METALLURGY OF THE BLACKBIRD COBALT ORE

A THESIS

SUBMITTED TO THE FACULTY OF THE UNIVERSITY OF NEVADA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF

MASTER OF SCIENCE

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Introduction States and States an

The Blackbird mine is located in Lemhi County, Idaho, about 20 miles west-southwest of Salmon. It is owned and operated by the Calera Mining Co., a subsidiary of the Howe Sound Co.

Cobalt was originally discovered in the area in 1901, but there was little interest in the metal until 1917. At that time the Haynes - Stellite Co. mined and milled about 4000 tons of the ore, producing 55 tons of concentrate assaying 17.7% cobalt. There was little activity in the area after this until 1938 when the Uncle Sam Mining Co. constructed a 75-ton flotation mill. No attempt was made to recover the cobalt, and this enterprise also proved unprofitable.

The Howe-Sound Co. became interested in the district in 1943, and through its subsidiary undertook a mapping and drilling program. World War II curtailed any extensive exploration, but at the close of the European fighting work in the area was begun in earnest. By 1949 enough ore had been blocked out to justify full-scale operation and construction was started that year. $\frac{1}{2}$

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General Geology

Geology of the area has been adequately described by Mr. E. B. Douglas as follows: 2/

"The rocks of the Blackbird District are Pre-Cambrian quartzites and metamorphosed sediments. The sediments strike northwest-southeast and dip 30 to 40 degrees north. Many basic dikes and at least one acid dike intrude the sedimentary rocks. The district is bounded on the west and east by quartzites; on the north by granites; and on the south by argillite.

"Known commercial orebodies occur as hydrothermal replacements of predominately schistose rocks along shear zones. Underground workings have indicated the presence of two sizeable orebodies, the Chicago and the Brown Bear.

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"The Chicago is a high sulfide ore and has been indicated to be 1800 feet along the strike, at least 350 feet in depth, and with an average width of 15 feet. The Brown Bear is characterized by a series of mineralized schistose zones with the cobaltite as finely disseminated grains in the schist. Massive sulfides occur in only a few spots. The Brown Bear has been developed along a 1000-foot length and a vertical distance of 550 feet.

"The basic mining method used at the Blackbird mine is a horizontal cut and fill, with deslimed mill tails used as the fill material. This method is very successful in the Chicago orebody. In the Brown Bear it has met with only partial success, and even with close sand filling, timbering is necessary to support the weak walls."

Present Milling Practice 3/

At present the mill is treating 1000 tons of ore per day. Grinding is carried out in a rod mill in open circuit and one ball mill in closed circuit. Classifier overflow is 38% solide and 64% -200 mesh. With the present flowsheet a second ball mill is out of operation.

The classifier overflow is the feed to the bulk rougher flotation section (reagents and amounts fed to each section are shown opposite the flowsheet in Appendix C). This bulk rougher concentrate is cleaned twice. The bulk rougher tail goes to mill tails, and the cleaner tails are recycled to the bulk rougher heads.

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The re-cleaned bulk concentrate is thickened and conditioned. During this conditioning the temperature of the pulp is maintained at about 140 degrees F. Lime is added and high pressure air is introduced. Total conditioning time at this point is approximately five hours.

This conditioned bulk concentrate forms the feed for the copper section. The pH at the copper head is 8.5 and the pulp density is 35% solids. The copper concentrate is cleaned once. A final copper concentrate of 20% - 25%copper is produced representing a recovery of 90% - 95% of the total copper in the ore.

Tailings from the copper rougher section are the heads for the iron flotation section. Iron is floated in rougher and scavenger cells. The iron concentrate goes to

mill tails and the scavenger concentrate is recycled to the head of the differential float. The tailing from the iron scavenger is the cobalt concentrate.

Grade of the cobalt concentrate varies between 14 and 17 pct., representing a recovery of 70% to 75% of the total cobalt.

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Concentration of the cobalt, a normally difficult task, is complicated by the requirements of the refinery at Salt Lake City, Utah. A chemical process is used which depends to a large degree on the correct ratio of iron and arsenic in the concentrate. The refinery requires a cobalt concentrate grade of about 17.5% cobalt. This adds the problem of separating the right amount of iron pyrites from the cobaltite.

C HE OF ALLANY IS THE PROVER AS

Present cost of the milling is \$2.98 per ton. Flotation represents 42% of this cost and grinding 14%.

Purpose of this Thesis

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The ore of the Blackbird mine has presented many perplexing problems. Besides those encountered in mining the irregularly shaped orebodies, there has been the problem of separating the cobaltite from the worthless iron pyrites. Because of the extreme fineness of some of the cobalt minerals, gravity methods have not been effective.

The present solution to the ore dressing problem has been long conditioning with lime at elevated temperatures. However, even with this method the recovery of the cobalt has been low. Up to the present it has not been possible to make a cold pulp separation with required grade of concentrate and high extraction.

The object of this work is to effect a concentration of the cobaltite in this ore by differential flotation from a cold pulp, producing a concentrate of the required grade with a high recovery.

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Specific gravity of the ora was determined to be 2.65. This figure converted to a tennets factor gives 11.2 ou. ft. per was, or 1.4 tens per con yord.

Preliminary Examination of the Gre

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A representative portion of the sample was cut out for mineralogical examination and chemical analysis. Results of these are shown in tables 1 and 2.

Table 1	anneninghis Look Th
Mineralogical Composition of	the Ore
Cobaltite	Quartz
Chalcopyrite	Mica
Erythrite*	Tourmaline
Pyrrohotite	Vivianíte
Pyrite	Iron Oxides
* minor amount only	and a start of the

The principal ore minerals are cobaltite and chalcopyrite. Erythrite was found in such a small quantity as to be considered a trace mineral. The texture of the ore sample ranges from a fine grained quartzite with massive sulfides to a mica schist with the sulfides finely disseminated in the schist.

Specific gravity of the ore was determined to be 2.85. This figure converted to a tonnage factor gives 11.2 cu. ft. per ton, or 2.4 tons per cu. yard.

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Cu -		n ann ann ann ann ann ann ann ann an			1.4	%
Fe -					17.8	adia isti
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Results of the above analyses indicated that the sulfide minerals comprised about 20% of the ore.

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Based on the current market values of copper at 39¢ per 1b. and cobalt at \$2.60 per 1b. the value of the ore is \$55.50 per ton. This does not take into account the silver value in the ore which would raise the value per ton to \$56.25.

TESTATION CARDE CHUCKLE CAUSER , WE'RE

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Method of Analysis

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Gravimetric, volumetric, and colorimetric methods of cobalt analysis were tried. The method that was found to be the quickest and most reliable for this ore was the colorimetric method of Young and Hall. 6/ The procedure is given in Appendix A.

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General Testing Procedure

The ore sample as received from the Blackbird mine was approximately 4" material. This was crushed through a jaw and roll crusher to minus 10 mesh. The minus 10 mesh charges were ground for flotation in a laboratory batch ball mill. Lime was the only reagent added to the ball mill.

Flotation was done in a laboratory size Fagergren Flotation machine. Conditioning of the pulp was done in the flotation cell by running the machine with the air valve closed. Aeration during all flotation tests was standard.

During the flotation tests certain factors were held constant. These constants were: (1) pulp density -60% solids during grinding; 20% solids during flotation, (2) pulp temperature - 65° to 70° F, (3) machines used in the tests, and (4) water - Reno city water.

A survey of available literature furnished little information concerning the flotation of cobaltite. The only article that did deal with this subject was the one written about the Blackbird ore. With minor changes in reagents, the flotation scheme mentioned as in use at that time was taken as a starting point. The major difference was the

pulp temperature during flotation.

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After preliminary tests were made, tests were run in series of 4 to 6 to investigate the effect of certain variables upon the concentration and recovery of the cobalt minerals.

FLOTATION TEST SUMMARIES

<u>Preliminary Tests</u>: Tests nos. 1 through 11 were conducted varying the reagents and flotation method. This was to determine a set of reagents and method of flotation that appeared to effer the most promise for further tests. Both differential flotation of the copper, iron, and cobalt minerals, and bulk sulfide flotation with cleaning of the bulk concentrate were tried. The differential float gave a better separation of the sulfide minerals than did attempts to clean a bulk concentrate.

Various aerofloats, xanthates, and acids were used in different combinations. Test no. 9, with a cobalt concentrate of 5.5% Co representing a recovery of 86.5%, was chosen as the base for further tests. Tables 3 and 4 show the reagents and results of test no. 9. Points of reagent addition are shown on the flotation log sheets in Appendix B.

Lime was used as the alkalinity regulator in all tests because of its depressant effect on iron pyrites. In the copper flotation sodium aerofloat was used because of

its low collecting power. It does not actively promote pyrites in an alkaline circuit, yet is an excellent promoter for chalcopyrite.

 Reagents and Quantities Used -- Test #9

 Reagent
 lbs. per ton

 Lime
 8.0

 Na Aero
 0.10

 X- 325
 0.20

 CuSO₄
 0.20

 H01
 *

 Y-F
 0.16

 * to lower pH to 3

And pair, when end Table 4 ---- the the seld and makehate

MUD	Products	and Assays	Test #9
	Product	<u>% Co</u>	% distribution
	Cu Conc	0.28	reagent was added.8 the cell
just	Fe Conc	0.28	5.5
	Co Conc	5.5	86.5
06 a)	Tails	0.06	6.2
	Function to be w	Sold Barts Se	

For the iron flotation a promoter strong enough to activate the slow floating pyrrohotite, but not powerful

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enough to float the cobaltite in the alkaline pulp, was needed. Of the xanthates tried, sodium ethyl xanthate gave the best results.

Sulfuric and hydrochloric acids were tried as pH regulators for the cobalt flotation. A greater amount of hydrochloric than sulfuric was necessary to lower the pH to the desired point. However, the grade of the cobalt concentrate and the cobalt recovery were both increased when HCl was used. It was noticed that when using hydrochloric acid a considerable amount of H_2S was liberated in the flotation cell. This might have had a sulphidizing effect on the cobaltite. A possible explanation for the H_2S formation would be the decomposition of xanthate under the slightly reducing conditions of the hydrochloric acid.

Although the xanthate appeared to work well in the acid pulp, when conditioning time with the acid and xanthate was increased more xanthate was necessary to maintain a mineralized froth. In order to keep xanthate consumption in the cobalt circuit low, the reagent was added to the cell just prior to flotation.

Copper sulfate was added to the third conditioning as an activator for the cobaltite. Subsequent tests showed this reagent to be unnecessary.

Yarmour-F was the standard frother used in all tests. The amount was varied slightly as needed to maintain a suitable froth.

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Conditioning times are shown on the flotation log sheets. The flotation time varied slightly from test to test. In each float the froth was removed until it became barren of sulfide mineral.

Effect of Grinding Time: After selection of a suitable set of reagents, tests were made in which the time of grinding was varied. Times of 10, 16, and 20 minutes were chosen (tests nos. 9, 12, and 13). Screen analyses made of the 10 and 20 minute grinds are given in table 5.

---- Tabla 5 ----

and manage that	WAR - TABLE	into 1			15 62 774
Screen	Analyses of 1	0 and 2	0 Minute	Grinda	westing the
mesh	% retained	Cum %	%	20 min retaine	grind d Cum %
65	0	0	13 1000023	activities	TARE ENS
100	1.4	1.4		0.2	0.2
150	2.9	4.3		1.4	1.6
200	7.3	11.6	a one cop	5.2	7.8
325	88.4	100.0	10-200.9.12	14.7	22.5
-325	and in cus La	Careford a		78.5	100.0

because of the over depression of iros minerals which are

Although the grade of the cobalt concentrate decreased in test no. 13, recovery of the cobalt increased. This was apparently due to insufficient scalping of the iron pyrites. Test no. 15 was made with the same grind as no. 13, but the amount of xanthate to the iron circuit was increased.

inter fleated with the cobalt, lowering the concentrate grain.

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In this test the grade of the cobalt concentrate was markedly improved, but with a decrease in the recovery of the cobalt. The lowered recovery in test no. 15 is probably because of an improper reagent balance. Results of the grinding tests are shown graphically on figure 1.

Effect of Lime: In tests 16 through 19 the quantity of lime added to the ball mill was varied. The amounts of the other reagents used remained the same as given in table 3, with the exception of xanthate which had been increased to 0.30 lbs. per ton. Figure 2 shows the relationship of lime (pH) upon the grade of the cobalt concentrate and cobalt recovery.

Below a pH of 9.0 both the cobalt concentrate grade and recovery drop sharply. Assay of the other flotation products shows that the cobalt mineral is not sufficiently depressed and is floated with both the copper and iron. Above a pH of 10.0 the grade of the cobalt concentrate decreases with an increase in the recovery of the cobalt. This is because of the over depression of iron minerals which are later floated with the cobalt, lowering the concentrate grade.

Effect of Depressants: After determining the optimum alkalinity for the ore, tests were made using various depressants. The effects of sodium cyanide, sodium ferro-cyanide, potassium permanganate, and Reagent 610 on the flotation and recovery of cobaltite were investigated. The other reagents used

Grinding Time (Minutes)

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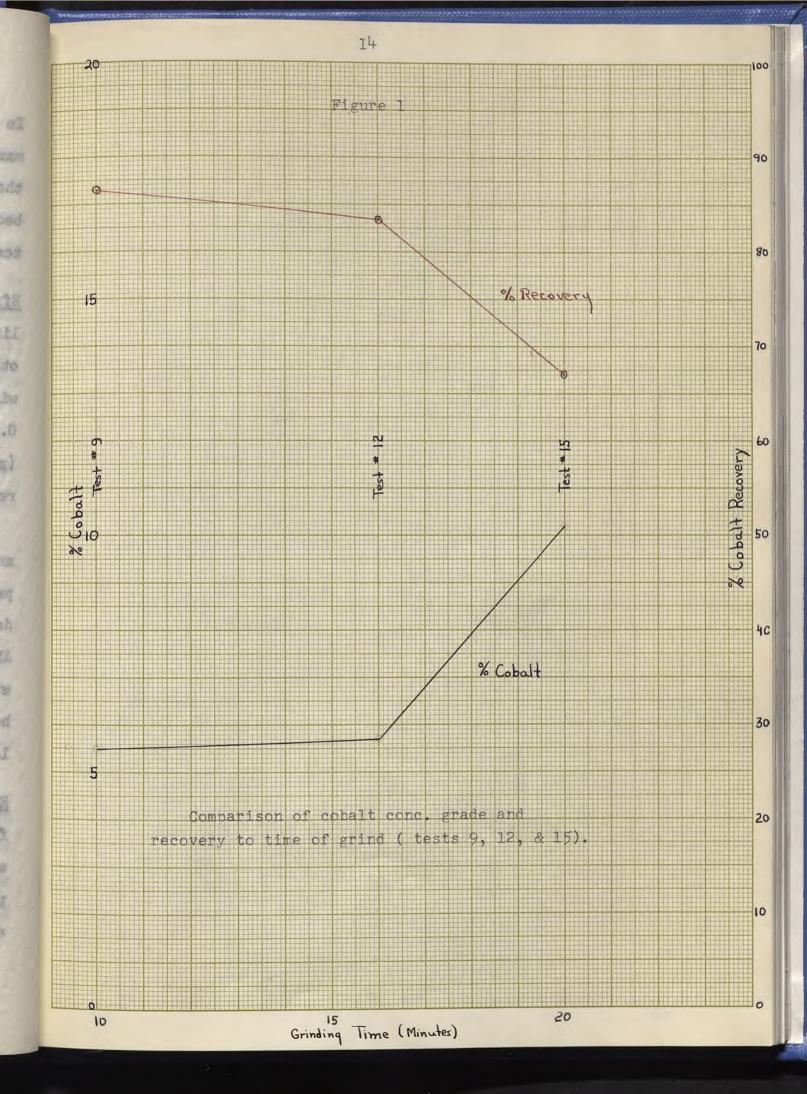
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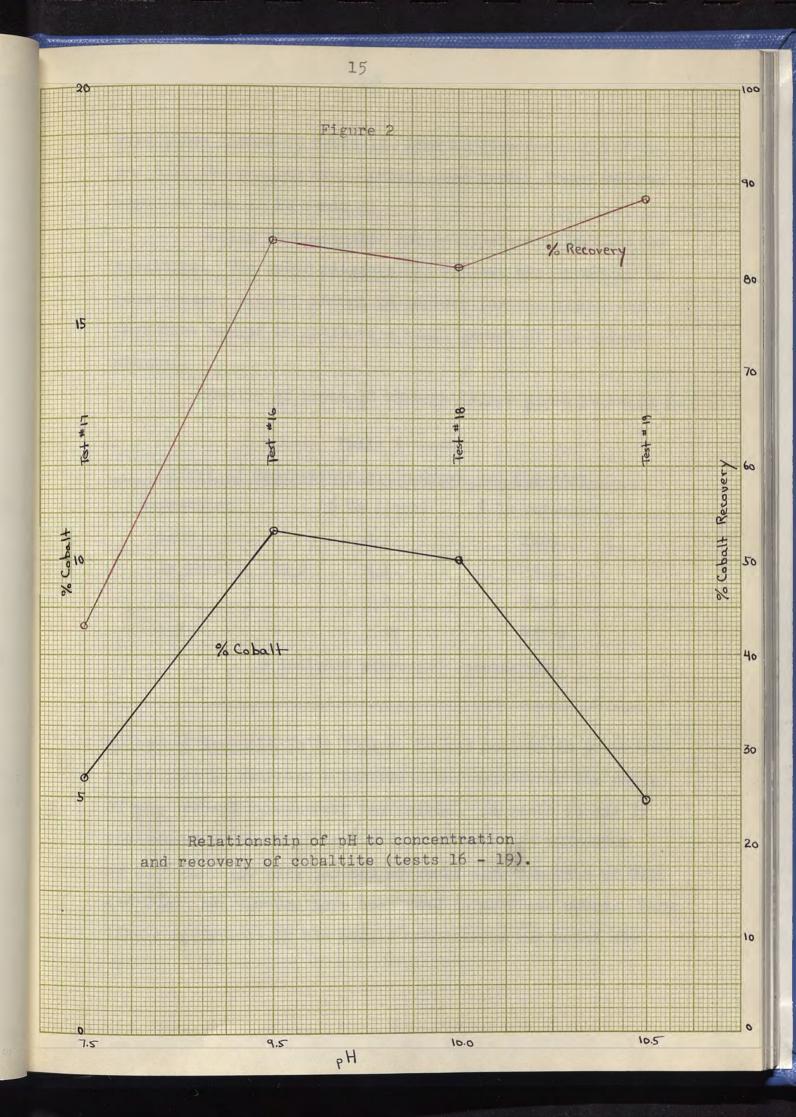
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were those listed in table 3. Lime to give a pH of 9.5 and 0.30 lbs per ton of xanthate were used. Other amounts were the same as in table 3.

Sodium ferro-cyanide had no apparent effect on the cobaltite. The other reagents did depress the cobaltite to some extent, but not enough to warrant further study. In fact they seemed to activate a small amount of the cobalt mineral. of the cobelt contentate and cobelt recovery with

Results of tests 20 through 23 are given in table 6.

Change in Gobala Dre	Table 6	E on atlant area had
	ssants on Co gra	
Depressant	% Co (conc)	% Co recovery
		12.3
Na ₄ Fe(CN)6 10H2		85.4
KMnO4	5.2	31.2
	5.5*	38.7*
* inc	cludes scavenger	concentrate

Effect of Manthate in Fe Float: It was noticed in previous tests that by scalping a heavier iron concentrate the grade of the cobalt concentrate was raised. In tests 24 and 25 the amount of xanthate to the iron circuit was increased to 0.25 and 0.30 lbs. per ton respectively. Amounts of 0.10 and 0.20 lbs. per ton have been used in previous tests. Very little difference in the cobalt concentrate was noted when

drespeak. He changes were collowd,

the amount of xanthate was 0.20 and 0.25 lbs. per ton. The use of less xanthate does not scalp enough iron from the circuit and leaves the pyrites to dilute the cobalt concentrate. Larger amounts of xanthate float the cobalt mineral with the iron concentrate with resulting loss in cobalt recovery. For further tests 0.20 lbs. per ton was used because of the slightly higher recovery of the cobalt. Figure 3 compares the grade of the cobalt concentrate and cobalt recovery with variation in xanthate in the iron circuit.

<u>Change in Cobalt Promoter</u>: Work done on other ores had shown Aerofloat 33 to be an excellent promoter of sulfide minerals in an acid pulp. In test no. 26 the cobalt promoter was changed from sodium ethyl xanthate to Aerofloat 33. Two other reagent changes were made at this point.

During the series of tests made with various depressants and xanthate additions, the lime consumption varied to maintain a pH of 9.5. The cause for this was attributed to the lime used. Several sources had been used and the CaO availability varied from 7% to 40%. A change was made to quicklime with a CaO availability of 60%. In order to re-evaluate the lime consumption a series of tests (27-33) varying the lime amount was again run. Results of these tests are shown in figure 4. As before, the optimum alkalinity was at a pH of 9.5.

Also in test no. 26 the use of copper sulfate was dropped. No changes were noticed.

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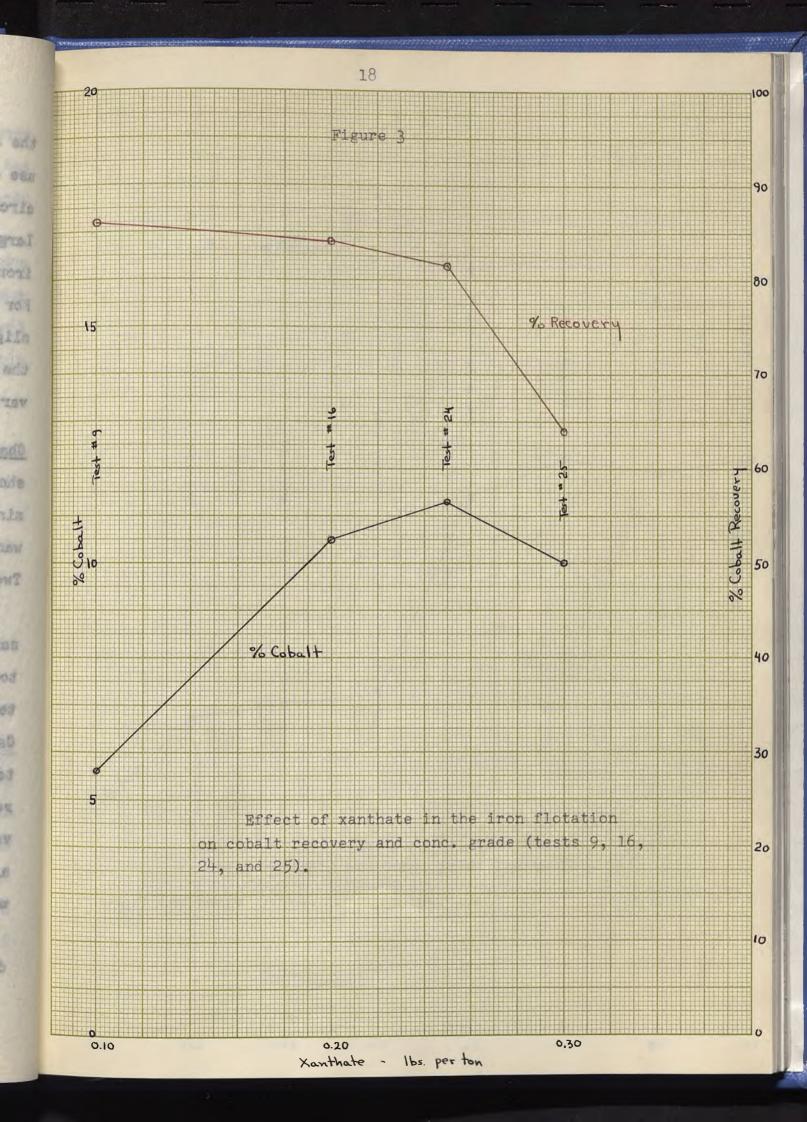
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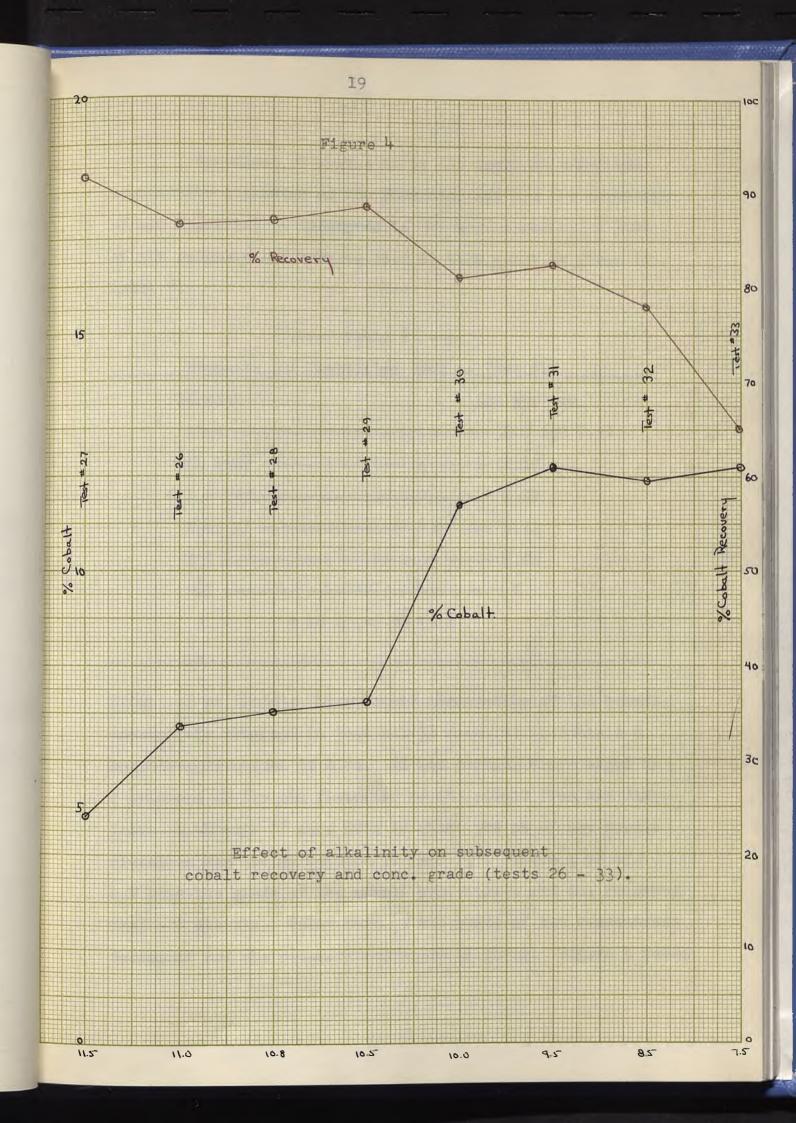
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Aerofloat 33 proved to be at least as effective a cobaltite collector as the xanthate, and had the advantage of not appearing to decompose in the acid circuit. A list of the reagents and amounts used at this point is given in table 7.

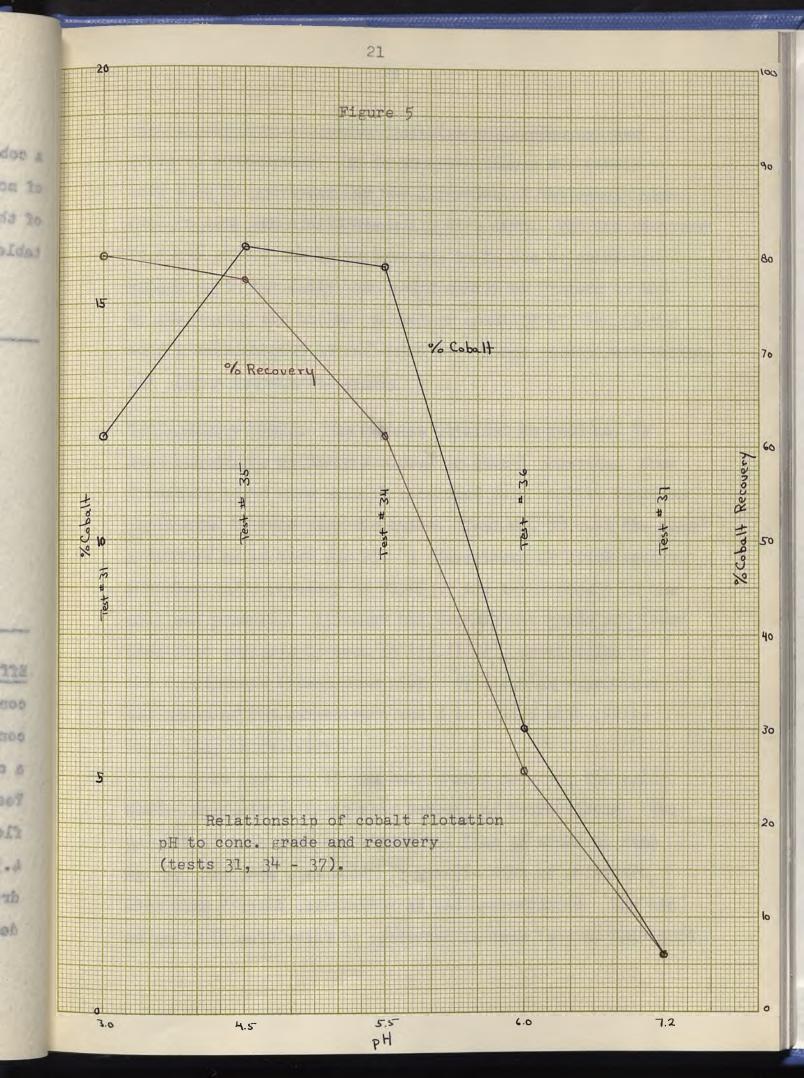
-- Table 7 ----

Reagents a	nd Quantities	Used Test 31	1. 31
Reagent	my	lbs per ton	
Lime		8.0 (pH 9	9.5)
Na Aero	r din naja ana dan dan sain aya ana dip din ana aya ana a	0.10	
X - 325	n alah masi mini mini mini din dijin kati mini mini alah diji mini m	0.20	
Aero 33		0.11	
Y-F	1 dan ant-Alfr air air dan Jun air	0.16	
HC1	1 400 - 130 - 400 - 400 - 130 - 140 - 400 - 400 - 400 - 400 - 400 - 400 - 400 - 400 - 400 - 400 - 400 - 400 - 4	*	
	* to lower pl	oH to 3	

Effect of pH (acid): Microscopic examination of the cobalt concentrate obtained in test no. 31 showed it to contain a considerable amount of mica. It was thought there might be a critical pH for the flotation of the cobalt from the mica. Tests 34 through 37 were made in which the pH of the cobalt flotation was varied between 3.0 and 7.5. Above a pH of 4.5 both the grade of the cobalt concentrate and the recovery drop off sharply. Below this pH the grade of the concentrate decreases and the recovery increases slightly. Figure 5 shows

PHE

7.2



the relationship of cobalt flotation pH to recovery and grade of concentrate. It is apparent that a moderately acid pulp is necessary for the flotation of the cobalt mineral in this ore after depression with line. The low recovery of 77.5% of the cobalt in test no. 35 is due to cobaltite remaining in the tails, and could easily be raised to 84% by scavenging the tails. A smaller quantity of mica in the cobalt concentrated is reflected in a lower concentrate weight, and higher concentrate grade.

<u>Confirmatory Tests</u>: The results obtained in test no. 35 were comparable to those achieved in actual practice. Confirmatory tests were made to show that such results could be duplicated by cold pulp flotation. Test no. 38 used the same procedure as in test no. 35. A concentrate of 15.0% cobalt, representing a recovery of 84.6% of the total cobalt in the ore, was produced. Although the concentrate grade was lower than that produced in test 35 (16.2% Co), examination of the concentrate showed some mica. By cleaning operations the grade of the concentrate could be raised with little or no loss in recovery.

In test no. 39 the only change made was the acid used. Sulfuric acid was used instead of hydrochloric. The results of this test are almost the same as those of test no. 35, and show that sulfuric acid is just as effective with this reagent combination as the hydrochloric. The use of sulfuric acid would be preferred as much less of this acid

is required to lower the pH to the desired point, and it is less expensive than hydrochloric acid.

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The log sheet for test no. 38 gives a more complete analysis of the products than has been given previously.

Cross a wold pulp by selective flotation. The grade of the conalt concentrates and the recovery of the senalt about equal that are obtained consercially. By conjunct exampling of the talls, recovery of the cobalt and be direct to appreciately sti. demorally, the recults obtained to a microscopy can be improved upon in a plant because circuits bely represent out to mare closely balanced.

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Recefficiebles of shis are seens to depend largely on two critical pits. Teo bigs a pit to the supper and iron directive over depresence the protice and requires in a low grade cobalt conventions. If whis initial pit is too low the oblaities is not sufficiently depressed and floats with the iron, lowering the cobalt recevery.

In the orbeit direction is the part is not acid second

The results of tests nos. 35, 38, and 39 indicate that the cobaltite in the Blackbird ore can be concentrated from a cold pulp by selective flotation. The grade of the cobalt concentrate and the recovery of the cobalt about equal that now obtained commercially. By complete scavenging of the tails, recovery of the cobalt can be raised to approximately 85%. Generally, the results obtained in a laboratory can be improved upon in a plant because circuits and reagents can be more closely balanced.

No attempt has been made in these tests to recover the copper in a high grade concentrate. However, a good grade of copper concentrate is produced, and it was noticed during the test work that the copper in the iron concentrate could be recovered easily by cleaning with a standard copper reagent. This copper cleaned from the iron concentrate, added to the copper rougher concentrate, would give a copper recovery of about 90% to 95%.

Beneficiation of this ore seems to depend largely on two critical pH's. Too high a pH in the copper and iron circuits over-depresses the pyrites and results in a low grade cobalt concentrate. If this initial pH is too low the cobaltite is not sufficiently depressed and floats with the iron, lowering the cobalt recovery.

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In the cobalt circuit if the pH is not acid enough it appears that the cobaltite is not activated. However, a pH too low at this point will result in a low grade concentrate, which seems to be due to flotation of more of the gangue material.

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The optimum pH ranges are 9.0 to 9.5 for the copper and iron floats, and 3.5 to 4.5 for the cobalt flotation.

By the use of low strength promoters in the copper and iron circuits the flotation of the cobaltite with these products can be kept to a minimum.

From the study made of this ore it appears that the cobalt content of the copper and iron products is due to one, or both, of two causes. Either the cobalt is present as very fine inclusions of the mineral in the pyrites, or it is present as cobaltiferrous pyrite. In the first case it could be liberated by finer grinding, but as the grind used in these tests is 75% -325 mesh, finer grinding would appear uneconomical. If the cobalt is present as cobaltiferrous pyrite only a chemical or pyrometallurgical treatment would recover it.

A detailed flowsheet based on the results of this paper is not proposed. A general flowsheet which could be used is given in Appendix C. With minor changes, this could be accomplished from the present flowsheet and equipment.

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APPENDIX A

Method of Cobalt Analysis Used

"Dessentes the sharp's with Hill, and ROL, adding a

"Disselve the scoples in opproximately 25 al of unter, the sid stately 1 al of 501 for every 50 al of andmequant dilation of the scople. Fail, seel, and such cut into appropriate suspectes cylinders or antibusced flathe. The antons of dilation depends on the second of scholt present and can be read all from the following table.

Va Sherry	velghe dr amaxio (ca)	allution 71	alligion galan (pit	Thater) Car S to
0.01 - 0.20				
0.16 - 0.60	0.5			
0,80 - 3,80	0.5	50		and a
small maximum to seat to seat	and the second	and the second second		

Went Cohell Secoles White Lege This 30 He Brok.

COLORIMETRIC DETERMINATION OF COBALT 5/

"Cobalt forms a complex with ammonium thiocyanate which can be extracted with amyl alcohol and ether, and the blue cobaltothiocyanate color measured in a colorimeter.

 $CoCl_2 + 4 \text{ MH, CMS} \rightarrow (\text{MH}_k)_2(Co(CHS)_k) + 2\text{NH}_kCl$

"Decompose the sample with HNO₃ and HCl, adding a few drops of bromine or HF if necessary. For high iron material use HNO₃ and KClO₃. Evaporate the sample to dryness, but do not bake. Traces of HNO₃ have no effect on the formation of the thiocyanate complex.

"Dissolve the samples in approximately 25 al of water, and add exactly 1 al of HCl for every 50 al of subsequent dilution of the sample. Boil, cool, and wash out into appropriate measuring cylinders or calibrated flasks. The amount of dilution depends on the amount of cobalt present and can be read off from the following table.

Co in Sample %	weight of sample (sm)	dilution	aliquot taken (ml)	factor for % Co
0.01 - 0.20	2.0	50	5	0.5
0.16 - 0.80	0.5	50	5	2
0.80 - 3.20	0.5	50	5	8

Table 8 ---- absorption of

"(a) <u>Cohelt Semples With Less Than 36 Mg Iron</u>. Measure out 5 ml of sodium thiosulfate solution, 3 ml of

absort it is proferable it all cases to and 2 al of associat

under (a), but in this case and 2 al of essential apprinte

sodium phosphate solution, and 10 ml of ammonium thiocyanate solution. Add with vigorous agitation 5 ml of the solution of the sample. The pH is now 3.5 to 4.0 and the concentration of the ammonium thiocyanate is 26%.

"Add 10 ml of the amyl alcohol-ether mixture and shake the whole thoroughly again. Transfer to a separatory funnel, run off the lower layer, and discard. Transfer the solution of the cobalt complex to a test tube or 1-cm absorptiometer cell. For visual comparison, match the intensity of the color of the test solution with the standard copper sulfate solutions. The comparisons may be carried out in a La Motte comparator for hydrogen-ion determinations with a source of artificial light, or the tube may be simply held against a white background out of direct sunlight. It will be possible to take a reading half way between any two of the standards if the color of the test solution lies between them.

"In the photoelectric comparison, absorption of the test solution is compared with an anyl alcohol-ether blank. The amount of cobalt present in the test solution is then read off from the calibration curve.

"(b) <u>Cobalt Samples With More Than 36 Mg Iron</u>. Carry out the analysis in exactly the same way as for those under (a), but in this case add 2 ml of ammonium acetate solution. The pH is still 3.5 to 4.0 and the concentration of ammonium thiocyanate is 24%. Unless iron is known to be absent it is preferable in all cases to add 2 ml of ammonium

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acetate as routine procedure. Copper does not interfere with the production of the blue color even when present to the extent of 60%. Iron, if present in amount greater than about 36 mg, will interfere unless ammonium acetate is used. Vanadium forms a blue complex which is extracted with the amyl alcohol-ether solution. If, however, ammonium acetate and a few drops of tartaric acid are added to the reagents this blue complex is not formed, and vanadium will not interfere. The following do not give colored complexes which are soluble in amyl alcohol-ether: Cr, Mn, Zn, Ti, Mo, U. Other common elements such as Al, Si, Mg, P, Bi, As, Pb, and the alkalies are without effect.

"This rapid procedure is very satisfactory for a range of 0.02 to 0.50 mg of cobalt or 0.0 to 4% Co.

Reagents

Ammonium thiocyanate: Dissolve 600 gm of NH4 CNS in 1 liter of water

Sodium phosphate: Dissolve 83.3 gm of Na3PO4 12H20 in 1

liter of water

Sodium thiosulfate: Dissolve 200 gm of Na2S203.5H20 in

1 liter of water

Ammonium acetate: Dissolve 700 gm of NH4C2H3O2 in 1 liter of water

Tartaric acid: Dissolve 50 gm of C4H606 in 1 liter of water Amyl alcohol-ether mixture: Mix 3 parts by volume of amyl alcohol with 1 volume of ethyl ether

"For visual comparisons a solution of copper sulfate in water containing 8 gm of GuSO₄ 5H₂O per liter will match an extract containing 0.02 mg of Co per 10 cc. For colorimetric comparison a calibration curve for the colorimeter is established giving colorimeter readings against mg of cobalt."

Figure 6 and table 9 are the calibration curve used and a list of factors for converting curve readings to pot cobalt.

Table 9 -----

Factors	for Conve	rting .	ng Co (fre	on graph	Fig. 6)	to % Co *
Sample wt (sms)	50	100	Dilution 200	(mls) 250	500	1000
2.00	0.5	1	2	2.5	5	10
1.00	1	2	4	5	10	20
0.50	2	4	8	10	20	40
0.25	4	8	16	20	40	80
0.20	5	10	20	40	80	160
0.10	10	20	40	80	160	320

a aliquote taken for complexing

By the selection of the proper dilution, samples containing any amount of cobalt can be analyzed. To get the % cobalt in a sample multiply mg of cobalt in 5 ml aliquot (from calibration curve) by the appropriate factor in table 9.

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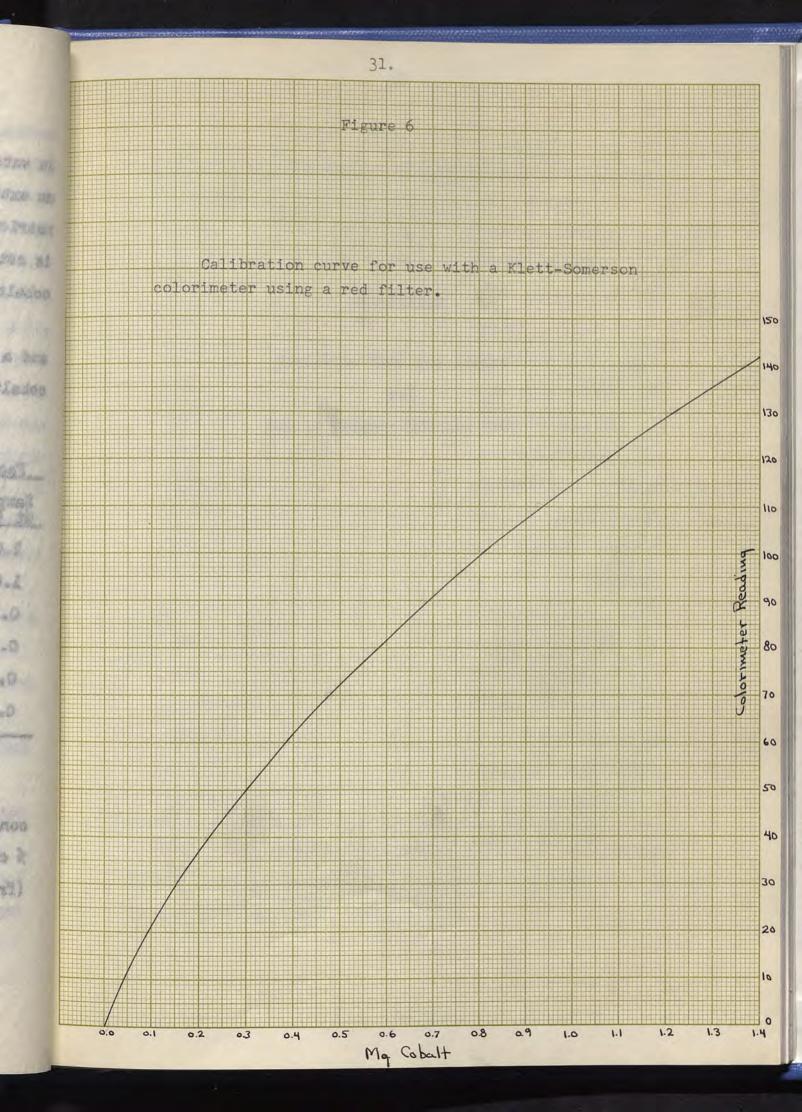


Table 13. Reasured GAME. 1. 325 APPENDIX B Flotation Test Log Sheets Asys manchate 301 and 330, Ent Key to Reagent Symbols Used Suppor milfare RaMON feno, Sydroohlaric sold San Person 610 Po_(00,)_ * All rangents used except Tarmour F and preducts

of the American Cycanadd Co. Termony 7 is a pine wil supplied by the Herculas Poster Company.

TATION TEST LOG SHEET

DINT OF	TINE	NDITIO	-	Tabl	e 10	KOVATS POUNDS PER YON
DDITICH	Leins	EPALOE	Key	to Passa	-	6-6 0000, Paper 7-7
Bried	130	60	IZO,3	to Reage	au Sym	± 2100
Cant #1	Symt	ol	10.5	0.08	8.10	Reagent
	Lime		1	1.1		Commercial Lime
Canal #2	Na Ae	ro	1			Sodium Aerofloat
23.04	X 325		10m			Aero xanthate 325
Cond 13	I-F	-	2.5		-	Yarmour F Pine Oil
Figh .	208	-	1000		1	Aerofloat 208
	301			12 132		Aero xanthate 301
123	350,	Z-6	James de			Aero xanthate 350
	CuSO4					copper sulfate
	H2 504					concentrated sulfuric acid
	HCl	1	and the second	ME TALLUR	GICAL 201	Conc. Hydrochloric acid
PRODUCT	404	100		Assars		Aero promoter 404
-1 (Qu)	77		55		1	Aerofroth 77 frother
Cull (Me)	A 238		3.0	17		Aerofloat 238
0-3 (00)	303		.20	1212		Aero xanthate 303
Vatto	NaCn		06 1	1.		Sodium cyanide
	Na-Fe		Pick I		1	Sodium ferro-cyanide
-	KMn04	1	198 1			Potassium permanganate
	610	-	N P	2.2.5.8	1	Aero depressant 610
	Feg (St	0, 1,	1			Ferrous sulfate

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* All reagents used except Yarmour F are products of the American Cyanamid Co. Yarmour F is a pine oil supplied by the Hercules Powder Company.

ATION TEST L	. 11/52 .0G SHI	EET			34	TABLE N	o. ackbi	rd	-	TEST NO).	
				CON	ITIONS							
POINT OF	C	ONDITION	IS	1. 12				POUNDS	S PER TO	N		
ADDITION	TIME	SOLIDS	PH	lime	208	301	2-6	Cu50,	H-SO,	Y-F	1	
Grind	10	60	10.5	8.0								
Cond #1	2	20	10.5		0.08	0.12		•				
Flot		79					- 1000			0.04		
Cond #2	2		Ħ				0.08					
Flot		-	97 80							0.04		
Cond #3	3	27	2.5				0.12	0.15	12.0			
Flot	1. 1. 17	19	11			-		-	- 194	0.04		

MARKS

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Td

			М	ETALLURGIC	AL RESUL	TS				
PRODUCT	%		A	SSAYS				% D1	STRIBUTION	
	WEIGHT	Co					Co			
C-1 (Cu)		0.35					2.8			
C-2 (Pe)		0.58					8.3			
C-3 (Co)		6.80					35.3			
Tails		0.04					3.6			
		0.0								
	36.1		19.0							

ATIO OF CONCENTRATION

TATION TEST	LOG SH	EET				TABLE N	o. ackbi	rd		TEST NO.	
				COWE	ITIONS	AND REA	GENTS				
POINT OF	С	ONDITION	IS			R	EAGENTS	POUNDS	PER TO	N	
ADDITION	TIME	SOL 105	PH	lime	301	208	Z-6	CuSOL	H250,	Y-F	
Grind	10	60	10.5	8.0		1					
Cond #1	- 3	20			0.08	0.08			1	1	
Flot		Ħ	Ħ	1.00	-				1.5.4	0.01	
Cond #2	2		.11			-	0.08				
Flot		Ħ	- 11	- 6							
Cond #3	3		3				0.12	0.20	11.0		
Flot		Ħ								0.04	

WARKS

		METALLUR	GICAL RESULTS
PRODUCT	%	ASSAYS	% DISTRIBUTION
	WEIGHT	Co	Co
Conc #1	7.5	0-44	4.2
Conc #2	7.6	0.56	7.6
Conc #3	10.7	4-7	45.8
Tails	74.0	0.45	42.6
-			

ATIO OF CONCENTRATION

TATION TEST							lackb	ird		3			
	1			CONC	TIONS	AND RE	AGENTS						
POINT OF	L	ONDITION	IS		A		REAGENTS	POUNDS	PER TO	N			
ADDITION	TIME	SOLIDS	PH	404	301	2-6	CuSO.	H-90.	77	1-2			
Grind	10	60	5	1.545		13 10	- tento			19.70	C/A		
Cond #1	2	20	17	0.25	0.10		" Grant "				0 2 203	9.	
Rougher Flot	80 (j. 19	8 # .55	樽	WE R	1100	1111	6/24		0.08	040	30607		
Cond #2	2	10	3	3.5		0.10	0.20	5.0					
Flot		10	17						0.04				
			1.4.5	1911									
		1. 200		=			11						
127													

MARKS

				ETALLURGIC	AL RESUL	TS				o ta	
PRODUCT	%		A	SSAYS				% DIS	TRIBUTI	ON	
	WEIGHT	Go					Co				
Cleaner Conc	18.8	3.4					82.8				
Cheener Tail	4.7	1.2					7.3				
Rougher Taj l	76.0	0.1					9.3				
1 2 7 -									10.00		
							-				
											_

TIO OF CONCENTRATION

ATION TEST	LOG SH	EET				TABLE N	o. Lackbi	rd		TEST NO		
	-			CONC	TIONS	AND REA	GENTS					
OINT OF	С	ONDITION	S			R	EAGENTS	POUNDS	PER TO	N		
DDITION	TIME	SOLIDS	P H	limo	208	301	NaCN	H2801	(582)	Y-F	-	
Grind	12	60	9.5	8.0		Constit.		(21)-			Den and	11
Cond #1	4	20		1.1810	0.12	0.08	0.12			a (1	1000	
Flot	Sec. Ro	17	88	of day				1 - 1-10		0.04		
Cond #2	3	11	2.5			0.08		12.0	0.12			
Flot	1	19								0.04		
	704		- 10			-	-				1 - 0	
_		de semi-la			2-							
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	1			ETALLURGIC	AL RESUL	13	1			110 11
PRODUCT	%		A:	SSAYS				% DIS	STRIBUTI	ON
	WEIGHT	Co					Co			
Cu Conc	7.5	0.24					2.2	1.4	and the	
Co-Fe Conc	18.9	3.48			-	1.4	83.8			
lails	73.6	0.15	4.4.4		·		14.0			
-	nie w	×		Sec. 10				1.14	nr-gai	
	1.1-1X.5e			11- *				3054	11.11	25.1
-	1				-					
				Generation of						
Y										

IO OF CONCENTRATION

					_		ackbi	TLAT		5		
	C	ONDITION		CONC	TIONS	AND REA						
	TIME	% SOLIDS	PH	11ma	203	301			S PER TO			
Grind	10	60	9.5	8.0				-		2=23	Y-P	
Cond #1	3	20	-		0.08	0.16	0,20					
Cu Flot			11								0.04	
Cond /2	3	**	6.0		0.06			9.0	0.10	0.15		12.5
Pe-Co Flot		-	6.0								0.04	
							-					

		· · · · ·		М	ETALLURGI	AL RESUL	TS		1 7			
	PRODUCT	%		A	SSAYS				% DIS	TRIBUTI	ON	
L	1999	WEIGHT	Eo					Co	1			
L	Conc #1	7.8	0.36					3.6	1			
L	Cone 2	19.5	2.38		4		_	72.4	1.1.4.200			
L	Tails	72.7	0.30					25.0				
			-			x						
L												
									1			
L										0.0		

RATIO OF CONCENTRATION

				VUILD	TITONS	AND REA	GENTS				
POINT OF	c	ONDITION	S					POUNDS	PER TO	 N	 L.
ADDITION	TIME	SOL 105	РH	11mm	208	301	350	H-80	YF		
Grind	10	60	9.5	8.0							
Cond #1	4	20	12		6.08	0.1:					
Flot		*	Ħ						0.04		
Cend #2	3	19	2.5				0.20	11.0			
Flot			et						0.08		

			М	ETALLURGIO	AL RESUL	TS			
PRODUCT	%	1	A	SSAYS				% DISTRIBUTIO	N
	WEIGHT	Co					Co		
Conc 1	6.8	0.36					3.0		
Conc 2	19.2	3.80					88.3		
Tails	74.0	0.09					8-2		
	-								
					1				
1 1 1 1 1									

				CONI	DITIONS	AND REA						
OINT OF		ONDITION	15	-		R	EAGENTS	POUNDS	PER TO	4		
DDITION	TIME	SOLIDS	PH	Line	H2SO	GuSO,	Z-6	301	Y-F	208		
Grind	13	60	5									
Cond #1	5	20	5		3.0	0.10	0.25					
Bulk Flot		17	5						0.0			
Cond #2	5	10	10.5	6.6				0.12		80-0		
Flot	3.0		10.5					5	0.04			
game and the												

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REMARKS

			ME	TALLURGIC	AL RESULT	rs				
PRODUCT	%		AS	SAYS				OISTRIB	NOITL	
	WEIGHT	Co			1		Go			
Rougher Tail	72.9	0.36					31.3			
Cleaner Tail	5.3	1.60					10.8			
Cleaner Conc	21.8	2.04					55.9			
-	1 m									

TATION TEST L	. 11/52 OG SH	EET Ju	me 2	1, 195	6	TABLE N	ackbi	Ird		TEST	NO.		
				COND	ITIONS	AND REA	GENTS			-		-	
POINT OF	С	ONDITION	S	1.1		R	EAGENTS	POUNDS	PERT	ON			
ADDITION	TIME	SOLIDS	PH	Haso	A-33				-		T	1	1
Grind	12	60	6										
Cond #1(a)	10	20	4	*									
(b)	2	11	4		0.2	t l			-				
Flot (bulk)	Ħ	4					0.04					
Cond #2(a)	10	10	10				10.4		-				
(b)	2	W	W			0.10							
Flot		19	17					0.04					

A-33 stage added 0.08 sa.

* Acid quantity - to give desired pH

	1		METALLURGICAL RESUL	LTS	
PRODUCT	%	-	ASSAYS	% DIS	TRIBUTION
	WEIGHT	Co		Co	
Rougher Teil	72.1	0.05		4-7	
Cleaner	13.3	3.40		82.7	
Cleaner Tail	9.6	1.0		12.6	

RATIO OF CONCENTRATION

			inly 1	-	A REAL PROPERTY AND INCOME.	AND REA	AFHTS	1 =0	_	0	-	_
POINT OF	0	ONDITION	IS					S POUNDS	PER TO	N		
ADDITION	TIME	SOLIDS	PH	line	Na			CuSO				 -
Grind	10	60	10.0	8.0								
Cond #1	10	20	10.0		0.10							
Flot		10	Ħ			-			0.08			
Cond #2	3	69	8.0			0.10	*		-		1	
Flot		N	Ħ						0.01		-	
Cond #3	3	19	3			0.10	*	0.20				
Flot		-	ti						0.04			

PRODUCT	%	ASSAYS	IRGICAL RESULTS	% DISTRIBUT	ION
PRODUCT	WEIGHT	Co	Co		
C-1	7-1	0.28	1.8	1	
C-2	110.00	0.28	5.5		
C-3	1.0	5.5	86.5		
Tails		0.06	6.2		

TATION TEST	. 11/52 .06 SHI	EET J	uly 6	. 195		43 TABLE N BL	o. ackbi	rd		TEST N	0.	
				CONE	TIONS	AND REA	GENTS					-
POINT OF		ONDITION	IS	-		R	EAGENTS	POUNDS	PER TO	N		
ADDITION	TIME	SOLIDS	РH	lime	RE	Y-F	325	Cu30,	HC1			
Grind	10	60	10.5	9.0								
Cond #1	10	20	10.5		0.15							
Flot	224		19	10-10		0.04						
Cond #2	3		4	(b)(b)	0.10	5.35			*			
Flot	15 10	18	Ħ		0.10	0.04		1				
Cond #3	2	-	3				0.10	0.20	*			
Flot			22			0.04		- Sier	1. 1	N		
	8 10		61			V-form				des al		

			М	ETALLURGICAL	RESUL	rs	1	1.1		SILC	
PRODUCT	%		A	SSAYS		-		% D1	STRIBUTI	ON	
	WEIGHT	Co				11 -	Co			6 UQ5	
<u>C-1</u>	7.1	0.36		-			4.5				
C-2	13.5	1.80				. 40	43.6				
C-3	7.2	3.3					42.8				
Tails	72.2	0.07	-				9.1				
						1	1				

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ATION TEST	LUG SH	EEI J	uly 6				lackb	ird		TEST NO.	
	1			CON	DITIONS	AND REA	GENTS				
POINT OF		ONDITION	S	-		F	REAGENTS	POUNDS	PER TOP	N	
ADDITION	TIME	SOLIDS	РH	lime	Lord S	303	350	T-F	CuSQ.	HCI	
Grind	10	60	10.5								
Cond #1	10	20	10.5		0.1						
Flot			W					0.01			
Cond #2	3		8.0			0.10				*	
Flot	1 - 1	88						0.04			
Cond #3	2	89	3				0.10		0,20	*	
Flot	1		ŧ		200			0.08	1		

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REMARKS

Par Se	T		М	ETALLURGIC	AL RESUL	TS				
PRODUCT	%		A	SSAYS				% D1	STRIBUT	ION
1000	WEIGHT	Co					Co			Law and the second
C-1	5.4	0.40					3.8		- 18	
C-2	10.9	0.28					5.4			
C-3	13.6	3.4					63.3			
Tails	70.2	0.06					7.5		1.5	
		-					1			
		1.00						2		

TATION TEST	LOG SH	EEI S	ept.	13. 1	the state of the local division in which the local division is not the local division of the local division is not the local division of the local divisio		ackbi	lrd		TEST NO		
				COW	TIONS	AND REA	GENTS					
POINT OF	C	ONDITION	S			R	EAGENT	S POUNDS	PER TO	N		
ADDITION	TINE	SOLIDS	РH	line	Na		HCL	CuSO.	Y-F			
Grind	16	60	Ģ	8.0		_						
Cond #1	10	20	9	20	0.10							
Flot		17	-						0.04			
Cond #2	3	Ħ	7.5			0.10	*					
Flot		- 11	Ħ						0.01			
Cond #3	2	11	3			0.10	*	0.20				
Flot		Ħ	n	1.4					0.04			

				ETALLURGI	CAL RESUL	TS			X		
PRODUCT	%		A	SSAYS				% D1	STRIBUTI	ON	
	WEIGHT	<u> </u>					Co				190
C-1	4.2	0.48					2.8				
0-2	9.8	0.44					6.0				
C-3	10.8	5.70					84.0				
Tails	75.2	0.07					7.2				

	LOG SH			17, 1	other Designation of the local division of t		ackb	44 VA		13	-	
POINT OF	0	ONDITION	IS			AND REA		S POUNDS	PER TO	N		
ADDITION	TIME	% SOLIDS	PH	lime	Na aero	325	1	CuSQ.			1	T
Grind	20	60	8.0	8.0	1.64	101					1	
Cond #1	10	20	9.0	2.0	0.10	lun						10
Flot			11	1			1 still		0.04			
Cond #2	3	19	7.5			0.10	*					
Flot	-	17	19					2.2	0.04	100		
Cond #3	2	89	3			0.10	*	0.20				
Flot	10.55	12	**					1	0.08			

				METALLURGICAL R	ESULTS				
	PRODUCT	%		ASSAYS		%	DISTRIBUTI	ON	
L		WEIGHT	Co			Co			
L	C-1	2.0	0.40			0.9			
-	C-2	3.5	0.40			1.5			
-	0-3	22.6	3.7			94.4			
-	Tails	73.9	0.04			3.2			
-									
-							_		
-				-					

ATION TEST	10			19, 1		AND REA	ackbi	ra		14			
POINT OF	c	ONDITION	s		TTONS			S POUNDS	DED TO				
ADDITION	TIME	SOLIDS	PH	lime	Na	325	HCL		KMinQ	77			1
Grind	20	60	8	8.0									
Cond #1	10	20	9	2.0	0.10								
Flot		FE	Ħ					0.04	0,43				
Cond #2	3	17	7.5			0.10	*						
Flot		24	W					0.04	-				
Cond #3	2	Ħ	3			0.10	*						
								0.01					
Flot		-	19					0.04			_		
#3 Conca			5					0.04	0.3	0.6			
#3 Conc: RKS C1 2x	000 g MnC,	n test	5 5 ; cha	rge pyrit	e in	clear	ler -		0.3			enutes	
#3 Conc: RKS C1 2x	Mn0, 7 - ⁴ u		5 5 ; cha	pyrit th mod	ETALLUR	clear C. GICAL RI			0.3	ful			10249
#3 Conc: RKS C1 2x	Mn0, 7 - 4u %	m test to dep sed as	5 5 cha press fro	pyrit th mod	-				0.3		RIBUTIO		
PRODUCT	Mn0, 7 - ⁴ u	n test	5 5 cha press fro	pyrit th mod	ETALLUR				0.3	ful	RIBUTIO		
#3 <u>Conc</u> RKS <u>Cl 2x</u> 2 K 7	Mn0, 7 - 4u %	m test to dep sed as	5 5 cha press fro	pyrit th mod	ETALLUR				0.3 0.2	ful	RIBUTIO		
PRODUCT	МпО, 7 - ч жетант 5.5	n test to dep sed as Co	5 5 cha press fro	pyrit th mod	ETALLUR				0.3 0.2 ccess	ful	RIBUTIO		
PRODUCT Combined G-1; C-2	MnO, 7 - 4 % WEIGHT 5.5 18 2.5	m test to dep sed as Co 0.6 9 2.7	5 5 5 5 5 7 6 7 6	pyrit th mod	ETALLUR				0.3 0.2 ccess Go 3.9	ful	RIBUTI		
PRODUCT Combined G-1; C-2 #1 Cl Tei	MnO, 7 - 4 weight 5.5 1s 2.4 1s 1.4	m test to dep sed as Co 0.6 9 2.7 0 5.8	5 5 cha press fro 6 0	pyrit th mod	ETALLUR			unsu	0.3 0.2 ccess ccess ccess 2.9 9.4	ful	RIBUTI		
PRODUCT Combined C-1; C-2 #1 Cl Tei #2 Cl Tei	MnO, 7 - 4 weight 5.5 1s 2.4 1s 1.4	m test to dep sed as 0.6 9 2.7 0 5.8 3 3.8	5 5 5 5 7 7 8 7 7 7 7 7 7 7 7 7 7 7 7 7	pyrit th mod	ETALLUR			unsu	0.3 0.2 ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess ccess cces ccess ccess ccess ccess cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces ccess cces ccess ccess ccess ccess cces cces cces cces cces cces ccess cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cces cc	ful	RIBUTIO		

		EET Se				AND REA	ACKbi	<u>uru</u>		15		
POINT OF	С	ONDITION	IS					SPOUNDS	PER TOP	4		
ADDITION	TIME	% SOLIDS	PH	line	Na			CuSO.				1
Grind	20	60	8.0	8.0	I							
Cond #1	10	20	9.0	2.0	0.10							
Flot	11	11	ft.						0.04			
Cond #2	3	65	-			0.10					_	
Flot		67	-			0.10			0.01			
Cond #3	2	Ħ	3			0.10	*	0.20		-		
Flot	100		12			-			0.04			

		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	METALLUR	GICAL RESUL	TS					
PRODUCT	%		ASSAYS				% DIS	TRIBUTI	ON	
00	WEIGHT	Co		-		Co	chi s			
C-1	5.0	0.64				3.7	-		Sec.	
C-2	16.9	1.12				22.1				
C-3	5.5	10.2				65.7				
Tails	72.6	0.10				8.5				
- 1 (rg)	0.00									
31	in st									
7.10									1	
1.10	1000 1									

	LOG SH			and the second	DITIONS			bird		16	
OINT OF	с	ONDITION	S			R	EAGEN	TS POUNDS	PER TON		
DDITION	TIME	SOLIDS	РH	1100	Na	325	Hei	CuSO	Y		
Grind	20	60	8.0	8.0							
Cond-#1	10	20	9.5	3.0	0.1)					
Flot		29	11						0.04		
Cond #2	3	11	11			0.10		_			
Flot		- 11	11			0.10			0.04		
Cond #3	2	87	3			0.10	-	0.20		Shall 1	
Flot		11	11						0.08		

				METALLURGICAL RESULT	S	
	PRODUCT	%		ASSAYS	%	DISTRIBUTION
l	PRODUCT	WEIGHT	Co		Co	
-	<u>C-1</u>	3.6	0.40		1.7	
-	<u>C-2</u>	16.4	0.52		20.6	
-	<u>C-3</u>	6.4	10.5		84.0	
-	Taila	73.6	0.04		3.7	
-						
-						
T						

ATION TEST	LOG SHE			0.0110	ITLANC	Black		<u>i</u>		17	,	
OF OF	c		s	CONU	TITONS	AND REA		SPOUNDS	PER TO			
ADDITION	TIME	% SOLIDS	РH	lime	Na	T	RCI					 T
Grind	20	60	7.5	6.0								
Cond #1	10	20	7.5		0.10							
Flot		**	17						0.04			
Cond #2	3	12	11			0.10						
Flot		. 19	Ħ			0.10			0.04			
Cond #3	2	11	3			0,10	*	0.20				
Flot			Ħ						0.08			

IEMARKS

i.				METALLUF	RGICAL RESULTS				
Г	PRODUCT	%		ASSAYS		%	DISTRIBUTI	ON	
L	PRODUCT	WEIGHT	Co			Co			
-	C-1	4.0	0.88			4.4			
-	C-2	16.8	1.80			40.2			
	C-3	6.7	5.4			46.2			
4	Tails	72.5	0.10			9.2			
L									
_	1.00							-	
		-							

				CON	DITIONS	AND REA	OCH13						
OINT OF		ONDITION	IS		E E E	37		S POUNDS		4			
DDITION	TIME	SOLIDS	РH	11.00	arg	325	HC1	CuSQ	Y-F				
Grind	20	60	8.5	8.0		-							
Cond #1	10	20	10.0	6.0	0.10								
Flot		Ħ							0.04				
Cond #2	3		-			0.10							
Flot		14	44			0.10			0.08	_			
THE R. L.													
Cond #3	2	*	3			0.10	举	0.20					
Cond #3 Flot		49 49	3			0.10	*		0.04				
Flot	2	-	69			0.10	*			-			
Plot KS		-	69		METALLUF								
Plot KS	%		69		METALLUF					% D1	STRIBU	TION	
Flot			29							% D1	STRIBU	TION	
Flot	%	••	0						0.04	% D1	STRIBU	TION	
Plot KS PRODUCT	% WE I GH T	() () () ()	0						0.04	% DI	STRIBU	TION	
Plot KS PRODUCT	% WE I GH T & 6	0.1	o 34 36						0.04 Co 2.1	% D1	STRIBU	TION	

ATION TEST			ept.			AND REA	Lacki	DITC		19		
OINT OF	c	ONDITIO	vs	UNI	111043			S POUNDS	PER TO	N		
DDITION	TIME	SOLIDS	PH	lime	Na	325	HCI	CuSO.	T-F			
Grind	20	60	8.0	8.0								
Cond #1	10	20	10.5	10.0	0.10		-					
Flot		e	89						0.04		-	
Cond 12	3	50				0.10						
Flot		19				0.10			0.04			
Cond #3	2	29	3			0.10	aju	0.20				
Flot		19	#						0.04			

			METALL	URGICAL RES	BULTS					
PRODUCT	%		ASSAYS	;			% DIS	TRIBUTI	ON	
	WEIGHT	Ga				Co				
C-1	4.0	0.40				2.1				
C-2	9-4	0.36				4.3				
C-3	14.0	4.9				88.5				
Tails	72.6	0-03				5.1				

ATION TEST						AND REA	ACKDI			2	 	_
POINT OF	C	ONDITION	IS					S POUNDS	PER TO	N	 	
ADDITION	TIME	% SOLIDS	PH	Lime	Na Barg	YI	-	CuSO.				1
Grind	20	60	8.5	8.0								
Cond #1	10	20	9.5	3.0	0.10					0.11		
Flot		Ħ	-						0.04			
Cond #2	3		-			0.10						
Flot			Ħ			0.10			0.04			
Cond #3	2		3			0.10	*	0.20				
Flot		-	-						0.08			

PRODUCT	%	ASSAYS	% (ISTRIBUTION
	WEIGHT	Co	Co	
C-1	1.3	1.04	2.1	
C-2	7.3	0.44	4.9	
0-3	16.2	0.5	12.5	
Tails	75.2	0.7	80.5	

	A. 11/52	EET		.*		TABLE NO).		1	TEST NO.
TION TEST		Se	pt. 2			B1:	ackbi	ird		21
	1			COND	ITIONS	AND REA	GENTS		0	
OINT OF		ONDITION	S				AGENT	S POUNDS	PER TOP	1
DDITION	TIME	SOLIDS	РН	line	Na	325	HC1	CuSQ.	NamFe	Y-F
Grind	20	60	8.5	8.0						
Cond #1	10	20	9.5	4.0	0.10				0.10	10.00
Flot		H	77						0.11	0.04
Cond #2	3		押			0.10				
Flot			.19			0.10			-	0.04
Cond #3	2	17	3			0.10	*	0.20		
Flot			19							0.08
and the sector										1
	76			MI	ETALLUR SSAYS				Pan Mp	
PRODUCT	% WEIGHT			MI	ETALLUR				Co	% DISTRIBUTION
Special Contract		Co		MI	ETALLUR					
PRODUCT C-1 C-2	WEIGHT	- Co 0.		MI	ETALLUR				Co	
C-1	WEIGHT	- Co 0.	42	MI	ETALLUR				Co 2.0	

an continer

	LOG SHI		Oct.			AND REAL	ACK'DI BENTS			22		
OINT OF	C	ONDITION	s					S POUNDS	PER TO	N		
DDITION	TIME	SOLIDS	PH	lime	aero	325	HC1	CuSO,	Y-F	KMn0		
Grind	20	60	8.5	8.0							4	
Cond #1	10	20	9.9	3.0	0.1	0	1		1.1	0.10	1-	
Flot	-		\$7		4				0.04			
Cond #2	3	11	17			0.10		12.17				
Flot	1.24	- 18	12			0.10	1 4		0.04			
Cond #3	2	- 18	3			0.10	*	0.20				
Flot		18	18					-	0.08			

PRODUCT	%	ASSAYS	 % DIST	RIBUTION
	WEIGHT	Co	Co	
C-1	6.5	0.63	6.6	
<u>C-2</u>	14-8	0.96	 21.0	
C-3	5.0	4.2	31.1	
Tails	73.7	0.38	41.3	
- ×.				

TION TEST				. 195	the second s		Lacki	ard		23	
DOINT OF	с	ONDITION	s	CONL		AND REA		SPOUNDS	PER TO)N	
ADDITION	TIME	SOLIDS	РH	lime	aaro		HC1	Cusol.		Y-F	A-33
Grind	20	60	8.5	8.0							
Cond #1	10	20	9.5	3.0	0.10				0.5		
Flot		38						1.0		0.04	
Cond #2	3	12				0.10					
Flot		30				0.10				0.04	
Cond #3	2	17	3			0.10	14	0.20			
Flot		re								0.08	
Scavenge		11									0.20

A-33 stage added -- CoAsS still in tails 610 to depress As minerals

			METALLURGICAL RESUL	TS	
PRODUCT	%		ASSAYS	%	DISTRIBUTION
	WEIGHT	Co		Co	
C-1	5.0	0.43		3.6	
<u>C-2</u>	16.0	1.02		24.5	
0-3	1.9	1.4		3.9	_
Scay. Conc	2.3	8.2		34.8	
Tails	74.3	0.3		33.2	

	LOG SH			, 1950			lackb	TLU		24	
OINT OF	с	ONDITION	IS	COND	111043	AND REA		S POUNDS	PER TO	N	
DDITION	TIME	SOLIDS	PH	Line	Baro		HCI		CuSO		
Grind	20	60	7.5	8.0							
Cond #1	10	20	9.5	6.0	0.10						
Flot		10	Ħ					0.04			
Cond #2	3	Ħ	Ħ			0.10					
Flot		99	-			0.25		0.04			
Cond #3	2		3			0.10	*		0.20		
Flot		Ħ	11					0.08			

			ETALLURGI	AL REDUL	10					
PRODUCT	%		 SSAYS				% D19	TRIBUTI	ON	
	WEIGHT	Co				Co	-			
C-1	5.4	0.40				3.0)			
<u>C-2</u>	16.1	0.52				11.9				
0-3	5.0	11.35	 			80.9				
Tails	73.5	0.04				4.2				

TION TEST				con		AND REA	GENTS			25		
INT OF		NDITION	15	100.000		R	EAGENTS	POUNDS	PER TO	N		
DITION	TIME MINS	SOLIDS	РH	lime	Rero	325	HCl	Y-F	CuSO.			
Grind	20	60	8.0	8.0								
Cond #1	10	20	9.5	6.0	0.10							
Flot		11	¥¥					0.04				
Cond #2	3	W	-			0.10						
Flot		Ħ	99			0.20		0.04				
Cond #3	2	-	3			0.10	*		0.20			
	* 325	n in F	n s flo	at sta	age ac	dded (0.10#	0.08		ime		
	* 325					dded (ime		
5	%			ę.							TRIBUT	ION
S			s flo	ę.	ETALLUR						TRIBUT	ION
Flot s RODUCT	%	in F	e flo	ę.	ETALLUR				8a. t.		TRIBUT	ION
s RODUCT	% WEIGHT	in Fo	e flo	ę.	ETALLUR			/ton	ea. t		TRIBUT	ION
S RODUCT G_1 G_2	% WEIGHT 4.5	in Fo	s flo	ę.	ETALLUR			/ton	ea. t		TRIBUT	ION
S	% WEIGHT 4.5 18.5	in F C 0.1 1.6	e flo	ę.	ETALLUR			/ton	ea. t. Co 2.9 27-4		TRIBUT	ION

TATION TEST			Oct.				ackbi	rd		26		
	T	12000		COND	ITIONS	AND REA	GENTS					
POINT OF	TIME SOLIDS PH	IS			R	EAGENTS	POUNDS	PER TOP	4			
ADDITION		SOLIDS	PH	1100	aaro	325	HCL	T- 7	A-33		1	Г
Grind	20	60	9.5	8.0								
Cond #1	10	20	11.0	4.0	0.10							t
Flot			-					0.04				
Cond #2	3	HP.	12			0.10						
Flot		10	89			0.10		0.04				
Cond #3	2	n	3				*		0.11			
Flot		12	77					0.03				

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		METALLURG	ICAL RESULTS	
PRODUCT	%	ASSAYS	7	6 DISTRIBUTION
	WEIGHT	Co	Co	
Cu Conc	5.5	0.46	3.0	
Fe Conc	12.7	0.36	5.9	
Ce Cone	10.0	6.70	86.6	
Tails	71.8	0.05	4.5	

RATIO OF CONCENTRATION

	LOG SH		Oct.			AND REA	ackbi	ra		27	
POINT OF	С	ONDITIO	NS	-		R		SPOUNDS	PER TO		
ADDITION	TIME	SOLIDS	РH	lime	Na	325	HCI	Y-F	A-33		
Grind	20	60	9.5	8.0							
	10	20	11.5	6.0	0.10						
Flot		Ħ	Ħ					0.01			
Cond #2	3	-	FE			0.10					
Flot		PT	19			0.10		0.04			
Cond #3	2	11	3				×e		0.11		
Flot		11	.11					0.08			

PRODUCT	%	ASSAYS		% DISTRIBUTION
	WEIGHT	Co	Co	
Cu Conc	3.7	0.44	1.9	
Fe Conc	8.2	0.40	4.0	
Co Conc	15.9	4.8	91.5	
Tails	72.2	0.03	2.6	

		IEET O				AND REA	GENTS			28	_		
POINT OF	C	ONDITION	IS			R	EAGENTS	POUNDS	PER TO	٠			
ADDITION	TIME	SOLIDS	PH	lime	aer(325	HC1	Y-F					
Grind	20	60	9.5	8.0									
Cond #1	10	20	10.5-	3.0	0.10								
Flot		11	tt					0.01					
Cond #2	3	R	18			0.10							
Flot		19	21			0.10		0.04					
Cond #3	2	-	3				*		0.11				
Flot		19	0					0.08					

SHOW COLLEGE

REMARKS

		METALLURG	ICAL RESULTS			
PRODUCT	%	ASSAYS		% DI	STRIBUT	ION
	WEIGHT	Co	Co			
Cu Conc	5.6	0.48	3.5			
Fe Conc	11.8	0.40	6.1			
Co Conc	9.6	7.0	86.6			
Tails	73.0	0.04	3.8			

TATION TEST	Log on		Oct.			AND REA	Lack	ird		TEST N		
POINT OF	C	ONDITIO	NS					S POUNDS	PER TO	N	 	
ADDITION	TIME	% SOLIDS	PH	lime	Na	325	HCI	Y.F	A-33			1
Grind	20	60	9.5	8.0								
Cond #1	10	20	10.5	2.0	0.10							
Flot		-	=					0.04		5		1
Cond #2	3	88	-			0.10			-			
Flot	-		**			0.10		0.04		1	1	
Cond #3	2	-	3	-			*		0.11			
Flot		13		11/1	h /j			0.08				

	r	METALLURG	ICAL RESULTS
PRODUCT	%	ASSAYS	% DISTRIBUTION
	WEIGHT	Co	Co.
Cu Cone	4.0	0.40	1.9
Fe Cone	13.9	0.36	6.1
Co Conc	10.2	7.2	88.5
Tetls	71.9	0.04	3.5

				COND	ITIONS	AND REA	ACKDS			30		
POINT OF	С	ONDITION	S	1.1		Ri	EAGENTS	POUNDS	PER TO	N		
ADDITION	TIME	SOLIDS	PH	lime	aero	325	HCL	Y-F	A-33			1
Grind	20	60	9.5	810								
Cond #1	10	20	10.0	1.0	0.10	Anna I						
Flot						1		0.0				
Cond #2	3	11	Ħ			0.10	1					
Flot	Sure a	=	- 11		1	0.10	Nol-	0.0	-			
Cond #3	2	Ħ	3	2			*		0.1			
Flot		-	ŧ					0.0				

b

:to2

RODUCT	%		A	SSAYS	0	% D15	STRIBUTIO	N
	WEIGHT	Co			Go	199		
Cu Cone	3.6	0.38			1.9			
Fe Conc	16.6	0.44			 10.1			
Co Conc	5.1	11.4	-		80.6			
Tails	74.5	0.10	-		7.4			

	LOG SH			and the second se	L956	AND REA	GENTS			31	-		-
POINT OF	C	ONDITION	S					POUNDS	PER TO	4		-	
ADDITION	TIME	SOLIDS	PH	lime	Na	TI			A=33				T
Grind	20	60	9.5	8.0									
Cond #1	10	20	11		0.10								
Flot		W	Ħ					0.04					
Cond #2	3	11	Ħ			0.10							
Flot		IT	n			0.10		0.04					
Cond #3	2	17	3	-			*		0.11				
Flot		-	-	-	_			0.04					

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And and a	%		METALLURGICAL RESUL	% DISTR	BUTION
PRODUCT	WEIGHT	Co		Co	
Cu Conc	4.1	0.32		1.7	
Fe Conc	15.2	0.44	1	8.9	
Co Conc	5.2	12.2		82.4	
Fails	75.5	0.07		7.0	

ATION TEST I			ct. 1		the second s		ackbi	rd		32		
OINT OF	С	ONDITION	s	COND		AND REA		POUNDS	PER TON			
DITION	TIME	SOLIDS	РH	lime	aero	325	HC1					
Grind	20	60	8.5	7.0								
Cond #1	10	20			0.10						-	
Flot		Ħ	17					0.04				
Cond #2	3	-	Ħ			0.10						
Flot		17	17			0.10		0.04				
Cond #3	2	π	3				*		0.11			
Flot			#					0.08				

PRODUCT	%	ASS	AYS	% D	ISTRIBUTION
	WEIGHT	Co		Co	
Cu Conc	5.9	0.44		3.3	
Fe Conc	14.9	0.52		9.4	
Co Conc	5.2	11.9		77.6	
Tails	74.0	0.10		9.7	
		-			

ATION TEST				CON	DITIONS	AND RE	GENTS			33	
POINT OF	C	ONDITION	S			1	REAGENT	S POUNDS	PER TO	N	
ADDITION	TIM	SOLIDS	PH	lime	aero		HC1	Y-F	A-33		
Grind	20	60	7.5	6.0							
Gond #1	10	20	7.5		0.10						
Flot		11	11					0.04			
Cond #2	3		Ħ			0.10					
Plot		-	-			0.10		0.04			
Cond #3	2	89	3				*		0.11		
Flot			17					0.08	-		

PRODUCT	%	ASSAYS	%	DISTRIBUTI	DN
	WEIGHT	Go	Co		
Cu Conc	4.9	0.44	2.8		
Fe Conc	16.5	0.80	17.2		
Co Conc	4.1	12.2	64.6		
Tails	74.5	0.16	15.5		

	LOG SH			CON	056	AND REA	Ckbin GENTS			34	 	
POINT OF	C	ONDITION	IS					POUNDS	PER TO	N	 	
ADDITION	TIME	SOLIDS	PH	lime	asro	325		7-F	A-33			
Grind	20	60	9.5	8.0								
Cond #1	10	20	9.5		0.10							
Flot		Ħ	22					0.04				
Cond #2	3	80	Ħ			0.10						
Flot		*	Ħ			0.10		0.04				
Cond #3	2	11	5.5				¥:		0.11			
Flot		24	20					0.08				

RODUCT	%		ASSAYS	%	DISTRIBUTION
	WEIGHT	Co		Co	
Cu Cone	5.7	0.40		2.7	
Te Cone	16.4	0.52		10.4	
to Conc	3.3	15.8		60.6	
	74.6	0,30		26.3	
1.					_

	T		-	COM	UTITUM3	AND REA						
INT OF	TIME	ND ITION %	1		No		REAGENTS	POUNDS	PER TON		-	
DITION	MINS	SOLIDS	PH	line	Na	325	HCL	Y-F	A-31			
Grind	20	60	9.5	8.0			-			-		
Cond #1	10	20	9.5		0.10	1					-	
Flot		Ħ	9.5					0.01				
Cond #2	3	π	8.5			0.10						
Flot		**	8.5			0.10		0.01				
Cond #3	2	11	4.5				15 cc		0.11			
		12	4.5					0.08				
Flot		17	4.5		METALLUF	RGICAL F	RESULTS	0.08				
5	76	17	4.5		METALLUF	RGICAL F	RESULTS	0.08		DISTRIBU	TION	
	% WEIGHT		4.5			RGICAL F	RESULTS	0.08		DISTRIBU	TION	
3		C				RGICAL F	RESULTS	0.08	%	DISTRIBU	TION	
RODUCT	WEIGHT 6.84	C 0.	0			RGICAL F	RESULTS	0.08	% Co	DISTRIBU	TION	
RODUCT Cu Conc	WEIGHT 6.84 15.18	C 0. 0.	Q 42 48			RGICAL F	RESULTS	0.08	% Co 3.5%	DISTRIBU	TION	
RODUCT Cu Conc Fe Conc	WEIGHT 6.84 15.18	C 0. 0. 16.	0 42 48 2			RGICAL F	RESULTS		% Co 3.52 8.95	DISTRIBU	TION	

1.100

RATIO OF CONCENTRATION REMARK S

tot.

ATION TEST				COND	ITIONS	AND REA	GENTS					
POINT OF	C	ONDITION	IS			R	EAGENTS	POUNDS	PER TOP	1		
ODITION	TIME	SOLIDS	PH	lime	aaro	325	AC1	Y-F	A-33		1	1
Grind	20	60	9.5	8.0								
Cond #1	10	20	9.5		0.10							
Flot		19	9.5					0.04				
Cond #2	3		8.5			0.10						
Flot		H	8.5			0.10		0.04				
Cond #3	2	n	6.0				5 cc		0.11			
Flot			6.0	-				0,04			-	

	%	ASSAYS	CAL RESULTS	% DISTRIBUTION	6
PRODUCT	WEIGHT	Co	Co		
Cu Conc	4.74	0.38	2.4		
Fe Conc	16.16	0.48	10.5		
Co Conc	3.14	6.0	25.5		
Tails	75.96	0.60	61.6		-
	-				

)ct. 2	0.010			ackbi	r.a		- 2	37	
				COND	TTOMS	AND REA						
INT OF		ONDITIO	NS	- 3	1.8.00	R	EAGENTS	POUNDS	PER TO	N		
NITION	TIME	SOLIDS	PH	lime	Na Boro	325	HCI	I-F	4-33	<u>1</u>	· · · ·	
Grind	20	60	9.5	8.0			-			-		
Cond #1	10	20	9.5		0.10							
Flot		11	9.5					0.04				
Cond #2	3	Ħ	8.5			0.10						
Flot		tt	8.5			0.10		0.04				
Cond 3	2	57	7-7.5				0		0.11			
Flot		-	7-7.5					0.08	0			

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REMARKS

			ME	TALLURGIC	AL RESUL	TS					
PRODUCT	%		AS	SAYS				% DI	STRIBUT		
	WEIGHT	Co	1000		1000		Co			10-100	
Cu Conc	5.6	0.38				-10.2	2.3				
Fe Conc	15.7	0.16			5.1		9.4				
Co Conc	4.0	1.2	100	-	11.0		6.2				12
Taila	74-7	0.85		Arrise			81.5				
		0.53			-	-					

3861 PTD. IN U.S.	A. 11/52	T	0		1	71 TABLE NO			1	TEST NO.			
TATION TEST	LUG SAEL	-1	Uct.	26. 1º	1TIONS	B1	Cki	bird		38			_
	COM	DITION	s	UUND	111045 /			TS POUNDS	S PER TOP				
POINT OF ADDITION	TIME	SOL IDS	P H	lime	BR	325	HCI	1				-	
Grind	20	60	9.5	8.0									
Cond #1	10	20	9.5		0.10		_			-			
Flot		20	9.5					0.0	-				
Cond #2	3	H	8.5			0.10	- !!						
Flot		Ħ	8.5			0.10		0.0				_	
Cond #3	2		4.5				*	10.3	0.11				
Flot			4.5					0.0	8				
RKS								-					
RKS					ETALLURG	ICAL RE	SULTS	3		* DIS		0N	
PRODUCT	% WEIGHT			A	SSAYS	1	-			1	TRIBUTI	in a	
PRODUCT	WEIGHT	Co		A Cu	Fe	Ins	101	S	Co 1.00	Cu	Fe	Insol	
	WEIGHT	0.	36	A Cu 26.2	Fe 28	Ins 0 6	.2	S 31.2	1.99	Cu 84.0	Fe 6.2	Inso) 0.5	13 4
PRODUCT Cu Conc	WEIGHT	0.:	36	A Cu	Fe	Ins 0 6 2 5	.2	S	1.99	Cu 84.0 15.9	Fe 6.2 30.9	Inso) 0.5	13 4 68.1
PRODUCT Cu Conc Fe Conc	WEIGHT 4.36 15.45	0.	36 44 0	A Cu 26.2 1.4	55AYS Fe 28, 39,	Ins 0 6 2 5 9 11	.2	s 31.2 44.8	1.99 8.62 84.60	Cu 84.0 15.9	Fe 6.2 30.9 5.1	Insol 0.5 1.7	13 4 68.1 12.4
Cu Conc Fe Conc Co Conc	WEIGHT 4.36 15.45 4.46 75.73	0.	36 44 0 05	A Cu 26.2 1.4 Tr.	SSAYS Fe 28. 39. 22. 12.	Ins 0 6 2 5 9 11	•9 •9 •4	S 31.2 44.8 28.1 0.81	1.99 8.62 84.60	Cu 84.0 15.9	Fe 6.2 30.9 5.1	1.7 0.9	13 4 68.1 12.4

ATTIO OF/CONCENTRATION = 19:1

Vehicle						72							
FLUTATION TEST L	. 11/52 .06 SHI	EET	Oct.	26, 19	956	TABLE N	o. ackbig	rd		TEST NO).		
-				CONE	ITIONS	AND REA	GENTS				1	_	
POINT OF	C	ONDITION	IS			e B	EAGENTS	P OUND S	PER TON				
ADDITION	TIME MINS	SOLIDS	яH	lime	2010	325	H2904	A-33	Y-F				
Grind	20	60	9.5	8.0		_							
Cond #1	10	20	9.5		0.10								
Flot	1 10	20	9.5						0.04				
Cond #2	3	-	8.5			0.10							
Flot		11	8.5			0.10			0.04				
Cond #3	2	Ħ	3.5	1			29.0	0.11	1				
Flot		ŧ	3.5					Santi	0.08				
0.4			5.0										

			ME	TALLURGIC	AL RESUL	.TS					
PRODUCT	% WEIGHT	ASSAYS					% DISTRIBUTION				
		Co			27107		Co				
Cu Conc	5.60	0.36		di i			2.7			i.	
Fe Conc	16.28	0.44				1.8.5.2	9.5			1.1	
Co Conc	3.36	16.6	4	Uria.	-	11 miles	74+0			-	- ,
Tails	74.70	0.14		- 1			13.8			- Sec	
Calcula hds.	ea	0.755									
Co											

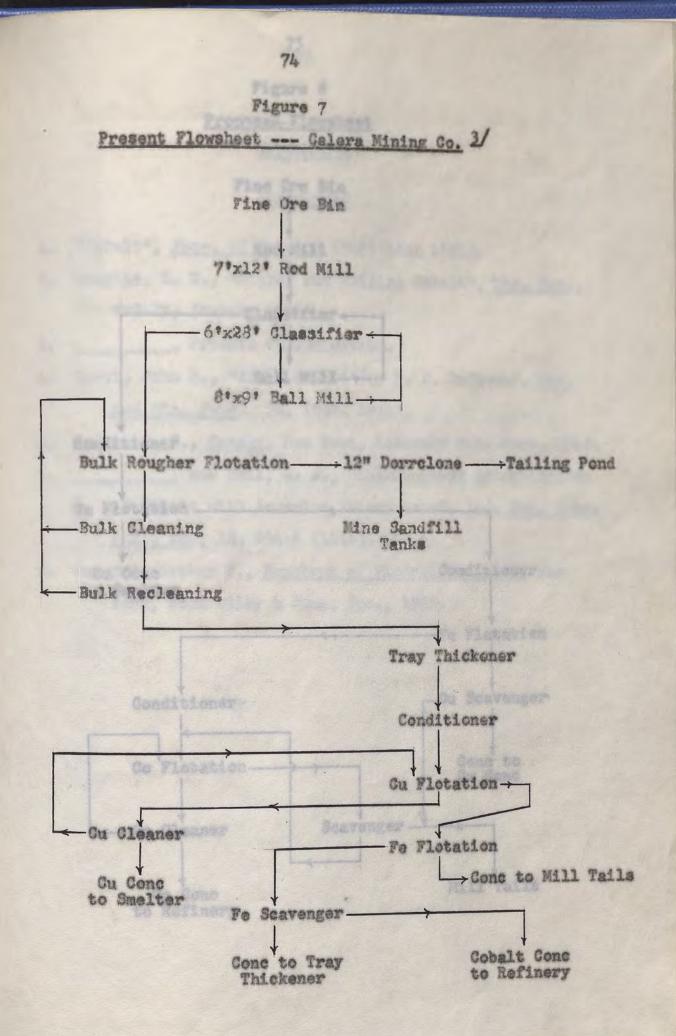
MATIO OF CONCENTRATION

APPENDIX C

Flowsheets

Ser Course

Reagents Points of Additi	on and Amounts (1bs/ton)
Rod Mill Sodium Sulfide	0.9
Bulk Flotation Potassium Amyl Xanthate Sodium Sulfide Potassium Ethyl Xanthate Sodium Aerofloat Methyl isobutyl Carbinol	0.25 0.30 0.10 0.10 (frother) as required
Bulk Cleaner Potassium Amyl Xanthate Sodium Sulfide Frother	0.25 0.25
Conditioner Lime Steam and Compressed Air	3.5
<u>Copper Flotation</u> Ethyl Xanthate Sodium Aerofloat Frother	0.013 0.013
<u>Iron Flotation</u> Potassium Amyl Xanthate Sodium Sulfide Aero Promoter 404 Frother	0.02 0.50 0.03
Iron Scavenger Potassium Amyl Xanthate Sodium Sulfide Frother	0.03 if required





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Proposed Flowsheet

VSSEDELY W

Fine Ore Bin

1. "debala", Jour. of Rod Mill 17-24 (Jan 1951).

2. Douglas, B. S., "Mining and Milling Gobalt", Mina Mar.

Classifier -

3. Private Communication,

Red I

7.

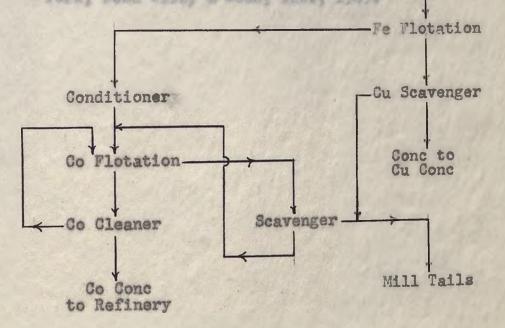
Bustl, John B., "I Ball Mill->- U. S. Berense", The

and Min. 2007.. 78. (Dec. 1951).

Conditioner Cu Flotation

Anal. Ed., 18, 264-5 (1946).

Cu Conc Conditioner



APPENDIX D

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