REPORT ON THE ELECTROMAGNETIC SURVEY
PINE CLAIMS
LAC LE JEUNE AREA
KAMLOOPS MINING DIVISION, B.C.
FOR
CANADIAN JOHNS-MANVILLE
COMPANY LIMITED

BY

WILLIAM H. PELTON, B.A.Sc.

AND

ASHTON W. MULLAN, P.ENG.

NAME AND LOCATION OF PROPERTY
PINE CLAIMS, LAC LE JEUNE AREA
KAMLOOPS MINING DIVISION, B.C. 50°N, 120°W.

DATE STARTED - APRIL 2, 1971

DATE FINISHED - MAY 11, 1971

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McPHAR GEOPHYSICS

GENERAL NOTES ON
VERTICAL-LOOP
ELECTROMAGNETIC PROSPECTING

1. THEORY

The field lines about a magnetic dipole (e.g. bar magnet) follow the form of donut-shaped shells. Fig. 1 shows a cross-section of one such shell. All flux lines pass through the dipole axis at the centre and form approximate ellipses which have a length/width ratio of 1.3.

When a magnetic dipole oscillates, an electric field is generated which is orthogonal to the magnetic flux lines. Thus electric currents, commonly called "eddy currents", are induced in any sheet-like conductor which is penetrated by the alternating magnetic flux lines. The eddy currents form large circles in the conductor and in turn produce a secondary alternating magnetic field which opposes the primary inducing field.

If the conducting sheet is relatively large and thick, with high conductivity and magnetic permeability, the secondary electromagnetic field will be strong enough to appreciably distort the primary field. An instrument capable of measuring the spatial distortions in the field can thus be used to locate conductors. One possible coil configuration is shown in Fig. 2.

2. FIELD PROCEDURES

There are three common field procedures which are used in conventional vertical-loop prospecting.

DIPOLE FIELD

$$\vec{H} = \frac{NAI}{4\pi} e^{-iwt} \frac{(2x^2 - y^2 - z^2)\vec{i} + 3xy\vec{j} + 3xz\vec{k}}{(x^2 + y^2 + z^2)^{5/2}}$$

Equipotentials satisfy $x^2 = c(x^2 + y^2)^3$

Flux lines satisfy $x = \pm (ky^{4/3} - y^2)^{1/2}$ and $\frac{dx}{dy} = o$ at $y = \pm \sqrt{2}x$

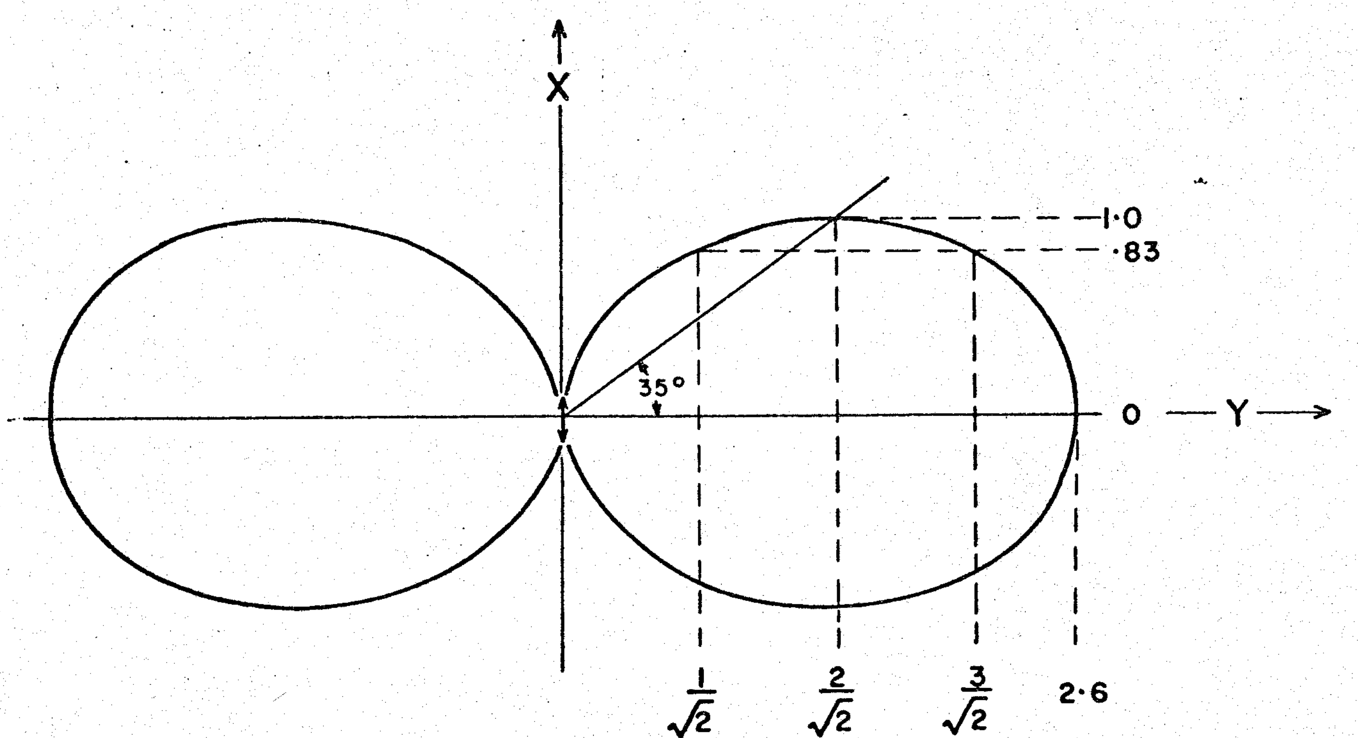


FIG. I

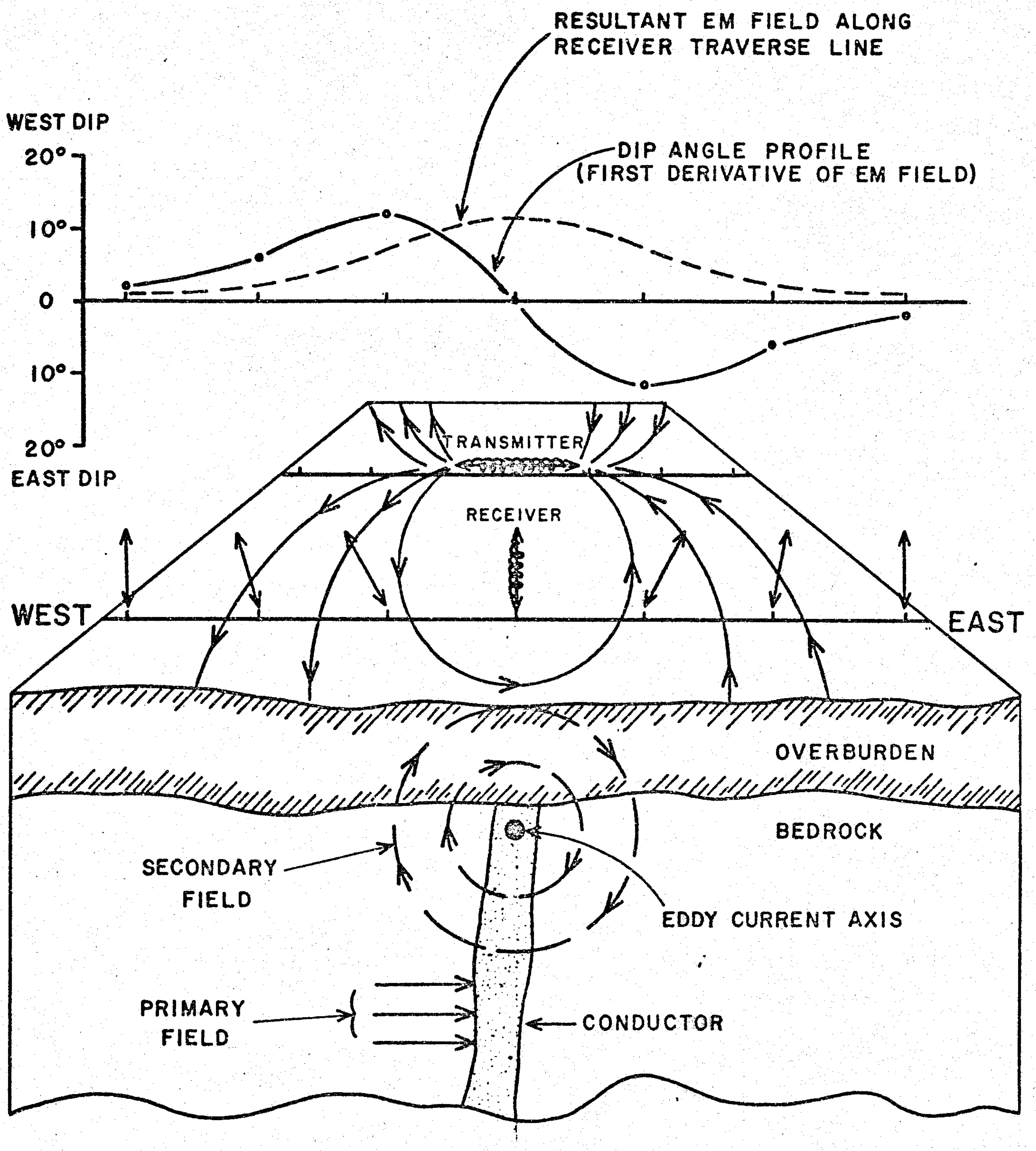
1) In-Line Method

This method is used for reconnaissance only, on lines which are widely-spaced or where there are no lines at all (as in the initial follow-up of airborne EM anomalies). The transmitter and receiver follow "in-line" along traverse lines which should be oriented at 45° to the suspected strike of the conductor. If the lines are exactly perpendicular, there will be little or no dip angle response over the zone.

Depending on relative position of the instruments, the direction of travel and the strike of the conductor, the in-line anomaly can be either positive or negative. As shown in Fig. 3, the peak response occurs when the transmitter is directly over the conductor, and in this case the dip angles are positive. If the conductor were at 135° to the strike instead of 45°, the profile would be negative, since the dip angles would all be to the north.

2) Broadside Method

This method is commonly used for reconnaissance on a well-cut grid. The transmitter and receiver move in co-ordination down adjacent parallel lines. The typical response over a conductor is shown in Fig. 3. Since all data sheets are drawn with west or south on the left, all bona fide anomalies (corresponding to "bumps" in the EM field) are indicated by "cross-overs" which go from positive on the left to negative on the right. A "reverse cross-over" which is negative on the left and positive on the right does not indicate an anomaly. Instead it corresponds to a "valley" in the EM field which possibly lies between two conductors.



SCHEMATIC DIAGRAM OF
VERTICAL LOOP
ELECTROMAGNETIC PROSPECTING METHOD

FIG. 2

3) Set-Up Method

This method is used for "detailing" or obtaining maximum information about a conductor. The transmitter is positioned over the conductor axis and is oriented perpendicular to the receiver as it follows the traverse line across the conductor. As shown in Fig. 3, the dip angle anomaly is considerably broader than that for the broadside configuration. This is because the transmitter stays above the conductor in a position of maximum electromagnetic coupling as the receiver makes the traverse. In the broadside method the transmitter is maximum-coupled with the conductor in only one position, usually where the dip angle is near the point of cross-over. When the transmitter and receiver are two stations away, the transmitter coupling with the conductor is very small and the dip angle response negligible; thus there is often only one strong anomalous reading on each side of the zone. Conversely, with the set-up method, the coupling between the transmitter and conductor stays relatively constant throughout the receiver traverse. Thus the anomalous dip angle profile is broader and more characteristic of the dip and depth of the source.

The same comments apply for the set-up method as well as the broadside method on the interpretation of "true" and "reverse" cross-overs. "Reverse" cross-overs may arise between two conductors but do not themselves indicate anomalies.

As a further aid to interpretation, two frequencies are usually used during a vertical-loop survey. The response parameter of a conductor depends upon the frequency of the electromagnetic field as well as its conductivity, magnetic permeability, thickness and size (in relation to the coil separation).

FIELD PROCEDURES

showing dip angle profiles—receiver and transmitter coils in plan

SCALE 1" = 500'

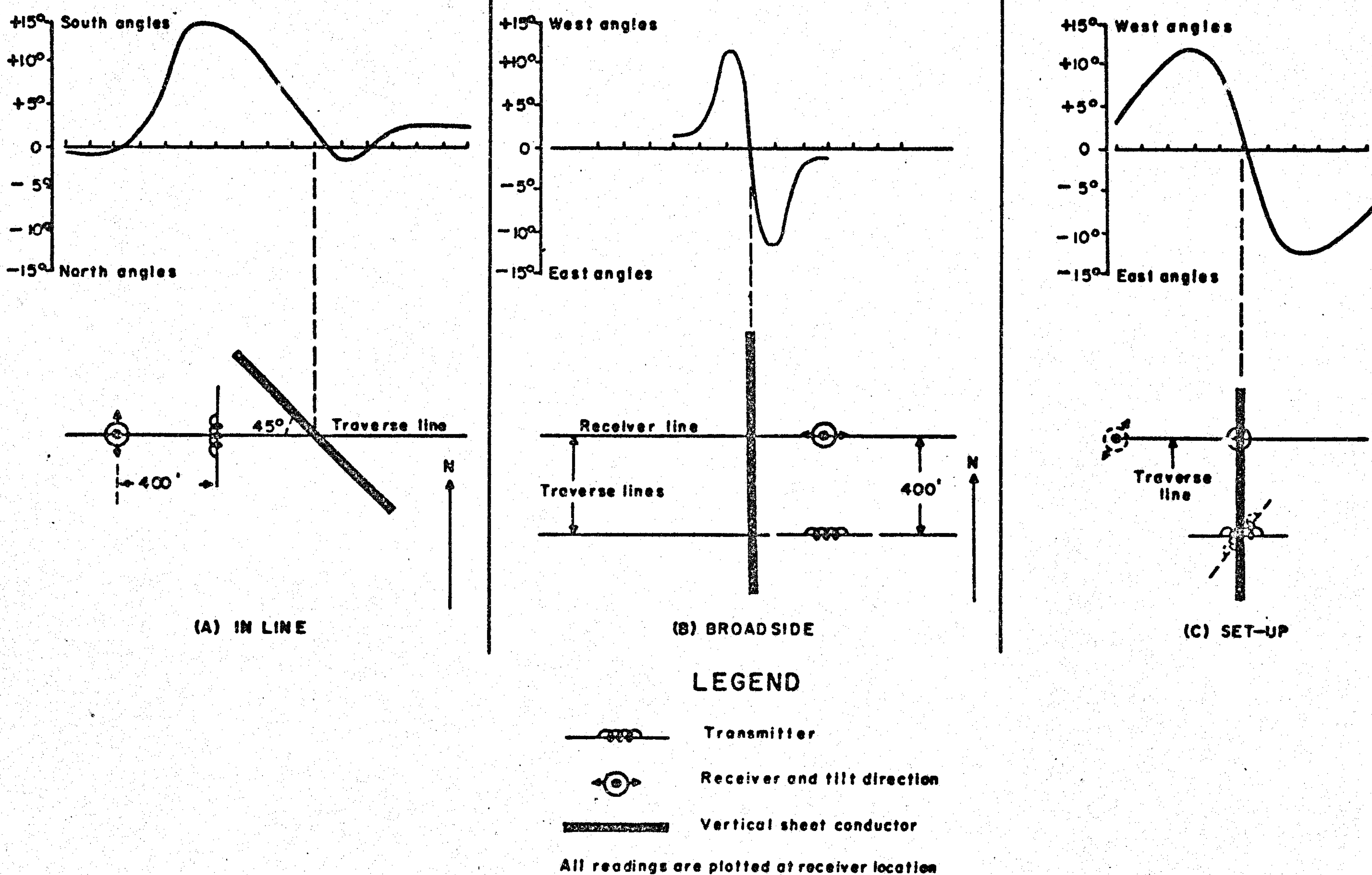


FIG. 3

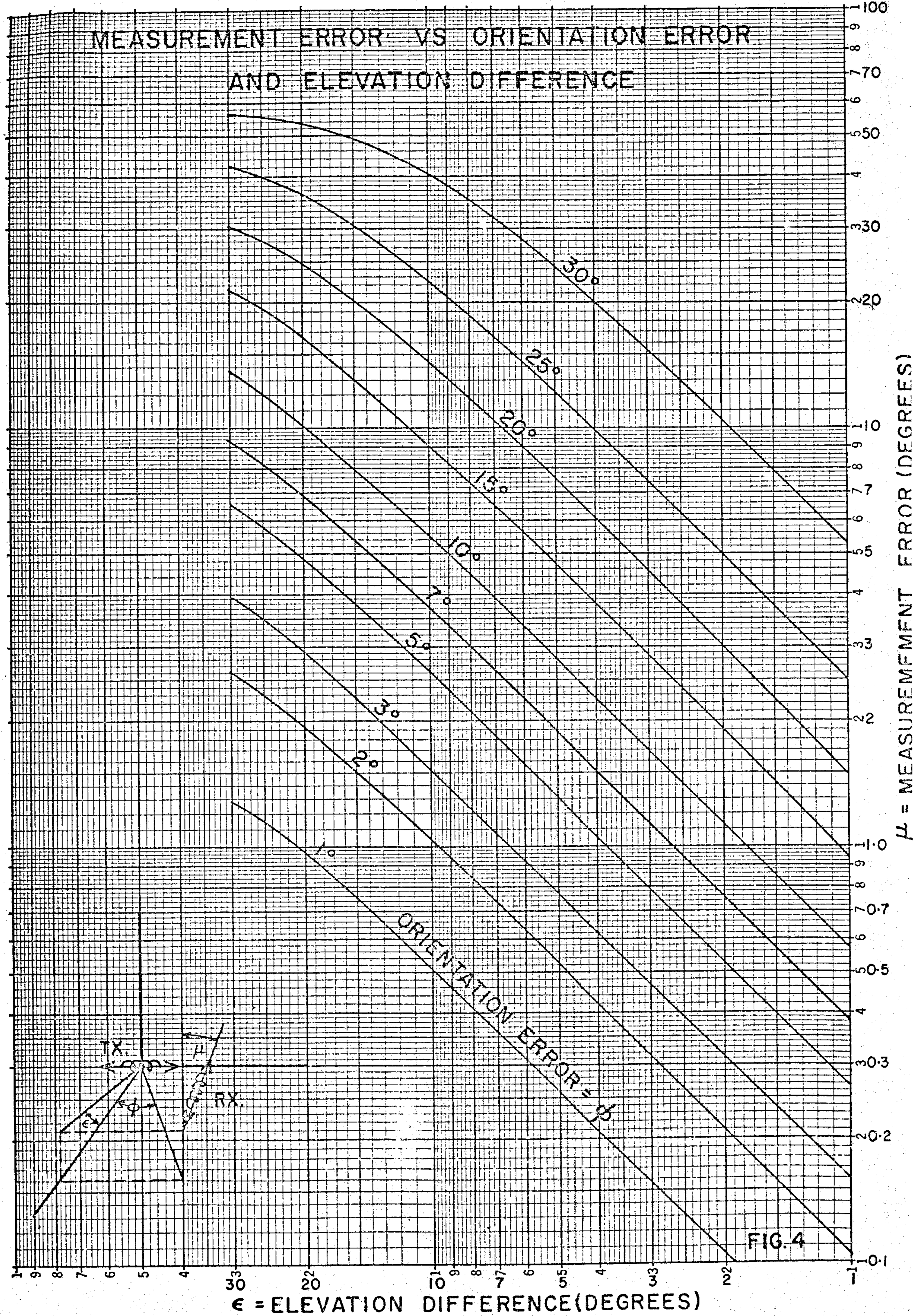
Consequently, by varying the frequency, an estimate can be obtained of the other parameters. The following is a "rule of thumb" guide for estimating conductivity:

1000 cps response / 5000 cps response	Conductivity	Typical Sources
0.9 to 1.0	excellent	massive sulphides, graphite
0.7 to 0.9	good	fracture-filling sulphides, graphitic schists
0.4 to 0.7	moderate	fault zones, shear zones, clay overburden, disseminated sulphides
less than 0.4	poor	lake bottom sediments, swamp

Another estimate of conductivity can be obtained from the "width of null" of the operator's measurements. Poor conductors have eddy currents which lag behind the inducing field. These eddy currents produce an "out-of-phase" secondary field in a different direction from the primary field at a time when the primary field is zero. Thus there is no orientation of the receiving coil that will result in a complete null of the incoming signal. The number of degrees the receiver must be rotated through to obtain a noticeable increase in signal is called the "null" and is an additional measure of the response parameter or conductivity.

3. ORIENTATION ERROR

There is only one main source of error in vertical-loop dip angle measurements (aside from reading errors when the signal is very weak, or when there is large out-of-phase response). On perfectly flat ground the


MEASUREMENT ERROR VS ORIENTATION ERROR
AND ELEVATION DIFFERENCE
30°
25°
20°
15°
10°
7°
5°
3°
2°
1°
ORIENTATION ERROR = φ
TX.
RX.
μ
ε
φ
FIG. 4
μ = MEASUREMENT ERROR (DEGREES)
ε = ELEVATION DIFFERENCE (DEGREES)
100
70
50
30
20
10
7
5
3
2
1·0
0·7
0·5
0·3
0·2
0·1
30
20
10
7
5
3
2
1

transmitter axis does not have to be kept absolutely perpendicular to the direction to the receiver. The dipole field is horizontal when both coils are in the same plane. However, when the survey is in rough topography and the receiving coil is above or below the transmitter, any departure of the transmitting coil from the perpendicular direction to the receiver will result in a fictitious anomalous dip angle. Fig. 4 shows the dip angles to be expected from various orientation errors and elevation differences. It can be seen that a misorientation of 15 degrees and an elevation difference of 10 degrees will result in a dip angle reading of 9 degrees.

Since few conductors have excellent conductivity, orientation errors may be suspected when the anomalous measurements are the same for both frequencies.

McPHAR GEOPHYSICS LIMITED

REPORT ON THE ELECTROMAGNETIC SURVEY PINE CLAIMS LAC LE JEUNE AREA KAMLOOPS MINING DIVISION, B.C. FOR CANADIAN JOHNS-MANVILLE COMPANY LIMITED

1. INTRODUCTION

As requested by Mr. H.K. Conn, Exploration Manager for Canadian Johns-Manville Company Limited, we have carried out an electromagnetic survey over the Pine Claims in the Lac Le Jeune Area of Kamloops Mining Division, British Columbia.

The property is located about 15 miles to the south of Kamloops at the centre of the 1 degree quadrilateral whose southeast corner is at 50°N latitude and 120°W longitude. Access is by gravel road.

The survey covered the following claims, all of which are believed owned or held under option by Canadian Johns-Manville Company Limited:-

P1	P12	P34	F1	F12
P2	P13	P53	F2	F13
P3	P14	P55	F3	F14
P4	P15	P84	F4	F15
P5	P16	P86	F5	F16
P6	P17	P103	F6	F39
P7	P18	P104	F7	F40
P8	P20	P105	F8	F41
P9	P22	P107	F9	F42
P10	P24	H Fr 7	F10	
P11	P33		F11	

2. GEOLOGY

Most of the claims are underlain by granitic rocks of the Nicola granitic batholith. This batholith intrudes the Nicola volcanics on the western side of the claim group. The youngest rocks are the Kamloops group basalts and underlying sediments, agglomerates and tuff located on the eastern and south central section of the claims. Most of the area is covered with persistent overburden, glacial till and drumlins.

No mineral deposits are known to occur on or near the property. The object of the present electromagnetic survey was to explore geochemical indications of copper, molybdenum and lead-zinc-silver.

3. PROCEDURE

The main grid over the claims consists of lines at 750' intervals. Electromagnetic measurements were carried out along these lines using a McPhar REM Unit in the in-line configuration. Where anomalous indications were encountered, intermediate lines were cut and traversed with the broadside configuration. Both of these configurations were used only for the initial detection of conductors. Further evaluation of the anomalies was carried out by set-up vertical-loop surveys in the areas of interest (see the general notes preceding this report).

4. PRESENTATION OF RESULTS

The results of the reconnaissance in-line survey over the main grid are shown as "stacked profiles" on Dwgs. EM 4786-1 and -2.

The electromagnetic survey results along shorter lines are shown in similar form on the following fold-outs:-

Method	Line	Dwg. No.
In-Line	72N	EM 5484-1
Broadside	56.5N, 52.5N, 49N	EM 5484-2
Set-Up	56.5N, 52.5N, 49N	EM 5484-3
Set-Up	55.5N, 52.5N, 49N, 45N, 41.5N 37.5N, 34N, 30N, 26.5N, 22.5N, 19.5N, 15N	EM 5484-4
Broadside	30N, 26.5N, 22.5N, 19N, 15N, 11.5N	EM 5484-5
Set-Up	30N, 26.5N, 22.5N, 19N, 15N, 11.5N	EM 5484-6
Broadside	7.5S, 11.5S	EM 5484-7
In-Line	30S	EM 5484-8
Broadside	30S	EM 5484-9
Broadside	41.25S, 45S, 48.75S, 52.5S	EM 5484-10
Set-Up	45S, 48.75S	EM 5484-11
In-Line	0	EM 5484-12
Broadside	0	EM 5484-13
In-Line	30E	EM 5484-14
Broadside	26.25E, 30E, 33.75E	EM 5484-15
Set-Up	26.25E, 30E, 33.75E	EM 5484-16
Set-Up	26.25E, 30E, 33.75E, 41.25E	EM 5484-17
In-Line	60E	EM 5484-18
Broadside	60E	EM 5484-19
Broadside	67.5E	EM 5484-20

All of these data sheets have a plan map scale of 1" = 200' and a profile scale of 1" = 10°. Anomalous indications have been judged "definite", "probable" or "possible" and are marked accordingly with "football" symbols.

The lines are shown in relation to the topographic features on Dwg. Misc. 3494 at a scale of 1" = 1000'.

5. DISCUSSION OF RESULTS

Dwg. EM 4786-1 : In-Line Survey:- Northern Grid

None of the anomalies are particularly strong and definite. However, most of the responses that are recognizable have been detailed with the broadside or set-up methods. The following are anomalous responses which have not been followed-up :-

Zone J and Zone K suggest a broad or multiple conductor passing between 28E and 38E from Line 45N to Line 67.5N. The apparent conductivity appears moderate to good.

Zone N and Zone O are very weak but they may indicate two long parallel conductive trends.

Dwg. EM 4786-2 : In-Line Survey:- Southern Grid

There is only very faint in-line response over Zone T, possibly because it lies nearly at right angles to the survey lines. The half-completed profile along Line 7.5S in Dwg. EM 5484-7, however, suggests a relatively strong source of moderate conductivity.

Weak responses near 12+00E and 26+00E on Line 7.5N and near 16+00E and 32+00E on Line 7.5S have been selected as "possible" anomalies. The in-line traverse over the stronger response near 11+00E on Line 30S has been repeated (see Dwg. EM 5484-8). In addition, the weak anomaly near 16E on Line 45S has been detailed and will be discussed in connection with Dwgs. EM 5484-10 and -11.

Dwg. EM 5484-1 : In-Line Survey:- Line 72N

No anomalous response was encountered on this survey.

Dwg. EM 5484-2 : Broadside Survey:- Line 56.5N, Line 52.5N and Line 49N

Weak anomalies were indicated on each line. The low frequency response was almost zero, suggesting poor conductivity; nevertheless, the lines were detailed with the set-up method.

Dwg. EM 5484-3 : Set-Up Survey:- Line 56.5N, Line 52.5N and Line 49N

The low frequency response is slightly higher for the set-up survey, but the profiles are still rather vague and inconclusive. The positions of the conductor axes are slightly shifted from the results of the broadside survey. This feature, combined with the broad crossovers and poor low frequency response, suggests that the two zones are caused by one broad, flat-lying, poor conductor such as a layer of conductive overburden.

Dwg. EM 5484-4 : Set-Up Survey:- Line 55.5N, Line 52.5N, Line 49N, Line 45N, Line 41.5N, Line 37.5N, Line 34N, Line 30N, Line 26.5N, Line 22.5N, Line 19.5N, Line 15N

The broad anomalous response, the relatively sharp crossovers, the long strike length and the poor apparent conductivity suggest that Zone L indicates a fault or shear zone. There is also strong response on Line 34N. Unfortunately, the profile was not completed over the zone.

The results over Zone M on Line 34N and Line 30N are much less conclusive; however, the half-profile on Line 22.5N suggests a similar long, deep, poor conductor such as a fault or shear zone.

Dwg. EM 5484-5 : Broadside Survey:- Line 30N, Line 26.5N, Line 22.5N, Line 19N, Line 15N, Line 11.5N

The low frequency response is relatively strong on Line 22.5N and suggests a probable conductor axis near 2+00E. The broadside results coincide very well with the in-line response over Zone R and indicate a single, moderate conductor.

Dwg. EM 5484-6 : Set-Up Survey:- Line 30N, Line 26.5N, Line 22.5N, Line 19N, Line 15N, Line 11.5N

It appears that the transmitter stations may have been positioned too far to the east to obtain good coupling with Zone R. Instead, the set-up results appear to have defined a weak, secondary trend - Zone S.

Dwg. EM 5484-7 : Broadside Survey:- Line 7.5S, Line 11.5S

The only anomalous response encountered in the survey suggests a possible moderate conductor located near 39E on Line 7.5S. This indication coincides with the very weak trend (Zone T) suggested by the results of the in-line survey on Dwg. EM 4786-2.

Dwg. EM 5484-8 : In-Line Survey:- Line 30S

Since the in-line response near 11+00E on Line 30S in Dwg. EM 4786-2 appeared as if it could have been caused by orientation error (the high and low frequency profiles are nearly identical), the survey was repeated. The response is much weaker, but a conductor axis is still suggested near 11+00E.

Dwg. EM 5484-9 : Broadside Survey:- Line 30S

The broadside survey has confirmed the weak anomaly near 11+00E and indicated another weak response near 16+00E.

Dwg. EM 5484-10 : Broadside Survey:- Line 41.25S, Line 45S, Line 48.75S, Line 52.5S

Zone U indicates a poor, possibly flat-lying source coinciding with a pond. It may be caused by conductive overburden. The profiles over Zone V also suggest a weak, poor conductor, possibly lying within the overburden.

Dwg. EM 5484-11 : Set-Up Survey:- Line 45S, Line 48.75S

The results of the set-up survey tend to confirm the interpretation of a poor, flat-lying conductor. No sharp crossovers indicating steeply-dipping, vein-type conductors were revealed.

Dwg. EM 5484-12 : In-Line Survey:- Line 0 (R & L Ranch Anomaly)

No anomalous response was observed on this traverse.

Dwg. EM 5484-13 : Broadside Survey:- Line 0 (R & L Ranch Anomaly)

A weak response, suggesting a poor, possibly flat-lying conductor was noted near 9+50E.

Dwg. EM 5484-14 : In-Line Survey:- Line 30E

A weak, poor conductor is suggested near 72+00N. However, no indication of a conductor was given by the survey along Line 72N (see Dwg. EM 5484-1) over the same location.

Dwg. EM 5484-15 : Broadside Survey:- Line 26.25E, Line 30E, Line 33.75E

The broadside survey has revealed two weak zones and one probable conductor axis near 59+50N on Line 30E. Zone W may correlate with the weak anomaly indicated by the in-line survey.

Dwg. EM 5484-16 : Set-Up Survey:- Line 26.25E, Line 30E, Line 33.75E

The results are vague and inconclusive but they may indicate a conductive trend (Zone Y) at 45° to the grid lines.

Dwg. EM 5484-17 : Set-Up Survey:- Line 26.25E, Line 30E, Line 33.75E, Line 37.5E, Line 41.25E

The anomaly near 49+50N on Line 33.75E is the most definite encountered in the survey. The profile is indicative of a steeply-dipping vein and the apparent conductivity is excellent. Two weaker responses occurring on Line 37.5E and Line 41.25E have been correlated with the definite anomaly to form Zone Z.

Dwg. EM 5484-18 & -19 : In-Line and Broadside Surveys:- Line 60E ("B" Anomaly)

Both the in-line and broadside surveys along Line 60E failed to reveal any anomalous response.

Dwg. EM 5484-20 : Broadside Survey:- Line 67.5E ("F" Anomaly)

Three very weak, poorly-conducting sources were suggested by the survey.

6. SUMMARY AND RECOMMENDATIONS

The vertical-loop electromagnetic survey has been valuable in economically outlining a number of anomalous zones on the property. However, not one of the anomalies has been classed as "definite". Even the relatively strong response over Zone Z may possibly be caused by orientation error. Usually the results of vertical-loop EM surveys are plotted at a scale of 1" = 20° in order to accommodate anomalous responses of 40° or more. There were few dip angles over 10° on this survey, so the profiles were expanded to a scale of 1" = 10° to amplify all small, weak trends.

This does not say that there is no mineralization on the grid - just that the vertical-loop survey has not outlined a definite, conclusive drill target. There are many mineral deposits, some of them massive sulphides, which have not responded to electromagnetic prospecting methods (see Appendix). However, virtually all near-surface, economic, base-metal sulphide deposits can be detected by the induced polarization method.

Since a number of possible conductor axes coincide with interesting geochemical anomalies, further follow-up definitely appears warranted. A dipole-dipole induced polarization survey with 100' electrode intervals, reading four separations would have good resolution for small, narrow deposits as well as have an effective depth of exploration of about 200'. The following short lines are recommended to be traversed by such a survey:-

Line	Stations
60N	32E to 42E
52.5N	10W to 14E
45N	36E to 70E
22.5N	4W to 8E
48.75S	10E to 25E
30E	55N to 75N
33.75E	45N to 55N

It is estimated that the program would take six days and cost $2,000.00.

The survey should have better resolution than the previous IP survey, and should: 1) determine if the EM anomalies arise from metallic sources in the bedrock or ionic sources such as fault zones and conductive overburden, and 2) definitely establish the location, depth and dip of prospective drill targets.

McPHAR GEOPHYSICS LIMITED

William H. Pelton

William H. Pelton,
Geophysicist.

A W Mullan

Ashton W. Mullan,
Geologist.

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
A. W. MULLAN

Dated: June 22, 1971

ASSESSMENT DETAILS

PROPERTY: Pine Claims

MINING DIVISION: Kamloops

SPONSOR: Canadian Johns-Manville Company Limited

PROVINCE: British Columbia

LOCATION: Lac Le Jeune Area

TYPE OF SURVEY: Electromagnetic

OPERATING MAN DAYS:	38	DATE STARTED:	April 2, 1971
EQUIVALENT 8 HR. MAN DAYS:	57	DATE FINISHED:	May 11, 1971
CONSULTING MAN DAYS:	5	NUMBER OF STATIONS:	641
DRAUGHTING MAN DAYS:	9	NUMBER OF READINGS:	1282
TOTAL MAN DAYS:	71	MILES OF LINE SURVEYED:	31.30

CONSULTANTS:

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Ashton W. Mullan, 1440 Sandhurst Place, West Vancouver, B.C.

FIELD TECHNICIANS:

P. Makulowich, 669 Valdes Drive, Brocklehurst, B.C.
Plus 1 helper supplied by client.

DRAUGHTSMEN:

K. Kingsbury, 58 Oak Avenue, Richvale, Ontario.
F. Hurst, 230 Woburn Avenue, Toronto 12, Ontario.
B. Marr, 19 Kenewen Court, Toronto 16, Ontario.

McPHAR GEOPHYSICS LIMITED

William H Pelton

William H. Pelton,
Geophysicist.

Dated: June 22, 1971

SUMMARY OF COST

Canadian Johns-Manville Company Limited
EM Survey, Pine Claims, Lac Le Jeune Area,
Kamloops Mining Division, B.C.

Crew (1 man) P. Makulowich

11 days	18.62 line miles	@ $ 90.00 per mile	$1,675.00
8 days	12.68 line miles Detail Operating	@ $ 100.00/day	800.00

Expenses

Travel (mileage)	96.83
	$2,572.63

McPHAR GEOPHYSICS LIMITED

William H Pelton

William H. Pelton,
Geophysicist.

Dated: June 22, 1971

CERTIFICATE

I, William H. Pelton, of the City of Toronto, in the Province of Ontario, hereby certify:

1. That I am a geophysicist with a business address at 139 Bond Avenue, Don Mills, Ontario.

2. That I hold a B.A.Sc. degree in Engineering Physics (Geophysics Option) from the University of British Columbia.

3. That I am a member of KEGS and an associate member of the Society of Exploration Geophysicists and the European Association of Exploration Geophysicists.

4. That I have been engaged in geophysical interpretation for more than four years.

5. I have no direct or indirect interest, nor do I expect to receive any interest directly or indirectly, in the property or securities of Canadian Johns-Manville Company Limited or any affiliate.

6. The statements made in this report are based on a study of published geological literature and unpublished private reports.

7. Permission is granted to use in whole or in part for assessment and qualification requirements but not for advertising purposes.

Dated at Toronto

This 22nd day of June 1971

William H Pelton

William H. Pelton, B.A.Sc.

CERTIFICATE

I, Ashton W. Mullan, of the City of Vancouver, in the Province of British Columbia, hereby certify:

1. That I am a geologist and a fellow of the Geological Association of Canada with a business address at Suite 811, 837 West Hastings Street, Vancouver, British Columbia.

2. That I am registered as a member of the Association of Professional Engineers of the Provinces of Ontario and British Columbia.

3. That I hold a B.Sc. degree from McGill University.

4. That I have been practising my profession as a geologist for about twenty years.

5. I have no direct or indirect interest, nor do I expect to receive any interest directly or indirectly, in the property or securities of Canadian Johns-Manville Company Limited or any affiliate.

6. The statements made in this report are based on a study of published geological literature and unpublished private reports.

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PROFESSIONAL
PROVINCE OF
A. W. MULLAN
BRITISH COLUMBIA
ENGINEER

Dated at Toronto

This 22nd day of June 1971

A.W. Mullan, B.Sc., P.Eng.

CANADIAN CENTENNIAL CONFERENCE ON
MINING AND GROUNDWATER GEOPHYSICS

The Use of Induced Polarization Measurements to Locate Massive Sulphide Mineralization in Environments in which EM Methods Fail.

by

Philip G. Hallof

****

THIS IS AN UNEDITED PREPRINT - SUBJECT TO CORRECTION

ABSTRACT

For many years the Electromagnetic Method has been used throughout the world in the search for massive sulphide mineralization. It has been particularly useful in environments in which the mineralization is at a shallow depth; many orebodies have been found using EM techniques.

However, experience in recent years has shown that some zones of "massive" sulphide mineralization are not EM conductors. In some cases this is due to the type and/or concentration of mineralization in the zone, or because of the depth to the top of the source. In other situations the geologic environment is such that the EM anomalies from sulphide mineralization can not be distinguished from those due to ionic conductors.

The induced polarization method has been found to be more useful than EM techniques in these situations. Results are available from areas where the source is at considerable depth, as well as areas of ultrabasic rocks and semi-arid and tropic weathering in which numerous ionic conductors are present.

THE USE OF INDUCED POLARIZATION MEASUREMENTS TO LOCATE MASSIVE SULPHIDE MINERALIZATION IN ENVIRONMENTS IN WHICH E.M. METHODS FAIL

INTRODUCTION

The induced polarization method was initially developed for, and widely used in, the search for disseminated sulphide mineralization. The method has been found to be of great use in this type of exploration. In recent years, it has been used in all of the mining areas of the world in which disseminated mineralization is of economic interest. Many zones of mineralization, some of which were "ore", have been located.

As geophysicists gained more experience with the IP method, their understanding of the method and its applicability increased. It became clear that the method could be used to locate and outline zones of massive (concentrated) sulphide mineralization. A great deal of controversy still exists concerning this point. In massive sulphide zones the conductivity is very high; under these conditions it is difficult to maintain polarization (store energy.)

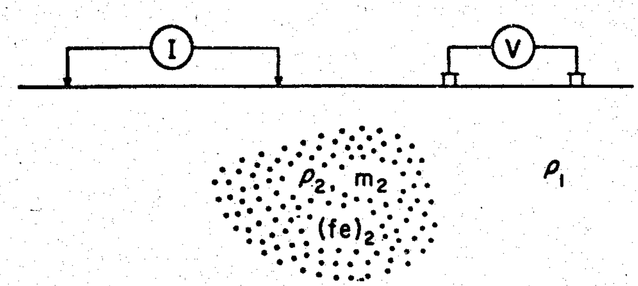
However, even the most massive sulphide mineralization is not a single crystal. There are many crystal faces; polarization takes place at an infinity of surfaces. Almost all sources contain disseminated, as well as massive, portions. It has been our experience that all zones of massive mineralization give rise to recognizable IP anomalies.

In many situations in which the massive mineralization is very conductive, and at a shallow depth, the various electromagnetic techniques have been successfully applied. The line-mile cost of EM is usually less than that of IP; it is therefore frequently preferable. However, in recent years we have found that in certain cases the IP method can be used to outline zones of massive mineralization that cannot be detected using EM techniques.

THE INDUCED POLARIZATION MEASUREMENT

The electrochemical phenomena giving rise to the induced polarization effects used in exploration have been previously described (Hallof 1957; Madden & Marshall 1959.) There are two well-known and widely applied measurement techniques used in exploration. (Seigel 1962; Wait 1959; Hallof 1960, 1961.) It has been shown that the chargeability parameter (M_a) used in the "pulse-transient" type survey is mathematically equivalent to the frequency effect parameter (Fe_a) usually recorded in the "variable frequency" type survey (Hallof 1964; Seigel 1959.)

Our field experience has confirmed that the chargeability and the frequency effect are exactly equivalent. Any differences that exist between the two measurement techniques have to do with the necessary instrumentation and the electrode configurations that are possible. In either measurement technique, it is possible to use one or more derived parameters.



$$m_a \simeq m_2 \rho_2 \times \frac{1}{\rho_a} \frac{\partial \rho_a}{\partial \rho_2} \qquad (fe)_a = (fe)_2 \rho_2 \times \frac{1}{\rho_a} \frac{\partial \rho_a}{\partial \rho_2}$$

$$mf \equiv \frac{(fe) \times 100}{\rho_{dc}/2\pi} \times 1000 = \frac{\left[\rho_{dc}/\rho_{ac} - 1\right] \times 100}{\rho_{dc}/2\pi} \times 1000$$

$$= \left[\frac{1}{\rho_{ac}} - \frac{1}{\rho_{dc}}\right] \times 2\pi \times 10^5 = \left[\sigma_{ac} - \sigma_{dc}\right] \times 2\pi \times 10^5$$

FIG. 1

One such parameter is the Metal factor, or Metallic conduction factor, (MF); the definition of this parameter is shown in Figure 1. It is very useful in the interpretation of induced polarization results. (Hallof 1964; 1967.) It is this parameter, the apparent Metal factor (MF_a), and the apparent resistivity ($\rho/2\pi_a$) that we use in our exploration work.

PLOTTING THE RESULTS

There are numerous techniques that can be used to plot induced polarization and resistivity results. Many geophysicists plot profiles along the measurement line; others construct two-dimensional, contoured plan maps using data measured along survey lines.

In our field work, we usually use the "dipole-dipole" electrode configuration shown in Figure 2. We find that this configuration has definite advantages because of its great flexibility; the relatively short wire lengths required in the field also speed the work.

METHOD USED IN PLOTTING DIPOLE-DIPOLE INDUCED POLARIZATION AND RESISTIVITY RESULTS

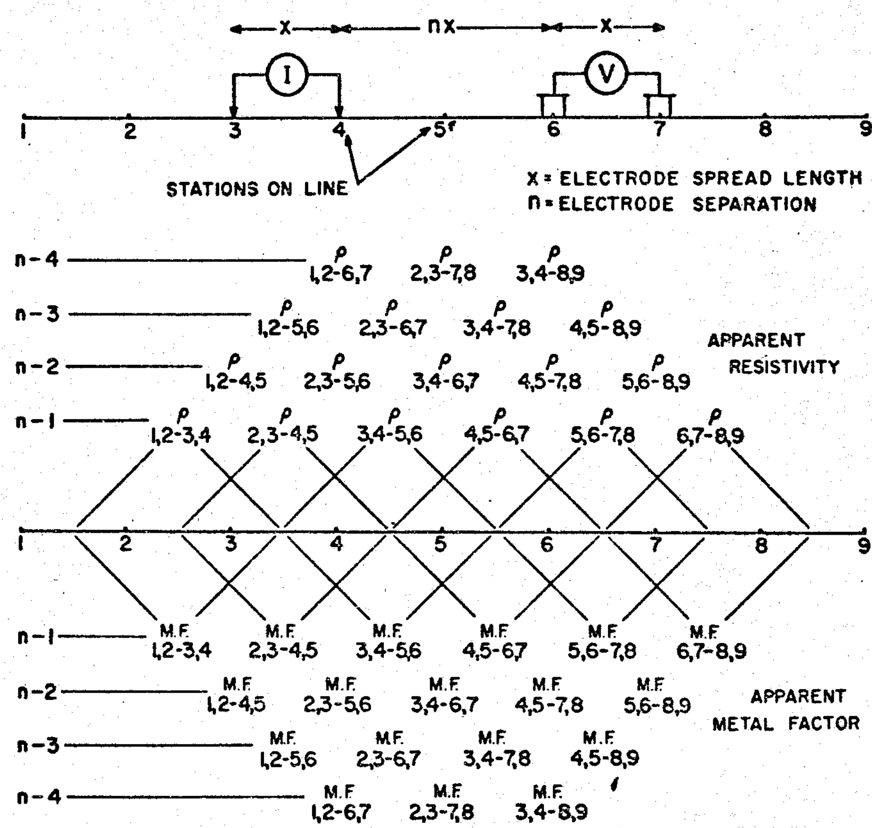


FIG. 2

The results are plotted in the two-dimensional, "pseudo-section" manner shown in Figure 2. In this field procedure, measurements on the surface are made in a way that allows the effects of lateral changes in the properties of the ground to be separated from the effects of vertical changes in the properties. Current is applied to the ground at two points a distance (X) feet apart. The potentials are measured at two other points (X) feet apart, in line with the current electrodes. The distance between the nearest current and potential electrodes is an integral number (n) times the basic distance (X).

The measurements are made along a surveyed line, with a constant distance (nX) between the nearest current and potential electrodes. In most surveys, several traverses are made with various values of (n); i.e. (n) = 1, 2, 3, 4, etc. The kind of survey required (detailed or reconnaissance) decides the number of values of (n) used.

In plotting the results, the values of the apparent resistivity and the apparent Metal factor measured for each set of electrode positions are plotted at the intersection of grid lines, one from the center point of the current electrodes and the other from the center point of the potential electrodes. The resistivity values are plotted above the line and the Metal factor values below. The lateral displacement of a given value is determined by the location along the survey line of the center point between the current and potential electrodes. The distance of the value from the line is determined by the distance (nX) between the current and potential electrodes when the measurement was made.

The separation between sender and receiver electrodes is only one factor which determines the depth to which the ground is being sampled in any particular measurement. These plots then, when contoured, are not section maps of the electrical properties of the ground under the survey line. They are merely convenient plots of all of the data. The interpretation of the results from any given survey must be carried out using the combined experience gained from field, model and theoretical investigations. The position of the electrodes when anomalous values are measured must be used in the interpretation.

MASSIVE SULPHIDE ZONES THAT DO NOT GIVE EM ANOMALIES

The various electromagnetic systems in use throughout the world were designed for the detection of zones of massive mineralization. Most massive sulphide mineralization is a good conductor; these zones give rise to definite EM anomalies. EM techniques have been applied in many mining areas and a great many orebodies have been located.

However, in recent years our experience has shown that in some areas there are massive sulphide zones that cannot be detected using EM methods. In some cases this is very difficult to explain. It may be that, although massive, the sulphide particles are separated by insulating material and are not interconnected to form a conductor. In these situations, the induced polarization method has been found to be of great use.

In other cases, while the mineralization may not be considered to be "massive", the percentage of sulphide present is substantial and would be expected to be sufficient to form a good conductor. In the "strata bound" lead-zinc deposits common in the limestone rocks of the mid-continent U.S.A., the Pine Point Region of Canada and in Ireland, there is associated pyrite and/or marcasite.

There is always 10% to 15% metallic mineralization; there is often as much as 25% to 35%. Numerous attempts have been made to detect these zones using EM methods. None of them have been successful.

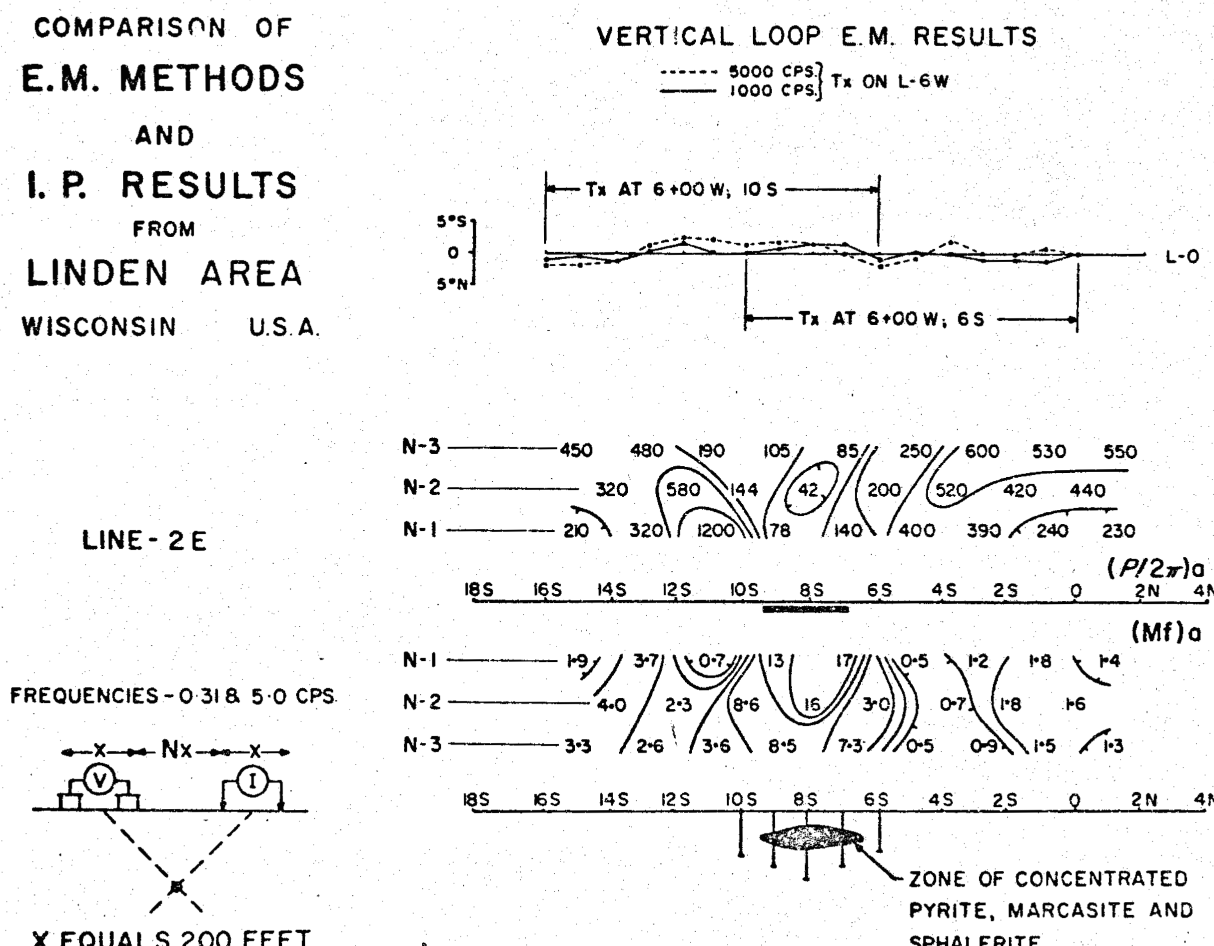


FIG. 3

The results shown in Figure 3 are typical for this type of mineralization. The ore zone shown was located by a reconnaissance IP survey in the Upper Mississippi Valley Zinc-Lead District. The ore mineralization is concentrated pyrite-marcasite, with sphalerite. The zone is almost 2000 feet long. As suggested by the IP results (maximum IP effect measured for n = 1), the source is relatively shallow.

When the ore zone had been outlined by drilling, a test EM survey was carried out using the Vertical Loop EM method. The results are plotted in the upper portion of Figure 3; the transmitter was 800 feet from the receiver and the frequencies were 1000 cps and 5000 cps. No significant EM anomaly was located.

In other mining areas, we have found that some ore zones can be detected using EM methods, while others cannot. This has been particularly true in the New Brunswick Area of eastern Canada. It was in this area that the EM methods were first used successfully in Canada in the mid-fifties. Many sulphide zones, some of which were ore, were located.

In recent years, we have found more than a dozen zones of massive mineralization, using IP, that were not detected by previous EM surveys. In some of these cases, the new zones of mineralization are less than 1000 feet from apparently similar massive mineralization located in the period 1954 - 1958 using EM. As is usual in New Brunswick, there is less than 30 feet of overburden in each of these areas.

The IP results shown in Figure 4 and Figure 5 located two of these zones; the EM results are shown on the upper portion of the drawings. The geologic situation is the same in both cases. The mineralization is located at the contact between high resistivity, massive-pyroclastic rocks and lower resistivity argillites. The IP results indicate a shallow (anomalous for $n = 1$) source in Figure 4 and a source at depth (maximum IP effect for $n = 3$) in Figure 5.

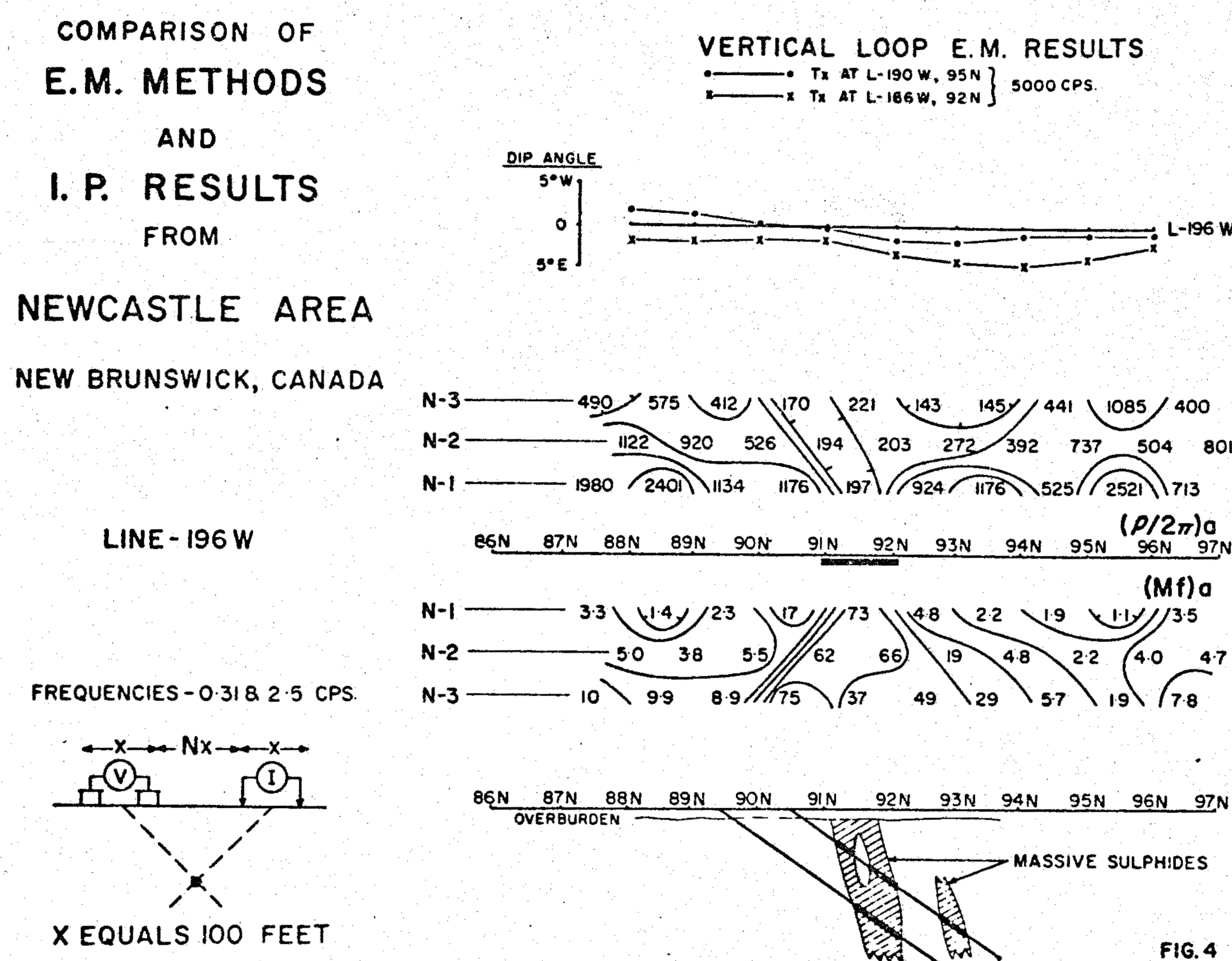


FIG. 4

In Figure 4, the 5000 cps Vertical Loop EM profiles show a weak conductor axis at the geologic contact. This feature has been traced for several miles across the property. The sulphide zone causing the IP anomaly is massive and it is 2200 feet long; there is no recognizable EM anomaly from the mineralization.

The results shown in Figure 5 are from two vertical field EM techniques. The sulphide zone is massive, but there is no conductor indicated by either the Horizontal Loop or Turam EM data. Here the IP results indicate some depth to the top of the source (perhaps 75 feet) and the zone is 1100 feet in length.

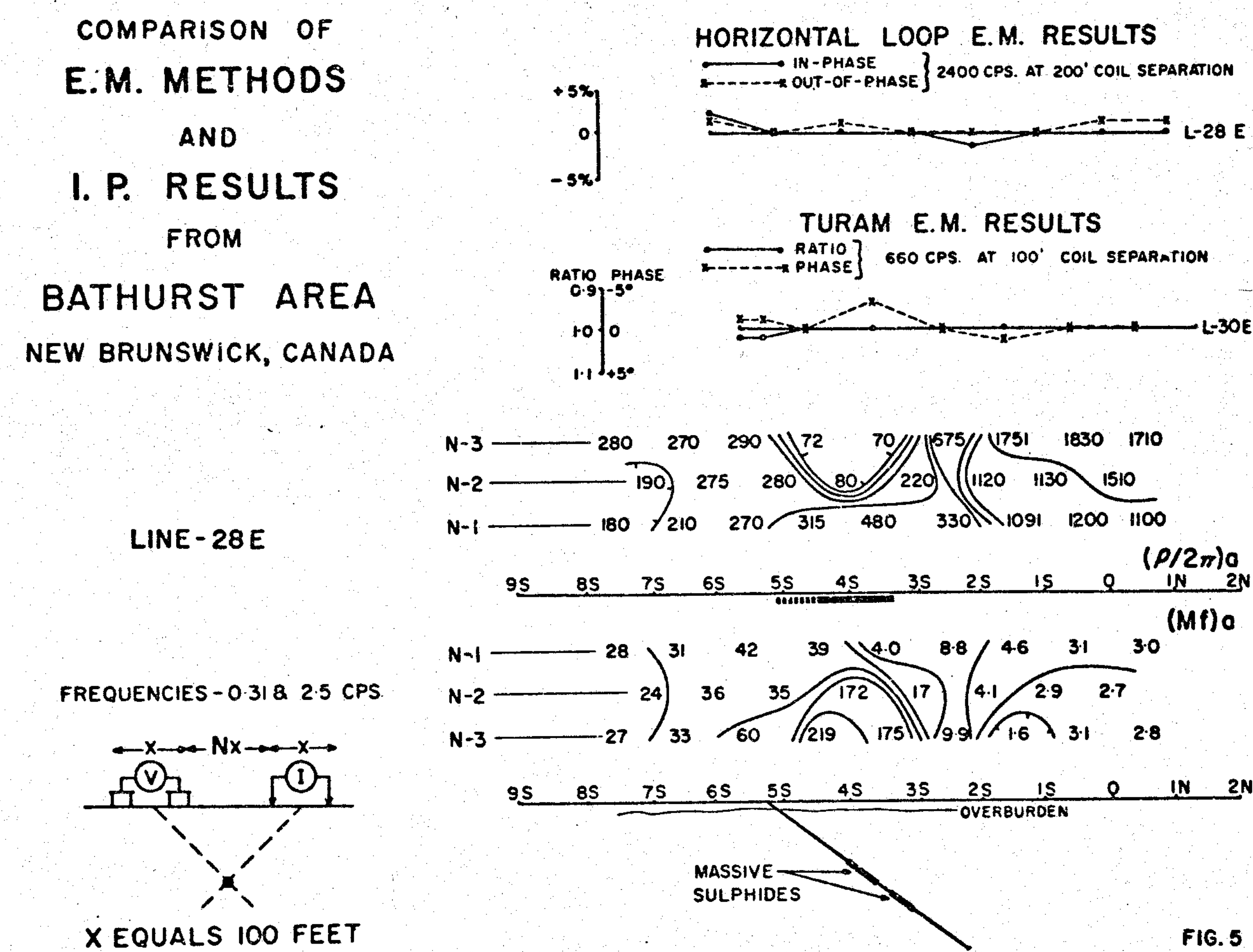


FIG. 5

SULPHIDE ZONES TOO DEEP TO BE DETECTED BY EM

As a sulphide zone is moved to greater and greater depth, the magntitude of the EM anomaly measured is reduced in magnitude. At some depth for the conductor, the anomalous effects cannot be distinguished from the normal "background" variations. This is the maximum depth of detection for the EM method and the particular conductor concerned. Our experience has shown that because of its greater discrimination, the IP method has a greater depth of detection than EM methods.

In Figure 6, there is a thickness of 180 feet of glacial

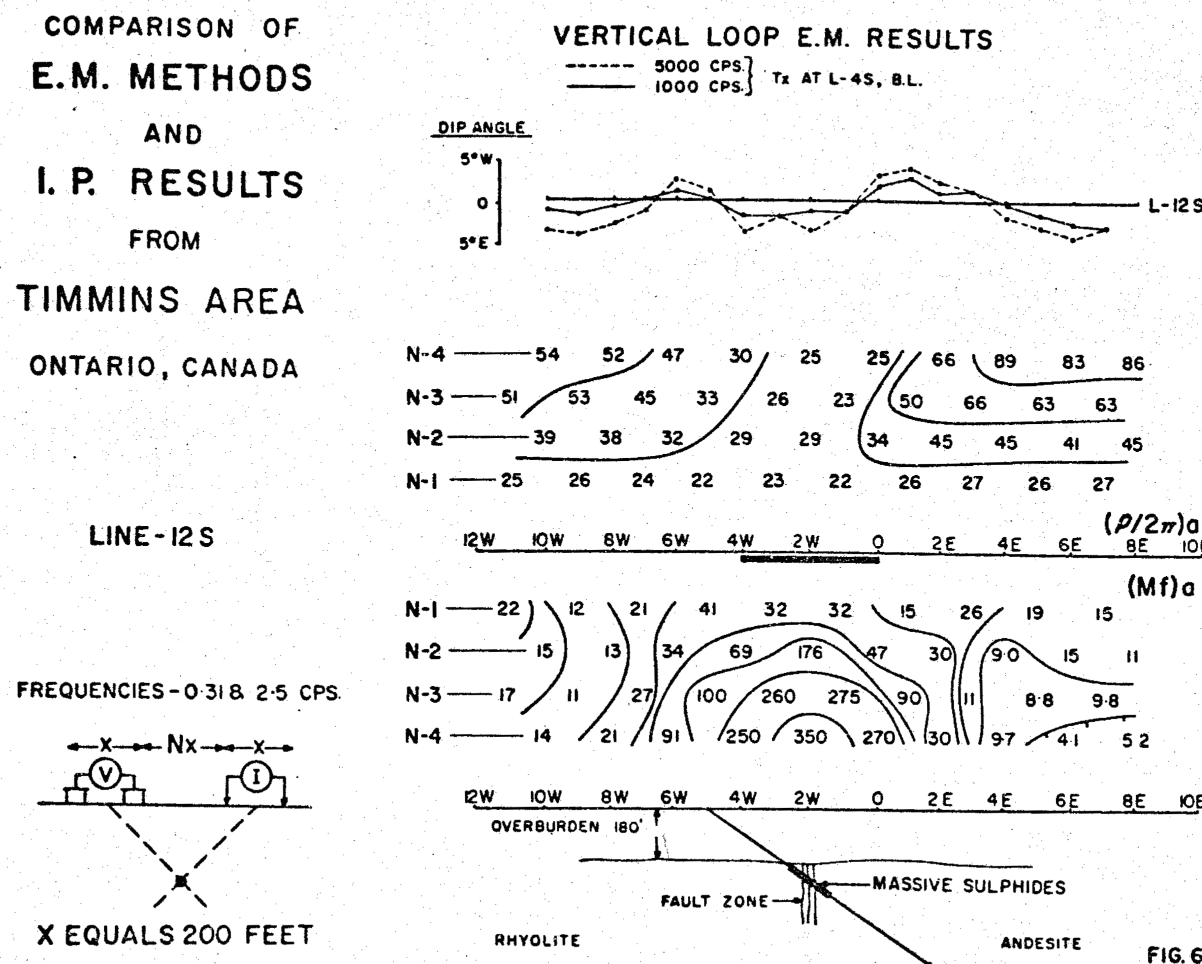


FIG. 6

overburden over the sulphide zone. The IP data was measured with an electrode interval of 200 feet, so that the depth to the top of the source is about one unit. To the east and west, the resistivity results show the presence of the porous, conductive overburden; the apparent resistivities increase, for the larger values of (n). At the conductor, the apparent resistivities do not increase with depth.

The IP anomaly is large in magnitude and very definite. The depth to the top of the source is indicated by the fact that the maximum IP effects were measured for n = 4. The angle drill hole shown on the geologic section was spotted to test the source of the definite IP anomaly.

The hole intersected a zone of massive sulphide mineralization within a fault zone. The increase in the basement resistivity (n = 4) east of the IP anomaly is explained by the change in rock type.

The IP anomaly had a length of almost 2000 feet; after the first hole was drilled an attempt was made to better evaluate the source using EM. The Vertical Loop EM method was employed, using 1000 cps and 5000 cps. Separations of 800 feet and 1200 feet between the transmitter and receiver were used; there were no interpretable EM anomalies.

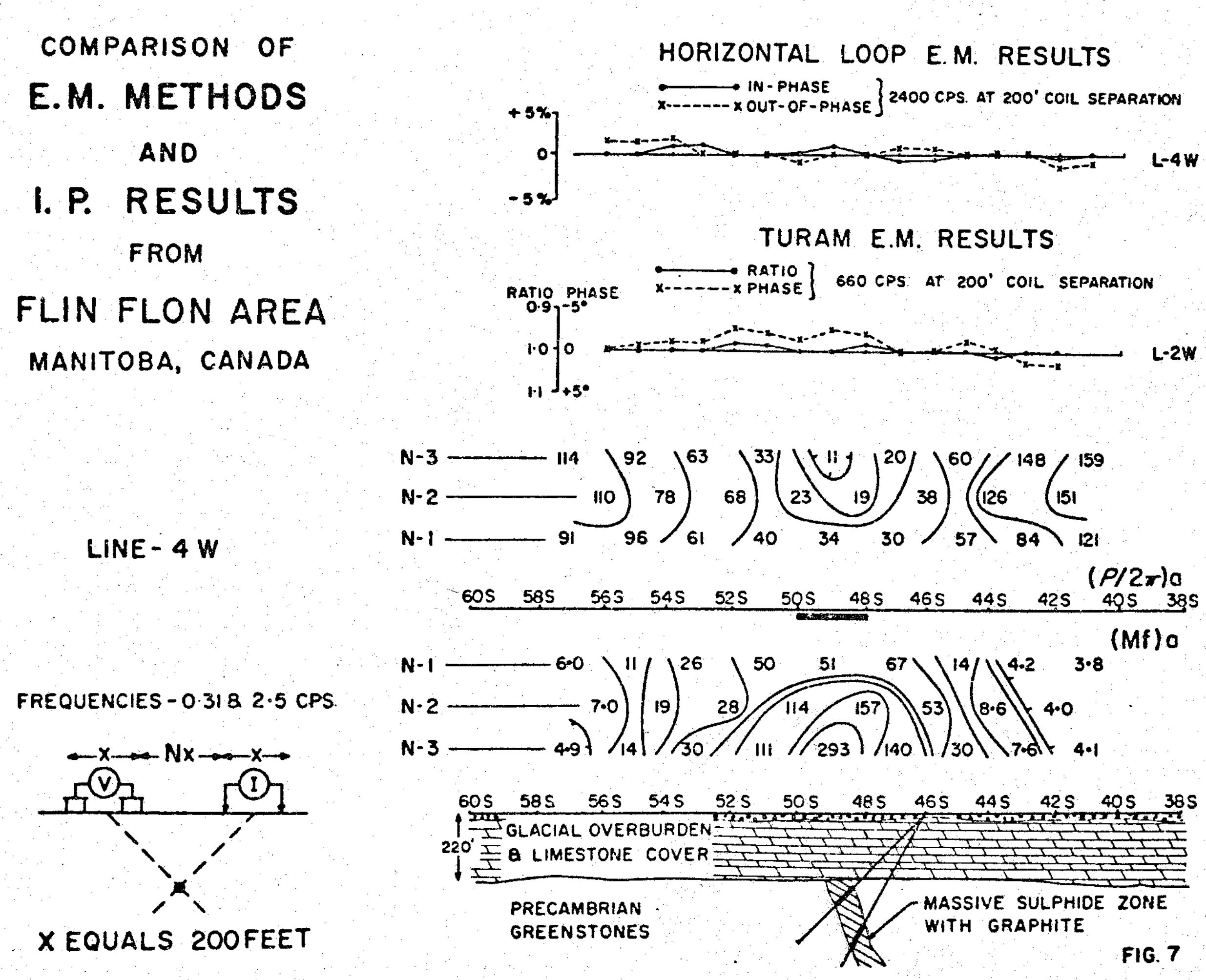


FIG. 7

In the example of the IP anomaly shown in Figure 7, the depth indicated to the top of the source is due to 220 feet of overlying overburden and Paleozoic limestone. The resistivity results show that there is no difference between the resistivity of the limestone and that of the basement greenstones.

As in the previous example, the IP anomaly is large in magnitude and definite. The drill holes intersected massive mineralization, with graphite; the zone is probably controlled by shearing. It is approximately 800 feet long.

The Turam EM and Horizontal Loop EM results shown on Figure 7 were measured as part of previous reconnaissance surveys. The variations shown must be considered to be normal background; there is no EM anomaly that can be interpreted.

GEOLOGIC ENVIRONMENTS THAT CAUSE EXTRANEOUS EM ANOMALIES

The post-war successes and widespread use of the EM methods were in Canada and, to a lesser extent, in Sweden. In these temperate to arctic areas, there is little or no surface weathering. Zones of massive sulphide mineralization may be covered by glacial overburden, but they will extend to bedrock surface.

The rock types encountered in these areas, with a few exceptions, are poor conductors of electricity. EM anomalies can be expected from massive mineralization, but there are almost no other geologic features that can be expected to be good conductors. This situation is a definite advantage to the geophysicist interpreting EM data.

With the successes of the method in Canada, its use was expanded into other areas. It was soon discovered that in other geologic environments and with other types of weathering, there were frequently other types of conductors that confused the EM results.

These extraneous anomalies are due to ionic conductors. Zones of porosity within the rocks are filled with ion-charged solutions. These zones of porosity may be due to oxidation and weathering, hydrothermal alteration, shearing and fracturing, etc. The high salinity solutions are created by the deep-weathering chemical reactions. Our experience has shown that these conditions occur in all arid and tropical areas.

There is one type of ionic conductor that is common even in temperate climates. Alteration and shearing in basic and ultrabasic rocks frequently creates talc and serpentine minerals. The platey structure of these minerals gives rise to many unbonded charges; very conductive layers of adsorbed ions form in the shears. These zones become excellent conductors that create EM anomalies.

The IP and EM results shown in Figure 8 are from a typical area of ultra-basic rocks in northern Manitoba. The 1000 cps Vertical Loop EM results show two conductors, depending upon the position of the transmitter. The two EM conductors correlate approximately with the edges of a broad, low resistivity zone within the ultra-basic rocks.

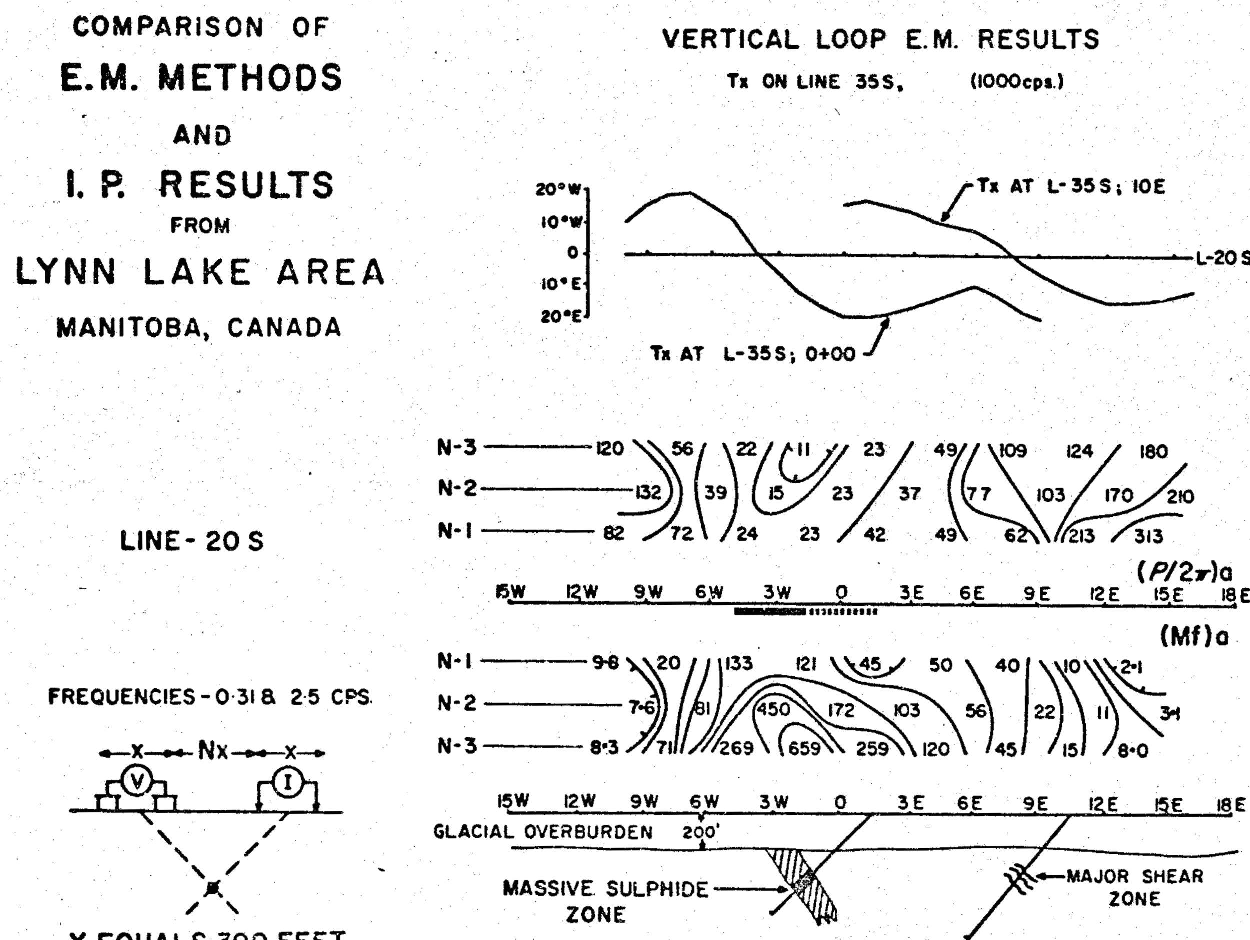


FIG. 8

Both of the EM conductors were tested by drilling before the IP survey was done. The western conductor is associated with a massive sulphide zone, at depth. The eastern conductor is due to a broad zone of intense shearing in the ultra-basic rocks.

The IP results show a strong, definite IP anomaly centered at 3+00W. The depth of overburden is indicated by the fact that the maximum apparent IP effects are measured for n = 3. There are no anomalous IP effects correlating with the EM conductor at 8+00E. As is most other ultra-basic areas, the background IP effects are high due to the presence of metallic magnetite.

The geologic evidence suggests that the zone of low resistivity is due to a broad zone of weak shearing. The major fault is located at the eastern edge; the replacement sulphide zone is at the western edge of the zone of porosity.

The EM responses from the two geologic features are exactly similar; they both appeared to be important enough to warrant drill holes. The IP measurements clearly indicate the location, and importance, of the zone of massive sulphide mineralization.

Many ionic conductors are located in carrying out EM surveys in arid and semi-arid areas such as Australia. Each shear zone and fault gives a response.

The IP results shown in Figure 9 were detailled to evaluate a definite anomaly located during a reconnaissance survey in South Australia. A very strong anomaly is indicated; it is centered, at depth, at 2W to 1W. Later drilling confirmed the presence of an extensive zone of massive mineralization. The zone is several thousand feet long. The depth to the top of the source of the IP anomaly is caused by the complete weathering (oxidation) of the mineralization to a depth of approximately 100 feet.

It should be noted, that the lowest resistivity zone in the area is indicated to be at 1+00E, at least 250 feet east of the center of the IP anomaly. A major fault zone, that can be observed to the north, is extrapolated to pass through this location. Our experience elsewhere in this type of environment indicates that most fault zones are saturated with saline solutions; they usually give re-

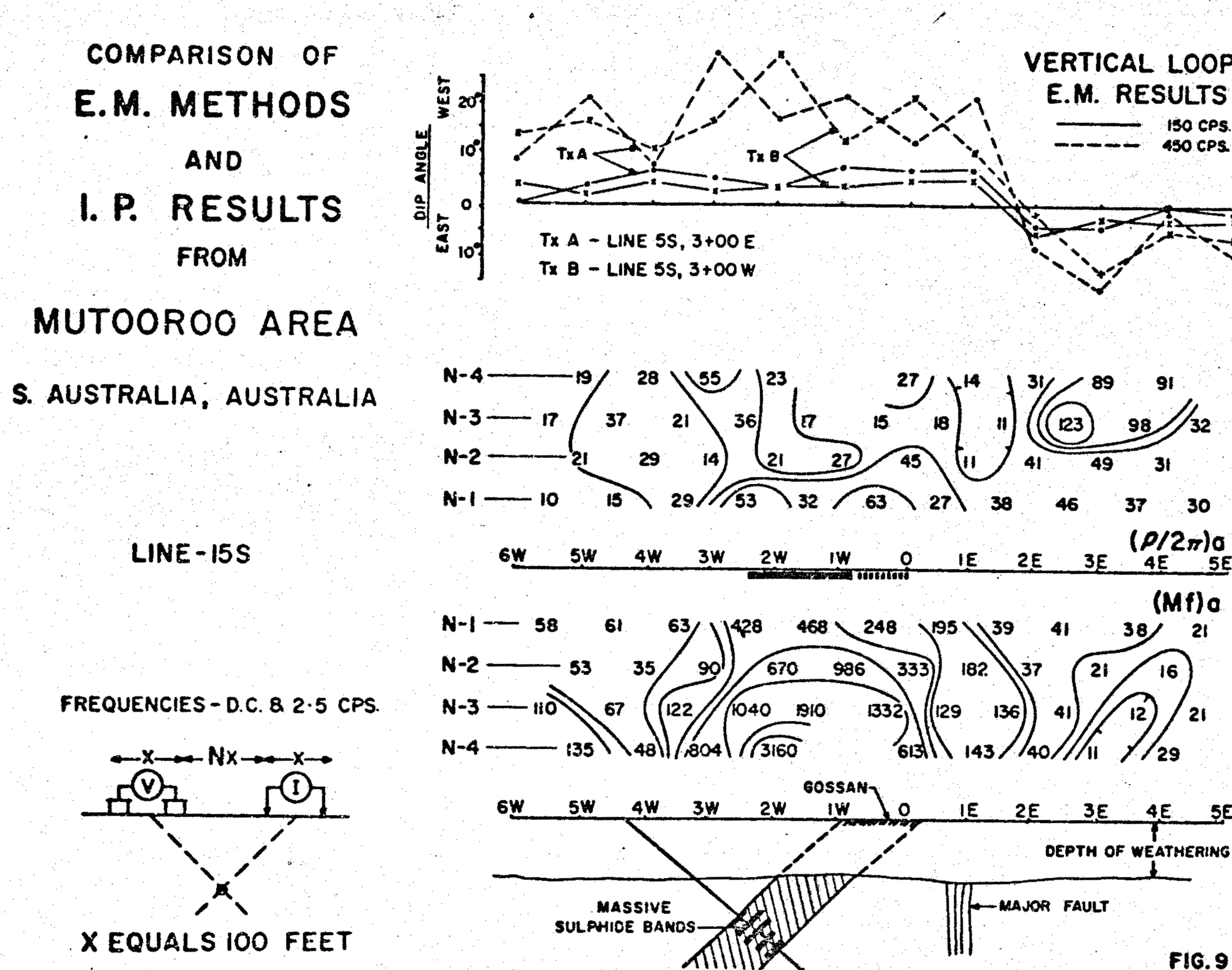


FIG. 9

sistivity lows and cause EM anomalies.

This is confirmed by the 150 cps and 450 cps EM results shown in the upper portion of Figure 9. The data shown was measured, as a test, after the drilling was completed. With the transmitter in two positions, the low frequency EM results show a conductor at 1+50E.

There are several sharp variations in the EM results to the west of the fault. These variations are probably due to changes in the salinity, or porosity, of the weathered layer. Some of them may be due to the massive mineralization at depth, but they cannot be distinguished. The EM response from the fault saturated with saline solutions is greater than that from the massive sulphide zone.

The same geologic situation encountered in semi-arid Australia usually occurs in areas of tropic weathering such as Cuba. The deep weathering conditions create zones of porosity and ion-charged ground water. The interpretation of EM results from tropic areas is usually confused by anomalies from ionic conductors.

The IP and EM results shown in Figure 10 are from a test survey carried out over a known zone of massive pyrite in Pinar del Rio Province, Cuba.

The weathering is very deep in this area. The rock types are quartzites and slates; this difference in rock type results

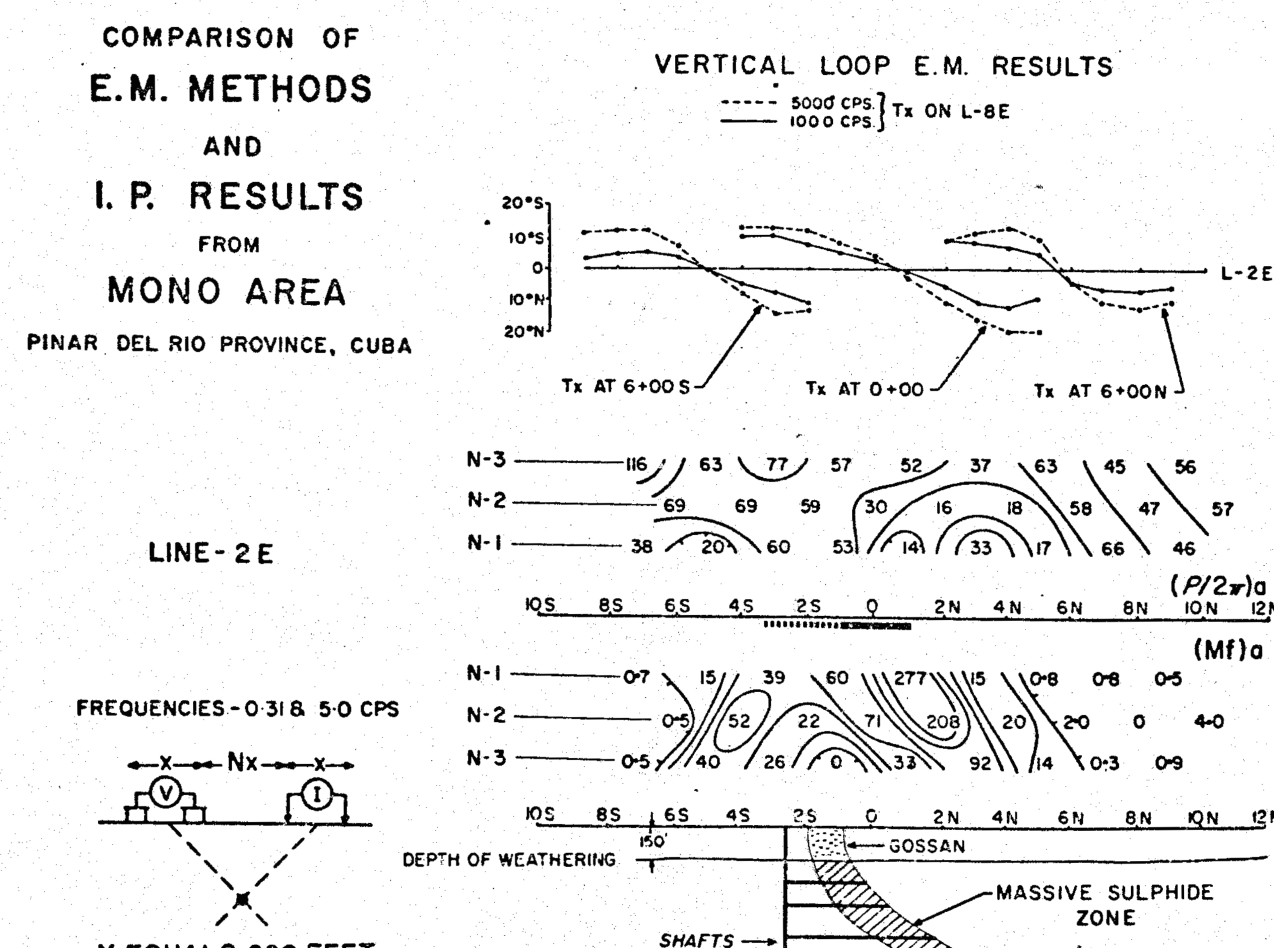


FIG. 10

in an extremely uneven depth of weathering. The apparent resistivity results show that the surface (n = 1) values are low and variable.

The Vertical Loop EM results (1000 cps and 5000 cps) show a conductor at each slate band. The deep weathering creates porous zones that are saturated during the rainy season. These ionic conductors give EM anomalies that are just as definite as that from the sulphide zone at depth.

The IP results show a strong anomaly that correlates with the pyrite zone. The ionic conductors give resistivity lows, but no IP effects. The IP data is much more discriminating than the EM results.

CONCLUSIONS

The electromagnetic method has been very successful in the exploration for massive sulphide deposits. Most zones of massive sulphide mineralization are good conductors of electricity; they give EM anomalies with any technique used.

However, experience in the last few years has shown that there are some zones of massive sulphide mineralization that do not give rise to EM anomalies. Even when these zones are known, when the sources are shallow, they do not give recognizable EM anomalies. This type of massive mineralization can be detected using induced polarization measurements.

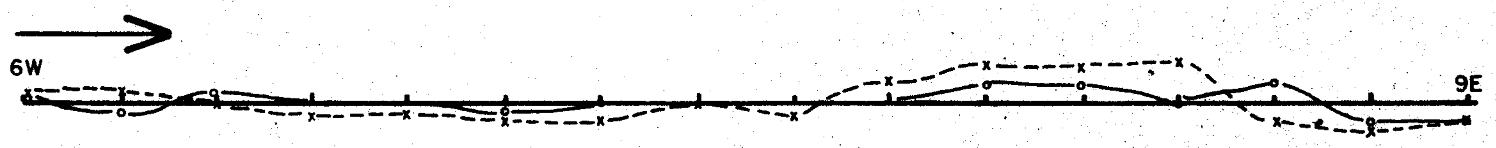
As with all geophysical methods, EM techniques have a limited depth of detection. The anomalies have lower magnitude as the source is deeper; at some depth the anomalous effects are too weak to be distinguished from the background effects. We have numerous examples of field results that show the appreciably greater depth of detection of the induced polarization method. Zones of massive sulphide mineralization have been located using IP that were too deep to give EM anomalies.

In some geologic environments, the presence of ionic conductors that give EM anomalies will badly confuse EM results. Typical examples of ionic conductors are shears in ultra-basic rocks and in areas of deep weathering (tropic and arid.) In these areas, there will be EM anomalies from massive sulphide zones, if the depth of oxidation is not too great; the interpretational difficulties arise in the separation of the two types of anomalies.

The IP effects used in field exploration are due to electrochemical phenomena at ionic conduction - electron conduction interfaces. There are no IP effects unless metallic minerals are present. IP surveys in tropic and arid areas are not confused by the presence of ionic conductors; anomalies are obtained only from metallic conductors.

In many areas, the search for massive sulphide mineralization can be effectively carried out using EM methods; the cost will be somewhat less than if IP is used. However, the geophysicist should always keep in mind that there are situations in which IP is much more effective than EM in exploration for massive mineralization.

L-72N



3891 M-4

DWG. NO. EM-5484-1

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 72N

LEGEND

Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

IN LINE METHOD

Rx ← 200' → Tx →

Scale: 1" = 200'

Profile Scale: 1" = 10°

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY

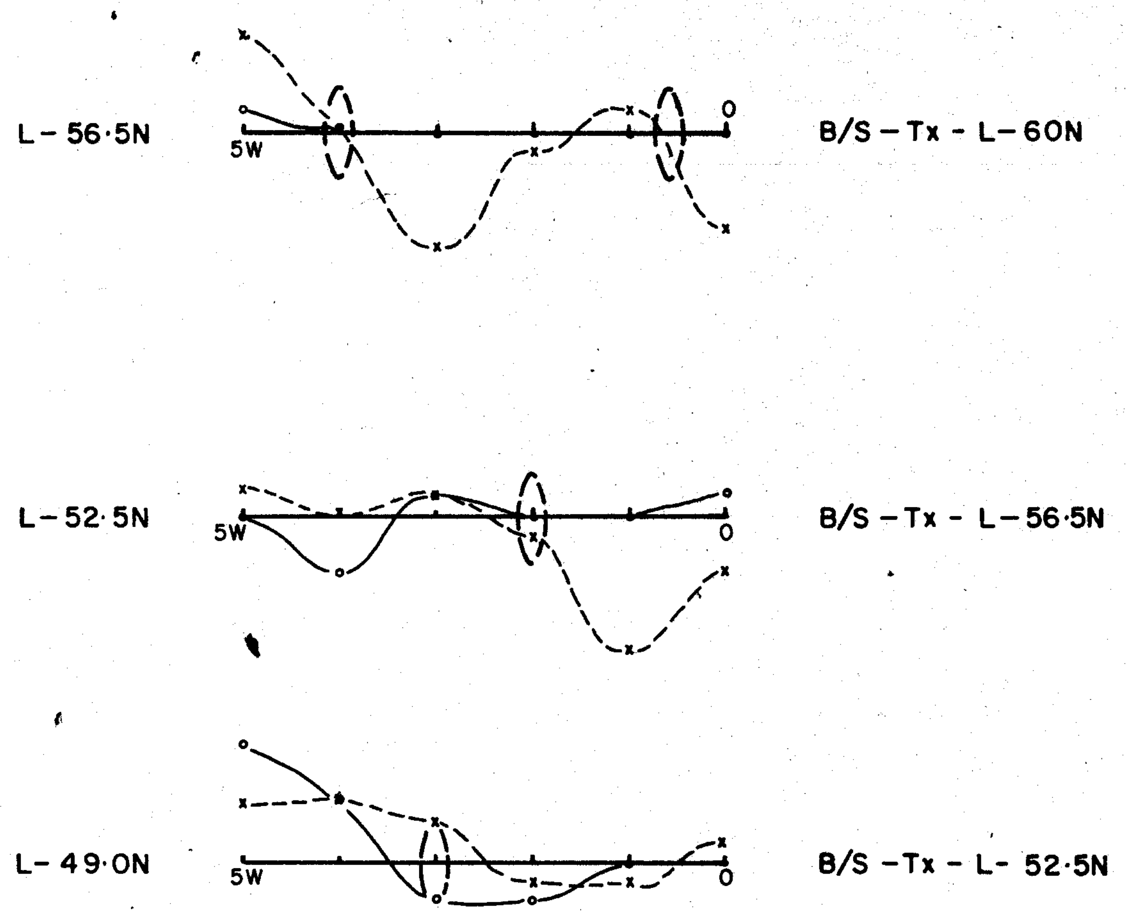
DWG. NO. EM-5484-2

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

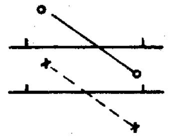
LINE NO. 56·5N, 52·5N, 49·0N



LEGEND

Anomaly	Trend	
(solid)	(solid line)	DEFINITE
(open)	(hatched line)	PROBABLE
(dashed)	(dashed line)	POSSIBLE

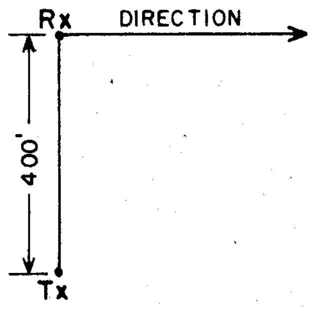
NOTE:



RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

BROADSIDE METHOD



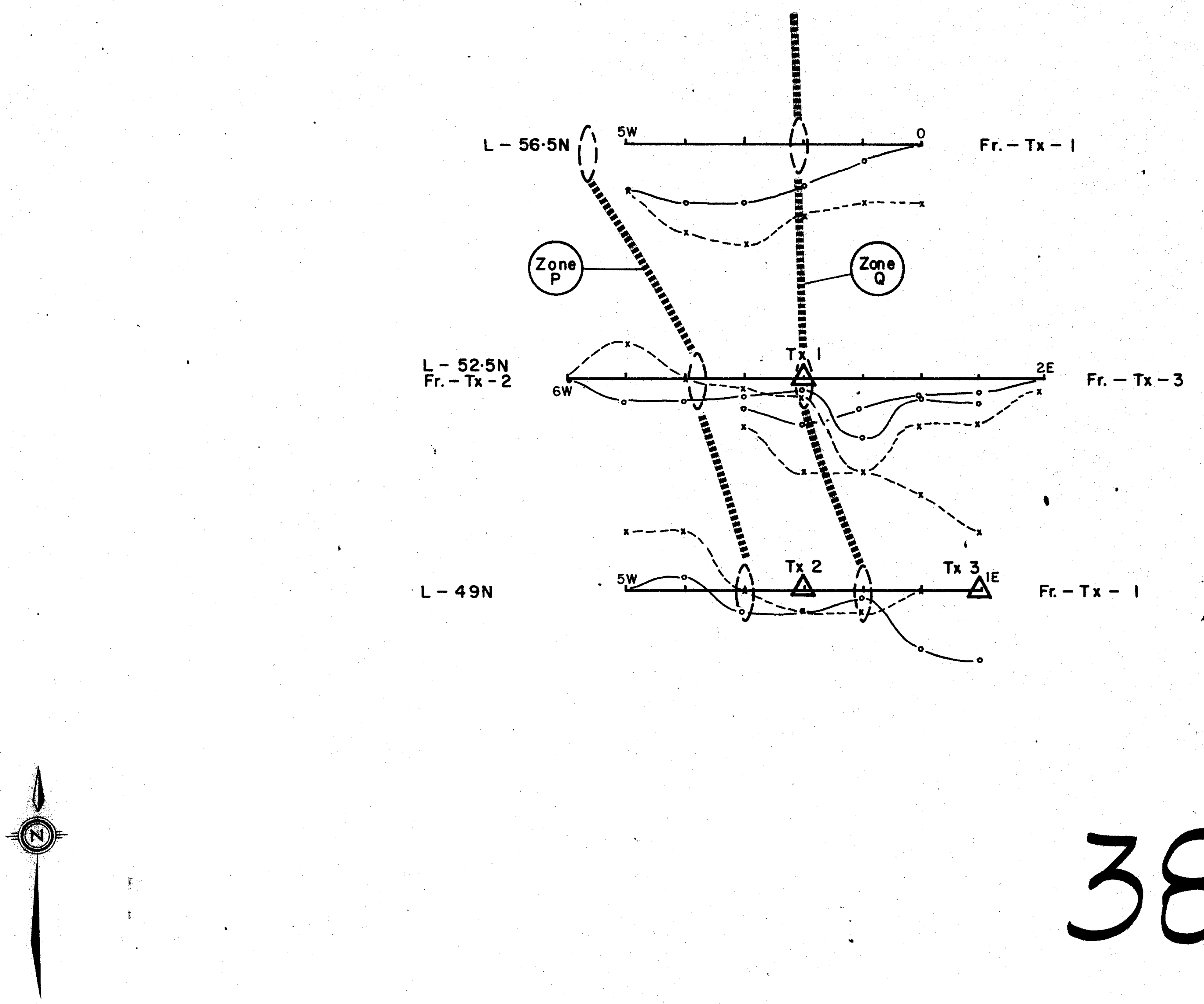
Scale: 1" = 200'

Profile Scale: 1" = 10°

3891 M-5

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY



3891 M-6

DWG. NO. EM-5484-3

CANADIAN JOHNS - MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 56·5N, 52·5N, 49N

LEGEND

Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

TRANSMITTER LOCATION

NOTE: CORRESPONDING TRANSMITTER IS INDICATED AT THE END OF EACH SERIES OF PROFILES.

Scale: 1" = 200'

Profile Scale: 1" = 10°

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY

3891
M-7

DWG. NO. EM-5484-4

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA
KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 55·5N, 52·5N, 49N, 45N, 41·5N, 37·5N, 34N, 30N, 26·5N, 22·5N, 19·5N, 15N

LEGEND

Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

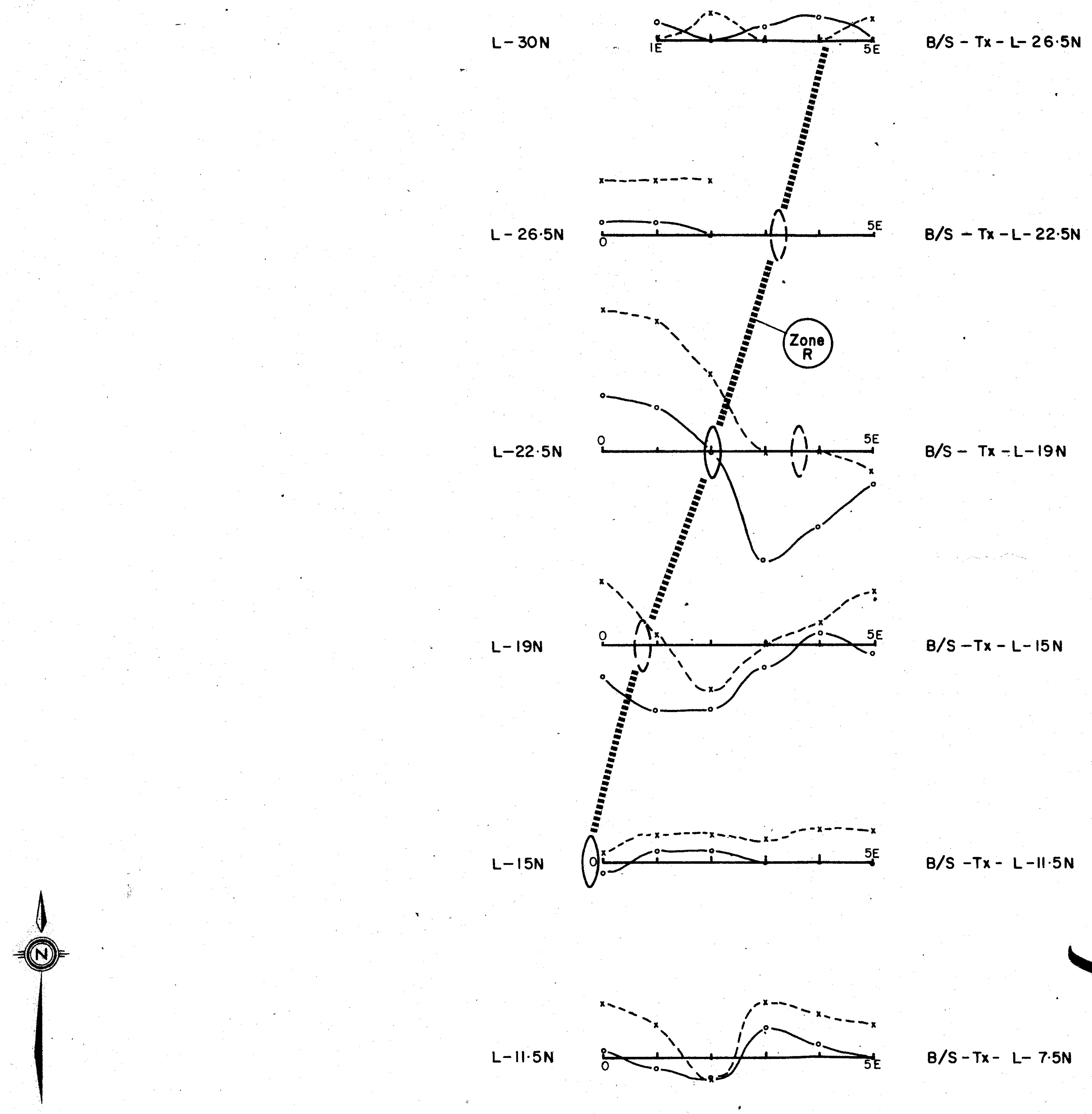
RECIEVER TRAVERSE AND PROFILES 1000Hz
RECIEVER TRAVERSE AND PROFILES 5000Hz
TRANSMITTER LOCATION

NOTE: CORRESPONDING TRANSMITTER IS INDICATED AT THE END OF EACH SERIES OF PROFILES.

Scale: 1" = 200'
Profile Scale: 1" = 10°

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY



3891 M-8

DWG. NO. EM-5484-5

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 30N, 26·5N, 22·5N, 19N, 15N, 11·5N

LEGEND

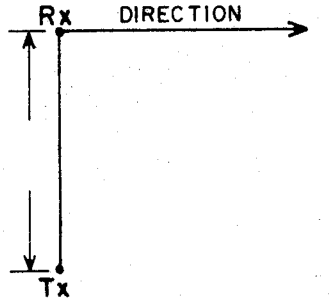
Anomaly	Trend	
(solid)	(solid)	DEFINITE
(outline)	(dotted)	PROBABLE
(dashed)	(hatched)	POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

BROADSIDE METHOD

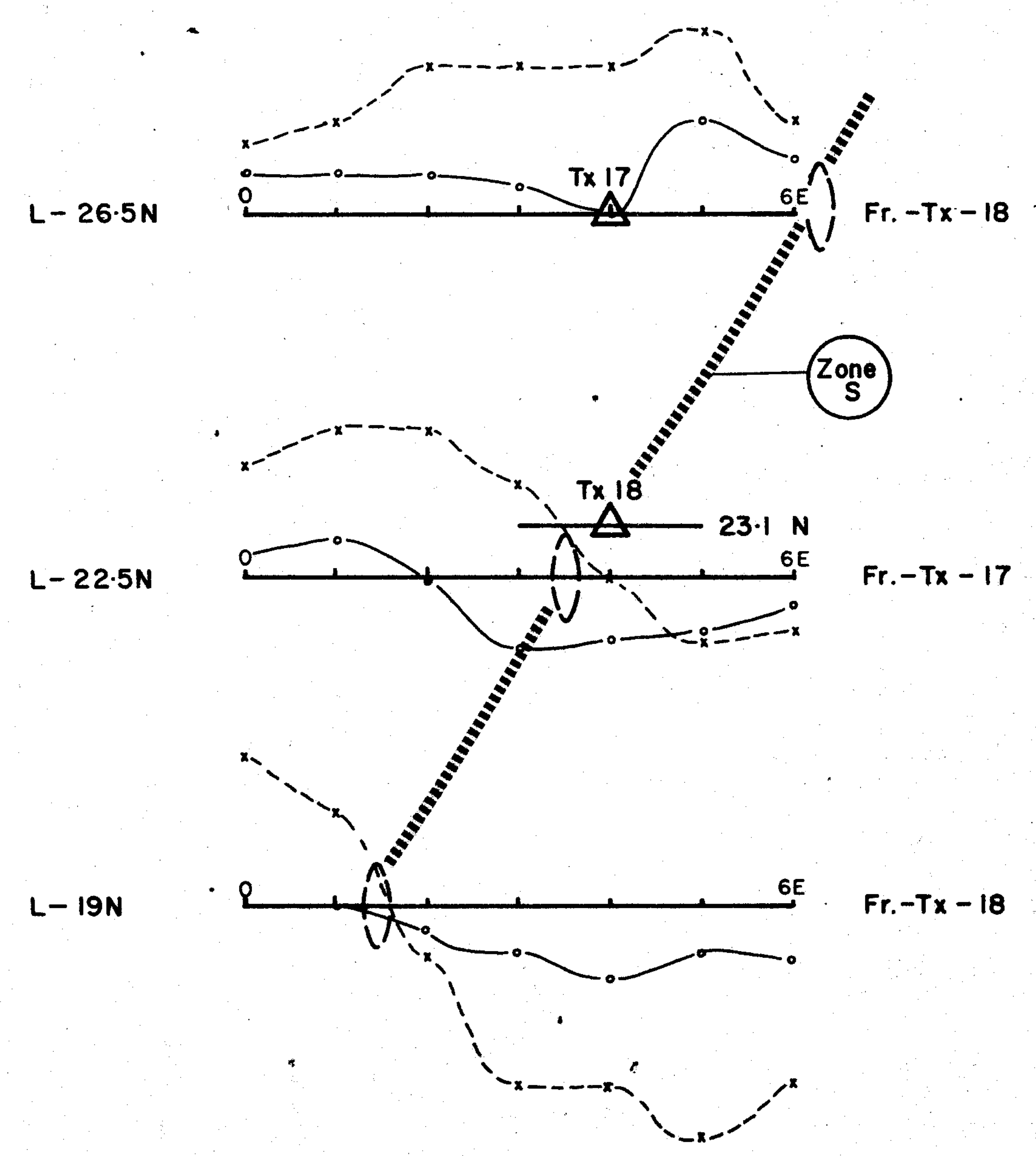


Scale: 1" = 200'

Profile Scale: 1" = 10°

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY



3891 M-9

DWG. NO. EM-5484-6

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 26·5N,22·5N,19N

LEGEND

Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

TRANSMITTER LOCATION

NOTE: CORRESPONDING TRANSMITTER IS INDICATED AT THE END OF EACH SERIES OF PROFILES.

Scale: 1" = 200'

Profile Scale: 1" = 10°

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY

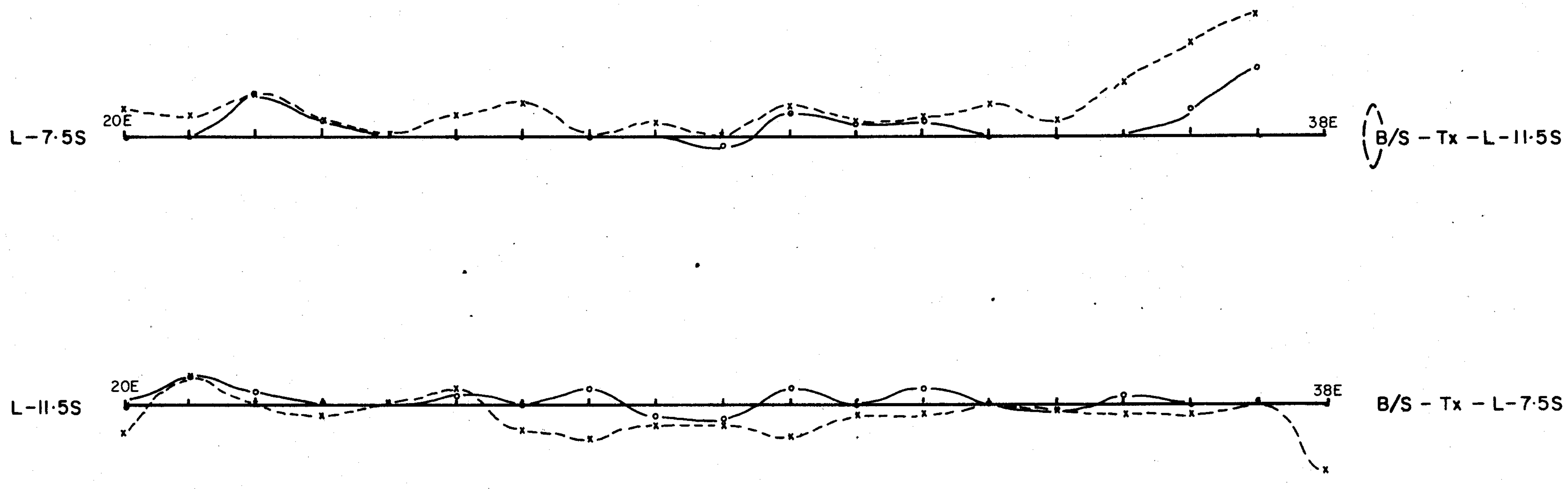
DWG. NO. EM-5484-7

CANADIAN JOHNS - MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 7·5S, 11·5S



LEGEND

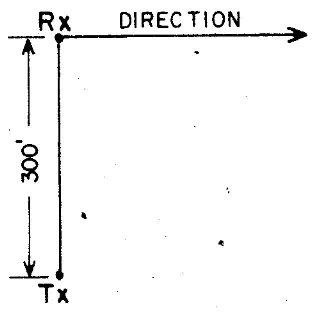
Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

BROADSIDE METHOD



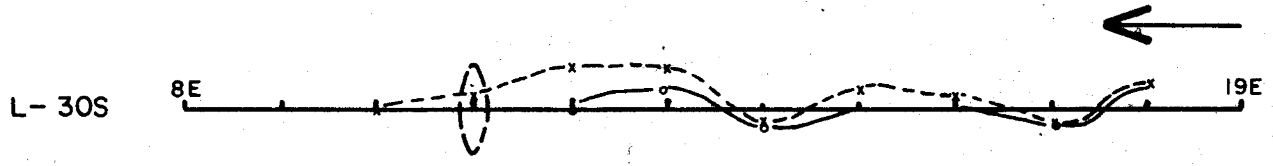
Scale: 1" = 200'

Profile Scale: 1" = 10°

3891 M-10

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY



DWG. NO. EM-5484-8

CANADIAN JOHNS - MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 30S

LEGEND

Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

IN LINE METHOD

Tx ←200'→ Rx

Scale: 1" = 200'

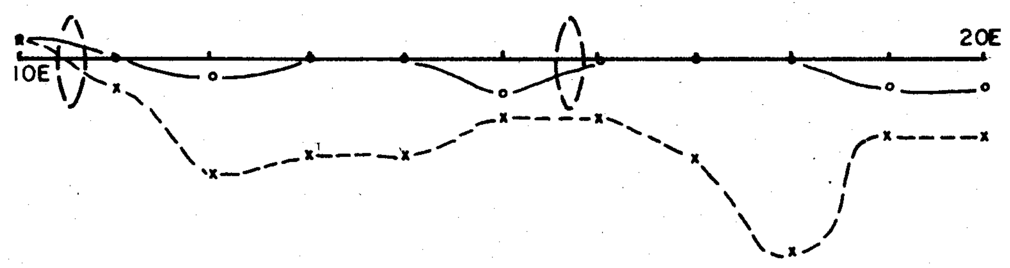
Profile Scale: 1" = 10°

3891 M-11

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY

L - 30S



B/S - Tx - 300'S

DWG. NO. EM-5484-9

CANADIAN JOHNS - MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

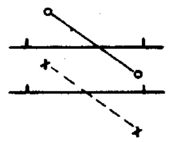
KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 30S

LEGEND

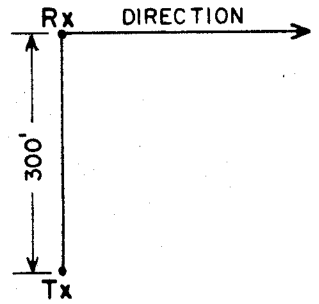
Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:



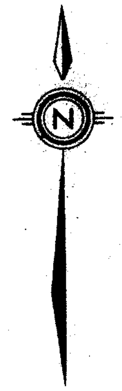
RECIEVER TRAVERSE AND PROFILES 1000Hz
RECIEVER TRAVERSE AND PROFILES 5000Hz

BROADSIDE METHOD



Scale: 1" = 200'

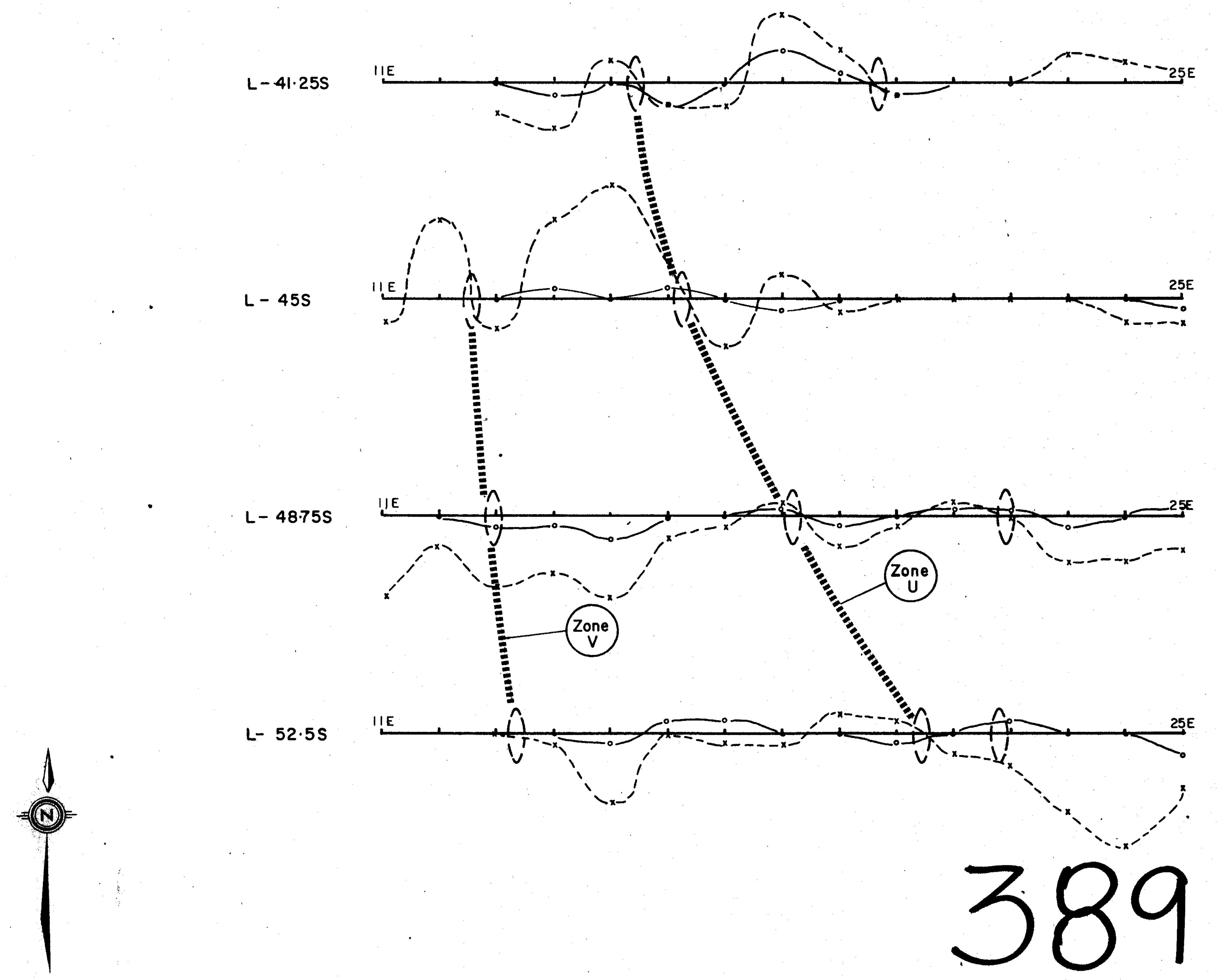
Profile Scale: 1" = 10°



3891 M-12

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY



3891 M-13

DWG. NO. EM-5484-10

CANADIAN JOHNS - MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 41·25S, 45S, 48·75S, 52·5S

LEGEND

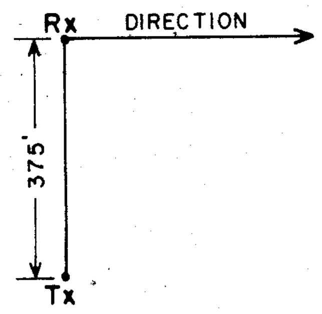
Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

BROADSIDE METHOD

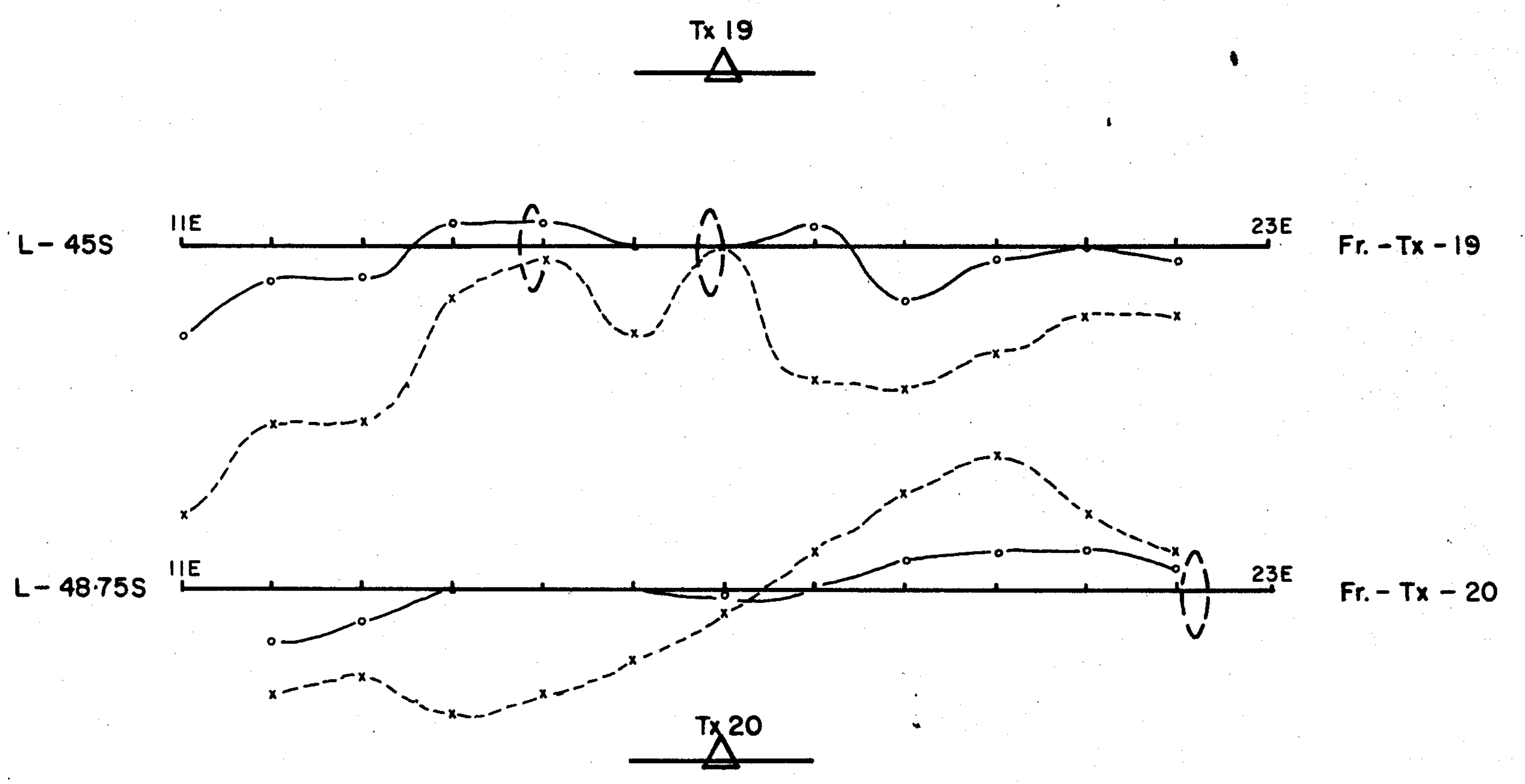


Scale: 1" = 200'

Profile Scale: 1" = 10°

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY



3891 M-14

DWG. NO. EM-5484-11

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 45S, 48·75S

LEGEND

Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

TRANSMITTER LOCATION

NOTE: CORRESPONDING TRANSMITTER IS INDICATED AT THE END OF EACH SERIES OF PROFILES.

Scale: 1" = 200'

Profile Scale: 1" = 10°

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY

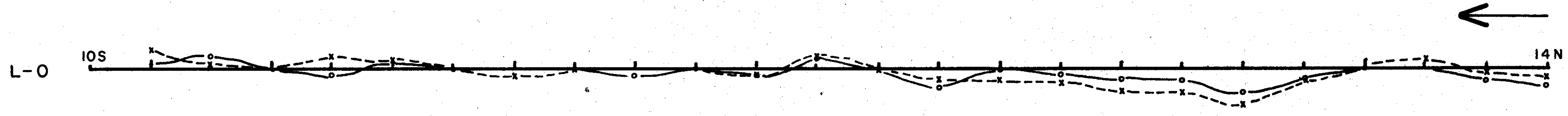
DWG. NO. EM-5484-12

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 0 (R & L RANCH ANOMALY)



LEGEND

Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

IN LINE METHOD

Tx ← 200' → Rx

Scale: 1" = 200'

Profile Scale: 1" = 10°

3891 M-15

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY

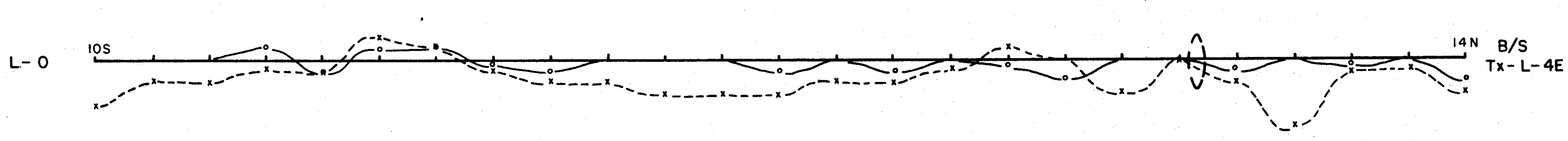
DWG. NO. EM-5484-13

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

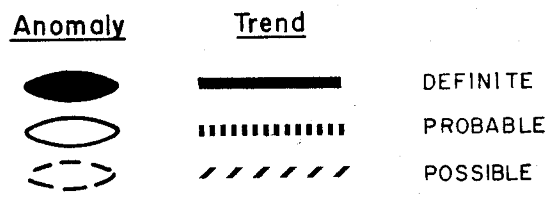
PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. L-O (R & L RANCH ANOMALY)



LEGEND



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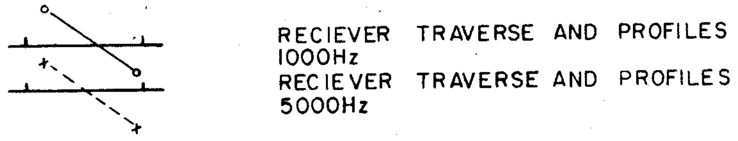
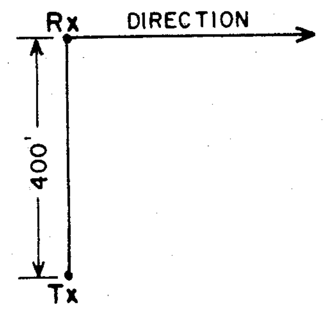


BROADSIDE METHOD



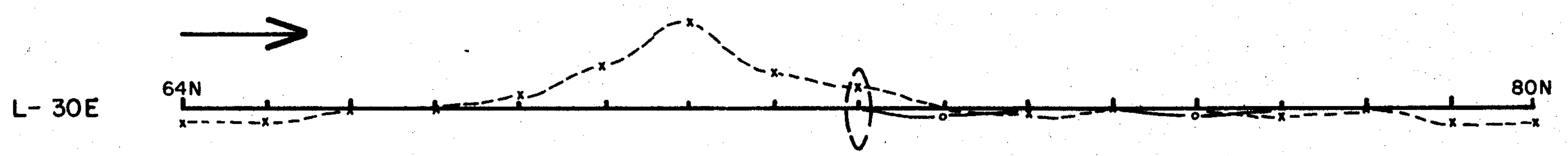
Scale: 1" = 200'

Profile Scale: 1" = 10°

3891 M-16

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY



3891 M-17

DWG. NO. EM-5484-14

CANADIAN JOHNS - MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 30E

LEGEND

Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

IN LINE METHOD

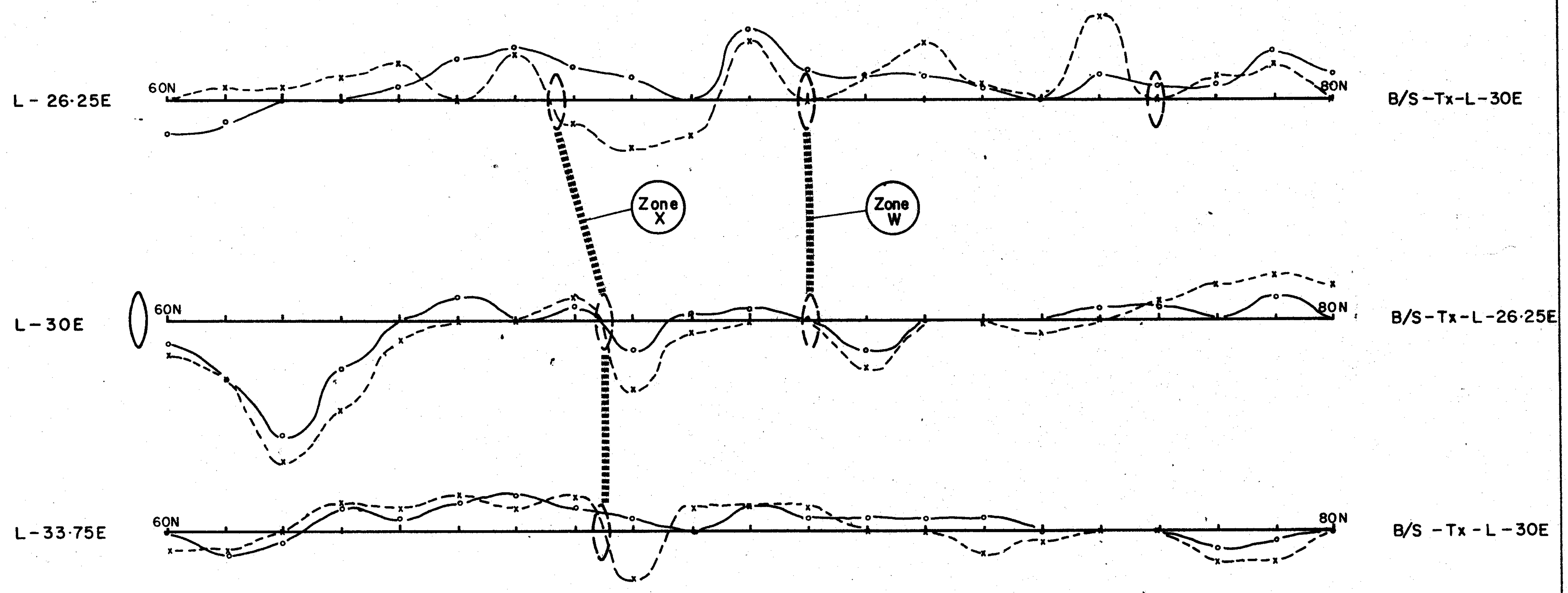
Rx ← 200' → Tx

Scale: 1" = 200'

Profile Scale: 1" = 10°

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY



3891 M-18

DWG. NO. EM-5484-15

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 26·25E, 30E, 33·75E

LEGEND

Anomaly	Trend	
(solid)	(solid)	DEFINITE
(open)	(dotted)	PROBABLE
(dashed)	(hatched)	POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

BROADSIDE METHOD

Rx DIRECTION

375'

Tx

Scale: 1" = 200'

Profile Scale: 1" = 10°

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY

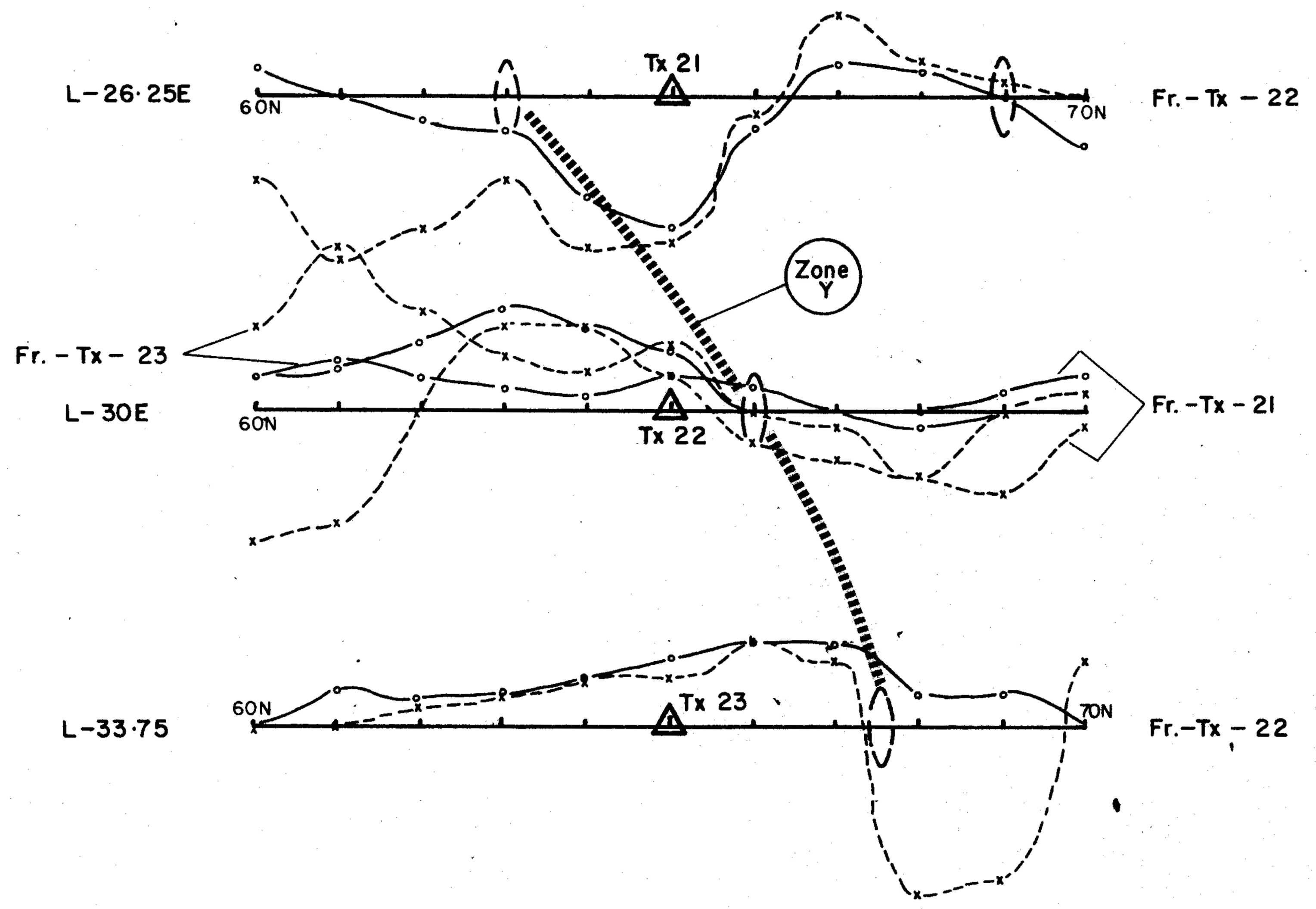
DWG. NO. EM-5484-16

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 26·25E, 30E, 33·75E



LEGEND

Anomaly	Trend	
(solid)	(solid)	DEFINITE
(open)	(dotted)	PROBABLE
(dashed)	(dashed)	POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

TRANSMITTER LOCATION

NOTE: CORRESPONDING TRANSMITTER IS INDICATED AT THE END OF EACH SERIES OF PROFILES.

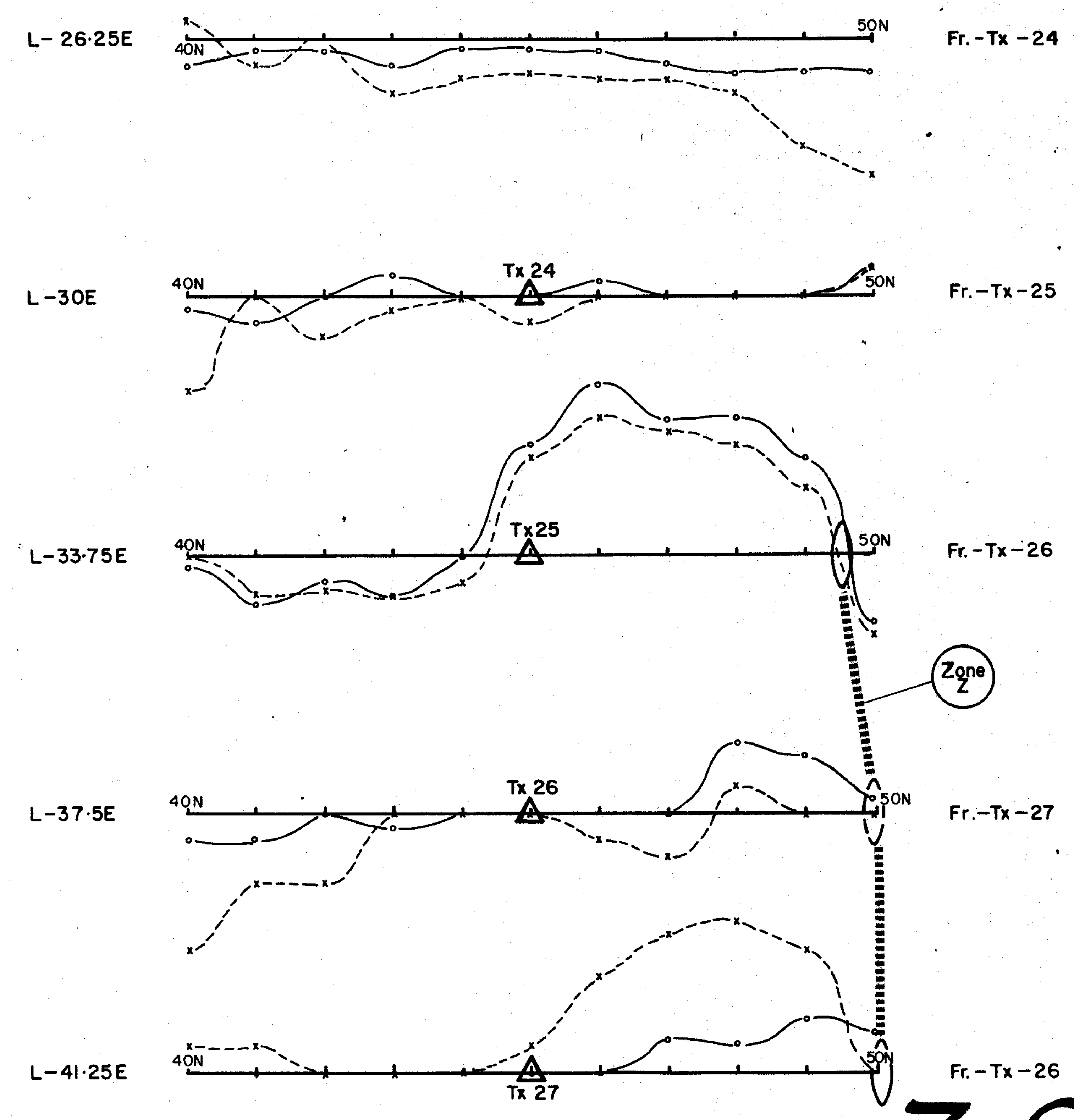
Scale: 1" = 200'

Profile Scale: 1" = 10°

3891 M-19

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY



DWG. NO. EM-5484-17

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 26·25E, 30E, 33·75E
37·5E, 41·25E

LEGEND

Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

TRANSMITTER LOCATION

NOTE: CORRESPONDING TRANSMITTER IS INDICATED AT THE END OF EACH SERIES OF PROFILES.

Scale: 1" = 200'

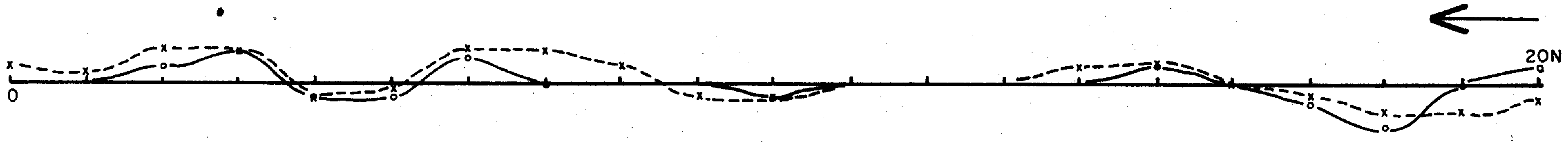
Profile Scale: 1" = 10°

3891M-20

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY

L-60E



3891 M-21

DWG. NO. EM-5484-18

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 60E

LEGEND

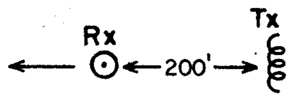
Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

IN LINE METHOD



Scale: 1" = 200'

Profile Scale: 1" = 10°

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY

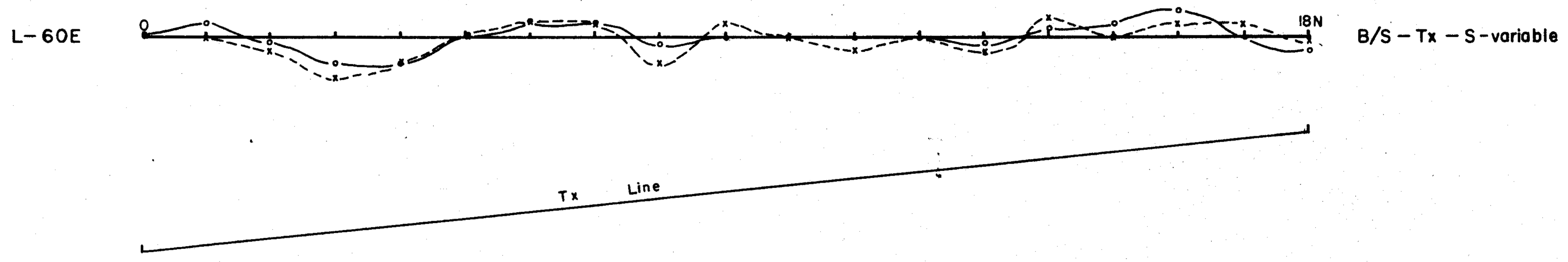
DWG. NO. EM-5484-19

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

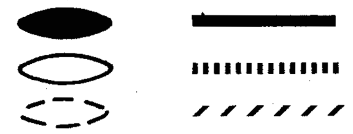
KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 60E



LEGEND

Anomaly | Trend



DEFINITE

PROBABLE

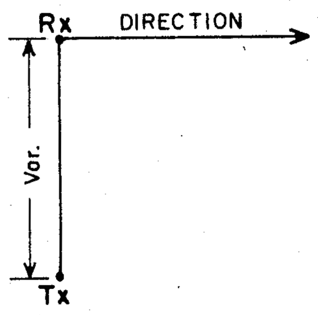
POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

BROADSIDE METHOD



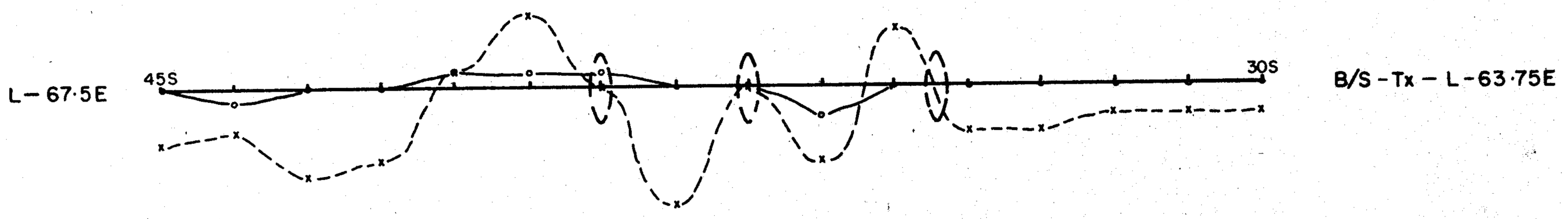
Scale: 1" = 200'

Profile Scale: 1" = 10°

3891 M-22

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY



3891 M-23

DWG. NO. EM-5484-20

CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

LINE NO. 67·5E

LEGEND

Anomaly	Trend	
		DEFINITE
		PROBABLE
		POSSIBLE

NOTE:

RECIEVER TRAVERSE AND PROFILES 1000Hz

RECIEVER TRAVERSE AND PROFILES 5000Hz

BROADSIDE METHOD

Rx DIRECTION

375'

Tx

Scale: 1" = 200'

Profile Scale: 1" = 10°

McPHAR GEOPHYSICS

ELECTROMAGNETIC SURVEY

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McPHAR GEOPHYSICS
ELECTROMAGNETIC SURVEY
PLAN MAP
Department of
Mines and Petroleum Resources
ASSESSMENT REPORT
NO. 3891 MAP #1
B/L-0
L-67.5N
L-60N
L-52.5N
L-45N
L-37.5N
L-30N
L-22.5N
3891 M-1
LEGEND
Anomaly
Trend
DEFINITE
PROBABLE
POSSIBLE
NOTE:
RECIEVER TRAVERSE AND PROFILES 1000Hz
RECIEVER TRAVERSE AND PROFILES 5000Hz
COIL CONFIGURATION
Rx
Tx
200'
Direction
NOTE: Profile Scale: 1"=10°
CANADIAN JOHNS-MANVILLE COMPANY LIMITED
PINE CLAIMS, LAC LE JEUNE AREA
KAMLOOPS M.D., BRITISH COLUMBIA
SCALE
ONE INCH EQUALS TWO HUNDRED FEET
SHEET INDEX
LOCATION MAP
PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
H. K. CONN
Expiry Date: Jan. 28, 1973
DRAWN KJK
DATE JUNE 1971
APPROVED
DATE
DWG.-EM-4786-1

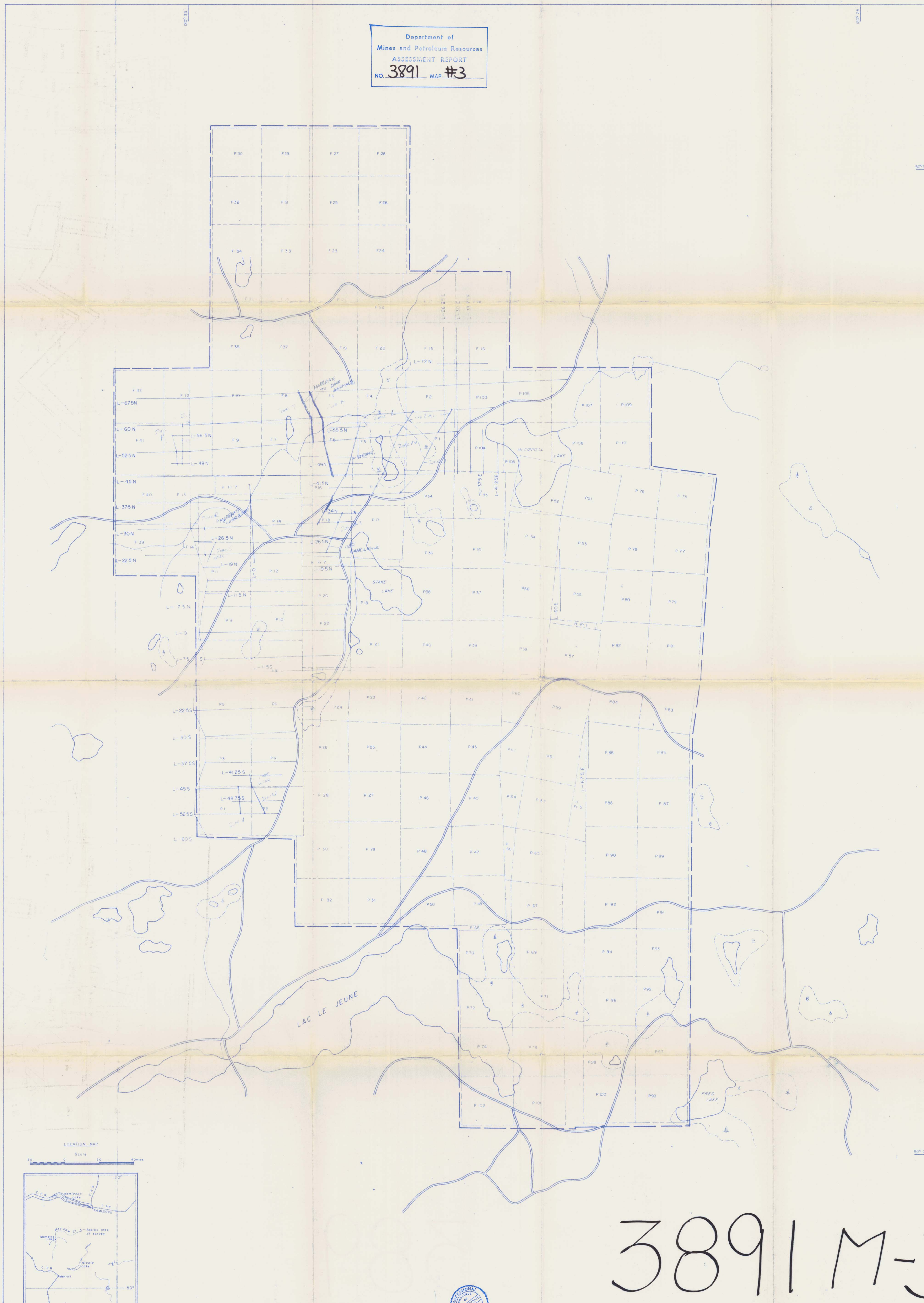
McPHAR GEOPHYSICS
ELECTROMAGNETIC SURVEY
PLAN MAP
Department of
Mines and Petroleum Resources
ASSESSMENT REPORT
NO. 3891 MAP #2
Zone R
Zone S
L-22.5N
B/L-0
15N
L-7.5N
L-0
Zone T
L-7.5S
L-15S
L-22.5S
L-30S
L-37.5S
L-45S
Zone V
Zone U
L-52.5S
L-60S
M-2
3891
LOCATION MAP
LEGEND
Anomaly
Trend
DEFINITE
PROBABLE
POSSIBLE
NOTE:
RECIEVER TRAVERSE AND PROFILES 1000Hz
RECIEVER TRAVERSE AND PROFILES 5000Hz
COIL CONFIGURATION
Rx
Tx
200'
Direction
NOTE: Profile Scale: 1" = 10°
CANADIAN JOHNS-MANVILLE COMPANY LIMITED
PINE CLAIMS, LAC LE JEUNE AREA
KAMLOOPS M.D., BRITISH COLUMBIA
SCALE
ONE INCH EQUALS TWO HUNDRED FEET
SHEET INDEX
DRAWN K.J.K.
DATE JUNE 1971
APPROVED
DATE
DWG.-EM-4786-2

DWG-MISC-3494

McPHAR GEOPHYSICS

GRID AND CLAIM LOCATION

PLAN MAP



CANADIAN JOHNS-MANVILLE COMPANY LIMITED

PINE CLAIMS, LAC LE JEUNE AREA

KAMLOOPS M.D., BRITISH COLUMBIA

SCALE

ONE INCH EQUALS ONE THOUSAND FEET

DRAWN F.J.H.
DATE JUNE 1971
APPROVED
DATE

DWG-MISC-3494