DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1976/47

GEOPHYSICAL SURVEY, ELURA PROSPECT, COBAR NEW SOUTH WALES, 1974

by

R.D. Ogilvy

Record 1976/47

GEOPHYSICAL SURVEY, ELURA PROSPECT, COBAR NEW SOUTH WALES, 1974

by

R.D. Ogilvy

CONTENTS

PLATES

SUMMARY

During Feburary and March 1974, the Bureau of Mineral Resources made two short geophysical surveys of the Elura Prospect, near Cobar, NSW. The surveys, undertaken with the co-operation of the Electrolytic Zinc Company of Australia Limited, were designed to evaluate down-hole systems and field test newly acquired equipment. Geophysical methods used were surface and down-hole induced polarization (time and frequency domain), mise-a-la-masse, gravity, and magnetics.

Owing to an unfavourable geo-electric environment, the surface induced polarization tests were only partly successful in indicating the presence of massive sulphides intersected by drilling. Down-hole measurements provided useful diagnostic information for the interpretation of the surface induced polarization anomalies. Experiments using in-hole electrodes are recommended to overcome the problems associated with surface induced polarization measurements in areas of thick conductive overburden.

The mise-a-la-masse, gravity, and magnetic data indicate the presence of a steeply plunging pipe-like sulphide body at depth. A detailed gravity survey is recommended as the most effective method of evaluating the Elura Prospect and as a guide for further development drilling.

1. INTRODUCTION

During February and March 1974 the Bureau of Mineral Resources (BMR) carried out geophysical surveys of the Elura Prospect, near Cobar, NSW (Pl. 1). The surveys, undertaken with the co-operation of the Electrolytic Zinc Company of Australia Limited (EZ), were designed to evaluate down-hole systems and field test newly acquired geophysical equipment.

The surveys were made within a 500 m x 500 m gridded area containing two drill holes which intersected sulphide mineralization. The grid and the location of the holes are shown in Plate 2. Principal methods were surface and down-hole induced polarization (IP) in both time and frequency domain, and mise-a-la-masse. Very limited gravity and magnetic data were also obtained to assist the interpretation of the electrical surveys.

Personnel engaged on the surveys were R.D. Ogilvy (Party Leader), P.W.B. Bullock (Geophysicist, J.W. Williams (Technical Officer), and H.G. Reith (Technical Assistant).

2. GEOLOGY

The Elura Prospect lies west of the main ore deposits of the Cobar region. The regional geological setting and mineralization of the area is described by Rayner (1969) and Suppel & Stevens (1973).

The survey area is flat with extensive alluvial cover and little outcrop. The Elura Prospect is considered to lie within the Lower Devonian Amphitheatre Beds which rest unconformably on the Cobar Group. Preliminary mapping based on drilling revealed a deeply oxidized zone about 90 m thick, below which the country rock consists predominantly of massive siltstone interbedded with thin bands of fine sandstone and greywacke. The formations are strongly deformed but indicate an approximate north-northwest strike and a dip to the east of 70°-80°.

There is no surface expression of mineralization but drilling to test geochemical and geophysical anomalies intersected massive sulphide mineralization below the base of oxidation. The mineralization consists predominantly of massive pyrite with significant galena and sphalerite.

3. PREVIOUS GEOPHYSICAL INVESTIGATIONS

In August 1973, Seigal Associates Australasia Pty Ltd carried out two IP/resistivity depth soundings and ten gradient array IP traverses in the area. This survey, designed to assess the geo-electric environment and outline possible subsurface mineralization, indicated a zone of anomalous chargeability centred below 19980N/ 20200E.

A detailed ground magnetic and radiometric survey was conducted by EZ. No anomalous radiometric response was obtained but the magnetics indicated an anomaly of amplitude 150 nT, centred on 20000N/20150E. A detailed gravity survey supported by electromagnetic, resistivity, and S-P measurements has also been made.

4. GEOPHYSICAL TECHNIQUES

Surface techniques

The gradient array IP survey previously conducted by Siegel Associates was repeated in part using the same electrode geometry and BMR's newly acquired Huntec time domain IP equipment. The work was intended to assess the comparative field performance of the Huntec equipment and to more clearly define the anomalous zone of chargeability indicated by Seigel Associates. Six traverses from 19900E to 20400E were surveyed using a single current dipole of 1000 m and a potential dipole of 50 m moved at 25 m intervals. An inductive coupling test at 20000N/ 20100E using various delay and integration times showed that an optimum IP response with negligible coupling would be obtained with a delay time of 120 ms and integration time of 60 ms (see Appendix 1). Accordingly these delay and integration times were used in the gradient array survey.

Frequency domain IP measurements were carried out on 20200E to test the BMR's Austral IP equipment and permit a comparison of time and frequency domain IP data. Measurements were made at 3.0Hz and 0.3Hz using a 100 m dipole-dipole electrode configuration.

Gravity and magnetic measurements were made over the major zone of interest to assist the interpretation of the electrical surveys. Gravity measurements were made on cross-traverses 20000N and 20100E at station intervals of 25 m using a LaCoste & Romberg gravity meter. Magnetic measurements were made on cross-traverses 20000N and 20150E at an average station interval of 25 m using a Geometrics G816 proton precession magnetometer. Magnetic measurements were made with the sensor head 8 ft above ground level to reduce noise caused by laterite.

The gravity and magnetic surveys produced co-incident anomalies centred approximately on 20000N/20150E which, were attributed to sulphide mineralization at depth. The location of the mineralization indicated by the magnetic and gravity surveys was used to assess the geological significance of the electrical results.

Down-hole techniques

Owing to the collapse of DDH1, only DDH2 was available for down-hole geophysical investigations.

Down-hole IP/resistivity measurements were recorded with both time and frequency domain IP equipment. Measurements were made using probes with 10 ft (3.05 m) and 30 ft (9.14 m) dipole-dipole arrays to locate possible 'near misses' and to establish the intrinsic response of the mineralization.

An attempt to record self-potential (SP), resistance, and gamma-ray logs using the Widco Portalogger was prevented by several partial blockages in the drill hole.

A mise-a-la-masse survey was carried out in an attempt to delineate the extent of massive sulphides which were intersected below 282 m in DDH2. The sulphide body was energized using an in-hole copper electrode attached by insulated cable to the Austral IP transmitter. The return current electrode was placed approximately 3 km south-east of DDH2. Surface potential measurements were made using a Fluke d.c. voltmeter.

Physical property measurements

Laboratory determinations of susceptibility, remanent magnetization, and specific gravity were made on split drill core supplied by EZ. The results are shown in Appendix 2.

5. RESULTS

Geo-electric section

A re-evaluation of Seigel Associates' IP/resistivity depth sounding at 20000N/20100E confirmed that the geo-electric environment was in general unfavourable for the routine application of surface electrical prospecting techniques. The geo-electric section shows that, apart from a thin resistive surface layer, the weathered country rock is more or less uniformly conductive to a depth of 95 m, resulting in a reflection coefficient of 0.91 between conductive overburden and fresh bedrock. It is considered that in this environment, time domain and, in particular, frequency domain IP methods may not be capable of detecting small conductive or polarizable targets below the base of oxidation.

Surface IP

(i) Time domain IP The results are presented in Plate 2 as contour maps of average chargeability and apparent resistivity. The average chargeability is a composite parameter of four chargeability measurements (Hutchins, 1971).

The chargeability contours show a north-northeast-trending IP anomaly approximately 100 m long and 100 m wide, centred on 20000N/20250E. In the anomalous area, peak chargeabilities of the order of 10 ms were recorded against fairly low background chargeabilities of about 4 ms. An isolated peak chargeability reading was obtained at 19850N/20400E. The corresponding apparent resistivity contours show few features. The absence of a resistivity low associated with the maximum IP response is probably due to the deep weathering and the type of array used. The IP/resistivity response is consistent with a body which is narrow relative to its depth and is vertical or near vertical.

During the course of the survey, difficulty was experienced with the synchronization of the Huntec receiver and field measurements could not always be obtained using normal operational procedures. Preliminary tests carried out at Elura and in subsequent areas suggest that inductive coupling may have been a significant factor in the synchronization failure. Although further tests are required to fully assess the courses of the malfunction, it appears that the Huntec receiver cannot be used for low coupling arrays in areas of highly conductive overburden.

(ii) Frequency domain IP The dipole-dipole results on Traverse 20200E are presented in Plate 3 together with drilling results.

The percent frequency effect (PFE) results indicate a weak but distinct anomaly centred on 20200E/20000N. The maximum PFE recorded was only 1.4%; this value nevertheless is anomalous compared with background values of about 0.4%. The apparent resistivity results clearly indicate the presence of the conductive overburden by the increase of apparent resistivity with dipole separation. The metal factor values show an anomaly below 20000N for the 500 m dipole spacing (n = 5). The symmetric PFE anomaly and the general characteristics of the apparent resistivity pattern for dipole separations 500 m and 600 m (n = 5 and 6) which show high resistivities surrounding a zone of low resistivity, imply, like the time domain data, a relatively narrow source at depth. Assuming a homogeneous half-space, this would indicate a source at a depth of approximately 160 m, which is immediately below the established depth of weathering. Drill hole DDH 2 sited on 20200E intersected sulphides below 20000N at a vertical depth of 244 m. The IP source could therefore represent either an upward extension of the sulphides intersected by DDH2 or an isolated mineralized occurrence.

Down-hole IP

The time and frequency domain IP results in DDH2 are presented in Plates 4 and 5 respectively.

(i) Time domain IP In the massive sulphide zone the profiles for both 10-ft and 30-ft dipoles show a distinct IP anomaly accompanied by a marked decrease in apparent resistivity. The chargeability anomaly is characterized by amplitude fluctiations ranging from 10 to 180 ms compared with a relatively uniform IP response of about 200 ms in the surrounding host rock; a massive siltstone lithology. Corresponding resistivity measurements indicate resistivities of less than 1.0 ohm-m in the massive sulphides against background levels of 100-2000 ohm-m in the siltstone. The down-hole measurements established that beneath the oxidized surface layer, both a strong IP and resistivity contrast exist between the sulphide mineralization and the country rock; a fact not evident from surface measurements owing to the masking effect of the conductive overburden. The in-hole measurements support the possibility that the surface time and frequency domain IP anomalies are due to sulphide mineralization below the oxidized layer.

It should also be noted that the down-hole IP and resistivity anomalies commence at a depth of about 260 m. Although sulphide veinlets were intersected around 260 m, the magnitude and width of the IP/resistivity response implies the presence of a larger sulphide body adjacent to DDH2 but not intersected until a depth of 282 m. This observation supports, in part, the contention that the massive sulphides intersected in DDH2 have an upward extension.

(ii) Frequency domain IP The frequency domain results (Pl. 5) have similar features to the equivalent time domain measurements. The maximum PFE is more than 10% in the massive sulphide zone compared with a maximum surface response of 1.4%.

A comparison of time and frequency domain IP data was not, in general, possible. Both time and frequency domain IP profiles show an erratic response in the sulphide zone, characterized by large variations in chargeability amplitude and negative PFEs. These effects, not uncommon with in-hole measurements, may be due to the geometry of the polarizable body and the inhole electrodes, or to inductive electromagnetic effects. Further experimental work using different electrode geometrics would assist interpretation of the in-hole data.

Mise-a-la-masse

The mise-a-la-masse results (Pl. 6) show the distribution of surface potentials when current was introduced into the massive sulphides intersected below 282 m in DDH2.

The equipotential contours are regular and nearly elliptical. The major axis strikes north and is interpreted to reflect the approximate strike direction of the sulphide body. In addition, the equipotential contours are more widely spaced towards the north than to the south, east, and west. These characteristics of the potential pattern would be compatible with an ellipsoidal or pipe-like body plunging steeply north.

It should also be noted that the centre of the potential contours does not correspond to the vertical projection of the current electrode in DDH2 but is offset some 80 m to the south and closer to the magnetic and gravity anomalies centred on 20000N/20150E. Generally a potential high will occur over the centre of mass of a sulphide body irrespective of its depth and shape or the position of the energizing electrode. The position of the potential maximum and the lack of distortion indicate that the sulphide intersection in DDH2 could be part of a larger sulphide mass centred below 20000N/20150E.

6. DISCUSSION

The interpretation of the gravity, magnetic, and mise-a-la-masse data indicates a dense, conductive, magnetic pipe-like body centred approximately below 20000N/20150E at a depth of about 114 m to 140 m.

The position of the IP anomaly obtained in the surface time domain IP survey is offset from the position of the body interpreted from the mise-a-la-masse, gravity, and magnetic data. Although this disparity is not easily explained, the down-hole IP measurements indicated that in the rock types encountered only the sulphide mineralization showed anomalous polarization effects. The surface IP anomaly therefore probably reflects a shallow mineralized occurrence offset, though not necessarily unrelated to, the deeper massive sulphides intersected by DDH2.

The laboratory measurements confirmed that a fairly strong density and magnetization contrast could be expected between the sulphides and country rock. Gravity and magnetic methods are therefore viable alternatives to electrical methods for further exploratory work. However, it should be noted that remanent magnetization may assume a more significant role than induced magnetization, and if quantitative evaluations of the magnetic data were required then comprehensive testing of laboratory samples should be undertaken to accurately determine the relative strength and direction of the remanent component.

7. CONCLUSIONS

Owing to adverse geo-electric conditions, the surface IP measurements were only partly successful in resolving anomalies attributable to the massive sulphides. The results did serve, however, to indicate the general areas of interest.

The down-hole IP measurements, although limited, provide useful diagnostic information for the interpretation of surface IP anomalies. It is possible that alternative measuring techniques using in-hole electrodes could enhance surface measurements and assist exploration below the conductive overburden. Consideration should be given to the development and testing of such techniques if further experimental work were made in the area.

The mise-a-la-masse, gravity, and magnetic data indicate a sulphide body centred approximately below station 20000N/ 20150E. Interpretation based on the data available indicates that the body may have a pipe-like form plunging steeply to the north. Drilling control and additional rock property measurements are required for a more refined quantitative evaluation of the potential field data.

In view of the flat terrain, and an unfavourable geo-electric environment, it would appear that the Elura Prospect is most suited to evaluation by a detailed gravity survey. Gravity data would better resolve the distribution of sulphide bodies at depth and provide a guide to development drilling.

8. REFERENCES

HUTCHINS, R.W., 1971 - A new induced polarization instrument. Toronto, Huntec (70) Limited.

RAYNER, E.O., 1969 - The copper ores of the Cobar region, New South Wales. Geol. Surv. N.S.W. Mem. 10.

SUPPEL, D.W., & STEVENS, B.P.J., 1973 - Geology and mineralization at the Tharsis Mine, with a general review of the Cobar field. Geol. Surv. N.S.W. Rec., 15(2), 169-204.

APPENDIX 1

INDUCTIVE COUPLING TEST

Because of the large transmitting dipole used in the gradient array IP survey and the high conductivity of the overburden, electro-magnetic inductive effects can be expected. To determine the extent of such effects, a complete transient decay curve was obtained at 20000N/20100E and the inductive coupling and chargeability components were determined using a graphical, approximate procedure described in a paper by Hutchins (1971) supplied with the manual for the Huntec M-3 induced polarization receiver.

Forty-five values of chargeability (M) were obtained by varying the delay and integration times. The data were plotted as a function of time on semi-logarithmic paper and Hutchins' method was applied. The result is shown in Plate 7.

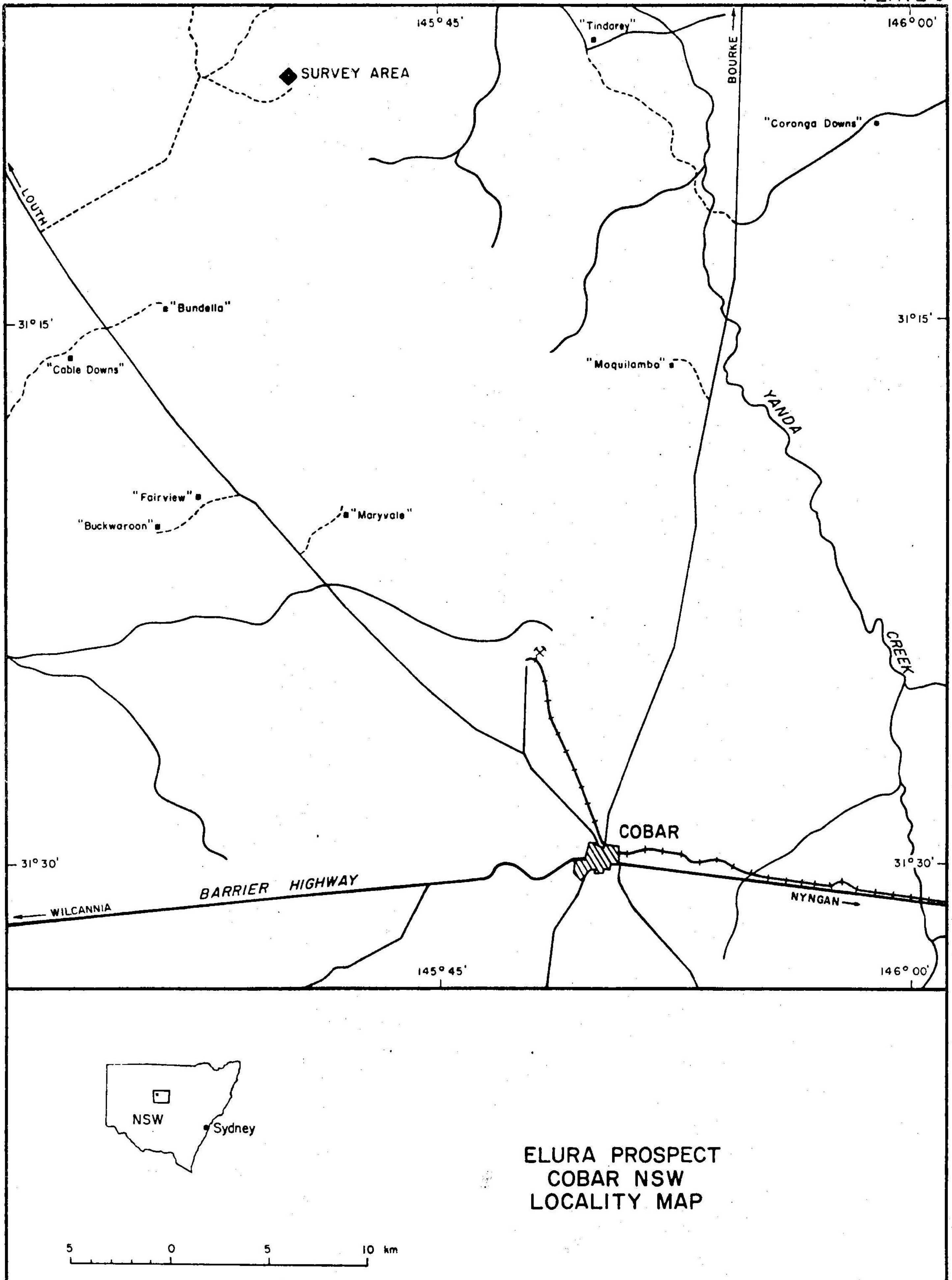
The observed chargeability is represented by the curve (t), the inductive coupling is represented by the curve $f_1(t)$ and the chargeability by the curve $f_2(t)$. The results show that for delay times greater than 75 ms the chargeability is larger than the inductive coupling.

On the basis of these results the Elura gradient array survey was conducted using a delay time of 120 ms and an integration time of 60 ms. With this arrangement M_1 starts at 120 ms, and M_4 ends at 1020 ms. Such a choice of times will maximize the IP response but eliminate inductive coupling.

APPENDIX 2

PHYSICAL PROPERTY MEASUREMENTS OF MASSIVE SULPHIDE SAMPLES, ELURA PROSPECT.

Laboratory No.	Susceptibility (10^{-6} SI units)	Remanent magnetization (A/m)	Specific gravity
75/306	150	0.006	3.63
75/307	12000	164	4.44
75/308	500		4.40
75/309	9500		4.62
75/310	210		4.25
73/311	170	0.002	4.76

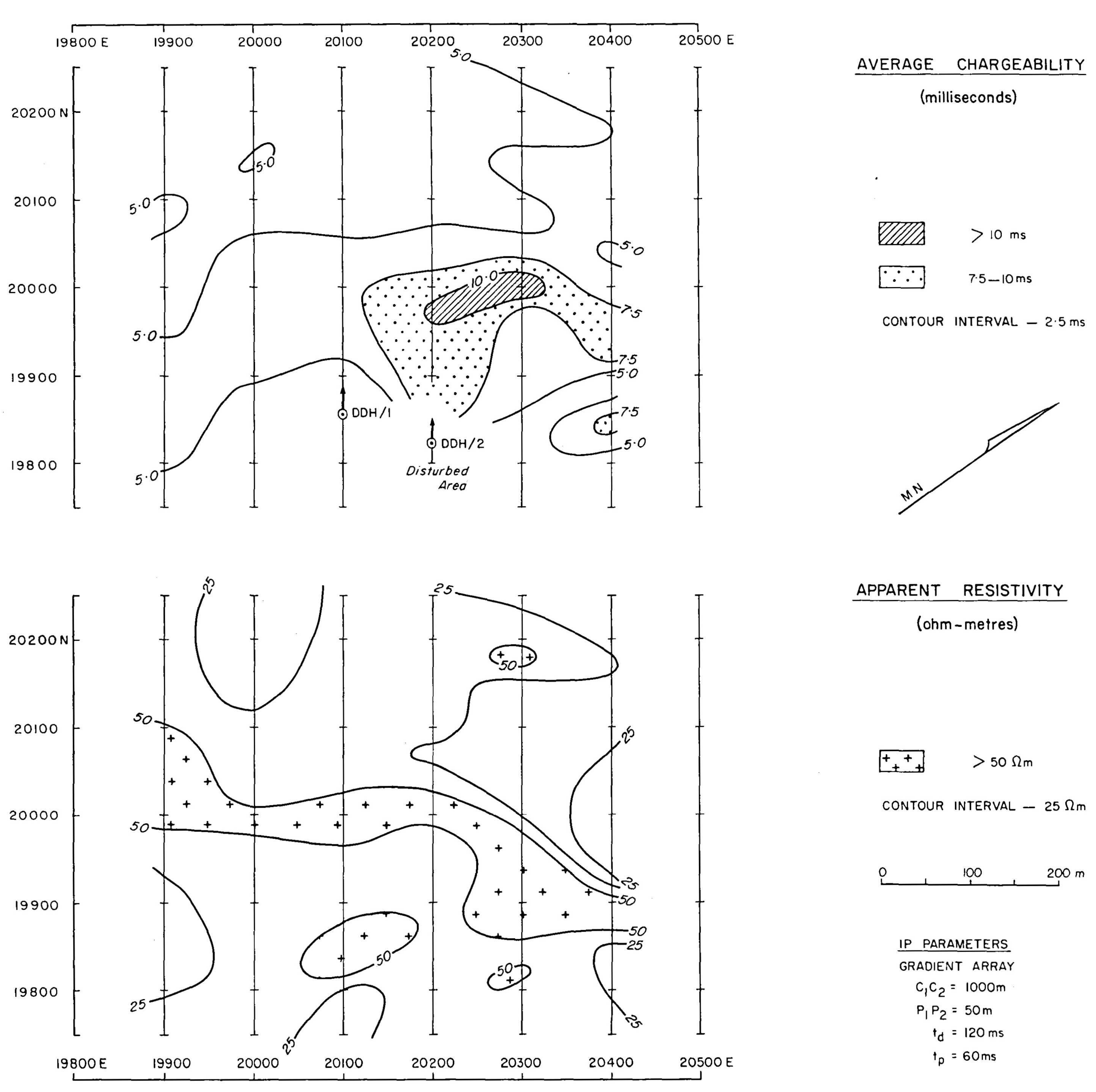


ELURA PROSPECT
COBAR NSW
LOCALITY MAP

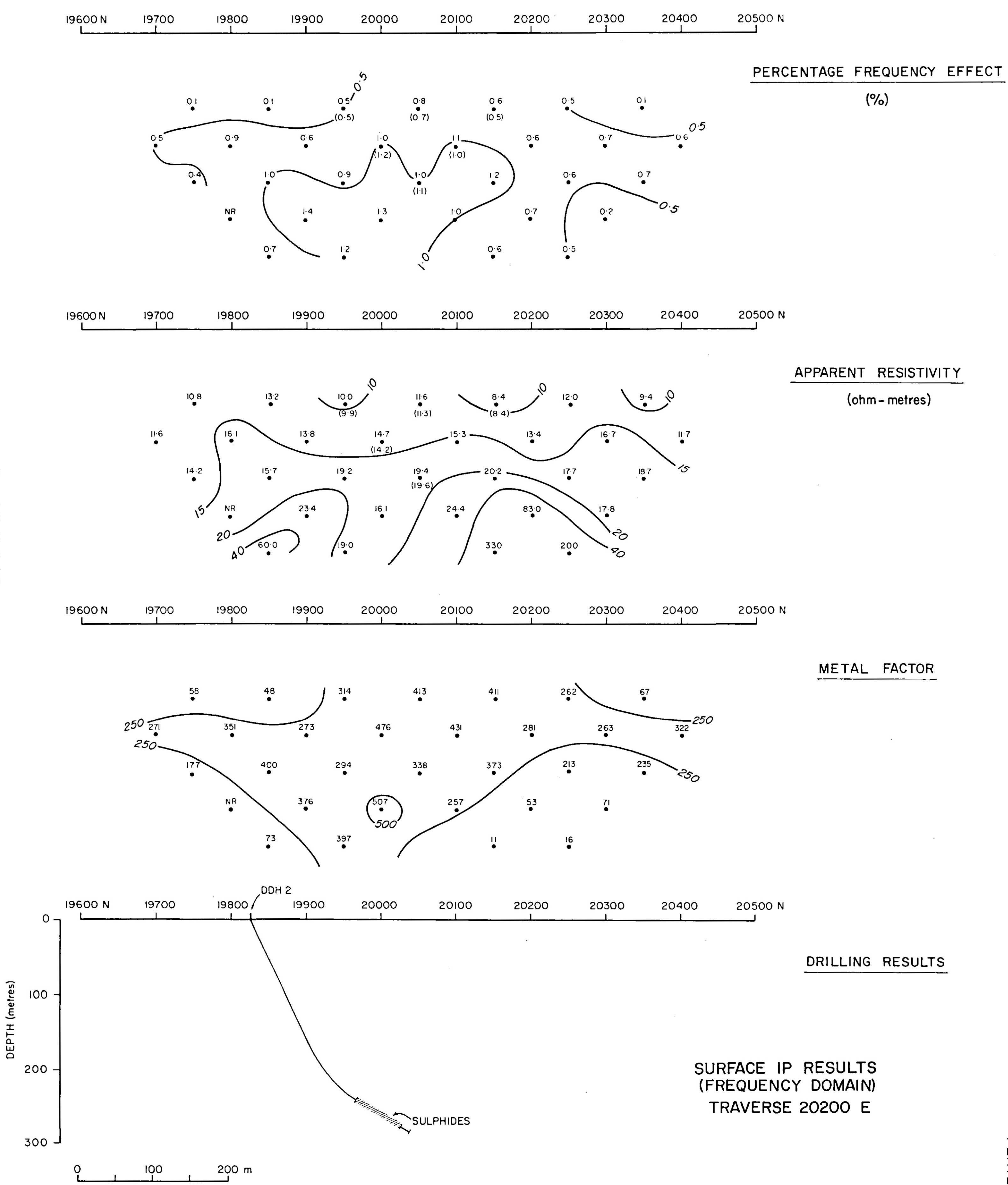
Record No. 1976/47

H55/B7 – 1A

PLATE 2



SURFACE IP RESULTS (TIME DOMAIN)

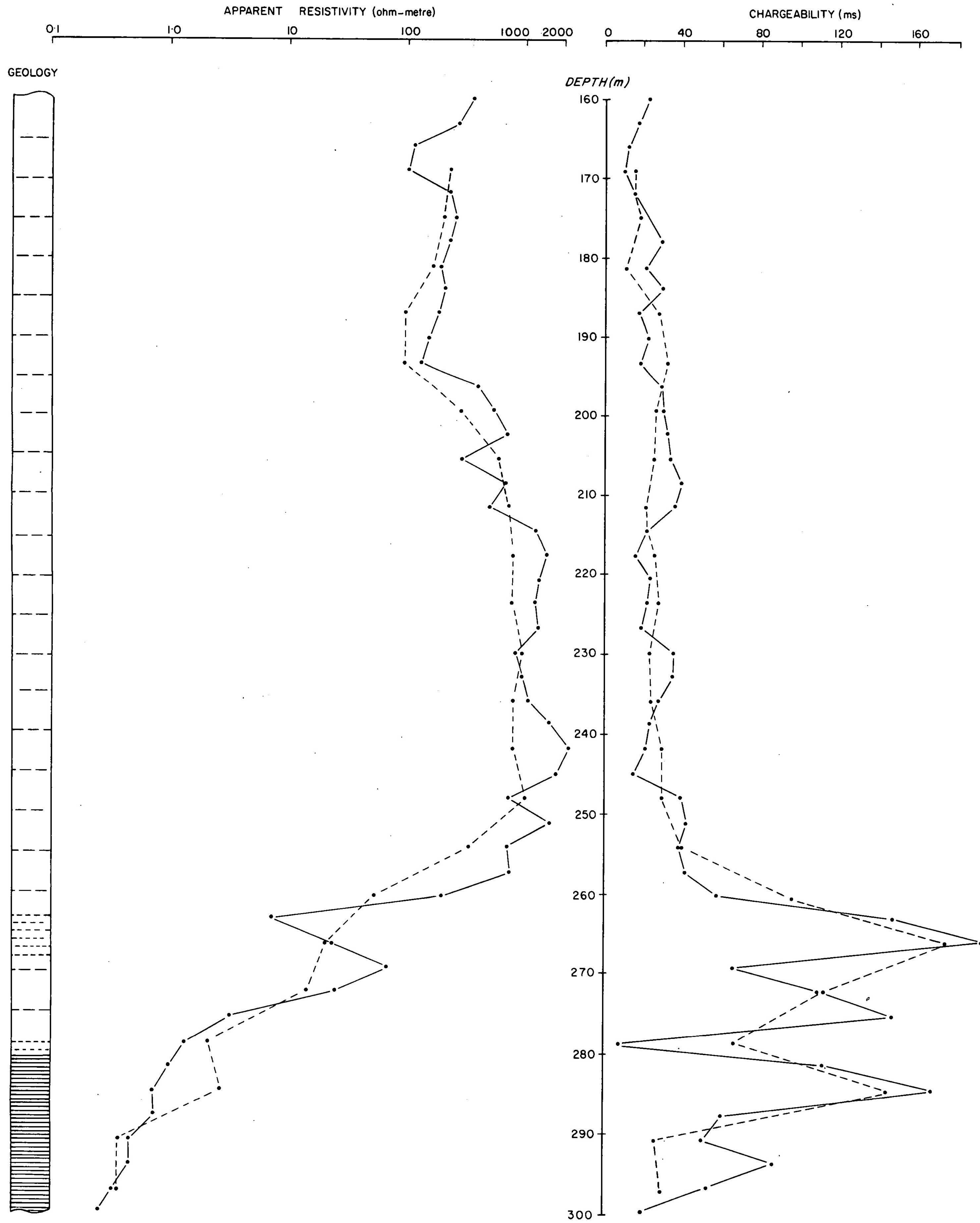


SURFACE IP RESULTS
(FREQUENCY DOMAIN)
TRAVERSE 20200 E

Record No.1976/47

H 55/B7-3

PLATE 3



IP PARAMETERS

—•— 3·05 m DIPOLE - DIPOLE PROBE

- - •- - 9·14 m DIPOLE - DIPOLE PROBE

t_d = 120 ms, t_p = 60 ms } TIME DOMAIN IP

LEGEND

SILTSTONE

SULPHIDES (VEINLETS)

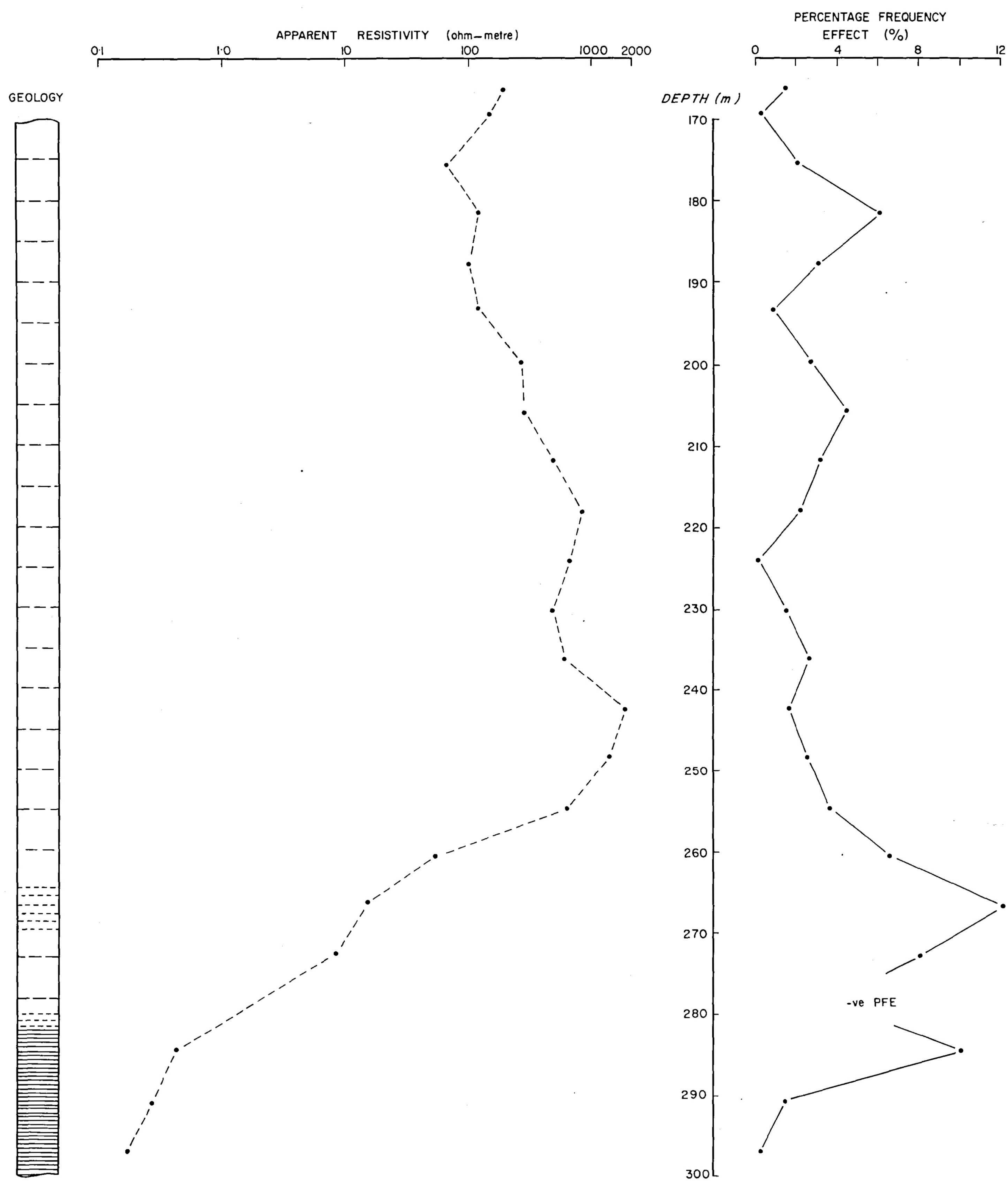
SULPHIDES (MASSIVE)

DOWNHOLE IP RESULTS (TIME DOMAIN) DDH 2

Record No.1976/47

H55/B7-4

PLATE 4



IP PARAMETERS

3·05m DIPOLE-DIPOLE PROBE

3·0 Hz } FREQUENCY DOMAIN IP
0·3 Hz

LEGEND

SILTSTONE

SULPHIDES (VEINLETS ONLY)

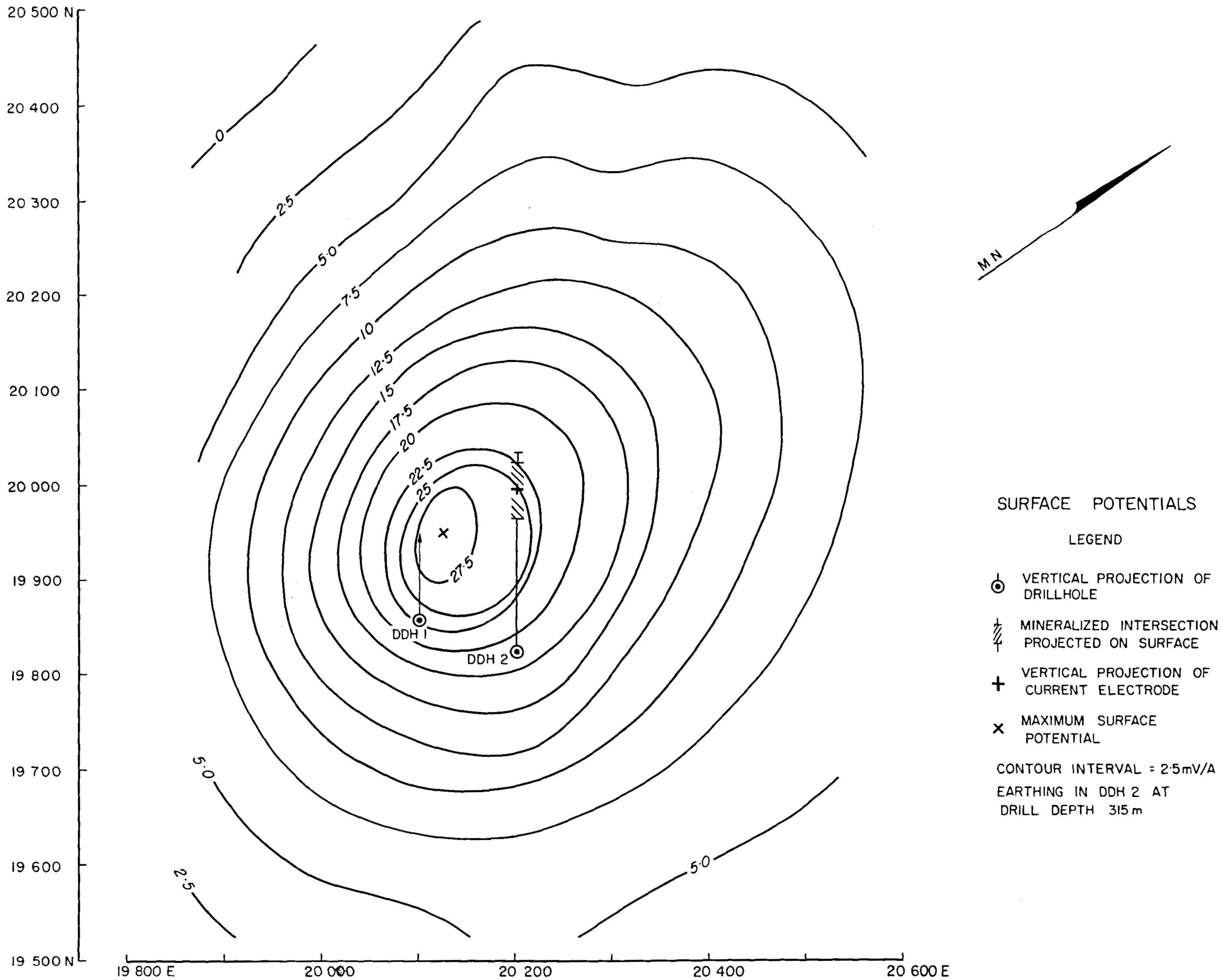
SULPHIDES (MASSIVE)

DOWNHOLE IP RESULTS (FREQUENCY DOMAIN) DDH 2

H55/B7-5

PLATE 5

Record No 1976/47

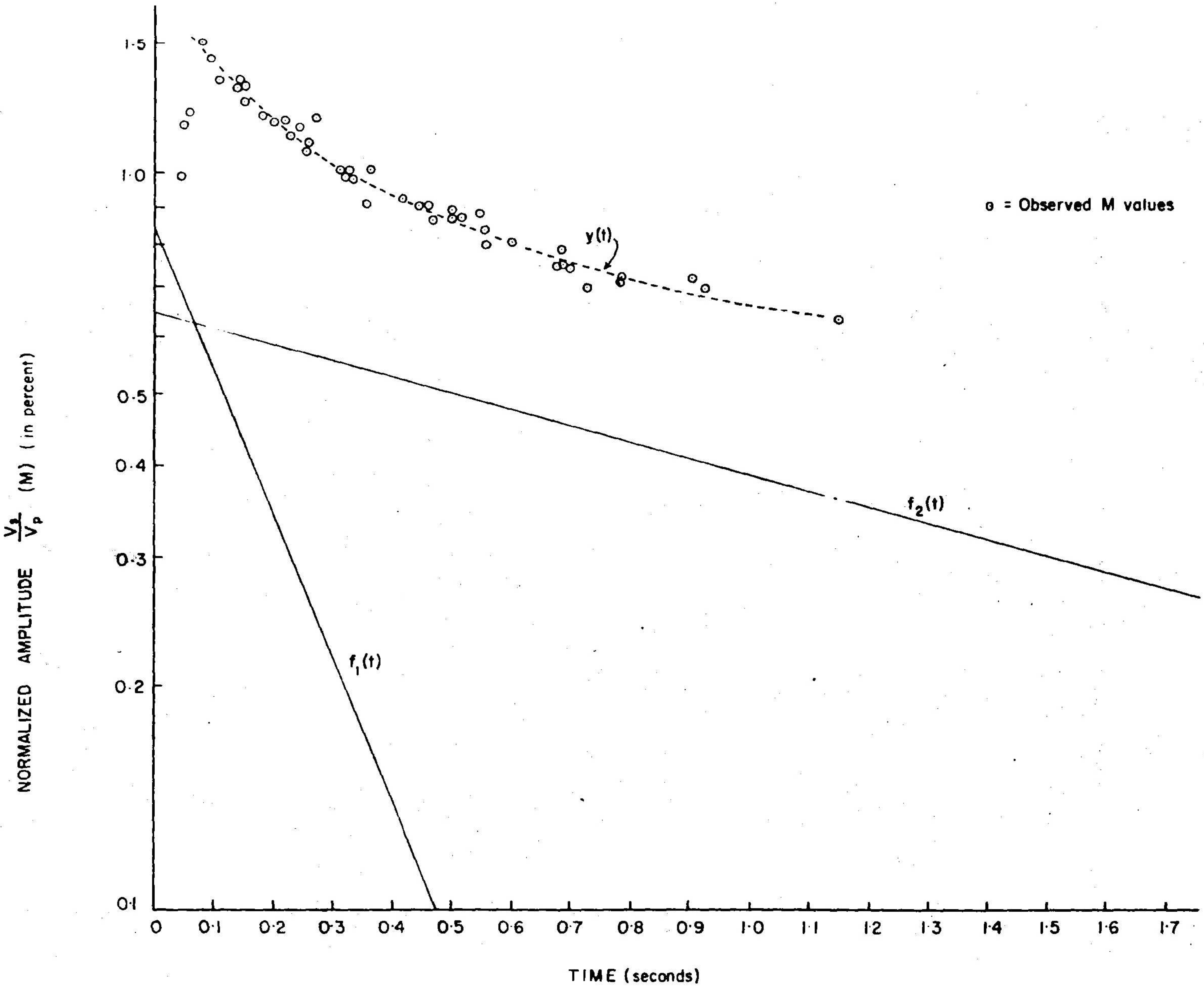


MISE Á LA MASSE RESULTS

H55/B7-8

PLATE 6

Record No. 1976/47



INDUCTIVE COUPLING TEST AT 20000N/20100E

H55/B7–9A

PLATE 7