MINES BRANCH INVESTIGATION REPORT IR 66-63

PILOT PLANT INVESTIGATION OF A Cu-Pb-Zn ORE FROM CUPRA MINES LIMITED, STRATFORD CENTRE, QUEBEC

by

T. F. BERRY

MINERAL PROCESSING DIVISION

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

COPY NO. 6

JULY 8, 1966

Mines Branch Investigation Report IR 66-63

Pilot Plant Investigation of a Cu-Pb-Zn Ore From Cupra Mines Limited, Stratford Centre, Quebec.

by

T. F. Berry*

SUMMARY OF RESULTS

The ore from Cupra Mines Limited analysed 2.44% Cu, 0.55% Pb and 2.04% Zn and contained 0.028 oz Au/ton and 2.24 oz Ag/ton.

Three main problems were associated with the treatment of this ore:

1. Depression of the sphalerite during Cu-Pb rougher flotation.
2. Cu-Pb separation.
3. Elimination of Cu from the zinc concentrate.

Generally, Cu-Pb rougher concentrates contained about 90% of the copper and 85% to 90% of the lead. The presence of bornite in the ore reduced the effectiveness of the cyanide used to depress the sphalerite during Cu-Pb flotation with the result that from 20% to as much as 75% of the zinc reported in the Cu-Pb rougher concentrates.

Cyanide was equally ineffective in the Cu-Pb separation circuit and tabling of the Cu-Pb rougher concentrate was tested with limited success.

Little success was achieved in stripping the copper from a final zinc concentrate.

---

*Technical Officer, Non-Ferrous Minerals Section, Mineral Processing Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

The results contained in the following table from Run No. 9 are representative of those obtained during the pilot plant test.

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu conc	13.40	15.80	1.95	3.10	92.0	52.6	21.9
Pb conc	0.40	3.10	45.20	0.55	0.5	36.4	0.1
Zn conc	2.36	2.80	0.55	55.60	2.9	2.6	69.2
Flot tail	83.84	0.12	0.05	0.20	4.6	8.4	8.8
Head (calcd)	100.00	2.30	0.50	1.90	100.0	100.0	100.0

CONTENTS

INTRODUCTION

On August 19, 1965, Mr. R.B. Gosselin, P. Eng., Manager of Solbec Copper Mines Limited, Stratford Centre, Quebec, requested a pilot plant investigation designed to develop a flowsheet for the milling of a copper-zinc-lead ore from a wholly owned subsidiary, Cupra Mines Limited.

Mr. E.W. Thorton, Mill Superintendent of Solbec Copper Mines Limited was in charge of this pilot plant investigation and the author was assigned to collaborate with him.

Location of Property

Cupra Mines Limited is a copper-zinc-lead property located about two miles from Stratford Centre, Quebec.

Shipment

Approximately 40 tons of freshly mined ore was received from Cupra Mines Limited on September 8, 1965.

Sampling and Analysis

As the ore was crushed, a head sample was riffled out for a semi-quantitative spectrographic and a chemical analysis. Representative pieces of the ore were retained for a mineralogical examination.

Chemical analysis of a riffled sample of the crushed ore (Table 1) showed the presence of copper, lead, zinc, gold and silver. During the pilot plant investigation, daily samples of flotation feed were assayed for copper, lead and zinc with good reproducibility.

TABLE 1

Chemical Analysis* of Head Sample

Element		Amount
Copper	(Cu)	2.44 per cent
Lead	(Pb)	0.55 " "
Zinc	(Zn)	2.04 " "
Iron	(sol Fe)	16.96 " "
Sulphur	(tot S)	20.89 " "
Insoluble		50.52 " "
Gold	(Au)	0.028 oz/ton
Silver	(Ag)	2.24 " "

*Internal Report MS-AC-65-1038

MINERALOGICAL INVESTIGATION*

Summary of Results

A mineralogical study of a copper-zinc-lead ore from the Cupra Mine in the Eastern Townships of Quebec shows that the ore minerals are chalcopyrite, bornite, tennantite, sphalerite and galena. They occur largely as interstitial material between rounded pyrite grains, minute inclusions in pyrite, and as small masses. The chalcopyrite also occurs as veins in quartz. A study of mill products to about 82.5% -200 mesh shows that at this size the ore minerals are largely liberated.

Procedure

Ten polished sections and one thin section were prepared from the hand specimens, and one polished section was prepared from each mill product. The minerals were identified by microscopical and X-ray diffraction studies, and the textural relationships of the minerals were determined microscopically.

*From Mines Branch Investigation Report IR65-90, by W. Petruck, Mineral Sciences Division, October 20, 1965.

Character of the Ore

The hand specimens vary considerably in composition, some consisting of massive sulphides, others of gangue, and still others of quartz with chalcopyrite and chlorite veins. The massive sulphides consist chiefly of rounded pyrite grains. The ore minerals occur as interstitial material between the pyrite grains, and as small masses. The gangue is a schistose rock that consists of quartz-talc layers and chlorite layers and contains disseminated pyrite. The chalcopyrite and chlorite veins in quartz are up to one-quarter inch wide; the chlorite veins contain disseminated pyrite.

Detailed Mineralogy

Pyrite is the most abundant mineral in the ore. It occurs as rounded grains in the massive sulphides and as euhedral crystals in chlorite veins and chloritic layers of the gangue. The grains and crystals vary from about 20 to 1000 microns in size and contain inclusions of the ore minerals.

The ore minerals are chalcopyrite, bornite, tennantite, sphalerite and galena. They occur chiefly in the massive sulphides and disseminated pyrite, although some chalcopyrite also occurs as veins. Those in the massive sulphides are present as interstitial material between rounded pyrite grains (Figure 1), as inclusions in pyrite, and as small masses. The interstitial material consists of complex mixtures of the ore minerals, and fills interstices that vary from about 2 to 300 microns in size. The inclusions in pyrite, both in the massive ore and disseminated pyrite, are present as rounded to irregular grains that vary from about 1 to 100 microns in size (Figure 2). Chalcopyrite is the most common type of inclusion and most of it is within the size range from 10 to 50 microns. The inclusions of the other minerals are generally smaller in size.

The unit cell parameter of the sphalerite, as determined by X-ray diffraction, is 5.411A. When applied to Kullerud's curve, this indicates 3.8 mol per cent FeS in the sphalerite, which corresponds to a composition of Zn 64.6%, Fe 2.4% and S 33.0%. The unit cell parameter of tennantite was found to be 10.22A, which is slightly higher than that of pure tennantite (10.19A). This may indicate either that the tennantite contains small amounts of silver or that some of the arsenic is replaced by antimony.

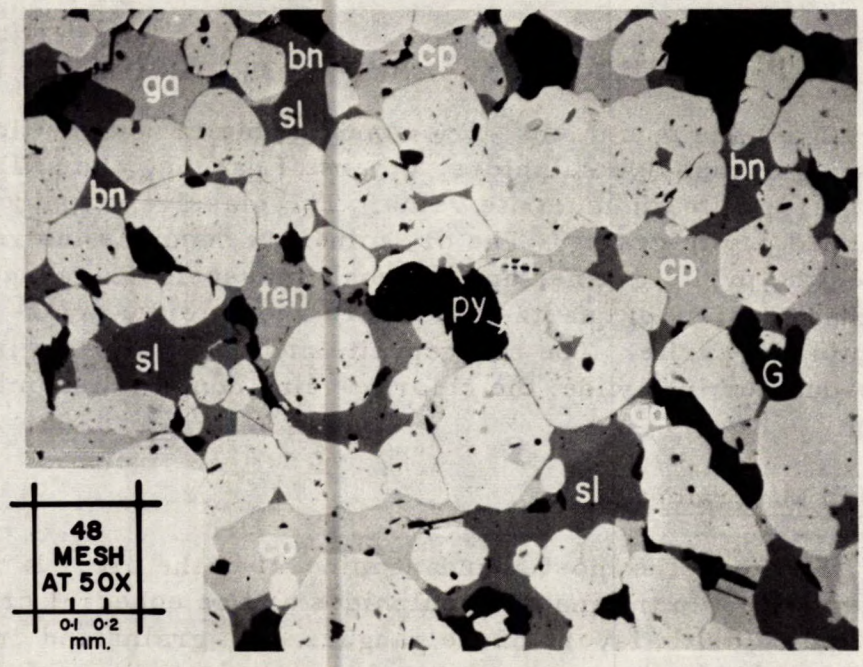


Figure 1 - Photomicrograph of a polished section of the massive sulphides showing the rounded pyrite grains (py) with interstitial chalcopyrite (cp), tennantite (ten), bornite (bn), sphalerite (sl) and galena (ga). The black areas marked G represent gangue.

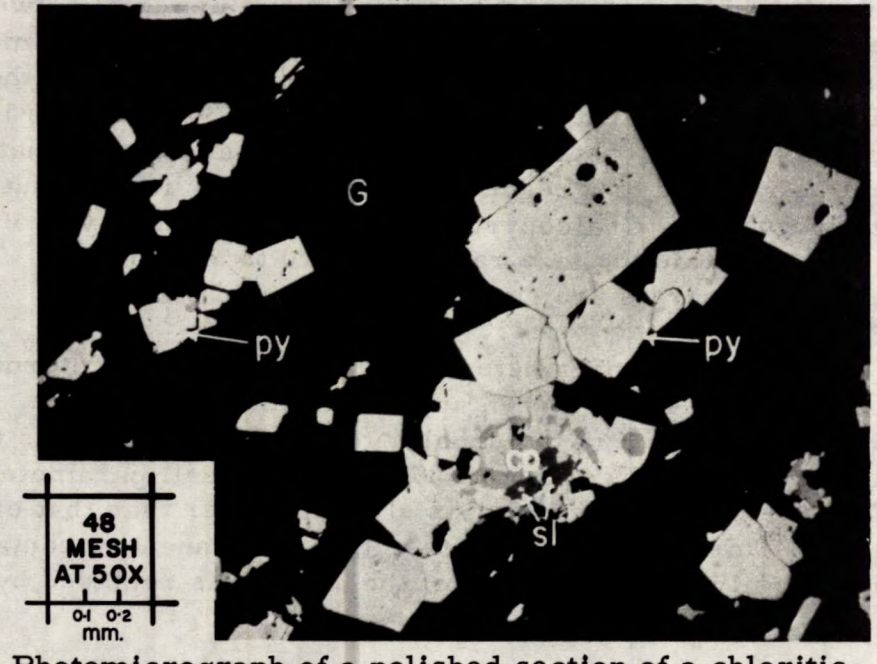


Figure 2 - Photomicrograph of a polished section of a chloritic layer of the rock showing euhedral pyrite crystals (py) with inclusions of chalcopyrite (cp) and sphalerite (sl). The dark area marked G represents the chloritic gangue.

Conclusions

The ore minerals present in the ore from Cupra Mine are chalcopyrite, bornite, tennantite, sphalerite and galena. They occur as interstitial material between pyrite, as minute inclusions in pyrite, as small masses, and as chalcopyrite veins. All the ore mineral grains, with the exception of the minute inclusions in pyrite, are largely liberated at a grind of 82.5% -200 mesh.

DETAILS OF INVESTIGATION

The basic flowsheet used in the treatment of this ore is shown in the Appendix. The variations in this flowsheet which are shown in dotted lines, were necessary to attempt to depress the sphalerite and pyrite in the copper circuit, to make a copper-lead separation and to reduce the copper content of the final zinc concentrate.

Grinding was tested in open circuit and in closed circuit with a Dorr classifier, with and without aeration of the ground pulp.

Cyanide and zinc sulphate were used to depress the sphalerite and pyrite in the copper circuit. The copper-lead separation circuit involved the conventional flotation method using cyanide as the copper depressant and one or more tabling steps to recover a lead concentrate.

In conventional zinc rougher flotation, lime, copper sulphate and Z-200 were used. The rougher zinc concentrate was cleaned three times in all tests. In two tests (Nos 7 and 9) the zinc recleaner concentrate was refloated using zinc sulphate in an attempt to reduce the copper content of the final zinc concentrate.

CONCLUSIONS AND DISCUSSION

There were two main problems associated with the pilot plant investigation of the Cupra ore. These were the depression of the sphalerite and the pyrite in the copper-lead rougher circuit and a copper-lead separation.

The ore contained substantial amounts of tennantite and bornite and these two minerals, particularly the latter, probably exerted a destructive influence on the cyanide, which was used in the grinding circuit to depress the sphalerite and pyrite. The same destruction of cyanide would account for the poor copper-lead separation by flotation.

There was also the problem of lowering the copper content of the zinc concentrate to comply with smelter requirements. This problem was accentuated by the high copper to zinc ratio in this ore and is probably related to the difficulties experienced in the copper-lead rougher circuit in which efforts to improve the grade and selectivity in the copper circuit tended to squeeze out some of the copper minerals which subsequently reported in the zinc concentrate.

Lime seemed to have little effect as a pyrite depressant and in some cases appeared to activate zinc in the copper-lead circuit. Of the reagent combinations tried the only one which exerted some control over the zinc and iron minerals was cyanide and zinc sulphate. The amounts of potassium amyl xanthate and Z-200 used had some effect but their influence was less important. A good part of the time during the pilot plant investigation was spent trying to obtain a reasonable reagent balance.

The lead in the copper-lead rougher concentrate posed a difficult problem and defied all attempts at a separation by conventional flotation using cyanide as the copper depressant. The rather unconventional method (for a base metal operation), of tabling the copper-lead rougher concentrate offered some hope. Retabling of the primary table tailing to recover additional slimed lead showed some merit but results were not as good as appeared from a visual examination. Further work on this method of lead recovery, perhaps on a classified feed should prove valuable.

Several mill products from Run No. 10 were prepared for a mineralogical examination. This report is included in the Appendix showing the metallurgical balance for Run No. 10. Generally while most of the minerals in the products examined were present as free grains, some mineral grains occurred as minute rounded inclusions in pyrite and as irregular grains at

the edges of the pyrite. Chalcopyrite, sphalerite, pyrite, galena, bornite and tennantite were present in all of the mill products.

ACKNOWLEDGMENT

The author wishes to thank W. Petruck of the Mineralogical Section, Mineral Sciences Division, and the staff of the Analytical Chemistry Subdivision of the Mineral Sciences Division of the Mines Branch who contributed to the results of this pilot plant investigation.

TFB:rlm

APPENDIX

APPENDIX

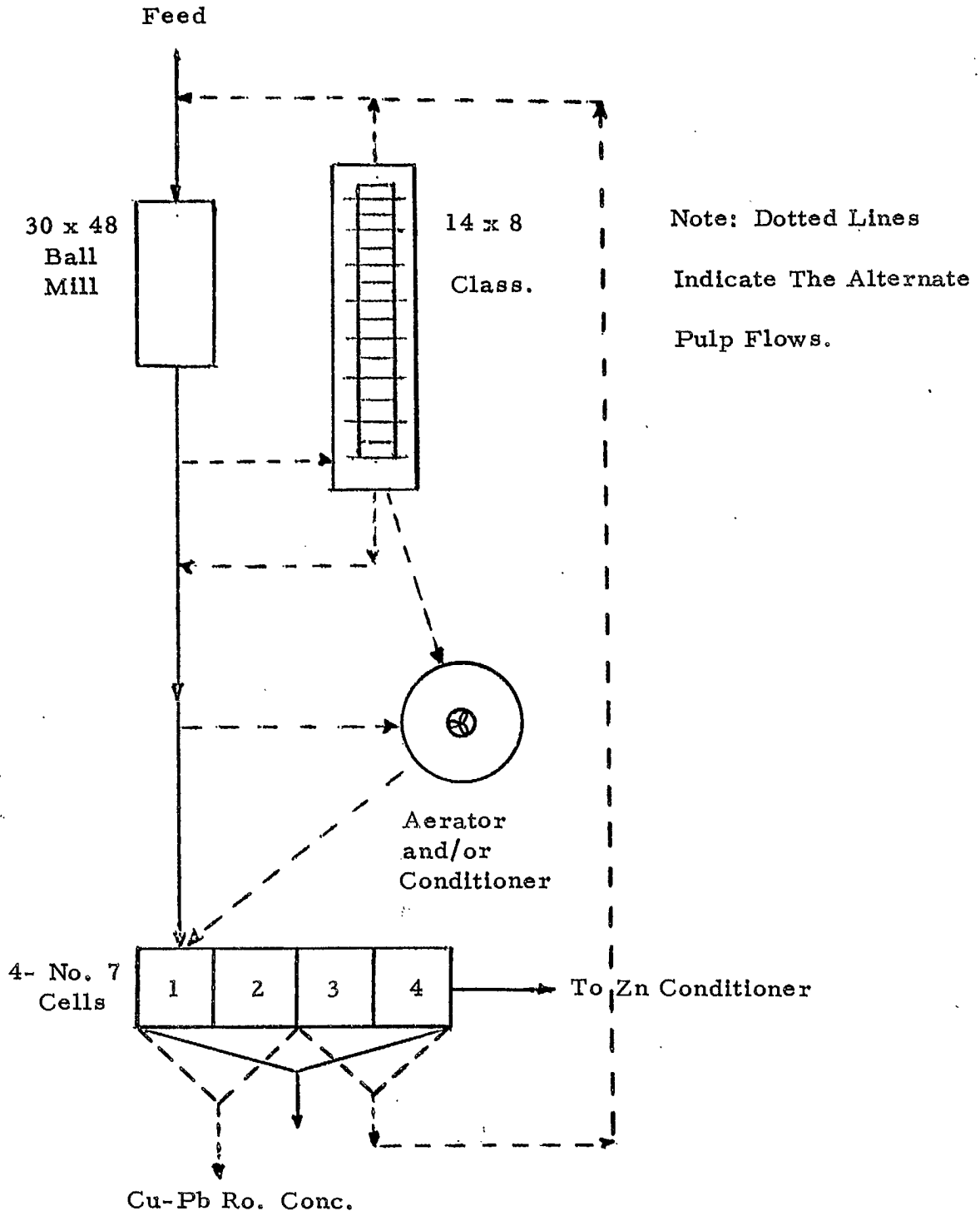
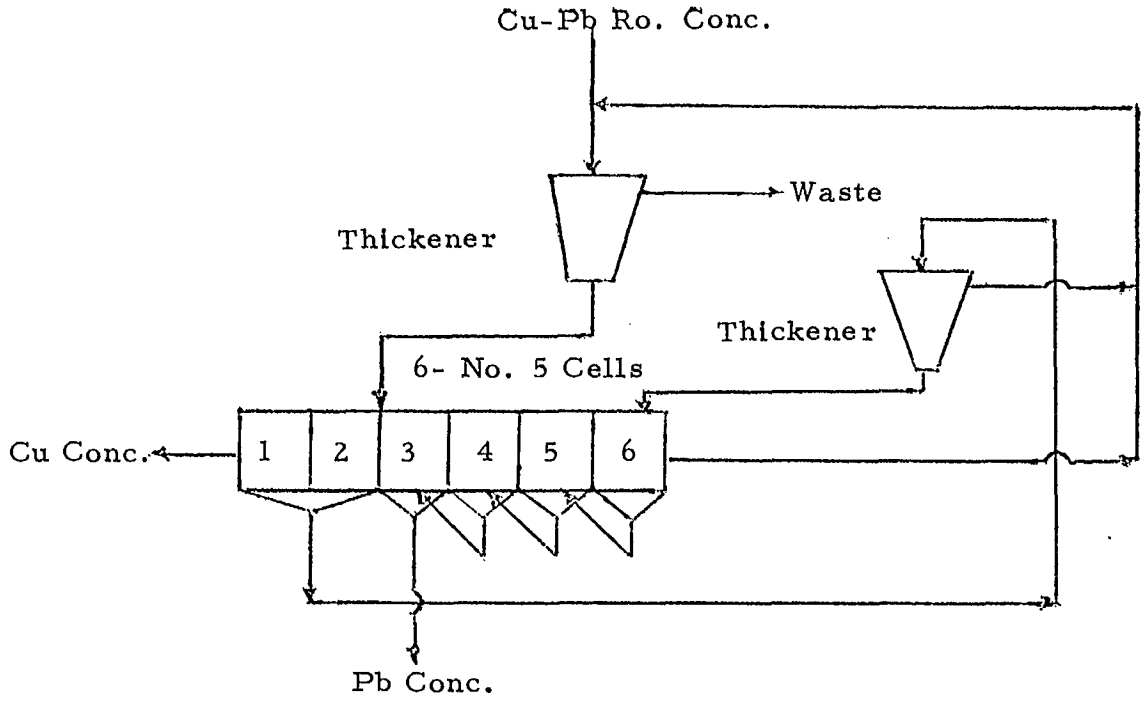


Figure 1 - Grinding - Classification & Cu-Pb Rougher Flotation



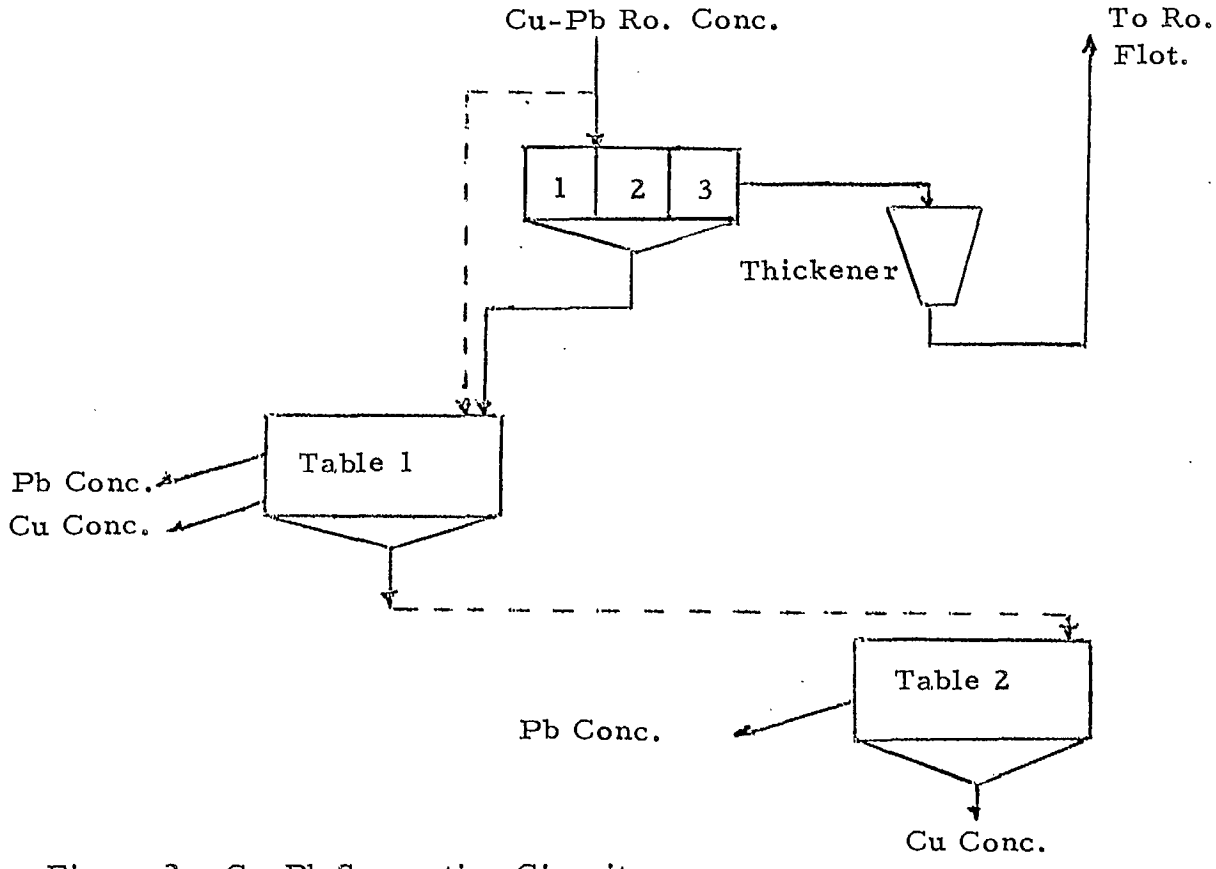


Figure 2 - Cu-Pb Separation Circuits

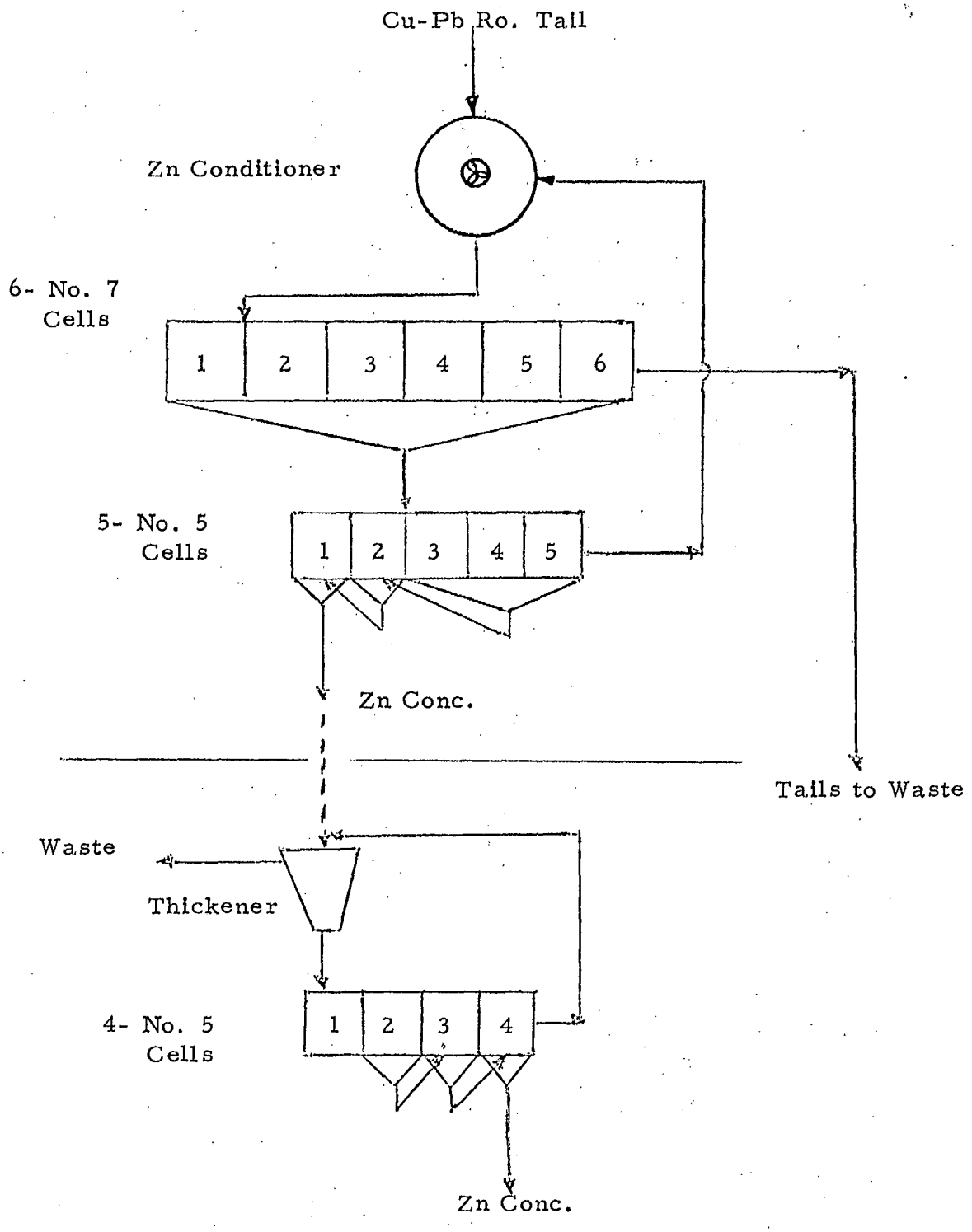


Figure 3 - Zn Flotation Circuits

RUN NO: 2	FEED RATE: 690
DATE: Sept. 14 - 65	TIME OPERATED: 3½ hr
ORE: Cupra	SAMPLING PERIOD: 11:15 AM - 12:30 PM

PURPOSE OF RUN: A preliminary attempt at a Cu-Pb rougher recovery and a final zinc concentrate.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	NaCN	Lime	$CuSO_4$	Z-200					
Ball mill	0.09			0.03			Ball mill disch	64	
Class o'flow	0.09						Flot feed	37	8.5
Cu-Pb ro #3	0.09								
Cu-Pb ro #4	0.09								
Zn cond		4.4	0.45						11.7
Total	0.36	4.4	0.45	0.03					

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M
Class. O'flow - Wt. %	0.2	1.4	5.4	6.8	15.4	70.8	86.2

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu-Pb conc	14.15	15.65	3.54	10.87	93.9	86.0	75.5
Zn "	0.74	2.30	1.77	38.56	0.7	2.2	14.0
Flot tail	85.11	0.15	0.08	0.25	5.4	11.8	10.5
Head (calcd)	100.00	2.36	0.58	2.04	100.0	100.0	100.0

RUN NO: 3	FEED RATE: 690
DATE: Sept. 14 - 65	TIME OPERATED: 3½ hr
ORE: Cupra	SAMPLING PERIOD: 2:30 PM - 4 PM

PURPOSE OF RUN: Same as No2 except grind in open circuit in attempt offset effect of iron in mill on sphalerite and reduce destructive action on cyanide.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	NaCN	Lime	$CuSO_4$	Z-200					
Ball mill	0.09			0.03			Ball mill disch	60	
Flot feed	0.09						Flot feed	42	8.5
Cu-Pb ro #3	0.09						Zn cond		11.7
Zn cond.		4.5	0.45						
Total	0.27	4.5	0.45	0.03					

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M
Ball mill disch - Wt. %	4.8	4.8	9.8	7.8	14.1	58.7	72.8

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu-Pb conc	10.28	18.89	4.04	9.79	87.5	70.2	49.3
Zn "	1.05	6.20	1.62	46.92	2.9	2.9	24.2
Flot tail	88.67	0.24	0.18	0.61	9.6	26.9	26.5
Head (calcd)	100.00	2.22	0.57	2.04	100.0	100.0	100.0

RUN NO: 5	FEED RATE: 480
DATE: Sept. 15 - 65	TIME OPERATED: 3½ hr
ORE: Cupra	SAMPLING PERIOD: 2:30 PM - 4 PM

PURPOSE OF RUN: Open circuit as in run No. 3. Cu-Pb separation circuit operating with cyanide.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	NaCN	Lime	$CuSO_4$	Z-6	Z-200				
Ball mill	0.1			0.01	0.03		Ball mill disch	54	
Flot feed	0.1						Flot feed	29	8.5
Cu-Pb ro 〃 3	0.25						Zn cond		11.8
Cu-Pb sep feed	0.25								
" " " 〃 2	0.1								
" " " 〃 4	0.05								
Zn cond		6.0	0.5						
Total	0.80	6.0	0.5	0.01	0.03				

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M
Ball mill disch - Wt. %	2.9	2.9	6.3	5.9	12.6	69.4	82.0

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu conc	3.07	13.26	3.00	9.90	18.5	18.4	15.5
Pb "	5.41	30.06	6.50	7.70	73.3	70.4	19.3
Zn "	2.20	2.60	0.92	52.00	2.6	4.0	58.3
Flot tail	89.32	0.14	0.04	0.15	5.6	7.2	6.9
Head (calcd)	100.00	2.22	0.50	1.96	100.0	100.0	100.0

RUN NO: 7	FEED RATE: 480
DATE: Sept. 16 - 65	TIME OPERATED: 3½ hr
ORE: Cupra	SAMPLING PERIOD: 1½ hr

PURPOSE OF RUN: $ZnSO_4$ in grind - Cu-Pb separation by tabling. Zn-Cu Separation circuit.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	NaCN	$ZnSO_4$	Lime	$CuSO_4$	Z-200				
Ball mill	0.10	0.27			0.025		Ball mill disch	58	
Flot feed	0.10						Flot feed	34	8.3
Cu-Pb ro #3	0.10						Zn cond		11.7
Zn cond			6.1	0.54			Zn cleaner		11.7
Zn-Cu sep #1		0.54					Zn-Cu sep 1		7.0
" " " #3		0.54							
Total	0.30	1.35	6.1	0.54	0.025				

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M
Ball mill disch - Wt. %	1.9	2.9	6.3	5.9	12.6	69.4	82.0

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu conc	13.40	14.98	2.00	10.00	90.4	53.7	65.7
Pb "	0.44	4.26	39.40	1.33	0.8	34.8	0.3
Zn recl conc	0.63	3.56	0.95	54.26	1.0	1.2	16.8
Flot tail	85.53	0.20	0.06	0.41	7.8	10.3	17.2
Head (calcd)	100.00	2.22	0.50	2.04	100.0	100.0	100.0
Zn-Cu circuit							
Head		3.56	0.95	54.26			
Conc		3.44	1.42	37.32			
Tail		3.44	1.27	52.22			

RUN NO: 9	FEED RATE: 480
DATE: Sept. 17 - 65	TIME OPERATED: 5½ hr
ORE: Cupra	SAMPLING PERIOD: 1:30 - 3:30 PM

PURPOSE OF RUN: Repeat of Run No. 7. Change in reagent amounts.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	NaCN	$ZnSO_4$	Lime	$CuSO_4$	Z-200	Dow-froth 250			
Ball mill	0.16	1.08			0.03		Ball mill disch	58	
Flot feed	0.16						Flot feed	34	8.3
Cu-Pb ro #3	0.16						Zn cond		11.5
Zn cond			6.8	1.02			Zn cleaner		11.2
Zn cleaner						0.01			
Zn-Cu sep #1		1.08							
Zn-Cu sep #3		0.54							
Total	0.48	2.70	6.8	1.02	0.03	0.01			

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu conc	13.40	15.80	1.95	3.10	92.0	52.6	21.9
Pb "	0.40	3.10	45.20	0.55	0.5	36.4	0.1
Zn recl conc	2.36	2.80	0.55	55.60	2.9	2.6	69.2
Flot tail	83.84	0.12	0.05	0.20	4.6	8.4	8.8
Head (calcd)	100.00	2.30	0.50	1.90	100.0	100.0	100.0
Zn-Cu Circuit							
Head		2.80	0.55	55.60			
Conc		2.65	0.30	23.00			
Tail		4.00	1.30	55.40			

RUN NO: 10	FEED RATE: 480
DATE: Sept. 20 - 65	TIME OPERATED: 6 hr
ORE: Cupra	SAMPLING PERIOD: 2 hr

PURPOSE OF RUN: Tabling of Cu-Pb rougher conc to recover Pb conc and 2nd Cu conc. No assays of zinc circuit.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	NaCN	Lime	$CuSO_4$	Z-6	Z-200				
Ball mill	0.22			0.01	0.03		Ball mill disch	56	
Flot feed	0.22						Flot feed	31	8.6
Cu-Pb ro # 3	0.22						Zn cond		11.6
Zn cond		5.4	1.02				Zn recleaner		11.1
Zn recleaner									
Total	0.66	5.4	1.02	0.01	0.03				

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M
Ball mill disch - Wt. %	2.5	2.8	6.2	6.0	12.2	70.3	82.5

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu conc # 1	8.38	15.48	1.55	6.94	58.9	25.8	30.19
Cu conc # 2	3.87	18.52	3.25	11.42	32.6	25.0	22.95
Combined (calcd)	12.25	16.44	2.09	8.36	91.5	50.8	53.14
Pb conc	0.40	2.32	50.20	0.17	0.4	39.9	0.04
Zn conc	1.34	2.40	0.92	54.47	1.5	2.4	37.89
Flot tail	86.01	0.17	0.04	0.20	6.6	6.9	8.93
Head (calcd)	100.00	2.20	0.50	1.93	100.0	100.0	100.0

Mineralogy of the Mill Products Run No. 10*

The mill products from mill run No. 10 are composed of grains that vary from about 5 to 120 microns in size. The flotation feed consists of pyrite, ore minerals and gangue. A grain count on the ore minerals shows that about 95% of the chalcopyrite, 88% of the sphalerite and most of the bornite, tennantite and galena are free. The remainder are present as minute inclusions in pyrite, irregular grains on the edges of pyrite, and intergrowths with other minerals.

The feed to No. 4 cell consists of gangue, pyrite, and small amounts of sphalerite, chalcopyrite, galena, and bornite. Most of the minerals are present as free grains, but a few of the ore mineral grains occur as minute rounded inclusions in pyrite and as irregular grains on the edges of pyrite.

The No. 4 copper-lead rougher concentrate consists of pyrite, sphalerite, chalcopyrite, and small amounts of galena and bornite. Most of the minerals are free of attached particles.

The copper-lead rougher concentrate consists chiefly of pyrite, chalcopyrite, sphalerite, and small amounts of tennantite, galena and bornite. Most of the minerals occur as free grains, but small amounts of the ore minerals are also present as inclusions in pyrite and irregular grains at the edges of pyrite.

The table tail (copper concentrate) is composed of very fine grained material and consists of chalcopyrite, sphalerite, pyrite, and small amounts of galena, bornite, and tennantite. Most of the grains are free but some of the bornite is intergrown with chalcopyrite, and traces of the bornite and sphalerite are present as minute inclusions in pyrite.

The zinc recleaner concentrate consists of sphalerite and traces of chalcopyrite, pyrite, bornite, galena and tennantite. Most of the sphalerite and some of the pyrite and chalcopyrite grains are free. The remaining sphalerite contains inclusions of the other minerals.

The flotation tail consists of gangue, pyrite, and traces of sphalerite and chalcopyrite. Most of the grains are free but some of the chalcopyrite is present as minute inclusions in pyrite.

*Mines Branch Investigation Report IR 65-90 by W. Petruk, Mineral Sciences Division, October 20, 1965.

RUN NO: 11	FEED RATE: 480
DATE: Sept. 21 - 65	TIME OPERATED: 7 hr
ORE: Cupra	SAMPLING PERIOD: 1½ hr

PURPOSE OF RUN: Table Cu-Pb rougher conc to recover a Cu and a Pb conc. Retable on ¼ deck Wilfley table - No. 1 Table tailing to recover slimed Pb conc. Cu-Pb scav conc floated from No. 4 cell of Cu circuit. No sampling of zinc circuit.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	NaCN	$ZnSO_4$	Lime	$CuSO_4$	Z-200				
Ball mill	0.16	1.62			0.03		Ball mill disch	58	
Flot feed	0.16						Flot feed	31	7.9
Cu-Pb ro #2	0.16						Zn cond		11.7
Zn cond			6.8	1.02			Zn recleaner		11.0
Zn recleaner									
Total	0.48	1.62	6.8	1.02	0.03				

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu conc #1	1.28	18.72	3.35	3.77	10.5	8.0	2.3
Cu conc #2	6.61	22.26	4.05	6.53	64.4	50.1	20.4
Combined (calcd)	7.89	21.68	3.94	6.08	74.9	58.1	22.7
Pb conc #1	0.144	2.54	58.20	0.71	0.2	15.7	0.05
Pb conc #2	0.033	10.32	38.20	1.43	0.1	2.4	0.02
Combined (calcd)	0.177	3.95	54.46	0.85	0.3	18.1	0.07
Cu-Pb scav conc	4.40	6.48	0.90	8.57	12.5	7.4	17.9
Cu-Pb ro tail	87.533	0.32	0.10	1.43	12.3	16.4	59.3
Head (calcd)	100.000	2.28	0.53	2.11	100.0	100.0	100.0

RUN NO: 13	FEED RATE: 480
DATE: Sept. 22 - 65	TIME OPERATED: 6½ hr
ORE: Cupra	SAMPLING PERIOD: 2½ hr

PURPOSE OF RUN: Tabling of Cu-Pb cleaner conc to recover Pb concentrates and copper concentrates. Repeat of Run 11 assay zinc circuit.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% S Solids	pH
	NaCN	$ZnSO_4$	Lime	$CuSO_4$	Z-6	Z-200			
Ball mill	0.16	1.62			0.01	0.03	Ball mill disch	58	
Flot feed	0.16						Class o'flow	32	7.9
Cu-Pb ro # 3	0.16						Cu-Pb ro 3		8.0
Zn cond			10.5	1.03			Zn cond		11.9
Zn recl # 3									11.4
Total	0.48	1.62	10.5	1.03	0.01	0.03			

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M
Class O'flow - Wt. %	1.1	1.2	3.0	3.5	10.4	80.8	91.2

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Table # 1 Cu conc	1.06	27.94	1.35	4.79	11.87	4.08	2.26
Table # 2 Cu conc	7.07	27.02	3.35	7.55	75.56	67.51	23.81
Combined (calcd)	8.13	27.14	3.09	7.19	88.43	71.59	26.07
Table # 1 Pb conc	0.02	15.48	17.20	1.12	0.14	1.08	0.01
Table # 2 Pb conc	0.09	21.86	13.10	3.16	0.79	3.36	0.13
Combined (calcd)	0.11	20.70	13.84	2.79	0.93	4.44	0.14
Zn recl conc	1.94	3.96	0.63	57.94	3.08	3.48	50.15
Flot tail	89.82	0.21	0.08	0.59	7.56	20.49	23.64
Head (calcd)	100.00	2.49	0.35	2.24	100.00	100.00	100.00

RUN NO: 14	FEED RATE: 690
DATE: Sept. 23 - 65	TIME OPERATED: 5½ hr
ORE: Cupra	SAMPLING PERIOD: 1:30 - 3:30 PM

PURPOSE OF RUN: Identical to flowsheet shown in Run 13 except that Cu-Pb cleaner tails were returned to Cu-Pb rougher float feed instead of the ball mill.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	NaCN	$ZnSO_4$	Lime	$CuSO_4$	Z-6	Z-200			
Ball mill	0.15	0.99			0.01	0.03	Ball mill disch	58	
Flot feed	0.15						Class o'flow	31	8.0
Cu-Pb ro #3	0.15						Cu-Pb cl 2		8.2
Cu-Pb cl #2							Zn cond		11.7
Zn cond			4.8	1.06			Zn recl		11.0
Zn recleaner									
Total	0.45	0.99	4.8	1.06	0.01	0.03			

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M
Class O'flow - Wt. %	0.4	1.8	6.4	7.5	16.3	67.6	83.9

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Table 1 Cu conc	1.00	29.14	1.80	5.61	13.2	5.1	2.8
Table 2 Cu conc	5.25	26.42	3.50	9.79	63.2	52.1	25.8
Combined (calcd)	6.25	26.85	3.23	9.12	76.4	57.2	28.6
Table #1 Pb conc	0.03	19.32	20.50	2.09	0.3	1.8	0.1
Table #2 Pb conc	0.08	21.26	16.20	4.69	0.8	3.8	0.1
Combined (calcd)	0.11	20.73	17.37	3.98	1.1	5.6	0.3
Zn recl conc	1.54	3.94	0.73	58.55	2.8	3.2	45.3
Flot tail	92.10	0.47	0.13	0.56	19.7	34.0	25.8
Head (calcd)	100.00	2.20	0.35	1.99	100.0	100.0	100.0

RUN NO: 16	FEED RATE: 480
DATE: Sept. 24 - 65	TIME OPERATED: 6 hr
ORE: Cupra	SAMPLING PERIOD: 2½ hr

PURPOSE OF RUN: Identical to flowsheet for Run No. 14 except that the flot feed was aerated in 6' high by 8" dia aerator.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	NaCN	$ZnSO_4$	Lime	$CuSO_4$	Z-6	Z-200			
Ball mill	0.16	1.08			0.01	0.03	Ball mill disch	58	
Class o'flow	0.16						Flot feed	31	7.7
Cu-Pb ro # 2							Cu-Pb ro 2		8.3
Cu-Pb ro # 3	0.16						Zn cond		11.7
Zn cond			8.1	1.02			Zn recl 2		11.1
Zn recl # 2									
Total	0.48	1.08	8.1	1.02	0.01	0.03			

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Table # 1 Cu conc	2.24	24.00	1.90	7.80	26.2	9.7	9.38
Table # 2 Cu conc	4.65	25.10	3.60	10.20	56.9	38.1	25.46
Combined (calcd)	6.89	24.74	3.05	9.42	83.1	47.8	34.84
Table # 1 Pb conc	0.07	3.30	67.20	0.30	0.1	10.7	0.01
Table # 2 Pb conc	0.01	29.80	9.00	3.00	0.1	0.2	0.02
Combined (calcd)	0.08	6.61	59.92	0.64	0.2	10.9	0.03
Zn recl conc	1.47	4.00	1.15	57.60	2.9	3.8	45.46
Flot tail	91.56	0.31	0.18	0.40	13.8	37.5	19.67
Head (calcd)	100.00	2.05	0.44	1.86	100.0	100.0	100.00

RUN NO: 18	FEED RATE: 480
DATE: Sept. 28 - 65	TIME OPERATED: 5 hr
ORE: Cupra	SAMPLING PERIOD: 2 hr

PURPOSE OF RUN: Grind in open circuit. Aerate flot feed. Return scavenger concentrate from Cu-Pb ro cells #3 and 4 to ball mill Table Cu-Pb ro conc.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	$ZnSO_4$	Z-200	Lime	$CuSO_4$	NaCN	Sod Aero			
Ball mill	0.54	0.03					Ball mill disch	56	
Cu-Pb ro #1		0.03			0.28		Flot feed	40	8.7
Cu-Pb ro #2					0.28		Aerator		7.8
Zn cond				1.03			Zn ro feed		12.0
Zn ro #1			6.04			0.08	Zn Cl cell 3		11.7
Total	0.54	0.06	6.04	1.03	0.56	0.08			

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M
Class O'flow - Wt. %	3.7	3.6	7.5	6.6	13.6	65.0	78.6

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu conc	11.02	16.50	2.15	11.93	82.6	42.7	64.5
Pb conc	0.53	6.88	37.00	1.73	1.6	35.4	0.4
Zn conc	3.65	8.06	2.63	16.12	13.4	17.3	28.8
Flot tail	84.80	0.06	0.03	0.15	2.4	4.6	6.3
Head (calcd)	100.00	2.20	0.55	2.04	100.0	100.0	100.0

RUN NO:	19	FEED RATE:	480
DATE:	Sept. 29 - 65	TIME OPERATED:	5½ hr
ORE:	Cupra	SAMPLING PERIOD:	3 hr

PURPOSE OF RUN: Repeat of Run #18 with no $ZnSO_4$ in grind.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	NaCN	Z-6	Z-200	Lime	$CuSO_4$				
Ball mill	0.16	0.02	0.04						
Cu-Pb ro #2	0.16						Flot feed		
Cu-Pb ro #3	0.16						Zn cond		
Zn cond				6.0	0.8		Zn ro 2 cell		
Aerator	0.16						Zn Cl 3 cell		
Total	0.64	0.02	0.04	6.0	0.8				

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M
Flot Feed - Wt. %	3.5	3.4	6.8	6.2	12.3	67.8	8.01

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu conc	9.79	15.68	2.35	11.53	84.3	45.9	58.2
Pb conc	0.44	4.14	36.90	1.43	1.0	32.4	0.3
Zn conc	1.96	9.56	3.30	36.52	10.4	12.9	36.9
Flot tail	87.81	0.09	0.05	0.10	4.3	8.8	4.6
Head (calcd)	100.00	1.82	0.50	1.94	100.0	100.0	100.0

RUN NO:	20	FEED RATE:	510
DATE:	Sept. 30 - 65	TIME OPERATED:	5 hr
ORE:	Cupra	SAMPLING PERIOD:	1½ hr

PURPOSE OF RUN: Conditioner placed in circuit in place of aerator.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	NaCN	Z-6	Z-200	Lime	$CuSO_4$				
Ball mill	0.16						Ball mill disch	58	
Cu-Pb cond	0.16	0.02	0.04				Cu-Pb cond	34	8.6
Cu-Pb ro #2	0.16								
Zn cond				6.0	0.8				11.8
Zn Cl #3									11.2
Total	0.48	0.02	0.04	6.0	0.8				

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M
Flot Feed - Wt. %	2.6	3.2	6.9	6.4	13.6	67.3	80.9

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu conc	10.48	17.20	2.53	10.20	90.2	45.7	44.9
Pb conc	0.18	4.10	41.80	1.00	0.4	13.0	0.1
Zn conc	3.04	3.10	0.78	38.80	4.7	4.1	49.6
Flot tail	86.30	0.11	0.25	0.15	4.7	37.2	5.4
Head (calcd)	100.00	2.00	0.58	2.40	100.0	100.0	100.0

RUN NO: 21	FEED RATE: 510 / hr
DATE: Oct. 1 - 65	TIME OPERATED: 3½ hr
ORE: Cupra	SAMPLING PERIOD: 1½ hr

PURPOSE OF RUN: To increase grade of Cu-Pb rougher conc by using only the first 2 No. 7 cells while maintaining Cu recovery. Longer float time seems to float more pyrite and zinc.

Open circuit conditioning of Cu-Pb ro feed no aeration.

AVERAGE CONDITIONS DURING SAMPLING PERIOD

Point of Addition	Reagents - lbs./ton ore treated						Product	% Solids	pH
	NaCN	Z-6	Z-200	Lime	$CuSO_4$				
Ball mill	0.16	0.02	0.04				Ball mill disch	55	
Cu-Pb cond							Flot feed	32	8.6
Cu-Pb ro 1	0.16						Zn cond		11.7
Cu-Pb ro 2	0.16						Zn Cl 3		11.4
Zn cond				6.2	0.8				
Total	0.48	0.02	0.04	6.2	0.8				

Screen Analysis	+65M	+100M	+150M	+200M	+325M	-325M	-200M
Flot Feed - Wt. %	3.3	3.2	6.5	5.9	12.5	68.6	81.1

METALLURGICAL BALANCE

PRODUCT	WT.%	ASSAYS			DISTRIBUTION - %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu conc	9.48	18.92	1.92	9.18	83.4	32.8	43.8
Pb conc	0.53	2.93	39.08	0.82	0.7	37.3	0.2
Zn conc	2.40	5.82	1.82	40.20	6.5	7.9	48.5
Flot tail	87.59	0.23	0.14	0.17	9.4	22.0	7.5
Head (calcd)	100.00	2.15	0.56	1.99	100.0	100.0	100.0