Technical Report

Heliborne Magnetic and TDEM Survey

Black Donald, Little Bryan, B.Lyall properties
Ontario – 2011

Standard Graphite
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Vancouver BC
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Prospectair Geosurveys

ED Géophysique

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I. INTRODUCTION

PROSPECTAIR conducted a heliborne magnetic (mag) and time-domain electromagnetic (tdem) survey for the mining exploration company Standard Graphite on their Black Donald, Little Bryan and B.Lyall properties in the NTS Mapsheets 31F02, 31F03, 31F06 and 31F07 in the Province of Ontario (see Figure 1). The survey was flown from December 29st 2011 to January 14st 2012.

3 survey blocks were flown for a total of 1484 lkm. A total of 11 production flights were performed using PROSPECTAIR's Robinson R-44 helicopter, registration C-GATM. The survey blocks are located about 100km West-South-West of Ottawa (figure 1 and 2). Survey operations were conducted from and the field crew was based at the Calabogie Resort located 4 km east of the survey area eastern limit.

The traverse lines were flown at 150m spacing and oriented N160° and the control lines at 1500m spacing and oriented N70°. During the survey, the average height above ground of the helicopter was 94m, the magnetic sensor at 60m and the transmitter loop at 33m. The average survey flying speed (calculated equivalent ground speed) was 33 m/s. The whole survey area is located in a hilly area with elevation ranging from 180 to 441m (ASL). The most important lakes included in the survey area are Black Donald, Leclaire, Wilson, Morrow and Green lakes (Black Donald block) and Graham lake (Little Bryan block) and the Madawaska river is crossing the Little Bryan and B.Lyall blocks.

Table 1: **Statistics of flown survey blocks**

Block	Total line-km flown	Flight numbers	Line Direction
Black Donald	1158	Flt 1 to 9	N160°
Little Bryan	235	Flt 10 and 11	N160°
B. Lyall	91	Flt 11	N160°

Figure 1: **Map of Survey Area (regional scale)**

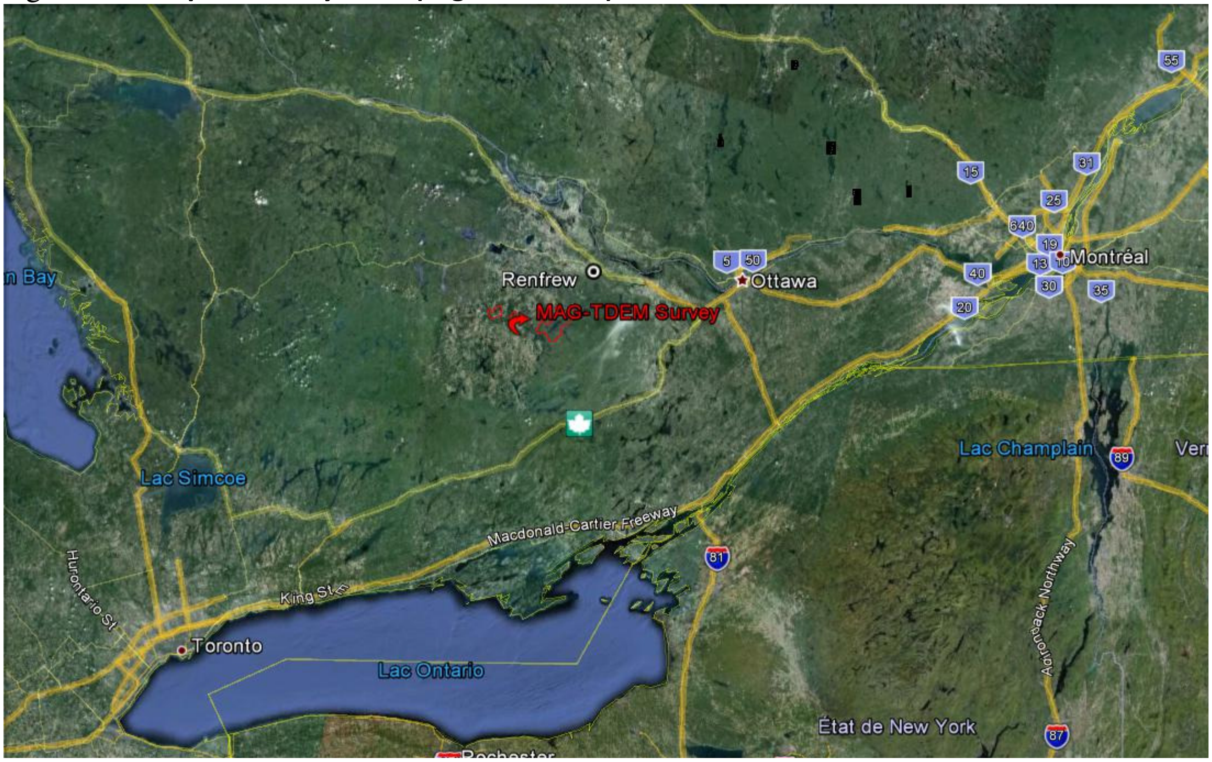


Figure 2: **Map of Survey Area (local scale)**

II. SURVEY EQUIPMENT

PROSPECTAIR provided the following instrumentation for this survey:

Airborne Magnetometers
Geometrics G-822A
Both the ground and heliborne systems used a non-oriented (strap-down) optically-pumped Cesium split-beam sensor. These magnetometers have a sensitivity of 0.005 nT and a range of 15,000 to 100,000 nT with a sensor noise of less than 0.02 nT. The heliborne sensor was mounted in a bird made of non-magnetic material located 15 m below the helicopter when flying. Total magnetic field measurements were recorded at 10 Hz in the aircraft. The ground system was recording magnetic data at 1 sample every 3 seconds.

Time-Domain Electromagnetic Transmitter and Receiver
ProspecTEM I
Prospectair Geosurveys significantly modified and improved the *Emosquito II* that was built by THEM Geophysics of Gatineau (Québec) to develop ProspecTEM. It is a powerful light-weight system adapted for the R44 Robinson performance with state-of-the-art acquisition computer. Advanced signal processing technique and a full processing package was developed in house to optimize the ProspecTEM data. The technical specifications are listed below in the table 2.

ProspecTEM system employs a transient or time-domain electromagnetic transmitter that drives an alternating current through an insulated electrical coil system. The towing bridle is constructed from a Kevlar rope and multi-paired shielded cables. It is attached to the helicopter by a weak link assembly. An onboard harness with outboard connectors mounted on a plate allows for quick disconnection or connection of the exterior elements. The system uses a 4 KW generator and a large condenser to transmit alternating 2.75-ms half sine pulses with intervening off-times of 13.916 ms electric pulse, 60 pulses per second.

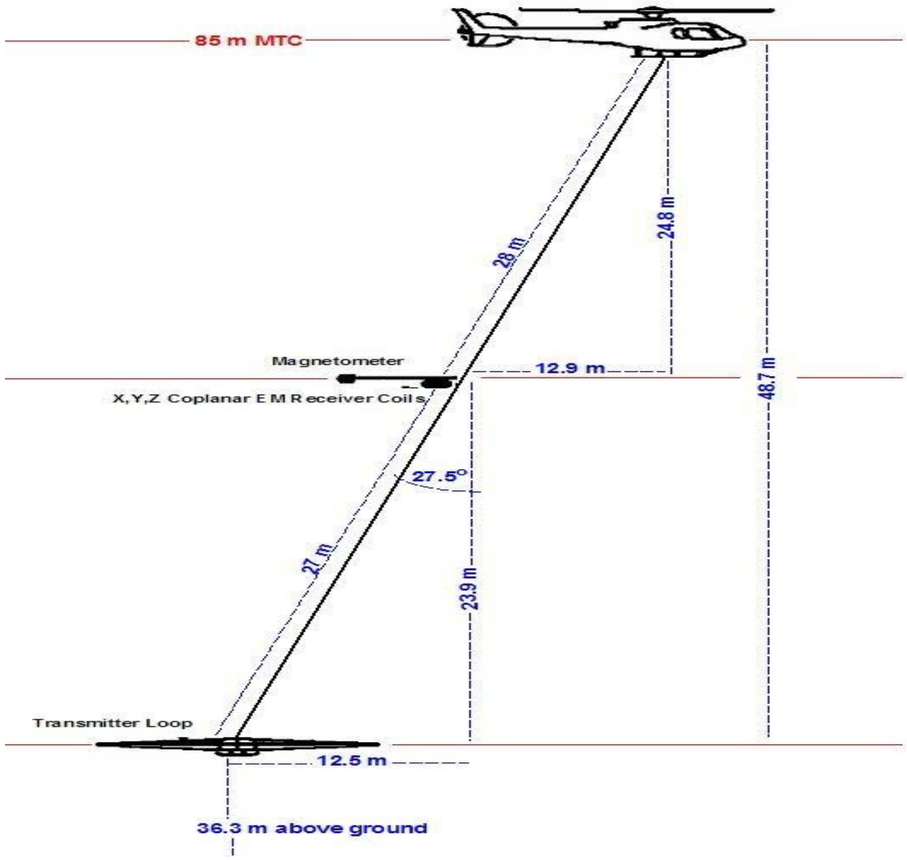
The current in the coil produces an electromagnetic field. Termination of the current flow is not instantaneous, but occurs over a very brief period of time (a few microseconds) known as the ramp time, during which the magnetic field is time-variant. The time-variant nature of the primary electromagnetic field creates a secondary electromagnetic field in the ground beneath the coil, in accordance with Faraday's Law. This secondary field immediately begins to decay in the process, generating additional eddy currents that propagate downward and outward into the subsurface. Measurements of the secondary currents are made only during the time-off period by a vertical component receiver located almost half way between the helicopter and the transmitter loop. It is placed with the magnetometer taped to a horizontal boom which supports the receiving coils tear-drop shape vessel at its end. The boom has an elastic suspension. A proprietary suspension system protects the orthogonal coils assembly and limits the total field excursions. The tear-drop vessel acts as a vane and maintains the mast in the line of flight.

Depth of investigation depends on the time interval after shutoff of the current, since at later times the receiver is sensing eddy currents at progressively greater depths. The intensity of the eddy currents at specific times and depths is determined by the bulk conductivity of subsurface rock units and their contained fluids.

Table 2: **Technical specifications of the ProspecTEM Time-Domain system**

Item	Specification
Transmitter:	
Loop Diameter:	5.6 meters
Current Waveform:	Half-Sine
Turns:	2
Pulse Length	2.75 ms
Frequencies	30
Loop Area	25 m²
Peak Current	2600A
Tow Cable Length	65 meters
Self-Powered	13HP Honda coupled with 28 Volts Alternator
Receiver:	
Coils axis	Z
Configuration	Coaxial (Z)
Two channels	Current and Z
Max Sampling rate	1000 points per half cycle at 90 Hz
Survey sampling rate	1000 per half cycle at 30Hz
Sampling	Full waveform
Gates	Programmable
On time signal	Recorded
Mechanical:	
Maximum survey speed:	125 km per hour
Transmitter height	30 meters AGL
Receiver height	60 meters
Weight (Total)	200 kg

Figure 3: **ProspecTEM system configuration**



Real-Time Differential GPS

Omnistar DGPS

PROSPECTAIR uses an OmniStar differential GPS navigation system to provide real-time guidance for the pilot and to position data to an absolute accuracy of better than 5 m. The *Omnistar* receiver provides real-time differential GPS for the Agis on-board navigation system. The differential data set was relayed to the helicopter via the Omnistar network appropriate geosynchronous satellite for the survey location. The receiver optimizes the corrections for the current location.

Airborne Navigation and Data Acquisition System

Pico-Envirotec AGIS-XP system

The Airborne Geophysical Information System (AGIS-XP**)** is advanced, software driven instrument specifically designed for mobile aerial or ground geophysical survey work. The AGIS instrumentation package includes an advanced Satellite navigation (GPS), real-time flight path information that is displayed over a map image (BMP format) of the area, and reliable data acquisition software. Thanks to simple interfacing, the radar and barometric altimeters, the RSI spectrometer and the Geometrics magnetometer are easily integrated into the system and digitally recorded. Automatic synchronization to the GPS position and time provides very close correlation between data and geographical position. The AGIS is equipped with a software suite allowing easy maintenance, upgrades, data QC, and project and survey area layout planning.

Magnetic Base Station

GEM GSM-19

A GEM GSM-19 Overhauser magnetometer, a computer workstation and a complement of spare parts and test equipment serve as the base station. PROSPECTAIR establish the base station in a secure location with low magnetic noise. The GSM-19 magnetometer has resolution of 0.01 nT, and 0.2 nT accuracy over its operating range of 20,000- to 100,000 nT. Its data output rate is 3 Hz.

Altimeters

Free Flight Radar Altimeter

The Free Flight radar altimeter measures height above ground to a resolution of 0.5 m and an accuracy of 5% over a range up to 2,500 ft. The radar altimeter data is recorded and sampled at 10 Hz.

Prospectair Digital Barometric Pressure Sensor

The barometric pressure sensor measures static pressure to an accuracy of ± 4 m and resolution of 2 m over a range up to 30,000 ft above sea level. The barometric altimeter data are sampled at 10 Hz.

Survey helicopter

Robinson R-44 (registration C-GATM)

PROSPECTAIR flew the survey using Prospectair's Robinson R44 helicopter that handle efficiently the equipment load and the required survey range. Table 3 presents the helicopter technical specifications and capacity.

Table 3: **Technical specifications of the R44 Robinson Helicopter**

Item	Specification
Powerplant	One 195kW (260hp) Textron Lycoming O-540
Rate of climb	1000 ft/min Rate of climb 1000 ft/min
Cruising speed at 75%	power 209 MPH
Service ceiling	14,000 ft
Range with no reserve	645 km
Empty weight	635 kg
Maximum takeoff	1,090 kg

III. SURVEY SPECIFICATIONS

Data Recording

The following parameters were recorded during the course of the survey:

In the helicopter:

- GPS positional data: (time, latitude, longitude, altitude, heading and accuracy (PDOP)) recorded at intervals of 0.1 s;
- Total magnetic field: recorded at intervals of 0.1 s;
- Pressure as measured by the barometric altimeter at intervals of 0.1 s;
- Outside air temperature: recorded by the pilot every flight;
- Terrain clearance as measured by the radar altimeter at intervals of 0.1 s;
- Z and Current TDEM channels at 90000Hz.

At the base and remote magnetic ground stations:

- Total magnetic field: recorded at intervals of 3 s;
- GPS time recorded every 1s to synchronize with airborne data.

Technical Specifications

The data quality control was performed on a daily basis. The following technical specifications were adhered to:

- *Height* – 90m mean terrain clearance for the mag-tdem survey except in areas where Transport Canada regulations prevent flying at this height. Traverse lines and control lines must be flown at the same altitude at points of intersection; the altitude tolerances are limited to no more than 30 m difference between traverse lines and control lines.
- *Airborne Magnetometer Data* - The noise envelope not to be exceeded 0.5 nT more than 500 m line-length without a reflight.
- *Diurnal Specifications* – A maximum tolerance of 5.0 nT (peak to peak) deviation from a long chord of one minute the base station.
- *EM data* – No spikes on Z channel and and constant current confirmed.
- *Flying Speed* – The average ground speed for the survey aircraft, flying traverse or control lines should be 125 kph. The acceptable high limit is 140 kph.
- *Radar Altimeter* – minimal accuracy of 5%, minimum range of 0-2500 m.
- *Barometer* – Absolute air pressure to 0.1 kPa.
- *Flight Path Following*

Traverse lines:

- azimuth: 160º from North
- spacing: 150m
- allowed minimum separation: 102.5m
- allowed maximum separation: 187.5m.

Control Lines:

- azimuth: 90º from traverse lines, spacing: 1500m

IV. SYSTEM TESTS

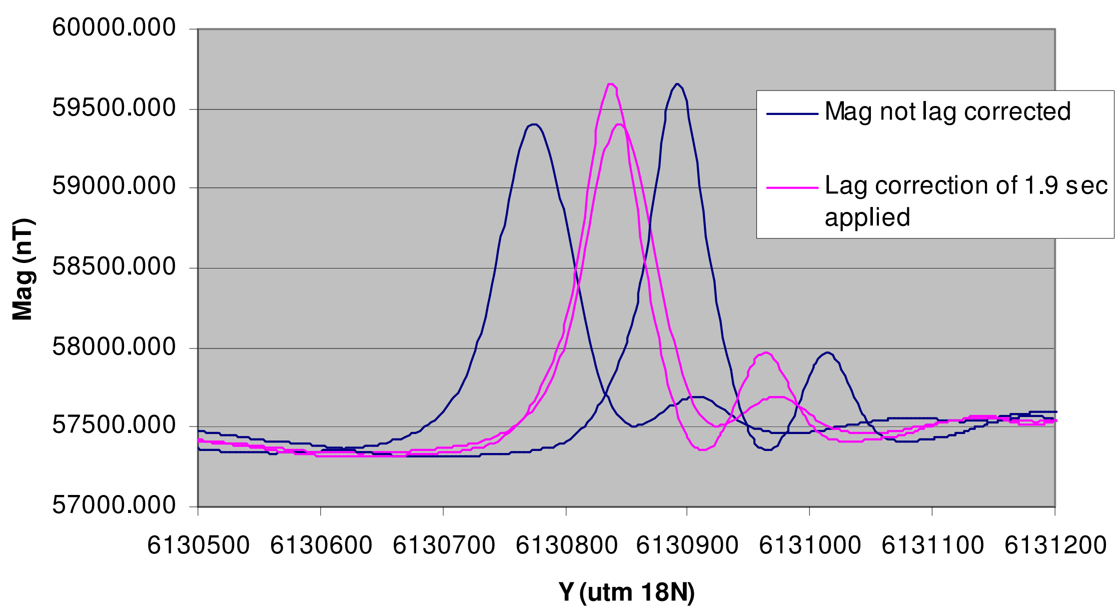
Magnetometer System Calibration

The survey configuration using a bird towed 25 m below any magnetic piece of the helicopter and 25m above the TDEM transmitter allows the simplification of the magnetic calibration requirement. Consequently, heading error and aircraft movement noise was considered negligible and no correction was applied to the data.

Instrumentation Lag

The magnetometer and tdem system lag is a combination of two factors: 1) the time difference between when a reading is sensed, and when that value is received by the data acquisition system, and 2) the time taken for the sensor to arrive at the location of the GPS antenna. The second factor is defined by the physical displacement of the GPS antenna and the sensor and the speed of the aircraft. Because the magnetic sensor (bird) is considered on the same vertical axis than the GPS antenna, this second factor is considered negligible. The total magnetic lag value for the AGIS acquisition system has been calculated by Pico-Envirotec to be 1.3 s. *Figure 4* shows graph of the lag corrected magnetic data compared to raw magnetic data over an important magnetite anomaly acquired in 2010. The tdem lag was determined by flying over a known conductive body in 2 opposite directions and was calculated to be 0.1 s.

Figure 4: **Comparison between lag corrected and raw magnetic data flown in 2 opposite directions over a known magnetite anomaly**



V. FIELD OPERATIONS

The survey operations were conducted out of the Calabogie Resort located 4km east of the survey area from on December 29th 2011 to January 14th 2012. At the end of each production days, the data were sent to the ED GÉOPHYSIQUE office via a satellite internet connection. The data were then checked for Quality Control to confirm they fulfill contract specification and a report was send to the field crew before the next production day. At the end of the survey work, the whole data set was checked and the crew had the authorization to demobilize. The GEM-19 magnetic base station was set up just west of the Calabogie Resort at the coordinate 359600E, 5014911N (UTM Zone 18) in a magnetically quiet area. The survey pilot was Alain Tremblay and the survey system engineer was Marcel Haineault.

Figure 5: **Magnetic base station setup at a fuel cache**

VI. DIGITAL DATA COMPILATION

Data compilation including editing and filtering, quality control, and final data processing was performed by Eric Desaulniers, MSc, Géo. Processing was performed on high performance desktop computers optimized for quick daily QC and processing tasks. Geosoft software Oasis Montaj version 7.1.1 and Matlab 7 R2009B were used.

Magnetometer Data

The airborne magnetometer data, recorded at 10 Hz, were plotted and checked for spikes and noise on a flight basis. A 1.1 second lag correction was applied to all data to correct for the time delay between detection and recording of the airborne data.

Ground magnetometer data were recorded at 1 sample every 3 seconds and interpolated by a spline function to 10 Hz to match airborne data. Data were inspected for cultural interference and edited where necessary. No filter was deemed necessary on ground station magnetometer because its remote location was noise free. The diurnal variations were removed by subtracting the ground magnetometer data to the airborne data and by adding back the average of the ground magnetometer value.

Levelling corrections were performed using intersection statistics between traverse and tie lines. After statistic levelling was considered satisfactory, decorrugation was done on data to completely remove any subtle non-geological features oriented in the direction of the traverse lines.

The magnetic data were interpolated onto a regular grid using a minimum curvature algorithm to create a two-dimensional grid equally incremented in x and y directions. The algorithm produces a smooth grid by iteratively solving a set of difference equations minimizing the total second horizontal derivative, while attempting to honor the input data (Briggs, I.C, 1974, Geophysics, v 39, no. 1).

The final grids of the magnetic data were created with 30 m grid cell size appropriate for survey lines spaced at 150 m. Traverse lines were used in the gridding process.

Radar Altimeter Data

The terrain clearance measured by the radar altimeter in metres was recorded at 10 Hz. The data were filtered to remove high frequency noise using a 1 sec low pass filter. The final data were plotted and inspected for quality.

Positional Data

Real time DGPS correction provided by Omnistar was applied to the recorded GPS positional data. No post-flight DGPS processing was made using a GPS base station.

Positional data (Lat, long, UTM X, UTM Y, geoid height) were recorded and 10 Hz sampling rate and all data processing was performed in the WGS-84 datum. The delivered data were provided in X, Y locations in UTM projection zone 18 North, with respect to the WGS-84 datum. Elevation data were recorded relative to the GRS-80 ellipsoid.

TDEM Data

The PicoEnvirotec EM Digital Acquisition System records the vertical component (Z) of the receiver coils at a sampling rate of 90000Hz. There are 30 full cycles (60 half cycles) of the full waveform (Tx ON and OFF time) every second.

The first data manipulation involves a stacking procedure where each half cycle is weighted with respect to the previous cycle (±¼), the next cycle (±¼) and its own value (± ½). The positive and negative signs of the respective multiplication coefficients are used to make positive all negative half cycles. The next step is the half cycle averaging corresponding to the desired sampling rate. In the present case, from the 60 stacked positive half cycles per second, 6 consecutive half cycles are averaged to produce one sample every 0.1 sec.

The windowing settings for the 40 different channels are presented in table 4. Channels 1 to 11 correspond to the ON-time measurements and channels 12 to 40 correspond to the OFF-time. Channel 12 isn't used for interpretation and mapping as it exists some 'ramp-off' effect that alters the data quality. Each window is filtered with a median filter removing spikes and with a finite impulse response (FIR) selective filter of the 251th order improving the signal to noise ratio. A lag correction of 0.1 sec was applied to the data after being empirically determined by flying a sharp anomaly in two opposite direction.

Table 4: **Setting used in the windowing of the full waveform**

Channel #	Starting time (msec)	Width (msec)	Pulse	Channel #	Starting time (msec)	Width (msec)	Pulse
1	0.16667	0.01667	**ON**	**21**	3.15000	0.53333	**OFF**
2	0.25000	0.01667	**ON**	**22**	3.26667	0.53333	**OFF**
3	0.33333	0.01667	**ON**	**23**	3.40000	0.53333	**OFF**
4	1.30000	0.01667	**ON**	**24**	3.26667	1.10000	**OFF**
5	1.31667	0.01667	**ON**	**25**	3.45000	1.10000	**OFF**
6	1.33333	0.01667	**ON**	**26**	3.65000	1.10000	**OFF**
7	2.58333	0.01667	**ON**	**27**	3.88333	1.10000	**OFF**
8	2.66667	0.01667	**ON**	**28**	4.13333	1.10000	**OFF**
9	2.80000	0.08333	**ON**	**29**	4.43333	1.10000	**OFF**
10	2.81667	0.08333	**ON**	**30**	4.76667	1.10000	**OFF**
11	2.83333	0.08333	**ON**	**31**	5.16667	1.10000	**OFF**
12	2.85000	0.16667	**RAMP**	**32**	5.05000	2.20000	**OFF**
13	2.86667	0.18333	**OFF**	**33**	5.55000	2.20000	**OFF**
14	2.86667	0.25000	**OFF**	**34**	6.13333	2.20000	**OFF**
15	2.86667	0.36667	**OFF**	**35**	6.78333	2.20000	**OFF**
16	2.91667	0.36667	**OFF**	**36**	7.51667	2.20000	**OFF**
17	2.91667	0.53333	**OFF**	**37**	8.36667	2.20000	**OFF**
18	2.95000	0.53333	**OFF**	**38**	9.33333	2.20000	**OFF**
19	3.00000	0.53333	**OFF**	**39**	10.4500	2.20000	**OFF**
20	3.03333	0.53333	**OFF**	**40**	11.7000	2.20000	**OFF**

VII. BASIC INTERPRETATION

General

The following basic interpretation is solely based on the helicopter-borne MAG and TDEM data acquired in this project and there was no match with the geology. Further interpretation works should include the determination of specific geological target type and the correlation between other data sources.

Overview of magnetic data

The magnetic signal is dominated by SW-NE elongated magnetic highs and small magnetic circular plugs on the Black Donald and Little Bryan properties (figure 6). These magnetic features follow the SW-NE topographic trends mostly in the Black Donald block.

Overview of Time-Domain Electromagnetic data

The figure 7 shows the location of a ground TDEM survey that was made on the Little Bryan property prior to the airborne to confirm the high conductive response of the graphitic trenches. The historical graphitic trenches location in relation with the MAG-TDEM airborne result suggests that the graphitic targets are associated to magnetic and conductive highs.

Figure 6: **Interpretative comments on the total magnetic intensity**

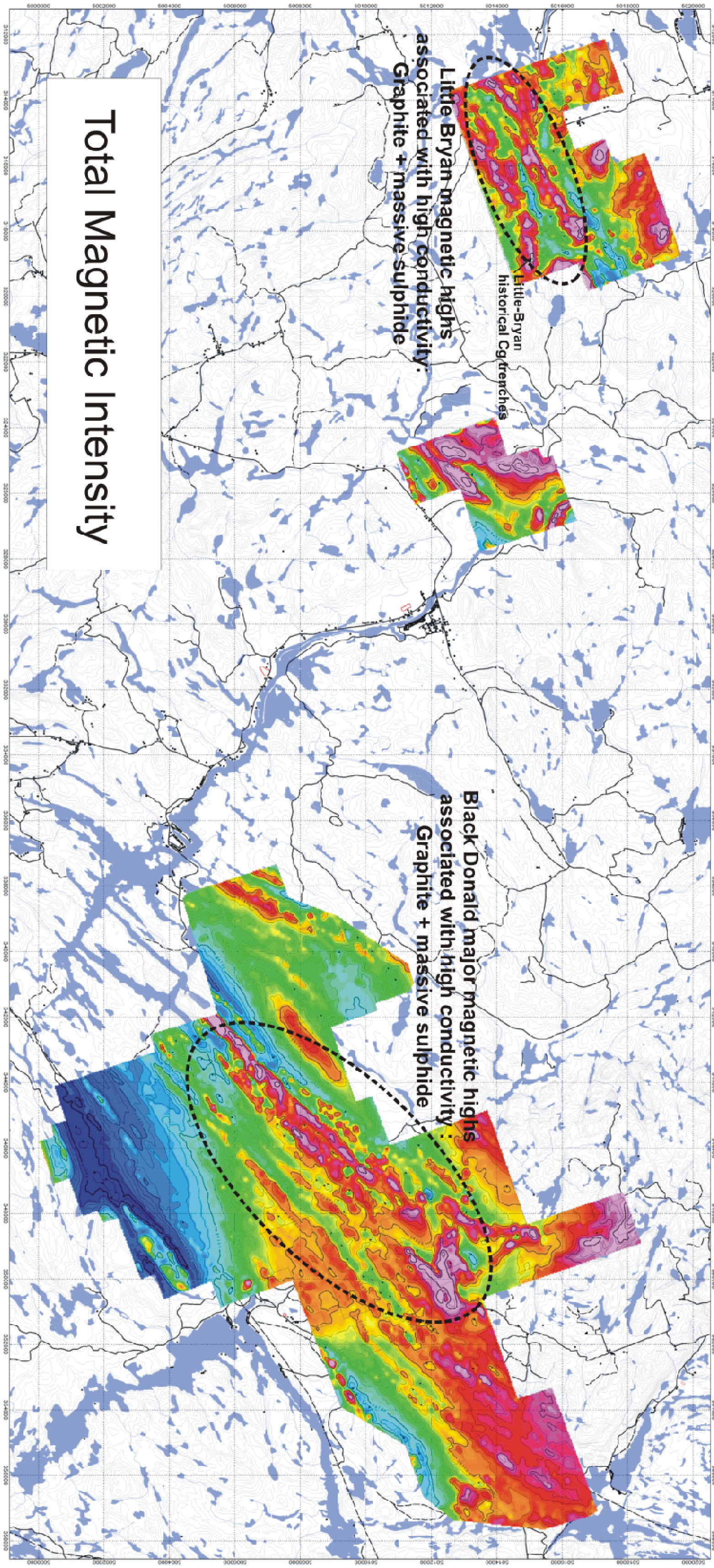
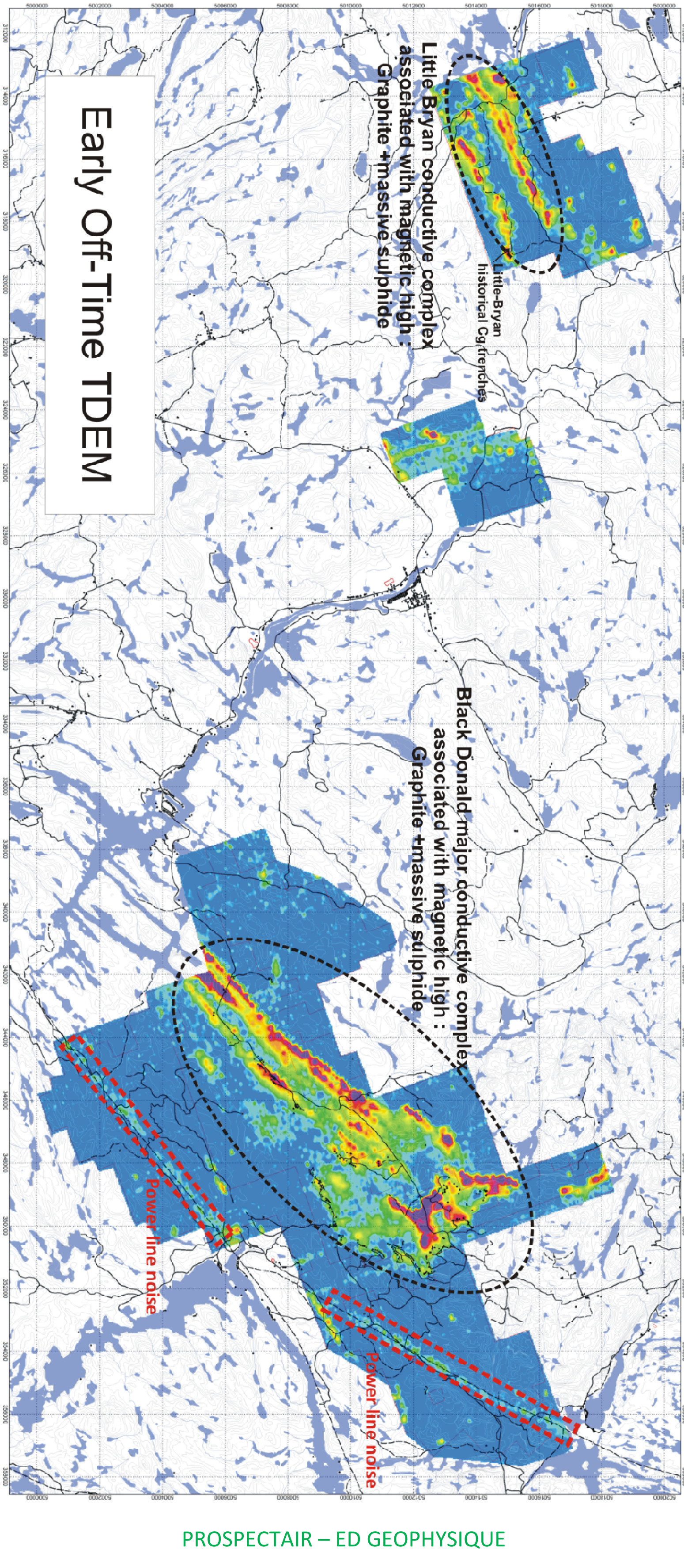


Figure 7: **Interpretative comments on the early off-time TDEM**



VIII. WORK RECOMMENDATION

The discussion on the geological implication of the survey data is minimal in this report. A more general study including knowledge of the local geology linked with other geosciences data would be necessary to extract the full potential of the geophysical data. Moreover, we recommend the following work on the geophysical data in order to maximize their usefulness in your geological model:

ELECTROMAGNETIC DATA

- Ground follow up using a small portable TDEM device like the IMAGEM system to precisely locate the conductive rock on the ground and take rock samples.

IX. FINAL PRODUCTS

Digital Line Data

A Geosoft database is provided for each survey block with the channels detailed in *Table 5.*

Table 5: **Mag-TDEM Line Data, Geosoft database (.gdb), Sampling rate: 0.1 sec**

No.	Name	Description	Units
1	UTM_X	UTM Easting, WGS-84, Zone 18N	m
2	UTM_Y	UTM Northing, WGS-84, Zone 18N	m
3	Lat_deg	Latitude in decimal degrees	Deg
4	Long_deg	Longitude in decimal degrees	Deg
5	Gtm_sec	Second since midnight GMT	Sec
6	Radar	Ground clearance given by the radar altimeter	m
7	Terrain	Digital Elevation Model	m
8	GPS_Z	Digital Elevation Model	m
9	Mag_Raw	Raw magnetic data	nT
10	Mag_Lag	1.5s lagged magnetic data	nT
11	Gnd_mag	Base station magnetic data	nT
12	TMI	Total Magnetic Intensity	nT
13	OFF_TIME	Off-time amplitude channels (1 to 24)	nT/s

Grid Files

All grids are referred to WGS-84 in the UTM projection Zone 18 North. Coordinates are in metres, grid cell size is 30m, and format is Geosoft binary. The following grids are provided.

1. TMI.grd – Total Magnetic Field
2. FVD.grd – Calculated Magnetic Vertical Gradient
3. DEM.grd – Digital Elevation Model
4. OFF_TIME.grd – TDEM Early Off-Time

Maps (scale 1:50,000)

PDF for the following products:

1. Total Magnetic Intensity Map
2. Magnetic First Vertical Derivative Map
3. DEM with Flight Path Map
4. TDEM Profiles Map
5. TDEM Early Off-Time Map

Project Report

PDF format

Respectfully submitted,

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Eric Desaulniers, MSc, Géo
February 13th 2012

X. Statement of Qualifications

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I, Eric Desaulniers, MSc, Géo, do hereby certify that:

I'm an independent consulting geophysicist, registered in Quebec under ED Géophysique.

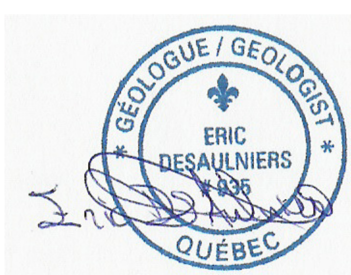
1. I earned a Bachelor of Science in Geology in 2002 and a Master of Science in 2005 from Université Laval in Quebec City.

2. I am a Professional Geoscientist registered with the Ordre des Géologues du Québec, No. 935.

3. I have practised my profession for 7 years in exploration geophysics.

4. I have not received and do not expect to receive a direct or indirect interest in the properties covered by this report.

Dated this 13rd of February, 2012



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