LOGISTICAL REPORT

Natural Source AMT GEOPHYSICAL SURVEY

Planet Project Basin Study

2, 24439
Red Lake, Ontario, Canada
for
Rubicon Minerals Corporation

Issue date: October 20, 2002
Zonge Job # 0233

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Reference:

Page 7, Figure 1: Labson et al., Geophysics, Vol. 50 No. 4 (April 1985) pages 656-664
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Lines 10000, 10200, 10400, 10600 and 10800 (1:10000)

Pseudosections (B & W), Cagniard Resistivity and Impedance Phase
1-D & 2-D Smooth-Model Inversion (color), Resistivity vs Depth
LOGISTICAL REPORT
Natural Source AMT GEOPHYSICAL SURVEY

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EXECUTIVE SUMMARY

On October 2\textsuperscript{nd}, 2002, Natural Source Audio-frequency Magnetotelluric (NSAMT) data collection started on the Planet Project. For this program, Zonge Engineering and Research Organization provided a crew chief with a single GDP-32 based NSAMT system. The crew chief/instrument operator from Zonge Engineering was Josh Matthews.

The Planet project grid is located near Red Lake in northern Ontario, Canada. Mining exploration operations on the Adams Lake Project supplied field assistants for the Planet NSAMT survey. Zonge Engineering equipment and crew chief had finished CSAMT data collection on the Adams Lake Grid prior to moving to the Planet Project. NSAMT data collection was completed on October 4\textsuperscript{th}, for a total of three production days. After the finishing work on the Adams Lake Grid on Saturday, October 5\textsuperscript{th}, the Zonge geophysical equipment was prepared for demobilization to Tucson and the Zonge crew chief returned to Tucson, Arizona.
A total of five NSAMT survey lines were completed on the Planet Program, for a total coverage of 4150 meters with eighty-three 50 meter stations. Data was collected from 3 Hz to 8192 Hz. These data are present in this logistics report as Cagniard Resistivity and Impedance Phase pseudosections, along with 1-D and 2-D Smooth-Model Inversion images.
PROJECT SCHEDULE

Mobilization from: Tucson, Arizona To: Red Lake, Ontario, Canada

Arrive Red Lake, Ontario, Canada: September 5th

Start Planet Project: October 2nd
- October 2
- October 3
- October 4

NSAMT Production

End of work on the Planet Project: October 4th

Leave Red Lake: October 6th, 2002
LOGISTICS

Survey Parameters

Natural source AMT (NSAMT) scalar data were collected in the vicinity of Red Lake on the Planet Grid. Scalar valued NSAMT were collected using the standard AMT frequency range extending from 3.0 Hz to 8192 Hz. While seasonal variations in the magnetic field spectral density can be expected to be high, as illustrated by Figure 1 (after Labson et al. 1985), background signal levels observed during the survey were satisfactory at most locations.

Concerns in collecting these NSAMT data were signal levels in the attenuation band between frequencies of 2 kHz and 4 kHz. In this band natural source signals are generally absent. The Zonge-Geotell ANT/06 magnetic field sensor, selected for AMT data collection, has a noise threshold level below typical natural source signal levels for typical NSAMT applications shown in Figure 1. For natural source AMT data collected on the Planet Grid, it was possible to collect useful data in this attenuation band.

Figure 1: Variation over a year in magnetic field spectral density at four frequencies (after Labson et al., 1985)
While electric-field and magnetic-field TENSOR measurements provide more comprehensive detail at each station, production rates using the SCALAR array maximizes linear production. Scalar NSAMT data were collected on the five survey lines completed on the Planet Grid. Six electric field dipoles, measuring Ex, were collected at each setup on all four survey lines. With 50 meter dipoles, each scalar AMT setup covers 300 meters. Each setup requires six 50 meter dipoles (six Ex dipoles) and one ANT06 magnetic field sensor (Hy) for a total of seven analog channels. NSAMT data collected with Ex perpendicular to strike, is defined as the Transverse Magnetic (TM) Mode direction.

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<th>Frequencies (Hz)</th>
<th>Sample Rate (Hz)</th>
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<td>32768</td>
</tr>
<tr>
<td>High</td>
<td>48-1024</td>
<td>8192</td>
</tr>
<tr>
<td>Medium</td>
<td>3-64</td>
<td>256</td>
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Tensor MT Setup

![Image of Tensor MT Setup]

Scalar MT Setup

![Image of Scalar MT Setup]

**Figure 2: Natural Source AMT/MT Array**

**Field Instrumentation**

The Scalar NSAMT coverage provides faster production rates than is possible using the tensor array. Scalar data provides reasonable production rates providing results that are directly comparable with controlled source CSAMT inversion models, an accepted industry standard. The backpack-portable GDP-32 receiver is based on a 16-bit microprocessor-controlled receiver capable of gathering data on as many as 16 analog channels simultaneously. For the NSAMT work completed on the Planet Grid, a large case GDP-32 was used with 8 channels. Six channels were used to collect Ex; a single channel was used with the ANT/06 coil to collected Hy.

Both the electric Ex and magnetic Hy field signals were preconditioned using an extremely low-noise signal conditioner, the SC-8 manufactured by Zonge Engineering. The SC-8 is an extremely low-noise signal conditioner that preconditions the electric Ex and magnetic Hy field signals digitized by the GDP-32. The electric-field signal is sensed at the receiver site using non-polarizable porous pot electrodes, connected to the receiver with 14-gauge insulated wire. The magnetic-field signal is sensed with the
ANT/06 AMT sensor, a mu-metal cored magnetic field antenna utilizing feedback technology, manufactured for Zonge Engineering by Geotell Instruments. The SC-8 allows operator selected gains, with operator selected high- and low-band noise filtering. Twenty-four volt power provides the SC-8 electronics with distortion-free processing of electromagnetic data containing ultra-high frequency noise.
DATA PROCESSING AND INVERSION MODELS

Processing, inversion and interpretation of the AMT data is a multistage process. Processing calculates averaged Cagniard Resistivity and Impedance Phase data. Cagniard Resistivity is a frequency dependent impedance, calculated from electric E and magnetic field H data. Resistivity is generally identified by \( \rho \) or \( \text{Rho} \). Impedance Phase, the time-related phase difference between E and H components of the electromagnetic field, is generally defined as \( \Delta \varnothing \). \( \text{Rho} \) and \( \Delta \varnothing \) are both used in the 1-D and 2-D inversion process to image resistivity changes in geology. This applies to both CSAMT and NSAMT data collection.

Because of the random variations characterizing the earth’s magnetotelluric field, NSAMT data cannot be stacked as synchronous data. NSAMT results are collected as a continuous time series set of data. The Cascade Decimation Method (Wight and Bostick, 1980) is a computationally efficient method for transforming time series data from “time” to “frequency” domain.

NSAMT Cagniard Resistivity and Impedance Phase are summarized concisely in the block-averaged natural source RAW field files. Time-Series records are stored for all AMT data collected on this project. Coherency Coefficients are a measure of the causal relationship between the electric E and magnetic H fields. Coherency limits can be set for GDP-32II data collection.

In processing the RAW NSAMT files, a minimum Coherency limit can be set to reject data with low coherence values between the electric and magnetic field (Egbert and Livelybrooks) data. In practice this tends to remove periods of low signal strength and portions of the data contaminated by major local noise sources. At this stage of the processing the impedance phase of each portion of the data set is checked to ensure that it is in the proper quadrant. Although this check has proven to be effective in removing the effects of large coherent noise sources that are effectively acting as near-field transmitters, each situation is different. Sometimes it is useful to set a maximum Coherency limit to reject these strong, nearby electromagnetic noise sources.

Processing produces an averaged data set ready to plot Cagniard Resistivity and Impedance Phase pseudosections, as well as data ready for 1-D and 2-D inversion modeling. Depending on the minimum Coherency limit used, resistivity and phase
measurements having unsatisfactory Coherency Coefficients are either left blank on the pseudosection or are bracketed [ ] showing the extreme resistivity and phase limits calculated for the plot point.

The more advanced stage of processing is available using Time Series results. This is an interactive procedure that allows the operator to visually evaluate individual segments of the time-series data stream. This Robust Processing (Chave and Thompson, 1989) method is an iterative process. The first stage makes a "least squares" estimate of the impedance values. For "least-squares" methods to successfully estimate the impedance, the inherent errors must have a Gaussian distribution, an assumption that is often not met by natural source MT-type data. The Robust Processing method forces a Gaussian distribution by down-weighting outlier points and then calculates a new least squares estimate. This process continues until a stable solution is obtained. This process effectively eliminates the influence of a small number of high power anomalous readings. Time Series processing was applied to all NSAMT data presented in this report.

Data Quality and Presentation

Time-series NSAMT results are presented as Cagniard Resistivity and Impedance Phase pseudosections for this report. These data are included as black-and-white plots (pseudosections) and are located in Appendix. Information is shown for each station across the top of the plot with decreasing frequencies (related to increasing depth) forming the vertical axis. Because the relationship between frequency and depth is complicated, these plots do not represent actual cross sections. The Cagniard Resistivity and Impedance Phase frequency plots are referred to as "pseudosections". NSAMT resistivities are influenced by static-shift. A comparison of the 1-D and 2-D inversion models does provide some indication of the severity of static-shift.

NSAMT deals with FAR-FIELD electromagnetic fields; where calculated resistivities depend on geology beneath the transmitter, not the distance to any source. FAR-FIELD assumes that signal sources are remote and that NSAMT is measuring a plane-wave electromagnetic field. The position of nearby electromagnetic sources influences NSAMT Cagniard Resistivity and Impedance Phase results, which can be undesirable. Useful magnetic field H and electric field E magnitudes are from NSAMT power spectra from a multitude of distant sources. In NSAMT, the ability to obtain coherent data in the earth’s natural frequency absorption bands is crucial in measuring Resistivity (Rho), and Impedance Phase data (ΔΦ).
No nearby sources of electromagnetic radiation were observed on the Planet Grid. No grounded culture or electric power lines were observed in the vicinity of the Planet Grid. The NSAMT data collected on the Planet Grid is not influenced by nearby noise sources or grounded culture.

**Inversion Models**

For the best use of NSAMT data collected on the Planet Grid, sophisticated modeling methods are required. The NSAMT data set has been modeled with the 1-D layered earth (Zonge SCSINV) and 2-D earth (Zonge SCS2D) inversion programs. For the 1-D inversion, geology is assumed uniform and orientation is not considered in these modeled results 1-D. All inversion models images are found in Appendix A.

For the 2-D inversion of scalar AMT data, the NSAMT array orientation is assumed to be **TM** (transverse magnetic). This requires that survey lines (Ex) are reasonably orientated perpendicular to geologic strike with the magnetic field (Hy) parallel to strike. In fact, this is not always the situation. On the Planet Grid it is possible that scalar Ex data are partly influenced by skew contacts and off-line features (3-D features) which tends to distort inversion models. Despite these off-line changes, scalar based resistivities represent a reasonable approximation of the TM response and effectively image geologic contacts.

The 2-D inversion models using scalar NSAMT data reasonably represent on-line changes in geology. While the 1-D inversion is also influenced by off-line geology, these modeled results make no assumptions about high-angle contacts in any direction. When interpreting changes in complex geology, confidence in the 1-D and 2-D imaged models is greatly enhanced where multiple lines form a grid. While plan-view images are provided for depths of 25, 100, 200, 300, and 400 meters, only information from the 2-D inversion models is provided.

**1-D Inversion versus 2-D Inversion Models**

1-D inversion models based on NSAMT data are strongly controlled by surface geology. This produces the extended vertical features observed on the 1-D modeled sections and is especially noticeable where vertical features extend from the surface. This is the problem of “static-shift”. The “shift” effect is defined as a shift in the resistivity sounding curve from station-to-station unsupported by changes in geologic. The “static-shift” phenomenon is useful because it serves as a sensitive indicator identifying high contrast
resistive or conductive zones defined by a sharp contact edge. This could be a high-angle tabular feature, or 3-D off-line feature.

While this makes high-angle faults and veining easy to see in the 1-D imaged section, depths estimated from the 1-D inversion models may be questionable. Many times the 2-D inversion will not see thin high-angle features. Therefore a comparison of the 1-D and 2-D inversion models is important in identifying certain high-angle features of potential interest. This comparison is an important tool in characterizing trends observed on 1-D and 2-D plan view sections.

2-D inversion models have several advantages over 1-D models. On this project 2-D models are able to show two-dimensional shaped structures (for example, edges associated with contacts at depth). This also allows topographic effects to be removed from 2-D modeled resistivities and corrects depths accordingly. Small, shallow conductivity anomalies responsible for static-shift are recognizable 2-D features. The 2-D inversion removes the need to perform static-shift corrections.

The 2-D inversion (SCS2D) used for modeling far-field data was developed at Zonge Engineering. Like the 1-D models, the 2-D results form a smooth model inversion and therefore the estimated resistivity varies smoothly both vertically and horizontally along the plane of the section. The 2-D assumption assumes that the calculated conductivity extends infinitely perpendicular to the section (in and out of the page).

The results of processing and modeling the data are shown in the color cross sections, with stations across the top and increasing depth down the side. In these plots, low resistivities are shown with "warm" colors (orange, red) and high resistivities are shown in "cool" colors (blue, green). It is important to note that the smooth-model inversion program shows gradational changes in resistivity, rather than abrupt, blocky changes, regardless of the true geological structure.

To illustrate the effects of the modeling scheme, the results of a small modeling project are presented. In this modeling exercise, synthetic AMT test data were generated for a conductive and a resistive prism embedded in a uniform 100 ohm-m background. Both prisms were 100 m below the surface, 100 m wide, 100 m deep, and with infinite strike length.
Figure 3: 2-D TM Inversion

Figure 3 displays the results of inverting TM mode data. The model in this case accurately images both the conductive and resistive prisms, and provides good estimates for the depth and width of each.
COMMENTS

The 2-D modeled inversions provided in this AMT survey program appear reasonable to depths of 800 meters. Technically it is possible for AMT results to image geology below 1000 meters, but there are practical limitations in resolving features below a certain size. This relates to size and conductivity contrasts. At depth below 1000 meters, interpretations based on either 1-D or 2-D data should be viewed critically. Only features the size of 15% of the burial depth, or more, will be reliably imaged at depth. It is possible that thin tabular trends plunging to depth may locate deeper features normally obscured by poor survey resolution.
Conclusions

The NSAMT survey on the Planet Project provides resistivity vs depth images, based on 1-D and 2-D smooth-models, for five lines. The 1-D and 2-D images clearly identify a conductive trend best seen on the plan-view plots. Given the limited NSAMT coverage collected on the Planer Grid, the natural source AMT data has certainly provided interesting and potentially important detail about geology characterizing the grid zone.

The natural source AMT survey proceeded with minimum problems. The survey task was completed in three days. NSAMT data collection, with the Zonge Engineering GDP-32, has certainly proved to be a practical geophysical tool for imaging resistive and conductive geology to depths of 800 meters, and potentially much deeper. In addition, the passive AMT technique has shown itself to be inherently safe. No high-voltage electric power sources are required as remote signal sources for the natural source AMT survey.

The five NSAMT traverses completed on the Planet Project would certainly complement future geophysical studies in the vicinity of the Planet Grid.

Emmett Van Reed
Senior Geophysicist

Dexin Liu
Geophysicist
APPENDIX A

Location Map

NSAMT Pseudosections
with
One and Two-Dimensional Inversion Models
Planet AMT Survey Line Location Map

GPS Datum: WGS-84
0 100 200 300 400

For Rubicon Minerals
Plotted Oct. 2002
By Zonge Engineering
Planet AMT Survey
2D Smooth-Model Resistivity at 25 Meters Depth

For Rubicon Minerals
Plotted Oct. 2002
By Zonge Engineering
Planet AMT Survey
2D Smooth-Model Resistivity at 100 Meters Depth

Easting (UTM, meter)

Northing (UTM, meter)

GPS Datum: WGS-84

For Rubicon Minerals
Plotted Oct. 2002
By Zonge Engineering
Planet AMT Survey
2D Smooth-Model Resistivity at 200 Meters Depth

GPS Datum: WGS-84
For Rubicon Minerals
Plotted Oct. 2002
By Zonge Engineering
Planet AMT Survey
2D Smooth-Model Resistivity at 300 Meters Depth

GPS Datum: WGS-84
For Rubicon Minerals
Plotted Oct. 2002
By Zonge Engineering
Planet AMT Survey
2D Smooth-Model Resistivity at 400 Meters Depth

For Rubicon Minerals
Plotted Oct. 2002
By Zonge Engineering

GPS Datum: WGS-84

Easting (UTM, meter)

Northing (UTM, meter)
## Work Report Summary

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**Status:** APPROVED  
**Recording Date:** 2002-OCT-31  
**Approval Date:** 2002-NOV-06  
**Work Done from:** 2002-SEP-27 to: 2002-OCT-04

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129617  
ENGLISH, PERRY VERN

### Survey Type(s):  
LC, MAG

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### Reserve:  
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Reserve of Work Report#: W0220.01667

### Total Remaining:  
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Status of claim is based on information currently on record.
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.

If you have any question regarding this correspondence, please contact STEVEN BENETEAU by email at steve.beneteau@ndm.gov.on.ca or by phone at (705) 670-5855.

Yours Sincerely,

Ron Gashinski
Senior Manager, Mining Lands Section

Cc: Resident Geologist
    Perry Vern English
    (Claim Holder)

    Assessment File Library
    Perry Vern English
    (Assessment Office)

    Darwin Green
    (Agent)
Natural Source Data
Receiver Data:
Length = 50 m
Orient. = S40E
Inversion control parameters:
dpW=1, dxW=1, dzW=2

Rubicon Minerals
Planet Line 10000

1D Smooth-Model Inversion
Scalar AMT Data

REPORT
Job 0233

SCALE
1:10000

AUTHOR
Zonge Engine

DRAWN
Zonge Engine

DATE
24/10/02

REP100001d.m1d
Rubicon Minerals
Planet Line 10200

1D Smooth-Model Inversion
Scalar NSAMT Data

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Rubicon Minerals
Planet Line 10400

1D Smooth-Model Inversion
Scalar NSAMT Data
Planet Line 10600

Natural Source Data
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Length = 50 m
Orient. = S40E
Inversion control parameters:
dpW=1, dxW=1, dzW=2
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Receiver Data:
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Rubicon Minerals
Planet Line 10200

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Rubicon Minerals
Planet Line 10400

2D Smooth-Model Inversion
Scalar AMT Data

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Rubicon Minerals
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2D Smooth-Model Inversion
Scalar AMT Data

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Inversion control parameters:
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Natural Source Data
Receiver Data:
Length = 50 m
Orient. = S40E
Inversion control parameters:
ResSmth=0.5, dpW=0.1, dxW=1, dzW=1

Rubicon Minerals
Planet Line 10000

2D Smooth-Model Inversion
Scalar AMT Data
Line 10400
Planet
for Rubicon Minerals

Field Job 0233
Zonge Zplot 7.35
File 10400T.ZCR, Plotted 25 Oct 02

- 8192 Hz
- 4096 Hz
- 2048 Hz
- 1024 Hz
- 512 Hz
- 256 Hz
- 128 Hz
- 64 Hz
- 32 Hz
- 16 Hz
- 8 Hz
- 4 Hz
- 2 Hz

NSAMT Zxy DATA
IMPEDEANCE PHASE
values in milliradians

RECEIVER DATA
Length = 50 m  Line = N 40 W
Spacing = 50 m  Dipole= N 40 W
Surveyed= Sept 12

TRANSMITTER DATA

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{ Interval: 100.00 }
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-100. 900.
0.00* 1000.
100. 1100
200. 1200
300. 1300
400. 1400
500. 15000
600. 1600
700. 1687
Line 10400
Planet for
Rubicon Minerals

Field Job 0233
ZONGE ZPLOT 7.35
File 104007.ZCR, Plotted 25 Oct 02

NSAMT Zxy DATA
CAGNIARD APP. RES.
values in ohm-m
Data from F:\job0233\timedata\10400\10400

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Surveyed= Sept 12

TRANSMITTER DATA
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[Plot limits]

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4096 Hz
2048 Hz
1024 Hz
512 Hz
256 Hz
128 Hz
64 Hz
32 Hz
16 Hz
8 Hz
4 Hz
2 Hz

2 Hz
Line 10600
Planet
Rubicon Minerals

Field Job 0233
ZONGE ZPLOT 7.35
File 10600T.ZCR, Plotted 25 Oct 02

NSAMT Zxy DATA
CAGNIARD APP. RES.

values in ohm-m
Data from 10600T.AVG

RECEIVER DATA
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Spacing= 50 m  Dipole= N 40 W
Surveyed= Sept 12

TRANSMITTER DATA
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Dipole= N 40 W

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( Interval: 0.20 )

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4096 Hz
2048 Hz
1024 Hz
512 Hz
256 Hz
128 Hz
64 Hz
32 Hz
16 Hz
8 Hz
4 Hz
2 Hz

8192 Hz
4096 Hz
2048 Hz
1024 Hz
512 Hz
256 Hz
128 Hz
64 Hz
32 Hz
16 Hz
8 Hz
4 Hz
2 Hz

31.7 cm A3
Line 10000
Planet
for
Rubicon Minerals

Field Job 0233
ZONGE ZPLOT 7.35
File 10000T.ZDR, Plotted 25 Dec 02

NSAMT Zxy DATA
IMPEDEANCE PHASE
values in milliradians

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500.* 600.*

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500.* 600.*

Plot limits and ARITHMETIC CONTOURS
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100. [1042]
200. 300.
400. 500.*
500.* 600.*