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A REPORT ON
GRADIENT ARRAY EIP SURVEY
OVER THE GLOBE MINE
NEAR ZEEHAN, TASMANIA
ON BEHALF OF
RENISON LIMITED

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**A REPORT ON
GRADIENT ARRAY EIP SURVEY
OVER THE GLOBE MINE
NEAR ZEEHAN, TASMANIA
ON BEHALF OF
RENISON LIMITED**

BY

**G.J. STREET, M.SC., D.I.C.
GEOPHYSICIST**

SYDNEY, N.S.W.

JUNE, 1981

TAS-081C

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GEOPHYSICAL CONSULTANTS AND CONTRACTORS

SUMMARY

A small gradient array survey over the Globe Mine area has located a large area of anomalous induced polarization response which is not closed off to the north, south, east or west. It is recommended that the area be repeated using a larger gradient array to better define the anomalous area and the zones within it.

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A REPORT ON
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INTRODUCTION

At the request of Mr. L.A. Newnham, Chief Geologist for Renison Limited, Scintrex Pty. Ltd. executed an electrical induced polarization survey using the gradient array over the Globe Grid, Trial Harbour Road, Zeehan, Tasmania. The work was carried out by a four man crew under the leadership of Mr. I. Newby over two days, 27th and 28th November, 1980.

On-site geological direction was supplied by Renison Limited Geologist, Mr. P. Roberts, while the author and Mr. A.W. Howland-Rose undertook such additional supervision as was required.

METHOD

The gradient array method is briefly described in the attached appendix. On the Globe grid one gradient array was employed for the whole grid, with electrodes at 290N and 250S on 160E.

A Scintrex IPTAA 3 kilowatt time domain transmitter was used for energisation with a current of 1.5 amps. A standard 2 second energising cycle was produced, with a Scintrex IPR-8 to monitor the primary and secondary fields with a three slice

programme.

Only the middle slice (M_3) has been used in the data profiles and contour maps.

A 10 metre potential dipole was employed throughout, and all data was calculated using a programmable HP-97 calculator.

DATA PRESENTATION

The chargeability, in millivolts/volt, and apparent resistivity, in ohm-metres, have been drafted onto standard Renison sheets at the scale of 1:2000. Chargeability and apparent resistivity have also been contoured at 1:5000 on Renison standard map sheets.

DISCUSSION OF RESULTS

Resistivity results show little over the area except to indicate the strike of the rocks to be more or less at right angles to the grid lines. Such a contour plan is partly biased by the grid lines and spacings.

Chargeability results over the area are generally high and the bulk of the area is considered anomalous. Using the 10 metre potential dipole, a high resolution is obtained. What is seen, therefore, is individual more polarizable zones within the main anomalous region.

Higher polarization is recorded on the southern side of the area compared to the northern side. This may be due to the southern electrode being placed within polarizable material. The anomalous region is not closed off in the south by

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this survey and examination of lines 2700 and 2750 on the East Heemskirk grid shows it extends at least towards the south-east. A better 'feel' for the area would be obtained by using a larger array and placing the current electrodes in background material outside the zone of anomalous polarization.

A number of possible linear marker zones are identified by the letter 'A' to 'H'. However, the correlation of these zones is partly due to the line spacings and contouring effects. Geological input is important for such correlation, the mineralisation may indeed be more pod-like and not continue from line to line.

Zone 'A' appears the most continuous, most significant and interesting. This passes through the area of old workings and continues strongly towards the south-east. The zone was picked on the previous gradient array survey on the East Heemskirk grid and is open to the south-east.

Zone 'B' is fairly continuous but the correlation is poor on lines 80E and 120E as the anomalous region has not been closed off on these lines. The zone is possibly continuous with anomalies recorded on the East Heemskirk grid.

Zone 'C' is correlated over four lines, but there appears to be some structural change around 160E. This break is most obvious towards the northern part of the area, but zone 'A' appears to have only a slight displacement.

Zone 'D' is recorded only on line 160E. The polarization sources in this region appear more randomly oriented than elsewhere. This anomaly is not correlated with sources on other lines. The source in this case may not be at right angles to

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the grid which would explain the irregular contour pattern in this region.

Zone 'E' is identified from a peak on line 00 at around 55S. It does not appear to have a definite continuation, but anomalously high polarization continues to the south-east, and is recorded again on line 2750N on the East Heemskirk grid.

Zones 'F', 'G' and 'H' are a series of polarization anomalies in the north-east of the area although these anomalies are not as high as those towards the south. The comparison with background is greater. Zone 'F' appears to die out to the east, but 'G' and 'H' are not closed off to the east.

A line by line description follows.

Line 00 A broad zone of high chargeability is recorded between 30S and 100N. Though a low chargeability is recorded at 135N, the zone is not properly closed off to both north and south.

Individual sources are suggested at 5S, 20N, 45N, 75N, 95N, 120N and 150N. Effects of sources overlap so depth calculations are not possible except at 150N where a maximum depth of 20 metres is indicated.

The resistivity profile shows little.

Line 40E A broad zone of high chargeability is recorded over this line. Although chargeability is lower towards the north, this zone is not properly closed off to north or south.

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Responses from individual sources overlap and depths cannot be accurately determined. Possible sources occur below 25S, 5S, 15N, 40N and 80N. The source at 40N appears deeper, of the order of 30 to 40 metres, while the rest of the responses suggest shallower 20 metres maxima.

Line 80E Two individual responses stand out on this line at 5S and 45N from sources at depths of 20 metres and 10 metres respectively. Possible other sources occur at south of 40S, 65N and 95N. The source at 5S coincides with a slightly lower resistivity zone centred slightly south at 10S. Sources appear to be steeply dipping.

The chargeability anomaly is not closed off to the south.

Line 120E The major anomaly on this line peaks at around 20S but appears to be due to two sources, one at 20S and one further to the north around 10N. Each of these sources is apparently slightly less resistive as resistivity minima are recorded at 25S and 5N. These are probably the surface expressions of the sources. Depth of the sources is shallow at around a maximum of 20 metres.

Further sources occur at 50N which appears deeper at around a maximum of 40 metres, and at about 65S where the source looks to be at about 25 metres but is not completely resolved.

Line 160E Again on this line the chargeability anomaly is not closed off.

Probable sources occur at 55S at a depth of 10 metres; at about 20S where a zone of high chargeability is not well defined - depth from the northern flank

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is indicated at about 10 metres; 10N, a chargeability source at about 20 metres; 40N and 65N where a source at a depth of about 20 metres or more is not completely resolved by these results.

Line 200E A chargeability anomaly on the southern end of this line is not closed off. The source appears to be at 90S or further south. The overall shape of the profile indicates the anomaly may be quite broad and the source deep or dipping to the north.

At 35S a chargeable source occurs at a maximum depth of 20 metres but is not completely resolved.

At 5S a chargeable source whose response is not completely resolved.

At 20N a chargeable source which appears shallow but is not completely resolved.

45N a chargeable source lying at a depth of around 30 metres

85N a chargeable source lies north of the end of the line.

Line 240E The chargeability remains high throughout the area surveyed by this line. A number of individual sources occur at 85S or to the south of the end of the line.

55S a chargeable source which lies at a maximum depth of around 20 metres.

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Three sources on the northern end of the line gave lesser responses but are possibly due to deeper sources. These are at 0, 35N and 60N. Although a much lower response than sources to the south, these still give a high chargeability

Line 320E The southern end of this line does not adequately close off the anomalous area. A major source lies somewhere to the south of 5N.

The anomaly due to this has further responses on the flanks at 25N and 45N plus a smaller response at 65N.

The second major anomaly on the line is at 110N from a source at a maximum depth of 25 metres.

A further minor response at 145N is not completely resolved.

CONCLUSIONS

The gradient induced polarization survey has shown the bulk of the area to have a high polarization response. Partly this may be due to the electrodes, or in particular, the southern electrode being placed in a high polarization source.

A number of parallel zones within the overall anomalous area are identified and appear to be fairly continuous from east to west. Some form of dislocation occurs around 160E. Possibly this is a fault and there is some suggestion of a polarizable source which is not at right angles to the line.

The area should be repeated using a larger gradient array but at the same potential dipole spacing. Further lines to the east and west would help define the area

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better as would extensions of all lines to the north and south.

Respectfully submitted on behalf of:

SCINTREX PTY. LTD.

G. J. STREET, M.Sc., D.I.C.

GEOPHYSICIST

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APPENDIX

BRIEF SIMPLE COMMENTS ON THE GRADIENT, DIPOLE-DIPOLE AND POLE-DIPOLE ARRAYS AND ON DECAY FORM

INTRODUCTION

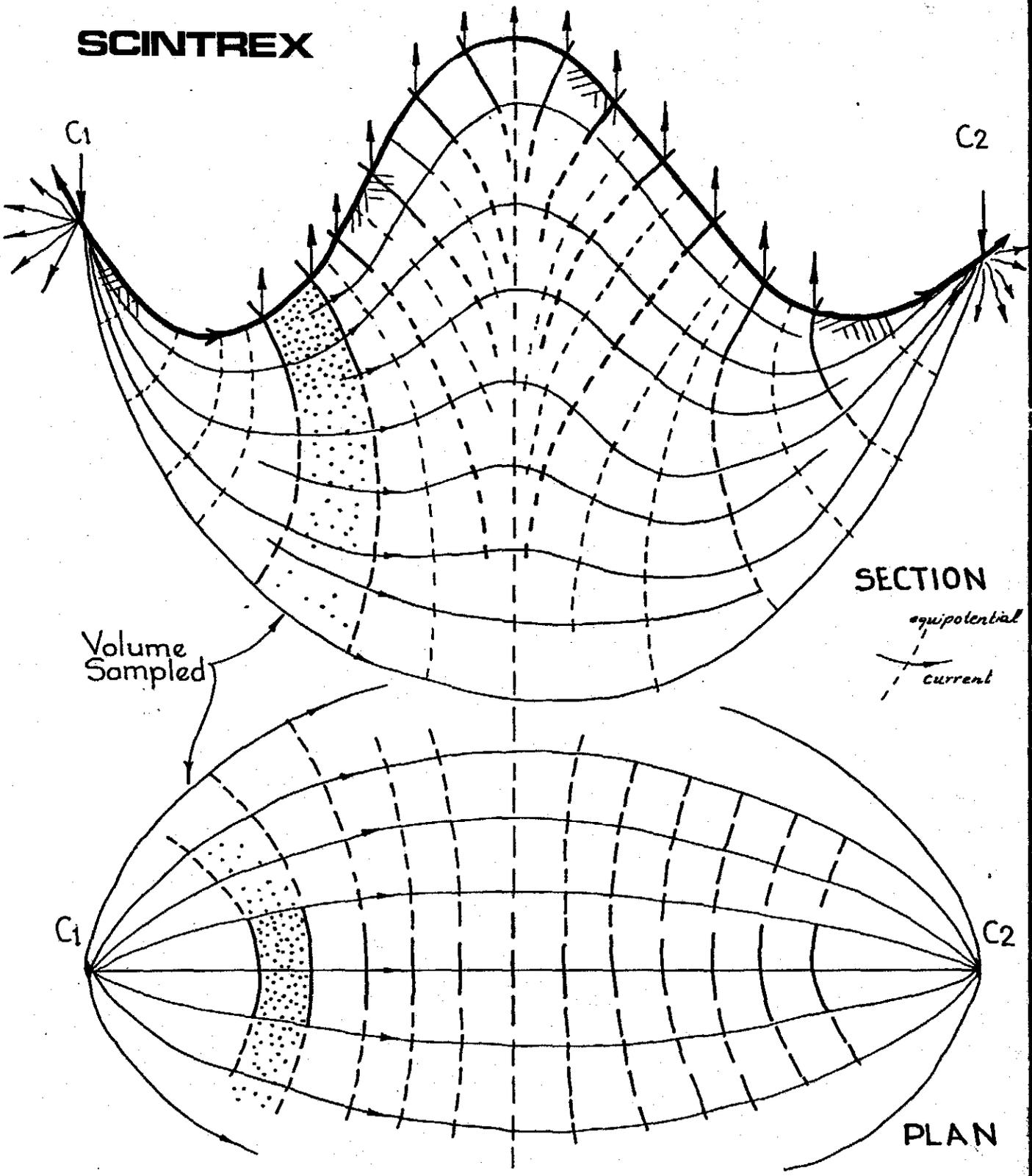
In the case of the surveys discussed in this report, it is important that the geologist can relate the geophysical data to the underlying geology if he is to make the best use of this data. It is the author's opinion that *only* the geologist will be able to relate the data to geology. For this reason brief, simple comments follow on the salient features of the gradient, dipole-dipole and pole-dipole arrays. These comments show how the data relates to the volume of underlying rock which influences it. Comments are also made on the decay form.

DISCUSSION

Gradient Array:- In this array both current electrodes are distant from the potential dipole. Figure 1 displays the salient features of the *primary* current flow and primary equipotential field generated during energisation and shows the influence of terrain on the current paths. From this diagram it can be seen that the *apparent resistivity* measurement is a summation of a volume of material normal to the local slope, *beneath* the surface and at *right angles* to the line.

The apparent resistivity will be *biased* by the influence of each current electrode, but the *relative* values of *adjacent* readings can be considered to be *reliable*. As each electrode is approached, the readings become *increasingly* biased by that electrode.

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Diagrammatic Representation of Primary Current and Potential Field in Steep Topography.

FIGURE 1.

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Note particularly that the *source volume* is *normal to slope* and not vertically beneath the potential dipole. Therefore all maximum depths refer to depths below surface *normal to the slope*.

Note also that the volume of material *closest to* the potential electrodes will influence the data most. It is difficult to easily quantify the complex relationship between the volume of material sampled and its distance from the potential dipole.

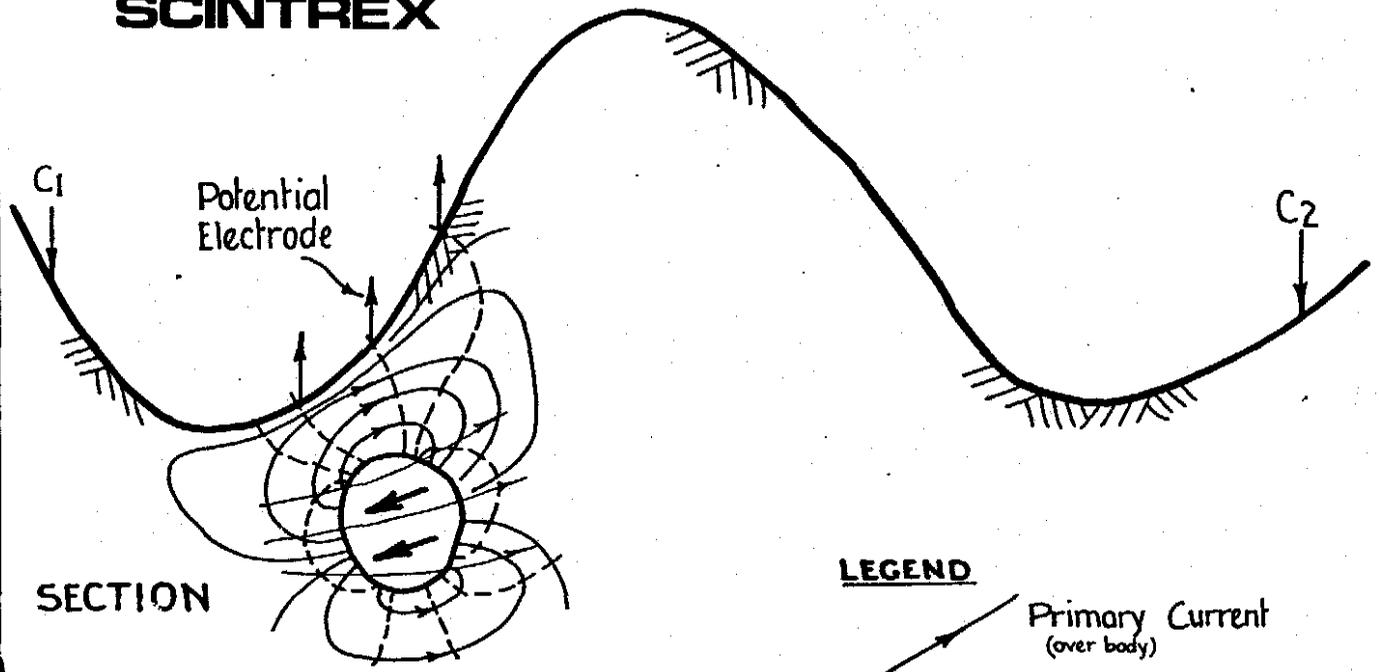
Figure 2 displays the secondary current pattern generated from the decay of induced polarization effect *within* a chargeable sulphide source, together with the equipotential field generated by that decay. Note that due to the necessarily curved nature of the current flow outside the body, the on-surface manifestation is *wider than* the *source width*. Note also that the volume sampled in the primary potential field (apparent resistivity ρ_a) is not necessarily the same volume as is the secondary potential field (apparent chargeability Ma). This is, of course, true for *any* array.

Dipole-Dipole:- In this array the current dipole is generally small, generally 20 to 100 metres. Figure 3 displays the current pattern in section and in plan for a dipole-dipole array. The equipotential P_1 and P_2 tap a volume as shown in this diagram whose characteristics are read on the $n = 1$ station and plotted as a single point midway between the transmitting dipole C_1 to C_2 and the potential dipole P_1 to P_2 . As progressively higher n values are read, a deeper and wider volume of material is sampled, this always being plotted midway between the transmitting and receiving dipole, and at a deeper level in the pseudo-section presentation used in this report. It is *vital* to realise that this data point

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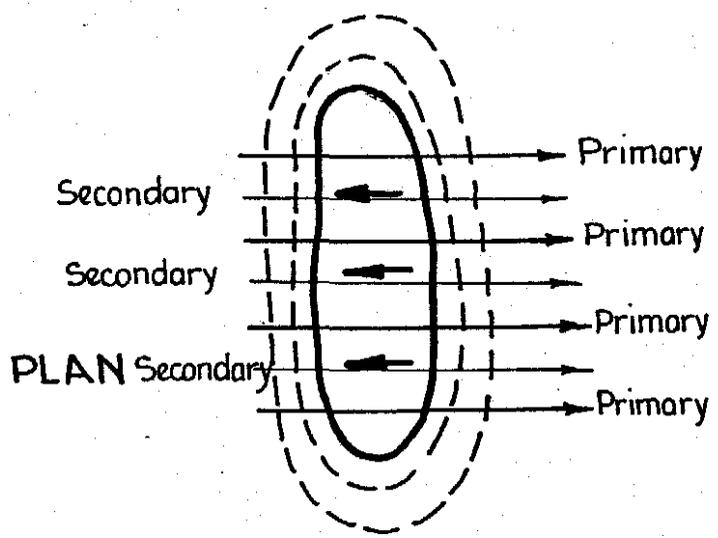
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LEGEND

-  Primary Current (over body)
-  Internal Polarization (at depth within body)
-  Secondary Current (I.P)
-  Secondary Potential Field



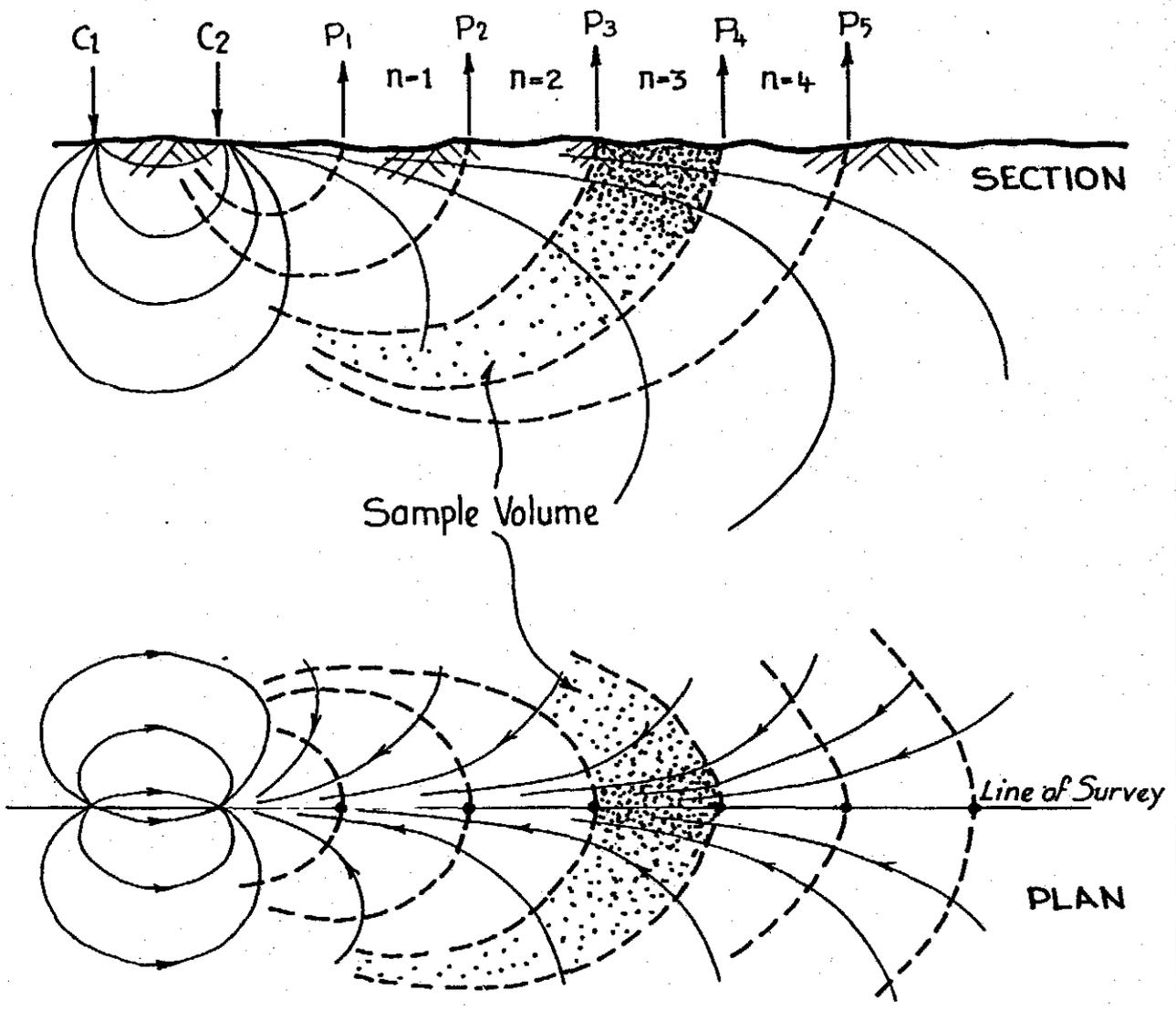
Diagrammatic representation of secondary current (I.P.effect) and secondary potential field in steep terrain.

FIGURE 2.

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Dipole - Dipole Array
Primary current paths and equipotential field
Showing volumes sampled

FIGURE 3

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Page - three

does not represent the characteristics of the ground at the point plotted, but that of the *total volume* sampled.

A further characteristic of the array is that where the effective spacing ($n \times a$) is greater than the depth to the source, a 'high' (or 'low', depending on characteristics) will occur as each of the dipoles (i.e. transmitting C_1 and C_2 and potential P_1 and P_2) pass over the source of that anomaly. The resultant 45° patterns on the pseudo-section DO NOT represent dip, or even depth extent, but merely represent a complex interference pattern over the source due to the potential and current dipoles. For a single source, this *double peak effect* can be recognised as it tends to have two maxima displaced by $(n \times a + w)$ where w is the width of the source. For multiple bodies this is difficult if not impossible to resolve by dipole-dipole arrays alone.

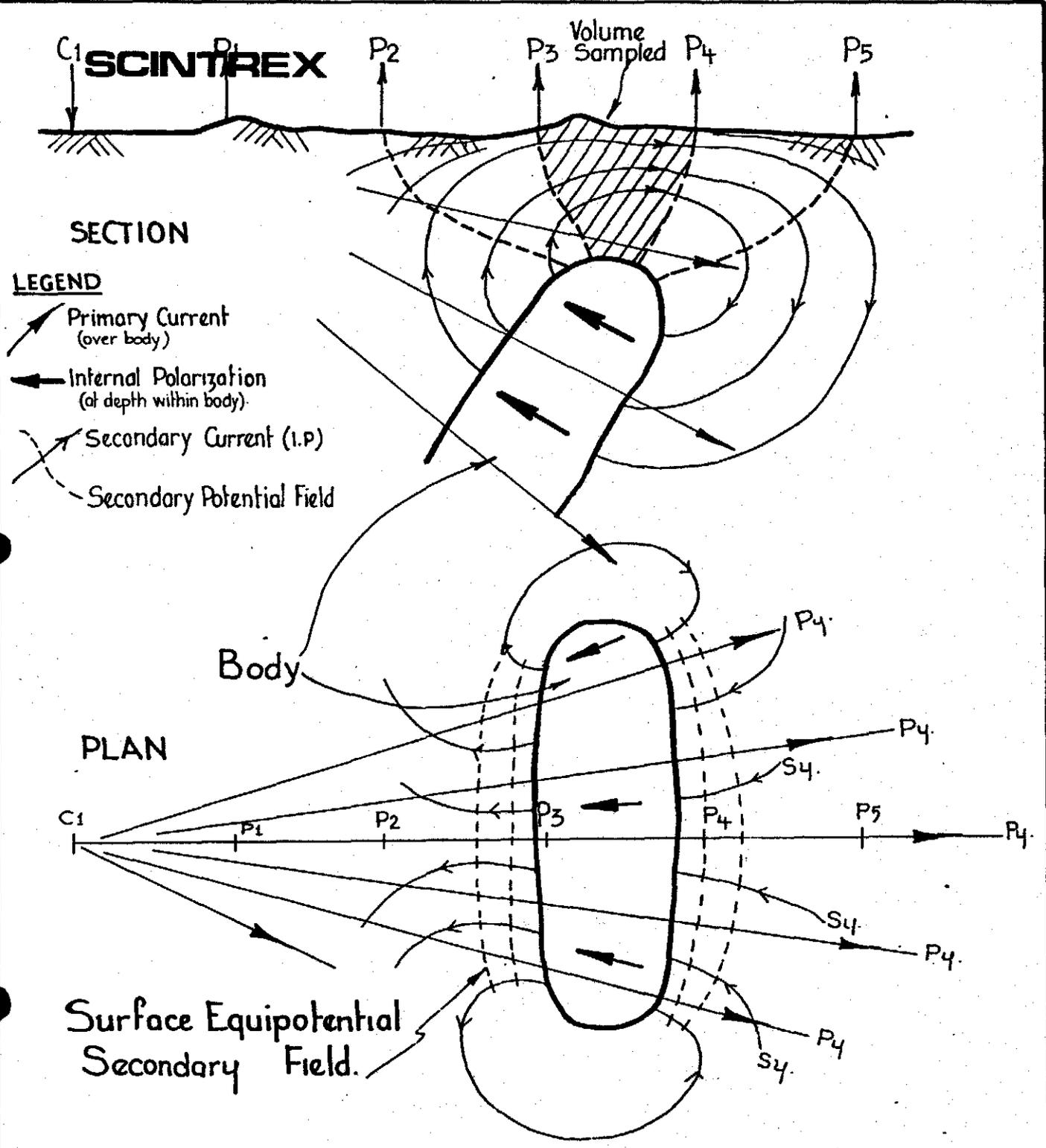
The enclosed Figure 4 shows the discharge of the energy stored in the body. As can be seen, the area sampled in section is tapped between the equipotentials generated by the discharge of the stored energy. These will not necessarily be of the same form as those for the resistivity data, although they are, for convenience, plotted in the same format as for resistivity. Again, it is vital to note that they represent the volume sampled as shown in Figure 4, *and not* the characteristics of the point at which they are plotted. Double peaks also occur as each of the two sets of electrodes pass over a source, where $n \times a$ is greater than the depth to source. Where $n \times a$ is less than the depth to source, a single maximum will be produced midway between the energising and measuring dipoles C_1/C_2 and P_1/P_2 .

Pole-Dipole:- This array is similar in principle to the dipole-dipole array,

except that a single electrode is placed 'close' to the potential dipole, with an 'infinite' electrode placed $10 \times n \times a$ away from the 'pole-dipole' set-up, and, where practical, at right angles to it. The enclosed Figure 5 shows the distribution of current flow in section and in plan, about the pole source C_1 . The potential electrodes P_1 and P_2 tap off the volume between them, which is contained between spheres whose centres are the pole source. The primary current reading is normalised for the geometry and plotted in profile or pseudo-section format as per dipole-dipole, namely, midway between the closest potential and current dipoles, which in the pseudo-section format is 45° towards the pole source. The chargeability reading is generated in a similar fashion to that described for dipole-dipole (Figure 4).

As with the dipole-dipole array, a double peak will result when $n \times a$ is greater than the depth to source, however, with pole-dipole it will be asymmetric. This will be true for both major resistivity features as well as for chargeability features. An example of this asymmetry for different depth to spacing arrays is shown for the three-array. (The three-array is a pole-dipole array when $n = 1$ and the a spacing is varied.)

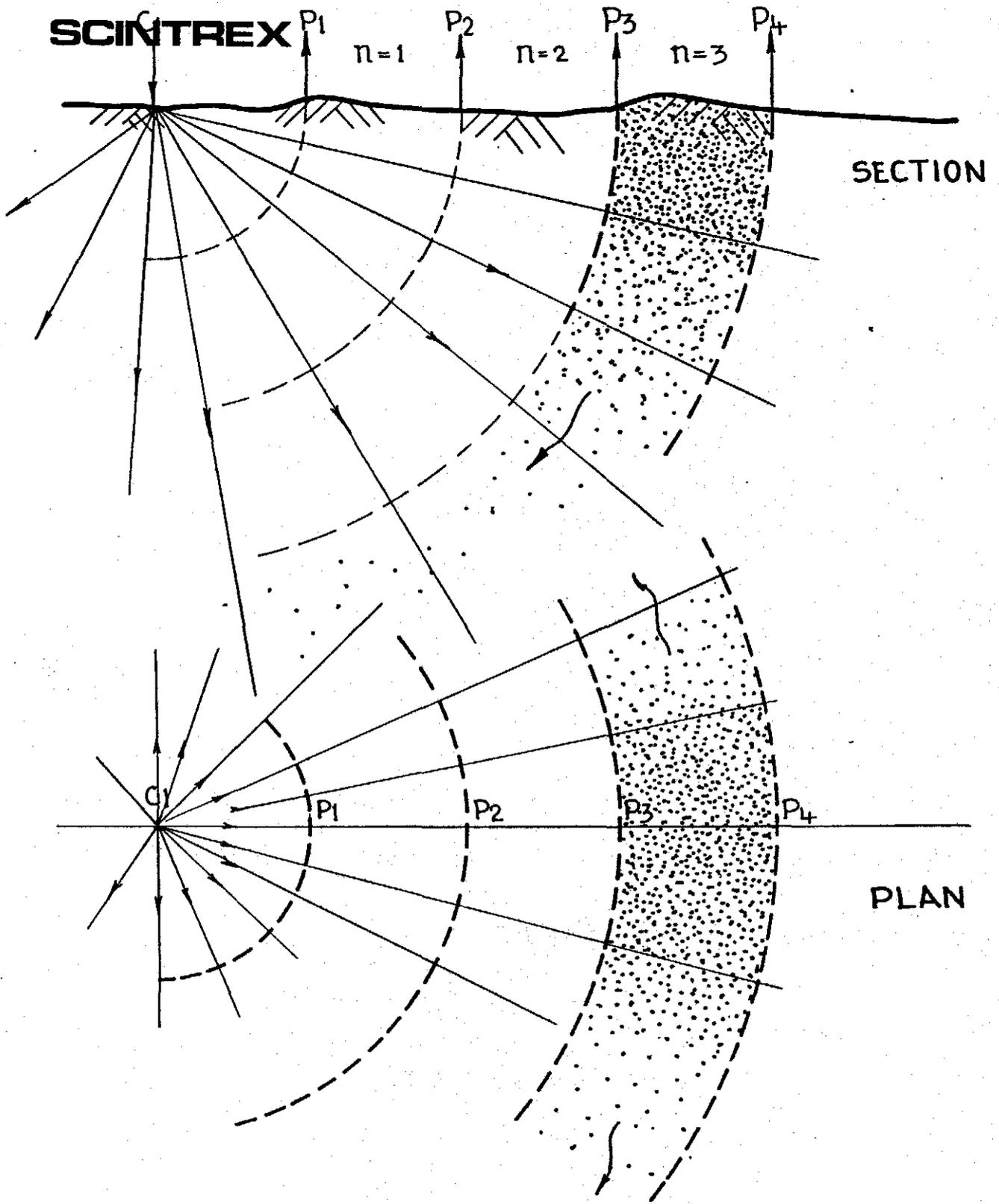
The Choice Between Arrays:- Even after some thirty years of active use of gradient, dipole-dipole and pole-dipole arrays, controversy still reigns as to the relative merit of the various arrays. Much depends on the object of the programme, the terrain, the type of source sought, the type and complexity of the overburden/oxidation. Table 1 shows a comparison between arrays which may be helpful, taken from a fairly recent Canadian Geological Survey publication. In resistive mountainous terrain the author prefers the gradient array as the prime reconnaissance method due to the high productivity (2 to 5 times that for



Current path and secondary equipotential field due to discharge of stored energy (I.P. effect) in the case of Pole-Dipole or Dipole-Dipole.

FIGURE 4.

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Current Path and Primary Equipotential Field
from Pole-Dipole Array

FIGURE 5

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SCINTREX SPHERE RESPONSE THREE ELECTRODE ARRAY

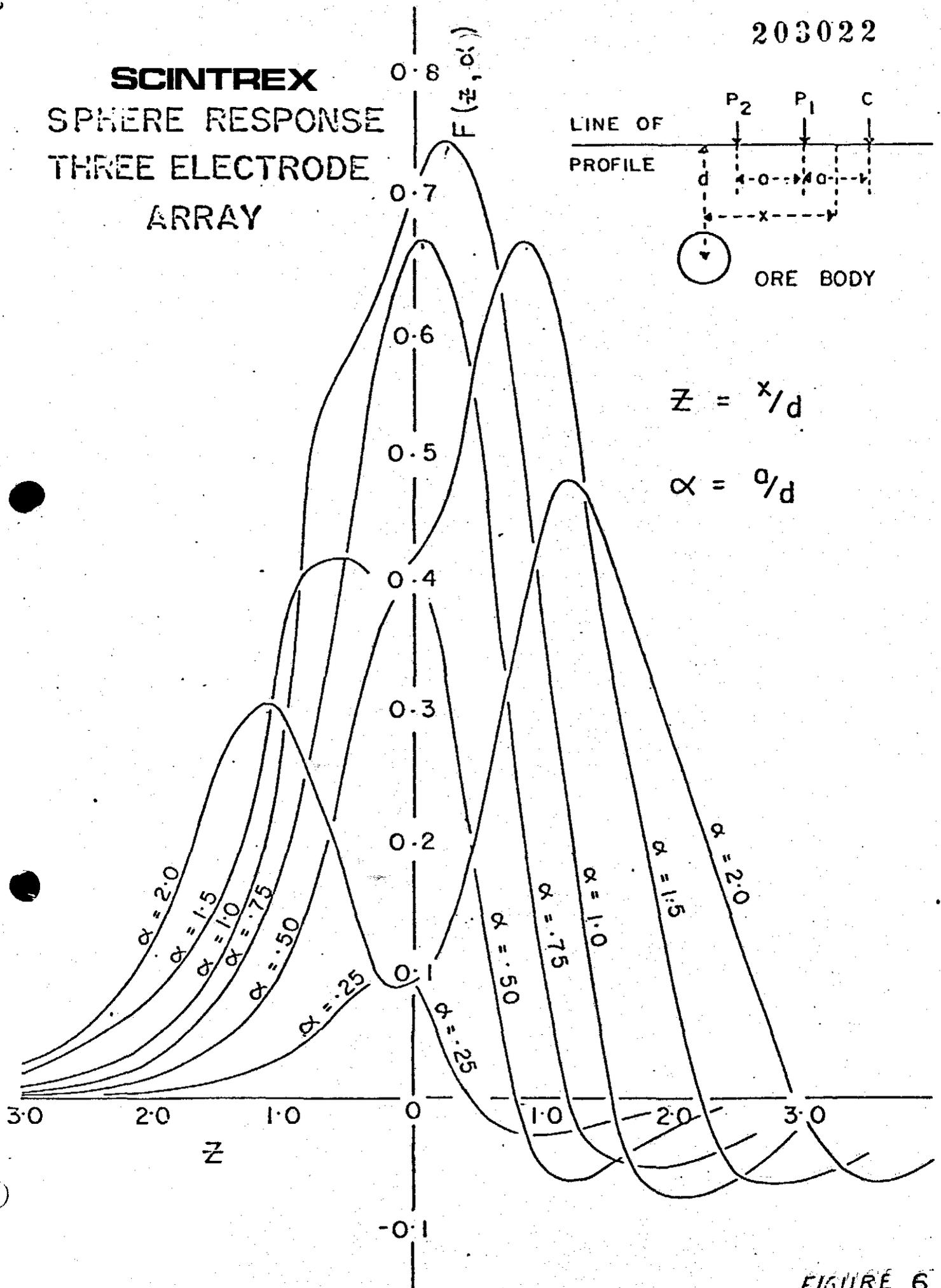


FIGURE 6

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dipole-dipole), but this should be followed-up by detailed dipole-dipole or pole-dipole surveys as the gradient array, while giving 'maximum depths', cannot give 'minimum depths' as moving source arrays can. Similarly pole-or dipole-dipole surveys which have complex or multiple sources can very often be resolved by use of limited gradient array detail. While pole-dipole is more efficient to apply in mountainous terrain, it tends to yield asymmetric double peak anomalies, however, to the trained observer, this is no disadvantage.

Brief Comments on Decay Form:- In most surveys three 'slices' of the decay form for the induced polarization response are acquired for each station as shown in Figure 7. While six slices are capable of being measured (M_1 to M_6), they are normally combined into pairs $M_1 + M_2 = M_1$ etc. as shown in Figure 7(C). Each of the slices M_1 to M_6 is normalised for a 'normal' decay form such that should the decay form be 'normal' $M_1 = M_3 = M_5$. Thus the operator can immediately recognise any anomalous decay forms which may arise from one of two major sources. Firstly the type of the source can influence the decay form. Coarse grained efficient sources such as sulphides show *slow* decay forms, magnetic and fine grained sulphides often show *fast* decay forms. This can be shown as $\Delta M = M_5 - M_1$, where positive ΔM infers *slow* decay form and negative ΔM *fast* decay form. A superior parameter is ΔM_n where

$$\Delta M_n = \frac{M_5 - M_1}{M_3} \times 100 \text{ (in percent)}$$

which is essentially ΔM normalised for the amplitude of the decay. ΔM and ΔM_n are merely short hand ways to profile changes in decay form and are essentially qualitative and relative.

Decay forms can also demonstrate the presence of electromagnetic coupling as Figure 7 shows. This is a regional effect as shown on Figure 7(b). This will

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normal decay

7(a)

decay curve modified by coupling

7(b)

electromagnetic coupling

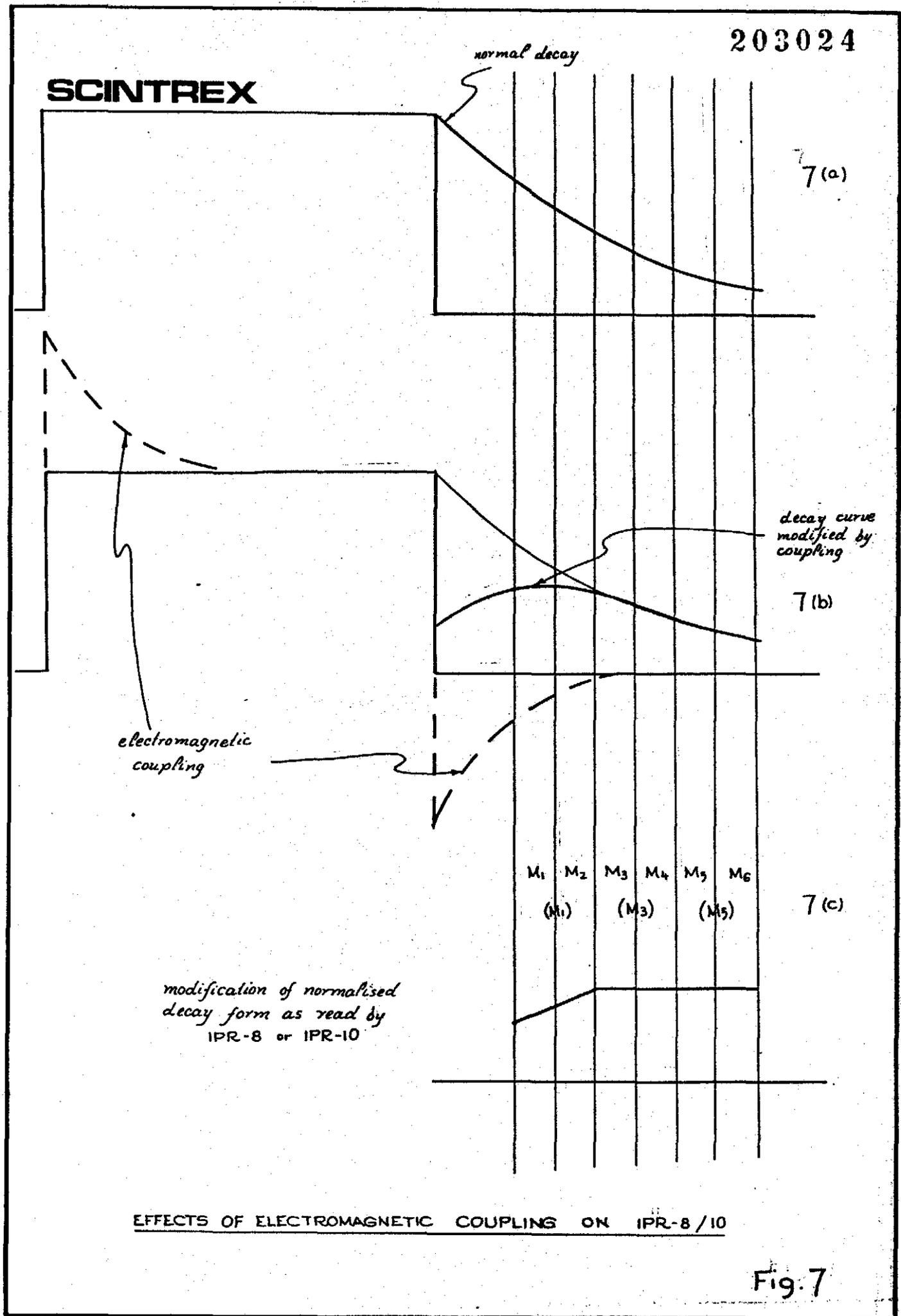
M ₁	M ₂	M ₃	M ₄	M ₅	M ₆
(M ₁)		(M ₃)		(M ₅)	

7(c)

modification of normalised decay form as read by IPR-8 or IPR-10

EFFECTS OF ELECTROMAGNETIC COUPLING ON IPR-8/10

Fig. 7



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produce a normalised M_1 smaller than either M_3 or M_5 .

Conclusion:- The above comments are indeed simplistic, and should be considered as a guide only. The author would be pleased to supply references on additional reading on any of the points commented upon.

A.W. HOWLAND-ROSE, MSc, DIC, AMAus IMM, FGS.

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TABLE 1
(Table 3.1)

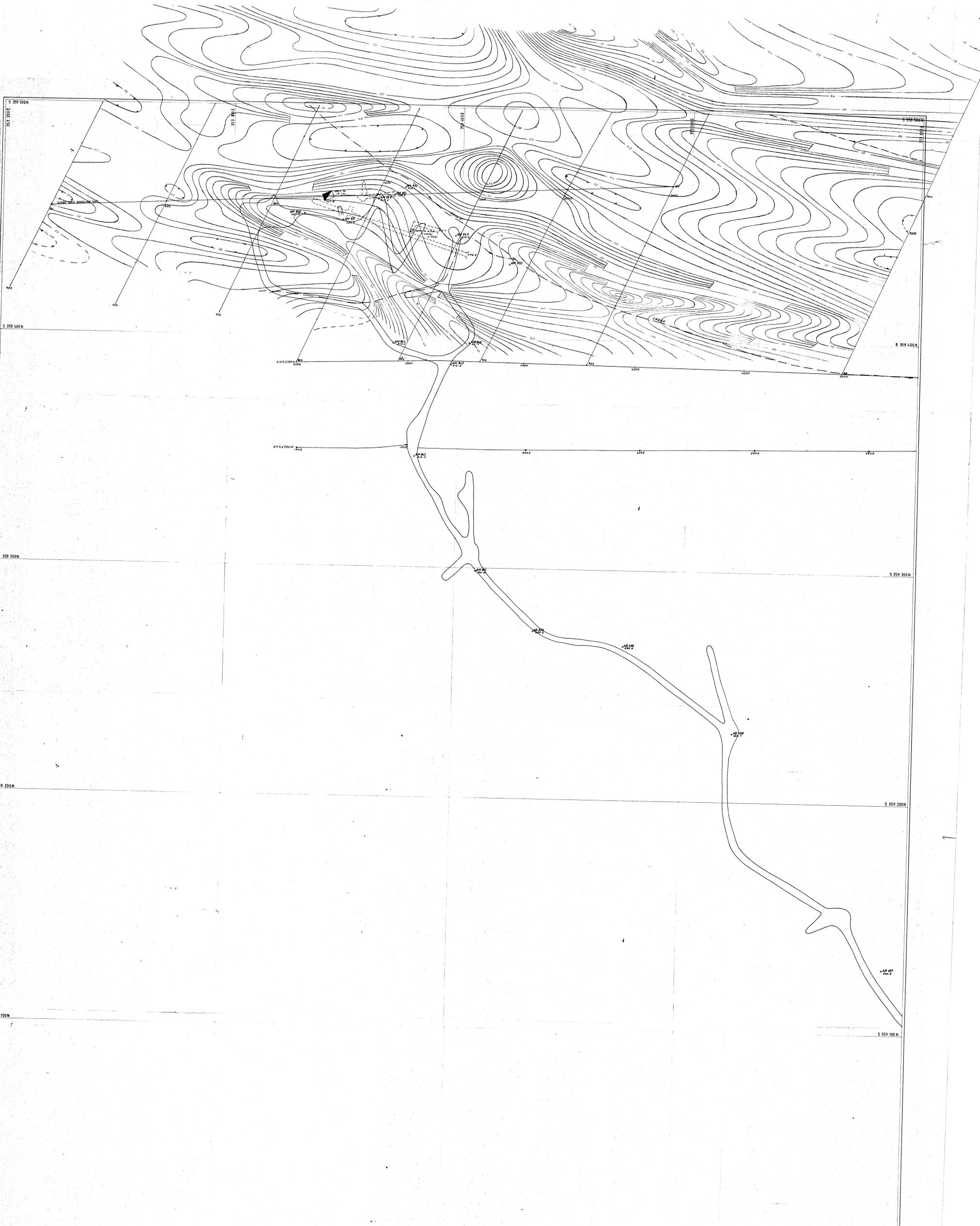
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SCINTREX Comparison of IP Survey Electrode Arrays

(after Sumner, 1972)

	Advantages	Disadvantages	Survey Speed	Signal to-Noise	EM Coupling Rejection
Parallel Field Arrays Wenner	Anomalies symmetrical Synchronous detector possible Many case histories available	Requires more wire: larger field crew Poor resolution Unfavourable in capacitive coupling situations	Fair	Good	Fair
Schlumberger	Symmetrical array Synchronous detection possible Fewer men required. Works well in layered earth Type curves available	Less horizontal resolution Unsuitable for horizontal profiling Capacitive coupling possible.	Fair	Fair	Fair
Gradient	Map interpretation easier Less masking by conductive overburden Penetration good; safer Communications easier Can use two or more receivers Less topographic effect Data easily contoured in plan Useful where difficulty in making good current contacts	Poor resolution with depth Poor in low resistivity areas Geometric factor varies complexly	Good	Fair	Poor
Point-About-a-Point Three-Array	Good reconnaissance array Fairly good resolution	Asymmetrical More wire needed	Fair	Good	Good
Pole-Dipole, Collinear	Good resolution Good subsurface coverage	Asymmetrical Asymmetrical	Fair	Fair	Fair
Perpendicular Three-Array, Pole-Dipole, Pole-Pole Pole-Pole (Two-Array)	Virtually eliminates EM coupling Smaller crew needed Less wire needed than for some arrays Good penetration in nonconductive overburden	More wire needed Susceptible to masking by conductive over-burden	Fair to Poor Good	Fair Fair	Very Good Poor
PDR (Potential Drop Ratio)	Sensitive to lateral variations "Common mode" noise rejection	Complex interpretation	Fair	Good	Fair
Dipole Field Array					
Dipole-Dipole, Collinear	Symmetrical, good resolution Good penetration Less survey wire needed	Slow unless equipment is portable Resistivity topographic effects Interpretation somewhat involved	Fair	Poor	Fair
Dipole-Dipole, Parallel	Special use for EM coupling interpretation.	Not used for routine surveying	Poor	Poor	Fair
Down-the-Hole Arrays					
Azimuthal Array (One Potential Electrode Down the Hole)	Fair for exploration purposes Useful in finding the best search direction	Interpretation complex Negative anomalies Strong geometric effects Mainly measures changes in resistivity	Fair	Good	Good
Radial Array (One Current Electrode Down the Hole, misc-à-la-masse)	Good for exploration purposes Useful in finding the best search direction Hole need not stay open	Interpretation complex Negative anomalies Not good for obtaining rock properties	Fair	Good	Good
In-Hole Arrays (More than One Electrode in the Hole)	Good for obtaining rock properties Good for assaying Interpretation simple	Current densities may be too large Possible capacitive coupling problems Not designed for exploration purposes Special equipment, expensive	Good	Fair	Good

Extract from: Geological Survey of Canada - Paper 75-31 "Borehole Geophysics Applied to Metallic Mineral Prospecting: A Review"



- Survey station and E.L.
- Grid line
- ▬ Wall
- ▭ Mine
- ▭ Trench
- Creek

TD13	TD14	TD15
TE13	TE14	TE15



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50m

85-2362

RENISON LIMITED

GLOBE MINE

GRADIENT ARRAY EIP SURVEY

CHARGEABILITY CONTOURS 874

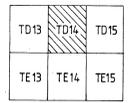
GEOLOGIST	A. ROBERTS	SCALE 1:500 METRES
DRAUGHTSMAN	P. COLSON	10 0 10 20
DATE	SEP. 1980	

SURVEYED & COMPILED BY SCINTREX
NOV-80 J44 P5 TAB-081C PLATE 1 SHEET 2

DRAWING No
TE 14



- Survey Station and R.L.
- Cut gold line
- Air
- Shed
- Wreck
- Stream

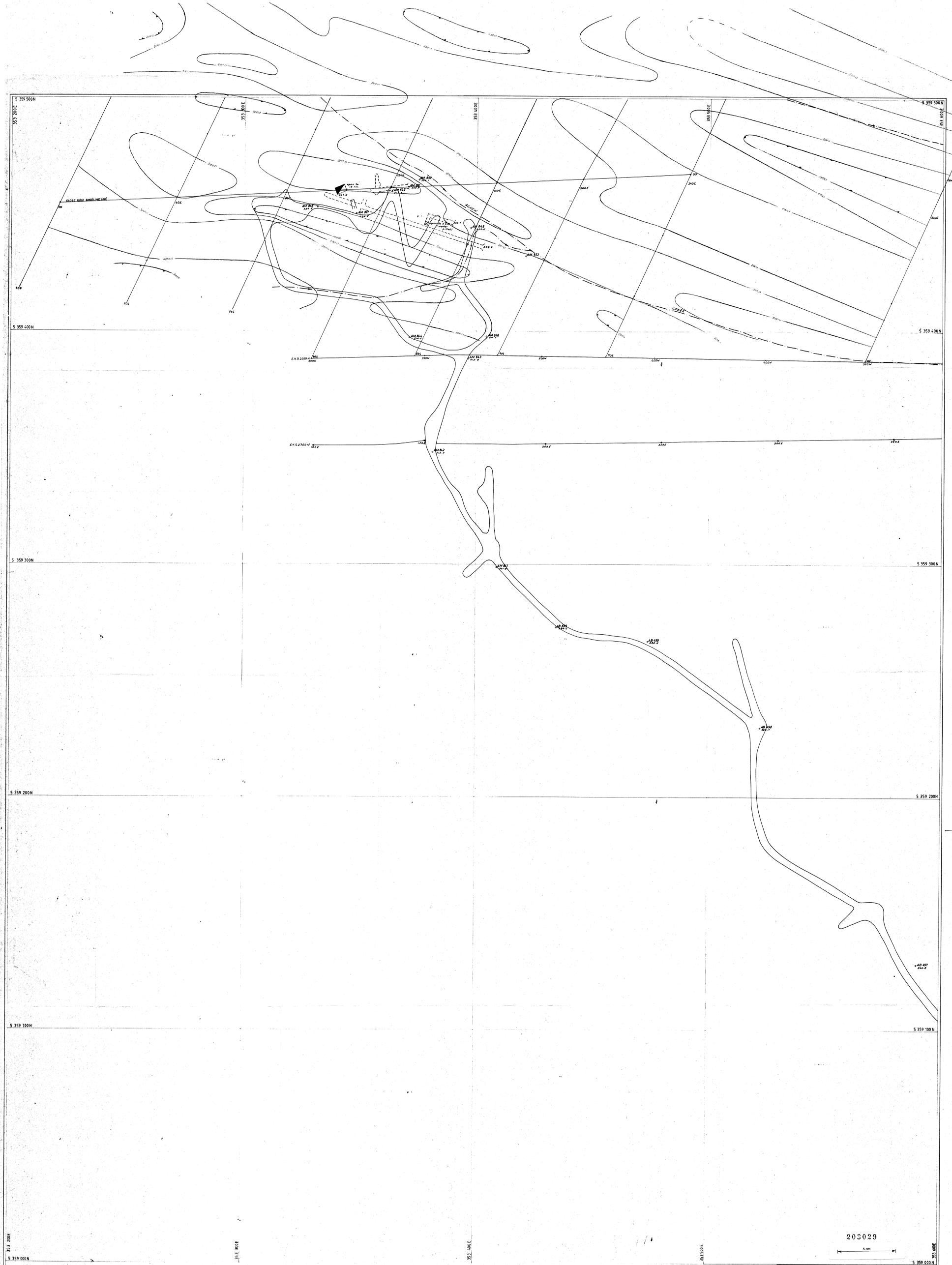


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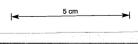
GLOBE MINE AREA

GRADIENT ARRAY EIP SURVEY
CHARGEABILITY CONTOURS 872

GEOLOGIST <i>P. ROBERTS</i>	SCALE 1:500 METRES
DRAUGHTSMAN <i>P. COLSON</i>	DATE <i>DEC 1980</i>
SURVEYED & COMPILED BY SCINTREX NOV 1980 JOB NO TAS-081C PLATE 1 SW 242	
DRAWING No TD 14	



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- Survey station and R.L.
- Grid line
- Shaft
- Mine
- Trench
- Creek

TD13	TD14	TD15
TE13	TE14	TE15



RENISON LIMITED

GLOBE MINE 03 875

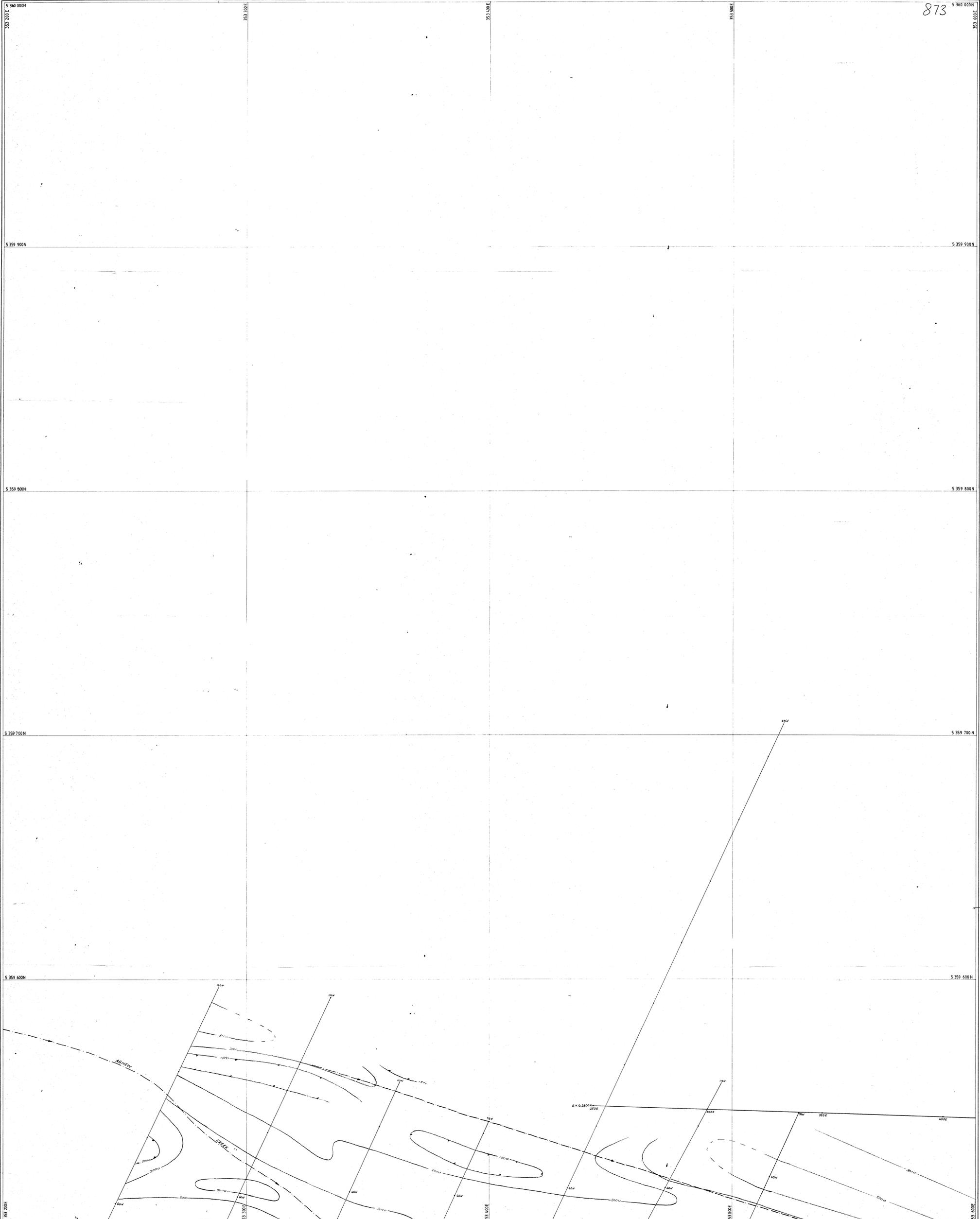
GRADIENT ARRAY EIP SURVEY
RESISTIVITY CONTOURS

GEOLOGIST A. ROBERTS SCALE 1:500 METRES
 DRAUGHTSMAN F. COLSON
 DATE Oct. 1980

SURVEYED & COMPILED BY SCHIREX DRAWING No. 10V 1880 Job No. TAS-081C PLATE 2, 1 of 2

TE 14

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GLOBE MINE AREA	
GRADIENT ARRAY EIP SURVEY RESISTIVITY CONTOURS 873	
GEOLOGIST	P. ROBERTS
DRAUGHTSMAN	F. COLSON
DATE	04F. 1980
SCALE 1:500 METRES	
SURVEYED & COMPILED BY SCITREX NOV 1980 Job No TAS-08/C PLATE 2 SHEET 2 of 2	
DRAWING No TD 14	

- Survey station and R.L.
- Cut grid line
- Shaft
- Mine
- Trench
- Creek

TD13	TD14	TD15
TE13	TE14	TE15



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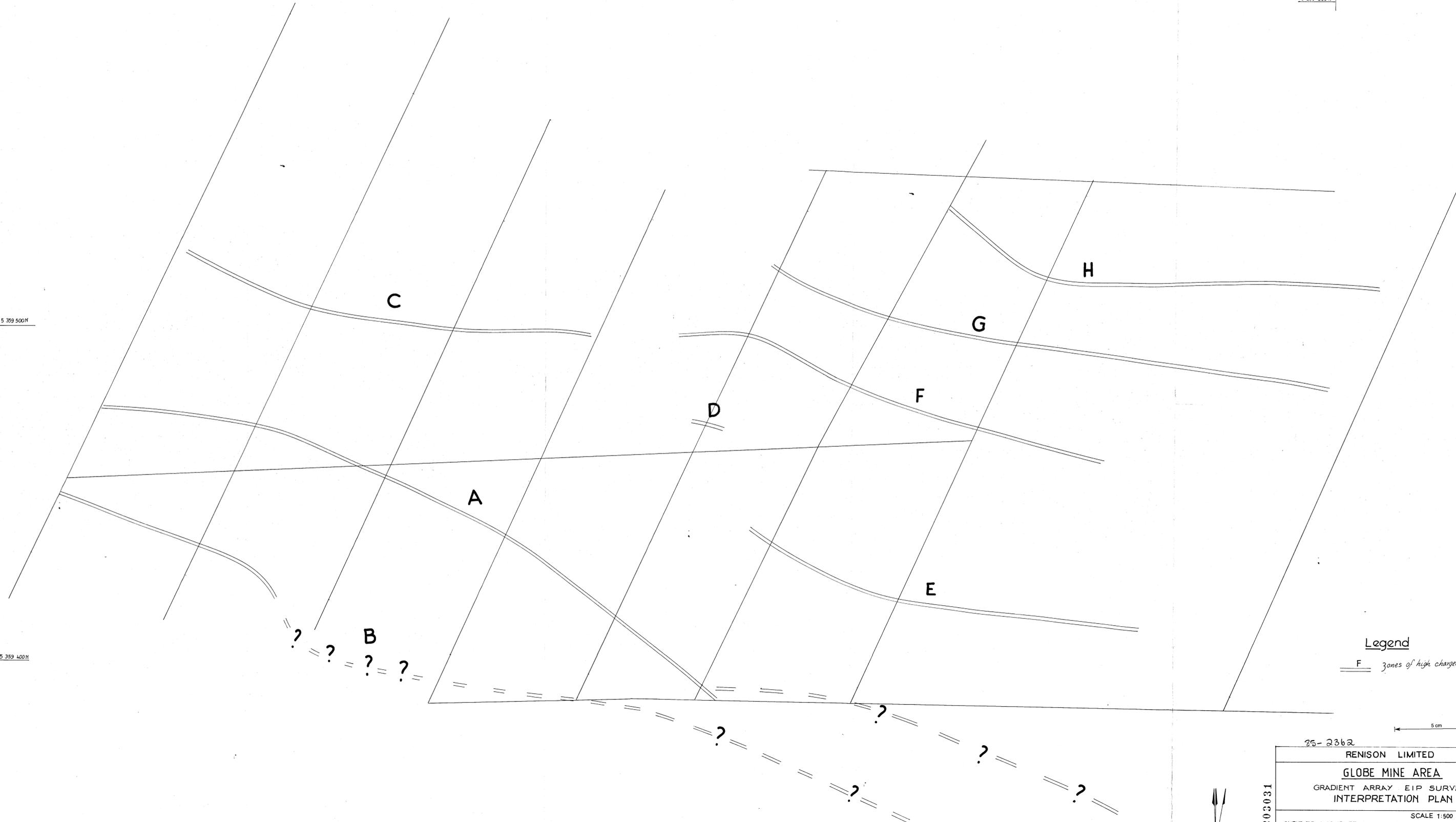
50m

5 359 600N

5 359 600 N

5 359 500N

5 359 400N



Legend

F zones of high chargeability

5 cm

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GLOBE MINE AREA 876

GRADIENT ARRAY EIP SURVEY
INTERPRETATION PLAN

203031

SURVEYED & COMPILED BY
SCINTREX

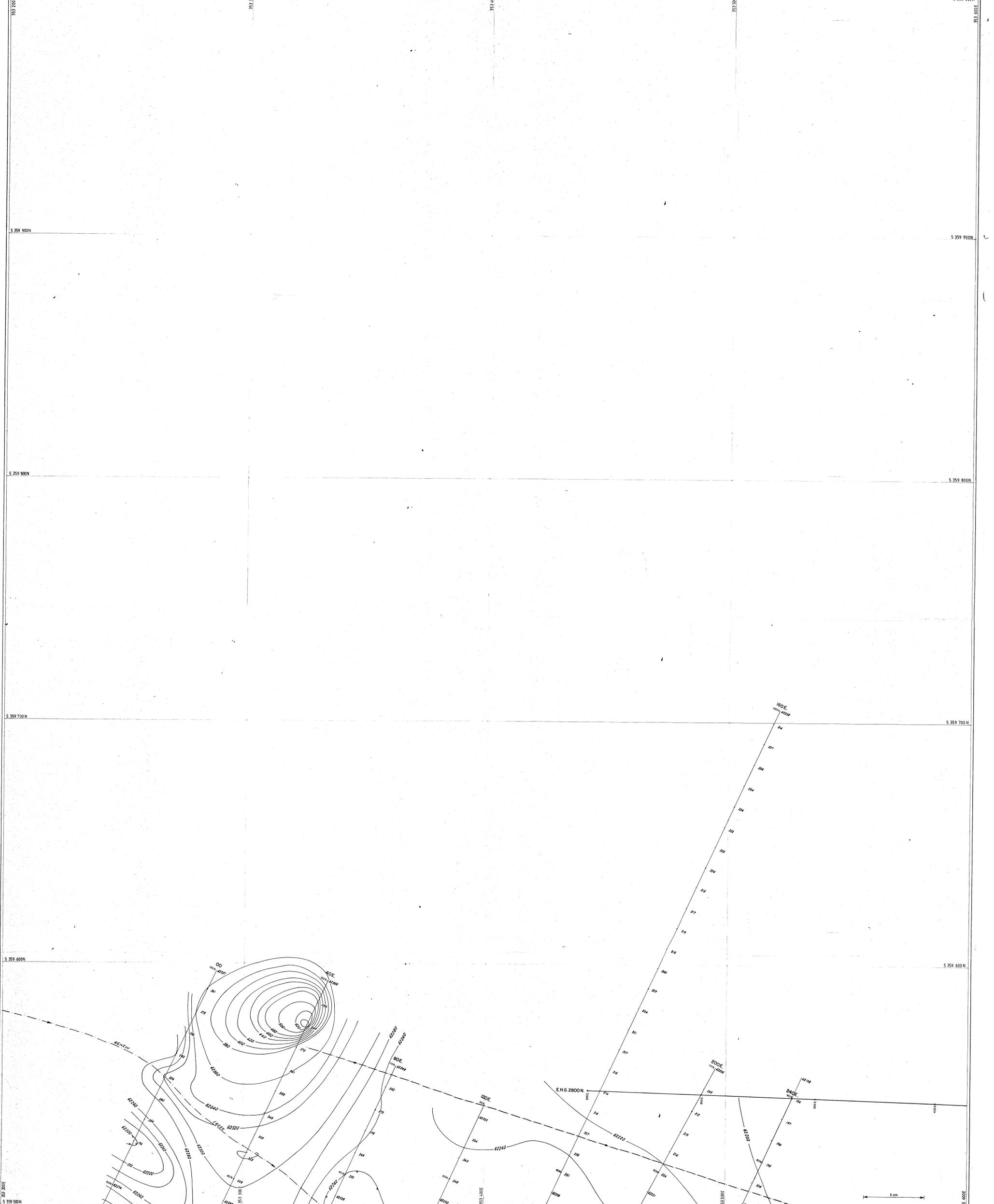
NOV-DEC 80
Job No TAS-081-C

SCALE 1:500 METRES



PLATE 3





- 4446 611 Survey Station and R.L.
 --- Cut grid line
 --- Airy
 ■ Shaft
 □ Mine
 --- Track
 --- Creek

NOTE: Contour Interval 20 G.
Readings taken with Proton Magnetometer.

TD13	TD14	TD15
TE13	TE14	TE15



RENISON LIMITED
GLOBE MINE AREA
GROUND MAGNETICS (TOTAL FIELD)

GEOLOGIST	C.C.	SCALE 1:500 METRES
DRAUGHTSMAN	T.G.D.S.	
DATE	July 1981	
REVISIONS	add on out	
		DRAWING No TD 14