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Prepared for

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THE METALLURGICAL INVESTIGATION OF THE BREWER SULFIDE ORE

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HRI Project 5801
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THE METALLURGICAL INVESTIGATION OF THE BREWER SULFIDE ORE

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INTRODUCTION AND SUMMARY

On November 7, 1983, James E. Reynolds and Associates, Wheat Ridge, Colorado, acting on behalf of Nicor Mineral Ventures, Denver, Colorado, authorized Hazen Research to proceed with preliminary metallurgical testing of a South Carolina gold ore identified as the Brewer sulfide ore.

The primary metal values in the ore are copper and gold which assay 0.31% and 0.085 oz/T, respectively. The copper is present as enargite, which is a copper-arsenic sulfide. The ore assays 0.11% arsenic.

Testing by other investigators indicated that probably the best process flowsheet should include producing, by flotation, (1) a high grade copper concentrate containing the majority of the copper and arsenic values and some gold, and (2) a pyrite concentrate containing the majority of the remaining gold values.

The plan was to treat the copper concentrate hydrometallurgically to recover the copper and gold, while rejecting the arsenic in an environmentally acceptable form, such as insoluble arsenates. The pyrite concentrate was to be blended with oxide ore from the same property for recovery of the gold by heap leaching.

A summary of the flotation results is given below. The ore responded well to flotation. The best bulk sulfide concentrate obtained contained approximately 97 and 91% of the copper and gold, respectively. Selective flotation produced higher grade copper concentrates of approximately 19% copper, but the copper and gold recoveries were less. Although not shown, the arsenic distributions were in direct proportion to the copper distributions. The best range of grind required for good metal recoveries was approximately 65 to 70% passing 200-mesh.

Summary of Flotation Alternatives

Process	Wt %	Concentrate Analyses % Cu	Concentrate Analyses oz Au/T	Concentrate Distribution % Cu	Concentrate Distribution % Au	Overall Au Recovery %
Bulk flotation	23.9	1.22	0.314	97.4	90.6	90.6
Selective flotation						
Bulk copper conc	5.44	5.10	1.10	93.8	72.2	90.2
Pyrite conc	20.71	0.075	0.072	5.3	18.0	
Selective flotation with copper cleaning						
Copper conc	1.13	19.2	2.44	79.0	44.6	72.9
Pyrite conc	18.65	0.11	0.094	7.5	28.3	

The dissolution of the gold values from the various concentrate products was investigated using cyanidation. The highest overall gold recovery of 80.3% was achieved by separately cyaniding a low grade bulk copper concentrate and its respective pyrite concentrate. The copper concentrate was treated prior to cyanidation using autoclave oxidation, and the pyrite concentrate was leached directly. The overall cyanide consumption was approximately 4 pounds sodium cyanide per ton of ore feed.

The autoclave treatment was chosen due to the presence of the arsenic. It was planned to recover the copper as a soluble species, and to produce a solids residue from which the gold could be recovered by cyanidation and which contained the arsenic as insoluble arsenates for easy disposal.

The overall copper recovery from this test was 86.9%. Approximately 42% of the contained arsenic in the concentrate remained in the solid autoclave residue; whereas, 58% was in solution. This undesirable condition might well be corrected once optimum autoclave conditions are established.

Thickening tests showed unit area requirements of 0.6 square feet or less per ton per day using flocculant dosages of less than 0.05 pound per ton ore feed.

The Bond Work Index at a grind of 73% passing 200-mesh was approximately 4 kwhr/ton ore feed.

No obvious physical problems were observed during testing, but it is strongly recommended that additional testing be done in an effort to improve the overall gold and copper recoveries. Gold recoveries by flotation were approximately 90% when all the sulfides were removed via either a bulk sulfide flotation or a combination of selective copper and pyrite flotation. However, the distribution of gold between the various types of concentrates was quite variable, indicating the need for detailed mineralogy and metallurgical testing to determine the modes of occurrences of the gold, and the best way to control its distribution to the most advantageous concentrate product.

SAMPLE

A single sample of ore identified as the Brewer sulfide ore was received for testing on November 9, 1983. It was assigned the identification number of HRI 26678.

It was prepared for testing by standard methods of stage crushing, blending, and splitting to achieve representative sample splits of minus 10-mesh ore for laboratory testing. A portion of the minus 10-mesh ore was reduced to minus 200-mesh for head analyses. The quantitative and semi-quantitative head analyses are listed in Tables 1 and 2, respectively.

Table 1

Quantitative Analyses of Test Sample

Element	Analysis
Gold	0.085 oz/t
Silver	0.09 oz/t
Copper	0.31%
Iron	8.51%
Arsenic	0.11%
Sulfur (total)	9.43%

Table 2

Qualitative and Semiquantitative X-ray Fluorescent Analysis of Test Sample

Element	%	Element	%
Copper	0.41	Barium	0.009
Zinc	0.008	Strontium	0.008
Tin	0.013	Zirconium	0.020
Lead	0.029	Vanadium	0.032
Arsenic	0.069	Columbium	0.007
Selenium	0.010	Molybdenum	0.007
Iron	3.4	Manganese	0.005
Rubidium	0.005	Yttrium	0.002

TEST PROCEDURES

Flotation

Feeds for flotation were prepared by wet grinding 1000 g of minus 10-mesh ore in a laboratory rod mill at 62% solids. The test products were filtered, dried, and prepared for analyses by reducing a representative portion to minus 200-mesh and blending. Reagent additions were measured and recorded as pound of reagent per ton of ore feed.

Recoveries for each test were determined from a metallurgical balance of the elements of interest.

Cyanidation

Cyanidation was done in a mechanically agitated vessel at varying levels of percent solids. The leach times and cyanide concentrations varied in accordance with the objectives of the tests. Free cyanide concentrations were monitored and additions of sodium cyanide were made to maintain the desired test concentrations. Protective alkalinity was provided by additions of hydrated lime to pH 10.5 to 11.5.

Some tests used a granular activated coconut carbon of 6 x 16-mesh (US) for the adsorption of the gold and silver from solution. This use of carbon during the leaching stage is defined as carbon-in-leach (CIL). By comparison, the use of carbon in a separate stage of contact after cyanidation is defined as carbon-in-pulp (CIP).

At the end of each leach, the slurry was filtered and the solids washed using three appropriately sized displacements of water on the filter cake. If activated carbon was used, it was removed by screening prior to the solids filtration and assayed separately.

Intermediate rates of gold dissolutions were determined by sampling and assaying the leach liquors at appropriate time intervals.

Distributions of the gold values were calculated from the metallurgical balances as determined for each test using the test product weights or volumes, and assayed values.

TEST RESULTS AND DISCUSSION

Data sheets for each test are given in Appendix A. Screen analyses of the various grind sizes are given in Appendix B.

Flotation

Cleaned Copper Concentrate

Testing by previous investigators, using different samples, had demonstrated good recoveries of gold and copper by flotation. These tests achieved cleaned copper concentrates containing approximately 2 to 3% of the ore feed weight and assaying in excess of 20% copper with approximately 80% copper recovery. The copper was shown to be present as enargite, which is a copper-arsenic sulfide containing 19.1% arsenic. It was also shown that a majority of the gold was not associated with the copper, and good gold recoveries required the flotation of a separate pyrite concentrate.

Therefore, the initial process flowsheet as proposed to Hazen included the production of cleaned copper and bulk pyrite concentrates. Then the cleaned copper concentrate was to be treated using aqueous oxidation in an autoclave. This would reduce the arsenic to relatively insoluble arsenates, while solubilizing the copper which could be recovered by precipitation or cementation. Gold contained in the oxidized copper concentrate was to be recovered by cyanidation after removal of the soluble species. It was anticipated that the bulk pyrite concentrate would be blended with oxide ore for treatment by heap leaching.

Five tests were made with this objective. Three tests successfully produced copper concentrates of 14% copper grade or better and are summarized in Table 3. Test 1590-42 achieved a cleaned concentrate assaying 19.2% copper and 2.44 oz gold/ton with respective recoveries of 79.3% and 44.6%. The concentrate contained 1.13% of the ore feed weight. The other tests achieved somewhat higher copper recoveries. No gold data are available for Test 47 due to insufficient sample quantities.

Table 3

Results of Selective Flotation and
Cleaning of the Copper Concentrate

Test 1590-	Grind, % Passing 200-mesh	Wt %	Analyses Cu %	Analyses Au oz/T	Distribution Cu %	Distribution Au %
42	98	1.13	19.20	2.44	79.3	44.6
43	100	1.82	14.3	2.28	84.0	59.7
47	94	1.45	16.9		80.2	

Determination of Primary Grind Size

Table 4 and Figure 1 summarize the results of several tests made to determine the effects of primary grind size on the gold and copper metallurgies. These data show an optimum grind of approximately 65 to 70% passing 200-mesh. Coarser sizes resulted in high copper and gold assays for the tails, whereas finer grinds did not show significant metallurgical differences in the tails assays.

Table 4

Effect of Grind on
Gold and Copper Metallurgy

Test 1590-	% Passing 200-mesh	Recoveries Cu %	Recoveries Au %	Tailings Analyses Cu %	Tailings Analyses Au oz/t
66	64	94.7	79.6	0.024	0.029
62	70	98.0	89.6	0.009	0.012
63	80	97.8	91.5	0.010	0.012
64	84	97.0	89.2	0.013	0.015
65	98	97.5	87.7	0.009	0.013

TAILINGS ANALYSES AND GRIND SIZE

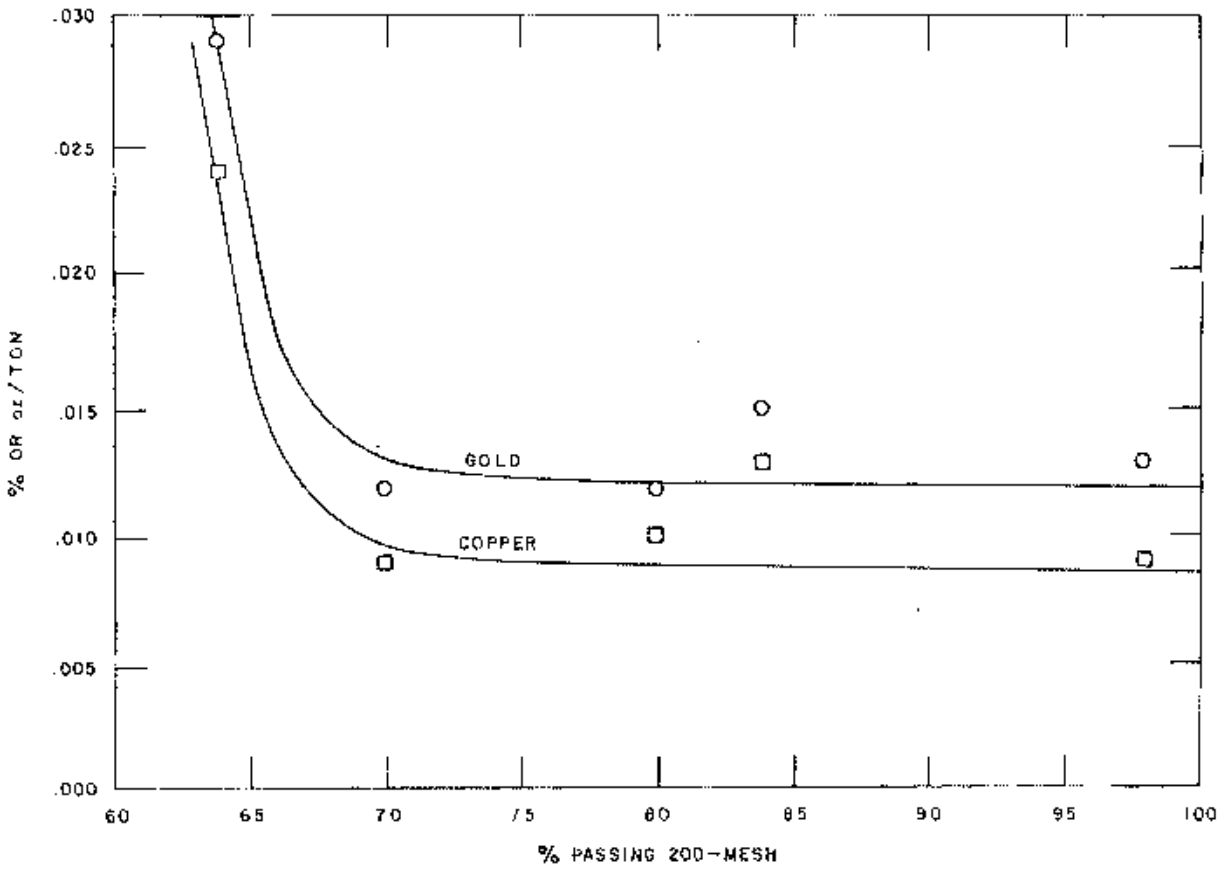

FIGURE 1

Bulk and Sequential Flotation

Although the cleaner tests demonstrated reasonable copper grades and recoveries, it was considered impractical to install an autoclave process for such a small amount of feed weight. Also, concurrent cyanidation tests were indicating successful treatment of a bulk sulfide concentrate to recover the contained gold.

Therefore, the scope of the project was changed to include the production of a lower grade copper concentrate with higher recoveries. Table 5 summarizes the results of producing a single bulk sulfide flotation product. These data show consistently high copper and gold recoveries with only a few percentage points of difference in the copper and gold recoveries. The average calculated bulk sulfide concentrate assayed 1.22% copper, 0.314 oz gold/ton, with copper and gold recoveries of 97.4 and 90.6%, respectively. However, it contained in excess of 20% of the ore feed weight which was considered too high for economic treatment via autocleve oxidation.

Table 5

Bulk Sulfide Concentrate Data

Test 1590-	Grind, % Passing 200-mesh	Wt %	Analyses Cu %	As %	Au oz/T	Distribution Cu %	As %	Au %
23	94	22.29	1.4	0.48	0.440	98.3	99+	92.6
24	94	23.95	1.22	0.44	0.362	94.5	99+	92.7
25	94	26.27	1.04	0.38	0.272	98.7	99+	89.8
42	98	23.37	1.16	0.39	0.245	98.8	99-	92.6
43	100	25.05	1.22		0.256	99.0		92.4
47	94	24.24	1.24			98.6		
65	98	22.68	1.18		0.316	97.5		87.7
60	94	24.02	1.24		0.313	95.8		88.4
61	94	23.46	1.26		0.310	95.5		88.8
Average		23.9	1.22	0.42	0.314	97.4		90.6

A second evaluation of the same test data is given in Figures 2 and 3, showing the relationships of copper grade, recovery, and weight recovered. These show that a bulk copper concentrate could be produced recovering greater than 92% of the copper into a concentrate assaying 4 to 6% copper and containing approximately 5% of the ore feed weight. This was the range of weight considered practical for autoclave treatment.

Test 87 was made to confirm the data in Figures 2 and 3, and to produce quantities of the bulk copper and pyrite concentrates sufficient for the subsequent testing via autoclave oxidation and/or cyanidation. The test achieved a copper concentrate assaying 5.1% copper and 1.10 oz gold/ton, and recovered 92% of the copper and 72.2% of the gold into 5.44% of the ore feed weight, confirming the earlier data. The pyrite concentrate assayed 0.072 oz gold/ton and contained 18% of the feed gold. Results for cyanidation of these concentrates are given in the next section.

COPPER GRADE AND RECOVERY

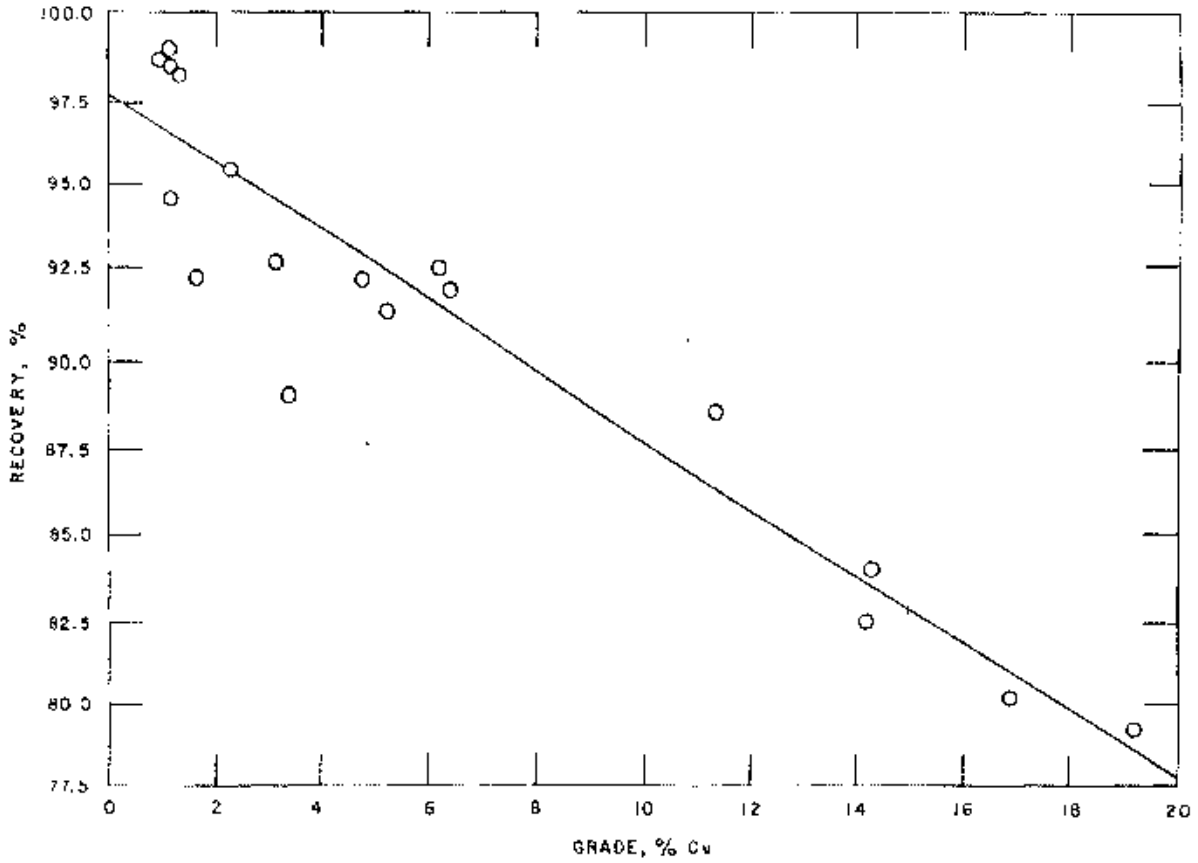

FIGURE 2

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COPPER GRADE AND WEIGHT RECOVERY FOR BULK COPPER CONCENTRATE

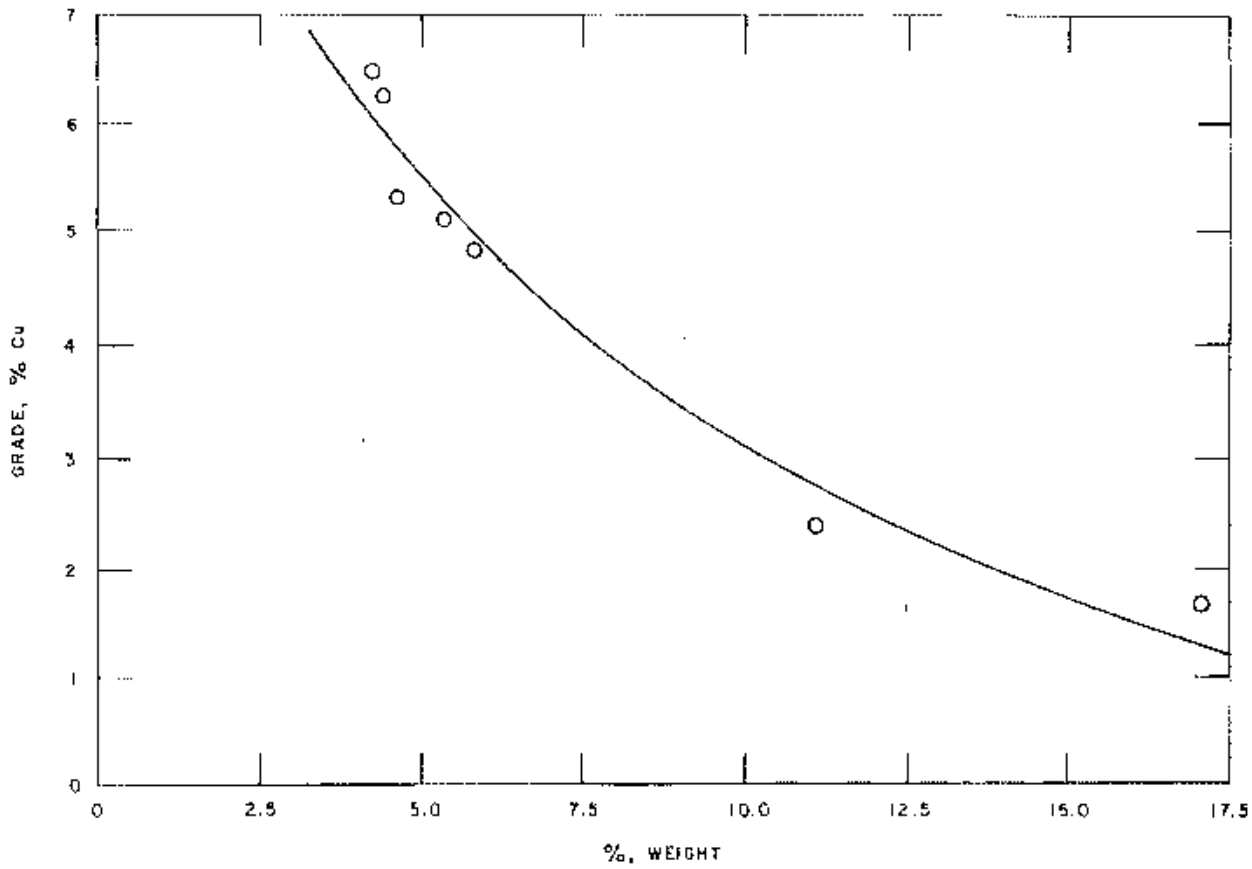

FIGURE 3

Noranda Research Ltd.

Cyanidation

Cyanidation tests for recovery of the contained gold values were made using bulk sulfide concentrates from two individual tests, and the pyrite and bulk copper concentrates from Test 87. The pyrite concentrate was tested with and without regrinding, and the copper concentrate with and without autoclave oxidation before cyanidation.

The results are summarized in Table 6, and show that autoclave oxidation (leaching) followed by cyanidation of the bulk copper concentrate achieved the highest, incremental cyanidation gold recovery of 99.0%. By comparison, the same material without autoclave oxidation achieved an incremental gold recovery of 80.4%. The incremental recovery of gold by cyanidation of the pyrite concentrate was approximately 50% irregardless of the grind size.

The overall recovery for Test 87 combining cyanidation of the pyrite concentrate and the autoclaved copper concentrate is 80.3%. This is approximately 9 percentage points higher than the 73.9% recovered by cyanidation of a bulk sulfide concentrate. However, the best process cannot be chosen based on test results alone, and an economic evaluation is considered necessary.

The cyanide consumptions for all tests were very reasonable with requirements ranging from approximately 2 to 3 pounds of sodium cyanide per ton of ore feed.

Autoclave Oxidation

Details of the autoclave oxidation leach for the copper bulk concentrate from Test 87 are given in Appendix A. The results of this test are summarized in Table 7. The leach achieved a copper extraction of 92.7% from the autoclave feed. This combined with the incremental flotation recovery of 93.8% gives an overall recovery of 86.9%.

The solubilization and subsequent precipitation of the arsenic as an insoluble arsenate were part of the objective for this treatment scheme. In this respect, it was only partially successful since approximately 58% of the arsenic contained in the autoclave feed solids was not reprecipitated and reported to the final liquor.

Table 6

Summary of Cyanidation Results

Test 1590-	Type of Sample	Incremental Gold Recovery, % Flotation	Incremental Gold Recovery, % Cyanidation @ 48 hr	Overall Gold Recovery, %	Cyanide Consumption lb/T 1/	Comments
60,67	Bulk sulfide concentrate	88.4	54.7	48.4	3.2	
61,68	Bulk sulfide concentrate	88.8	83.2	73.9	3.5	Carbon-in-leach (CIL)
110	Pyrite concentrate (Test 87)	18.0	48.3	8.7	2.4	No regrind (~ 65-mesh)
111	Pyrite concentrate (Test 87)	18.0	52.5	9.4	2.0	Regrind to 200-mesh
112	Pyrite concentrate (Test 87)	18.0	46.1	8.3	2.6	Regrind to 325-mesh
135	Copper bulk concentrate (Test 87)	72.2	80.4	58.0	2.6	Carbon-in-leach (CIL)
136	Copper bulk concentrate (Test 87)	72.2	99.0	71.5	1.6	Autoclave oxid. & CIL

1/ Pound NaCN per ton of ore feed.

Table 7

Oxidizing Autoclave Leach Results

Product	Wt, g or Vol, ml	Analyses, g/l, %, ppm, or oz/T Au	Cu	Fe	As	Ag	Distribution, % Au	Cu	Fe	As	Ag
Feed, assay	90.0	1.10	5.10	24.3	1.85	0.75					
Feed, calc			5.26	24.0		0.73	100.0	100.0	100.0	100.0	100.0
Residue	33.8	(2.91)	1.02	9.04	(2.07)	1.10	99.4	7.3	14.2	42.0	56.4
Liquor	985	0.019	4.46	18.8	0.980	1	0.6	92.7	85.8	58.0	43.6

Numbers in parentheses are calculated values; all others are assayed values.

The data show that 8.6% of the gold was solubilized. This calculated value may be more a result of indeterminant analytical results than actual values, and is not considered to be metallurgically significant.

Thickening

Thickening tests using the Kynch method for determination of the unit area requirements were made for the rougher flotation tails from Test 1590-87. The results in Table 8 show unit area requirements of 0.6 square feet per ton per day or less using flocculant additions of 0.03 pound/ton feed or less. The liquor clarities were excellent.

Table 8

Thickening Data for
Rougher Flotation Tails
(Test 1590-87)

Test	Feed Slurry		Terminal Pulp		Unit	Flocculant
1590-	% Solids	Density, g/l	% Solids	Density, g/l	Area 1/	lb/ton 2/
107	27.5	1211	67.6	1724	0.4	0.014
108	27.3	1248	67.6	1891	0.5	0.03
109	27.5	1188	66.9	1730	0.6	0.03

1/ Unit areas are given as ft^2/ton/day and include no design or safety factors.
2/ Pound of flocculant per ton of tailings feed.

Bond Work Indices

Two Bond Work Index determinations were made using Bond's Third Theory of Comminution. The results, given in Table 9, show values of 3.9 and 6.0 kwhr/ton for grinds of 73 and 89% passing 200-mesh, respectively. The differences indicate that energy usage at the coarser grind was required primarily to break the ore along natural grain boundaries. This conforms with the previous data investigating the effect of grind on the copper recovery which indicated an optimum grind of approximately 65 to 70% passing 200-mesh. It is expected that

optimum liberation would occur when the grains are liberated by breaking the ore along its natural grain boundaries.

By contrast, the increase in energy for the finer size is probably caused by the breakage of individual grains after the natural grain boundaries have been broken. This does not imply that such a mechanism did not occur during the coarser grind, but probably not to the same extent.

Table 9

Summary of Bond Work Index Data

	Grind		Product		Bond
Product	Time min	Ore Wt g	K80 μ	% Passing 200-mesh	Work Index
10-mesh feed	-	-	1455	17.9	
BMG	5	1000	90	72.8	3.9
BMG	10	1000	60	89.2	6.0

APPENDIX A
Test Data Sheets

BATCH FLOTATION TEST

TITLE	MINOR MINERAL REMOVAL	SAMPLE	ARL 2a&2b, minus 10 mesh, 1000 grams
OBJECTIVE	Sequential copper and pyrite flotation.		
REMARKS	Pyrite was very sensitive to additions of the AF 350 or AF 208	GRIND	94% passing 200-mesh
		MACHINE	LA-500

TEST NO 1599-23
PROJECT 5866
DATE 15 Nov '83
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OPERATOR JCG
WATER TAP

OPERATION	Grind	Cond	Copper Rougher	Cond	Pyrite Rougher
CELL	rod	1000	1000	1000	1000
TIME, minutes	20	1	3	1	5
pH	11.4	11.4	11.4	11.4	11.0
% SOLIDS	62	30	30		

REAGENTS, lb/ton

CaO(Hi Z	2.0			
AF 350		0.01	0.04	
AF 208		0.01	0.04	
AF 76		0.064	0.077	
AF 65				0.011

PRODUCTS No.	Description	Dry weight, g	Weight %	Assays copper %	arsenic %	gold oz/ton	Distribution, % copper	arsenic	gold
1	Cu Rc Conc	43.39	4.33	8.45	0.24	0.946	81.9	95.2	49.1
2	Pyr Rg Conc	199.62	19.92	0.11	0.03	0.304	6.6	4.8	51.5
3	Pyr Rg Tails	229.01	22.85	0.097	<0.005	0.010	1.7	<0.1	2.4
	Calculated Feed	1002.03	100.00	0.31	0.11	0.106	100.0	100.0	100.0
	Assayed Feed			0.3	0.11	0.095			
Calculated Products:									
	3,1& Conc Comb:		23.25	1.4	0.48	0.447	98.3	99+	52.6

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HAZEN FLOTATION TEST

TITLE NICOR MINERAL VENTURES
OBJECTIVE Sequential flotation of copper and pyrite with cleaning of the copper.

REMARKS

SAMPLE HRI 26678, minus 10-mesh, 1000 grams
GRIND 94% passing 200-mesh
MACHINE LA-500

TEST NO 1590-24
PROJECT 5801
DATE 15 Nov '83
PAGE 1 OF 1
OPERATOR JCG
WATER TAP

OPERATION	Grind	Cond	Cond	Copper Rougher	Cond	Copper Rougher	Cond	Pyrite Rougher	Cond	Cond	Copper Clnr 1	Cond	Copper Clnr 1	Copper Clnr 2
CELL	rod	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
TIME, minutes	20	5	2	4	2	4	1	5	3	2	5	1	5	8
pH	6.7	12.0	12.0	11.7	11.7	11.6	11.5	11.3	2.8	8.7	8.7	8.1	8.0	8.2
% SOLIDS	62	30	30	30										
REAGENTS, lb/ton														
Ca(OH)2		2.0								1.3				1.7
Minerec 1661			0.011		0.022							0.011		
AF 76			0.022											
AF 65				0.011	0.011		0.011	0.022			0.022		0.022	
AP 208				0.02			0.08							
AI 350							0.08							
SO2									9.0					1.8

PRODUCTS No.	Description	Dry Weight, g	Weight %	Assays copper %	arsenic %	gold oz/ton	Distribution, % copper	arsenic	gold
1	Cu Clnr Conc 2	73.84	7.36	3.33	1.21	0.740	79.1	84.9	58.2
2	Cu Clnr Tail 2	48.48	4.83	0.40	0.13	0.168	6.2	6.0	8.7
3	Cu Clnr Tail 1	49.47	4.93	0.44	0.15	0.206	7.0	7.1	10.8
4	Pyr Ro Conc	68.53	6.83	0.10	0.03	0.206	2.2	2.0	15.0
5	Pyr Ro Tail	763.58	76.05	0.022	<0.005	0.009	5.5	<0.1	7.3
	Calculated Feed	1003.90	100.00	0.31	0.10	0.094	100.0	100.0	100.0
	Assayed Feed			0.31	0.11	0.085			
Calculated Products									
	Cu Clnr Conc 1 (1+2)		12.19	2.17	0.78	0.513	85.3	90.9	66.9
	Cu Ro Conc (1 to 3)		17.12	1.67	0.60	0.425	92.3	98.0	77.7
	Bulk Conc (1 to 4)		23.95	1.22	0.44	0.362	94.5	+99	92.7

HAZEN FLOTATION TEST

TITLE NICOR MINERAL VENTURES
OBJECTIVE Sequential flotation of copper and pyrite with cleaning of the copper.
REMARKS

SAMPLE HRI 26678, minus 10-mesh, 1000 grams
GRIND 94% passing 200-mesh
MACHINE LA-500

TEST NO 1590-25
PROJECT 5801
DATE 15 Nov '83
PAGE 1 OF 1
OPERATOR JCG
WATER TAP

OPERATION	Grind	Cond	Copper Rougher	Cond	Copper Rougher	Cond	Pyrite Rougher	Cond	Copper Clnr 1	Cond	Cond	Copper Clnr 2
CELL	rod	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
TIME, minutes	20	2	3	2	12	1	5	4	8	3	1	8
pH	11.4	11.4	11.3	11.3	10.2	10.2	10.2	9.0	8.5	5.8	8.7	7.7
% SOLIDS	62	30	30	30								
REAGENTS, lb/ton												
Ca(OH)2	2.9										0.1	
AP 31		0.036		0.036	.108 (1)							
AP 208					0.01	0.06						
AF 76		0.022			0.011				0.011			0.033
AI 350						0.06						
AF 65						0.022						
SO2								1.0		1.8		

(1) 0.036 increments

PRODUCTS No.	Description	Dry Weight, g	Weight %	Assays copper %	arsenic %	gold oz/ton	Distribution, % copper	arsenic	gold
1	Cu Clnr Conc 2	71.99	7.18	3.45	1.29	0.708	89.1	92.0	63.8
2	Cu Clnr Tail 2	9.09	0.91	1.12	0.39	0.479	3.7	3.5	5.5
3	Cu Clnr Tail 1	30.37	3.03	0.25	0.093	0.190	2.7	2.8	7.2
4	Pyr Ro Conc	151.96	15.15	0.058	0.011	0.070	3.2	1.7	13.3
5	Pyr Ro Tail	739.58	73.73	0.005	<0.005	0.011	1.3	<0.1	10.2
	Calculated Feed	1002.99	100.00	0.28	0.10	0.080	100.0	100.0	100.0
	Assayed Feed			0.31	0.11	0.085			
Calculated Products:									
	Cu Clnr Conc 1 (1+2)		8.09	3.19	1.19	0.682	92.8	95.5	69.3
	Cu Ro Conc (1 to 3)		11.12	2.39	0.89	0.548	95.5	98.3	76.5
	Bulk Conc (1 to 4)		26.27	1.04	0.38	0.272	98.7	+99	89.8

HAZEN FLOTATION TEST

TITLE NICOR MINERAL VENTURES
OBJECTIVE Sequential flotation of copper and pyrite with cleaning of the copper.
REMARKS

SAMPLE HRI 26678, minus 10-mesh, 1000 grams
GRIND 98% passing 200-mesh
MACHINE LA-500

TEST NO 1590-42
PROJECT 5801
DATE 21 Nov '83
PAGE 1 OF 1
OPERATOR JCG
WATER TAP

OPERATION	Grind	Cond	Copper Rougher	Cond	Copper Rougher	Cond	Copper Rougher	Cond	Pyrite Rougher	Pyrite Rougher	Cond	Copper Clnr 1	Cond	Copper Clnr 2
CELL	rod	1000	1000	1000	1000	1000	1000	1000	1000	1000	500	500	500	500
TIME, minutes	30	1	2-1/2	1/2	2-1/2	1/2	5	2	4	4	2	8	2	8
pH	11.6	11.6	11.6	11.6	11.6	11.6	11.4	11.4	11.4	11.1	10.9	10.5	7.0	7.7
% SOLIDS	62	30	30	30										
REAGENTS, lb/ton														
Ca(OH)2	3.0													
AX 325		0.01		0.01		0.01						0.006		0.003
AP 208		0.01						0.06		0.04				
AF 76		0.022			0.011	0.011	0.022	0.022	0.022					0.011
AX 350								0.06		0.04				
DF 250										0.022		0.011		0.011
SO2											0.9		0.6	

PRODUCTS No.	Description	Dry Weight, g	Weight %	Assays copper %	arsenic %	gold oz/ton	Distribution, % copper	arsenic	gold
1	Cu Clnr Conc 2	11.28	1.13	19.20	6.70	2.440	79.3	83.8	44.6
2	Cu Clnr Tail 2	4.62	0.46	1.87	0.61	0.765	3.1	3.1	5.7
3	Cu Clnr Tail 1	31.37	3.13	0.78	0.260	0.277	8.9	9.0	14.0
4	Pyr Ro Conc	186.73	18.65	0.110	0.020	0.094	7.5	4.1	28.3
5	Pyr Ro Tail	767.47	76.63	0.004	<0.005	0.006	1.2	<0.1	7.4
	Calculated Feed	1001.47	100.00	0.27	0.09	0.062	100.0	100.0	100.0
	Assayed Feed			0.31	0.11	0.085			
Calculated Products:									
	Cu Clnr Conc 1 (1+2)		1.59	14.19	4.94	1.955	82.4	86.9	50.3
	Cu Ro Conc (1 to 3)		4.72	5.30	1.84	0.842	91.3	95.9	64.3
	Bulk Conc (1 to 4)		23.37	1.16	0.39	0.245	98.8	+99	92.6

HAZEN FLOTATION TEST

TITLE NICOR MINERAL VENTURES
OBJECTIVE
REMARKS

SAMPLE HRI 26678, minus 10-mesh, 1000 grams
GRIND 100% passing 200-mesh
MACHINE LA-500

TEST NO 1590-43
PROJECT 5801
DATE 21 Nov '83
PAGE 1 OF 1
OPERATOR JCG
WATER TAP

OPERATION	Grind	Cond	Copper Rougher	Copper Rougher	Copper Rougher	Copper Rougher	Cond	Pyrite Rougher	Cond	Copper Clnr 1
CELL	rod	1000	1000	1000	1000	1000	1000	1000	500	500
TIME, minutes	40	2	2	2	2	4	2	10	3	10
pH	11.6	11.6	11.6	11.4	11.3	11.2	11.2	11.0	9.5	9.6
% SOLIDS	62	30	30	30						
REAGENTS, lb/ton										
Ca(OH)2	3.0									
AI 325		0.01		0.01	0.01	0.01				0.006
AF 76		0.022		0.011	0.022	0.022	0.033			
AI 350							0.06	0.06		
SF 250								0.044		0.022
SO2									1.8	

PRODUCTS No.	Description	Dry Weight, g	Weight %	Assays copper %	Assays gold oz/ton	Distribution, % copper	Distribution, % gold
1	Cu Clnr Conc 1	18.32	1.82	14.3	2.28	84.0	59.7
2	Cu Clnr Tail 1	41.17	4.10	0.62	0.19	8.2	11.2
3	Pyrite Ro Conc	192.22	19.13	0.11	0.078	6.8	21.5
4	Pyrite Ro Tail	752.96	74.95	0.004	0.007	1.0	7.6
	Calculated Feed	1004.67	100.00	0.31	0.069	100.0	100.0
	Assayed Feed			0.31	0.085		
Calculated Products:							
	Cu Ro Conc		5.92	4.83	0.833	92.2	70.9
	Bulk Conc		25.05	1.22	0.256	99.0	92.4

HAZEN FLOTATION TEST

TITLE NICOR MINERAL VENTURES
OBJECTIVE Sequential flotation of copper and pyrite with cleaning of the copper.
REMARKS Yellow prussiate of soda (YPS) used for pyrite depression.

SAMPLE HRI 26678, minus 10-mesh, 1000 grams
GRIND 94% passing 200-mesh
MACHINE LA-500

TEST NO 1590-47
PROJECT 5801
DATE 22 Nov '83
PAGE 1 OF 1
OPERATOR JCG
WATER TAP

OPERATION	Grind	Cond	Cond	Copper Rougher	Cond	Pyrite Rougher	Copper Clnr 1	Copper Clnr 2
CELL	rod	1000	1000	1000	1000	1000	500	500
TIME, minutes	20	8	1	8	1	5	8	8
pH	11.7	11.6	11.5	11.2	11.2	10.9	10.5	8.9
% SOLIDS	62	30	30	30				
REAGENTS, lb/ton								
Ca(OH)2	3.0							
YPS		0.20						
AP 242			0.013	0.065			0.006	
AF 76			0.022			0.022		
AX 325				0.04				
AX 350					0.08	0.04		
DF 250						0.022	0.011	0.022
Silicate N								1.0

PRODUCTS No.	Description	Dry Weight, g	Weight %	Assays copper %	Distribution, % copper
1	Cu Clnr Conc 2	14.57	1.45	16.90	80.2
2	Cu Clnr Tail 2	9.19	0.92	2.79	8.4
3	Cu Clnr Tail 1	21.65	2.16	0.56	4.0
4	Pyr Ro Conc	197.49	19.71	0.093	6.0
5	Pyr Ro Tail	759.19	75.76	0.006	1.4
	Calculated Feed	1002.09	100.00	0.31	100.0
	Assayed Feed			0.31	
Calculated Products:					
	Cu Clnr Conc 1 (1+2)		2.37	11.42	88.6
	Cu Ro Conc (1 to 3)		4.53	6.24	92.6
	Bulk Conc (1 to 4)		24.24	1.24	98.6

HAZEN FLOTATION TEST

TITLE NICOR MINERAL VENTURES
OBJECTIVE Produce bulk concentrate for cyanidation testing.

REMARKS See Test 1590-67 for cyanidation results.

SAMPLE HRI 26678,minus 10-aesh, 1000 grams
GRIND 94% passing 200-aesh
MACHINE LA-500

TEST NO 1590-60
PROJECT 5801
DATE 30 Nov '83
PAGE 1 OF 1
OPERATOR JCG
WATER T&P

OPERATION	Grind	Cond	Rougher	Cond	Rougher	Rougher
CELL	rod	1000	1000	1000	1000	1000
TIME, minutes	20	1	2	1/2	5	3
pH	7.2	7.4	7.1	7.1	7.6	7.6
% SOLIDS	62	30	30	30		
REAGENTS, lb/ton						
Silicate N		1.0				
AX 325		0.05		0.05		0.02
AP 208		0.05		0.05		0.02
AF 76		0.02	0.02	0.02	0.01	
AF 65					0.01	

PRODUCTS No.	Description	Dry Weight, g	Weight %	Assays copper %	Assays gold oz/ton	Distribution, % copper	Distribution, % gold
1	Ro Conc	240.77	24.02	1.24	0.313	95.8	88.4
2	Ro Tails	761.68	75.98	0.017	0.013	4.2	11.6
	Calculated Feed	1002.45	100.00	0.31	0.085	100.0	100.0
	Assayed Feed			0.31	0.085		
Calculated Products:							

HAZEN FLOTATION TEST

TITLE NICOR MINERAL VENTURES
OBJECTIVE Produce bulk concentrate for cyanidation testing.

REMARKS See Test 1590-68 for cyanidation results.

SAMPLE HRI 26678,minus 10-mesh, 1000 grams
GRIND 94% passing 200-mesh
MACHINE LA-500

TEST NO 1590-61
PROJECT 5801
DATE 30 Nov '83
PAGE 1 OF 1
OPERATOR JCB
WATER TAP

OPERATION	Grind	Cond	Rougher	Cond	Rougher	Rougher
CELL	rod	1000	1000	1000	1000	1000
TIME, minutes	20	1	2	1/2	5	3
pH	7.2	7.4	7.1	7.1	7.6	7.6
% SOLIDS	62	30	30	30		
REAGENTS, lb/ton						
Silicate N		1.0				
AX 325		0.05		0.05		0.02
AP 208		0.05		0.05		0.02
AF 76		0.02	0.02			
AF 65				0.01		0.01

PRODUCTS No.	Description	Dry Weight, g	Weight %	Assays copper %	Assays gold oz/ton	Distribution, % copper	Distribution, % gold
1	Ro Conc	235.46	23.46	1.26	0.310	95.5	88.8
2	Ro Tails	768.14	76.54	0.018	0.012	4.5	11.2
	Calculated Feed	1003.60	100.00	0.31	0.082	100.0	100.0
	Assayed Feed			0.31	0.085		

Calculated Products:

HAJEK FLOTATION TEST

TITLE: HILGER MINERAL SERVICES
OBJECTIVE: Determination of primary grind.
REMARKS:

SAMPLE: HSC Z6678,minus 10-mesh, 1000 grams
TEST NO: 1590-82
PROJECT: SBCI
DATE: 30 Nov '82
PAGE: 1 OF 1
GRIND: 70% passing 200-mesh
OPERATOR: JCG
MACHINE: LA-500
WATER: TAP

OPERATION	Grind	Conc	Rougher	Cond	Rougher	Rougher
CELL	rod	1000	1000	1000	1000	1000
TIME, minutes	5	4	3	12	5	3
pH	6.5	6.5	6.5	6.5	7.0	7.0
% SOLIDS	62	30	30	30		

REAGENTS, lb/ton

Sidrate A	1.0				
AL 350	0.05		0.05		0.02
AF 30E	0.05		0.05		0.02
AF 76	0.02	0.02	0.01	0.01	0.01
AF 65			0.01	0.01	0.01

PRODUCTS No.	Description	Dry Weight, g	Weight %	Assays copper %	Assays gold oz/ton	Distribution, % copper	Distribution, % gold
1	As Conc	258.31	26.04	1.68	0.254	94.0	89.6
2	Ro Tails	711.53	71.76	0.049	0.012	2.0	10.4
	Calculated Feed	986.84	100.00	0.32	0.087	100.0	100.0
	Assayed Feed			0.31	0.085		

Calculated Products:

BATCH FLOTATION TEST

TITLE: MICOR MINERAL VENTURES
OBJECTIVE: Determination of primary grind.
REMARKS:

SAMPLE: MRJ 2E57B,minus 10-mesh, 1000 grams
GRIND: 60% passing 200-mesh
MACHINE: LA-500

TEST NO: 15Y0-A3
PROJECT: 5801
DATE: 30 Nov '85
PAGE: 1 OF 1
OPERATOR: JCB
WATER: TAP

OPERATION	Grind	Conditioner	Rougher 1	Conditioner	Rougher 2	Rougher 3
CELL	rod	1000	1000	1000	1000	1000
TIME, minutes	8	1	2	1/2	5	3
pH	7.9	7.6	7.1	7.2	7.2	7.2
% SOLIDS	67	30	30	30		

REAGENTS, lb/ton

Sodium Silicate N		1.0			
AP 350		0.05		0.05	0.02
AP 208		0.05		0.05	0.02
AP 76		0.01		0.01	0.01
AP 65		0.01	0.01	0.01	0.01

PRODUCTS		Dry Weight, g	Weight %	Assays copper %	Assays gold oz/ton	Distribution, % copper	Distribution, % gold
No.	Description						
1	Pb Conc	278.71	27.86	1.14	0.334	97.9	91.5
2	Rm Tails	721.84	72.14	0.010	0.012	2.2	8.5
	Calculated Feed	1050.52	104.50	0.32	0.092	100.0	100.0
	Assayed Feed			0.31	0.065		

Calculated Products:

TITLE NICOR MINERAL VENTURES
OBJECTIVE Determination of primary grind.
REMARKS

SAMPLE HRI 2667B,Minum 19-mesh, 1000 grams
TEST NO 1590-84
PROJECT 2301
DATE 30 Nov '85
PAGE 1 OF 1
GRIND 84% passing 200-mesh
MACHINE LA-500
OPERATOR JCS
WATER TAP

OPERATION	Grind	Cond	Rougher	Cond	Rougher	Rougher
Cell	rod	1000	1000	1000	1000	
TIME, minutes	10	1	2	1/2	5	3
pH	6.9	6.9	6.8	6.8	7.4	7.5
% SOLIDS	62	30	30	30		

REAGENTS, lb/ton

Silicate N	1.0				
AU 530	0.05		0.05		0.02
AF 208	0.05		0.05		0.02
AF 76	0.02		0.01	0.01	0.01
AF 65	0.01		0.01	0.01	0.01

PRODUCTS No.	Description	Dry Weight, g	Weight %	Assays copper %	Assays gold oz/ton	Distribution, % copper	Distribution, % gold
1	Ro Conc	267.10	25.66	1.65	0.342	97.0	89.1
2	Ro Tails	774.07	75.34	0.013	0.015	3.0	10.8
	Calculated Feed	1002.07	100.00	0.32	0.102	100.0	100.0
	Assayed Feed			0.31	0.085		

Calculated Products

MODIFIED FLOTATION TEST

TITLE: MICOR MINERAL SEARCHES
OBJECTIVE: Determination of primary grind.

REMARKS:

SAMPLE: HRI 26678,minus 10-mesh, 1000 grams
GRIND: 98% passing 200-mesh
MACHINE: LA-500

TEST NO: L593-85
PROJECT: 5801
DATE: 30 Nov '85
PAGE: 1 OF 1
OPERATOR: JCB
WATER: TAP

OPERATION	Grind	Cond	Rougher	Cond	Rougher	Rougher
CELL	rod	1000	1000	1000	1000	1000
TIME, minutes	30	1	2	1/2	5	3
pH	7.2	7.2	7.1	7.1	7.0	7.0
% SOLIDS	62	39	30	30		

REAGENTS, lb/ton

Silicate N	1.0				
AL 350	0.05		0.05		0.02
AP 208	0.05		0.05		0.02
AF 76	0.02	0.01	0.01	0.01	0.01
AF 65	0.01	0.01	0.01	0.01	0.01

No.	PRODUCTS Description	Dry Weight, g	Weight %	Assays copper %	Assays gold oz/ton	Distribution, % copper	Distribution, % gold
1	Ro Conc	228.32	22.68	1.58	0.336	47.5	87.7
2	Ro Tails	778.10	77.32	0.009	0.015	2.5	12.3
	Calculated Feed	1006.42	100.00	0.27	0.082	100.0	100.0
	Assayed Feed			0.31	0.085		

Calculated Products:

HAZEN FLOTATION TEST

TITLE NICOR MINERAL VENTURES
OBJECTIVE Determination of primary grind.
REMARKS

SAMPLE HRI 26678,minus 10-mesh, 1000 grams
GRIND 64% passing 200-mesh
MACHINE LA-500

TEST NO 1590-66
PROJECT 5801
DATE 30 Nov '83
PAGE 1 OF 1
OPERATOR JCG
WATER TAP

OPERATION	Grind	Cond	Rougher	Cond	Rougher	Rougher
CELL	rod	1000	1000	1000	1000	1000
TIME, minutes	3.5	1	2	1/2	5	3
pH	6.3	6.6	6.8	7.8	7.3	7.5
% SOLIDS	62	30	30	30		
REAGENTS, lb/ton						
Silicate N		1.0				
AX 350		0.05		0.05		0.02
AP 208		0.05		0.05		0.02
AF 76		0.02	0.01	0.01	0.01	0.01
AF 65		0.01	0.01	0.01	0.01	0.02

PRODUCTS No.	Description	Dry Weight, g	Weight %	Assays copper %	Assays gold oz/ton	Distribution, % copper	Distribution, % gold
1	Ro Conc	314.44	31.48	0.94	0.246	94.7	79.6
2	Ro Tails	684.51	68.52	0.024	0.029	5.3	20.4
	Calculated Feed	998.95	100.00	0.31	0.097	100.0	100.0
	Assayed Feed			0.31	0.085		

Calculated Products:

HAZEN CYANIDE LEACH TEST

TITLE Nicor Mineral Ventures
OBJECTIVE Cyanidation of rougher flotation concentrate.
REMARKS

SAMPLE Rougher Concentrate from Test 1590-60
GRIND No regrind

TEST NO 1590-67
PROJECT 5801
DATE 30 Nov '83
PAGE 1 OF 1
OPERATOR JCG
WATER TAP

Time, hr	0	1	4	24	48
pH, initial	6.6	11.5	11.6	11.2	11.0
adjusted	11.3				
Temperature, deg C	amb	amb	amb	amb	amb
% Solids				31	32
Pulp weight, g				784	743
NaCN, g/l		1.90	1.80	1.12	0.58

REAGENTS						Total
Ca(OH)2, g	0.19					0.19
NaCN, g	1.64		0.25			1.89

PRODUCTS No.	Description	Wet Weight g	Dry weight or Volume g or ml	Gold oz/ton or ppm	Assays Copper ppm	Iron ppm	Arsenic ppm	Cumulative Dissolution, % Gold	Cumulative Consumptions lb reagent/ton feed NaCN	Ca(OH)2
1	24 hour liquor		50	2.01	469	97	70	42.2	10.6	1.6
2	48 hour liquor		710	1.85	345	72	73	54.7	13.3	1.6
3	48 hr solids		240.77	0.142						
	Calculated Feed			0.313						
	Assayed Feed									

TITLE	Nicor Mineral Ventures	SAMPLE	Rougher Concentrate	TEST NO	1590-CR
OBJECTIVE	Evaluation of rougher flotation concentrate with carbon-in-leach.		from test 1590-5C	PROJECT	5881
				DATE	30 Nov '83
REMARKS				PAGE	1 OF 1
		GRIND	No regrind	OPERATOR	JCG
				WAITR	TAP

Time, hr	0	1	4	24	48
pH, initial	9.7	10.9	11.0	11.2	11.9
adjusted	10.8				
Temperature, deg C	amb	amb	amb	amb	amb
% Solids					30
Pulp weight, g					803
NaCN, g/l		2.20	1.69	1.88	0.18

REAGENTS						Total
Ca(OH)2, g	0.11					0.11
NaCN, g	1.61		0.27			1.88
AgNO3, g	15.01					

PRODUCTS		Wet Weight g	Dry weight or Volume g or ml	Assays Gold oz/ton or ppm	Assays Copper ppm	Assays Iron ppm	Assays Arsenic ppm	Gold Distribution, %	Cumulative Consumptions lb reagent/ton feed NaCN	Cumulative Consumptions lb reagent/ton feed Ca(OH)2
No.	Description									
1	48 hour liquor		2430	0.005	104	4	22	3.0		
2	48 hour carbon		14.76	4.25				83.2	14.8	0.9
3	48 hr solids		240.77	0.052				16.5		
	Calculated feed			0.310						
	Assayed Feed									

HAZEN FLOTATION TEST

TITLE	NICOR MINERAL VENTURES	SAMPLE	HRI 26578, minus 10-mesh, 10,000 grams
OBJECTIVE	Sequential copper and pyrite flotation.	TEST NO	1590-87
		PROJECT	5801
		DATE	14 Dec '87
REMARKS	Copper and pyrite concentrates were used for cyanidation tests; see Tests 1590-109, -111, -117, -135, -136. The rougher tails were used for thickening tests; see Tests 1590-107, -108, and -109.	PAGE	1 OF 1
		GRIND	84% passing 200-mesh
		OPERATOR	JCG
		MACHINE	Denver No. 7
		WATER	TAP

OPERATION	Grind	Cond	Copper Rougher	Cond	Copper Rougher	Cond	Pyrite Rougher
CELL	rod	No.7	No.7	No.7	No.7	No.7	No.7
TIME, minutes	10	3	9	2	10	1	15
pH	11.2	11.2		10.5	9.2		
% SOLIDS	62	30	30				

REAGENTS, lb/ton

CaLOH)2	2.0						
AP 208		0.03		0.005	0.001		
AP 242		0.01		0.005	0.003		
AF 65		0.01	0.01	0.01	0.02	0.01	0.03
AC 325						0.05	0.05

PRODUCTS	Dry Weight,	Weight	Assays						Distribution, %		
No. Description	g	%	Copper %	Arsenic %	Gold oz/ton	Iron %	Silver oz/ton	Selenium ppm	Copper	Arsenic	Gold
1 Cu Ro Conc	41.79	5.44	5.10	1.85	1.10	24.1	0.75	140	93.8	94.6	72.7
2 Pyr Ro Conc	179.62	20.71	0.075	0.020	0.032	30.9	<0.02	208	5.2	4.3	18.0
3 Pyr Ro Tails	7385.92	73.85	0.004	<0.005	0.011				1.0	0.6	9.3
Calculated Feed	7680.41	100.00	0.39	0.10	0.061				100.0	100.0	100.0
Assayed Feed			0.31	0.11	0.065			92			
Calculated Products:											
Bulk Conc (1+2)		26.15	1.12	0.40	0.286				99.0	100.0	90.2

BOTTLE CYANIDE LEACH TEST

CLIENT	Argor Mineral Ventures	SAMPLE	Pyrite Concentrate from Test 1990-07
OBJECTIVE	Cyanidation of pyrite rougher concentrate.		
REMARKS		GRIND	No regrind

TEST NO	1990-110				
PROJECT	5801				
DATE					
PAGE	1 OF 1				
OPERATOR	JCG				
WATCH	TAP				

Time, hr	0	2	6	24	48
pH, initial	7.5	11.1	12.9	13.1	10.8
adjusted	11.2		11.0		
Temperature, deg C	amb	amb	amb	amb	amb
% Solids				20	33
Pulp weight, g				734	644
NaCN, g/l		1.93	2.02	1.66	1.36

REAGENTS

						Total
Ca(OH)2, g	0.10					0.10
NaCN, g	1.19		0.29			1.48

PRODUCTS		Wet Weight	Dry weight or Volume	Assays	Cumulative Dissolution, %	Cumulative Consumptions lb reagent/ton feed	
No.	Description	g	g or ml	Gold oz/ton or ppm	Gold	NaCN	Ca(OH)2
1	24 hour liquor		50	0.35	42.6	5.3	1.5
2	48 hour liquor		50	0.43	52.3	11.5	1.3
3	48 hour filtrate		1120	0.18	56.5		
4	NG or solids		189.98	0.648			
	Calculated Feed			0.993			
	Assayed Feed			0.972			

HAZEN CYANIDE LEACH TEST

TITLE Nicor Mineral Ventures
OBJECTIVE Cyanidation of pyrite rougher concentrate.
REMARKS

SAMPLE Pyrite Concentrate from Test 1590-87
GRIND Reground to >95% passing 200-mesh

TEST NO 1590-111
PROJECT 5801
DATE
PAGE 1 OF 1
OPERATOR JCG
WATER TAP

Time, hr	0	2	8	24	48
pH, initial	7.0	11.5	11.0	11.1	11.0
adjusted	11.6		11.0		
Temperature, deg C	amb	amb	amb	amb	amb
% Solids				21	23
Pulp weight, g				743	664
NaCN, g/l		2.04	1.88	1.92	1.34

REAGENTS				Total
Ca(OH)2, g	0.15			0.15
NaCN, g	1.23		0.30	1.53

No.	PRODUCTS Description	Wet Weight g	Dry weight or Volume g or ml	Assays Gold oz/ton or ppm	Cumulative Dissolution, % Gold	Cumulative Consumptions lb reagent/ton feed NaCN	Ca(OH)2
1	24 hour liquor		50	0.47	52.2	5.2	2.0
2	48 hour liquor		50	0.50	52.5	9.8	2.0
3	48 hour liquor		1100	0.22	54.6		
4	48 hr solids		152.91	0.046			
	Calculated Feed			0.101			
	Assayed Feed			0.072			

MAIN CHANGE LEACH TEST

TITLE	Nicor Mineral Ventures	SAMPLE	Pyrite Concentrate	TEST NO	15VU-L12
OBJECTIVE	Oxidation of pyrite rougher concentrate.		from Test 15VU-60	PROJECT	5605
				DATE	
REMARKS				PAGE	1 OF 1
		GRIND	Reground to 98%	OPERATOR	JEB
			passing 325-mesh	WATER	TAP

Time, hr	0	2	8	24	48
pH, initial	7.0	11.2	11.2	11.1	11.0
adjusted	11.5				
Temperature, deg C	amb	amb	amb	amb	amb
T Solids				28	23
Pulp weight, g				743	683
NaOH, g/l		2.04	1.88	1.83	1.81

REAGENTS	Total
Ca(OH)2, g	0.13
NaOH, g	1.57

PRODUCTS No.	Description	Wet Weight g	Dry Weight or Volume g or ml	Assays Gold per ton or ppm	Cumulative Dissolution, % Gold	Cumulative Consumption lb reagent/ton feed NaOH	Ca(OH)2
1	24 hour liquor		50	0.02	46.2	6.5	1.7
2	48 hour liquor		50	0.05	46.1	12.0	1.7
3	48 hour wash liquor		111	0.15	47.5		
4	48 hr solids		154.5	5.98			
	Calculated Feed			2.080			
	Assayed Feed			2.072			

[illegible] CYANIDE LEACH TEST

TITLE	Nicor Mineral Ventures	SAMPLE	Rougher Copper Concentrate from Test 1590-87
OBJECTIVE	Examination of copper rougher concentrate with carbon-in-leach.		
REMARKS			
		GRIND	No regrind

TEST NO	1590-135
PROJECT	5801
DATE	9 Jan '88
PAGE	1 OF 1
OPERATOR	JCG
WATER	TAP

Time, hr	0	8	24
pH, initial	6.7	10.9	11.0
adjusted	10.8		
Temperature, deg C	amb	amb	amb
% Solids			16
Pulp weight, g			218.5
NaCN, g/l			1.00

REAGENTS [qty]

Ca(OH)2, g			6.50
NaCN, g	1.08	0.25	1.26
SZ108S, g	4.01		

No	PRODUCTS Description	Net Weight g	Dry weight or Volume g or ml	Assays Gold oz/ton or ppm	Gold Distribution, %	Cumulative Consumptions lb reagent/ton feed NaCN	Ca(OH)2
1	24 hour liquor		443	<0.003	0.0		
2	24 hour carbon		3.93	9.74	80.4	87.5	0.0
3	24 hr slime		39.14	0.236	19.6		
	Calculated Feed			0.293			
	Assayed Feed			1.167			

HAZEN CYANIDE LEACH TEST

TITLE: Nicor Mineral Ventures
OBJECTIVE: Cyanidation of copper rougher concentrate after autoclave oxidizing leach and with carbon-in-leach.
REMARKS:

SAMPLE: Rougher Copper Concentrate from Test 359C-87 after autoclave oxidizing leach.
GRIND: No regrind

TEST NO: 359C-13A
PROJECT: 580
DATE: 9 Jan 1988
PAGE: 1 OF 1
OPERATOR: JCH
WATER: TAP

Time, hr	0	8	24
pH, initial	3.6	11.0	10.9
adjusted	10.8		
Temperature, deg C	amb	amb	amb
% Solids			4
Pulp weight, g			249.5
NaCN, g/l			41.0

REAGENTS		Total
Ca(OH)2, g		0.00
NaCN, g	10.00	10.00
SPIGAS, g	5.00	

PRODUCTS No.	Description	Wet Weight g	Dry weight or Volume g or ml	Assays Gold oz/ton or ppm	Gold Distribution, %	Cumulative Consumptions lb reagent/ton feed NaCN	Ca(OH)2
1	24 hour liquor		475	<0.003	0.0		
2	24 hour carbon		5.33	3.1	99.5	77.4	0.0
3	24 hr solids		8.77	0.009	0.5		
	Calculated Feed			1.822			
	Assayed Feed						

Oxidizing Autoclave Leach of Nicor Copper Rougher Concentrate

Object: To liberate Au from the Cu-As-Fe sulfide flotation concentrate by oxidizing acid leaching to destroy the sulfide minerals.

Conditions:

Feed concentrate	90 g, Cu-rougher conc, produced in Test 1590-87.
Water	810 ml
% solids	10%
Initial slurry emf	+413 mv
Initial pH adjustment	To pH 0.8, requires 350 lb H_2SO_4/T conc, emf changes to +122 mv
Temperature	200°C
Time	1 hour
Pressure	
Total	280 psig
O_2 overpressure	50 psig
O_2 Sparge rate	~5 l/min
1/2 hour sample	To assess progress of leach by measuring slurry emf. 1/2 hour emf = +440 mv

Residue Cyanidation:

The residue from this leach was treated in a cyanidation leach to solubilize the gold and determine cyanide consumption.

For comparison, a sample of unoxidized Cu-rougher concentrate was also leached.

APPENDIX B
Screen Analyses

SCREEN ANALYSIS

Sample: HRI 26678, 3.5 minute rod mill grind; 62% solids.

Tyler Mesh	Direct Weight grams	Direct Weight %	Cumulative Weight, % Retained	Cumulative Weight, % Passing
65	2.36	2.4	2.4	97.6
100	8.29	8.3	10.7	89.3
150	14.42	14.4	25.1	74.9
200	10.97	11.0	36.1	63.9
270	16.02	16.0	52.1	47.9
325	23.44	23.5	75.6	24.4
400	2.94	2.9	78.5	21.5
500	9.26	9.3	87.8	12.2
Pan	12.19	12.2	100.0	
Total	99.89	100.0		

SCREEN ANALYSIS

Sample: HRI 26678, 5 minute rod mill grind; 62% solids.

Tyler Mesh	Direct Weight grams	Direct Weight %	Cumulative Weight, % Retained	Cumulative Weight, % Passing
65	0.20	0.2	0.2	99.8
100	2.16	2.2	2.4	97.6
150	5.95	6.0	8.4	91.6
200	21.71	21.7	30.1	69.9
270	14.71	14.7	44.8	55.2
325	17.40	17.4	62.2	37.8
400	9.63	9.6	71.8	28.2
500	11.26	11.3	83.1	16.9
Pan	16.96	16.9	100.0	
Total	99.98	100.0		

SCREEN ANALYSIS

Sample: MRI 3667B, 8 minute rod mill grind; 62% solids.

Tyler Mesh	Direct Weight grams	%	Cumulative Weight, % Retained	Passing
65	0.04	0.0	0.0	100.0
100	0.23	0.2	0.2	99.8
150	1.94	1.9	2.1	97.9
200	17.66	17.7	19.8	80.2
270	17.09	17.1	36.9	63.1
325	26.94	26.9	63.8	36.2
400	5.35	5.3	69.1	30.9
500	11.70	11.7	81.0	19.0
Pan	18.90	19.0	100.0	
Total	100.05	100.0		

SCREEN ANALYSIS

Sample: MRI 3667B, 10 minute rod mill grind; 61% solids.

Tyler Mesh	Direct Weight grams	%	Cumulative Weight, % Retained	Passing
65	0.04	0.0	0.0	100.0
100	0.11	0.1	0.1	99.9
150	0.81	0.8	0.9	99.1
200	15.01	15.0	15.9	84.1
270	17.15	17.2	33.1	66.9
325	28.54	28.5	61.6	38.4
400	5.51	5.5	67.1	32.9
500	13.49	13.5	80.6	19.4
Pan	19.50	19.4	100.0	
Total	100.20	100.0		

SCREEN ANALYSIS

Sample: HRI 26678, 20 minute rod mill grind; 62% solids.

Tyler Mesh	Direct Weight grams	Direct Weight %	Cumulative Weight, % Retained	Cumulative Weight, % Passing
65	0.14	0.1	0.1	99.9
100	0.12	0.1	0.2	99.8
150	0.13	0.1	0.3	99.7
200	5.35	5.3	5.6	94.4
270	13.97	13.9	19.5	80.5
325	26.81	26.8	46.3	53.7
400	5.28	5.3	51.6	48.4
500	24.92	24.9	76.5	23.5
Pan	23.48	23.5	100.0	
Total	100.20	100.0		

SCREEN ANALYSIS

Sample: HRI 26678, 30 minute rod mill grind; 62% solids.

Tyler Mesh	Direct Weight grams	Direct Weight %	Cumulative Weight, % Retained	Cumulative Weight, % Passing
65	0.15	0.1	0.1	99.9
100	0.70	0.7	0.8	99.2
150	0.09	0.1	0.9	99.1
200	0.48	0.5	1.4	98.6
270	7.88	7.8	9.2	90.8
325	34.09	33.9	43.1	56.9
400	7.81	7.8	50.9	49.1
500	19.69	19.6	70.5	29.5
Pan	29.74	29.5	100.0	
Total	100.63	100.0		

APPENDIX C
Thickening Data

KYNCH PROCEDURE - THICKENING TEST DATA

Project 5801
Notebook 1590
Page 107
Date
By

Objective Thickening of flotation tails from Test 1590-84

Flocculant MGL, 0.5 g/l Amount 5 ml
0.014 lb/ton

Settling Rate			Pulp Density Measurements		
Level ml	Time min		Feed Pulp	Terminal Pulp	Clear Liquor
1000	0	Volume, ml	104.5	298	747
900	0.3	Gross pulp weight, g			
800	0.7	Tare, g			
700	1.1	Net pulp weight, g	1265.1	513.84	
600	1.5	Gross dry weight, g		350.95	
500	2.4	Tare, g		3.52	
442	3.0	Net dry weight, g	347.43	347.43	
385	4.0	Density, g/l	1211	1724	
335	5.0	Solids, %	27.5	67.6	
310	6.0				
302	8.0				
300	10.0				
298	15.0				
298	30.0				

Terminal Level
18 hrs

Time rake installed None

Thickener rake rotation min/rev

Thickener Unit Area Requirement

Cylinder height ft
Terminal pulp: 67.6% solids
Initial height, H_o 1.24 ft

Initial pulp density, $C_o = (31.3 \times 10^{-6})$ (feed solids content, g solids/liter slurry) = ton/ft^3

$C_o = (31.3 \times 10^{-6}) \times 332.5 =$ 0.0104 ton/ft^3

Critical time, $T_x =$ 0.0049 days

Unit area, $UA = \frac{T_x}{C_o H_o} =$

UA = 0.4 ft^2/ton/day

Liquor Clarity Observations Initial clarity excellent; final

KYNCH PROCEDURE – THICKENING TEST DATA

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By

Objective See Test 1590-107

Flocculant MGL, 0.5 g/l Amount 10 ml
0.03 lb/ton

Settling Rate Level ml	Settling Rate Time min		Pulp Density Measurements: Feed Pulp	Terminal Pulp	Clear Liquor
1000	0	Volume, ml	1063	290	773
900	0.4	Gross pulp weight, g			
800	0.8	Tare, g			
700	1.25	Net pulp weight, g	1326.2	536.7	
600	1.80	Gross dry weight, g		366.00	
500	2.8	Tare, g		3.38	
400	4.25	Net dry weight, g	362.62	362.62	
362	5.0	Density, g/l	1298	1851	
320	6.0	Solids, %	27.3	67.6	
296	10.0				
293	16.0				
291	30				
290	18 hr				

Terminal Level _____ hrs

Time rake installed None

Thickener rake rotation _____ min/rev

Thickener Unit Area Requirement

Cylinder height _____ ft
Terminal pulp: 67.6% solids
Initial height, H_o 1.26 ft

Initial pulp density, $C_o = (31.3 \times 10^{-6})$ (feed solids content, g solids/liter slurry) = ton/ft^3

$C_o = (31.3 \times 10^{-6}) \times 341.1 = 0.0107$ ton/ft^3

Critical time, T_x = 0.0063 days

Unit area, $UA = \frac{T_x}{C_o H_o}$ = _____

UA = 0.5 ft^2/ton/day

Liquor Clarity Observations: Initial clarity, excellent

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Notebook 1590
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Date
By

Objective See Test 1590-107

Flocculant MG 200, 0.5 g/l Amount 10 ml
0.03 lb/ton

Settling Rate Level ml	Settling Rate Time min		Pulp Density Measurements: Feed Pulp	Terminal Pulp	Clear Liquor
1000	0	Volume, ml	1936	292	744
900	0.4	Gross pulp weight, g			
800	0.8	Tare, g			
700	1.25	Net pulp weight, g	1231.1	505.3	
600	1.8	Gross dry weight, g		341.32	
500	2.6	Tare, g		3.34	
465	3.0	Net dry weight, g	337.98	337.98	
402	4.0	Density, g/l	1188	1730	
362	5.0	Solids, %	27.5	66.9	
338	6.0				
300	10.0				
294	15				
292	30				

Terminal Level _____ hrs

Time rake installed None

Thickener rake rotation _____ min/rev

Thickener Unit Area Requirement

Cylinder height _____ ft

Initial height, H_o 1.25 ft

Initial pulp density, C_o = (31.3×10^{-6}) (feed solids content, g solids/liter slurry) = ton/ft^3

$C_o = (31.3 \times 10^{-6}) \times 326.2 = 0.0101$ ton/ft^3

Critical time, T_x = 0.0078 days

Unit area, $UA = \frac{T_x}{C_o H_o} =$ _____

UA = 0.6 ft^2/ton/day

Liquor Clarity Observations _____

APPENDIX D
Bond Work Index Data

WORK INDEX CALCULATIONS

The Work Indices were calculated in accordance with Bond's "Third Theory of Comminution" from the following formula:

$$\text{Work Index} = \frac{C \times T}{W} \times \frac{1}{10/\sqrt{P} - 10/\sqrt{F}}$$

where C = mill constant (622)
T = grinding time in minutes
W = weight of feed in grams
P = size modulus K_{80} of product
F = size modulus K_{80} of feed

The mill constant C was determined by grinding a reference ore of known work index.

SCREEN ANALYSIS

Sample: MRI 2667B, minus 10-mesh feed to Bond Work Index

Tyler Mesh	Direct Weight grams	Direct Weight %	Cumulative Weight, % Retained	Cumulative Weight, % Passing
6	0.00	0.0	0.0	100.0
10	0.30	0.1	0.1	99.9
14	89.00	42.2	42.3	57.7
20	33.23	15.8	58.1	41.9
28	14.81	7.0	65.1	34.9
35	9.11	4.3	69.4	30.6
48	6.09	2.9	72.3	27.7
65	4.01	1.9	74.2	25.8
100	3.62	1.7	75.9	24.1
150	3.73	1.8	77.7	22.3
200	9.32	4.4	82.1	17.9
270	7.71	3.7	85.8	14.2
325	8.37	4.0	89.8	10.2
400	4.74	2.2	92.0	8.0
Pan	16.73	8.0	100.0	
Total	210.77	100.0		

SCREEN ANALYSIS

Sample: HRI 26678, Bond Work Index Product;
5 minute grind.

Tyler Mesh	Direct Weight grams	Direct Weight %	Cumulative Weight, % Retained	Cumulative Weight, % Passing
6	0.00	0.0	0.0	100.0
10	0.00	0.0	0.0	100.0
14	0.00	0.0	0.0	100.0
20	0.00	0.0	0.0	100.0
28	5.90	3.0	3.0	97.0
35	1.11	0.6	3.6	96.4
48	1.63	0.8	4.4	95.6
65	2.49	1.2	5.6	94.4
100	5.23	2.6	8.2	91.8
150	8.10	4.1	12.3	87.7
200	29.75	14.9	27.2	72.8
270	30.64	15.3	42.5	57.5
325	37.58	18.8	61.3	38.7
400	10.34	5.2	66.5	33.5
Pan	67.23	33.5	100.0	
Total	200.00	100.0		

SCREEN ANALYSIS

Sample: HRI C6678, Bond Work Index Product;
10 minute grind.

Tyler Mesh	Direct Weight grams	Direct Weight %	Cumulative Weight, % Retained	Cumulative Weight, % Passing
8	0.00	0.0	0.0	100.0
10	0.00	0.0	0.0	100.0
14	0.00	0.0	0.0	100.0
20	0.00	0.0	0.0	100.0
28	0.71	0.4	0.4	99.6
35	0.14	0.1	0.5	99.5
48	0.19	0.1	0.6	99.4
65	0.29	0.1	0.7	99.3
100	0.85	0.4	1.1	98.9
150	2.41	1.2	2.3	97.7
200	16.99	8.5	10.8	89.2
270	25.52	12.8	23.6	76.4
325	51.60	25.8	49.4	50.6
400	11.47	5.7	55.1	44.9
Pan	89.87	44.9	100.0	
Total	200.00	100.0		

APPENDIX E
Additional Analyses

FLUO RESCENT
X RAY
SPEC TROGRAPHIC
Analytical Laboratory

E-1
718 Sherman Street (rear)
Denver, Colorado 80203
Phone (303) 837-1396
Merlyn L. Salmon, Manager

XXXX QUALITATIVE
XXXX SEMI-QUANTITATIVE
____ QUANTITATIVE

ANALYTICAL REPORT

Job Number 31259
Page 1 of 6 Pages
Date 26 Dec 1983

TO: Hazen Research, Inc 0730 R. Rostad

SAMPLE: Test 1590-87-1
Copper Ro conc

Copper	6.8	Iron	18.	Lanthanum	
Silver	0.016	Cobalt		Cerium	
Gold		Nickel	0.047	Praseodymium	
Zinc	0.050	Cesium		Neodymium	
Cadmium		Rubidium		Samarium	
Mercury		Barium		Europium	
Gallium		Strontium	0.020	Gadolinium	
Indium		Titanium	0.036	Terbium	
Thallium		Zirconium	0.037	Dysprosium	
Germanium		Hafnium		Holmium	
Tin	0.092	Thorium		Erbium	
Lead	0.24	Vanadium		Thulium	
Arsenic	0.88	Columbium		Ytterbium	
Antimony	0.13	Tantalum		Lutetium	
Bismuth	0.029	Chromium	0.020	Yttrium	
Selenium	0.19	Molybdenum	0.049		
Tellurium	0.037	Tungsten			
Bromine		Uranium	0.054		
Iodine		Manganese	0.018		

The values above are estimated elemental concentrations in:
XXXXX per cent _____ parts per million _____ grams per liter

No check was made for elements with atomic numbers less than 22.

By Merlyn Salmon

NOTE: A PORTION OF THE REPORTED SAMPLES WILL BE RETAINED ON FILE FOR A PERIOD OF TWO YEARS FROM THE ABOVE DATE. THE REMAINDER OF THE SAMPLE WILL BE RETAINED FOR THIRTY DAYS PENDING RECEIPT OF WRITTEN INSTRUCTIONS FOR DISPOSAL FROM THE ADDRESSEE ABOVE.

FLUO RESCENT
X RAY
SPEC TROGRAPHIC
Analytical Laboratory

E-2
718 Sherman Street (rear)
Denver, Colorado 80203
Phone (303) 837-1396
Merlyn L. Salmon, Manager

XXXX QUALITATIVE
XXXX SEMI-QUANTITATIVE
_____QUANTITATIVE

ANALYTICAL REPORT

Job Number 31259
Page 2 of 6 Pages
Date 26 Dec 1983

TO: Hazen Research, Inc

SAMPLE: Test 1590-87-2
Pyrite Ro Conc

Copper	0.075	Iron	7.0	Lanthanum	
Silver	0.007	Cobalt		Cerium	
Gold		Nickel	0.006	Praseodymium	
Zinc	0.013	Cesium		Neodymium	
Cadmium		Rubidium		Samarium	
Mercury		Barium	0.072	Europium	
Gallium		Strontium	0.009	Gadolinium	
Indium		Titanium	0.089	Terbium	
Thallium		Zirconium	0.009	Dysprosium	
Germanium		Hafnium		Holmium	
Tin	0.014	Thorium		Erbium	
Lead	0.086	Vanadium		Thulium	
Arsenic	0.006	Columbium		Ytterbium	
Antimony		Tantalum		Lutetium	
Bismuth		Chromium		Yttrium	
Selenium	0.058	Molybdenum	0.015		
Tellurium		Tungsten			
Bromine		Uranium			
Iodine		Manganese	0.013		

The values above are estimated elemental concentrations in:
~~XXXXX~~ per cent _____ parts per million _____ grams per liter

No check was made for elements with atomic numbers less than 22.

By Merlyn L Salmon

NOTE: A PORTION OF THE REPORTED SAMPLES WILL BE RETAINED ON FILE FOR A PERIOD OF TWO YEARS FROM THE ABOVE DATE. THE REMAINDER OF THE SAMPLE WILL BE RETAINED FOR THIRTY DAYS PENDING RECEIPT OF WRITTEN INSTRUCTIONS FOR DISPOSAL FROM THE ADDRESSEE ABOVE.