GLEN COPPER MINES LTD.

REPORT

ON

PROPERTY IN

HALLIDAY AND MIDLOTHIAN TOWNSHIPS

LARDER LAKE MINING DIVISION

ONTARIO

E. W. BAZINET, P. ENG.

Dated

at

Timmins, Ontario
September 20, 1971.

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GLEN COPPER MINES LTD.

REPORT

ON

PROPERTY IN

HALLIDAY AND MIDLOTHIAN TOWNSHIPS

LARDER LAKE MINING DIVISION

ONTARIO

SUMMARY AND CONCLUSIONS:-

Glen Copper Mines Ltd. has the right to acquire 28 unpatented mining claims in Halliday and Midlothian Townships, approximately 40 miles south of Timmins. Widespread low grade lead-zinc-copper-silver mineralization has recently been exposed intermittently in a series of over 50 trenches covering an area 3600 feet long and 500 feet wide. The mineralization occurs in rhyolite and dacite breccia, the same favourable volcanic rock types which host most of the Timmins Area's base metal deposits including Texas Gulf Sulphur's Kidd Township deposit.

Sampling carried out by the writer, has yielded values as high as 4.37% combined lead-zinc and 0.34 ounces of silver per ton along with low copper values over widths of up to 20 feet, but the average tenor of the mineralized zone is less

than this.

Continuity and grade of the exposed mineralization has not been established but because of the extent and character of the deposit an exploration program to investigate the properties potential for large low grade deposits and smaller higher grade concentrations is warranted. Since deposits of this nature are frequently zoned mineralogically, emphasis is placed on deep exploration.

In order to assess the properties possibilities the writer has recommended an extensive exploration program consisting of geological mapping, geophysical surveys and diamond drilling.

INTRODUCTION:

This report was prepared at the request of the Directors of Glen Copper Mines Ltd. Its purpose is to outline an exploration program in order to assess the base metal potential of a property located in Halliday and Midlothian Townships, Ontario. Glen Copper Mines Ltd. has the right to acquire the property.

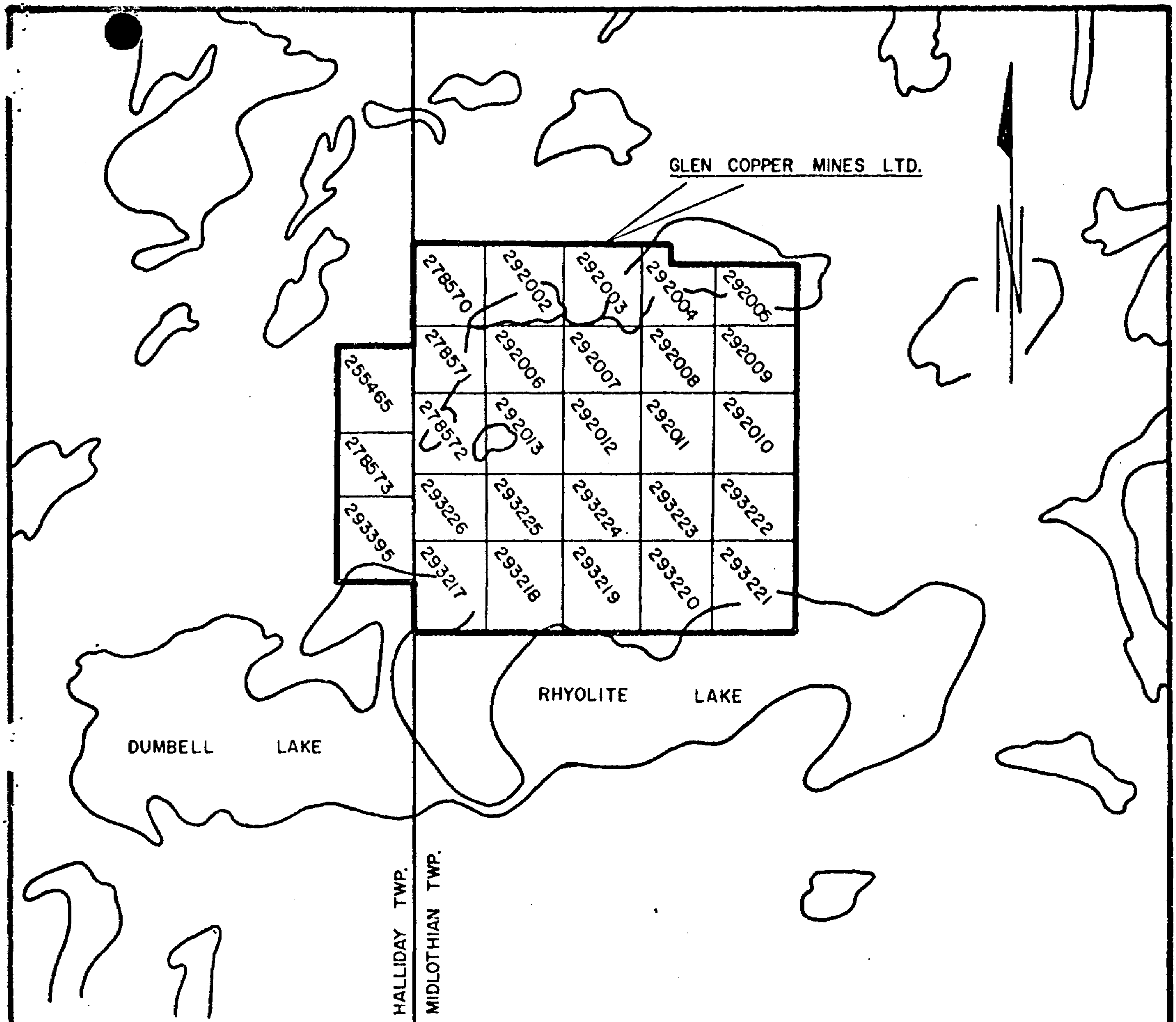
Prospecting and trenching recently completed on the property by two Timmins area prospectors has uncovered widespread, low grade lead-zinc-copper mineralization. These showings have been exposed intermittently over an area 3600 feet long and 500 feet wide. The report outlines an exploration program designed to test for the possibility of either outlining a large tonnage low grade base metal deposit or smaller concentrations of higher grade mineralization.

The writer visited the property on June 10, 1971. All trenches and known mineralized outcrops were examined and samples were taken from areas containing typical mineralization. The author studied all of the data relating to the property available at the Ontario Department of Mines.

PROPERTY:

The property consists of twenty-eight contiguous unpatented mining claims totalling approximately 1120 acres, more precisely described as follows:-

CLAIM NO.	STATUS	ACRES
255465 ✓	Unpatented	40
278570	"	40
278571	"	40
278572	"	40
278573 ✓	"	40
292002	"	40
292003	"	40
292004	"	40
292005	"	40
292006	"	40
292007	"	40
292008	"	40
292009	"	40
292010	"	40
292011	"	40
292012	"	40
292013	"	40
293217	"	40
293218	"	40
293219	"	40



PROPERTY PLAN

GLEN COPPER MINES LTD.

HALLIDAY & MIDLOTHIAN TOWNSHIPS

LARDER LAKE MINING DIVISION

ONTARIO

SCALE: 1" = 1/2 MILE

REGISTERED PROFESSIONAL ENGINEER
E. W. BAZINET
PROVINCE OF ONTARIO

FROM: O.D.M. CLAIM MAP M.235

1971

293220	Unpatented	40
293221	"	40
293222	"	40
293223	"	40
293224	"	40
293225	"	40
293226	"	40
293395 ✓	"	40

The titles of these claims were ascertained at the Ontario Department of Mines and it is understood that Glen Copper Mines Ltd. has the right to acquire the property, although no legal document to this effect has been examined by the writer. The claims are in good standing until July 1972.

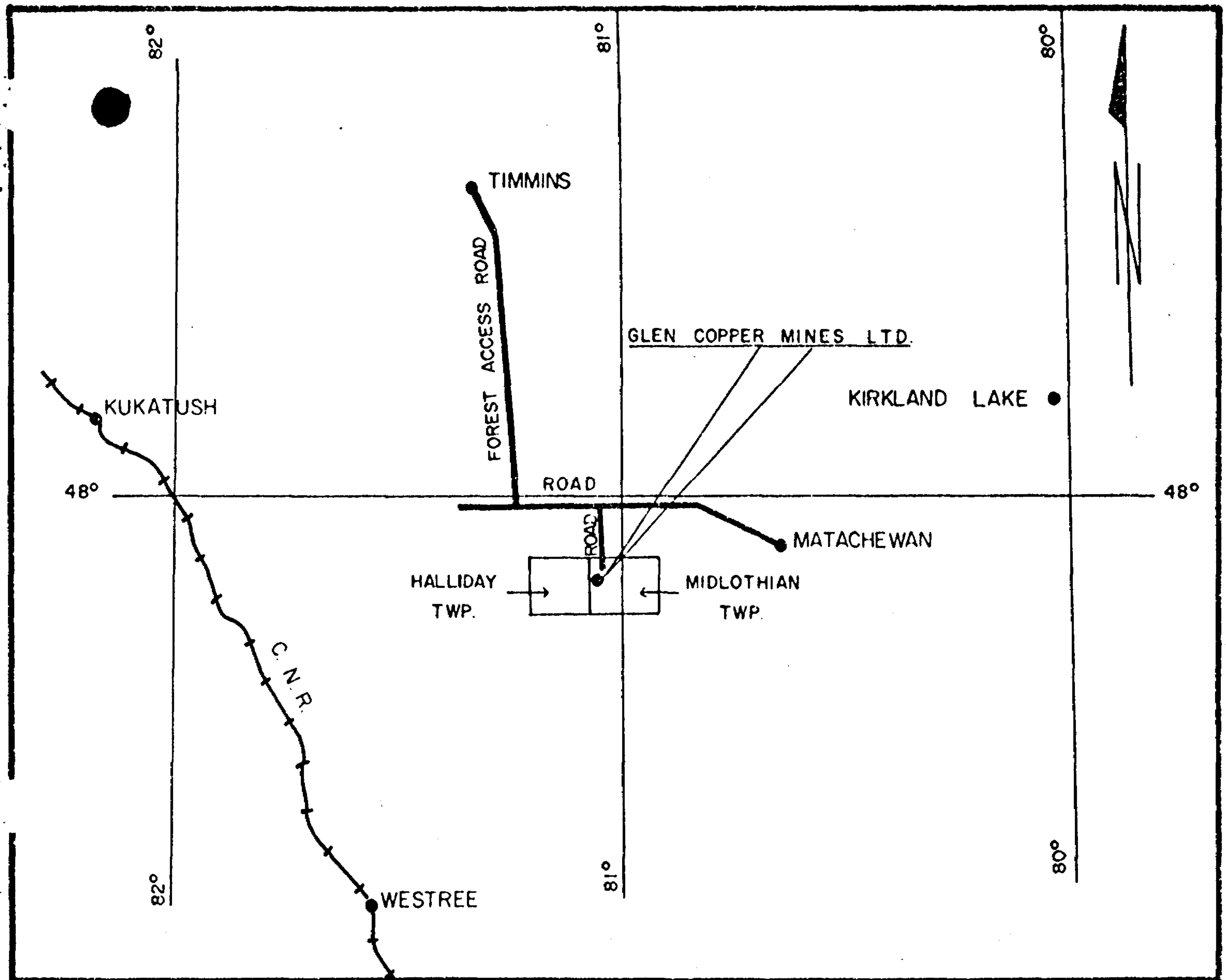
LOCATION AND ACCESS:

The property straddles the township line between Halliday and Midlothian Townships in the Larder Lake Mining Division of Ontario. The south boundary is situated along the north shore of Rhyolite Lake.

The property is approximately 40 air miles south of the Town of Timmins and is accessible by gravel road from the towns of Timmins and Matachewan.

HISTORY:

According to records available at the Ontario Department of Mines, part of the property was prospected for gold in the 1940's. Chip samples obtained at that time from a pit on the



LOCATION PLAN

GLEN COPPER MINES LTD.

HALLIDAY & MIDLOTHIAN TOWNSHIPS

LARDER LAKE MINING DIVISION,

ONTARIO

SCALE: 1" = 16 MILES

REGISTERED PROFESSIONAL ENGINEER
E. W. BAZINET
Sept 20/71
PROVINCE OF ONTARIO

1971

property assayed as high as 0.44 ounces of gold per ton. There is no record as to the width or continuity of these values. Two old pits, caved and overgrown by vegetation were observed by the writer in the approximate area described in the Ontario Department of Mines records.

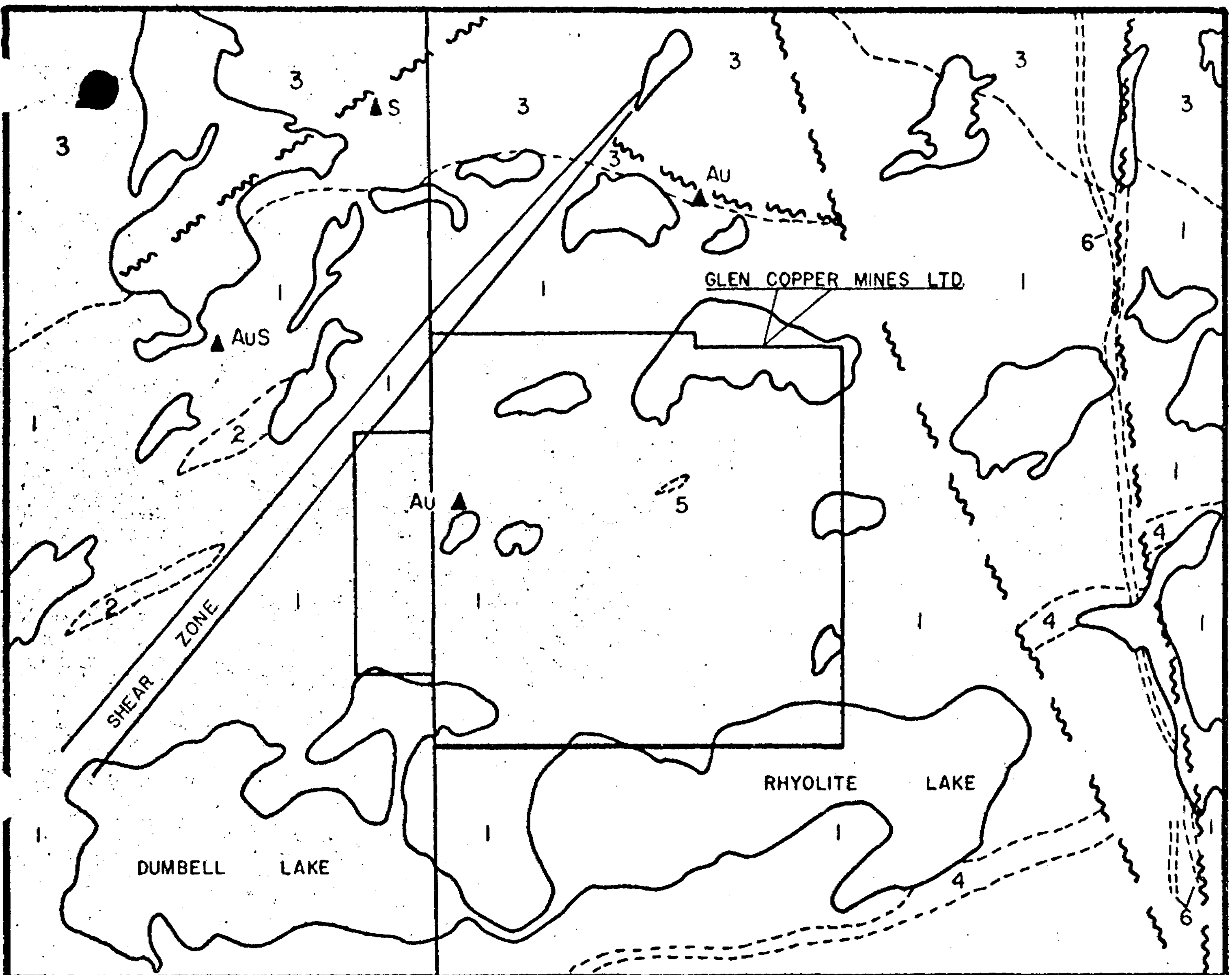
It was these old reports of gold which originally attracted the two Timmins prospectors to the area in 1969 and while they were prospecting for gold, base metal mineralization was discovered. Since then work has been concentrated on the base metal possibilities of the property and no attempt has been made to locate the gold occurence described in the old reports.

The work recently completed by the two Timmins area prospectors consists of prospecting and a large amount of trenching.

GENERAL GEOLOGY:

The property is underlain by the same favourable volcanic rock types which host most of the Timmins area base metal deposits including Texas Gulf Sulphur's Kidd Township deposit, Kam - Kotia Mines Ltd. deposit, Canadian Jamieson Mines Limited deposit and Jameland Mines Limited deposit.

The area is largely overburden covered but there are sufficient outcrops to outline the general geology. The general geology is described by E. G. Bright in the O.D.M. Geological Report 79, "Geology of Halliday and Midlothian Townships" as



LEGEND

PRECAMBRIAN:

6	DIABASE
5	GRANITE
4	GABBRO, DIORITE, PERIDOTITE
3	GREYWACKE, CONGLOMERATE
2	ANDESITE
1	RHYOLITE - DACITE BRECCIA, SERICITE SCHIST
∿∿	FAULT
▲ Au	GOLD SHOWING
▲ S	SULFIDE SHOWING

GEOLOGY PLAN

GLEN COPPER MINES LTD.

HALLIDAY & MIDLOTHIAN TOWNSHIPS

LARDER LAKE MINING DIVISION, ONT.

SCALE: 1" = 1/2 MILE

N

REGISTERED PROFESSIONAL ENGINEER
E. W. BAZINET
PROVINCE OF ONTARIO
Sept 20/71

GEOLOGY FROM: O.D.M. MAP 2187

1971

follows:-

"The map - area occupies the greater part of a felsic volcanic dome which covers the adjoining townships of Sothman, Halliday and Midlothian". The "dome, lies near the western flank of the Round Lake granitic batholith".

"All the bedrock in the map - area is of Precambrian age. Felsic (dacitic to rhyolitic) metavolcanics in the central area of the Halliday dome are interstratified with and surrounded by, intermediate (andesitic to dacitic) metavolcanics. On the north-east margin of the dome, metasediments are intercalated with minor disconformity, between a younger and older volcanic series. The metavolcanics and metasediments along the margins of the dome occupy axial areas of tight folds. Ultramafic and mafic sills and stocks intrude the outer rhyolitic strata of the dome, and younger, Matachewan-type, diabase dikes occupy some of the north-trending faults and fractures that traverse the map - area".

The property is underlain by northeast - trending rhyolite-dacite breccias locally intruded by small granitic dikes. The dip of the schistocity of the rock is vertical or predominantly steeply south.

MINERAL DEPOSITS:

More than 50 trenches have been blasted in the outcrop areas to expose widespread, low grade lead-zinc-copper mineralization intermittently over an area of 3600 feet by 500 feet. All sulfide minerals have been leached out of the bedrock down to a depth of approximately 1 ft. and it is only where trenching has exposed unweathered bedrock that the base metal sulfides are evident. For this reason and because of overburden cover continuity of mineralization between trenches has not been established and this will require detailed exploration.

Sulfide mineralization occurs in rhyolite breccia host rock and consists of pyrite, sphalerite, galena and chalcopyrite in order of abundance. These sulfides occur in three habits; (1) as disperse disseminations in rhyolite fragments, (2) as thin films and lenses along fractures, and (3) as matrix filling surrounding rhyolite breccia fragments.

The host rock is silicified and shows varying degrees of sericite and chlorite alteration.

Although good grade mineralization assaying as high as 4.12% zinc, 0.25% lead and 0.05% copper can be observed in widths of up to 20 feet, the average tenor of the mineralization appears to be considerably lower grade.

Because of the extent and character of the exposed mineralization the potential for a large tonnage low grade deposit warrants investigation. Emphasis should be placed on the depth potential of the property since zoning of both the grade and type of mineralization can be expected in this type of deposit. The possibility of locating smaller concentrations of higher grade mineralized zones should also be investigated.

Because of the disseminated nature of mineralization and because the major mineral present (Sphalerite) is non conductive, electromagnetic techniques will probably not be successful in detecting this type of mineralized zone. However pyrite and galena (both of which are present in small amounts) if present in sufficient concentrations would be detectable using Induced Polarization methods. A magnetometer survey would also be useful for geological correlation in the overburden covered areas.

SAMPLING:

Two separate bulk samples were taken. Sample No. 2 is composed of mineralization from pits in outcrop areas "A" and "B" and sample No. 3 from pits in outcrop area "C". A separate sample was taken from the best grade trench in area "C" and is representative of a width of 20 feet. Samples 2 and 3 are selected grab samples and are not necessarily representative of the average grade of the mineralized area. They serve only as an indication of the widespread nature of the mineralization. Truly representative samples would require a large complex sampling program and is beyond the scope of the investigation carried out by the writer.

The following is a list showing the assay results. The sample locations are shown on the attached plan.

Sample No.	Zinc %	Lead %	Copper %	Silver oz. per ton.	Combined Lead-zinc %
No. 1	4.12	0.25	0.05	0.34	4.37
No. 2	1.80	0.59	0.05	0.22	2.39
No. 3	2.45	1.40	0.08	0.40	3.85

RECOMMENDATIONS:

It is therefore recommended that the property be mapped geologically by a competent geologist. Emphasis should be placed on outlining alteration patterns and zonal dispersement of sulfide minerals. As an aid to correlating geology in overburden covered areas a sensitive magnetometer survey should be completed. Sphalerite, the main sulfide mineral present in the mineralized showings is not normally detectable using electrical geophysical surveys. There is however small quantities of pyrite, galena and chalcopyrite present in the showings and these sulfide minerals should be detectable using Induced Polarization geophysical techniques. It is therefore also recommended that this type of survey be carried out over the entire property.

It is also recommended that a diamond drillprogram be initiated to test the continuity of the mineralized areas. Holes should be drilled to a vertical depth of at least 1000 feet in order to determine if the tenor of the mineralization tends to improve at depth. A tentative general layout of the drill holes is shown on the accompanying map, however this is intended only as a guide and the exact locations and direction should be based on the results of the geological mapping. In all, ten diamond drill holes totalling 12,000 feet are recommended to cross section the known mineralized zones at appropriate intervals. There is a possibility that results of the geophysical work will warrant some follow up diamond drilling. Since holes numbers 3,4,7 and 8 are in area covered by overburden their location should be dictated by the geophysical results.

The tentative details of the recommended drill holes are as follows:-

D.D.H. No.	Length	Dip	Direction
1	1200	-60°	N
2	1200	-60°	N
3	1200	-60°	S
4	1200	-60°	N
5	1200	-60°	S18°E
6	1200	-60°	N18°W
7	1200	-60°	S32°E
8	1200	-60°	N32°W
9	1200	-60°	N
10	1200	-60°	N32°W

The cost of completing this work is estimated as follows:-

Line cutting (38 miles @ $100/mile)...........$ 3800.

Magnetometer Survey (38 miles @ $85/mile)..... 3230.

Geological Mapping............................ 5000.

Induced Polarization Survey (38 miles @ $400/mile)...............	15,200.
Diamond Drilling (12,000 feet @ $10/ft).....	120,000.
Assaying (Lead,zinc,copper,silver @ $3/ assay, 50% of core assayed at 10 foot intervals)................	7,200.
Engineering,Field supervision,Transportation Servicing (5 months @ $3000/month)..........	15,000.
Contingencies 15%.........................	25,400.
Total....$	194,830.

Respectfully Submitted

E. W. Bazinet, P. Eng.

Timmins, Ontario.
September 20, 1971.

REFERENCES

1. "Geology of Halliday and Midlothian Townships", By E. G. Bright, O.D.M. Geological Report No. 79.

2. Records O.D.M. Branch Office, Kirkland Lake, Ontario.

LIST OF ILLUSTRATIONS

1. Location Plan.

2. Property Plan.

3. Geology Plan.

4. Plan showing Trenches, Location of Samples & Proposed Diamond Drill Holes.

CERTIFICATE

I, the undersigned, E. W. Bazinet of the Town of Timmins, in the District of Cochrane, and Province of Ontario, hereby certify:

1. That I am a Mining Engineer and reside at 456 Brousseau Ave., Timmins, Ontario.

2. That I graduated from the University of Toronto in 1955 with a Bachelor of Science degree, and that I have been practising my profession continuously since that time.

3. That I am a member in good standing of the Association of Professional Engineer of the Province of Ontario.

4. That I do not have nor do I expect to receive directly or indirectly an interest in the properties or securities of Glen Copper Mines Ltd.

5. That the accompanying report on the property in Halliday and Midlothian Townships which Glen Copper Mines Ltd. has the right to acquire is based on my personal examination of the property, and an examination of available reports and maps.

Respectfully Submitted

EW Bazinet

E. W. Bazinet, P. Eng.

REGISTERED PROFESSIONAL ENGINEER
MINING
E. W. BAZINET
Sept 20/71
PROVINCE OF ONTARIO

September 20, 1971.

TEL. 824-4337 – 824-3872

Val d'Or, Que., September 17 1971

BOURLAMAQUE ASSAY OFFICE

REG'D.

J. C. JENSEN, PROPRIETOR

MEMBER CANADIAN TESTING ASSOCIATION

Certificate of Analysis

No. 23917

Identification: 3Ag, 3Cu, 3Zn, 3Pb — Samples of: / Echantillons de: Surface

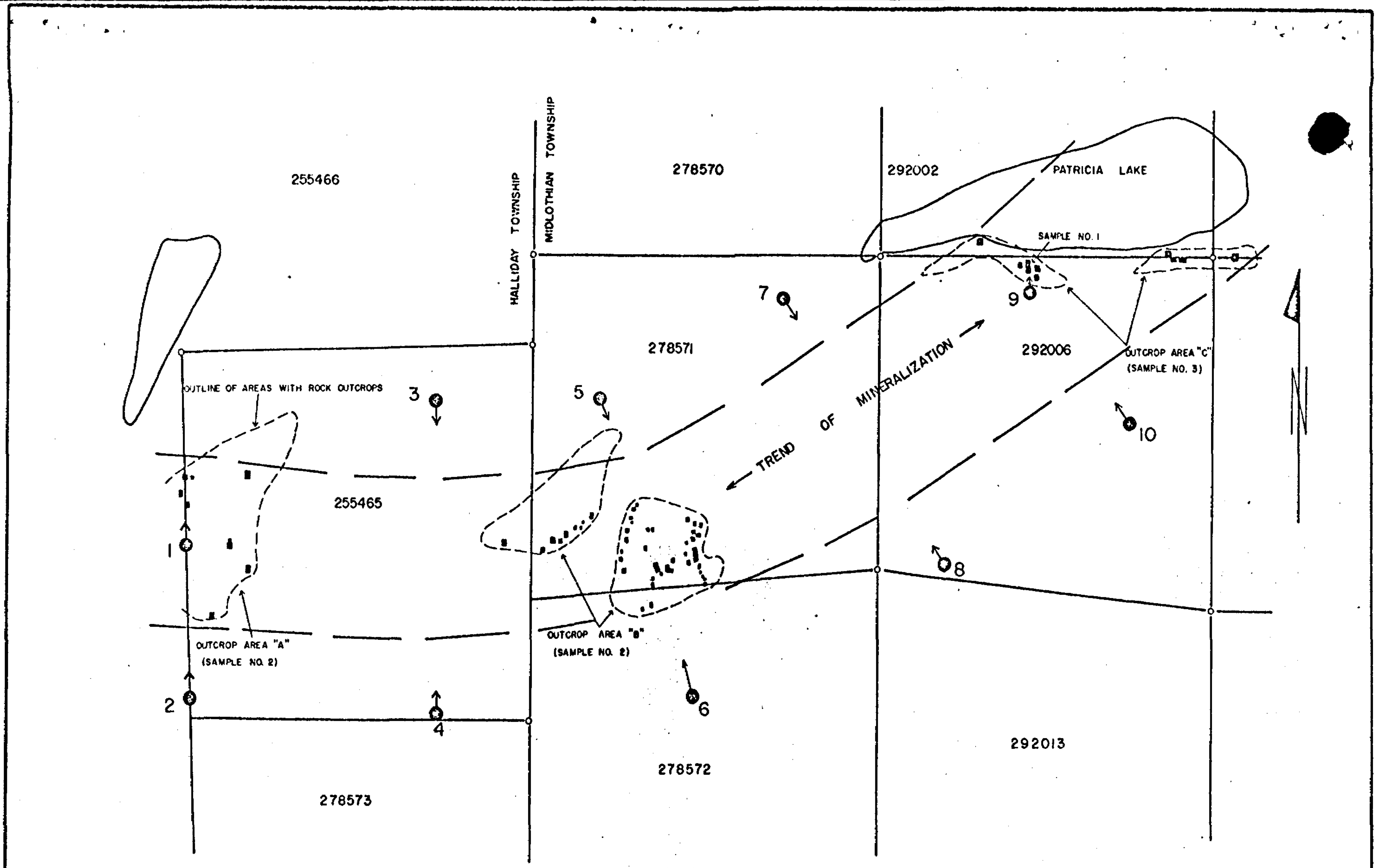
Received from: / Reçu de: Bus — Date Received: / Reçu le: Sept. 17

E. W. Bazinet, Larche Rousseau Property — with the following results: / avec les résultats suivants:

	Sample No.	Ag oz/ton	Cu %	Zn %	Pb %
No. 1	1901	0.34	0.05	4.12	0.25
No 2	1902	0.22	0.05	1.80	0.59
No 3	1903	0.40	0.08	2.45	1.40

REGISTERED PROFESSIONAL ENGINEER
E. W. BAZINET
PROVINCE OF ONTARIO

Assayer.



PLAN SHOWING

TRENCHES, MINERAL TREND, SAMPLE LOCATION

PROPOSED DDHOLES

GLEN COPPER MINES LTD.

HALLIDAY AND MIDLOTHIAN TOWNSHIPS

LARDER LAKE MINING DIVISION,

ONTARIO

SCALE 1" = 300 FEET

E. W. BAZINET

1971

REPORT ON

AN I.P. SURVEY OF 28 CLAIMS

HALLIDAY AND MIDLOTHIAN TOWNSHIPS, ONTARIO

LARDER LAKE MINING DIVISION

(LAT. 47° 53'; LONG. 81° 04')

For

GLEN COPPRER MINES LIMITED

By

S.L. SANDNER & ASSOCIATES

VANCOUVER, B.C.

NOVEMBER 12, 1971

Report by:

A.J. Sinclair PhD.

P.Eng.

Instrument Operator:

J. Denham.

S. L. SANDNER & ASSOCIATES

[illegible] GEOPHYSICISTS

6-[illegible] W. HASTINGS ST.

VANCOUVER 1, B.C

REPORT ON

AN I.P. SURVEY OF 28 CLAIMS

HALLIDAY AND MIDLOTHIAN TOWNSHIPS, ONTARIO,

LARDER LAKE MINING DIVISION

(Lat. 47° 53'; Long. 81° 04')

for

GLEN COPPER MINES LIMITED

by

A.J. Sinclair, P. Eng.

November 12, 1971

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FIGURES

1. Normalized I.P. (chargeability)
2. Apparent Resistivity
3. Self Potential
4. Ground Magnetometer Survey

REPORT ON AN I.P. SURVEY OF 28 CLAIMS HALLIDAY AND MIDLOTHIAN TOWNSHIPS, ONTARIO, LARDER LAKE MINING DIVISION for GLEN COPPER MINES LIMITED

SUMMARY

1. An I.P. survey totalling 10.1 line miles was conducted under the supervision of Mr. S.L. Sandner on claims between Sirola and Rhyolite Lakes, Halliday and Midlothian Townships, Larder Lake Mining Division, Ontario, for Glen Copper Mines Limited during the period October 24 to 30, 1971 inclusive.

2. The survey was carried out on N-S lines spaced 400 feet apart. A Hewitt Enterprises pulse-type I.P. instrument was used with a standard Wenner electrode array with "a" spacings of 400 feet.

3. Chargeability results indicate a large anomalous area in the northern and western parts of the claims group, part of which coincides with known mineralized outcrops. Within this large area are 5 anomalous peaks the four westernmost of which appear worthy of more detailed examination. The northern two of these peaks are of particular interest because they coincide in part with known mineralized rock. The southern two peaks occur within a regional shear zone and are of lower priority than those to the north.

4. Apparent resistivity results show the somewhat unexpected result that low values are superimposed over areas of known mineralization.

5. Self potential results are generally difficult to interpret but in the northwestern part of the claims group have a northwestern trend that corresponds with a very pronounced chargeability high.

6. Ground magnetometer data for the western part of the property have trends that parallel the regional structural trend. The pattern in the eastern part of the claims group is much more complicated.

INTRODUCTION

During the period October 24th to 30th inclusive a field party under the supervision of Mr. S.L. Sandner conducted an I.P. survey of 28 contiguous claims in Halliday and Midlothian townships, Larder Lake Mining Division, Province of Ontario, for Glen Copper Mines Limited. Total length of grid lines surveyed was approximately 10.1 miles. Purpose of the survey was to obtain specific targets for further detailed examination in an area of known mineralization. This report describes the instrumentation, field procedures and results of the survey. The I.P. survey was originally recommended by Mr. E.W. Bazinet, P. Eng. (1971).

Access to the property is by an all-weather road south from Timmins, Ontario, some 60 miles to Sirola Lake near the site of the abandoned Stears Gold Mine. Sirola Lake is crossed by canoe to its southwestern end where the survey grid is located.

The 28 full size, contiguous claims in the group surveyed have claim numbers as follows: 255465, 278570-278573 inclusive, 292002-292013 inclusive, 293217-293236 inclusive and 293395. The property has not been visited by the writer. This report is based on various published data for the area and survey results obtained by Mr. S.L. Sandner, and is written at the request of Mr. Sandner.

The claims occur in an area mapped by Bright (1970) as being underlain by felsic metavolcanics of Archean age. This unit consists of a variety of rock types including rhyolite, dacite, tuff and various sericite and sericite-chlorite schists. Some of the rhyolites and dacites are pillowed, fractured, amygdaloidal and/or porphyritic. Most of these varieties are indicated as being present on the property. Mineralized specimens from the property examined by the writer occur in a fractured and brecciated rhyolite with sulphides (mainly sphalerite) concentrated in fractures and interstitial to angular fragments. Bazinet (1971) describes the results of recent work which includes 50 trenches that expose low grade lead-zinc-copper-silver mineralization intermittently over an area 3,600 feet long and 500 feet wide. Assays as high as 4.37% combined lead-zinc and 0.34 oz. Ag per ton over widths of up to 20 feet have been obtained although average grade is lower.

The ground control grid was established prior to the induced polarization survey. The grid consists of north-south trending cross lines (approximately), crossing a single east-west trending (approximately) base line. The cross lines are 400 feet apart. The base line is located about 2,500' south of the north boundary of the property and crosses all but the easternmost 1,300 feet of the property.

Total line mileage for the induced polarization survey was 10.1 miles. The normalized induced polarization, resistivity, and self-potential data are shown on accompanying figures with a horizontal scale of 1" = 400'.

THE INDUCED POLARIZATION SURVEY

General Considerations of the Pulse Type Induced Polarization Method

Two varieties of induced polarization surveys are in common use today in mineral exploration. The first is the time domain or pulse type method in which a steady direct current is impressed on the ground for a few seconds and then abruptly terminated. A fraction of a second after cessation of current impulse, the decay voltage, (caused by sub-surface capacitive-like storage) is measured. The second method is the variable (dual) frequency technique or frequency domain. In this variety, the percentage difference between the impedance (a.c. resistance) offered at two separate frequencies, is measured.

The Hewitt (HEW 100) I.P. unit is a time domain unit and the exact method of measurement is outlined in the field procedure section.

The reader is referred to Wait, J.R. (1966), for a thorough treatment of frequency domain, and Seigel, H.O. (1966) and/or Brant (1966), for a discussion of time domain.

I.P. effect occurs when a current is passed through a volume of rock containing electrical conductors. Geophysical conductors, or "metallic minerals" include most sulphides, (pyrite, chalcopyrite, bornite, molybdenite) certain oxides, clays, graphite and certain micas.

Empirical methods have shown, however, that sulphides differ from other geophysical conductors in that charge builds up on them in an exponential manner. In the field, this means that the impressed dV measured by the receiving pots climbs steadily during the current pulse. Also, sulphides sometimes demonstrate an almost unique polarization response, known as metallic polarization. Either type of response is the best test available for distinguishing sulphide response from that of other geophysical electronic conductors. Apart from the sulphides, minerals with highly unsatisfied basal lattice surfaces act as leaky condensers and give rise to I.P. effects. All common rocks are responsive to some degree, and this response is designated background. It is commonly equivalent to one volume percent of scattered pyrite, and probably due to unsatisfied charges at lattice imperfections, mineral and rock boundaries, fractures, and so on.

Factors other than the amount of metallic conductors which affect I.P. response are grain size, conductivity of mineral, porosity, tortuosity (pore geometry), type of gangue minerals, composition and amount of pore fluid, degree of alteration, and mode of mineralization (disseminated, lode, vein type, etc.).

The apparent resistivity is also measured during the I.P. survey. Rogers, (1966), has pointed out that the resistivity of rock is only slightly influenced by changes in the sulphide content at low levels. Much of the change is due to other effects such as moisture content, fracturing, pore space, ground water, extent, degree and type of alteration, type of sulphides and mode of sulphide distribution, etc. However, alteration in combination with increased sulphide content, not uncommonly affects the resistivity significantly. Unfortunately, there are many additional causes for resistivity variation and rarely can sulphides be recognized or predicted from resistivity data alone.

Previous to current impression, the receiving pots are balanced, and thus, the self-potential value in millivolts is often a useful geophysical tool. When metallic lustered sulphide minerals are situated in a suitable geological-hydrological environment, the sulphides oxidize and a natural or spontaneous "battery effect" occurs. Often the self-potential effect over sulphide bodies is negative and in the order of a few hundred millivolts.

With a Wenner electrode configuration, the self-potential and first derivative of the self-potential are valuable information if the transit interval is equal to, or is one-half the "a" spacing distance. In other cases, where the "a" spacing and transit interval are not evenly proportional, the self-potential results are of little useful value.

Bibliography

(1) Frequency Domain:

Wait, J.R. (1951) Editor, Overvoltage Research and Geophysical Applications. Longon, Porgamon Press.

(2) Time Domain:

Brant, A.A. (1966) Examples of Induced Polarization Field.

Results in the Time Domain - Society of Exploration Geophysicists' Mining Geophysics, Volume I, Case Histories.

Seigel, H.O. (1966) Three Recent Irish Discovery Case Histories using Pulse Type Induced Polarization - S.E.G. Volume I, Case Histories - p.p. 341

Rogers, G.R. Introduction to the Search for Disseminated Sulphides, S.E.G. Volume I.

Field Procedure

A Hewitt Enterprises Pulse Type IP was used throughout the survey.

The standard Wenner electrode array was employed with an "a" spacing (one-third the distance between the current electrodes) of 400 feet. A brief description of the field procedure follows.

Prior to voltage application, the self-potential is balanced, and recorded, between the two receiving pots "a" feet apart. Normally a voltage of 250, 500 or 1,000 volts is impressed between the back electrode (one "a" behind the instrument) and front electrode (two "a" in front of the instrument). The electrodes consist of a single (or multiple) steel stake. A four second pulse of d.c. current is applied, during which time the I (current in milliamperes) and dV (impressed EMF in millivolts) is observed and recorded. Three-tenths seconds after cessation of pulse, the residual (decay) voltage is integrated for 0.8 seconds (on integration function #1). From these data, the apparent d.c. resistivity and normalized induced polarization value may be calculated, as described in the data reduction portion of this report.

The transit interval was 400 feet along all the cross lines, and the front electrode positive.

Induced Polarization Data Reduction

The following information was recorded by Mr. J. Dinham, the instrument operator, at each pulse station:

1. The property, operator's initials, job and page number, "a" spacing, transit interval and remarks on topography.
2. The line and station co-ordinates;
3. The self-potential reading in millivolts (S.P. mv);
4. The current in milliamperes (I ma);
5. The impressed EMF in millivolts (dV mv);
6. The induced polarization decay voltage in millivolts (IP mv);
7. The resistor capacitor switch (R.C.) setting;
8. The current electrode voltage switch value;
9. The integration function switch (I.F.) setting;
10. The pulse time in seconds.

From this data, the apparent resistivity is calculated from the following relation:

$$\text{Rho} = \frac{2\text{pi} \times a \ dV}{I \ (\text{ma})}$$

Where: Rho = apparent resistivity in ohm-feet

Pi = 3.1416

"a" = 1/3 distance between the current electrodes

The normalized IP value is obtained by utilization of the following relation:

$$\text{IP norm} = \frac{\text{IP (mV)} \times 100 \times k \times \text{R.C.}}{\text{dV (mV)}}$$

Where: IP norm = normalized IP in millivolt seconds per millivolt or milliseconds

K = a constant depending on the IP setting.

R.C. = resistor - capacitor shunt.

DISCUSSION OF RESULTS

Results of the survey are shown on three contour maps, each with a scale of 1 inch equals 400 feet. These are (1) chargeability (figure 1), (2) apparent resistivity (figure 2), and (3) self potential (figure 3). In addition, contoured results of an independent ground magnetometer survey are included (figure 4) as an aid in interpretation of the I.P. survey results.

Chargeability

Chargeability data were analyzed graphically on log probability paper. This analysis indicated that two lognormal populations could be separated effectively by a threshold value of about 10 milliseconds. In other words, chargeability values greater than 10 belong to a high or anomalous population whereas values below 10 represent background readings. The 10 millisecond contour on figure 1, therefore, effectively separates anomalous areas from areas characterized by background readings. It can be seen that a fairly large area including much of the northern and western parts of the claims group features anomalous chargeability values. Within this area are 5 pronounced highs that warrant detailed consideration. It should be noted that the mineralized areas shown by Bazinet (1971) lie entirely within the anomalous region of normalized I.P. values, but do not coincide exactly with the five localized areas of very high values.

The trend of mineralization shown by Bazinet (1971) follows the regional geological trend in the area as mapped by Bright (1970), approximately northeasterly. The northeastern-most anomalous high extending south-

southwesterly from the southwestern end of Sirola Lake coincides with an outcrop scarp and therefore, might be a function of physiography and structure rather than mineralization. Of the remaining four anomalous highs, the two northernmost are most closely associated with known mineralization and warrant close examination. These two anomalous highs are characterized by northwesterly trends and are largely coincident with apparent resistivity lows (cf. figure 2). The two southernmost anomalous highs near the western boundary of the claims group occur in an area of no outcrop. It is therefore difficult to interpret their significance. They do, however, occur within a much larger area mapped by Bright (1970) as a shear zone of regional extent. The possibility that these two anomalously high chargeability zones represent a part of the shear zone that is mineralized, should not be ignored.

Apparent Resistivity

Contoured apparent resistivity values are shown in figure 2. The most significant aspect of this map is that known mineralization correlates with relatively low to moderate values of apparent resistivity. This is a somewhat unexpected result because the abundant mineral in surface showings, sphalerite, is a poor conductor. As Bazinet (1971) points out, however, mineral zoning may prevail and other highly conducting sulphides might be present at depth.

Apparent resistivity maps are as a rule difficult to interpret because of the effects of wet overburden, water table, shear zones and variations in lithology. Consequently, little else can be said of these data.

Self Potential

Self potential results, shown in figure 3, are highly variable over short distances. One feature, however, may be of considerable importance. In the northwestern part of the claims group a very pronounced northwesterly trend to S.P. contours is evident. This might serve to verify the northwesterly trend of a pronounced and coincident chargeability anomaly that in part coincides with known mineralized outcrops.

Ground Magnetometer Survey

Contoured results of a ground magnetometer survey done independently of the I.P. survey considered here are shown in figure 4. The area of known mineralization includes readings mainly in the range 600 to 700 gammas with a few values above and below these limits. The general trend of magnetic contour lines in the western part of the claims group where known mineralization is located, parallels the regional geological trend. The pattern is much more complicated in the eastern part of the group.

CONCLUSIONS

Known mineralized areas in the northwestern part of the claims group are characterized as follows:

(1) They are located intermittently in a zone that approximately parallels the regional geological trend as shown by Bright (1970).

(2) They occur in an area of generally moderate magnetic intensity relative to values throughout the claims group. Generalized magnetic trend lines in and near known mineralized areas parallel the regional geological trend,

(3) All known mineralized outcrops as figured by Bazinet (1970) lie within a larger zone of anomalous chargeability values.

Within the large area characterized by anomalous chargeability values are 5 anomalous peaks. The easternmost of these coincides with a scarp and appears to have lowest priority. The two northernmost anomalous peaks of the remaining 4 coincide in part with known mineralized outcrops and have approximately northwesterly trends (opposed to the northeasterly regional geological trend). This northwestern trend is substantiated by similar trend on the S.P. map. The two anomalies in question occur in an area of low apparent resistivity values. They warrant detailed examination!

South of these two anomalies are 2 additional chargeability highs that occur in a shear zone of regional extent (Bright, 1970). Outcrops are not known in the immediate vicinity of these anomalies but the possibility that they represent mineralized parts of the shear zone cannot be ignored.

REFERENCES

Bazinet, E.W., P. Eng., 1971, Report for Glen Copper Mines Limited on the Timmins, Ontario Property; dated September 20, 1971, 18 p.

Bright, E.G., 1970, Geology of Halliday and Midlothian Townships, Ontario Dept. Mines, Geol. Rept. 79, 33 p. (including map).

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA A. J. SINCLAIR

....
Dr. A.J. Sinclair, P. Eng.
November 12, 1971

APPENDIX

PERSONNEL AND DATES WORKED

A: Field Work

Supervisor	S.L. Sandner	October 24-30 incl.
Operator	J. Dinham	October 24-30 incl.
Helpers	R. Turner	October 24-30 incl.
	C. Dubois	October 24-30 incl.
	A. Picard	October 24-30 incl.

B: Report Preparation

Dr. A.J. Sinclair, P. Eng.	November 9, 11, 12
A. Mlcuch - data processor	November 2, 3, 4 and 5

C: Drafting and Reproduction

T. Malesku	November 11, 12, 13

CERTIFICATE

I, Alastair J. Sinclair, of the city of Vancouver, province of British Columbia, hereby certify:

1. That I am a Geological Engineer residing at 5869 Dunbar Street, Vancouver 13, British Columbia.

2. That I obtained a B.A.Sc. degree in Applied Geology from the University of Toronto in 1957, an M.A.Sc. degree in Geological Engineering from the University of Toronto in 1958, and a Ph.D. in Geology from the University of British Columbia in 1964.

3. That I am a registered Professional Engineer in the Province of Ontario in the Mining Division, and in the Province of British Columbia in the Geology Division.

4. That I have practiced my profession for fourteen years.

5. That I have no interest directly or indirectly, nor do I expect to have any direct or indirect interest in the properties or securities of Glen Copper Mines Limited.

6. That the accompanying report is based upon my studies of geophysical results obtained under the supervision of Mr. S.L. Sandner, and two publications listed under "references".

Dated at Vancouver in the Province of British Columbia this 12th day of November, 1971.

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
A. J. SINCLAIR

....

A.J. Sinclair, P. Eng.

REPORT ON AN INDUCED POLARIZATION SURVEY, HALLIDAY AND MIDLOTHIAN TWP., LARDER LAKE MINING DIVISION ON BEHALF OF GLEN COPPER MINES LTD.

by

Jan Klein, M.Sc., P.Eng.,
Geophysicist

TORONTO, Canada

August, 1972

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"Induced Polarization Method", by Dr. H.O. Seigel

"Mark VII Induced Polarization Systems" Specification Sheet

SUMMARY

An induced polarization and resistivity survey was executed over an E-W grid in the northern parts of Halliday and Midlothian Twps.

The background chargeabilities and resistivities obtained over the felsic metavolcanics are in the neighbourhood of 5 milliseconds, and ranging up to 10,000 ohmmeters respectively.

At least three parallel bands of polarizable material are detected. Zone B, which is the center band, shows the strongest responses, with Zones A and C respectively south and north of Zone B being somewhat weaker.

An initial drill program totalling 1,800 feet in length is recommended to investigate the sources of anomalous polarization.

REPORT ON AN
INDUCED POLARIZATION SURVEY
HALLIDAY AND MIDLOTHIAN TWP.,
LARDER LAKE MINING DIVISION
ON BEHALF OF
GLEN COPPER MINES LTD.

INTRODUCTION

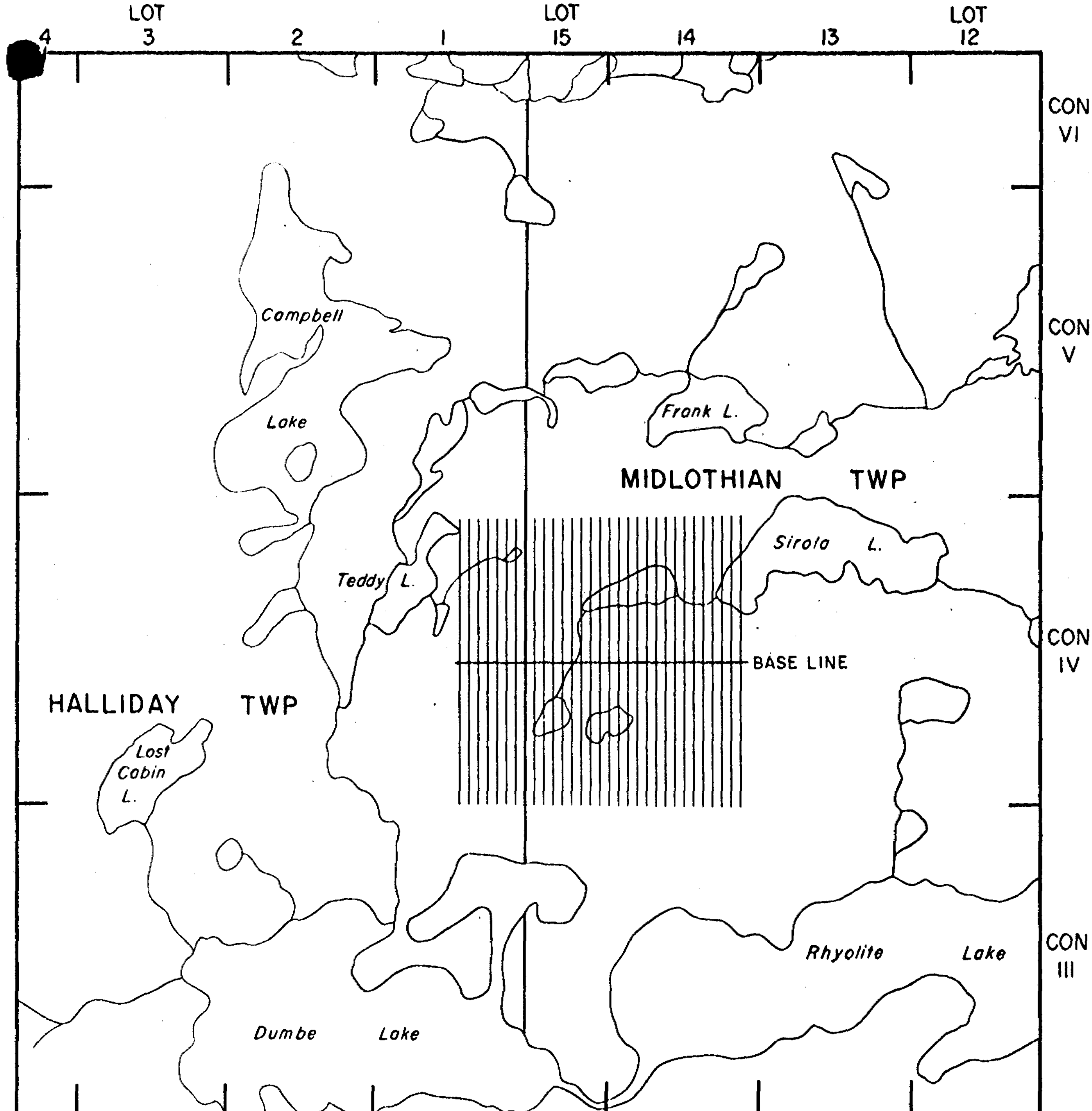
During the period July 18th to 26th, 1972, an induced polarization survey was conducted in Halliday and Midlothian Twps., Larder Lake Mining Division, Northern Ontario, under the direction of Mr. P. Robertshaw, M.Sc., of Seigel Associates Limited, on behalf of Glen Copper Mines Ltd.

The property is located in northern Halliday and Midlothian Twps., approximately 20 miles west of Matachewan, Northern Ontario (Figure 1). Access is by dirt road from Highway 566 to the Stairs Midlothian Mine, then by logging road to Sirola Lake.

During the period June 1st to 10th, 1972, Mr. J.R. Boissoneault, P.Eng., conducted a magnetometer survey over the property and performed geological mapping as well. This work does not fall under the responsibility of Seigel Associates Limited. The results, however, are incorporated in this report and used in the interpretation.

GEOLOGY

The grid area is underlain by Precambrian felsic metavolcanics consisting of brecciated rhyolites, rhyolite-dacite, sericite schists, etc. This area is located within the northeastern part of a 20-mile long rhyolitic dome (Geology of Halliday and Midlothian Townships, Geological Report #79,



LOCATION MAP

GLEN COPPER MINES LTD.

HALLIDAY & MIDLOTHIAN TOWNSHIP
ONTARIO

INDUCED POLARIZATION SURVEY

SCALE: 1/2 mile to 1 inch

FIGURE VI

72-9574

E.G. Bright, 1970). A number of showings occur on the property, mainly close to the base line, indicating widespread pyrite and sphalerite mineralization. The paragenisis of the mineralization here is uncertain and direct coincidence of sphalerite and pyrite concentrations may not occur. Minor lead and copper, and some silver occur in some showings.

Sphalerite, although a metallic sulphide mineral, is considered undetectable to induced polarization methods due to its high resistivity (especially in the case of low-iron forms). The purpose of the induced polarization survey, therefore, was to detect concentrations of other sulphides (pyrite, galena, chalcopyrite, etc.) with which sphalerite may be associated.

METHOD AND INSTRUMENTATION

During the present survey, a 2.5 kw Scintrex Mk VII time domain. pulse-type induced polarization unit was employed (see Specification Sheet attached). The receiver was the remote-triggered Scintrex IPR-VII. Current-on and -off times of two seconds were used, and normalized transient polarization voltages are integrated from .45 seconds to 1.10 seconds after current-off time. The resulting quantities are expressed in units of milliseconds and called the chargeability, 'M'. Beside the chargeability, the resistivity, in units of ohmmeters, is simultaneously measured. Anomalous induced polarization responses may result from metallic sulphides, graphitic and carbonaceous material, as well as from clay minerals, chlorite, sericite, serpentinized rocks and other platey minerals derived from weathering, etc. It is not always possible on the basis of induced polarization data alone to discriminate between these potential sources of anomalous polarization.

The principles, field procedures and nature of results obtained over several base metal deposits are described in the accompanying article by Dr. H.O. Seigel entitled "Induced Polarization Method".

PRESENTATION OF DATA

The induced polarization results are presented in profile form on Plate 1, on a horizontal scale of 1" = 400 feet. The interline spacing is not to scale. The chargeabilities are plotted with a vertical scale of 1" = 10 milliseconds, and the resistivities are on a logarithmic vertical scale for which 1.33" = a factof of 10. The datum level for the resistivity profiles is 100 ohm-meters.

The 3-array electrode configuration was used throughout the survey with the potential dipole always to the north.

The magnetic results obtained by Mr. J.R. Boissoneault are shown in contour plan on Figure 2 on a scale of 1" = 400' , and a contour interval of 50 gammas. A McPhar M-700 magnetometer was used.

The location of pits and trenches (Figure 4) and the geological results (Figure 3) are shown on separate plates on a scale of 1" = 400' . Showings are indicated by means of a circle and a description of the rocks found. The pits and trenches are numbered with the percentages of zinc and lead, and ounces of silver and gold tabulated.

The anomalous zones obtained with the 200-foot electrode spacing are presented on the base of Figure 2 in Figure 5.

DISCUSSION OF RESULTS

The magnetic contour plan shows a N60° strike direction, which is undoubtedly related to the formational strike of the felsic metavolcanics. The relief is in general low (150 gammas), ranging from the low 500 gamma values to the higher 600 gamma values, as marked on Mr. J.R. Boissoneault's contour plan. Several narrow, linear structures have been shown, which might suggest that the different rhyolite horizons are not exceeding 50-100 feet in thickness. However, in sections where the contours are wider apart, more massive rhyolite bodies might be present. It is difficult to say if the change in magnetic values is directly related to a change in magnetite content only, or that remnant magnetism is part of the pattern displayed.

The geological plan shows that on many places pyrite, iron oxides, minor copper, zinc or lead have been found. The assay results reveal that the highest zinc content is 2.10% (pit #28).

The background chargeability level obtained employing spacings ranging from 100-400 feet are approximately 5 milliseconds (southern parts of lines 20-28E). The corresponding resistivities are in the neighbourhood of 10,000 ohmmeters, and the magnetic contour plan shows a more-or-less homogeneous mass with values ranging from 400-600 gammas. However, on the average, they lie between 450-550 gammas.

This 5 millisecond level is quite normal for unmineralized rhyolitic rocks, and one might assume that values rising over 10 milliseconds are anomalous.

Anomalous regions are shown on all lines. The profile patterns suggest that at least three parallel anomalous zones are present in the eastern part of the grid. These zones seem to merge into one vast anomalous region to the west of line 0+00. The strongest chargeabilities were measured on lines 0+00 and 4E employing the narrowest spacing (100 feet). A value of 39 milliseconds was measured at line 0+00 at station 5+50N, and a value of 36.7 milliseconds on line 4E at station 6+50N. Comparing the peak amplitudes and curve shapes of the anomalous zone directly north of the baseline on lines 0+00, 4E and 8E suggests that two parallel bands of steeply-dipping material are coming close to surface. The material might increase in volume or percentage of sulphide with depth.

Further to the west the chargeability level increases gradually, showing a broad anomaly on line 12W of approximately 25 milliseconds, with no apparent change in resistivity from on or about 5,000 ohmmeters. Comparing the chargeability and resistivity results on this line shows that the strongest chargeabilities correspond with minor decreases in resistivities. The same is obvious on lines 0+00, 4E and 8E. This might suggest that a certain amount of interconnection between the polarizable grains (sulphide) might occur even though the writer does not want to call it massive mineralization.

The anomalous zones are superimposed on Figure 2 (Mr. J.R. Boissoneault's magnetic contour plan), and in Figure 5 the chargeabilities indicated are those higher than 10 milliseconds obtained with the 200-foot electrode separation. The main zone described above is labelled 'B'.

Two other zones are indicated on Figure 5, labelled 'A' and 'C'. Both, as mentioned earlier, parallel Zone B, but they are of lesser strength. However, the peak amplitudes of Zone A on line 8E and 12E, of approximately 20 milliseconds, might still be representing 1-3% of sulphides by volume while Zone B near its highest peaks might contain as much as 5-7% of polarizable material by volume. Zone C is interrupted by Patricia Lake (lines 16E, 20E and 24E), but possibly reappears on line 28E near station 19N.

Figure 5 shows that the anomalous zones parallel approximately the strike direction as given by the magnetics. It is of great importance to see that the pits as located between lines 0+00 and 8E immediately around or north of the baseline are not underlain directly by the chargeability peaks but are located near the proximities of the anomalous zones. One might therefore assume that better sulphide values will occur at depth, and that the pits only might reflect patchy mineralization.

CONCLUSIONS AND RECOMMENDATIONS

An induced polarization and resistivity survey was executed over an E-W grid in the northern parts of Halliday and Midlothian Twps. The eleven lines vary in length from 1,300 feet to 3,400 feet.

The background chargeabilities and resistivities obtained over the felsic metavolcanics are in the neighbourhood of 5 milliseconds, and ranging up to 10,000 ohmmeters respectively. Five milliseconds might be considered normal for unmineralized felsic metavolcanics. The magnetic contour plan as obtained from Mr. J.R. Boissoneault reveals a relatively homogeneous magnetic pattern over the area in the southwestern part of the grid, which only revealed background chargeability levels.

Most of the grid shows strong chargeabilities, and Figure 5 shows the zones as delineated from the 200-foot electrode separation and a 10 millisecond cut-off level. At least three parallel bands of polarizable material are detected. Zone B, which is the center band, shows the strongest responses, with Zones A and C respectively south and north of Zone B being somewhat weaker. However to the west these three zones most likely merge, presenting chargeabilities in the range of those obtained over Zone B.

At the present time it is suggested to test only parts of those zones by means of diamond drilling:

1. Collar on line 0+00 at station 8+00N; drill 45° south for 400 feet depth.
2. Collar on line 0+00 at station 0+50N; drill 45° north for 400 feet.

Holes 1 and 2 were discussed between the writer and Mr. J.R. Boissoneault and started 100' further away from the anomaly than suggested by the geophysical results, to allow intersecting of possible sphalerite.

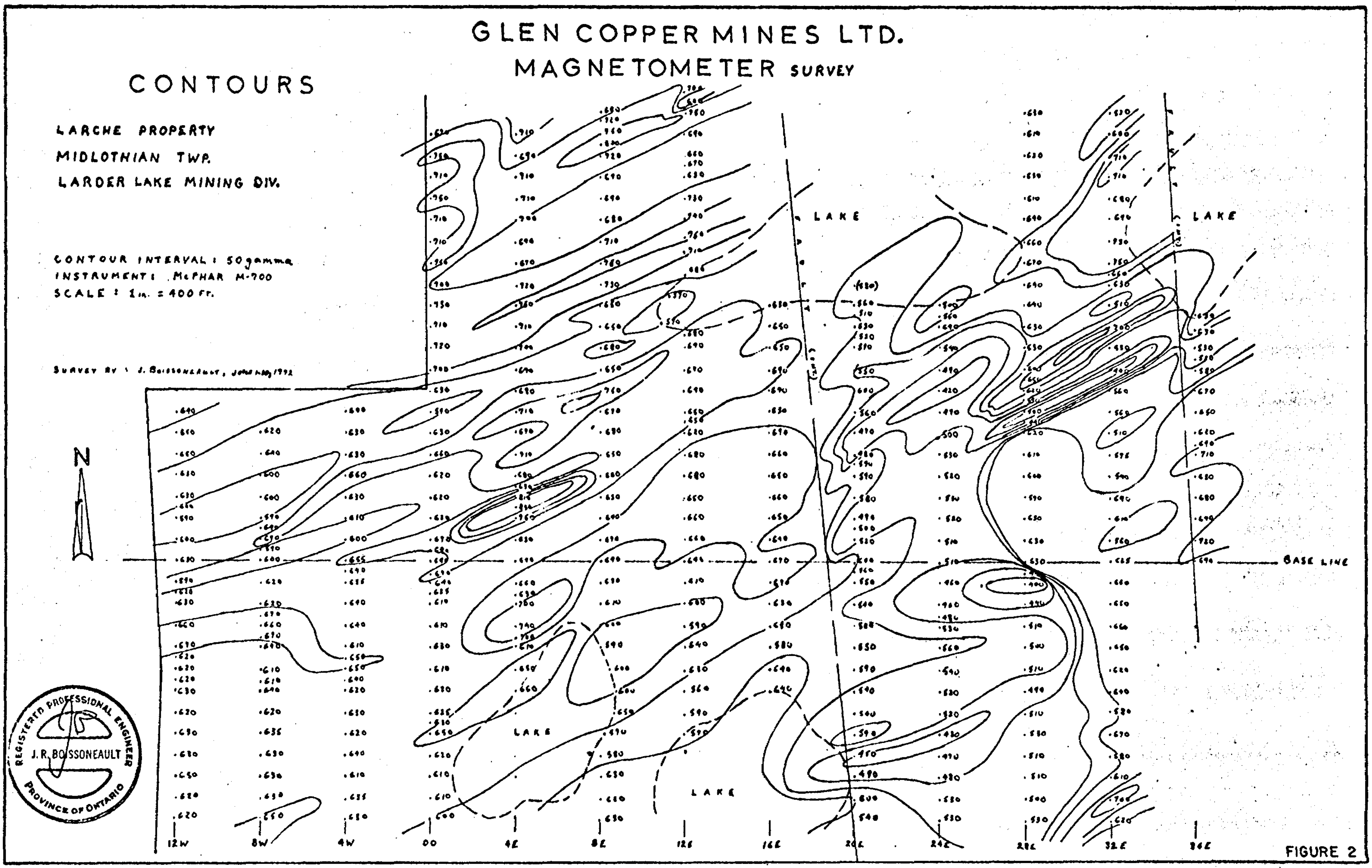
3. Collar on line 4E at station 5+50N; drill 45° north for 400 feet.
4. Collar on line 12E at station 6+00S; drill 45° north for 300 feet depth.
5. Collar on line 28E at station 14N; drill 45° south for 300 feet.

Additional drilling on Zones A, B and C, as well as the western extension of those zones would be predicated on the results of these initial holes, whereas the above holes are up to 400 feet recommended length this length is intended as a minimum one. In the event that interesting sulphide mineralization persists beyond the indicated depth in any one of the holes, this hole should obviously be extended.

Respectfully submitted,

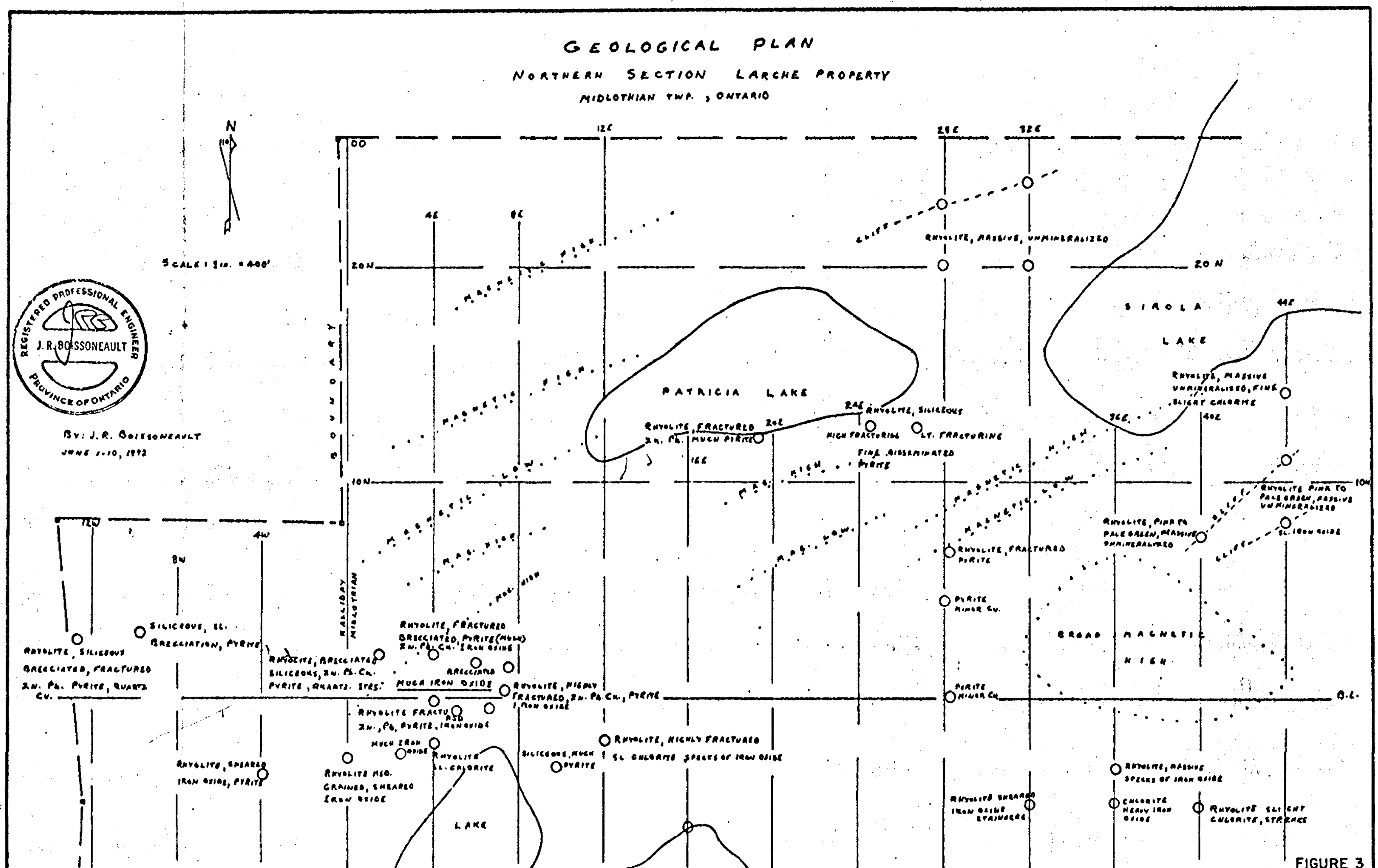
Jan Klein

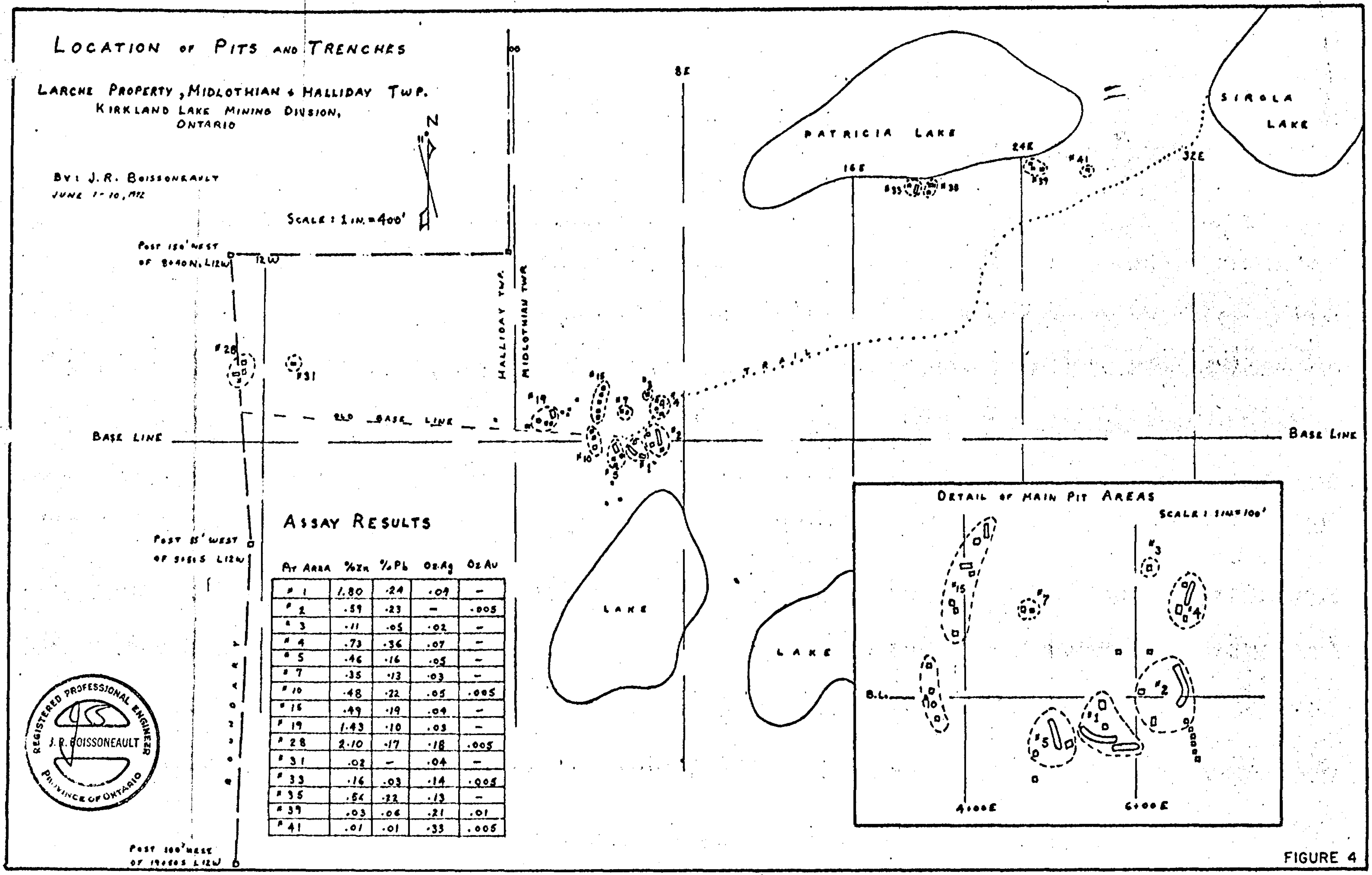
Jan Klein, M.Sc., P.Eng.,
Geophysicist.



GLEN COPPER MINES LTD.
MAGNETOMETER SURVEY
CONTOURS
LARCHE PROPERTY
MIDLOTHIAN TWP.
LARDER LAKE MINING DIV.
CONTOUR INTERVAL : 50 gamma
INSTRUMENT : McPHAR M-700
SCALE : 1 in. = 400 FT.
N
LAKE
LAKE
LAKE
LAKE
BASE LINE
12W
8W
4W
00
4E
8E
12E
16E
20E
24E
28E
32E
36E
REGISTERED PROFESSIONAL ENGINEER
J. R. BOISSONEAULT
PROVINCE OF ONTARIO

FIGURE 2


GEOLOGICAL PLAN
NORTHERN SECTION LARCHE PROPERTY
MIDLOTHIAN TWP., ONTARIO
N
SCALE 1 IN. = 400'
REGISTERED PROFESSIONAL ENGINEER
J. R. BOISSONEAULT
PROVINCE OF ONTARIO
BY: J.R. BOISSONEAULT
JUNE 1-10, 1972
BOUNDARY
KALLIBAY
MIDLOTHIAN
PATRICIA LAKE
SIROLA LAKE
LAKE
BROAD MAGNETIC HIGH
MAGNETIC HIGH
MAGNETIC LOW
MAG. HIGH
MAG. LOW
CLIFF
20 N
10N
B.L.
RHYOLITE, MASSIVE, UNMINERALIZED
RHYOLITE, FRACTURED ZN. PB. MUCH PYRITE
RHYOLITE, SILICEOUS
HIGH FRACTURING
LT. FRACTURING
FINE DISSEMINATED PYRITE
RHYOLITE, MASSIVE UNMINERALIZED, FINE, SLIGHT CHLORITE
RHYOLITE PINK TO PALE GREEN, MASSIVE UNMINERALIZED
RHYOLITE, PINK TO PALE GREEN, MASSIVE UNMINERALIZED
SL. IRON OXIDE
RHYOLITE, FRACTURED PYRITE
PYRITE MINOR CU.
RHYOLITE, SILICEOUS BRECCIATED, FRACTURED ZN. PB. PYRITE, QUARTZ CU.
SILICEOUS, SL. BRECCIATION, PYRITE
RHYOLITE, BRECCIATED SILICEOUS, ZN. PB. CU. PYRITE, QUARTZ STRS.
RHYOLITE, FRACTURED BRECCIATED, PYRITE (MUCH) ZN. PB. CU. IRON OXIDE
BRECCIATED
MUCH IRON OXIDE
RHYOLITE, HIGHLY FRACTURED, ZN. PB. CU., PYRITE IRON OXIDE
RHYOLITE FRACTURED ZN., PB, PYRITE, IRON OXIDE
MUCH IRON OXIDE
RHYOLITE SL. CHLORITE
RHYOLITE, HIGHLY FRACTURED SL. CHLORITE SPECKS OF IRON OXIDE
SILICEOUS, MUCH PYRITE
RHYOLITE, SHEARED IRON OXIDE, PYRITE
RHYOLITE MED. GRAINED, SHEARED IRON OXIDE
RHYOLITE, MASSIVE SPECKS OF IRON OXIDE
RHYOLITE SHEARED IRON OXIDE STRINGERS
CHLORITE HEAVY IRON OXIDE
RHYOLITE SLIGHT CHLORITE, STREAKS
FIGURE 3



ASSAY RESULTS

Pit Area	%Zn	%Pb	Oz.Ag	Oz Au
# 1	1.80	.24	.09	–
# 2	.59	.23	–	.005
# 3	.11	.05	.02	–
# 4	.73	.36	.07	–
# 5	.46	.16	.05	–
# 7	.35	.13	.03	–
# 10	.48	.22	.05	.005
# 15	.49	.19	.04	–
# 19	1.43	.10	.03	–
# 28	2.10	.17	.18	.005
# 31	.02	–	.04	–
# 33	.16	.03	.14	.005
# 35	.56	.22	.13	–
# 39	.03	.06	.21	.01
# 41	.01	.01	.33	.005

FIGURE 4

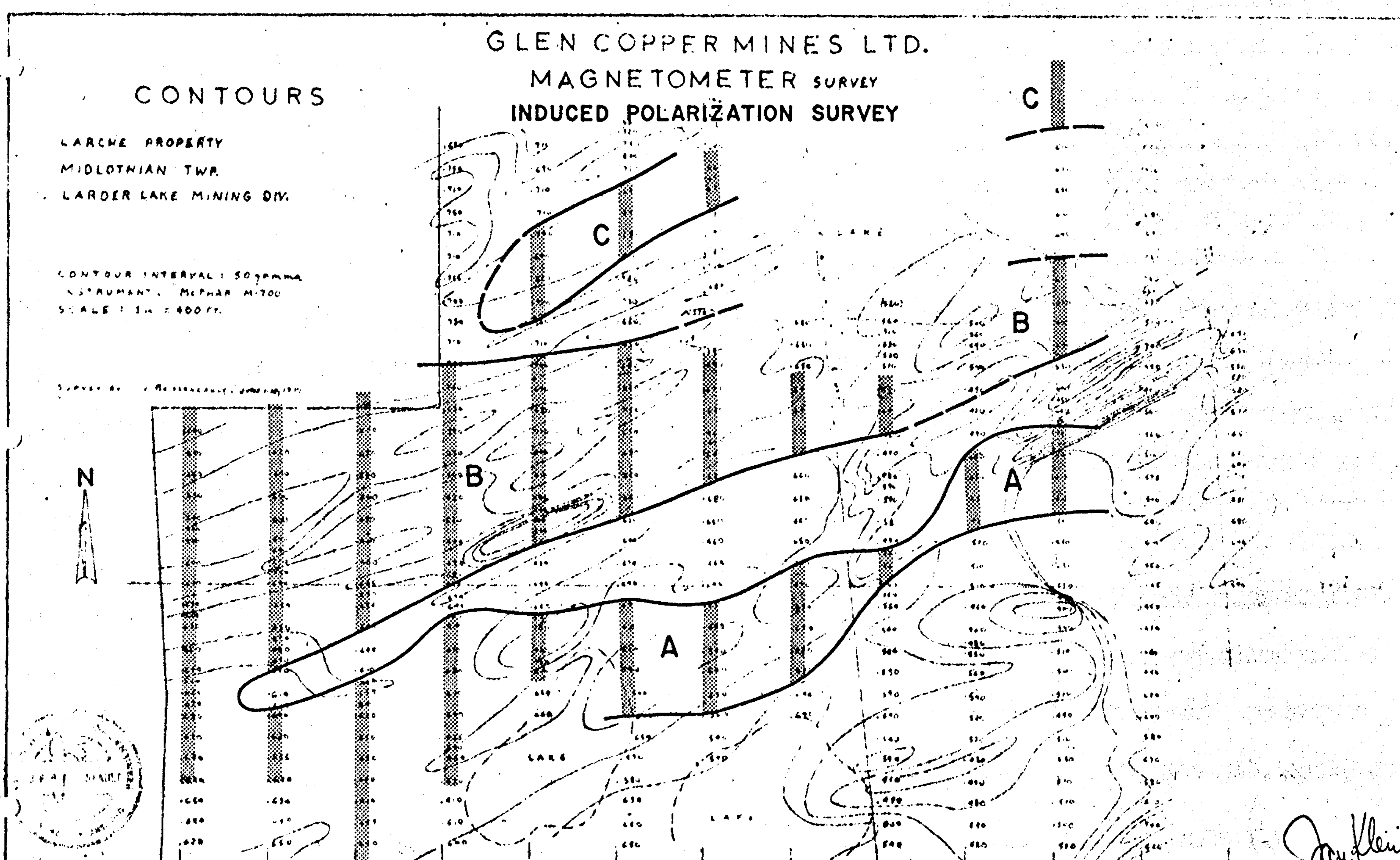


FIGURE 5

72 - 9574

Induced polarisation method

By Dr. HAROLD O. SEIGEL
President, Scintrex Limited

REPRINTED FROM THE OCTOBER 1970 ISSUE OF.... MINING IN CANADA

for SCINTREX

The induced polarization method is based on the electrochemical phenomenon of Overvoltage, that is, on the establishment and detection of double layers of electrical charge at the interface between ionic and electronic conducting material when an electrical current is caused to pass across the interface.

In practice, two different field techniques (Time Domain and Frequency Domain) have been employed to execute surveys with this method. These techniques can yield essentially equivalent information but do not always do so. Instrumentation and field procedures using both techniques have evolved considerably over the past two decades. Much theoretical information for quantitative interpretation has been accumulated.

All naturally occurring sulphides of metallic lustre, some oxides and graphite, give marked induced polarization responses when present in sufficient volume, even when such materials occur in low concentrations and in the form of discrete, non-interconnected particles.

Induced Polarization is the only method presently available which has general application to the direct detection of disseminated sulphide deposits such as "porphyry type" or bedded copper deposits, and bedded lead-zinc deposits in carbonate rocks.

A number of case histories are documented where standard geo-electrical and other geophysical methods failed to yield an indication of sulphide mineralization detectable by the induced polarization method.

Each rock and soil type exhibits appreciable induced polarization response, usually confined to a relatively low amplitude range, which is characteristic of the specific rock or soil. Certain clays and platey minerals including serpentine, sericite and chlorite, sometimes give rise to abnormally high responses. These effects are attributed largely to so-called "membrane" polarizations.

Despite a moderate amount of laboratory and field investigation, it is not feasible in general to differentiate between induced polarization responses due to Overvoltage and non-metallic sources, nor to differentiate between possible sources within each group.

Because of other variables, it is likewise difficult to uniquely equate a specific induced polarization response to a specific percentage of metallic content, although mean relationships have been established.

Through the measurement of secondary parameters, such as the transient decay curve form characteristics, one may obtain useful information relating to the average particle size of metallic responsive bodies or to the influence of electromagnetic transients on the I.P. measurements. The latter effect becomes prominent when surveys are made in areas with highly conducting surface materials, e.g. semi-arid regions.

Induced polarisation method

By Dr. HAROLD O. SEIGEL
President, Scintrex Limited

THE induced polarization (or I.P. as it is commonly known) method is, in application, the newest of our mining geophysical tools, having come into active use only in late 1948. Its roots extend somewhat farther back, however. Schlumberger (1920) reports having noted a relatively lengthy decay of the residual voltages in the vicinity of a sulphide body after the interruption of a primary D.C. current. Unfortunately, measurements in non-mineralized areas gave rise to rather similar residual polarization potentials, so he apparently abandoned his efforts.

In the late 1930's in the U.S.S.R. (Dakhnov, 1941) I.P. measurements were being made in petroleum well logging in an attempt to obtain information relating to the fluid permeability of the formations traversed by the well. Dakhnov mentions the possible application of the method to the exploration for sulphide mineralization, although it would appear that no such use was being made use thereof at that time. Unfortunately the volume of Dakhnov did not come to the attention of abstracters in North America until the spring of 1950.

Active development of the I.P. method as applied to mineral exploration in North America commenced with the writer's theoretical study in 1947 of the phenomenon of Overvoltage and his report (Seigel, 1948) on its possible application to geophysical prospecting. Laboratory and subsequent field investigation, sponsored by Newmont Mining Corporation in 1948 eventually led to the development of a working field technique and the recognition of polarization effects in all rocks (Seigel 1949).

Contemporaneously and independently D.A. Bleil (Bleil 1953) indicated the possibility of utilizing I.P. in prospecting for magnetite and sulphide mineralization but apparently did not recognize the presence of non-metallic polarization effects in rocks.

Until 1950 all I.P. measurements were of the "time-domain" type (see below). In 1950, as the result of some laboratory measurements, L.S. Collett and the writer suggested the method of measuring I.P. effects using sinusoidal current forms of different frequencies. J.R. Wait expanded greatly on the possibilities of this approach and successful field tests were carried out in that year. The work of the Newmont group is summarized in a monograph (Wait 1959).

Since 1950 several groups have been active in the development of the I.P. method by means of theoretical laboratory model and field studies. Prominent among these groups has been that at the Massachusetts Institute of Technology (Hall of 1957) (Madden 1957) (Marshall 1959).

Within the literal meaning of the term, polarization is a separation of charge to form an effective dipolar distribution within a medium. Induced polarization is, therefore, a separation of charge which is due to an applied electric field. It may also include phenomena which cause voltage distributions similar to those due to true polarization effects.

For practical purposes, only polarization effects with time constants of build up and decay longer than a few milliseconds are of importance. This usually excludes such phenomena as dielectric polarization and others which are encompassed by the normal electromagnetic equations.

In order to measure I.P. effects in a volume of rock one passes current through the volume by means of two contact points or electrodes and measures existing voltages across two other contact points.

Theoretically, any time varying current form can be used, but in practice only two such forms are employed. In the first technique a steady current is passed for a period of from one second to several tens of seconds and then abruptly interrupted.

The polarization voltages built up during the passage of the current will decay slowly after the interception of the current and will be visible for at least several seconds after the interception. This is termed the "Time Domain" method.

The "Frequency Domain" method entails the passage of sine wave current forms of two or more low, but well separated, frequencies, e.g. 0.1 and 2.5 c.p.s., or 0.5 c.p.s. and 10 c.p.s.

Since polarization effects take an appreciable time to build up, it can be seen that they will be larger at the lower frequency than at the higher, so that apparent resistivities or transfer impedances between the current and measuring circuits will be larger at the lower frequency. The change of measured resistivities with frequency is, therefore, an indication of polarization effects.

Further discussion of the precise quantities measured in the Time and Frequency Domain methods will be resumed after a presentation of some of the polarization phenomena involved.

When a metal electrode is immersed in a solution of ions of a certain concentration and valence, a potential difference is established between the metal and the solution sides of the interface. This difference in potential is an explicit function of the ion concentration and valence, etc.

When an external voltage is applied across the interface a current is caused to flow and the potential drop across the interface changes from its initial value. If the electrode is a cathode it becomes more negative with respect to the solution, whereas if it is an anode, it becomes more positive with respect to the solution.

The change in interface voltage is called the "Overvoltage" or "Polarization Potential" of the electrode. If the electrode is a cathode, we speak of "Hydrogen Overvoltage" and, if an anode, of "Oxygen Overvoltage".

These Overvoltages are due to an accumulation of ions on the electrolyte side of the interface, waiting to be discharged. The charge of these ions will be balanced by an equal opposite charge due to electrons or protons on the electrode side of the interface.

For small current densities the Overvoltage is proportional to the current density, i.e. is a linear phenomenon. The variation of Overvoltage with several other factors is presented in the writer's Doctoral Thesis. (Seigel, 1949). The time constant of build up and decay is of the order of several tenths of seconds.

Overvoltage is, therefore, established whenever current is caused to flow across an interface between ionic and electronic conduction. In normal rocks the current which flows under the action of an impressed E.M.F. does so by virtue of ionic conduction in the electrolyte in the capillaries of the rock.

There are, however, certain rock forming minerals which have a measure of electronic conduction, and these include almost all the metallic sulphides (except sphalerite), graphite, some coals, some oxides such as magnetite, and pyrolusite, native metals and some arsenides and other minerals with a metallic lustre.

When these are present in a rock subjected to an impressed E.M.F., current will be caused to flow across capillary – mineral interfaces and

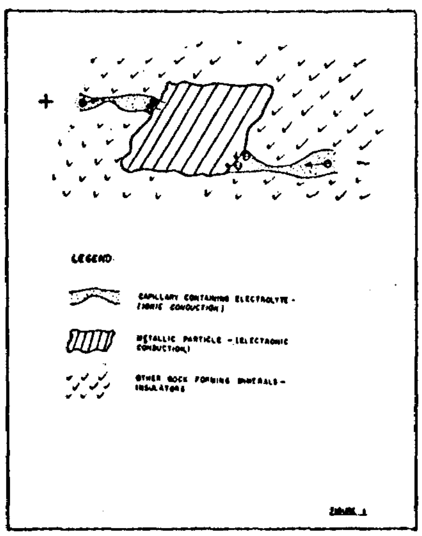


FIGURE 1

Induced Polarization Response of a Metallic Conducting Particle in a Rock.

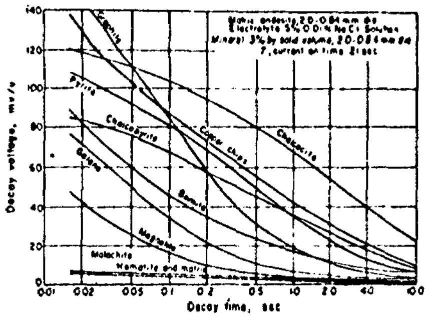


FIGURE 2

Decay Curves for Metallic and Non-metallic Minerals (after Wait, 1959).

hydrogen and oxygen Overvoltages will be established. Figure 1 is a simplified representation of what happens to an electronic conducting particle in a rock under the influence of current flow.

Despite attempts by various workers to investigate the source of non-metallic I.P. in rocks, an adequate explanation of all observed effects is still lacking. A number of possible contibutory agents have been established. Vacquier (Vacquier et al, 1957) has carefully examined strong polarization effects due to certain types of clay minerals.

These effects he believed to be related to electrodialysis of the clay particles. This is only one type of phenomenon which can cause "ion-sorting" or "membrane effects".

For example, a cation selective membrane zone may exist in which the mobility of the cation is increased relative to that of the anion, causing ionic concentration gradients and, therefore, polarization effects (see also Marshall, 1959). Much work remains to be done to determine the various agencies, other than clay particles, which can cause such membrane effects.

Time Domain Method: Figure 2 shows the typical transient I.P. voltage decay forms for various rock forming materials in a laboratory testing apparatus. See also Scott (1969). A primary current time of the order of 21 seconds was employed on these tests.

It will be noted that the voltages are plotted against the logarithm of the decay time and are approximate linear functions of the log t for reasonable lengths of time (t). The amplitude of the transient voltages has been normalized with respect to the steady state voltage existing immediatly before the interception of the primary current.

In order to indicate the magnitude of the I.P. effects one may measure one or more characteristics of the transient decay curve and relate it back to the amplitude of the measured primary steady state voltage prior to the interception of the primary current.

It may be shown that the ratio is Vs/Vp, i.e. peak polarization voltage to the primary voltage just before interception is a physical property of the medium, which has been called the "Chargeability" of the medium.

Since it has been demonstrated that most I.P. decay voltages are similar in form but differ in amplitude (for the same charging time) one can take the average of several transient voltages at different times, or indeed use the time integral of the transient voltages as a diagnostic criterion. The advantage of averaging or integrating lies in the suppression of earth noises and of electromagnetic coupling effects.

The chargeability is often designated by the letter "M". If the time integral is used the units of M will be in millivolt seconds/volt or milliseconds. If one or more transient voltage values are measured and normalized, M will be dimensionless.

For homogeneous, isotropic material, the value of M is independent of the shape or size of the volume tested and of the location of the electrodes on it. It is a true physical property. For a given medium it is dependent on the current charging time and on the precise parameter of the decay curve measured. There are also subsidary variations with temperatures and electrolyte content, etc.

Frequency Variation Method: Figure 3 shows typical curves of the variation of normalized resistivities with frequency for various sulphide, graphite and non-metallic rock minerals in artificial mixtures. Both the fact of the variation of apparent resistivity with frequency and the presence of phase angle lags may be used to indicate the presence of I.P. effects, although generally only the first is so employed.

Since the I.P. phenomena may be shown to be linear, within the usual range of voltages and currents, there is

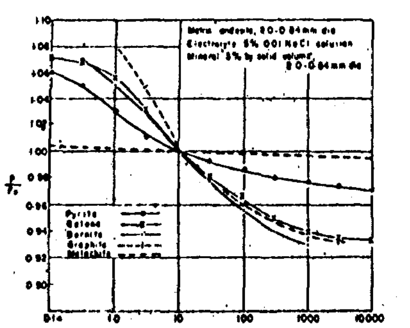


FIGURE 3

Resistivity-frequency Characteristics of Metallic and Non-metallic Minerals (after Wait, 1959).

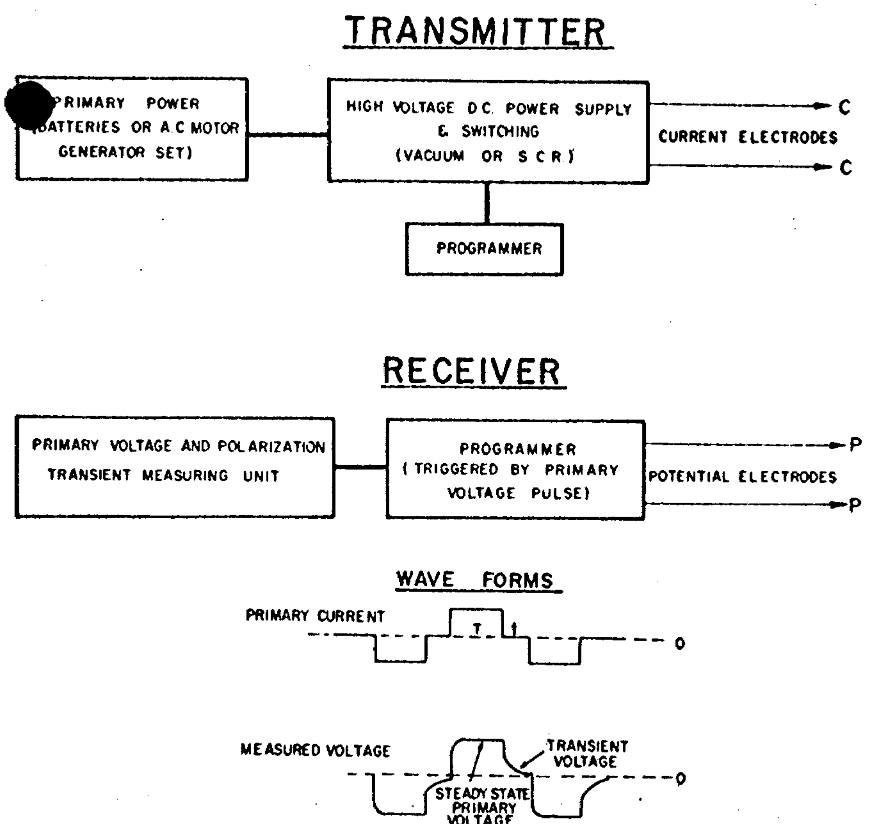


FIGURE 4

Time Domain Apparatus, Block Diagram and Wave Forms.

a direct relationship between the transient curve form and the variation of apparent resistivity with frequency. To arrive at a dimensionless parameter equivalent to the chargeability, one would have to normalize the apparent resistivity, by dividing by the resistivity at one particular frequency. The factor used is called the "Percent Frequency Effect" or P.F.E. and is defined as (R1 – R2 /R1) x 100 where R1 and R2 are the apparent resistivities at the lower and higher frequencies used (Marshall, 1959).

A second parameter is sometimes employed which is really a mixture of physical properties. It is called the Metal Factor (M.F.) and is proportional to P.F.E./R2 or to M/R. As such, it serves to emphasize I.P. effects which occur in obviously conductive environments, i.e. concentrated sulphide deposits or sulphides and graphite in shear zones.

Since it is not a dimensionless factor nor a true single physical property, it is subject to variation related to the changes of shape and resistivity of the medium under investigation, rather than simply to variations in polarization characteristics.

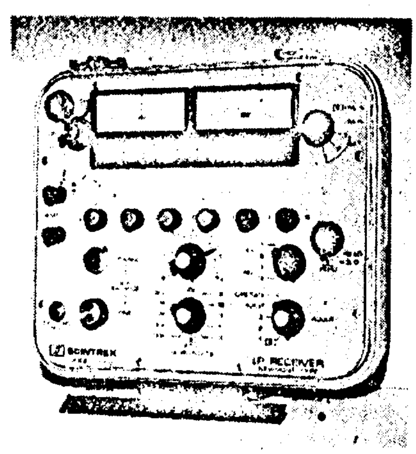
In my opinion, the metal factor has some merit in emphasizing I.P. anomalies due to concentrated metallic bodies, but should not be used as a primary indicator of abnormal I.P. conditions.

Figure 4 shows a block diagram of apparatus commonly used in field operations with the time-domain method and the primary current and resultant voltage wave forms. The transient voltage amplitudes are considerably exaggerated to be visible.

Power sources up to 30 K.V.A., 5000 volts and 20 amperes have been employed where extreme penetration is desired in low resistivity areas. The current-on time T ranges from one second to as much as 30 seconds, and the current-off time t may be as much as 10 seconds. It is not strictly necessary to employ a cyclic current wave form, but considerable advantages in signal-to-noise ratio are achieved thereby.

Most of the receivers now employed are remote triggering, i.e. they are internally programmed, triggered by the primary voltage pulse and do not require a cable interconnection to the cycle timer on the power control unit. Figure 5a shows a typical time-domain remote-triggered receiver (Scintrex MK VII, Newmont-Type). This particular receiver has several interesting features.

For one, there is a memory circuit which provides an automatic self potential adjustment at the tail end of each cycle. For another, it has the ability to integrate the area either below the transient curve (standard M measurement) or above the transient curve (denoted as the L measurement) over a specific time interval. The ratio of these quantities gives a direct



Typical Modern Time Domain I.P. Receiver (Scintrex Mk. VII)

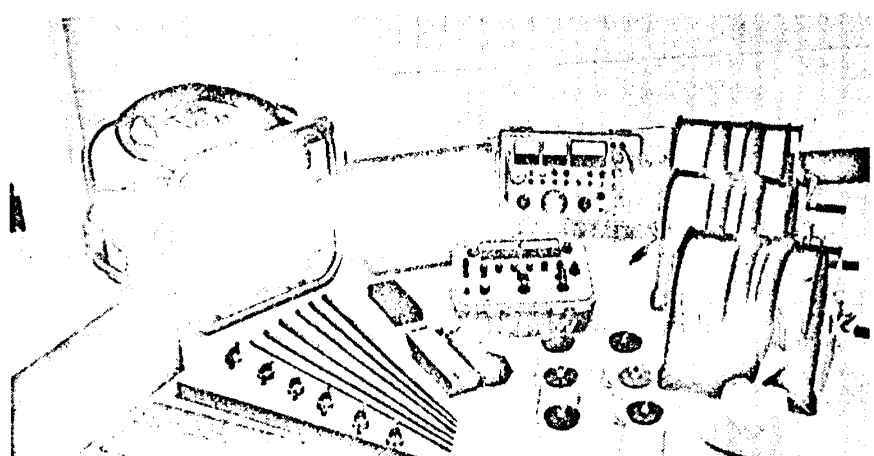


FIGURE 5b

Typical Modern Time Domain I.P. Unit (Scintrex Mk VII)

Array	Domain Employed	Advantages	Disadvantages
Wenner	Time	For local vertical profiling.	Poor depth penetration. Requires four linemen.
Three Electrode (or Pole-Dipole)	Time and Frequency	Three linemen. Universal coupling. Good depth penetration.	Susceptible to surface masking effects.
Dipole-Dipole	Frequency	Good resolution. Universal coupling.	Complex curve forms. Low order signals. Susceptible to surface masking effects.
Gradient	Time	Minimum masking. Two linemen only. Excellent depth penetration. Excellent resolution. Can use multiple receivers for speed.	Couples best with steeply dipping bodies. Low order signals.

measure of the decay curve form, which may be of diagnostic value (see below). In areas of low electric earth noise useful measurements may be made with primary voltages as low as 300 microvolts. Figure 5b shows a complete typical modern time domain induced polarization unit (Scintrex MkVII) of which the Newmont-type receiver above is a part.

Figure 6 shows a block diagram of a typical frequency domain field apparatus and voltage wave form. Since the primary current and earth voltages are usually measured by separate devices and their ratio employed to obtain the apparent earth resistivity and its variation with frequency, it is common practice to adjust the current to a standard value and maintain it there to the required accuracy.

The primary wave form is usually a commutated D.C. Commonly, up to 6 frequencies are available in the range of 0.05 to 10 c.p.s. Figure 7 shows a typical modern frequency domain measuring unit. This unit has a high degree of power line frequency (50 c.p.s. to 60 c.p.s.) rejection.

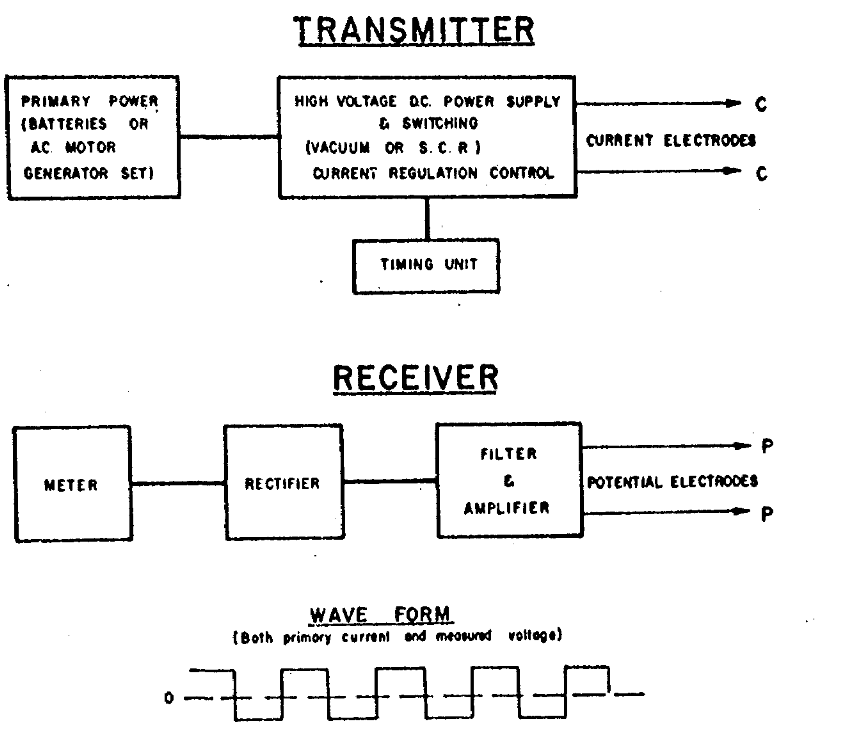


FIGURE 6

Frequency Domain Apparatus, Block Diagram and Wave Forms.

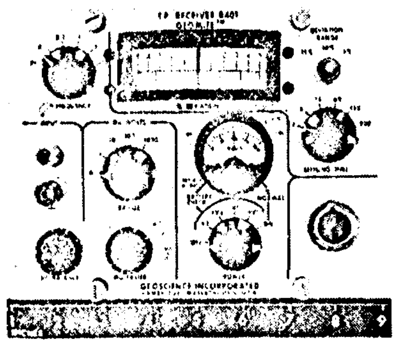


FIGURE 7

Typical Modern Frequency Domain Receiver (Geoscience).

It measures both the primary voltage and the change of primary voltage with change in operating frequency, the latter to an accuracy of about ∓0.3% when the former exceeds 100 microvolts. It has the added feature of a phase lock voltmeter which assists in making measurements under low signal-to-noise conditions.

Common field electrode arrays are shown in Figure 8. The electrodes marked C are current electrodes and those marked P are potential or measuring electrodes. Each of the electrode arrays has its own advantages and disadvantages in respect of depth of penetration, labour requirements for moving, susceptibility to earth noise, electromagnetic earth transients and interline coupling. The following table summarizes the features of these arrays.

For each array (except the gradient array) the basic electrode spacing "a" is selected to give adequate penetration down to the desired depth of exploration. For the pole-dipole and double dipole it is customary to obtain several profiles for different values of "a" or for integral values of n from 1 to as much as 4.

For the symmetric arrays (Wenner and Dipole-Dipole) the measured values are plotted against the midpoint of the array. When using the Three Electrode Array (time-domain) the station position is taken to be the midpoint of the moving current and the nearest potential electrode. When using the Pole-Dipole (frequency domain) the station position is taken as the midpoint between the moving current electrode and the *midpoint* of the two potential electrodes.

With the Gradient array it is the midpoint of the two potential electrodes. For the Three Electrode array and Pole-Dipole these station locations are not unique and represent conventions only.

I.P. data may be plotted in profile form or contoured, although it should be noted that somewhat different results will be obtained with different line orientations so that contouring is

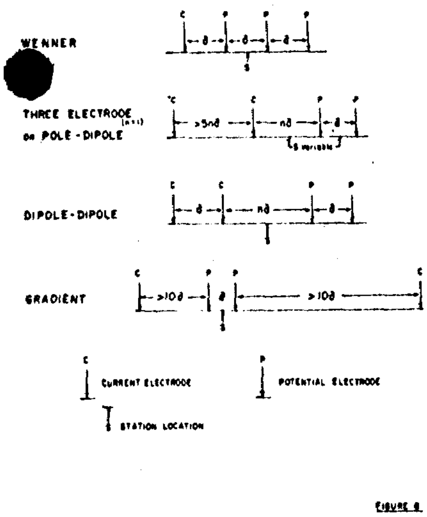


FIGURE 8

Common Field Electrode Arrays.

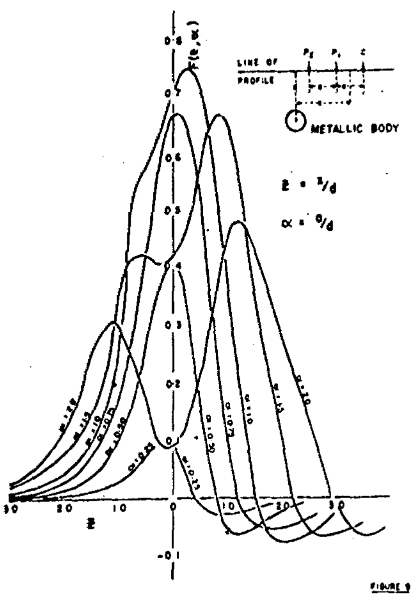


FIGURE 9

Theoretical Response of a Sphere, Three Electrode Array.

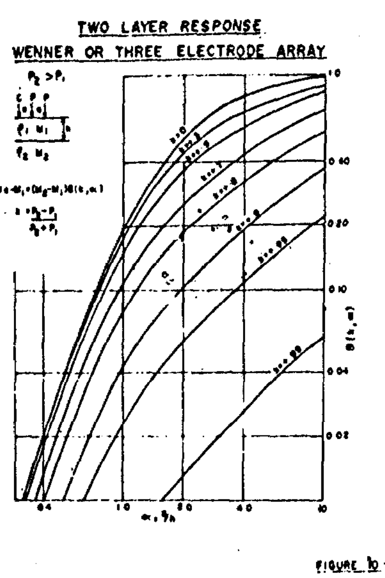


FIGURE 10

Theoretical Response of Two Layer Earth, Wenner or Three Electrode Array.

not strictly justified. Profile interpretation is superior, particularly for shallow, confined bodies, because multiple peaked curves may arise from such bodies using certain electrode arrays, and the plotted peaks may give an erroneous impression of the location of the polarizable body.

To obtain the variation of physical properties with depth, expanding arrays may be used with any of the electrode systems, keeping the spread centre fixed and simply changing the relative spacing "a". This is of particular value where it is known or expected that vertical variations of physical properties will be much greater than lateral variations.

As the spacing is increased the influence of the deeper regions becomes more significant, and the resultant resistivity and I.P. curves may often be interpreted to give the depth to discontinuities in physical properties and the physical properties themselves.

Common practice in presenting frequency domain results is to plot the measured data below the line at a depth equal to the distance of the station position (as defined above) from the midpoint of the pontential dipole. When this is done for a variety of values of "n" a pseudo two-dimensional section results which show, albeit in a markedly distorted fashion, the variation of physical properties with depth.

A mathematical representation of I.P. effects has been developed by the writer (Seigel, 1959), which relates the observed I.P. response of a heterogeneous medium to the distribution of resistivities and I.P. characteristics. To a first approximation it is equally applicable to any I.P. parameter measured in the time and frequency domains.

From this theory, one may predict the anomalous response to be expected from a specific body with a given chargeability and resistivity contrast. For example, Figure 9 shows the form factor F plotted for the Three Electrode Array for a sphere for various values of ✓, where ✓ is the ratio of the electrode spacing to the depth to the centre of the sphere. The sphere response is proportional to F times the chargeability contrast, times its volume and times a resistivity-ratio factor. A number of such theoretical curves, for the pole-dipole and gradient arrays, using spheres and ellipsoids as models, may be seen in the paper by Dieter (1969) et al.

Curves of this sort permit one to interpret anomalies due to localized bodies. It will be seen that for each array there is an optimum spacing for a body at a particular depth, and, therefore, there is some meaning to the term "depth of penetration", except for the gradient array.

When the dimensions of the polarizable medium are large in comparison with its depth below surface, as is often the case, particularly in investigation of porphyry copper type deposits, a two layer approximation is adequate. Theoretical curves based on this approximation (Figure 10) may be used to interpret the results of expanding Wenner or Three Electrode array depth determinations.

For more complex geometrics mathematical solutions in closed form are often lacking. For such cases one may resort to model studies (e.g. Figure 11 for buried dike.) or to computer calculated solutions.

The most productive use of the I.P. method to date has been in the exploration for deposits of metallically conducting minerals, where the amounts and degree of interconnection of these minerals are too low to give rise to an electromagnetically detectable body.

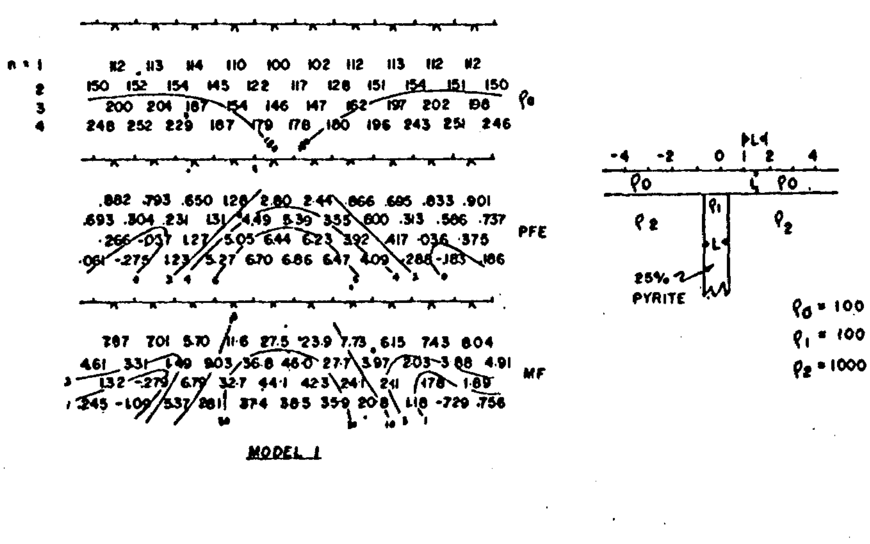
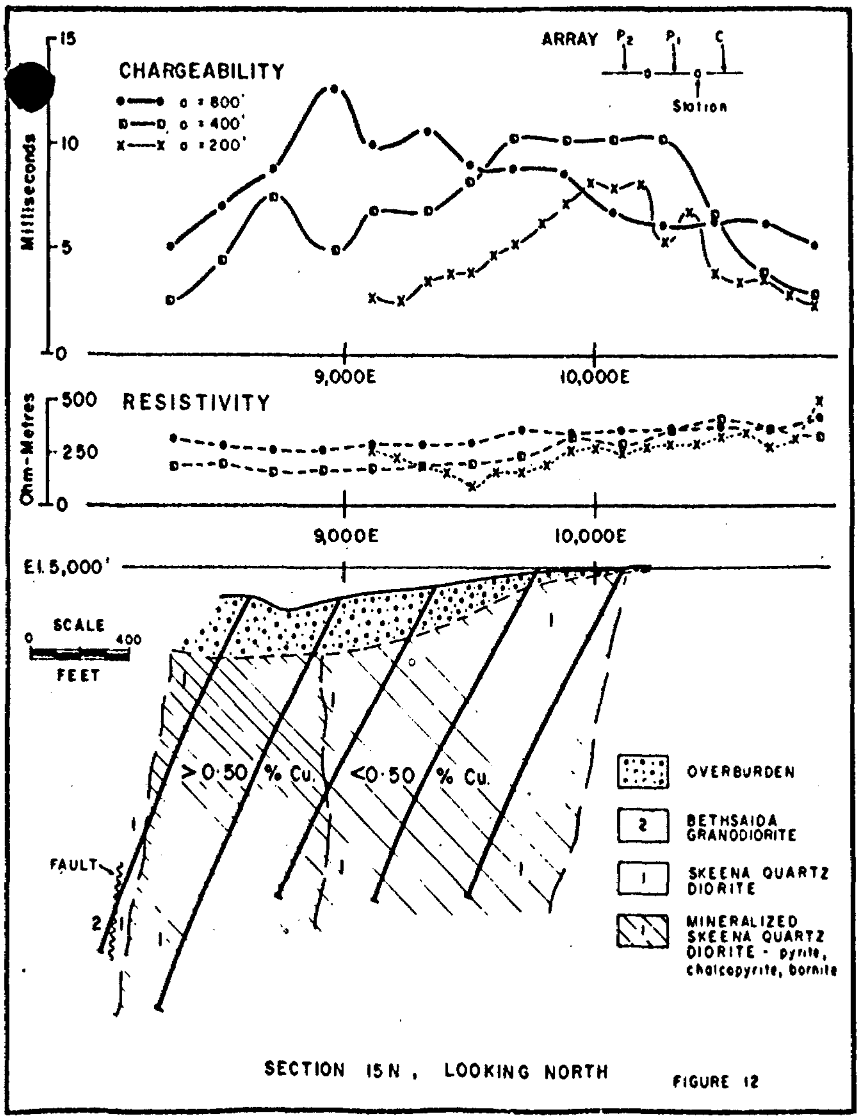
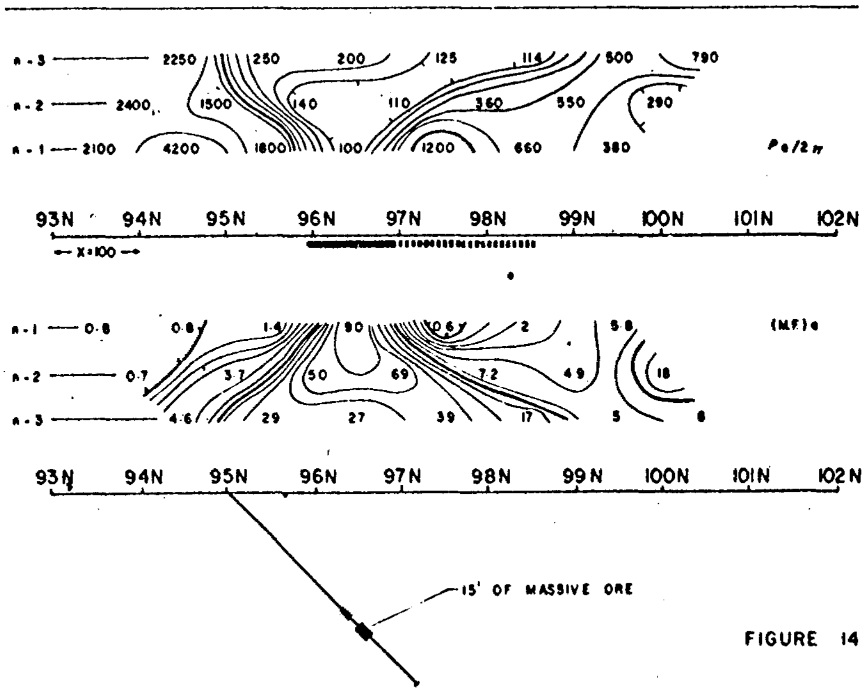


FIGURE 11

Model Response of a Dike, Dipole-Dipole Array (courtesy K. Vozoff).



Geophysical and Drilling Results, Lornex Porphyry Copper Ore Body, British Columbia, Canada (courtesy Lornex Mining Corp. Ltd.)



Geophysical and Drilling Results Lead-Zinc-Copper Ore Body, Heath Steele Mine, New Brunswick, Canada (courtesy P. Hallof).

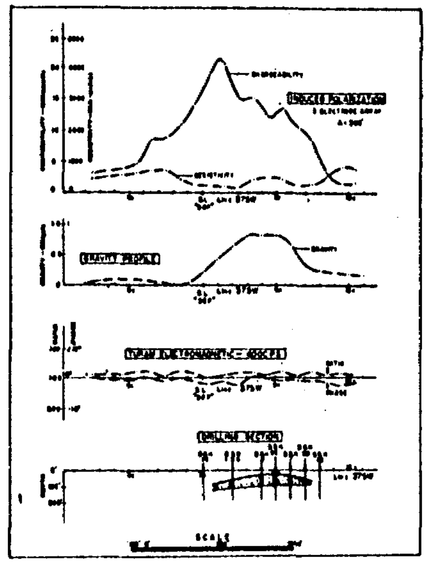


FIGURE 13

Geophysical and Drilling Results, Pyramid No. 1 Lead-Zinc Ore Body Pine Point Area, Northwest Territories, Canada (courtesy Pyramid Mines, Ltd.).

Where electromagnetic detection is feasible it is usually far more rapid and economical to apply electromagnetic induction methods to the problem. The I.P. method is the only geophysical tool available which is capable of direct detecting 1 percent or less by volume of metallic conducting sulphides.

It is best used, therefore, where there is a high ratio of economic minerals to total sulphide mineralization. Included in the proper I.P. range are such types of deposits as disseminated copper ores, in porphyry or bedded forms; lead-zinc deposits, particularly of the bedded type in carbonate rocks; gold and other deposits which have an association with disseminated metallic conductors. For many of these mineral occurrences the I.P. method is unique in providing detection.

Figure 12 shows time-domain discovery traverses over a typical newly discovered porphyry copper deposit in British Columbia. The lateral limits of the mineralization can be readily determined from the geophysical data, as well as the depth to the upper surface of the mineralization.

Figure 13 shows a discovery traverse over a major bedded body of sphalerite-galena-marcasite mineralization in carbonate rocks in the Pine Point area, Northwest Territories, Canada. For comparison purposes both gravity and Turam electromagnetic profiles on the same section are shown.

It is interesting to note that, despite an appreciable resistivity depression over the mineralization there is no significant Turam response at 400 c.p.s. The conductivity of the ore is, in fact, no higher than that of the surficial deposits in the general area, so that electromagnetic and resistivity methods yield, in themselves, no useful information.

The gravity method, although yielding a positive response in this instance, does not provide a good reconnaissance tool in this area because of karst topography and other sources of changes in specific gravity.

One occasionally encounters a deposit of the "massive sulphide" type which is normally thought of as an electromagnetic type of target because of its high conducting sulphide content, but which, obviously because of the lack of large scale continuity of the conducting sulphides, does not respond to the electromagnetic techniques. Figure 14 shows an intersection of ore grade material of this type, in New Brunswick, Canada, where electromagnetic methods had yielded negative results.

In many types of ore deposits the bulk of the I.P. response is due to the accessory non-economic sulphides, usually pyrite and pyrrhotite, and the ore minerals themselves are in the minority. A true test of the sensitivity of the I.P. method is an example of a low grade disseminated deposit with no such accessory minerals. Figure 15 illustrates such a case, with an I.P. discovery section over the Gortdrum copper-silver-mercury deposit in Ireland. The ore minerals consist of chalcocite, bornite and chalcopyrite in a dolomitic limestone, and there is less than 2% average by volume of metallic conducting minerals.

Whereas the bulk of I.P. measurements in mineral exploration has, naturally, been made on surface, the technology of drill hole exploration has been well developed, particularly by the Newmont group (see Wagg, 1963). The time-domain method is suitable for drill hole applications since it permits a relatively close coupling of the current and potential lines in a small diameter bore hole.

The three electrode array has been extensively employed for logging purposes, with a variety of electrode spacings to give varying ranges of detection away from the hole. In this fashion the variation of electrical properties with distance from the hole may be determined. A second, "directional log" then gives information on the direction of any anomalous material indicated by the detection log.

Whereas the I.P. method is usually employed as a primary exploration tool it may play an auxiliary role as well, e.g. to distinguish between metallic and ionic conducting sources of other types of electrical anomalies, e.g. electromagnetic.

Figure 16 shows a typical conducting zone revealed by a ground

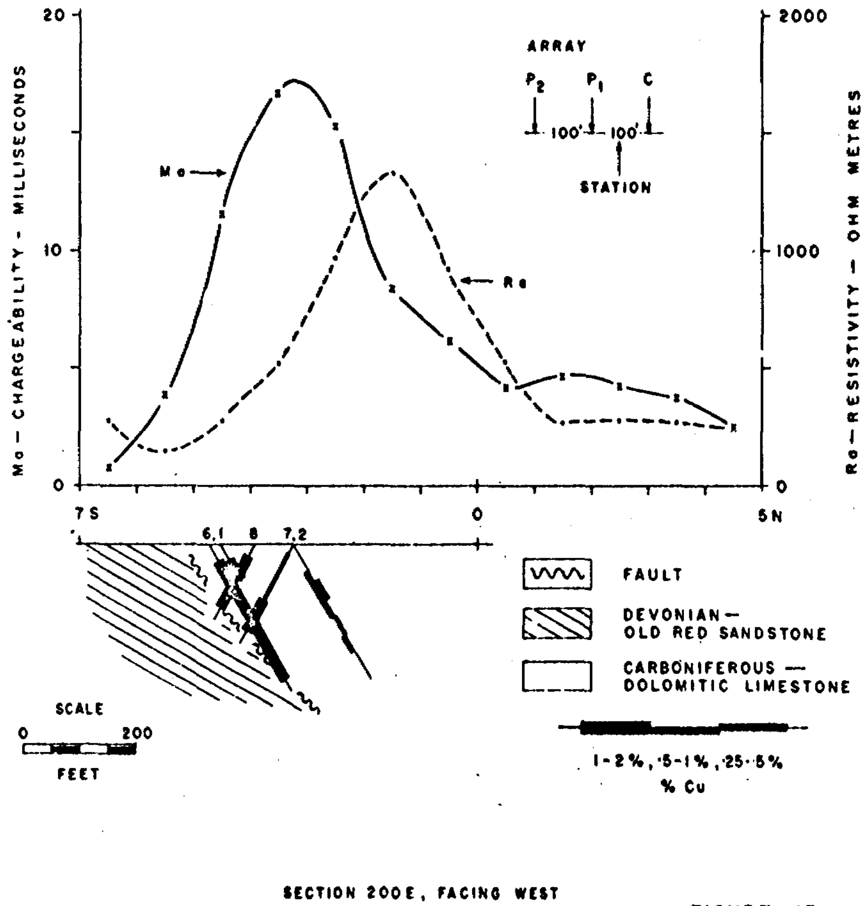


FIGURE 15

Geophysical and Drilling Results, Copper-Silver Ore Body, Gortdrum Mines, Ireland (courtesy Gortdrum Mines, Ltd.).

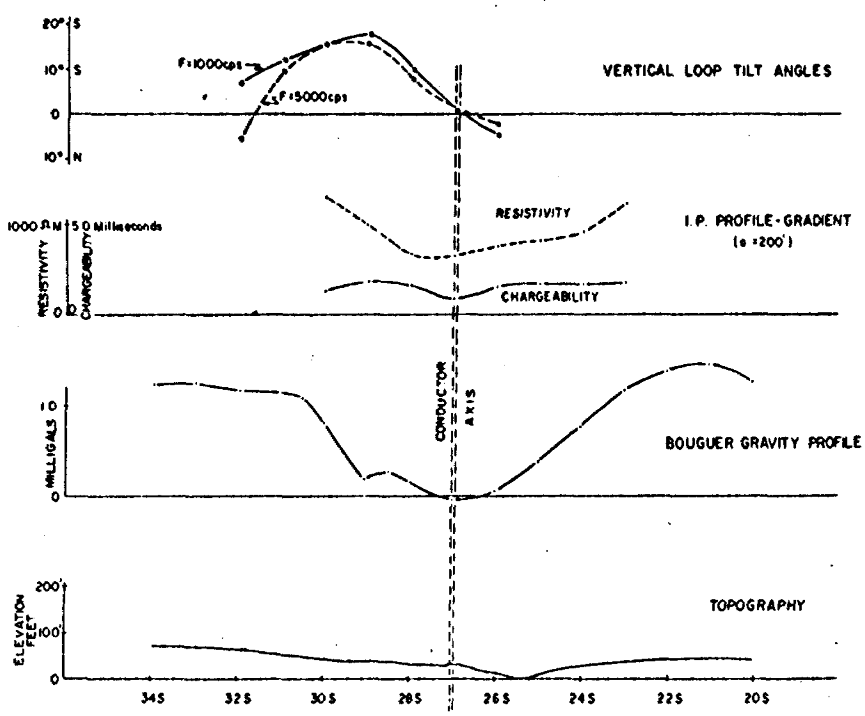


FIGURE 16

Geophysical Recognition of Overburden Trough, Northwest Quebec, Canada.

electromagnetic survey which was later proven, by drilling, to be due to overburden conduction in a bedrock trough. The I.P. response is in the low-normal range. The gravity profile, also shown, corroborates the presence of the bedrock depression.

Attempts have been made by a number of workers to employ the I.P. method in the field of groundwater exploration (e.g. Vacquier, 1957, Bodmer, 1968) but with no consistent success as yet. There are variations of chargeability from one type of non-consolidated sediment to another, but these fall, in general, within a relatively small range compared to the usual sulphide responses.

More investigation remains to be done in this area before a definitive conclusion can be reached. It is clear that more accurate measurements will have to be made in groundwater I.P. than in base metal I.P. investigations.

The I.P. method has a number of recognized limitations, some of a fundamental nature and others of a temporary nature reflecting the current state of the art. On a unit coverage basis the method is relatively expensive to apply, costing between $200 and $500 per line mile surveyed, in most instances. This cost has, however, been progressively reduced by advances in instrumentation resulting in decreased weight, increased sensitivity and rejection of earth noise effects. Some degree of improvement is yet to be expected in this area.

The same geometric limitations apply as with the resistivity method employing the comparable array. As a rule, a body of up to 10 per cent disseminated metallic conductors cannot be detected at a distance from its nearest point much exceeding its mean diameter. This detectability may be somewhat improved by the use of secondary criteria, but such improvement is likely to be only marginal.

Since Overvoltage is essentially a surface phenomenon the I.P. response from a given volume percentage of metallic conductors generally increases as the individual particle size is decreased. From the usual simple I.P. measurements, therefore, one cannot reliably predict the percentage by volume of such conductors in a deposit as there may be a variation of particle size throughout the deposit.

Still less can one differentiate between metallic conductors (e.g. chalcopyrite, galena, pentlandite) of economic interest and those of non-economic interest (e.g. pyrite, pyrrhotite and graphite). In addition we cannot even reliably differentiate between metallic sources of I.P. responses. The latter may include certain types of clay and, in consolidated rocks, such platey alteration minerals as serpentine, talc and sericite.

Empirically it has been found that, on the average, 1% by volume of metallic sulphides will increase the chargeability by about 2 – 3 times, depending on the host rock type.

Figure 17 shows a section across each of two anomalous I.P. areas in the Pine Point area, Northwest Territories, Canada. Section A is a discovery traverse across an ore body containing one half million tons of 11.4 per cent combined Pb and Zn and coming within 40 ft. of the ground surface. Section B is a traverse across what proved, by drilling, to be a karst sink hole, filled in with a variety of unconsolidated material including boulders and clay.

Based upon the chargeability amplitudes and the relative resistivity depressions the second case would appear to be far more promising than the first. In such cases the gravimeter has sometime proven to be of value in resolving the two types of occurrence but there is the very real possibility of the coincidence of a sink hole and a lead-zinc deposit, which would give rise to an uncertain resulting gravity response.

Any normal transient (time-domain) polarization decay and equivalently any curve of variation of apparent resistivity with frequency may be simulated by means of a mixture of metallic conductors of a suitable particle size distribution.

It is, however, possible in an area of common geology, that the various possible sources of I.P. responses may have significantly different characteristic curves in each of these two domains. A more thorough analysis of these curves at significant points is, therefore, of value.

Modern receivers in both domains (Figures 5 and 7) have the ability to give curve form information as well as a single quantity related to an I.P. amplitude.

Komarov (1967) documents such an example over a copper nickel deposit in the U.S.S.R. where, effectively the sulphide responses have a longer time constant than the normal non-metallic polarization.

An important source influencing I.P. measurements is the electromagnetic response of the earth. For a given electrode array the electromagnetic effect is dependent upon the frequency times the conductivity and the square of the spacing. In the frequency domain this source becomes troublesome (communication from P.G. Hallof) when:

1. The electrode spacing is 500 ft. or over and n = 3 or greater.
2. The highest frequency employed is 2.5 c.p.s. or greater.

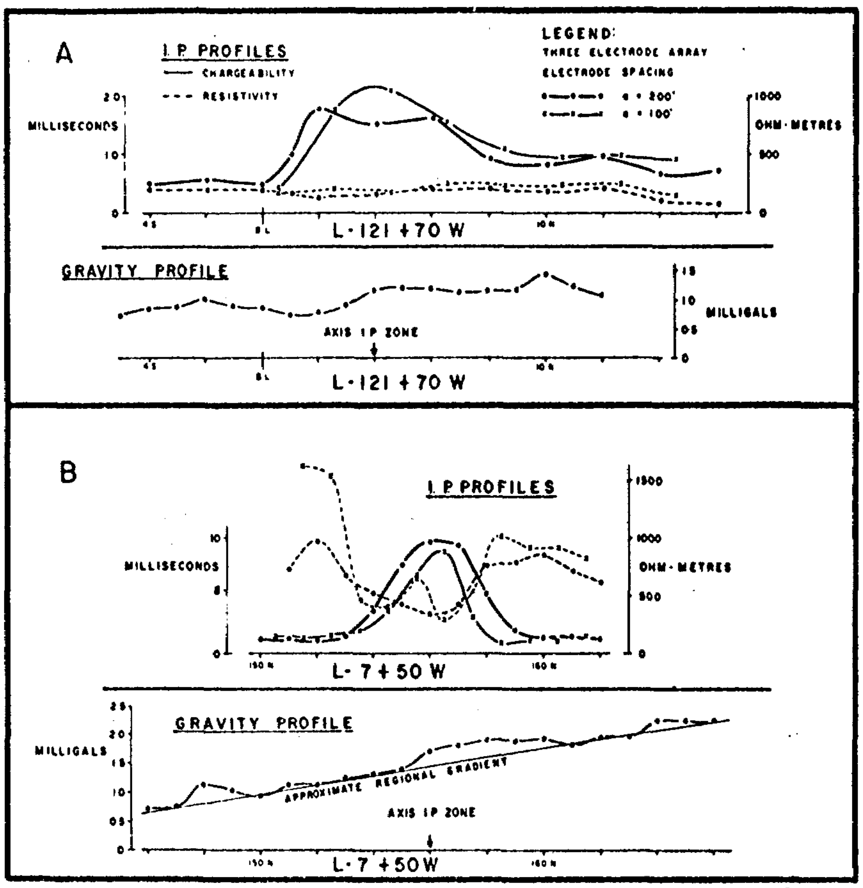


FIGURE 17

Possible Ambiguity of Induced Polarization Results, Pine Point Area, Northwest Territories, Canada.

3. The average earth resistivity is lower than about 25 ohm metres.

Electromagnetic effects are present in time-domain measurements as well, of course, but are usually of lesser amplitude for the same array and earth conductivity, because the effective frequencies employed in the time domain are considerably lower (commonly 0.03 to 0.125 c.p.s.).

In the extreme, the electromagnetic response of a conducting earth may seriously interfere with useful I.P. measurements in either domain.

In the time domain I.P. measurements commonly only a single amplitude (at a specific time after current interruption) or an average amplitude over an interval of time after the current interruption is used to characterize the transient decay curve and act as a measure of the induced polarization characteristics of the medium in question.

It has been known since 1950 that useful secondary information is available in the shape of the transient decay curve associated with time domain induced polarization measurements. Equivalent remarks may be made in respect of frequency domain measurements where, instead of measuring the average slope of resistivity frequency over one decade of frequency, more information is obtained about the shape of this curve.

The type of information inherent in the curve shape relates primarily to two factors – (a) average metallic particle size associated with the source of an anomalous I.P. response, and (b) the presence of electromagnetic transients arising from highly conducting geologic units. For convenience we will restrict the following remarks to time domain measurements, although equivalent statements may be made in the frequency domain.

It has been established through laboratory measurements that (a) metallic conductors of large average particle size give rise to time domain decay curves of relatively long time constant, and (b) metallic conductors of small average particle size give rise to decay curves of relatively short time constant. For these reasons, if a shape factor as well as an amplitude factor of the decay curve can be established we may obtain information which is helpful in some of the following circumstances:

(1) very large or very small metallic particles – the response from these may distort the shape as well as the amplitude of the transient curve. Thus rather small amplitude anomalous metallic responses may be recognized in the presence of equal I.P. relief due only to non-metallic variations.

(2) two different types of anomalous response materials, in the same survey area, but differing in average particle size and/or decay curve form – e.g. serpentine, graphitic particles of small average size and coarse grained metallic sulphides.

One additional and rather common circumstance is the presence of (ionically) highly conductive overburden or consolidated rock units (e.g. saline overburden or shales). These units can give rise to electromagnetic transients of sufficiently long time constant to affect the usual I.P. amplitude measurement.

The shape of the E.M. transient is, in practice, markedly different from that of the usual I.P. transient, having a much shorter time constant than the latter. In addition, the polarity of the E.M. transient is often reversed to that of the I.P. transient. Curve shape measurements can provide a clear indication of the presence of significant E.M. interference and even a semi-quantitative estimate of the latter, enough to allow a correction factor to be applied.

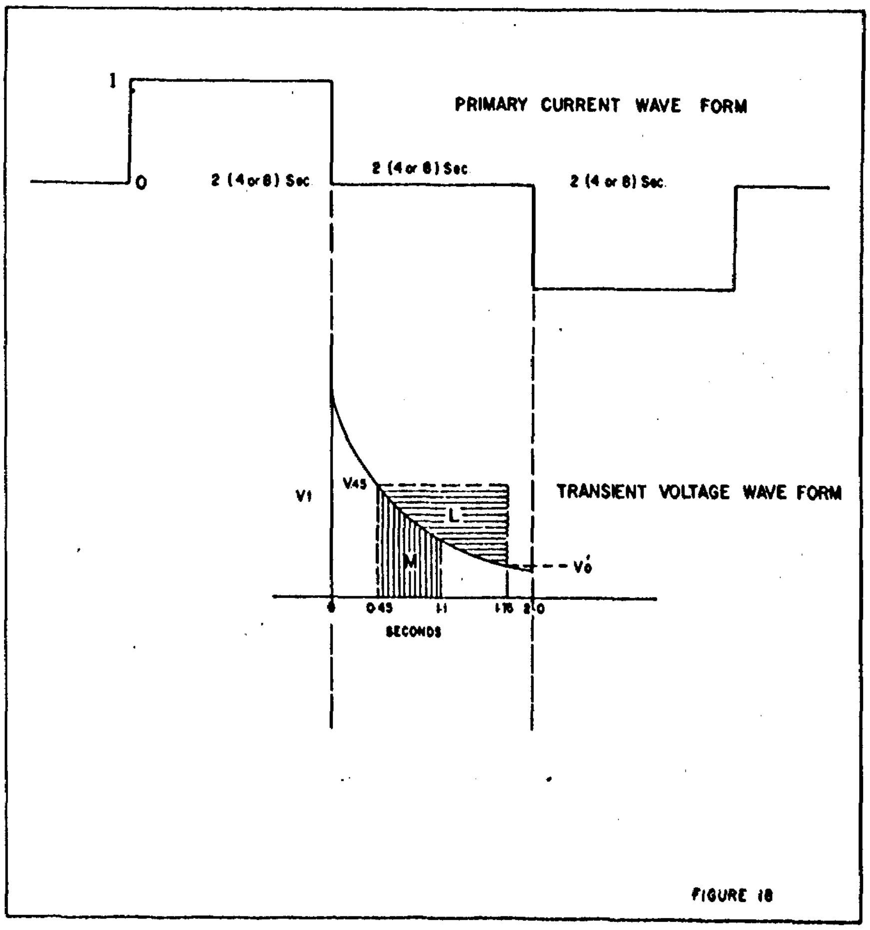
Equipment of the type illustrated in Figures 4 and 5 (e.g. Scintrex MK VII System) permit appropriate transient curve shape information to be obtained. Common to all the transmitters in this system is the ability to pass a repetitive, interrupted square wave pattern current into the ground, as shown on Figure 4. The current-on time may be 2, 4, or 8 seconds and the current-off time may be likewise selected. Measurements of I.P. transient curve characteristics are made during the current-off time.

Figure 18 shows the quantities measured by the Newmont-type receiver. In these receivers one sets the gain of certain amplifiers common to both the primary voltage Vp and transient voltage Vt measurements so that these voltages are essentially normalized.

The usual amplitude measurement performed by these receivers consists of an integration of the area under the transient curve over a specified interval after the interruption of the primary current and is designated by the letter M – the "chargeability" namely, 0.45 seconds to 1.1 seconds.

The 0.45 second delay time allows most E.M. transients, switching transients and interline coupling effects to disappear prior to the making of the measurement. Different measuring intervals may be employed under specific conditions.

In addition to M, the Newmont-type MK VII receiver is equipped to measure a quantity "L" which is defined as the time integral of the area *over* the transient curve, for a specified time interval, taking as reference voltage the



Operation of Scintrex Mk VII (Newmont-type) I.P. System.

transient voltage value at the beginning of the time interval. In practice, the interval selected is 0.45 seconds to 1.75 seconds, as shown on Figure 18, although different intervals may be employed under certain conditions.

The ratio of L/M is taken as a sensitive indication of transient curve shape. It has been well established, by many tens of thousands of I.P. measurements with these systems in many parts of the world, that the L/M measurements in non-metallically-mineralized areas, for a given current wave form, are constant within better than 20%.

Significant departures from these ratios usually imply an abnormal condition – either an anomalous metallic polarization response, electromagnetic or interline coupling.

Figure 19 shows a range of transient curves and their possible cause. For each case the "normal" transient curve is also shown. These cases illustrate the sensitivity of the L/M ratio to the transient time constant. A significant increase in L/M implies an abnormally short time constant, (Case A) reflecting either positive E.M. effects or small particle size. This should, in either case, normally be accompanied by an increase in apparent chargeability M.

A modest increase in L/M ratio, reflecting an increase in time constant (Case B) may reflect either the presence of large particle size metallic conductors, in which event an increase in M may or may not be appreciably reduced.

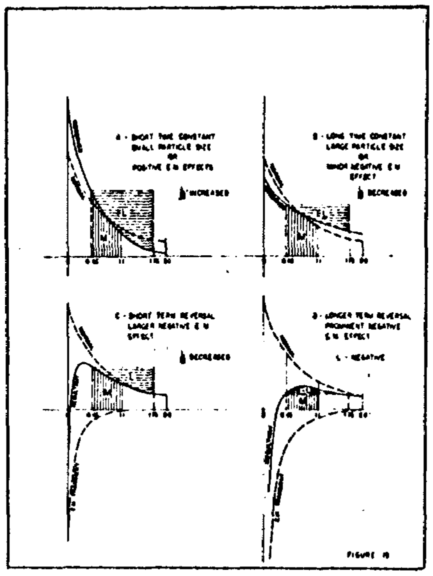
Cases C and D show the effect of reversed polarity E.M. transients of increasing amplitude. In Case C there is a short term Vt reversal and, although M is only slightly reduced, L/M is considerably reduced. In Case D, which is considerably more extreme, Vt is still rising at 0.45 seconds, so that L and thus L/M are, in fact, negative. M is considerably reduced from its normal value in this case, but a warning to this effect is clearly indicated by the L measurement.

A quantitative estimate of the E.M. transient response and, therefore, correction for it, may be obtained by one of a number of means. One may, for example, vary the current-on time, e.g. from 2 seconds to 8 seconds. The E.M. transient, being of relatively short time constant, will not change. The I.P. response will change by an amount which is fairly predictable, assuming a normal decay form. We thus obtain two equations in two unknowns from which the true I.P. response may be derived.

Curve shape measurements may be made in other ways as well, for example, by actually recording the complete transient decay curve. Whereas theoretically useful, such measurements have proven unwieldy from a weight and time standpoint. To obtain clean decay curves requires a high signal/noise ratio and thus high powers.

In the frequency domain the equivalent curve form information would be obtained through the use of three or more properly selected operating frequencies.

There is a continuing rivalry between protagonists of time-domain and frequency domain measurements. All that is clear is that neither method is superior in all respects to the other. The same phenomenon is being measured in different ways often with different arrays and the results are presented different formats (pseudo-sections in the frequency domain versus profiles in or contour plans in the time domain).



Significance of Curve Shape (L/M) Information.

The "Metal Factor", which is a mixture of physical properties, is commonly presented with frequency domain measurements only. These differences are largely superficial and are based on separate historical developments and subjective preferences.

There is a direct mathematical transformation between I.P. measurements in the two domains. Theoretically, at least, the same information can be obtained in either domain. Practically, however, there are certain differences.

The time domain measurements are absolute, i.e. are measured in the absence of the steady state voltage and are disturbed only by earth noises as a background. The amplitude of these measurements is usually less than 1% of the steady state voltage, but even so they can usually be made to an accuracy of better than 10 per cent even in unmineralized rocks.

The limit of useful sensitivity is related only to the regional uniformity of the background I.P. response. In the frequency domain the I.P. response is measured as a difference in transfer impedances. This difference can be measured with an accuracy of only 0.3% with extremely stable equipment. Since the non-metallic background P.F.E. over the interval of 0.1 to 2.5 c.p.s. is usually less than 1%, the probable error of these measurements may be 30% or more.

For this reason it is seen that it is feasible to obtain greater sensitivity of measurement in the time domain. This increased sensitivity is of value in areas of low "geologic" and electrical noise. By "geologic noise" is meant the range of variation of I.P. parameters within the normal rock types of the area. The application of I.P. to groundwater prospecting may have to develop through the time domain avenue because of the sensitivity requirements.

The frequency domain equipment requires somewhat less primary power than the time domain equipment because the former measurements in an A.C. one with the ability to use tuned filters and amplifiers as well as devices as phase-lock detectors. This advantage is not so marked as it once was, as current time-domain equipment, with its self adjusting earth voltage balance and ability to sum any desired number of integrations, provides a high degree of noise rejection.

Under truly random noise conditions the summation of n integrations provides the usual $1/\sqrt{n}$ reduction in statistical noise and is a powerful non-subjective means of noise suppression. The suppression of A.C. power line noise is much better with the time domain (integrating type) measurements than with frequency domain measurements.

Reference has already been made above to the relative effects of the electromagnetic response of the earth in both methods. Similar remarks apply to capacitative and inductive coupling effects between current and potential cables, although such effects can be largely avoided in any event by careful positioning of the cables, except possibly in drill hole surveying. So far, only in the time domain may useful drill hole measurements be made with both current and potential electrodes lying side by side in a small diameter bore hole.

An individual geologist or geophysicist may have had his first acquaintance with or instruction in the I.P. method using either the time domain or frequency domain. He becomes familiar with the arrays used and with the method of presentation of data employed. Thereafter, he tends to resist switching to the other domain in the belief that not only will he have to deal with different geophysical equipment and electrode arrays but also with different quantities, presented in quite a different fashion. This is erroneous.

So far as arrays are concerned the time domain uses them all – dipole-dipole, pole-dipole (three electrode) Wenner and gradient (Schlumberger). The frequency domain commonly uses only the first two and is restricted from using the latter two because of interline coupling effects.

Of the quantities measured in both domains the resistivity is, of course, the same, making due allowance for units. The time domain "Chargeability" is, normally very nearly proportional to the "Percent Frequency Effect" or "P.F.E.". The so-called "Metal Factor" is the ratio of P.F.E./Resistivity, and would, therefore, be equivalent to the ratio of Chargeability/Resistivity.

The time domain data presentation is commonly in the form of profiles and contour plans.

The frequency domain presentation is commonly in the form of "pseudo-sections" showing the different spacing results displaced progressively downwards with increased electrode spacing. Either type of data may be presented in either form of course, to suit the tastes and experience of the individual geologist or geophysicist.

The Gradient array is very useful in obtaining bedrock penetration where the bedrock is highly resistive compared to the overlying overburden. In such cases using the pole-dipole or dipole-dipole array very little current actually penetrates the bedrock and the I.P. characteristics observed are those of the overburden only. As was mentioned above, only time domain measurements may be carried out using this array.

There is a special practical advantage to the time domain measurements in areas where it is very difficult to make good ground contact. In such areas the problem of keeping the primary current rigidly constant, necessary for the frequency domain measurements, becomes severe.

In the time domain, if the primary current varies by as much as 10% during the measurement the absolute error in the chargeability may only be about 5%, which is not significant. This problem is often encountered in very arid areas, e.g. parts of Peru, Chile and other desert regions.

Despite these slight effective differences both methods of I.P. exploration have amply demonstrated their value through important mineral discoveries in many parts of the world. The role of I.P. in mineral exploration is well acknowledged and rapidly expanding.

The writer wishes to thank the various sources of case histories and illustrations cited in the text and in particular, Dr. Keeva Vozoff and Dr. Philip Hallof for valuable contributions.

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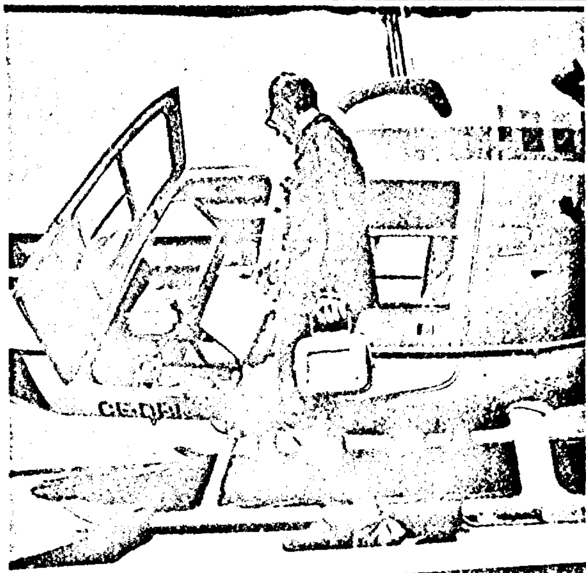

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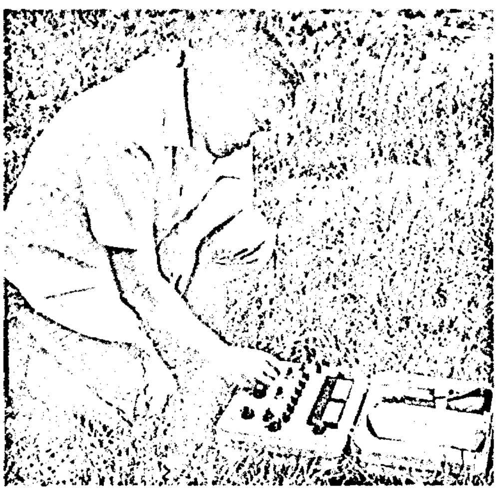
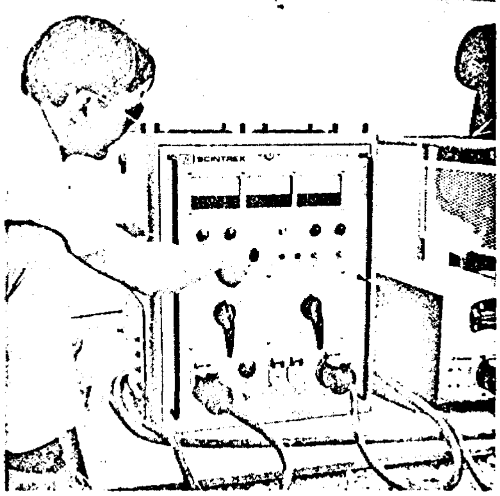
INDUCED POLARIZATION SYSTEMS





Scintrex Induced Polarization systems, employing the Time Domain method, are very sensitive and accurate tools for Induced Polarization prospecting. The Transmitter and Receiver are light-weight, small-sized units of advanced, solid-state design, predominantly featuring Integrated Circuits. The latest (Mk VII) I.P. system offers a choice of three transmitters of different capacity (IPC-7) series which can be combined with the same Newmont type receiver (IPR-7).

The IPR-7 receiver is self-triggering, which removes the need for a direct cable connection between transmitter and receiver. As a result, mobility and operational flexibility are increased. Further advantages of the IPR-7 are, automatic self-potential compensation, automatic summation of any desired number of polarization signals, built-in A.C. noise filter and the ability to obtain transient curve shape information.

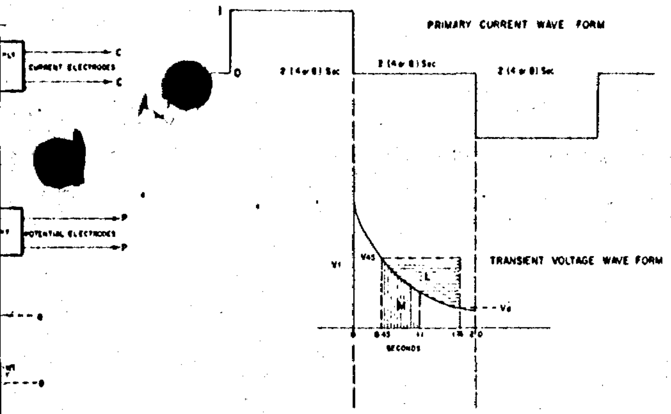
The IPC-7 transmitters all provide alternating, interrupted square wave current pulses of 2, 4 or 8 seconds duration and equal on and off times.

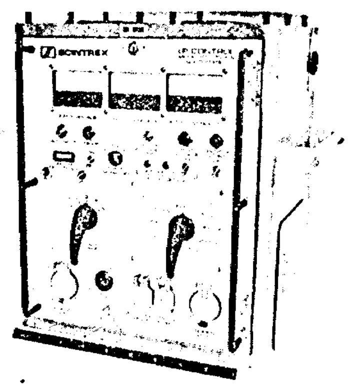
All Mk VII systems are of extremely rugged construction and have an excellent record of performance under the widest variety of climatic and topographic conditions and temperatures ranging from —20°F to 130°F (—30°C to 55°C).

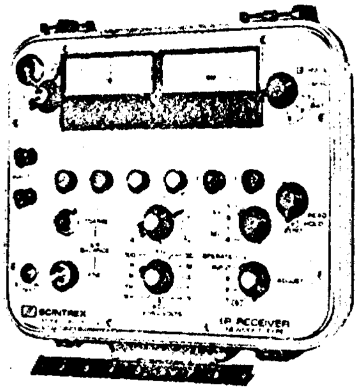
Due to the inherent noise suppression capability of this system, I.P. surveys can be conducted closer to sources of spurious electrical noise, such as power lines or mines. The receiver cannot be falsely triggered by a short duration electrical pulse. The direct reading of chargeability values enables even a relatively inexperienced operator to immediately recognize an anomaly.

ILLUSTRATIONS:

Top: IP 25W System — lightweight and portable.
Center: In-situ use of IPR-7 receiver.
Bottom: IPC-7/15 kW Transmitter.







IPR-7 NEWMONT TYPE RECEIVER

This I.P. receiver measures the chargeability (M) by integrating the area under the decay curve for 0.65 sec. with a delay of 0.45 sec. after the transmitter cut-off. This delay under most conditions largely eliminates the influence of electromagnetic transient effects. Besides the chargeability, which is read directly on a meter scale, it is possible to measure the "complement" (L) of the decay curve and thus obtain a sensitive curve shape factor. In this fashion, it is possible to learn more about the nature of the sources of anomalous chargeability and the influence of electromagnetic transients. Since the signal to noise ratio increases approximately as the square root of the number of readings taken, effective filtering is achieved by the automatic summing of as large a number of readings as necessary. Both M and L are read directly without the necessity of computation, giving an immediate indication of anomalous conditions.

Although the integration measurement provides a high degree of A.C. noise suppression, a special 60 Hz filter (50 Hz opt.) has been incorporated to further reduce possible power line interference. A simulatinn network is provided for calibration and general function testing of the receiver in situ.

SPECIFICATIONS:

Primary voltage range	0.0003 V - 30 V
Accuracy	±3%
Input impedance	300 kilohms
Chargeability:	
reading range	0 - 100 and 0 - 300 msec.
accuracy	±5%
Curve factor:	
reading range	0 - 100 and 0 - 300 msec.
accuracy	±5%
SP and Telluric noise compensation	
Manual	± 1.5 V
Automatic	depending on primary voltage range: up to ±10 V total on 30 V range
Power Supply	rechargeable nickel cadmium batteries: rated life 45 hours per charge
Temperature range	—20°F to 130°F (—30°C to 55°C)
Dimensions	14"x 11"x 6½" (36 cm x 28 cm x 16 cm)
Weight	13½ lbs., including batteries (6 kg)

15 kW TRANSMITTER

The construction of this control unit is of modular design with solid state electronics and high voltage switching. Because of its larger size and weight, the dummy load is packaged separately. The 15 kW motor generator set provides single phase, regulated 400 Hz current. It is driven by an air-cooled Volkswagen industrial engine. This power system and control unit are adequate for all mineral exploration problems, including exploration for porphyry copper bodies to depths in excess of 2000′ (600 m).

SPECIFICATIONS:

Control Unit:	
Max. output voltage	5,000 V (D.C.)
Max. output current	20 amps
Dimensions	18½"x 27"x 27" (47 cm x 69 cm x 69 cm)
Weight	170 lbs. (77 kg)
Motor Generator Set:	
Max. output power	15 kW (single phase)
Output voltage	208 V (A.C.), 400 Hz
Weight	500 lbs. (227 kg)
Dummy Load:	
Dimensions	10"x 10"x 20" (25 cm x 25 cm x 51 cm)
Weight	75 lbs. (34 kg)
Max. power dissipation	15 kW

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040

REPORT ON

Glen Copper Mines Ltd.'s 28 optional mineral claims in Midlothian - Halliday Twp. Timmins, Ontario.

by

E.D. Dodson, P. Eng.

January 22, 1973

January 22, 1973

CERTIFICATE

I, Earl Dodson, do hereby declare that:

1. I reside at 2990 St. Kilda Avenue, North Vancouver, B.C., and have business address at 12 - 425 Howe Street, Vancouver 1, B.C.
2. I am a graduate in geology of the University of British Columbia, 1954.
3. Since 1954, I have been employed in various phases of mineral exploration; in the latter years, in posts of considerable responsibility.
4. I am a professional engineer registered in the Association of Professional Engineers of the Province of British Columbia and the Yukon Territory.
5. I spent the periods June 24 - July 2, 1972 and August 30 - September 31, 1972 working on the property.
6. I have no interest, direct or indirect, nor do I expect to receive either directly or indirectly any interest in the properties or securities of Glen Copper Mines Ltd.

Respectfully submitted,

Earl D. Dodson, P. Eng.

EDD:is

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INTRODUCTION

This is a report on progress on the property held under option by Glen Copper Mines Ltd. in Halliday and Midlothian Townships, Ontario. The writer outlines the work done to date with the results obtained and recommends further work.

Appended to this report are the following:

Ontario Department of Mines Geological Report # 79
"Geology of Halliday and Midlothian Townships" E.G. Bright 1970

Scintrex Ltd. Report on an Induced Polarization Survey, Halliday and Midlothian Twp. Larder Lake Mining Division on behalf of Glen Copper Mines Ltd.

Jan Klein, M. Sc., P. Eng.
Geophysicist

E.W. Bazinet, P. Eng.
Report on Property in Halliday and Midlothian Townships, Larder Lake Mining Division, Ontario. September 20, 1971

J. Boissoneault
Glen Copper Mines Ltd. Magnetometer Survey Larche Property, Midlothian Township, Larder Lake Mining Division (Map at scale of 1 inch = 400 feet)

Diamond drill logs of DDH #1 and DDH #2.

Newmont Mining Corporation (employees)

Diamond drill logs DDH #1 - #5, #7 - #8

Geological map titled "Halliday Project" at scale of 1 inch = 400 feet.

List of assays taken on diamond-drill core as assembled by Mr. Guilford Brett from samples taken by J. Boissoneault (DH #1 - #4) and J. Larche and G. Brett on remaining holes.

PROPERTY

The property consists of twenty-eight contiguous unpatented mining claims as listed below:

Claim Number	No. of Claims	Township	Acres
255465	1	Halliday	40
278570 to 278572	3	Midlothian	120
278573	1	Halliday	40
292002 to 292013	12	Midlothian	480
293217 to 293226	10	Midlothian	400
293395	1	Halliday	40

Location and Access

The claims are situated within Halliday and Midlothian Townships in the Larder Lake Mining Division, Ontario. Access is by gravel road from Timmins or Matachewan. Float planes can land on Sirola Lake near the north edge of the property, approximately 40 air miles south of Timmins.

History

The property lies directly to the south of the former Stairs Mine. Activity there in the 1940's resulted in this property being prospected for gold. One chip sample from the property assayed .44 oz. Au per ton. The writer has been unsuccessful in determining the source of this sample reported by the Ontario Department of Mines, although several

Old pits are present in the vicinity.

The current owners of the property were first attracted to the area by the reported gold values. In their prospecting they discovered the base-metal mineralization which has been the focus of attention since that time.

Glen Copper Mines Ltd. optioned the property in November 1971.

WORK DONE

The following work has been done on the property:

Trenching

The prospectors have done a very creditable job of pitting and trenching most mineralized areas. Some of the trenches are simply re-openings or expansions of former trenches done in the search for gold. Many are, however, sizeable new excavations in mineralized bedrock.

Magnetometer Survey

In November 1971, Mr. John Boissoneault performed a magnetometer survey over the property.

I.P. Survey

In the fall of 1971, S.L. Sandner of S.L. Sandner Associates completed an I.P. survey of the property.

On the writer's recommendation a second I.P. survey was undertaken in July 1972 by Scintrex Ltd., over portions of the claims in the vicinity of the known mineralization.

Geological Surveys

A sketch geologic map was prepared by J. Boissoneault as a by-product of the magnetometer survey. The writer has traversed much of the ground but has not produced a geologic map.

In November 1972 employees of Newmont Mining Corporation of Canada Ltd., working by agreement with Glen Copper Mines Ltd. prepared a geologic map at a scale of 1" = 400'.

Diamond Drilling

Eight diamond drill holes were drilled for Glen Copper for a total footage of 4124 feet. The holes ranged in length from 113 feet to 1031 feet.

GEOLOGY

Mapping of the area by the Ontario Department of Mines was completed in 1970. (1) The property lies within a large rhyolite dome of Archean age. The rocks of the dome are chiefly rhyolite to dacite with local bands of andesite and ultramafic material.

(1) E.G. Bright. Geology of Halliday and Midlothian Townships. Ontario Department of Mines Geological Report # 79

The property lies toward the north edge of the dome just to the south of a series of infolded or intercalated sediments and pyroclastics, also of Archean age.

Within the claims area the rocks are entirely rhyolites or rhyodacites. These include massive structureless units, with and without quartz phenocrysts; a tuffaceous unit, rhyolitic breccias suggestive of coarse pyroclastics; rhyolite breccias apparently developed through cataclasis and intensely sheared derivatives of these rocks now represented by sericite and chlorite schists.

Throughout the area mapped there is a pervasive ENE'ly trending schistosity. This is most pronounced in the schistose areas but even in the most massive units shear planes, schistose elements and stretched fragments trend in this direction.

In spite of the varied types of rhyodacite present none of the workers to date has succeeded in obtaining a bedding attitude. Strikes within the bedded rocks to the north are near east-west with generally steep northerly dips. These may reflect the approximate attitude of the rhyolites. However, since that portion of the dome south of the sediments is approximately four miles across and is without major lithologic change it would appear likely that there is repetition by faulting and/or folding.

Alteration of the rhyolites is extremely widespread. The minerals recognizeable in hand specimen are sericite, fuchsite, ankeritic carbonate, chlorite and silica.

In the vicinity of the known mineralization a peculiar greenish sericite (chromian?) is common. In hand specimen it compares well with similar alteration at Kidd Creeek. Fuchsite (?) occurs as discreet crystals and shreds in some units within the mineralized zone. Ankerite occurs within the mineralized zone in conjunction with the phyllosilicates but is developed to its maximum elsewhere. Chlorite occurs both within and beyond the mineralized zone but is the least common phyllosilicate where the rock is well mineralized.

Irregular quartz veinlets a fraction of an inch in thickness are common in the mineralized areas. These often contain pyrite, sphalerite and to a lesser extent chalcopyrite and galena.

Magnetometer Survey Results

The magnetometer work by Boissoneault shows a low relief (a total of 430 gammas) and when contoured a pronounced northeasterly grain. A break in the magnetic contours at 16 to 20 E suggests a structural discontinuity, possible a fault.

Scintrex in the discussion of results of their I.P. survey include a discussion of the magnetometer results. (2)

I.P. Survey Results

The initial I.P. survey (Sandner) appears not to have been successful. Correlation with known geologic features is poor as is correspondence with the later survey.

(2) Scintrex Ltd: Report on an Induced Polarization Survey, Halliday and Midlothian Twp. Larder Lake Mining Division on Behalf of Glen Copper Mines Ltd. by Jan Klein, M.Sc., P. Eng. Geophysicist

The survey performed by Scintrex Ltd. is discussed at length in their report (q.v.) In general three parallel bands of polarizable material were indicated (A B & C). Of these, Zone B was tested quite extensively in drilling (drill holes 1, 2 and 3) and Zone A was probed to a lesser extent with a single hole (drill hole #5). Zone B is represented in holes 1, 2 and 3 by increased pyrite.

Diamond Drill Results

Bazinet recommended 12,000 feet of diamond drilling to explore the known mineralized zone. To date only 4124 feet have been completed. The writer suggests that this is hardly a sufficient test of the potential of the extensive mineralization known to occur on the property.

In general, drill holes which penetrated I.P. Zone B intersected large sections containing 1 to 10% pyrite. Associated with the pyrite and to some extent along the south wall of the intensive pyritization, sphalerite and minor galena occur sporadically disseminated and in quartz veinlets.

Nothing approaching ore-grade material was cut in any of the holes.

CONCLUSIONS AND RECOMMENDATIONS

Work to date has only partially tested the 3600 foot long pyritized zone known on the Glen Copper Mines Ltd. option. Final assessment of the work will require drafting of drill sections and interpretations of the geophysics and surface geology in relation to the sections.

It is also desirable to plot the positions of the known intersections on the supposed walls of the sulphidized zone to indicate the areas tested and further attempt to relate the results to any areas which might be expected to carry potential massive sulphide base-metal deposits.

The writer believes that such work will better indicate:

1. The amount of the zones as yet untested.
2. Any trends which may exist in the extensively drilled area in the vicinity of line OOE.
3. The geometry of the sulphide zone and the relationship between the heavy pyrite, the base-metals and possible the alteration pattern.

On completion of the above work, further diamond-drilling will be in order. The writer believes a minimum of 4000 feet will be necessary to establish whether further work is desirable.

Respectfully Submitted

Earl D. Dodson

Earl D. Dodson, P. Eng.

900

GLEN COPPER MINES LTD.
706-1111 W. Hastings St.
Vancouver 1, B.C.

February 28, 1973

Minister of Natural Recources
Queens Park
Toronto, Ontario

ATTENTION: Mr. Leo Bernier

Dear Sir:

Please find enclosed copy of Swastika's Certificate of Analysis as requested.

Yours truly,

G. Brett
President
GLEN COPPER MINES LTD.

GB:IS
Enclosures: 2

W.M. GERRIE M.A.
D. KERR LAWSON B.A. PH.D.

TELEPHONE 642-3244
P.O. DRAWER 10

Swastika, Ont., Sept.5,1972 19

SWASTIKA LABORATORIES LIMITED

Certificate of Analysis

No. 42922

Copy

We have assayed six samples of split core

Received Sept.2,1972 and submitted by Glen Copper Limited,

per: John Boissonnault, Esq. with the following results:

Sample No.	Gold Ozs.	Silver Ozs.	Lead %	Zinc %
No ticket	Nil	Nil	0.08	0.19
B4801 & B4802	Nil	Nil	0.06	0.09
B4827	Nil	Nil		
B4828	Nil	Nil		
B4829	0.005	Trace		
Special	Nil	0.73		

SWASTIKA LABORATORIES LIMITED,

per: [signature]

As is the established North American custom, unless it is specifically stated otherwise gold and silver values reported on these sheets have not been adjusted to compensate for losses and gains inherent in the fire assay process

WM. GERRIE M.A.
D. KERR-LAWSON B.A. PH.D.

TELEPHONE 642-3244
P.O. DRAWER 10

Swastika, Ont., Sept. 1, 1972 19

SWASTIKA LABORATORIES LIMITED

Certificate of Analysis

No. 42914

Copy

We have assayed seventeen samples of split core and pulp

Received Aug. 31, 1972 and submitted by Glen Copper Mines Limited,

per: John Boissoneault, Esq. P.Eng. with the following results:

Sample No.	Gold Ozs.	Silver Ozs.	Copper %	Lead %	Zinc %
4816	Nil	Nil	None		Trace
4817	Nil	0.01	None		Trace
4818	Nil	Trace	0.01		0.01
4819	Nil	Nil	None		Trace
4820	Nil	Trace	None		0.01
4821	Nil	Nil	None		None
4822	Nil	Nil	None		None
4823	Nil	Trace	None		None
4824	Nil	0.01	None		None
4825	Nil	Nil	None		None
4826	Nil	Trace	None		None
B4803	Nil	3.80		0.28	0.52
B4804	0.005	0.19		0.11	0.34
B4805	Nil	0.07		0.03	0.06
B4806	Nil	0.02		0.02	0.22
B4807	0.005	Nil		0.13	0.23
B4808	0.005	0.06		0.01	0.01

SWASTIKA LABORATORIES LIMITED:

per: [signature]

WM. CERRIE M.A.
D. KERR LAWSON B.A. PH.D

TELEPHONE 642-3244
P.O. DRAWER 10

Swastika, Ont., Aug. 28, 1972 19

SWASTIKA LABORATORIES LIMITED

Certificate of Analysis

No. 12900.

Copy

We have assayed five samples of split core

Received Aug. 25, 1972 and submitted by Glen Copper Mines Limited.

per: John R. Boissoneault, Esq., P.Eng. with the following results:

Sample No.	Gold Ozs.	Silver Ozs.	Copper %	Zinc %
B 4811	Nil	0.03	0.01	None
B 4812	Nil	Trace	0.01	None
B 4813	Nil	0.02	0.01	None
B 4814	Nil	0.03	None	Trace
B 4815	Nil	0.04	None	Trace

SWASTIKA LABORATORIES LIMITED

per: D. Kerr Lawson

[illegible] established North American custom, unless it is specifically stated otherwise gold and silver values reported on these sheets have not been adjusted to compensate for losses and gains inherent in the fire assay process.

FORM 12

Effective date July 19, 1971

SECURITIES ACT, 1967

Neither the British Columbia Securities Commission nor the Vancouver Stock Exchange has in any way passed upon the merits of the securities offered hereunder and any representation to the contrary is an offence.

BRITISH COLUMBIA SECURITIES COMMISSION
VANCOUVER STOCK EXCHANGE

GLEN COPPER MINES LIMITED
(Full name of company.)

Head Office - 706 - 1111 West Hastings Street, Vancouver 1, B.C.
(Address of head office and registered office of company.)

Registered Office: 1403-1030 West Georgia Street, Vancouver 5, B. C.

Statement of Material Facts

1. Give details of the circumstances relating to the offering of the securities and any material changes in the affairs of the issuer.	See Item 1 attached
2. Set out the description, designation, and number of shares being offered by the issuer or selling shareholder. If any of the shares being offered are to be offered for the account of a selling shareholder, name such shareholder and state the number of shares owned by him, the number to be offered for his account, and the number to be owned by him after the offering.	See Item 1 attached
3. Set out the price to the public, underwriting discounts or commissions and the estimated net proceeds to the issuer or selling shareholder, on both a per share and an aggregate basis. If it is not possible to state the price to the public or the underwriting discount or commissions, the method by which they are to be determined shall be explained. Give the range of the market price during the previous 90 days.	See Item 1 attached
4. State the principal purposes for which the estimated net proceeds to be derived by the issuer from the sale of the shares to be offered are intended to be used and the approximate amount intended to be used for each such purpose.	See Item 4 attached
5. State the laws under which the issuer was incorporated and whether incorporated by memorandum of association, Letters Patent, or otherwise or under a particular part of an incorporating Statute dealing with mining companies and the date thereof.	B.C. Companies Act - Memorandum of Association dated November 19, 1965
6. Give names, addresses, and chief occupations for the past five years of the officers and directors of the issuer.	See Item 6 attached
7. State the share capitalization of the issuer showing authorized and issued capital.	Authorized: 3,000,000 shares without nominal or par value with a maximum price of $1.00 per share. Issued: 1,800,000 shares
8. Give particulars of any bonds, debentures, notes, mortgages, charges, liens, or hypothecations of the issuer.	Nil
9. Outline briefly the manner in which the shares being offered are to be distributed, giving particulars of any outstanding or proposed underwriting, sale, or option agreement, including the name and address of each underwriter, purchaser, or optionee. Give similar particulars of sub-underwriting or sub-option agreements outstanding or proposed to be given and particulars of any assignments or proposed assignments of any such agreements. Give names and addresses of persons having any interest, direct or indirect, in underwritten or optioned shares.	See Item 1 attached INTERIM LISTING

21. Give the aggregate direct remuneration, including amounts for services rendered, paid or payable by the issuer and its subsidiaries during the past year to the insiders of the issuer.	Guilford Brett - $400.00 Glen Huck - $800.00
22. Give brief particulars of all options to purchase securities (other than such as are granted or proposed to be granted to shareholders as such on a *pro rata* basis) outstanding or proposed to be given by the issuer and its subsidiaries to any person or company, naming each such person or company and showing separately all such options outstanding or proposed to be given to the insiders of the issuer or its subsidiaries.	Nil
23. State the prices at which shares of the issuer have been issued for cash during the past year. If any shares have been issued for services, state the nature and value of the services and give the name and address of the person or company who received such shares. State the number of shares issued at each price.	See Item 23 attached
24. Give the dates of and parties to and the general nature of every material contract entered into by the issuer or any subsidiary within the preceding two years which is still in effect and is not disclosed in the foregoing.	See Item 24 attached
25. Give particulars of any other material facts relating to the shares proposed to be offered and not disclosed pursuant to the foregoing items.	Nil
26. If assets include investments in the shares or other securities of other companies, give an itemized statement thereof showing cost of book value and present market value.	See Item 26 attached

27.

CERTIFICATE OF THE COMPANY

INTERIM LISTING

Dated July 12th, 1971

Glen Huck (Pres)

[Corporate Seal.]

CERTIFICATE OF UNDERWRITER OR OPTIONEE

Dated July 12 /71

To the best of our knowledge, informationand belief, the foregoing constitutes full, true and plain disclosure of all material facts relating to the securities offered by this Statement of Material Facts.

WEST COAST SECURITIES LIMITED

Per:

ITEM 6

Name	Address	Occupation for Last Five Years
Glen Huck President and Director	Box 545 Vanderhoof, B. C.	Rancher
Andrew Robertson Director	130 South Oxley Street West Vancouver, B. C.	Mining Executive
Guilford H. Brett Director, Vice-President and Managing Director	3641 West 48th Avenue Vancouver, B. C.	Mining Executive
Thomas S. Mackay Director	801 - 1200 Alberni Street Vancouver, B. C.	Investment Dealer
Alexander W. Fisher Director	1870 West 35th Avenue Vancouver, B. C.	Barrister and Solicitor
W. Earl Essery Secretary-Treasurer	2323 West 2nd Avenue Vancouver, B. C.	Corporate Secretary

ITEM 10

The beneficial shareholders in the Underwriter, West Coast Securities Ltd. 306 - 845 West Pender Street, Vancouver, B. C., are as follows:

Name of Shareholder	Class of Shares	Number of Shares	Percentage
James D. Thomas 2088 Westdean Crescent West Vancouver, B. C.	Common	999	99.9%
W. R. Bullen 1079 Roselea Crescent Richmond, B. C.	Common	1	.01%

ITEM 12

1. Omineca Mining Division - Legate Creek, East of Terrace, British Columbia.

The Company owns the following mineral claims free and clear of all encumbrances:

Claim	Record Nos.
Carmin 1-2	42867-8
Carmin 5-8	42871-4
Carmin 13-18	45879-84
Carmin 23-28	45724-9
Carmin 31	45732
Carmin 37	45738
Carmin 39	45740
Carmin 41	45742
Carmin 46	45747

INTERIM LISTING

INTERIM LISTING

Claim	Record Nos.
Dome 25-40 incl.	32587-32602 incl.
Dome 41A	36223
Iron Cap 7	1650
Iron Cap 8	1651
Dome 42-76 incl.	38493-38527 incl.
Brett 6-13	40520-40527 incl.
Brett 1-8 Fr. incl.	40159-40166 incl.
Brett 9 fr.	39969
Brett 11 - 14 fr.	40516-40519

Reed Mines Ltd. (N.P.L.) was incorporated by Memorandum of Association, pursuant to the provisions of the B. C. Companies Act., on the 11th day of December, 1970. It is a private company and is authorized to issue 5,000,000 shares with a maximum price or consideration of 50¢. Of the 5,000,000 shares authorized, a total of 500,000 shares have been issued for properties as hereafter set out. The registered office of Reed Mines Ltd. (N P.L.) is 845 Hornby Street, Vancouver, British Columbia, and its directors and officers are:

Donald Esplen	Director, Vice-President and Secretary-Treasurer
Jack Ashton	Director and President.

Reed Mines Ltd. (N.P.L.) holds the above claims pursuant to an option agreement with Joseph Reed dated May 25th, 1971. The Agreement provides for a $500.00 down-payment, $5,000.00 to be paid to Mr. Reed on July 15, 1971, $5,000.00 on the 15th day of November, 1971, and a further $5,000.00 on the 15th days of March, July and November in each subsequent year until such time as the property is placed into production. At such time as the property is placed into production Mr. Reed is to receive a royalty payment of 4% of the net proceeds derived from the operation of the property.

The Company has an Agreement with Reed Mines Ltd.(N.P.L.) dated June 4th, 1971, pursuant to which 250,000 shares of the Company would be issued to Reed Mines Ltd. (N.P.L.) for and in consideration of the issuance of 250,000 shares of Reed Mines Ltd. (N.P.L.) to the Company. The Agreement also provides for the granting of an option to the Company to purchase a further 4,250,000 shares of Reed Mines Ltd. (N.P.L.) at a price of 20¢ per share, such money to be either paid by the Company to Reed Mines Ltd. (N.P.L.) or spent by the Company on the properties of Reed Mines Ltd. (N.P.L.). No part of the option can be exercised until at least $100,000.00 has been paid or spent by the Company. There are presently 500,000 shares of Reed Mines Ltd. (N.P.L.) issued and outstanding.

The above Dome, Iron Cap and Brett claims were held by the Company and Brettland Mines Ltd. (N.P.L.) pursuant to an option agreement with Joseph Reed until May of 1971. Pursuant to an agreement with Pacific Petroleums Ltd., Pacific Petroleums Ltd. spent a total of $105,234.30 on the property before terminating the agreement. The work was managed by Guilford Brett and supervised and directed by P. E. Hirst, P.Eng., in conjunction with Mr. Pearse, geologist, who acted as resident manager of the program.

Most of the work was directed towards evaluating the potential of molybdenum and tungsten mineralized areas in the vicinity of the Cirque Creek, specifically anomalies 1, 2 and 3. Lesser attention was devoted to evaluating anomalies 4, 5, 6 and 7.

3. Omineca Mining Division - 25 miles N. W. of Smithers, British Columbia.

The Company is also the owner of six Coal Licences being numbers 516 - 521 inclusive, which were acquired by the Company for a cost of approximately $2,200.00. Adjacent to these licences are licences owned by Kaiser Resources Ltd. and Western Coal & Coke Ltd. (NPL). On April 1, 1970, the Company entered into an Agreement for the exploration and development of all of the properties held by the three companies. Pursuant to the Agreement Kaiser Resources Ltd. spent a total of $60,000.00 on the licences. A report dated October 1, 1970 was prepared on the properties by G. P. Gormally, B. SC. under the direction of Allan A. Johnson, B. SC. and supervised by J. E. Morris, P. Eng. The following quotation is from this report:

> "Geological mapping has reduced the potential coal bearing area to a maximum of 2 square miles. Using an 8 foot average seam thickness, a possible reserve of 35 million tons could be calculated for this area. However, various features of the coal make mineable reserves of this magnitude very improbable."

As a result of this conclusion the report did not recommend the expenditure of any further monies on the licences.

ITEM 18

Of the 750,000 shares issued for properties Glen Huck received 500,000 and Guilford Brett 250,000 shares. Of the 750,000 shares 500,000 remain in escrow with the registrar and transfer agent of the Company pursuant to an escrow Agreement providing inter alia, that except with the written consent of the Superintendent of Brokers for the Province of British Columbia, the holders of escrow shares shall not sell, deal in, assign or transfer in any manner whatsoever or agree to sell, deal in, or assign beneficial ownership or interest in them and that without the written consent of the Superintendent, the transfer agent shall not accept or acknowledge any transfer, assignment, declaration of trust, or other document evidencing a change in legal or beneficial ownership of interest in the said shares except as may be required by reason of a death or bankruptcy of any one or more of the holders of the escrow shares, in which case the transfer agent shall hold the said certificate representing such shares for whatever person or persons, firm or corporation that may thus become legally entitled thereto and that, in the event of the Company losing or not obtaining good and marketable title to, or abandoning, or discontinuing development of any of the property which was or formed part of the consideration for any of the said 750,000 shares, or in the event of the property not being as represented, there shall be surrendered by way of gift to the Company for cancellation such number of the said shares as the Superintendent in his sole discretion deems fair and equitable.

ITEM 19

The following shareholders own more than 5% of the outstanding shares of the Company:

Glen Huck	427,167 shares
Guilford Brett	191,420 shares

PURCHASERS RIGHT TO RESCISSION

A person who has entered into a contract for the purchase of a security to which this Statement of Material Facts applies is entitled to rescission of the contract where:

(a) such purchaser has not received a copy of, the Statement of Material Facts, the latest financial statement and reports, and a fair and accurate summary of the report on the Company's property that issued the security;

(b) written notice of intention to commence an action for rescission of the contract is served on the person who contracted to sell the security within sixty (60) days of the date of delivery of the written confirmation of the sale of the security; and

(c) the purchaser is still the owner of the security.

In an action for rescission under the above paragraph the onus of proving delivery of the documents referred to in paragraph (a) above is upon the person who, under the contract, was or would be the seller of the securities.

No action shall be commenced after the expiration of three months from the date of service of the notice referred to in paragraph (b) above.

SUMMARY OF P. E. HIRST & ASSOCIATES LTD.'S
REPORT ON THE DOME, IRON CAP AND BRETT CLAIMS
(HELD UNDER OPTION BY REED MINES LTD. (N.P.L.))

The 1970 work programme has indicated that molybdenite (and tungsten) mineralization occurs over a wider area than previously established. Within an approximate 3,600 foot square, three separate and different types of molybfenite (and tungsten) deposits have been recognized, viz;

1. disseminated in a heavily clay altered porphyritic granite; and

2. as fracture fillings in meta siltstones; and

3. as desseminations in skarn zones peripheral to or capping porphyritic granite and allied intrusives.

These zones were the prime targets for the 1970 drilling, which failed to encounter any economic grades in two of the areas (Anomalies 1 and 2), but insufficient work has been done to evaluate the molybdenite-scheelite mineralized skarns in Anomaly 3.

Further work is recommended to evaluate a possible small openpit potential of combined moly-tungsten mineralization in Anomaly 3, and a deep drill test is recommended to test for an

GLEN COPPER MINES LIMITED

BALANCE SHEET

May 31, 1971

ASSETS

Current:		
Cash	233.53	
Accounts receivable	1,597.50	
Prepaid insurance	195.00	2,026.03
Investments, at nominal value		2.00
Mineral claims		4,600.00
Coal licences		150.00
Equipment, at cost		3,434.81
Deferred exploration and administration expenditures		433,229.29
		$ 443,442.13

LIABILITIES

Current:	
Accounts payable	4,789.26

SHAREHOLDERS' EQUITY

Capital stock			
Common shares without nominal or par value			
Authorized	3,000,000 shares		
Issued and fully paid	1,800,000, see note	1,222,500.00	
Deduct Deficit		783,856.13	
			438,643.87
			$ 443,442.13

NOTE: Capital stock issued	Number of Shares	Amount
For mineral claims (now abandoned)	750,000	$ 750,000.00
For cash	1,050,000	472,500.00
	1,800,000	1,222,500.00

APPROVED ON BEHALF OF THE BOARD:

Glen Huck Director

Gifford Bett V.P. Director

GLEN COPPER MINES LIMITED

STATEMENT OF DEFICIT

for the year ended May 31, 1971

Balance at beginning of year		8,750.00
Additions during year		
Mineral claims abandoned	757,800.00	
Investments, write-off to nominal value	17,306.13	775,106.13
Balance at end of year		$ 783,856.13

GLEN COPPER MINES LIMITED

STATEMENT OF DEFERRED EXPLORATION AND ADMINISTRATION

for the year ended May 31, 1971

Balance at beginning of year		423,204.65
Additions during year		
Exploration		
Government fees and taxes	1,230.00	
Insurance and workmen's compensation	348.90	
Rental income	(160.00)	
Sundry	61.93	
	1,480.83	
Equipment write-off	4,023.38	5,504.21
Administration		
Rent	450.00	
Administration fee	2,400.00	
Salaries	1,371.90	
Legal	867.55	
Stock transfer expense	1,127.44	
Shareholders' information	151.82	
Telephone	604.20	
Listing fees	300.00	
Sundry	20.02	
Interest earned	(97.50)	
Management fee income	(2,675.00)	4,520.43
Balance at end of year		$ 433,229.29

NOTE 1:

Reed Mines Ltd. (NPL) acquired the following mineral leases and claims for and in consideration of 500,000 shares:

Mineral Claim	Record Numbers
Brett 1 - 4 inclusive	39846 - 39849
Brett 5	39850
Brett 10	39970

Mineral Lease	Record Numbers
Monarch	4754 - 36.73 acres
Searcher #6	4753 - 33.90 acres
Searcher #2	4755 - 47.00 acres
E.B. Fraction	4760 - 12.25 acres
Searcher #4	4756 - 36.51 acres
White Pass	4741 - 25.72 acres
Searcher #5	4739 - 18.08 acres

The shares were issued as follows:

200,000 shares - John M. Ashton
200,000 shares - Donald C. Esplen
100,000 shares - Joseph Reed

NOTE 2:

In June 1971, the Company, together with Glen Copper Mines Ltd., entered into an Agreement whereby Glen shall assume all of the obligations of Reed Mines Ltd. to Joe Reed, including making all payments due to Joe Reed thereunder.

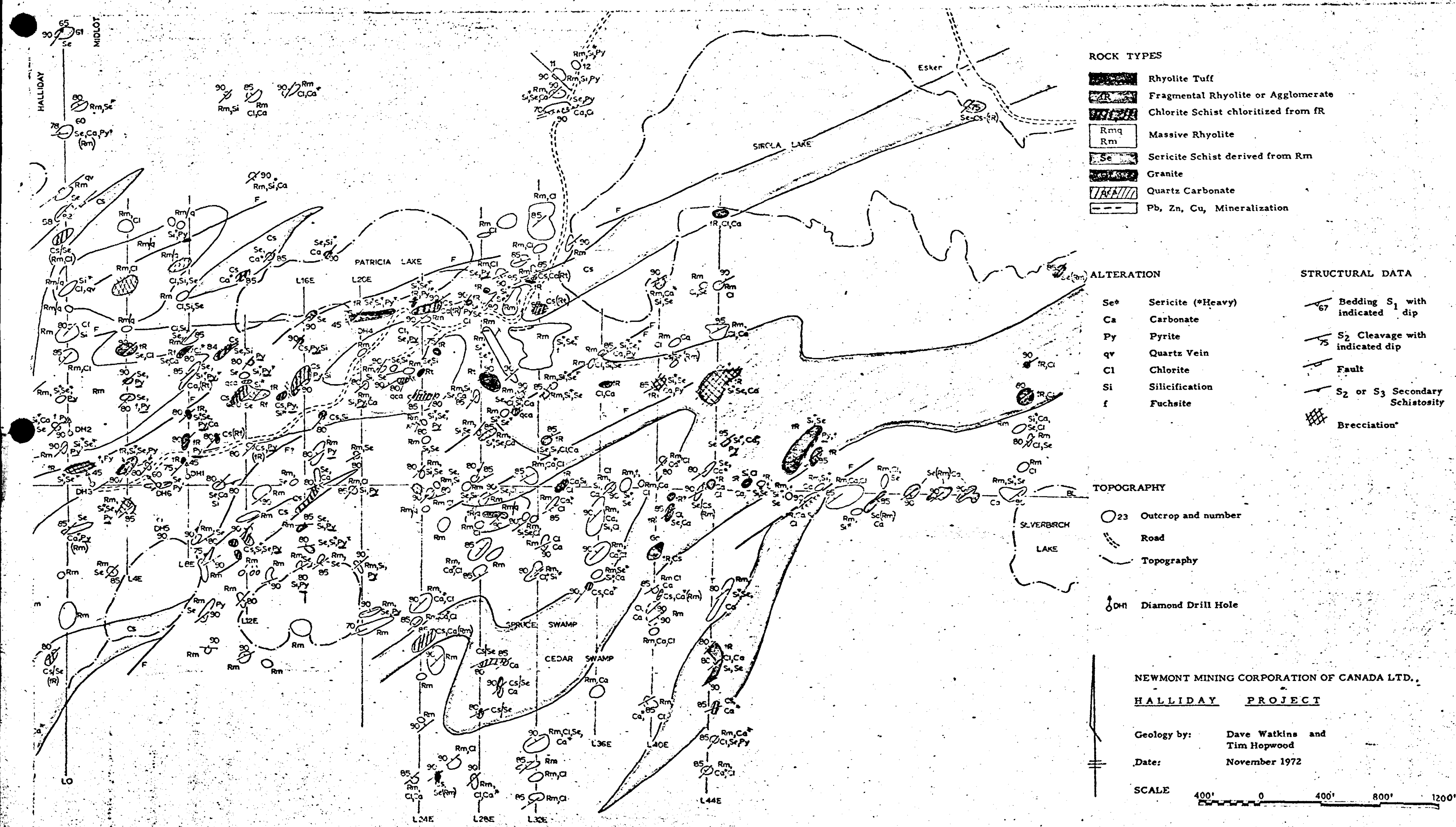
NOTE 3:

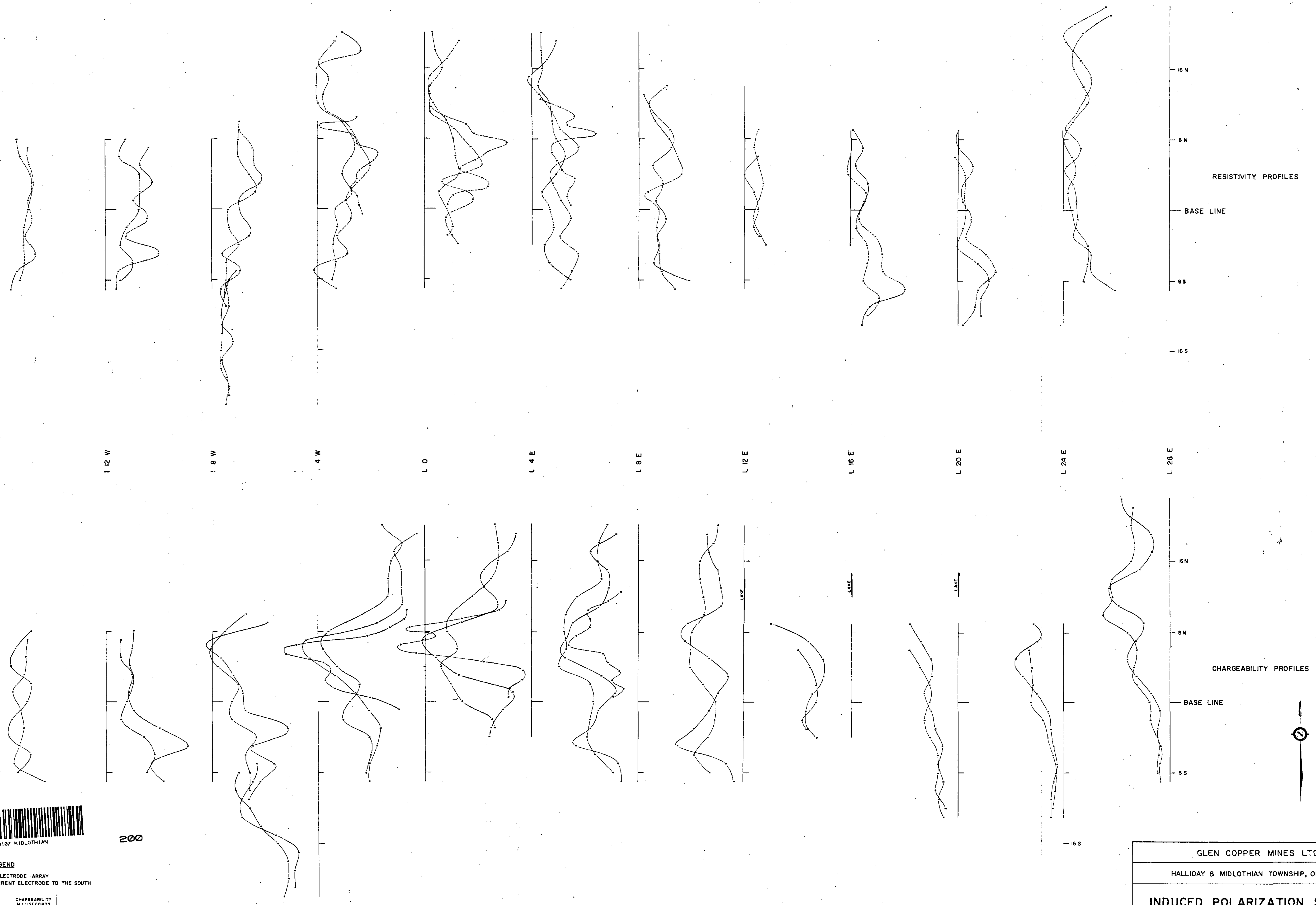
The Company has an Agreement with Reed Mines Ltd. (NPL) (hereinafter called "Reed") dated June 4, 1971, pursuant to which 250,000 shares of Glen Copper Mines Ltd. (hereinafter called "Glen") would be issued to Reed for and in consideration of the issuance of 250,000 shares of Reed to Glen. The Agreement also provides for the granting of an option to Glen to purchase a further 4,250,000 shares of Reed at a price of .20¢ per share, such money to be either paid by Glen to Reed, or spent by Glen on the properties of Reed. No part of the option can be exercised until at least $100,000.00 has been paid or spent by Glen. There are presently 500,000 shares of Reed issued and outstanding.

63.3107

CG-20


GLEN COPPER MINES LTD.
292005
292009
292010
293222
293221
292004
292008
292011
293223
293220
292003
292007
292012
293224
293219
292002
292006
292013
293225
293218
278570
278571
278572
293226
293217
255465
278573
293395
RHYOLITE LAKE
DUMBELL LAKE
MIDLOTHIAN TWP.
ALLIDAY TWP.

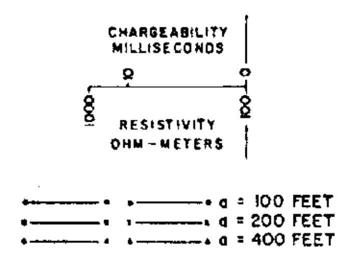

HALLIDAY
MIDLOT
PATRICIA LAKE
SIRCOLA LAKE
Esker
SPRUCE SWAMP
CEDAR SWAMP
SILVERBIRCH LAKE
L0
L4E
L8E
L12E
L16E
L20E
L24E
L28E
L32E
L36E
L40E
L44E
DH1
DH2
DH3
DH4
DH5
DH6
ROCK TYPES
Rhyolite Tuff
Fragmental Rhyolite or Agglomerate
Chlorite Schist chloritized from fR
Massive Rhyolite
Sericite Schist derived from Rm
Granite
Quartz Carbonate
Pb, Zn, Cu, Mineralization
ALTERATION
Se* Sericite (*Heavy)
Ca Carbonate
Py Pyrite
qv Quartz Vein
Cl Chlorite
Si Silicification
f Fuchsite
STRUCTURAL DATA
Bedding S1 with indicated dip
S2 Cleavage with indicated dip
Fault
S2 or S3 Secondary Schistosity
Brecciation
TOPOGRAPHY
Outcrop and number
Road
Topography
Diamond Drill Hole
NEWMONT MINING CORPORATION OF CANADA LTD.
HALLIDAY PROJECT
Geology by: Dave Watkins and Tim Hopwood
Date: November 1972
SCALE
400' 0 400' 800' 1200'



200

LEGEND

3 ELECTRODE ARRAY
CURRENT ELECTRODE TO THE SOUTH



NOTE
INTERLINE SPACING NOT TO SCALE

GLEN COPPER MINES LTD.

HALLIDAY & MIDLOTHIAN TOWNSHIP, ONTARIO

INDUCED POLARIZATION SURVEY

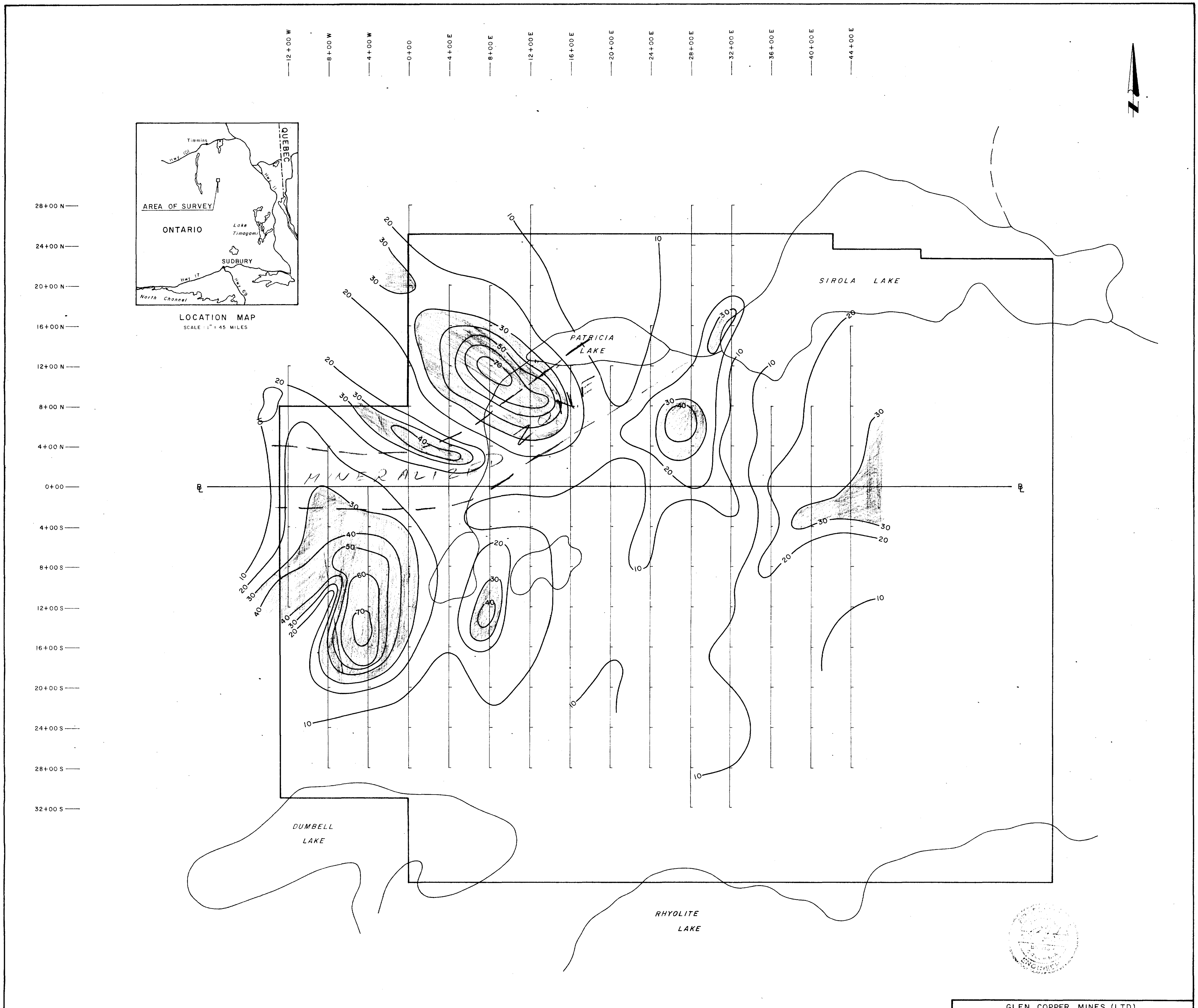
SCINTREX MARK VII 2.5 kW IP UNIT

SCALE 1" = 400'

SURVEY BY
SEIGEL ASSOCIATES LIMITED
JULY, 1972

PLATE

72-9574-



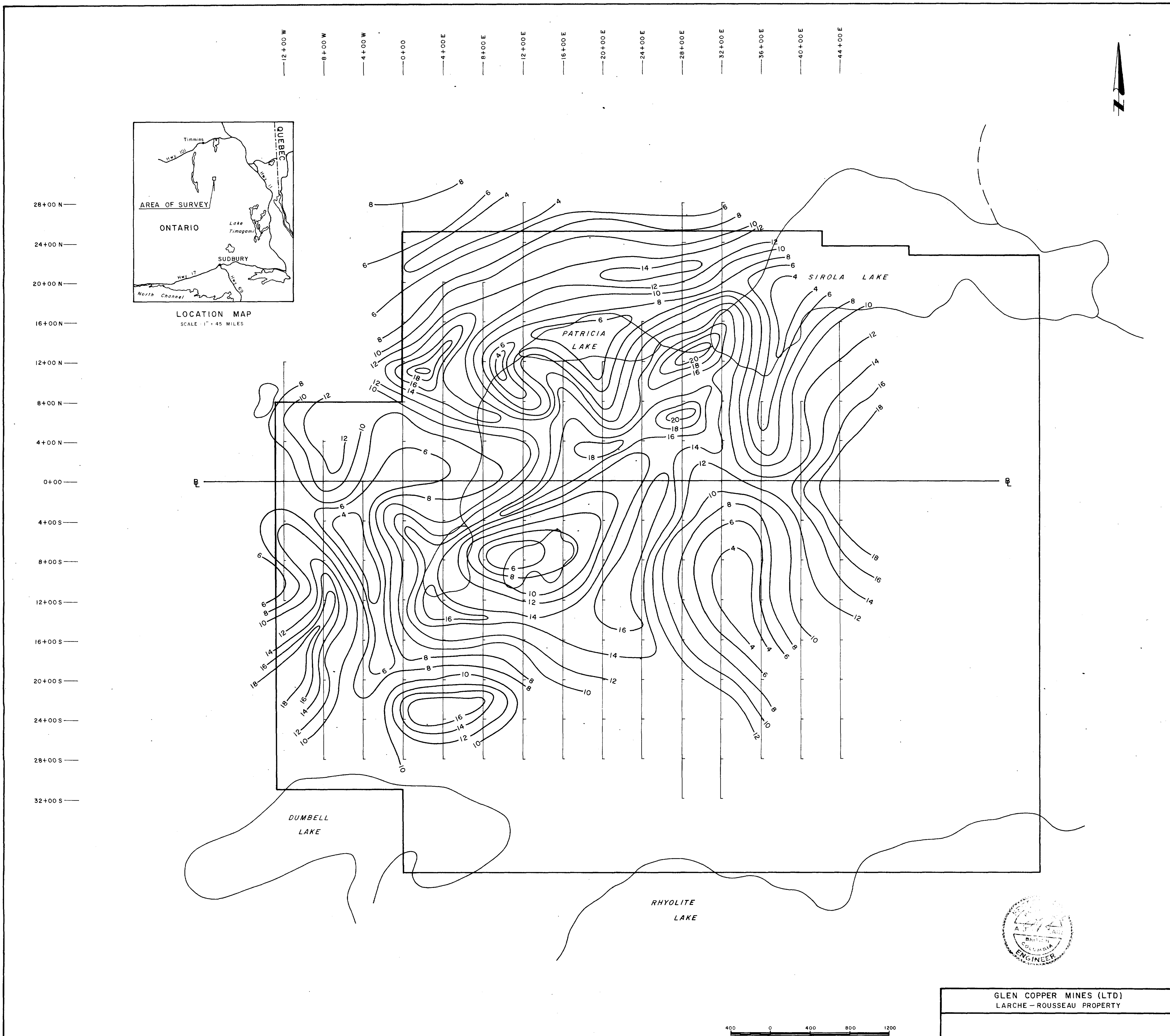
GLEN COPPER MINES (LTD)
LARCHE – ROUSSEAU PROPERTY

NORMALIZED
INDUCED POLARIZATION
CONTOUR INTERVAL : 10 MILLISECONDS

S.L. SANDNER & ASSOCIATES

DWN BY:	DATE:	FIG. No.
CHK BY:	SCALE 1" = 400'	1

210



GLEN COPPER MINES (LTD)
LARCHE – ROUSSEAU PROPERTY

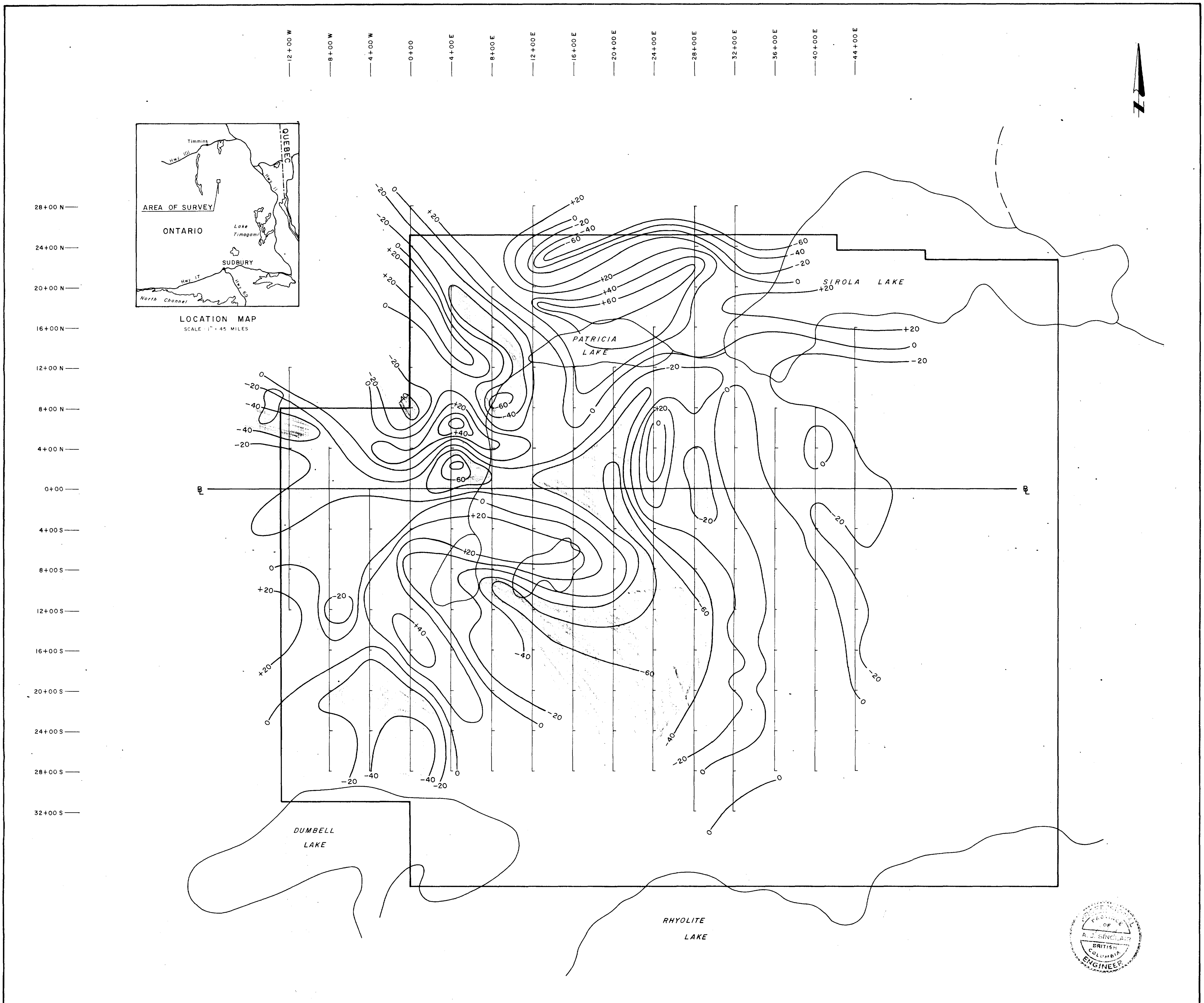
APPARENT RESISTIVITY

CONTOUR INTERVAL : 2000 OHM FT.

S.L. SANDNER & ASSOCIATES

DWN. BY: *Jm*	DATE *Nov. 12, 1971*	FIG. No.
CHK. BY: *SLS*	SCALE: 1" = 400'	2

220



GLEN COPPER MINES (LTD)
LARCHE – ROUSSEAU PROPERTY

SELF POTENTIAL

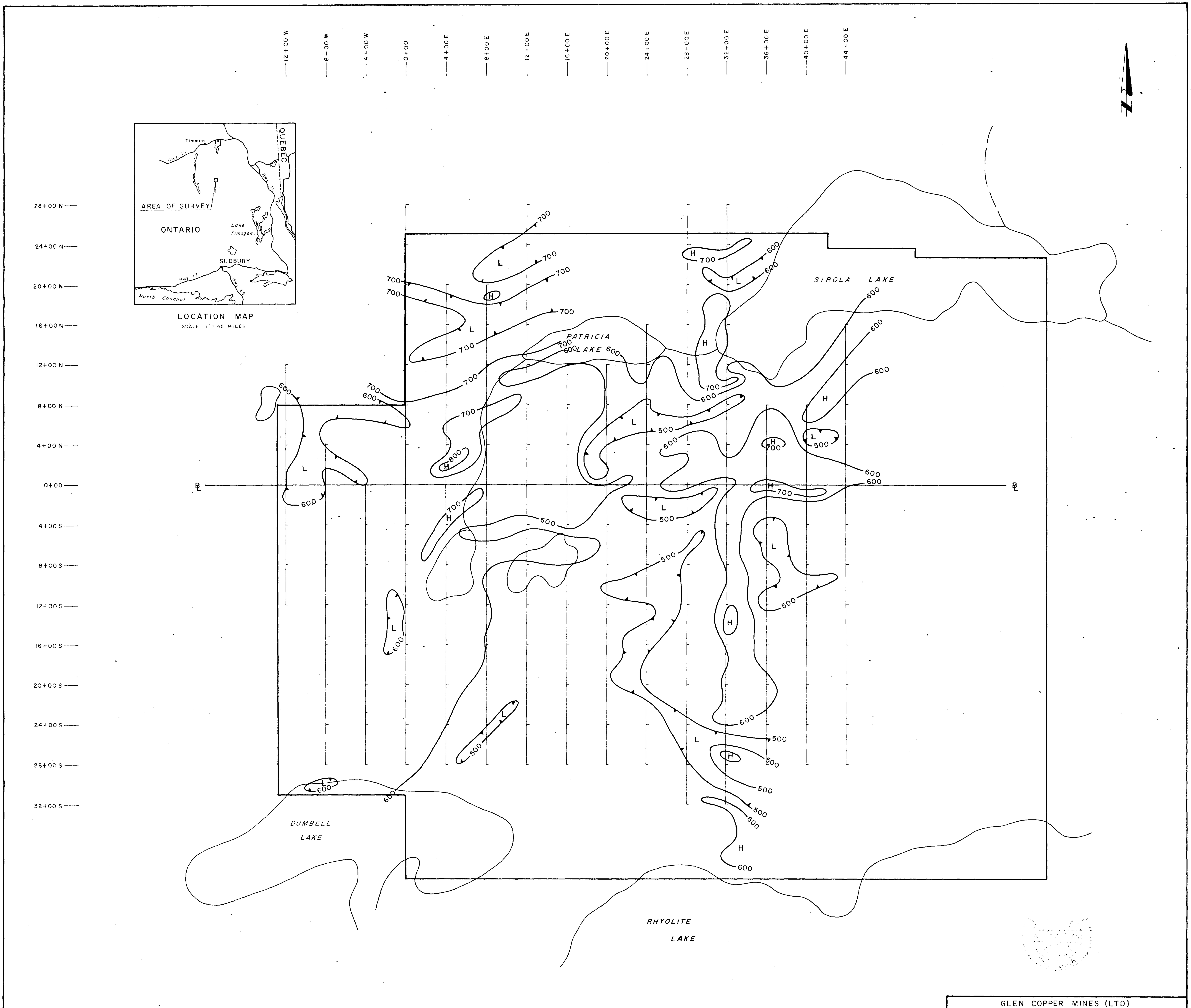
CONTOUR INTERVAL : 20

S.L. SANDNER & ASSOCIATES

DWN. BY :
CHK. BY :
DATE :
SCALE : 1" = 400'
FIG. No. 3

41P14NE0022 63.3187 NICLOTHIAN

230



GLEN COPPER MINES (LTD)
LARCHE – ROUSSEAU PROPERTY

ISOMAGNETIC PLAN

CONTOUR INTERVAL : 100 GAMMAS

S.L. SANDNER & ASSOCIATES

DWN. BY:	DATE	FIG. No.
CHK. BY:	SCALE 1" = 400'	4

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