Report of the Ore Dressing & Metallurgical Laboratories

Report No 351

"The Flotation of Copper and Iron Pyrites in the Ore of the Aldermac Mines".

by A K Anderson

Shipments. Four hundred and fourteen pounds of ore were received by freight on Dec 12. 1929 from the Aldermac Mines Ltd., Rouyn district, Quebec, forwarded by Anderson & MacKay, consulting Mining Engineers, New Birks Bldg., Montreal.

Characteristics of the Ore. The shipment consisted of heavy, massive iron sulphides containing a small amount of copper sulphide. Practically no gangue minerals were visible.

Purpose of Experimental Tests. The purpose of the tests was to determine what recovery of copper could be obtained and also to produce an iron sulphide concentrate as low in zinc as possible. Twenty five pounds of this iron sulphide concentrate was required by the Canadian Industries, Ltd., Bell Telephone Bldg., Montreal, Que for testing ~~in the Freeman Pyrite Burner, developed at Shawinigan Falls, Que~~ for its suitability for sulphuric acid manufacture.

Sampling and Analysis. The lot was crushed to pass ¼ inch mesh and after thorough mixing passed through a Jones riffle sampler. One half was then crushed to pass 14 mesh. After several passes through the sampler a representative portion of this was secured for analysis showing the shipment to contain:

351.

Copper = 1.98 %
Zinc - 0.49 %
Iron = 40.5 %
Gold - 0.02 g/ton
Silver - 1.18 g/ton

Experimental Tests: All tests were made by the flotation process. The procedure was the same in all tests. The first step was grinding and conditioning the ore with reagents known to depress zinc and iron sulphides and floating the copper minerals. The second step was reactivating the zinc sulphide and floating this mineral in order to remove as much zinc as possible from the remaining pyrrhotite and pyrite. The third stage was floating the iron pyrite to secure a concentrate high in sulphur, leaving the pyrrhotite as a tailing too low grade to meet the specified requirements of 48-50 % Sulphur.

All the tests were made on 2000 gramme portions of the mines 14 mesh material ground with an equal weight of water in an iron ball-mill containing iron balls. Grinding was such that 85% passed 200 mesh. Each test, while conforming to the main procedure, was made with its own individual set of reagents.

The detailed tests follow:

Test No 1.

Reagents in lb/ton

To Ball Mill		To Flotation Machine			
			Copper	Zinc	Iron
Soda Ash	= 5.0	Potassium Xanthate	0.10	0.04	
Cyanide	= 0.14	Amyl Xanthate			0.30
		Copper Sulphate		1.0	
		Pine Oil	0.04	0.04	0.08

Product	% Wt	assay			% Values		
		Cu %	Zn %	Fe %	Cu	Zn	Fe
Heads		1.98	0.49	40.5			
Cu Concentrate	24.9	8.28	0.76	42.5	93.2	38.3	25.2
Zn "	15.2	0.46	1.75	43.5	3.2	53.9	15.8
Fe "	30.7	0.08	0.05	46.5	1.1	3.1	34.0
Tailing	29.2	0.19	0.08	35.8	2.5	4.7	25.0
	100.0				100.0	100.0	100.0

The conditions under which this test was made result in the production of a bulky, low-grade copper concentrate representing 24.9 % of the weight of ore milled. A recovery of 93.2 % of the copper is obtained in this product. This concentrate was not cleaned. In practice it would be passed through one or two cleaner cells, thus raising the grade of the final product. The tailing from these cleaner cells called 'middling' would be returned to the circuit for further treatment.

The iron concentrate is apparently of the required grade, being very low in zinc. However, due to the large amount of low-grade copper concentrate the weight of iron pyrite recovered is only 30.7 %

of the total weight.

Test No 2.

In this test the amount of soda ash added to the ball mill was increased over that used in Test No 1.

Reagents in lb/ton

To Ball Mill		To Flotation Machine			
			Copper	Zinc	Iron
Soda Ash	10.0	Potassium Xanthate	0.10	0.04	
Cyanide	0.14	Amyl Xanthate			0.30
		Copper Sulphate		1.0	
		Pine Oil	0.04	0.04	0.08

Product	% Wt	Assay			% Values		
		Cu	Zn	Fe	Cu	Zn	Fe
Heads		1.98	0.49	40.5			
Cu Concentrate	24.6	7.86	0.76	42.4	92.0	38.3	28.2
Zn "	15.5	0.50	1.75	44.3	3.7	55.6	18.6
Fe "	32.4	0.12	0.05	47.5	1.8	3.3	28.8
Tailing	27.5	0.19	0.05	32.8	2.5	2.8	24.4
	100.0				100.0	100.0	100.0

Increasing the soda ash does not have any marked beneficial effect. The bulk and grade of the copper concentrate and the recovery of copper are approximately the same. The iron concentrate also is similar to that of Test No 1.

Test #3.

In this test the alkaline reagent was changed, lime being used in place of soda ash.

Reagents in Circuit

To Ball Mill	To Flotation Machine			
		Copper	Zinc	Iron
Lime - 6.0	Potassium Xanthate	0.05	0.05	
Cyanide = 0.10	Amyl Xanthate			0.30
	Copper Sulphate		1.0	
	Pine Oil	0.04	0.04	0.08

Product	% Wt	Assay			% Values		
		Cu %	Zn %	Fe %	Cu	Zn	Fe
Heads		1.98	0.49	40.5			
Cu Concentrate	7.8	18.86	0.63	36.9	75.3	13.9	6.9
Zn "	6.7	1.32	3.72	47.7	4.5	70.5	7.7
Fe "	44.7	0.70	0.05	45.8	16.0	6.3	49.2
Tailing	40.8	0.20	0.08	36.9	4.2	9.3	36.2
	100.0				100.0	100.0	100.0

The use of lime and cyanide as depressants for zinc and iron sulphides has a marked detrimental effect. It also depresses copper sulphides. This is indicated by the lowered recovery of copper in the copper concentrate and the presence of 20.5 % copper in the combined zinc and iron concentrates. The grade of copper concentrate is much higher than that produced in Tests 1 & 2, 18.86% as against 8.28%. The bulk is much less, 7.8% as against 24.9%.

There is an increase in the amount of iron pyrite recovered. The zinc in this product is also low.

Test # 4

The reagents ~~in this test~~ used for the flotation of copper and zinc in this test were the same as in Test # 3. After removing the zinc concentrate, the pulp was acidified with Sulphuric acid and the iron pyrite floated with Amyl Xanthate and pine oil.

Reagents as per flow sheet

To Ball Mill	To Flotation Machine			
		Copper	Zinc	Iron
Lime = 6.0	Potassium Xanthate	0.05	0.05	
Cyanide = 0.10	Amyl Xanthate			0.30
	Copper Sulphate		1.0	
	Sulphuric acid			17.0
	Pine oil	0.04	0.04	0.08

Product	% Wt	Assay			% Values		
		Cu %	Zn %	Fe %	Cu	Zn	Fe
Heads		1.98	0.49	40.5			
Cu Concentrate	9.9	14.72	0.76	40.1	72.1	19.5	9.5
Zn "	4.8	1.46	4.87	41.9	3.5	60.7	4.8
Fe "	67.2	0.68	0.10	47.7	22.6	17.4	76.3
Tailing	18.1	0.20	0.06	22.0	1.8	2.4	9.4
	100.0				100.0	100.0	100.0

These results bear out the deductions made in the preceding test that lime and cyanide are detrimental to the flotation of copper sulphides.

Acidifying the pulp for the flotation of iron pyrite has a marked effect, increasing the weight of iron concentrate recovered. 67% of the total weight of ore treated is obtained as against 44.7% in an alkaline circuit. The percentage of zinc in this product is 0.10% as against 0.05% in preceding tests.

Test No 5

The four preceding tests were made to establish flotation conditions prior to making twenty five pounds of iron pyrite concentrate as low in zinc as possible for shipment to the Canadian Industries, Ltd., Montreal, Que.

As the best grade of material ~~was~~ resulted from grinding with soda ash and cyanide and floating in alkaline circuit, these conditions were adopted. Sixty six pounds of the ore was ground in batches of 2000 grammes each, and floated. The copper concentrate was cleaned once to note the effect on the grade of this product.

Reagents in lbs/ton

To Ball Mill	To Flotation Machine			
		Copper	Zinc	Iron
Soda ash = 7.0	Potassium Xanthate	0.10	0.04	
Cyanide = 0.14	Amyl Xanthate			0.30
	Copper Sulphate		1.0	
	Pine oil	0.04	0.04	0.06

Product	% Wt	Assay				% Values		
		Au %	Zn %	Fe %	S %	Cu	Zn	Fe
Heads		1.98	0.49	40.5				
Cu Concentrate 1	6.7	13.03	0.24	38.9		43.6	4.5	6.4
" Middling	10.5	8.98	0.36	41.7		47.0	10.6	10.7
Zn Concentrate	6.1	1.54	4.15	42.1		4.7	70.8	6.3
Fe "	40.6	0.10	0.08	46.5	50.9	2.0	9.1	46.2
Tailing	36.1	0.15	0.05	34.5		2.7	5.0	30.4
	100.0					100.0	100.0	100.0

Under these conditions every 100 tons of ore milled would yield 40.6 tons of iron concentrate with an analysis of 50.9% Sulphur, 46.5% iron, 0.10% copper and 0.08% zinc.

Cleaning the roughed copper concentrate raises the grade to 13% copper. A second cleaning would result in a still higher-grade product. The middling in practice would be returned to the circuit for further treatment.

Test #6.

In the preceding tests flotation in a circuit alkaline with soda ash is shown to produce a bulky, low-grade copper concentrate. In this test the amount of collecting agent added for the flotation of copper was reduced and the cyanide increased. The iron pyrite was floated from an acid pulp.

Reagents in lbs/ton

To Ball Mill	To Flotation Machine			
		Copper	Zinc	Iron
Soda Ash = 7.0	Potassium Xanthate	0.05	0.05	
Cyanide = 0.20	Amyl Xanthate			0.30
	Copper Sulphate		1.0	.
	Sulphuric Acid			17.0
	Pine Oil	0.04	0.04	0.06

Product	% Wt	Assay			% Values		
		Cu %	Zn %	Fe %	Cu	Zn	Fe
Heads		1.98	0.49	40.5			
Cu Concentrate	12.0	14.73	0.41	38.1	89.7	14.2 ~~1.4~~	11.2
Zn "	4.3	1.82	5.85	40.1	4.0	72.7 ~~7.3~~	4.2
Fe "	48.1	0.06	0.05	48.3	1.5	6.9 ~~0.7~~	56.8
Tailing	35.6	0.27	0.06	31.9	4.8	6.2 ~~0.6~~	27.8
	100.0				100.0		100.0

Under these conditions, 89.7% of the copper is recovered in a roughes concentrate assaying 14.73% copper. This grade would be raised by cleaning. The precious metals in this product were found to be 0.06 oz gold and 5.96 oz per ton, representing 36.0% and 60.6% respectively of the values in the ore.

The grade and recovery of the iron pyrite is good.

Test #7

Lime and cyanide in reduced amounts were used in this test, and the iron pyrite floated in acid circuit.

Reagents in lb/ton

To Ball Mill	To Flotation Machine			
		Copper	Zinc	Iron
Lime = 1.5	Potassium Xanthate	0.05	0.05	
Cyanide = 0.05	Amyl Xanthate			0.30
	Copper Sulphate		1.0	
	Sulphuric Acid			7.1
	Pine Oil	0.04	0.04	0.06

Product	% Wt	assay			% Values		
		Cu	Zn	Fe	Cu	Zn	Fe
Heads		1.98	0.49	40.5			
Cu Concentrate	7.4	18.91	0.35	35.2	73.0	9.2	6.3
Zn "	4.1	5.85	2.57	40.8	12.5	37.4	4.1
Fe "	47.9	0.15	0.22	47.4	3.7	37.5	55.6
Tailing	40.6	0.51	0.11	35.1	10.8	15.9	34.6
	100.0				100.0	100.0	100.0

These results bear out the conclusions arrived at in previous tests. The use of lime and cyanide results in poor copper recoveries and also

increases the impurities in the iron pyrite concentrate.

The copper concentrate assays 0.08 oz gold and 6.22 oz silver per ton, representing recoveries of 29.6 % and 39.0 % respectively.

Test #8.

As the lime - cyanide combination has a strong depressing action on the copper sulphides in this ore, this test was made to note the effect of lime alone, no cyanide being added. The iron pyrite was floated in acid circuit.

Reagents in lbs/ton

To Ball Mill	To Flotation Machine			
		Copper	Zinc	Iron
Lime = 6.0	Potassium Xanthate	0.06	0.05	
	Amyl Xanthate			0.30
	Copper Sulphate		1.0	
	Sulphuric Acid			17.0
	Pine Oil	0.04	0.04	0.06

Product	% Wt	Assay				% Values		
		Cu %	Zn %	Fe %	S %	Cu	Zn	Fe
Heads		1.98	0.49	40.5				
Cu - Concentrate	7.5	22.00	0.47	33.7		85.3	12.9	6.0
Zn "	2.9	5.65	6.78	33.1		8.5	71.9	2.3
Fe "	60.9	0.08	0.04	48.6	48.2	2.5	8.9	70.8
Tailing	28.7	0.25	0.06	30.4		3.7	6.3	20.9
	100.0					100.0	100.0	100.0

156

Omitting the cyanide added to the ball mill raises the recovery of copper from 75.3 % as indicated in Test #3 to 85.3 %. a high grade roughed concentrate assaying

22.00 % copper is produced. By taking off a lower grade concentrate and cleaning, a higher recovery would likely result.

Very good results are obtained in the flotation of the iron pyrite. This product analyses 48.2 % sulphur, 0.04 % zinc and represents 60.9 % of the total weight of ore milled.

The copper concentrate assays 0.07 g gold and 6.49 g silver per ton, representing 26.3 % and 41.2 % of the gold and silver in the ore.

Test #9

This test is the same as test #8 with the exception that after the flotation of zinc, the pulp was dewatered and re-pulped with fresh water before acidifying for the flotation of the iron pyrite.

Reagents in oz/ton

To Ball Mill	To Flotation Machines			
		Copper	Zinc	Iron
Lime = 6.0	Potassium Xanthate	0.06	0.05	
	Amyl Xanthate			0.30
	Copper Sulphate		1.0	
	Sulphuric Acid			5.0
	Pine Oil	0.04	0.04	0.06

Product	% Wt	Assay				% Values		
		Cu %	Zn %	Fe %	S %	Cu	Zn	Fe
Heads		1.98	0.49	40.5				
Cu Concentrate	7.2	23.28	0.46	33.1		86.2	13.1	5.9
Zn "	2.6	6.60	5.85	33.6		8.9	60.3	2.2
Fe "	53.7	0.07	0.05	47.3	48.2	1.9	10.6	62.6
Tailing	36.5	0.16	0.11	32.6		3.0	16.0	29.3
	100.0					100.0	100.0	100.0

The results of this test duplicate those obtained in Test #8 with the exception that less pyrite concentrate was produced. There was 28.8 % of the gold and 41.5 % of the silver in the copper concentrate which assayed 0.083 gold and 6.80 g. Silver per ton.

Twelve pounds per ton less Sulphuric acid was used in this test. It is apparent that it is advantageous to to dewater the pulp prior to acidifying, thus getting rid of lime in solution which would require acid to neutralize it.

Summary and Conclusions

A comparison of results secured in the copper flotation when using soda ash - cyanide, lime - cyanide and lime alone for conditioning agents is of interest.

Copper Concentrate

Conditioning Agents	Test No	Assay % Cu	% Values Cu	% of Feed %
Soda ash - cyanide	6	14.73	89.7	12.0
Lime - Cyanide	7	18.91	73.0	7.4
Lime	9	23.28	86.2	7.2

It is evident that a lime - cyanide combination is highly detrimental as its use results in low copper recoveries.

When using lime alone, the bulk of concentrate produced is much lower than that when soda ash - cyanide is used, coupled with a higher grade product. Due to this feature, that a rougher concentrate assaying 23.28% is produced when using lime with no cyanide, an increase in the recovery can be expected on taking off more of a lower grade rougher concentrate. This can then

be re-floated in cleaner cells resulting in a high grade finished copper concentrate and a middling product which will be returned to the circuit.

Acidifying the pulp after the zinc flotation yields the highest recoveries of iron pyrite. 50-60% of the ore milled can be recovered in a product with an analysis of 48-50% Sulphur and containing from 0.10 to 0.05% zinc.

Dewatering the tailing from the zinc flotation cells prior to acidifying will result in a saving of acid without affecting the recoveries of iron pyrite.

It is recommended that grinding be done in a circuit alkaline with lime. The use of cyanide is not advised as it results in lowered copper recoveries. A saving in cost of reagents and royalties is also effected by its omission. The amount of lime necessary to add will be determined by actual mill operation, only enough to depress the iron pyrite and maintain sufficient alkalinity for best copper flotation conditions being indicated.

The removal of the zinc presents no difficulties as the ore does not contain any great quantity of this but if not removed will contaminate the iron pyrite concentrate, it is therefore floated with a minimum addition of reagents and sent to waste.

A saving in acid will be effected by de-watering the pulp before entering the iron pyrite flotation circuit. This can be achieved by using any of the standard thickeners as de-waterers followed by dilution of the thickened product while passing to the flotation cells.

Filtering the iron pyrite concentrate should give no trouble as the moisture content is reduced very rapidly on a suction filter.

The flotation of this ore presents no extraordinary metallurgical problems. However, due to the extremely massive nature of the ore, oxygen depletion of the pulp may result in the grinding mill and flotation be affected, making necessary a conditioning of the pulp prior to flotation.

Jan 29/30