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COMMENTS ON
ELECTRICAL INDUCED POLARIZATION SURVEYS
CARRIED OUT OVER HOWARD'S ANOMALY GRID
NEAR QUEENSTOWN, TASMANIA
ON BEHALF OF
MOUNT LYELL MINING AND RAILWAY COMPANY LTD.

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NEAR QUEENSTOWN, TASMANIA
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MOUNT LYELL MINING AND RAILWAY COMPANY LTD.

BY

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SYDNEY, N.S.W.

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GEOPHYSICAL CONSULTANTS AND CONTRACTORS

SUMMARY

A gradient array reconnaissance survey has defined some nine significant induced polarization anomalies within the rock unit mapped as Feldspar Feldspar-Hornblende Intermediate Tuffs, and four to five anomalous responses from within the rock unit mapped as Fe and Mn rich Lithic (Crystal) Tuffs, Pyritic Feldspar Crystal Tuffs, Carbonates and Minor Shales.

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INTRODUCTION

At the request of Mr. K. Reid, Chief Geologist for Mount Lyell Mining and Railway Company Ltd., Scintrex Pty. Ltd. executed gradient array and pole-dipole surveys over the Howard's Anomaly grid in the 79/80 field season. The details showing method, survey dates and personnel are as per Table I.

Earlier work carried out over Howard's Anomaly is presented in report dated October-December, 1974, pages 22 to 36, by the author.

The survey consisted of gradient array and pole-dipole arrays, each of which is separately described below.

*GRADIENT ARRAY SURVEY**INTRODUCTION*

The equipment consisted of a Scintrex 2.5/3 kilowatt generating time domain transmitter system. This was used to energise the ground in 6000 feet and 7000 feet arrays using a 2 second on, two second off, two second on and reverse and repeat sequence. The resultant field was investigated using a 100 feet potential dipole by an IPR-8 receiver employing a 2 second programme and three slices under the decay curve, of which only M_{32} (the centre slice)

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TABLE I

DATE	CREW LEADER	P	X	S	T	D. Allen	P. Duncan	K. Ryan	G. Cahill	M. Herrman	T. Cumming	M. Giles	J. Vella
22-10-79	B. Ekstrom				1	X							
23	"	1/2			1/2	X							
24	"	1					T						
25	"		1				T						
26	"		1				X						
27	"	1				AP	X						
28	"			1		AP	X						
29	"	1				AP	X						
30	"	1				AP	X						
31	"	1				AP	X						
1-11-79	"	1				AP	X						
2	"	1				AP	X						
3	"	1/2	1/2			AP	X						
4	"	1				AP	X						
5	"	1				AP	X						
6	"	1				G	X						
7	"	1				DD	X						
8	"	1				PD	X						
9	"	1				G	X						
10	"	1				G	X						
11	"			1		G	X						
12	"	1/4		3/4		G	X						
13	"	1				G	X						
14	"	1				G	X						
15	"	1/2		1/2		G	X						
16	"	1				G	X						
17	"					G	X	X					
18	"	1				G	X	X					
19	"	1				G	X	X					
20	"	1				G	X	X					
21	"			1		G	X	X					
22	"	1				G	X	X					
23	"	1				G	X	X					
24	"	1				PD	X	X					
25	"	1				PD	X	X					
26	"	1				PD	X	X					
27	"	1				M	X	X					
28	"			1		M	X	X					
29	"			1		M	X	X					
30	"			1		M	X	X					
1-12-79	"			1		M	X	X					
2	"	1				M	X	X					
3	"			1		M	X	X					
4	"	1				PD	X	X					
5	"			1		PD	X	X					
6	"	1				PD	X	X					
7	"	1				PD	X	X					
8	"	1/2		1/2		PD	X	X					

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TABLE I

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DATE	CREW LEADER	P	X	S	T	D. Allen	P. Duncan	K. Ryen	G. Cahill	M. Herrman	T. Cumming	M. Gilles	J. Vella
9-12-79	B. Ekstrom			1			X	X					
10	"			1			X	X					
11	"	1/2	1/4	1/4			X	X					
12	"	1				DHIP	X	X					
13	"			1			X	X					
14	"			1			X	X					
15	"	1					X	X					
16	"	1/2		1/2			X	X					
17	"			1			X	X					
18	"	3/4		1/4			X	X					
19	"	3/4		1/4			X	X					
20	"	1					X	X					
21-12-79	"				1		X	X					
~~~~~													
4-1-80	R. Malor				1		X		X	X			
5	"	1				PD	X		X	X			
6	"	1				G	X		X	X			
7	"	1				G	X		X	X			
8	"	1/2	1/2			G	X		X	X			
9	"	1				G	X		X	X			
10	"	1				PD	X		X	X			
11	"	1/2		1/2		PD	X		X	X			
12	"	1				PD	X		X	X			
13	"	1				PD	X		X	X			
14	"	1				PD	X		X	X			
15	"	1/2		1/2		PD	X		X	X			
16	"	1				PD	X		X	X			
17	"	1				PD	X		X	X			
18	"	1/2		1/2		PD	X		X	X			
19	"	1/2		1/2		PD			X		X	X	
20	"	1				PD			X		X	X	
21	"	1				PD			X		X	X	
22	"	1/2		1/2		PD			X		X	X	
23	"	1				PD			X		X	X	
24	"	1				PD			X		X	X	
25	"	1				PD			X		X	X	
26	"	1				PD			X		X		X
27	"		1			PD			X		X		X
28	"		1			PD			X		X	X	
29	"	1				PD			X		X	X	
30	"	1				PD			X		X	X	
31	"		1			PD			X		X	X	
1-2-80	"	1				PD			X		X	X	
2	"	1				PD			X		X	X	
3-1-80	"	1/2			1	PD			X		X	X	

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 G = Gradient PD = Pole-dipole DD = Dipole-dipole M = Magnetics AP = Applied Potential DHIP = Down hole EIP
 Relevant survey dates outlined in red

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has been plotted.

Table 2 lists the various current dipoles used to cover the survey lines.

TABLE 2

| | |
|--------------------------------------|---------------------------------------|
| 6250W and 750 E on 250' south of 24N | Lines 25N, 24.5N, 24N, 23.7N, 23.4N |
| 7000 feet | 23N, 22.5N, 22.2N, 22N, 21.9N |
| 4750W and 1250E on 20N | Lines 21.6N, 21.3N, 21N, 20.6N, 20.3N |
| 6000 feet | 20N, 19.7N, 19.4N, 19N |

DATA PRESENTATION

The data profiles are displayed at the scale of 1 centimetre = 100 feet, with chargeability at 1 centimetre = 2 millivolts/volt, decay curve information, ΔM , at 1 centimetre = 1 millivolt/volt, while resistivity is displayed on a 5 centimetre log scale.

The resistivity and chargeability data have been contoured on a scale of 1:5000 and are displayed on Plates 1 and 2.

DISCUSSION OF RESULTS

General Geophysical Characteristics:-

The geological strike in the area varies about grid north south and each of the mapped units have distinct geophysical characteristics. In the west the unit mapped as *Intermediate Lavas and Volcanics (A)* is characterised by lower than average apparent resistivities of 700 ohm-metres to 2000 ohm-metres where it adjoins the *Feldspar Unit (B)*. However, much higher resistivities of

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10,000 ohm-metres were noted in the western sections of lines 19N to 21N which are more akin to rock type (A) (Intermediate Lavas). Chargeabilities within unit (A) range about the 20 millivolts/volt $\pm 2\frac{1}{2}$ millivolts/volt.

Geological unit (B) *Feldspar and Feldspar-Hornblende Intermediate Tuffs*, has significantly higher resistivity backgrounds of 3000 ohm-metres plus, and is invariably accompanied by 20 to 25 millivolts/volt background chargeabilities on which a number of significant induced polarization maxima to twice this background have been recorded. The eastern boundary of the unit is marked by a series of significant resistivity lows at or within unit (C) (Lithic Tuff) together with a fall-off in chargeability background to 15 to 20 millivolts/volt. The resistivity and chargeability data suggests some slight adjustment in the interpreted boundary between units A, B and C is warranted.

Unit (C) *Fe and Mn rich Lithic (Crystal) Tuffs, Pyritic Feldspar Crystal Tuffs, Carbonates and Minor Shales*. It is suggested that the low resistivities noted near the boundary with unit (B) represents a distinct rock unit, perhaps non-pyritic or non-graphitic shales, as they are accompanied by low to normal chargeability backgrounds. Only one distinct induced polarization anomaly was located on one line either side of 23N. Other than the low resistivity 'marker' horizon referred to above which reaches less than 2000 ohm-metres on a discontinuous trend, resistivities in this unit are similar to those recorded within unit (B).

Unit (D) *Quartz Feldspar Agglomerates, Lavas and Flow Crystal Tuffs* are not well covered by the induced polarization survey, however, where they are, distinctly lower chargeabilities of less than 10 to 15 millivolts/volt and

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moderate (5000 ohm-metres<sub>+</sub>) resistivities were recorded.

Significant Induced Polarization Anomalies:-

These are described from north to south. The zone number is marked both on the profiles and on the chargeability contour map.

ANOMALIES ASSOCIATED WITH ROCK UNITS (A) AND (B) (Zones A to I)

ZONE A

This anomaly was located on lines 25N, 24.5N and 24N and is open to the north. On *line 25N* the maximum value is seen at 3950W where a 36 millivolts/volt value was recorded. A second maximum of 34 millivolts/volt was recorded at 3750W. The western maximum is flanked by a steep change in chargeability and as such, the maximum depth to source cannot be greater than 200 feet. The eastern maximum shows a more gradual decline, and could have a maximum depth of 300 feet. The *form* of the response suggests a broad zone, 200 feet wide, with two segregations. The asymmetry of the anomaly *may* indicate an easterly dip. The very high associated resistivities of 5000 ohm-metres<sub>(+)</sub> clearly infer a disseminated source, or if 'massive', an electrically discontinuous one. The rocks to the immediate west are significantly *less* resistive at 1000-2000 ohm-metres, however, the background chargeability is 20 to 22 millivolts/volt and therefore they are not anomalously polarizable.

To the south on *line 24.5N*, two distinct peaks were defined, one at 3850W (shoulder) and the second at 3650W of 36 millivolts/volt and 41 millivolts/volt respectively. The maximum depth to source in both cases looks to be of the order of 200 feet. The associated resistivity is about 3000 ohm-metres, and shows no contrast with the less polarizable enclosing material. Therefore

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the source is disseminated in nature.

On *line 24N* a 39 millivolts/volt maximum was noted at 3750W accompanied by a minor decrease in the otherwise high 3000 ohm-metres resistivity. A second related maximum (as a shoulder) was recorded at 3500W. The maximum depth to source for these two maxima are respectively 200 feet and 150 feet.

To the south a broad minor increase in chargeability of 4 millivolts/volt from the 20 millivolts/volt background was noted between 3200W and 3900W (note true position, pegging error present) which indicates that a weak disseminated halo or end effect is present on this line (23.7N). The 'steep' cut-off infers the former rather than the latter.

ZONE B

This anomaly was recorded within rock unit (B) (*Feldspar and Feldspar-Hornblende Intermediate Tuffs*) on two lines as a major response - 24.5N and 24N - with a sinistral en-echelon displacement to anomaly C to the south, which is of similar form. Lesser along strike responses were recorded on lines 25N and 23.7N.

Line 25N - A small but significant reading of 30 millivolts/volt was recorded at 3250W which is some 10 millivolts/volt above the 20 millivolts/volt background to the west, but over 20 millivolts/volt above the background to the east. The associated resistivity shows a minor decline to 3000 ohm-metres and thus the source must be disseminated in nature. The maximum depth to source is estimated to be of the order of 200 feet.

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Line 24.5N-The anomaly on this line reaches 18 millivolts/volt above the 20 millivolts/volt background to the west, but 35 millivolts/volt above the low chargeability to the east at 2850W. Again the maximum depth is assessed at about 200 feet, and the origin disseminated, or if 'massive' electrically discontinuous.

Line 24N - On this line the anomaly reaches 19 millivolts/volt against the 20 millivolts/volt background to the west, but 30 millivolts/volt against the much lower background to the east. The associated resistivity is again high, 3500 ohm-metres to the west of the maximum and 10,000 ohm-metres to the east of the maximum. Thus, in this case the chargeable source is associated with a marked change in resistivity, but is nevertheless very high. Therefore the source is again inferred to be disseminated. The maximum depth to source is assessed to be of the order of 250 feet.

Line 23.7N - At 3000W a relatively small 17 millivolts/volt induced polarization response from a source whose bulk resistivity is of the order of 3000 ohm-metres is considered to be the most southerly extension of zone B. The maximum depth is estimated at 150 feet +50 feet, and the source is again inferred to be disseminated in nature.

ZONE C

The main anomaly within this zone was located on line 23.4N at about 2600W, with lesser responses on the adjacent lines.

Line 23.7N - This is the most northerly line on which the anomaly can be identified. Here a 10 millivolts/volt maximum is associated with very high

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10,000 ohm-metres resistivities. The maximum depth to the disseminated source is estimated at 150 feet +50 feet at 2750W.

Line 23.4N - The maximum chargeability is centred at 2600W where a 16 millivolts/volt above the western (20 millivolts/volt) background was recorded. This contrasts with the 10 to 12 millivolts/volt background to the east. The associated resistivity at 4000 ohm-metres while high, is *less* than the enclosing resistivity of 9000 to 10,000 ohm-metres, and as such the chargeable material may well show weak interconnection between the chargeable source grains. The maximum depth is no greater than 150 feet.

Line 23N - On this line the anomaly is seen only as a 4 to 5 millivolts/volt above background chargeability response centred at 2650W and extending some 100 feet either side thereof. A slight decrease in the high resistivity was noted over this anomaly.

ZONE D

This is a relatively minor response recorded on line 22.5N at 2350W as a 7 millivolts/volt above background anomaly and *perhaps* on line 22.2N at 2650W as a 5 millivolts/volt anomaly. The high resistivities again show a disseminated source to be present, the maximum depth to which is 150 feet. This anomaly is of minor interest only.

ZONE E

This zone is one of three significant induced polarization responses associated with rocks units (A) and (B) between lines 22.2N and 21.3N.

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The anomaly lies within the zone mapped as *unit (A)* and is seen on *line 22N* as a maximum chargeable value of 32 millivolts/volt centred at 3000W as against a background of about 20 millivolts/volt. The associated resistivity recorded over the anomaly was 2000 ohm-metres, which while less than for other zones, is nevertheless high, and thus the source is again thought to be predominantly disseminated. The maximum depth is difficult to gauge due to the *broad* nature of the source, however, a guesstimate is 150 feet.

Line 21.9N - the anomaly is best seen on this line as a distinct and dramatic 12 millivolts/volt above background (22 millivolts/volt) anomaly centred at 2700W. The resistivity falls to 2000 ohm-metres over the anomaly peak to reach a low 600 ohm-metres at 2450E. The maximum depth to the chargeable source is of the order of 150 feet.

Line 21.6N - No clear, unambiguous manifestation of this zone was recorded on this line.

ZONE F

This zone is one of the most significant induced polarization anomalies recorded in the area on both lines 22N and 21.9N. Each lies in close proximity to the mapped contact between rocks units (A) and (B) (*Intermediate Lavas and Intrusives against Feldspar and Feldspar-Hornblende Intermediate Tufts*)

Line 22N - The maximum of 24 millivolts/volt above background was defined at 2650W with the hint of a second maximum at 2500W inferred as a shoulder. The anomaly lies on a sharp change in resistivity from less than 1000 ohm-metres at 2750W to over 8000 ohm-metres at 2450W. Thus the disseminated sulphides

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lie on the contact between two markedly different rock types. The maximum depth to source is estimated at 100 to 150 feet.

Line 21.9N - An even more significant maximum of 30 millivolts/volt above background was recorded on line 21.9N at 2250W. As with line 22N, the anomaly is centred on a material change in resistivity from less than 1000 ohm-metres at 2450W to over 7000 ohm-metres at 2000W. Thus disseminated sulphides (or graphite) on a contact between two markedly different rock types is suggested. The maximum depth to source is estimated to be of the order of 200 feet.

Line 21.6N - A 12 millivolts/volt anomaly centred at 2050W again on a sharp resistivity contact is considered to be the most southerly manifestation of this zone. Again a disseminated sulphide origin for this anomaly is suggested.

Note on Zones E and F

The form of the anomalies which make up zones E and F on lines 22N and 21.9N are such that a distinct resistivity low of 700 ohm-metres on lines 22N at 2450W and 22N at 2750W are flanked to the east and west by the high chargeability of zones E and F. It is quite possible that the *entire width* enclosing zones E and F on these lines make up a single broad zone, with the resistivity low in the centre representing a *relatively more interconnected source* centre (i.e. more massive?). This possibility should be borne in mind when considering the geological implications of these two zones.

ZONE G

This zone extends over four lines (22N to 21.3N) as a contact zone and lies

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wholly within the rock unit mapped as *Feldspar and Feldspar-Hornblende Intermediate Tuffs* (unit (B)).

Line 22N - A most significant 15 millivolts/volt anomaly centred at 2150W was located associated with a slight decrease in apparent resistivity to 4000 ohm-metres from 8000 ohm-metres plus to the immediate east and west. The source is narrow, probably dips steeply to the east, and has a maximum depth to source of about 150 feet.

Line 21.9N - A much broader response was defined on line 21.9N at 1800W where a 12 millivolts/volt anomaly was recorded from a zone whose 2000 ohm-metres resistivity is a distinct decrease on the 7000 ohm-metres to 10,000 ohm-metres seen to the immediate east and west. Thus the source probably has weakly interconnecting sulphides (or graphite) as well as disseminated material also. The maximum depth to source is estimated at 150 to 200 feet.

Line 21.6N - A 12 millivolts/volt anomaly at 1850W is considered to be the southerly extension of zone G. A slight decrease in resistivity to 4000 ohm-metres was recorded which *may* infer weak interconnection within the source. The maximum depth is difficult to assess as the source is broad, or multiple - a guesstimate would be about 200 feet(?).

Line 21.3N - The broad zone over which higher induced polarization values were obtained extends from 1650W to 2300W and probably represents the extremities of both zones F and G as they merge into zone H. G is however, seen as a distinct 10 millivolts/volt broad anomaly situated at 1750W over 4000 ohm-metres material which is *more* resistive than the 2500 ohm-metres rocks which

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enclose it. Thus, in this case, Zone G is not only disseminated but may also show some silicification, or is contained in a more resistive rock type. The maximum depth to source is estimated at 200 feet.

Line 21N represents a line midway between zones F and G in the north, and zone H to the south. The sharp boundaries to the anomaly at 2400W and 1750W are significant, and as the western background is now decreased to 14 millivolts/volt this emphasises this anomaly on this line.

ZONE H

This zone is situated on the western flank of the zone mapped as *Feldspar and Feldspar-Hornblende Intermediate Tuffs*. Unlike other induced polarization responses on the western margin of this unit, the amplitudes are more prominent due to the much lower background chargeability noted over unit A (*Intermediate Lavas and Intrusives*). A significant facies change is thus inferred in this unit from north to south, particularly south of line 21.6N.

Line 20.6N - Two significant maxima of 36 millivolts/volt and 32 millivolts/volt were recorded at 1950W and 1650W respectively. These are on a 'local' background of about 20 millivolts/volt. Each maximum shows lower resistivity of 2000 ohm-metres as against over 3000 ohm-metres between, and east and west of, the chargeability maximum. Thus some weak interconnection within the source is postulated. The maximum depth to those sources is estimated at 300 feet at 1950W and 200 feet at 1650W.

Line 20.2N - A most significant 18 millivolts/volt above background anomaly was recorded centred at 1850W while a secondary 'shoulder' of 10 millivolts/volt

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at 1600W was also recorded. The 3000 ohm-metres resistivity infers a disseminated source for both maxima. The maximum depths are estimated at 300 feet at 1850W and 150 feet at 1600W.

Line 20N - On this line a single impressive maximum of 20 millivolts/volt was recorded at 1750W together with 3000 to 4000 ohm-metres resistivities. The form of the anomaly suggests a steep east dip, however, a second source to the east of the major peak may cause a similar slope.

Line 19.7N - A most impressive symmetric induced polarization anomaly of 25 millivolts/volt above background was recorded centred at 1750W. A minor depression in resistivity to 1800 ohm-metres from 3000 ohm-metres to the immediate east and west shows some weak interconnection between grains within the source. The maximum depth to source looks to be about 300 feet. This zone reaches its maximum amplitude on this line.

Line 19.4N - On this line a most significant 20 millivolts/volt above background chargeability anomaly was located at 1950W whose asymmetry suggests a shallow maximum depth of 100 to 150 feet, and an east dip. A distinct resistivity low centred at 1750W may be a related feature, either being down dip, or on the flank of a more disseminated zone. This is the most southerly line on which zone H was recorded, as on line 19N, it appears to fishtail out.

ZONE I

Within rock unit B (Feldspar and Feldspar-Hornblende Intermediate Tuffs), two small but definite anomalies were located which make up zone I. IN was

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centred on line 21N at 1450W, and I_S on line 20N at 1300W.

Line 21N (I_N) - A single station 7 millivolts/volt induced polarization anomaly was located at 1450W associated with a very slight decrease in the otherwise high 6000 ohm-metres resistivity. The maximum depth to source is less than the potential dipole used, namely 100 feet. The source therefore is narrow, and slightly more conductive than the enclosing rocks. On *line 20.6N* a minor response at 1350W is probably the southernmost manifestation of this high.

Line 20N (I_S) - A substantial 8 millivolts/volt to 10 millivolts/volt induced polarization response was centred at 1300W from a source whose resistivity shows a 60% decrease to 3000 ohm-metres. The source therefore is relatively weakly conductive. The maximum depth to source is estimated at 150 feet.

Line 19.7N (I_S) - A minor, but still significant 5 millivolts/volt recorded at 1300W is allied to a depression in the resistivity data. This is a small disseminated source whose maximum depth is of the order of 150 feet.

ANOMALIES ASSOCIATED WITH ROCK UNIT (C) (Zones V to Z)

ZONE V

The zone occurs close to the *unit (B)/unit (C)* contact. This zone is really only seen on *line 25N* centred at about 2700W where it rises some 10 millivolts/volt above the background with no appreciable change in resistivity. The maximum depth to source is about 200 to 250 feet. On *line 24.5N* a sharp local end of line anomaly of the same order is open to the east. Again a disseminated source is inferred at 200 feet centred at 2750W.

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The remainder of the anomalies occur wholly within zone C, east of a distinct low chargeability marker horizon (see chargeability contour plan).

ZONE W

The most northerly manifestation of this zone is probably recorded on *line 25N* as a 10 millivolts/volt response above the 8 millivolts/volt background. The background resistivities remain a high 7000 to 10,000 ohm-metres, inferring a disseminated source, while the maximum depth to source at 1950W is of the order of 200 feet.

Line 24N - On this line a sharp 16 millivolts/volt maximum was recorded centred at 1900W from a source at an estimated depth of 150 feet. The resistivity shows a decline to 8000 ohm-metres from 11,000 ohm-metres inferring a slight conduction within the otherwise disseminated source.

Line 23.7N - On this line, zone W reaches some 20 millivolts/volt above background at 1650W but is open to the east. The higher 7000 ohm-metres resistivities infer a disseminated source at a maximum depth of 200 feet.

Line 23.4N - Zone W on this line is seen as a strong 16 millivolts/volt above the low 8 millivolts/volt background centred at 1550W. A slight depression in the resistivity data to 4000 ohm-metres suggests very weak conduction within the source relative to the enclosing rocks. The source is therefore disseminated in nature, and has an estimated maximum depth of the order of 250 feet.

To the south of this line, zone W is insignificant.

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ZONE X

This zone extends from line 23.7N to 22N, but is material only on lines 23.4N 23N and 22.5N. The associated resistivities invariably remain high, thus the source is considered to be disseminated.

Line 23.7N - A relatively small 8 millivolts/volt above the 8 millivolts/volt background anomaly was located at 1950W from within 6000 to 7000 ohm-metres material. A shallow (100 feet) narrow disseminated source is interpreted.

Line 23.4N - A most significant 27 millivolts/volt anomaly above the 8 millivolts/volt background was recorded at 1800W. The resistivity shows a slight decrease to 3000 ohm-metres from 6000 ohm-metres to the east and west inferring weak conduction within the source. The maximum depth to that source is estimated at 250 feet.

Line 23N - A substantial 35 millivolts/volt above background (8 millivolts/volt) anomaly was recorded at 1750W from 7000 ohm-metres material. The disseminated source is both narrow (i.e. less than 100 feet) and has a maximum depth of the order of 150 feet.

Line 22.5N - A reduced, but still substantial 20 millivolts/volt above background response was recorded on this line at 1650W. The maximum depth to source is estimated at 200 feet, and in this case the source shows *increased* resistivity, inferring a relatively resistive host (silicified?) to the causative disseminated sulphides (or graphite).

Line 22.2N - On this line, zone X reached a maximum value of 18 millivolts/volt

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against background at 1950W within 8000 ohm-metres material. The source therefore remains disseminated, and is slightly more resistive than the enclosing rocks. A minor shoulder at 1750W infers a second source at that point. The maximum depth of both responses is estimated at 200 feet.

Line 22N - A 14 millivolts/volt anomaly superimposed on a slightly higher background of 12 millivolts/volt was defined at 1500W. Distinctly *higher* resistivity was noted over the maximum chargeability which clearly indicates the host to be more resistive (silicified perhaps?). The asymmetry of the chargeability data suggests a steep east dip, while the gradient suggests a maximum depth to source of 250 feet.

Line 21.9N - On this line a slightly narrower anomaly also of 14 millivolts/volt was defined at 1150W from a source estimated to lie within 200 feet of surface. The high resistivity again infers a disseminated source, while the asymmetry of profile suggests a steep *west* dip in this case.

ZONE Y

A narrow shallow disseminated source is inferred by a series of relatively minor anomalies as follows:

| <u>Line</u> | <u>Station</u> | <u>Above background anomaly</u> |
|-------------|----------------|---------------------------------|
| 21N | 1250W | 6 millivolts/volt |
| 20.6N | 950W | 8 millivolts/volt |
| 20.2N | 1050W | 8 millivolts/volt |
| 20N | 950W | 7 millivolts/volt |

HA 4 target

In all cases the maximum depth to source is estimated as being of the order of

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50 to 100 feet, while the source is narrow (i.e. less than 100 feet), and disseminated in nature. The anomaly is not considered of geophysical significance. !!

ZONE 2

A similar series of relatively narrow disseminated sources at shallow maximum depths of less than 100 feet were inferred on the following lines.

| <u>Line</u> | <u>Station</u> | <u>Above Background Anomaly</u> |
|-------------|----------------|---------------------------------|
| 19.7N | 850W | 5 millivolts/volt |
| 19.4N | 750W | 4 millivolts/volt |
| 19N | 780W | 10 millivolts/volt |

This zone is also considered of minor geophysical interest.

POLE - DIPOLE SURVEY

INTRODUCTION

Over selected sections of lines 24.5N, 23N, 22N, 21.3N, 20.6N, 20.2N and 20N, pole-dipole arrays were surveyed using an $a = 50$ feet, $n = 1$ to 6. Lines 22N, 21.3N and 23.4N employed an $a = 300$ feet, $n = 1$ to 6 spacing. These results are displayed in classic pseudo-section format, with the gradient anomalies superimposed thereon.

Additional comments are made on each gradient anomaly located on the reconnaissance survey on a line by line basis.

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DISCUSSION OF RESULTS

LINE 24.5N (a = 50 feet, n = 1 to 6)

Zone A: is confirmed to be broad and lie within 100 feet of surface. However, the main gradient maximum at 3650W lies within 30 to 50 feet of surface.

Zone B: is confirmed to be a significant response on this line and lies within 30 to 50 feet of surface at 3250W. The anomaly however, continues east to 3100W, inferring a multiple source within the zone at shallow depths (30 to 50 feet).

LINE 23.4N (a = 300 feet, n = 1 to 6)

The large 300 feet spacing employed has confirmed the interest of zones X and W at 1800W and 1550W, but has not resolved them due to the large potential dipole spacing. It does confirm their interest to depth, as higher values are obtained on the larger spacings. This latter point, however, may be due to interference from zone C (2600W).

Similarly Zone C is confirmed to be of interest at depth, however, the whole zone (C plus higher values to the immediate west) has been integrated in the pseudo-section, particularly at later spacings.

LINE 23N a = 50 feet, n = 1 to 6

This line was re-surveyed using pole-dipole from 3300W to 1300W using the above spacings.

Zone X: is confirmed as a material anomaly and a typical double peak anomaly

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was located. The source was seen as highly chargeable and centred at 1725W lying very close to surface. The source is seen as being of the order of 100 feet in width.

The remainder of the profile gives similar results to the gradient array data when geometries are considered. A possible exception is the eastern sector east of about 1500W, where masking is inferred in the pole-dipole data. This infers the anomaly seen for some 300 feet or so east of the gradient anomaly X has greater significance with depth. However, this may(?) be an interference effect from a source east of the end of the surveyed line.

LINE 22N

This line was resurveyed using a 300 feet pole-dipole spacing to $n = 1$ to 6 over zones F, G and a portion of E. The larger dipole could not resolve the detail but has confirmed their importance with depth.

LINE 21.3N

Zone G was also resurveyed on this line using a 300 feet, $n = 1$ to 6 pole-dipole spacing. This certainly confirmed the importance of the anomaly source with depth as a significant *increase* in response was obtained on the $n = 2$ spacing.

LINE 20.6N

This line was surveyed again using pole-dipole from 1500W to 900W to cover zone Y. The presence of the anomaly was confirmed by a typical lower pole-dipole anomaly centred at 950W, and the depth inferred is 50 feet(+).

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LINE 20.2N

This line was re-surveyed over zone Y using a pole-dipole array of $a = 50$ feet, $n = 1$ to 6. The pole-dipole data over zone Y has much enhanced its importance. It is seen as an extremely narrow (less than 50 feet) source at a maximum depth of 50 feet. The accompanying resistivity remains relatively high, inferring a disseminated source.

LINE 20N

This line was surveyed from 2600W to 900W also using a pole dipole a spacing of 50 feet and $n = 1$ to 6.

Zone H: The pole-dipole data emphasises the significance of this anomaly particularly on spacings $n = 2$ to 4. The depth to source is about 100 feet, however, at 1700W it may come within 50 feet of surface. The pole-dipole data confirms the broad nature of the source, but demonstrates that east of 1400W the source either dips to the east at a shallow angle or there is a second source, perhaps under some cover.

Zone I<sub>G</sub>: is also confirmed as a minor source, however, its significance does appear to increase with depth as greater chargeabilities are recorded at $n = 2$ and 3 (further increases on $n = 4$ to 6 are due at least in part to the influence of the eastern extension of zone H).

Zone Y: In contrast to line 20.2N where this zone was much enhanced on the pole-dipole data, zone Y here was seen as a very minor response.

SCINTREX*CONCLUSIONS*

- 1 - The gradient array reconnaissance survey has defined a number of significant induced polarization anomalies, which vary in strike length from 500 to 1000 feet. Invariably their sources are inferred to be disseminated in nature, either being slightly more or less resistive than the enclosing rocks.

- 2 - A distinct low resistivity- low chargeability horizon was noted which lies close to the mapped contact between rock units B and C, but does not precisely follow it. Each of the rock units A to C have different backgrounds, and anomalies have to be judged not by *absolute* amplitude but by reference to this background. The majority occur within rock unit B (*Feldspar and Feldspar-Hornblende Intermediate Tuffs*) and this unit in fact has a higher chargeability background overall. The second grouping of significant anomalies occurs within rock unit C (*Fe and Mn Rich Lithic Crystal Tuffs, Pyritic Feldspar Crystal Tuffs, Carbonates and Minor Shales*) The anomalies occurring in this group are more lenticular than those seen in rock unit B, which are broader. Those in unit C are reminiscent of shale horizons.

- 3 - Although three decay slices were monitored for every chargeability reading, no significant variations from normal were observed when the amplitude of the chargeability is borne in mind.

- 4 - Significant induced polarization responses located on this survey are summarised below by zone. Those marked with an asterisk(\*) are considered geophysically the most significant. No induced polarization anomalies

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located were actually indicated to be conductive, thus for the most part a disseminated to very weakly conductive sulphide or graphite source is the interpreted source.

The maximum depth can go from 100 feet to 250 feet. Note that these are *maximum*. Where the pole-dipole data is available, the depth to source has been shown to be considerably less, e.g. zone A line 24.5N where the maximum depth from gradient array was 150 to 200 feet, and from pole-dipole 30 to 50 feet.

Summary of Significant Anomalies (assumes 20 mV background)

Zone A

Line 25N: Maximum 16 millivolts/volt at 3950W\*, 15 millivolts/volt at 3750W\* - maximum depth 200 feet and 300 feet - disseminated source - steep to west dip.

Line 24.5N: Maximum 21 millivolts/volt at 3650W\*, 16 millivolts/volt at 3850W\* (shoulder) - maximum depth 200 feet - disseminated source - steep dip.

Line 24N: Maximum 11 millivolts/volt at 3500W\* (shoulder), 19 millivolts/volt at 3750W\* - maximum depth 150 feet, 200 feet - disseminated source - steep dip.

The pole-dipole data shows maximum depth of zone A on line 24.5N to be 30 to 50 feet.

SCINTREX*Zone B*

Line 25N: Maximum 10 millivolts/volt at 3250W - maximum depth 200 feet - disseminated source - steep dip.

Line 24.5N: Maximum 18 millivolts/volt at 3250W\* - maximum depth 200 feet - disseminated source.

Line 24N: Maximum 19 millivolts/volt at 3125W\* - maximum depth 250 feet - disseminated source - steep dip, perhaps east.

Line 23.7N: Maximum 17 millivolts/volt at 3000W - maximum depth 150 feet +50 feet - disseminated source. ?

The pole-dipole data shows a maximum depth on line 24.5N of 30 to 50 feet.

Zone C

Line 23.7N: 10 millivolts/volt at 2750W - maximum depth 150 feet +50 feet - disseminated source.

Line 23.4N: Maximum of 16 millivolts/volt at 2600W - maximum depth 150 feet - disseminated source.

Line 23N: Not significant

Zone D

Line 22.5N: Maximum of 7 millivolts/volt at 2350W - maximum depth 150

feet - disseminated source.

Zone E

Line 22N: Maximum of 12 millivolts/volt at 3000W - weak interconnection within source possible - maximum depth perhaps 150 feet.

Line 21.9N: Maximum of 12 millivolts/volt at 2700W\* - weak interconnection within source - maximum depth 150 feet.

Zone F

Line 22N: Maximum of 24 millivolts/volt at 2650W\* - disseminated sulphides on a contact - maximum depth to source 100 to 150 feet.

Line 21.9N: Maximum of 30 millivolts/volt at 2250W\* - disseminated sulphides on contact - maximum depth to source 200 feet.

Line 21.6N: Maximum of 12 millivolts/volt at 2050W - maximum depth to source on contact, 250 feet.

Note: Zones E and F may form more disseminated haloes to a more massive, less resistive core centred between them (see main text).

Zone G

Line 22N: Maximum of 15 millivolts/volt at 2150W - narrow disseminated source shows weak interconnection - maximum depth about 150 feet.

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Line 21.9N: Maximum of 12 millivolts/volt at 1800W - broader (200 feet?)
source - weak interconnection within sulphide (or graphite?)
source - maximum depth 150 to 200 feet.

Line 21.6N: Maximum of 12 millivolts/volt at 1850W - weak interconnection
within source - maximum depth difficult to assess but perhaps
200 feet.

Line 21.3N: Maximum of 11 millivolts/volt at 1750W - resistive source -
maximum depth 200 feet.

Line 21N: Broad 20 millivolts/volt response over rock unit B between 2400W
and 1750W represents merging along strike of zones F and G
in the north, with H to the south. Maximum depth to source on
flanks, 150 to 200 feet.

Zone H

Line 20.6N: Maximum of 16 millivolts/volt at 1950W\* and 12 millivolts/
volt at 1650W - maximum depth estimates, 300 feet and 200 feet
respectively - weakly interconnecting sulphides (or graphite)
is the suggested source.

Line 20.2N: Maximum of 18 millivolts/volt at 1850W\*, 10 millivolts/volt
at 1600W - maximum depths estimated at 300 feet and 150 feet
respectively - disseminated source.

Line 20N: Maximum of 20 millivolts/volt at 1750W - maximum depth 250 feet -

disseminated sulphide (or graphite) source - pole-dipole data infers a shallow maximum depth of the order of 100 feet.

Line 19.7N: Maximum of 25 millivolts/volt at 1750W\* - maximum depth to source 300 feet - weak interconnection within centre of disseminated source - of major interest.

Line 19.4N: Maximum of 20 millivolts/volt at 1950W - maximum depth 100 to 150 feet - disseminated source.

Zone I

Line 21N (I<sub>N</sub>): Maximum of 7 millivolts/volt at 1450W - maximum depth 100 feet - narrow weakly conductive source

Line 20N (I<sub>S</sub>): Maximum of 8 millivolts/volt at 1300W - maximum depth to source 150 feet - weakly conductive host.

Line 19.7N (I<sub>S</sub>): Maximum of 5 millivolts/volt at 1300W - maximum depth 100 to 150 feet - source weakly conductive.

Zone V

Line 25N: Maximum of 10 millivolts/volt at 2700W - maximum depth 200 feet - disseminated source.

Line 24.5N: Maximum of 10 millivolts/volt at 2750W - maximum depth 200 feet - disseminated source.

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Zone W

Line 25N: Maximum of 10 millivolts/volt at 1950W - maximum depth 200 feet - disseminated source.

Line 24N: Maximum of 16 millivolts/volt at 1900W - maximum depth 150 feet - disseminated source - steep dip.

Line 23.7N: Maximum of 20 millivolts/volt at 1650W\* - maximum depth 200 feet - disseminated source.

Line 23.4N: Maximum of 16 millivolts/volt at 1550W - maximum depth 250 feet - disseminated source.

Zone X

Line 23.7N: Maximum of 8 millivolts/volt at 1950W - maximum depth 100 feet - narrow disseminated source.

Line 23.4N: Maximum of 27 millivolts/volt at 1800W\* - maximum depth 250 feet - weakly conductive source is disseminated halo - narrow source.

Line 23N: Maximum of 35 millivolts/volt at 1750W\* - maximum depth 150 feet - disseminated narrow source - the pole-dipole data shows maximum depth as 30 to 50 feet on this line.

Line 22.5N: Maximum of 20 millivolts/volt at 1650W - maximum depth 200 feet.

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Line 22.2N: Maximum of 18 millivolts/volt at 1950W - maximum depth 200 feet.

Line 22N: Maximum of 14 millivolts/volt at 1500W - maximum depth 250 feet -
resistive host - steep east dip(?).

Line 21.9N: Maximum of 14 millivolts/volt at 1150W - maximum depth 200 feet -
disseminated source - steep west dip (?).

Zone Y

A relatively minor zone showing narrow disseminated sources at maximum depths of 50 to 100 feet on lines 21N, 20.6N, 20.2N and 20N at 1250W, 950W, 1050W and 950W respectively.

The pole-dipole data much enhances the interest of this zone on line 20.2N where a 60 millivolts/volt response was recorded within 50 feet of surface at 1075W from a minor resistive source. However, on line 20N only a minor response is seen for zone Y.

Zone Z

A similar series of anomalies to zone Y make up this zone in a stratigraphically similar location. On lines 19.7N, 19.4N and 19N at 850W, 750W and 780W respectively, small induced polarization anomalies coincide with high resistivity, inferring a disseminated source of minor interest.

5 - As with all geophysical data, the actual economic potential of each of the induced polarization zones defined depend more on the associated

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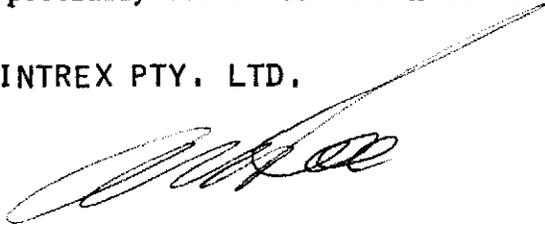
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geochemistry and geology rather than absolute amplitude of each zone.

The author looks forward to a detailed discussion of the data in the near future.

Respectfully submitted on behalf of:

SCINTREX PTY. LTD.



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

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

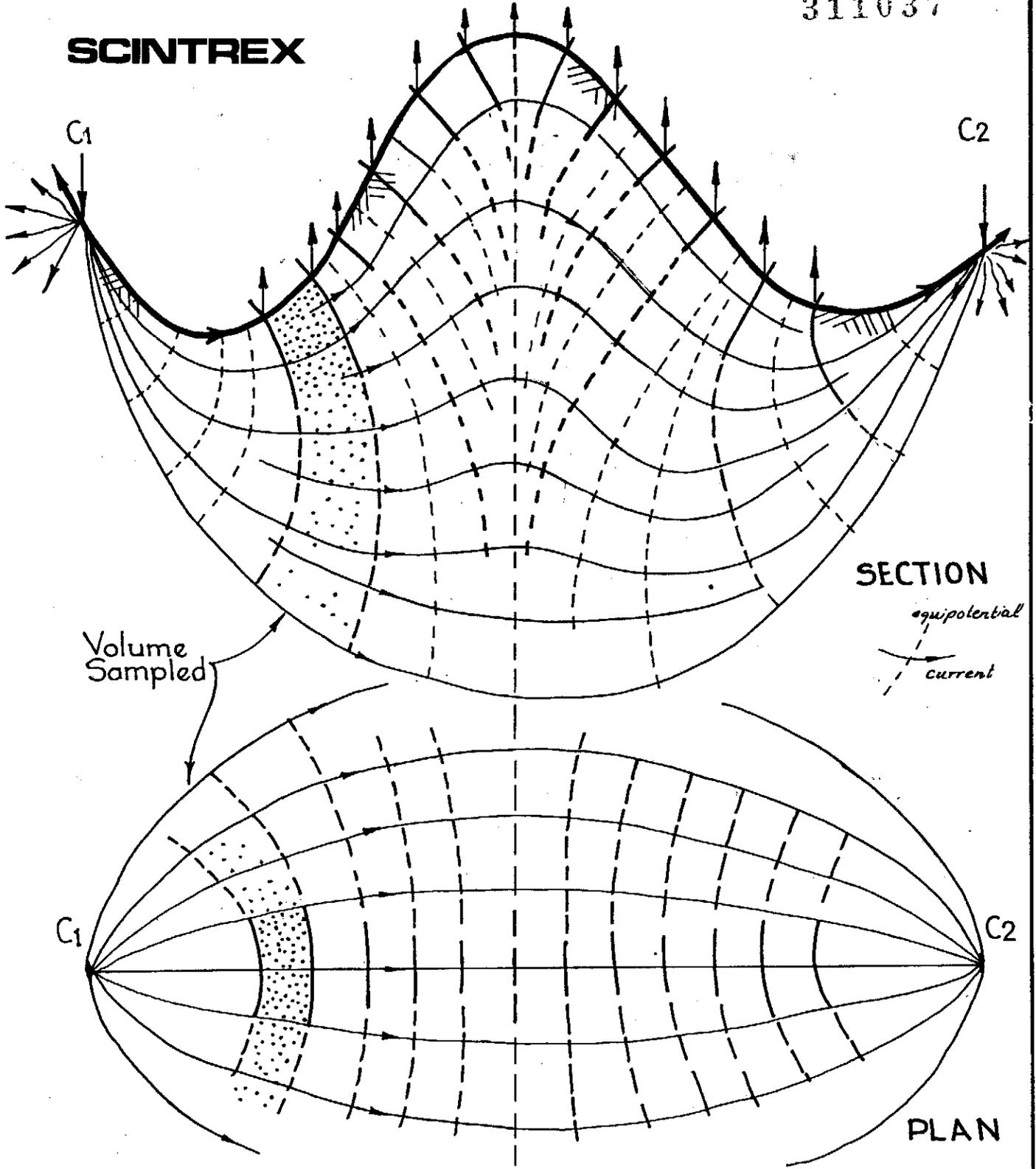
Gradient Array:- In this array both current electrodes are distant from the potential dipole. Figure 1 displays the salient features of the *primary* current flow and primary equipotential field generated during energisation and shows the influence of terrain on the current paths. From this diagram it 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.

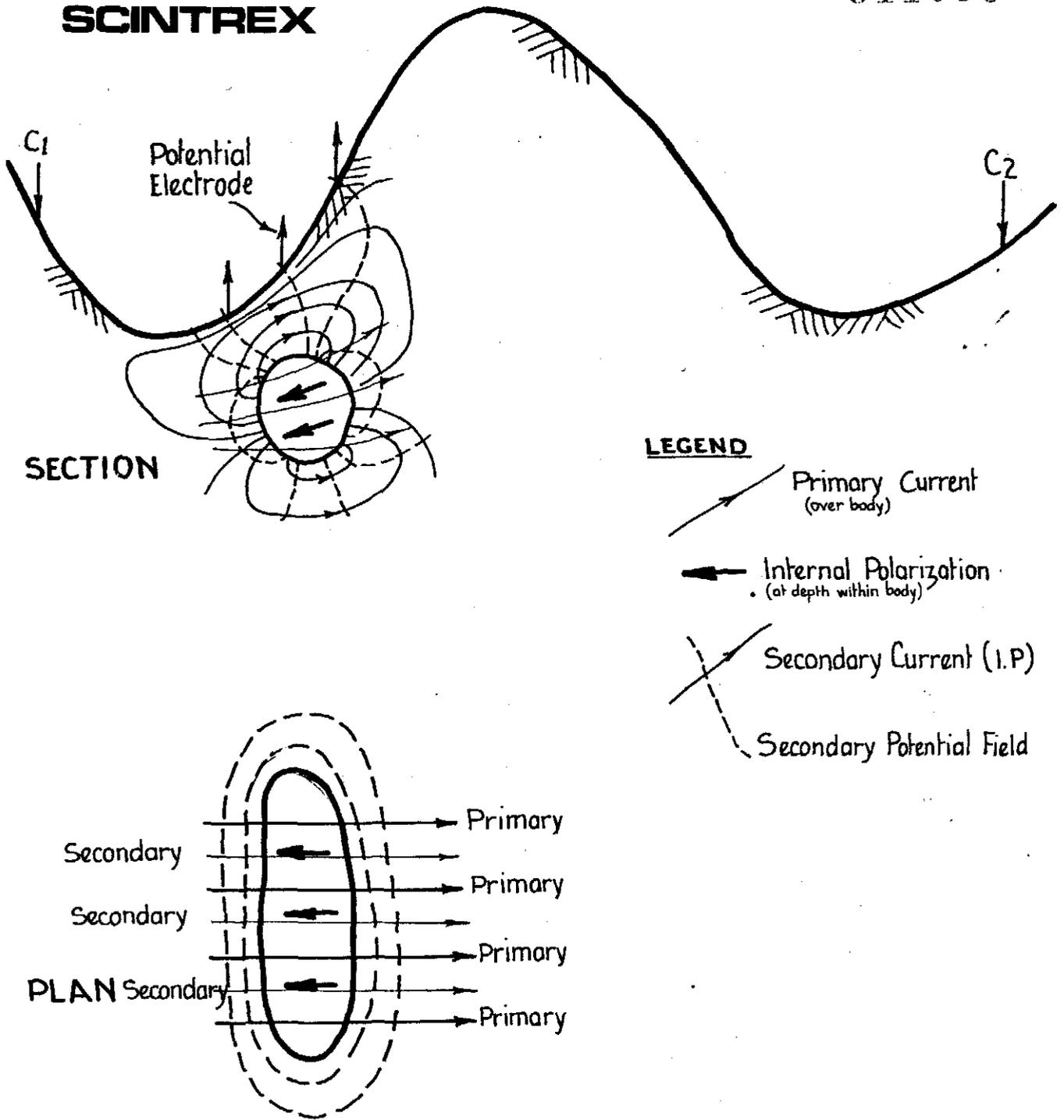
Figure 2 displays the secondary current pattern generated from the decay of induced polarization effect *within* a chargeable sulphide source, together with the equipotential field generated by that decay. Note that due to the necessarily curved nature of the current flow outside the body, the on-surface 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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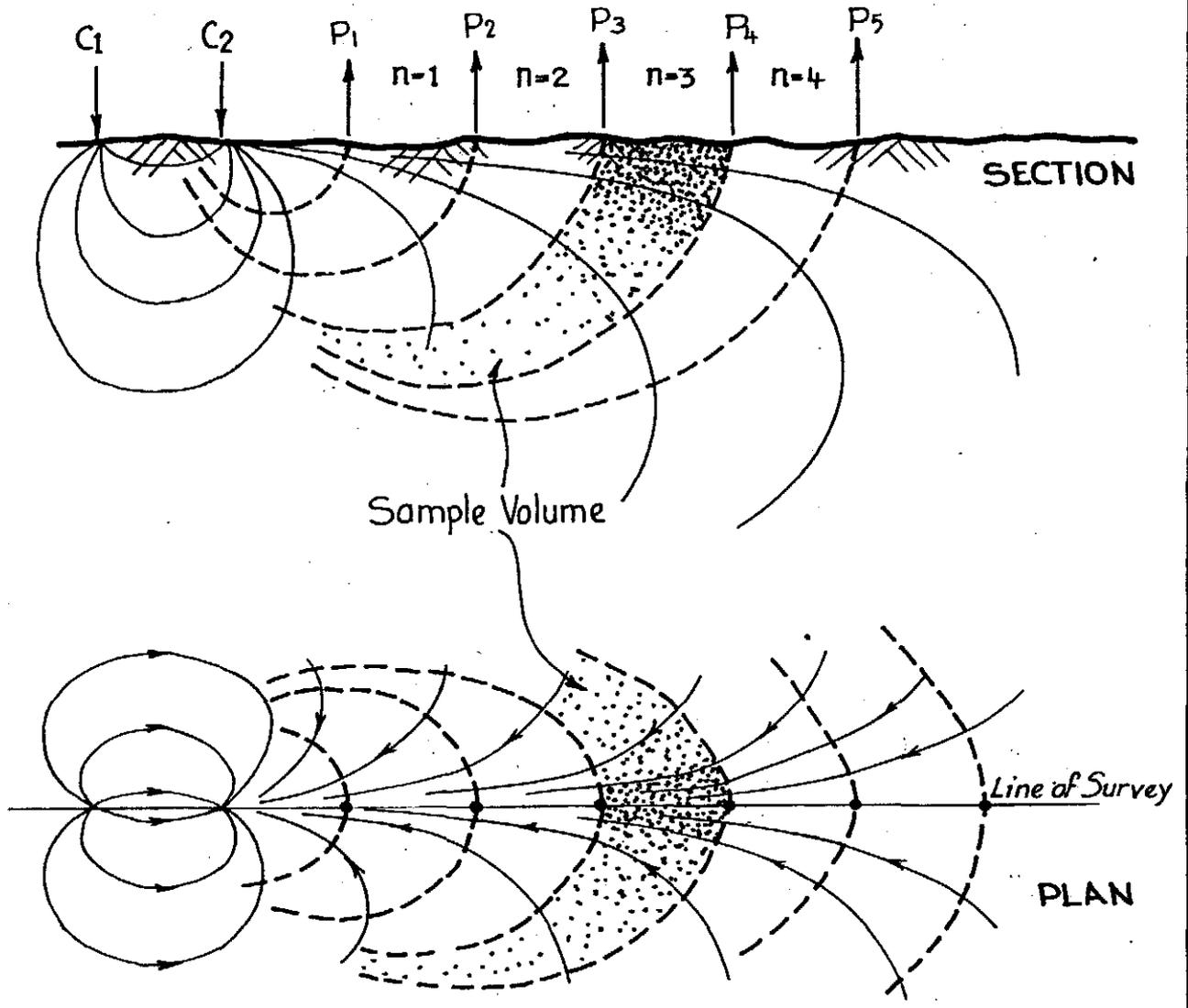
Diagrammatic representation of secondary current (I.P. effect) and secondary potential field in steep terrain.

FIGURE 2.

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

FIGURE 3.

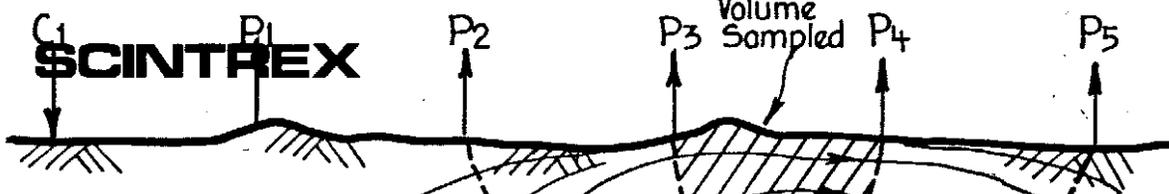
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does not represent the characteristics of the ground at the point plotted, but that of the *total volume* sampled.

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,

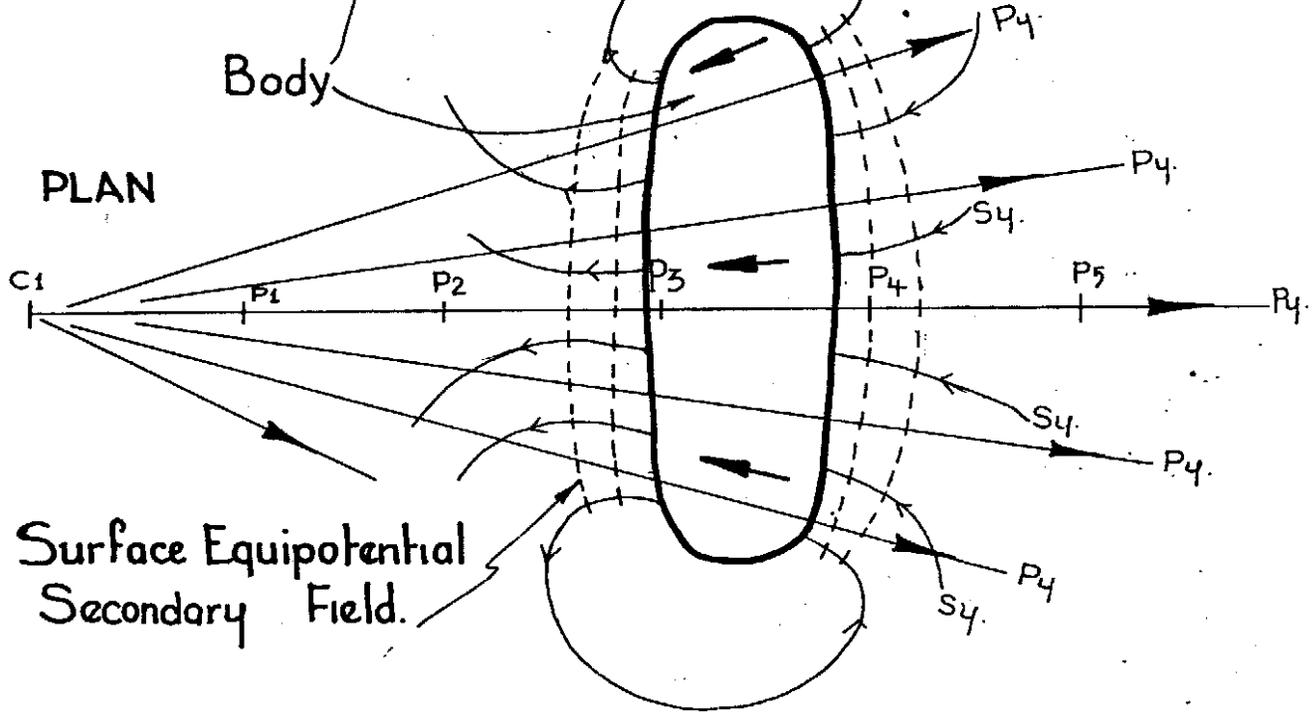


SECTION

LEGEND

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

PLAN



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.

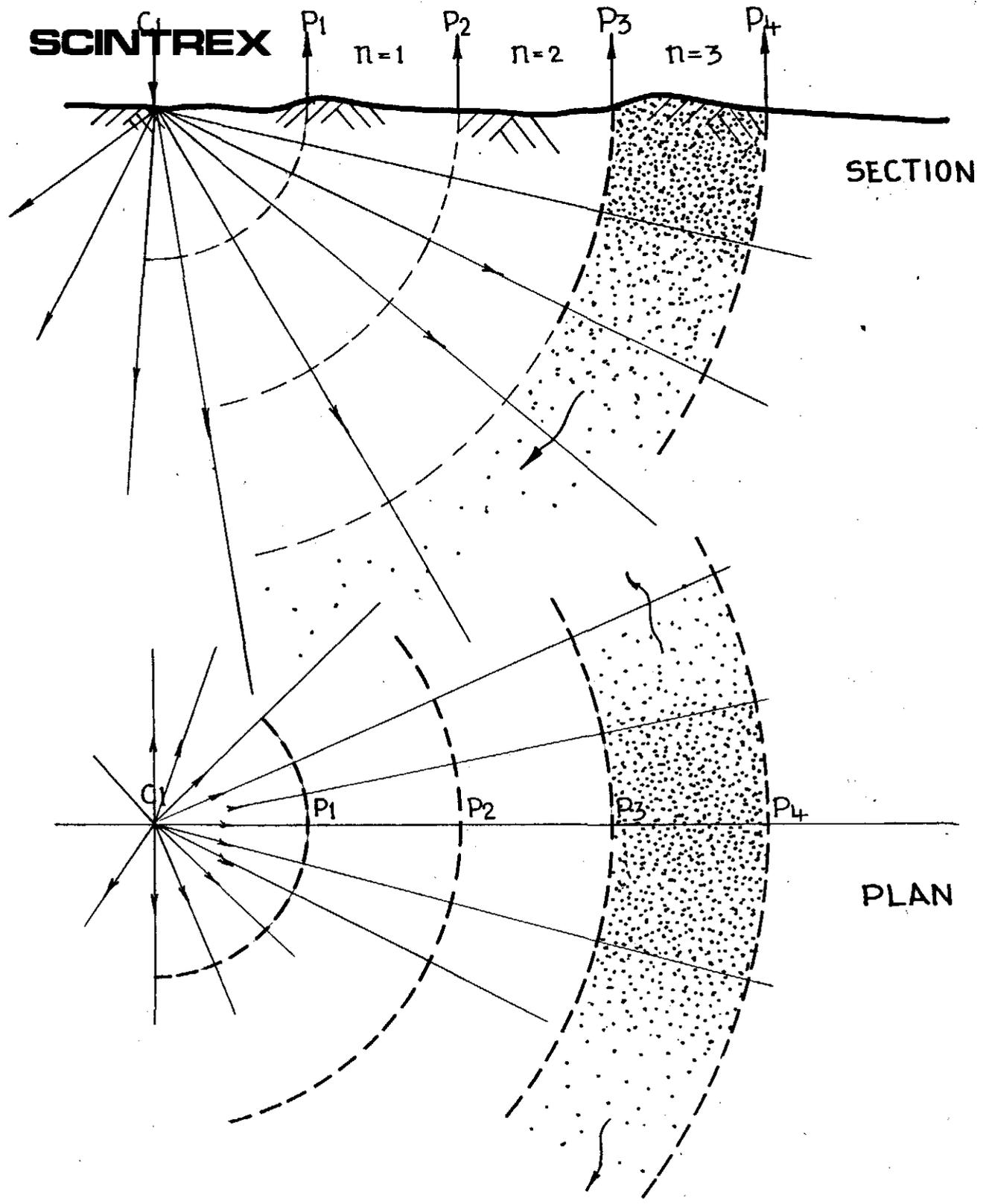
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except that a single electrode is placed 'close' to the potential dipole, with an 'infinite' electrode placed $10 \times n \times a$ away from the 'pole-dipole' set-up, and, where practical, at right angles to it. The enclosed Figure 5 shows the distribution 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 dpoles, 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

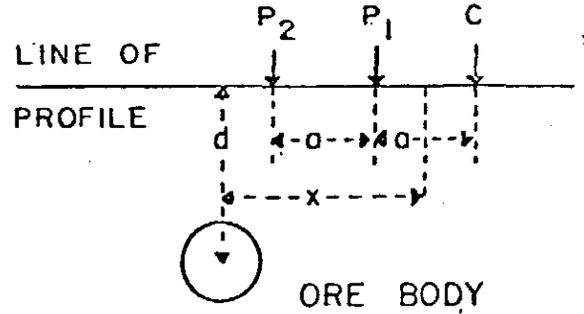
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Current Path and Primary Equipotential Field from Pole-Dipole Array

FIGURE 5

SCINTREX SPHERE RESPONSE THREE ELECTRODE ARRAY



$$z = x/d$$

$$\alpha = a/d$$

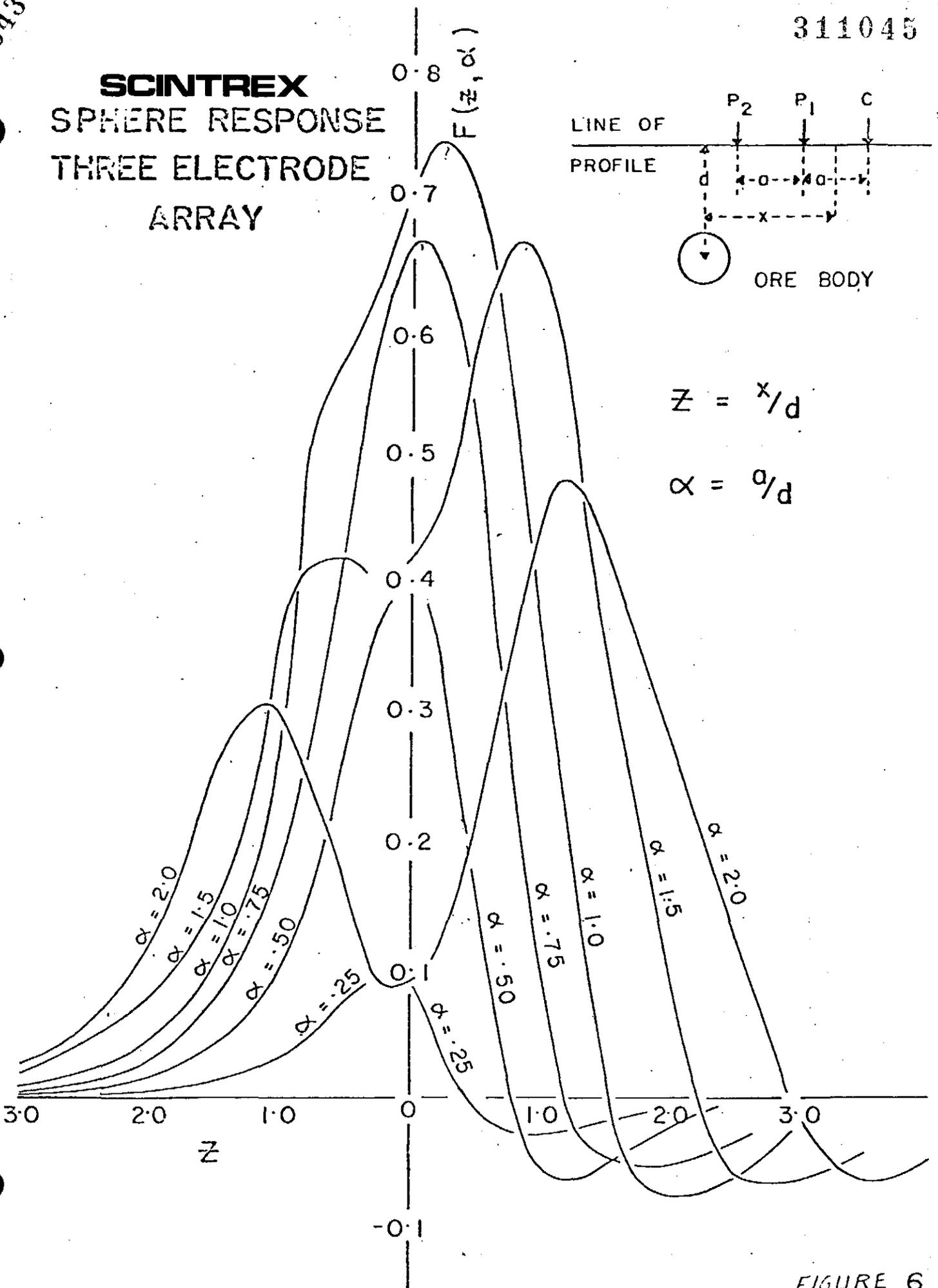


FIGURE 6

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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 |
| Potential-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 | More wire needed | Fair to Poor | Fair | Very Good |
| | Smaller crew needed
Less wire needed than for some arrays
Good penetration in nonconductive overburden | Susceptible to masking by conductive over-burden | Good | Fair | 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, mise-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"

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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 $M_1 + M_2 = M_3$ 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

SCINTREX

normal decay

7(a)

decay curve modified by coupling

7(b)

electromagnetic coupling

V

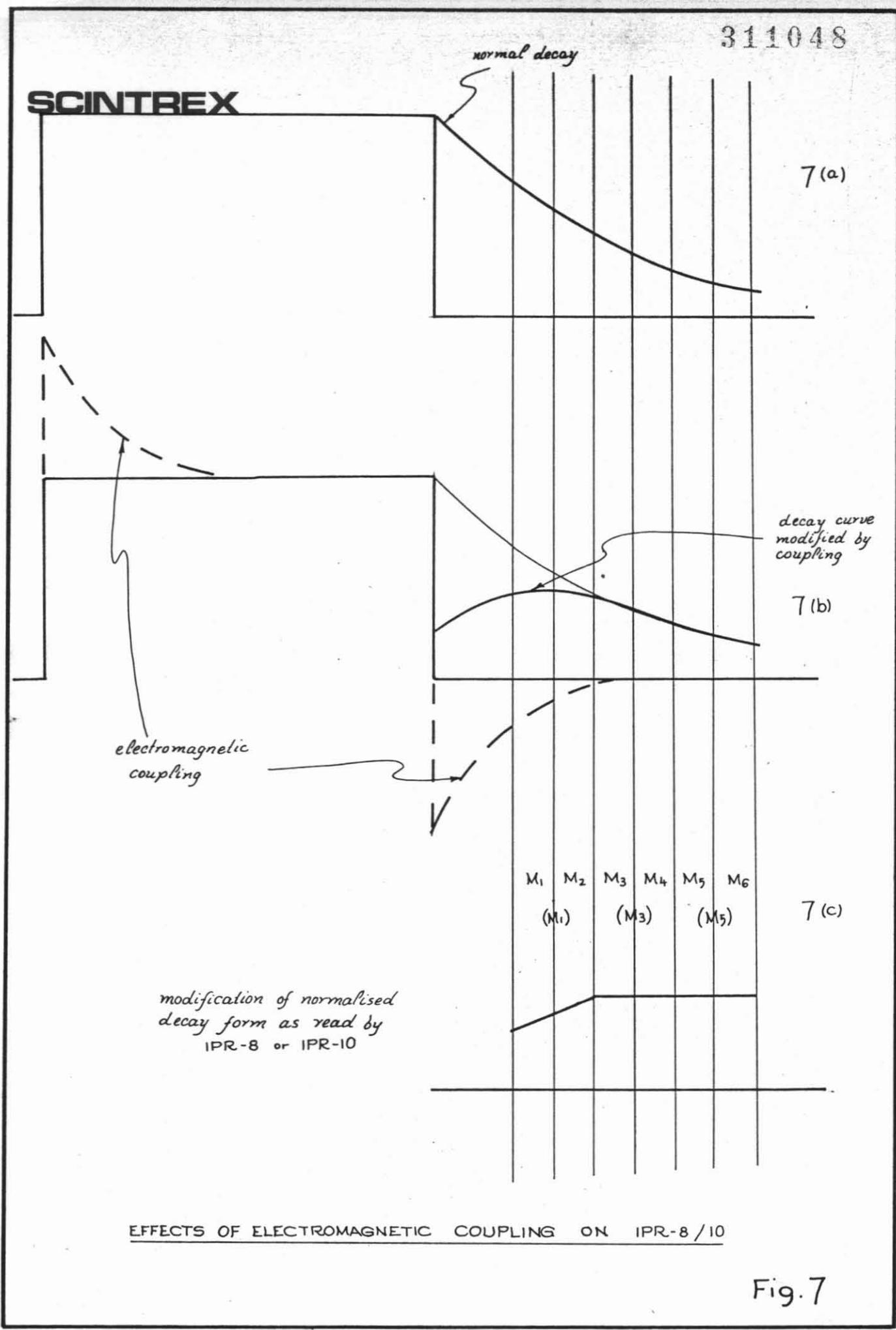
M<sub>1</sub> M<sub>2</sub> M<sub>3</sub> M<sub>4</sub> M<sub>5</sub> M<sub>6</sub>
(M<sub>1</sub>) (M<sub>3</sub>) (M<sub>5</sub>)

7(c)

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

EFFECTS OF ELECTROMAGNETIC COUPLING ON IPR-8/10

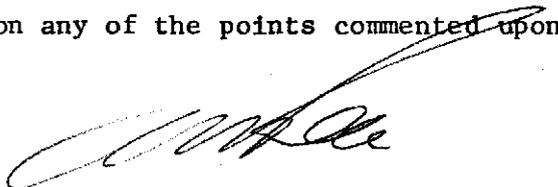
Fig. 7



SCINTREX

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.

SCINTREX

ADDENDUM TAS-073A

COMMENTS ON 100 FEET POLE-DIPOLE ARRAY

HOWARD'S ANOMALY

LINE 23.7N FROM 2200W TO 4000W

The most significant anomaly recorded on the pole-dipole data was defined from a source centred between 2600W and 2700W. The amplitude of the anomaly on the $n = 1$ spacing was 22 millivolts/volt as against a 12 millivolts/volt background to the west. The amplitude of the response increases with increasing n values signifying increasing polarization with depth. The steep gradient of the contours in the east (at 45°), contrasts with a much shallower dip to the pseudo section in the west, and a less steep gradient. This can be interpreted as indicating a dip to the source to the west, and a more gradual fall off in polarizable material in that direction. The maximum depth to the bulk of the source at 2800W is 150 feet, although some material comes to within 100 feet of surface. This pole-dipole anomaly is that denoted as zone 'C' (and 'B') in the gradient reconnaissance survey.

A second source was located at 2250W (+50 feet) which is equivalent to a relatively minor gradient array indication at the same point. The maximum depth to source is about 100 feet. The increase in amplitude with depth is, at least in part, due to the current pole being west of zones 'B' and 'C'.

Slightly increased chargeabilities were noted from a source at about 1900W-2000W (zone 'X') as seen on $n = 3$ at 2250W, but the signature is incomplete.

049

311051

Page - two

SCINTREX

To the west of the main response a distinctive chargeability low of 12 millivolts/volt was defined at 3100W (+100 feet), to the west of which a sharp low amplitude increase to 14 millivolts/volt was recorded at 3200W to 3300W. This zone reduces gradually to the west over the next 200 feet. The maximum depth to source is again about 100 feet.

CONCLUSION

The gradient anomaly 'C' centred at 2750W is much emphasised on the pole-dipole data and in addition incorporated with zone 'B'. The suggested dip is to the west, and the maximum depth to source less than 100 feet, with the source being more polarizable with depth.

Respectfully submitted on behalf of:

SCINTREX PTY. LTD.

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

GEOPHYSICIST

MICROFILMED

311052

SCINTREX

OPEN FILE

TAS-073A
COMMENTS ON

ELECTRICAL INDUCED POLARIZATION SURVEYS
CARRIED OUT OVER HOWARD'S ANOMALY GRID
NEAR QUEENSTOWN, TASMANIA
ON BEHALF OF
MOUNT LYELL MINING AND RAILWAY COMPANY LTD.

| | | | |
|----------------|------|------|-----------|
| A.O. | C.B. | E.O. | D.S.L.E. |
| | | | Registrar |
| 2 OCT 1984 | | | E & H |
| DEPT. OF MINES | | | |
| No. 10,076/84 | | | |

063

311053

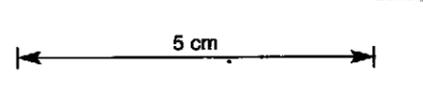
LINE 20-6N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

NOTE 1cm = 100 FF



ΔM
 +2
 +1
 0
 -1
 -2
 slow
 fast

Chargability in Milliohm/put (Ms)

Resistivity in Ohm-meter (Pa)

36
 30
 20
 10

10000
 5000
 3000
 1000

3000 W 2500 W 2000 W 1500 W 1000 W 700 W



Fig 1 V

064

311054

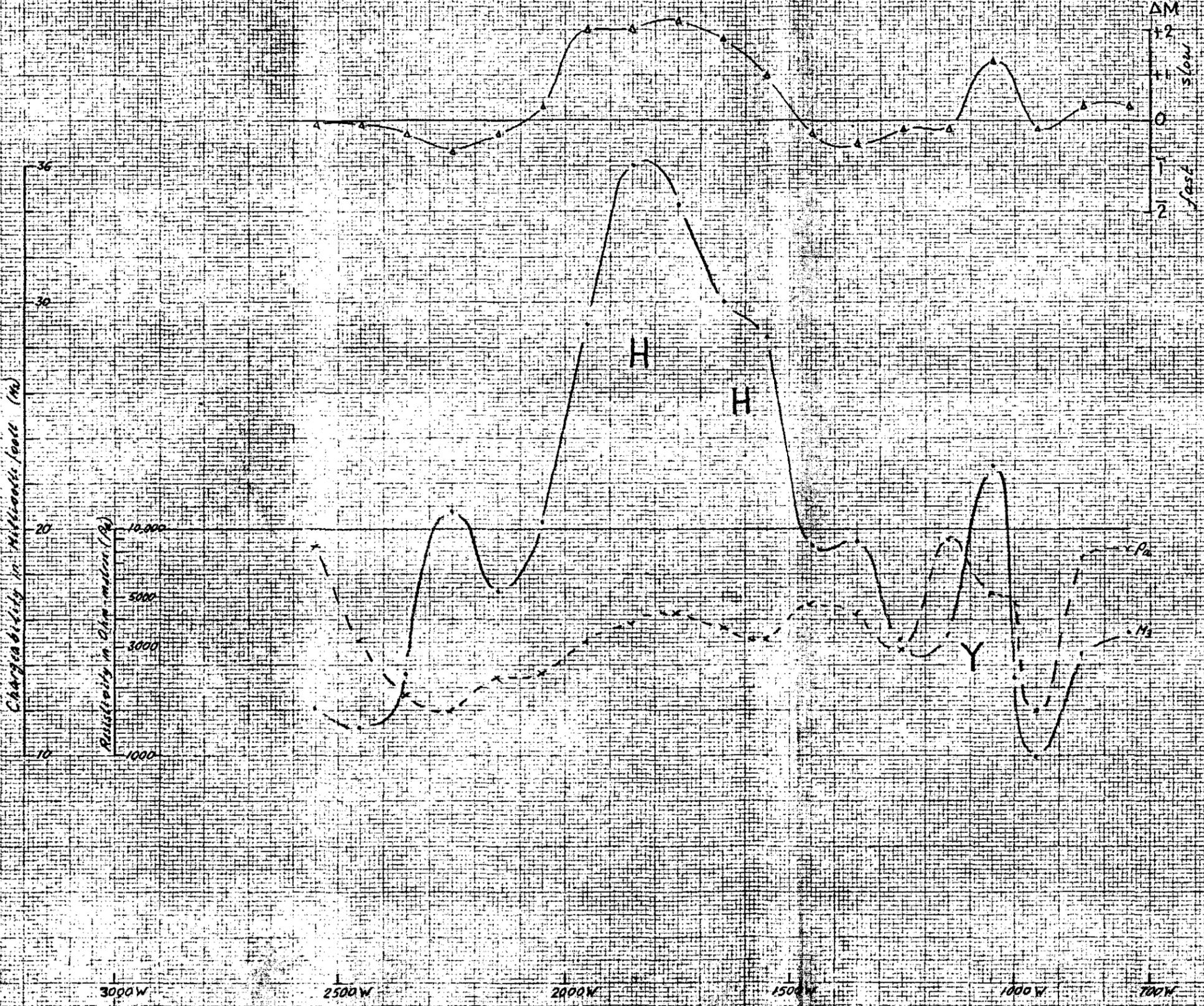
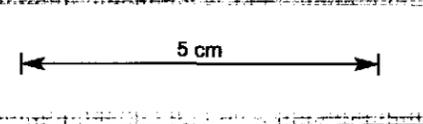
LINE 20 2N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

NOTE: 1cm = 100ft



U.S. GEOLOGICAL SURVEY

WIDE

065

311055

LINE 20N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

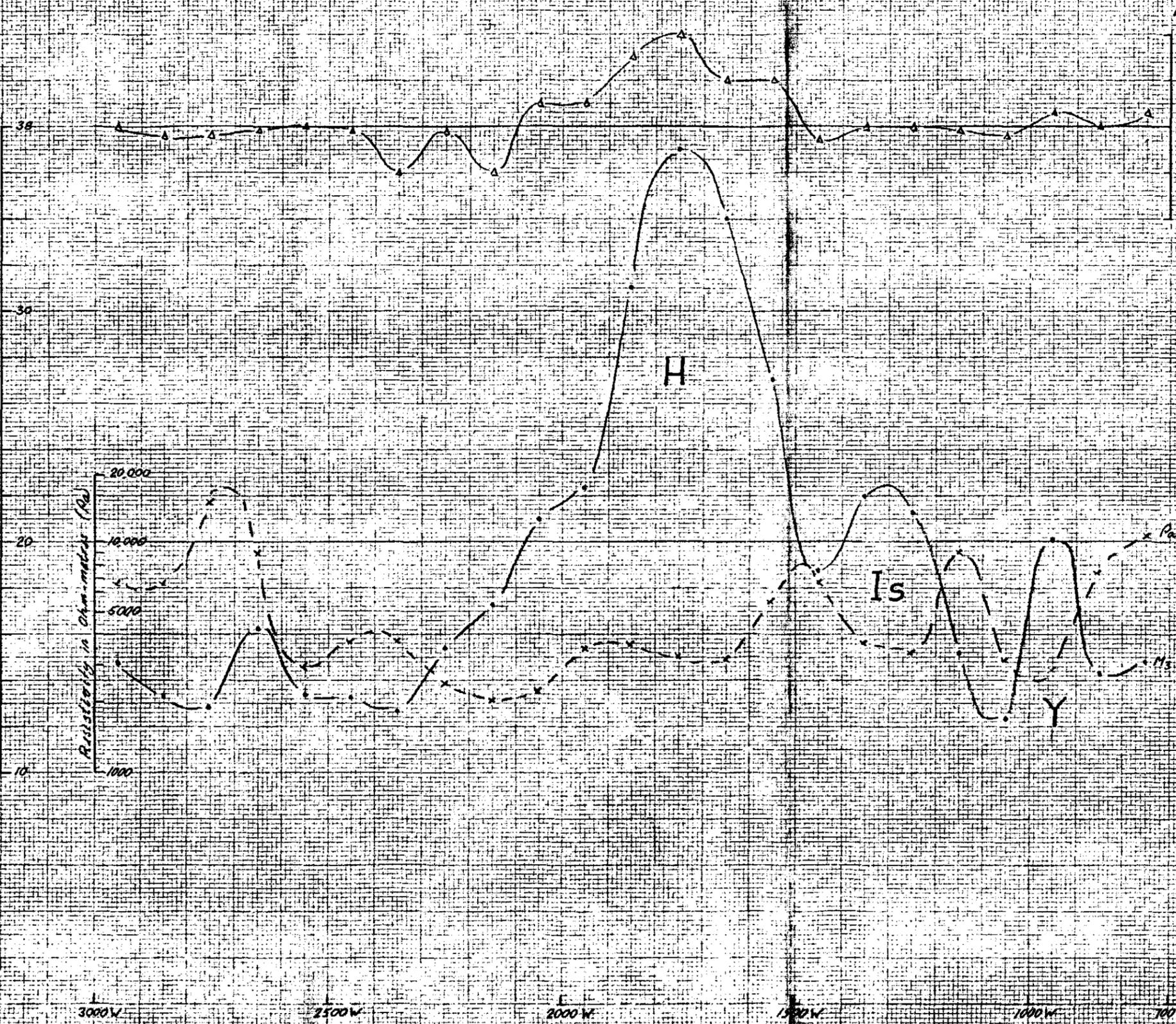
NOTE: 1cm = 100ft

5 cm

ΔM
+2
+1 slow
0
-1 fast
-2

Chargability in Milliohm-ft (M<sub>h</sub>)

Resistivity in Ohm-meters (R<sub>h</sub>)



TA 1213

066

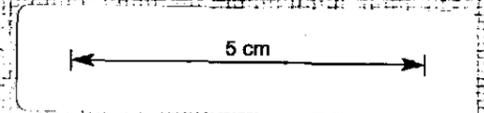
LINE 19-7N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

NOTE: 1cm = 100ft



ΔM
+2
+1
0
-1
-2

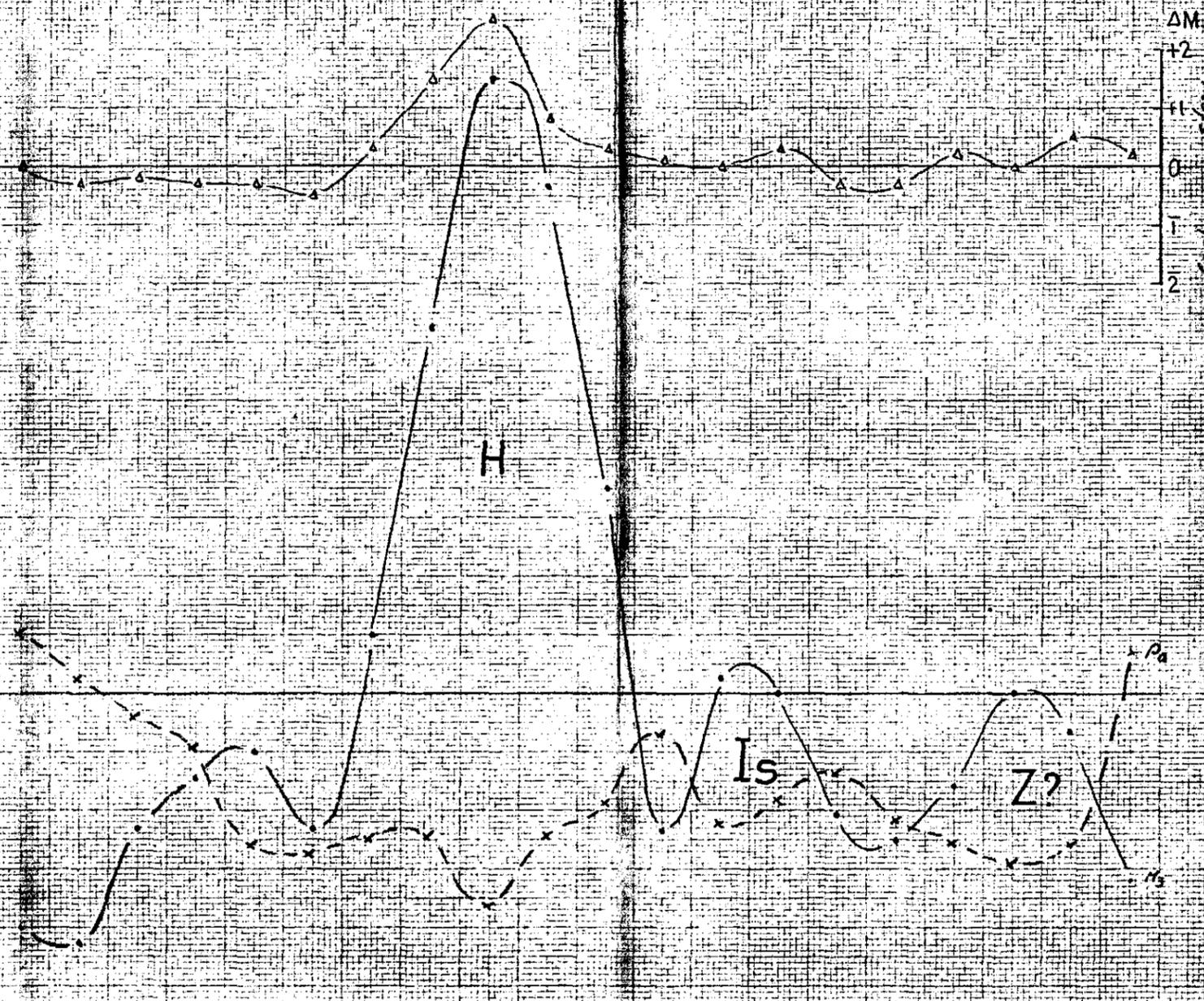
60
30
20
10

Char. Velocity in Meters/Sec (Ms)

10,000
5,000
3,000
1,000

Resistivity in Ohm-meters (Rm)

3000 W 2500 W 2000 W 1500 W 1000 W 600 W



067

311057

LINE 19-4N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS=073A

NOTE: 1cm=100ft

5 cm



U.S. GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
WASHINGTON, D.C. 20506
1971

068

311058

LINE 19N

HOWARD'S ANOMALY

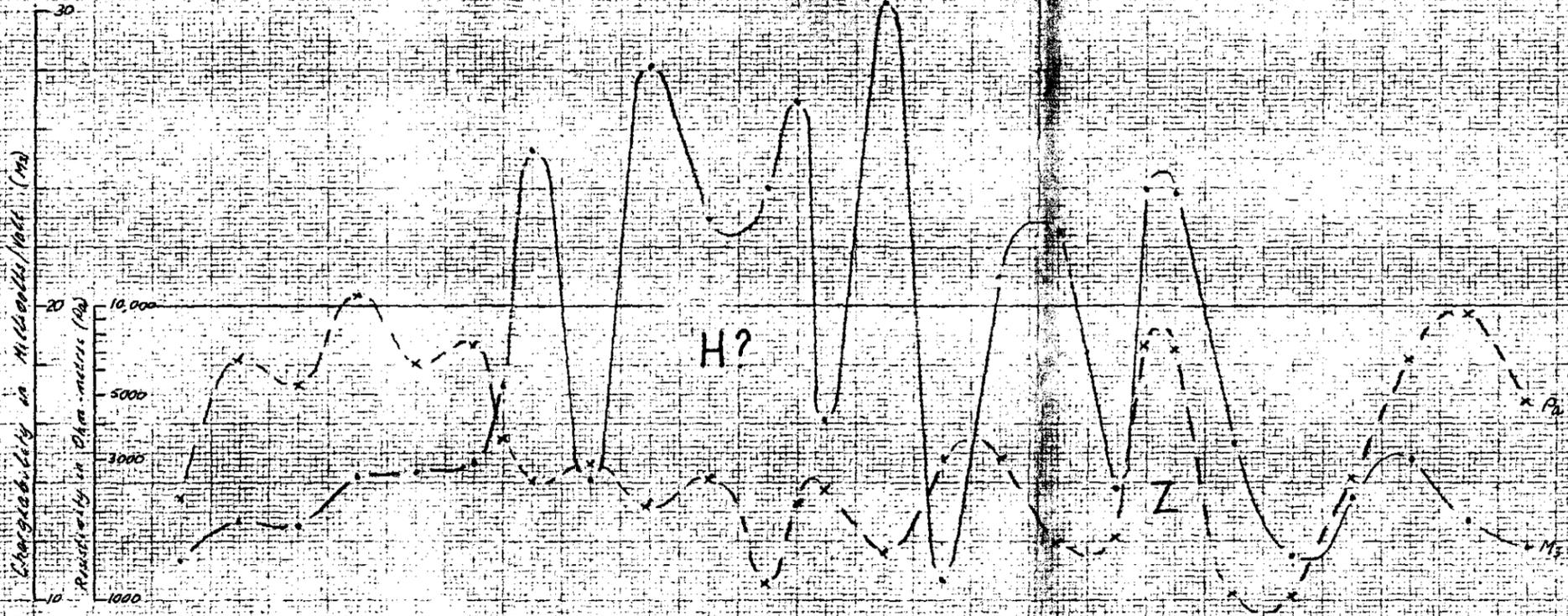
GRADIENT ARRAY EIP

TAS-073A

NOTE 1cm = 100 ft

5 cm

ΔM
+2
+1
0
-1
-2
slow
fast



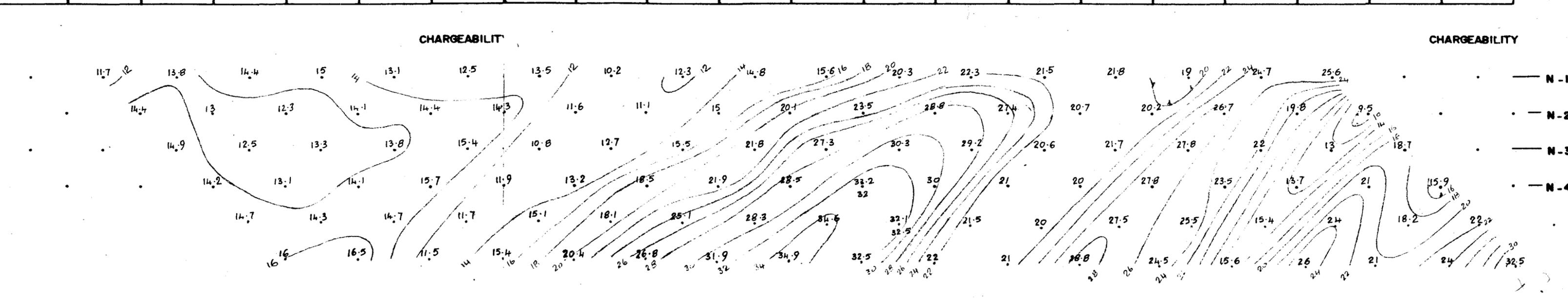
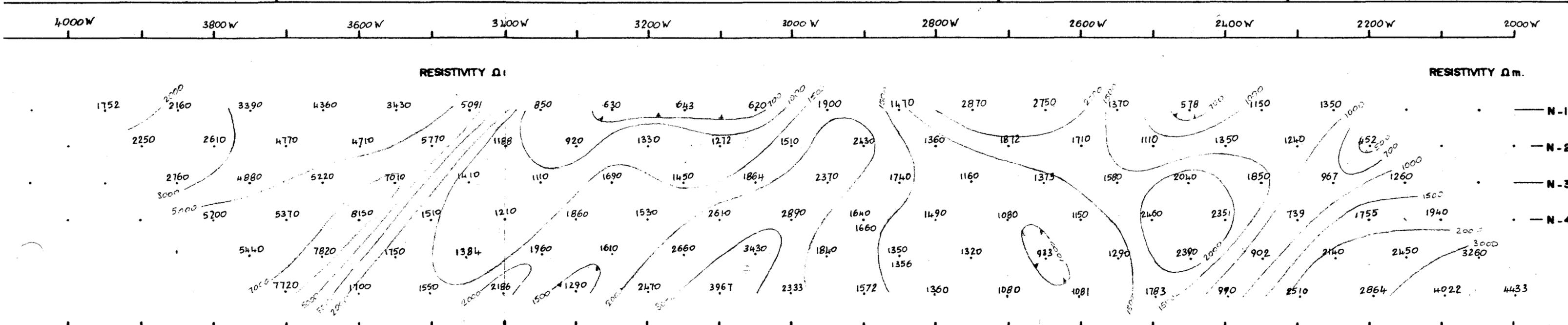
2500W 2000W 1500W 1000W 500W 0

AN 1973

070

311060

| | | | | | | |
|----------------|-----|---|---------------------|-----|------------------------------|--|
| DATE | |  <p>SCINTREX PTY. LTD.
INDUCED POLARIZATION AND RESISTIVITY SURVEY
POLE - DIPOLE ARRAY</p> | DATE 14-3-1980 | | LINE No. 23-7N | |
| PLOTTED BY | | | PLOTTED BY G.S. | | PROSPECT HOWARD'S ANOMALY | |
| PULSE | Rx. | | PULSE 2 sec. | Rx. | JOB No. TAS-073A
Addendum | |
| DIPOLE SPACING | | | DIPOLE SPACING 100' | | | |



071



SCINTREX PTY. LTD.

INDUCED POLARIZATION AND RESISTIVITY SURVEY

POLE - DIPOLE ARRAY

DATE 1-2-2-80

PLOTTED BY P.M.

PULSE 2 sec

Rx.

DIPOLE SPACING 300'

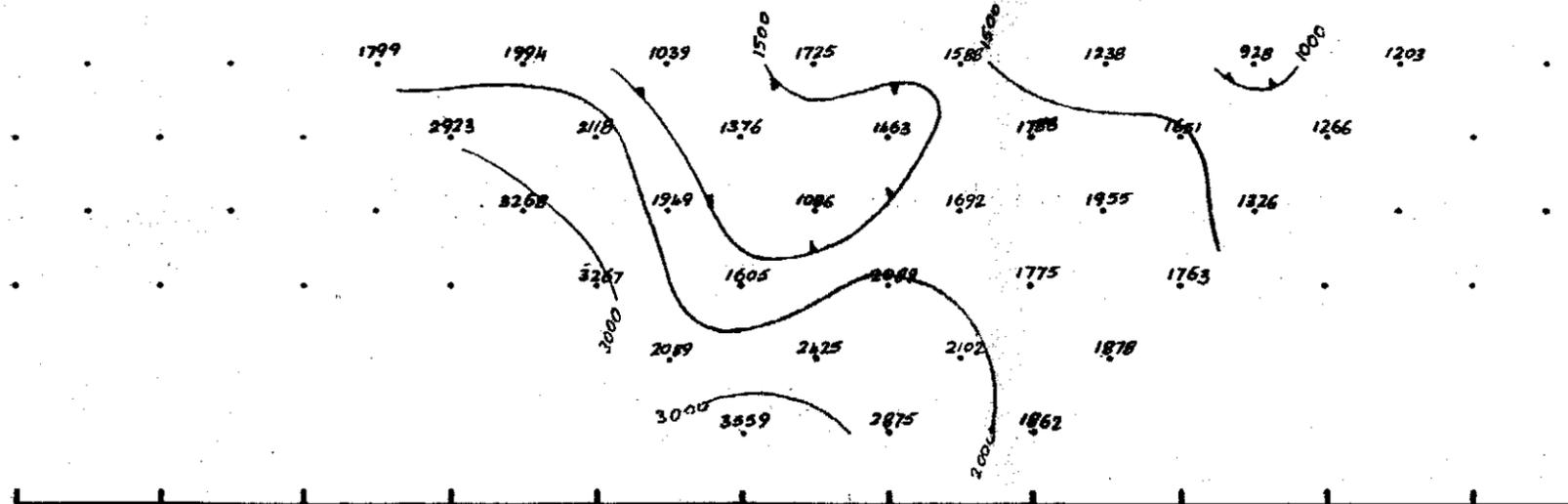
LINE No. 23-4N

PROSPECT HOWARD'S ANOMALY

JOB No. TAS-073A

3100W 3000W 3000W Hill 2800W 2500W Hill 2200W Road River 1900W 1600W 1300W Hill

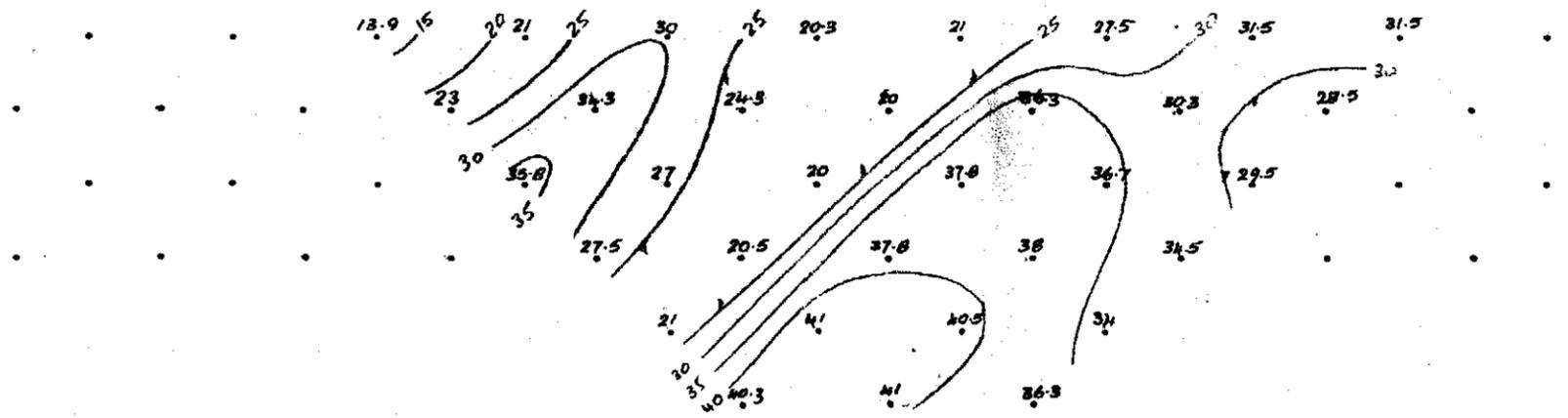
RESISTIVITY Ωm .



- N-1
- N-2
- N-3
- N-4
- N-5
- N-6

C X W

CHARGEABILITY



- N-1
- N-2
- N-3
- N-4
- N-5
- N-6

050

5 cm

LINE 25N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

NOTE: 1cm = 100 ft

ΔM
1.2
1
0
-1
-2

Chargability in kilohm/foot (Kfs)

Resistivity in Ohm-meters (Ωm)



U.S. GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
BULLETIN 14-B
1965

PL 121A

051

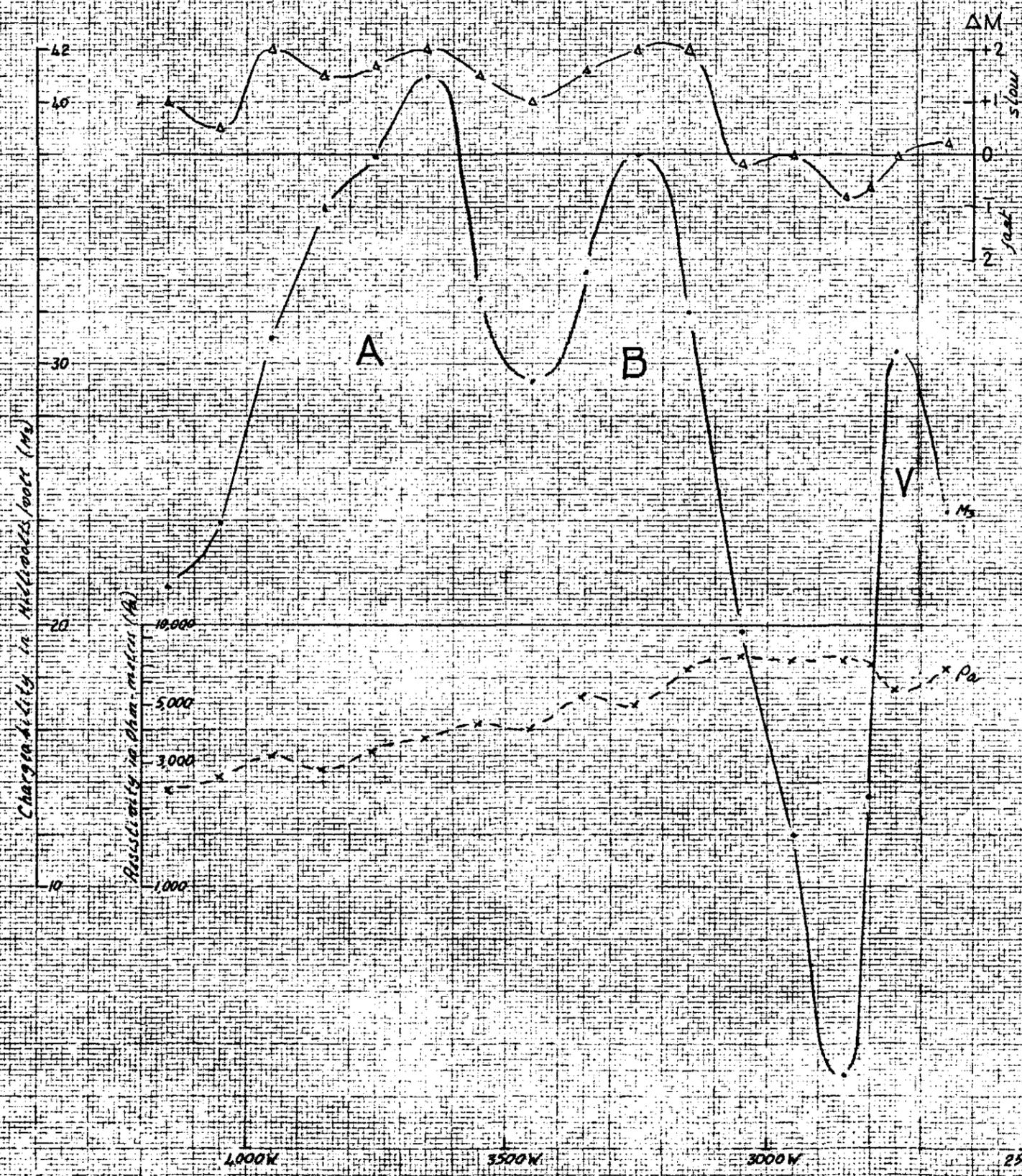
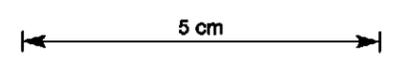
LINE 24-5N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

NOTE: 1cm = 100ft



PROJECT 8-1961, 1962, 1963, 1964, 1965, 1966, 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020

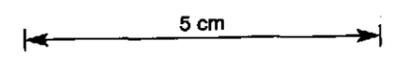
LINE 24N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

NOTE: 1cm = 100ft



AM
+2
+1
0
-1
-2

slow
fast

Chargability in milliamperes/foot (mA)

Resistivity in ohm-meters (Ωm)

10,000
5,000
3,000
1,000

1000W 3500W 3000W 2500W 2000W 1500W

A

B

W

X

M

053

5 cm

LINE 23-7N

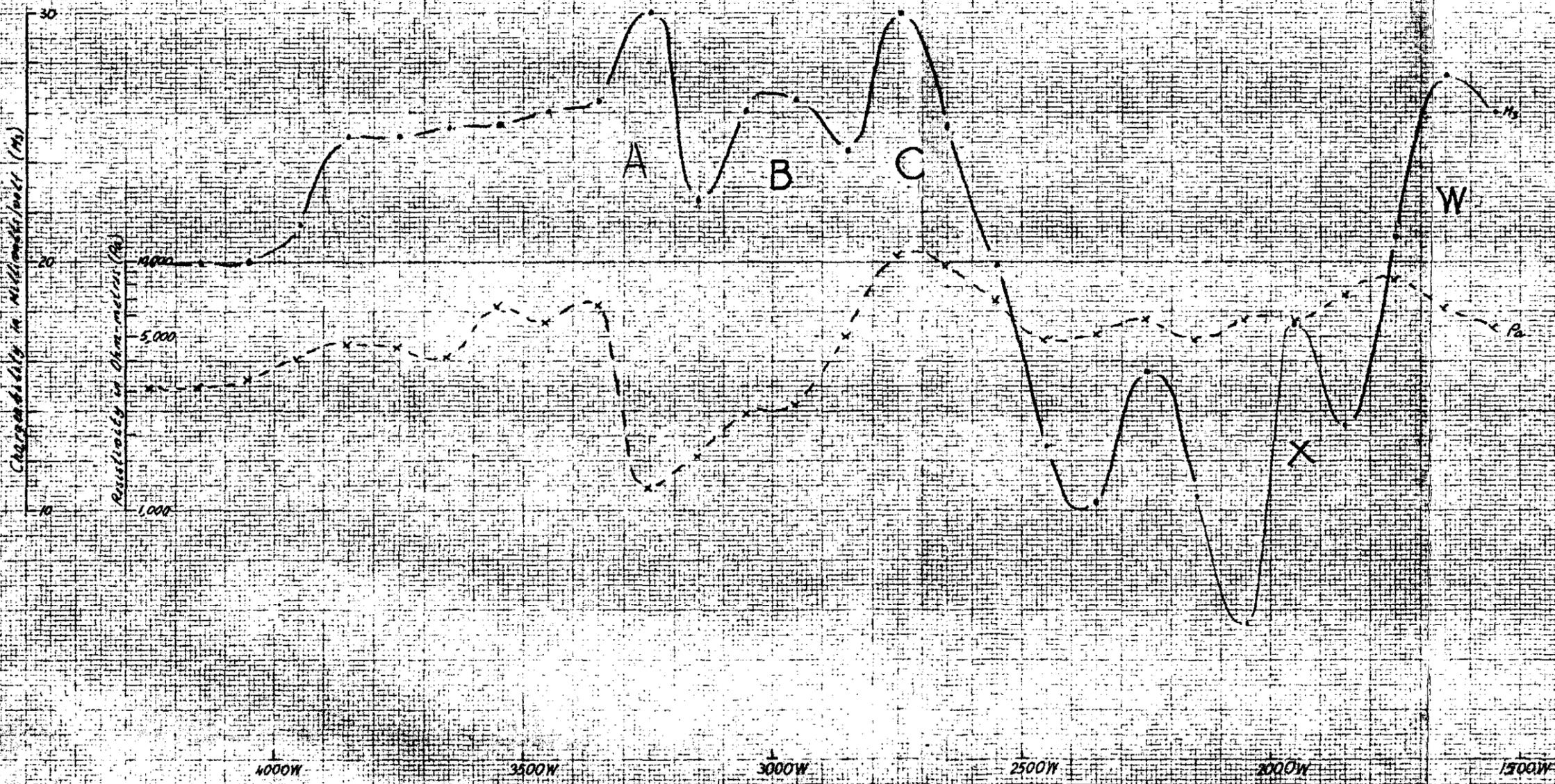
HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

NOTE: 1 cm = 100 ft

ΔM
 +2
 +1
 0
 -1
 -2
 slow
 fast



Pegs marked 4000W 3500W 3000W 2700W 2500W 2000W 1500W
 ← line not pegged →

054

VIETNAM

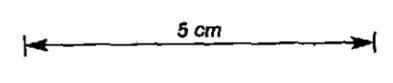
LINE 23-4N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

NOTE: 1cm = 100 ft



ΔM
2
1
0
1
2
slow
fast

Chargability in Millivolts (Mv)

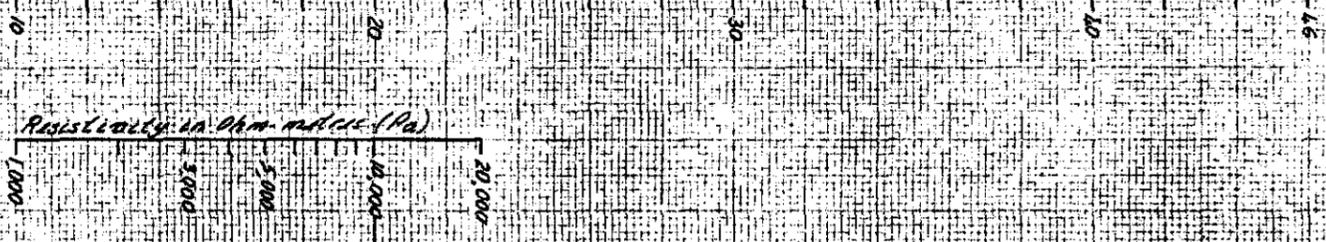
Resistivity in Ohm-meters (Ω)

1000W 850W 700W 550W 400W 250W 100W

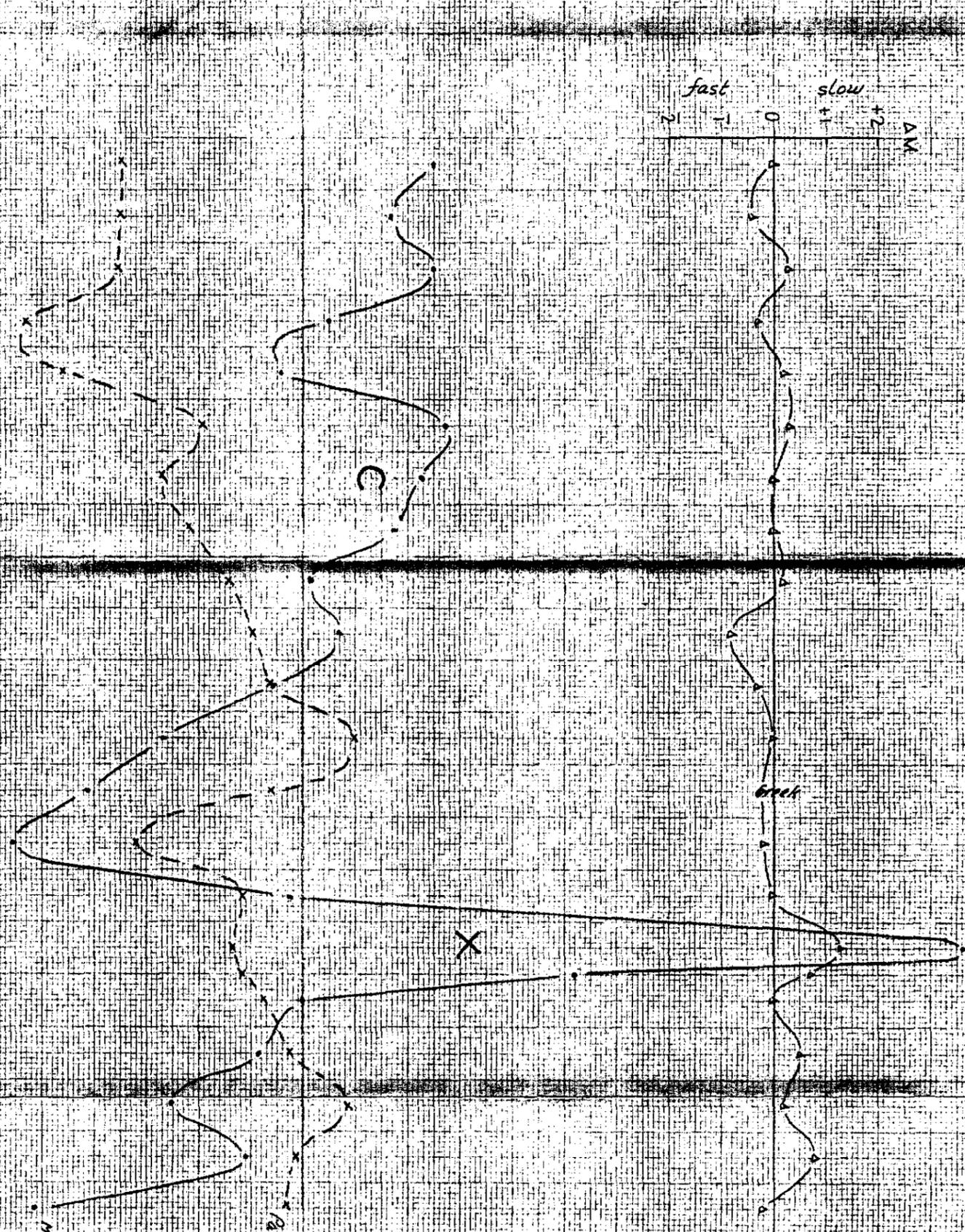


Chargeability in Milli-mho/foot (Ma)

Resistivity in Ohm-meters (Pa)



fast
slow
AM
+2
+1
0
-1
-2



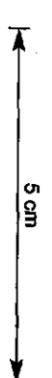
LINE 23N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

NOTE: 1cm = 100ft



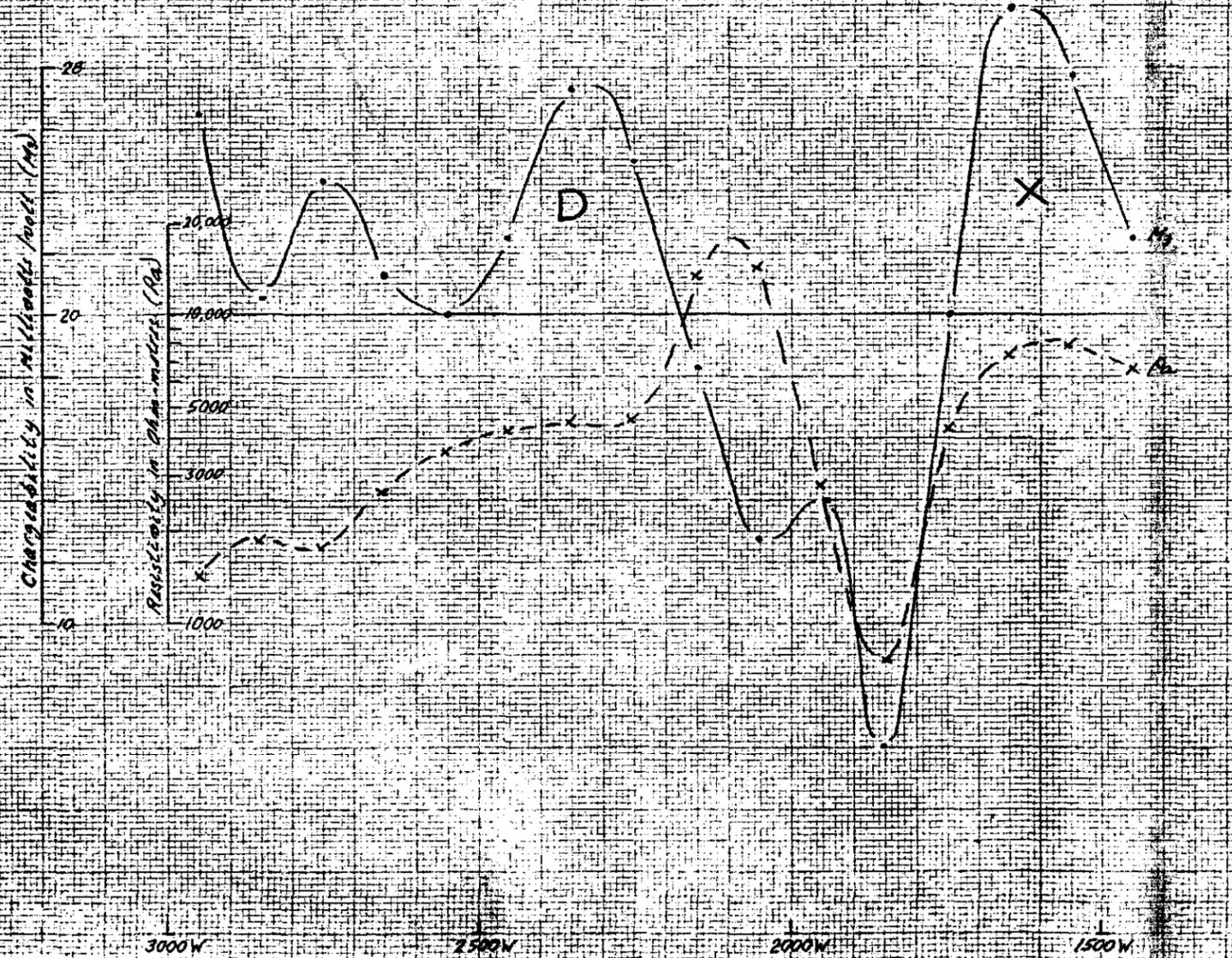
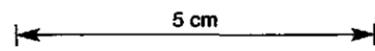
LINE 22.5N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

NOTE 1cm = 100ft



057

U.S. GEOLOGICAL SURVEY

VIC 14

5 cm

LINE 22-2N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS = 073A

NOTE: 1cm = 100 ft

ΔM
+2
+1
0
-1
-2
slow
fast

Chargability in Millivolts/foot (Ms)

Resistivity in Ohm-meters (R<sub>m</sub>)

30
20
10

10,000
5,000
3,000
1,000

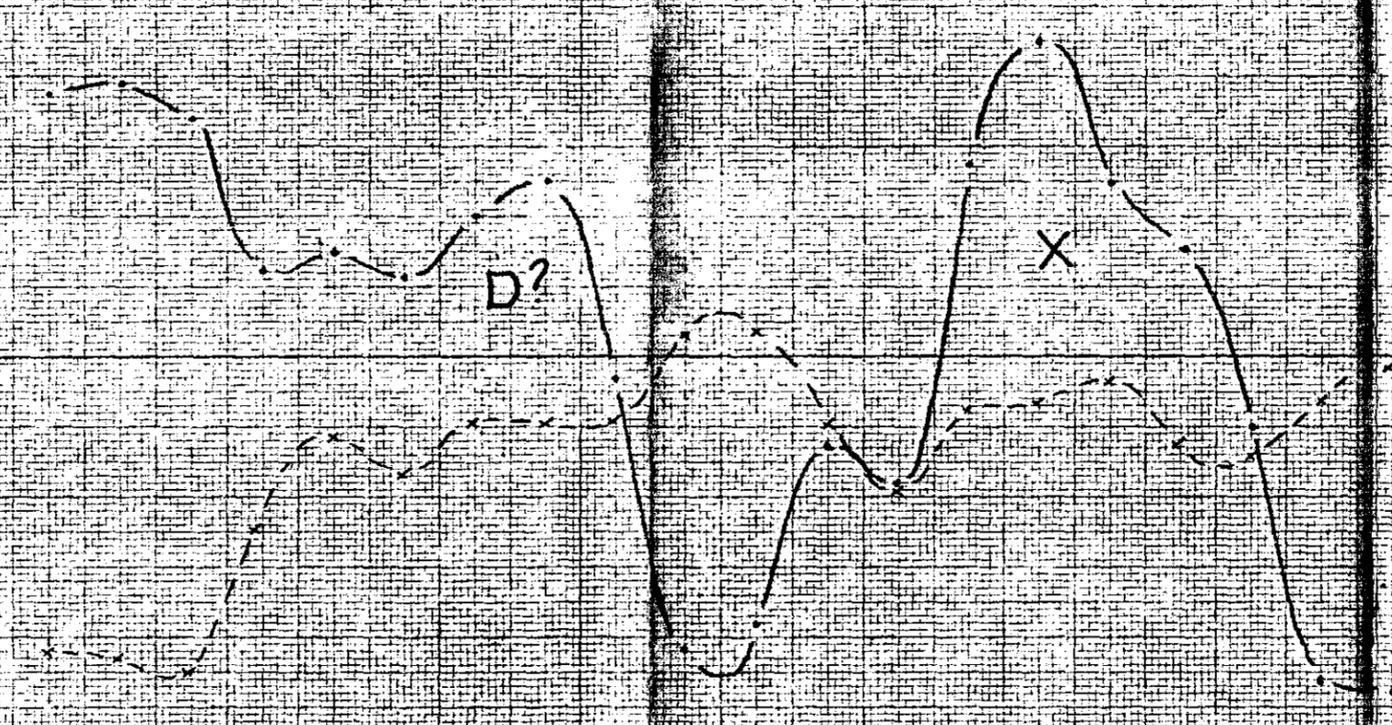
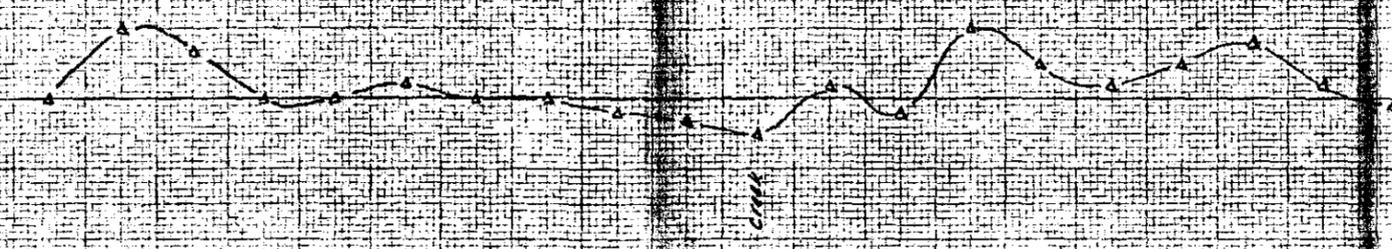
500W

300W

250W

200W

150W



Ms
R<sub>m</sub>

3110C9

058

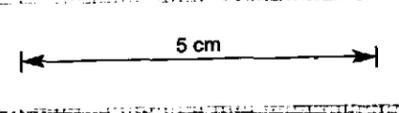
LINE 22N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

NOTE: 1cm = 100ft



ΔM
+2
+1
0
-1
-2
fast slow



VIGI Vp

13. Refer to the adjacent station charts

LINE 21-9N

HOWARD'S ANOMALY

GRADIENT ARRAY EIP

TAS-073A

NOTE: 1cm = 100ft

5 cm

Chargability in Millipots/volt (Mv)
Resistivity in Ohm-meters (R<sub>m</sub>)

10,000
5,000
3,000
1,000

ΔM
slow
+2
+1
0
-1
-2
fast

3000W 2500W 2000W 1500W 1000W

E

F

G

crack

X

M<sub>2</sub>

P<sub>2</sub>

060

LINE 21-6N

HOWARD'S ANOMALY

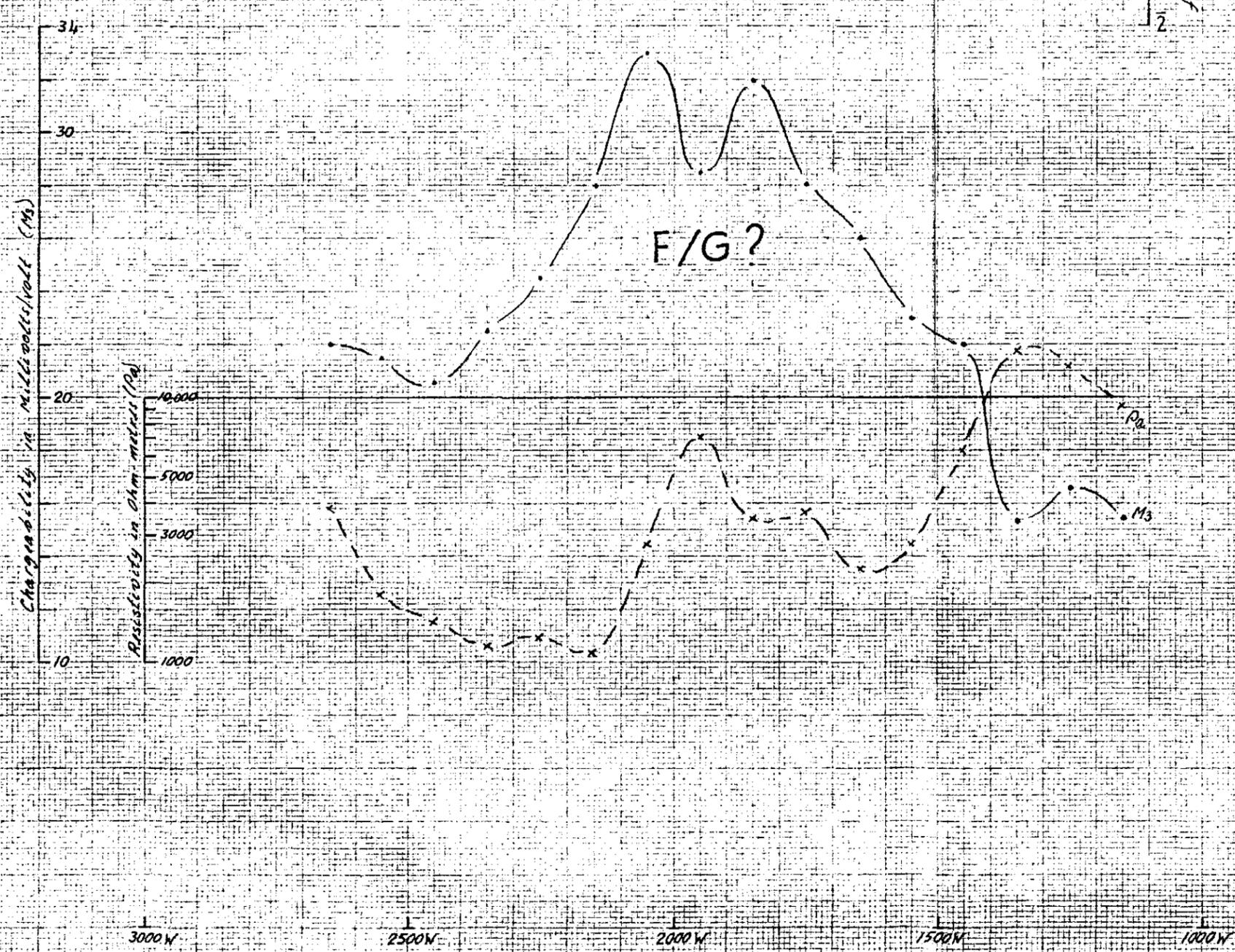
GRADIENT ARRAY EIP

TAS-073A

NOTE: 1cm = 100 ft

5 cm

ΔM
+2
+1
0
-1
-2
slow
fast



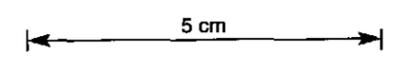
LINE 213N

HOWARD'S ANOMALY

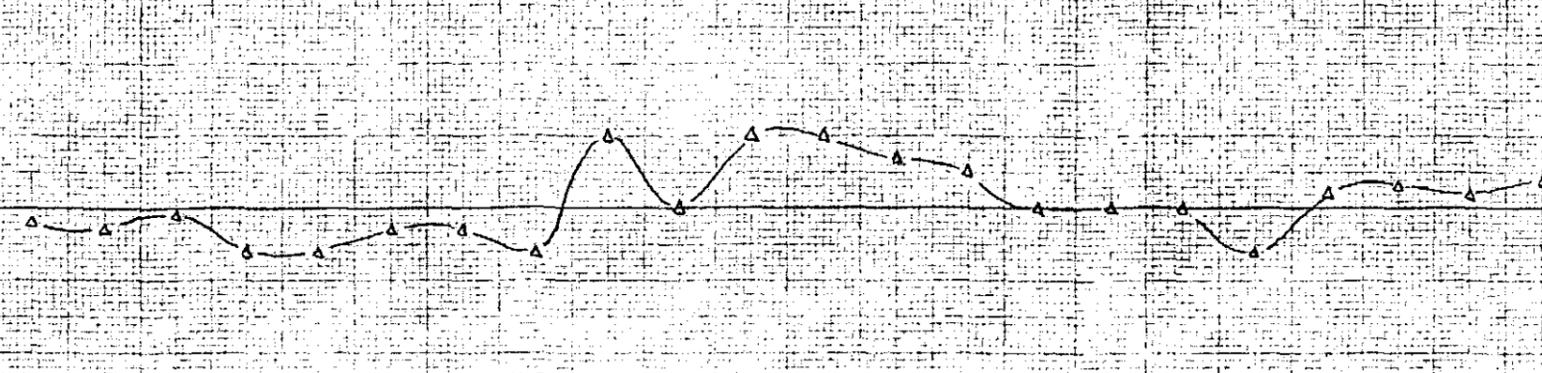
GRADIENT ARRAY EIP

TAS-073A

NOTE 1cm = 100ft



ΔM
+2
+1
0
-1
-2
slow
fast



LINE 21N

HOWARD'S ANOMALY

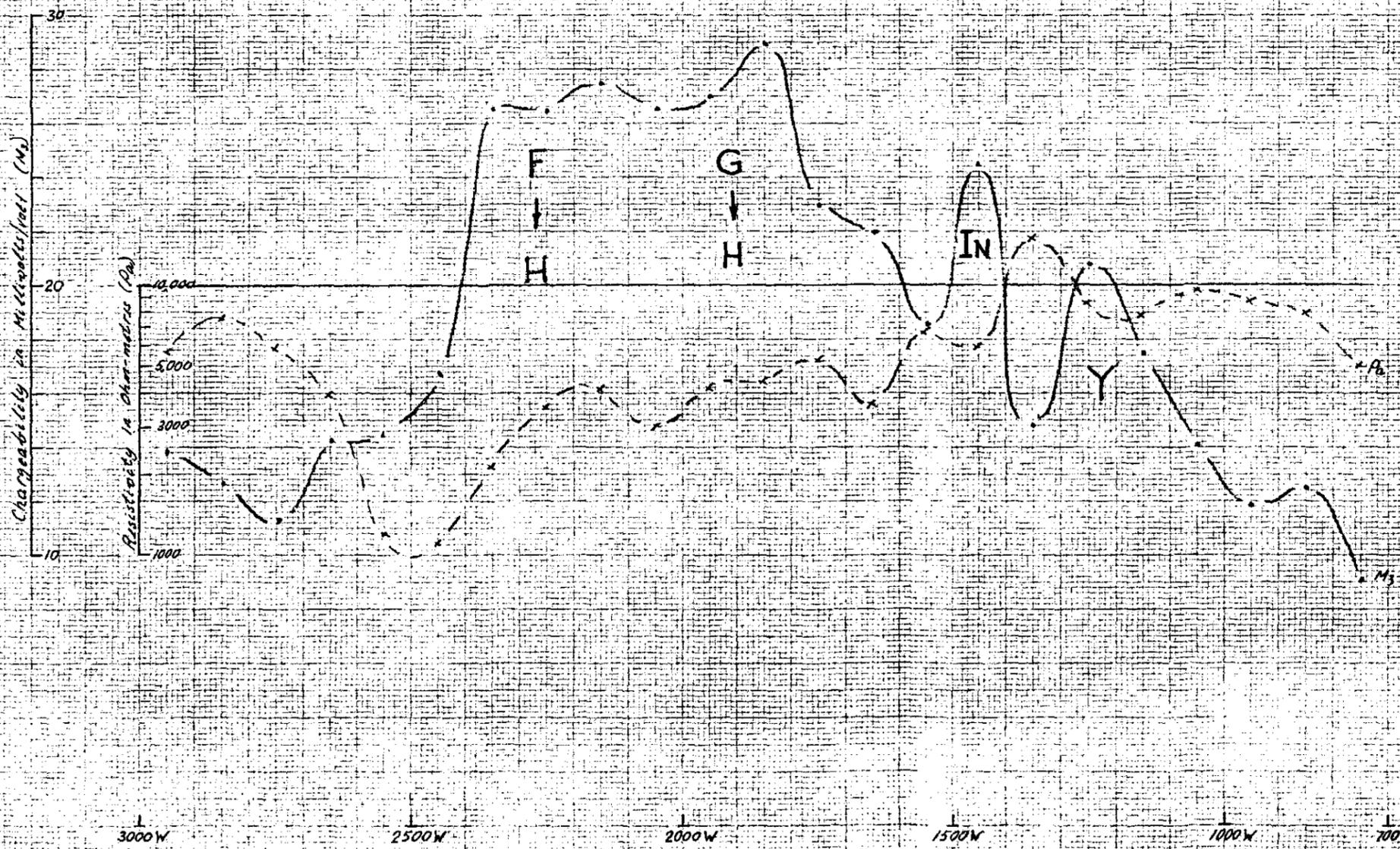
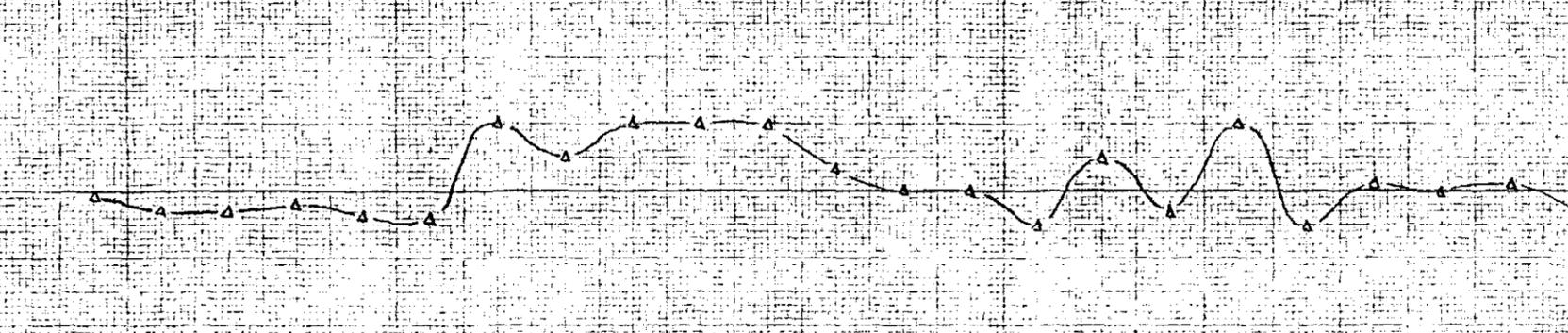
GRADIENT ARRAY EIP

TAS-073A

NOTE 1cm = 100 ft

5 cm

ΔM
+2
+1
0
-1
-2
slow
fast



073



SCINTREX PTY. LTD.

INDUCED POLARIZATION AND RESISTIVITY SURVEY

POLE - DIPOLE ARRAY

DATE 29-30-1-80 & 1-2-80

PLOTTED BY R.M.

PULSE 2 sec

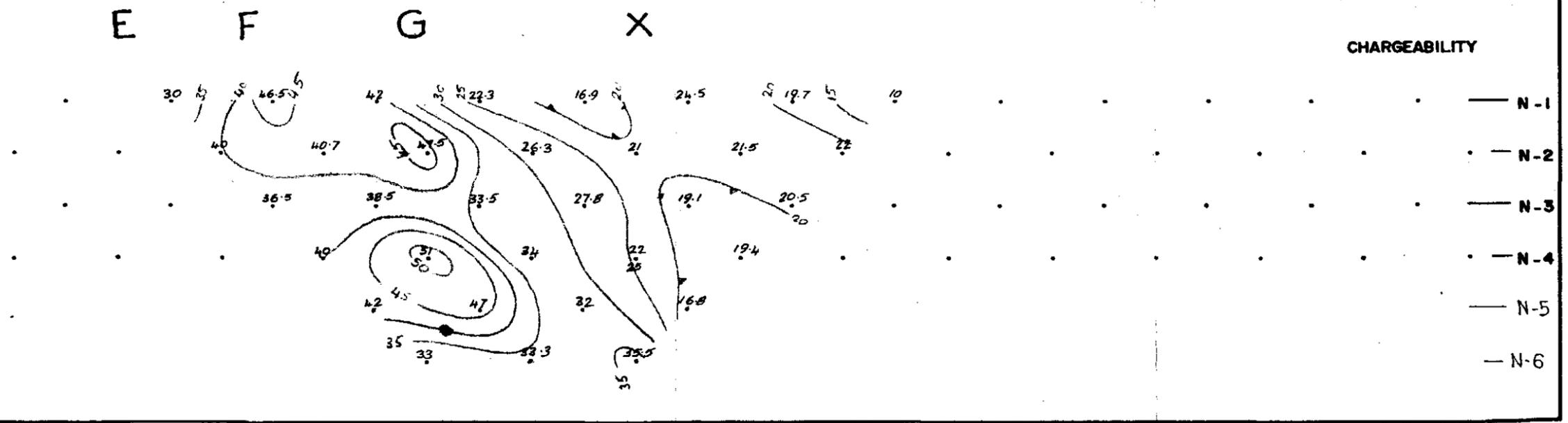
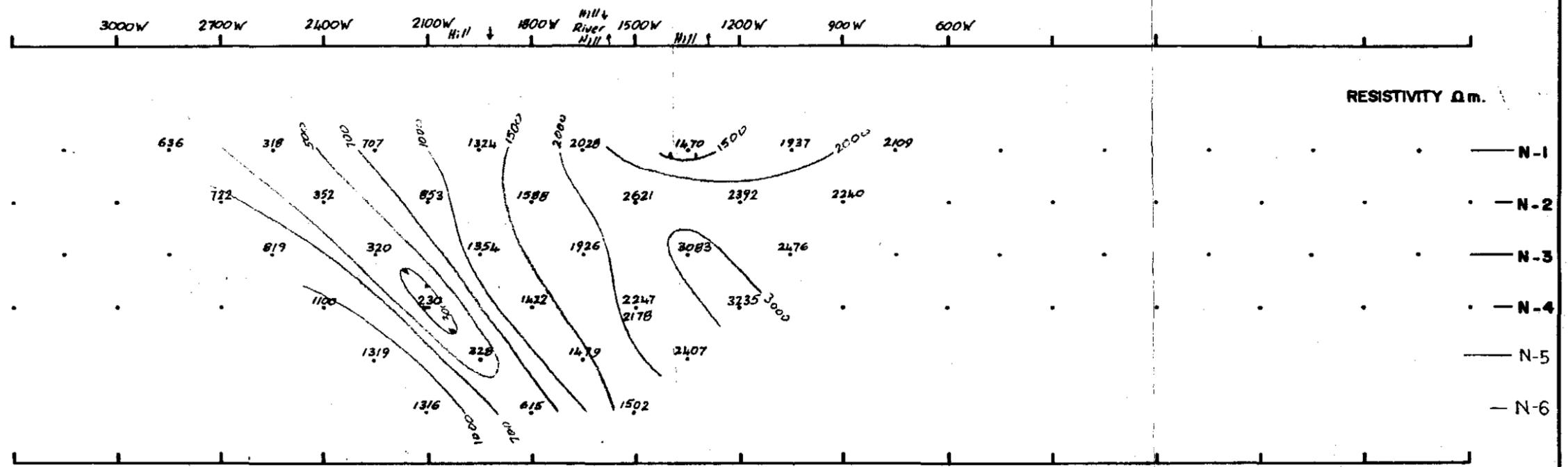
Rx.

DIPOLE SPACING 300'

LINE No. 22N

PROSPECT HOWARD'S ANOMALY

JOB No. TAS-073 A



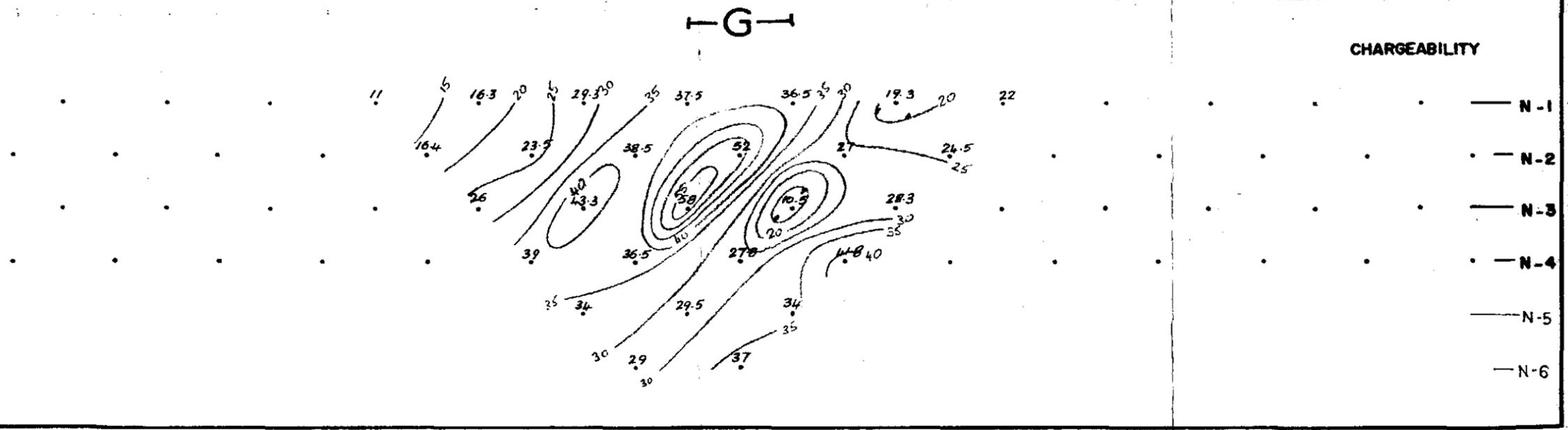
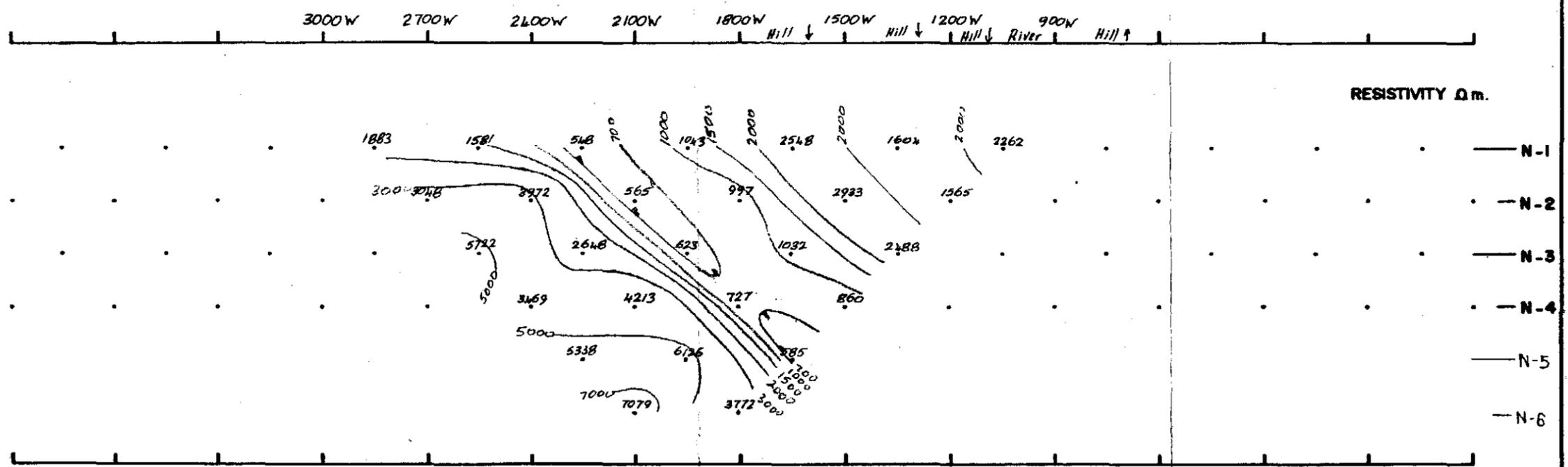
07A



SCINTREX PTY. LTD.
 INDUCED POLARIZATION AND RESISTIVITY SURVEY
 POLE - DIPOLE ARRAY

DATE 25, 27, 29.1.80
 PLOTTED BY R.M.
 PULSE 2 sec. Rx.
 DIPOLE SPACING 300'

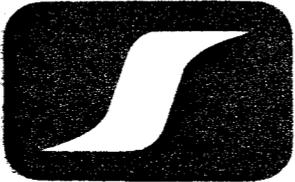
LINE No. 21-3N
 PROSPECT HOWARD'S ANOMALY
 JOB No. TAS-073A



- N-1
- N-2
- N-3
- N-4
- N-5
- N-6

075

| | | | |
|----------------------|-----|---------------------------|--|
| DATE 17, 18, 20-1-80 | | LINE No. 20-6 N | |
| PLOTTED BY R.M. | | PROSPECT HOWARD'S ANOMALY | |
| PULSE 2 sec | Rx. | JOB No. TAS-073 A | |
| DIPOLE SPACING 50' | | | |

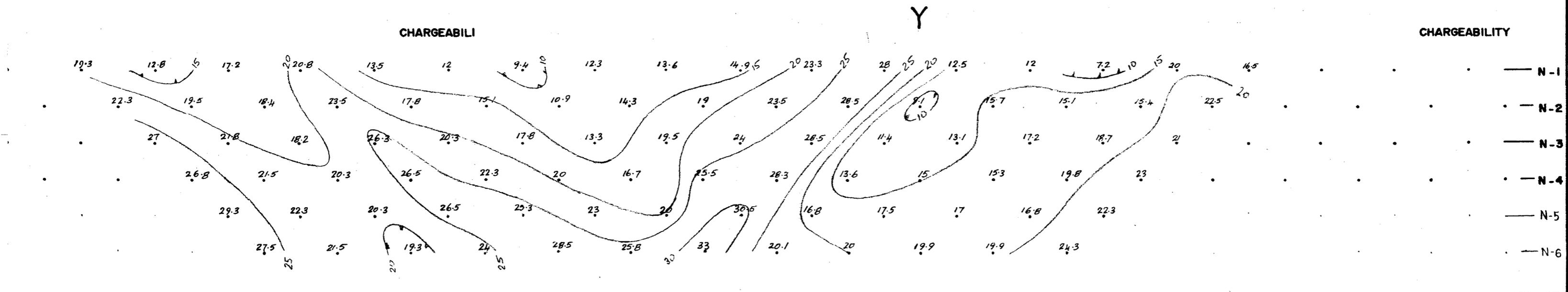
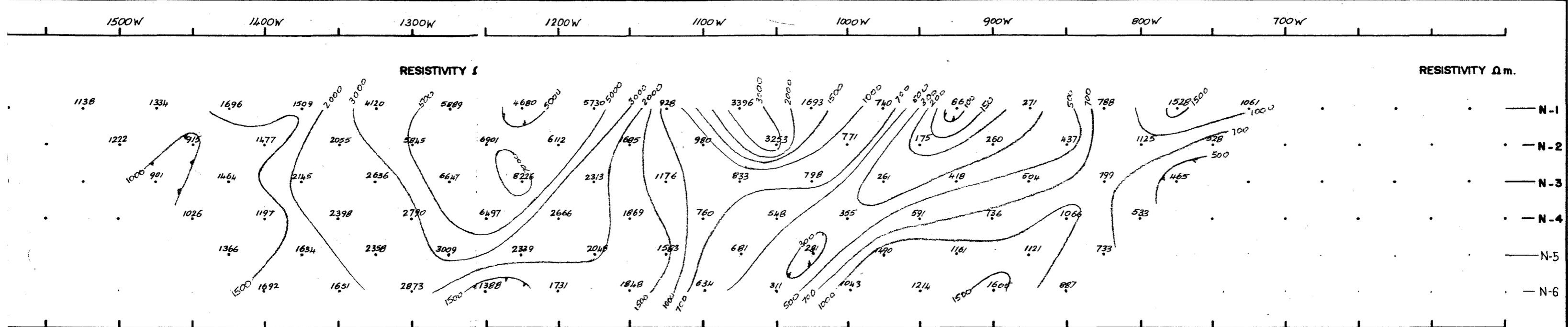


SCINTREX PTY. LTD.

INDUCED POLARIZATION AND RESISTIVITY SURVEY

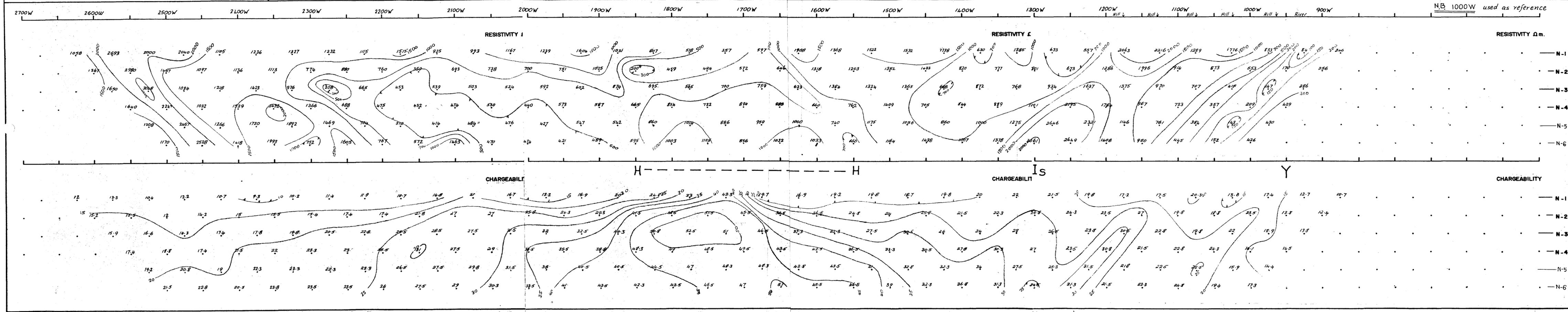
POLE - DIPOLE ARRAY

| | | |
|----------|----------|---------|
| LINE No. | PROSPECT | JOB No. |
|----------|----------|---------|



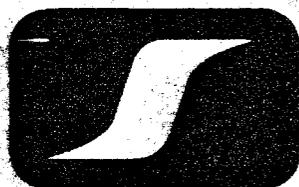
077

| | | | | | | | | | | |
|--|----------------|----------|--|--|-----------------|--------------|--------------------|-----|---------------------------|--|
|  <p>SCINTREX PTY. LTD.
INDUCED POLARIZATION AND RESISTIVITY SURVEY
POLE - DIPOLE ARRAY</p> | DATE | LINE No. |  <p>SCINTREX PTY. LTD.
INDUCED POLARIZATION AND RESISTIVITY SURVEY
POLE - DIPOLE ARRAY</p> |  <p>SCINTREX PTY. LTD.
INDUCED POLARIZATION AND RESISTIVITY SURVEY
POLE - DIPOLE ARRAY</p> | DATE 20-24-1-80 | LINE No. 20N | | | | |
| | PLOTTED BY | | | | PROSPECT | | PLOTTED BY R.M. | | PROSPECT HOWARD'S ANOMALY | |
| | PULSE | Rx. | | | JOB No. | | PULSE 2 sec. | Rx. | JOB No. TAS-073 A | |
| | DIPOLE SPACING | | | | | | DIPOLE SPACING 50' | | | |



078

311081



SCINTREX PTY. LTD.

INDUCED POLARIZATION AND RESISTIVITY SURVEY

POLE - DIPOLE ARRAY

DATE 24-1-80

PLOTTED BY R.M.

PULSE 2 sec

Rx. 304127

DIPOLE SPACING 50'

LINE No. 20N

PROSPECT HOWARDS ANOMALY

JOB No. TAS-073A

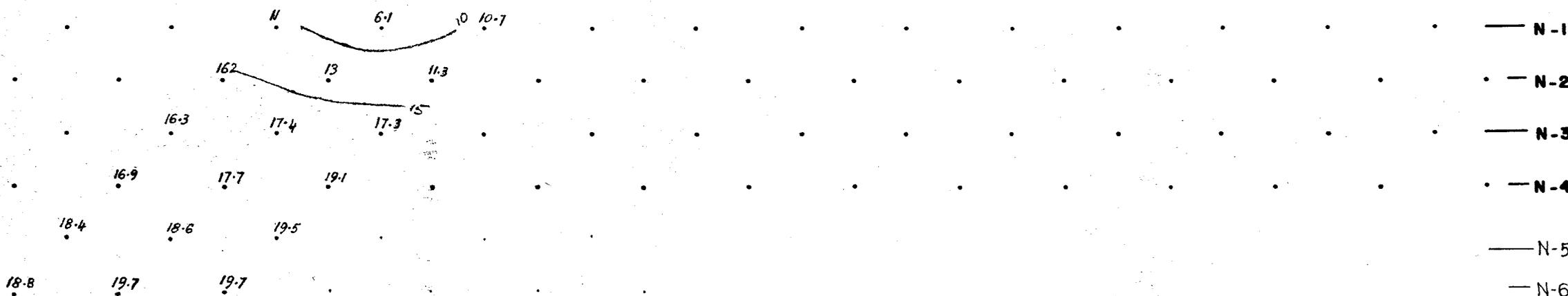
hill ↑ 800W hill ↑ hill ↑ 700W

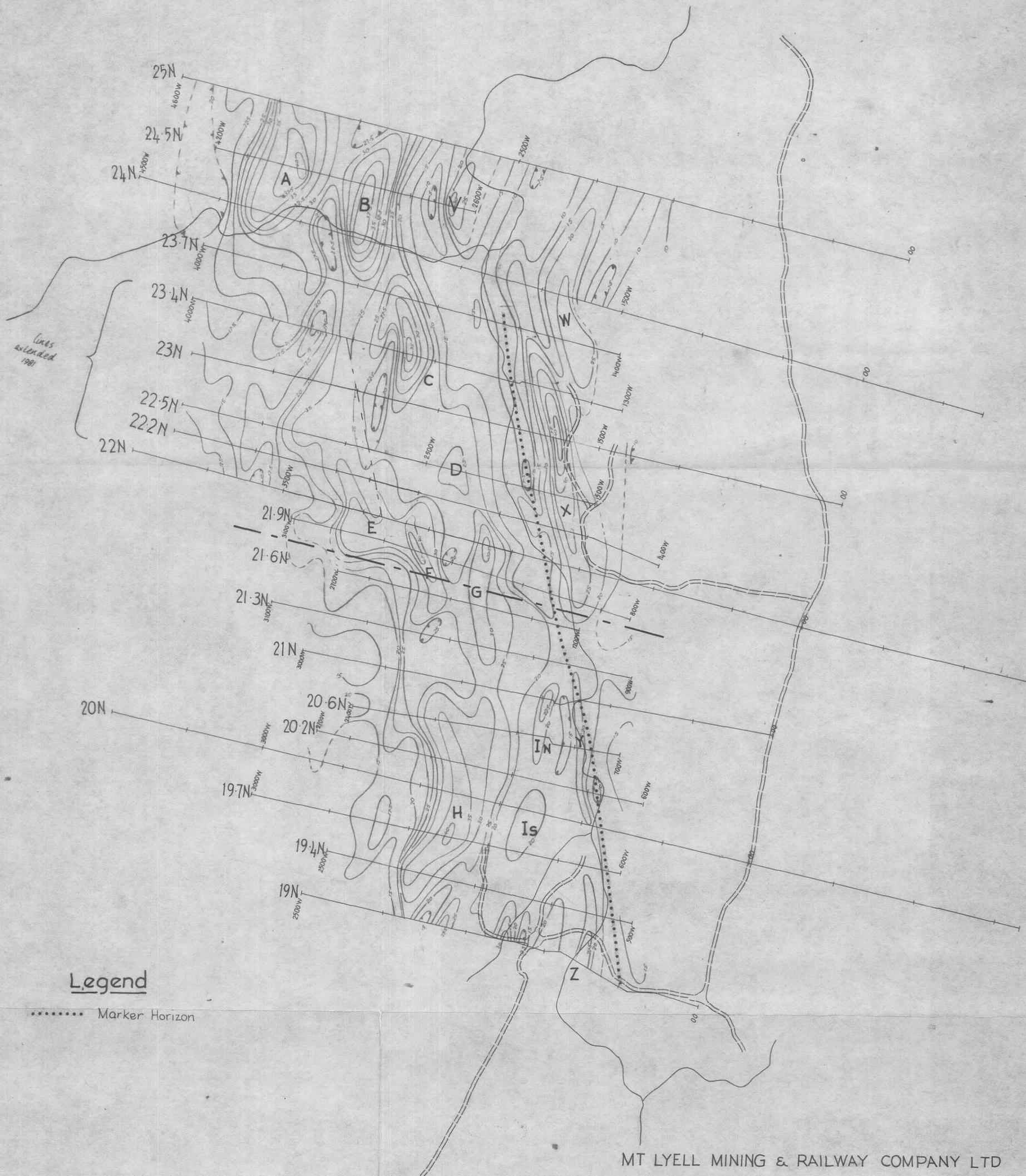
N.B. 700W used as reference

RESISTIVITY Ωm.



CHARGEABILITY





Legend

..... Marker Horizon

MT LYELL MINING & RAILWAY COMPANY LTD

HOWARD'S ANOMALY
NR. QUEENSTOWN - TAS.

GRADIENT ARRAY EIP SURVEY

**CHARGEABILITY
CONTOUR PLAN**

SURVEYED & COMPILED BY
SCINTREX



NOVEMBER, 1979

311082

SCALE 1:5000 ft.

Job N° TAS-073A

PLATE 1.

Alterations & extensions TAS-084
(1981)

MAP NUMBER: 2/438

079

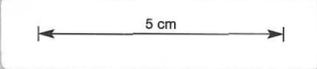
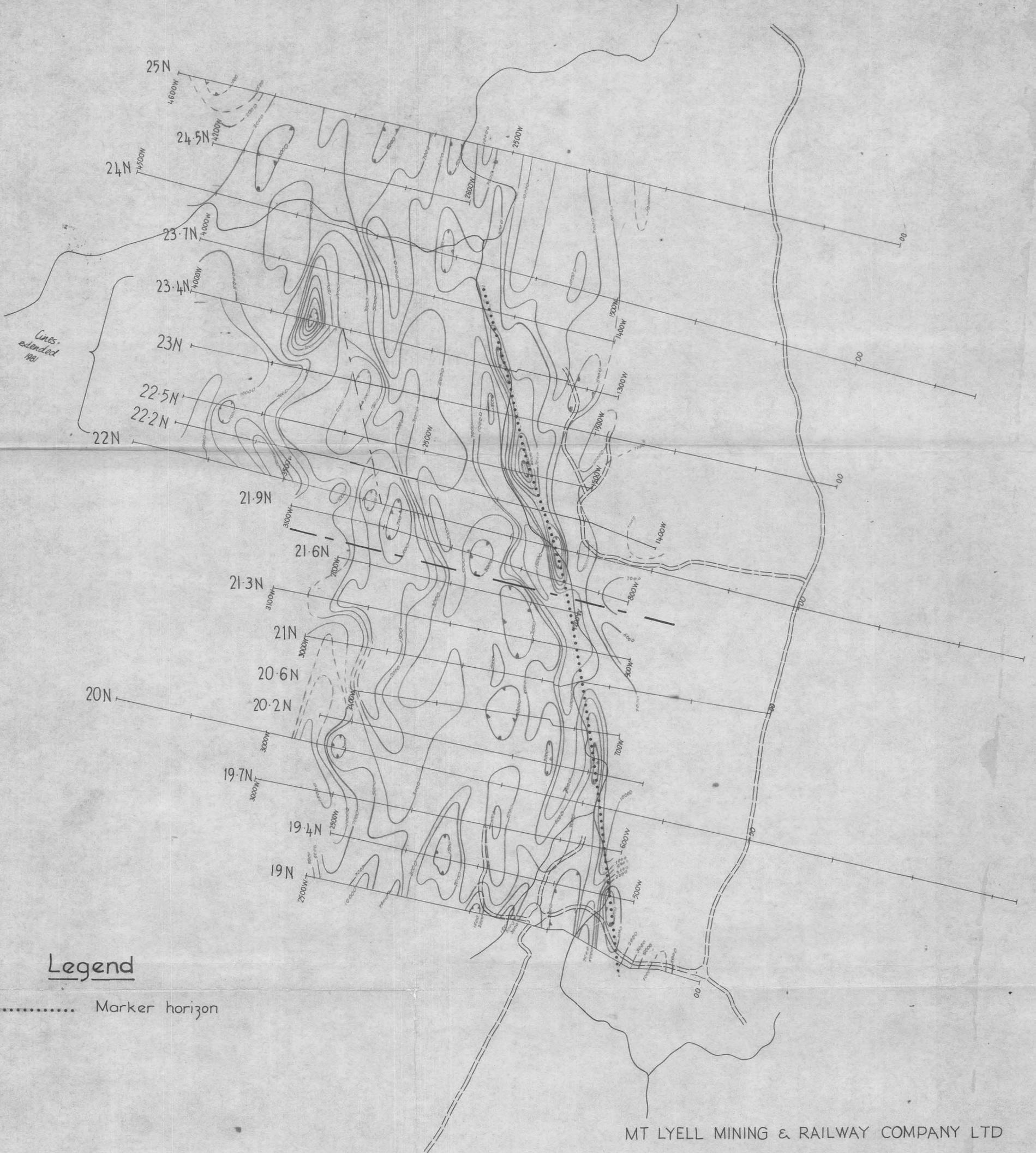


FIG: 34



Legend

..... Marker horizon

MT LYELL MINING & RAILWAY COMPANY LTD

HOWARD'S ANOMALY

NR. QUEENSTOWN - TAS.

GRADIENT ARRAY EIP SURVEY

**RESISTIVITY
CONTOUR PLAN**

SURVEYED & COMPILED BY
SCINTREX



NOVEMBER 1979

SCALE 1:5000 ft.

311083

Job N° TAS-073A

PLATE 2.

Alterations & extensions TAS-084
(1981)

MAP NUMBER: 2/439

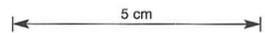


FIG:35 080