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COMMENTS ON
"AT HOLE" DOWN-HOLE EIP AND RESISTIVITY LOGS
DOWN VARIOUS DRILL HOLES AT MT. LYELL
NEAR QUEENSTOWN, TASMANIA
ON BEHALF OF
THE MOUNT LYELL MINING & RAILWAY COMPANY LTD.

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NEAR QUEENSTOWN, TASMANIA
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BY

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SYDNEY, N.S.W.

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TAS-054E

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Data Profiles

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GEOPHYSICAL CONSULTANTS AND CONTRACTORS

SUMMARY

A series of 'at hole' three-array induced polarization and resistivity logs down diamond drill holes at Red Hills, West Sedgwick and Basin Lake, have demonstrated the electrical characteristics of the various rock types encountered. This data will be able to be incorporated into the interpretation of gradient array reconnaissance surveys in the region.

Mineralisation and Carbonaceous Shales in the holes logged were observed to have a similar range of resistivity and chargeability levels which infers that they could not be differentiated on a basis of these properties alone. All further logging should be executed using decay form monitoring such as that used on Basin Lake holes.

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COMMENTS ON

"AT HOLE" DOWN-HOLE EIP AND RESISTIVITY LOGS

DOWN VARIOUS DRILL HOLES AT MT. LYELL

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ON BEHALF OF

THE MOUNT LYELL MINING & RAILWAY COMPANY LTD.

INTRODUCTION

At the request of Mr. K. Reid, Chief Geologist for the Mount Lyell Mining & Railway Company Ltd., Scintrex Pty. Ltd. carried out down hole, "at hole", electrical logs for chargeability and apparent resistivity. These surveys were performed at various times from April, 1977 onwards by several Scintrex operators as follows:-

| Area | Hole | Job Code | Operator | Date |
|---------------|-------|----------|----------|----------|
| Red Hills | RH-5 | TAS-042 | Ekstrom | 4.4.77 |
| Red Hills | RH-6R | TAS-054A | Bennett | 10.12.77 |
| Red Hills | RH-7 | TAS-054A | Bennett | 13.12.77 |
| Red Hills | RH-8 | TAS-054A | Bennett | 10.12.77 |
| Red Hills | RH-9 | TAS-054A | Bennett | 15.12.77 |
| Red Hills | RH-10 | TAS-054A | Bennett | 17.1.78 |
| West Sedgwick | WS-3 | TAS-054 | Bennett | 14.12.77 |
| Basin Lake | BL-1 | TAS-054E | Ekstrom | 3.3.78 |
| Basin Lake | BL-2 | TAS-054E | Ekstrom | 15.3.78 |

In addition, certain applied potential surveys were carried out, with current electrodes emplaced in ore intersections in Red Hills,

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DDH-RH5. These results are discussed under a separate heading.

The objective of each of the individual down hole surveys was to ascertain the physical properties of chargeability and resistivity of each of the rock units and mineralised sections with a view to not only unambiguously identify the sources of surface responses, but also of obtaining physical property information on the rocks to aid in the interpretation of the reconnaissance gradient array surveys.

DATA PRESENTATION

The down-hole position of each data point is plotted at the scale of 1 centimetre = 5 metres (1:500). The resistivity is plotted on a five centimetre log cycle and expressed in ohm-metres, and chargeability at the scale of 1 centimetre = 5 milliseconds (for the IPR-7 data) and 1 centimetre = 5 millivolts/volt (for the IPR-8 data). For those holes where the IPR-8 was employed, the decay form has been displayed in a normalised percentage variation from normal, ΔM_n , at the scale of 1 centimetre = 5%.

The resistivity, chargeability and decay factor are plotted in the same relative positions on each of the data profile sheets (except for chargeability data for RH9 and RH10), in order to show clearly the relative order of each physical property between sheets.

SCINTREX*DISCUSSION OF RESULTS**A- "AT HOLE" PHYSICAL PROPERTY MEASUREMENTS*

General Comments:- A brief description of the method, equipment and meaning of the data is set down below. In summary, small electrode spacings give the bulk characteristics of the rocks in the immediate vicinity of the drill hole. This is far superior to analysing small samples of drill core on two major grounds (i) such core is an extremely small sample and may or may not be characteristic of the rock unit (or mineralisation) and (ii) small samples are extremely difficult to measure in the laboratory with the *original pore fluid* employed. (The chances of acquiring characteristic data from core once dessication has taken place are remote, particularly within "tight" rocks such as found at Mt. Lyell.)

Comments on the Method:- The objective of the down hole surveys under discussion was to ascertain the properties of the rocks "at hole" where they can be correlated to the core intersected. For such surveys a three-array log having a small a spacing, less than $2\frac{1}{2}$ metres, is usually used. The current from electrode C_1 moves to C_2 at infinity in three dimensions as shown in Figure 1. A series of equipotentials having spherical surfaces whose centre is the electrode C_1 , will be formed about the hole. The two potential electrodes at P_1 and P_2 will "tap" a volume between the two spheres passing through P_1 and P_2 . This can be regarded as a measurement of the physical properties of chargeability and resistivity around a cylinder having

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EQUIPOTENTIAL DIAGRAM

DOWN HOLE THREE ARRAY LOGGER

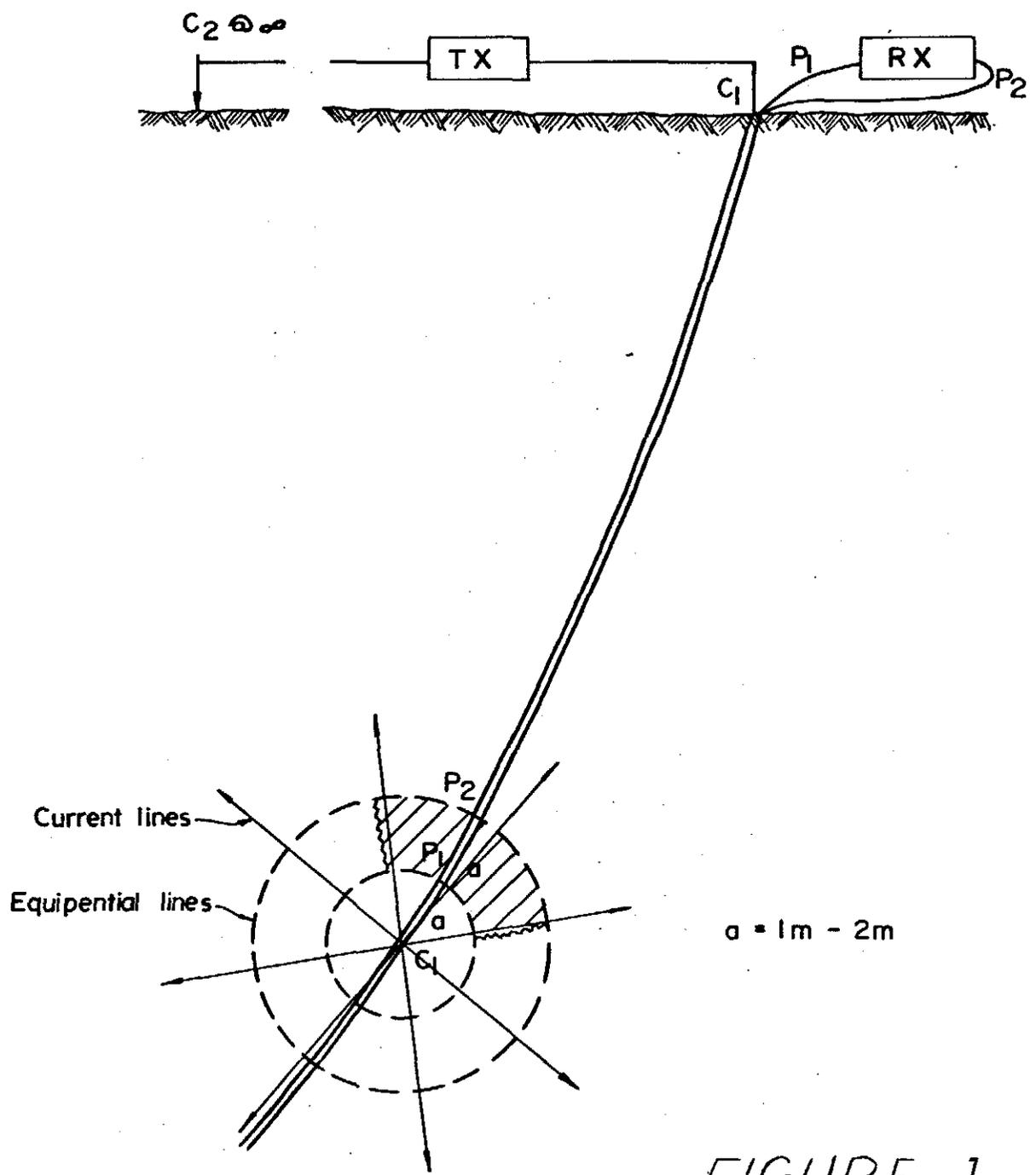


FIGURE 1

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a radius of *about 'a'* around the hole, and a length of *'a'* down the hole. This samples from 40 to 80 tons of rock.

It is important that the current densities be kept low, preferably of the same order as those used on the surface surveys. As the rock resistivity *increases*, the current density must be *decreased*. It is important to keep the current low. Either small battery operated 25 watt transmitters are 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.

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.

In those holes which were logged with the IPR-8, decay form information was obtained. This has been described in report TAS-054C (White Spur Detail), but is repeated below for completeness.

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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.

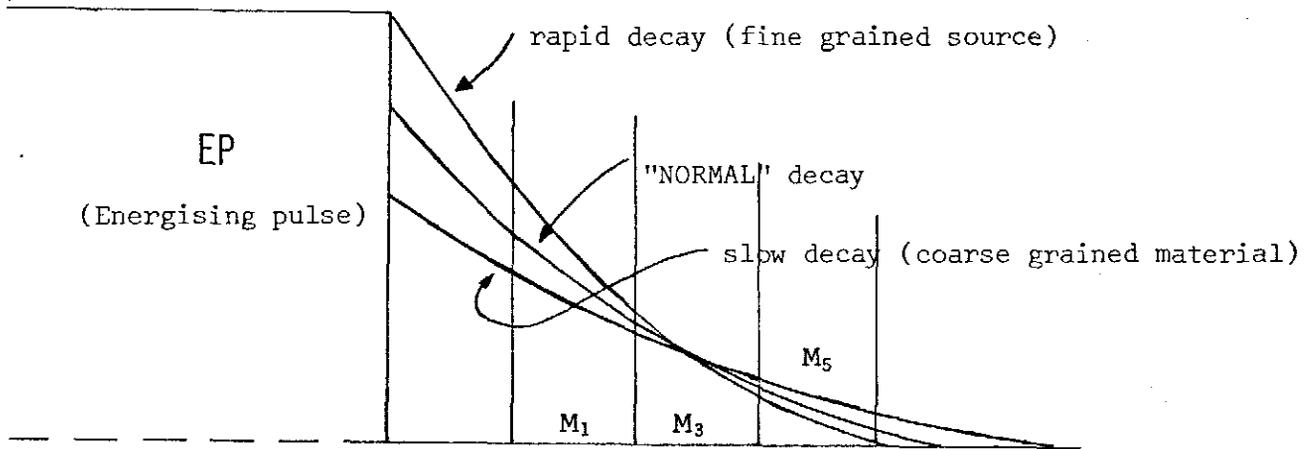
While the above comments refer to "mineralisation" they are also true of chargeability background. The background in rocks is usually determined by mafic mineral content, while the decay form appears often to be dependent on the rock grain size.

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.

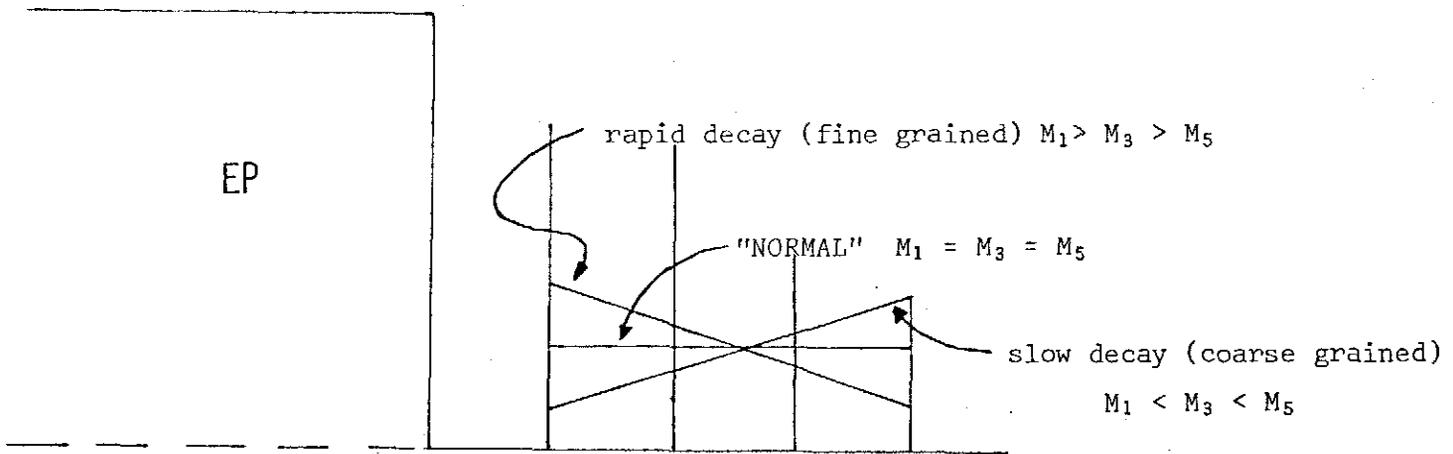
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(A) DECAY AS OBSERVED BY IPR-8 MIP RECEIVER PRIOR TO PROCESSING



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

FIGURE 2

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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 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 ΔM , $|M_5| - |M_1|$, 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 ΔMn , the *normalised decay form* in percent.

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

ΔMn , 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.

BASIN LAKE DDH BL-1

130m - 260m:- The chargeability data shows a fairly even and low background of about 5 millivolts/volt +3 millivolts/volt between

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130 and 265 metres. Within this background the decay form infers a faster than normal $-9\%(+)$ between 130 metres and 162 metres, and an even faster -15% between about 190 metres and 265 metres. This infers the source of the background to be fine grained and a low percentage volume of the rock.

A distinct 5000 ohm-metres shoulder at 165 metres is probably due to rocks described as COARSE GRAINED ALTERED CALCITIC LITHIC CRYSTAL TUFF (B), while even higher resistivities of 50,000 ohm-metres+ at 172 metres were due to MEDIUM GRAINED EPIDOTISED CRYSTAL LITHIC TUFFS (C).

Between about 180 metres and 197 metres, resistivities remained at about 1000 to 2500 ohm-metres with chargeabilities between 3 and 5 millivolts/volt, and very slow decay forms (-20%) from within the unit recorded as COARSE GRAINED ALTERED CALCITIC LITHIC TUFF.

A specific rise in resistivity to 30,000 ohm-metres at 200 metres cannot be identified in the geological log.

Between 220 metres and 255 metres the background resistivity rises from 3000 to 4000 ohm-metres to between 20,000 and 50,000 ohm-metres. This zone appears coincident with MEDIUM GRAINED CRYSTAL TUFF AND MEDIUM TO COARSE GRAINED ALTERED CRYSTAL LITHIC TUFF (E). Extremely fast decay forms indicate fine grained, inefficient sources for the little chargeable material present ($M = 7$ millivolts/volt).

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Within the 130 metres to 260 metres section, the most significant chargeability response was recorded between about 205 metres and 215 metres where chargeabilities of up to 80 millivolts/volt were recorded at 207½ metres and 30 millivolts/volt at 215 metres. The decay form observed was, respectively, 15% and 10% *slower* than normal as against 15% *faster* than normal within 5 +2½ millivolts/volt background immediately above or below. The source is interpreted as coarser than normal sulphides, which a depression in the resistivity to 2500 ohm-metres indicated is contained within a host less resistive than background. The source lies at or within 2 metres of the drill hole, at or in close proximity to the boundary between the MEDIUM GRAINED CRYSTAL TUFF and the COARSE GRAINED ALTERED CALCITIC LITHIC TUFF. (No sulphides have been recorded at this point in the drill hole.)

260m - 330m:- Below about 260 metres the background resistivities fall to about 200 ohm-metres at 310 metres and then rise to 1500 ohm-metres (+) between 330 metres and 360 metres. Over this zone, high chargeabilities were recorded between 282 metres and 327 metres, which over this section remain always above 50 millivolts/volt. The decay forms show positive values over the section and remain above +10%, showing *slow* decay forms between 295 metres and 325 metres, which infer a coarse grained source. This zone can be differentiated into a number of distinct units as follows:-

(a) 282 metres to 290 metres, local decrease in resistivity from 4000 ohm-metres to 1500 ohm-metres with 55 millivolts/volt

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chargeability, and a decay form which infers a coarse grained source. This coincides with the geological units described as ALTERED FINE-MEDIUM GRAINED CALCITIC HAEMATITE CRYSTAL AND LITHIC TUFFS. (F)

(b) 298 metres to 306 metres, very high chargeabilities in excess of 90 millivolts/volt with very slow (+15%) decay forms (indicating coarse grain size), are accompanied by 1500 ohm-metres resistivities. This zone lies close to the mapped unit described as SERICITE PYRITE SILICEOUS TUFFS (Ga).

(c) 308 metres to 330 metres, the chargeabilities remain at about 70 millivolts/volt, show slow decay forms of +10%, while resistivity varies from 150 ohm-metres to about 400 ohm-metres. This zone is logged as being SERICITE PYRITE SILICEOUS TUFFS CARRYING MINOR SPHALERITE AND GALENA. The magnitude of the IP response suggests the presence of pyrite (or other sulphides) within 2 metres or so of the hole to 2½%+ (Gb).

330m - 390m:- Between 330 metres and 390 metres the apparent resistivities show a progressive *decrease* from about 2000 ohm-metres to about 500 ohm-metres, while the chargeabilities show a progressive *increase* from 10 millivolts/volt to 60 ±10 millivolts/volt. Two distinct zones can be differentiated as follows:

(a) Between 330 metres and 360 metres chargeabilities invariably increase from 10 millivolts/volt to 25 millivolts/volt with slower

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than normal decay forms of +5%(+). Over this zone the resistivity remains between 1000 and 2000 ohm-metres. This unit approximately coincides with the unit mapped as FINE GRAINED ALTERED CRYSTAL LITHIC TUFFS. (H)

(b) At about 360 metres the recorded chargeability shows a rapid increase to about 50 millivolts/volt while the decay form lengthens from +5%(+1%) to +8%(+1%). The resistivity varies between 400 and 700 ohm-metres (J).

Although no sulphides or graphite have been recorded within this unit, a coarser than normal chargeable source must be present. This unit is described as being MEDIUM GRAINED ALTERED SERICITE CALCITE CRYSTAL TUFF, and compared with the rock of similar description but *without sericite*, demonstrates that the presence of sericite considerably lowers the apparent resistivity. Normally sericite is however, *not* considered chargeable, and is therefore probably *not* the source of the higher chargeability background.

BASIN LAKE DDH BL-2

Unfortunately no meaningful chargeability data was obtained over substantial sections of this hole, namely down to about 230 metres. While negative values were recorded from 242 to 275 metres, no readings were obtained from 208 to 228 metres, probably due to exceedingly low resistivities within the rocks close to the hole over this section. The lack of chargeability readings could be

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occasioned by the presence of graphite within the hole muds.

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172m - 197m:- From 172 metres to 197 metres the apparent resistivity falls from 2500 ohm-metres to 100 ohm-metres. This fall was observed from the units mapped as ALTERED MEDIUM-COARSE GRAINED CRYSTAL LITHIC TUFF TO FINE-COARSE GRAINED LITHIC TUFF. Some negative chargeabilities were recorded within this unit which may be caused by graphite within the drill hole muds, or graphite within the rock unit itself.

197m - 227m:- From 197 metres to 200 metres the apparent resistivity falls rapidly from the order of 100 ohm-metres to 5+ ohm-metres, while between 208 metres and 228 metres, extremely low apparent resistivities are assumed to be due to low potential gradients. This zone coincides with the presence of FINE-COARSE GRAINED LITHIC TUFFS and CARBONACEOUS SHALES.

228m - 240m:- From 228 metres the apparent resistivity shows a significant increase from 500 ohm-metres to over 5000 ohm-metres at 240 metres. This is coincident with high chargeability maxima of 80 millivolts/volt at 235 metres and 25 millivolts/volt at 240 metres. The former shows *slow* decay forms of +15% while the latter is near normal. This zone coincides with the mapped position of the upper section of FINE AND COARSE GRAINED CALCITIC MIXED LITHIC AND CRYSTAL TUFFS. It is considered likely that coarse grained graphite or sulphides exist in this unit.

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240m - 275m:- Extremely high 15,000 ohm-metres resistivities were observed between 240 and 252 metres within background chargeabilities of the order of 5 millivolts/volt. These are accompanied by very fast decay forms of the order of -25% or less, inferring a finer grain size to the causative source. This unit is mapped under the overall description of FINE AND COARSE GRAINED CALCITIC AND MIXED LITHIC AND CRYSTAL TUFFS. A similar unit was recorded between 262 and 268 metres. Presumably these two units are more akin to unit 'B' in Basin Lake #1 (See Table 1), while the two zones 252 metres to 262 metres and 268 metres to 275 metres represent less calcitic varieties.

275m - 280m (end of log):- An increase in chargeability to 60 millivolts/volt was recorded at 280 metres which shows slower than normal decay form (+5%) and is accompanied by 25,000 ohm-metres apparent resistivities. Although not differentiated in the geological log, this is considered to be a separate unit. Perhaps the more calcitic unit contains either sulphides or graphite.

WEST SEDGWICK DDH WS-3

There is no detailed geological log available at the time of writing. The unit used to log the hole was an IPR-7.

The most prominent features were two related chargeability maxima centred at 155 metres and 160 metres of 116 milliseconds and 70

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milliseconds respectively. These chargeability anomalies are accompanied by a 90% reduction in apparent resistivity to 2500 ohm-metres and 5000 ohm-metres from 15,000 ohm-metres (above) and 50,000 ohm-metres (below). Thus the source cannot be considered conductive, although it is less resistive than the enclosing host rocks.

Between about 162 metres and 170 metres a resistive 50,000 ohm-metres unit shows low 5 milliseconds chargeability and is interpreted as being due to an acid, resistive unit.

Centred at 172 metres, a significant decrease in apparent resistivity from 50,000 to 65,000 ohm-metres "background" down to 15,000 ohm-metres was recorded coincident with an increase in background chargeability from 5 milliseconds to just under 40 milliseconds. The source is interpreted as very disseminated sulphide (or graphite) within a less resistive host.

Below 175 metres, resistivities range about the 40,000 ohm-metres mark to about 195 metres and correlate with higher chargeability backgrounds of 10 and 20 milliseconds. The source rock is a resistive one containing a higher mafic mineral content than the units centred at 166 metres or between 202 metres and 215 metres. The source rock is probably intermediate in composition. A more acid unit is suggested between 202 metres to 215 metres where resistivities rise to 100,000 ohm-metres and chargeabilities were about 1½ milliseconds.

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RED HILLS DDH RH-5

This hole was logged using an IPR-7 and thus the chargeability is expressed in milliseconds (1 millisecond = 1.4 millivolts/volt)

20m - 30m:- The apparent resistivities over this section vary between 600 and 1200 ohm-metres with background chargeability being about 25 milliseconds. This zone is logged as being *MEDIUM GRAINED FELSIC TUFF (M)*.

30m - 65m:- Between 30 metres and 65 metres much increased chargeabilities of 80 milliseconds plus, were recorded. The average was about 130 milliseconds. Over this zone the resistivities vary from 40 ohm-metres (at 40 metres) to 1000 ohm-metres (at 52 metres). This zone is clearly correlated with the logged position of *CARBONACEOUS SHALES (N)*.

65m - 110m:- (Oa) This section is marked by a variable decline in apparent chargeability from the very high levels within the *CARBONACEOUS SHALES* of 70 milliseconds to 10 milliseconds, while the resistivity remained between the 800 to 2500 ohm-metres level. Individual maxima of the order of 30 milliseconds were recorded (as against this declining background), at 75 metres and 88 metres. This section is logged geologically as *MEDIUM GRAINED FELSIC TUFF* and is not differentiated from the underlying section between 110 metres and 155 metres (from which it shows a significant variation).

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110m - 155m:- (Ob) Over this section the resistivity averages about 10,000 ohm-metres, but varies between 2000 and 20,000 ohm-metres. The background chargeabilities are a low 8 to 10 milliseconds with a 20 to 25 milliseconds anomaly centred at 128 metres. This zone is clearly different to that above and below.

155m - 215m:- The background resistivities over this section vary from 800 ohm-metres to 7000 ohm-metres and indicate an alternating series of more and less resistive zones. Also, the chargeability similarly shows variation from a background of about 20 milliseconds to over 50 milliseconds. This zone crosses SEDIMENTS, TUFFS AND LAVAS but differentiation is not possible.

There are three anomalous zones within this alternating series of chargeable/less resistive - less chargeable/resistive zones.

(i) The first is centred at 157 metres where 90 milliseconds chargeabilities were recorded coincident with 600 ohm-metres resistivities as against 4000 ohm-metres background. Significant geochemical values were recorded in the geochemical log in this vicinity (0.288 and 0.151 Copper).

(ii) Chargeabilities of 172 milliseconds were recorded coincident with a 95% fall in the apparent resistivity to 400 ohm-metres at 185 metres. While no significant geochemical values were recorded, there must, however, be appreciable amounts of associated pyrite within 2 to 3 metres of the hole to produce the observed chargeability.

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response. Perhaps a lens similar to (iii) below lies in close proximity to the hole.

(iii) A substantial 224 milliseconds induced polarization response coincident with a fall in resistivity from 5000 ohm-metres plus to 45 ohm-metres was recorded at 197 metres within the *VERY FINE GRAINED TUFFACEOUS SEDIMENTS* with mineralisation of over 3 metres of 0.29% copper, 11% lead, etc. *It is significant that the resistivity is 45 ohm-metres. This is high bearing in mind the chalcopyrite and galena content.*

222m - 230m:- (Q) This section is characterised by high (averaging 10,000 ohm-metres) resistivities and low 10 milliseconds chargeabilities, and is delineated as *RED HILLS LAVAS*. (These characteristics are very similar to Ob above.)

RED HILLS DDH 6R

This hole was logged using an IPR-7.

10m - 30m:- The apparent resistivities over this sector range between 350,000 and 500,000 ohm-metres, while the chargeability remains about 1 millisecond. The logged *MEDIUM GRAINED FELSIC TUFF* must be highly silicified to cause such high resistivities.

30m - 130m:- The rocks remain an extremely resistive 150,000 ohm-metres over the entire section, with the background chargeability

being about 5 milliseconds. These zones appear coincident with the logged position of MEDIUM-FINE-COARSE GRAINED FELSIC TUFFS, but are some ten times as high as similar units mapped in DDH #5.

130m - 170m:- Apparent resistivities fall to about 60,000 ohm-metres while chargeability rises to 12 milliseconds over this unit. An individual anomaly 25 milliseconds above this background was noted at 157 metres. A variety of rock types including MEDIUM GRAINED FELSIC TUFFS, FINE GRAINED FELSIC TUFFS, and VERY FINE GRAINED TUFFACEOUS SEDIMENTS were noted, and having almost identical characteristics.

170m - 300m:- The resistivities over this section vary from 80,000 to 150,000 ohm-metres but average about 100,000 ohm-metres. The chargeability has a higher 12 milliseconds background. Individual maxima were at 200 metres, 205 metres, 210 metres and 292 metres (the latter being a high 80 milliseconds). The geological unit logged over this section of core is FINE GRAINED FELSIC TUFF.

300m - 370m:- Over this section the apparent resistivity shows a variable fall from 100,000 ohm-metres above and below the interval to less than 5000 ohm-metres between 345 metres and 370 metres. There are two individual sections of note within this zone.

(i) Coincident with a resistivity "low" of 15,000 ohm-metres, high 100 milliseconds chargeabilities were recorded at 315 metres.

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(ii) Between 326 metres and 370 metres the recorded chargeabilities varied between 80 milliseconds and 150 milliseconds, all within resistivities of between 3,000 and 10,000 ohm-metres.

370m - 420m:- Below 370 metres the resistivity shows a sharp increase to 40,000 to 200,000 ohm-metres within the RED HILLS LAVAS, while apparent chargeabilities fall to still high 20 to 30 milliseconds backgrounds. Within this zone, one significant chargeability response was logged as follows:-

At 390 metres a 95% depression in apparent resistivity to 4000 ohm-metres is coincident with a 90 milliseconds chargeability response. The presence of chalcopyrite (0.46% copper), with perhaps significant pyrite, explains the resistivity low.

The source is obviously quite disseminated sulphides over the entire section. The extremely high resistivities show that the sulphides play no part in reducing the observed resistivity.

RED HILLS DDH RH7

This hole was logged using an IPR-7.

5m - 15m:- The apparent resistivity reaches a high 400,000 ohm-metres at 10 metres, with near zero chargeabilities. The geological log shows COARSE GRAINED FELSIC TUFF. (These characteristics are as per hole RH#6R for this rock unit.

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15m - 93m:- The apparent resistivity varies from 40,000 ohm-metres to 150,000 ohm-metres but average about 60,000 ohm-metres. The background chargeabilities vary *about* the 5 milliseconds level between 15 metres and 65 metres, and above the 8 milliseconds level between 65 metres and 90 metres. This unit is logged as being MEDIUM GRAINED FELSIC TUFF. (V)

97m:- A sharp increase in apparent chargeability to 50 milliseconds from 10 milliseconds was found to be coincident with a 70% fall in resistivity to 11,000 ohm-metres within the geological unit logged as VERY FINE GRAINED TUFFACEOUS SEDIMENTS. Although not specified in the geological log, sulphides or graphite are probably also present within this unit (W).

102m:- At this point 40,000 ohm-metres resistivities are coincident with lower (10 milliseconds) chargeabilities. This zone lies within the unit mapped as FINE GRAINED FELSIC TUFF, and fits the characteristics for this zone noted in other holes.

105m - 125m:- A marked fall in apparent resistivity to less than 1000 ohm-metres between 105 metres and 113 metres, and to 3000 ohm-metres between 115 metres and 122 metres, is accompanied by high 170 to 200 milliseconds chargeabilities. This zone coincides with the known position of CARBONACEOUS SHALES, but commences earlier at 105 metres than the geological position logged for this unit at 110 metres.

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125m - 165m:- Within high resistivities of 25,000 ohm-metres, 30% to 40% falls in resistivity are accompanied by 25 +5 milliseconds chargeability increases. The MEDIUM TO COARSE GRAINED FELSIC TUFFS probably contain some disseminated graphite and/or sulphide material not recorded in the log.

Within this zone at 147 metres, a reduction in resistivities to 5000 ohm-metres from greater than 30,000 ohm-metres above and below, is accompanied by a material increase in chargeability to 77 milliseconds. Sulphides and/or graphite within the logged MEDIUM TO COARSE GRAINED FELSIC TUFFS are considered the source.

165m - 210m:- The zone is characterised by high 4000 to 8000 ohm-metres (average 6000 ohm-metres) resistivities and low 2 to 5 milliseconds chargeabilities. This unit is coincident with COARSE GRAINED FELSIC TUFFS and MEDIUM TO FINE GRAINED FELSIC TUFFS whose characteristics cannot be differentiated.

217m:- Centred at 217 metres, a decrease in resistivity by a 70% fall to 9,000 ohm-metres is accompanied by a 65 milliseconds chargeability response. This response lies on the boundary between the units logged as COARSE GRAINED FELSIC TUFFS and FINE TO MEDIUM GRAINED FELSIC TUFF. The source is considered to be either graphitic or pyritic material within a less resistive host.

217m - 235m:- 25,000 ohm-metres resistivities and 20₊ milliseconds chargeabilities are logged as containing the FINE TO MEDIUM GRAINED

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FELSIC TUFF unit.

232m - 247m (End of log):- The resistivity falls sharply from 25,000 ohm-metres to 6000 ohm-metres at about 232 metres, while the chargeability rises from 15 milliseconds at 230 metres to 60 milliseconds at 245 metres. This unit is associated with the FINE GRAINED TO MEDIUM GRAINED FELSIC TUFF. The increase in chargeability is probably due to an increase in sulphides as the mineralised section is approached.

RED HILLS DDH RH-8

This hole was logged using an IPR-7

0 - 110m:- From the collar to 110 metres the electrical log shows a series of alternating resistive and less resistive units which have respectively low and high chargeability backgrounds. An alteration of two quite different rock units is suggested by this over the zone logged as FINE GRAINED FELSIC TUFF. In detail these are as follows:-

| | | |
|------|------------------------------------|------------------------------|
| 0m | | |
| ↓ | $\rho_a = 3,000 \Omega m$ | $M = 70 \pm 10$ milliseconds |
| 14m | | |
| ↓ | $\rho_a = 50,000 \Omega m$ | $M = 15$ milliseconds |
| 27m | | |
| ↓ | $\rho_a = 6,000 - 11,000 \Omega m$ | $M = 35 - 60$ milliseconds |
| 47m | | |
| ↓ | $\rho_a = 46,000 \Omega m$ | $M = 15$ milliseconds |
| 57m | | |
| ↓ | $\rho_a = 3,000 \Omega m$ | $M =$ to 70 milliseconds |
| 71m | | |
| ↓ | $\rho_a = 23,000 \Omega m$ | $M = 15$ to 25 milliseconds |
| 92m | | |
| ↓ | $\rho_a = 4,000 \Omega m$ | $M = 30$ to 40 milliseconds |
| 108m | | |

The chargeable zones in the uppermost less resistive sections must be due to sulphides and/or graphite within the rock unit, as the observed chargeability maxima of 60 to 70 milliseconds are 3 to 5 times normal background.

115m - 180m:- The apparent resistivities show a gradual increase from about the 15,000 ohm-metres mark to 75,000 ohm-metres, while the chargeability shows a decrease in background chargeability from 10₊ milliseconds to less than 2₊ milliseconds. These characteristics are similar to those observed in the COARSE GRAINED FELSIC TUFF unit.

Unfortunately this log did not pass through the mineralisation.

RED HILLS DDH RH-9

This hole was logged to only 85 metres using an IPR-7 receiver.

35m - 65m:- The resistivity shows 4000 to 10,000 ohm-metres, while the chargeability shows negative chargeability. This zone corresponds approximately with FINE GRAINED TO MEDIUM GRAINED FELSIC TUFF.

65m:- 8 milliseconds (relative) chargeability was recorded on the contact of the units listed above and below.

65m - 85m:- The bulk resistivity varied from 2000 ohm-metres to 5000 ohm-metres while the chargeability background remained low within the unit logged as FINE GRAINED FELSIC TUFFS.

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In this case the electrical logs were not of sufficient length to be of great assistance.

RED HILLS DDH RH-10

This hole was logged to 240 metres using an IPR-7 receiver.

35m - 52m:- Resistivities between 26,000 and 40,000 ohm-metres were recorded to 52 metres. The negative chargeabilities probably infer a low background within the source. The rock unit logged over this section was COARSE GRAINED FELSIC TUFF(1C).

52m - 67m:- A distinctly less resistive unit of 4000 ohm-metres has a sharp contact with the more resistive rocks above and below. Although this unit is logged as FINE GRAINED FELSIC TUFF, it does not have the greater resistivities (up to two orders of magnitude) associated with this rock unit. This unit is considered more extensive than the geological log indicates. A similar zone was observed between 74 metres and 82 metres.

70m +2m:- An increase in resistivity to 23,000 ohm-metres from 4000 to 5000 ohm-metres above and below, lies within the FINE GRAINED FELSIC TUFF unit logged at about that point. This unit is considered less extensive than the geological log indicates.

82m - 105m:- A resistive 25,000 ohm-metres unit mapped as MEDIUM/ COARSE GRAINED FELSIC TUFF (1D) was recorded between these depths.

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The chargeability is inferred to be low by the negative *but* uniform readings.

105m - 115m:- Within this zone, apparent resistivities fall to less than 1000 to 600 ohm-metres, while the chargeability increases to some 40 milliseconds above the negative base. This response is associated with the lower sections of the *MEDIUM/COARSE GRAINED FELSIC TUFF*, however, it is difficult to believe it does not relate to the *CARBONACEOUS SHALES* which the geological log shows to be present at 120 metres (1E).

118m:- The geological log shows the narrow relatively resistive source of about 6000 ohm-metres to be associated with the boundary between *MEDIUM GRAINED FELSIC TUFF* and *CARBONACEOUS SHALES*, however, the geological log shows the resistive *FINE GRAINED FELSIC TUFF* between 120 metres to 125 metres, and this is the favoured source.

125m - 145m:- The resistivities vary about the 1500 ohm-metres mark with low chargeabilities. This zone is logged as *COARSE GRAINED FELSIC TUFF*, however, the resistivity is 10% of that recorded over similar units in this and other holes, and therefore appears geophysically as not the same unit. Inferred background chargeability is low.

150m - 225m:- Between these points the recorded resistivity varies between 5000 and 17,000 ohm-metres, while the background chargeability is inferred to be low. The logged unit over this

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section is described as FINE GRAINED/MEDIUM GRAINED FELSIC TUFF.

225m - 240m (End of log):- Below 225 metres the apparent resistivities fall rapidly to 60 ohm-metres from 4000 ohm-metres immediately above, while the chargeability is strongly negative. This zone correlates with the logged position of CARBONACEOUS SHALES, which the geological log shows to be present at about 235 metres. The earlier (from 225 metres) fall-off in resistivity may indicate an increasing shale content within the last 10 metres of the FINE GRAINED/MEDIUM GRAINED FELSIC TUFF unit.

CONCLUSIONS

- 1 - A summary of the range of resistivities of identifiable rock units is shown in Table 1A, together with the bulk chargeability of each unit. Table 1B identifies each of the rock units in Table 1A.
- 2 - Rock types described similarly in the same or in different holes do not always have similar *absolute* characteristics, although their *relative* characteristics are similar. This is seen in the case of the COARSE GRAINED FELSIC TUFF in the Red Hills holes.
- 3 - Considerable variation within the CARBONACEOUS SHALES was noted. These range from 5 ohm-metres in BL-2, 40 to 1000 ohm-metres in RH-5, and 1000 and 3000 ohm-metres in RH-7. Invariably the

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chargeabilities remain high. The resistivity is no doubt related to the degree of interconnection between grains. The high resistivities in RH-7 within the graphite zone must be due to grain separation.

- 4 - The mineralised sections logged at Red Hills at 197 metres in RH-5 was the most conductive mineralised section logged. The resistivity reached only 40 to 50 ohm-metres within the body. While this is a considerable contrast with the enclosing host rocks, it cannot be considered to be conductive. Other mineralised sections such as those in RH-6R between 320 and 360 metres are generally over 2000 ohm-metres. It would appear that bearing in mind logs through other "volcanogenic" deposits, that while the mineralisation does not have to be "conductive" as such, it should have resistivities less than 100 ohm-metres within the mineralisation. Only one logged "volcanogenic" body of significant grade had resistivities in excess of 100 ohm-metres, namely about 500 ohm-metres.
- 5 - Within volcanogenic sequences it can be expected that the physical properties of chargeability and resistivity for pyrite-lead-zinc lodes both lean, and rich, in copper, will overlap those for graphitic shales.
- 6 - Some extremely resistive units were recorded at Red Hills, particularly in holes RH-7 and 8. In particular, the COARSE

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GRAINED FELSIC TUFFS, FELSIC TUFFS and FELSIC LAVAS of various grain sizes, all showed very high resistivities of 40,000 to 400,000 ohm-metres with very low to medium chargeability backgrounds (1 to 2 milliseconds). Although not specified on the geological logs kindly provided by Mt. Lyell, it is considered that silicification must be present within these units, while the low chargeability in units R and V infer low mafic mineral content.

In the Basin Lake holes, the units logged as COARSE GRAINED ALTERED CALCITIC AND LITHIC TUFF also had resistivities to 40,000 ohm-metres. Both silica and carbonates (SiO_2 and CaCO_3) have low chargeabilities and high resistivities, due no doubt to the "cementing" properties each has. This will result in the reduction of pore spaces, and increase in bulk resistivities.

- 7 - All rocks (see Tables 1A and 1B) lie within a broad zone ranging from about 1000 to 500,000 ohm-metres at "low" chargeability to 25 to 4000 ohm-metres at "high" (100 millivolts/volt+) chargeability.
- 8 - The majority of rocks logged had low to very low background chargeabilities of less than 10 milliseconds, and high resistivities in excess of 5000 ohm-metres.
- 9 - The very high resistivity levels observed down hole in all

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areas require that *low* current densities be employed. Therefore rather than the larger 3KW IP transmitter employed, the 25 watt battery operated unit will prove more efficient for most holes. It should be noted that *low* current densities are necessary down hole to (a) duplicate the current densities generated from the surface surveys, and (b) to avoid "turbulence" effects. (The *higher* the rock resistivity, the *lower* the current density required to log the unit.)

- 10 - It is recommended that all future logging should be executed using the IPR-8 (or IPR-10) receiver which is capable of decay form discrimination. While very little work has been carried out down hole to establish decay form, that which has, has proved most useful. It is through decay form that further differentiation between rock units and perhaps between mineralisation also, will be possible.
- 11 - It is recommended that in areas where no significant intersections are obtained within rocks which are prospective, or where low percentages of sulphides are located within prospective rock units, "large" (i.e. 10 to 25 metres) three-array surveys should be undertaken to search for near miss situations. The observed differences between "at hole" and "away from hole" arrays can be interpreted to give distance from hole for prospective mineralisation not actually intersected.
- 12 - From the experience Scintrex has gained of the physical problems of down-hole logging, as well as a basic knowledge of the range

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of rock type characteristics, it is recommended that Mt. Lyell personnel should execute both "at" and "away from" hole logging as soon as holes become available. This should prove far less expensive and more efficient for Mt. Lyell. It is therefore recommended that Scintrex train a number of Mt. Lyell personnel for this task.

- 13 - One minor recommendation is that on drill hole cross-sections, the down hole distance be annotated. Due to paper stretch, the precise positioning and correlation between the electrical and geological logs proved uncertain in detail.

TABLE 1B TYPICAL ELECTRICAL CHARACTERISTICS

BASIN LAKE BL-1

A - MEDIUM-COARSE GRAINED ALTERED CRYSTAL LITHIC TUFF

ρ_a 500 to 2500 ohm-metres

M 5 millivolts/volt

ΔMn -8% (+1%)

B - COARSE GRAINED ALTERED CALCITIC TUFF

ρ_a 5000 ohm-metres +30%

M 10 to 12 millivolts/volt

ΔMn -5%

C - MEDIUM GRAINED EPIDOTISED CRYSTAL LITHIC TUFF

ρ_a to 50,000 ohm-metres

M 6 millivolts/volt (+)

ΔMn -15%

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D - COARSE GRAINED ALTERED CALCITIC LITHIC TUFF ρ_a 1000 to 2500 ohm-metres M 3 to 5 millivolts/volt ΔMn -20%**E - MEDIUM GRAINED CRYSTAL TUFF/MEDIUM-COARSE GRAINED ALTERED CRYSTAL LITHIC TUFF** ρ_a 20,000 to 50,000 ohm-metres M 7 millivolts/volt ΔMn -20%**F - ALTERED, FINE-MEDIUM GRAINED CALCITIC HAEMATITE CRYSTAL AND LITHIC TUFFS** ρ_a 4000 ohm-metres +25% M 50 millivolts/volt ΔMn +7%**Ga- SERICITE PYRITE SILICEOUS TUFFS** ρ_a 1000 to 1500 ohm-metres M 90 millivolts/volt ΔMn +15%**Gb- SERICITE PYRITE SILICEOUS TUFFS** ρ_a 150 to 400 ohm-metres M 70 millivolts/volt ΔMn +12%

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H - FINE GRAINED ALTERED CRYSTAL LITHIC TUFFS

ρ_a 1000 to 2000 ohm-metres

M 10 to 25 millivolts/volt

ΔMn +5%

J - MEDIUM GRAINED ALTERED SERICITE CALCITE CRYSTAL TUFF

ρ_a 500 +200 ohm-metres

M 50 millivolts/volt

ΔMn +8% (+1%)

BASIN LAKE BL-2

K - FINE-COARSE GRAINED LITHIC TUFFS

ρ_a 100 to 500 ohm-metres

M ?

L - CARBONACEOUS SHALES

ρ_a 5 ohm-metres

RED HILLS RH-5

M - MEDIUM GRAINED FELSIC TUFF

ρ_a 250 to 1000 ohm-metres

M 25 milliseconds

N - CARBONACEOUS SHALES

ρ_a 40 to 1000 ohm-metres

M 130 + milliseconds

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Qa- MEDIUM GRAINED FELSIC TUFF (UPPER SECTION)

ρa Average 1,000 ohm-metres (800 to 2500 ohm-metres)

M Variable: 60 milliseconds declining to 10 milliseconds.

Qb- MEDIUM GRAINED FELSIC TUFF (LOWER SECTION)

ρa Average 10,000 ohm-metres (2000 to 20,000 ohm-metres)

M background 10 to 4 milliseconds.

(Note: Qa and Qb although mapped as the same unit, show VERY different characteristics)

P - ZINC/LEAD/PYRITE MINERALISATION (11%Pb, 31%Zn)

ρa 45 ohm-metres

M 225 milliseconds

Q - RED HILLS LAVAS

ρa 10,000 ohm-metres

M 10 milliseconds

RED HILLS RH-6R

R - MEDIUM GRAINED FELSIC TUFF (UPPER ZONE ONLY)

ρa 350,000 ohm-metres

M 1 millisecond

(This zone must be highly silicified)

S - FINE GRAINED FELSIC TUFF

ρa 80,000 to 150,000 ohm-metres

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M 10 milliseconds.

T - DISSEMINATED SULPHIDES PYRITE, ZINC, LEAD, WITHIN FINE GRAINED AND COARSE GRAINED FELSIC TUFFS

ρ_a 3000 to 10,000 ohm-metres

M 100 milliseconds

U - RED HILLS LAVAS

ρ_a 40,000 to 200,000 ohm-metres (average 25,000 ohm-metres)

M 10 to 20 milliseconds (average 25 milliseconds)

RED HILLS RH-7

V - MEDIUM GRAINED FELSIC TUFF

ρ_a 40,000 to 150,000 ohm-metres (average 60,000 ohm-metres)

M 7 +2 milliseconds

W - VERY FINE GRAINED TUFFACEOUS SEDIMENTS

ρ_a 11,000 ohm-metres

M 50 milliseconds

X - CARBONACEOUS SHALES

ρ_a 1000 ohm-metres and 3000 ohm-metres

M 170 milliseconds

Y - COARSE GRAINED FELSIC TUFFS & MEDIUM TO FINE GRAINED FELSIC TUFFS

ρ_a 4000 to 8000 ohm-metres

M 2 to 5 milliseconds

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RED HILLS RH-8

Z - FINE GRAINED FELSIC TUFF

Alterations of $\rho_a = 3000$ to 6000 ohm-metres and $M = 40$ to 80 milliseconds, with zones of $\rho_a = 25,000$ to $50,000$ ohm-metres and $M = 15$ milliseconds.

RED HILLS RH-9

1A- MEDIUM AND FINE GRAINED FELSIC TUFF

ρ_a 4000 to 10,000 ohm-metres

M low

1B- FINE GRAINED FELSIC TUFFS

ρ_a 2000 to 5000 ohm-metres

RED HILLS RH-10

1C- COARSE GRAINED FELSIC TUFF

ρ_a 26,000 to 40,000 ohm-metres

M low

1D- MEDIUM-COARSE GRAINED FELSIC TUFF

ρ_a 20,000 to 40,000 ohm-metres

M low

1E- CARBONACEOUS SHALES

ρ_a 1000 ohm-metres (+400 ohm-metres)

M 30 to 40 milliseconds

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1F- COARSE GRAINED FELSIC TUFF

pa 1500 ohm-metres

M low

1G- FINE-MEDIUM GRAINED FELSIC TUFF

pa 5000 to 17,000 ohm-metres

M low

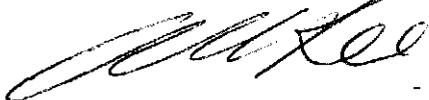
1H- CARBONACEOUS SHALES

pa 60 to 400 ohm-metres

M large, negative

Respectfully submitted on behalf of:

SCINTREX PTY. LTD.



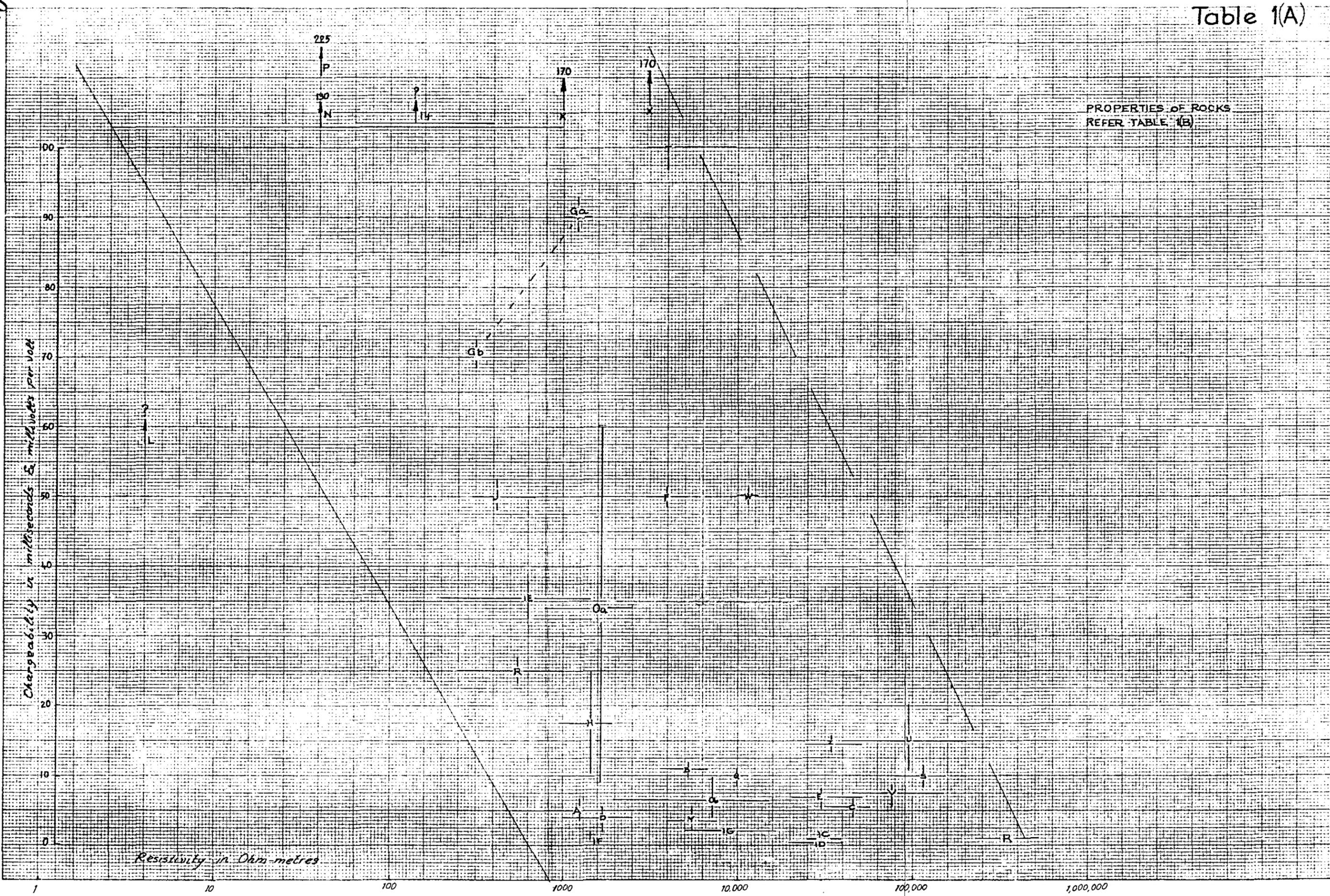
A.W. HOWLAND-ROSE, MSc, DIC, AMAusIMM, FGS.

GEOPHYSICIST

K.E. REPORT TO THE COMMISSIONER OF THE GENERAL INVESTIGATION

41 1211

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PROPERTIES OF ROCKS
REFER TABLE (B)

Resistivity in Ohm-metres

1 10 100 1000 10,000 100,000 1,000,000

D.H. I.
Basin Lake
Down hole I.P.
TAS-054-E

0 041
WHEELER & ESKER CO.
MEMPHIS, TENN.
MADE IN U.S.A.
NO. 10 X 10 TO THE CENTIMETER
NO. 1913



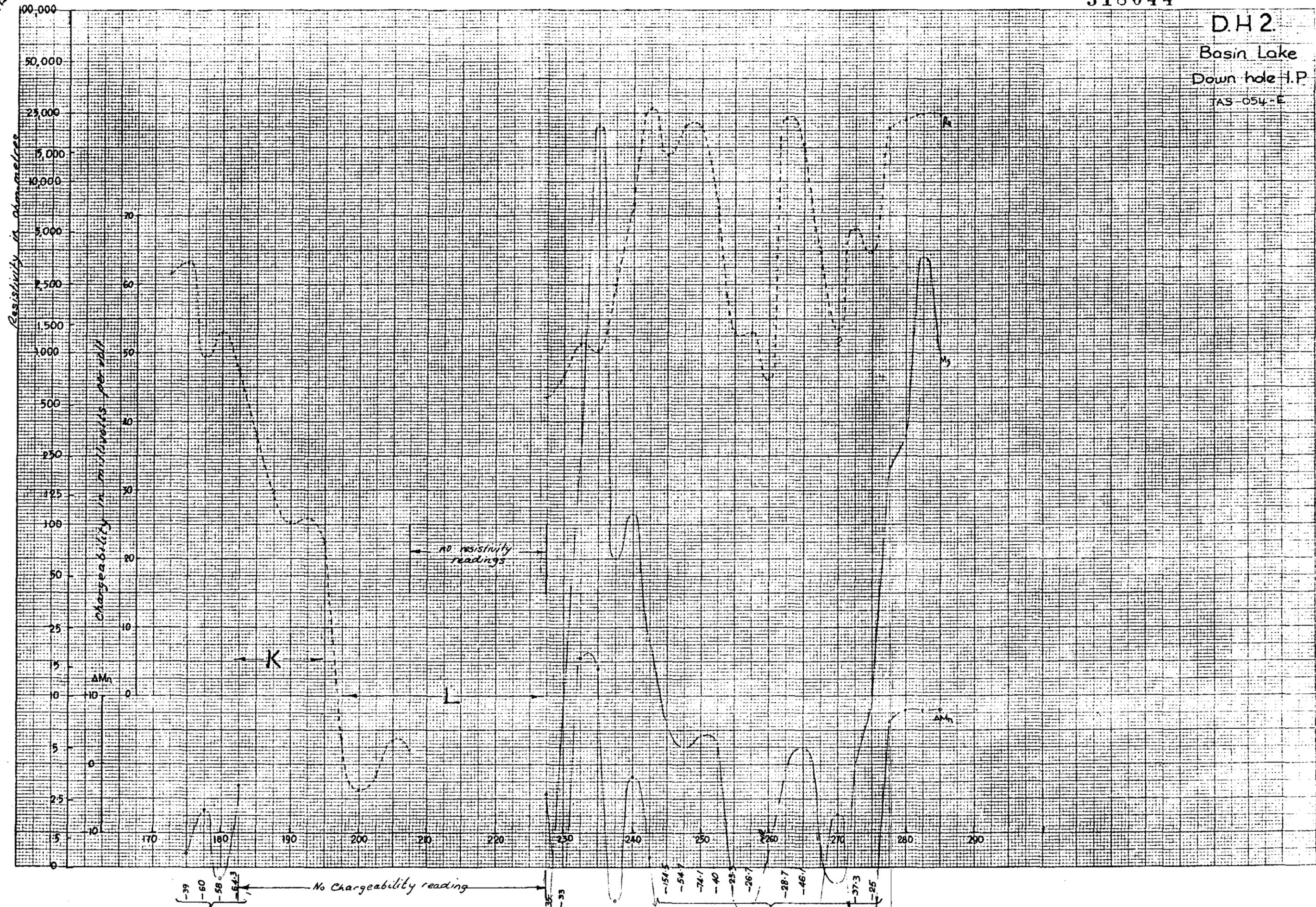
ΔM_n
 -44.7
 -27.9
 -34.9
 -43.3
 -27.5
 -34.7
 -35.6
 -27.9
 -28.6
 -28.2

042

318044

D.H. 2
Basin Lake
Down hole I.P.
TAS-054-E

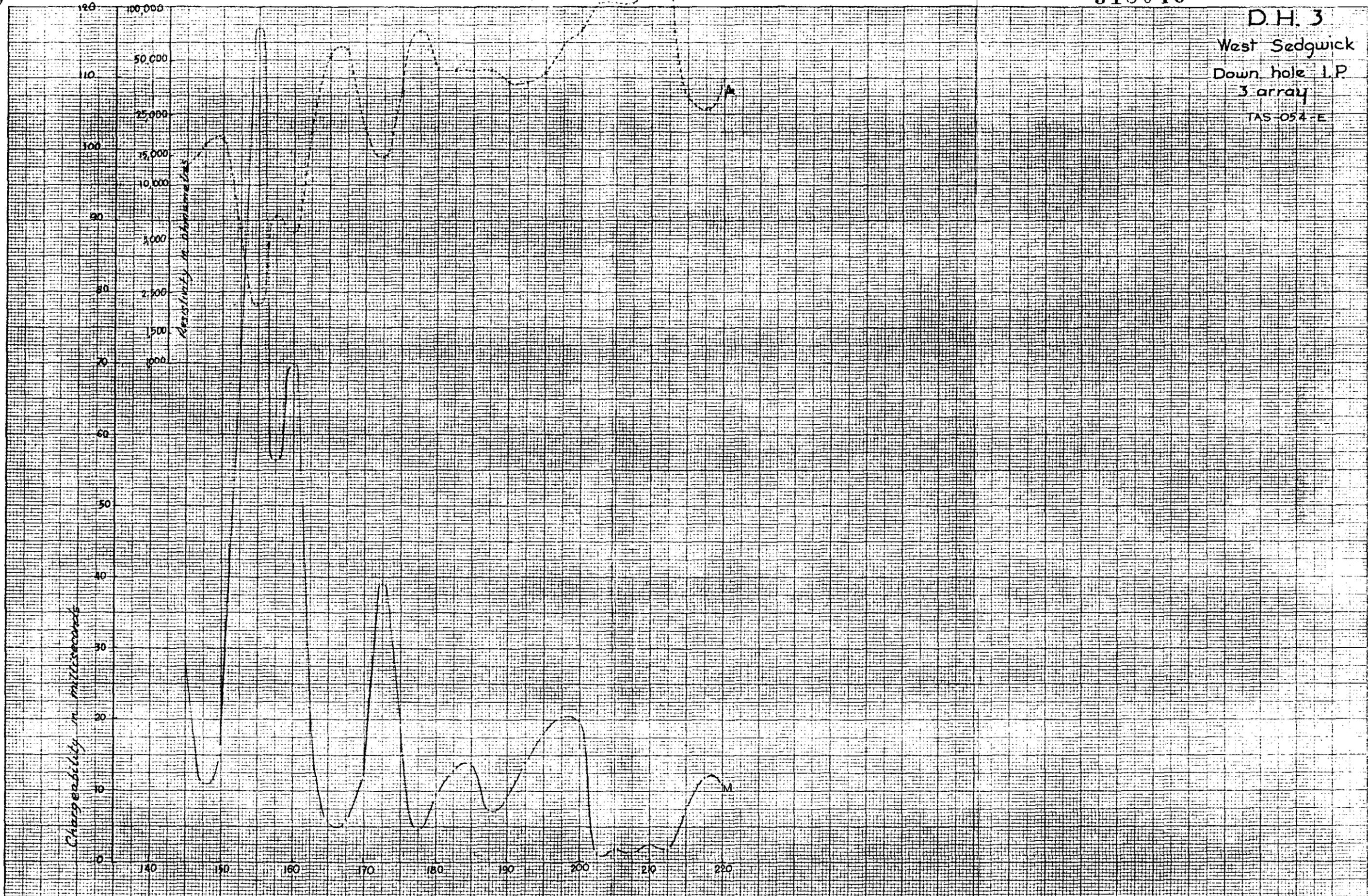
K&E
32 X 38 CM. • VERNIER
10 X 10 TO THE CENTIMETER
MADE IN U.S.A.
KOHLENBERG & BROSCH CO.



043

318045

D.H. 3
West Sedgwick
Down hole L.P.
3 array
TAS-054-E

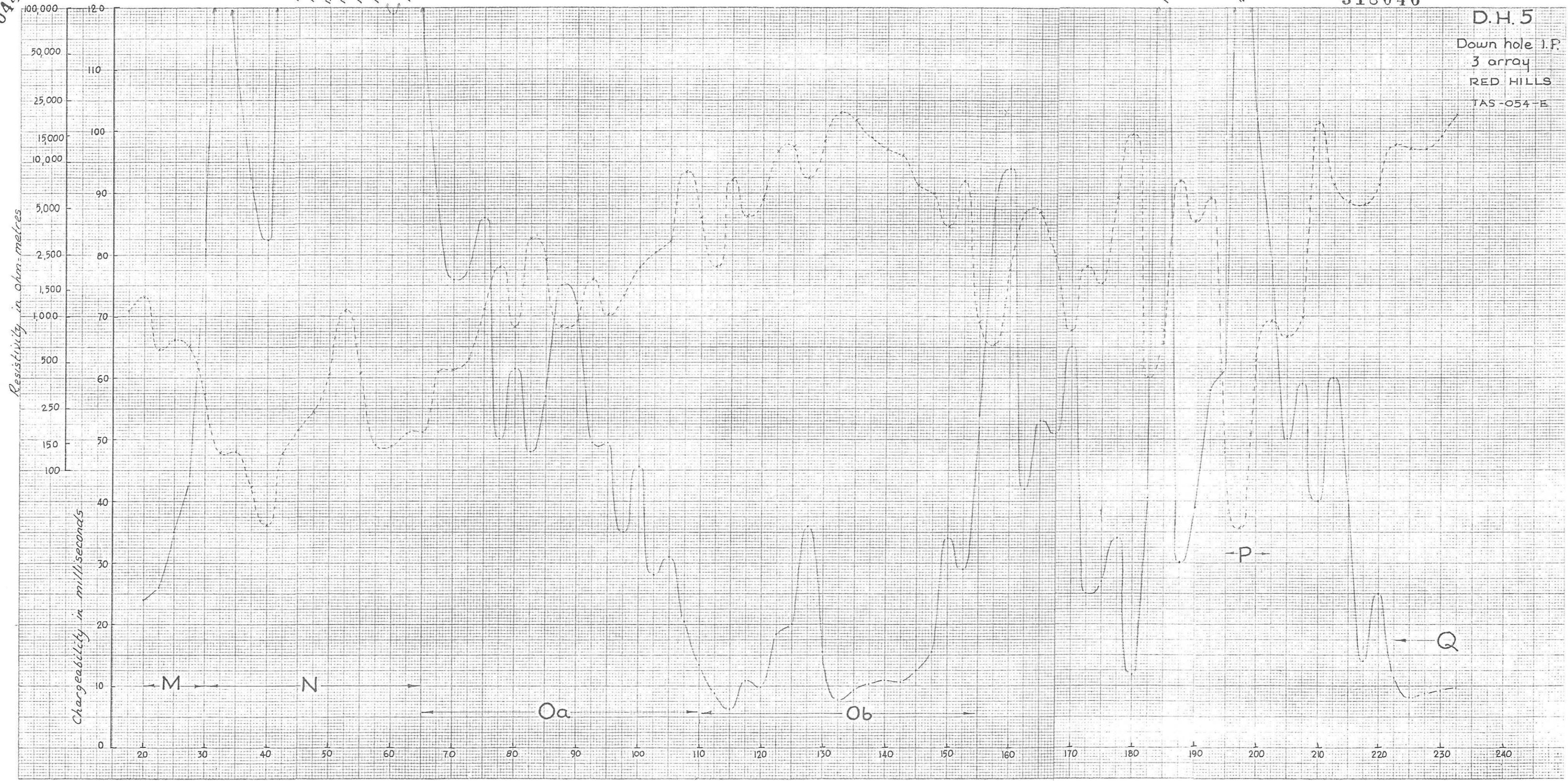


KE
28 X 38 CM. • VERNACULAR
MADE IN U.S.A.
KEULHOF & SAGER CO.
10 X 10 TO THE CENTIMETER 1:1

044

318046

D.H. 5
Down hole I.P.
3 array
RED HILLS
TAS-054-E



WILSON & JONES CO.

045

246,002
246,866
536,046
748,838
938,298
1131,814
1319,919
1509,971

246,937

132.5

172
150

201,387

100,000

318047

DH6R

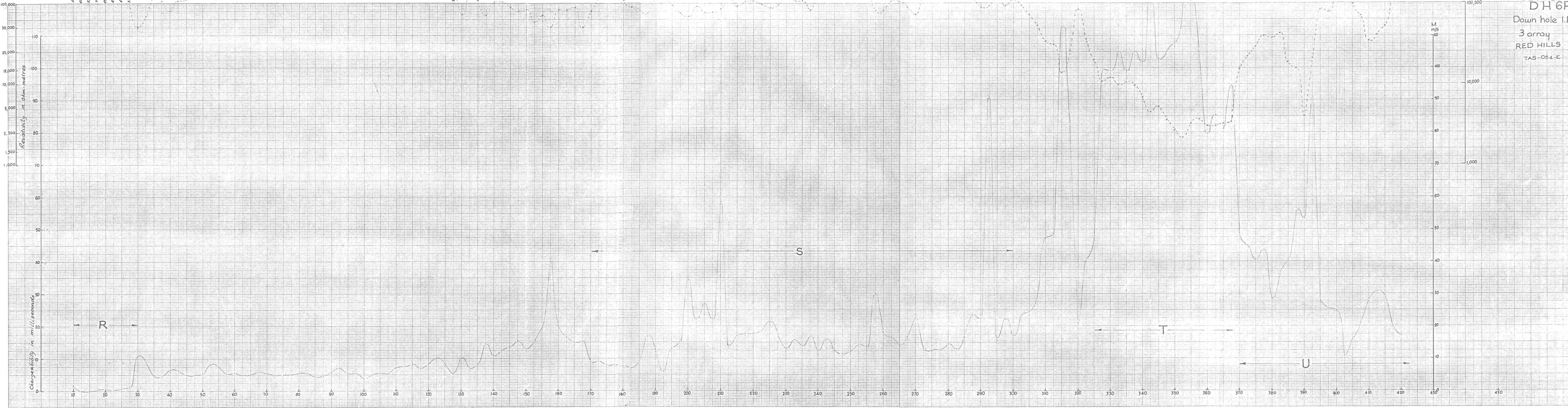
Down hole I.P.

3 array

RED HILLS

TAS-054-E

RESISTIVITY LOG
BY BRUCE E. JAYSON



D.H. 7

Down hole I.P.

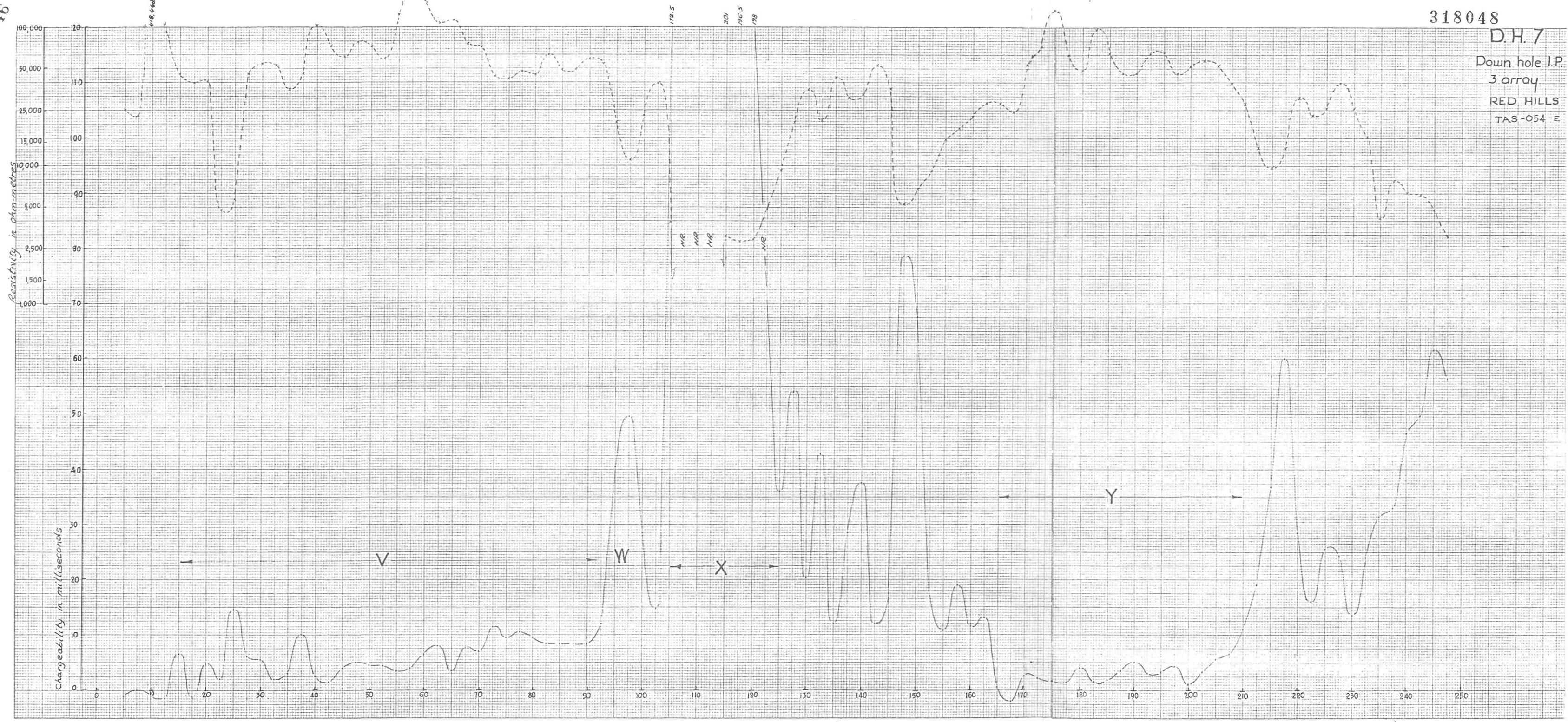
3 array

RED HILLS

TAS-054-E

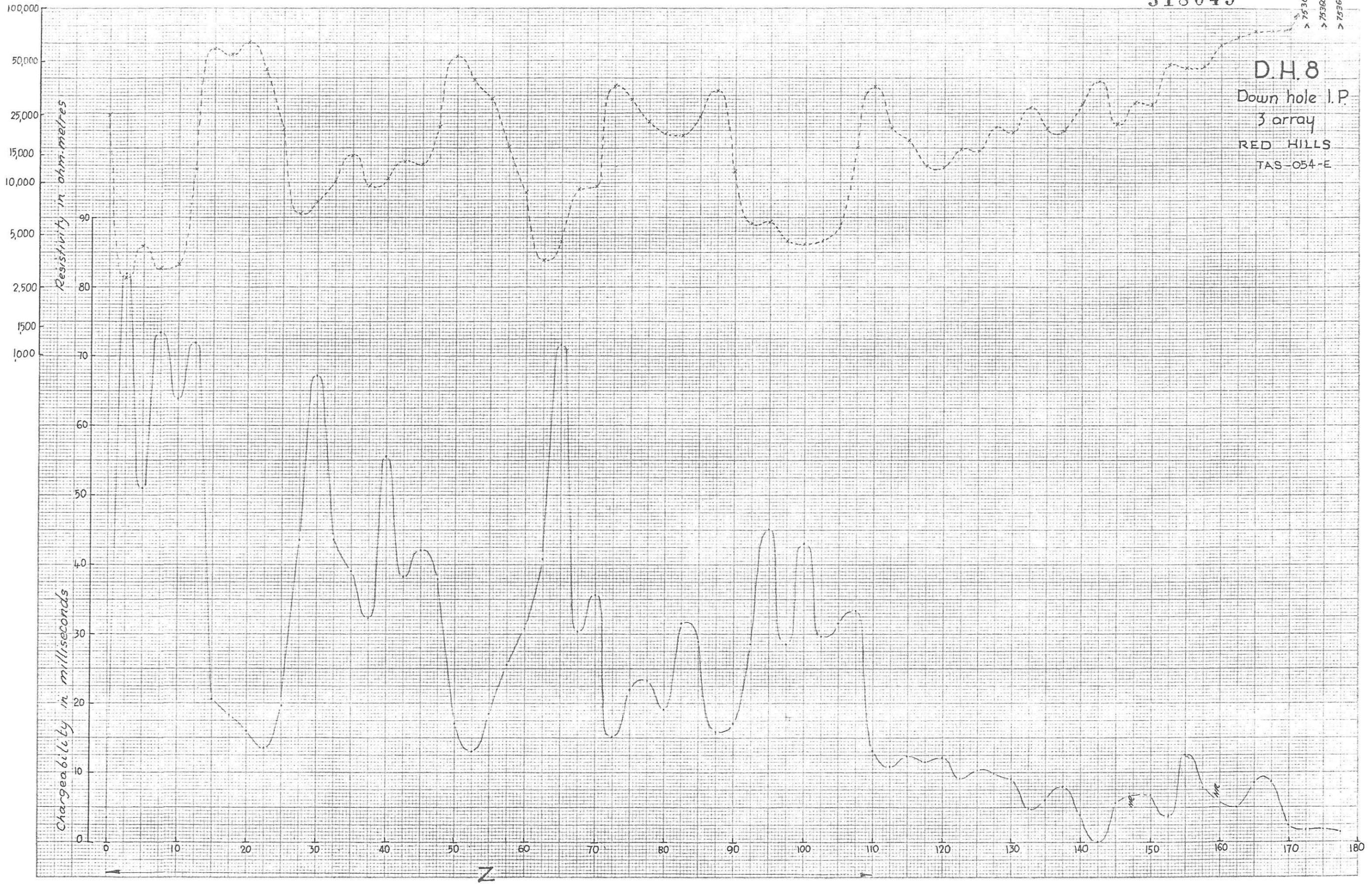
046

KE 32 X 36 CM. ALUMINUM MADE IN U.S.A. MODEL 1211

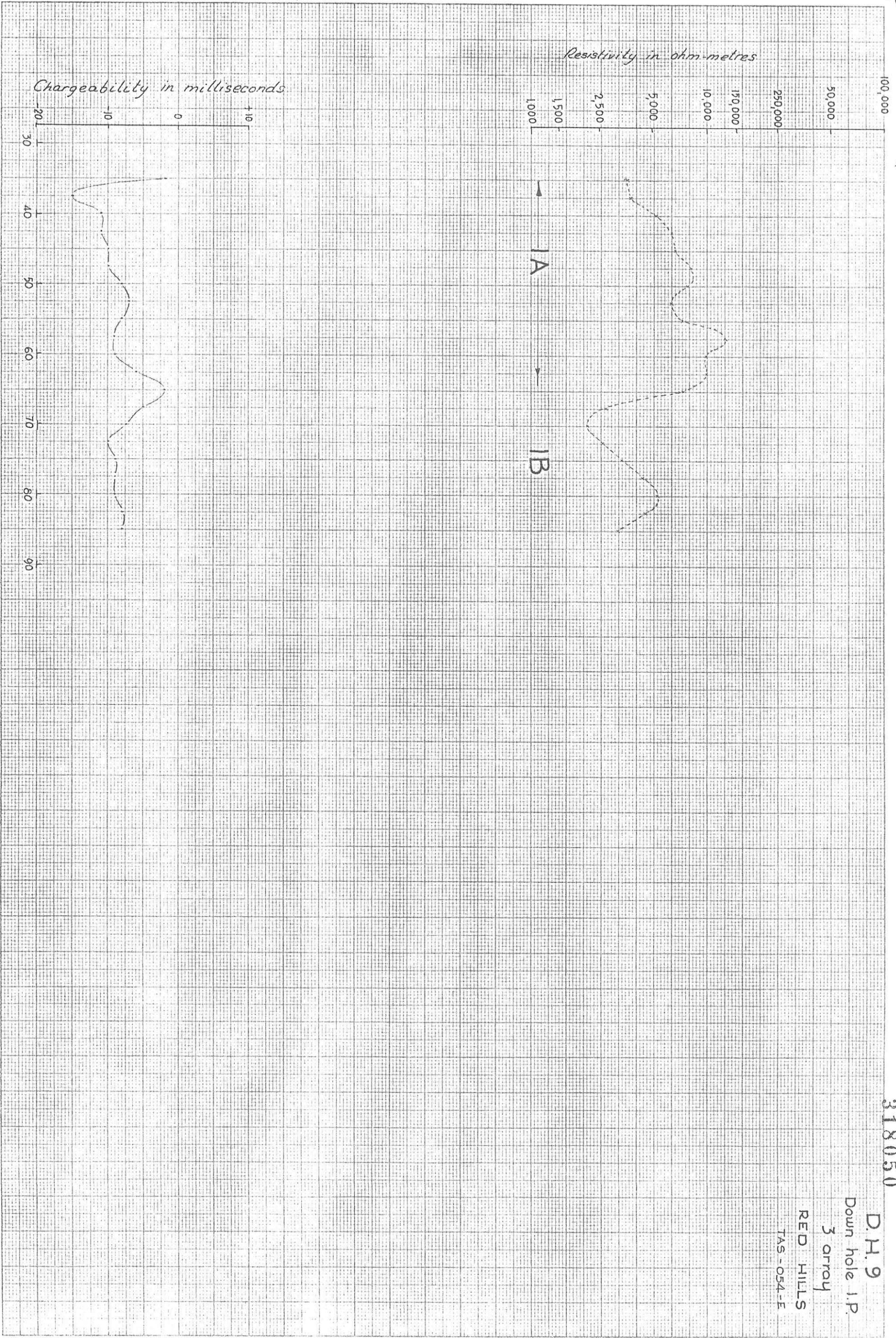


D.H. 8
Down hole I.P.
3 array
RED HILLS
TAS-054-E

K&E
52 X 39 CM. • VIBRATING
KENTLET & EIDER CO.
MADE IN U.S.A.
NO. 1211



75360
75360
75360

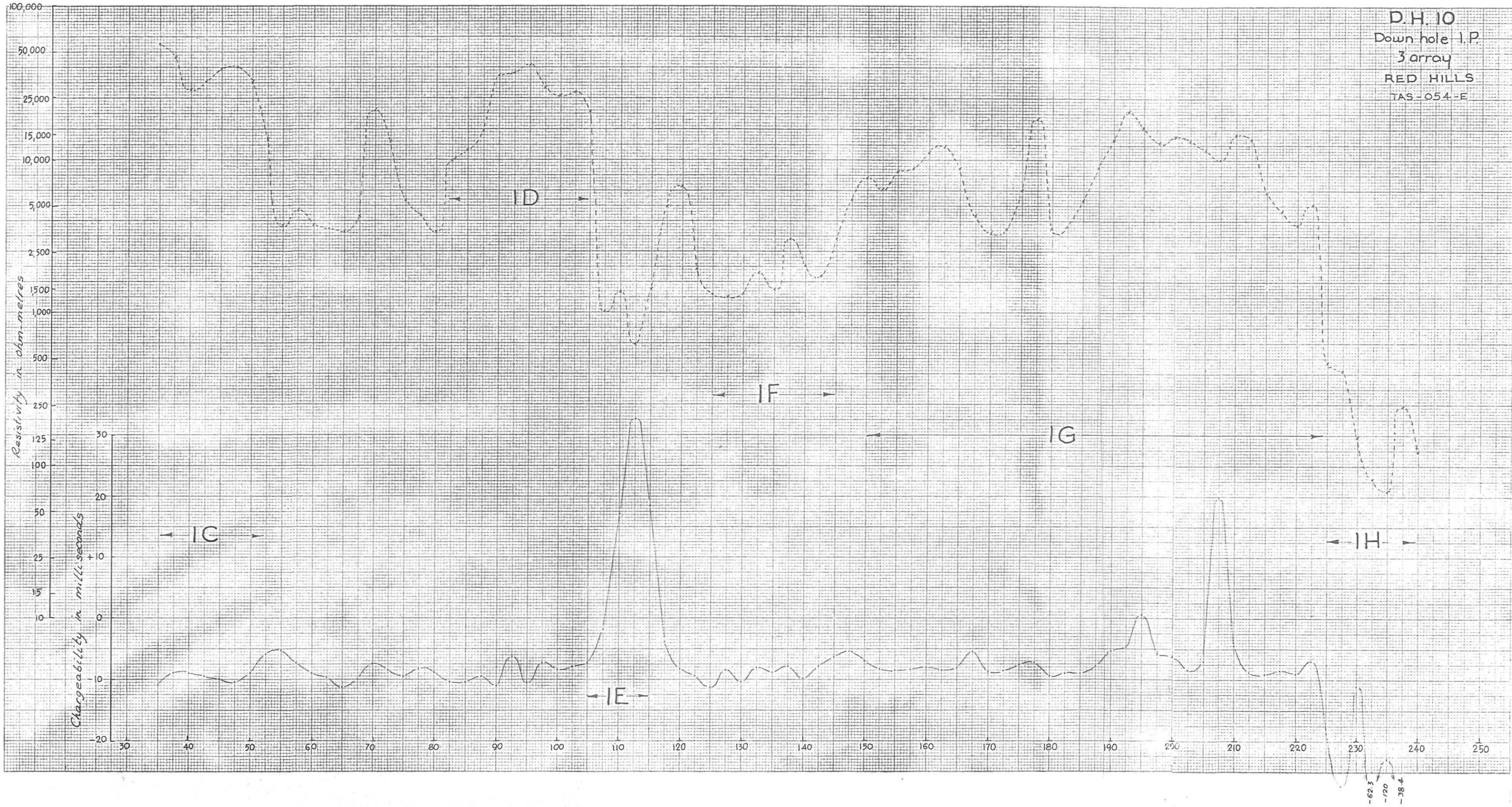


318050

D.H.9
Down hole I.P.
3 array
RED HILLS
TAS - 054 - E

049

D.H. 10
Down hole I.P.
3 array
RED HILLS
TAS-054-E



-62.3
-120
-38.4