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REPORT ON  
DOWN-HOLE THREE-ARRAY AND  
APPLIED POTENTIAL SURVEYS  
MT. AGNEW, NEAR ZEEHAN, TASMANIA  
ON BEHALF OF  
RENISON LIMITED  
22 OCT 1982

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PRIVATE AND CONFIDENTIAL

REPORT ON  
DOWN-HOLE THREE-ARRAY AND  
APPLIED POTENTIAL SURVEYS  
MT. AGNEW, NEAR ZEEHAN, TASMANIA  
ON BEHALF OF  
RENISON LIMITED

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JULY, 1982

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*SUMMARY*

*Three array down hole surveys carried out down diamond drill holes FED-20 to 23 have shown the mineralisation in FED-20 to be relatively conductive and the mineralisation in FED-21 to be somewhat more resistive, but still less resistive than the host rocks. Both intersections, however, were highly chargeable.*

*An applied potential survey on surface, and down holes FED-20 to 22 (but not 23), has implied the strike is about grid 075° and plunges on grid 290° - 300° at about 60° - 70°. An analysis of the data implies the conductor associated with the mineralisation in FED-20 was located above DDH FED-20 and to the north-west of FED-23.*

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## DISCUSSION OF RESULTS

Each of the aspects of the surface and down-hole surveys are discussed separately below.

### *GEOPHYSICAL SIGNATURE OF THE MINERALISATION IN DIAMOND DRILL HOLES FED-20 and 21*

*FED-20* ..... was logged using a 1.5 metre three-array from 36 metres to 152 metres. Unfortunately the hole could not be logged above 36 metres due to casing. The chargeability background between 64 metres and 118 metres varies from 2 millivolts/volt to 8 millivolts/volt and probably represents the normal background within unmineralised granites. (However, the geological log notes mineralised medium grained granites between 40.5 and 96.5 metres.) Between these limits the resistivities recorded ranged from 200 ohm-metres to 1000 ohm-metres, perhaps averaging about 400 ohm-metres.

At precisely 63 metres and 60 metres respectively, sharp contacts were recorded between a highly chargeable and conductive unit above, and a low chargeability/moderate resistivity unit below. Between 49 metres and 62 metres, high chargeabilities to 100 millivolts/volt were recorded from rocks whose bulk resistivities are of the order of 85 ohm-metres(+), while above 44 metres the resistivities fall to less than 10 ohm-metres. Chargeabilities fall also to a still high 50 millivolts/volt. The decay forms here are slow with  $\Delta M_n$  values being as low as +11% at 40 metres, but below this, the  $\Delta M_n$  values varied from fast in the lower amplitudes to slow in the higher amplitudes. (The slower values imply coarser grain size while the fast values imply finer grain size.)

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A further significant change was noted below 120 metres. Here, resistivities were elevated over narrow (5 to 8 metres) widths to 20,000 ohm-metres at 125 metres and 120,000 at 138 metres. While chargeabilities of 30 millivolts/volt were observed centred at 125 metres and 145 metres, these are associated with high rather than low resistivities observed within the mineralised section.

The characteristics observed here are similar to those seen at the Sweeneys deposit, namely, hundreds of ohm-metres within the mineralised section, and tens of thousands away from mineralisation. Certainly the mineralised section in this hole is seen to be less resistive than the non-mineralised section, and thus a reasonable situation for the applied potential method. In the present case the electrode was emplaced at about 50 metres.

FED-21 ..... This hole was logged using a 1.5 metre three array between 46 metres and 114 metres. In the upper section low resistivities were observed above 50 metres, and between 57 and 67 metres. In both cases lower resistivities of 250 ohm-metres were recorded as against two to three times this level away from the chargeable source. 10% sulphides were recorded between 59 and 65 metres which accounts for the high chargeability in one section, while an average of 5% sulphides are recorded between 31 and 70 metres.

Between 70 metres(+) and 92 metres, low background chargeabilities of 5 millivolts/volt(+) and higher resistivities of 350 to 1300 ohm-metres were recorded, while below 92 metres both resistivity and chargeability rise significantly.

While the mineralised section centred at 60 metres (as seen from the chargeability

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maximum) shows high chargeability akin to that seen within the mineralised section of FED-20, the resistivities are significantly higher at 200 ohm-metres as against 25 ohm-metres or less in FED-20.

The significance is that the mineralised section of FED-20 at 50 metres(+) where the current electrode was placed will be able to be traced out *providing* that electrical continuity is present. Sulphides which are not electrically continuous within themselves and with the mineralisation, will not contribute to the applied potential anomaly. In any analysis of the data this important proviso must always be borne in mind.

#### *SURFACE APPLIED POTENTIAL SURVEY*

The appendix describing the method should be carefully read by those unfamiliar with the method. Essentially the *conductive* section of the body is energised by placing a current electrode within it, thus making the *conductor* the electrode. Electrodes of opposite polarity are placed either side at a distance across strike to approximate infinity. The equipotential field will then mirror the shape of the *conductor* into which the electrode was placed. In the present survey two measurements were taken,  $V_p$ , the primary potential at points along the traverse lines, and  $M$ , the chargeability. From these measurements  $V_s$  ( $M = V_s/V_p$ ) was calculated. Contour maps of  $V_p$ ,  $V_s$  and  $M$  at the scale of 1:1000 are shown.

*Primary Field Data (Plate 1)* ..... The data shows a distinct primary voltage potential ( $V_p$ ) centred at or to the south of 855N on line 650E. Since the electrode was emplaced 50 metres down FED-20 this would imply:-

- a) a pitch of the conductor of up to  $65^\circ$ - $70^\circ$  in a grid  $290^\circ$ - $300^\circ$  direction,
- b) the elongation of the equipotential contours in the grid  $075^\circ$  direction suggests

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a 'strike' in that direction.

c) the equipotential suggests a strike length of the order of 60 metres(+).

*Secondary Field Data (Plate 2)* ..... shows two distinct maxima of 50 millivolts and 42.5 millivolts centred at 870N on line 600E and 840N on line 700E respectively. As the secondary field reflects the polarization of the body, these two maxima may well reflect the more disseminated material flanking the more conductive section. This appears to fit the simplified descriptions of drill holes FED-20 and FED-21 provided by David Kilpatrick of Renison, however, the detailed log will be required to clarify this. A simple interpretation of these two maxima together with the 35 millivolts contour which joins both maxima, would appear to imply that the upper and flanking sections of the body are more disseminated and more resistive than the central section of the body. The secondary field contours remain elongated along a  $075^{\circ}(+)$  grid orientation.

*DOWN-HOLE ELECTRICAL LOGS IN DDH FED-22*

The  $a = 1.5$  metre log was carried out between 46 metres and 226 metres. The first contrast with FED-20 and 21 is that the general level of resistivity observed is much higher, particularly below 110 metres. However, above this level, while resistivities remain low, chargeabilities are also low. Between about 135 metres and 170 metres, just about coinciding with the "fine-medium porphyritic white granite unit" localised high chargeability anomalies were defined at 145 metres(+), (90 millivolts/volt), 155-170 metres (60 millivolts/volt). As the  $a$  spacing of the array is small (1.5 metres) this strongly suggests sulphides to be present within the hole, or within a few metres thereof. The decay forms are almost normal suggesting an 'average' grain size to the source. A 20 metre three-array log over the same section shows only 10 to 20 millivolts/

volt anomalies over this section which suggests that the source of the anomaly is limited to within a few metres of the hole and does not increase in importance away from the hole.

It is considered that the body must be located above the central and lower sections of drill hole FED-22.

*RELATIONSHIP OF DOWN-HOLE APPLIED POTENTIAL LOGS CARRIED OUT IN HOLES FED-20, 21 and 22 WITH RESPECT TO THE SURFACE SURVEY*

*For all three drill hole sections the applied potential (both primary and secondary) has been contoured from surface to depth using the projected surface data over the trace of the hole, and the actual measurements made down hole.*

FED-20 ..... The simple contour pattern for  $V_p$  is shown on plate 4a. As would be expected on this, the energised hole, a strong applied potential anomaly is seen centred on the current electrode position at 50 metres.

It is important to note that the anomaly is closed off to the north, but could be open to the south at depth, however, this is not likely due to the surface contour pattern. The anomaly could be open to depth with a steep south dip. However, when viewed together with the surface data, it is clear that a steep pitch to the west-north-west is present. It is suggested that in this case there is little doubt that the *conductor* in fact pitches in that direction. A detailed analysis suggests (as stated above) that:-

- a) The pitch is  $60^{\circ}$ - $70^{\circ}$
- b) the direction is  $290^{\circ}$ - $300^{\circ}$

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Plate 4b gives the simplified contour pattern of the secondary field. Due to the 'twin' maxima along the surface trace of the drill hole, the anomaly has two surface lobes which tend to lie on the flanks of the primary field anomaly. Again the anomaly is closed off to the north and south, and may be open to depth steeply south. The clear west-north-west pitch is not evident on this data.

FED-21 ..... The simplified primary potential field is shown on plate 5a. This very clearly shows that the conductor is closed off to the south-east. Similarly the conductor is closed off to the north-west when the surface contours are considered. Also the conductor cannot be present to the north-east when the surface contours are considered. However, it is clear that when the surface and down hole contours are considered the boundary lies to the west of drill hole 21 and could extend to depth.

Of great interest is the fact that the significant mineralisation investigated in the hole between about 35 metres and 50 metres produces no distortion in the primary potential field. This means that:

- a) the mineralisation while being of lower resistivity (see log) than background, may form a separate conductor to that energised in hole FED-20, and perhaps
- b) may be a separate body.

Should this mineralisation be energised, and the surface survey be repeated, a different form of equipotential contour would indicate a quite separate body. Certainly as far as the main *conductor* is concerned, this intersection is not clearly joined to it, however, it may form part of the disseminated electrically non-continuous flank of the conductor (see below).

The secondary field contours are shown on plate 5. Here a generally similar overall

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contour pattern is seen. There is, however, one important difference. The secondary field contours bend towards the significant mineralisation intersection seen at 35 metres to 50 metres, thus suggesting the 'disseminated halo' possibility.

FED-22 ..... The simplified primary field contours are presented on plate 6a. This very clearly shows the anomaly to be closed off between the surface and the drill hole, and when viewed in conjunction with the surface and down hole FED-20 Vp contours, clearly demonstrates the west-north-west plunge to the source. Thus the source lies *above* drill hole.

Similarly the secondary field contours presented on plate 6b show the source closed off between drill hole and surface. What is most interesting is that when the 42.5 millivolts contour on both the down hole and surface Vs contours is considered, the western plunge of the secondary field response is clearly seen, although inferred to be west-south-west rather than west-north-west. However, this is a local trend only.

## BRIEF COMMENTS ON THE SIGNIFICANCE OF THE DATA IN AND AROUND FED-23

Clearly from the applied potential survey on surface and down holes FED-20, 21 and 22 (unfortunately no down hole applied potential survey was carried out on hole 23), drill hole 23 was situated well *under* the conductor associated with the mineralisation in drill hole FED-20.

Down-hole surveys carried out in FED-23 showed small narrow zones of chargeable material to be present at 105 metres(+), 175 metres(+), 195 metres(+), and 225 metres(+), the latter being associated with highly resistive 10,000+ ohm-metres

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resistivities and chargeabilities of over 80 millivolts/volt. As with hole 22, these zones occur within the medium-coarse and fine grained white granite units. Fast decay forms suggest a fine grained source, perhaps sulphides, although none have been recorded. Large spaced logs (25 metres and 50 metres) show nothing significant within these distances from the hole.

*Decay Forms*

The decay form observed within, or close to mineralisation at 50 metres in FED-20, is slightly slower than normal, but on the whole the decay forms were fast down this hole. In hole FED-21 the decay forms observed were invariably fast, but with the higher chargeability/lower resistivity sections at 60 metres and 65 metres showing relatively slower than average values.

This would appear to indicate that the mineralisation in FED-20 is of 'average' grain size, while that in FED-21 is of finer grain size than average. The fast to very fast decay forms within the host granites are typical of those of granites.

In FED-22 a series of higher chargeability values were noted between about 120 metres and 170 metres. The decay forms within this zone were generally much slower at  $\Delta Mn = +10\%$  to  $-15\%$  than seen within the granitic rocks above and below. This may be a sign of a coarser grained source at hole, and may be part of the 'halo' mineralisation around the body. While a similar series of slower than average decay forms was noted between 85 metres and 120 metres in hole FED-23 coincident with higher than average chargeabilities, it is difficult to relate this to a 'halo' effect. It is suggested that the core of holes 22 and 23 be re-examined to ascertain the cause of both the anomalous polarization and of the slower decays noted over these sections.

## CONCLUSIONS AND RECOMMENDATIONS

- 1 The surface and down hole primary applied potential surveys have yielded significant results which imply that the conductor associated with the mineralisation in drill hole FED-20 at 50 metres:
  - a) pitches steeply grid  $290^{\circ}$ - $300^{\circ}$  at  $60^{\circ}$  to  $70^{\circ}$
  - b) has a 'strike direction' of about  $075^{\circ}$
  - c) has a strike length of about 60 metres(+)
  
- 2 The secondary field data suggests a more disseminated section to the eastern and western ends of the conductor, and also on the upper hanging wall of the conductor.
  
- 3 The data suggests that the body lies above drill hole FED-22, and to the north-west of drill hole FED-23.
  
- 4 Only after detailed geological evaluation of this data should further drill holes be recommended, however, this data suggests drilling should be carried out parallel to FED-20 to intersect a steeply plunging source to the west-north-west thereof.
  
- 5 Applied potential surveys using *the same* electrode system should be carried out down any further drill holes to guide further work.

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Respectfully submitted on behalf of:

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## DETAILS OF WORK CARRIED OUT

*LIST OF LINES SURVEYED WITH APPLIED POTENTIAL*

500E	765N to 1020N
550E	750N to 1020N
600E	600N to 840N and 870N to 885N
650E	630N to 780N
700E	600N to 1020N
725E	795N to 1020N
750E	660N to 890N
800E	690N to 915N

*LIST OF DOWN-HOLE SURVEYS*
*DDH-1 (FED-20)*

Applied potential, 60 metres to 150 metres. (In conjunction with surface survey).

Three-array,  $a = 1.5$  metres from 35 metres to 150 metres.

*DDH-2 (FED-21)*

Applied potential, 30 metres to 117 metres. (In conjunction with surface survey.)

Three-array,  $a = 1.5$  metres, from 46 metres to 114 metres.

*DDH-3 (FED-22)*

Applied potential, 30 metres to 230 metres. (In conjunction with surface survey.)

Three-array,  $a = 1.5$  metres from 46 metres to 226 metres

" "  $a = 20$  metres from 70 metres to 220 metres

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DDH-4 (FED-23)

No applied potential survey

Three-array,  $a = 2$  metres, from 30 metres to 230 metres

$a = 25$  metres, from 90 metres to 220 metres

$a = 50$  metres, from 145 metres to 205 metres

pole-pole,  $a = 50$  metres,  $p_2 < \infty$ , from 75 metres to 205 metres

$a = 50$  metres,  $p_2$  at  $\infty$ , from 65 metres to 205 metres

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## EQUIPMENT

The applied potential survey used a standard 2.5 kilowatt time domain transmitter using a standard 2 second square wave for energisation. The three-array down-hole surveys used a Scintrex 25 watt transmitter. The primary (resistivity) and secondary (chargeability and Vs) fields were monitored using standard Scintrex IPR-8 receivers.

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## PERSONNEL AND TIMING

The work was carried out first under the supervision of Scintrex party leader Mr. R.A. Bennett (between 19th and 20th February, 1982) and thereafter by P. List (21st to 23rd February, 1982).

The surface applied potential surveys were carried out between 21st and 22nd February, with the down-hole applied potential logs being taken on 22nd and 23rd February.

The down-hole three-array surveys of diamond drill holes FED-20, 21 and 22 were undertaken between 19th and 22nd February, 1982, while the detailed down-hole work on FED-23 was carried out on 8th and 9th March, 1982.

Scintrex operators K. Brown and G. Kennedy assisted in this work as did Scintrex field hand A. Hudson.

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## METHOD

The general principles of the applied potential method are discussed in the attached appendix. The down-hole three-arrays were quite conventional and are also described in the appendix.

The applied potential was carried out with one current pole (electrode) within the mineralisation at 50 metres down FED-20, and the current through the opposite pole split equally through two electrodes placed across the strike at about 700 metres north and south of FED-20 on line 600E. This has the effect of pulling out the current from the energised body as if the distant electrodes were at infinity. The resultant potential field was measured using a Scintrex IPR-8 receiver. The standard pot position (zero potential) was at 600E/720N, and all surface and down-hole potentials were measured with respect to this position. The field between the standard pot position and the energising current electrode in FED-20 was assigned a positive sign.

The chargeability was also measured on a single slice programme (130 to 1690 milliseconds), and the secondary field,  $V_s$ , calculated therefrom ( $V_s = (k) \times M \times V_p$ ).  $V_s = M \times V_p$ , and  $V_p$ , were then contoured on surface and down hole.

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## DOWN HOLE SURVEYS

## THREE-ARRAY

In order to assess the resistivity and chargeability of rocks 'at' and around a drill hole, it is most advisable to take electrical logs at suitable spacings. In practice it is difficult to quantify by mere observation the influence of sulphides viewed in a core. Further, core samples analysed in the lab will give meaningful results only when the core is shipped with the original pore fluid in place - any dessication materially affecting the characteristics.

General Principles

In Figure 1 a current electrode,  $C_1$ , is placed down hole, with a second current electrode being placed on surface at infinity. At the current electrode  $C_1$ , the current paths followed will be as shown by the solid lines. These will generate a series of concentrated equipotential surfaces of spheroidal shape concentric to the current electrode,  $C_1$ . Two potential electrodes,  $P_1$  and  $P_2$ , tap two of these surfaces. In the three-array down hole method, the spacing ( $a$ ) between  $C_1$ ,  $P_1$  and  $P_2$  is kept equidistant. The actual volumes of rock analysed can be considered to be the area shaded in Figure 1. This is considered a reasonable approximation, although the *actual* volume is complex.

For 'at hole' logging, smaller  $a$  spacings to  $2\frac{1}{2}$  metres are generally used. Such spacings will yield the bulk characteristics of resistivity, chargeability and decay form for the material within a distance  $a$  of the hole, i.e. the bulk characteristics of 40 to 80 tons of material for a  $2\frac{1}{2}$  metres three-array.

To search 'about' the hole, larger  $a$  spacings are used. The differences between these spacings can be interpreted to infer the continuity or otherwise of events

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defined with an 'at hole'  $a$  spacing. Similarly, should the 'at hole' spacing show no significant event, but larger  $a$  spacings an anomalous condition, this would infer a source away from the hole which does not cut the hole.

The use of multiple spacings allows an estimate of distance from the source to the hole to be made.

It is important that the current densities be kept low, preferably of the same order as those on the surface surveys. As the rock resistivity *increases*, the current density must be *decreased*. It is important to keep the current low. Either a small battery operated 25 watt transmitter is used, or if larger units are used, suitable modifications are made to enable the transmission of low current. This problem can be best envisaged as "turbulence" as when water is *forced* to flow down a stream at a rate above the steady flow rate where no turbulence occurs. This effect can be easily identified by quite asymmetric decay forms and by negative chargeabilities.

Decay Form

Down hole decay form information has been found to be most helpful in distinguishing chargeable materials. Generally *grain size* is the most predominant influence within a mineral assemblage - coarser grained mineral assemblages decay more slowly than average, while finer grained sources decay more rapidly. Magnetite of an equal grain size to sulphides will decay *more rapidly*, magnetite being a less efficient holder of charge. Similarly low chargeability backgrounds in certain acid volcanic rocks are often accompanied by rapid decay forms.

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# EQUIPOTENTIAL DIAGRAM DOWN HOLE THREE ARRAY LOGGER

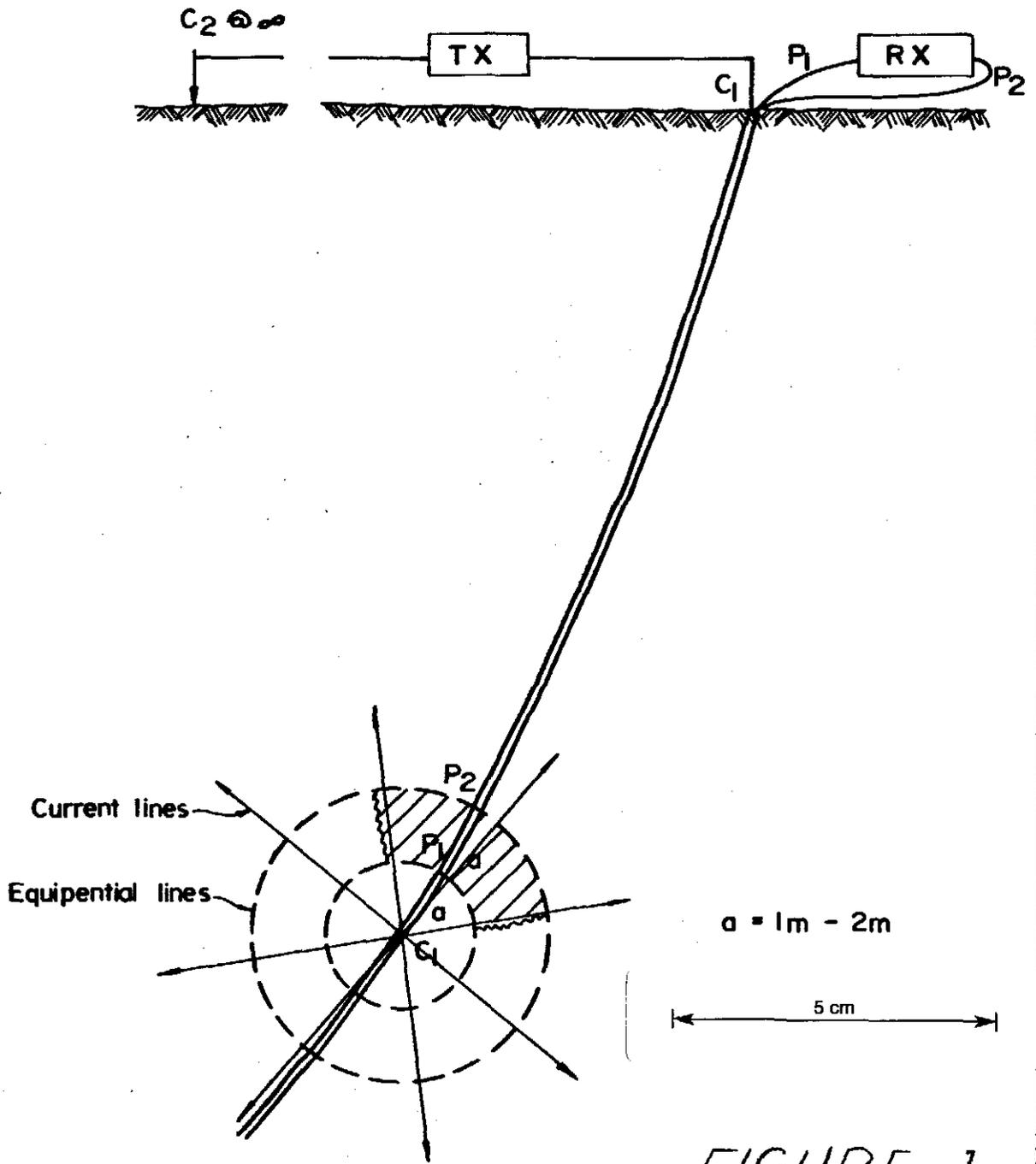


FIGURE 1

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Fine grained mineralisation absorbs the charge *rapidly*, and once the passage of the energising current is stopped, the stored charge is *rapidly* discharged. If the mineralisation is *effectively* coarse grained (i.e. either coarse grained as such, or agglomerates of finer grain), the charging and consequent discharging will be much *slower*. Only with MIP or in small spaced EIP down hole logs is the actual decay *within* the source monitored, therefore major differences in decay form can be observed. However, in EIP these differences in decay form can also be observed when the body is 'shallow'. However, with MIP the origin of the decay is *INTERNAL*, while with EIP it is *EXTERNAL*, and the latter is subject to change by the environment.

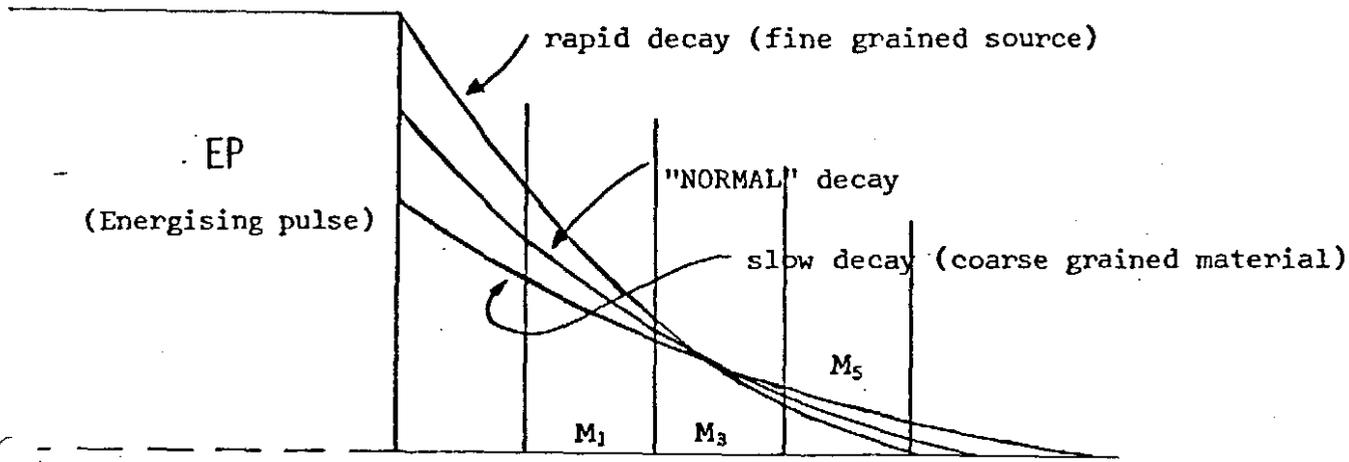
While the above comments refer to 'mineralisation' they are also true of chargeability background. The chargeability background in rocks is usually determined by mafic mineral content, while the decay form appears often to be dependent on the bulk mineral grain size.

Both for 'mineralisation' and 'background' the mechanism is similar. Figure 2 shows how this is accomplished using the IPR-8 time domain receiver. In sketch (A) EP represents the energising pulse, while the rapid decay form is due to fine grained material discharge, and the slow decay form is due to coarse grained mineralisation. You will note from the diagram that the rapid decay form has a greater amplitude to start with. This is due to the fact that as the IP effect depends on the total surface area of the sulphides presented, the disseminated material per sulphide volume present will give a greater IP effect.

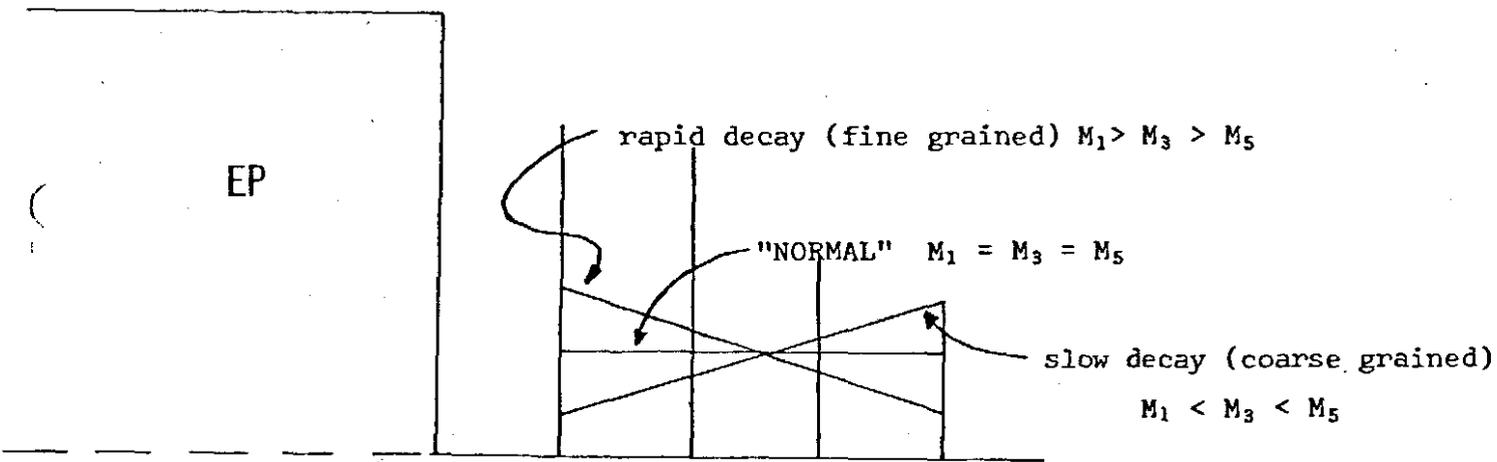
The three decay slices are shown in the diagram as  $M_1$ ,  $M_3$  and  $M_5$ . The red decay form included in Figure 2A is the 'normal' or 'average' decay form usually observed

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(A) DECAY AS OBSERVED BY IPR-8 MIP RECEIVER PRIOR TO PROCESSING



(B) DECAY AS OBSERVED BY IPR-8 MIP RECEIVER AFTER NORMALISATION FOR A "NORMAL" DECAY FORM

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over normal rocks. The IPR-8 processes the data by dividing this normal decay into each of the slices  $M_1$ ,  $M_3$  and  $M_5$ . This is done so that any deviation from 'normal' is readily apparent. Figure 2B displays the result of this processing of data. The rapid decay form (e.g. fine grained disseminated) will result in  $M_1 > M_3 > M_5$ , while the slow decay form (e.g. coarse grained massive, but not necessarily electrically continuous) will result in  $M_1 < M_3 < M_5$ .

On EIP surface surveys this data is usually presented as  $\Delta M$ ,  $|M_5| - |M_1|$ , which displays the difference in amplitude of the first and last slice. However, due to the large variation in the amplitudes of the chargeability ( $M_3$ ) down hole, it is here presented as  $\Delta M n$ , the *normalised decay form* in percent.

$$\Delta M n \% = \frac{\Delta M}{M_3} \times 100 = \frac{M_5 - M_1}{M_3} \times 100$$

$\Delta M n$ , when positive, infers a 'coarser than normal' grain size, and when negative, a 'finer than normal' grain size. The amplitude (in percent) variation from normal will give some indication of the departure of the decay from normal.

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## APPLIED POTENTIAL METHOD

*FIELD PROCEDURES*

In order to satisfactorily execute an applied potential survey, it is essential to understand the concepts involved in placing an electrode in a conductive target zone. For a single electrode emplaced within resistive rock, the current moves to infinity as shown in Figure 1A. In section, the equipotentials will form a series of equipotential surfaces, essentially spheres, concentric with the emplaced electrode *providing the resistivity of the medium is homogeneous*. Figure 1B shows a plan of the equipotentials concentric about the surface projection of the emplaced electrode.

However, in the applied potential method, the body itself is made to act as an electrode, by placing an energising current electrode within the body. For the method to work, the body must be significantly more conductive than the enclosing rocks. When current is introduced into the body, it will give the whole body an equal potential and the current will then flow to infinity as shown in *figure 2*. In the applied potential method we aim to locate equipotential surfaces by using a moving potential electrode on the surface. It will be noted from *figure 2* that these equipotential surfaces will wrap themselves around the body as the current will leave the body at right angles.

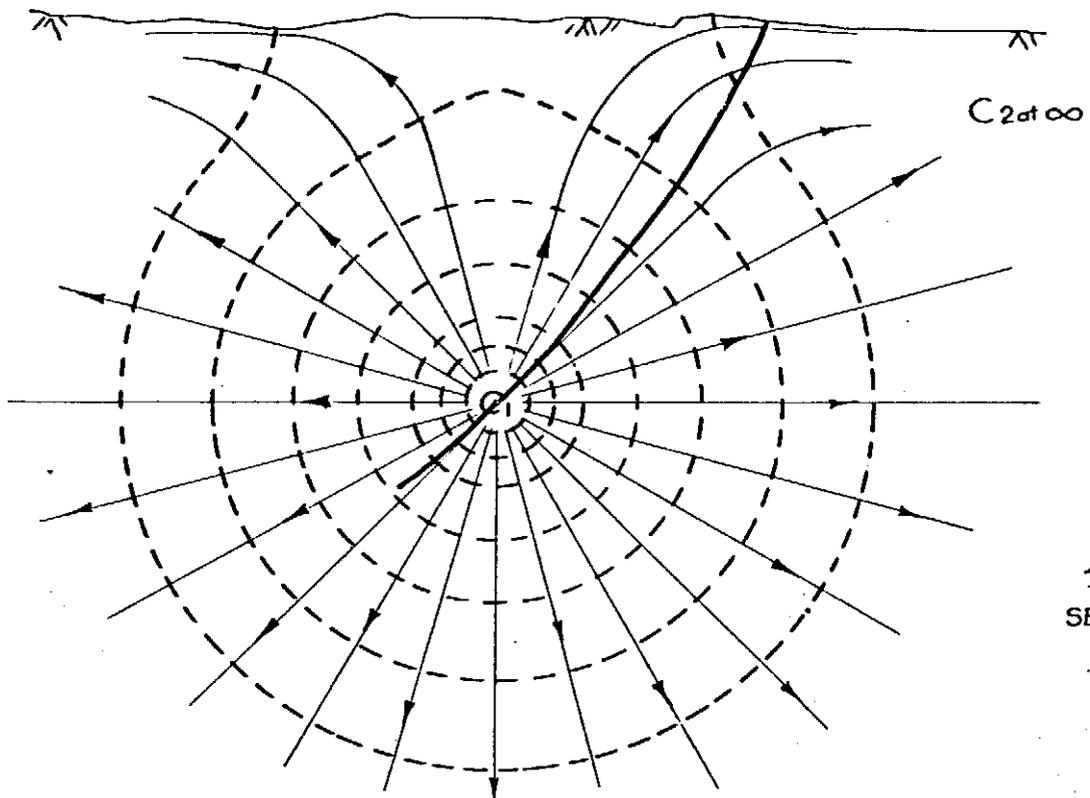
Once the approximate position of the target body is located, either by down-hole IP or by surface surveys, we can emplace a current electrode more or less in the centre of the zone. An infinite electrode is then placed at a distance across strike. This electrode must be infinite to ensure that the current is drawn out of the energised body at right angles in all directions. However, this would necessitate placing the infinite at least ten times the maximum distance surveyed along strike i.e., approximately five times the strike length of the body. In practice it is more convenient and geometrically better to place two (or more) infinite current electrodes *across* the strike of the body and at least four times the distance to be surveyed *along* strike. Therefore we have one electrode

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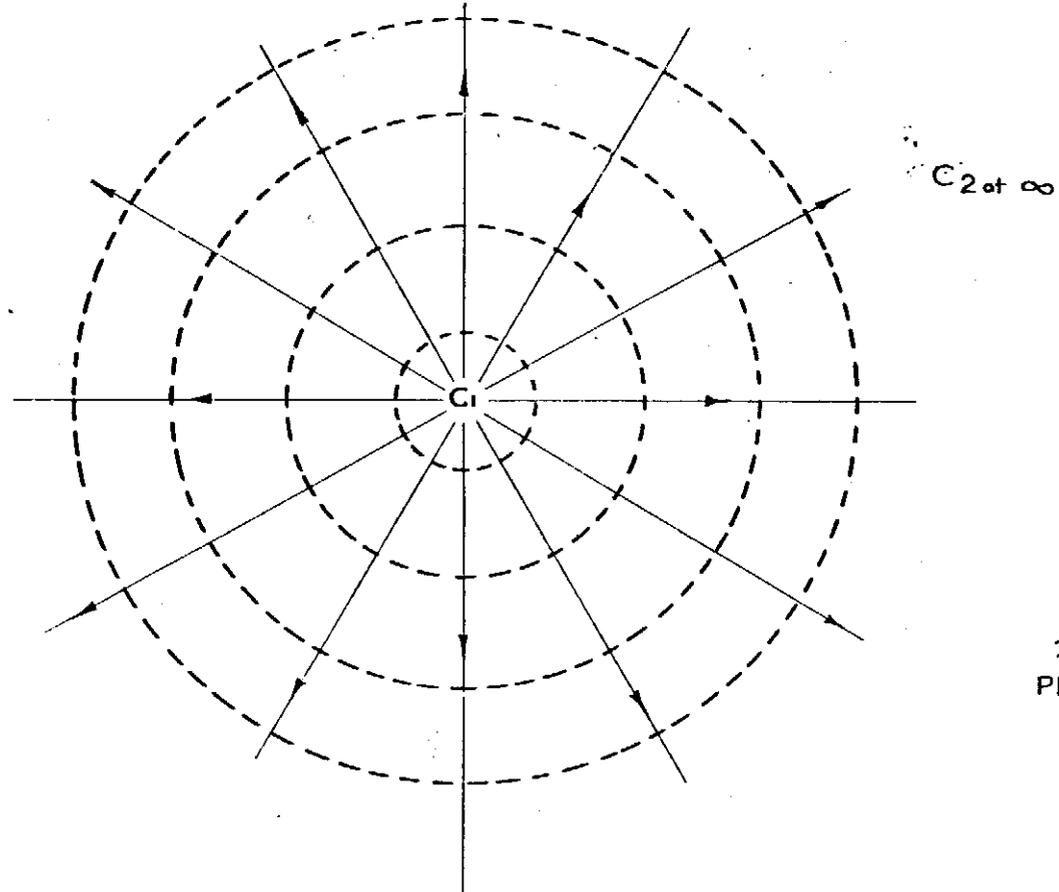
# Current Electrodes Emplaced in a Drill Hole

**SCINTREX** homogeneous medium-

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1a.  
SECTION



1b.  
PLAN

Fig 1

Current Electrode Emplaced in a Drill Hole

**SCINTREX** - within a conductor -

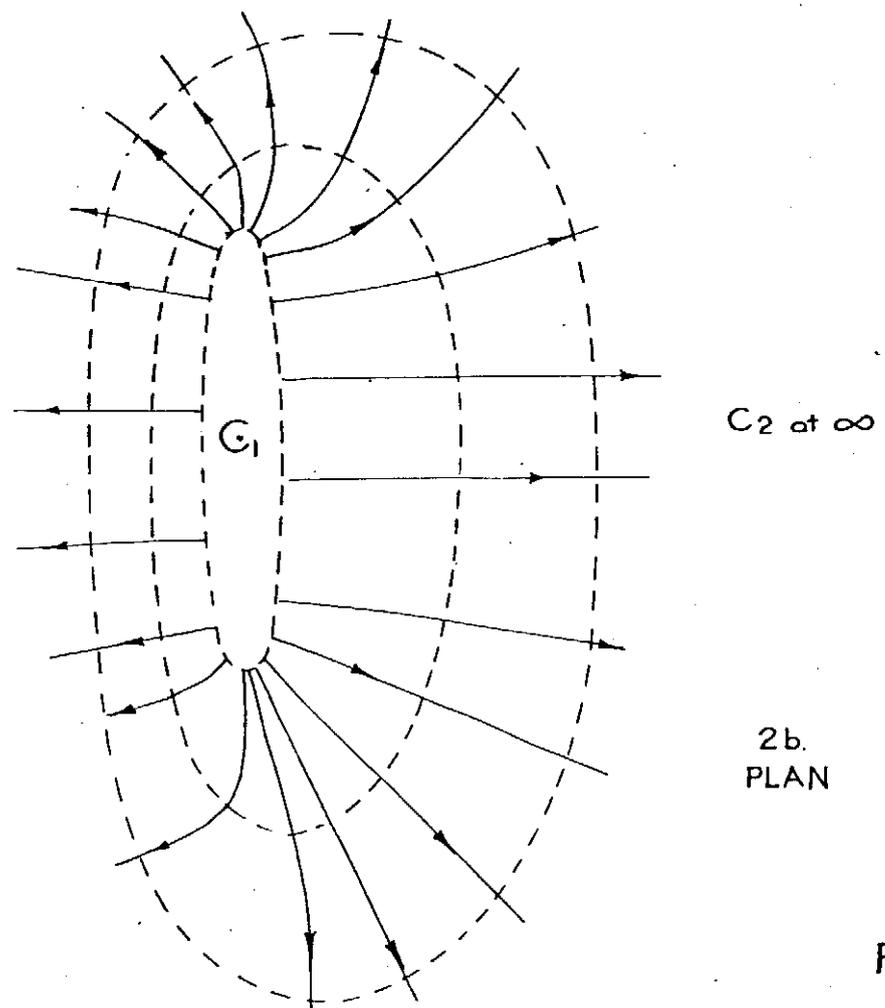
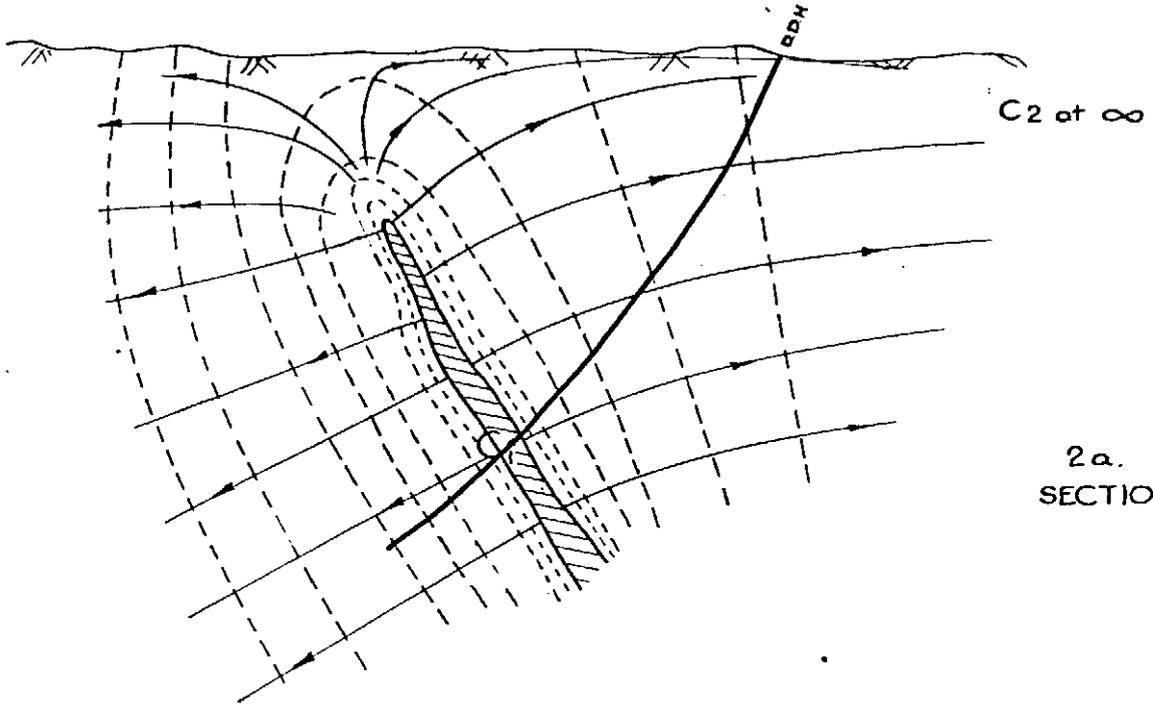


Fig 2.

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**SCINTREX**

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placed in the target mineralisation with two (or more) of opposite sign at an 'infinite' distance. As current is going into these infinite electrodes simultaneously, they must be balanced (i.e., of equal resistance.) To do this, it is best to measure the current which can be put into each when connected to the centre electrode, as just measuring the resistance with a multi-meter is not sufficient. The effective resistivity changes when a potential difference is applied.

Once this array is set up, the equipotentials can be mapped on the surface. Generally it is convenient to use a regular spaced grid for convenience of spacing and location of points. One stationary potential pot is used and the potential difference is measured between this and another potential which is moved across the surface or down drillholes. This stationary pot can be placed anywhere in a sense. Ideally it is placed at the centre of the equipotential contours i.e., in the centre of the surface expression of the body. However, it is not always possible to locate this position before the survey, as in fact this is often the very purpose of the survey. To attempt to locate this spot before survey defeats the very purpose of the survey. For convenience therefore the stationary potential is generally placed some distance from the top of the drill-hole. Relative to this stationary potential the field can then be mapped. When moving towards the mineralisation, the observed potential difference ( $V_p$ ) will be a maximum over the centre of the body. Once the body is crossed the  $V_p$  will then decrease as the potential is moved away from the energised body. The  $V_p$  will reach zero when the moving potential is placed on the equipotential which passes through the spot where the stationary potential was placed. When moving further away, the sense of the signal will change and the  $V_p$  will once more increase. This change in sense can be monitored by observing the relative sense of the needles on the IP receiver and the transmitter - i.e., in the centre of the area over the energised body the needles may deflect to the right simultaneously for one pulse then to the left on the next pulse. Alternatively they may be deflected in opposite directions. Whatever the case, the direction of deflection on the receiver will change relative to the transmitter when the zero equipotential

# SCINTREX

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is crossed. Radio communication is necessary to ascertain this. It is therefore necessary to have a centre swing meter on the transmitter to compare the pulses. It is most important to monitor this relationship as the shape of the body may not be perfectly regular and therefore not easy to visualise until contoured in plan.

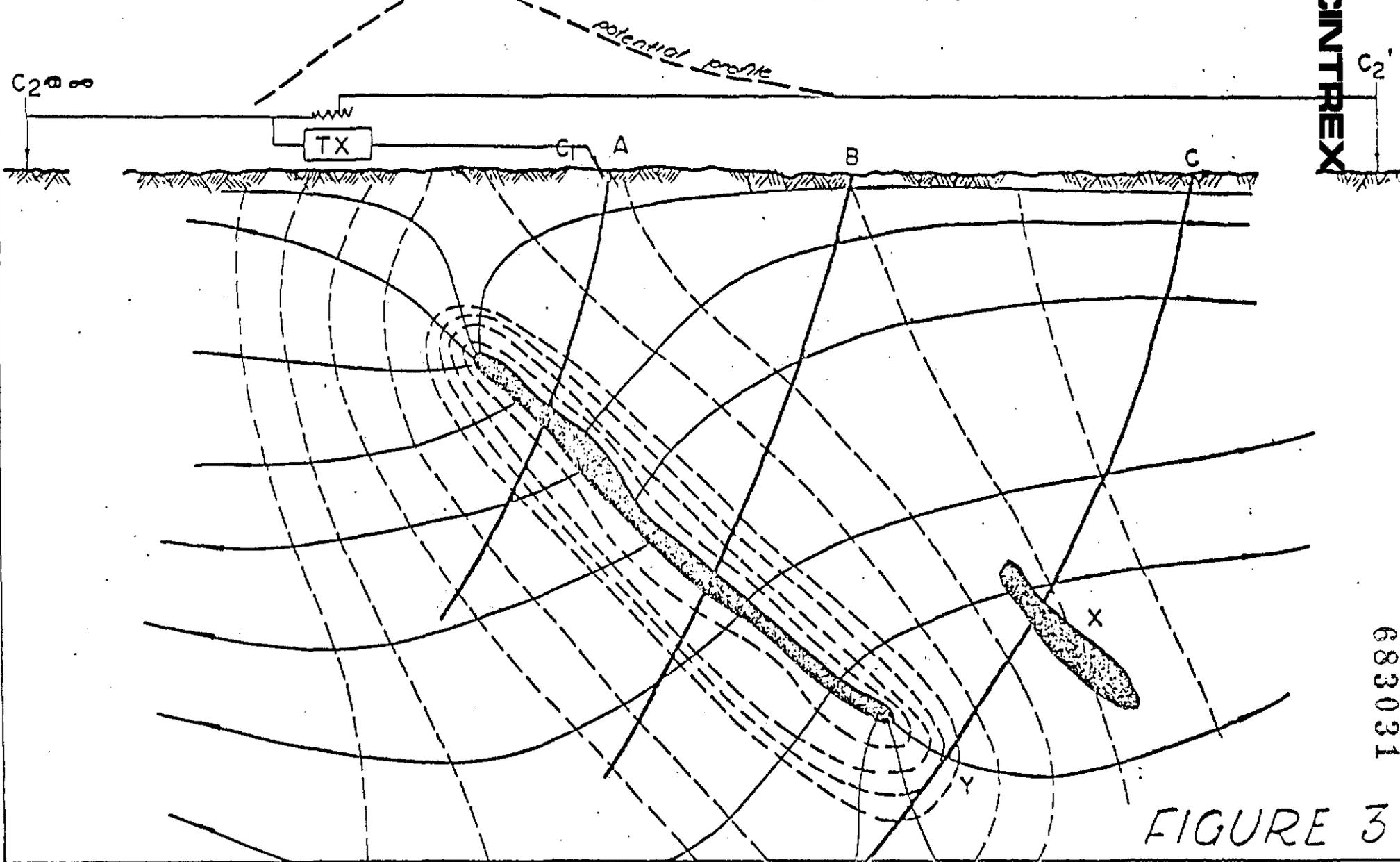
Providing there is a significant contrast between the body and the enclosing rocks, the equipotential gradient will be steeper on the up-dip side of the body. The steepness of the potential field will show the depth. Therefore it should be possible to ascertain the following information from an applied potential survey (providing always that the "infinite current electrode" is effectively at infinity).

1. Depth to the top of the source.
2. Strike length.
3. Dip of source.
4. The pitch of the source.

Once a surface survey has been done, the equipotentials can also be mapped down hole. This can be done either in the hole where a current electrode has been placed or in any other drill holes into the body. A three dimensional picture of the mineralisation can then be drawn up.

In Figure 3 the salient points to note are (a) the body energised via C1 emplaced in DDH-A will produce a severe potential gradient when logged down hole 'B' drilled down dip, which should unambiguously show that this hole intersected the same conductor in holes 'A' and 'B'. (This would also be true *along strike* as well as down dip). In DDH-C a change in gradient at 'Y' would indicate the close proximity of the conductor, but the absolute equipotential level indicated would show that the body had been missed. In practise a three-array log at 2 or 3 spacings would then be run to ascertain the distance of the source from the hole.

# EQUIPOTENTIAL DIAGRAM APPLIED POTENTIAL ARRAY



SCINTREX

683031

FIGURE 3

**SCINTREX**

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Down-hole 'C', a potential log would show that the sulphide body 'X' was not in electrical continuity with the energised body, and therefore not part of it. In practise this body would be energised and the resultant surface and down-hole (hole 'C') equipotential contour plans would show the extent of the body 'X'.

The shape of the potential field on the surface is ascertained by holding a single potential stationary and moving a second over the surface (or down-hole) to map the potential field. The resultant potential readings are then contoured. The shape of the contour plan will reflect the shape of the *conductive* source, the position of the distant electrodes C2 and C2' *if close to* the emplaced current electrode C1, and also the position of the stationary potential pot P1. Diagram 4 will illustrate this last point ...a) shows the geological section while b) shows the Vp readings observed which show a high over the body and also as the electrodes C1 and C2 - C2' are approached.

It is important to realise that the reference pot will be the zero equipotential contour *wherever* it is placed in the field, and the resultant 'low' will not represent a physical property. This is because when the moving potential electrode passes to the one side of the zero contour, the current will move in one sense, and when on the other, it will be in the opposite sense. Diagram 4C is a reconstruction of a profile form when the *sense* of the current flow with respect to the reference pot is taken into account.

For a pipe-like body, multiple balanced infinities can be used which can again allow the dips and plunge of the pipe to be traced.

Figure 5 dramatically shows some typical equipotential patterns over bodies energised in the manner outlined above.

Further to mapping the equipotential lines across the surface, measurements of chargeability can also be taken. Care must be taken in the analysis of this data. Difficulties may arise because resistivity contrasts near a polarisable body can

032

683033

# SCINTREX

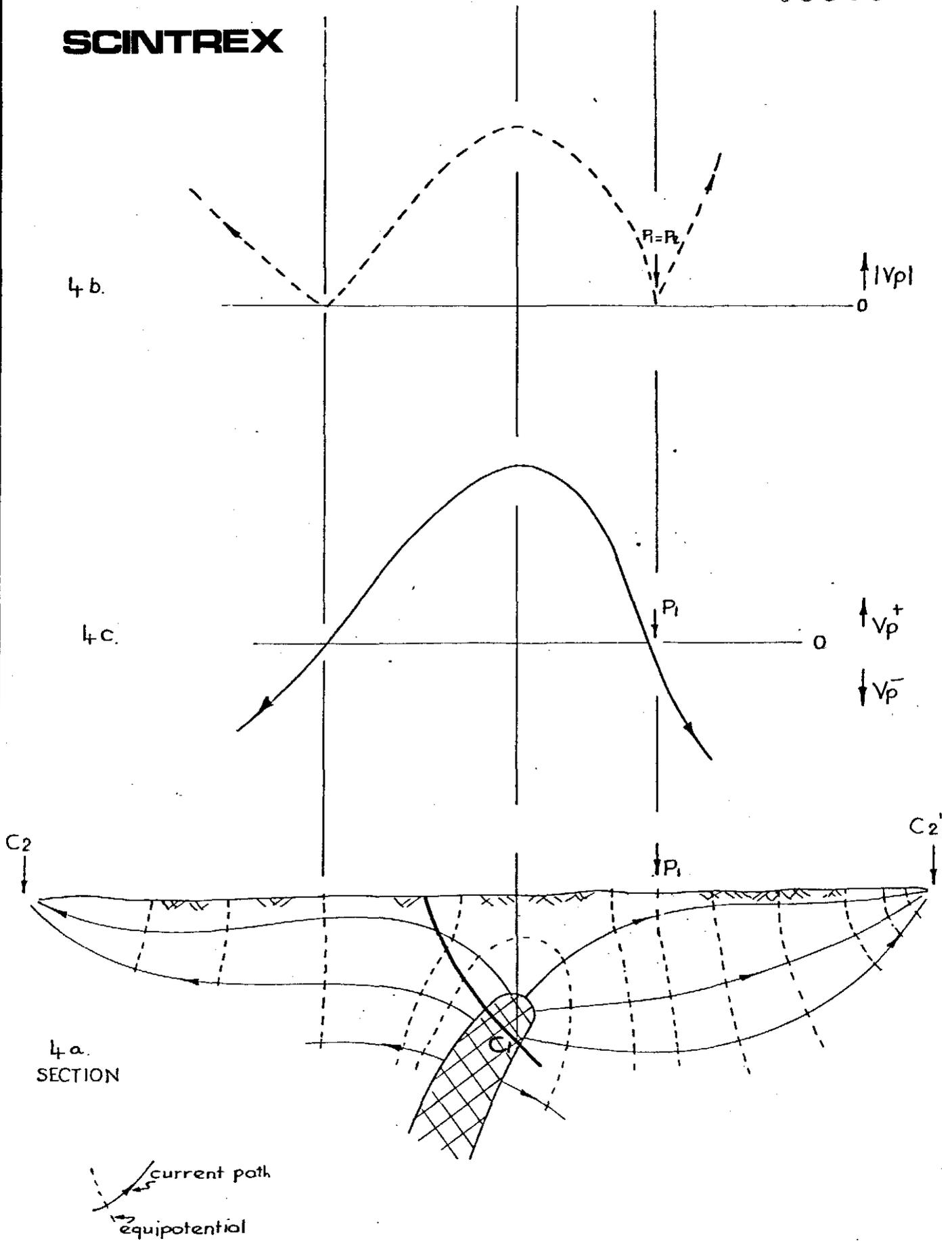
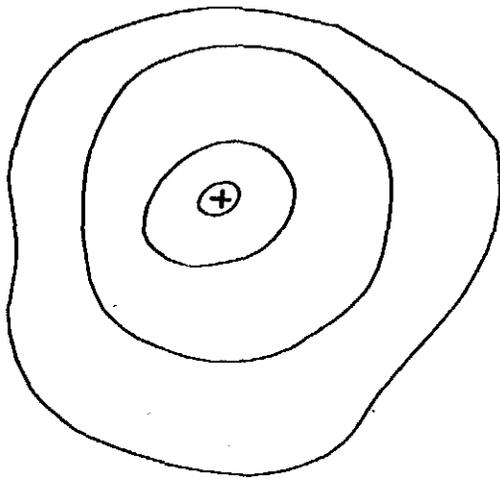
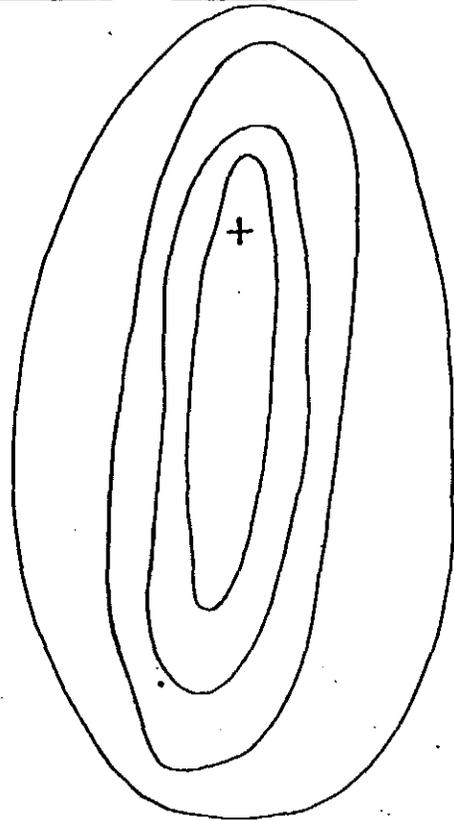


Fig 4

# SCINTREX Typical Applied Potential Patterns

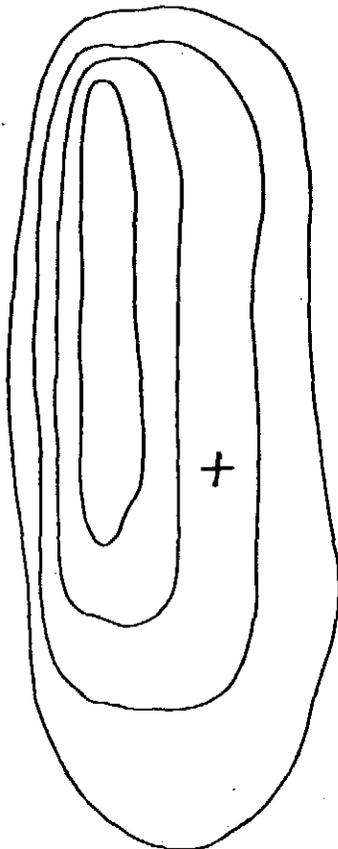


INTERSECTION  
OF LIMITED EXTENT

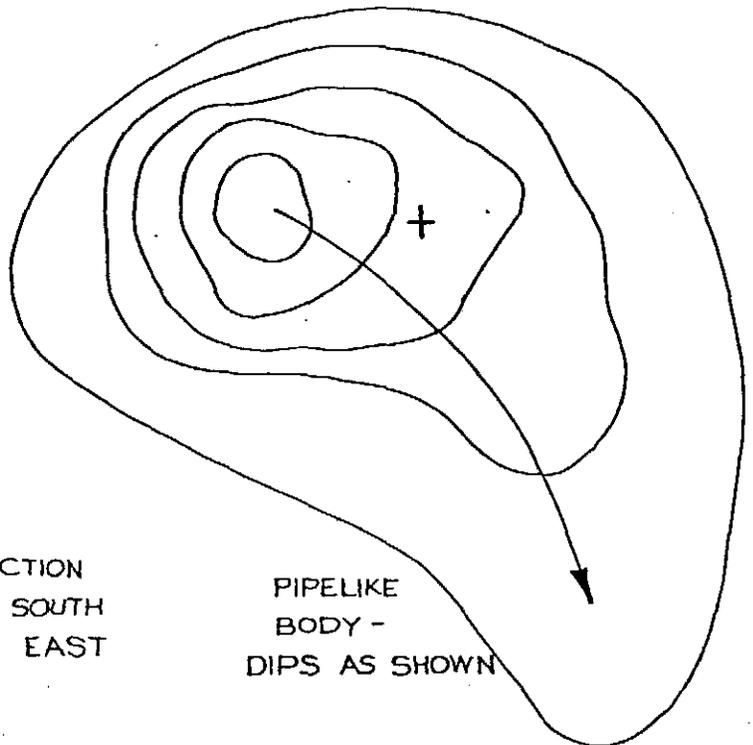


INTERSECTION ELONGATE  
STEEPLY DIPPING

+ Vertical projection  
of  $C_1$



INTERSECTION  
PITCHES SOUTH  
STRIKES EAST



PIPELIKE  
BODY -  
DIPS AS SHOWN

034

# SCINTREX

distort the polarising and depolarising currents. In an anisotropic rock environment an apparent anomaly measured on the earth's surface may actually be due to the peculiar focussing nature of the subsurface electrical anisotropism. This is not uncommon and may shift a surface electrical anomaly a considerable lateral distance from the cause of it's source.

In addition the calculation of chargeability by the IP receiver is a ratio of Vs or secondary potential field due to polarisation effects.

Vs is calculated from the Vp and chargeability data using the formula:

$$M = \frac{Vs \ 1000}{Vp} \text{ in mV/V}$$

where Vs =  $\frac{t^1 \int_{t^1}^{t^2} Vs \ dt + Vx}{tr}$

t<sup>1</sup> = time at beginning of slice.

t<sup>2</sup> = time at end of slice.

Vx ≐ residual transient voltage at the end of the automatic self-potential correction.

Tr = t<sup>2</sup> - t<sup>1</sup> i.e., the integrating period.

Therefore Vs is a direct measure of the secondary voltage in millivolts.

**SCINTREX**

## LIST OF PLATES

- 1 Applied Potential Survey - Primary Field Contours - 1:1000
- 2 Applied Potential Survey - Secondary Field Contours - 1:1000
- 3 Applied Potential Survey - Chargeability Contours - 1:1000
- 4a Applied Potential Survey - FED-20, Primary Field Contours - 1:500
- 4b Applied Potential Survey - FED-20, Secondary Field Contours - 1:500
- 5a Applied Potential Survey - FED-21, Primary Field Contours - 1:500
- 5b Applied Potential Survey - FED-21, Secondary Field Contours - 1:500
- 6a Applied Potential Survey - FED-22, Primary Field Contours - 1:1000
- 6b Applied Potential Survey - FED-22, Secondary Field Contours - 1:1000
- 7 Interpretation Diagram, 1:1000

037

036

683037

FED-20  
(DDH-01)

Mt Agnew

D.H. JARRAY & DIPOLE -  
DIPOLE

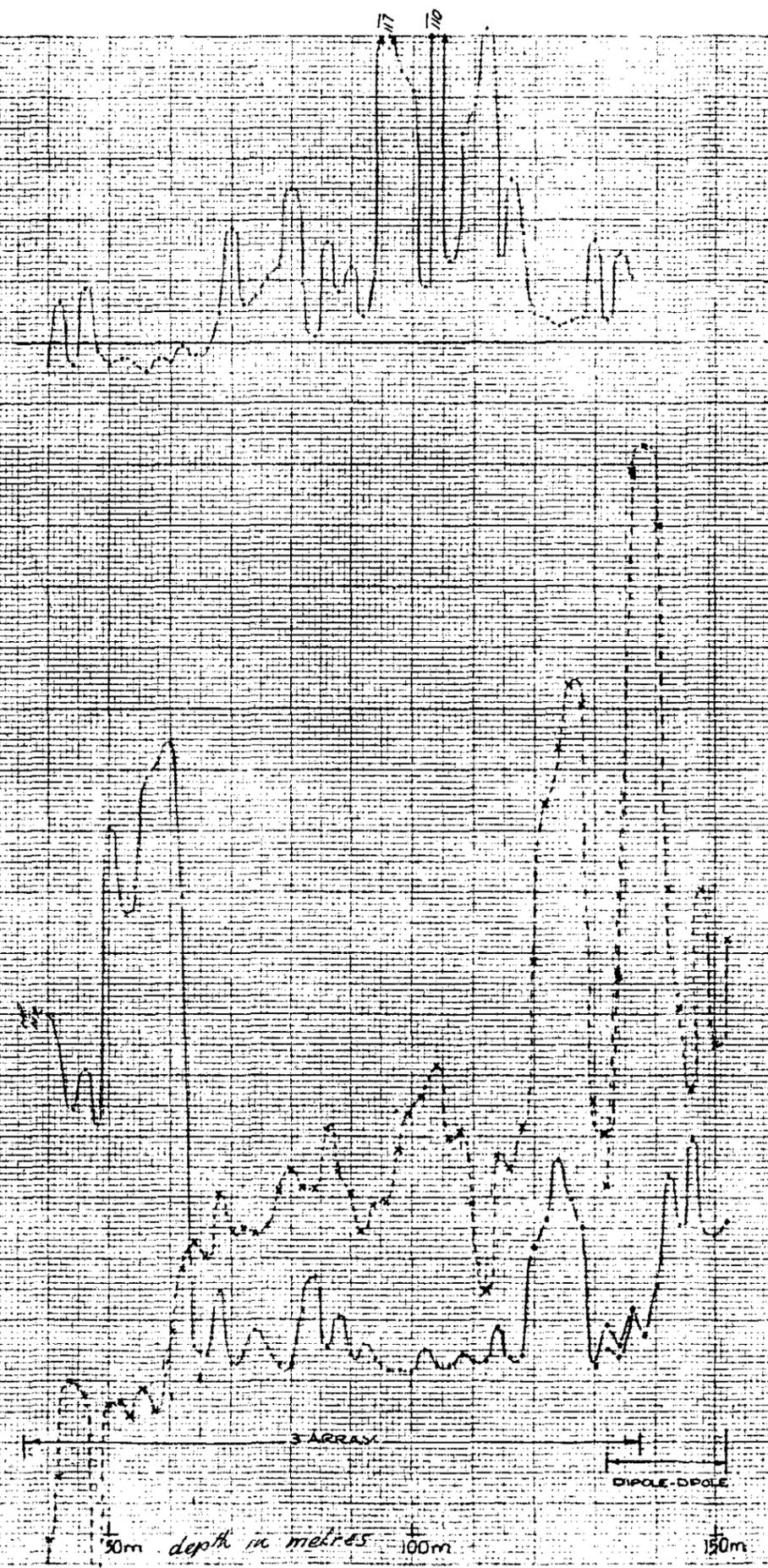
$a = 1.5m$

5 cm

Chargeability in millivolts per volt

Resistivity in ohm metres

10000  
100  
50  
1000  
10000  
100



JARRAY

DIPOLE-DIPOLE

30m depth in metres

100m

150m

(DDH-02)  
W. Agnew  
D.H. 3 ARRAY  
 $a = 15m$   
TAS-097

5 cm

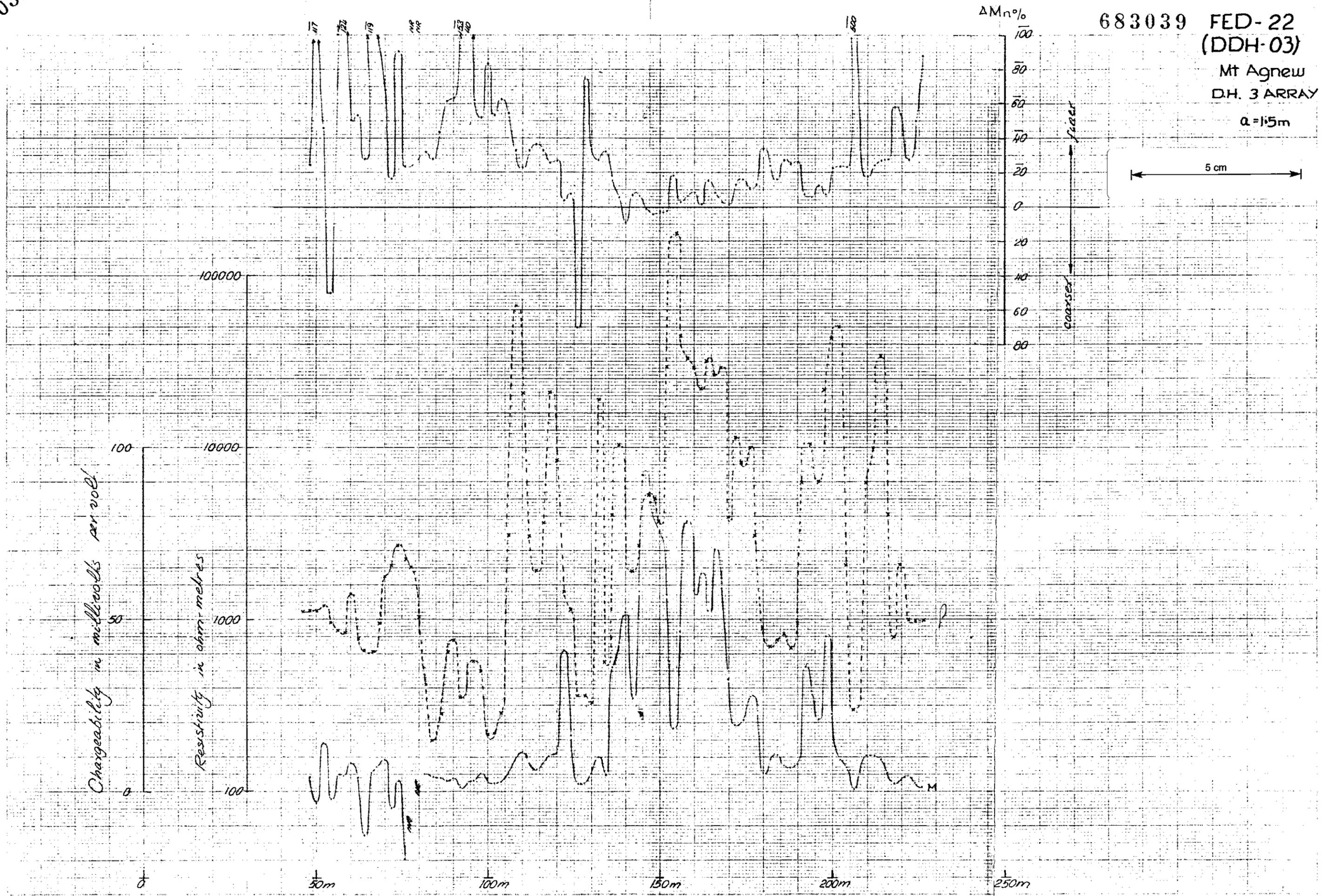
$\Delta m\%$



Changeability in millivolts per meter  
Resistivity in ohm meters

030

683039 FED-22  
(DDH-03)  
Mt Agnew  
DH. 3 ARRAY  
 $\alpha = 1.5m$



Chargeability in millivolts

Resistivity in ohm-metres

AMn%

100000

100

10000

50

1000

0

100

100  
80  
60  
40  
20  
0  
20  
40  
60  
80

5 cm

0 50m 100m 150m 200m 250m

finer  
coarser

039

683040 FED-22  
(DDH-03)  
Mt Agnew  
DH. 3 ARRAY  
 $a = 20m$   
TAS-097

$\Delta M_n\%$   
100  
80  
60  
40  
20  
0  
20  
40  
60  
80  
100

5 cm

5000  
10000

Chargeability in millivolts per volt  
100  
50  
0

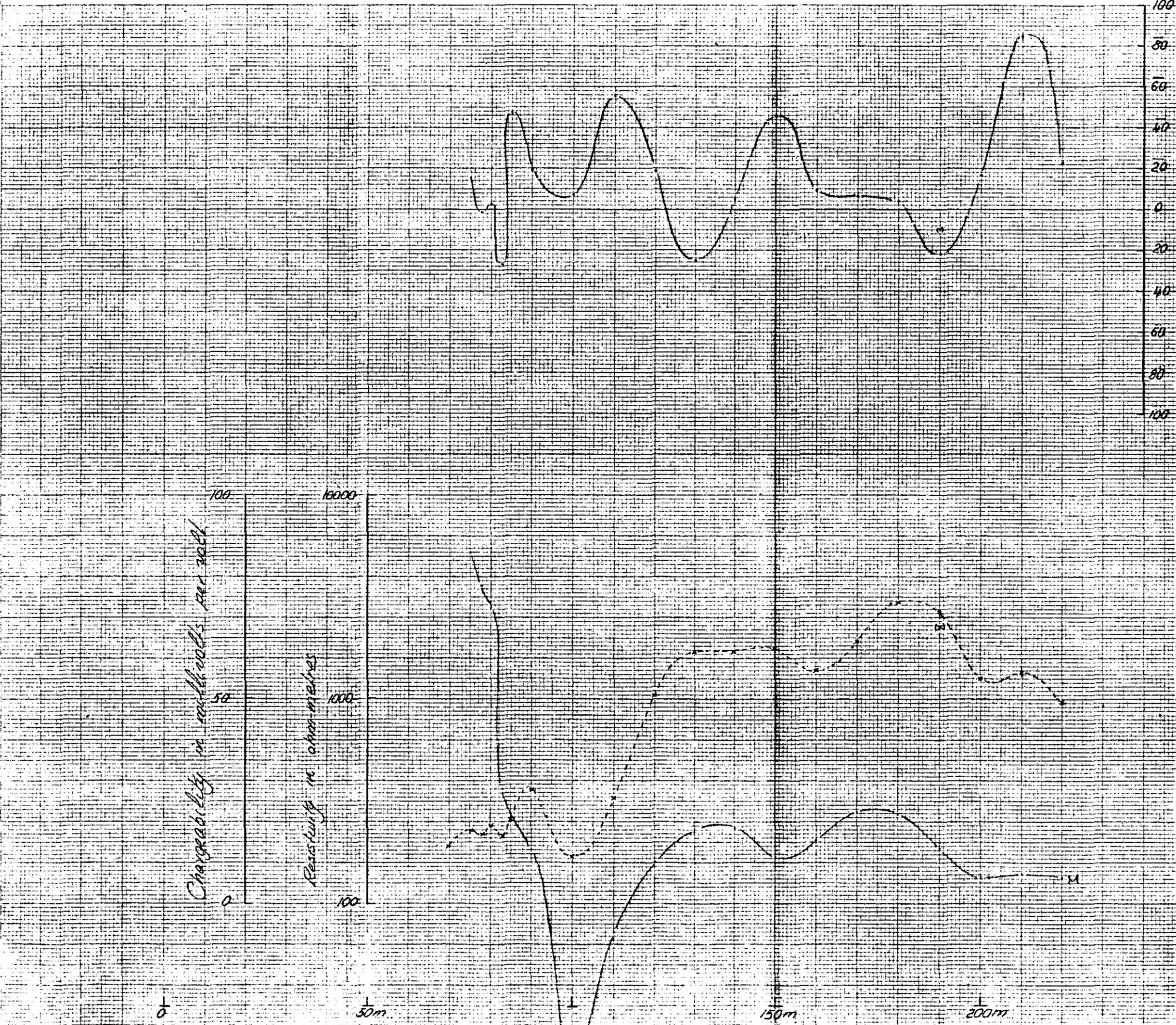
Resistivity in ohm-metres  
16000  
1000  
100

0

50m

150m

200m



REPRODUCED FROM THE ORIGINAL RECORDS OF THE U.S. GEOLOGICAL SURVEY

13 1971

040

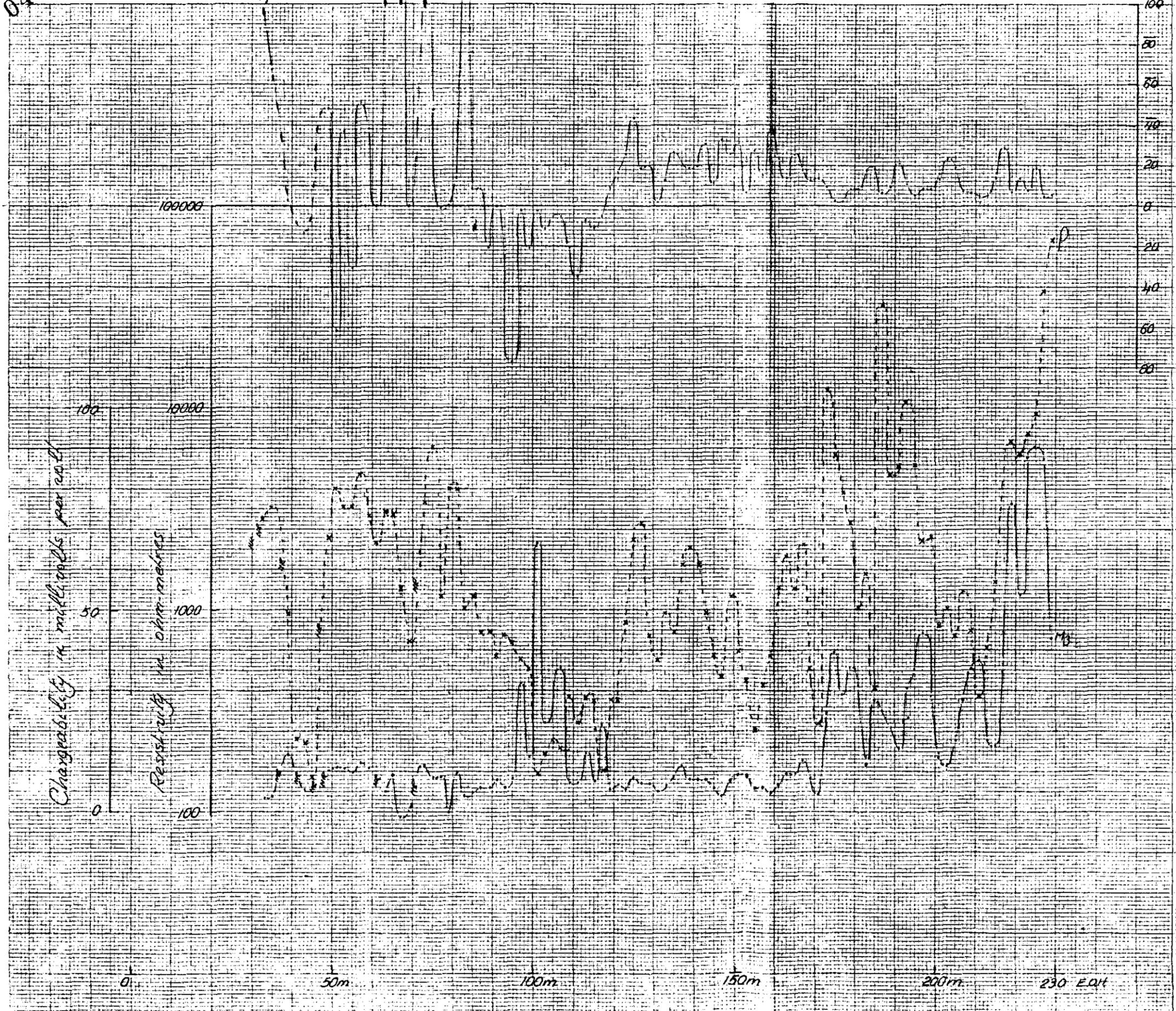
683041 FED-23  
(DDH-04)  
Mt. Agnew  
D.H. JARRAY  
a = 2m  
TAS-097

$\Delta Mn\%$

100  
50  
0  
-20  
-40  
-60

5 cm

finer  
coarser



U.S. GEOLOGICAL SURVEY

VICI 14

041

683042

FED-23

(DDH-04)

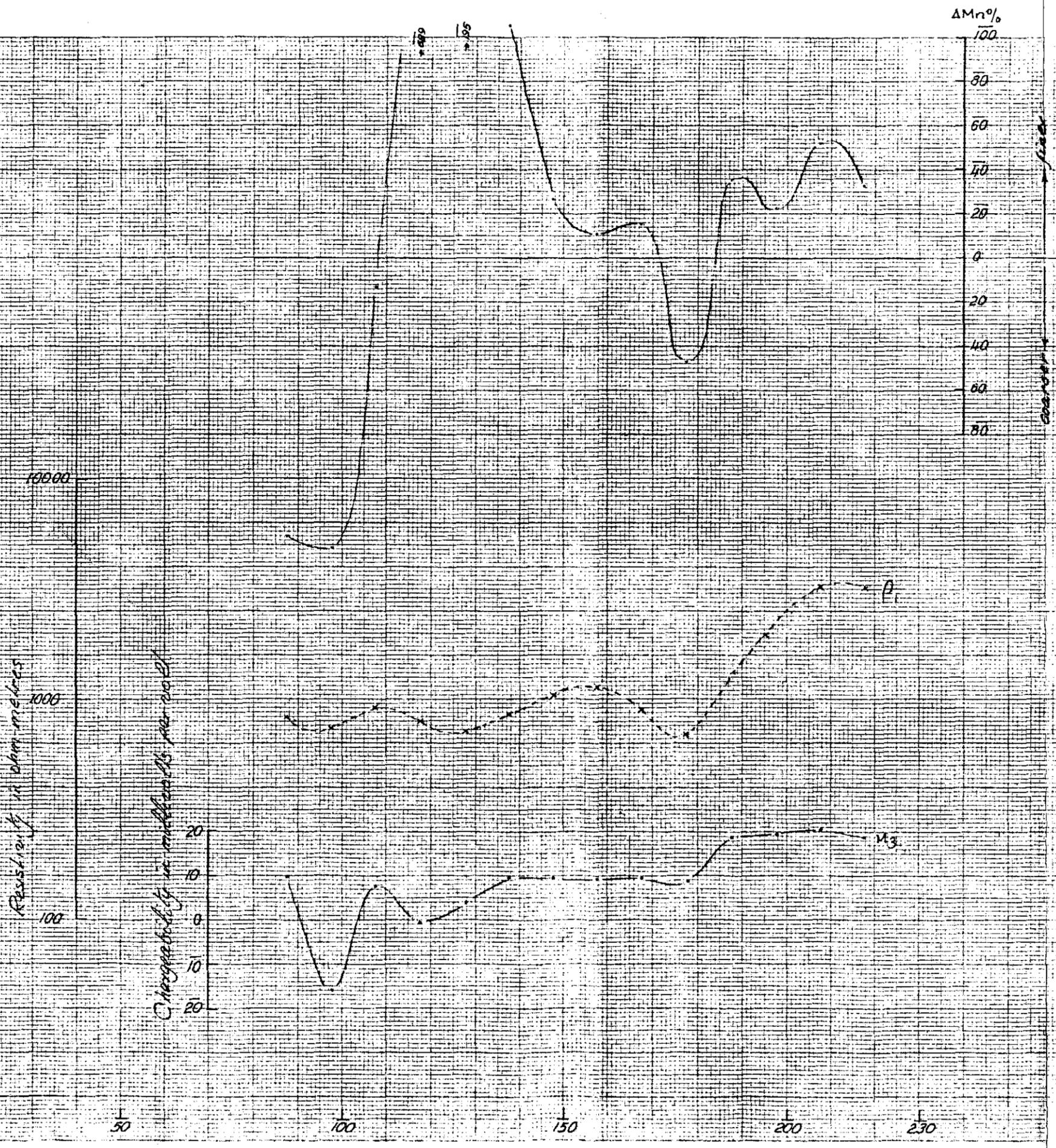
Mt Agnew

DH. 3 ARRAY

a = 25m

TAS-097

5 cm



14711

042

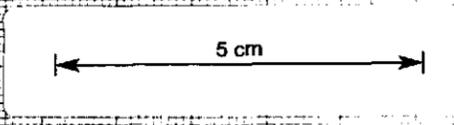
683043 FED-23  
(DDH-04)

Mt Agnew  
D.H. 3 ARRAY  
a=50m  
TAS-097



$\Delta M_n\%$   
100  
80  
60  
40  
20  
0  
20  
40  
60  
80

Series  
Comparison



143  
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41 (P13)

043

683044 FED-23

DDH-04

Mt. Agnew

DH POLE-POLE

$\alpha = 50m$

$P_2$  at  $\infty$

TAS-097

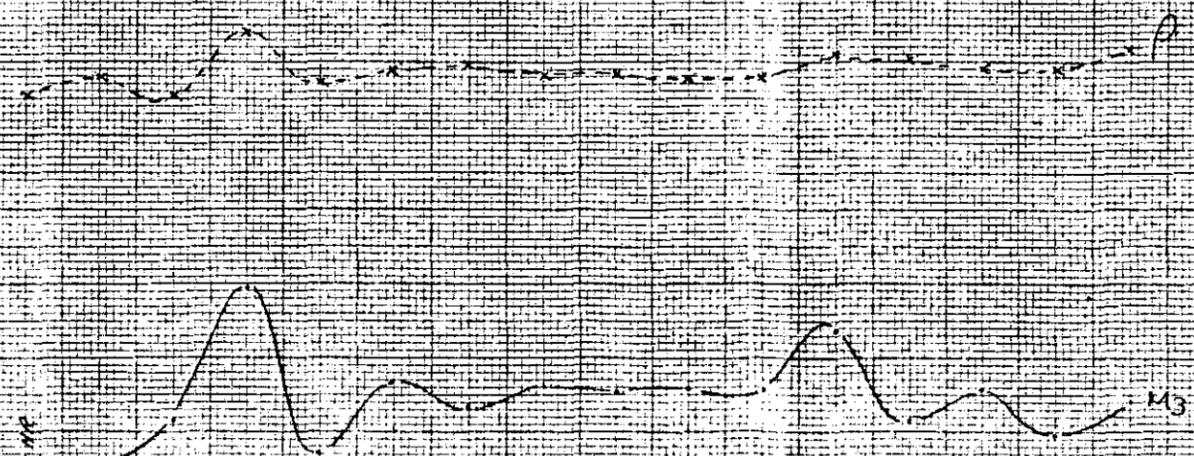
5 cm

Resistivity in ohm-meters

10000  
1000

Chargeability in millivolts per volt

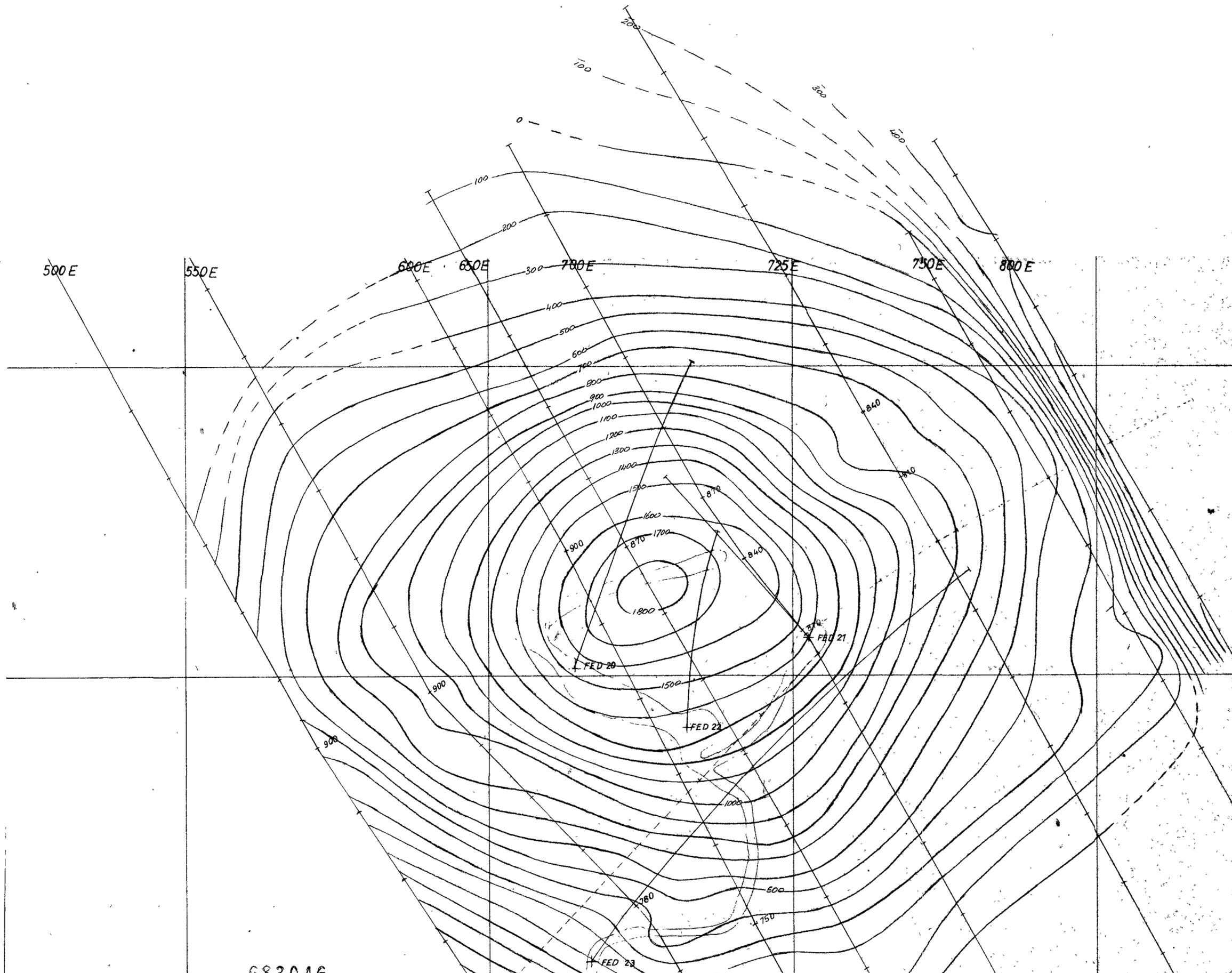
30  
0



REPORT OF FIELD CO. METERER

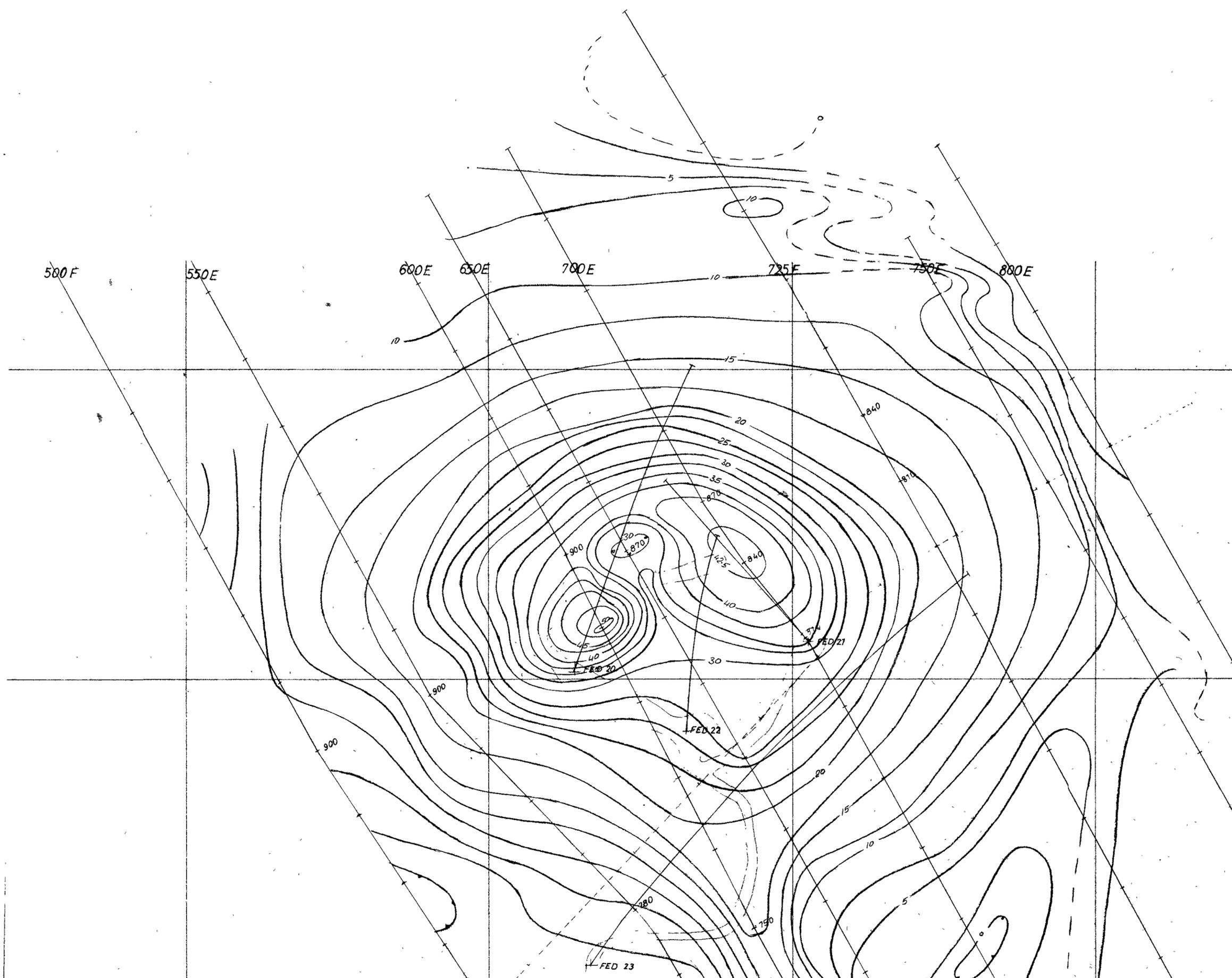
VA 121A





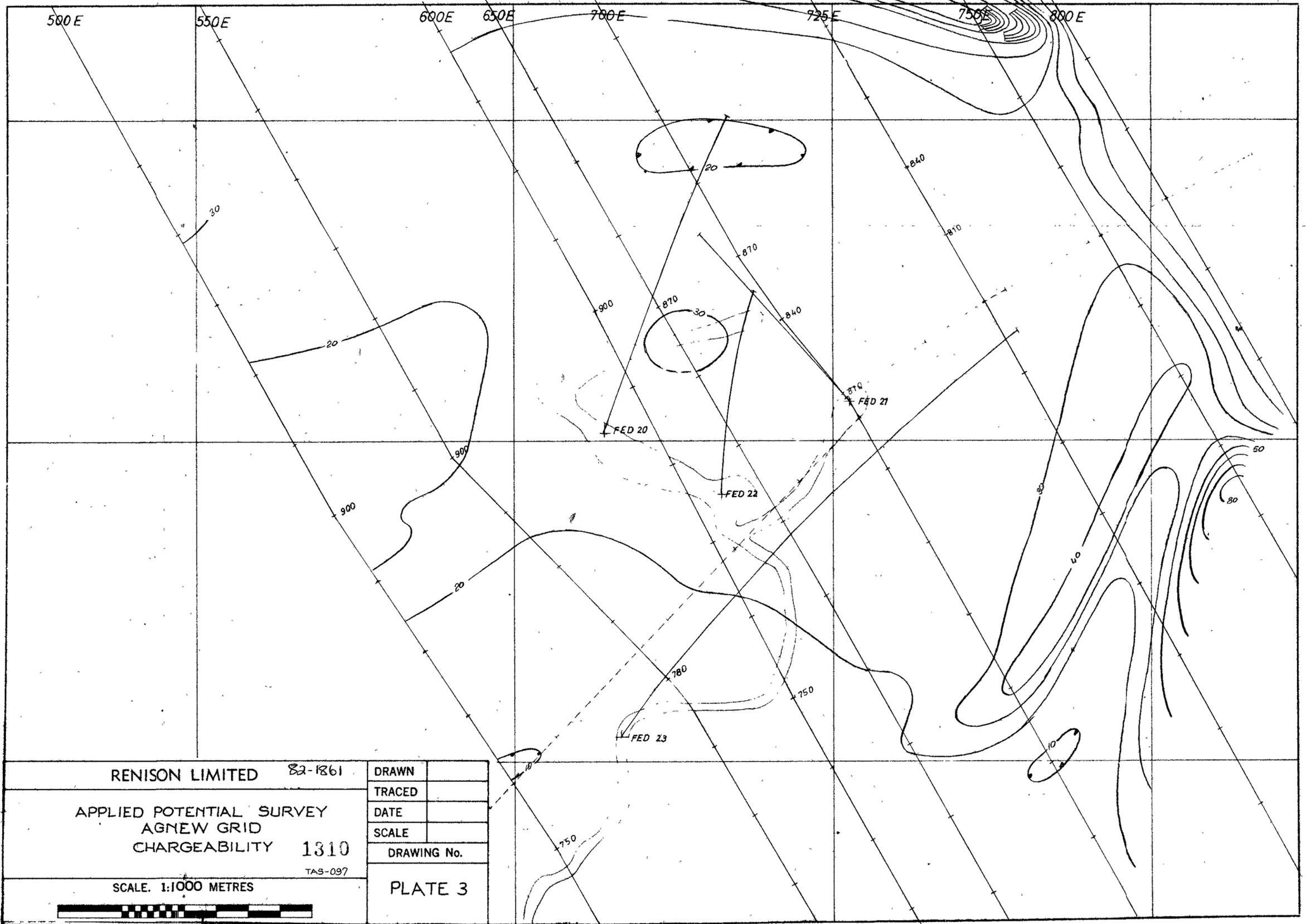
683046

82-1861	RENISON LIMITED	DRAWN	
APPLIED POTENTIAL SURVEY AGNEW GRID PRIMARY FIELD (Vp) 1308 TAS-097		TRACED	
		DATE	
		SCALE	
		DRAWING No.	
SCALE. 1:1000 METRES 		PLATE 1.	



RENISON LIMITED 82-1861		DRAWN	
APPLIED POTENTIAL SURVEY AGNEW GRID SECONDARY FIELD(Vs) 1309 TAS-097		TRACED	
		DATE	
		SCALE	
SCALE. 1:1000 METRES		DRAWING No.	
		PLATE 2	

683047



RENISON LIMITED 82-1861

APPLIED POTENTIAL SURVEY  
AGNEW GRID  
CHARGEABILITY 1310

TAS-097

SCALE. 1:1000 METRES

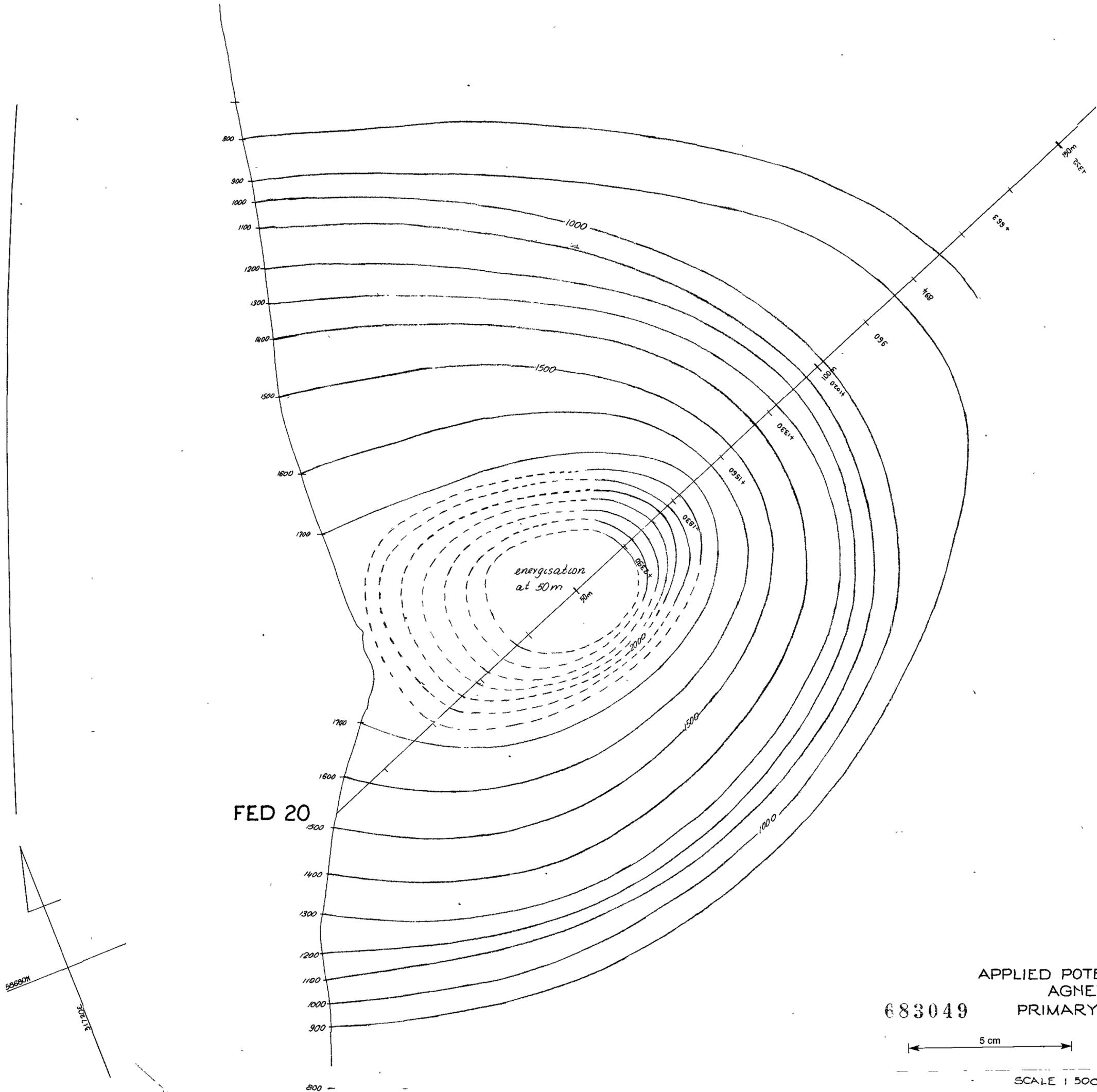


5 cm

DRAWN	
TRACED	
DATE	
SCALE	
DRAWING No.	

PLATE 3

683048



APPLIED POTENTIAL SURVEY  
 AGNEW GRID  
 683049 PRIMARY FIELD(Vp)

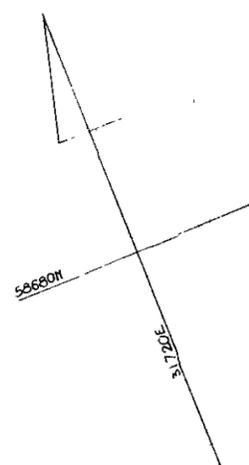
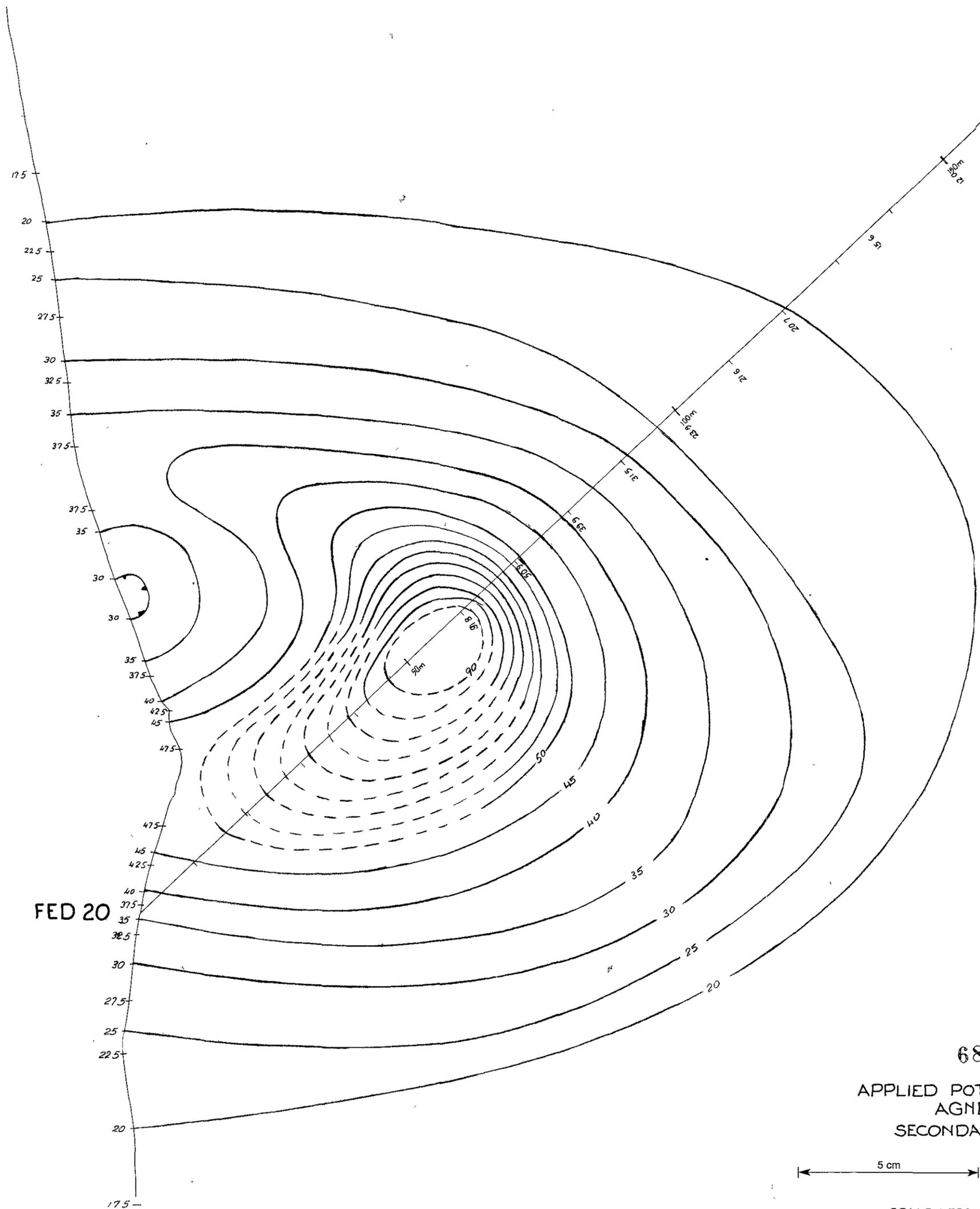
5 cm

SCALE 1:500m

TAS-097

1311

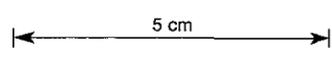
4a



FED 20

683050

APPLIED POTENTIAL SURVEY  
AGNEW GRID  
SECONDARY FIELD (Vs)



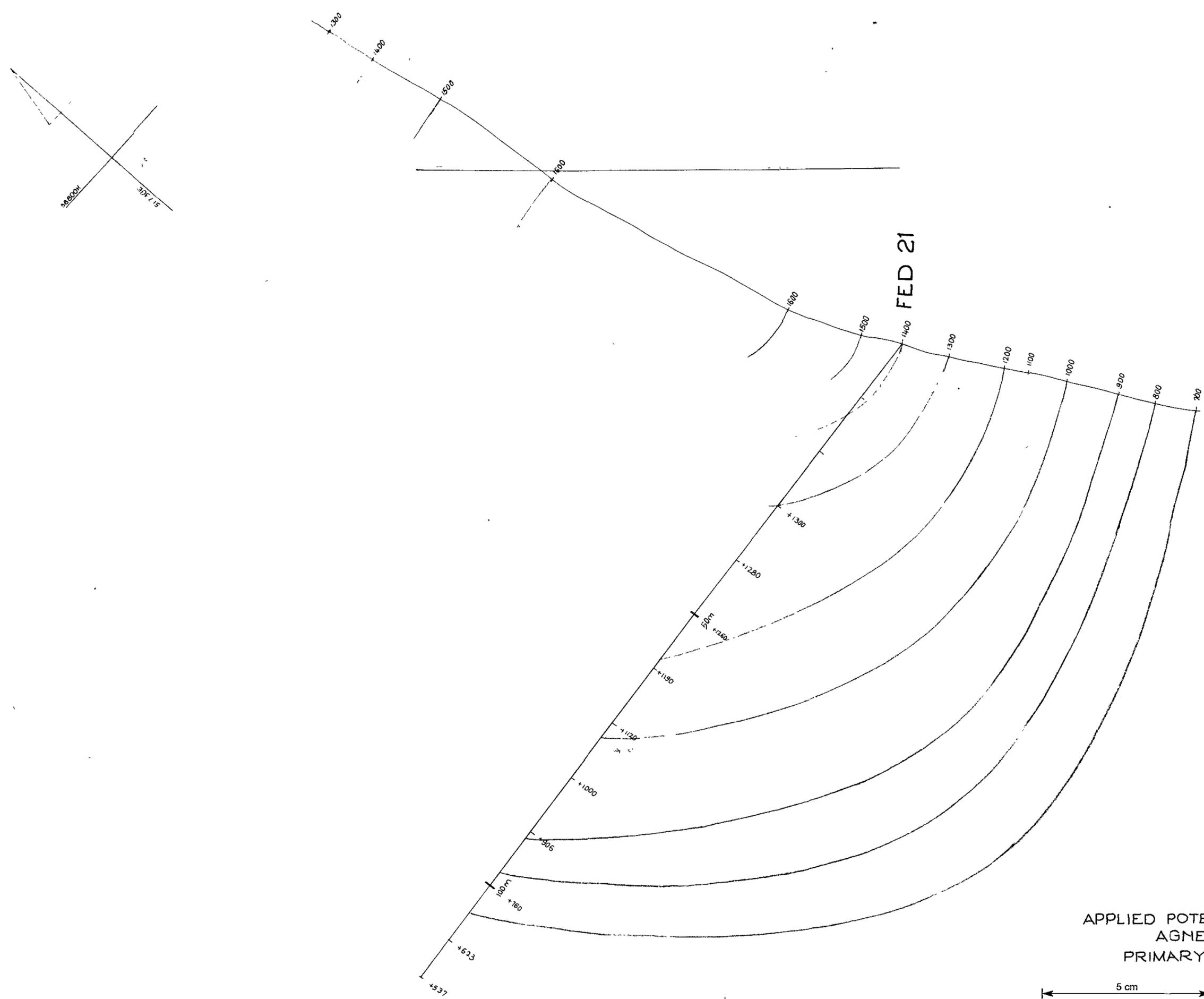
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1312

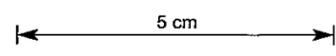
TAS-097

4b

82-1861



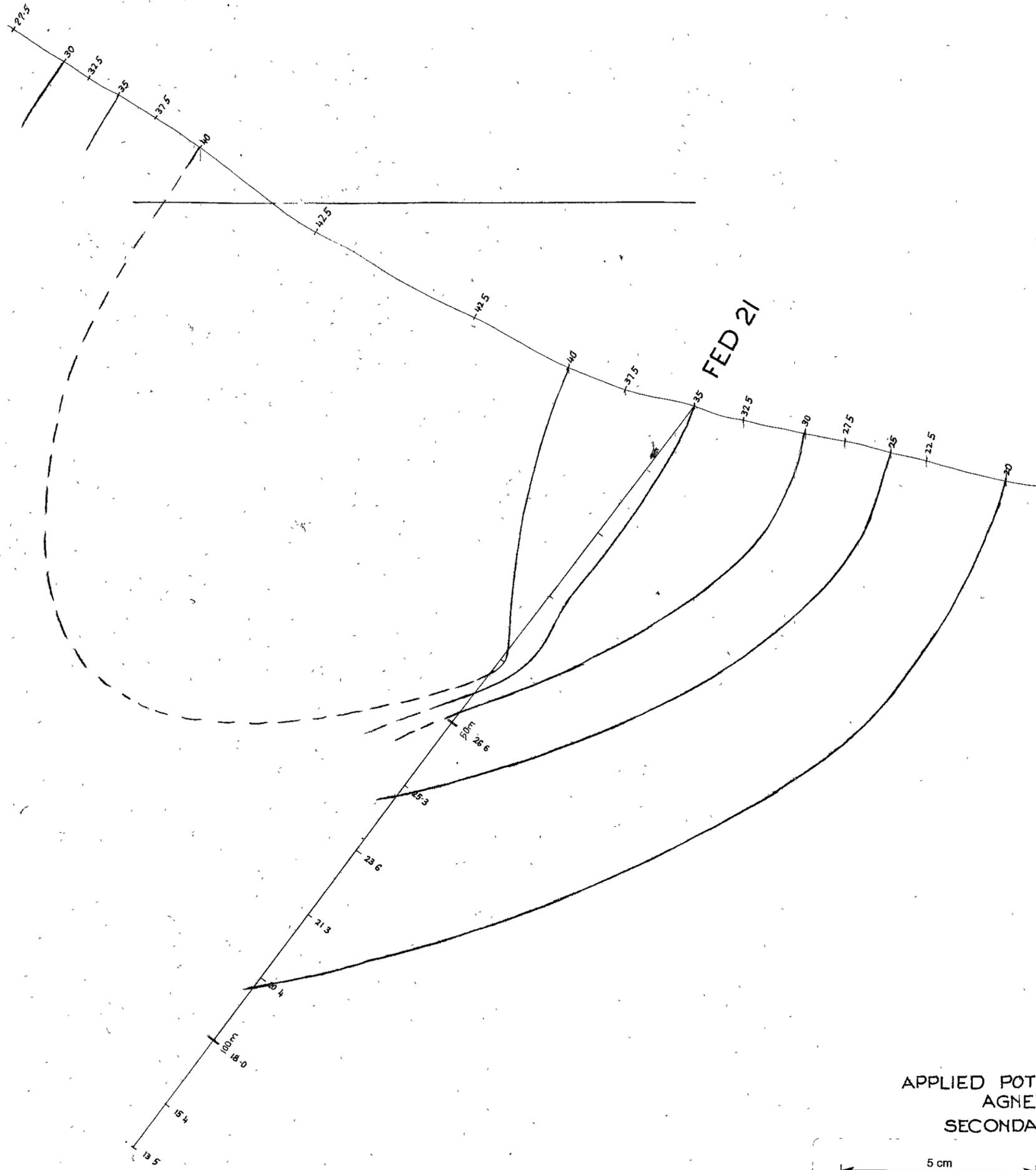
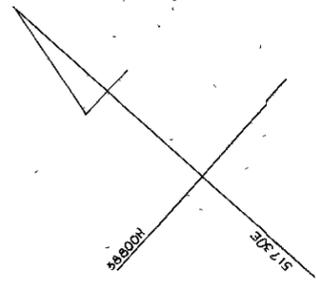
683051  
 APPLIED POTENTIAL SURVEY  
 AGNEW GRID  
 PRIMARY FIELD (Vp)



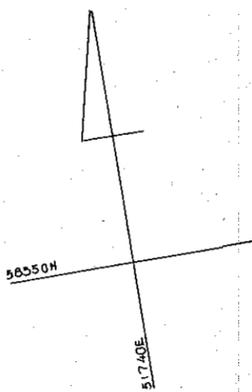
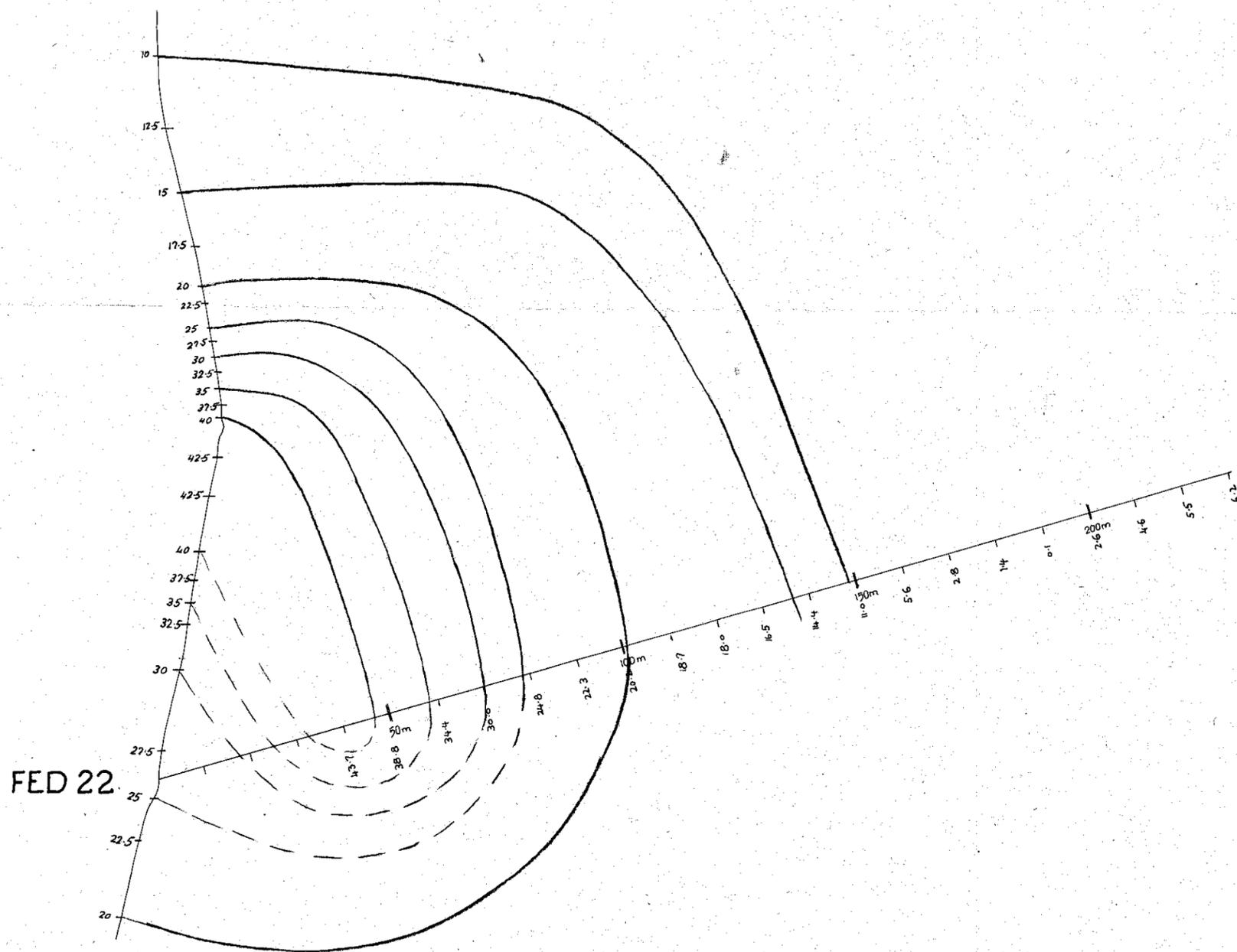
SCALE 1:500m TAS-097

1313

5a







683054

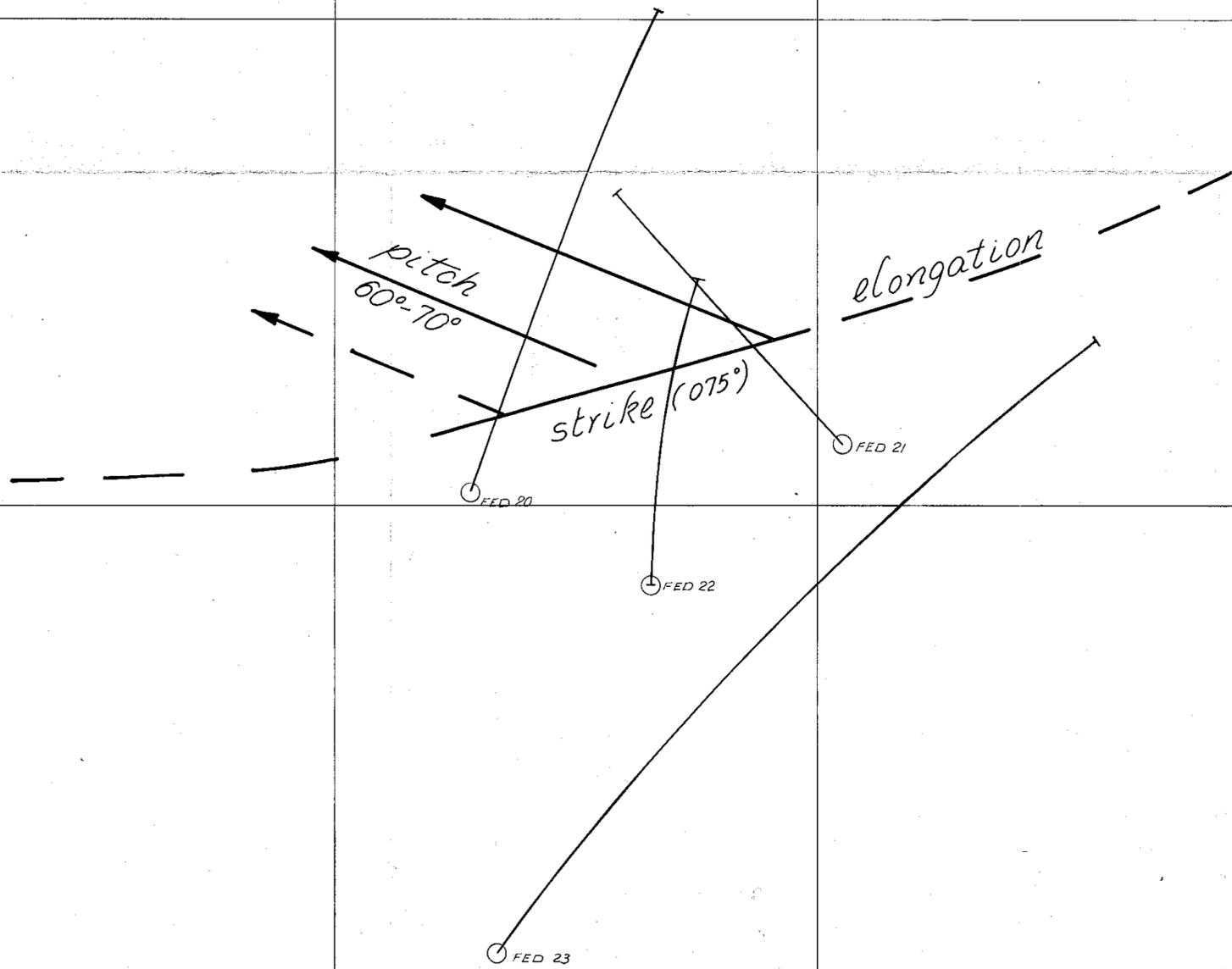
APPLIED POTENTIAL SURVEY  
AGNEW GRID  
SECONDARY FIELD (Vs)



1316

TAS-097

6b



RENISON LIMITED

APPLIED POTENTIAL SURVEY  
AGNEW GRID  
INTERPRETATION PLAN

TAS - 097

SCALE 1:1000 METRES

PLATE 7

5cm

1317

683055