

GRAPHITE

ELECTROCHEMICAL PERFORMANCE OF HIGH PURITY GRAPHITE FROM THE LAC KNIFE FLAKE GRAPHITE DEPOSIT IN QUÉBEC, CANADA

32nd International Battery Seminar and Exhibition, Fort Laude rida March 10, 2015 Dr. Joseph E. Doninger, MSc, BSc — Director of Manufacturing and Technology



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OUTLINE OF PRESENTATION

- History of the Lac Knife Graphite Deposit
- Lac Knife Exploration and Drilling Program
- Pilot Plant Testing Program Conducted on Lac Knife Graphite
- Electrochemical Performance of High-Purity Lac Knife Graphite
- Current Status of the Development of the Lac Knife Graphite Deposit









PROJECT LOCATION

Lac Knife, Québec, Canada

- Located in northern Québec, 27 km southwest of Fermont
- Large, established iron-ore mining camp and home to billion-dollar mining projects — ArcelorMittal, RioTinto's IOC, Cliffs Natural Resources' Bloom Lake and Wabush Mines
- Consists of 57 claims covering 3,000 ha/7,500 acres
- ~60 km to the Wabush Airport (YWK)
- Near 2 railway lines connected to Port-Cartier and the Port of Sept-Iles







LAC KNIFE GRAPHITE PROJECT

Lac Knife, Québec, Canada







LAC KNIFE HAS A PROVEN HISTORY

- Graphite showing discovered by Québec Ministry mapping survey in 1959
- Prospected and explored for graphite by Mazarin Inc. and Le Fond d'Exploration Minière du Nouveau Québec 1982-1988
- Drilling program in 1989 by Mazarin indicated the potential for an 8.1 Mt deposit grading 16.7% Cg (NI 43-101 noncompliant)
- Pre-Feasibility and Feasibility studies were conducted for mine development







Davy /ROCHE





LAC KNIFE HAS A PROVEN HISTORY

- Joint Venture agreement between Mazarin and Cambior in August 1990
- In 2002 Graftech International and Ballard Power Systems (looking for graphite for fuel-cell batteries) and Mazarin plan a joint venture to start production in 2004
- In 2010, Focus Graphite acquires Lac Knife from IAMGOLD and begins assessing the resource



The geological contact between ore and waste at the Lac Knife flake graphite deposit, Quebec, Canada. Following up an early report of a graphite exposure of one square metre, Mazarin Inc. has proved up a substantial flake graphite reserve which it is currently developing — production is scheduled for 1991.





DRILLING RIG AND CORES









LAC KNIFE DEPOSIT

Focus Graphite 2012 PQ drill program

 56 drill holes for 5,638 meters in PQ caliber (4 inches in diameter) for infill and testing margins of the deposit as well as gathering ore for Phase II metallurgical tests











LAC KNIFE DEPOSIT







MINERAL RESOURCE MODEL



have not demonstrated economic viability



Lac Knife Open Pit Mine

700 metres Long400 metres Wide100 metres Deep



LAC KNIFE OPEN PIT MINERAL RESERVES

Lac Knife Mineral Resource Estimate

@ 3% Graphitic Carbon (Cg) Cut-off Grade

Categories	Tonnage (tonnes)	Graphitic Carbon	In Situ Graphite (tonnes)
Measured	432,000	22.66 %	102,000
Indicated	9,144,000	14.35 %	1,312,000
Measured and Indicated	9,576,000	14.77 %	1,414,000
Inferred	3,102,000	13.25 %	411,000

Lac Knife Open Pit Mineral Reserves

@ 3% Graphitic Carbon (Cg) Cut-off Grade

Categories	Tonnage (tonnes)	Graphitic Carbon	In Situ Graphite (tonnes)
Proven	429,000	23.61 %	101,000
Probable	7,428,000	14.64 %	1,088,000
Proven and Probable	7,857,000	15.13 %	1,189,000





OBJECTIVES OF PILOT PLANT TEST PROGRAM

- Evaluate the performance of proposed flowsheet under continuous operating conditions
- Produce concentrate for downstream testing
- Generate data to support engineering design
- Generate representative tailings samples to use in environmental studies









LAC KNIFE PILOT PLANT FLOWSHEET

- 2 Rod Mills
- 4 Polishing Mills
- 7 Sets of Flotation Cells
- 5 Cleaning Columns
- 5 Screens
- 40+ Tons of Ore Processed







CLEANING CIRCUIT







ROUGHER FLOTATION CELL







MAGNETIC SEPARATOR AND POLISHING MILLS







48 MESH CLASSIFICATION SCREEN







HIGH-PURITY GRAPHITE CONCENTRATE

Flake Size & Purity

SGS Lakefield Pilot Plant Tests

- 11.1% large flake +48 @ 98.8% Cg
- High-purity affords low-cost Value-Added Products as a result of very cost-effective purification processes
- Overall Carbon Recovery of 91%
- Adding of fines polishing circuit could increase Cg content of -200 mesh fines to 97% Cg

Size	Distribution	Total Carbon Grade
Coarse (+80 mesh)	33.5%	98.3%
Medium and fine (-80 to +150 mesh)	29.8%	98.2%
-150 to +200 mesh	16.6%	98.0%
Average of all sizes (+200 mesh)		98.1%
-200 mesh	20%	91.1%







FLAKE PURIFICATION PROCESS

Flotation Concentrate **96%** Cg Crystalline Flake Graphite

Concentrate after Polishing **98.3%** Cg



Flake Graphite after Purification at **99.98%+** Cg









SCANNING ELECTRON MICROGRAPH (SEM)

99.98% Cg Uncoated Standard-Grade Purified Spherical Graphite

- SEM shows flake graphite has been successfully processed to produce spherical particles (SPG)
- SPG was coated with carbon to reduce the Specific Surface Area (SSA) to make it suitable for use in Lithium-ion Batteries
- Coating also has the effect of reducing reactivity with the electrolyte further reducing the irreversible capacity loss







CROSS SECTION OF CR2016 COIN CELL

All electrochemical tests were run on CR2016 coin cells



- Values of reversible capacity (RC) and irreversible capacities (ICL) at C/20 cycling were determined and the first cycle irreversible capacity loss was calculated by dividing the reversible capacity by the irreversible capacity
- The electrolyte is 1.0M LiPF6 in FEC/EMC (30:70 vol%) for 8mm thick electrodes with a composition of 90 wt% graphite and 10 wt% supporting additives, including a PVDF-based binders







INITIAL GALVANOSTATIC CHARGE – DISCHARGE CURVES

Standard Grade (D50 = $24\mu m$)









INITIAL GALVANOSTATIC CHARGE – DISCHARGE CURVES

Fine Grade (D50 = $17\mu m$)



C/20; Elotrolyte 1M LiPF6 in FEC/EMC (30:70 vol%)







RESULTS FROM CR2016 COIN CELLS TESTS

Electrochemical Tests on Lithium-ion-Grade Graphite

- SPG battery test results have excellent performance metrics when compared to current benchmark commercial SPG grades
- Note the very high Reversible Capacities of 363.7 and 365.1 Ah/kg and very low Irreversible Capacity Losses (ICL) of 1.44 and 1.01%

Focus Graphite Coin Cell Test Samples	Reversible Capacity (Ah/kg)	Irreversible Capacity Loss (%)	Surface Area (m2/g)
Standard Carbon Coated SPG Grade (D50=24µm)	363.7	1.44	0.48
Fine Carbon Coated SPG Grade (D50=17µm)	365.1	1.01	1.14





FOCUS GRAPHITE'S SPHERICAL GRAPHITE VS. SPHERICAL SYNTHETIC GRAPHITE

320

(D50=16.5µm)

Comparing Focus Graphite's Natural SPG vs. Commercially Available Synthetic Graphite

Focus Graphite's Natural SPG vs. Synthetic SPG	Reversible Capacity (Ah/kg)	Irreversible Capacity Loss (%)	Surface Area (m2/g)
Standard Carbon Coated SPG Grade (D50=24µm)	363.7	1.44	0.48
Synthetic Carbon Coated SPG Grade (D50=22µm)	330	9.00	1.00
Focus Graphite's Natural SPG vs. Synthetic SPG	Reversible Capacity (Ah/kg)	Irreversible Capacity Loss (%)	Surface Area (m2/g)
Fine Carbon Coated SPG (D50=17µm)	365.1	1.01	1.14
Fine Synthetic Carbon Coated SPG	320	9.00	1.50

9.00

1.50





PURIFIED -200 MESH

Lac Knife Fine Flake

• Specific capacity versus cycle number of anode produced from Purified -200 mesh Lac Knife Graphite Fines at a current density of 50 mAh/g







PURIFIED +80 MESH

Lac Knife Large Flake

• Specific capacity versus cycle number of anode produced from Purified +80 mesh Lac Knife Flake Graphite at a current density of 50 mAh/g







COMMERCIAL PURIFIED SPHERICAL GRADE OF FLAKE GRAPHITE

• Specific capacity versus cycle number of anode produced from a commercial Purified Grade of Carbon-Coated Spherical Flake Graphite at a current density of 50 mAh/g







LAC KNIFE MILESTONES

Current Developments

- Completed Feasibility Study
 - 7,857 kt of Proven and Probable Mineral Reserves grading 15%Cg
 - Reduced operating costs from \$458/t of concentrate to \$441/t
- NI 43-101 Mineral Resource Estimate
 updated January 2014
- Achieved excellent test results from our spherical graphite product for Lithium ion battery market

Upcoming Milestones

- Project Financing underway
- Negotiating Offtake Agreements
- Permitting underway
- Detailed Engineering:
 - Hydro-Québec
 electricity connection
 - Access road upgrade
 - Purification facilities





THANK YOU

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