Zinc rougher high grade but extremely "gummy" - effect of high $CuSO_4$?

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 20	SAMPLE: Nadina Explorations Limited No. 2	DATE: Feb. 4, 1971
OBJECT OF TEST:	Copper-lead separation on new sample using SO_2-starch method in conjunction with regrinding prior to cleaning	CHARGE: 2 x 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Na_2SO_3	NaCN	AF208	AF242	DF250	Lime	$CuSO_4$	Z-200	NaAF
Grinding	45	65		7 x 14 RM	3.0	1.0	0.1	0.015	0.015					
Conditioning	5		7.6	1000-g cell				0.01	0.01	0.02				
Copper-lead rougher														
Stage 1	½													
" 2	½							0.01	0.01					
" 3	1							0.01	0.01					
" 4	1								0.02					
Conditioning 1	10		9.1								3.0	0.5	0.02	
" 2	5		10.2								1.0			
Zinc rougher - Stage 1	1													
" " " 2	1													0.05
" " " 3	2													0.10

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Insol	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper conc	0.27	19.48	33.03	2.70	13.17		3.02	142.26	8.0	5.1	0.1	7.6	4.3
Copper cleaner tail	0.60	12.09	47.30	3.86	8.93		0.99	134.46	11.1	16.2	0.3	5.6	9.1
Lead conc	1.76	7.06	50.00	5.00	8.63		0.47	109.19	19.0	50.2	1.0	7.7	21.6
Copper-lead cl tail No.2	0.98	9.69	9.79	12.70	13.02		0.30	80.47	14.5	5.5	1.4	2.7	8.9
" " " " No.1	4.43	4.12	2.65	11.19	17.44		0.16	30.37	27.9	6.7	5.4	6.6	15.1
Zinc conc	10.18	0.56	0.60	40.92	15.54	2.44	0.13	10.07	8.7	3.5	45.4	12.5	11.5
Zinc cleaner tail	4.48	0.35	0.94	18.58	20.41		0.17	9.23	2.4	2.4	9.1	7.2	4.6
Pyrite conc	17.35	0.19	0.46	18.64	28.94	7.78	0.22	9.43	5.0	4.6	35.2	35.2	18.4
Pyrite cleaner tail	3.06	0.17	0.57	1.35	15.02	48.14	0.15	5.72	0.8	1.0	0.4	4.2	2.0
Final tailing	56.89	0.03	0.15	0.30	6.14		0.02	0.73	2.6	4.8	1.7	10.7	4.5
Feed (calcd)	100.00	0.65	1.75	9.18	12.61		0.11	8.91	100.0	100.0	100.0	100.0	100.0

REMARKS: Two 2000-g batches ground and floated separately - rougher concentrates combined for cleaning
%S, pyrite conc: 41.58, final tailing: 1.38

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 20 | SAMPLE: Nadina Explorations Limited No. 2 | DATE: Feb. 4, 1971

OBJECT OF TEST: | CHARGE: | TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Na_2SO_3	NaCN			DF250	Lime		H_2SO_4	CX51
Conditioning - 1	5		8.6										0.35	
" - 2	2													0.05
Pyrite rougher														
Stage 1	1													
" 2	1													0.05
" 3	1													0.05
Zinc cleaner	2		10.6	1000-g cell						0.01	0.5			
Pyrite cleaner	2			" " "						0.01				
Cu-Pb conc regrinding		*		**	1.0	0.5	0.05							

PRODUCT	WT %	ANALYSIS %						DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag	Cu	Pb	Zn	Au	Ag
Metallurgical Balance for Copper-Lead Sepn												
Copper conc	10.24	19.48	33.03	2.70	13.17	3.02	142.26	21.0	7.1	6.1	36.4	12.3
Copper cleaner tail	22.75	12.09	47.30	3.86	8.93	0.99	134.46	29.0	22.6	19.5	26.5	25.9
Lead conc	67.01	7.06	50.00	5.00	8.63	0.47	109.19	50.0	70.3	74.4	37.1	61.8
Feed (calcd)	100.00	9.48	47.65	4.51	9.16	0.85	118.33	100.0	100.0	100.0	100.0	100.0
Copper ro conc (calcd)	32.99	14.38	42.87	3.50	10.25	1.62	136.88	50.0	29.7	25.6	62.9	38.2

REMARKS: * Wet filter cake + 350 cc water

** In Abbé porcelain mill with full charge of steel balls.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 20	SAMPLE: Nadina Explorations Limited No. 2	DATE: Feb. 4, 1971
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
								AF208	AF242	DF250		Z-200	CS	SO_2
Copper-lead cleaner No.1				500-g cell										
Stage 1	1							.0025	.0025					
" 2	1							.0025	.0025					
" 3	1							.0025	.0025					
" 4	2								0.005					
Copper-lead cleaner No.2	2									0.002				
Copper-lead separation														
Conditioning*	5		5.5										0.05	0.75
Copper rougher				250-g cell										
Stage 1	1											0.008		
" 2	1											0.005		
Copper cleaner	1			250-g cell										

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				

REMARKS: * All sulphides depressed upon addition of caustic starch - could not get copper to float effectively even though excess amounts of Z-200 were added.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 21 | SAMPLE: Nadina Explorations Limited No. 2 | DATE: Feb. 5, 1971

OBJECT OF TEST: To try selective flotation of lead and copper concentrates from reground copper-lead rougher concentrate | CHARGE: 2 x 2000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Na_2SO_3	NaCN	AF208	AF242	DF250	Lime	$CuSO_4$	Z-200	NaAF
Grinding	45	65		7 x 14 RM	4.0	1.0	0.10	0.015	0.015					
Conditioning	5		8.0					0.01	0.02	0.02				
Copper-lead rougher				1000-g cell										
Stage 1	½													
" 2	½							0.01	0.01					
" 3	1							0.01	0.01					
" 4	1								0.02					
Conditioning 1	10		10.8								7.0	1.0		
" 2	2									0.02			0.01	0.10
Zinc rougher														
Stage 1	3													
" 2	3													

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Insol	Au	Ag	Cu	Pb	Zn	Au	Ag
Lead rougher conc	2.44	7.02	46.60	4.50	9.69		0.95	112.65	26.0	65.4	1.2	22.0	30.9
Copper rougher conc	1.62	10.00	13.72	24.75	8.81		0.29	75.65	24.6	12.8	4.3	4.5	13.8
Copper rougher tail	5.17	3.57	2.11	6.50	20.72		0.18	28.75	28.0	6.3	3.6	8.8	16.7
Zinc conc	11.73	0.36	0.24	65.44	1.39	1.64	0.06	7.68	6.4	1.6	83.2	6.6	10.1
Zinc cleaner tail	3.55	0.64	1.00	10.85	11.89		0.11	7.47	3.4	2.0	4.2	3.7	3.0
Pyrite conc	18.67	0.26	0.56	1.03	38.18	12.88	0.25	9.97	7.4	6.0	2.1	44.2	20.9
Pyrite cleaner tail	3.53	0.20	0.59	0.63	10.73	57.70	0.08	3.43	1.1	1.2	0.2	2.7	1.4
Final tailing	53.29	0.04	0.15	0.20	5.68		0.15	0.53	3.1	4.7	1.2	7.5	3.2
Feed (calcd)	100.00	0.66	1.74	9.23	12.57		0.11	8.89	100.0	100.0	100.0	100.0	100.0

REMARKS: Two 2000-g batches ground and floated separately - rougher concentrates combined for cleaning.
%S, pyrite conc: 43.42, final tailing: 0.98

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 21 | SAMPLE: Nadina Explorations Limited No. 2 | DATE: Feb. 5, 1971

OBJECT OF TEST: | CHARGE: | TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
										DF250	Lime		H_2SO_4	CX51
Conditioning	5		8.6										1.2	
Pyrite rougher														
Stage 1	1													0.10
" 2	1													0.05
" 3	1													0.05
" 4	1													0.05
Zinc cleaner	3		10.9	1000-g cell						0.02	0.5			
Pyrite cleaner	3			" " "						0.01				

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag		Cu	Pb	Zn	Au	Ag
Metallurgical Balance for Selective Flotation from Cu-Pb Conc													
Lead rougher conc	26.42	7.02	46.60	4.50	9.69	0.95	112.65		33.1	77.5	13.0	62.3	50.3
Copper rougher conc	17.52	10.00	13.72	24.75	8.81	0.29	75.65		31.2	15.1	47.3	12.6	22.4
Copper rougher tail	56.06	3.57	2.11	6.50	20.72	0.18	28.75		35.7	7.4	39.7	25.1	27.3
Feed (calcd)	100.00	5.61	15.90	9.17	15.72	0.40	59.13		100.0	100.0	100.0	100.0	100.0

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 21	SAMPLE: Nadina Explorations Limited No. 2	DATE: Feb. 5, 1971
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton								
					Na_2CO_3	Na_2SO_3	NaCN	AF208		DF250		$CuSO_4$	Z-200
Cu-Pb conc regrinding	30	*		**	1.0	0.5	0.05						
Lead rougher													
Stage 1	1		9.9	500-g cell				0.005					
" 2	2							0.005					
Conditioning	5		9.6									0.1	
Copper rougher	2									0.01			0.003

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				

REMARKS: * Wet filter cake + 400 cc water
** In Abbé porcelain mill with full charge of steel balls

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 22 | SAMPLE: Nadina Explorations Ltd. No. 2 | DATE: Feb. 11/71

OBJECT OF TEST: To try proposed October 1970 Nadina flowsheet* - preliminary test without Cu-Pb separation or lead flotation from secondary tailings (see attached flowsheet). | CHARGE: 2000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2SO_3	$ZnSO_4$	AF208	DF250	Lime	NaCN	Z-3			
Grinding	45	65		7 x 14 RM	0.5	0.1	0.015							
Conditioning	5		6.8	1000-g cell			0.015	0.02						
Copper-lead rougher	3													
Conditioning	5		8.2						2.0	0.15				
Copper-lead scavenger														
Stage 1	½										0.03			
" 2	1										0.02			
" 3	1										0.02			
" 4	1½										0.02			
Copper-lead cleaner	1			250-g cell										

PRODUCT	WT %	ANALYSIS %						DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper-lead conc	2.79	12.85	5.39	7.63	28.27	0.75	102.28	58.6	9.7	2.1	19.1	33.0
" " cleaner tail	1.50	2.32	11.57	9.08	20.63	0.20	22.64	5.7	11.2	1.4	2.7	3.9
Secondary Cu-Pb conc	1.37	3.06	59.81	4.41	5.56	0.41	64.44	6.9	52.8	0.6	5.3	10.2
" " " cl tail	1.13	0.74	18.30	12.03	11.61	0.32	43.28	1.4	13.3	1.4	3.3	5.7
" " " ro tail	3.64	0.43	2.55	11.27	13.19	0.12	8.95	2.6	6.0	4.1	4.0	3.8
Copper-lead scav tail	89.57	0.17	0.12	10.00		0.08	4.20	24.8	7.0	90.4	65.6	43.4
Feed (calcd)	100.00	0.61	1.55	9.91		0.11	8.65	100.0	100.0	100.0	100.0	100.0
Cu-Pb ro conc (calcd)	4.29	9.17	7.55	8.14	25.60	0.56	74.43	64.3	20.9	3.5	21.8	36.9
Cu-Pb scav conc (calcd)	6.14	1.07	18.22	9.88	11.20	0.22	27.65	10.9	72.1	6.1	12.6	19.7

REMARKS: *Developed by Mr. J. D. Gunn of Dolmage Campbell & Associates Ltd., Vancouver, B.C.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 22	SAMPLE: Nadina Explorations Ltd. No. 2	DATE: Feb. 11, 1971
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2SO_3	$ZnSO_4$	AF208	DF250	Lime		Z-3	SO_2		
Flotation from														
Cu-Pb scav conc														
Regrinding	20	50		*	0.15	0.10	0.01		0.5					
Secondary Cu-Pb ro				500-g cell										
Stage 1	1						0.005				0.005			
" 2	½										0.005			
" 3	½							0.004						
" 4	½										0.005			
Secondary Cu-Pb cl														
Condition	5		6.6	250-g cell								0.7		
Float	½						0.005	0.002						

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %					

REMARKS: * 8-in.-dia Abbe porcelain mill with half charge of steel balls.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 23	SAMPLE: Nadina Explorations Ltd. No. 2	DATE: Feb. 12, 1971
OBJECT OF TEST: As in Test 22 but with copper-lead separation and lead flotation from secondary rougher and cleaner tailings (see attached flowsheet)		CHARGE: 2 x 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2SO_3	$ZnSO_4$	AF208	DF250	Lime	NaCN	Z-3			
Grinding	45	65		7 x 14 RM	0.5	0.1	0.03							
Conditioning	5			1000-g cell			0.01	0.02						
Copper-lead rougher	3		6.3											
Conditioning	5		7.9						1.5	0.15				
Copper-lead scavenger														
Stage 1	½										0.03			
" 2	1										0.02			
" 3	1							0.004			0.02			
" 4	1							0.004			0.02			
" 5	1½										0.02			
Copper-lead cleaner #1	1½			500-g cell										
" " " #2	1			250-g cell										

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag		Cu	Pb	Zn	Au	Ag
Copper conc	2.45	12.50	2.12	3.10	31.65	0.74	75.57		48.9	3.0	0.8	16.5	21.1
Copper cleaner tail	0.52	4.84	17.90	4.17	26.32	0.56	70.60		4.0	5.4	0.2	2.6	4.2
Lead conc	2.04	3.36	25.50	4.53	23.33	0.40	67.29		10.9	30.1	1.0	7.4	15.6
No. 2 copper-lead cl tail	0.74	2.36	7.70	9.71	22.63	0.35	42.62		2.8	3.3	0.8	2.4	3.6
No. 1 " " " "	2.83	2.07	7.01	10.19	18.08	0.23	29.69		9.4	11.5	3.2	5.9	9.6
Secondary lead conc	0.70	1.37	51.60	5.10	5.57	0.20	36.67		1.5	20.9	0.4	1.3	2.9
" " cl tail	0.29	1.29	22.86	14.00	10.55	0.18	25.66		0.6	3.8	0.5	0.5	0.8
" " ro tail	2.15	0.60	7.40	12.00	13.38	0.16	13.97		2.1	9.2	2.9	3.1	3.4
Copper-lead scav tail	88.28	0.14	0.25	9.20		0.075	3.86		19.8	12.8	90.2	60.3	38.8
Feed (calcd)	100.00	0.63	1.73	9.01		0.11	8.79		100.0	100.0	100.0	100.0	100.0
Combined lead conc	2.74	2.85	32.17	4.68	18.79	0.35	59.47		12.4	51.0	1.4	8.7	18.5

REMARKS: Two 2000-g lots ground and floated separately - copper-lead rougher and scavenger concentrates combined for further treatment. Appeared to float more weight in Cu-Pb rougher than Test 22 - is this due to extra 0.01 lb/ton AF208?

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 23 | SAMPLE: Nadina Explorations Limited No. 2 | DATE:

OBJECT OF TEST: | CHARGE:

TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2SO_3	$ZnSO_4$	AF208	DF250	Lime	NaCN	Z-3	SO_2		
Flotation from														
Cu-Pb scav conc														
Regrinding	20	50		*	0.15	0.1	0.01		0.5					
Secondary Cu-Pb ro				500-g cell										
Stage 1	1		9.9				0.005				0.005			
" 2	1							0.004			0.005			
" 3	½										0.005			
Secondary Cu-Pb cl														
Condition	5		6.4	250-g cell								0.35		
Float	1½						0.005				0.002			

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag		Cu	Pb	Zn	Au	Ag
Metallurgical Balance for Copper-Lead Separation													
Copper conc	48.81	12.50	2.12	3.10	31.65	0.74	75.57		76.5	7.8	39.9	62.2	51.5
Copper cleaner tail	10.37	4.84	17.90	4.17	26.32	0.56	70.60		6.3	14.0	11.4	10.0	10.2
Lead conc	40.82	3.36	25.50	4.53	23.33	0.40	67.29		17.2	78.2	48.7	27.8	38.3
Feed (calcd)**	100.00	7.97	13.30	3.79	27.70	0.58	71.67		100.0	100.0	100.0	100.0	100.0
Copper rougher conc(calcd)	59.18	11.16	4.89	3.29	30.72	0.71	74.70		82.8	21.8	51.3	72.2	61.7

REMARKS: * 8-in.-dia Abbe porcelain mill with half charge of steel balls. Cu-Pb secondary rougher conc appeared to be high grade lead conc - some of the galena was depressed in subsequent cleaning with SO_2 at pH of 6.4.

** Copper-lead cleaner conc + copper-lead secondary cleaner conc.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 23 | SAMPLE: Nadina Explorations Ltd. No. 2 | DATE: Feb. 12, 1971

OBJECT OF TEST: | CHARGE: | TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
							AF208	DF250		NaCN	Z-3	SO_2	CS	
Flotation from														
Secondary tailings														
Secondary lead ro				500-g cell										
Stage 1	½		8.5					0.01		0.10	0.01			
" 2	1							0.01			0.01			
" 3	1										0.01			
Secondary lead cl				250-g cell						0.05				
Copper-lead separation				" " "										
Conditioning	5		3.3									0.75		
"	5		5.4										0.05	
Copper rougher	1¼						0.01							
Copper cleaner	3/4		3.1	250-g cell								0.50		

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				

REMARKS: Copper-lead separation: Bright, coppery froth after addition of SO_2 but subsequent addition of starch depressed copper which came up again, however, upon addition of AF208.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 24	SAMPLE: Nadina Explorations Ltd. No. 2	DATE: Feb. 25, 1971
OBJECT OF TEST: To try selective flotation of copper, lead and zinc concentrates from reground copper-lead rougher concentrate.		CHARGE: 2 x 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Na_2SO_3	NaCN	AF208	AF242	DF250	Lime	$CuSO_4$	Z-200	NaAF
Grinding	45	65		7 x 14 RM	4.0	1.0	0.1							
Conditioning	10		7.9	2000-g cell				0.02	0.02	0.02				
Copper-lead rougher				" " "										
Stage 1	1							0.01	0.01					
" 2	1							0.01	0.01					
" 3	1								0.02					
" 4	1								0.02					
Conditioning	10		10.9								7.0	0.75		
Zinc rougher, Stage 1	1									0.02			0.01	
" " Stage 2	1									0.02				
" " Stage 3	2													0.05
" " Stage 4	1													0.05

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	S	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper conc	1.20	21.94	21.18	3.82	14.00		1.25	178.90	41.3	14.3	0.5	14.6	24.5
No. 2 Copper cleaner tail	0.35	9.48	32.11	4.41	14.96		0.76	120.84	5.2	6.3	0.2	2.6	4.8
No. 1 " " "	0.69	6.24	26.37	5.30	18.41		0.46	72.94	6.8	10.2	0.4	3.1	5.7
Lead conc	1.15	3.79	51.82	6.74	7.45		0.40	72.00	6.8	33.4	0.9	4.5	9.5
No. 2 Lead cleaner tail	0.29	4.36	14.36	10.50	17.25		0.33	54.67	2.0	2.3	0.3	1.0	1.8
No. 1 " " "	1.62	2.74	7.87	9.87	29.46		0.25	34.73	7.0	7.2	1.8	4.0	6.4
Secondary zinc ro conc	0.58	2.21	5.63	11.29	21.31		0.21	26.56	2.0	1.8	0.7	9.0	7.8
" Cu-Pb ro tail	5.02	1.05	3.15	5.37	29.46		0.19	13.60	8.3	8.9	3.0	1.2	1.8
Zinc rougher conc	15.90	0.45	0.49	47.02	5.60		0.075	8.00	11.2	4.4	82.3	11.6	14.5
Pyrite conc	14.56	0.25	0.58	5.32	37.47	44.58	0.25	10.04	5.7	4.7	8.5	35.4	16.7
Pyrite cleaner tail	1.69	0.27	0.75	1.02	14.00		0.12	5.57	0.7	0.7	0.2	1.9	1.1
Final tailing	56.95	0.034	0.18	0.21		1.29	0.02	0.82	3.0	5.8	1.2	11.1	5.4
Feed (calcd)	100.00	0.64	1.78	9.09			0.10	8.60	100.0	100.0	100.0	100.0	100.0
Cu-Pb ro tail (calcd)	89.10	0.15	0.31				0.07	3.70	20.6	15.6		60.0	37.7

REMARKS: Two 2000 gram batches ground and floated separately - rougher concentrates combined for further treatment.
Coarse pyrite floated at end of copper-lead rougher.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 24	SAMPLE: Nadina Explorations Ltd. No. 2	DATE: Feb. 25, 1971
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	NaCN	AF242	DF 250	H_2SO_4	Z-6	Z-200	SO_2	CS	
Conditioning	5		8.5	1000-g cell					1.4					
Pyrite ro, Stage 1	1									0.10				
" " " 2	1									0.05				
" " " 3	1									0.05				
" " " 4	1									0.05				
Pyrite cleaner	2½			1000-g cell				0.02						
Selective flotation														
from Cu-Pb rougher conc														
Regrinding	30	50		*								0.75	0.03	
Conditioning	2		5.7	500-g cell								0.5		
Copper ro, Stage 1	1							0.003			0.003			
" " Stage 2	1							0.003			0.003			

PRODUCT	WT %	ANALYSIS %						DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag	Cu	Pb	Zn	Au	Ag
Metallurgical Balance for Selective Flotation from Copper-Lead Rougher Conc												
Copper conc	11.01	21.94	21.18	3.82	14.00	1.25	178.90	52.1	16.9	6.5	36.7	39.4
No. 2 Copper cleaner tail	3.19	9.48	32.11	4.41	14.96	0.76	120.84	6.5	7.4	2.2	6.4	7.7
No. 1 " " "	6.29	6.24	26.37	5.30	18.41	0.46	72.94	8.5	12.0	5.2	7.7	9.2
Lead conc	10.54	3.79	51.82	6.74	7.45	0.40	72.00	8.6	39.6	11.0	11.2	15.2
No. 2 Lead cleaner tail	2.69	4.36	14.36	10.50	17.25	0.33	54.67	2.5	2.8	4.4	2.4	2.9
No. 1 " " "	14.91	2.74	7.87	9.87	21.10	0.25	34.73	8.8	8.5	22.9	9.9	10.3
Secondary Zn ro conc	5.29	2.21	5.63	11.29	21.31	0.21	26.56	2.5	2.2	9.3	3.0	2.8
" Cu-Pb ro tail	46.08	1.05	3.15	5.37	29.46	0.19	13.60	10.5	10.6	38.5	22.7	12.5
Feed (calcd)	100.00	4.64	13.79	6.43	22.27	0.38	50.05	100.0	100.0	100.0	100.0	100.0
Copper ro conc (calcd)	20.49	15.18	24.47	4.37	15.50	0.93	137.33	67.1	36.3	13.9	50.8	56.3
Lead ro conc (calcd)	28.14	3.29	24.95	8.76	15.62	0.31	50.60	19.9	50.9	38.3	23.5	28.4

REMARKS: * 8-in.-dia Abbé ceramic ball mill with full charge of ceramic balls.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 24	SAMPLE: Nadina Explorations Ltd. No. 2	DATE:
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3		NaCN		AF242	DF250	Lime	$CuSO_4$	Z-200	SO_2
Conditioning	5		8.7	500-g cell	0.5		0.05							
Lead rougher														
Stage 1	1								0.005					
" 2	2								0.005					
Conditioning	10		11.5								0.75	0.2		
Secondary zinc ro	1½												0.005	
Copper cleaners														
No. 1	1½		3.5	250-g cell						0.004				0.5
No. 2	1¼		3.2	" " "						0.002				0.5
Lead cleaners														
No. 1	1½			500-g cell						0.004				
No. 2	1½			250-g cell					0.003					

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 25	SAMPLE: Nadina Explorations Ltd. No. 2	DATE: Mar. 25, 1971
OBJECT OF TEST: To try modified version of October 1970 Nadina flowsheet as a method for selectively floating copper and lead concentrates directly from the ore		CHARGE: 2 x 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2SO_3	$ZnSO_4$	Z-200	Lime	NaCN	Z-3	DF250			
Grinding	45	65		7 x 14 RM	0.5	0.1	0.02							
Conditioning	10		6.6	1000-g cell										
Copper rougher	3						0.01				0.02			
Conditioning	5		9.5					2.0	0.15					
Lead rougher														
Stage 1	½									0.03				
" 2	1									0.02				
" 3	1									0.02				
" 4	1½									0.02				

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	S	Au	Ag	Cu	Pb	Zn	Au	Ag
Copper conc	1.06	17.86	2.74	3.06	28.94		0.28	70.94	26.8	1.6	0.4	2.8	8.1
No. 2 copper cleaner tail	1.29	7.49	2.62	4.03	33.93		0.41	51.31	14.2	2.0	0.6	5.2	7.5
No. 1 " " "	3.56	3.74	4.21	6.30	27.34		0.43	36.91	19.5	8.8	2.6	14.9	14.8
Lead conc	0.70	1.25	67.70	2.50	2.59		0.50	94.92	1.3	27.7	0.2	3.4	7.5
No. 2 lead cleaner tail	0.63	1.90	48.88	6.30	6.09		0.31	69.49	1.8	18.0	0.5	1.9	4.9
No. 1 " " "	1.95	1.90	17.01	10.00	11.48		0.26	41.42	5.4	19.4	2.2	5.0	9.1
Zinc rougher conc	13.35	0.63	0.47	50.00	4.19		0.09	11.52	12.3	3.7	76.0	11.7	17.3
Pyrite conc	16.42	0.63	0.53	8.00	36.49	44.68	0.23	12.66	15.2	5.1	14.9	36.8	23.4
Pyrite cleaner tail	2.60	0.24	0.59	4.42	19.77	17.04	0.16	6.87	0.9	0.9	1.3	4.1	2.0
Final tailing	58.48	0.03	0.38	0.19		2.23	0.025	0.82	2.6	12.8	1.3	14.2	5.4
Feed (calcd)	100.00	0.68	1.71	8.77					100.0	100.0	100.0	100.0	100.0
Copper rougher conc (calcd)	5.87	7.02	3.60	5.24	29.07		0.40	45.99	60.5	12.4	3.6	32.9	30.4
Lead rougher conc (calcd)	3.28	1.77	33.95	7.69	8.55		0.32	58.23	8.5	65.1	2.9	10.3	21.5
Lead rougher tail (calcd)	90.85	0.23	0.43				0.075	4.70	31.0	22.5		66.8	48.1

REMARKS: Two 2000-gram batches ground and floated separately - rougher concentrates combined for cleaning.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 25	SAMPLE: Nadina Explorations Ltd. No. 2	DATE: March 25, 1971
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
							Z-200	Lime			$CuSO_4$	NaAF	H_2SO_4	Z-6
Conditioning	10		11.2					3.0			1.0			
Zinc rougher														
Stage 1	1						0.01							
" 2	1						0.01							
" 3	1											0.05		
" 4	2											0.05		
Conditioning	5		8.2										1.5	
Pyrite rougher														
Stage 1														0.01
" 2														0.05
" 3														0.05
" 4														0.05

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 25	SAMPLE: Nadina Explorations Ltd., No. 2	DATE: March 25, 1971
OBJECT OF TEST:		CHARGE: 2 x 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2SO_3	$ZnSO_4$		Lime	Z-3			DF250	SO_2	
Copper cleaners														
No. 1	2		5.1	500-g cell									0.5	
No. 2	1		4.0	250-g cell									0.15	
No. 3	1		4.7	" "									0.1	
Lead rougher conc														
regrinding	20			*	0.15	0.1		0.5	0.005					
Lead cleaners			***											
No. 1	2		10.0	500-g cell		0.1**			0.04			0.005	0.25**	
No. 2	1½			250-g cell								0.002		
Pyrite cleaner	3			1000-g cell								0.03		

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				

REMARKS: * 8 in.-dia Abbe porcelain mill with ½ charge of steel balls
** added to lower pH
*** 11.2 before addition of $ZnSO_4$ and SO_2

MINES BRANCH FLOTATION TEST REPORT Sheet 1 of 2

TEST NO. 26	SAMPLE: Nadina Explorations Ltd. No.2	DATE: Mar. 30, 1971
OBJECT OF TEST: Bulk float with separation of copper-lead rougher conc using SO_2-starch method followed by lead flotation from reground separation tailing.		CHARGE: 2 x 2000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Na_2SO_3	NaCN	AF 208	AF 242	DF250	SO_2	CS		
Grinding	45	65		7 x 14 RM	4.0	1.0	0.1	0.01	0.02					
Conditioning	10		7.9					0.01	0.01	0.02				
Copper-lead rougher														
Stage 1														
" 2								0.01	0.02					
" 3								0.01	0.02					
Copper-lead separation														
Conditioning	10		5.1	500-g cell							2.5	0.05		
Copper rougher	1½													
Copper Cleaner No. 1	1		3.7	250-g cell							0.25			
" " " 2	1		4.0	" "							0.15			

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag		Cu	Pb	Zn	Au	Ag
Copper conc	1.11	27.08	4.45	5.15	17.47	0.94	163.36		44.7	3.0	0.6	9.8	21.4
No. 2 copper cleaner tail	0.67	10.00	13.79	4.79	23.95	1.09	141.34		10.0	5.6	0.3	6.9	11.2
No. 1 " " "	0.75	5.29	15.80	5.45	23.95	0.45	79.72		5.9	7.2	0.4	3.2	7.1
Lead conc	0.99	0.69	70.45	3.00	3.49	0.26	43.71		1.0	42.6	0.3	2.4	5.1
Lead cleaner tail	0.48	2.21	25.43	10.00	12.48	0.32	43.33		1.6	7.5	0.5	1.4	2.5
" rougher "	3.23	1.80	6.22	10.41	17.56	0.22	24.23		8.6	12.3	3.6	6.7	9.2
Copper-lead ro tail	92.77	0.21	0.39	9.44		0.08	3.98		28.2	21.8	94.3	69.6	43.5
Feed (calcd)	100.00	0.67	1.64	9.30		0.11	8.47		100.0	100.0	100.0	100.0	100.0
Separation tail (calcd)	4.70	1.61	21.71	8.81	14.08	0.24	30.28		11.2	62.4	4.4	10.5	16.8

REMARKS: Two 2000-g batches ground and floated separately - rougher concentrates combined for further treatment.

MINES BRANCH FLOTATION TEST REPORT Sheet 2 of 2

TEST NO. 26	SAMPLE: Nadina Explorations Ltd. No. 2	DATE: Mar. 30, 1971
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Na_2SO_3	NaCN		AF242	DF250				
Lead flotation from separation tailing														
Regrinding	30			*	0.4	0.1	0.025		0.005					
Lead rougher				500-g cell										
Stage 1	½									0.003				
" 2	½								0.003					
" 3	1								0.003	0.003				
" 4	1									0.003				
Lead cleaner	1½			250-g cell										

PRODUCT	WT %	ANALYSIS %						DISTRIBUTION %				
		Cu	Pb	Zn	Fe	Au	Ag	Cu	Pb	Zn	Au	Ag
Metallurgical Balance for Copper-Lead Separation												
Copper conc	15.38	27.08	4.45	5.15	17.47	0.94	163.36	62.3	3.9	16.3	32.3	38.0
No. 2 copper cleaner tail	9.21	10.00	13.79	4.79	23.95	1.09	141.34	13.8	7.2	13.3	22.4	19.7
No. 1 " " "	10.36	5.29	15.80	5.45	23.95	0.45	79.22	8.2	9.2	15.0	10.4	12.5
Lead rougher conc	65.05	1.61	21.71	8.81	14.08	0.24	30.28	15.7	79.7	55.4	34.9	29.8
Feed (calcd)**	100.00	6.68	17.71	7.53	16.53	0.45	66.10	100.0	100.0	100.0	100.0	100.0

REMARKS: * 8 in.-dia. Abbe porcelain mill with ½ charge of steel balls.
** Copper-lead rougher concentrate.

MINES BRANCH
CYANIDATION TEST REPORT

Sheet 1 of 2

Test No: 1	Sample: Nadina Explorations pyrite conc
Test By: M.R.	from Tests 17 and 18 (Composite No. 1)

OBJECT OF TEST: Initial test on reground, raw pyrite conc*

TEST DATA

Date	Time hr	NaCN, lb/ton Solution		Lime lb/ton Solution		Charge:	
		Added	Titrn	Added	Titrn	Solids, g	581
						Water, cc	1000
Sept.2/70	0	2.0		0.6		Dilution (Water : Solids)	1.7:1
" "	1.25	1.7	0.3	0.5	trace		
" "	3.25	2.6	0.4	1.5	"	Nominal Solution Strength,	
Sept.3/70	20.25	2.0	0.3	1.5	"	lb/ton Solution:	
" "	23.25	1.4	1.4	0.7	0.3	NaCN	2.0
" "	26.25	0.5	2.0	0.2	0.7	Lime	0.5
Sept.4/70	44.25	0.5	1.5	0.2	0.3	Reagent Consumption,	
" "	48.50		1.76		0.24	lb/ton Solids Cyanided:	
Total		10.7		5.2		NaCN	15.4
						Lime	8.5
						Reducing power**	1984

METALLURGICAL BALANCE

Product	Wt %	Assays, oz/ton		Distribution, %	
		Au	Ag	Au	Ag
Pregnant solution***	-	0.07	4.06	25.0	37.2
Cyanidation residue	100.0	0.21	6.84	75.0	62.8
Feed (assay)	100.0	0.28	10.90	100.0	100.0

Remarks: Additional feed analyses (%):

Cu	Pb	Zn	Fe	S	Insol	As	Sb
0.32	0.48	4.63	32.00	38.68	18.28	0.38	0.14

*Reground for 60 min in an 8-in. dia porcelain mill with steel balls and 500 cc water (screen analysis on Sheet 2).

** No. of cc of 0.01N $KMnO_4$ soln required to oxidize all reducing agents present in 1000 cc of pregnant solution.

*** Assays expressed as oz/ton feed and obtained by difference.

Cyanidation Test Report

Test No. 1

Screen Analysis of Pyrite Concentrate

Tyler Mesh Size	Before Regrinding % Wt	After Regrinding % Wt
+200	14.0	-
+325	21.1	1.2
+400	5.2	0.7
+500	19.3	6.8
-500	40.4	91.3
Total	100.0	100.0

MINES BRANCH
CYANIDATION TEST REPORT Sheet 1 of 2

Test No: 2	Sample: Nadina Explorations - calcines from roasting
Test By: M.R.	of pyrite conc composite No. 1

OBJECT OF TEST: To try a complete, high-temperature roast prior to cyanidation.

TEST DATA

Date	Time hr	NaCN, lb/ton Solution		Lime lb/ton Solution		Charge:	
		Added	Titrn	Added	Titrn	Solids, g	386
						Water, cc	1000
Sept 2/70	0	2.0		0.6		Dilution (Water : Solids)	2.6:1
" "	1.25	1.5	0.5	0.4	0.1		
" "	3.25	1.0	1.4	0.2	0.5	Nominal Solution Strength,	
Sept 3/70	20.25		2.0		0.7	lb/ton Solution :	
" "	23.25		2.0		0.7	NaCN	2.0
" "	26.25		1.9		0.7	Lime	0.5
Sept 4/70	44.25		1.8		0.7	Reagent Consumption,	
" "	48.5		2.04		0.68	lb/ton Solids Cyanided:	
Total		4.5		1.2		NaCN	6.4
						Lime	1.3
						Reducing power	44

METALLURGICAL BALANCE

Product	Wt %	Assays, oz/ton		Distribution, %	
		Au	Ag	Au	Ag
Loss in roasting*	24.44	-	0.04	-	0.4
Pregnant solution*	-	0.16	3.11	58.4	28.5
Cyanidation residue	75.56	0.16	10.64	41.6	71.1
Feed (assay)	100.00	0.28	10.90	100.0	100.0
Calcines		0.39	14.36		

Remarks: Additional analyses %

	Cu	Pb	Zn	Fe	Total S	Sulphide S	Insol	As	Sb
Feed	0.32	0.48	4.63	32.00	38.68	-	18.28	0.38	0.14
Calcines	0.33	0.65	5.77	42.41	1.13	0.09	22.55	0.36	0.08

*Assays for roasting loss and pregnant solution expressed as oz/ton feed and obtained by difference. Losses in calcine grinding and wash solution not determined but assumed to be negligible because of the complete nature of the roast.

Cyanidation Test Report

Test No. 2

Roasting Procedure

Elapsed time hr	Elapsed time min	Temp °C	Remarks
start		room	Charge in, controller set at 450°
1	5	410	Charge ignited, fan on, door open 2 inches
1	15	450	
2	15	450	Controller set at 600°
2	30	600	Door ½ open
3	30	600	Controller set at 700°
4	5	700	
5	5	700	Shut power off, calcine cooled in furnace

Calcine Treatment Before Cyanidation

(1) After removing 50 grams for analysis, calcines ground with pebbles for 30 min in an 8-in. dia. porcelain mill with 500 cc water.

(2) Ground calcines filtered, and the filter cake washed 3 times to remove last traces of soluble salts.

(3) Washed cake repulped in agitation bottle to make up a volume of 1000 cc water.

MINES BRANCH

CYANIDATION TEST REPORT

Test No: 3	Sample: Nadina Explorations - calcines from roasting
Test By: J.C.B.	of pyrite conc from Test 19

OBJECT OF TEST: To try a short partial roast at a low temp (475°C) prior to cyanidation with lime added to roasting charge

TEST DATA

Date	Time hr	NaCN, lb/ton Solution		Lime lb/ton Solution	
		Added	Titrn	Added	Titrn
Nov 24/70	0	2.0		0.5	
" "	1	2.0	0.05	1.0	-
" "	2	1.2	0.8	1.0	0.05
" "	4	0.6	1.5	0.4	0.3
" "	7	0.6	1.8	0.4	0.4
Nov 25/70	23.5	0.6	1.7	0.4	0.3
" "	26.5	0.2	1.95	0.2	0.4
" "	31.0	0.2	2.05	0.2	0.4
Nov 26/70	48.0		1.88		0.28
Total		7.4		4.1	

Charge:	253
Solids, g	1000
Water, cc	4.0:1
Dilution (Water : Solids)	
Nominal Solution Strength, lb/ton Solution:	
NaCN	2.0
Lime	0.5
Reagent Consumption, lb/ton Solids Cyanided:	
Na CN	21.8
Lime	15.1
Reducing power	1000

METALLURGICAL BALANCE

Product	Wt %	Assays, oz/ton		Distribution, %	
		Au	Ag	Au	Ag
Loss in roasting*	10.41	-	0.70	-	6.4
Loss in calcine wash soln	14.29	-	0.092**	-	0.9
Pregnant solution*	-	0.18	6.07	64.5	55.9
Cyanidation residue	75.30	0.13	5.31	35.5	36.8
Feed (assay)***	100.00	0.28	10.86	100.0	100.0
Calcines (after washing		0.37	13.37		

Remarks: Additional analyses %

	Cu	Pb	Zn	Fe	Total S	Sulphide S
Feed	0.60	0.59	2.46	33.71	38.47	-
Cyanidation residue	0.26	0.71	1.75	-	12.71	2.04

* Assays for roasting loss and pregnant solution expressed as oz/ton feed and obtained by difference.

** Expressed as oz/ton feed, actual value: 0.15 mg/litre in first wash soln, none in second wash soln.

*** Adjusted for dilution effect of the addition of 20 g lime to charge, actual values: Au 0.29 oz/ton, Ag 11.41 oz/ton.

Cyanidation Test Report

Test No. 3

Preparation of Roasting Charge

(1) Ground pyrite conc for 60 min in 8 in.-dia porcelain mill with full charge of steel balls.

(2) Ground conc filtered and dried.

(3) Dried cake bucked through 100 mesh screen to break up lumps.

(4) Added 20 grams of lime and mixed thoroughly in tumbler mixer.

Roasting Procedure

Elapsed time		Temp °C	Remarks
hr	min		
			Furnace heated to 475°C
start		475	Put charge in furnace
	5	475	Charge ignited, fan on, door open 2 inches
	50	475	Hot calcines removed from furnace and cooled in fume hood

Calcine Treatment Before Cyanidation

(1) Repulped cooled calcines with cold water, conditioned in a 2000-g lab cell for 5 min and filtered.

(2) Step (1) repeated on filter cake.

(3) Both filterates from above saved and analysed for precious metals content.

(4) Filter cake dried and 50 grams cut out for assay.

(5) Balance of sample ground for 10 min in an 8 in.-dia ceramic mill with 1/2 charge of steel balls (this was done to break up hard lumps).

(6) Wet cake transferred to agitation bottle and additional water added to bring volume to 1000 cc.

MINES BRANCH
CYANIDATION TEST REPORT

Test No: 4	Sample: Nadina Explorations - calcines from roasting of
Test By: J.C.B.	pyrite conc from Test 19

OBJECT OF TEST: To try a partial roast at a low temp with lime as in Test 3 but increased roasting time from 45 min to 3 hours*.

TEST DATA

Date	Time hr	NaCN, lb/ton Solution		Lime lb/ton Solution		Charge:	
		Added	Titrn	Added	Titrn	Solids, g	220
						Water, cc	1000
Nov.24/70	0	2.0		0.5		Dilution (Water : Solids)	4.5:1
" "	1	0.2	0.85	1.0	-		
" "	2	0.8	1.2	0.5	0.1	Nominal Solution Strength,	
" "	4	0.2	1.9	0.5	0.15	lb/ton Solution:	
" "	7	-	1.9	0.4	0.25	NaCN	2.0
Nov 25/70	23.5	0.1	1.95	0.5	0.15	Lime	0.5
" "	26.5	-	2.0	0.4	0.25	Reagent Consumption,	
" "	31.0	0.1	2.0	0.6	0.25	lb/ton Solids Cyanided:	
Nov.26/70	48.0		1.95		0.34	NaCN	6.6
Total		3.4		4.4		Lime	18.5
						Reducing power	75

METALLURGICAL BALANCE

Product	Wt %	Assays, oz/ton		Distribution, %	
		Au	Ag	Au	Ag
Loss in roasting	14.36	0.01	0.80	3.5	7.4
Loss in calcine wash soln	18.81	-	0.04**	-	0.4
Pregnant solution	-	0.20	7.44	71.1	68.6
Cyanidation residue	66.83	0.105	3.83	25.4	23.6
Feed (assay)	100.00	0.28	10.86	100.0	100.0
Calcines (after washing)		0.40	14.97		

Remarks: Additional analyses %

	Cu	Pb	Zn	Total S	Sulphide S
Cyanidation residue	0.14	0.80	1.94	1.31	0.67

*Procedure identical to Test 3 except that pyrite conc was not reground prior to roasting.

**Expressed as oz/ton feed, actual value: none in first wash solution, 0.066 mg/litre in second washsolution.

MINES BRANCH
CYANIDATION TEST REPORT

Test No: 5	Sample: Nadina Explorations pyrite conc from
Test By: M.R.	Tests 20, 21, and 24 (Composite No. 2)

OBJECT OF TEST: To try cyanidation of reground raw pyrite conc produced from No. 2 ore sample*.

TEST DATA

Date	Time hr	NaCN, lb/ton Solution		Lime lb/ton Solution	
		Added	Titrn	Added	Titrn
Mar 8/71	0	2.0		0.5	
" "	1	2.0	0.2	1.0	-
" "	4	2.0	0.2	1.0	-
" "	6.5	1.2	0.9	1.0	-
Mar 9/71	23	1.4	0.6	0.6	trace
" "	26	0.8	1.3	0.6	0.1
" "	30.5	0.2	1.9	0.6	0.1
Mar 10/71	48		1.24		0.12
Total		9.6		5.3	

Charge:	
Solids, g	509
Water, cc	1000
Dilution (Water : Solids)	2.0:1
Nominal Solution Strength,	
lb/ton Solution:	
NaCN	2.0
Lime	0.5
Reagent Consumption,	
lb/ton Solids Cyanided:	
NaCN	16.4
Lime	10.2
Reducing power	1276

METALLURGICAL BALANCE

Product	Wt %	Assays, oz/ton		Distribution, %	
		Au	Ag	Au	Ag
Pregnant solution	0.62**	0.066	3.91	28.1	40.8
Cyanidation residue	99.38	0.17	5.72	71.9	59.2
Feed (assay)	100.00	0.24	9.60	100.0	100.0

Remarks: Additional feed analysis (%):

Cu	Pb	Zn	Fe	Insol	Total S
0.21	0.51	8.50	35.13	10.10	43.35

* Same grinding procedure as in Test 1.

** Weight loss in pregnant solution accurately determined in this and succeeding tests, in preceding 4 tests it was assumed that cyanidation residue = cyanidation feed.

MINES BRANCH
CYANIDATION TEST REPORT

Sheet 1 of 2

Test No: 6	Sample: Nadina Explorations, calcines from low temp roast
Test By: M.R.	of pyrite conc composite No. 2

OBJECT OF TEST: Repeat of Test 4 on composite No. 2, i.e., 3 hour roast at 475°C with lime added to charge

TEST DATA

Date	Time hr	NaCN, lb/ton Solution		Lime lb/ton Solution		Charge:	
		Added	Titrn	Added	Titrn	Solids, g	338
						Water, cc	1000
Mar. 8/71	0	2.0		0.5		Dilution (Water : Solids)	5.9:1
" "	1	2.0	0.3	1.0	-		
" "	4	1.0	0.6	0.4	0.1	Nominal Solution Strength,	
" "	6.5	1.2	1.1	1.0	0.1	lb/ton Solution:	
Mar 9/71	23	1.2	0.8	0.4	0.2	NaCN	2.0
" "	26	0.6	1.4	0.2	0.4	Lime	0.5
" "	30.5	0.4	1.6	0.2	0.4	Reagent Consumption,	
Mar 10/71	48		1.04		0.24	lb/ton Solids Cyanided:	
Total		8.4		3.7		NaCN	21.8
						Lime	10.2
						Reducing power	996

METALLURGICAL BALANCE

Product	Wt %	Assays, oz/ton		Distribution, %	
		Au	Ag	Au	Ag
Loss in roasting	15.74	-	-	-	-
Loss in calcine wash soln	10.89	-	-	-	-
Pregnant solution*	0.51	0.15	5.27	66.2	57.1
Cyanidation residue	72.86	0.105	5.43	33.8	42.9
Feed (assay)**	100.00	0.23	9.23	100.0	100.0
Calcines (before washing)		0.29	12.11		

Remarks: Additional analyses, %:

	Cu	Pb	Zn	Fe	Total S	Sulphide S
Calcines (before washing)	0.26	0.60	9.90	41.85	16.71	1.54
Cyanidation residue	0.10	0.65	8.76	45.39	12.34	1.59

* Assays expressed as oz/ton feed and obtained by difference

** Adjusted for dilution effect of the addition of 20 g lime to charge, actual values: 0.24 oz/ton Au, 9.60 oz/ton Ag.

Cyanidation Test Report

Test No. 6

Preparation of Roasting Charge

(1) Added 20 grams of lime to charge.

(2) Mixed thoroughly in a tumbler mixer.

Roasting Procedure

Identical to that outlined for Test 3, Sheet 2.

Calcine Treatment Before Cyanidation

(1) Cold calcines weighed and a 50 gram sample cut out for analysis.

(2) Balance of sample ground for 20 min in an 8 in.-dia porcelain mill with a full charge of steel balls and 1000 cc water.

(3) Reground calcines transferred to 2000-g lab cell, conditioned for 5 min and filtered.

(4) Filter cake repulped with fresh water and again conditioned in a 2000-g cell for 5 min.

(5) Both filterates from above saved and analyzed for precious metals content.

(6) Filter cake dried and weighed before being transferred to agitation bottle.

MINES BRANCH
CYANIDATION TEST REPORT

Test No: 7	Sample: Nadina Explorations, calcines from low temp
Test By: M.R.	roast of pyrite conc composite No. 2

OBJECT OF TEST: To try 3 hour roast at 475°C prior to cyanidation as in Test 6 but without the addition of lime to the charge.

TEST DATA

Date	Time hr	NaCN, lb/ton Solution		Lime lb/ton Solution		Charge:	
		Added	Titrn	Added	Titrn	Solids, g	341
Mar. 8/71	0	2.0		0.5		Water, cc	1000
" "	1	2.0	0.3	1.0	–	Dilution (Water : Solids)	2.9:1
" "	4	1.0	0.7	0.4	0.1		
" "	6.5	1.2	0.9	1.0	0.1	Nominal Solution Strength, lb/ton Solution:	
Mar. 9/71	23	1.0	0.9	0.4	0.2	NaCN	2.0
" "	26	0.4	1.7	0.2	0.3	Lime	0.5
" "	30.5	0.2	1.8	0.2	0.3	Reagent Consumption, lb/ton Solids Cyanided:	
Mar 10/71	48		1.08		0.16	NaCN	21.8
Total		7.8		3.7		Lime	10.2
						Reducing power	1388

METALLURGICAL BALANCE

Product	Wt %	Assays, oz/ton		Distribution, %	
		Au	Ag	Au	Ag
Loss in roasting	17.10	–	–	–	–
Loss in calcine wash soln	5.02	–	–	–	–
Pregnant solution	0.24	0.14	5.63	60.4	58.7
Cyanidation residue	77.64	0.12	5.11	39.6	41.4
Feed (assay)	100.00	0.24	9.60	100.0	100.0
Calcines (before washing)		0.28	11.44		

Remarks: Additional analyses, %

	Cu	Pb	Zn	Fe	Total S	Sulphide S
Calcines (before washing)	0.24	0.58	9.52	40.12	13.48	1.52
Cyanidation residue	0.11	0.63	9.34	43.97	16.56	2.43

MINES BRANCH
CYANIDATION TEST REPORT

Test No: 8	Sample: Nadina Explorations, calcines from low temp roast
Test By: M.R.	of pyrite conc from Tests 25 and 26 (Composite No. 3)

OBJECT OF TEST: To try 4-hour, 475°C roast of pyrite conc prior to cyanidation with lime added to roasting charge*

TEST DATA

Date	Time hr	NaCN, lb/ton Solution		Lime lb/ton Solution		Charge:	
		Added	Titrn	Added	Titrn	Solids, g	348
						Water, cc	1000
Apr 13/71	0	6.0		2.0		Dilution (Water : Solids)	2.9:1
" "	2	1.0	1.4	0.6	0.7		
" "	7	0.4	1.9	-	0.8	Nominal Solution Strength,	
Apr 14/71	24	-	1.8	-	0.5	lb/ton Solution:	
" "	26	0.2	1.85	-	0.5	NaCN	2.0
" "	31	-	1.8	-	0.5	Lime	0.5
Apr 15/71	48		1.36		0.4	Reagent Consumption,	
Total		7.6		2.6		lb/ton Solids Cyanided:	
						NaCN	17.9
						Lime	6.3
						Reducing power	400

METALLURGICAL BALANCE

Product	Wt %	Assays, oz/ton		Distribution, %	
		Au	Ag	Au	Ag
Loss in roasting	21.84	-	-	-	-
Loss in calcine wash soln	10.27	-	-	-	-
Pregnant solution	0.46	0.166	6.07	72.1	55.7
Cyanidation residue	67.43	0.095	7.16	27.9	44.3
Feed (assay)*	100.00	0.23	10.90	100.0	100.0
Calcines (before washing)		0.30	14.75		

Remarks: Additional analyses:	Total S %	Sulphide S %
Feed	44.53	-
Calcines (before washing)	5.05	0.86

*Had intended a 6-hour roast but because of the use of a larger roasting dish which gave an increase in exposed surface area of sulphides, roasting rate was faster than anticipated. Roasting time was therefore cut back to 4 hours. Other details of test procedure identical to Test 6.

* Adjusted for dilution effect of 20 g lime to charge.

MINES BRANCH
CYANIDATION TEST REPORT

Test No: 9	Sample: Nadina Exploration, calcines from low temp roast
Test By: M.R.	of pyrite conc composite No. 3

OBJECT OF TEST: 4-hour, 475°C roast prior to cyanidation as in Test 8, but without lime added to roasting charge.

TEST DATA

Date	Time hr	NaCN, lb/ton Solution		Lime lb/ton Solution	
		Added	Titrn	Added	Titrn
Apr 13/71	0	6.0		2.0	
" "	2	1.4	1.1	0.6	0.7
" "	7	0.4	1.9	–	0.8
" "	24	0.2	1.8	–	0.5
" "	26	–	1.9	–	0.5
" "	31	–	1.9	–	0.5
Apr 15/71	48		1.72		0.4
Total		8.0		2.6	

Charge:	
Solids, g	344
Water, cc	1000
Dilution (Water : Solids)	2.9:1
Nominal Solution Strength, lb/ton Solution:	
NaCN	2.0
Lime	0.5
Reagent Consumption, lb/ton Solids Cyanided:	
NaCN	18.2
Lime	6.4
Reducing power	408

METALLURGICAL BALANCE

Product	Wt %	Assays, oz/ton		Distribution, %	
		Au	Ag	Au	Ag
Loss in roasting	24.23	0.005	–	–	–
Loss in calcine wash soln	7.09	–	–	–	–
Pregnant solution	0.41	0.17	6.89	70.8	61.0
Cyanidation residue	68.27	0.095	6.45	27.1	39.0
Feed (assay)	100.00	0.24	11.29	100.0	100.0
Calcines (before washing)		0.31	15.45		

Remarks: Additional analyses:

	Total S, %	Sulphide S, %
Calcines (before washing)	4.30	0.78