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FARO DOWN VALLEY TAILINGS

RESEARCH PROGRAM

REPORT: TAILINGS REPROCESSING

By

G. W. McDonald - Curragh Resources Limited

INDIAN AND NORTHERN AFFAIRS - AFFAIRES INDIENNES ET DU NORD

WHI-EV 5510-5-002C

UNC REP 10

5/28/1993

5/28/1993

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PROJECTS

CURRAGH - DVT ABANDONMENT

FA022-R233
FARO DOWN VALLEY TAILINGS
RESEARCH PROGRAM
TAILINGS REPROCESSING



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Exploration and Geological Services Division,
Indian and Northern Affairs Canada,
200 Range Road, Whitehorse, Yukon Y1A 3V1**

FARO DOWN VALLEY TAILINGS
RESEARCH PROGRAM
REPORT: TAILINGS REPROCESSING

May 28, 1993
G. W. McDonald
Vice President, Metallurgy

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INTRODUCTION

The Faro Down Valley Tailing Ponds (see map and section) have a contained, gross metal value of more than a billion dollars. A research proposal for the development of an economical reprocessing method for the recovery of this resource, which would create jobs and eliminate an environmental liability, was approved for co-funding by the Government of the Yukon, Department of Economic Development (Canada/Yukon Economic Development Agreement). We thank them for their understanding and support. This ambitious and diligent research program involved Canmet (Mineral Sciences Laboratories), Lakefield Research, Normet and Curragh Inc.

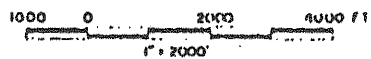
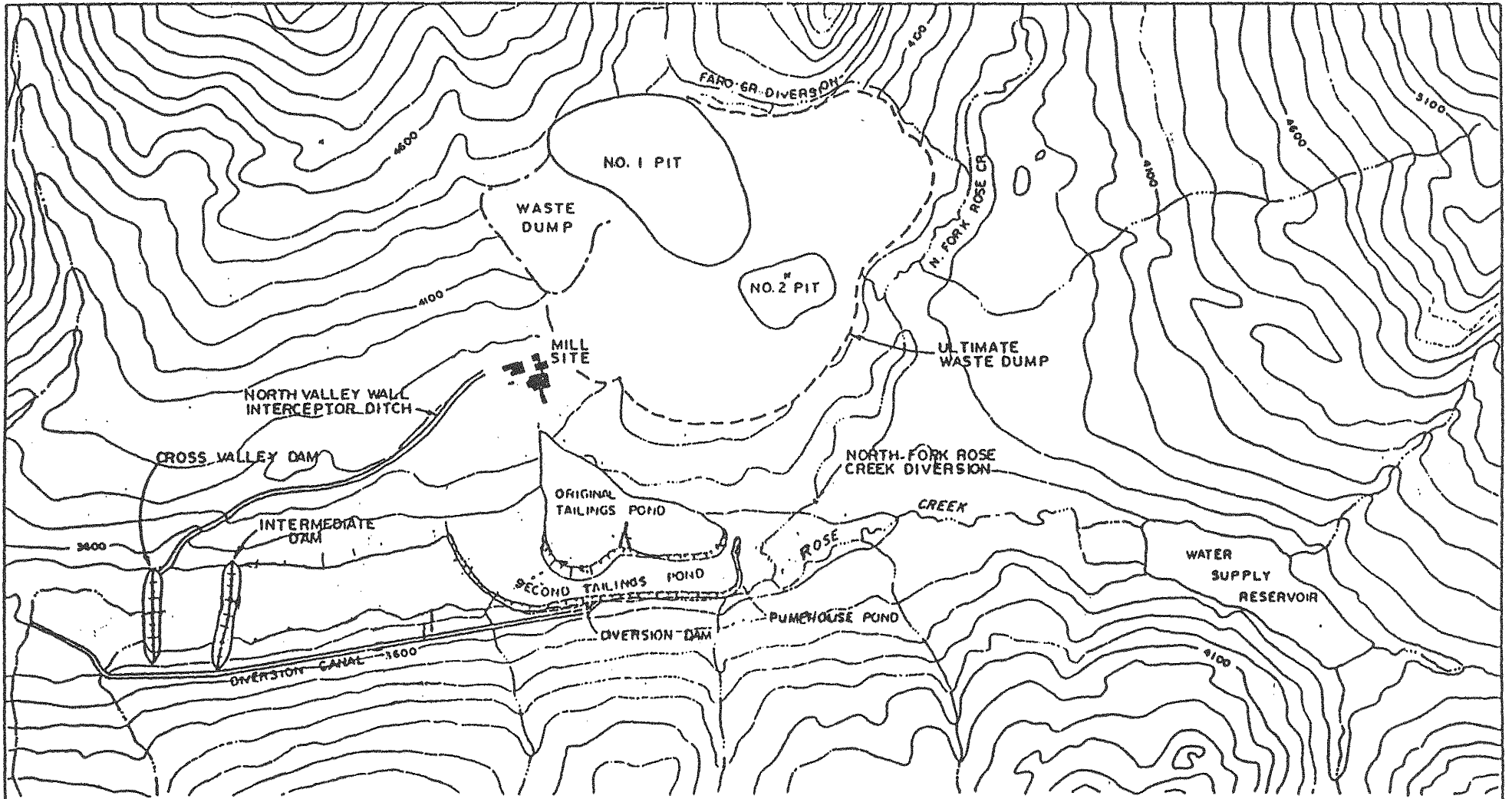
The Laboratory test results from the initial research programs are very encouraging with the production of a marketable bulk concentrate of 50% lead plus zinc metal content at a zinc metal recovery of 58%. There is considerable confidence in the Faro Down Valley Tailings reprocessing approach because of the metallurgical results attained, the implementation of proven new technology equipment, the use of current reagents and the availability of the Faro Mill (low capital requirement) when the known, economic ore reserves are depleted.

CONCLUSION

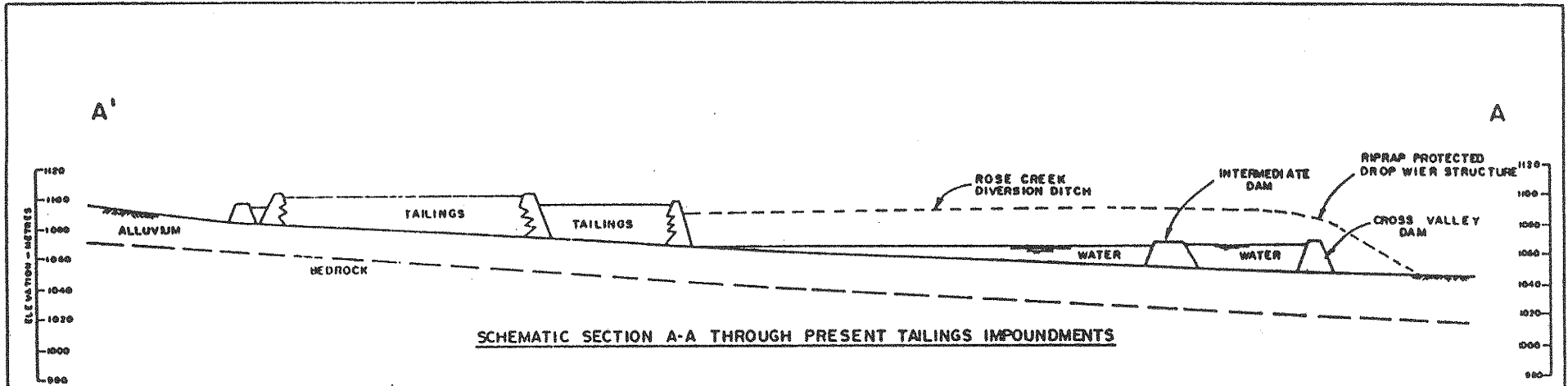
The research programs run at Canmet (Mineral Sciences Laboratories), Lakefield Research and Normet on Faro Down Valley Tailing composites indicate a technical success with the production of a marketable bulk sulphide concentrate at a respectable recovery.

Testwork Composite	Product	Assay		Recovery	
		Pb%	Zn%	Pb%	Zn%
pH >7	Final Bulk Conc	10.2	37.4	25.4	58.2
	Rghr Bulk Conc	2.88	6.1	59.4	78.6
	Calc. Headgrade	0.70	1.12	100.0	100.0
pH <7	Final Bulk Conc	5.13	31.2	15.8	57.9
	Rghr Bulk Conc	1.73	3.81	61.4	81.2
	Calc. Headgrade	0.62	1.03	100.0	100.0

The research programs of each laboratory were scoped to develop a reprocessing flowsheet for the Down Valley Tailings. Although the Canmet and Normet laboratories did not attain the same metallurgical results as Lakefield Research, an extrapolation of their test results would indicate very similar overall metallurgical results.



CURRAGH RESOURCES		DATE
FARO MINE LAYOUT		FIG. NO.
		APPROVED
		NO.
		1.1



CURRAGH RESOURCES		DATE
FARO ABANDONMENT PLAN EVALUATION		PROJ NO
LONG SECTION THROUGH EXISTING IMPOUNDMENTS		APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		NO
		1.2

The research testwork must continue as there is more information needed for the final reprocessing flowsheet. Larger volume laboratory bench testwork is needed to determine the high intensity conditioner equipment design criteria, bulk rougher concentrate regrind requirements and bulk cleaner concentrate flotation tests.

PURPOSE OF THE RESEARCH

All of the flotation tailings from the Faro mill, from start up in July 1969 through to August 1992, have been impounded in the Rose Creek Valley area. Subsequent tailings are pumped to the mined-out Faro Open Pit. There are 51,926,452 tonnes of tailings assaying 0.8% Pb, 1.3% Zn, 0.12% Cu, 30 g/t Ag placed in this Down Valley area behind water/solids impervious dams. At current metal prices, the gross value of these tailings is over a billion dollars.

A major factor in the design, cost estimating and implementation of the Faro Decommissioning plan is this large quantity of AMD tailings. Many decommissioning scenarios have been discussed, plans developed to a preliminary engineering status and costs estimated. These decommissioning scenarios varied from complete water flooding of the entire Down Valley Tailing Impoundment area by the construction of a high Cross Valley Dam (at an estimation capital cost of \$ million) to placing a composite dry cover over the exposed tailing with permanent water cover of the remaining tailings behind the structurally modified existing Cross Valley Dam (at an estimated capital cost of \$ million).

It is apparent that these estimated decommissioning costs are excessive so a further search and/or development of new technology is imperative. Since sufficient space would be available in the mined-out Faro Pit for final deposition of the reprocessed Down Valley tailing, the question is "Can the tailings be reprocessed, economically?". There will be many positive spin offs of a successful reprocessing approach: site jobs for more operating years, a more complete usage of the natural resource and an integral part of a better decommissioning plan for Faro (all processed tailing would be water flooded thereby eliminating acid mine drainage).

RESEARCH PROPOSAL AND MDA YUKON FUNDING

In 1990-91, Denhurst Limited in Australia developed a laboratory flowsheet for the recovery of a bulk, mineral sulphide concentrate from the impounded tailings at their Woodlawn Mine. This successful laboratory program culminated in the design, construction and commissioning of a production tailings reprocessing mill in 1991. Their process flowsheet was kept secret, however, they were willing to give a Faro Down Valley tailings sample a preliminary evaluation. Their laboratory test (1992) produced better metallurgical results than previous testwork run on a similar sample.

Discussions were held with Ms. L. Walton, MDA Co-ordinator (Government of the Yukon, Department of Economic Development), Mr. M.C. Campbell, Manager (Canmet, Resource Utilization Laboratories), Mr. S. Bulatovic, Consulting Metallurgist (Lakefield Research) and Mr. I. Pattison, Executive Director (Denhurst Limited) re: Reprocessing Faro Down Valley tailing to produce a bulk, mineral sulphide concentrate (at least 50% lead and zinc metal) - program, schedule and cost.

Subsequently each party prepared a research proposal that had a very limited overlap of the testwork. Curragh Inc. would co-ordinate the program and be responsible for the project report. The program must be complete by March 31, 1993. The cost estimate for the proposed research is as follows:

<u>Sub Contractor</u>	<u>Type of Work</u>	<u>Original Budget</u>
Canmet	Laboratory Flotation Mineralogy	\$120,000
Curragh Inc.	Sample Acquisition Sample Analysis Project Management	\$ 45,000
Lakefield Research	Laboratory Flotation	\$ 20,000
Denhurst Limited (Normet Pty Ltd)	Laboratory Flotation	<u>\$ 40,000</u>
TOTAL		\$225,000

The co-funded program cost was distributed as follows:

<u>Co-Funders</u>	<u>Original Budget</u>
Curragh Inc.	\$ 80,000
MDA	<u>\$145,000</u>
TOTAL	\$225,000

We want to take this opportunity to thank Ms. L. Walton and the management of the Government of Yukon, Department of Economic Development for the approval of this research program and the co-operation extended throughout the life of the program. The research program commenced on schedule on October 28, 1992.

RESEARCH PROGRAM

The research program was divided into two phases. Phase One, was sample acquisition and sample analysis. Phase Two, was the laboratory testwork with metallurgical balance results.

PHASE ONE

1.0 Sample Acquisition

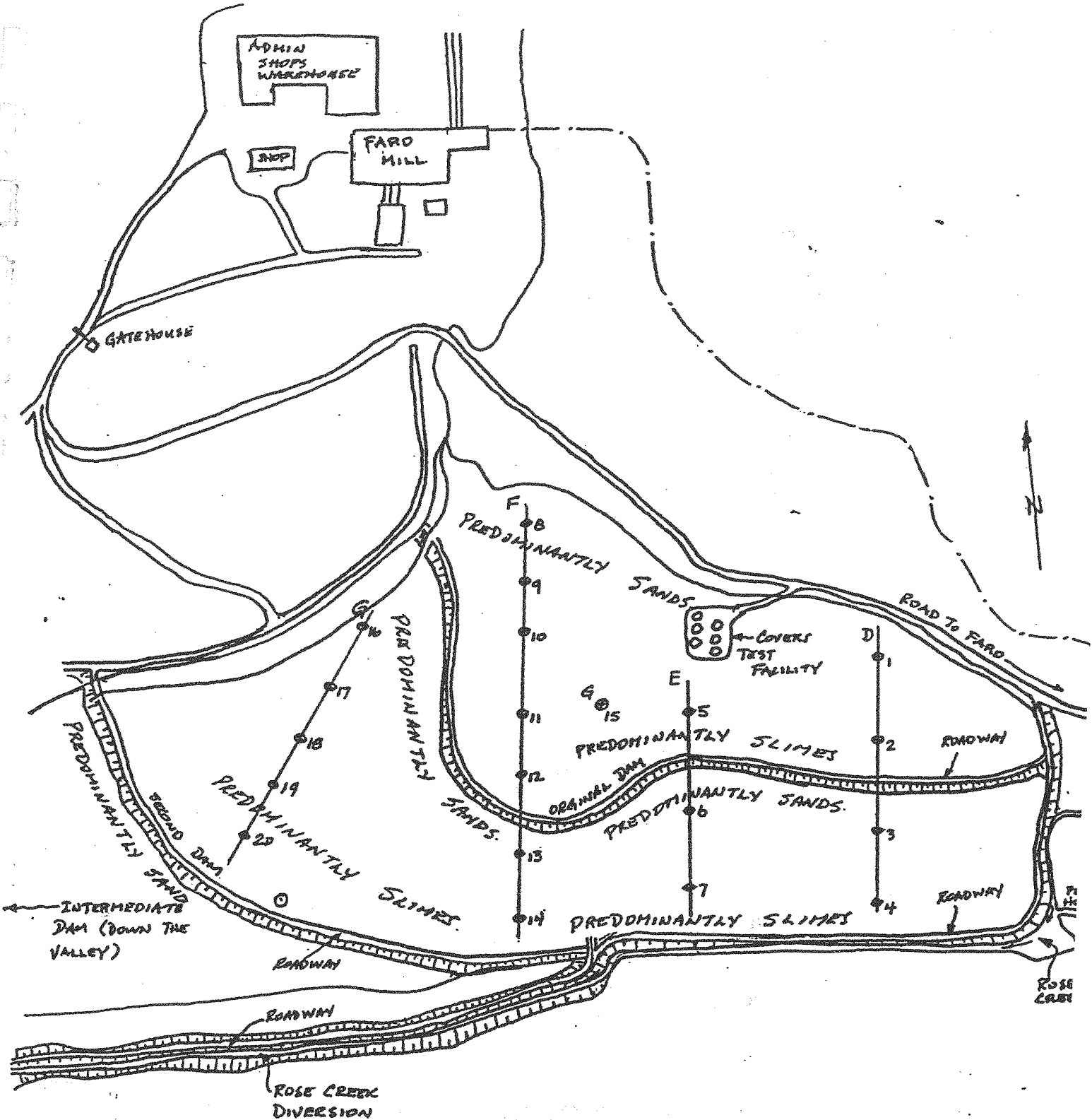
The geological department of Curragh Inc. reviewed available historical data (pre-1983) and site maps to best identify the spigot points of the mill flotation tailing within the two upper tailing pond areas. They recommended four section lines (letters) and the collar location of twenty drill holes (numbers) so the drill hole, core samples should best represent the stored tailing. The tailing drill hole locations are shown in figure no. 1.

A vibro core drill was selected as the preferred equipment to drill the tailing ponds. It was light weight and readily mobile; it had a special "shoe" attachment that will lock the core in the rods (NQ rods with no core barrel - 2 3/8") on retrieval so no sample is lost. No air, water, etc. is added to the drilling face thereby preventing sample mixing or dilution during the drilling program. Ace Drilling from Surrey, B.C. was the closest available vibro core driller and they did a good job.

The drilling program was designed to recover all core from the tailing pond's surface to the valley floor or an impregnable subsurface. The drill hole, core sample was composited in one meter increments which were numbered from the surface downward in consecutive order. Each drill hole core, sample composite was subjected to the following procedure:

- a) weighed (wet weight) and recorded (254 core composites)
- b) paste pH read and recorded (254 core composites)
- c) observed degree of moisture content and recorded
- d) screen analysis (200 and 325 mesh screen) and size distribution recorded (762 screen fractions)
- e) each sample composite was cut into four, one kilogram portions for metallurgical testwork, identified as I, II, III, and IV.
- f) chemical analysis (lead, zinc, copper, iron) run on each screen fraction and a metal balance recorded (4064 chemical analyses).

The mean metal content of the drill hole, core increments was 0.72% lead, 1.26% zinc, 0.12% copper and 29.9% iron. A condensed copy of each reporting sheet is shown in figure no. 2; while the complete sample increment analyses for this program is reported in Addendum I.



CURRAGH INC
 FARO DOWN VALLEY AREA
 - ORIGINAL POND
 - SECOND POND
 - INTERMEDIATE POND

VIBRO CORE DRILL HOLE ROW LETTER
 AND HOLE NO.

Figure No. 1

FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)

VIBRO CORE DRILLING
METER SAMPLE INCREMENT LENGTH

DATE: _____

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg		

SAMPLE #	DEGREE OF MOISTURE CONTENT				WATER CLAIRITY	
	LOW	MODER	VERY	EXTREME	CLEAR	MUDDY
	1	2	3	4	1	2

SCREEN DISTRIBUTION AND METAL ANALYSIS

ROW NO.	INCRE. NO.	SCREEN			ASSAYS				DISTRIBUTION			
		SIZE	WT.	% WT.	Pb %	Zn %	Cu %	Fe %	Pb %	Zn %	Cu %	Fe %
		+ 200										
		+ 325										
		- 325										
TOTAL												

INCREMENT METAL ANALYSIS

ROW LETTER	HOLE NO.	INCREM. NO.	ANALYSIS			
			Pb %	Zn %	Cu %	Fe %

Figure No. 2

2.0 Laboratory Testwork Composites

Individual drill hole, core sample increments, sealed in plastic bags and identified with Roman Numerals, were gathered into "testwork composite" lots and shipped to designated research laboratories. In turn, they were instructed to keep the sample and subsequent composite factions: sealed, moist and in cold storage when not in use. The following "weight of samples" were shipped to:

Lakefield Research	- 50 kilograms
Denhurst Ltd. (Normet)	- 75 kilograms
Canmet	- 250 kilograms

PHASE TWO

1.0 Laboratory Research Programs

a) Lakefield Research

The laboratory testwork program was quite focused - prefloat conditioning and reagents. The individual drill hole, core sample increments were composited into two testwork composites. One testwork composite contained increments with paste pH's <7 and the other testwork composite contained increments with paste pH's >7. The testwork program evaluated flotation responses following prefloat conditioning (conventional conditioning, a short grind or high intensity conditioning, a Lakefield specialization). This program also evaluated reagents (pH modifiers, pyrite depressants and collectors) to produce a high recovery, bulk rougher concentrate. At optimum bulk rougher concentrate recovery conditions, several cleaner flotation tests were run to determine concentrate upgrade.

(b) Denhurst Limited (Normet)

The laboratory testwork program was quite focused - Denhurst flowsheet evaluation and modified flowsheet evaluation. The drill hole, core sample increments were combined to make one testwork composite and then subjected to the Denhurst established pre-float conditioning and reagent scheme to produce a bulk concentrate (special emphasis on the zinc content). This work was followed with several flotation tests in which the slurry was oxygenated during prefloat conditioning and another series of flotation tests in which the prefloat conditioning step was eliminated.

(c) Canmet

The scope of this laboratory testwork program was a broad baseline - mineralogy, bulk rougher prefloat conditioning bulk concentrate cleaning and reagent evaluations.

Mineralogy via an optical microscope, an electron microscope and an image analyzer was done on testwork composites from the entire Down Valley drilling program. These composites were assembled at three specific pH levels (< 5, 5 to 7, >7). Each composite was screened on four sizes and prepared for instrument assisted mineral identification mineral liberation count and mineral particle size.

A second mineralogical program was done to provide information on the surface characteristics that may affect reprocessing. This mineralogical work was done on a Laser Ionization Mass Spectrometer on individual grains of sphalerite and pyrite/marcasite.

The metallurgical program started with a broad baseline search/development approach. The testwork composite, a mix of all the drill hole, core sample increments, was subjected to eleven prefloat and flotation activities/conditions at two levels for the recovery of a bulk sulphide rougher concentrate. The flotation test results were analyzed by a fractional statistical model to determine which activities/conditions provide the highest bulk sulphide rougher concentrate grade and recovery. In turn, the most favourable activities/conditions were run at 3 levels; then another statistical analysis of the test results were done to advance the development of the Down Valley tailings reprocessing flowsheet. Several bulk sulphide cleaner flotation tests as well as some comparative flotation tests were run on Lakefield and Normet testwork procedures/conditions.

2.0 Laboratory Research Results

(a) Lakefield Research

The laboratory flotation test results were very encouraging, a marketable grade bulk sulphide concentrate (31 - 37% Zn, 5 - 10% Pb) was produced at respectable metal recoveries. The Lakefield Research report is attached in Addendum II.

The two Down Valley Tailings testwork composites (pH <7, pH >7) were subjected to similar laboratory development tests:

- (i) Preflotation Conditioning
 - standard conditioner (single and multi stage)
 - high intensity conditioner (single and multi stage)
 - grinding (varying time duration)

- (ii) Reagent Balance
 - types of pyrite depressants
 - sphalerite activation
 - galena/sphalerite collectors
 - pH modifiers

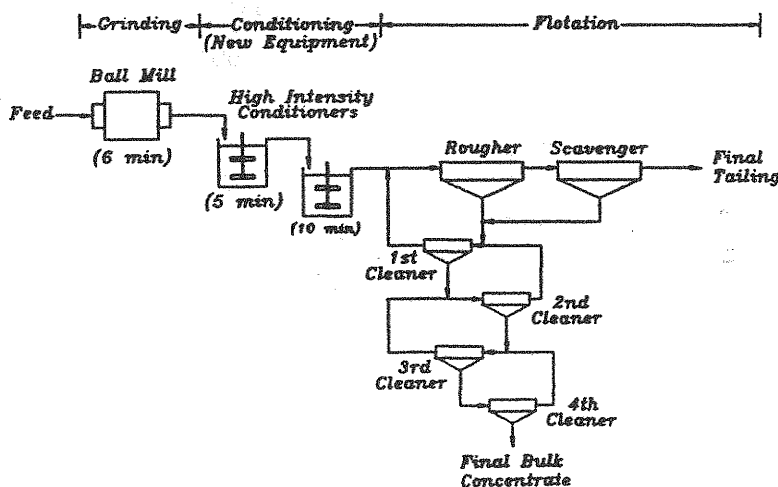
The laboratory program on each testwork composite did develop a reprocessing flowsheet and conventional reagent scheme. The following metallurgical balances were calculated from laboratory batch flotation tests which do not include the metal that would be recovered in the final concentrate by recycling the cleaner tailing, as occurs in the mill operation. Therefore, the mill will have slightly higher metal recoveries.

Testwork Composite	Product	Assay		Recovery	
		Pb %	Zn %	Pb %	Zn %
pH > 7	Final Bulk Conc	10.2	37.4	25.4	58.2
	Rghr Bulk Conc	2.88	6.1	59.4	78.6
	Calc. Headgrade	0.70	1.12	100.0	100.0
pH < 7	Final Bulk Conc	5.13	31.2	15.8	57.9
	Rghr Bulk Conc	1.73	3.81	61.4	81.2
	Calc. Headgrade	0.62	1.03	100.0	100.0

A Release Analysis Plot (see figure 3) of the laboratory batch flotation test results (roughing and for stages of cleaning) on Testwork Composites pH < 7 and pH > 7, illustrates the family of Bulk Concentrates grades and recoveries. The overlap of metallurgical performances for the composites indicates an upside potential and in higher overall recoveries in a mill operation.

The laboratory developed, reagent scheme is very conventional; it uses lime for the pH modifier, copper sulphate for the sphalerite activator, xanthate and M2030 for the galena/sphalerite collector and MIBC for the frothed.

The laboratory developed flowsheet is as follows:



Faro - Down Valley Tailings Reprocessing

Release Analysis Curves

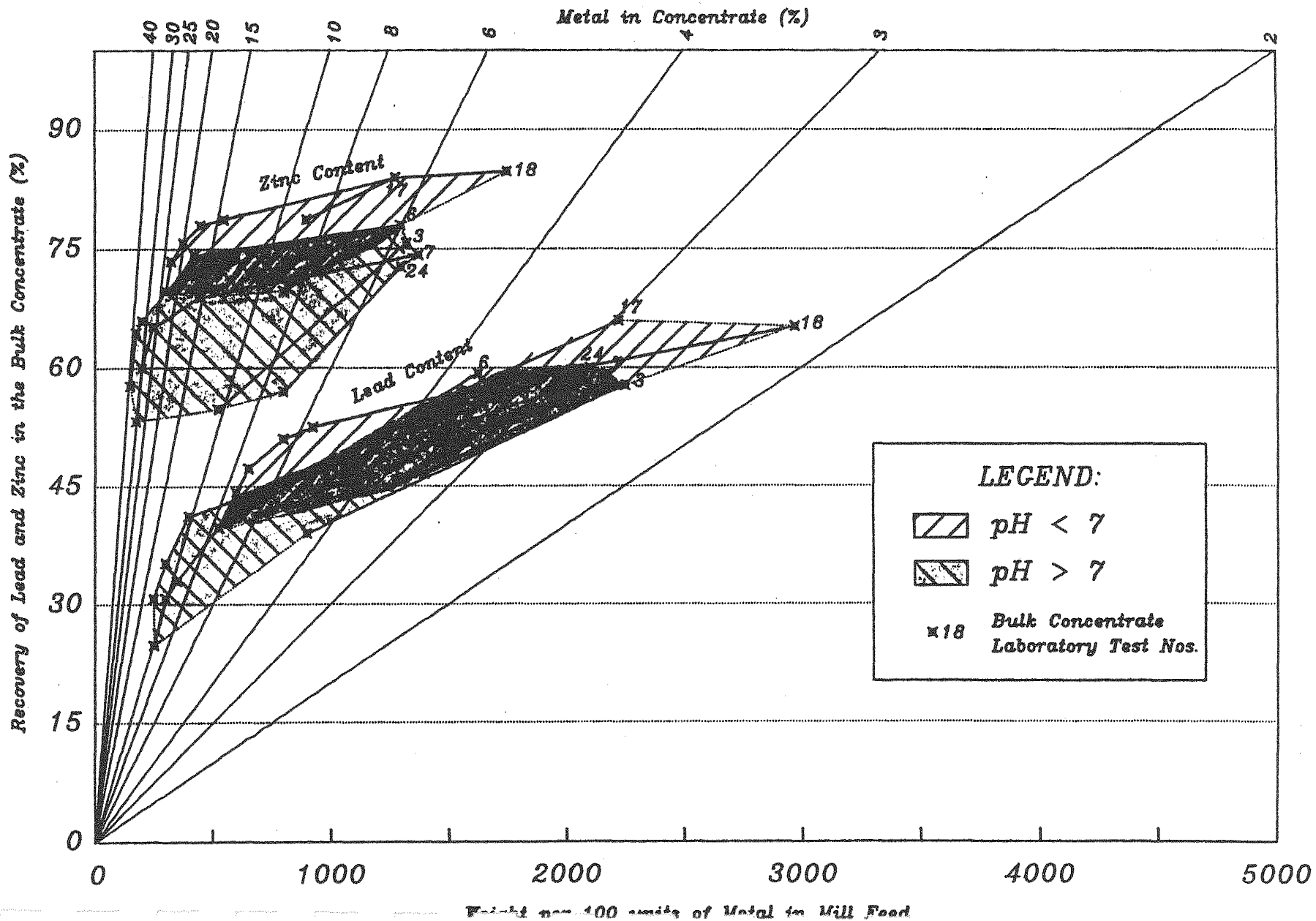


Figure No. 3

(b) Normet

The laboratory flotation test results confirm and improve upon the metallurgical response reported on preliminary Down Valley tailings flotation testwork done in 1992 by Denhurst. The Normet testwork was done on a Testwork Composite comprising samples from twelve drill holes that give a good cross-section of the Down Valley tailings area. The Normet report is attached in Addendum III.

Nine of twelve laboratory flotation tests were run on a flowsheet which included bulk sulphide roughing and three stages of cleaning. The laboratory testwork evaluated the following flowsheet configurations:

- (i) Prefloat Conditioning - without oxygenation
 - with oxygenation*
- (ii) No Prefloat Conditioning

* oxygenation (Oxygen gas is bubbled into the slurry during conditioning to ensure replacement of the oxygen that was consumed through chemical reaction with the mineral surfaces and the flotation reagents.)

The metallurgical balances for batch flotation tests on different flowsheet configurations, are as follows:

Conditioning	Products	Assays		Recover	
		Pb%	Zn%	Pb%	Zn%
Pre Float - No Oxygenation	Final Bulk Conc	2.5	35.7	4.6	37.5
	Rougher Bulk Conc	3.3	17.5	22.0	66.7
	Calc. Headgrade	0.63	1.09	100.0	100.0
Pre Float - With Oxygenation	Final Bulk Conc	n.a.	33.6	n.a.	42.2
	Rougher Bulk Conc	n.a.	12.8	n.a.	65.0
	Calc. Headgrade	n.a.	1.14	n.a.	100.0
No Pre Float	Final Bulk Conc	3.5	44.8	4.6	34.5
	Rougher Bulk Conc	4.1	20.5	21.5	62.0
	Calc. Headgrade	0.68	1.17	100.0	100.0

The design and operation of the Denhurst/Normet high intensity conditioner is not much different than a conventional conditioner re: comparative metallurgical balance, in previous table, with and without prefloat conditioning. However, the Lakefield design of high intensity conditioner, which will be installed in the Faro mill as part of the Grum ore, process flowsheet modifications and is currently used in other milling operations, provides very vigorous mixing. This cleans the surface of the mineral particles and forces those particles to collide with reagents thereby improving the overall mineral recoveries into the bulk sulphide concentrate.

(c) **Canmet**

The Canmet research program was very thorough and started with an investigation of the physical nature of the flotation feed:

What will be reprocessed?

How is the mineral worth distributed in the feed?

Are there any physical detriments to flotation recovery (liberation, coatings, etc.)?

These questions are best answered in a detailed mineralogical study of the reprocessing feed (Down Valley tailings). This approach is very common when developing or evaluating process flowsheets.

A mineralogical investigation was initiated to determine mineral occurrence, identification, distribution and the degree of liberation, as well as the occurrence of secondary minerals suggesting mineral remobilization. This work involved an optical microscope, an electron microscope, an image analyzer and an X-ray diffraction analyzer and was done on three Testwork Composites (pH < 5, pH 5-7, pH 7). This mineralogical report prepared by Dr. W. Petruk is attached in Addendum IV.

The mineralogical report stated that in the < 75 micron size fraction the sphalerite and chalcopyrite are 40% totally liberated and 60% are 75% liberated. In all screens size fractions the galena showed random liberation. In the > 75 micron size fraction considerable locking of sphalerite, galena and chalcopyrite with pyrite and quartz was observed. Some goethite and iron sulphate was associated with pyrite and some was present as free grains. Pyrite, marcasite and pyrrhotite were observed as liberated and locked particles. Regrinding will be an integral part of the final reprocessing flowsheet in order to upgrade the bulk sulphide concentrate.

The second mineralogical investigation was initiated to look at the surface chemistry of selected sphalerite and pyrite/marcasite particles (grains) to obtain a semi-quantitative analysis in any coatings that have developed on the surface of these particles. This mineralogical report prepared by Dr. L.J. Cabri is attached in Addendum V.

This mineralogical investigation was done on a very special analyzer called the Laser Ionization Mass Spectrometer (located in California) which was equipped with a laser microprobe. This analyzer will determine the composition of the very surface of the particle and by consecutive shots of the laser microprobe on the same spot, gradually penetrating the surface a few angstroms at a time, thereby peeling away the coating while compiling data on the composition of each successive layer through to the original particle mass. This information will be useful in determining if the coating(s) can be removed and if it will be detrimental to the subsequent reprocessing procedure or if the coating(s) have to be removed at all.

The analysis showed that most sphalerite particles have copper coatings (Cu S) a result of previous processing. Selected, liberated sphalerite particles from Testwork Composites pH < 5 and pH 5-7 showed erratic occurrences of lead in their coatings while the liberated sphalerite particles from Testwork Composite pH > 7 showed a dominance of lead in their coatings. Lead and copper coatings on sphalerite should not be detrimental to subsequent reprocessing. No coatings on pyrite/marcasite were mentioned but should be further investigated in samples of bulk sulphide concentrate.

The broad research approach employed on Canmet has developed a lot of data (factorial metallurgical tests - fractional analysis modelling, etc.) and generally is directing the researcher to the flowsheet developed in the Lakefield testwork. This is a good response as it shows that the work done at Lakefield and Normet (Denhurst), on very specific scopes, was indeed correct. The nature of the metallurgical research work at Canmet has been time and sample consuming but they have diligently and expeditiously carried on the testwork. The laboratory metallurgical testwork was done on a Testwork Composite comprising all the drillhole, core samples. The Preliminary Report on this testwork is attached in Addendum VI.

The following eleven prescreening variables at two levels were run to produce a rougher bulk sulphide concentrate only:

	<u>Variable</u>	<u>High Level</u>	<u>Low Level</u>
A.	Agitation Intensity	1800 rpm	700 rpm
B.	Agitation Time	20 min.	5 min.
C.	Slurry Density	40%	35%
D.	Aeration Time	10 min.	5 min.
E.	Alkalinity Agent*	lime	soda ash
F.	Lime/Soda Rate	3000 g/t	750 g/t
G.	Copper Sulphate	300 g/t	150 g/t
H.	Sulphur Dioxide	600 g/t	250 g/t
I.	Sodium Cyanide	100 g/t	50 g/t
K.	Collector Type**	3418A	5AX
I.	Collector Level	35 g/t	20 g/t

* Lime

** Dithiophosphinate (3418A)

The statistical results from the prescreening testwork, in respect to zinc recovery has reduced the number of significant variables to the following:

- Agitator Intensity
- Agitator Time
- Aeration Time
- Level of Soda Ash or Lime
- Level of Sulphur Dioxide

Subsequently each variable was tested at three levels. The statistical analysis is not complete at this time.

In the meantime testwork has been initiated to investigate the following unit functions at the reprocessing flowsheet development:

- Regrinding (at varying pH's) followed by Low Intensity Conditioning
- Different Sphalerite Collectors
- Varying pH's for the Bulk Rougher float
- Some initial Bulk Rougher Concentrate Cleaning

The initial results are encouraging.

A mineralogical examination of two bulk rougher concentrates (one-high recovery and one-low recovery) and two bulk rougher tailings, showed that sphalerite coarser than 53 microns after 5 minutes agitation, did not float whereas 36% of the sphalerite floated after a 20 minute agitation.

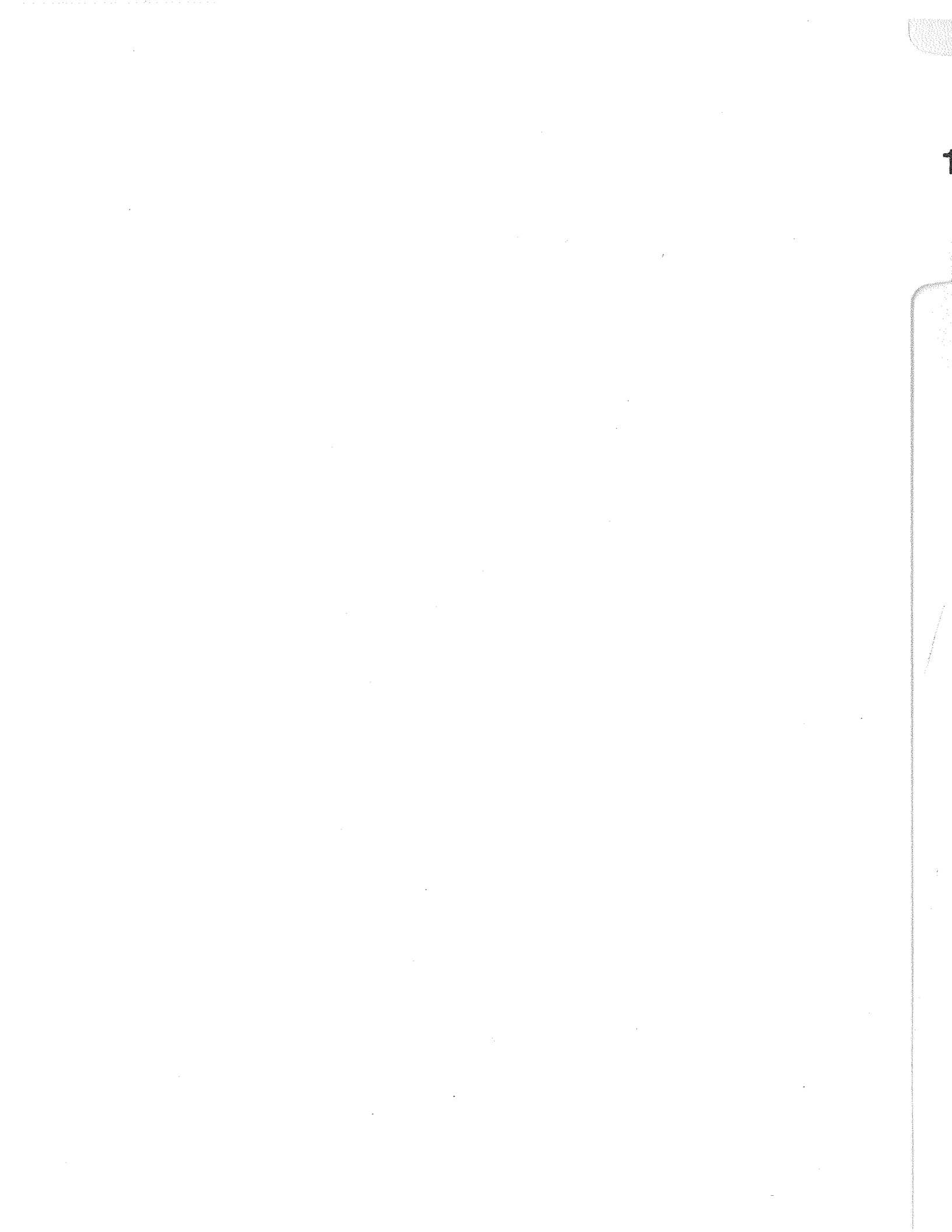
RECOMMENDED ON-GOING RESEARCH PROGRAM

The objectives of the on-going research program are:

- a) develop the reprocessing flowsheet
- b) finalize the reagent scheme
- c) prepare equipment design criteria.

The laboratory flotation tests will be run on 20 kilogram tailings samples (current test work used 2 kilogram samples). The higher sample weight per test will produce a higher weight of bulk rougher concentrate which is necessary for regrind testwork, bulk concentrate cleaner testwork and to confirm the reagent scheme. Separate laboratory testwork will be required to optimize the high intensity conditioner(s) equipment design criteria. Locked-cycle laboratory testwork will confirm the reprocessing flowsheet metallurgical performance.

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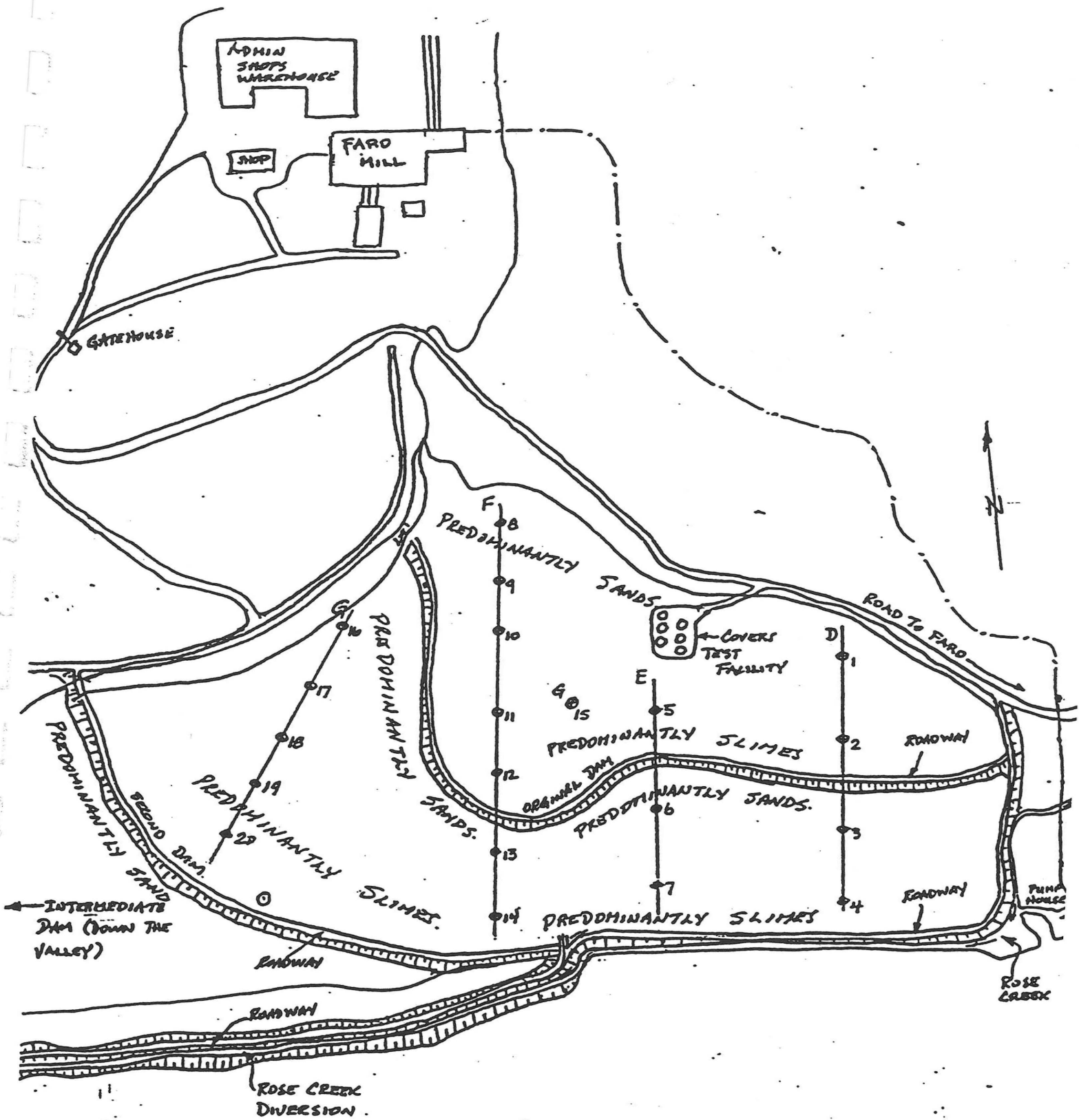


CURRAGH INC.

FARO DIVISION

DOWN VALLEY TAILING AREA

SAMPLING - 1992

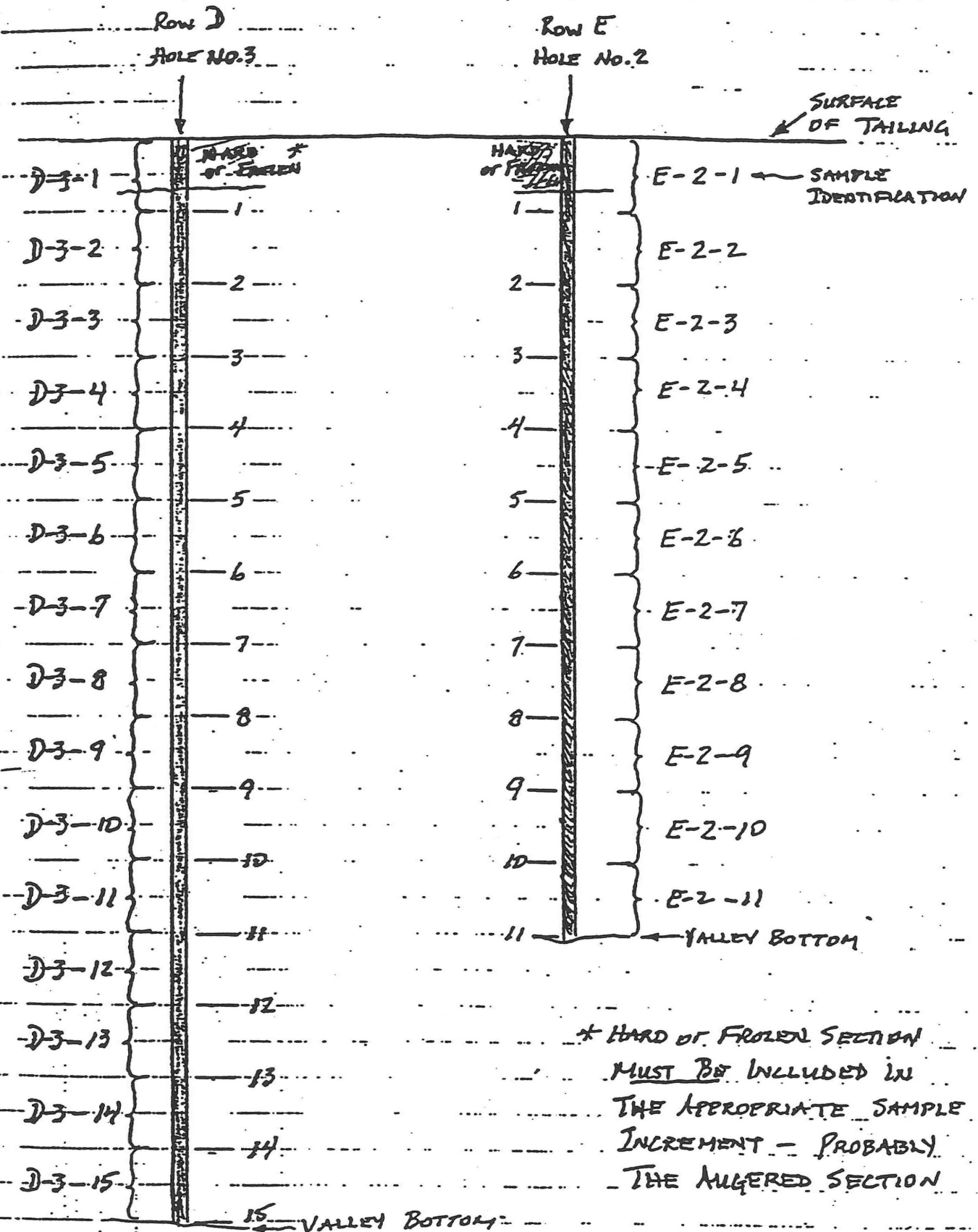


CURRAGH INC
 FARO DOWN VALLEY AREA
 - ORIGINAL POND
 - SECOND POND
 - INTERMEDIATE POND

VIBRO CORE DRILL HOLE ROW LETTER
 AND HOLE NO.

FIGURE No. 1

FARO DOWN VALLEY TAILING SAMPLE IDENTIFICATION



**FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)**

**- VIBRO CORE DRILLING
- 1 METER SAMPLE INCREMENT LENGTH**

DATE: October 23/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg *		
D	1	1	6235	2.45	✓	✓	✓	✓	(#2)	✓	red/yellow stain
		2	1345.9	2.87	✓	✓	✓	✓	(#2)	✓	red/yellow stain
		3	4103	3.34	✓	✓	✓	✓		✓	
		4	14496	4.53	✓	✓	✓	✓	(#2)	✓	
		5	5868	7.08	✓	✓	✓	✓	(#2)	✓	coarse gravel in sample
		6	3847.6	6.98	✓	✓	✓	✓		✓	
		7	11073	6.22	✓	✓	✓	✓	(#4)	✓	(21-32 ft)

* Pail No. for extra samples

FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)

TBRO CORE DRILLING
METER SAMPLE INCREMENT LENGTH

DATE: October 23/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg *		
D	2	1	8142	2.32	✓	✓	✓	✓	(#4)	✓	1 1/2 m. red/yellow stain
		2	3492.3	5.46	✓	✓	✓	✓		✓	free liquid
		3	6099	5.58	✓	✓	✓	✓		✓	free liquid
		4	13555	5.62	✓	✓	✓	✓	(#2)	✓	free liquid
		5	4439	6.16	✓	✓	✓	✓		✓	free liquid
		6	5933	6.56	✓	✓	✓	✓		✓	
		7	5443	7.18	✓	✓	✓	✓		✓	
		8	6646	8.00	✓	✓	✓	✓	(#2)	✓	
		9	6366	7.44	✓	✓	✓	✓		✓	
		10	11821	7.54	✓	✓	✓	✓	(#4)	✓	
		11	5175	7.81	✓	✓	✓	✓		✓	
		12	5267	7.66	✓	✓	✓	✓		✓	
		13	9959	7.62	✓	✓	✓	✓	(#2)	✓	
		14	7307	7.55	✓	✓	✓	✓		✓	
		15	6154	7.68	✓	✓	✓	✓		✓	
		16	7841	7.73	✓	✓	✓	✓	(#2)	✓	
		17	8894	7.54	✓	✓	✓	✓	(#4)	✓	free liquid
		18	6562	8.05	✓	✓	✓	✓		✓	

* Pail No. for extra samples

FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)

- VIBRO CORE DRILLING
METER SAMPLE INCREMENT LENGTH

DATE: October 24/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	1 kg *		
D	3	1	6074	2.28	✓	✓	✓	✓	(#4)	✓	
		2	3391	3.89	✓	✓	✓	✓		✓	
		3	3638	3.95	✓	✓	✓	✓		✓	
		4	9976	6.11	✓	✓	✓	✓	(#2)	✓	
		5	1419.7	6.41	✓	✓	✓	✓	(#4)	✓	

* Pail No. for extra samples

**FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)**

- VIBRO CORE DRILLING
METER SAMPLE INCREMENT LENGTH

DATE: October 24/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg*		
D	4	1	5056	2.48	✓	✓	✓	✓		✓	
		2	4115	4.19	✓	✓	✓	✓		✓	
		3	5344	4.59	✓	✓	✓	✓		✓	
		4	6924	6.01	✓	✓	✓	✓	(#2)	✓	
		5	5762	8.10	✓	✓	✓	✓		✓	
		6	16127	8.20	✓	✓	✓	✓	(#2)	✓	
		7	8890	6.90	✓	✓	✓	✓	(#1)	✓	
		8	7080	8.66	✓	✓	✓	✓		✓	
		9	8869	9.21	✓	✓	✓	✓	(#4)	✓	
		10	7200	9.24	✓	✓	✓	✓	(#4)	✓	

* Pail No. for extra samples

FARO DOWN VALLEY TAILING SAMPLING PROGRAM (1992)

- VIBRO CORE DRILLING
 - 1 METER SAMPLE INCREMENT LENGTH

DATE: October 24/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I 1 kg	II 1 kg	III 1 kg	IV 1 kg	EXTRA kg *		
E	5	1	6313	4.16	✓	✓	✓	✓	(#3)	✓	
		2	2832.5	6.03	✓	✓	✓	✓		✓	
		3	6078	6.22	✓	✓	✓	✓		✓	
		4	4276	7.83	✓	✓	✓	✓		✓	
		5	7974	7.61	✓	✓	✓	✓		✓	coarse gravel in sample
		6	8158	8.23	✓	✓	✓	✓		✓	
		7	12625	8.36	✓	✓	✓	✓	(#2)	✓	
		8	4409	8.21	✓	✓	✓	✓		✓	
		9	5035	7.94	✓	✓	✓	✓		✓	

* Pail No. for extra samples

FARO DOWN VALLEY TAILING
 SAMPLING PROGRAM (1992)

- VIBRO CORE DRILLING
 METER SAMPLE INCREMENT LENGTH

DATE: October 26/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg		
E	6	1	No sample								
		2	4841	3.41	✓	✓	✓	✓		✓	
		3	4386	4.21	✓	✓	✓	✓		✓	
		4	6151	4.63	✓	✓	✓	✓	(#3)	✓	
		5	6457	4.36	✓	✓	✓	✓		✓	
		6	1698	-	-	-	-	-	(#4)		Very Small Size
		7	8513	6.11	✓	✓	✓	✓		✓	
		8	10007	5.67	✓	✓	✓	✓	(#3)	✓	
		9	9333	5.39	✓	✓	✓	✓	(#3)	✓	
		10	11540	5.72	✓	✓	✓	✓	(#3)	✓	
		11	11276	5.21	✓	✓	✓	✓	(#3)	✓	
		12	3429	5.95	✓	✓	✓	✓	(#3)	✓	some rocks in sam

* Pail No. for extra samples

FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)

- VIBRO CORE DRILLING
METER SAMPLE INCREMENT LENGTH

DATE: October 26/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg		
E	7	1	5866	3.19	✓	✓	✓	✓	(#3)	✓	
		2	5204	4.51	✓	✓	✓	✓	(#3)	✓	
		3	4589	4.43	✓	✓	✓	✓		✓	
		4	4750	4.64	✓	✓	✓	✓	(#2)	✓	
		5	1349	-							<i>No Sample.</i>
		6	3437	4.02	✓	✓	✓	✓		✓	
		7	8546	6.64	✓	✓	✓	✓		✓	
		8	7444	7.43	✓	✓	✓	✓		✓	
		9	8027	8.46	✓	✓	✓	✓	(#3)	✓	
		10	9926	8.46	✓	✓	✓	✓	(#3)	✓	
		11	7949	7.83	✓	✓	✓	✓		✓	
		12	6265	8.77	✓	✓	✓	✓		✓	
		13	7531	8.54	✓	✓	✓	✓		✓	
		14	8076	8.78	✓	✓	✓	✓		✓	
		15	6826	8.51	✓	✓	✓	✓	(#3)	✓	
		16	7846	8.46	✓	✓	✓	✓	(#3)	✓	
		17	3887	8.12	✓	✓	✓	✓		✓	

* Pail No. for extra samples

FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)

- VIBRO CORE DRILLING
METER SAMPLE INCREMENT LENGTH

DATE: November 1/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg*		
F	8	1	4367	3.47	✓	✓	✓	✓		✓	
		2	6255	4.05	✓	✓	✓	✓		✓	
		3	6003	4.55	✓	✓	✓	✓		✓	

* Pail No. for extra samples

FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)

- VIBRO CORE DRILLING
- METER SAMPLE INCREMENT LENGTH

DATE: November 1/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg *		
F	9	1	4396	2.71	✓	✓	✓	✓		✓	
		2	6759	4.23	✓	✓	✓	✓		✓	
		3	6007	3.90	✓	✓	✓	✓		✓	
		4	6521	5.20	✓	✓	✓	✓		✓	
		5	5501	5.69	✓	✓	✓	✓		✓	
		6	4724	5.95	✓	✓	✓	✓		✓	
		7	5125	6.05	✓	✓	✓	✓		✓	
		8	8855	6.02	✓	✓	✓	✓	(04)	✓	
		9	8394	5.82	✓	✓	✓	✓	(04)	✓	
		10	1962.9	5.91	✓	✓				✓	
		11	3227.8	5.55	✓	✓	✓			✓	

* Pail No. for extra samples

**FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)**

**- VIBRO CORE DRILLING
METER SAMPLE INCREMENT LENGTH**

DATE: October 31/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	.1 kg	kg*		
F	10	1	3584	2.20	✓	✓	✓	✓		✓	
		2	3975	2.67	✓	✓	✓	✓		✓	
		3	5267	4.66	✓	✓	✓	✓		✓	
		4	8158	5.30	✓	✓	✓	✓		✓	
		5	1779	5.24	✓	✓				✓	
		6	4313	6.01	✓	✓	✓	✓		✓	
		7	8190	4.93	✓	✓	✓	✓		✓	
		8	9456	5.65	✓	✓	✓	✓		✓	
		9	6291	5.21	✓	✓	✓	✓		✓	
		10	10348	6.21	✓	✓	✓	✓		✓	
		11	8941	6.47	✓	✓	✓	✓		✓	
		12	9604	7.22	✓	✓	✓	✓		✓	
		13	8088	7.46	✓	✓	✓	✓		✓	
		14	7973	7.79	✓	✓	✓	✓		✓	
		15	8683	6.40	✓	✓	✓	✓		✓	
		16	5981	7.32	✓	✓	✓	✓		✓	
		17	4245	6.94	✓	✓	✓	✓		✓	

* Pail No. for extra samples

FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)

- VIBRO CORE DRILLING
- 1 METER SAMPLE INCREMENT LENGTH

DATE: October 31/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg*		
F	11	1	5772	3.32	✓	✓	✓	✓		✓	
		2	3694	3.41	✓	✓	✓	✓		✓	
		3	6048	5.42	✓	✓	✓	✓		✓	
		4	5712	5.99	✓	✓	✓	✓		✓	
		5	7727	6.86	✓	✓	✓	✓		✓	
		6	7673	8.98	✓	✓	✓	✓		✓	
		7	6963	8.42	✓	✓	✓	✓		✓	
		8	6038	8.84	✓	✓	✓	✓		✓	
		9	5561	8.85	✓	✓	✓	✓		✓	
		10	5643	8.18	✓	✓	✓	✓		✓	
		11	4773	7.94	✓	✓	✓	✓		✓	
		12	9080	8.20	✓	✓	✓	✓		✓	
		13	7480	8.29	✓	✓	✓	✓		✓	
		14	7297	9.08	✓	✓	✓	✓		✓	
		15	9574	8.58	✓	✓	✓	✓		✓	
		16	5487	9.00	✓	✓	✓	✓		✓	
		17	5638	9.03	✓	✓	✓	✓		✓	

* Pail No. for extra samples

**FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)**

**IBRO CORE DRILLING
- 1 METER SAMPLE INCREMENT LENGTH**

DATE: October 29/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg *		
G	16	1	6098	4.25	✓	✓	✓	✓		✓	
		2	7290	4.77	✓	✓	✓	✓		✓	
		3	5069	4.73	✓	✓	✓	✓		✓	
		4	6978	5.13	✓	✓	✓	✓		✓	
		5	5591	6.05	✓	✓	✓	✓		✓	
		6	5755	5.74	✓	✓	✓	✓		✓	
		7	6615	6.34	✓	✓	✓	✓		✓	
		8	4833	5.90	✓	✓	✓	✓		✓	
		9	7791	6.50	✓	✓	✓	✓		✓	
		10	8472	6.51	✓	✓	✓	✓		✓	
		11	10309	6.43	✓	✓	✓	✓		✓	
		12	2907	5.47	✓	✓	✓			✓	
		13	4153	6.43	✓	✓	✓	✓		✓	

* Pail No. for extra samples

FARO DOWN VALLEY TAILING SAMPLING PROGRAM (1992)

**- VIBRO CORE DRILLING
- 1 METER SAMPLE INCREMENT LENGTH**

DATE: October 28, 1992

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg		
G	17	1	5147	2.53	✓	✓	✓	✓		✓	
		2	4284	4.03	✓	✓	✓	✓		✓	
		3	6725	3.91	✓	✓	✓	✓		✓	
		4	7201	5.42	✓	✓	✓	✓		✓	
		5	4421	7.29	✓	✓	✓	✓		✓	
		6	6022	7.85	✓	✓	✓	✓		✓	
		7	4953	8.32	✓	✓	✓	✓		✓	
		8	9590	8.75	✓	✓	✓	✓		✓	
		9	2582	6.07	✓	✓	✓	✓		✓	
		10	12869	6.61	✓	✓	✓	✓		✓	
		11	6247	7.91	✓	✓	✓	✓		✓	
		12	5639	8.00	✓	✓	✓	✓		✓	

No. for extra samples

FARO DOWN VALLEY TAILING SAMPLING PROGRAM (1992)

- VIBRO CORE DRILLING
- 1 METER SAMPLE INCREMENT LENGTH

DATE: October 29/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg *		
G	18	1	4685	2.79	✓	✓	✓	✓		✓	
		2	6451	3.85	✓	✓	✓	✓	(#1)	✓	
		3	7888	4.94	✓	✓	✓	✓		✓	
		4	5977	4.98	✓	✓	✓	✓		✓	
		5	2613	5.67	✓	✓				✓	
		6	4704	5.62	✓	✓	✓	✓		✓	
		7	5009	6.25	✓	✓	✓	✓	(#1)	✓	
		8	7832	5.52	✓	✓	✓	✓		✓	
		9	6666	6.18	✓	✓	✓	✓		✓	
		10	7805	8.17	✓	✓	✓	✓		✓	
		11	5747	9.06	✓	✓	✓	✓		✓	
		12	6408	8.43	✓	✓	✓	✓		✓	
		13	8407	8.45	✓	✓	✓	✓		✓	
		14	6710	8.45	✓	✓	✓	✓		✓	
		15	7003	9.38	✓	✓	✓	✓		✓	

* Soil No. for extra samples

**FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)**

**- VIBRO CORE DRILLING
- METER SAMPLE INCREMENT LENGTH**

DATE: October 28/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg *		
G	19	1	3852	2.35	✓	✓	✓			✓	
		2	5891	5.45	✓	✓	✓	✓		✓	
		3	6930	4.39	✓	✓	✓	✓	(#1)	✓	
		4	6502	4.87	✓	✓	✓	✓	(#1)	✓	
		5	6285	5.86	✓	✓	✓	✓		✓	
		6	10837	5.95	✓	✓	✓	✓	(#1)	✓	
		7									bagging no. error
		8	6931	6.18	✓	✓	✓	✓		✓	
		9	3896	5.98	✓	✓	✓			✓	
		10	7000	7.63	✓	✓	✓	✓		✓	
		11	6429	8.62	✓	✓	✓	✓		✓	
		12	7305	9.01	✓	✓	✓	✓		✓	free liquid
		13	8314	9.50	✓	✓	✓	✓	(#1)	✓	free liquid
		14	8142	9.24	✓	✓	✓	✓		✓	free liquid
		15	6997	8.54	✓	✓	✓	✓		✓	
		16	6125	8.66	✓	✓	✓	✓		✓	
		17	7820	8.23	✓	✓	✓	✓	(#1)	✓	free liquid
		18	7250	8.04	✓	✓	✓	✓	(#1)	✓	
		19	7907	8.97	✓	✓	✓	✓	(#1)	✓	
		20	6775	8.88	✓	✓	✓	✓		✓	
		21	6854	8.70	✓	✓	✓	✓		✓	
		22	8076	8.42	✓	✓	✓	✓	(#1)	✓	
		23	6674	8.79	✓	✓	✓	✓		✓	
		24	6771	8.49	✓	✓	✓	✓	(#1)	✓	

* Pail No. for extra samples

**FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)**

**- VIBRO CORE DRILLING
- 1 METER SAMPLE INCREMENT LENGTH**

DATE: October 27/92

ROW LETTER	HOLE NO.	INCREM. NO.	TOTAL WEIGHT kg	PASTE pH	TESTWORK COMPOSITES					SCREEN & ANALYSIS 0.5 kg	COMMENTS
					I	II	III	IV	EXTRA		
					1 kg	1 kg	1 kg	1 kg	kg "		
G	20	1	5341	2.88	✓	✓	✓	✓	(#1)	✓	
		2	8258	5.75	✓	✓	✓	✓	(#1)	✓	
		3	7014	5.99	✓	✓	✓	✓	(#1)	✓	
		4	5843	6.63	✓	✓	✓	✓		✓	
		5	4316	7.21	✓	✓	✓	✓		✓	
		6	4914	7.79	✓	✓	✓	✓		✓	
		7	7032	7.75	✓	✓	✓	✓		✓	
		8	3098	7.71	✓	✓	✓	✓		✓	
		9	3986	8.54	✓	✓	✓	✓		✓	
		10	5657	9.32	✓	✓	✓	✓		✓	
		11	6930	9.25	✓	✓	✓	✓		✓	
		12	6067	9.26	✓	✓	✓	✓		✓	
		13	7556	9.13	✓	✓	✓	✓		✓	
		14	6151	9.07	✓	✓	✓	✓	(#1)	✓	
		15	5994	9.07	✓	✓	✓	✓	(#1)	✓	
		16	8741	8.85	✓	✓	✓	✓		✓	
		17	5218	8.89	✓	✓	✓	✓		✓	
		18	4848	9.12	✓	✓	✓	✓		✓	
		19	8482	9.26	✓	✓	✓	✓	(#1)	✓	
		20	6084	9.05	✓	✓	✓	✓	(#1)	✓	
		21	5646	9.34	✓	✓	✓	✓		✓	

...il No. for extra samples

**FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)
MOISTURE CONTENT AND FREE WATER OCCURRENCE**

- MOISTURE CONTENT - VISUAL DESCRIPTION

ROW LETTER	HOLE NO.	INCREM. NO.	MOISTURE CONTENT				FREE WATER		
			LOW	MODERATE	VERY	EXTREME	CLEAR	MUDDY	
G	19	1	✓						
		2	✓						
		3	✓						
		4	✓						
		5				✓			
		6				✓			
		7			—	—	—	—	—
		8			✓				
		9				✓			
		10				✓			
		11				✓			
		12						✓	
		13					✓		
		145					✓		
		15					✓		
		16					✓		
		17						✓	
		18					✓		
		19					✓		
		20					✓		
		21					✓		
		22					✓		
		23				✓			

**FARO DOWN VALLEY TAILING
 SAMPLING PROGRAM (1992)
 MOISTURE CONTENT AND FREE WATER OCCURRENCE**

MOISTURE CONTENT - VISUAL DESCRIPTION

ROW LETTER	HOLE NO.	INCREM. NO.	MOISTURE CONTENT				FREE WATER	
			LOW	MODERATE	VERY	EXTREME	CLEAR	MUDY
G	20	1	✓					
		2		✓				
		3		✓				
		4					✓	
		5				✓		
		6					✓	
		7					✓	
		8					✓	
		9					✓	
		10					✓	
		11					✓	
		12				✓		
		13					✓	
		14					✓	
		15				✓		
		16				✓		
		17				✓		
		18				✓		
		19				✓		
		20					✓	
		21					✓	

**FARO DOWN VALLEY TAILING
SAMPLE PROGRAM (1992)
INCREMENT METAL ANALYSIS**

ROW LETTER	HOLB NO.	INCREM. NO.	ANALYSIS			
			Pb %	Zn %	Cu %	Fe %
F	14	1	0.54	1.09	0.11	28.9
		2	0.62	1.05	0.09	28.9
		3	0.67	1.13	0.07	19.6
		4	0.65	1.15	0.10	24.5
		5	0.61	1.12	0.09	24.5
		6	0.65	1.28	0.11	27.3
		7	0.69	0.76	0.12	30.0
		8	0.67	0.89	0.15	32.9
		9	0.68	0.97	0.20	38.0
		10	0.35	0.98	0.14	41.0
		12	0.44	0.98	0.12	31.7
		13	0.34	0.93	0.12	39.3
		14	0.40	1.02	0.11	38.0
		15	0.56	0.93	0.07	36.0
		16	1.10	1.03	0.10	35.1
		17	1.65	1.16	0.15	35.9
		18	0.99	0.77	0.10	35.0
		19	1.05	1.09	0.18	32.3
		20	1.40	1.10	0.18	30.9
		21	0.65	0.96	0.16	28.3

**FARO DOWN VALLEY TAILING
SAMPLE PROGRAM (1992)
INCREMENT METAL ANALYSIS**

ROW LETTER	HOLE NO.	INCREM. NO.	ANALYSIS			
			Pb %	Zn %	Cu %	Fe %
G	19	1	0.65	0.63	0.11	27.8
		2	0.77	1.12	0.11	26.3
		3	0.58	1.04	0.08	22.7
		4	0.72	0.71	0.07	28.2
		5	0.71	1.14	0.08	21.4
		6	0.57	1.51	0.10	30.0
		8	0.79	1.23	0.08	22.1
		9	0.80	1.27	0.10	23.9
		10	0.71	1.08	0.06	23.8
		11	0.73	0.84	0.05	20.0
		12	1.00	0.88	0.07	17.3
		13	0.58	0.93	0.09	29.4
		14	0.69	1.50	0.18	36.3
		15	0.59	1.26	0.19	41.1
		16	0.78	1.29	0.22	30.1
		17	0.58	0.93	0.11	28.5
		18	0.49	0.78	0.11	29.4
		19	0.66	1.49	0.12	25.6
		20	1.02	2.75	0.17	27.7
		21	0.39	0.96	0.20	35.7
		22	0.88	1.39	0.15	30.6
		23	0.84	1.32	0.12	31.4
		24	0.62	1.25	0.09	25.4

**FARO DOWN VALLEY TAILING
SAMPLE PROGRAM (1992)
INCREMENT METAL ANALYSIS**

ROW LETTER	HOLE NO.	INCREM. NO.	ANALYSIS			
			Pb %	Zn %	Cu %	Fe %
G	20	1	0.64	0.84	0.14	29.6
		2	0.98	1.17	0.13	26.0
		3	0.58	0.90	0.09	24.2
		4	1.09	1.49	0.09	26.5
		5	0.89	1.40	0.08	27.5
		6	1.08	1.15	0.15	26.2
		7	0.94	1.14	0.11	23.3
		8	0.60	0.87	0.10	20.5
		9	0.65	0.89	0.05	17.1
		10	0.64	0.92	0.06	19.1
		11	0.54	0.78	0.05	23.0
		12	0.87	0.75	0.08	17.9
		13	0.90	1.30	0.15	23.4
		14	0.64	1.35	0.16	22.4
		15	0.61	1.00	0.13	28.4
		16	0.67	1.04	0.13	27.0
		17	0.59	1.08	0.10	25.4
		18	0.68	0.97	0.10	24.4
		19	0.67	1.20	0.10	24.8
		20	0.67	1.41	0.12	24.9
		21	0.69	1.13	0.10	26.0

An Investigation of
THE RECOVERY OF LEAD, ZINC & SILVER

from Faro Tailing samples
submitted by

CURRAGH RESOURCES INC

Progress Report No. 2

Project No. L.R. 4390

NOTE:

This report refers to the samples as received.

The practice of this Company in issuing reports of this nature is to require the recipient not to publish the report or any part thereof without the written consent of Lakefield Research.

LAKEFIELD RESEARCH
A DIVISION OF FALCONBRIDGE LIMITED
February 8, 1993

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ABSTRACT

Preliminary laboratory testwork was conducted on Faro Tailing composite samples to recover lead, zinc and silver values in a marketable bulk concentrate. The major objective of this testwork was to evaluate the effect of high intensity conditioning on bulk flotation. The flotation feeds used in the laboratory testwork were Down Valley tailings representing a composite with pH <7 and a composite with pH >7. The average feed assays were 0.72% Pb, 1.16% Zn and 13.0 g/t Ag for both composites.

The laboratory testwork, performed with a conventional reagent scheme and with staged high intensity conditioning, indicated that a marketable grade bulk concentrate with respectable metal recoveries may be produced after detailed development and optimization testwork. Table No. 1 shows bulk flotation results obtained in the preliminary testwork.

TABLE NO. 1 :
Preliminary Upgrading Tests on Faro Tailing Composites

Test No.	Composite	Product	Weight %	Assays %, g/t		% Distribution	
				Pb	Zn	Pb	Zn
6	DV pH >7	Bulk 4th Cl Conc	1.74	10.2	37.4	25.4	58.2
		Bulk 1st Cl Conc	3.70	7.4	21.0	39.0	69.7
		Bulk Rougher Conc	14.43	2.88	6.1	59.5	78.6
		Bulk Rougher Tail	85.57	0.33	0.28	40.5	21.4
		Feed (Calc)	100.00	0.70	1.12	100.0	100.0
21	DV pH <7	Bulk 4th Cl Conc	1.92	5.13	31.2	15.8	57.9
		Bulk 1st Cl Conc	8.66	3.03	8.7	42.2	73.0
		Bulk Rougher Conc	22.03	1.73	3.81	61.2	81.2
		Bulk Rougher Tail	77.97	0.31	0.25	38.8	18.8
		Feed (Calc)	100.00	0.62	1.03	100.0	100.0

The reagent scheme used in these tests included the following: lime and an organic based depressant for iron sulphide rejection, CuSO₄ for sphalerite activation and collectors xanthate A317 and Minerec M2030.

Staged high intensity conditioning with depressant, activator and collectors was the determining factor in achieving high bulk recoveries.

INTRODUCTION

Faro tailings, generated since 1966, have been deposited in a 1 km wide and 8 km long valley below the mill. At the end of the mine life, the tailings will be reclaimed and pumped to the Faro open pit. The tailings contain significant metal values which, if recovered in a marketable bulk concentrate, would cover the tailing reclamation cost.

Previous testwork showed that using conventional treatment methods, production of a high grade bulk concentrate is not feasible. Further preliminary testwork was designed at the request of Mr. G. McDonald of Curragh Resources (authorized in a letter dated November 7th, 1992), to examine new technology available at Lakefield for treatment of Faro tailings by flotation.

The results of the testwork were discussed with Mr. McDonald in regular telephone conversations. Periodic letter reports were also issued.

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SUMMARY AND CONCLUSIONS

1. Description of Samples Used in the Laboratory Testwork

The samples used in the preliminary laboratory testwork were composited from Faro Down Valley hole samples E and F. The tailing samples were separated according to pH into composite pH >7 and composite pH <7. The low pH composite (i.e. pH <7) represented Upper Zone tailings and composite pH >7 represented Lower Zone tailings. The head analyses of the tailing composites are shown in Table No. 2.

TABLE NO. 2 :
Head Assays

Element	Assays %, g/t	
	Down Valley pH >7	Down Valley pH <7
Lead Pb	0.72	0.73
Zinc Zn	1.16	1.17
Iron Fe	30.9	31.0
Sulphur S	25.9	26.7
Silver Ag	12.9	13.1
%-200 mesh	87.0	66.9

The head analyses of the two composites were similar but the size analyses were significantly different.

2. Laboratory Testwork

2.1. Preliminary Tests

Preliminary tests were conducted to determine the effect of high intensity conditioning on lead-zinc bulk flotation. The flowsheet used in these tests is shown in Figure No. 1.

In the first test (Table 3), conventional conditioning with depressant, activator and collectors was used. In the second test, the conventional conditioning was replaced with high intensity conditioning. The use of high intensity conditioning increased lead and zinc recoveries and bulk concentrate grade.

FIGURE NO. 1
Preliminary Bulk Flotation Flowsheet

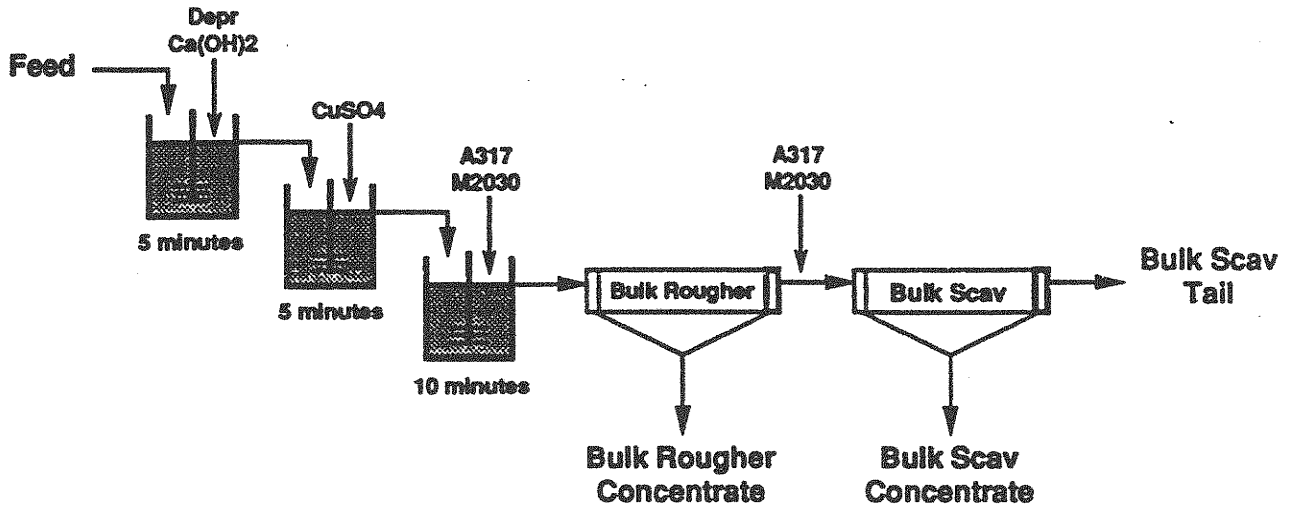


TABLE NO. 3 :
Preliminary Tests with Conventional and High Intensity Conditioning

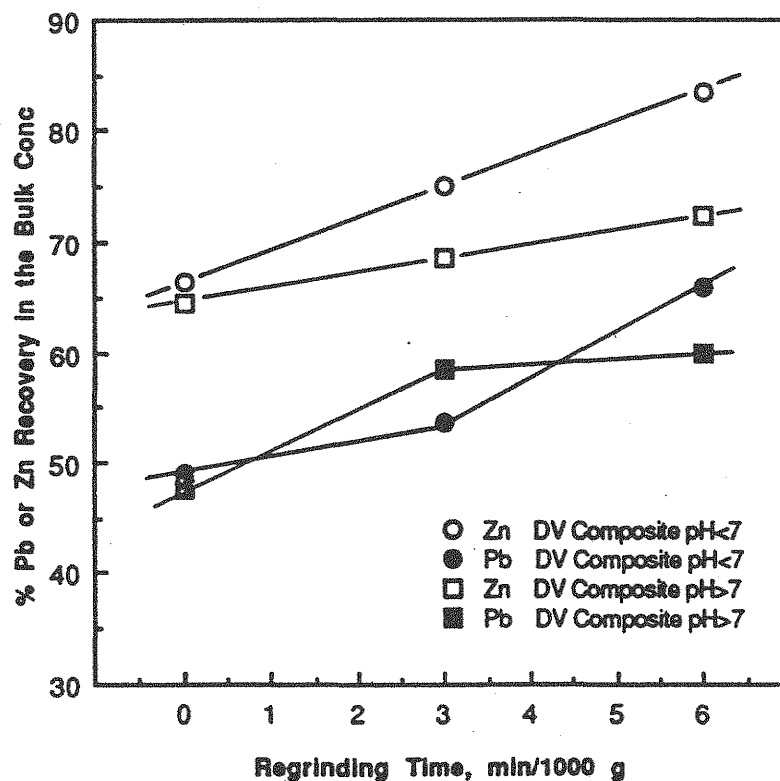
Test No.	Comp	Conditions	Product	Weight %	Assays %		% Distribution	
					Pb	Zn	Pb	Zn
1	>7 pH	Conventional conditioning	Bulk Rougher Conc	18.28	1.52	2.77	38.2	42.2
			Bulk Scav Tail	81.72	0.55	0.85	61.8	57.8
			Feed (Calc)	100.00	0.73	1.20	100.0	100.0
2	>7 pH	H.I.C.	Bulk Rougher Conc	7.36	4.23	10.7	43.4	66.0
			Bulk Ro + Scav Conc	18.17	2.42	5.21	61.3	79.4
			Bulk Scav Tail	81.83	0.34	0.30	38.7	20.6
			Feed (Calc)	100.00	0.72	1.19	100.0	100.0

2.2. Effect of Regrind on Bulk Flotation

Series of tests were performed on both ore composites to examine the effect of regrinding of the tailing on bulk flotation. In these tests, the lime conditioning step was replaced with a regrind and times of 3 and 6 minutes were evaluated. The results obtained showed that with slight regrinding of the pH <7 composite, bulk lead and zinc recoveries in the bulk concentrate increased significantly (Figure No. 2). The effect of regrinding of the pH >7 composite on lead and zinc flotation was less pronounced.

Composite pH <7, however, was much coarser than composite pH >7 tailing and this may have contributed to the differences in flotation response. It therefore appeared that a "polishing" regrind would be beneficial for lead and zinc recoveries in the bulk concentrate.

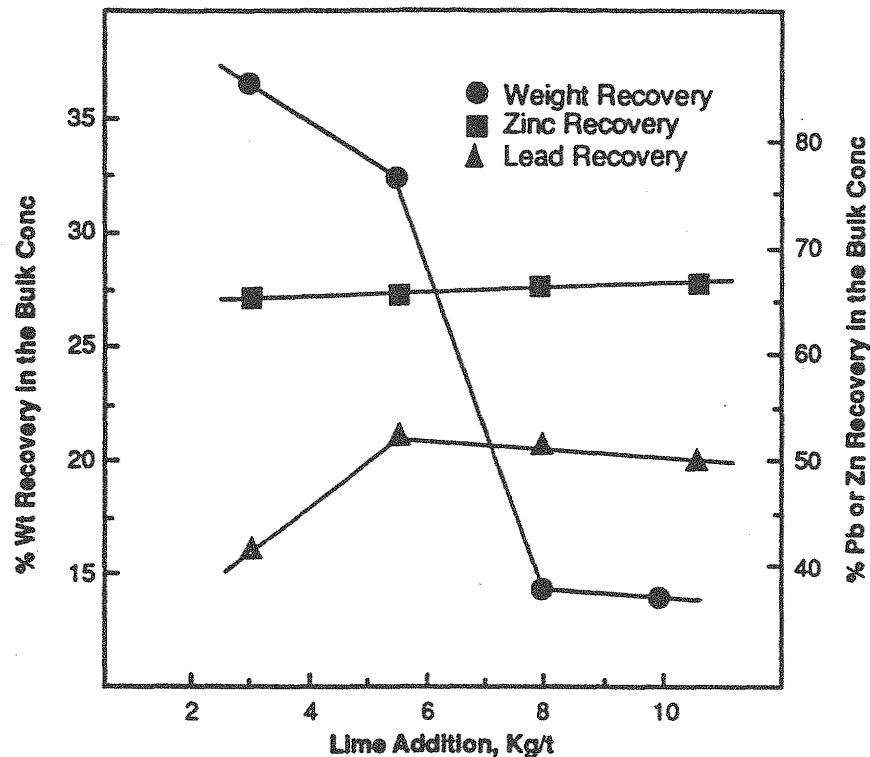
FIGURE NO. 2
Regrinding Time vs Lead and Zinc Recoveries in the Bulk Concentrate



2.3. Effect of Level of Lime Additions on Bulk Lead-Zinc Flotation from Composite pH <7

Because the Faro tailing composite pH <7 was acidic with a natural pH of 4.5, the pyrite was highly active after conditioning with reagents. A series of tests was therefore performed (Figure No. 3) with different levels of lime addition (i.e. pH).

FIGURE NO. 3
Effect of Level of Lime Addition on Bulk Pb-Zn Flotation



From the results obtained, the following conclusions are made:

- An addition of about 8 kg/t of lime was required to obtain a pH of 11.2. Ten kg/t of lime gave a pH of 11.8.
- Higher lime additions reduced flotability of pyrite significantly, but did not affect zinc and lead recoveries in the bulk concentrate.

2.4. Effect of Organic Depressant Addition In Bulk Flotation

During the course of the testwork, organic depressants BPW and SW2 were examined. The effect of these depressants on bulk rougher flotation was not clarified in this testwork. However, the use of these depressants in bulk cleaning was beneficial in improving selectivity between iron sulphide and lead-zinc minerals. Table No. 4 shows the effect of depressant SW2 on bulk concentrate upgrading on tailing composite pH <7.

TABLE NO. 4 :
Effect of Depressant SW2 on Bulk Concentrate Cleaning from Composite pH <7

Test No.	Test Conditions	Product	Weight %	Assays %		% Distribution	
				Pb	Zn	Pb	Zn
18	lime only	Bulk 4th Cleaner Conc	3.21	7.72	23.2	40.4	70.6
		Bulk 1st Cleaner Conc	4.88	6.37	16.8	50.7	77.8
		Bulk Rougher Conc	18.18	2.20	4.90	65.3	84.5
		Bulk Rougher Tailing	81.82	0.26	0.20	34.7	15.5
		Feed (Calc)	100.00	0.61	1.05	100.0	100.0
21	lime + depressant SW2 to the cleaners	Bulk 4th Cleaner Conc	1.92	5.13	31.2	15.8	57.9
		Bulk 1st Cleaner Conc	8.66	3.03	8.7	42.2	73.0
		Bulk Rougher Conc	22.03	1.73	3.81	61.2	81.2
		Bulk Rougher Tailing	77.97	0.31	0.25	38.8	18.8
		Feed (Calc)	100.00	0.62	1.03	100.0	100.0

2.5. Evaluation of High Intensity Conditioning

Since improvement in bulk flotation recovery was mainly attributed to the use of high intensity conditioning, detailed examination of HIC was performed. The main variables examined included:

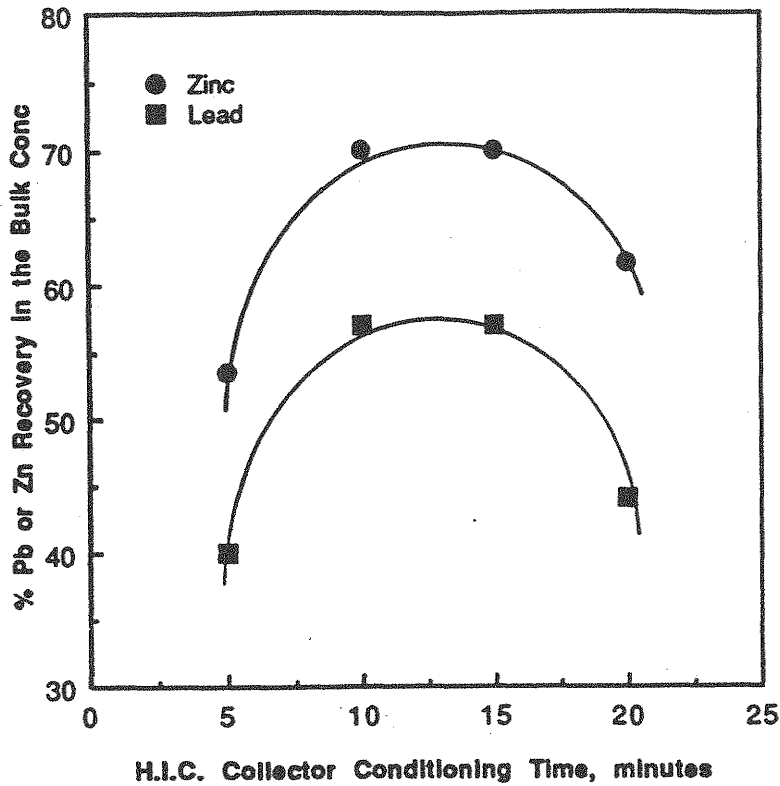
- Collector high intensity conditioning time at fixed conventional depressant and activator conditioning times.
- Collector high intensity conditioning time at fixed high intensity conditioning times with depressant and activator.
- High intensity collector conditioning speed.

With fixed conventional depressant and activator conditioning times and varied collector high Intensity conditioning times, the maximum lead and zinc recoveries in the bulk concentrate were obtained between 10 minutes and 15 minutes of high intensity conditioning time (Figure 4).

At 20 minutes of conditioning time, both lead and zinc recoveries in the bulk concentrate were reduced.

FIGURE NO. 4

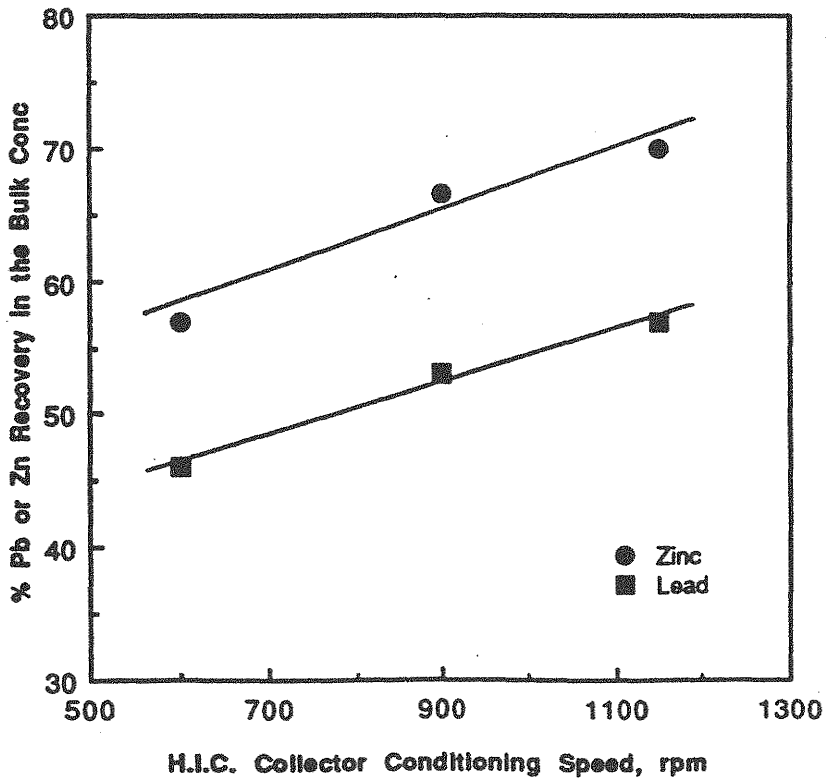
Effect of Collector High Intensity Conditioning Time on Pb-Zn Bulk Flotation at Fixed Conventional Depressant and Activator Conditioning Times



Varying the collector conditioning speed but using a fixed conditioning time (10 minutes) had a significant effect on lead and zinc recoveries in the bulk concentrate. Figure No. 5 shows the relationship between high intensity conditioning speed and lead and zinc recoveries.

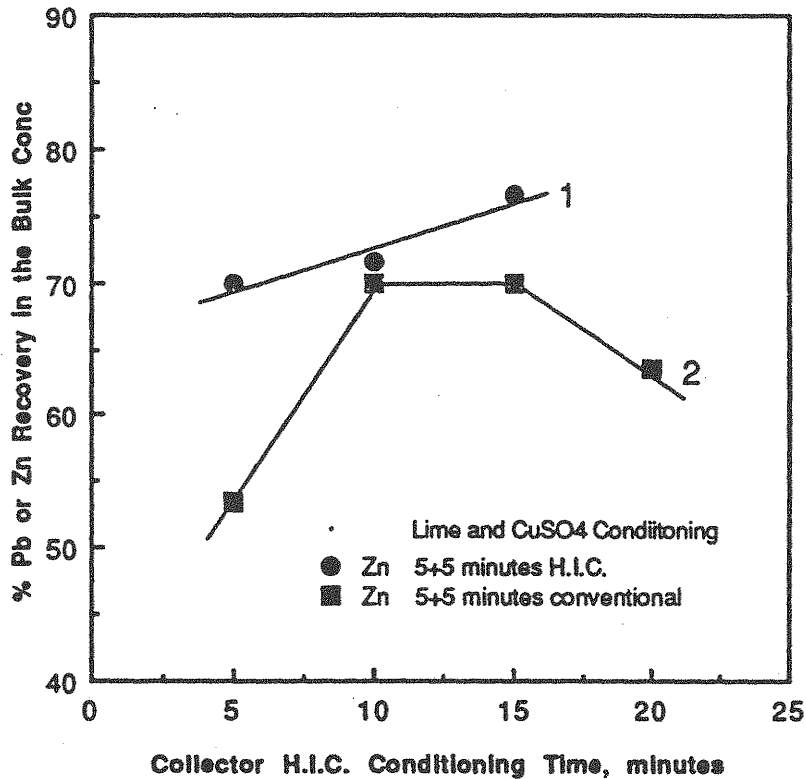
FIGURE NO. 5

Effect of Collector HIC Speed on Lead & Zinc Recoveries in the Bulk Concentrate - Composite pH >7



Stage high intensity conditioning with depressant, activator and collector (where collector conditioning time was varied at fixed depressant and activator HIC times) gave much better recoveries (Curve 1) than when conventional conditioning with depressant and activator was used (Curve 2, Figure 6).

FIGURE NO. 6
Effect of Different Conditioning Configurations on Zinc Recovery in the Bulk Concentrate



It has been established from the testwork that, with the introduction of high intensity conditioning, the recovery of lead and zinc in the bulk concentrate increased by 20%.

2.6. Preliminary Upgrading Tests

Several preliminary tests were carried out to determine whether upgrading of the bulk concentrate is possible. The results of these preliminary tests are shown in Table No. 5.

TABLE NO. 5 :
Preliminary Upgrading Tests on Faro Tailing Composites

Test No.	Composite	Product	Weight %	Assays %, g/t		% Distribution	
				Pb	Zn	Pb	Zn
6	DV pH >7	Bulk 4th Cl Conc	1.74	10.2	37.4	25.4	58.2
		Bulk 1st Cl Conc	3.70	7.4	21.0	39.0	69.7
		Bulk Rougher Conc	14.43	2.88	6.1	59.5	78.6
		Bulk Rougher Tail	85.57	0.33	0.28	40.5	21.4
		Feed (Calc)	100.00	0.70	1.12	100.0	100.0
21	DV pH <7	Bulk 4th Cl Conc	1.92	5.13	31.2	15.8	57.9
		Bulk 1st Cl Conc	8.66	3.03	8.7	42.2	73.0
		Bulk Rougher Conc	22.03	1.73	3.81	61.2	81.2
		Bulk Rougher Tail	77.97	0.31	0.25	38.8	18.8
		Feed (Calc)	100.00	0.62	1.03	100.0	100.0

The results obtained showed that commercial grade bulk concentrates may be produced with reasonably good zinc recoveries. On both composites, however, lead recoveries in the bulk concentrate were low, mainly because of the high lime additions in the bulk cleaners.

3. Conclusions

- The two Faro tailing composites used in the laboratory testwork represented Down Valley tailings from the Lower (alkaline) and Upper (acidic) zones. Both tailing samples had similar head assays but significantly different size analyses. The Upper Zone composite also had a high pyrrhotite content.
- In the preliminary testwork, it was demonstrated that marketable grade bulk concentrates can be produced after the treatment process is fully developed and optimized.
- Relatively high lead and zinc recoveries in the bulk concentrate were obtained after introduction of high intensity conditioning with depressant-activators and collector. High intensity conditioning with only collector gave reasonably good recoveries but with prolonged conditioning times.
- Limited regrinding of the tailings before HIC and flotation improved lead and zinc recoveries on the pH <7 composite (i.e. Upper Zone).

RECOMMENDATIONS

Recommendations proposed in this section are based on the results obtained in this preliminary laboratory testwork and on testwork reported in Progress Report No. 1, LR 4208. In order to fully develop a process for the recovery of metal values from the Faro tailings, detailed laboratory development testwork has to be conducted. This development testwork would include the following tasks:

1. Reagent Scheme Development

With respect to reagent scheme development, the following parameters should be evaluated and optimized:

- optimize the type and level of collector
- determine the need for the use of a secondary lead collector in the bulk rougher and in cleaning.
- evaluate and select suitable depressants for bulk cleaning. Two major contaminants in the bulk cleaner concentrate were identified as pyrrhotite and stained quartz.

Pyrrhotite flotation in the cleaners was controlled with additions of organic depressant and some of these depressants also showed a depressing effect on stained silica. Formulation and evaluation of such depressants should be performed.

2. Pulp Preparation

Pulp preparation refers to high intensity conditioning (HIC). For determination of scale up parameters for industrial unit design, the following laboratory testwork is required:

- Carry out laboratory tests using a 25L HIC unit to determine the relationship between power input and overall metallurgical results. The variables that would be examined in this testwork will include:
 - conditioning time
 - positioning of impellers
 - conditioning speed.
- Conduct laboratory tests using a 5L HIC unit with the variables used with the 25L unit.

3. Flowsheet Evaluation

Variables that would need detailed evaluation would include the following:

- requirement for "polishing" grinding
- regrinding of bulk concentrate prior to cleaning.
- requirement for staged HIC with depressant-activator-collector.

DISCUSSION

1. Description of Samples Used in the Laboratory Testwork

A total of four 25L pails containing tailing samples from Area E were received on November 6th, 1992 for laboratory testwork. The tailings were identified as Down Valley Tailings (Appendix 2).

As per the instructions of Mr. G. McDonald of Curragh Resources, the two following composites were prepared:

- Composite Down Valley (DV) pH >7. These were mainly Lower Zone samples.
- Composite Down Valley (DV) pH <7. These were mainly Upper Zone tailing samples.

The composites were prepared by repulping the samples at 65% solids in a 50L container and removing slurry test charges equivalent to dry weights of 1kg and 2kg.

The head analyses of the composite samples are shown in Table No. 6. Size analyses and the metal distributions in size fractions are shown in Table 7(a) and (b).

TABLE NO. 6 :
Head Assays of the Tailing Composites Used in Laboratory Testwork

Element		Assays %, g/t	
		Down Valley pH >7	Down Valley pH <7
Lead	Pb	0.72	0.73
Zinc	Zn	1.16	1.17
Iron	Fe	30.9	31.0
Sulphur	S	25.9	26.7
Silver	Ag	12.9	13.1

Note that composite pH >7 was much finer than composite pH <7 and that composite pH <7 was higher in pyrrhotite.

TABLE NO. 7 :
Size Analyses & Metal Distributions in the Size Fractions of the Faro Tailing Composites

A. Faro Tails pH <7 Composite

Microns	Mesh	Ind. Wt %	Assays, %		% Distribution	
			Pb	Zn	Pb	Zn
417	35	2.4	0.42	0.84	1.8	1.9
295	48	2.4	0.43	1.04	1.8	2.3
208	65	2.9	0.46	1.22	2.3	3.3
147	100	6.8	0.42	1.29	4.9	8.0
104	150	8.5	0.36	1.23	5.3	9.6
74	200	10.1	0.29	0.97	5.0	9.0
53	270	11.3	0.25	0.80	4.9	8.3
38	400	10.0	0.26	0.70	4.5	6.4
-38	-400	45.6	0.88	1.22	69.5	51.2
Total		100.0	0.58	1.09	100.0	100.0

B. Faro Tails pH >7 Composite

Microns	Mesh	Ind. Wt %	Assays, %		% Distribution	
			Pb	Zn	Pb	Zn
295	48	0.8	0.35	1.33	0.3	1.0
208	65	0.7	0.44	1.88	0.4	1.4
147	100	1.7	0.36	1.55	0.8	2.6
104	150	4.0	0.30	1.13	1.5	4.4
74	200	5.7	0.34	0.94	2.4	5.2
53	270	9.1	0.39	0.81	4.4	7.2
38	400	9.0	0.45	0.74	5.0	6.5
-38	-400	69.1	0.99	1.06	85.2	71.7
Total		100.0	0.80	1.02	100.0	100.0

2. Initial Testwork

Initially, comparative tests using conventional conditioning and high intensity conditioning were performed to determine whether high zinc and lead recoveries can be obtained. The results of the preliminary tests are shown in Table No. 8.

TABLE NO. 8 :
Initial Laboratory Test Bulk Flotation Results

Test No.	Comp	Conditions	Product	Weight %	Assays %		% Distribution	
					Pb	Zn	Pb	Zn
1	>7 pH lower zone	standard	Bulk Rougher Conc	18.28	1.52	2.77	38.2	42.2
			Bulk Scav Tail	81.72	0.55	0.85	61.8	57.8
			Feed (Calc)	100.00	0.73	1.20	100.0	100.0
2	>7 pH lower zone	H.I.C. Dep BPW	Bulk Rougher Conc	7.36	4.23	10.7	43.4	66.0
			Bulk Ro + Scav Conc	18.17	2.42	5.21	61.3	79.4
			Bulk Scav Tail	81.83	0.34	0.30	38.7	20.6
			Feed (Calc)	100.00	0.72	1.19	100.0	100.0
3	<7 pH upper zone	H.I.C. Dep BPW	Bulk Rougher Conc	6.75	4.12	10.0	38.7	55.5
			Bulk Ro + Scav Conc	16.23	2.60	5.70	58.0	75.9
			Bulk Scav Tail	83.77	0.36	0.35	42.0	24.1
			Feed (Calc)	100.00	0.72	1.22	100.0	100.0

The results obtained showed that the use of staged high intensity conditioning with depressants, CuSO₄ and collector improved Pb and Zn bulk recovery significantly.

3. Laboratory Testwork on DV pH <7 Composite

The variables examined using composite DV pH <7 included the following:

- effect of pH
- effect of organic depressant BPW in the bulk rougher
- effect of regrind
- preliminary cleaning tests.

3.1. Effect of pH

Because composite DV pH <7 had an acid pH (i.e. 5.5), a series of tests was carried out to examine the effect of pH on bulk lead-zinc flotation.

TABLE NO. 9 :
Effect of Level of Lime on Bulk Flotation from Faro Tailing DV Composite pH <7

Test No.	Lime, Added g/t	Product	Weight %	Assays %		% Distribution	
				Pb	Zn	Pb	Zn
11	3,000 pH 7.2	Bulk Rougher Conc	27.0	0.74	1.92	30.8	48.3
		Bulk Ro+Scav Conc	38.75	0.70	1.80	43.7	64.8
		Bulk Scavenger Tail	61.25	0.60	0.62	56.3	35.2
		Feed (Calc)	100.00	0.65	1.08	100.0	100.0
12	5,000 pH 9.8	Bulk Rougher Conc	17.89	1.42	3.4	39.7	52.6
		Bulk Ro+Scav Conc	40.26	0.80	1.9	53.3	66.9
		Bulk Scavenger Tail	59.74	0.50	0.64	46.7	33.1
		Feed (Calc)	100.00	0.64	1.16	100.0	100.0
13	8,000 pH 11.3	Bulk Rougher Conc	9.74	2.79	6.76	43.4	60.4
		Bulk Ro+Scav Conc	13.69	2.4	5.3	51.7	66.8
		Bulk Scavenger Tail	86.31	0.35	0.42	48.3	33.2
		Feed (Calc)	100.00	0.63	1.09	100.0	100.0
14	10,000 pH 11.8	Bulk Rougher Conc	8.14	2.88	7.87	38.3	58.3
		Bulk Ro+Scav Conc	14.02	2.20	5.40	50.9	68.7
		Bulk Scavenger Tail	85.98	0.35	0.40	49.1	31.3
		Feed (Calc)	100.00	0.61	1.10	100.0	100.0

The conditions and results of these tests are summarized in Table No. 9. From the results obtained, the following conclusions are made:

- Higher pH (i.e. above 9.8) resulted in improved selectivity between lead-zinc and iron sulphide minerals with no loss in recovery.
- With changes in pH, the lead and zinc recoveries were not affected. In fact, at very high pH, the lead and zinc assays of the rougher tailing were much lower than those obtained at low pH.

3.2. Effect of Organic BPW Depressant on Bulk Lead and Zinc Flotation

The BPW reagent is an organic-based depressant designed for pyrite-pyrrhotite depression during lead and zinc flotation. A series of comparative tests was conducted to determine the effect of BPW on lead and zinc bulk rougher-scavenger flotation.

The conditions and results of these tests are summarized in Table No. 10.

TABLE NO. 10 :
Effect of Depressant BPW on Bulk Rougher Flotation

Test No.	BPW Additions g/t	Product	Weight %	Assays %		% Distribution	
				Pb	Zn	Pb	Zn
14	400	Bulk Rougher Conc	8.14	2.88	7.87	38.3	58.3
		Bulk Ro+Scav Conc	14.02	2.20	5.40	50.9	68.7
		Bulk Scavenger Tail	85.98	0.35	0.40	49.1	31.3
		Feed (Calc)	100.00	0.61	1.10	100.0	100.0
15	200	Bulk Rougher Conc	8.11	3.11	8.24	40.5	59.8
		Bulk Ro+Scav Conc	12.86	2.50	6.00	50.9	68.8
		Bulk Scavenger Tail	87.14	0.35	0.40	49.1	31.2
		Feed (Calc)	100.00	0.62	1.12	100.0	100.0
16	0	Bulk Rougher Conc	6.03	3.92	10.6	38.0	57.4
		Bulk Ro+Scav Conc	10.34	2.90	7.30	48.2	67.8
		Bulk Scavenger Tail	89.66	0.36	0.40	57.8	32.2
		Feed (Calc)	100.00	0.62	1.11	100.0	100.0

From the results obtained, it did not appear that addition of depressant BPW is required in bulk flotation.

3.3. Effect of Re grinding of the Tailing before High Intensity Conditioning

Because the pH <7 composite gave lower lead and zinc recoveries than composite pH >7 and due to the fact that composite pH <7 was much coarser than composite pH >7, tests were performed to examine the effect of re grinding of the tailing before treatment and flotation.

Note that in tests where re grinding was used, the lime was added to the grind and lime in the high intensity conditioner was omitted.

The results of the comparative tests are shown in Table No. 11.

The results showed that slight re grinding of the tailing before flotation significantly improved lead and zinc recoveries in the bulk concentrate. When the flotation feed was re ground for 6 minutes per 1000 grams, the lead recovery increased from 48% to 66% Pb while zinc recovery increased from 67% Zn to 83% Zn.

TABLE NO. 11 :
Effect of Re grind of the Tailing on Bulk Flotation

Test No.	Regrind Time min/1000 g	Product	Weight %	Assays %		% Distribution	
				Pb	Zn	Pb	Zn
16	0	Bulk Rougher Conc	6.03	3.92	10.6	38.0	57.4
		Bulk Ro+Scav Conc	10.34	2.90	7.30	48.2	67.8
		Bulk Scavenger Tail	89.66	0.36	0.40	57.8	32.2
		Feed (Calc)	100.00	0.62	1.11	100.0	100.0
12	3	Bulk Rougher Conc	8.80	3.32	8.8	46.3	69.7
		Bulk Ro+Scav Conc	12.17	2.80	6.82	54.1	74.8
		Bulk Scavenger Tail	87.83	0.33	0.32	45.9	25.3
		Feed (Calc)	100.00	0.63	1.11	100.0	100.0
17	6	Bulk Rougher Conc	9.88	3.69	8.79	57.3	78.6
		Bulk Ro+Scav Conc	14.33	2.94	6.45	66.3	83.7
		Bulk Scavenger Tail	85.67	0.25	0.21	33.7	16.3
		Feed (Calc)	100.00	0.64	1.10	100.0	100.0

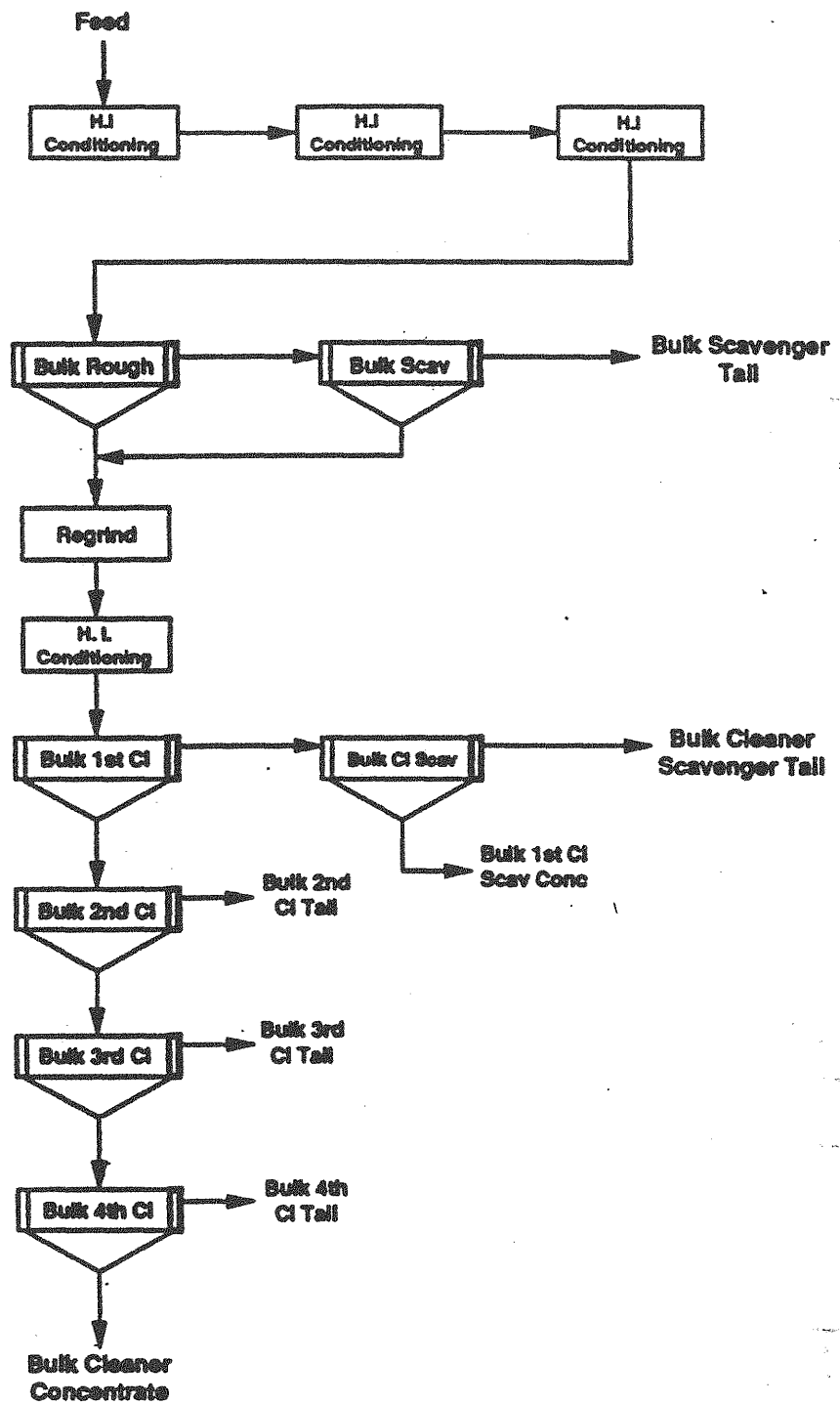
3.4. Preliminary Cleaning Tests

Preliminary cleaning tests were carried out with the use of lime only and with lime and depressant SW2. The results of these tests are summarized in Table No. 12 and the flowsheet used is shown in Figure No. 7.

TABLE NO. 12 :
Preliminary Upgrading Tests

Test No.	Test Conditions	Product	Weight %	Assays %		% Distribution	
				Pb	Zn	Pb	Zn
18	lime only	Bulk 4th Cleaner Conc	3.21	7.72	23.2	40.4	70.6
		Bulk 1st Cleaner Conc	4.88	6.37	16.8	50.7	77.8
		Bulk Rougher Conc	18.18	2.20	4.90	65.3	84.5
		Bulk Rougher Tailing	81.82	0.26	0.20	34.7	15.5
		Feed (Calc)	100.00	0.61	1.05	100.0	100.0
21	lime + depressant SW2 to the cleaners	Bulk 4th Cleaner Conc	1.92	5.13	31.2	15.8	57.9
		Bulk 1st Cleaner Conc	8.66	3.03	8.7	42.2	73.0
		Bulk Rougher Conc	22.03	1.73	3.81	61.2	81.2
		Bulk Rougher Tailing	77.97	0.31	0.25	38.8	18.8
		Feed (Calc)	100.00	0.62	1.03	100.0	100.0

FIGURE NO. 7
Preliminary Faro Tailing Flowsheet



Using lime only, upgrading of the bulk concentrate was not satisfactory (Test No. 18). Additions of depressant SW2 to the cleaners improved concentrate grade significantly (Test 21) but the concentrate was still below marketable grade. However, production of a high grade bulk concentrate would be possible with adjustment in cleaning conditions.

4. Laboratory Testwork on DV pH >7 Composite

4.1. Effect of Re Grinding of the Tailing Before Treatment and Bulk Flotation

As with the DV pH <7 composite, tests were conducted to examine the effect of re grinding of the tailing before treatment and separation. The conditions and results of these tests are summarized in Table No. 13.

TABLE NO. 13 :
Effect of Re grind on Bulk Lead-Zinc Flotation

Test No.	Regrind Time min/1000 g	Product	Weight %	Assays %		% Distribution	
				Pb	Zn	Pb	Zn
34	0	Bulk Rougher Conc	15.25	1.91	4.30	41.0	56.6
		Bulk Ro+Scav Conc	26.69	1.59	3.13	59.7	72.1
		Bulk Scavenger Tail	73.31	0.39	0.44	40.3	27.9
		Feed (Calc)	100.00	0.71	1.16	100.0	100.0
23	3	Bulk Rougher Conc	11.32	2.88	5.50	46.0	54.0
		Bulk Ro+Scav Conc	17.18	2.44	4.59	59.1	68.4
		Bulk Scavenger Tail	82.82	0.35	0.44	40.9	31.6
		Feed (Calc)	100.00	0.71	1.15	100.0	100.0
24	6	Bulk Rougher Conc	9.26	3.56	6.97	47.1	57.2
		Bulk Ro+Scav Conc	14.76	2.84	5.56	59.8	72.8
		Bulk Scavenger Tail	85.24	0.33	0.36	40.2	27.2
		Feed (Calc)	100.00	0.70	1.13	100.0	100.0

The effect of regrind was not as pronounced as with composite DV pH <7 (see Table 11). The beneficial effect of tailing regrinding was improved selectivity towards iron sulphides.

4.2. Effect of Depressant SW2 on Bulk Flotation

A series of three tests was performed on DV composite pH >7 in which depressant SW2 was varied from 0-300 g/t. The conditions and results of these tests are summarized in Table No. 14. From the results obtained, it appeared that the presence of SW2 had a positive effect on lead and zinc recoveries in the bulk concentrate.

TABLE NO. 14 :
Effect of Depressant SW2 on Bulk Rougher Flotation

Test No.	SW2 Addition g/t	Product	Weight %	Assays %		% Distribution	
				Pb	Zn	Pb	Zn
27	300	Bulk Rougher Conc	6.62	2.79	6.87	25.5	39.6
		Bulk Ro+Scav Conc	16.49	2.53	4.89	57.4	70.2
		Bulk Scavenger Tail	83.51	0.37	0.41	42.6	29.8
		Feed (Calc)	100.00	0.73	1.15	100.0	100.0
31	0	Bulk Rougher Conc	6.28	2.92	7.82	27.7	41.0
		Bulk Ro+Scav Conc	12.72	2.67	5.57	51.3	59.2
		Bulk Scavenger Tail	87.28	0.37	0.56	48.7	40.8
		Feed (Calc)	100.00	0.66	1.20	100.0	100.0
32	150	Bulk Rougher Conc	9.83	2.04	4.51	28.2	38.4
		Bulk Ro+Scav Conc	16.14	2.12	4.19	48.1	58.6
		Bulk Scavenger Tail	83.86	0.44	0.57	51.9	41.4
		Feed (Calc)	100.00	0.71	1.15	100.0	100.0

4.3. Evaluation of High Intensity Conditioning

4.3.1. Effect of Collector Conditioning Time

In a series of tests (25 to 28), the collector HIC conditioning time was varied from 5 minutes to 20 minutes. The conditions and results of these tests are summarized in Table No. 15.

In these tests, conventional conditioning with lime and CuSO_4 was maintained constant in all tests.

The results obtained showed that with an increase in the collector HIC time, lead and zinc recoveries in the bulk concentrate increased for conditioning time up to 15 minutes. Further increase from 15 to 20 minutes resulted in a reduction in the overall lead and zinc recoveries in the bulk concentrate (Test 28).

TABLE NO. 15 :
Effect of Collector HIC on Pb-Zn Bulk Flotation

Test No.	HIC Time Speed rpm	Product	Weight %	Assays %		% Distribution	
				Pb	Zn	Pb	Zn
25	5 1150	Bulk Rougher Conc	6.92	2.39	6.1	23.0	36.5
		Bulk Ro+Scav Conc	12.91	2.26	4.85	40.6	54.1
		Bulk Scavenger Tail	87.09	0.49	0.61	59.4	45.9
		Feed (Calc)	100.00	0.72	1.16	100.0	100.0
26	10 1150	Bulk Rougher Conc	11.37	2.67	5.88	42.2	58.0
		Bulk Ro+Scav Conc	18.16	2.27	4.46	57.0	70.2
		Bulk Scavenger Tail	81.84	0.38	0.42	43.0	29.8
		Feed (Calc)	100.00	0.72	1.15	100.0	100.0
27	15 1150	Bulk Rougher Conc	6.62	2.79	6.87	25.5	39.6
		Bulk Ro+Scav Conc	16.49	2.53	4.89	57.4	70.2
		Bulk Scavenger Tail	83.51	0.37	0.41	42.6	29.8
		Feed (Calc)	100.00	0.73	1.15	100.0	100.0
28	20 1150	Bulk Rougher Conc	5.27	2.86	7.28	20.1	33.5
		Bulk Ro+Scav Conc	11.24	2.96	6.48	44.4	63.6
		Bulk Scavenger Tail	88.76	0.47	0.47	55.6	36.4
		Feed (Calc)	100.00	0.75	1.15	100.0	100.0

4.3.2. Effect of High Intensity Conditioning Speed

In this series of tests, the collector conditioning time was fixed at 10 minutes and the conditioning speed was varied from 600 rpm to 1150 rpm. The conditions and results of these tests are summarized in Table No. 16. Note that the lime and CuSO_4 conditioning were conventional and were fixed at 5 minutes per stage.

The results obtained demonstrated that with an increase in conditioning speed, the lead and zinc recoveries in the bulk concentrate increased significantly. In fact, the increases in the lead and zinc recoveries in the bulk concentrate were proportional to the increase in the conditioning speed. Note that a conditioning speed of 600 rpm is near conventional conditioning power input.

TABLE NO. 16 :
Effect of HIC Speed on Pb-Zn Bulk Flotation at Fixed Conditioning Time of 10 minutes

Test No.	Conditioning Speed, rpm	Product	Weight %	Assays %		% Distribution	
				Pb	Zn	Pb	Zn
29	600	Bulk Rougher Conc	7.04	2.66	6.11	25.6	37.1
		Bulk Ro+Scav Conc	14.47	2.33	4.58	46.2	57.3
		Bulk Scavenger Tail	85.53	0.46	0.58	53.8	42.8
		Feed (Calc)	100.00	0.73	1.16	100.0	100.0
30	900	Bulk Rougher Conc	6.96	3.04	7.57	29.2	45.3
		Bulk Ro+Scav Conc	16.05	2.42	4.84	53.6	66.8
		Bulk Scavenger Tail	83.95	0.40	0.46	46.4	33.2
		Feed (Calc)	100.00	0.72	1.16	100.0	100.0
26	1150	Bulk Rougher Conc	11.37	2.67	5.88	42.2	58.0
		Bulk Ro+Scav Conc	18.16	2.27	4.46	57.0	70.2
		Bulk Scavenger Tail	81.84	0.38	0.42	43.0	29.8
		Feed (Calc)	100.00	0.72	1.15	100.0	100.0

4.3.3. Effect of Collector High Intensity Conditioning Time Using Fixed HIC with Lime and CuSO₄

Comparative tests were performed in which constant high intensity conditioning times of 5 minutes per stage with lime and CuSO₄ were used and the collector conditioning time was varied from 5 to 15 minutes. The conditions and results of these tests are summarized in Table No. 17.

TABLE NO. 17 :
Effect of High Intensity Collector Conditioning Time Using Fixed HIC Times with Depressant and Activator

Test No.	HIC Time rpm	Product	Weight %	Assays %		% Distribution	
				Pb	Zn	Pb	Zn
33	5+5+5	Bulk Rougher Conc	12.82	1.98	4.84	35.8	52.8
		Bulk Ro+Scav Conc	22.37	1.75	3.69	55.2	70.3
		Bulk Scavenger Tail	77.63	0.41	0.45	44.8	29.7
		Feed (Calc)	100.00	0.71	1.18	100.0	100.0
34	5+5+10	Bulk Rougher Conc	15.25	1.91	4.3	41.0	56.6
		Bulk Ro+Scav Conc	26.69	1.59	3.13	59.7	72.1
		Bulk Scavenger Tail	73.31	0.39	0.44	40.3	27.9
		Feed (Calc)	100.00	0.71	1.16	100.0	100.0
35	5+5+15	Bulk Rougher Conc	16.09	1.92	4.28	42.6	59.9
		Bulk Ro+Scav Conc	28.55	1.59	3.12	62.6	77.6
		Bulk Scavenger Tail	71.45	0.38	0.36	37.4	22.9
		Feed (Calc)	100.00	0.73	1.15	100.0	100.0

From these results and from the results obtained in the series of tests with conventional lime and CuSO_4 conditioning, the following conclusions are made:

- The positioning of high intensity conditioning is an important parameter in the Faro tailing retreatment flowsheet design.
- The use of conventional conditioning with lime and CuSO_4 and HIC with collector gave poorer recoveries (Table 15), than when using split high intensity conditioning with lime- CuSO_4 and collector (Table 17).
- The average power requirement remained the same whether split high intensity conditioning or the combination of conventional and high intensity conditioning were used.

4.4. Preliminary Bulk Concentrate Upgrading Tests

During the preliminary testwork, two cleaning tests were carried out using the flowsheet shown in Figure No. 7. The results obtained in these tests are shown in Table No. 18.

TABLE NO. 18 :
Preliminary Bulk Concentrate Upgrading Tests

Test No.	Product	Weight %	Assays %, g/t			% Distribution	
			Pb	Zn	Ag	Pb	Zn
6	Bulk 4th Cl Conc	1.74	10.2	37.4	92.2	25.4	58.2
	Bulk 1st Cl Conc	4.71	6.7	17.6	68.6	45.6	74.1
	Bulk Rougher Conc	14.43	2.88	6.1	22.4	59.5	78.6
	Bulk Rougher Tail	85.57	0.33	0.28	-	40.5	21.4
	Feed (Calc)	100.00	0.70	1.12	-	100.0	100.0
7	Bulk 4th Cl Conc	1.67	12.7	35.1	115	30.4	52.6
	Bulk 1st Cl Conc	5.15	6.37	15.0	64.8	47.0	69.4
	Bulk Rougher Conc	15.53	2.64	5.28	21.5	58.8	73.5
	Bulk Rougher Tail	84.47	0.34	0.35	-	41.2	26.5
	Feed (Calc)	100.00	0.70	1.12	-	100.0	100.0

The results showed that production of marketable bulk concentrates is possible.

APPENDIX NO. 1

Details of Tests

TEST NO. 1

Purpose: Preliminary test on Faro tailing lower zone composite to examine Zn-Pb bulk flotation.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing Composite DV pH >7.

Conditions:

	Reagents Added, grams per tonne					Time, minutes			pH
	RO	Ca(OH) ₂	CuSO ₄	A317	MIBC	Grind	Cond.	Froth	
Conditioning 1	100	500	-	-	-	-	5	-	-
2	-	-	300	-	-	-	5	-	10.0
Bulk Fo 1	-	-	-	15	5	-	1	3	-
2	-	-	-	10	5	-	1	3	-
3	-	-	-	5	5	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	169.8	18.28	1.52	2.77	38.2	42.2
2 Bulk Rougher Tail	759.3	81.72	0.55	0.85	61.8	57.8
Head (calc)	929.1	100.0	0.73	1.20	100.0	100.0

TEST NO. 2

Purpose: Preliminary test to examine the effect of H.I.C. using a lime-BPW depressant system.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing Composite DV pH >7.

Conditions:

	Reagents Added, grams per tonne					Time, minutes			pH
	Ca(OH) ₂	BPW	CuSO ₄	A317	M2030	Grind	Cond.	Froth	
H.I. Cond	1	1000	150	-	-	-	5	-	-
	2	-	-	380	-	-	5	-	-
	3	-	-	-	15	10	5	-	-
Bulk Rougher		-	-	-	-	-	-	4	-
Bulk Scav		-	-	-	10	5	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	65.1	7.36	4.23	10.7	43.4	66.0
2 Bulk Rougher Conc 2	95.6	10.81	1.19	1.48	17.9	13.4
3 Bulk Rougher Tail	723.5	81.83	0.34	0.3	38.7	20.6
Head (calc)	884.2	100.0	0.72	1.19	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	18.17	2.4	5.2	61.3	79.4
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TEST NO. 3

Purpose: As in Test No. 2, but with upper zone tailings composite.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing DV Composite pH <7.

Conditions:

	Reagents Added, grams per tonne					Time, minutes			pH
	Ca(OH) ₂	BPW	CuSO ₄	A317	M2030	Grind	Cond.	Froth	
H.I. Cond	1	1500	300	-	-	-	5	-	-
	2	-	-	350	-	-	5	-	-
	3	-	-	-	15	10	10	-	-
Bulk Fo	1	-	-	-	-	-	1	5	10.2
Bulk Fo	2	-	-	-	5	5	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	63.3	6.75	4.12	10	38.7	55.5
2 Bulk Rougher Conc 2	89.0	9.48	1.46	2.62	19.3	20.4
3 Bulk Rougher Tail	786.1	83.77	0.36	0.35	42.0	24.1
Head (calc)	938.4	100.0	0.72	1.22	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	16.23	2.6	5.7	58.0	75.9
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TEST NO. 4

Purpose: An initial scoping test, but with increased collector and CuSO₄.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing Composite DV pH <7.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	Lime	CuSO ₄	343	M2030	Grind	Cond.	Froth	
H.I. Condition 1	5000	-	-	-	-	5	-	10.6
2	-	700	-	-	-	5	-	-
3	-	-	50	10	-	5	-	-
Bulk Rougher 1	-	-	-	-	-	-	5	-
2	-	-	10	5	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	50.5	5.40	2.98	8.94	24.4	42.3
2 Bulk Rougher Conc 2	22.8	2.44	1.2	2.1	4.4	4.5
3 Bulk Rougher Tail	861.4	92.16	0.51	0.66	71.2	53.2
Head (calc)	934.7	100.0	0.66	1.14	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	7.84	2.4	6.8	28.8	46.8
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TEST NO. 5

Purpose: To repeat Test 4, but with the decreased collector, decreased CuSO₄ and the addition of depressant BPW.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing Composite DV pH <7.

Conditions:

		Reagents Added, grams per tonne					Time, minutes			pH
		Lime	CuSO ₄	343	M2030	BPW	Grind	Cond.	Froth	
H.I. Cond	1	5000	-	-	-	200	-	5	-	-
	2	-	350	-	-	-	-	5	-	-
	3	-	-	30	10	-	-	5	-	-
Bulk Flo	1	-	-	-	-	-	-	-	5	-
	2	-	-	10	5	-	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	77.8	8.39	2.26	5.61	28.8	41.2
2 Bulk Rougher Conc 2	38.4	4.14	0.97	1.41	6.1	5.1
3 Bulk Rougher Tail	810.8	87.46	0.49	0.7	65.1	53.6
Head (calc)	927.0	100.0	0.66	1.14	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	12.54	1.8	4.2	34.9	46.4
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TEST NO. 6

Purpose: A preliminary bulk flotation and upgrading test on DV Faro Tailing pH >7.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing Composite DV pH >7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	BPW	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
H.I. Condition 1	1000	150	-	-	-	-	-	5	-	9.8
2	-	-	380	-	-	-	-	5	-	-
3	-	-	-	5	10	-	-	10	-	-
Bulk Rougher	-	-	-	-	-	-	-	1	4	-
Bulk Scavenger	-	-	-	10	5	-	-	1	3	-
Regrind (PM)	700	100	-	-	-	-	15	-	-	-
H.I. Condition	-	-	-	15	5	-	-	10	-	11.5
Bulk 1st Cleaner	-	-	-	-	-	-	-	1	3	-
	-	-	-	-	2	-	-	1	2	-
Bulk 1st CI Scav	-	-	-	5	2	-	-	1	3	-
Bulk 2nd Cleaner	150	20	-	-	-	-	-	3	3	11.5
Bulk 3rd Cleaner	150	20	-	-	-	-	-	3	3	11.5
Bulk 4th Cleaner	150	20	-	-	-	-	-	3	3	11.5

METALLURGICAL RESULTS

Product	Weight		Assays, %g/t			% Distribution		
	g	%	Pb	Zn	Ag	Pb	Zn	Ag
1 Bulk 4th Cleaner Conc	65.6	1.74	10.2	37.4	92.2	25.4	58.2	14.7
2 Bulk 4th Cleaner Tail	13.8	0.37	9.91	18.3	124	5.2	6.0	4.2
3 Bulk 3rd Cleaner Tail	11.8	0.31	4.88	5.46	64.5	2.2	1.5	1.8
4 Bulk 2nd Cleaner Tail	48.5	1.29	3.38	3.5	35.2	6.2	4.0	4.1
5 Bulk 1st CI Scav Conc	38.0	1.01	4.52	4.86	51.5	6.5	4.4	4.7
6 Bulk 1st CI Scav Tail	366.9	9.72	1	0.51	15.8	13.9	4.4	14.1
7 Bulk Rougher Tail	3228.8	85.57	0.33	0.28	7.2	40.5	21.4	56.4
Head (calc)	3773.4	100.00	0.70	1.12	10.9	100.0	100.0	100.0

Combined Products

1-2 Bulk 3rd Cleaner Conc	2.10	10.1	34.1	97.7	30.6	64.2	18.8
1-3 Bulk 2nd Cleaner Conc	2.42	9.47	30.4	93.4	32.8	65.7	20.7
1-4 Bulk 1st Cleaner Conc	3.70	7.4	21.0	73.2	39.0	69.7	24.8
1-5 Bulk 1st CI-Cl Scav Concs	4.71	6.7	17.6	68.6	45.6	74.1	29.6
1-6 Bulk Rougher Conc	14.43	2.88	6.1	33.0	59.5	78.6	43.6
6-7 Bulk Ro-1st CI Scav Tails	95.29	0.40	0.30	8.08	54.4	25.9	70.4

TEST NO. 7

Purpose: To repeat the conditions of Test No. 6, but reduce lime additions to the bulk cleaners.

Procedure: Similar to Test 6.

Feed: ~4000 grams of Faro Tailing Composite DV pH >7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	BPW	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
H.I. Condition 1	1000	150	-	-	-	-	-	5	-	-
2	-	-	380	-	-	-	-	5	-	-
3	-	-	-	15	10	-	-	10	-	9.5
Bulk Rougher	-	-	-	-	-	-	-	1	4	-
Bulk Scavenger	-	-	-	10	5	-	-	1	3	-
Regrind (PM)	500	100	-	-	-	-	15	-	-	-
H.I. Condition	-	-	-	15	5	-	-	10	-	-
Bulk 1st Cleaner	-	-	-	-	-	-	-	1	3	-
	-	-	-	-	2	-	-	1	2	-
Bulk 1st Cl Scav	-	-	-	5	2	-	-	1	3	-
Bulk 2nd Cleaner	50	20	-	-	-	-	-	3	3	9.8
Bulk 3rd Cleaner	50	20	-	-	-	-	-	3	3	9.8
Bulk 4th Cleaner	50	20	-	-	-	-	-	3	3	9.8

METALLURGICAL RESULTS

Product	Weight		Assays, %g/t			% Distribution		
	g	%	Pb	Zn	Ag	Pb	Zn	Ag
1 Bulk 4th Cleaner Conc	62.4	1.67	12.7	35.1	115	30.4	52.6	17.0
2 Bulk 4th Cleaner Tail	17.1	0.46	8.03	17.1	58.6	5.3	7.0	2.4
3 Bulk 3rd Cleaner Tail	30.8	0.83	4.28	7.21	69.5	5.1	5.3	5.1
4 Bulk 2nd Cleaner Tail	49.0	1.31	1.79	1.84	21.6	3.4	2.2	2.5
5 Bulk 1st Cl Scav Conc	33.0	0.88	2.28	2.87	32.6	2.9	2.3	2.5
6 Bulk 1st Cl Scav Tail	387.5	10.38	0.79	0.44	12.7	11.8	4.1	11.6
7 Bulk Rougher Tail	3153.0	84.47	0.34	0.35	7.9	41.2	26.5	58.9
Head (calc)	3732.8	100.00	0.70	1.12	11.3	100.0	100.0	100.0

Combined Products

1-2 Bulk 3rd Cleaner Conc	2.13	11.7	31.2	103	35.7	59.6	19.3
1-3 Bulk 2nd Cleaner Conc	2.95	9.62	24.5	93.6	40.8	65.0	24.4
1-4 Bulk 1st Cleaner Conc	4.27	7.21	17.5	71.4	44.2	67.1	26.9
1-5 Bulk 1st Cl+Cl Scav Concs	5.15	6.37	15.0	64.8	47.0	69.4	29.5
1-6 Bulk Rougher Conc	15.53	2.64	5.28	30.0	58.8	73.5	41.1
6-7 Bulk Ro+1st Cl Scav Tails	94.85	0.39	0.36	8.43	53.0	30.6	70.5

TEST NO. 8

Purpose: The first in a series of tests to investigate various collector types on Faro Tailing pH <7.

Procedure: Similar to Test 3, but replace M2030 with M748.

Feed: ~1000 grams of Faro Tailing Composite DV pH <7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	BPW	CuSO ₄	A317	M748	MIBC	Grind	Cond.	Froth	
H.I. Condition 1	5000	300	-	-	-	-	-	5	-	10.2
2	-	-	350	-	-	-	-	5	-	9.7
3	-	-	-	15	10	-	-	10	-	-
Bulk Rougher 1	-	-	-	-	-	10	-	1	5	9.4
2	-	-	-	5	5	-	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	77.9	8.38	1.85	3.58	24.3	27.0
2 Bulk Rougher Conc 2	18.5	1.99	1.31	2.57	4.1	4.6
3 Bulk Rougher Tail	832.8	89.63	0.51	0.85	71.6	68.4
Head (calc)	929.2	100.0	0.64	1.11	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	10.37	1.7	3.4	28.4	31.6
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TEST NO. 9

Purpose: To repeat the conditions of Test 3, but replace M2030 with LST0.

Procedure: As for Test 3.

Feed: -1000 grams of Faro Tailing Composite DV pH <7.

Conditions:

	Reagents Added, grams per tonne					Time, minutes			pH
	Ca(OH) ₂	BPW	CuSO ₄	A317	LST0	Grind	Cond.	Froth	
H.I. Cond 1	5000	300	-	-	-	-	5	-	-
2	-	-	350	-	-	-	5	-	9.7
3	-	-	-	15	10	-	10	-	-
Bulk Rougher 1	-	-	-	-	-	-	1	5	9.4
2	-	-	-	5	5	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays,%		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	45.0	4.79	3.02	6.41	22.7	28.1
2 Bulk Rougher Conc 2	26.3	2.80	1.44	3.35	6.3	8.6
3 Bulk Rougher Tail	867.7	92.41	0.49	0.75	71.0	63.3
Head (calc)	939.0	100.0	0.64	1.09	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	7.59	2.4	5.3	29.0	36.7
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TEST NO. 10

Purpose: To repeat the conditions of Test 3, but add 20 g/t A317 to the H.I. Conditioner.

Procedure: As for Test 3.

Feed: ~1000 grams of Faro Tailing Composite DV pH <7.

Conditions:

	Reagents Added, grams per tonne					Time, minutes			pH
	Ca(OH) ₂	BPW	CuSO ₄	A317	M2030	Grind	Cond.	Froth	
H.I. Cond 1	5000	300	-	-	-	-	5	-	10.2
2	-	-	350	-	-	-	5	-	9.7
3	-	-	-	20	10	-	10	-	-
Bulk Rougher 1	-	-	-	-	-	-	1	5	9.4
2	-	-	-	5	5	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	59.4	6.33	2.74	6.78	27.1	37.3
2 Bulk Rougher Conc 2	35.4	3.77	1.14	2.42	6.7	7.9
3 Bulk Rougher Tail	844.1	89.90	0.47	0.7	66.1	54.7
Head (calc)	938.9	100.0	0.64	1.15	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	10.10	2.1	5.2	33.9	45.3
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TEST NO. 11

Purpose: The first in a series of tests to examine the effect of pH on DV Faro Tailing Composite DV pH <7.

Procedure: As shown below.

Feed: ~1000 grams of Faro Tailing Composite DV pH <7.

Conditions:

	Reagents Added, grams per tonne					Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	BPW	Mod M2030	A317	Grind	Cond.	Froth	
H.I. Cond 1	3000	-	400	-	-	-	5	-	7.2
2	-	350	-	-	-	-	5	-	-
3	-	-	-	16	30	-	10	-	-
Bulk Rougher 1	-	-	-	-	-	-	1	4	-
2	-	-	-	4	5	-	1	2	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	252.1	27.15	0.74	1.92	30.8	48.3
2 Bulk Rougher Conc 2	107.7	11.60	0.73	1.54	13.0	16.5
3 Bulk Rougher Tail	568.6	61.25	0.6	0.62	56.3	35.2
Head (calc)	928.4	100.0	0.65	1.08	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	38.75	0.7	1.8	43.7	64.8
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TEST NO. 12

Purpose: To repeat the conditions of Test 11, but at higher pH.

Procedure: As for Test 11 with 5000 g/t lime.

Feed: ~1000 grams of Faro Tailing Composite DV pH <7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	BPW	Mod M2030	A317	MIBC	Grind	Cond.	Froth	
H.I. Condition 1	5000	-	400	-	-	-	-	5	-	-
2	-	350	-	-	-	-	-	5	-	-
3	-	-	-	15	25	8	-	10	-	9.8
Bulk Rougher 1	-	-	-	-	-	-	-	1	4	-
2	-	-	-	8	10	-	-	1	2	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	146.2	17.89	1.42	3.4	39.7	52.6
2 Bulk Rougher Conc 2	182.9	22.38	0.39	0.74	13.6	14.3
3 Bulk Rougher Tail	488.3	59.74	0.5	0.64	46.7	33.1
Head (calc)	817.4	100.0	0.64	1.16	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	40.26	0.8	1.9	53.3	66.9
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TEST NO. 13

Purpose: To repeat the conditions of Test 11 and 12, at higher pH.

Procedure: Similar to Tests 11 and 12.

Feed: ~1000 grams of Faro Tailing Composite DV pH <7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	BPW	Mod M2030	A317	MIBC	Grind	Cond.	Froth	
H.I. Condition 1	8000	-	400	-	-	-	-	5	-	-
2	-	350	-	-	-	-	-	5	-	-
3	-	-	-	15	25	8	-	10	-	11.3
Bulk Rougher 1	-	-	-	-	-	-	-	1	4	-
2	-	-	-	10	10	-	-	1	2	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	92.5	9.74	2.79	6.76	43.4	60.4
2 Bulk Rougher Conc 2	37.5	3.95	1.32	1.77	8.3	6.4
3 Bulk Rougher Tail	819.7	86.31	0.35	0.42	48.3	33.2
Head (calc)	949.7	100.0	0.63	1.09	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	13.69	2.4	5.3	51.7	66.8
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TEST NO. 14

Purpose: To repeat the conditions of Tests 11 to 13 at higher pH.

Procedure: Similar to Tests 11 to 13.

Feed: ~1000 grams of Faro Tailing Composite DV pH <7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	BPW	Mod M2030	A317	MIBC	Grind	Cond.	Froth	
H.I. Condition 1	10000	-	400	-	-	-	-	5	-	-
2	-	350	-	-	-	-	-	5	-	-
3	-	-	-	15	25	8	-	10	-	11.5
Bulk Rougher 1	-	-	-	-	-	-	-	1	4	-
2	-	-	-	8	10	-	-	1	2	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	77.2	8.14	2.88	7.87	38.3	58.3
2 Bulk Rougher Conc 2	55.8	5.88	1.31	1.94	12.6	10.4
3 Bulk Rougher Tail	815.8	85.98	0.35	0.4	49.1	31.3
Head (calc)	948.8	100.0	0.61	1.10	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	14.02	2.2	5.4	50.9	68.7
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TEST NO. 15

Purpose: To repeat the conditions of Test 14, but reduce the depressant BPW addition to 200 g/t.

Procedure: As indicated below.

Feed: ~1000 grams of Faro Tailing Composite DV pH <7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	BPW	Mod M2030	A317	MIBC	Grind	Cond.	Froth	
H.I. Condition 1	10000	-	200	-	-	-	-	5	-	-
2	-	350	-	-	-	-	-	5	-	-
3	-	-	-	15	25	8	-	10	-	11.5
Bulk Rougher 1	-	-	-	-	-	-	-	1	4	-
2	-	-	-	8	10	-	-	1	2	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	80.6	8.11	3.11	8.24	40.5	59.8
2 Bulk Rougher Conc 2	47.3	4.76	1.36	2.13	10.4	9.1
3 Bulk Rougher Tail	866.5	87.14	0.35	0.4	49.1	31.2
Head (calc)	994.4	100.0	0.62	1.12	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	12.86	2.5	6.0	50.9	68.8
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TEST NO. 16

Purpose: To repeat the conditions of Test 14 but eliminate the BPW.

Procedure: Similar to Test 15, but without BPW addition.

Feed: ~1000 grams of Faro Tailing Composite DV pH <7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	BPW	Mod M2030	A317	MIBC	Grind	Cond.	Froth	
H.I. Condition 1	10000	-	-	-	-	-	-	5	-	-
2	-	350	-	-	-	-	-	5	-	-
3	-	-	-	15	25	8	-	10	-	11.5
Bulk Rougher 1	-	-	-	-	-	-	-	1	4	-
2	-	-	-	8	10	-	-	1	2	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	60.5	6.03	3.92	10.6	38.0	57.4
2 Bulk Rougher Conc 2	43.2	4.31	1.48	2.7	10.2	10.4
3 Bulk Rougher Tail	899.4	89.66	0.36	0.4	51.8	32.2
Head (calc)	1003.1	100.0	0.62	1.11	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	10.34	2.9	7.3	48.2	67.8
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Product: Bulk Ro. Tail Test No: 16

Microns	Mesh	Weight Grams	% Weight		
			Ind.	Cum.	Passing
589	28	4.8	2.0	2.0	98.0
417	35	2.7	1.1	3.2	96.8
295	48	5.5	2.3	5.5	94.5
208	65	6.8	2.9	8.4	91.6
147	100	14.8	6.3	14.6	85.4
104	150	18.9	8.0	22.6	77.4
74	200	23.5	9.9	32.5	67.5
53	270	27.2	11.5	44.0	56.0
38	400	24.0	10.1	54.1	45.9
-38	-400	108.6	45.9	100.0	-
	Total	236.8	100.0	-	-

TEST NO. 17

Purpose: To repeat the conditions of Test 16, but regrind the tailing and omit lime from the HIC stage.

Procedure: As shown below.

Feed: ~1000 grams of Faro Tailing Composite DV pH <7.

Grind: 6 minutes at 65% solids in a laboratory rod mill.

Conditions:

	Reagents Added, grams per tonne					Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	M2030	A317	MIBC	Grind	Cond.	Froth	
Grind	10000	-	-	-	-	6	-	-	-
H.I. Cond	1	-	-	-	-	-	0	-	-
	2	-	350	-	-	-	5	-	-
	3	-	-	15	25	-	10	-	-
Bulk Ro	1	-	-	-	-	-	1	3	-
	2	-	-	5	8	-	1	2	-

METALLURGICAL RESULTS

Product	Weight		Assays,%		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	100.9	9.88	3.69	8.79	57.3	78.6
2 Bulk Rougher Conc 2	45.5	4.45	1.29	1.26	9.0	5.1
3 Bulk Rougher Tail	875.3	85.67	0.25	0.21	33.7	16.3
Head (calc)	1021.7	100.0	0.64	1.10	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	14.33	2.94	6.45	66.3	83.7
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TEST NO. 18

Purpose: A preliminary cleaning test on Faro Tailing Composite DV pH <7 using the rougher conditions of Test 17.

Procedure: As shown below.

Feed: ~2000 grams of Faro Tailing Composite DV pH <7.

Grind: 12 minutes at 65% solids in a laboratory rod mill.

Conditions:

	Reagents Added, grams per tonne					Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	M2030	A317	MIBC	Grind	Cond.	Froth	
Grind	10000	-	-	-	-	12	-	-	-
H.I. Cond	1	-	-	-	-	-	0	-	11.4
	2	-	350	-	-	-	5	-	-
	3	-	-	15	25	-	10	-	-
Bulk Ro	1	-	-	-	-	-	1	4	-
	2	-	-	5	8	-	1	3	-
Regrind (PM)	1000	80	-	-	-	25	-	-	-
H.I. Cond	-	-	5	10	-	-	15	-	-
Bulk 1st Cl	-	-	-	-	-	-	1	4	11.8
Bulk 1st Cl Scav	-	-	-	-	-	-	1	3	-
Bulk 2nd Cl	50	-	-	-	-	-	1	3	11.5
Bulk 3rd Cl	20	-	-	-	-	-	1	2	11.5
Bulk 4th Cl	20	-	-	-	-	-	1	2	11.5

METALLURGICAL RESULTS

Product	Weight		Assays, %, g/t			% Distribution		
	g	%	Pb	Zn	Ag	Pb	Zn	Ag
1 Bulk 4th Cleaner Conc	62.8	3.21	7.72	23.2	110	40.4	70.6	27.5
2 Bulk 4th Cleaner Tail	7.1	0.36	6.37	8.29	108	3.8	2.9	3.1
3 Bulk 3rd Cleaner Tail	8.5	0.43	4.82	6.03	130	3.4	2.5	4.4
4 Bulk 2nd Cleaner Tail	17.0	0.87	2.18	2.29	38.8	3.1	1.9	2.6
5 Bulk 1st Cl Scav Conc	15.0	0.77	1.37	1.78	24.8	1.7	1.3	1.5
6 Bulk 1st Cl Scav Tail	245.2	12.53	0.63	0.45	12.9	12.9	5.3	12.6
7 Bulk Rougher Tail	1600.8	81.82	0.26	0.2	7.6	34.7	15.5	48.4
Head (calc)	1956.4	100.00	0.61	1.05	12.9	100.0	100.0	100.0

Combined Products

1-2 Bulk 3rd Cleaner Conc	3.57	7.58	21.7	110	44.2	73.5	30.5
1-3 Bulk 2nd Cleaner Conc	4.01	7.28	20.0	112	47.6	76.0	34.9
1-4 Bulk 1st Cleaner Conc	4.88	6.37	16.8	98.9	50.7	77.8	37.5
1-5 Bulk 1st Cl+Cl Scav Concs	5.64	5.69	14.8	88.9	52.4	79.1	39.0
1-6 Bulk Rougher Conc	18.18	2.20	4.90	36.5	65.3	84.5	51.6
6-7 Bulk Ro+1st Cl Scav Tails	94.36	0.31	0.23	8.30	47.6	20.9	61.0

TEST NO. 19

Purpose: To repeat the conditions of Test 18, but use SD200 in the bulk cleaners.

Procedure: Similar to Test 18.

Feed: ~2000 grams of Faro Tailing Composite DV pH <7.

Grind: 12 minutes at 65% solids in a laboratory rod mill.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	M2030	A317	MIBC	SD200	Grind	Cond.	Froth	
Grind	10000	-	-	-	-	-	12	-	-	-
H.I. Cond	1	-	-	-	-	-	-	0	-	-
	2	-	350	-	-	-	-	5	-	11.5
	3	-	-	15	25	-	-	10	-	-
Bulk Rougher	1	-	-	-	-	-	-	1	4	-
	2	-	-	5	10	-	-	1	3	-
Bulk Regrind	1000	-	-	-	-	50	25	-	-	-
H.I. Condition	-	-	5	10	-	-	-	15	-	-
Bulk 1st Cleaner	-	-	-	-	-	-	-	1	4	11.8
Bulk 1st CI Scav	-	-	2	4	-	-	-	1	2	-
Bulk 2nd Cleaner	100	-	-	-	-	20	-	1	3	11.5
Bulk 3rd Cleaner	50	-	-	-	-	20	-	1	2	11.5
Bulk 4th Cleaner	50	-	-	-	-	20	-	1	2	11.5

METALLURGICAL RESULTS

Product	Weight		Assays, %/g/t			% Distribution		
	g	%	Pb	Zn	Ag	Pb	Zn	Ag
1 Bulk 4th Cleaner Conc	35.3	1.75	6.88	28.6	89.3	19.2	46.9	12.9
2 Bulk 4th Cleaner Tail	19.9	0.99	6.69	13.7	83.5	10.5	12.7	6.8
3 Bulk 3rd Cleaner Tail	26.6	1.32	4.65	7.56	66.3	9.8	9.3	7.2
4 Bulk 2nd Cleaner Tail	43.1	2.13	2.74	3.54	43.5	9.3	7.1	7.7
5 Bulk 1st CI Scav Conc	26.4	1.31	1.61	1.58	27.7	3.4	1.9	3.0
6 Bulk 1st CI Scav Tail	210.9	10.44	0.76	0.6	15.1	12.6	5.9	13.0
7 Bulk Rougher Tail	1657.9	82.07	0.27	0.21	7.3	35.3	16.2	49.5
Head (calc)	2020.1	100.00	0.63	1.07	12.1	100.0	100.0	100.0

Combined Products

1-2 Bulk 3rd Cleaner Conc	2.73	6.81	23.2	87.2	29.6	59.6	19.7
1-3 Bulk 2nd Cleaner Conc	4.05	6.11	18.1	80.4	39.4	68.9	26.9
1-4 Bulk 1st Cleaner Conc	6.18	4.95	13.1	67.7	48.7	76.0	34.5
1-5 Bulk 1st CI+CI Scav Concs	7.49	4.36	11.1	60.7	52.1	77.9	37.5
1-6 Bulk Rougher Conc	17.93	2.27	4.98	34.1	64.7	83.8	50.5
6-7 Bulk Ro+1st CI Scav Tails	92.51	0.33	0.25	8.18	47.9	22.1	62.5

TEST NO. 20

Purpose: To examine the effect of depressant SW2 in bulk concentrate upgrading.

Procedure: As indicated below.

Feed: 2 x 2000 grams of Faro Tailing Composite DV pH <7.

Grind: 12 minutes at 65% solids in a lab rod mill.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	M2030	A317	MIBC	SW2	Grind	Cond.	Froth	
Grind	10000	-	-	-	-	-	12	-	-	-
H.I. Cond	-	-	-	-	-	-	-	0	-	10.8
1	-	-	-	-	-	-	-	5	-	-
2	-	350	-	-	-	-	-	10	-	-
3	-	-	15	25	-	-	-	-	-	-
Bulk Rougher	-	-	-	-	-	-	-	1	4	-
1	-	-	-	-	-	-	-	1	4	-
2	-	-	4	5	-	-	-	1	4	-
Bulk Regrind	1000	-	-	-	-	150	35	-	-	-
H.I. Condition	-	-	-	5	6	-	-	15	-	-
Bulk 1st Cleaner	-	-	-	-	-	-	-	1	4	11.7
Bulk 1st Cl Scav	-	-	2	2	-	-	-	1	3	-
Bulk 2nd Cleaner	100	-	-	-	-	20	-	1	4	11.7
Bulk 3rd Cleaner	100	-	-	-	-	20	-	1	3	11.7
Bulk 4th Cleaner	100	-	-	-	-	20	-	1	2	11.9

METALLURGICAL RESULTS

Product	Weight		Assays, %g/t			% Distribution		
	g	%	Pb	Zn	Ag	Pb	Zn	Ag
1 Bulk 4th Cleaner Conc	47.4	1.26	3.58	33.9	67.9	7.8	41.6	6.9
2 Bulk 4th Cleaner Tail	29.6	0.79	5.66	17	84.8	7.7	13.0	5.4
3 Bulk 3rd Cleaner Tail	42.3	1.13	3.93	5.38	58.9	7.6	5.9	5.4
4 Bulk 2nd Cleaner Tail	104.1	2.77	2.24	2.2	33.5	10.7	5.9	7.5
5 Bulk 1st Cl Scav Conc	54.3	1.45	5.02	5.8	64.3	12.5	8.2	7.5
6 Bulk 1st Cl Scav Tail	550.2	14.65	0.8	0.56	15.1	20.2	8.0	17.9
7 Bulk Rougher Tail	2927.8	77.96	0.25	0.23	7.8	33.6	17.4	49.3
Head (calc)	3755.7	100.00	0.58	1.03	12.3	100.0	100.0	100.0

Combined Products

1-2 Bulk 3rd Cleaner Conc	2.05	4.38	27.4	74.4	15.5	54.6	12.4
1-3 Bulk 2nd Cleaner Conc	3.18	4.22	19.6	68.9	23.1	60.5	17.7
1-4 Bulk 1st Cleaner Conc	5.95	3.30	11.5	52.4	33.8	66.4	25.3
1-5 Bulk 1st Cl-Cl Scav Concs	7.39	3.63	10.4	54.7	46.3	74.6	32.8
1-6 Bulk Rougher Conc	22.04	1.75	3.85	28.4	66.4	82.6	50.7
6-7 Bulk Ro-1st Cl Scav Tails	92.61	0.34	0.28	8.95	53.7	25.4	67.2

TEST NO. 21

Purpose: To repeat the conditions of Test 20, but add depressant SW2 to the bulk grind.

Procedure: As indicated below.

Feed: 2 x 2000 grams of Faro Tailing Composite DV pH <7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	M2030	A317	MIBC	SW2	Grind	Cond.	Froth	
Grind	10000	-	-	-	-	100	12	-	-	-
H.I. Cond	-	-	-	-	-	-	-	0	-	10.6
1	-	350	-	-	-	-	-	5	-	-
2	-	-	15	25	-	-	-	10	-	-
3	-	-	-	-	-	-	-	-	-	-
Bulk Rougher 1	-	-	-	-	-	-	-	1	4	-
2	-	-	5	10	-	-	-	1	4	-
Bulk Re grind	1000	100	-	-	-	100	35	-	-	-
H.I. Condition	-	-	-	5	4	-	-	15	-	-
Bulk 1st Cleaner	-	-	-	-	-	-	-	1	4	11.0
Bulk 1st Cl Scav	-	-	-	5	2	-	-	1	3	-
Bulk 2nd Cleaner	100	-	-	-	-	20	-	1	4	11.7
-	-	-	-	-	2	-	-	1	1	-
Bulk 3rd Cleaner	100	-	-	-	-	20	-	1	4	11.8
-	-	-	-	-	2	-	-	1	1	-
Bulk 4th Cleaner	100	-	-	-	-	20	-	1	3	11.9

METALLURGICAL RESULTS

Product	Weight		Assays, %/g/t			% Distribution		
	g	%	Pb	Zn	Ag	Pb	Zn	Ag
1 Bulk 4th Cleaner Conc	72.1	1.92	5.13	31.2	83	15.8	57.9	12.6
2 Bulk 4th Cleaner Tail	33.7	0.90	5.42	7.81	73.9	7.8	6.8	5.2
3 Bulk 3rd Cleaner Tail	64.5	1.72	2.91	2.42	41.1	8.0	4.0	5.6
4 Bulk 2nd Cleaner Tail	154.9	4.12	1.59	1.08	24.2	10.5	4.3	7.9
5 Bulk 1st Cl Scav Conc	47.5	1.26	2.56	2.41	40.9	5.2	2.9	4.1
6 Bulk 1st Cl Scav Tail	455.0	12.11	0.71	0.45	13.5	13.8	5.3	12.9
7 Bulk Rougher Tail	2929.1	77.97	0.31	0.25	8.4	38.8	18.8	51.7
Head (calc)	3756.8	100.00	0.62	1.03	12.7	100.0	100.0	100.0

Combined Products

1-2 Bulk 3rd Cleaner Conc	2.82	5.22	23.7	80.1	23.6	64.6	17.8
1-3 Bulk 2nd Cleaner Conc	4.53	4.35	15.7	65.3	31.6	68.6	23.4
1-4 Bulk 1st Cleaner Conc	8.66	3.03	8.7	45.7	42.2	73.0	31.3
1-5 Bulk 1st Cl+Cl Scav Concs	9.92	2.97	7.9	45.1	47.4	75.9	35.4
1-6 Bulk Rougher Conc	22.03	1.73	3.81	27.7	61.2	81.2	48.3
6-7 Bulk Ro+1st Cl Scav Tails	90.08	0.36	0.28	9.09	52.6	24.1	64.6

TEST NO. 22

Purpose: As for Test 17, but with a 3 minute grind.

Procedure: As shown below.

Feed: ~1000 grams of Faro Tailing Composite DV pH <7.

Grind: 3 minutes at 65% solids in a laboratory rod mill.

Conditions:

	Reagents Added, grams per tonne					Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	M2030	A317	MIBC	Grind	Cond.	Froth	
Grind	10000	-	-	-	-	3	-	-	-
H.I. Cond	-	-	-	-	-	-	0	-	-
2	-	350	-	-	-	-	5	-	-
3	-	-	15	25	-	-	10	-	-
Bulk Rougher	-	-	-	-	-	-	-	3.5	11.9
1	-	-	5	8	5	-	-	2.5	11.0
2	-	-	-	-	-	-	-	-	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	83.8	8.80	3.32	8.8	46.3	69.7
2 Bulk Rougher Conc 2	32.1	3.37	1.45	1.64	7.7	5.0
3 Bulk Rougher Tail	836.5	87.83	0.33	0.32	45.9	25.3
Head (calc)	952.4	100.0	0.63	1.11	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	12.17	2.80	6.82	54.1	74.7
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TEST NO. 23

Purpose: To evaluate the effect of grind time on pH >7 tailings.

Procedure: Similar to Test 22 with lower lime.

Feed: ~1000 grams of Faro Tailing Composite DV pH >7.

Grind: 3 minutes at 65% solids in a laboratory rod mill.

Conditions:

	Reagents Added, grams per tonne					Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	M2030	A317	MIBC	Grind	Cond.	Froth	
Grind	1000	-	-	-	-	3	-	-	-
H.I. Cond	-	-	-	-	-	-	0	-	-
2	-	380	-	-	-	-	5	-	-
3	-	-	15	25	-	-	10	-	-
Bulk Rougher 1	-	-	-	-	25	-	1	3.5	8.9
2	-	-	5	8	10	-	1	2.5	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	104.5	11.32	2.88	5.5	46.0	54.0
2 Bulk Rougher Conc 2	54.1	5.86	1.59	2.84	13.1	14.4
3 Bulk Rougher Tail	764.5	82.82	0.35	0.44	40.9	31.6
Head (calc)	923.1	100.0	0.71	1.15	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	17.18	2.44	4.59	59.1	68.4
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TEST NO. 24

Purpose: As for Test 23, but with a 6 minute grind.

Procedure: As shown below.

Feed: ~1000 grams of Faro Tailing Composite DV pH >7.

Grind: 6 minutes at 65% solids in a laboratory rod mill.

Conditions:

	Reagents Added, grams per tonne					Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	M2030	A317	MIBC	Grind	Cond.	Froth	
Grind	1000	-	-	-	-	6	-	-	-
H.I. Cond	-	-	-	-	-	-	0	-	-
1	-	380	-	-	-	-	5	-	-
2	-	-	15	25	-	-	10	-	-
Bulk Rougher 1	-	-	-	-	25	-	1	3.5	8.8
2	-	-	5	8	-	-	1	2.5	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	82.2	9.26	3.56	6.97	47.1	57.2
2 Bulk Rougher Conc 2	48.8	5.50	1.62	3.19	12.7	15.6
3 Bulk Rougher Tail	756.4	85.24	0.33	0.36	40.2	27.2
Head (calc)	887.4	100.0	0.70	1.13	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	14.76	2.84	5.56	59.8	72.8
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TEST NO. 25

Purpose: The first in a series of tests to evaluate collector high intensity conditioning time.

Procedure: Condition the pulp in a 2 L Denver cell at 1200 rpm for 2 stages then place the pulp in the high intensity conditioning cell and dilute the pulp until the blades are covered. Condition for 5 minutes then transfer the pulp to a 4L cell and float 2 bulk roughers.

Feed: 1000 grams of Faro Tailing Composite DV pH >7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	SW2	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
Condition	1500	300	-	-	-	-	-	5	-	11.9
Condition	-	-	350	-	-	-	-	5	-	11.6
H.L. Condition	-	-	-	25	10	-	-	5	-	-
Bulk Rougher 1	-	-	-	-	-	5	-	1	5	10.5
2	-	-	-	15	5	-	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	65.5	6.92	2.39	6.1	23.0	36.5
2 Bulk Rougher Conc 2	58.6	5.98	2.12	3.4	17.6	17.6
3 Bulk Rougher Tail	824.0	87.09	0.49	0.61	59.4	45.9
Head (calc)	948.1	100.0	0.72	1.16	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	12.91	2.26	4.85	40.6	54.1
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TEST NO. 26

Purpose: As for Test 25 but increase HIC time to 10 minutes.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing Composite DV pH <7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	SW2	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
Condition	1500	300	-	-	-	-	-	5	-	11.9
Condition	-	-	350	-	-	-	-	5	-	-
H.I. Condition	-	-	-	25	10	15	-	10	-	-
Bulk Rougher 1	-	-	-	-	-	-	-	-	5	10.5
2	-	-	-	15	5	-	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	105.5	11.37	2.68	5.88	42.2	58.0
2 Bulk Rougher Conc 2	62.9	6.78	1.58	2.08	14.8	12.2
3 Bulk Rougher Tail	759.1	81.84	0.38	0.42	43.0	29.8
Head (calc)	927.5	100.0	0.72	1.15	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	18.16	2.27	4.46	57.0	70.2
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TEST NO. 27

Purpose: As for Test 25, but increase HIC time to 15 minutes.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing Composite DV pH >7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	SW2	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
Condition	1500	300	-	-	-	-	-	5	-	11.8
Condition	-	-	350	-	-	-	-	5	-	-
H.I. Condition	-	-	-	25	10	15	-	15	-	-
Bulk Rougher 1	-	-	-	-	-	-	-	-	5	10.5
2	-	-	-	15	5	-	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	61.2	6.62	2.79	6.87	25.5	39.6
2 Bulk Rougher Conc 2	91.1	9.86	2.35	3.56	31.9	30.6
3 Bulk Rougher Tail	771.5	83.51	0.37	0.41	42.6	29.8
Head (calc)	923.8	100.0	0.73	1.15	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	16.49	2.53	4.89	57.4	70.2
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TEST NO. 28

Purpose: As for Test 25 but increase HIC time to 20 minutes.

Procedure: As for Test 27, but increase HIC time from 15 to 20 minutes

Feed: 1000 grams of Faro Tailing at pH 7.5.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	SW2	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
Condition	1500	300	-	-	-	-	-	5	-	11.9
Condition	-	-	350	-	-	-	-	5	-	-
H.I. Condition	-	-	-	25	10	15	-	20	-	-
Bulk Rougher 1	-	-	-	-	-	-	-	-	5	10.5
2	-	-	-	15	5	-	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	49.6	5.27	2.86	7.28	20.1	33.5
2 Bulk Rougher Conc 2	56.3	5.98	3.05	5.77	24.3	30.1
3 Bulk Rougher Tail	836.1	88.76	0.47	0.47	55.6	36.4
Head (calc)	942.0	100.0	0.75	1.15	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	11.24	2.96	6.48	44.4	63.6
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TEST NO. 29

Purpose: The first in a series of tests to investigate the effect of various speeds of HIC.

Procedure: As for Test 25, but with an HIC speed of 600 rpm for 10 minutes.

Feed: 1000 grams of Faro Tailing Composite DV pH >7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	SW2	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
Condition	1500	300	-	-	-	-	-	5	-	11.9
Condition	-	-	350	-	-	-	-	5	-	-
H.I. Condition	-	-	-	25	10	15	-	10	-	-
Bulk Rougher 1	-	-	-	-	-	-	-	-	5	10.5
2	-	-	-	15	5	-	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	64.8	7.04	2.66	6.11	25.6	37.1
2 Bulk Rougher Conc 2	68.4	7.43	2.02	3.14	20.5	20.1
3 Bulk Rougher Tail	787.1	85.53	0.46	0.58	53.8	42.8
Head (calc)	920.3	100.0	0.73	1.16	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	14.47	2.33	4.58	46.2	57.2
------------------------	-------	------	------	------	------

TEST NO. 30

Purpose: As for Test 29, but with an HIC speed of 900 rpm.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing Composite DV pH >7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	SW2	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
Condition	1500	300	-	-	-	-	-	5	-	11.9
Condition	-	-	350	-	-	-	-	5	-	-
H.I. Condition	-	-	-	25	10	15	-	10	-	-
Bulk Rougher 1	-	-	-	-	-	-	-	-	3	10.5
2	-	-	-	15	5	-	-	1	5	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	64.6	6.96	3.04	7.57	29.2	45.3
2 Bulk Rougher Conc 2	84.5	9.10	1.94	2.75	24.4	21.5
3 Bulk Rougher Tail	779.7	83.95	0.4	0.46	46.4	33.2
Head (calc)	928.8	100.0	0.72	1.16	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	16.05	2.42	4.84	53.6	66.8
------------------------	-------	------	------	------	------

TEST NO. 31

Purpose: To repeat the conditions of Test 27, but omit depressant SW2.

Procedure: Similar to Test 27, but without SW2 depressant.

Feed: ~1000 grams of Faro Tailing Composite DV pH >7.

Conditions:

	Reagents Added, grams per tonne					Time, minutes			pH
	Ca(OH) ₂	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
Condition	1500	-	-	-	-	-	5	-	11.7
Condition	-	350	-	-	-	-	5	-	-
H.L. Condition	-	-	25	10	15	-	15	-	-
Bulk Rougher 1	-	-	-	-	-	-	-	5	10.5
2	-	-	15	5	-	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	54.0	6.28	2.92	7.82	27.7	41.0
2 Bulk Rougher Conc 2	55.4	6.44	2.43	3.38	23.6	18.2
3 Bulk Rougher Tail	750.7	87.28	0.37	0.56	48.7	40.8
Head (calc)	860.1	100.0	0.66	1.20	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	12.72	2.67	5.57	51.3	59.2
------------------------	-------	------	------	------	------

TEST NO. 32

Purpose: To repeat the conditions of Test 27, but use 150 g/t of SW2 depressant.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing Composite DV pH >7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	SW2	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
Condition	1500	150	-	-	-	-	-	5	-	11.8
Condition	-	-	350	-	-	-	-	5	-	-
H.I. Condition	-	-	-	25	10	15	-	15	-	-
Bulk Rougher 1	-	-	-	-	-	-	-	-	5	10.5
2	-	-	-	15	5	-	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	91.0	9.83	2.04	4.51	28.2	38.4
2 Bulk Rougher Conc 2	58.4	6.31	2.24	3.7	19.9	20.2
3 Bulk Rougher Tail	776.4	83.86	0.44	0.57	51.9	41.4
Head (calc)	925.8	100.0	0.71	1.15	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	16.14	2.12	4.19	48.1	58.6
------------------------	-------	------	------	------	------

TEST NO. 33

Purpose: To repeat the conditions of Test 25, but use high intensity conditioning in all 3 stages of conditioning.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing Composite DV pH >7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	SW2	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
H.I. Cond 1	1500	300	-	-	-	-	-	5	-	10.7
2	-	-	350	-	-	-	-	5	-	-
3	-	-	-	25	10	15	-	5	-	-
Bulk Rougher 1	-	-	-	-	-	10	-	1	5	10.6
2	-	-	-	15	5	5	-	1	5	-

METALLURGICAL RESULTS

Product	Weight		Assays,%		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	118.5	12.82	1.98	4.84	35.8	52.8
2 Bulk Rougher Conc 2	88.3	9.55	1.44	2.15	19.4	17.5
3 Bulk Rougher Tail	717.5	77.63	0.41	0.45	44.8	29.7
Head (calc)	924.3	100.0	0.71	1.18	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	22.37	1.75	3.69	55.2	70.3
------------------------	-------	------	------	------	------

TEST NO. 34

Purpose: To repeat the conditions of Test 33, but increase the length of high intensity conditioning time with collector to 10 minutes.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing Composite DV pH >7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	SW2	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
H.I. Cond 1	1500	300	-	-	-	-	-	5	-	-
2	-	-	350	-	-	-	-	5	-	-
3	-	-	-	25	10	15	-	10	-	-
Bulk Rougher 1	-	-	-	-	-	10	-	1	5	10.5
2	-	-	-	15	5	5	-	1	3	-

METALLURGICAL RESULTS

Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	142.3	15.25	1.91	4.3	41.0	56.6
2 Bulk Rougher Conc 2	106.7	11.44	1.16	1.57	18.7	15.5
3 Bulk Rougher Tail	684.0	73.31	0.39	0.44	40.3	27.9
Head (calc)	933.0	100.0	0.71	1.16	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	26.69	1.59	3.13	59.7	72.1
------------------------	-------	------	------	------	------

TEST NO. 35

Purpose: To repeat the conditions of Test 34, but increase the high intensity conditioning stage with collector to 15 minutes.

Procedure: As indicated below.

Feed: 1000 grams of Faro Tailing Composite DV pH >7.

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	Ca(OH) ₂	SW2	CuSO ₄	A317	M2030	MIBC	Grind	Cond.	Froth	
H.I. Cond	1	1500	300	-	-	-	-	5	-	-
	2	-	-	350	-	-	-	5	-	-
	3	-	-	-	25	10	15	15	-	-
Bulk Rougher	1	-	-	-	-	10	-	1	5	10.5
	2	-	-	-	15	5	5	1	5	-

METALLURGICAL RESULTS

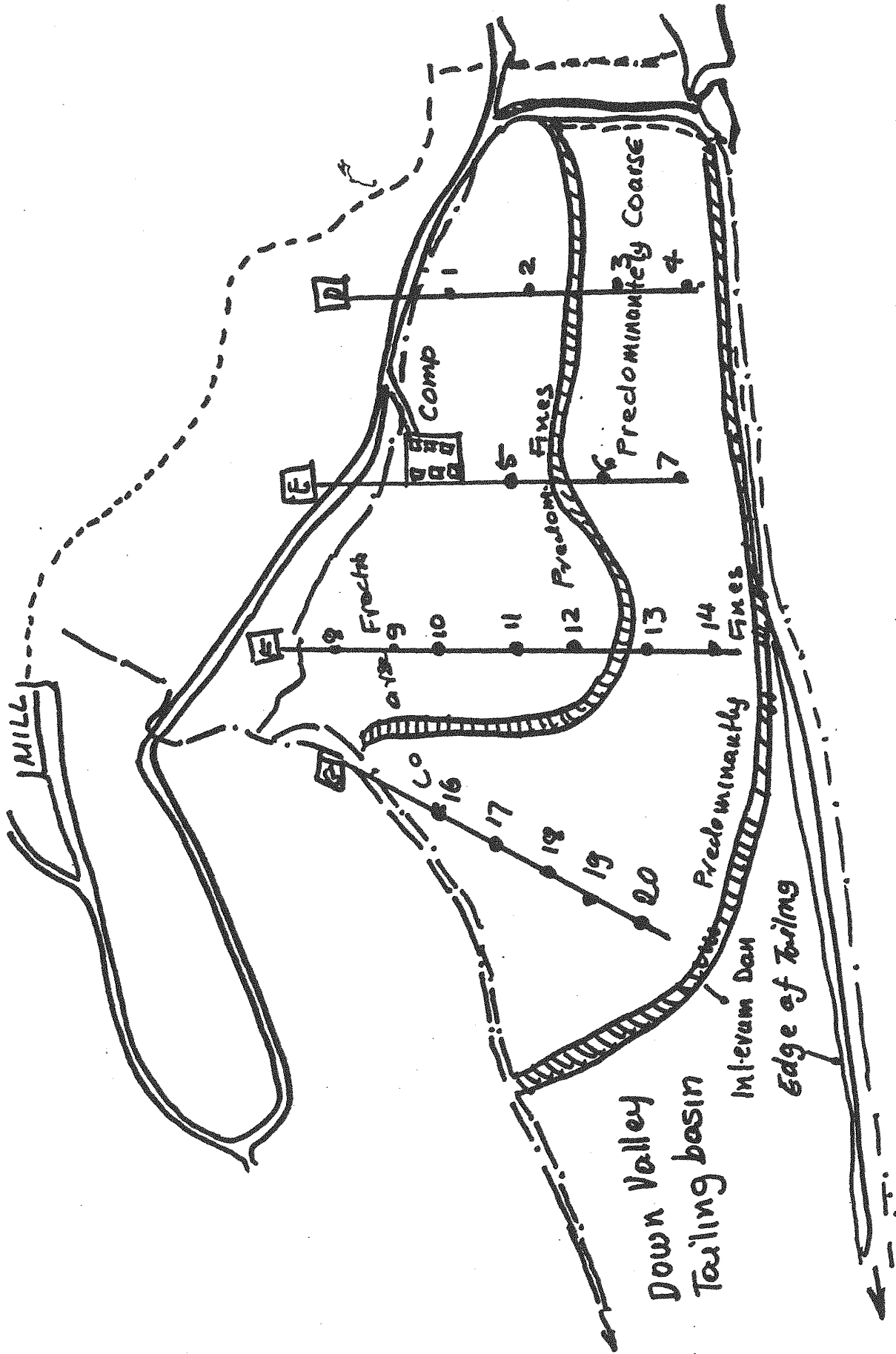
Product	Weight		Assays, %		% Distribution	
	g	%	Pb	Zn	Pb	Zn
1 Bulk Rougher Conc 1	148.2	16.09	1.92	4.28	42.6	59.9
2 Bulk Rougher Conc 2	115.5	12.46	1.16	1.63	19.9	17.7
3 Bulk Rougher Tail	662.4	71.45	0.38	0.36	37.4	22.4
Head (calc)	927.1	100.0	0.73	1.15	100.0	100.0

Combined Products

Bulk Rougher Conc. 1+2	28.55	1.59	3.12	62.6	77.6
------------------------	-------	------	------	------	------

APPENDIX NO. 2

Faro Talling Drilling Program

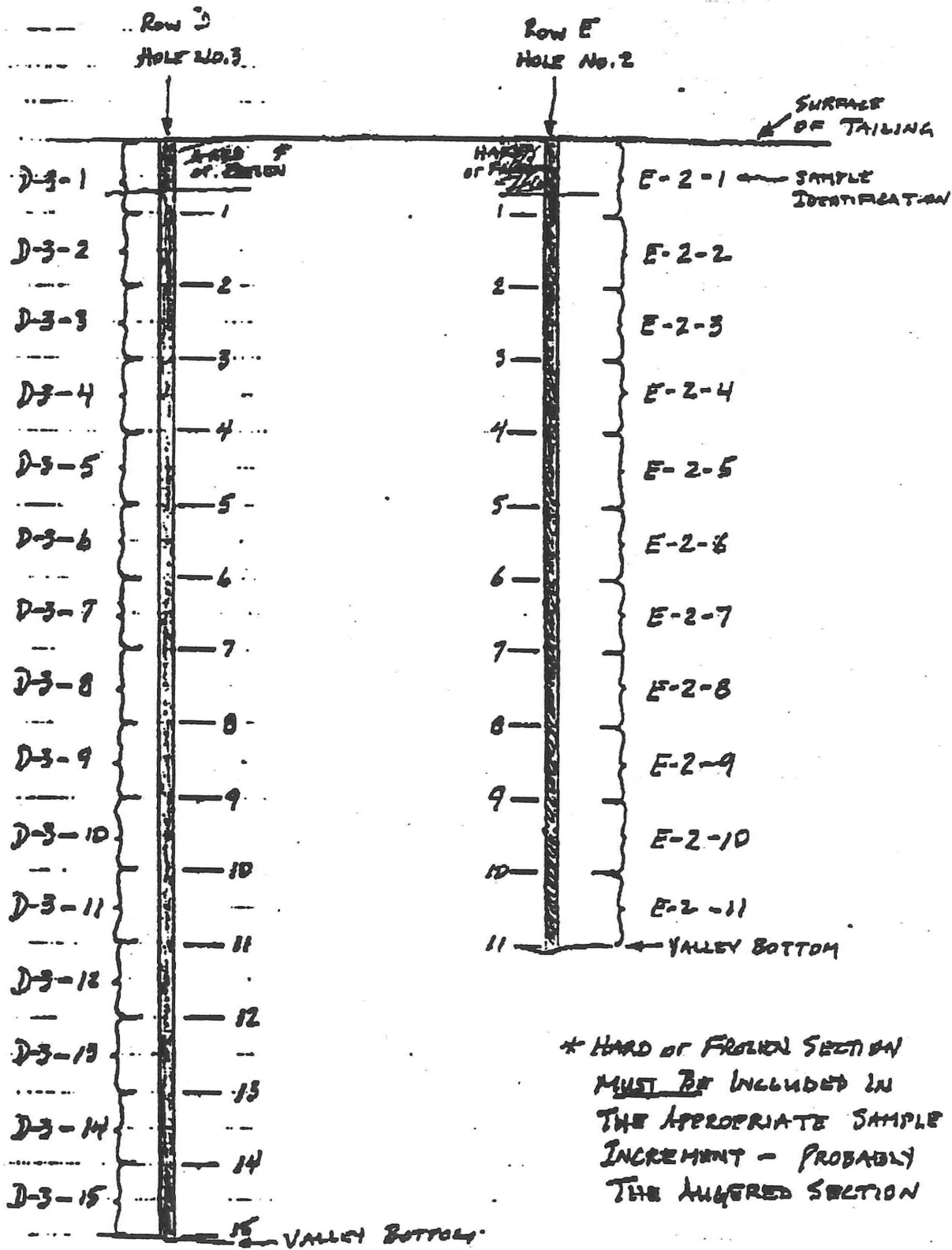


FARO DOWN VALLEY TAILING

Pound Area

Samples Drilling Program 1992

FARO DOWN VALLEY TAILING SAMPLE IDENTIFICATION



FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)

- VIBRO CORE DRILLING
- 1 METER SAMPLE INCREMENT LENGTH

DATE: 07/27/92

HOLE NO.	DEPTH (M)	INCR. NO.	SAMPLE NO.	GRAVITY	TESTWORK COMPOSITE					SCREEN & ANALYSED USE	COMMENTS
					IC	II	III	IV	V		
7	14	1	3801	✓ 3.47	✓	✓	✓	✓		✓	
		2	5325	✓ 5.14	✓	✓	✓	✓	✓	✓	
		3	3884	✓ 5.37	✓	✓	✓	✓		✓	
		4	8146	6:20	✓	✓	✓	✓	✓	✓	
		5	5760	✓ 9.88	✓	✓	✓	✓	✓	✓	
		6	4705	8.78	✓	✓	✓	✓		✓	
		7	7636	✓ 6.87	✓	✓	✓	✓		✓	
		8	18359	8.17	✓	✓	✓	✓	✓	✓	
		9	8365	✓ 7.82	✓	✓	✓	✓	✓	✓	
		10	8791	✓ 7.49	✓	✓	✓	✓	✓	✓	
		11	No Sample								Bagging number error
		12	6238	7.02	✓	✓	✓	✓	✓	✓	
		13	9801	✓ 6.94	✓	✓	✓	✓	✓	✓	
		14	9763	✓ 7.17	✓	✓	✓	✓	✓	✓	
		15	8746	✓ 7.63	✓	✓	✓	✓	✓	✓	
		16	8733	✓ 8.24	✓	✓	✓	✓	✓	✓	
		17	8897	✓ 7.97	✓	✓	✓	✓	✓	✓	
		18	7774	✓ 7.54	✓	✓	✓	✓	✓	✓	
		19	12089	✓ 8.48	✓	✓	✓	✓	✓	✓	
		20	7063	✓ 8.13	✓	✓	✓	✓	✓	✓	
		21	7342	✓ 8.83	✓	✓	✓	✓	✓	✓	

FARO DOWN VALLEY TAILING
SAMPLING PROGRAM (1992)

- VIBRO CORE DRILLING
- 1 METER SAMPLE INCREMENT LENGTH

DATE: Oct 27/92

G	INCR	NO.	TOTAL HEIGHT	WATE IN	TESTING CONDITIONS					SCREEN & ANALYSIS 0.5 kg	COMMENTS	
					10	20	30	40	50			ESTIM
	1	3853	✓	3.35	✓	✓	✓	✓	✓	✓		
	2	8891	✓	5.48	✓	✓	✓	✓	✓	✓		
	3	8890	✓	4.39	✓	✓	✓	✓	✓	✓		
	4	6803	✓	4.57	✓	✓	✓	✓	✓	✓		
	5	6305	✓	5.26	✓	✓	✓	✓	✓	✓		
	6	10037	✓	5.95	✓	✓	✓	✓	✓	✓		
	7											
	8	6931	✓	6.18	✓	✓	✓	✓	✓	✓		
	9	3095		5.98	✓	✓	✓	✓	✓	✓		
	10	7000	✓	7.03	✓	✓	✓	✓	✓	✓		
	11	6430	✓	8.03	✓	✓	✓	✓	✓	✓		
	12	7305	✓	9.01	✓	✓	✓	✓	✓	✓		
	13	8014	✓	9.00	✓	✓	✓	✓	✓	✓		
	14	8142	✓	9.24	✓	✓	✓	✓	✓	✓		
	15	6997	✓	8.94	✓	✓	✓	✓	✓	✓		
	16	6125	✓	8.66	✓	✓	✓	✓	✓	✓		
	17	7020	✓	8.23	✓	✓	✓	✓	✓	✓		
	18	7180	✓	8.04	✓	✓	✓	✓	✓	✓		
	19	7417	✓	8.43	✓	✓	✓	✓	✓	✓		
	20	6796		8.98	✓	✓	✓	✓	✓	✓		
	21	6884	✓	8.70	✓	✓	✓	✓	✓	✓		
	22	8076	✓	8.48	✓	✓	✓	✓	✓	✓		
	23	6574	✓	8.79	✓	✓	✓	✓	✓	✓		
	24	6771	✓	8.48	✓	✓	✓	✓	✓	✓		

bagging re. after

TAILINGS SAMPLING PROJECT

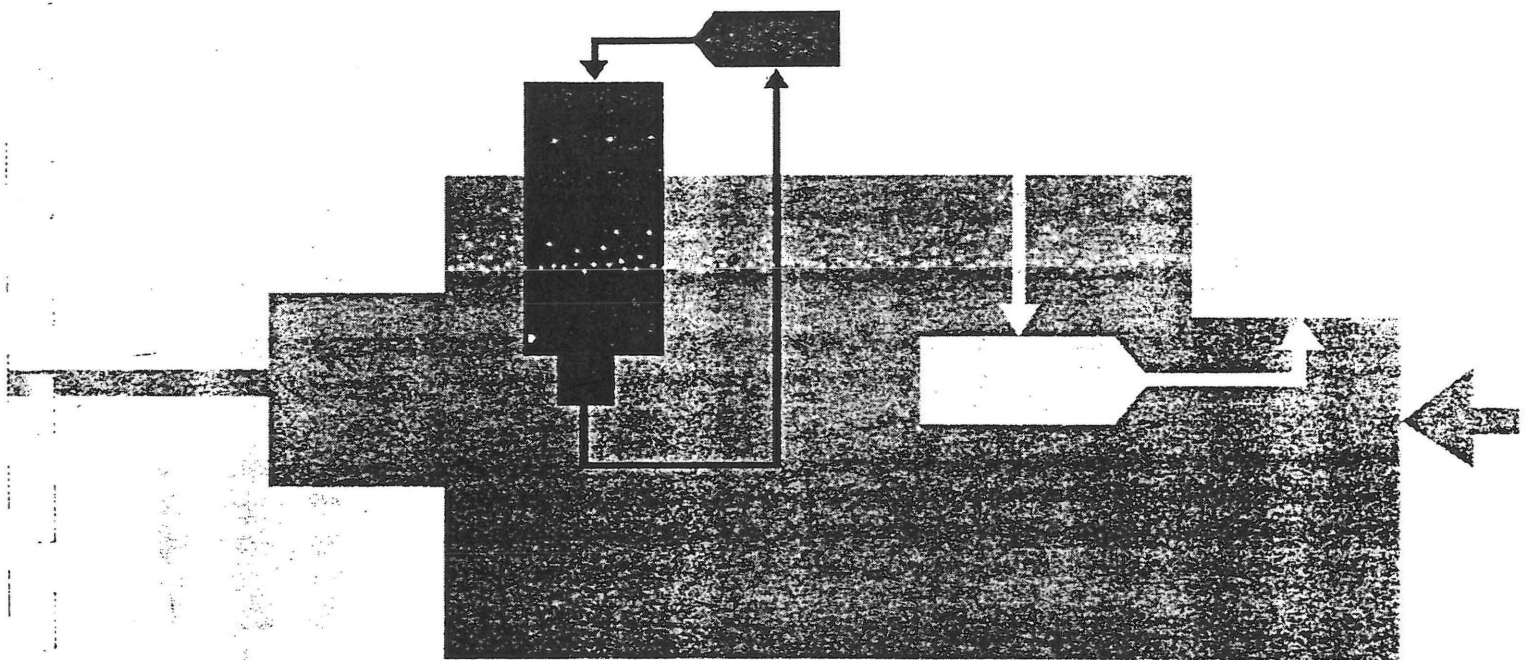
COMP I		DEGREE OF MOISTURE CONTENT				WATER CLAIRITY	
SAMPLE #		LOW 1	MODER 2	VERY 3	EXTREME 4	CLEAR 1	MUDDY 2
F-14	1	✓					
	2		✓				
	3	✓					
	4				✓		
	5			✓			
	6				✓	✓	
	7			✓			✓
	8				✓		
	9		✓				
	10	✓					
	11	No SAMPLE					
	12		✓				✓
	13		✓				
	14	✓					
	15	✓					
	16		✓				✓
	17			✓			✓
	18		✓				
	19			✓			✓
	20			✓			
	21		✓				



FLOTATION TESTWORK

FARO TAILINGS
YUKON, CANADA

FINAL REPORT



NORMET



FLOTATION TESTWORK

FARO TAILINGS
YUKON, CANADA


FINAL REPORT

CLIENT: Curragh Inc. / Denehurst Ltd

JOB No.: 23/583

DATE: 7 May 1993


per Phil Hearse


Roger Gilby

Normet Pty Ltd

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ACN 050 123 503

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Tables 1 - 13

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1 SUMMARY

Results from the flotation testwork indicate that zinc concentrate at an acceptable grade and recovery is achievable from Faro tailings.

Comparison between the Faro 6 result (Test 6 from testwork conducted by RMS Waterford and Associates, May 1992) and those from Normet indicates that higher overall zinc rougher recoveries are possible, and improvements to this are likely.

	FARO 6	TEST 10
Zn Recovery	65	67
Zn Grade	11	18

Final cleaner concentrate grade/recovery relationship is still not as high as that outlined on the Faro 6 test. However, recoveries achieved by Normet are superior, and recovery to the final cleaner stage is close to that previously achieved.

The reagent costs based on Test 8 are significantly lower than that of the \$3.00/t quoted by RMS Waterford at an estimated \$1.70/t.

Continuation onto Stage 2 of the testwork program is recommended to optimise conditioning.

2 INTRODUCTION

Denehurst Ltd, in conjunction with Curragh Inc of Canada, are investigating the feasibility of a project to recover zinc from the Faro Mine tailings dams. Normet was requested to conduct flotation testing on tailings samples from the Faro Mine in Yucon, Canada, aimed at zinc recovery with particular emphasis on application of the Denehurst flotation technology.

A program of testwork had been proposed by Normet (ref: "Metallurgical Testwork Program For Curragh Tailings Re-treatment Project" 25 November 1993). The proposed program was broken down into three stages, with a stagewise approach to the testwork. This report is based on the first stage of the testwork, which was aimed at emulating testwork conducted earlier on a separate sample of Faro tailings by RMS Waterford.

The aim of this preliminary stage of the program were to repeat the results previously achieved.

3 SAMPLES / SAMPLE PREPARATION

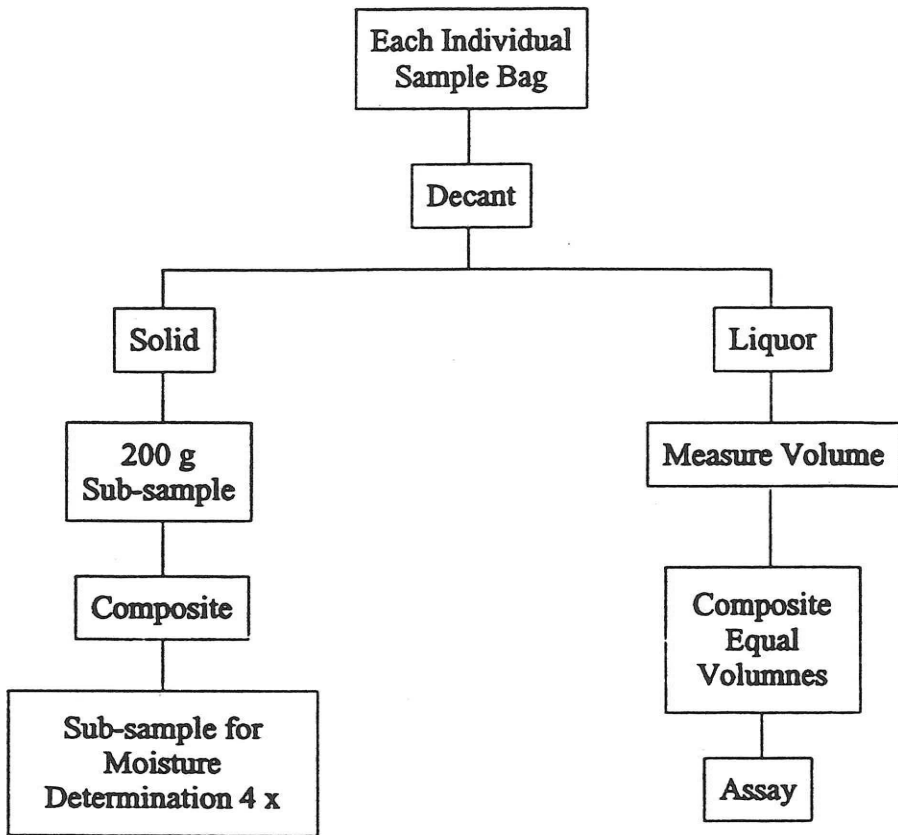
3.1 CURRAGH TAILINGS

A total of seven 20 litre buckets arrived in good condition and were stored in Normet's quarantine facility. The buckets contained in total 144 individual sealed sample bags. The samples ranged from damp to wet.

The samples received were as follows:

	HOLE	METRE INTERVALS	COMMENTS
1	D1	1 - 7	
2	D2	8 - 18	(No. 8 missing)
3	D3	1 - 4	
4	D4	1 - 10	
5	E5	1 - 9	
6	E6	2 - 11	
7	E7	1 - 17	(No. 5 missing)
8	F13	1 - 5	
9	F14	1 - 21	(No. 6 missing)
10	G18	1 - 6	
11	G19	1 - 24	
12	G20	1 - 21	(No. 8 missing)
Total of 144 samples			
1 unlabelled			
1 doubled up (E5 No. 2)			

The samples were treated separately and individually and each sample resealed after sub-sampling. The procedure is outlined in the following flowsheet:



Of the samples only seven had sufficient free water to yield solution for sampling. A composite was made from the solution.

The solid samples were thoroughly mixed and the moisture content determined. From this, samples containing 1,500 g of dry solids were split out for flotation testing.

4 TESTWORK PROCEDURES AND RESULTS

4.1 WATER ANALYSIS

The decanted water collected during the sample preparation was composited by equal volume. Analysis of the solution sample is shown below.

A sample was collected from the wash filtrate solution. Samples were despatched for analysis for float tests 1 and 2. Subsequent test wash solutions were not tested due to assumed similarity.

The results are presented below:

ANALYTE		COMPOSITE SOLUTION	WASH FILTRATE	
			TEST 1	TEST 2
Cu	mg/L	0.40	0.30	0.31
Zn	mg/L	12.70	60.00	59.30
Fe	mg/L	<0.1	<0.1	<0.1
Na	mg/L	384	57	83
Mg	mg/L	348	114	100
Ca	mg/L	1041	490	597
Al	mg/L	4.6	-	-
SO ₄	mg/L	3477	1311	1249
Cl ⁻	mg/L	2615	95	127
pH		7.62	6.7	6.7

4.2 MOISTURE DETERMINATION

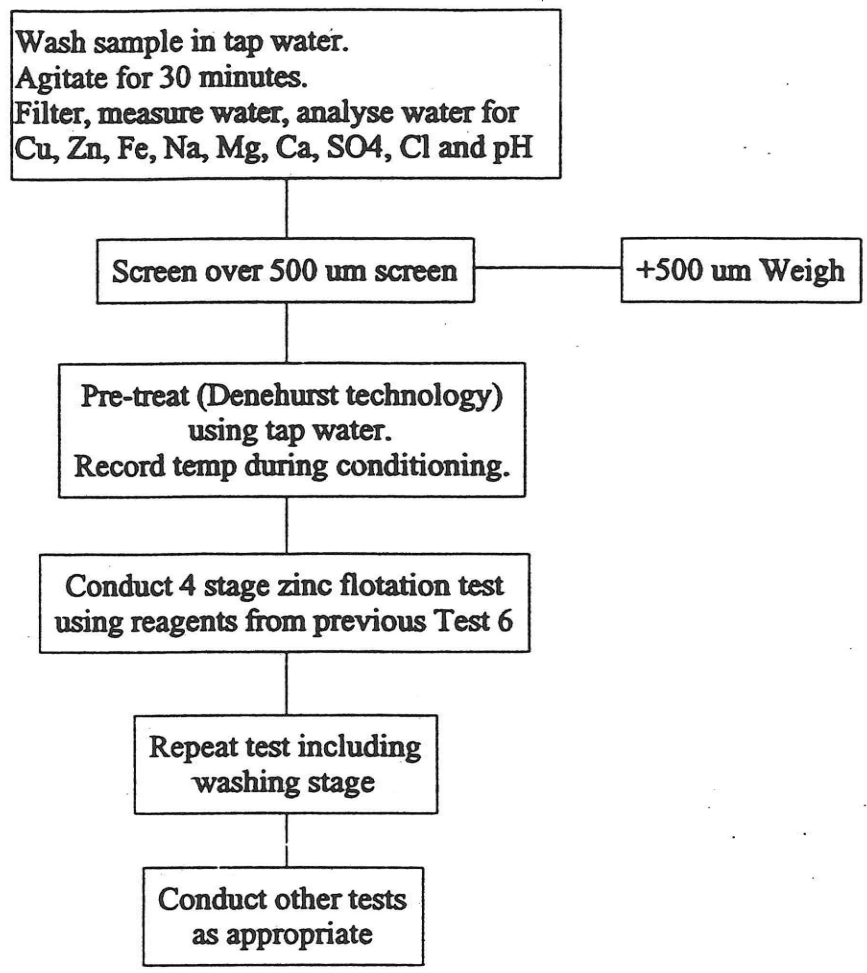
From the composited samples, 4 representative sub-samples were split out and moisture determined on the samples. The results are presented below:

MOISTURE (%)				AVERAGE
13.51	13.63	13.58	13.43	13.54

4.3 FLOTATION TESTING

A series of 12 flotation tests was conducted on the Curragh tailings samples. The detailed results are presented in Section 5.

The testwork procedure was conducted as follows:



The tests were conducted under the following general conditions:

- Tests 1 to 8 and 10 utilised Denehurst pretreatment technology.
- Tests 6, 7 and 10 utilised oxygenation during the pretreatment.
- Tests 9, 11 and 12 did not utilise pretreatment technology, Test 12 did not have the washing/filtration stage prior to flotation as did all the other tests.

The first seven flotation tests concentrated on producing a concentrate from the roughing stage comparable to the work done by RMS Waterford. The results gained from their Test 6 (Table 1, Section 5) resulted in the following:

FARO TEST 6	
Zn Recovery	65%
Zn Grade	11%

The results gained by Normet achieved this result with good repeatability.

TEST	7	8	9	10	11
Zn Recovery	65%	65%	60%	67%	62%
Zn Grade	13%	17%	18%	18%	20.5%

5 DISCUSSION OF RESULTS

5.1 ZINC

The general conclusions gained from the roughing testwork suggests that Denehurst technology and also oxygenation may be beneficial to the recovery of a zinc concentrate. It is however not clear how the technologies can be best utilised to improve on this recovery by optimisation of the two.

Recovery of a final concentrate from the rougher concentrate grade gave very encouraging results. The results that indicate the high recoveries and grade are possible from the rougher concentrate. For Test 9, the recovery from the initial rougher concentrate was 70% in comparison to the 75% gained by the Faro 6 test. However, the lower initial concentrate grade resulted in the poorer recovery. On a pro rata basis it could be expected to achieve grades and recoveries similar to those of Faro 6.

The upgrade ratio for the work indicates that the major difference in the work is that of the upgrading of the No. 1 Cleaner stage, however improvements to this have been made and the emulation of the overall Faro work is expected to be achievable with work progressing into Stages 2 and 3 of the testwork program.

5.2 OTHER MINERALS

Iron

Iron was sufficiently depressed to give a concentrate grade in the region of 10% to 12%. The use of UNIMAX, an iron depressant, had some effect, however this reagent requires further investigation to optimise it.

Iron appears to be readily suppressed during flotation by close pH control, in particular, during the rougher stage.

Copper

Copper grades in the concentrate were similar to that of the Faro 6 testwork remaining well below 5%, however recoveries were well up on that of the Faro 6 testwork.

Lead

The recovery of lead into the concentrate was influenced by the conditioning and the oxygenation. As a general rule, conditioning reduces the percentage lead in the concentrate, conversely, no conditioning increases lead in the concentrate eg Test 9.

The inclusion of oxygenation during conditioning increases the recovery and grade of lead, however this increase is far less than the increase of lead in the concentrate should there be no conditioning step.

Further work would be required to see the effect of a greatly reduced conditioning time and oxygenation.

5.3 COMPARISON WITH PREVIOUS SAMPLES

Normet does not know how similar the set of samples supplied for this testwork program were to the sample for the previous work. However, the work conducted to date indicates that results similar to the previous work are achievable, and are yet to be optimised in terms of grade/recovery and reagents.

Based on the reagent additions for Test 8, reagent costs would be approximately \$1.70/t (reagent cost estimates are presented in Table 13). Lime consumption of 4 kg/t is some 20% less than the Faro Test 6 consumption. These reagents costs are significantly lower than that of the Faro 6 work where \$3.00/t was estimated.

5.4 FURTHER TESTWORK

From the results presented it is clear that it is possible to achieve the desired grade and recovery for this material. It is recommended that further testwork be conducted to improve on the foundations laid down.

It is recommended that further testing be carried out to optimise the technologies and reagents for the conditioning stage.

Detailed flotation results are tabulated in Section 6.

6 DETAILED TEST DATA

Table 1

Faro 6

Tables 2 and 3

Tests 1 and 2

Table 4

Tests 3 to 6

Tables 5 to 11

Tests 7 to 12

Table 12

Flotation Conditions

Table 13

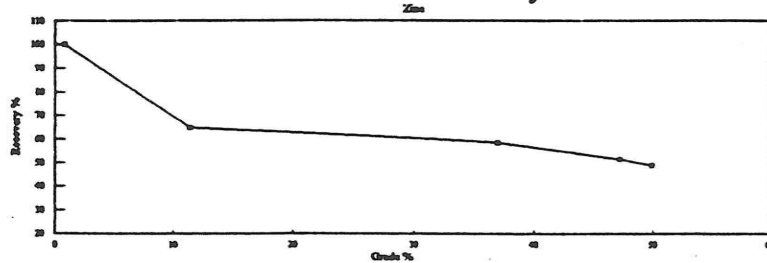
Reagent Costs

FLOTATION TEST

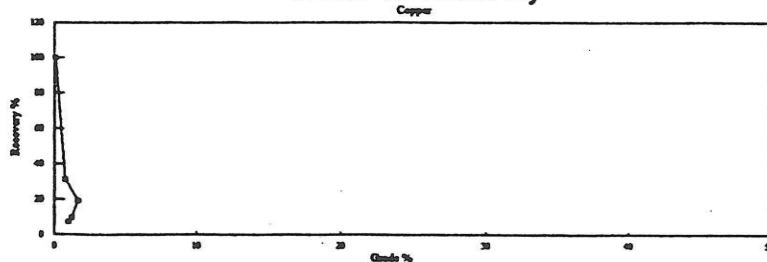
Client Name	Curragh Resources
Sample Reference	Test 0
Sample Description	FARO 6
Job Number	23/583
Date	1992

PRODUCT	Weight		Copper		Zinc		Lead		Iron	
	g	%	%	Distribution	%	Distribution	%	Distribution	%	Distribution
3rd Cleaner Conc	10.7	0.79	1.0	7.17	49.9	48.71	0.9	1.25	11.7	0.35
3rd Cleaner Tail	1.3	0.10	3.0	2.61	24.9	2.95	3.1	0.52	18.6	0.07
2nd Cleaner Conc	12.0	0.89	1.2	9.78	47.2	51.66	1.1	1.78	12.4	0.41
2nd Cleaner Tail	5.4	0.40	2.6	9.40	14.3	7.04	2.4	1.69	27.1	0.41
1st Cleaner Conc	17.4	1.29	1.6	19.18	37.0	58.71	1.5	3.46	17.0	0.82
1st Cleaner Tail	44.9	3.33	0.4	12.03	1.5	6.14	0.8	4.67	36.0	4.48
Rougher Conc	62.3	4.63	0.7	31.20	11.4	64.85	1.0	8.13	30.7	5.30
Rougher Tail	1284.2	95.37	0.08	68.80	0.30	35.15	0.6	91.87	26.6	94.70
Calculated Head	1346.5	100.00	0.1	100.00	0.81	100.00	0.57	100.00	28.8	100.0

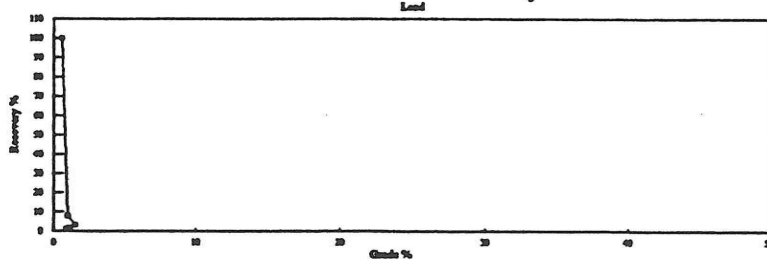
Grade Vs Recovery



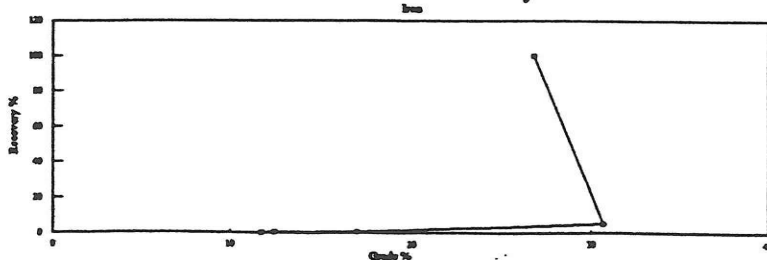
Grade Vs Recovery



Grade Vs Recovery



Grade Vs Recovery

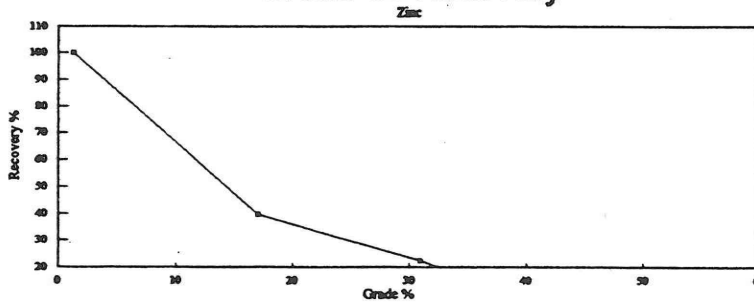


FLOTATION TEST

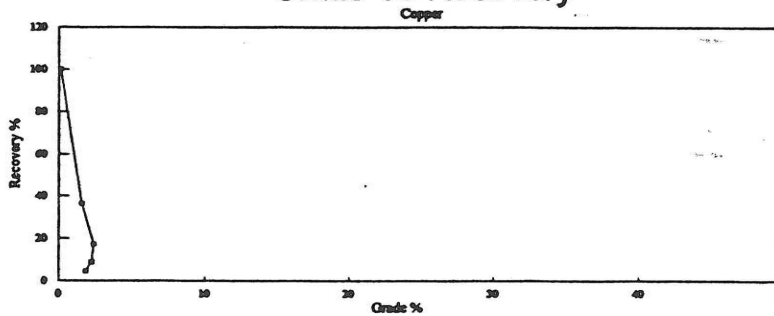
Client	Curragh Resources
Test Number	Test 1
Sample Description	Curragh Flot 1
Job Number	23/583
Date	25/3/93

PRODUCT	Weight		Copper		Zinc		Iron	
	g	%	%	Distribution	%	Distribution	%	Distribution
3rd Cleaner Conc	4.4	0.31	1.8	4.53	39.7	9.81	14.2	0.2
3rd Cleaner Tail	2.5	0.18	2.9	4.19	30.5	4.34	17.4	0.1
2rd Cleaner Conc	6.9	0.48	2.2	8.72	36.3	14.16	15.4	0.3
2rd Cleaner Tail	6.0	0.42	2.5	8.56	24.7	8.33	18.1	0.3
1rd Cleaner Conc	12.9	0.90	2.3	17.28	30.9	22.48	16.6	0.5
1rd Cleaner Tail	28.7	2.00	1.2	19.25	10.7	17.22	25.0	1.8
Rougher Conc	41.6	2.91	1.5	36.53	16.9	39.71	22.4	2.3
Rougher Tail	1390.8	97.09	0.1	63.47	0.77	60.29	28.1	97.7
Calculated Head	1432.4	100.00	0.1	100.00	1.24	100.00	27.9	100.0

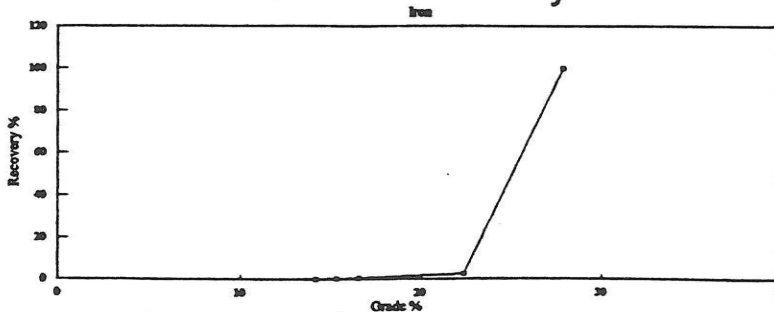
Grade Vs Recovery



Grade Vs Recovery



Grade Vs Recovery

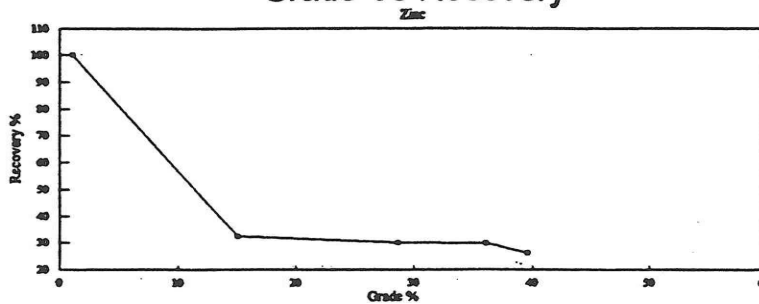


FLOTATION TEST

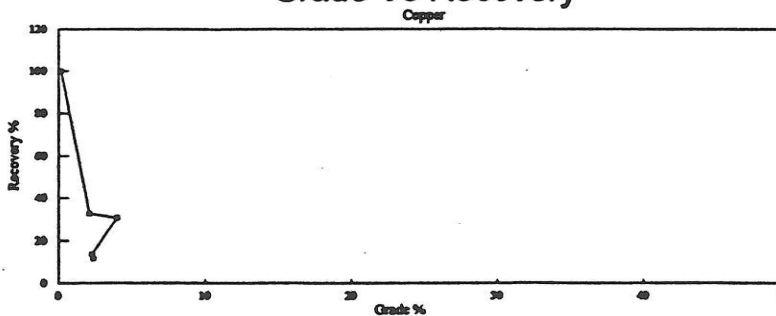
Client	Curragh Resources
Test Number	Test 2
Sample Description	Curragh Flot 2
Job Number	23/583
Date	26/3/93

PRODUCT	Weight		Copper		Zinc		Iron	
	g	%	%	Distribution	%	Distribution	%	Distribution
3rd Cleaner Conc	10.7	0.74	2.3	11.35	39.5	26.27	14.9	0.4
3rd Cleaner Tail	2.6	0.18	2.0	2.40	21.9	3.61	17.7	0.1
2nd Cleaner Conc	13.3	0.93	2.3	13.75	36.0	29.88	15.4	0.5
2nd Cleaner Tail	3.5	0.25	10.6	17.05	0.9	0.20	21.2	0.2
1rd Cleaner Conc	16.8	1.17	4.0	30.80	28.7	30.08	16.6	0.7
1rd Cleaner Tail	17.9	1.24	0.2	2.00	2.0	2.27	24.9	1.2
Rougher Conc	34.7	2.42	2.1	32.80	15.0	32.35	20.9	1.9
Rougher Tail	1400.1	97.58	0.1	67.20	0.78	67.65	26.6	98.1
Calculated Head	1434.8	100.00	0.2	100.00	1.12	100.00	26.5	100.0

Grade Vs Recovery



Grade Vs Recovery



Grade Vs Recovery

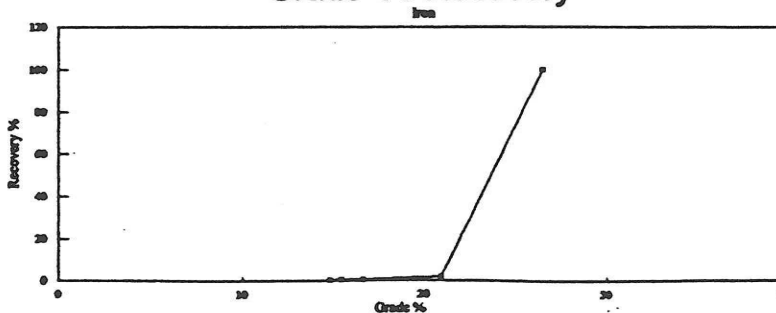


Table 4

Flotation Test Results Tests CTF3 to CTF5

Date	31/3/93
Sample	Curragh Comp 5/2/93
Test Number	Test 3
Objective	Single Rougher (NaAF 3418A)

Stage	Wt	Wt %	Assay %	Dist'n % Copper	Cum %	Assay %	Dist'n % Zinc	Cum %	Assay %	Dist'n % Iron	Cum %
Zinc Rougher 1	1430	98.17	0.10	64.11	64.11	0.64	54.04	54.04	28.68	95.77	95.77
Zinc Con	57	3.83	1.40	35.89	100.00	13.55	45.96	100.00	31.81	4.23	100.00
Total	1487	100.00	0.15	100.00		1.13	100.00		28.80	100.00	

Date	31/3/93
Sample	Curragh Comp 5/2/93
Test Number	Test 4
Objective	Single Rougher (NaAF 3418A) Additional NaAF

Stage	Wt	Wt %	Assay %	Dist'n % Copper	Cum %	Assay %	Dist'n % Zinc	Cum %	Assay %	Dist'n % Iron	Cum %
Zinc Rougher 1	1374	95.95	0.08	51.17	51.17	0.63	53.49	53.49	28.43	92.38	92.38
Zinc Con	58	4.05	1.81	48.83	100.00	12.97	46.51	100.00	55.59	7.62	100.00
Total	1432	100.00	0.15	100.00		1.13	100.00		29.53	100.00	

Date	1/4/93
Sample	Curragh Comp 5/2/93
Test Number	Test 5
Objective	Two Stage Rougher (SIPX 3418A)

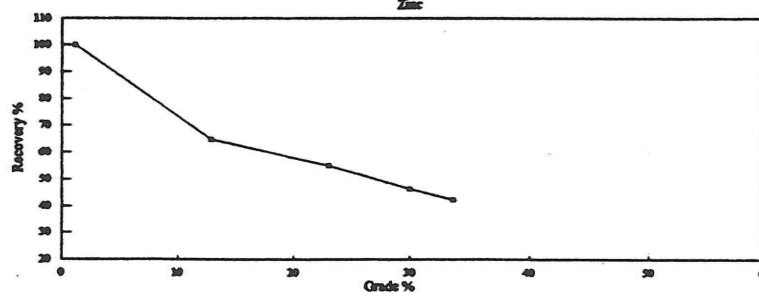
Stage	Wt	Wt %	Assay %	Dist'n % Copper	Cum %	Assay %	Dist'n % Zinc	Cum %	Assay %	Dist'n % Iron	Cum %
Zinc Rougher 1	1355.93	90.40	0.06	36.16	36.16	0.54	42.80	42.80	27.71	92.09	92.09
Zinc Con	144.07	9.60	0.10	63.84	100.00	6.73	57.20	100.00	22.40	7.91	100.00
Total	1500	100.00	0.15	100.00		1.13	100.00		27.20	100.00	

FLOTATION TEST

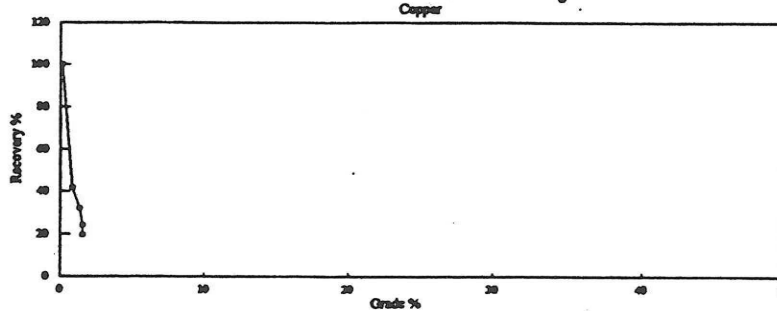
Client	Curragh Resources
Test Number	Test 6
Sample Description	Curragh Flot 3
Job Number	23/583
Date	1/4/93

PRODUCT	Weight		Copper		Zinc		Iron	
	g	%	%	Distribution	%	Distribution	%	Distribution
3rd Cleaner Conc	20.9	1.43	1.5	19.52	33.6	42.19	15.8	0.8
3rd Cleaner Tail	4.9	0.34	1.5	4.58	14.3	4.20	23.4	0.3
2nd Cleaner Conc	25.8	1.77	1.5	24.10	30.0	46.39	17.2	1.1
2nd Cleaner Tail	14.0	0.96	0.9	8.01	10.1	8.53	25.7	0.9
1rd Cleaner Conc	39.7	2.73	1.3	32.11	23.0	54.92	20.2	2.1
1rd Cleaner Tail	44.5	3.06	0.4	9.71	3.7	10.01	28.2	3.2
Rougher Conc	84.3	5.79	0.8	41.82	12.8	64.94	24.4	5.3
Rougher Tail	1372.3	94.21	0.1	58.18	0.43	35.06	27.0	94.7
Calculated Head	1456.6	100.00	0.1	100.00	1.14	100.00	26.9	100.0

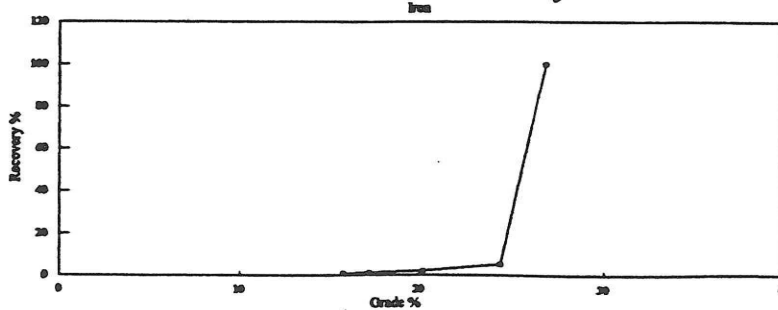
Grade Vs Recovery



Grade Vs Recovery



Grade Vs Recovery

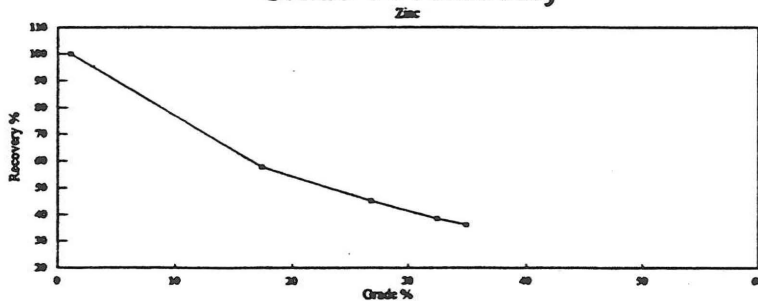


FLOTATION TEST

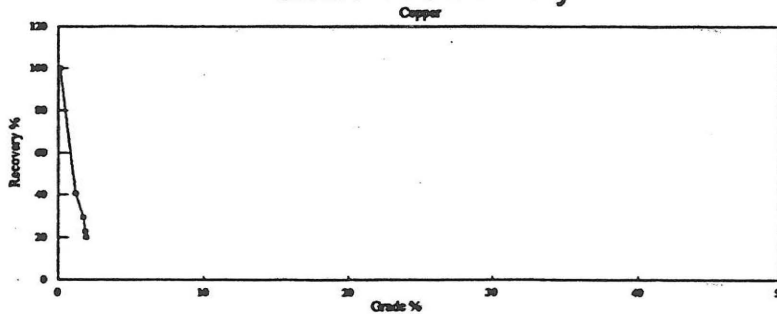
Client	Curragh Resources
Test Number	Test 7
Sample Description	Curragh Flot 4
Job Number	23/583
Date	1/4/93

PRODUCT	Weight		Copper		Zinc		Iron	
	g	%	%	Distribution	%	Distribution	%	Distribution
3rd Cleaner Conc	16.5	1.15	1.9	20.10	34.9	35.95	14.9	0.6
3rd Cleaner Tail	2.5	0.17	1.7	2.64	16.3	2.53	23.9	0.1
2nd Cleaner Conc	19.0	1.32	1.9	22.74	32.5	38.48	16.0	0.7
2nd Cleaner Tail	8.0	0.55	1.3	6.79	13.3	6.59	25.3	0.5
1rd Cleaner Conc	26.9	1.87	1.7	29.53	26.8	45.07	18.8	1.2
1rd Cleaner Tail	26.6	1.85	0.7	11.16	7.7	12.88	27.9	1.8
Rougher Conc	53.6	3.73	1.2	40.69	17.3	57.95	23.3	3.0
Rougher Tail	1383.5	96.27	0.1	59.31	0.49	42.05	28.8	97.0
Calculated Head	1437.1	100.00	0.1	100.00	1.11	100.00	28.6	100.0

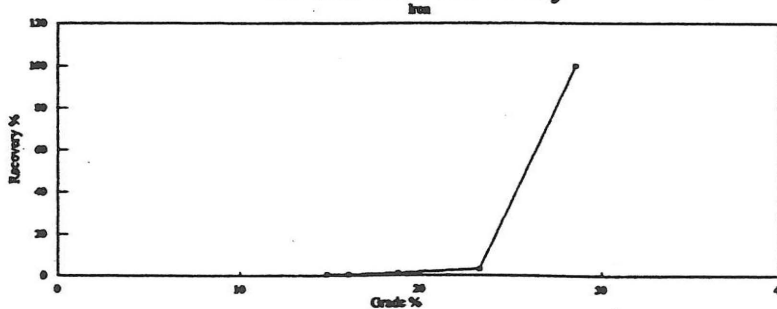
Grade Vs Recovery



Grade Vs Recovery



Grade Vs Recovery

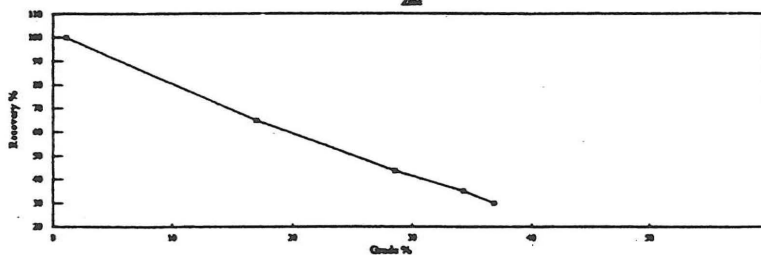


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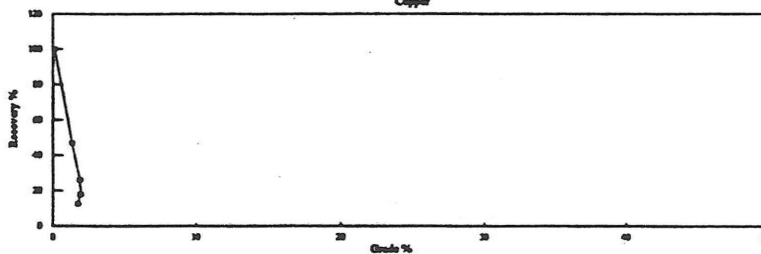
Client Name	Curragh Resources
Sample Reference	Test 8
Sample Description	Curragh Flot 8
Job Number	23/583
Date	5/4/93

PRODUCT	Weight		Copper		Zinc		Lead		Iron	
	g	%	%	Distribution	%	Distribution	%	Distribution	%	Distribution
3rd Cleaner Conc	13.4	0.92	1.7	12.67	36.9	29.98	2.0	2.72	15.8	0.51
3rd Cleaner Tail	3.6	0.25	2.6	5.14	24.6	5.35	3.9	1.42	22.1	0.19
2nd Cleaner Conc	17.0	1.17	1.9	17.81	34.3	35.33	2.4	4.14	17.1	0.71
2nd Cleaner Tail	8.2	0.56	1.8	8.21	16.7	8.30	3.1	2.62	23.8	0.48
1rd Cleaner Conc	25.2	1.73	1.9	26.02	28.6	43.62	2.6	6.76	19.3	1.18
1rd Cleaner Tail	37.7	2.59	1.0	20.85	9.3	21.33	2.1	8.14	28.5	2.61
Rougher Conc	62.9	4.32	1.4	46.87	17.0	64.98	2.3	14.89	24.8	3.79
Rougher Tail	1392.6	95.68	0.07	53.13	0.42	35.04	0.6	85.11	28.4	96.21
Calculated Head	1455.5	100.00	0.1	100.00	1.13	100.00	0.67	100.00	28.3	100.0

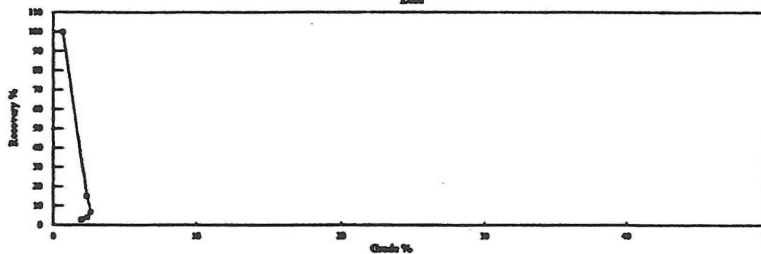
Grade Vs Recovery



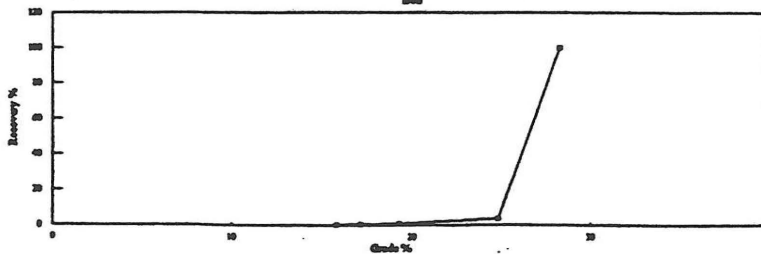
Grade Vs Recovery



Grade Vs Recovery



Grade Vs Recovery

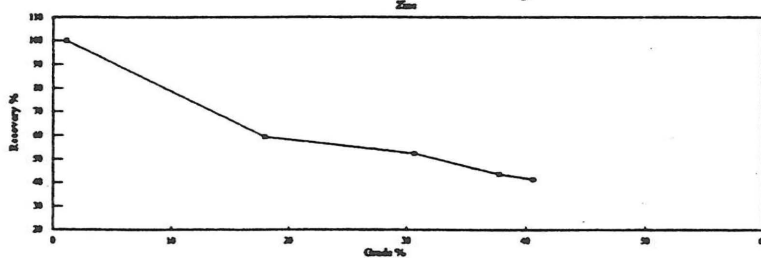


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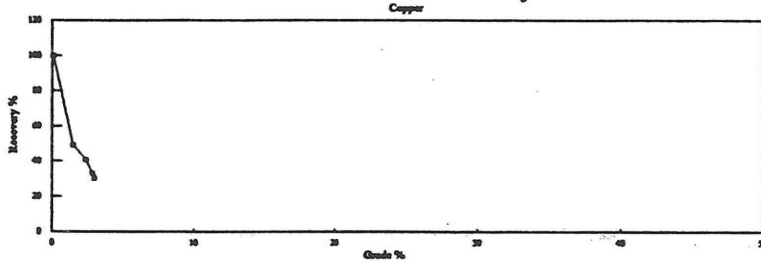
Client Name	Curragh Resources
Sample Reference	Test 9
Sample Description	Curragh Flot 9
Job Number	23/583
Date	6/4/93

PRODUCT	Weight		Copper		Zinc		Lead		Iron	
	g	%	%	Distribution	%	Distribution	%	Distribution	%	Distribution
3rd Cleaner Conc	16.9	1.16	3.0	30.28	40.6	41.33	4.4	7.47	10.6	0.53
3rd Cleaner Tail	2.3	0.16	1.9	2.65	17.3	2.40	7.8	1.79	20.3	0.14
2nd Cleaner Conc	19.2	1.32	2.8	32.94	37.8	43.72	4.8	9.27	11.7	0.67
2nd Cleaner Tail	9.1	0.63	1.4	7.92	15.7	8.65	5.6	5.07	22.2	0.60
1rd Cleaner Conc	28.3	1.95	2.4	40.85	30.7	52.37	5.1	14.33	15.1	1.28
1rd Cleaner Tail	26.5	1.83	0.5	8.30	4.5	7.20	2.9	7.70	28.5	2.25
Rougher Conc	54.8	3.78	1.5	49.15	18.0	59.58	4.0	22.03	21.6	3.53
Rougher Tail	1394.3	96.22	0.06	50.85	0.48	40.42	0.6	77.97	23.2	96.47
Calculated Head	1449.0	100.00	0.1	100.00	1.14	100.00	0.69	100.00	23.1	100.0

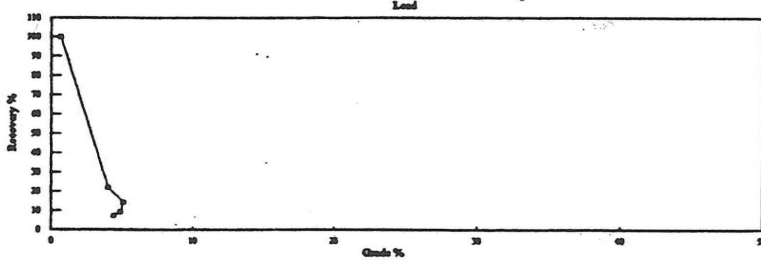
Grade Vs Recovery



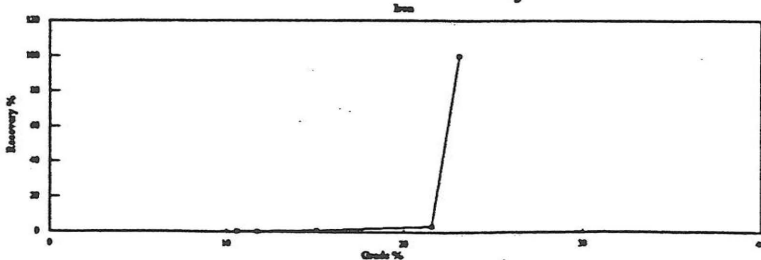
Grade Vs Recovery



Grade Vs Recovery



Grade Vs Recovery

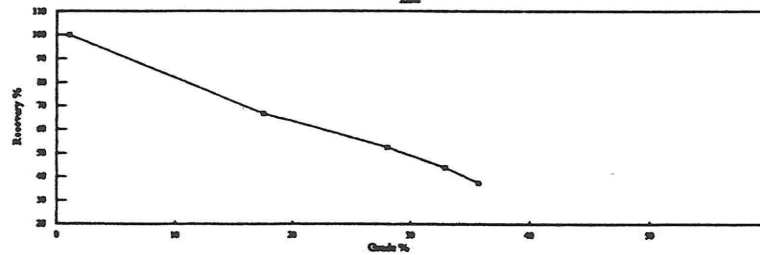


FLOTATION TEST

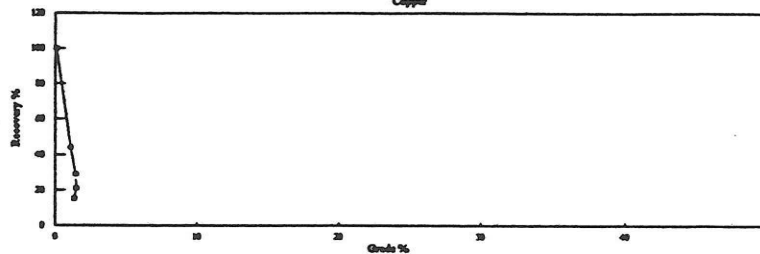
Client Name	Curragh Resources
Sample Reference	Test 10
Sample Description	Curragh Flot 10
Job Number	23/583
Date	7/4/93

PRODUCT	Weight		Copper		Zinc		Lead		Iron	
	g	%	%	Distribution	%	Distribution	%	Distribution	%	Distribution
3rd Cleaner Conc	16.6	1.15	1.4	15.19	35.7	37.46	2.5	4.55	12.2	0.60
3rd Cleaner Tail	4.6	0.32	1.9	5.84	22.8	6.59	4.7	2.37	16.4	0.22
2nd Cleaner Conc	21.2	1.46	1.5	21.03	32.9	44.04	3.0	6.92	13.1	0.82
2nd Cleaner Tail	8.3	0.58	1.4	7.90	15.7	8.25	4.6	4.25	19.7	0.48
1rd Cleaner Conc	29.5	2.04	1.5	28.93	28.1	52.30	3.4	11.17	14.9	1.30
1rd Cleaner Tail	30.8	2.13	0.7	15.10	7.4	14.44	3.2	10.79	23.7	2.15
Rougher Conc	60.3	4.16	1.1	44.03	17.5	66.74	3.3	21.96	19.4	3.45
Rougher Tail	1386.9	95.84	0.06	55.97	0.38	33.26	0.5	78.04	23.6	96.55
Calculated Head	1447.1	100.00	0.1	100.00	1.09	100.00	0.63	100.00	23.4	100.0

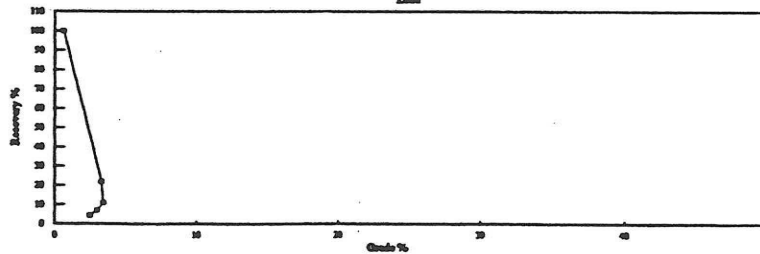
Grade Vs Recovery



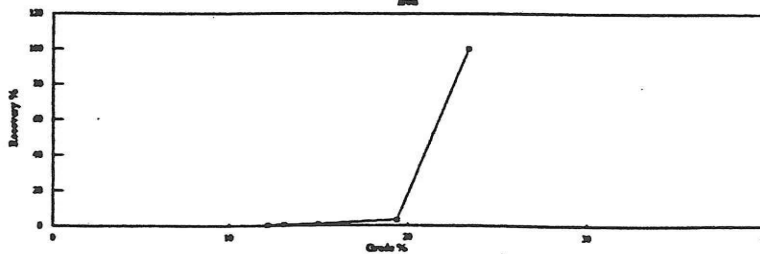
Grade Vs Recovery



Grade Vs Recovery



Grade Vs Recovery

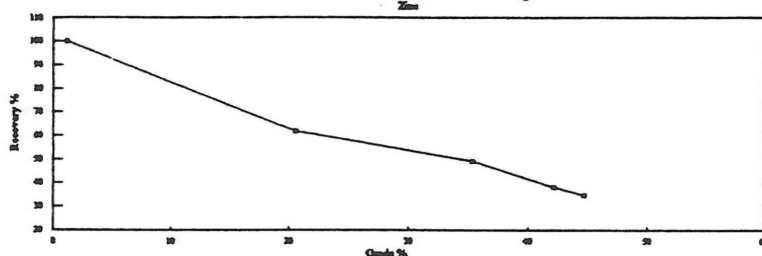


FLOTATION TEST

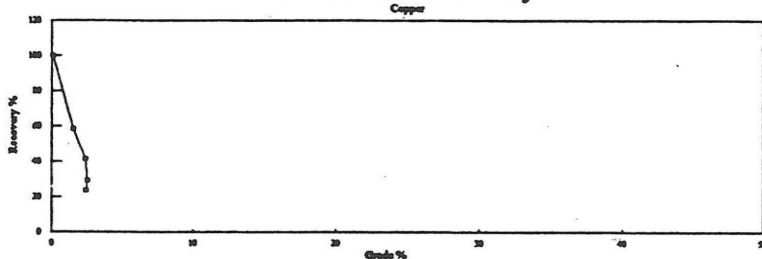
Client Name	Curragh Resources
Sample Reference	Test 11
Sample Description	Curragh Flot 11
Job Number	23/583
Date	8/4/93

PRODUCT	Weight		Copper		Zinc		Lead		Iron	
	g	%	%	Distribution	%	Distribution	%	Distribution	%	Distribution
3rd Cleaner Conc	13.1	0.90	2.5	23.80	44.8	34.52	3.5	4.62	10.5	0.34
3rd Cleaner Tail	2.3	0.16	3.0	5.17	27.8	3.80	7.8	1.84	17.2	0.10
2nd Cleaner Conc	15.4	1.06	2.5	28.97	42.2	38.32	4.1	6.46	11.5	0.44
2nd Cleaner Tail	8.2	0.56	2.1	12.56	22.5	10.85	6.2	5.14	21.4	0.44
1st Cleaner Conc	23.5	1.62	2.4	41.53	35.4	49.16	4.8	11.60	15.0	0.88
1st Cleaner Tail	27.6	1.90	0.8	16.84	7.9	12.83	3.5	9.91	29.6	2.05
Rougher Conc	51.2	3.53	1.5	58.37	20.5	61.99	4.1	21.52	22.9	2.93
Rougher Tail	1399.9	96.47	0.04	41.63	0.46	38.01	0.6	78.48	27.7	97.07
Calculated Head	1451.1	100.00	0.1	100.00	1.17	100.00	0.68	100.00	27.8	100.0

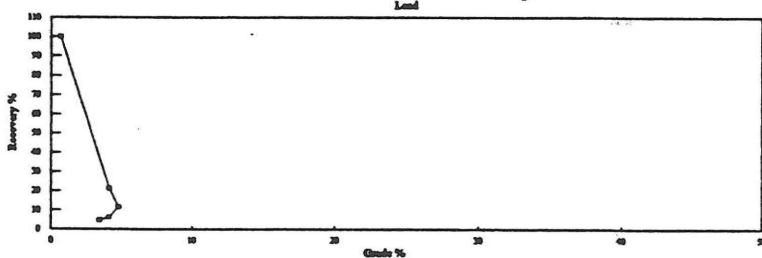
Grade Vs Recovery



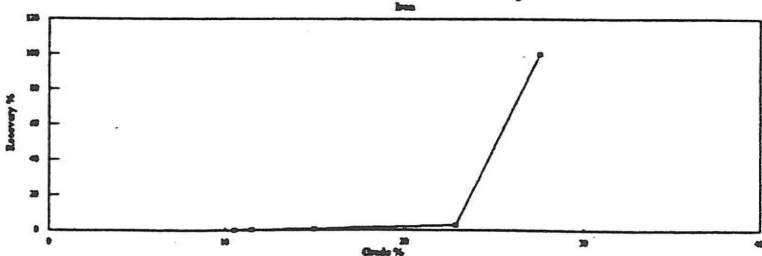
Grade Vs Recovery



Grade Vs Recovery



Grade Vs Recovery

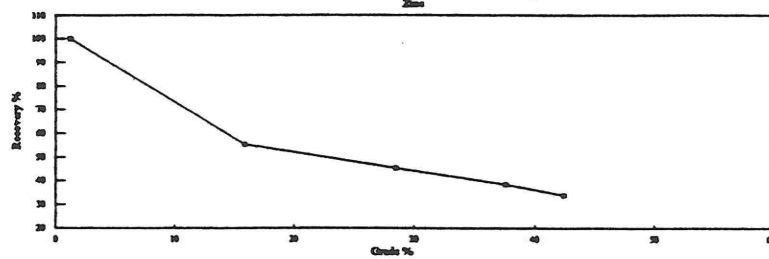


FLOTATION TEST

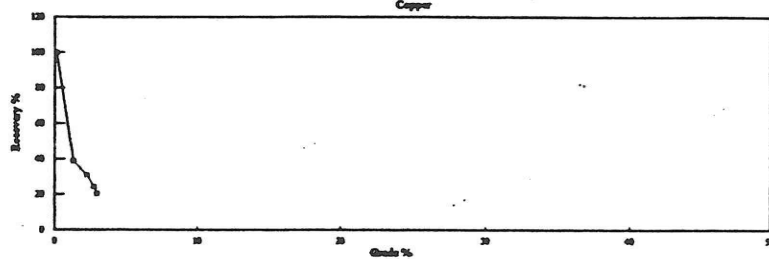
Client Name	Curragh Resources
Sample Reference	Test 12
Sample Description	Curragh Flot 12
Job Number	23/583
Date	19/4/93

PRODUCT	Weight		Copper		Zinc		Lead		Iron	
	g	%	%	Distribution	%	Distribution	%	Distribution	%	Distribution
3rd Cleaner Conc	14.2	0.98	3.0	20.46	42.5	33.93	5.0	6.49	13.4	0.48
3rd Cleaner Tail	4.0	0.27	2.1	4.02	20.0	4.45	4.8	1.72	23.9	0.24
2nd Cleaner Conc	18.2	1.25	2.8	24.48	37.6	38.38	4.9	8.20	15.7	0.71
2nd Cleaner Tail	10.1	0.69	1.3	6.57	12.4	7.01	3.6	3.30	28.2	0.71
1rd Cleaner Conc	28.2	1.94	2.3	31.05	28.6	45.39	4.5	11.51	20.1	1.42
1rd Cleaner Tail	33.7	2.32	0.5	7.88	5.3	9.95	2.1	6.49	32.7	2.75
Rougher Conc	61.9	4.26	1.3	38.93	15.9	55.34	3.2	18.00	26.9	4.17
Rougher Tail	1391.9	95.74	0.09	61.07	0.57	44.66	0.6	82.00	27.6	95.83
Calculated Head	1453.8	100.00	0.1	100.00	1.22	100.00	0.75	100.00	27.5	100.0

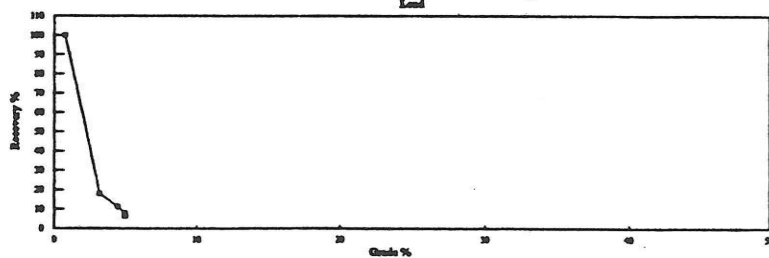
Grade Vs Recovery



Grade Vs Recovery



Grade Vs Recovery



Grade Vs Recovery

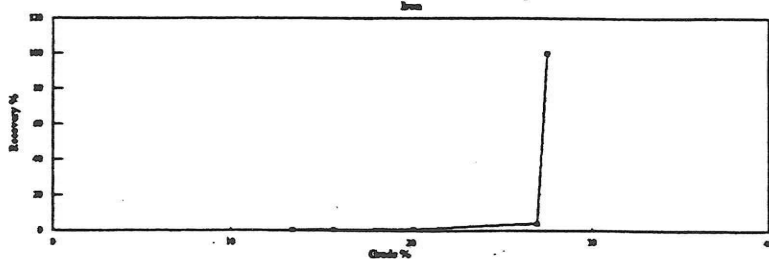


TABLE 12

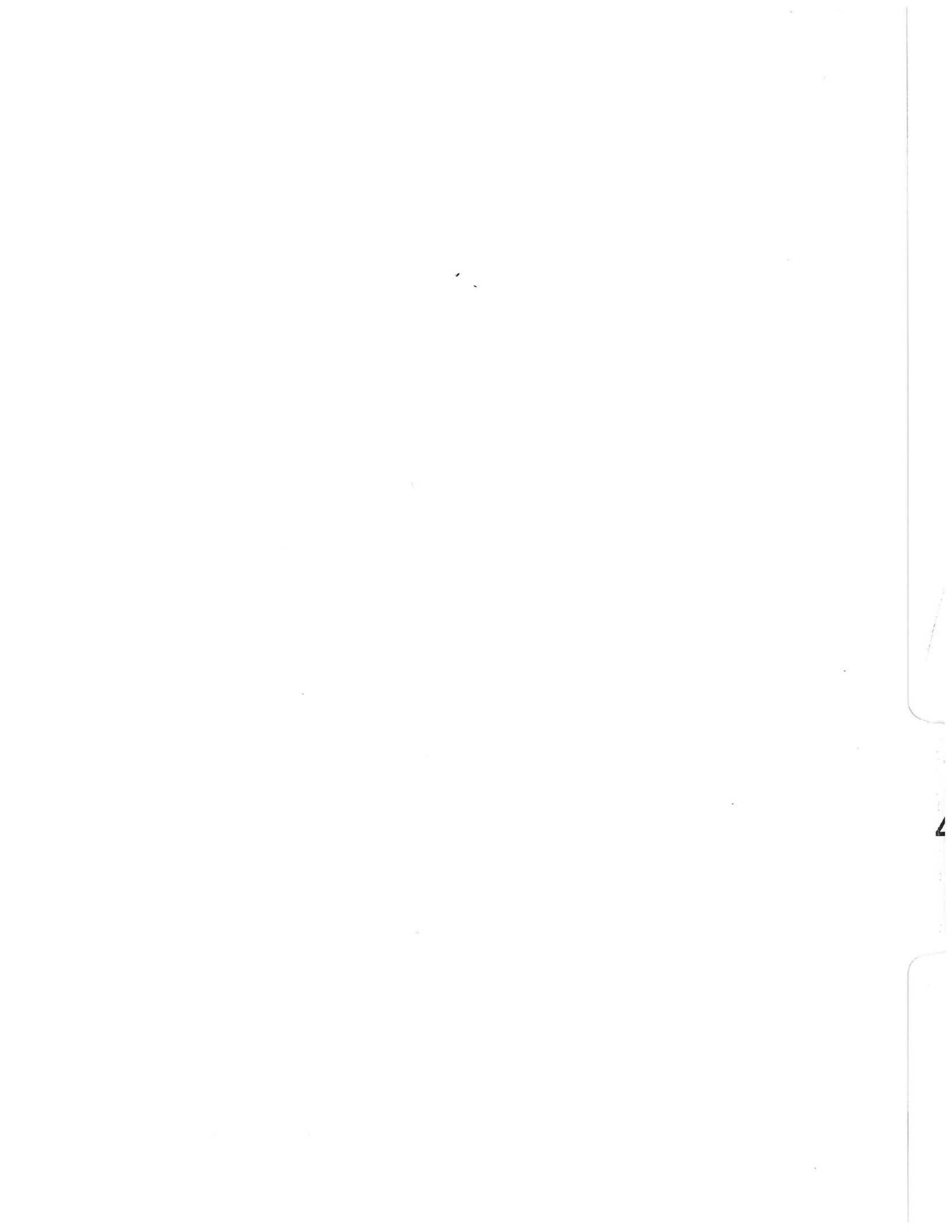
	TEST NUMBER											
	1	2	3	4	5	6	7	8	9	10	11	12
CONDITIONING												
Washed	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	No
+500 Material (g)	18.35	16.26	15.06	14.76	14.26	13.21	13.65	12.76	12.85	N/A	N/A	12.6
Initial pH	6.23	6.4	6.14	N/A	N/A	5.92	5.09	5.8	6.1	5.97	5.59	5.51
Conditioning time (Denek)	4	4	4	4	4	4	4	4	0	4	0	0
Starting Temp (C)	25	26	26	26		26	31	26		24		26
Finishing Temp (C)	37	35	38			35	36	38		37		27
D O initial (ppm)	N/A	N/A	N/A	N/A	N/A	1.3	2	N/A	N/A	6.5	6.5	N/A
D O final (ppm)	N/A	N/A	N/A	N/A	N/A	29.8	30.5	4.6	N/A	26.1	N/A	N/A
FLOTATION												
Rougher												
Cell volume (ml)	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Conditioning time	13	13	13	13	13	13	10	10+5	10+5	10+5	10+5	13
pH initial	6.23	6.18	6.03	5.67	5.13	4.54	4.19	5	4.56	4.56	5.59	5.51
pH final	11	10.73	11.03	11.1	11.02	10.87	11.06	10.96	11	10.98	11.03	10.98
Flot time	6	6	20	10	10	11	15	10+5	10+5	10+5	10+5	6
MIBC g/l	0	0	13	13	13	13	13	13	26	26	26	26
CuSO4 g/l	375	375	375	375	375	375	440	440	440	440	440	440
SMBS g/l	80	80	80	80	80	80	80	80	80	100	100	100
3418A g/l	7.5	7.5	7.5	7.5	20	30	30	30	30	30	30	30
SIPX g/l	20	20	0	0	40	60	60	60	60	60	60	60
NaAF g/l	0	0	40	100	0	0	0	0	0	0	0	0
Unimax g/l	0	0	0	0	0	0	0	0	0	0	0	0
Lime g/l	2000	2400	4130	4330	4330	4500	4000	4500+325	3200+550	5000+700	2800+200	5000
Cleaner 1												
Cell Volume (ml)	500	500	500	500	500	500	500	500	500	500	500	500
Conditioning time	2	2	2	2	2	2	2	2	2	2	2	2
pH initial	11.3	11.77	11.52	11.57	11.3	11.54	11.4	11.5	11.32	11.3	10.66	10.27
pH final	11.06	11.3	11.41	11.72	11.87	11.32	11.2	11.09	10.92	11.23	11.32	11.0
Flot time	6	13	8	8	8	8	8	8	8	8	8	8
MIBC g/l	0	6.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.85	0.7	0.7
CuSO4 g/l	0	0	0	0	0	0	0	0	0	0	0	0.85
SMBS g/l	0	0	0	0	0	0	0	0	0	0	0	0
3418A g/l	0	0	0	0	0	0	0	0	0	0	0	0
SIPX g/l	0	0	0	0	0	0	0	0	0	0	0	0
NaAF g/l	0	0	0	0	0	0	0	0	0	0	5	0
Unimax g/l	0	0	0	0	0	0	0	0	0	0	10	0
Lime g/l	50	68	200	200	66	133	66	86	66	66	66	66
Cleaner 2												
Conditioning time	2	2	2	2	2	2	2	2	2	2	2	2
pH initial	11.7	11.73	11.63	11.85	11.69	11.6	11.45	11.47	11.5	11.44	11.57	11.6
pH final		11.54	11.43	11.74	11.6	11.34	11.21	11.26	11.32	11.31	11.21	11.49
Flot time	4	7	8	8	8	8	8	8	8	8	8	8
MIBC g/l	0	6.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.85	0.7	0.7
CuSO4 g/l	0	0	0	0	0	0	0	0	0	0	0	0
SMBS g/l	0	0	0	0	0	0	0	0	0	0	0	0
3418A g/l	0	0	0	0	0	0	0	0	0	0	0	0
SIPX g/l	0	0	0	0	0	0	0	0	0	0	0	0
NaAF g/l	0	0	0	0	0	0	0	0	0	0	5	0
Unimax g/l	0	0	0	0	0	0	0	0	0	0	10	0
Lime g/l	80	68	130	130	68	120	68	68	68	68	68	100
Cleaner 3												
Conditioning time	2	2	2	2	2	2	2	2	2	2	2	2
pH initial	11.56	11.74	11.73	11.85	11.43	11.54	11.41	11.52	11.3	11.34	11.53	11.55
pH final	11.56	11.43	11.61	11.74	11.3	11.48	11.39	11.14	11.13	11.01	11.5	11.44
Flot time	3	5	8	8	8	8	8	8	8	8	8	8
MIBC g/l	0	0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.86	0.7	0.7
CuSO4 g/l	0	0	0	0	0	0	0	0	0	0	0	0
SMBS g/l	0	0	0	0	0	0	0	0	0	0	0	0
3418A g/l	0	0	0	0	0	0	0	0	0	0	0	0
SIPX g/l	0	0	0	0	0	0	0	0	0	0	0	0
NaAF g/l	0	0	0	0	0	0	0	0	0	0	5	0
Unimax g/l	0	0	0	0	0	0	0	0	0	0	10	0
Lime g/l	0	68	130	130	68	120	82	68	68	68	68	66

TABLE 13

REAGENT COSTS

Prices based on estimates from operating mines in Australia:

Reagent	\$/t
Lime	150
Frother	2840
Copper Sulphate	1200
SMBS	630
3418A	9200
SIPX	1526



MINERALOGICAL AND IMAGE ANALYSIS
INVESTIGATION OF SAMPLES FROM THE TAILINGS OF
CURRAGH RESOURCES AT FARO, YUKON

W. Petruk
MINERAL SCIENCES LABORATORIES

Work performed for:
CURRAGH RESOURCES LTD.

JANUARY 1993

Project: 30.20.99

Job. No.: 50854

CONFIDENTIAL

MINERAL SCIENCES LABORATORIES
DIVISION REPORT MSL 93-2 (CR)

EXECUTIVE SUMMARY

A suite of pyrite-rich samples from the Curragh resources tailings site was studied by mineralogical and image analysis techniques in connection with a mineral processing investigation on recovering the zinc, lead and copper from the tailings. The samples contain 1.00 to 1.66 wt% Zn, 0.07 to 0.12 wt% Pb and 0.11 to 0.14 wt% Cu. The study involved identifying the minerals, determining mineral quantities, determining liberations of sphalerite and chalcopyrite, and determining distributions of liberated and unliberated sphalerite. The minerals in the samples do not show much evidence of weathering although all samples contain small amounts of an iron sulphate and goethite which are products of pyrite weathering. The presence of these secondary minerals suggests that special conditioning may be required for flotation.

Liberation analyses show high liberations for sphalerite and chalcopyrite in fractions that are finer grained than $75\ \mu\text{m}$ (-200 mesh). More than 40% of the sphalerite and chalcopyrite in the $-75\ \mu\text{m}$ (-200 mesh) fractions is totally liberated, and more than 60% of the sphalerite and chalcopyrite is in particles that contain $>75\%$ of the mineral of interest. (Particles with $>75\%$ sphalerite are invariably recovered in Zn concentrates containing 50% to 55% Zn produced from Faro type sphalerite).

Sphalerite distribution data show that most of the liberated sphalerite is in fractions which are finer-grained than $150\ \mu\text{m}$ (-100 mesh), and most of the unliberated sphalerite is in fractions which are coarser-grained than $75\ \mu\text{m}$ (+200 mesh).

It is interpreted that:

- (1) About 60% of the sphalerite and chalcopyrite in the $-75\ \mu\text{m}$ (-200 mesh) fractions of the tailings are liberated sufficiently to be recovered in saleable grade concentrates. This represents about 41% of the sphalerite in sample P1, 33% in sample P2, and 68% in sample P3. The minerals may not, however, be directly recoverable due to surface chemistry of the particles.
- (2) Flow streams containing unliberated mineral grains need to be reground to 80% minus $53\ \mu\text{m}$ (-270 mesh) to liberate most of large (potentially recoverable) sphalerite and chalcopyrite grains.

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INTRODUCTION

A suite of sieved fractions from three samples of tailings was received from Mr. T. Cienski, project leader, MSL Project 854, on December 1, 1992. Mr. Cienski requested that the samples be analyzed to determine mineral quantities and liberations of sphalerite, chalcopyrite, galena and combined base metals. The samples had been prepared by separating drill hole samples of Curragh tailings according to pH and combining fractions with a pH <5, 5 to 7, and >7. The samples were labelled P1, P2 and P3 respectively. The average pH for sample P1 is 3.64, for P2 is 5.90, and for P3 is 8.13. The samples were sieved, by the Mineral Processing Laboratory, into +48 mesh, 48 to 100 mesh, 100 to 200 mesh, 200 to 400 mesh, and -400 mesh fractions (Table 1) to provide suitable fractions for mineralogical and image analysis studies.

Table 1 - Sieve analysis of samples*

Size range (mesh)	Weight %			Cumulative wt%**		
	P1	P2	P3	P1	P2	P3
+48	3.6	5.0	1.0			
48 to 100	11.0	14.7	3.7	96.4	95.0	99.0
100 to 200	26.7	25.5	14.1	85.5	80.3	95.4
200 to 400	27.7	21.5	21.6	58.7	54.8	81.3
-400	31.1	33.3	59.7	31.1	33.3	59.7

* Data supplied by Mr. T. Cienski

** % passing

METHOD OF INVESTIGATION

Three sets of sub-fractions were taken from the sieved fractions. One set of sub-fractions was ground to -200 mesh and submitted for chemical assays for Zn, Cu and Pb (Table 2); another sub-fraction was submitted to X-ray diffraction analysis for identification of major and minor minerals; and polished sections were prepared from third set of sub-fractions. The polished sections were studied by optical microscopy,

electron microscopy, and image analysis to identify the minerals, determine mineral textures, determine mineral liberations, and determine distributions of liberated and unliberated sphalerite.

Table 2 - Chemical assays*

Sample	Weight %		
	Zn	Pb	Cu
P1 +48	0.72	0.40	0.04
P1 48 to 100	1.29	0.25	0.07
P1 100 to 200	1.35	0.05	0.10
P1 200 to 400	0.71	0.02	0.08
P1 -400	0.88	0.18	0.16
P1 Total**	1.00	0.12	0.11
P2 +48	2.91	0.86	0.12
P2 48 to 100	2.88	0.30	0.15
P2 100 to 200	1.75	0.02	0.14
P2 200 to 400	0.89	0.02	0.11
P2 -400	1.35	0.11	0.16
P2 Total**	1.66	0.13	0.14
P3 +48	0.69	0.22	0.05
P3 48 to 100	1.77	0.28	0.10
P3 100 to 200	1.36	0.06	0.12
P3 200 to 400	0.76	0.03	0.09
P3 -400	1.32	0.07	0.16
P3 Total**	1.22	0.07	0.14

* performed by R. McCorkell and R. Fortin

** calculated

RESULTS

MINERALOGY

The major minerals in the samples are pyrite and quartz; minor minerals are muscovite, biotite, K feldspar, barite, goethite, Fe sulphate, sphalerite, pyrrhotite and marcasite: trace minerals are chalcopyrite, galena, Fe-Al silicate (pyroxene or amphibole), chlorite and kaolinite. X-ray diffraction tracings show that all minerals are

present in all fractions. Mineral quantities, determined by image analysis, are given in Tables 3a, 3b and 3c. The values for siderite and Fe sulphate (identified as $\text{FeSO}_4(\text{OH})_7$ by X-ray diffraction analysis) are combined because they have the same grey level in the SEM electron backscattered image, and the image analysis procedure which separates them was not incorporated into the macro that was used to perform the analyses. It was qualitatively observed, however, that the Fe sulphate was the dominant phase in sample P1 and siderite the dominant phase in sample P3.

Table 3a - Mineral quantities in sieved fractions of Sample P1

Mineral	+48M	48 -100M	100 -200M	200 -400M	-400M	Combined
Pyrite*	2.0	39.5	68.6	69.2	60.1	60.6
Quartz	81.0	45.2	18.2	16.4	14.9	21.9
Muscovite and K feld.	13.2	4.0	2.1	2.5	2.6	3.0
Barite	tr.	2.1	3.7	4.1	8.1	4.9
Goethite	0.4	3.5	3.5	3.8	9.1	5.2
Fe sulphate and siderite**	1.6	2.3	0.8	1.5	2.1	1.6
Sphalerite	1.2	2.15	2.25	1.18	1.47	1.7
Pyrrhotite	tr.	0.7	0.5	1.0	0.8	0.7
Chalcopyrite	0.12	0.21	0.29	0.23	0.47	0.3
Galena	0.47	0.29	0.06	0.02	0.21	0.1
Kaolinite	tr.	tr.	tr.	tr.	tr.	tr.

* includes minor marcasite

** includes biotite, chlorite and FeAl silicate (pyroxene or amphibole).

Table 3b - Mineral quantities in sieved fractions of Sample P2

Mineral	+48M	48 -100M	100 -200M	200 -400M	-400M	Combined
Pyrite*	16.4	77.0	77.4	74.4	62.1	68.5
Quartz	63.1	7.7	7.2	9.3	16.2	13.5
Muscovite and K feld.	6.4	0.9	1.1	1.1	0.9	1.3
Barite	0.3	2.8	3.8	7.0	9.4	6.0
Goethite	4.3	3.9	4.8	4.2	2.4	3.7
Fe sulphate and siderite**	2.5	0.7	0.7	0.9	4.9	2.2
Sphalerite	4.85	4.8	2.92	1.48	2.25	2.8
Pyrrhotite	0.9	1.4	1.7	1.2	1.3	1.4
Chalcopyrite	0.35	0.44	0.41	0.32	0.47	0.4
Galena	1.0	0.35	0.02	0.02	0.13	0.2
Kaolinite	tr.	tr.	tr.	tr.	tr.	tr.

* includes minor marcasite

** includes biotite, chlorite and FeAl silicate (pyroxene or amphibole).

Table 3c - Mineral quantities in sieved fractions of Sample P3

Mineral	+48M	48 -100M	100 -200M	200 -400M	-400M	Combined
Pyrite*	8.4	59.4	74.2	65.3	61.2	63.4
Quartz	81.0	27.3	9.8	15.4	11.8	13.6
Muscovite and K feld.	6.3	1.9	1.5	1.6	2.4	2.1
Barite	0.02	1.5	5.3	4.5	13.8	10.0
Goethite	1.6	4.7	4.4	8.5	0.8	3.1
Siderite and Fe sulphate**	1.1	1.1	0.5	1.3	5.7	3.8
Sphalerite	1.15	2.95	2.27	1.27	2.20	2.0
Pyrrhotite	0.02	0.5	1.7	1.8	1.4	1.5
Chalcopyrite	0.15	0.29	0.35	0.26	0.47	0.4
Galena	0.26	0.33	0.07	0.03	0.08	0.1
Kaolinite	tr.	tr.	tr.	tr.	tr.	tr.

* includes minor marcasite

** includes biotite, chlorite and FeAl silicate (pyroxene or amphibole).

TEXTURES AND LIBERATIONS

The sphalerite, galena, and chalcopyrite in the +48 mesh fraction are generally locked in quartz and pyrite (Fig. 1). In contrast, the sphalerite and chalcopyrite in sieved fractions finer than 48 mesh occur as liberated particles and as inclusions in pyrite and quartz (Fig. 2). The galena in all fractions has a low liberation. Some of the goethite and Fe sulphate are associated with pyrite, and some are present as free grains.

PARTICLE CLASSIFICATION

Degrees of liberation were measured for sphalerite and chalcopyrite and the data were classified according to percent of mineral in the host particle.

The scheme for classifying the liberation data was selected on the basis of an evaluation of products from a bench test that was conducted in 1988 (Petruk, 1990) on ore from the Faro deposit. In that bench test the ore was ground to 80% -56 μm . Recoveries with respect to particle sizes were nearly identical for particles containing free sphalerite, 90 to 99.9% sphalerite, and 70 to 90% sphalerite in the rougher concentrate grading 34 wt% Zn (Fig. 3A). The rougher concentrate was reground to

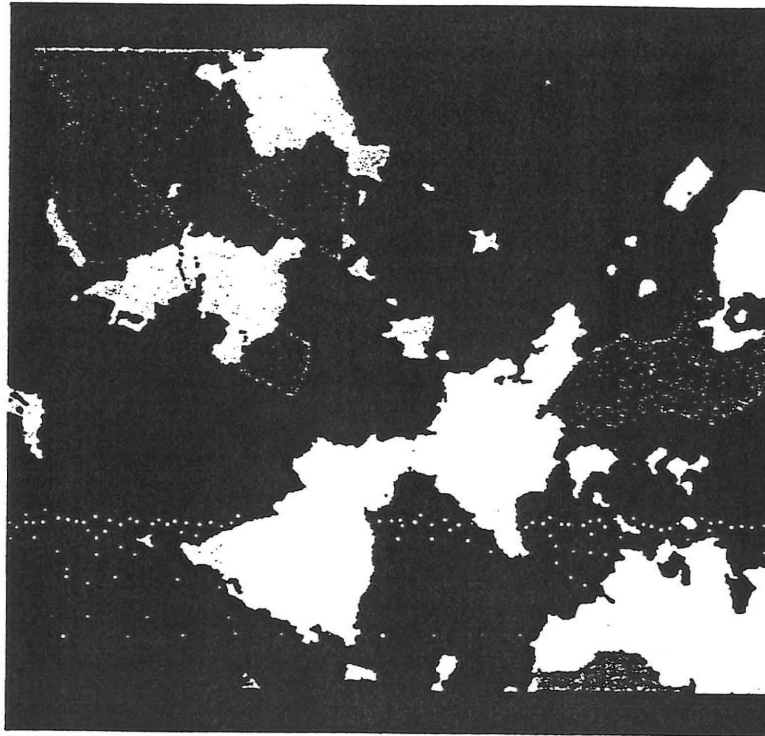
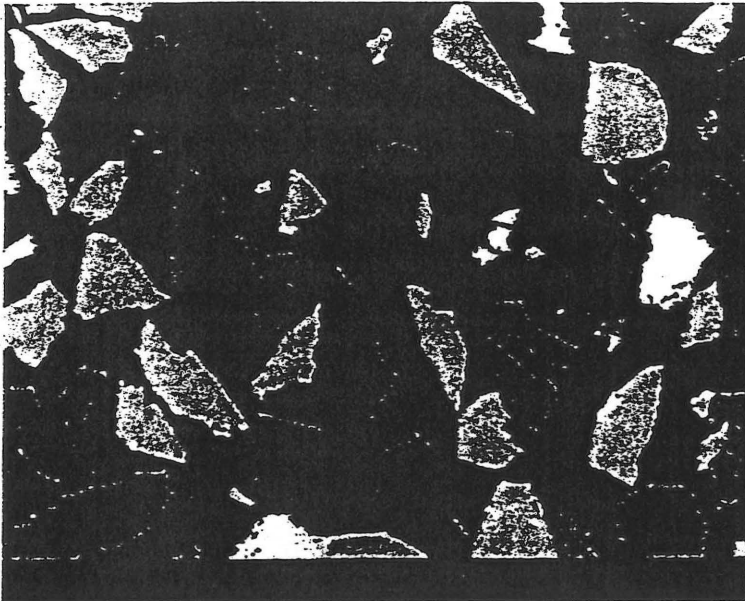
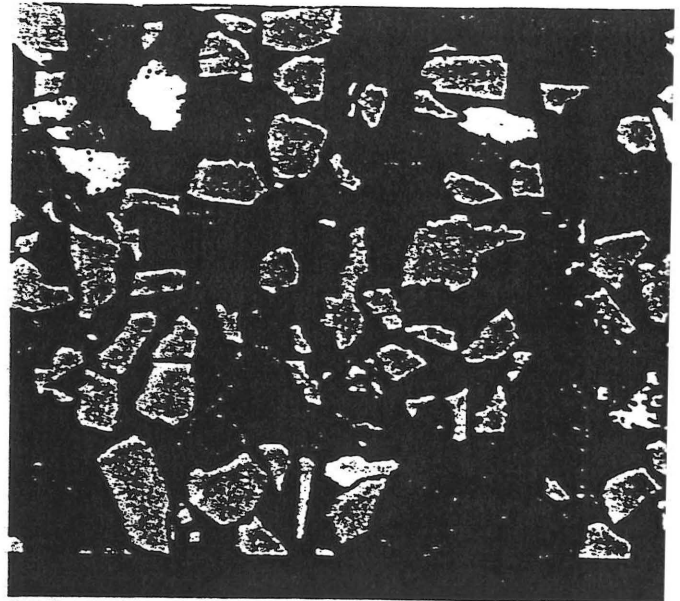


Fig. 1 - Photomicrograph of BSE image of +48 mesh fraction of sample P3. The grey levels have been modified with image analyzer to enhance discrimination between minerals.

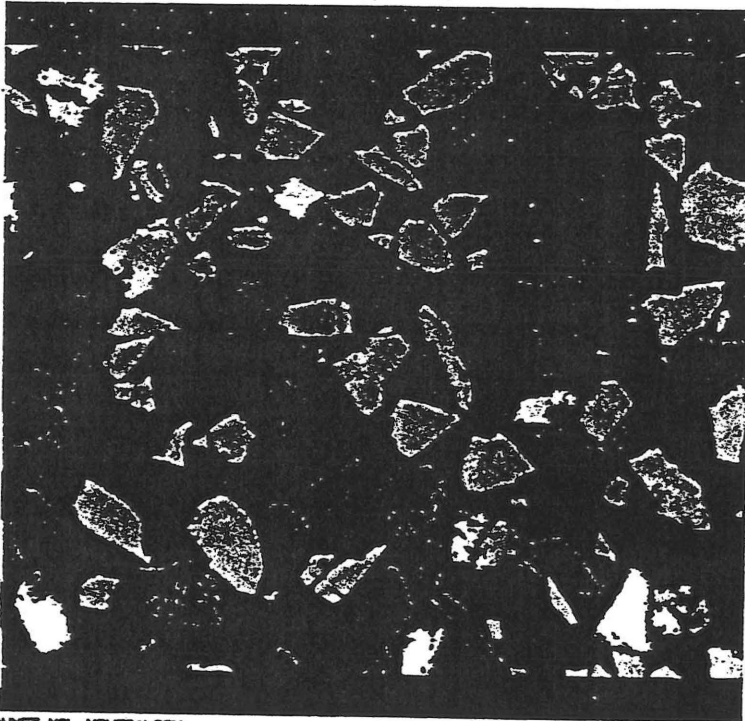
White = sphalerite + chalcopyrite + galena: Light grey = pyrite + minor marcasite: dark grey = silicates + barite + alteration products.



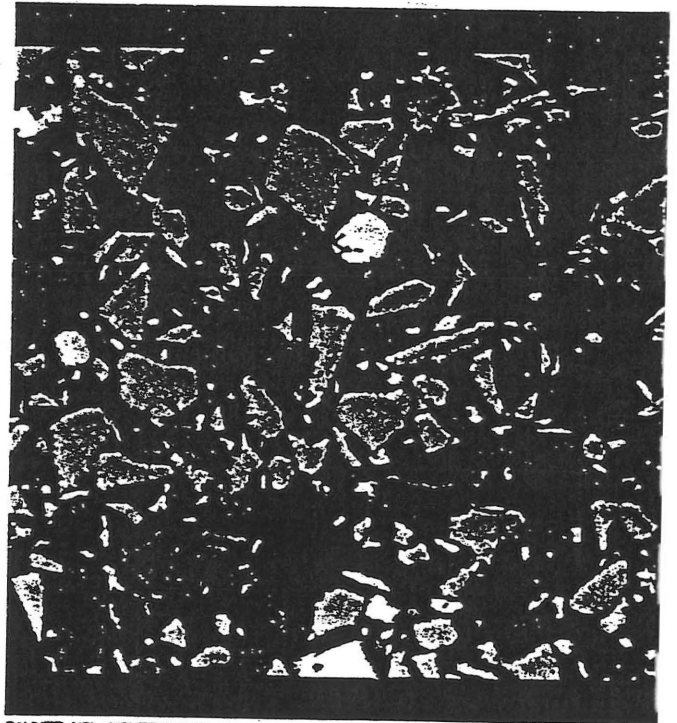
MINET HSL MINERALOGY



MINET HSL MINERALOGY



MINET HSL MINERALOGY



MINET HSL MINERALOGY

Fig. 2 - Photomicrograph of BSE images of screened fractions of sample P3. The grey levels have been modified with image analyzer to enhance discrimination between minerals. (a) 48 to 100 mesh, (b) 100 to 200 mesh, (c) 200 to 400 mesh, (d) -400 mesh.

White = sphalerite + chalcopyrite + galena: Light grey = pyrite + minor marcasite: dark grey = silicates + barite + alteration products.

80% -39 μm and cleaned to produce a Zn concentrate grading 52.9 wt% Zn. Recoveries in the Zinc concentrate were highest for 90 to 99.9% sphalerite particles (89%), and were nearly equal for free and for 70 to 90% sphalerite particles (68% and 66% respectively) (Fig. 3B). The recovery of free sphalerite was lower than for the 90 to 99.9% sphalerite because most of the slimed sphalerite (-6 μm) which was lost to tails was free. The recovery of 70 to 90% sphalerite is relatively high which indicates that 70 to 90% sphalerite particles were preferentially recovered in the zinc concentrate grading 52.9% Zn. The proportion of sphalerite present as 70 to 90% particles represented only 9.3% of the sphalerite in the Zn concentrate (Fig. 3C), and hence did not reduce the Zn concentrate grade. It is noteworthy that 3% of the zinc in the Zn concentrate grading 52.9% Zn was in particles that contained from 70% to 5% sphalerite.

The scheme for classifying the sphalerite and chalcopyrite, based on the above evaluation, was selected as:

- (1) particles containing 100% of mineral of interest (free),
- (2) >75% [including free] (recoverable),
- (3) 25 to 75% (middlings), and
- (4) <25% (unrecoverable middlings).

The recoverable category of >75% sphalerite is used because it is assumed that the Zn concentrate which will be produced from the Faro tailings will contain about 50 to 55 Wt% Zn. A recoverable category of more than 90% sphalerite would have to be used if Zn concentrates containing more than 55% Zn were required. Data on >90 sphalerite were automatically collected with the image analyzer, but for simplicity of presentation, were not included in this report. They can, however, be extrapolated from the free and >75% data.

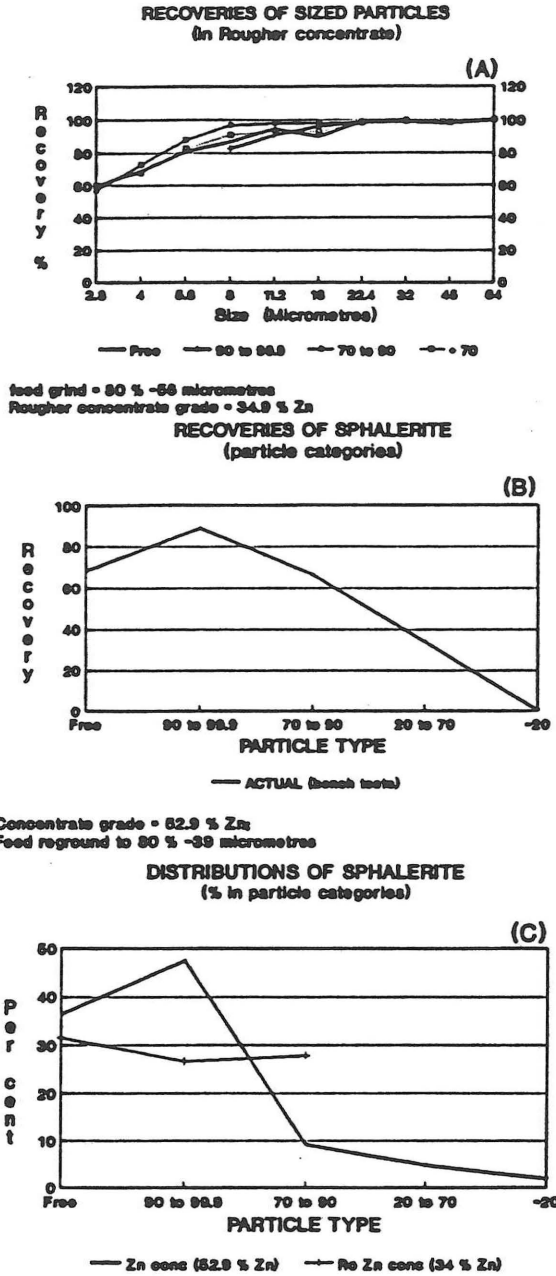


Fig. 3 - Graphs: (A) Recovery of sphalerite in a Zn rougher concentrate in different sized particles containing different amounts of sphalerite. (B) Recoveries of sphalerite as free grains, 90 to 99.9%, 70 to 90%, 20 to 70% and -20% sphalerite particles. (C) Proportions of sphalerite in different types of particles.

LIBERATION ANALYSIS

Results for free, recoverable (>75%), middlings (25 to 75%) and unrecoverable middlings (<25%) are plotted with respect to particle sizes (determined by sieving) in Figures 4 to 6 for sphalerite and chalcopyrite in samples P1, P2, and P3. The results show that liberations of recoverable sphalerite (>75%) are higher than 60% for particles that are finer grained than 200 mesh (75 μm), and higher than 40% for free sphalerite finer grained than 200 mesh. Liberation data are given in Tables 4a and 4b for sieved fractions of the samples.

DISTRIBUTION OF SPHALERITE

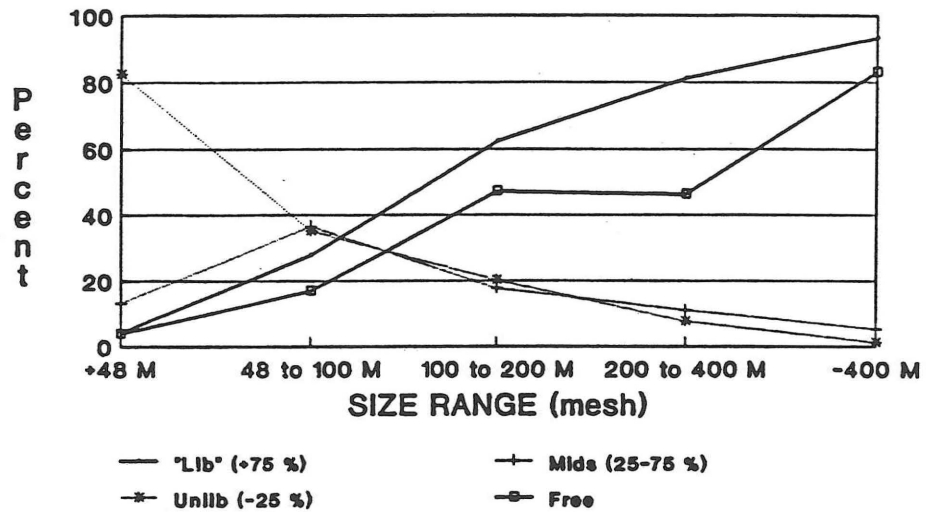
The distribution of free, recoverable, middling and unrecoverable sphalerite in each sample were calculated by using the sieve analysis data, Zn assays, and the liberation characteristics of the sphalerite in the sieved fractions. The results, given in Table 5, show that 39% to 51.2% of the sphalerite in samples P1, P2 and P3 is free, and 65% to 79.1% is recoverable (>75% sphalerite in particles). The table also shows that most of the free and recoverable sphalerite is in sieved fractions that are finer grained than 106 μm (100 mesh), and most of the unliberated sphalerite is in fractions coarser-grained than 75 μm (200 mesh).

CONCLUSIONS

The samples contain small amounts of secondary minerals, such as Fe sulphate and goethite, produced by weathering of pyrite. These minerals may interfere with flotation reagents, therefore appropriate conditioning should be performed prior to flotation to minimize their affect.

The liberation of sphalerite and chalcopyrite can be interpreted by using either the free or the recoverable ("liberated" >75) particles. In both instances the liberation data show relatively high liberations in fractions which are finer-grained than 75 μm (200 mesh). The percentages of sphalerite occurring as "liberated" grains, smaller than 75 μm , are 41%, 33% and 68% in samples P1, P2 and P3 respectively.

LIBERATION, SAMPLE P1 Sphalerite



LIBERATION, SAMPLE P1 Chalcopyrite

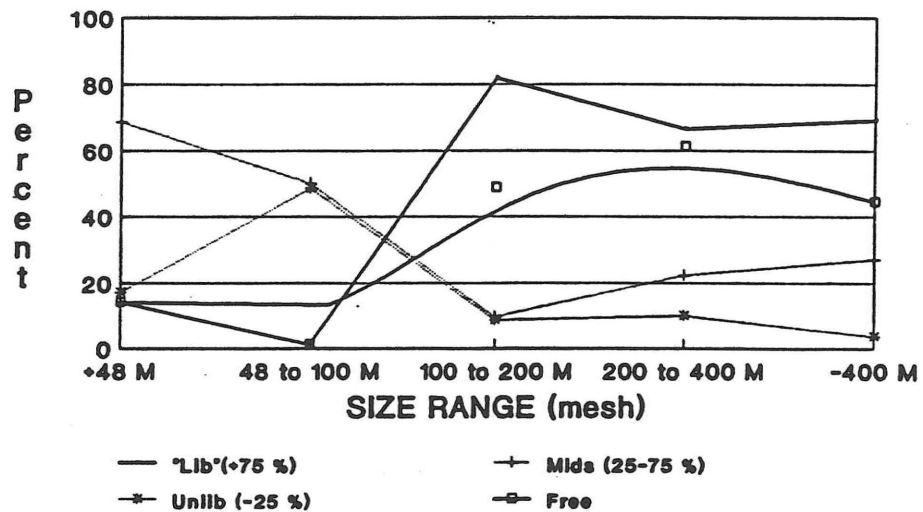
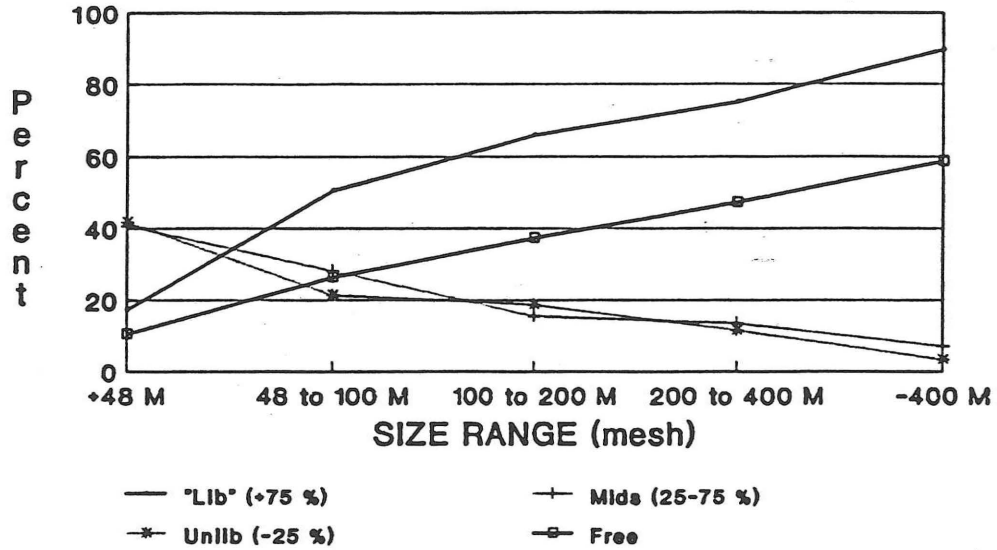


Fig. 4 - Graphs showing liberations of minerals with respect to particle sizes (determined by sieving) for: (a) Sphalerite, and (b) chalcopyrite. Sample P1.

LIBERATION, SAMPLE P2 Sphalerite



LIBERATION, SAMPLE P2 Chalcopyrite

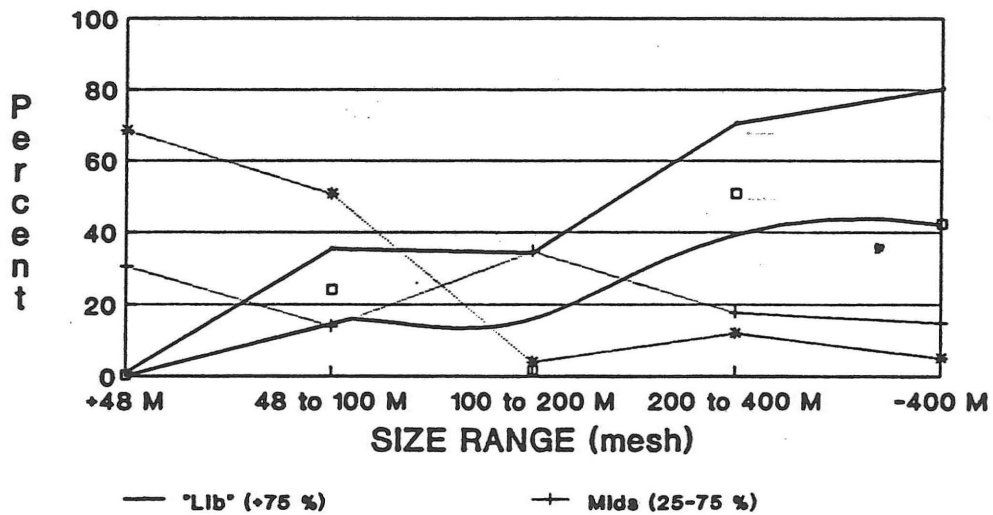
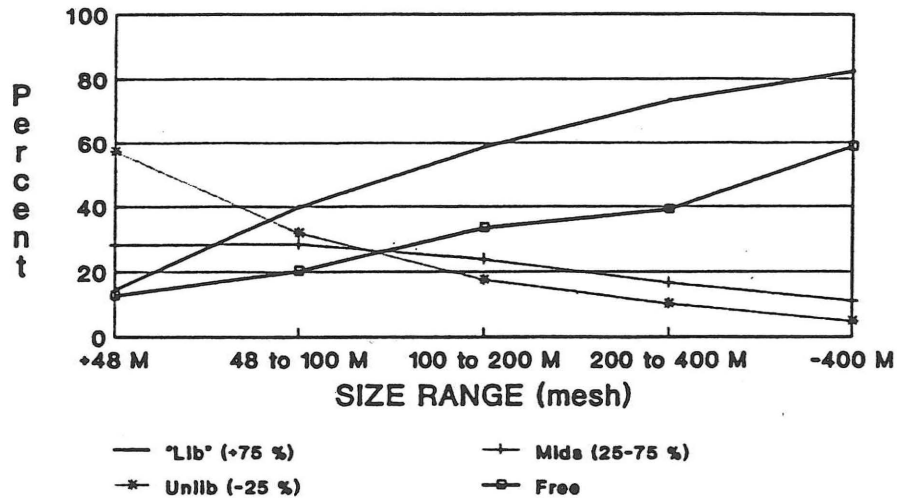


Fig. 5 - Graphs showing liberations of minerals with respect to particle sizes (determined by sieving) for: (a) Sphalerite, and (b) chalcopyrite. Sample P2.

LIBERATION, SAMPLE P3 Sphalerite



LIBERATION, SAMPLE P3 Chalcopyrite

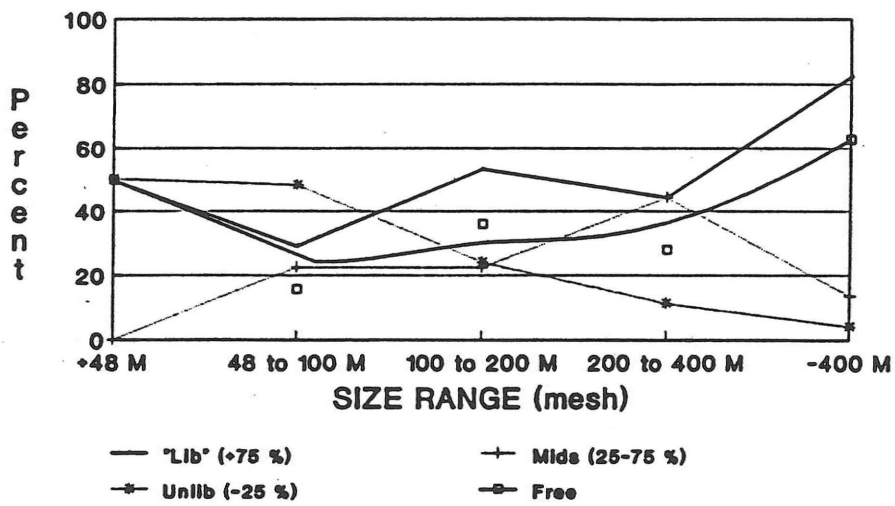


Fig. 6 - Graphs showing liberations of minerals with respect to particle sizes (determined by sieving) for: (a) Sphalerite, and (b) chalcopyrite. Sample P3.

Table 4a - Liberations for sphalerite

Sample	Size range (mesh)	Recoverable	Middling	Non-recoverable	Free
		>75%*	25 to 75%*	<25%*	100%*
P1	+48	4.3	13.2	82.4	3.9
P1	48-100	27.9	36.9	35.2	17.0
P1	100-200	62.2	17.7	20.2	47.2
P1	200-400	81.3	11.0	7.7	46.4
P1	-400	93.2	5.4	1.3	83.0
P2	+48	17.4	40.7	41.9	10.5
P2	48-100	50.4	28.2	21.4	26.4
P2	100-200	65.8	15.5	18.7	37.4
P2	200-400	74.9	13.5	11.6	47.2
P2	-400	89.6	7.1	3.3	58.7
P3	+48	14.4	28.3	57.3	12.7
P3	48-100	39.9	28.4	31.8	20.2
P3	100-200	58.6	23.8	17.5	33.5
P3	200-400	73.2	16.6	10.1	39.2
P3	-400	89.6	7.1	3.3	58.7

* = % sphalerite in particles

Table 4b - Liberations for chalcopyrite

Sample	Size range (mesh)	Recoverable	Middling	Non-recoverable	Free
		>75%*	25 to 75%*	<25%*	100%*
P1	+48	14.1	68.7	17.2	14.1
P1	48-100	1.3	50.0	48.7	1.3
P1	100-200	81.9	9.5	8.7	48.9
P1	200-400	66.6	22.4	10.0	61.1
P1	-400	69.2	27.1	3.7	44.5
P2	+48	1.1	30.5	68.4	0.1
P2	48-100	35.4	14.0	50.6	23.9
P2	100-200	34.4	34.7	30.9	1.5
P2	200-400	70.3	17.6	12.1	50.6
P2	-400	80.2	14.8	5.0	42.2
P3	+48	49.7	0	50.3	49.7
P3	48-100	29.1	22.6	48.3	15.6
P3	100-200	53.3	22.6	24.1	35.9
P3	200-400	44.3	44.4	11.2	27.9
P3	-400	82.3	13.6	4.1	62.6

* = % chalcopyrite in particles

Table 5 - Distribution of sphalerite in samples

Sample	Size range (mesh)	Recoverable	Middling	Non-recoverable	Free	Total
		>75%*	25 to 75%*	<25%*	100%*	
P1	+48	0.1	0.4	2.5	0.1	3.0
P1	48-100	3.9	5.2	4.9	2.4	14.0
P1	100-200	22.4	6.3	7.3	17.0	36.1
P1	200-400	16.3	2.2	1.5	9.3	20.0
P1	-400	25.1	1.5	0.4	22.4	27.0
Total		67.8	15.6	16.6	51.2	100.0
P2	+48	1.6	3.7	3.8	0.9	9.1
P2	48-100	12.8	7.1	5.4	6.7	25.3
P2	100-200	17.8	4.2	5.1	10.1	27.1
P2	200-400	8.6	1.5	1.3	5.4	11.4
P2	-400	24.3	1.9	0.9	15.9	27.1
Total		65.1	18.4	16.5	39.0	100.0
P3	+48	0.1	0.2	0.5	0.1	0.8
P3	48-100	2.3	1.6	1.8	1.2	5.7
P3	100-200	9.2	3.7	2.7	5.2	15.6
P3	200-400	9.6	2.2	1.3	5.1	13.1
P3	-400	58.0	4.6	2.2	38.0	64.8
Total		79.2	12.3	8.5	49.6	100.0

* = % chalcopyrite in particles

Liberations are low for galena in all sieved fractions, and for sphalerite and chalcopyrite in particles which are coarser-grained than 150 μm (100 mesh).

A regrind of 100% minus 75 μm (200 mesh) (or 80% minus 53 μm (-270 mesh)) is needed to liberate most of the large (> 10 μm) (potentially recoverable) sphalerite and chalcopyrite grains.

ACKNOWLEDGEMENTS

The author gratefully acknowledges J. Greer for preparing polished sections of the samples and P. Carrière for performing the XRD analysis.

REFERENCE

1. W. Petruk, 1990, Image analysis evaluation of mineral behaviour during a laboratory flotation test of the zinc-lead volcanogenic ore from the Faro deposit, Yukon; Process Mineralogy IX, AIME/TMS, Warrendale, PA, Edited by W. Petruk, R.D. Hagni, S. Pinolet-Brandom and D.M. Hausen, pp. 37-48.

**SURFACE CHEMISTRY OF COMPOSITE TAILINGS
SAMPLES FROM THE FARO DEPOSIT, YUKON**

**L.J. Cabri
Core Technologies and Services Laboratory**

December 1992

Cost Recovery

Job No.: 50854

CONFIDENTIAL

**MINERAL SCIENCES LABORATORIES
DIVISION REPORT MSL 92-41 (CR)**

**SURFACE CHEMISTRY OF COMPOSITE TAILINGS
SAMPLES FROM THE FARO DEPOSIT, YUKON**

by

L.J. Cabri*

EXECUTIVE SUMMARY

Laser Ionization Mass Spectrometry (LIMS) was used to obtain semi-quantitative data on the surface chemistry of a series of 15 composite tailings samples from the Faro deposit, Yukon. Optical microscopy of polished sections indicated that the sulphides are not altered and consist of the following minerals, in decreasing order of abundance: pyrite, marcasite, sphalerite, pyrrhotite, chalcopyrite, and galena. Sphalerite, pyrite, and pyrrhotite occur mostly as liberated particles.

LIMS analyses of selected sphalerite grains showed that in all 15 samples, the sphalerite grains were activated with Cu (percent of Cu-activated grains range from 33.3 to 100%) with no obvious correlation with pH at the sample site. On the other hand, there was a negative correlation between Pb-activated sphalerite grains (percent of Pb-activated grains range from 12.5 to 50%) at low pH (2.6 to 5.5). This was followed by erratic values in the intermediate zone (pH 6.3 to 6.9) and, at high pH values (7.5 to 8.3) with increased sample depths, by fairly consistent highly Pb-activated sphalerite grains (percent of Pb-activated grains range from 62.5 to 100%). The dominance of Pb-activated liberated sphalerite particles should guide processing options, but the common occurrence of marcasite should also be noted.

Keywords: Flotation tailings, sulphides, LIMS analyses, surface chemistry, Cu-activation, Pb-activation

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INTRODUCTION

Curragh Resources is investigating the possibility of reprocessing old flotation tailings from the Faro deposit, Yukon, prior to transfer of the tailings for final deposition in the mined-out Faro open pit. Results obtained from laboratory tests carried out previously on the old tailings indicated a limited response to standard sulphide flotation. The study of the surface chemistry of particles from the tailings is part of a more comprehensive study by CANMET (Project 50854, T. Cienski, Project Leader). It was decided to use a Laser Ionization Mass Spectrometer (LIMS) for the surface characterization, based on earlier unpublished analyses and tests on base metal flotation products.

METHODOLOGY

Fifteen composite samples were provided by Mr. T. Cienski (RUL/CANMET). The samples had been screened to +200 mesh with distilled water and dried (Table 1). A polished section was made for each composite in order to obtain mineralogical information by optical microscopy, necessary for guiding sample selection and preparation for the LIMS analyses. Sphalerite and pyrite/marcasite grains were hand-picked under a binocular microscope by Mr. D.R. Owens (CTSL/CANMET) and carefully placed on top of thin pieces of pure indium foil (~5 mm square), because the grains stick to the indium surface. The indium pieces themselves were very lightly stuck

Table 1. Curragh Resources: Faro Down Valley Tailings Composite Samples

Composite Sample	Curragh Sample	pH	Average pH	Composite Sample	Curragh Sample	pH	Average pH
C1	D-2-1	2.32		C10	D-2-10	7.54	
	E-7-1	3.19			E-7-10	8.46	
	F-10-1	2.20	2.57		F-10-10	6.21	
				F-11-10	8.18	7.60	
C2	E-7-2	4.51		C11	D-2-11	7.81	
	F-10-2	2.67	3.59		E-7-11	7.83	
C3	E-7-3	4.43		C12	F-10-11	6.47	
	F-10-3	4.66	4.55		F-11-11	7.94	7.51
C4	D-2-4	5.62		C13	D-2-12	7.66	
	E-7-4	4.64			E-7-12	8.77	
	F-10-4	5.30	5.19		F-10-12	7.22	
				F-11-12	8.20	7.96	
C5	F-9-5	5.69		C14	D-2-13	7.62	
	F-10-5	5.24	5.47		E-7-13	8.54	
C6	D-2-6	6.56		C15	F-10-13	7.46	
	F-10-6	6.01	6.29		F-11-13	8.29	7.98
C7	D-2-7	7.18		C15	D-2-14	7.55	
	E-7-7	6.64	6.91		E-7-14	8.78	
				F-10-14	7.79		
C8	D-2-8	8.00		C15	F-11-14	9.08	8.30
	E-7-8	7.43			D-2-15	7.68	
	F-11-8	8.84	8.09		E-7-15	8.51	
C9	D-2-9	7.44		C15	F-10-15	6.40	
	E-7-9	8.46			F-11-15	8.58	7.79
	F-10-9	5.21					
	F-11-9	8.85	7.49				

with double-sided tape to the base of small plastic sample boxes. The laser ionization mass spectrometer used was a LIMA-2A laser microprobe manufactured by Cambridge Mass Spectrometry Ltd. (Cambridge, England). The indium pieces were attached to steel sample holders with conducting carbon paint and were evacuated to about 10^7 Torr (in about 5-10 min). A He-Ne pilot laser, mounted co-axially with the primary Nd-YAG ablation laser, was used for focusing. The primary laser was set at 28.7% transmission with a 1.4 μ sec delay time (Δt) for the post-ionization laser. The ions produced in the laser/solid interaction (focused to ~ 2 to 5 μ m) were then analyzed using a time-of-flight (TOF) mass spectrometer. The acquired spectrum was deconvoluted and calibrated in terms of mass, with the entire process, from "firing" the laser to display of the mass spectrum, taking less than about one minute. The spectra are then saved on diskettes.

The procedure followed was to analyze all sphalerite grains stuck to each indium substrate, as well as analyzing a few grains of pyrite/marcasite. From one to five areas were analyzed with a surface "shot" on each sphalerite grain, followed by one to two (in rare cases, fifteen) further shots penetrating into deeper layers, until neither Cu nor Pb could be detected. This was done in order to assure that the Cu and Pb were due to surface coatings and not to other mineral impurities. A series of successive LIMS spectra demonstrating sampling depth is shown in Figure 1. A CuS layer thick enough to make sphalerite float is, typically, a few atomic layers thick (Mellgrán et al., 1973).

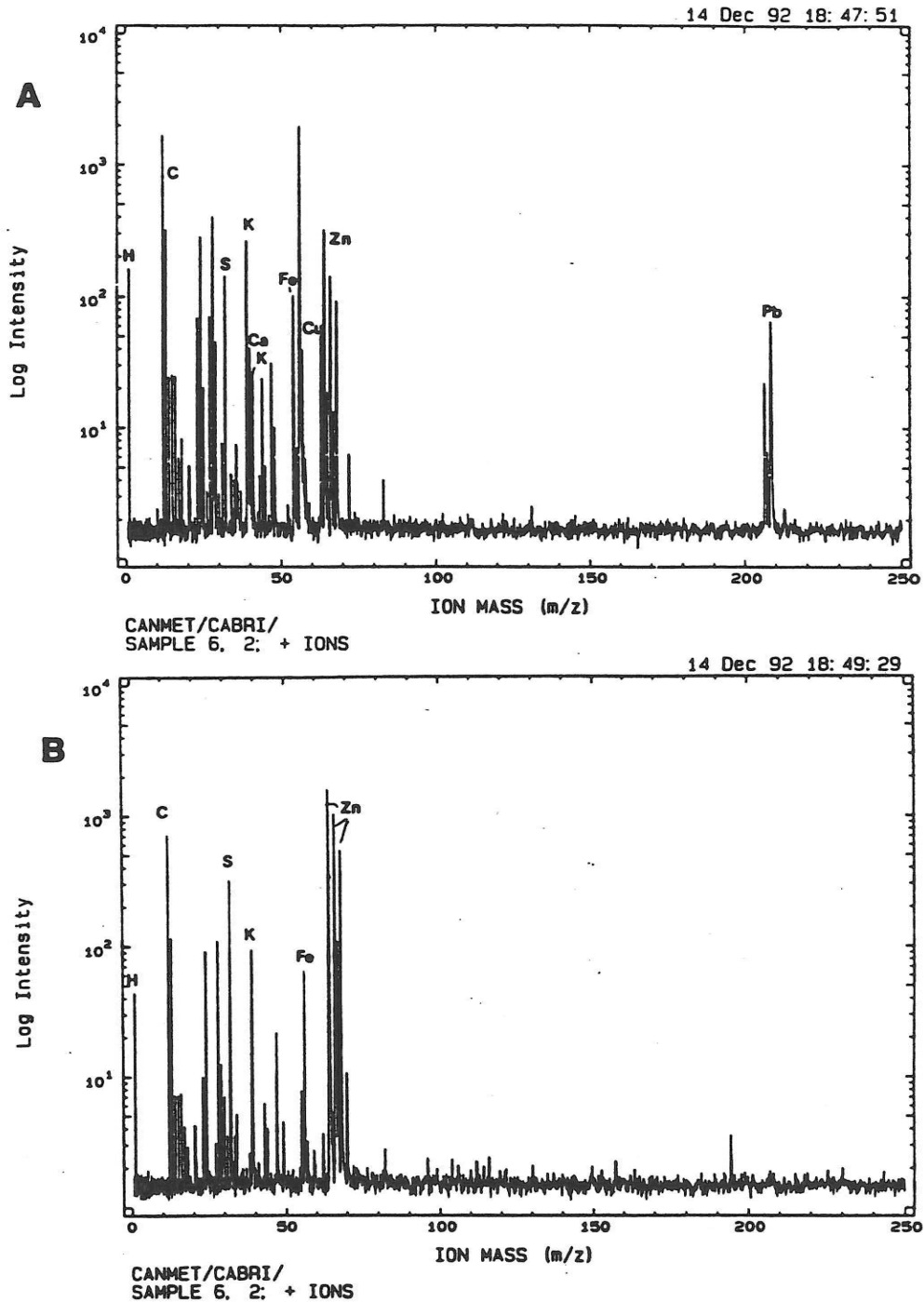


Figure 1. Two LIMS spectra obtained from the upper surface layers (A) of a Cu- and Pb-activated sphalerite grain and (B) obtained by a third firing of the primary laser on the same spot, penetrating into deeper layers. Note that Ca, Cu and Pb have disappeared, Zn has increased.

RESULTS

A total of 568 spectra were recorded and the peak area signal intensity values computed for most common elements found at the surface of sphalerite grains: K, Ca, Fe, Cu, Zn, and Pb (see Fig. 1). It must be emphasized that element sensitivities are highly variable, up to one order of magnitude, and thus relative peak heights for different elements in the LIMS spectra are not proportional to their concentrations. Thus, all the results must be considered only as semi-quantitative. The relative quantity present for each element is obtained by computing the peak signal intensity value, i.e., the sum of areas under the peak corresponding to a specific isotope. Calibration of results for specific minerals is possible, but was beyond the scope of this study. Other elements such as Ba, In, Cd, and Sn, were occasionally found and noted.

Optical microscopy of polished sections revealed that the sulphides are not obviously altered and consist of the following minerals, in decreasing order of abundance: pyrite, marcasite, sphalerite, pyrrhotite, chalcopyrite, and galena. Pyrite is by far the most abundant sulphide and marcasite is quite common, and, from this cursory examination, appears to be primary in origin. Sphalerite, pyrite, and pyrrhotite occur mostly as liberated particles. Sphalerite often contains micro-inclusions of chalcopyrite and no liberated galena was observed. Typical grains are shown in Figure 2.

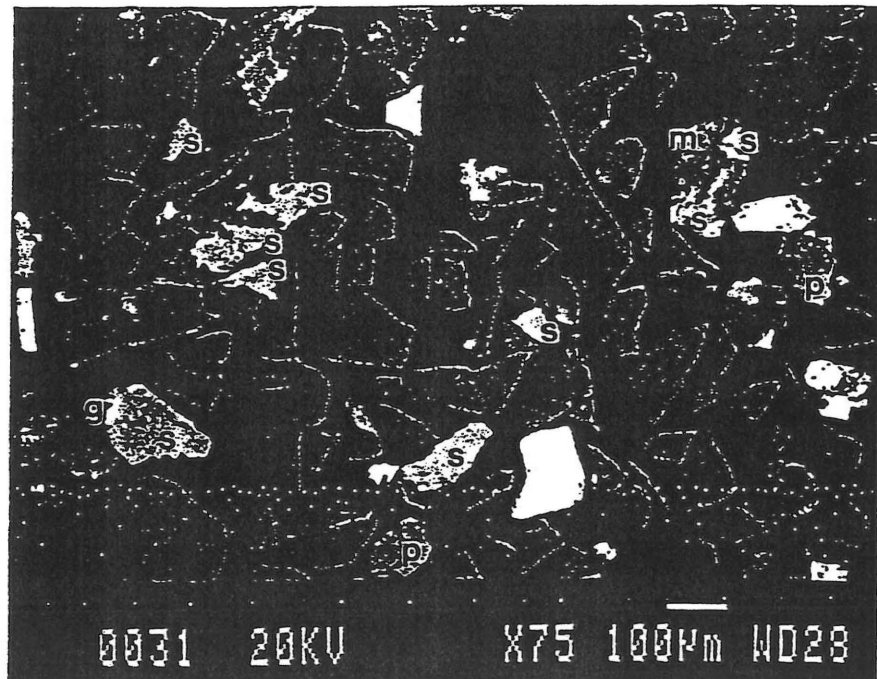


Figure 2. Backscattered Electron Image showing typical liberated sphalerite (s), attached to galena (g), pyrite (grey), and marcasite (m) as well as free pyrrhotite (p) and barite (white). Sample C-5.

The percent of sphalerite grains with detectable Cu and/or Pb for all 15 samples is shown graphically in Figure 3. It can be observed that Pb is most erratic, partly due to its greater sensitivity, and that the number of grains with Pb is low for samples 2 to 5, whereas only sample 5 had significantly fewer grains coated with Cu.

Results for Cu and Pb for individual samples are shown graphically in Figures 4 to 6, illustrating, respectively, typical distribution of Cu- and Pb-activated sphalerite grains with dominance of Cu-activation and low degree of Pb-activation near the surface of the tailings (low pH from 2.6 to 5.5) through a "mixed" zone at intermediate pH (6.3 to 6.9) to

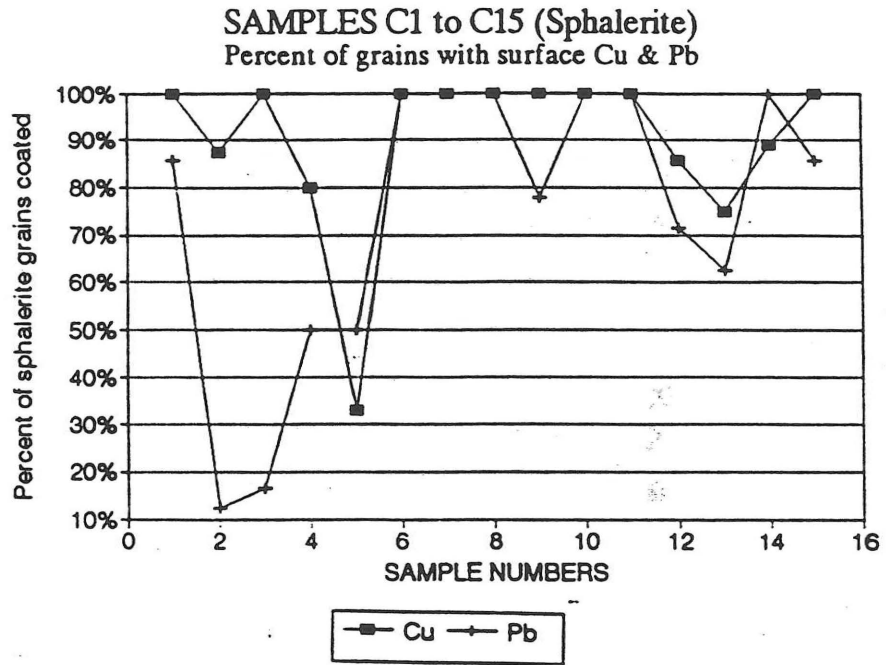


Figure 3. Percent of Cu- and Pb-activated sphalerite grains.

LIMS Sphalerite Surface Analyses

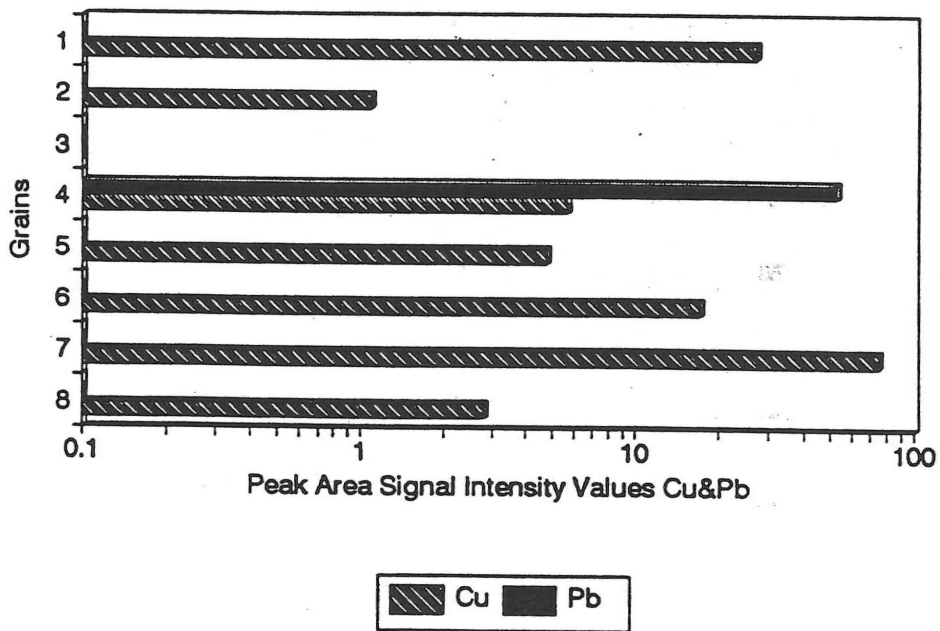


Figure 4. Relative distribution of Cu- and Pb-activated sphalerite, Sample C-2.

LIMS Sphalerite Surface Analyses

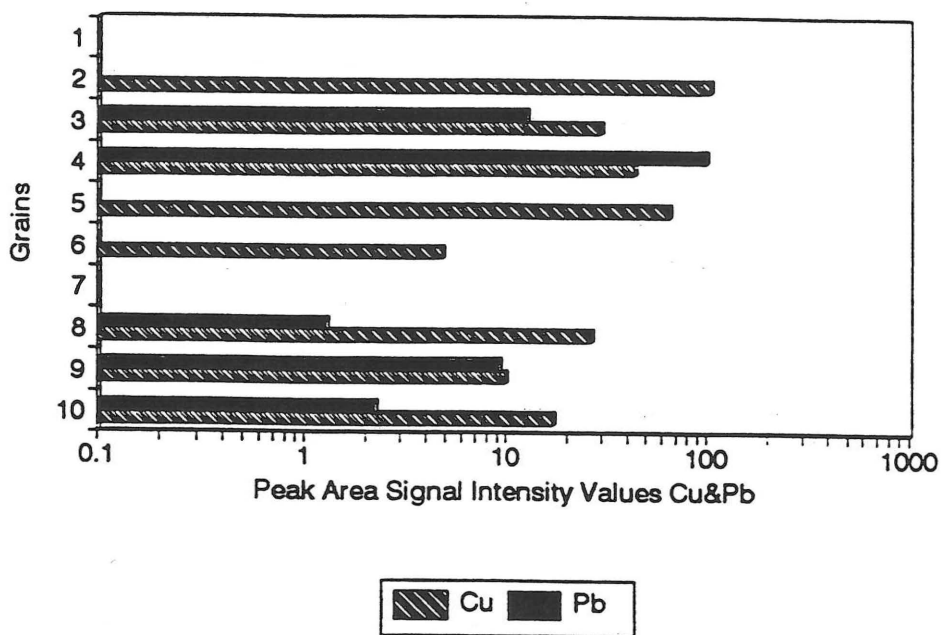


Figure 5. Relative distribution of Cu- and Pb-activated sphalerite, Sample C-4.

LIMS Sphalerite Surface Analyses

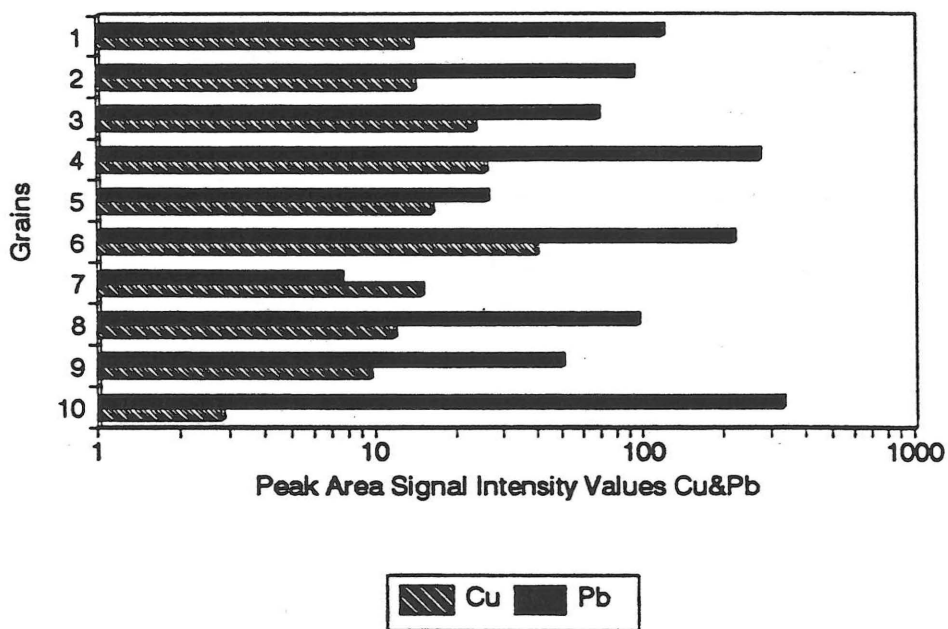


Figure 6. Relative distribution of Cu- and Pb-activated sphalerite, Sample C-10.

typical Pb-activated dominant samples at higher pH (7.5 to 8.3). These results are summarized in Table 2 and Figure 7.

Table 2. Sphalerite grains analyzed

Sample	Cu grains*	Pb grains*	Cu**	Pb**	pH
1	7/7	6/7	25.5	15.7	2.57
2	7/8	1/8	16.7	6.6	3.59
3	6/6	1/6	17.8	0.2	4.55
4	8/10	5/10	30.2	12.5	5.19
5	2/6	3/6	12.9	7.8	5.47
6	8/8	8/8	39.0	225.9	6.29
7	10/10	10/10	39.4	18.2	6.91
8	10/10	10/10	27.6	173.9	8.09
9	9/9	7/9	24.3	83.8	7.49
10	10/10	10/10	17.2	127.8	7.6
11	10/10	10/10	58.1	188.9	7.51
12	6/7	5/7	60.9	65.9	7.96
13	6/8	5/8	23.6	81.2	7.98
14	8/9	9/9	16.3	155.8	8.3
15	7/7	6/7	27.4	174.3	7.79

- * Number of grains with detectable Cu or Pb/total number of grains examined.
 ** These represent the median peak area signal intensity values for Cu and Pb for all grains in each sample.

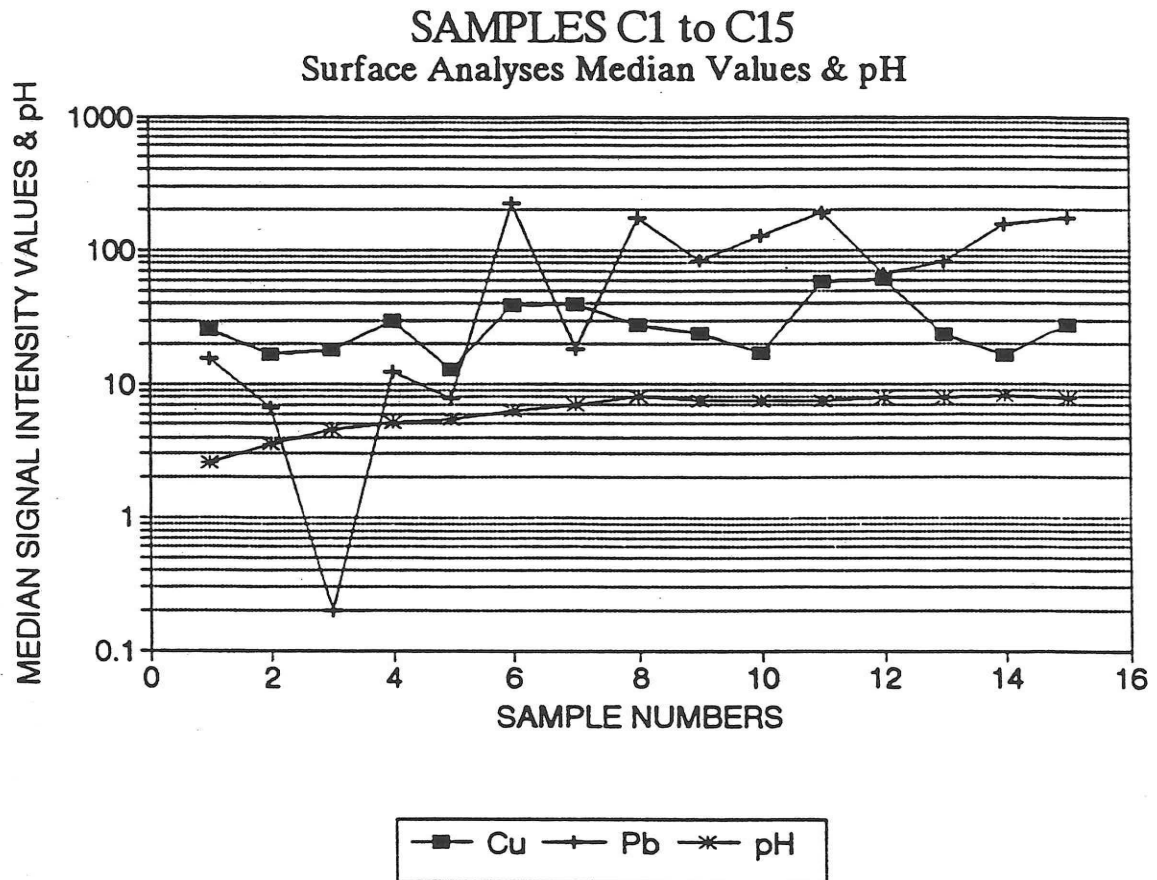


Figure 7. Summary illustrating pH versus relative degree of Cu- and Pb-activation for all 15 composite samples.

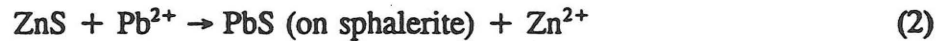
DISCUSSION AND CONCLUSIONS

Though Pb-activated sphalerite is a minor factor for the first five samples derived from the surface zones of the tailings pile with lowest pH, it becomes dominant in the other samples with neutral to slightly alkaline pH. This suggests that the liberated sphalerite grains in the tailings may represent grains that were Pb- and Cu-activated during the original processing.

The reactions leading to Pb-activation of sphalerite may be (after Fuerstenau, 1982):



and



It is possible that the lower degree of Pb-activation evident on the sphalerite surface in the upper zones of the tailings pile may be due to dissolution of the PbS as indicated by equation 1. Analysis of water samples for Pb in the upper parts of the tailings pile may contribute to verification of this hypothesis.

ACKNOWLEDGEMENTS

The technical assistance of Messrs. M. Beaulne and D.R. Owens in polished section preparation, selection of sphalerite grains, and SEM photography is gratefully acknowledged.

REFERENCES

1. Fuerstenau, D.W. (1982) Activation in the flotation of sulphide minerals. In: Principles of Flotation, Ed. R.P. King, S.A. Inst. Min. Metall., Johannesburg, 183-198 pp.
2. Mellgran, O., Gochin, R.J., Shergold, H.L., and Kitchener, J.A. (1973) Thermochemical measurements in flotation research. Proc. 19th Int. Min. Processing Congr., London, 451 pp.

DRAFT

TAILINGS RE-PROCESSING FOR CURRAGH INC.
PHASE I REPORT

T. Ciencki

CONFIDENTIAL

PHASE I REPORT

Preliminary Evaluation and Planning.

Objective:

To determine the physical and mineralogical characteristics of the material to be treated. This information is necessary for optimum planning and execution of work in Phases II and III.

1. Introduction

Tailings samples were received at CANMET laboratories on November 23, 1992. These samples were obtained from 20 holes drilled in the Faro Down Valley Tailings Impoundment Area. As the samples were taken from the holes at each meter in depth, the total number of samples received was 224.

Curragh Inc. provided also the following data for each sample: paste pH, screen analysis on 200 and 325 mesh and chemical analysis (Pb, Zn, Cu, Fe) in size fractions. This information was used to plan and execute Phase I work.

Sample pH increases from approximately 2 at the surface to close to 9 in the deeper regions of the dam. It was assumed that the pH variations would affect the mineralogy and in particular the surface of the sulphide minerals. Three distinct layers were therefore selected for initial evaluation:

- P1 (pH < 5)
- P2 (5 < pH < 7)
- P3 (pH > 7)

It is expected that the response to flotation could be different for the materials coming from different pH layers. For this reason, mineralogical examination (liberation and surface) and part of the process testing will be preformed separately on samples originating from different pH areas. Process emphasis however, will be on common treatment of the combined feed.

2. Samples preparation

Two sets of composite samples were prepared: one for liberation mineralogy study and one for surface chemistry.

2.1 Liberation mineralogy

Liberation mineralogy required three composites made up of samples derived from the three pH areas listed above. Samples were screened on 48, 100, 200 and 400 mesh and each size fraction (a total of 15 samples) was submitted to liberation study.

2.2 Surface chemistry

Surface chemistry work involved the identification of species present on the surfaces of sulphides and in particular, on the surface of the sphalerite mineral particles. Composites were made up representing various depths and pH values. In total, 15 composites were prepared and screened on a 200 mesh screen. Approximately ten particles of sphalerite were removed from each coarse fraction for surface mineralogy study.

2.3 Process test samples

Composite samples were obtained again representing the three pH areas. The weight of each composite was approximately 60 kilo. Three head samples were taken from each composite and a general composite was made, containing material from all three areas. 70 one kilo lots were prepared for Phase II process testing.

3. Literature search

A brief literature survey initiated by CANMET library and carried out personally by the Project Leader resulted in finding several publications on subjects related to tailings retreatment. However, differences in mineralogy made these publications of little practical value to the current project. It is perhaps worth noting however that the main common emphasis was on the necessity for vigorous pre-conditioning.

4. Liberation mineralogy

Liberation mineralogy study was carried out by Dr. W. Petruk and the following is a summary of his activity and findings to-date.

4.1 Method of investigation.

Three sets of sub-fractions were taken from the sieved fractions. One set of sub-fractions was ground to -200 mesh and submitted for chemical assays for Zn, Cu and Pb; another set of sub-fractions was submitted to x-ray diffraction analysis for identification of major and minor minerals. Polished sections were prepared from the third set of sub-fractions. The polished sections were studied by optical microscopy and image analysis to identify the minerals, determine mineral textures and determine mineral liberations.

Table 1. Sieve analysis and pH of samples

Size range (mesh)	Weight %		
	P1	P2	P3
+48	3.6	5.0	1.0
48 - 100	11.0	14.7	3.7
100 - 200	26.7	25.5	14.1
200 - 400	27.7	21.5	21.6
-400	31.1	33.3	59.7
pH (average)	3.64	5.9	8.13

4.2 Results.

4.2.1. Mineral quantities by weight %, determined for each fraction and for the combined samples, are given in Tables 2a, 2b and 2c.

Table 2a. Mineral quantities in sieved fractions in Sample P1

Mineral	+48M	48-100M	100-200M	200-400M	-400M	Combined
Pyrite	2.0	39.4	69.0	69.1	59.3	60.4
Quartz	81.7	45.0	18.3	16.4	14.7	21.9
Muscovite & K feld.	13.3	4.0	2.1	2.5	2.6	3.0
Barite	tr.	2.1	3.7	4.1	8.0	4.8
Goethite*	0.4	3.5	3.5	3.8	9.0	5.2
Fe sulfate & siderite	1.6	2.3	0.8	1.5	2.1	1.6
Sphalerite	0.5	2.0	1.3	1.0	1.3	1.3
Pyrrhotite	tr.	0.7	0.5	1.0	0.8	0.7
Chalcopyrite	tr.	0.2	0.3	0.2	0.5	0.3
Galena	0.4	0.8	0.4	0.4	1.7	0.8
Kaolinite	tr.	tr.	tr.	tr.	tr.	tr.

Table 2b. Mineral quantities in sieved fractions in Sample P2

Mineral	+48M	48-100M	100-200M	200-400M	-400M	Combined
Pyrite	16.4	77.2	77.4	73.9	61.9	68.3
Quartz	63.2	7.7	7.2	9.2	16.1	13.5
Muscovite & K feld.	6.4	0.9	1.1	1.1	0.9	1.3
Barite	0.3	2.8	3.8	7.0	9.3	6.0
Goethite	4.3	3.9	4.8	4.2	2.4	3.7
Fe sulfate & siderite	2.5	0.7	0.7	0.9	4.9	2.2
Sphalerite	5.1	3.9	2.3	1.5	2.2	2.5
Pyrrhotite	0.9	1.4	1.7	1.2	1.3	1.4
Chalcopyrite	0.3	0.4	0.3	0.3	0.3	0.3
Galena	1.4	1.1	0.7	0.7	0.9	0.9
Kaolinite	tr.	tr.	tr.	tr.	tr.	tr.

* FeO - leaching product

Table 2c. Mineral quantities in sieved fractions of Sample P3

Mineral	+48M	48-100M	100-200M	200-400M	-400M	Combined
Pyrite	8.3	59.2	74.4	64.5	61.0	63.1
Quartz	80.0	27.2	9.8	15.2	11.8	13.5
Muscovite & K feld.	6.2	1.9	1.5	1.6	2.4	2.1
Barite	0.2	1.5	5.3	4.4	13.8	10.0
Goethite	1.6	4.7	4.4	8.4	0.8	3.1
Fe sulfate & siderite	1.1	1.1	0.5	1.3	5.7	3.8
Sphalerite	2.2	2.9	1.6	1.5	1.8	1.7
Pyrrhotite	0.2	0.5	1.7	1.8	1.4	1.4
Chalcopyrite	0.1	0.3	0.2	0.4	0.3	0.3
Galena	0.5	0.7	0.6	0.9	1.0	0.9
Kaolinite	tr.	tr.	tr.	tr.	tr.	tr.

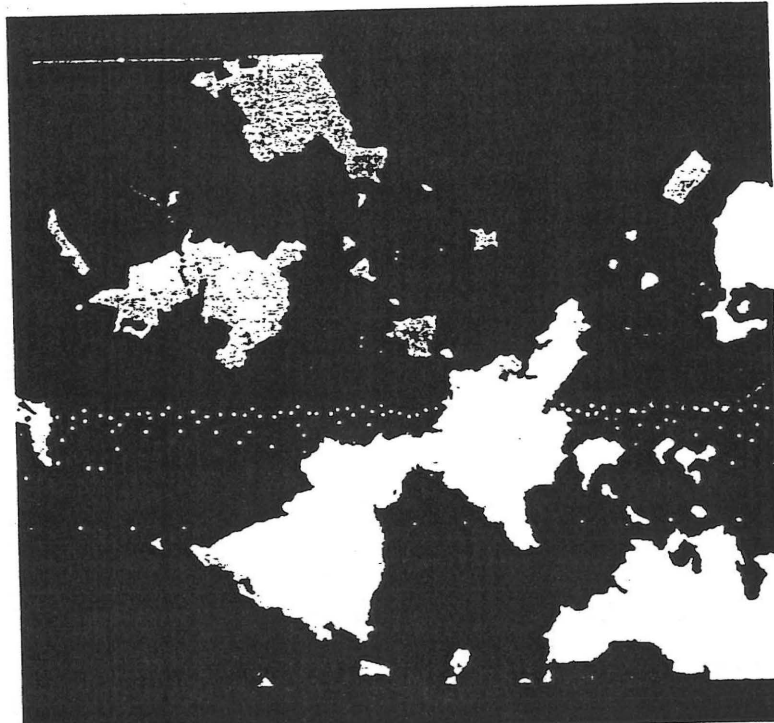
It is observed that sulphides, in particular pyrite and sphalerite have been largely leached out of the coarse fractions in the top layers of the dam.

4.2.2. Textures and liberations.

The sphalerite, galena and chalcopyrite in the +48 mesh fraction are generally locked in quartz and pyrite (Fig. 1). In contrast, the sphalerite and chalcopyrite in sieved fractions finer than 48 mesh occur as liberated particles and as inclusions in pyrite and quartz

(Fig. 2). The galena in all fractions has low liberation.

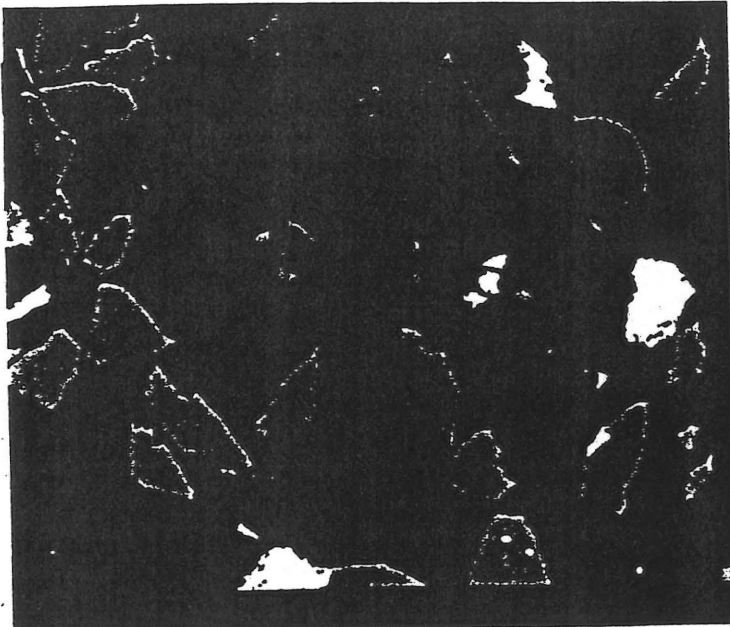
Degrees of liberation were measured for sphalerite, chalcopyrite, galena and for base metals (sphalerite, chalcopyrite and galena). The particles were classified as containing 100 % of mineral of interest (free), 75 to 100 % (recoverable), 50 to 75 % (middlings), 25 to 50 % (middlings) and <25 % (unrecoverable middlings). Results for Recoverable (75%) , Middlings (25 to 75 %) and Unrecoverable middlings are plotted with respect to particle sizes determined by sieving: see Figures 3 to 5 for base metals, sphalerite, galena and chalcopyrite in samples P1, P2 and P3. The results show that liberation of base metals and sphalerite is higher than 60 % for particles that are finer than 100 mesh. Liberation data are given in Tables 3a, 3b, 3c and 3d for sieved fractions of the samples.



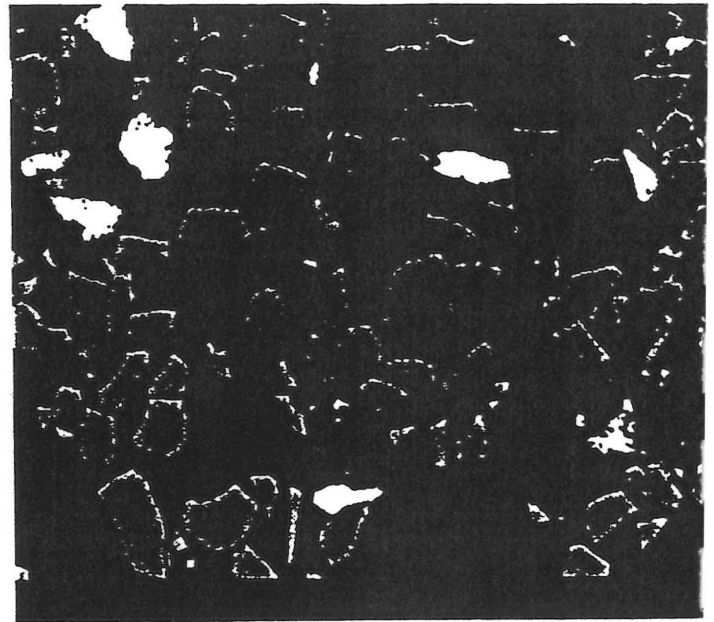
CANMET MSL MINERALOGY

Fig. 1. Photomicrograph of BSE image of +48 mesh fraction of sample P3. The grey levels have been modified with image analyzer to enhance discrimination between minerals.

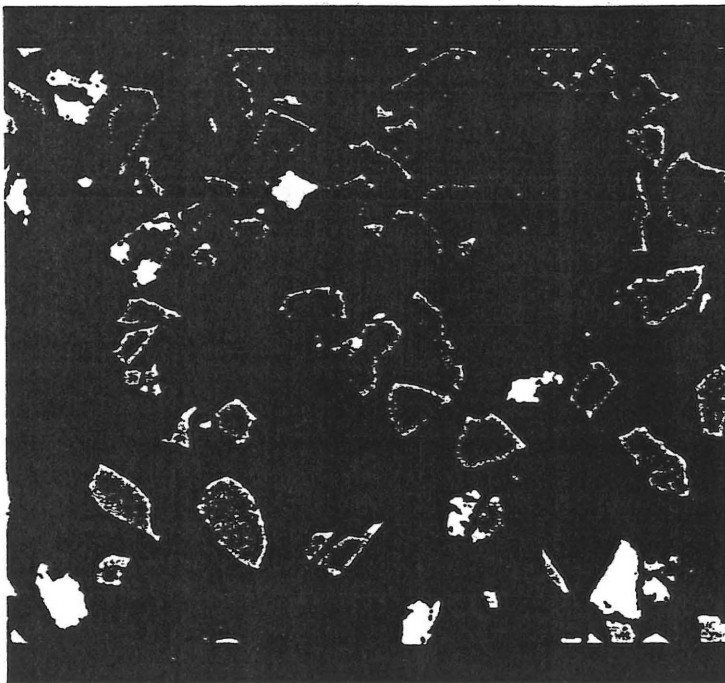
White = sphalerite + chalcopyrite + galena: Light grey = pyrite + minor marcasite: dark grey = silicates + barite + alteration products.



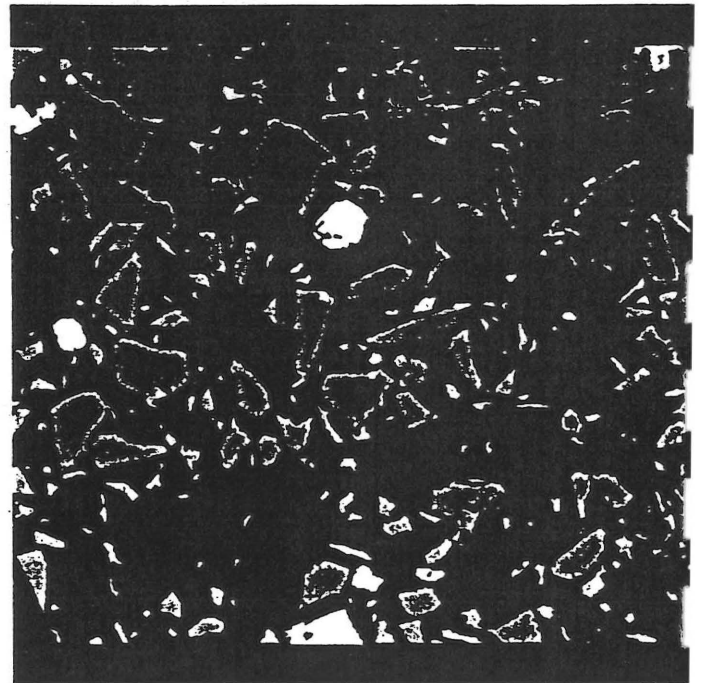
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CANMET HSL MINERALOGY



CANMET HSL MINERALOGY

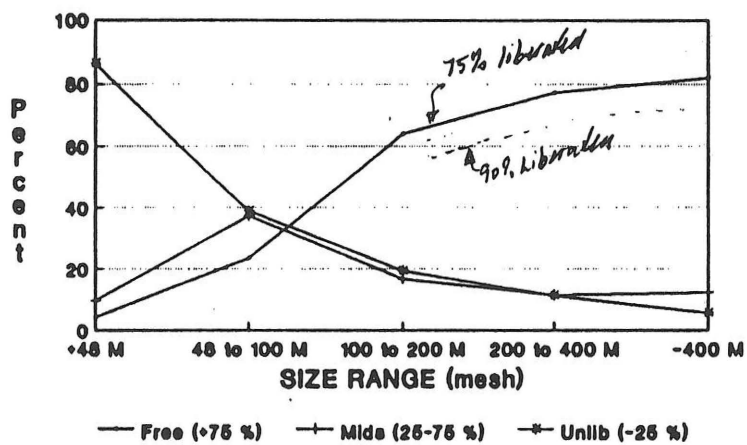


CANMET HSL MINERALOGY

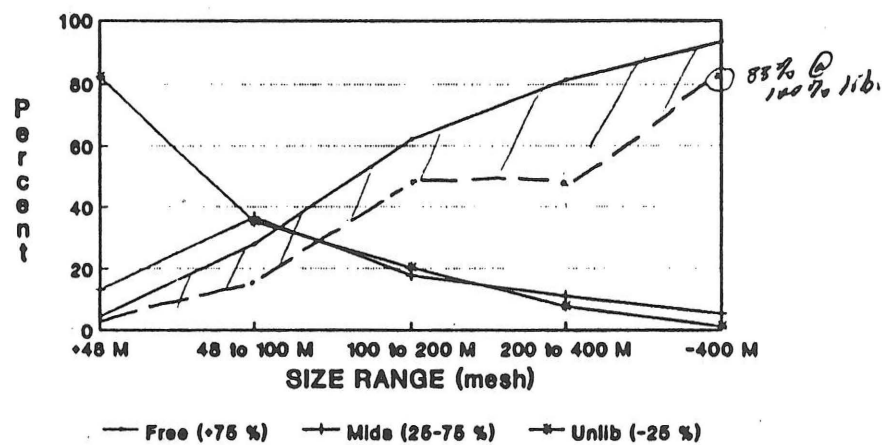
Fig. 2. Photomicrograph of BSE images of screened fractions of sample P3. The grey levels have been modified with image analyzer to enhance discrimination between minerals. (a) 48 to 100 mesh, (b) 100 to 200 mesh, (c) 200 to 400 mesh, (d) -400 mesh

White = sphalerite + chalcopyrite + galena: Light grey = pyrite + minor marcasite: dark grey = silicates + barite + alteration products.

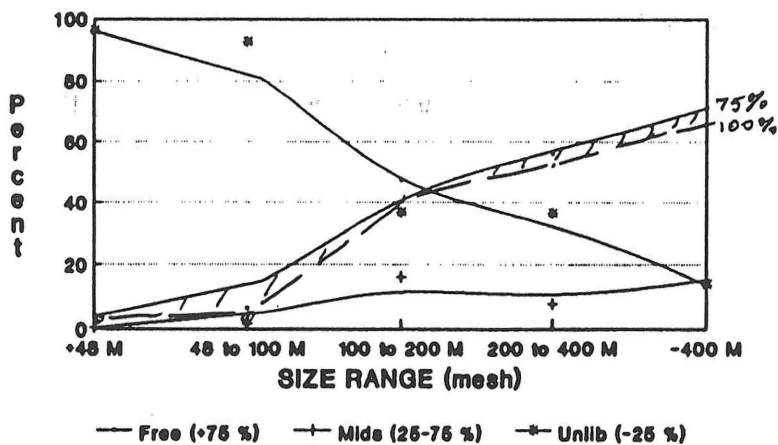
LIBERATION, SAMPLE P1
Sphalerite + chalcopyrite + galena



LIBERATION, SAMPLE P1
Sphalerite



LIBERATION, SAMPLE P1
Galena



LIBERATION, SAMPLE P1
Chalcopyrite

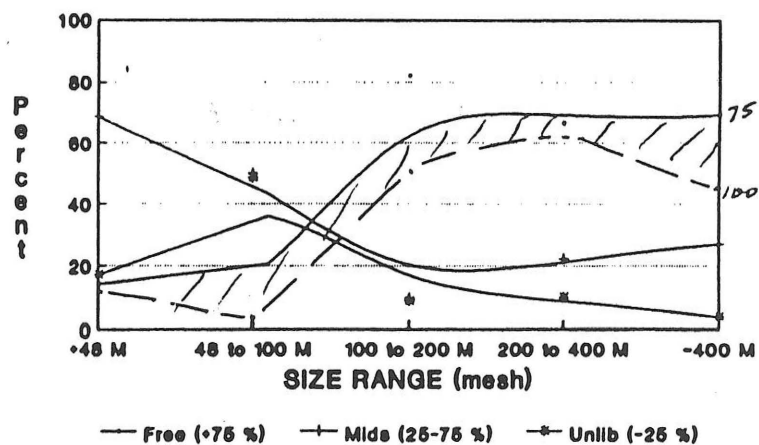
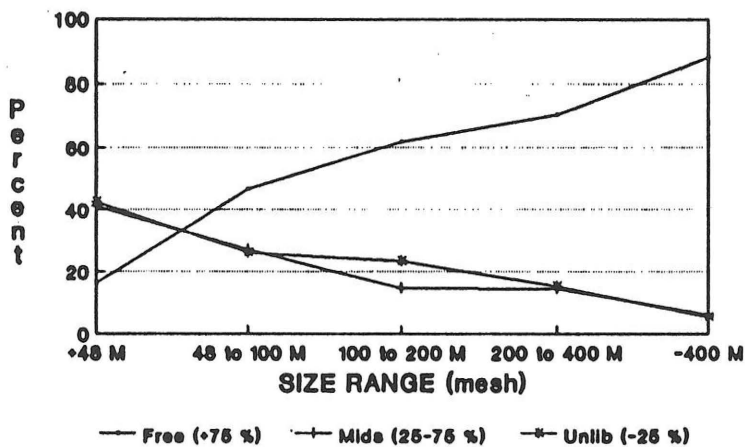
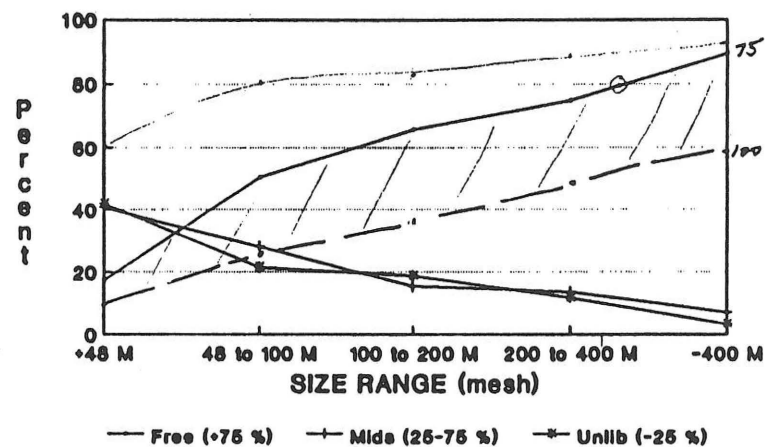


Fig. 3. Graphs showing liberations of minerals with respect to particle sizes (determined by ... (a) Sphalerite + chalcopyrite + galena, (b) Sphalerite, (c) galena, and (d)

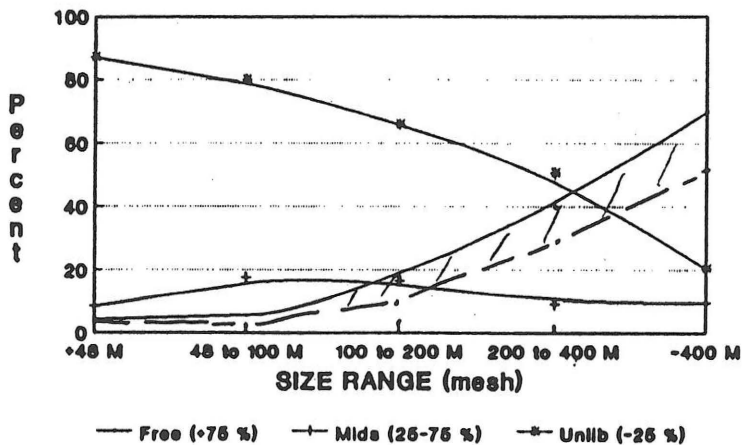
LIBERATION, SAMPLE P2
Sphalerite + chalcopyrite + galena



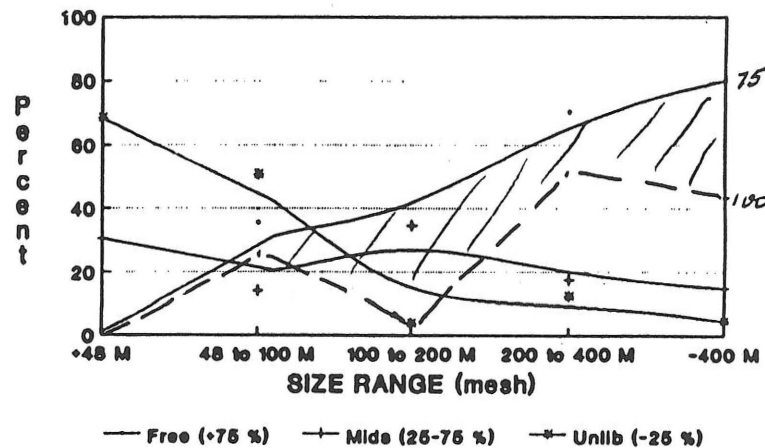
LIBERATION, SAMPLE P2
Sphalerite



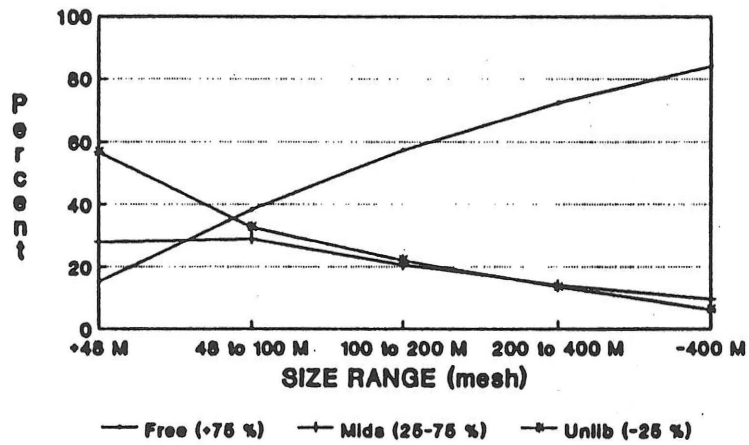
LIBERATION, SAMPLE P2
Galena



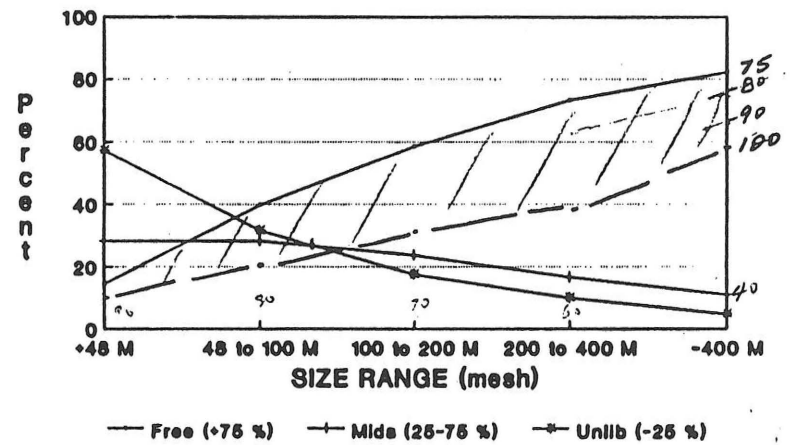
LIBERATION, SAMPLE P2
Chalcopyrite



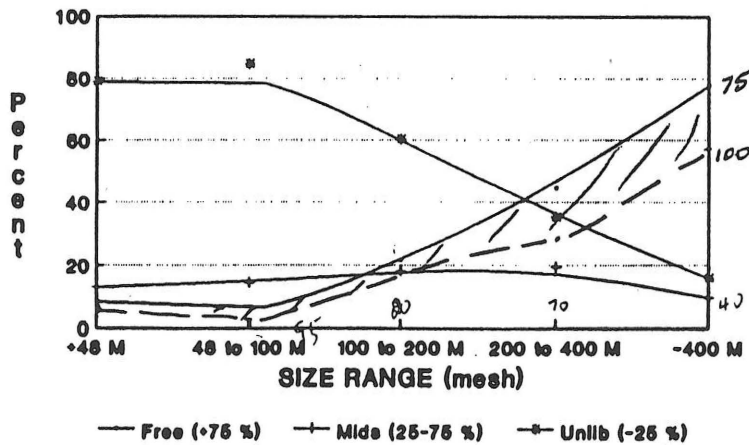
LIBERATION, SAMPLE P3
Sphalerite + chalcopyrite + galena



LIBERATION, SAMPLE P3
Sphalerite



LIBERATION, SAMPLE P3
Galena



LIBERATION, SAMPLE P3
Chalcopyrite

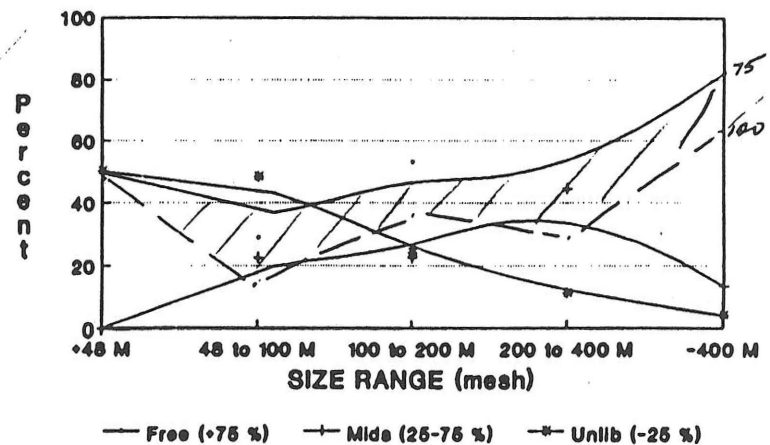


Fig. 5. Graphs showing liberations of minerals with respect to particle sizes (determined by ... (a) Sphalerite + chalcopyrite + galena). (b) Sphalerite, (c) galena, and (d)

Table 3a. Liberations for base metals (sphalerite, chalcopryrite galena,

Sample	Size range (mesh)	Recoverable	Middling	Non-recoverable	Free
		<75 %*	5 to 75%*	>25 %*	100 %*
P1	+48	4.1	9.6	86.3	3.8
P1	48-100	23.6	37.4	39.0	17.0
P1	100-200	64.0	16.6	19.4	52.0
P1	200-400	77.2	11.5	11.3	55.9
P1	-400	82.1	12.3	5.6	71.7
P2	+48	16.3	41.2	42.5	9.4
P2	48-100	46.7	27.2	26.1	29.3
P2	100-200	62.0	14.6	23.4	41.8
P2	200-400	70.3	14.5	15.2	55.4
P2	-400	88.2	6.3	5.5	62.8
P3	+48	15.3	27.9	56.8	13.0
P3	48-100	38.3	29.0	32.7	21.9
P3	100-200	57.3	20.6	22.1	39.1
P3	200-400	72.3	14.1	13.6	48.7
P3	-400	84.1	9.6	6.3	62.3

* = % base metal minerals in particle

Table 3b. Liberations for sphalerite

Sample	Size range (mesh)	Recoverable	Middling	Non-recoverable	Free
		<75 %*	25 to 75%*	>25 %*	100 %*
P1	+48	4.3	13.2	82.4	3.9
P1	48-100	27.9	36.9	35.2	17.0
P1	100-200	62.2	17.7	20.2	47.2
P1	200-400	81.3	11.0	7.7	46.4
P1	-400	93.2	5.4	1.3	83.0
P2	+48	17.4	40.7	41.9	10.5
P2	48-100	50.4	28.2	21.4	26.4
P2	100-200	65.8	15.5	18.7	37.4
P2	200-400	74.9	13.5	11.6	47.2
P2	-400	89.6	7.1	3.3	58.7
P3	+48	14.4	28.3	57.3	12.7
P3	48-100	39.9	28.4	31.8	20.2
P3	100-200	58.6	23.8	17.5	33.5
P3	200-400	73.2	16.6	10.1	39.2
P3	-400	89.6	7.1	3.3	58.7

* = % sphalerite in particles

Table 3c. Liberations for galena

Sample	Size range (mesh)	Recoverable	Middling	Non-recoverable	Free
		<75 %*	25 to 75%*	>25 %*	100 %*
P1	+48	3.4	0.4	96.2	3.3
P1	48-100	6.1	1.4	92.6	3.8
P1	100-200	47.3	17.0	36.7	43.0
P1	200-400	56.2	7.6	36.5	53.6
P1	-400	71.1	15.3	13.6	65.4
P2	+48	4.3	8.8	86.9	2.8
P2	48-100	2.4	17.6	80.0	1.4
P2	100-200	17.6	16.4	66.0	10.4
P2	200-400	39.8	9.4	50.8	28.0
P2	-400	69.9	9.7	20.4	51.6
P3	+48	8.2	13.0	78.8	7.4
P3	48-100	1.1	14.5	84.4	1.0
P3	100-200	21.6	18.2	60.2	19.2
P3	200-400	44.5	19.5	35.3	29.2
P3	-400	77.7	9.5	15.8	58.5

* = % galena in particles

Table 3d. Liberations for chalcopyrite

Sample	Size range (mesh)	Recoverable	Middling	Non-recoverable	Free
		<75 %*	25 to 75%*	>25 %*	100 %*
P1	+48	14.1	68.7	17.2	14.1
P1	48-100	1.3	50.0	48.7	1.3
P1	100-200	81.9	9.5	8.7	48.9
P1	200-400	66.6	22.4	10.0	61.1
P1	-400	69.2	27.1	3.7	44.5
P2	+48	1.1	30.5	68.4	0.1
P2	48-100	35.4	14.0	50.6	23.9
P2	100-200	34.4	34.7	30.9	1.5
P2	200-400	70.3	17.6	12.1	50.6
P2	-400	80.2	14.8	5.0	42.2
P3	+48	49.7	0	50.3	49.7
P3	48-100	29.1	22.6	48.3	15.6
P3	100-200	53.3	22.6	24.1	35.9
P3	200-400	44.3	44.4	11.2	27.9
P3	-400	82.3	13.6	4.1	62.6

* = % chalcopyrite in particles

4.3 Discussion

The purpose of the liberation study was to establish the degree of liberation of the base metal sulphides and the need for regrinding of the reprocessed tailings. Information obtained allows us to draw the following conclusions:

1. The degree of sulphide liberation remains constant irrespective of the depth from which a sample was obtained.
2. For improved liberation (recovery) of sphalerite, a coarse (+100 mesh) fraction should be separated and reground. This fraction represents approximately 15 % of material to be retreated.
3. Liberation of sphalerite in fractions finer than 100 mesh is over 60 %, increasing to 90 % in the -400 mesh size.
4. Significant (70 %) liberation of galena is found only in very fine sizes (-400 mesh). In coarser (+200 mesh) fractions galena is mainly present as non-recoverable middlings.
5. Regrinding of the rougher flotation feed could be considered only in respect of the sphalerite present in the +100 mesh fraction.

5. Surface chemistry

In order to gain more detailed knowledge of the nature of minerals surface alterations caused by oxidation over a long period of time, a study was carried out using Laser Ionization Mass Spectrometry (LIMS). The study results are reported by Dr. L. Cabri and included in this report as Appendix 1.

Conclusions from this study are as follows:

1. A varying but substantial proportion of the sphalerite surface is coated with Cu and Pb. This proportion often reaches 100 %.
2. While Cu activation is more pronounced at lower pH areas, deeper regions are characterized by nearly total Pb coating.
3. Cu and Pb activation is observed throughout the cross section of the tailing dam, irrespectively of the depth and pH of samples.

4. In most cases coating is very thin.

6. Phase II process testing

Mineralogical examination of Curragh tailings provided important information needed for the detailed planning of the laboratory testwork. This information deals mainly with regrinding and pre-conditioning.

As only coarse (+200 mesh) sphalerite present in the feed is predominately locked in middlings, it is this fraction that will require regrinding. Therefore classification and regrinding steps will have to be included in the process development work. However, economics may dictate direct disposal of this fraction.

Liberated galena is found mostly in very fine sizes (-400 mesh), with a majority of this mineral present in fine intrusions as unrecoverable middlings. It can therefore be projected that lead recovery will not be very high.

Copper and lead activation of sphalerite is found in all tailings samples, suggesting that all the material could be treated together, without regard to the depth of its origin. Such an approach could greatly simplify the recovery process.

In order to restore the flotation properties of sphalerite a pre-conditioning step may be required. Detailed investigation of this step will be carried out.