Technical Report

Airborne Magnetic and HELITEM® Survey of the TL Property, Tsuius Creek, Southeastern British Columbia

North Okanagan Regional District, Kamloops Land Title District, British Columbia

NTS 82L/9-10; 82L/057-058; 82L/067-068

UTM Zone 11, 560600N; 392500E (NAD 83)
(50° 35' 37" N, 118° 31' 30" W)

By

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For

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1.0 Summary

A HELITEM® electromagnetic/magnetic survey was flown by Fugro Airborne Surveys, Ontario from October 5th to 20th, 2011 for Cullen Resources Ltd over the TL Property near Lumby, British Columbia. Fugro Airborne Surveys is a professional services company specializing in low altitude remote sensing technologies and collects, processes and interprets airborne geophysical data related to the subsurface of the earth and the sea bed. The TL Property survey consisted of one survey block with a total coverage of 387.4 km.

The purpose of the survey was to determine the existence and locations of bedrock conductors and to better understand the subsurface geology within the survey areas of the TL Property. The EM data and the magnetic data were processed to produce images and profiles that are indicative of the magnetic and conductive properties of the survey areas. A GPS electronic navigation system ensured accurate positioning of the geophysical data with respect to the base maps.
The survey data were processed and compiled in the Fugro Airborne Surveys office. Maps and data in digital format are provided in the report attached in Appendix 1.

The TL property is underlain by upper amphibolite-grade, penetratively deformed paragneiss and schist belonging to the Paleoproterozoic Monashee cover assemblage intruded by Eocene pegmatitic granite called the Ladybird granite. This succession contains marble, quartzite and amphibolites typical of the host rocks for the Kingfisher (Colby) and Ledge deposits occurring to the northwest and southeast of the TL properties, respectively. The sulphide-bearing succession at the TL properties is interpreted to be the same stratigraphic interval as that at Kingfisher and Ledge.

2.0 Introduction and Terms of Reference

RIT Minerals Corp. and Colin E. Dunn PhD (independent consultant) jointly staked the TL1 through TL11 claims (706178, 706191, 831234, 831248, 839424, 839425, 839426, 839427, 839428, 839429, 839430, respectively) totaling 4656.67 hectares on the north-facing slope of Tsuius Creek, western Monashee Mountains. This report summarizes the results from electromagnetic/magnetic airborne surveys undertaken between October 5th and 20th 2011.

2.1 Terms of Reference

The authors have formed the *TL Property Partnership* for the purpose of exploring the TL claims. No fees were paid the partnership, and the preparation of this Technical Report is not dependent in whole or in part on any prior or future engagement. The claim for work done is in accordance with industry standards for work of this nature.

The figures in this report were prepared by Fugro Airborne Surveys, or by, or under the direction of, the authors. The sections of this report that discuss geophysical airborne surveys rely on new analyses collected by Fugro Airborne Surveys, Mississauga, Ontario, Canada, a professional services company that specializes in low-altitude remote sensing technologies and collects, processes and interprets airborne geophysical data related to the subsurface of the earth and the sea bed. Fugro Airborne Surveys has successfully achieved certification to the international standard *ISO 9001:2000 Quality Management Systems – Requirement*s.

Sections of the report that describe regional-, local- and property-scale geology rely on field work undertaken by the authors and on the following reports:

Dunn, C.E. and R.I. Thompson 2007, Biogeochemical Exploration using Douglas-fir Tree Tops in the Mabel Lake Area, Southern British Columbia (NTS 82L09 and 10), GSC Open File 5538.

Thompson, R.I., Glombick, P., Erdmer, P., Heaman, L.M., Lemieux, Y. and Daughtry, K.L., 2006, Evolution of the ancestral Pacific margin, southern Canadian Cordillera: Insights from new geological maps, *in* Colpron, M. and Nelson, J.L., eds., Paleozoic Evolution and Metallogeny of Pericratonic Terranes at the Ancient Pacific Margin of North American, Canadian and Alaskan Cordillera: Geological Association of Canada, Special Paper 45, p. 433-482.

This report presents: 1) a description of the general geological setting of the Property, and 2) a description and results of a geophysical airborne survey. Reports reviewed by the authors are listed in the references at the end of this report.

The authors are familiar with the TL1 and TL2 and adjacent properties having spent 5 days exploring them in July and September of 2010, as well as having spent several days over the period from 2005-2008 evaluating the area. The authors are familiar with the TL3 and TL4 and adjacent properties having each spent 2.5 days exploring them in July and September of 2010, as well as having spent several days over the period from 2005-2008 evaluating the area in general. The authors also performed a 2-week channel sampling program on TL1 and TL2 properties during June 2011. As well, the authors have examined the area as part of regional mapping and geochemical surveys (references cited above).

All measurement units used in this report are metric. The coordinate system in use on the Property and on all maps is UTM zone 11 (NAD83).

2.2 Abbreviations and Acronyms

A list of frequently used acronyms and abbreviations follow:

Ag	silver
As	arsenic
Au	gold
Bi	bismuth
cm	centimetre
Cu	copper
g/t	grams per tone
Hg	mercury
ICP-ES	Inductively Coupled Plasma Emission Spectrometry (analytical method)
ICP-MS	Inductively Coupled Plasma Mass Spectrometry (analytical method)
INAA	Instrumental neutron activation analysis (analytical method)
kg	kilogram
km	kilometre
m	metre
masl	metres above sea level
mm	millimetre
ppb	parts per billion
ppm	parts per million (34.286 ppm equals one troy ounce per short ton)
Pb	lead
Tl	thallium
tonne	metric ton (1000 kg)
Zn	zinc

A list of frequently used acronyms and abbreviations used in the airborne surveys follow:

k	Magnetic susceptibility
ε	Dielectric permittivity
μ, μ**r**	Magnetic permeability, relative permeability
ρ, ρ**a**	Resistivity, apparent resistivity
σ,σ**a**	Conductivity, apparent conductivity
σ**t**	Conductivity thickness
τ	Tau, or time constant
Ω**m**	ohm-metres, units of resistivity
AGS	Airborne gamma ray spectrometry.
CDT	Conductivity-depth transform, conductivity-depth imaging (Macnae and Lamontagne, 1987; Wolfgram and Karlik, 1995)

CPI, CPQ	Coplanar in-phase, quadrature
CPS	Counts per second
CTP	Conductivity thickness product
CXI, CXQ	Coaxial, in-phase, quadrature
FOM	Figure of Merit
fT	femtoteslas, normal unit for measurement of B-Field
EM	Electromagnetic
keV	kilo electron volts – a measure of gamma-ray energy
MeV	mega electron volts – a measure of gamma-ray energy 1MeV = 1000keV
NIA	dipole moment: turns x current x Area
nT	nanotesla, a measure of the strength of a magnetic field
nG/h	nanoGreys/hour – gamma ray dose rate at ground level
ppm	parts per million – a measure of secondary field or noise relative to the primary or radioelement concentration.
pT/s	picoteslas per second: Units of decay of secondary field, dB/dt
S	siemens – a unit of conductance
x	the horizontal component of an EM field parallel to the direction of flight.
y	the horizontal component of an EM field perpendicular to the direction of flight.
z	the vertical component of an EM field.

3.0 Mineral Tenure Description and Location

The TL1 through TL11 properties are roughly centered at: UTM Zone 11,560600N; 392500E (NAD 83) (50° 35' 37" N, 118° 31' 30" W) within NTS map sheets 82L/9-10; 82L/057-058; 82L/067-068 in the southwest portion of the Monashee Mountains of southern British Columbia (Fig. 1). The tenures occupy the north facing slope of Tsuius Creek (Fig. 2), which drains west into Mabel Lake; the town of Lumby is located 59 km to the south southwest on highway 6; and the town of Vernon is located a further 21 km west of Lumby, in the North Okanagan Valley at the junction of highways 6 and 97.

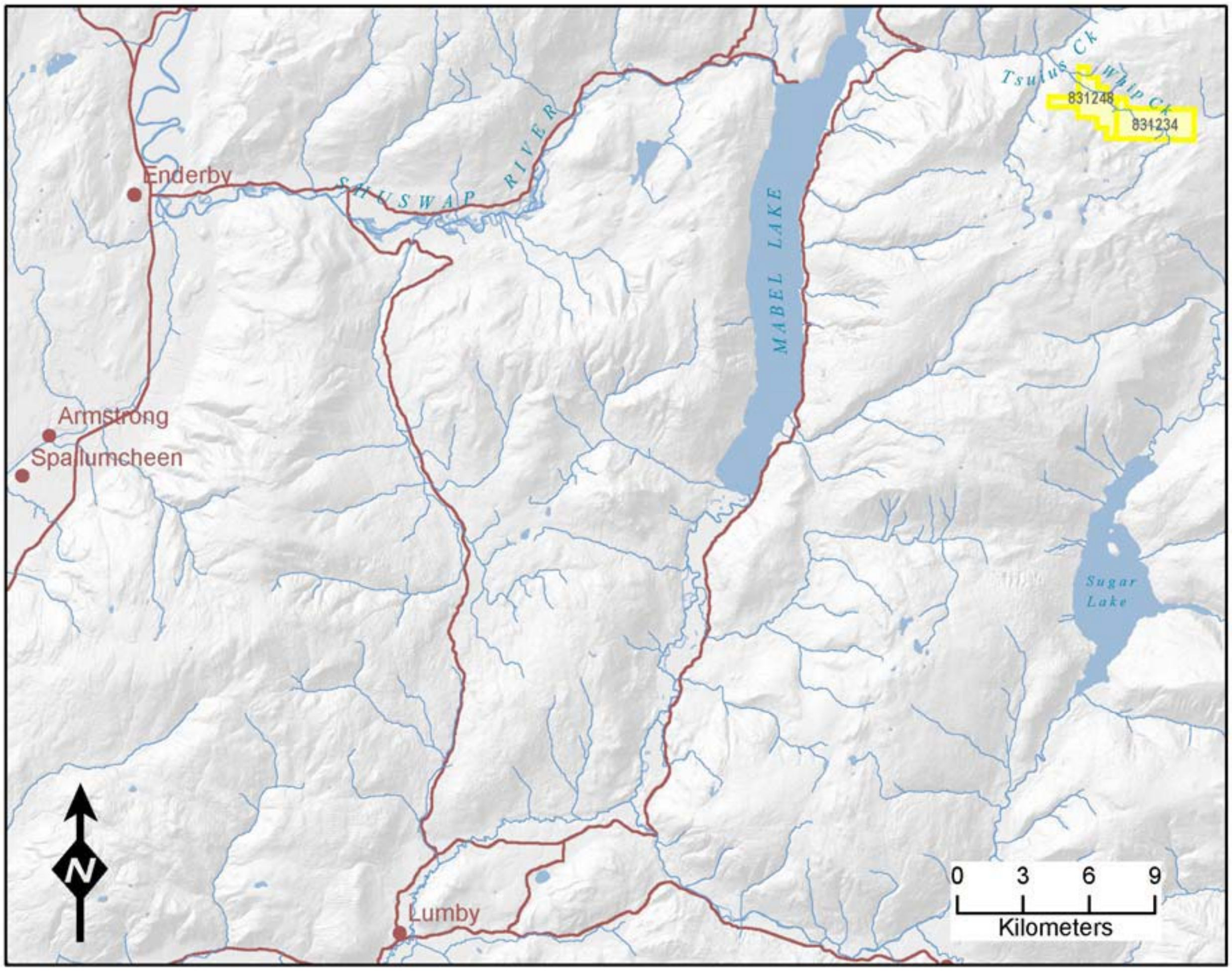

Figure 1: Location of TL1 through TL11 mineral tenures on the southwest margin of the Monashee Mountains. Vernon just SW of the map, is the closest major logistical centre.

Figure 2: View east up Tsuius Creek showing its steep, north-facing slope.

The TL Property comprises 15 tenures encompassing 6379.71 hectares. Tenures TL1 through TL11 comprise 4656.67 hectares (Fig. 3; Table 1). The mineral cell titles were acquired online and as such there are no posts or lines marking the location of the Property on the ground.

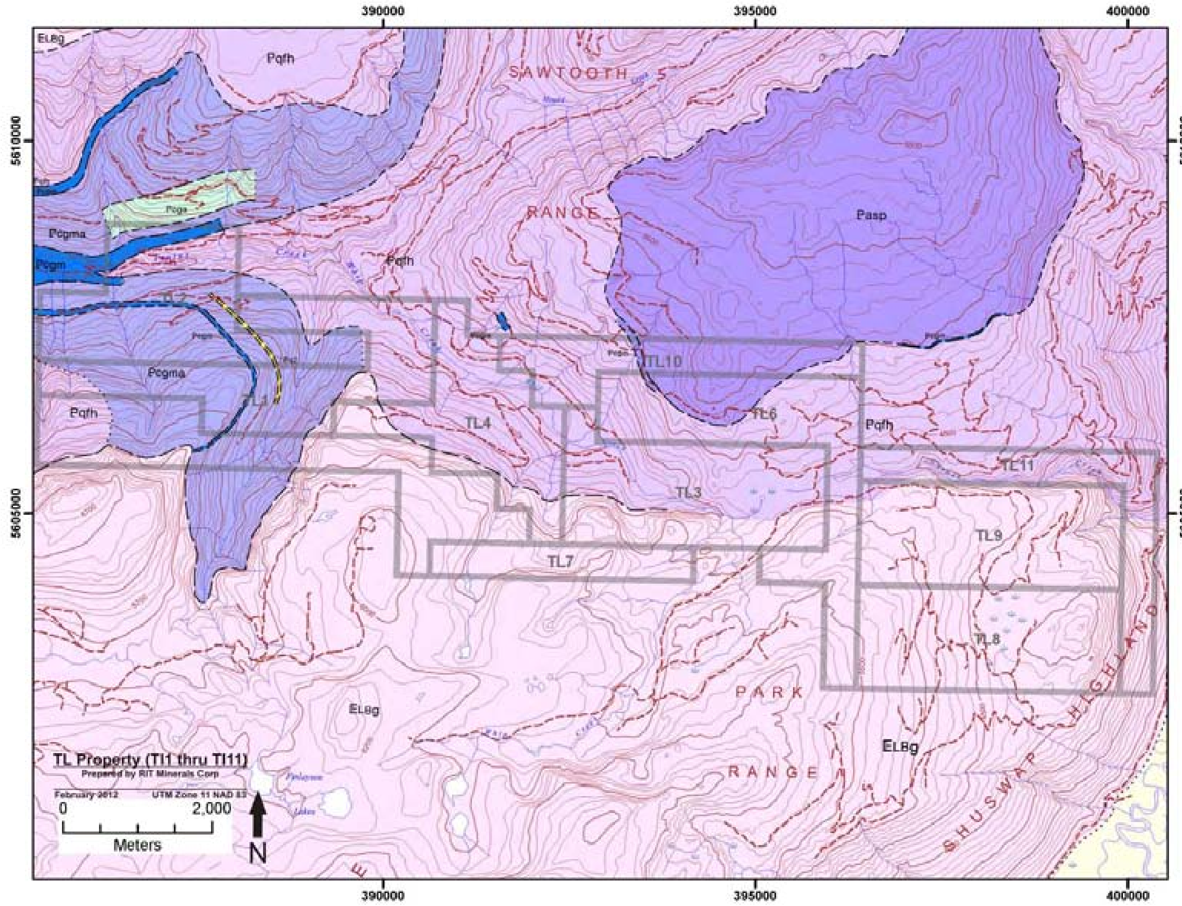

Figure 3: Location of the TL1 through TL11 mineral tenures relative to the geology, topography and drainage. Refer to Appendix 2 for scale-independent viewing and plotting.

Tenure Number	Good To Date	Claim Name	Owner	Area (Hectares)
706178	08-08-2014	TL1	50% RITM Corp / 50% Colin Dunn	492.22
706191	08-08-2014	TL2	50% RITM Corp / 50% Colin Dunn	492.16
831234	08-08-2014	TL3	50% RITM Corp / 50% Colin Dunn	512.88
831248	08-08-2014	TL4	50% RITM Corp / 50% Colin Dunn	410.24
839424	08-08-2014	TL5	50% RITM Corp / 50% Colin Dunn	512.86
839425	08-08-2014	TL6	50% RITM Corp / 50% Colin Dunn	512.85
839426	08-08-2014	TL7	50% RITM Corp / 50% Colin Dunn	164.16
839427	08-08-2014	TL8	50% RITM Corp / 50% Colin Dunn	492.55
839428	08-08-2014	TL9	50% RITM Corp / 50% Colin Dunn	492.41
839429	08-08-2014	TL10	50% RITM Corp / 50% Colin Dunn	266.61
839430	08-08-2014	TL11	50% RITM Corp / 50% Colin Dunn	307.74

Table 1: Description of the TL1 through TL11 mineral tenures.

4.0 Accessibility, Climate, Local Resources, Infrastructure, and Physiography

Maps showing up-to-date road access for the region are available from Front Counter BC located in the Provincial Forest Services office in Vernon.

The Property is accessible from the town of Lumby (Fig. 1): Proceed north and then east on the Lumby-Mabel Lake road (paved) to the south end of Mabel Lake; continue north on the Mabel Lake Main logging road (gravel) 18 km to the Simard spur road at 18 km or the Tsuius spur road at 21 km; both spur roads provide access to the property.

Given the steep terrain, off road traverses require significant physical effort.

The towns of Lumby and Vernon are the nearest major supply centres where material and services adequate to explore the property can be found. Infrastructure resources are excellent and readily available. The Property is within a few kms of the hydroelectric grid. The region has a long history of mining, hence personnel with heavy equipment, exploration and mining experience are available. The climate is benign, with agreeable spring-summer-fall seasons and a temperate winter that sees significant (>1 m) snow accumulations at upper levels of Tsuius Valley while valley bottoms may be relatively snow-free. Work above 1200 m is seasonal, limited to June through mid October; at lower elevations the field season extends from late April until November.

The Property is underlain by moderate to rugged slopes cut by deeply incised, steep tributary streams that flow north and south into Tsuius Creek. Elevations range from 700m to 2500m. Tree species are dominated at lower elevations by Interior Douglas Fir (*Pseudotsuga menziesii*), Western Hemlock (*Tsuga heterophylla*), and Western Redcedar (*Thuja plicata*); Subalpine Fir (*Abies lasiocarpa*) and Engelmann Spruce *(Picea engelmannii)* are present at higher elevations; Sitka Alder (*Alnus crispa*) may occupy moist, shaded areas, avalanche shoots and steep stream beds; White-Flowered Rhododendron (*Rhododendron albiflorum*) grows in very thick masses on shady, moist, subalpine slopes and lives up to its nickname “mountain misery.”

5.0 Exploration History

Streams that drain the Monashee Mountains are gold-bearing and have been prospected for placer minerals since the late 1800’s. Lode occurrences, mainly as gold in quartz veins cutting the black siltstone and shale of the Triassic Slocan Formation, have provided a focus for prospectors and local entrepreneurs; however, major exploration effort and expenditure in more recent times has focused on the base-metal potential of the region.

Two significant base metal occurrences, Kingfisher (Colby) and Big Ledge, occur northwest and southeast of the TL properties, respectively (Fig. 4). The reader is referred to geological accounts prepared by Höy, 1976, 1977a, 1977b.

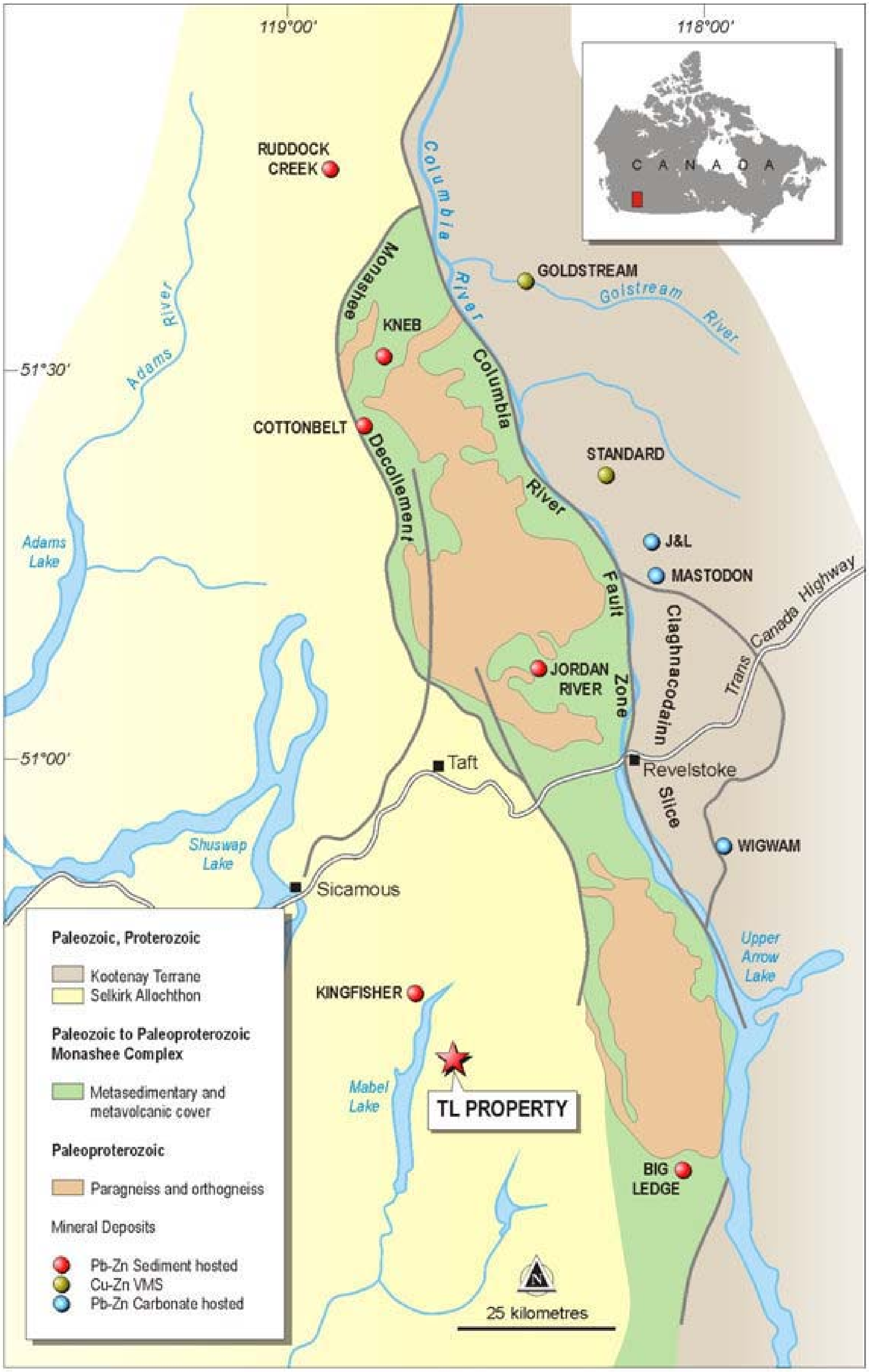

Figure 4: Regional geological map showing the distribution of stratabound Pb-Zn-Ag deposits around the TL Property (note the Selkirk Allochthon rocks between Kingfisher and Big Ledge, have been remapped as Monashee Cover Sequence**).**

6.0 Geological Setting

Six stratabound zinc-lead-silver deposits, called the "Monashee Zn-Pb-Ag" deposits, are known in highly metamorphosed and deformed Palaeoproterozic metasedimentary and meta-igneous rocks of the Monashee Complex of southeastern British Columbia (Fig 4). In all of the six monashee Zn-Pb-Ag deposits, mineralization occurs within a relatively narrow (~50-100m thick), pelitic schist-calcsilicate-marble-amphibolite-quartzite succession, called the Monashee Cover Sequence (Fig. 5). A strong case can be made that the mineralized interval is part of the same stratigraphic interval at all deposit localities. The TL property geochemical anomaly contains the target (mineralized) Monashee cover sequence. Its geographic location, between the Big Ledge and Kingfisher (Colby) deposits (Fig. 4) in the southern portion of the Monashee complex, defines an east-west trending belt that, until recently, was not recognized as belonging to the Monashee cover sequence (Thompson et al., 2006), hence exploration companies have tended to ignore the area.

The TL1 and TL2 properties occur near the eastern edge of a Proterozoic basin developed between 1.8 and 2.0 billion years ago (Thompson et al., 2006; Fig. 5). This basin has an analogue in Yukon and Northwest Territories called Wernecke (Thorkelson, 2000; Thorkelson et al., 2001) and as such represents a new interpretation of strata hosting Monashee stratiform base metal deposits. In the Monashees, the succession has been metamorphosed to upper amphibolite metamorphic facies and penetratively deformed.

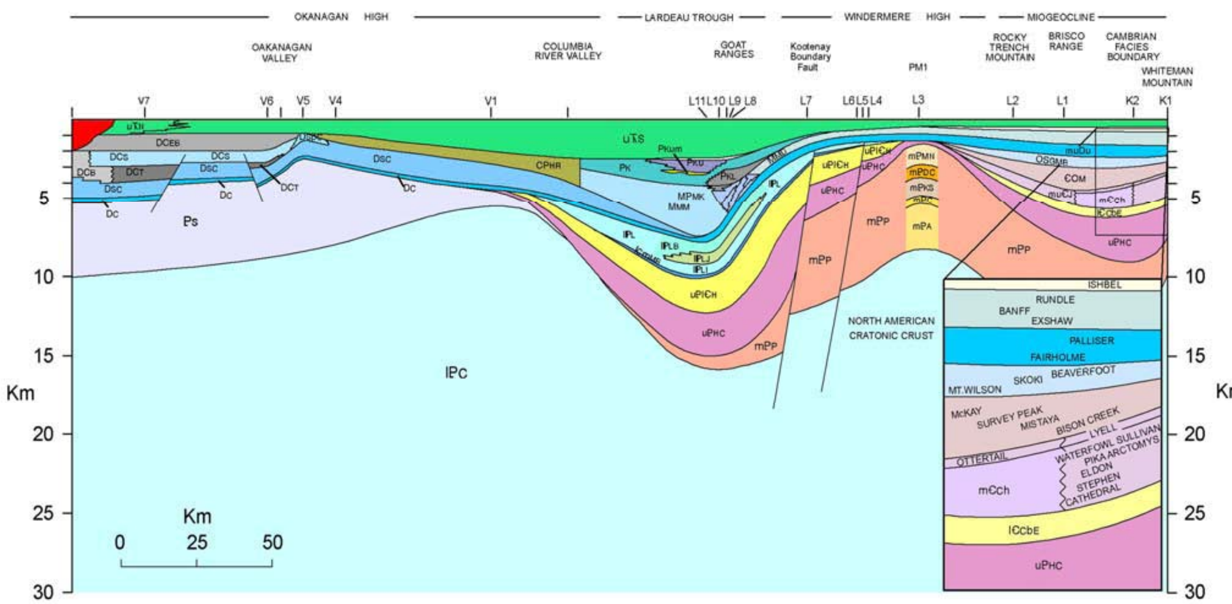

Figure 5: Regional stratigraphic cross section (not restored) showing the relative distribution and thickness of the major stratigraphic sequences making up the southern Canadian Cordillera (from Thompson et al., 2006). mPP (orange) = Mesoproterozoic Purcell sequence; uPHC (pink) = Neoproterozoic Windermere assemblage; uPlCH (yellow) + lPL (turquoise) = lower Paleozoic ancient Pacific margin assemblage; D + M + MP + P + uTr (blue, grey, green) = upper Paleozoic-Mesozoic back-arc assemblage.

6.1 Local Geology

The local area geology comprises a homoclinal succession of biotite-garnet (±hornblende) schist and paragneiss, marble, calcsilicate, amphibolitic schist and quartzite which dips gently to moderately west (Fig. 6).

The most distinctive marker units – white, massive marble – are continuous and vary in thickness from less than 1 m to more than 10 m. Composition varies along strike with more pelitic layers and facies exhibiting calc-silicate minerals. A significant change in thickness and facies occurs along the lower, north slope of Tsuius Creek where massive white marble changes eastward into pelitic calc-silicate before passing laterally into biotite-garnet schist. Marble occurs at two levels on the properties; they are considered separate and distinct; however, one cannot rule out an attenuated nappe interpretation.

Two other marker units, a calc-silicate gneiss unit and a pelitic quartzite unit were also distinguished from the host of schist and paragneiss. The calc-silicate gneiss weathers light grey to rusty brown, consisting of massive, white to brown marble intercalated with amphibolitic schist and amphibolite. The quartzite is less than 5 m thick and is intercalated with sillimanite-garnet-biotite schist, biotite-quartz-feldspar paragneiss.

Biotite-garnet (±hornblende) schist and paragneiss is host to the marker units. It also contains thin units of amphibolite schist, calcsilicate, marble and pelitic marble which were not individually mappable due to lack of exposure.

The homoclinal disposition of rock units is interpreted to be the consequence of recumbent isoclinal folds having sub-horizontal southeast-northwest trending axes. Fold hinges can be mapped at the macroscopic scale.

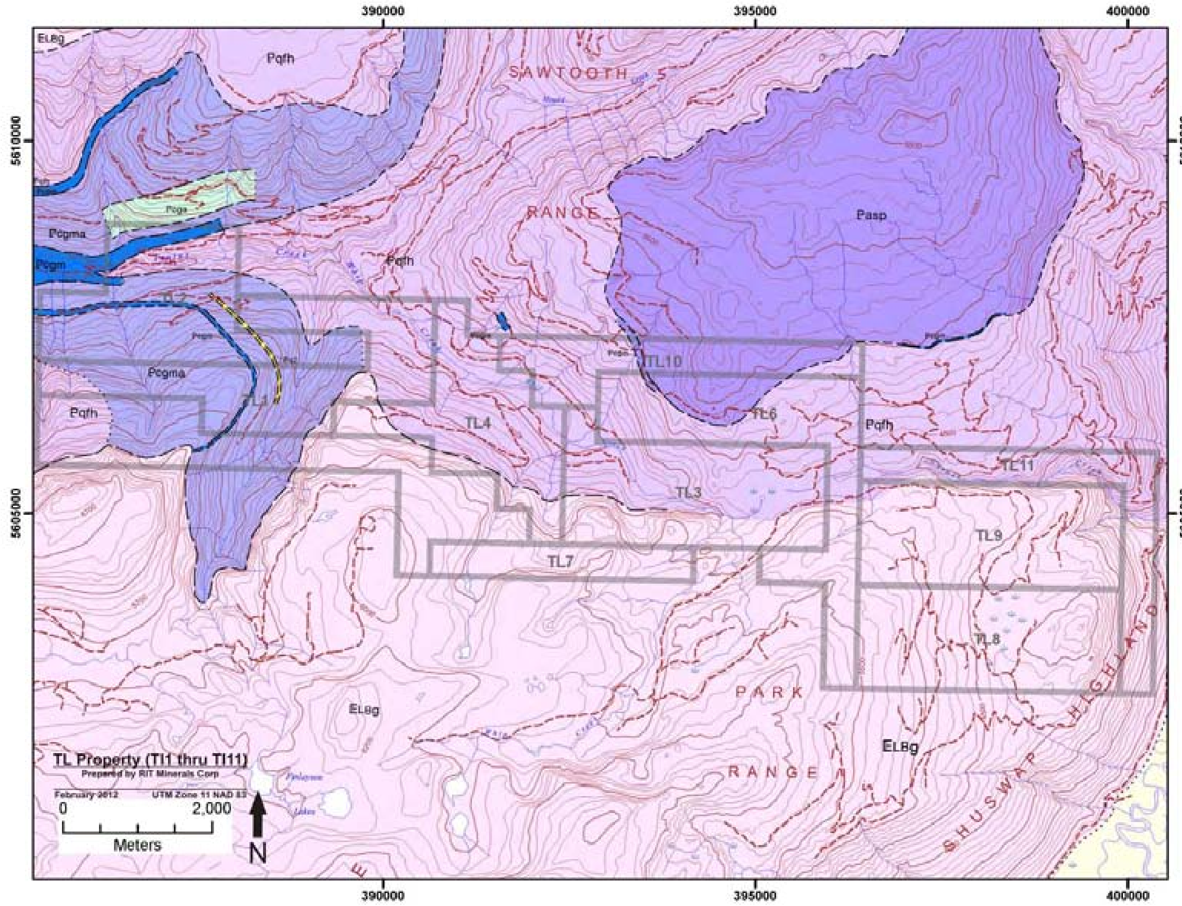

Figure 6: Local geology of the TL1 through TL11 properties. Map units are the following: Pqfh: Quartz-feldspar-biotite schist, feldspar-quartzhornblende-biotite schist, amphibolite, calc-silicate gneiss, micaceous quartzite; Pcgma: Amphibolitic schist, calc-silicate, marble, pelitic marble; Pcgm: Marble; Pcgma: Calc-silicate gneiss; ELBg: Ladybird granite (Eocene). Refer to Appendix 2 for scale-independent figure appropriate for viewing detail.

6.2 Property Geology

Exposure is very limited on the property. June 2011 trenching and channel sampling in tenures TL1 and TL2 exposed graphitic and micaceous quartzite with disseminated pyrite, dark-grey to black, biotite-quartz-garnet schist, a white, light grey and pale green calc-silicate quartzite and a calcareous quartzite and marble containing sphalerite and a semi-massive sulphide in a glassy quartz matrix that was deeply weathered and gossanous in places. Exposed rocks were very graphitic and limonitic and ranged from non- to very magnetic.

7.0 Mineralization

The semi-massive to massive sulphide zone trenched and channel-sampled in June 2011 is 10 to 35 m wide by 50 m long and was open to the southeast and northwest (Fig. 7 and Fig. 8). The best continuous section of zinc uncovered was 3 m at 8.98%. The lateral and vertical limits of this sulphide showing have yet to be determined and were a stimulus for the **HELITEM**® Survey.

Figure7: TL Property trench TL00N looking east across the semi-massive sulphide

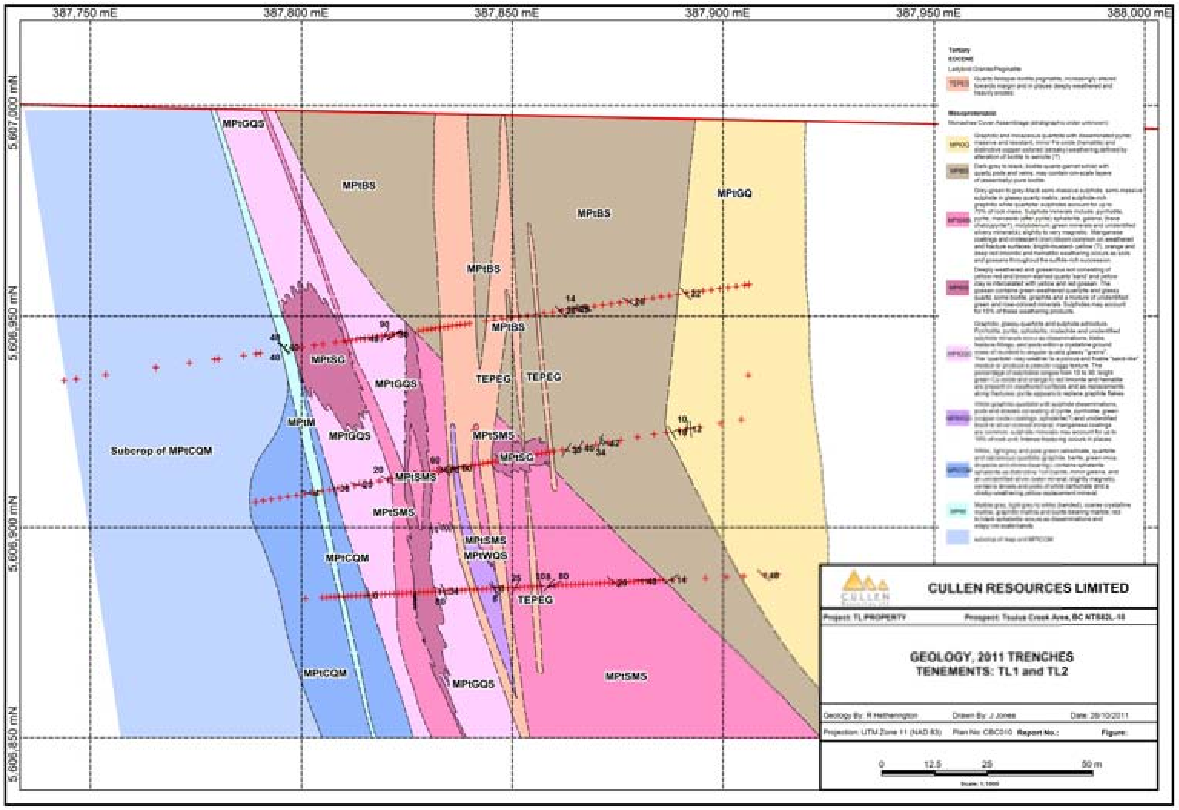

Figure 8: Geology, 2011 trenches TL Property tenures TL 1 and TL 2

8.0 2011 HELITEM® Survey Operations

8.1 Location of the Survey Blocks

Figure 9 shows the locations of the 2011 TL Property airborne magnetic and HELITEM® survey block. The base of operations was setup at Salmon Arm, British Columbia, from October 5th to 20th, 2011. Total coverage of the block amounted to 387.4 line km.

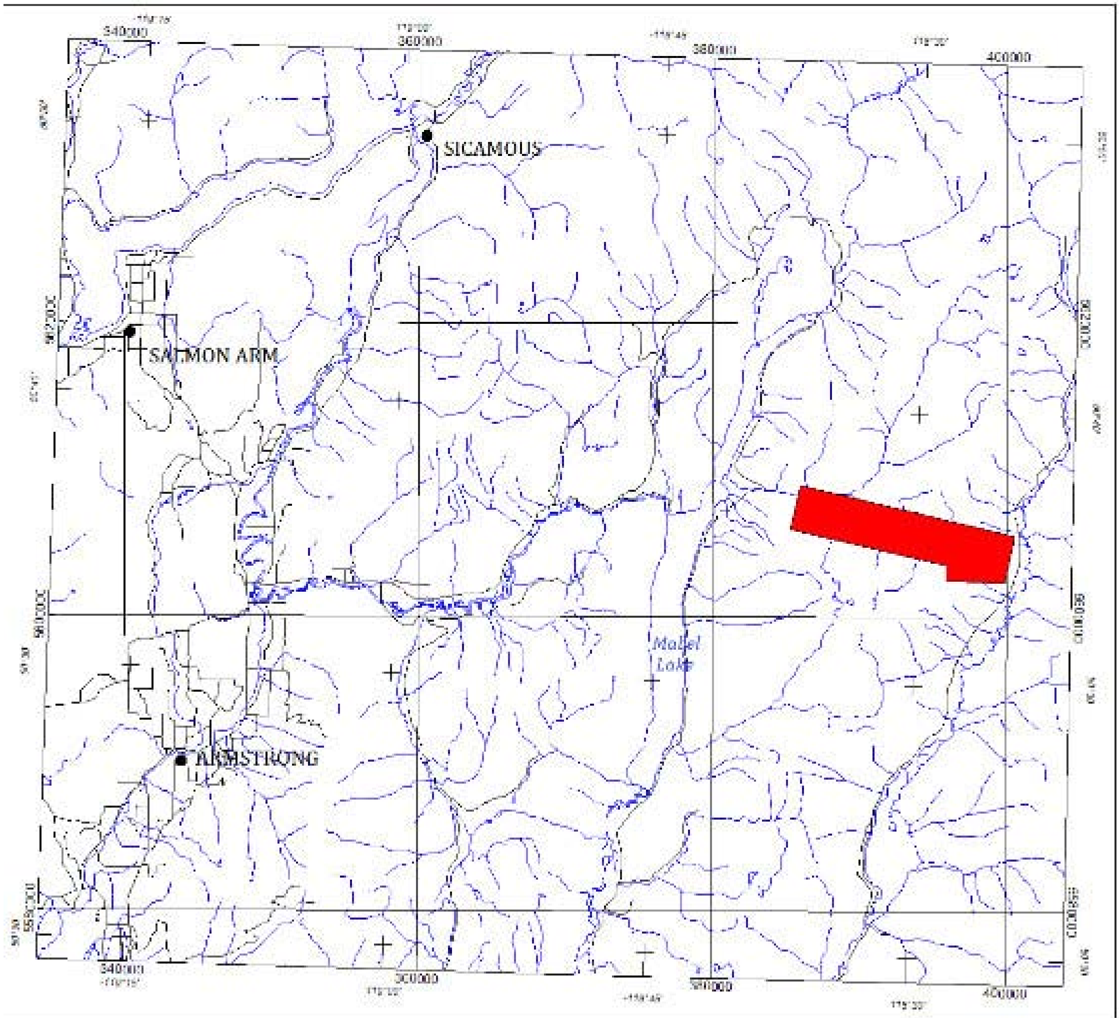

Figure 9: Survey location

Table 2 lists coordinates of the corner points of the survey blocks.

Block	Corners	X-UTM (E)	Y-UTM (N)
11086	1	385943.1	5608946
TL Property	2	400537.2	5605541
	3	399829.7	5602354
	4	395859.8	5602522
	5	395906.1	5603553
	6	385257.7	5605981

Table 2: Area Corners in UTM 11N, WGS84

8.2 System Information

The HELITEM® system is composed of a 51.9 m cable to which is attached a receiver platform 22.4 m along the cable below the Helicopter, a magnetometer attached to the transmitter loop 47 m below the helicopter in flight. The top of the cable is attached to a helicopter and when in flight it drags to form a 25 degree angle from the vertical. The real time navigation GPS antenna is on the tail boom of the helicopter, the barometric altimeter, radar altimeter, video camera and data recorder are all installed in the helicopter. One GPS antenna is attached near the centre of transmitter loop to give positional information of the loop.

Aircraft and Geophysical On-Board Equipment

Aircraft:	AS 350 B3 Helicopter
Operator:	Great Slave Helicopters
Registration:	C-FIDA
Survey Speed:	55 knots / 65 mph / 30 m/s
Magnetometer:	Scintrex CS-3 caesium vapour, attached to transmitter loop, sensitivity = 0.01 nT, sampling rate = 0.1 s, ambient range 20,000 to 100,000 nT. The general noise envelope is kept below 0.5 nT. The nominal sensor height is ~35 m above ground.
Electromagnetic system:	HELITEM® 30 channel multicoil system
Transmitter:	Vertical axis loop slung below helicopter
Loop area:	708 m2
Number of turns:	2
Nominal height above ground:	35 m
Receiver:	Multicoil system (X, Y and Z) with a final recording rate of 10 samples per second, of 30 channels of X, Y and Z component data. The nominal height above ground is ~62 m.
Base frequency:	30 Hz
Pulse width:	4 ms
Pulse delay:	0.163 ms
Off-time:	12.646 ms
Point value:	8.14 µs
Transmitter Current:	1270 A
Dipole moment:	2x106Am^2

Fugro uses the Fugro Airborne Surveys HeliDAS digital acquisition system; a Motorola MPX4115AP analog pressure sensor with a pressure sensitivity of 150mV/kPa and a 10 Hz sample interval. The Honeywell RT300 short pulse modulation 4.3 GHz radar altimeter is used along with the Panasonic WVCD/32 colour video camera. Electronic navigation and positional data is performed using the Novatel OEMV4/V at a 0.5 sec recording interval.

Base Station Equipment
During the survey a base station GPS was set up to collect data to allow post processing of the positional data for increased accuracy. The locations of the GPS base stations can be found in Appendix 1.

8.3 Survey Specifications

Table 3 summarizes the survey specifications for the TL Property block, including line spacing and flight directions.

BLOCK	LINES FROM	LINES TO	FLIGHT DIRECTION	LINE SPACING	MEASURED LINE km
1	10010 19010	11000 19030	NNE-SSW (13°) WNW-ESE (103°)	150 metres 1400 metres	318.2 45.0
1 (infill)	10125	10195	NNE-SSW (13°)	150 metres (for 75m spacing with main lines)	24.2
				TOTAL:	**387.4**

Table 3: Summary of Survey Specification

9.0 2011 HELITEM® Data Processing

9.1 Field

All digital data were verified for validity and continuity. The data from the aircraft and base station were transferred to the field PC. Basic statistics were generated for each parameter recorded, these included: the minimum, maximum, and mean values; the standard deviation; and any null values located. Data were checked in the field by the FUGRO AIRBORNE SURVEYS field geophysicist for adherence to the survey specifications as outlined in the survey specifications section. Any failure to meet the survey specifications resulted in a re-flight of the line or portion of the line unless aircraft safety was at risk or the client’s on site representative approved the data.

9.2 Flight Path Recovery

The quality of the GPS navigation was controlled on a daily basis by recovering the flight path of the aircraft. The correction procedure uses the raw ranges from the base station to create improved models of clock error, atmospheric error and satellite orbit. These models are used to improve the conversion of aircraft raw ranges to differentially corrected aircraft position.

To check the quality of the positional data the aircraft speed is calculated using the differentially corrected x, y and z data. Any sharp changes in the speed are used to flag possible problems with the positional data. Where speed jumps occur the data are inspected to determine the source of the error. The erroneous data are deleted and splined if less than two seconds in length. If the error is greater than two seconds the raw data are examined and if acceptable may be shifted and used to replace the bad data. The GPS z component is the most common source of error. When it shows problems that cannot be corrected by recalculating the differential correction the barometric altimeter is used as a guide to assist in making the appropriate correction.

9.3 Altitude Data

Radar altimeter data is de-spiked by applying a one and a half second median and smoothed using a one and a half second Hanning filter. The data are then subtracted from the GPS elevation to create a digital elevation model that is gridded and consulted in conjunction with profiles of the radar altimeter and flight path video to detect any spurious points.

9.4 Base Station Diurnal Magnetics

The raw diurnal data are sampled at 1 Hz are imported into a database. The data are filtered with a 5 second median filter and then a 5 second Hanning filter to remove spikes and smooth short wavelength variations. A nonlinear variation is then calculated and a flag channel is created to indicate where the variation exceeds the survey tolerance. Acceptable diurnal data are interpolated to a 10 Hz sample rate and the local regional field value calculated from the average of the first day's diurnal data is removed to leave the diurnal variation. This diurnal variation is then ready to be used in the processing of the airborne magnetic data.

9.5 Airborne Magnetics

Residual Magnetic Intensity (RMI)

The Total Magnetic Intensity (TMI) data collected in flight are profiled on screen along with a fourth difference channel calculated from the TMI. Spikes were removed manually where indicated by the fourth difference. The de-spiked data were then corrected for lag by 24 samples. The diurnal variation extracted from the filtered ground station data was then removed from the de-spiked and lagged TMI. The TMI is then tie line levelled, manually corrected and micro-levelled if necessary.

The Residual Magnetic Intensity was generated by subtracting the modelled IGRF regional from the levelled TMI data. The IGRF was calculated as at October 15th, 2011

Calculated Vertical Gradient (CVG)

The first vertical derivative was calculated in the frequency domain from the final gridded RMI values to enhance subtleties related to geological structures. A separate vertical derivative was calculated from the profile RMI data for display on the multi-parameter profiles.

9.6 Electromagnetics

dB/dt Data

Lag correction:	0 samples
Data correction:	The X, Y and Z component data are re-processed from the raw stream to produce the 30 raw channels at 10 samples per second.

The following processing steps are applied to the dB/dt data from all coil sets:

a) The raw stream data is re-processed post-flight using start-of-flight and end of-flight calibrations to remove spheric spikes, coil oscillation and system drift.

b) Noise filtering is done using an adaptive filter technique based on time domain triangular operators. Using a second difference value to identify changes in gradient along each channel, minimal filtering (21 points) is applied over the peaks of the anomalies, ranging in set increments up to a maximum amount of filtering in the resistive background areas (35 points for both the X and the Z component data);

c) The filtered X, Y and Z component data are then levelled in flight form for any residual and nonlinear drift that was not adequately corrected during the drift correction.

d) Finally, line-based levelling and microlevelling are applied as required.

B-field Data

The data acquisition system produces 30 B-field channels each for X, Y and Z components in realtime during flight, however these channels are only used for field QC. For delivery, mapping and generation of derived products, the final B-field channels are derived from the final levelled dB/dt data.

Coil Oscillation Correction

The electromagnetic receiver sensor of the HELITEM® is housed in a platform container which is slung below the helicopter using a cable and attached to the transmitter loop through a network of cables. The platform design reduces the rotation of the receiver coils in flight as well as improves the stability of the receiver-transmitter geometry. However sudden changes in airspeed of the aircraft, strong variable crosswinds, or other turbulence can still result in sudden moves of the platform. This can cause the induction sensors inside the platform to rotate about their mean orientation. The effect of coil oscillation on the data increases as the signal from the ground (conductivity) increases and may not be noticeable when flying over areas which are generally resistive.

Using the changes in the coupling of the primary field, it is possible to estimate the pitch, roll and yaw of the receiver sensors. Only the pitch, which affects mainly the X and Z components, was considered for correction. The nominal pitch can be computed using the ideal system geometry. The pitch angles during flight are estimated and corrected to this nominal value, removing the effects caused by the deviation of the receiver sensor from its nominal position. For the present datasets the data from all 30 channels of dB/dt and B-Field parameters have been corrected for coil oscillation.

dB/dt Z Data

Except for extremely conductive areas, the amplitude of the dB/dt Z component increases with the conductivities of the earth. Due to the geometry of the HELITEM® system, the Z component response from a near vertical discrete conductor peaks at either side but nulls where the transmitter is on top of the conductor. This results an "M" shaped Z component anomaly over a vertical conductor. The amplitudes of, and the distance between the two peaks can be used to indicate the dip angle and dip direction of the conductor.

Decay Constant (TAU)

The decay constant values are obtained by fitting the channel data from either the complete off-time signal of the decay transient or only a selected portion of it (as defined by specific channels) to a single exponential of the form:

$$Y = Ae^{-t/\tau}$$

where A is amplitude at time zero, t is time in microseconds and τ is the decay constant, expressed in microseconds. A semi-log plot of this exponential function will be displayed as a straight line, the slope of which will reflect the rate of decay and therefore the strength of the conductivity. A slow rate of decay, reflecting a high conductivity, will be represented by a high decay constant.

As a single parameter, the decay constant provides more useful information than the amplitude data of any given single channel, as it indicates not only the peak position of the response but also the relative strength of the conductor. It also allows better discrimination of conductive axes within a broad formational group of conductors.

For the present dataset, the decay constant channel and grid were generated for a range of midtime channels to characterise bedrock conductors. The decay constant channel was calculated by fitting the response of the B-field Z-component to the exponential function over windows 14-20 (window centres 0.675 - 1.864ms after turnoff).

Differential Conductivity™ Depth Sections

Differential Resistivity/Conductivity is a simple, relatively accurate resistivity/conductivity section developed by Fugro to be derived from airborne electromagnetic data1. This type of resistivity/conductivity section is fast and robust, and provides an excellent picture of conductivity conditions in the earth. It can be derived from both frequency domain and time domain EM data.

Differential Resistivity/Conductivity is derived from a homogeneous halfspace model of the resistivity/conductivity calculated for each time channel or EM frequency, each at an approximate depth. The early time channel or high frequency data provide a measure of the shallow resistivity/conductivity, and the deeper (later time, lower frequency) halfspace resistivities/conductivities are modified using the shallow information to give a more accurate measure of the resistivity/conductivity at depth. The depth of investigation for each time channel or frequency is adjusted as well.

Differential Resistivity/Conductivity sections tend to smooth sharply defined layers (compared to layered-earth inversions) but provide an excellent model of the resistivity/conductivity, quickly and without the complex processing necessary for inversions. The sections are valuable as a QC tool, as an overview of the resistivity/conductivity distribution in the earth, and often to provide guidance and a starting model for more complex inversions.

The differential conductivity™ depth sections, derived from each survey line, are created as individual grids and displayed on stacked section profiles with 4 lines on each sheet to allow line-toline comparison. The grids have been corrected for elevation variations such that the top of each section reflects the true terrain topography.

10.0 2011 HELITEM® Results

A series of maps and multi-parameter and multi-line profile plots were generated in UTM Zone 11N NAD83, as well as a report and flight path videos (in .BIN/BDX format). Figure 10 provides a depth slice from dB/dt Z Component at 50m below surface. Figure 11 provides a depth slice from dB/dt Z Component at 150m below surface. Additional maps and plots are provided in Appendix 1.

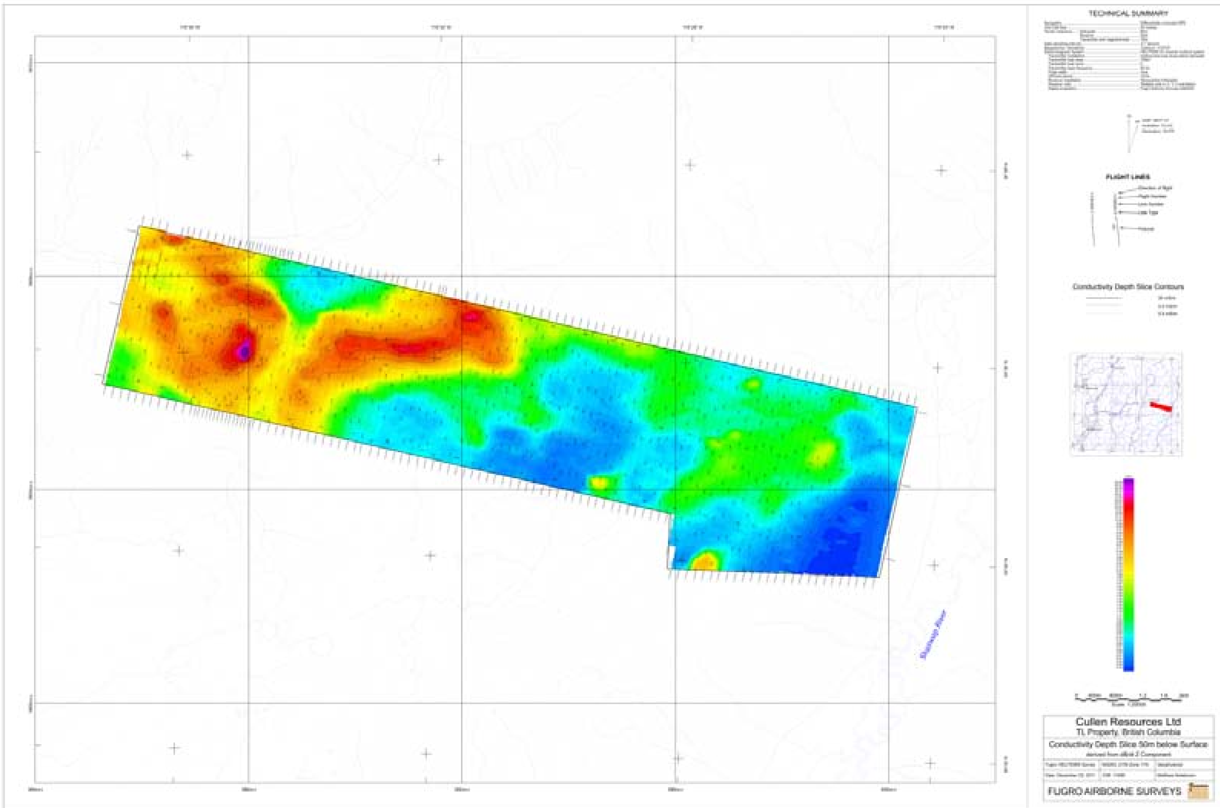

Figure 10: Depth Slice at 50m below surface

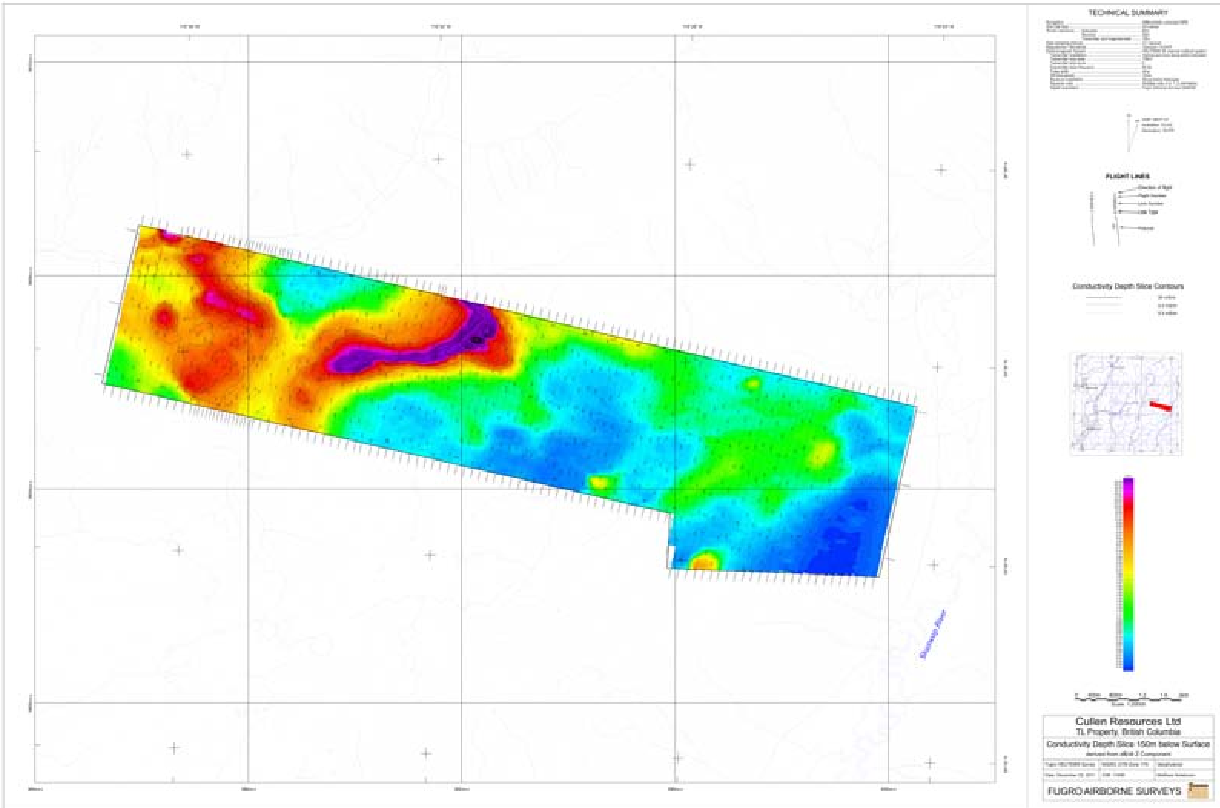

Figure 11: Depth slice at 150m below surface

11.0 References

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12.0 Statement of Costs

TL CLAIMS – Airborne Magnetic and HELITEM® Survey conducted on claims TL1 through TL11 (Tenures 706178, 706191, 831234, 831248, 839424, 839425, 839426, 839427, 839428, 839429, 839430) (October 5th to 20th, 2011)

Costs:

Geophysical Survey by Fugro Airborne Services	$118,120.00
Geophysical Consulting (Southern Geoscience)	5,491.18
Report writing and preparation: 3 days @ $800/day	2,400.00
Database management: 7.5 days @ $500/day	3,750.00
Total	**$129,761.18**

13.0 Statement of Qualifications

I, **Robert I. Thompson**, do hereby certify that:

I attained the degree of Doctor of Philosophy (PhD) in geology from Queens University, Kingston, Ontario in 1972.
I have a Hon. B.Sc. in geology from Queens University, Kingston, Ontario (1968).
I am a registered member of the Association of Professional Engineers and Geoscientists of British Columbia (P.Eng. 1972).
I am a Fellow of the Geological Association of Canada.
I have worked as a geologist for a total of 38 years since my graduation from university, all of it in the Canadian Cordillera.
I have worked for the BC Geological Survey (1972-74) and the Geological Survey of Canada (1974-2007) and now act as an independent consultant (2007-present).
I acted as a consultant to the Petroleum Department of the Bolivian Government (1990) under the auspices of PCIAC (Petro Canada International Aid Corp).
I have a thorough knowledge of the geology of southern British Columbia based on extensive field mapping.
I have authored numerous scholarly publications in peer-reviewed journals, and have published or am preparing to publish 32, 1:50,000 scale geological maps of Lardeau (NTS 82K) and Vernon (NTS: 82L) areas.
I am a co-author of this report.
I am not aware of any material fact or material change with respect to the subject matter of this report, which is not reflected in this report.

“signed and sealed” at North Saanich, B.C.
Robert I. Thompson, PhD, P.Eng
RIT Minerals Corporation
10915 Deep Cove Rd.,
North Saanich, B.C.

Dated at North Saanich, B.C. this 14th day of February, 2012
Reg. No. 115741 **Association of Professional Engineers and Geoscientists of British Columbi**a

I, **Colin E. Dunn**, do hereby certify that:

I attained the degree of Doctor of Philosophy (PhD) in geology and geochemistry from London University, UK, in 1972.
I have a Hon. B.Sc. in geology from London University, UK (1968).
I am a registered member of the Association of Professional Engineers and Geoscientists of British Columbia (P.Geo. 2000)
I am a registered member of the Association of Professional Engineers and Geoscientists of Saskatchewan (P. Eng from 1974-1985; and P.Geo since 2000)

I have worked as a geologist for a total of 39 years since my graduation from university, all of it in Canadian except for short contracts overseas.
I have worked for the Saskatchewan Geological Survey (1972-85) and the Geological Survey of Canada (1985-1998) and now act as an independent consultant (1998-present).
From 1974-1976 I was a Sessional Lecturer in Geology at the University of Regina.
I have published about 250 papers, book chapters, and articles covering a wide range of topics (mostly geochemistry), and more than 100 confidential reports for private companies and presented research papers and courses in dozens of countries on 6 continents.
Among the positions that I have held there are:

- President, Saskatchewan Geological Society (1975).
- Chairman and Canadian representative to International Atomic Energy Agency/Nuclear Energy Agency Working Group on Uranium Biogeochemistry (1979 -1982).
- Councillor, Association of Exploration Geochemists (1986-1992).
- Headed the implementation and co-ordination of GSC program on Environmental Geochemistry (1988-1993)
- Federal Geoscience program coordinator for Mineral Development Agreement with Saskatchewan (1991-1996)
- Participant in two scientific expeditions sponsored by the National Geographic Society - Morocco in 1993; Brazil, Paraguay and Argentina in 1996.
- Project leader of Canada/Brazil project (CIDA) on biogeochemical study of mercury and gold in vegetation around garimpeiro gold workings at Creporizão, Pará, Brazil (1998).
- Principal (1998-present) – Colin Dunn Consulting.

I was sole author of a book detailing latest developments on biogeochemical methods, entitled Dunn, C.E. , 2007, *Biogeochemistry in Mineral Exploration*, (Handbook of Exploration and Environmental Geochemistry 9, Series editor, M. Hale), Elsevier, Amsterdam (462 pp. + CD)
I am a co-author of this present report.
I am not aware of any material fact or material change with respect to the subject matter of this report, which is not reflected in this report.

“signed and sealed” at North Saanich, B.C.
Colin E. Dunn, PhD, P.Geo
Colin Dunn Consulting Inc.
8756 Pender Park Drive
North Saanich
BC, V8L3Z5.

Dated at North Saanich, B.C. this 14th day of February, 2012
Reg. No. 136910 **Association of Professional Engineers and Geoscientists of British Columbia**

I, **Renée Hetherington**, do hereby certify that:

I attained the degree of Doctor of Philosophy (PhD) in interdisciplinary studies (anthropology, biology, geography and geology) from University of Victoria, Victoria, British Columbia in 2002.

I have a Masters in Business Administration from the University of Western Ontario, London, Ontario (1985).
I have a B.A. in Business Administration from Simon Fraser University, Burnaby, British Columbia (1981).
I am a member of the Geological Association of Canada.
I was co-leader of UNESCO IUGS International Geological Correlation Program (IGCP) Project 526 “Risks, Resources and Record on the Continental Shelf (2007-2011).
I was Canadian co-leader of UNESCO IUGS IGCP Project 464 from 2003-2007.
I was a SSHRC Research Postdoctoral Fellow at the University of Victoria, School of Earth and Ocean Sciences (2005-2007).
I was Research Associate for Dr. Andrew Weaver, University of Victoria, Climate Modelling Group (2003-2007).
I have been a field assistant and volunteer for the Geological Survey of Canada (1996-2008; 2011-present).
I now act as an independent consultant (2007- present).
I acted as a consultant to the Ministry of Agriculture, Cattle Industry Development Council of British Columbia (1994-1995).
I was Executive Director, Finance and Research & Development, BC Cattlemen’s Association (1992-1994).
I was a member of the Executive Council, Cattle Industry Development Council of British Columbia, BC Ministry of Agriculture (1992-1994).
I was Financial and Systems Analyst for Lever Bros. A & W Canada (1985-1986).
I have authored numerous scholarly publications in peer-reviewed journals, and have recently co-authored an academic text published by Cambridge University Press: *The Climate Connection* (2010) and authored a second book to be published by Cambridge University Press: *Living in a Dangerous Climate: Climate Change and Human Evolution* (in press).
I am a co-author of this report.
I am not aware of any material fact or material change with respect to the subject matter of this report, which is not reflected in this report.

“signed and sealed” at North Saanich, B.C.
Renée Hetherington, PhD, MBA
RIT Minerals Corporation
10915 Deep Cove Rd.,
North Saanich, B.C.

Dated at North Saanich, B.C. this 14th day of February, 2012

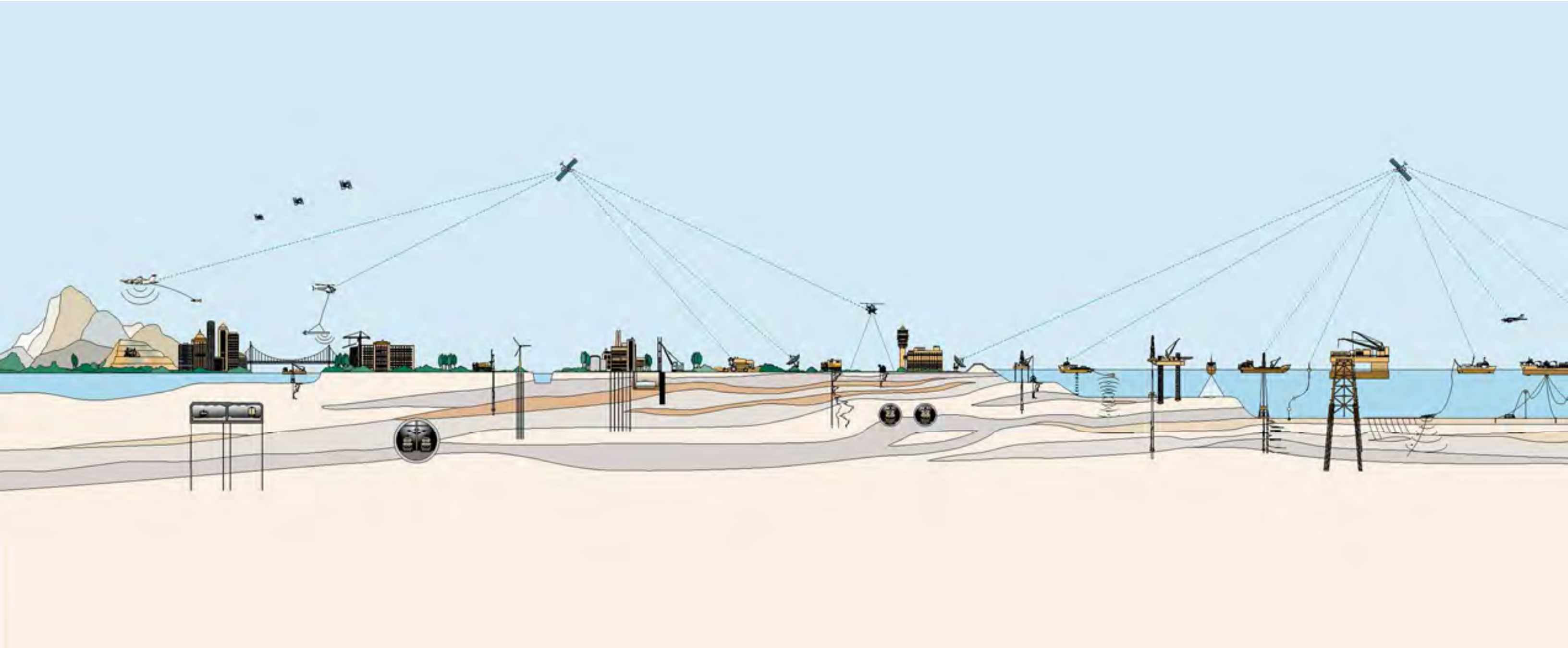
Fugro Airborne Surveys

LOGISTICS AND PROCESSING REPORT
Airborne Magnetic and HELITEM® Survey

TL PROPERTY, BRITISH COLUMBIA, CANADA

Project No. 11086

Cullen Resources Ltd



LOGISTICS AND PROCESSING REPORT
AIRBORNE MAGNETIC AND HELITEM® SURVEY
TL PROPERTY
BRITISH COLUMBIA, CANADA

PROJECT NO. 11086

Client: Cullen Resources Ltd
Unit 4, 7 Hardy Street
South Perth, 6151
Western Australia

Date of Report: January 9th, 2011

FUGRO AIRBORNE SURVEYS

Fugro Airborne Surveys was formed in early 2000 through the global merger of leading airborne geophysical survey companies: Geoterrex-Dighem, High-Sense Geophysics, and Questor of Canada; World Geoscience of Australia; Geodass and AOC of South Africa. Sial Geosciences of Canada joined the Fugro Airborne group in early 2001; Spectra Exploration Geosciences followed thereafter. In mid 2001, Fugro acquired Tesla 10 and Kevron in Australia, and certain activities of Scintrex. Fugro also works with Lasa-Geomag located in Brazil, for surveys in South America. With a staff of over 400, Fugro Airborne Surveys now operates from 12 offices worldwide.

Fugro Airborne Surveys is a professional services company specializing in low altitude remote sensing technologies and collects, processes and interprets airborne geophysical data related to the subsurface of the earth and the sea bed. The data and map products produced have been an essential element of exploration programs for the mining and oil & gas industries for over 50 years. Engineers, scientists and others with a need to map the earth's subsurface geology use Fugro Airborne Surveys for environmental and engineering solutions. From mapping kimberlite pipes and oil and gas deposits to detecting water tables and unexploded ordnance, Fugro Airborne Surveys designs systems dedicated to specific targets and survey needs. State of the art geophysical systems and techniques ensure that clients receive the highest quality survey data and images.

Fugro Airborne Surveys acquires both time domain and frequency domain electromagnetic data as well as, magnetic, radiometric and gravity data from a wide range of fixed wing (airplane) and helicopter platforms. Depending on the geophysical mapping needs of the client, Fugro Airborne Surveys can field airborne systems capable of collecting one or more of these types of data concurrently. The company offers all data acquisition, processing, interpretation and final reporting services for each survey.

Fugro Airborne Surveys is a founding member of IAGSA, the International Airborne Geophysics Safety Association. Our quality management system has successfully achieved certification to the international standard *ISO 9001:2000 Quality Management Systems - Requirement*s

SUMMARY

This report describes the logistics, data acquisition, processing and presentation of results of a HELITEM® electromagnetic/magnetic survey flown from October 5th to 20th, 2011 for Cullen Resources Ltd over the TL Property near Sicamous, British Columbia. The TL Property survey consists of one survey block. Total coverage of the survey blocks amounted to 387.4km.

The purpose of the survey was to determine the existence and locations of bedrock conductors and for better understanding of the subsurface geology within the survey areas. The EM data and the magnetic data were processed to produce images and profiles that are indicative of the magnetic and conductive properties of the survey areas. A GPS electronic navigation system ensured accurate positioning of the geophysical data with respect to the base maps.

The survey data were processed and compiled in the Fugro Airborne Surveys office. Maps and data in digital format are provided with this report.

Respectfully submitted,

FUGRO AIRBORNE SURVEYS CORP.

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B HELICOPTER AIRBORNE ELECTROMAGNETIC SYSTEMS

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E GLOSSARY

Survey Operations

Locations of the Survey Blocks

Figure 1 shows the locations of the TL Property survey block near Sicamous, British Columbia, Canada. The base of operations was setup at Salmon Arm, British Columbia, from October 5th to 20th, 2011. Total coverage of the block amounted to 387.4 km.

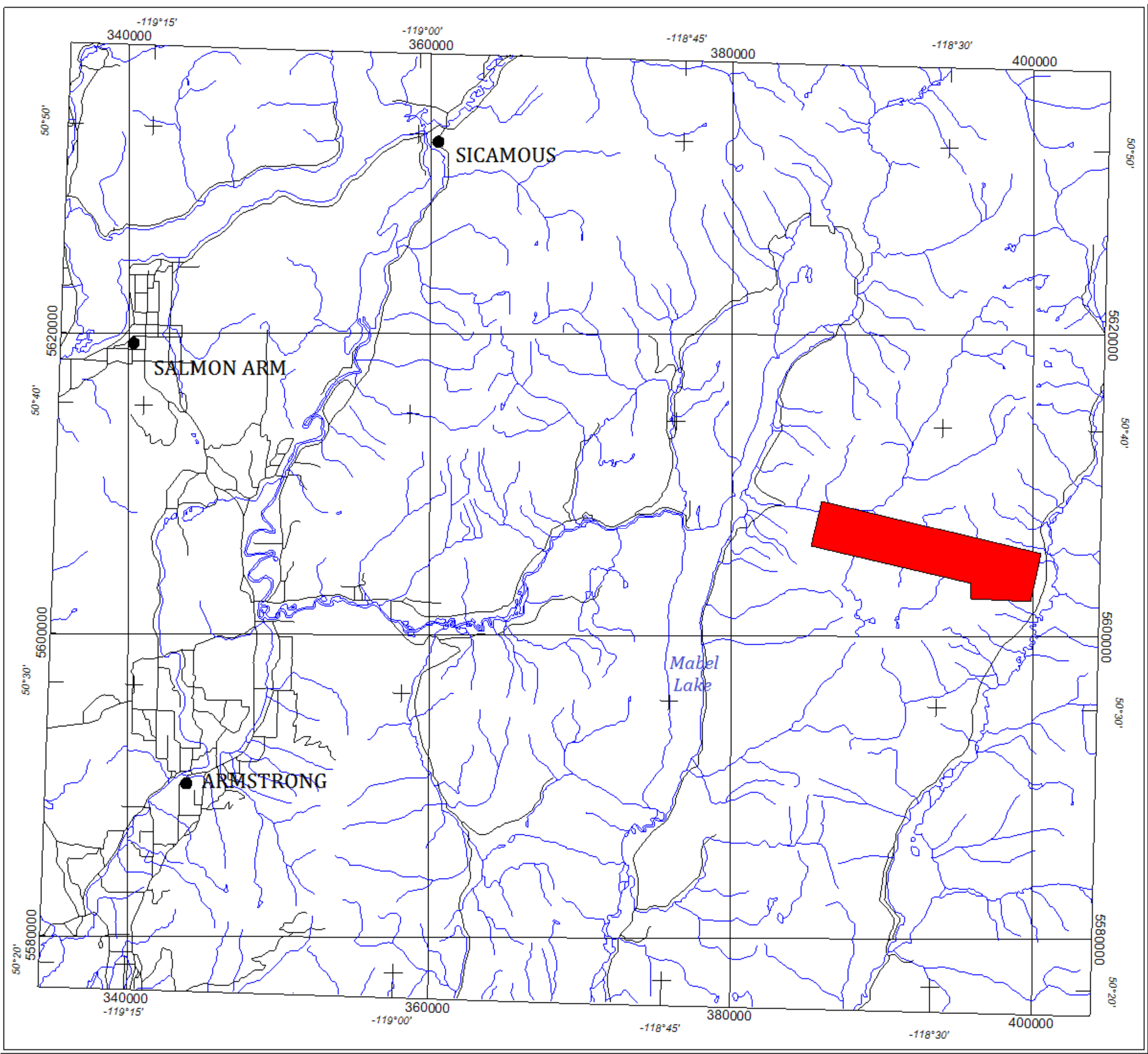

Figure 1. Survey Location.

Table 1 lists coordinates of the corner points of the survey blocks.

Block	Corners	X-UTM (E)	Y-UTM (N)
11086	1	385943.1	5608946
TL Property	2	400537.2	5605541
	3	399829.7	5602354
	4	395859.8	5602522
	5	395906.1	5603553
	6	385257.7	5605981

Table 1. Area Corners in UTM 11N, WGS84

System Information

Figure 2. HELITEM® System in Flight

Figure 2 depicts the HELITEM® system in flight. The HELITEM® system is composed of a 51.9 m cable to which is attached a receiver platform 22.4 m along the cable below the Helicopter, a magnetometer attached to the transmitter loop 47 m below the helicopter in flight. The top of the cable is attached to a helicopter and when in flight it drags to form a 25 degree angle from the vertical. The real time navigation GPS antenna is on the tail boom of the helicopter, the barometric altimeter, radar altimeter, video camera and data recorder are all installed in the helicopter. One GPS antenna is attached near the centre of transmitter loop to give positional information of the loop.

Aircraft and Geophysical On-Board Equipment

Aircraft:	AS 350 B3 Helicopter
Operator:	Great Slave Helicopters
Registration:	C-FIDA
Survey Speed:	55 knots / 65 mph / 30 m/s
Magnetometer:	Scintrex CS-3 caesium vapour, attached to transmitter loop, sensitivity = 0.01 nT, sampling rate = 0.1 s, ambient range 20,000 to 100,000 nT. The general noise envelope is kept below 0.5 nT. The nominal sensor height is ~35 m above ground.
Electromagnetic system:	HELITEM® 30 channel multicoil system
Transmitter:	Vertical axis loop slung below helicopter
Loop area:	708 m^2
Number of turns:	2
Nominal height above ground:	35 m
Receiver:	Multicoil system (X, Y and Z) with a final recording rate of 10 samples per second, of 30 channels of X, Y and Z component data. The nominal height above ground is ~62 m.
Base frequency:	30 Hz
Pulse width:	4 ms
Pulse delay:	0.163 ms
Off-time:	12.646 ms
Point value:	8.14 µs
Transmitter Current:	1270 A
Dipole moment:	$2x10^6 Am^2$

Times from start of cycle:						Times after Tx turnoff:				
Gate	**Start time (ms)**	**End Time (ms)**	**Midpoint (ms)**	**Width (ms)**		**Gate**	**Start time (ms)**	**End Time (ms)**	**Midpoint (ms)**	**Width (ms)**
1	0.041	0.155	0.098	0.114	Ontime					
2	0.155	1.432	0.793	1.278	Ontime					
3	1.432	2.718	2.075	1.286	Ontime					
4	2.718	3.996	3.357	1.278	Ontime					
5	4.134	4.150	4.142	0.016	Offtime	5	0.138	0.154	0.146	0.016
6	4.150	4.175	4.163	0.024	Offtime	6	0.154	0.179	0.167	0.024
7	4.175	4.207	4.191	0.033	Offtime	7	0.179	0.211	0.195	0.033
8	4.207	4.240	4.224	0.033	Offtime	8	0.211	0.244	0.228	0.033
9	4.240	4.281	4.260	0.041	Offtime	9	0.244	0.285	0.264	0.041
10	4.281	4.329	4.305	0.049	Offtime	10	0.285	0.333	0.309	0.049
11	4.329	4.395	4.362	0.065	Offtime	11	0.333	0.399	0.366	0.065
12	4.395	4.468	4.431	0.073	Offtime	12	0.399	0.472	0.435	0.073
13	4.468	4.549	4.508	0.081	Offtime	13	0.472	0.553	0.512	0.081
14	4.549	4.655	4.602	0.106	Offtime	14	0.553	0.659	0.606	0.106
15	4.655	4.785	4.720	0.130	Offtime	15	0.659	0.789	0.724	0.130
16	4.785	4.940	4.862	0.155	Offtime	16	0.789	0.944	0.866	0.155
17	4.940	5.127	5.033	0.187	Offtime	17	0.944	1.131	1.037	0.187
18	5.127	5.355	5.241	0.228	Offtime	18	1.131	1.359	1.245	0.228
19	5.355	5.623	5.489	0.269	Offtime	19	1.359	1.627	1.493	0.269
20	5.623	5.957	5.790	0.334	Offtime	20	1.627	1.961	1.794	0.334
21	5.957	6.348	6.152	0.391	Offtime	21	1.961	2.352	2.156	0.391
22	6.348	6.828	6.588	0.480	Offtime	22	2.352	2.832	2.592	0.480
23	6.828	7.406	7.117	0.578	Offtime	23	2.832	3.410	3.121	0.578
24	7.406	8.105	7.756	0.700	Offtime	24	3.410	4.109	3.760	0.700
25	8.105	8.944	8.525	0.838	Offtime	25	4.109	4.948	4.529	0.838
26	8.944	9.961	9.452	1.017	Offtime	26	4.948	5.965	5.456	1.017
27	9.961	11.190	10.575	1.229	Offtime	27	5.965	7.194	6.579	1.229
28	11.190	12.663	11.926	1.473	Offtime	28	7.194	8.667	7.930	1.473
29	12.663	14.453	13.558	1.790	Offtime	29	8.667	10.457	9.562	1.790
30	14.453	16.667	15.560	2.214	Offtime	30	10.457	12.671	11.564	2.214

Table 2. HELITEM® Gate positions

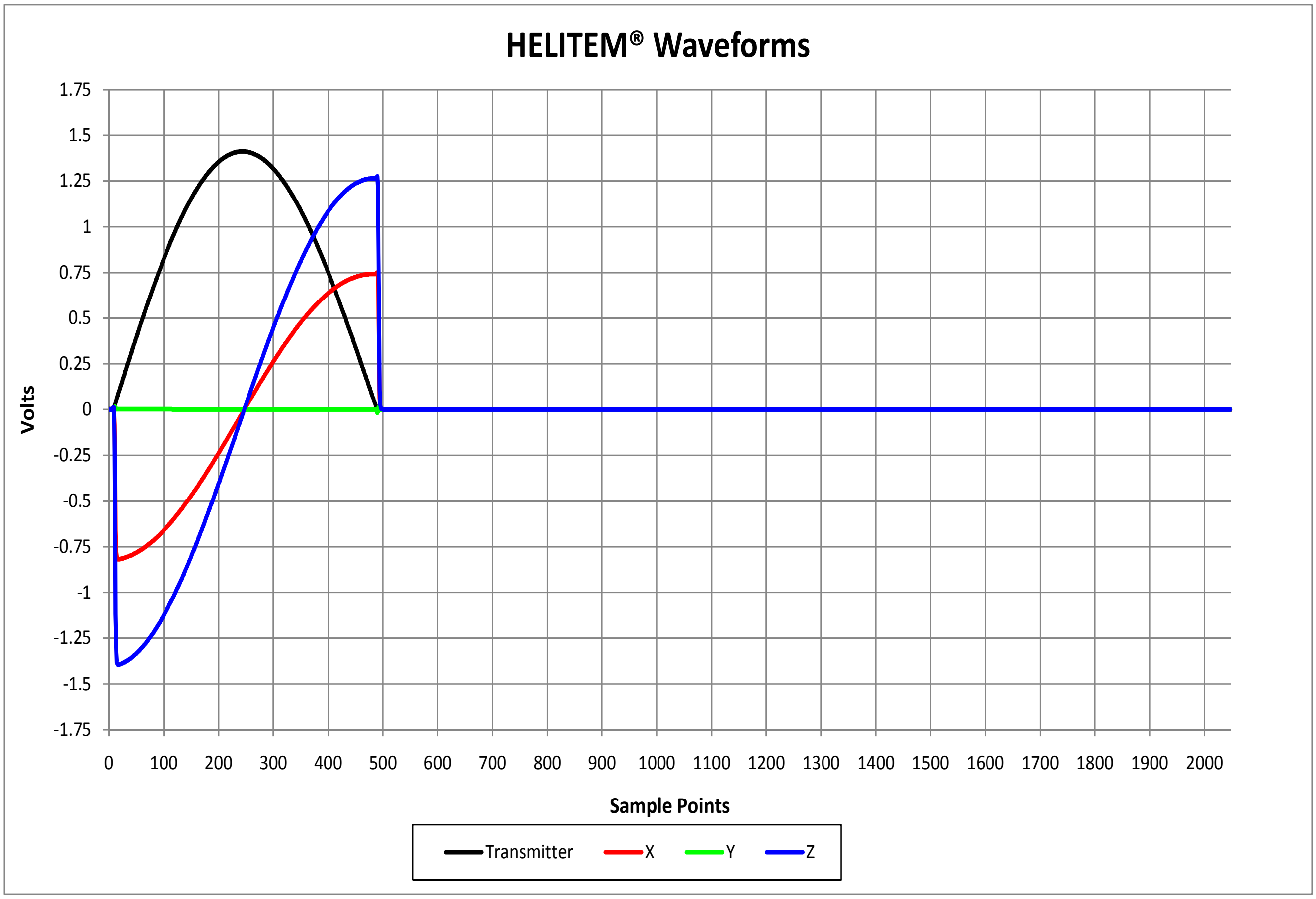

Figure 3. HELITEM® System Waveforms

Digital Acquisition System:	Fugro Airborne Surveys HeliDAS.
Barometric Altimeter:	Motorola MPX4115AP analog pressure sensor with a pressure sensitivity of 150mV/kPa and a 10 Hz sample interval, mounted in the helicopter.
Radar Altimeter:	Honeywell RT300 short pulse modulation 4.3 GHz, sensitivity 1 ft, range 0 to 2500 ft, 10 Hz recording interval mounted in the helicopter.
Camera:	Panasonic WVCD/32 Colour Video Camera.
Electronic Navigation:	Novatel OEMV4/V, 0.5 sec recording interval. Antenna mounted on the tail of the helicopter.
Positional Data:	Novatel OEMV4/V, 0.5 sec recording interval. Antenna mounted on the tail of the helicopter.

Base Station Equipment

During the survey a base station GPS was set up to collect data to allow post processing of the positional data for increased accuracy. The locations of the GPS base stations are recorded in Table 3.

Status	Location Name	WGS84 Latitude (deg-min-sec)	WGS84 Longitude (deg-min-sec)	Orthometric Height EGM96 (m)	Date Setup	Date Shut Down
Primary	Salmon Arm Airport	50 41 15.98 N	119 14 02.72 W	531.163	06-Oct-11	20-Oct-11
Secondary		50 41 15.84 N	119 14 02.66 W	526.440		

Table 3. GPS Base Station Locations

The magnetic base stations were setup near the GPS base stations to record diurnal data. The magnetic base station locations and base value (calculated for primary only) are listed in Table 4.

Status	Location Name	WGS84 Latitude (deg-min-sec)	WGS84 Longitude (deg-min-sec)	Base Level (nT)	Date Setup	Date Shut Down
Primary	Salmon Arm Airport	50 41 15.84 N	119 14 02.66 W	55889	06-Oct-11	20-Oct-11
Secondary		50 41 15.84 N	119 14 02.66 W	55689		

Table 4. Magnetic Base Station Locations

GPS — Novatel OEM4/V receiver system

Magnetometer — CS-3 (primary) caesium vapour sensor with timing provided by CFI Marconi GPS receiver.

Survey Specifications

Block Summary

Table 5 summarizes the survey specifications for the TL Property block, including line spacing and flight directions.

BLOCK	LINES FROM	LINES TO	FLIGHT DIRECTION	LINE SPACING	MEASURED LINE km
1	10010	11000	NNE-SSW (13°)	150 metres	318.2
	19010	19030	WNW-ESE (103°)	1400 metres	45.0
1 (infill)	10125	10195	NNE-SSW (13°)	150 metres (for 75m spacing with main lines)	24.2
				TOTAL:	**387.4**

Table 5. Summary of Survey Specification

Survey Elevation

Optimum survey elevations for the helicopter and instrumentation during normal survey flying are:

Helicopter	82 metres
HELITEM Receiver	62 metres
Magnetometer	35 metres
HELITEM Transmitter	35 metres

Survey elevations will not deviate by more than 20% over a distance of 2 km from the contracted elevation.

Survey elevation is defined as the measurement of the helicopter radar altimeter to the tallest obstacle in the helicopter path. An obstacle is any structure or object which will impede the path of the helicopter to the ground and is not limited to and includes tree canopy, towers and power lines.

Survey elevations may vary based on the pilot's judgement of safe flying conditions around man-made structures or in rugged terrain.

Noise Levels

Electromagnetic Data

The noise levels of the EM data as indicated on the raw traces of dB/dt & B field channel 30 shall not exceed the following tolerances continuously over a horizontal distance of 1000 meters under normal survey conditions:

- dB/dt X and Z ± 5 nT/s
- B-Field X and Z ± 12.5 pT

Airborne High Sensitivity Magnetometer

Magnetic total-field intensity data will be recorded on-board the aircraft as follows:

- Sample interval will be 0.1 second (10 samples/second)
- Magnetometer sensitivity will be 0.1 nT

Magnetometer noise level will not exceed ±1.0 nT for a distance of 1 km or more.

Ground Base Station Magnetometer

Base station magnetometer information will be recorded digitally at 1.0 second intervals.

For acceptance of the magnetic data, non-linear variations in the magnetic diurnal should not exceed 10 nT over a chord of 60 seconds.

Field Crew

The field crew for the survey were as follows:

Data Processor:	Amanda Heydorn, Keith Landon
Pilot:	Danny Ragan
Electronics Operators:	Ali Allam, Keith Lavalley, Logan Streun
Maintenance Engineer:	Will Harper

Data Processing

Field

All digital data were verified for validity and continuity. The data from the aircraft and base station were transferred to the field PC. Basic statistics were generated for each parameter recorded, these included: the minimum, maximum, and mean values; the standard deviation; and any null values located. Data were checked in the field by the FUGRO AIRBORNE SURVEYS field geophysicist for adherence to the survey specifications as outlined in the survey specifications section. Any failure to meet the survey specifications resulted in a re-flight of the line or portion of the line unless aircraft safety was at risk or the client's on site representative approved the data.

Flight Path Recovery

The quality of the GPS navigation was controlled on a daily basis by recovering the flight path of the aircraft. The correction procedure uses the raw ranges from the base station to create improved models of clock error, atmospheric error and satellite orbit. These models are used to improve the conversion of aircraft raw ranges to differentially corrected aircraft position.

To check the quality of the positional data the aircraft speed is calculated using the differentially corrected x, y and z data. Any sharp changes in the speed are used to flag possible problems with the positional data. Where speed jumps occur the data are inspected to determine the source of the error. The erroneous data are deleted and splined if less than two seconds in length. If the error is greater than two seconds the raw data are examined and if acceptable may be shifted and used to replace the bad data. The GPS z component is the most common source of error. When it shows problems that cannot be corrected by recalculating the differential correction the barometric altimeter is used as a guide to assist in making the appropriate correction.

Altitude Data

Radar altimeter data is de-spiked by applying a one and a half second median and smoothed using a one and a half second Hanning filter. The data are then subtracted from the GPS elevation to create a digital elevation model that is gridded and consulted in conjunction with profiles of the radar altimeter and flight path video to detect any spurious points.

Base Station Diurnal Magnetics

The raw diurnal data are sampled at 1 Hz are imported into a database. The data are filtered with a 5 second median filter and then a 5 second Hanning filter to remove spikes and smooth short wavelength variations. A nonlinear variation is then calculated and a flag channel is created to indicate where the variation exceeds the survey tolerance. Acceptable diurnal data are interpolated to a 10 Hz sample rate and the local regional field value calculated from the average of the first day's diurnal data is removed to leave the diurnal variation. This diurnal variation is then ready to be used in the processing of the airborne magnetic data.

Airborne Magnetics

Residual Magnetic Intensity (RMI)

The Total Magnetic Intensity (TMI) data collected in flight are profiled on screen along with a fourth difference channel calculated from the TMI. Spikes were removed manually where indicated by the fourth difference. The de-spiked data were then corrected for lag by 24 samples. The diurnal variation extracted from the filtered ground station data was then removed from the de-spiked and lagged TMI. The TMI is then tie line levelled, manually corrected and micro-levelled if necessary.

The Residual Magnetic Intensity was generated by subtracting the modelled IGRF regional from the levelled TMI data. The IGRF was calculated as at October 15th, 2011

Calculated Vertical Gradient (CVG)

The first vertical derivative was calculated in the frequency domain from the final gridded RMI values to enhance subtleties related to geological structures. A separate vertical derivative was calculated from the profile RMI data for display on the multi-parameter profiles.

Electromagnetics

dB/dt Data

Lag correction: 0 samples

Data correction: The X, Y and Z component data are re-processed from the raw stream to produce the 30 raw channels at 10 samples per second.

The following processing steps are applied to the dB/dt data from all coil sets:

a) The raw stream data is re-processed post-flight using start-of-flight and end-of-flight calibrations to remove spheric spikes, coil oscillation and system drift.

b) Noise filtering is done using an adaptive filter technique based on time domain triangular operators. Using a second difference value to identify changes in gradient along each channel, minimal filtering (21 points) is applied over the peaks of the anomalies, ranging in set increments up to a maximum amount of filtering in the resistive background areas (35 points for both the X and the Z component data);

c) The filtered X, Y and Z component data are then levelled in flight form for any residual and nonlinear drift that was not adequately corrected during the drift correction.

d) Finally, line-based levelling and microlevelling are applied as required.

B-field Data

The data acquisition system produces 30 B-field channels each for X, Y and Z components in real-time during flight, however these channels are only used for field QC. For delivery, mapping and generation of derived products, the final B-field channels are derived from the final levelled dB/dt data.

Coil Oscillation Correction

The electromagnetic receiver sensor of the HELITEM® is housed in a platform container which is slung below the helicopter using a cable and attached to the transmitter loop through a network of cables. The platform design reduces the rotation of the receiver coils in flight as well as improves the stability of the receiver-transmitter geometry. However sudden changes in airspeed of the aircraft, strong variable crosswinds, or other turbulence can still result in sudden moves of the platform. This can cause the induction sensors inside the platform to rotate about their mean orientation. The effect of coil oscillation on the data increases as the signal from the ground (conductivity) increases and may not be noticeable when flying over areas which are generally resistive.

Using the changes in the coupling of the primary field, it is possible to estimate the pitch, roll and yaw of the receiver sensors. Only the pitch, which affects mainly the X and Z components, was considered for correction. The nominal pitch can be computed using the ideal system geometry. The pitch angles during flight are estimated and corrected to this nominal value, removing the effects caused by the deviation of the receiver sensor from its nominal position.

For the present datasets the data from all 30 channels of dB/dt and B-Field parameters have been corrected for coil oscillation.

dB/dt Z Data

Except for extremely conductive areas, the amplitude of the dB/dt Z component increases with the conductivities of the earth. Due to the geometry of the HELITEM® system, the Z component response from a near vertical discrete conductor peaks at either side but nulls where the transmitter is on top of the conductor. This results an "M" shaped Z component anomaly over a vertical conductor. The amplitudes of, and the distance between the two peaks can be used to indicate the dip angle and dip direction of the conductor.

Decay Constant (TAU)

The decay constant values are obtained by fitting the channel data from either the complete off-time signal of the decay transient or only a selected portion of it (as defined by specific channels) to a single exponential of the form:

$$Y = Ae^{-t/\tau}$$

where A is amplitude at time zero, t is time in microseconds and τ is the decay constant, expressed in microseconds. A semi-log plot of this exponential function will be displayed as a straight line, the slope of which will reflect the rate of decay and therefore the strength of the conductivity. A slow rate of decay, reflecting a high conductivity, will be represented by a high decay constant.

As a single parameter, the decay constant provides more useful information than the amplitude data of any given single channel, as it indicates not only the peak position of the response but also the relative strength of the conductor. It also allows better discrimination of conductive axes within a broad formational group of conductors.

For the present dataset, the decay constant channel and grid were generated for a range of mid-time channels to characterise bedrock conductors. The decay constant channel was calculated by fitting the response of the B-field Z-component to the exponential function over windows 14-20 (window centres 0.675 - 1.864ms after turnoff).

Differential Conductivity™ Depth Sections

Differential Resistivity/Conductivity is a simple, relatively accurate resistivity/conductivity section developed by Fugro to be derived from airborne electromagnetic data[1]. This type of resistivity/conductivity section is fast and robust, and provides an excellent picture of conductivity conditions in the earth. It can be derived from both frequency domain and time domain EM data.

Differential Resistivity/Conductivity is derived from a homogeneous halfspace model of the resistivity/conductivity calculated for each time channel or EM frequency, each at an approximate depth. The early time channel or high frequency data provide a measure of the shallow resistivity/conductivity, and the deeper (later time, lower frequency) halfspace resistivities/conductivities are modified using the shallow information to give a more accurate measure of the resistivity/conductivity at depth. The depth of investigation for each time channel or frequency is adjusted as well.

Differential Resistivity/Conductivity sections tend to smooth sharply defined layers (compared to layered-earth inversions) but provide an excellent model of the resistivity/conductivity, quickly and without the complex processing necessary for inversions. The sections are valuable as a QC tool, as an overview of the resistivity/conductivity distribution in the earth, and often to provide guidance and a starting model for more complex inversions.

The differential conductivity™ depth sections, derived from each survey line, are created as individual grids and displayed on stacked section profiles with 4 lines on each sheet to allow line-to-line comparison. The grids have been corrected for elevation variations such that the top of each section reflects the true terrain topography.

[1] Huang, Haoping and Fraser, Douglas, 1996, The differential parameter method for multifrequency airborne resistivity mapping, Geophysics Vol 61, No 1, January-February 1996, P 100-109

Final Products

Digital Archives

Line and grid data in the form of Geosoft database (*.gdb) and Geosoft grids (*.grd) have been written to a DVD. The formats and layouts of these archives are further described in Appendix C (Data Archive Description). Hardcopies of all maps have been created as outlined below.

Maps

Scale:	1:20,000
Parameters:	Residual Magnetic Intensity Calculated Vertical Gradient from the Residual Magnetic Intensity data Decay constant (Tau) from B-field Z Component at 0.675-1.864ms from the end of pulse Depth Slice from dB/dt Z Component at 50m below surface Depth Slice from dB/dt Z Component at 150m below surface
Media/Copies:	PDF and 2 paper copies

Multi-parameter Profile Plots

Horizontal Scale:	1:20,000
Parameters:	Multi-parameter presentation of Radar Altimeter, Transmitter height above the EGM96 Geoid, Terrain (also above Geoid), Residual Magnetic Intensity, Calculated Vertical Gradient, 21 channels (10-30) of both dB/dt and B field of X and Z component, and Powerline Monitor (1 line per sheet).
Media/Copies:	PDF

Multi-line Profile Plots

Horizontal Scale:	1:20,000
Parameters:	Differential Conductivity™ Sections, Terrain (above Geoid) and Transmitter altitude (4 lines per sheet).
Media/Copies:	PDF

Report

Media/Copies: PDF and 2 paper copies

Flight Path Videos

Media/Copies: 4 DVDs (.Bin/BDX format)

All grids and maps have been produced with the following coordinate system.

Projection:	Universal Transverse Mercator (UTM Zone 11N)
Datum:	NAD83
Central meridian:	117° West
False Easting:	500000 metres
False Northing:	0 metres
Scale factor:	0.9996

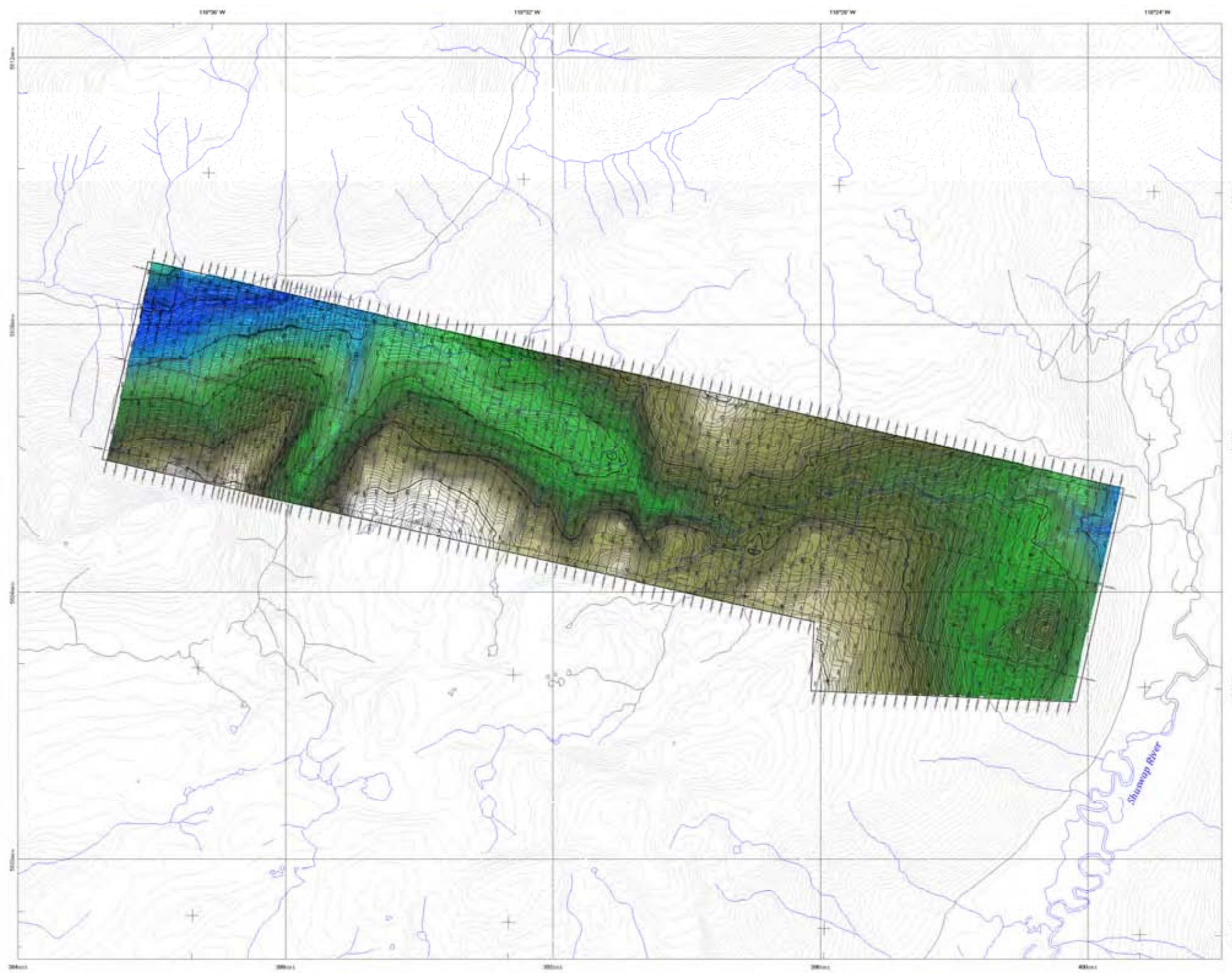

Figure 1: Digital Elevation Model

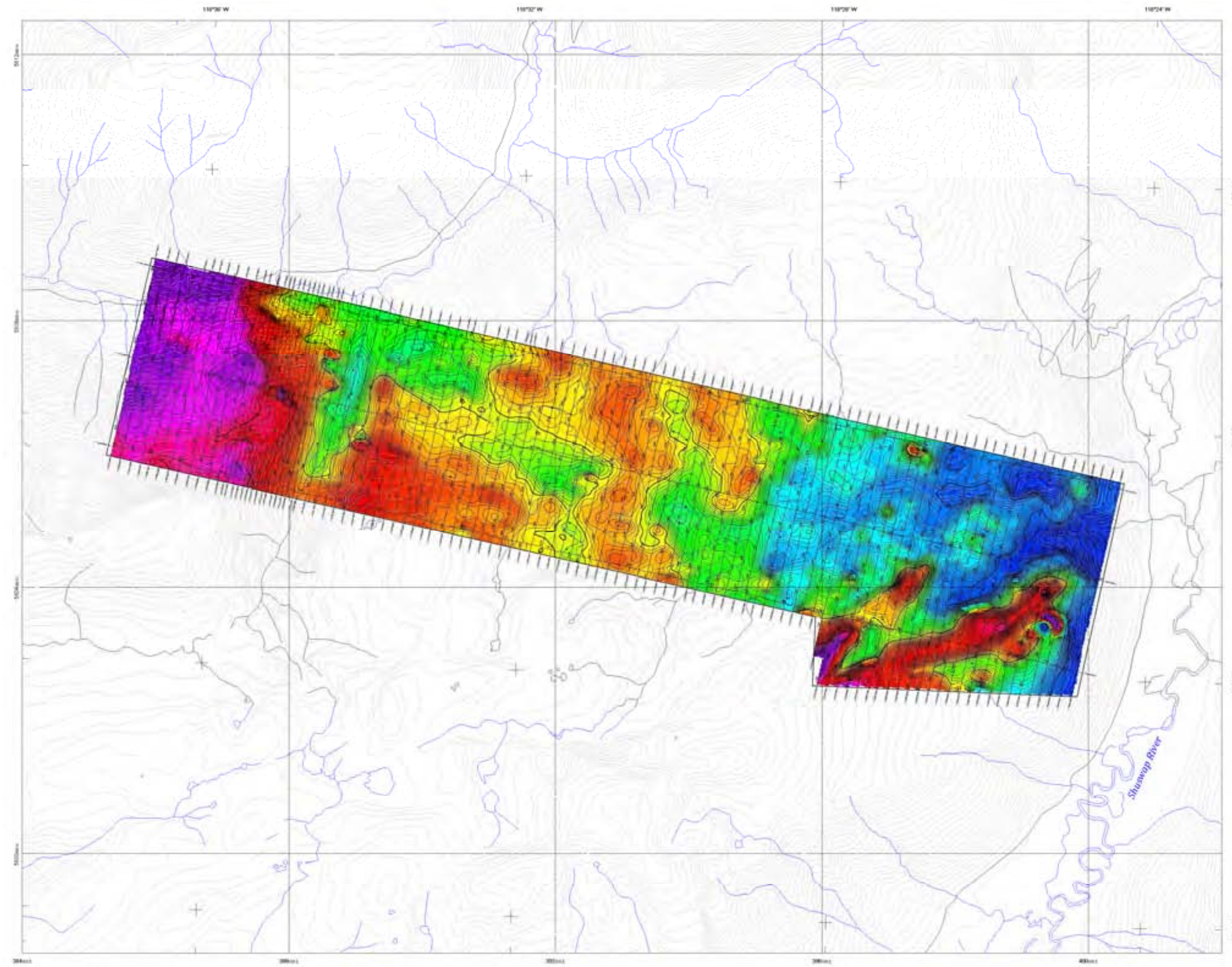

Figure 2: Residual Magnetic Intensity

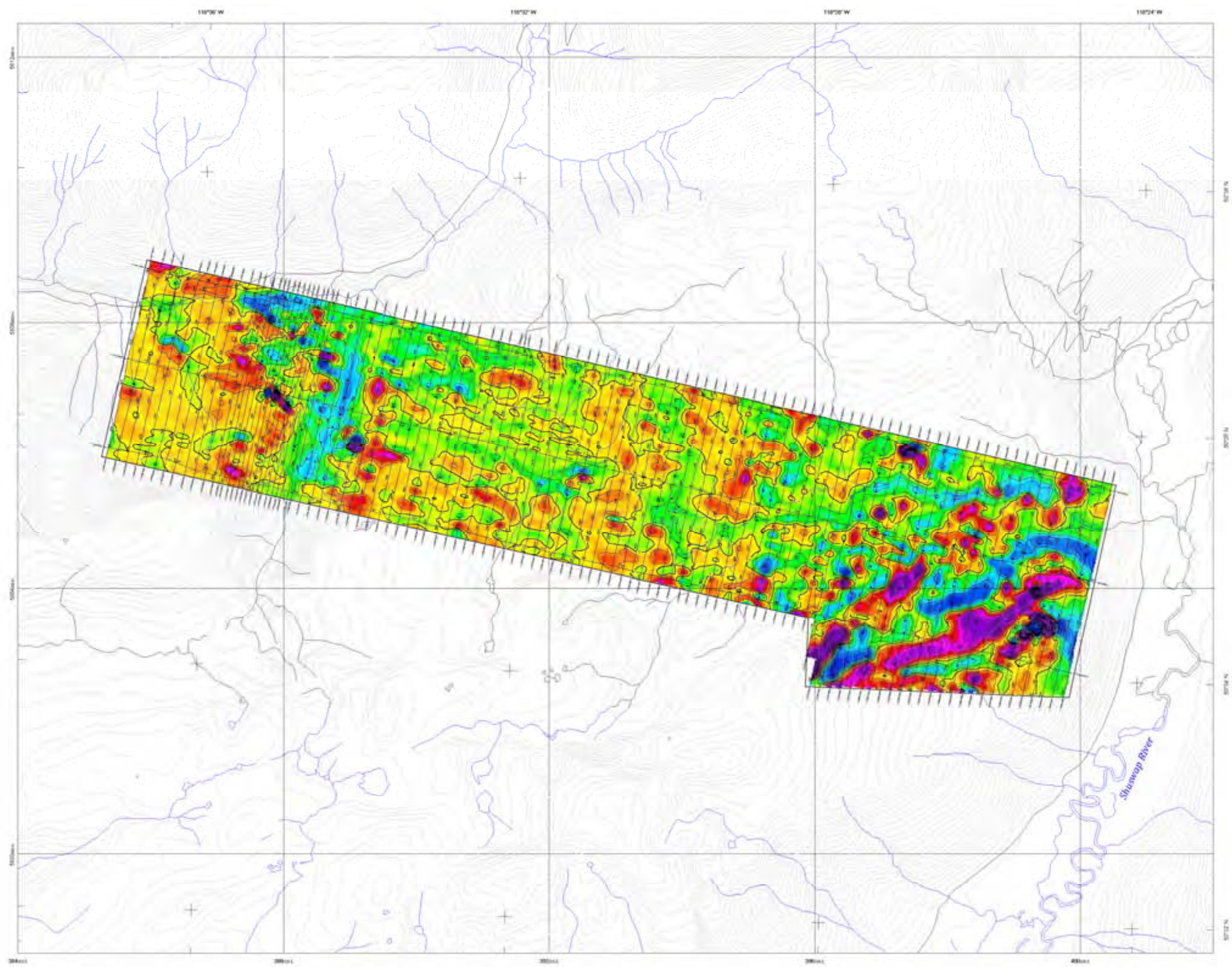

Figure 3: Calculated Vertical Magnetic Gradient

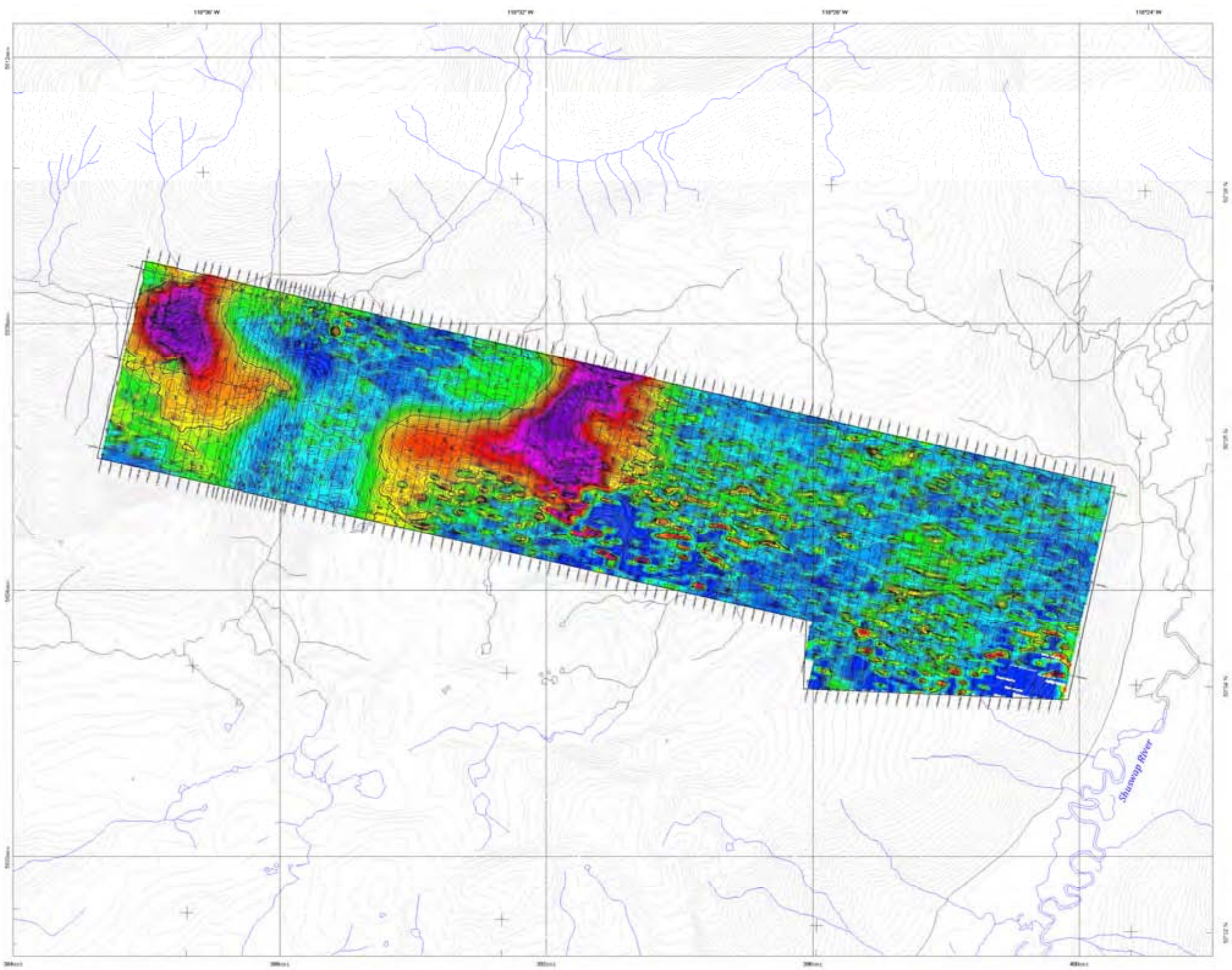

Figure 4: Decay Constant from Mid Time dB/dt Z component

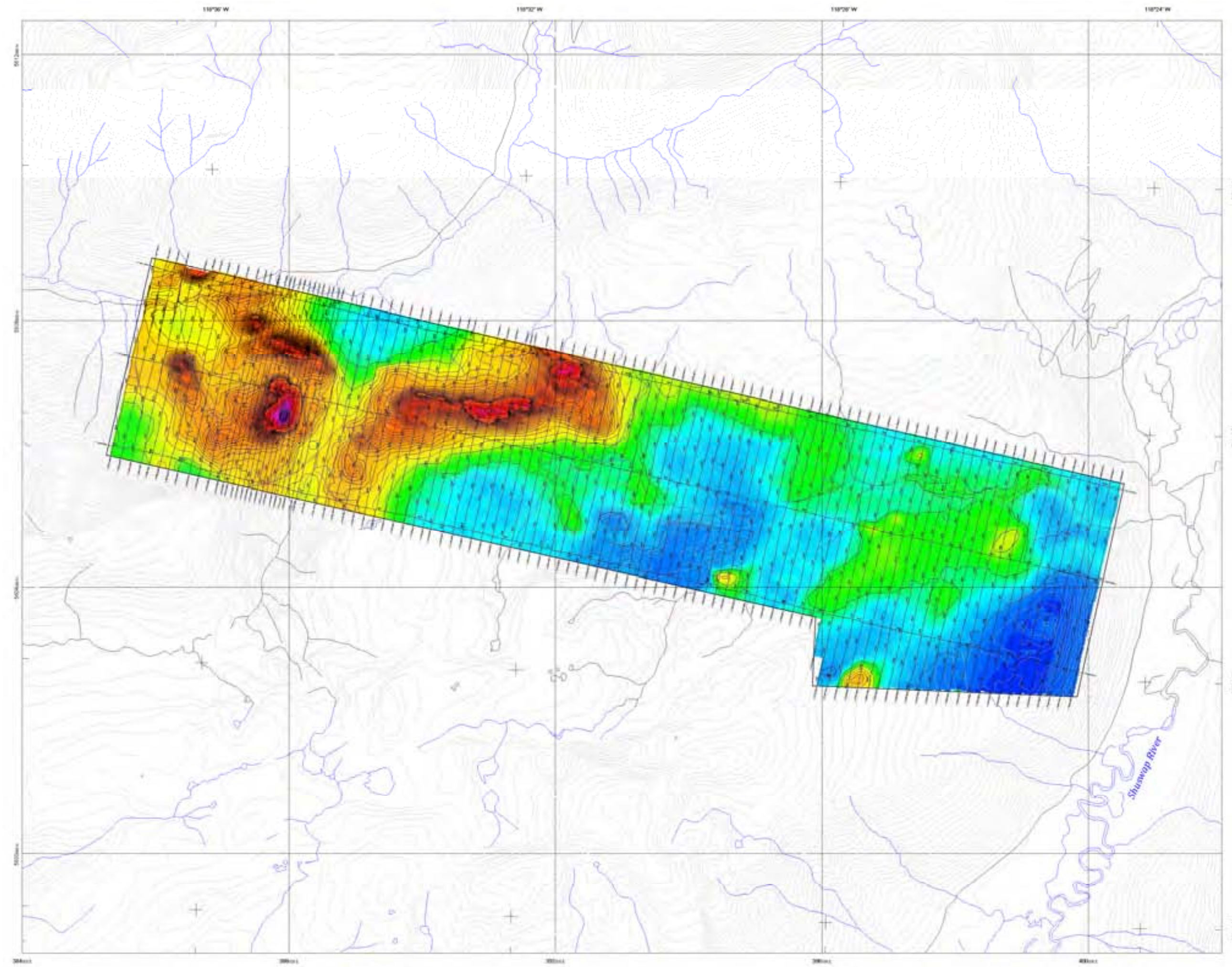

Figure 5: Depth Slice at 50m below surface

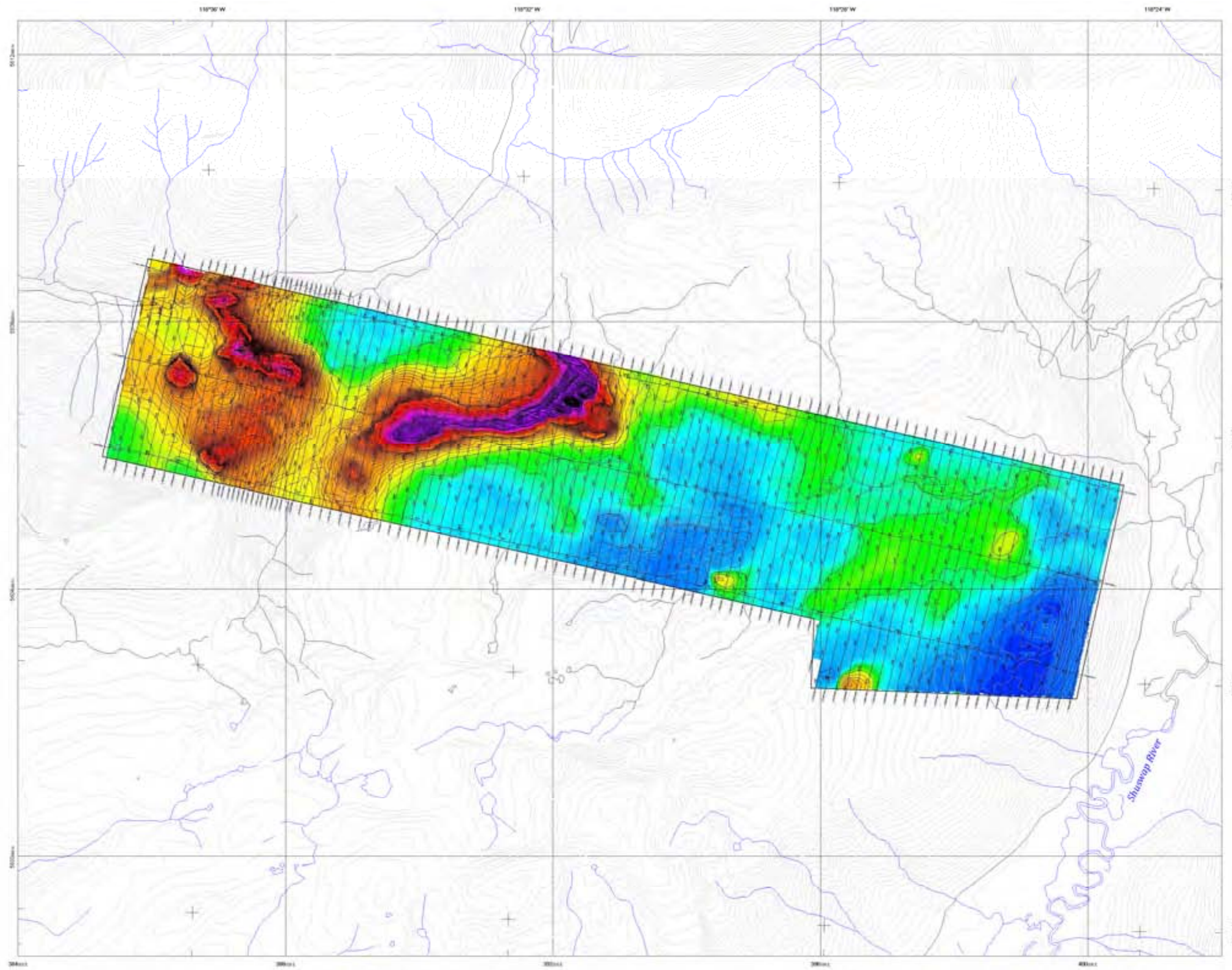

Figure 6: Depth Slice at 150m below surface

Appendix A

Data Archive Description

Data Archive Description:

Survey Details

Survey Area Names:	TL Property, British Columbia
Job number:	11086
Client:	Cullen Resources Ltd
Survey Company Name:	Fugro Airborne Surveys
Flown Dates:	October 5th to 20th, 2011
Archive Creation Date:	11 January, 2012

Geodetic Information for map products

Projection:	Universal Transverse Mercator (Zone 11N)
Datum:	NAD83
Central meridian:	117°West
False Easting:	500000 metres
False Northing:	0 metres
Scale factor:	0.9996

GRIDS:

Geosoft Grids:

File	Description	Units
TLProperty_RMI	Residual Magnetic Intensity (RMI)	nT
TLProperty_CVG	Calculated Vertical Gradient from RMI	nT/m
TLProperty_DEM	Digital Elevation Model	m ASL
TLProperty_Decay_BZ_Mid	Decay constant from B-field Z Component at 0.675-1.864ms from the end of pulse	µs
TLProperty_DepthSlice_50m	Depth Slice from dB/dt Z Component at 50m below surface	mS/m
TLProperty_DepthSlice_150m	Depth Slice from dB/dt Z Component at 150m below surface	mS/m

LINDEDATA:

Geosoft Database Layout (11086_TLProperty.gdb):

Variable	Description	Units
X	Easting NAD83	m
Y	Northing NAD83	m
Fid	fiducial	s
Longitude	Longitude WGS84	degrees
Latitude	Latitude WGS84	degrees
Flight	Flight number	-
Date	Flight date	*yyyymmdd*
AltRad	Height above surface from radar altimeter	m
GPSZ	Helicopter height above geoid (EGM96)	m

DEM	Digital Elevation model above geoid (EGM96)	m
Diurnal	Measured ground magnetic intensity	nT
mag_raw	Total magnetic field – spike rejected	nT
RMI	Residual Magnetic intensity - levelled	nT
CVG	Calculated Vertical Gradient of RMI	nT/m
x_db_Post[0 – 29]	dB/dt X component channels 1 – 30 - Post-processed	nT/s
y_db_Post[0 – 29]	dB/dt Y component channels 1 – 30 - Post-processed	nT/s
z_db_ Post[0 – 29]	dB/dt Z component channels 1 – 30 - Post-processed	nT/s
x_bf_ Post[0 – 29]	B field X component channels 1 – 30 - Post-processed	pT
y_bf_Post[0 – 29]	B field Y component channels 1 – 30 - Post-processed	pT
z_bf_Post[0 – 29]	B field Z component channels 1 – 30 - Post-processed	pT
x_db_fnl[0 – 29]	dB/dt X component channels 1 – 30 – final	nT/s
y_db_fnl[0 – 29]	dB/dt Y component channels 1 – 30 – final	nT/s
z_db_fnl[0 – 29]	dB/dt Z component channels 1 – 30 – final	nT/s
x_bf_fnl[0 – 29]	B field X component channels 1 – 30 – final	pT
y_bf_fnl[0 – 29]	B field Y component channels 1 – 30 – final	pT
z_bf_fnl[0 – 29]	B field Z component channels 1 – 30 – final	pT
CDI_dBZ[0-99]	Conductivity-Depth Section, 5m intervals, 5-500m below surface	mS/m
Decay_BZ_Mid	Decay constant from B-field Z Component at 0.675-1.864ms from the end of pulse	µs
Powerline_X	Power line monitor channel from X coil	µV
Powerline_Z	Power line monitor channel from Z coil	µV
tx_current	Transmitter peak current	A

Geosoft XYZ Archive File Layout (11086_TLProperty.xyz):

Field	Description	Format	Units
1	Easting NAD83	12.1	m
2	Northing NAD83	12.1	m
3	Fiducial	10.1	s
4	Longitude WGS84	12.6	degrees
5	Latitude WGS84	12.6	degrees
6	Flight number	10	
7	Flight date	10	*yyyymmdd*
8	Height above surface from radar altimeter	10.1	m
9	Helicopter height above geoid (EGM96)	10.1	m
10	Digital Elevation model above geoid (EGM96)	10.1	m
11	Residual Magnetic intensity	10.1	nT
12	Calculated Vertical Gradient	10.1	nT/m
13	Depth Slice from dB/dt Z Component at 50m below surface	10.2	mS/m
14	Depth Slice from dB/dt Z Component at 150m below surface	10.2	mS/m
15	Decay constant from B-field Z Component at 0.675-1.864ms from the end of pulse	10.2	µs
16	Transmitter peak current	10.1	A

17	Power line monitor channel from X coil	10.2	µV
18	Power line monitor channel from Z coil	10.2	µV
19-48	dB/dt X component channels 1 – 30 - levelled	10.3	nT/s
49-78	dB/dt Y component channels 1 – 30 - levelled	10.3	nT/s
79-108	dB/dt Z component channels 1 – 30 - levelled	10.3	nT/s
109-138	B field X component channels 1 – 30 - levelled	10.3	pT
139-168	B field Y component channels 1 – 30 - levelled	10.3	pT
169-198	B field Z component channels 1 – 30 - levelled	10.3	pT
199-228	Fraser filtered dB/dt X channels 1 - 30	10.3	nT/s/m
229-258	Fraser filtered B field X channels 1 - 30	10.3	nT/m

Geosoft XYZ Archive File Layout (11086_TLProperty_CDI.xyz):

Field	Description	Format	Units
1	Easting NAD83	12.1	m
2	Northing NAD83	12.1	m
3	Fiducial	10.1	s
4	Longitude WGS84	12.6	degrees
5	Latitude WGS84	12.6	degrees
6	Flight number	10	
7	Flight date	10	*yyyymmdd*
8	Height above surface from radar altimeter	10.1	m
9	Helicopter height above geoid (EGM96)	10.1	m
10	Digital Elevation model above geoid (EGM96)	10.1	m
11	Transmitter peak current	10.1	A
12	Power line monitor channel from X coil	10.2	µV
13	Power line monitor channel from Z coil	10.2	µV
14-113	Conductivity-Depth Section, 5m intervals, 5-500m below surface	10.3	mS/m

Geosoft XYZ Archive File Layout (11086_TLProperty_raw.xyz):

Field	Description	Format	Units
1	Easting NAD83	12.1	m
2	Northing NAD83	12.1	m
3	Fiducial	10.1	s
4	Longitude WGS84	12.6	degrees
5	Latitude WGS84	12.6	degrees
6	Flight number	10	
7	Flight date	10	*yyyymmdd*
8	Height above surface from radar altimeter	10.1	m
9	Helicopter height above geoid (EGM96)	10.1	m
10	Digital elevation model above geoid (EGM96)	10.1	m
11	Measured ground magnetic intensity	10.1	nT
12	Total magnetic field – spike rejected	10.1	nT
13	Transmitter peak current	10.1	A
14	Power line monitor channel from X coil	10.2	µV

15	Power line monitor channel from Z coil	10.2	µV
16-45	dB/dt X component channels 1 – 30 - Post-processed	10.3	nT/s
46-75	dB/dt Y component channels 1 – 30 - Post-processed	10.3	nT/s
76-105	dB/dt Z component channels 1 – 30 - Post-processed	10.3	nT/s
106-135	B field X component channels 1 – 30 - Post-processed	10.3	pT
136-165	B field Y component channels 1 – 30 - Post-processed	10.3	pT
166-195	B field Z component channels 1 – 30 - Post-processed	10.3	pT

MAPS:

PDF files of delivered maps for each block at a scale of 1:20,000.

File	Description	Units
TLProperty_RMI	Residual Magnetic Intensity (RMI)	nT
TLProperty_CVG	Calculated Vertical Gradient from RMI	nT/m
TLProperty_DEM	Digital Elevation Model	m ASL
TLProperty_Decay_BZ_Mid	Decay constant from B-field Z Component at 0.675-1.864ms from the end of pulse	µs
TLProperty_DepthSlice_50m	Depth Slice from dB/dt Z Component at 50m below surface	mS/m
TLProperty_DepthSlice_150m	Depth Slice from dB/dt Z Component at 150m below surface	mS/m

PROFILES:

MULTI_PLOTS:
PDF files of Multi-parameter profiles at a scale of 1:20,000, one line per sheet:
*Prof_**LINE***.pdf

STACKED CDIs:
PDF files of stacked plots of CDI sections draped on topography, 4 lines per sheet:
*Stacked_CDI_**LINE**.pdf*

where ***LINE*** is the survey line number (for stacked profiles, the first line on each sheet)

REPORT:

A logistics and processing report for Project #11086 in PDF format:

R11086_TLProperty_CullenRes.pdf

FLIGHTLOGS:

A PDF file of all the survey flights:

11086 Flight logs.pdf

WAVEFORM:

The information shown below is only an example.

```
/Calibration Data [FLT 99004 Cal# 1 Start FID 68320 End Fid 68442]
/Base Frequency : 30 Hz
/Sample Interval: 8.1380208 µs

/ ---------------------------------------------------------------------------------
/ XYZ REF WAVEFORM EXPORT
/SAMPLE  T_Current[A] dB/dt_X[nT/s] dB/dt_Y[nT/s] dB/dt_Z[nT/s]  BF_X[pT]  BF_Y[pT]  BF_Z[pT]
      0         1.835        -6.485        -1.632       -11.408   -74.504    -9.119  -141.561
      1         1.835        -8.620         0.844        -9.315   -74.451    -9.106  -141.468
      2         1.835       -16.606         0.196       -11.655   -74.381    -9.113  -141.392
      …             …             …             …             …         …         …         …
      …             …             …             …             …         …         …         …
      …             …             …             …             …         …         …         …
   2045        -1.835        13.734        -0.196         9.622     0.285     0.013     0.240
   2046        -1.835        14.000         1.548        10.476     0.173     0.014     0.162
   2047        -1.835         7.259         0.186         9.422     0.059     0.002     0.077
```

The first column is the sample number. There are a total of 2048 samples representing a half-wave cycle or one pulse. The subsequent columns are: transmitter current, measured X primary field, measured Y primary field, and measured Z primary field for dB/dt and B-Field.

VIDEO:

Digital video in BIN/BDX format are archived for all survey flights. To view the files, a video viewer is included.

FUGROVIDEOVIEWER.ZIP (Stand alone)

If you have any problems with this archive please contact

Processing Manager
Fugro Airborne Surveys Corp.
2505 Meadowvale Boulevard
Mississauga, Ontario
Canada L5N 5S2
Phone: +1 905 812 0212
FAX: +1 905 812 1504
Website: www.fugroairborne.com

Appendix B

Helicopter Airborne Electromagnetic Systems

HELICOPTER AIRBORNE ELECTROMAGNETIC SYSTEMS

General

The operation of a helicopter time-domain electromagnetic system (EM) involves the measurement of decaying secondary electromagnetic fields induced in the ground by a series of short current pulses generated from a towed transmitter. Variations in the decay characteristics of the secondary field (sampled and displayed as windows) are analyzed and interpreted to provide information about the subsurface geology.

A number of factors combine to give the helicopter platforms good signal-to-noise ratio, depth of penetration and excellent resolution: 1) the principle of sampling the induced secondary field in the absence of the primary field (during the “off-time”), 2) the large dipole moment 3) the low flying height of the system and spatial proximity of the transmitter and receiver. Such a system is also relatively insensitive to noise due to air turbulence. However, sampling in the “on-time” can also result in excellent sensitivity for mapping very resistive features and very conductive geologic features (Annan et al, 1991, Geophysics v.61, p. 93-99).

Methodology

The Fugro time-domain helicopter electromagnetic system (HELITEM®) uses a high-speed digital EM receiver. The primary electromagnetic pulses are created by a series of discontinuous sinusoidal current pulses fed into a two-turn transmitting loop towed below the helicopter. The base frequency rate is selectable, with 25, 30, 75 and 90 currently being available. The length of the pulse can be tailored to suit the targets. Standard pulse widths available are 2.0 and 4.0 ms. The available off-time can be selected to be as great as 16 ms. The dipole moment depends on the pulse width and base frequency used on the survey. The specific dipole moment, waveform and gate settings for this survey are given in the main body of the report.

The receiver sensor is a three-axis (x, y & z) induction coil set housed in a platform suspended on the tow cable below the helicopter and above the transmitter. The tow cable is non-magnetic to reduce noise levels. The tow cable is 51.9 m long. The receiver is 26.7 m above and 12.9 m ahead of the transmitter in flight.

For each primary pulse a secondary magnetic field is produced by decaying eddy currents in the ground. These in turn induce a voltage in the receiver coils, which is the electromagnetic response. Good conductors decay slowly, poorer conductors more rapidly.

Operations, which are carried out in the receiver, are:

1. *Primary-field removal:* In addition to measuring the secondary response from the ground, the receiver sensor coils also measure the primary response from the transmitter. During flight, the receiver sensor position and orientation changes slightly, and this has a very strong effect on the magnitude of the total response (primary plus secondary) measured at the receiver coils. The variable primary field response is distracting because it is unrelated to the ground response. The primary field is measured by flying at an altitude such that no ground response is measurable. These calibration signals are used to define the shape of the primary waveform. By definition this primary field includes the response of the current in the transmitter loop plus the response of any slowly decaying eddy currents induced in the

helicopter. We assume that the shape of the primary will not change as the receiver sensor position changes, but that the amplitude will vary. The primary-field-removal procedure involves solving for the amplitude of the primary field in the measured response and removing this from the total response to leave a secondary response. Note that this procedure removes any “in-phase” response from the ground which has the same shape as the primary field.

2. *Digital Stacking:* Stacking is carried out to reduce the effect of broadband noise in the data.

3. *Windowing of data*: The digital receiver samples the secondary and primary electromagnetic field at 2048 points per EM pulse and windows the signal in up to 30 time gates whose centres and widths are software selectable and which may be placed anywhere within or outside the transmitter pulse. This flexibility offers the advantage of arranging the gates to suit the goals of a particular survey, ensuring that the signal is appropriately sampled through its entire dynamic range.

4. *Primary Field:* The primary field at the receiver sensor is measured for each stack and recorded as a separate data channel to assess the variation in coupling between the transmitter and the receiver sensor induced by changes in system geometry.

One of the major roles of the digital receiver is to provide diagnostic information on system functions and to allow for identification of noise events, such as sferics, which may be selectively removed from the EM signal. The high digital sampling rate yields maximum resolution of the secondary field.

System Hardware

The airborne EM system consists of the helicopter, the on-board hardware, and the software packages controlling the hardware.

Transmitter System

The transmitter system drives high-current pulses of an appropriate shape and duration through the coils towed below the helicopter.

System Timing Clock

This subsystem provides appropriate timing signals to the transmitter, and also to the analog-to-digital converter, in order to produce output pulses and capture the ground response. All systems are synchronized to GPS time.

Platform Systems

A three-axis induction coil sensor is mounted inside a platform on the tow cable. The platform is connected to the transmitter loop through a network of cables to ensure a more robust and better stability of the transmitter-receiver geometry. A magnetometer sensor is attached to the transmitter loop near its centre.

Appendix C

Airborne Transient EM Interpretation

Interpretation of transient electromagnetic data

Introduction

The basis of the transient electromagnetic (EM) geophysical surveying technique relies on the premise that changes in the primary EM field produced in the transmitting loop will result in eddy currents being generated in any conductors in the ground. The eddy currents then decay to produce a secondary EM field which may be sensed in the receiver coil.

The HELITEM® airborne transient (or time-domain) EM system incorporates a high-speed digital receiver which records the secondary field response with a high degree of accuracy. Most often the earth's total magnetic field is recorded concurrently.

Although the approach to interpretation varies from one survey to another depending on the type of data presentation, objectives and local conditions, the following generalizations may provide the reader with some helpful background information.

The main purpose of the interpretation is to determine the probable origin of the responses detected during the survey and to suggest recommendations for further exploration. This is possible through an objective analysis of all characteristics of the different types of responses and associated magnetic anomalies, if any. If possible the airborne results are compared to other available data. Certitude is seldom reached, but a high probability is achieved in identifying the causes in most cases. One of the most difficult problems is usually the differentiation between surface conductor responses and bedrock conductor responses.

Types of Conductors

Bedrock Conductors

The different types of bedrock conductors normally encountered are the following:

1. *Graphites*. Graphitic horizons (including a large variety of carbonaceous rocks) occur in sedimentary formations of the Precambrian as well as in volcanic tuffs, often concentrated in shear zones. They correspond generally to long, multiple conductors lying in parallel bands. They have no magnetic expression unless associated with pyrrhotite or magnetite. Their conductivity is variable but generally high.

2. *Massive sulphides*. Massive sulphide deposits usually manifest themselves as short conductors of high conductivity, often with a coincident magnetic anomaly. Some massive sulphides, however, are not magnetic, others are not very conductive (discontinuous mineralization or sphalerite), and some may be located among formational conductors so that one must not be too rigid in applying the selection criteria.

   In addition, there are syngenetic sulphides whose conductive pattern may be similar to that of graphitic horizons but these are generally not as prevalent as graphites.

3. *Magnetite and some serpentinized ultrabasics*. These rocks are conductive and very magnetic.

4. *Manganese oxides*. This mineralization may give rise to a weak EM response.

Surficial Conductors

1. Beds of clay and alluvium, some swamps, and brackish ground water are usually poorly conductive to moderately conductive.

2. Lateritic formations, residual soils and the weathered layer of the bedrock may cause surface anomalous zones, the conductivity of which is generally low to medium but can occasionally be high. Their presence is often related to the underlying bedrock.

Cultural Conductors (Man-Made)

3. *Power lines*. These frequently, but not always, produce a conductive type of response. In the case when the radiated field is not removed by the power line comb filter, the anomalous response can exhibit phase changes between different windows. In the case of current induced by the EM system in a grounded wire, or steel pylon, the anomaly may look very much like a bedrock conductor.

4. *Grounded fences or pipelines*. These will invariably produce responses much like a bedrock conductor. Whenever they cannot be identified positively, a ground check is recommended.

5. *General culture*. Other localized sources such as certain buildings, bridges, irrigation systems, tailings ponds etc., may produce EM anomalies. Their instances, however, are rare and often they can be identified on the visual path recovery system.

Analysis of the Conductors

The rate of decay of a conductor is generally indicative of the conductivity of the anomalous material. However, the decay rate alone is not generally a decisive criterion in the analysis of a conductor. In particular, one should note:

- its shape and size,
- all local variations of characteristics within a conductive zone,
- any associated geophysical parameter (e.g. magnetism),
- the geological environment,
- the structural context, and
- the pattern of surrounding conductors.

The first objective of the interpretation is to classify each conductive zone according to one of the three categories which best defines its probable origin. The categories are cultural, surficial and bedrock. A second objective is to assign to each zone a priority rating as to its potential as an economic prospect.

Bedrock Conductors

This category comprises those anomalies which cannot be classified according to the criteria established for cultural and surficial responses. It is difficult to assign a universal set of values which typify bedrock conductivity because any individual zone or anomaly might exhibit some, but not all, of these values and still be a bedrock conductor. The following criteria are considered indicative of a bedrock conductor:

1. An intermediate to high conductivity identified by a response with slow decay, with an anomalous response present in the later windows.

2. For vertical conductors, the anomaly should be narrow, relatively symmetrical, with two well-defined z-component peaks and a null between the peaks.

3. If the conductor is thin, the response characteristics varies as a function of depth and dips. If the conductor is wider, the responses might look more similar to the sphere responses.

4. A small to intermediate amplitude. Large amplitudes are normally associated with surficial conductors. The amplitude varies according to the depth of the source.

5. A degree of continuity of the EM characteristics across several lines.

6. An associated magnetic response of similar dimensions. One should note, however, that those magnetic rocks which weather to produce a conductive upper layer will possess this magnetic association. In the absence of one or more of the characteristics defined in 1, 2, 3, 4 and 5, the related magnetic response cannot be considered significant.

Most obvious bedrock conductors occur in long, relatively monotonous, sometimes multiple zones following formational strike. Graphitic material is usually the most probable source. Massive syngenetic sulphides extending for many kilometres are known in nature but, in general, they are not common. Long formational structures associated with a strong magnetic expression may be indicative of banded iron formations.

In summary, a bedrock conductor reflecting the presence of a massive sulphide would normally exhibit the following characteristics:

- a high conductivity,
- an appropriate anomaly shape,
- a small to intermediate amplitude,
- an isolated setting,
- a short strike length (in general, not exceeding one kilometre), and
- preferably, with a localized magnetic anomaly of matching dimensions.

Surficial Conductors

This term is used for geological conductors in the overburden, either glacial or residual in origin, and in the weathered layer of the bedrock. Most surficial conductors are probably caused by clay minerals. In some environments the presence of salts will contribute to the conductivity. Other possible electrolytic conductors are residual soils, swamps, brackish ground water and alluvium such as lake or river-bottom deposits, flood plains and estuaries.

Normally, most surficial materials have low to intermediate conductivity so they are not easily mistaken for highly conductive bedrock features. Also, many of them are wide and their anomaly shapes are typical of broad horizontal sheets.

When surficial conductivity is high it is usually still possible to distinguish between a horizontal plate (more likely to be surficial material) and a vertical body (more likely to be a bedrock source) thanks to the characteristic shapes of the two anomalies and the differences in the x-component responses.

One of the more ambiguous situations as to the true source of the response is when surface conductivity is related to bedrock lithology as for example, surface alteration of an underlying bedrock unit. At times, it is also difficult to distinguish between a weak conductor within the bedrock (e.g. near-massive sulphides) and a surficial source.

In the search for massive sulphides or other bedrock targets, surficial conductivity is generally considered as interference but there are situations where the interpretation of surficial-type conductors is the primary goal. When soils, weathered or altered products are conductive, and in-situ, the responses are a very useful aid to geologic mapping. Shears and faults are often identified by weak, usually narrow, anomalies.

Analysis of surficial conductivity can be used in the exploration for such features as lignite deposits, kimberlites, paleochannels and ground water. In coastal or arid areas, surficial responses may serve to define the limits of fresh, brackish and salty water.

Cultural Conductors

The majority of cultural anomalies occur along roads and are accompanied by a response on the power line monitor. This monitor is set to 50 or 60 Hz, depending on the local power grid. In some cases, the current induced in the power line results in anomalies which could be mistaken for bedrock responses. There are also some power lines which have no response whatsoever.

The power line monitor, of course, is of great assistance in identifying cultural anomalies of this type. It is important to note, however, that geological conductors in the vicinity of power lines may exhibit a weak response on the monitor because of current induction via the earth.

Fences, pipelines, communication lines, railways and other man-made conductors can give rise to responses, the strength of which will depend on the grounding of these objects.

Another facet of this analysis is the line-to-line comparison of anomaly character along suspected man-made conductors. In general, the amplitude, the rate of decay, and the anomaly width should not vary a great deal along any one conductor, except for the change in amplitude related to terrain clearance variation. A marked departure from the average response character along any given feature gives rise to the possibility of a second conductor.

In most cases a visual examination of the site will suffice to verify the presence of a man-made conductor. If a second conductor is suspected the ground check is more difficult to accomplish. The object would be to determine if there is (i) a change in the man-made construction, (ii) a difference in the grounding conditions, (iii) a second cultural source, or (iv) if there is, indeed, a geological conductor in addition to the known man-made source.

The selection of targets from within extensive (formational) belts is much more difficult than in the case of isolated conductors. Local variations in the EM characteristics, such as in the amplitude, decay, shape etc., can be used as evidence for a relatively localized occurrence. Changes in the character of the EM responses, however, may be simply reflecting differences in the conductive formations themselves rather than indicating the presence of massive sulphides and, for this reason, the degree of confidence is reduced.

Another useful guide for identifying localized variations within formational conductors is to examine the magnetic data in map or image form. Further study of the magnetic data can reveal the presence of faults, contacts, and other features which, in turn, help define areas of potential economic interest.

Finally, once ground investigations begin, it must be remembered that the continual comparison of ground knowledge to the airborne information is an essential step in maximizing the usefulness of the airborne EM data.

Appendix D

Multicomponent Modeling

Multicomponent helicopter airborne EM modelling

PLATE MODELING

The PLATE program has been used to generate synthetic responses over a number of plate models with 75 m of burial depth and varying dips (0, 45, 90 and 135 degrees). The geometry assumed for the HELITEM system is shown in Figure 3. In all cases the plate has a strike length of 200m, with a strike direction into the page. The width of the plate is 200m. As the flight path traverses the center of the plate, the Y component is zero and has not been plotted.

Figure 4 shows the model results as flying from left to right and Figure 5 shows the modeling results flying from right to left.

The plotting point is the transmitter receiver midpoint.

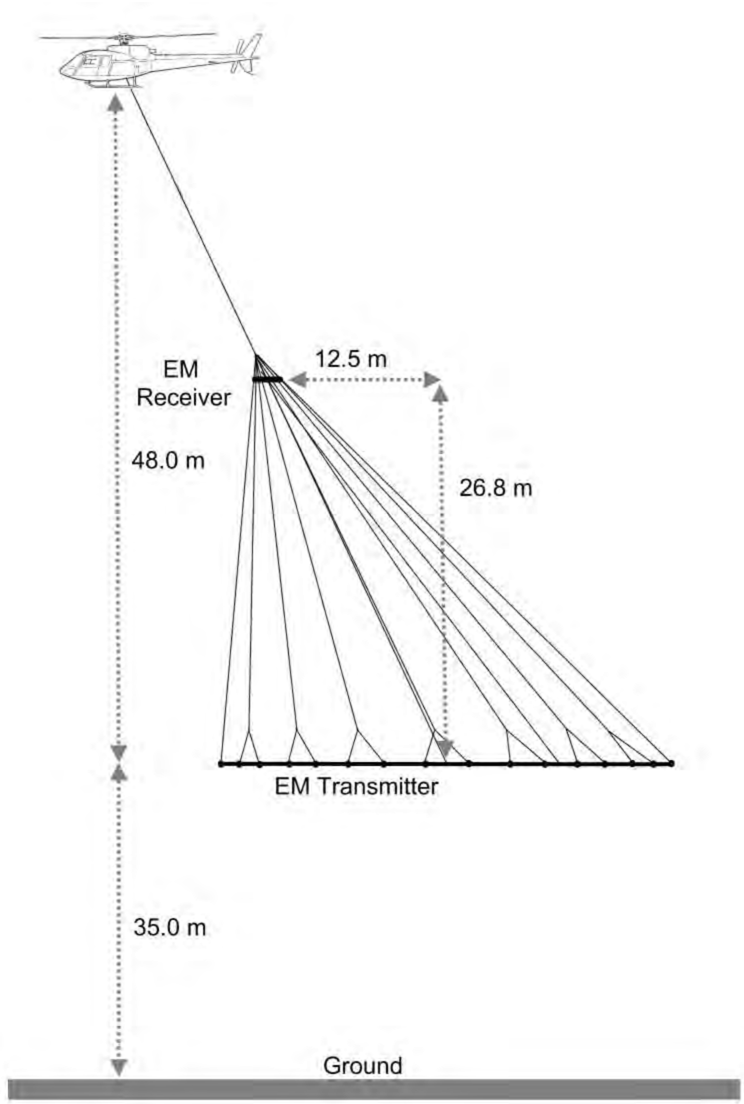

Figure 4 Geometry of the HELITEM System

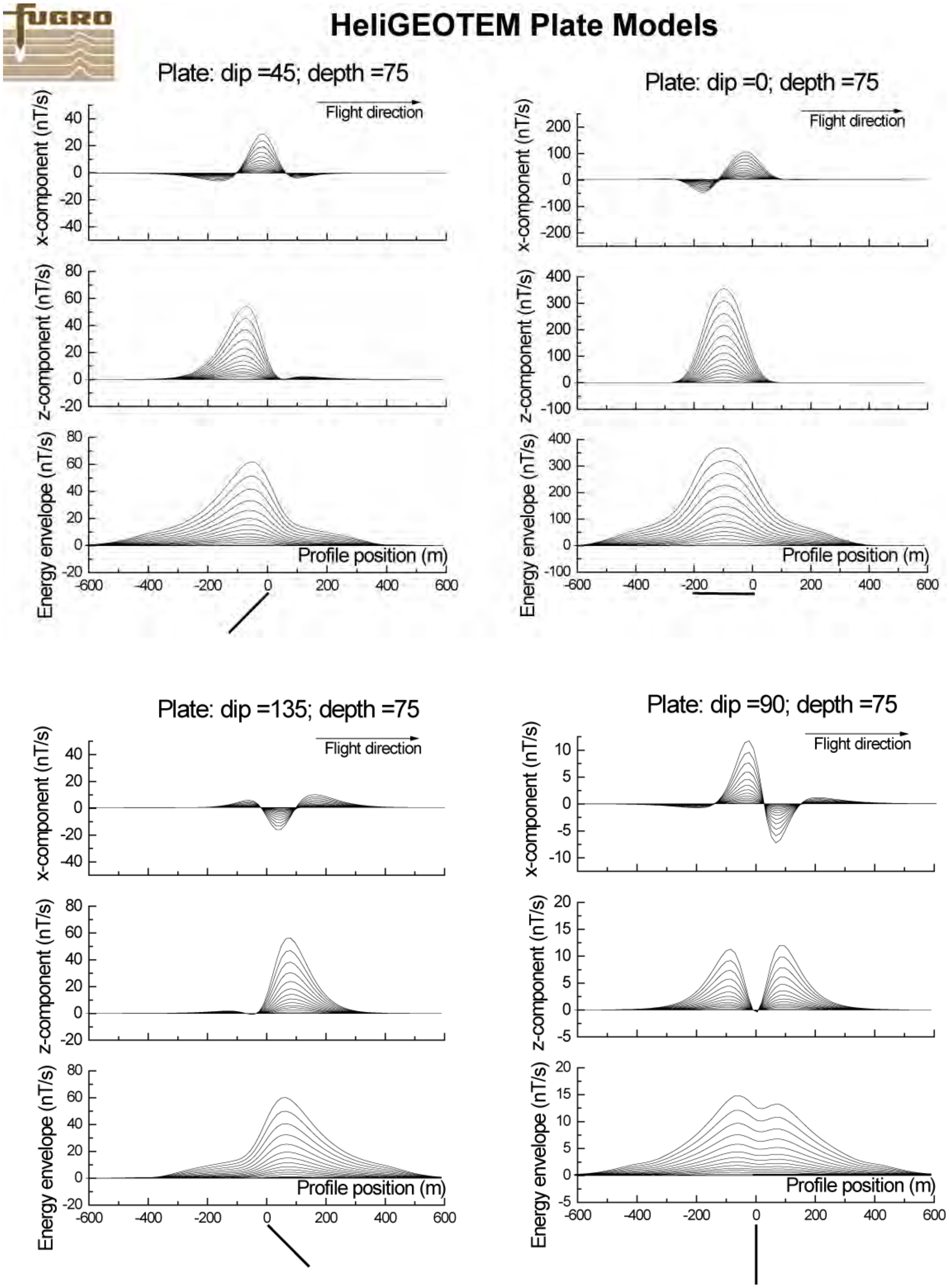

Figure 5 Plate model with a flying direction of left to right

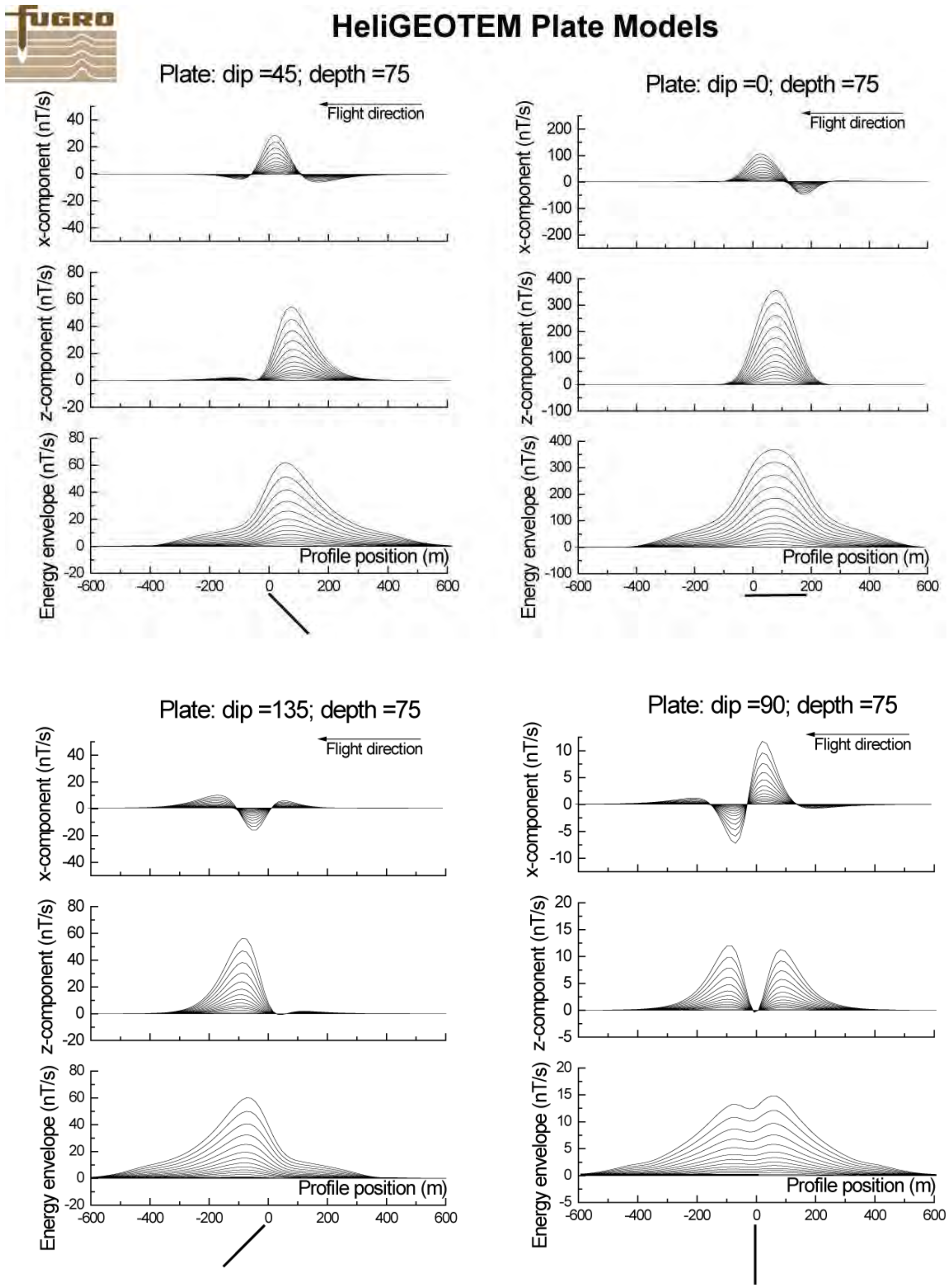

Figure 6 Plate model with flying direction from right to left

Appendix E

Glossary

GLOSSARY OF AIRBORNE GEOPHYSICAL TERMS

Note: The definitions given in this glossary refer to the common terminology as used in airborne geophysics.

altitude attenuation: the absorption of gamma rays by the atmosphere between the earth and the detector. The number of gamma rays detected by a system decreases as the altitude increases.

apparent- : the ***physical parameters*** of the earth measured by a geophysical system are normally expressed as apparent, as in "apparent ***resistivity*"**. This means that the measurement is limited by assumptions made about the geology in calculating the response measured by the geophysical system. Apparent resistivity calculated with ***HEM***, for example, generally assumes that the earth is a ***homogeneous half-space*** – not layered.

amplitude: The strength of the total electromagnetic field. In ***frequency domain*** it is most often the sum of the squares of ***in-phase*** and ***quadrature*** components. In multi-component electromagnetic surveys it is generally the sum of the squares of all three directional components.

analytic signal: The total amplitude of all the directions of magnetic ***gradient***. Calculated as the sum of the squares.

anisotropy: Having different ***physical parameters*** in different directions. This can be caused by layering or fabric in the geology. Note that a unit can be anisotropic, but still **homogeneous**.

anomaly: A localized change in the geophysical data characteristic of a discrete source, such as a conductive or magnetic body: something locally different from the **background**.

B-field: In time-domain **electromagnetic** surveys, the magnetic field component of the (electromagnetic) **field**. This can be measured directly, although more commonly it is calculated by integrating the time rate of change of the magnetic field **dB/dt**, as measured with a receiver coil.

background: The "normal" response in the geophysical data – that response observed over most of the survey area. **Anomalies** are usually measured relative to the background. In airborne gamma-ray spectrometric surveys the term defines the **cosmic**, radon, and aircraft responses in the absence of a signal from the ground.

base-level: The measured values in a geophysical system in the absence of any outside signal. All geophysical data are measured relative to the system base level.

base frequency: The frequency of the pulse repetition for a ***time-domain electromagnetic*** system. Measured between subsequent positive pulses.

bird: A common name for the pod towed beneath or behind an aircraft, carrying the geophysical sensor array.

bucking: The process of removing the strong ***signal*** from the ***primary field*** at the ***receiver*** from the data, to measure the ***secondary field***. It can be done electronically or mathematically. This is done in ***frequency-domain EM***, and to measure ***on-time*** in ***time-domain EM***.

calibration coil: A wire coil of known size and dipole moment, which is used to generate a field of known ***amplitude*** and ***phase*** in the receiver, for system calibration. Calibration coils can be external, or internal to the system. Internal coils may be called Q-coils.

coaxial coils: **[CX]** Coaxial coils in an HEM system are in the vertical plane, with their axes horizontal and collinear in the flight direction. These are most sensitive to vertical conductive objects in the ground, such as thin, steeply dipping conductors perpendicular to the flight direction. Coaxial coils generally give the sharpest anomalies over localized conductors. (See also ***coplanar coils***)

coil: A multi-turn wire loop used to transmit or detect electromagnetic fields. Time varying ***electromagnetic*** fields through a coil induce a voltage proportional to the strength of the field and the rate of change over time.

compensation: Correction of airborne geophysical data for the changing effect of the aircraft. This process is generally used to correct data in ***fixed-wing time-domain electromagnetic*** surveys (where the transmitter is on the aircraft and the receiver is moving), and magnetic surveys (where the sensor is on the aircraft, turning in the earth's magnetic field.

component: In ***frequency domain electromagnetic*** surveys this is one of the two **phase** measurements – ***in-phase or quadrature***. In "multi-component" electromagnetic surveys it is also used to define the measurement in one geometric direction (vertical, horizontal in-line and horizontal transverse – the Z, X and Y components).

Compton scattering: gamma ray photons will bounce off electrons as they pass through the earth and atmosphere, reducing their energy and then being detected by ***radiometric*** sensors at lower energy levels. See also ***stripping***.

conductance: See ***conductivity thickness***

conductivity: [σ] The facility with which the earth or a geological formation conducts electricity. Conductivity is usually measured in milli-Siemens per metre (mS/m). It is the reciprocal of ***resistivity***.

conductivity-depth imaging: see ***conductivity-depth transform***.

conductivity-depth transform: A process for converting electromagnetic measurements to an approximation of the conductivity distribution vertically in the earth, assuming a ***layered earth***. (Macnae and Lamontagne, 1987; Wolfgram and Karlik, 1995)

conductivity thickness: [σt] The product of the ***conductivity***, and thickness of a large, tabular body. (It is also called the "conductivity-thickness product") In electromagnetic geophysics, the response of a thin plate-like conductor is proportional to the conductivity multiplied by thickness. For example a 10 metre thickness of 20 Siemens/m mineralization will be equivalent to 5 metres of 40 S/m; both have 200 S conductivity thickness. Sometimes referred to as conductance.

conductor: Used to describe anything in the ground more conductive than the surrounding geology. Conductors are most often clays or graphite, or hopefully some type of mineralization, but may also be man-made objects, such as fences or pipelines.

coplanar coils: **[CP]** In HEM, the coplanar coils lie in the horizontal plane with their axes vertical, and parallel. These coils are most sensitive to massive conductive bodies, horizontal layers, and the ***halfspace***.

cosmic ray: High energy sub-atomic particles from outer space that collide with the earth's atmosphere to produce a shower of gamma rays (and other particles) at high energies.

counts (per second): The number of ***gamma-rays*** detected by a gamma-ray ***spectrometer*****.** The rate depends on the geology, but also on the size and sensitivity of the detector.

culture: A term commonly used to denote any man-made object that creates a geophysical anomaly. Includes, but not limited to, power lines, pipelines, fences, and buildings.

current channelling: See current gathering.

current gathering: The tendency of electrical currents in the ground to channel into a conductive formation. This is particularly noticeable at higher frequencies or early time channels when the formation is long and parallel to the direction of current flow. This tends to enhance anomalies relative to inductive currents (see also ***induction***). Also known as current channelling.

daughter products: The radioactive natural sources of gamma-rays decay from the original "parent" element (commonly potassium, uranium, and thorium) to one or more lower-energy "daughter" elements. Some of these lower energy elements are also radioactive and decay further. ***Gamma-ray spectrometry*** surveys may measure the gamma rays given off by the original element or by the decay of the daughter products.

dB/dt: As the ***secondary electromagnetic field*** changes with time, the magnetic field [**B**] component induces a voltage in the receiving ***coil***, which is proportional to the rate of change of the magnetic field over time.

decay: In ***time-domain electromagnetic*** theory, the weakening over time of the ***eddy currents*** in the ground, and hence the ***secondary field*** after the ***primary field*** electromagnetic pulse is turned off. In ***gamma-ray spectrometry***, the radioactive breakdown of an element, generally potassium, uranium, thorium, or one of their ***daughter*** products.

decay constant: see time constant.

decay series: In ***gamma-ray spectrometry***, a series of progressively lower energy ***daughter products*** produced by the radioactive breakdown of uranium or thorium.

depth of exploration: The maximum depth at which the geophysical system can detect the target. The depth of exploration depends very strongly on the type and size of the target, the contrast of the target with the surrounding geology, the homogeneity of the surrounding geology, and the type of geophysical system. One measure of the maximum depth of exploration for an electromagnetic system is the depth at which it can detect the strongest conductive target – generally a highly conductive horizontal layer.

differential resistivity: A process of transforming ***apparent resistivity*** to an approximation of layer resistivity at each depth. The method uses multi-frequency HEM data and approximates the effect of shallow layer ***conductance*** determined from higher frequencies to estimate the deeper conductivities (Huang and Fraser, 1996)

dipole moment: [NIA] For a transmitter, the product of the area of a ***coil***, the number of turns of wire, and the current flowing in the coil. At a distance significantly larger than the size of the coil, the magnetic field from a coil will be the same if the dipole moment product is the same. For a receiver coil, this is the product of the area and the number of turns. The sensitivity to a magnetic field (assuming the source is far away) will be the same if the dipole moment is the same.

diurnal: The daily variation in a natural field, normally used to describe the natural fluctuations (over hours and days) of the earth's magnetic field.

dielectric permittivity: **[ε]** The capacity of a material to store electrical charge, this is most often measured as the relative permittivity [ε_r], or ratio of the material dielectric to that of free space. The effect of high permittivity may be seen in HEM data at high frequencies over highly resistive geology as a reduced or negative ***in-phase***, and higher ***quadrature*** data.

drape: To fly a survey following the terrain contours, maintaining a constant altitude above the local ground surface. Also applied to re-processing data collected at varying altitudes above ground to simulate a survey flown at constant altitude.

drift: Long-time variations in the base-level or calibration of an instrument.

eddy currents: The electrical currents induced in the ground, or other conductors, by a time-varying ***electromagnetic field*** (usually the ***primary field***). Eddy currents are also induced in the aircraft's metal frame and skin; a source of ***noise*** in EM surveys.

electromagnetic: **[EM]** Comprised of a time-varying electrical and magnetic field. Radio waves are common electromagnetic fields. In geophysics, an electromagnetic system is one which transmits a time-varying ***primary field*** to induce ***eddy currents*** in the ground, and then measures the ***secondary field*** emitted by those eddy currents.

energy window: A broad spectrum of ***gamma-ray*** energies measured by a spectrometric survey. The energy of each gamma-ray is measured and divided up into numerous discrete energy levels, called windows.

equivalent (thorium or uranium): The amount of radioelement calculated to be present, based on the gamma-rays measured from a **daughter** element. This assumes that the ***decay series*** is in equilibrium – progressing normally.

exposure rate: in radiometric surveys, a calculation of the total exposure rate due to gamma rays at the ground surface. It is used as a measurement of the concentration of all the **radioelements** at the surface. See also: **natural exposure rate**.

fiducial, or fid: Timing mark on a survey record. Originally these were timing marks on a profile or film; now the term is generally used to describe 1-second interval timing records in digital data, and on maps or profiles.

Figure of Merit: **(FOM)** A sum of the 12 distinct magnetic noise variations measured by each of four flight directions, and executing three aircraft attitude variations (yaw, pitch, and roll) for each direction. The flight directions are generally parallel and perpendicular to planned survey flight directions. The FOM is used as a measure of the **manoeuvre noise** before and after **compensation.**

fixed-wing: Aircraft with wings, as opposed to “rotary wing” helicopters.

footprint: This is a measure of the area of sensitivity under the aircraft of an airborne geophysical system. The footprint of an ***electromagnetic*** system is dependent on the altitude of the system, the orientation of the transmitter and receiver and the separation between the receiver and transmitter, and the conductivity of the ground. The footprint of a ***gamma-ray spectrometer*** depends mostly on the altitude. For all geophysical systems, the footprint also depends on the strength of the contrasting ***anomaly***.

frequency domain: An ***electromagnetic*** system which transmits a ***primary field*** that oscillates smoothly over time (sinusoidal), inducing a similarly varying electrical current in the ground. These systems generally measure the changes in the ***amplitude*** and ***phase*** of the ***secondary field*** from the ground at different frequencies by measuring the **in-phase** and **quadrature** phase components. See also ***time-domain***.

full-stream data: Data collected and recorded continuously at the highest possible sampling rate. Normal data are stacked (see ***stacking***) over some time interval before recording.

gamma-ray: A very high-energy photon, emitted from the nucleus of an atom as it undergoes a change in energy levels.

gamma-ray spectrometry: Measurement of the number and energy of natural (and sometimes man-made) gamma-rays across a range of photon energies.

gradient: In magnetic surveys, the gradient is the change of the magnetic field over a distance, either vertically or horizontally in either of two directions. Gradient data is often measured, or calculated from the total magnetic field data because it changes more quickly over distance than the ***total magnetic field***, and so may provide a more precise measure of the location of a source. See also ***analytic signal***.

ground effect: The response from the earth. A common calibration procedure in many geophysical surveys is to fly to altitude high enough to be beyond any measurable response from the ground, and there establish ***base levels*** or ***backgrounds***.

half-space: A mathematical model used to describe the earth – as infinite in width, length, and depth below the surface. The most common halfspace models are ***homogeneous*** and ***layered earth***.

heading error: A slight change in the magnetic field measured when flying in opposite directions.

HEM: Helicopter ElectroMagnetic, This designation is most commonly used for helicopter-borne,

frequency-domain electromagnetic systems. At present, the transmitter and receivers are normally mounted in a ***bird*** carried on a sling line beneath the helicopter.

herringbone pattern: A pattern created in geophysical data by an asymmetric system, where the **anomaly** may be extended to either side of the source, in the direction of flight. Appears like fish bones, or like the teeth of a comb, extending either side of centre, each tooth an alternate flight line.

homogeneous: This is a geological unit that has the same ***physical parameters*** throughout its volume. This unit will create the same response to an HEM system anywhere, and the HEM system will measure the same apparent ***resistivity*** anywhere. The response may change with system direction (see ***anisotropy***).

HTEM: Helicopter Time-domain ElectroMagnetic, This designation is used for the new generation of helicopter-borne, ***time-domain*** electromagnetic systems.

in-phase: the component of the measured ***secondary field*** that has the same phase as the transmitter and the ***primary field***. The in-phase component is stronger than the ***quadrature*** phase over relatively higher ***conductivity***.

induction: Any time-varying electromagnetic field will induce (cause) electrical currents to flow in any object with non-zero ***conductivity***. (see ***eddy currents***)

induction number: also called the "response parameter", this number combines many of the most significant parameters affecting the ***EM*** response into one parameter against which to compare responses. For a ***layered earth*** the response parameter is $\mu\omega\sigma h^2$ and for a large, flat, ***conductor*** it is $\mu\omega\sigma th$, where μ is the ***magnetic permeability***, ω is the angular ***frequency***, σ is the **conductivity**, t is the thickness (for the flat conductor) and h is the height of the system above the conductor.

inductive limit: When the frequency of an EM system is very high, or the **conductivity** of the target is very high, the response measured will be entirely **in-phase** with no **quadrature** (**phase** angle =0). The in-phase response will remain constant with further increase in conductivity or frequency. The system can no longer detect changes in conductivity of the target.

infinite: In geophysical terms, an "infinite' dimension is one much greater than the ***footprint*** of the system, so that the system does not detect changes at the edges of the object.

International Geomagnetic Reference Field: **[IGRF]** An approximation of the smooth magnetic field of the earth, in the absence of variations due to local geology. Once the IGRF is subtracted from the measured magnetic total field data, any remaining variations are assumed to be due to local geology. The IGRF also predicts the slow changes of the field up to five years in the future.

inversion, or **inverse modeling**: A process of converting geophysical data to an earth model, which compares theoretical models of the response of the earth to the data measured, and refines the model until the response closely fits the measured data (Huang and Palacky, 1991)

layered earth: A common geophysical model which assumes that the earth is horizontally layered – the ***physical parameters*** are constant to ***infinite*** distance horizontally, but change vertically.

magnetic permeability: **[μ]** This is defined as the ratio of magnetic induction to the inducing magnetic field. The relative magnetic permeability [μ_r] is often quoted, which is the ratio of the rock permeability to the permeability of free space. In geology and geophysics, the ***magnetic susceptibility*** is more commonly used to describe rocks.

magnetic susceptibility: **[k]** A measure of the degree to which a body is magnetized. In SI units this is related to relative ***magnetic permeability*** by $k=\mu_r-1$, and is a dimensionless unit. For most geological material, susceptibility is influenced primarily by the percentage of magnetite. It is most often quoted in units of 10^{-6}. In HEM data this is most often apparent as a negative ***in-phase*** component over high susceptibility, high ***resistivity*** geology such as diabase dikes.

manoeuvre noise: variations in the magnetic field measured caused by changes in the relative positions of the magnetic sensor and magnetic objects or electrical currents in the aircraft. This type of noise is generally corrected by magnetic **compensation**.

model: Geophysical theory and applications generally have to assume that the geology of the earth has a form that can be easily defined mathematically, called the model. For example steeply dipping **conductor**s are generally modeled as being **infinite** in horizontal and depth extent, and very thin. The earth is generally modeled as horizontally layered, each layer infinite in extent and uniform in characteristic. These models make the mathematics to describe the response of the (normally very complex) earth practical. As theory advances, and computers become more powerful, the useful models can become more complex.

natural exposure rate: in radiometric surveys, a calculation of the total exposure rate due to natural-source gamma rays at the ground surface. It is used as a measurement of the concentration of all the natural **radioelements** at the surface. See also: **exposure rate**.

noise: That part of a geophysical measurement that the user does not want. Typically this includes electronic interference from the system, the atmosphere (***sferics***), and man-made sources. This can be a subjective judgment, as it may include the response from geology other than the target of interest. Commonly the term is used to refer to high frequency (short period) interference. See also ***drift***.

Occam's inversion: an ***inversion*** process that matches the measured ***electromagnetic*** data to a theoretical model of many, thin layers with constant thickness and varying resistivity (Constable et al, 1987).

off-time: In a ***time-domain electromagnetic*** survey, the time after the end of the ***primary field pulse***, and before the start of the next pulse.

on-time: In a ***time-domain electromagnetic*** survey, the time during the ***primary field pulse***.

overburden: In engineering and mineral exploration terms, this most often means the soil on top of the unweathered bedrock. It may be sand, glacial till, or weathered rock.

Phase, phase angle: The angular difference in time between a measured sinusoidal electromagnetic field and a reference – normally the primary field. The phase is calculated from $\tan^{-1}$(***in-phase*** / ***quadrature***).

physical parameters: These are the characteristics of a geological unit. For electromagnetic surveys, the important parameters are ***conductivity***, ***magnetic permeability*** (or ***susceptibility***) and ***dielectric permittivity***; for magnetic surveys the parameter is magnetic susceptibility, and for gamma ray spectrometric surveys it is the concentration of the major radioactive elements: potassium, uranium, and thorium.

permittivity: see ***dielectric permittivity***.

permeability: see ***magnetic permeability***.

primary field: the EM field emitted by a transmitter. This field induces ***eddy currents*** in (energizes) the conductors in the ground, which then create their own ***secondary*** **fields**.

pulse: In time-domain EM surveys, the short period of intense ***primary*** field transmission. Most measurements (the ***off-time***) are measured after the pulse. **On-time** measurements may be made during the pulse.

quadrature: that component of the measured ***secondary field*** that is phase-shifted 90° from the ***primary field***. The quadrature component tends to be stronger than the ***in-phase*** over relatively weaker ***conductivity***.

Q-coils: see ***calibration coil***.

radioelements: This normally refers to the common, naturally-occurring radioactive elements: potassium (K), uranium (U), and thorium (Th). It can also refer to man-made radioelements, most often cobalt (Co) and cesium (Cs)

radiometric: Commonly used to refer to ***gamma ray*** spectrometry.

radon: A radioactive daughter product of uranium and thorium, radon is a gas which can leak into the atmosphere, adding to the non-geological background of a gamma-ray spectrometric survey.

receiver: the ***signal*** detector of a geophysical system. This term is most often used in active geophysical systems – systems that transmit some kind of signal. In airborne ***electromagnetic*** surveys it is most often a ***coil***. (see also, ***transmitter***)

resistivity: **[ρ]** The strength with which the earth or a geological formation resists the flow of electricity, typically the flow induced by the ***primary field*** of the electromagnetic transmitter. Normally expressed in ohm-metres, it is the reciprocal of ***conductivity***.

resistivity-depth transforms: similar to ***conductivity depth transforms***, but the calculated ***conductivity*** has been converted to ***resistivity***.

resistivity section: an approximate vertical section of the resistivity of the layers in the earth. The resistivities can be derived from the ***apparent resistivity***, the ***differential resistivities***, ***resistivity-depth transforms***, or ***inversions***.

Response parameter: another name for the **induction number**.

secondary field: The field created by conductors in the ground, as a result of electrical currents induced by the ***primary field*** from the ***electromagnetic*** transmitter. Airborne ***electromagnetic*** systems are designed to create and measure a secondary field.

Sengpiel section: a ***resistivity section*** derived using the ***apparent resistivity*** and an approximation of the depth of maximum sensitivity for each frequency.

sferic: Lightning, or the ***electromagnetic*** signal from lightning, it is an abbreviation of "atmospheric discharge". These appear to magnetic and electromagnetic sensors as sharp "spikes" in the data. Under some conditions lightning storms can be detected from hundreds of kilometres away. (see ***noise***)

signal: That component of a measurement that the user wants to see – the response from the targets, from the earth, etc. (See also ***noise***)

skin depth: A measure of the depth of penetration of an electromagnetic field into a material. It is defined as the depth at which the primary field decreases to 1/e of the field at the surface. It is calculated by approximately 503 x √(resistivity/frequency). Note that depth of penetration is greater at higher ***resistivity*** and/or lower ***frequency.***

spectrometry: Measurement across a range of energies, where ***amplitude*** and energy are defined for each measurement. In gamma-ray spectrometry, the number of gamma rays are measured for each energy ***window***, to define the ***spectrum***.

spectrum: In ***gamma ray spectrometry***, the continuous range of energy over which gamma rays are measured. In ***time-domain electromagnetic*** surveys, the spectrum is the energy of the **pulse** distributed across an equivalent, continuous range of frequencies.

spheric: see ***sferic***.

stacking: Summing repeat measurements over time to enhance the repeating ***signal***, and minimize the random ***noise***.
stripping: Estimation and correction for the gamma ray photons of higher and lower energy that are observed in a particular ***energy window***. See also ***Compton scattering***.

susceptibility: See ***magnetic susceptibility***.

tau: [τ] Often used as a name for the ***time constant***.

TDEM: ***time domain electromagnetic***.

thin sheet: A standard model for electromagnetic geophysical theory. It is usually defined as a thin, flat-lying conductive sheet, ***infinite*** in both horizontal directions. (see also ***vertical plate***)

tie-line: A survey line flown across most of the ***traverse lines***, generally perpendicular to them, to assist in measuring ***drift*** and ***diurnal*** variation. In the short time required to fly a tie-line it is assumed that the drift and/or diurnal will be minimal, or at least changing at a constant rate.

time constant: The time required for an ***electromagnetic*** field to decay to a value of 1/e of the original value. In ***time-domain*** electromagnetic data, the time constant is proportional to the size and ***conductance*** of a tabular conductive body. Also called the decay constant.

Time channel: In ***time-domain electromagnetic*** surveys the decaying ***secondary field*** is measured over a period of time, and the divided up into a series of consecutive discrete measurements over that time.

time-domain: ***Electromagnetic*** system which transmits a pulsed, or stepped ***electromagnetic*** field. These systems induce an electrical current (***eddy current***) in the ground that persists after the ***primary field*** is turned off, and measure the change over time of the ***secondary field*** created as the currents ***decay***. See also ***frequency-domain***.

total energy envelope: The sum of the squares of the three ***components*** of the ***time-domain electromagnetic secondary field***. Equivalent to the ***amplitude*** of the secondary field.

transient: Time-varying. Usually used to describe a very short period pulse of ***electromagnetic*** field.

transmitter: The source of the ***signa***l to be measured in a geophysical survey. In airborne ***EM*** it is most often a **coil** carrying a time-varying electrical current, transmitting the ***primary field***. (see also ***receiver***)

traverse line: A normal geophysical survey line. Normally parallel traverse lines are flown across the property in spacing of 50 m to 500 m, and generally perpendicular to the target geology.

vertical plate: A standard model for electromagnetic geophysical theory. It is usually defined as thin conductive sheet, ***infinite*** in horizontal dimension and depth extent. (see also ***thin shee***t)

waveform: The shape of the ***electromagnetic pulse*** from a ***time-domain*** electromagnetic transmitter.

window: A discrete portion of a ***gamma-ray spectrum*** or ***time-domain electromagnetic decay***. The continuous energy spectrum or ***full-stream*** data are grouped into windows to reduce the number of samples, and reduce ***noise***.

Version 1.5, November 29, 2005
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Fugro Airborne Surveys, Toronto

Common Symbols and Acronyms

k Magnetic susceptibility
ε Dielectric permittivity
μ, μ_r Magnetic permeability, relative permeability
ρ, ρ_a Resistivity, apparent resistivity
σ,σ_a Conductivity, apparent conductivity
σt Conductivity thickness
τ Tau, or time constant
Ωm ohm-metres, units of resistivity
AGS Airborne gamma ray spectrometry.
CDT Conductivity-depth transform, conductivity-depth imaging (Macnae and Lamontagne, 1987; Wolfgram and Karlik, 1995)
CPI, CPQ Coplanar in-phase, quadrature
CPS Counts per second
CTP Conductivity thickness product
CXI, CXQ Coaxial, in-phase, quadrature
FOM Figure of Merit
fT femtoteslas, normal unit for measurement of B-Field
EM Electromagnetic
keV kilo electron volts – a measure of gamma-ray energy
MeV mega electron volts – a measure of gamma-ray energy 1MeV = 1000keV
NIA dipole moment: turns x current x Area
nT nanotesla, a measure of the strength of a magnetic field
nG/h nanoGreys/hour – gamma ray dose rate at ground level
ppm parts per million – a measure of secondary field or noise relative to the primary or radioelement concentration.
pT/s picoteslas per second: Units of decay of secondary field, dB/dt
S siemens – a unit of conductance
x: the horizontal component of an EM field parallel to the direction of flight.
y: the horizontal component of an EM field perpendicular to the direction of flight.
z: the vertical component of an EM field.

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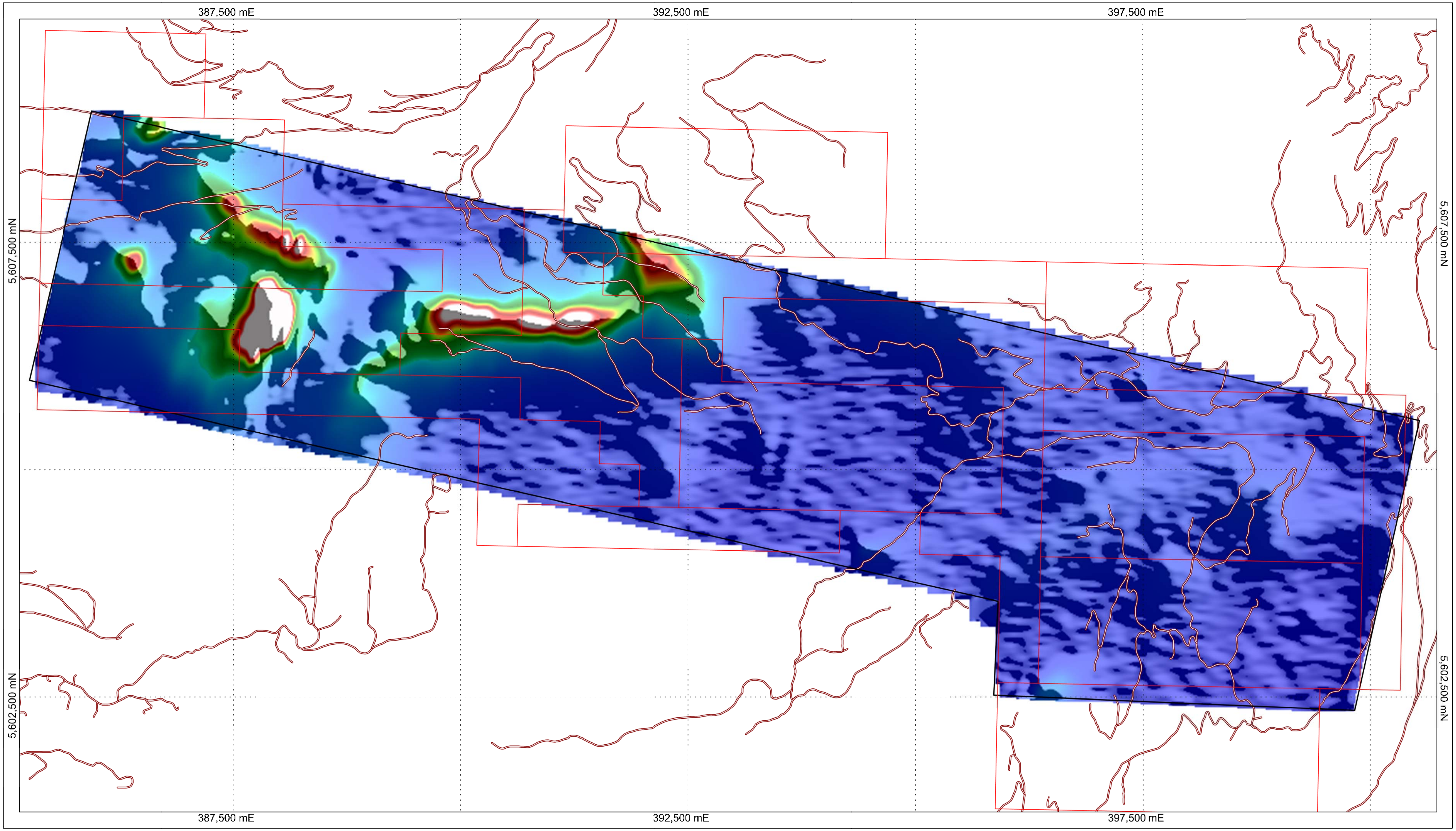

SOUTHERN GEOSCIENCE CONSULTANTS

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metres

SCALE 1:25 000

DATUM: WGS 84
GRID: UTM ZONE 11N

SOUTHERN GEOSCIENCE CONSULTANTS

Cullen Resources Limited
TL-Mabel Lake Project
British Columbia, Canada
HELITEM Survey
Channel 10 dB/dT Z-Component Image

SCALE: 1:25 000	GEO: W .S. PETERS
DATE: 18th September 2012	GIS: W.S.Peters

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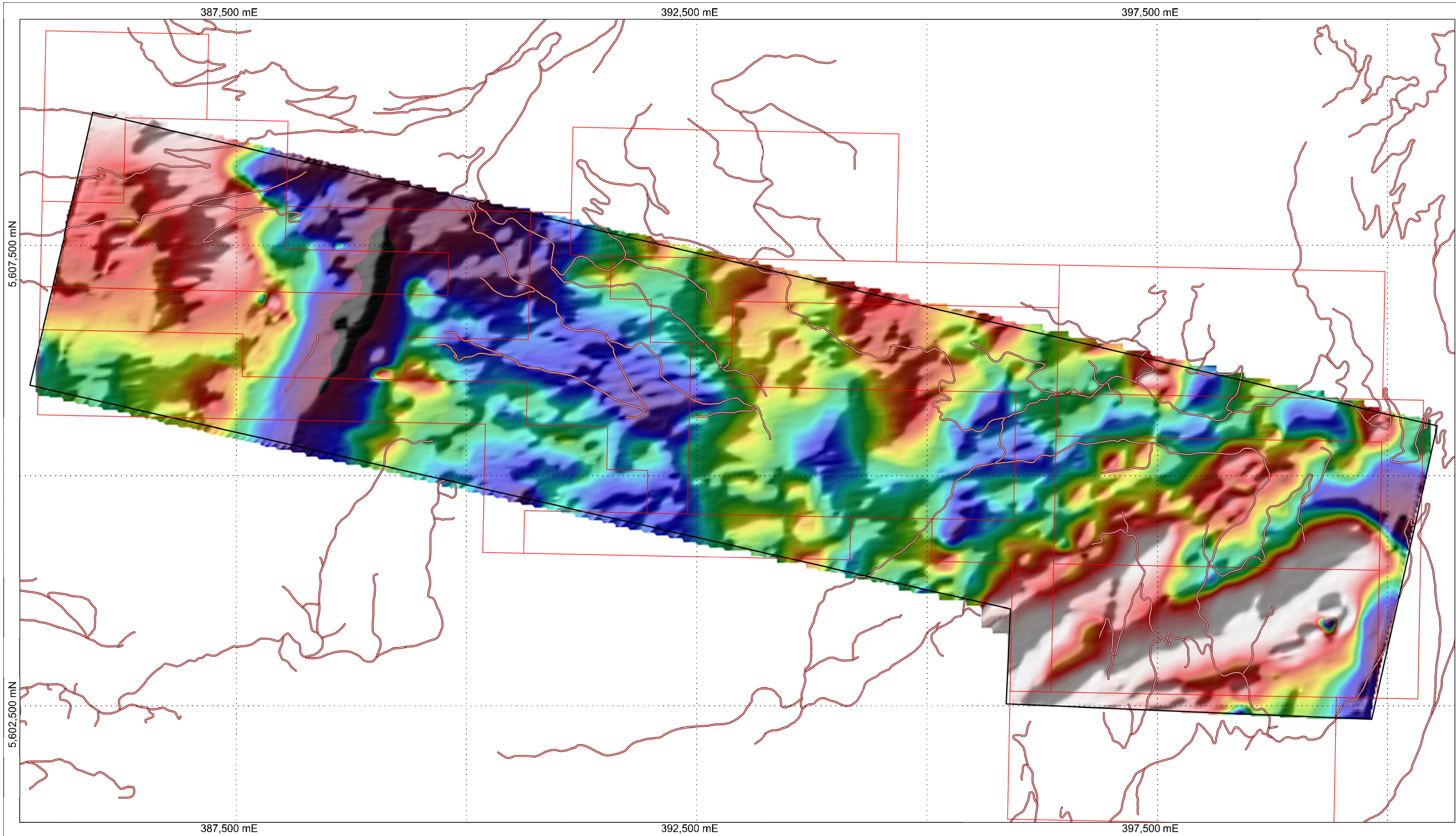

SOUTHERN GEOSCIENCE
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SCALE 1:25 000

DATUM: WGS 84
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Cullen Resources Limited

TL-Mabel Lake Project

British Columbia, Canada

HELITEM Survey

Reduced to Pole Total Magnetic Intensity Image

SCALE: 1:25 000	GEO: W .S. PETERS
DATE: 18th September 2012	GIS: W.S.Peters

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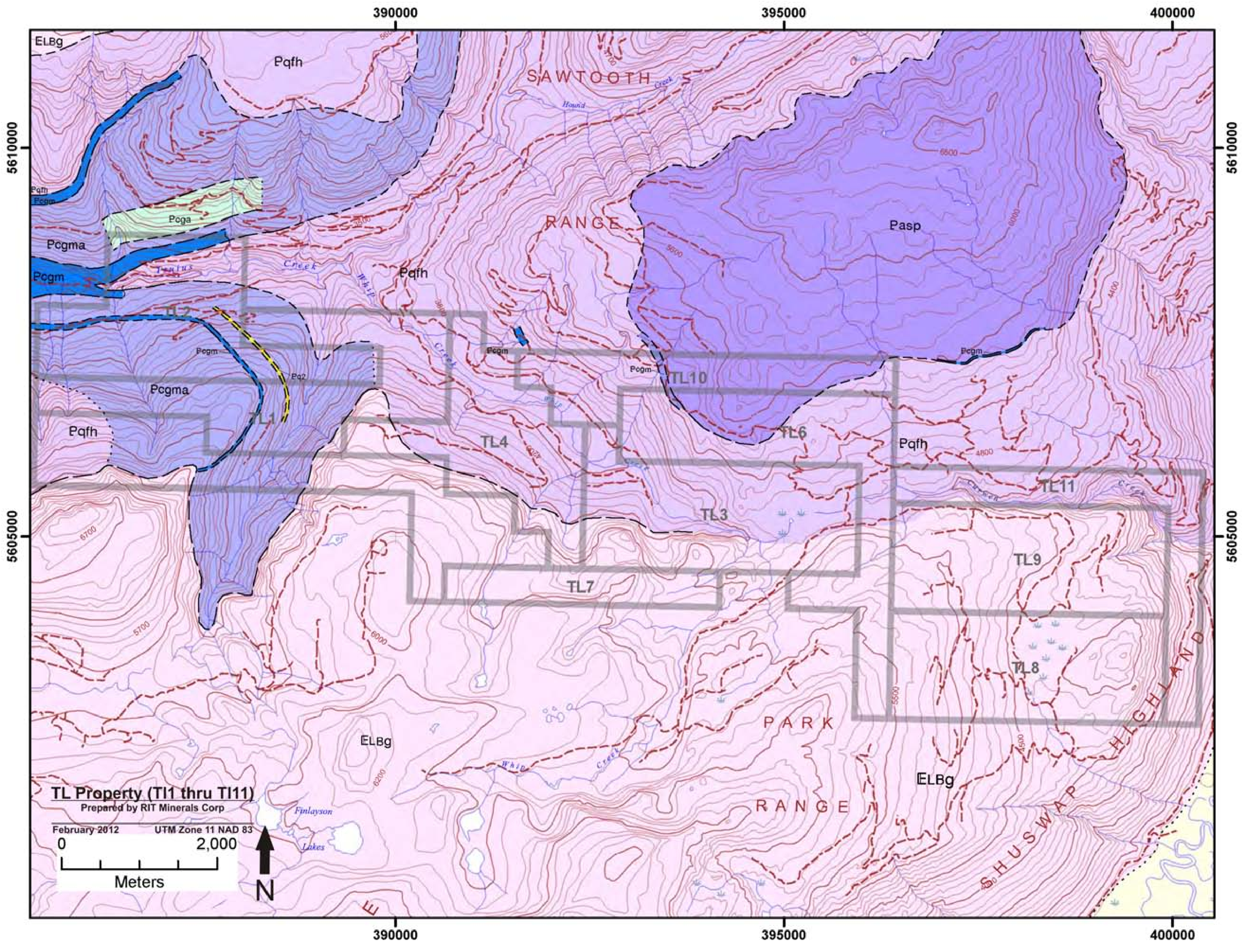
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TL10
TL11
PARK
RANGE
SHUSWAP HIGHLAND
ELBg
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Finlayson
Lakes
TL Property (Tl1 thru Tl11)
Prepared by RIT Minerals Corp
February 2012
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