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A REPORT ON

ELECTRICAL INDUCED POLARIZATION AND
TURAM ELECTROMAGNETIC SURVEYS

AT DIAL RANGE, NEAR ULVERSTONE, TASMANIA

ON BEHALF OF

PENNZOIL OF AUSTRALIA LIMITED

OPEN FILE

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ON BEHALF OF
PENNZOIL OF AUSTRALIA LIMITED

BY

A. W. HOWLAND-ROSE
MSc, DIC, AMAusIMM, FGS?
GEOPHYSICIST

SYDNEY, N.S.W.

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**SCINTREX PTY. LTD.**

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GEOPHYSICAL CONSULTANTS AND CONTRACTORS

S U M M A R Y

The results of a Turam Electromagnetic and Electrical Induced Polarization survey carried out by Scintrex Pty. Ltd. on behalf of Pennzoil of Australia Limited over their Dial Range prospect near Ulverstone, Tasmania, has defined induced polarization anomalies which, due to their apparent correlation with copper soil geochemistry, are considered worthy of further investigation by diamond or percussion drilling.

The results of soil samples run for mercury, discussed in Appendix I, indicate that additional sampling is desirable prior to drilling.

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INTRODUCTION

At the request of Mr. M.C. Tippett, Manager of Exploration, for Pennzoil of Australia Limited, Scintrex Pty. Ltd. executed electrical induced polarization and Turam Electromagnetic surveys over the Dial Range grid near Ulverstone, northern Tasmania. The field operation was under the immediate direction of Scintrex staff geophysicist, Mr. D. Robson BSc., with field assistants and logistics provided by Pennzoil of Australia Limited.

The field work was executed on $5\frac{1}{2}$ production days between 20th and 26th September, 1974. Geological supervision was provided by Mr. T. Scott, District Geologist, of Pennzoil of Australia Limited, while Mr. A.W. Howland-Rose provided such additional technical supervision as was required.

Appendices 'IP' and 'T' briefly describe the induced polarization and Turam methods.

GEOLOGY

The geological mapping relies for the most part on rock float and therefore the geological boundaries are not precisely known.

Based on float mapping the area consists of a series of lenticular zones of volcanic rock types including very coarse breccias, mineralised in part, lithic tuffs, agglomerates, tuffs/lavas/mudstones and flow banded rhyolite, all considered to be of Cambrian age.

The general strike is approximately north west-south east, while the dip is thought to be to the east, although this has not been firmly established.

GEOCHEMISTRY

The grid area has been soil sampled and in general the more highly chargeable zones are those showing the highest copper values. A series of samples were collected for mercury vapour analysis by the Scintrex HGG-3 Mercury Spectrometer, but at the time of writing these results were not available to the author. (See Appendix I)

THE INDUCED POLARIZATION METHOD EMPLOYED

Some brief comments on the salient features of the two arrays employed is warranted.

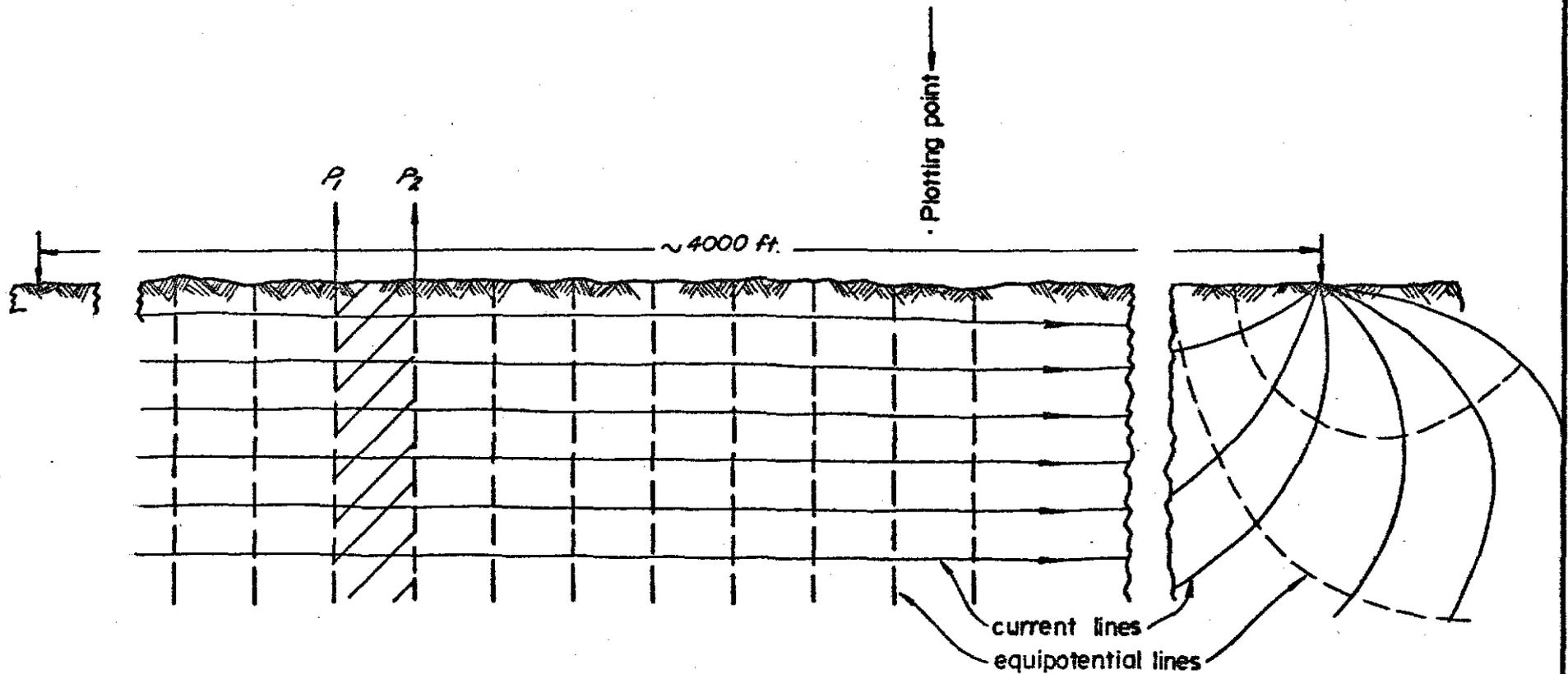
Gradient Array: In the case of the gradient array, positional information is excellent, but depth estimates rely on profile shape and then only give a "maximum depth". An additional inhibiting factor of course, is resolution of the potential dipole used. In this survey the potential dipole employed was 25 metres, thus it is not possible to resolve the depth better than "within 12 metres". Thus many of the 12 metre determinations may in fact either outcrop, or lie within a few metres of surface. The plotted position of the data represents a summation of the characteristics of the material immediately below that point between the potential dipoles.

Similarly the width of bodies is not easy to determine for narrow zones having a width less than half the dipole spacing used. These estimated maximum widths are educated guesses at best. However, the wider zones are resolved more accurately.

The attitude of a chargeable zone can only really be gauged with any precision in the centre of the gradient array and providing the body has strongly contrasting resistivity and chargeability characteristics to the enclosing rock units.

EQUIPOTENTIAL DIAGRAM

GRADIENT ARRAY



5 cm

SCALE, 1" = 200 ft.

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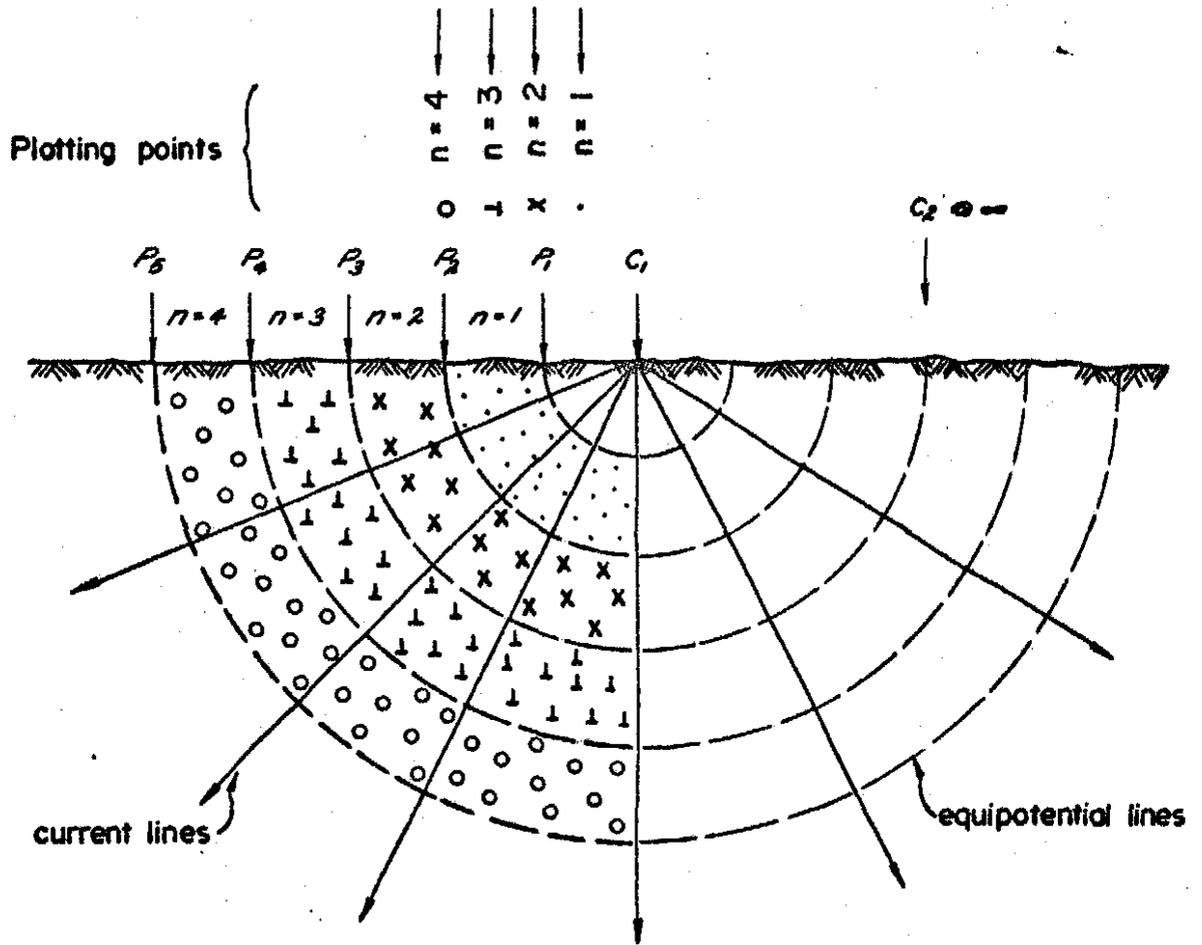
All field measurements were taken between slope distances along lines. This will, in steep areas, produce errors in the calculated apparent resistivity data, however, these errors will be arithmetic, and as significant changes in resistivity are logarithmic, this source of error is not significant. In assessing the position of the source in areas of extreme terrain, it does not lie vertically below the plotted position of the anomaly, but normal to the "local slope". All positions in the text refer to source positions normal to the local slope.

Each current dipole block should be considered separately. As would be expected, the continuity along strike is generally good, especially in the chargeability data. However, "end on" current dipole blocks cannot be expected to give identical data due to the different base levels of the current dipoles, and, in zones close to the current poles, the data will not sample identical volumes on the overlap between current dipoles. This phenomenon will result in more extreme divergence of data as the current dipole is approached. However, these factors are entirely predictable.

Moving Source Arrays: For the moving source arrays such as pole-dipole, depth information is excellent but width and attitude are difficult to define with any precision. For multiple sources within the resolution of the electrode

EQUIPOTENTIAL DIAGRAM

POLE-DIPOLE ARRAY



SCALE, 1"=200 ft.

5 cm

Page - five

geometry, positional information may be difficult to obtain in some instances. For this reason multiple effective spacings are employed.

The plotted position of the data does not represent the characteristics of the material immediately below the point of measurement, but of a complex volume between the potential electrode and its proximity to the current pole. An example is shown in the enclosed figure.

These arrays are materially influenced by near surface variations in oxidation and superficial cover, and of course, as their resolution and penetration are inter-related, an increase in one results in a decrease in the other.

As a rule, near surface responses using a gradient array are of lower magnitude than with moving source arrays (see 1800E-2000E on line 2200N), while sources at depth have lower amplitude or indeed cannot be resolved from background at all with moving source arrays, but are well defined with gradient array (see 1650E on line 2200N)

DISCUSSION

The data profiles for the gradient survey are presented on Plate 1 at the horizontal scale of 1:2500 with vertical scales for chargeability of 1 centimetre = 5 milliseconds and a 5 centimetre log cycle for resistivity expressed in ohm-metres.

Plate 2 displays the detailed induced polarization pole-dipole data at the same scales as for Plate 1, together with the Turam data at vertical scales of 1 centimetre = 10% field strength ratio and 1 centimetre = 5° phase shift.

The gradient array reconnaissance survey was executed employing current dipoles as listed below:

<u>Current Dipoles</u>	<u>Dipole</u>	<u>Lines</u>
987.5E and 2487.5E on line 1900N	1500 m	1700N, 1800N, 1900N, 2000N
887.5E and 2387.5E on line 2200N	1500 m	2100N, 2200N, 2300N, 2400N

The apparent background resistivities recorded with gradient array vary between about 50 ohm-metres and 400 ohm-metres while the apparent chargeabilities range between 20 to 25 milliseconds. However, the pole-dipole data reveals a quite different picture, namely, background resistivities and chargeabilities of the

order of 1000 ohm-metres and 5 milliseconds respectively, between 1500E and 1800E. This indicates a near surface resistive layer of not less than 40 metres in thickness, with a slightly lower than normal background chargeability. The rock units at depth display very much lower resistivities and an indicated bulk sulphide content overall of at least 1%-2%. The inference therefore is of a leached surface zone within the area where the sulphides have been oxidised and/or leached out, but the decay products removed so as to reduce the salinity and therefore resistivity within this layer. The sulphide content of the rocks beneath is inferred to make some contribution to the lower than normal resistivities observed in this unit.

As there is both gradient and pole-dipole data on line 2200N, this is discussed in detail first.

On the background chargeability, which can be considered to be about twice normal, there are a number of anomalies which can be considered significant. The positions and approximate widths are as follows:

1160E(?), 1275E-1425E, 1650E-1675E, 1850E-1900E, 1960E (20 metres) and 2112E (20 metres).

The pole-dipole data indicates only two of these zones to be reasonably close to surface. The broad gradient anomaly seen from 1275E to 1425E indicates a source closest to surface at about 1375E at a depth greater than 40 metres.

The apparent resistivity data shows a 90% depression on the pole-dipole array, inferring conduction near surface which is not apparent from depth as seen on the gradient data. The source zone is therefore inferred to be relatively less resistive near surface compared with the host rocks, but shows little contact at depth, while the sulphide content of the zone increases in importance with depth.

The most significant response on the pole-dipole data was a 75 millisecond anomaly recorded centred at 1938E which is interpreted as having a width of 40 metres at a maximum depth of 20 metres. The sulphide content over this width would be expected to at least be of the order of 6%-7%, and the reduction in apparent resistivity clearly demonstrates conduction within the source, but the absolute apparent resistivities of about 50 ohm-metres infers this to be relatively weak. This response correlates with the gradient anomaly at 1960E, while the slightly higher $n = 2$ pole-dipole data west of 1900E is considered to infer that the gradient anomaly centred at 1875E is from a source greater than the effective penetration of the pole-dipole array, namely 40 to 50 metres.

Very minor responses on the pole-dipole data at 1650E, only barely above the "geological noise level" infer a source at a depth greater than 40 to 50 metres for the gradient anomaly

located at this point. The source in this case is inferred to be of either a disseminated, or if "massive" electrically discontinuous nature, unlike the two zones discussed above.

The gradient anomaly seen at 2112E was not covered by pole-dipole, but a disseminated sulphide source having a maximum depth of 25 metres is interpreted.

No clear indication of the dip can be gauged due to the resistive surface layer, however, in most cases a west dip is inferred.

On this line the lowest apparent resistivities were observed over zones mapped as "Fine-Medium Agglomerates", while the highest apparent resistivities correlate with Undifferentiated fine grained tuffs. The level of induced polarization does not correlate with any particular rock unit, but does show an increase over zones of high copper geochemistry in the soils.

The Turam electromagnetic data shows two minor but excellent conductors centred at 1362E and 1438E, both within a zone of very high chargeability, but also high resistivity. This indicates some conduction within narrow zones within an otherwise disseminated source. The maximum indicated depths are of the order of 30 metres. Again little phase distortion

infers high conductivity.

Lines North of 2200N The correlation suggested, based on the profile form of the apparent resistivity, is as follows:

2400N	1375E	1412E	1612E	1888E	1950E
2300N	1462E	1512E	1662E	1938E	2025E
2200N	1462E	1512E	1662E	2012E	2112E

The chargeability anomalies are not clearly traced between lines but the following correlations are suggested.

2400N	1350E	1625E(?)	-	1875E
2300N	1400E	1638E(?)	1825E	1912E
2200N	1380E	1662E	1888E	1950E
2100N	?	1688E(?)	1900E(?)	1988E

On line 2400N the significant anomalies are interpreted as follows: 1350E at a depth and width of 25 metres, 1412E and 1462E (Minor), 1625E at a depth of 30 metres and having a width of 25 metres, 1875E at a depth of 20 metres and a width of 30 metres, dip perhaps west. While on line 2300N the entire zone west of 1450E can be considered anomalous, with additional significant responses at 1550E where a source whose maximum width is 20 metres is interpreted at a maximum depth of 25 metres. A smaller anomaly at 1638E has a maximum width and depth of 25 metres. A broad zone

whose source is inferred to be of the order of 50 to 60 metres wide at a maximum depth of 40 metres, was centred at 1825E. This anomaly was seen on line 2200N, but not on line 2400N. A narrow source of the order of say 15 metres or less was defined at a depth less than the 25 metre dipole used.

As on line 2200N, both lines 2300N and 2400N show the lowest apparent resistivities over the Agglomerate unit, and the highest soil copper values over the highest chargeabilities.

The Turam data suggests some good conduction from narrow zones at about 1388E and 1462E - both within a zone of high chargeability. This is seen by an increase in field strength ratio with little distortion in phase. No maximum depths can be interpreted.

Lines South of 2200N On the eastern section of the lines to the south of 2200N, the chargeability anomalies can be correlated as follows:

2200N	1888E	1950E	2112E
2100N	1900E(?)	1988E	2100E
2000N	-	1988E	2088E
1900N	-	2038E	-

The general strike as mapped by the float appears in general to be confirmed by the apparent resistivity profile. In the western sections, interline correlation is not possible, but

between lines 2000N and 1900N the following correlation is suggested based on resistivity:

2000N	1412E	1488E
1900N	1500E	1575E

An analysis of the chargeability data suggests the following interpretation of the significant induced polarization anomalies on each line.

Line 2100N Between 1288E and 1375E, high chargeability over resistive rock units suggests a disseminated source. The depth is difficult to gauge but 25 metres is suggested. Smaller responses at 1437E, 1512E and 1638E are not considered significant but 7 to 10 millisecond anomalies at 1588E and 1688E are considered significant and are interpreted as having maximum widths of 12 metres and depths of the order of 20 metres. A very significant response of 40 milliseconds at 1988E is considered to arise from a source whose maximum depth is 20 metres and whose width is not greater than 30 metres. The apparent dip is vertical. The source does not appear conductive. A wide 40 metre chargeable zone from a resistive source was logged centred at about 2100E. East of 2175E chargeability rises steeply while resistivity drops off, the anomaly is open to the east, but maximum depth to the source is estimated to be 25 metres.

Between 1400E and 1450E relatively high field strength ratios with no phase distortion infer conduction from multiple sources whose maximum depths are of the order of 20 metres or so. As on other lines, the sources are highly chargeable. A conductor within an otherwise resistive disseminated sulphide source is the interpretation of this feature.

Line 2000N West of 1425E chargeability levels remain over 30 milliseconds accompanied by relatively high resistivities. A disseminated source is thus inferred. Significant anomalies at 1388E, 1488E and 1562E are interpreted from disseminated sources at depths of 35 metres, 25 metres and 30 metres respectively. The widths of the sources are of the order of the dipole used, namely, 25 metres.

East of 1750E the apparent chargeability background increases from about 20 milliseconds to in excess of 40 millisecond. Superimposed on this steady increase, a number of minor anomalies at 1788E, 1838E, 1938E and 1988E are interpreted as being due to relatively narrow and shallow sulphide concentrations within a generally disseminated sulphide host. Between 2062E and 2200E very high chargeability of in excess of 45 to 50 milliseconds were recorded from sources between 2062E and 2112E and between 2138E and 2200E. In the first case the apparent resistivity increases, inferring

a disseminated source, while in the latter, the apparent resistivity decreases inferring weak conduction within the source.

Line 1900N Both the apparent chargeability and resistivity profiles exhibit very similar characteristics, with lower background chargeability and resistivities in the centre of the array and higher resistivities at the margins. However, in detail the anomaly pattern observed on these lines is almost impossible to correlate.

The 5 to 8 millisecond chargeability anomalies at 1400E and 1512E can be correlated to more substantial responses of 10 to 15 milliseconds at 1388E and 1488E on the previously described line respectively.

Two responses, one at 1612E and a substantial 15 millisecond response at 1662E are interpreted from narrow shallow responses of 25 metres and 12 metres respectively. The general level of chargeability rises from 20 milliseconds to in excess of 40 milliseconds between 1850E and 2200E, but the substantial anomalies observed on the eastern end of line 2000N was not observed here.

Lines 1800N and 1700N On both these lines a gradual increase in the high background was noted from west to east, with

relatively small 5 to 8 millisecond anomalies superimposed on this background. It is not possible to make clear correlations between lines either on a basis of apparent chargeability or resistivity.

CONCLUSIONS

- 1 - The two arrays run over line 2200N clearly indicate a resistive near surface zone of low chargeability having a depth of the order of 25 to 40 metres, which is interpreted as a leached zone.
- 2 - Beneath the above, zones of more conductive and chargeable rock units were observed, the levels of which infer disseminated sulphide (or graphite) content of the order of 2%-4% over most of the areas surveyed (assuming that line 2200N is typical).
- 3 - Within the highly chargeable backgrounds observed with the gradient array, the chargeability anomalies observed in general appear to relate to areas of increased copper soil geochemistry, thus inferring that the largest induced polarization anomalies may be of most interest.
- 4 - If the conditions observed on lines 2200N are in fact typical of those of the entire area surveyed, it will be difficult to gauge the degree of conductivity within

the chargeable sources, however, at best they are weakly conductive.

- 5 - Similarly widths and depths are difficult to estimate but the latter appear to range from 12 metres to 40 metres.
- 6 - The limited electromagnetic data infers narrow zones of limited extent but of excellent conduction within disseminated sulphide haloes on lines 2100N, 2200N and 2300N.

RECOMMENDATIONS

- 1 - As the induced polarization data has defined zones of chargeable material which, due to associated copper geochemistry, are considered to be due to copper sulphide in association with pyrite, percussion or diamond drilling is recommended to intersect the chargeable sources. These will, in general, lie within the potential dipole and immediately below the point of measurement (Subject to the qualifications made on Page 4)
- 2 - In the present circumstances it is difficult to single out any for individual investigation, however, the following are suggested:

Line 1900N at 1662E

Line 2000N at 1488E, 2088E, and 2138E to 2200E

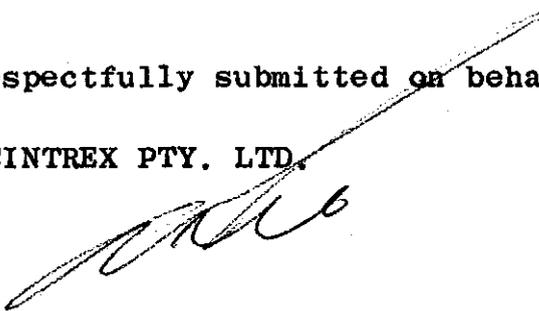
Line 2100N at 1990E
Line 2200N at 1662E, 1875E, 1962E, 2112E
Line 2300N at 1550E, 1638E, 1825E, 1912E and west
of 1425E
Line 2400N at 1625E, 1350E

All holes should be drilled against the local dip to intersect a target below the above, at depths interpreted. (see text). Where no dips can be gauged, vertical holes are recommended.

3 - No additional geophysics is warranted until such time as the economic potential of the above inferred sulphide sources have been clearly established.

Respectfully submitted on behalf of:

SCINTREX PTY. LTD.



A.W. HOWLAND-ROSE, MSc, DIC, AMAusIMM, FGS.

GEOPHYSICIST

APPENDIX I

Comments on the analysis of soil samples at Dial Range for mercury content using the Scintrex HGG-3 Mercury Vapour Analyser.

DISCUSSION

During the course of the geophysical survey which is the subject of this report, some 25 soil samples were collected on line 2200N for subsequent mercury analysis. The results of these analyses are shown in Table I.

The procedure adopted in the analysis was as follows:

The soil mercury analyses were carried out using the Scintrex HGG-3 Mercury Vapour Analyser. The reading given is in instrument units (millivolts). 1 millivolt is equivalent to $1/250$ ng Hg as calibrated against standard quantities of mercury. The approximate p.p.b. equivalent is reading in millivolts
1000

During the course of these sample analyses, frequent calibrations of the instrument were carried out against standard amounts of mercury vapour over the range of samples analysed, and high values were repeated to check their accuracy. These were always within sampling error.

The procedure adopted in the present tests was as follows:

- 1 - Approximately 3 millilitres of sample is ground in an agate mortar. Experience in the Perth laboratory has shown that grain size is not critical. However, the sample should be fairly finely ground and also be fairly uniform in grain size.
- 2 - Approximately 0.5 millilitres (4 grams) of the ground sample is placed in a 1 inch diameter pyrex test tube.
- 3 - The air line to the HGG-3 is connected to the test tube. It is important that there is an air inlet into the tube as well as the air line to the HGG-3, i.e. a two hole rubber bung is used to close the test tube off, with one hole carrying the air line and the other acting as an air intake, preferably through a glass tube 4 to 5 inches long.
- 4 - The sample is heated for 10 seconds. A Ronson butane multifill torch using a blue centre flame approximately 1 centimetre long was found to give the best results.
- 5 - The air is drawn slowly through the HGG-3 using the stirrup pump provided. The maximum metre deflection is recorded directly in millivolts.

Some comments on the relevance of the method to your exploration programme at Dial Range are warranted.

The mobility of mercury is well known but unfortunately not as well documented as it deserves. Any zone yielding mercury can be thought of as "breathing" through a surface soil filter with mercury becoming weakly bonded to organic material within soils. (It is understood that some 200 organic mercury compounds have been identified in recent years). A state of steady equilibrium is set up and areas of active emission can be identified as such by significantly anomalous mercury levels in the soils.

Our method involves the analysis of soils to release the weakly bonded mercury referred to above.

In moraine and non-residual soil areas such as, and including, Tasmania, mercury is clearly seen in soils above mercury carrying deposits. It is essential to the method, however, that the ores which are the subject of the search, carry mercury. This is certainly the case with the ores of the Cambrian age located on Tasmania's west coast.

The anomalies considered of greatest significance are those having not only the greatest absolute values, but those having also a broad halo of lower amplitude for scores of

metres surrounding the peak value. For this reason it is essential to consider area rather than lines. Therefore the test line run at Dial Range can be considered to confirm the presence in the soils of anomalous mercury.

Anomalous responses in excess of 200 millivolts are considered highly significant in other zones of known mineralisation. Therefore any significant responses above this level are obviously of prime interest, especially when accompanied by adjacent readings of a smaller magnitude. In all test areas to date, anomalies of this magnitude have invariably been associated with known mineralisation, very often accompanied by zinc. However, to date, such surveys have been carried out in areas where economic mineralisation was known to be associated with mercury. Sources other than sulphides are also known to exist for mercury such as thermal areas, shales, biotites, chlorites, fluorite, barite, etc.

The nature of the source is such that the maximum values recorded in soils represent the area where mercury from the source material becomes fixed in the soils by weak bonding to organic matter or in certain circumstances as native mercury. However, this does not necessarily mean that the source lies immediately below the maximum value, but rather that the peak value represents the nearest point of access of the vapour to the surface from the source.

Faults, fissures, etc. are often noted in the area of high soil mercury, but are not the source, merely the access.

The mode of operation is to station the instrument in a convenient spot and bring samples for analysis to it. Some 150 - 200 samples can be analysed per day, with the average to date being of the order of 180.

As mentioned above, additional data would be required on adjacent lines for a meaningful analysis of the results to be made. However, the background appears to be a high 50 - 100 millivolts (normal background ranges from 25 to 40 millivolts) with a number of highly significant responses, particularly at 1325E/1350E, 1550E/1575E and 1650E. (All these analyses were confirmed by re-analysing and are therefore considered meaningful).

CONCLUSIONS AND RECOMMENDATIONS

In view of the above data, it is strongly recommended that additional samples be run over all existing lines on a 25 metres sampling interval, preferably on a 50 metre line spacing, prior to more expensive investigation by diamond or percussion drilling, as deposits having an inferred similar mineralisation (copper-zinc) and age on the west coast, have been found to be associated with mercury

within the soils in the vicinity of these deposits.

Respectfully submitted on behalf of:

SCINTREX PTY. LTD.



A.W. HOWLAND-ROSE, MSc, DIC, AMAusIMM, FGS.

GEOPHYSICIST

TABLE I

Soil samples analysed by Scintrex HGG-3 for mercury, in machine units (millivolts)

Station	Reading	Station	Reading
1150E	150	1475E	90
1175E	70	1500E	220
1200E	40	1525E	120
1225E	50	1550E	350
1250E	130	1575E	400
1275E	125	1600E	90
1300E	120	1625E	60
1325E	260	1650E	350
1350E	350	1675E	90
1375E	90	1700E	150
1400E	170	1725E	125
1425E	60	1750E	170
1450E	40		


SCINTREX

earth science division

mercury spectrometer

HGG-3

features

Sensitivity is better than 40×10^{-12} grams mercury.

Specific readings of trace quantities of mercury are achieved by atomic absorption measurements using the intense 2537 Å mercury spectral line.

To reject other ultra-violet absorbing gases and vapours, a Zeeman spectral line-splitting technique is used to create reference wavelengths on either side of the parent line.

A robust, modular construction combines the HGG-3 optics, which have no moving parts, and fully solid-state electronics with an easily replaceable lead-silica gel battery pack and charger.

As a line-operated unit in a vehicle, camp or laboratory, the HGG-3 yields sensitivities and sample throughputs significantly beyond those achievable by conventional instruments.

Versatility of approach is assured by the compatibility of the HGG-3 with most sampling accessories including soil gas kits, organic convertors, pyrolisers, wet chemical kits and silver foil collectors.



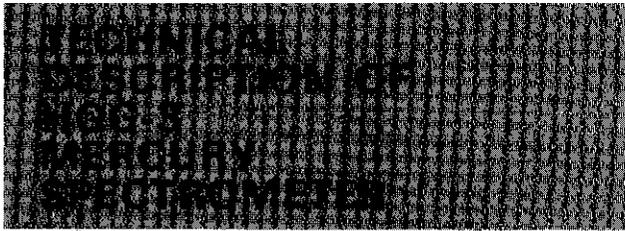
The Scintrex HGG-3 mercury spectrometer is a field-portable unit which provides a rapid and economical geochemical technique for on-the-spot determinations of mercury in soils, soil gases, rocks, water and sediments.

Its high sensitivity and selectivity permit unambiguous mercury analyses to previously unobtainable detection limits.



030

562032



DETECTION LIMIT:

RESPONSE TIME:

METER RANGES:

RECORDER OUTPUT:

POWER SOURCE:

DISCHARGE TIME:

POWER REQUIREMENTS FOR CHARGER:

BATTERY ELIMINATOR:

DIMENSIONS AND WEIGHTS:

Spectrometer with Battery Pack:

Battery Pack:

Charger:

Backpack:

OPERATING TEMPERATURE:

< 40 x 10⁻¹² g HG

6 seconds

0 — 1.5 x 10⁻⁹ g Hg F.S. and
0 — 15 x 10⁻⁹ g Hg F.S.

5 x 10⁻⁹ g Hg/Volt
Maximum 10 Volts

4 GC 660-1 lead-acid gel-type rechargeable batteries

1 day normal field use 3.5 hours continuous

115/230 V, 50 to 400 Hz, 100 W

115/230 V, 50/60 Hz, 100 W
(optional continuous power source)

5½ x 12 x 26" (14 x 30 x 66 cm)
40 lbs. (18 kg)

5½ x 12 x 5½" (14 x 30 x 14 cm)
14 lbs. (6.4 kg)

5½ x 12 x 5½" (14 x 30 x 14 cm)
9 lbs. (4.1 kg)

3 lbs. (1.4 kg)

0°C to +45°C



APPENDIX 'I.P.'

INTRODUCTION

For the benefit of those who are unfamiliar with the Induced Polarization method in general, or with the pulse-type method in particular, a few introductory remarks will be directed on the Induced Polarization, or overvoltage, phenomenon. Those who wish a fuller treatment of the subject are directed to Seigel (1962), which paper also includes an extensive list of references.

Induced Polarization in its broadest sense means a separation of charge to form an effective dipolar (polarised) distribution of electrical charges throughout a medium under the action of an applied electric field. When current is caused to pass across the interface between electrolyte and a metallic conducting body, double layers of charge are built up at the interface, in the phenomenon known to electrochemists as "overvoltage". This is the phenomenon which can be utilised for the detection of metallic conducting, rock-forming, minerals such as most sulphides, arsenides, a few oxides and, unfortunately, graphite. In addition, effective dipolar charge distribution occurs to some extent in all rocks, due to ion-sorting in the fine capillaries in which the current is passing.

Page - two

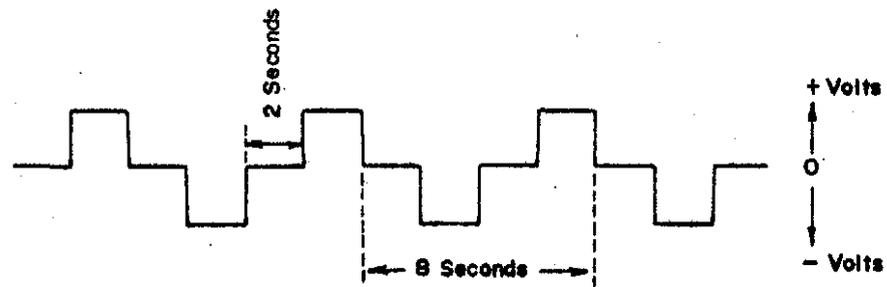
Induced Polarization responses may therefore arise from metallic or non-metallic agencies. Fortunately, the latter generally falls within fairly low and narrow limits for almost all rock types, although there is still no reliable criterion for differentiating overvoltage responses from graphite and metallic sulphides, or for distinguishing between the responses of one type of sulphide and another. Despite these limitations the Induced Polarization method has amply demonstrated its value in mineral exploration since its initial development as a useful exploration tool in 1948 (ed. Wait, 1959).

DESCRIPTION OF METHOD AND EQUIPMENT

For the present programme the pulse or time domain system was employed, using a Scintrex Induced Polarization unit. The standard current-wave form with the unit is two seconds on-time and two seconds off-time. (see Figure 1). This unit features the Newmont type self-triggered receiver which operates remote from the current transmitting equipment. Three fundamental quantities are measured with this unit - the chargeability of 'M' measurement, the 'L' measurement and the resistivity.

The receiver integrates the area under the decay curve during the time interval from 0.45 seconds to 1.1. seconds

MEASUREMENTS TAKEN



Energising frequency is a square wave having a frequency of 0.125 cps.

FIELD MEASUREMENTS MADE

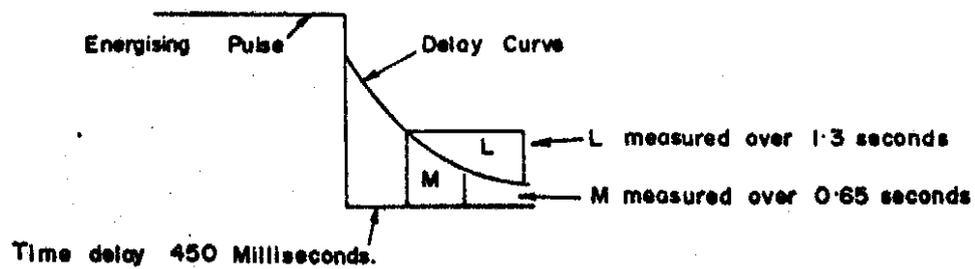


Fig. 1

Page - three

after termination of the primary current pulse. This integral normalised with respect to its corresponding primary voltage is the chargeability or 'M' measurement, that is, the fundamental Induced Polarization characteristic. It is in units of milliseconds. The Induced Polarization phenomena is dependent on the existence of electronically conducting material within the matrix of ionically conducting material. The chargeability is therefore a measure of the presence of electronically conducting material within the ground being tested.

The second quantity measured is the area over the transient decay curve between 0.45 seconds and 1.75 seconds of the current off-time. This measurement is designated the 'L' measurement and is also in units of milliseconds. The ratio L/M gives a curve factor related to the shape of the transient voltage curve, and is a measure of the rate of decay of the transient voltage. This is of secondary diagnostic value in that the rate of decay of the transient voltage is partially a function of particle size. A large L/M ratio reflects a short time constant, commonly associated with finely disseminated sulphide or graphite, whereas a small L/M ratio reflects the longer time constants associated with the larger sized metallic particles.

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The L/M ratio is also effective in determining the presence of electromagnetic coupling effects. With the Scintrex Induced Polarization unit, electromagnetic coupling effects are essentially eliminated by an 0.45 second delay-time following termination of the primary current pulse before measurement of the transient voltage commences. However, in extremely low resistivity areas coupling may occur. Under these conditions the presence of electromagnetic coupling can distort the Induced Polarization response, and it is extremely important to know when this occurs. The presence of such coupling is immediately recognizable from the L/M ratios.

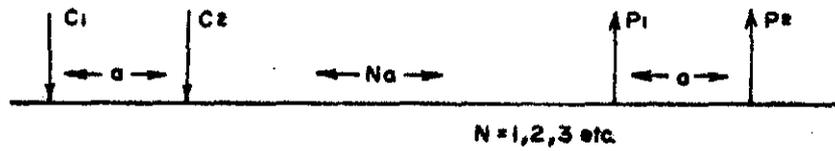
Resistivity measurements are also made as an integral part of all Induced Polarization measurement using the Scintrex Induced Polarization unit. The resistivity values are of primary importance in determining subsurface geological features such as contact zones, faulting, etc., and are of assistance in mapping the geology in general.

Electrode geometries (see Figure 2) utilised in obtaining field measurements are important and no one electrode array is applicable for all conditions. In areas where a low resistivity oxidised surface layer overlies a much higher resistivity freshrock, a high degree of

COMMONLY USED ELECTRODE ARRAYS

CLOSE - COUPLED ARRAYS

DIPOLE - DIPOLE



POLE - DIPOLE



GRADIENT ARRAY

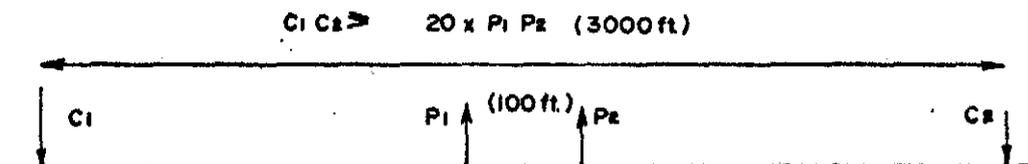


Fig. 2

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masking occurs using any of the close-coupled arrays, such as pole-dipole or dipole-dipole. An electrode spacing many times greater than the depth to freshrock must be used in order to obtain responses reasonably representative of the freshrock. With such large electrode spacings the physical properties are effectively averaged over so large a volume that we lose the ability to detect moderate sized bodies of polarizable material. However, under these conditions the gradient array is both feasible and desirable in that it minimises the effects of masking and at the same time has a high degree of resolution for small targets.

In the present areas of investigation, abnormal induced polarization responses may be expected to arise from the electronically conducting sulphide minerals such as pyrite, pyrrhotite, chalcopyrite and pentlandite, plus graphite and magnetite. The response from magnetite has been found to be quite variable and somewhat unpredictable, reflecting the great variation in the mode of electrical conduction in this material. It is not always possible to differentiate between these potential sources of high chargeability from the Induced Polarization and resistivity data alone. Complementary geophysical, geochemical and geological data enable a more complete interpretation to be made of the Induced Polarization data.

Page - six

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APPENDIX 'T'

BRIEF DESCRIPTION OF THE
TURAM ELECTROMAGNETIC SYSTEM

GENERAL

The Turam method can be classified as a fixed source compensation method. The primary or source field consists of a large energising layout in the form of a long wire or a large loop laid out on the terrain, to which an audio frequency alternating current is fed by means of a motor generator. The resulting current pattern is investigated inductively, with two identical receiving coils connected to a bridge compensator which compares the signal received in each coil in relative phase and amplitude. When grounded cable is used, the energisation is both galvanic and inductive; when the primary layout consists of a closed loop, the energisation is purely inductive. Under most conditions the presence of galvanic current is undesirable and inductive energisation, is as a rule, preferred.

Although the system allows the comparison of any two components of the resultant field, it is standard procedure on systematic surveys to measure the gradient of the vertical component.

The pattern for a typical Turam survey is shown in Figure 1. A large rectangular loop is used as primary

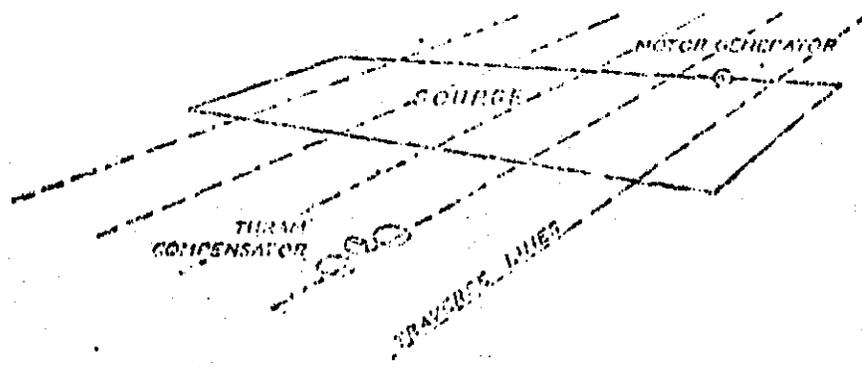


Fig. 1 The Turam method. General layout

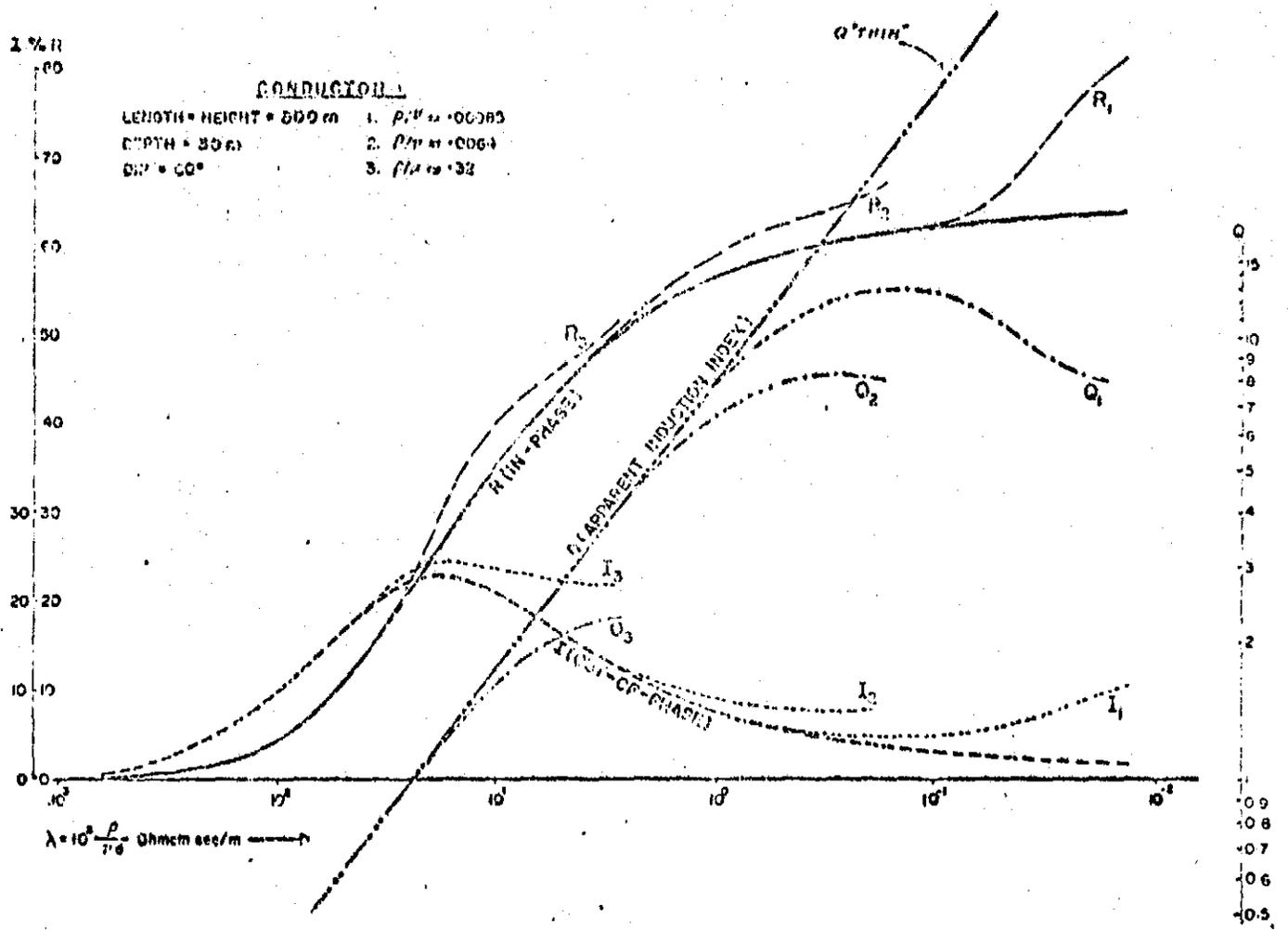


FIG. 2 RESPONSE OF A FINITE TABULAR CONDUCTOR. (R.A. Bosschart 1964)

Page - two

layout and the field gradients are measured with horizontal receiving coils along profiles perpendicular to a long side of the transmitting loop.

DATA REDUCTION

The relative strength of the undisturbed primary field is dependent on the loop dimensions and the location of the observation points, and can be determined by calculation. The measured field strength ratios are normalised through division by these calculated free space ratios.

The primary field causes eddy current to flow in subsurface conductors. As a result the resultant field will be distorted in both amplitude and phase. The presence of conductors will thus be indicated by abnormal strength ratios and phase differences.

PRESENTATION

The measuring results are usually presented in profile form as (reduced) field strength ratio and phase difference curves, with the observed values plotted at the midpoint between coil positions.

Occasionally one of the two parameters is presented in contour form, but contour plans are generally inadequate

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to express the full significance of the data.

INTERPRETATION

Where field distortion occurs the curves indicate the location and the depth of burial of the main current flow. The "current axis" is well defined when the current is concentrated as, for instance, in thin, steeply dipping conductors. In wide, banded conductors or in horizontal conductors such as, for instance, overburden, the current is usually more dispersed and the anomalies will yield less positive information.

As a rule the current axis is located right below the maximum field strength ratio deflection or the maximum negative phase shift. Its depth under the traverse is indicated by the shape of the anomaly.

The relative amplitudes of field strength and phase distortions are a measure of the conductivity of the conducting bodies, i.e. good conductors are characterised by field strength distortion combined with relatively little phase shifting, whereas poor conductors affect the phase rather than the strength of the resultant field.

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For an accurate grading the resistivity thickness (r/d) ratios of the individual conductors can be derived from the calculated in-phase and out-of-phase components, taking further into consideration the exciting frequency and the strike length of the conductor. The relations are shown in Figures 2 and 3. The obtained r/d values are marked on the upper right side of the anomalies, in units of ohmcm/m. On the lower left side the depth of the current axis (ft.) is marked. It is normally located 30 - 40 feet within the body and the indicated depth should be regarded as the maximum depth to the upper surface of the conductor.

To obtain the projection of the current pattern, the anomalies are connected between lines whereby depth and r/d values as well as other characteristics of the curves are used as criteria. The strike of the formations, if known, is also taken into consideration.

Figure 4 and 5 show a plan and section of a typical Turam survey and interpretation.

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- 1937, Hedstrom, E.H. Phase Measurements in Electrical Prospecting. AIME Tech. Publ. 827.
- 1964, Bosschart, R.A. Analytical Interpretation of Fixed Source Electromagnetic Prospecting Data. Delft.

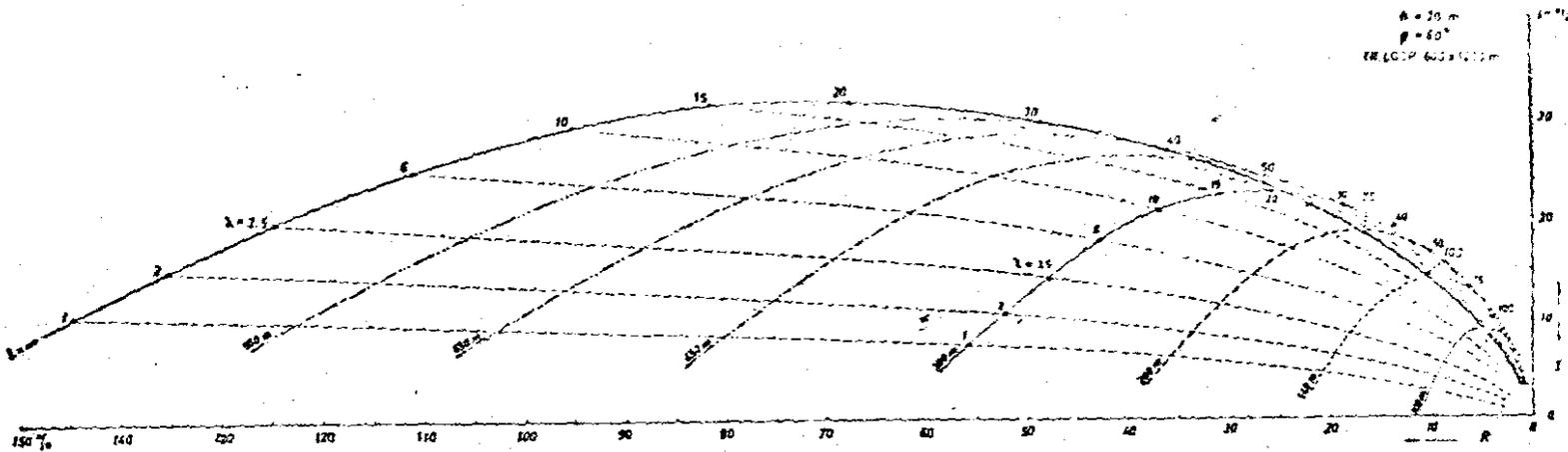
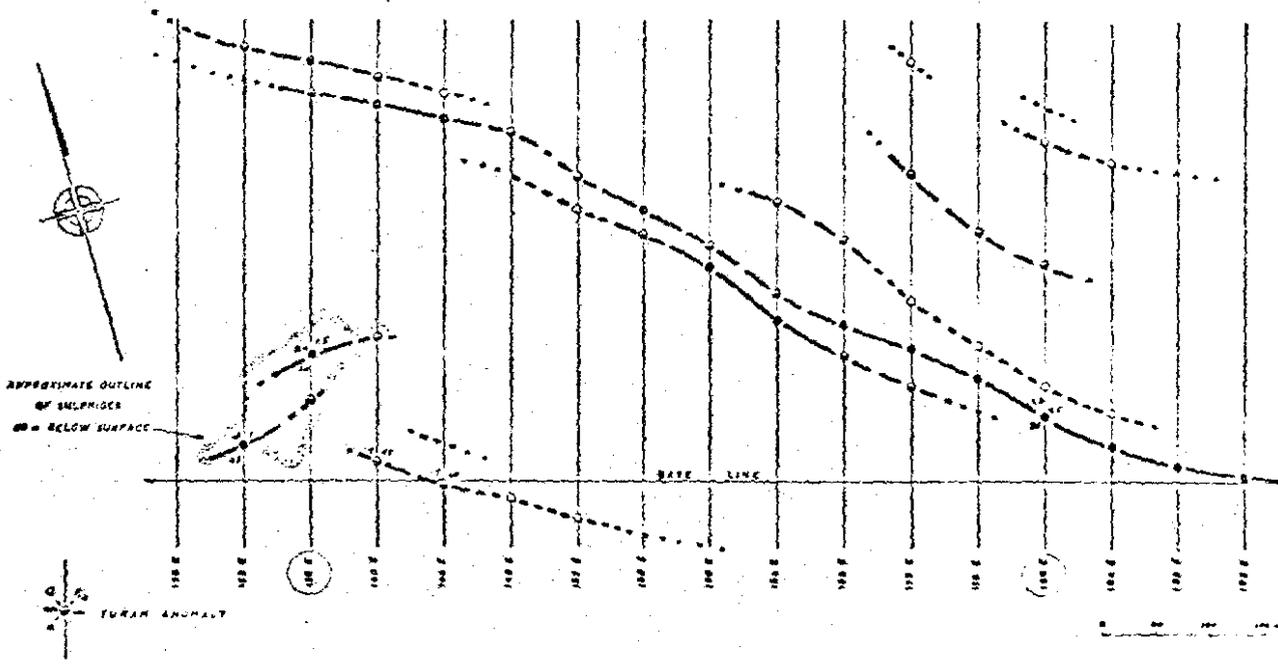


FIG. 3 RESPONSE DIAGRAM FOR CONDUCTORS OF VARYING STRIKE LENGTHS.

FIG. 4 TURAM SURVEY ON THE MURRAY GROUP, NEW-BRUNSWICK. (R.A. Bosschart 1964)



5 cm

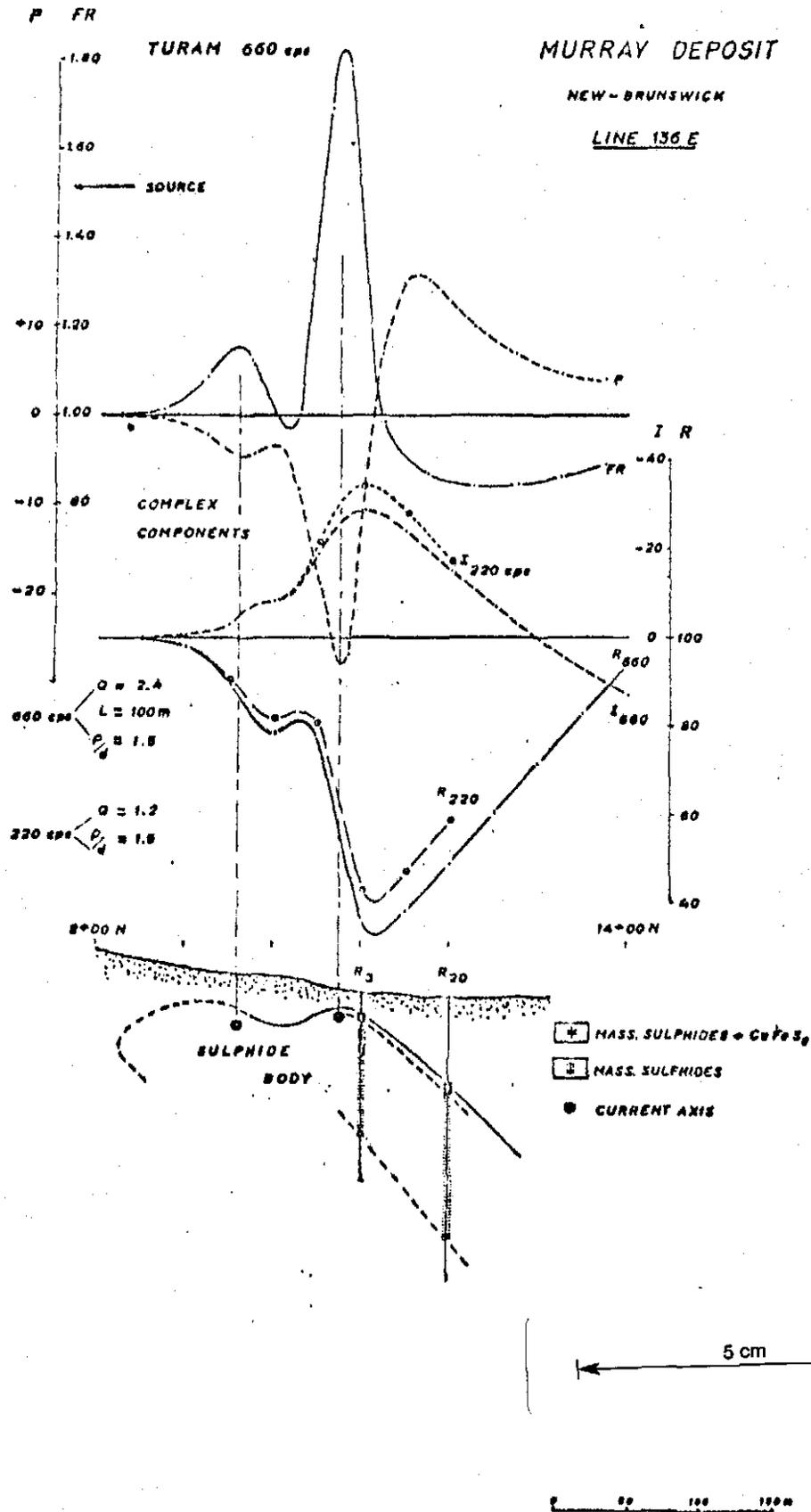
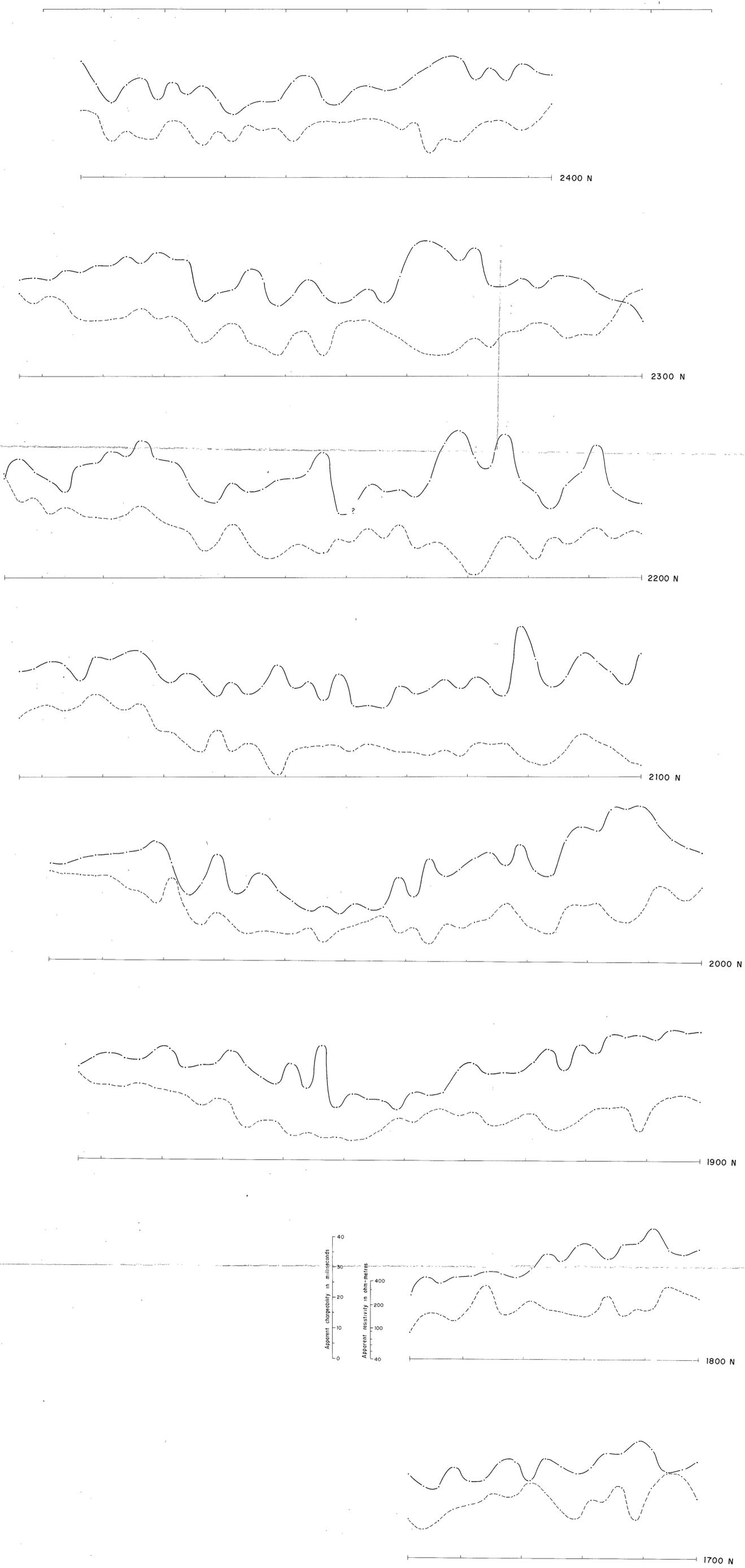


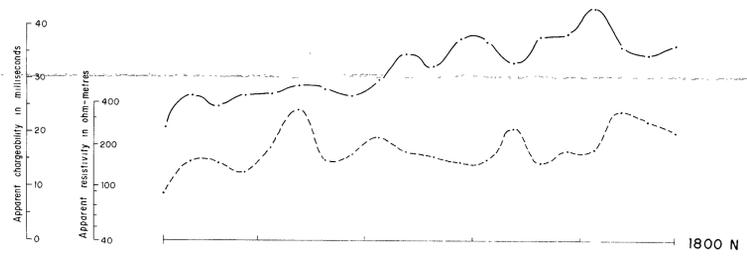
FIG. 5 TURAM SURVEY ON THE MURRAY GROUP, NEW BRUNSWICK. INTERPRETATION OF A TYPICAL SECTION. (R.A. Bosschart 1964)



LEGEND

Apparent chargeability :-
 1 cm = 5 milliseconds
 Base level = 0
 Symbol = ————

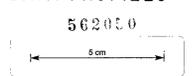
Apparent resistivity :-
 5 cm = 1 logarithmic cycle
 Base level = 40 ohm-metres
 Symbol = - - - - -



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DIAL RANGE
 NR. ULVERSTONE, TASMANIA

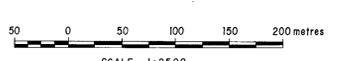
**GRADIENT ARRAY
 ELECTRICAL INDUCED POLARIZATION SURVEY
 DATA PROFILES**

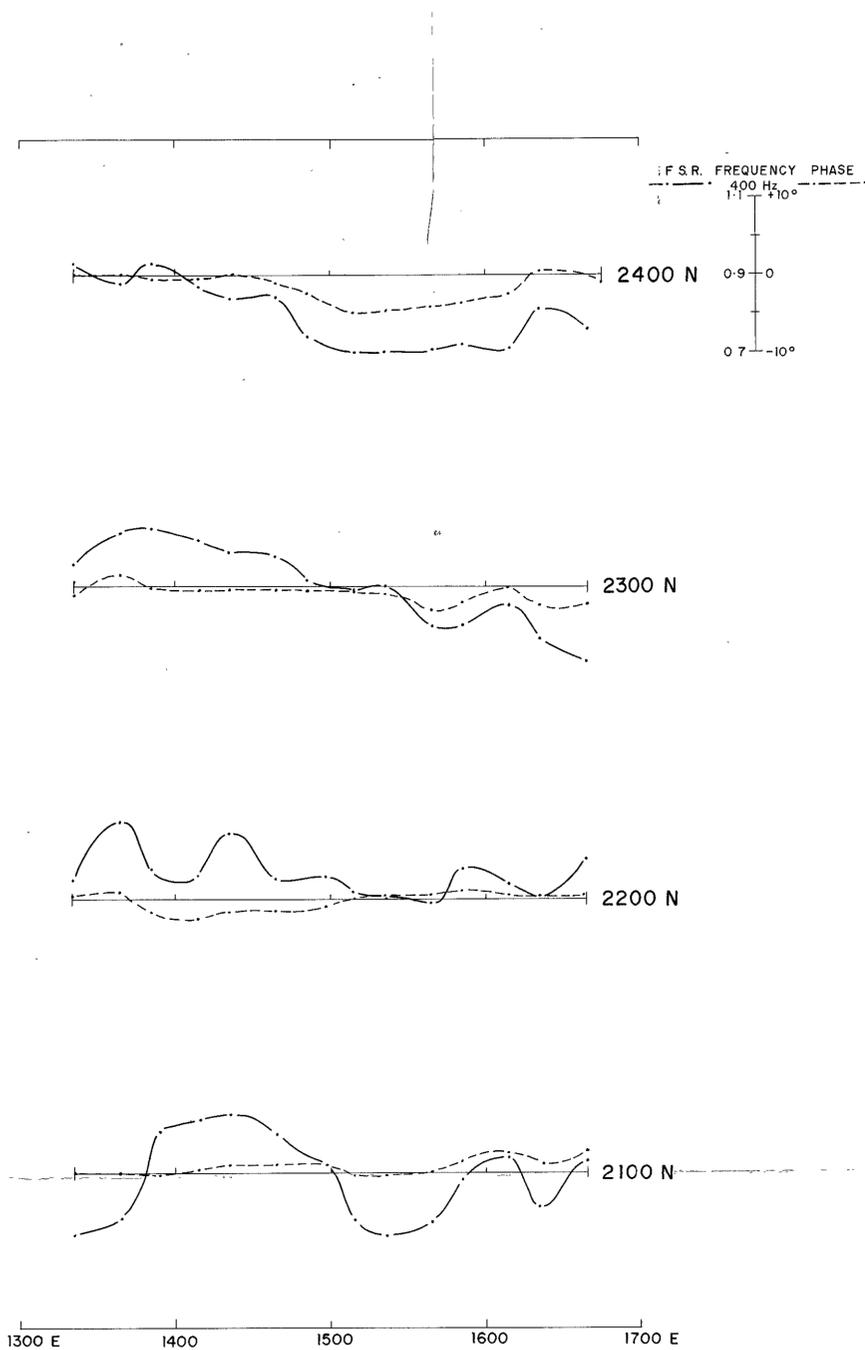


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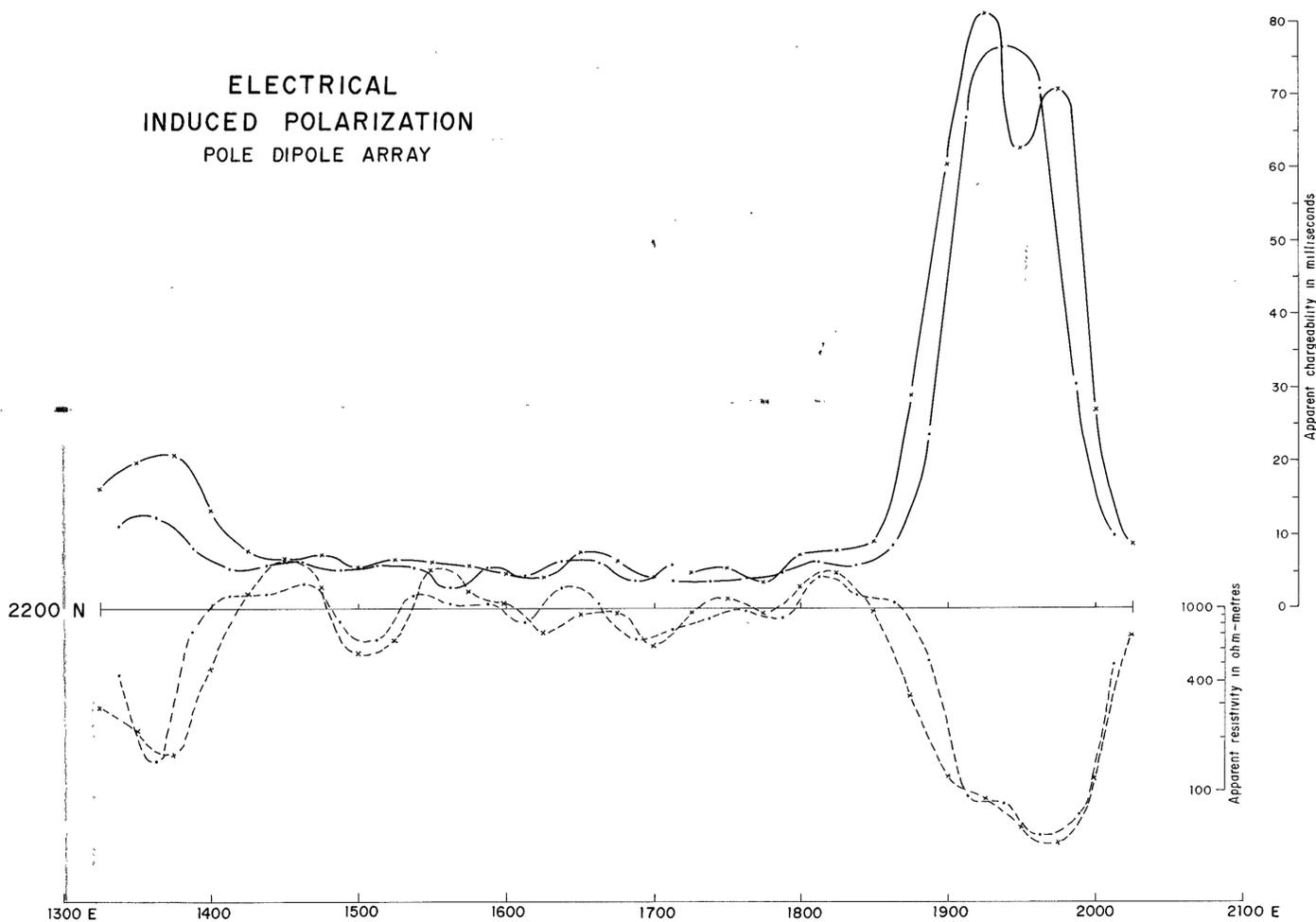


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**ELECTRICAL
INDUCED POLARIZATION
POLE DIPOLE ARRAY**



LEGEND (E.I.P.)

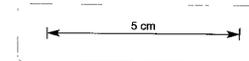
- Chargeability
- - - Resistivity
- a = 25 m, n = 1
- a = 25 m, n = 2

PENNZOIL OF AUSTRALIA LIMITED

**DIAL RANGE
NR. ULVERSTONE, TASMANIA**

**POLE DIPOLE ARRAY
ELECTRICAL INDUCED POLARIZATION SURVEY
& TURAM ELECTROMAGNETIC
DATA PROFILES**

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