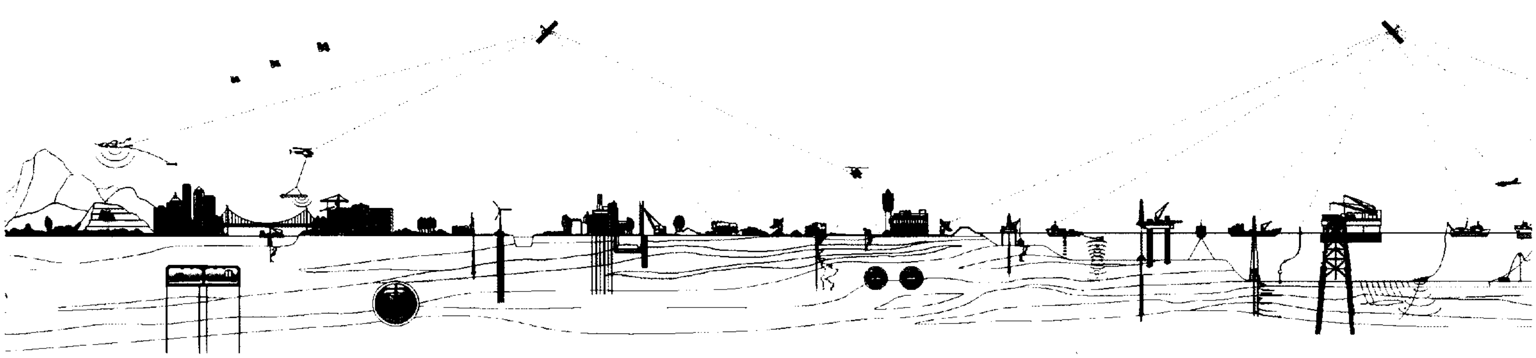
Fugro Airborne Surveys

LOGISTICS AND PROCESSING REPORT
Airborne Magnetic and MEGATEM® Survey

STURGEON LAKE SURVEY AREA
THUNDER BAY, ONTARIO, CANADA

Job No. 03-438

Unitronix Corp. and 1522923 Ontario Inc.



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Client : Unitronix Corp. and 1522923 Ontario Inc.

Date of Report : August, 2003

2060 Walkley Road, Ottawa, Ontario K1G 3P5. Phone: (1-613) 731-9575,

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I

Introduction

Between June 10th and June 13th, 2003, Fugro Airborne Surveys conducted a MEGATEM electromagnetic and magnetic survey of the Sturgeon Lake Area on behalf of Unitronix Corp. and 1522923 Ontario Inc.. Using Thunder Bay, Ontario as the base of operations, a total of 416 line kilometres and 43 tie line kilometres of data were collected using a Dash 7 modified aircraft (Figure 1).

The survey data were processed and compiled in the Fugro Airborne Surveys Ottawa office. It is presented as maps of Residual Magnetic Intensity (RMI), Total Energy Envelope of B-Field Channel 12, Calculated Apparent Conductance, Decay Constants of B-field X-Coil and B-field Z-coil, B-field X and Z-coil Anomalies and Flight Path. Multi-parameter profiles, digital archives of the raw and processed survey data in line format and gridded Magnetic and EM data were also provided.

Figure 1: Specially modified Dash-7 aircraft used by Fugro Airborne Surveys.

II

Survey Operations

Location of the Survey Area

The Sturgeon Lake Survey Block was flown with Thunder Bay as the base of operations. (Figure 2) For the Sturgeon Lake Survey Block, 45 lines and 7 tie lines were flown for a total distance of 459 km. The survey lines were flown N-S with a spacing of 200m with the tie lines E-W at a spacing of ~2500m.

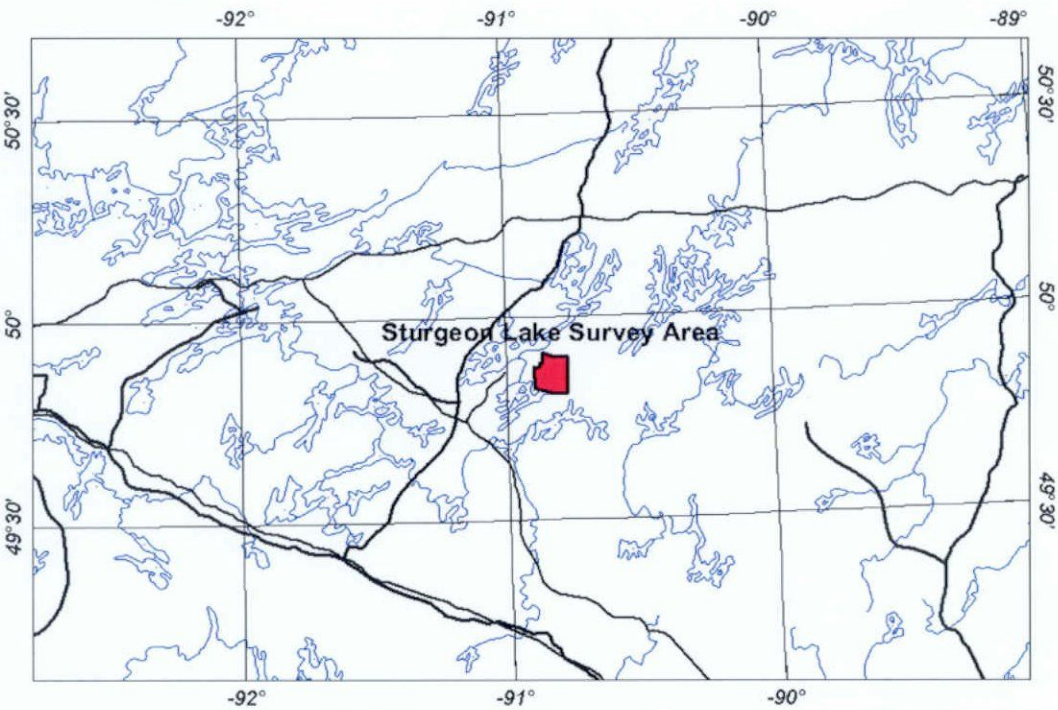


Figure 2: Survey Block Location.

Aircraft and Geophysical On-Board Equipment

Aircraft	DeHavilland Dash-7
Operator	FUGRO AIRBORNE SURVEYS
Registration	C-GJPI
Survey Speed	125 knots / 145 mph / 65 m/s
Magnetometer	Scintrex Cs-2 single cell cesium vapour, towed-bird installation, sensitivity = 0.01 nT[1], sampling rate = 0.1 s, ambient range 20,000 to 100,000 nT. The general noise envelope was kept below 0.5 nT. The nominal sensor height was ~73 m above ground.
Electromagnetic system	MEGATEM® 20 channel Multicoil System
Transmitter:	Vertical axis loop mounted on aircraft of 406 m^2
	Number of turns: 5
	Nominal height above ground of 120 m
Receiver :	Multicoil system (x, y and z) with a final recording rate of 4 samples/second, for the recording of 20 channels of x, y and z-coil data. The nominal height above ground is ~70 m, placed ~130 m behind the centre of the transmitter loop.
Base frequency:	90 Hz
Pulse width:	2200 µs
Pulse delay:	100 µs
Off-time:	3255 µs
Point value:	43.4 µs
Transmitter Current:	730 A
Dipole moment:	$1.48x10^6 Am^2$

Figure 3: Dash-7 in flight.

1 One nanotesla (nT) is the S.I. equivalent of one gamma.

Table 1: Electromagnetic Data Windows.

Channel	Start (p)	End (p)	Width (p)	Start (ms)	End (ms)	Mid (ms)
1	4	10	7	0.13	0.434	0.282
2	11	25	15	0.434	1.085	0.76
3	26	36	11	1.085	1.563	1.324
4	37	51	15	1.563	2.214	1.888
5	52	56	5	2.214	2.431	2.322
6	57	58	2	2.431	2.517	2.474
7	59	60	2	2.517	2.604	2.561
8	61	63	3	2.604	2.734	2.669
9	64	66	3	2.734	2.865	2.799
10	67	70	4	2.865	3.038	2.951
11	71	74	4	3.038	3.212	3.125
12	75	78	4	3.212	3.385	3.299
13	79	83	5	3.385	3.602	3.494
14	84	88	5	3.602	3.819	3.711
15	89	93	5	3.819	4.036	3.928
16	94	98	5	4.036	4.253	4.145
17	99	104	6	4.253	4.514	4.384
18	105	110	6	4.514	4.774	4.644
19	111	118	8	4.774	5.122	4.948
20	119	128	10	5.122	5.556	5.339

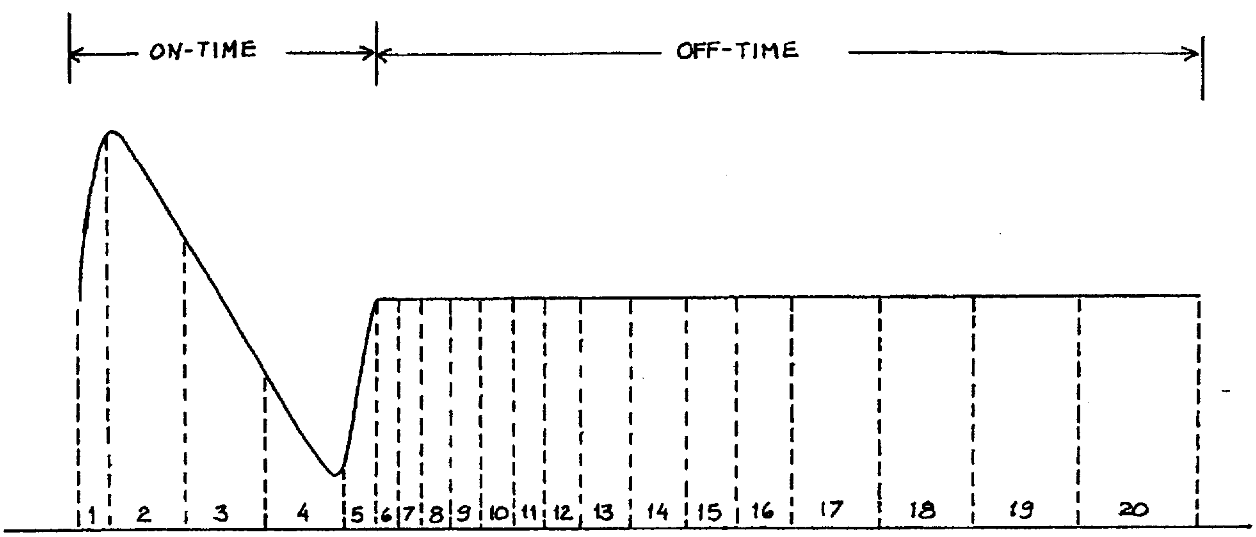


Figure 4. Pulse response waveform showing the gate numbers and relative positions to the on and off-time.

Digital Acquisition	FUGRO AIRBORNE SURVEYS GEODAS SYSTEM.
Analogue Recorder	RMS GR-33, showing the total magnetic field at 2 vertical scales, the radar and barometric altimeters, the time-constant filtered traces of the dB/dt X and Z coil channels 1, 10, 13, 18, B-field X and Z coil channels 10, 13, 18, the raw traces of the dB/dt and B-field X and Z coil channels 20, and dB/dt Y coil channel 20, the X and Y coil EM primary fields, the X coil powerline monitor, the 4th difference of the magnetics, the X coil earth's field monitor and the fiducials.
Barometric Altimeter	Rosemount 1241M, sensitivity 1 ft, 1 sec recording interval.
Radar Altimeter	King KRA405, accuracy 2%, sensitivity 1 ft, range 0 to 2500 ft, 1 sec recording interval.
Camera	Panasonic colour video, super VHS, model WV-CL302.
Electronic Navigation	Novatel Propak 4E-315R, 1 sec recording interval, with a resolution of 0.00001 degree and an accuracy of ±10m.

Analogue Recorder Display Setup:

Name	Descirption	Scale	Unit
XF10	dB/dt X coil Time Filtered Channel 10	10000	pV/cm
XF13	dB/dt X coil Time Filtered Channel 13	10000	pV/cm
XF18	dB/dt X coil Time Filtered Channel 18	10000	pV/cm
ZF10	dB/dt Z coil Time Filtered Channel 10	10000	pV/cm
ZF13	dB/dt Z coil Time Filtered Channel 13	10000	pV/cm
ZF18	dB/dt Z coil Time Filtered Channel 18	10000	pV/cm
BX10	B-field X coil Time Filtered Channel 10	10000	pT/cm
BX13	B-field X coil Time Filtered Channel 13	10000	pT/cm
BX18	B-field X coil Time Filtered Channel 18	10000	pT/cm
BZ10	B-field Z coil Time Filtered Channel 10	10000	pT/cm
BZ13	B-field Z coil Time Filtered Channel 13	10000	pT/cm
BZ18	B-field Z coil Time Filtered Channel 18	10000	pT/cm
X20	DB/dt X coil Raw channel 20	20000	pV/cm
Z20	DB/dt Z coil Raw channel 20	20000	pV/cm
BZ20	B-Field Z coil Raw channel 20	20000	pT/cm
BX20	B-Field X coil Raw channel 20	20000	pT/cm
X01	dB/dt X coil Raw channel 01	40000	pV/cm
XPL	Powerline Monitor	0.2	V/cm
XEFM	Earth Field Monitor	1	V/cm
XPRM	X Primary Field	0.4	V/cm
YPRM	Y Primary Field	133.3	V/cm
Y20	dB/dt Y coil Raw channel 20	20000	pV/cm
CMAG	Coarse Total Field Magnetics	1000	nT/cm
FMAG	Fine Total Field Magnetics	100	nT/cm
RADR	Radar Altimeter	50	ft/cm
4DIF	Magnetic 4th Difference Filtered	1	nT/cm
BARO	Barometric Altimeter	200	ft/cm

Base Station Equipment

Magnetometer: Scintrex CS-2 single cell cesium vapour, mounted in a magnetically quiet area, measuring the total intensity of the earth's magnetic field in units of 0.01 nT at intervals of 0.5 sec, within a noise envelope of 0.20 nT.

GPS Receiver: NOVATEL, measuring all GPS channels, for up to 10 satellites.

Computer: Laptop, model Pentium II, 220 MHz.

Converter: Picodas, model MEP710 3/10901 GTS 780008

Field Office Equipment

Computers: Dell Inspiron 7500 Pentium III laptop with 30 GB hard drive.

Printer: Hewlett Packard Deskjet 690C.

DAT Tape Drive: DDS-90 4 mm.

Hard Drive: 8 GB Removable hard drive

Survey Specifications

Traverse Line Direction: North – South
Traverse Line Spacing: 200 m

Tie Line direction: East – West
Tie Line spacing: ~2500m

Navigation: Differential GPS. Traverse and tie line spacing was not to exceed specified line spacing by 70m over a distance of 2kms.

Altitude: The survey was flown at a mean terrain clearance of 120 m. Altitude was not to exceed 140 m over 3 km.

Diurnal Variation: No deviations greater than 10 nT over a chord of 30 seconds.

Magnetic Noise Levels: The noise envelope on the magnetic data was not to exceed ± 0.25 nT over 3 km.

EM Noise Levels: The noise envelope on the raw electromagnetic dB/dt X and Z coil channels 20 was not to exceed ± 2500 pT/s over a distance greater than 3 km.

Field Crew

Project Manager:	A. Proulx
Pilots:	D. Mitchell, J. Gronset
Data Processors:	S. Laloo
Electronics Operator:	A. Proulx
Engineer:	S. Dinel

Production Statistics

Flying dates:	June 10th until June 13th
Total production:	459 line kilometres
Number of production flights:	3
Days lost weather:	0

III

Quality Control and Compilation Procedures

In the field after each flight, all analogue records were examined as a preliminary assessment of the noise level of the recorded data. Altimeter deviations from the prescribed flying altitudes were also closely examined as well as the diurnal activity, as recorded on the base station.

All digital data were verified for validity and continuity. The data from the aircraft and base station was transferred to the PC's hard disk. Basic statistics were generated for each parameter recorded, these included: the minimum, maximum, and mean values; the standard deviation; and any null values located. All recorded parameters were edited for spikes or datum shifts, followed by final data verification via an interactive graphics screen with on-screen editing and interpolation routines.

The quality of the GPS navigation was controlled on a daily basis by recovering the flight path of the aircraft. The C3NavG2 correction procedure employs the raw ranges from the base station to create improved models of clock error, atmospheric error, satellite orbit, and selective availability. These models are used to improve the conversion of aircraft raw ranges to aircraft position.

Checking all data for adherence to specifications was carried out in the field by the FUGRO AIRBORNE SURVEYS field geophysicist.

IV

Data Processing

Flight Path Recovery

GPS Recovery:	GPS positions recalculated from the recorded raw range data, and differentially corrected.
Projection:	Universal Transverse Mercator (UTM Zone 15N)
Datum:	NAD 27 (Canada Mean)
Central meridian:	93° West
False Easting:	500000 metres
False Northing:	0 metres
Scale factor:	0.99960

Altitude Data

Noise editing:	Alfatrim median filter used to eliminate the highest and lowest values from the statistical distribution of a 5 point sample window for the radar altimeter, the barometric altimeter and the gps-elevation.

Base Station Diurnal Magnetics

Noise editing:	Alfatrim median filter used to eliminate the two highest and two lowest values from the statistical distribution of a 9 point sample window.
Culture editing:	Polynomial interpolation via a graphic screen editor.
Noise filtering:	Running average filter set to remove wavelengths less than 7 seconds.

Extraction of long wavelength component:

Running average filter set to retain only wavelengths greater than 77 seconds.

Airborne Magnetics

Lag correction:	3.4 s
Noise editing:	4th difference editing routine set to remove spikes greater than 0.5 nT.
Noise filtering:	Triangular filter set to remove noise events having a wavelength less than 0.9 seconds and an amplitude less than 0.5 nT.

Diurnal subtraction: The long wavelength component of the diurnal (greater than 77 seconds) was removed from the data, prior to the levelling analysis.

Regional removal: The International Geomagnetic Reference Field (IGRF) was calculated for the period 2003.4 and removed from the data prior to levelling.

Gridding: The data was gridded using an akima routine with a grid cell size of 50 m.

Residual Magnetic Intensity

The residual magnetic intensity (RMI) is derived from the total magnetic intensity (TMI), the diurnal, and the regional magnetic field. The total magnetic intensity is measured in the aircraft, the diurnal is measured from the ground station, and the regional magnetic field is calculated from the IGRF. The low frequency component of the diurnal is extracted from the filtered ground station data and removed from the TMI. The average of the diurnal is then added back in to obtain the resultant total magnetic intensity. The regional magnetic field, calculated for the specific survey location and the time of the survey, is then removed from the resultant total magnetic intensity. After compensation values created by the tie line and micro-levelling processes are applied the final residual magnetic intensity parameter is generated.

Electromagnetics

dB/dt data

Lag correction: 3.5 s

Data correction: The x, y and z-coil data were processed from the 20 raw channels recorded at 4 samples per second.

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

a) The data from channels 1 to 5 (on-time) and 6 to 20 (off-time) were corrected for drift in flight form (prior to cutting the recorded data back to the correct line limits) by passing a low order polynomial function through the baseline minima along each channel, via a graphic screen display;

b) The data were edited for residual spheric spikes by examining the decay pattern of each individual EM transient. Bad decays (i.e. not fitting a normal exponential function) were deleted and replaced by interpolation;

c) Corrections were made in the x- and z-coil data for low frequency, incoherent noise elements (that do not correlate from channel to channel) in the data, by analysing the decay patterns of channels 10 to 20 (OMEGA process).

d) Noise filtering was done using an adaptive filter technique based on time domain triangular operators. Using a 2nd difference value to identify changes in gradient along each channel, minimal filtering (3 point convolution) is applied over the peaks of the anomalies, ranging in set increments up to a maximum amount of filtering in the resistive background areas (27 points for both the x-coil and the z-coil data).

e) The filtered data from the x, y and z-coils were then re-sampled to a rate of 5 samples/s and combined into a common file for archiving.

B-field data

Processing steps: The processing of the B-Field data stream is essentially the same as that described above for the regular dB/dt stream. The lag adjustment used was the same, followed by: 1) drift adjustments; 2) spike editing for spheric events; 3) correction for low frequency, incoherent and non-decaying noise events; and 4) final noise filtering with an adaptive filter. The processing step 3) was applied in the B-field processing but not in the dB/dt processing. By nature, the B-Field data will contain a higher degree of coherency of the noise that automatically gets eliminated (or considerably attenuated) in the regular dB/dt, since this is the time derivative of the signal.

Note: The introduction of the B-Field data stream, as part of the GEOTEM system, provides the explorationist with a more effective tool for exploration in a broader range of geological environments and for a larger class of target priorities.

The advantage of the B-Field data compared with the normal voltage data (dB/dt) are as follows:

1. A broader range of target conductance that the system is sensitive to. (The B-Field is sensitive to bodies with conductance as great as 100,000 Siemens);
2. Enhancement of the slowly decaying response of good conductors;
3. Suppression of rapidly decaying response of less conductive overburden;
4. Reduction in the effect of spherics on the data;
5. An enhanced ability to interpret anomalies due to conductors below thick conductive overburden;
6. Reduced dynamic range of the measured response (easier data processing and display).

Figures 5 and 6 display the calculated vertical plate response for the GEOTEM signal for the dB/dt and B-Field respectively. For the dB/dt response, you will note that the amplitude of the early channel peaks at about 25 Siemens, and the late channels at about 250 Siemens. As the conductance exceeds 1000 Siemens the response curves quickly roll back into the noise level. For the B-Field response, the early channel amplitude peaks at about 80 Siemens and the late channel at about 550 Siemens. The projected extension of the graph in the direction of increasing conductance, where the response would roll back into the noise level, would be close to 100,000 Siemens. Thus, a strong conductor, having a conductance of several thousand Siemens, would be difficult to interpret on the dB/dt data, since the response would be mixed in with the background noise. However, this strong conductor would stand out clearly on the B-Field data, although it would have an unusual character, being a moderate to high amplitude response, exhibiting almost no decay.

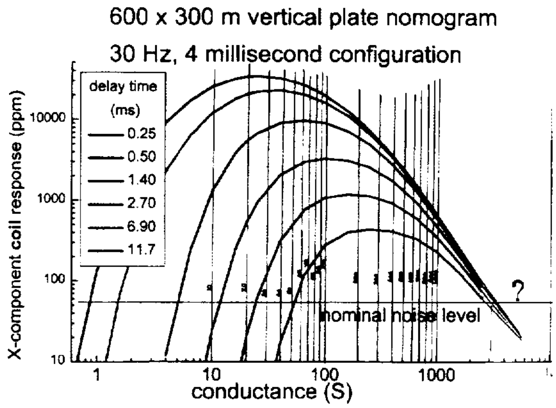


Figure 5. dB-dt vertical plate nomogram

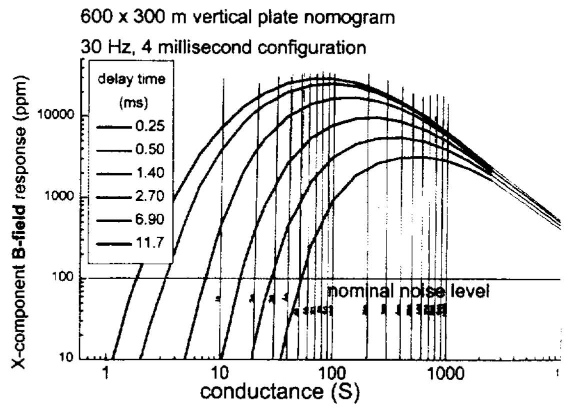


Figure 6. B-field vertical plate nomogram

In theory, the response from a super conductor (50,000 to 100,000 Siemens) would be seen on the B-Field data as a low amplitude, non-decaying anomaly, not visible in the off-time channels of the dB/dt stream. Caution must be exercised here, as this signature can also reflect a residual noise event in the B-Field data. In this situation, careful examination of the dB/dt on-time (in-pulse) data is required to resolve the ambiguity. If the feature were strictly a noise event, it would be not be present in the dB/dt off-time data stream. This would locate the response at the resistive limit, and the mid in-pulse channel (normally identified as channel 3) would reflect little but background noise, or at best a weak negative peak. If, on the other hand, the feature does indeed reflect a superconductor, then this would locate the response at the inductive limit. In this situation, channel 3 of the dB/dt stream will be a mirror image of the transmitted pulse, i.e. a large negative.

Coil Oscillation Correction

The electromagnetic receiver sensor is housed in a bird which is towed behind the aircraft using a cable. Any changes in airspeed of the aircraft, variable crosswinds, or other turbulence will result in the bird swinging from side to side. This can result in the induction sensors inside the bird rotating about their mean orientation. The rotation is most marked when the air is particularly turbulent. The changes in orientation results in variable coupling of the induction coils to the primary and secondary fields. For example, if the sensor that is normally aligned to measure the x-axis response pitches upward, it will be measuring a response that will include a mixture of the X and Z component responses. The effect of coil oscillation on the data increases as the signal from the ground (conductivity) increases and may not be noticeable when flying over areas which are generally resistive. This becomes more of a concern when flying over highly conductive ground.

Using the changes in the coupling of the primary field, it is possible to estimate the pitch, roll and yaw of the receiver sensors. In the estimation process, it is assumed that a smoothed version of the primary field represents the primary field that would be measured when the sensors are in the mean orientation. The orientations are estimated using a non-linear inversion procedure, so erroneous orientations are sometimes obtained. These are reviewed and edited to insure smoothly varying values of orientations. These orientations can then be used to unmix the measured data to generate a response that would be measured if the sensors were in the correct orientation. (For more information on this procedure, see:
http://www.fugroairborne.com/TechnicalPapers/r_atem.shtml).

For the present dataset, the data from all 20 channels of dB/dt and B-Field parameters have been corrected for coil oscillation.

Total Energy Envelope

To combine the benefits of the measurement from both the X and Z coil data and reduce the asymmetry in the signature of the anomalies, the channel data from both the X and Z coils can be used to compute the Total Energy Envelope of the response. This is done through a Hilbert Transform and essentially reflects the square root of the sum of the squares of each component.

For the present dataset, channel 12 of the B-Field component (mid-time position of 998 µsec after turn-off) was selected as the optimum window along the transient to map the response over features of interest. This channel is sufficiently late in time to avoid minor variations in the signal due to overburden conductivity and altitude effects and yet, not so late in time that the possible weak response over features of interest would get lost in the background.

Decay Constant (TAU)

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

$$Y = A\,e^{-\lambda t}$$

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

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

For the present dataset, the decay constants were calculated by fitting the dB/dt component X coil response from channels 9 to 20 (mean delay times of 499 to 3038 µsec after turn-off) and the B-field component Z-coil response from channels 9 to 20 (mean delay times of 499 to 3038 µsec after turn-off) to the exponential function.

Apparent Conductance

The apparent conductance was calculated by fitting all 20 channels of the combined X and Z-coil response of the dB/dt component to the thin sheet model. Prior to the fitting, the data is deconvolved to the step response in order to provide a linear relationship as the conductivity of the ground increases from the resistive limit to the inductive limit.

The apparent conductance provides the maximum information on the near-surface conductivity of the ground which, when combined with the magnetic signature, provides good geological mapping.

EM Anomaly selection

EM anomalies were selected by fitting the data from the B-field X-coil channels 9 to 20 to a vertical plate model, in order to extract conductance and depth information. Comparisons of the response from the dB/dt and B-field X and Z coil data were made during the anomaly review for the final selection of the anomalies. B-field Z coil anomaly selections are displayed on the maps.

Refer to Appendix F for a full listing of the anomaly selections which provides the particulars of each selected anomaly, including the conductivity-thickness-product (CTP) and the depth of the conductor below surface. It is important to note that the derived values of CTP and depth associated with the anomaly selections are only valid if the geometry of the conductive source can be well approximated by a vertical plate of 300 by 600 m. A note is also included to guide the correct evaluation of the anomaly information.

V

Final Products

Digital Archives

Survey raw and processed line data in GEOSOFT Oasis Montaj®, GEOSOFT grid files, EM waveform reference files (pre and post flight, ASCII format), raw EM halfwave flight data (binary format) have been written to either CD-ROM or DVD. The formats and layouts of these archives are further described in Appendix E (Data Archive Description).

Maps

Black & White

Scale: 1:20,000
Parameter: Residual Magnetic Intensity (Contours)
Apparent Conductance (Contours)
Decay Constant (Tau) derived from dB/dt X-coil channels 9-20 (Contours)
Decay Constant (Tau) derived from B-field Z-coil channels 9-20 (Contours)
Total Energy Envelope derived from B-field X- and Z-coil channel 12 (Contours)
Anomaly Selection and Survey Flight Path.

Colour

Scale: 1:20,000
Parameter: Residual Magnetic Intensity (Contours)
Apparent Conductance (Contours)
Decay Constant (Tau) derived from dB/dt X-coil channels 9-20 (Contours)
Decay Constant (Tau) derived from B-field Z-coil channels 9-20 (Contours)
Total Energy Envelope derived from B-field X- and Z-coil channel 12 (Contours)

Profile Plots

Scale: 1:20,000
Parameters: Multi-channel presentation with 12 channels of both dB/dt and B-field X and Z coil, Residual Magnetic Intensity, Magnetic Vertical Gradient, Radar Altimeter, EM Primary Field and Hz Monitor.

Logistics and Processing Report

Copies: 1 digital (PDF format)

Appendix A

GEOTEM® ELECTROMAGNETIC SYSTEM

GEOTEM® ELECTROMAGNETIC SYSTEM

General

The operation of a towed-bird time-domain electromagnetic system (EM) involves the measurement of decaying secondary electromagnetic fields induced in the ground by a series of short current pulses generated from an aircraft-mounted transmitter. Variations in the decay characteristics of the secondary field (sampled and displayed as windows) are analyzed and interpreted to provide information about the subsurface geology. The response of such a system utilizing a vertical-axis transmitter dipole and a multicomponent receiver coil has been documented by various authors including Smith and Keating (1991, Geophysics v.61, p. 74-81).

The principle of sampling the induced secondary field in the absence of the primary field (during the "off-time") and the large separation of the receiver coils from the transmitter combine with the large dipole moment and power available from the fixed wing platform to provide excellent signal-to-noise ratio and depth of penetration. Such a system is also relatively free of noise due to air turbulence. However, also sampling in the "on-time" (Annan et al., 1991, Geophysics v.61, p. 93-99) can result in excellent sensitivity for mapping very resistive features and very conductive features, and thus mapping geology.

Through free-air model studies using the University of Toronto's Plate and Layered Earth programs it may be shown that the "depth of investigation" depends upon the geometry of the target. Typical depth limits would be 400 m below surface for a homogeneous half-space, 550 m for a flat-lying inductively thin sheet or 350 m for a large vertical plate conductor. These depth estimates are based on the assumptions that the overlying or surrounding material is resistive.

The method also offers very good discrimination of conductor geometry. This ability to distinguish between flat-lying and vertical conductors combined with excellent depth penetration results in good differentiation of bedrock conductors from surficial conductors.

Methodology

GEOTEM® (GEOterrex Transient ElectroMagnetic system) is a time-domain towed-bird electromagnetic system incorporating a high-speed digital EM receiver. The primary electromagnetic pulses are created by a series of discontinuous sinusoidal current pulses fed into a three- or six-turn transmitting loop surrounding the aircraft and fixed to the nose, tail and wing tips. The base frequency rate is selectable: 25, 30, 75, 90, 125, 150, 225 and 270 Hz. The length of the pulse can be tailored to suit the targets. Standard pulse widths available are 0.6, 1.0, 2.0 and 4.0 ms. The available off-time can be selected to be as great as 16 ms. The current depends on the pulse width but the dipole moment can be as great as 6.7×10^5 Am ^{2}.

The receiver is a three-axis (x,y,z) induction coil which is towed by the aircraft on a 135-metre or 125-metre cable. The tow cable is non-magnetic, to reduce noise levels. The usual mean terrain clearance for the aircraft is 120 m with the EM bird being situated nominally 50 m below and 125 m behind the aircraft (see figure 1).

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

The measured signals pass through anti-aliasing filters and are then digitized with an A/D converter at sampling rates of up to 80 kHz. The digital data flows from the A/D converter into an industrial-grade computer where the data are processed to reduce the noise.

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

Primary-field removal:

In addition to measuring the secondary response from the ground, the receiver sensor coils also measure the primary response from the transmitter. During flight, the bird position and orientation changes slightly, and this has a very strong effect on the magnitude of the total response (primary plus secondary) measured at the receiver coils. The variable primary field response is distracting because it is unrelated to the ground response. The primary field can be measured by flying at an altitude such that no ground response is measurable. These calibration signals are used to define the shape of the primary waveform. By definition this primary field includes the response of the current in the transmitter loop plus the response of any slowly decaying eddy currents induced in the aircraft. We assume that the shape of the primary will be unchanged as the bird position changes, but that the amplitude will vary. The primary field removal procedure involves solving for the amplitude of the primary field in the measured response and removing this from the total response to leave a secondary response. Note that this procedure removes any ("in-phase") response from the ground which has the same shape as the primary field. For more details on the primary-field removal procedure, see http://www.fugroairborne.com/TechnicalPapers/inphasequad.shtml

1. *Transient Analysis:* Transient analysis permits the separation of specific types of noise from the signal in real time.

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

3. *Windowing of data*: The GEOTEM® digital receiver samples the secondary and primary electromagnetic field at 64, 128 or 384 points per EM pulse and windows the signal in up to 20 time gates whose centres and widths are software selectable and which may be placed anywhere within or outside the transmitter pulse. This flexibility offers the advantage of arranging the gates to suit the goals of a particular survey, ensuring that the signal is appropriately sampled through its entire dynamic range.

4. *Power Line Filtering:* Digital comb filters are applied to the data during real-time processing to remove power line interference while leaving the EM signal undisturbed. The RMS power line voltage (at all harmonics in the receiver passband) are computed, displayed and recorded for each data stack.

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

6. *Earth Field Monitor:* A monitor of sensor coil motion noise induced by coil motion in the Earth's magnetic field is also extracted in the course of the real-time digital processing. This information is also displayed on the real-time chart as well as being recorded for post-survey diagnostic processes.

7. *Noise/Performance:* A monitor computes the RMS signal level on an early off-time channel over a running 10-second window. This monitor provides a measure of noise levels in areas of low ground response. This information is printed at regular intervals on the side of the flight record and is recorded for every data stack.

One of the major roles of the GEOTEM® digital receiver is to provide diagnostic information on system functions and to allow for identification of noise events, such as sferics, which may be selectively removed from the EM signal.

GEOTEM®'s high digital sampling rate yields maximum resolution of the secondary field. The absence of an analog system time-constant filter results in minimal signal distortion and, therefore, superior representation of the anomaly amplitudes and shapes.

System Hardware

The GEOTEM® system is an integrated whole, consisting of the CASA 212 aircraft, the on-board hardware, and the software packages controlling the hardware.
The software packages in the GEODAS data acquisition system and in the GEOTEM® receiver were developed in-house. Likewise, certain elements of the hardware (GEOTEM® transmitter, system timing clock, towed-bird receiver system) were developed in-house.

Transmitter System

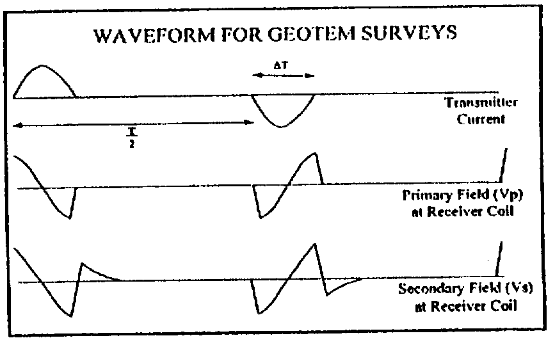
The transmitter system drives high-current pulses of an appropriate shape and duration through the coils mounted on the CASA aircraft.

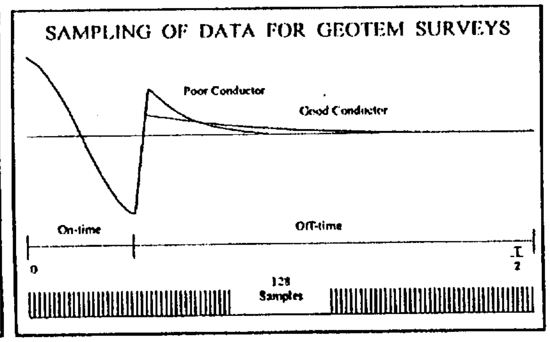
System Timing Clock

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

Towed-Bird Receiver System

A three-axis induction coil is mounted inside a towed bird, which is typically 50 metres below and 125 metres behind the aircraft. (A second bird, housing the magnetometer sensor, is typically 45 metres below and 80 metres behind the aircraft.)

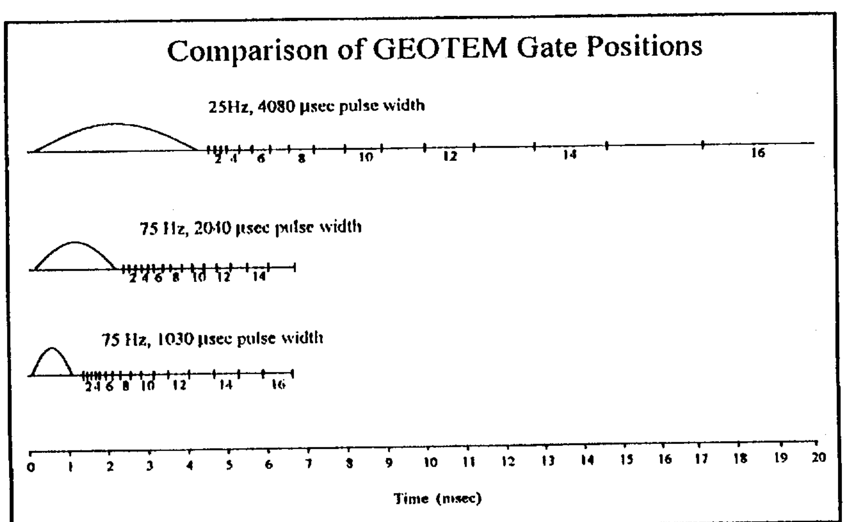




The GEOTEM system waveform (left frame) and sampling (right frame)

Timing of GEOTEM™ data acquisition for typical configurations

Base Frequency [Hz] **Pulse Width [ms]**	**150** **1.02**	**90** **2.04**	**30** **4.14**	**125** **1.02**	**75** **2.04**	**25** **4.14**
Total Halfcycle [ms]	3.33	5.56	16.67	4.00	6.67	20.00
Off-Time [ms]	2.31	3.52	12.53	2.98	4.63	15.86
TX pulses / second	240	144	48	200	120	40
Eff.Digitising Rate [samples/sec]	38,400	23,040	7,680	32,000	19,200	6,400
Pulses per Reading	60	36	12	50	30	10
Stored readings / second	4	4	4	4	4	4
Samples per transient	128	128	128	128	128	128
Number of Channels	20	20	20	20	20	20
- off-time	16	15	15	16	15	16
- in-pulse	4	5	5	4	5	4



Standard GEOTEM gate positions

Appendix B

GEOTEM® Interpretation

GEOTEM® Interpretation

Introduction

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

GEOTEM1 (GEOterrex Transient ElectroMagnetic system) is an airborne transient (or time-domain) towed-bird EM system incorporating a high-speed digital receiver which records the secondary field response with a high degree of accuracy. Most often the total magnetic field is recorded concurrently.

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

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

Types Of Conductors

Bedrock Conductors

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

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

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

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

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

1 GEOTEM®: Registered Trade Mark of Fugro Airborne Surveys Corporation.

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

Surficial Conductors

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

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

Cultural Conductors (Man-Made)

1. *Power lines*. These frequently, but not always, produce a conductive type of response on the GEOTEM record. In the case of direct radiation of its field, a power line is easily recognized by a GEOTEM anomaly which exhibits phase changes between different channels. In the case of a grounded wire, or steel pylon, the anomaly may look very much like a bedrock conductor.

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

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

Analysis Of The Conductors

The apparent conductivity alone is not generally a decisive criterion in the analysis of a conductor. In particular, one should note:

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

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

Bedrock Conductors

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

An intermediate to high conductivity identified by a response with slow decay, with deflections most often present in the later channels.

The anomaly should be narrow, relatively symmetrical, with a well-defined peak.

There should be no serious displacement of anomaly position or change in anomaly shape (other than mirror image) with respect to flight direction, except in the case of non-vertical dipping bodies. The alternating character of the response as a result of line direction can be diagnostic of conductor geometry. Figures 2 to 6 illustrate anomalies associated with different target models.

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

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

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

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

A bedrock conductor reflecting the presence of a massive sulphide would normally exhibit the following characteristics:

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

Surficial Conductors

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

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

When surficial conductivity is high it is usually still possible to distinguish between a horizontal plate (more likely to be surficial material) and a vertical body (more likely to be a bedrock source) thanks to the asymmetry of the GEOTEM responses observed at the edges of a broad conductor when flying adjacent lines in opposite directions. The configuration of the system is such that the response recorded at the leading edge is more pronounced than that registered at the trailing edge. Figure 1 illustrates the "edge effect" and the resulting conductive pattern in plan view. In practice there are many variations on this very diagnostic phenomenon.

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

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

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

Cultural Conductors

The majority of cultural anomalies occur along roads and are accompanied by a response on the power line monitor. (This monitor is set to 50 or 60 Hz, depending on the local power grid.) Power lines are the most common source of the anomalies and many are recognized immediately by virtue of phase reversals or an abnormal rate of decay. A certain number yield normal GEOTEM anomalies which could be mistaken for bedrock responses. There are also some power lines which have no GEOTEM response whatsoever.

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

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

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

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

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

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

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

EDGE EFFECT

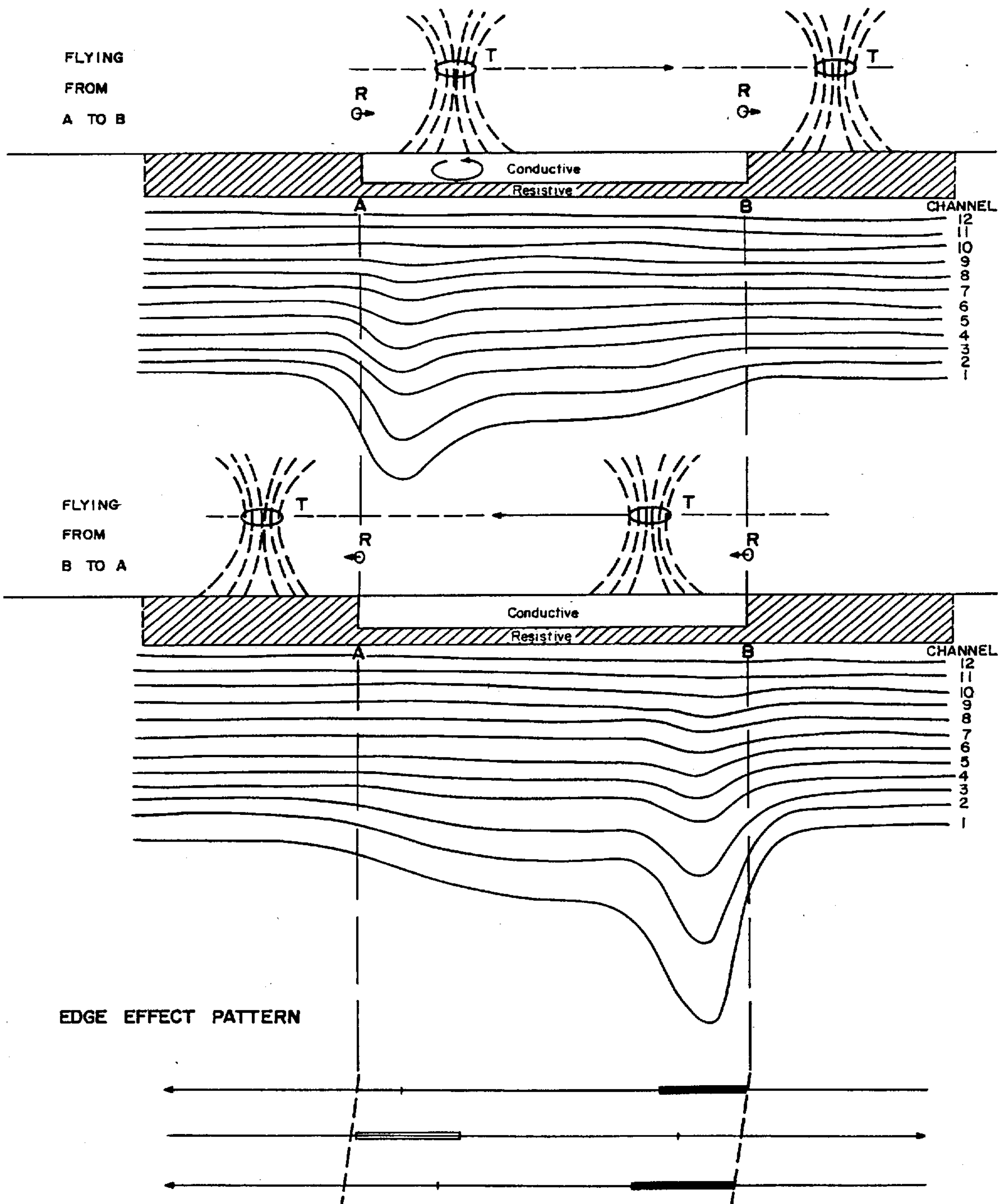


FIGURE 1

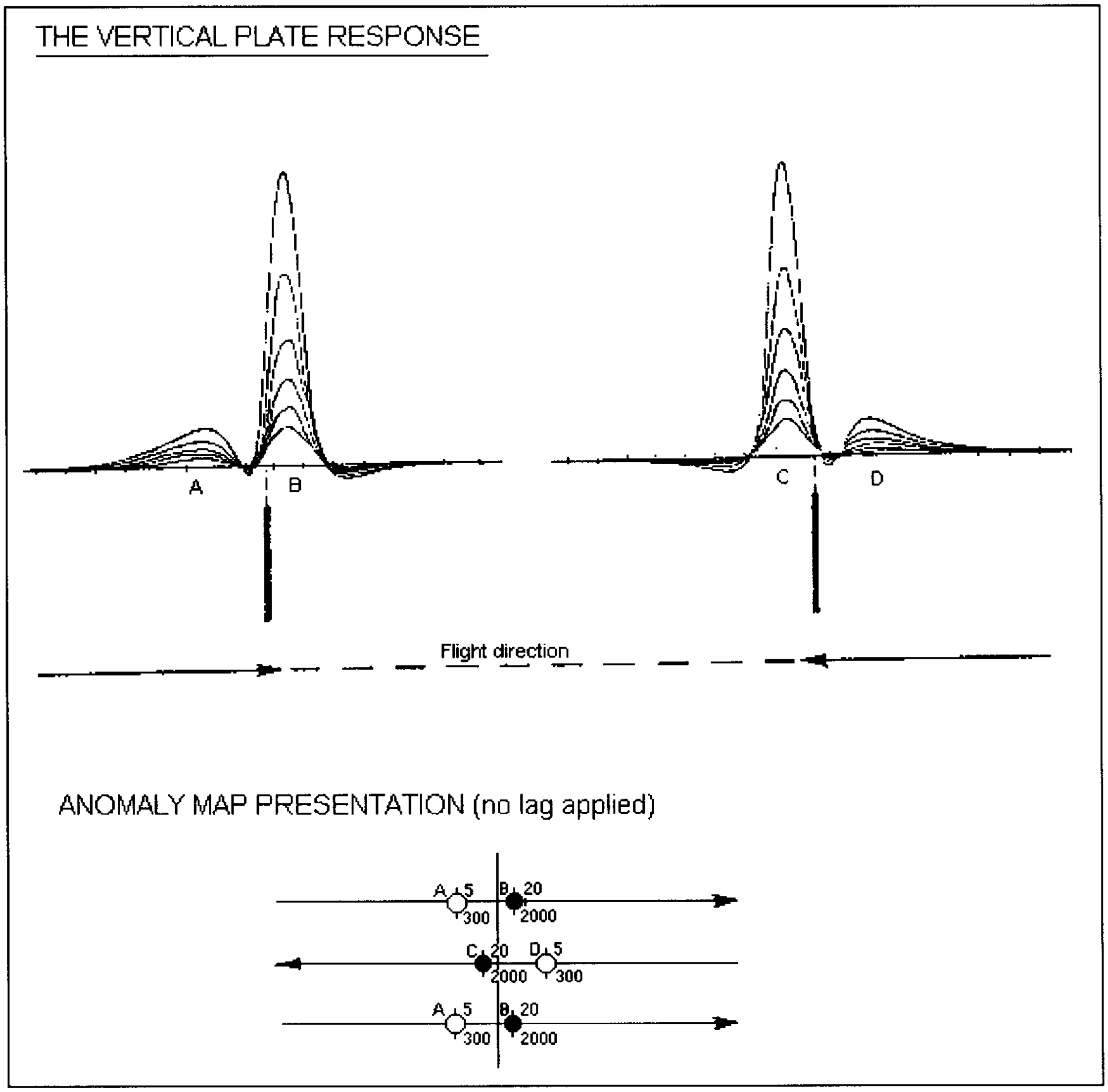

THE VERTICAL PLATE RESPONSE
A
B
C
D
Flight direction
ANOMALY MAP PRESENTATION (no lag applied)
A 5
300
B 20
2000
C 20
2000
D 5
300
A 5
300
B 20
2000

Figure 2

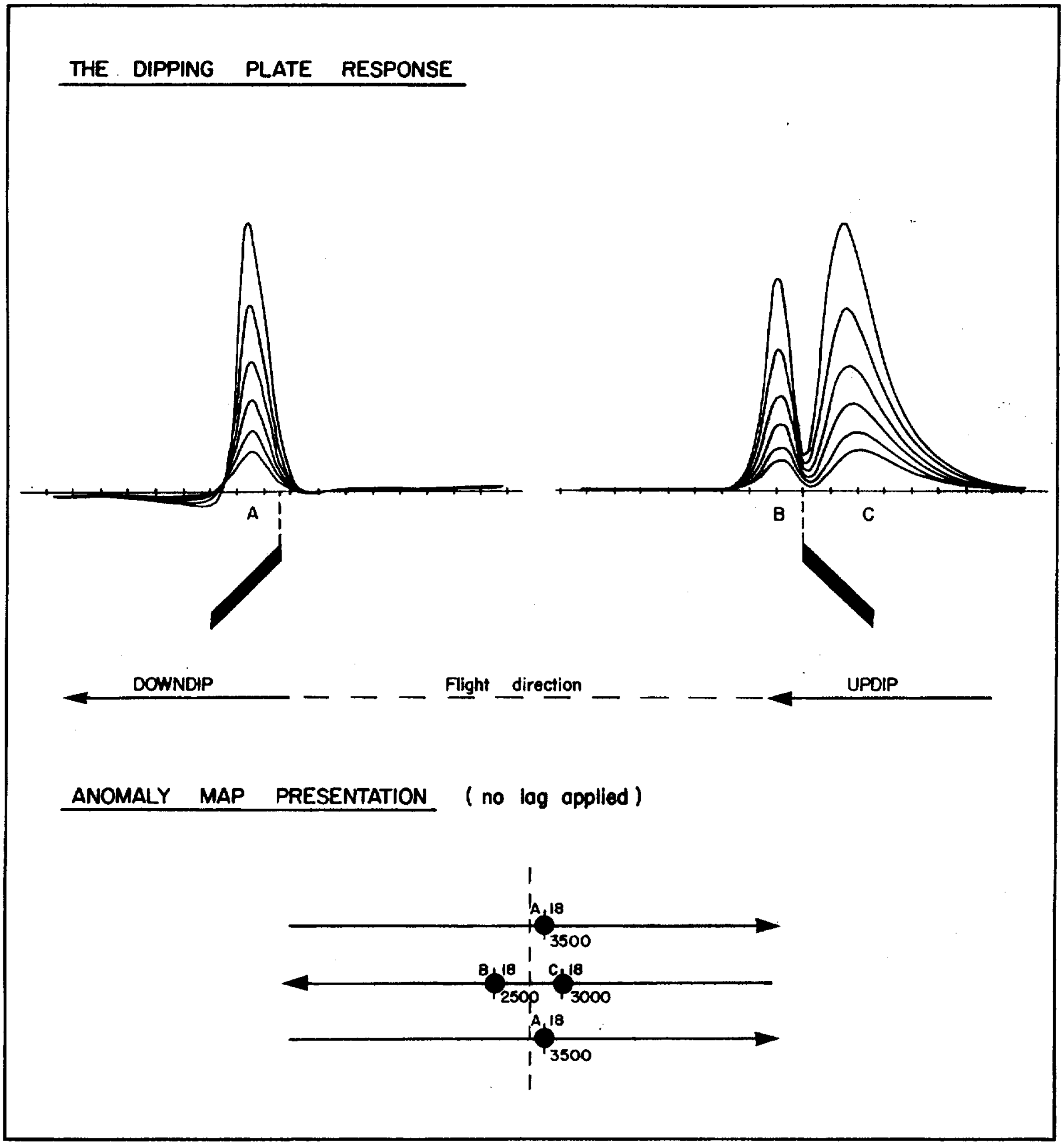

THE DIPPING PLATE RESPONSE
A
B
C
DOWNDIP
Flight direction
UPDIP
ANOMALY MAP PRESENTATION (no lag applied)
A, 18
3500
B, 18
2500
C, 18
3000
A, 18
3500

Figure 3

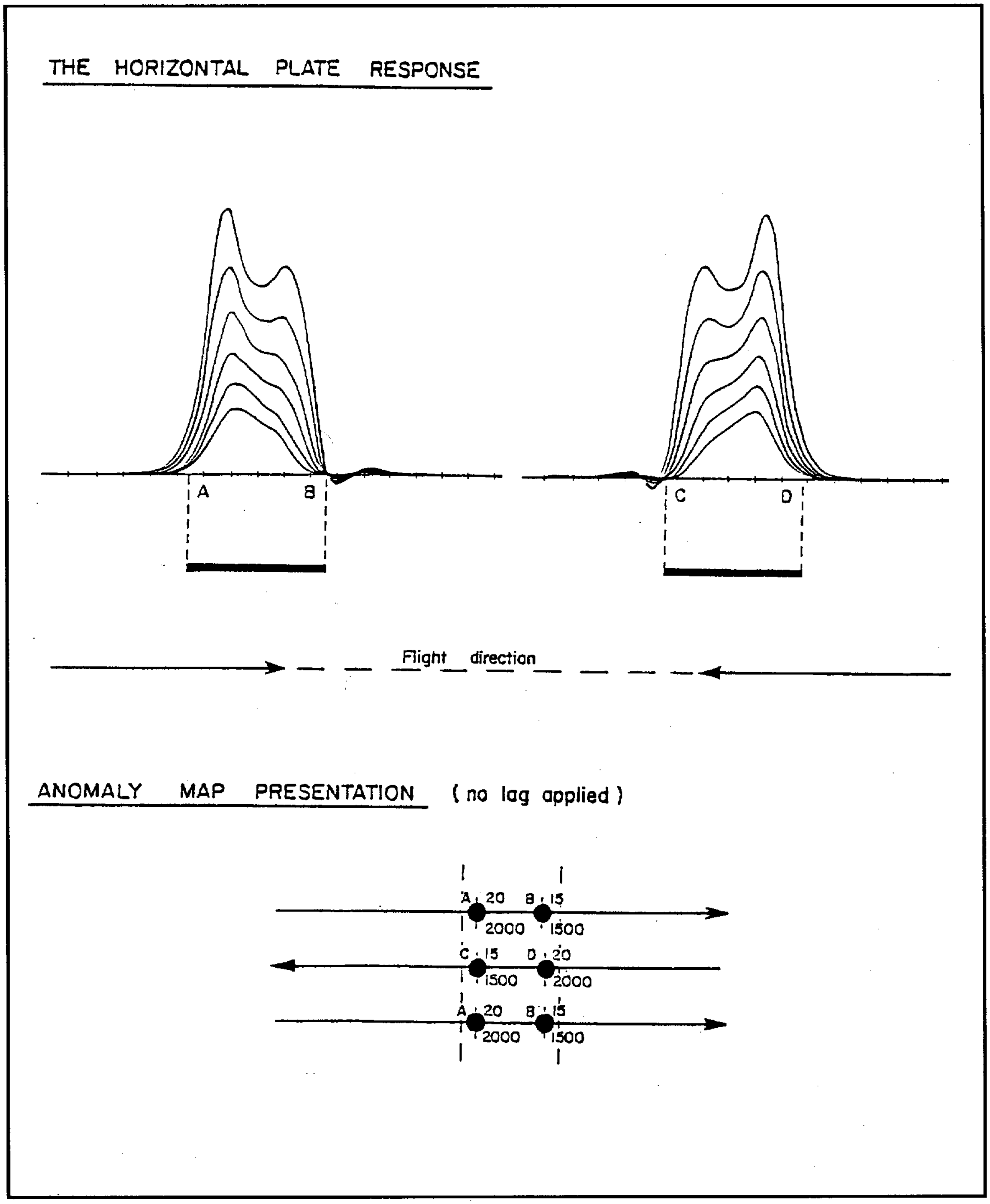

THE HORIZONTAL PLATE RESPONSE
A
B
C
D
Flight direction
ANOMALY MAP PRESENTATION (no lag applied)
A 20
B 15
2000
1500
C 15
D 20
1500
2000
A 20
B 15
2000
1500

Figure 4

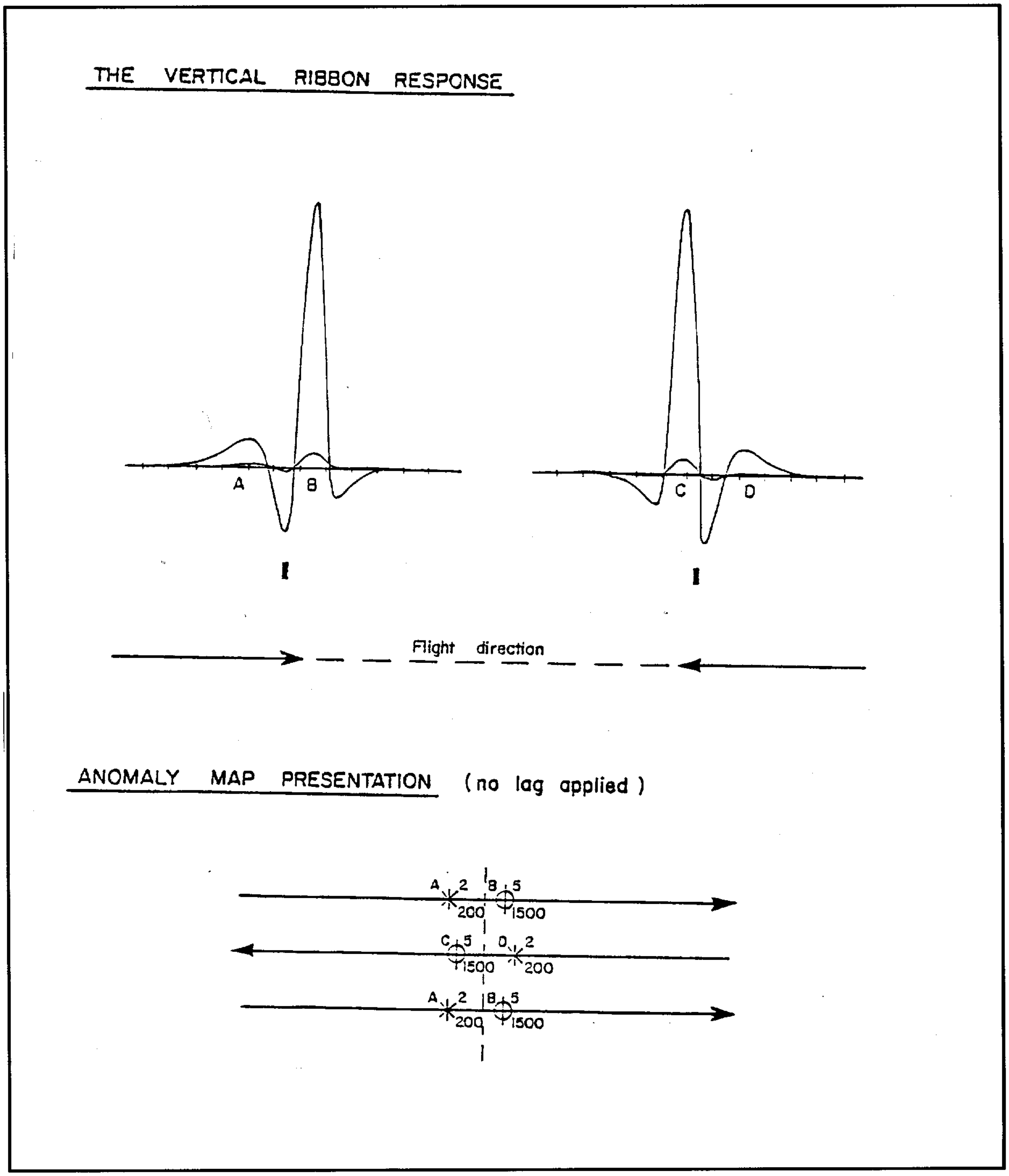

THE VERTICAL RIBBON RESPONSE
A
B
C
D
Flight direction
ANOMALY MAP PRESENTATION (no lag applied)
A 2 B 5
200 1500
C 5 D 2
1500 200
A 2 B 5
200 1500

Figure 5

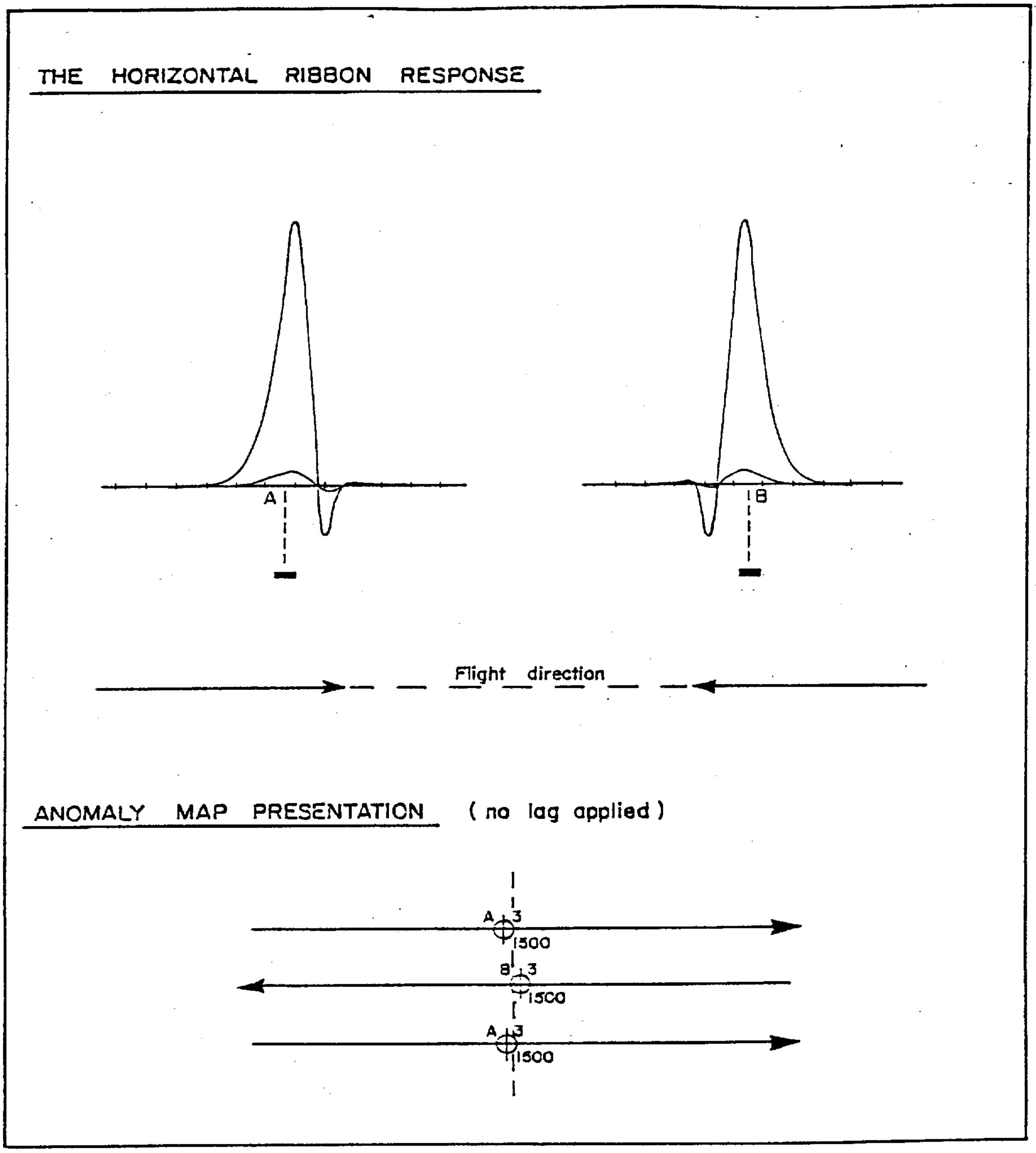

THE HORIZONTAL RIBBON RESPONSE
A
B
Flight direction
ANOMALY MAP PRESENTATION (no lag applied)
A 3
1500
B 3
1500
A 3
1500

Figure 6

Appendix C

Multicomponent GEOTEM® modelling

Multicomponent GEOTEM® modelling

Introduction

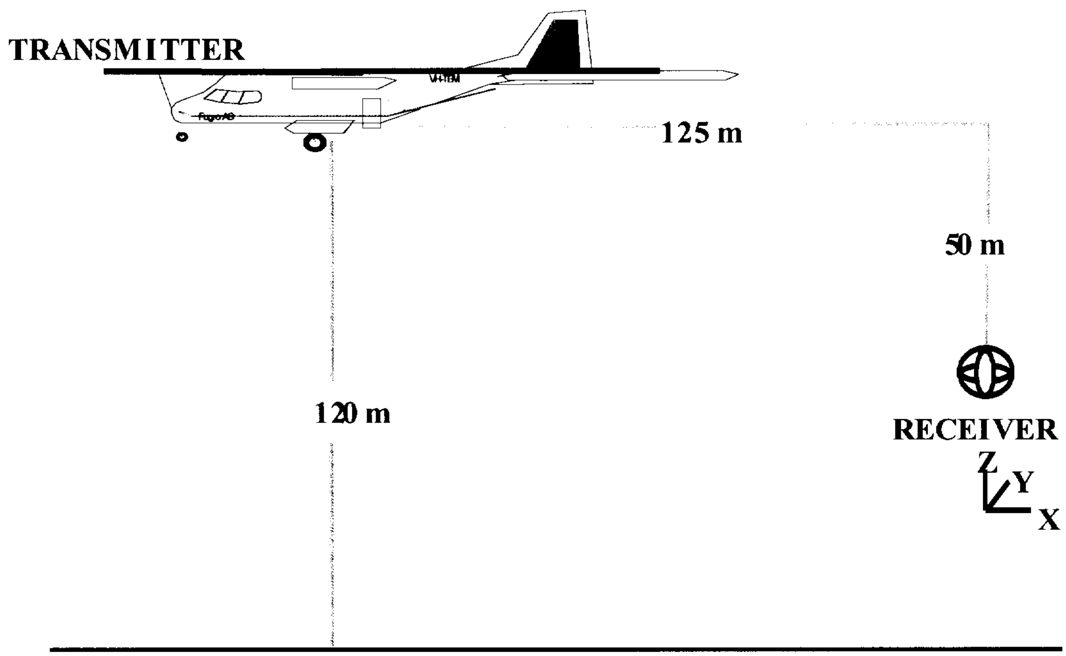
The PLATE program has been used to generate synthetic responses over a number of plate models with varying depth of burial (0, 150 and 300m) and dips (0, 45, 90 and 135 degrees). The geometry assumed for the GEOTEM system is shown on the following page, and the transmitter waveform on the subsequent page. For simplicity, only six receiver gates have been calculated and plotted.

In all cases the plate has a strike length of 600 m with a strike direction into the page. The width of the plate is 300 m. As the flight path traverses the centre of the plate, the y component is zero and has not been plotted.

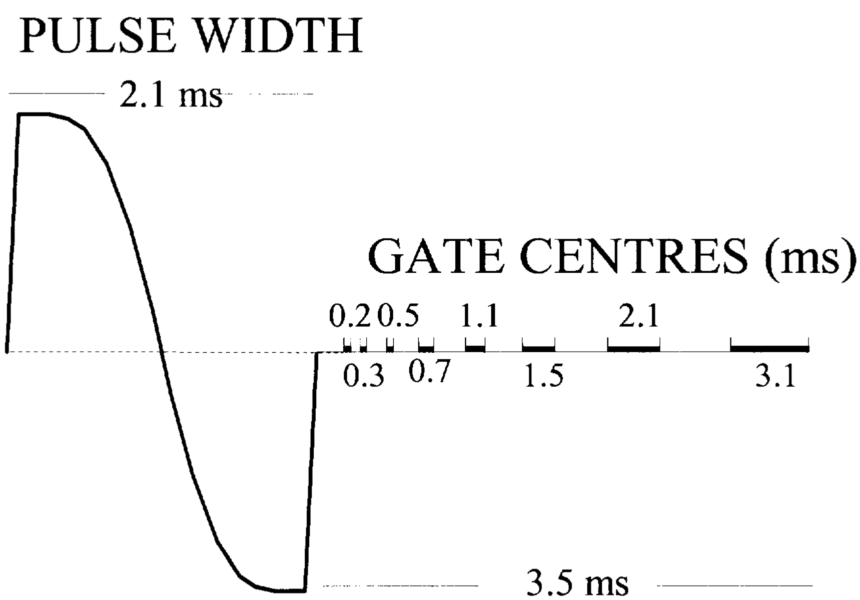
The conductance of the plate is 20 S. In cases when the conductance is different, an indication of how the amplitudes may vary can be obtained from the nomogram included.

In the following plots all components are normalized to the total primary field.

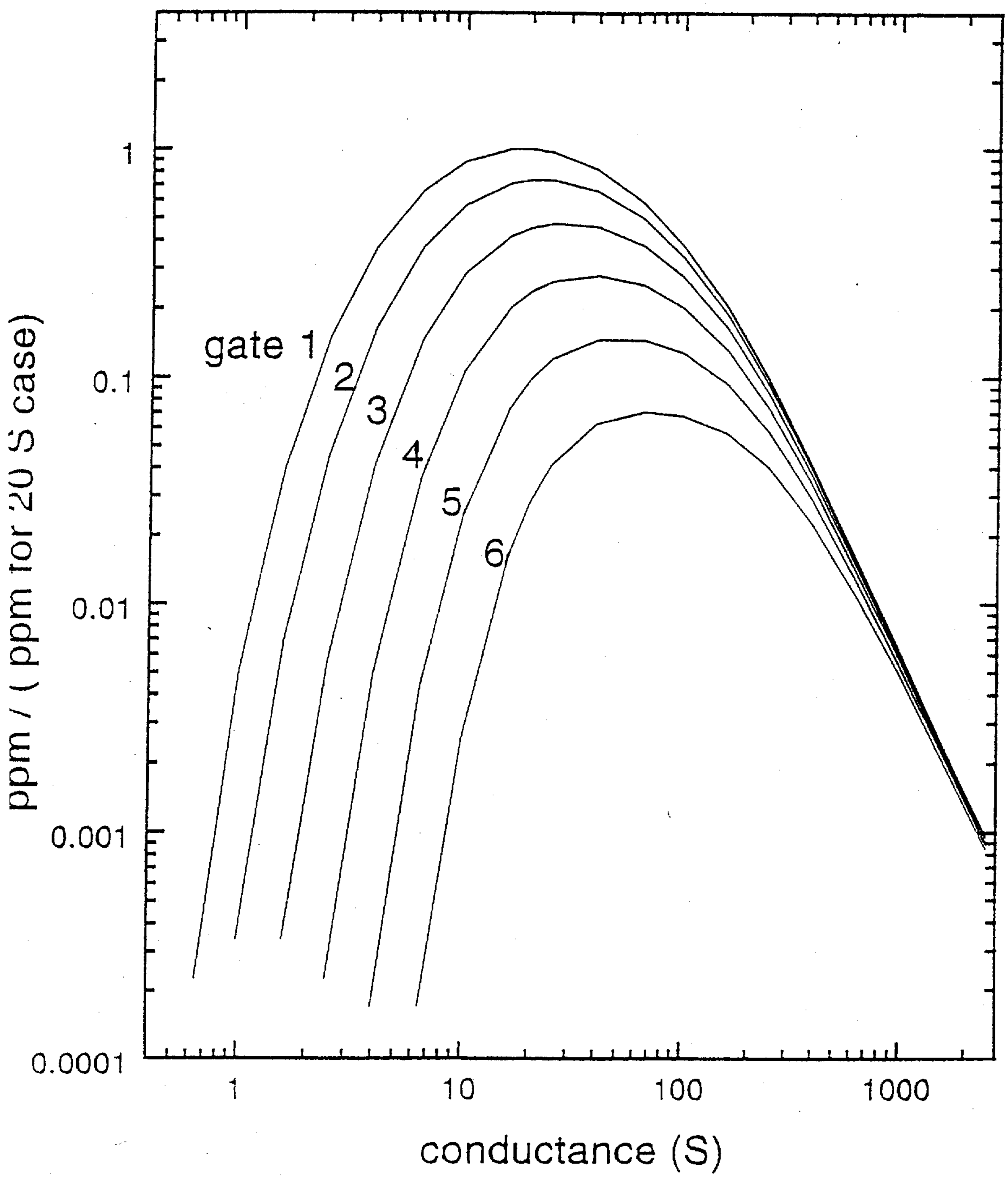
Nominal GEOTEM geometry



Transmitter waveform and receiver sampling (90 Hz)



Nomogram



ppm / (ppm for 20 S case)
1
0.1
0.01
0.001
0.0001
gate 1
2
3
4
5
6
1
10
100
1000
conductance (S)

Plate: depth =0; dip =0

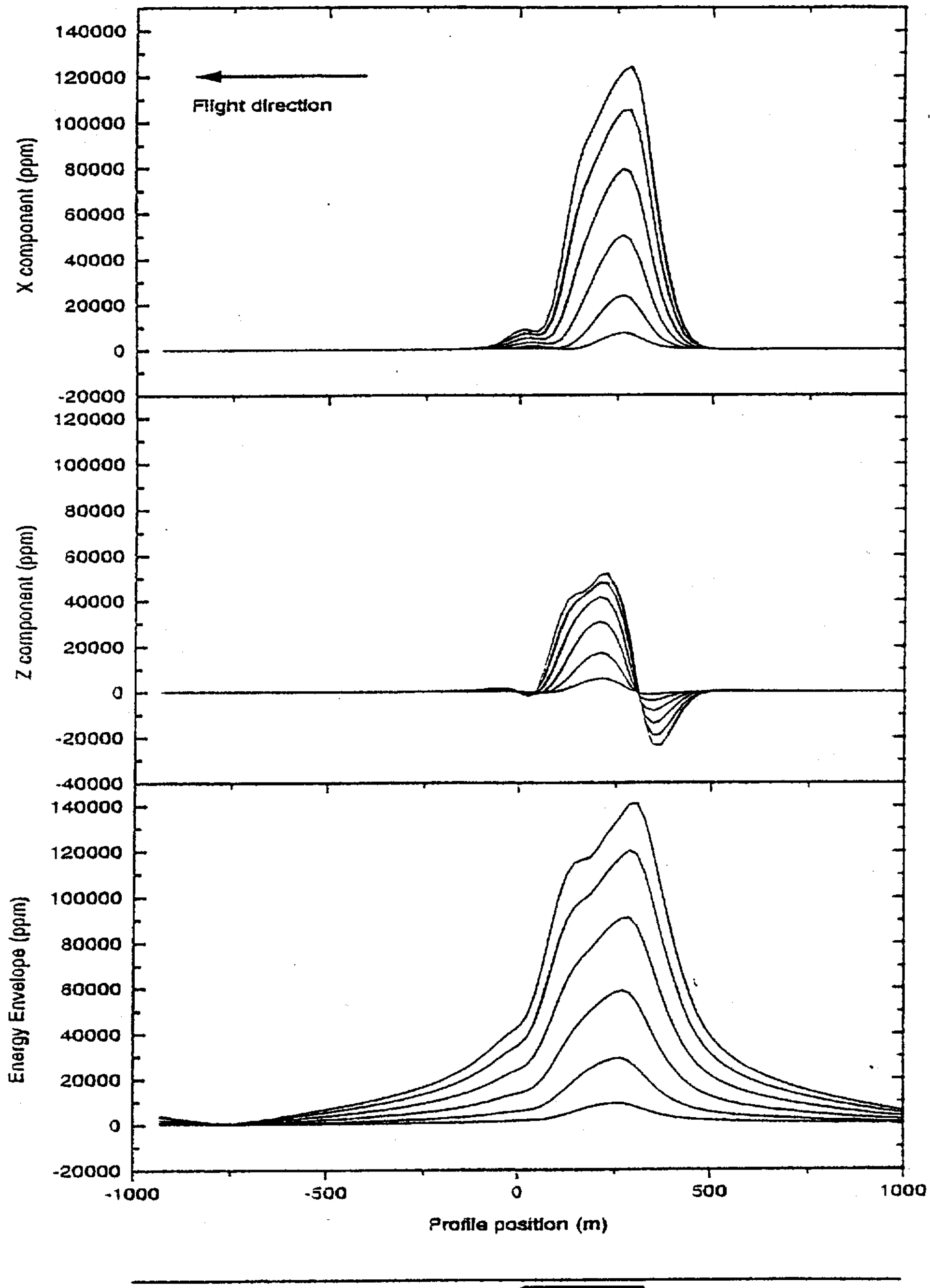


Plate: depth =0; dip =45

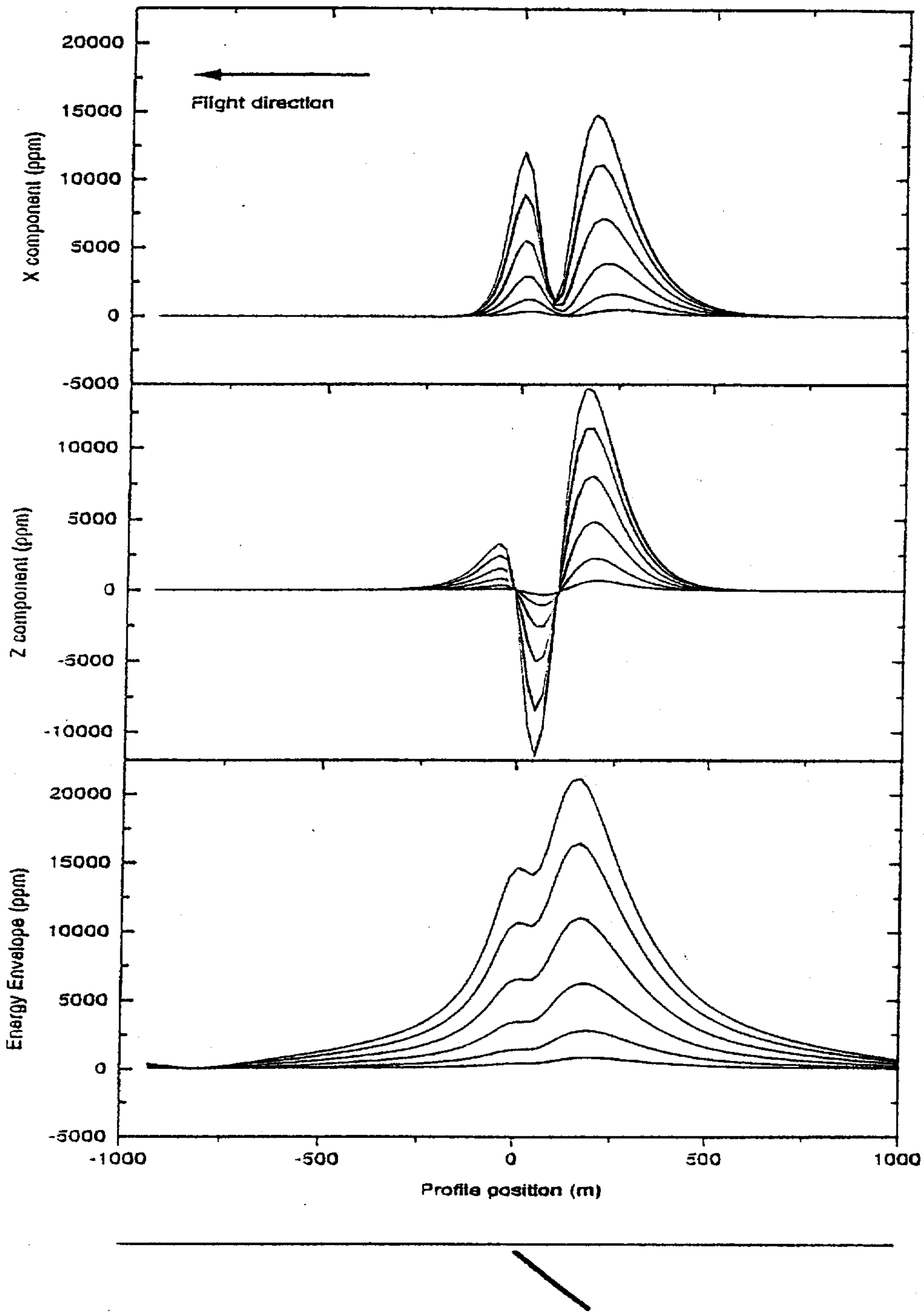


Plate: depth =0; dip =90

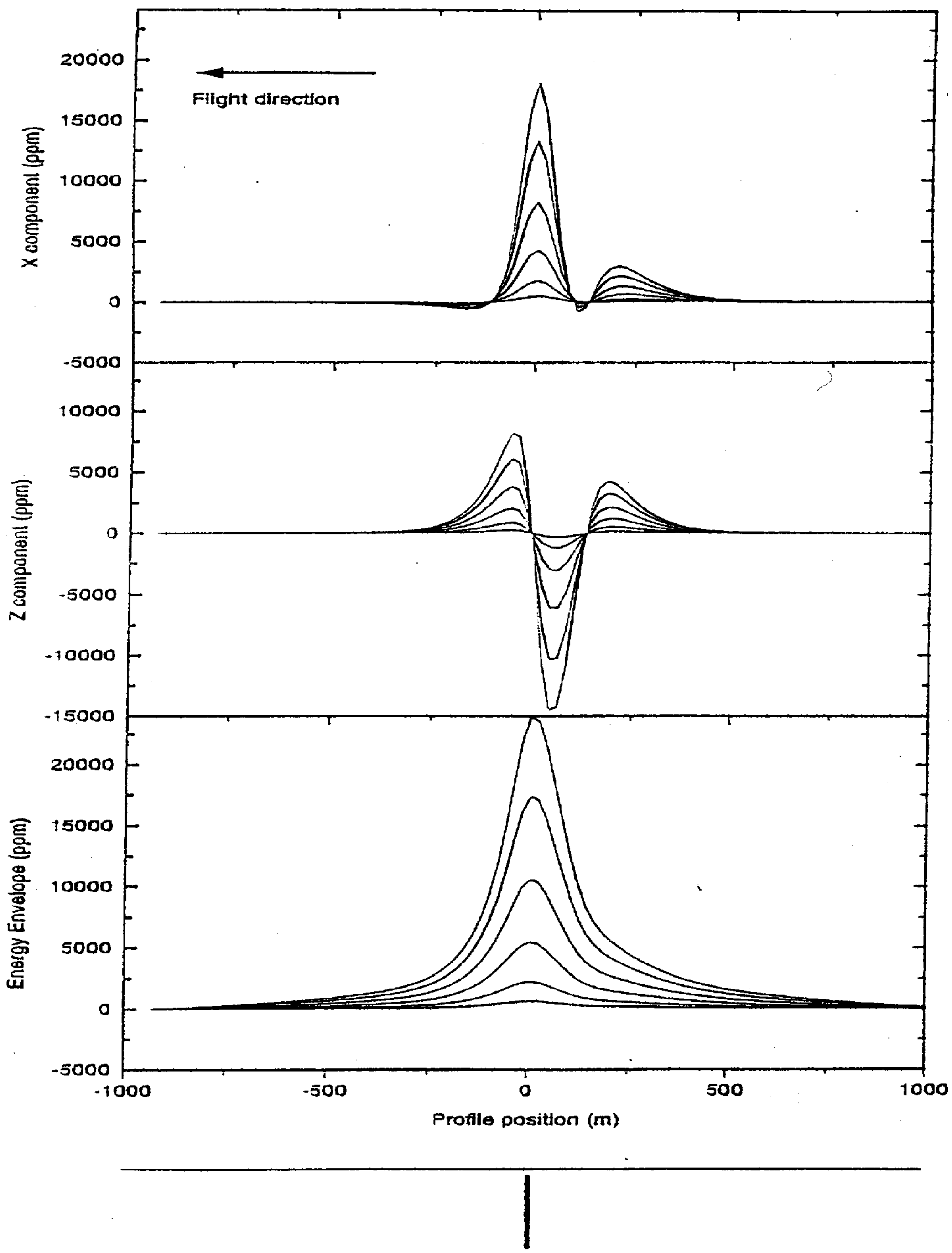


Plate: depth =0; dip =135

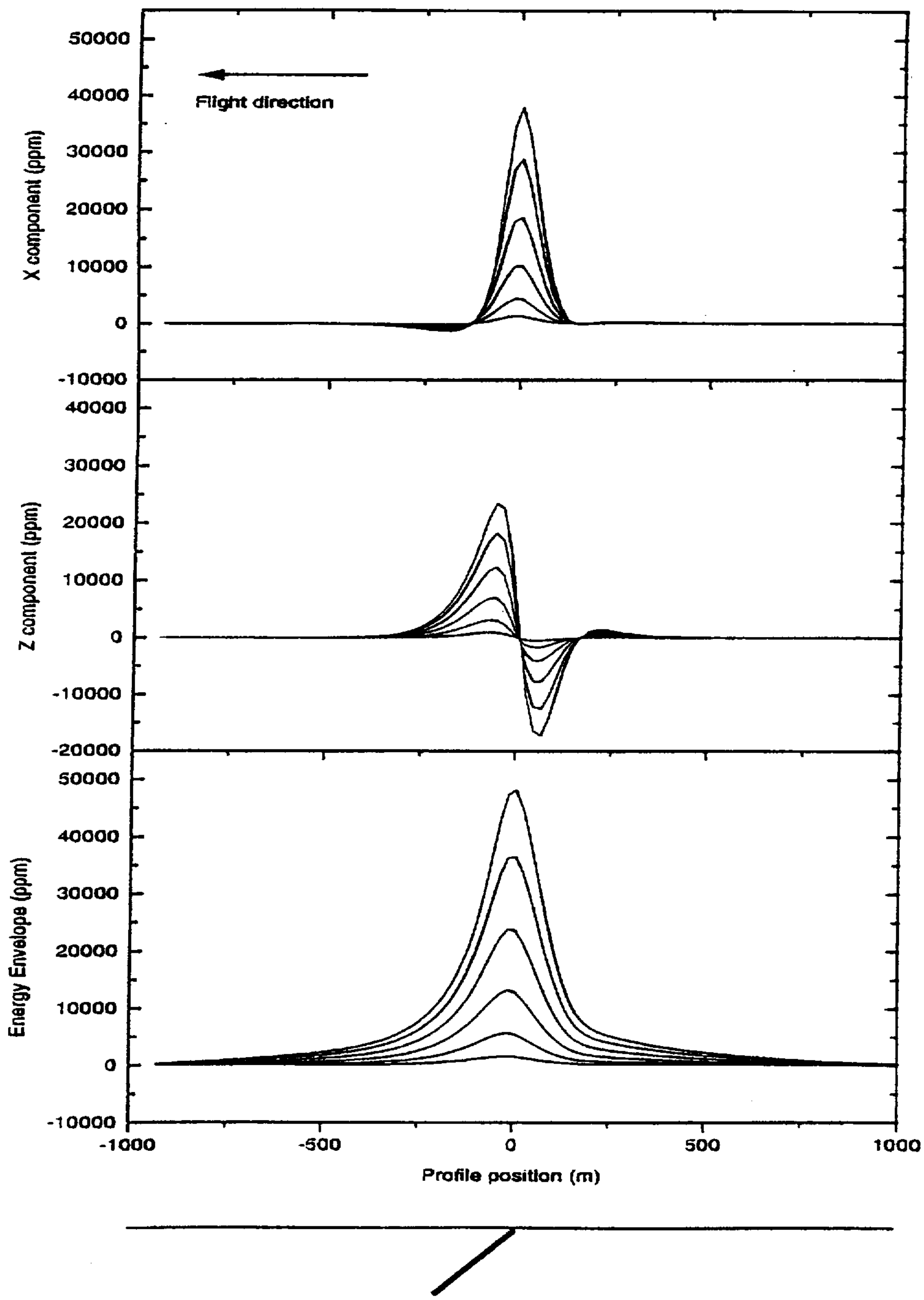


Plate: depth =150; dip =0

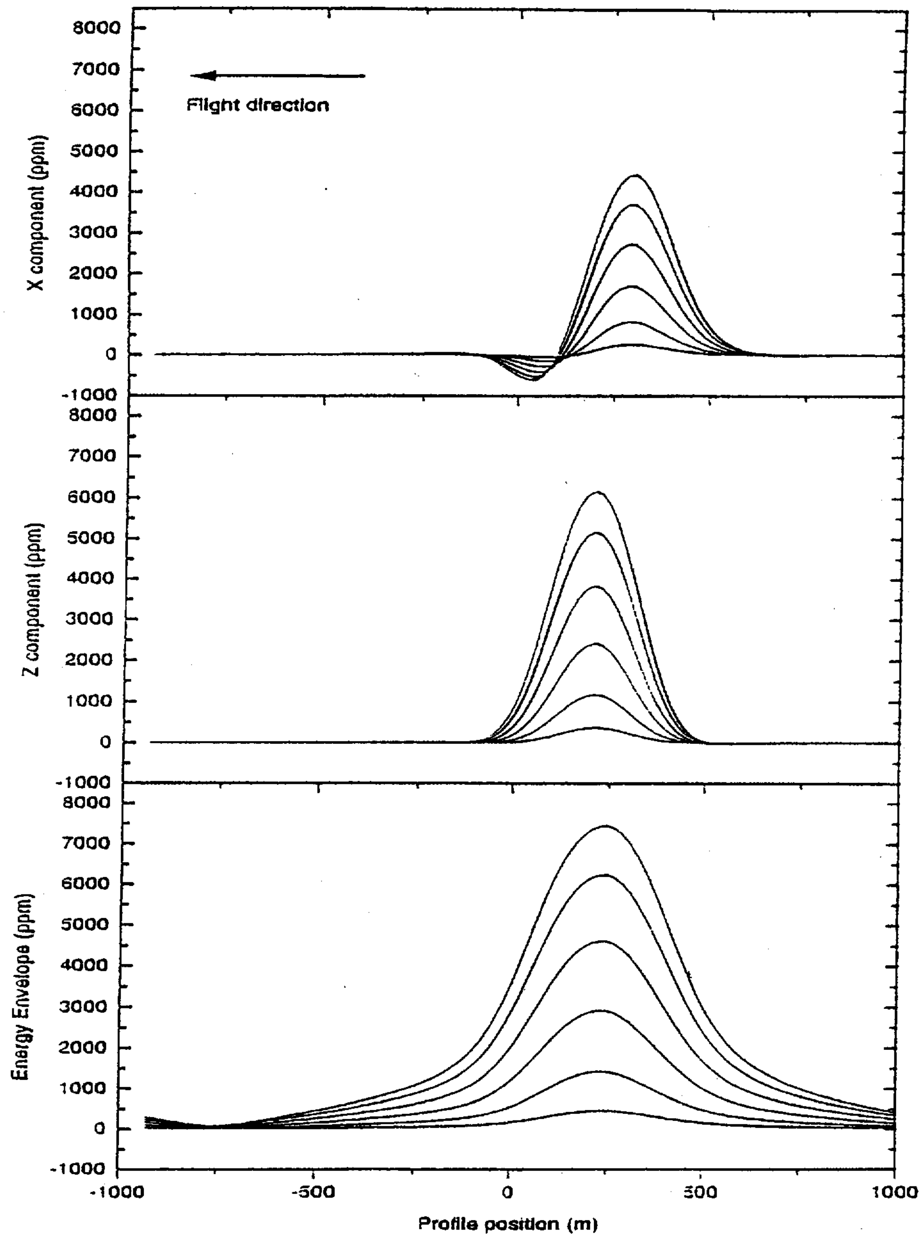
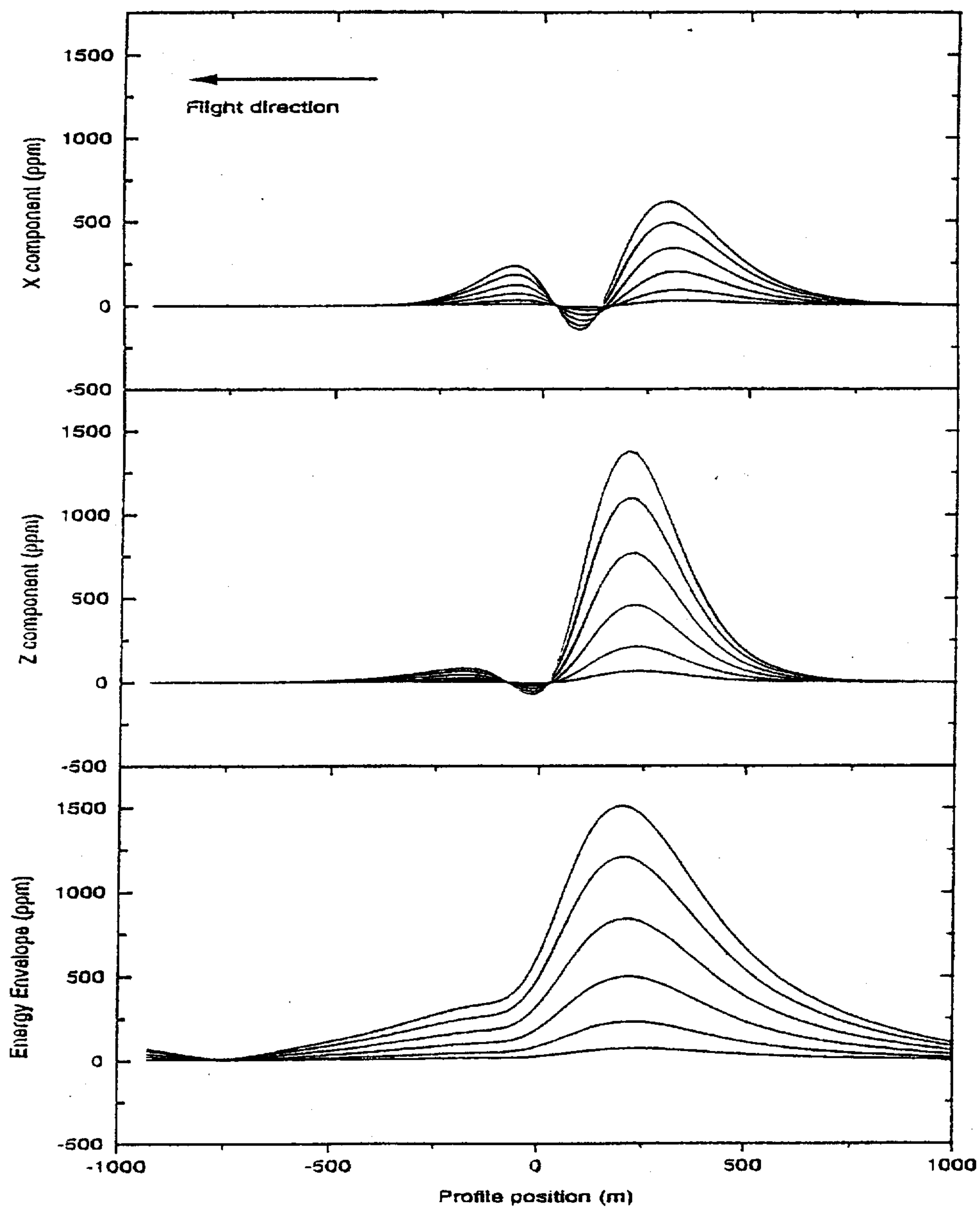


Plate: depth =150; dip =45



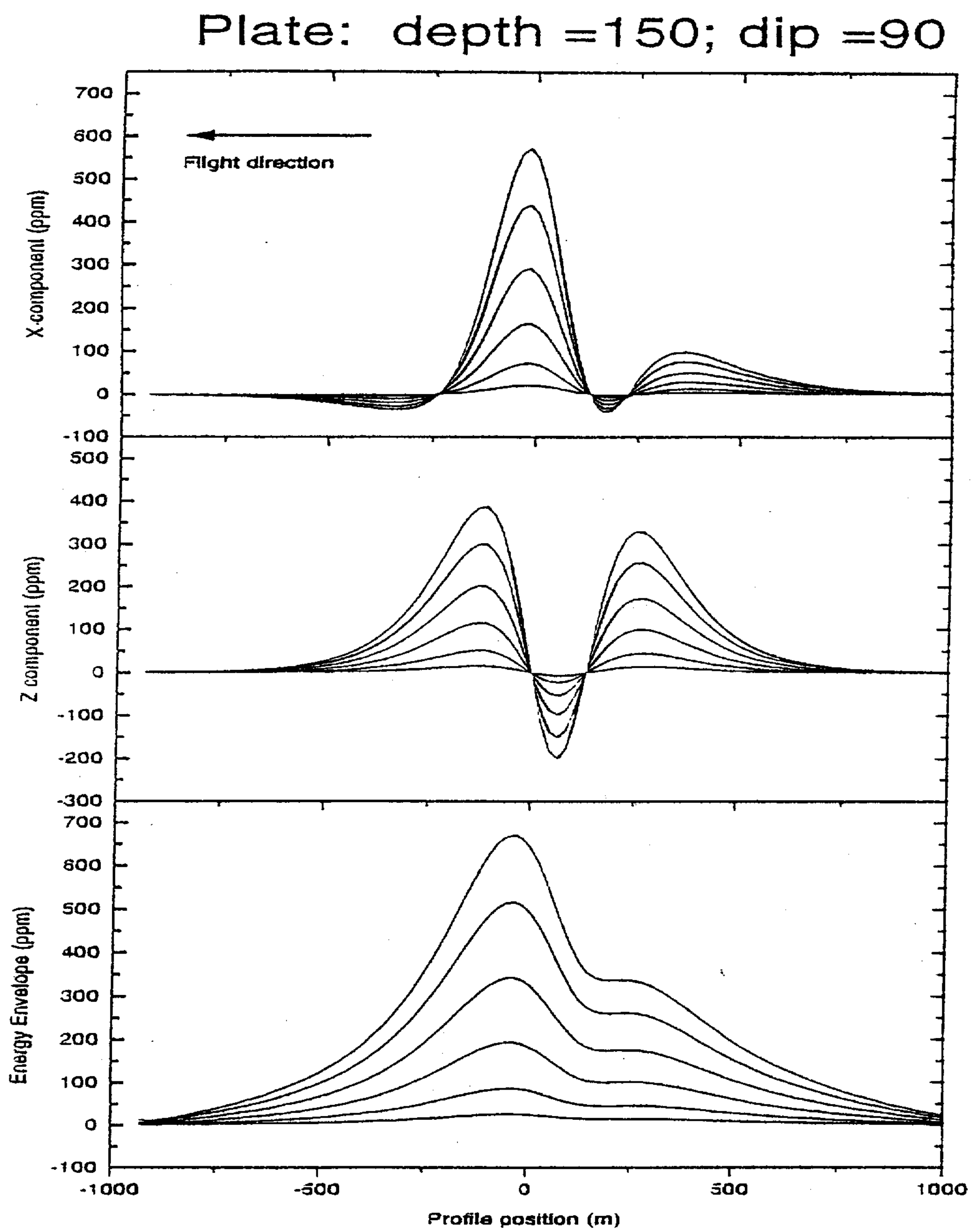


Plate: depth =150; dip =90
Flight direction
X-component (ppm)
Z component (ppm)
Energy Envelope (ppm)
Profile position (m)
-1000
-500
0
500
1000

Plate: depth =150; dip =135

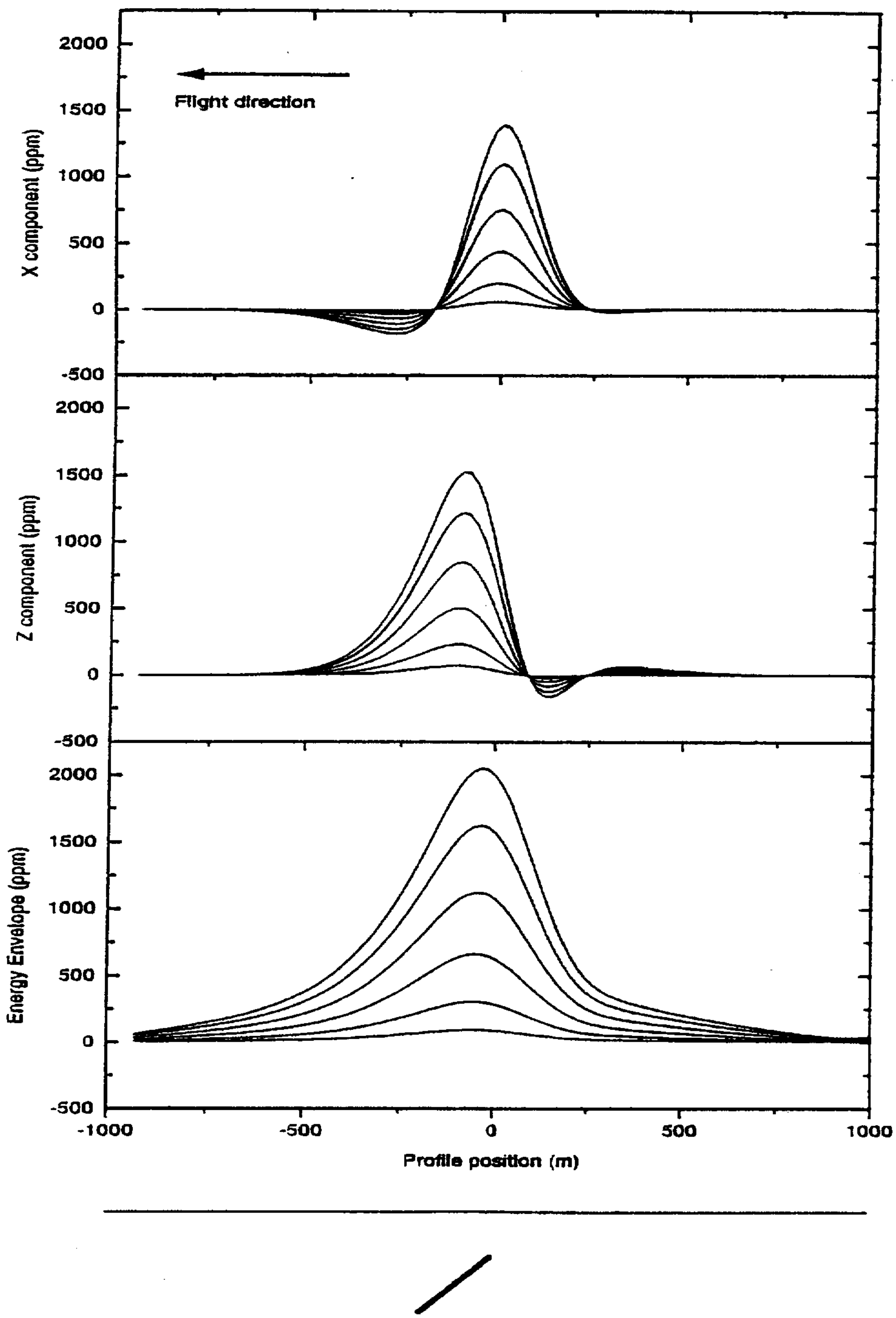
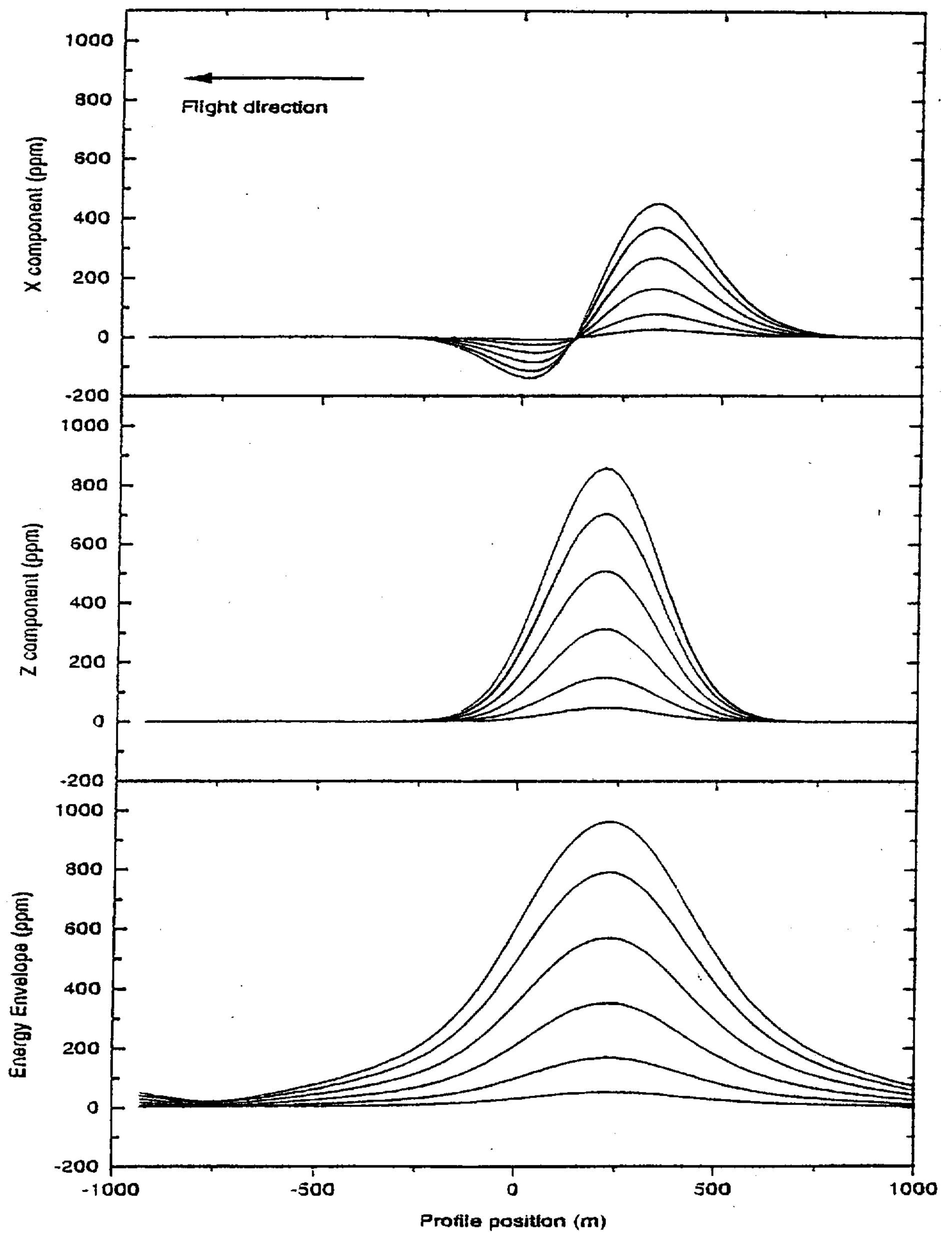


Plate: depth =300; dip =0



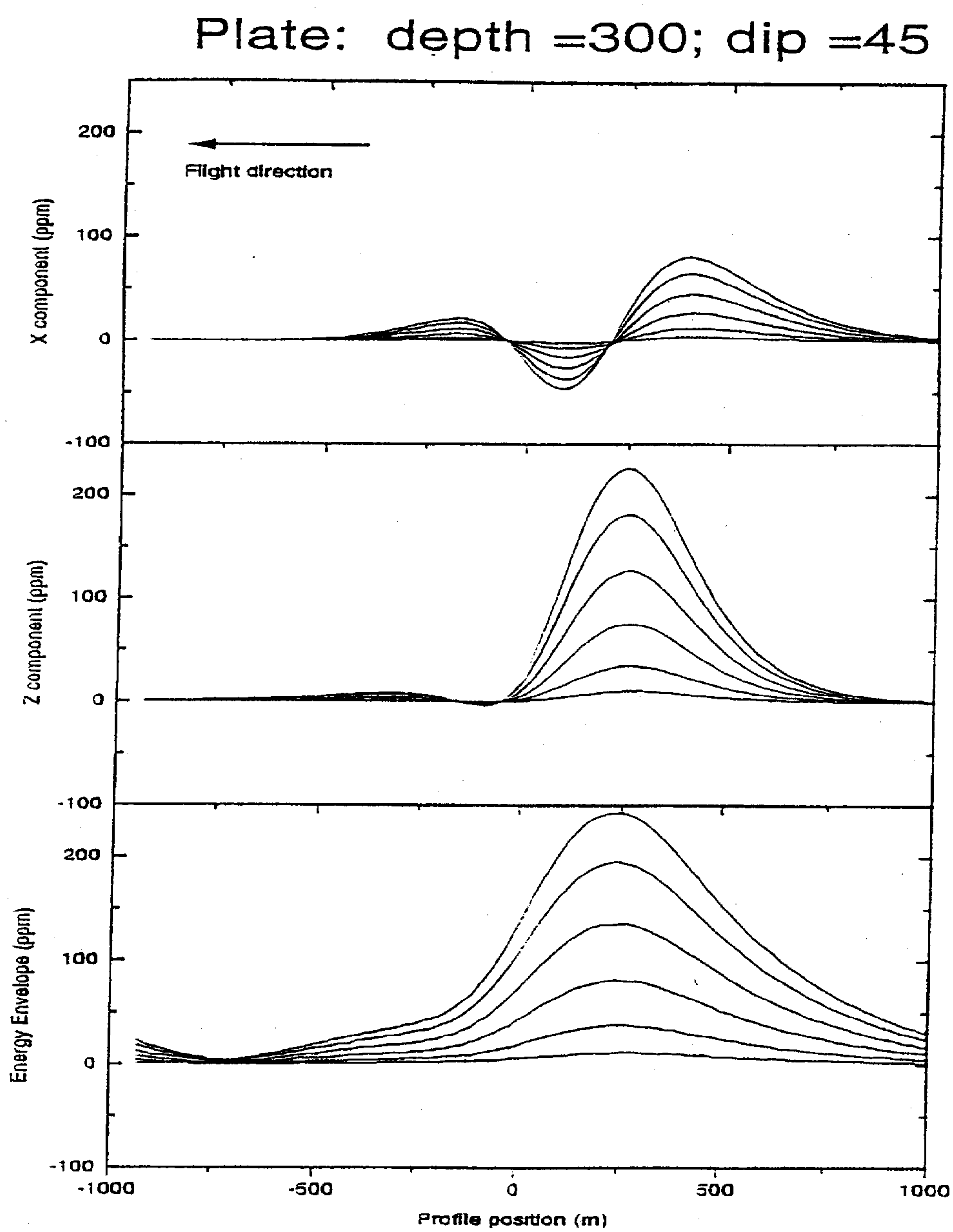


Plate: depth =300; dip =45
Flight direction
X component (ppm)
Z component (ppm)
Energy Envelope (ppm)
200
100
0
-100
-1000
-500
0
500
1000
Profile position (m)

Plate: depth =300; dip =90

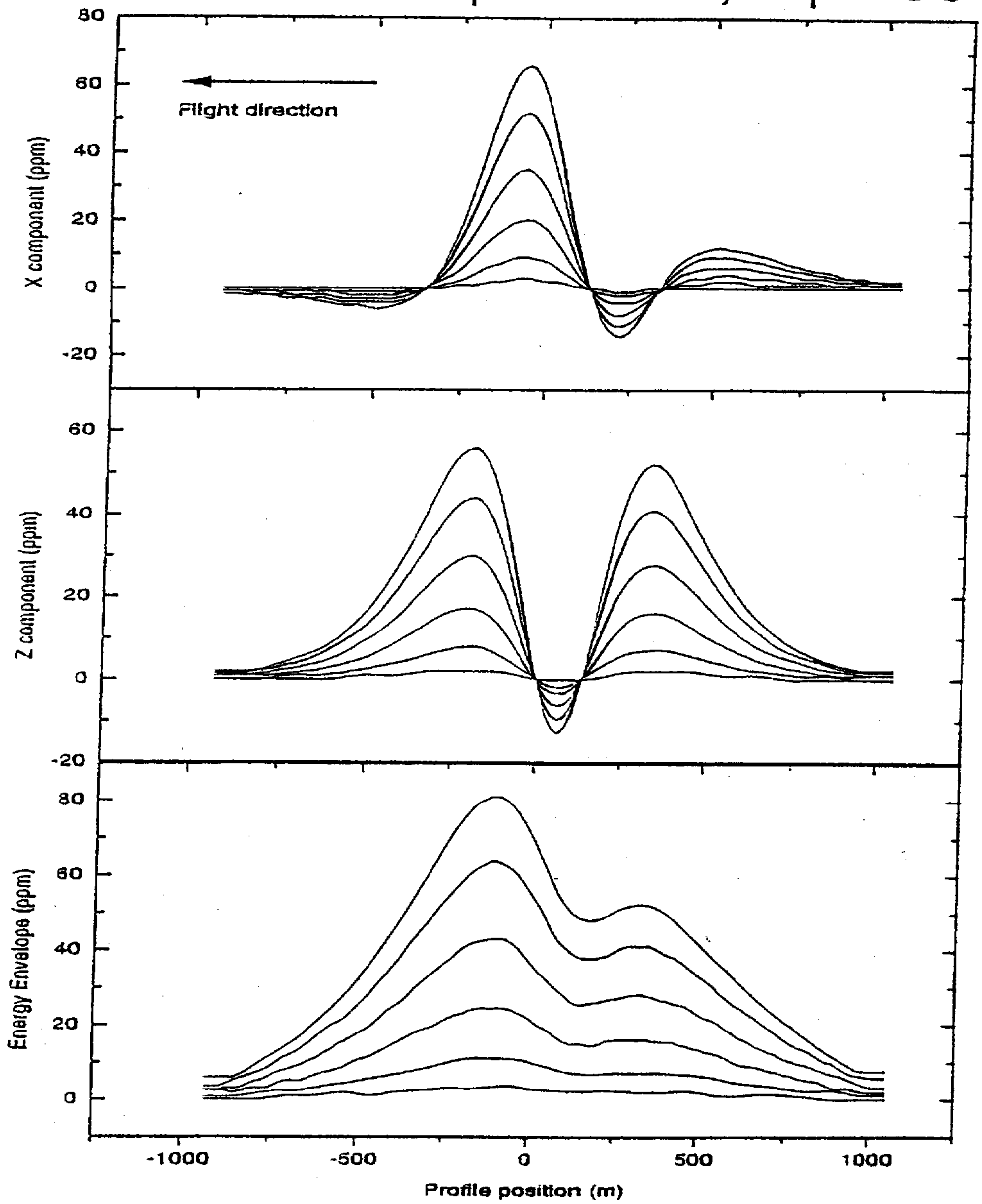
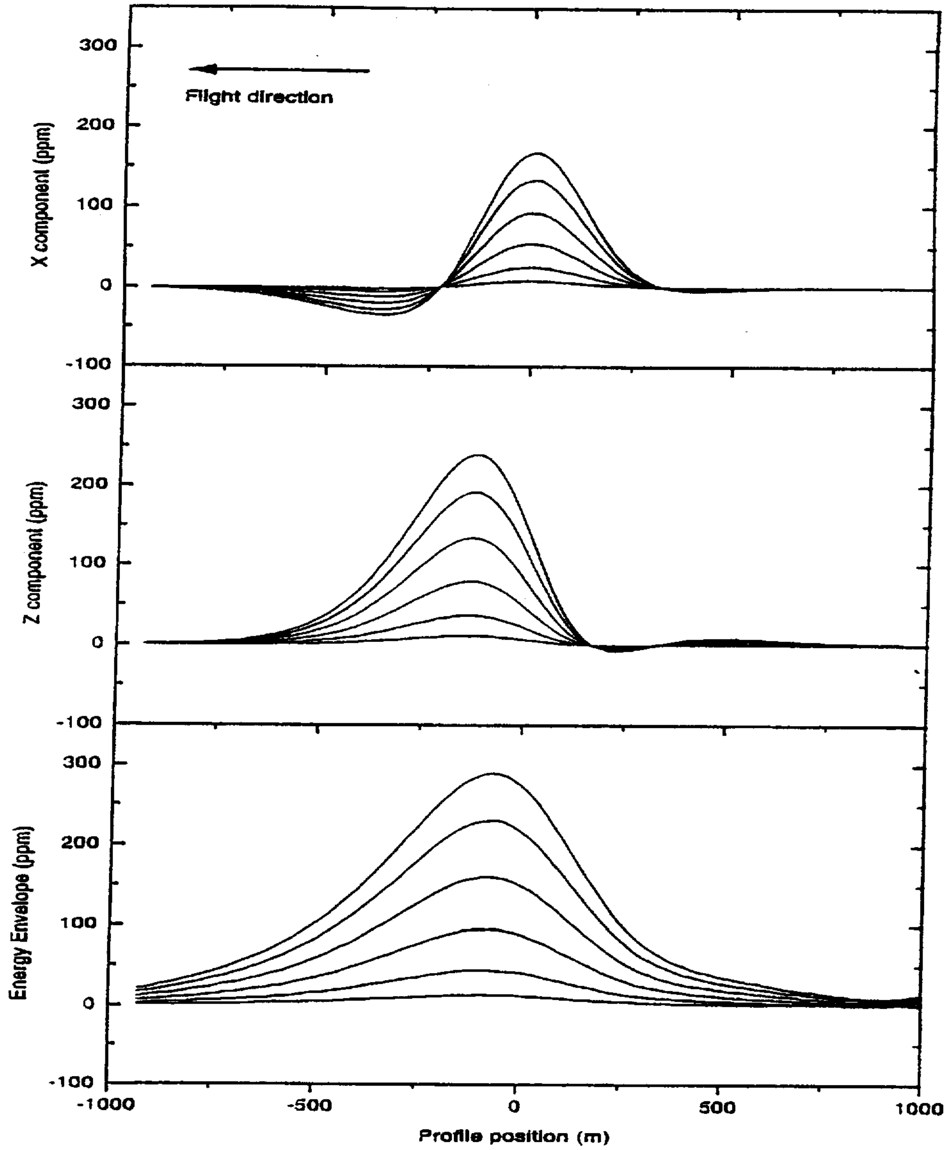


Plate: depth =300; dip =135



Appendix D

The Usefulness Of Multicomponent, Time-Domain Airborne Electromagnetic Measurement

GEOPHYSICS, VOL 61, NO. 1 (JANUARY-FEBRUARY 1996); P. 74-81, 17 FIGS.

The Usefulness Of Multicomponent, Time-Domain Airborne Electromagnetic Measurements

Richard S. Smith* and Pierre B. Keating ‡

ABSTRACT

Time-domain airborne electromagnetic (AEM) systems historically measure the inline horizontal (*x*) component. New versions of the electromagnetic systems are designed to collect two additional components [the vertical (*z*) and the lateral horizontal (*y*) component] to provide greater diagnostic information.

In areas where the geology is near horizontal, the *z*-component response provides greater signal to noise, particularly at late delay times. This allows the conductivity to be determined to greater depth. In a layered environment, the symmetry implies that the *y* component will be zero; hence a non-zero *y* component will indicate a lateral inhomogeneity.

Three components can be combined to give the "energy envelope" of the response. Over a vertical plate, the response profile of this envelope has a single positive peak and no side lobes. The shape of the energy envelope is dependent on the flight direction, but less so than the *x* component.

In the interpretation of discrete conductors, the *z* component data can be used to ascertain the dip and depth to the conductor using simple rules of thumb. When the profile line is perpendicular to the strike direction and over the center of the conductor, the *y* component will be zero; otherwise it appears to be a combination of the *x* and *z* components. The extent of contamination by the *x* and *z* components can be used to ascertain the strike direction and the lateral offset of the target respectively.

Having the *z* and *y* component data increases the total response when the profile line has not traversed the target. This increases the possibility of detecting a target located between adjacent flight lines or beyond a survey boundary.

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*Geoterrex, 2060 Walkley Rd., Ottawa, Ontario, K1G 3P5, Canada.

‡Geological Survey of Canada, 1 Observatory Crescent, Ottawa, Ontario K1A 0Y3, Canada.

INTRODUCTION

The acquisition of multiple-component electromagnetic (EM) data is becoming more commonplace. In some techniques, such as those which use the plane-wave assumption (MT, CSAMT and VLF) more than one component has been acquired as a matter of routine for some time (see reviews by Vozoff, 1990, 1991; Zonge and Hughes, 1991; McNeill and Labson, 1991). Historically, commercially available controlled-waveform finite-source systems generally measure only one component. The only systems designed to acquire multiple component data are generally experimental [e.g., those described in the appendixes of Spies and Frischknecht (1991) or proprietary (the EMP system of Newmont Exploration).

Slingram EM systems, comprising a moving dipolar transmitter and a moving receiver, generally only measure one component of the response. Although the MaxMin system was designed with a capability to measure a second (minimum coupled) component, this capability is not used extensively in practice. The only systems that use two receiver coils in practice are those that measure the wavetilt or polarization ellipse (Frischknecht et al., 1991).

Historically, time-domain EM systems have been capable of collecting multicomponent data in a sequential manner by reorienting the sensor for each component direction. The usefulness of additional components is discussed by Macnae (1984) for the case of the UTEM system. Macnae concluded that, as extra time was required to acquire the additional components, this time was better spent collecting more densely spaced vertical-component data. The vertical-component, which is less subject to sferic noise, could subsequently be converted to the horizontal components using the Hilbert transform operators.

Recent instrument developments have been towards multicomponent systems. For example, commercially available ground-EM systems such as the Geonics PROTEM, the Zonge GDP-32 and the SIROTEM have been expanded to include multiple input channels that allow three (or more) components to be acquired simultaneously. There is also a version of the UTEM system currently being developed at Lamontagne Geophysics Ltd. These multichannel receivers require complimentary multicomponent sensors -- for ground-based systems these have been developed by Geonics Ltd and Zonge Engineering and Research Organization. The interpretation of fixed-source, multi-component ground-EM data is described in Barnett (1984) and Macnae (1984).

In the past, multi-component borehole measurements have been hindered by the lack of availability of multi-component sensor probes. Following the development of two prototype probes (Lee, 1986; Hodges et al., 1991), multi-component sensors are now available from Crone Geophysics and Exploration Ltd and Geonics. Three component UTEM and SIROTEM borehole sensors are also in development at Lamontagne and Monash University (Cull, 1993), respectively. Hodges et al. (1991) present an excellent discussion of techniques that can be used to interpret three-component borehole data.

Airborne systems such as frequency-domain helicopter electromagnetic methods acquire data using multiple sensors. However, each receiver has a corresponding transmitter that either operates at a different frequency or has a different coil orientation (Palacky and West, 1991). Hence, these systems are essentially multiple single-component systems. The exception to this rule is the now superseded Dighem III system (Fraser, 1972) which used one transmitter and three receivers.

The only multicomponent airborne EM (AEM) system currently in operation is the SPECTREM system (Macnae, et al., 1991). This is a proprietary (owned and operated by Anglo-American Corporation of South Africa Ltd.), based on the PROSPECT system (Annan, 1986). The Prospect system was originally designed to acquire the x, y and z components, but SPECTREM is apparently only collecting two components (x and z) at the time of writing. Other multi-component systems currently in development are:

i) the SALTMAP system,
ii) a helicopter time-domain system (Hogg, 1986), and
a new version of the GEOTEM® system (GEOTEM is a registered trademark of Geoterrex).

Apart from a few type curves in Hogg (1986), there is little literature available which describes how to interpret data from these systems.

This paper is intended to give an insight into the types of responses expected with the new multi-component AEM systems, and the information that can be extracted from the data. The insight could be of some assistance in interpreting data from multicomponent moving-source ground EM systems (should this type of data be acquired).

The use of multi-component data will be discussed for a number of different applications. For illustration purposes, this paper will use the transmitter-receiver geometry of the GEOTEM system (Figure 1), which is comparable to the other fixed-wing geometries (SPECTREM and SALTMAP). The GEOTEM system is a digital transient EM system utilizing a bipolar half-sinusoidal current waveform [more details are in Annan and Lockwood (1991)]. The sign convention used in this paper is shown in Figure 1, with the *y* component being into the page. In a practical EM system, the receiver coils will rotate in flight. We will assume that the three components of the measured primary field and an assumed bird position have been used to correct for any rotation of the coil.

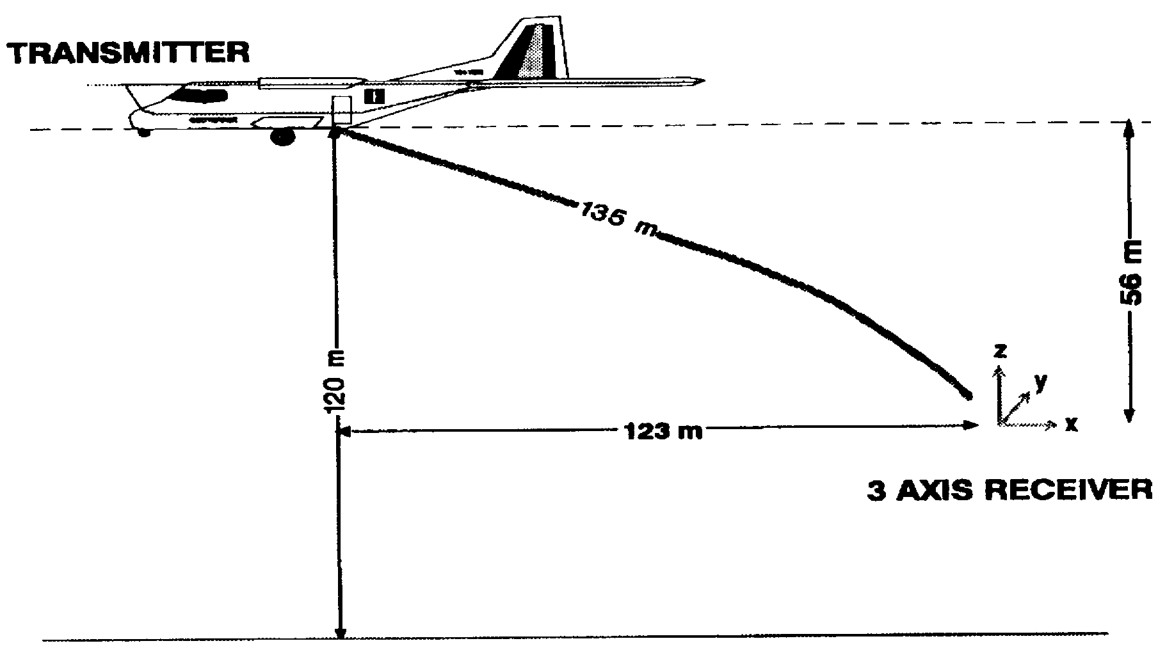

Figure 1: The geometric configuration of the GEOTEM system. The system comprises a transmitter on the aircraft and a receiver sensor in a "bird" towed behind the aircraft. The z direction is positive up, x is positive behind the aircraft, and y is into the page (forming a right-hand coordinate system).

SOUNDING IN LAYERED ENVIRONMENTS

In a layered environment, the induced current flow is horizontal (Morrison et al., 1969) so the z component of the secondary response (V_z) is much larger than the x component (V_x), particularly in resistive ground and/or at late delay times. At the same time, the sferic noise in the z direction is 5 to 10 times less than in the horizontal directions(Macnae, 1984; McCracken et al., 1986), so V_z has a greater signal-to-noise ratio. Figure 2 shows theoretical curves over two different, but similar, layered earth models. One model is a half-space of 500 Ω·m and the other is a 350 m thick layer of 500 Ω·m overlying a highly resistive basement. In this plot the data have been normalized by the total primary field. The z component (V_z) is 6 to 10 times larger than V_x, and both curves are above the noise level, at least for part of the measured transient. On this plot, a noise level of 30 ppm has been assumed, which would be a typical noise level for both components when the sferic activity is low. To distinguish between the response of the half-space and thick layer, the difference between the response of one model and the response of the other model must be greater than the noise level. Figure 3 shows this difference for both components. Only the V_z difference is above the noise level. Hence for the case shown, V_z is more useful than V_x for determining whether there is a resistive layer at 350 m depth. Because V_z is generally larger in a layered environment, the vertical component will generally be better at resolving the conductivity at depth.

In the above discussion, we have assumed that corrections have been made for the coil rotation. An alternative approach is to calculate and model the magnitude of the total field, as this quantity is independent of the receiver orientation. Macnae et al. (1991) used this strategy when calculating the conductivity depth sections for SPECTREM data.

The symmetry of the secondary field of a layered environment is such that the y component response (V_y) will always be zero. In fact, the V_y component will be zero whenever the conductivity structure on both sides of the aircraft is the same. A non-zero V_y is therefore useful in identifying off-line lateral inhomogeneities in the ground.

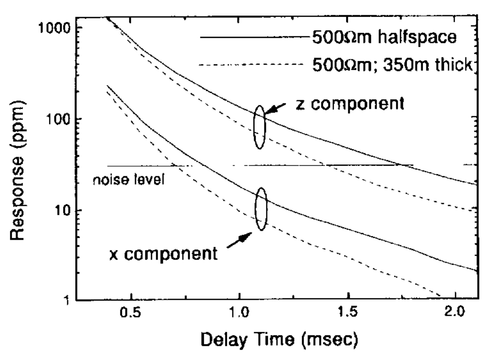

Figure 2: The response for a 500 Ω·m half-space (solid line) and a 500 Ω·m layer of thickness 350 m overlying a resistive half-space (dashed line). The z-component responses are the two curves with the larger amplitudes and the two x-component response curves are 6 to 10 times smaller than the corresponding z component. A noise level of 30 ppm is considered to be typical of both components in the absence of strong sferics.

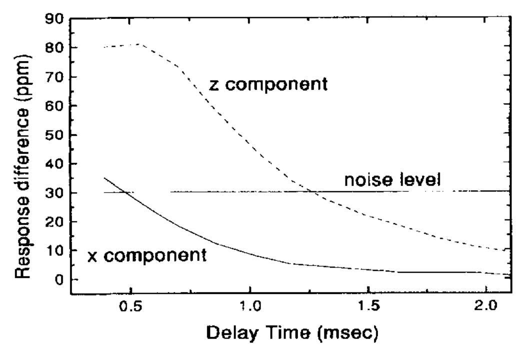

Figure 3: The difference in the response of each component for the half-space and thick layer models of Figure 2. Only the z component difference is above the noise level for a significant portion of the transient. Therefore, this is the only component capable of distinguishing between the responses of the two models.

DISCRETE CONDUCTORS

In our discrete conductor study, models have been calculated using a simple plate in free-space model (Dyck and West, 1984) to provide some insight into the geometry of the induced field. The extension to more complex models, such as those incorporating current gathering, will not be considered in this paper.

Historically, airborne transient electromagnetic (TEM) data have been used for conductor detection. The old INPUT system was designed to measure V_x because this component gave a large response when the receiver passed over the top of a vertical conductor. The bottom part of Figure 4 shows the response over a vertical conductor, which has been plotted at the receiver position. The V_x profile (smaller of the two solid lines) has a large peak corresponding with the conductor position. Note that there is also a peak at 200 m, just before the transmitter passes over the conductor, and a trailing edge negative to the left of the conductor. The *z* component (dashed line) has two peaks and a large negative trough just before the conductor. Because of the symmetry, the V_y response (dotted line) is zero.

All the peaks, troughs and negatives make the response of a single conductor complicated to display and hence interpret. The display can be simplified by plotting the "energy envelope" (EE) of the response. This quantity is defined as follows:

$$EE = \sqrt{V_x^2 + \overline{V}_x^2 + V_y^2 + \overline{V}_y^2 + V_z^2 + \overline{V}_z^2},$$

where $\overline{}$ denotes the Hilbert transform of the quantity. The energy envelope plotted on Figure 4 (the larger of the two solid curves) is almost symmetric, and would be a good quantity to present in plan form (as contours or as an image). For flat-lying conductors, the energy envelope has a maximum at the leading edge (just after the aircraft flies onto the conductor).

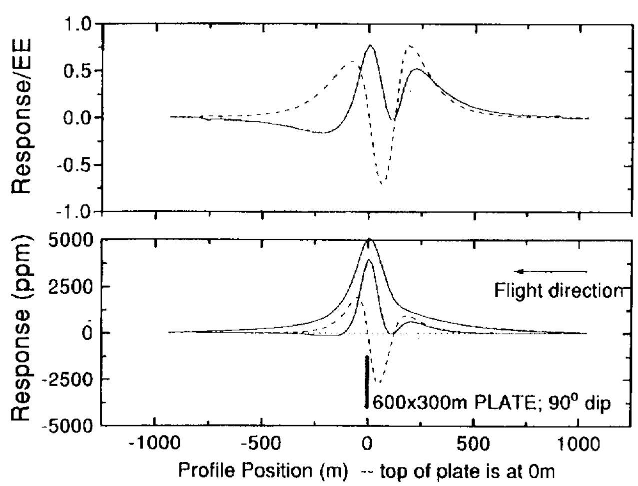

Figure 4: (Bottom) The response of a 600 by 300 m plate 120 m below an aircraft flying from right to left. The plotting point for the response is below the receiver. The x-component response is the smaller amplitude solid line, the z-component is the dashed line, and the y-component response is the dotted line. The larger amplitude solid line is the "energy envelope" of all three components. (Top) The z- and x-components normalized by the energy envelope. These and all subsequent curves are for a delay time of 0.4 ms after the transmitter current is turned off.

What little asymmetry remains in the energy envelope is a good indication of the coupling of the AEM system to the conductor. If the response profile for each component is normalized by the energy envelope, then the effect of system coupling will be removed (at least partially) and the profiles will appear more symmetric. For example, the top part of Figure 4 shows the Vx and Vz normalized by the energy envelope at each point. The size of the two x peaks and the two z peaks are now roughly comparable.

Dip determination

The response of a plate with a dip of 120° is shown on Figure 5. For the V_x/EE and V_z/EE profiles, the peak on the down dip side is larger. For shallow dips, it becomes difficult to identify both V_x/EE peaks, but the two positive V_z/EE peaks remain discernable. Plotting the ratio of the magnitudes of these two V_z/EE peaks, as has been done with solid squares on Figure 6, shows that the ratio is very close to the tangent of the dip divided by 2. Hence, calculating the ratio of the peak amplitudes (R) will yield the dip angle θ using the following formula:

$$\theta = 2\tan^{-1}(R).$$

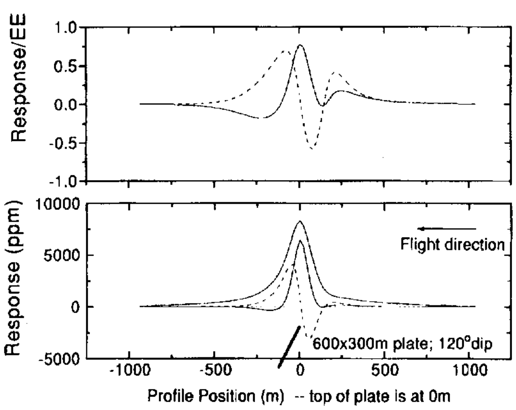

FIG. 5. (Bottom) same as Figure 4, except the plate is now dipping at 120°. On the top graph note that the down-dip (left) peak on the normalized z-component response is larger that the right peak (cf. Figure 4).

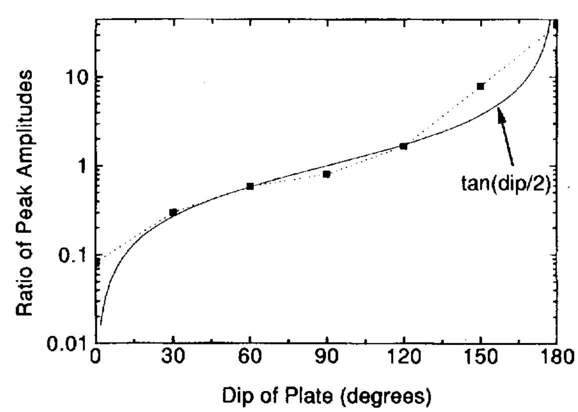

FIG. 6. The ratio of the peak amplitudes of the normalized z-component response (left/right) plotted with solid squares. The ratio plots very close to the tangent of half the dip angle θ of the plate.

Depth Determination

As the depth of the body increases, there is a corresponding increase in the distance between the two positive peaks in the V_z/EE profile. As an example of this, Figure 7 shows the case of a plate 150 m deeper than the plate of Figure 4. The peaks are now 450 m apart, as compared with 275 m on Figure 4. A plot of the peak-to-peak distances for a range of depths is shown on Figure 8 for plates with 60, 90 and 120° dips. Because the points follow a straight line, it can be concluded that for near vertical bodies (60° to 120° dips), the depth to the top of the body d can be determined from the measured peak-to-peak distances using the linear relationship depicted in Figure 8. The expected error would be about 25 m. Such an error is tolerable in airborne EM interpretation. More traditional methods for determining d analyze the rate of decay of the measured response (Palacky and West, 1973). Our method requires only the V_z/EE response profile at a single delay time. Analyzing this response profile for each delay time allows d to be determined as a function of delay time, and hence any migration of the current system in the conductor could be tracked.

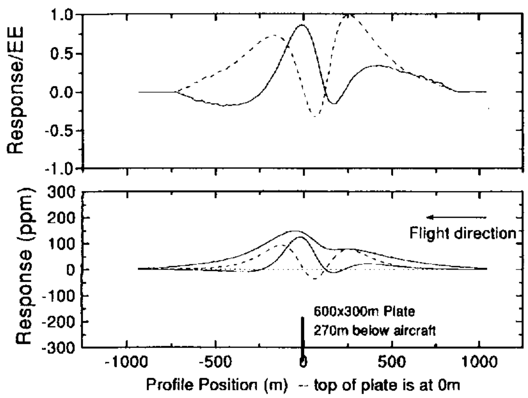

FIG. 7. The same as Figure 4, except the plate is now 270 m below the aircraft. Note that the distance between the z-component peaks is now much greater.

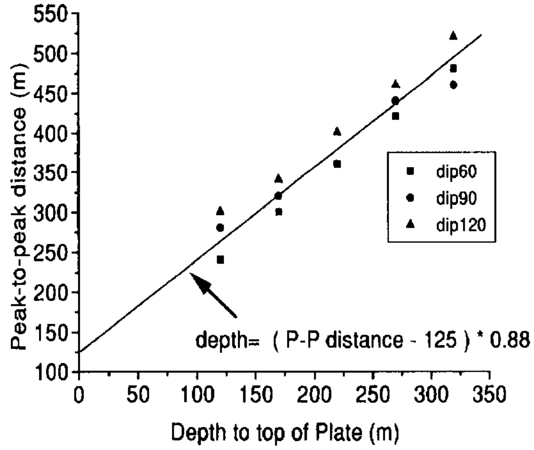

FIG. 8. The peak-to-peak distance as a function of plate depth for three different dip angles θ. A variation in dip of ±30° does not result in a large change in the peak-to-peak distance.

Strike and offset determination

The response shown in Figure 4 varies in cases when the plate has a strike different from 90° or the flight path is offset from the center of the plate.

Figure 9 shows the response for a plate with zero offset and Figure 10 shows the plate when it is offset by 150 m from the profile line. The calculated voltages V_z and V_x are little changed from the no offset case, but the V_y response, is no longer zero. In fact, the shape of the V_y curve appears to be the mirror image of the V_z curve.

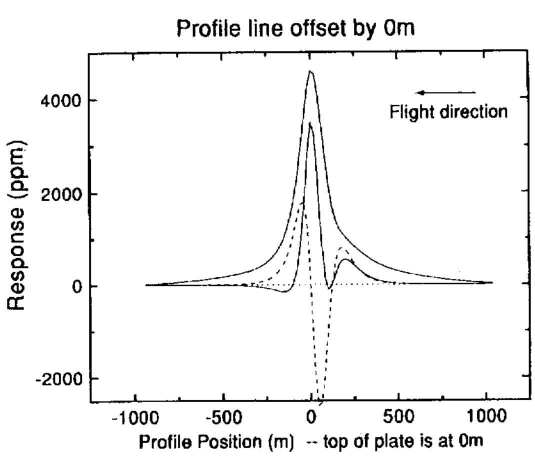

FIG. 9. The response of a 300 by 300 m plate traversed by a profile line crossing the center of the plate in a direction perpendicular to the strike of the plate (the strike angle ζ of the plate with respect to the profile line is 90°).

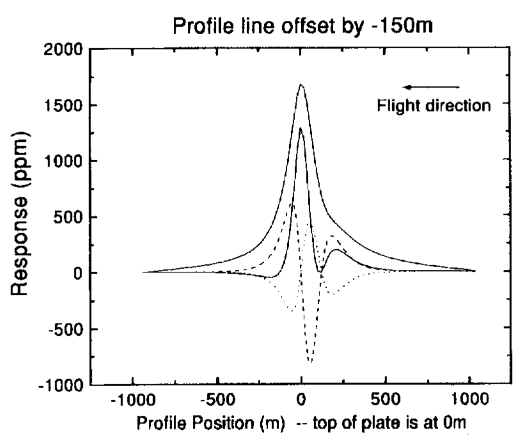

FIG. 10. Same as Figure 9, except the profile line has been offset from the center of the plate by −150 m in the y direction (equivalent to a +150 m displacement of the plate).

In the case when the plate strikes at 45°, the *y* component is similar in shape but opposite in sign to the *x*-component response (Figure 11).

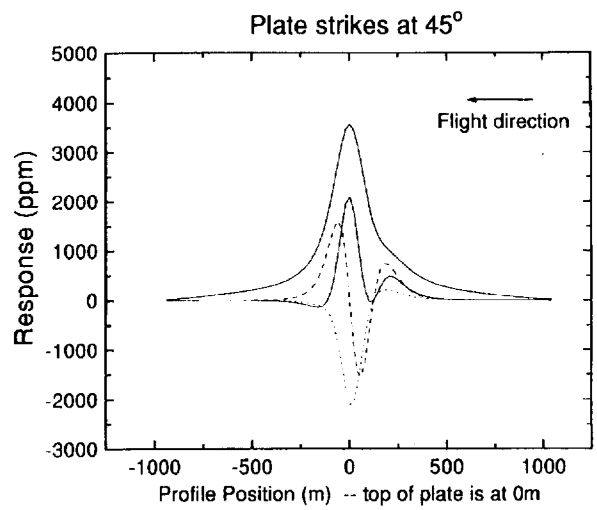

FIG. 11. Same as Figure 9, except the profile line traverses the plate such that the strike angle ζ of the plate, with respect to the profile line, is 45°.

These similarities can be better understood by looking at schematic diagrams of the secondary field from the plate. Figure 12 shows a plate and the field in section. For zero offset, the field is vertical (*z* only). As the offset increases, the aircraft and receiver moves to the right and the measured field rotates into the *y*-component.

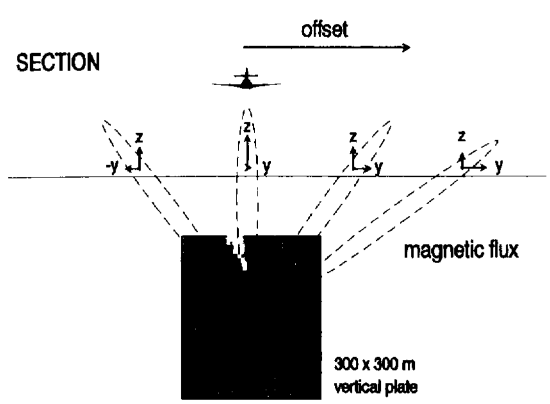

FIG. 12. A schematic diagram of the plate and the magnetic flux of the secondary field (section view). For increasing offset of the aircraft and receiver from the center of the plate, the magnetic field at the receiver rotates from the *z* to the *y* component.

The secondary field is depicted in plan view in Figure 13. Variable strike is simulated by leaving the plate stationary and changing the flight direction. When the strike of the plate is different from 90°, the effective rotation of the EM system means that the secondary field, which was previously measured purely in the *x* direction, is now also measured in the *y* direction.

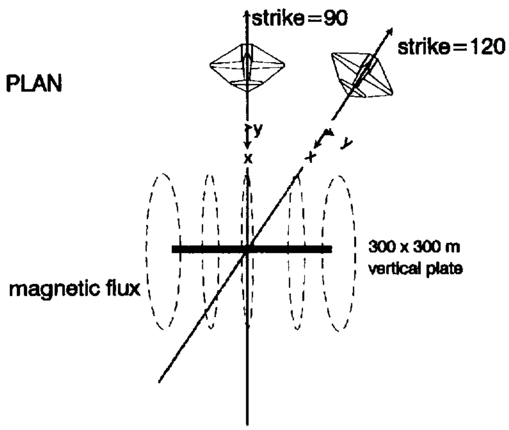

FIG. 13. A schematic diagram of the plate and the magnetic flux of the secondary field (plan view). Here varying strike is depicted by an equivalent variation of the flight direction. As the flight direction rotates from a strike angle of 90°, the receiver rotates so as to measure a greater response in the y direction.

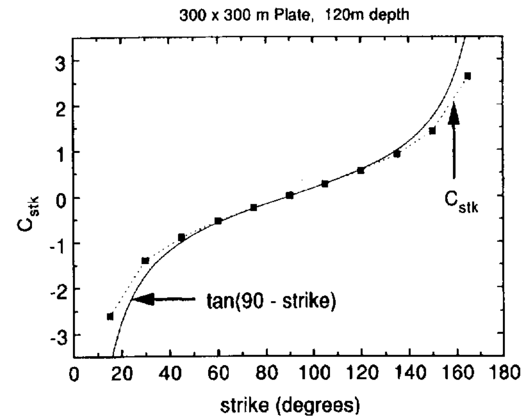

FIG. 14. The ratio $C_{stk} = V_y/V_x$ plotted as a function of varying strike angle (solid squares). The data agree very closely with the cotangent of the ζ.

The *y* component (V_y) can thus be considered to a be a mixture of V_x and V_z components,

$$V_y = C_{stk} V_x + C_{off} V_z ,$$

an equation that is only approximate. The response for a variety of strike angles and offset distances has been calculated and in each case the *y*-component response has been decomposed into the *x* and *z* components by solving for the constants of proportionality C_{stk} and C_{off}.

A plot of C_{stk} for the case of zero offset and varying strike direction ξ is seen on Figure 14. The values of C_{stk} determined from the data are plotted with solid squares and compared with the tan(90°- ξ). Because the agreement is so good, the formula

$$\xi = 90 - \tan^{-1}(C_{stk})$$

can be used to determine the strike. This relation was first obtained by Fraser (1972).

When the strike is fixed at 90°, and the offset varies, the corresponding values obtained for C_{off} have been plotted with solid squares on Figure 15. Again, there is good agreement with the arctangent of C_{off} and the angle φ between a vertical line and the line that joins the center of the top edge of the plate with the position where the aircraft traverse crosses the plate containing the plate. If an estimate of the distance to the top of the conductor *D* is already obtained using the method described above, or by the method described in Palacky and West (1973), then

$$D = \sqrt{(O2 + d2)} ,$$

(where *d* is the depth below surface). Hence, the offset distance *O* can be written as follows

$$O = d \tan(\varphi)$$
$$= d\,C_{off}$$
$$= C_{off}\sqrt{(D^2 - O^2)}$$

which can be rearranged to give

$$O = C_{off}\, D / \sqrt{(1 + C_{off}^2)} .$$

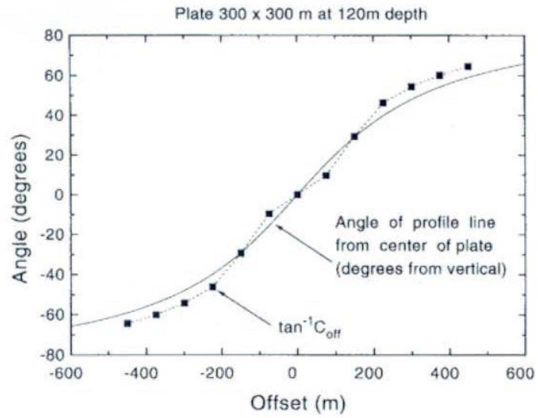

FIG. 15. The arctangent of $C_{off} = V_y/V_z$, plotted as a function of varying offset (solid squares). There is good agreement between this quantity and the angle ϕ between a vertical line and the line from the center of the top edge of the plate to the profile line.

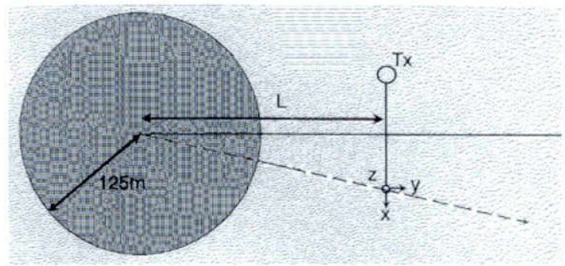

FIG. 16. Plan view of a flat-lying conductor (a circular loop with a radius of 125 m). The AEM system is offset a distance L from the center of the conductor in a direction perpendicular to the traverse direction. The traverse direction of the system is from the bottom to the top of the figure.

Lateral delectability

Figure 12 illustrates that V_y becomes relatively strong as the lateral displacement from the conductor is increased. Thus, if V_y is measured, then the total signal will remain above the noise level at larger lateral displacements of the traverse line from the conductor. This has been illustrated by assuming a flat-lying conductor, here approximated by a wire-loop circuit of radius 125 m (Figure 16). The *x*, *y* and *z* components of the response have been computed using the formula for the large-loop magnetic fields in Wait (1982). The results are plotted on Figure 17 as a function of increasing lateral displacement *L* of the transmitter/receiver from the center of the conductor. The transmitter and receiver are separated in a direction perpendicular *L* to simulate the case when the system is maximal coupled to the conductor, but the flight line misses the target by an increasing amount. The effect of varying the conductance or measurement time has been removed by normalizing the response to the total response measured when the system is at zero displacement. At displacements greater than 80 m, the *y* component is clearly larger than any other component. Assuming the same sensitivity and noise level for each component (which is a realistic assumption if the data are corrected for coil rotation and the sferic activity is low), it is clearly an advantage to measure V_y, as this will increase the chances of detecting the target when the flight line has not passed directly over the conductor.

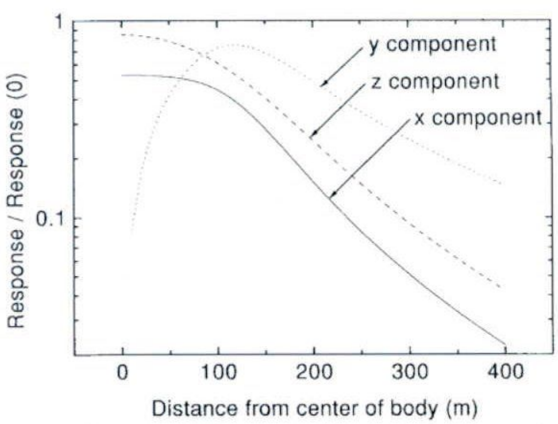

FIG. 17. The normalized response of the EM system plotted as a function of increasing offset distance L. The x component falls off most rapidly and the y component most slowly with increasing offset distance.

CONCLUSIONS

AEM systems measuring three components of the response can be used to infer more and/or better information than those systems that measure with only one component, i.e., V_x.

The *z*-component data enhances the ability of the AEM system to resolve layered structures as the *z*-component has a larger signal and a smaller proportion of sferic noise than any other component. If all the components are employed to correct for coil rotation, then the data quality and resolving power is increased further, as individual components are not contaminated by another component. Having better signal-to-noise and greater fidelity in the data will allow deeper layers to be interpreted with confidence.

A non-zero *y* component is helpful in identifying when the conductivity structure has a lateral inhomogeneity that is not symmetric about the flight line.

All components can be used to calculate the energy envelope, which is a valuable quantity to image. The energy envelope has a single peak over a vertical conductor and two peaks over a dipping conductor (one at either end). The asymmetry in the response profile of each individual component can be reduced by normalizing each profile by the energy envelope.

All three components are of great use in determining the characteristics of discrete conductors. For example, the distance between the two positive peaks in the V_z/EE profile can be employed to determine the depth. Also, the ratio of the magnitude of the two V_z/EE peaks helps to ascertain the dip of the conductor. The *x* component has been used in the past for these purposes, but is not as versatile, as it requires the data at all delay times, or an ability to identify a very small peak.

The *y* component can be utilized to extract information about the conductor that cannot be obtained from single component AEM data. The degree of mixing between the *y* and *z* components can give the lateral offset of the conductor (provided the depth is known), while the mixing between the *y* and *x* component gives the strike of a vertical conductor.

Finally, because the *y* component decreases most slowly with increasing lateral offset, this component gives an enhanced ability to detect a conductor positioned at relatively large lateral distances from the profile line, either between lines or beyond the edge of a survey boundary.

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Appendix E

Data Archive Description

Data Archive Description:

Survey Details

Survey Area Name:	Sturgeon Lake Survey Area
Job number:	03-438
Client:	Noranda Inc.
Survey Company Name:	Fugro Airborne Surveys
Flown and compiled dates:	June 10th – June 13th, 2003
Archive Creation Date:	August 22, 2003

Survey Specifications

Sturgeon Lake

Survey Line Azimuth:	North - South
Survey Line Spacing:	200m
Tie Line Azimuth:	East - West
Tie Line Spacing:	~2500m
Flying Elevation:	120 m Mean Terrain Clearance
Average Aircraft Speed:	65 m/s

Geodetic Information for map products

Map Projection	Universal Transverse Mercator (UTM)
Datum	NAD 27 (Canada Mean)
Central Meridian	93° West
	False Easting 500000 m
False Northing	0 m
Scale Factor	0.9996
UTM Zone	15 N
I.G.R.F. Model	2000
I.G.R.F. Correction Date	2003.4

Equipment Specifications:

Navigation

Differential GPS Receiver	Novatel, measuring all GPS channels, for up to 10 satellites
Aircraft	DeHavilland Dash-7
Video Camera	Panasonic WV-CL302

Magnetics

Type	Scintrex CS-2 Cesium Vapour
Installation	Towed bird
Sensitivity	0.01 nT
Sampling	0.10 s

Electromagnetics

Type	MEGATEM®, 20 channel multicoil system
Installation	Vertical axis loop (406m^2 area with 5 turns) mounted on the aircraft.

	Receiver coils in a towed bird.
Coil Orientation	X, Y and Z
Frequency	90 Hz
Pulse Width	2 ms
Geometry	Tx-Rx horizontal separation of ~130 m
	Tx-Rx vertical separation of ~50 m
Sampling	0.25 s

System Configuration:

Pulse repetition rate	90Hz
Pulse width	2200µs
Offtime	3355µs
Receiver-transmitter horizontal separation	130m
Receiver-transmitter vertical separation	50m

Data Windows:

CHANNEL	START (P)	END (P)	WIDTH (P)	START (MS)	END (MS)	MID (MS)
1	4	10	7	0.13	0.434	0.282
2	11	25	15	0.434	1.085	0.76
3	26	36	11	1.085	1.563	1.324
4	37	51	15	1.563	2.214	1.888
5	52	56	5	2.214	2.431	2.322
6	57	58	2	2.431	2.517	2.474
7	59	60	2	2.517	2.604	2.561
8	61	63	3	2.604	2.734	2.669
9	64	66	3	2.734	2.865	2.799
10	67	70	4	2.865	3.038	2.951
11	71	74	4	3.038	3.212	3.125
12	75	78	4	3.212	3.385	3.299
13	79	83	5	3.385	3.602	3.494
14	84	88	5	3.602	3.819	3.711
15	89	93	5	3.819	4.036	3.928
16	94	98	5	4.036	4.253	4.145
17	99	104	6	4.253	4.514	4.384
18	105	110	6	4.514	4.774	4.644
19	111	118	8	4.774	5.122	4.948
20	119	128	10	5.122	5.556	5.339

Archive files formats are as follows:

Field	Variable	Units
1 - 1	Line	Line *100 + part
2 - 2	Fiducials	seconds
3 - 3	Flight Number	
4 - 4	Date	ddmmyy
5 - 5	Latitude in Nad 27	degrees
6 - 6	Longitude in Nad 27	degrees
7 - 7	Easting (X) in Nad 27	m
8 - 8	Northing (Y) in Nad 27	m
9 - 9	GPS Elevation	metres
10 - 10	Radar Altimeter	metres
11 - 11	Terrain	metres
12 - 12	Ground Magnetic Intensity (Diurnal)	nT
13 - 13	Airborne Total Magnetic Intensity (TMI)	nT
14 - 14	IGRF	nT
15 - 15	Final Airborne Residual Magnetic Intensity	nT
16 - 16	Electromagnetic Primary Field	μV
17 - 17	Powerline Monitor (60Hz)	μV
18 - 37	Final dB/dt X-coil Channels 1-20	pT/s
38 - 57	Final dB/dt Y-coil Channels 1-20	pT/s
58 - 77	Final dB/dt Z-coil Channels 1-20	pT/s
78 - 97	Final B-Field X-coil Channels 1-20	fT
98 - 117	Final B-Field Y-coil Channels 1-20	fT
118 - 137	Final B-Field Z-coil Channels 1-20	fT
138 - 157	Raw dB/dt X-coil Channels 1-20	pT/s
158 - 177	Raw dB/dt Y-coil Channels 1-20	pT/s
178 - 197	Raw dB/dt Z-coil Channels 1-20	pT/s
198 - 217	Raw B-Field X-coil Channels 1-20	fT
218 - 237	Raw B-Field Y-coil Channels 1-20	fT
238 - 257	Raw B-Field Z-coil Channels 1-20	fT

NOTES

1. The raw EM data from the X, Y and Z coils were initially recorded at a sample rate of 4 Hz and re-interpolated to a sample rate of 5 Hz after editing and filtering.

2. The EM data were corrected for a system lag of 3.5 sec.; the magnetic data were corrected for a system lag of 3.4 seconds.

3. All grid files archived in GEOSOFT format. All grid files were generated with a grid cell size of 50m.

4. Any undefined variable (null) is assigned the constant of –9999999.

Halfwave Data Description:

CONTENTS OF THE HALFWAVE DATA (HWA Files)

The HWA files contain the Fiducial and the 384 waveform points for the 4 components, T, X, Y, and Z, stored in that order. For each of the 4 components, the following data is given : Primary field, Powerline monitor, Earth's Field monitor and the 384samples of the waveform. All values are stored as voltages.

The format always allows storage of the waveform as 384 points. Depending on the frequency, if the waveform is not defined by the full 384 points, then the remaining points are simply filled with zeroes.

The utility < read_halfwave.exe > will read the raw binary file and write out its contents in a standard ASCII format. This utility is run in a standard command line mode, as follows :

read_halfwave input output

Appendix F

TDEM ANOMALY SELECTION

Current approach to TDEM anomaly selection

The current routine for the selection and fitting of EM anomalies is still based on the University of Toronto plate program which fits the response (at the anomaly peak) from the X-coil channels to a vertical plate nomogram. Given that the current GEOTEM and MEGATEM system have evolved to offer the response from coils of 3 different orientations (X, Y and Z) and from dB/dt and B-Field, this approach to the classification of the anomalies is limited and no longer fully reflects all the information being measured by the system. The resulting shortcomings are:

- All anomaly peaks, from the x-coil response, are fitted to a vertical plate model of fixed dimensions, regardless of the nature of the conductive source. The derived CTP and depth-to-source values are then only valid if the conductor can be properly represented by a vertical plate. CTP and depth values derived from "non vertical plate" type conductors will be erroneous. In some conductive terrains, marked by prominent conductive overburden or surface alteration of other sorts, "non-vertical" type conductors may represent 90 % or more of the conductive response.
- The response from the conductor must deflect a minimum of 6 channels above the background to be fitted to the nomogram. CTP or depth-to-source values will not be calculated for a valid but weaker response (a weak or deep source).
- Only the response from the X-coil channels are used in the selection and fitting. A response appearing only on the Z-coil will not be identified. This is sometimes the case for a very deep source. As the depth to the conductor increases, although it may have considerable depth extent, the system becomes less sensitive to the vertical extent of the body and conductors will appear to be more flat-lying than vertical. As a result, as depth of burial increases, the coupling of the response may disappear on the X-coil response but will persist on the Z-coil response (see figure 1, anomalies A and B).
- The fitting of the response is only done from the amplitudes at the peak position of the anomaly and does not take-in the full shape of the anomaly or relate the difference in response between the X-coil and Z-coil. This does not allow for the distinction between vertical, flat-lying or dipping plates.

Fugro is presently working on the development of a new anomaly selection and classification routine which will use a window of data centered about the anomaly peak (to properly define the entire anomaly shape), using both the response from the X and Z coils and fitting to a suite of models from flat-lying to dipping to vertical plates and spheres. This will hopefully address all the above shortcomings of the present method.

Unfortunately the current anomaly fitting program must continue to be in use until this new routine is made available. Until such time, our approach is to present the full information being measured by the system within the confines of the present program's limitations. Some responses may not be visible on the regular channels of the dB/dt X-coil data but will be identified on either the B-Field response or the Z-coil response. The initial selection of the anomalies is still being derived from the X-coil channels of the dB/dt data but at the "review" stage (via a graphic screen editor), the response from all components (X and Z, dB/dt and B-Field) are examined. All significant responses from any of the components are inserted in the anomaly field. Since all anomaly edits are still being updated by the same routine, again only fitting the X-coil response from the dB/dt data, many of these "other" responses which have no measurable signature on the dB/dt X-coil data will only be flagged as an anomaly location with no measurable response suitable for fitting to the reference nomogram. Although improperly represented, these "other" anomalies, at the very least, are identified by their location in the EM anomaly database (listing) and on the anomaly map.

Figures 1 and 2 provide examples of a typical display of the channel data used when reviewing the EM anomaly selection. Given the limited space available on a computer screen, a good display can include every even numbered channel, 8 to 20 (in more resistive areas, often all off-time channels can be displayed) for X and Z for both dB/dt and B-Field, along with the Hz monitor and the radar altimeter (the EM primary field can also be very useful).

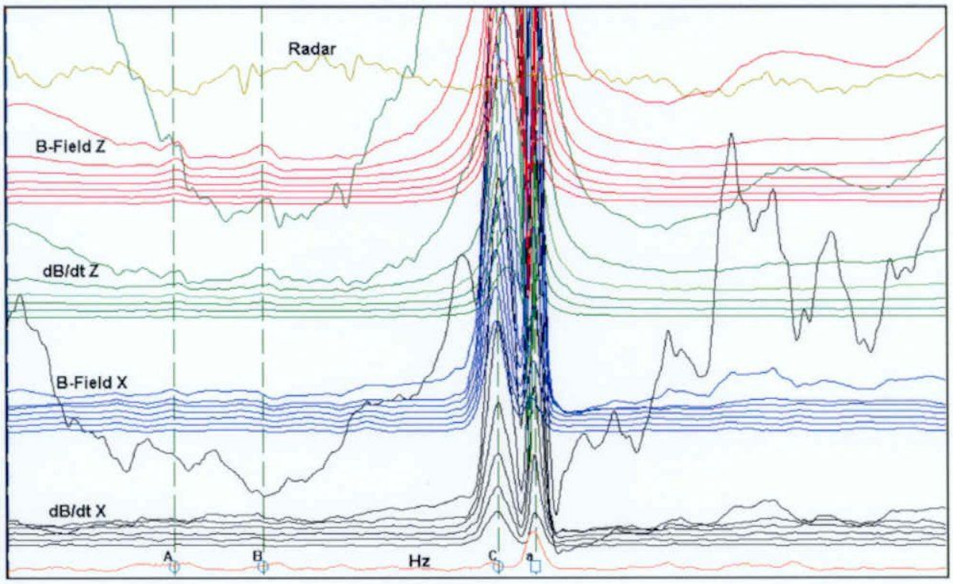

Figure 1

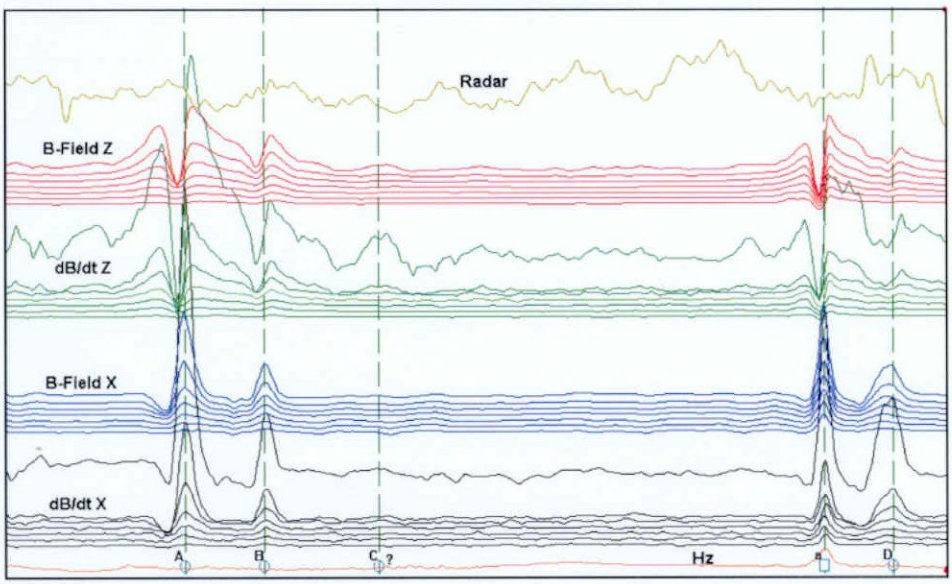

Figure 2

In **Figure 1**, anomalies identified as A and B could be indicative of a very deep source, where the coupling of the response is lost on the X-coil but persists on the Z-coil. The dB/dt X-coil response is devoid of any response while a weak response is visible of the Z-coil of the dB/dt response. Greater support for this selection is provided by the response on the B-Field. Although weak and very questionable on the X-coil (close to the noise level) the response is clearly marked on the Z-coil, as a low amplitude response of slow decay. This is a good indication of a high conductance body having a long time constant and therefore enhanced by the B-Field. These two anomalies may be prime targets for mineralization but will be indistinguishable from weak surface responses, as represented on the anomaly map or in the anomaly listing. Hence, the importance of always reviewing the EM anomaly selection against the data profiles.

In **Figure 2**, anomaly C? is similar to the responses discussed in Figure 1 above, in that it presents no measurable signature on the X-coil response (for both dB/dt and B-Field) but a weak response on the Z-coil response. The difference here however, is that the B-Field response does not show an enhancement of the response on the Z-coil but an attenuation. This is indicative of a conductive response with a short time constant and hence more likely a weak surficial source.

The anomalies discussed in Figures 1 and 2 have very similar characteristics on dB/dt X and Z and B-Field X and yet may reflect very different conductive sources, one being of potentially economic interest. The only distinguishing signature is offered by the B-Field Z-coil response. Be aware that these differences are not properly accounted for in the current anomaly selection and presentation process.

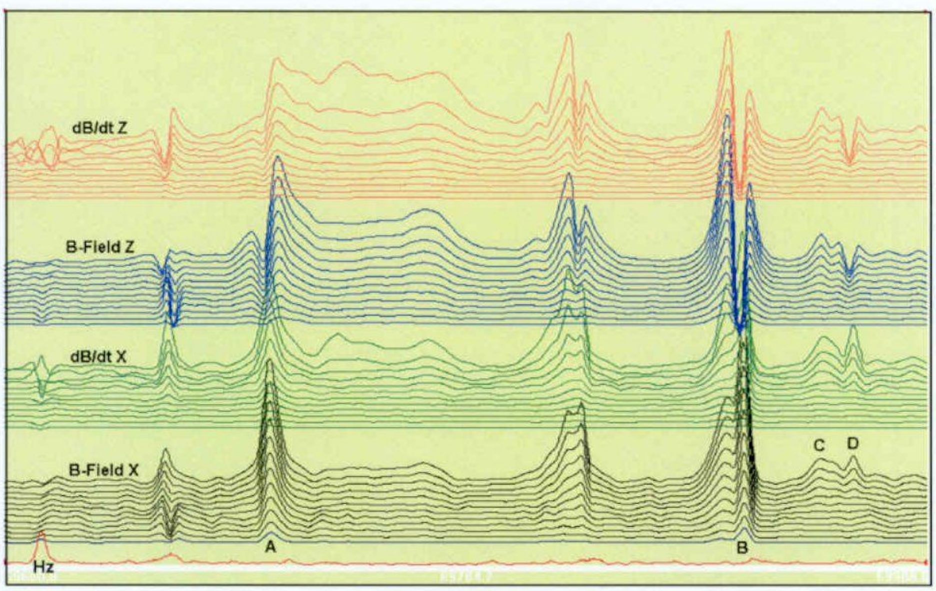

Figure 3

Figure 3 shows the importance of looking at the response with all components when evaluating the possible source of a conductive response. Anomalies identified as A and B look quite similar on the X-coil response and could both be interpreted as narrow, vertical conductors. However, looking at the response on the Z-coil clearly shows that anomaly A is the leading edge of a broad tabular body, better displayed on Z because of the enhanced coupling with the Z-coil, whereas anomaly B does reflect a narrow, near-vertical conductor. Anomalies C and D again look very similar on the response from the X-coil and could be interpreted as related to the same source. However, the response on the Z-coil indicates that the response at C is from a tabular or flat-lying source whereas the response at D is from a vertical source.

Fugro Airborne Surveys

ANOMALY LISTING REPORT
Airborne Magnetic and MEGATEM® Survey

STURGEON LAKE SURVEY AREA
THUNDER BAY, ONTARIO, CANADA

Job No. 03-438

Unitronix Corp. and 1522923 Ontario Inc.

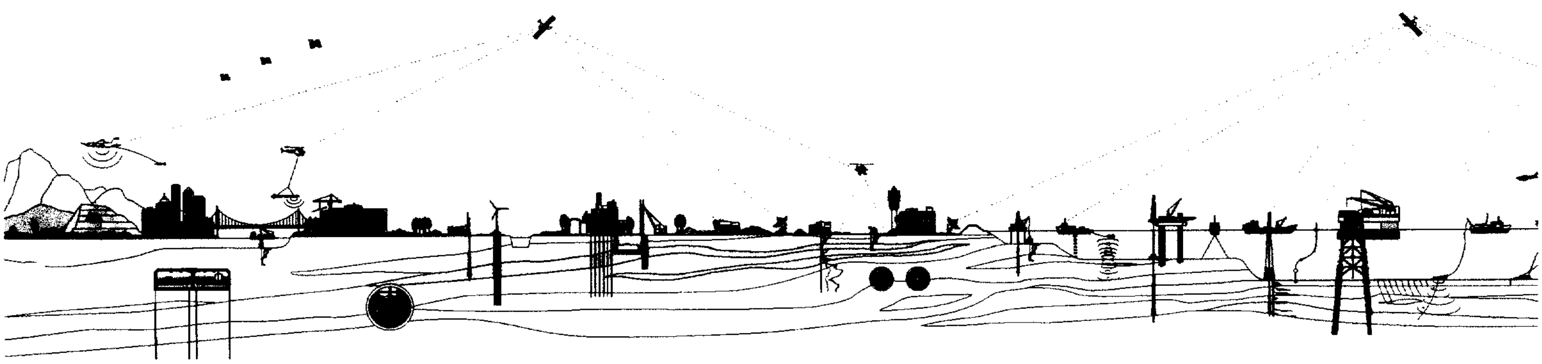

PLATE NOMOGRAM CHARACTERISITICS

```
HEIGHT =   120.0 TX-RX H =  131.0 TX-RX V =   50.0
DIP =   90.0
GATE TIMES =   573.0   703.0   833.0   985.0  1159.0  1353.0  1592.0  1875.0
GATE TIMES =  2178.0  2504.0  2851.0  3220.0
CTP=    1000.000000
```

```
MINIMUM PEAK THRESHOLDS     60.    60.    50.    50.    40.    40. PPM

MINIMUM PEAK THRESHOLDS     30.    30.    20.    20.    15.    15. PPM
```

GEOTEM Anomaly Listing

SYSTEM CONFIGURATION:
- Pulse repetition rate..................................90Hz
- Pulse width..2200us
- Offtime..3255us
- Receiver-transmitter horizontal separation.............130m
- Receiver-transmitter vertical separation...............50m
- Receiver axis orientation..............................Horizontal

MODEL USED IN FITTING:
- Vertical plate model
- Length of 600 m
- Depth extent of 300 m
- Vertical dip
- Strike perpendicular to flight line

ANOMALY LISTING DESCRIPTION:

- FLT...Flight Number
- LINE..Line Number
- PRT..Line part number
- AZ...Flight line heading
- CAT..............Anomaly category   N = normal, S = surficial, C = culture
- ID...Anomaly identifier
- FID.......................................Fiducial value at anomaly peak
- BX20...Amplitude of B Field X Coil Channel 20 (ppm)
- BX18...Amplitude of B Field X Coil Channel 18 (ppm)
- BX16...Amplitude of B Field X Coil Channel 16 (ppm)
- BX14...Amplitude of B Field X Coil Channel 14 (ppm)
- BX12.........Amplitude of channel used to select anomaly (channel 12, ppm)
- BX10...................Amplitude of a reference channel (channel 10, ppm)
- NC...Number of channels deflected
- ALT................................Terrain clearance of aircraft (metres)
- X...............................UTM X coordinate of anomaly peak (metres)
- Y...............................UTM Y coordinate of anomaly peak (metres)
- CTP........Computed conductance as conductivity-thickness-produce (siemens)
- DEP..................................Depth to source relative to surface

)TE: 1. Selections with 0 in the CTP and DEP columns reflect surficial or culture selections which were not fitted to the vertical plate model.

2. Selections with a negative number shown in the DEP column indicate a normal selection (bedrock) where

the vertical plate model used does not properly reflect the true conductor geometry.

STATISTICS OF ANOMALIES
========== == =========

TOTAL NUMBER OF ANOMALIES 347

	CHANNELS	(IN PERCENT)						
CULTURE	1-5	6	7	8	9	10	11	12
0	7	0	0	1	2	1	1	88

FLT	LINE	PRT	AZ	CAT	ID	FID	BX20	BX18	BX16	BX14	BX12	BX10	NC	ALT	X	Y	CTP	DEP
2	1068	1	180	N	A	72035	0	2	7	19	78	212	5	124.4	651313	5526371	0	0
2	1070	1	180	N	A	72535	12	29	48	63	50	43	1	125.9	651701	5525467	0	0
2	1070	1	180	N	B	72590	123	174	229	300	403	540	12	122.2	651700	5521522	47	95
2	1070	1	180	N	C	72593	57	68	84	100	118	168	12	126.2	651701	5521334	46	120
2	1072	1	180	N	A	73048	782	1141	1522	2038	2813	3886	12	125	652091	5521363	54	21
2	1074	1	180	N	A	73496	1365	1778	2170	2642	3277	4090	12	119.2	652530	5521429	121	18
2	1076	1	180	N	A	73966	322	417	514	635	810	1061	12	128.3	652911	5521406	78	52
2	1078	1	180	N	A	74452	99	151	217	322	505	833	12	114.9	653302	5521568	36	102
2	1078	1	180	N	B	74454	502	791	1128	1607	2373	3412	12	126.5	653298	5521399	43	26
2	1069	1	0	N	A	75113	19	44	46	62	71	89	3	130.1	651498	5521268	0	0
2	1069	1	0	N	B	75116	21	33	48	68	89	134	12	125	651501	5521551	30	168
2	1069	1	0	N	C	75166	31	44	57	64	61	52	1	104.5	651500	5525396	0	0
2	1069	1	0	N	D	75180	11	24	42	59	99	214	11	117.3	651510	5526434	25	183
2	1071	1	0	N	A	75670	352	466	580	717	902	1080	12	109.7	651900	5521197	77	67
2	1071	1	0	N	B	75672	596	821	1056	1351	1778	2384	12	111.3	651902	5521383	65	48
2	1071	1	0	N	C	75733	32	41	51	62	76	83	2	114.9	651903	5526033	0	0
2	1073	1	0	N	A	76202	195	259	322	395	510	637	12	132	652252	5521120	65	67
2	1073	1	0	N	B	76203	220	315	410	513	699	951	12	131.7	652257	5521224	49	61
2	1073	1	0	N	C	76206	455	630	817	1057	1413	1913	12	126.8	652266	5521430	60	41
2	1073	1	0	N	D	76276	9	19	31	47	65	108	9	138.1	652301	5526645	26	185
2	1075	1	0	N	A	76731	412	518	625	748	909	1075	12	131.1	652697	5521243	92	40
2	1075	1	0	N	B	76734	697	910	1123	1377	1723	2166	12	125.9	652694	5521427	93	30
2	1077	1	1	N	A	77188	86	142	213	305	497	773	12	115.2	653121	5521162	32	99
2	1077	1	1	N	B	77192	187	296	428	621	951	1442	12	114	653144	5521417	36	72
2	1079	1	0	N	A	77718	64	93	134	183	244	327	12	135.3	653472	5521134	36	108
2	1079	1	0	N	B	77721	209	324	455	639	936	1361	12	123.1	653478	5521385	39	62
2	1079	1	0	N	C	77809	74	99	109	133	167	218	12	120.1	653509	5528184	52	114
2	1079	1	0	N	D	77814	473	596	715	851	1038	1308	12	118.9	653510	5528548	100	48
2	1079	1	0	N	E	77821	320	482	669	929	1352	1988	12	105.2	653507	5529137	47	69
2	1094	1	180	N	A	77986	283	383	488	621	819	1120	12	117.7	656498	5530256	64	68
2	1094	1	180	N	B	78042	1603	2238	2909	3756	4974	6602	12	132	656506	5526298	73	-2
2	1094	1	180	N	C	78054	1076	1403	1729	2117	2647	3341	12	124.1	656506	5525491	105	19
2	1094	1	180	N	D	78108	458	574	687	811	972	1227	12	134.1	656497	5521574	98	33
2	1094	1	180	N	E	78112	343	444	547	671	858	1050	12	121	656498	5521277	82	56
2	1081	1	0	N	A	78270	60	80	101	126	161	187	12	128.6	653918	5521117	47	119
2	1081	1	0	N	B	78276	159	214	278	361	478	653	12	135.9	653913	5521521	52	73
2	1081	1	0	N	C	78357	27	44	61	79	101	130	3	119.2	653903	5527768	0	0
2	1081	1	0	N	D	78363	153	209	268	344	464	650	12	119.2	653908	5528258	56	90
2	1081	1	0	N	E	78367	113	142	183	234	297	385	12	125.3	653909	5528544	55	97
2	1081	1	0	N	F	78371	437	584	729	898	1121	1435	12	123.1	653914	5528855	78	47
2	1081	1	0	N	G	78379	72	104	140	188	264	384	12	129.2	653915	5529404	40	113
2	1081	1	0	N	H	78384	57	81	109	150	216	308	12	132	653909	5529839	38	120
2	1081	1	0	N	I	78394	21	31	42	58	81	129	12	125	653915	5530608	34	184
2	1096	1	180	N	A	78534	18	33	55	100	162	261	12	121	656888	5530014	38	158
2	1096	1	180	N	B	78590	1486	1921	2417	3081	4092	5497	12	119.8	656908	5526077	132	14
2	1096	1	180	N	C	78599	273	355	438	537	669	830	12	121.9	656915	5525415	74	64
2	1096	1	180	N	D	78601	243	307	368	440	539	680	12	119.2	656916	5525297	78	69
2	1096	1	180	N	E	78651	628	887	1122	1412	1824	2430	12	109.7	656911	5521570	88	47
2	1096	1	180	N	F	78656	482	633	778	951	1194	1512	12	128.6	656900	5521243	84	39
2	1083	1	0	N	A	78845	64	86	111	146	191	248	12	129.2	654293	5521174	47	115
2	1083	1	0	N	B	78849	252	360	467	604	808	1109	12	110.6	654295	5521520	48	76
2	1083	1	0	N	C	78851	178	266	364	496	707	1026	12	105.2	654296	5521661	42	91
2	1083	1	0	N	D	78886	6	14	23	35	37	40	1	117	654300	5524304	0	0
2	1083	1	0	N	E	78925	313	448	589	750	1069	1542	12	126.8	654282	5527393	55	53
2	1083	1	0	N	F	78927	302	393	494	615	772	988	12	117	654282	5527532	73	66
2	1083	1	0	N	G	78939	666	855	1050	1288	1617	2069	12	117	654281	5528474	101	40

2	1083	1	0	N	H	78951	56	64	69	79	96	119	9	104.5	654287	5529352	43	150
2	1083	1	0	N	I	78960	18	30	45	67	111	142	12	108.5	654290	5530082	29	193
2	1083	1	0	N	J	78970	16	31	37	56	94	192	9	124.4	654286	5530847	24	174
2	1098	1	180	N	A	79076	40	68	107	164	265	446	12	124.1	657311	5530131	28	118
2	1098	1	180	N	B	79080	99	157	233	353	548	829	12	116.1	657306	5529867	33	95
2	1098	1	180	N	C	79134	320	451	592	772	1055	1453	12	131.4	657325	5526007	53	48
2	1098	1	180	N	D	79137	1067	1507	2002	2651	3628	5036	12	121.9	657324	5525820	65	18
2	1098	1	180	N	E	79146	1002	1310	1649	2087	2691	3432	12	109.7	657319	5525169	97	35
2	1098	1	180	N	F	79197	131	175	221	279	364	484	12	107.9	657316	5521553	55	107
2	1098	1	180	N	G	79201	928	1148	1350	1573	1858	2257	12	125.9	657318	5521290	142	20
2	1085	1	0	N	A	79329	315	427	533	688	902	1190	12	125.9	654721	5521316	69	56
2	1085	1	0	N	B	79331	879	1199	1537	1944	2539	3360	12	111.9	654717	5521539	73	36
2	1085	1	0	N	C	79333	496	654	820	1033	1340	1775	12	110	654714	5521682	85	56
2	1085	1	0	N	D	79335	167	224	280	346	436	581	12	112.8	654712	5521825	58	93
2	1085	1	0	N	E	79402	192	246	300	363	450	582	12	124.7	654684	5527009	69	73
2	1085	1	0	N	F	79411	55	77	98	127	173	227	8	119.5	654683	5527772	45	130
2	1085	1	0	N	G	79416	811	1038	1259	1518	1868	2365	12	118.6	654689	5528161	112	32
2	1085	1	0	N	H	79424	18	32	49	79	128	189	12	121.6	654699	5528746	31	180
2	1085	1	0	N	I	79430	13	25	38	48	56	55	1	112.5	654705	5529231	0	0
2	1100	1	180	N	A	79558	133	217	322	482	765	1195	12	107	657694	5529959	43	97
2	1100	1	180	N	B	79564	85	105	133	174	228	353	12	118.3	657702	5529557	50	116
2	1100	1	180	N	C	79619	433	562	699	861	1089	1420	12	100	657692	5525871	81	71
2	1100	1	180	N	D	79621	1509	2012	2547	3222	4180	5549	12	120.7	657692	5525692	102	13
2	1100	1	180	N	E	79623	654	844	1041	1284	1628	2084	12	119.2	657693	5525539	96	39
2	1100	1	180	N	F	79629	2135	2639	3156	3783	4616	5721	12	117.3	657695	5525163	217	6
2	1100	1	180	N	G	79677	56	78	102	133	177	227	12	117.7	657733	5521802	40	140
2	1100	1	180	N	H	79679	346	503	680	911	1251	1686	12	99.1	657729	5521602	49	74
2	1100	1	180	N	I	79683	662	862	1057	1286	1595	2050	12	105.2	657726	5521348	97	52
2	1087	1	0	N	A	79804	41	59	78	99	112	134	3	116.4	655111	5520961	0	0
2	1087	1	0	N	B	79809	401	530	660	812	1036	1325	12	120.1	655111	5521327	80	52
2	1087	1	0	N	C	79811	1357	1733	2129	2624	3308	4196	12	111.3	655111	5521480	126	26
2	1087	1	0	N	D	79814	684	976	1284	1672	2228	2955	12	114.9	655113	5521662	61	37
2	1087	1	0	N	E	79877	83	115	151	200	277	383	12	115.5	655099	5526393	45	121
2	1087	1	0	N	F	79886	90	115	128	167	228	282	9	118	655101	5527130	39	129
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2	1087	1	0	N	H	79895	1911	2384	2821	3309	3984	4873	12	120.1	655094	5527815	174	8
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2	1087	1	0	N	J	79904	487	691	913	1201	1630	2224	12	110.9	655091	5528469	55	53
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2	1102	1	180	N	B	80049	166	250	340	444	646	916	12	118	658075	5529387	41	81
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2	1102	1	180	N	D	80102	1243	1537	1794	2140	2649	3400	12	125.9	658100	5525596	171	12
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2	1102	1	180	N	H	80159	655	861	1056	1262	1534	1891	12	127.4	658109	5521495	97	30
2	1089	1	0	N	A	80324	466	664	877	1154	1558	2144	12	122.5	655505	5521441	55	42
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2	1089	1	0	N	C	80383	207	292	377	483	643	892	12	122.5	655500	5526022	53	73
2	1089	1	0	N	D	80393	38	48	71	92	121	178	12	123.1	655494	5526754	40	151
2	1089	1	0	N	E	80398	222	286	347	417	494	642	12	125.3	655491	5527127	73	68
2	1089	1	0	N	F	80402	1113	1433	1771	2214	2841	3733	12	109.4	655494	5527432	113	33
2	1104	1	180	N	A	80551	339	574	871	1320	2114	3456	12	110.3	658489	5529440	35	46
2	1104	1	180	N	B	80554	344	486	645	859	1185	1698	12	110.9	658495	5529221	53	65
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2	1104	1	180	N	D	80603	750	1009	1272	1597	2052	2655	12	124.7	658511	5525815	85	29
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2	1104	1	180	N	G	80614	921	1146	1360	1593	1907	2299	12	127.7	658515	5525038	132	19
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2	1091	1	0	N	A	80814	451	592	733	903	1142	1492	12	120.4	655918	5521387	82	49
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2	1091	1	0	N	D	80872	64	77	87	111	133	158	11	124.7	655899	5525880	50	111
2	1091	1	0	N	E	80877	150	178	206	247	313	391	12	125.9	655904	5526306	74	73
2	1091	1	0	N	F	80884	1998	2695	3509	4577	6137	8278	12	116.7	655913	5526873	95	9
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2	1106	1	180	N	B	81054	341	472	616	806	1103	1580	12	126.2	658914	5528947	56	52
2	1106	1	180	N	C	81077	128	154	179	221	273	352	12	130.5	658904	5527286	67	76
2	1106	1	180	N	D	81096	344	556	810	1167	1760	2641	12	118	658892	5525909	40	45
2	1106	1	180	N	E	81098	358	561	798	1129	1669	2501	12	117.3	658895	5525720	50	50
2	1106	1	180	N	F	81101	184	243	304	380	491	673	12	124.1	658901	5525489	62	78
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2	1106	1	180	N	H	81109	709	980	1258	1621	2195	3074	12	129.2	658921	5524918	70	24
2	1106	1	180	N	I	81153	68	81	99	122	158	207	12	121	658923	5521786	49	118
2	1106	1	180	N	J	81157	1011	1253	1514	1820	2229	2783	12	114.3	658923	5521428	131	30
2	1093	1	0	N	A	81305	238	304	370	449	557	708	12	109.4	656296	5521148	74	81
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2	1093	1	0	N	D	81362	101	139	183	223	275	350	12	118.3	656309	5525592	47	109
2	1093	1	0	N	E	81368	216	302	388	483	612	806	12	121	656309	5526071	52	74
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2	1108	1	180	N	A	81552	64	94	127	173	245	349	12	129.5	659327	5530107	38	116
2	1108	1	180	N	B	81554	89	138	195	271	390	560	12	128.9	659325	5529965	36	93
2	1108	1	180	N	C	81557	45	65	87	112	146	200	12	118.3	659318	5529711	37	146
2	1108	1	180	N	D	81562	158	240	332	453	634	918	12	120.4	659305	5529277	40	79
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2	1108	1	180	N	G	81593	370	481	593	729	919	1218	12	124.4	659312	5527083	81	51
2	1108	1	180	N	H	81606	60	96	140	208	330	525	12	113.1	659303	5526153	37	126
2	1108	1	180	N	I	81612	199	291	402	553	781	1185	12	129.8	659300	5525764	49	65
2	1108	1	180	N	J	81615	120	157	198	243	307	388	12	132.3	659299	5525557	55	88
2	1108	1	180	N	K	81622	560	752	952	1201	1563	2097	12	118.6	659302	5525028	79	44
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2	1108	1	180	N	M	81663	32	49	66	88	116	138	2	124.7	659305	5522052	0	0
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2	1108	1	180	N	O	81673	298	405	518	659	875	1205	12	110.6	659306	5521399	59	73
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2	1109	1	0	N	C	82283	117	163	197	269	358	437	12	130.8	659491	5521801	55	89
2	1109	1	0	N	D	82321	383	513	648	810	1040	1384	12	116.4	659498	5524849	72	59
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2	1109	1	0	N	L	82370	580	919	1322	1894	2820	4190	12	148.7	659497	5528642	40	-2
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2	1109	1	0	N	N	82378	22	34	51	81	136	227	12	142.3	659499	5529277	31	153
2	1109	1	0	N	O	82383	133	196	266	359	511	730	12	123.1	659502	5529695	44	87
2	1109	1	0	N	P	82386	22	31	47	76	125	176	10	124.7	659504	5529929	27	168
2	1080	1	180	N	A	82557	39	57	78	101	124	157	4	118.6	653697	5529829	0	0
2	1080	1	180	N	B	82565	540	694	840	1010	1239	1583	12	109.4	653708	5529232	98	54

2	1080	1	180	N	C	82569	537	720	911	1151	1497	1996	12	114	653710	5528969	78	50
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2	1080	1	180	N	E	82578	184	237	291	355	443	593	12	107.3	653717	5528362	65	94
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2	1095	1	0	N	A	82839	293	364	432	511	615	765	12	138.1	656683	5521266	86	44
2	1095	1	0	N	B	82843	75	110	147	198	263	361	12	121.9	656689	5521598	47	114
2	1095	1	0	N	C	82889	246	316	388	477	602	784	12	115.2	656693	5525161	73	75
2	1095	1	0	N	D	82893	693	945	1208	1537	2016	2666	12	121	656697	5525410	79	34
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2	1095	1	0	N	F	82955	70	96	124	162	221	301	12	111.3	656706	5530207	45	134
2	1082	1	180	N	A	83068	131	190	254	339	467	653	12	107.3	654103	5530379	44	105
2	1082	1	180	N	B	83073	74	103	136	178	253	354	12	107.9	654106	5530061	43	132
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2	1082	1	180	N	I	83155	18	33	53	74	85	107	3	119.5	654112	5524235	0	0
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2	1084	1	180	N	A	83632	127	160	195	236	293	372	12	126.2	654506	5528670	60	89
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2	1084	1	180	N	C	83637	499	641	775	932	1139	1412	12	128.3	654500	5528297	100	36
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2	1084	1	180	N	F	83729	289	441	619	864	1254	1914	12	120.1	654493	5521670	41	54
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2	1099	1	0	N	A	83888	158	212	267	336	440	591	12	129.2	657525	5521137	57	79
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2	1099	1	0	N	E	83945	623	876	1146	1493	2005	2735	12	130.5	657508	5525578	69	25
2	1099	1	0	N	F	83946	735	988	1254	1588	2075	2767	12	127.1	657507	5525721	80	27
2	1099	1	0	N	G	83994	12	25	44	73	118	189	11	141.4	657497	5529469	23	142
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2	1086	1	180	N	A	84171	24	36	52	76	113	165	12	122.8	654921	5528832	33	174
2	1086	1	180	N	B	84175	418	566	718	905	1173	1558	12	121	654924	5528485	70	51
2	1086	1	180	N	C	84179	85	120	159	210	288	381	12	122.5	654918	5528211	44	112
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2	1103	1	0	N	A	84934	236	307	377	458	565	710	12	132.9	658310	5521345	75	57
2	1103	1	0	N	B	84936	528	670	806	962	1164	1420	12	136.2	658307	5521505	100	27
2	1103	1	0	N	C	84978	237	302	377	461	575	730	12	114.6	658305	5524802	70	77
2	1103	1	0	N	D	84981	1129	1411	1723	2133	2751	3639	12	120.1	658308	5525040	130	22
2	1103	1	0	N	E	84989	1868	2293	2738	3258	3934	4832	12	125.6	658308	5525635	172	3
2	1103	1	0	N	F	85036	238	369	527	749	1153	1848	12	129.5	658319	5529341	39	50
2	1103	1	0	N	G	85040	129	216	318	460	686	1015	12	118.6	658320	5529613	38	77
2	1090	1	180	N	A	85204	1079	1367	1661	2008	2467	3110	12	112.5	655720	5527231	123	31
2	1090	1	180	N	B	85205	1114	1412	1726	2125	2704	3476	12	111.3	655720	5527160	118	31
2	1090	1	180	N	C	85219	56	78	105	141	196	274	12	110.6	655710	5526194	40	146
2	1090	1	180	N	D	85223	22	30	44	54	62	80	4	115.2	655713	5525907	0	0
2	1090	1	180	N	E	85281	253	336	422	527	688	921	12	123.1	655710	5521745	65	67
2	1090	1	180	N	F	85283	1534	1971	2405	2920	3641	4598	12	107.6	655711	5521576	131	26
2	1090	1	180	N	G	85287	300	418	542	702	934	1263	12	128	655712	5521310	59	54
2	1105	1	0	N	A	85440	242	303	363	471	593	781	9	134.1	658708	5521218	52	65
2	1105	1	0	N	B	85442	656	893	1139	1443	1856	2440	12	134.1	658713	5521445	71	23
2	1105	1	0	N	C	85487	880	1154	1438	1789	2280	2956	12	138.7	658711	5524992	94	10
2	1105	1	0	N	D	85488	704	931	1158	1432	1804	2258	12	139.3	658711	5525119	89	16
2	1105	1	0	N	E	85495	804	1135	1467	1903	2558	3458	12	138.1	658714	5525678	65	10
2	1105	1	0	N	F	85518	15	25	39	56	74	92	12	130.8	658711	5527492	28	181
2	1105	1	0	N	G	85535	149	225	309	420	587	820	12	124.1	658706	5528849	40	79
2	1105	1	0	N	H	85538	436	703	1023	1477	2225	3349	12	135.9	658706	5529127	39	18
2	1105	1	0	N	I	85541	133	231	351	520	786	1164	12	128.6	658707	5529390	34	63
2	1092	1	180	N	A	85715	2087	2699	3319	4071	5147	6611	12	110.6	656116	5526860	138	15
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2	1092	1	180	N	C	85732	6	10	16	24	35	57	2	123.1	656097	5525693	0	0
2	1092	1	180	N	D	85783	57	63	67	81	101	129	8	121	656128	5522010	41	151
2	1092	1	180	N	E	85789	2047	2678	3289	3994	4911	5986	12	113.4	656117	5521577	137	13
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3	1107	1	0	N	L	63917	18	20	23	41	76	174	7	116.7	659103	5529500	15	143
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3	1110	1	180	N	B	64092	38	58	81	113	161	237	12	132.3	659702	5529371	37	139
3	1110	1	180	N	C	64096	340	474	610	782	1032	1425	12	121.6	659703	5529136	56	56
3	1110	1	180	N	D	64097	506	705	918	1186	1572	2150	12	116.7	659702	5529023	61	47
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3	1110	1	180	N	G	64128	707	986	1279	1649	2220	3015	12	137.2	659699	5526888	64	16

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3	1110	1	180	N	J	64144	113	170	236	326	468	678	12	119.5	659712	5525734	38	95
3	1110	1	180	N	K	64155	461	615	771	962	1234	1621	12	114.6	659706	5524898	79	54
3	1110	1	180	N	L	64157	728	984	1249	1577	2042	2681	12	113.7	659705	5524754	80	40
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3	1801	1	90	N	H	66421	5	14	21	33	59	106	5	114.9	659146	5521803	0	0
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3	1802	1	270	N	B	66563	314	387	455	534	638	786	12	121.9	660174	5524527	92	56
3	1803	1	90	N	A	67247	245	295	338	416	537	710	12	101.2	654425	5527130	93	81
3	1803	1	90	N	B	67249	323	413	502	602	730	915	12	102.4	654532	5527127	82	77
3	1803	1	90	N	C	67251	215	264	311	367	441	542	12	105.5	654640	5527123	79	86
3	1803	1	90	N	D	67258	5	18	21	34	57	81	5	118.3	655102	5527109	0	0
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3	1803	1	90	N	F	67312	46	50	60	74	88	103	10	126.2	658652	5527112	41	134
3	1803	1	90	N	G	67321	70	79	98	125	166	230	9	135.6	659253	5527116	40	124
3	1803	1	90	N	H	67326	129	172	216	272	351	468	12	116.4	659621	5527113	54	101
3	1804	1	270	N	A	67443	53	85	121	170	244	350	12	125.9	660274	5529711	32	118
3	1804	1	270	N	B	67450	67	102	148	216	334	527	12	117	659678	5529714	35	118
3	1804	1	270	N	C	67454	24	33	46	66	97	136	12	117.7	659335	5529734	33	185
3	1804	1	270	N	D	67466	30	49	73	113	190	302	12	120.4	658291	5529777	31	155
3	1804	1	270	N	E	67471	74	129	199	306	492	798	12	122.2	657928	5529785	29	89
3	1804	1	270	N	F	67472	79	131	181	262	403	624	12	121.6	657813	5529785	30	91
3	1804	1	270	N	G	67478	28	49	82	144	260	419	12	125.9	657358	5529783	27	130

3	1806	1	104	N	A	68399	123	178	239	319	440	630	12	130.5	654040	5530382	46	85

Lionel Martin
1158 Pegasus Crescent
Greely (Ottawa), Ontario
K4P 1P1

Res/Messages: (613) 821-4648
Cell: (613) 220-7227
Email: lionel.martin@sympatico.ca

Mr. Dale Hendrick
President, Unitronix Exploration
Suite 901, 111 Richmond Street West
Toronto, Ontario
M5H 2G4

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STURGEON LAKE DATA ASSESSMENT (PHASE ONE)

DATA OF NORANDA INC. (LAVAL) AND INMET MINING CORPORATION (ROUYN-NORANDA)

Page

INTRODUCTION

The Sturgeon Lake volcanogenic massive sulphide (VMS) mining camp is located in the South Sturgeon Lake greenstone belt, approximately 250 kilometres northwest of Thunder Bay, Ontario. This mining camp has produced in excess of 17 million tonnes of base metals-hosting massive sulphide ore from six ore bodies. Production was active from 1971 to 1991 during which time ongoing exploration delineated limited additional reserves; insufficient to extend the life of the mining camp.

After 1991, exploration was subdued with most work being conducted by Noranda Inc. in the form of detailed field studies and digital data compilation. Most recently Unitronix Exploration became involved and acquired rights to a large package of land (the "Properties") through agreements with Noranda Inc. and Inmet Mining Corporation, and through sole-ownership staking. Unitronix is applying new and innovative exploration technologies, largely in computer applications and geophysics. On July 11, 2003 John Gingerich and Bruce Mackie reviewed the preliminary results of a MEGATEM survey flown over the Properties. The MEGATEM data is the "driver" to the anticipated follow-up drill campaign. Preliminary interpretations by John Gingerich and Michel Allard (Noranda Inc.) resulted in seven potential drill targets.

During August 2003 Lionel Martin traveled to the Noranda and Inmet field offices to undertake a pragmatic investigation of existing exploration data. The results and recommendations of this assessment are reported herein.

SUMMARY

After discussions with Dale Hendrick, John Gingerich and Bruce Mackie, a collation and assessment of existing geological, geochemical and drill hole information was commenced. The context is a support, filtering and prioritizing role to the drill targets being generated by John Gingerich (Geotechnical Business Solutions) and Michel Allard (Noranda Inc.) using results of the Unitronix/Noranda MEGATEM survey.

Project and archived data relevant to the MEGATEM survey area and Properties was examined at the Noranda office in Laval, Quebec, and the Inmet office in Rouyn-Noranda, Quebec. The Noranda data was disorganized and personnel were unable to present compilation maps or facilitate efficient data access. Nonetheless, the Noranda digital data appears to be reasonably robust (with resolvable gaps) due to recent electronic filing and compilation. The Inmet data was well organized although generally limited to the immediate vicinity of the Sturgeon and Lyon Lake deposits. This data provided excellent background information and several key areas of diamond drilling were revealed that are not on the current Noranda MapInfo compilation. There is no digital Inmet data.

The Noranda digital data platform will be used to finalize whether or not the preliminary MEGATEM targets have been previously drilled; thus far it appears that the targets are untested. The geological and geochemical information will assist in prioritizing the drill holes. At this stage of the review the geology supports the preliminary MEGATEM drill hole proposals and no "red-flags" exist at a property scale. The Inmet data corroborated existing stratigraphic trends and also provided information indicating the presence of desired felsic volcanism in the target areas. The Inmet files presented regional drill hole locations that will act as an excellent due diligence tool when the Noranda MapInfo compilation is completed. It appears that the existing Noranda digital database contains the drill holes not compiled into the MapInfo tables.

This review supports the strategy that the MEGATEM data plays the leading role for the anticipated Unitronix drill program.

It is concluded that an in-depth re-compilation and geological reconstruction exercise is not warranted. The extended efforts of George Hudac and Ron Morton of the University of Minnesota, the Geological Survey of Canada and industry have effectively updated the geology. The shortening of stratigraphic trends to the southeast of the Sturgeon Lake deposit from that of historic interpretations coincides closely to the new and higher resolution MEGATEM data, thus adding to the confidence of the current geophysical drill targeting. To repeat this geological exercise (with the voluminous data in the Noranda and Inmet offices) would add no value and is beyond the scope of this stage of targeting. In addition, there has been a significant effort by Noranda to compile the data digitally. The

existing MapInfo database appears robust in the areas adjacent to the Sturgeon Lake deposit and will be used to move forward.

Elsewhere on the Properties the stratigraphy presented by the MapInfo database is generalized and not all information is plotted. Outside of the detailed geology extending south and southeast from the Sturgeon Lake deposit the indicated mafic stratigraphy contains an abundance of favorable felsic units. From the Noranda perspective, Al Smith mapped felsic stratigraphy to the west of Claw Lake during reconnaissance work. This is plotted on field notes and maps that were not located during this data assessment. In support of this interpretation, the Inmet data was invaluable. Felsic volcanics are reported and presented on maps west of Claw Lake (in the area of preliminary MEGATEM target "b"), adjacently south of preliminary MEGATEM targets "c' and "d", and further south between Bell Lake and Glitter Lake (in the area of preliminary MEGATEM targets "e to g"). Falconbridge studies also report that many outcrops extending east from the productive horizons that were classified as andesite are actually rhyolite. The felsic geology will not be substantially improved upon without further detailed mapping and geochemical work, which is not required at this stage.

The review of Sturgeon Lake Mine stratigraphy extending to the area of preliminary MEGATEM target "a" indicates that the target is significant. Although drill holes in the vicinity must be assessed in detail based on expert GIS treatment and appropriate geo-referencing, the favorable contact of the Sturgeon Lake deposit appears to extend just south of target "a" where a series of exploration holes are plotted. A stratigraphic horizon has also been drill tested immediately to the north of this target. Due to the variation of felsic stratigraphy in this area (refer to Inmet discussion), and the existence of preliminary target "a" in the immediate extension area of productive stratigraphy, further investigation is required including compiling some key drill sections. Other than tracks/access roads there is no evidence of a cultural source to this anomaly; this must be verified in the field.

The Inmet database includes 31 holes plotted on the Claw Lake Property (Santa Maria option circa 1970's), and a hole adjacently north of the property boundary in the Swamp Lake area. There are no corresponding MEGATEM anomalies, however, these will provide due diligence to the Noranda drill hole database that has yet to be brought into the MapInfo compilation. Other drill areas that will provide due diligence are along the southernmost MEGATEM formational conductor (area of preliminary MEGATEM targets "e" to "g"), and extending southeast from the Sturgeon Lake deposit past Swamp Lake (area of preliminary MEGATEM targets "c" and "d"). These are largely Noranda holes and are not on the current MapInfo compilation, nor do they appear to have tested the preliminary MEGATEM targets.

The diamond drill hole database of Noranda is (apparently) complete and will be critical to ensure the preliminary MEGATEM targets are valid and untested. The MapInfo diamond drill hole database will be updated with this information, and cross-referenced to the above due diligence information discovered at the Inmet office. This is the priority at this time. It is certain that preliminary MEGATEM target "a" has several drill holes in the vicinity and these are on a portion of the MapInfo compilation where drill data is complete. Elsewhere on the property and regarding MEGATEM targets "b" to "g" the MapInfo database requires updating to ensure that holes in those areas have not tested these preliminary targets. The historic holes are more regional in nature and were confined to shallow 1969 to 1972 follow-up to the old Questor Mark V survey.

Based on information assessed to date, preliminary MEGATEM target "a" remains valid, and preliminary MEGATEM targets "b to g" appear to be new and untested. All targets are potentially within preferred volcanic stratigraphy. Regionally the stratigraphy is prospective due to extension of the South Sturgeon Lake greenstone belt and productive Sturgeon Lake Mine stratigraphy onto the untested areas of the optioned (and recently staked) ground. The presence of felsic stratigraphy at a property scale where the preliminary MEGATEM targets have been defined is considered promising.

A large collection of data has been copied onto several CD-ROMs to be used to finalize property scale maps. As well, a library of historic information has been placed on CD-ROMs; this will be worthwhile to have with Unitronix in the event the program moves past the initial drill stage.

Refer to Figure 1 at the end of this report for a comparison of preliminary MEGATEM targets "a" to "g" (after J. Gingerich, July 2003), versus preliminary assessment of previously drilled areas.

RECOMMENDATIONS

The MEGATEM survey represents a significant advancement for drill hole generation in the area of the Properties and is proposed to remain the driver for the initial Unitronix drill campaign.

Stratigraphically the preliminary targets generated by the MEGATEM survey are valid. The potential for on-strike, stacked or dislocated productive horizons is supported by the current geological understanding and the MEGATEM results. No further stratigraphic reconstruction is proposed at this early stage of drill targeting.

The priority recommendation is that a GIS expert completes/cleans up the MapInfo drill hole database (with all the information that has been collected). This upgrading is required to determine with further accuracy whether or not the preliminary MEGATEM drill targets have been previously and adequately tested. Where previously drill tested it must be determined if room remains for additional drill targeting and if the enclosing stratigraphy is valid. Due to the regional and early stage targeting of this program it is recommended that a radius of 200 metres be used around the preliminary MEGATEM targets to locate drill holes that might impact on the prioritization process.

In the vicinity of MEGATEM target "a", extending from the Sturgeon Lake productive horizon, there has been abundant drilling. Upon completion of the MapInfo database detailed cross-and long-sections are required to reference and fine-tune this MEGATEM target. This will need to incorporate geological logs for holes 23-129, -216, -274A, -275, -300B, -309 and SLM-187.

It is recommended that further drill target prioritization is conducted through the creation of property scale base and precious metals geochemical maps. The MapInfo database is disorganized albeit it appears complete in this aspect, thus it is recommended that the data be sent to a GIS expert for structuring and plotting.

Following conversion/entry of the full drill hole database into the MapInfo tables, a final property scale geological and drill hole compilation map may be produced for general reporting purposes. It is recommended this be completed concurrent to the above recommendations. For due diligence a cross-reference to drill holes found in the Inmet paper files is recommended. This covers stratigraphy west of Claw Lake (in the area of preliminary MEGATEM target "b"), further south between Bell Lake and Glitter Lake (in the area of preliminary MEGATEM targets "e to g") and along the trend of preliminary MEGATEM targets "c" and "d".

No further investigation of the Noranda pdf and map tube database and Inmet paper files is recommended prior to the initial Unitronix drill campaign.

Field evaluations are recommended to;
-verify MEGATEM target "a" for possible cultural effects if final data assessment shows the target is untested,
-assess mine site data,
-review stratigraphy in all target areas where reasonably possible,
-review any field highlights via Noranda representative.

LOCATION AND ACCESS OF THE STURGEON LAKE AREA

The Sturgeon Lake properties optioned and wholly owned by Unitronix Exploration are located in the Patricia Mining Division of Ontario, approximately 250 kilometres northwest of Thunder Bay, Ontario and 50 kilometres north of Ignace, Ontario. A paved 20-kilometre all-weather road links the near-by Sturgeon Lake Mine property to Highway 599 approximately 0.5 kilometres north of the village of Silver Dollar. A network of gravel roads and secondary logging and drill roads branch off of the Sturgeon - Lyon Lake Mine Road, and traverses the ground of interest.

HISTORY OF THE STURGEON LAKE MINING CAMP

Early exploration in the Sturgeon Lake area in 1898 resulted in the discovery of the St. Anthony and Darkwater Gold Mines. Gold and silver were mined at the St. Anthony Gold Mine between 1905 and 1941, and limited development with no production was undertaken at the Darkwater Mine.

Exploration for base metals commenced in the 1960's and was extensive. In 1969 the Mattabi deposit was discovered by Mattagami Lake Mines during follow-up of a Questor Mark V Input survey. The deposit was discovered on a block of claims that were optioned from Abitibi Paper Company Limited. Mattabi Mines Limited was established and the deposit was mined by open pit method from 1972 to 1980, and subsequently produced as an underground operation until depletion of the ore in 1988. Other follow-up of AEM anomalies west of the Mattabi deposit resulted in the discovery of the smaller F-Group ore body in 1981, and open pit mining began the same year.

In 1970, Falconbridge Nickel Mines Limited discovered the Sturgeon Lake Mine ore body during follow-up of an induced polarization anomaly. The property was originally staked by N.B.U. Mines Limited and was optioned to Falconbridge. Open pit mining began in 1974 and the ore was exhausted in 1980.

Stratigraphic drill testing of the Sturgeon Lake Mine Horizon on the Group 23 property by Noranda resulted in the discovery of the Falconbridge Boundary Zone in 1971. The two claims hosting this extension to the Sturgeon Lake Mine ore body were leased to Falconbridge. Continued drilling of this productive horizon resulted in the discoveries of the Lyon Lake Zone in 1971 and the Creek Zone in 1972. The Sub-Creek Zone was discovered in 1974 while deep drill testing on a proposed shaft site. Production from these deposits began in 1983 and ceased in 1991 following depletion of ore.

Abitibi Price discovered the sub-economic Abitibi Deposit (87W Zone) in 1981 while in-fill drilling around deeper anomalies previously defined by Mattagami Lake Mines. This zone is interpreted by previous geologists to represent the down-plunge extension of the F-Group deposit. Definition drilling has been unsuccessful in outlining any significant size.

Recent exploration (1990's) has been limited to small programs by Rio Algom Exploration Inc. and Noranda. Of most benefit to the herein reported program is the recent work conducted by Noranda, universities and the Geological Survey of Canada, resulting in up-to-date geological interpretation and a collection of digital data.

GENERAL GEOLOGY OF THE STURGEON LAKE AREA

The Sturgeon Lake volcanogenic massive sulphide (VMS) mining camp is located in the South Sturgeon Lake greenstone belt approximately 250 kilometres northwest of Thunder Bay, Ontario. The South Sturgeon Lake greenstone belt consists of a +8800 meter thick west-northwest facing, north dipping (70-75°) sequence of mixed tholeiitic/calc-alkalic volcanics forming the southern limb of a syncline. The volcanic pile rests on Archean gneissic basement, and is intruded by syn-to post-volcanic plutons, sills and dykes. The north facing, steeply dipping nature of the South Sturgeon Lake assemblage has resulted from folding about an east-west axis with the fold axis situated in the south part of Sturgeon Lake. A weaker deformation about a north-south axis produced a gradual concave arching to the east, with a change from 90° strikes in the Mattabi Mine area to 120° strikes in the Lyon Lake area.

Laterally extensive mappable units originally recognized as distinct volcanic cycles by Mattagami Exploration personnel were grouped into a number of volcanic cycles by Franklin and other GSC workers (1977), with each cycle beginning with mafic to intermediate volcanic flows and terminating with felsic pyroclastic events. A thin sedimentary layer caps each cycle. Subsequent mapping by Trowell (1983) confirmed the cyclical nature of the volcanism, although his interpretation of the belt as a simple north-facing homoclinal sequence was suggested to be an over-simplification by Morton and co-workers (1990) and that the observed thickness was probably due to thrust repetition of the stratigraphy.

Detailed re-mapping of much of the mining camp along with volcanological/stratigraphic studies have been completed by Ron Morton (University of Minnesota) and various graduate students over the last decade. Their work suggests the South Sturgeon Lake assemblage represents a large submarine caldera complex, with 5 separate caldera-collapse events each marked by ash tuff horizons. They have demonstrated the importance of volcanism and synvolcanic structures in controlling the occurrence and location of VMS deposits in the camp. The stratigraphic succession and setting of each ore body as resolved by Morton is presented in Table 1.

TABLE 1 - STRATIGRAPHY AND VMS DEPOSIT SETTINGS

NORANDA 1980	MORTON 1990	THICKNESS	DEPOSIT LOCATION
Upper Cycle	No Name Lake Succession	1000 m to 3000 m	
Lyon Lake Cycle	No Name Lake Succession	1000 m	
N.B.U. Cycle	L. Succession	1650 m (+)	Lyon Lake + Sturgeon Lake
	Mattabi Succession		Mattabi B, C, D
	Tailings Lake Succession		Mattabi E
Mattabi Cycle	High Level Lake Succession	3000 m (+)	F-Group
	Jackpot Lake Succession		
	Darkwater Lake Succession		

ORE DEPOSIT FORMATION

The Sturgeon Lake base metal orebodies all occur at or near the top of two volcanic cycles and are in three distinct horizons at three stratigraphic levels (see above Table 1). Stratigraphically lowest, the F-Group formed during deposition of the High Level Lake ash flow tuff deposits. The Mattabi deposit formed slightly higher in the stratigraphy within the Mattabi Succession, the most voluminous eruptive event in the caldera. The Sturgeon Lake Mine, Lyon Lake and Creek Zone massive sulphide deposits formed within the later pyroclastic sequence of the L Succession (or N.B.U. Cycle), immediately above the Mattabi Succession. Table 2 below provides a summary of the grades and tonnages of the main Sturgeon Lake volcanogenic massive sulphide deposits and occurrences.

TABLE 2 – DEPOSIT TONNAGES AND GRADES

(Noranda Inc. and Inmet Mining Corp. reference from general files – converted to metric)

	Size(million metric tonnes)	Zn (%)	Cu (%)	Pb (%)	Ag (gpt)	Au (gpt)
Mattabi	11.69	7.60	0.91	0.85	97.36	0.218
F-Zone	0.57	8.10	0.98	0.49	55.99	
Sturgeon Lake	1.91	10.64	2.98	1.47	190.98	0.653
Lyon Lake	2.76	5.85	1.12	0.59	94.56	0.218

Creek Zone	0.83	8.85	1.66	0.76	146.50	0.591
Sub-Creek Zone	0.28	11.0			159.87	
Abitibi (87W) Zone	? Best DDH (12.8 m)	5.65	1.25			
Simax Oil & Gas	? Best DDH (4.3 m)	0.64	2.62			
Area 17 Zone (Abitibi)	? Best DDH (2.1 m)	1.4	0.17			

DISCUSSION OF NORANDA INC. DATA REVIEW (LAVAL)

General

Data in the Laval office is voluminous and comprises a large scanned collection of historic reports and data, a large collection of maps and miscellaneous data stored in map tube files, and an extensive collection of digital data and MapInfo files. The review of data in these three mediums is discussed below.

The data was disorganized, and Noranda was unable to present compilation maps or facilitate efficient access to information. After a brief telephone discussion with Al Smith of the Falconbridge Ltd. Sudbury office it was further confirmed that within the Noranda Group he is the most knowledge of this property.

A listing of collated data on CD-ROM is included at the end of this report.

Digital Data (not including pdf files)

Although Matt Rees (Senior Project Geologist – Noranda Inc.) was not available at the time of review, Matt did provide several digital files on CD-ROM, and access to files on the Noranda/Falconbridge server. The data is a catch-all collection of MapInfo tables, GEMCOM and Bore Serve drill hole files, geological and geophysical reports, monthly reports, contacts lists, miscellaneous Document and Power Point files, project support and other non-value added information.

The most significant data is the Noranda MapInfo tables and Bore Serve diamond drill hole database. These will be used to complete the evaluation of the preliminary MEGATEM targets, and to provide presentation and working maps. It is noted that although the data is geo-referenced and relates well to itself, there is an NAD shift that does not correspond to the more accurate MEGATEM data positioning, thus the data cannot be overlain directly on the new geophysical information. In the event re-registering the data is problematic relative to the requirements of this project, the MapInfo and MEGATEM maps can be correlated sufficiently using reference points. The objective is to validate-prioritize the MEGATEM drill targets with geochemistry and geology, and determine whether there has been previous drilling.

The MapInfo database is complete regarding geological and chemical information; however, important regional drill hole data is lacking. In the vicinity of the Sturgeon Lake Mine the drill hole database is complete and the density of drill spacing is significant. Outside of the known productive horizon drilling has been scattered and is generally confined to 1969-1972 shallow drill hole follow-up to the 1960's Questor Mark V Input survey. Of these holes, only those re-logged for the Hudac/Morton interpretations are in the MapInfo database.

The drill hole database has been copied onto CD-ROM for Unitronix, and is largely spread between Noranda's previously used Bore Serve format and MapInfo. The Bore Serve data can be readily converted into MapInfo tables. For the purposes of the Unitronix exercise the drill hole collars will be transferred into the MapInfo compilation via Ascii files. Should any holes exist in the vicinity of the preliminary MEGATEM drill targets, the drill log data may be accessed through conversion to text files. It is recommended that all the data be converted to accommodate the MapInfo compilation especially if the project continues past the initial Unitronix drilling stage.

The drill hole database will be critical to ensure the preliminary MEGATEM targets are valid and untested. This is the priority. At this stage it is certain that MEGATEM drill target "a" has several drill holes in the vicinity and these are on a portion of the MapInfo compilation where drill data is complete. Following further database manipulation by a GIS expert (contacted by John Gingerich) the appropriate drill information will be evaluated.

Elsewhere on the property and regarding MEGATEM targets "b" to "g" the MapInfo database requires updating. The review of paper data suggests that this regional drilling has not tested the preliminary MEGATEM targets and was confined to shallow 1969 to 1972 follow-up to the early Questor Mark V Input survey. This will be validated.

During discussions with Unitronix, reference has been made to a set of longitudinal sections completed along the productive horizons (by Al Smith). These are located as AUTOCAD files on the CD-ROM directory line of "Kruser > Sturgeon > Longsect.dwg > Highlake.dwg, Lyonlake.dwg and Mattsucc.dwg". There are three main longitudinal sections broken into different figures (i.e. A-A', B-B', C-C') to accommodate changing strike. These may be useful for presentation purposes.

Reflecting the robustness of the Noranda MapInfo geological compilation is that it has incorporated the recent academic interpretations. The detailed geology immediately south and southeast of the Sturgeon Lake Mine presents a shortened known productive horizon in contrast to the historical interpretations. This corresponds well with the new and higher resolution MEGATEM data, thus adding to the effectiveness/confidence of the current geophysical drill targeting.

At a property scale the stratigraphy presented by the MapInfo database is acceptable, although not all information is plotted. The area of detailed geology extending south and east from the Sturgeon Lake Mine includes all available data, and is the product of over a decade of work by George Hudac and Ron Morton (University of Minnesota), the Geological Survey of Canada, and industry. This is considered a valid product not requiring improvement for the purposes of the anticipated Unitronix drill campaign. However, further south (west of Claw Lake) the mafic stratigraphy contains favorable felsic units that were noted during reconnaissance work by Al Smith. These are plotted on field notes and maps that were not located during this data assessment. The impact of knowing that this felsic stratigraphy exists is positive in the conceptual sense, and the lack of detail is not critical for the MEGATEM targeting. The geology will not be substantially improved upon without further detailed mapping and geochemical work. Also refer to the felsic volcanic references in the Inmet data discussion to follow.

PDF Files (Archived Data)

During consolidation of Noranda's field offices an extensive exercise of scanning data into pdf files was completed to save on expensive storage space. The original data has been destroyed. For the area of NTS 52G14 and 15, which encompasses the Properties, approximately 1200 pdf files have been catalogued.

A selected/random check of approximately 10% of the database was completed. The data is generally historic information and is very diverse – geological, geophysical and geochemical reports, sample records, assays, general correspondence, property submissions and evaluations, field book notes, assessment reports, prospecting notes and sketches, claim maps, diamond drill hole records, legal data, and etc. All told, the data is a collection of archived historic files Noranda maintained over the decades in paper format, and represents historic value rather than meaningful information for current targeting priorities. All data of consequence is effectively captured by the MapInfo and digital diamond drill hole database, with the historic work representing the ramping up to achieve current understanding.

This data has been assessed to meet the current exploration objectives.

A library of these pdf files has been placed on CD-ROM and will be provided to Unitronix Exploration.

Map Tube Files (Archived Data)

A collection of more than 50 map tubes has been warehoused for the NTS 52G14 and 15 map sheets, which overlap the Properties. The map tubes are roughly organized within a larger inventory and contain a variety of geological, geochemical and geophysical maps, diamond drill hole sections, mine sections and plans, and support information spanning from the late 1950's into the 1990's. A large number of selected map tubes were opened and the data reviewed. The data pre-dates the current MapInfo compilation where it is captured with the exception of some detailed work. This was verified by discussions with Noranda staff, and validated by a semi-randomized review of the data. No obvious "red flags" were noted in the process.

The map tubes are not catalogued in a manner by which data can be directly correlated to a particular area. It is a bulk collection of data with a generic data-type description for each map tube. In effect this data is more for historic value.

Assessment of the map tube drill hole data verified that not all information has been entered into the MapInfo database. However, this information has been captured separately in Bore Serve digital format (communication with Al Smith, August 6, 2003) – see above discussion of digital data.

This data has been assessed to meet the current exploration objectives.

DISCUSSION OF INMET MINING CORPORATION DATA REVIEW (ROUYN-NORANDA)

General

Data in the Rouyn-Noranda office comprises eight well-organized banker boxes, and loose maps that have been mixed over the years with those of several closed offices. The data was easy to work with – when items of interest were found the data was sufficiently organized to locate additional background details. The information is generally limited to the vicinity of the Sturgeon and Lyon Lake deposits (but not exclusively), and is not digital. There is mine-site and exploration data ranging from technical to administrative. It provided excellent background and served its purpose well. Several key areas of diamond drilling were discovered that were not observed during the Noranda Inc. Laval office review.

Inmet has not worked this area since the mid-1980's. During those reducing exploration years some deep drilling was conducted south of the Sturgeon Lake deposit to follow-up pulse-EM surveys. The holes were in the range of 300-metres down-hole and at best encountered good alteration (not described). Communication with Gerald Riverin (Inmet) indicated that there were likely coupling errors and that the drilling was not effective. This does not overlap the area of preliminary MEGATEM target "a".

In general the various project maps correspond well to the upgraded Noranda MapInfo compilation. In favor of the preliminary MEGATEM drill targets, the Inmet data was encouraging. There is an abundance of felsic stratigraphy outside the area of detailed geology (on the Noranda compilation) where coarseness of the data only presents unclassified mafic stratigraphy. This impacts on preliminary MEGATEM targets "b" through to "g".

Within the Inmet property where the drill spacing is most tight (surrounding the Sturgeon Lake deposit, extending east to the property boundary, and to the south and west), the Noranda digital database overlaps the Inmet data. In this area of dense drill spacing there are some holes that exist on Inmet maps that are not on the Noranda compilation (i.e.: Falconbridge Copper Limited – Lyon Lake Mine – Sturgeon Lake Mine Sketch of Area Geology 1":400' May 1978), and the inverse also occurs. Fortunately the density of drilling in the Noranda digital database facilitates a detailed picture of the geology and provides information that exceeds the requirements of this program. Drill data in the area of preliminary MEGATEM target "a" appears complete, with the inconsistencies occurring to the west near the past producer.

Discussion regarding preliminary MEGATEM target "a"

This target occurs to the southeast along general strike of the Sturgeon Lake Mine stratigraphy. There are roads in the area (of the anomaly), but there is no evidence of workings that may have resulted in a cultural source to the response. This will need to be verified prior to drilling. The area has experienced a high degree of exploration drilling, limiting the upside potential of this target. The geological, geochemical and drill data must be geo-referenced to fit with the MEGATEM data, however, this discussion assumes that the current fit is reasonable for general observations.

The area south and extending southeast of the Sturgeon Lake deposit (over preliminary target "a") has received detailed geological/geochemical studies aimed at generating advanced stage drill targets and meeting academic challenges. The drilling appears to have focused on the Sturgeon Lake interface interpreted to extend just south of preliminary target "a". Another horizon has been tested parallel to this interface just to the north of the target. It appears that preliminary target "a" may be untested due to lack of earlier detection. A detailed review of holes and sections is required following accurate positioning relative to the MEGATEM data.

Drill holes SLM-187, 23-129, -216 and –219 occur in the stratigraphy immediately south of preliminary target "a". These holes comprise a favorable mafic to felsic interface. Unlike the Sturgeon Lake stratigraphy, which comprises a mafic contact with underlying quartz-porphyry-rhyolite and then rhyolite tuff, these holes do not have the quartz-porphyry-rhyolite component. It is noted, however, that this component does not occur at Mattabi and the F-Zone either. Holes 23-274A, -275 and –300B were drilled along stratigraphy immediately north of preliminary target "a" and the end of hole 23-274A may have tested an edge of the target. Hole 23-309 was collared east along strike of the target.

Logs for holes SLM-187, 23-129, -216 and –219 indicate a greater volume of felsic volcanism than displayed on surface maps. This bodes well. The lack of recognized quartz-porphyry-rhyolite is not proposed as a reason to abandon preliminary MEGATEM target "a". Variation of felsic geology is not considered a deterrent to grass roots testing of new concepts/applications in prospective felsic terrains (especially in consideration of the cyclical nature of this stratigraphy, variation of interface models, and the occurrence of satellite deposits such as Lyon Lake and the Creek Zone).

In John Gingerich's Unitronix Exploration – Sturgeon Lake AEM report, dated July 2003, there is reference to two horizons having been tested extending southeast from the Falconbridge (Inmet) property onto the Noranda ground (and in the area of preliminary target "a"). One horizon trends towards preliminary target "a" and is the interpreted extension of the productive Sturgeon Lake Mine stratigraphy. This horizon remains a priority. The second horizon, to the south of the Sturgeon Lake deposit, has lithogeochemistry displaying typical volcanogenic massive sulphide-type alteration. This horizon is interpreted as a possible extension to the lower cycle Mattabi horizon and remains partially untested to the east. Of significance is that this horizon has received intensive drill exploration and the discovery of the uneconomic 49 Stringer Zone. Based on current modeling whereby this lower horizon is truncated to the east, and combined with priority MEGATEM targets elsewhere, follow-up of the lower horizon is not recommended at this time.

Also refer to geochemical discussion below for reference to preliminary MEGATEM target "a".

Discussion regarding preliminary MEGATEM targets "b" to "g"

The Inmet data focuses on the ground surrounding and closely extending from the Sturgeon Lake deposit. Elsewhere on their large property, Inmet and predecessor exploration has been limited. This exploration was regional in nature and largely comprised geochemistry, reconnaissance mapping, ground electromagnetic follow-up to Input anomalies, and shallow drilling. The corresponding drill data is anticipated to exist on Noranda's Bore Serve database (especially since much of the drilling is historic Noranda work). A due diligence cross-reference is possible, and will be described below.

For Inmet (Falconbridge), the regional work was carried only to a level required to maintain the claims in good standing (200 man-days per year per claim method). This procedure now provides Unitronix with an opportunity at a property scale to explore new and untested targets.

Claw Lake Area – In the area of Claw Lake the Noranda digital database displays a claim group for which an Inmet paper copy was reviewed; the Lyon Lake Mines Limited – Santa Maria Option. The archived map displays 31 drill holes (L.L.M.-1 to 31), however, the drill logs were not found. In addition, hole SL-51-72-10 is plotted adjacently to the north on the Swamp Lake Property. The Claw Lake holes are located approximately halfway between preliminary MEGATEM targets "b" and "d", and extend east-southeast to Claw Lake. Although there is magnetic relief, there are no AEM anomalies in this area (including MEGATEM). These holes have no impact on the preliminary MEGATEM targets, however, their presence will provide due diligence for the upgrading to be conducted on the Noranda MapInfo compilation. A general location has been hand-drawn on a MEGATEM map on file with Lionel Martin.

Felsic Volcanic Reference - General – To add to Al Smith's (Noranda Inc.) recognition of felsic volcanics outside the area of detailed mapping, further support was noted in the Inmet data. During the Falconbridge mapping campaigns in the 1970's to evaluate for possible eastern extensions of the Mattabi horizon, thin section studies noted that many of the outcrops field classified as andesites are rhyolites. When combined with Al Smith's more recent recognition of felsic volcanics in the southern survey area, this provides additional evidence of favorable stratigraphy to a greater extent than exhibited by the existing and "up-to-date" Noranda compilation. This supports the interpretation of favorable stratigraphy the areas of the preliminary MEGATEM targets.

Felsic Volcanic Reference - Area of preliminary MEGATEM targets "b", "c" and "d" – An interpretive map (Falconbridge Nickel Mines Limited; R.N. Saukko, 1975) depicts felsic horizons extending generally east-southeast in the vicinity of preliminary target "b", and adjacently south of targets "c" and "d". Felsic volcanics near "c" and "d" were frequently observed on reports and maps viewed in the Inmet and Noranda offices.

Area of preliminary MEGATEM targets "c" and "d" – A significant number of holes are plotted on the Noranda compilation extending east-southeast from the Sturgeon Lake deposit, and past preliminary MEGATEM target "a" to the west side of Swamp Lake. This coincides with the Inmet data. A regional compilation of drill holes on an air photo mosaic in the Inmet archives also shows this intense drilling to continue southeast of Swamp Lake to Claw Lake, and is represented as being on Noranda's Group 23 Property. No drill hole numbers are provided. This information does not show up on the existing Noranda MapInfo compilation. The holes are along a formational conductor with preliminary MEGATEM targets "c" and "d" occurring along the north flank. These targets also flank the south side of a stronger formational conductor to north. Targets "c" and "d" appear to be new and untested, and will receive final validation from the upcoming GIS processing. As above, these holes will also provide due diligence to the completeness of the final digital product. The general location of these holes has been hand-plotted on a MEGATEM map on file with Lionel Martin.

Felsic Volcanic Reference - Bell Lake Claims – Area of preliminary MEGATEM targets "e", "f" and "g" – Further reference to felsic tuffs is made for the area coincident to the southernmost preliminary targets "e" to "g". M.J. Knuckey (Lake Default Mines Limited; 1976) recommended the staking of the Bell Lake Claims. This was predicated on the interpretation of repetition of the Mattabi Horizon and possibly the Sturgeon Lake Horizon towards Bell Lake. Although a 1975 Aerodat Survey did not extend to this property, M.J. Knuckey reported that Noranda Exploration and New Territorial Uranium both drilled airborne anomalies in the area. Apparently massive sulphides with local trace chalcopyrite were encountered. The drill logs were not located in the Inmet office (holes B-1 to B-6, and 70-1 to 70-5), but will be cross-referenced to the Bore Serve data that will be incorporated into the Noranda MapInfo compilation. It appears that none of the preliminary MEGATEM targets have been tested by these holes based on cross-referencing between maps. No evidence of later drilling by Falconbridge or Inmet was discovered in the data search. The general location of these holes has been hand-plotted on a MEGATEM map on file with Lionel Martin.

Historical observations relevant to MEGATEM as a program driver

Historical evaluation of the Inmet data emphasizes the importance of geophysics to the discoveries along the South Sturgeon Lake greenstone belt. All of the deposits were discovered as a result of follow-up to airborne geophysics. At Lyon Lake two holes (totalling 424 metres) were drilled on Input anomalies and encountered barren sulphides in the underlying footwall iron sulphide facies. The discovery hole was 30 metres to the north. Mattabi was also a first priority Input anomaly.

The airborne data was clearly the driver to the early and successful discoveries, which have since waned. There is a predominance of magnetics coinciding with formational conductors (sulphide-magnetite), and the presence of important isolated anomalies. This strategy is essential when considering the advantages of the higher resolution and deeper penetrating MEGATEM system (i.e. Matagami, Quebec, Perseverance discovery in 2000). Regarding the improved discriminating capability of MEGATEM, an excellent analogue to the potential of new anomalies is the history of the F-Zone discovery in 1981, to the west along similar stratigraphy.

-"Input anomaly along lake shore,

-Crone JEM located conductor but did not detect any conductors on land to the south,
-2 holes in original conductor cut black argillite with pyrite,
-Radem VLF picked up original conductors plus several more to the north and one over a ¼ mile to the south,
-first ddh on southern anomaly cut 29 feet of massive sulphides (16% Zn, 1% Cu),
-a weak VLF disturbance 800 feet south of the discovery holes was drilled (6 feet and 12 feet of 8% Zn)."

General Geological Comments

As established with the Noranda data, review of the Inmet data concludes that the known stratigraphic and geological interpretations do not warrant refining at this stage of the program. The stratigraphy is concluded to be prospective regarding the new MEGATEM data and targets.

It is interesting that although the Lyon Lake deposit lacks an alteration pipe in the conventional sense, chlorite, garnet, carbonate, and pyrite-magnetite veins permeate the coarser footwall rocks. This describes (somewhat) the alteration that is typically ascribed to pyroclastic dominated volcanogenic massive sulphide deposits. In contrast, there are well-defined alteration pipes at Sturgeon Lake and Mattabi. When targeting, the explorer will need to be cognizant of both alteration system types, each having a recognizable but different footprint. Some past workers interpret that the Lyon Lake and Creek sulphides are satellite deposits; this setting and its impact on targeting must also be prepared for.

General Geochemical Comments

The detailed geochemical data in the Inmet files does not warrant in-depth study at this time due to the fragmented and variable nature of the data, and the scope of this program. This is offset by a large geochemical database that has been incorporated into the Noranda MapInfo compilation. Property scale maps are planned to be generated from this data to assist in target filtering and prioritizing.

In the area of focused exploration near the Sturgeon Lake deposit, lithogeochemical study has been detailed. This overlaps the Sturgeon and Lyon Lake deposits, the Creek Zone, ground to the immediate south, and ground to the east covering preliminary MEGATEM target "a". The Sturgeon Lake deposit is hosted by stratigraphy displaying textbook alteration (sodium depletion, potassium enrichment, and various classical indices). Similar alteration patterns also occur to the south where detailed drilling has encountered uneconomic stringer sulphides of the 49 Stringer Zone. This area may be an extension of the lower cycle Mattabi stratigraphy. As corroborated by the MEGATEM survey, this stratigraphy is truncated to the east, just northwest of preliminary MEGATEM target "b".

The area of preliminary MEGATEM target "a" does not possess the classical alteration patterns observed at the Sturgeon Lake deposit; neither does the stratigraphy containing the Lyon Lake deposit. The Lyon Lake deposit was an underground operation, comparing somewhat to the deep nature of preliminary target "a" (>200 metres).

REFERENCES

Falconbridge Ltd./ Noranda Inc. – Al Smith, Senior Project Geologist; personal communications, August 6, 2003
Geotechnical Business Solutions – John Gingerich; Unitronix Exploration – Sturgeon Lake AEM, July 11, 2003
Inmet Mining Corporation Rouyn-Noranda, Quebec Office – Files
Noranda Inc. (Laval, Quebec Office) – Database and Files

LIST-DESCRIPTION OF CD-ROM DATA COLLATED FOR UNITRONIX EXPLORATION

a) CD-ROM Sturgeon Lake MapInfo files
-needs to be re-registered – NAD shifts
-workspaces will not directly overlay MEGATEM data

b) CD-ROM Sturgeon Lake Archive Data

-Geotech1 – Diamond Drill Hole data
-Geotech2 – geochemistry, MapInfo files
-Kruse – survey data, miscellaneous Power Point files, MapInfo, geochemistry, etc.
-Smith A. – Diamond Drill Hole data/logs, MapInfo files, geophysical reports and data, miscellaneous and monthly reports, loose project data, unrelated data

c) CD-ROM Sturgeon Lake ARCHIVE #1
-Noranda PDF files – 52G14-001 to 274
-Canadian Map Tube Database
-Ontario Map Tube Database

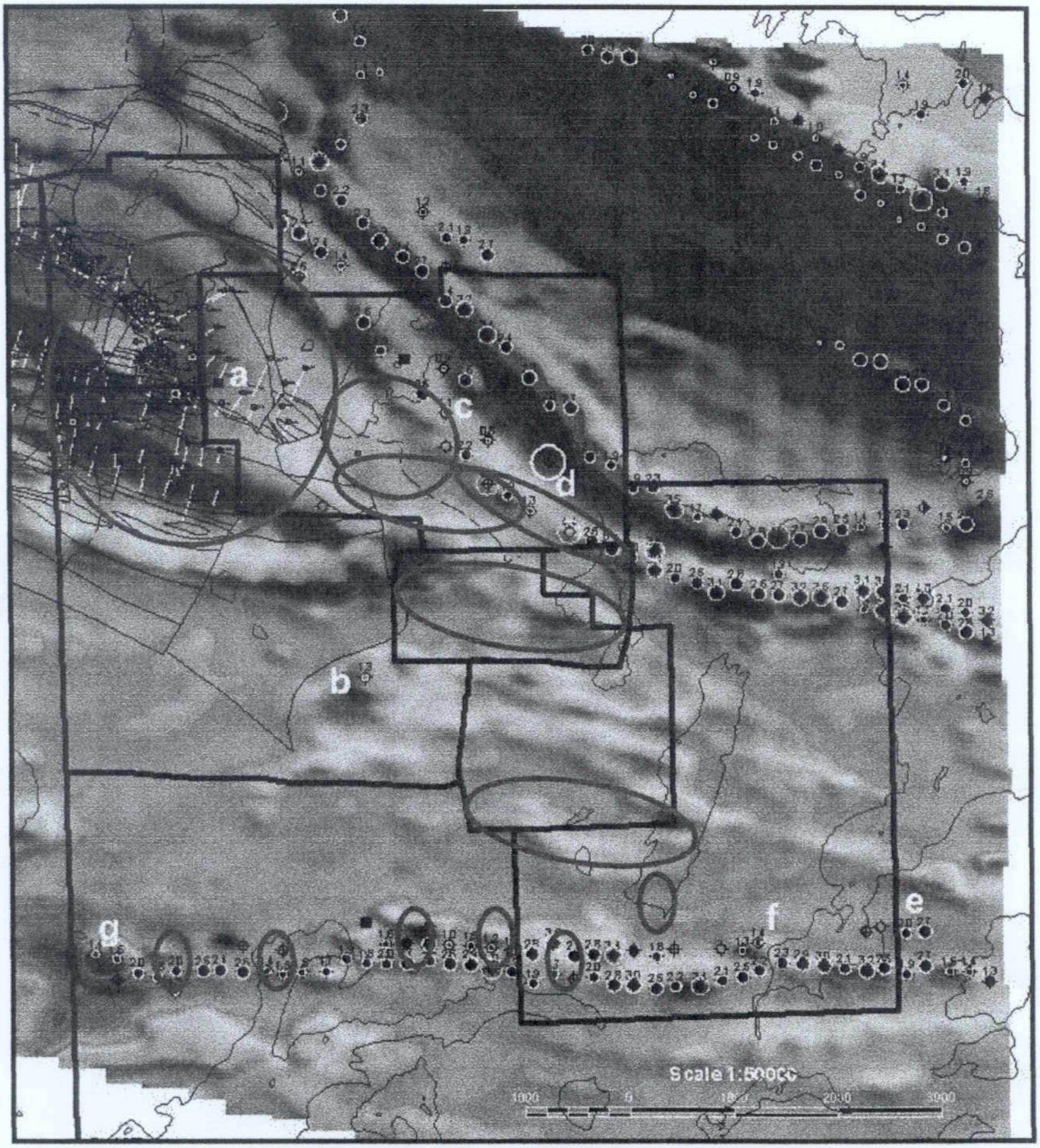
d) CD-ROM Sturgeon Lake ARCHIVE #2
-Noranda PDF files – 52G14-275 to 289
-Noranda PDF files – 52G15-001 to 158

e) CD-ROM Sturgeon Lake ARCHIVE #3
-Noranda PDF files – 52G15-159 to 463

f) CD-ROM Sturgeon Lake ARCHIVE #4
-Noranda PDF files – 52G15-464 to 729

g) CD-ROM Sturgeon Lake ARCHIVE #5
-Noranda PDF files – 52G15-730 to 779
-Sturgeon Lake pdf data reference list

FIGURE 1
PRELIMINARY MEGATEM TARGETS "A" TO "G" (AFTER J. GINGERICH, JULY 2003)
VERSUS PRELIMINARY ASSESSMENT OF PREVIOUSLY DRILLED AREAS



"a" to "g" = preliminary MEGATEM targets proposed by John Gingerich

◯ = areas previously drilled based on August, 2003 data assessment

***G**eotechnical **B**usiness **S**olutions*
5623 Goldenbrook Drive, Mississauga, Ontario L5M 3W2 (905) 821-2872

Unitronix Exploration
Mr. Dale Hendrick, President
111 Richmond St West, Suite 900
Toronto, Ontario

July 11, 2003

Re: Unitronix Exploration – Sturgeon Lake AEM

On Thursday July 10, 2003 Bruce Mackie and I traveled to Montreal to review the preliminary results of the MEGATEM survey and available historic data. In attendance were Matt Reese and Michel Allard and we briefly talked with Al Smith via phone as he could not attend due to other commitments. While we were able to review the airborne data in detail, Noranda was unable to provide much information at this time with respect to historical work. Compilation and consolidation of this information is a priority. Given the reorganization and relocation of Noranda personnel and offices, this will be a significant undertaking that should commence as soon as possible.

The final airborne EM data will be forwarded to me once it has been leveled and the interpretations of Fugro and Michel Allard have been completed. The final numbers have not been determined but it would appear that the Unitronix dataset comprises approximately 600 line kilometers flown at 200m spaced lines. The line spacing was increased from the 150m recommended separation because of budget considerations. Thus short strike length, offline conductors may not be resolved by this survey. However, this is not expected to significantly affect our ability to find larger (economic) targets. The data quality appears to be very good and we can expect maximum performance (~250m) for target detection nadir to the survey lines.

General

A comparison of the preliminary AEM anomaly picks (black circles, figure 1) and those from previous airborne surveys (red circles) clearly shows the superior performance of the MEGATEM system. A number of conductive trends (formational conductors) that were sporadically resolved are now completely mapped. In addition to resolving the major conductive lithologic trends, the survey was able to discriminate a number of flanking, isolated, short strike-length conductors as well. While the larger conductive trends of no interest, a review of previous drilling, geology and geochem is needed to assess the significance of the flanking anomalies.

In the southern limits of the AEM, northeast of Bell Lake, several isolated flanking anomalies along a conductive formation feature were identified on open ground (anomalies, "g" and "e" discussed later in this report). While research may substantially downgrade these anomalies, it would be prudent to acquire the land to protect Unitroniox's potential interest.

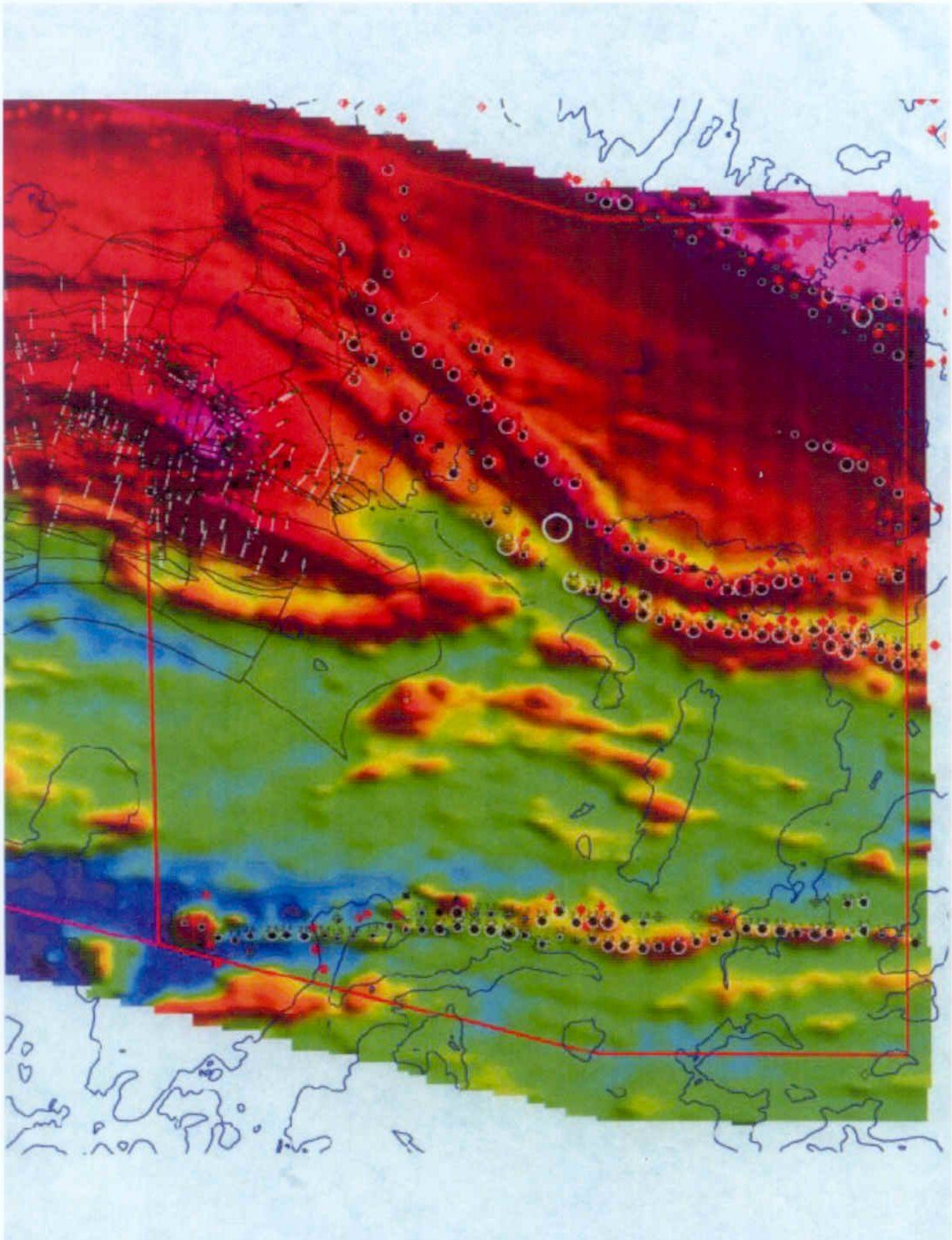


Figure 1: Summary of AEM conductors

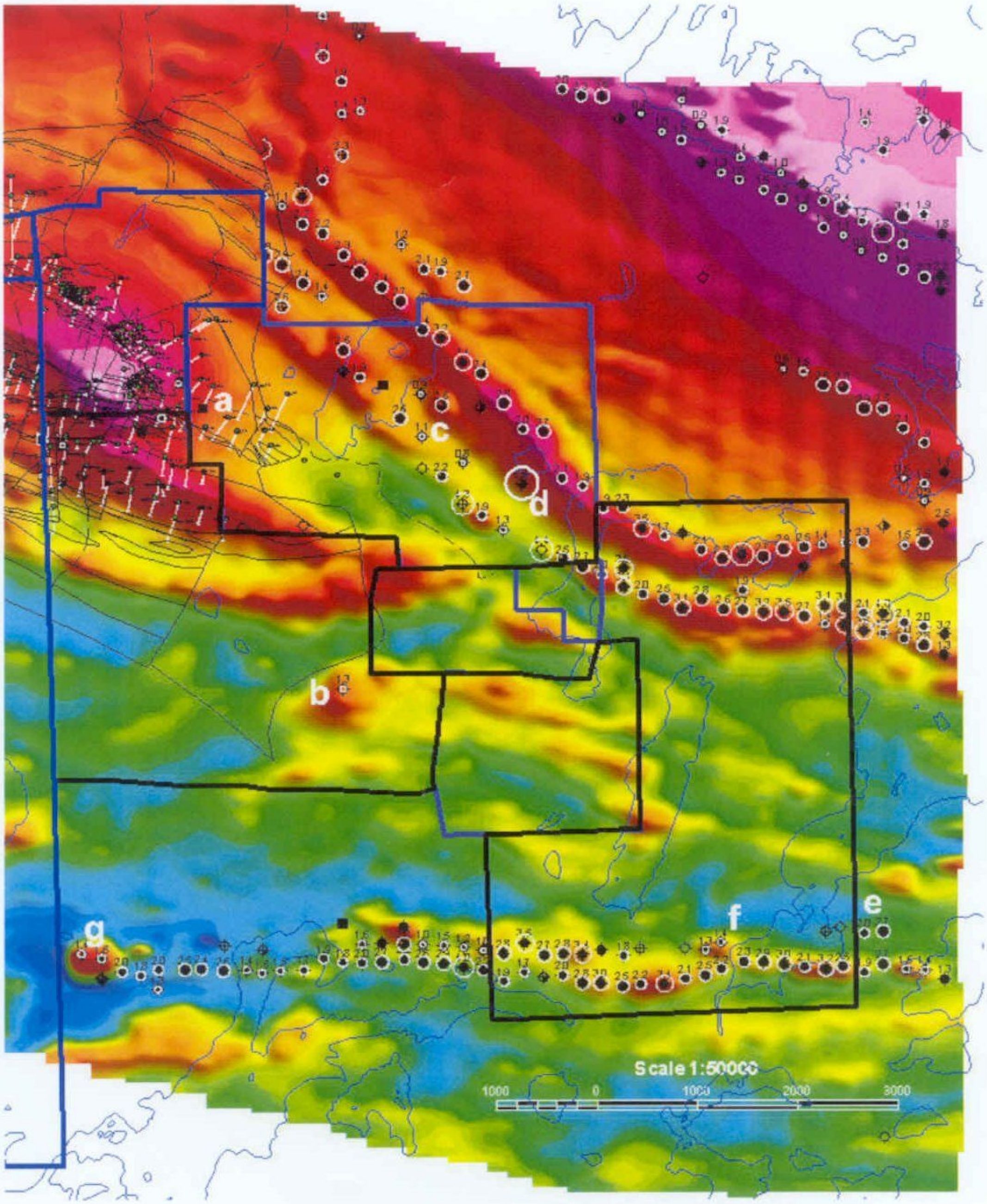


Figure 2: Summary of MEGATEM anomalies (Preliminary)

Preliminary Targets
A review of the line profile data was done with particular focus on the isolated later time channel responses. For the purpose of the preliminary interpretation, the symbols used follow the style originally used by Input. The difference is that a one channel anomaly is actually a 10 channel response grading by increments of two where a 6 channel (solid circle) is actually 18-20 channels on the MEGATEM system.. The profile interpretation was done on a split Geosoft screen with the spatial GIS image on the left and 3 series of profiles on the right. The upper sequence of profiles is the raw 20 channel x-coil data, the middle set are the calculated B-field response for the x-coil data and the lower panel is the calculated z-coil data for all 20 channels. The x-coil is the same geometric configuration that was used by Input and thus the anomaly shapes are identical. However, for deep targets the x-coil is less sensitive than the z-coil and it is possible to have a weak or non-existent response on the x-coil and still see a very sharp anomaly on the z-coil. In this scenario it is safe to conclude that the target depth is in the order of 200m.

A preliminary summary of the priority EM anomalies identified is shown in the attached figure 2. In all 7 potential targets (a - e) have been identified. Each of these will need to be screened with respect to historical information (drilling, geology, geochem, geophysics) which was not available at the time of this review.

Anomaly "a" (figure 3) is a classic deep seated (>200m) response from a highly conductive body. As mentioned above there is no signature on the x-coil yet a very strong well defined B_z response even in channel 20. The anomaly is located due east of the Sturgeon lake deposit within area 23. A similar anomaly is also seen to the northeast on the mine block. There has been a significant amount of drilling in the area that should have intersected this target. Determining the location of the underground working will be important to ensure that this is not a cultural anomaly.

Note: The historical drilling by Falconbridge (Inmet) and Noranda in this area suggest each was pursuing a different target horizon. Where the eastern extent of the main stratigraphic unit that Inmet drilled, strikes onto the Noranda claims, there is an apparent absence of drilling by Noranda. Two weak conductors are defined along this trend. This is clearly an area that will need to be researched as to the amount of previous drilling. There are obviously a number of holes missing from this compilation and this trend may or may not have been adequately drill tested.

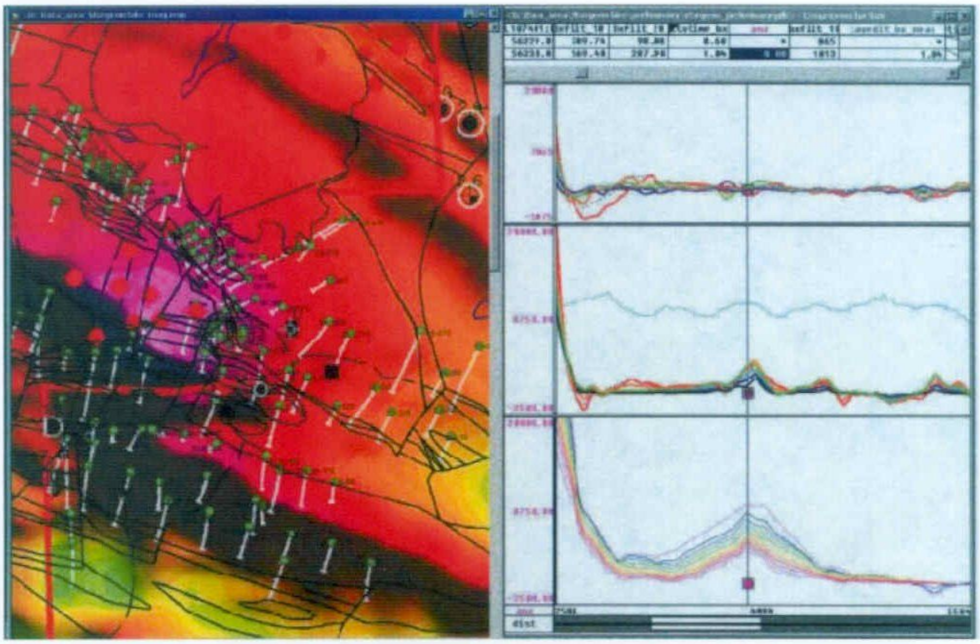


Figure 3: Anomaly "a"

Anomaly "b" (figure 4) is a shallow short strike length conductor located on a broad annular magnetic feature. The anomaly is located within what appears to be footwall rocks but mapping in this area was not undertaken by Hudack et al. The anomaly itself is not considered to be an economic target, but it may be a lead (distal) to a more significant target at depth. What should also be noted is the northeastern trending magnetic low (structural trend) that terminates the eastern extension of the sturgeon lake stratigraphy and the western extension of a magnetic trend that hosts anomaly "b". This lower magnetic unit should be investigated as to whether it defines the faulted extension to one of the Matabbi/Sturgeon horizons.

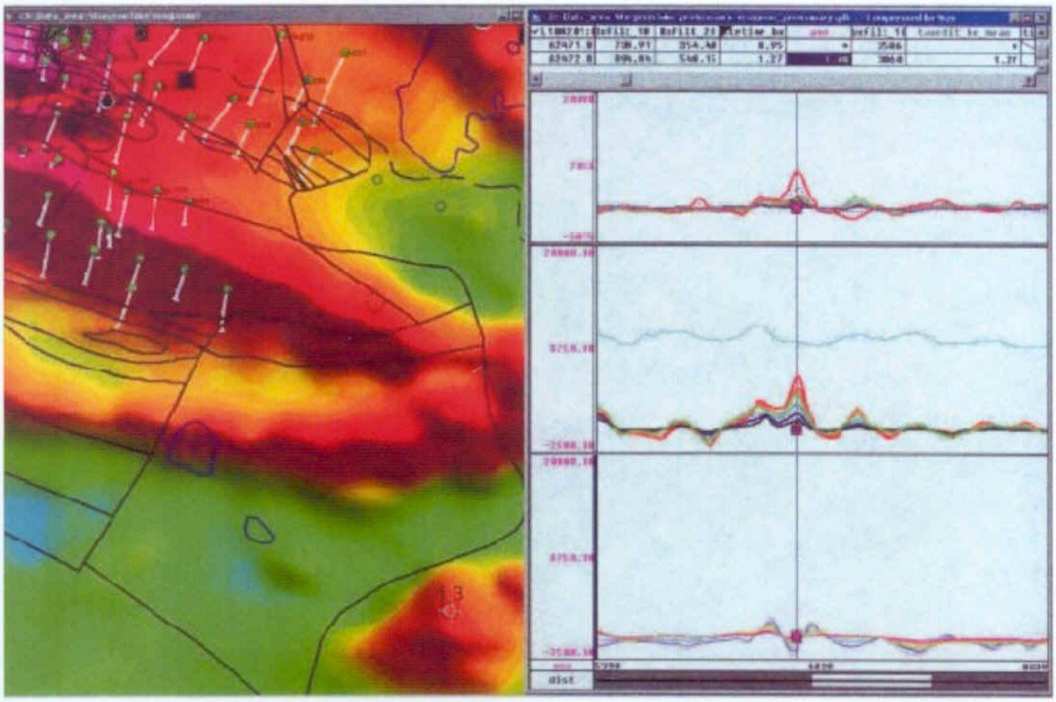


Figure 4: Anomaly "b"

Anomaly "c" (figure 5) is a isolated, 20 channel conductor with direct magnetic association located on the southern flank of a formational conductor. Further research is required to assess the significance of this anomaly.

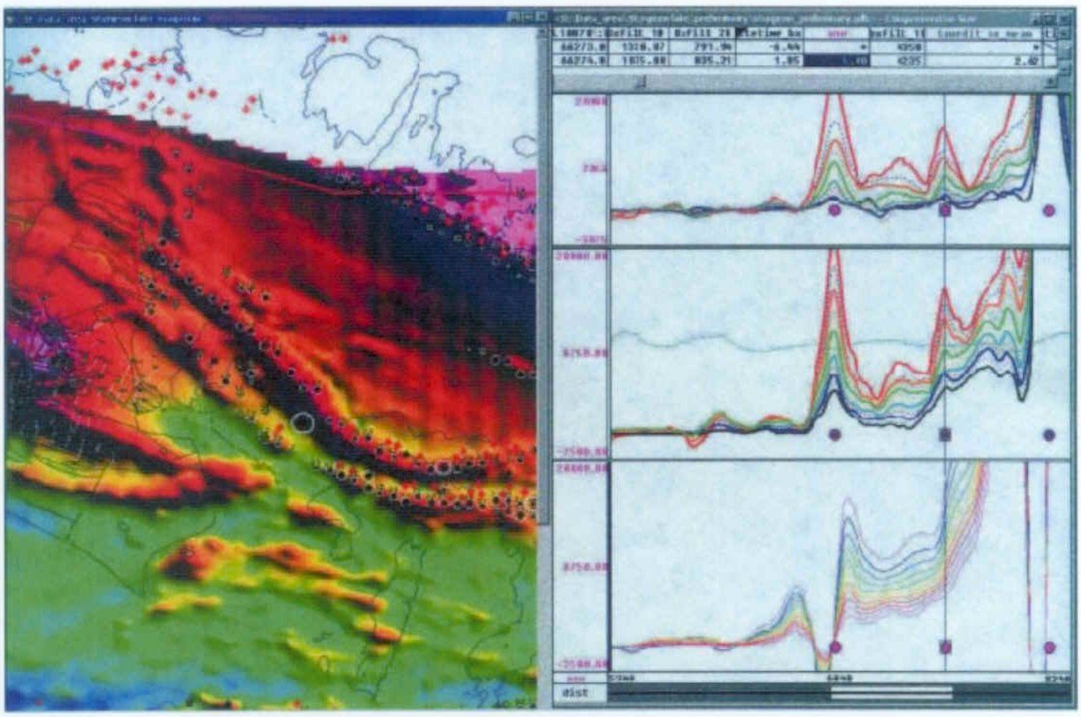


Figure 5: Anomaly "c"

Anomaly "d" (figure 6) is a isolated, 20 channel conductor (long time constant) with direct weak, magnetic association located on the southern flank of a formational conductor. Further research is required to assess the significance of this anomaly.

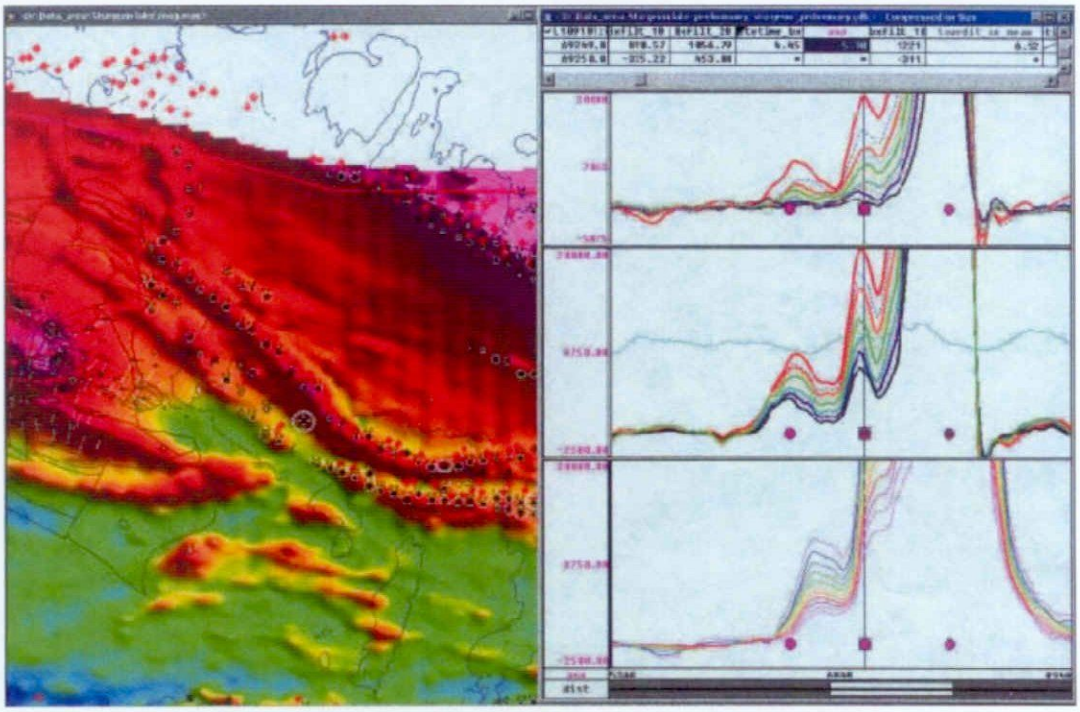


Figure 6: Anomaly "d"

Anomaly "e" (figure 7) is a strong (20 channel) EM anomaly, with a subtle magnetic association, located 400m-600m north of a formational conductor that strikes due east-west near the southern limits of the survey area.. This anomaly lies east of the current holding and it is proposed the anomaly be staked.

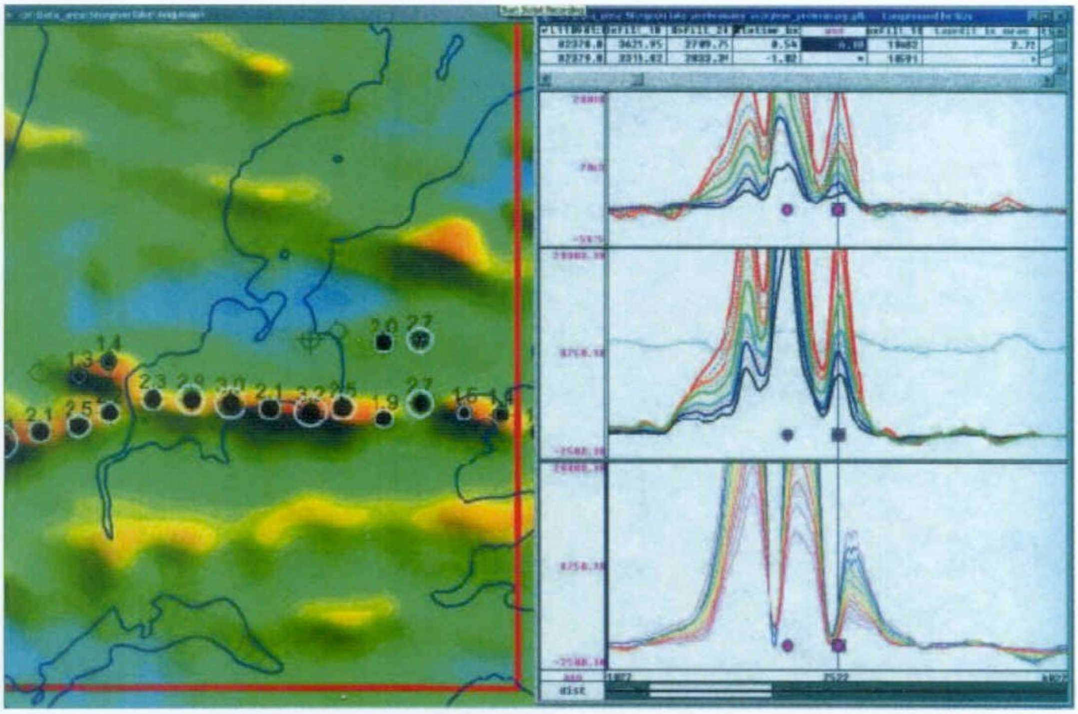


Figure 7: Anomaly "e"

Anomaly "f" (figure 8) is a short strike-length, 20 channel conductor located 200m north of the southern formational conductor and has a strong, direct magnetic association. There has been previous work done in this area (geophysics, geology, drilling) and this target will need to be reviewed to assess the merits of future work.

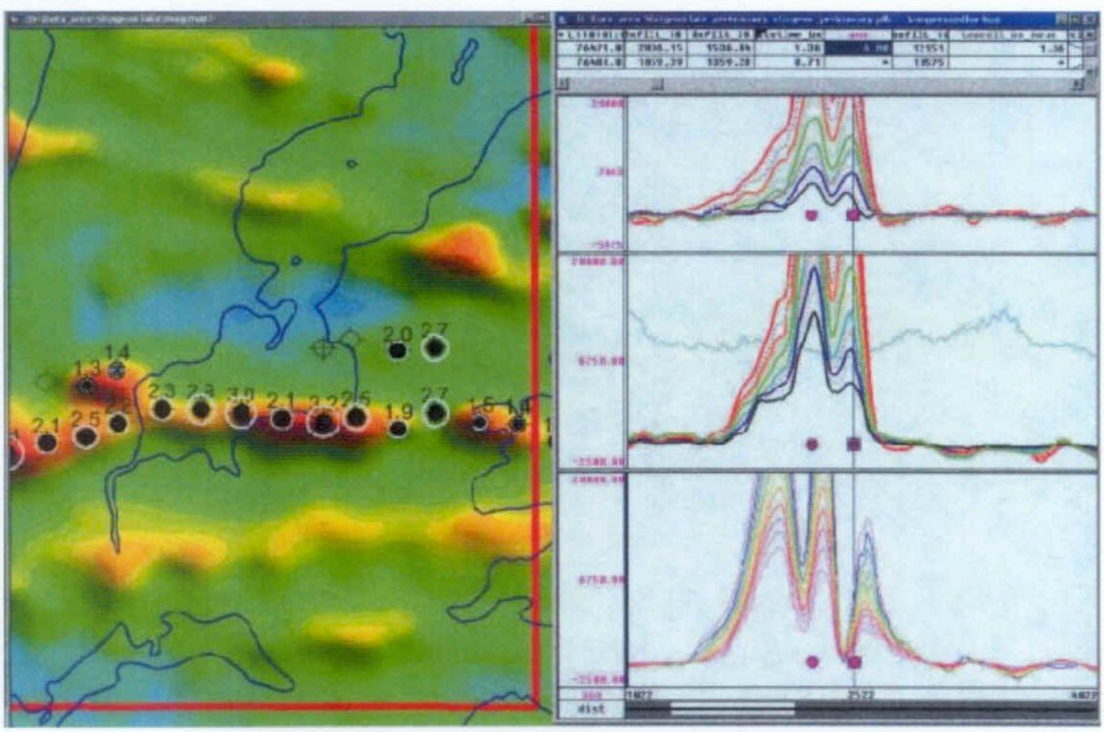


Figure 8: Anomaly "f"

Anomlay "g" (figure 9) is short strike-length, 20 channel conductor with a strong, direct magnetic association located approximately 200m north of the southern formational conductor. This conductor lies at the western terminus of the southern formational conductor. Clearly the character of the magnetics changes west of this area, probably defining the contacts with the synvolcanic intrusive. This anomaly also lies outside the current holding and has been recommended for staking.

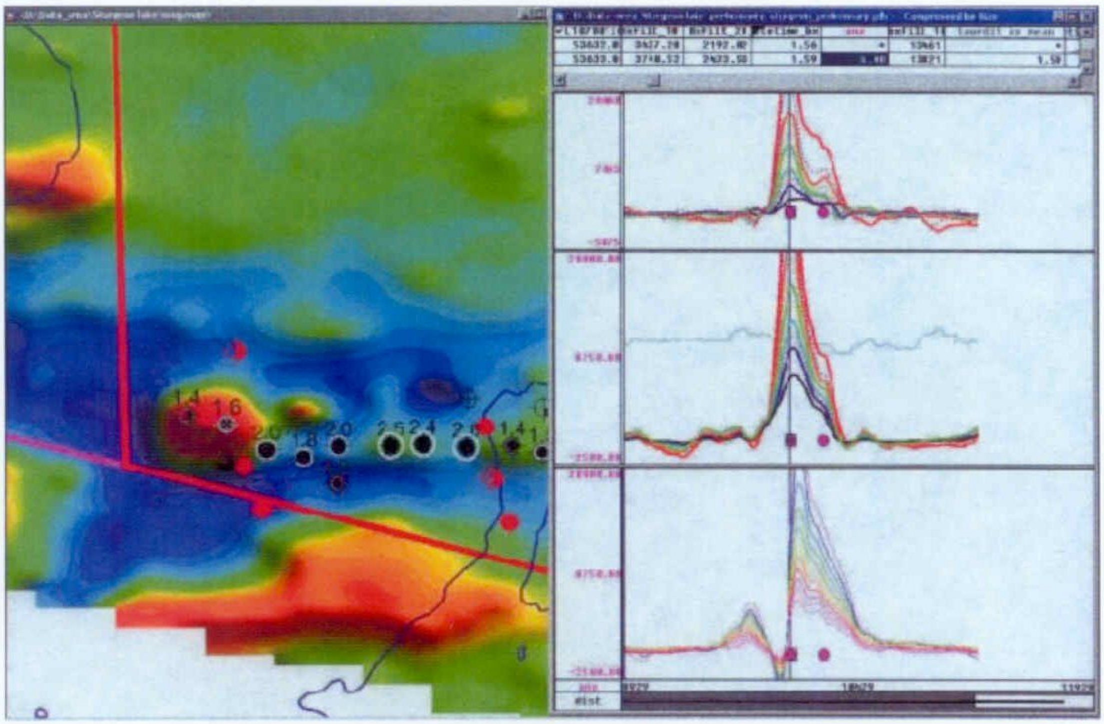


Figure 9: Anomaly "g"

Once the final data is received by Noranda and reviewed by Michel Allard, he will forward to me the raw data plus his interpretation. I will then go through the data in detail to see what additional information can be extracted from the data. Hopefully more of the historical data will be available by then. The final EM anomaly picks will then be used as a guide to review historical work on the project. We are obviously interested in new, untested anomalies within prospective geology. Targets at depths greater than 250m will undoubtedly be generated from the compilation of previous drilling and mapping.

From a technical point of view, we also need to tie in the Geo-Sleuth targeting to assess the merits of the technology. If the technical results provide support to Geo-Sleuth methodology then a plan is required to effectively leverage the technology into new exploration areas and financing opportunities.

Respectively Submitted
John Gingerich

ONTARIO MINISTRY OF NORTHERN DEVELOPMENT AND MINES

Work Report Summary

Transaction No: W0430.01030 **Status:** APPROVED
Recording Date: 2004-JUN-28 **Work Done from:** 2003-JUN-01
Approval Date: 2004-OCT-01 **to:** 2003-SEP-30

Client(s):

176208 MINES ET EXPLORATION NORANDA INC./NORANDA MINING AND EXPLORATION INC.
176211 NORANDA INC.
400914 1522923 ONTARIO INCORPORATED

Survey Type(s):

AEM AMAG

Work Report Details:

Claim#	Perform	Perform Approve	Applied	Applied Approve	Assign	Assign Approve	Reserve	Reserve Approve	Due Date
G 3030231	$5,584	$5,584	$0	$0	$0	0	$5,584	$5,584	
G 3030232	$5,339	$5,339	$0	$0	$2,158	2,158	$3,181	$3,181	
G 3030233	$7,790	$7,790	$0	$0	$0	0	$7,790	$7,790	
G 3030234	$4,917	$4,917	$0	$0	$0	0	$4,917	$4,917	
G 3030235	$5,327	$5,327	$0	$0	$0	0	$5,327	$5,327	
G 3031043	$4,252	$4,252	$0	$0	$0	0	$4,252	$4,252	
G 3031109	$5,129	$5,129	$0	$0	$0	0	$5,129	$5,129	
PA 1195743	$1,730	$1,730	$1,600	$1,600	$130	130	$0	$0	2005-JUN-25
PA 1195744	$5,934	$5,934	$6,400	$6,400	$0	0	$0	$0	2005-JUN-25
PA 1195858	$679	$679	$400	$400	$279	279	$0	$0	2006-AUG-10
PA 3001029	$5,583	$5,583	$6,000	$6,000	$0	0	$0	$0	2005-OCT-31
PA 3001620	$1,380	$1,380	$1,200	$1,200	$180	180	$0	$0	2005-JUN-26
PA 3001621	$5,934	$5,934	$6,400	$6,400	$0	0	$0	$0	2005-JUN-26
PA 3001622	$5,934	$5,934	$6,400	$6,400	$0	0	$0	$0	2005-JUN-26
PA 3001623	$5,934	$5,934	$6,400	$6,400	$0	0	$0	$0	2005-JUN-26
PA 3001624	$5,934	$5,934	$6,400	$6,400	$0	0	$0	$0	2005-JUN-26
	$77,380	$77,380	$41,200	$41,200	$2,747	$2,747	$36,180	$36,180	

External Credits: $0

Reserve:

$36,180 Reserve of Work Report#: W0430.01030

$36,180 Total Remaining

Status of claim is based on information currently on record.

52G15NW2005 2.27992 SIXMILE LAKE 900

Ministry of
Northern Development
and Mines

Ministère du
Développement du Nord
et des Mines

Ontario

GEOSCIENCE ASSESSMENT OFFICE
933 RAMSEY LAKE ROAD, 6th FLOOR
SUDBURY, ONTARIO
P3E 6B5

Tel: (888) 415-9845
Fax:(877) 670-1555

Date: 2004-OCT-13

1522923 ONTARIO INCORPORATED
C/O DALE HENDRICK, PRESIDENT
111 RICHMOND ST. WEST, SUITE 901
TORONTO, ONTARIO
M5H 2G4 CANADA

Submission Number: 2.27992
Transaction Number(s): W0430.01030

Dear Sir or Madam

Subject: Approval of Assessment Work

We have approved your Assessment Work Submission with the above noted Transaction Number(s). The attached Work Report Summary indicates the results of the approval.

At the discretion of the Ministry, the assessment work performed on the mining lands noted in this work report may be subject to inspection and/or investigation at any time.

The revisions outlined in the Notice dated August 17, 2004 have been corrected. Accordingly, assessment work credit has been approved as outlined on the AMENDED Declaration of Assessment Work Form that accompanied this submission.

If you have any question regarding this correspondence, please contact BRUCE GATES by email at bruce.gates@ndm.gov.on.ca or by phone at (705) 670-5856.

Yours Sincerely,

Ron C Gashinski

Ron C. Gashinski
Senior Manager, Mining Lands Section

Cc: Resident Geologist

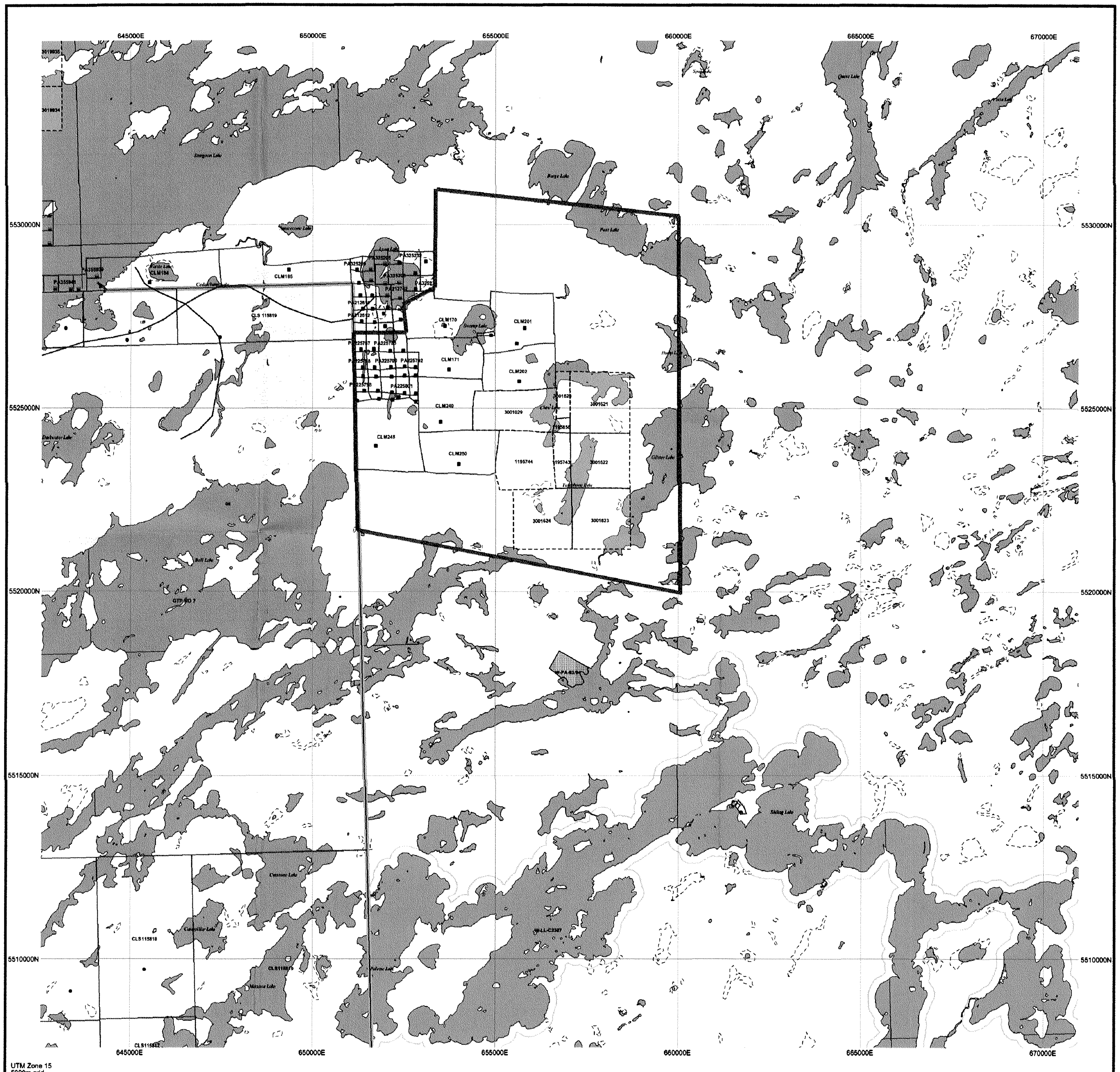
Mines Et Exploration Noranda Inc./Noranda Mining And Exploration Inc.
(Claim Holder)

1522923 Ontario Incorporated
(Claim Holder)

Assessment File Library

Noranda Inc.
(Claim Holder)

1522923 Ontario Incorporated
(Assessment Office)



ONTARIO CANADA
MINISTRY OF NORTHERN DEVELOPMENT AND MINES
PROVINCIAL MINING RECORDER'S OFFICE

Mining Land Tenure Map

Date / Time of Issue: Wed Oct 13 10:11:04 EDT 2004

TOWNSHIP / AREA **PLAN**
BELL LAKE AREA **G-2533**

ADMINISTRATIVE DISTRICTS / DIVISIONS

Mining Division	Patricia
Land Titles/Registry Division	THUNDER BAY
Ministry of Natural Resources District	DRYDEN

TOPOGRAPHIC

Administrative Boundaries
Township
Concession, Lot
Provincial Park
Indian Reserve
Cliff, Pit & Pile
Contour
Mine Shafts
Mine Headframe
Railway
Road
Trail
Natural Gas Pipeline
Utilities
Tower

Land Tenure

Freehold Patent
Surface And Mining Rights
Surface Rights Only
Mining Rights Only

Leasehold Patent
Surface And Mining Rights
Surface Rights Only
Mining Rights Only

Licence of Occupation
Uses Not Specified
Surface And Mining Rights
Surface Rights Only
Mining Rights Only

Land Use Permit
Order In Council (Not open for staking)
Water Power Lease Agreement
1234567 Mining Claim
1234567 Filed Only Mining Claims

LAND TENURE WITHDRAWALS

1234 Areas Withdrawn from Disposition
Mining Acts Withdrawal Types
Wsm Surface And Mining Rights Withdrawn
Ws Surface Rights Only Withdrawn
Wm Mining Rights Only Withdrawn
Order In Council Withdrawal Types
W'sm Surface And Mining Rights Withdrawn
W's Surface Rights Only Withdrawn
W'm Mining Rights Only Withdrawn

IMPORTANT NOTICES

Scale 1:40000
1km 0km 3km

LAND TENURE WITHDRAWAL DESCRIPTIONS

Identifier	Type	Date	Description
W-LL-C2327	Wsm	Feb 14, 2003	W-LL-C2327-03 ONT M&S withdrawal S.35 Mining Act RSO 1990, 14/02/03 Boundary generally depicts area withdrawn Click to view actual area .
W-PA-92/94	Wsm	Jan 1, 1994	SECTION 35 W-PA-92/94 NWR M+S 195150-TO OLD PINE STAND
W-52/83	Wsm	Jan 1, 1983	SURFACE AND MINING RIGHTS WITHDRAWN W-52/83 FILE 188542

2.27992
AMAG
AEM

General Information and Limitations

Those wishing to stake mining claims should consult with the Provincial Mining Recorders' Office of the Ministry of Northern Development and Mines for additional information on the status of the lands shown hereon. This map is not intended for navigational, survey, or land title determination purposes as the information shown on this map is compiled from various sources. Completeness and accuracy are not guaranteed. Additional information may also be obtained through the local Land Titles or Registry Office, or the Ministry of Natural Resources.

Contact Information:
Provincial Mining Recorders' Office
Willet Green Miller Center 933 Ramsey Lake Road

Toll Free
Tel: 1 (888) 415-9845 ext 5742
Fax: 1 (877) 670-1444

Map Datum: NAD 83
Projection: UTM (6 degree)
Topographic Data Source: Land Information Ontario

This map may not show unregistered land tenure and interests in land including certain patents, leases, easements, right of ways, flooding rights, licenses, or other forms of disposition of rights and interest from the Crown. Also certain land tenure and land uses that restrict or prohibit free entry to stake mining claims may not be illustrated.

"Property – Claim Plan"

Airborne MEGATEM® / Magnetic Survey

For

Unitronix Corp. and 1522923 Ontario Inc.
Sturgeon Lake Survey
Thunder Bay, Ontario

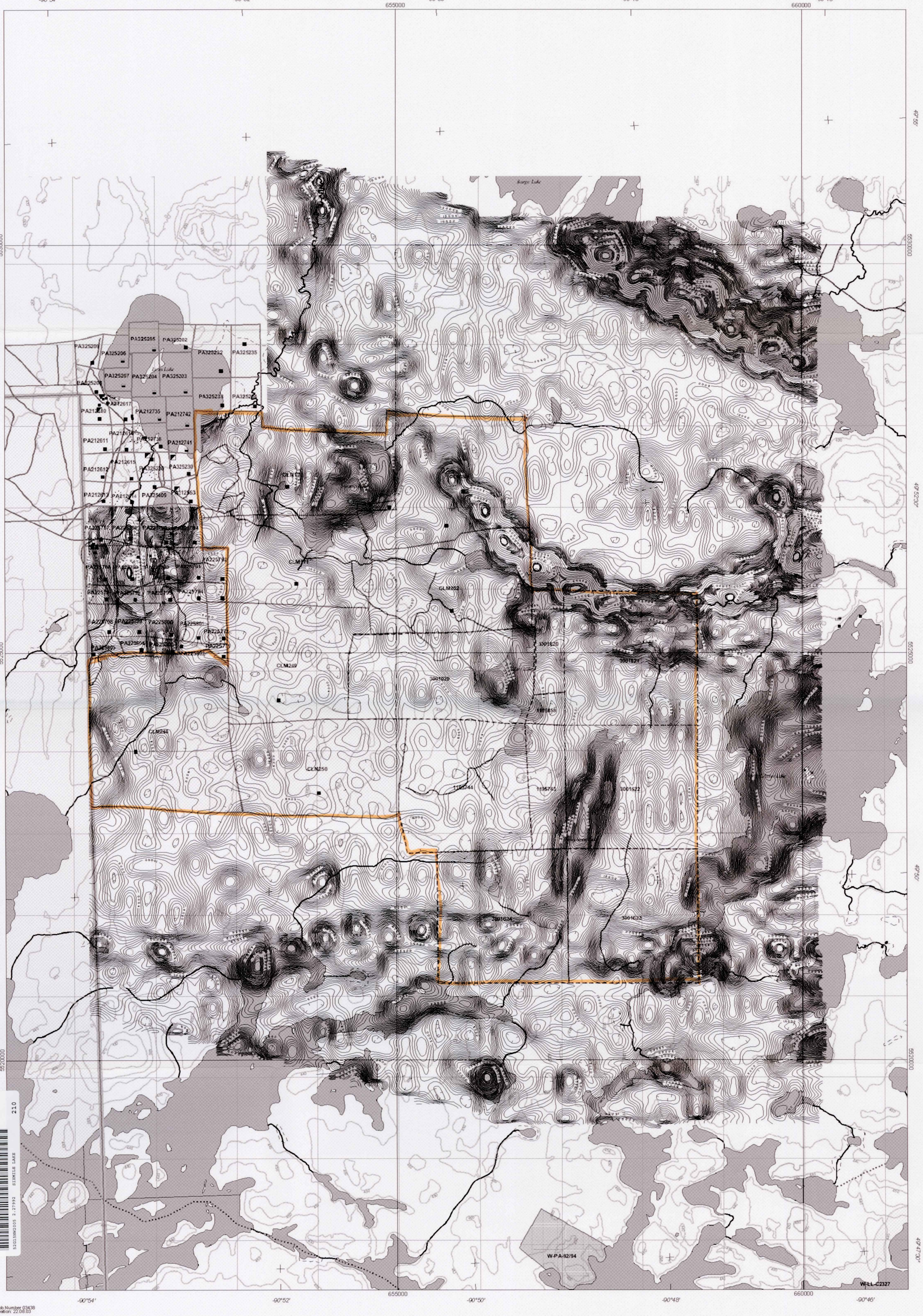
Calculated Apparent Conductance

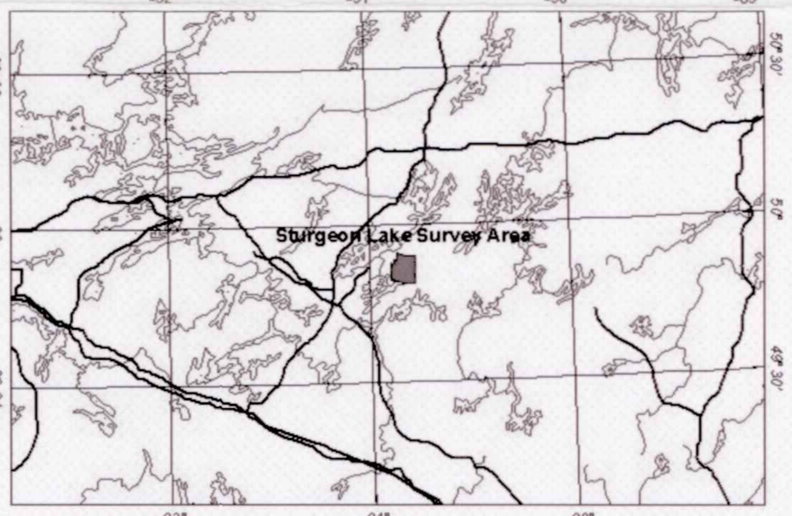
Derived from dB/dt X & Z Coil Channels 1-20

Contour Interval 1000 milliSiemens

RECEIVED
SEP 21 2004
GEOSCIENCE ASSESSMENT OFFICE

2.27992





Survey Specifications

Survey Line Spacing	200m
Survey Line Azimuth	000°-180°
Tie-Line Spacing	2500m
Tie-Line Azimuth	090°-270°
Survey Type	Airborne Electromagnetic and Magnetic

Aircraft Specifications

Survey Aircraft	DeHavilland Dash-7
Aircraft Elevation	120m Mean Terrain Clearance
Average Aircraft Speed	65m /sec
GPS Receiver	NOVATEL Propak 4E-315R 12 Channel Differential
GPS Sample Rate	1.0s

Magnetic Specifications

Magnetometer	Scintrex CS-2 Cesium Vapour
Magnetometer Installation	Towed Bird
Magnetometer Sensitivity	0.01nT
Sample Rate	0.10s
I.G.R.F. Model	2000
I.G.R.F. Correction Date	2003.4

Electromagnetic Specifications

Electromagnetic System	MEGATEM® 20 Channel Multicoil System
Transmitter Installation	Vertical Axis Loop Mounted on Aircraft
Transmitter Loop Area	406m²
Transmitter Loop Turns	5
Transmitter Base Frequency	90Hz
Pulse Width	2200μs
Pulse Offtime	3255μs
Receiver Installation	Towed Bird
Receiver Coils	Multiple Coils in X, Y, Z Orientation
Receiver Sample Rate	0.25s
Digital Acquisition	Fugro Airborne Surveys Geodas System
Analogue Acquisition	RMS GR-33 Chart Recorder
Video Acquisition	Colour VHS Video

Geodetic Specifications

Map Projection	UTM
Datum	NAD27
UTM Zone	15 North
Central Meridian	93° West
False Easting	500000
False Northing	0
Scale Factor	0.9996

N

Inclination 76 degrees
Declination -1.85 degrees

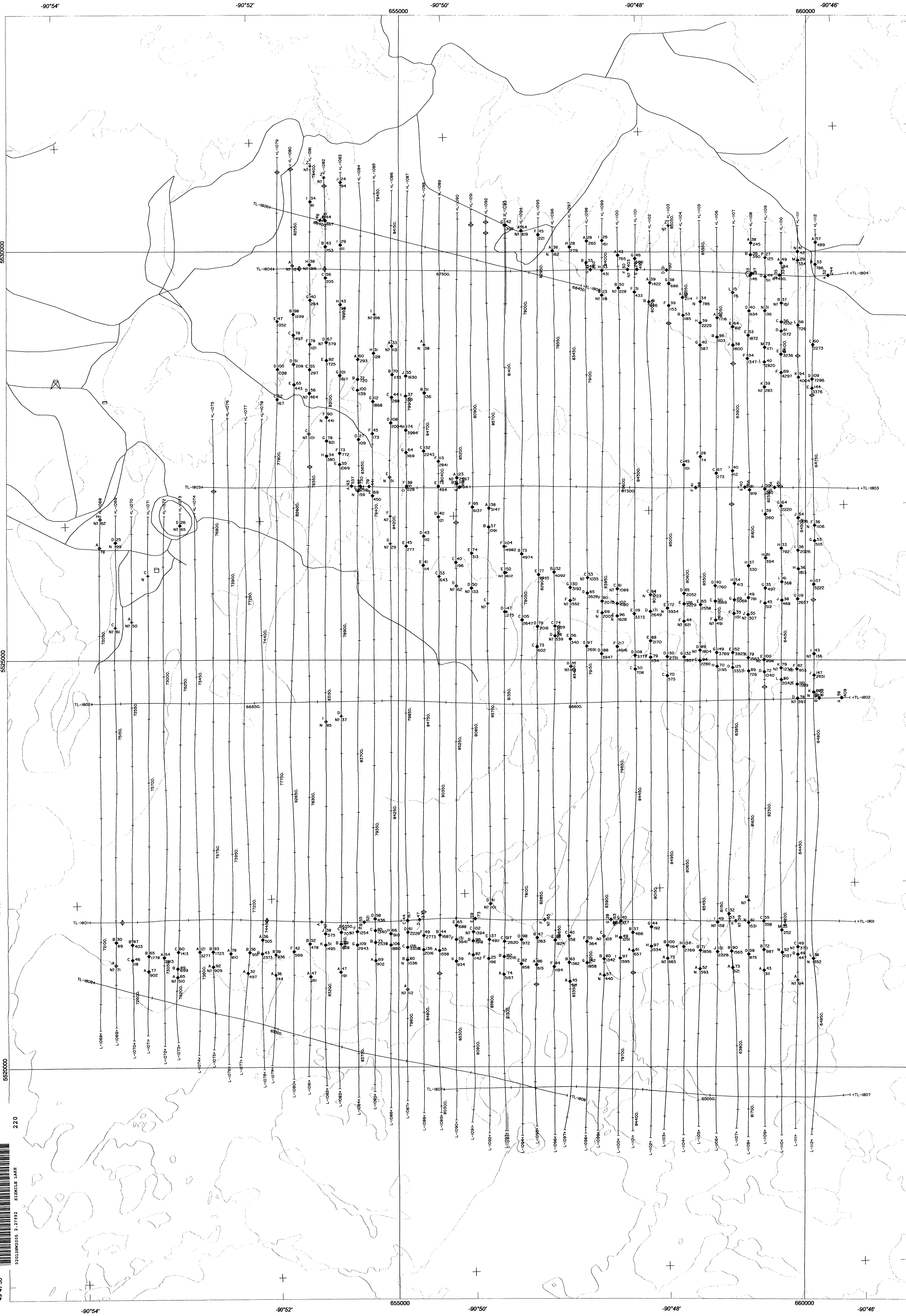
Scale 1:20000

250 0 250 500 750 1000 1250 1500
metres
NAD27 / UTM zone 15N

DeHavilland Dash-7

Fugro Job Number 03438
Map Creation: 22.08.03

FUGRO AIRBORNE SURVEYS



Airborne MEGATEM®/ Magnetic Survey

For

Unitronix Corp. and 1522923 Ontario Inc.

Sturgeon Lake Survey

Thunder Bay, Ontario

Anomaly selection and Flight Path

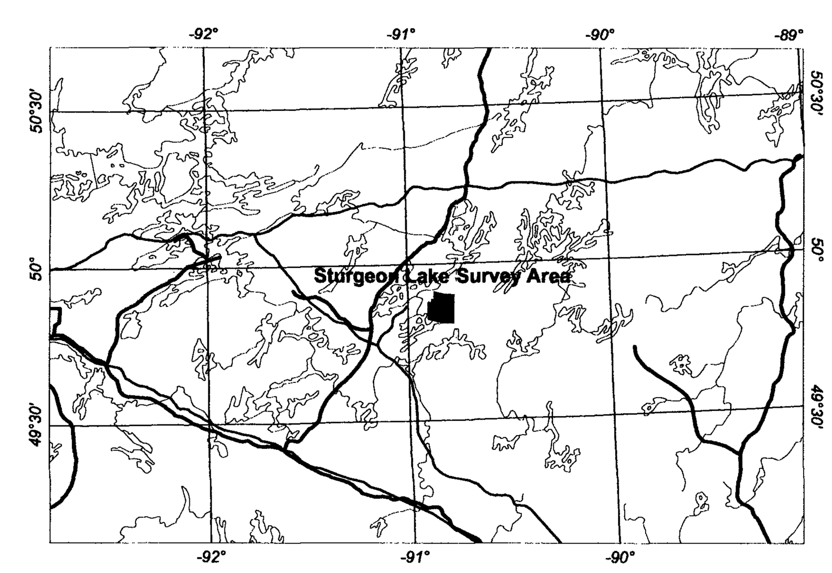
Anomalies Selected from B Field X and Z Coil

ANOMALY	CLASSIFICATION
✳	1-2 Channels and/or Surficial
⊕	3-4 Channels
⊕	5-6 Channels
⊕	7-8 Channels
⊕	9-10 Channels
●	11-12 Channels
◊	B field Z coil

Anomaly Letter — B
Apparent Conductance (siemens) — 7
CH 10 AMPLITUDE (ppm) — 1800
Interpreted as a possible Surficial Contribution — S
Interpreted as possible Cultural Contribution — C

Culture Response

Anomaly Letter — a
Type of Source not Clear — ?



Survey Specifications

Survey Line Spacing 200m
Survey Line Azimuth .... 000°-180°
Tie-Line Spacing 2500m
Tie-Line Azimuth .... 090°-270°
Survey Type .... Airborne Electromagnetic and Magnetic

Aircraft Specifications

Survey Aircraft .... DeHavilland Dash-7
Aircraft Elevation .... 120m Mean Terrain Clearance
Average Aircraft Speed 65m/sec
GPS Receiver .... NOVATEL Propak 4E-315R 12 Channel Differential
GPS Sample Rate 1.0s

Magnetic Specifications

Magnetometer .... Scintrex CS-2 Cesium Vapour
Magnetometer Installation .... Towed Bird
Magnetometer Sensitivity 0.01nT
Sample Rate 0.10s
I.G.R.F. Model 2000
I.G.R.F. Correction Date 2003.4

Electromagnetic Specifications

Electromagnetic System .... MEGATEM® 20 Channel Multicoil System
Transmitter Installation .... Vertical Axis Loop Mounted on Aircraft
Transmitter Loop Area 406m²
Transmitter Loop Turns 5
Transmitter Base Frequency 90Hz
Pulse Width 2200μs
Pulse Offtime 3255μs
Receiver Installation .... Towed Bird
Receiver Coils .... Multiple Coils in X, Y, Z Orientation
Receiver Sample Rate 0.25s
Digital Acquisition .... Fugro Airborne Surveys Geodas System
Analogue Acquisition .... RMS GR-33 Chart Recorder
Video Acquisition .... Colour VHS Video

Geodetic Specifications

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Datum NAD27
UTM Zone .... 15 North
Central Meridian .... 93° West
False Easting 500000
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Scale Factor 0.9996

N

Inclination 76 degrees
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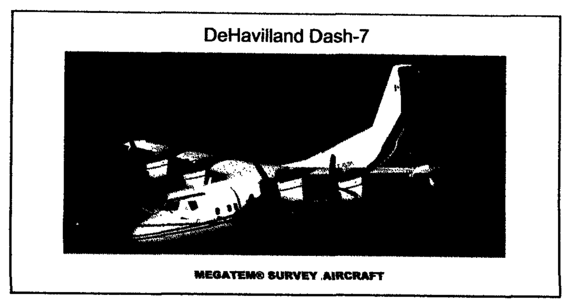
Scale 1:20000

250 0 250 500 750 1000 1250 1500

metres

NAD27 / UTM zone 15N

DeHavilland Dash-7



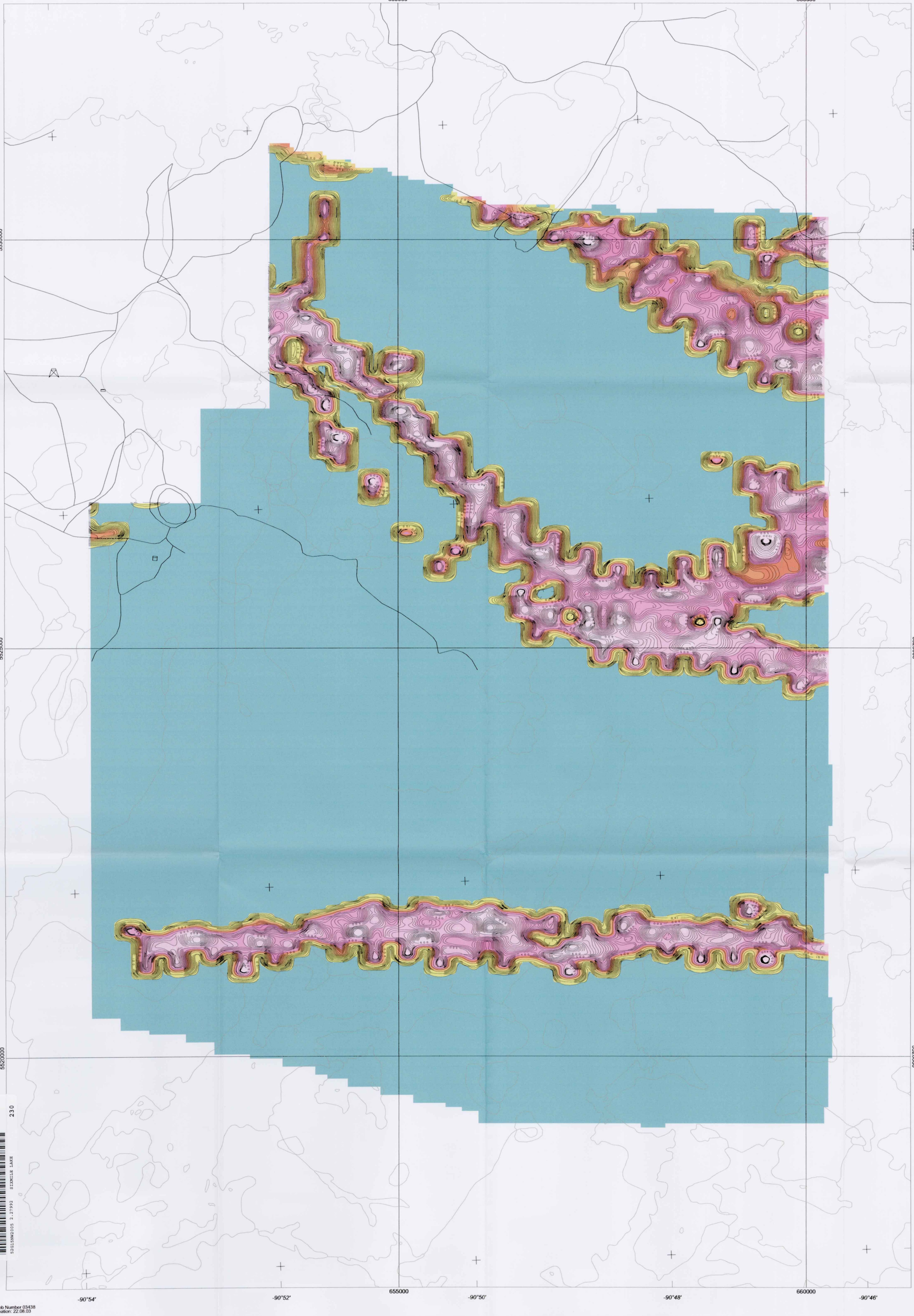
MEGATEM® SURVEY AIRCRAFT

FUGRO

FUGRO AIRBORNE SURVEYS

Fugro Job Number 03438
Map Creation: 22.08.03

220



Airborne MEGATEM® / Magnetic Survey

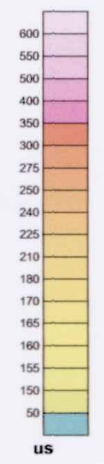
For

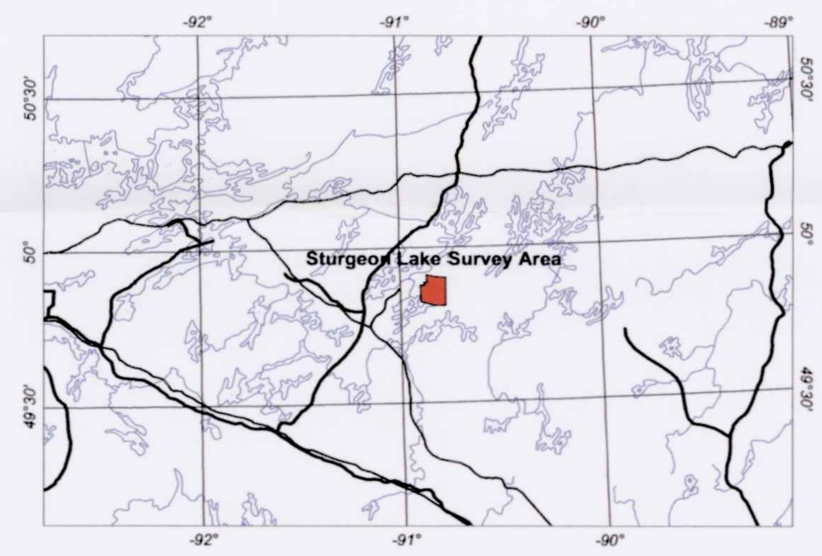
Unitronix Corp. and 1522923 Ontario Inc.
Sturgeon Lake Survey
Thunder Bay, Ontario

Calculated Decay Constant (Tau)

Derived from dB/dt X Coil Channels 9-20

Contour Interval 10 microseconds





Survey Specifications

Survey Line Spacing	200m
Survey Line Azimuth	000°-180°
Tie-Line Spacing	2500m
Tie-Line Azimuth	090°-270°
Survey Type	Airborne Electromagnetic and Magnetic

Aircraft Specifications

Survey Aircraft	DeHavilland Dash-7
Aircraft Elevation	120m Mean Terrain Clearance
Average Aircraft Speed	65m/sec
GPS Receiver	NOVATEL Propak 4E-315R 12 Channel Differential
GPS Sample Rate	1.0s

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Magnetometer Installation	Towed Bird
Magnetometer Sensitivity	0.01nT
Sample Rate	0.10s
I.G.R.F. Model	2000
I.G.R.F. Correction Date	2003.4

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Pulse Width	2200μs
Pulse Offtime	3255μs
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Analogue Acquisition	RMS GR-33 Chart Recorder
Video Acquisition	Colour VHS Video

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False Northing	0
Scale Factor	0.9996

N

Inclination 76 degrees
Declination -1.85 degrees

Scale 1:20000

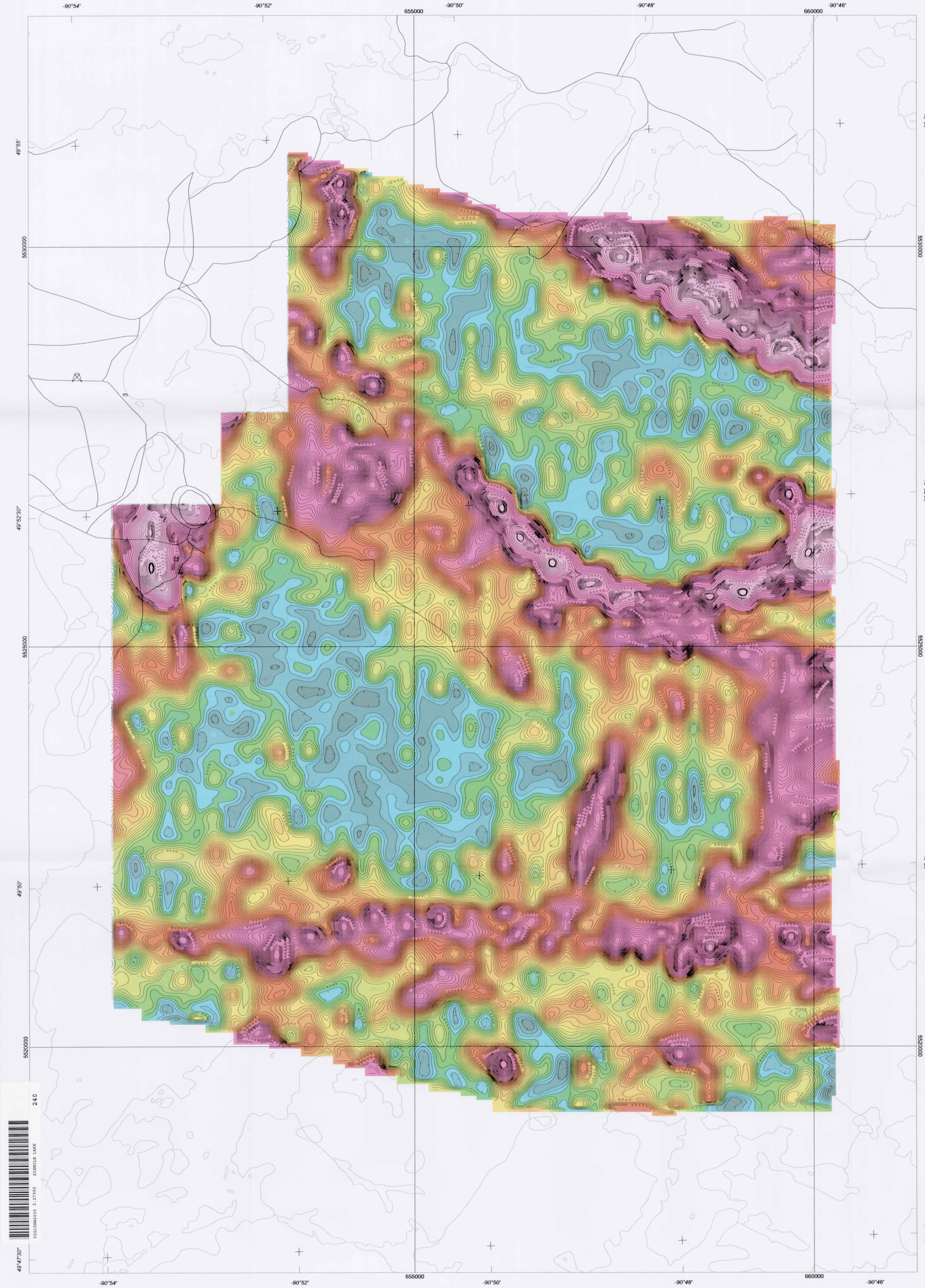
250 0 250 500 750 1000 1250 1500
metres
NAD27 / UTM zone 15N

DeHavilland Dash-7

MEGATEM® SURVEY AIRCRAFT

FUGRO AIRBORNE SURVEYS

Fugro Job Number 03438
Map Creation: 22.08.03

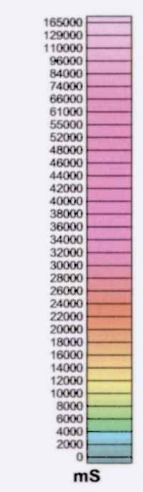


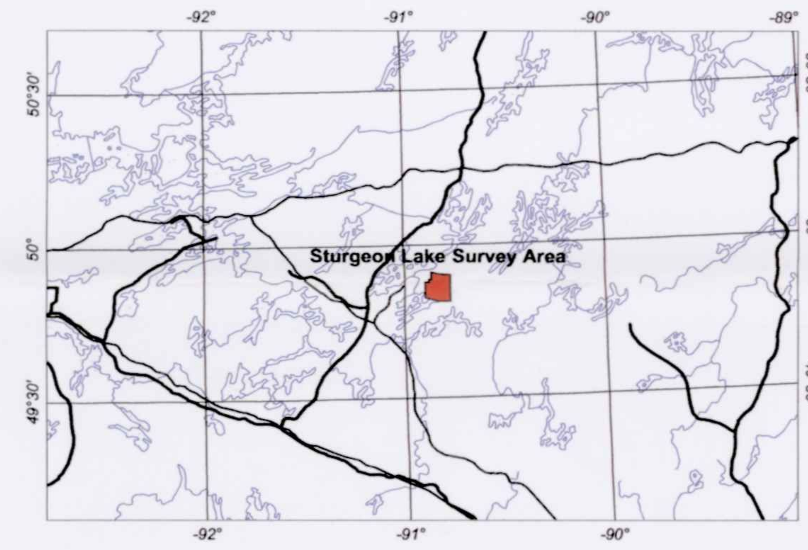
2.27992

Airborne MEGATEM® / Magnetic Survey
For
Unitronix Corp. and 1522923 Ontario Inc.
Sturgeon Lake Survey
Thunder Bay, Ontario

Calculated Apparent Conductance
Derived from dB/dt X & Z Coil Channels 1-20

Contour Interval 1000 milliSiemens





Survey Specifications

Survey Line Spacing	200m
Survey Line Azimuth	000°-180°
Tie-Line Spacing	2500m
Tie-Line Azimuth	090°-270°
Survey Type	Airborne Electromagnetic and Magnetic

Aircraft Specifications

Survey Aircraft	DeHavilland Dash-7
Aircraft Elevation	120m Mean Terrain Clearance
Average Aircraft Speed	65m/sec
GPS Receiver	NOVATEL Propak 4E-315R 12 Channel Differential
GPS Sample Rate	1.0s

Magnetic Specifications

Magnetometer	Scintrex CS-2 Cesium Vapour
Magnetometer Installation	Towed Bird
Magnetometer Sensitivity	0.01nT
Sample Rate	0.10s
I.G.R.F. Model	2000
I.G.R.F. Correction Date	2003.4

Electromagnetic Specifications

Electromagnetic System	MEGATEM® 20 Channel Multicoil System
Transmitter Installation	Vertical Axis Loop Mounted on Aircraft
Transmitter Loop Area	406m²
Transmitter Loop Turns	5
Transmitter Base Frequency	90Hz
Pulse Width	2200μs
Pulse Offtime	3255μs
Receiver Installation	Towed Bird
Receiver Coils	Multiple Coils in X, Y, Z Orientation
Receiver Sample Rate	0.25s
Digital Acquisition	Fugro Airborne Surveys Geodas System
Analogue Acquisition	RMS GR-33 Chart Recorder
Video Acquisition	Colour VHS Video

Geodetic Specifications

Map Projection	UTM
Datum	NAD27
UTM Zone	15 North
Central Meridian	93° West
False Easting	500000
False Northing	0
Scale Factor	0.9996

N

Inclination 76 degrees
Declination -1.85 degrees

Scale 1:20000

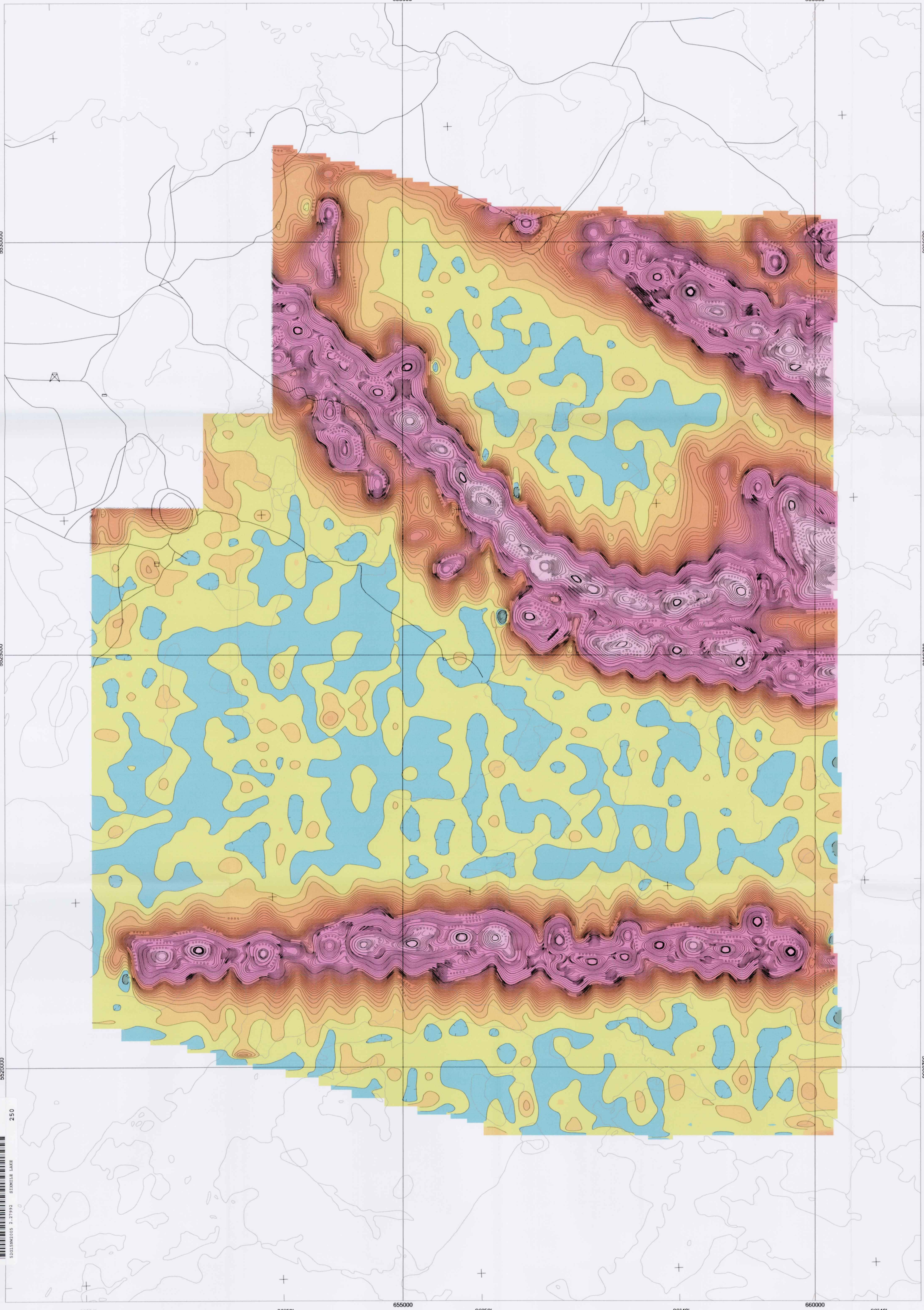
250 0 250 500 750 1000 1250 1500
metres
NAD27 / UTM zone 15N

DeHavilland Dash-7

MEGATEM® SURVEY AIRCRAFT

FUGRO AIRBORNE SURVEYS

Fugro Job Number 03438
Map Creation: 22.08.03



Airborne MEGATEM® / Magnetic Survey

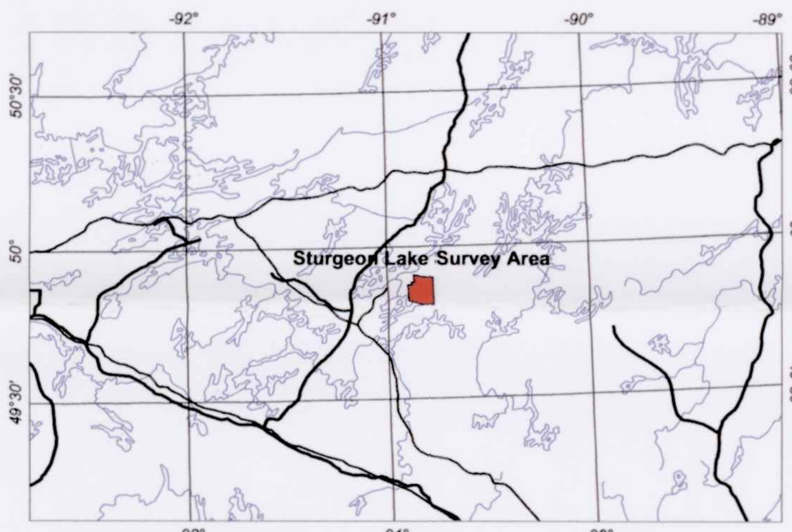
For

Unitronix Corp. and 1522923 Ontario Inc.
Sturgeon Lake Survey
Thunder Bay, Ontario

Total Energy Envelope
of dB/dt X Coil Channel 12

Contour Interval 1000 picoTeslas per second

pT/s



Survey Specifications

Survey Line Spacing	200m
Survey Line Azimuth	000°-180°
Tie-Line Spacing	2500m
Tie-Line Azimuth	090°-270°
Survey Type	Airborne Electromagnetic and Magnetic

Aircraft Specifications

Survey Aircraft	DeHavilland Dash-7
Aircraft Elevation	120m Mean Terrain Clearance
Average Aircraft Speed	65m/sec
GPS Receiver	NOVATEL Propak 4E-315R 12 Channel Differential
GPS Sample Rate	1.0s

Magnetic Specifications

Magnetometer	Scintrex CS-2 Cesium Vapour
Magnetometer Installation	Towed Bird
Magnetometer Sensitivity	0.01nT
Sample Rate	0.10s
I.G.R.F. Model	2000
I.G.R.F. Correction Date	2003.4

Electromagnetic Specifications

Electromagnetic System	MEGATEM® 20 Channel Multicoil System
Transmitter Installation	Vertical Axis Loop Mounted on Aircraft
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Transmitter Loop Turns	5
Transmitter Base Frequency	90Hz
Pulse Width	2200μs
Pulse Offtime	3255μs
Receiver Installation	Towed Bird
Receiver Coils	Multiple Coils in X, Y, Z Orientation
Receiver Sample Rate	0.25s
Digital Acquisition	Fugro Airborne Surveys Geodas System
Analogue Acquisition	RMS GR-33 Chart Recorder
Video Acquisition	Colour VHS Video

Geodetic Specifications

Map Projection	UTM
Datum	NAD27
UTM Zone	15 North
Central Meridian	93° West
False Easting	500000
False Northing	0
Scale Factor	0.9996

N

Inclination 76 degrees
Declination -1.85 degrees

Scale 1:20000

250 0 250 500 750 1000 1250 1500

metres

NAD27 / UTM zone 15N

DeHavilland Dash-7

MEGATEM® SURVEY AIRCRAFT

Fugro Job Number 03438
Map Creation: 22.08.03

FUGRO AIRBORNE SURVEYS

Property Map
Airborne Survey
"Fugro"

RECEIVED
AUG 23 2004
GEOSCIENCE ASSESSMENT OFFICE

Airborne MEGATEM®/ Magnetic Survey

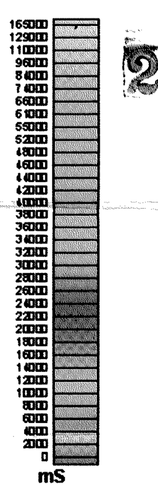
For

Unitronix Corp. and 1522923 Ontario Inc.
Sturgeon Lake Survey
Thunder Bay, Ontario

Calculated Apparent Conductance

Derived from dB/dt X & Z Coil Channels 1-20

Contour Interval 1000 milliSiemens



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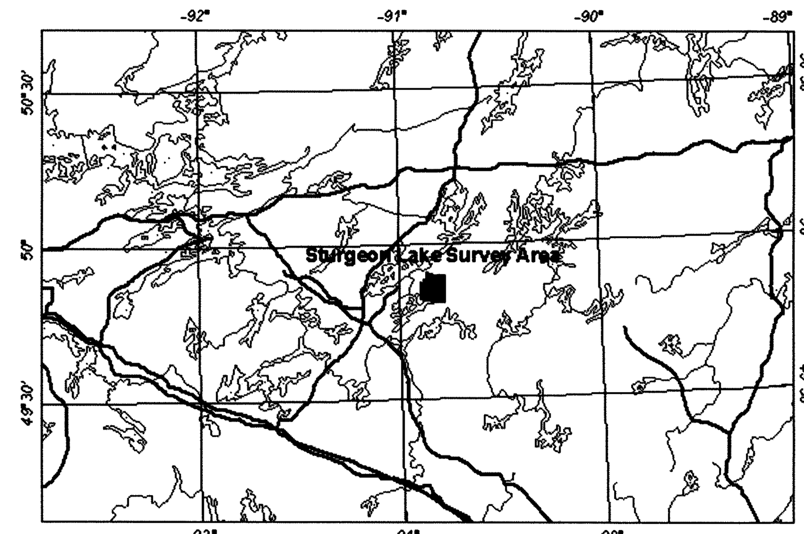


Survey Specifications

Survey Line Spacing 200m
Survey Line Azimuth .... 000°-180°
Tie-Line Spacing 2500m
Tie-Line Azimuth .... 090°-270°
Survey Type .... Airborne Electromagnetic and Magnetic

Aircraft Specifications

Survey Aircraft .... DeHavilland Dash-7
Aircraft Elevation .... 120m Mean Terrain Clearance
Average Aircraft Speed 65m/sec
GPS Receiver .... NOVATEL Propak 4E-315R 12 Channel Differential
GPS Sample Rate 1.0s

Magnetic Specifications

Magnetometer .... Scintrex CS-2 Cesium Vapour
Magnetometer Installation .... Towed Bird
Magnetometer Sensitivity 0.01nT
Sample Rate 0.10s
I.G.R.F. Model 2000
I.G.R.F. Correction Date 2003.4

Electromagnetic Specifications

Electromagnetic System .... MEGATEM® 20 Channel Multicoil System
Transmitter Installation .... Vertical Axis Loop Mounted on Aircraft
Transmitter Loop Area 406m²
Transmitter Loop Turns 5
Transmitter Base Frequency 90Hz
Pulse Width 2200µs
Pulse Offtime 3255µs
Receiver Installation .... Towed Bird
Receiver Coils .... Multiple Coils in X, Y, Z Orientation
Receiver Sample Rate 0.25s
Digital Acquisition .... Fugro Airborne Surveys Geodas System
Analogue Acquisition .... RMS GR-33 Chart Recorder
Video Acquisition .... Colour VHS Video

Geodetic Specifications

Map Projection .... UTM
Datum NAD27
UTM Zone .... 15 North
Central Meridian .... 93° West
False Easting 500000
False Northing 0
Scale Factor 0.9996

N

Inclination 76 degrees
Declination -1.85 degrees

Scale 1:20000

250 0 250 500 750 1000 1250 1500
metres
NAD27 / UTM zone 15N

DeHavilland Dash-7

MEGATEM SURVEY AIRCRAFT

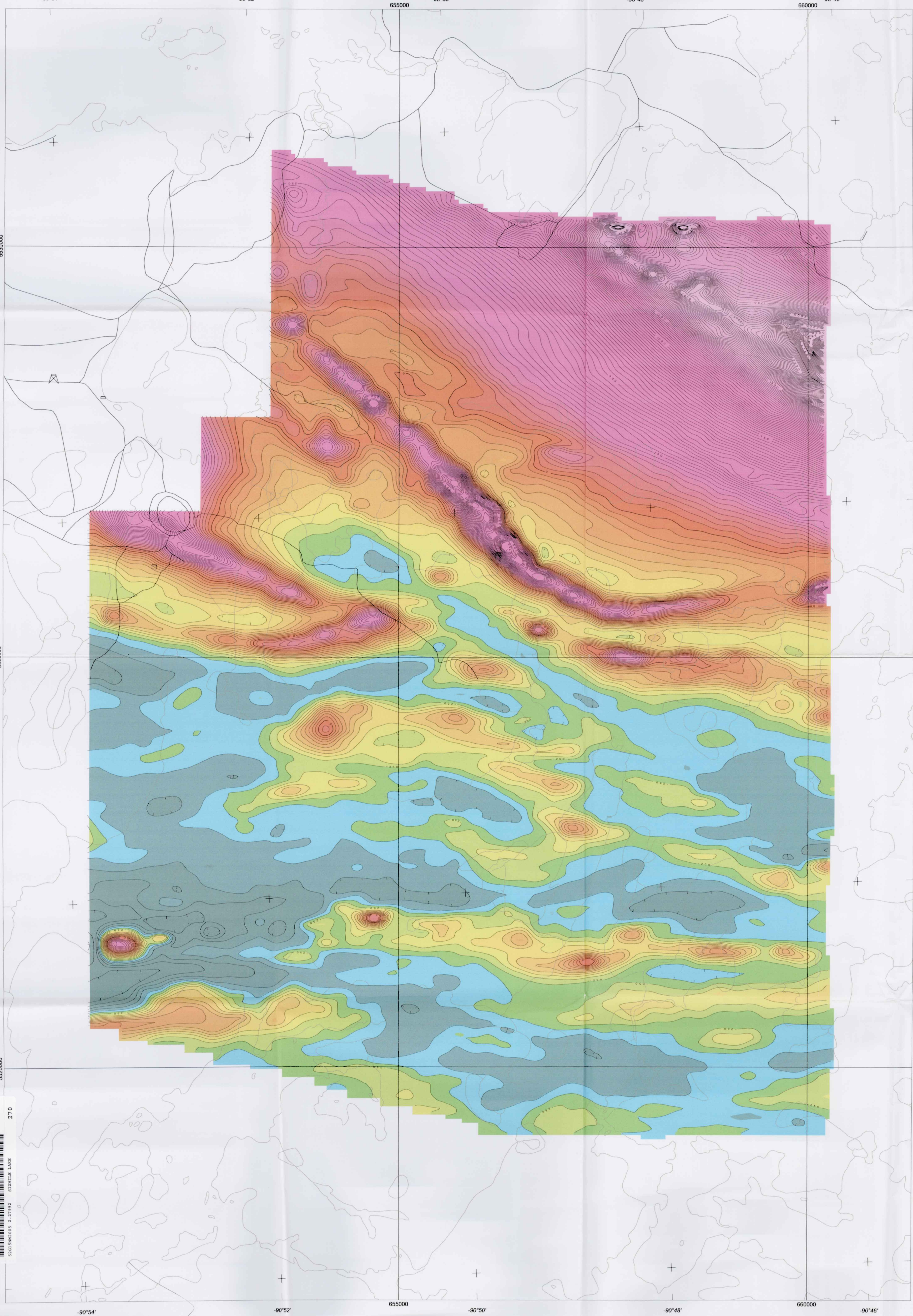
Fugro Job Number 03438
Map Creation: 22.08.03

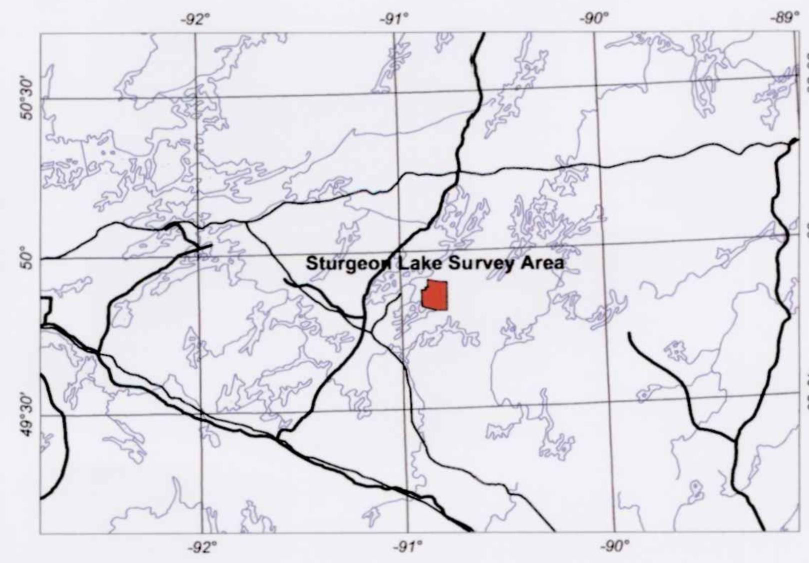
FUGRO AIRBORNE SURVEYS

Airborne MEGATEM® / Magnetic Survey
For
Unitronix Corp. and 1522923 Ontario Inc.
Sturgeon Lake Survey
Thunder Bay, Ontario

Residual Magnetic Intensity

Contour Interval 25 nanoTeslas





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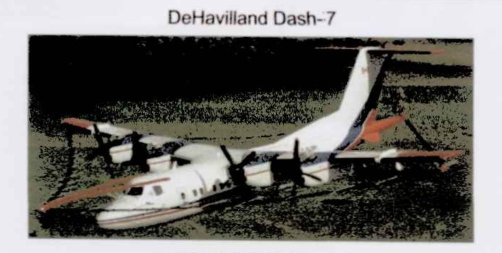
Scale 1:20000

250 0 250 500 750 1000 1250 1500
metres
NAD27 / UTM zone 15N

2.27992

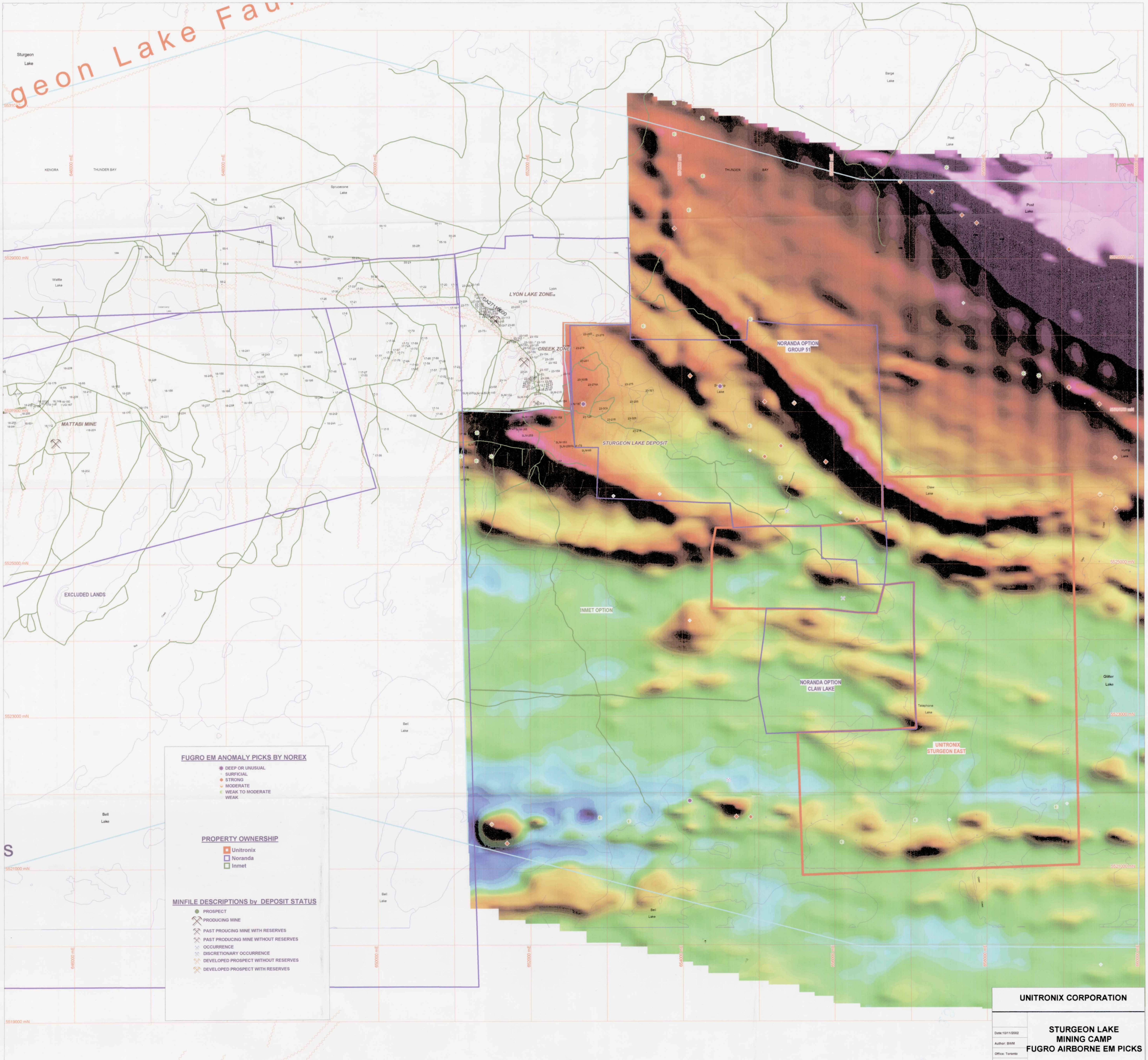
DeHavilland Dash-7



MEGATEM® SURVEY AIRCRAFT

Fugro Job Number 03438
Map Creation: 22.08.03

FUGRO AIRBORNE SURVEYS


Sturgeon Lake Fault
LYON LAKE ZONE
CREEK ZONE
STURGEON LAKE DEPOSIT
MATTABI MINE
EXCLUDED LANDS
INMET OPTION
NORANDA OPTION GROUP 51
NORANDA OPTION CLAW LAKE
UNITRONIX STURGEON EAST
FUGRO EM ANOMALY PICKS BY NOREX
DEEP OR UNUSUAL
SURFICIAL
STRONG
MODERATE
WEAK TO MODERATE
WEAK
PROPERTY OWNERSHIP
Unitronix
Noranda
Inmet
MINFILE DESCRIPTIONS by DEPOSIT STATUS
PROSPECT
PRODUCING MINE
PAST PROUCING MINE WITH RESERVES
PAST PRODUCING MINE WITHOUT RESERVES
OCCURRENCE
DISCRETIONARY OCCURRENCE
DEVELOPED PROSPECT WITHOUT RESERVES
DEVELOPED PROSPECT WITH RESERVES
UNITRONIX CORPORATION
STURGEON LAKE MINING CAMP FUGRO AIRBORNE EM PICKS
Date:10/11/2002
Author: BWM
Office: Toronto
Drawing:
Scale: 1:50000
Projection: UTM Zone 15 (NAD 83)
0 0.5 1 2
kilometres