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CONCENTRATION OF LEAD-ZINC ORES OF EASTERN CANADA

by

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Introductory

The steady advance in the price of lead and zinc in the metal markets of the world during the past few years has resulted in an active search for new deposits of these metals, and to the re-examination of known properties that are now idle.

There are a number of deposits of these metals in eastern Canada, the best known of which are the Tetreault mine at Notre Dame des Anges, Que; the Reader mine on Calumet Island, Que; the Stirling property in Cape Breton, and the Federal mine in Gaspe district, Que. The author has run concentration tests on the ores from the first three mentioned properties. The ores from Notre Dame des Anges and Calumet Island presented problems in concentration which were not successfully solved until the past year. Although considerable experimental work has been done by the Ore Testing Laboratories on the ore from the Stirling mine we have not been successful in developing a satisfactory method of treatment.

Character and types of ores

Metallurgically the lead-zinc ores of eastern Canada may be classified into three distinct types as follows:

First: Ores in which the sulphide minerals are fairly coarsely crystalline and can be freed by crushing to 40 or 60 mesh. The zinc blend has a high iron content (not marmatite) and gives a dark brown colour on grinding. The ores of Notre Dame des Anges and Calumet Island, Que. may be cited as examples.

Second: Ores in which the sulphide minerals are very finely disseminated and require extremely fine grinding. The zinc blend contains such high percentages of iron that it can be classed as marmatite. The

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ore of the Stirling mine, Cape Breton is an example.

Third: Ores in which the sulphide minerals are fairly coarsely crystalline and the zinc blend is of the light resin-coloured variety containing very little iron. The ore of the Federal Lead and Zinc Co's mine in Gaspe, Que, is an example.

Early methods of concentration

The ore at Notre Dame des Anges was discovered in 1910, and in 1912 Mr. Tetreault erected a concentrating mill in the hope of treating this complex ore by methods used in the Joplin district. The mill failed to produce a marketable gra de of concentrate. In 1914 the Weedon Mining Company obta ined a lease on the property and remodelled the mill. The galena was concentrated by graded crushing and tabling. A zinc-iron middling product was obtained on tables, and oil flotation was used to save the slimed blend, but as the iron sulphide floated with the zinc, the product was too low grade to market. To eliminate the iron sulphide a magnetic separation plant was built and the non-magnetic p yrite was given a roast to convert it to the magnetic form. A considerable tonnage of zinc concentrates produced in this manner was marketed. It is said that they averaged about 42% zinc. The process was costly and could not be looked upon as a commercial success. A large dump of zinc-iron middlings containing about 24% zinc was left on the property and these are now being successfully concentrated by the British Metals Corporation (Canada) Ltd.

The Reader property on Calumet Island was operated intermittently from 1896 to 1913. In 1910 a small concentrator was built and trial shipments were made to Newark, N.J. In 1912 a 150-ton concentrator was built, equipped with jaw crusher, coarse rolls, screens, fine rolls, jigs, Huntingdon mill, Wilfley and Overstrom tables. The mill was only operated for a few months and then closed down. The records show that a marketable lead product was made containing on the average, 65% lead, 8% zinc, 0.5% copper, and 87 ozs. silver. A low grade zinc concentrate was obtained averaging about 3.5% lead, 28% zinc and 18 ozs. silver, the remainder being iron sulphides. A sample of the mill tailings recently taken from the dump contained 1.77% lead, 12.15% iron, and 8.? ozs. silver, showing that the recovery of lead and silver obtained was very poor and probably did not exceed 50% of either mineral

Results of Mines Branch experiments.

The problem of concentrating ores possessing such characteristics as the first type mentioned above has been solved in many cases by the application of the froth flotation process. The object in conducting experimental tests on these ores was to determine whether a method of selective flotation could be worked out which would produce a marketable lead and zinc product with high recoveries of values, especially of the silver.

Notre Dame des Anges ore: The first shipment received from the Notre Dame des Anges property consisted of a sample taken from a dump of zinc-iron middlings from the old mill. This was followed by a sample of the mine ore. Small scale tests were made on these samples and very satisfactory results obta ined. These small scale tests were further checked by large scale tonnage tests made on car lots. A synopsis of the results obtained from both small scale and tonnage scale tests are given below in table form. The small scale tests were run during the fall of 1923 and the winter of 1924.

The large scale tests on the run of mine ore were made during the summer of 1924, but the large scale tests on the zinc middlings were made in February 1925.

Small scale flotation tests on zinc middlings:

Head Analysis

Zinc	.. .. ..	17.23 %
Lead	.. .. ..	2.16
Iron	.. .. ..	37.57
Gold	.. .. ..	0.12 oz/ton
Silver	.. ..	4.68

General Procedure: The middlings were ground in a small ball mill to 65 mesh. The density of the pulp in the mill was 1:1 A charge was prepared for each test. Some of the reagents were added to the ball mill and others directly to the flotation cell.

Results:

Product	Weight %	Analysis					Per cent of zn. values
		Zn %	Pb %	Fe %	Au oz.	Ag oz.	
Concentrate	36.6	42.08	4.69	13.23	0.16	9.90	90.4
Middling	7.5	11.60	1.75	45.85	0.02	4.20	5.1
Tailing	55.9	1.25	tr.	52.92	0.03	1.65	4.5

Conclusions: Although the results of these tests could very probably be duplicated in actual practice on the freshly produced middling, difficulty might be encountered in the case of the old dump material. Small batch tests have been found to give, in some cases, unreliable results on such material. It would be necessary to run large scale tonnage check tests on a truly representative shipment of the dump material before a definite opinion could be given on this method of trea tment.

Tonnage scale flotation tests on zinc-iron middlings: The British Metals Corporation (Canada) operated a flotation plant on this material during last summer with fairly satisfactory results. Just before closing the plant for the winter, a portion of the dump was encountered which had become badly oxidized. Trouble was experienced in floating this material, and a carload was sent to the Mines Branch testing plant at Ottawa for the purpose of determining whether the results could be improved so that data would be available for the resumption of operations in the spring. The result of one of these tests is given below:

General procedure: The zinc-iron middling was crushed in a Hardinge ball mill, the discharge from the mill fed direct to a four-cell Ruth flotation machine, where a lead concentrate was made in one operation, no cleaner cell being used. The tailing was pumped to a Callow unit consisting of two rougher cells and two cleaner cells where a zzinc concentrate was produced.

Lead reagents used during period in which No. 1 & 2 samples were taken:

18.0	lbs/ton	Soda ash
0.26	"	Cyanide
0.42	"	Oil mixture - Dominion Tar & Chemical Co's acid creosote 50%
		Barretts water gas tar .. 50%

Zinc reagents used during period in which no. 1 sample was taken:

2.0 lbs/ton Copper sulphate
0.4 " Potassium xanthate
Pine oil - sufficient to froth (about 3 drops per minute)

Zinc reagents used during period in which no. 2 sample was taken:

2.0 lbs/ton Copper Sulphate
0.7 " Dominion Tar & Chem.Co's No. 2 neutral creosote oil.

Density samples:

Time	Feed to lead cells	Feed to zinc cells	Tailing discharge from zinc cells.
11.20	1 : 1.273		
1.25		1 : 2.846	1 : 6.692
1.50	1 : 1.632	1 : 2.846	
2.45		1 : 2.846	
4.00	1 : 2.125	1 : 4.263	1 : 8.091

Analysis of samples:

Time taken	Product	Lead %	Zinc %
Whole time	Head sample	2.45	23.00
"	Lead concentrate	16.50	12.40
"	Lead tailing	0.40	24.50
10.45-3.00	Zinc concentrate sample No. 1	0.30	51.62
10.45-3.00	Zinc tailing "	0.45	0.85
3.45-4.00	Zinc concentrate sample No. 2	0.55	48.86
3.00-4.00	Zinc tailing "	0.55	3.00

These samples were obtained by sampling the products from the machines at two minute intervals.

Recoveries: The recovery in the above test was approximately:

Lead 85%
Zinc 91%

Summary & Conclusions: It will be observed that the samples marked No. 1 give a higher grade concentrate and a lower tailing than those marked No. 2. Referring to the reagents used, it will be seen that the use of potassium xanthate was responsible for the more favourable result. It is worth while to point out that the production of a 50% zinc concentrate with a tailing containing less than 1% zinc from material of this kind is a remarkable result. Potassium xanthate is a new flotation reagent, and to the author's knowledge has never before been used in this class of work.

Small scale flotation tests on run of mine ore: General procedure: The ore was ground in a ball mill to 65 mesh. The density of the pulp in the mill was 1:1. For the flotation of the lead, some of the reagents were added to the ball mill, and others directly to the flotation cell. The lead tailing was dewatered, the pulp density lowered to 1:3 by the addition of fresh water, and the reagents for the flotation of the zinc added to the flotation cell.

Results of three selective flotation tests:

Product	Weight %	Analysis				%age of values	
		Zn %	Pb %	Au oz/tn	Ag oz/tn	Zn	Pb
Lead conc.	8.6	7.52	24.42	0.32	32.48	12.9	93.5
Zinc conc.	9.7	40.45	0.51	tr	1.38	78.4	2.2
Middling	5.5	4.43	0.41	0.02	1.44	4.9	1.0
Lead conc.	4.8	4.12	25.44	0.28	34.86	4.1	55.5
Zinc conc.	10.5	40.87	7.50	0.04	9.08	86.0	35.8
Zinc midd.	6.5	4.92	1.18	0.22	5.12	6.4	3.5
Tailing	78.2	0.21	0.15	tr	0.24	3.2	5.3
Lead conc.	7.7	8.49	34.47			10.9	90.5
Zinc conc.	15.1	34.94	1.13			83.5	5.8
Tailing	77.2	0.47	0.14			5.7	3.7

Conclusions: The results of these tests were very satisfactory, showing the possibility of selective flotation of the ore with the production of marketable lead a nd zinc concentrates. In conducting the tests, the lead concentrate was not recleaned, and in the last test given above, the zinc concentrate was not recleaned.

Tonnage flotation tests on run-of-mine ore: General procedure: This is a selective flotation test. The object was to produce a high grade lead and zinc concentrate. The classifier overflow which would pass 48 mesh was fed directly to a four-cell Ruth flotation machine, where a lead concentrate was made in one operation, no cleaner cell being used. The concentrates from the last two cells were returned to the feed end of the machine, a finished concentrate being taken from the first two cells. The tailing was pumped to Callow cells consisting of two rougher cells operated in parallel, and two cleaners in parallel. The middling product from the two cleaners was returned to the feed end of the rougher cells. Rate of feed: 1,400 lbs per hour.

Lead reagents: Soda ash, sodium cyanide, cresylic acid, oil mixture

Zinc reagents: Copper sulphate, No.634 oil, TT mixture, Pine oil No. 5

Analysis of products:

Time	Product	Zinc %	Lead %	Iron %	Insol %	Gold oz.	Silver oz.
Whole	Classifier overflow (Head smp	5.52	1.96	7.42		0.02	3.28
"	Lead conc. sample no. 1	4.17	51.09	2.60	16.13	0.30	
"	Lead tailing " " 1	5.12	0.22	6.16	49.04	tr	0.7
"	Zinc concentrate " " 1	41.46	2.72				
"	Zinc tailing " " 1	0.15	0.22	9.39			
	Zinc concentrate " " 2	47.18	1.15				
	Zinc tailing " " 2	0.53	0.17				
	Zinc concentrate, total sample	46.19	1.09				
	Zinc tailing " "	0.30	0.15				
	Special sample first cleaner, zn conc	20.86	1.29	11.92	11.30		
	Special sample of table concentrate by tabling final flotation tailg		3.64			0.06	6.44

Recapitulation of results using classifier overflow as head sample:

Average grade of lead concentrate 51.09 %
Average recovery of lead 89.4 %

Average grade of zinc concentrate	46.17 %
Average recovery of zinc	94.8 %

Gravity concentration of lead followed by flotation of zinc: A number of large scale tests were made in which the lead was tabled and the table tailings treated by flotation to recover the zinc. These tests are not given but are referred to in the general summary and conclusions:

General summary and conclusions: Two methods of concentration are suggested for the treatment of this ore, namely: tabling to recover the lead, followed by flotation of the table tailing to recover the zinc, and re-tabling the flotation zinc concentrate to recover additional lead. The alternative method is selective flotation, where a slightly lower grade lead concentrate is obtained, but with a much higher recovery than in the first method, and a higher grade zinc concentrate, lower in lead, with approximately the same recovery as in the first method. By the first method, provided that a system of graded crushing, screening, and classification is used, and a classified product fed to the tables, and the flotation concentrate is re-tabled, 80% of the lead values should be recovered in a high-grade lead concentrate containing 65 to 70% lead. The gold and silver values in the ore are practically all recovered and chiefly report in the lead concentrate. The zinc concentrate consistently contains only 0.10 oz. gold and approximately 12.0 oz. per ton silver. The zinc recovery is high, and 90% can be expected with a grade of concentrate assaying around 43 to 45% zinc. The chief difficulty in obtaining a high grade zinc concentrate is due to the tendency of the chloritic gangue mineral to float. This may not be so marked in a large flotation unit. By the second method of selective flotation, a 50% lead concentrate can be obtained with a 90% recovery of the lead values, and containing, from figures obtained in small scale flotation test No. 1, 95% of the gold and 97% of the silver. A 50% zinc concentrate can be obtained having a lead content of less than 1.5% and with a recovery of better than 90% of the zinc values.

The British Metals Corporation (Canada) are now building a mill the flow sheet of which is based on the results obtained from these tests. Due to the fact that the grade of the ore from the mine will be at times much higher than the shipment received by us, the flow sheet of the mill will include tabling, to recover part of the lead before flotation.

Reader Mine ore from Calumet Island: A shipment of four samples, submitted by W. B. Timm, Mines Branch, Ottawa, was received at the Ore Testing Laboratories. They consisted of (1) a sample taken for the purpose of experimental tests from the stock piles, and (2) a sample of selected high-grade ore for analysis to determine if a marketable product could be sorted from the ore for direct shipment to the smelter; (3) a sample of ground mill feed for analysis to obtain an idea of the assay value of the feed to the old concentrator; and (4) a sample of the concentrator tailings. From the analysis it will be seen that the latter two samples are not representative ones, especially that of the mill tailings, but they do show that there were high tailing losses with the former methods of concentration.

Analysis of samples
for experimental purposes:

	Lead %	Zinc %	Iron %	Silver oz/ton	Gold oz/ton
No. 1 - Stock pile ore	3.35	7.08	4.82	9.50	
No. 2 - Selected high-grade ore	16.52	28.26	8.35	39.78	0.02
No. 3 - Supposed ground mill feed	2.12	10.04	8.93	3.15	
No. 4 - Mill tailings	1.77	12.15	8.16	8.20	

Experimental tests: The tests were conducted on sample No. 1, the stock pile ore, as oxidation had not taken place to any appreciable extent. Three flotation tests were conducted on the ore which was ground to varying degrees of fineness as given in the screen tests following, to determine the results from selective flotation. The reagents used in making the flotation tests are given in a separate table, and the results of the table and flotation tests are also given in tabulated form.

Screen tests of flotation tailings showing fineness of grinding:

Mesh	Test No. 1		Test No. 2		Test No. 3	
	grams	percent	grams	percent	grams	percent
+48	2.5	0.5	0.1	0.0	0.3	0.1
-48+65	18.2	3.6	4.0	0.8	6.5	1.3
-65+100	77.4	15.5	19.6	3.9	39.5	7.9
-100+150	86.0	17.2	53.0	10.6	45.5	9.1
-150+200	62.5	12.7	62.0	12.4	71.5	14.3
-200	252.4	50.5	361.3	72.3	335.7	67.3

Reagents used in flotation tests:

Test No. 1 - 1000 grams ore

Lead reagents:	5.0 lbs/ton	Sodium carbonate
	0.2 "	Z cake
	0.4 "	Sodium cyanide
	0.75 "	Cresylic acid
Zinc reagents:	2.0 "	Copper sulphate
	0.2 "	YZ mixture
	0.1 "	TT mixture
	0.01 "	Pine oil

Test No. 2 - 1000 grams ore

Lead reagents:	5.0 lbs/ton	Sodium carbonate
	0.1 "	QED reagent
	0.4 "	Sodium cyanide
	0.75 "	Cresylic acid
Zinc reagents:	2.0 "	Copper sulphate
	0.2 "	YZ mixture
	0.15 "	TT mixture
	0.01 "	Pine oil

Test No. 3 - 1000 grams ore

Lead reagents:	5.0 lbs/ton	Sodium carbonate
	0.2 "	Z cake
	0.25 "	Sodium cyanide
	0.75 "	Cresylic acid

Zinc reagents: 2.0 lbs/ton Copper sulphate
0.5 " Dominion Tar & Chem.Co's neutral creoso oil No. 2
0.01 " Potassium xanthate

Results of tests:

Test No.	Product	Weight grams	Weight %	Analysis Pb %	Analysis Zn %	Analysis Ag.oz.	Percent of values Pb	Percent of values Zn	Percent of values Ag.
1	Lead conc.	43.7	4.37	55.27	2.10	152.5	69.4	1.4	56.6
	Lead midd.	77.2	7.72	11.20	7.63	5.5	24.8	8.3	3.6
	Zinc conc.	110.7	11.07	0.50	52.21	33.1	1.6	84.3	31.1
	Zinc midd.	53.0	5.30	0.62	4.92	6.56	0.9	3.8	3.0
	Tailing	715.9	71.54	0.16	0.21	0.94	3.3	2.2	5.7
2	Lead conc.	95	9.5	34.66	4.10	91.7	89.2	5.5	79.4
	Zinc conc.	162	16.2	1.48	38.70	8.8	6.8	88.8	13.1
	Tailing	748	74.8	0.20	0.54	1.1	4.0	5.7	7.5
3	Lead conc.	59.7	6.0	46.54	2.74	134.0	80.9	2.2	72.2
	Lead midd.	59.0	5.9	9.02	6.88	28.5	15.5	5.6	15.2
	Zinc conc.	108.7	10.9	0.32	55.32	4.5	1.0	82.7	4.4
	Zinc midd.	35.5	3.5	0.80	15.16	7.44	0.8	7.4	2.4
	Tailing	737.1	73.7	0.08	0.21	0.88	1.7	2.1	5.8

Summary of Results: The flotation tests conducted were only of a preliminary nature but the separations were so readily obtained with so little attention to manipulation that equally as good results, if not better, should be obtained in actual milling operations. Both the grade of the lead and zinc concentrates and the recoveries of these metals were good, as well as the recovery of the silver values. One very important point has been determined, namely, that fine grinding increases the proportion of silver values in the lead concentrate, as may be seen by comparing the distribtion of silver values in test no. 1 with that in test no. 2 and test no. 3. The screen tests show that much finer grinding was done in the latter tests. The results of this fine grinding were that the silver content of the zinc concentrate was reduced from 33 ozs. to 4.5 ozs. per ton, thereby increasing the recovery of the silver values in the lead products from 60% to 87%. This increased recovery of silver values with the lead concentrate is a very important item from an economic standpoint in the marketing of the concentrates.

Conclusions: It is reasonably safe to assume from the results of the small scale experimental tests conducted that the ore of the Reader mine can be successfully concentrated by selective flotation with the production of high-grade lead and zinc products, and with good recoveries of the lead, zinc, and silver values.