TEST NUMBER
1 2 6

OTTAWA -
30 - 12 - 1919

R E P O R T

of the

ORE DRESSING & METALLURGICAL LABORATORIES

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GRAPHITE ORE

from the

:: QUEBEC GRAPHITE COMPANY, ::
Buckingham,
Quebec.

126

OTTAWA
30th.December 1919

REPORT OF THE ORE DRESSING & METALLURGICAL LABORATORIES

TEST NO. 126

A carload shipment of Graphite Ore was received on October 4th. 1919, from the Quebec Graphite Company, Buckingham, Que.

Examination of specimens selected from this carload showed that the graphite occurs as disseminated flake, from a tenth of an inch in diameter down to the finest grains. The associated minerals are iron pyrite, mica, calcite, pyroxene and other silicates. The graphite is intimately interfoliated with the gangue minerals, making purification difficult without destroying the size of the flake. This point was determined by selecting a flake larger than 28 mesh which from microscopic examination would be declared pure graphite, but upon analysis was found to contain - graphitic carbon, 92.25%; iron and alumina 3.60%; insoluble residue, 3.00%; and volotile 1.15%. This clearly demonstrated that the above analysis was the upward limit that could be obtained by any mechanical operation, without destroying the flake.

The object of the tests was to determine a suitable flow-sheet adaptable to this ore using oil-flotation, and if necessary, as much of the old equipment possible, such as tables and classifiers, to make a high grade product

Different combinations were tried out to arrive at the best possible flow sheet and for this purpose the carload was divided into approximately three-ton lots, the weight, analysis and content of which ~~was~~ were as follows:-

Test No.	Net weight of ore	Assay	pounds carbon
1.	5673.5	13.40%	760.25
2.	5785.5	13.40%	775.25
3.	5761.0	13.45%	773.85
4.	5738.0	13.85%	794.71
5.	5694.0	13.25%	754.45
6.	8309.0	13.10%	1088.47
Total	36961.0	13.34%	4947.00
	or 18.48 tons.		

In each of the six test runs the ore, after being previously crushed in a jaw crusher to about road metal size, was weighed and sampled automatically and stored in a bin. From the bin it was automatically fed into a 4 ft. Hardinge Ball-Mill with a charge of 2000 pounds of balls at an approximate rate of 1200 pounds of ore per hour, water being added in the Ball Mill and also the desiredamount of oil, which was fed at varying rates in the different runs of from 1.7 pounds to 2.9 pounds per ton of ore treated.

The ground material discharged from the ball mill in the form of a pulp was elevated by means of a centrifugal pump to a Callow screen, the material which passed through the screen was fed to the Callow Cells, the oversize material which would not pass through the screen being returned to the ball mill for further reduction.

The density of the pulp going to the Rougher flotation cells varied from 3½ to 5½ parts by weight of water to 1 part of ore, and sometimes even more dilute when an excess of wash water was used, but in the mill this should be more easily controlled.

TEST #1. The ore was ground in the ballmill until it all passed a 35 x 12 Greening Ton Cap Screen (smallest opening .015")

Average amount of oil used per ton of ore treated 2.9 lbs of mixture, containing 40% #5 Pine Oil, 40% #26 F.P.L. & 20% Coal Oil.

It was then floated in Callow Roughing Cells, a low

grade concentrate being made, and a very low tailing. These concentrates were ground in a Hardinge Ball Mill using pebbles instead of balls (the charge being 1223 pounds of pebbles) and refloated in Callow Cells, but although this material passed through four retreatment cells the grade was not sufficiently enriched by this particular method of treatment.

TEST #2 The ore was ground in the ball mill until it all passed a 24 X 8 Greening Ton Cap Screen (smallest opening .02")

Average amount of oil used per ton of ore treated, 2.2 pounds of mixture containing 70% #26 F.P.L. & 30% Pine Oil.

It was then floated in Callow Roughing Cells, aiming to make a cleaner concentrate than in test #1 by allowing a little more graphite to go off in the tailings. But the results are not of sufficient interest to more than refer to in passing, as the treatment followed would not give the desired results. But several points were disclosed which assisted in the subsequent tests. For one thing it was found that the grinding effect in the pebble mill was very slight, and in the case of the fine concentrate it was almost negative, consequently it was decided that the balls would be used instead of pebbles for regrinding the concentrate and the feed to the ball mill would be thickened by using a settling tank in order to assist the grinding.

TEST #3 The ore was ground in the ball mill until it all passed a 24X8 Greening Ton Cap Screen (smallest opening .02").

Average amount of oil used per ton of ore treated 2.9 pounds of #26 F.P.L.

It was then floated in Callow Roughing Cells making a concentrate assaying 34.1% Carbon and a tailing which represents a recovery in this initial operation of over 90% of the total carbon contents.

The concentrate was passed over a 60 x 20 Greening Ton Cap Screen (smallest opening .009") and the over size was

concentrated on a Wilfley Table, while the undersize was ground in the pebble mill and re-floated in Callow Cells.

This test demonstrated that by screening the rougher floatation concentrates on 60 mesh, and tabling the oversize, a concentrate of about 80% carbon was made, and the separation of this material on the table was better than the previous attempts when using the cells.

It was also found that refloating the undersize (-60 mesh material) only gave a concentrate assaying 57.4%, and by tabling the tailings of this operation a good separation was made giving a plus 80 mesh concentrate assaying 81.4% carbon.

This information led us to extend the use of the tables at suitable stages.

A probable reason why the tables make a better separation and a higher grade product on this concentrated material than the cells, may be that the rougher concentrates consist partly of particles of almost clean flake and partly of particles composed of graphite and gangue attached, and on the tables these attached particles of gangue and graphite, having a slightly greater specific gravity than graphite itself, travel to the head of the table, while pieces of graphite being more bouyant float off the side. This action is probably augmented by the fact that the small amount of oiling tends to increase the bouyancy of the clean graphite flakes, while its effect is not shown much on the combined particles of graphite and gangue when travelling over the deck of the table.

On the other hand apparently these attached particles, oiled and floated in the first instance, do not escape the bouyancy of the bubles in the second flotation cells, and consequently tend to float over with the clean graphite.

TEST #4 The ore was ground in the ball mill until it all passed a 24 x 8 Greening Ton Cap Screen (smallest opening

.02").

Average amount of oil used per ton of ore treated 1.8 pounds of #25 F.P.L.

It was then floated in Callow Roughing Cells (adjusted as counter current cells) the aim being to make a higher grade concentrate than previously obtained, using less oil, with the idea that the attached particles would not float in the final flotation process. But with this arrangement too much graphite was lost in the rougher tailings. without sufficiently enriching the grade of concentrates, and the idea was abandoned.

Another new departure was tried in this test, namely to screen the -60 mesh material over a 80 x 36 Greening Ton Cap Screen (.008") after being reground in the ball mill, and to table the -60 plus 80 material, and it was found that a considerable portion of the graphite contents were recovered in this way in the form of a high grade concentrate assaying over 80% carbon.

From the information gained in this test, it was agreed to modify the flowsheet of the mill accordingly, and in this way it is expected to recover a satisfactory proportion of the total graphite in the form of a #1 flake assaying over 80% carbon by tabling the plus 60 rougher concentrates and also the plus 80 portion of the -60 rougher concentrate after they have been reground in the ball mill.

TEST #5 The ore was ground in the ball mill and screened on 35 x 12 Greening Ton Cap Screen (.015").

Average amount of oil used per ton of ore treated 1.7 pounds of mixture, 80% Coal Oil and 20% Pine Oil.

The material which passed through the screen was floated in Callow Roughing Cells making a concentrate of 43.20% Carbon and a tailing of 1.85% Carbon. The material which remained on the screen was screened through a coarser screen (24 x 8 Greening Ton Cap) and the oversize which in practice

would be returned to the ball mill to be regound, was dried and weighed, while the undersize was tabled, producing a low grade concentrate of 53.15% carbon.

In this test a settling tank was provided to dewater the -80 rougher concentrate before entering the ballmill in order to permit of a better grinding effect, and a considerable reduction in the size of the material leaving the ball mill was in this way obtained. As already stated, once the #1 flake has been removed, this grinding is necessary in order to liberate the attached particles of graphite and gangue.

TEST #6 The ore was ground in the ball mill until it all passed a 24 x 8 Greening Ton Cap Screen (.02").

Average amount of oil used per ton of ore treated 2 pounds of mixture, 50% Coal Oil and 50% Pine Oil.

It was then floated in one Callow Roughing Cell, making a concentrate assaying 31.4% carbon and tailing 0.76% carbon, representing a recovery in this initial operation of 96% of the total carbon contents.

The concentrate was passed over a 60 x 20 Greening Ton Cap Screen and the oversize concentrated on a Wilfley Table, producing a concentrate assaying 80.4% carbon, and the undersize was ground in the ball mill and screened on a 80 x 36 Greening Ton Cap Screen (.008") and then tabled, producing a concentrate assaying 82.6% carbon. These two concentrates represent 29.1% of the total carbon in the ore. It is interesting to note that using one Rougher Cell instead of two, as in the other tests, apparently made no difference in the satisfactory results of the tabling.

The -80 material was floated in Callow Cells, making a concentrate assaying 57.5% carbon. The tailing from the Callow Cleaner Cells assayed 36.1% carbon, and was enriched up to 70.9% carbon by tabling.

The procedure followed in this test was considered the

most applicable to this particular ore, so the results are given in detail with a flow sheet showing the procedure and arrangement.

The following table gives details of the products of test #6 with their respective weights, assays and contents of carbon:-

Product	Wt. lbs.	%Carbon	Lbs.Carbon	% Total carbn
(a) Table Conc. +60	189.0	80.40	152.0	14.0
(b) Table Tails +60	394	12.30	48.5	4.5
(c) Callow Conc. -80	514.5	57.50	295.8	27.1
(d) Rougher Tails -80	530	2.75	14.6	1.3
(e) Table Conc. +80	198.5	82.60	164.0	15.1
(f) Table Tails +80	243.5	9.35	22.8	2.1
(g) Table Conc. -80	274	70.90	194.3	17.8
(h) Table Tails -80	363.5	6.00	21.8	2.0
(i) Callow Tails -24	4963	.76	37.7	3.5
(j) Slime & other loss etc.	639	21.44	137.0	12.6
(k) Heads	8309.0	13.10	1088.5	100.0

By rearranging the results we get the following:-

+80 Products

(a) No. 1 Flake recovered assaying 80.40% C. representing 14% of total carbon.

(e) No. 1 Flake recovered assaying 82.60% C. representing 15.1% of total carbon.

(b) Table tailings which in practice will be returned to the ball mill for retreatment - 12.30% C. representing 4.5% total carbon

(f) do. do. do. - 9.35% C. representing 2.1% do.

35.7% do.

of which 29.1% was actually recovered. In practice most of the balance (6.6%), would be also recovered, but probably not all as +80 material.

-80 Products

(c) Flotation Conc. assaying 57.50% representing 27.1% of total carbon

Forward.....	27.1%	35.7%
(g) Table conc. assaying 70.90% representing ..... of total carbon	17.8%	
(h) Table tails assaying 6.00% representing ..... of total carbon	2.0%	
	46.9%	46.9%
		82.6%

of which 44.9% was actually recovered, and in practice most of the balance (2.0) would be also recovered.

Actual Tailings to waste, assyg. 0.76% representing of total carbon	3.5%	
Actual Tailings to waste assyg. 2.75% representing of total carbon	1.3%	
	4.8%	4.8%
		87.4%
Loss in Slimes, etc. - - - - - - - - - - - - - - -		12.6%
		100.0%

This 12.6% loss is due to overflows and accidental losses always more or less in evidence when handling small quantities in intermittent runs, but these will not occur during regular mill operations.

While the exact figures of the recovery that will be obtained cannot be given, owing to necessary difference between a test run and regular mill operations, the above figures show that a high recovery should be attained, giving the proportion of +80 flake assaying 80% Carbon or better as about 1/3 of the total carbon content.

The actual recovery of the +80 was 29.1% of the total carbon content
The actual recovery of the -80 was 44.9% of the total carbon contents
74.0%

The total loss in tailings was only 4.8% which would represent a recovery of 95.2%, assuming that the whole of the retreatment products were recovered, and there was no slime loss. But as milling is always accompanied by some accidental losses and occasional bad operating conditions from time to time, a recovery of 95% (as represented by the tailings losses in this test) should not be expected.

On the other hand it is only fair to expect that when the plant is adjusted, a considerably higher recovery will be made than that actually obtained when making a test run of only four tons, with all the disadvantages of intermittent running and its attendant losses. So by striking the average between the

two figures 74% and 95%, namely 85%, a conservative estimate of the recovery should be arrived at, although it is quite likely that a 90% recovery will ultimately be made.

A conservative estimate, based on this test, of the proportion of #1 flake (+80) recovered in practice can be taken as one third of the total carbon contents, but by adjusting the milling conditions, it is possible that this percentage can be increased by coarser screening of the flotation feed to the Rougher Cell. In this connection a sample of the Rougher Cell concentrate and tailings were screened through Tyler standard screens with the following results:-

	Conc.by wgt.	Tailgs by wgt
Remaining on 35 sq. mesh screen (.0164" opening)	5.8%	3.5%
Remaining on 65 sq. mesh screen (.0082" opening)	18.9%	13.2%
Remaining on 150 sq. mesh screen (.0041" opening)	27.5%	23.7%
Passing through 150 sq. mesh screen	47.8%	59.6%
	100.0%	100.0%

In practice it is expected that the feed can be delivered to the Rougher Cell with a larger percentage of +65 mesh material than indicated by the above screen analysis, without any detrimental effect and the coarser this feed can be kept, within certain limits, the greater will be the proportion of #1 flake recovered.

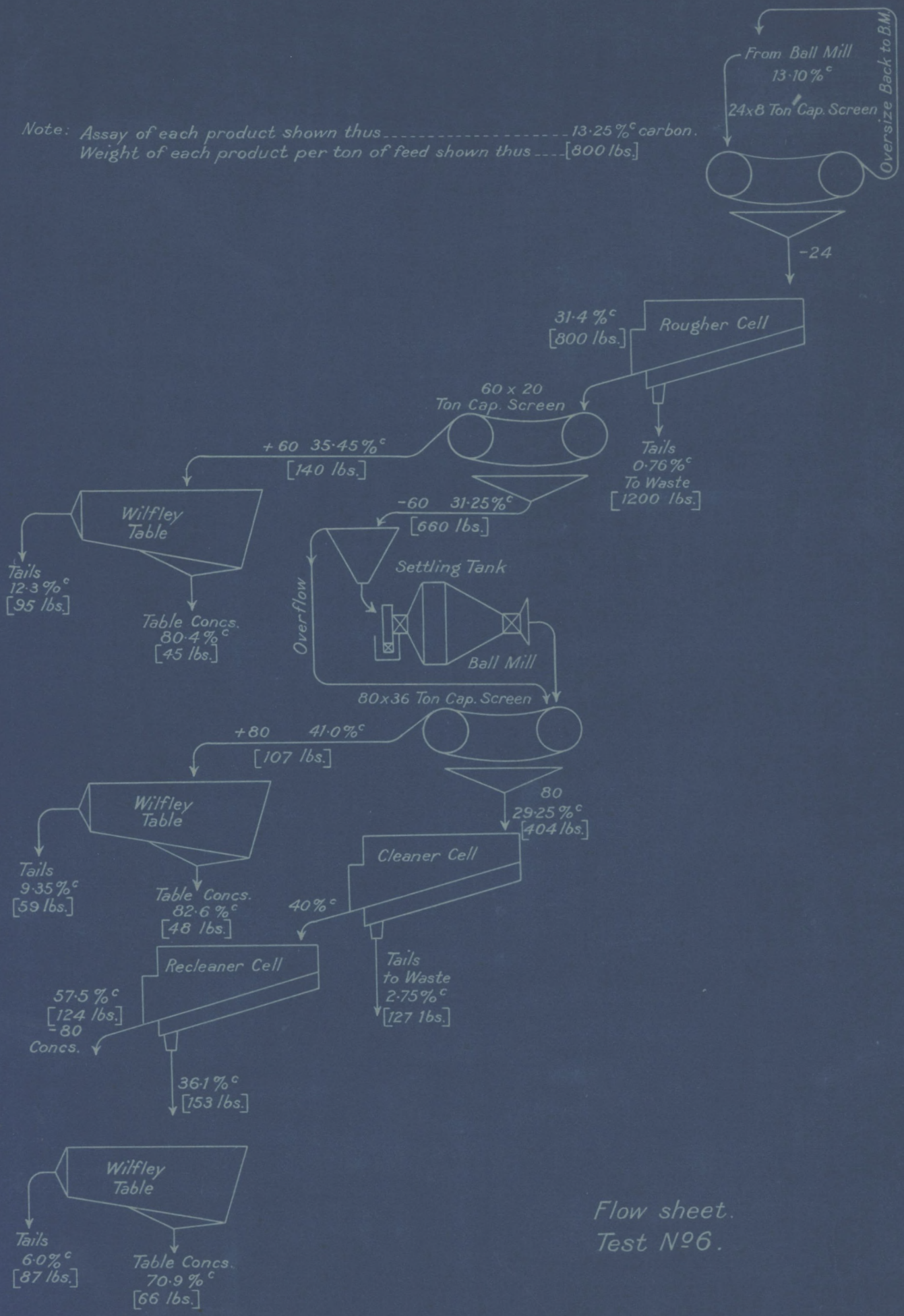
This test does not include the final finishing of the flake for the market. It is understood that the Company has already this equipment and are in a position to undertake this work themselves.

A.B. Timm

ACTG. CHIEF OF DIVISION.

T/H.

Note: Assay of each product shown thus ---------- 13·25 %c carbon.
Weight of each product per ton of feed shown thus ---- [800 lbs.]



Flow sheet.
Test No 6.