BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

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Electrical Properties of the Flying Doctor Prospect, Broken Hill, NSW

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SUMMARY

During October 1977, the Bureau of Mineral Resources and the Geological Survey of NSW investigated the electrical properties of rocks of the Flying Doctor prospect near Broken Hill NSW by down-hole and surface induced polarisation and resistivity surveys.

The results of this work show that the mineralisation at the Flying Doctor prospect has a resistivity of 2 to 10 ohm-m and a chargeability of 200 to 300 ms. Down-hole logs indicate that the mineralisation is heterogeneous and there is a suggestion of a change in the nature of mineralisation along strike. Weathering of surface rocks has produced a surface layer of low resistivity which varies from 10 to 30 m thick.

INTRODUCTION

During October 1977, the Bureau of Mineral Resources (BMR) and the Geological Survey of NSW (GSNSW), conducted down-hole and surface induced polarisation surveys, and mise-a-la-masse surveys, at the Flying Doctor lead-zinc prospect near Broken Hill, NSW.

The induced polarisation surveys were designed to document some aspects of electrical properties of the Flying Doctor prospect and were part of a joint BMR-GSNSW program to develop a test site for down-hole and surface geophysical methods in the Broken Hill area.

The surveys at the Flying Doctor prospect were conducted with the co-operation and assistance of North Broken Hill Limited.

GEOLOGY

The Flying Doctor prospect is located 8 km northeast of Broken Hill, near the Broken Hill Royal Flying Doctor Radio Control Centre (Fig. 1). This prospect hosts a small body of lead-zinc sulphide mineralisation, which takes the form of a steeply dipping but irregular body up to 10 m wide extending from near the surface to a depth of over 200 m.

The mineralisation occurs within siliceous gneisses of the Broken Hill mine sequence and has been intersected by a number of exploration holes drilled by North Broken Hill Ltd. As indicated in Figure 1, induced polarisation logs were run in five holes drilled along lines 24,500 S, 25,250 S and 26,000 S. The geological sections along these lines are shown in Figure 2.

METHOD AND SURVEY DETAILS

Down-hole surveys

Equipment: The probe used in the down-hole surveys has been described by Tyne (1978) and consists of a bottom current electrode and six lead/lead-oxide potential electrodes spaced 1.5, 3, 6, 12, 24, and 48 m from the current electrode. A 2.5 kW time-domain IP transmitter and a Huntec Mk III IP receiver were used for the survey. Chargeability measurements were recorded between 480 and 1530 ms.

Electrode configuration: The electrode configuration used in holes at the Flying Doctor prospect was the three-array (Fig. 3). Electrode spacings of 1.5 and 3 m were used to measure the electrical properties of the rocks. Larger electrode spacings of 12 and 24 m were used to examine the response due to mineralisation away from the hole.

Interpretation: The ability of down-hole IP logs to measure the electrical properties of the rocks intersected by a drillhole depends on the electrode configuration used and the size of the resistivity structure intersected. The relation between true and apparent electrical measurements for different sized two-array and three-array surveys passing through a simple resistivity structure is shown in Figure 3. This figure shows that the three-array provides a better measure of the true resistivity and chargeability of resistivity structures than a two-array with a similar spacing a. Note that the apparent resistivity and chargeability measurements approach the true electrical properties of the surrounding rocks only when the spacing is considerably smaller than the width of the restivity structure. Other factors that influence the interpretation of IP logs are electrical properties of the bore fluid and the geometry of the resistivity structure.

Interpretation of the electrical properties of off-hole resistivity structures is at best qualitative; but resistivity boundaries in a drillhole can be located accurately provided the probe actually crosses the boundary. Quantitative interpretation of the IP logs is also complicated, but a strong indication of changes in chargeability will be obtained even for a structures smaller than the array size.

IP resistivity soundings

A Schlumberger array IP and resistivity sounding was made with a 2.5 kW transmitter and a Scintrex IPR8 receiver at 25 250 S/750 W.

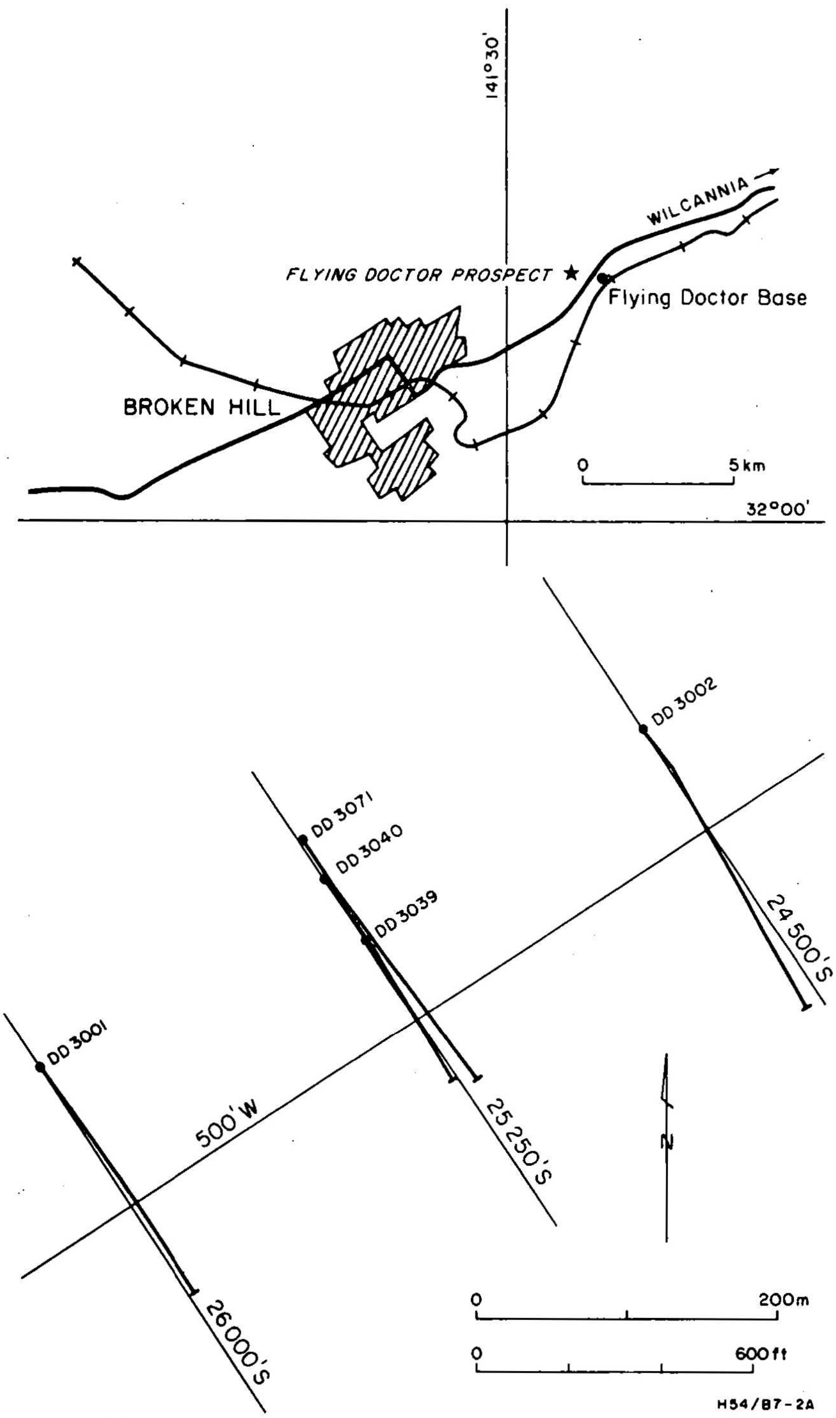

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Fig. 1 Locality map, Flying Doctor prospect

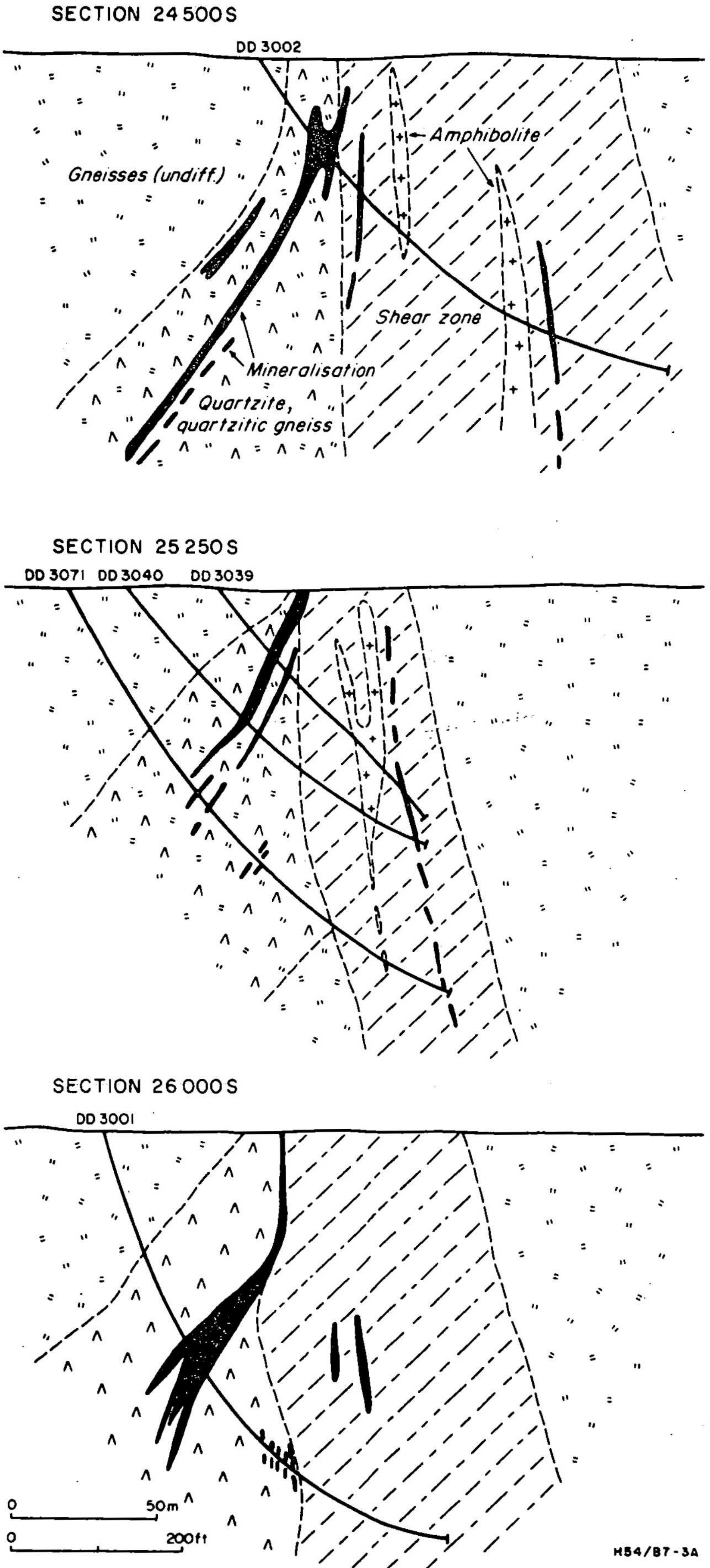

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Fig.2 Geological sections, Flying Doctor prospect

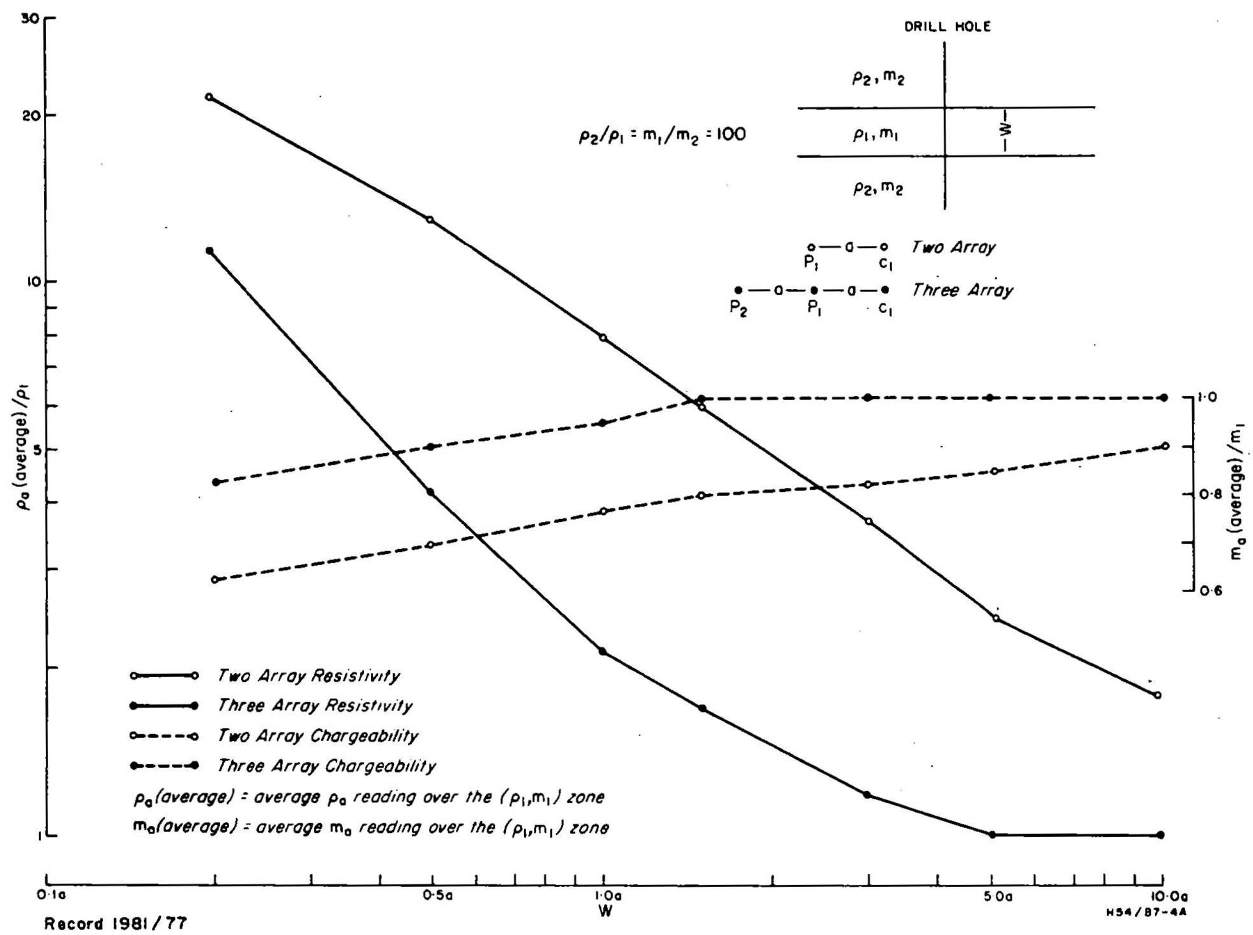

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Fig.3 Theoretical response, two-array and three-array logs

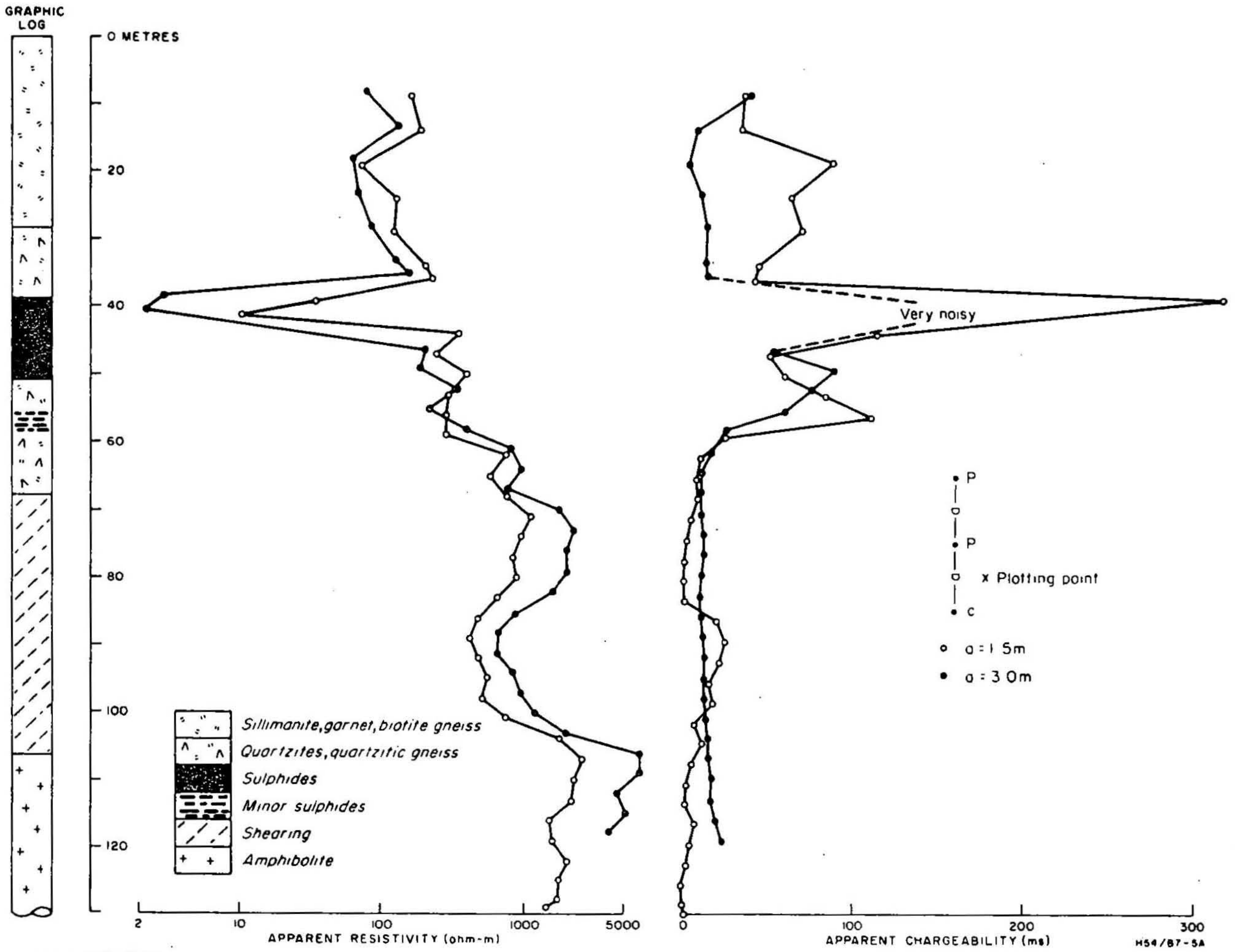

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Fig. 4 Resistivity and chargeability logs, DD3039

The maximum current electrode spacing for the array was 200 m, and the results were interpreted as a horizontally layered model.

RESULTS

DD 3039

This hole was drilled along section 25 250 S (Fig. 2) and intersected mineralisation between 39 and 51 m. The results of the logs are shown in Figure 4. The results show a clear correlation between the sulphides intersected at 40 m and anomalies in the chargeability and resistivity logs. However, it is apparent that the peaks of the anomalies occur near the top of the sulphide zone and the anomaly peaks are much narrower than the width of the mineralised zone. The narrow widths of the anomalies indicate that the sulphide zone is not homogeneous, and suggest a more massive section of mineralisation at the top of the intersection. The increase in the 1.5 m chargeability log between 20 and 35 m cannot be explained easily, but similar results were recorded in the logs of other holes. This effect might be related to the oxidation of the wall rocks around the hole. The logs indicate that the sulphide zone at 40 m has a resistivity of less than 2 ohm-m and a chargeability of at least 300 ms. The resistivity recorded with the a = 1.5 m log is considerably less than that recorded with the 3.0 m log; the most obvious explanation for this observation is oxidation of the sulphide minerals in the vicinity of the wall of the hole.

The resistivity data also show two other distinct boundaries. The first occurs at about 60 m where the apparent resistivity rises from about 300 ohm-m to 1000 ohm-m on the a = 1.5 m log. The second occurs between 100 and 110 m where the apparent resistivity rises from an average of 700 ohm-m to 1500 ohm-m on the a = 1.5 m log. This boundary coincides with the boundary between gneisses and amphibolite at 108 m, while the boundary at 60 m may indicate the footwall of a wide zone of miner sulphides, as indicated by the chargeability logs.

DD 3040

This hole was also drilled along section 25 250 S (Fig. 2) directly below DD 3039. The hole intersected mineralisation in the interval 90 to 95 m. The results of the logs are shown in Figure 5. Note that casing in the hole prevented logs being obtained from 30 to 60 m. However, the intersected sulphides show up as resistivity lows and chargeability highs. The contact between the sulphides and the surrounding rocks appears to be sharp.

Owing to the effect of the casing it is difficult to determine a resistivity and chargeability for the unmineralised rock. However the response to the mineralisation is similar to that observed in hole DD 3039. The 1.5 m log indicates the heterogeneity of the sulphide body. The 3.0 m log indicates that the sulphide zone has a resistivity of approximately 3 ohm-m, which is similar to the value recorded in DD 3039. Both logs indicate the high chargeability of the sulphide zone, but accurate measures of chargeability were precluded owing to the effects of the zone of high conductivity.

DD 3002

This hole was drilled along section 24 500 S (Fig. 2) and intersected mineralisation between 42 and 65 m. The results of the log zone are shown in Figure 6. Owing to the high conductivity of the sulphide zone, accurate measurements of the resistivity and chargeability of the sulphide zone were not possible. However, the resistivity is clearly less than 10 ohm-m, and high chargeabilities were recorded over the whole mineralised section. The section of massive sulphides does not appear to have uniform electrical properties, the lower part being more conductive and chargeable.

Above the zone of mineralisation the host rocks have a resistivity of about 500 ohm-m. Low apparent resistivity and high apparent chargeability at about 35 m suggest the presence of minor sulphides which are not shown in the geological log.

DD 3001

This hole was drilled along section 26 000 S (Fig. 2) and intersected mineralisation from 115 to 135 m. The results of the log are shown in Figure 7. This log shows very distinct IP and resistivity anomalies in the sulphide zone. In this respect, the results are similar

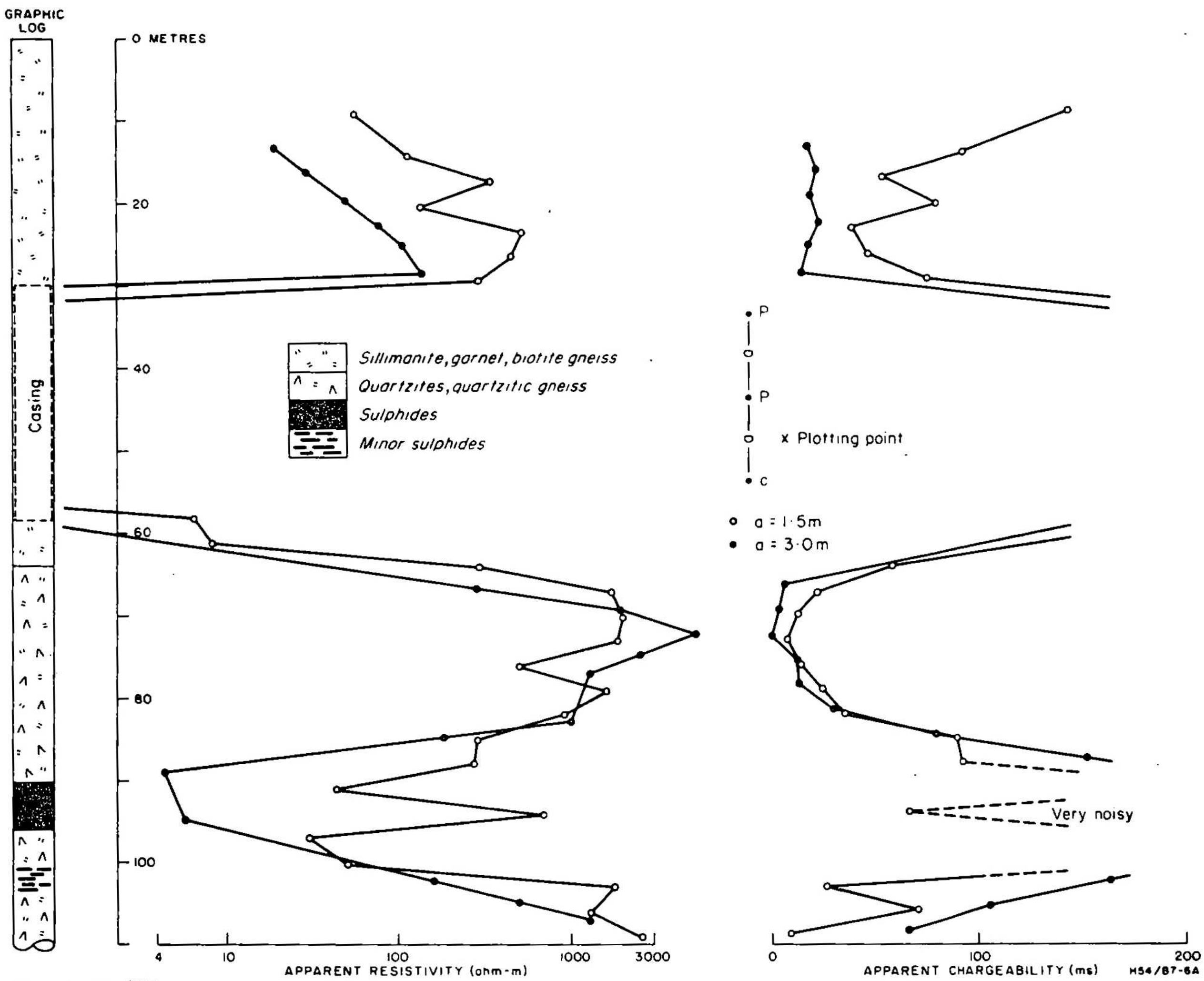

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Fig.5 Resistivity and chargeability logs, DD3040

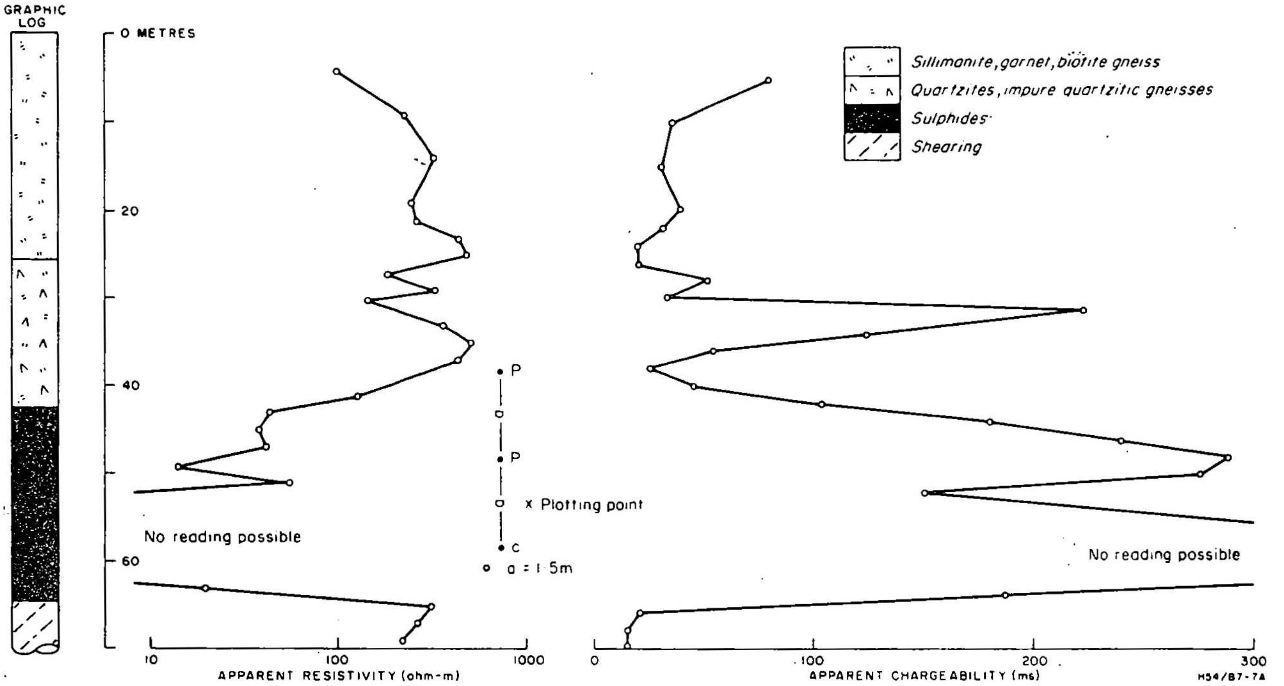

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Fig.6 Resistivity and chargeability logs, DD3002

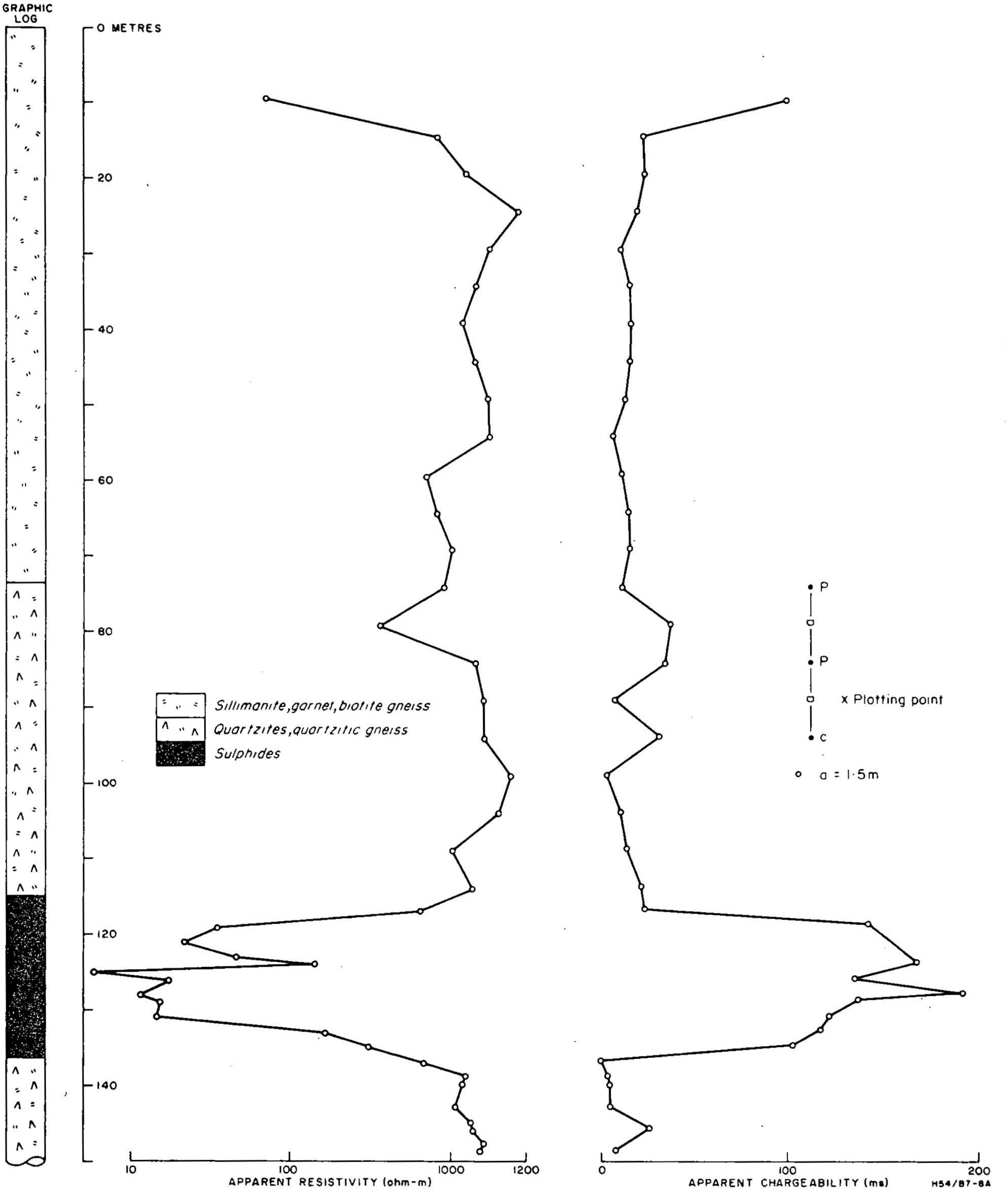

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Fig. 7 Resistivity and chargeability logs, DD3001

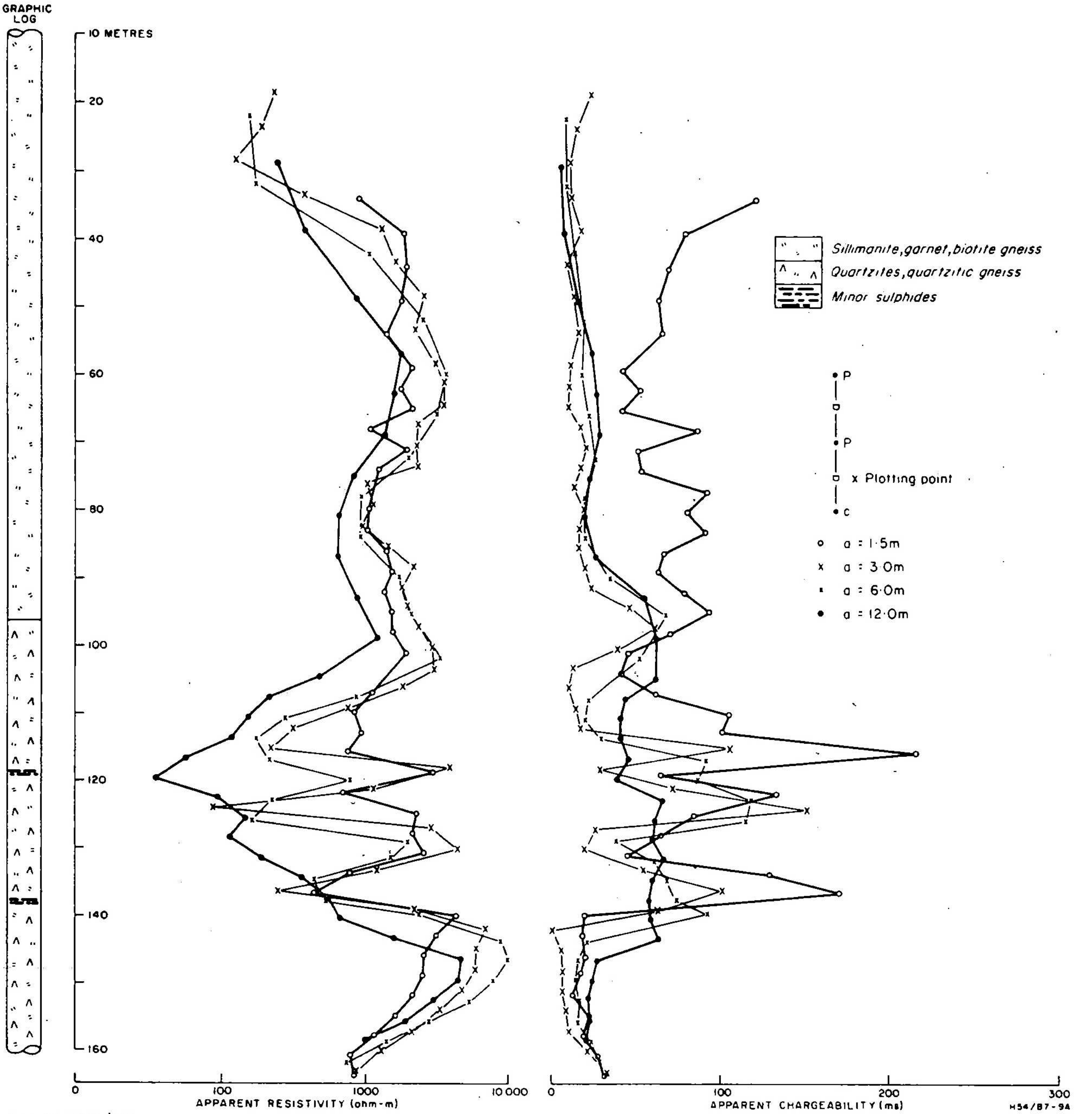

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Fig. 8 Resistivity and chargeability logs, DD3071 to the logs obtained in holes DD 3040 and DD 3002 on sections to the north. As observed in other logs, the electrical properties of the mineralised zone do not appear to be uniform. The log indicates that the sulphide zone has a resistivity of approximately 10 ohm-m and a chargeability of less than 200 ms. These resistivity and chargeability values are somewhat different from the values recorded within mineralised zones on the northern drill sections, and this difference may reflect the generally higher resistivity of the country rock hosting the mineralisation. It is apparent that the resistivity and chargeability of the host rocks are extremely uniform except for the effects of weathering, which are evident to a depth of approximately 15 m.

DD 3071

This hole was drilled along section 25 250 S (Fig. 2) approximately 60 m below DD 3040. The hole intersected only minor sulphides which occur just above 120 m and 140 m. Extrapolation of the log from hole DD 3040 suggests that a substantial volume of massive mineralisation lies above DD 3071 at approximately 120 m down the hole. The results of the logs are shown in Figure 8. In an endeavour to observe mineralisation off-hole from DD 307, logs with array spacings of 6 m and 12 m were employed.

With the exception of the 1.5 m chargeability logs a consistent charge in response is observed as the array spacing is increased from 3 m to 12 m. The logs become smoother, chargeability peaks in the vicinity of mineralisation are reduced, and the apparent resistivity low associated with the high-chargeability zone becomes more pronounced. There is fair correspondence between the chargeability peaks in the 1.5 m, 3.0 m, and 6.0 m logs and the small zones of sulphides observed at 119 m and 138.5 m.

The reduction in chargeability with increasing array size can be attributed to the effect, illustrated in Figure 3, of increasing the array spacing when the width of the mineralised zone is small. The higher apparent resistivity of the 1.5 m array in comparison with the apparent resistivity of larger arrays can be explained as the result of wall rock oxidation as was proposed for the other logs at the Flying Doctor prospect. The broad resistivity low of approximately 30 ohm-m observed with the 12.0 m log is not associated with a pronounced chargeability anomaly and might therefore be attributed to the low resistivity of the ore-bearing host rocks rather than off-hole mineralisation.

Other notable features of the logs are the sharp resistivity boundary at 40 m, which may reflect the base of local weathering. The relatively higher chargeability of the 1.5 m log between 10 and 100 m is not observed deeper in the hole, but is similar to the effects seen in the log of DD 3039, and may be the result of oxidation of the wall rocks.

Resistivity sounding

To obtain the bulk geoelectric section for the area, a Schlumberger array was expanded to a maximum current electrode spacing of 200 m at station 25 250 S/750 W. The results indicate that there is a 5 ohm-m surface layer to a depth of about 5 m, below which the resistivity was interpreted as being very high.

CONCLUSIONS

Electrical properties of mineralisation

Sulphide-bearing zones are defined by low resistivities and high chargeabilities. The logs indicate the resistivity of the lode to be relatively low (2 to 10 ohm-m) and the chargeability to be high (200 to 300 ms). The logs indicate that the mineralised zones are not homogeneous, and there is a suggestion of a change in the nature of mineralisation or host rock along strike.

Electrical properties of host rocks

Resistivity boundaries were observed within the host rocks, which have an average and mainly uniform resistivity of about 1000 ohm-m. However, amphibolite zones have a resistivity of approximately 3000 ohm-m, and weathered rocks having a low resistivity are evident to depths of 10 to 30 m. None of the host rocks appears to be chargeable. The mineralisation appears to occur within a zone approximately 30 m wide, which has a distinctive low resistivity.

Effectiveness of exploration methods

The resistivity logs show the mineralisation to be a good to moderate conductor. There is a resistivity contrast of approximately 100:1 between the mineralisation and the host rocks, and there is no thick conductive weathered layer above the prospect. Hence, surface electromagnetic prospecting could be an appropriate tool if the cross-sectional area of a body of Flying doctor type mineralisation were large.

The mineralisation has a very high chargeability, and is reasonably shallow, and the host rocks are very uniform in their electrical properties. Hence "geological noise" will be small, and the prospect should be a good target for surface IP prospecting if the volume of sulphides is sufficiently large.

REFERENCE

TYNE, E.D., 1978, Drill hole resistivity and induced polarisation detection logging at Woodlawn. _In_ Electrical and Potential Field Geophysical Surveys over the Woodlawn Deposit: A collection of Papers. _Geological Survey of New South Wales_; Report GS 1978/005.