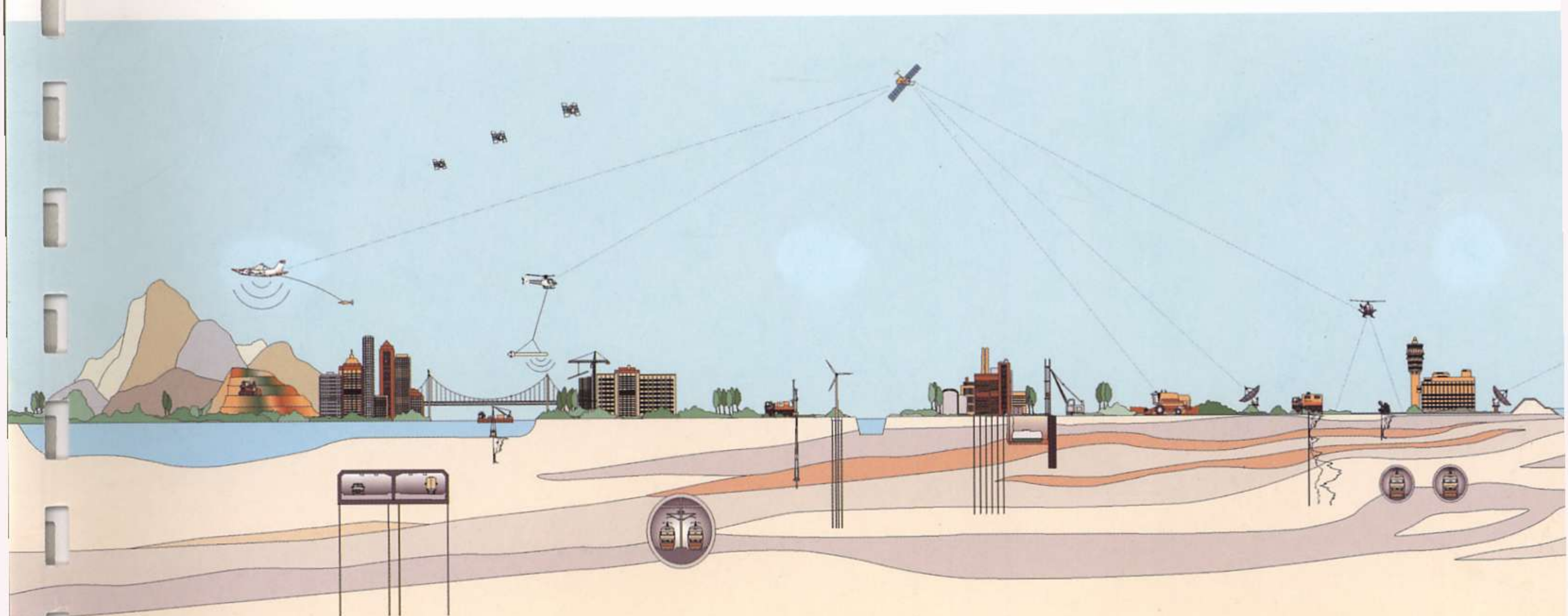
FUGRO AIRBORNE SURVEYS

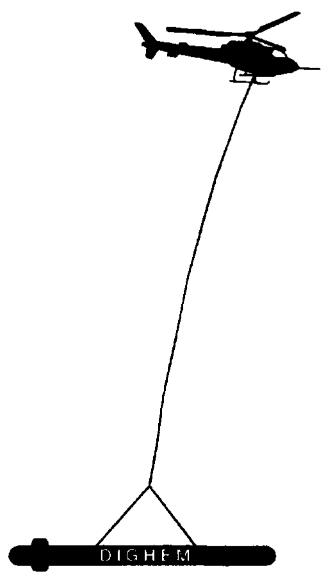
DIGHEM$^{V\text{-}DSP}$ SURVEY
FOR
GOLDRUSH RESOURCES LTD.
OK PROPERTY
POWELL RIVER AREA, B.C.



Report #04054

DIGHEM^{V-DSP} SURVEY FOR GOLDRUSH RESOURCES LTD. OK PROPERTY POWELL RIVER AREA, B.C.

NTS 92K/2; 92F/15



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SUMMARY

This report describes the logistics, data acquisition, processing and presentation of results of a DIGHEM^V airborne geophysical survey carried out for Goldrush Resources Ltd., over a property located near Powell River, B.C. Total coverage of the survey block amounted to 337 km. The survey was flown from July 12 to July 15, 2004.

The purpose of the survey was to detect porphyry-hosted mineralization, to detect any other zones of conductive sulphide mineralization, and to provide information that could be used to map the geology and structure of the survey area. This was accomplished by using a DIGHEM^{V-DSP} multi-coil, multi-frequency electromagnetic system, supplemented by a high sensitivity cesium magnetometer. The information from these sensors was processed to produce maps that display the magnetic and conductive properties of the survey area. A GPS electronic navigation system ensured accurate positioning of the geophysical data with respect to the base maps.

The survey data were processed and compiled in the Fugro Airborne Surveys Toronto office. Map products and digital data were provided in accordance with the scales and formats specified in the Survey Agreement.

The survey property contains several anomalous features, a few of which are considered to be of moderate to low priority as exploration targets. Some of the resistivity lows and resistivity highs may warrant further investigation using appropriate surface exploration techniques. Areas of interest may be assigned priorities on the basis of supporting

geophysical, geochemical and/or geological information. After initial investigations have been carried out, it may be necessary to re-evaluate the remaining anomalies based on information acquired from the follow-up program.

CONTENTS

APPENDICES

1. INTRODUCTION

A DIGHEM^{V-DSP} electromagnetic/resistivity/magnetic survey was flown for Goldrush Resources Ltd., from July 12 to July 15, 2004, over the OK Property, about 20 km north-northwest of Powell River, B.C. The survey area can be located on NTS map sheets 92K/2 and 92F/15.

Survey coverage consisted of approximately 337 line-km, including two tie lines. Flight lines were flown in an azimuthal direction of 062°/242° with a line separation of 100 metres. Orthogonal tie lines were flown near the eastern and western limits of the survey block.

The survey employed the DIGHEM^{V-DSP} electromagnetic system. Ancillary equipment consisted of a magnetometer, radar and barometric altimeters, video camera, a digital recorder, and an electronic navigation system. The instrumentation was installed in an AS350B3 turbine helicopter (Registration C-GECL) which was provided by Questral Helicopters Ltd. The helicopter flew at an average airspeed of 63 km/h with an EM sensor height of approximately 30 metres.

In some portions of the survey area, the moderately steep topography forced the pilot to exceed normal terrain clearance for reasons of safety. It is possible that some weak conductors may have escaped detection in any areas where the bird height exceeded 120 m. In difficult areas where near-vertical climbs were necessary, the forward speed of the helicopter was reduced to a level that permitted excessive bird swinging. This problem, combined with the severe stresses to which the bird was subjected, gave rise to aerodynamic noise levels that are slightly higher than normal on some lines. Where warranted, reflights were carried out to minimize these adverse effects.

2. SURVEY AREA

The base of operations for the survey was established at the Texada Island Inn, Powell River, B.C.

Table 2-1 lists the corner coordinates of the survey area in NAD83, UTM Zone 10, central meridian 123°W.

Table 2-1

Nad83 Utm Zone 10

Block	Corners	X-UTM (E)	Y-UTM (N)
04054-1	1	378918	5545578
OK Property	2	382435	5547483
	3	386131	5540838
	4	382614	5538933

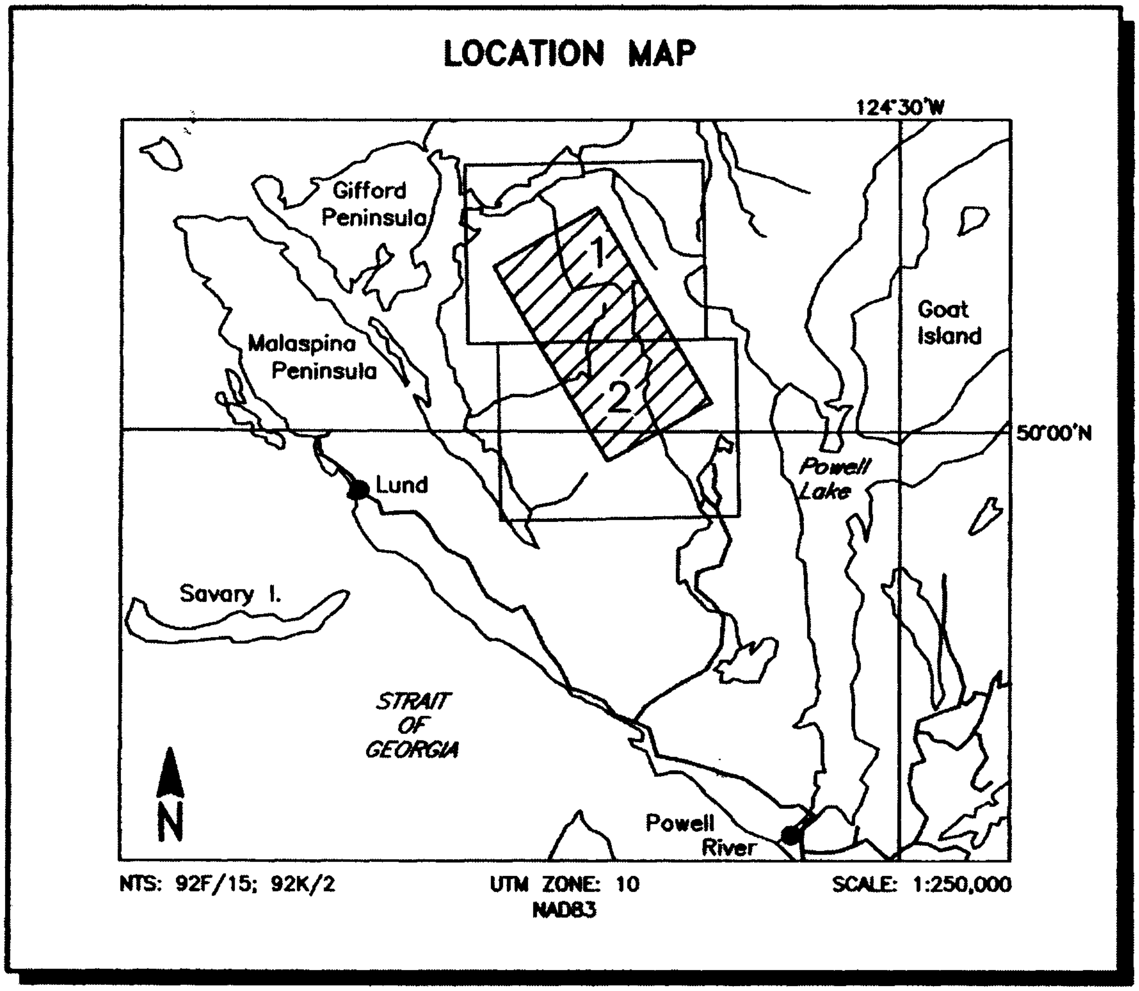

Figure 1
Location Map and Sheet Layout
OK Property, B.C.
Job # 04054

The survey specifications were as follows:

Parameter	Specifications
Traverse line direction	062°/242°
Traverse line spacing	100 m
Tie line direction	152°/332°
Tie line spacing	3.6 km
Sample interval	10 Hz, 2.3 m @ 65 km/hr
Aircraft mean terrain clearance	58 m
EM sensor mean terrain clearance	30 m
Mag sensor mean terrain clearance	30 m
Average speed	63 km/h
Navigation (guidance)	±5 m, Real-time GPS
Post-survey flight path	±2 m, Differential GPS
Traverse lines	322 km
Tie lines	15 km
Total	337 km

3. SURVEY EQUIPMENT

This section provides a brief description of the geophysical instruments used to acquire the survey data and the calibration procedures employed. The geophysical equipment was installed in an AS350B3 helicopter. This aircraft provides a safe and efficient platform for surveys of this type.

Electromagnetic System

Model: DIGHEM^{V-DSP} (BK54)

Type: Towed bird, symmetric dipole configuration operated at a nominal survey altitude of 30 metres. Coil separation is 8 metres for 900 Hz, 1000 Hz, 5500 Hz and 7200 Hz, and 6.3 metres for the 56,000 Hz coil-pair.

Coil orientations, frequencies and dipole moments

Atm^2	orientation	nominal	actual
211	coaxial	/ 1000 Hz	1090 Hz
211	coplanar	/ 900 Hz	876 Hz
68	coaxial	/ 5500 Hz	5795 Hz
56	coplanar	/ 7200 Hz	7253 Hz
15	coplanar	/ 56,000 Hz	56,090 Hz

Channels recorded: 5 in-phase channels
5 quadrature channels
2 monitor channels

Sensitivity:
0.06 ppm at 1000 Hz Cx
0.12 ppm at 900 Hz Cp
0.12 ppm at 5,500 Hz Cx
0.24 ppm at 7,200 Hz Cp
0.60 ppm at 56,000 Hz Cp

Sample rate: 10 per second, equivalent to 1 sample every 3.0 m, at a survey speed of 110 km/h.

The electromagnetic system utilizes a multi-coil coaxial/coplanar technique to energize conductors in different directions. The coaxial coils are vertical with their axes in the flight direction. The coplanar coils are horizontal. The secondary fields are sensed simultaneously by means of receiver coils that are maximum coupled to their respective transmitter coils. The system yields an in-phase and a quadrature channel from each transmitter-receiver coil-pair.

EM System Calibration

The initial calibration procedure at the factory involves three stages; primary field bucking, phase calibration and gain calibration. In the first stage, the primary field at each receiver coil is cancelled, or "bucked out", by precise positioning of five bucking coils.

The initial phase calibration adjusts the phase angle of the receiver to match that of the transmitter. A ferrite bar, which produces a purely in-phase anomaly, is positioned near each receiver coil. The bar is rotated from minimum to maximum field coupling and the responses for the in-phase and quadrature components for each coil pair/frequency are measured. The phase of the response is adjusted at the console to return an in-phase only response for each coil-pair.

The initial gain calibration uses external coils designed to produce an equal response on in-phase and quadrature components for each frequency/coil-pair. The coil parameters and distances are designed to produce pre-determined responses at the receiver, when the calibration coil is activated. The gain at the console is adjusted to yield secondary responses of exactly 100 ppm and 200 ppm on the coaxial and coplanar channels respectively. Gain calibrations on the ground are carried out at the beginning and end of the survey, or whenever key components are replaced.

The phase and gain calibrations each measure a relative change in the secondary field, rather than an absolute value. This removes any dependency of the calibration procedure on the secondary field due to the ground, except under circumstances of extreme ground conductivity.

Subsequent calibrations of the gain, phase and the system zero level are performed in the air. These internal calibrations are carried out before, after, and at regular intervals during each flight. The system is flown to an altitude high enough to be out of range of any secondary field from the earth (the altitude is dependent on ground resistivity) at which point the zero, or base level of the system is established. Calibration coils in the bird are activated for each frequency by closing a switch to form a closed circuit through the coil. The transmitter induces a current in this loop, which creates a secondary field in the receiver of precisely known phase and amplitude. Linear system drift is automatically removed by re-establishing zero levels between the internal calibrations. Any phase and gain changes in the system are recorded by the digital receiver to allow post-flight corrections.

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

Magnetometer

Model:	Scintrex CS-2 sensor with AM102 counter
Type:	Optically pumped cesium vapour
Sensitivity:	0.01 nT
Sample rate:	10 per second

The airborne magnetometer consists of a high sensitivity cesium sensor housed in the HEM bird which is flown 28 m below the helicopter.

Magnetic Base Station

Primary

Model:	Fugro CF1 base station with timing provided by integrated GPS	
Sensor type:	Scintrex CS-2	
Counter specifications:	Accuracy:	±0.1 nT
	Resolution:	0.01 nT
	Sample rate	1 Hz
GPS specifications:	Model:	Marconi Allstar
	Type:	Code and carrier tracking of L1 band, 12-channel, C/A code at 1575.42 MHz
	Sensitivity:	-90 dBm, 1.0 second update

	Accuracy:	Manufacturer's stated accuracy for differential corrected GPS is 2 metres

Environmental Monitor specifications: Temperature:

- Accuracy: ±1.5°C max
- Resolution: 0.0305°C
- Sample rate: 1 Hz
- Range: -40°C to +75°C

Barometric pressure:

- Model: Motorola MPXA4115A
- Accuracy: ±3.0° kPa max (-20°C to 105°C temp. ranges)
- Resolution: 0.013 kPa
- Sample rate: 1 Hz
- Range: 55 kPa to 108 kPa

A digital recorder is operated in conjunction with the base station magnetometer to record the diurnal variations of the earth's magnetic field. The clock of the base station is synchronized with that of the airborne system, using GPS time, to permit subsequent removal of diurnal drift. The Fugro CF1 was the primary magnetic base station. It was located at WGS84 Latitude 49°50'03.21417"N, Longitude 124°29'48.05791"W at an ellipsoidal elevation of 104 m.

Navigation (Global Positioning System)

Airborne Receiver for Real-time Navigation & Guidance

Model:	Ashtech Glonass GG-24 unit with Picodas PNAV2100 interface
Type:	Code and carrier tracking of L1-C/A code at 1575.42 MHz and S code at 0.5625 MHz. Dual frequency, 24-channel, real-time differential.

Sensitivity:	-132 dBm; 0.5 second update.
Accuracy:	Better than 10 metres in real time.
Antenna:	Mounted on tail of aircraft

GPS Base Station for Post-Survey Differential Correction

Model:	Ashtech Z-Surveyor
Type:	Code and carrier tracking of L1 band, 12-channel, C/A code at 1575.42 MHz, and L2P-code at 1227 MHz.
Sensitivity:	-90 dBm, 0.5 second update
Accuracy:	Manufacturer's stated accuracy for differential corrected GPS is better than 1 metre.

The Ashtech GG24 is a line of sight, satellite navigation system that utilizes time-coded signals from at least four of forty-eight available satellites. Both Russian GLONASS and American NAVSTAR satellite constellations are used to calculate the position and to provide real time guidance to the helicopter. An Ashtech Z-Surveyor was used as the base station receiver for post-survey processing of the flight path. The mobile and base station raw XYZ data were recorded, thereby permitting post-survey differential corrections for theoretical accuracies of better than 2 metres. A Marconi Allstar GPS unit, part of the CF1, was used as a back-up base station receiver.

The base station receiver is able to calculate its own latitude and longitude. For this survey, the primary GPS station was located at latitude 49°50'03.47824"N, longitude 124°29'50.43081"W at an elevation of 107.221 metres above the ellipsoid. The GPS records data relative to the WGS84 ellipsoid, which is the basis of the revised North

American Datum (NAD83). Conversion software is used to transform the WGS84 coordinates to the NAD83, UTM system displayed on the maps.

Radar Altimeter

Manufacturer:	Honeywell/Sperry
Model:	RT220/RT330
Type:	Short pulse modulation, 4.3 GHz
Sensitivity:	0.3 m

The radar altimeter measures the vertical distance between the helicopter and the ground. This information is used in the processing algorithm that determines conductor depth.

Barometric Pressure and Temperature Sensors

Model:	DIGHEM D 1300	
Type:	Motorola MPX4115AP analog pressure sensor AD592AN high-impedance remote temperature sensors	
Sensitivity:	Pressure:	150 mV/kPa
	Temperature:	100 mV/°C or 10 mV/°C (selectable)
Sample rate:	10 per second	

The D1300 circuit is used in conjunction with one barometric sensor and up to three temperature sensors. Two sensors (baro and temp) are installed in the EM console in the aircraft, to monitor pressure (1KPA) and internal operating temperatures (2TDC).

Analog Recorder

Manufacturer:	RMS Instruments
Type:	DGR33 dot-matrix graphics recorder
Resolution:	4x4 dots/mm
Speed:	1.5 mm/sec

The analog profiles are recorded on chart paper in the aircraft during the survey. Table 3-1 lists the geophysical data channels and the vertical scale of each profile.

Table 3-1. The Analog Profiles

Channel Name	Parameter	Scale units/mm
1X9I	coaxial in-phase (1000 Hz)	2.5 ppm
1X9Q	coaxial quad (1000 Hz)	2.5 ppm
3P9I	coplanar in-phase (900 Hz)	2.5 ppm
3P9Q	coplanar quad (900 Hz)	2.5 ppm
2P7I	coplanar in-phase (7200 Hz)	5 ppm
2P7Q	coplanar quad (7200 Hz)	5 ppm
4X7I	coaxial in-phase (5500 Hz)	5 ppm
4X7Q	coaxial quad (5500 Hz)	5 ppm
5P5I	coplanar in-phase (56000 Hz)	10 ppm
5P5Q	coplanar quad (56000 Hz)	10 ppm
ALTR	altimeter (radar)	3 m
MAGC	magnetics, coarse	20 nT
MAGF	magnetics, fine	2.0 nT
CXSP	coaxial spherics monitor	
CPSP	coplanar spherics monitor	
CXPL	coaxial powerline monitor	
CPPL	coplanar powerline monitor	
1KPA	altimeter (barometric)	30 m
2TDC	external temperature	1° C

Digital Data Acquisition System

Manufacturer:	RMS Instruments
Model:	DGR 33
Recorder:	San Disk compact flash card (PCMCIA)
Sampling rate:	10 Hz

The data are stored on a compact flash card (PCMCIA) and are downloaded to the field workstation PC at the survey base for verification, backup and preparation of in-field products.

Video Flight Path Recording System

Type:	Panasonic WV-CL322 VHS Colour Video Camera (NTSC)
Recorder:	Panasonic AG-720

Fiducial numbers are recorded continuously and are displayed on the margin of each image. This procedure ensures accurate correlation of data with respect to visible features on the ground.

4. QUALITY CONTROL

Digital data for each flight were transferred to the field workstation, in order to verify data quality and completeness. A database was created and updated using Geosoft Oasis Montaj and proprietary Fugro Atlas software. This allowed the field personnel to calculate, display and verify both the positional (flight path) and geophysical data on a screen or printer. Records were examined as a preliminary assessment of the data acquired for each flight.

In-field processing of Fugro 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, verification of flight videos, calculation of preliminary resistivity data, diurnal correction, and preliminary leveling of magnetic data.

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

Navigation - Positional (x,y) accuracy of better than 10 m, with a CEP (circular error of probability) of 95%.

Flight Path - No lines to exceed ±50 m departure from nominal line spacing over a continuous distance of more than 2 km, except for reasons of safety.

Clearance - Mean terrain sensor clearance of 30 m, ±10 m, except where precluded by safety considerations, e.g., restricted or populated areas, severe topography, obstructions, tree canopy, aerodynamic limitations, etc.

Airborne Mag - Aerodynamic magnetometer noise envelope not to exceed 0.5 nT over a distance of more than 500 m.

Base Mag - Diurnal variations not to exceed 10 nT over a straight line time chord of 1 minute.

EM - Noise envelope not to exceed specified noise limits over a distance of more than 2 km. Fewer than 10 spheric spikes for any given frequency per 100 data samples.

5. DATA PROCESSING

Flight Path Recovery

The raw range data from at least four satellites are simultaneously recorded by both the base and mobile GPS units. The geographic positions of both units, relative to the model ellipsoid, are calculated from this information. Differential corrections, which are obtained from the base station, are applied to the mobile unit data to provide a post-flight track of the aircraft, accurate to within 2 m. Speed checks of the flight path are also carried out to determine if there are any spikes or gaps in the data.

The corrected WGS84 latitude/longitude coordinates are transformed to the UTM coordinate system used on the final maps. Images or plots are then created to provide a visual check of the flight path.

Electromagnetic Data

EM data are processed at the recorded sample rate of 10 samples/second. If necessary, appropriate spheric rejection filters are applied to reduce noise to acceptable levels. EM test profiles are then created 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.

Anomalous electromagnetic responses are selected and analysed by computer to provide a preliminary electromagnetic anomaly map. The automatic selection algorithm is intentionally oversensitive to assure that no meaningful responses are missed. Using the preliminary map in conjunction with the multi-parameter stacked profiles, the interpreter then classifies the anomalies according to their source and eliminates those that are not substantiated by the data. The final interpreted EM anomaly map includes bedrock, surficial and cultural conductors. A map containing only bedrock conductors can be generated, if desired.

Apparent Resistivity

The apparent resistivity in ohm-m can be generated from the in-phase and quadrature EM components for any of the frequencies, using a pseudo-layer half-space model. The inputs to the resistivity algorithm are the inphase 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. The upper (pseudo) layer is merely an artifice to allow for the difference between the computed sensor-source distance and the measured sensor height, as determined by the radar or laser altimeter. 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.

In areas where the effects of magnetic permeability or dielectric permittivity have suppressed the inphase 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. This full coverage contrasts with the electromagnetic anomaly map, which provides information only over interpreted conductors. The large dynamic range afforded by the multiple frequencies makes the apparent resistivity parameter an excellent mapping tool.

The preliminary apparent resistivity maps and 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 to eliminate or minimize resistivity differences that can be attributed, in part, to changes in operating temperatures. These leveling adjustments are usually very subtle, and do not result in the degradation of discrete anomalies.

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

The calculated resistivities for the three coplanar frequencies are included in the XYZ and grid archives. Values are in ohm-metres on all final products.

Resistivity-depth Sections (optional)

The apparent resistivities for all frequencies can be displayed simultaneously as coloured resistivity-depth sections. Usually, only the coplanar data are displayed as the close frequency separation between the coplanar and adjacent coaxial data tends to distort the section. The sections can be plotted using the topographic elevation profile as the surface. The digital terrain values, in metres a.m.s.l., can be calculated from the GPS Z-value or barometric altimeter, minus the aircraft radar altimeter.

Resistivity-depth sections can be generated in three formats:

(1) Sengpiel resistivity sections, where the apparent resistivity for each frequency is plotted at the depth of the centroid of the in-phase current flow[1]; and,

(2) Differential resistivity sections, where the differential resistivity is plotted at the differential depth[2].

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[1] Sengpiel, K.P., 1988, Approximate Inversion of Airborne EM Data from Multilayered Ground: Geophysical Prospecting 36, 446-459.

[2] Huang, H. and Fraser, D.C., 1993, Differential Resistivity Method for Multi-frequency Airborne EM Sounding: presented at Intern. Airb. EM Workshop, Tucson, Ariz.

(3) Occam[3] or Multi-layer[4] inversion.

Both the Sengpiel and differential methods are derived from the pseudo-layer half-space model. Both yield a coloured resistivity-depth section that attempts to portray a smoothed approximation of the true resistivity distribution with depth. Resistivity-depth sections are most useful in conductive layered situations, but may be unreliable in areas of moderate to high resistivity where signal amplitudes are weak. In areas where in-phase responses have been suppressed by the effects of magnetite, or adversely affected by cultural features, the computed resistivities shown on the sections may be unreliable.

Both the Occam and multi-layer inversions compute the layered earth resistivity model that would best match the measured EM data. The Occam inversion uses a series of thin, fixed layers (usually 20 x 5m and 10 x 10m layers) and computes resistivities to fit the EM data. The multi-layer inversion computes the resistivity and thickness for each of a defined number of layers (typically 3-5 layers) to best fit the data.

Total Magnetic Field

A fourth difference editing routine was applied to the magnetic data to remove any spikes. A lag correction of –1.0 second was then applied.

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[3] Constable et al, 1987, Occam's inversion: a practical algorithm for generating smooth models from electromagnetic sounding data: Geophysics, 52, 289-300.

[4] Huang H., and Palacky, G.J., 1991, Damped least-squares inversion of time domain airborne EM data based on singular value decomposition: Geophysical Prospecting, 39, 827-844.

The aeromagnetic data were corrected for diurnal variation using the magnetic base station data. The results were then leveled using tie and traverse line intercepts. Manual adjustments were applied to any lines that required leveling, as indicated by shadowed images of the gridded magnetic data. The manually leveled data were then subjected to a microleveling filter.

Calculated Vertical Magnetic Gradient

The diurnally-corrected total magnetic field data were subjected to a processing algorithm that enhances the response of magnetic bodies in the upper 500 m and attenuates the response of deeper bodies. The resulting vertical gradient map provides better definition and resolution of near-surface magnetic units. It also identifies weak magnetic features that may not be evident on the total field map. However, regional magnetic variations and changes in lithology may be better defined on the total magnetic field map.

EM Magnetite (optional)

The apparent percent magnetite by weight is computed wherever magnetite produces a negative in-phase EM response. This calculation is more meaningful in resistive areas.

Magnetic Derivatives (optional)

The total magnetic field data can be subjected to a variety of filtering techniques to yield maps or images of the following:

residual magnetic intensity

second vertical derivative

reduction to the pole/equator

magnetic susceptibility with reduction to the pole

upward/downward continuations

analytic signal

All of these filtering techniques improve the recognition of near-surface magnetic bodies, with the exception of upward continuation. Any of these parameters can be produced on request.

Digital Terrain (optional)

The radar altimeter values (ALTR – aircraft to ground clearance) are subtracted from the differentially corrected and de-spiked GPS-Z values to produce profiles of the height above the ellipsoid along the survey lines. These values are gridded to produce contour maps showing approximate elevations within the survey area. The calculated digital terrain data are then tie-line leveled and adjusted to mean sea level. Any remaining subtle line-to-line discrepancies are manually removed. After the manual corrections are applied, the digital terrain data are filtered with a microleveling algorithm.

The accuracy of the elevation calculation is directly dependent on the accuracy of the two input parameters, ALTR and GPS-Z. The ALTR value may be erroneous in areas of heavy tree cover, where the altimeter reflects the distance to the tree canopy rather than the ground. 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 ±10 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 geophysical 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.

Monochromatic shadow maps or images are generated by employing an artificial sun to cast shadows on a surface defined by the geophysical grid. There are many variations in the shadowing technique. These techniques can be applied to total field or enhanced magnetic data, magnetic derivatives, resistivity, etc. The shadowing technique is also used as a quality control method to detect subtle changes between lines.

Multi-channel Stacked Profiles

Distance-based profiles of the digitally recorded geophysical data are generated and plotted at an appropriate scale. These profiles also contain the calculated parameters that are used in the interpretation process. These are produced as worksheets prior to interpretation, and are also presented in the final corrected form after interpretation. The profiles display electromagnetic anomalies with their respective interpretive symbols. Table 5-1 shows the parameters and scales for the multi-channel stacked profiles.

In Table 5-1, the log resistivity scale of 0.06 decade/mm means that the resistivity changes by an order of magnitude in 16.6 mm. The resistivities at 0, 33 and 67 mm up from the bottom of the digital profile are respectively 1, 100 and 10,000 ohm-m.

Table 5-1. Multi-channel Stacked Profiles

Channel Name (Freq)	Observed Parameters	Scale Units/mm
MAG5	total magnetic field (fine)	5 nT
MAG50	total magnetic field (coarse)	50 nT
ALTBIRDM	EM sensor height above ground	6 m
CXI1000	vertical coaxial coil-pair in-phase (1000 Hz)	2 ppm
CXQ1000	vertical coaxial coil-pair quadrature (1000 Hz)	2 ppm
CPI900	horizontal coplanar coil-pair in-phase (900 Hz)	4 ppm
CPQ900	horizontal coplanar coil-pair quadrature (900 Hz)	4 ppm
CXI5500	vertical coaxial coil-pair in-phase (5500 Hz)	4 ppm
CXQ5500	vertical coaxial coil-pair quadrature (5500 Hz)	4 ppm
CPI7200	horizontal coplanar coil-pair in-phase (7200 Hz)	8 ppm
CPQ7200	horizontal coplanar coil-pair quadrature (7200 Hz)	8 ppm
CPI56K	horizontal coplanar coil-pair in-phase (56,000 Hz)	20 ppm
CPQ56K	horizontal coplanar coil-pair quadrature (56,000 Hz)	20 ppm
CXSP	coaxial spherics monitor	
CXPL	coaxial powerline monitor	
CPPL	coplanar powerline monitor	
CPSP	coplanar spherics monitor	
	Computed Parameters	
DIFI (mid-freq)	difference function in-phase from CXI and CPI	5 ppm
DIFQ (mid-freq)	difference function quadrature from CXQ and CPQ	5 ppm
RES900	log resistivity	.06 decade
RES7200	log resistivity	.06 decade
RES56K	log resistivity	.06 decade
DEP900	apparent depth	6 m
DEP7200	apparent depth	6 m
DEP56K	apparent depth	6 m
CDT	conductance	1 grade

6. PRODUCTS

This section lists the final maps and 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.

Base Maps

Base maps of the survey area were produced from digital data files provided by Goldrush. This process provides a relatively accurate, distortion-free base that facilitates correlation of the navigation data to the UTM grid. The topographic files were combined with geophysical data for plotting the final maps. All maps were created using the following parameters:

Projection Description:

Datum:	NAD83		
Ellipsoid:	Clarke 1866		
Projection:	UTM (Zone: 10)		
Central Meridian:	123°W		
False Northing:	0		
False Easting:	500000		
Scale Factor:	0.9996		
WGS84 to Local Conversion:	Molodensky		
Datum Shifts:	DX: 0	DY: 0	DZ: 0

The following parameters are presented on two map sheets, at a scale of 1:10,000. All maps include flight lines and topography, claim outlines and EM anomalies, unless otherwise indicated.

Final Products

	No. of Map Sets = 2		
	Mylar	Blackline	Colour
EM Anomalies	-	2x2	-
Total Magnetic Field	-	-	2x2
Calculated Vertical Magnetic Gradient	-	-	2x2
Apparent Resistivity 7200 Hz	-	-	2x2
Apparent Resistivity 56,000 Hz	-	-	2x2

<u>Additional Products</u>

Digital Archive (see Archive Description)	1 CD-ROM
Survey Report	2 copies
Multi-channel Stacked Profiles	All lines
Flight Path Videos (VHS)	2 cassettes
Analog chart data	4 rolls

7. SURVEY RESULTS

General Discussion

Table 7-1 summarizes the EM responses in the survey area, with respect to conductance grade and interpretation.

The anomalies shown on the electromagnetic anomaly map are based on a near-vertical, half plane model. This model best reflects "discrete" bedrock conductors. Wide bedrock conductors or flat-lying conductive units, whether from surficial or bedrock sources, may give rise to very broad anomalous responses on the EM profiles. These may not appear on the electromagnetic anomaly map if they have a regional character rather than a locally anomalous character. These broad conductors, which more closely approximate a half-space model, will be maximum coupled to the horizontal (coplanar) coil-pair and should be more evident on the resistivity parameter. Resistivity maps, therefore, may be more valuable than the electromagnetic anomaly maps, in areas such as this, where broad or flat-lying conductors are considered to be of importance. Contoured resistivity maps, based on the 7200 Hz and 56,000 Hz coplanar data are included with this report.

TABLE 7-1 EM ANOMALY STATISTICS

OK PROPERTY

CONDUCTOR GRADE	CONDUCTANCE RANGE SIEMENS (MHOS)	NUMBER OF RESPONSES
7	>100	0
6	50 - 100	0
5	20 - 50	0
4	10 - 20	0
3	5 - 10	0
2	1 - 5	0
1	<1	0
*	INDETERMINATE	101
TOTAL		101

CONDUCTOR MODEL	MOST LIKELY SOURCE	NUMBER OF RESPONSES
B	DISCRETE BEDROCK CONDUCTOR	3
S	CONDUCTIVE COVER	98
TOTAL		101

(SEE EM MAP LEGEND FOR EXPLANATIONS)

Excellent resolution and discrimination of conductors was accomplished by using a fast sampling rate of 0.1 sec and by employing a "common" frequency (5500/7200 Hz) on two orthogonal coil-pairs (coaxial and coplanar). The resulting difference channel parameters often permit differentiation of bedrock and surficial conducters, even though they may exhibit similar conductance values.

Anomalies that occur near the ends of the survey lines (i.e., outside the survey area), should be viewed with caution. Some of the weaker anomalies could be due to aerodynamic noise, i.e., bird bending, which is created by abnormal stresses to which the bird is subjected during the climb and turn of the aircraft between lines. Such aerodynamic noise is usually manifested by an anomaly on the coaxial in-phase channel only, although severe stresses can affect the coplanar in-phase channels as well.

Magnetic Data

A Fugro CF-1 cesium vapour magnetometer was operated at the survey base to record diurnal variations of the earth's magnetic field. The clock of the base station was synchronized with that of the airborne system to permit subsequent removal of diurnal drift.

The total magnetic field data have been presented as contours on the base maps using a contour interval of 5 nT where gradients permit. The maps show the magnetic properties of the rock units underlying the survey area.

The total magnetic field data have been subjected to a processing algorithm to produce maps of the calculated vertical gradient. This procedure enhances near-surface magnetic units and suppresses regional gradients. It also provides better definition and resolution of magnetic units and displays weak magnetic features that may not be clearly evident on the total field maps.

There is some evidence on the magnetic maps that suggests that the survey area has been subjected to deformation and/or alteration. These structural complexities are evident on the contour maps as variations in magnetic intensity, irregular patterns, and as offsets or changes in strike direction.

Magnetic valves vary from a low of less than 56,100 nT in the NE corner, to a high of more than 58,600 nT on line 10550. A central unit of relatively low magnetic susceptibility strikes SSE from the middle of line 10010, to fiducial 453 on line 10760. The vertical gradient map shows that this central unit is intersected at a shallow angle by at least four linear trends that strike almost due south. Several plug-like pods of more magnetic material are evident within the central non-magnetic zone.

The central zone is bounded on the west and east by two complex magnetic units. The vertical gradient maps suggest that both flanking zones are also structurally complex, indicating the presence of several linear intrusions or offsets.

There are a few elongated magnetic highs and lows that might represent mafic to felsic intrusive plugs, but few that show close correlation with conductive zones. Some of these, however, correlate with moderately resistive zones that are at least partially due to magnetite suppression of the inphase responses. Although it is impractical to attempt to prioritize these responses, there are a few that exhibit circular shapes of moderate dimensions that should probably be subjected to further investigation. These include the lows and highs at the following locations:

Lows		Highs	
Line	Fiducial	Line	Fiducial
10170	4065	10020	2705
10190	3585	10020	2858
10280	7763	10230	2362
10320	6820	10290	7592
10370	5743	10300	7304
10460	3392	10480	2944
10540	1298	10620	4931
10580	6060	10620	4746
10700	2014	10680	3316
10720	1954	10710	2126

The locations listed above are approximate centres of some of the non-magnetic//magnetic units on the property. Although these generally exhibit relatively small size, with poorly defined edges, it is possible that some of these could reflect felsic to mafic intrusions. Only three of these coincide with weak EM anomalies; anomaly 10370C, 10620A, and possibly 10630E.

The magnetic results, in conjunction with the other geophysical parameters, have provided valuable information that can be used to effectively map the geology and structure in the survey area.

Apparent Resistivity

Apparent resistivity maps, which display the conductive properties of the survey area, were produced from the 7200 Hz and 56,000 Hz coplanar data. The maximum resistivity values, which are calculated for each frequency, are 8,000 and 20,000 ohm-m respectively. These cutoffs eliminate the erratic higher resistivities that would result from unstable ratios of very small EM amplitudes.

In general, the resistivity patterns show only moderate agreement with the magnetic trends. This suggests that some of the resistivity lows are probably related to near-surface conductive units, lake-bottom sediments, or overburden, rather than deeper bedrock features. Most of the stronger resistivity lows are associated with lakes. There are some areas, however, where resistivity contour patterns appear to be controlled or partially influenced by magnetic units, zones of structural deformation, and topography. There are only three or four subtle resistivity lows that do not appear to be directly associated with topographic depressions. These occur in the vicinity of EM anomalies 10020A, 10070A, 10090B and possibly 10530B.

The property is generally quite resistive, except in the water-covered areas. The four strongest resistivity lows at 10220B, 10440A, 10500A and 10620B are all lake-hosted. There are several other more subtle resistivity lows that might also be of interest. All of these have been attributed to probable surficial sources. However, as they often occur on high ground that would normally have less conductive overburden, some of these could reflect conductive rock units or zones of alteration, that might also warrant further investigation.

There is no consistent relationship between magnetic susceptibility and conductivity. In general, most of the weakly conductive zones appear to coincide with the less magnetic units. However, there are several exceptions. Approximately 43% of the "surficial" conductors correlate with magnetic anomalies, and yield positive magnetic correlation. It should be noted that in many cases, this correlation could be coincidental, rather than direct.

Although sulphide mineralization is more likely to give rise to resistivity lows, porphyry-type mineralization is often associated with relative resistivity highs, due to the calc-alkaline host rocks. Depending on the type of mineralization expected in the area, it is possible that some of the resistive, non-magnetic (or magnetic) zones could prove to be as important as the conductive (sulphide-type) responses.

Electromagnetic Anomalies

The EM anomalies resulting from this survey appear to fall within one of three general categories. The first type consists of discrete, well-defined anomalies that yield marked inflections on the difference channels. These anomalies are usually attributed to faults or shears, conductive sulphides, or graphite, and are generally given a "B", "T" or "D" interpretive symbol, denoting a bedrock source. Only three anomalies on the property have been attributed to possible discrete bedrock sources.

The second class of anomalies comprises moderately broad responses that exhibit the characteristics of a half-space and do not yield well-defined inflections on the difference channels. Anomalies in this category are usually given an "S" or "H" interpretive symbol. The lack of a difference channel response usually implies a broad or flat-lying conductive source such as overburden. Some of these anomalies could reflect alteration zones, conductive rock units, or zones of deep weathering, all of which can yield "non-discrete" signatures.

The effects of conductive overburden are evident in most of the topographic depressions. Although the difference channels (DIFI and DIFQ) are extremely valuable in detecting bedrock conductors that are partially masked by conductive overburden, sharp undulations in the bedrock/overburden interface can yield anomalies in the difference channels which may be interpreted as possible bedrock conductors. Such anomalies usually fall into the

"S?" or "B?" classification but may also be given an "E" interpretive symbol, denoting a resistivity contrast at the edge of a conductive unit.

The "?" symbol does not question the validity of an anomaly, but instead indicates some degree of uncertainty as to which is the most appropriate EM source model. This ambiguity results from the combination of effects from two or more conductive sources, such as overburden and bedrock, gradational changes, or moderately shallow dips. The presence of a conductive upper layer has a tendency to mask or alter the characteristics of bedrock conductors, making interpretation difficult. This problem is further exacerbated in the presence of magnetite.

The third anomaly category includes responses that are associated with magnetite. Magnetite can cause suppression or polarity reversals of the in-phase components, particularly at the lower frequencies in resistive areas. The effects of magnetite-rich rock units are usually evident on the multi-parameter geophysical data profiles as negative excursions of the lower frequency in-phase channels.

In areas where EM responses are evident primarily on the quadrature components, zones of poor conductivity are indicated. Where these responses are coincident with magnetic anomalies, it is possible that the in-phase component amplitudes have been suppressed by the effects of magnetite. Poorly-conductive magnetic features can give rise to resistivity anomalies that are only slightly below or slightly above background. If it is expected that poorly-conductive economic mineralization could be associated with magnetite-rich units, most of these weakly anomalous features will be of interest. In areas where magnetite causes the in-phase components to become negative, the apparent conductance and depth of EM anomalies will be unreliable. Magnetite effects usually give rise to overstated (higher) resistivity values and understated (shallow) depth calculations.

As targets of interest within the survey area can be associated with magnetic sulphides such as pyrrhotite, or non-magnetic (siliciclastic) units, or possibly magnetite-rich plugs, it is impractical to assess the relative merits of EM anomalies on the basis of conductance or magnetic correlation. It is racommended that an attempt be made to compile a suite of geophysical "signatures" over any known areas of interest. Anomaly characteristics are clearly defined on the multi-parameter geophysical data profiles that are supplied as one of the survey products. It is unlikely that disseminated mineralization in the survey area would yield discrete conductors, unless it was associated with intense alteration, or associated with appreciable amounts of sulphide mineralization. Nevertheless, there are at least two conductive zones in the survey areas that are considered to be moderate priority targets, plus several other weaker, poorly-defined anomalies that may also be of interest.

Potential Targets in the Survey Area

The magnetic and resistive characteristics of porphyry deposits are quite diverse, which often makes them difficult to detect. Although felsic to intermediate intrusions normally yield low to moderate magnetic signatures, the presence of magnetite or magnetic sulphides would obviously contribute to a stronger magnetic anomaly. The resistivity values would be affected differently, with magnetite generally yielding higher resistivities, and increases in sulphide content giving rise to lower resistivities. Resistivities are also affected by the degree and type of alteration associated with the deposit. Porphyries can therefore be either more or less conductive than background, with or without magnetic correlation.

The Mount Milligan porphyry, for example, yields a distinct circular resistivity high, and hosts three subtle positive magnetic anomalies with a maximum variation of about 150 nT. It is not know if this signature would be applicable to porphyritic intrusions on the OK Property, but the resistive, weakly magnetic signature should serve as a starting model.

In the search for high sulphide lode deposits, the resistivity parameter should yield a distinct resistivity low. However, if the sulphides are disseminated, and are closely associated with magnetite-rich units, the latter will tend to cancel the positive inphase results from the sulphides. The final resistivities will depend largely on the sulphide/oxide ratio.

The electromagnetic anomaly maps show the anomaly locations with the interpreted conductor type, dip, conductance and depth being indicated by symbols. Direct magnetic correlation is also shown if it exists. The strike direction and length of the inferred bedrock conductors are indicated only where anomalies can be correlated from line to line with a reasonable degree of confidence.

Many of the weaker, poorly-defined anomalies are associated with magnetite-rich units. Although most of these are considered to be of low priority, based on their geophysical signatures, some are associated with plug-like units, or with probable faults or contacts that have been inferred from the magnetic data.

There are five areas on the 7200 Hz resistivity maps that yield values of less than 4000 ohm-m. Four of these are associated with lakes, and are at least partially due to conductive lake-bottom material. However, in some cases, the signatures suggest the presence of conductive material that might underlie the lake. These five anomalies are considered to be the most likely areas for weak concentrations of conductive (sulphide?) material. They are located in the vicinity of anomalies 10130A, 10220B, 10330C, 10440A and 10500A.

The following list includes some of the more conductive areas.

Anomaly	Type	Mag	Comments
10020A	S	53	This very weak and poorly defined anomaly is associated with a weak magnetic high in the central, non- magnetic unit. Although it has been attributed to a surficial source, it is not lake-hosted, and is located on a small ridge between two streams.
10070A	S?	147	Similar to 10020A, this surficial conductor is located between two streams. It coincides with an oval-shaped magnetic high.
10120A	S?	375	A possible surficial source that coincides with an elongate magnetic anomaly, west of a north-trending valley.
10130A	S	-	Part of a broad, weak resistivity low that is located in close proximity to an inferred NNE break.
10220B	B?	29	This is a moderately attractive, moderately strong resistivity low that coincides with a magnetite-rich unit. The zone is lake-hosted, and also includes a

Anomaly	Type	Mag	Comments
			second small lake at 10210A. The vertical gradient map suggests the presence of a probable SE-trending break, south of 10220B. Although this anomaly is at least partially due to lake-bottom material, it should be investigated.
10330C	S	-	Part of a lake-hosted resistivity low that is associated with a 100 m wide non-magnetic unit that strikes SSE.
10370C	S	-	A very weak surficial response, associated with a small lake, and coincident with a circular magnetic low. A very weak peak on the coaxial 5500 quadrature response could reflect a thin source, but is more likely due to a spheric spike.
10400A	S?	131	This small, lake-hosted low is very weak, but coincides with a well-defined magnetic trough, about 100 m southeast of a NNE-trending linear low. Possible remanent magnetization.
10440A	S?	-	This is part of an attractive resistivity low that coincides with a lake. The resistivity low correlates closely with a similarly shaped magnetic low that may be indicative of a bedrock source. It is interesting to note that this magnetic trough might be partially due to remanent magnetization, as the low frequency inphase response is slightly negative. The western edge of this conductive/low magnetic zone abuts a south-trending valley that is probably fault-controlled. This zone should be subjected to further investigation.
10500A	S?	-	This lake-hosted response gives rise to a moderately strong resistivity low, and is associated with a SSE-trending magnetic low that is clearly defined on the vertical gradient map. This conductor might also warrant further investigation, although it is primarily due to conductive lake-bottom material.
10520A	S?	187	This magnetite-hosted anomaly has been attributed to a probable surficial source, but it is located on moderately high ground. It occurs near the eastern contact of small magnetic high, in close proximity to an inferred south-trending break.
10590C	S?	269	This weak surficial response occurs on high ground. It is located near the southwestern contact of a strong, 100m-wide magnetic unit that strikes south-southeast, and then south, beyond anomaly 10590C. The magnetic contours depict an east-

Anomaly	Type	Mag	Comments
			west contact, south of the anomaly, The weakly-conductive trend continues south into the non-magnetic unit, through 10600C to 10620A.
10620B	B?	145	This anomaly gives rise to a moderate resistivity low that coincides with a small lake. The resistivity trend is east/west, along the lake axis, while the coincident magnetic anomaly transects the lake in a SSE-direction. Although this anomaly has been attributed to a possible bedrock source, it is probably caused by conductive lake-bottom material. The magnetic correlation is coincidental.
10630E	S?	358	This very weak response is mentioned only because it coincides with a moderately strong magnetic anomaly.
10680B	S	-	A circular magnetic low hosts this very weak surficial conductor.
10680A	S?	98	This weak response is located near the southern edge of a small, ovate, plug-like magnetic anomaly. A similar, smaller magnetic high is evident at 10700A, about 200 m to the south. These two anomalies appear to be separated by a less magnetic unit, at 10690A.
10730A	S?	173	A very weak response occurs near the northern edge of a small ovate magnetic high.
10740A	S?	-	This weak resistivity low is associated with a narrow magnetic low that is probably due to an ENE-trending fault. The negative inphase responses, however, suggest a magnetite-rich environment.
10760A	S?	279	A very weak anomaly is associated with a magnetic unit near the southern property boundary. This anomaly, and 10760B to the east, could be open to the south.

There are several other subtle resistivity lows, many of which are associated with magnetite, that have not been described in the foregoing table. Some of these may also be of interest. There are no clearly-defined circular resistivity highs that exhibit the characteristics one might expect over siliceous caps, or plug-like felsic intrusives.

However, the numerous negative inphase responses on the property clearly indicate the presence of magnetite-rich units, which might host skarn type mineralization.

The foregoing paragraphs provide a very brief description of what are considered to be the more attractive anomalies. There are several other weak or broad responses that have been attributed to possible surficial sources. These may also be of interest in the search for broad zones of weakly conductive mineralization, particularly if they are associated with changes in magnetic intensity and/or zones of structural deformation. Some of the isolated resistivity or magnetic anomalies may also reflect potential target areas, even if they do not exhibit discrete conductor signatures.

8. 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 survey over the OK Property.

There are only three or four anomalies in the survey block that have been attributed to possible conductive sulphide sources. All of these are associated with lakes, and could therefore be due to conductive lake-bottom sediments. The survey was also successful in locating a few very weak, poorly-defined conductors that might also warrant additional work. Some of these appear to be associated with relatively resistive, magnetic zones that could reflect porphyritic intrusions. Both conductive and resistive zones are considered to be favourable areas for mineral deposition in this area.

The various maps included with this report display the magnetic and conductive properties of the survey property. It is recommended that a complete assessment and detailed evaluation of the survey results be carried out, in conjunction with all available geophysical, geological and geochemical information. Particular reference should be made to the multi-parameter data profiles that clearly define the characteristics of the individual anomalies.

Most anomalies are moderately weak and poorly defined. Most have been attributed to conductive overburden, alteration, or deep weathering, although several are associated with magnetite-rich rock units that could host disseminated to semi-massive mineralization. Others coincide with magnetic gradients that could reflect contacts, faults or shears. Such structural breaks are considered to be of particular interest as they may have influenced or controlled the emplacement of economic mineralization within the survey area.

The anomalous resistivity zones and the possible bedrock conductors defined by the survey should be subjected to further investigation, using appropriate surface exploration techniques. Anomalies that are currently considered to be of moderately low priority may require upgrading if they occur in areas of favourable geology or geochemistry, or if follow-up results are encouraging.

It is also recommended that image processing of existing geophysical data be considered, in order to extract the maximum amount of information from the survey results. Current software and imaging techniques often provide valuable information on structure and lithology, which may not be clearly evident on the contour and colour maps. These techniques can yield images that define subtle, but significant, structural details.

Respectfully submitted,

FUGRO AIRBORNE SURVEYS CORP.

Paul A. Smith
Geophysicist

R04054AUG.04

APPENDIX A

LIST OF PERSONNEL

The following personnel were involved in the acquisition, processing, interpretation and presentation of data, relating to a DIGHEM^V airborne geophysical survey carried out for Goldrush Resources Ltd., over the OK Property, Powell River, B.C.

David Miles	Manager, Helicopter Operations
Emily Farquhar	Manager, Data Processing and Interpretation
Jonathon Martin	Geophysical Operator
Chris Kahue	Field Geophysicist/Crew Leader
Mark Lapointe	Pilot (Questral Helicopters)
Gord Smith	Geophysical Data Processor/Supervisor
Paul A. Smith	Interpretation Geophysicist
Lyn Vanderstarren	Drafting Supervisor
Susan Pothiah	Word Processing Operator
Albina Tonello	Secretary/Expeditor

The survey consisted of 337 km of coverage, flown from July 12 to July 15, 2004.

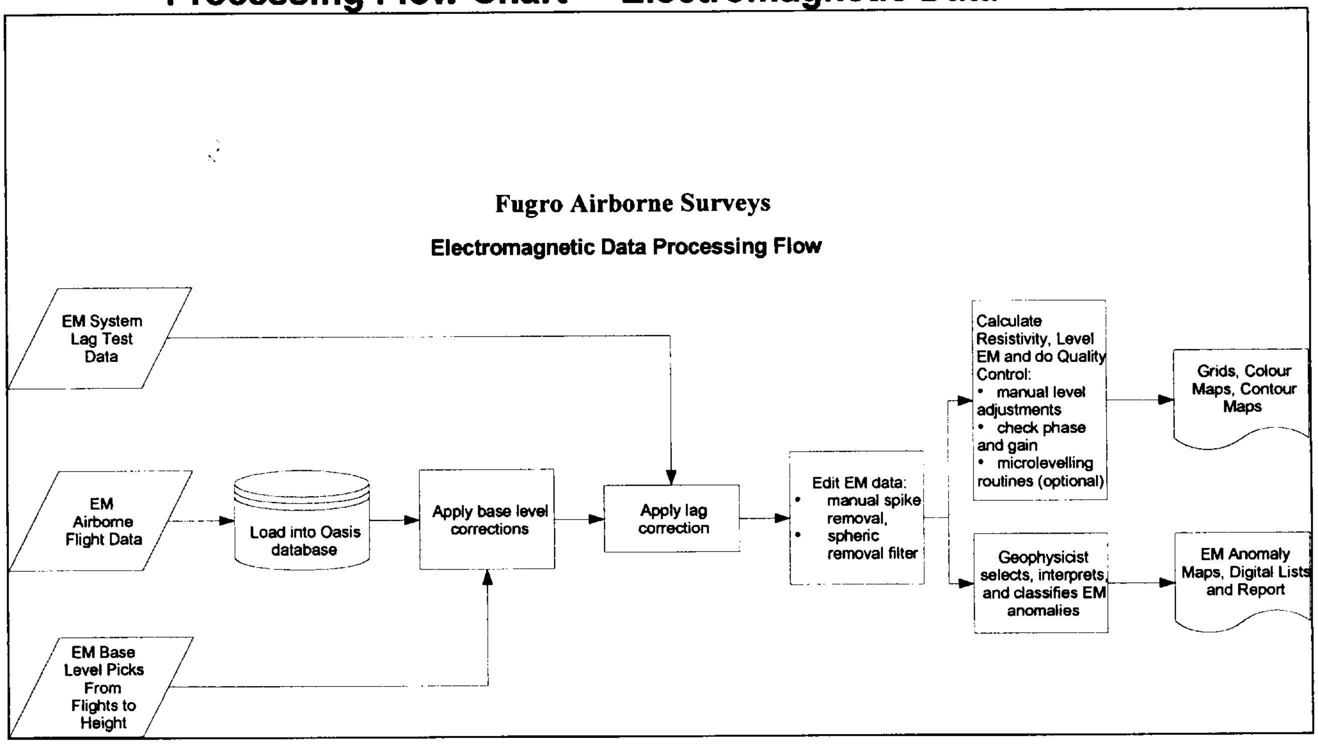
All personnel are employees of Fugro Airborne Surveys, except for the pilot who is an employee of Questral Helicopters Ltd.

APPENDIX B

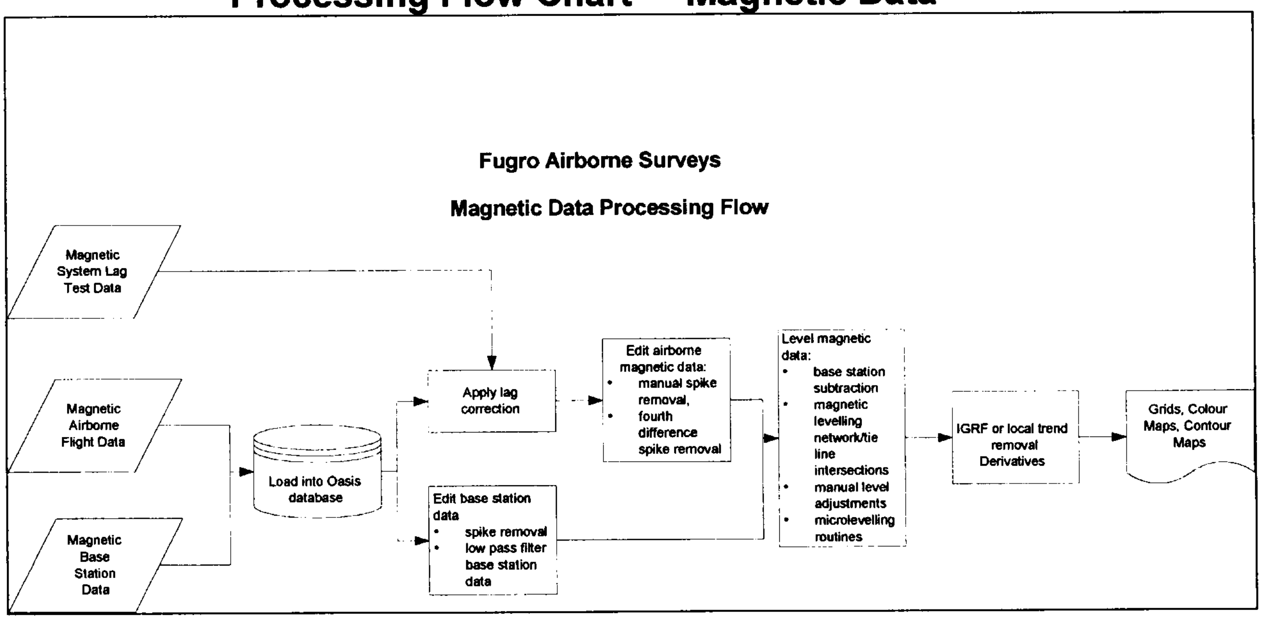
DATA PROCESSING FLOWCHARTS

APPENDIX B

Processing Flow Chart - Electromagnetic Data



Processing Flow Chart - Magnetic Data



BACKGROUND INFORMATION

Electromagnetics

Fugro 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 vertical sheet (half plane) is the most common model used for the analysis of discrete conductors. All anomalies plotted on the geophysical maps are analyzed according to this model. The following section entitled **Discrete Conductor Analysis** describes this model in detail, including the effect of using it on anomalies caused by broad conductors such as conductive overburden.

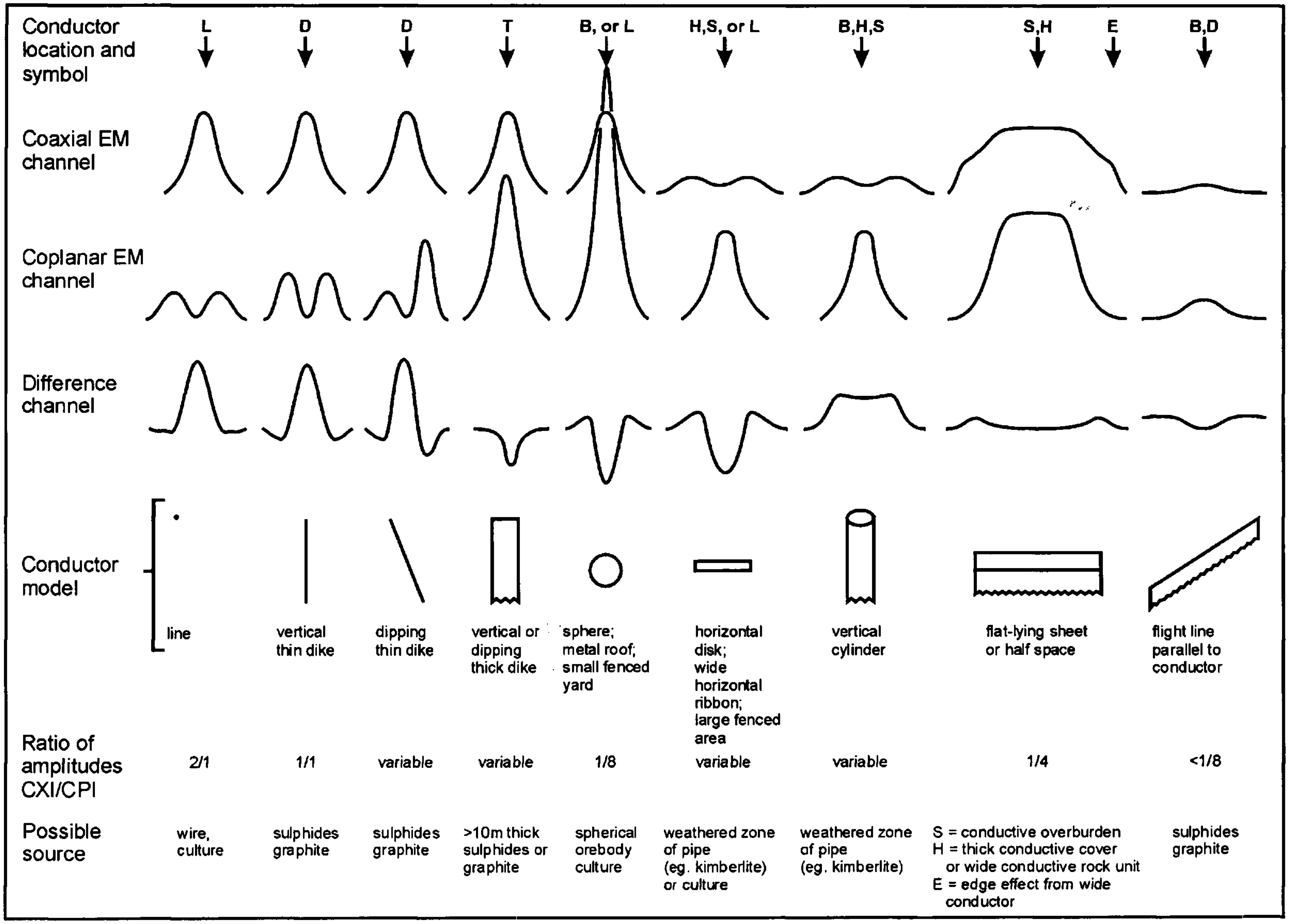
The conductive earth (half-space) model is suitable for broad conductors. Resistivity contour maps result from the use of this model. A later section entitled **Resistivity Mapping** describes the method further, including the effect of using it on anomalies caused by discrete conductors such as sulphide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

Geometric Interpretation

The geophysical interpreter attempts to determine the geometric shape and dip of the conductor. Figure C-1 shows typical HEM anomaly shapes which are used to guide the geometric interpretation.

Discrete Conductor Analysis

The EM anomalies appearing on the electromagnetic map are analyzed by computer to give the conductance (i.e., conductivity-thickness product) in siemens (mhos) of a vertical sheet model. This is done regardless of the interpreted geometric shape of the conductor. This is not an unreasonable procedure, because the computed conductance increases as the electrical quality of the conductor increases, regardless of its true shape. DIGHEM anomalies are divided into seven grades of conductance, as shown in Table C-1. The conductance in siemens (mhos) is the reciprocal of resistance in ohms.



Typical DIGHEM anomaly shapes

Figure C-1

The conductance value is a geological parameter because it is a characteristic of the conductor alone. It generally is independent of frequency, flying height or depth of burial, apart from the averaging over a greater portion of the conductor as height increases. Small anomalies from deeply buried strong conductors are not confused with small anomalies from shallow weak conductors because the former will have larger conductance values.

Table C-1. EM Anomaly Grades

Anomaly Grade	Siemens
7	> 100
6	50 - 100
5	20 - 50
4	10 - 20
3	5 - 10
2	1 - 5
1	< 1

Conductive overburden generally produces broad EM responses which may not be shown as anomalies on the geophysical maps. However, patchy conductive overburden in otherwise resistive areas can yield discrete anomalies with a conductance grade (cf. Table C-1) of 1, 2 or even 3 for conducting clays which have resistivities as low as 50 ohm-m. In areas where ground resistivities are below 10 ohm-m, anomalies caused by weathering variations and similar causes can have any conductance grade. The anomaly shapes from the multiple coils often allow such conductors to be recognized, and these are indicated by the letters S, H, and sometimes E on the geophysical maps (see EM legend on maps).

For bedrock conductors, the higher anomaly grades indicate increasingly higher conductances. Examples: the New Insco copper discovery (Noranda, Canada) yielded a grade 5 anomaly, as did the neighbouring copper-zinc Magusi River ore body; Mattabi (copper-zinc, Sturgeon Lake, Canada) and Whistle (nickel, Sudbury, Canada) gave grade 6; and the Montcalm nickel-copper discovery (Timmins, Canada) yielded a grade 7 anomaly. Graphite and sulphides can span all grades but, in any particular survey area, field work may show that the different grades indicate different types of conductors.

Strong conductors (i.e., grades 6 and 7) are characteristic of massive sulphides or graphite. Moderate conductors (grades 4 and 5) typically reflect graphite or sulphides of a less massive character, while weak bedrock conductors (grades 1 to 3) can signify poorly connected graphite or heavily disseminated sulphides. Grades 1 and 2 conductors may not respond to ground EM equipment using frequencies less than 2000 Hz.

The presence of sphalerite or gangue can result in ore deposits having weak to moderate conductances. As an example, the three million ton lead-zinc deposit of Restigouche Mining Corporation near Bathurst, Canada, yielded a well-defined grade 2 conductor. The 10 percent by volume of sphalerite occurs as a coating around the fine grained massive pyrite, thereby inhibiting electrical conduction. Faults, fractures and shear zones may produce anomalies that typically have low conductances (e.g., grades 1 to 3). Conductive rock formations can yield anomalies of any conductance grade. The conductive materials in such rock formations can be salt water, weathered products such as clays, original depositional clays, and carbonaceous material.

For each interpreted electromagnetic anomaly on the geophysical maps, a letter identifier and an Interpretive symbol are plotted beside the EM grade symbol. The horizontal rows of dots, under the interpretive symbol, indicate the anomaly amplitude on the flight record. The vertical column of dots, under the anomaly letter, gives the estimated depth. In areas where anomalies are crowded, the letter identifiers, interpretive symbols and dots may be obliterated. The EM grade symbols, however, will always be discernible, and the obliterated information can be obtained from the anomaly listing appended to this report.

The purpose of indicating the anomaly amplitude by dots is to provide an estimate of the reliability of the conductance calculation. Thus, a conductance value obtained from a large ppm anomaly (3 or 4 dots) will tend to be accurate whereas one obtained from a small ppm anomaly (no dots) could be quite inaccurate. The absence of amplitude dots indicates that the anomaly from the coaxial coil-pair is 5 ppm or less on both the in-phase and quadrature channels. Such small anomalies could reflect a weak conductor at the surface or a stronger conductor at depth. The conductance grade and depth estimate illustrates which of these possibilities fits the recorded data best.

The conductance measurement is considered more reliable than the depth estimate. There are a number of factors that can produce an error in the depth estimate, including the averaging of topographic variations by the altimeter, overlying conductive overburden, and the location and attitude of the conductor relative to the flight line. Conductor location and attitude can provide an erroneous depth estimate because the stronger part of the conductor may be deeper or to one side of the flight line, or because it has a shallow dip. A heavy tree cover can also produce errors in depth estimates. This is because the depth estimate is computed as the distance of bird from conductor, minus the altimeter reading. The altimeter can lock onto the top of a dense forest canopy. This situation yields an erroneously large depth estimate but does not affect the conductance estimate.

Dip symbols are used to indicate the direction of dip of conductors. These symbols are used only when the anomaly shapes are unambiguous, which usually requires a fairly resistive environment.

A further interpretation is presented on the EM map by means of the line-to-line correlation of bedrock anomalies, which is based on a comparison of anomaly shapes on adjacent lines. This provides conductor axes that may define the geological structure over portions of the survey area. The absence of conductor axes in an area implies that anomalies could not be correlated from line to line with reasonable confidence.

The electromagnetic anomalies are designed to provide a correct impression of conductor quality by means of the conductance grade symbols. The symbols can stand alone with geology when planning a follow-up program. The actual conductance values are printed in the attached anomaly list for those who wish quantitative data. The anomaly ppm and depth are indicated by inconspicuous dots which should not distract from the conductor patterns, while being helpful to those who wish this information. The map provides an interpretation of conductors in terms of length, strike and dip, geometric shape, conductance, depth, and thickness. The accuracy is comparable to an interpretation from a high quality ground EM survey having the same line spacing.

The appended EM anomaly list provides a tabulation of anomalies in ppm, conductance, and depth for the vertical sheet model. No conductance or depth estimates are shown for weak anomalous responses that are not of sufficient amplitude to yield reliable calculations.

Since discrete bodies normally are the targets of EM surveys, local base (or zero) levels are used to compute local anomaly amplitudes. This contrasts with the use of true zero levels which are used to compute true EM amplitudes. Local anomaly amplitudes are shown in the EM anomaly list and these are used to compute the vertical sheet parameters of conductance and depth.

Questionable Anomalies

The EM maps may contain anomalous responses that are displayed as asterisks (*). These responses denote weak anomalies of indeterminate conductance, which may reflect one of the following: a weak conductor near the surface, a strong conductor at depth (e.g., 100 to 120 m below surface) or to one side of the flight line, or aerodynamic noise. Those responses that have the appearance of valid bedrock anomalies on the flight profiles are indicated by appropriate interpretive symbols (see EM legend on maps). The others probably do not warrant further investigation unless their locations are of considerable geological interest.

The Thickness Parameter

A comparison of coaxial and coplanar shapes can provide an indication of the thickness of a steeply dipping conductor. The amplitude of the coplanar anomaly (e.g., CPI channel) increases relative to the coaxial anomaly (e.g., CXI) as the apparent thickness increases, i.e., the thickness in the horizontal plane. (The thickness is equal to the conductor width if the conductor dips at 90 degrees and strikes at right angles to the flight line.) This report refers to a conductor as <u>thin</u> when the thickness is likely to be less than 3 m, and <u>thick</u> when in excess of 10 m. Thick conductors are indicated on the EM map by parentheses "( )". For base metal exploration in steeply dipping geology, thick conductors can be high priority targets because many massive sulphide ore bodies are thick. The system cannot sense the thickness when the strike of the conductor is subparallel to the flight line, when the conductor has a shallow dip, when the anomaly amplitudes are small, or when the resistivity of the environment is below 100 ohm-m.

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)[5]. 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.

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

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 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 nbt 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

Environments having low background resistivities (e.g., below 30 ohm-m for a 900 Hz system) yield very large responses from the conductive ground. This usually prohibits the recognition of discrete bedrock conductors. However, Fugro data processing techniques produce three parameters that contribute significantly to the recognition of bedrock conductors in conductive environments. These are the in-phase and quadrature difference channels (DIFI and DIFQ, which are available only on systems with "common" frequencies on orthogonal coil pairs), and the resistivity and depth channels (RES and DEP) for each coplanar frequency.

The EM difference channels (DIFI and DIFQ) eliminate most of the responses from conductive ground, leaving responses from bedrock conductors, cultural features (e.g., telephone lines, fences, etc.) and edge effects. Edge effects often occur near the perimeter of broad conductive zones. This can be a source of geologic noise. While edge effects yield anomalies on the EM difference channels, they do not produce resistivity anomalies. Consequently, the resistivity channel aids in eliminating anomalies due to edge effects. On the other hand, resistivity anomalies will coincide with the most highly conductive sections of conductive ground, and this is another source of geologic noise. The recognition of a bedrock conductor in a conductive environment therefore is based on the anomalous responses of the two difference channels (DIFI and DIFQ) and the resistivity channels (RES). The most favourable situation is where anomalies coincide on all channels.

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.

Reduction of Geologic Noise

Geologic noise refers to unwanted geophysical responses. For purposes of airborne EM surveying, geologic noise refers to EM responses caused by conductive overburden and magnetic permeability. It was mentioned previously that the EM difference channels (i.e., channel DIFI for in-phase and DIFQ for quadrature) tend to eliminate the response of conductive overburden.

Magnetite produces a form of geological noise on the in-phase channels. Rocks containing less than 1% magnetite can yield negative in-phase anomalies caused by magnetic permeability. When magnetite is widely distributed throughout a survey area, the in-phase EM channels may continuously rise and fall, reflecting variations in the magnetite percentage, flying height, and overburden thickness. This can lead to difficulties in recognizing deeply buried bedrock conductors, particularly if conductive overburden also exists. However, the response of broadly distributed magnetite generally vanishes on the in-phase difference channel DIFI. This feature can be a significant aid in the recognition of conductors that occur in rocks containing accessory magnetite.

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 compenents, 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 1/4% 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[6] 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.

---

6 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).

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 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 homegeneous 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. High-susceptibility 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, HEM-derived 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 susceptibillty (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.

The table below shows the effects of varying permittivity over a resistive (10,000 ohm-m) half space, at frequencies of 56,000 Hz (DIGHEM^{V}) and 102,000 Hz (RESOLVE).

Apparent Resistivity Calculations
Effects of Permittivity on In-phase/Quadrature/Resistivity

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

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.[7] When the flight crosses the cultural line at a high 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.[8] Anomalies of this type are virtually certain to be cultural if they occur in an area of culture.

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.[5] Anomalies of this type are virtually certain to be cultural if they occur in an area of culture.

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[7] See Figure C-1 presented earlier.

[8] It is a characteristic of EM that geometrically similar anomalies are obtained from: (1) a planar conductor, and (2) a wire which forms a loop having dimensions identical to the perimeter of the equivalent planar conductor.

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 m-shaped 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.

APPENDIX D

DATA ARCHIVE DESCRIPTION

APPENDIX D

ARCHIVE DESCRIPTION

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Geosoft  ARCHIVE SUMMARY
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JOB TITLE:
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JOB #                  :04054
TYPE OF SURVEY         :FUGRO EM, MAGNETICS, RESISTIVITY
AREA                   :OK Property,  B.C.
CLIENT                 :Goldrush Resources Ltd.


SURVEY DATA FORMAT :
NUMBER OF DATA FIELDS :   37
  # CHANNAME          TIME   UNITS / DESCRIPTION


  1 X                  0.1    m      UTME-NAD83  Zone 10N
  2 Y                  0.1    m      UTMN-NAD83  Zone 10N
  3 FID                0.1           fiducial
  4 ALTBIRDM           0.1    m      Radar Altimeter  Bird to surface distance
  5 MAG                0.1    nT     diurnally correct lagged and levelled mag
  6 DEM                0.1    m      Digital Elevation Model NAD83
  7 DIURNAL            0.1    nT     basestation diurnal readings
  8 CXI1000            0.1    ppm    levelled inphase     - coaxial   1090 Hz
  9 CXQ1000            0.1    ppm    levelled quadrature - coaxial   1090 Hz
 10 CXI5500            0.1    ppm    levelled inphase     - coaxial   5795 Hz
 11 CXQ5500            0.1    ppm    levelled quadrature - coaxial   5795 Hz
 12 CPI900             0.1    ppm    levelled inphase     - coplanar 876   Hz
 13 CPQ900             0.1    ppm    levelled quadrature - coplanar 876   Hz
 14 CPI7200            0.1    ppm    levelled inphase     - coplanar 7253 Hz
 15 CPQ7200            0.1    ppm    levelled quadrature - coplanar 7253 Hz
 16 CPI56K             0.1    ppm    levelled inphase     - coplanar 56090 Hz
 17 CPQ56K             0.1    ppm    levelled quadrature - coplanar 56090 Hz
 18 CPPL               0.1           POWERLINE MONITOR COPLANAR
 19 CPSP               0.1           SPHERICS MONITOR COPLANAR
 20 CXPL               0.1           POWERLINE MONITOR COAXIAL
 21 CXSP               0.1           SPHERICS MONITOR COAXIAL
 22 RES1000            0.1    ohm*m apparent resistivity 1090 Hz
 23 RES5500            0.1    ohm*m apparent resistivity 5795 Hz
 24 RES7200            0.1    ohm*m apparent resistivity 7253 Hz
 25 RES56K             0.1    ohm*m apparent resistivity 56090 Hz
 26 RES900             0.1    ohm*m apparent resistivity 876 Hz
 27 DEP900             0.1    m      apparent DEPTH 876 Hz
 28 DEP56K             0.1    m      apparent DEPTH 876 Hz
 29 DEP7200            0.1    m      apparent DEPTH 7253 Hz
 30 DEP5500            0.1    m      apparent DEPTH 5795 Hz
 31 DEP1000            0.1    m      apparent DEPTH 1090 Hz
 32 GPSLAT             0.1    deg    DGPS latitude WGS84
 33 GPSLON             0.1    deg    DGPS longitude WGS84
 34 GPSZ               0.1    m      DGPS bird height above ellipsoid WGS84
 35 TIME               0.1    s      local time
 36 DIFI               0.1           difference based on inphase
 37 DIFQ               0.1           difference based on quadrature
```

The coordinate system for all grids and XYZ files is projected as follows

Datum	NAD83
Projection	UTM (Zone 10N)
Central meridian	123 West
False easting	500000
False northing	0
Scale factor	0.9996
WGS84 to local conversion method	Molodensky
Delta X shift	0
Delta Y shift	0
Delta Z shift	0

If you have any problems with this archive please contact

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APPENDIX E

EM ANOMALY LIST

EM Anomaly List

Label	Fid	Interp	XUTM m	YUTM m	CX 5500 HZ Real ppm	CX 5500 HZ Quad ppm	CP 7200 HZ Real ppm	CP 7200 HZ Quad ppm	CP 900 HZ Real ppm	CP 900 HZ Quad ppm	Vertical Dike COND siemens	Vertical Dike DEPTH* m	Mag. Corr NT
LINE 10010			FLIGHT 5										
A	2992.7	S	381212	5546766	0.8	2.3	7.2	11.6	8.8	3.3	---	---	0
B	2957.0	S?	381815	5547095	0.3	4.2	32.4	14.2	34.3	17.5	---	---	0
LINE 10020			FLIGHT 5										
A	2740.0	S	381015	5546568	2.1	2.9	14.0	14.4	7.6	2.4	---	---	53
B	2838.3	S?	381957	5547082	5.3	1.8	28.1	12.5	27.6	3.8	---	---	430
LINE 10030			FLIGHT 5										
A	2293.5	S	381004	5546435	1.2	4.8	8.4	11.1	10.6	3.2	---	---	0
LINE 10070			FLIGHT 3										
A	7572.2	S?	382583	5546850	0.0	4.2	13.5	20.6	10.2	4.6	---	---	147
LINE 10081			FLIGHT 5										
A	1332.7	S?	382614	5546755	1.1	3.2	8.1	18.7	0.1	5.7	---	---	152
LINE 10090			FLIGHT 3										
A	6571.2	S	380555	5545509	3.7	6.1	30.4	27.6	35.0	5.2	---	---	0
B	6770.1	S?	382799	5546718	0.0	5.6	0.6	31.3	1.2	6.9	---	---	9
LINE 10100			FLIGHT 3										
A	6276.4	S?	380498	5545366	6.4	5.3	25.1	32.5	27.4	9.0	---	---	0

CX = COAXIAL
CP = COPLANAR

Note: EM values shown above are local amplitudes

*Estimated Depth may be unreliable because the stronger part of the conductor may be deeper or to one side of the flight line, or because of a shallow dip or magnetite/overburden effects

EM Anomaly List

Label	Fid	Interp	XUTM m	YUTM m	CX 5500 HZ Real ppm	CX 5500 HZ Quad ppm	CP 7200 HZ Real ppm	CP 7200 HZ Quad ppm	CP 900 HZ Real ppm	CP 900 HZ Quad ppm	Vertical Dike COND siemens	Vertical Dike DEPTH* m	Mag. Corr NT
LINE 10110		FLIGHT 3											
A	5925.5	S?	380586	5545299	0.0	4.3	11.2	16.6	14.1	3.4	---	---	114
B	6075.8	S?	382923	5546563	0.0	5.7	22.9	28.2	0.0	4.4	---	---	0
LINE 10120		FLIGHT 3											
A	5635.5	S?	380930	5545352	0.0	5.7	0.0	25.7	28.4	5.9	---	---	375
B	5578.7	S	381861	5545870	3.5	2.2	14.4	16.4	14.8	6.1	---	---	0
LINE 10130		FLIGHT 3											
A	5332.7	S	381935	5545789	2.9	2.1	8.8	13.1	11.5	2.8	---	---	0
LINE 10140		FLIGHT 3											
A	4905.1	S	381889	5545665	2.0	2.0	12.9	16.9	14.6	5.6	---	---	0
LINE 10150		FLIGHT 3											
A	4668.4	S	381890	5545542	3.3	3.3	7.2	14.1	8.2	5.0	---	---	0
LINE 10200		FLIGHT 3											
A	3211.0	S	381851	5544963	2.5	1.4	5.6	10.0	6.0	6.6	---	---	0
LINE 10210		FLIGHT 3											
A	2950.0	S	381868	5544857	1.8	11.2	23.4	50.4	14.0	6.0	---	---	0
B	2963.5	B?	382121	5544993	0.3	23.5	4.7	107.2	44.6	14.8	---	---	243

CX = COAXIAL
CP = COPLANAR

Note: EM values shown above are local amplitudes

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EM Anomaly List

Label	Fid	Interp	XUTM m	YUTM m	CX 5500 HZ Real ppm	CX 5500 HZ Quad ppm	CP 7200 HZ Real ppm	CP 7200 HZ Quad ppm	CP 900 HZ Real ppm	CP 900 HZ Quad ppm	Vertical Dike COND siemens	Vertical Dike DEPTH* m	Mag. Corr NT
LINE 10220			FLIGHT 3										
A	2679.2	S	381715	5544664	2.2	5.1	12.4	37.6	12.0	5.2	---	---	0
B	2661.3	B?	382124	5544882	1.9	49.5	10.1	250.9	4.2	33.4	---	---	29
LINE 10230			FLIGHT 3										
A	2409.1	S	382149	5544773	1.3	4.0	3.8	31.5	2.8	4.4	---	---	0
LINE 10240			FLIGHT 3										
A	2037.5	S	381728	5544439	0.3	3.2	4.4	32.8	2.2	6.4	---	---	0
LINE 10260			FLIGHT 3										
A	1437.2	S	382973	5544869	2.5	7.8	15.5	31.3	17.6	7.3	---	---	0
LINE 10290			FLIGHT 2										
A	7627.2	S	383547	5544841	1.7	6.8	51.6	27.5	31.4	4.2	---	---	0
LINE 10300			FLIGHT 2										
A	7274.0	S	382451	5544139	1.9	9.6	5.6	57.0	0.0	10.1	---	---	23
B	7208.1	S?	383656	5544786	1.6	8.9	1.0	68.3	1.8	9.9	---	---	0
LINE 10310			FLIGHT 2										
A	7150.7	S	383696	5544696	9.2	10.8	43.9	90.0	44.6	12.7	---	---	0

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EM Anomaly List

Label	Fid	Interp	XUTM m	YUTM m	CX 5500 HZ Real ppm	CX 5500 HZ Quad ppm	CP 7200 HZ Real ppm	CP 7200 HZ Quad ppm	CP 900 HZ Real ppm	CP 900 HZ Quad ppm	Vertical Dike COND siemens	Vertical Dike DEPTH* m	Mag. Corr NT
LINE 10320			FLIGHT 2										
A	6869.6	S?	381700	5543503	6.8	11.1	17.6	42.3	14.9	8.9	---	---	0
B	6826.0	S?	382481	5543925	5.6	5.9	17.8	33.8	18.2	7.6	---	---	76
C	6760.0	S?	383600	5544530	0.0	7.1	0.0	40.2	0.0	7.4	---	---	0
D	6748.3	S?	383825	5544650	2.3	19.0	36.1	76.7	28.5	11.8	---	---	0
LINE 10330			FLIGHT 2										
A	6590.4	S?	381367	5543208	9.2	7.3	30.1	10.5	35.0	2.7	---	---	46
B	6694.7	S?	383690	5544466	5.3	10.0	3.5	35.8	5.1	4.9	---	---	240
C	6701.7	S	383841	5544551	8.1	2.7	64.6	45.6	71.5	6.8	---	---	0
LINE 10340			FLIGHT 2										
A	6311.5	S	383866	5544444	3.2	8.5	37.4	83.4	41.5	14.7	---	---	0
LINE 10350			FLIGHT 2										
A	6103.3	S?	380869	5542697	0.3	5.3	2.7	15.8	4.1	3.7	---	---	0
B	6257.0	S?	383793	5544291	13.2	12.4	54.8	57.1	56.0	8.5	---	---	0
LINE 10360			FLIGHT 2										
A	5956.0	S	380927	5542625	3.6	4.4	6.9	13.4	7.9	1.6	---	---	0
B	5896.8	S	382101	5543256	0.1	3.9	0.0	18.2	0.0	6.2	---	---	0
C	5813.3	S?	383555	5544054	0.0	3.4	34.7	28.5	41.0	5.1	---	---	63
D	5801.4	S?	383807	5544187	0.0	8.1	5.9	20.1	0.0	4.4	---	---	456

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EM Anomaly List

Label	Fid	Interp	XUTM m	YUTM m	CX 5500 HZ Real ppm	CX 5500 HZ Quad ppm	CP 7200 HZ Real ppm	CP 7200 HZ Quad ppm	CP 900 HZ Real ppm	CP 900 HZ Quad ppm	Vertical Dike COND siemens	Vertical Dike DEPTH* m	Mag. Corr NT
LINE 10370			FLIGHT 2										
A	5582.0	S?	380886	5542505	1.1	3.0	4.5	10.4	1.4	5.0	---	---	34
B	5666.4	S?	382684	5543468	0.5	14.3	0.0	52.8	0.0	6.4	---	---	38
C	5741.4	S	384020	5544186	2.1	7.4	14.4	18.3	17.6	2.7	---	---	0
LINE 10390			FLIGHT 2										
A	5162.7	S?	381181	5542436	4.3	2.6	0.0	8.9	0.9	4.6	---	---	0
B	5261.1	S?	383430	5543653	2.3	1.7	3.7	8.3	5.9	3.8	---	---	0
C	5280.0	S?	383866	5543880	0.0	4.9	6.2	12.6	6.8	2.3	---	---	0
LINE 10400			FLIGHT 2										
A	4926.1	S?	383475	5543547	30.6	9.9	124.1	40.7	141.2	6.9	---	---	131
LINE 10410			FLIGHT 2										
A	4700.5	S?	383397	5543400	0.2	1.5	20.0	7.5	29.5	2.8	---	---	882
LINE 10431			FLIGHT 5										
A	752.7	S	381997	5542412	0.2	18.8	5.0	90.9	5.8	14.9	---	---	0
B	735.3	S?	382319	5542596	0.1	3.4	17.8	11.1	18.7	4.0	---	---	116
C	660.3	S?	383666	5543321	0.5	1.2	71.4	10.1	75.8	3.4	---	---	345
LINE 10440			FLIGHT 2										
A	3882.7	S?	382048	5542324	0.0	36.6	3.3	168.5	4.0	27.4	---	---	0

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Label	Fid	Interp	XUTM m	YUTM m	CX 5500 HZ Real ppm	CX 5500 HZ Quad ppm	CP 7200 HZ Real ppm	CP 7200 HZ Quad ppm	CP 900 HZ Real ppm	CP 900 HZ Quad ppm	Vertical Dike COND siemens	Vertical Dike DEPTH* m	Mag. Corr NT
LINE 10450			FLIGHT 2										
A	3555.2	S	382050	5542208	1.4	10.8	7.3	58.0	8.3	7.5	---	---	0
LINE 10470			FLIGHT 2										
A	3042.0	S	382172	5542055	0.7	5.6	2.7	25.3	3.5	2.6	---	---	64
LINE 10480			FLIGHT 2										
A	2865.2	S?	382361	5542043	4.3	1.2	18.4	11.9	21.0	4.0	---	---	72
B	2789.3	S?	383434	5542634	11.1	2.3	24.4	15.6	26.0	7.9	---	---	0
C	2750.0	S?	384079	5542983	2.9	4.0	53.4	11.2	56.3	3.1	---	---	314
LINE 10490			FLIGHT 2										
A	2635.1	S	384325	5542995	4.9	10.4	16.1	56.6	18.3	6.6	---	---	0
LINE 10500			FLIGHT 2										
A	2168.5	S?	384400	5542921	0.9	26.3	30.3	137.7	30.0	20.3	---	---	0
LINE 10511			FLIGHT 3										
A	770.6	S?	383271	5542197	0.1	3.8	64.1	15.6	5.7	7.4	---	---	0
B	730.4	S?	383930	5542553	0.0	4.1	0.0	10.8	0.0	3.5	---	---	437
LINE 10520			FLIGHT 2										
A	1722.0	S?	383464	5542181	0.4	3.4	61.6	19.3	71.1	3.9	---	---	187

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EM Anomaly List

Label	Fid	Interp	XUTM m	YUTM m	CX 5500 HZ Real ppm	CX 5500 HZ Quad ppm	CP 7200 HZ Real ppm	CP 7200 HZ Quad ppm	CP 900 HZ Real ppm	CP 900 HZ Quad ppm	Vertical Dike COND siemens	Vertical Dike DEPTH* m	Mag. Corr NT
LINE 10530		FLIGHT 2											
A	1491.1	S?	383372	5542026	5.2	4.1	23.0	8.9	20.8	1.4	---	---	53
B	1586.5	S?	384998	5542908	0.0	4.9	11.1	18.0	12.3	1.5	---	---	159
LINE 10571		FLIGHT 2											
A	724.0	S?	382220	5540951	8.1	4.2	0.0	15.5	0.0	5.3	---	---	0
LINE 10590		FLIGHT 1											
A	5754.0	S	383183	5541240	1.0	7.3	8.0	32.9	8.6	5.2	---	---	0
B	5804.1	S?	384107	5541721	0.0	3.1	11.8	17.5	11.5	3.7	---	---	0
C	5826.3	S?	384304	5541847	0.0	0.9	13.3	15.3	13.7	3.5	---	---	269
LINE 10600		FLIGHT 1											
A	5590.9	S?	382273	5540624	4.0	2.2	7.0	14.9	6.7	2.7	---	---	22
B	5537.4	S?	383078	5541065	4.1	4.9	18.1	27.3	17.6	6.0	---	---	53
C	5463.3	S?	384248	5541695	0.0	3.7	16.5	22.9	19.4	7.1	---	---	0
D	5400.1	S?	385120	5542170	2.0	4.8	20.4	21.2	20.8	7.7	---	---	161
LINE 10610		FLIGHT 1											
A	5257.7	S?	384237	5541569	4.2	4.9	40.2	22.5	38.0	2.8	---	---	0
LINE 10620		FLIGHT 1											
A	4932.3	S?	382431	5540480	0.0	3.6	0.0	20.2	0.0	4.7	---	---	152
B	4831.0	B?	384054	5541359	0.2	30.2	43.7	149.1	42.4	23.5	---	---	145

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EM Anomaly List

Label	Fid	Interp	XUTM m	YUTM m	CX 5500 HZ Real ppm	CX 5500 HZ Quad ppm	CP 7200 HZ Real ppm	CP 7200 HZ Quad ppm	CP 900 HZ Real ppm	CP 900 HZ Quad ppm	Vertical Dike COND siemens	Vertical Dike DEPTH* m	Mag. Corr NT
LINE 10620			FLIGHT 1										
C	4786.8	S?	384668	5541694	0.0	2.7	0.0	19.7	0.4	5.1	---	---	557
LINE 10630			FLIGHT 1										
A	4582.7	S?	383591	5540998	0.0	4.4	4.9	20.7	4.3	2.8	---	---	43
B	4607.6	S?	384177	5541315	1.3	11.6	54.6	55.2	61.8	7.4	---	---	82
C	4620.0	S?	384398	5541428	1.8	4.7	7.5	14.3	8.5	3.6	---	---	0
D	4653.2	S?	384645	5541581	0.0	3.1	43.1	19.0	45.6	6.4	---	---	149
E	4696.1	S?	385368	5541957	0.0	1.7	4.0	6.6	3.4	2.1	---	---	358
LINE 10640			FLIGHT 1										
A	4313.2	S?	384331	5541280	0.9	3.7	10.2	14.4	12.9	4.1	---	---	0
B	4239.8	S?	385297	5541811	2.1	3.1	25.7	18.2	25.3	7.8	---	---	497
LINE 10660			FLIGHT 1										
A	3683.5	S	384921	5541367	3.7	2.6	22.4	15.7	22.0	2.4	---	---	0
LINE 10670			FLIGHT 1										
A	3518.2	S?	384857	5541240	0.7	6.3	20.5	30.4	23.5	4.4	---	---	0
LINE 10680			FLIGHT 1										
A	3162.9	S?	384828	5541088	0.1	5.7	29.6	25.4	12.0	7.5	---	---	98
B	3112.0	S	385614	5541514	0.0	7.9	6.7	42.9	5.3	11.1	---	---	0

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EM Anomaly List

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LINE 10690			FLIGHT 1										
A	2972.2	S	384848	5540999	2.8	0.8	30.6	11.1	31.7	2.4	---	---	0
LINE 10700			FLIGHT 1										
A	2456.0	S?	384830	5540866	1.7	2.4	63.0	24.0	63.4	3.8	---	---	170
LINE 10710			FLIGHT 1										
A	2142.0	S?	383262	5539898	2.9	3.1	32.0	16.6	31.7	3.4	---	---	45
LINE 10730			FLIGHT 1										
A	1496.1	S?	383442	5539774	0.0	1.7	1.6	13.5	0.8	2.2	---	---	173
LINE 10740			FLIGHT 1										
A	1213.7	S?	384473	5540224	8.4	5.0	0.4	28.7	5.1	5.3	---	---	0
LINE 10750			FLIGHT 1										
A	729.0	S	384311	5540021	0.0	3.9	23.8	17.9	33.7	3.0	---	---	475
LINE 10760			FLIGHT 1										
A	404.0	S?	384418	5539971	0.1	4.9	39.6	24.0	43.5	6.5	---	---	279
B	394.4	S?	384546	5540041	0.0	4.2	62.2	21.9	67.5	5.5	---	---	170
LINE 19010			FLIGHT 5										
A	3513.2	S?	380866	5542589	0.0	5.4	9.6	20.5	13.0	6.9	---	---	0

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EM Anomaly List

Label	Fid	Interp	XUTM m	YUTM m	CX 5500 HZ Real ppm	CX 5500 HZ Quad ppm	CP 7200 HZ Real ppm	CP 7200 HZ Quad ppm	CP 900 HZ Real ppm	CP 900 HZ Quad ppm	Vertical Dike COND siemens	Vertical Dike DEPTH* m	Mag. Corr NT
LINE 19020			FLIGHT 5										
A	4166.9	S	383792	5544701	3.7	7.5	9.0	77.9	9.1	10.9	---	---	20
B	4160.3	S?	383893	5544536	4.5	5.6	5.7	77.9	4.7	10.9	---	---	45

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APPENDIX F

GLOSSARY

APPENDIX F

GLOSSARY OF AIRBORNE GEOPHYSICAL TERMS

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

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

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

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

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

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

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

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

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

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

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

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

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

coaxial coils: **[CX]** Coaxial coils 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 the nuclei of atoms they pass through (earth and atmosphere), reducing their energy and then being detected by ***radiometric*** sensors at lower energy levels. See also ***stripping***.

conductance: See ***conductivity thickness***

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

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

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

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

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

coplanar coils: **[CP]** 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 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.

current channelling: See current gathering.

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

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

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

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

decay constant: see time constant.

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 tha same if the dipole moment product is the same. For a receiver coil, this is the product of the area and the number of turns. The sensitivity to a magnetic field (assuming the source is far away) will be the same if the dipole moment is the same.

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

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

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

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

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

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

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

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.

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

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

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

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

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

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

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

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

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

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

HEM: Helicopter ElectroMagnetic, This designation is most commonly used to helicopter-borne, ***frequency-domain*** electromagnetic systems. At present, the transmitter and receivers are normally mounted in a ***bird*** carried on a sling line beneath the helicopter.

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

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

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***)

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

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

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

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

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

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

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***.

phase: 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 for electromagnetic surveys are ***conductivity, magnetic permeability*** (or ***susceptibility***) and ***dielectric permittivity***; for magnetic surveys the parameter is magnetic susceptibility, and for gamma ray spectrometric surveys it is the concentration of the major radioactive elements: potassium, uranium, and thorium.

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

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

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

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

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***.

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.

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

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

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

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

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

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

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

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

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

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

spheric: see ***sferic***.

stacking: Summing repeat measurements over time to enhance the repeating ***signal***, and minimize the random ***noise***.

stripping: Estimation and correction for the gamma ray photons of higher and lower energy that are observed in a particular ***energy window***. See also ***Compton scattering***.

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

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

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

thin sheet: A standard model for electromagnetic geophysical theory. It is usually defined as thin, flat-lying, and ***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.

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

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

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***.

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Common Symbols and Acronyms

k Magnetic susceptibility
ε Dielectric permittivity
μ, μ_r Magnetic permeability, apparent permeability
ρ, ρ_a Resistivity, apparent resistivity
σ,σ_a Conductivity, apparent conductivity
σ**t** Conductivity thickness
τ Tau, or time constant
Ω**.m** Ohm-metres, units of resistivity
AGS Airborne gamma ray spectrometry.
CDT Conductivity-depth transform, conductivity-depth imaging (Macnae and Lamontagne, 1987; Wolfgram and Karlik, 1995)
CPI, CPQ Coplanar in-phase, quadrature
CPS Counts per second
CTP Conductivity thickness product
CXI, CXQ Coaxial, in-phase, quadrature
fT femtoteslas, normal unit for measurement of B-Field
EM Electromagnetic
keV kilo electron volts – a measure of gamma-ray energy
MeV mega electron volts – a measure of gamma-ray energy 1MeV = 1000keV
NIA dipole moment: turns x current x Area
nT nano-Tesla, a measure of the strength of a magnetic field
ppm parts per million – a measure of secondary field or noise relative to the primary.
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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