A REPORT ON INDUCED POLARIZATION SURVEYS ON THE THUNDER LAKE PROJECT ZEALAND TOWNSHIP WABIGOON, NW ONTARIO

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On Behalf Of

Teck Explorations Limited

1. INTRODUCTION

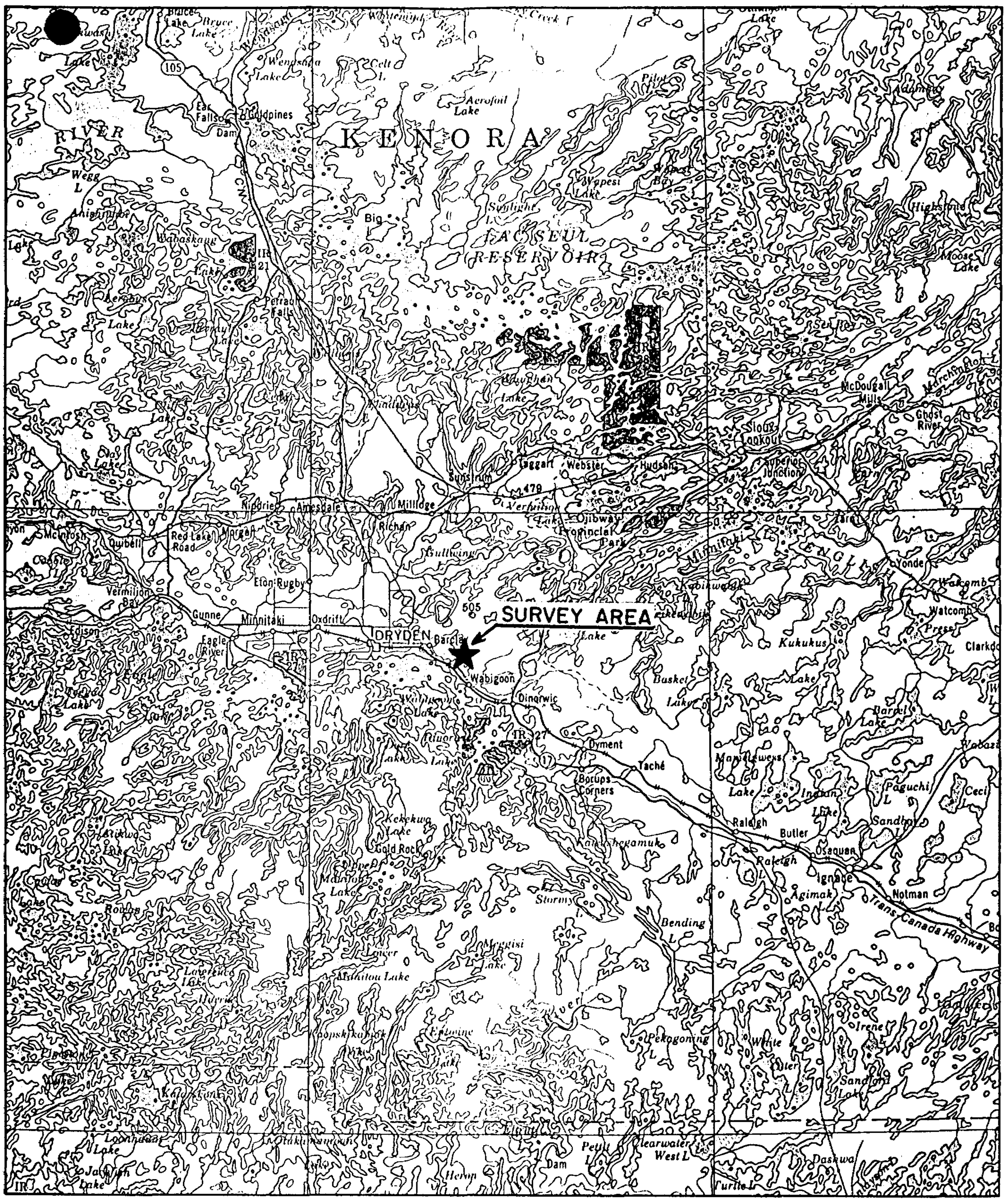
Between January 14th and March 1st, 1991, a Time Domain Spectral Induced Polarization/Resistivity survey was conducted by JVX Ltd. on behalf of Teck Explorations Limited on the Thunder Lake Project, near Wabigoon, Northwestern Ontario.

The IP survey employed the pole-dipole array with six potential dipoles (n=1 to 6) and a dipole spacing of 25 metres. A total of 34.0 line-km (measured P1 to P1) of IP coverage over 40 lines was achieved.

This report describes the survey logistics, field procedures, and data processing/presentation. An interpretation of the results is included. The results are presented as a compilation/anomaly map, contour plan maps, and offset pseudosections.

2. SURVEY LOCATION

Figure 1 and Figure 2 show the location of the survey area at scales of 1:1,000,000 and 1:20,000 respectively. The Thunder Lake property is situated about 15 kilometres east of Dryden, Ontario. Topographic map reference is NTS 52 F/NE.



LOCATION MAP

TECK EXPLORATIONS LTD.

THUNDER LAKE PROJECT

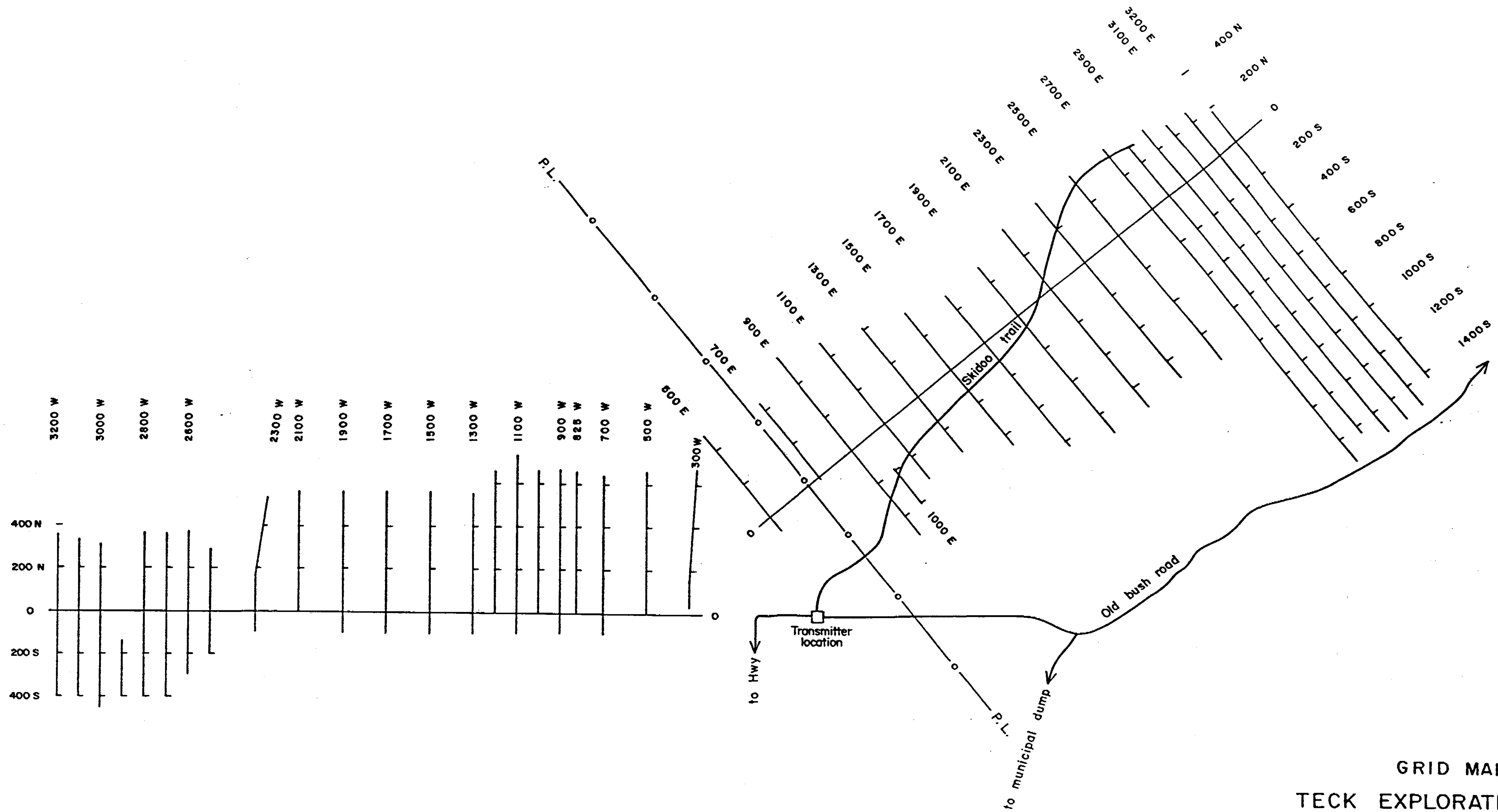
ZEALAND TWP., WABIGOON, ONTARIO

IP / RESISTIVITY SURVEY

Scale: 1 : 1,000,000

Survey by JVX Ltd.

Figure 1



GRID MAP

TECK EXPLORATIONS LTD.

THUNDER LAKE PROJECT

ZEALAND TWP., WABIGOON, ONTARIO

IP / RESISTIVITY SURVEY

Scale: 1 : 20,000

Survey by JVX Ltd.

Figure 2

QVX

3. SURVEY GRID AND COVERAGE

On the Thunder Lake Property, 34.0 line-km of pole-dipole survey was achieved. A detailed production summary of the IP survey follows in Table 1 below.

TABLE 1
PRODUCTION SUMMARY - INDUCED POLARIZATION
P1 to P1

LINE	COVERAGE FROM	TO	LINE LENGTH (metres)	MEASUREMENT POINTS
L-32W	400S	375N	775	177
L-31W	400S	350N	750	171
L-30W	450S	325N	775	177
L-29W	400S	150S	250	66
L-28W	400S	375N	775	177
L-27W	400S	375N	775	177
L-26W	300S	375N	675	153
L-25W	200S	300N	500	111
L-23W	100S	525N	625	146
L-21W	BL	575N	575	129
L-19W	100S	575N	675	153
L-17W	100S	575N	675	153
L-15W	100S	575N	675	153
L-13W	100S	575N	675	153
L-12W	BL	675N	675	153
L-11W	100S	725N	825	194
L-10W	BL	675N	675	153
L-9W	100S	675N	775	177
L-825W	BL	675N	675	151
L-7W	100S	625N	725	174
L-5W	BL	650N	650	152
L-3W	25N	650N	625	146
L-4E	75S	500N	575	129
L-7E	25N	425N	400	96
L-9E	500S	550N	1050	248
L-10E	400S	200S	200	48
L-11E	300S	500N	800	183
L-13E	325S	400N	725	174
L-15E	450S	325N	775	178
L-17E	600S	275N	875	177
L-19E	700S	275N	975	209
L-21E	700S	350N	1050	217
L-23E	700S	350N	1050	212

...Table 1 continued

LINE	COVERAGE FROM	TO	LINE LENGTH (metres)	MEASUREMENT POINTS
L-25E	750S	350N	1100	231
L-27E	1525S	350N	1875	419
L-28E	1425S	325N	1750	351
L-29E	1500S	325N	1825	345
L-30E	1500S	250N	1750	297
L-31E	1500S	800S	700	90
L-31E	400S	275N	675	112
L-32E	1400S	850S	550	87
L-32E	300S	200N	500	74
		Total	34.0 km	7273 pts.

4. PERSONNEL

From January 14th to January 28th:

Mr. Fred Moher - Geophysical Techician/Party Chief. Mr. Moher was party chief for the startup of the project. Mr. Moher operated the IP receiver and compiled the data with a Compaq microcomputer.

Mr. Gerry Gereghty - Field Technician. Mr. Gereghty assisted the Party Chief in the execution of the project and operated the IP transmitter.

Ms. Tammy Jusczzynski, Mr. Cory Banks, and Mr. Pat Coutu were field assistants.

From January 29th to March 1st:

Mr. Dennis Palos - Geophysicist/Party Chief. Mr. Palos was party chief for the latter part of the project. Mr. Palos operated the IP receiver and compiled the data with a Corona microcomputer.

Mr. Frank Mihelcic - Field Technician. Mr. Mihelcic assisted the Party Chief in the execution of the project and operated the IP transmitter.

Mr. Bob Chataway, Ms. Heather Moore, and Mr. Marcel Vaillancourt were field assistants.

Mr. Blaine Webster - Geophysicist. Mr. Webster provided overall supervision of the survey, interpreted the geophysical results, and prepared this report.

5. INSTRUMENTATION

5.1 IP Receiver

The IP survey employed the 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 is stored internally in solid-state memory.

5.2 IP Transmitter

The survey employed the Scintrex IPC-7/2.5 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.

5.3 Data Processing

The survey data were archived, processed and plotted with Compaq and Corona microcomputers using Epson EX-800 and FX-80 dot matrix printers. The system was configured to run JVX's proprietary software, a suite of programmes that was written specifically to interface with the IPR-11 receiver. At the conclusion of each day's data collection, data resident in the receiver memory was transferred, via serial communication link, to the computer - thereby facilitating editing, processing and presentation operations. All data were archived on floppy disk.

In the Richmond Hill office the data were ink-plotted in contour plan map, and pseudosection formats on Nicolet Zeta drum plotters interfaced to an IBM compatible microcomputer.

The instrumentation is described in detail in the specification sheets appended to this report.

6. SURVEY METHOD

6.1 Exploration Target

The exploration target for the current IP survey is gold. Induced Polarization anomalies will result from disseminated metallic sulphides if they are of sufficient concentration and volume. The resistivity data is 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.

6.2 Quantities Measured (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 groundwaters 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-logarithmically 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 are located as follows:

SLICE	DURATION msec	FROM msec	TO msec	MIDPOINT msec
M0	30	30	60	45
M1	30	60	90	75
M2	30	90	120	105
M3	30	120	150	135
M4	180	150	330	240
M5	180	330	510	420
M6	180	510	690	600
M7	360	690	1050	870
M8	360	1050	1410	1230
M9	360	1410	1770	1590

Traditionally, the M7 slice (from 690 to 1050 ms after shut-off) is chosen to represent chargeability in pseudosection form.

6.3 Field Procedures (IP/resistivity)

The surface IP/resistivity survey employed the time domain method with a pole-dipole array. The geometry of the pole-dipole array is illustrated in Figure 3.

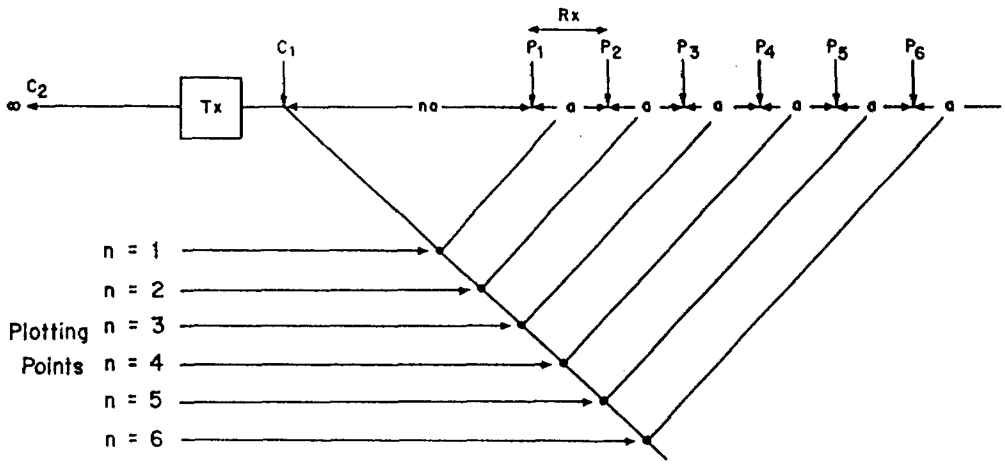
The electrodes marked C1 and C2 are the current electrodes. Those marked as P1, P2, etc., are the potential electrodes. The receiver measures the voltage across adjacent pairs of potential electrodes; e.g. P1-P2, P2-P3, ... P6-P7. These potential pairs are labelled by an integer 'n' which indicates the multiple of the dipole width that the given dipole lies away from the near current electrode.

The further the potential dipole lies from the current dipole the greater is the depth of investigation. Resolution of the survey is increased by decreasing the 'a' separation. The current survey employed a dipole spacing of 25 metres.

7. DATA PROCESSING AND PRESENTATION

7.1 Summary

To allow for the computer processing of the survey data, the raw data stored internally in the IPR-11 were transferred at the end of a survey day to floppy diskettes. The raw data were filed on diskette in ASCII character format using an IBM compatible (MS-DOS) microcomputer.



ARRAY GEOMETRY

Apparent Resistivity:

$$\rho_a = 2\pi \; na(n+1) \; Vp/I$$

where

ρ_a = apparent resitivity (ohm.m)
n = dipole number (dimensionless)
a = dipole spacing (m)
Vp = primary voltage (mV)
I = primary current (mA)

Pole-Dipole Array
Array Geometry and Formula for Apparent Resistivity

Figure 3

An archived 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 spectral parameters (c, tau and MIP) are derived from the IPR-11 data with the Soft II software. The edited data were then dumped to a printer as formatted data listings, contoured pseudosections and profiles.

The apparent resistivity, M7 chargeability, spectral M-IP and tau data were machine contoured and plotted in pseudosection form and then photo-reduced to a scale of 1:2500. Pseudosection pairs (resistivity and chargeability or M-IP and tau) were then joined according to the survey grid to form 'offset' pseudosections.

IP anomalies were picked from the pseudosections and entered on a compilation map as anomaly bars parallel to the grid lines. IP characteristics of chargeability amplitude, time constant and MIP amplitude are indicated by the bar style or by numerical values. Areas of relatively high (or low) resistivity are outlined.

The results of the survey are presented on the following plates:

Plate 1: M7 chargeability plan map, scale 1:5000
Plate 2: Resistivity plan map, scale 1:5000
Plate 3: Anomaly/Compilation plan map, scale 1:5000
Plate 4a: Stacked M7/Res. Pseudosections; L32W - L27W, scale 1:2500
Plate 4b: Stacked MIP/tau Pseudosections; L32W - L27W, scale 1:2500
Plate 5a: Stacked M7/Res. Pseudosections; L26W - L17W, scale 1:2500
Plate 5b: Stacked MIP/tau Pseudosections; L26W - L17W, scale 1:2500
Plate 6a: Stacked M7/Res. Pseudosections; L15W - L9W, scale 1:2500
Plate 6b: Stacked MIP/tau Pseudosections; L15W - L9W, scale 1:2500
Plate 7a: Stacked M7/Res. Pseudosections; L825W - L3W, scale 1:2500
Plate 7b: Stacked MIP/tau Pseudosections; L825W - L3W, scale 1:2500
Plate 8a: Stacked M7/Res. Pseudosections; L4E - L17E, scale 1:2500
Plate 8b: Stacked MIP/tau Pseudosections; L4E - L17E, scale 1:2500
Plate 9a: Stacked M7/Res. Pseudosections; L19E - L25E, scale 1:2500
Plate 9b: Stacked MIP/tau Pseudosections; L19E - L25E, scale 1:2500
Plate 10a:Stacked M7/Res. Pseudosections; L27E - L32E, scale 1:2500
Plate 10b:Stacked MIP/tau Pseudosections; L27E - L32E, scale 1:2500

Elements of the data processing are discussed in greater detaïl below.

7.2 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 MIP)- 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. 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.

c - Exponent (dimensionless). A high c value (e.g. 0.5) implies one uniform polarizable source. A low c 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 priorize IP anomalies which have been picked from the pseudosections of conventional single slice (or average) chargeability. In this regard, the chargeability amplitude (MIP) 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 per cent) 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.

7.3 Anomaly Selection and Classification

Standard IP/resistivity anomaly shapes are shown in contoured pseudo-section form in Figure 4. These are theoretical results for a pole-dipole survey over a near surface tabular body. In the example shown the body has a width which is two times the dipole spacing.

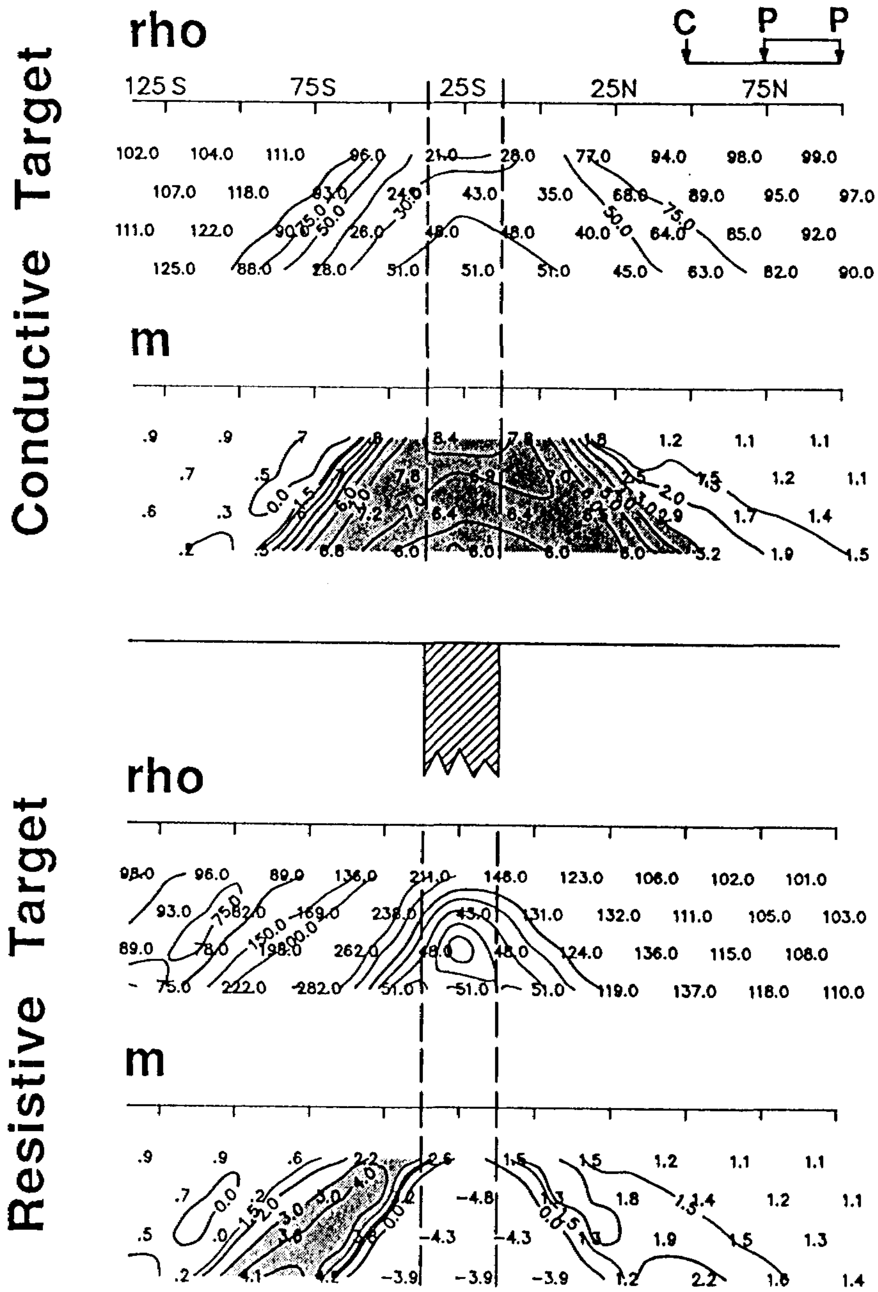


Figure 4. Theoretical resistivity / IP pseudosections for a vertical tabular body at surface. Results are for a pole-dipole array traversing from left to right. The host medium has a resistivity (rho) of 100 and a chargeabiltiy (m) of 1. The tabular body has resistivities of 10 and 1000 respectively and a chargeability of 10 (all units are relative). Areas with chargeabilities greater than 3 have been shaded.

Of note in these results is the change in IP anomaly shape as the target changes from being more conductive than the host to being more resistive. In the later case, the IP response is very much to one side of the target (the current side) and of reduced amplitude and breadth.

Areas of high resistivity have been noted with an H(n) where the 'n' represents the dipole in which the peak value occurs; accompanying arrows symbolize the high resistive blocks. Areas of low resistivity are rated as very weak, weak, medium or strong and are shown as anomaly bars.

Chargeability anomalies are represented on the pseudosections by anomaly bars that take the following form:

- (thick solid bar) very strong chargeability high; > 30 mV/V and well defined
- (solid bar) strong chargeability high; 20 - 30 mV/V and well defined
- (long dashes) moderate chargeability high; 10 - 20 mV/V
- (short dashes) weak chargeability high; 5 - 10 mV/V
- . . . . . very weak chargeability high; < 5 mV/V and poorly defined

A similar scheme describes the resistivity anomalies.

If a given IP anomaly has a resolvable peak then the dipole in which the peak value occurs is indicated by the notation "n=1" or "n=4", etc., beside the anomaly bar. The dipole in which the peak IP response occurs suggests in a very qualitative sense the depth to the top of the source. The location of the notation with respect to the anomaly bar represents the interpreted centre of the source body.

The numerical value of the chargeability amplitude (MIP) of the peak response and the time constant range value (L(ong),M(edium),or S(hort)) are shown beside the IP anomaly bar. L(ong), M(edium) and S(hort) indicate values between 30 and 100 s, 1 and 10 s and .01 and .3 s respectively.

IP anomalies showing line to line correlation have been grouped into anomalous zones and labelled with a letter. Resistivity highs (or lows) which show good line to line correlation may be grouped into anomalous zones. Definable resistivity peak highs (or lows) which show good line to line correlation may be joined as axes.

The peak magnetic anomaly axis have also been noted on the Anomaly/Compilation map.

8. DISCUSSION OF RESULTS AND RECOMMENDATIONS

West Grid

Seventeen IP anomalies were located in the western part of the survey grid.

Anomaly A (L2800W/stn.0 to L300W/stn.200N):

Anomaly A is a strong chargeability anomaly usually associated with low resistivities. The spectral signature of long time constants associated with conductivity indicates a well connected source such as graphite or massive sulphides. The anomaly exhibits a change of texture to medium on lines 2700W, 1300W, 825W and 300W. On line 1000W a short time constant is observed indicating a fine-grained source.

Anomaly A has been recommended for drilling on line 1000W and areas of medium and short time constant should be examined geologically and geochemically. From discussions with a Teck geologist, Anomaly A is a stratigraphic marker containing graphite.

Anomaly B (L1300W/stn.300N to L300W/stn.400N):

A weak to medium strength deep anomaly is part of a wider polarizable area including anomalies C and D. The anomaly has known gold values on line 1000W. The most chargeable areas are on lines 1100W, 1000W, 900W, and 825 W. This may be the main mineralized gold zone along the IP anomaly. The anomaly is well formed on lines 900W, 1000W, and 825W which again may be the most favourable part of the anomaly for gold mineralization.

Anomaly C (L1200W/stn.400N to L500W/stn.400S):

A weak, broad, chargeability anomaly that may be associated with a wide zone of disseminated sulphides. The anomaly is fine-grained to the east, mixed in the centre, and coarse-grained to the west. It is recommended to test this anomaly in association with the drilling of Anomaly B on 1000W.

Anomaly D, D', and D" (L500W/stn.600N to L1300W/stn.600N):

Chargeability anomalies D, D', and D" may be geologically related or three separate units. Anomaly D' is the strongest chargeability unit which is very strong on lines 1200W and 1300W. Line 1200W has a nicely shaped resistivity high associated with it and could be drilled. Line 1100W has short time constants in an area of possible shearing.

The strong chargeability anomaly has a long time constant and a uniform (3000 ohm-m) to high (11,500 ohm-m) resistivity associated with it. The source could be a coarse-grained sulphide in a resistive host. On line 1100W it could be finer-grained or less volume percent (lower Mo)

Anomaly E (L1500W/stn.200N to L2100W/stn.150N):

Anomaly E is a very strong, well interconnected (low resistivity, long time constant) unit flanked to the south by a resistivity high. The eastern end of the anomaly exhibits a fine-grained spectral (tau) signature and is therefore recommended for testing. The relationship of this anomaly with anomaly B should also be explored. (Note: Previous drilling may have provided information to explain this target).

Anomaly F (L1500W/stn.275N to L2300W/stn.325N):

Anomaly F is a medium to strong chargeability anomaly with the resistivity and time constant data indicating the sulphides/graphite are coarse-grained and interconnected. The flank resistivities are only intermediate in range not indicating silicification. It is recommended that line 1500W is drilled to check its relationship with anomaly B.

Anomaly G (L1700W/stn.450N to L2100W/stn.375N):

Anomaly G is a weak to moderate strength deep chargeability anomaly associated with 2000 ohm-m to 5000 ohm-m resistivities with short time constants tau.

The anomaly could be a few percent of a fine-grained sulphide in a resistive environment. The anomaly is similar to anomaly B and should be tested on line 2100W where it may be a sheared off piece or remobilized sulphide from Anomaly F. It is recommended for drilling as a medium priority target at L2100W/stn.325N.

Anomaly H (L2400W/stn.225N to L2800W/stn.175N):

Anomaly H is a medium to strong chargeability anomaly with time constants indicating a coarse- to medium-grained source. On line 2700W at 150N the spectral time constants decrease with a decrease of resistivity indicating possible alteration. The flank resistivity anomalies are 5000 ohm-m to 7500 ohm-m which may be due to minor silicification.

It is recommended that the anomaly on line 2700W would be explained by drilling from a collar at L2700W/stn.113N.

Anomaly I (L2900W/stn.200S to L2700W/stn.25S):

This is a strong chargeability anomaly with short time constants and high Mo flanked by high resistivities. The anomaly is on the southern part of a chargeability high from the chargeability contour map consisting of the western parts of Anomaly A and Anomaly H.

The zone is not as discrete as the compilation map makes it appear. On line 2800W, Anomalies J, I, A and H are part of a very strong IP high that may strike north-south. Anomaly I has some short time constants associated with it which may indicate some alteration.

Drilling of Anomaly I on line 2800W is recommended. The geology should be examined in the field to check the strike of the sulphides.

Anomaly J (L2700W/stn.425S to L3200W/250S):

Anomaly J is a medium strength to very strong chargeability anomaly associated with a resistivity low. The time constants remain generally short indicating a fine-grained source. The flank resistivities are not high but are shapes usually formed by discrete resistive units.

It is recommended that Anomaly J be drilled on lines 2800W or 2900W - priorized geologically and geochemically.

Anomalies A', K, and H:

These anomalies are short anomalies that should be looked at geochemically and geologically.

<u>East Grid</u>

Ten IP anomalies were located on the east grid.

Anomaly AE (L1500E/stn.500S to L3200E/stn.500S):

This anomaly may be the eastern stratigraphic equivalent of Anomaly A. Anomaly AE is a very strong chargeability anomaly associated with a very low resistivity and long time constants. The source could be massive sulphides or graphite. The northern contact of Anomaly AE in the compilation map correlates approximately with the northern contact of a lithologic unit that has an active magnetic signature.

Anomaly AE is recommended for exploration near line 2800E at stations 400S to 450S which is near a resistivity high with moderate time constants.

Anomaly BE (L900E/stn.400S to L3200E/stn.100S):

Anomaly BE is a long medium to strong chargeability crossing the entire east grid. The spectral data indicate grain size variations along strike; coarse-grained in the west grading through medium-grained to fine-grained in the cental region (BE and BE'). The fine-grained sections generally correlates to resistivity highs.

BE should be examined on lines 1000E, 1900E, 2500E and 2900E. The sources may be explored by drilling or trenching.

Anomaly CE (L1300E/stn.275S to L1500E/stn.225E):

Anomaly CE is a short, weak, fine-grained chargeability anomaly. It correlates with a slight resistivity increase. The anomaly should be examined geologically and geochemically but does not warrant drilling based solely on the geophysics.

Anomaly DE (L400E/stn.325S to L3200E/stn.100N):

DE is a very long, medium to strong chargeability anomaly with coarse-grained units on its western and eastern parts. The anomaly is fine-grained to medium-grained from L900E to L1500E. The anomaly is recommended for drilling on lines 900E in a region of short time constants. On line 1900E drilling is recommended in a coarse-grained section of the anomaly on the northern flank of a resistivity high.

Anomaly EE (L400E/stn.225N to L1300E/stn.50S):

Anomaly EE is a weak to medium strength chargeability anomaly in a region of lower resistivities. The source is fine-grained on its western portion, coarse-grained in its central part and medium-mixed-grained on its eastern part.

A low priority target is recommended for evaluation on line 700E. Geology and geochemistry should be reviewed.

Anomaly EE' (L2100E/stn.100N to L2500E/stn.50N):

Anomaly EE' is a short, weak, deep, and fine-grained anomaly located on the southern flank of Anomaly DE. The anomaly should be reviewed geologically and geochemically.

Anomaly FE (L900E/stn.500N to L1100E/stn.475N):

FE is a short (200 metres), weak chargeability anomaly associated with long time constants indicating a coarse-grained source. The source should be evaluated geologically and geochemically.

Anomaly GE (L2800E/stn.1050S to L3200E/stn.1000S):

Anomaly GE is a very weak to strong chargeability anomaly that is associated with very low resistivities indicating a massive sulphide or graphite source. The anomaly should be prospected on lines 2700E to 2900E at about stn.1050S.

Anomaly HE (L2900E/stn.1450S):

This is a weak chargeability anomaly correlating with a narrow resistivity high. The spectral data indicates the target to be fine-grained. The anomaly appears to have gold potential and should be evaluated geologically and probably drilled.

Anomaly IE (L3000E/stn.1250S):

IE is a weak to moderate short time constant anomaly occurring coincident to the north flank of a resistivity high of up to 8000 ohm-m. The anomaly should be thoroughly prospected and possibly drilled.

FRASER FILTERED PROCESSING - Figures A, B, C, D

Gold zone - West Grid - Lines 1900W to 300W

A Fraser Filter was applied on the IP, Resistivity and IP spectral data in and attempt to bring out the deeper more subtle targets. An overlay of short time constants was made in an attempt to correlate regions of short time constants with areas of high chargeability.

The maps indicate the gold zone is in a region of fine-grained sulphides. Therefore other areas of high chargeability and short time constants should be explored.

The other significant pieces of information are:

(1) Anomaly B has its highest volume percent of fine-grained sulphides between lines 1100W and 900W.

(2) Anomaly A on line 1000W has a high percent of sulphides and the time constant indicates it is fine-grained.

(3) The area of low time constant between anomalies E and A on lines 1300W and 1500W appears to be caused by insufficient spectral data in that area.

(4) A region of very low chargeabilities and resistivities may indicate a deep bedrock trough at 1100W and 1200W at 150N.

(5) One or two faults (F1, F2) interupts IP anomalies B, C, F, and D.

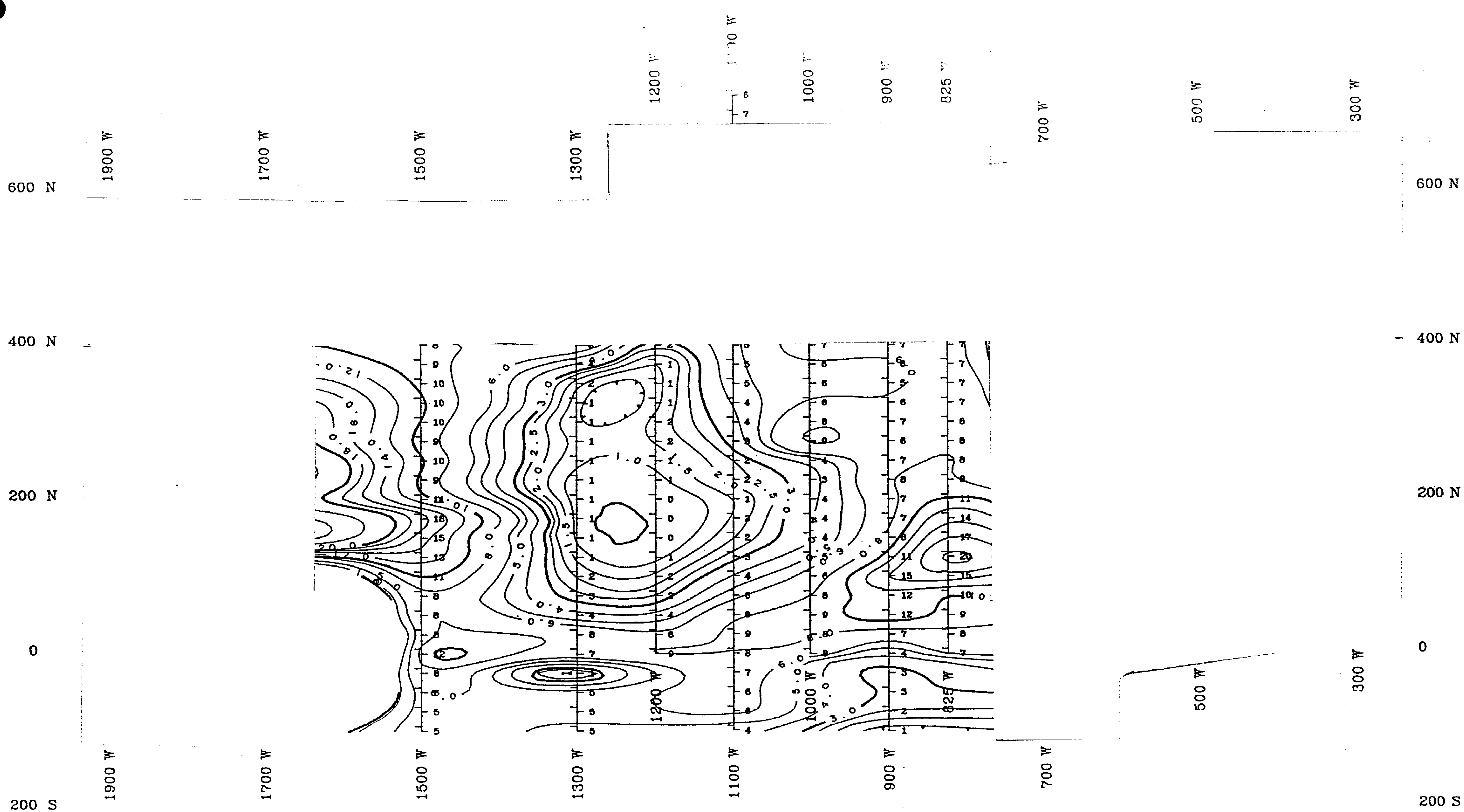
(6) There may be a high background amount of sulphides striking from L825W/stn.50N to L1200W/stn.600N (i.e. the 200 contour on the Fraser filtered Mo data).

9. SUMMARY AND CONCLUSIONS

From January 14th to March 1st, 1991, JVX Limited carried out a Spectral Time Domain Induced Polarization survey on the Thunder Lake property, near Wabigoon, Northwestern Ontario, on behalf of Teck Explorations Limited.

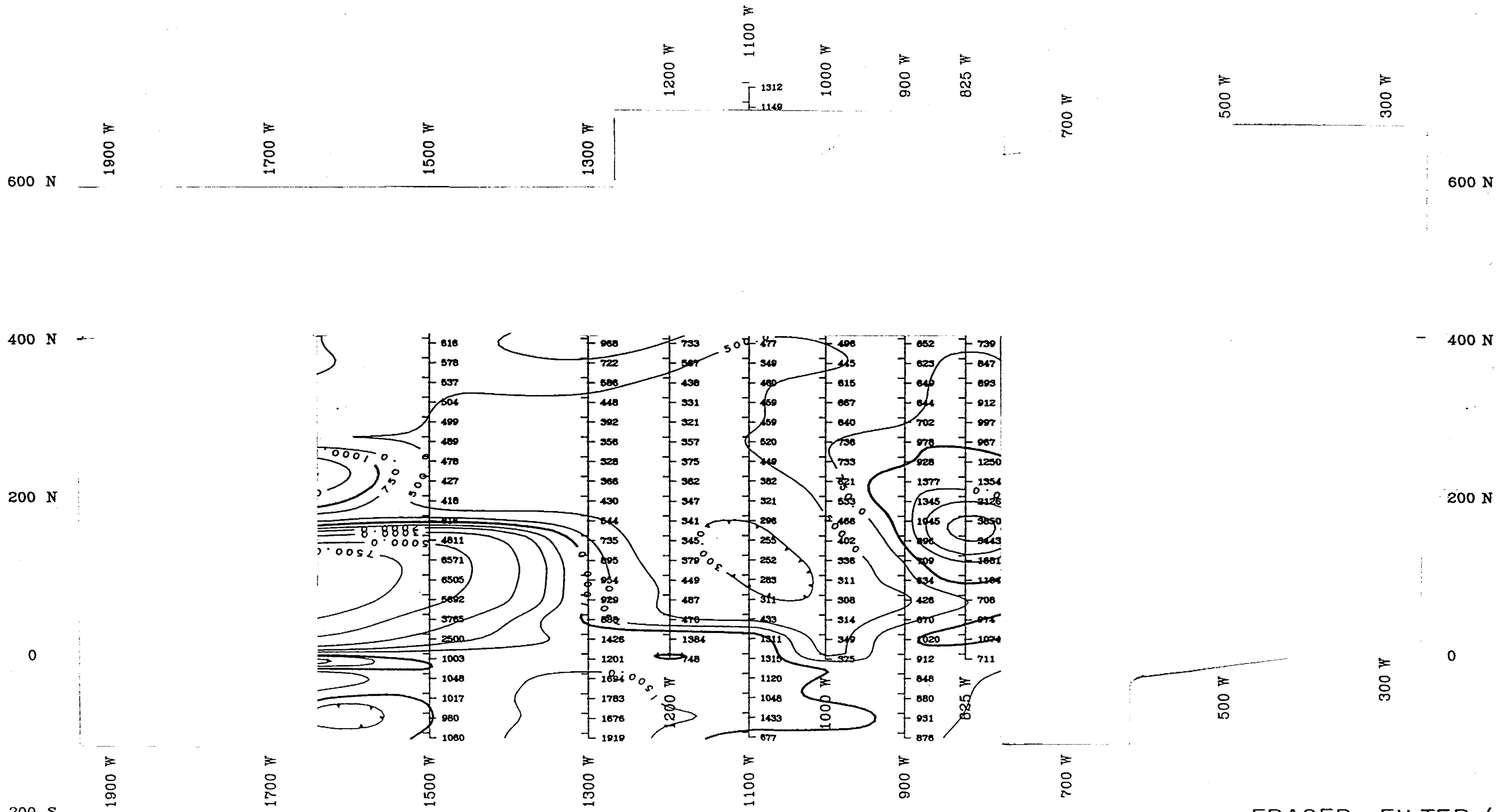
A total of 34.0 km of a=25 metre, pole-dipole IP survey was carried out on the grid. The results are presented as contour maps, pseudosections and an anomaly/compilation plan map.

The present interpretation has selected exploration targets based on the IP survey. A full integration of the magnetic and geological data with the IP data will allow an improved compilation to be made. The recommended target areas on the IP survey will improve the geological data base from which other targets can be further priorized.



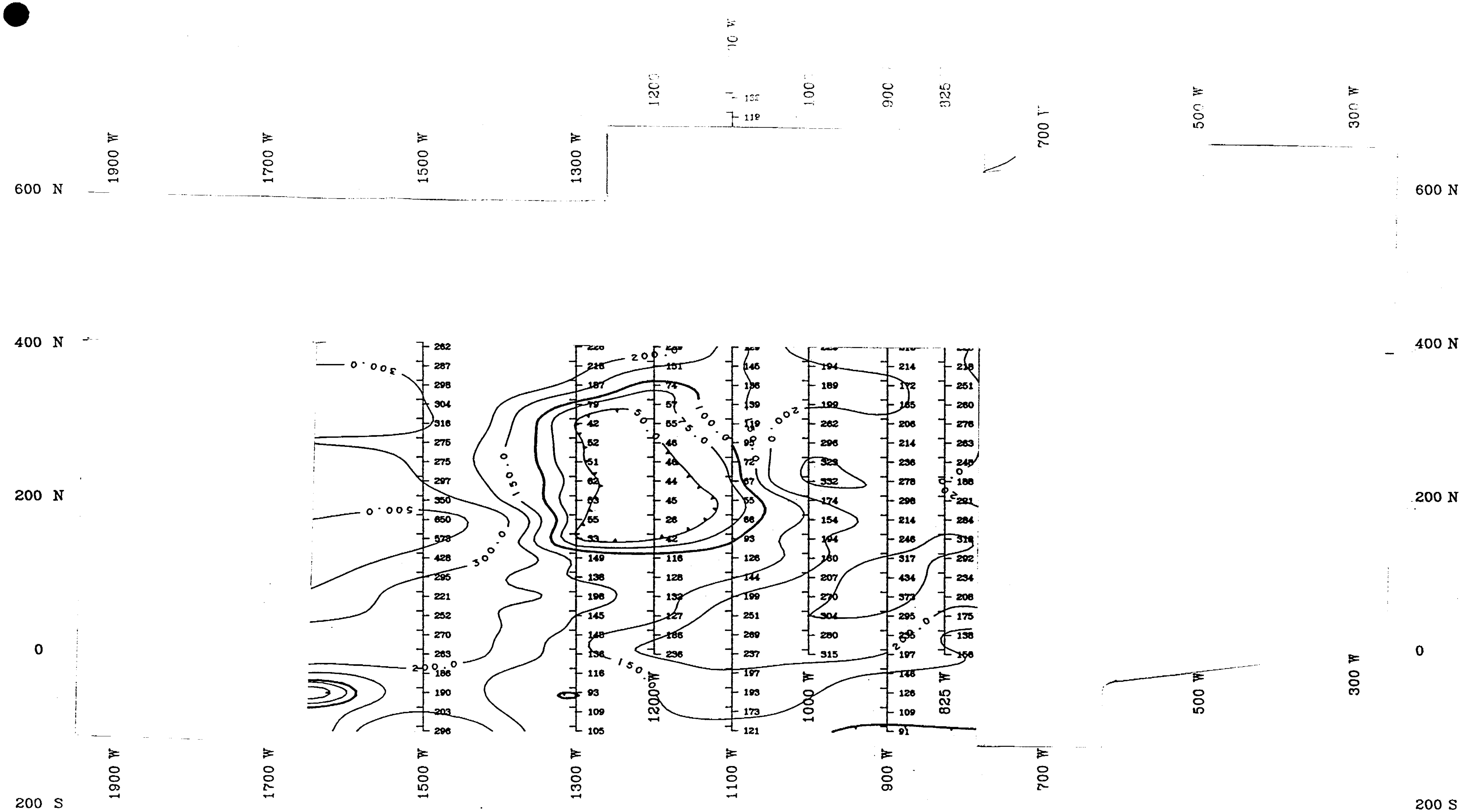
FRASER FILTER (M7)

Figure A



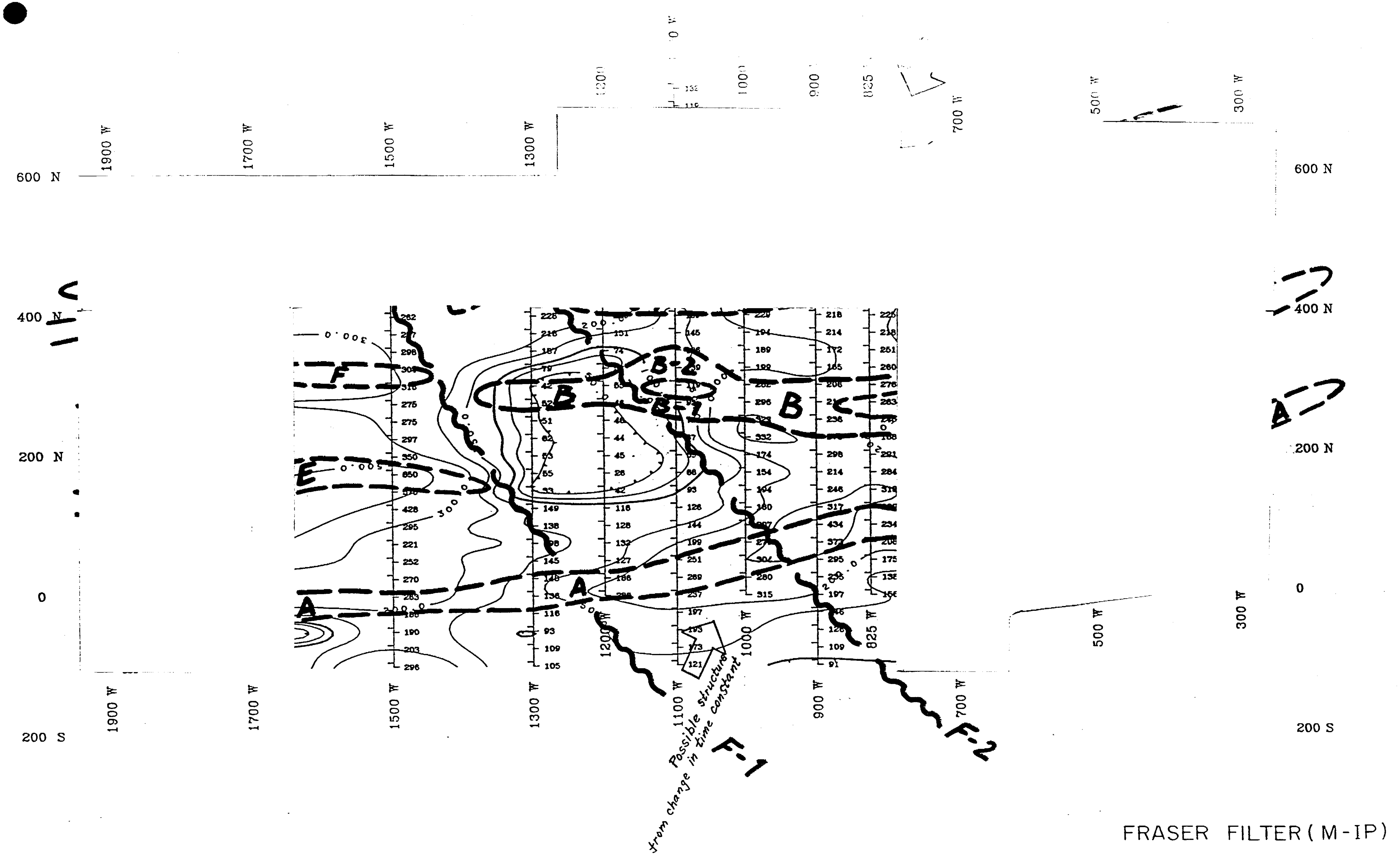
FRASER FILTER (ρ_a)

Figure 6



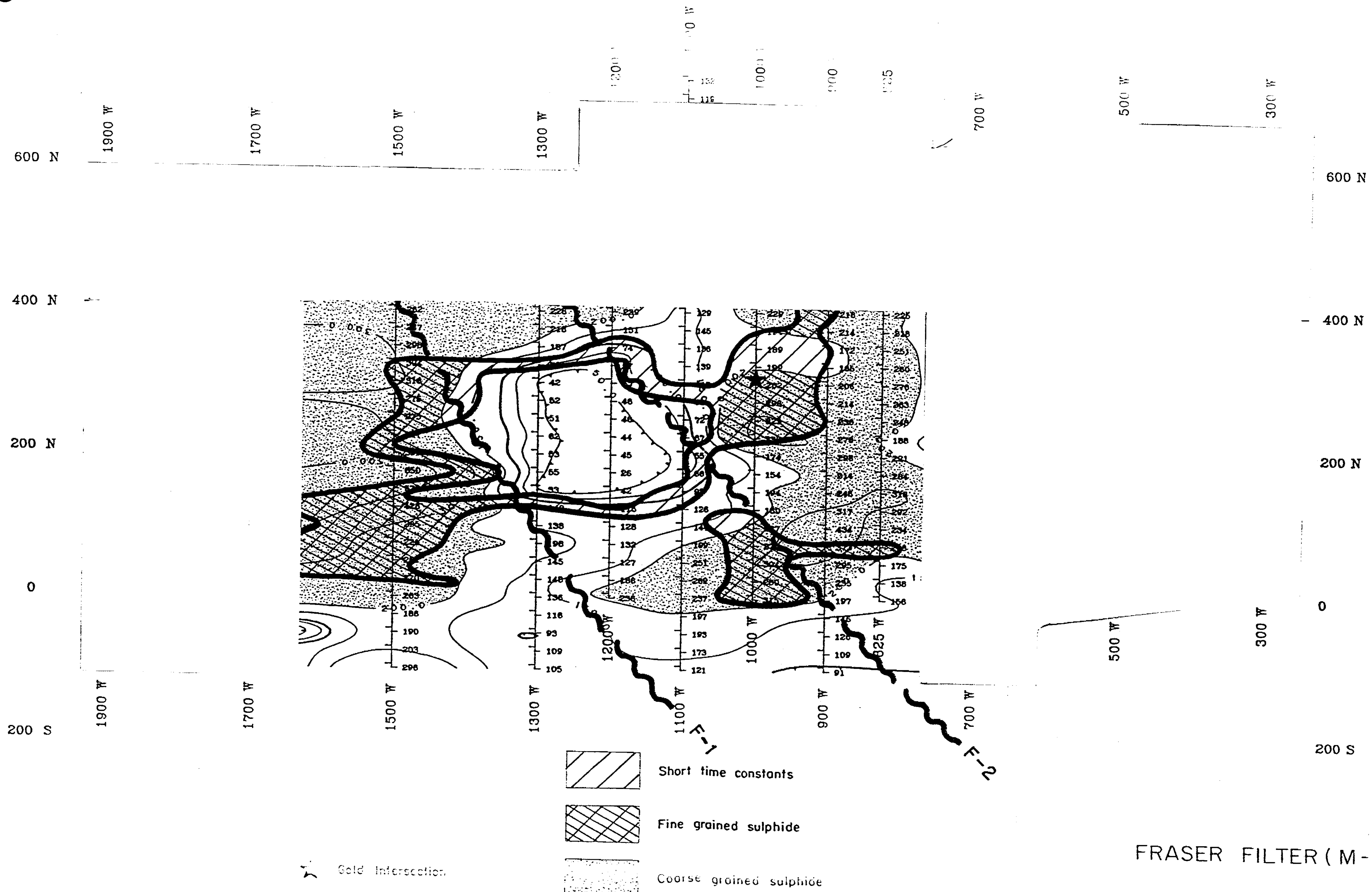
FRASER FILTER (M-IP)

Figure C



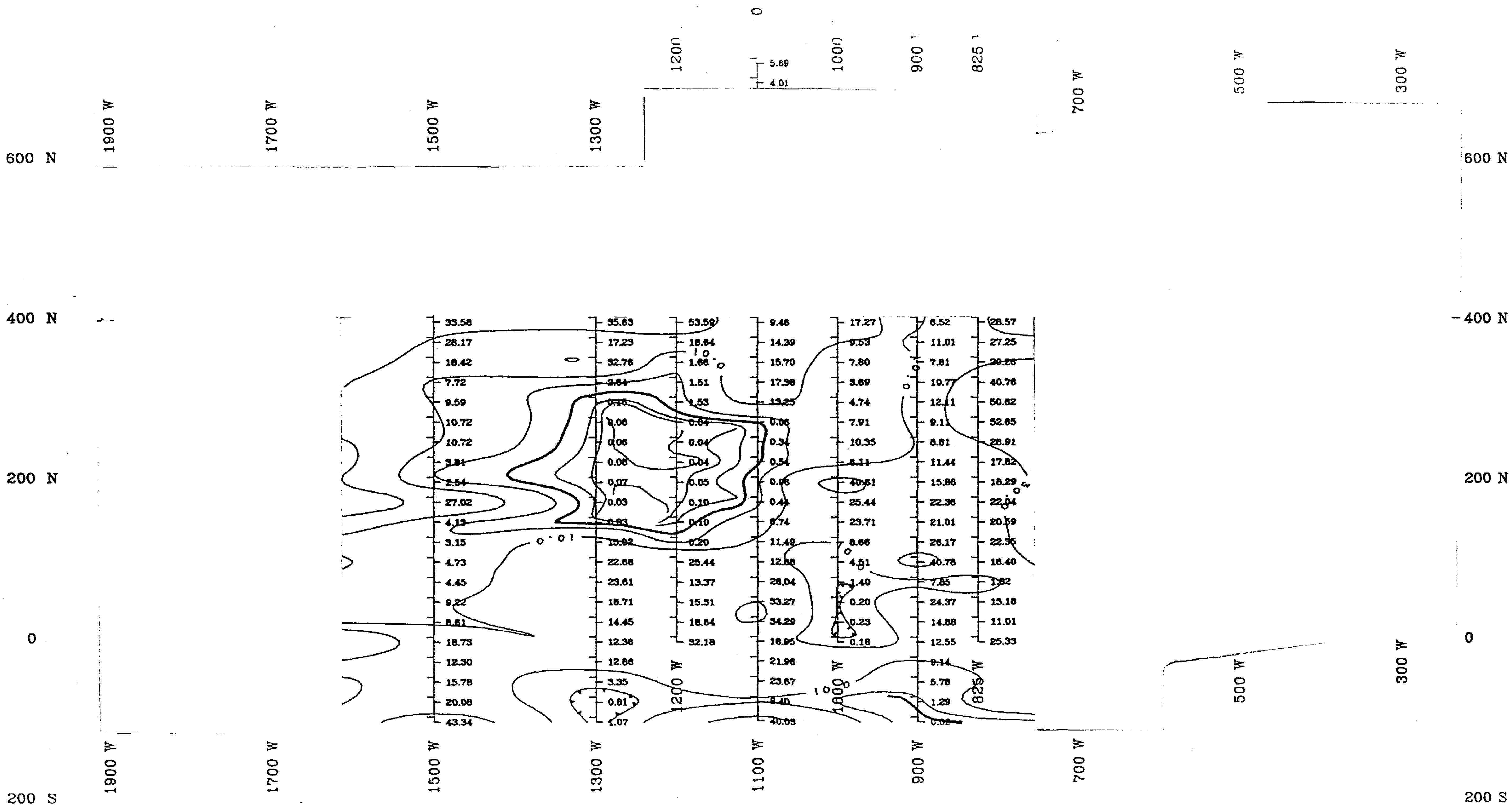
FRASER FILTER (M-IP)

Figure C-1



FRASER FILTER (M-IP)

Figure C-2



FRASER FILTER (Tau)

Figure D

Recommendations for geophysical/geological compilation follow:

- Calculate a 2nd Derivative map of the magnetics.
- Calculate the Fraser Filter of the IP and resistivity data.
- Superimpose all geochemical data and geological data.
- Derive a revised compilation map.

If there are any questions with regard to the survey or the reporting, please call the undersigned at JVX Limited.

Respectfully submitted,

JVX LIMITED

Blaine Webster, B.Sc.
Geophysicist, President

Appendix 1

Specification Sheets

SCINTREX IPR-11 Broadband Time Domain IP Receiver

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.

Function

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 pseudosection plots, 3) digital printer listing, 4) a cassette tape record or 5) 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 desk top or mainframe computer.

The IPR-11 is designed for use with the Scintrex line of transmitters, primarily the TSQ series 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.

Major Benefits

Following are some of the major benefits which you can derive through the key features of the IPR-11.

Speed up surveys. The IPR-11 is primarily designed to save you time and money in gathering spectral induced polarization data.

For example, consider the advantage in gradient, dipole-dipole or pole-dipole surveying with multiple 'n' or 'a' spacings, of measuring up to six potential dipoles simultaneously. If the specially designed Multidipole Potential Cables are used, members of a crew can prepare new dipoles at the end of a spread while measurements are underway. When the observation is complete, the operator walks only one dipole length and connects to a new spread leaving the cable from the first dipole for retrieval by an assistant.

Simultaneous multidipole potential measurements offer an obvious advantage when used in drillhole logging with the Scintrex DHIP-2 Drillhole IP/Resistivity Logging Option.

The built-in, solid state memory also saves time. Imagine the time that would be taken to write down line number, station number, transmitter and receiver timings and other header information as well as data consisting of SP, Vp and ten IP parameters for each dipole. With the IPR-11, a record is filed at the touch of a button once the operator sees that the measurement has converged sufficiently.

The IPR-11 will calculate resistivity for you. Further time will then be saved when the IPR-11 begins plotting your data in profile or pseudo-section format in your base camp on a digital printer. The same printer can also be used to make one or more copies of a listing of the day's results. If desired, an output to a cassette tape recorder can be made. Or, the IPR-11 data memory can be output directly into a modem, saving time by transmitting data to head office by telephone line and by providing data which are essentially computer compatible.

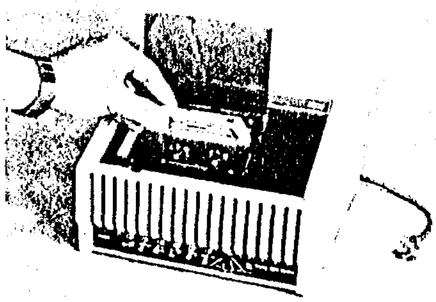
If the above features won't save as much time as you would like, consider how the operator will appreciate the speed in taking a reading with the IPR-11 due to: 1) simple keyboard control, 2) resistance check of six dipoles simultaneously, 3) fully automatic SP buckout, 4) fully automatic Vp self ranging, 5) fully automatic gain setting, 6) built-in calibration test circuits, and 7) self checking programs. The amount of operator manipulation required to take a great deal of spectral IP data is minimal.

Compared with frequency domain measurements, where sequential transmissions at different frequencies must be made, the time domain measurement records broadband information each few seconds. When successive readings are stacked and averaged, and when the pragmatic window widths designed into the IPR-11 measurement are used, full spectral IP data are taken in a minimum of time.

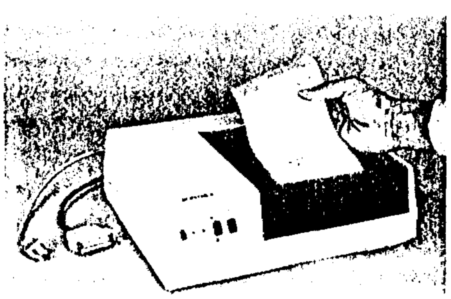
Improved interpretation of data. The quasi-logarithmically spaced transient windows are placed to recover the broadband information that is needed to calculate the standard spectral IP parameters with confidence. Scintrex offers its SPECTRUM software package which can take the IPR-11 outputs and generate the following standard spectral IP parameters: M, chargeability; T, time constant and C, exponent.

Technical Description of the IPR-11 Broadband Time Domain IP Receiver

Input Potential Dipoles	1 to 6 simultaneously
Input Impedance	4 megohms
Input Voltage (Vp) Range	100 microvolts to 6 volts for measurement. Zener diode protection up to 50 V
Automatic SP Bucking Range	±1.5 V
Chargeability (M) Range	0 to 300 mV/V (mils or 0/00)
Absolute Accuracy of Vp, SP and M	Vp; ±3% of reading for Vp > 100 microvolts SP; ±3% of SP bucking range M; ±3% of reading or minimum ±0.5m V/V
Resolution of Vp, SP and M	Vp; 1 m V above 100 m V approaching 1 microvolt at 100 microvolt SP; 1 m V M; 0.1 m V/V except for M_0 to M_3 in 0.2 second receive time where resolution is 0.4 m V/V.
IP Transient Program	Ten transient windows per input dipole. After a delay from current off of t, first four windows each have a width of t, next three windows each have a width of 6t and last three windows each have a width of 12t. The total measuring time is therefore 58t. t can be set at 3, 15, 30 or 60 milliseconds for nominal total receive times of 0.2, 1, 2 and 4 seconds.
Vp Integration Time	In 0.2 and 1 second receive time modes; 0.51 sec In 2 second mode; 1.02 sec In 4 second mode; 2.04 sec
Transmitter Timing	Equal on and off times with polarity change each half cycle. On/off times of 1, 2, 4 or 8 seconds with ±2.5% accuracy are required.
Header Capacity	Up to 17 four digit headers can be stored with each observation.
Data Memory Capacity	Depends on how many dipoles are recorded with each header. If four header items are used with 6 dipoles of SP, Vp and 10 M windows each, then about 200 dipole measurements can be stored. Up to three Optional Data Memory Expansion Blocks are available, each with a capacity of about 200 dipoles.
External Circuit Check	Checks up to six dipoles simultaneously using a 31 Hz square wave and readout on front panel meters, in range of 0 to 200 k ohms.
Filtering	RF filter, spheric spike removal; switchable 50 or 60 Hz notch filters, low pass filters which are automatically removed from the circuit in the 0.2 sec receive time.
Internal Calibrator	1000 mV of SP, 200 mV of Vp and 24.3 mV/V of M provided in 2 sec pulses.
Digital Display	Two, 4 digit LCD displays. One presents data, either measured or manually entered by the operator. The second display; 1) indicates codes identifying the data shown on the first display, and 2) shows alarm codes indicating errors.
Analog Meters	Six meters for; 1) checking external circuit resistance, and 2) monitoring input signals.
Digital Data Output	RS-232C compatible, 7 bit ASCII, no parity, serial data output for communication with a digital printer, tape recorder or modem.

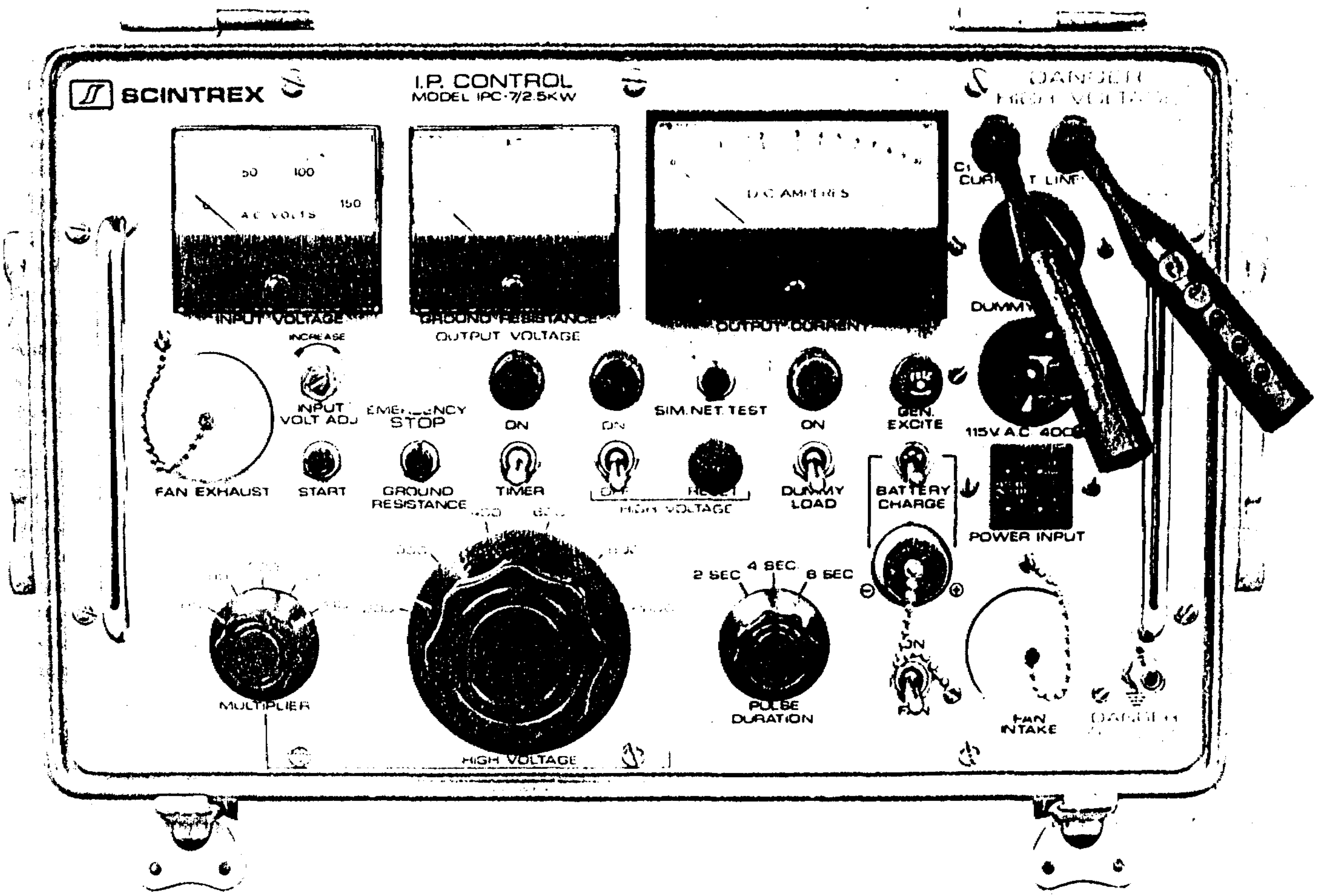


Industry standard cassette recorders such as this MFE-2500 can be connected directly to the IPR-11.



DP-4 Digital Printer

SCINTREX IPC-7/2.5kW Induced Polarization and Commutated DC Resistivity Transmitter System



Function

The IPC-7/2.5 kW is a medium power transmitter system designed for time domain induced polarization or commutated DC resistivity work. It is the standard power transmitting system used on most surveys under a wide variety of geophysical, topographical and climatic conditions.

The system consists of three modules: A Transmitter Console containing a transformer and electronics, a Motor Generator and a Dummy Load mounted in the Transmitter Console cover. The purpose of the Dummy Load is to accept the Motor Generator output during those parts of the cycle when current is not transmitted into the ground, in order to improve power output and prolong engine life.

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.

Features

Maximum motor generator output, 2.5 kW; maximum power output, 1.85 kW; maximum current output, 10 amperes; maximum voltage output, 1210 volts DC.

Removable circuit boards for ease in servicing.

Automatic on-off and polarity cycling with selectable cycling rates so that the optimum pulse time (frequency) can be selected for each survey.

The overload protection circuit protects the instrument from damage in case of an overload or short in the current dipole circuit.

The open loop circuit protects workers by automatically cutting off the high voltage in case of a break in the current dipole circuit.

Both the primary and secondary of the transformer are switch selectable for power matching to the ground load. This ensures maximum power efficiency.

The built-in ohmmeter is used for checking the external circuit resistance to ensure that the current dipole circuit is grounded properly before the high voltage is turned on. This is a safety feature and also allows the operator to select the proper output voltage required to give an adequate current for a proper signal at the receiver.

The programmer is crystal controlled for the very high stability required for broadband (spectral) induced polarization measurements using the Scintrex IPR-11 Broadband Time Domain Receiver.

Appendix 2

Plates 1 to 10

Plate 1: M7 chargeability plan map, scale 1:5000
Plate 2: Resistivity plan map, scale 1:5000
Plate 3: Anomaly/Compilation plan map, scale 1:5000
Plate 4a: Stacked M7/Res. Pseudosections; L32W - L27W, scale 1:2500
Plate 4b: Stacked MIP/tau Pseudosections; L32W - L27W, scale 1:2500
Plate 5a: Stacked M7/Res. Pseudosections; L26W - L17W, scale 1:2500
Plate 5b: Stacked MIP/tau Pseudosections; L26W - L17W, scale 1:2500
Plate 6a: Stacked M7/Res. Pseudosections; L15W - L9W, scale 1:2500
Plate 6b: Stacked MIP/tau Pseudosections; L15W - L9W, scale 1:2500
Plate 7a: Stacked M7/Res. Pseudosections; L825W - L3W, scale 1:2500
Plate 7b: Stacked MIP/tau Pseudosections; L825W - L3W, scale 1:2500
Plate 8a: Stacked M7/Res. Pseudosections; L4E - L17E, scale 1:2500
Plate 8b: Stacked MIP/tau Pseudosections; L4E - L17E, scale 1:2500
Plate 9a: Stacked M7/Res. Pseudosections; L19E - L25E, scale 1:2500
Plate 9b: Stacked MIP/tau Pseudosections; L19E - L25E, scale 1:2500
Plate 10a:Stacked M7/Res. Pseudosections; L27E - L32E, scale 1:2500
Plate 10b:Stacked MIP/tau Pseudosections; L27E - L32E, scale 1:2500

Appendix 3

Literature

Spectral IP parameters as determined through Time Domain Measurements by I.M. Johnson, Scintrex Limited, Toronto, Ontario, Canada, 1984.

Spectral IP: Experience over a number of Canadian Gold Deposits by B. Webster, JVX Ltd., and I.M. Johnson, Scintrex Limited, Toronto, Ontario, Canada, 1985.

Time domain Spectral Induced Polarization, some recent examples for gold, by Ian M. Johnson and Blaine Webster, JVX Limited, Thornhill, Ontario, Canada, 1987. Prepared for delegates to Exploration 87, 1987, Toronto, Canada.

GEOPHYSICS, VOL. 49, NO. 11 (NOVEMBER 1984); P. 1993-2003, 9 FIGS., 1 TABLE.

Spectral induced polarization parameters as determined through time-domain measurements

Ian M. Johnson*

ABSTRACT

A method for the extraction of Cole-Cole spectral parameters from time-domain induced polarization data is demonstrated. The instrumentation required to effect the measurement and analysis is described. The Cole-Cole impedance model is shown to work equally well in the time domain as in the frequency domain. Field trials show the time-domain method to generate spectral parameters consistent with those generated by frequency-domain surveys. This is shown to be possible without significant alteration to field procedures. Cole-Cole time constants of up to 100 s are shown to be resolvable given a transmitted current of a 2 s pulse-time. The process proves to have added usefulness as the Cole-Cole forward solution proves an excellent basis for quantifying noise in the measured decay.

INTRODUCTION

The induced polarization (IP) phenomenon was first observed as a relaxation or decay voltage as a response to the shut-off of an impressed dc current. This decay was seen to be quasi-exponential with measurable effects several seconds after shut-off. Differences in the shape of decay curves seen for different polarizable targets have been recognized from the start (Wait, 1959). A systematic method of analyzing time-domain responses in order to generate an unbiased measure of source character has, until recently, been lacking. Developments in the frequency domain have been more pronounced.

In an attempt to improve our understanding of time-domain IP phenomenon, the Cole-Cole impedance model, developed and tested in the frequency domain, is used to generate the equivalent time-domain responses. Time-domain field data are then analyzed for Cole-Cole parameters and the results used to interpret differences in the character of the source.

The theoretical basis for the work will be presented. The instrumentation required to effect the measurement and analysis will be described. Field examples will be discussed.

SPECTRAL IP

The term "spectral IP" has been used to designate a variety of methods which look beyond the familiar resistivity and chargeability (or "percent frequency effect") as measured in electrical surveys. A number of geophysical instrument manufacturers/contractors have developed instrumentation and methodologies which, in essence, collect and analyze data from electrical surveys at a number of frequencies or delay times. The data analysis produces a set of quantities which characterize the information gained. These quantities or parameters are promoted by the sponsor for application in a variety of search problems for mineral and hydrocarbon resources.

In recognition of the pioneering work of Pelton (Pelton et al., 1978), the Cole-Cole impedance model has been adopted. The model has been extensively field tested and found to be reliable (Pelton et al., 1978). Pelton suggested that the complex impedance (transfer function) of a simple polarizable source may be best expressed as

$$Z(\omega) = R_0\left\{1 - m\left[1 - \frac{1}{1 + (i\omega\tau)^c}\right]\right\}, \tag{1}$$

where

$Z(\omega)$ = complex impedance (in $\Omega \cdot$ m),

R_0 = the dc resistivity (in $\Omega \cdot$ m),

m = the chargeability (in volts/volt),

τ = the time constant (in seconds),

ω = the angular frequency (in seconds^{-1}),

c = the exponent (or frequency dependence), (dimensionless)

and

$$i = \sqrt{-1}.$$

The dc resistivity (R_0) is related to the apparent resistivity

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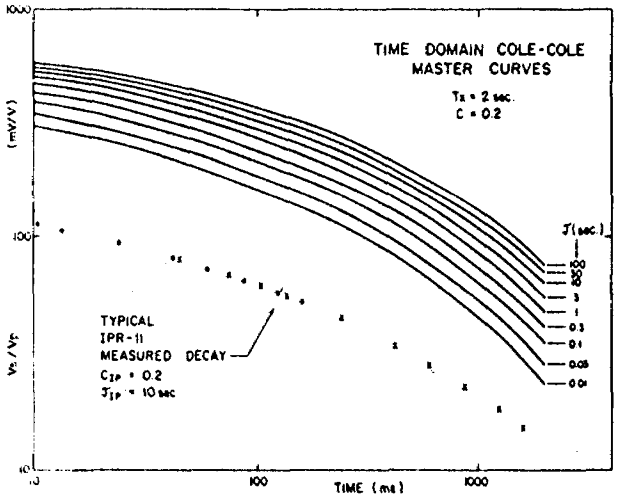

FIG. 1. Theoretical time-domain decay curves for fixed c and variable τ. A typical IPR-11 measured decay is shown as a series of dots (0.2 s receiver mode) and x's (2 s receiver mode).

as

$$V_p = I_0 R_0 - I_0 R_0 m + I_0 R_0 mG(t_a, t_b, \tau, c, T), \qquad (7)$$

where t_a, t_b are the limits of integration during the current on-time.

Combining equations (6) and (7), the theoretical decay is given by

$$S_i = \frac{10^3\, mG(t_i, t_{i+1}, \tau, c, T)}{1 - m + mG(t_a, t_b, \tau, c, T)} \quad (\text{mV/V}),\ i = 1, N. \qquad (8)$$

Preferred Cole-Cole spectral parameters may be determined by a "best-fit" match of measured data to a suite of master curves. The process used may be summarized as follows.

The master-curve set is numerically generated through equation (8) by allowing c and τ to vary in discrete steps over ranges of interest. The chargeability is set to 1 V/V and the pulse time to 2 s. Both S_i and $G(t_a, t_b, \tau, c, T)$ are retained in the master-curve set.

If the measured decay is given by M_i mV/V ($i = 1, N$), an observed chargeability m_0 V/V is defined as the weighted average amplitude shift in log amplitude space between measured and master curves, i.e.,

$$\log m_0 = \frac{1}{N} \sum_{i=1}^{N} (\log M_i - \log S_i) w_i. \qquad (9)$$

Observed chargeability values are determined for all master curves. The weighting factors w_i bias the averaging to late delay times where integration intervals are longest.

The "best-fit" master curve is selected by minimizing

$$\text{SD} = \sum_{i=1}^{N} [\log M_i - \log (m_0 S_i)]^2 w_i, \qquad (10)$$

where the m_0 used is that value appropriate to the master curve under consideration.

The true chargeability m may be found by setting

$$\frac{mG(t_i, t_{i+1}, \tau, c, T)}{1 - m + mG(t_a, t_b, \tau, c, T)} = \frac{m_0\, G(t_i, t_{i+1}, \tau, c, T)}{G(t_a, t_b, \tau, c, T)}. \qquad (11)$$

Hence,

$$m = \frac{m_0 \times 10^3}{G(t_a, t_b, \tau, c, T) + m_0[1 - G(t_a, t_b, \tau, c, T)]} \quad \text{mV/V}. \qquad (12)$$

Confidence in the spectral parameters so determined is related to the agreement between measured data and the selected master curve. This agreement is quantified by the root-mean-square (rms) deviation defined as

$$D = \left\{ \frac{1}{N} \sum_{i=1}^{N} \left(1 - \frac{M_i}{m_0 S_i}\right)^2 \times 10^4 \right\}^{1/2} \text{percent}. \qquad (13)$$

The process outlined above will yield spectral parameters which are only apparent. Polarizable targets of interest are most often of finite size and embedded in a medium which may itself possess characteristic impedances. The theoretical problem of greater generality is a complex one with no reasonably general forward solution yet available.

Pelton et al. (1978) presented the case of a simple polarizable target buried in a nonpolarizing host. They showed that as the relative size of the target, as defined by the dilution factor decreases, the exponent is effectively unchanged. The time constant is similarly unaffected as long as the true chargeability is not large. The apparent resistivity and apparent chargeability are, however, not as stable under large changes in the dilution factor.

This implies that the shape of the time-domain decay and therefore the apparent time constant τ and exponent c are relatively stable under large changes in the dilution factor. The apparent chargeability is not.

By inspection,

$$G(t_i, t_{i+1}, \tau, c, T) = G(nt_i, nt_{i+1}, n\tau, c, nT). \qquad (14)$$

If for example, the receiver timing, pulse time, and Cole-Cole time constant are all doubled, the master-curve values are unaffected. This is a useful result for predicting the pulse length required to resolve spectral parameters given that one already has a complete understanding of the resolution capabilities of the method for one pulse time (e.g., $T = 2$ s). As an example, let us assume that time-domain IP surveys using a pulse time of 2 s are known to result in spectral discrimination (i.e., decay curve shape differences) for time constants up to 100 s. If it is suspected that it may be important to resolve time constants of 1 000 s, for example, all other things being equal, a pulse time of 20 s would be required.

All of the above applies for a homogeneous earth whose behavior is described by a single Cole-Cole impedance. Measured decays may be the result of the superposition of effects due to more than one source type. Resolution of more than one impedance type should be possible if all types are sufficiently different in time constant (Major and Silic, 1981). If this condition is met, the net impedance may be expressed as the sum of impedances of each type. This implies that measured voltages may be modeled as the sum of voltages due to both IP and inductive coupling effects and the mathematical summary

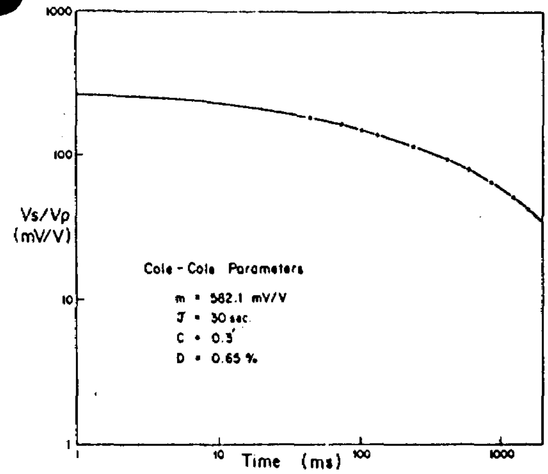

FIG. 4. Measured data (10 point), best-fit master decay curve, and calculated spectral parameters. Array is pole-dipole with $a = 10$ m, $n = 6$ with $V_p = 1.2$ mV. Rms deviation = 0.65 percent. V_s designates the voltage measured during the transmitter off-time.

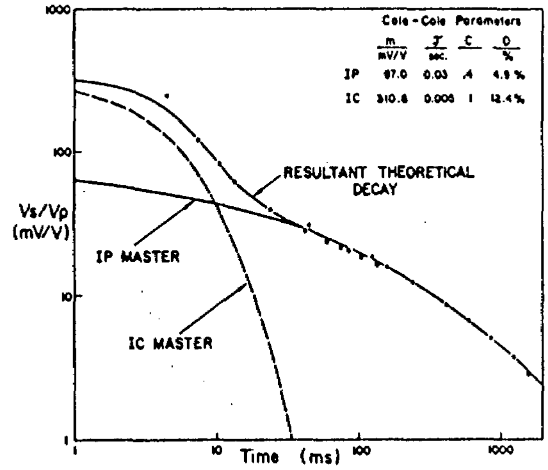

FIG. 5. Measured data (20 point composite), best-fit master curves, and calculated spectral parameters. Both IP and inductive coupling (IC) effects are modeled. Array is dipole-dipole with $a = 100$ m, $n = 6$ with $V_p = 2.6$ mV.

ing rms deviation. The results for part of this work are shown in Figure 3. The left-hand column shows the ranking in order of increasing curve shape difference away from a measured decay as given by the $c = .2$, $\tau = 1$ s master curve. The right-hand column shows the ranking away from a measured decay as given by the $c = .5$, $\tau = 1$ s master curve. These results serve to illustrate the following.

(1) As c is reduced from 0.5 to 0.2, the differences in the shape of the curve between master curves of different τ are reduced and the confidence in the time-constant determination is lessened. This is no more than the familiar result obtained in the frequency domain. That is, as c approaches 0.1, the phase spectrum flattens, the peak in the phase spectrum becomes less distinct, and the time constant becomes more poorly determined.

(2) Figure 3 gives an indication of the order of rms deviation required to achieve reasonably reliable spectral parameters. An rms deviation between the measured and master curve data on the order of 1 percent is indicated.

An important consideration in any time-domain spectral IP approach is the maximum resolvable time constant given a fixed transmitted pulse time. Resolution will be in part a function of the differences in master curves as quantified by the rms deviation. The differences measured between the $\tau = 30$ s and the $\tau = 100$ s master curves are 3.06 percent for $c = 0.5$ and 0.12 percent for $c = 0.1$.

A number of unknown factors will be introduced when the method is taken into the field. The performance of various IP transmitters under the normal variety of load conditions is not precisely known. Measured decays will display a reliability which is a complex function of the design of the receiver, field procedures, natural noise, etc. Most conventional IP targets are not well modeled as a homogeneous earth. The role of spectral IP parameters in minerals exploration is still in debate.

Given all of these factors, the method described herein has been designed with reasonable compromise such that basic spectral parameters can be determined using traditional field procedures. Through such a scheme, spectral data over a wide variety of targets may be collected to improve understanding of the method reliability and function and to modify strategy to best fit the exploration problem at hand.

FIELD WORK

The results shown below have been taken from a variety of field IP surveys. Most of these surveys have been undertaken without modification or special consideration for the determination of spectral parameters. The IPR-11 receiver was used exclusively. All of the data were gathered with a pulse time of 2 s. A variety of crystal-controlled transmitters were used. Analysis was, in all cases, effected by a specially prepared application software set which is resident on a microcomputer of common manufacture.

Decay curve analysis

Measured decays are shown in Figures 4 and 5.

The time-domain decay shown in Figure 4 is taken from a survey over a near-surface Canadian volcanogenic sulfide zone. Array geometry was pole-dipole with a spacing of 10 m and $n = 1$ to 6. The decay shown is from the $n = 6$ dipole. The measured primary voltages were 3 685 mV ($n = 1$) and 1.2 mV ($n = 6$). Apparent resistivity for the sixth dipole was 290 $\Omega \cdot$m. Eight transmit cycles were stacked or averaged to make the reading.

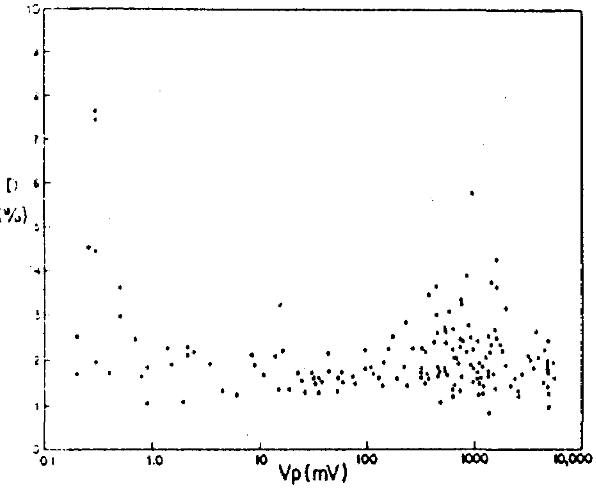

FIG. 7. Rms deviation as a function of primary voltage (V_p) for spectral fits from data shown in part in Figure 6.

subtraction of the IP effect. The first measuring point at 4.5 ms after shut-off shows an anomalously high value. This value causes the large rms deviation seen for the IC component.

It was remarked earlier that impedances could be summed without excessive error if time constants were sufficiently different. Figure 5 shows the effective decomposition of a decay curve into IP and IC components where respective time constants are less than one order of magnitude apart. The difference in c values is influential in giving recognizably different forms.

In the example cited, the IC component has died out before seriously affecting the 10 point IP measurement from which the spectral IP parameters are determined. In extreme cases, inductive effects may persist and the early sample points of the 10 point IP decay will be corrupted. Spectral parameters determined without removal of such inductive effects may be unreliable. In such cases, the early-time measurement is important to the proper definition of IC effects, separation of IP and IC decays, and determination of spectral parameters.

Pseudosection plots

The results of a portion of a time-domain induced polarization survey are shown in Figure 6. Shown are the apparent resistivity (divided by 100) in Ω·m, the 8th slice chargeability (690 to 1 050 ms) in mV/V, the time constant in seconds, and the exponent c. Array geometry was pole-dipole, with a = 10 m. The current trailed the potential electrode string, the whole advancing to the right. The standard 10 point decay of the 2 s receive mode was used throughout.

The area is one of very resistive Precambrian basic volcanics with little or no overburden. The line segment shown passes into a broad zone of near-surface metallic sulfides of which pyrite is the most common.

Two distinct zones are seen in the pseudosections. The left-hand portion or host rock is an area of high resistivities and low chargeabilities. The right-hand portion is an area of extremely low resistivities and high chargeabilities. The ground is indeed so conductive under the "anomaly" as to reduce primary voltages below that point at which a reliable IP measurement can be made.

Table 1. Spectral parameters, average values. Spectral parameter summary for different array geometries. The data set for the survey line is a portion of that shown in Figure 6.

Array	c Host	c Anomaly	c Total	τ Agreement (%)	D (%)
Pole-dipole	0.26	0.27	0.27	100	2.17
Dipole-dipole	0.27	0.29	0.28	88	2.59
Gradient	0.10	0.17	0.13	75	2.40

The time constant shows a strong correlation with the two zones. The time constant is uniformly low in areas of the host rock and uniformly high over the anomaly. The spatial stability of the calculated time constant is promising given the low inherent chargeabilities of the host and the sometimes low primary voltages over the anomaly.

The c values averaged 0.26 for the host and 0.27 for the anomaly. These exponent values compare well with the 0.25 value suggested by Pelton et al. (1978) as the most expected value.

The distribution of rms deviations as a function of primary voltages is shown in Figure 7. In this example, the spectral fits are equally good down to primary voltages of 1 mV below which the rms deviations have become large, and the spectral IP results are judged unreliable.

The same line segment was surveyed with both dipole-dipole and gradient arrays. Average values of the c value for the three arrays used, for host and anomalous regions, are shown in Table 1. The time-constant agreement column shows the percentage of calculated time constants which are within a factor of three of those calculated using the pole-dipole array. The gradient array time constants are compared with the nearest plotted vertical average of time constants as determined using the pole-dipole array.

The calculated time constants are reasonably stable and independent of array geometry. The gradient array gives consistently lower c values. This is a reasonable result given that the primary field in the gradient array will, in general, energize a wider variety of polarizable targets. The measured decay may be the result of the superposition of responses of possibly different time constants from more than one source.

Comparison with frequency-domain spectral results

In 1981, Selco Mining Corporation contracted Scintrex Ltd. and Phoenix Geophysics Ltd. to conduct spectral IP surveys on five selected lines over the Detour deposit. Cole-Cole parameters were determined independently by Scintrex working in the time domain and by Phoenix working in the frequency domain. Array setups were in each case dipole-dipole with a = 100 m, n = 1 to 6. Surveys were completed within one month of each other over the same grid.

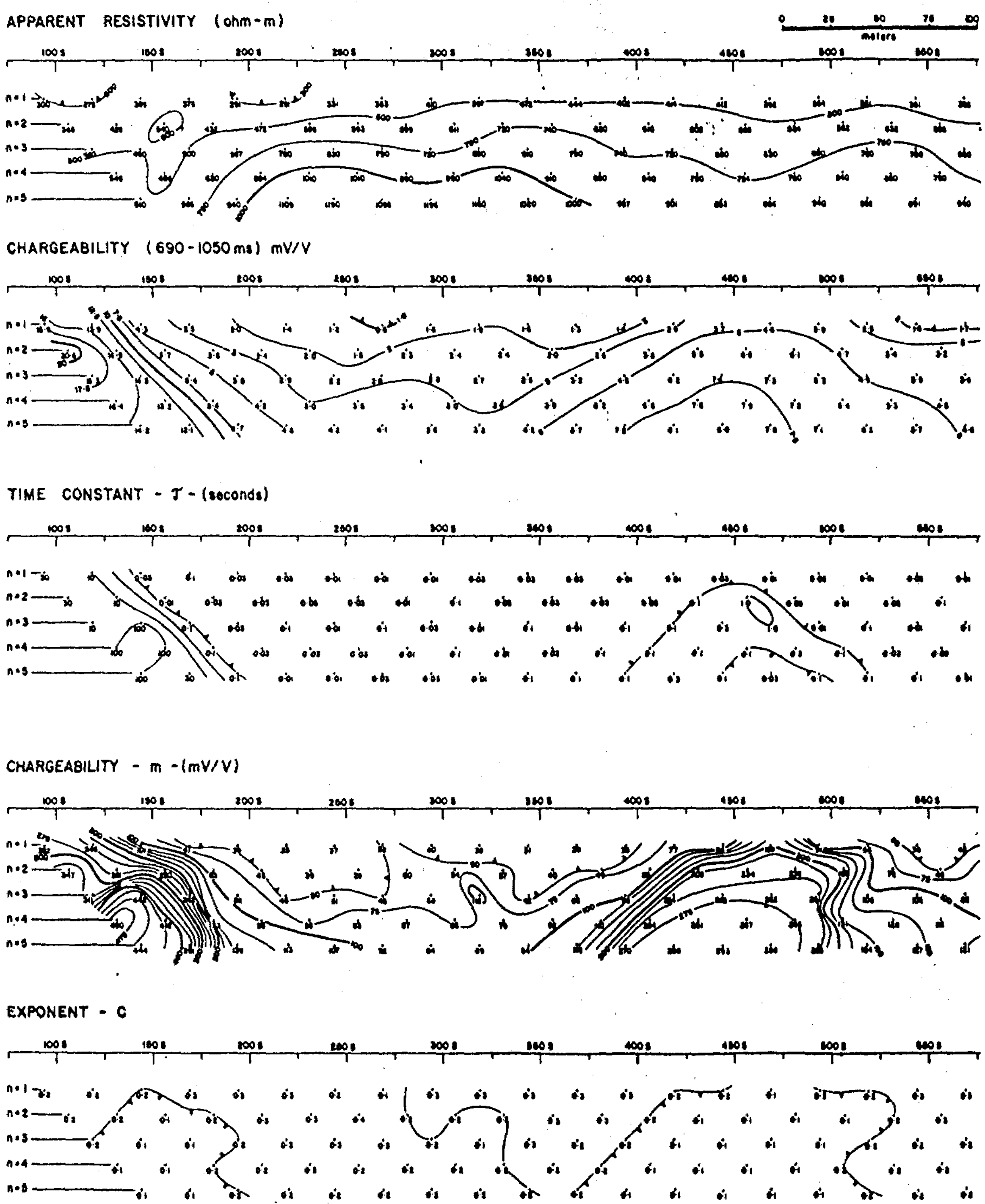

FIG. 9. Time-domain spectral IP results over a known gold producer. Deposit is centered some 50 m below station 450 S. An iron formation is located near the baseline.

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Expanded Abstract

SPECTRAL IP: EXPERIENCE OVER A NUMBER OF CANADIAN GOLD DEPOSITS

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SUMMARY

Time domain induced polarization survey results over a variety of Canadian volcanogenic gold deposits are presented. The results are accompanied by the interpreted spectral parameters and the usefulness of such parameters is discussed. A variety of geological interpretation problems are shown to be simplified by spectral IP survey results. The time constant may be used to map areas of fine grained disseminated metallic sulphides which experience has shown to be favourable targets for gold. The true chargeability may be used as a more accurate representation of the volume percent metallic sulphides. Spectral IP parameters may be used to prioritize areas which may appear uninteresting in conventional IP surveys.

SPECTRAL IP: EXPERIENCE OVER A NUMBER OF CANADIAN GOLD DEPOSITS

Discussions about spectral IP have appeared regularly in the literature for more than ten years. Despite a high academic profile, the method has failed to make a significant impact on routine IP surveys. The result to date has been a well developed theory with too few examples of application to exploration problems. Geophysicists remain unsure about cost benefits and cautious about recommending spectral analysis in their IP surveys.

This paper is intended to present data from a variety of surveys over a number of gold prospects. All are taken from essentially routine time domain surveys in which the spectral requirement was not considered important in advance and did not result in significant additional survey costs. It is intended that these examples will better illustrate the strengths and limitations of the method. The cost benefits are examined.

When conducting spectral IP surveys in the time domain, field procedures are effectively unaltered from conventional methods. That extra time required to produce the better quality data at each station is compensated for by the efficiencies of the new microprocessor controlled receivers. The spectral analysis which is done in the field on a microcomputer is of value in the first instance as a quality control device. Measured decays are compared to a suite of master curves. The comparison yields an rms deviation which is used by the operator to check data quality. Independent of the use of spectral parameters, spectral analysis is an essential tool in high quality production IP surveys. The spectral parameters so derived are, in essence, "free".

Spectral IP should therefore be viewed more as the next step in the natural evolution towards better IP/resistivity surveys and not as some exotic or hybrid technique suitable for special applications only. The latter is a more common attitude when using frequency domain techniques where production rates suffer from the requirement of sequential measurements at a number of frequencies.

Figure 1 shows the contoured chargeability data over the Jellicoe deposit in the Beardmore-Geraldton area of Ontario. The gold is found in a sheared silicified and brecciated zone of quartz stringers hosted by arkose. Disseminated metallic sulphides (mainly pyrite), with concentrations greater than 10 percent locally, are found in association with the gold. The deposit is centered some 60 m below surface and under some 10 to 20 m of moderately conducting transported overburden. Hole to hole correlation of the mineralization is often complicated by faulting and folding. An oxide iron formation lies 200 m north of the deposit.

The IP survey was done with a pole-dipole array employing an a spacing of 25 m and n values of 1 to 5. The Scintrex IPR-11 receiver was used with a two second pulse time.

The topmost contour map shows the seventh slice chargeability (690 to 1050 ms after shutoff) from the n=2 dipole. This type of presentation is common for conventional IP surveys. The deposit is roughly outlined by the 4 mV/V contour line in the center of the survey area. The largest IP response is moderate (less than 8 mV/V) above relatively low (less than 2 mV/V) background values. The pseudosections show this to be true for dipoles 2 to 5. There is no coincident resistivity response. The iron formation to the north is seen as a more prominent chargeability high. A pipeline running NE-SW gives an equally large response in the northwest corner of the area.

The lower contour map shows the Cole-Cole chargeability as derived from the spectral analysis of measured decays. The IP anomaly over the deposit is enhanced relative to background levels. The response is now more suited to that expected from some 15% sulphides by volume at these depths. The conventional IP response is quite modest and might be overlooked in a more complex electrical environment. The Cole-Cole chargeability is thus more sensitive to small variations in volume percent sulphides. The spectral IP presentation appears to define the complex structure of the deposit more so than conventional IP.

Figure 2 is taken from an IP survey in an area of Manitoba with a geological model similar to that described above - that is, gold in a relatively resistive environment in association with disseminated metallic sulphides adjacent to an iron formation. This type of model is thought to give an IP response characterized by:

- high apparent resistivities due to silicification
- higher chargeabilities due to the metallic sulphides
- short Cole-Cole time constants resulting from the fine-grained nature of the sulphides

Experience has shown this to be a promising IP signature for some types of volcanogenic gold deposits.

The IP survey was conducted using a pole-dipole array with an a spacing of 100 feet and n values of 1 to 6. The IPR-11 receiver was used with a two second pulse time.

The pseudosection in Figure 2 shows a broad chargeability high in an area of moderate to high apparent resistivities. The chargeability anomaly is quite wide and a drill location would be difficult to assign if no other information were available. The Cole-Cole time constants as determined from spectral analysis of the measured decays does show a segmentation of the IP anomaly into areas of different time constants. The areas of low time constant values are the preferred areas for follow-up.

Limited trenching has revealed a two foot thick zone of massive arsenopyrite and pyrite with pods of sphalerite and galena at station 29+50S. Prospecting away from the showing indicates disseminated sulphides. HLEM surveys over the same ground gave no response. Drilling is currently in progress.

The spectral IP results illustrate the possibility of mapping based solely on the IP characteristics (as opposed to volume percent) of metallic sulphides. Conventional IP data are handicapped by the inability to map these characteristics and by the mixing of different types of geological information, i.e. grain size and percent sulphides.

These and other examples which illustrate the use of time domain spectral IP data are presented. The spectral parameters so determined are shown to be important in assessing data quality and useful in interpreting IP survey results. With modern receivers and analysis techniques, the method is very cost-effective given the small additional cost associated with spectral IP in the time domain.

ACKNOWLEDGEMENTS

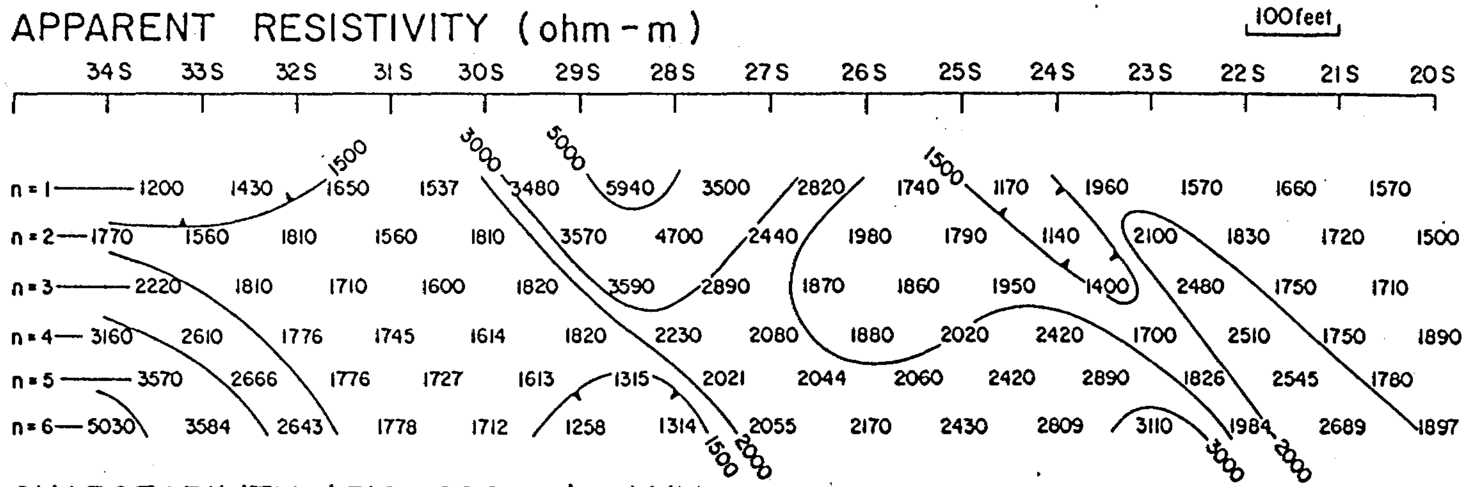
The cooperation of Dome Mines and Manitoba Mineral Resources Limited is gratefully acknowledged.

FIGURE CAPTIONS

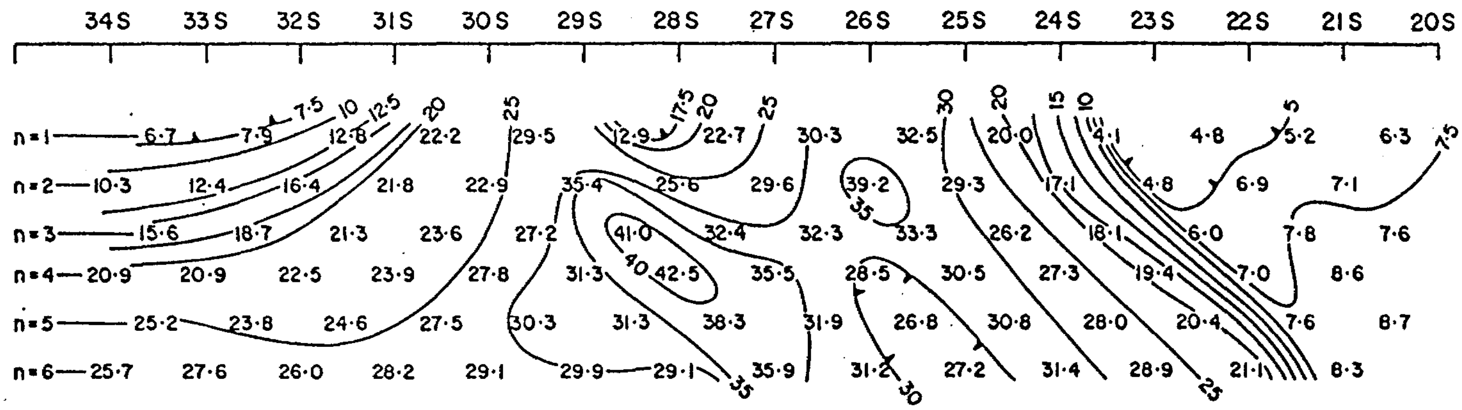
Figure 1: Contoured chargeabilities in mV/V. Pole-dipole array with a=25 m, n=1 to 5. Seventh slice IPR-11 (690 to 1050 ms after shutoff) data for the n=2 dipole shown in upper half. Cole-Cole chargeabilities in mV/V for the same area and dipole number shown below.

Figure 2: Pseudosections showing apparent resistivity, sixth slice IPR-11 (510 to 690 ms after shutoff) and Cole-Cole time constant. Pole-dipole array with a=100 feet and n values from 1 to 6.

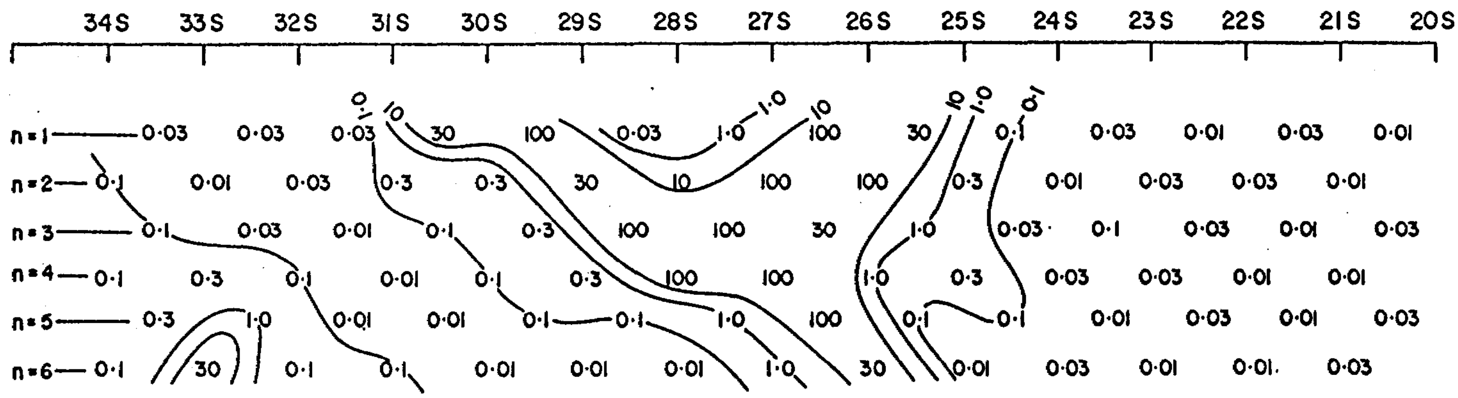
APPARENT RESISTIVITY (ohm-m)



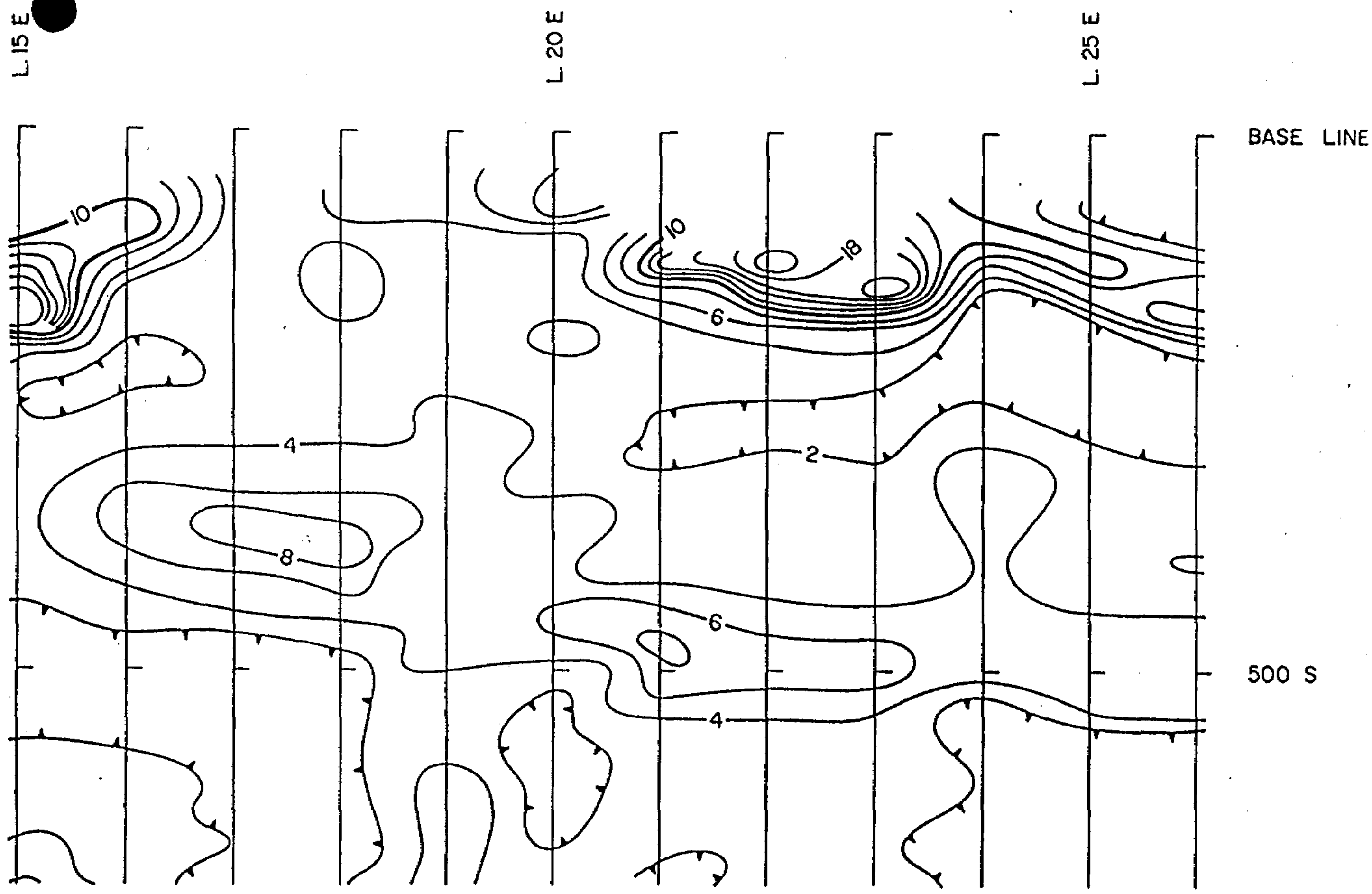
CHARGEABILITY (510-690 ms) mV/V



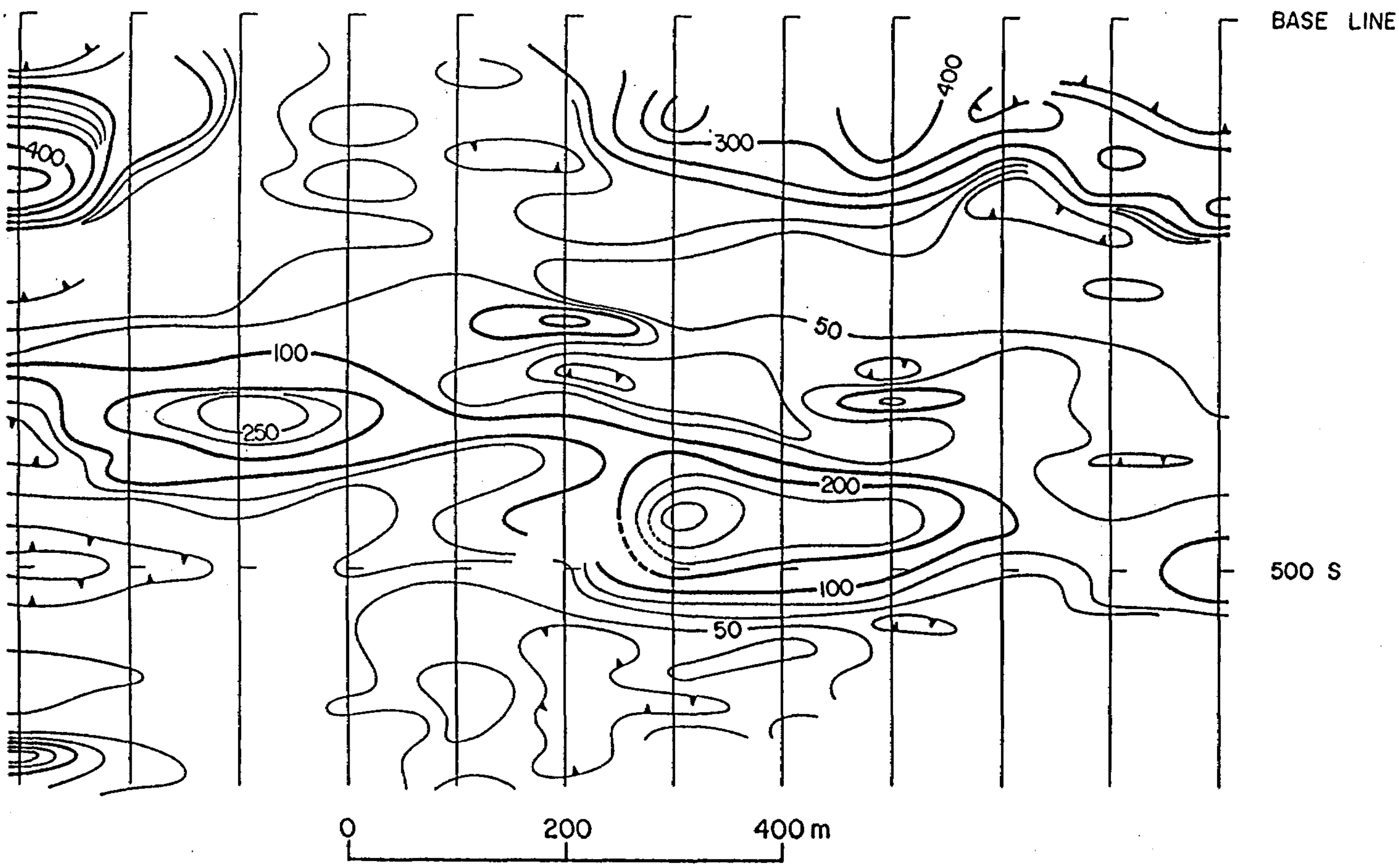
TIME CONSTANT - τ - (seconds)

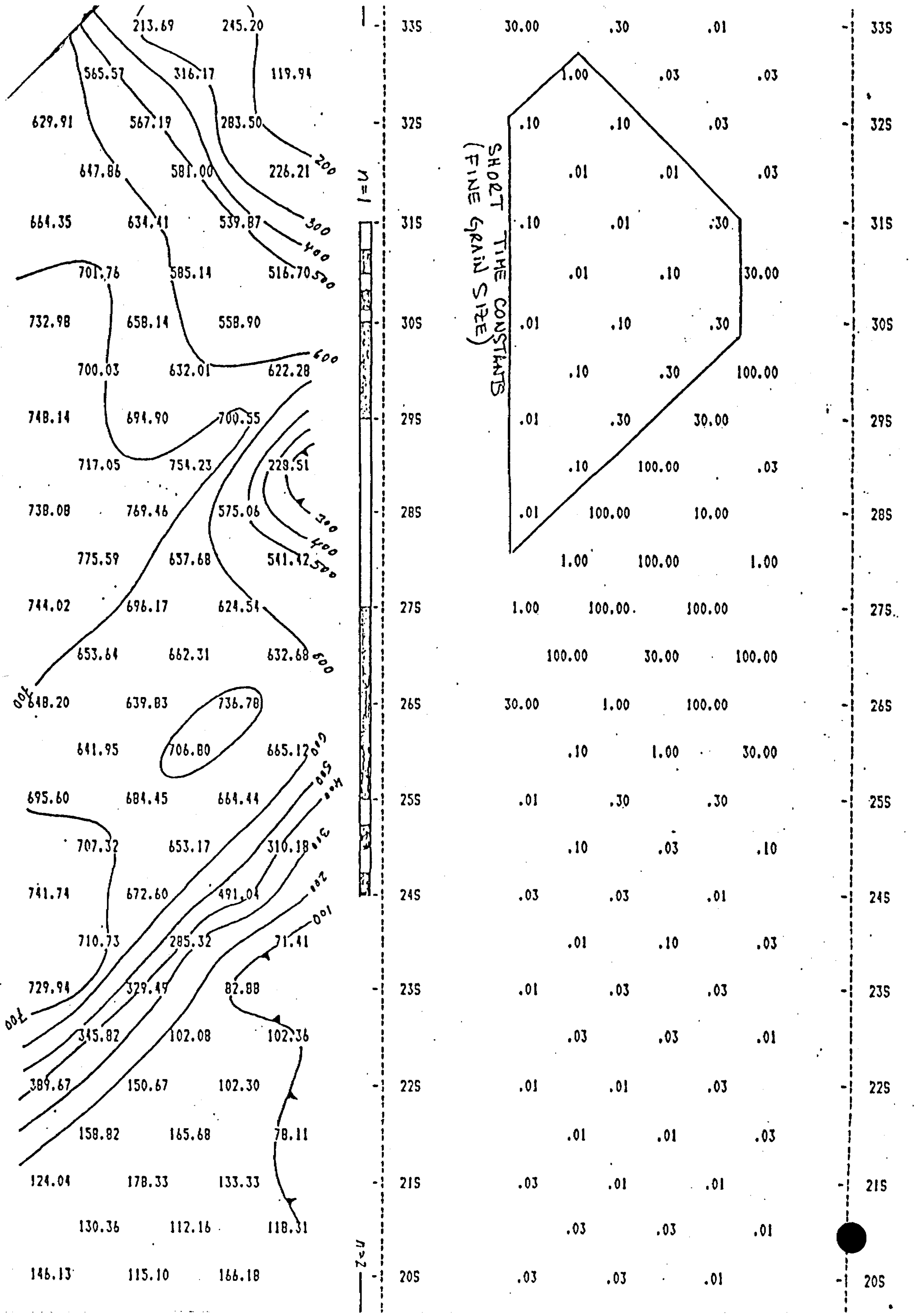


CONVENTIONAL CHARGEABILITY



SPECTRAL CHARGEABILITY





213.69
245.20
33S
30.00
.30
.01
33S
565.57
316.17
119.94
1.00
.03
.03
629.91
567.19
283.50
32S
.10
.10
.03
32S
647.86
581.00
226.21
200
.01
.01
.03
SHORT TIME CONSTANTS (FINE GRAIN SIZE)
n=1
664.35
634.41
539.87
300
31S
.10
.01
.30
31S
400
701.76
585.14
516.70
500
.01
.10
30.00
732.98
658.14
558.90
30S
.01
.10
.30
30S
700.03
632.01
622.28
600
.10
.30
100.00
748.14
694.90
700.55
29S
.01
.30
30.00
29S
717.05
754.23
228.51
.10
100.00
.03
738.08
769.46
575.06
300
28S
.01
100.00
10.00
28S
400
775.59
637.68
541.12
500
1.00
100.00
1.00
744.02
696.17
624.54
27S
1.00
100.00
100.00
27S
653.64
662.31
632.68
600
100.00
30.00
100.00
700
648.20
639.83
736.78
26S
30.00
1.00
100.00
26S
641.95
706.80
665.12
600
.10
1.00
30.00
695.60
684.45
664.44
500
400
25S
.01
.30
.30
25S
707.32
653.17
310.18
300
.10
.03
.10
741.74
672.60
491.04
200
24S
.03
.03
.01
24S
710.73
285.32
71.41
100
.01
.10
.03
729.94
329.49
82.88
23S
.01
.03
.03
23S
700
345.82
102.08
102.36
.03
.03
.01
389.67
150.67
102.30
22S
.01
.01
.03
22S
158.82
165.68
78.11
.01
.01
.03
124.04
178.33
133.33
21S
.03
.01
.01
21S
130.36
112.16
118.31
.03
.03
.01
n=2
146.13
115.10
166.18
20S
.03
.03
.01
20S

TIME DOMAIN SPECTRAL INDUCED POLARIZATION
SOME RECENT EXAMPLES FOR GOLD

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TIME DOMAIN SPECTRAL INDUCED POLARIZATION
SOME RECENT EXAMPLES FOR GOLD

Spectral induced polarization was developed for the frequency domain in the 1970s. An early development was the establishment of the Cole-Cole model as that which best fit field results. The advantage to spectral IP was the ability to extract more usefull physical properties from survey data by way of the Cole-Cole model parameters. Among those are the time constant which is related to grain size and the chargeability amplitude which is related to the volume percent metallic sulphides. Application was not routine however because of the need to make sequential measurements of phase at a number of frequencies. This was and is too time consuming for most surveys.

The time domain equivalent was established in the early 1980s. In this case, the spectral parameters are extracted from the measured decays. This was an improvement on the frequency domain based method as all of the information needed for spectral IP is in a single measurement: survey production rates are unaffected.

The result has been the routine use by some of time domain spectral IP and the collection of a wide range of field experience. Methods of intepretation based on this experience have been developed. The spectral information has been found to be of particular use in gold exploration where the interest is often in fine grained disseminated sulphides. Coarse grained or massive sulphides may not be of interest. The spectral parameters may be the only indicators as to which is which.

The adoption of spectral analysis techniques for properly sampled time domain decays is a natural evolution of the IP method. IP receivers and transmitters, survey methods and analysis schemes are expected to evolve with time in response to the greater accuracy demands of spectral IP.

Spectral IP results from five areas in Ontario and Quebec are presented. All of the data has been collected in exploration projects for gold. The Scintrex IPR-11 receiver and IPC-7 or TSQ-3 transmitter has been used throughout. The data have been collected by JVX survey crews using the pole-dipole array and a 2 second pulse time.

1. CHIBOUGAMAU AREA, QUEBEC

Figure 1 shows the results from part of a survey conducted in the Chibougamau area of Quebec. The data was collected with an a spacing of 25 meters and six potential dipoles. The survey area is covered with up to 10 meters of sand and clay overburden.

The contoured pseudosections show the apparent resistivity divided by 100. The chargeability is that of the eighth slice (IPR-11 designation - M7) which is taken over the period from 690 to 1050 milliseconds after shut-off. The unit of measurement is millivolts per volt (mV/V). The spectral parameters tau (time constant) and M are derived by comparing the measured decay curve with a library of known curves. The best fit between the measured curve and the chosen master curve is often better than 2 % rms deviation. The time constant is shown in seconds. The Cole-Cole amplitude factor M is shown in mV/V.

The IP survey mapped two anomalous zones. The northern zone, Zone A, at station 825N is characterised by M7 chargeability values of 30 to 33 mV/V. There is a slight decrease in the coincident apparent resistivity. The southern zone, Zone B-1, at station 500N to 575N exhibits slightly higher M7 chargeabilities at from 33 to 39 mV/V and a resistivity response lower than background.

The most notable feature of these results is the clear difference in the derived time constant associated with the two zones. The spectral computation returned a high tau (time constant) for Zone A and a low tau for Zone B-1. The time constant is considered to be a semi-quantitative measure of grain size of the polarizable source. A high tau indicates a coarse grained source and a low tau indicates a fine grained source.

Diamond drilling has confirmed this interpretation. Drill testing of Zone B-1 encountered a wide zone of fine grained disseminated sulphides with a ten foot section running 0.5 oz Au/ton. Zone A was tested 200 meters along strike from the profile and barren course grained sulphides were intersected.

It should be noted that without the spectral information, the zone A anomaly might have been selected as the more promising drill target. This would have been based on the higher apparent resistivities as a possible indicator of silicification.

This case history demonstrates the capability of the time domain spectal IP method to discriminate between anomalies that exhibit similar values of chargeability amd resistivity. In this project, the spectral parameters proved to be a valuable diagnostic in separating IP anomalies with associated gold from those without.

2. RATIOS vs. SPECTRAL IP

The ratio of selected slices has been suggested as an alternative to the time constant derived from spectral analysis. The idea is that polarizable sources which are fine grained will show a faster decay than that from course grained or massive sources. The ratio of chargeabilities from early and late times would therefore be greatest for fine grained and least for course grained sources.

This is correct in a rough sense only. The routine use of ratios as a substitute for the Cole-Cole model time constant is an error. Some reasons are:

1. All of the work which has been done on spectral IP (time of frequency domain) supports the Cole-Cole model. This is a three parameter model for chargeability with one parameter for amplitude and two parameters to describe decay curve shape. These two parameters are the time constant (tau) and the exponent (c). They are linked in a complicated way and there is no simple method in the time domain to separate their effects.

   Characterizing the decay with a ratio assumes a two parameter model; amplitude and decay ratio. The ratio (or decay rate) is a mixture of time constant and exponent. Variations in the ratio can be due to variations in either time constant (ie. grain size) or exponent (ie uniformity of grain size).

   The assumption that the decay can be characterised by a ratio is equivalent to setting the exponent to a value of 1.0 (ie. modelling the decay as a negative exponential). All of the spectral IP work done to date suggests this is not the case. Exponent values between 0.1 and 0.5 are expected.

2. Spectral analysis uses a least squares fit over the whole measured decay. Ratios use two slices one of which is normally taken in the early part of the decay. Such slices arise from a short window width for which noise is greatest. Using one of the first four slices from the IPR-11 for example means the ratio is limited by data collected over 30 milliseconds. The spectral parameters are determined from data taken over almost 2 seconds.

3. For low exponent values (eg. c=0.1), the differences in ratios is least pronounced. This is the expected value of c however (the Newmont standard decay fits best to a c value of 0.1). The following table lists the theoretical ratios of the IPR-11 M3 (fourth slice centered at 135ms after shut off) to M7 (eighth slice centered at 870ms after shut off). A Cole-Cole exponent of 0.1 and time constants of 0.01 to 100 seconds are used.

Cole-Cole Time Constant (Sec)	M3/M7
0.01	2.61
0.03	2.59
0.10	2.58
0.30	2.57
1.00	2.56
3.00	2.54
10.00	2.53
30.00	2.51
100.00	2.50

The difference in the ratio between time constants for 0.01 and 100 seconds is only 4.2%. Assuming that M3=10.0mV/V and M7=3.9mV/V and that M7 is error free, the full range of ratios is found within the range for M3 of 10.0 +/- 0.4mV/V.

Spectral analysis using the whole decay is not so dependent upon the quality of chargeability values for a single slice.

A field example of ratios vs. Spectral IP is shown in figure 2. The data is taken from figure 1. Reading from top to bottom, pseudosections show the Cole-Cole time constant, the exponent and the M3/M7 ratio. It is clear from this example that variations in the ratio may be explained by either a change in time constant (ie grain size) or a charge in exponent (uniformity of grain size). The ratio alone cannot be relied upon to discriminate between coarse and fine grained metallic sulphides.

3. POWER LINE RESPONSE

Figure 3 shows the measured apparent resistivity, eighth slice chargeability and time constant. These results are from a survey in Joutel area. A pole-dipole array with an "a" spacing of 25m was used.

A power line is located at station 975N. The pseudosection of chargeability shows a distinct anomaly which could pass for that due to bedrock sources.

The time constant is uniformly long under the power line. This pattern was repeated at all points where the survey passed under the power line. This result might be expected given the nature of the cause of the response. This same signature can be seen for fences.

The spectral parameters have been determined in an area of only modest chargeabilities. Away from the power line, background chargeabilities are low. The rms deviation between the measured and theoretical decays is greater than 5% due mostly to the resolution limit of the IPR-11 (0.1 mV/V). Five percent is the limit beyond which spectral parameters are not plotted.

The long time constant characteristic of cultural sources could be exploited when exploring for fine grained sulphides in their vicinity. Identification might be made on the basis of time constant alone.

4. SUFFIELD, QUEBEC

Figure 4 shows the IP/resistivity results for one line in the area of the Suffield mine, Sherbrooke, Quebec. A pole-dipole array with an "a" spacing of 100 feet was used.

The resistivity low and associated chargeability high west of the base line suggest massive conductor. This is supported by the long time constant. This interpretation is correct. This is the area where a graphitic phyllite outcrops. This unit is known to be conductive and may be mapped using EM techniques.

There is a subtle IP response in the area of station 300E. There is no parallel variation in apparent resistivities and an interpretation without access to the spectal information might have passed over this part of the pseudosection.

The spectral parameters however suggest that this may be an area of fine grained disseminated sulphides. The Cole-Cole amplitude M is as large at 300E as over the graphities. This suggests an equal amount of polarizable material. This information is not available from single slice (or phase or PFE) presentation. The M7 results at 300E are as uninteresting as they appear because the time constant is so short. The decay is faster than would be seen with a long time constant source. The amplitude is depressed at M7.

The area around station 300E was identified as one for further investigation. Drilling immediately to the north of station 300E revealed fine grained disseminated sulphides. The locally high resistivities were explained by silicification.

5. JELLICOE DEPOSIT, ONTARIO

In 1983, the Ontario Geological Survey sponsored a series of geophysical surveys over known gold deposits in the Beardmore-Geraldton greenstone belt. Part of this work involved IP surveys on five lines over the Jellicoe deposit. Earlier gold production came from a sheared silicified and brecciated zone of quartz stringers and veinlets hosted by arkose. Mineralization consists of gold and disseminated sulfides (pyrite, arsenopyrite, and sphalerite) up to 10 percent locally. The deposit is centered some 50m subsurface. Overburden is moderately conductive and of 10 to 20 m thickness. The host rocks are Precambrian metasediments including arkose and greywacke. The deposit is some 200 m south of an extensive and prominent iron oxide formation.

The IP survey was carried out using a pole-dipole array with an a spacing of 25m and n=1 to 5. The results over one survey line are shown in pseudosection form in Figure 5. The apparent resistivity, eighth-slice chargeability, Cole-Cole time-constant, chargeability amplitude, and exponent values are shown in contoured pseudosection form.

The deposit is centered at station 450S and is seen as a broad chargeability high. The apparent resistivity section shows no marked coincident low. At the extreme north end of the line a resistivity low and strong chargeability high are indicated. This is most probably an area of barren sulfides, probably pyrite, associated with the iron formation.

The spectral IP results are interesting from a number of points of view. The time constant of the deposit is higher than the host and yet noticeably lower than that indicated by the barren sulfides near the baseline. The chargeability amplitude has amplified the anomaly over the deposit. As in the earlier examples, the amplitude M is a more reliable indicator of the volume percent metallic sulphides. The single slice (or phase or PFE) is less reliable. Variations therein can be caused by changes in grain size alone.

6. AVERAGE CHARGEABILITY

Figure 6 shows the results from a survey in the Casa Berardi area in which the M7 presentation showed little obvious variation and therfore no clear indication of areas of greater interest.

The lowest pseudosection shows the average of all ten slices. Where the eighth slice (M7) is of 380ms width, all ten lices occupy a window width of 1760ms. This is more than a fourfold increase in time averaging. A two times increase in signal to noise results. Subtle variations in chargeability are amplified and areas of possible interest are more easily identified.

In some ways, the average chargeability shown here is the chargeability parameter with the greatest signal to noise ratio possible. The survey operator is concerned with noise in the decay. Power or measuring time requirements are hence more severe than would be seen if looking at the average alone. The high quality of the average chargeability data is a result of the care needed to make IP measurements accurate enough to be used for spectral analysis.

CONCLUSIONS

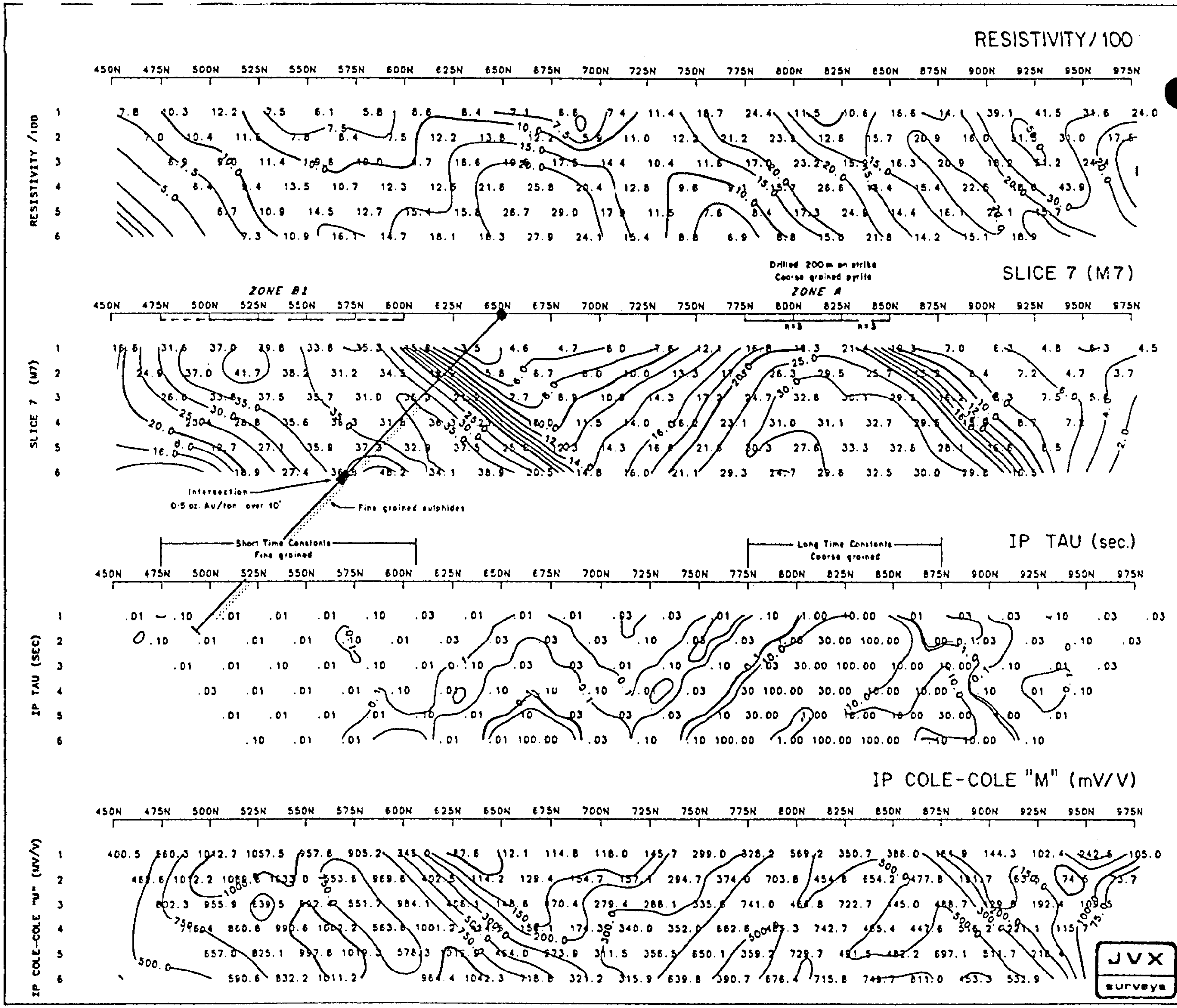
The spectral paramters have been shown to be usefull compliment to the traditional chargeability data. This is particularly true where it is important to separate fine grain disseminated sulphides from their coarse grained equivalents. This is important in gold explortion as it is common to find gold associated with fine grained sulphides.

The calculated spectral parameter M is a more reliable indicator of the presence of metallic sulphides. The time constant reflects grain size. Fine grained disseminated sulphides may yield little or no IP response when viewed through the non-spectral measurement of single slice (or PFE or phase). Spectral analysis corrects this problem and the risk of missing interesting targets is less.

The spectral parameters may be used to separate cultural responses from those due to bedrock sources. The ratio of slices from time domain surveys is not equivalent to spectral analysis and the use of ratios will lead to errors where the ratio is related to the time constant or grain size. In addition, the ratio ignores the true chargeability amplitude which is used to indicate the concentration of disseminated sulphides.

The type of source discrimination seen with time domain spectral IP is not possible when measuring a single IP quantity such as a particular slice, PFE or phase at one frequency. These methods are restricted to a measurement of a quantity which is a mixture of source characteristics such as volume percent metallic sulphides and grain size. There is no way to extract each separately and the interpretation of such data is done and recommendations made while lacking important information.

The time domain spectral IP method does not suffer this limitation. The argument for spectral IP is particularly strong given that there is little effect on production rates when using the instrumentation, analysis software and field methods used for the results shown herein.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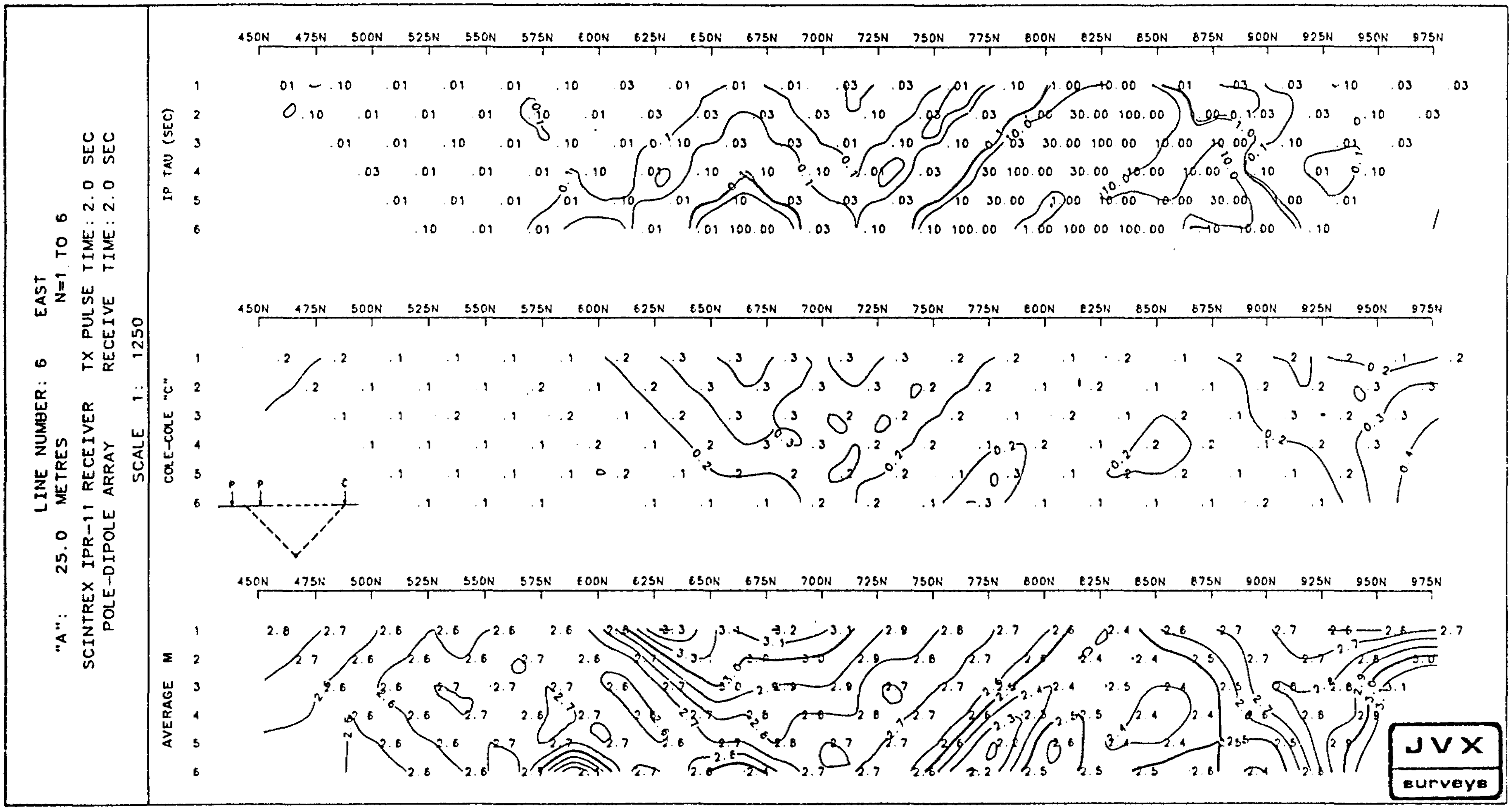
450N 475N 500N 525N 550N 575N 600N 625N 650N 675N 700N 725N 750N 775N 800N 825N 850N 875N 900N 925N 950N 975N
RESISTIVITY /100
SLICE 7 (M7)
Drilled 200m on strike
Coarse grained pyrite
ZONE B1
ZONE A
SLICE 7 (M7)
Intersection
0.5 oz. Au/ton over 10'
Fine grained sulphides
IP TAU (sec.)
Short Time Constants
Fine grained
Long Time Constants
Coarse grained
IP TAU (SEC)
IP COLE-COLE "M" (mV/V)
IP COLE-COLE "M" (MV/V)
JVX
surveys
Figure 1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"A": 25.0 METRES N=1 TO 6
SCINTREX IPR-11 RECEIVER TX PULSE TIME: 2.0 SEC
POLE-DIPOLE ARRAY RECEIVE TIME: 2.0 SEC
SCALE 1: 1250
IP TAU (SEC)
COLE-COLE "C"
AVERAGE M
450N 475N 500N 525N 550N 575N 600N 625N 650N 675N 700N 725N 750N 775N 800N 825N 850N 875N 900N 925N 950N 975N
JVX
surveys

Figure 2

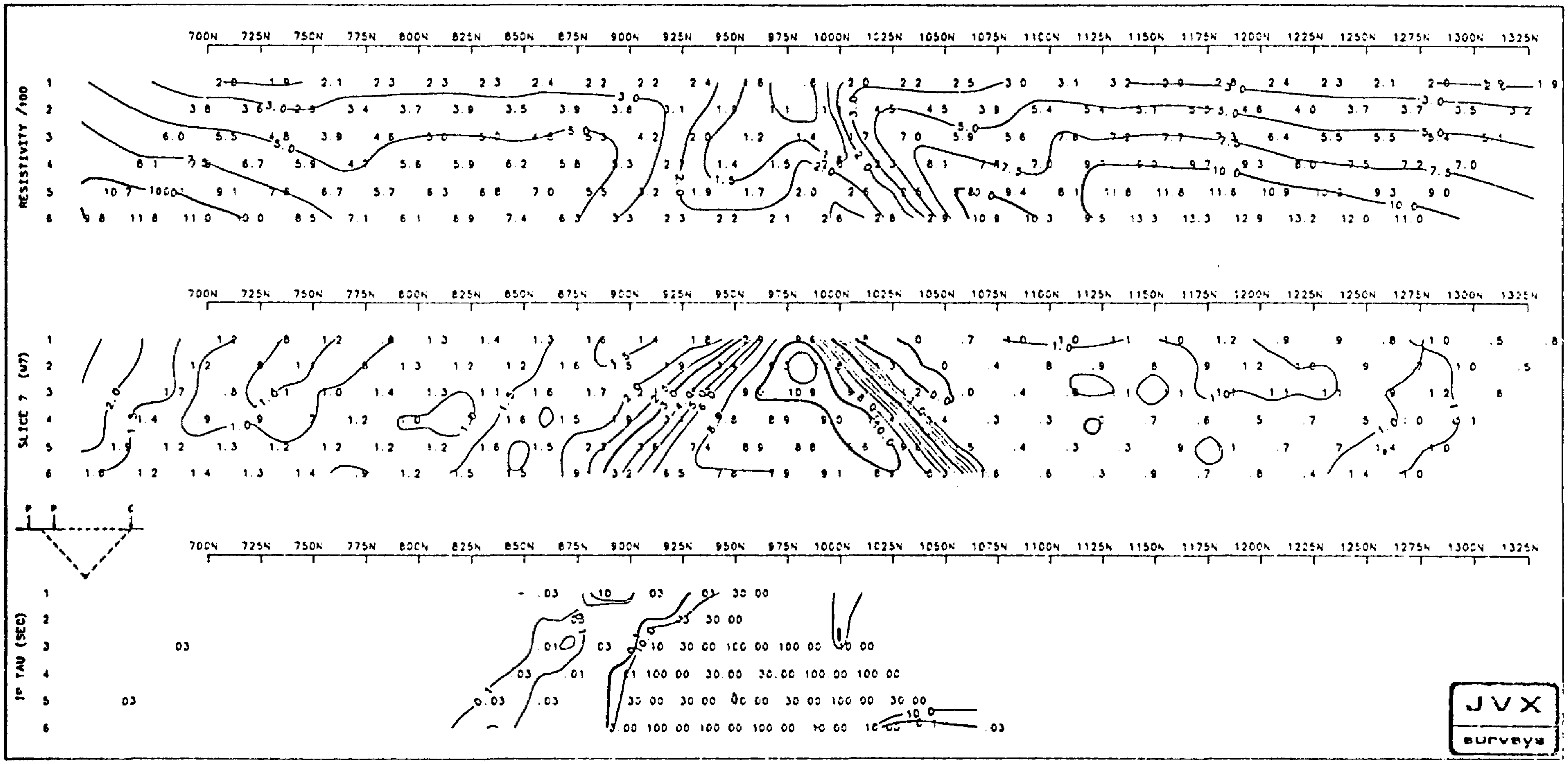


Figure 3

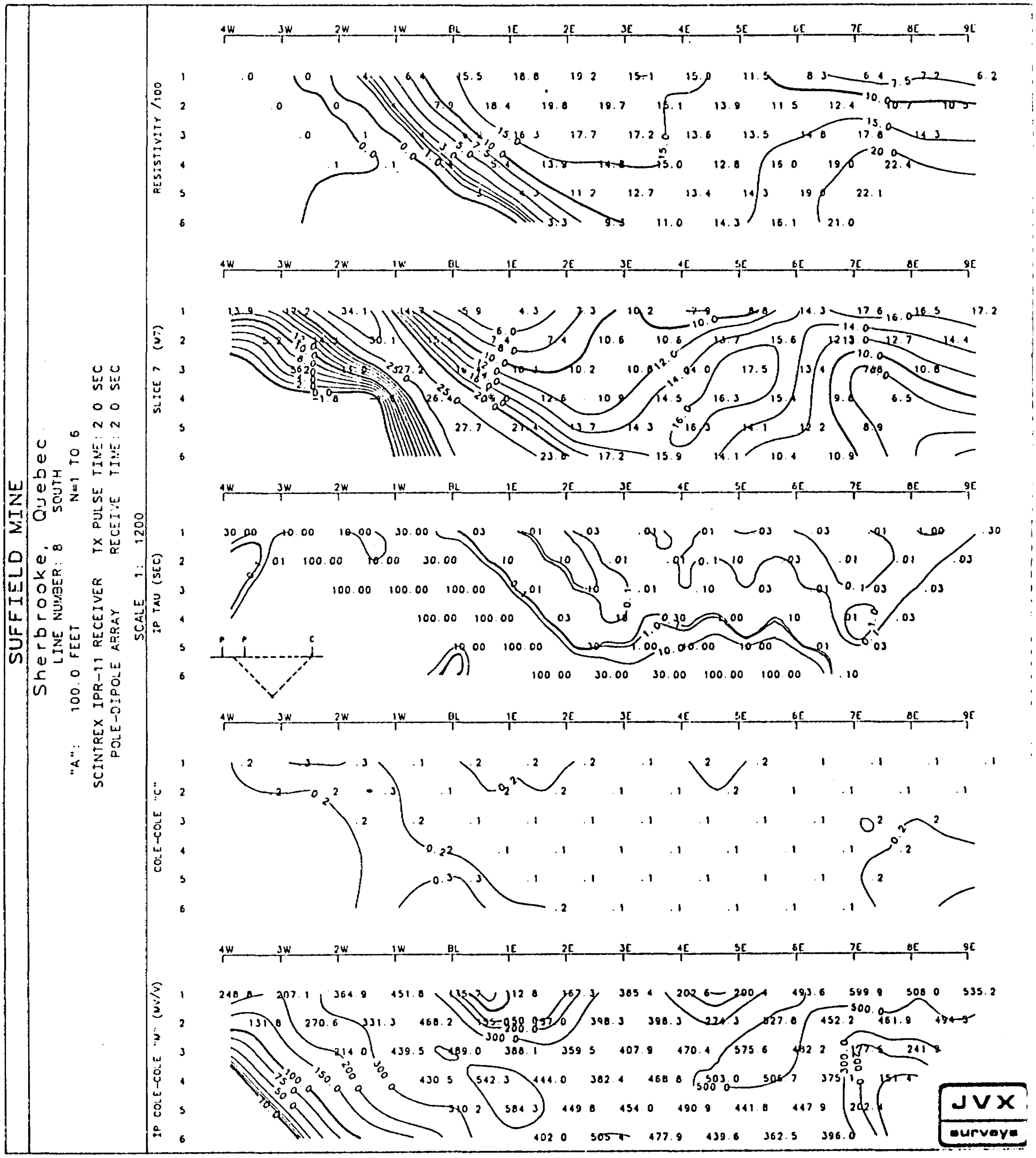

SUFFIELD MINE
Sherbrooke, Quebec
LINE NUMBER: 8 SOUTH
"A": 100.0 FEET N=1 TO 6
SCINTREX IPR-11 RECEIVER TX PULSE TIME: 2.0 SEC
POLE-DIPOLE ARRAY RECEIVE TIME: 2.0 SEC
SCALE 1: 1200
RESISTIVITY /100
SLICE 7 (M7)
IP TAU (SEC)
COLE-COLE "C"
IP COLE-COLE "M" (MV/V)
4W 3W 2W 1W BL 1E 2E 3E 4E 5E 6E 7E 8E 9E
JVX
surveys

Figure 4

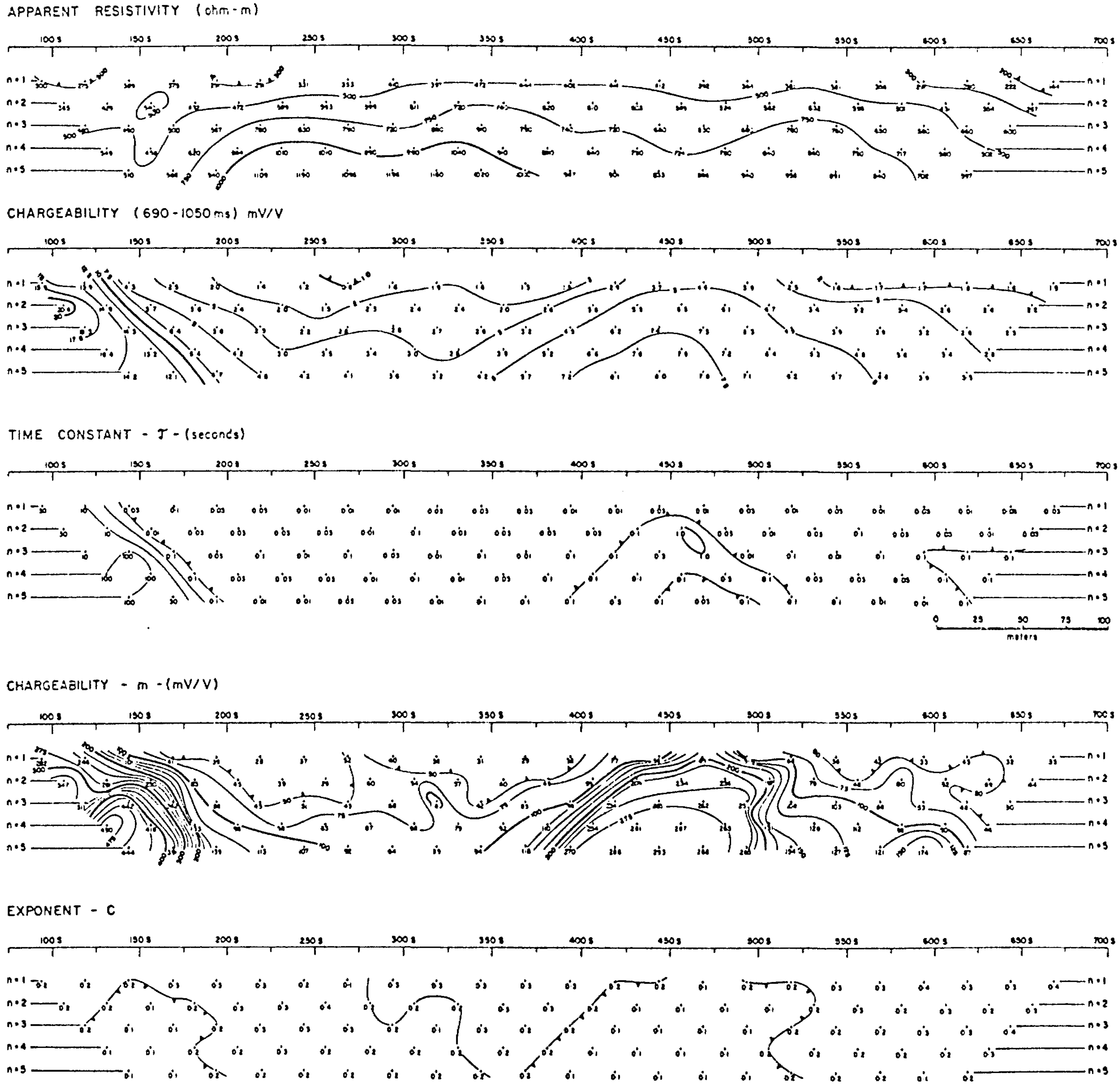
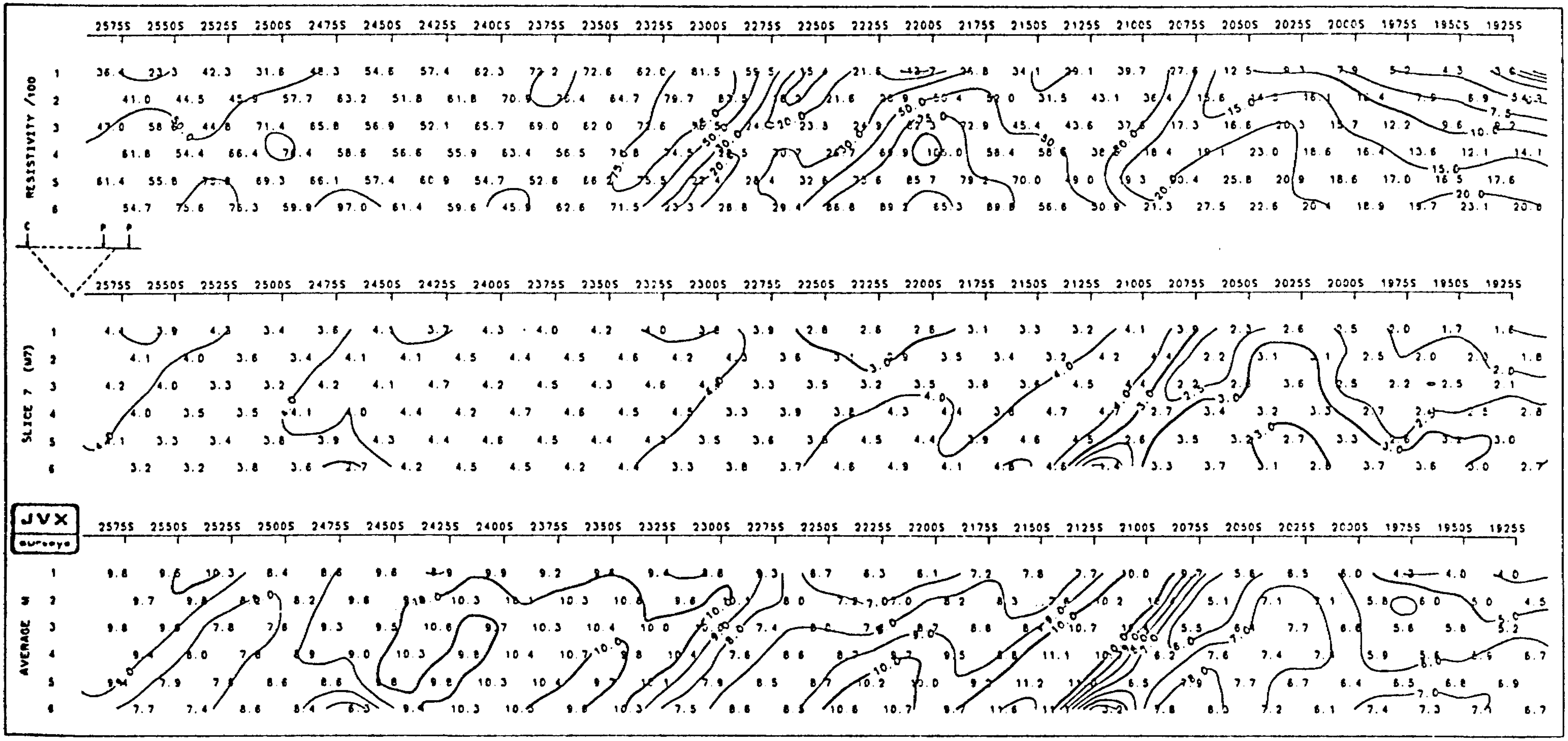

APPARENT RESISTIVITY (ohm-m)
CHARGEABILITY (690-1050ms) mV/V
TIME CONSTANT - T - (seconds)
CHARGEABILITY - m - (mV/V)
EXPONENT - C
100 S
150 S
200 S
250 S
300 S
350 S
400 S
450 S
500 S
550 S
600 S
650 S
700 S
n=1
n=2
n=3
n=4
n=5
0
25
50
75
100
meters

Figure 5



RESISTIVITY /100
SLICE 7 (N7)
AVERAGE
JVX surveys
2575S 2550S 2525S 2500S 2475S 2450S 2425S 2400S 2375S 2350S 2325S 2300S 2275S 2250S 2225S 2200S 2175S 2150S 2125S 2100S 2075S 2050S 2025S 2000S 1975S 1950S 1925S

Figure 6

Appendix 4

Miscellaneous Field Notes

Field Notes, Fred Moher:

Line	Station(s)	Topography/Comments
825W		Infinity is at L600W/stn.700S.
825W	50N	Current electrode is 6 m south of 50N.
825W	200N	Spruce swamp.
825W	350N	DDH TL-5-50.
1000W		Infinity is at L600W/stn.700S.
1000W	25S to 250N	swamp.
1000W	200N	DDH TL-1, no casing.
1000W	240N	DDH TL-4.
1000W	350N	Drill Road.
1000W	400N to 425N	Alders, creek ?
1200W		Infinity is at L600W/stn.700S.
1200W	25S to 100N	Side of hill (sand?).
1200W	125N to 300N	Swamp.
3200W		Infinity is at L600W/stn.700S.
3200W	400S	Stn. is 30 m east of line.
3200W	375S	Stn. is 24 m east of line.
3200W	350S	Stn. is 18 m east of line.
3200W	300S	Stn. is 12 m east of line.
3200W	275S	Stn. is on line.
3200W	35S	Driveway west side of road, no culvert.
3200W	100N	Rock cut west side of road & top of hill.
3225W	25S	End of Hydro line but Bell line continues.
3100W	240S to 150S	Willow swail.
3100W	245N	Edge of cleared field.
3100W	350N	Wire fence.
3100W	375N, 400N	no reading - culture (metal beds, cars).
3000W		Infinity is at L600W/stn.700S.
3000W	175S to 140S	Willow swail.
3000W	125S	Rock O/C.
3000W	south of BL	Chainage error. If any anomaly in this area and drilling planned then line <u>must</u> be re-chained.
3000W	330N	End of line, skidoo trail.
2900W		Infinity is at L600W/stn.700S.
2900W	275S	Rock O/C.
2900W	75S	Rock O/C.

Field Notes, Fred Moher, continued...

Line	Station(s)	Topography/Comments
2900W		Infinity is at L600W/stn.700S.
2900W		Temp. -31 celsius.
2900W	425S	Rock O/C.
2900W	400S	Rock O/C.
2900W	375S	Top of rock exposure, height = 10 m.
2900W	350S to 360S	Bottom of rock face.
2900W	325S	Rock O/C.
2900W	250S	Rock O/C.
2900W	75S	Rock O/C.
2900W	100N	Rock O/C.
2700W		Infinity is at L600W/stn.700S.
2700W	230S to 175S	Alder swamp.
2600W		Infinity is at L600W/stn.700S.
2600W	325S to 155S	Alder and white ash swamp.
2600W	175S	First chainage picket.
2500W		Infinity is at L600W/stn.700S.
2500W	225S to 60S	Beaver pond (castor).
2500W	150N to 175N	Rock O/C.

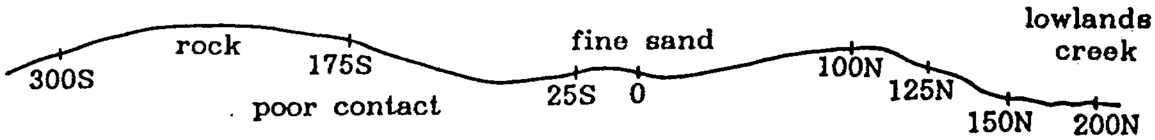
Field Notes, Dennis Palos:

Line	Station(s)	Topography/Comments
700E	450N	Power line.
2500E	650S, 625S	No reading possible.
2700E	625S	No reading possible.
3100E	1225S to 1150S	No readings possible.
1300W	BL	Picket O.K.
1300W	25N	No picket.
1300W	50N	No picket.
1300W	75N to 600N	Pickets marked 25 m too high.
100W		Line not found.

Field Notes, Dennis Palos, continued...

Line	Station(s)	Topography/Comments
400E		Read with east infinity.
400E	75N to 100N	Road.
700E	500S	Station under 230 kV powerline, no reading.
700E	BL	50 m from powerline, start readings here.
700E	450N	Under local electric wire.
700E	450N to 475N	Road.
900E	125N to north	Sand.
1100E	309S	Claim line.
1300E	BL	Rock O/C.
1700E	160S to 110S	Alders, creek bed.
1700E	25N to 50N	Rock O/C.
1700E	175N to 190N	Alders.
1900E	P1 at 525S	P1 and P2 at 550S and 500S for higher Vp.
1900E	150S	Small creek bed.
1900E	425N	Higher ground, maybe sand (poor contact).
2500E	(see sketch)	Chainage errors.
2700E	(see sketch)	Chainage errors; BL is 22 m between pickets 25N and 50N. North of BL pickets generally 3 m south of where they are supposed to be.
2700E	250N	Pocket of alders, wet.
2700E	north ext.	Extended line north to 425N to make sure no anomaly missed while Potential electrodes in "shadow-zone".
2900E	1150S	Picket 5 m south of TL1200S
2900E	1075S	Pocket of alders.
3000E	1225S to 1200N	Sand covered hills sloping west.
3000E	850S	Lowland between ridges.
3000E	825S	Rock O/C.
3100E	400S to 100S	Flat and conductive.

L1[illegible]E



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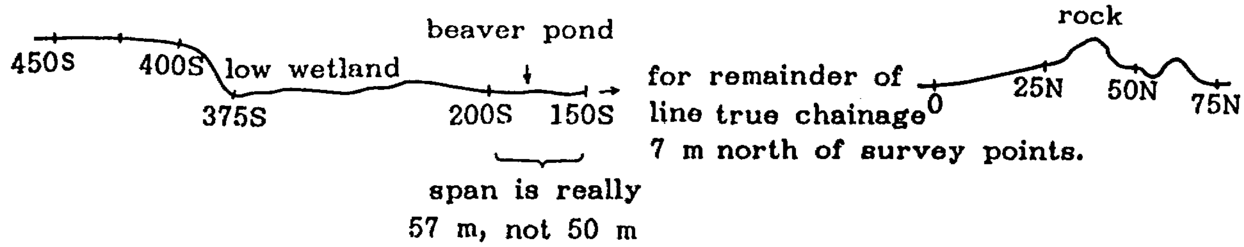

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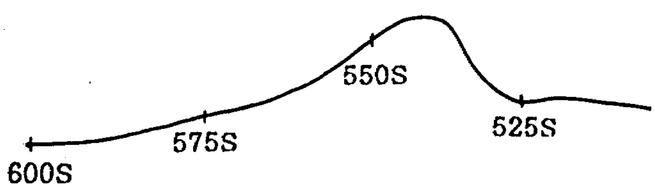

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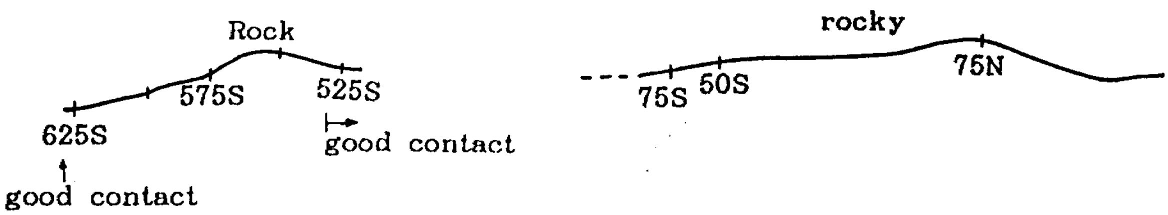

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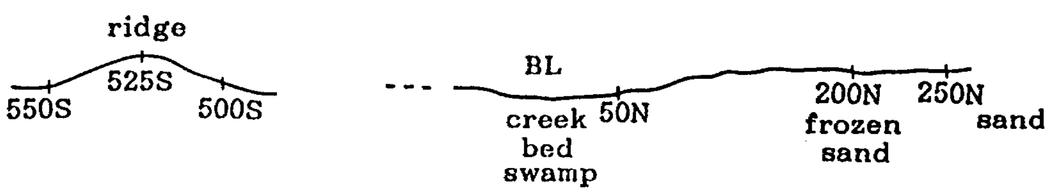

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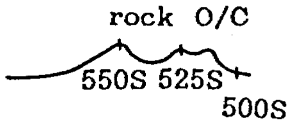

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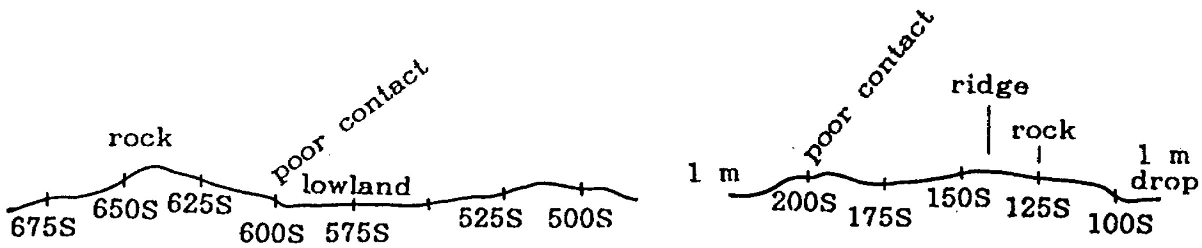

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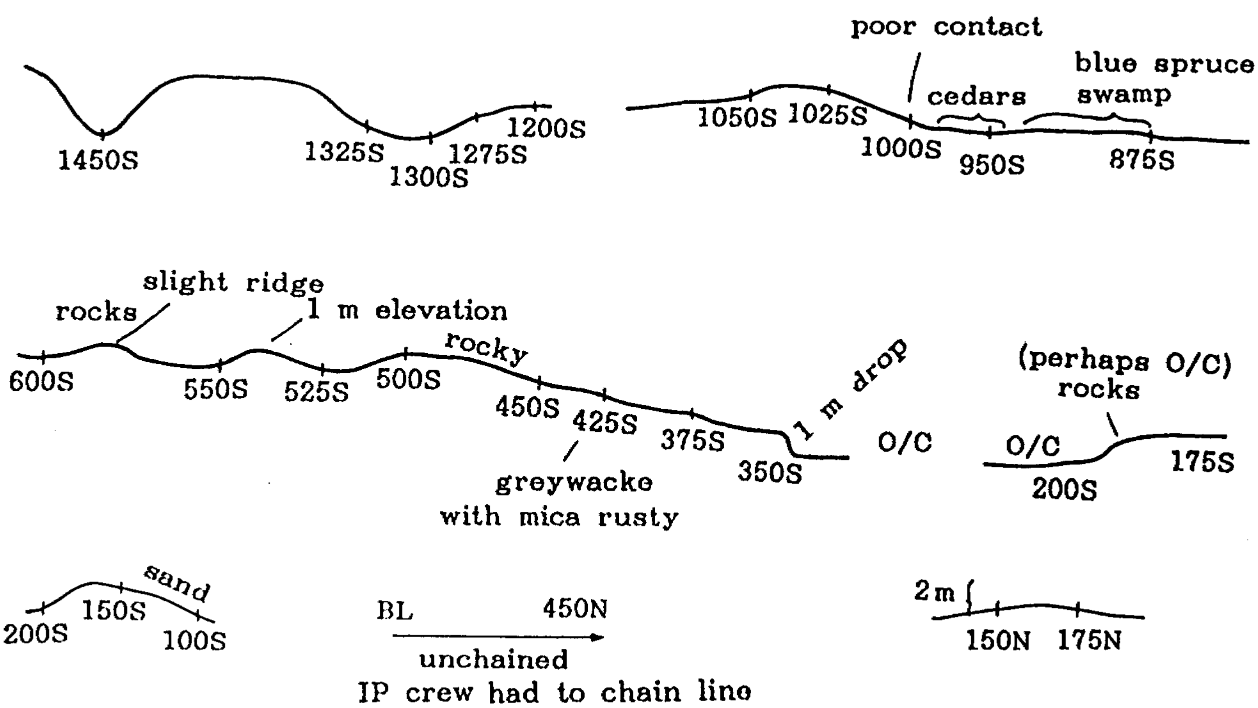

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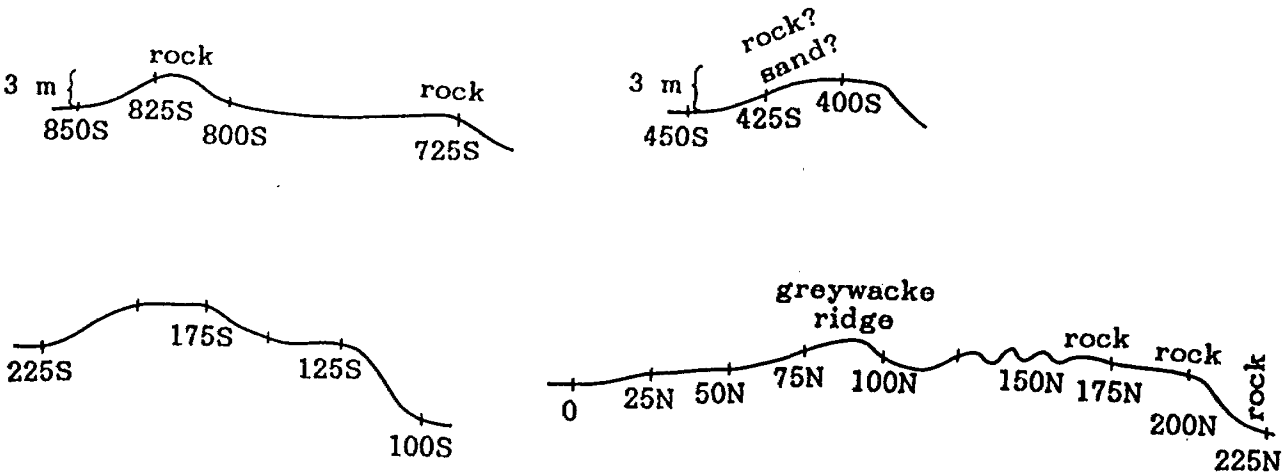
3 m
rock
850S
825S
800S
rock
725S
3 m
rock?
sand?
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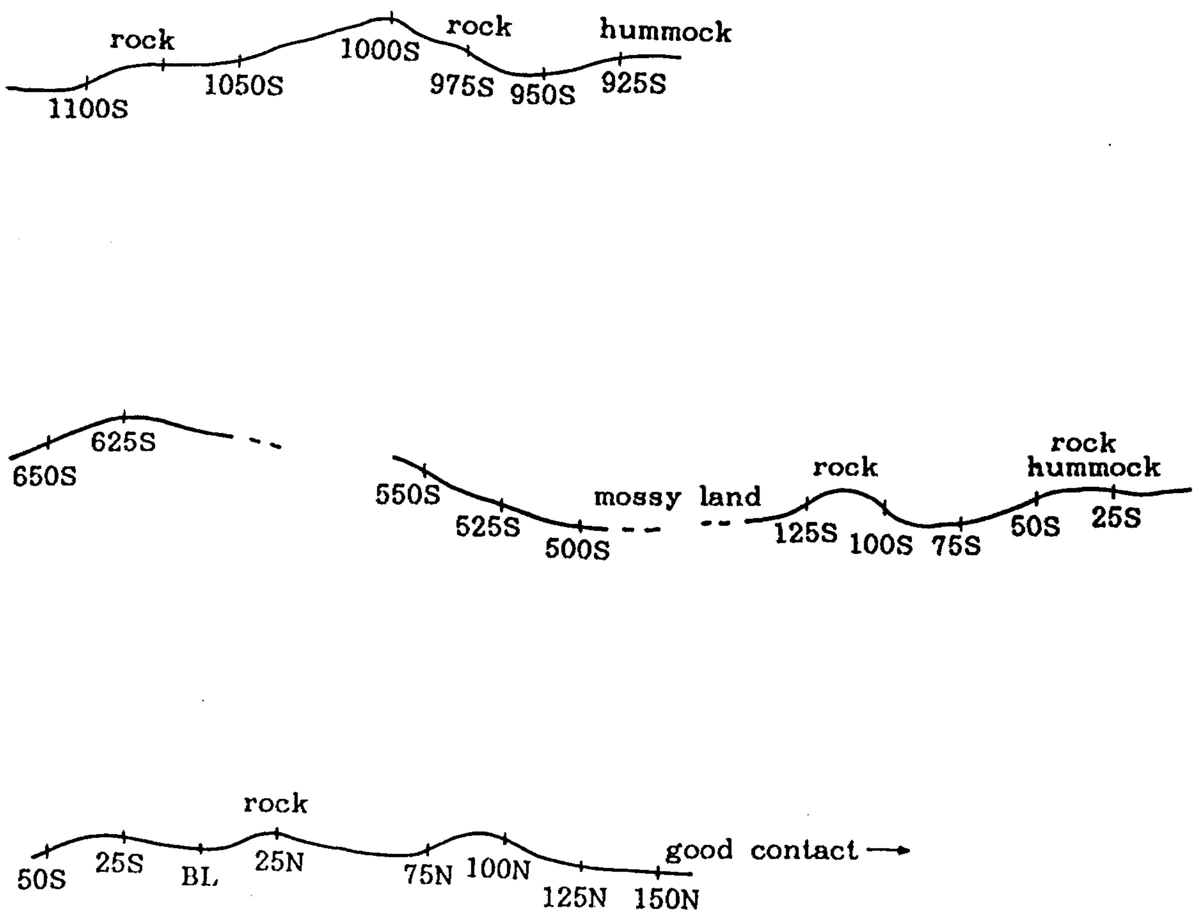
425S
400S
225S
175S
125S
100S
greywacke
ridge
0
25N
50N
75N
100N
150N
rock
175N
rock
200N
rock
225N

L3000E


rock
1100S
1050S
1000S
rock
975S
950S
hummock
925S
650S
625S
550S
525S
500S
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rock
125S
100S
75S
rock
hummock
50S
25S
rock
50S
25S
BL
25N
75N
100N
125N
150N
good contact →

SAGAX GEOPHYSIQUE

TECK EXPLORATIONS LIMITED

NORTH BAY, ONTARIO

2.14711

THUNDER LAKE PROJECT
ZEALAND TOWNSHIP
WABIGOON, ONTARIO

RECEIVED

SEP 9 1992

MINING LANDS BRANCH

NOVEMBER 1990

SAGAX 90368

SAGAX Géophysique inc.

6700 Avenue du Parc, suite 110, Montréal, Québec, Canada H2V 4H9
Fax: (514) 271-4679 Telex: 05-826577 Téléphone: (514) 271-3150

SAGAX GEOPHYSIQUE

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C) Comparative profiles for dipole-dipole and PPT arrays
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D) Resistivity and chargeability colour maps (1 : 15 000)

E) Interpretation map (1 : 5 000)

2nd Pocket

F) Resistivity, chargeability and metal factor contour maps (1: 5 000)

1. INTRODUCTION

At the request of **Teck Explorations Ltd.**, *SAGAX Geophysics Inc.* conducted an induced polarization survey over the **Thunder Lake** property in Zealand Township, Ontario.

The purpose of the survey was to discriminate between sulfide-bearing and graphite-bearing horizons.

The I.P. survey delineated eighteen (18) chargeability/resistivity anomalies of which four are first priority diamond drillholes.

2. THE THUNDER LAKE PROPERTY

2.1 Location and access

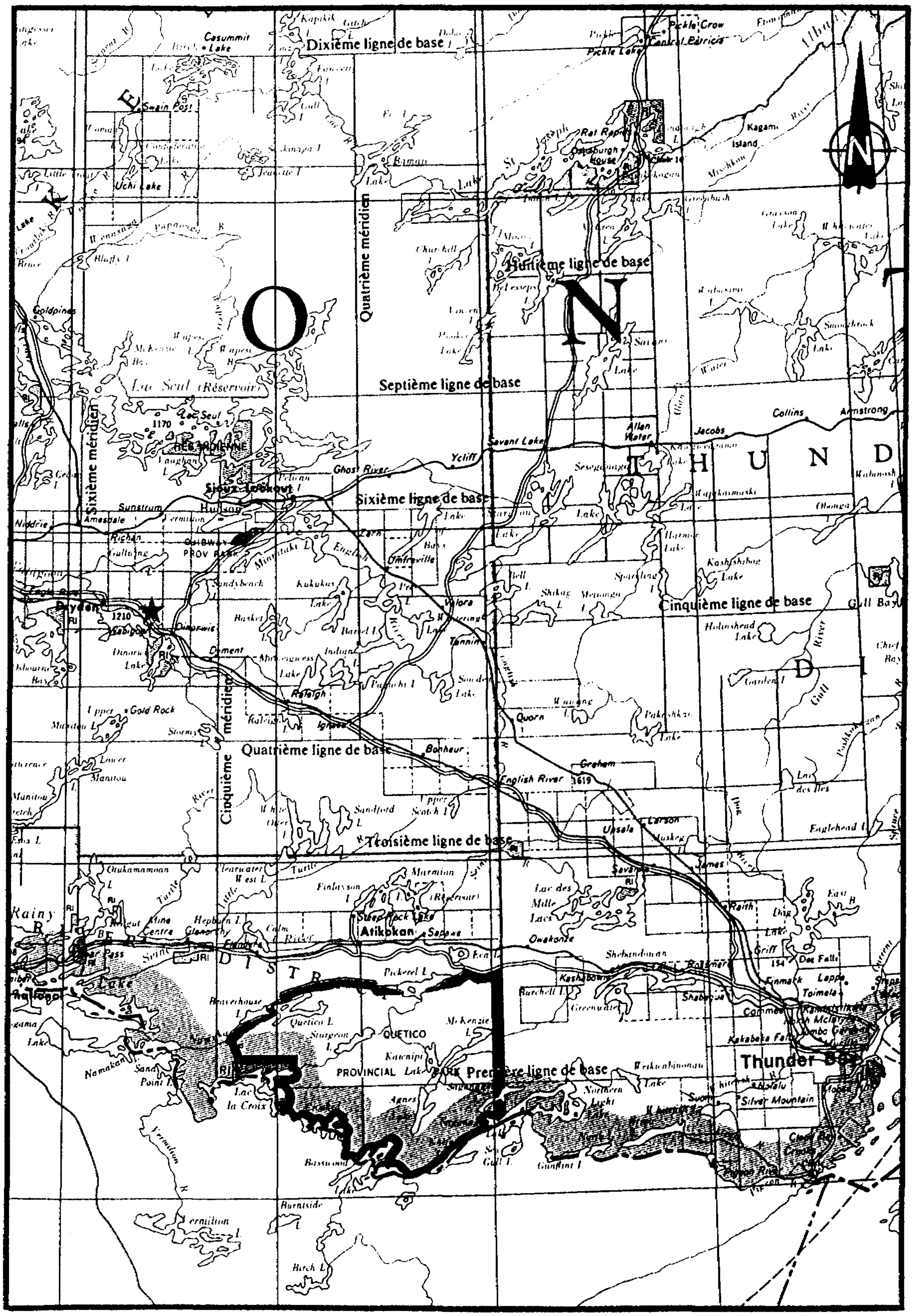
The survey area is located 15 kilometers east of Dryden, Ontario. The grid is accessible by road by means of several secondary roads crossing the grid (figure 1).

2.2 Survey grid

A control grid chained in the metric system covers the survey area with survey lines spaced 200 to 300 meters. The grid can be divided in two parts. The western part of the grid (lines 24+00W to 2+00W) has a base line striking E-W whereas the eastern part of the grid (lines 3+00E to 26+00E) has a base line striking N40°. All grid lines are picketed every 25 meters.

The lines surveyed in September 1990 are identified on figure 2 and in table 1.

Figure 1 : *Localisation of Thunder Lake Project.*



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milles 20 0 20 40 60 80 100 milles

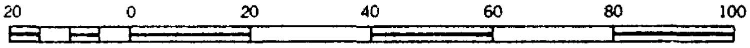
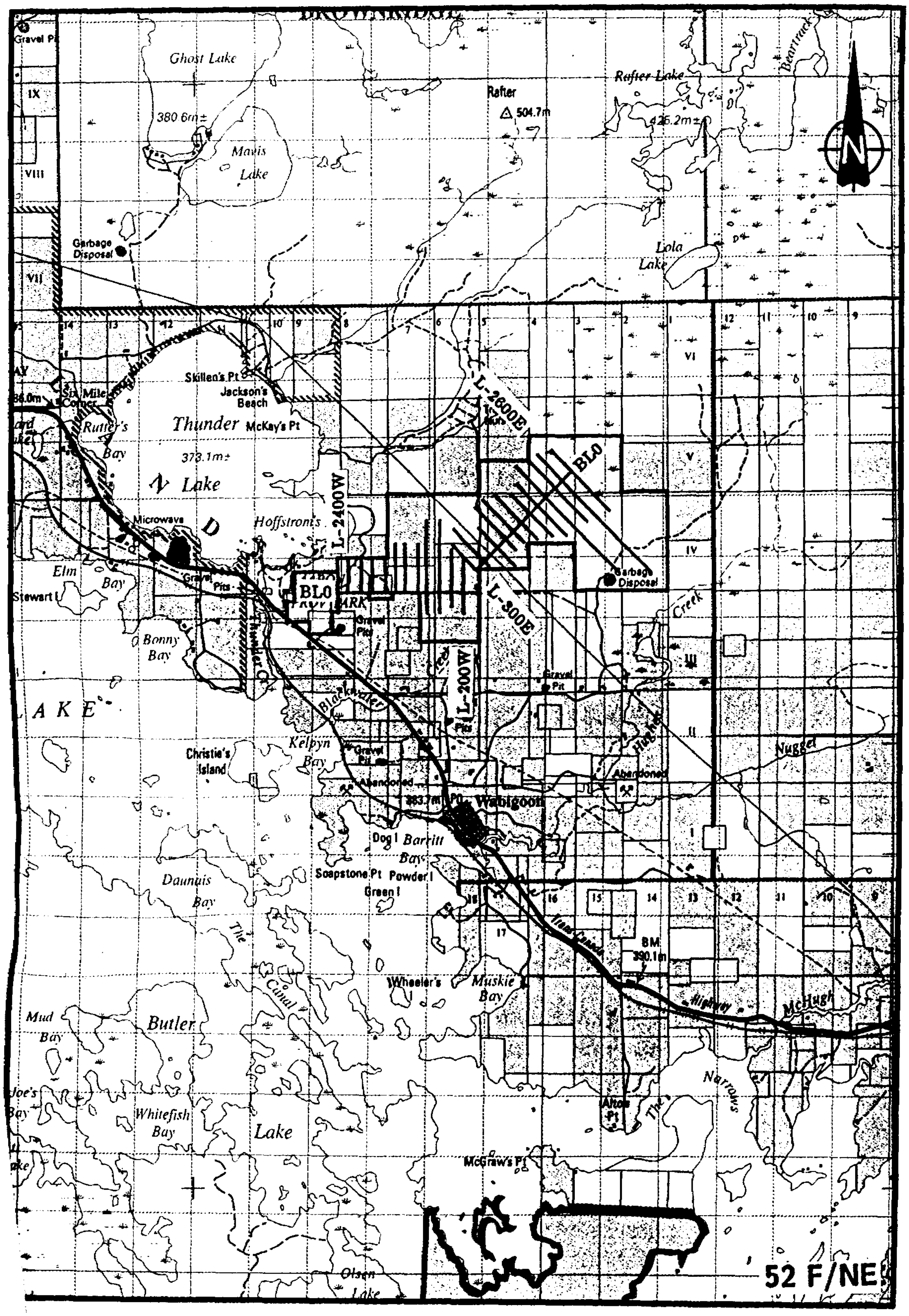


Figure 2 : *Location of the Thunder Lake Property and Survey Grid.*



Scale 1:100 000

Km

1 0 1 2 3 4 5 6 7 8 9 10

Table 1 : Lines surveyed on Thunder Lake grid

Line Number	Station	Line-km	Array
L 24W	6+00N - 0+50S	0.65	Dipole-dipole
L 22W	6+00N - 0+50S	0.65	Dipole-dipole
L 20W	6+00N - 0+50S	0.65	Dipole-dipole
L 18W	6+25N - 0+50S	0.675	Dipole-dipole
L 16W	6+25N - 0+25S	0.65	Dipole-dipole
L 14W	8+50N - 0+25S	0.875	Dipole-dipole
L 12W	8+50N - BLO	0.85	Dipole-dipole
L 10W	8+25N - 0+25S	0.85	Dipole-dipole
L 8+25W	12+25N - 4+25S	1.65	Dipole-dipole
L 6W	12+25N - 3+25S	1.55	Dipole-dipole
L 4W	9+00N - 3+25S	1.225	Dipole-dipole
L 2W	5+25N - 4+25S	0.95	Dipole-dipole
L 3E	6+25N - 0+75S	0.75	Dipole-dipole
L 5E	8+25N - 1+25S	0.95	Dipole-dipole
L 8E	5+00N - 4+25S	0.925	PPT
L 10E	8+00N - 2+00S	1.0	PPT
L 12E	8+25N - 2+00S	1.025	PPT
L 14E	7+00N - 3+00S	1.0	PPT
L 16E	5+50N - 5+25S	1.075	PPT
L 18E	5+50N - 7+00S	1.25	PPT
L 20E	7+00N - 18+25S	2.525	PPT
L 22E	7+00N - 8+25S	1.525	PPT
L 24E	6+00N - 21+00S	2.7	PPT
L 24E	6+00N - 21+00S	2.7	Dipole-dipole
L 26E	5+00N - 9+00S	1.4	PPT
L 26E	5+75N - 9+50S	1.525	Dipole-dipole

3. INDUCED POLARIZATION SURVEY

3.1 Generalities

Survey work, for a total of 17.05 line-kilometers of dipole-dipole and 14.425 line-kilometers of in line pole-pole (PPT) was conducted between September 14 and October 6, 1990 by a five-man crew under the supervision of Mr. Pierre Caron, geophysicist with *SAGAX Geophysics Inc.*

3.2 Electrode configuration

On the western part of the grid, a dipole-dipole array (figure 3) with a 25 meter nominal "a" dipole and 1 to 4 "n" separations (in some cases 1 to 5) from potential dipole to current dipole was used to survey all lines.

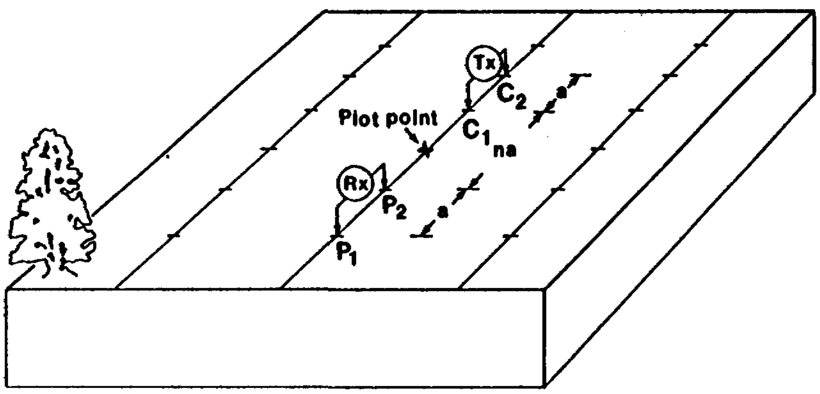


Figure 3: *The dipole-dipole configuration.*

For the eastern part, an in line pole-pole configuration (figure 4) with a 25-meter nominal "a" spacing between the roving potential P_1 and current C_1 poles was used. Both the current electrode to ground C_2 and the reference potential electrode P_2 were never less than 250 meters from either of the roving electrodes C_1 and P_1. At least 500 meters separated C_2 and P_2. The contribution of the "infinity" electrodes to the measured signal could therefore be considered negligible. Readings were taken at 25-meter intervals along the survey lines.

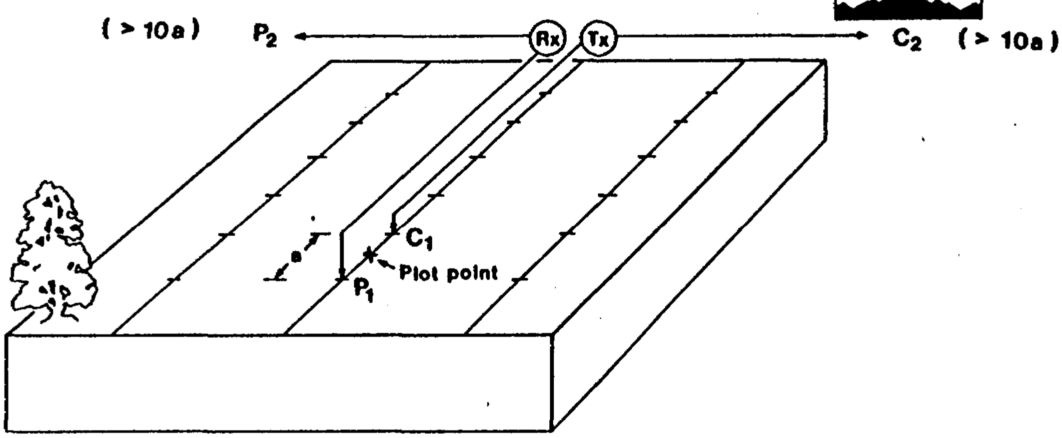


Figure 4: *The in line pole-pole configuration (PPT™).*

3.3 Equipment

The survey was performed with time domain induced polarization equipment. The transmitter was a Phoenix Geophysics Ltd IPT-1 model powered by a 2.0 kW Honda/ Phoenix motor generator. Stainless steel electrodes were used for current transmission. The commutated signal had an 8-second period and a 50% duty cycle (figure 5). The amplitude of the current driven into the ground ranged from 50 to 2 700 mA.

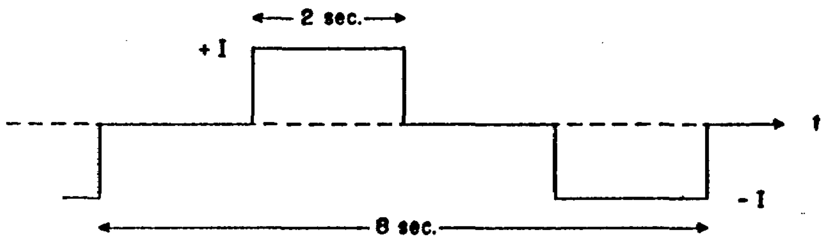


Figure 5: *The signal injected at C_1-C_2.*

Primary voltages (V_p) and apparent chargeabilities (M) were measured with an EDA Instruments IP-6 model time domain receiver. The transient voltage was integrated over ten (10) windows during the off-time (figure 6). The M_1 to M_{10} integration windows being normalized with respect to the standard induced polarization decay curve, it was possible to detect in the field all other contributions to the transient voltage by comparing the values measured by the receiver.

Between 6 and 20 pulses were stacked and averaged in order to record high quality data. However, chargeability readings were usually stable after only 4 pulses (2 cycles). No readings were taken with a primary voltage lower than 10 mV and contact resistance did not exceed 2.0 K-ohm in 85% of the cases. Porous pots or stainless steel electrodes were used at the receiver depending on ground contact conditions.

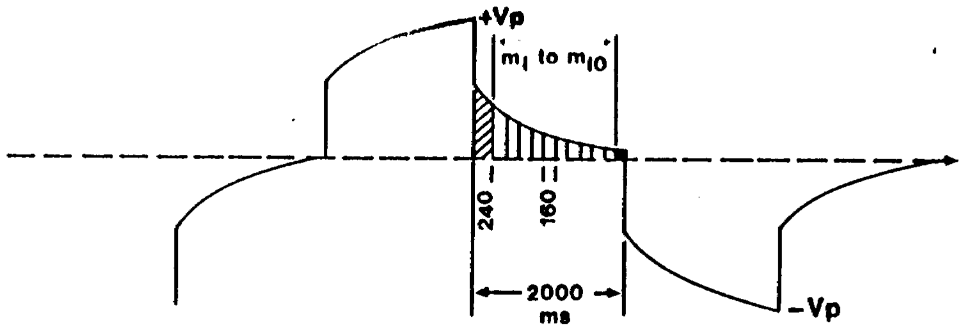


Figure 6: *The ten integration windows measured at P_1-P_2.*

3.4 Difficulties encountered and measurement accuracy

The measurement quality of both the apparent resistivity and apparent chargeability was closely monitored throughout the course of the survey. However the presence of a thick layer of sandy overburden, much thicker than expected in the eastern part and some places of the western part, rendered accurate measurements difficult for the dipole-dipole array. This is the reason why the pole-pole transversal array was chosen for the eastern part. In all other areas of the grid, no technical weaknesses (such as electromagnetic coupling, telluric noise, bad electrical contacts, etc.) affected the reliability of chargeability and resistivity readings. The accuracy of the resistivity and chargeability values are 5% and 0.5 mV/V respectively.

3.5 Presentation of survey results

Apparent resistivity, apparent chargeability and metal factor values are presented in pseudosections on a 1 : 2 500 scale. One copy of colour pseudosections at the same scale has also been submitted separately.

Contour maps for the same three parameters on a 1 : 5 000 scale are also presented in the appendice for the Fraser-filtered values for dipole-dipole and PPT data. Colour versions of the apparent resistivity and apparent chargeability on a 1 : 15 000 scale are also appended.

The interpreted anomalies are indicated on both the pseudosections and the geophysical interpretation map which is on a 1 : 5 000 scale.

Comparative profiles for the dipole-dipole and PPT arrays are presented for lines 24+00E and 26+00E at a 1 : 5 000 scale.

4. INTERPRETATION AND RECOMMENDATIONS

4.1 Discussion of results

The I.P. survey delineated eighteen (18) chargeability and resistivity anomalous sources (IP-1 to IP-16, IP-1', IP-5'). A compilation of all the chargeability/resistivity anomalies is presented in table 2. The anomalies and drilling targets have been prioritized according to their geophysical signature and known target horizons prior to the geophysical survey. These priorities might be modified by **Teck Explorations Ltd.**, according to additional geoscientific information and drilling results. All the resistivity and chargeability anomalies have been traced on the geophysical interpretation map enclosed with this report.

The known target horizons are located approximately at: (Thorsen, personal communication) :

[Lines 21+00W and 20+00W, Station 1+00N]
[Lines 17+00W, 16+00W and 15+00W, Station 2+00N]
[Line 2+00W, Station 4+00N] to [Line 0+00, Station 5+00N]
[Lines 17+00E to 19+00E, Station 2+00S]
[Lines 8+00E to 10+00E, Station 0+50N].

All of these target horizons are observed to correspond to chargeability/resistivity horizons. For instance the target horizon on the western part of the grid is represented by IP-1. The target horizons on the eastern part of the grid are represented by sources IP-2 and IP-12 respectively.

Four resistive horizons (RA, RB, RC, RD) have been mapped. These areas correspond to outcrops or as in the case of the eastern part of the grid to a pervasive amount of sandy overburden.

The chargeability signature varies widely among the sources delineated by the dipole-dipole array in the western part of the grid, whereas the signature of those delineated by the PPT array in the eastern part of the grid is much more stable. The phenomenon could be explained by a masking effect caused by conductive overburden known to be present between lines 14+00W and 2+00W (Thorsen, personal communication).

Several general trends of I.P. anomalies can be observed; they can be divided into three types :

- *Type 1* : I.P. anomalies with a general trend of N60°, which are denoted IP-1, IP-2, IP-3, IP-5, IP-6, IP-7, IP-13

- *Type 2* : I.P. anomalies with a general trend of N90°, which are denoted IP-1', IP-4, IP-12, IP-14, IP-15, IP-16.

- *Type 3* : I.P. anomalies with a general trend of N45° which are denoted IP-8, IP-9, IP-10, IP-11.

As for anomaly IP-5' its trend varies from N60° to N90°; it is thought to be related to IP-5 because of similar geophysical signature but lack of coverage does not allow us to confirm this hypothesis. Anomaly IP-2 has a general trend of N60° in the western part of the grid and N90° in the eastern part.

As a general rule, type 1 anomalies are only observed in the western part of the grid and type 2 and 3 in the eastern part of the grid. This can be explained by a difference in lithological strike which was hypothesized by Thorsen.

Note that sulfide-bearing horizons may have a different geophysical signature than graphite-bearing horizons. A graphite-bearing horizon can be more conductive than a sulfide-bearing one. However this is not always the case as anomaly IP-1 seems to indicate. As we mentioned before, a masking effect by conductive overburden has possibly attenuated the signature of a known target horizon : it is characteristically polarizable and conductive at its western edge (L18+00W and L16+00W) and weakly polarizable and weakly conductive at its eastern edge (3+00E and 5+00E).

This effect can also be observed on the western edge of IP-3 (line 20+00W and 19+00W). According to the apparent resistivity map, this area should be covered by conductive overburden, and consequently the chargeability masking effect is observed.

A set of N160° trending faults is observed in the northern half of line 12+00W and the southern part of line 14+00W. The former presents a horst-graben structure whereas the latter is a dextrous cross-fault.

4.2 Interpretation of chargeability/resistivity anomalies

The majority of type 1 and type 2 anomalies (IP-1, IP-1', IP-2, IP-3, IP-4, IP-5, IP-6, IP-12, IP-13, IP-16) are interpreted to possibly represent sulfide-bearing horizons. The remaining (IP-5', IP-7, IP-14, IP-15) are interpreted to possibly represent intercalated graphite and sulfide-bearing horizons. In general those with strong conductivity signatures are interpreted to represent a more graphitic facies.

The type 3 anomalies (IP-8, IP-9, IP-10, IP-11), which are all located on the northern part of the eastern grid are interpreted to possibly represent sulfide-facies iron formation since banded iron-formations are to be expected in this part of the grid (Thorsen, personal communication).

A summary of the characteristics of the induced polarization anomalies is presented in table 2 (page 15).

4.3 Comparison of PPT and Fraser-filtered dipole-dipole profiles

Since the western and eastern parts of the grid were done with different arrays due to overburden consideration, it is noteworthy to compare both arrays in order to assess their effectiveness in certain conditions.

The profiles of data collected from both arrays are presented for lines 24+00E and 26+00E respectively and are included in the appendices.

The profiles for dipole-dipole are indicated in dashed lines and those for PPT in solid lines.

One must keep in mind that since the PPT array normally penetrates deeper than the dipole-dipole array, the background level for chargeability and resistivity will be higher for the former than the latter.

4.3.1 Comparison of chargeability profiles

As expected, the background level for PPT is higher but it is not at a constant level higher. Therefore it would not be pertinent to substract a fixed value from the PPT profile. At the southernmost extremity of line 24+00E however, both profiles have similar values.

It can noted that the PPT profiles are less wavy (noisy) than the dipole-dipole profiles. However the values are similar for the anomalies located at [2+00N, 24+00E] to [1+75N, 26+00E] and [0+25S, 24+00E]. In all other cases the chargeability values are higher for PPT profiles.

An interesting phenomenon can also be observed for line 26+00E : the peaks are located farther south (around 25 m) for dipole-dipole versus PPT whereas it is the opposite for line 24+00E.

This can be explained by the nature of the Fraser-filter weight triangle conventionally used. All points of the weight triangle are equally weighted based on the fact that dipole-dipole anomalies are usually symetrical, but as we can observe this is not usually the case.

4.3.2 Comparison of resistivity profiles

As expected, the background level is higher for PPT than dipole-dipole. However, this bias is not constant from one line to another. Typically it is constant for line 26+00E (approximately 20 Kohm-m), whereas for line 24+00E it varies considerably. The opposite lag from line 24+00E to 26+00E described in the previous chapter is also observed and is also explained in the same way.

4.4 Summary of subsequent work

Of the eighteen (18) anomalies delineated by the I.P. survey, four (4) first priority and four (4) second priority diamond drillholes were selected.

The criteria used to select the diamond drillholes were as follows :

- Location on strike of a known target horizon
- Strong polarizability with weak conductivity
- Good strike extent
- Correct stratigraphic orientation (parallel to known target horizons).

Extension of lines or addition of new lines to be surveyed by I.P. should be done on the basis of diamond drillhole results.

A summary of susbsequent work is presented on table 3.

SAGAX GEOPHYSIQUE

TABLE 2 : CHARACTERISTICS OF INDUCED POLARIZATION ANOMALIES - THUNDER LAKE GRID.

NAME	STRIKE LENGTH	MAXIMUM - POLARISABILITY	RESPONSE /RESISTIVITY	REMARKS AND/OR RECOMMENDATIONS	DRILLING TARGET (LINE, STATION, DEPTH)	PRIORITY LEVEL
IP-1	>2200 m	+++++ 20W to 14W	----- 16W	Very strongly polarizable at its western edge. Cross-cut by a dextrous fault (?). Outcrops at the western edge. Moderately polarizable and non-conductive. Open to the east. A known target horizon.	L : 10+00W S : 2+50N D : - 40 m	1
IP-1'	> 500 m	+++ 20E to 24E	0	Moderately polarizable and non-conductive. Thought to be the continuation of IP-1. Should be investigated second priority hole. Interpreted to possibly represent sulfides.	L : 24+00E S : 12+75S D : - 40 m	2
IP-2	>1800 m	++++ 5E	---- 8+25W	Polarizability wanes considerably at the western edge. Otherwhere moderately to strongly polarizable. Interpreted to possibly represent sulfides. Could represent some interest. A known target horizon at lines 8E to 10E.	L : 5+00E S : 2+75N D : - 40 m	2
IP-3	1200 m	+++++ 14W to 10W	---- 20W to 18W	Offset by a horst-graben structure (?). Very strongly polarizable at its western edge (except line 8+25W) and non-conductive. Strongly conductive at its western edge. Interpreted to possibly represent sulfides, nature of western edge remains doubtful. Should be drilled near line 12+00W, first priority.	L : 12+00W S : 5+50N D : - 40 m	1
IP-4	1000 m	+++ 16E to 24E	0	Moderately polarizable and non-conductive. Very favorable at its extremities but unfavorable in its center because of increase in resistivity. Second priority. Possibly sulfides.	L : 16+00E S : 2+00N D : - 40 m	2
IP-5	> 900 m	+++++ 6W	----- 4W	Open to the east and west. Strongly to very strongly polarizable and generally weakly conductive except on line 4W. Very good target because of high polarizability and low conductivity. First priority DDH. Possibly sulfides.	L : 6+00W S : 1+00N D : - 40 m	1

SAGAX GEOPHYSIQUE

TABLE 2 : CHARACTERISTICS OF INDUCED POLARIZATION ANOMALIES - THUNDER LAKE GRID.
(Cont.d)

NAME	STRIKE LENGTH	MAXIMUM POLARISABILITY	RESPONSE RESISTIVITY	REMARKS AND/OR RECOMMENDATIONS	DRILLING TARGET (LINE, STATION, DEPTH)	PRIORITY LEVEL
IP-5'	> 700 m	+++++ 24W and 18W	----- 24W and 18W	Open to the east and west. Generally very polarizable and very conductive. Interpreted to represent graphitic horizons, of no interest.		3
IP-6	> 700 m	++++ 8+25W	--- 6W	Open to the east and west. Generally weakly polarizable and weakly conductive. Of no interest. Possibly (?) sulfides.		3
IP-7	> 700 m	+++++ 8+25W to 2W	----- 8+25W to 6W	Very strongly polarizable and conductive. Most likely graphitic horizons. Of no interest.		3
IP-8	> 400 m	+++ 24E to 26E	--- 26E	Open to the east. Moderately polarizable and non-conductive (except line 26E). Interpreted to possibly represent sulfide-facies iron formation.		3
IP-9	>1400 m	+++++ 20E	----- 20E	Open to the east and west. Moderately polarizable except at its eastern edge where it is strongly polarizable. Very strongly conductive at line 20E. Of same nature as IP-8.		3
IP-10	> 600 m	+++ 10E to 12E	- 10E to 12E	Weakly to moderately polarizable and non-conductive to weakly conductive. Interpreted to be of same nature as IP-8.		3
IP-11	> 400 m	+++ 10E to 12E	0	Moderately polarizable and non-conductive. Interpreted to be of same nature as IP-8.		3
IP-12	>1400 m	+++ 14E and 18E	--- 18E to 20E	Open (?) to the west. Known target since it outcrops at line 16E. Should be drilled at line 14E. Moderately polarizable and non-conductive to moderately conductive.	L : 14+00E S : 0+00 D : - 40 m	1
IP-13	200 m	+++ 24W	--- 24W	Open to the west. Moderately polarizable and conductive, possibly sulfides. Too short to be a worthwhile target, likely to be abandoned.		3

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TABLE 2 : CHARACTERISTICS OF INDUCED POLARIZATION ANOMALIES - THUNDER LAKE GRID. (Cont.d)

NAME	STRIKE LENGTH	MAXIMUM POLARISABILITY	RESPONSE RESISTIVITY	REMARKS AND/OR RECOMMENDATIONS	DRILLING TARGET (LINE, STATION, DEPTH)	PRIORITY LEVEL
IP-14	> 700 m	+++++ 20E to 24E	----- 20E to 24E	Open to the east. Very polarizable and very conductive. Interpreted to be of same nature as IP-7. Likely to be abandoned.		3
IP-15	> 200 m	+++++ 24E to 26E	---- 24E to 26E	Open to the east. Very strongly polarizable and strongly conductive. Interpreted to be of same nature as IP-7.		3
IP-16	450 m	+++++ 18E to 20E	----- 16E	Strongly to very strongly polarizable and non-conductive except at line 16E. Because of lack of conductivity can present interest.	L : 18+00E S : 5+25S D : - 40 m	2

LEGEND:

DECREASE	INCREASE	
0	0	None
-	+	Very weak
--	++	Weak
---	+++	Moderate
----	++++	Strong
-----	+++++	Very strong

Drilling target: Line, station and depth of the target (NOT the location of the diamond drillhole collar hole)

TABLE 3 : SUMMARY OF SUBSEQUENT WORK

PRIORITY ORDER	ANOMALY	WORK RECOMMENDED	LINE	STATION	DEPTH
1	IP-1	First priority DDH	10+00W	2+50N	- 40 m
2	IP-3	First priority DDH	12+00W	5+50N	- 40 m
3	IP-5	First priority DDH	6+00W	1+00N	- 40 m
4	IP-12	First priority DDH	14+00E	BLO	- 40 m
5	IP-16	Second priority DDH	18+00E	5+25S	- 40 m
6	IP-2	Second priority DDH	5+00E	2+75N	- 40 m
7	IP-1'	Second priority DDH	24+00E	12+75S	- 40 m
8	IP-4	Second priority DDH	16+00E	2+00N	- 40 m

Respectfully submitted,

SAGAX Geophysics Inc.

For: Richard Lachapelle, Eng.
Geophysicist

November 1990

APPENDIX A

SAGAX GEOPHYSIQUE

Induced Polarization Method

INTRODUCTION

Induced polarization (I.P.) is a geophysical exploration method which permits the direct detection of disseminated and massive concentrations of metallic minerals such as:

- pyrite;
- chalcopyrite;
- sphalerite;
- bornite;
- galena;
- magnetite;

(the method is also very sensitive to graphite).

Thus geologic structures which are favorable to economical mineralization and not susceptible to magnetic and electromagnetic methods can be detected by the IP method:

- disseminated sulphides (1 to 10% volume content);

- massive lenses of non-conductive sulphides (either sphalerite-rich or silicified);

- small lenses of sulphides.

PHYSICAL PHENOMENA

The IP effect is similar to the cycle phenomena of charge and discharge in a car battery. The "battery" (conductive minerals) is charged when a transmitted current is injected in the ground. And when the current is shut off, the "battery" discharges itself within the resistive ground. The IP receiver measures the voltage caused by the "battery discharge" which decreases with time.

Chargeability, the measured parameter, is defined as the capacity of the ground to accumulate electrochemical energy.

As in a battery, the electric charge is accumulated at the surface of conductive material soaked in an electrolyte: lead in sulfuric acid for a battery, and metallic minerals in underground water for mineral exploration.

This phenomena, called electrode polarization, is a surface effect. The chargeability increases as the interfaces between the conductive minerals and the electrolyte is increased. Therefore, disseminated sulphides can cause strong IP effects. (For a similar volume content of sulphides, the total surface increases very rapidly with a decrease in grain size or an increase in fracturation.)

The IP phenomena is weakly sensitive to the nature of the conductive material and the electrolyte. Any conductive mineral soaked in an electrolyte will cause an IP effect. Thus IP anomalies can be observed for sulphides, graphite, magnetite and some other minerals. These minerals can be either massive or disseminated.

In cases of very little fracturation and porosity of the host rocks (such as very clean granitoid rocks), no electrolyte is present and very little or no IP effect will be observed, even in the presence of metallic minerals.

THE THREE IP TECHNIQUES

With the geophysical instruments presently available on the market, three types of IP measurements can be performed:

TIME DOMAIN TECHNIQUE (Androtex, BRGM, Huntec, Newmont, Scintrex)

A pulsed current is transmitted on and off and the ground discharges itself during the off cycle causing an IP effect. The **chargeability** (M) is defined as the surface under the voltage as it decays with time.

FREQUENCY DOMAIN TECHNIQUE (McPhar, Phoenix)

An alternating current is injected at fixed frequencies and apparent resistivity differences are measured. The **frequency effect** (FE) expresses this variation in percent.

PHASE SHIFT, COMPLEX RESISTIVITY TECHNIQUE (Phoenix, Zonge)

When polarizable minerals are present in the ground, its apparent resistivity has to be expressed in a complex form. The **phase shift** (Q) between the received voltage and the injected current can thus be measured when the receiver and transmitter are linked.

These three types are theoretically equivalent. In practice, however, it is easier and advantageous to measure some effects over others. The phase shift measurement is more precise than the frequency effect and more rapid than measuring chargeability. The advantage of the chargeability measurement is the possibility of in-situ verification of noise effects (telluric noise, electromagnetic coupling, bad contacts, etc.) by the normalization of the discharge curve shape. Parasitic effects can easily distort the signal and create IP anomalies. Measurements in time domain, performed with adequate instruments, permit to control more efficiently the quality and accuracy of IP values during field surveys and to identify with more certainty weak anomalies.

SPECTRAL IP

This technique is generally used in specific applications. One of the three parameters mentioned above is measured over a wide spectrum to evaluate the characteristic signature associated with different types of mineralization present in a specific geologic environment. By accompanying it with signatures, anomaly sources can thus be identified (within the same geologic environment).

IP SURVEYING

In general, six electrode configurations are used in I.P.: Wenner, dipole-dipole, pole-dipole, gradient, transversal (or in-line) pole-pole, and lateral pole-pole. None of these configurations can be said to be superior for all cases. The choice of an electrode configuration must be done with respect to the metallogeny, physiography, logistics and economics of the area to be surveyed. The choice of an electrode configuration can be done according to seven factors with different degrees of importance (table 1). According to the specifics of the project, each factor can be given a weight and their combined results for each configuration totaled to determine which one should be used.

TABLE 1: DETERMINATIVE TABLE FOR CONFIGURATION CHOICE

Comparison point	Weight (to be fixed)	Grade (1 to 3) W	DD	PD	G	PPL	PPT
Depth of investigation		1	2	2	2	3	3
Horizontal resolution & location		2	2	2	3	2	2
Vertical resolution & location		2	2	2	1	1	1
Production		2	1	2	3	3	3
Signal to noise ratio		2	1	2	1	3	3
EM coupling rejection		2	3	3	1	1	1
Interpretation ease		2	2	1	3	2	2
TOTAL :	100						

W : Wenner
DD : Dipole-dipole
PD : Pole-dipole
G : Gradient
PPL : Lateral pole-pole
PPT : Transversal pole-pole

SAGAX GEOPHYSIQUE

INTERPRETATION

The first difficulty which has to be dealt with in IP interpretation is the identification and, if possible, the removal of the overburden thickness variation effects. The bedrock, being more polarizable than the overburden, will increase I.P. values and appear anomalous as the overburden thins out. However, the bedrock is generally much more resistive than the overburden, and the resistivity signature can be used simultaneously with the IP results for interpretation. Two techniques can also be used to eliminate (or at least minimize) the overburden thickness variation effects:

1. Calculation of a third parameter (metal factor or normalized chargeability) which will tend to be independent of the overburden thickness variations. This parameter can be calculated as follows:

$$MF = K * M/(rho_a)^x$$

   Where K is a constant and rho_a the apparent resistivity. The value of the exponent x has to be defined empirically (x is generally between 0.25 and 1).

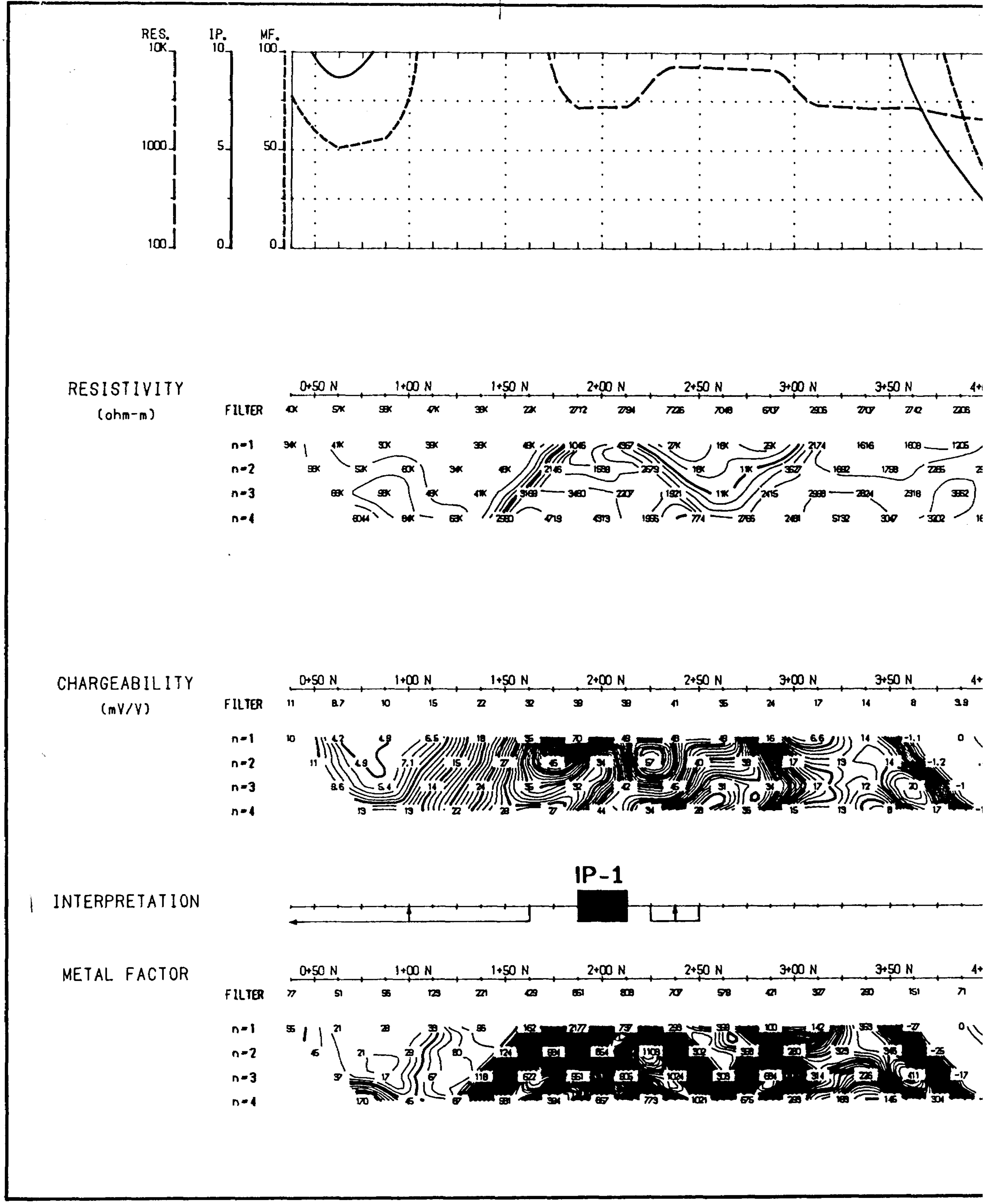
2. Construction of a correction diagram of apparent chargeability (IP effect) from results of soundings (IP/resistivity) over barren ground (non anomalous). This solution is preferable to the previous one.

Once the anomalies caused by mineralization are identified, quantitative interpretation of these can be performed through comparison of field results to theoretical models.

The amplitude of an anomaly is a secondary parameter in the interpretation of IP surveys. It is more critical to identify the characteristic signature of an anomalous source for the electrode configuration being used. When the anomalous pattern has clearly been identified, signature quantification can be done for each of the parameters with respect to non-anomalous zones. Hence the interpretation of pseudo-sections (pole-dipole and dipole-dipole) must be done by seaching the "reversed V" or "pant-legs" pattern. A pseudosection should never be considered to represent a vertical cross-section of the ground; it is only a method of data presentation. Finally, dip interpretation of IP results is very tricky, particularly for the pole-dipole and dipole-dipole arrays.

APPENDIX B

APPENDIX C



RES.
IP.
MF.
10K
1000
100
10
5
0
100
50
0
RESISTIVITY
(ohm-m)
CHARGEABILITY
(mV/V)
INTERPRETATION
IP-1
METAL FACTOR
FILTER
n=1
n=2
n=3
n=4
0+50 N
1+00 N
1+50 N
2+00 N
2+50 N
3+00 N
3+50 N

MF	IP	RES
100	10	10K
50	5	1000
0	0	100

RESISTIVITY
(ohm-m)

FILTER

n=1
n=2
n=3
n=4

CHARGEABILITY
(mV/V)

FILTER

n=1
n=2
n=3
n=4

3

INTERPRETATION

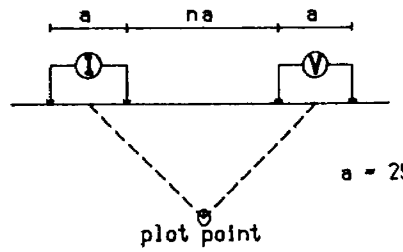
METAL FACTOR

FILTER

n=1
n=2
n=3
n=4

INDUCED POLARIZATION SURVEY

Dipole-Dipole Array



Filter

a = 25 M

Contour Interval:
Resistivity: 1, 1.5, 2, 3, 5, 7.5, 10,
Chargeability: 1, 5
Metal Factor: 10, 50

Metal Factor Definition: MF = 1000•IP/√F

Line 16+00 W

Scale 1:2500

25 0 25 50 75 100 125
(metres)

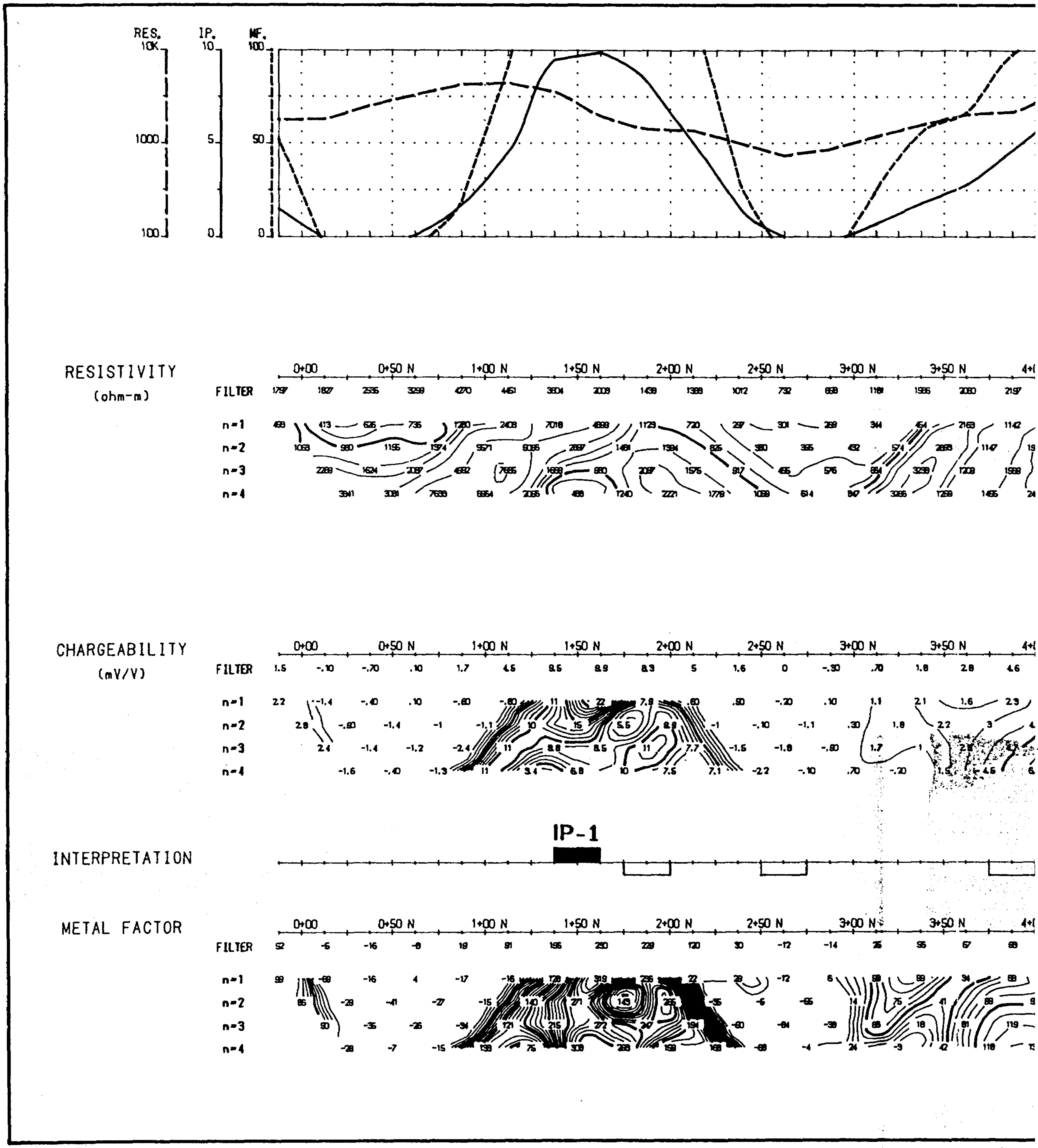
TECK EXPLORATION LTD.

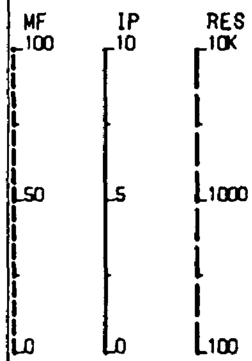
THUNDER LAKE PROJECT
ZEALAND TOWNSHIP
WABIGOON, ONT.

Interpreted by: Joël Simard
Date of Survey: September 1990
Intruments: IP-6, IPT-1
Surveyed by: Pierre Caron

SAGA
GEOPHYSI

Reference: SAGAX 90368


RES.
IP.
MF.
RESISTIVITY (ohm-m)
CHARGEABILITY (mV/V)
INTERPRETATION
IP-1
METAL FACTOR
FILTER
0+00
0+50 N
1+00 N
1+50 N
2+00 N
2+50 N
3+00 N
3+50 N



RESISTIVITY
(ohm-m)

FILTER

n=1

n=2

n=3

n=4

CHARGEABILITY
(mV/V)

FILTER

n=1

n=2

n=3

n=4

INTERPRETATION

METAL FACTOR

FILTER

n=1

n=2

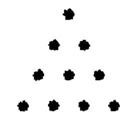
n=3

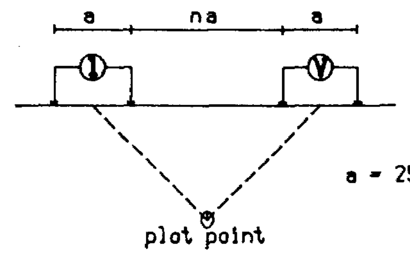
n=4

INDUCED POLARIZATION SURVEY

Dipole-Dipole Array

Filter





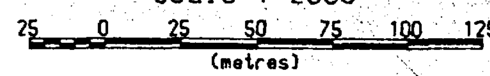
a = 25 M

Contour Interval:
- Resistivity: 1, 1.5, 2, 3, 5, 7.5, 10,...
- Chargeability: 1, 5
- Metal Factor: 10, 50

Metal Factor Definition: $MF = 1000 \cdot IP/\sqrt{res}$

Line 14+00 W

Scale 1:2500



TECK EXPLORATION LTD.

THUNDER LAKE PROJECT
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WABIGOON, ONT.

Interpreted by: Joël Simard
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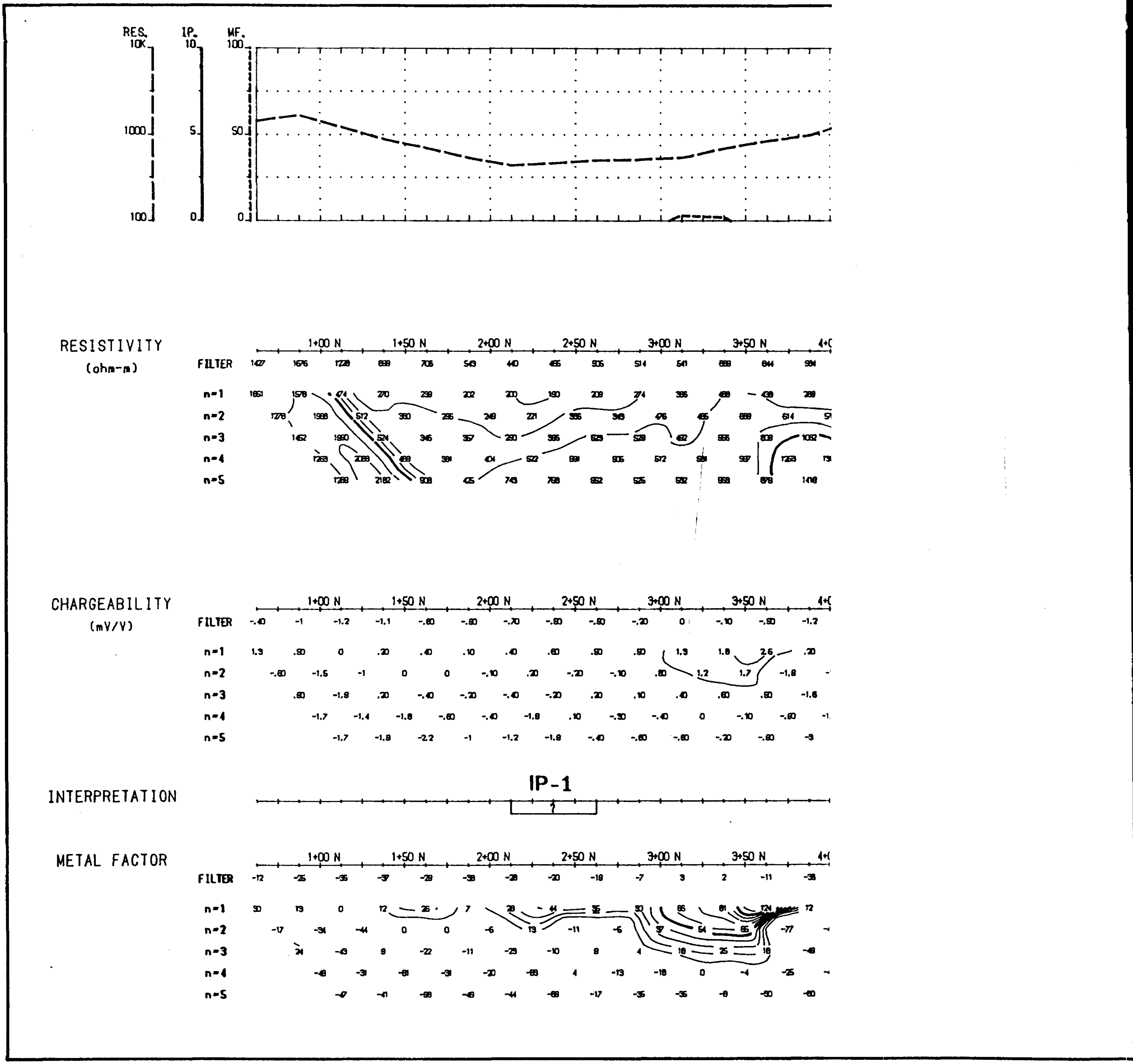
SAGAX GEOPHYSIQUE

Reference: SAGAX 90368



RES.
10K
1000
100
IP.
10
5
0
MF.
100
50
0
RESISTIVITY
(ohm-m)
CHARGEABILITY
(mV/V)
INTERPRETATION
IP-1
METAL FACTOR
FILTER
n=1
n=2
n=3
n=4
n=5
1+00 N
1+50 N
2+00 N
2+50 N
3+00 N
3+50 N

MF 100 50 0 | IP 10 5 0 | RES 10K 1000 100

RESISTIVITY
(ohm-m)

FILTER
n=1
n=2
n=3
n=4
n=5

CHARGEABILITY
(mV/V)

FILTER
n=1
n=2
n=3
n=4
n=5

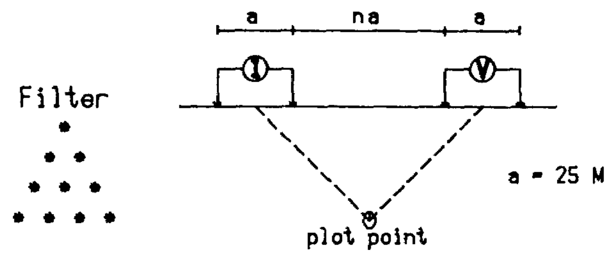
INTERPRETATION

METAL FACTOR

FILTER
n=1
n=2
n=3
n=4
n=5

INDUCED POLARIZATION SURVEY

Dipole-Dipole Array



Contour Interval:
Resistivity: 1, 1.5, 2, 3, 5, 7.5, 10,...
Chargeability: 1, 5
Metal Factor: 10, 50

Metal Factor Definition: $MF = 1000 \cdot IP/\sqrt{res}$

Line 12+00 W

Scale 1:2500

25 0 25 50 75 100 125
(metres)

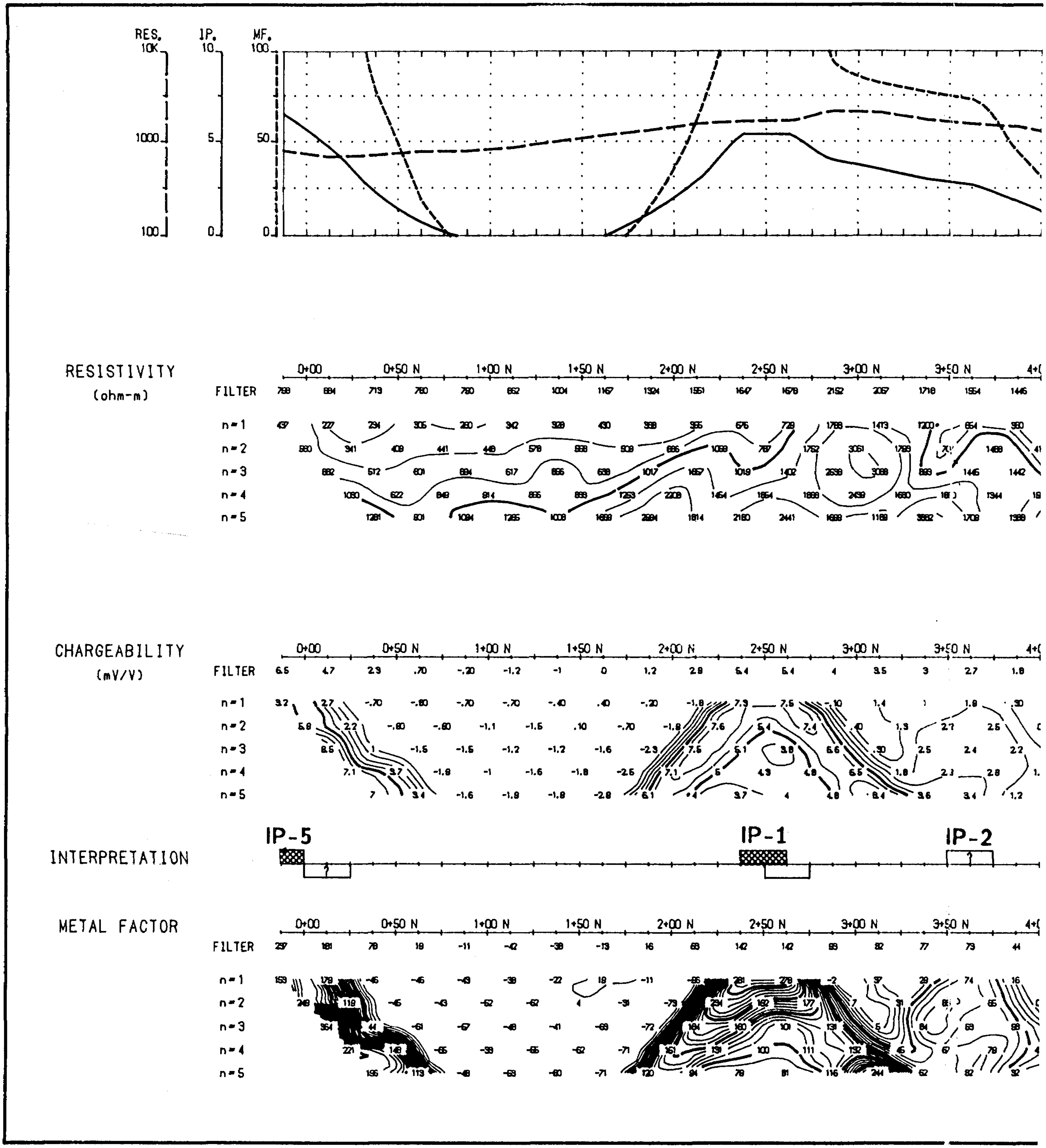
TECK EXPLORATION LTD.

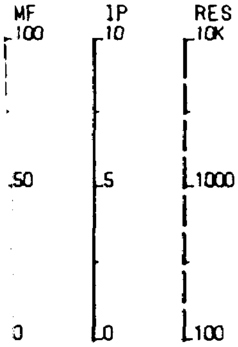
THUNDER LAKE PROJECT
ZEALAND TOWNSHIP
WABIGOON, ONT.

Interpreted by: Joël Simard
Date of Survey: September 1990
Intruments: IP-6, IPT-1
Surveyed by: Pierre Caron

SAGAX GEOPHYSIQUE

Reference: SAGAX 90368

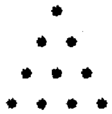

RES.
10K
1000
100
IP.
10
5
0
MF.
100
50
0
RESISTIVITY
(ohm-m)
CHARGEABILITY
(mV/V)
INTERPRETATION
IP-5
IP-1
IP-2
METAL FACTOR
FILTER
n=1
n=2
n=3
n=4
n=5
0+00
0+50 N
1+00 N
1+50 N
2+00 N
2+50 N
3+00 N
3+50 N

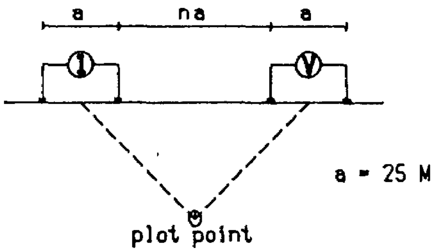


INDUCED POLARIZATION SURVEY

Dipole-Dipole Array

Filter





RESISTIVITY
(ohm-m)

FILTER

n=1
n=2
n=3
n=4
n=5

Contour Interval:
Resistivity: 1, 1.5, 2, 3, 5, 7.5, 10,...
Chargeability: 1, 5
Metal Factor: 10, 50

Metal Factor Definition: $MF = 1000 \cdot IP/\sqrt{res}$

CHARGEABILITY
(mV/V)

FILTER

n=1
n=2
n=3
n=4
n=5

Line 10+00 W

Scale 1:2500

INTERPRETATION

METAL FACTOR

FILTER

n=1
n=2
n=3
n=4
n=5

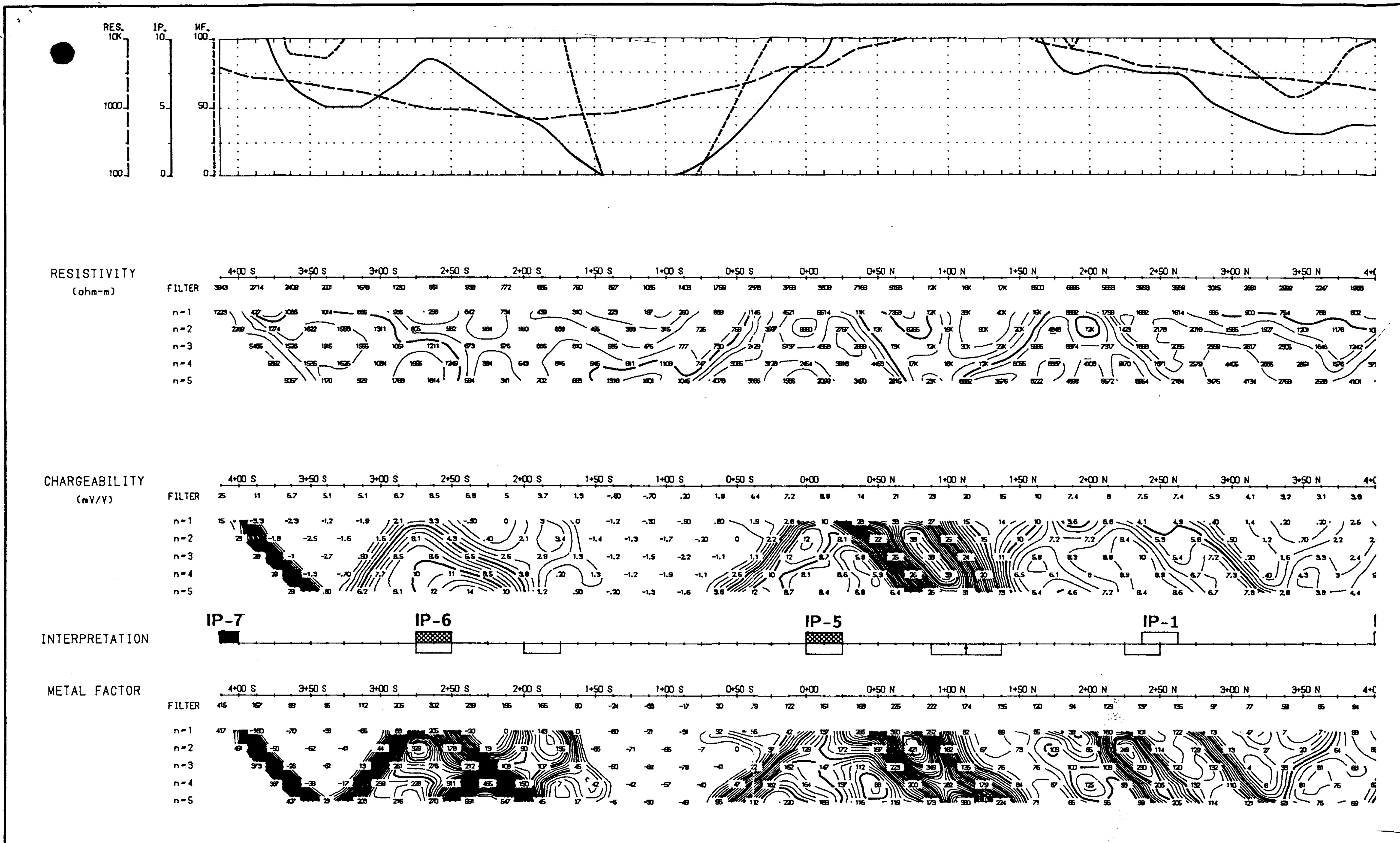
TECK EXPLORATION LTD.

THUNDER LAKE PROJECT
ZEALAND TOWNSHIP
WABIGOON, ONT.

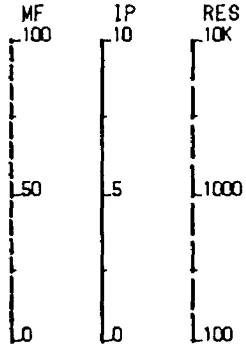
Interpreted by: Joël Simard
Date of Survey: September 1990
Intruments: IP-6, IPT-1
Surveyed by: Pierre Caron

SAGAX
GEOPHYSIQUE

Reference: SAGAX 90368



RES.
IP.
MF.
RESISTIVITY
(ohm-m)
CHARGEABILITY
(mV/V)
INTERPRETATION
METAL FACTOR
FILTER
n=1
n=2
n=3
n=4
n=5
4+00 S
3+50 S
3+00 S
2+50 S
2+00 S
1+50 S
1+00 S
0+50 S
0+00
0+50 N
1+00 N
1+50 N
2+00 N
2+50 N
3+00 N
3+50 N
IP-7
IP-6
IP-5
IP-1



RESISTIVITY

FILTER (ohm-m)

n=1
n=2
n=3
n=4
n=5

CHARGEABILITY

FILTER (mV/V)

n=1
n=2
n=3
n=4
n=5

INTERPRETATION

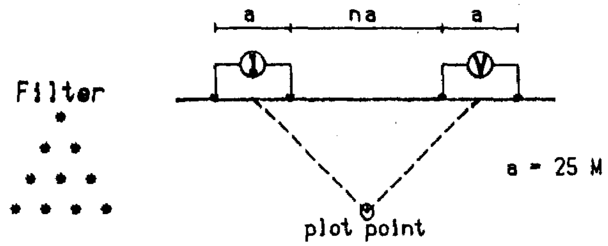
METAL FACTOR

FILTER

n=1
n=2
n=3
n=4
n=5

INDUCED POLARIZATION SURVEY

Dipole-Dipole Array



Contour Interval:
Resistivity: 1, 1.5, 2, 3, 5, 7.5, 10,...
Chargeability: 1, 5
Metal Factor: 10, 50

Metal Factor Definition: $MF = 1000 \cdot IP/\sqrt{res}$

Line 8+25 W

Scale 1:2500

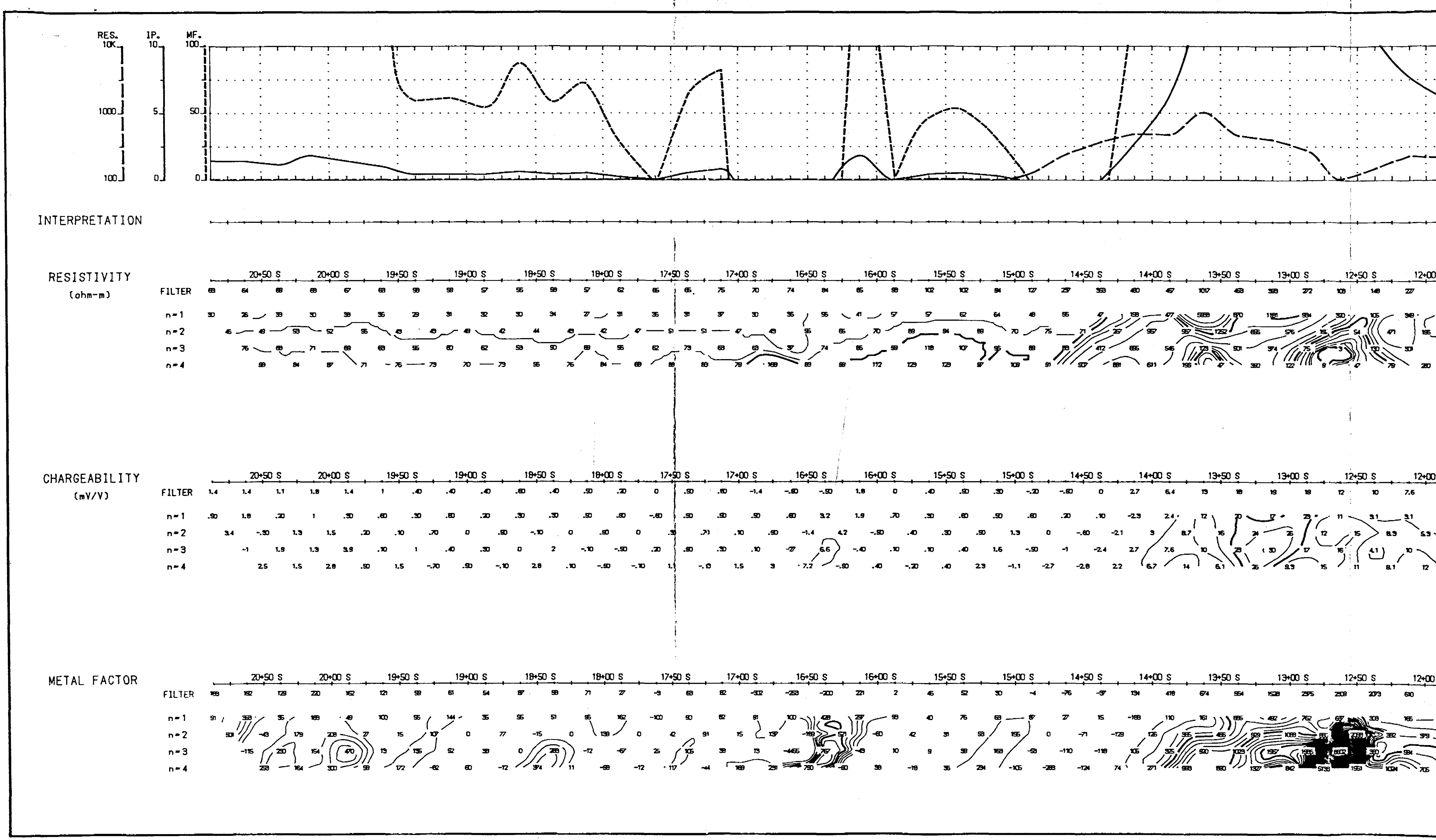
TECK EXPLORATION LTD.

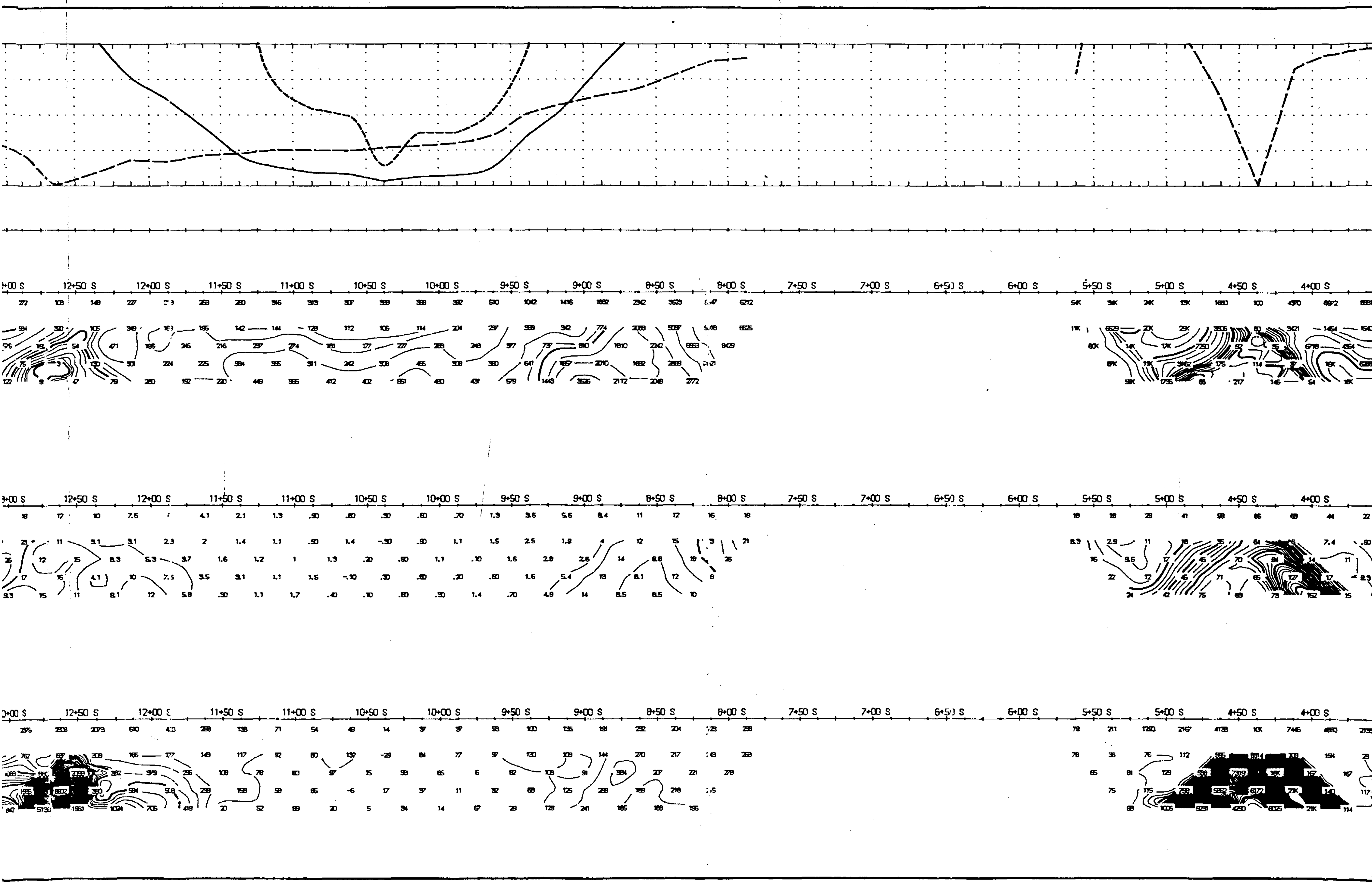
THUNDER LAKE PROJECT
ZEALAND TOWNSHIP
WABIGOON, ONT.

Interpreted by: Joël Simard
Date of Survey: September 1990
Intruments: IP-6, IPT-1
Surveyed by: Pierre Caron

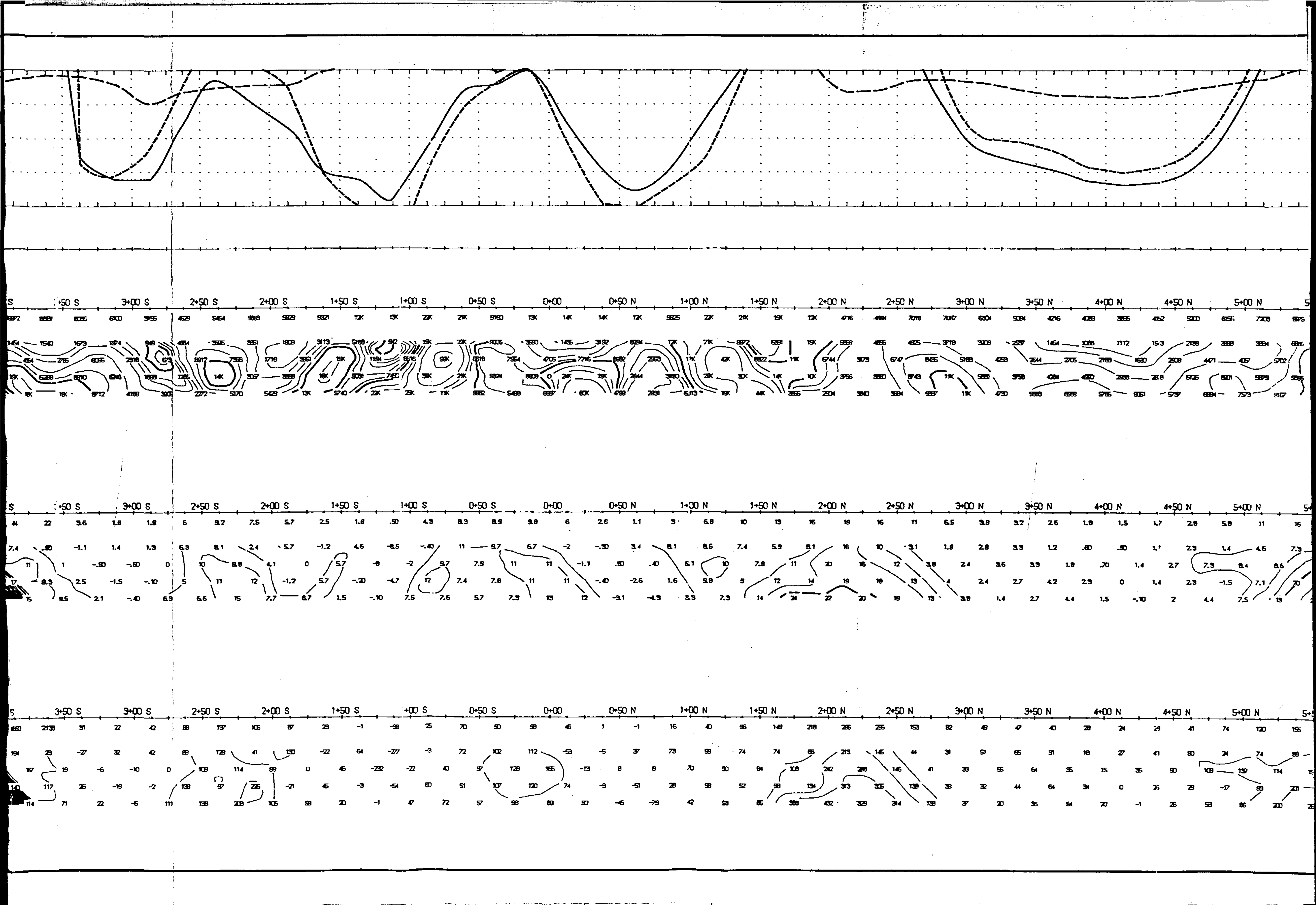
SAGAX GEOPHYSIQUE

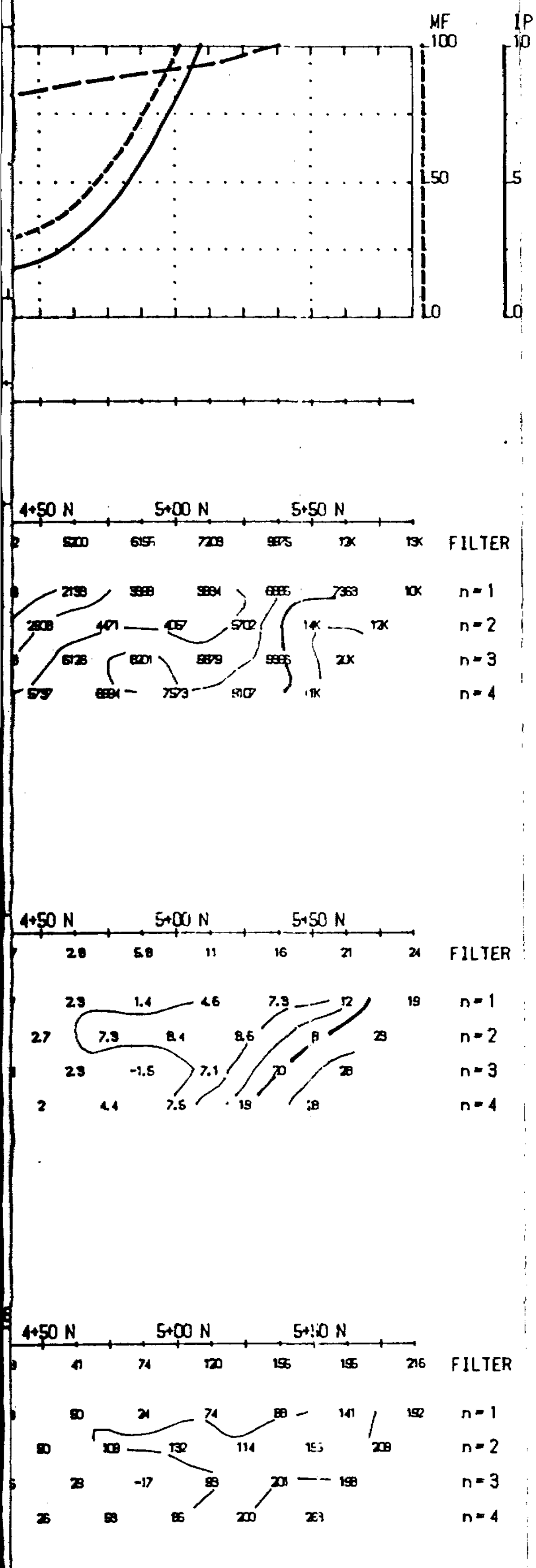
Reference: SAGAX 90368


RES.
IP.
MF.
INTERPRETATION
RESISTIVITY
(ohm-m)
CHARGEABILITY
(mV/V)
METAL FACTOR
FILTER
n=1
n=2
n=3
n=4
20+50 S
20+00 S
19+50 S
19+00 S
18+50 S
18+00 S
17+50 S
17+00 S
16+50 S
16+00 S
15+50 S
15+00 S
14+50 S
14+00 S
13+50 S
13+00 S
12+50 S
12+00 S



12+50 S
12+00 S
11+50 S
11+00 S
10+50 S
10+00 S
9+50 S
9+00 S
8+50 S
8+00 S
7+50 S
7+00 S
6+50 S
6+00 S
5+50 S
5+00 S
4+50 S
4+00 S


3+50 S
3+00 S
2+50 S
2+00 S
1+50 S
1+00 S
0+50 S
0+00
0+50 N
1+00 N
1+50 N
2+00 N
2+50 N
3+00 N
3+50 N
4+00 N
4+50 N
5+00 N



INTERPRETATION

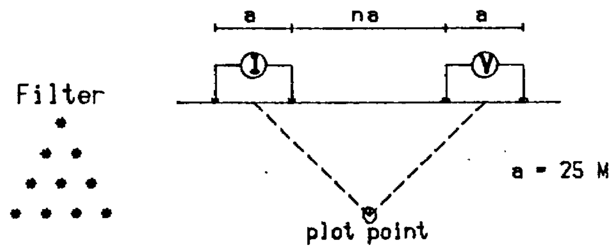
RESISTIVITY
(ohm-m)

CHARGEABILITY
(mV/V)

METAL FACTOR

INDUCED POLARIZATION SURVEY

Dipole-Dipole Array



Contour Interval:
Resistivity: 1, 2, 5, 7, 10,...
Chargeability: 2, 10
Metal Factor: 20, 100

Metal Factor Definition: MF = 1000*IP/√res

Line 24+00 E

Scale 1:2500

25 0 25 50 75 100 125
(metres)

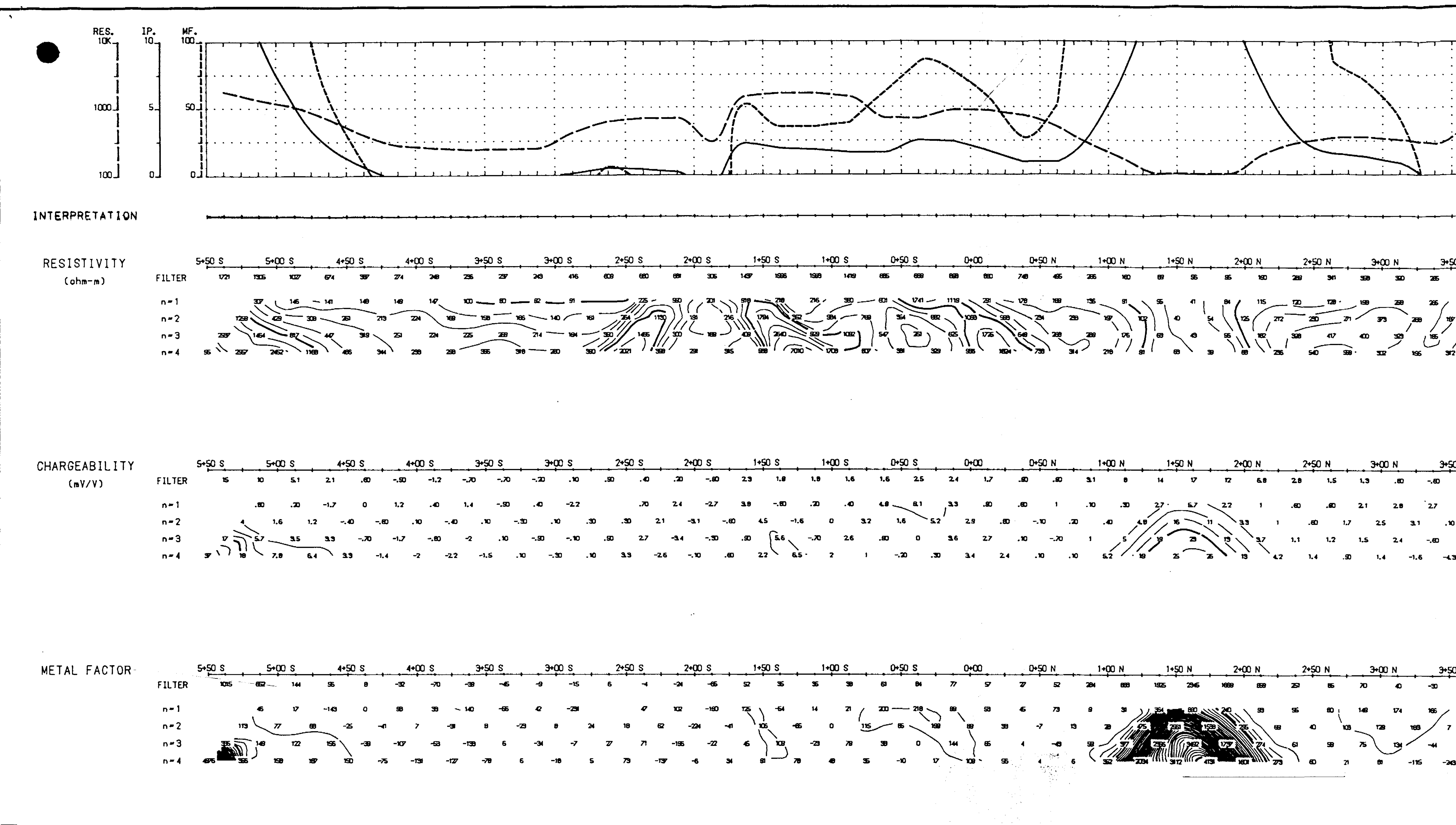
TECK EXPLORATIONS LTD.

THUNDER LAKE PROJECT
ZEALAND TOWNSHIP
WABIGOON, ONT.

Interpreted by: Joël Simard
Date of Survey: September 1990
Intruments: IP-6, IPT-1
Surveyed by: Pierre Caron

SAGAX GEOPHYSIQ

Reference: SAGAX 90368


RES.
10K
1000
100
IP.
10
5
0
MF.
100
50
0
INTERPRETATION
RESISTIVITY
(ohm-m)
CHARGEABILITY
(mV/V)
METAL FACTOR
FILTER
n=1
n=2
n=3
n=4
5+50 S
5+00 S
4+50 S
4+00 S
3+50 S
3+00 S
2+50 S
2+00 S
1+50 S
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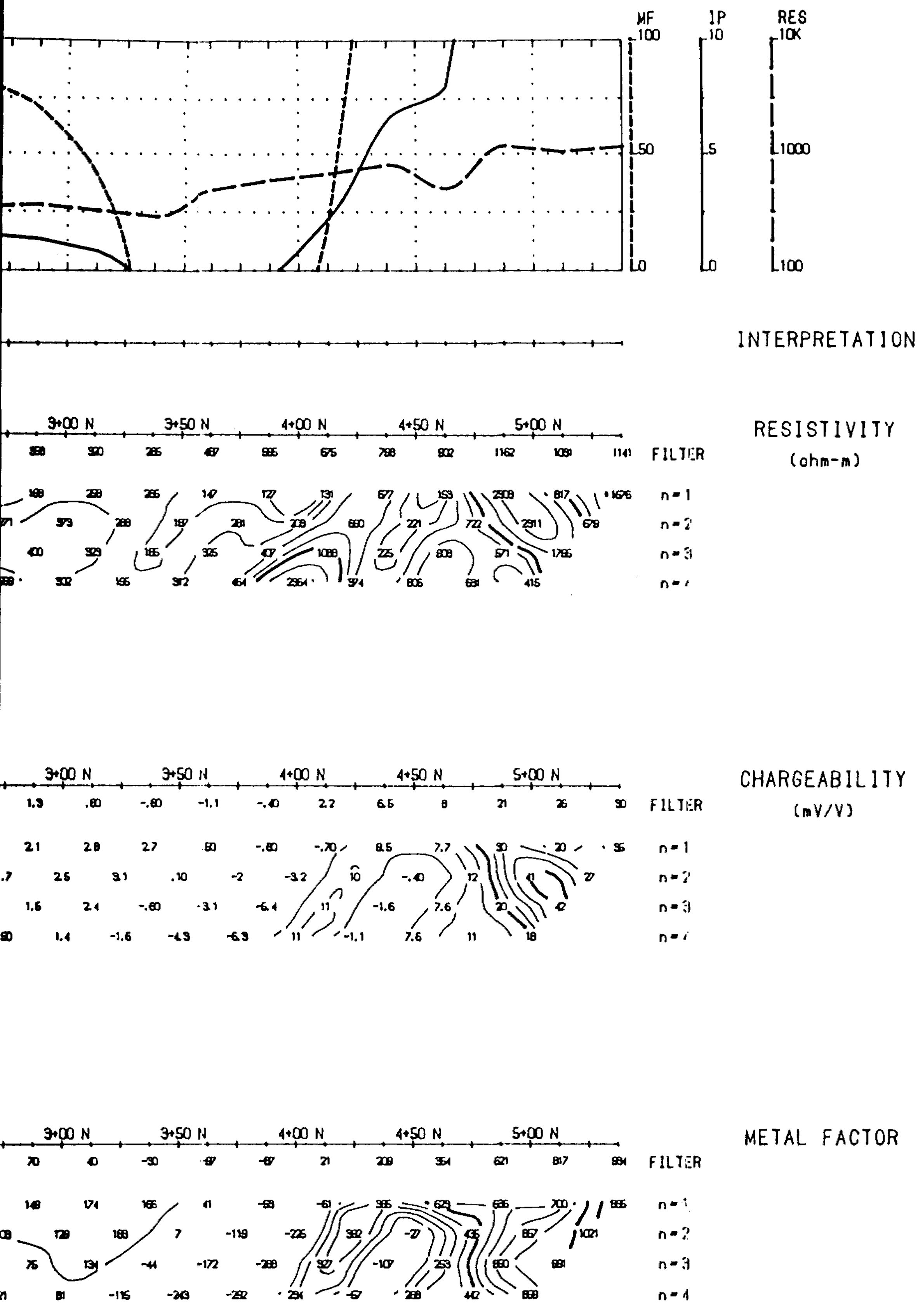
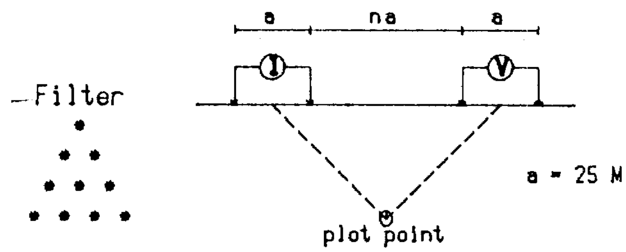
2+50 N
3+00 N
3+50



INDUCED POLARIZATION SURVEY



Contour Interval:
- Resistivity: 1, 2, 5, 7, 10,...
- Chargeability: 2, 10
- Metal Factor: 20, 100

Metal Factor Definition: MF = 1000•IP/$\sqrt{res}$

Line 26+00 E

Scale 1:2500

25 0 25 50 75 100 125

(metres)

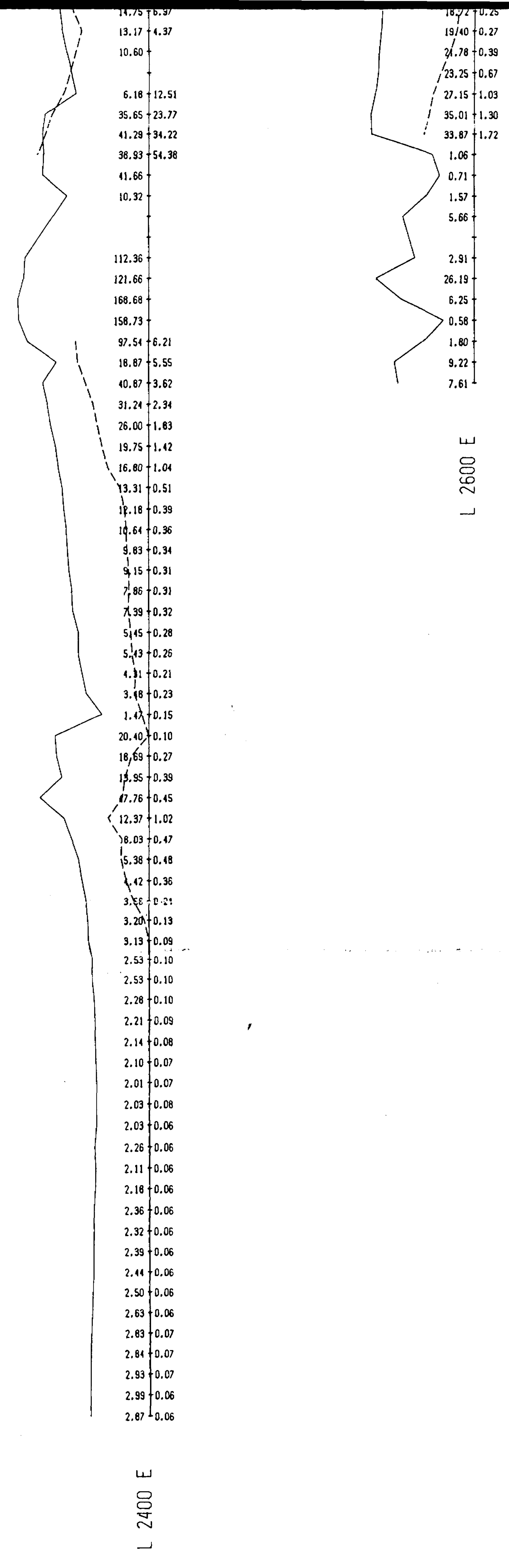
TECK EXPLORATIONS LTD.

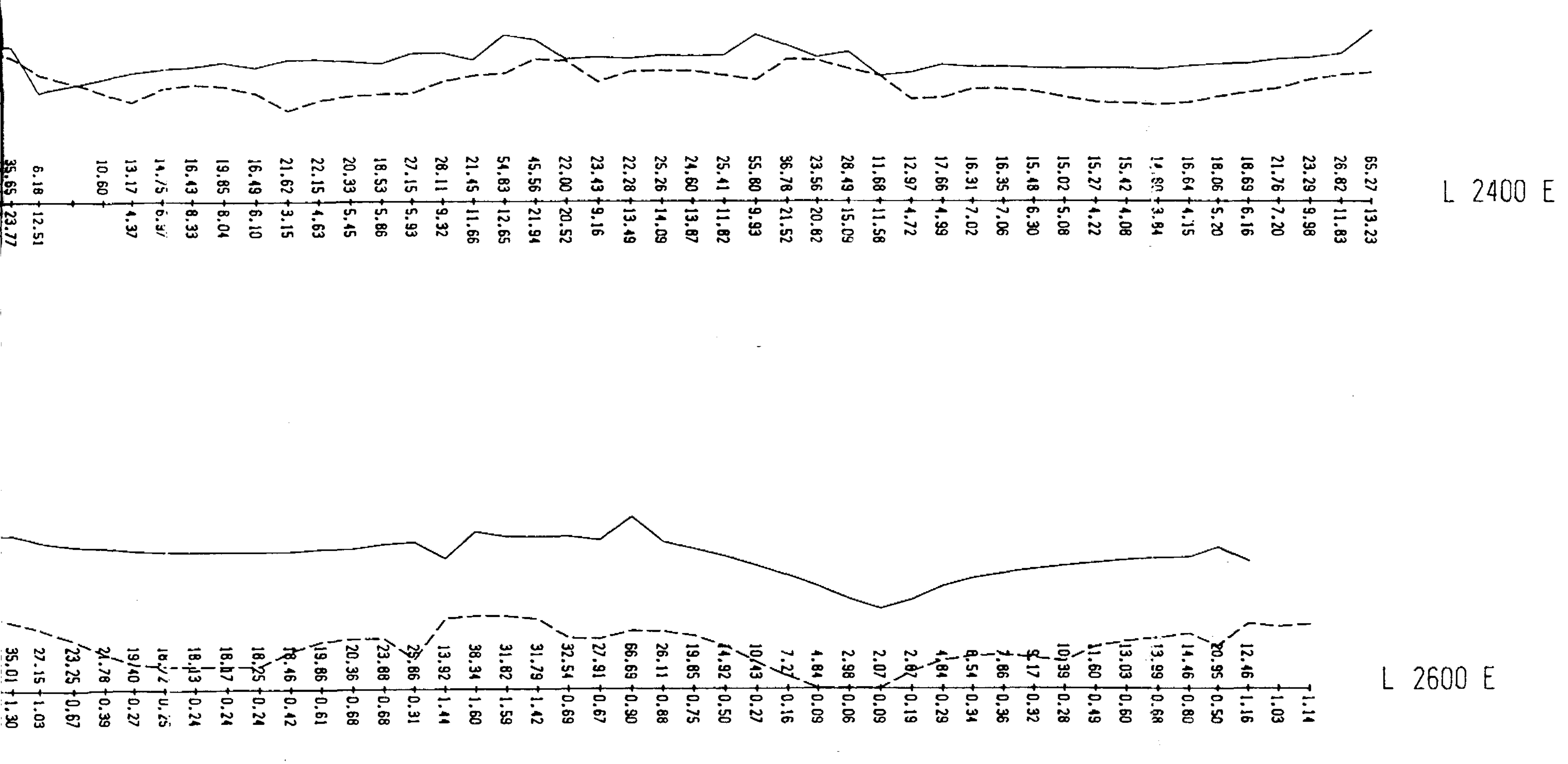
THUNDER LAKE PROJECT
ZEALAND TOWNSHIP
WABIGOON, ONT.

Interpreted by: Joël Simard
Date of Survey: September 1990
Intruments: IP-6, IPT-1
Surveyed by: Pierre Caron

SAGAX GEOPHYSIQUE

Reference: SAGAX 90368


14.75 6.97
13.17 4.37
10.60
6.18 12.51
35.65 23.77
41.29 34.22
38.93 54.38
41.66
10.32
112.36
121.66
168.68
158.73
97.54 6.21
18.87 5.55
40.87 3.62
31.24 2.34
26.00 1.83
19.75 1.42
16.80 1.04
13.31 0.51
12.18 0.39
10.64 0.36
9.83 0.34
9.15 0.31
7.86 0.31
7.39 0.32
5.45 0.28
5.43 0.26
4.31 0.21
3.48 0.23
1.47 0.15
20.40 0.10
18.69 0.27
13.95 0.39
17.76 0.45
12.37 1.02
18.03 0.47
5.38 0.48
4.42 0.36
3.58 0.21
3.20 0.13
3.13 0.09
2.53 0.10
2.53 0.10
2.28 0.10
2.21 0.09
2.14 0.08
2.10 0.07
2.01 0.07
2.03 0.08
2.03 0.06
2.26 0.06
2.11 0.06
2.18 0.06
2.36 0.06
2.32 0.06
2.39 0.06
2.44 0.06
2.50 0.06
2.63 0.06
2.83 0.07
2.84 0.07
2.93 0.07
2.99 0.06
2.87 0.06
L 2400 E
18.72 0.25
19.40 0.27
21.78 0.39
23.25 0.67
27.15 1.03
35.01 1.30
33.87 1.72
1.06
0.71
1.57
5.66
2.91
26.19
6.25
0.58
1.80
9.22
7.61
L 2600 E



PPT : ————

Dipole-Dipole : – – – –

Vertical Scale: 1 decade per cm

SCALE 1 : 5 000

TECK EXPLORATIONS LTD.

THUNDER LAKE PROJECT

ZEALAND TWP., WABIGOON, ONT.

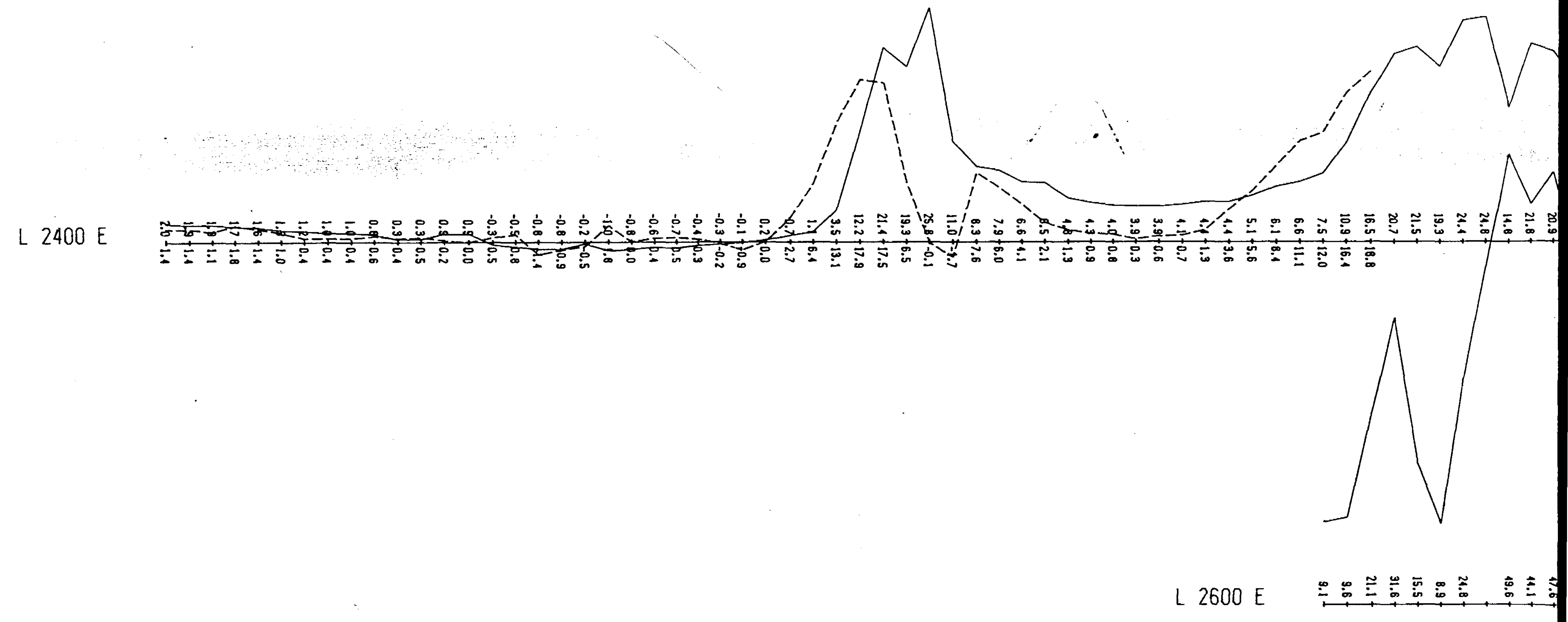
INDUCED POLARIZATION SURVEY

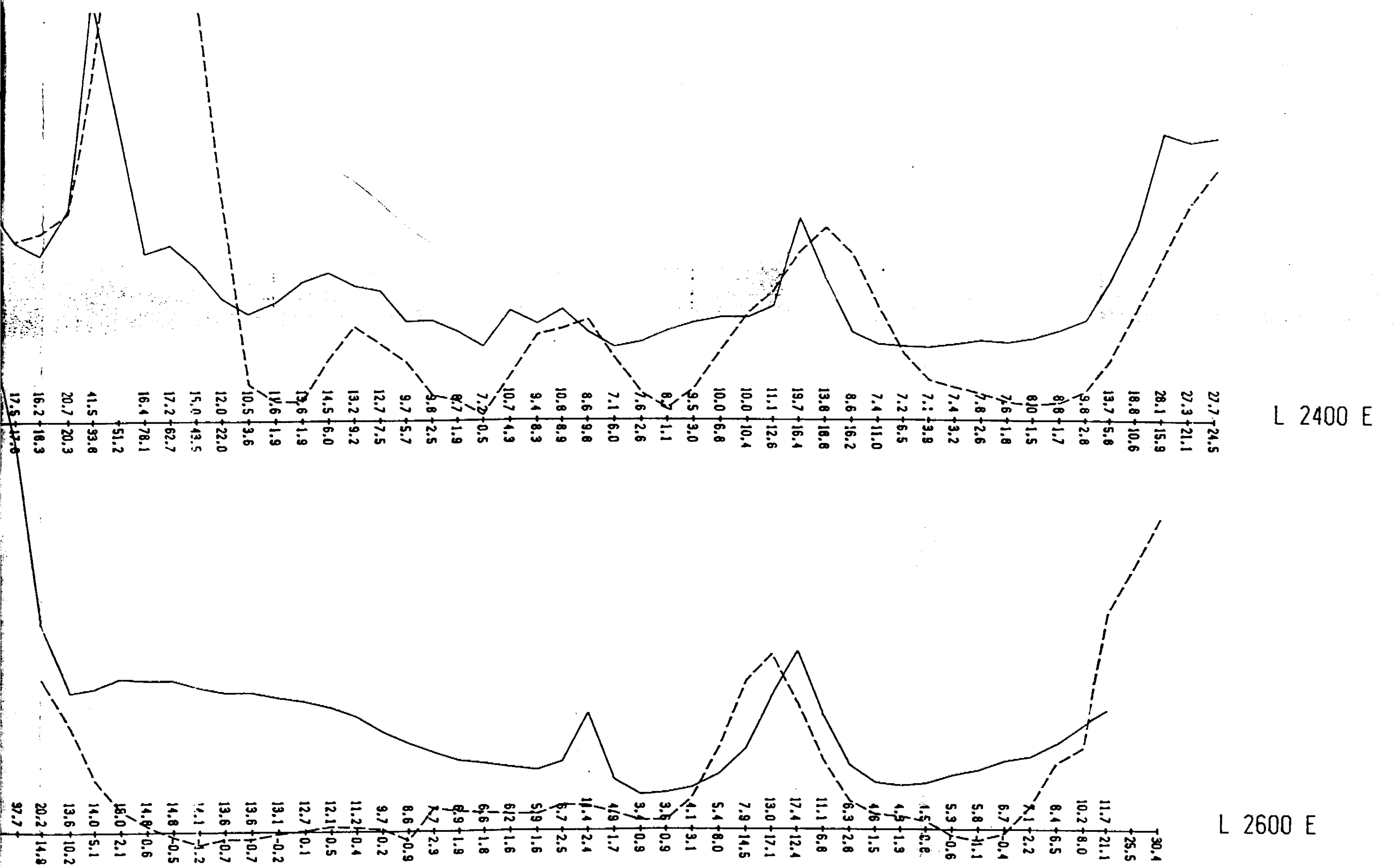
APPARENT RESISTIVITY PROFILES

(Ω ohm-m)

Survey by:	P. Caron, B.Sc.
Interpreted by:	R. Lachapelle, P.Eng.
Date :	September 1990
Reference:	SAGAX 90358

SAGAX GEOPHYSIQUE


L 2400 E
L 2600 E



PPT : ————

Dipole-Dipole : – – – –

Vertical Scale: 5 mV/V per cm

SCALE 1 : 5 000

TECK EXPLORATIONS LTD.

THUNDER LAKE PROJECT

ZEALAND TWP., WABIGOON, ONT.

INDUCED POLARIZATION SURVEY

APPARENT CHARGEABILITY PROFILES

(mV/V)

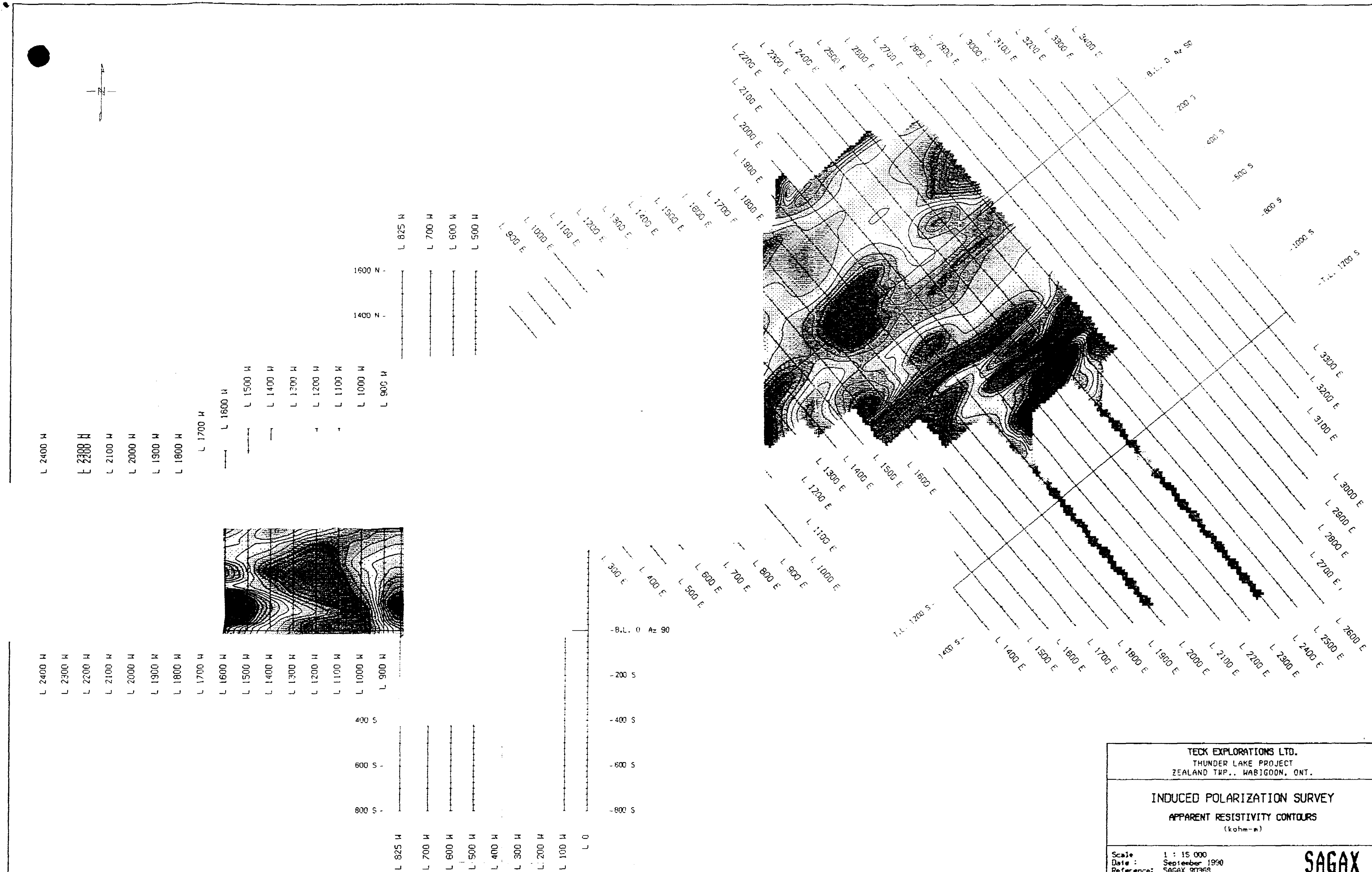
Survey by: P. Caron, B.Sc.

Interpreted by: R. Lachapelle, P.Eng.

Date : September 1990

Reference: SAGAX [illegible]

SAGAX GEOPHYSIQUE



TECK EXPLORATIONS LTD.
THUNDER LAKE PROJECT
ZEALAND TWP., WABIGOON, ONT.

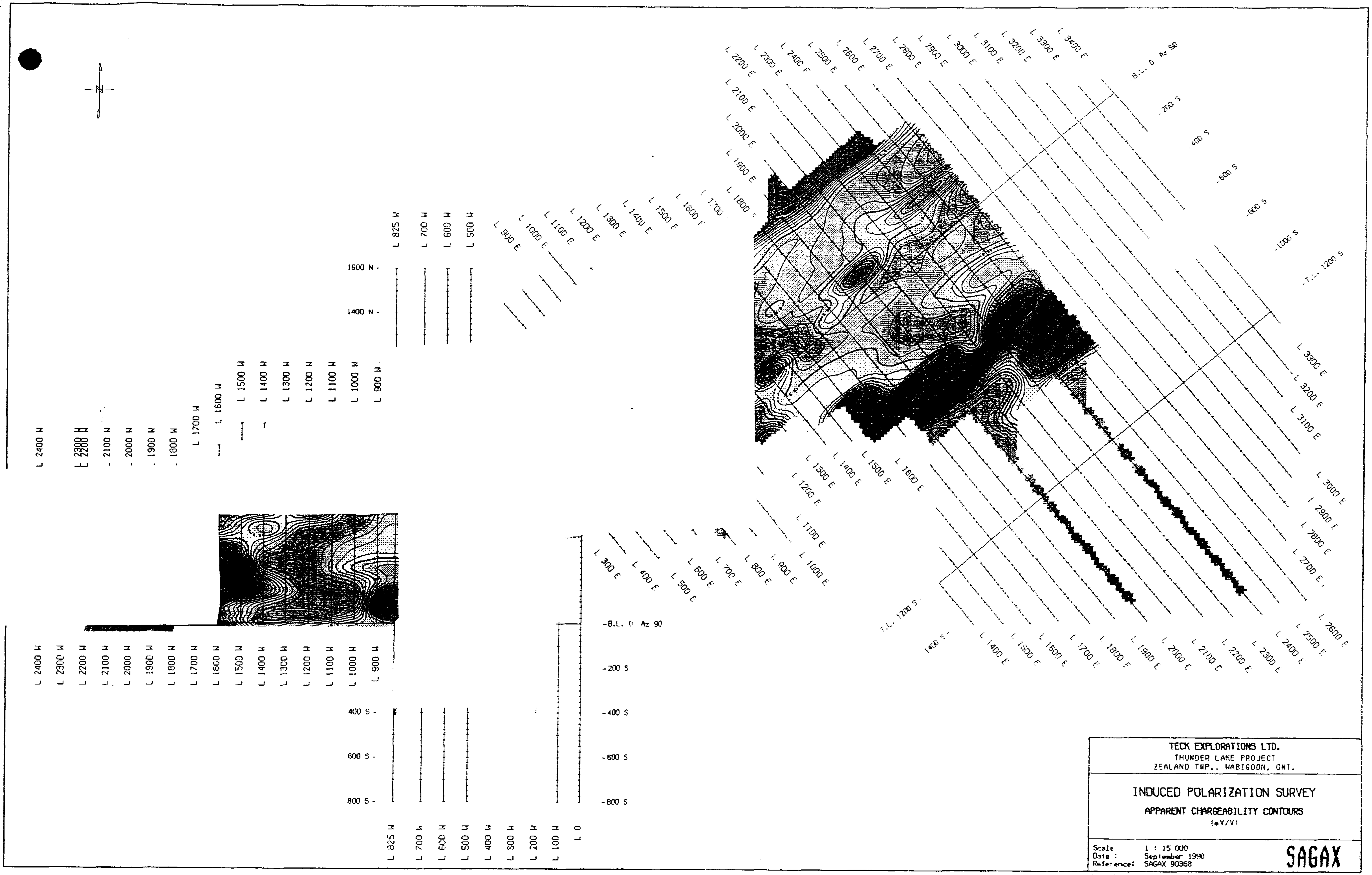
INDUCED POLARIZATION SURVEY

APPARENT RESISTIVITY CONTOURS

(kohm-m)

Scale: 1 : 15 000
Date: September 1990
Reference: SAGAX 90368

SAGAX



TECK EXPLORATIONS LTD.
THUNDER LAKE PROJECT
ZEALAND TWP., WABIGOON, ONT.

INDUCED POLARIZATION SURVEY

APPARENT CHARGEABILITY CONTOURS
(mV/V)

Scale : 1 : 15 000
Date : September 1990
Reference: SAGAX 90368

SAGAX

"ECK EXPLORATIONS LIMITED

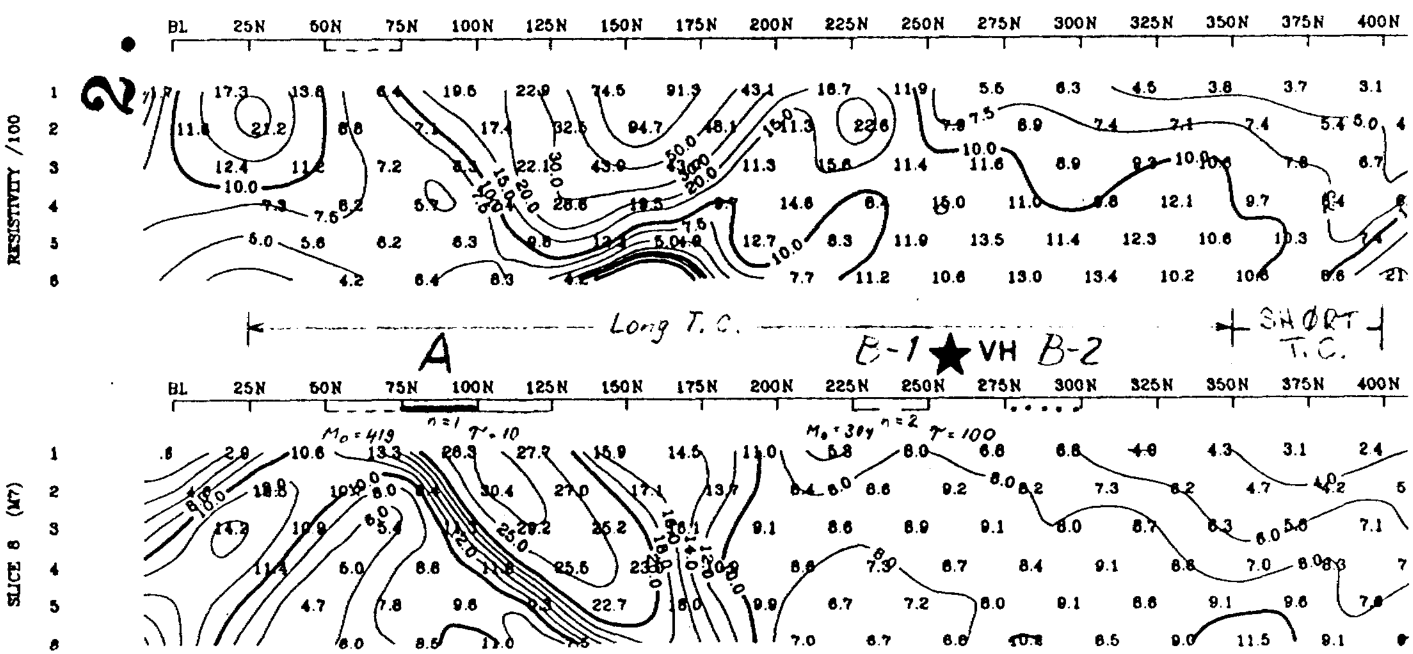
Thunder Lake Property, NW Ont.

LINE NUMBER: 825 WEST

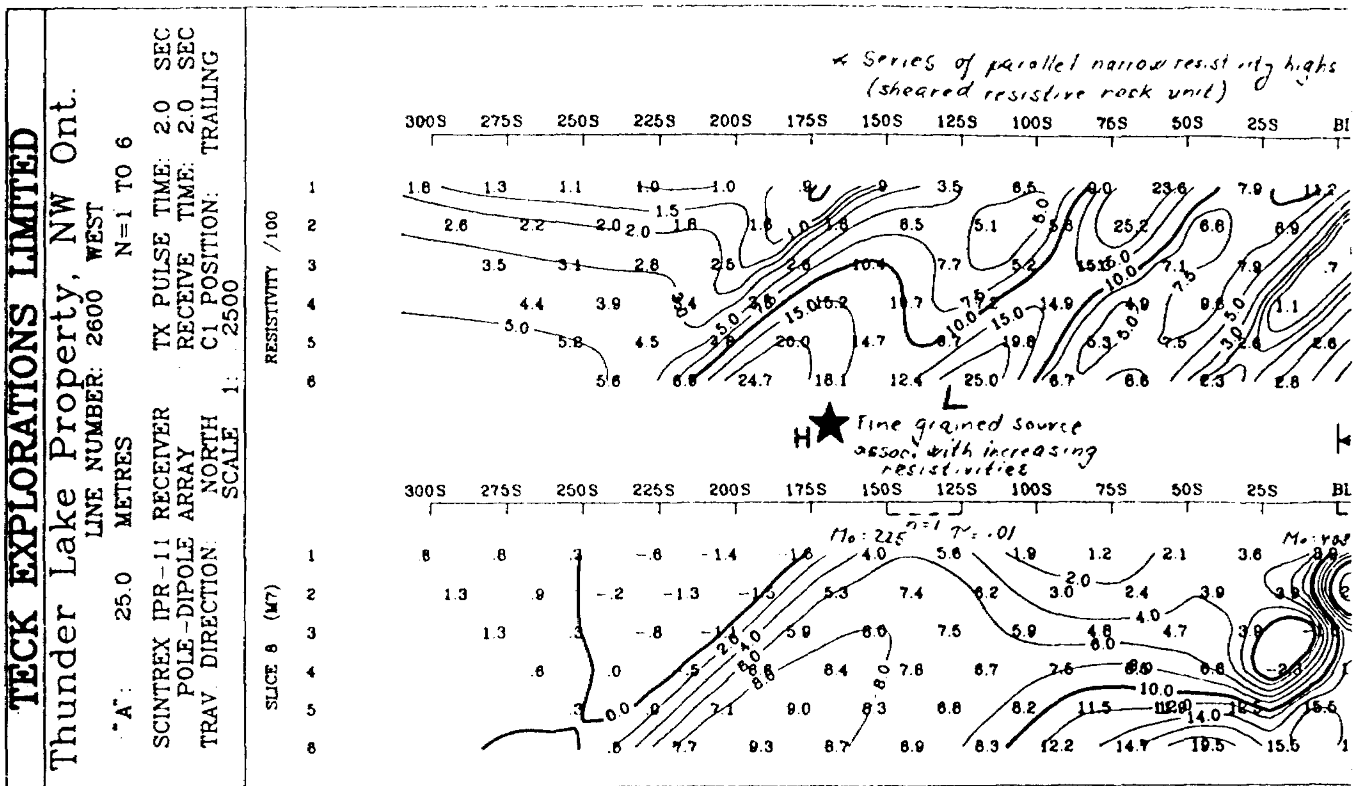
"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER TX PULSE TIME: 2.0 SEC
POLE-DIPOLE ARRAY RECEIVE TIME: 2.0 SEC
TRAV. DIRECTION: NORTH C1 POSITION: TRAILING
SCALE 1: 2500

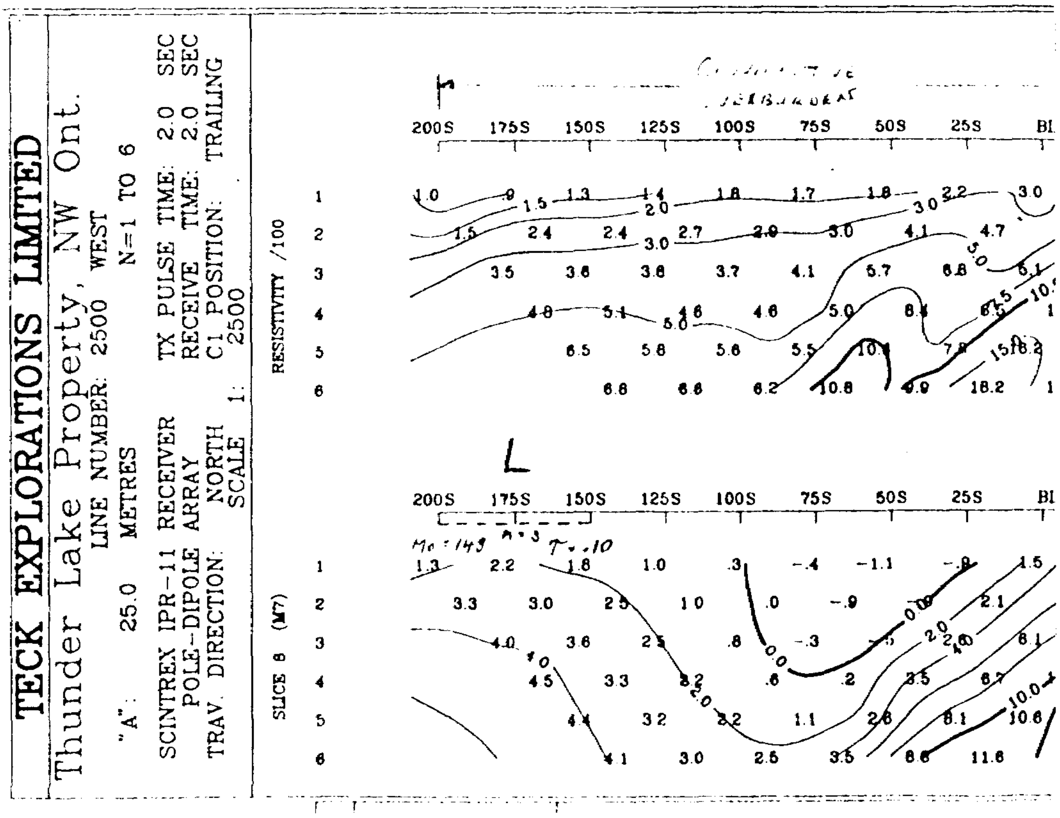
2.14711



2.14711



TECK EXPLORATIONS LIMITED
Thunder Lake Property, NW Ont.
LINE NUMBER: 2600 WEST
"A": 25.0 METRES
N=1 TO 6
SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH
TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING
SCALE 1: 2500
RESISTIVITY /100
SLICE 8 (M7)
* Series of parallel narrow resistivity highs (sheared resistive rock unit)
Fine grained source assoc. with increasing resistivities
300S 275S 250S 225S 200S 175S 150S 125S 100S 75S 50S 25S BL



TECK EXPLORATIONS LIMITED
Thunder Lake Property, NW Ont.
LINE NUMBER: 2500 WEST
"A": 25.0 METRES
N=1 TO 6
SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH
TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING
SCALE 1: 2500
RESISTIVITY /100
SLICE 8 (M7)
200S 175S 150S 125S 100S 75S 50S 25S BL

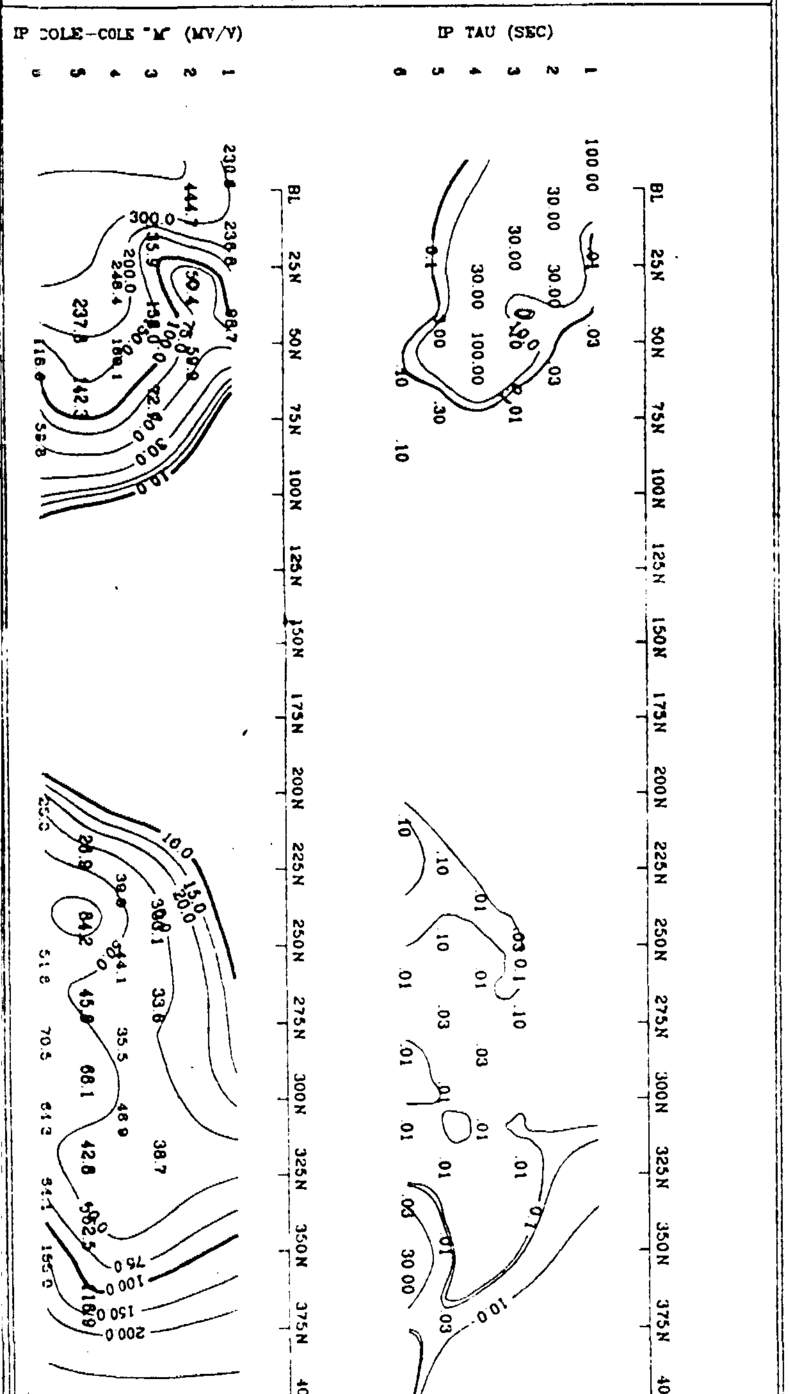
2.14711

TECK EXPLORATIONS LIMITED

Thunder Lake Property, NW Ont.
LINE NUMBER: 1200 WEST
"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH
SCALE 1: 2500

TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING

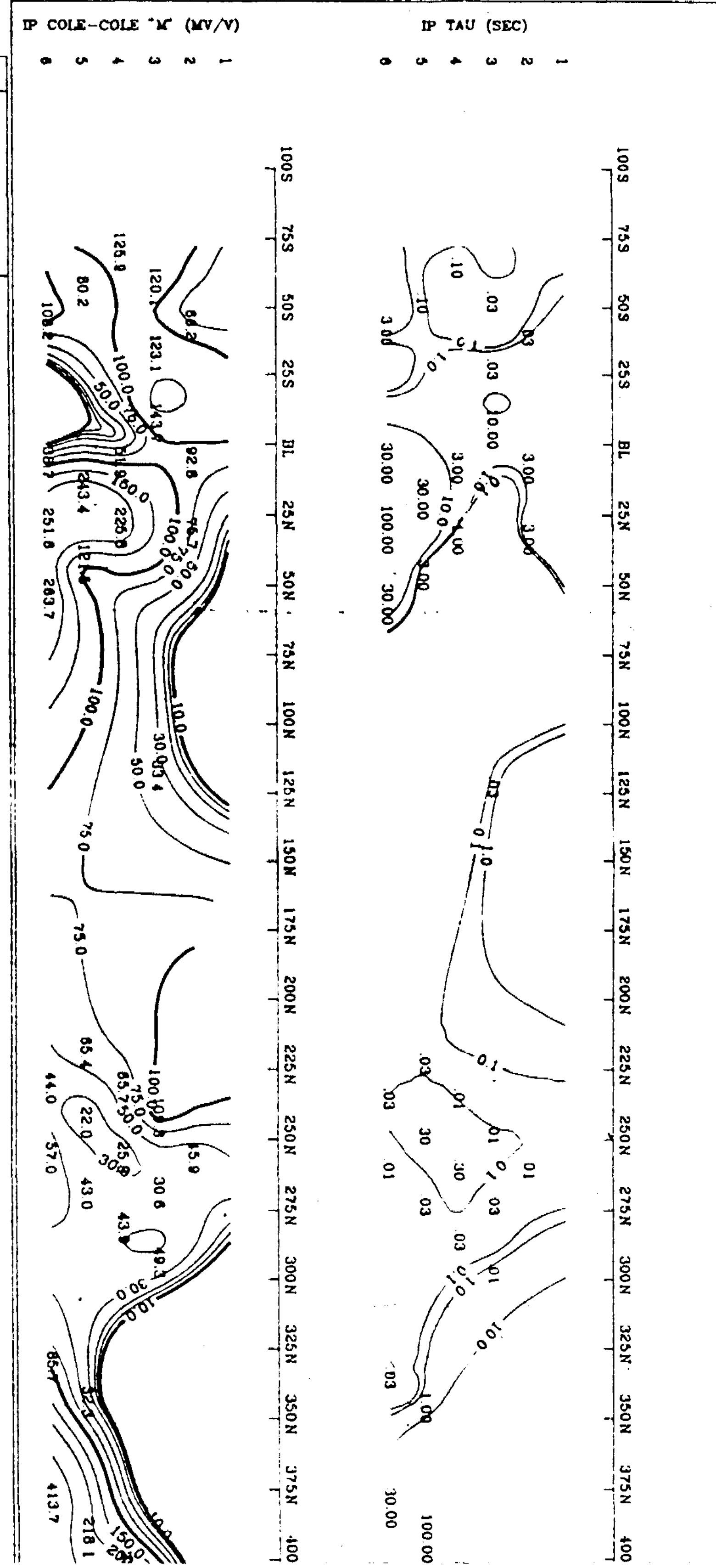


TECK EXPLORATIONS LIMITED

Thunder Lake Property, NW Ont.
LINE NUMBER: 1300 WEST
"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH
SCALE 1: 2500

TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING

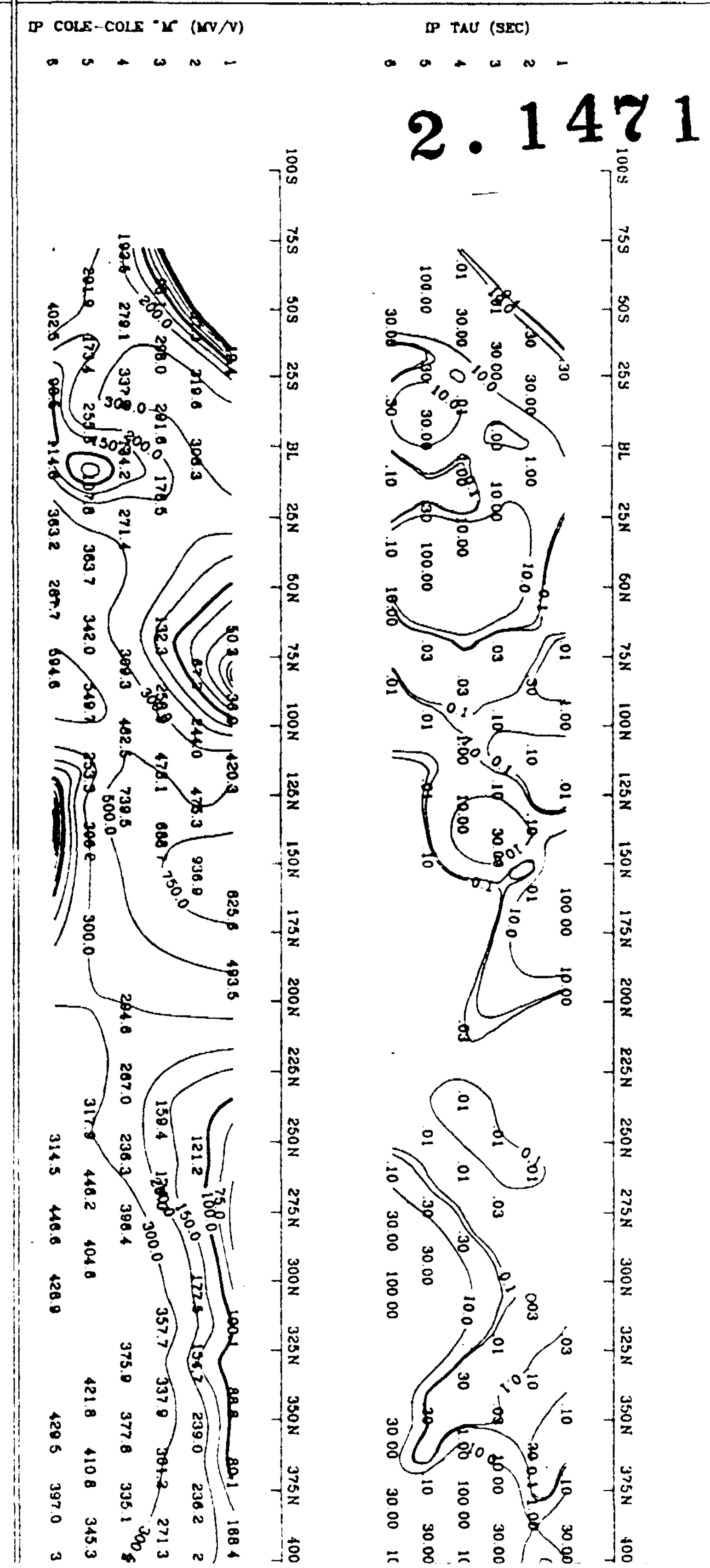


TECK EXPLORATIONS LIMITED

Thunder Lake Property, NW Ont.
LINE NUMBER: 1500 WEST
"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH
SCALE 1: 2500

TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING



TECK EXPLORATIONS LIMITED

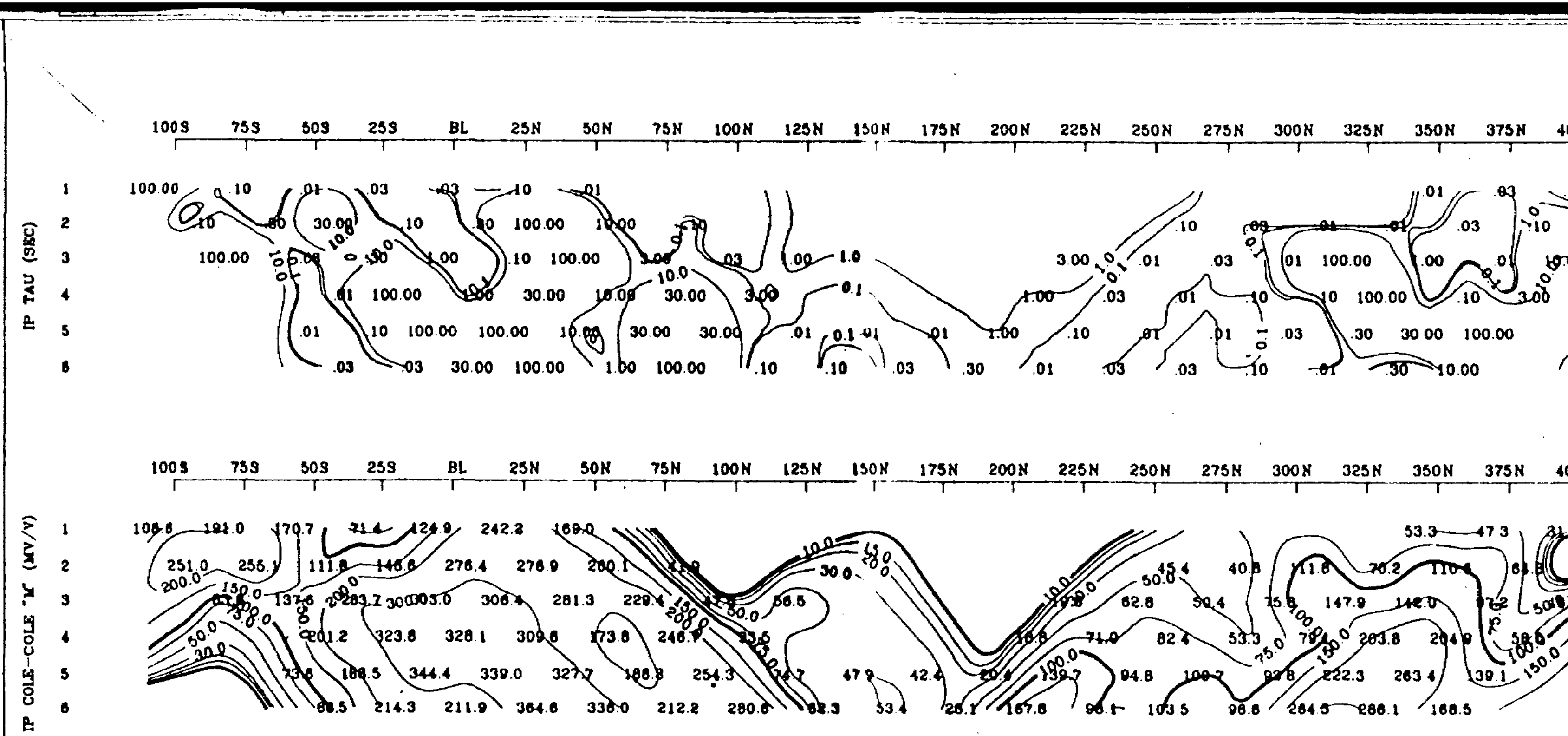
Thunder Lake Property, NW Ont.

LINE NUMBER: 1100 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH
SCALE 1: 2500

TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING



TECK EXPLORATIONS LIMITED

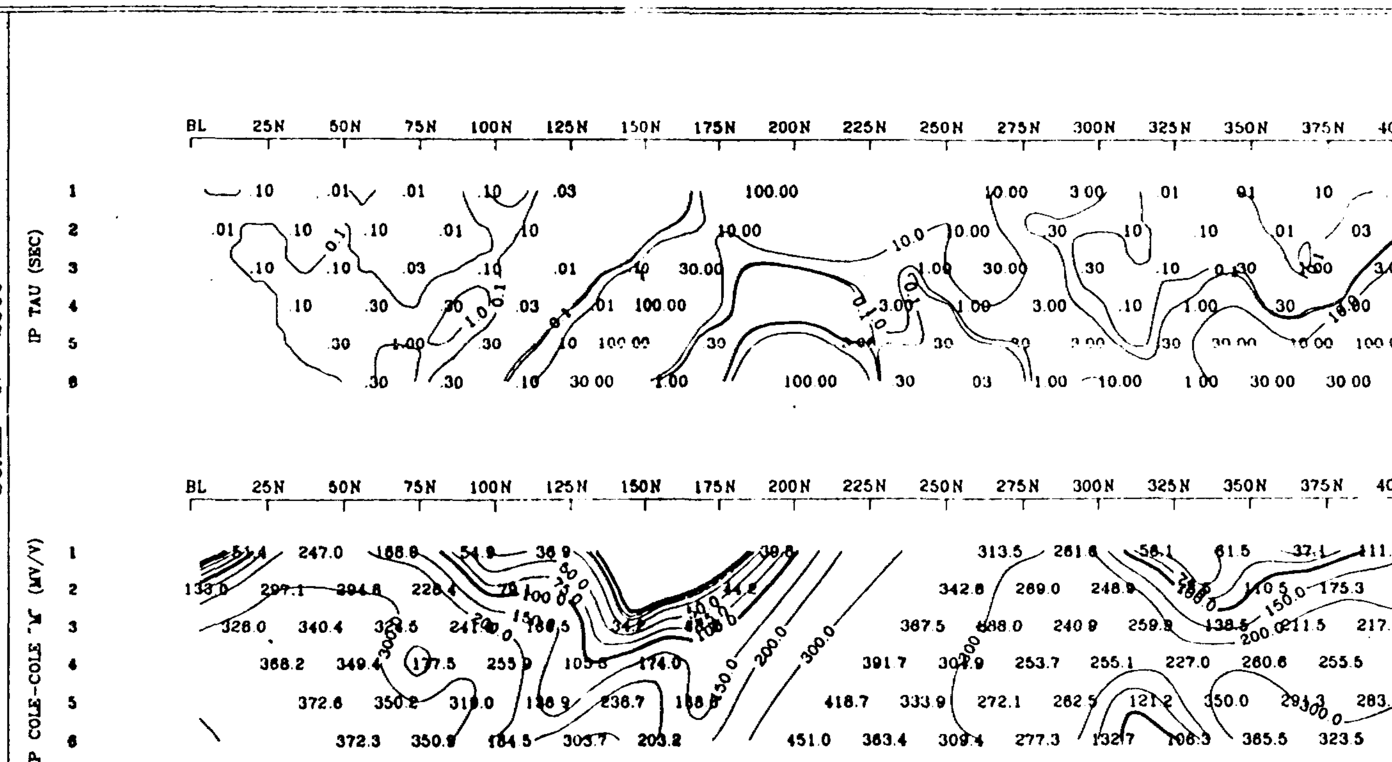
Thunder Lake Property, NW Ont.

LINE NUMBER: 1000 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH
SCALE 1: 2500

TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING



TECK EXPLORATIONS LIMITED

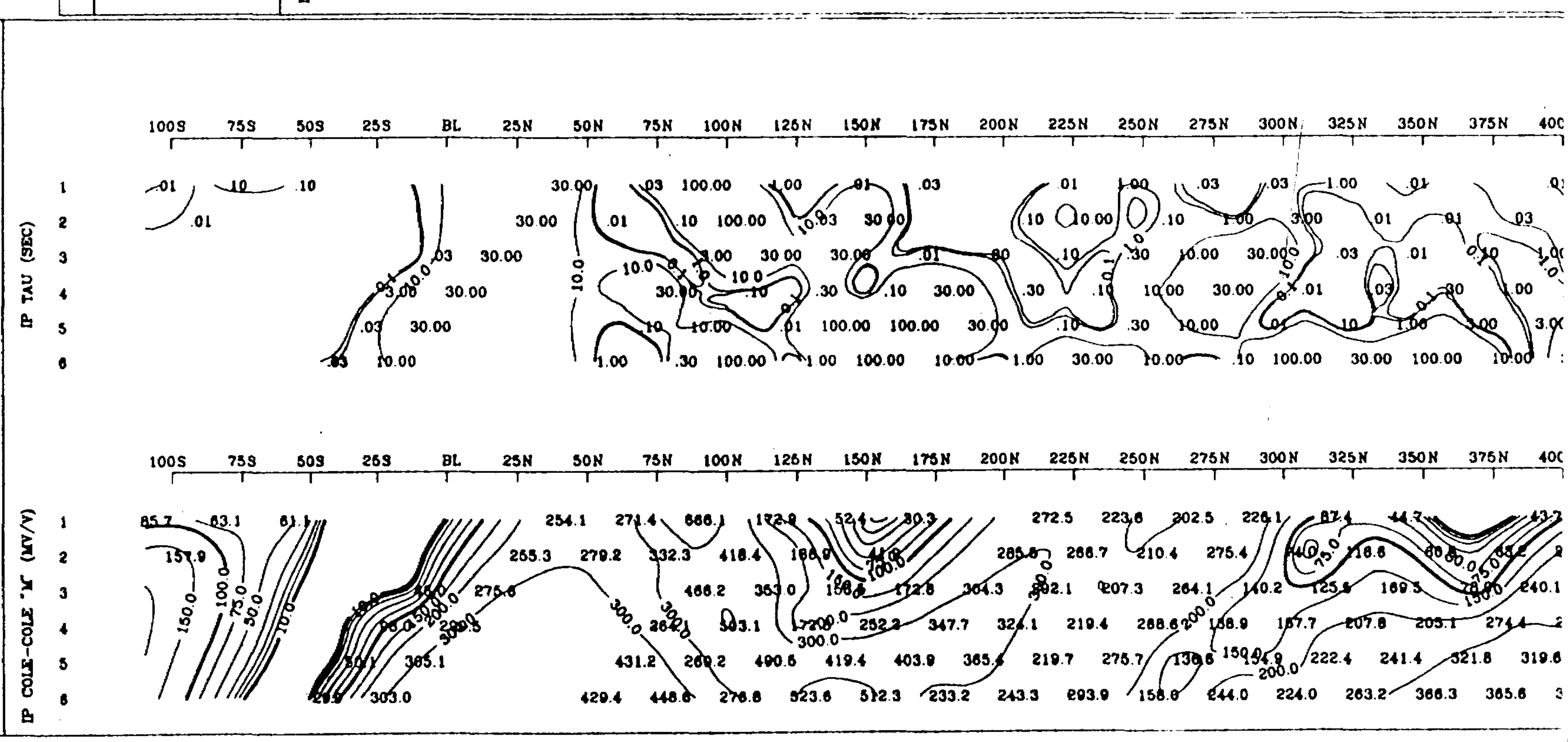
Thunder Lake Property, NW Ont.

LINE NUMBER: 900 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH
SCALE 1: 2500

TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING



2.14711

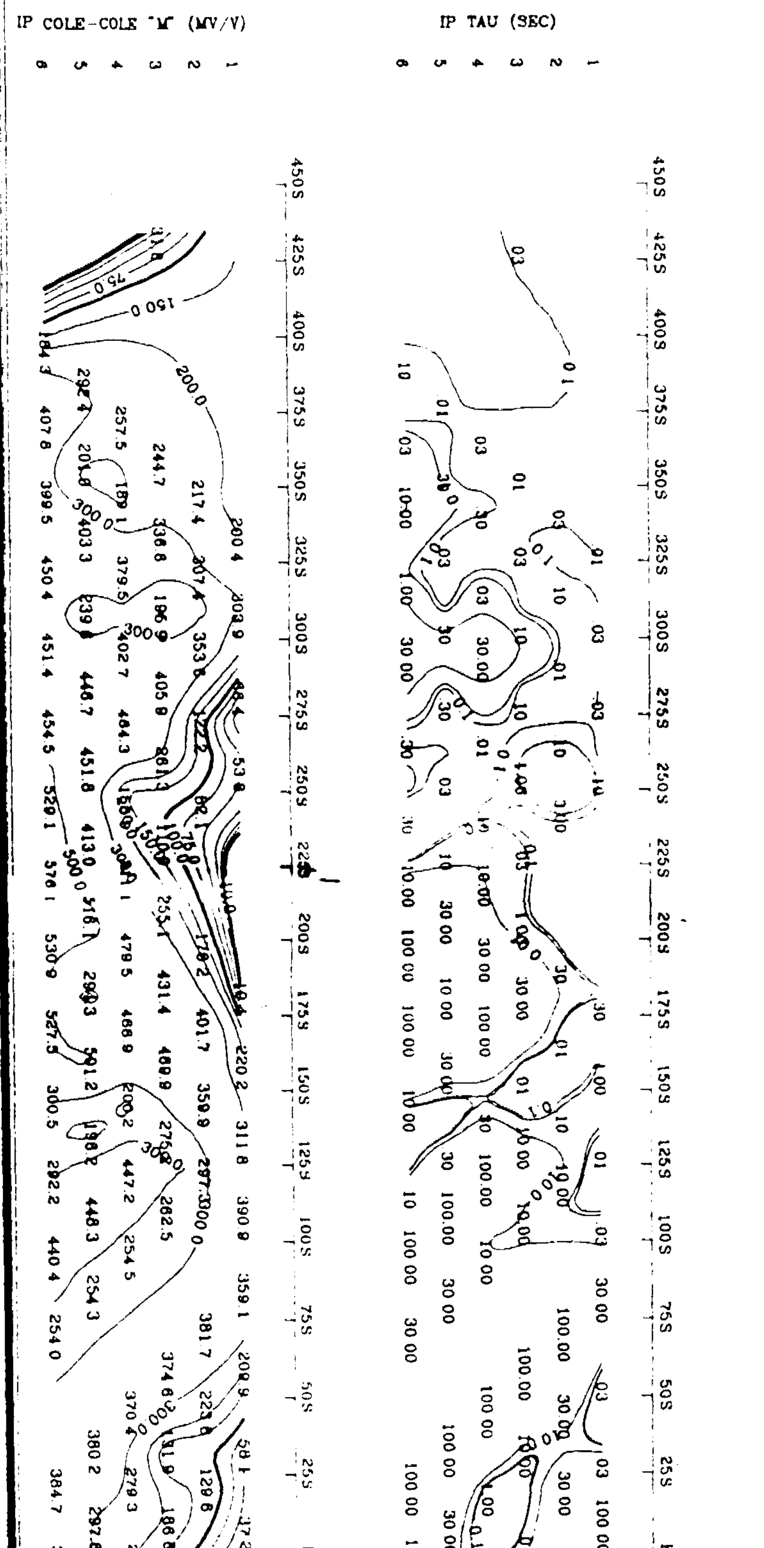
TECK EXPLORATIONS LIMITED

Thunder Lake Property, NW Ont.

LINE NUMBER: 3000 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER TX PULSE TIME: 2.0 SEC
POLE-DIPOLE ARRAY RECEIVE TIME: 2.0 SEC
TRAV. DIRECTION: NORTH C1 POSITION: TRAILING
SCALE 1: 2500



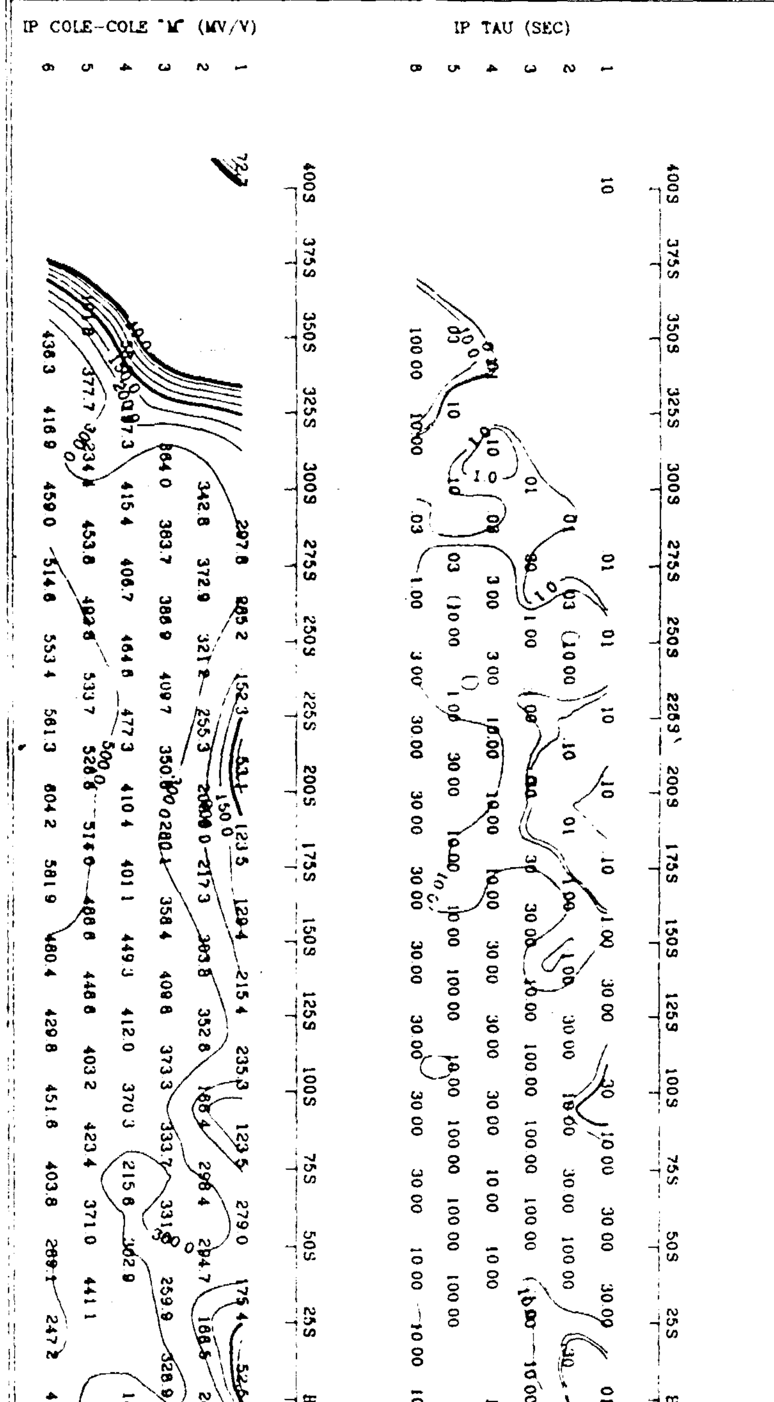
TECK EXPLORATIONS LIMITED

Thunder Lake Property, NW Ont.

LINE NUMBER: 3100 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER TX PULSE TIME: 2.0 SEC
POLE-DIPOLE ARRAY RECEIVE TIME: 2.0 SEC
TRAV. DIRECTION: NORTH C1 POSITION: TRAILING
SCALE 1: 2500



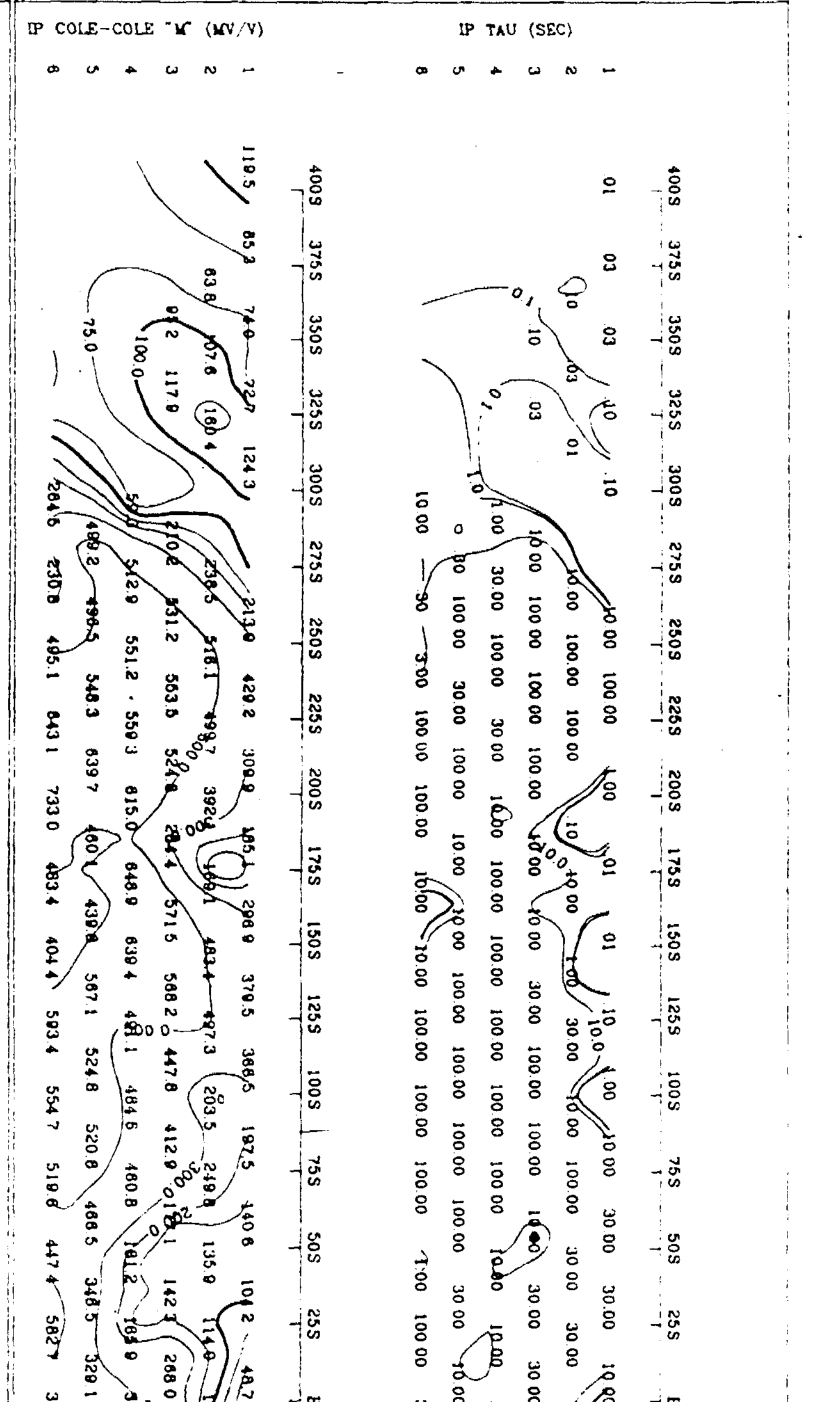
TECK EXPLORATIONS LIMITED

Thunder Lake Property, NW Ont.

LINE NUMBER: 3200 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER TX PULSE TIME: 2.0 SEC
POLE-DIPOLE ARRAY RECEIVE TIME: 2.0 SEC
TRAV. DIRECTION: NORTH C1 POSITION: TRAILING
SCALE 1: 2500



TECK EXPLORATIONS LIMITED

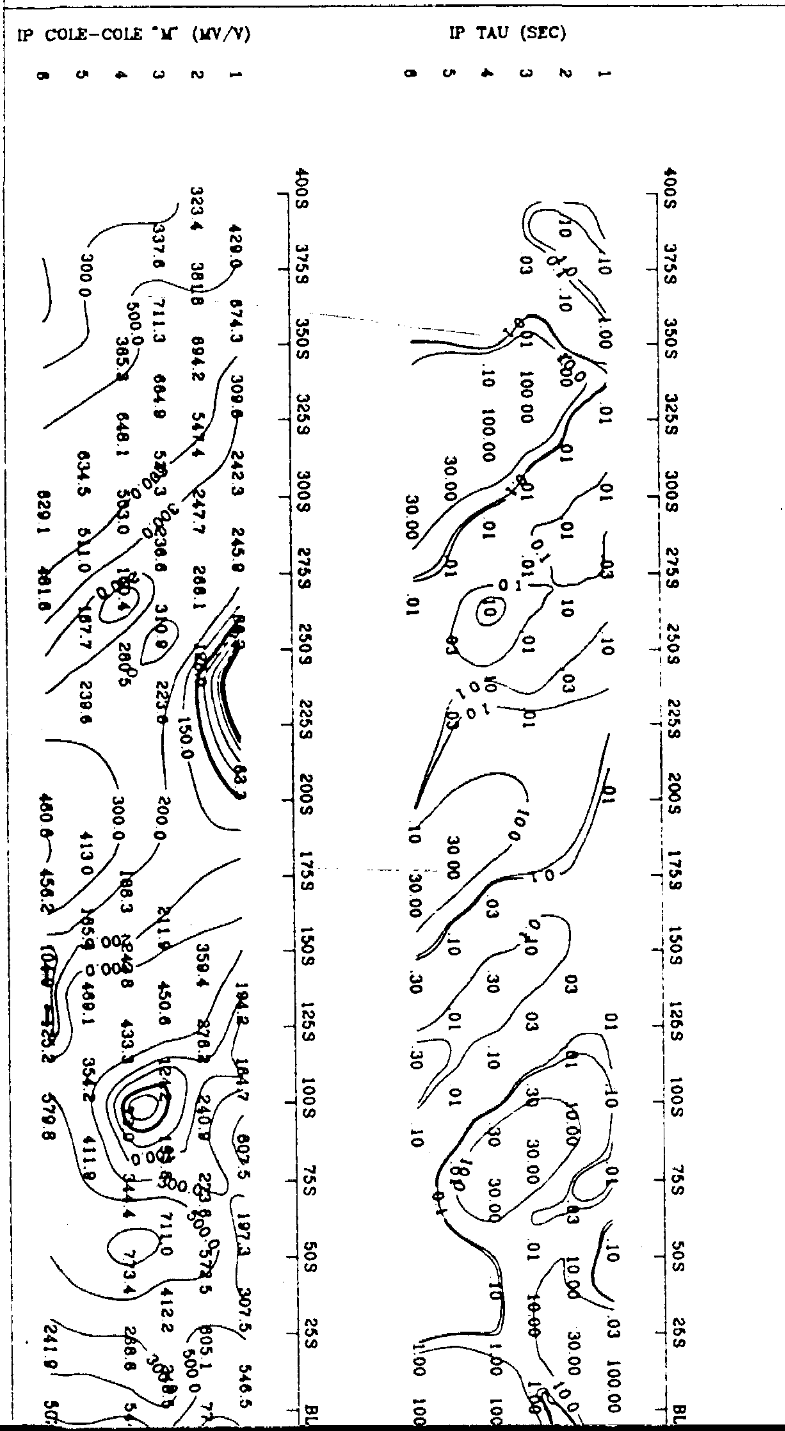
Thunder Lake Property, NW Ont.

LINE NUMBER: 2700 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH

TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING
SCALE 1: 2500



TECK EXPLORATIONS LIMITED

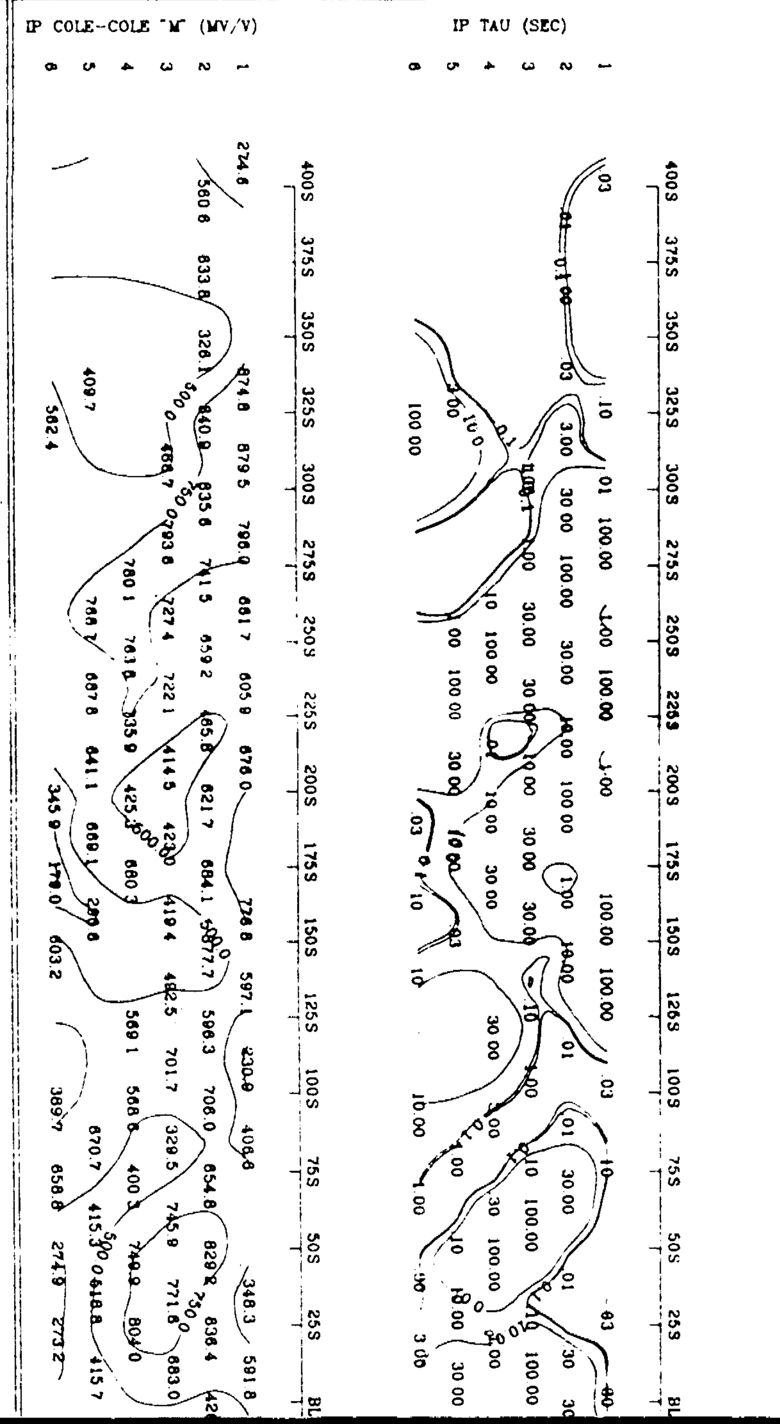
Thunder Lake Property, NW Ont.

LINE NUMBER 2800 WEST

"A": 25.0 , METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH

TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING
SCALE 1: 2500



TECK EXPLORATIONS LIMITED

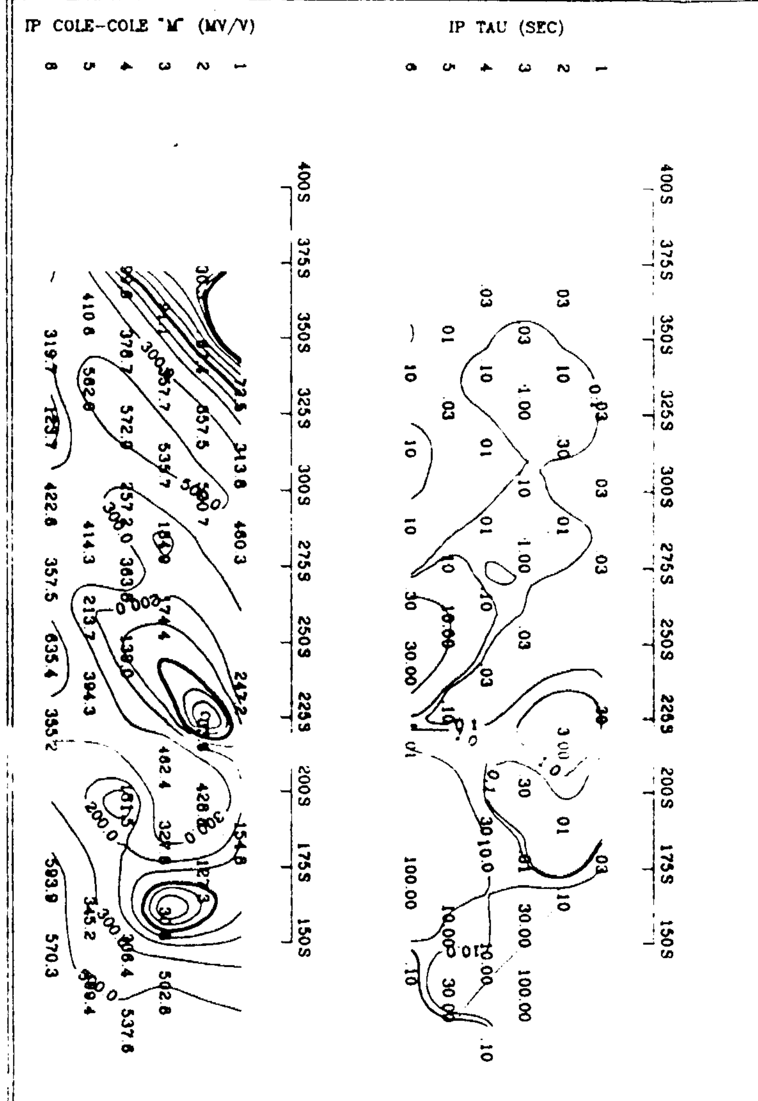
Thunder Lake Property, NW Ont.

LINE NUMBER: 2900 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH

TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING
SCALE 1: 2500



2.14711

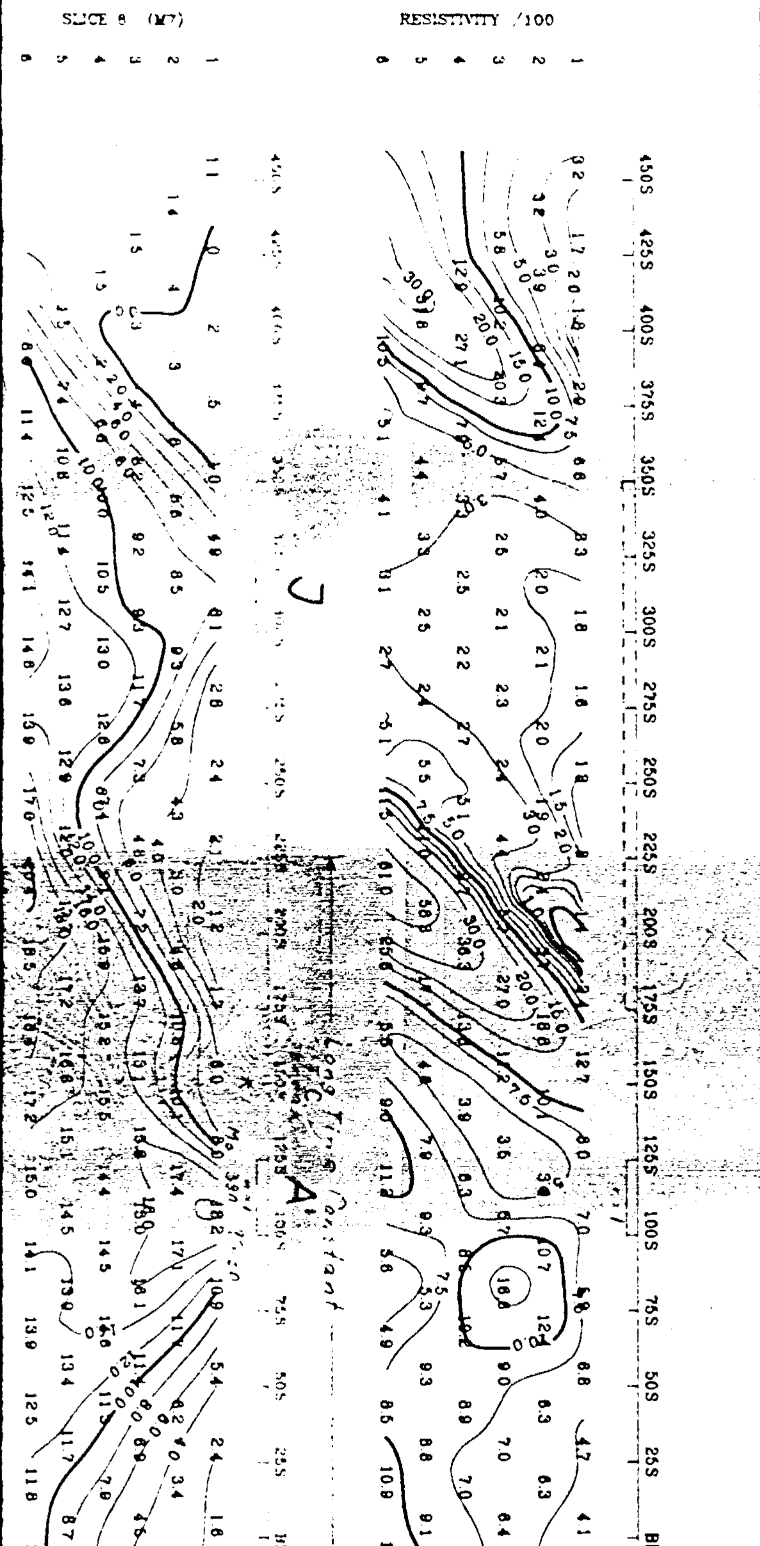
TECK EXPLORATIONS LIMITED

Thunder Lake Property, NW Ont.

LINE NUMBER: 3000 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER | TX PULSE TIME: 2.0 SEC
POLE-DIPOLE ARRAY | RECEIVE TIME: 2.0 SEC
TRAV. DIRECTION: NORTH | C1 POSITION: TRAILING
SCALE 1: 2500



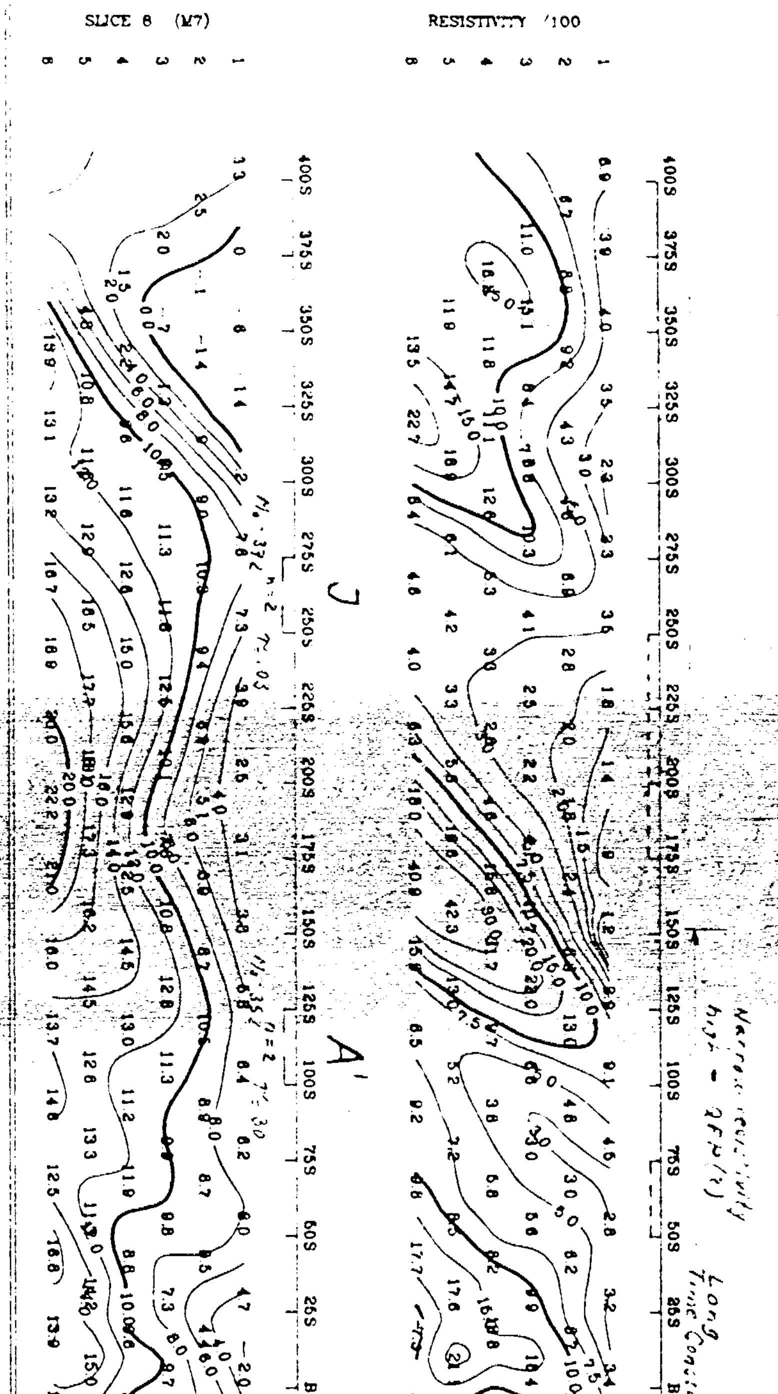
TECK EXPLORATIONS LIMITED

Thunder Lake Property, NW Ont.

LINE NUMBER: 3100 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER | TX PULSE TIME: 2.0 SEC
POLE-DIPOLE ARRAY | RECEIVE TIME: 2.0 SEC
TRAV. DIRECTION: NORTH | C1 POSITION: TRAILING
SCALE 1: 2500



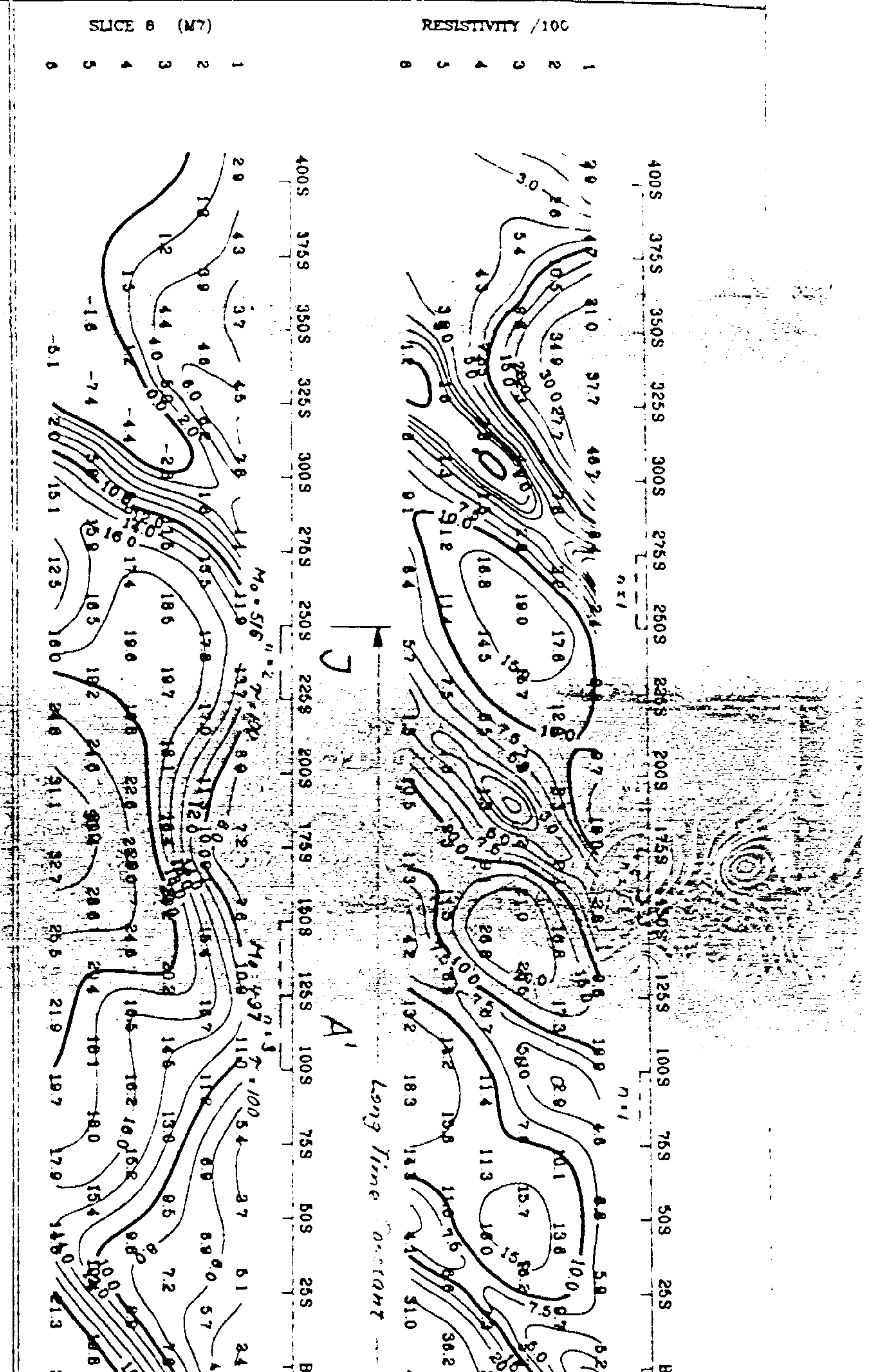
TECK EXPLORATIONS LIMITED

Thunder Lake Property, NW Ont.

LINE NUMBER: 3200 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER | TX PULSE TIME: 2.0 SEC
POLE-DIPOLE ARRAY | RECEIVE TIME: 2.0 SEC
TRAV. DIRECTION: NORTH | C1 POSITION: TRAILING
SCALE 1: 2500



TECK EXPLORATIONS LIMITED

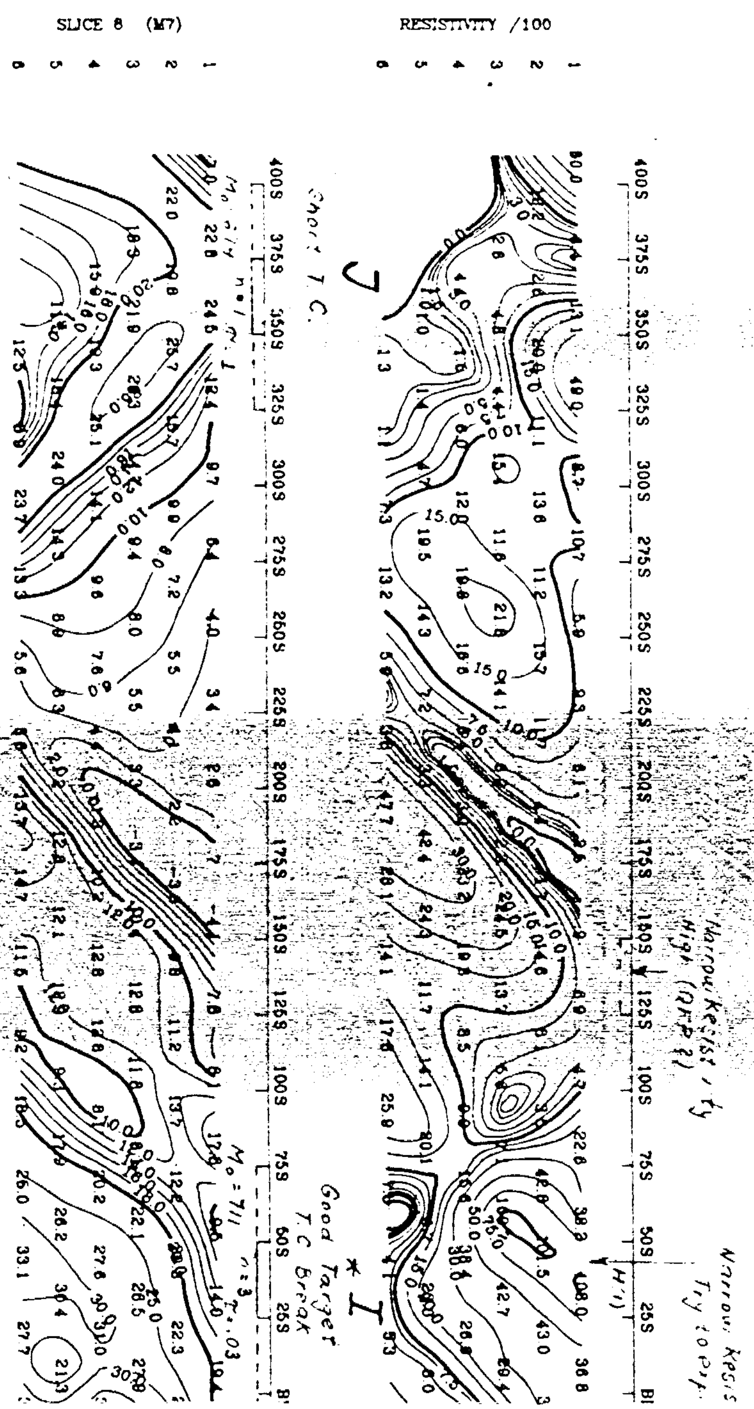
Thunder Lake Property, NW Ont.

LINE NUMBER: 2700 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH

TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING
SCALE 1: 2500



TECK EXPLORATIONS LIMITED

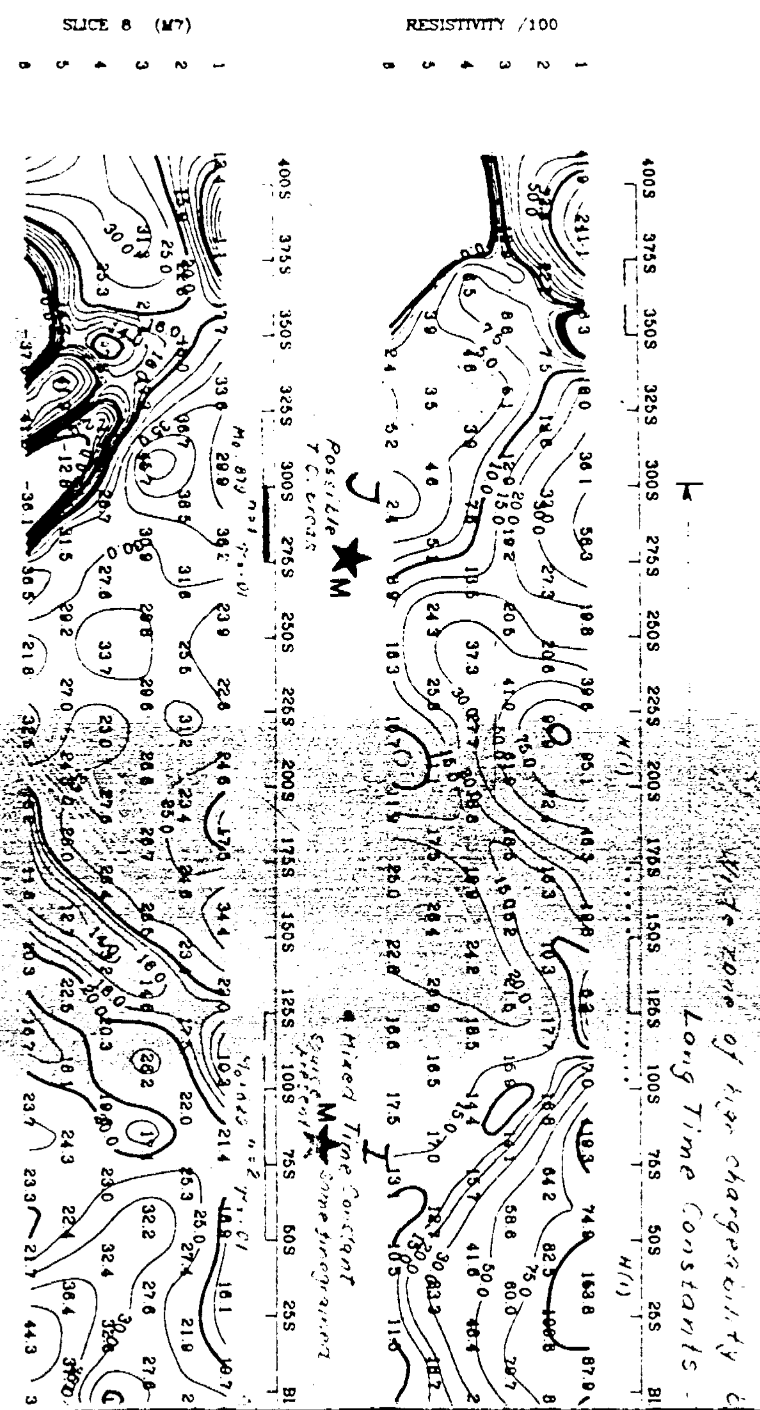
Thunder Lake Property, NW Ont.

LINE NUMBER: 2800 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH

TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING
SCALE 1: 2500



TECK EXPLORATIONS LIMITED

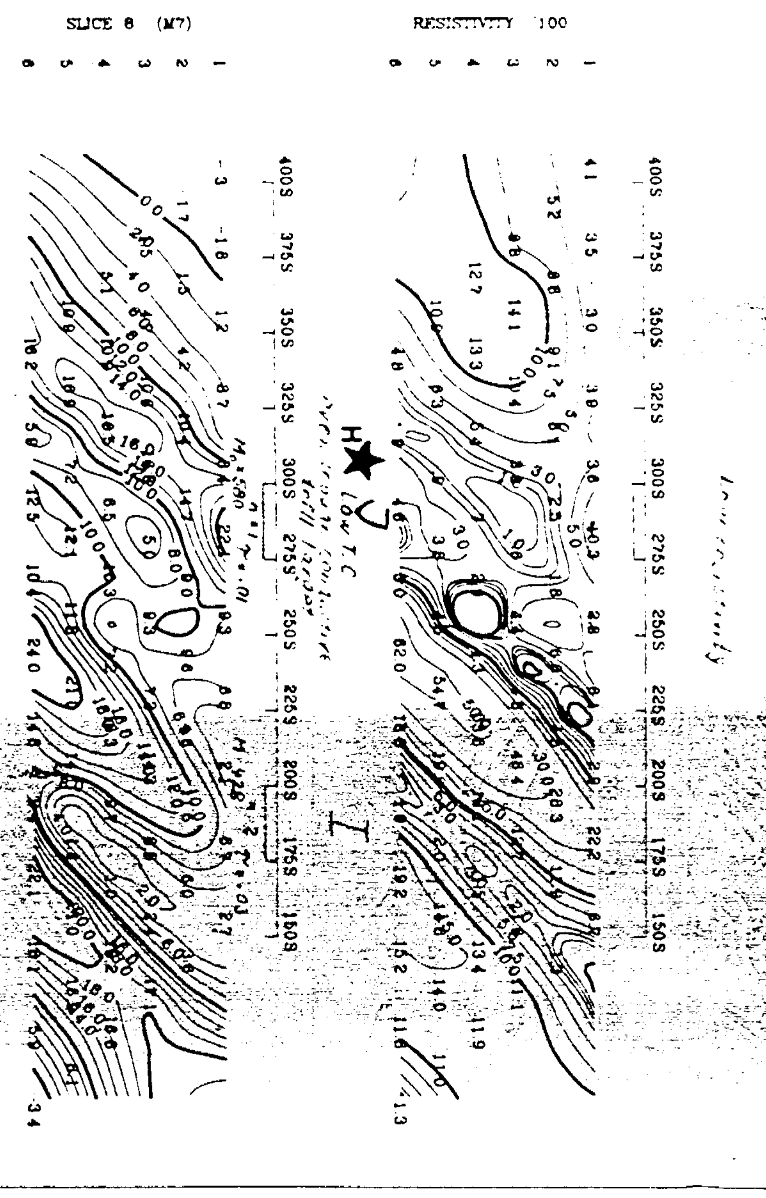
Thunder Lake Property, NW Ont.

LINE NUMBER: 2900 WEST

"A": 25.0 METRES N=1 TO 6

SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH

TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING
SCALE 1: 2500



Ontario

Ministry of Northern Development and Mines

Ministère du Développement du Nord et des Mines

Geoscience Approvals Section
Mining Lands Branch
Willet Green Miller Centre
933 Ramsey Lake Rd., 6th Flr
Sudbury, Ontario
P3E 6B5

Telephone: (705) 670-5853
Fax: (705) 670-5863

Our File:2.14711
Transaction #: W9210.00047

November 9, 1992

Mining Recorder
Ministry of Northern Development
and Mines
808 Robertson Street
P.O. Box 5200
Kenora, Ontario
P9N 3X9

Dear Sir:

RE: Approval of Assessment Work on mining claims K1106347 et al. in Zealand Township.

The assessment credits for geophysics, section 14 of the Mining Act Regulations, as listed on the original Report of Work, have been approved as of **November 9, 1992.**

If you have any questions concerning this matter please contact Dale Messenger at (705) 670-5858.

Yours sincerely,

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

DEM/jl
Enclosures:

cc: Assessment Files Office
Toronto, Ontario

Resident Geologist
Kenora, Ontario

MINING LANDS

Ministry of Northern Development and Mines

Ontario

Report of Work Conducted After Recording Claim

Mining Act

Transaction Number
W9210.00047

2.14711

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)		Client No.
Teck Exploration Ltd.		200408
Address		**Telephone No.**
1 First Canadian Place, Suite 7000, Toronto, Ontario M5X 1G9		416-862-7102
Mining Division	**Township/Area**	**M or G Plan No.**
Kenora	Zealand Township	G-0844
Dates Work Performed — From: September 14, 1990	To: March 1, 1991	

Work Performed (Check One Work Group Only)

	Work Group	Type
X	Geotechnical Survey	2 Induced Polarization (IP) Geophysical Surveys
	Physical Work, Including Drilling	
	Rehabilitation	RECEIVED
	Other Authorized Work	SEP 9 1992
	Assays	
	Assignment from Reserve	MINING LANDS BRANCH

Total Assessment Work Claimed on the Attached Statement of Costs $ 41,565

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.

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

Name	Address
SAJAX Geophysique Inc.	110-6700 Avenue de Parc, Montreal, PQ H2V 4H9
JVX Ltd.	22-60 West Wilmot Street, Richmond Hill, ON L4B 1M6

(attach a schedule if necessary)

Certification of Beneficial Interest * See Note No. 1 on reverse side

I certify 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 by the current recorded holder.	Date: Jul 31 92	Recorded Holder or Agent (Signature): [signature]

Certification of Work Report

I certify 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 its completion and annexed report is true.

Name and Address of Person Certifying

B. Miller, R.R. #5, 19 Legault Street, North Bay, Ontario P1B 8Z4

Telepone No.	Date	Certified By (Signature)
705-474-5500	Jul 31, 92	[signature]

For Office Use Only

Total Value Cr. Recorded	Date Recorded	Mining Recorder	Received Stamp
41565.00	Sept. 1/92	Scott Rivett	KENORA RECEIVED SEP - 1 1992 AM PM 7891011121234[illegible]
	Deemed Approval Date: Nov 30/92	Date Approved	
	Date Notice for Amendments Sent		

0241 (03/91)

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

Statement of Costs for Assessment Credit
État des coûts aux fins du crédit d'évaluation

Mining Act/Loi sur les mines

Transaction No./N° de transaction

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, Minings Lands, Ministry of Northern Development and Mines, 4th Floor, 159 Cedar Street, Sudbury, Ontario P3E 6A5, telephone (705) 670-7264.

Les renseignements personnels contenus dans la présente formule sont recueillis en vertu de la Loi sur les mines et serviront à tenir à jour un registre des concessions minières. Adresser toute quesiton sur la collece de ces renseignements au chef provincial des terrains miniers, ministère du Développement du Nord et des Mines, 159, rue Cedar, 4e étage, Sudbury (Ontario) P3E 6A5, téléphone (705) 670-7264.

1. Direct Costs/Coûts directs

Type	Description	Amount Montant	Totals Total global
Wages Salaires	Labour Main-d'oeuvre		
	Field Supervision Supervision sur le terrain		
Contractor's and Consultant's Fees Droits de l'entrepreneur et de l'expert-conseil	Type SAJAX IP	10,888	
	JVX IP	30,577	
			41,565
Supplies Used Fournitures utilisées	Type		
Equipment Rental Location de matériel	Type		
		Total Direct Costs Total des coûts directs	41,565

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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.

Type	Description	Amount Montant	Totals Total global
Transportation Transport	Type		
Food and Lodging Nourriture et hébergement			
Mobilization and Demobilization Mobilisation et démobilisation			
Sub Total of Indirect Costs Total partiel des coûts indirects			
Amount Allowable (not greater than 20% of Direct Costs) Montant admissible (n'excédant pas 20 % des coûts directs)			
Total Value of Assessment Credit (Total of Direct and Allowable Indirect costs)	Valeur totale du crédit d'évaluation (Total des coûts directs et indirects admissibles		41,565

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SEP -1 1992
AM 7 8 9 10 11 12 1 2 3 4 5 6 PM

Note: The recorded holder will be required to verify expenditures claimed in this statement of costs within 30 days of a request for verification. If verification is not made, the Minister may reject for assessment work all or part of the assessment work submitted.

Note : Le titulaire enregistré sera tenu de vérifier les dépenses demandées dans le présent état des coûts dans les 30 jours suivant une demande à cet effet. Si la vérification n'est pas effectuée, le ministre peut rejeter tout ou une partie des travaux d'évaluation présentés.

Filing Discounts

1. Work filed within two years of completion is claimed at 100% of the above Total Value of Assessment Credit.
2. Work filed three, four or five years after completion is claimed at 50% of the above Total Value of Assessment Credit. See calculations below:

Total Value of Assessment Credit		Total Assessment Claimed
	× 0.50 =	

Remises pour dépôt

1. Les travaux déposés dans les deux ans suivant leur achèvement sont remboursés à 100 % de la valeur totale susmentionnée du crédit d'évaluation.
2. Les travaux déposés trois, quatre ou cinq ans après leur achèvement sont remboursés à 50 % de la valeur totale du crédit d'évaluation susmentionné. Voir les calculs ci-dessous.

Valeur totale du crédit d'évaluation		Évaluation totale demandée
	× 0,50 =	

Certification Verifying Statement of Costs

I hereby certify:
that the amounts shown are as accurate as possible and these costs were incurred while conducting assessment work on the lands shown on the accompanying Report of Work form.

that as Project Geologist I am authorized
(Recorded Holder, Agent, Position in Company)

to make this certification

Attestation de l'état des coûts

J'atteste par la présente :
que les montants indiqués sont le plus exact possible et que ces dépenses ont été engagées pour effectuer les travaux d'évaluation sur les terrains indiqués dans la formule de rapport de travail ci-joint.

Et qu'à titre de ______________ je suis autorisé
(titulaire enregistré, représentant, poste occupé dans la compagnie)

à faire cette attestation.

Signature	Date
[signature]	Jul 31 92

0212 (04/91)

Nota : Dans cette formule, lorsqu'il désigne des personnes, le masculin est utilisé au sens neutre.

Work Report Number for Applying Reserve	Claim Number (see Note 2)	Number of Claim Units	Value of Assessment Work Done on this Claim	Value Applied to this Claim	Value Assigned from this Claim	Reserve: Work to be Claimed at a Future Date
	K1106347	1	$3,523	$ 800	648	2,075
	K1106348	1	2,152	800	0	2,000
	K1106349	1	996	800	196	0
	K1106350	1	854	800	0	506
	K1106351	1	1,537	800	737	0
	K1106352	1	826	800	0	507
	K1119531	1	482	800	0	0
	K1119532	1	676	800	0	0
	K1119537	1	0	800	0	0
	K1119538	1	0	800	0	0
	K1119541	1	0	800	0	0
	K1119542	1	152	800	0	0
	K1119543	1	157	800	0	0
	K1119544	1	1,424	800	624	0
	K1119545	1	4,284	800	2,684	800
	K1119546	1	1,502	800	0	800
	K1119547	1	1,253	800	53 ~~0~~	400
	17 Total Number of Claims		19,818 Total Value Work Done	13,600 Total Value Work Applied	~~4,889~~ 4,942 Total Assigned From	7,088 Total Reserve

Group 1 / Group 2 / Group 3

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Credits you are claiming in this report may be cut back. In order to minimize the adverse effects of such deletions, please indicate from which claims you wish to priorize the deletion of credits. Please mark (✓) one of the following:

1. ☐ Credits are to be cut back starting with the claim listed last, working backwards.
2. ☐ Credits are to be cut back equally over all claims contained in this report of work.
3. ☐ Credits are to be cut back as priorized on the attached appendix.

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

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Note 1: Examples of beneficial interest are unrecorded transfers, option agreements, memorandum of agreements, etc., with respect to the mining claims.

Note 2: If work has been performed on patented or leased land, please complete the following:

I certify that the recorded holder had a beneficial interest in the patented or leased land at the time the work was performed.	Signature	Date Jul 31 92

0241 (03/91)

Work Report Number for Applying Reserve	Claim Number (see Note 2)	Number of Claim Units	Value of Assessment Work Done on this Claim	Value Applied to this Claim	Value Assigned from this Claim	Reserve: Work to be Claimed at a Future Date
	K1119548	1	$1,231	$ 800	431	0
	K1119549	1	2,293	800	693	800
	K1119550	1	1,328	800	0	877
	K1119551	1	1,804	800	204	800
	K1119552	1	2,009	800	1,209	0
	K1119553	1	1,509	800	709	0
	K1119554	1	1,153	800	353	0
	K1119555	1	2,171	800	1,371	0
	K1119556	1	1,299	800	499	0
	K1119557	1	852	800	52	0
	K1119558	1	1,310	800	510	0
	K1119559	1	1,285	800	0	800
	K1119560	1	1,861	800	261	800
	K1119561	1	160	800	0	0
	K1119562	1	291	800	0	0
	K1119563	1	431	800	0	0
	K1119564	1	0	800	0	0
	17 Total Number of Claims		20,987 Total Value Work Done	13,600 Total Value Work Applied	6,292 Total Assigned From	4,077 Total Reserve

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MINING LANDS BRANCH

All Grp (2)

Credits you are claiming in this report may be cut back. In order to minimize the adverse effects of such deletions, please indicate from which claims you wish to priorize the deletion of credits. Please mark (✓) one of the following:

1. ☐ Credits are to be cut back starting with the claim listed last, working backwards.
2. ☐ Credits are to be cut back equally over all claims contained in this report of work.
3. ☐ Credits are to be cut back as priorized on the attached appendix.

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

[illegible] - 1 1992
AM 7 8 9 10 11 12 1 2 3 4 5 6 PM

Note 1: Examples of beneficial interest are unrecorded transfers, option agreements, memorandum of agreements, etc., with respect to the mining claims.

Note 2: If work has been performed on patented or leased land, please complete the following:

I certify that the recorded holder had a beneficial interest in the patented or leased land at the time the work was performed.	Signature	Date Jul 31 92

0241 (03/91)

Work Report Number for Applying Reserve	Claim Number (see Note 2)	Number of Claim Units	Value of Assessment Work Done on this Claim	Value Applied to this Claim	Value Assigned from this Claim	Reserve: Work to be Claimed at a Future Date
	K1119565	1	$ 182	$ 800	0	0
	K1119566	1	304	800	0	0
	K1119567	1	274	800	0	0
	K1119568	1	0	800	0	0
	Totals	4	760	3,200	0	0
Totals	38		41,565	30,400	10,834 ~~10,781~~	11,165
	Total Number of Claims		Total Value Work Done	Total Value Work Applied	Total Assigned From	Total Reserve

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MINING LANDS BRANCH

Credits you are claiming in this report may be cut back. In order to minimize the adverse effects of such deletions, please indicate from which claims you wish to priorize the deletion of credits. Please mark (✓) one of the following:

1. ☐ Credits are to be cut back starting with the claim listed last, working backwards.
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Note 2: If work has been performed on patented or leased land, please complete the following:

I certify that the recorded holder had a beneficial interest in the patented or leased land at the time the work was performed.	Signature	Date Jul 31 92

0241 (03/91)

Thunder Lake 1991 Assessment Schedule

Claim	Number	Recorded	Due Date	1990 IP (km)	1990 IP $	1991 IP (km)	1991 IP $	Claim Total	
K1106347	1	13/10/89	13/10/93	0.800	$675	2.000	$2,847	$3,523	Group ①
K1106348	1	[illegible]	13/10/93	0.525	$443	1.200	$1,708	$2,152	
K1106349	1	13/10/89	13/10/93	0.000	$0	0.700	$996	$996	
K1106350	1	13/10/89	13/10/93	0.000	$0	0.600	$854	$854	Group ②
K1106351	1	13/10/89	13/10/93	0.000	$0	1.080	$1,537	$1,537	
K1106352	1	13/10/89	13/10/93	0.000	$0	0.580	$826	$826	
K1119531	1	26/10/89	26/10/93	0.520	$439	0.030	$43	$482	
K1119532	1	26/10/89	26/10/93	0.800	$675	0.000	$0	$675	
K1119537	1	26/10/89	26/10/93	0.000	$0	0.000	$0	$0	
K1119538	1	26/10/89	26/10/93	0.000	$0	0.000	$0	$0	
K1119541	1	26/10/89	26/10/93	0.000	$0	0.000	$0	$0	
K1119542	1	26/10/89	26/10/93	0.180	$152	0.000	$0	$152	
K1119543	1	26/10/89	26/10/93	0.000	$0	0.110	$157	$157	
K1119544	1	26/10/89	26/10/93	0.000	$0	1.000	$1,424	$1,424	
K1119545	1	26/10/89	26/10/93	0.050	$42	2.980	$4,242	$4,284	
K1119546	1	26/10/89	26/10/93	0.700	$591	0.640	$911	$1,502	
K1119547	1	26/10/89	26/10/93	0.650	$549	0.495	$705	$1,253	
K1119548	1	26/10/89	26/10/93	1.045	$882	0.245	$349	$1,231	
K1119549	1	26/10/89	26/10/93	1.030	$870	1.000	$1,424	$2,293	
K1119550	1	26/10/89	26/10/93	0.595	$502	0.580	$826	$1,328	
K1119551	1	26/10/89	26/10/93	0.720	$608	0.840	$1,196	$1,804	
K1119552	1	26/10/89	26/10/93	0.550	$464	1.085	$1,545	$2,009	
K1119553	1	26/10/89	26/10/93	0.000	$0	1.060	$1,509	$1,509	
K1119554	1	26/10/89	26/10/93	0.000	$0	0.810	$1,153	$1,153	Group ③
K1119555	1	26/10/89	26/10/93	0.000	$0	1.525	$2,171	$2,171	
K1119556	1	26/10/89	26/10/93	0.055	$46	0.880	$1,253	$1,299	
K1119557	1	26/10/89	26/10/93	0.630	$532	0.225	$320	$852	
K1119558	1	26/10/89	26/10/93	0.725	$612	0.490	$698	$1,310	
K1119559	1	26/10/89	26/10/93	0.595	$502	0.550	$783	$1,285	
K1119560	1	26/10/89	26/10/93	0.780	$659	0.845	$1,203	$1,861	
K1119561	1	26/10/89	26/10/93	0.190	$160	0.000	$0	$160	
K1119562	1	26/10/89	26/10/93	0.345	$291	0.000	$0	$291	
K1119563	1	26/10/89	26/10/93	0.510	$431	0.000	$0	$431	
K1119564	1	26/10/89	26/10/93	0.000	$0	0.000	$0	$0	
K1119565	1	26/10/89	26/10/93	0.215	$182	0.000	$0	$182	
K1119566	1	26/10/89	26/10/93	0.360	$304	0.000	$0	$304	
K1119567	1	26/10/89	26/10/93	0.325	$274	0.000	$0	$274	
K1119568	1	26/10/89	26/10/93	0.000	$0	0.000	$0	$0	
Total	38			12.895	$10,888	21.550	$30,677	$41,565	

TECK EXPLORATION LTD.

R.R. #5, 19 Legault Street, North Bay, Ontario
PIB 8Z4

Telephone # 705-474-5500
Fax # 705-474-4053

TELECOPIER MESSAGE

DATE: Sept 2, 1992

TO: Katrina

FROM: Bruce Miller

SUBJECT: Thunder Lake IP Assessment

NO. OF COPIES (including this copy):______ NORTH BAY OPERATOR ______

Hope these changes are to your satisfaction

Bm

RECEIVE

SEP 9 1992

MINING LANDS BRANC

Work Report Number for Applying Reserve	Claim Number (see Note 2)	Number of Claim Units
	K1106347	1
	K1106348	1
	K1106349	1
	K1106350	1
	K1106351	1
	K1106352	1
	K1119531	1
	K1119532	1
	K1119537	1
	K1119538	1
	K1119541	1
	K1119542	1
	K1119543	1
	K1119544	1
	K1119545	1
	K1119546	1
	K1119547	1
	17	
	Total Number of Claims	

08/02/92 13:44 ☎705 474 4053 TECK EXPLORATION 002

Work Report Number for Applying Reserve	Claim Number (see Note 2)	Number of Claim Units	Value of Assessment Work Done on this Claim	Value Applied to this Claim	Value Assigned from this Claim	Reserve: Work to be Claimed at a Future Date
	K1119565	1	$ 182	$ 800	0	0
	K1119566	1	304	800	0	0
	K1119567	1	274	800	0	0
	K1119568	1	0	800	0	0
	Totals	4	760	3,200	0	0
Totals	38		41,565	30,400	10,834	11,165
	Total Number of Claims		Total Value Work Done	Total Value Work Applied	Total Assigned From	Total Reserve

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SEP 9 1992
MINING LANDS BRANCH

Credits you are claiming in this report may be cut back. In order to minimize the adverse effects of such deletions, please indicate from which claims you wish to priorize the deletion of credits. Please mark (✓) one of the following:

1. ☐ Credits are to be cut back starting with the claim listed last, working backwards.
2. ☐ Credits are to be cut back equally over all claims contained in this report of work.
3. ☐ Credits are to be cut back as priorized on the attached appendix.

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

Note 1: Examples of beneficial interest are unrecorded transfers, option agreements, memorandum of agreements, etc., with respect to the mining claims.

Note 2: If work has been performed on patented or leased land, please complete the following:

I certify that the recorded holder had a beneficial interest in the patented or leased land at the time the work was performed.	Signature [signature]	Date Jul 31 92

705 474 4053 PAGE.002

SEP 2 '92 13:41

Value of Assessment Work Done on this Claim	Value Applied to this Claim	Value Assigned from this Claim	Reserve: Work to be Claimed at a Future Date
$3,523	$ 800	648	2,075
2,152	800	0	2,000
996	800	196	0
854	800	0	506
1,537	800	737	0
826	800	0	507
482	800	0	0
676	800	0	0
0	800	0	0
0	800	0	0
0	800	0	0
152	800	0	0
157	800	0	0
1,424	800	624	0
4,284	800	2,684	800
1,502	800	0	800
1,253	800	53	400
19,818	13,600	4,942	7,088
Total Value Work Done	Total Value Work Applied	Total Assigned From	Total Reserve

Credits you are claiming in this report may be cut back. In order to minimize the adverse effects of such deletions, please indicate from which claims you wish to priorize the deletion of credits. Please mark (✓) one of the following:

1. ☐ Credits are to be cut back starting with the claim listed last, working backwards.
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I certify that the recorded holder had a beneficial interest in the patented or leased land at the time the work was performed.	Signature	Date Jul 31 92

SEP 2 '92 13:40 705 474 4053 PAGE.001

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SEP 9 1992

MINING LANDS BRANCH

NOTE: Approx. location of "GRID"

Group ① xxx

Group ② + + +

Group ② 0000

2.14711

Teck Explorations Limited

CLAIMS & GRID LOCATION

THUNDER LAKE PROJECT
THUNDER LAKE AREA

DATE: 11/03/91	JOB: 15711	N.T.S.: 52F/15,16
SCALE: 1 : 20,000		DWG.NO.: 6781

200 0 200 400 600 800 1000 metres

52F15SE8387 2.14711 ZEALAND

200

LEGEND

CHARGEABILITY CONTOUR
0,10,20,30... mV/V
2,4,6,8,12,14... mV/V
DEPRESSION

TECK EXPLORATIONS LTD.

THUNDER LAKE PROJECT
ZEALAND TWP., WABIGOON, ONTARIO

CHARGEABILITY (M7) CONTOUR MAP
POLE-DIPOLE ELECTRODE ARRAY
n=2 a=25m
SCINTREX IPR-11 RECEIVER
SCINTREX IPC-7 2.5 kW TRANSMITTER

SCALE: 1 : 5000

SURVEY BY
JVX LTD.
JAN.-FEB. 1991

PLATE 1

210

2.14711

100 0 100 200 300 400
metres

LEGEND

RESISTIVITY CONTOUR IN MULTIPLES (*1, *10, *100, etc.) OF
10 ohm-m
1·5, 2, 3, 5, 7·5 ohm-m
DEPRESSION

TECK EXPLORATIONS LTD.

THUNDER LAKE PROJECT
ZEALAND TWP., WABIGOON, ONTARIO

APPARENT RESISTIVITY CONTOUR MAP

POLE-DIPOLE ELECTRODE ARRAY
n=2 a=25m
SCINTREX IPR-11 RECEIVER
SCINTREX IPC-7 2·5 kW TRANSMITTER

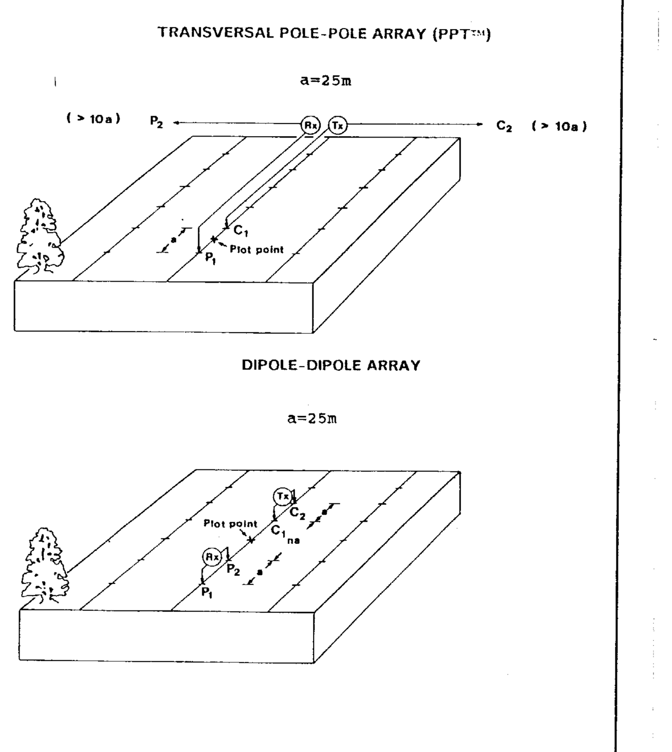
SCALE: 1 : 5000

SURVEY BY
JVX LTD.
JAN.–FEB. 1991

PLATE 2

220

TECK EXPLORATIONS LTD.
THUNDER LAKE PROJECT
ZEALAND TWP., WABIGOON, ONTARIO
COMPILATION MAP
SCALE: 1 : 5000
SURVEY BY JVX LTD. JAN - FEB 1991
PLATE 3
2.14711
metres
EAST GRID
WEST GRID
Magnetic active area
Iron Formation
Possible structure from change in time constant
ANOMALY LEGEND
VERY STRONG
STRONG
MEDIUM
WEAK
VERY WEAK
CHARGEABILITY ANOMALY
RESISTIVITY ANOMALY
Chargeability zone
Resistivity high
Exploration target
VH - Very high priority
H - High priority
M - Medium priority
L - Low priority



Instruments:
IPT-1 from PHOENIX (transmitter)
IP-6 from EDA (receiver)

Transmitted signal:

Contour Interval: 20

Dipole-Dipole: Lines 24W to 5E
PPT Survey: Lines 8E to 26E

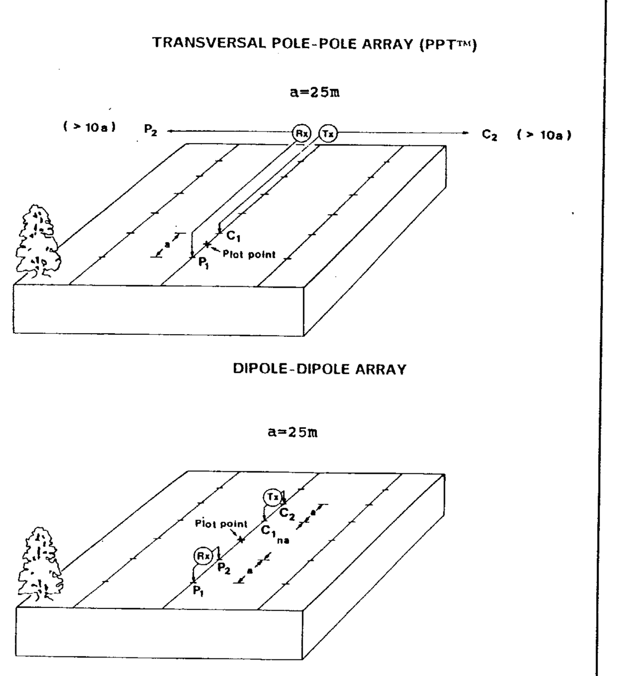
SCALE 1 : 5 000

TECK EXPLORATIONS LTD.
THUNDER LAKE PROJECT
ZEALAND TWP., WABIGOON, ONT.

INDUCED POLARIZATION SURVEY

METAL FACTOR CONTOURS

2.14711



Instruments:
IPT-1 from PHOENIX (transmitter)
IP-6 from EDA (receiver)

Transmitted signal:

Contour Interval: 1.0 mV/V

Dipole-Dipole : Lines 24W to 5E
PPT Survey: Lines 8E to 26E

SCALE 1 : 5 000

TECK EXPLORATIONS LTD.

THUNDER LAKE PROJECT
ZEALAND TWP., WABIGOON, ONT.

2.14711

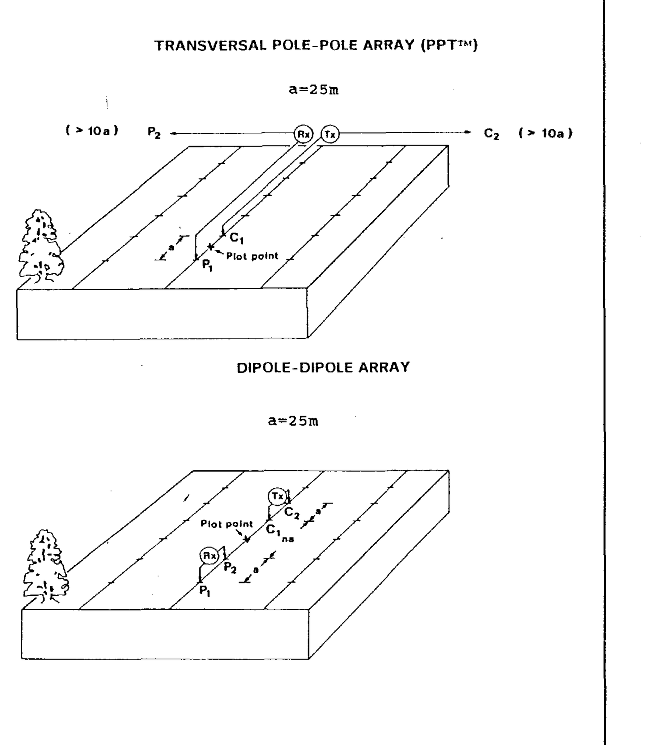
INDUCED POLARIZATION SURVEY

APPARENT CHARGEABILITY CONTOURS
(mV/V)

Survey by: P. Caron, B.Sc.
Interpreted by: R. Lachapelle, P.Eng.
Date : September 1990
Reference: SAGAX 90368

SAGAX GEOPHYSIQUE

250



Instruments:
IPT-1 from PHOENIX (transmitter)
IP-6 from EDA (receiver)

Transmitted signal:

Contour Interval: logarithmic

Dipole-Dipole : Lines 24W to 5E
PPT Survey: Lines 8E to 26E

SCALE 1 : 5 000

TECK EXPLORATIONS LTD.

THUNDER LAKE PROJECT
ZEALAND TWP., WABIGOON, ONT.

2.14711

INDUCED POLARIZATION SURVEY

APPARENT RESISTIVITY CONTOURS

(kΩ-m)

Survey by: P. Caron, B.Sc.
Interpreted by: R. Lachapelle, P.Eng.
Date : September 1990
Reference: SAGAX 90368

SAGAX GEOPHYSIQUE

260

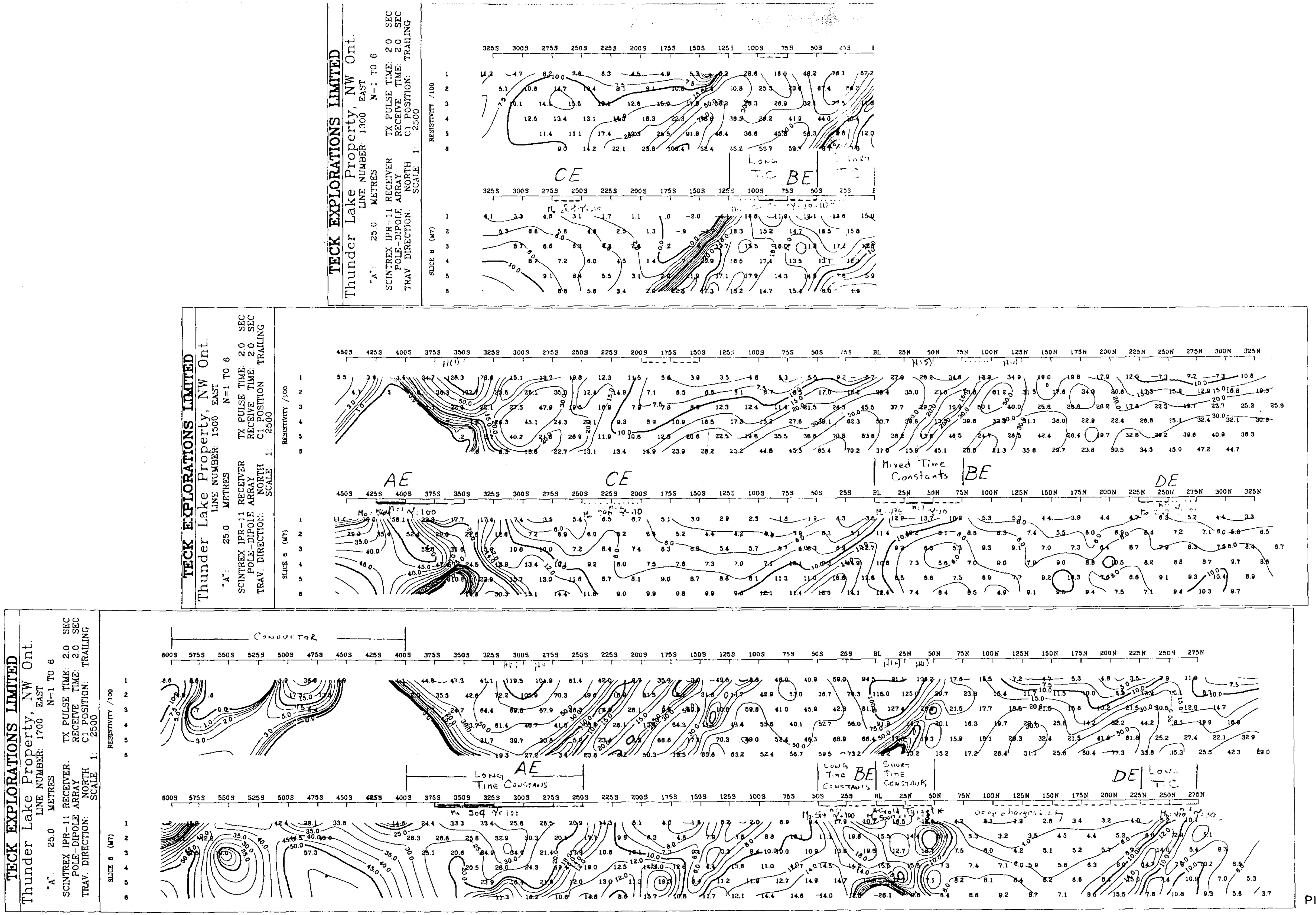


Plate 8

2.14711

52F15SE8307 2.14711 ZEALAND

270

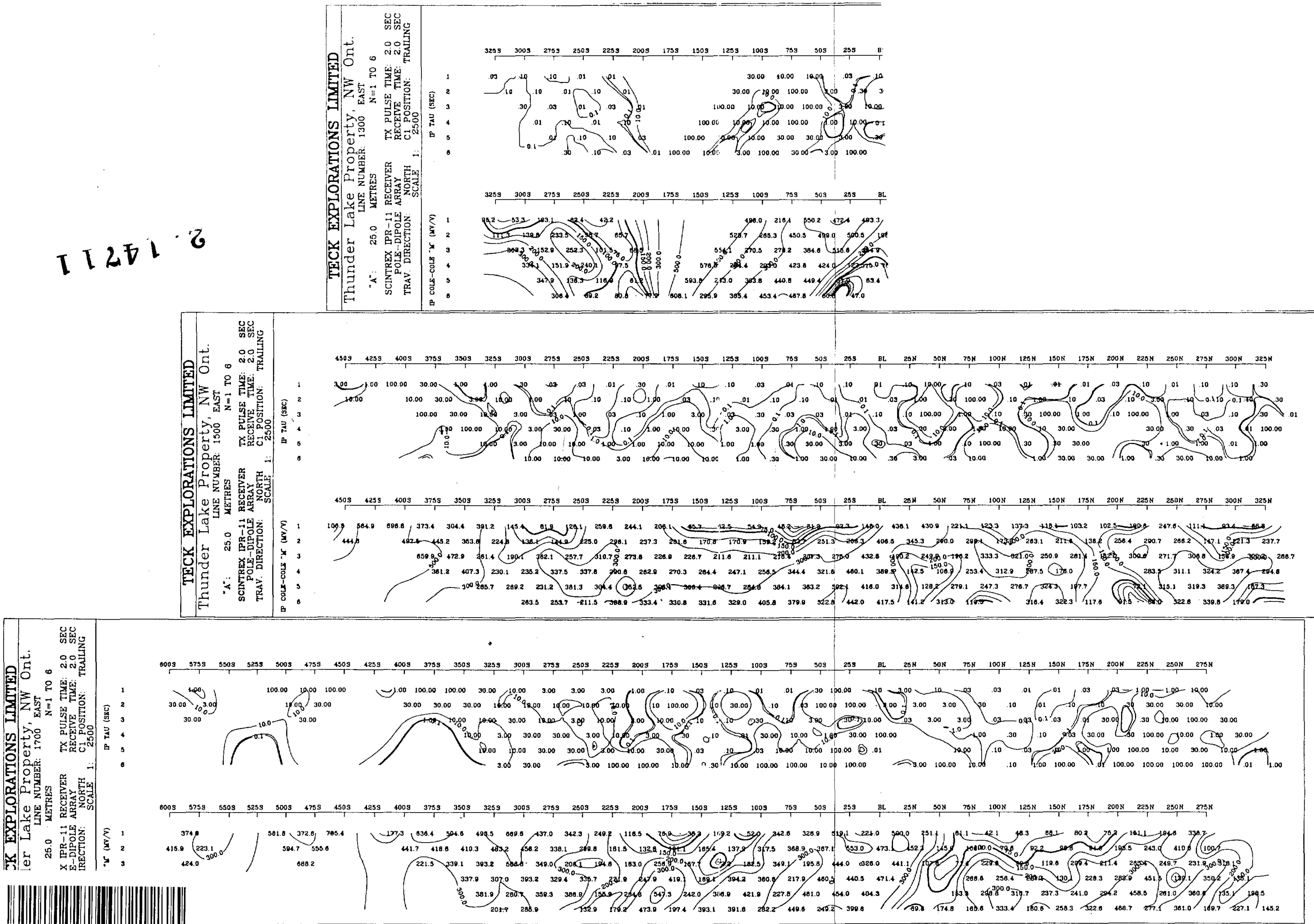
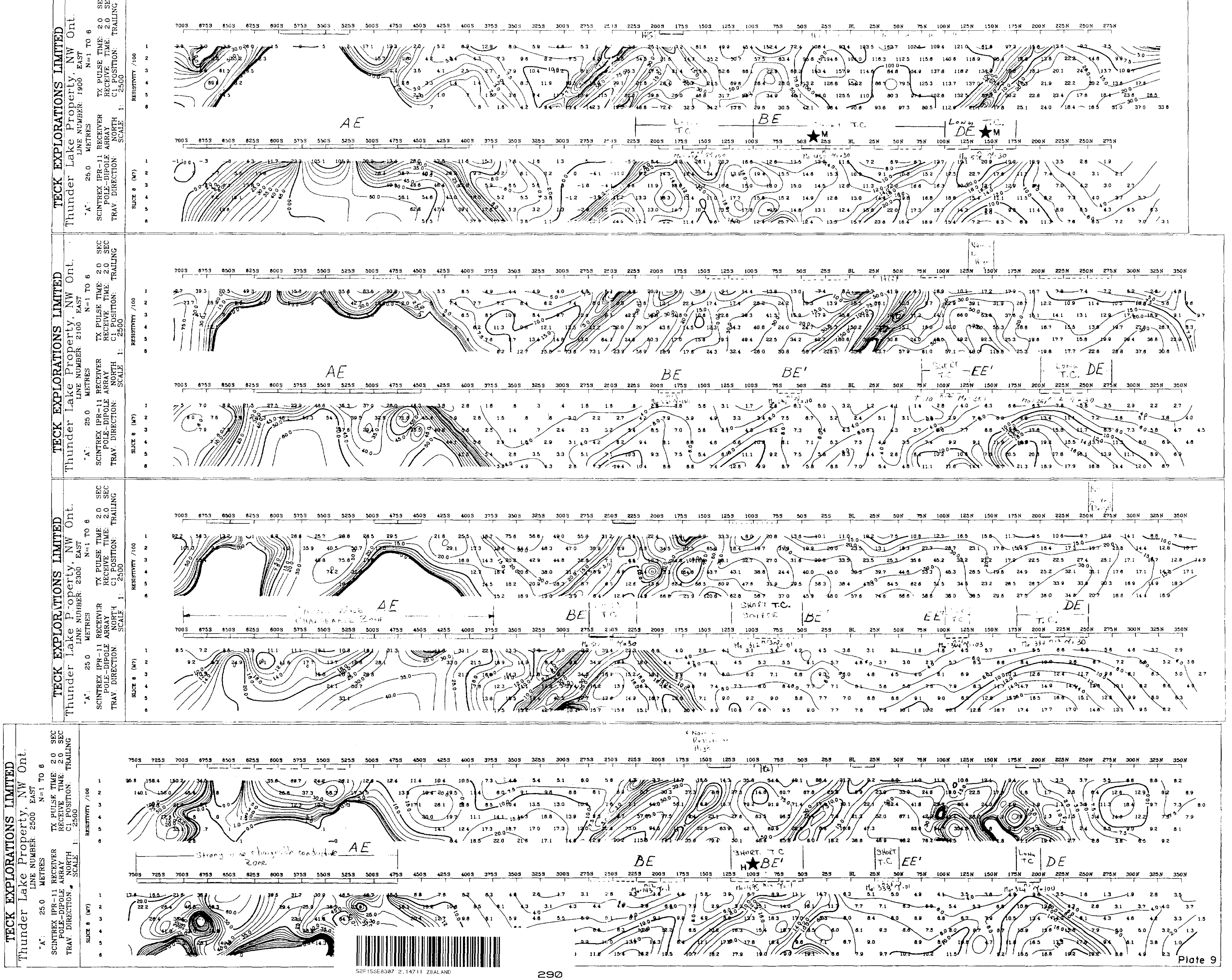


Plate 8a

52F15SE8307 2.14711 ZEALAND

280

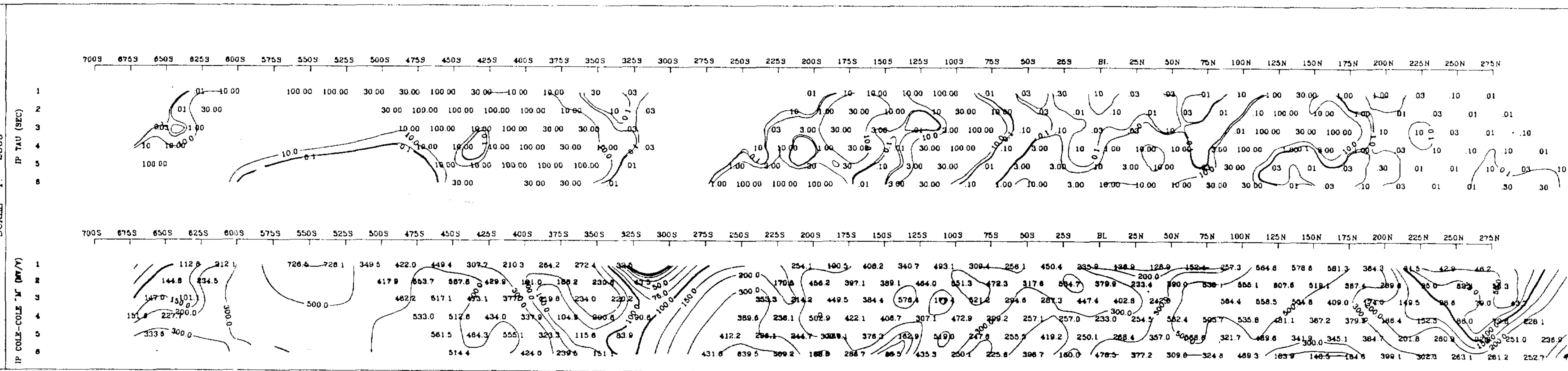
2.14711



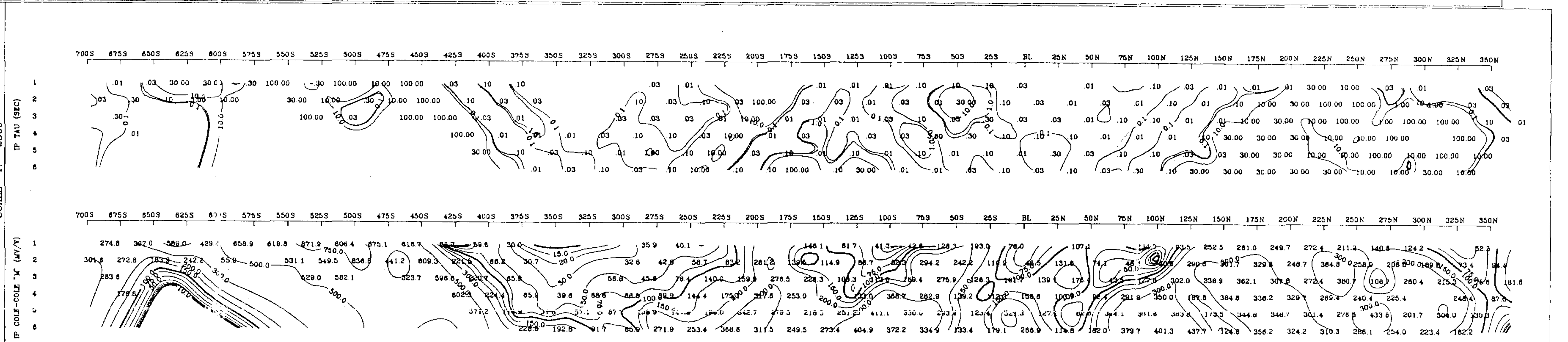
52F15SE8307 2.14711 ZEALAND

2.14711

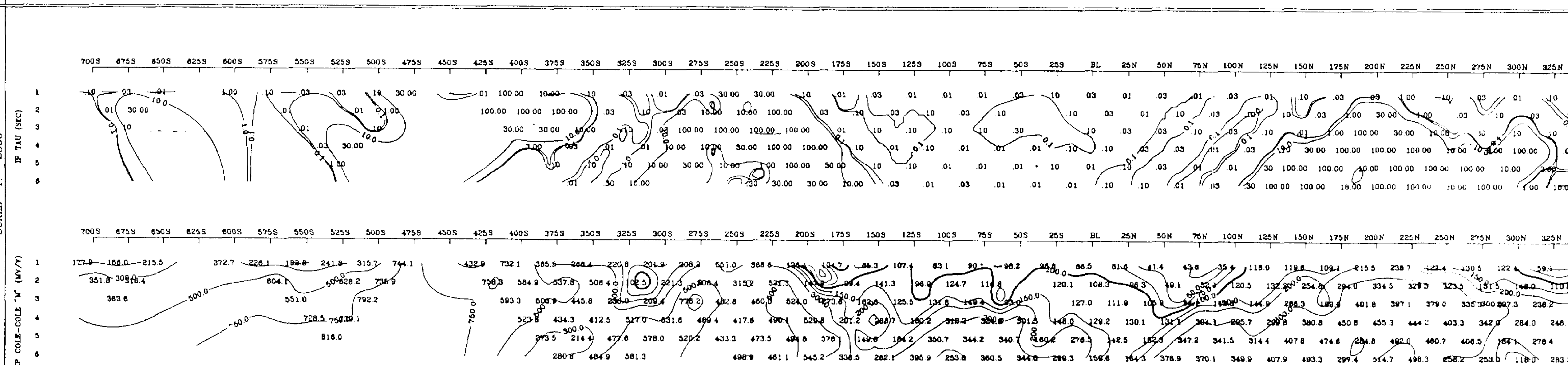
TECK EXPLORATIONS LIMITED
Thunder Lake Property, NW Ont.
LINE NUMBER: 1900 EAST
"A": 25.0 METRES N=1 TO 6
SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH
TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING
SCALE 1: 2500



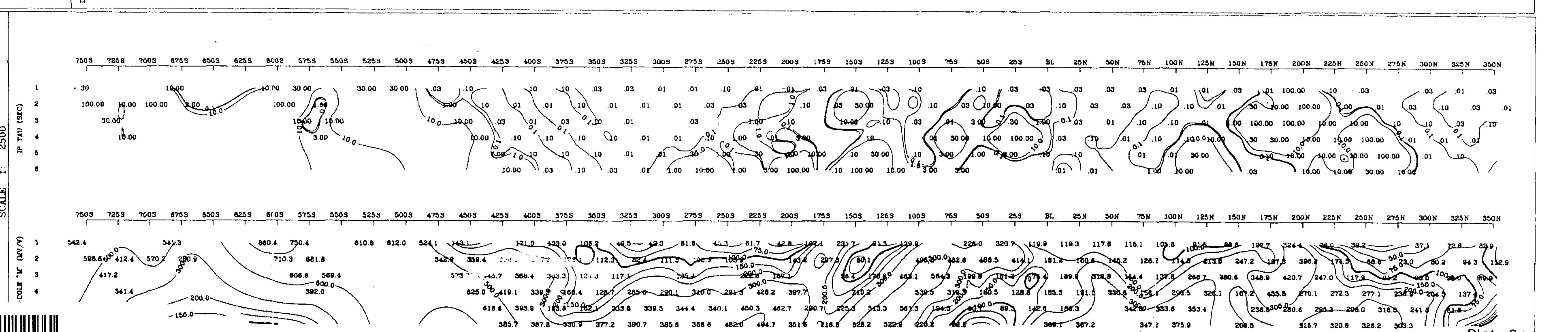
TECK EXPLORATIONS LIMITED
Thunder Lake Property, NW Ont.
LINE NUMBER: 2100 EAST
"A": 25.0 METRES N=1 TO 6
SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH
TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING
SCALE 1: 2500



TECK EXPLORATIONS LIMITED
Thunder Lake Property, NW Ont.
LINE NUMBER: 2300 EAST
"A": 25.0 METRES N=1 TO 6
SCINTREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
TRAV. DIRECTION: NORTH
TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING
SCALE 1: 2500



TECK EXPLORATIONS LIMITED
nder Lake Property, NW Ont.
LINE NUMBER: 2500 EAST
25.0 METRES N=1 TO 6
TREX IPR-11 RECEIVER
POLE-DIPOLE ARRAY
/. DIRECTION: NORTH
TX PULSE TIME: 2.0 SEC
RECEIVE TIME: 2.0 SEC
C1 POSITION: TRAILING
SCALE 1: 2500



300

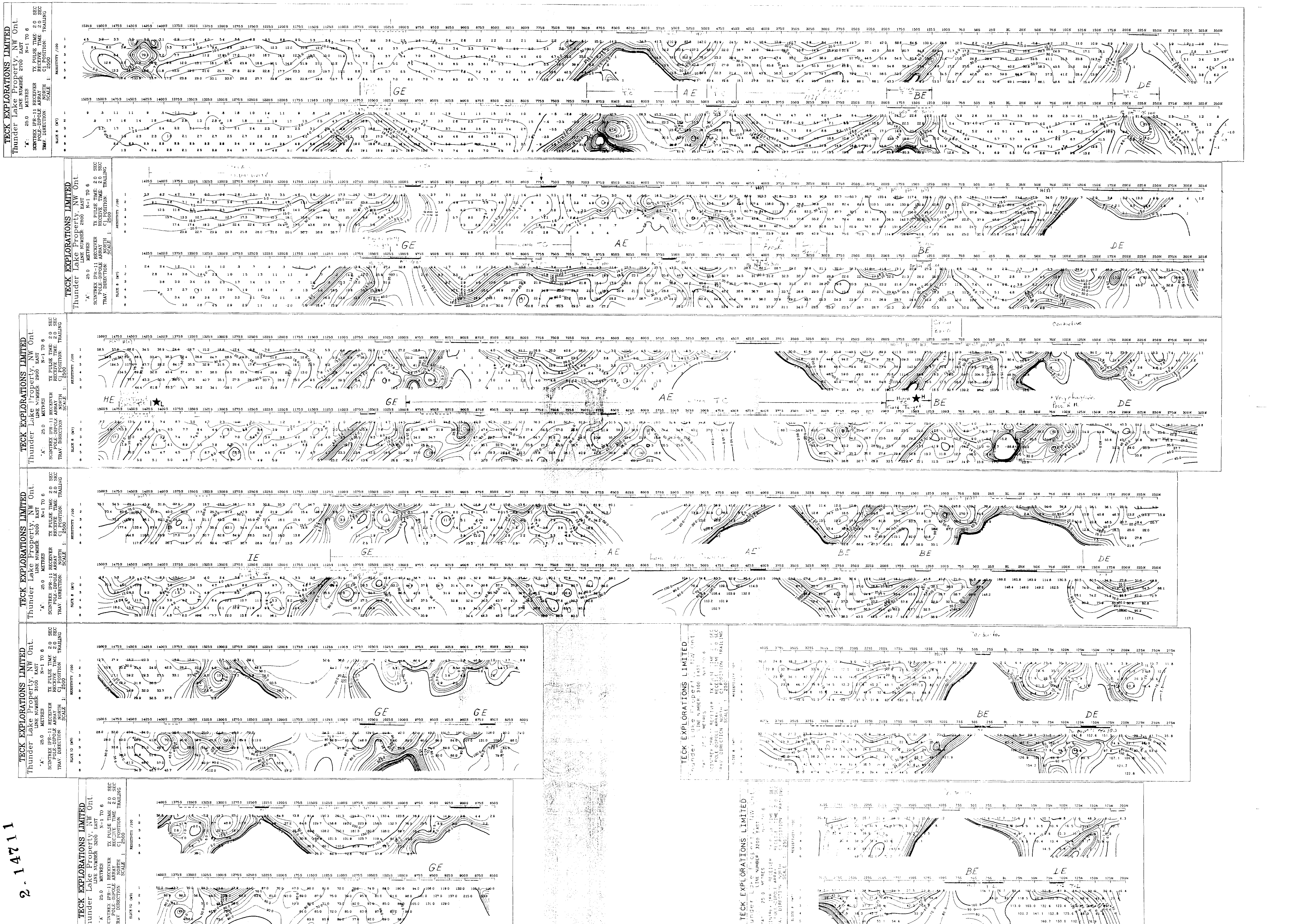
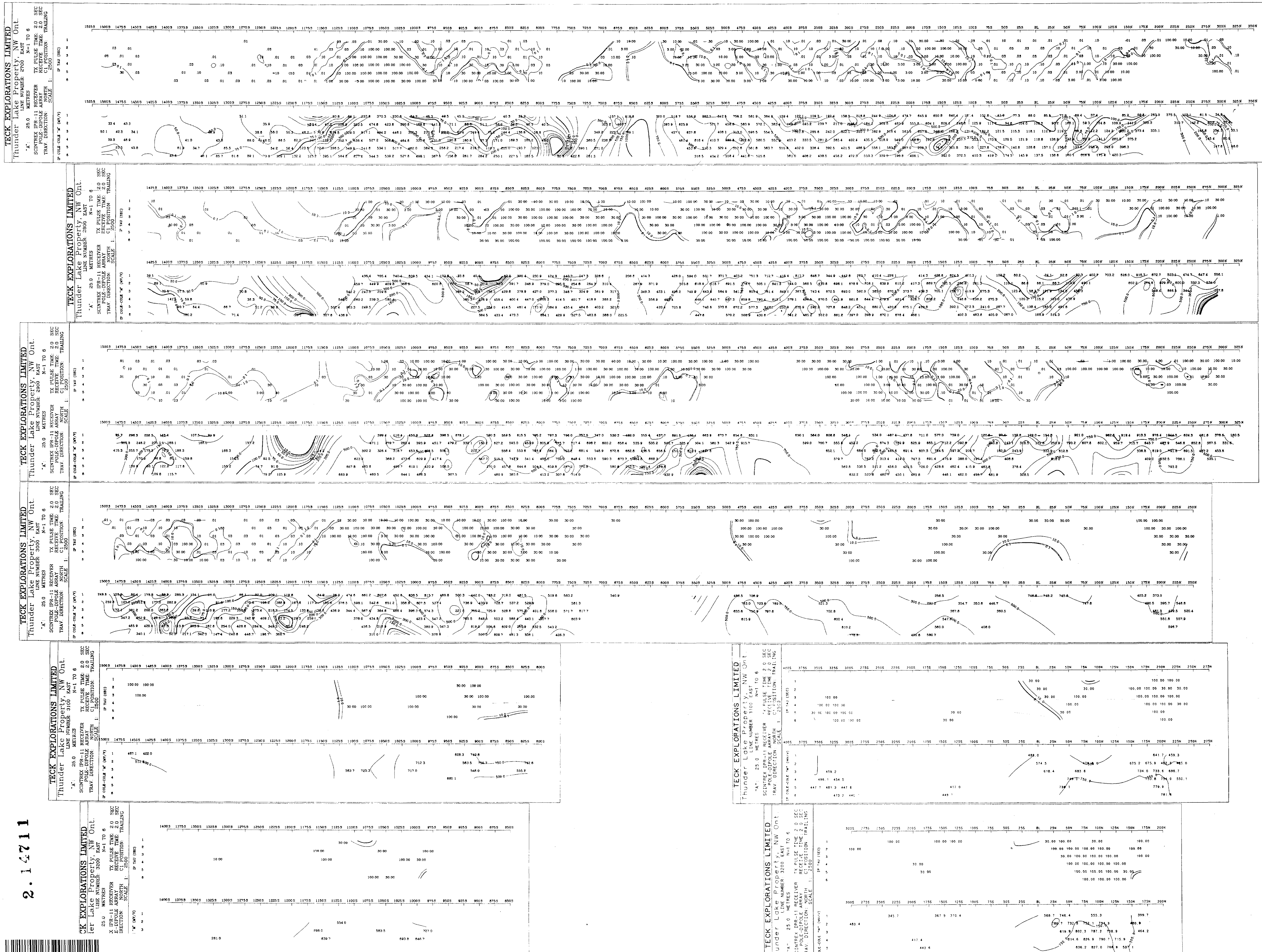


Plate 10

2.14711



2.14711

320

Plate 10a