A REPORT ON GRADIENT IP /RESISTIVITY, AND MAGNETOMETER GEOPHYSICAL SURVEYS ON THE DIAMOND LAKE WEST EXTENSION GRID, McVITIE TOWNSHIP PROPERTY, LARDER LAKE AREA, NORTHEASTERN ONTARIO (NTS 32D/4)

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DIAMOND LAKE EAST EXTENSION, McVITTIE TWP. PROJECT
(NTS 32D/4)

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Scale 1:5000

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Scale 1:5000

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SUMMARY

Between August 10th and August 15, 1993, Total Field Magnetics, and Gradient Array SPECTRAL Induced Polarization (IP) /Resistivity surveys were conducted on behalf of Sudbury Contact Mines Ltd. on the Diamond Lake West Extention on the Diamond Lake project, near Larder Lake, Ontario by JVX Ltd.

A total of approximately 8.5 line-kilometers of IP/Resistivity and 9.25 line-kilometers of Magnetics coverage were surveyed.

The results are presented as, contour maps, off set profiles and anomaly compilation plan maps. Resistivity highs / lows, magnetic trends and interpreted structures. The physical characteristics of each chargeability response are marked beside each anomaly bar. Target areas are outlined in the compilation map and the individual anomalies considered to be exploration targets are circled and labeled "L, M, or H" (low, medium or high priority).

The geophysical targets which warrant further work are listed below:

Targets for follow-up

T-1 MH1a...L-2800N / 800W Magnetic high with resistivity low; Evaluate for Kimberlite. Medium to High Priority (Based on proximity of Diamond Lake Pipe.)

T-2 MH1b...L-2600N / 800W Magnetic high with resistivity low on west shoulder; Evaluate for Kimberlite. Medium to High Priority (Based on proximity of Diamond Lake Pipe.)

T-3 IP1e...L-2800N / 550W Strong IP with resistivity high. Evaluate for gold; Medium Priority

Structure on the WEST GRID EXTENTION
( COMPILATION MAP - PLATE : 1-G )

A series of faults have been interpreted from the magnetic data. The right angle nature of them make them favourable for kimberlite emplacement.
A REPORT ON GRADIENT SPECTRAL IP / RESISTIVITY,
AND MAGNETOMETER GEOPHYSICAL SURVEYS
ON THE DIAMOND LAKE WEST EXTENSION GRIDS
McVITTIE TWP. PROPERTY
LARDER LAKE AREA,
NORTHEASTERN ONTARIO

(NTS 32D/4)

On Behalf Of

SUDBURY CONTACT MINES LTD.

1. INTRODUCTION

From August 10 to August 15, 1993, time domain SPECTRAL polarization / resistivity
(gradient array), total field magnetic survey and line-cutting were conducted by JVX Ltd. on
behalf of Sudbury Contact Mines Ltd. (2302, 401 Bay Street, P.O. Box 102, Toronto, Ontario,
M5H 2Y4) care of W. A. Hubacheck Consultants Ltd. (141 Adelaide St. West, Suite 1401,
Toronto, ON, M5H 3L5) on the Diamond Lake West Extension Grid, McVittie Twp. Property,
Larder Lake Area, Northeastern Ontario (NTS 32D/4). The purpose of the survey was to utilize
IP/resistivity and total field magnetics to define spatial orientation and strike extent of
disseminated metallic sulphides and magnetic susceptibility which may be related to gold
mineralization and kimberlite. The final products of this survey include interpreted SPECTRAL
IP anomalies, associated resistivity responses and magnetic trends anomalies prioritized for
further examination.

The IP survey employed the gradient array with a dipole spacing of 50 meters and a station
separation of 25 metres. A total of 8.475 km of gradient IP/resistivity coverage was achieved
over 14 lines. The total field magnetics was surveyed at a nominal 12.5 meter station
separation on 100 m spaced lines. A total of 9.250 km of total field magnetics was achieved
over 15 lines. A total of 9.250 line-km of line-cutting also was achieved.

This report describes the survey logistics, field procedures, and data processing/presentation
with an interpretation of the results. The results are presented as a compilation/anomaly plan
map and contour plan maps.
2. SURVEY LOCATION

Figure 1 shows the location of the survey area at a scale of 1:1,600,000. The survey grid is in the McVittie Township approximately 10 km west of Larder Lake, Ontario. Access to the property is by dirt road from highway 66.

3. SURVEY GRID AND COVERAGE

3.1 Grid Description

The West Extension Grid consists of 9.25 km of refined metric grid. The line spacing of the grid is 100 meters. Figure 2 outlines the grid coverage.

IP/Resistivity Coverage

Diamond Lake West Extension was surveyed with a total of 8.5 km of line IP/resistivity coverage, achieved over 14 cross-lines employing the gradient array with one gradient IP block covering the grid (see figure 2 and appendix 2 for gradient IP block). The 'a'-spacing was 50 meters with 25 meter station separation.

Total Field Magnetics Coverage

Diamond Lake West Grid was surveyed with a total of 9.25 km of total field magnetics, achieved over 15 cross-lines. The readings were taken at a nominal 12.5 meter station separation on 100 m spaced lines.

The following tables, 1 and 2, give a detailed geophysical production summary.
LOCATION MAP

SUDBURY CONTACT MINES LTD.

Panthco - MaryAnn Joint Venture
Royal Oak (Lac) Joint Venture
DIAMOND LAKE GRID

GROUND GEOPHYSICAL SURVEY

Scale: 1 : 1,600,000

Survey by JVX Ltd.,
1993

Figure 1
GRID MAP
SUDBURY CONTACT MINES LTD.
PANTHCO - MARY - ANN JOINT VENTURE
DIAMOND LAKE GRID
WEST EXTENSION
GROUND GEOPHYSICAL SURVEY
Scale : 1 : 50,000
Survey by JVX Ltd.

FIGURE 2
### TABLE 1
WEST EXTENSION GRID
IP/RESISTIVITY (gradient array) PRODUCTION SUMMARY

Baseline Az 90 deg.
50 m "a"-spacing
25 m station separation

<table>
<thead>
<tr>
<th>Line</th>
<th>Station From</th>
<th>Length (meters)</th>
<th>Number of Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>3500N</td>
<td>275W</td>
<td>1062.5W</td>
<td>775</td>
</tr>
<tr>
<td>3400N</td>
<td>300W</td>
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<td>750</td>
</tr>
<tr>
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<td>325W</td>
<td>1062.5W</td>
<td>725</td>
</tr>
<tr>
<td>3200N</td>
<td>425W</td>
<td>1062.5W</td>
<td>625</td>
</tr>
<tr>
<td>3050N</td>
<td>425W</td>
<td>1060W</td>
<td>625</td>
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<tr>
<td>3000N</td>
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<td>980W</td>
<td>500</td>
</tr>
<tr>
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<td>500W</td>
<td>980W</td>
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<td>575</td>
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<td>550</td>
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<td>625</td>
</tr>
<tr>
<td>2200N</td>
<td>675W</td>
<td>980W</td>
<td>300</td>
</tr>
</tbody>
</table>

WEST EXTENSION GRID Total: 8475

### TABLE 2
WEST EXTENSION METRIC GRID
TOTAL FIELD MAGNETIC PRODUCTION SUMMARY

Baseline Az 90 deg.
12.5 m station separation

<table>
<thead>
<tr>
<th>Line</th>
<th>Station From</th>
<th>Length (meters)</th>
<th>Number of Readings</th>
</tr>
</thead>
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<tr>
<td>3500N</td>
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<td>775</td>
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<tr>
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<td>650</td>
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</table>


### 4. PERSONNEL

Mr. Fred Moher - Geophysical Technician. Mr. Moher operated the Scintrex IP receiver and IGS/MP-4 magnetometer and was responsible for the data quality, day to day operation and direction of the surveys.

Mr. Robert Chataway - Geologist BSc., Mr. Chataway operated the IP transmitter and was responsible for locating the grid and topographic/geology maps.

Three field assistants were also engaged by JVX.

Mr. Albert Vickers - Geophysicst BSc., Mr. Vickers assisted in data compilation.

Mr. Jan Kozel - Geophisicsts MSc., Mr. Kozel processed and plotted all the geophysical data.

Mr. Blaine Webster - President, JVX Ltd. Mr. Webster provided overall supervision and prepared the interpretation section of the report.

### 5. GEOPHYSICAL INSTRUMENTATION

JVX supplied the following geophysical instruments, accessories and software.

#### 5.1 MAGNETOMETER

The Scintrex IGS-2/MP-4 proton precession magnetometer microprocessor-based receiver system was employed to measure the total magnetic field over the survey grids. Measurements were taken along the line at 12.5 meter (50 ft. on imperial grids) station intervals. The geophysical measurements, time and position information are recorded in the instrument's solid state memory. A second base magnetometer was used to monitor the diurnal change, the base magnetometer was set to take readings at 10 second intervals. At the end of each day

<table>
<thead>
<tr>
<th>Distance (N)</th>
<th>Magnitude (W)</th>
<th>Distance (W)</th>
<th>Magnitude (N)</th>
<th>Distance (N)</th>
<th>Magnitude (W)</th>
<th>Distance (W)</th>
<th>Magnitude (N)</th>
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<td>2500N</td>
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<tr>
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<td>987.5W</td>
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</tr>
<tr>
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<td>650W</td>
<td>987.5W</td>
<td>350</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WEST EXTENSION GRID Total: 9250 385
the correction for the diurnal shift was made automatically by either linking the base station magnetometer to the field magnetometer or by dumping each magnetometer to a IBM compatible computer and running appropriate JVX software for the drift correction.

5.2 IP RECEIVER

The IP survey utilized the Scintrex IPR-11 time domain microprocessor-based receiver. This unit operates on a square wave primary voltage and samples the decay curve at ten gates or slices. The instrument continuously averages primary voltage and chargeability until convergence takes place. At this point, the averaging process is stopped. Data are stored internally in solid-state memory.

5.3 IP TRANSMITTER

The survey engaged the Scintrex TSQ-3/3.0 kW time domain transmitter powered by an 8 hp motor generator. This instrument is capable of putting out a square wave of 2, 4 or 8 seconds 'on-off' time. The current output was accurately monitored with a digital multimeter placed in series with the current loop.

Specification sheets for the Scintrex geophysical instrumentation are appended to this report.

5.4 DATA PROCESSING SYSTEM

The survey data were archived, processed and plotted with Geopak Software and in-house JVX software on a Compaq 286 PC microcomputer using an Epson EX-800 dot matrix printer. This system will run magnetic and IP/Resistivity Geopak contouring profiling and RTICAD color software packages, and is also configured to run JVX proprietary software, a suite of programmes that were written specifically for spectral processing and to interface with the IPR-11 receiver. At the conclusion of each day's data collection, data resident in the instruments' memory were transferred, via serial communication link, to the computer - thereby facilitating editing, processing and presentation operations. All data were archived on floppy disk.

In the Toronto office the IP/Resistivity and Magnetic data were ink-plotted in contour and profile with posted values plan map formats with a Nicolet Zeta drum plotter and color on a Fujitsu dot matrix and/or Tectronics Ink-Jet printer plotter interfaced to an IBM compatible microcomputer.

6. SURVEY METHOD AND FIELD PROCEDURES

6.1 EXPLORATION TARGET

The exploration target for the geophysical surveys is gold mineralization and diamond bearing kimberlites. Induced Polarization anomalies will result from disseminated metallic sulphides if they are of sufficient concentration and volume. The resistivity data are useful in mapping
lithologic units and zones of alteration, shearing or conductive sulphides, all of which may help define the geological / geophysical character of the area. Total field magnetic data will delineate magnetic units and non magnetic units allowing structural and lithologic interpretations to be made.

6.2 QUANTITIES MEASURED AND SURVEY METHOD (IP/Resistivity)

The phenomenon of the IP effect, which in the time domain can be likened to the voltage relaxation effect of a discharging capacitor, is caused by electrical polarization at the rock or soil interstitial fluid boundary with metallic or clay particles lying within pore spaces. The polarization occurs when a voltage is applied across these boundaries. It can be measured quantitatively by applying a time varying sinusoidal wave (as in the frequency domain measurement) or by an interrupted square wave (as in the time domain measurement). In the time domain the IP effect is manifested by an exponential type decrease in voltage with time.

The direct current apparent resistivity is a measure of the bulk electrical resistivity of the subsurface. Electricity flows in the ground primarily through the ground-waters present in rocks either lying within fractures or pore spaces or both. Silicates which form the bulk of the rock forming minerals are very poor conductors of electricity. Minerals that are good conductors are the sulphide minerals, some oxides and graphite where the current flow is electronic rather than electrolytic.

Measurements are made by applying a current across the ground using two electrodes (current dipole). The current is in the form of an interrupted square wave with on-off periods of 2 seconds. The primary voltage and IP effect is mapped in an area around the current source using what is essentially a sensitive voltmeter connected to a second electrode pair (potential dipole). The primary voltage determines the apparent resistivity after corrections for transmitter current and array geometry. (See Figure 3).

For any array, the value of resistivity is a true value of subsurface resistivity only if the earth is homogeneous and isotropic. In nature, this is very seldom the case and apparent resistivity is a qualitative result used to locate relative changes in subsurface resistivity only.

The IPR-11 also measures the secondary or transient relaxation voltage during the two second off cycle. Ten slices of the decay curve are measured at semi-logarithmical spaced intervals between 45 and 1590 milliseconds after turn-off. The measured transient voltage when normalized for the width of the slice and the amplitude of the primary voltage yields a measure of the polarizability called chargeability in units of millivolts/volt.

For a 2 second transmit and receive time the slices of integration are as follows:
Traditionally, the M7 slice (from 690 to 1050 ms after shut-off) is chosen to represent chargeability in pseudosection form. The ten slices, of the decay curve may also follow a different convention where M0 - M9 are referred to as M1 - M10. (This convention of M1 - M10 is followed by the Geopak color IP plotting software package).

The spectral parameters M-IP, tau and "c" may be derived from the IPR-11 data with the Soft IP software. Johnson (1984) summarises the spectral parameters as follows in section 7.1.1 of this report.

Gold mineralization, one of the surveys targets, does not occur in sufficient quantities to effect either the bulk polarizability or resistivity of the ground. The anomalous IP response will be engendered by the sulphides which are commonly associated with gold deposits.

The resistivity data is useful in mapping lithologic units and geologic structures such as faults and shear zones. For gold exploration it is particularly useful to delineate zones of silicification which is often associated with gold mineralization.

The spectral data has proved useful in differentiating between fine-grained and coarse-grained sulphides or graphite (see section 7.1.1 of this report). Gold is often found associated with sulphides that are fine grained. Experience has shown the M-IP parameter (derived m) is helpful in ranking anomalies in areas of high resistivity, where the apparent chargeability is increased sympathetically. Also in areas of low conductivity, the parameter has proved advantageous in determining which anomalies have sulphide sources or which may be associated with alteration zones.

As the source discrimination capability of the IP measurement (either time or frequency domain) remains somewhat unclear, we might recommend that in areas with geologic control, the IP decay forms be studied for significant and systematic differences. If such differences appear, such may be applied elsewhere in the same geologic environment. Our experience has shown time constants (tau) are important interpretation aids in areas of moderate to high resistivities which occur with pyrite in zones of silicification. The MIP parameter is very helpful in analyzing possible sulphide content associated with fine grained sulphides.

---

**TABLE 3**

<table>
<thead>
<tr>
<th>SLICE</th>
<th>DURATION (msec)</th>
<th>FROM (msec)</th>
<th>TO (msec)</th>
<th>MIDPOINT (msec)</th>
</tr>
</thead>
<tbody>
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<td>M0</td>
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<td>30</td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td>M1</td>
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<td>M3</td>
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<td>M9</td>
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<td>1410</td>
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<td>1590</td>
</tr>
</tbody>
</table>

Traditionally, the M7 slice 8 (from 690 to 1050 ms after shut-off) is chosen to represent chargeability in pseudosection form. The ten slices, of the decay curve may also follow a different convention where M0 - M9 are referred to as M1 - M10. (This convention of M1 - M10 is followed by the Geopak color IP plotting software package).
6.3 FIELD PROCEDURES (IP/Resistivity)

The IP/resistivity survey employed the time domain method with the gradient electrode array. The geometry of the gradient array is illustrated below in figure 3. The electrodes marked C1 and C2 comprise the current electrodes. Those marked by a P1 and P2 are the potential electrodes. The receiver measures the voltage across adjacent pairs of potential electrodes P1-P2.

The electrodes marked C1 and C2 comprise the fixed current electrodes. Those marked by a P1 and P2 are the potential electrodes and are moved between the current electrodes on a grid within the following constraints:

\[
\frac{x}{L} \text{ remains less than } 0.3 \\
\frac{d}{L} \text{ remains less than } 0.3 \\
\frac{a}{L} \text{ remains less than } 0.05
\]

The line joining the two potential electrodes must remain parallel to the line joining the current electrodes. A separate and adjoining fixed current electrode set-up is needed if gradient IP/resistivity measurements are to be read outside the current \(x/L\) or \(d/L\) constraints. The gradient array survey employed a 50m potential electrode separation \(l\) and \(a\) spacing and current electrode separation that was determined for IP block. The positions for the fixed current electrode separation are illustrated in Appendix B.

The waveform of the transmitted current is a two second on-off alternating square wave. The IPR-11 measures the voltage (primary voltage) across each potential dipole at an appropriate time after the current begins its on cycle, which approximates a D.C. measurement of voltage, in order to determine the apparent resistivity of the ground.
The equation for the apparent resistivity is given by

\[ \rho_s = L^2 \frac{k}{4\pi} \cdot \frac{V}{I} \]

where \( k = \frac{2}{L} \left[ \frac{Z^2 + (1-D)^2/4}{Z^2 + (1+D)^2/4} \right] \)
and \( Z = 2x/L \) and \( D = 2d/L \).

For any array, the value of resistivity is a true value of subsurface resistivity only if the earth is homogeneous and isotropic. In nature, this is very seldom the case and apparent resistivity is a qualitative result used to locate relative changes in subsurface resistivity only.

As discussed earlier the IPR-11 also measures the secondary or transient relaxation voltage during the two second off cycle of the current, which is a measure of the polarizability of the ground. Employing the two second cycle time, ten slices of the decay curve are measured at semi-logarithmical spaced intervals starting at 45 milliseconds after current turn-off and ending 1590 milliseconds after turn-off. The measured transient voltage when normalized for the width of the slice and the amplitude of the primary voltage yields a measure of the polarizability called chargeability in units of millivolts/volt.

Chargeability (M) as measured by the IPR-11, is averaged over several periods of the transmitted waveform and normalized for:

1. the length of the integration interval;
2. the steady state voltage and
3. the number of pulses.

Mathematically this is described as:

\[ M = \frac{1000}{V_p} \int_{t_1}^{t_2} V_s \, dt \]

where

- \( M \) = chargeability (mV/V)
- \( V_s \) = secondary voltage
- \( V_p \) = primary steady state voltage
- \( t_r \) = integration interval \( (t_2 - t_1) \)
- \( t_1 \) = time at beginning of integration
- \( t_2 \) = time at end of integration

By adjusting \( t_1 \) and \( t_2 \) the chargeability is sampled at different points of the decay. Figure 4 illustrates the decay waveform with the 10 slices of integration and table 3, of section 6.2, also list the decay windows measured.

Traditionally, the M7 slice 8 (from 690 to 1050 ms after shut-off) is chosen to represent chargeability in pseudosection form. The ten slices of the decay curve may also follow a different convention where M0 - M9 are referred to as M1 - M10 (This convention of M1 - M10 is followed by the Geopak color IP plotting software package).
The spectral parameters M-IP, tau and "c" may be derived from the IPR-11 data with the Soft II software. The spectral parameters are summarized by Johnson (1984) in section 7.1.1 of this report.

6.4 MAGNETICS METHOD

The magnetic method consists of measuring the magnetic field of the earth as influenced by rock formations having different magnetic properties and configurations. The measured field is the vector sum of primary, induced and remanent magnetic effects. Thus, there are three factors, excluding geometric factors which determine the magnetic field. These are the strength of the earth's magnetic field, the magnetic susceptibilities of the rocks present and their remanent magnetism.

The earth's magnetic field is similar in form to that of a bar magnet. The flux lines of the geomagnetic field are vertical at the north and south magnetic poles where the strength is approximately 60,000 nT (or gammas). In the equatorial region, the field is horizontal and its strength is approximately 30,000 nT.
The primary geomagnetic field is, for the purposes of normal mineral exploration surveys, constant in space and time. Magnetic field measurements may, however, vary considerably due to short term external magnetic influences. The magnitude of these variations is unpredictable. In the case of sudden magnetic storms, it may reach several hundred nT over a few minutes. It may be necessary therefore, to take continuous readings of the geomagnetic field with a base station magnetometer while the magnetic survey is done.

The intensity of magnetization induced in rocks by the geomagnetic field \( F \) is given by:

\[
I = kH
\]

where:
- \( I \) is the intensity of magnetisation
- \( k \) is the volume magnetic susceptibility
- \( H \) is the magnetic field field intensity

The susceptibilities of rocks are determined primarily by their magnetite content since the it is strongly magnetic and widely distributed.

The remanent magnetization of rocks depends both on their composition and their previous history. Whereas the induced magnetization is nearly always parallel to the direction of the geomagnetic field, the natural remanent magnetization may bear no relation to the present direction and intensity of the earth's field. The remanent magnetization is related to the direction of the earth's field at the time the rocks were last magnetized. Interpretation of most magnetometer surveys is normally done by assuming no remanent magnetic component.

Since the distribution of magnetic minerals (magnetite, pyrrhotite) will, in general, vary with different rock types, the magnetic method is often used to aid in geologic mapping. In gold exploration, the magnetic survey is of particular importance because it may map areas of structural complexity, carbonization, and silicification.

7. DATA PROCESSING AND PRESENTATION

7.1 IP/RESISTIVITY

To allow for the computer processing of the IP data, the raw data stored internally in the IPR-11 system was transferred at the end of a survey day to floppy diskette by the in-field microcomputer and appropriate communications software. The raw data was filed on diskette in ASCII character format using an IBM compatible (MSDOS) microcomputer. Once the data was stored on diskette, a number of processing techniques were employed.

An archive edited data file, in binary format, was created in the field from the raw data file by the operator removing repeat or unacceptable readings and correcting any header errors such as station or line numbers. The concisely labelled and edited data was then dumped to a printer.
The spectral parameters M-IP, c, and tau were computed employing the Scintrex Soft software package. This programme compares the raw transient decay curve with a library of curves calculated from known parameters and by least squares fitting selects a best matching curve. A listing of the spectral parameters and a measure of fit with appropriate station and line labels were then generated on a printer. The computation of the spectral parameters was done in the evening.

The Soft and Geopaq programs generated in-field contours of the M7 slice/apparent resistivity and of M-IP/tau.

Upon completion of the survey IP/Resistivity data and calculated spectral parameters were computer generated and plotted at a scale of 1:5000. This processing was performed for all grids (i.e. Imperial and Metric).

In the Toronto office all data was reviewed and necessary editing performed. In the JVX office the resistivity/M7 and M-IP/tau contours and profiles/posted values plan maps were re-plotted in ink on paper employing a Nicolet Zeta drum plotter and an IBM PC 486DX-66 MHz. Color maps were produced with a Fujitsu dot matrix and/or Tecktronics printer plotter, to further facilitate line to line correlation of the various IP and resistivity anomalies.

7.1.1 IP Spectral Analysis

Historically the time domain IP response was simply a measure of the amplitude of the decay curve, usually integrated over a given period of time. Over the last decade, advances have made it possible to measure the decay curve at a number of points, thus allowing the reconstruction of the shape of the curve. By measuring the complete decay curve in the time domain, the spectral characteristics of the IP response may be derived.

Recent studies have shown there is a relationship between the decay form and the texture or grain size of the polarizable minerals, i.e. the IP response is not only a function of the amount of the polarizable material. This could be important when it comes to ranking anomalies of equal amplitude or discriminating between economic and non-economic sources.

IP decay forms are quantified using the Cole-Cole model developed by Pelton et al (1978). Pelton was one of the first to use the term Spectral IP. The Cole-Cole model is determined by the resistivity and three spectral parameters m, tau and c. These parameters are interpreted as follows:

- **m (or M-IP)** - Chargeability Amplitude (mV/V). This is related to the volume percent metallic sulphides (although there is no simple quantitative relationship between the two).

- **tau** - Time Constant (sec). A short time constant (e.g. 0.01 to 0.1 s) suggests a fine grained source. A long time constant (e.g. 10 to 100 s) suggests a coarse grained (or interconnected or massive) source.
Exponent (dimensionless). A high value (e.g. 0.5) implies one uniform polarizable source. A low value (e.g. 0.1) implies a mixture of sources.

Conventional chargeability is a mixture of these spectral parameters and a change in any one parameter will produce a change in the apparent chargeability. In the absence of spectral analysis, such changes are always ascribed to a change in the volume percent metallic sulphides, even though the cause may be a shift from fine to coarse grained material.

In practice, the spectral parameters are used to characterise and prioritise IP anomalies which have been picked from the pseudosections of conventional single slice (or average) chargeability. In this regard, the chargeability amplitude (M-IP) and the time constant are the most useful. IP anomalies which are similar in all other respects may be separated based on their spectral characteristics.

Spectral parameters are extracted from all measured decay curves by finding a best fit between the measured decay and a suite of master curves. The process yields a fit parameter which is the root mean square difference (expressed as percent) between the ten values of the measured and best fit master decays. The fit parameter is low (i.e. less than 1%) for high quality data of moderate to high amplitude. The fit parameter is high (i.e. greater than 10%) for poor quality or low amplitude data.

7.2 ANOMALY SELECTION AND CLASSIFICATION (IP/Resistivity)

Chargeability (M7 slice) and resistivity anomalies have been categorised as strong, moderate, weak and very weak. Areas of high resistivity have been noted with where the peak value occurs. Anomalous signatures are represented on the contour and profile plan maps by anomaly bars that take the following form:

_____ strong chargeability high; 20-30 mV/V and well defined

____ moderate chargeability high; 10-20 mV/V and well defined

_____ weak chargeability high; 5-10 mV/V and well defined

..... very weak chargeability high; < 5 mV/V and poorly defined

XXX very weak anomaly may be caused by overburden (changes in resistivity are mirrored in chargeabilities)

Areas of high resistivity may be marked by arrows on top of the resistivity representing the peak of the anomaly.
If a given IP anomaly has a resolvable peak then the peak value is indicated by the above notation. The location of the notation with respect to the anomaly bar represents the interpreted centre of the source body.

In addition to the IP/Resistivity notation, the computed spectral M-IP of the peak response is also indicated. A third diagnostic parameter, the time constant, \( \tau \), is indicated after the M-IP value by an H(igh), M(edium), or L(low). High indicates an average \( \tau \) between 10 and 100 sec, Medium between 0.3 and 3.0 sec, and Low between .01 and 0.1 sec.

Both the IP/Resistivity and spectral notations are marked on the compilation/anomaly plates. IP anomalies showing line to line correlation have been grouped into anomalous zones and labelled on the compilation map by an identifying letter.

7.3 MAGNETICS

To allow for the computer processing of the Magnetic data, the data resident in the IGS-2/MP-4 system's memory was transferred via a serial communication link to the Compaq 286 computer - thereby facilitating editing, processing and presentation operations. All data was archived on floppy disk.

In the Toronto office all data was reviewed and necessary editing performed. The corrected data was ink-plotted in plan map format as contour and profiles with posted values on a Nicolet Zeta drum plotter and in color with a Fujitsu dot matrix and/or Tecktronics printer plotter, interfaced to an IBM PC 486DX-66MHz microcomputer.

Contoured and profiles with posted values, plan maps of the corrected data were computer generated and fine-drafted on mylar at the Toronto office, at a scale of 1:5000 with appropriate contour intervals and profile scales.

A list of all maps produced can be found in appendix D.

The ACAD drawing files of all geophysical plates and a complete data set including all the field measurements made and any calculated products is available, on floppy disk or printed listing, upon request from JVX Ltd. on a time and material basis.

7.4 MAGNETICS ANOMALY SELECTION AND CLASSIFICATION

The total field magnetic data have been studied for lateral changes of the strength of the magnetic field. The representative contours have been chosen and included as part of the compilation maps, expressing the physical boundaries that are thought to be related to local geology and/or lithology.

Assuming the background level of 58000 nT, the values above are to be considered local magnetic highs and values below the base level, as magnetic lows.
This generalized presentation of the magnetic data allows the survey area to be divided into the blocks suggesting the structural and lithological composition of the property.

8. DISCUSSION OF RESULTS

8.1 INTRODUCTION

The gradient IP/Resistivity, Magnetics surveys conducted on the Diamond Lake Extension are of uniform high quality. The data show interesting variations over the entire survey area.

The interpretation is based on general geophysical criteria and on results of similar surveys carried out by JVX previously.

The criteria applied to the IP/Resistivity data set as bases for interpretation are as follows:

1/ All chargeability responses are picked, classified and located on the grid map.

2/ Every line is studied for lateral apparent resistivity variations. The high resistivity areas are marked on the grid map.

3/ The peaks of resistivity highs on adjacent lines are joined where continuity of zones is likely.

4/ The chargeability anomalies are studied in conjunction with resistivity responses and are combined into zones of high chargeability.

5/ A moderate strength chargeability anomaly associated with a sharp narrow resistivity high is considered to be a favourable exploration target for gold.

6/ The chargeability anomalies are rated further by studying the associated spectral parameters. Their values are marked beside each anomalous chargeability bar on the grid map. The IP responses with high M-IP values and short time constants are thought to be the most interesting. IP anomalies associated with resistivity lows and good MIP values with short time constants must also be carefully evaluated.
In summary the highest priority exploration targets for gold are characterized as being of medium chargeability amplitude, in areas of lateral change of apparent resistivities, with high values of M-IP and very short time constants (see Case History VII). An area of low magnetic relief is preferred.

Figure 5 - Example of two strong chargeability anomalies with different Spectral signatures. Note: Gold is with the short time constant response.

The geological model for this ideal geophysical response is a volume of fine-grained disseminated metallic sulphides with an associated concentration of gold. The target is on the edge of or related to an area of silicification. The target may also be in a hydrothermal alteration system with an associated resistivity low but the IP response has a good associated MIP with a short time constant.

High apparent resistivity zones as picked from the pseudosections are considered as possible areas of silicification. IP responses (which are not accompanied by a resistivity low) are probably the result of disseminated metallic sulphides. This conclusion may be supported by the calculated time constant, as short time constants are often diagnostic of disseminated (as opposed to massive or coarse-grained) sulphides. IP anomalies with short time constants have, however, a depressed response in the traditional eighth slice. This is overcome by looking at the spectral parameter MIP, which is a more honest measure of the volume percent metallic sulphides. In other words, a modest IP anomaly in M7 should be upgraded if MIP values are high.

A brief description of the anomalous zones follows. The discussion is based on information which has been entered on the compilation map. The targets of interest have been shown on these maps with priority label IP (low priority), MP (medium priority), HP (high priority).

8.2 DESCRIPTION OF THE GEOPHYSICAL RESPONSES

The compilation map includes the general magnetic trends, SPECTRAL chargeability zones resistivity anomalies and structural interpretation, colour plots of magnetic chargeability, resistivity, M-IP, time constant (tau) and black and white shaded map of tau and M-IP.

8.2.1 WEST EXTENSION GRID

The west grid has six small magnetic anomalies within a larger area of elevated magnetic values. Five chargeability responses were located on the grid. Magnetic anomaly MH1a had an associated resistivity low which indicates the source is a possible kimberlite.

8.2.1a : MAGNETIC ZONE 1 with associated SPECTRAL IP anomalies and RESISTIVITY responses

Magnetic zone 1 consists of six magnetic highs labelled MH1a, MH1b, MH1c, MH1d, MH1e, and MH1f.
MH1a is a moderate magnetic response (500nT) correlating with low to moderate resistivities and a chargeability low. A series of IP anomalies labelled IP1b, IP1b', IPb'', and IPb''' occur on the east flank of magnetic high MH-1a and MH-1b. The anomalies have an associated resistivity low which indicates the IP sources are a linked sulphide/graphite.

**Recommendation:** Evaluate MH1a for a kimberlite source.

MH1b is a moderate magnetic response (500nT) the west of which correlates with a resistivity low.

**Recommendation:** Evaluate the western side of MH1b for a kimberlite source which should correlate with a resistivity low.

MH1c is a wide area of higher magnetics occurring in the southwestern corner of the grid and correlates with a resistivity high. IP1c is a one line response which indicates some minor sulphides may be associated with the magnetic response. For example, if the magnetic source is a diabase dike it is not uncommon to have some sulphides associated with the dike.

MH1d, MH1e, and MH1f is a series of weak magnetic anomalies occurring on the eastern side of the grid. The anomalies generally have higher resistivities with it. Also IP anomaly IP1e is strong enough to warrant investigation.

**Recommendation:** Evaluate IP-1e. The magnetic anomalies do not appear to be caused by kimberlite.
9. CONCLUSIONS AND RECOMMENDATIONS:

Between August 10th and August 15, 1993, Total Field Magnetics, and Gradient Array SPECTRAL Induced Polarization (IP) / Resistivity surveys were conducted on behalf of Sudbury Contact Mines Ltd. on the Diamond Lake West Extension on the Diamond Lake project, near Larder Lake, Ontario by JVX Ltd.

A total of approximately 8.5 line-kilometers of IP/Resistivity and 9.25 line-kilometers of Magnetics coverage were surveyed.

The results are presented as, contour maps, off set profiles and anomaly compilation plan maps.

The anomaly compilation map includes the IP anomalies, Resistivity highs / lows, magnetic trends and interpreted structures. The physical characteristics of each chargeability response are marked beside each anomaly bar. Target areas are outlined in the compilation map and the individual anomalies considered to be exploration targets are circled and labeled "L, M, or H" (low, medium or high priority).

The geophysical targets which warrant further work are listed below:

9.1 Targets for follow-up

T-1 MH1a...L-2800N / 800W Magnetic high with resistivity low; Evaluate for Kimberlite. Medium to High Priority (Based on proximity of Diamond Lake Pipe.)

T-2 MH1b...L-2600N / 800W Magnetic high with resistivity low on west shoulder; Evaluate for Kimberlite. Medium to High Priority (Based on proximity of Diamond Lake Pipe.)

T-3 IP1c...L-2800N / 550W Strong IP with resistivity high. Evaluate for gold; Medium Priority

9.2 Structure on the WEST GRID EXTENSION
(Compilation Map - Plate: 1-G)

A series of faults have been interpreted from the magnetic data. The right angle nature of them make them favourable for kimberlite emplacement. Magnetic highs MH1a, MH1b and kimberlites IP ie. is a good target.
9.3 Recommendations for additional work.

Pole dipole IP surveys could be done to better assess some of the recommended targets. The pseudosection data would improve the interpretation of targets prior to drilling.

A review of the drilling and geology on the area should be done to improve the geophysical interpretation.

If there are any questions with regard to the survey or interpretation please call the undersigned at JVX Ltd.

Respectfully submitted,

JVX LIMITED

[Signature]

Blaine Webster, President
The microprocessor-based IPR-11 is the heart of a highly efficient system for measuring, recording and processing spectral IP data. More features than any remotely similar instrument will help you enhance signal/noise, reduce errors and improve data interpretation. On top of all this, tests have shown that survey time may be cut in half, compared with the instrument you may now be using.

The IPR-11 Broadband Time Domain IP Receiver is principally used in electrical (EIP) and magnetic (MIP) induced polarization surveys for disseminated base metal occurrences such as porphyry copper in acidic intrusives and lead-zinc deposits in carbonate rocks. In addition, this receiver is used in geoelectrical surveying for deep groundwater or geothermal resources. For these latter targets, the induced polarization measurements may be as useful as the high accuracy resistivity results since it often happens that geological materials have IP contrasts when resistivity contrasts are absent. A third application of the IPR-11 is in induced polarization research projects such as the study of physical properties of rocks.

Due to its integrated, microprocessor-based design, the IPR-11 provides a large amount of induced polarization transient curve shape information from a remarkably compact, reliable and flexible format. Data from up to six potential dipoles can be measured simultaneously and recorded in solid-state memory. Then, the IPR-11 outputs data as: 1) visual digital display, 2) digital printer profile or pseudo-section plots, 3) digital printer listing, 4) a cassette tape or floppy disk record, 5) to a microcomputer or 6) to a modem unit for transmission by telephone. Using software available from Scintrex, all spectral IP and EM coupling parameters can be calculated on a microcomputer.

The IPR-11 is designed for use with the Scintrex line of transmitters, primarily the TSQ series of current and waveform stabilized models. Scintrex has been active in induced polarization research, development, manufacture, consulting and surveying for over thirty years and offers a full range of time and frequency domain instrumentation as well as all accessories necessary for IP surveying.
Function

The TSQ-3 is a multi-frequency, square wave transmitter suitable for induced polarization and resistivity measurements in either the time or frequency domain. The unit is powered by a separate motor-generator.

The favourable power/weight ratio and compact design of this system make it portable and highly versatile for use with a wide variety of electrode arrays. The medium range power rating is sufficient for use under most geophysical conditions.

The TSQ-3 has been designed primarily for use with the Scintrex Time Domain and Frequency Domain Receivers, for combined induced polarization and resistivity measurements, although it is compatible with most standard time domain and frequency domain receivers. It is also compatible with the Scintrex Commutated DC Resistivity Receivers for resistivity surveying. The TSQ-3 may also be used as a very low frequency electromagnetic transmitter.

Basically the transmitter functions as follows. The motor turns the generator (alternator) which produces 800 Hz, three phase, 230 V AC. This energy is transformed upwards according to a front panel voltage setting by a large transformer housed in the TSQ-3. The resulting AC is then rectified in a rectifier bridge. Commutator switches then control the DC voltage output according to the waveform and frequency selected. Excellent output current stability is ensured by a unique, highly efficient technique based on control of the phase angle of the three phase input power.

Features

- Current outputs up to 10 amperes, voltage outputs up to 1500 volts, maximum power 3000 VA.
- Solid state design for both power switching and electronic timing control circuits.
- Circuit boards are removable for easy servicing.
- Switch selectable wave forms: square wave continuous for frequency domain and square wave interrupted with automatic polarity change for time domain.
- Switch selectable frequencies and pulse times.
- Overload, underload and thermal protection for maximum safety.
- Digital readout of output current.
- Programmer is crystal controlled for very high stability.
- Low loss, solid state output current regulation over broad range of load and input voltage variations.
- Rectifier circuit is protected against transients.
- Excellent power/weight ratio and efficiency.
- Designed for field portability; motor-generator is installed on a convenient frame and is easily man-portable. The transmitter is housed in an aluminum case.
- The motor-generator consists of a reliable Briggs and Stratton four stroke engine coupled to a brushless permanent magnet alternator.
- New motor-generator design eliminates need for time domain dummy load.

Waveforms output by the TSQ-3

- Time Domain: Switch selectable, 1.24 or 8 seconds
- Frequency Domain: Switch selectable, 1/10 or 1/30 Hz

TSQ-3 3000 W

Time and Frequency Domain IP and Resistivity Transmitter
Scintrex has used low power consumption microprocessors and high density memory chips to create the IGS Integrated Portable Geophysical System; instrumentation which will change the way you do ground geophysics.

Here are the main benefits which you will derive from the IGS family of instrumentation:

1. Depending on your choice of optional sensors you can make one, two or all of: magnetic, VLF and electromagnetic measurements. Thus, you may optimize the IGS system for different geophysical conditions and production requirements.

2. You will save time and money in the acquisition, processing and presentation of ground geophysical survey data.

3. You will achieve an improvement in the quality of data through enhanced reading resolution, an increase in the number of different parameters measured and/or a higher density of observations. Further, errors which occur in manual transcription and calculation will be eliminated.

4. Your operator will appreciate the simplicity of operation achieved through automation.

5. Since add-on sensors are relatively less expensive, your investment in a range of IGS instrumentation may be much less than it would be with a number of different instruments, each dedicated to a different measurement.

The Scintrex IGS-2/MP-4/VLF-4/EM-4 permits one operator to efficiently measure magnetic, VLF and EM fields and to record data in computer compatible solid-state memory.
APPENDIX B

GRADIENT ARRAY CURRENT ELECTRODE POSITIONS
(IP/Resitivity Blocks)
<table>
<thead>
<tr>
<th>Electrode</th>
<th>Line</th>
<th>Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 C₁</td>
<td>2700 N</td>
<td>2250 W</td>
</tr>
<tr>
<td>1 C₂</td>
<td>2700 N</td>
<td>725 W</td>
</tr>
<tr>
<td>1 CPT</td>
<td>2700 N</td>
<td>775 W</td>
</tr>
</tbody>
</table>

**GRADIENT ARRAY FIXED CURRENT ELECTRODE POSITIONS (IP BLOCKS)**
CPT — position of central point
1C1 and 1C2 positions of current electrodes

scale 1 : 10,000

GRADIENT ARRAY FIXED CURRENT ELECTRODE
POSITIONS (IP BLOCK)
APPENDIX C

REFERENCES

Time Domain Spectral IP results from three gold deposits in northern Saskatchewan

by Ian M. Johnson, B. Webster, JVX Ltd
and Ron Matthews and Steve McMullan, Cameco
MINERAL EXPLORATION

Time domain spectral IP results from three gold deposits in northern Saskatchewan

Ian Johnson and Blaine Webster, JVX Ltd., and Ron Matthews and Steve McMullan, Cameco

ABSTRACT

Time domain spectral Induced Polarization (IP) data from the Tower, Jojay and Laurel Lake gold deposits in northern Saskatchewan are presented. The resistivity data shows both resistivity lows (due to fault, shear or alteration zones) and resistivity highs (due to silicification) in the area of the deposits. The high resistivity zones suppress and distort coincident IP responses, calling for high quality surveys and special care in interpreting the IP data.

Electromagnetic methods are not effective in locating the deposits. This is due, in part, to masking by conductive cover. The Jojay Lake deposit has a strong magnetic response. A more indirect magnetic association is seen for the Tower Lake deposit. The Laurel Lake deposit has no magnetic signature. Magnetic data are useful in defining structure in all cases.

All three deposits are outlined in the IP survey results. IP anomaly amplitudes from the pole-dipole array are from two times (Tower and Laurel Lake) to six times (Jojay Lake) background values. Gradient array IP anomalies are of less amplitude. The spectral time constant is short for the Tower and Laurel Lake deposits and long for the Jojay deposit. This implies that the metallic sulphides in the Jojay deposit are more interconnected than those of the other two deposits.

INTRODUCTION

Induced polarization/resistivity surveys are commonly used in gold exploration programs in the Canadian shield because the IP method is effective in detecting disseminated metallic sulphides which are often found associated with gold. Other common geophysical survey methods such as magnetics, VLF and EM are not generally capable of direct detection of disseminated sulphides.

Keywords: Exploration, Gold deposits, Induced polarization (IP) methods, Tower Lake deposit, Jojay Lake deposit, Laurel Lake deposit, Spectral IP.

Paper reviewed and approved for publication by the Geology Division of CIM.

Since the introduction of the IP method in the 1950s, it has undergone continuous improvement. The most recent improvement is the development of time domain receivers which sample the full decay and record it in digital form. This results in a more complete measurement of the response which permits analysis and enhancement of data quality and the derivation of anomaly parameters which characterize the measured decay. This extension of conventional time domain IP methods is called spectral IP, a term first introduced by Pelton et al. working in the frequency domain (1). Spectral IP surveys are attractive because they allow the possibility of discriminating between IP responses which have similar amplitudes but are due to dissimilar geologic targets. The discrimination can be important in the selection of IP anomalies for follow-up.

Time domain spectral IP survey results are presented over three known gold deposits in northern Saskatchewan—Tower Lake, Jojay Lake and Laurel Lake. The surveys were initiated and supported by Cameco—A Canadian Mining and Energy Corporation (formerly the Saskatchewan Mining and Development Corporation—SMDQ) and were carried out by JVX Limited using the Scintrex IPR-11 receiver and attendant spectral analysis software.

Time Domain Spectral IP

In conventional time domain IP/resistivity surveys, the chargeability is recorded as an average of the residual voltage after shut-off of an interrupted square wave. In spectral IP, the receiver samples the decay at a number of time periods, thus defining the shape of the decay. Each measured decay can then be analyzed for curve shape characteristics using simple models.

The model most commonly used is the Cole-Cole model (2), originally developed by Pelton et al. for the analysis of frequency domain IP data. This model is defined by four parameters. They are:

1. $R$—the resistivity in ohm-meters
2. $m$—the chargeability amplitude in mV/V
3. $\tau$—the time constant in seconds
4. $c$—the exponent (dimensionless)

These parameters are independent physical properties of the subsurface. Conventional chargeability (or per cent frequency effect or phase if working in the frequency domain) is a mix-

Ian Johnson received a B.Sc. in geophysics from the University of Western Ontario in 1968 and a Ph.D. in geophysics from the University of British Columbia in 1972. On graduation, he worked for Paterson, Grant and Watson Ltd. From 1978 to 1986, he worked in the surveys division of Scintrex Ltd. in Toronto. He is currently a consulting geophysicist working in areas of resistivity/IP and helicopter borne surveys.

Blaine Webster received a B.Sc. in geophysics from the University of British Columbia in 1970. He joined Inco in Sudbury in 1971 where he worked until 1979. Between 1979 and 1983, he was manager of ground and drillhole surveys for the Toronto office of Scintrex Ltd. He founded JVX Ltd. in 1983. The company has performed a variety of services including contract geophysical surveys and regional and property geological and geophysical studies. Included are more than 200 time domain spectral IP surveys.
figure of the more fundamental properties m, tau and c.

In practice a suite of master decay curves is built up assuming a range of values of c and tau. Measured decays are compared to these curves. The best agreement yields the spectral parameters m, tau and c for each dipole. As with resistivity and conventional IP, the spectral parameters are presented using normal pseudosection plotting conventions.

The derived spectral parameters are used to supplement the conventional IP/resistivity survey results. Pseudosections of apparent resistivity and one chargeability slice are often the basic presentation from profile type surveys. Ten slices are recorded by the IPR-11 receiver. The eighth slice located between 690 and 1050 ms after shut-off is commonly plotted. IP anomalies are picked from the chargeability pseudosections. The spectral parameters are also presented in pseudosection form so that they may be correlated with the IP anomalies.

The parameters m and tau are the most useful in separating anomalies with similar resistivity and chargeability characteristics. The chargeability amplitude m is related to the volume percent metallic sulphides (although there is no convenient quantitative relationship between m and the volume percent polarizable material). The time constant is related to grain size and commonly varies from 0.01 to over 100 s. Finely disseminated sulphides should give a short time constant. Interconnected or more massive sulphides should give a long time constant. The exponent c is a measure of the uniformity of grain size and varies from 0.1 to 0.5. A c value of 0.5 suggests a single polarizable source. Smaller c values imply a mixture of sources. These concepts from Pelton et al. (10) are the starting point for interpreting spectral IP data. They will be refined and improved as more experience with the spectral IP method is gained.

An example of the use of spectral IP surveys for gold exploration is shown in Figure 1. Two distinct, but similar.
IP/resistivity anomalies are seen in the pseudosections of apparent resistivity and chargeability. The time constants are generally short (i.e. 0.01 to 0.1 s) for the anomaly to the left and long (i.e. 10 to 100 s) for the anomaly to the right. Both anomalies have been drilled. The anomaly showing the short time constants was confirmed to be caused by fine grain disseminated sulphides. The long time constant anomaly was found to be caused by more coarse-grained sulphides. Economic gold was found in association with the fine grained sulphides whereas only small amounts of gold were found in the area of the long time constant IP anomaly.

Time domain spectral IP is beneficial for reasons additional to that of source discrimination. The analysis provides a measurement of data quality which can be used by the operator to improve survey procedures. The analysis can be used to separate signal from instrument or geologic noise. In very resistive areas, for example, potential electrode cable effects may produce false chargeability highs, particularly at early times. Inductive coupling effects may give problems in conductive areas. Spectral IP allows the identification and separation of decays which are of interest from those which are noise related.

Regional Setting of the Tower Lake, Jojay Lake and Laurel Lake Deposits

Figure 2 shows the location of the deposits relative to the regional geology of northeastern Saskatchewan. The area is underlain by Proterozoic metasediments, metavolcanics and intrusives of the La Ronge Domain. Paleozoic sediments lie to the south and west and the Athabasca Basin is located to the northwest.

Current gold exploration in northern Saskatchewan has focussed on known gold showings and their immediate surroundings in the Central Metavolcanic Belt of the La Ronge Domain, particularly in the Sulphide Lake, Star Lake and Waddy-Tower Lakes areas. The Jojay Lake deposit is located approximately 8 km north of the Star Lake mine. Most gold deposits in this area are structurally controlled and are hosted by quartz veins. Controlling structures may be shear zones (Jojay Lake), or late regional fault structures such as the Byers Lake fault (Tower Lake). Another major auriferous area is located in the Flin Flon-Amisk Lake area in the Flin Flon Domain. Gold occurrences (e.g. Laurel Lake) in the West Channel of Amisk Lake are characterized by quartz-vein systems surrounded by extensive alteration haloes of carbonate, sericite and silica.

Tower Lake Project

The Tower Lake Project is a gold exploration joint venture operated by Golden Rule Resources Ltd. in partnership with Goldsi Resources Ltd. and Cameco. The project is located approximately 170 km northeast of La Ronge, Saskatchewan. Geologic reserves of the Tower East deposit are 1.36 million tonnes at 3.4 g/tonne gold (1.5 million short tons at 0.1 oz/ton). Definition diamond drilling of the deposit is currently in progress.

Geology

The project is located within the Central Volcanic Belt of the La Ronge Domain which hosts most of the major gold occurrences in the La Ronge area. The Tower East deposit is hosted by quartz diorite of the Brindson Lake pluton and is associated with the regional Byers fault system.
FIGURE 5. Theoretical resistivity/IP pseudosections for a vertical tabular body at surface. Results are for a pole-dipole array traversing from left to right. The host medium has a resistivity ($\rho$) of 100 and a chargeability ($m$) of 1. The tabular body has resistivities of 10 and 1000 respectively and a chargeability of 10 (all units are relative). Areas with chargeabilities greater than 2 have been shaded.

FIGURE 6. Contoured magnetic map for the Jofay Lake area. Minimum contour interval = 25 nT. The shaded areas outline the mineralized zones. Lines of pole-dipole coverage are highlighted.

IP response. There is no direct electromagnetic response associated with the deposit. The deposit has an indirect magnetic response.

IP Survey Results

The IP/resistivity results for line 1 + 00 W are shown in contoured pseudosection form in Figure 4. South of station 0 + 25 S bedrock responses are masked by conductive lake sediments. Mineralization in the Pat, A, and B zones correlate to a broad low resistivity zone of apparent resistivities less than 3000 ohm-m and anomalous M7 chargeabilities in three zones from 0 + 25 N to 2 + 00N (5.5 to 6.5 mV/V with background values of 1 to 4 mV/V). A local resistivity high at stations 1 + 25 N to 1 + 50 N may indicate an area of silicification. The Byers fault is interpreted at 2 + 25 N and is characterized by a 125 m wide zone of low chargeabilities.

The lower two pseudosections show the spectral time constant and chargeability amplitude. Plot positions with no data are where the IP decay has been judged too noisy for reliable determination of spectral parameters. As most of the spectral data has been plotted, the IP survey is judged to be of good quality.

The time constant is consistently short in the area of the deposit indicating a fine-grained texture. The chargeability amplitude may be used to locate areas of highest metallic sulphide concentrations. The pseudosections show three chargeability anomalies. These correspond to the three mineralized zones when allowance is made for a shift of approximately one dipole spacing between the chargeability high and the causative body, i.e. the IP anomaly is located one dipole spacing before the target. This positional shift may be explained by the model results shown in Figure 5. Theoretical apparent resistivities and chargeabilities for a pole-dipole array passing over both a conductive-charging and a resistive-charging body are shown. These results have been calculated by the computer program IPNDIKE from Urquhart Dvorak Ltd. The algorithm is from Hanneson.

Figure 5 illustrates how the chargeability anomaly is cen-
MINERAL EXPLORATION

TIME DOMAIN SPECTRAL IP RESULTS FROM THREE GOLD DEPOSITS

FIGURE 7. Stacked pseudosections for the pole-dipole survey on line 12 + 50 S over the Jojay Lake deposit. Shown are the apparent resistivity in ohm-m divided by 100, the chargeability in mV/V (M7), the time constant in seconds (τ), the chargeability amplitude in mV/V (m) and the exponent (c). The location of the deposit is shown. The chargeability pseudosections have been shaded for M7 values greater than 20 mV/V and m values greater than 300 mV/V.

FIGURE 8. Contour plan maps of the apparent resistivity and chargeability (M7) from the pole-dipole and gradient surveys over the Jojay Lake deposit. Values from the second dipole of the pole-dipole data have been used.

... tonnes at 9.1 g/tonne gold (313 200 short tons at 0.26 oz/ton) following the winter 1987 program. The deposit is open below a depth of 250 m and is currently being considered for development.

Geology

The deposit is hosted by intermediate to mafic volcanics close to the fault contact with clastic metasediments. Pyrrhotite, pyrite, galena, sphalerite and quartz occur in a quartz-carbonate vein stockwork which is structurally controlled. Metallic sulphides range from 0 to 15% and average 2% of the rock volume. The deposit is 0.5 m to 10 m wide and is covered by 0 to 10 m of sandy boulder till.

Geophysical Setting

The deposit is outlined on the contoured magnetic map in Figure 6. The deposit is seen as a break in the isomagnetic contours. The Jojay Lake fault marks the contact between clastic metasediments to the west and mafic to intermediate volcanics to the east.

IP/resistivity surveys were carried out using both gradient (dipole spacing = 25 m) and pole-dipole (six dipoles with a dipole spacing of 25 m) arrays. As gradient surveys are often two to three times less expensive than pole-dipole surveys, they are sometimes initially used to establish the regional IP/resistivity character of an area. Profile surveys are then carried out to provide detail in areas of interest.

The geophysical signature of the deposit is a strong magnetic anomaly together with a strong IP response. Electromagnetic surveys are dominated by surficial conductivity.

IP Survey Results

The apparent resistivities and chargeabilities obtained for the pole-dipole survey are shown as contoured pseudosections...
FIGURE 9. Contoured magnetic map for the Laurel Lake area. The minimum contour interval is 10 nT. The shaded area outlines the deposit. The line of pole-dipole coverage is highlighted.

in Figure 7. The mineralized zones are indicated. The resistivities are low (2000 to 5000 ohm-m) in the area of the Jojay fault relative to the volcanics to the east which have resistivities greater than 20 000 ohm-m. The resistivities to the west of the Jojay fault are of the same order as those seen in the area of the fault. This may be due to the overburden cover which consists of swamp and muskeg.

The M7 chargeability pseudosection is dominated by a strong response which correlates with the mineralized area. IP response amplitudes are from 25 to 35 mV/V with background values of 5 mV/V. The IP anomaly does not separate the mineralized zones. This is expected given that the array spacing is twice their separation. The mineralized zone near station 2 + 00 W is of limited extent and does not significantly add to the total reserves of the deposit. As metallic sulphides are limited, there is no coincident IP/resistivity response.

The long time constant values imply coarse-grained sulphides. This may be an oversimplification as it is not clearly supported by the geology. The change in time constants from those seen at Tower Lake does, however, suggest some geological difference, although a better explanation for the difference is lacking. Physical property studies in both areas should give a basis on which to better interpret the spectral IP data.

The chargeability amplitude data suggests that there may be significant concentrations of metallic sulphides to the west of the Jojay fault. The spectral c value is included for completeness. In theory, a high c value suggests a single target whereas a low c value suggests that a mixture of polarizable sources is present.

The pole-dipole and gradient data are presented as contour plan maps in Figure 8. Both datasets show a low resistivity zone located west of a strong chargeability anomaly over the deposit. The gradient array appears to have provided a reliable picture of the regional resistivity and IP character. The pole-dipole results, however, give better resolution and a larger relative anomaly amplitude for the IP response which corresponds to the deposit.

Spectral parameters may also be derived from the gradient array data. The results are usually less reliable because the array is less focussed on one polarizable source. This is observed in this case where the average c value for line 12 + 50 S is 0.19 for the gradient array compared to 0.26 for the pole-dipole array. The time constants for the two arrays are in total disagreement east of the Jojay fault. The gradient array time constant is short (.01 to 1 s) whereas the pole-dipole array time constant is long (30 to 100 s). The pole-dipole time constants are more reliable in view of the higher c values.

Laurel Lake Project

The Laurel Lake deposit is part of the Amisk Lake project operated by Cameco in partnership with Husky Oil. The deposit is situated on Missis Island within Amisk Lake approximately 25 km southwest of Flin Flon, Manitoba. It is located within the Amisk Group volcanics which hosts all of the major base metal deposits in the Flin Flon area. Geologic reserves of the Laurel Lake deposit are 255 800 tonnes at 15.1 g/tonne gold and 75.7 g/tonne silver (281 970 short tons at 0.44 oz/ton Au and 2.21 oz/ton Ag) (press release, January 27, 1988). Underground exploration of the deposit started in the spring of 1988 as part of an economic feasibility study.

Geology

The deposit is hosted by quartz-feldspar porphyry, which forms part of an interpreted intrusive-flow complex. The mineralization appears to be synvolcanic in origin. Metallic minerals include pyrite, tetrahedrite, chalcopyrite, sphalerite and galena, which occur as disseminations and veins in a broad sericite alteration zone(6).

Gold occurs as fine specks of free gold in and along intergranular boundaries between sulphide grains. The sulphides occur as veins, stockworks, disseminations and irregular masses. Mineralization occurs in discrete sub-zones which are distinguishable by their dominant ancillary sulphide species. Sulphide
concentrations vary from 10% to 30% of rock volume in a zone 1 m to 2 m wide. The overburden cover varies from 0 to 20 m in thickness and consists of glacio-lacustrine clay and boulder till.

Geophysical Setting

The outline of the deposit is shown on the contoured magnetic map in Figure 9. This outline is a much simplified view of what is a complex network of mineralized veins. The area was surveyed with the gradient array. Selected lines were also surveyed using the pole-dipole array. Electromagnetic and magnetic surveys have not been effective in outlining mineralization although they have been useful for regional mapping. The most useful survey for outlining the deposit directly has been IP/resistivity.

IP Survey Results

The spectral IP/resistivity results for line 1 + 25 W are presented in Figure 10. The mineralized zone correlates with a well-defined chargeability high with M7 anomaly amplitudes of 6 to 9 mV/V with background values of 3 to 4 mV/V. A resistivity low with apparent resistivities from 300 to 1000 ohm-m from stations 1 + 25 S to 0 + 75 N may outline the zone of alteration which contains the deposit. The chargeability high which maps the deposit coincides with higher resistivities. This could be interpreted as a region of silicification. The shape and location of the IP/resistivity anomalies are consistent with the model results shown in the lower half of Figure 5. The IP/resistivity anomaly to the north of the deposit has been drilled and an additional vein system has been discovered.

The time constant is uniformly short over the entire survey line. No significant difference in the texture of the polarizable material has been detected and the deposit appears to be associated with fine-grained material. The IP dataset is of good quality as most of the spectral results have been plotted. The chargeability amplitude data defines the target zone somewhat better than the M7 results. The chargeability amplitude anomaly is four to five times background.

Gradient surveys were conducted in two directions. The chargeability high seen in the pole-dipole survey which correlates with the deposit was also noted in the gradient IP data. The mineralized zones can be traced out using the gradient array although individual anomalies are less distinct.

Conclusions

Time domain spectral IP/resistivity surveys were conducted over three known gold deposits in northern Saskatchewan. In all cases the deposits were seen as chargeability highs. IP anomaly amplitudes varied from weak (Tower Lake), through moderate (Laurel Lake) to strong (Jojay Lake). The spectral data (time constant and chargeability amplitude) were most useful in the Tower Lake area where the conventional IP response was weak. This illustrates the usefulness of the spectral IP method in providing more diagnostic and better quality IP data needed to better select anomalies for follow-up. In all cases, the interpretation of the spectral parameters would benefit from access to more extensive model results and physical property studies.

The apparent resistivity data mapped the faults and alteration zones as resistivity lows. Local resistivity highs (often within the resistivity lows) may indicate areas of silicification and, hence, areas more promising for gold mineralization. High resistivities may also be responsible for a reduction in the amplitude and a distortion of IP anomalies. The interpretation of pole-dipole IP data must make allowance for these effects.

The gradient array IP surveys gave somewhat mixed results. They have proved to be a useful method for establishing the regional character of an area and locating areas for follow-up.

There is no consistent magnetic signature to the deposits. Magnetic anomalies in the Jojay area are probably due to high concentrations of pyrrhotite. This association is not as apparent in the Tower Lake area and is absent in the Laurel Lake area. Electromagnetic methods are not useful for direct detection because the deposits are associated with disseminated sulphides which are normally only detectable using IP methods. The EM survey results are also strongly influenced by variations in conductive overburden.

Acknowledgments

The cooperation of Claude Resources Inc., Golden Rule Resources Ltd., Goldsilk Resources Ltd., Husky Oil and Shore Gold Fund Inc. is gratefully acknowledged.

REFERENCES

7. COOMBE, W., Gold in Saskatchewan; Saskatchewan Geological Survey, Open File Report Number 84-1.

(Reprinted from The Canadian Mining and Metallurgical Bulletin, February 1989)

Printed in Canada
APPENDIX D

PLATES

DIAMOND LAKE WEST EXTENSION, McVITTIE TWP. PROJECT
(NTS 32D/4)
Plate 1-A: Total Field Magnetic Contours
Panthco - Mary-Ann Joint Venture
Scale 1:5000

Plate 1-AA: Filtered Magnetic Contours
Panthco - Mary-Ann Joint Venture
Scale 1:5000

Plate 1-B: Total Field Magnetic Profiles
Panthco - Mary-Ann Joint Venture
Scale 1:5000

Plate 1-C: Apparent Resistivity Contours
Panthco - Mary-Ann Joint Venture
Scale 1:5000

Plate 1-D: Chargeability (M7) Contours
Panthco - Mary-Ann Joint Venture
Scale 1:5000

Plate 1-E: Integral of Apparent Resistivity Contour
Panthco - Mary-Ann Joint Venture
Scale 1:5000

Plate 1-F: IP/Resistivity Profiles/Posted Values
Panthco - Mary-Ann Joint Venture
Scale 1:5000

Plate 1-G: Compilation/Interpretation Map
IP Zones, Resistivity highs and Lows, on Filtered Magnetic Base
Scale 1:5000

Colour Plate:

la: West Extention
Total Field Magnetic Contours
Scale 1:10000
Statement of Costs for Assessment Credit
Etat des coûts aux fins du crédit d’évaluation

Ministry of Northern Development and Mines
Ministère du Développement du Nord et des mines

Personal Information collected on this form is obtained under the authority of the Mining Act. This information will be used to maintain a record and ongoing status of the mining claim(s). Questions about this collection should be directed to the Provincial Manager, Mining Lands, Ministry of Northern Development and Mines, 4th Floor, 159 Cedar Street, Sudbury, Ontario P3E 6A5, telephone (705) 670-7264.

PERSONAL INFORMATION

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Total Direct Costs
Total des coûts directs

2. Indirect Costs/Coûts indirects

**Note:** When claiming Rehabilitation work indirect costs are not allowable as assessment work.

Pour le remboursement des travaux de réhabilitation, les coûts indirects ne sont pas admissibles en tant que travaux d’évaluation.

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Sub Total of Indirect Costs
Total partial des coûts indirects

Value total of Assessment Credit
(Total of Direct and Allowable indirect costs)

Remises pour dépôt

1. Les travaux déposés dans les deux ans suivant leur achevement sont remboursés à 100 % de la valeur totale susmentionnée du crédit d’évaluation.

2. Les travaux déposés trois, quatre ou cinq ans après leur achevement sont remboursés à 50 % de la valeur totale du crédit d’évaluation susmentionné. Voir les calculs ci-dessous.

Valeur totale du crédit d’évaluation
Evaluation totale demandée

Certification Verifying Statement of Costs

Je/Je/t. hereby certify:

at the amounts shown are as accurate as possible and these costs are incurred while conducting assessment work on the lands shown the accompanying Report of Work form.

as (Recorded Valuer, Agent, Factor et Company) I am authorized

make this certification

Certification

Note: Dans cette formule, lorsque désigné des personnes, le masculin est utilisé au sens neutre.
Report of Work Conducted
After Recording Claim

Transaction Number

Personal information collected on this form is obtained under the authority of the Mining Act. This information will be used for correspondence. Questions about this collection should be directed to the Provincial Manager, Mining Lands, Ministry of Northern Development and Mines, Fourth Floor, 159 Cedar Street, Sudbury, Ontario, P3E 5A5, telephone (705) 670-7264.

2.15841

Instructions:
- Please type or print and submit in duplicate.
- Refer to the Mining Act and Regulations for requirements of filing assessment work or consult the Mining Recorder.
- A separate copy of this form must be completed for each Work Group.
- Technical reports and maps must accompany this form in duplicate.
- A sketch, showing the claims the work is assigned to, must accompany this form.

Recorded Holder(s)
SUDBURY CONTACT MINES LTD.

Client No.
198617 AND 179267

Address
401 BAY ST., STE. 2302, TORONTO, ONT. M5H 2B7

Client No.
416-947-1212

Mining Division
LARDER LAKE

Township/Range
GAUTHIER

Fifth ROOT. 159 CADAR STRAT.


Instructions:
- Please type or print and submit in duplicate.
- Refer to the Mining Act and Regulations for requirements of filing assessment work or consult the Mining Recorder.
- A separate copy of this form must be completed for each Work Group.
- Technical reports and maps must accompany this form in duplicate.
- A sketch, showing the claims the work is assigned to, must accompany this form.

Work Performed (Check One Work Group Only)

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Assessment Work Claimed on the Attached Statement of Costs

$9056.

Note: The Minister may reject for assessment work credit all or part of the assessment work submitted if the recorded holder cannot verify expenditures claimed in the statement of costs within 30 days of a request for verification.

Name and Survey Company Who Performed the Work (Give Name and Address of Author of Report)

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<td>60 WEST WILMOT ST., UNIT 22 RICHMOND HILL, ONT. L4B 1M6</td>
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A schedule if necessary)

Certification of Beneficial Interest

Signed that at the time the work was performed the claims covered in this work report were recorded in the current holder's name or held under a beneficial interest in the current recorded holder.

Date: JAN. 20/95

Certification of Work Report

Signed that I have a personal knowledge of the facts set forth in this Work report, having performed the work or witnessed same during and/or after completion and approved report is true.

Date: JAN. 20/95

Office Use Only

$9056.

Received Stamp

RECEIVED JAN 27 1995
2. If work has been performed on patented or leased land, please complete the following:

an event that you have not specified your choice of priority, option one will be implemented.

- Examples of beneficial interest are unrecorded transfers, option agreements, memorandum of agreements, etc., with respect to the mining claim.

   - If the recorded holder had a beneficial interest in the patented or leased land at the time the work was performed, complete the following table:

   - Credits are to be cut back starting with the claim listed first, working backwards.

   - Credits are to be cut back equally over a fixed period of time.

   - Credits are to be cut back as prioritized on the attached appendix.

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- Credits are to be cut back equally over all claims contained in this report of work.
- Credits are to be cut back as prioritized on the attached appendix.

If you have not specified your choice of priority, option one will be implemented.

Examples of beneficial interest are unrecorded transfers, option agreements, memorandum of agreements, etc., with respect to the mining claims.

If work has been performed on patented or leased land, please note that the recorded holder had a beneficial interest in the patented or leased land at the time the work was performed.

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### Claim of Interest

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</table>
April 27, 1995

Mining Recorder
Ministry of Northern Development & Mines
4 Government Road East
Kirkland Lake, Ontario
P2N 1A2

Dear Mr. Spooner:

Subject: APPROVAL OF ASSESSMENT WORK CREDITS ON MINING CLAIMS 884026 et al. IN GAUTHIER TOWNSHIP

All deficiencies associated with this report of work have been corrected. Accordingly, assessment work credits have been approved as outlined on the report of work form. The credits have been approved under Section 14 (Geophysical) of the Mining Act Regulations.

The approval date is April 26, 1995.

If you have any questions regarding this correspondence, please contact Steven Beneteau at (705) 670-5858.

ORIGINAL SIGNED BY:

Ron C. Gashinski
Senior Manager, Mining Lands Section
Mining and Land Management Branch
Mines and Minerals Division

Enclosure:

cc: Resident Geologist
Kirkland Lake, Ontario

Assessment Files Library
Sudbury, Ontario
INDEX TO LAND DISPOSITION

PLAN
G-3211
TOWNSHIP
GAUTHIER

INDEX TO LAND DISPOSITION

RECEIVED
FEB 3 -1995
MINING LANDS BRANCH

SYMBOLS

DESCRIPTION

BOUNDARY
Township, Meridian, Baseline...

Road allowance, surveyed

Lot/Concession, surveyed

unsurveyed

Parcel, surveyed...

unsurveyed

Right-of-way, road...

railway...

utility...

Reservation

Cliff, Pit, Pile

Contour...

Interpolated...

Approximate
Depression...

Control point (horizontal)

Flooded land

Mine head frame...

Pipeline (above ground)

Railway; single track...

double track...

abandoned

Road, highway, county, township...

access...

trail, bush...

Shoreline (original)

Transmission line

Wooded area

DEPOSITION OF CROWN LANDS

Patent

Surface A Mlnfno, Rights

Surface Rights Only

Mining Rights Only

Lease

Surface 4 Mining Rights

Surface Rights Only

Mining Rights Only

Licence of Occupation

Order - Council

Cancelled

Reserve...


NOTICE OF FORESTRY ACT

This Township Area falls within the
TIMISKAMING MANAGEMENT UNIT
and may be subject to Forestry operations.

The MNR Unit Forester for this area can be
contacted at:
P.O. Box 129
Swastika, Ont.
PO Box 129
705-642-3222

The information that appears on this map
has been compiled from various sources
and accuracy is not guaranteed. Those wishing to stake mining claims should consult with the mining recorder, Ministry of Northern Development and Mines, for additional information on the status of the lands shown hereon.

Gaithier Township

Map base and land disposition drafting by Surveys and Flipping Branch, Ministry of Natural Resources

The disposition of land, location of lot fabric and parcel boundaries on this index was compiled for administrative purposes only.

Date: 23 January 1995

Distributed on G-3211

Ministry of Natural Resources

Ministry of Northern Development and Mines

INDEX TO LAND DISPOSITION

S.T.

LAND TITLES/REGISTRY DIVISION

TIMISKAMING
SUDBURY CONTACT MINES LTD.
DIAMOND LAKE GRID
PANTHO - MARY-ANN JOINT VENTURE
FILTERED MAGNETIC CONTOURS
CONTOUR INTERVALS 50 & 250 nT
50 m UPWARD CONTINUATION
BASE LEVEL: 56000 nT
SCINTEX IGS-2/MP-4
SCALE 1:5000

RECEIVED
FEB 3 - 1995
MINING LANDS BRANCH

SUDbury CONTACT MINES LTD.
DIAMOND LAKE GRID
PANTHO - MARY-ANN JOINT VENTURE
FILTERED MAGNETIC CONTOURS
CONTOUR INTERVALS 50 & 250 nT
50 m UPWARD CONTINUATION
BASE LEVEL: 56000 nT
SCINTEX IGS-2/MP-4
SCALE 1:5000

SURVEY BY
JX LTD.
JULY, 1993

WEST EXT.
PLATE 1-AA
SUDBURY CONTACT MINES LTD.

DIAMOND LAKE GRID

PANTHO - MARY-ANN JOINT VENTURE

APPARENT RESISTIVITY CONTOURS

CONTOUR INTERVALS: 500 & 2500 ohm m

GRADIENT ARRAY: a SPACING 50 m

SCINTREX IPR-11 RECEIVER

SCINTREX TSQ-3/3 0 kW TRANSMITTER

SCALE 1:5000

SURVEY BY

JVX LTD.

JULY, 1993

WEST EXT.

PLATE 1-C
CHARGEABILITY (M7) CONTOURS
CONTOUR INTERVALS: 0.5 & 2.5 mV/V
GRADIENT ARRAY: 50 m SPACING
SCINTREX IPR-11 RECEIVER
SCINTREX TSQ-3/3.0 kW TRANSMITTER
SCALE 1:5000

SUDBURY CONTACT MINES LTD.
DIAMOND LAKE GRID
PANTHO- MARY-ANN JOINT VENTURE
RECEIVED
RELATIVE HIGH:
FEB 3 - 1995
RELATIVE LOW:
JULY, 1993
WEST EXT.
PLATE 1-D
RESISTIVITY VALUES POSTED ON SOUTH SIDE OF LINE

CHARGEABILITY (M7) VALUES POSTED ON NORTH SIDE OF LINE

RECEIVED
FEB 3 - 1995
MINING LANDS BRANCH

2 158 4 1

SUDBURY CONTACT MINES LTD.
DIAMOND LAKE GRID
PANTHO - MARY-ANN JOINT VENTURE

IP PROFILES
RESISTIVITY: —— SCALE 1 cm rep 5000 ohm m
CHARGEABILITY (M7): —— SCALE 1 cm rep 5 mV/V
POSITIVE PROFILE DIRECTION: EAST
SCINTEX IPR-11 RECEIVER, TSQ-3/3.0 kW TRANSMITTER

SCALE 1:5000

SURVEY BY JVX LTD
JULY, 1993

WEST EXT.

PLATE 1-F