REPORT ON A FIXED WING AND MAGNETIC GEOPHYSICAL SURVEY

Mosku Project

Sodankylä, Finland

For:

Anglo American Exploration Finland

By:

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Survey flown during June - July 2014

Project GL140190
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REPORT ON A FIXED WING AND MAGNETIC SURVEY

Mosku Project
Sodankylä, Finland

Executive Summary

During June 29th to July 19th 2014 Geotech Airborne Limited carried out a geophysical survey over the Mosku Project for Anglo American Exploration Finland. The survey area was situated near Sodankylä, Finland. Geotech Ltd. was responsible for processing the airborne magnetic data.

Principal geophysical sensors included three geometrics high-sensitivity cesium magnetometers, fluxgate reference magnetometer and RMS DAARC500 Adaptive Aeromagnetic Real Time Compensator - three magnetometers input with gradiometer capability. Ancillary equipment included a GPS navigation system and a radar altimeter. A total of 20,171 line-km of geophysical data were acquired during the survey.

In-field data quality assurance and preliminary processing were carried out on a daily basis during the acquisition phase. Preliminary and final data processing for the survey, including generation of final digital data and map products were undertaken from the office of Geotech Ltd. in Aurora, Ontario.

The processed survey results are presented as Magnetic products.

The survey report describes the procedures for data acquisition, processing, final image presentation and the specifications for the digital data set for the survey. No formal interpretation was requested for this survey.

1. INTRODUCTION

1.1 General Considerations

Geotech Airborne Limited performed a geophysical survey over the Mosku Project. The survey area was situated near Sodankylä, Finland.

Ryan Preece and Pascal Pare represented Anglo American Exploration Finland during the data acquisition and data processing phases of this project.

The geophysical sensors consisted of fixed wing, three geometrics high-sensitivity cesium magnetometers, fluxgate reference magnetometer and RMS DAARC500 Adaptive Aeromagnetic Real Time Compensator. A total of 20,171 line-km of geophysical data were acquired during the survey.

The crew was based out of Sodankylä, Finland for the Beyla block (Figure 2) for the acquisition phase of the survey. Survey flying started on June 29th and was completed on July 19th 2014.

Data quality control and quality assurance, and preliminary data processing were carried out on a daily basis during the acquisition phase of the project. Final data processing followed immediately after the end of the survey. Final reporting, data presentation and archiving were completed from the Aurora office of Geotech Ltd. in August 2014.

Figure 1: Property Location.

1.2 Survey and System Specifications

The Mosku Project was situated approximately 8 kilometers north of Sodankylä, Finland (Figure 2).

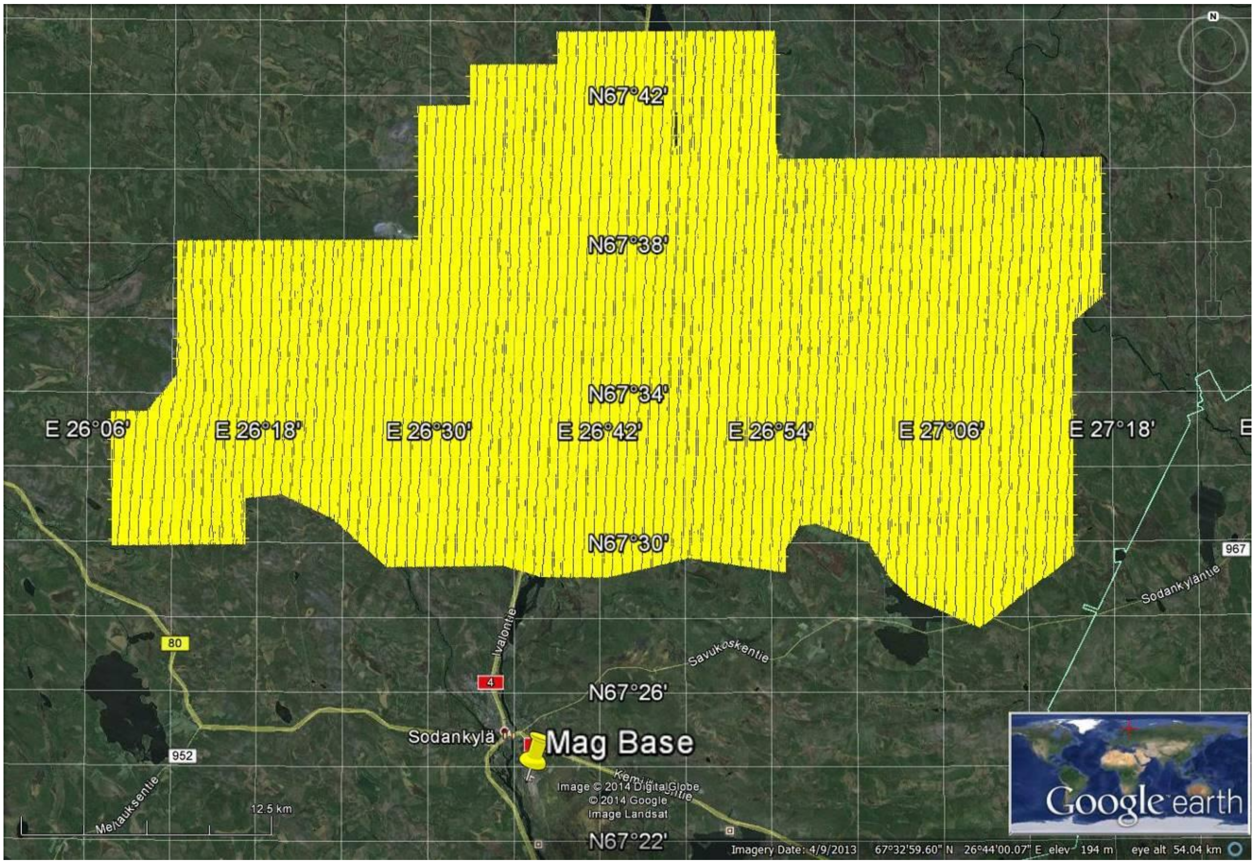


Figure 2: Survey area location on Google Earth.

The survey area was flown in a north to south (N 0° E azimuth) direction with traverse line spacing of 50 metres as depicted in Figure 3. Tie lines were flown perpendicular to the traverse lines at a spacing of 1000 metres (N 90° E azimuth).

For more detailed information on the flight spacing and direction see Table 1.

1.3 Topographic Relief and Cultural Features

The Mosku Project exhibits a moderately rugged relief with an elevation ranging from 172 to 418 metres above sea level over an area of 955 square kilometres (Figure 3).

There are a few rivers and streams running through the survey area. There are visible signs of culture such as roads running through the survey area.

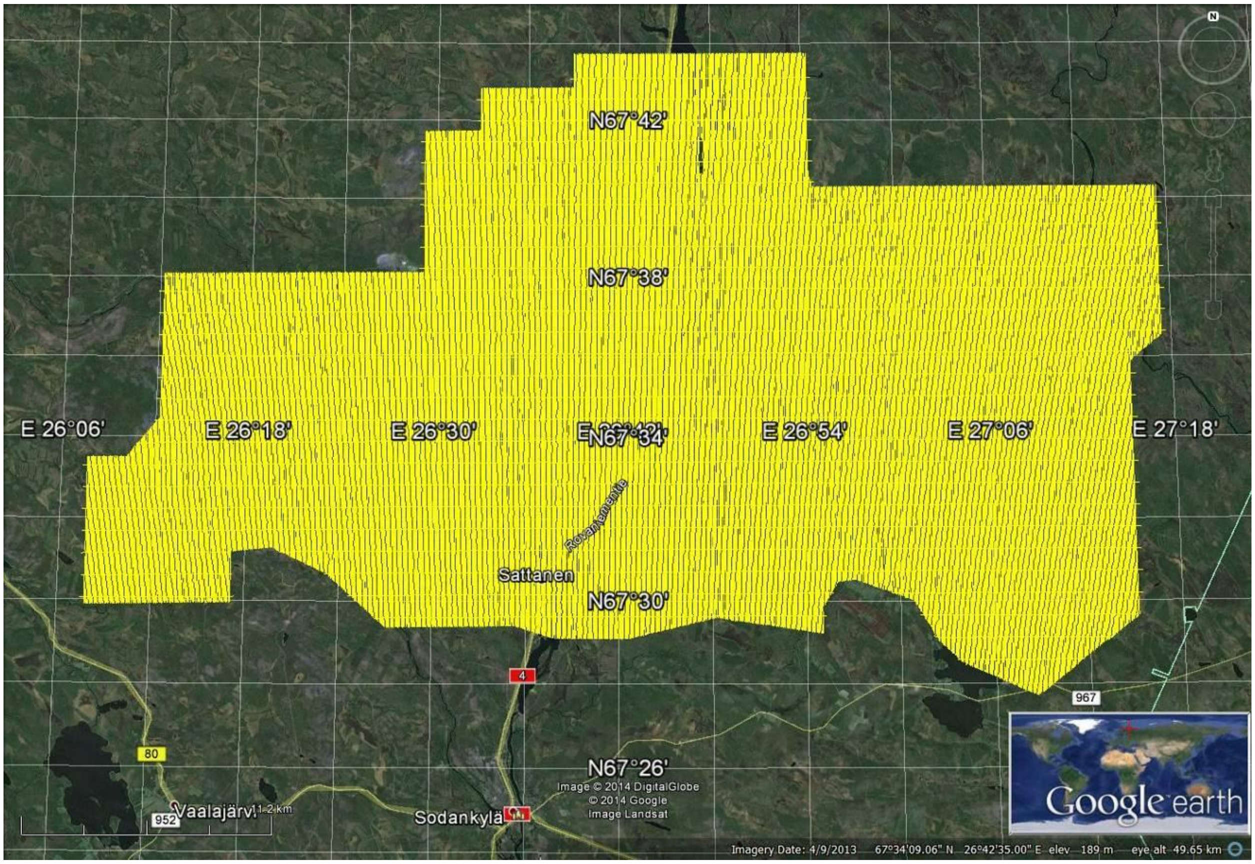


Figure 3: Flight path of Mosku Project over a Google Earth Image.

2. DATA ACQUISITION

2.1 Survey Area

The survey area (see Figure 3 and Appendix A) and general flight specifications are as follows:

Table 1: Survey Specifications

Survey block	Traverse Line spacing (m)	Area (Km^2)	Planned[1] Line-km	Actual Line-km	Flight direction
Mosku	Traverse: 50	955	20,171	19,593	N 0° E / N 180° E
	Tie: 1000			970.3	N 90° E / N 270° E
TOTAL		955	20,171	20,563.3	

Survey block boundaries co-ordinates are provided in Appendix B.

2.2 Survey Operations

Survey operations were based out of Sodankylä, Finland from June 24th to July 19th, 2014. The following table shows the timing of the flying.

Table 2: Survey schedule

Date	Flight #	Flown km	Block	Crew location	Comments
24-Jun-2014				Sodankylä, Finland	Crew arrived
25-Jun-2014				Sodankylä, Finland	Waiting on aircraft
26-Jun-2014				Sodankylä, Finland	Aircraft arrived
27-Jun-2014				Sodankylä, Finland	Aircraft inspection & base station set up
28-Jun-2014				Sodankylä, Finland	Reccon flight
29-Jun-2014	1	290	Mosku	Sodankylä, Finland	290km flown
30-Jun-2014	2	400	Mosku	Sodankylä, Finland	400km flown
1-Jul-2014	3,4,5	1560	Mosku	Sodankylä, Finland	1560km flown
2-Jul-2014	6,7	707	Mosku	Sodankylä, Finland	707km flown
3-Jul-2014				Sodankylä, Finland	No production due to weather
4-Jul-2014				Sodankylä, Finland	No production due to weather
5-Jul-2014	8,9,10	1593	Mosku	Sodankylä, Finland	1593km flown
6-Jul-2014	11,12	1343	Mosku	Sodankylä, Finland	1343km flown
7-Jul-2014	13,14	1334	Mosku	Sodankylä, Finland	1334km flown
8-Jul-2014	15,16,17	1900	Mosku	Sodankylä, Finland	1900km flown
9-Jul-2014	18,19	662	Mosku	Sodankylä, Finland	662km flown limited due to weather
10-Jul-2014	20,21	1234	Mosku	Sodankylä, Finland	1234km flown
11-Jul-2014	22,23	1016	Mosku	Sodankylä, Finland	1016km flown
12-Jul-2014	24,25,26	1829	Mosku	Sodankylä, Finland	1829km flown
13-Jul-2014	27,28	1575	Mosku	Sodankylä, Finland	1575km flown
14-Jul-2014	29,30	1511	Mosku	Sodankylä, Finland	1511km flown
15-Jul-2014	31	685	Mosku	Sodankylä, Finland	685km flown

[1] Note: Actual Line kilometres represent the total line kilometres in the final database. These line-km normally exceed the planned line-km, as indicated in the survey NAV files.

Date	Flight #	Flown km	Block	Crew location	Comments
16-Jul-2014				Sodankylä, Finland	No production due to weather
17-Jul-2014	32	662	Mosku	Sodankylä, Finland	662km flown
18-Jul-2014	33,34	1170	Mosku	Sodankylä, Finland	1170km flown
19-Jul-2014	35,36	919	Mosku	Sodankylä, Finland	Remaining kms were flown – flying complete

2.3 Flight Specifications

During the survey the aircraft was maintained at a mean altitude of 46 metres above the ground with a nominal survey speed of 250 km/hour.

The on board operator was responsible for monitoring the system integrity. He also maintained a detailed flight log during the survey, tracking the times of the flight as well as any unusual geophysical or topographic features.

On return of the aircrew to the base camp the survey data was transferred from a compact flash card (PCMCIA) to the data processing computer. The data were then uploaded via ftp to the Geotech office in Aurora for daily quality assurance and quality control by qualified personnel.

2.4 Aircraft and Equipment

2.4.1 Survey Aircraft

The survey was flown using a Cessna Grand C208B Caravan aircraft registration C-FBOA. The aircraft is owned and operated by Geotech Aviation Ltd.

Figure 4: Magnetic Sensors on Aircraft.

Figure 5: Gradiometer Magnetometer Configuration.

2.4.2 Radar Altimeter

A Freeflight – TRA 3000 radar altimeter was used to record terrain clearance.

2.4.3 Magnetic System

Three magnetometers were used to set up the gradiometer system. Two sensors were mounted on the wingtip pods and one sensor was installed in the tail stinger.

2.4.4 GPS Navigation System

The navigation system used was a Novatel WAAS enable OEM4-G2-3151W GPS receiver, navigate software, a full screen display with controls in front of the pilot to direct the flight and a NovAtel GPS antenna mounted on the aircraft. As many as 11 GPS and two WAAS satellites may be monitored at any one time. The position accuracy (CEP) is 1.8 m, with WAAS on – 1.2 m.

2.4.5 Digital Acquisition System

A Geotech data acquisition system recorded the digital survey data on an internal compact flash card. Data is displayed on an LCD screen as traces to allow the operator to monitor the integrity of the system. The data type and sampling interval as provided in Table 3.

Table 3: Acquisition Sampling Rates

DATA TYPE	SAMPLING
Magnetometer	0.1 sec
GPS Position	0.2 sec
Radar Altimeter	0.2 sec

2.5 Base Station

A base station was utilized on this project. A Geometrics magnetometer was used and located in the same location for the entire project. The base station was recording the magnetic field together with the GPS time at 1 Hz on a base station computer.

The base station magnetometer sensor was installed at the Sodankylä airport (26°36.8587'E, 67°23.6089'N); away from electric transmission lines and moving ferrous objects such as motor vehicles. The base station data were backed-up to the data processing computer at the end of each survey day.

3. PERSONNEL

The following Geotech Ltd. personnel were involved in the project.

Field:

Project Manager:	Jerome Vidal (Office)
Data QC:	Thomas Wade (Office)
Crew chief:	Adolf Masiyandima
Operator:	Mduduzi Maphumulo

The survey pilot and the mechanical engineer were employed directly by the helicopter operator – Geotech Aviation.

Pilot:	Alex Murray Bob Grant
Mechanical Engineer:	n/a

Office:

Preliminary Data Processing:	Thomas Wade
Data processing:	Adam Schubert
Final Data QA/QC:	Geoffrey Plastow
Reporting / Mapping:	Liz Mathew

Data acquisition phase was carried out under the supervision of Andrei Bagrianski, P. Geo, Chief Operating Officer. The processing phase was under the supervision of Geoffrey Plastow, P. Geo, Data Processing Manager. The customer relations were looked after by David Hitz.

4. DATA PROCESSING AND PRESENTATION

Data compilation and processing were carried out by the application of Geosoft OASIS Montaj and programs proprietary to Geotech Ltd.

4.1 Flight Path

The flight path, recorded by the acquisition program as WGS 84 latitude/longitude, was converted into the KKJ, Finland Uniform coordinate system in Oasis Montaj.

The flight path was drawn using linear interpolation between x, y positions from the navigation system. Positions are updated every second and expressed as UTM easting's (x) and UTM northing's (y).

4.2 Magnetic Data

The processing of the magnetic data first involved the correction for diurnal variations by using the digitally recorded ground base station magnetic values. The diurnal data are subtracted from the airborne magnetic data, and the average of the diurnal data was added in order to maintain the base level.

Lag corrections were applied to diurnal corrected magnetic data.

Tie line levelling was carried out on the draped magnetic data from the tail sensor by adjusting intersection points along traverse lines. A micro-levelling procedure was applied to remove persistent low-amplitude components of line-to-line noise still remaining in the data after tie line levelling.

The levelled magnetic data was interpolated between survey lines using the minimum curvature gridding to yield x-y grid values for a standard grid cell size of 12 metres.

The axial, lateral and vertical gradients were created on the basis of lag corrected data acquired from the three sensors. The polarity reversal has been applied to correct the horizontal gradient data due to line direction changes.

5. DELIVERABLES

5.1 Survey Report

The survey report describes the data acquisition, processing, and final presentation of the survey results. The survey report is provided in three paper copies and digitally in PDF format.

5.2 Maps

Final maps were produced at scale of 1:50,000 for best representation of the survey size and line spacing. The coordinate/projection system used was KKJ, Finland Uniform Coordinate System. All maps show flight path trace and topographic data; latitude and longitude are also noted on maps.

- Maps at 1:50,000 in Geosoft MAP format, as follows:

  GL140190_50K_Mosku_1VD: Calculated Vertical Gradient of TMI
  GL140190_50K_Mosku_DEM: Digital Elevation Model
  GL140190_50K_Mosku_TMI: Total Magnetic Intensity (TMI) IGRF Corrected

  Maps are also presented in PDF format.

  The topographic data base was derived from DIVA-GIS at 1:1,000,000 scale http://www.diva-gis.org/gdata

- A Google Earth file *GL140190_FP.kml* showing the flight path of the block is included. Free versions of Google Earth software from: http://earth.google.com/download-earth.html

5.3 Digital Data

- Three copies of the data and maps on DVD were prepared to accompany the report. Each DVD contains a digital file of the line data in GDB Geosoft Montaj format as well as the maps in Geosoft Montaj Map and PDF format.

- DVD structure.

Data	contains databases, grids and maps, as described below.
Report	contains a copy of the report and appendices in PDF format.

Database is in Geosoft GDB format, containing the following channels:

Table 4: Geosoft GDB Data Format Magnetics Database

Channel name	Units	Description
KKJ_Easting:	metres	Easting, KKJ Finland Uniform coordinate system
KKJ_Northing:	metres	Northing, KKJ Finland Uniform coordinate system
WGS84_Easting:	metres	Easting, WGS84 UTM Zone 35N
WGS84_Northing:	metres	Northing, WGS84 UTM Zone 35N
GPS_Height	metres	Height above geoid
WGS84_Longitude:	Decimal Degrees	WGS84 from x
WGS84_Latitude:	Decimal Degrees	WGS84 from y
Line		Line Number
Date	ddmmyy	Date of the survey
Flight		Flight number
GPStime:	Seconds of the day	GPS time
Radar:	metres	Terrain clearance from radar altimeter
DEM:	metres	Digital Elevation Model (z-radar)
TFRAW 1	nT	Raw Total Magnetic field data from sensor 1
TFRAW 2	nT	Raw Total Magnetic field data from sensor 2
TFRAW 3	nT	Raw Total Magnetic field data from sensor 3
TFCMP1	nT	De-spiked and compensated Total Magnetic field data from sensor 1
TFCMP 2	nT	De-spiked and compensated Total Magnetic field data from sensor 2
TFCMP3	nT	De-spiked and compensated Total Magnetic field data from sensor 3
Basemag:	nT	Magnetic Diurnal variation data
Mag2	nT	Diurnally Corrected Magnetic Data
TMI	nT	Tie-leveled Magnetic Data
TMI_IGRF	nT	Total Magnetic Intensity IGRF Corrected
Vx	nT	Fluxgate mag
Vy	nT	Fluxgate mag
Vz	nT	Fluxgate mag
HX_Raw	nT/m	Raw Lateral (cross-line) Gradient
HX_final	nT/m	Levelled Lateral (cross-line) Gradient

- Grids in Geosoft GRD format, as follows:

1VD:	Calculated Vertical Gradient of TMI
DEM:	Digital Elevation Model
TMI:	Total Magnetic Intensity

A Geosoft .GRD file has a .GI metadata file associated with it, containing grid projection information. A grid cell size of 12 metres was used.

6. CONCLUSIONS AND RECOMMENDATIONS

An airborne magnetic survey has been completed over the Mosku Project for Anglo American Exploration Finland near Sodankylä, Finland.

The total area coverage for the Mosku Project is 955 km^2. Total survey line coverage is 20,563.3 line kilometres. The principal sensors included a gradient magnetometer with three magnetic sensors, fluxgate reference magnetometer and a RMS DAARC500 Adaptive Aeromagnetic Real-Time Compensator. The results of the data have been presented as contour color images at a scale of 1:50,000 by Geotech Ltd. No formal interpretation has been included.

We recommend a detailed structural interpretation of the available magnetic data. Zones of strong magnetization should be quantitatively interpreted by 3D inversions, using UBC's MAG3D software. The geophysical interpretations should be evaluated in conjunction with other available data, such as geochemistry or geology, prior to any ground follow-up and/or test drilling work.

Respectfully submitted[2],

Thomas Wade
Geotech Ltd.

Adam Schubert
Geotech Ltd.

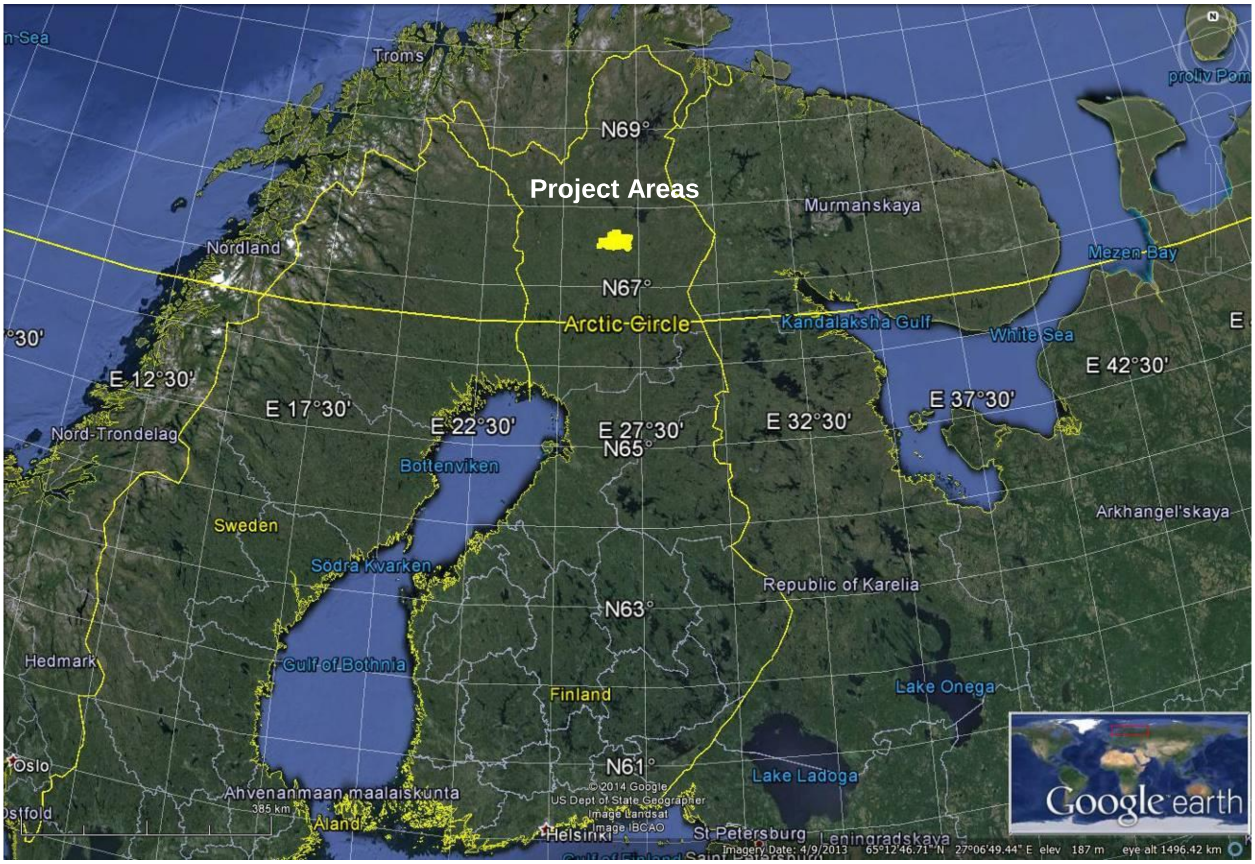
Geoffrey Plastow
Data Processing Manager
Geotech Ltd.

August 2014

[2] Final data processing of the data were carried out by Adam Schubert, under the supervision of Geoffrey Plastow, P.Geo., Data Processing Manager, from the office of Geotech Ltd. in Aurora, Ontario.

APPENDIX A

SURVEY BLOCK LOCATION MAP



Survey Overview of the Block

APPENDIX B

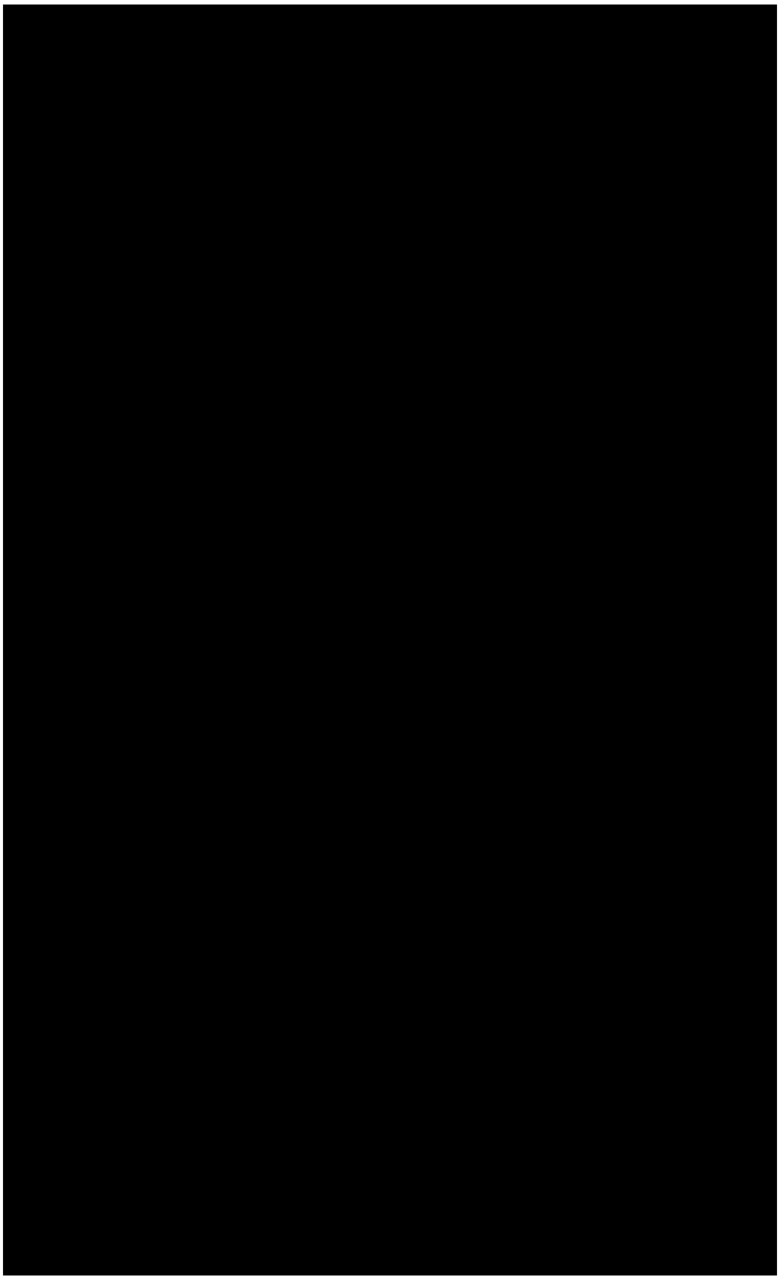
SURVEY BLOCK COORDINATES
(WGS 84, UTM Zone 35 North)

Mosku Project

X	Y
462835	7493677
462835	7487379
469503	7487413
469200	7489669
471321	7489871
473813	7488693
476541	7486234
482401	7486268
484220	7485695
487587	7485662
491629	7486605
496478	7485864
496377	7486908
497152	7488187
497960	7488288
500587	7487345
501664	7485561
502742	7484550
506110	7483068
510824	7486720
510824	7498358
512306	7499560
512306	7506104
496242	7506070
496074	7506811
494727	7506743
494457	7507552
494794	7509438
496074	7510178
496074	7512469
485163	7512469
485163	7510852
480818	7510852
480818	7508831
478225	7508798
478191	7502130
466169	7502163
466169	7495462
464620	7493677
462835	7493677

APPENDIX C

GEOPHYSICAL MAPS[1]



[1] Full size geophysical maps are also available in PDF format on the final DVD

[redacted]

[redacted]

APPENDIX D

GENERAL INTERPRETATION PRINCIPLES

Magnetics

The total magnetic intensity (TMI) responses reflect major changes in the magnetite and/or other magnetic minerals content in the underlying rocks and overburden. Precambrian rocks have often been subjected to intense heat and pressure during structural and metamorphic events in their history. Original magnetic signatures imprinted on these rocks at the time of formation have, in most cases, been modified, resulting in low magnetic susceptibility values.

The amplitude of magnetic anomalies, relative to the regional background, helps to assist in identifying specific magnetic rock units related to, for example, mafic flows, mafic to ultramafic intrusives, felsic intrusives, felsic volcanics and/or sediments etc. Obviously, several geological sources can produce the same magnetic response. These ambiguities can be reduced considerably if basic geological information in the area is available to the geophysical interpreter. In addition to simple amplitude variations, the shape of the response expressed in the wavelength and the symmetry or asymmetry, are used to estimate the depth, dip, or other geometric parameters. For example, long narrow magnetic linears usually reflect mafic flows or intrusive dykes. Large areas with complex magnetic patterns may be produced by intrusive bodies with significant magnetization, flat lying magnetic sills or sedimentary iron formation. Local isolated circular magnetic patterns often represent plug-like igneous intrusives such as kimberlites, pegmatites or volcanic vents.

Because TMI responses may represent two or more closely spaced bodies within a single and broad response, the first or second vertical derivative of the TMI response can be helpful for distinguishing these smaller features. The derivatives are most useful in mapping near surface linears and other subtle magnetic structures that are partially masked by nearby higher amplitude magnetic bodies. The broad zones of higher magnetic amplitude, however, are severely attenuated in the vertical derivative. These higher amplitude zones reflect rock units having strong magnetic susceptibilities. For this reason, both the TMI and the vertical derivative maps should be evaluated together.