Interpretation Report

On Blocks 03, 05 and 07 of a Helicopter-Borne Electromagnetic and Magnetic Survey

Carried out by

Aeroquest Ltd.

Under Contract to

Billiken Management

On behalf of Temex Resources
And Participating Companies

McFauld's Lake Area, James Bay Lowlands

Ontario, Canada

SCOTT HOGG & ASSOCIATES LTD

June 2008
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1 INTRODUCTION

In late 2007, Noront Resources Ltd. wished to carry out an airborne magnetic and electromagnetic survey over its properties in the McFauld's Lake Area of Northern Ontario. Other companies, such as Temex, with properties in the vicinity of Noront, wished to participate in the airborne geophysical program.

To meet the objectives of a multi-partner program, Noront arranged for Billiken Management to manage the operation. Billiken contracted Aeroquest Ltd. to fly the survey using the AeroTem III helicopter transient electromagnetic system. Scott Hogg & Associates Ltd., SHA, were contracted to provide technical management, compilation and interpretation services.

While the survey was in progress Aeroquest provided SHA with field-processed digital data from which preliminary maps, representative of the magnetic and electromagnetic data were prepared. An interim report that included preliminary anomaly identification and follow-up recommendations was also provided by SHA. When completed, the final Aeroquest data, maps and report were distributed. This report documents the processing and interpretation methodology applied to the final corrected geophysical data and provides follow-up recommendations.
2 SURVEY LOCATION

Figure 1 - Survey Location Map

3 SURVEY BOUNDARY

The airborne survey encompassed a number of claim blocks held by different companies. The subdivision of the survey data was based on the Ministry of Natural Resources claim maps that provide a uniform coordinate definition for each mining claim. It was known that the accuracy of these claim boundary coordinates was poor and a buffer zone of about 300 metres was added to each claim block to compensate for potential error in claim boundary definition.
4 AIRBORNE SURVEY

4.1 AeroTem III Electromagnetic System

The AeroTem III system uses a superimposed dipole configuration with the receiver located within the transmitter loop. The transmitter axis is vertical (Z). The receiver has two independent axes; vertical Z and in the direction of flight X. The transmitter current waveform is a triangular ramp, repeated with reversing polarity at 90 Hz. The receiver measures the secondary field at intervals during and after the transmitter current pulse.

A plot of the transmitted pulse, along with on-time and off-time channels is presented in Figure 2.

The system was towed 53 metres below the helicopter at a nominal terrain clearance of 30 metres.

Figure 2 - AeroTem III System: The current waveform, or primary field Bp, is illustrated as black line together with the location of the On-time and Off-time channels. The receiver measures the derivative of the secondary field dBs/dt, as illustrated by the red or blue profiles, for each of these channels. An anomaly from a high conductance source will decay more slowly than that of a low conductance source.
**AeroTem III Time Gates:** The blue shading indicates measurements taken during the transmitted pulse, the On-Time. The yellow shading indicates those taken during the Off-Time, following the pulse.

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4.2 AeroTem III System Geometry and Response Shape

The system geometry, as defined by the relative orientation and position of the transmitter and receiver, influences the shape of response for a given geologic conductor or target. This response shape is sensitive to the form of the target but is largely independent of the conductivity of the target. The figure below presents the response shape for a thin sheet conductor in various orientations for a generalized superimposed dipole system. In the case of the Aerotem III, only the Tz-Rz and Tz-Rx combinations are relevant.

Figure 3 - Response shapes for a superimposed dipole electromagnetic system. A thin rectangular plate, 300 m in strike extent, 150 m in depth extent, 50 m below sensor with a conductance of 60 S was modelled with the University of Toronto Plate program. Strike and dip are indicated as are the axis of the transmitter and receiver antennae dipoles. The response amplitude has been normalized.
The Tz-Rz configuration is minimum coupled with a vertical thin sheet when the system is directly overhead. This results in an "M" shaped response. As the horizontal thickness of the conductor increases, induced currents can flow across the sheet and the central null is reduced. When the width is of the same order as the other dimensions, like a sphere, the null disappears completely and a simple broad peak over the conductor results. As the dip of the sheet decreases an asymmetry of the side lobes becomes evident with the greater amplitude on the down dip side. This asymmetry is most notable between about 60 and 30 degrees. With shallower dip the smaller lobe is relatively very weak and a slightly asymmetric single peak is the dominant signature. In the case of near horizontal conducting layers the response amplitude stabilizes within the unit but if the edges are sharply defined, edge effects will be noted.

4.3 Magnetometers

Two Geometrics optically pumped cesium sensors recorded the total magnetic field. One was located on the electromagnetic bird, 53 metres below the helicopter at a nominal terrain clearance of 31 metres, the second sensor was towed 21 metres below the helicopter at a nominal terrain clearance of 51 metres. A magnetic base station was located at the base of operations and recorded variations were used for diurnal correction.
5 COMPILATION AND PRESENTATION

5.1 Total Field Magnetics

The magnetic data from a lower sensor in the EM bird was not available throughout the survey. For consistency, the magnetic data recorded at the nominal terrain clearance of 51 metres has been used for presentation and analysis. Variations recorded by the magnetic base station were subtracted to remove diurnal magnetic variation. The corrected profile, provided by Aeroquest, was gridded using at 25 metre cell size. In addition to the Total Magnetic Field, the following two map enhancements were calculated for interpretive use.

5.2 Pole Reduced Vertical Magnetic Gradient

This map has combined two map enhancements. The pole reduction process alters the shape of the magnetic anomalies to appear as they would if the inclination of the magnetic field were vertical. The inclination of the magnetic field in the survey area is about 78 degrees and the difference is subtle but notable. The vertical magnetic gradient sharpens and enhances the response from shallow magnetic sources relative to those originating at greater depth.

The combined pole reduction and vertical gradient process will provide a positive peak directly over a vertical dipping, inductively magnetized source. A negative side-lobe will surround the anomaly. If the horizontal dimensions of the magnetic unit are significantly larger than the height above source, the zero gradient contour will tend to follow the magnetic contact.

5.3 Apparent Magnetic Susceptibility

The amplitude of a magnetic anomaly is a function of the size, depth, form and magnetic susceptibility of the source. The apparent susceptibility process approximates the underlying geology by a regular array of vertical prism forms at uniform depth. Each rectangular prism is 25 metres in horizontal dimension, with large depth extent and an upper surface 25 metres below ground. The process assigns a susceptibility to each prism such that the combined result would emulate the observed total field map. The resulting map approximates the magnetic susceptibility of the underlying geology.

The susceptibility values presented are not absolute but are relative to a mean map value of zero. The change from one level to another represents the susceptibility contrast.

The Palaeozoic limestone and glacial cover will have essentially no magnetic contribution. In the bedrock the lowest susceptibility is expected with the metasedimentary rocks with increasing susceptibility through the acid to intermediate to mafic volcanic rock sequence.
5.4 Electromagnetic Time Constant Tau

The primary electromagnetic field is created by the current flowing in the transmitter loop. It induces current flow in the underlying ground, which in turn, creates a secondary electromagnetic field. This secondary magnetic field $B$ induces a voltage in the receiver which is proportional to $dB/dt$, the rate of change of the secondary field passing through the coil. An estimate of the $B$ field can be derived by either digital or electronic integration of the directly measured signal $dB/dt$.

The basic time-domain electromagnetic anomaly can be expressed as an exponential.

$$B = ke^{-t/\tau}$$

where $B$ is the amplitude of the B-field signal, $k$ is a constant related to the size, shape and depth of the source, $t$ is time in microseconds and $\tau$ is the time-constant Tau. A large conductive body will have a large Tau and thus the signal will decay slowly. A small poor conductor will have a small Tau and thus decay quickly.

$$dB/dt = \left( \frac{k}{\tau} \right)e^{-t/\tau}$$

The $dB/dt$ signal, sensed by the receiver coil, decays in the same fashion as $B$ but its amplitude is modified by $1/\tau$. As a result the amplitude of the early time channels associated with poorer conductors is exaggerated but the rate of change Tau remains the same.
A value for the apparent time constant Tau can be calculated using any two channels.

\[
\text{Tau} = -(t1-t2) / \log(\text{Amplitude1}/\text{Amplitude2})
\]

The actual signal measured is a sum of exponentials. A time constant calculated using early channels will predominantly reflect the shorter time constants and one based on late channels will predominantly reflect the longer time constants.

The Zoff array channel contains the signal amplitude for each of the system time gates. The time constant Tau was calculated for each successive pair of gates and the results, in units of microseconds, were stored in the SHA_Tau array channel. The last channel element of SHA_Tau array contains the largest time constant of the sequence.

As the channel amplitudes decrease, noise will enter the calculation, with increased sensitivity to the denominator, Amplitude2. The calculation of the time constant was suspended when signal levels were less than about 10 nT/s.

5.5 Electromagnetic Conductance Calculation

A variety of related measurement units are often used to quantify an electromagnetic anomaly. Electrical resistance is measured in ohms, resistivity in ohm-m. Conductance is the inverse of resistance and measured in mhos or Siemens. Conductivity is the inverse of resistivity is measured in mhos/m or Siemens/m.

Conductance reflects not only the conductivity but also the size of the anomaly source. For a time-domain system conductance can be derived from the time-constant Tau and is largely independent of depth. A channel SHA_conductance has been created on the
assumption that the conductor is a flat-lying plate, 100m. by 100m. This is the same reference model used by Aeroquest. The point by point calculation has been filtered along line to stabilize the calculation and the result, in Siemens, has been presented in both profile and gridded form.

As a very general rule, conductance indications above 10 Siemens are anticipated for VMS deposits and can exceed 100 Siemens for MMS nickel deposits.

This AeroTem response diagram is copied from the Aeroquest report. The system is insensitive to a conductance less than 0.5 S and is optimal in the off-time to the range of 5 to 50 S. The on-time response is optimal for conductance values of 50 S and greater.
6 INTERPRETATION OVERVIEW

The McFaulds VMS deposits discovered by Spider-KWG are copper-zinc bearing and have been compared to those in the Matagami area of Quebec. An electromagnetic signature has been identified at the sites, initially by the fixed-wing GeoTem system, as well as the VTEM and AeroTem helicopter systems. In addition to a conductivity anomaly the deposits tend to have an associated magnetic signature.

The conductivity expectations for a zinc rich VMS deposit are tempered by the fact that zinc sulphide is not a notable conductor as illustrated in table 1, below. Due to the usually associated presence of chalcopyrite and pyrrhotite, copper-zinc VMS deposits are often moderately conductive. It might be speculated that very rich zinc deposits may exist but remain undetected since the primary exploration method, electromagnetics, would be ineffective for a pure sphalerite deposit.

The Noront Eagle One is a copper nickel MMS deposit. It also provided an electromagnetic signature on the fixed-wing and helicopter electromagnetic systems and has an associated magnetic anomaly. Nickel deposits can have very high associated conductivity.

A third deposit type in the area is the Spider, KWG, Freewest chrome-platinum-palladium discovery in a peridotite host. Conductivity expectations for such mineralization are variable; chromite is not a notable conductor but other sulphides in the formation may create a significant electromagnetic anomaly. The peridotite host is a notable magnetic rock.

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<td>Niccolite NiAs</td>
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In the McFaulds Lake environment, a higher conductivity may be encouraging but is not considered a prerequisite for a significant deposit. Higher conductances might be considered more typical of the copper and nickel bearing mineralization while low to moderate conductances might be considered more typical of the copper-zinc or the chromitite-platinum group mineralization.
The conductivity anomalies of the known VMS deposits in the area are of limited size. This attribute of limited strike length is typical for VMS deposits in general. An isolated response, limited to a few flight lines is a normal expectation. A coincident or adjacent magnetic signature is also a common VMS attribute. A similar scale magnetic anomaly might be considered an encouraging factor but it should not be considered a prerequisite.

7 INTERPRETATION PROCEDURE

A preliminary anomaly identification process was carried out by SHA using data provided by the Aeroquest field crew. The uncorrected electromagnetic profile data was reviewed, line by line, and anomalies of potential interest were identified. The location of the anomalies on each line was evaluated in a map presentation and conductor axes were interpreted.

During this initial review of the profile data a database channel named Anom was created which was flagged with a numeric value when a response of possible interest was noted. The purpose of this channel was to provide a convenient profile-to-map interface for revisiting and correlating profile and map events. These Anom events were plotted as symbols on the preliminary interpretation maps. They are not anomalies in the traditional sense but simply working reference points used in the interpretation process. These references have been carried forward into the final database. Those not associated with interpreted conductor axes of interest are attributed to conductive overburden.

The geophysical data was then corrected and processed internally by the contractor Aeroquest. As part of this operation, Aeroquest has independently provided a "standard" report and maps with conductive responses symbolized. The associated report, maps and digital data has been divided along property boundaries and provided to each participant in the overall program. The Aeroquest anomalies and other interpretive information are not referred to and do not have any bearing on the content of this interpretation and report. However, the corrected profile database, provided by Aeroquest, has been used for the interpretation and processing by Scott Hogg & Associates Ltd. Digital database channels, created by Aeroquest, have been preserved.

The analysis of the geophysical data was carried out on the full survey block without regard for property boundaries within. The corrected electromagnetic profile data was reviewed, line by line, and anomalies of potential exploration interest were identified. Responses that were believed to simply reflect conductive overburden are not included or discussed further. The location of the anomalies on each line was evaluated in a map presentation and conductor axes were interpreted. The conductors have been provided a report identifier “ Area# - reference# “. No significance is attached to the numerical sequence. The interpretation map was then divided in accordance with property boundaries and the map contents and related geophysical comments for the specific client are included with this report.
8 DISCUSSION AND RECOMMENDATIONS

The following discussion, of the interpreted electromagnetic anomalies, is organized by conductor reference number.

A difficulty with the map presentation of electromagnetic data is the large dynamic range of the response and the variety of information available; on-time, off-time, Z-axis and X-axis receiver configurations, all with multiple time-gates. This information is viewable on a line by line basis but not in useful map presentations. For most of the anomalies a profile response figure, from a representative flight line, has been included to illustrate the anomaly detail. The Z-on response is presented with an expanded vertical scale, suited to identifying the weaker anomalies. The typical noise threshold of the system, about 5 nT/s, is discernible at the scale chosen. The corresponding magnetic and conductance profile is also presented. The horizontal scale units are UTM easting coordinates which can be identified on the map for chosen flight line.

Follow-up investigation is recommended where a clear indication of a bedrock conductor has been interpreted. The highest priority recommendation was reserved for those with a high conductance that can often indicate major sulphide mineralization. Lower priorities are suggested for lower conductance indications; however, it is important to again note that the lower conductance values can be associated economic mineralization such as thinner zones of high value minerals or large zones of a less conductive mineral such as zinc.
This isolated anomaly is primarily a one-line response with reduced response on adjacent lines. The profile shape reflects significant width and the response amplitude, significant across all channels, yields a very high conductance of 250 S. The conductor has an associated, small, similar scale, magnetic anomaly aligned NW-SE, at odds with the surrounding magnetic fabric. Although the EM anomaly peaks align WSW-ENE, the conductor axis has been drawn to align with the associated magnetic axis. This suggested strike interpretation attributes the flanking EM peaks to lateral detection of the main body as opposed to profiles that cross the conductor. This anomaly is considered to be an excellent exploration target and follow-up investigation is recommended on a high priority.
This conductive axis has no direct magnetic association but is aligned with and follows a low magnetization zone between magnetic formations. In its mid-section, around Line 10820, the profile shape could be interpreted to suggest a thin source dipping to the southeast; however, to the northwest and southeast the profile shape is increasingly ambiguous.

Towards the northwest, on Line 10790, the upper illustration, there is a definite possibility of two parallel conductors. To the southeast, on Line 10840, the lower illustration there is the possibility of two conductors or a broad conductive zone.

In both cases presented above the calculated conductance is high, 60 to 80 S, and could indicate significant sulphide mineralization. In light of the strike length of about 1200 metres there is the possibility of a formational graphite source. Nevertheless, limited follow-up investigation is recommended with the primary objective being the identification of the conductivity source, graphite of sulphide.
This isolated, short axis conductor is coincident with an intense, discrete magnetic anomaly. The EM profile shape suggests a steeply dipping source of significant width. The response is well defined in all channels and the conductance of more than 100 S could reflect significant sulphide mineralization. This anomaly is considered a good prospect for VMS or MMS mineralization and follow-up investigation is recommended on a high priority.
This isolated, short axis conductor appears to lie on the margin of a discrete magnetic anomaly. The EM profile shape suggests a steeply dipping source of significant width. The response is well defined in all channels and the calculated conductance of about 18 S could reflect significant sulphide mineralization. This anomaly is considered a good prospect for VMS or MMS mineralization and follow-up investigation is recommended on a moderate to high priority. On Line 2020 illustrated above there is evidence of a weak secondary peak at 5,902,650 north and ground survey should include coverage of this southern flank.
5-03  This isolated, short axis conductor is coincident with an intense, discrete magnetic anomaly. On line 20670, illustrated above, the EM profile shape suggests two steeply dipping sources of significant width, but there is a possibility of a single thinner, central source with south dip. The response is well defined in all channels and the calculated conductance of about 60 S could reflect significant sulphide mineralization. This anomaly is considered a good prospect for MMS mineralization and follow-up investigation is recommended on a high priority.
Anomaly 5-04

This short axis conductor is well defined on three flight lines. It follows the southern margin of a longer linear magnetic anomaly that strikes WSW-ENE. The EM profile shape suggests a thin source with shallow south dip. The response is well defined in all channels and the calculated conductance of about 25 S could reflect significant sulphide mineralization. This anomaly is considered to have potential and follow-up is recommended.
These conductors have an EM profile shape that is consistent with a thin source with shallow dip to the south. The anomalies appear to be associated with a weakly magnetic, gently curving band that strikes E-W at its northern apex. The calculated conductance on Line 20720, illustrated above, is a low 6 S. It is possible that the anomalies reflect a formational conductor or minor-moderate sulphide mineralization. Follow up investigation might be considered but on a low priority basis.
Anomaly 5-05e

This conductor has an EM profile shape that is consistent with a thin source with shallow dip to the south. The anomaly is aligned with the neighbouring magnetic trend but has no discernable associated magnetic signature. The calculated conductance is a high 60 S which could reflect significant sulphide mineralization; however, the potential for a formational conductive source is high. Follow up investigation is recommended but on a low priority basis.
A high amplitude anomaly is developing on the end of lines 20980 and 20970. A corresponding increase on the magnetic map is also noted. Without the full anomaly shape and context the potential significance cannot be ascertained; however, the calculated conductance is more than 100 S and this could prove to be a very interesting anomaly. Extension of the airborne survey and/or ground geophysics is recommended to map the response.

Respectfully submitted,

Scott Hogg & Associates Ltd.  
Toronto, Canada  
June 16, 2008
Report on a Helicopter-Borne AeroTEM System Electromagnetic & Magnetic Survey

Aeroquest Job # 08055

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www.aeroquest.ca

Report date: April 2008
Report on a Helicopter-Borne AeroTEM System Electromagnetic & Magnetic Survey

Aeroquest Job # 08055

Blocks 3 - 8
McFaulds Lake Camp, Ontario, Canada
NTS 043D16, 043E01, 02, 07, 08

For

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by

Report date: April 2008
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LIST OF MAPS (1:20,000)

- TMI – Coloured Total Magnetic Intensity (TMI) with line contours and EM anomaly symbols.
- ZOFF1 – AeroTEM Z1 Off-time with line contours, Magnetic Analytic Signal contour and EM anomaly symbols.
- EM – AeroTEM off-time profiles Z2 – Z12 and EM anomaly symbols.
3. SURVEY SPECIFICATIONS AND PROCEDURES

The survey specifications are summarised in the following table:

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Line Spacing (metres)</th>
<th>Line Direction</th>
<th>Survey Coverage (line-km)</th>
<th>Date flown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block 3</td>
<td>100</td>
<td>N-S (0º)</td>
<td>1351</td>
<td>Jan. 20 - Feb. 06, 2008</td>
</tr>
<tr>
<td>Block 4</td>
<td>100</td>
<td>N-S (0º)</td>
<td>1284.8</td>
<td>Jan. 29 - Feb. 06, 2008</td>
</tr>
<tr>
<td>Block 5</td>
<td>100</td>
<td>N-S (0º)</td>
<td>819</td>
<td>Feb. 04 - 05, 2008</td>
</tr>
<tr>
<td>Block 6</td>
<td>100</td>
<td>N-S (0º)</td>
<td>219.9</td>
<td>Feb. 02 - 03, 2008</td>
</tr>
<tr>
<td>Block 7</td>
<td>100</td>
<td>N-S (0º)</td>
<td>243.3</td>
<td>Feb. 03 - 05, 2008</td>
</tr>
<tr>
<td>Block 8</td>
<td>100</td>
<td>N-S (0º)</td>
<td>184.5</td>
<td>Feb 03, 2008</td>
</tr>
</tbody>
</table>

Table 1. Survey specifications summary

The survey coverage was calculated by adding up the along-line distance of the survey lines and control (tie) lines as presented in the final Geosoft database. The survey was flown with a line spacing of 100 metres. The control (tie) lines were flown perpendicular to the survey lines with a spacing of 1000 metres.

The nominal EM bird terrain clearance is 30 metres, but can be higher in more rugged terrain due to safety considerations and the capabilities of the aircraft. The magnetometer sensor is mounted in a smaller bird connected to the tow rope 33 metres above the EM bird and 21 metres below the helicopter (Figure 4). Nominal survey speed over relatively flat terrain is 75 km/hr and is generally lower in rougher terrain. Scan rates for ancillary data acquisition is 0.1 second for the magnetometer and altimeter, and 0.2 second for the GPS determined position. The EM data is acquired as a data stream at a sampling rate of 36,000 samples per second and is processed to generate final data at 10 samples per second. The 10 samples per second translate to a geophysical reading about every 1.5 to 2.5 metres along the flight path.

3.1. NAVIGATION

Navigation is carried out using a GPS receiver, an AGNAV2 system for navigation control, and an RMS DGR-33 data acquisition system which records the GPS coordinates. The x-y-z position of the aircraft, as reported by the GPS, is recorded at 0.2 second intervals. The system has a published accuracy of less than 3 metres. A recent static ground test of the Mid-Tech WAAS GPS yielded a standard deviation in x and y of less than 0.6 metres and for z less than 1.5 metres over a two-hour period.

3.2. SYSTEM DRIFT

Unlike frequency domain electromagnetic systems, the AeroTEM III system has negligible drift due to thermal expansion. The operator is responsible for ensuring the instrument is properly warmed up prior to departure and that the instruments are operated properly throughout the flight. The operator maintains a detailed flight log during the survey noting the
times of the flight and any unusual geophysical or topographic features. Each flight included at least two high elevation ‘background’ checks. During the high elevation checks, an internal 5 second wide calibration pulse in all EM channels was generated in order to ensure that the gain of the system remained constant and within specifications.

3.3. FIELD QA/QC PROCEDURES

On return of the pilot and operator to the base, usually after each flight, the AeroDAS streaming EM data and the RMS data are carried on removable hard drives and Flashcards, respectively and transferred to the data processing work station. At the end of each day, the base station magnetometer data on FlashCard is retrieved from the base station unit.

Data verification and quality control includes a comparison of the acquired GPS data with the flight plan; verification and conversion of the RMS data to an ASCII format XYZ data file; verification of the base station magnetometer data and conversion to ASCII format XYZ data; and loading, processing and conversion of the steaming EM data from the removable hard drive. All data is then merged to an ASCII XYZ format file which is then imported to an Oasis database for further QA/QC and for the production of preliminary EM, magnetic contour, and flight path maps.

Survey lines which show excessive deviation from the intended flight path are re-flown. Any line or portion of a line on which the data quality did not meet the contract specification was noted and reflowed.

4. AIRCRAFT AND EQUIPMENT

4.1. AIRCRAFT

A Eurocopter (Aerospatiale) AS350B2 "A-Star" helicopter - registration C-GPTY was used as survey platform. The helicopter was owned and operated by Hi-Wood Helicopters, Calgary, Alberta. Installation of the geophysical and ancillary equipment was carried out by Aeroquest Limited personnel in conjunction with a licensed aircraft. The survey aircraft was flown at a nominal terrain clearance of 220 ft (65 metres).

Figure 3. Helicopter registration number C-GPTY
4.2. MAGNETOMETER

The AeroTEM III airborne survey system employs the Geometrics G-823A caesium vapour magnetometer sensor installed in a two metre towed bird airfoil attached to the main tow line, 21 metres below the helicopter (Figure 4). The sensitivity of the magnetometer is 0.001 nanoTesla at a 0.1 second sampling rate. The nominal ground clearance of the magnetometer bird is 51 metres (170 ft.). The magnetic data is recorded at 10 Hz by the RMS DGR-33.

4.3. ELECTROMAGNETIC SYSTEM

The electromagnetic system is an Aeroquest AeroTEM III time domain towed-bird system (Figure 4). The current AeroTEM III transmitter dipole moment is 183 kNIA. The AeroTEM bird is towed 53 metres (175 ft) below the helicopter. More technical details of the system may be found in Appendix 4.

The wave-form is triangular with a symmetric transmitter on-time pulse of 1.10 ms and a base frequency of 90 Hz (Figure 5). The current alternates polarity every on-time pulse. During every Tx on-off cycle (300 per second), 120 contiguous channels of raw X and Z component (and a transmitter current monitor, itx) of the received waveform are measured. Each channel width is 27.78 microseconds starting at the beginning of the transmitter pulse. This 120 channel data is referred to as the raw streaming data. The AeroTEM system has two separate EM data recording streams, the conventional RMS DGR-33 and the AeroDAS system which records the full waveform (Figure 5).

Figure 4. The magnetometer bird (A) and AeroTEM III EM bird (B)
### 4.4. AERODAS ACQUISITION SYSTEM

The 120 channels of raw streaming data are recorded by the AeroDAS acquisition system (Figure 6) onto a removable hard drive. The streaming data are processed post-survey to yield 33 stacked and binned on-time and off-time channels at a 10 Hz sample rate. The timing of the final processed EM channels is described in the following table:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Sample Range</th>
<th>Time Width (us)</th>
<th>Time Center (us)</th>
<th>Time After TxOn (us)</th>
</tr>
</thead>
<tbody>
<tr>
<td>On1</td>
<td>5 - 5</td>
<td>27.778</td>
<td>125.000</td>
<td>131.793</td>
</tr>
<tr>
<td>On2</td>
<td>6 - 6</td>
<td>27.778</td>
<td>152.778</td>
<td>159.571</td>
</tr>
<tr>
<td>On3</td>
<td>7 - 7</td>
<td>27.778</td>
<td>180.556</td>
<td>187.349</td>
</tr>
<tr>
<td>On4</td>
<td>8 - 8</td>
<td>27.778</td>
<td>208.333</td>
<td>215.127</td>
</tr>
<tr>
<td>On5</td>
<td>9 - 9</td>
<td>27.778</td>
<td>236.111</td>
<td>242.904</td>
</tr>
<tr>
<td>On6</td>
<td>10 - 10</td>
<td>27.778</td>
<td>263.889</td>
<td>270.682</td>
</tr>
<tr>
<td>On7</td>
<td>11 - 11</td>
<td>27.778</td>
<td>291.667</td>
<td>298.460</td>
</tr>
<tr>
<td>On8</td>
<td>12 - 12</td>
<td>27.778</td>
<td>319.444</td>
<td>326.238</td>
</tr>
<tr>
<td>On9</td>
<td>13 - 13</td>
<td>27.778</td>
<td>347.222</td>
<td>354.016</td>
</tr>
<tr>
<td>On10</td>
<td>14 - 14</td>
<td>27.778</td>
<td>375.000</td>
<td>381.793</td>
</tr>
<tr>
<td>On11</td>
<td>15 - 15</td>
<td>27.778</td>
<td>402.778</td>
<td>409.571</td>
</tr>
<tr>
<td>On12</td>
<td>16 - 16</td>
<td>27.778</td>
<td>430.556</td>
<td>437.349</td>
</tr>
<tr>
<td>On13</td>
<td>17 - 17</td>
<td>27.778</td>
<td>458.333</td>
<td>465.127</td>
</tr>
<tr>
<td>On14</td>
<td>18 - 18</td>
<td>27.778</td>
<td>486.111</td>
<td>492.904</td>
</tr>
<tr>
<td>On15</td>
<td>19 - 19</td>
<td>27.778</td>
<td>513.889</td>
<td>520.682</td>
</tr>
<tr>
<td>On16</td>
<td>20 - 20</td>
<td>27.778</td>
<td>541.667</td>
<td>548.460</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Channel</th>
<th>Sample Range</th>
<th>Time Width (us)</th>
<th>Time Center (us)</th>
<th>Time After TxOff (us)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off0</td>
<td>70 - 70</td>
<td>27.778</td>
<td>1930.556</td>
<td>161.750</td>
</tr>
<tr>
<td>Off1</td>
<td>71 - 71</td>
<td>27.778</td>
<td>1958.333</td>
<td>189.527</td>
</tr>
<tr>
<td>Off2</td>
<td>72 - 72</td>
<td>27.778</td>
<td>1986.111</td>
<td>217.305</td>
</tr>
<tr>
<td>Off3</td>
<td>73 - 73</td>
<td>27.778</td>
<td>2013.889</td>
<td>245.083</td>
</tr>
<tr>
<td>Off4</td>
<td>74 - 74</td>
<td>27.778</td>
<td>2041.667</td>
<td>272.861</td>
</tr>
<tr>
<td>Off5</td>
<td>75 - 75</td>
<td>27.778</td>
<td>2069.444</td>
<td>300.639</td>
</tr>
<tr>
<td>Off6</td>
<td>76 - 78</td>
<td>83.333</td>
<td>2125.000</td>
<td>356.194</td>
</tr>
<tr>
<td>Off7</td>
<td>79 - 81</td>
<td>83.333</td>
<td>2208.333</td>
<td>439.527</td>
</tr>
</tbody>
</table>
4.5. RMS DGR-33 ACQUISITION SYSTEM

In addition to the magnetics, altimeter and position data, six channels of real time processed off-time EM decay in the Z direction and one in the X direction are recorded by the RMS DGR-33 acquisition system at 10 samples per second and plotted real-time on the analogue chart recorder. These channels are derived by a binning, stacking and filtering procedure on the raw streaming data. The primary use of the RMS EM data (Z1 to Z6, X1) is to provide for real-time QA/QC on board the aircraft.

The channel window timing of the RMS DGR-33 6 channel system is described in the table below.

<table>
<thead>
<tr>
<th>RMS Channel</th>
<th>Start time (μs)</th>
<th>End time (μs)</th>
<th>Width (μs)</th>
<th>Streaming Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z1, X1</td>
<td>1269.8</td>
<td>1322.8</td>
<td>52.9</td>
<td>48-50</td>
</tr>
<tr>
<td>Z2</td>
<td>1322.8</td>
<td>1455.0</td>
<td>132.2</td>
<td>50-54</td>
</tr>
<tr>
<td>Z3</td>
<td>1428.6</td>
<td>1587.3</td>
<td>158.7</td>
<td>54-59</td>
</tr>
<tr>
<td>Z4</td>
<td>1587.3</td>
<td>1746.0</td>
<td>158.7</td>
<td>60-65</td>
</tr>
<tr>
<td>Z5</td>
<td>1746.0</td>
<td>2063.5</td>
<td>317.5</td>
<td>66-77</td>
</tr>
<tr>
<td>Z6</td>
<td>2063.5</td>
<td>2698.4</td>
<td>634.9</td>
<td>78-101</td>
</tr>
</tbody>
</table>
4.6. MAGNETOMETER BASE STATION

The base magnetometer was a Geometrics G-859 cesium vapour magnetometer system with integrated GPS. Data logging and UTC time synchronisation was carried out within the magnetometer, with the GPS providing the timing signal. The data logging was configured to measure at 1.0 second intervals. Digital recording resolution was 0.001 nT. The sensor was placed on a tripod in an area of low magnetic gradient and free of cultural noise sources. A continuously updated display of the base station values was available for viewing and regularly monitored to ensure acceptable data quality and diurnal variation.

4.7. RADAR ALTIMETER

A Terra TRA 3500/TRI-30 radar altimeter is used to record terrain clearance. The antenna was mounted on the outside of the helicopter beneath the cockpit. Therefore, the recorded data reflect the height of the helicopter above the ground. The Terra altimeter has an altitude accuracy of +/- 1.5 metres.

4.8. VIDEO TRACKING AND RECORDING SYSTEM

A high resolution digital colour 8 mm video camera is used to record the helicopter ground flight path along the survey lines. The video is digitally annotated with GPS position and time and can be used to verify ground positioning information and cultural causes of anomalous geophysical responses.
4.9. GPS NAVIGATION SYSTEM

The navigation system consists of an Ag-Nav Incorporated AG-NAV2 GPS navigation system comprising a PC-based acquisition system, navigation software, a deviation indicator in front of the aircraft pilot to direct the flight, a full screen display with controls in front of the operator, a Mid-Tech RX400p WAAS-enabled GPS receiver mounted on the instrument rack and an antenna mounted on the magnetometer bird. WAAS (Wide Area Augmentation System) consists of approximately 25 ground reference stations positioned across the United States that monitor GPS satellite data. Two master stations located on the east and west coasts collect data from the reference stations and create a GPS correction message. This correction accounts for GPS satellite orbit and clock drift plus signal delays caused by the atmosphere and ionosphere. The corrected differential message is then broadcast through one of two geostationary satellites, or satellites with a fixed position over the equator. The corrected position has a published accuracy of less than 3 metres.

Survey co-ordinates are set up prior to the survey and the information is fed into the airborne navigation system. The co-ordinate system employed in the survey design was WGS84 [World] using the UTM zone 16N projection. The real-time differentially corrected GPS positional data was recorded by the RMS DGR-33 in geodetic coordinates (latitude and longitude using WGS84) at 0.2 s intervals.

4.10. DIGITAL ACQUISITION SYSTEM

The AeroTEM received waveform sampled during on and off-time at 120 channels per decay, 300 times per second, was logged by the proprietary AeroDAS data acquisition system. The channel sampling commences at the start of the Tx cycle and the width of each channel is 26.04 microseconds. The streaming data was recorded on a removable hard-drive and was later backed-up onto DVD-ROM from the field-processing computer.

The RMS Instruments DGR33A data acquisition system was used to collect and record the analogue data stream, i.e. the positional and secondary geophysical data, including processed 6 channel EM, magnetics, radar altimeter, GPS position, and time. The data was recorded on 128 Mb capacity FlashCard. The RMS output was also directed to a thermal chart recorder.

5. PERSONNEL

The following Aeroquest personnel were involved in the project:
Manager of Operations: Bert Simon  
Manager of Data Processing: Gord Smith  
Field Data Processor: Geoff Plastow, Ali Latrous, Greg Roman  
Field Operator: Gab Genier  
Data Interpretation and Reporting: Matt Pozza, Marion Bishop

The survey pilots, Joel Reavie and Trevor Wheelie, were employed directly by the helicopter operator – Hi-Wood Helicopters.

6. DELIVERABLES

6.1. HARDCOPY DELIVERABLES

The report includes a set of eleven 1:20,000 maps and the following three geophysical data products are delivered:

- TMI – Coloured Total Magnetic Intensity (TMI) with line contours and EM anomaly symbols.
- ZOFF1 – AeroTEM Z1 Off-time with line contours, Magnetic Analytic Signal contour and EM anomaly symbols.
- EM – AeroTEM off-time profiles Z2 – Z12 and EM anomaly symbols.

The coordinate/projection system for the maps is NAD83 – UTM Zone 16N. For reference, the latitude and longitude in WGS84 are also noted on the maps.

All the maps show flight path trace, skeletal topography, and conductor picks represented by an anomaly symbol classified according to calculated off-time conductance. The anomaly symbol is accompanied by postings denoting the calculated off-time conductance, a thick or thin classification and an anomaly identifier label. The anomaly symbol legend and survey specifications are displayed on the left margin of the maps.

6.2. DIGITAL DELIVERABLES

6.2.1. Final Database of Survey Data (.GDB, .XYZ)

The geophysical profile data is archived digitally in a Geosoft GDB binary format database. A description of the contents of the individual channels in the database can be found in Appendix 2. A copy of this digital data is archived at the Aeroquest head office in Mississauga.

6.2.2. Geosoft Grid files (.GRD)

Levelled Grid products used to generate the geophysical map images.

- Total Magnetic Intensity from Mag sensor on the tow cable (Bloc#_TMI), (20m cell size)
- Magnetic Analytic Signal (Block#_3DAS), (20m cell size)
- AeroTEM Z Offtime Channel 1 (Block#_ZOFF1), (25m cell size)

6.2.3. Digital Versions of Final Maps (.MAP, .PDF)

Map files in Geosoft .map and Adobe PDF format.
6.2.4. Google Earth Files (.kmz)

Flight navigation lines, EM Anomalies and geophysical grids in Google earth kmz format. Double click to view in Google Earth.

6.2.5. Free Viewing Software (.EXE)

- Geosoft Oasis Montaj Viewing Software
- Adobe Acrobat Reader
- Google Earth Viewer

6.2.6. Digital Copy of this Document (.PDF)

Adobe PDF format of this document.

7. DATA PROCESSING AND PRESENTATION

All in-field and post-field data processing was carried out using Aeroquest proprietary data processing software and Geosoft Oasis Montaj software. Maps were generated using 36-inch and 42-inch wide Hewlett Packard ink-jet plotters.

7.1. BASE MAP

The geophysical maps accompanying this report are based on positioning in the NAD83 datum. The survey geodetic GPS positions have been projected using the Universal Transverse Mercator projection in Zone 16 North. A summary of the map datum and projection specifications is given following:

- Ellipse: GRS 1980
- Ellipse major axis: 6378137m eccentricity: 0.081819191
- Datum: North American 1983 - Canada Mean
- Datum Shifts (x,y,z) : 0, 0, 0 metres
- Map Projection: Universal Transverse Mercator Zone 16 (Central Meridian 87ºW)
- Central Scale Factor: 0.9996
- False Easting, Northing: 500,000m, 0m

For reference, the latitude and longitude in WGS84 are also noted on the maps.

The background vector topography derived from Natural Resources Canada 1:250000 National Topographic Data Base data and the background shading was derived from NASA Shuttle Radar Topography Mission (SRTM) 90 metre resolution DEM data.

7.2. FLIGHT PATH & TERRAIN CLEARANCE

The position of the survey helicopter was directed by use of the Global Positioning System (GPS). Positions were updated five times per second (5 Hz) and expressed as WGS84 latitude and longitude calculated from the raw pseudo range derived from the C/A code signal. The instantaneous GPS flight path, after conversion to UTM co-ordinates, is drawn using linear interpolation between the x/y positions. The terrain clearance was maintained with reference to the radar altimeter. The raw Digital Terrain Model (DTM) was derived by taking the GPS survey elevation and subtracting the radar altimeter terrain clearance values. The calculated topography elevation values are relative and are not tied in to surveyed geodetic heights.
Each flight included at least two high elevation ‘background’ checks. These high elevation checks are to ensure that the gain of the system remained constant and within specifications.

7.3. ELECTROMAGNETIC DATA

The raw streaming data, sampled at a rate of 36,000 Hz (120 channels, 300 times per second) was reprocessed using a proprietary software algorithm developed and owned by Aeroquest Limited. Processing involves the compensation of the X and Z component data for the primary field waveform. Coefficients for this compensation for the system transient are determined and applied to the stream data. The stream data are then pre-filtered, stacked, binned to the 33 on and off-time channels and checked for the effectiveness of the compensation and stacking processes. The stacked data is then filtered, levelled and split up into the individual line segments. Further base level adjustments may be carried out at this stage. The filtering of the stacked data is designed to remove or minimize high frequency noise that can not be sourced from the geology.

The final field processing step was to merge the processed EM data with the other data sets into a Geosoft GDB file. The EM fiducial is used to synchronize the two datasets. The processed channels are merged into ‘array format; channels in the final Geosoft database as Zon, Zoff, Xon, and Xoff.

Apparent bedrock EM anomalies were interpreted with the aid of an auto-pick from positive peaks and troughs in the off-time Z channel responses correlated with X channel responses. The auto-picked anomalies were reviewed and edited by a geophysicist on a line by line basis to discriminate between thin and thick conductor types. Anomaly picks locations were migrated and removed as required. This process ensures the optimal representation of the conductor centres on the maps.

At each conductor pick, estimates of the off-time conductance have been generated based on a horizontal plate source model for those data points along the line where the response amplitude is sufficient to yield an acceptable estimate. Some of the EM anomaly picks do not display a Tau value; this is due to the inability to properly define the decay of the conductor usually because of low signal amplitudes. Each conductor pick was then classified according to a set of seven ranges of calculated off-time conductance values. For high conductance sources, the on-time conductance values may be used, since it provides a more accurate measure of high-conductance sources. Each symbol is also given an identification letter label, unique to each flight line. Conductor picks that did not yield an acceptable estimate of off-time conductance due to a low amplitude response were classified as a low conductance source. Please refer to the anomaly symbol legend located in the margin of the maps.

7.4. MAGNETIC DATA

Prior to any levelling the magnetic data was subjected to a lag correction of -0.1 seconds and a spike removal filter. The filtered aeromagnetic data were then corrected for diurnal variations using the magnetic base station and the intersections of the tie lines. No corrections for the regional reference field (IGRF) were applied. The corrected profile data were interpolated on to a grid using a bi-directional grid technique with a grid cell size of 20 metres. The final levelled grid provided the basis for threading the presented contours which have a minimum contour interval of 10 nT.
8. GENERAL COMMENTS

The survey was successful in mapping the magnetic and conductive properties of the geology throughout the survey area. Below is a brief interpretation of the results. For a detailed interpretation please contact Aeroquest Limited.

8.1. MAGNETIC RESPONSE

The magnetic data provide a high resolution map of the distribution of the magnetic mineral content of the survey area. This data can be used to interpret the location of geological contacts and other structural features such as faults and zones of magnetic alteration. The sources for anomalous magnetic responses are generally thought to be predominantly magnetite because of the relative abundance and strength of response (high magnetic susceptibility) of magnetite over other magnetic minerals such as pyrrhotite.

8.2. EM ANOMALIES

The EM anomalies on the maps are classified by conductance (as described earlier in the report) and also by the thickness of the source. A thin, vertically orientated source produces a double peak anomaly in the z-component response and a positive to negative crossover in the x-component response (Figure 8). For a vertically orientated thick source (say, greater than 10 metres), the response is a single peak in the z-component response and a negative to positive crossover in the x-component response (Figure 9). Because of these differing responses, the AeroTEM system provides discrimination of thin and thick sources and this distinction is indicated on the EM anomaly symbols (N = thin and K = thick). Where multiple, closely spaced conductive sources occur, or where the source has a shallow dip, it can be difficult to uniquely determine the type (thick vs. thin) of the source (Figure 10). In these cases both possible source types may be indicated by picking both thick and thin response styles. For shallow dipping conductors the ‘thin’ pick will be located over the edge of the source, whereas the ‘thick’ pick will fall over the downdip ‘heart’ of the anomaly.

![Figure 8. AeroTEM response to a ‘thin’ vertical conductor.](image-url)
Figure 9. AeroTEM response for a ‘thick’ vertical conductor.

Figure 10. AeroTEM response over a ‘thin’ dipping conductor.
All cases should be considered when analyzing the interpreted picks and prioritizing for follow-up. Specific anomalous responses which remain as high priority should be subjected to numerical modeling prior to drill testing to determine the dip, depth and probable geometry of the source.

Respectfully submitted,

________________________
Matt Pozza, MSc., P.Geo.
Aeroquest Limited
April 2008

Reviewed By:

________________________
Doug Garrie
Aeroquest Limited
April 2008
APPENDIX 3: DESCRIPTION OF DATABASE FIELDS

The GDB file is a Geosoft binary database. In the database, the Survey lines and Tie Lines are prefixed with an "L" for "Line" and "T" for "Tie".

<table>
<thead>
<tr>
<th>COLUMN</th>
<th>UNITS</th>
<th>DESCRIPTOR</th>
</tr>
</thead>
<tbody>
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<td>Line number</td>
</tr>
<tr>
<td>Flight</td>
<td></td>
<td>Flight #</td>
</tr>
<tr>
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<td></td>
<td>AERODAS Fiducial</td>
</tr>
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<td>hh:mm:ss.s</td>
<td>UTC time</td>
</tr>
<tr>
<td>x</td>
<td>m</td>
<td>UTM Nad83 Zone 16</td>
</tr>
<tr>
<td>y</td>
<td>m</td>
<td>UTM Nad83 Zone 16</td>
</tr>
<tr>
<td>Galtf</td>
<td>m</td>
<td>GPS altitude of Mag bird</td>
</tr>
<tr>
<td>bheight</td>
<td>m</td>
<td>Terrain clearance of EM bird</td>
</tr>
<tr>
<td>dtm</td>
<td>m</td>
<td>Digital Terrain Model</td>
</tr>
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<td>nT</td>
<td>Final levelled total magnetic intensity</td>
</tr>
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<td>nT</td>
<td>Base station total magnetic intensity</td>
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<td>Processed Streaming On-Time Z component Channels 1-16</td>
</tr>
<tr>
<td>Zoff</td>
<td>nT/s</td>
<td>Processed Streaming Off-Time Z component Channels 0-16</td>
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<td>nT/s</td>
<td>Processed Streaming On-Time X component Channels 1-16</td>
</tr>
<tr>
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<td>nT/s</td>
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<td>Levelled Off-Time Z component Channels 0</td>
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<td>ms</td>
<td>Transmitter on</td>
</tr>
<tr>
<td>TranSwitch</td>
<td>ms</td>
<td>Transmitter switch</td>
</tr>
<tr>
<td>TranOff</td>
<td>ms</td>
<td>Transmitter off</td>
</tr>
<tr>
<td>TranPeak</td>
<td>ms</td>
<td>Transmitter peak</td>
</tr>
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<td>Indicates a thick or thin conductor</td>
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<td>Alphanumeric label of conductor pick</td>
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<td>S</td>
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</tr>
<tr>
<td>Off_Tau</td>
<td>µs</td>
<td>Off-time decay constant at conductor pick</td>
</tr>
<tr>
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<td>Anomaly Character (K= thick, N = thin)</td>
</tr>
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<td>S</td>
<td>Off-time conductance</td>
</tr>
<tr>
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<td>Off-time decay constant</td>
</tr>
<tr>
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<tr>
<td>TranOn</td>
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<tr>
<td>TranPeak</td>
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<td>Transmission Peak</td>
</tr>
<tr>
<td>TranSwitch</td>
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<td>Transmission Switch</td>
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APPENDIX 5: AEROTEM DESIGN CONSIDERATIONS

Helicopter-borne EM systems offer an advantage that cannot be matched from a fixed-wing platform. The ability to fly at slower speed and collect data with high spatial resolution, and with great accuracy, means the helicopter EM systems provide more detail than any other EM configuration, airborne or ground-based. Spatial resolution is especially important in areas of complex geology and in the search for discrete conductors. With the advent of helicopter-borne high-moment time domain EM systems the fixed wing platforms are losing their only advantage – depth penetration.

Advantage 1 – Spatial Resolution

The AeroTEM system is specifically designed to have a small footprint. This is accomplished through the use of concentric transmitter-receiver coils and a relatively small diameter transmitter coil (5 m). The result is a highly focused exploration footprint, which allows for more accurate “mapping” of discrete conductors. Consider the transmitter primary field images shown in Figure 1, for AeroTEM versus a fixed-wing transmitter.

The footprint of AeroTEM at the earth’s surface is roughly 50m on either side of transmitter

The footprint of a fixed-wing system is roughly 150 m on either side of the transmitter

Figure 1. A comparison of the footprint between AeroTEM and a fixed-wing system, highlights the greater resolution that is achievable with a transmitter located closer to the earth’s surface. The AeroTEM footprint is one third that of a fixed-wing system and is symmetric, while the fixed-wing system has even lower spatial resolution along the flight line because of the separated transmitter and receiver configuration.

At first glance one may want to believe that a transmitter footprint that is distributed more evenly over a larger area is of benefit in mineral exploration. In fact, the opposite is true; by energizing a larger surface area, the ability to energize and detect discrete conductors is reduced. Consider, for example, a comparison between AeroTEM and a fixed-wing system over the Mesamax Deposit (1,450,000 tonnes of 2.1% Ni, 2.7% Cu, 5.2 g/t Pt/Pd). In a test survey over three flight lines spaced 100 m apart, AeroTEM detected the Deposit on all three flight lines. The fixed-wing system detected the Deposit only on two flight lines. In exploration programs that seek to expand the flight line spacing in an effort to reduce the cost of the airborne survey, discrete conductors such as the Mesamax Deposit can go undetected. The argument often put forward in favour of using fixed-wing systems is that because of their larger footprint, the flight line spacing can indeed be widened. Many fixed-wing surveys are flown at 200 m or 400 m. Much of the survey work performed by Aeroquest has been to survey in areas that were previously flown at these wider line spacings. One of the reasons for AeroTEM’s impressive discovery record has been the strategy of flying closely spaced lines and finding all the discrete near-surface conductors. These higher resolution surveys are being flown within existing mining camps, areas that improve the chances of discovery.
Figure 2. Fixed-wing (upper) and AeroTEM (lower) comparison over the eastern limit of the Mesamax Deposit, a Ni-Cu-PGE zone located in the Raglan nickel belt and owned by Canadian Royalties. Both systems detected the Deposit further to the west where it is closer to surface.

The small footprint of AeroTEM combined with the high signal to noise ratio (S/N) makes the system more...
suitable to surveying in areas where local infrastructure produces electromagnetic noise, such as power lines and railways. In 2002 Aeroquest flew four exploration properties in the Sudbury Basin that were under option by FNX Mining Company Inc. from Inco Limited. One such property, the Victoria Property, contained three major power line corridors.

The resulting AeroTEM survey identified all the known zones of Ni-Cu-PGE mineralization, and detected a response between two of the major power line corridors but in an area of favorable geology. Three boreholes were drilled to test the anomaly, and all three intersected sulphide. The third borehole encountered 1.3% Ni, 6.7% Cu, and 13.3 g/t TPMs over 42.3 ft. The mineralization was subsequently named the Powerline Deposit.

The success of AeroTEM in Sudbury highlights the advantage of having a system with a small footprint, but also one with a high S/N. This latter advantage is achieved through a combination of a high-moment (high signal) transmitter and a rigid geometry (low noise). Figure 3 shows the Powerline Deposit response and the response from the power line corridor at full scale. The width of power line response is less than 75 m.

**Figure 3.** The Powerline Deposit is located between two major power line corridors, which make EM surveying problematic. Despite the strong response from the power line, the anomaly from the Deposit is clearly detected. Note the thin formational conductor located to the south. The only way to distinguish this response from that of two closely spaced conductors is by interpreting the X-axis coil response.

**Advantage 2 – Conductance Discrimination**

The AeroTEM system features full waveform recording and as such is able to measure the on-time response due to high conductance targets. Due to the processing method (primary field removal), there is attenuation of the response with increasing conductance, but the AeroTEM on-time measurement is still superior to systems that rely on lower base frequencies to detect high conductance targets, but do not measure in the on-time.

The peak response of a conductive target to an EM system is a function of the target conductance and the EM system base frequency. For time domain EM systems that measure only in the off-time, there is a drop in the peak response of a target as the base frequency is lowered for all conductance values below the peak system
response. For example, the AeroTEM peak response occurs for a 10 S conductor in the early off-time and 100 S in the late off-time for a 150 Hz base frequency. Because base frequency and conductance form a linear relationship when considering the peak response of any EM system, a drop in base frequency of 50% will double the conductance at which an EM system shows its peak response. If the base frequency were lowered from 150 Hz to 30 Hz there would be a fivefold increase in conductance at which the peak response of an EM occurred.

However, in the search for highly conductive targets, such as pyrrhotite-related Ni-Cu-PGM deposits, a fivefold increase in conductance range is a high price to pay because the signal level to lower conductance targets is reduced by the same factor of five. For this reason, EM systems that operate with low base frequencies are not suitable for general exploration unless the target conductance is more than 100 S, or the target is covered by conductive overburden.

Despite the excellent progress that has been made in modeling software over the past two decades, there has been little work done on determining the optimum form of an EM system for mineral exploration. For example, the optimum configuration in terms of geometry, base frequency and so remain unknown. Many geophysicists would argue that there is no single ideal configuration, and that each system has its advantages and disadvantages. We disagree.

When it comes to detecting and discriminating high-conductance targets, it is necessary to measure the pure in-phase response of the target conductor. This measurement requires that the measured primary field from the transmitter be subtracted from the total measured response such that the secondary field from the target conductor can be determined. Because this secondary field is in-phase with the transmitter primary field, it must be made while the transmitter is turned on and the transmitter current is changing. The transmitted primary field is several orders of magnitude larger than the secondary field. AeroTEM uses a bucking coil to reduce the primary field at the receiver coils. The only practical way of removing the primary field is to maintain a rigid geometry between the transmitter, bucking and receiver coils. This is the main design consideration of the AeroTEM airframe and it is the only time domain airborne system to have this configuration.

![Graph](image)

The off-time AeroTEM response for the 16 channel configuration.

The on-time response assuming 100% removal of the measured primary field.

**Figure 4.** The off-time and on-time response nomogram of AeroTEM for a base frequency of 150 Hz. The on-time response is much stronger for higher conductance targets and this is why on-time measurements are more important than lower frequencies when considering high conductance targets in a resistive environment.

**Advantage 3 – Multiple Receiver Coils**

AeroTEM employs two receiver coil orientations. The Z-axis coil is oriented parallel to the transmitter coil and both are horizontal to the ground. This is known as a maximum coupled configuration and is optimal for detection. The X-axis coil is oriented at right angles to the transmitter coil and is oriented along the line-of-flight.

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This is known as a minimum coupled configuration, and provides information on conductor orientation and thickness. These two coil configurations combined provide important information on the position, orientation, depth, and thickness of a conductor that cannot be matched by the traditional geometries of the HEM or fixed-wing systems. The responses are free from a system geometric effect and can be easily compared to model type curves in most cases. In other words, AeroTEM data is very easy to interpret. Consider, for example, the following modeled profile:

Figure 5. Measured (lower) and modeled (upper) AeroTEM responses are compared for a thin steeply dipping conductor. The response is characterized by two peaks in the Z-axis coil, and a cross-over in the X-axis coil that is centered between the two Z-axis peaks. The conductor dips toward the higher amplitude Z-axis peak. Using the X-axis cross-over is the only way of differentiating the Z-axis response from being two closely spaced conductors.

**HEM versus AeroTEM**

Traditional helicopter EM systems operate in the frequency domain and benefit from the fact that they use narrowband as opposed to wide-band transmitters. Thus all of the energy from the transmitter is concentrated in
a few discrete frequencies. This allows the systems to achieve excellent depth penetration (up to 100 m) from a transmitter of modest power. The Aeroquest Impulse system is one implementation of this technology.

The AeroTEM system uses a wide-band transmitter and delivers more power over a wide frequency range. This frequency range is then captured into 16 time channels, the early channels containing the high frequency information and the late time channels containing the low frequency information down to the system base frequency. Because frequency domain HEM systems employ two coil configurations (coplanar and coaxial) there are only a maximum of three comparable frequencies per configuration, compared to 16 AeroTEM off-time and 12 AeroTEM on-time channels.

Figure 6 shows a comparison between the Dighem HEM system (900 Hz and 7200 Hz coplanar) and AeroTEM (Zaxis) from surveys flown in Raglan, in search of highly conductive Ni-Cu-PGM sulphide. In general, the AeroTEM peaks are sharper and better defined, in part due to the greater S/N ratio of the AeroTEM system over HEM, and also due to the modestly filtered AeroTEM data compared to HEM. The base levels are also better defined in the AeroTEM data. AeroTEM filtering is limited to spike removal and a 5-point smoothing filter. Clients are also given copies of the raw, unfiltered data.

Aeroquest Limited is grateful to the following companies for permission to publish some of the data from their respective surveys: Wolfden Resources, FNX Mining Company Inc, Canadian Royalties, Nova West Resources, Aurogin Resources, Spectrem Air. Permission does not imply an endorsement of the AeroTEM system by these companies.
AEROTEM Helicopter Electromagnetic System

System Characteristics

- Transmitter: Triangular Pulse Shape Base Frequency 90 Hz
- Tx On Time – 1,833 (90 Hz) µs
- Tx Off Time – 3,667 (90 Hz) µs
- Loop Diameter - 10 m
- Peak Current - 455 A
- Peak Moment – 183,131 NIA
- Typical Z Axis Noise at Survey Speed = 5 nT/s peak to peak
- Sling Weight: 1000 lb
- Length of Tow Cable: 53 m
- Bird Survey Height: 30 m nominal

Receiver

- Two Axis Receiver Coils (x, z) positioned at centre of transmitter loop
- Selectable Time Delay to start of first channel 21.3, 42.7, or 64.0 ms

Display & Acquisition

- AERODAS Digital recording at 120 samples per decay curve at a maximum of 300 curves per second (27.778 µs channel width)
- RMS Channel Widths: 52.9, 132.3, 158.7, 158.7, 317.5, 634.9 µs
- Recording & Display Rate = 10 readings per second.
- On-board display - six channels Z-component and 1 X-component

System Considerations

Comparing a fixed-wing time domain transmitter with a typical moment of 500,000 NIA flying at an altitude of 120 m with a Helicopter TDEM at 30 m, notwithstanding the substantial moment loss in the airframe of the fixed wing, the same penetration by the lower flying helicopter system would only require a sixty-fourth of the moment. Clearly the AeroTEM system with nearly 183.131 NIA has more than sufficient moment. The airframe of the fixed wing presents a response to the towed bird, which requires dynamic compensation. This problem is non-existent for AeroTEM since transmitter and receiver positions are fixed. The AeroTEM system is completely portable, and can be assembled at the survey site within half a day.