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THE LAKE GEORGE ANTIMONY ORES AND THEIR CONCENTRATION

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History: Antimony in Canada is somewhat of a rare mineral. The deposit at West Gore, Hants Co., Nova Scotia, and the one at Lake George, York Co., New Brunswick, are the only ones that have produced any tonnage of ore.

The Lake George deposits were discovered in 1863 and the property has been worked off and on for the past 60 years by various companies. Many years ago, the property was operated by the Lake George Mining & Smelting Company and a small smelting plant was erected which produced about one ton of metal per week when in full operation. Attempts were made to concentrate the ore by hand cobbing, and ship in lump form to Swansea, but this met with failure owing to the disseminated nature of the mineral in the vein material. Gravity concentration in jigs and vanners was tried but the slime losses were so high that this method was also abandoned. The Canadian Antimony Company installed a dry method of concentration similar to a method used extensively in France. This process consisted of heating the ore, which was then supposed to decrepitate, the flying pieces to be picked up in a current of air. No previous test work was done on the ore, and after the process had been installed it was found that the ore would not decrepitate, so the process was abandoned.

In mining the ore considerable wall rock was broken which contained arsenical pyrites. In refining operations the arsenic condensed with the antimony and produced a metal with properties objectionable to the trade. Some Montreal people took up the matter of the elimination of the arsenic. They undertook to remove the arsenic by leaching the antimony oxide produced by roasting the ore. Most of the arsenic could be removed in this way, but the method was not successful from an economic standpoint.

Geology: The mineral occurs in the slates and quartzites as stibnite (antimony sulphide). Masses of intrusive granite and diabase occur in the vicinity and have led to local alteration of the strata resulting in extensive fissuring. The ore occurs in lenses in the fissuring. The veins have been opened for a distance of a mile in length and a large number of shafts have been sunk. The deepest shaft is about 375 feet.

Concentration: The many failures recorded in the history of the operation of the antimony deposits in Canada have been partly due to want of suitable methods for the concentration of the ores. Stibnite is an extremely friable mineral and slimes very badly, and it is impossible to save these slimes by any known method of gravity concentration.

Two samples of ore from the Lake George deposits have been submitted to the Ore Dressing and Metallurgical Laboratories of the Mines Branch. The first was received in 1916 from A. P. Slipp, K.C., of Fredericton, who was then interested in the deposits. This sample was low grade ore from the waste dumps, and on analysis gave:

Antimony 3.15%; arsenic 0.28%; gold and silver tr.

The second sample was received in 1922 and was submitted by the North American Antimony Smelting Company, Ltd. This sample was claimed to be a true and representative sample of the milling ore from the company's mine. The sample on analysis gave:

Antimony 11.65%; arsenic 0.37%

Synopsis of concentration test on shipment No. 1: A brief synopsis will be given of the work done on the concentration of the low grade ore. Gravity concentration on jigs and tables followed by flotation of the slimes was tried, and straight flotation of the ore.

Gravity concentration

There was not enough mineral freed at the coarser sizes, and the jig tailing would have had to be recrushed and retreated. Tabling of the sized material gave the following results:

-20+80 mesh	Concentrate	Sb	31.10 %
		As	0.65
	Tailing	Sb	0.67
		As	0.34
-80 mesh	Concentrate	Sb	31.02 %
		As	2.71
	Tailing	Sb	2.10
		As	0.28

These results show conclusively the difficulty of concentrating stibnite by gravity concentration. The slime loss is very high and there is also a corresponding loss in the coarser sizes from flat flakes of mineral which are carried into the tailing. The concentrate produced was also low grade and another point of importance is that the concentrate still contains a relatively high percentage of arsenic which is detrimental. The above tests were made on standard size jigs and tables.

Flotation

A number of small scale laboratory flotation tests were made on the original sample, using a standard Callow laboratory testing unit. Various combinations of reagents were tried with the object of producing a high grade concentrate with the elimination of the arsenic.

Test No. 1: 0.6 lb/ton hardwood creosote
0.2 " pine oil - steam distilled
10.0 " sulphuric acid

Product	Analysis		% of values	
	Antimony %	Arsenic %	Antimony	Arsenic
Concentrate	47.52	0.92	91.8	23.0
Tailing	0.24	0.24	8.2	77.0
Heads	2.75	0.29		

Test No. 3: 0.6 lb/ton crude hardwood creosote
0.2 " pine oil
3.0 " caustic soda

Product	Analysis		% of values	
	Antimony %	Arsenic %	Antimony	Arsenic
Concentrate	49.00	1.0	75.5	13.5
Tailing	0.66	0.28	24.5	86.5
Heads	2.58	0.31		

Test No. 3: 0.5 lb/ton fuel oil from asphalt base
0.3 " pine oil
neutral pulp

Product	Analysis		% of values	
	Antimony %	Arsenic %	Antimony	Arsenic
Concentrate	58.52	0.24	87.6	3.5
Tailing	0.40	0.28	12.4	96.5
Heads	3.06	0.29		

These tests show that even with a low grade ore a very high grade concentrate can be obtained with a good recovery, and that it is possible to eliminate 90% or more of the arsenic contained in the feed. Flotation in a neutral pulp with a fuel oil from a petroleum oil with an asphalt base gave the best results.

Synopsis of concentration tests on shipment No. 2: These tests were run to design a flow sheet suitable for the treatment of the ore on a basis of 100 tons daily capacity, the erection of a mill being contemplated on the results of this work.

Hand sorting: The ore was examined for the possibility of sorting sufficient lumps of pure stibnite to warrant hand picking, but this was found to be impracticable.

Jigging: Considerable stibnite was freed at ¼" size and it was found possible to produce a jig concentrate containing 50% antimony. A large proportion of true middling would have to be handled and the tailing would have to be recrushed. Considering the use of jigs from the standpoint of operating costs in a small mill, it was decided that their use would not be advisable owing to the necessity of recrushing machinery for the tailing and middling products, which would mean a more complicated flow sheet.

Table concentration: Table concentration tests were tried on -14 to -48 mesh material. It was found possible to obtain a table concentrate, by recleaning the primary table concentrate in special cleaner deck, containing 58% antimony and 0.25% arsenic, but with a recovery of only 57% of the antimony in the table feed. It was found after a careful examination of the table products under the microscope that tailing and middling products from sizes coarser than 24 mesh would have to be crushed again and that the middling from the finer sizes down to 48 mesh would also have to be recrushed. The losses in the sizes from -35 to -48 mesh, due to flotation on the table, were very high and practically all the stibnite passing to the tailing was found to be entirely freed from the gangue.

Summary of jigging and tabling tests: It was found that by jigging or tabling carefully sized feed that had been crushed to -14 mesh, a recovery of 56% of the antimony could be obtained in a concentrate averaging approximately 53% antimony and 0.30% arsenic. This grade of concentrate was considered too low grade to meet the company's requirements. By crushing to -24 mesh and tabling classified or sized feed a 58% antimony concentrate can be obtained but the recovery drops to 55% and less.

Flotation tests: These tests were made on the original ore and consisted of a series of small scale tests and one large scale or tonnage test under conditions similar to actual mill operation. The ore for these tests was crushed so that 95% passes 65 mesh Tyler standard screen.

Small scale tests:

Test No. 1:- Reagents used in this test were a mixture of coal tar and coal tar creosote (40% & 60%) and pine oil for frothing. A neutral pulp was used.

Test No. 2: - The Southwestern Engineering Company's oil KK 1, and steam distilled pine oil for frothing. Neutral pulp used.

Test No. 3: - The Southwestern Engineering Company's oil KK 1, pine oil, and 4 lbs per ton of lime (pulp alkaline)

Test No. 4: - The Southwestern Engineering Company's oil KK 1, pine oil and 10 pounds per ton of sulphuric acid (pulp acid)

Test No.	Product	Weight %	Analysis Sb %	Analysis As %	% of values Sb	% of values As
1.	Concentrate	16.0	64.24	0.28	86.7	
	Middling	2.8	6.38	1.62	1.4	
	Tailing	81.2	1.75	0.35	11.9	
2.	Concentrate	17.7	61.80	0.62	81.4	35.6
	Middling	4.0	4.50	1.04	13.4	13.5
	Tailing	78.3	0.88	0.27	5.2	50.9
3.	Concentrate	15.3	62.70	1.00	83.6	40.0
	Middling	4.1	13.10	1.44	4.7	15.4
	Tailing	80.6	1.65	0.21	11.7	44.5
4.	Stibnite would not float in lime pulp					
5.	Concentrate	17.4	63.36	0.31	95.6	16.4
	Middling	4.3	5.94	1.29	2.2	16.7
	Tailing	78.3	0.35	0.28	2.2	66.9

Large scale Pilot Tests: A large scale tonnage check test was made in a Callow flotation unit consisting of two rougher cells and two cleaner cells of the new flat bottom type. The ore was reduced to ½" in a jaw crusher and rolls and fed to a 4'6" Hardinge mill in closed circuit with a standard Dorr simplex classifier. The overflow of the classifier was -50 mesh and went direct to the flotation cells. The reagents used were a mixture of coal tar 40% and coal tar creosote 60% from the Dominion Tar & Chemical Company and sufficient pine oil to maintain a good froth. Sulphuric acid was used amounting to 5 lbs per ton of ore.

Concentrate -- Antimony 58.21% Arsenic 0.28%
Tailing -- " 0.94%
Recovery .. 93.5%

The results from this large scale test confirmed the results obtained from the small laboratory tests. The grade of concentrate is slightly lower, but this does not mean that a concentrate of higher grade cannot be obtained. It was difficult to guage the grade of concentrate being produced, but as the operator becomes more familiar with the operation of the flotation cells, better work and even a higher grade concentrate than 63% antimony can be expected, containing less than 0.3% arsenic.

Conclusions: The following flow sheet was recommended as the simplest and most feasible method of concentrating the ore:- "Crushing the run of mine ore to 2" in a breaker, ball milling in closed circuit with drag classifier to 65 mesh, the classifier overflow to go to the flotation unit of the pneumatic type."

In the construction of a small concentrator of 50-100 tons capacity, simplicity of design is important. Jigging and tabling followed by flotation would have required regrinding, classification, sizing, and thickening units, making a complicated flow sheet and adding greatly to the initial cost of the mill as well as to the labour, power and other operating costs. On the other hand a mill designed for straight flotation would have a very simple flow sheet and would occupy about 1/3 of the floor space. The ore from the breaker, crushed to 2", could be fed directly to a ball mill operated in closed circuit with a drag classifier to produce a product approximately -65 mesh, which would go directly to the flotation units.

The grade of the final concentrate from the flow sheet using straight flotation would be five percent higher than that from the flow sheet using jigs and tables.