GroundTruth Exploration

Airborne Geophysical Assessment Report:
Dighem Aerial Survey

Black Fox GOLD PROJECT

Black Fox 1-10	YC30519-528
Black Fox 11-38	YC35176-203
Black Fox 39-52	YC36525-538

Dawson Mining District
NTS: 115O/03
Easting: 598000 Northing: 6985000
UTM Zone 7N, NAD83
Work Performed on:

August 14 to 19 2017

Prepared for White Gold Corp (Selene Holdings LP)
By GroundTruth Exploration

Written by:
Adam Fage, M.Sc
Amir H. Radjaee, P.Geo

May 23, 2018

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1 Introduction

White Gold Corporation commissioned Groundtruth Exploration Ltd. ("Groundtruth") of Dawson, Yukon to perform a Dighem aerial survey program on their Black Fox Gold Property ("the Property", located in Yukon's White Gold district, approximately 75 km south of Dawson, YT) in the Dawson Mining District on NTS Map Sheet 115O/03, north of the Yukon River at the headwaters of Britannia Creek (Figures 1, 2).

232.2 line km of Dighem were collected on the property during the 2017 field program. The Dighem survey was contracted to CGG Global of Toronto.

Results and interpretation of this survey forms the basis of this report. Appendices to this report are attached as digital files.

2 Property Description, Location, Accessibility, Climate

The Black Fox Gold Property is located in the central-western part of Yukon, approximately 130km southeast of Dawson (Figure 1) near the confluence of the Yukon River and Britannia Creek. The center of the property is located at Latitude 62°45'N and Longitude -149°38'W.

The property is located in an unglaciated region of the Dawson Range. Elevations range from 975m to 1460m. Vegetation is typical of the Boreal forest, with mixed white and black spruce forests in valley bottoms, stunted black spruce and moss matt forests underlain by permafrost on north facing slopes and as elevation increases, transitioning into moss, talus and felsenmeer with increasing elevation. The typical climate of the area is moderate precipitaiton, warm summers, and cold winters.

Access to the property is by helicopter from Dawson City or via fixed wing aircraft to one of 4 airstrips within 20km of the property. Thistle airstrip is accessible by plane from Dawson or commercial barge. Dawson is the nearest supply center and 538km by paved highway from Whitehorse, Yukon Territory (Figure 1).
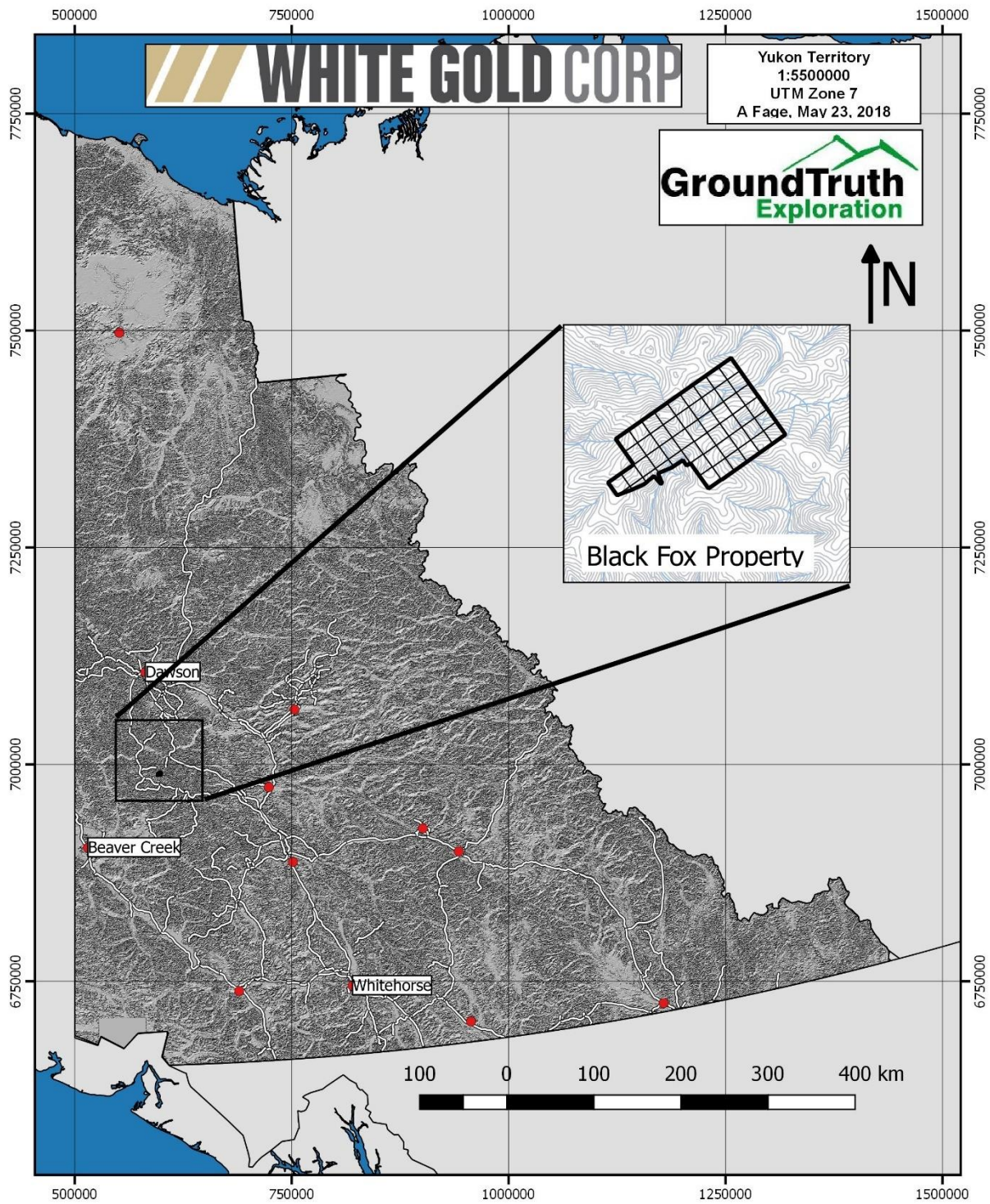
Figure 1: Location of the Black Fox Property, Yukon, Canada

3 Claim Information

The Black Fox Gold Project is registered in the Dawson Mining district on mapsheet 115O/03. (Figure 2, Appendix A) It encompasses 1020 hectares and is composed of the following 52 claims:

Claim name	Grant Number	Owner	Operator
Black Fox 1-10	YC30519-528	Selene Holdings LP - 100%	White Gold Corp. - 100%
Black Fox 11-38	YC35176-203	Selene Holdings LP - 100%	White Gold Corp. - 100%
Black Fox 39-52	YC36525-538	Selene Holdings LP - 100%	White Gold Corp. - 100%
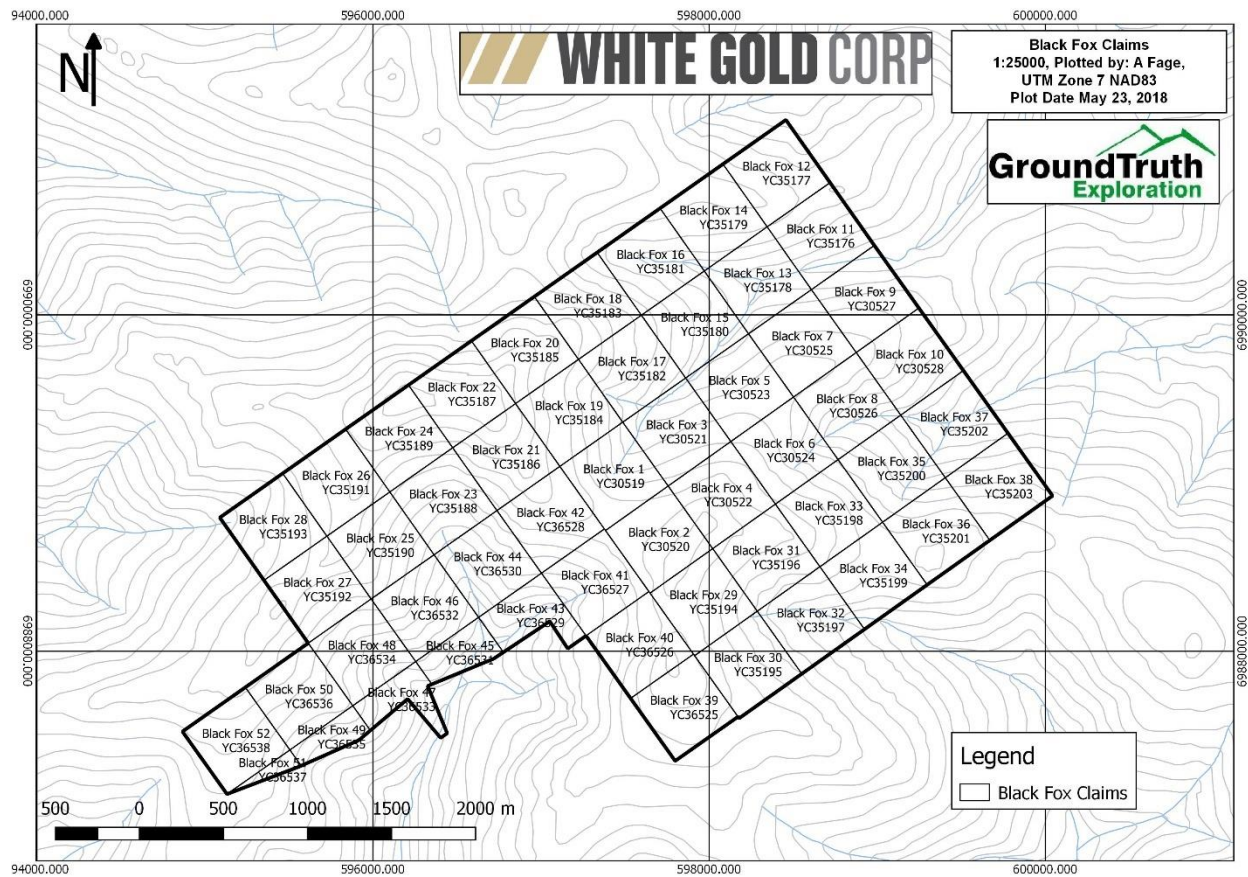
Figure 2: Claim Map of the Black Fox property

4 History

The area saw its first recorded work in 1915 where it was staked as Black Fox. A small open cut uncovered a 0.9 m quartz vein with pockets of galena, chalcopyrite and pyrite (Minfile 115O 014) (Paulsen et al., 2010; Hollis, 2011).

Shawn Ryan re-staked the Black Fox claims in 2004. Between 2004 and 2007, Ryanwood Exploration collected 1,311 soil samples identifying several gold-in-soil anomalies. Two shallow trenches were also dug exposing a quartz vein with visible gold. In 2007 Underworld Resources optioned the Black Fox property from Ryanwood Exploration and dug a further 6 trenches exposing the same quartz vein, the "Thistle Vein" (Paulsen et al., 2010). The Thistle quartz vein at Black Fox strikes approximately Northwest/Southeast. A high-grade grab spot sample of the host rock amphibolite collected from the eastern part of the trench contained 17.73 g/t Au. Two spot samples taken from the quartz vein at its North-western end contained just over 10 g/t Au and 7.6 g/t Au. Gold assay values from the quartz vein towards the southwest decreased compared to those observed to the northwest, down to approximately 3 and 4 g/t Au (Hollis, 2011).

4.1 Regional Geology

The following regional geology is primarily summarized from Gordey and Ryan (2005) for the Stewart River map sheet (115 N-O) and integrated with the older geology for map sheet 115 J by Tempelman-Kluit (1974).

The Black Fox Project occurs within the unglaciated Yukon Plateau portion of the Paleozoic Yukon Tanana Terrane, southwest of the Tintina Fault, dominated in the regional area by Devonian to Mississippian metasiliciclastic rocks (DMps), which interfinger with, and are stratigraphically overlain by, intermediate to mafic amphibolite (DMa). The metasiliciclastic rocks include metamorphosed fine clastic rocks, quartzite and conglomerate. The above lithologies include marble horizons (DMc) and are metamorphosed to amphibolite grade. Devonian to Mississippian metasedimentary rocks (quartzite and metapelite) of the Nasina Assemblage (DMq) lie structurally above and/or may partly be equivalent to the above metaclastic unit.

 Abundant orthogneiss bodies of Devonian to Mississippian (DMog - undivided, DMogg, DMoga, DMogt, DMogta) and Permian ages (Pog - undivided, Pogg, Poga), with compositions ranging from granite (g) to K-spar augen bearing (a), to tonalite and diorite (t), occur within Yukon-Tanana Terrane. DMogta represents undivided DMogt and DMa. Narrow bodies of Paleozoic ultramafic rocks (mPum), commonly serpentinized (mPums) also occur within the area.

On map sheet 115 J the above units are generally undifferentiated with the Devono-Mississippian, and possible minor Permian, felsic and lesser mafic orthogneiss, with

interlayered amphibolite and metasedimentary basement rocks represented as the Pelly Gneiss (DMgPW). Unit DMN3 is dominated by Devono-Mississippian metasedimentary quartzite ±chlorite schist), locally with feldspar augen bearing orthogneiss.

The above units are interpreted to represent two arcs, an older Devonian to Mississippian arc consisting of amphibolite (DMa) and associated subvolcanic intrusions (DMogg, DMoga, DMogt) built on a siliciclastic basement (DMps, DMq, DMcg, DMNq) and a Permian arc of granitic orthogneiss (Pogg, Poga) and coeval metavolcanic rocks (PKs) built on the Devono-Mississippian arc.

The above lithologies are intruded by small plugs and stocks of Cretaceous aged quartz monzonite and granodiorite (Kg), Late Cretaceous Prospector Mountain suite felsic, commonly quartz and/or feldspar porphyries (LKp) and Jurassic aged granodiorite (eJgd, eJgA), and unconformably overlain by massive andesite flows and breccias of the Late Cretaceous Carmacks Group (uKCv), locally with Early Cretaceous coarse clastic to conglomerate sedimentary rocks (lKTcg) at the base of the sequence. Early

Tertiary feldspar ±quartz porphyry stocks and dykes (Tg) intrude the above. All of the above litholgies are overlain by small, isolated occurrences of Quaternary basalt (Qb).
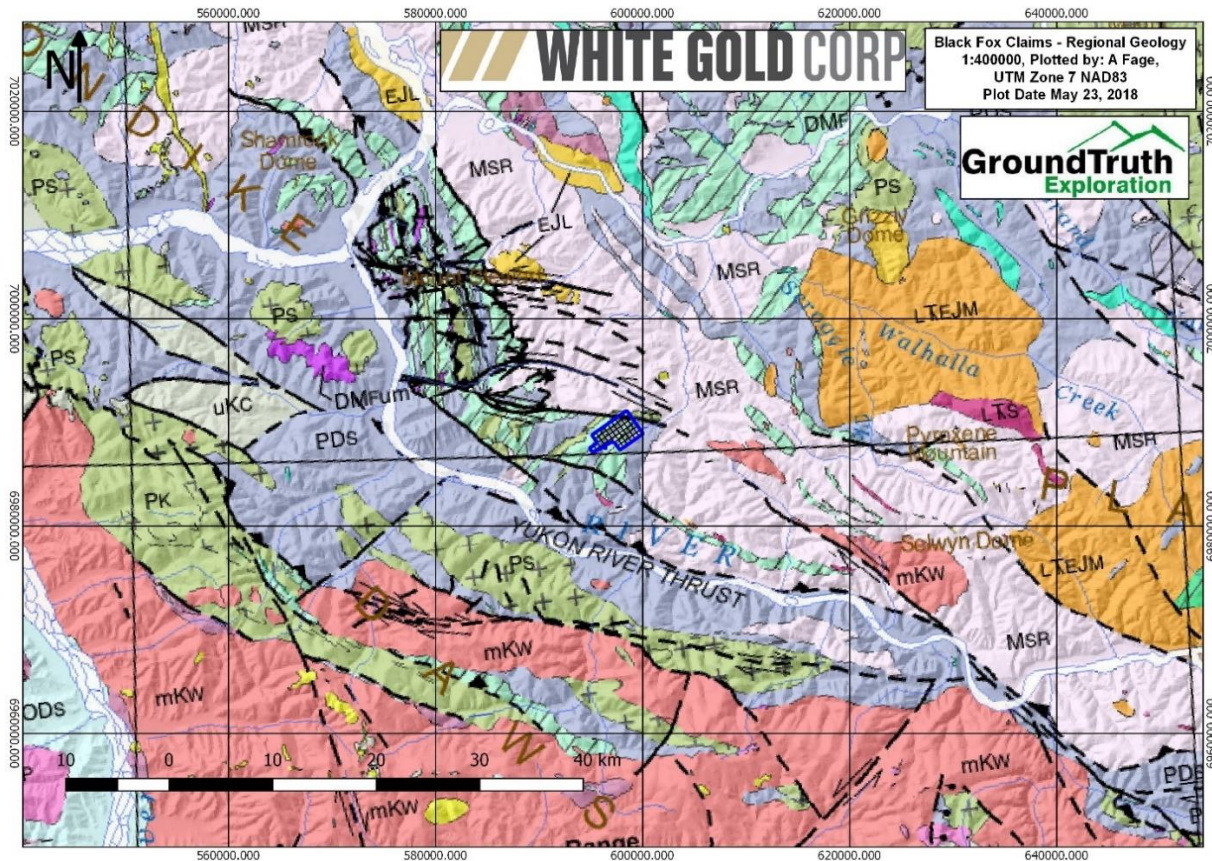
Figure 3: Regional Geology of the Black Fox Property (From Colpron et al., 2016)

4.2 Property Geology

The Black Fox Project is primarily underlain by undifferentiated Devono-Mississippian, and minor Permian, felsic and lesser mafic orthogneiss, with interlayered amphibolite and metasedimentary basement rocks of the Yukon-Tanana Terrane (Figure 4). This unit lies on trend of similar lithologies that underlie the White property, which includes the White Gold deposit, of Kinross Gold Corporation.

The interlayered metamorphic assemblages are in contact to the north and west of the property with the Mississippian Simpson Range Batholith (Tonalite with minor intermediate to mafic orthogneiss).

The Black Fox Project is located 20 km northeast of the Coffee Project, 20 km southeast of the White Gold deposit and 30 km northwest of the Casino gold-copper-molybdenum deposit.
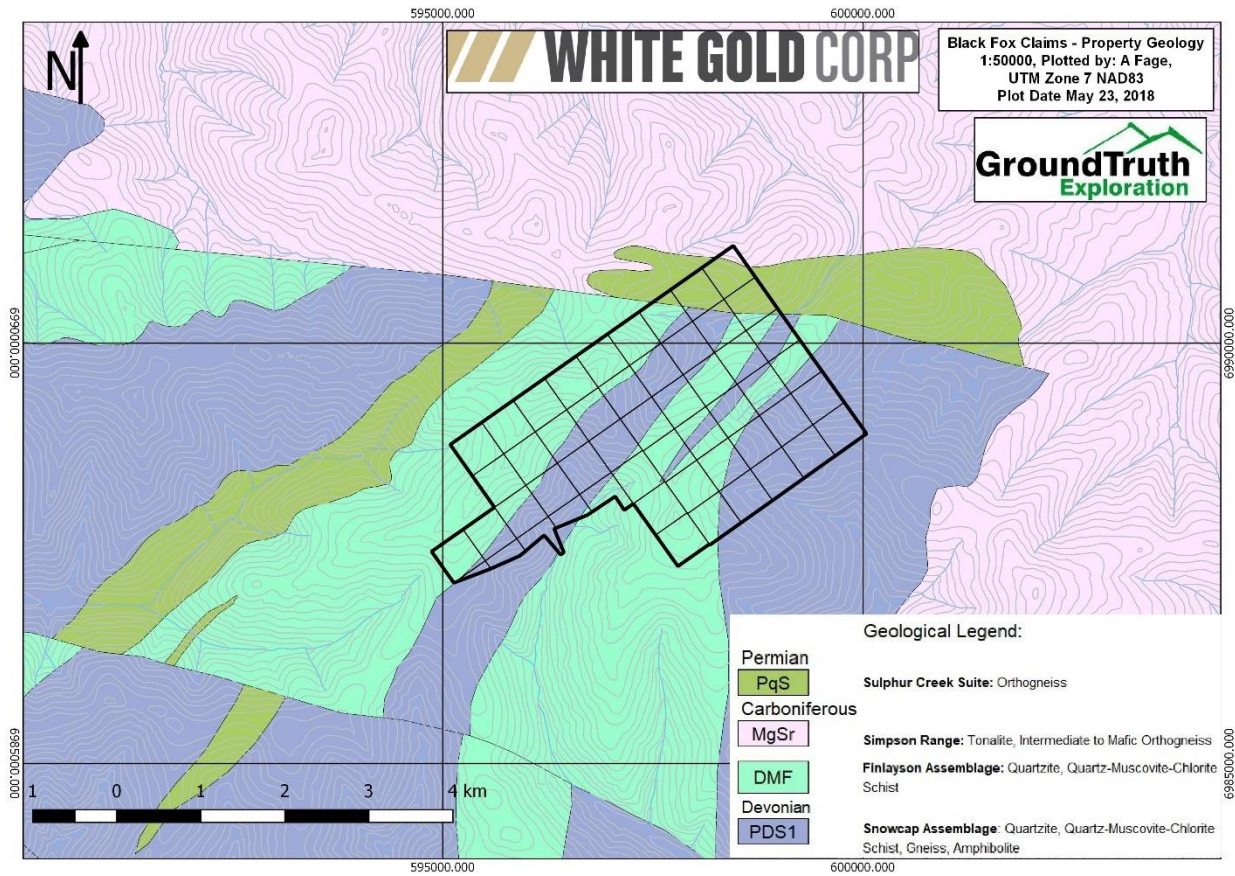
Figure 4: Local Geology of the Black Fox Property
Source: GSC (Jim Ryan, et al, 2013)

5   Dighem Survey Program

5.1   Introduction

This report describes data acquisition and preliminary data processing results of 2017 airborne frequency domain electromagnetic FDEM and magnetic survey. The survey has been carried out by CGG Canada Services. GroundTruth Exploration was commissioned by White Gold Corp, Toronto, ON to plan airborne survey and process the data.

Between August 14 and August 19, 2017, airborne-electromagnetic (AEM) and airborne-magnetic (AM) surveys were completed over Black Fox claims located in the Yukon Territory. This survey is a part of a comprehensive airborne FDEM and magnetic survey completed in order to target future exploration on the property.

Dawson City, Yukon was the base of operations. The airborne-geophysical surveys were undertaken using the DIGHEM frequency-domain system. Purpose and Scope

The primary purpose of completing AEM and AM geophysical surveys is to determine the spatial distribution of subsurface electrical and magnetic properties of rocks. This, in turn, will allow to characterize geophysical signatures for zones of mineralization and support geological models and structural mapping.

5.2   Survey Description

Block 602997-53 (Black Fox) of the DIGHEM 2017 survey covers some target areas on the Black Fox property. Total coverage of the survey block amounted to 232.2 line-km.

Data were acquired using a multi-coil, multi-frequency electromagnetic system, supplemented by a high-sensitivity cesium magnetometer. A GPS electronic navigation system ensured accurate positioning of the geophysical data with respect to the base map coordinates. The outline of survey areas and layout of flight lines are shown in Figure-5.

Block-53 was flown in an azimuthal direction of SE-NW (NE 120°) with line spacing 100m, and NE-SW (NE 210°) with tie lines spacing 2000m. Survey coverage consisted of 216.4 line-km of traverse lines and 15.7 line-km of tie lines for Block-53. The coordinates of the corner points of the survey block are presented in Table 1. Flight lines and total line-kilometers are summarized in Table 2 (after CGG report #602997, Oct. 6, 2017).
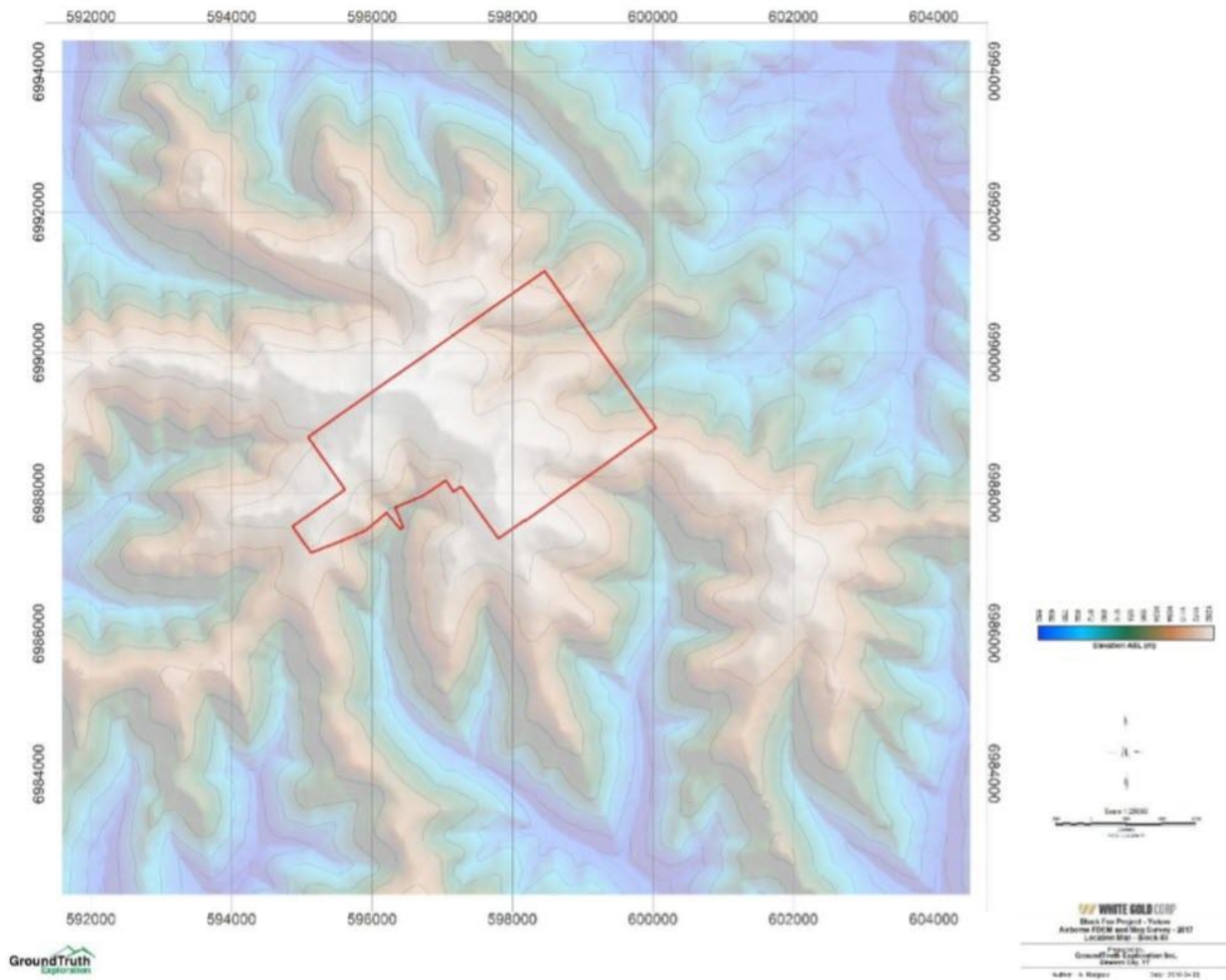
Figure 5: Location of airborne FDEM and Mag survey 2017 on Black Fox property.

Table 1: The coordinates of the corner points of the survey blocks.

Block	Corners	X-UTM (E)	Y-UTM (N)
602997-53	1	594985	6987155
Black Fox	2	597492	6991506
	3	601007	6989515
	4	598479	6985141

Table 2: Flight lines and line kilometers.

Block	Line Numbers	Line direction	Line Spacing	Line km
Block-53	530010-530500	SE-NW (120°)	100 metres	216.4
Black Fox	539010-539030	NE-SW (210°)	2000 metres	15.7

During the survey GPS base stations were set up to collect data to allow post-processing of the positional data for increased accuracy. The location of the GPS base stations are shown in Table 3 (after CGG report #602997, Oct. 6, 2017).

Table 3: GPS Base Station Location.

Location Name	WGS84 Longitude (deg-min-sec)	WGS84 Latitude (deg-min-sec)	Orthometric Height (m)	Date
Dawson City	139° 25' 34.30630" W	64° 03' 41.59730" N	336.380	31-Oct-16
Dawson City Airport	139° 06' 46.0395" W	64° 02' 51.1498" N	381.961	22-May-17
Camp	139° 25' 22.0172" W	63° 04' 00.3615" N	422.181	28-Aug-17

The location of the Magnetic base stations are shown in Table 4 (after CGG report #602997, Oct. 6, 2017).

Table 4: Magnetic Base Station Location.

Station	Location Name	WGS84 Longitude (deg-min-sec)	WGS84 Latitude (deg-min-sec)	Date
A	Dawson City, Yukon	139° 25' 49.22633" W	64° 03' 0.91004" N	31-Oct-16
B	Dawson City, Yukon	139° 25' 48.72540" W	64° 03' 1.10627" N	23-Nov-16
C	Dawson City, Yukon Airport	139° 7' 47. 4005" W	64° 02' 25.8578" N	22-May-17
D	Dawson City, Yukon	139° 7' 47.4087" W	64° 02' 25.7904" N	22-May-17
E	Camp	139° 25' 19.572" W	63° 04' 3.144" N	5-Aug-17
F	Camp	139° 25' 19.13448" W	63° 04' 3.00396" N	5-Aug-17

5.3 Survey Theory

5.3.1 Electromagnetic surveys

Electromagnetic (EM) methods can be used to map subsurface variability in electrical properties caused by changes in lithology, structure, alteration, and contamination due to mining activity. These methods are sensitive to low resistivity targets and thus can be used to map the location and moderately conductor bodies. The depth of investigation can range from less than a few tens through hundreds of meters depending on amounts of subsurface conductivity and applied frequency. Resolution of targets and detectability tend to decrease with increasing depth of burial.

The data include in-phase and quadrature components for each frequency. The electrical conductivity of rocks can be modeled by inversion of electromagnetic data. 2D grids and derivative products provide information for mapping lithological and structural features or linear conductors.

In EM surveys, a transmitter does generate a time-varying electromagnetic field in the earth, known as the primary field. This field gives rise to small time-varying voltages in the earth. Where the earth is conductive, the voltages drive small time-varying flows of current, which give rise to electromagnetic fields of their own called secondary fields. EM surveys measure the earth's willingness to conduct electricity, or conductivity in siemens/m. The higher the conductivity, the more current will flow in the earth for a given electrical field strength.

Any time-harmonic signal can be expressed by an amplitude factor times an oscillating term of a sinusoidal function. We denote the transmitter current as $I_o cos\omega t$, which indicates a peak current I_o and a fixed angular frequency ω. According to Biot-Savart's law, the primary magnetic field generated by this current is $H_p cos\omega t$, where H_p can be determined using the distance from the transmitter to an observation point in the whole-space, and the primary field is entirely in-phase with the transmitter current. Then the primary field induces eddy currents in the subsurface. In most cases, this induced current is no longer in-phase with the primary and usually bears a phase lag ψ. So the secondary magnetic field due to the induction has the form $H_s cos(\omega t-\psi)$, where the amplitude H_s is determined by the distance and geometric coupling. Finally, at the location of the receiver, we can observe the primary field $H_p cos\omega t$ the phase-lagged secondary field $H_s cos(\omega t-\psi)$.

An FDEM system in practice only measures the secondary field $H_s cos(\omega t - \psi)$. The convention in FDEM is to use the primary field $H_p cos\omega t$ as the reference to describe the secondary field data. First, the secondary field is considered as a linear combination of two orthogonal sinusoidal signals

$$H_s cos(\omega t - \psi) = H_s cos(\psi).cos(\omega t) + H_s sin(\psi).\sin(\omega t)$$

where $cos(\psi).cos(\omega t)$ represents a signal in-phase with the source and $sin(\psi).sin(\omega t)$ represents a signal out of phase with the source. The first term is also called "real"' and the second term "imaginary" or "quadrature". Next, the amplitudes of the two sinusoidal signals are normalized by the amplitude of the primary field at the receiver to obtain the data in real and imaginary components. Figure 6 shows primary and secondary fields, transmitter and receiver. The normalization provides significant convenience, as it eliminates the need for timing the measured signals and the effect of the transmitter and receiver's dipole moments. Because the data are relative quantities, they are expressed in percent or most often in parts per million (ppm).
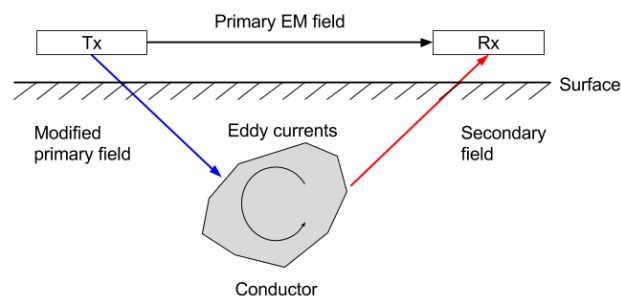
Figure 6: A time varying electrical current generates a primary magnetic field which induces secondary currents in the subsurface, and creates secondary magnetic field. Both the primary and secondary fields reach the receiver (2017, GeoSci Developers).

5.3.2 Magnetic surveys

Magnetic is the most commonly used geophysical method for gold, diamond, platinum group metals and base metal exploration. Measurements of the magnetic field contain information about subsurface variations in magnetic susceptibility. Data can be acquired in the air (planes, satellites), on the ground (stationary, moving platforms, marine) and underground (boreholes, tunnels). The measurements record the sum of Earth's field and fields induced in magnetic materials. More

magnetic (i.e. susceptible) materials have stronger induced fields. Removing Earth's field from the observations yields anomalous fields that can be interpreted in terms of where magnetic material lies and also its susceptibility and shape. Processed data are presented as maps or profiles, and advanced processing, involving inversion, yields parametric structures or 3D models of the subsurface susceptibility distribution.

Magnetic surveying is extremely versatile and can be applied in many areas in the geosciences including geologic mapping and mineral exploration. In gold exploration, magnetics helps in direct detection of associated mineralization and for mapping large- and local-scale structure (faults, dikes, and shear zones).

To a first approximation, Earth's magnetic field resembles a large dipolar source with a negative pole in the northern hemisphere and a positive pole in the southern hemisphere. The dipole is offset from the center of the earth and also tilted. The north magnetic pole at the surface of the earth is approximately at Melville Island. The field at any location on the Earth is generally described in terms described of magnitude $/B/$, declination D and inclination I as illustrated in Figure 7.

When the magnetic source field is applied to earth materials it causes the material to become magnetized. Magnetization is dipole moment per unit volume. This is a vector quantity because a dipole has a strength and a direction. For many cases of interest, the relationship between magnetization M and the source H (earth's magnetic field) is given by:

$$M = \kappa H$$

where κ is the magnetic susceptibility. Thus the magnetization has the same direction as the earth's field. Because Earth's field is different at different locations on the earth, then the same object gets magnetized differently depending on where it is situated. As a consequence, magnetic data from a steel drum buried at the north pole will be very different from that from a drum buried at the equator.

The magnetic field that results from the magnetized earth is evaluated with the equation:

$$B_A = \frac{\mu_0}{4\pi} \int_V M \cdot \nabla^2 \left(\frac{1}{r} \right) dV$$

where μ_0 is the magnetic permeability of free space, M is the magnetization per unit volume V, and r defines the distance between the object and the location of the

observer. This magnetic field is referred to as the "secondary" field or sometimes the "anomalous" field B_A. For geological or engineering problems, these anomalous fields are the data to be interpreted, and this is what we seek to measure.

When the magnetization is governed by the linear relationship (1) then the above anomalous field can be written as:

$$B_A = \frac{\mu_0}{4\pi} \int_V \kappa\, H_0 . \nabla^2 \left(\frac{1}{r}\right)\, dV$$

where (·) is a vector inner product. This means that B_x is the projection of the vector B onto a unit vector in the x-direction. Similar understandings exist for B_y and B_z.
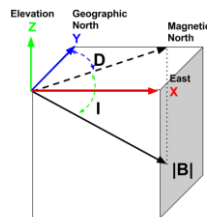
Figure 7: Earth's magnetic field, declination (D) and inclination angles (2017, GeoSci Developers).

5.4 Field Survey

Details of system information and survey parameters including aircraft, geophysical equipment, quality control and in-field data processing are presented in Appendix-A of this report.

5.5 Results and Interpretation

Survey flight lines of DIGHEM 2017 are shown in Figure 8, apparent resistivity maps for different frequencies are presented in Figure 9 through Figure 13. Residual magnetic intensity map is presented in Figure 14. The data can be processed in advanced levels using inversion techniques, and be presented in 3D formats for detail analysis and visualization. This will ensure that 3D geological models respect a consistent structural, stratigraphic, and topological framework in addition to ensuring consistency between different geophysical models.

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5.6 Deliverables
Report in pdf format

AIRBORNE FDEM AND MAGNETIC SURVEY for Black Fox Project, March 2018

Database in Geosoft format

602997_Archive-53.gdb

Maps in pdf format

DGM2017_BFX_AppResisivity900Hz.pdf	Apparent resistivity map at freq. 900 Hz
DGM2017_BFX _AppResisivity1000Hz.pdf	Apparent resistivity map at freq. 1000 Hz
DGM2017_BFX_AppResisivity5500Hz.pdf	Apparent resistivity map at freq 5500 Hz
DGM2017_BFX_AppResisivity7200Hz.pdf	Apparent resistivity map at freq 7200 Hz
DGM2017_BFX_AppResisivity56kHz.pdf	Apparent resistivity map at freq 56 kHz
DGM2017_BFX_LocationMap.pdf	Location Map
DGM2017_BFX_TMI_Blk-53.pdf	Total Magnetic Intensity
DGM2017_BFX_Flight_Lines.pdf	DIGHEM 2017 Flight Lines
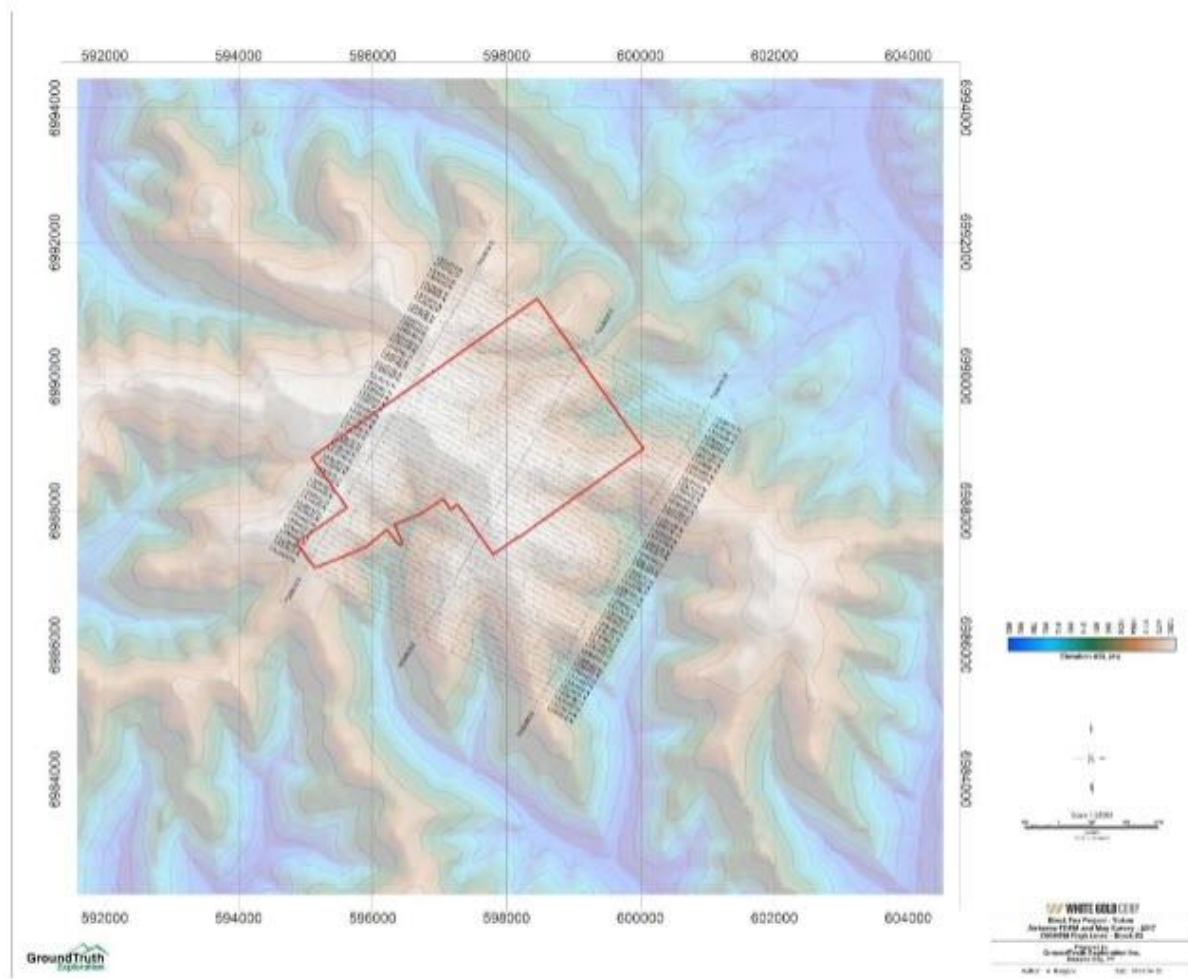
Figure 8: Flight line of DIGHEM 2017 survey.
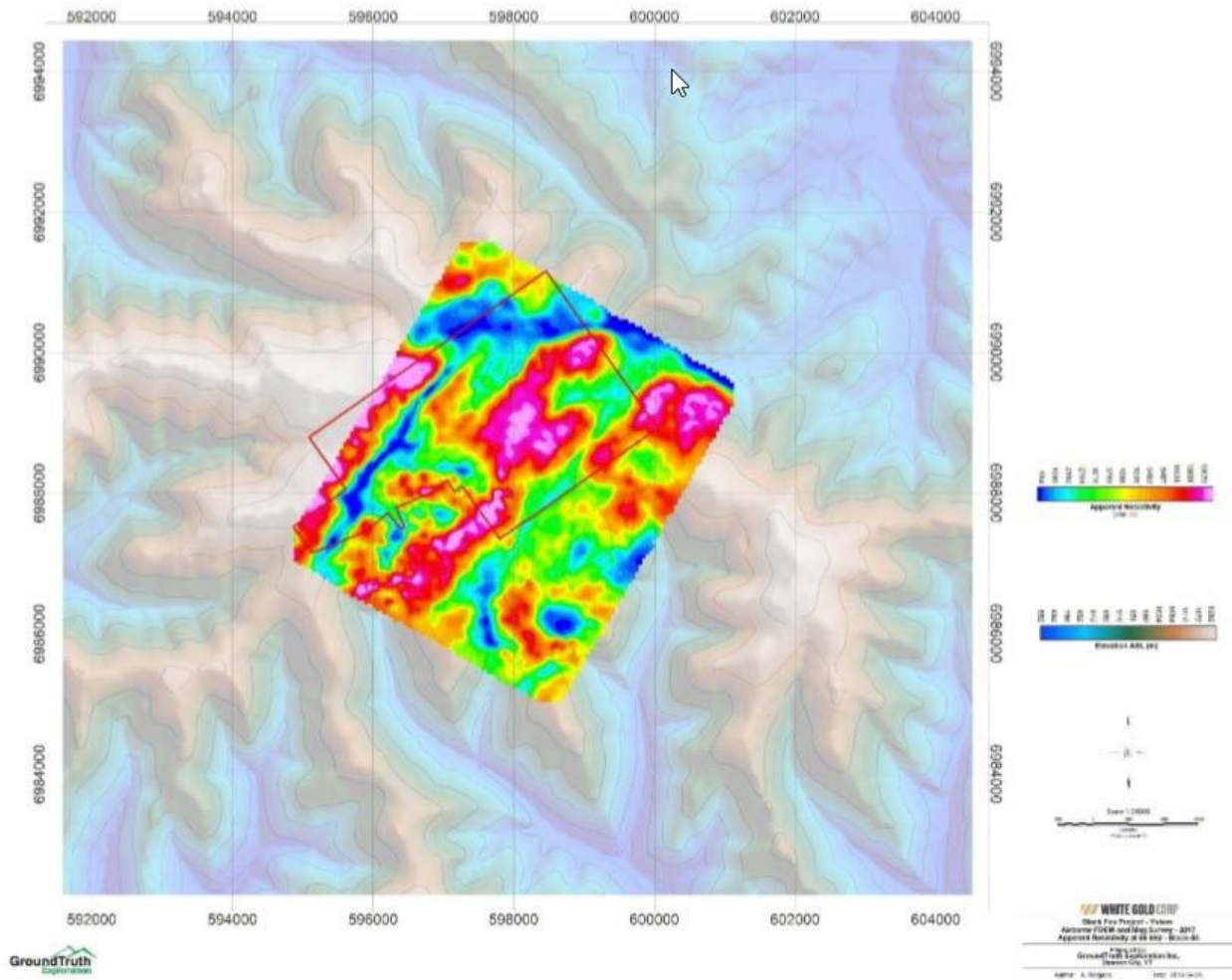
Figure 9: Apparent resistivity map at frequency 56 kHz from airborne DIGHEM survey 2017 on the Black Fox property
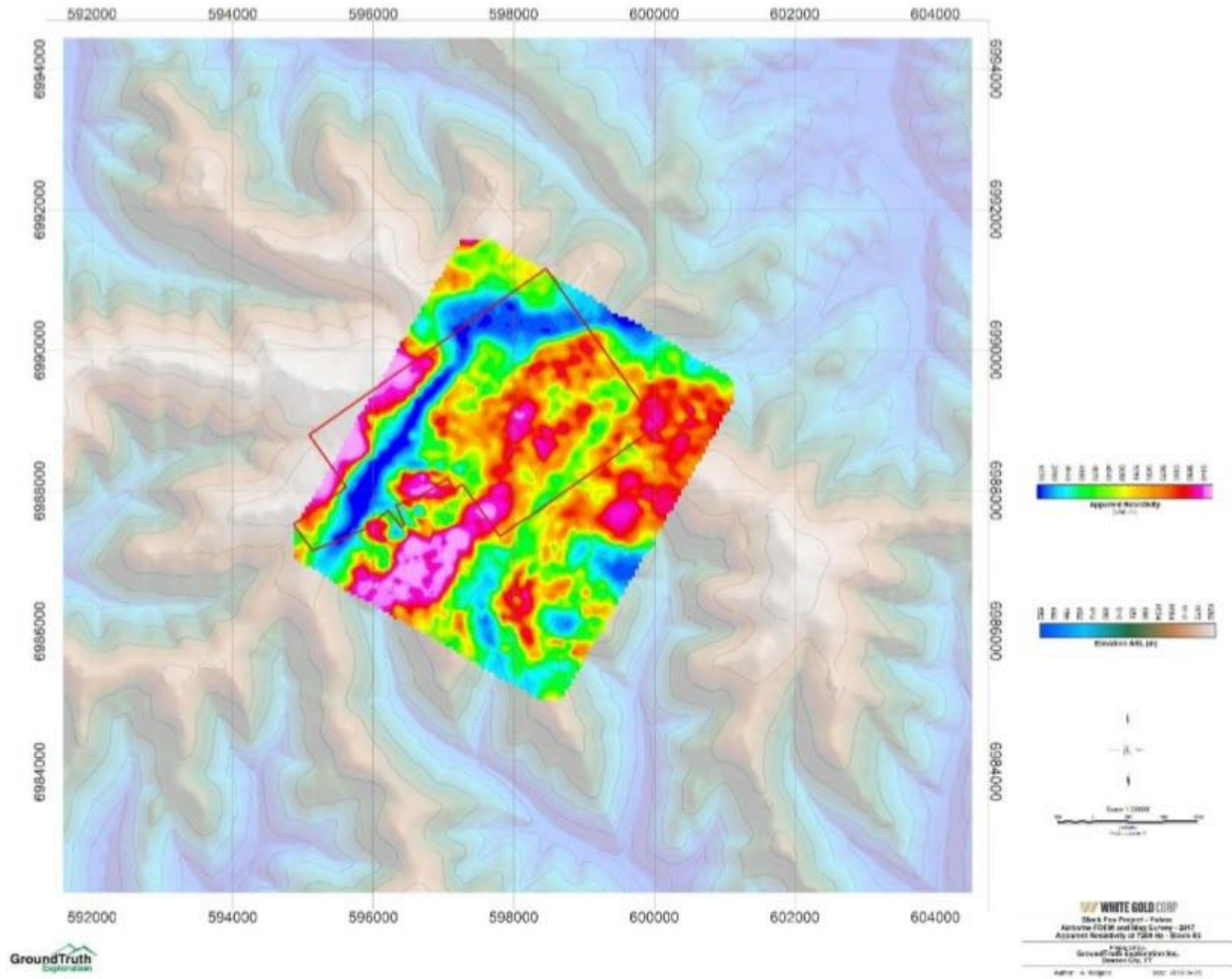
Figure 10: Apparent resistivity map at frequency 7200 Hz from airborne DIGHEM survey 2017 on the Black Fox property.
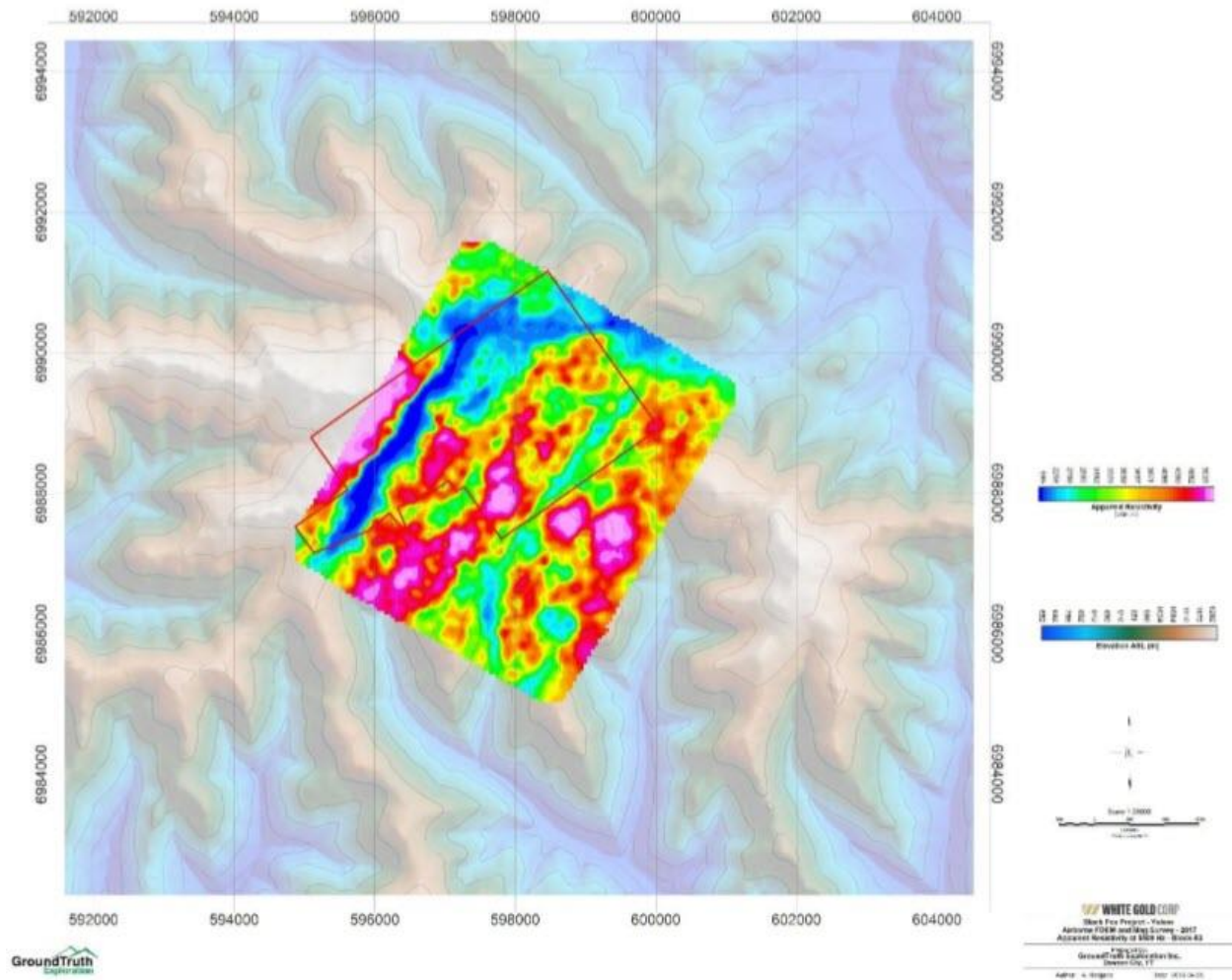
Figure 11: Apparent resistivity map at frequency 5500 Hz from airborne DIGHEM survey 2017 on the Black Fox property.
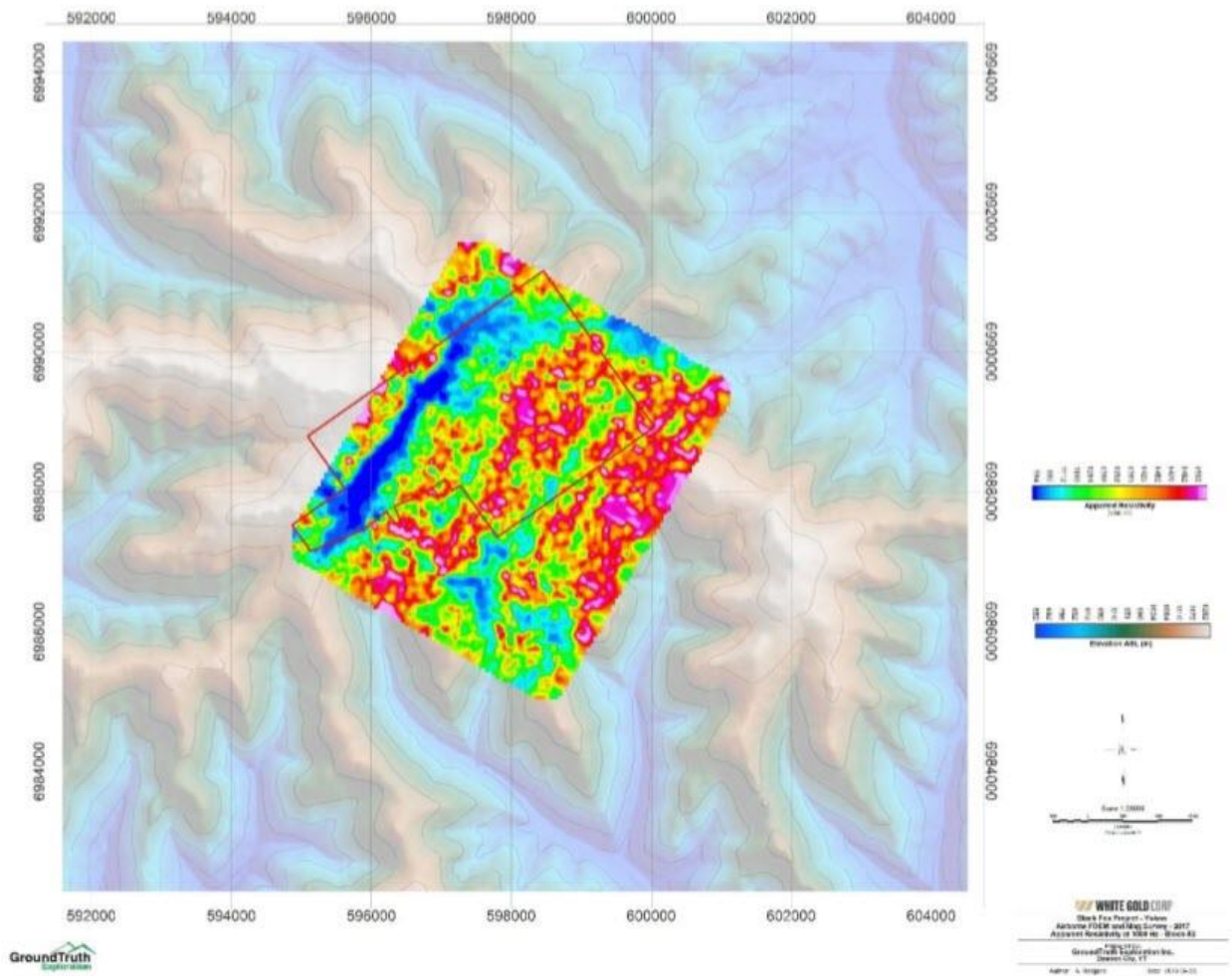
Figure 12: Apparent resistivity map at frequency 1000 Hz from airborne DIGHEM survey 2017 on the Black Fox property.
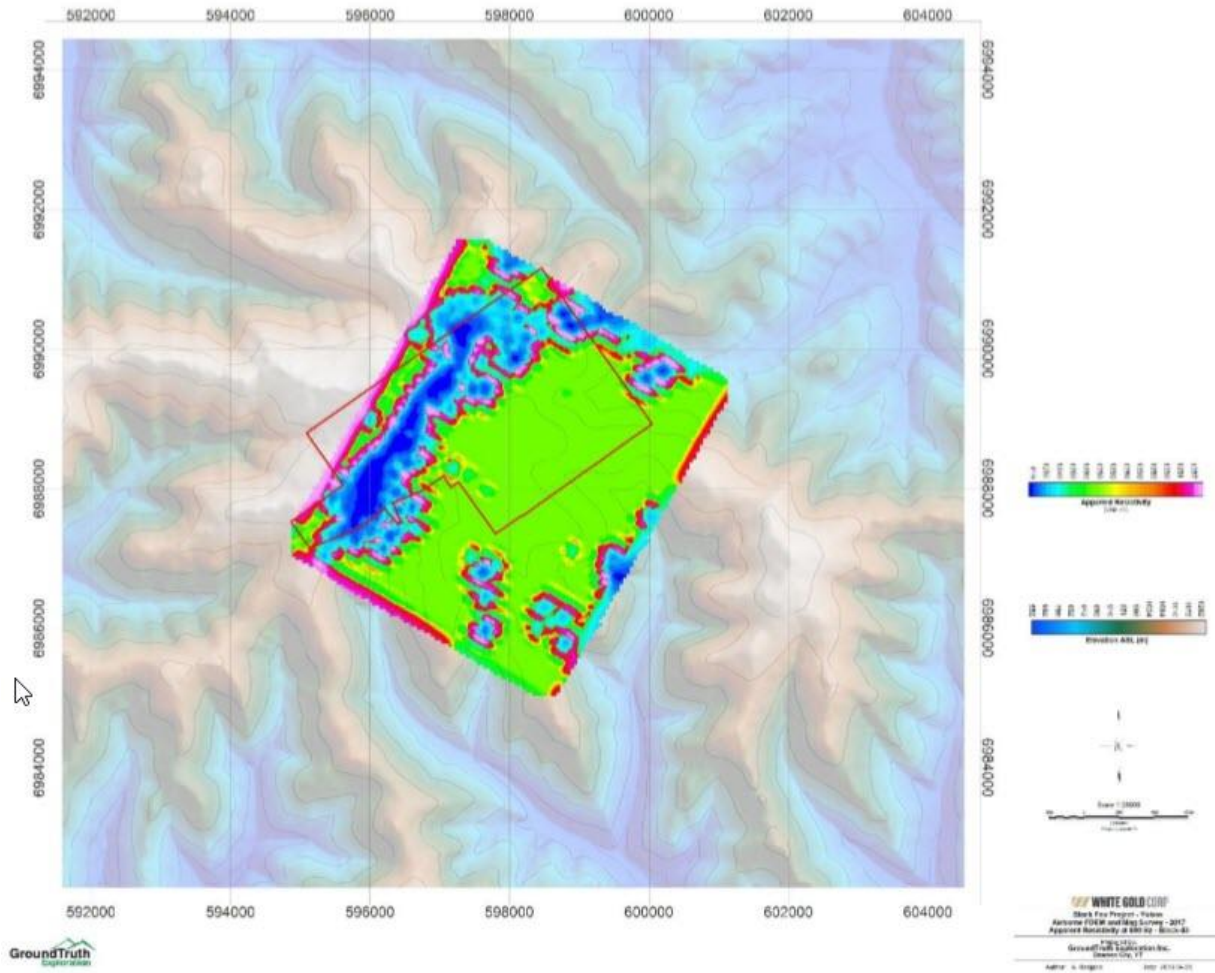
Figure 13: Apparent resistivity map at frequency 900 Hz from airborne DIGHEM survey 2017 on the Black Fox property.
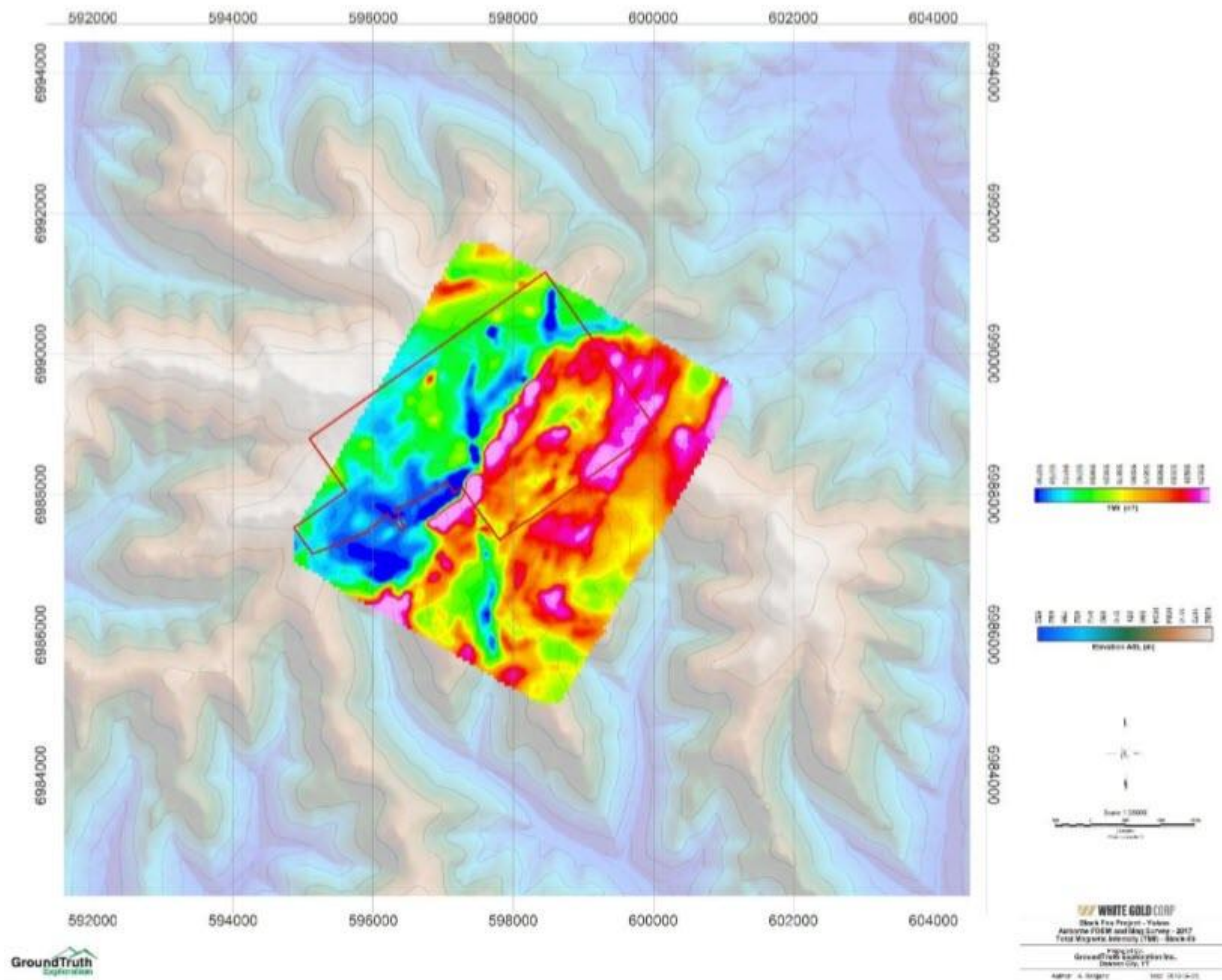
Figure 14: Total Magnetic Intensity from airborne DIGHEM survey 2017 on the Black Fox property.

6   Discussion and Interpretation

6.1   Dighem Survey

The combination of geophysical models and geological information allows some general correlations to be made. Commonly, geologic setting of epithermal deposits includes faulted, fractured, and brecciated rocks. Predominantly, geophysical signatures of epithermal deposits for electrical resistivity and magnetic susceptibility can be characterized as:

- Short-wavelength magnetic anomalies are common over volcanic terranes because of variable magnetizations and polarizations. This pattern may contrast with an area of moderate to intense alteration that will display a longer-wavelength low, often linear in the case of vein systems, caused by the destruction of magnetite. Local magnetic highs may be associated with intrusions. Magnetic lows will be associated with alteration, however, discriminating such lows from the background may be difficult on a deposit scale.

- Regional resistivity is generally low for weathered and altered rocks as compared to high resistivity typical of buried intrusions. A resistivity high flanked by resistivity lows is characteristic of a simple and idealized quartz vein system with associated argillic to propylitic alteration. However, there may be geologic structures and petrologic complications that distort this ideal picture. More generally, resistivity lows will be associated with: 1) Sulfides when concentrated and connected at about 5-percent volume or more, 2) argillic alteration, and 3) increased porosity related to wet, open fractures and brecciation. Resistivity highs will be associated with zones of silification, intrusion, or basement uplifts.

The apparent resistivity maps of airborne FDEM survey (Figure 9 to Figure 13) allow the geological structures to be remapped based on their conductivity. The EM results define a SW-NE trending conductor at the western part of Block-53 cut by an E-W conductive feature at the northern part. This might result from a change in lithology. There is also another linear sub-parallel conductive feature striking ESE-WNW. The boundaries and extension of the conductive features are more visible in higher frequency response. The conductive features are mappable after more processing works.

6.2 Interpretation

The total magnetic intensity TMI map (Figure 14) shows the magnetic field amplitude variation, which is within a range of 56550nT to 57750nT with a mean value of 56850nT for Block-53. The magnetic intensity is lower in the western parts of the block relative to the other areas. The magnetic results also define a pronounced N-S trending low magnetic anomaly which is broken across with a set of ENE-WSW trending linear features. Some major high magnetic anomaly exists at the center and eastern parts of Block-53.

The lineament interpretations of EM and magnetic results can better identify lithological and structures features as well as the fracture zones. Advanced inversion modeling and interpretation of EM and magnetic data is recommended for detailed and property scale explorational targeting works.

7   Recommendations

It is recommended that a comprehensive desktop study be undertaken combining all of the available geochemical, geophysical, and geological data available for the Black Fox property in order to determine a deposit, structural and exploration model for the multielement geochemical soil anomalies encountered to date. Once an exploration model is in place, further work can be planned.

8   Costs

Black Fox Dighem Survey	$26,867.50
Total 2017 expenditures on the Black Fox Property	$26,867.50

9   References

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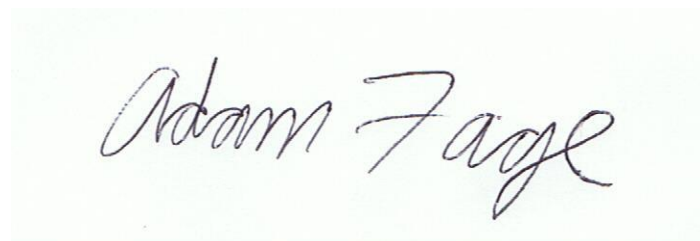
10 Qualification

I, Adam Fage have continuously been involved in Mineral Exploration since 2004. I graduated from Dalhousie University with an Honours Bachelor of Science (Earth Science) in 2008. I graduated from Lakehead University with a Master's of Science (Geology) in 2011.

Dated this 23th day of May, 2018.

Respectfully submitted

Adam Fage

Appendix A: Claims List

Grant Number	Name	Owner	Operator
YC30519	Black Fox 1	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC30520	Black Fox 2	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC30521	Black Fox 3	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC30522	Black Fox 4	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC30523	Black Fox 5	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC30524	Black Fox 6	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC30525	Black Fox 7	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC30526	Black Fox 8	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC30527	Black Fox 9	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC30528	Black Fox 10	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35176	Black Fox 11	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35177	Black Fox 12	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35178	Black Fox 13	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35179	Black Fox 14	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35180	Black Fox 15	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35181	Black Fox 16	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35182	Black Fox 17	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35183	Black Fox 18	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35184	Black Fox 19	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35185	Black Fox 20	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35186	Black Fox 21	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35187	Black Fox 22	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35188	Black Fox 23	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35189	Black Fox 24	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35190	Black Fox 25	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35191	Black Fox 26	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35192	Black Fox 27	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35193	Black Fox 28	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35194	Black Fox 29	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35195	Black Fox 30	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35196	Black Fox 31	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35197	Black Fox 32	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35198	Black Fox 33	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35199	Black Fox 34	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35200	Black Fox 35	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35201	Black Fox 36	Selene Holdings LP - 100%	White Gold Corp. - 100%

YC35202	Black Fox 37	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC35203	Black Fox 38	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36525	Black Fox 39	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36526	Black Fox 40	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36527	Black Fox 41	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36528	Black Fox 42	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36529	Black Fox 43	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36530	Black Fox 44	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36531	Black Fox 45	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36532	Black Fox 46	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36533	Black Fox 47	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36534	Black Fox 48	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36535	Black Fox 49	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36536	Black Fox 50	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36537	Black Fox 51	Selene Holdings LP - 100%	White Gold Corp. - 100%
YC36538	Black Fox 52	Selene Holdings LP - 100%	White Gold Corp. - 100%

Appendix B: Statement of Expenditures

Item	Quantity	Cost	unit	Total	Comment
Survey	232.2	$50.00	line km	$11,610.00	
Helicopter - Survey	6.25	$1,550.00	hour	$9,687.50	
Helicopter -Ferry	0.25	$1,550.00	hour	$387.50	
Fuel	1170	$2.00	litre	$2,340.00	sealed drum inclusive of delivery and positioning
Crew R&B	8	$50.00	man day	$400.00	$50 /day CDN charge for R&B at Thistle
Total				**$24,425.00**	
10% Management Fee				**$2,442.50**	Management fee includes Amirs Report
Total				**$26,867.50**	
Fights completed on: Aug 14, 17-19					

GroundTruth
Exploration

Appendix C: SURVEY REPORT - AIRBORNE DIGHEM 2017GENERAL INFORMATION / DATA ARCHIVE After CGG Canada Project 602997 (Oct. 6, 2017)

GEOPHYSICAL REPORT
AIRBORNE FDEM AND MAGNETIC SURVEY

Appendix-H

SURVEY REPORT - AIRBORNE DIGHEM 2017
GENERAL INFORMATION / DATA ARCHIVE

After CGG Canada Project 602997 (Oct. 6, 2017)

GEOPHYSICAL SURVEY REPORT
AIRBORNE MAGNETIC, AND DIGHEM SURVEY
DAWSON CITY AREAS
PROJECT 602997
GROUNDTRUTH EXPLORATION

October 6 2017

Passion for Geoscience
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Disclaimer

1. The Survey that is described in this report was undertaken in accordance with current internationally accepted practices of the geophysical survey industry, and the terms and specifications of a Survey Agreement signed between the CLIENT and CGG. Under no circumstances does CGG make any warranties either expressed or implied relating to the accuracy or fitness for purpose or otherwise in relation to information and data provided in this report. The CLIENT is solely responsible for the use, interpretation, and application of all such data and information in this report and for any costs incurred and expenditures made in relation thereto. The CLIENT agrees that any use, reuse, modification, or extension of CGG's data or information in this report by the CLIENT is at the CLIENT's sole risk and without liability to CGG. Should the data and report be made available in whole or part to any third party, and such party relies thereon, that party does so wholly at its own and sole risk and CGG disclaims any liability to such party.

2. Furthermore, the Survey was performed by CGG after considering the limits of the scope of work and the time scale for the Survey.

3. The results that are presented and the interpretation of these results by CGG represent only the distribution of ground conditions and geology that are measurable with the airborne geophysical instrumentation and survey design that was used. CGG endeavours to ensure that the results and interpretation are as accurate as can be reasonably achieved through a geophysical survey and interpretation by a qualified geophysical interpreter. CGG did not perform any observations, investigations, studies or testing not specifically defined in the Agreement between the CLIENT and CGG. The CLIENT accepts that there are limitations to the accuracy of information that can be derived from a geophysical survey, including, but not limited to, similar geophysical responses from different geological conditions, variable responses from apparently similar geology, and limitations on the signal which can be detected in a background of natural and electronic noise, and geological variation. The data presented relates only to the conditions as revealed by the measurements at the sampling points, and conditions between such locations and survey lines may differ considerably.   CGG is not liable for the existence of any condition, the discovery of which would require the performance of services that are not otherwise defined in the Agreement.

4. The passage of time may result in changes (whether man-made or natural) in site conditions. The results provided in this report only represent the site conditions and geology for the period that the survey was flown.

5. Where the processing and interpretation have involved CGG's interpretation or other use of any information (including, but not limited to, topographic maps, geological maps, and drill information; analysis, recommendations and conclusions) provided by the CLIENT or by third parties on behalf of the CLIENT and upon which CGG was reasonably entitled or expected to rely upon, then the Survey is limited by the accuracy of such information. Unless otherwise stated, CGG was not authorized and did not attempt to independently verify the accuracy or completeness of such information that was received from the CLIENT or third parties during the performance of the Survey. CGG is not liable for any inaccuracies (including any incompleteness) in the said information.

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System Information

Figure 1 DIGHEM System

The DIGHEM system comprises a 30 m cable which tows a 9 m bird containing the EM transmitter and receiver coil pairs (three coplanar and two coaxial), a magnetometer, a laser altimeter and a GPS antenna for flight path recovery. The helicopter has a tail boom mounted GPS antenna for in-flight navigation, radar and barometric altimeters, a video camera and a data acquisition system.

Aircraft and Geophysical On-Board Equipment

Helicopter: AS350 B2

Operator: Trans North Helicopters

Registration: C-GRBT, C-FCHN

Average Survey Speed: 110 km/h (30m/s)

EM System: DIGHEM, symmetric dipole configurations.

Dipole Moment (Atm^2)	Orientation	Nominal Frequency	Actual Frequency	Coil Separation (m)
211	Coaxial	1,000 Hz 900 Hz	1,121 Hz 924 Hz	7.97 7.98
211	Coplanar Coaxial			7.92 7.98
67	Coplanar	5,500 Hz	5,453 Hz	6.32
56	Coplanar	7,200 Hz	7,452 Hz	
15		56,000 Hz	55,600 Hz	

Table 1 DIGHEM BKS51 Configuration

Dipole Moment (Atm^2)	Orientation	Nominal Frequency	Actual Frequency	Coil Separation (m)
211	Coaxial	1,000 Hz 900 Hz	1,112 Hz 920 Hz	7.98 7.98
211	Coplanar Coaxial			7.92 7.98
67	Coplanar	5,500 Hz	5,665 Hz	6.33
56	Coplanar	7,200 Hz	7,160 Hz	
15		56,000 Hz	56,260 Hz	

Table 2 DIGHEM BKS54 Configuration

Digital Acquisition: CGG HeliDAS.

Video: Panasonic WVCD/32 Camera with Axis 241S Video Server. Camera is mounted to the exterior bottom of the helicopter between the forward skid tubes

Magnetometer: Scintrex Cesium Vapour (CS-3), mounted in the EM bird;

Operating Range: 15,000 to 100,000 nT
Operating Limit: -40°C to 50°C

Accuracy: ±0.002 nT

Measurement Precision: 0.001 nT

Sampling rate: 10.0 Hz

Radar Altimeter: Honeywell Sperry Altimeter System. Radar antennas are mounted to the exterior bottom of the helicopter between the forward skid tubes

Operating Range: 0 – 2500ft
Operating Limit: -55°C to 70°C
                      0 to 55,000 ft
Accuracy:

                ± 3% (100 – 500ft above obstacle)

            ± 4% (500 – 2500ft above obstacle)
Measurement Precision: 1 ft
Sample Rate: 10.0 Hz

Laser Altimeter: Optech G-150 mounted in the EM bird;

Operating Range: 0.2 to 250 m Operating
Limit: -10°C to 45°C Accuracy:
                      ±5 cm (10°C to 30°C)
                      ±10 cm (-10°C to 45°C)
Measurement Precision: 1 cm
Sample Rate: 10.0 Hz

Aircraft Navigation: NovAtel OEM4 Card with an Aero antenna mounted on the tail of the helicopter;

Operating Limit: -40°C to 85°C
Real-Time Accuracy: 1.2m CEP (L1 WAAS);
Real-Time Measurement Precision: 6 cm RMS Sample Rate:
2.0 Hz

EM Bird Positional Data: NovAtel OEM4 with Aero Antenna mounted on the EM bird.

Operating Limit: -40°C to 85°C
Real-Time Accuracy: 1.8m CEP (L1);
Real-Time Measurement Precision: 6 cm RMS
Sample Rate: 2.0 Hz

Barometric Altimeter: Motorola MPX4115AP analog pressure sensor mounted in the helicopter

Operating Range: 55 kPa to 108 kPa Operating Limit: -40°C to 125°C
Accuracy:

                      ± 1.5 kPa (0°C to 85°C)

                      ± 3.0 kPa (-20°C to 0°C, 85°C to 105°C)

                      ± 4.5 kPa (-40°C to -20°C, 105°C to 125°C)
Measurement Precision: 0.01 kPa Sampling Rate = 10.0 Hz

Temperature:	Analog Devices 592 sensor mounted on the camera box

Operating Range: -40°C to + 75°C
Operating Limit: -40°C to + 75°C

Accuracy: ± 1.5°C
Measurement Precision: 0.03°C
Sampling Rate = 10.0 Hz

Base Station Equipment

Primary Magnetometer:	CGG CF1 using Scintrex cesium vapour sensor with Marconi GPS card and antenna for measurement synchronization to GPS. The base station also collects barometric pressure and outside temperature.

Magnetometer Operating Range: 15,000 to 100,000 nT
Barometric Operating Range: 55kPa to 108 kPa
Temperature Operating Range: -40°C to 75°C
Sample Rate: 1.0 Hz

GPS Receiver:	NovAtel OEM4 Card with an Aero antenna

Real-Time Accuracy: 1.8m
CEP (L1)
Sample Rate: 1.0 Hz

Secondary Magnetometer:	GEM Systems GSM-19

Operating Range: 20,000 to 120,000 nT Operating
Limit: -40°C to 60°C

Accuracy: ± 0.2 nT

Measurement Precision: 0.01 nT

Sample Rate: 0.33 Hz

Quality Control and In-Field Processing

Digital data for each flight were uploaded to the Mississauga office daily in order to verify data quality and completeness. A database was created and updated using Geosoft Oasis Montaj and proprietary CGG Atlas software. This allowed personnel to calculate, display and verify both the positional (flight path) and geophysical data. The initial database was examined as a preliminary assessment of the data acquired for each flight.

Initial processing of CGG survey data consists of differential corrections to the airborne GPS data, verification of EM calibrations, drift correction of the raw airborne EM data, spike rejection and filtering of all geophysical and ancillary data, calculation of preliminary resistivity data, and diurnal correction of magnetic data.

All data, including base station records, were checked on a daily basis to ensure compliance with the survey contract specifications. Re-flights were required if any of the following specifications were not met.

Navigation

A specialized GPS system provided in-flight navigation control. The system determined the absolute position of the helicopter by monitoring the range information of twelve channels (satellites). The Novatel OEM4 receiver was used for this application. In North America, the OEM4 receiver is WAAS-enabled (Wide Area Augmentation System) providing better real-time positioning.

A Novatel OEM4 GPS base station was used to record pseudo-range, carrier phase, ephemeris, and timing information of all available GPS satellites in view at a one second interval. These data are used to improve the conversion of aircraft raw ranges to differentially corrected aircraft position. The GPS antenna was setup in a location that allowed for clear sight of the satellites above. The set-up of the antenna also considered surfaces that could cause signal reflection around the antenna that could be a source of error to the received data measurements.

Flight Path

Flight lines did not deviate from the intended flight path by more than 25% of the planned flight path over a distance of more than 1 kilometre. Flight specifications were based on GPS positional data recorded at the helicopter.

Clearance

The 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.

The average survey elevation achieved for the helicopter and instrumentation during data collection was:

Helicopter	60 metres
Magnetometer	35 metres
DIGHEM EM sensor	35 metres

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

The achieved survey height was achieved for almost all the survey areas but was impacted by steep terrain in a few locations.

Airborne High Sensitivity Magnetometer

To assess the noise quality of the collected airborne magnetic data, CGG monitors the 4th difference results during flight which is verified post flight by the processor. The contracted specification for the collected airborne magnetic data was that the non-normalized 4th difference would not exceed 1.6 nT over a continuous distance of 1 kilometre excluding areas where this specification was exceeded due to natural anomalies.

Magnetic Base Station

Ground magnetic base stations were set-up to measure the total intensity of the earth's magnetic field. The base stations were placed in a magnetically quiet area, away from power lines and moving metallic objects. The contracted specification for the collected ground magnetic data was the non-linear variations in the magnetic data were not to exceed 10 nT per minute. CGG's standard of setting up the base station within 50 km from the centre of the survey block allowed for successful removal of the active magnetic events on the collected airborne magnetic data.

Electromagnetic Data

The contracted specification for the EM channels was a peak to peak noise envelope not to exceed the specified tolerance (Table 3) continuously over a horizontal distance of 2,000 metres under normal survey conditions.

The effects of spheric pulses were monitored on the EM channels by visual assessment of the data and monitoring of two spheric channels during flight operations. Spheric pulses may occur having strong peaks but narrow widths. During survey operation, there was minimal spheric activity and when it occurred it was manually removed. Flying was not performed when spheric pulses became sufficiently intense and frequent that digital data processing techniques could not recover useful data.

The acceptable noise limits of the EM channels are stated below:

Frequency	Coil Orientation	Peak to Peak Noise Envelope (ppm)
1,000 Hz	vertical coaxial	5.0
900 Hz 5,500 Hz	horizontal coplanar	10.0 10.0 20.0
7,200 Hz	vertical coaxial	40.0
56,000 Hz	horizontal coplanar	
	horizontal coplanar	

Table 3 EM System Noise Specifications

In-Flight EM System Calibration

Calibration of the system during the survey uses the CGG AutoCal automatic, internal calibration process. At the beginning and end of each flight, and at intervals during the flight, the system is flown up to high altitude to remove it from any "ground effect" (response from the earth). Any remaining signal from the receiver coils (base level) is measured as the zero level, and is removed from the data collected until the time of the next calibration. Following the zero level setting, internal calibration coils, for which the response phase and amplitude have been determined at the factory, are automatically triggered – one for each frequency. The on-time of the coils is sufficient to determine an accurate response through any ambient noise. The receiver response to each calibration coil "event" is compared to the expected response (from the factory calibration) for both phase angle and amplitude, and any phase and gain corrections are automatically applied to bring the data to the correct value.

In addition, the outputs of the transmitter coils are continuously monitored during the survey, and the gains are adjusted to correct for any change in transmitter output.

Because the internal calibration coils are calibrated at the factory (on a resistive half-space) ground calibrations using external calibration coils on-site are not necessary for system calibration. A check calibration may be carried out on-site to ensure all systems are working correctly. All system calibrations will be carried out in the air, at sufficient altitude that there will be no measurable response from the ground.

The internal calibration coils are rigidly positioned and mounted in the system relative to the transmitter and receiver coils. In addition, when the internal calibration coils are calibrated at the factory, a rigid jig is employed to ensure accurate response from the external coils.

Using real time Fast Fourier Transforms and the calibration procedures outlined above, the data are processed in real time, from measured total field at a high sampling rate, to in-phase and quadrature values at 10 samples per second.

Data Processing

Flight Path Recovery

To check the quality of the positional data the speed of the bird 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 five seconds in length. If the error is greater than five 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. The corrected WGS84 longitude and latitude coordinates were transformed to WGS84 using the following parameters.

Datum:	WGS84
Ellipsoid:	GRS80
Projection:	UTM Zone 7N
Central meridian:	141° West
False Easting:	500000 metres
False Northing:	0 metres
Scale factor:	0.9996
WGS84 to Local Conversion:	Molodensky
Dx,Dy,Dz:	0, 0, 0

Recorded video flight path may also be linked to the data and used for verification of the flight path. Fiducial numbers are recorded continuously and are displayed on the margin of each digital image. This procedure ensures accurate correlation of data with respect to visible features on the ground. The fiducials appearing on the video frames and the corresponding fiducials in the digital profile database originate from the data acquisition system and are based on incremental time from start-up. Along with the acquisition system time, UTC time is also recorded in parallel and displayed (Figure 3).

Altitude Data

Radar altimeter data are despiked by applying a 1.5 second median and smoothed using a 1.5 second Hanning filter. The radar altimeter data are then subtracted from the GPS elevation to create a digital elevation model that is gridded and used in conjunction with profiles of the radar altimeter and flight path video to detect any spurious values.

Laser altimeter data are despiked and filtered using an alpha-trim filter. The laser altimeter data are then subtracted from the GPS elevation to create a digital elevation model that is examined in grid format for spurious values. The laser does a better job of piercing the tree canopy than the radar altimeter, and was used in the resistivity/depth calculation.

Flight Number   **Heading (°)**   **Fiducial**

(HH:MM:SS.S)

UTC Time

Speed (km/h)

Latitude DDMM.MMMM (WGS84)
Longitude: DDMM.MMMM (WGS84)

Figure 2 Flight path video

Magnetic Base Station Diurnal

The raw diurnal data are sampled at 1 Hz and imported into a database. The data are filtered with a 51 second median filter and then a 51 second Hanning filter to remove spikes and smooth short wavelength variations. A non-linear 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, was removed to leave the diurnal variation. This diurnal variation is then ready to be used in the processing of the airborne magnetic data.

Residual Magnetic Intensity

The Total Magnetic Field (TMF) data collected in flight were profiled on screen along with a fourth difference channel calculated from the TMF. Spikes were removed manually where indicated by the fourth difference.

The despiked data were then corrected for lag by 2.1 seconds. The diurnal variation that was extracted from the filtered ground station data was then removed from the despiked and lagged TMF. The IGRF was calculated using the 2014 IGRF model for the specific survey location, date and altitude of the sensor and removed from the TMF to obtain the Residual Magnetic Intensity (RMI). The results were then levelled using tie and traverse line intercepts if necessary. Manual adjustments were applied to any lines that required levelling, as indicated by shadowed images of the gridded magnetic data. The manually levelled data were then subjected to a microlevelling filter if it was deemed necessary.

Calculated Vertical Magnetic Gradient

The levelled, Residual Magnetic Intensity grid was subjected to a processing algorithm that enhances the response of magnetic bodies in the upper 500 metres and attenuates the response of deeper bodies. The resulting calculated vertical gradient grid provides better definition and resolution of near-surface magnetic units. It also identifies weak magnetic features that may not be quite as evident in the RMI data. Regional magnetic variations and changes in lithology, however, may be better defined on the Residual Magnetic Intensity.

Electromagnetic Data

EM data are processed at the recorded sample rate of 10 Hz. Profiles of the data were examined on a flight by flight basis on screen to check in-flight calibrations and high altitude background removal. A lag of 1.1 seconds was applied and then a 0.9 second median and a 0.9 second Hanning filter were used to reduce noise to acceptable levels. Flights were then displayed and corrected for drift. Following that individual lines were displayed and further levelling corrections were applied while referencing the calculated apparent resistivity.

The EM data are examined to allow the interpreter to select the most appropriate EM anomaly picking controls for a given survey area. The EM picking parameters depend on several factors but are primarily based on the dynamic range of the resistivities within the survey area, and the types and expected geophysical responses of the targets being sought.

Apparent Resistivity

The apparent resistivities in ohm·m are generated from the in-phase and quadrature EM components for all of the coplanar frequencies, using a pseudo-layer half-space model. The inputs to the resistivity algorithm are the in-phase and quadrature amplitudes of the secondary field. The algorithm calculates the apparent resistivity in ohm·m, and the apparent height of the bird above the conductive source. Any difference between the apparent height and the true height, as measured by the laser altimeter, is called the pseudo-layer and reflects the difference between the real geology and a homogeneous halfspace. This difference is often attributed to the presence of a highly resistive upper layer. Any errors in the altimeter reading, caused by heavy tree cover, are included in the pseudo-layer and do not affect the resistivity calculation. The apparent depth estimates, however, will reflect the altimeter errors. Apparent resistivities calculated in this manner may differ from those calculated using other models.
In areas where the effects of magnetic permeability or dielectric permittivity have suppressed the in-phase responses, the calculated resistivities will be erroneously high. Various algorithms and inversion techniques can be used to partially correct for the effects of permeability and permittivity.

Apparent resistivity maps portray all of the information for a given frequency over the entire survey area. The large dynamic range afforded by the multiple frequencies makes the apparent resistivity parameter an excellent mapping tool.

The preliminary apparent resistivity images are carefully inspected to identify any lines or line segments that might require base level adjustments. Subtle changes between in-flight calibrations of the system can result in line-to-line differences that are more recognizable in resistive (low signal amplitude) areas. If required, manual level adjustments are carried out on the EM data to eliminate or minimize resistivity differences that can be attributed, in part, to changes in operating temperatures. These levelling adjustments are usually very subtle, and do not result in the degradation of discrete anomalies.

After the manual levelling process is complete, revised resistivity grids are created. The resulting grids can be subjected to a microlevelling technique in order to smooth the data for contouring. The coplanar resistivity parameter has a broad 'footprint' that requires very little filtering.

Digital Elevation

The laser altimeter values are subtracted from the differentially corrected and de-spiked GPS-Z values to produce profiles of the height above mean sea level along the survey lines. These values are gridded to produce contour maps showing approximate elevations within the survey area. Any subtle line-to-line discrepancies are manually removed. After the manual corrections are applied, the digital terrain data are filtered with a microlevelling algorithm.

The accuracy of the elevation calculation is directly dependent on the accuracy of the two input parameters, laser altimeter and GPS-Z. The GPS-Z value is primarily dependent on the number of available satellites. Although post-processing of GPS data will yield X and Y accuracies in the order of 1-2 metres, the accuracy of the Z value is usually much less, sometimes in the ±5 metre range. Further inaccuracies may be introduced during the interpolation and gridding process.

Because of the inherent inaccuracies of this method, no guarantee is made or implied that the information displayed is a true representation of the height above sea level. Although this product may be of some use as a general reference, THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.

Contour, Colour and Shadow Map Displays

The magnetic and resistivity data are interpolated onto a regular grid using a modified Akima spline technique. The resulting grid is suitable for image processing and generation of contour maps. The grid cell size is 20% of the line interval.

Colour maps are produced by interpolating the grid down to the pixel size. The parameter is then incremented with respect to specific amplitude ranges to provide colour "contour" maps.

Final Products

This section lists the final products that have been provided under the terms of the survey agreement. Other products can be prepared from the existing dataset, if requested. These include magnetic enhancements or derivatives, percent magnetite, resistivities corrected for magnetic permeability and/or dielectric permittivity, digital terrain, resistivity-depth sections, inversions, and overburden thickness. Most parameters can be displayed as contours, profiles, or in colour. All grids were created using the following parameters:

Projection Description:

Datum:	WGS84
Ellipsoid:	GRS80
Projection:	UTM Zone 7N
Central meridian:	141° West
False Easting:	500000 metres
False Northing:	0 metres
Scale factor:	0.9996
WGS84 to Local Conversion:	Molodensky

Dx,Dy,Dz: 0, 0, 0

Digital Archives

Line and grid data in the form of a Geosoft database (*.gdb) and XYZ file and Geosoft grids (*.grd) have been written to DVD. The formats and layouts of these archives are further described in Data Archive Description.

Report

Two paper copies of this Geophysical Survey Report plus a digital copy in PDF format.

Flight Path Videos

All survey flights in BIN/BDX format with a viewer.

CONCLUSIONS AND RECOMMENDATIONS

This report provides a very brief description of the survey results and describes the equipment, data processing procedures and logistics of the airborne survey over the Dawson City Areas, near Dawson City , Yukon.

Respectfully submitted,

CGG

R602997D

List of Personnel

The following personnel were involved in the acquisition, processing, interpretation and presentation of data, relating to a DIGHEM airborne geophysical survey carried out for GroundTruth Exploration over the Dawson City Areas near Dawson City , Yukon.

Amanda Heydorn	Project Manager
Brett Robinson	Project Manager
David Grenier	Project Manager
Chris Sawyer	Flight Planner
Serguei Ermakov	Electronics Technician
Gary Ellis	Electronics Technician
Andrew Hisperger	Electronics Technician
Lucas Charbonneau	Operator
Keith Lavalley	Operator
David Patzer	Operator
Devon Watson	Operator
Rob Brideau	Pilot (Trans North Helicopters)
Thomas McMahon	Pilot (Trans North Helicopters)
Robert Fauteaux	Pilot (Trans North Helicopters)
Jeff Anhel	AME (Trans North Helicopters)
Brian Haight	AME (Trans North Helicopters)
Alex Zlojutro	Data Processor
Ron Wiseman P.Geo	Data Processor
Russell Imrie P.Geo	Data Processor
Ruth Pritchard P.Geo	Data Processor

All personnel were employees of CGG, except where indicated.

Data Archive Description

Survey Details:

Survey Area Name:	Dawson City Areas
Project number:	602997
Client:	GroundTruth Exploration
Survey Company Name:	CGG
Flown Dates:	October 6, 2016 to July 7, 2017, 2012
Archive Creation Date:	September 12, 2012

Geodetic Information for map products:

Datum:	WGS84
Ellipsoid:	GRS80
Projection:	UTM Zone 7N
Central meridian:	141° West
False Easting:	500000 metres
False Northing:	0 metres
Scale factor:	0.9996
WGS84 to Local Conversion:	Molodensky
Dx,Dy,Dz:	0, 0, 0

Grid Archive:

Geosoft Grids:

File	Description	Units
rmi-*	Residual Magnetic Intensity block *	nT
cvg-*	Calculated Vertical Magnetic Gradient block *	nT/m
dtm-*	Digital Terrain Model block *	m
res56k-*	Apparent Resistivity coplanar 56,000 Hz block *	ohm·m
res7200-*	Apparent Resistivity coplanar 7,200 Hz block *	ohm·m
res900-*	Apparent Resistivity coplanar 900 Hz block *	ohm·m
res 1000-*	Apparent Resistivity coaxial 1,000 Hz block *	ohm·m
res 5500-*	Apparent Resistivity coaxial 900 Hz block *	ohm·m

Linedata Archive:

Geosoft Database Layout for files named 602997_archive-* where * indicates block number:

Field	Variable	Description	Units
1	x_wgs84_z7n	Easting WGS84	m
2	y_wgs84_z7n	Northing WGS84	m
3	zhg_tx	EM bird height above geoid	m
4	lat_tx	Latitude WGS84	degrees

5	lon_tx	Longitude WGS84	degrees
6	fid	fiducial	-
7	flight	Flight number	
8	date	Flight date	ddmmyy
9	altlas_tx	Bird height above surface from laser altimeter	m
10	altrad_heli	Helicopter height above surface from radar altimeter	m
11	dtm	Digital elevation model (above geoid)	m
12	mag_ds	Total magnetic field – spike rejected	m
13	diurnal_cor	Diurnal correction – base removed	nT
14	mag_ld	Total magnetic field –corrected for lag and diurnal variation	nT
15	igrf	international geomagnetic reference field	nT
16	rmi	Leveled residual magnetic intensity	nT
17	cpi900_filt	Coplanar inphase 900 Hz – spherics rejected	nT
18	cpq900_filt	Coplanar quadrature 900 Hz – spherics rejected	nT
19	cpi7200_filt	Coplanar inphase 7200 Hz – spherics rejected	ppm
20	cpq7200_filt	Coplanar quadrature 7200 Hz – spherics rejected	ppm
21	cpi56k_filt	Coplanar inphase 56 kHz – spherics rejected	ppm
22	cpq56k_filt	Coplanar quadrature 56 kHz – spherics rejected	ppm
23	cxi1000_filt	Coaxial inphase 1000 Hz – spherics rejected	ppm
24	cxq1000_filt	Coaxial quadrature 1000 Hz – spherics rejected	ppm
25	cxi5500_filt	Coaxial inphase 5500 Hz – spherics rejected	ppm
26	cxq5500_filt	Coaxial quadrature 5500 Hz – spherics rejected	ppm
27	cpi900_lev	Coplanar inphase 900 Hz – levelled	ppm
28	cpq900_lev	Coplanar quadrature 900 Hz – levelled	ppm
29	cpi7200_lev	Coplanar inphase 7200 Hz – levelled	ppm
30	cpq7200_lev	Coplanar quadrature 7200 Hz – levelled	ppm
31	cpi56K_lev	Coplanar inphase 56 kHz – levelled	ppm
32	cpq56K_lev	Coplanar quadrature 56 kHz – levelled	ppm
33	cxi1000_lev	Coaxial inphase 1000 Hz – levelled	ppm
34	cxq1000_lev	Coaxial quadrature 1000 Hz – levelled	ppm
35	cxi5500_lev	Coaxial inphase 5500 Hz – levelled	ppm
36	cxq5500_lev	Coaxial quadrature 5500 Hz – levelled	ppm
37	res900	Apparent Resistivity 900 Hz coplanar	ohm·m
38	res7200	Apparent Resistivity 7,200 Hz coplanar	ohm·m
39	res56K	Apparent Resistivity 56,000 Hz coplanar	ohm·m
40	res1000	Apparent Resistivity 1000 Hz coaxial	ohm·m
41	res5500	Apparent Resistivity 5500 Hz coaxial	ohm·m
42	dep900	Apparent Depth 900 Hz coplanar	m
43	dep7200	Apparent Depth 7,200 Hz coplanar	m
44	dep56K	Apparent Depth 56,000 Hz coplanar	m

45	dep1000	Apparent Depth 1000 Hz coaxial	m
46	dep5500	Apparent Depth 5500 Hz coaxial	m
47	powerline	Coplanar powerline monitor	

Note – The null values in the GDB and XYZ archives are displayed as *.

Report:

This geophysical survey report and the anomaly listing for Project #602997D in PDF format:

R602997D.pdf

Video:

Digital video in BIN/BDX format for all survey flights including a viewer.

CGGSurveyReplay

Background Information

Electromagnetics

CGG electromagnetic responses fall into two general classes, discrete and broad. The discrete class consists of sharp, well-defined anomalies from discrete conductors such as sulphide lenses and steeply dipping sheets of graphite and sulphides. The broad class consists of wide anomalies from conductors having a large horizontal surface such as flatly dipping graphite or sulphide sheets, saline water-saturated sedimentary formations, conductive overburden and rock, kimberlite pipes and geothermal zones. A vertical conductive slab with a width of 200 m would straddle these two classes.

The conductive earth (half-space) model is suitable for broad conductors. Resistivity contour maps result from the use of this model. A later section entitled **Resistivity Mapping** describes the method further, including the effect of using it on anomalies caused by discrete conductors such as sulphide bodies.

Geometric Interpretation

Figure 3 shows typical HEM anomaly shapes which are used to guide the geometric interpretation.
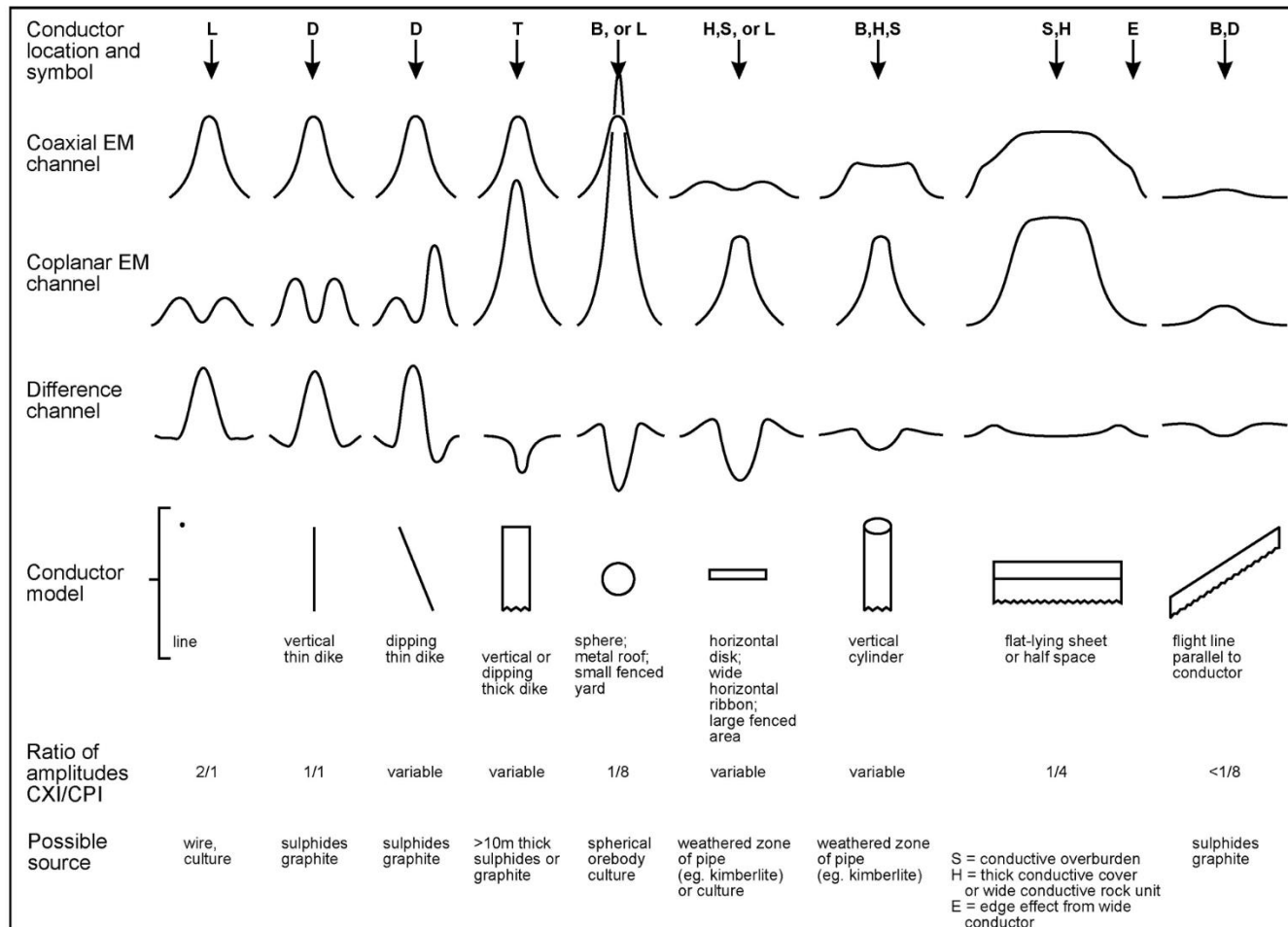
Typical HEM anomaly shapes

Figure **3** EM Anomaly Shapes

Resistivity Mapping

Resistivity mapping is useful in areas where broad or flat lying conductive units are of interest. One example of this is the clay alteration which is associated with Carlin-type deposits in the south west United States. The resistivity parameter was able to identify the clay alteration zone over the Cove deposit. The alteration zone appeared as a strong resistivity low on the 900 Hz resistivity parameter. The 7,200 Hz and 56,000 Hz resistivities showed more detail in the covering sediments, and delineated a range front fault. This is typical in many areas of the south west United States, where conductive near surface sediments, which may sometimes be alkalic, attenuate the higher frequencies.

Resistivity mapping has proven successful for locating diatremes in diamond exploration. Weathering products from relatively soft kimberlite pipes produce a resistivity contrast with the unaltered host rock. In many cases weathered kimberlite pipes were associated with thick conductive layers that contrasted with overlying or adjacent relatively thin layers of lake bottom sediments or overburden.

Areas of widespread conductivity are commonly encountered during surveys. These conductive zones may reflect alteration zones, shallow-dipping sulphide or graphite-rich units, saline ground water, or conductive overburden. In such areas, EM amplitude changes can be generated by decreases of only 5 m in survey altitude, as well as by increases in conductivity. The typical flight record in conductive areas is characterized by in-phase and quadrature channels that are continuously active. Local EM peaks reflect either increases in conductivity of the earth or decreases in survey altitude. For such conductive areas, apparent resistivity profiles and contour maps are necessary for the correct interpretation of the airborne data. The advantage of the resistivity parameter is that anomalies caused by altitude changes are virtually eliminated, so the resistivity data reflect only those anomalies caused by conductivity changes. The resistivity analysis also helps the interpreter to differentiate between conductive bedrock and conductive overburden. For example, discrete conductors will generally appear as narrow lows on the contour map and broad conductors (e.g., overburden) will appear as wide lows.

The apparent resistivity is calculated using the pseudo-layer (or buried) half-space model defined by Fraser (1978)[1]. This model consists of a resistive layer overlying a conductive half-space. The depth channels give the apparent depth below surface of the conductive material. The apparent depth is simply the apparent thickness of the overlying resistive layer. The apparent depth (or thickness) parameter will be positive when the upper layer is more resistive than the underlying material, in which case the apparent depth may be quite close to the true depth.

The apparent depth will be negative when the upper layer is more conductive than the underlying material, and will be zero when a homogeneous half-space exists. The apparent depth parameter

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[1]Resistivity mapping with an airborne multicoil electromagnetic system: Geophysics, v. 43, p.144-172

must be interpreted cautiously because it will contain any errors that might exist in the measured altitude of the EM bird (e.g., as caused by a dense tree cover). The inputs to the resistivity algorithm are the in-phase and quadrature components of the coplanar coil-pair. The outputs are the apparent resistivity of the conductive half-space (the source) and the sensor-source distance. The flying height is not an input variable, and the output resistivity and sensor-source distance are independent of the flying height when the conductivity of the measured material is sufficient to yield significant in-phase as well as quadrature responses. The apparent depth, discussed above, is simply the sensor-source distance minus the measured altitude or flying height. Consequently, errors in the measured altitude will affect the apparent depth parameter but not the apparent resistivity parameter.

The apparent depth parameter is a useful indicator of simple layering in areas lacking a heavy tree cover. Depth information has been used for permafrost mapping, where positive apparent depths were used as a measure of permafrost thickness. However, little quantitative use has been made of negative apparent depths because the absolute value of the negative depth is not a measure of the thickness of the conductive upper layer and, therefore, is not meaningful physically.

Qualitatively, a negative apparent depth estimate usually shows that the EM anomaly is caused by conductive overburden. Consequently, the apparent depth channel can be of significant help in distinguishing between overburden and bedrock conductors.

Interpretation in Conductive Environments

The DEP channels, which give the apparent depth to the conductive material, also help to determine whether a conductive response arises from surficial material or from a conductive zone in the bedrock. When these channels ride above the zero level on the depth profiles (i.e., depth is negative), it implies that the EM and resistivity profiles are responding primarily to a conductive upper layer, i.e., conductive overburden. If the DEP channels are below the zero level, it indicates that a resistive upper layer exists, and this usually implies the existence of a bedrock conductor. If the low frequency DEP channel is below the zero level and the high frequency DEP is above, this suggests that a bedrock conductor occurs beneath conductive cover.

EM Magnetite Mapping

The information content of HEM data consists of a combination of conductive eddy current responses and magnetic permeability responses. The secondary field resulting from conductive eddy current flow is frequency-dependent and consists of both in-phase and quadrature components, which are positive in sign. On the other hand, the secondary field resulting from magnetic permeability is independent of frequency and consists of only an in-phase component which is negative in sign. When magnetic permeability manifests itself by decreasing the measured amount of positive in-phase, its presence may be difficult to recognize. However, when it manifests itself by yielding a negative in-phase anomaly (e.g., in the absence of eddy current flow), its presence is assured. In this latter case, the negative component can be used to estimate the percent magnetite content.

A magnetite mapping technique, based on the low frequency coplanar data, can be complementary to magnetometer mapping in certain cases. Compared to magnetometry, it is far less sensitive but is more able to resolve closely spaced magnetite zones, as well as providing an estimate of the amount of magnetite in the rock. The method is sensitive to ¼% magnetite by weight when the EM

sensor is at a height of 30 m above a magnetitic half-space. It can individually resolve steep dipping narrow magnetite-rich bands which are separated by 60 m. Unlike magnetometry, the EM magnetite method is unaffected by remanent magnetism or magnetic latitude.

The EM magnetite mapping technique provides estimates of magnetite content which are usually correct within a factor of 2 when the magnetite is fairly uniformly distributed. EM magnetite maps can be generated when magnetic permeability is evident as negative in-phase responses on the data profiles.

Like magnetometry, the EM magnetite method maps only bedrock features, provided that the overburden is characterized by a general lack of magnetite. This contrasts with resistivity mapping which portrays the combined effect of bedrock and overburden.

The Susceptibility Effect

When the host rock is conductive, the positive conductivity response will usually dominate the secondary field, and the susceptibility effect[2] will appear as a reduction in the in-phase, rather than as a negative value. The in-phase response will be lower than would be predicted by a model using zero susceptibility. At higher frequencies the in-phase conductivity response also gets larger, so a negative magnetite effect observed on the low frequency might not be observable on the higher frequencies, over the same body. The susceptibility effect is most obvious over discrete magnetite-rich zones, but also occurs over uniform geology such as a homogeneous half-space.

High magnetic susceptibility will affect the calculated apparent resistivity, if only conductivity is considered. Standard apparent resistivity algorithms use a homogeneous half-space model, with zero susceptibility. For these algorithms, the reduced in-phase response will, in most cases, make the apparent resistivity higher than it should be. It is important to note that there is nothing wrong with the data, nor is there anything wrong with the processing algorithms. The apparent difference results from the fact that the simple geological model used in processing does not match the complex geology.

Measuring and Correcting the Magnetite Effect

Theoretically, it is possible to calculate (forward model) the combined effect of electrical conductivity and magnetic susceptibility on an EM response in all environments. The difficulty lies, however, in separating out the susceptibility effect from other geological effects when deriving resistivity and susceptibility from EM data.

Over a homogeneous half-space, there is a precise relationship between in-phase, quadrature, and altitude. These are often resolved as phase angle, amplitude, and altitude. Within a reasonable

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[2] Magnetic susceptibility and permeability are two measures of the same physical property. Permeability is generally given as relative permeability, μ_r, which is the permeability of the substance divided by the permeability of free space ($4\pi \times 10^{-7}$). Magnetic susceptibility k is related to permeability by $k=\mu^r-1$. Susceptibility is a unitless measurement, and is usually reported in units of 10^{-6}. The typical range of susceptibilities is -1 for quartz, 130 for pyrite, and up to 5×10^5 for magnetite, in 10^{-6} units (Telford et al, 1986).

range, any two of these three parameters can be used to calculate the half space resistivity. If the rock has a positive magnetic susceptibility, the in-phase component will be reduced and this departure can be recognized by comparison to the other parameters.

The algorithm used to calculate apparent susceptibility and apparent resistivity from HEM data, uses a homogeneous half-space geological model. Non half-space geology, such as horizontal layers or dipping sources, can also distort the perfect half-space relationship of the three data parameters. While it may be possible to use more complex models to calculate both rock parameters, this procedure becomes very complex and time-consuming. For basic HEM data processing, it is most practical to stick to the simplest geological model.

Magnetite reversals (reversed in-phase anomalies) have been used for many years to calculate an "FeO" or magnetite response from HEM data (Fraser, 1981).   However, this technique could only be applied to data where the in-phase was observed to be negative, which happens when susceptibility is high and conductivity is low.

Applying Susceptibility Corrections

Resistivity calculations done with susceptibility correction may change the apparent resistivity. Highsusceptibility conductors, that were previously masked by the susceptibility effect in standard resistivity algorithms, may become evident. In this case the susceptibility corrected apparent resistivity is a better measure of the actual resistivity of the earth. However, other geological variations, such as a deep resistive layer, can also reduce the in-phase by the same amount. In this case, susceptibility correction would not be the best method. Different geological models can apply in different areas of the same data set. The effects of susceptibility, and other effects that can create a similar response, must be considered when selecting the resistivity algorithm.

Susceptibility from EM vs Magnetic Field Data

The response of the EM system to magnetite may not match that from a magnetometer survey. First, HEMderived susceptibility is a rock property measurement, like resistivity. Magnetic data show the total magnetic field, a measure of the potential field, not the rock property. Secondly, the shape of an anomaly depends on the shape and direction of the source magnetic field.   The electromagnetic field of HEM is much different in shape from the earth's magnetic field. Total field magnetic anomalies are different at different magnetic latitudes; HEM susceptibility anomalies have the same shape regardless of their location on the earth.

In far northern latitudes, where the magnetic field is nearly vertical, the total magnetic field measurement over a thin vertical dike is very similar in shape to the anomaly from the HEM-derived susceptibility (a sharp peak over the body). The same vertical dike at the magnetic equator would yield a negative magnetic anomaly, but the HEM susceptibility anomaly would show a positive susceptibility peak.

Effects of Permeability and Dielectric Permittivity

Resistivity algorithms that assume free-space magnetic permeability and dielectric permittivity, do not yield reliable values in highly magnetic or highly resistive areas. Both magnetic polarization and displacement currents cause a decrease in the in-phase component, often resulting in negative values that yield erroneously high apparent resistivities. The effects of magnetite occur at all frequencies, but are most evident at the lowest frequency. Conversely, the negative effects of dielectric permittivity are most evident at the higher frequencies, in resistive areas.

Table 4 below shows the effects of varying permittivity over a resistive (10,000 ohm-m) half space, at frequencies of 56,000 Hz (DIGHEM) and 102,000 Hz (RESOLVE).

Apparent Resistivity Calculations

Freq (Hz)	Coil	Sep (m)	Thres (ppm)	Alt (m)	In Phase	Quad Phase	App Res	App Depth (m)	Permittivity
56,000	CP	6.3	0.1	30	7.3	35.3	10118	-1.0	1 Air
56,000	CP	6.3	0.1	30	3.6	36.6	19838	-13.2	5 Quartz
56,000	CP	6.3	0.1	30	-1.1	38.3	81832	-25.7	10 Epidote
56,000	CP	6.3	0.1	30	-10.4	42.3	76620	-25.8	20 Granite
56,000	CP	6.3	0.1	30	-19.7	46.9	71550	-26.0	30 Diabase
56,000	CP	6.3	0.1	30	-28.7	52.0	66787	-26.1	40 Gabbro
102,000	CP	7.86	0.1	30	32.5	117.2	9409	-0.3	1 Air
102,000	CP	7.86	0.1	30	11.7	127.2	25956	-16.8	5 Quartz
102,000	CP	7.86	0.1	30	-14.0	141.6	97064	-26.5	10 Epidote
102,000	CP	7.86	0.1	30	-62.9	176.0	83995	-26.8	20 Granite
102,000	CP	7.86	0.1	30	-107.5	215.8	73320	-27.0	30 Diabase
102,000	CP	7.86	0.1	30	-147.1	259.2	64875	-27.2	40 Gabbro

Table 4 Effects of Permittivity on In-phase/Quadrature/Resistivity

Methods have been developed (Huang and Fraser, 2000, 2001) to correct apparent resistivities for the effects of permittivity and permeability. The corrected resistivities yield more credible values than if the effects of permittivity and permeability are disregarded.

Recognition of Culture

Cultural responses include all EM anomalies caused by man-made metallic objects. Such anomalies may be caused by inductive coupling or current gathering. The concern of the interpreter

is to recognize when an EM response is due to culture. Points of consideration used by the interpreter, when coaxial and coplanar coil-pairs are operated at a common frequency, are as follows:

1. Channels CXPL and CPPL monitor 60 Hz radiation. An anomaly on these channels shows that the conductor is radiating power. Such an indication is normally a guarantee that the conductor is cultural. However, care must be taken to ensure that the conductor is not a geologic body that strikes across a power line, carrying leakage currents.

2. A flight that crosses a "line" (e.g., fence, telephone line, etc.) yields a centre-peaked coaxial anomaly and an m-shaped coplanar anomaly (see Figure 3). When the flight crosses the cultural line at an acute angle of intersection, the amplitude ratio of coaxial/coplanar response is 2. Such an EM anomaly can only be caused by a line. The geologic body that yields anomalies most closely resembling a line is the vertically dipping thin dike. Such a body, however, yields an amplitude ratio of 1 rather than 2. Consequently, an m-shaped coplanar anomaly with a CXI/CPI amplitude ratio of 2 is virtually a guarantee that the source is a cultural line.

3. A flight that crosses a sphere or horizontal disk yields centre-peaked coaxial and coplanar anomalies with a CXI/CPI amplitude ratio (i.e., coaxial/coplanar) of $1/8$. In the absence of geologic bodies of this geometry, the most likely conductor is a metal roof or small fenced yard.

4. A flight that crosses a horizontal rectangular body or wide ribbon yields an m-shaped coaxial anomaly and a centre-peaked coplanar anomaly. In the absence of geologic bodies of this geometry, the most likely conductor is a large fenced area. Anomalies of this type are virtually certain to be cultural if they occur in an area of culture.

5. EM anomalies that coincide with culture, as seen on the camera film or video display, are usually caused by culture. However, care is taken with such coincidences because a geologic conductor could occur beneath a fence, for example. In this example, the fence would be expected to yield an mshaped coplanar anomaly as in case #2 above. If, instead, a centre-peaked coplanar anomaly occurred, there would be concern that a thick geologic conductor coincided with the cultural line.

6. The above description of anomaly shapes is valid when the culture is not conductively coupled to the environment. In this case, the anomalies arise from inductive coupling to the EM transmitter. However, when the environment is quite conductive (e.g., less than 100 ohm-m at 900 Hz), the cultural conductor may be conductively coupled to the environment. In this latter case, the anomaly shapes tend to be governed by current gathering. Current gathering can completely distort the anomaly shapes, thereby complicating the identification of cultural anomalies. In such circumstances, the interpreter can only rely on the radiation channels and on the camera film or video records.

Magnetic Responses

The measured total magnetic field provides information on the magnetic properties of the earth materials in the survey area. The information can be used to locate magnetic bodies of direct interest for exploration, and for structural and lithological mapping.

The total magnetic field response reflects the abundance of magnetic material in the source. Magnetite is the most common magnetic mineral. Other minerals such as ilmenite, pyrrhotite, franklinite, chromite, hematite, arsenopyrite, limonite and pyrite are also magnetic, but to a lesser extent than magnetite on average.
In some geological environments, an EM anomaly with magnetic correlation has a greater likelihood of being produced by sulphides than one which is non-magnetic. However, sulphide ore bodies may be non-magnetic (e.g., the Kidd Creek deposit near Timmins, Canada) as well as magnetic (e.g., the Mattabi deposit near Sturgeon Lake, Canada).

Iron ore deposits will be anomalously magnetic in comparison to surrounding rock due to the concentration of iron minerals such as magnetite, ilmenite and hematite.

Changes in magnetic susceptibility often allow rock units to be differentiated based on the total field magnetic response. Geophysical classifications may differ from geological classifications if various magnetite levels exist within one general geological classification. Geometric considerations of the source such as shape, dip and depth, inclination of the earth's field and remanent magnetization will complicate such an analysis.

In general, mafic lithologies contain more magnetite and are therefore more magnetic than many sediments which tend to be weakly magnetic. Metamorphism and alteration can also increase or decrease the magnetization of a rock unit.

Textural differences on a total field magnetic contour, colour or shadow map due to the frequency of activity of the magnetic parameter resulting from inhomogeneities in the distribution of magnetite within the rock, may define certain lithologies. For example, near surface volcanics may display highly complex contour patterns with little line-to-line correlation.

Rock units may be differentiated based on the plan shapes of their total field magnetic responses. Mafic intrusive plugs can appear as isolated "bulls-eye" anomalies. Granitic intrusives appear as sub-circular zones, and may have contrasting rings due to contact metamorphism. Generally, granitic terrain will lack a pronounced strike direction, although granite gneiss may display strike.

Linear north-south units are theoretically not well-defined on total field magnetic maps in equatorial regions due to the low inclination of the earth's magnetic field. However, most stratigraphic units will have variations in composition along strike that will cause the units to appear as a series of alternating magnetic highs and lows.

Faults and shear zones may be characterized by alteration that causes destruction of magnetite (e.g., weathering) that produces a contrast with surrounding rock. Structural breaks may be filled by magnetite-rich, fracture filling material as is the case with diabase dikes, or by non-magnetic felsic material.

Faulting can also be identified by patterns in the magnetic total field contours or colours. Faults and dikes tend to appear as lineaments and often have strike lengths of several kilometres. Offsets in narrow, magnetic, stratigraphic trends also delineate structure. Sharp contrasts in magnetic lithologies may arise due to large displacements along strike-slip or dip-slip faults.

GLOSSARY

CGG GLOSSARY OF AIRBORNE GEOPHYSICAL TERMS

accelerometer: an instrument that measures both acceleration (due to motion) and acceleration due to *gravity*.

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.

AGG: Airborne *gravity gradiometer.*

AGS: Airborne *gamma-ray spectrometry*.

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**.

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.

attitude: the orientation of a geophysical system relative to the earth. Some surveys assume the instrument attitudes are constant, and other surveys measure the attitude and correct the data for the changes in response because of attitude.

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.

base magnetometer: A stationary magnetometer used to record the *diurnal* variations in the earth's magnetic field; to be used to correct the survey magnetic data.
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: a procedure to ensure a geophysical instrument is measuring accurately and repeatably. Most often applied in *EM* and *gamma-ray spectrometry*.

calibration coil: A wire coil of known size and dipole moment, which is used to generate a field of known *amplitude* and *phase* or *decay constant* 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: [] 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: [t] 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 manmade objects, such as fences or pipelines.

continuation: mathematical procedure applied to *potential field* geophysical data to approximate data collected at a different altitude. Data can be continued upward to a higher altitude or downward to a lower altitude.

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, into 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: [] The capacity of a material to store electrical charge, this is most often measured as the relative permittivity [$_r$], 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.

dose rate: see **exposure rate**.

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 timevarying *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. Sometimes called "dose rate".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.

flight: a continuous interval of survey data collection, generally between stops at base to refuel.

flight-line: a single line of data across the survey area. Surveys are generally comprised of many parallel flight lines to cover the survey area, with wider-spaced *tie lines* perpendicular. Flight lines are generally separated by *turn-arounds* when the aircraft is outside the survey area.

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 harmonic *primary field* that oscillates over time (e.g. 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 *timedomain*.

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.

GGI: gravity gradiometer instrument. An airborne gravity gradiometer (AGG) consists of a GGI mounted in an inertial platform together with a temperature control system.

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 can be 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*.

gradiometer, gradiometry: instrument and measurement of the gradient, or change in a field with location usually for *gravity* or *magnetic* surveys. Used to provide higher resolution of *targets*, better *interpretation* of *target* geometry, independence from drift and absolute field and, for *gravity*, accelerations of the aircraft.

gravity: Survey collecting measurements of the earth's gravitational field strength. Denser objects in the earth create stronger gravitational pull above them.

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, *frequencydomain* 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*).

HFEM: Helicopter Frequency-domain ElectroMagnetic, This designation is used for helicopter-borne, **frequency-*domain*** electromagnetic systems. Formerly most often called HEM.

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 $\square\square\square\mathbf{h^2}$ and for a large, flat, *conductor* it is $\square\square\square\mathbf{th}$, where $\square$ is the *magnetic permeability*, $\square$ is the angular *frequency*, $\square$ 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.

lead-in: approach to a *flight line* outside of survey area to establish proper track and stabilize instrumentations. The lead-in for a helicopter survey is generally shorter than required for fixed-wing.

line source, or line current: a long narrow object that creates an ***anomaly*** on an ***EM*** survey. Generally man-made objects like fences, power lines, and pipelines (***culture***).

mag: common abbreviation for ***magnetic.***

magnetic: ("**mag**") a survey measuring the strength of the earth's magnetic field, to identify geology and targets by their effect on the field.

magnetic permeability: **[ ]** This is defined as the ratio of magnetic induction to the inducing magnetic field. The relative magnetic permeability [$_r$] 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= $_r$-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**.

natural source: any geophysical technique for which the source of the energy is from nature, not from a man-made object. Most commonly applied to natural source ***electromagnetic*** surveys.

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***.

potential field: A field that obeys Laplace's Equation. Most commonly used to describe ***gravity*** and ***magnetic*** measurements.

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: [□] 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*.

spec: common abbreviation for *gamma-ray spectrometry*.

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**.

stinger: A boom mounted on an aircraft to carry a geophysical sensor (usually **magnetic**). The boom moves the sensor farther from the aircraft, which might otherwise be a source of **noise** in the survey data.

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

TDEM: **time domain electromagnetic**.

thin sheet: A standard model for electromagnetic geophysical theory. It is usually defined as a thin, flatlying 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 **signal** 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. Also called a **flight line**.

turn-arounds: The time the aircraft is turning between one *traverse* or *tie line* and the next. Turn-arounds are generally outside the survey area, and the data collected during this time generally are not useable, because of aircraft *manoeuvre noise*.

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*.

zero, or zero level: The *base level* of an instrument, with no *ground effect* or *drift*. Also, the act of measuring and setting the zero level.

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, common unit for measurement of B-Field in time-domain EM
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

nT/s	nanoteslas/second; standard unit of measurement of secondary field dB/dt in time domain EM.
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	picoteslas: standard unit of measurement of B-Field in time-domain EM
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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