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GEOPHYSICAL SURVEYS AT THE JUBILEE PLUNGER GOLD DEPOSIT, GEORGETOWN INLIER, QUEENSLAND, 1974-6

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ABSTRACT

In the period 1974 to 1976 the Bureau of Mineral Resources (BMR) made geophysical surveys over the Jubilee Plunger gold deposit in the Georgetown area of north Queensland to investigate the geophysical characteristics of the deposit and the significance of base-metal soil geochemical anomalies overlying the deposit. The geophysical surveys were part of an investigation by BMR and the Geological Survey of Queensland into the size, nature, possible origin, and economic potential of the gold deposits of the Georgetown Inlier.

Induced polarisation proved the most effective of the methods used to detect mineralisation in the lode. However, the mineralisation detected was tested by diamond-drilling and found to be mostly minor disseminated sulphides. The geophysical results show that massive sulphides intersected in one diamond-drill hole have limited dimensions and that the Jubilee Plunger lode has little economic potential.

INTRODUCTION

In the period 1974 to 1976 the Bureau of Mineral Resources, Geology and Geophysics (BMR) made geophysical surveys over the Jubilee Plunger gold deposit in the Georgetown area of north Queensland. The deposit is 30 km south-southeast of Forsayth and 2 km west of Robin Hood homestead in the central part of the Georgetown Inlier (Fig. 1).

Geophysical methods used in the surveys included IP/resistivity, magnetic, electromagnetic (EM), gravity, and self-potential (S-P). The surveys were used to investigate the geophysical characteristics of the deposit and the significance of base-metal soil geochemical anomalies recorded over the deposit (Armstrong, 1975; Bain, 1976).

The geophysical surveys were part of an extensive investigation by BMR and the Geological Survey of Queensland into the size, nature, possible origin, and economic potential of the gold deposits of the Georgetown Inlier (Bain, 1976).

GEOLOGY

The Jubilee Plunger gold deposit is contained within a zone of sericitised and quartz-veined Siluro-Devonian granodiorite (the Robin Hood Granodiorite) about 1200 m by 100 m in area. Shallow collapsed workings are scattered along the length of the quartz vein system. Incomplete mining records indicate that more than 46 kg of gold/silver bullion was extracted from some 2400 tonnes of easily crushed, oxidised ore between 1894 and 1897 (Bain, 1976).

At the surface, the zone of sericitisation and quartz veining is ferruginous and gossanous. The dip of the zone varies from 35° to 65°E and the depth of oxidation is about 12 m. The zone strikes about 330° for about 1 km. The central part of the zone is buried beneath alluvium. At the northern end it divides into two branches which have been traced for a further 300 m (Fig. 1). Dumps at the southern end of the zone contain a few malachite-stained boulders, and a dump on the northern end contains cobbles rich in sphalerite and galena.

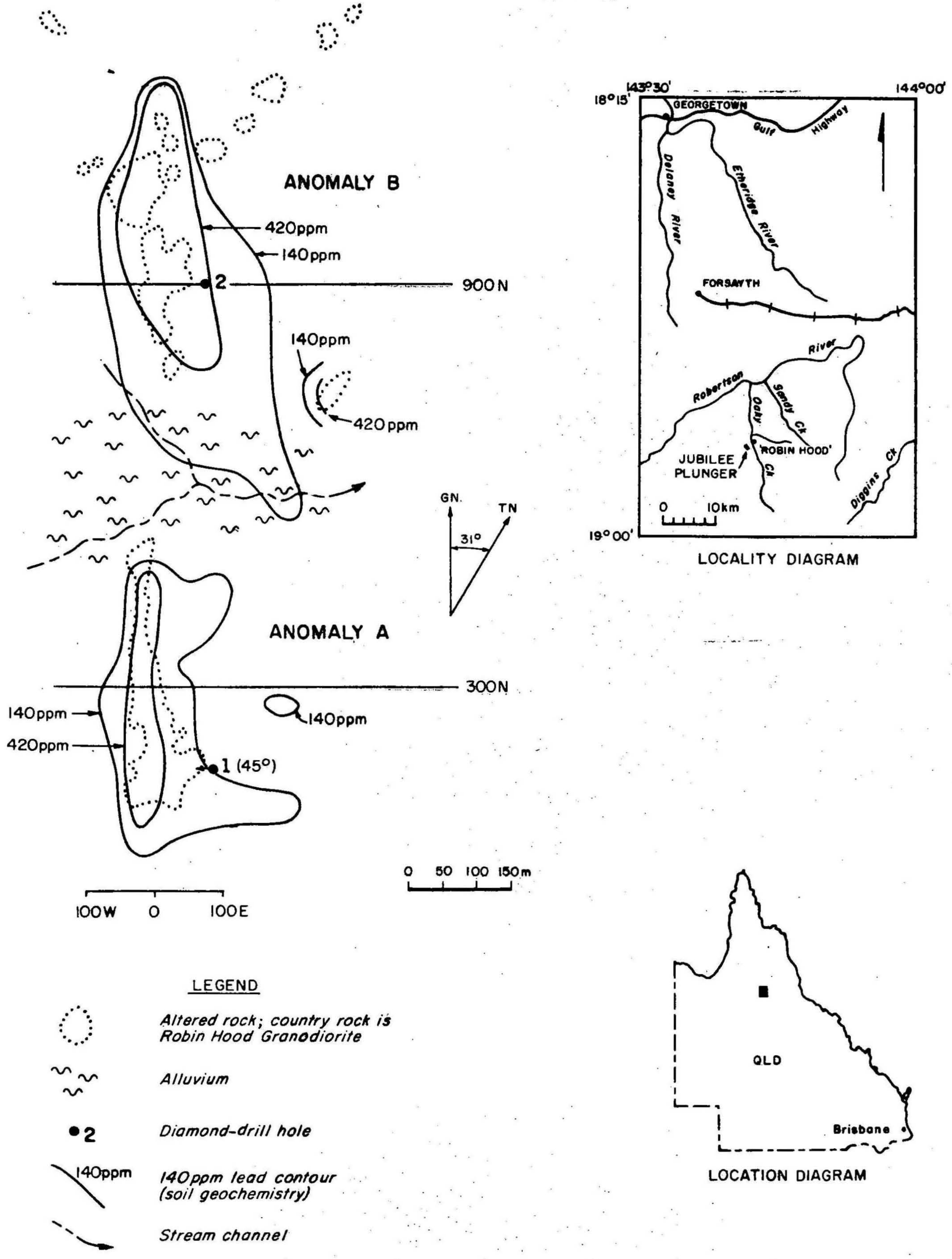

Fig.1 Location map, geology and geochemistry.

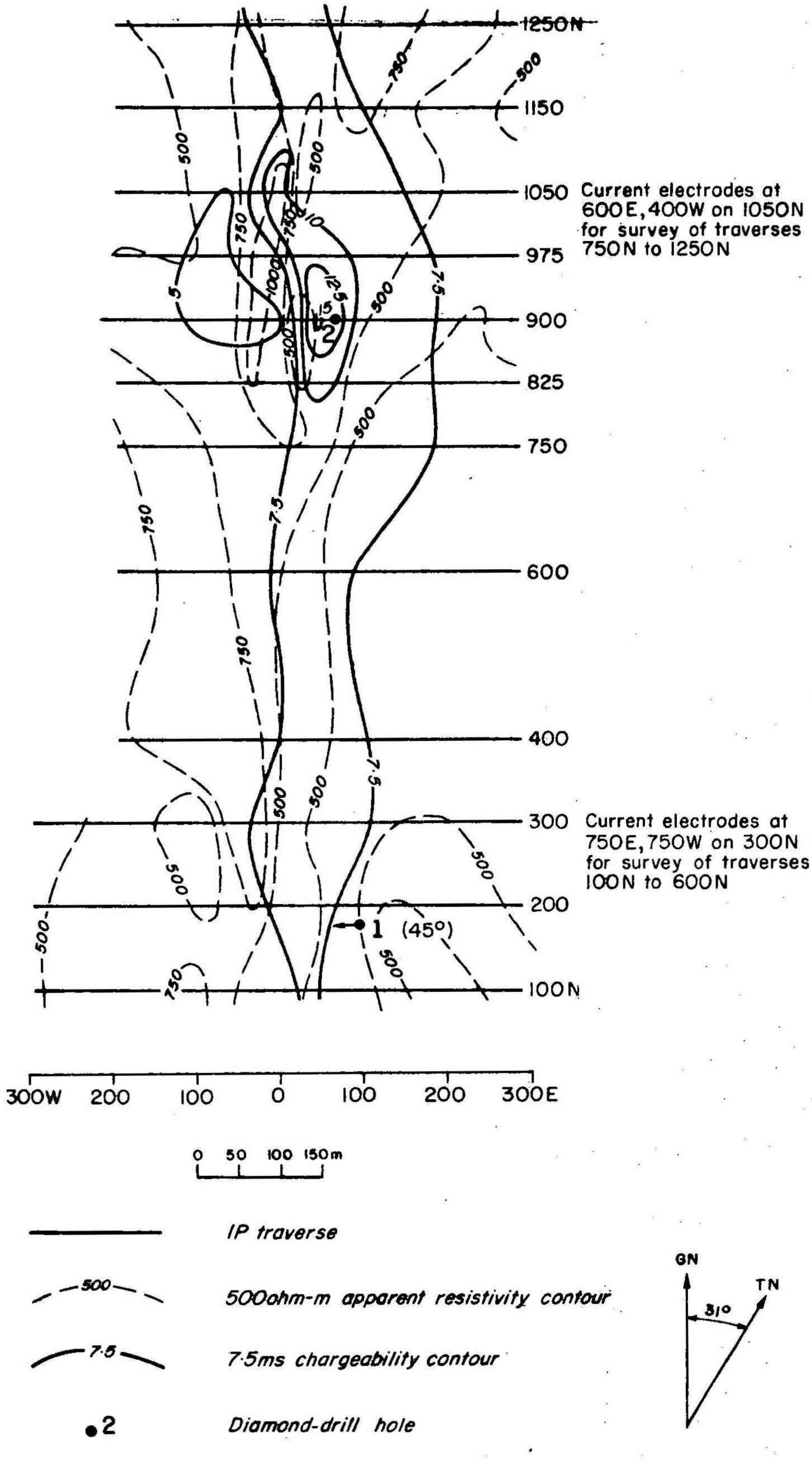

Fig. 2 Induced polarisation and apparent restivity contours

Geochemistry

In 1973 and 1974 BMR investigated the geochemistry of the soils and related stream sediments in the area and found an extensive Au-Ag-Pb-Zn-Cu anomaly in soils overlying the deposit (Armstrong, 1975; Bain, 1976).

Two anomalous areas separated by a zone of transported alluvium were found. The southern area is designated anomaly A, and the northern anomaly B. Lead geochemical contours are shown in Figure 1.

Drilling

In 1975 two holes were diamond-drilled on anomalies A and B. The northern hole (DDH 2), sited on an induced polarisation anomaly, intersected sulphide mineralisation from below 12 m, the level of oxidation. The hole was drilled vertically to 56 m, and the metal content of the mineralised section from 37 m to 44.6 m was 7 g per tonne gold, 86 g per tonne silver, 2.6% zinc, 1.1% lead, and 0.35% copper.

The southern hole (DDH 1) was drilled at 45° grid west to 100 m. It intersected minor pyrite, sphalerite and galena in the altered zone.

The positions of the holes are shown in Figures 1 and 2.

SURVEY DETAILS

1974 survey

In October 1974 a BMR field party led by I.G. Hone made a very brief reconnaissance in the area of the geochemical anomalies to establish the geophysical characteristics of mineralisation below the geochemical anomalies and whether or not this mineralisation is continuous below the alluvium between anomalies A and B.

Magnetic, S-P and IP/resistivity surveys were made along traverses 300 N, 600 N and 900 N (Figs 1 and 2). Traverse 300 N crossed geochemical anomaly A, traverse 900 N crossed geochemical anomaly B, and traverse 600 N crossed the alluvial area between anomalies A and B.

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Total magnetic field and S-P measurements were made from 500 E to 500 W on all traverses using a Geometrics G816 proton precession magnetometer and a Sharpe VP-6 S-P meter respectively. Magnetic measurements were made at 25 m intervals and repeated at 12.5 m intervals over the altered zone. S-P measurements were made at 25 m intervals over the altered zone and 50 m intervals elsewhere.

The three traverses were surveyed with IP/resistivity from 200 E to 150 W using a dipole-dipole array with 50-m dipoles and dipole separations of n=1 to n=5. The IP surveys were made in the frequency domain using an Austral receiver and transmitter on traverses 300 N and 900 N and an Austral receiver and Geoscience transmitter on traverse 600 N. Frequencies used were 3 and 0.3 Hz. Small IP anomalies were recorded over the line of lode on all traverses.

1975 survey

During August 1975 a BMR field party led by D.R. Wilson made a detailed geophysical survey to define more precisely the IP anomalies recorded in the 1974 survey of I.G. Hone and to determine if electromagnetic and magnetic methods could assist in the definition of the source of the IP anomalies.

The survey clearly defined IP anomalies associated with the geochemical anomalies, with the highest chargeability over anomaly B. Both geochemical anomalies were drilled late in 1975 after the geophysical survey had been completed. DDH 2 was sited to test the IP anomaly within geochemical anomaly B and intersected massive sulphides.

Magnetic, electromagnetic (Turam and VLF) and IP/resistivity methods were used on the same grid as used in 1974. Traverses surveyed in 1975 are shown in Figure 2.

Total magnetic field measurements were made on each traverse at 10 m or 20 m intervals using a Geometrics G816 proton precession magnetometer.

The IP survey was made in the time domain using gradient arrays. For traverses 100 N to 600 N current electrodes were at 750 E and 750 W on traverse 300 N. For traverses 750 N to 1250 N current electrodes were at 600 E and 400 W on traverse 1050 N. Potential electrodes were 20 m apart and were moved at 20 m intervals. Instruments used were a Huntec Mk3 receiver and a Huntec Mk2 model 2500W transmitter. The chargeabilities were measured in the time interval 120 ms to 1020 ms. The total cycle time was 8 s with a duty ratio (time on/time off) of one.

The Turam survey used a 400 m by 400 m square transmitting loop which was laid out west of geochemical anomaly B. The leading edge of the loop was along 100 W and the sides were along traverses 750 N and 1150 N. The equipment was an ABEM 2S system and measurements were made at 20 m intervals on traverses 750 N to 1150 N (except traverse 975 N) from 50 W to 230 E using 220 Hz and 660 Hz. The separation of the two receiving coils was 20 m. VLF measurements were made along each traverse at 10 m or 20 m intervals using a Geonics EM16 instrument. The source of the VLF signal was the 22.3 kHz communication transmitter at Northwest Cape.

1976 survey

A further geophysical survey was made from 27 July to 7 August 1976 by a BMR field party led by J.A. Major. The objectives were to make a gravity survey to investigate the size of mineralisation found during the drilling, and to establish the gravity response of the Jubilee Plunger mineralised zone. Magnetic, induced polarisation and gravity traverses were extended to the east and west to locate other possible zones of mineralisation.

Magnetic, gravity and IP surveys were made on the same grid used in 1974 and 1975. Total magnetic field measurements were made using a Geometrics G816 proton precession magnetometer. Traverses 600 N, 700 N, 800 N, 900 N, 1000 N, 1100 N and 1250 N were surveyed. All traverses crossed the alteration zone, but they varied in length from 700 m to 2.1 km. Station intervals were 10 m near the centre of the grid and 20 m or 25 m elsewhere.

Gravity measurements were made using Worden gravity meter W140. Stations were levelled using a Topcon AT32 level. Station spacing was 20 m over the alteration zone and 50 m elsewhere; a 10 m spacing was used from 100 E to 100 W on traverse 900 N over the mineralisation intersected by DDH 2. Traverse 600 N was surveyed from 1400 E to 600 W, traverses 700 N and 800 N from 1000 E to 260 W, traverse 900 N from 1450 E to 500 W, and traverse 1250 N from 400 E to 260 W. The results were reduced using station 0 on traverse 900 N as base. This station was arbitrarily assigned an observed value of 50 mGal and a height of 100 m. Bouguer anomalies were calculated using a density of 2.67 g/cm^3.

The IP survey was made in the time domain using a dipole-dipole array and the same equipment used in 1975 and with the same integration and cycle times. Dipole length was 50 m and dipole spacings were n=1, 2 and 3. Traverses 600 N and 900 N were surveyed from 1300 E to 600 W.

RESULTS

Induced polarisation and resistivity

The gradient array time domain chargeability and resistivity results from the 1975 survey are shown in contoured form in Figure 2. Background chargeability values are low (less than 7.5 ms) and fairly uniform. A weak anomaly was recorded on all traverses over the alteration zone. The maximum chargeability within this anomaly is 20.2 ms at 50 E on traverse 900 N with the 10 ms contour extending from traverse 825 N to traverse 1050 N. Comparable dipole-dipole array frequency domain frequency effects obtained in 1974 are background values of less than 1%, an anomaly over the alteration zone of about 1%, and a maximum on traverse 900 N of 2.5%.

The apparent resistivity values recorded in the vicinity of the Jubilee Plunger lode average about 500 ohm-m (Fig. 2) and are generally less than those recorded over the surrounding rocks. Typical gradient and dipole-dipole array apparent resistivity profiles are shown in Figure 3. The apparent resistivity results along traverse 600 N, which crosses the area where the alteration zone is concealed by alluvium, are lower and more uniform than elsewhere in the alteration zone.

Figure 3 also shows the IP results on traverse 900 N and the summarised results from DDH 2. The gradient array chargeability is greatest between 50 E and 70 E and this is probably where the mineralisation intersected in DDH 2 is nearest the surface. The gradient array apparent resistivity minimum is 366 ohm-m at 30 E near the chargeability anomaly maximum. This resistivity minimum is near the up-dip projection of the mineralisation intersected in DDH 2. Displacement of the resistivity minimum and chargeability maximum may be caused by weathering of the top of the mineralised body.

The chargeability contour pattern (Fig. 2) suggests minor sulphides in the alteration zone on each traverse surveyed. This is confirmed on traverse 200 N by DDH 1 which showed that the alteration zone contains minor amounts of pyrite, galena and sphalerite. The chargeability and resistivity contour patterns also suggest that the mineralised body intersected by DDH 2 has limited strike length (825 N to 1050 N) and that the sulphide content diminishes rapidly away from traverse 900 N.

The results of the extended IP/resistivity surveys along traverses 900 N and 600 N are indicated in Figure 4. The most prominent feature in the IP results is the anomaly in excess of 15 ms which occurs over the mineralisation intersected by DDH 2. Another notable feature is the increase in conductivity and chargeability east of 600 E. This feature is observed on traverses 900 N and 600 N and suggests a change in the character of the Robin Hood Granodiorite at about 600 E. Away from the alteration zone the apparent resistivities increase with the n-spacing of the dipole-dipole array, indicative of horizontal layering which may be associated with weathering.

Magnetic

The results of the magnetic survey over the Jubilee Plunger lode are shown in Figure 5. The results indicate that the mineralised zone is commonly associated with an indistinct local high of less than 100 nT. However there appears to be no direct association between the magnetic results and the mineralisation intersected in DDH 2.

The extensionsof traverses 900 N and 600 N to the east and west reveal many minor magnetic anomalies but it is not possible to trace anomalies between traverses.

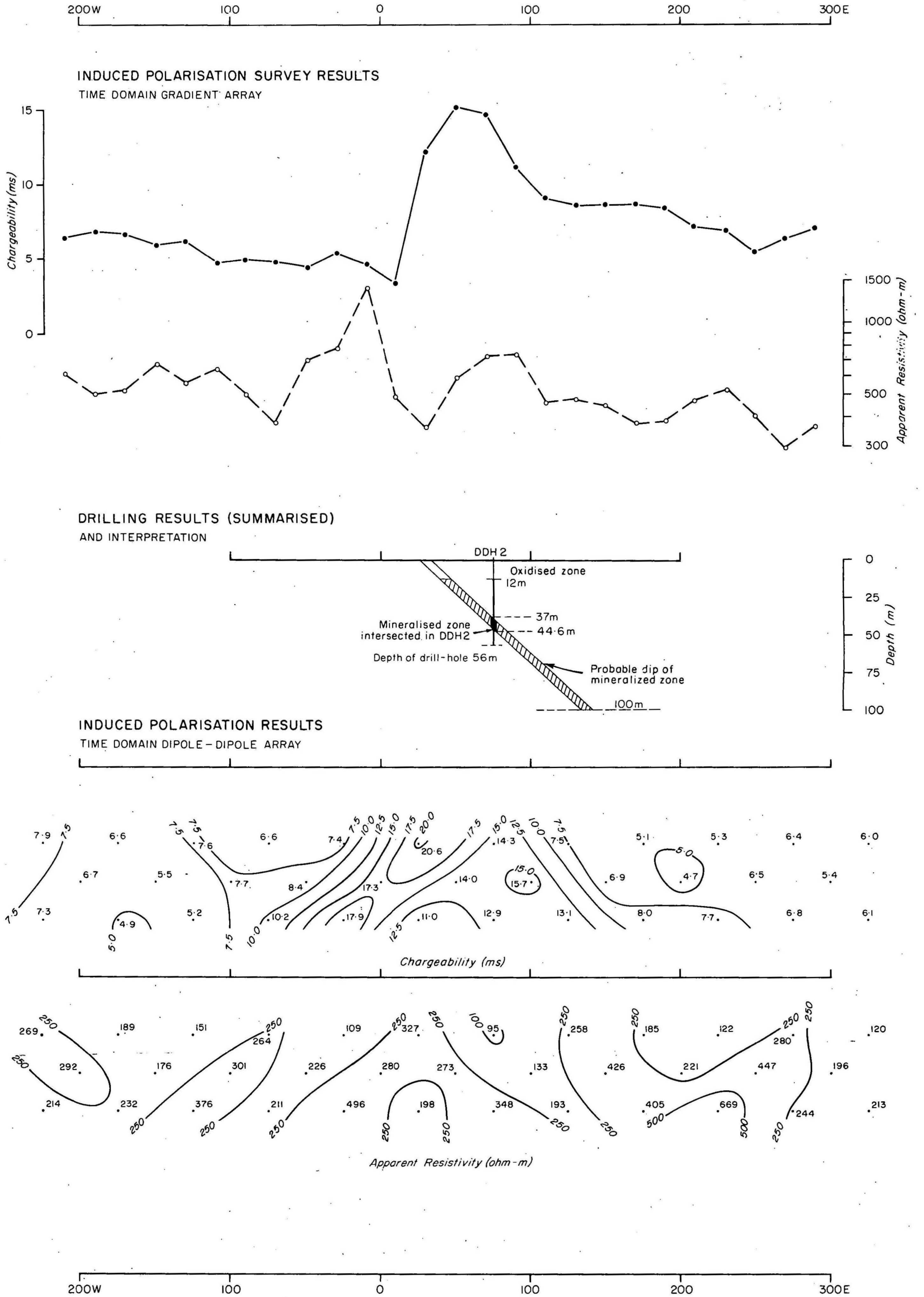

Fig.3 Induced polarisation and drilling results, traverse 900 N

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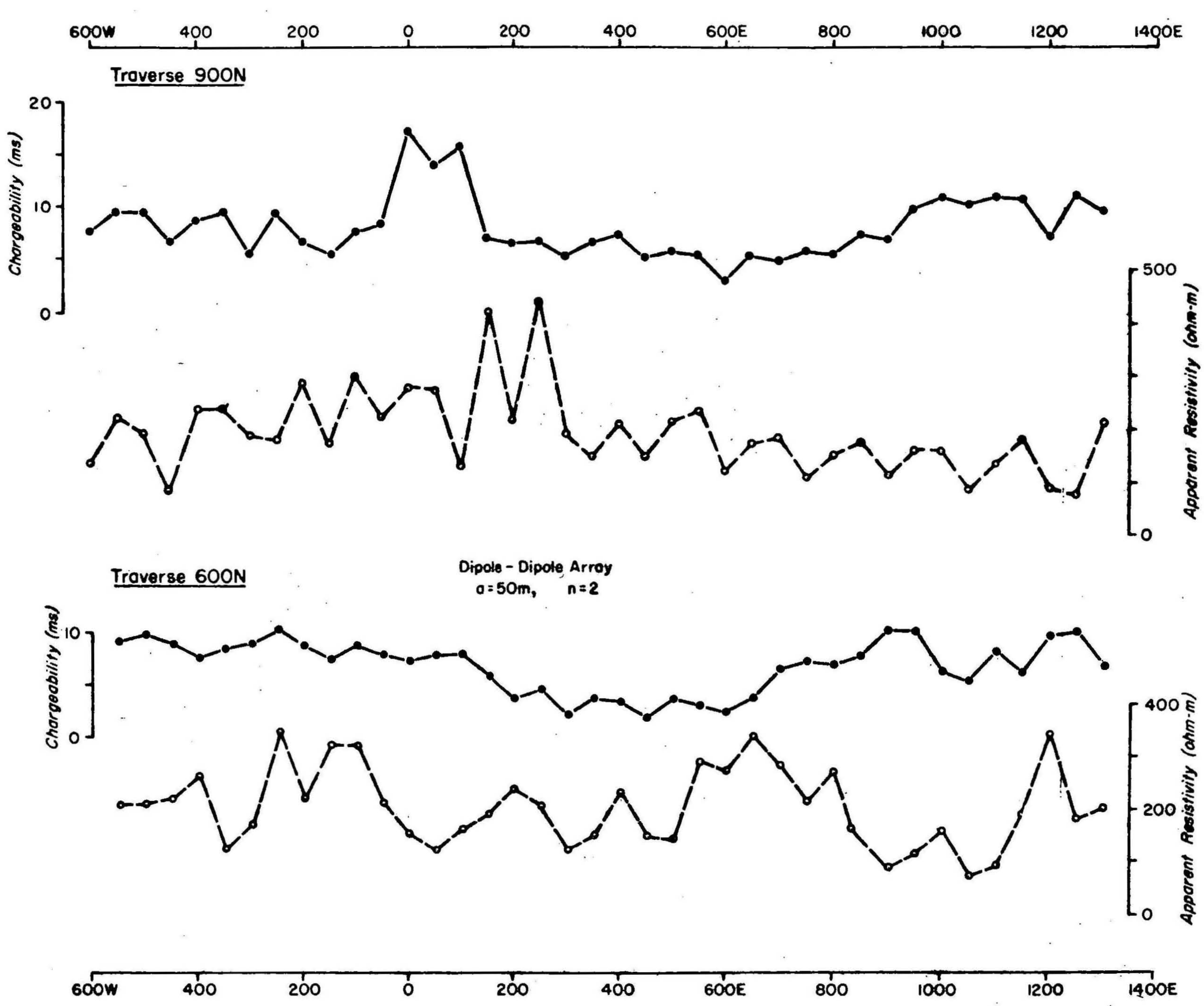

Fig.4 Regional induced polarisation and resistivity profiles

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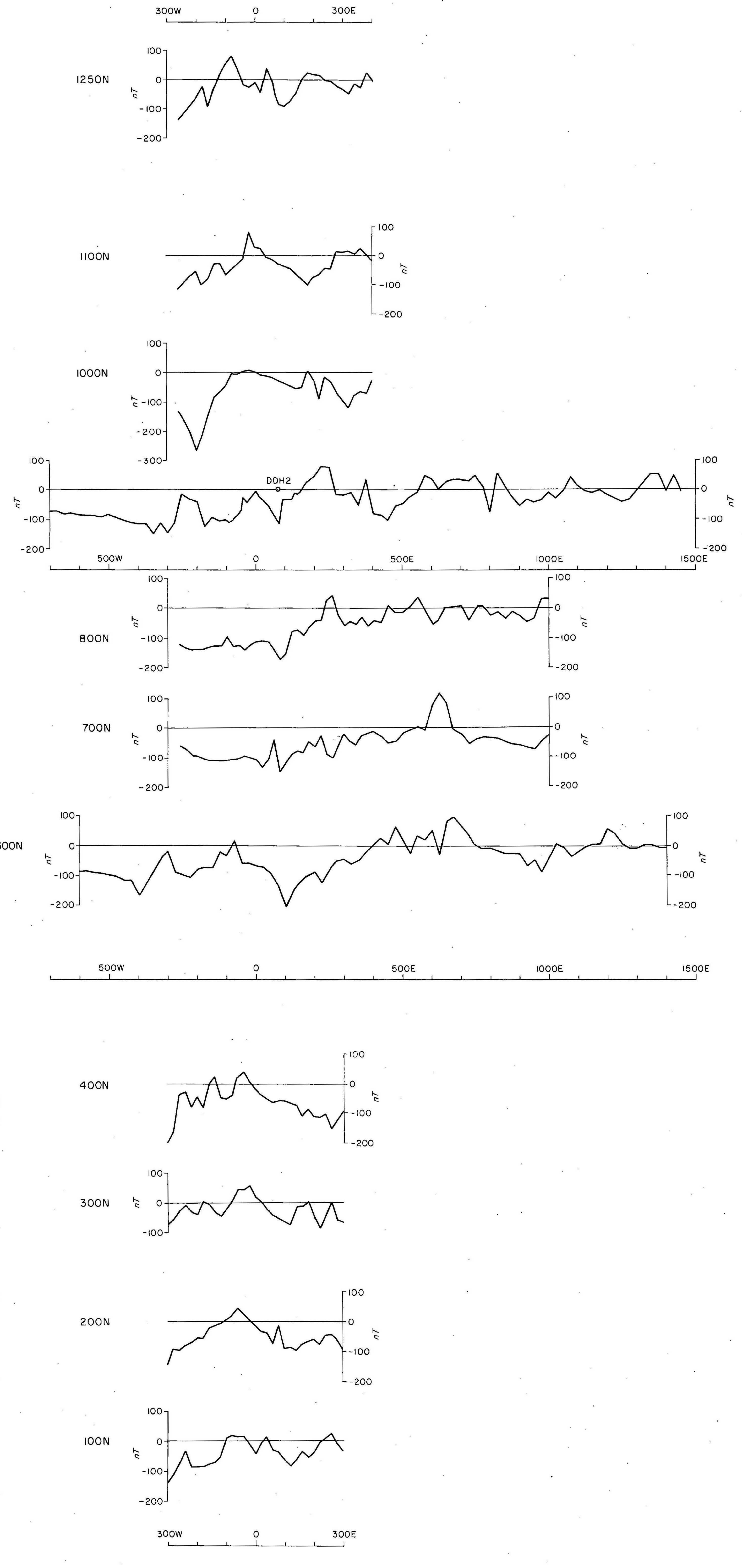

Fig.5 Regional magnetic profiles

The source of the magnetic anomalies at, and in the vicinity of the Jubilee Plunger lode is not clear but may be the result of alteration of iron bearing minerals during mineralisation.

Gravity

The results of the gravity survey over the Jubilee Plunger lode were reduced to Bouguer anomaly values using a density of 2.67 g/cm^3 and are shown in Figure 6.

The most prominent feature of the results is the strong regional gradient. The results show no features that can be attributed to either a large body of sulphides or to major changes in the lithology of the surface rocks. The small erratic variations over the lode are less than 0.01 mGal, which is the order of accuracy of the survey.

The absence of a gravity anomaly over the Jubilee Plunger lode is not surprising. Modelling shows that thin tabular bodies produce very small gravity anomalies unless they are very close to the surface and are in a homogeneous ground mass. For example, a tabular body 10 m thick, extending from 10 m to 200 m below ground surface, dipping at 70^{o} and with a density contrast of 0.5 g/cm^3 (10% by volume of galena in a host rock of 2.7 g/cm^3) produces a gravity anomaly of only 0.2 mGal with a half-width of 50 m.

Turam

The Turam results using a 220 Hz transmitter are shown in Figure 7. The reduced ratios and phase differences are everywhere small. The largest reduced ratio obtained was only 1.02 at 230 E on traverse 1050 N, with an accompanying phase difference of -2^{o}. Although the anomalies are small, it is possible to trace them from traverse to traverse, especially phase difference anomalies. For instance, from 30 E on traverse 1050 N to 30 E on traverse 750 N, and from 250 E on traverse 1150 N to 250 E on traverse 1050 N. However, the VLF results, discussed in the next section, show a complex system of anomalies, and it may not be valid to assume that anomalies on adjacent traverses are due to the same, continuous, conductor.

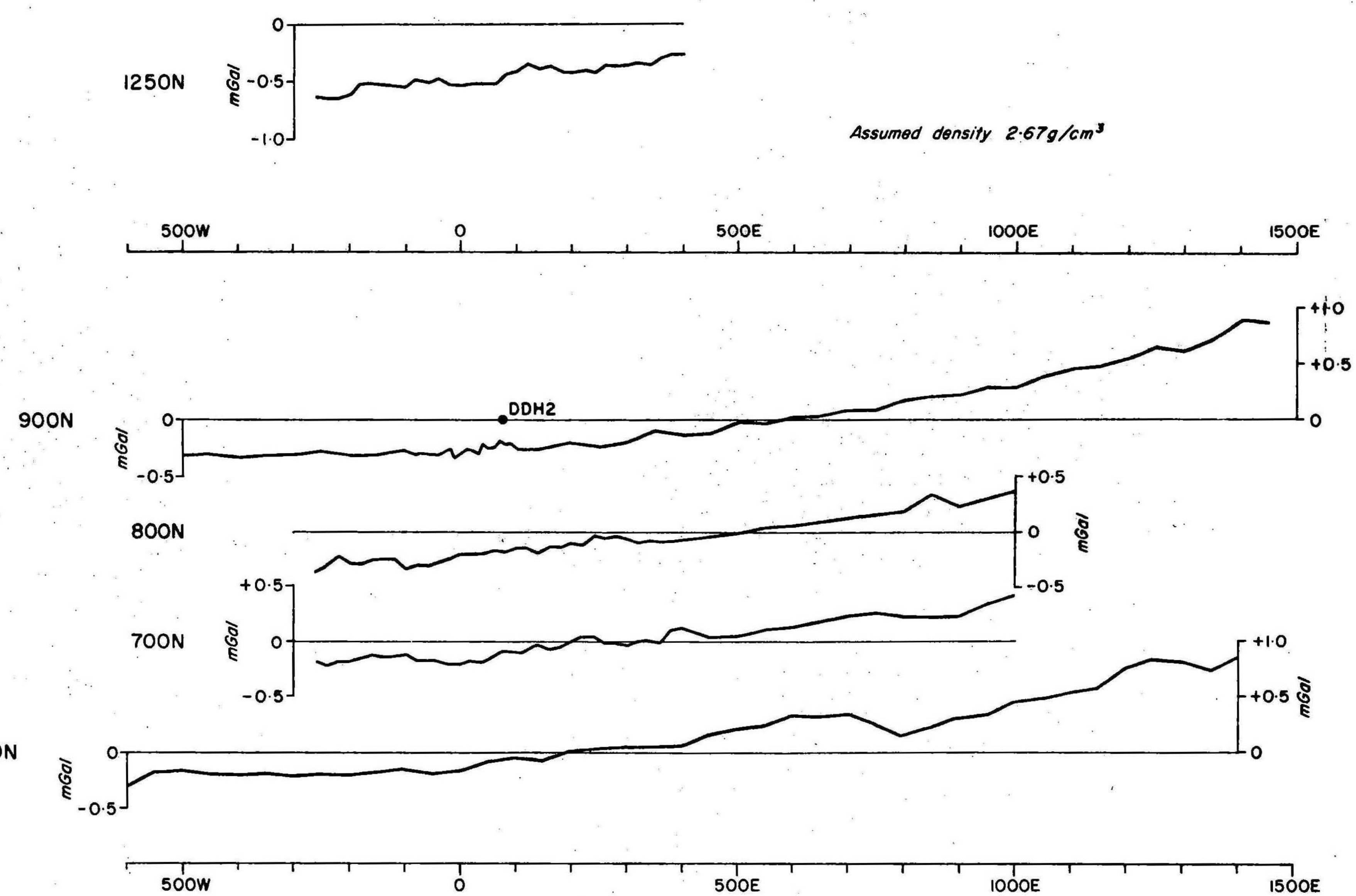

Fig.6 Regional Bouguer anomaly profiles

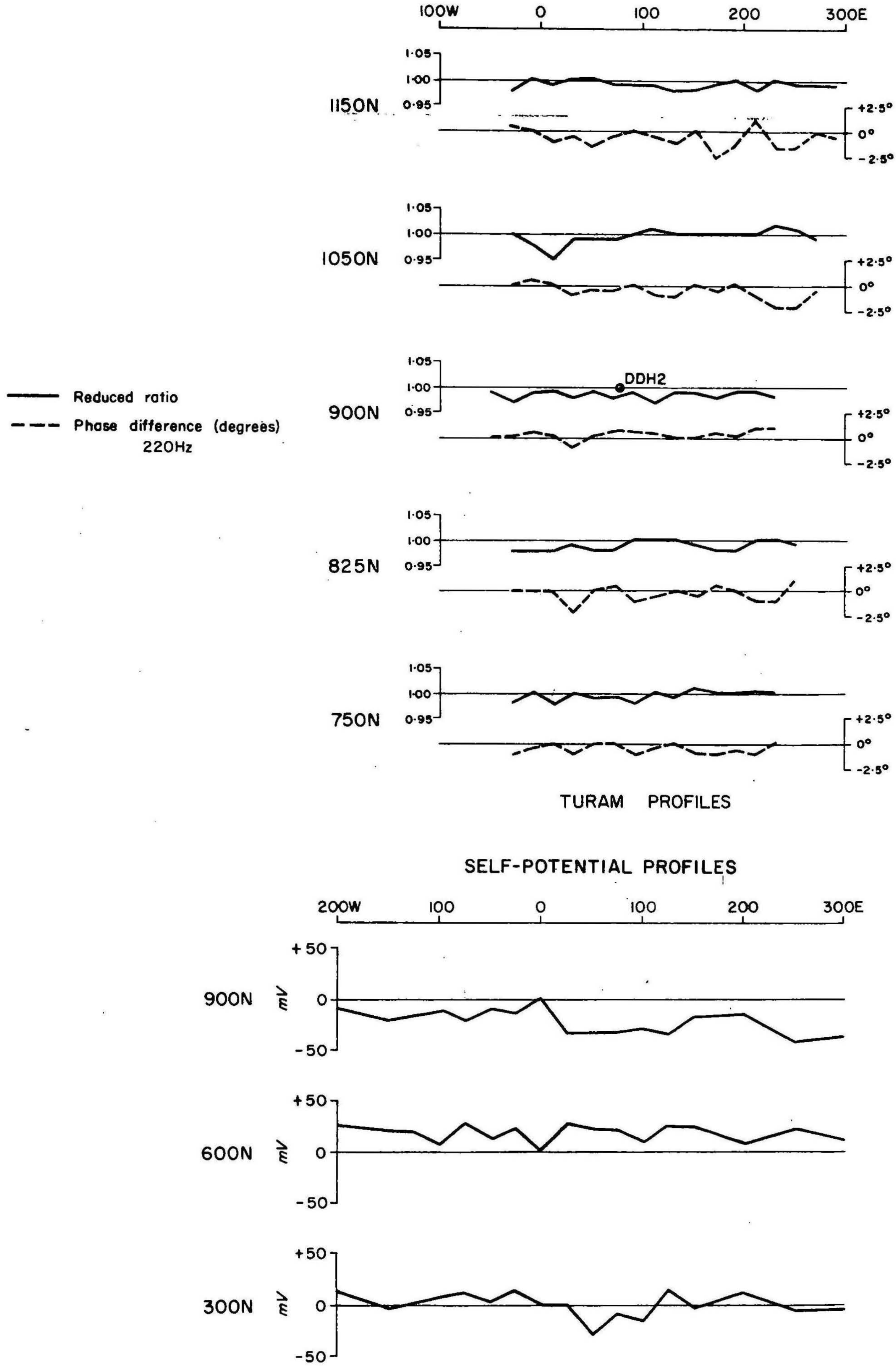

Fig.7 Turam and self-potential profiles

The weakness of the Turam responses is an indication of the resistive nature of the alteration zone and of the absence of large, shallow bodies of conductive sulphides. The high resistivity of the alteration zone is confirmed by the apparent resistivity results obtained in the IP/resistivity survey (Fig. 4).

Figure 7 shows that no Turam anomaly was detected above the sulphide zone intersected by DDH 2. Accordingly, it is probable that the sulphide body is either small or is distributed discontinuously through a resistive matrix.

VLF

The VLF profiles are shown in Figure 8. The geological strike in the area surveyed is nearly orthogonal to the propagation direction of the field from North West Cape. Hence the area is not ideal for VLF survey measurements. The profiles are plotted so that negative cross-overs of the in-phase component, in which the profile crosses from positive to negative going grid east, indicate the presence of conductors.

The profiles obtained are complex with many anomalous readings. If the average resistivity of the area surveyed is about 400 ohm-m (see Figure 2) then the effective depth of penetration of the VLF signal is about 65 m. The complexity of the profiles indicates the presence of numerous conductors probably due to variations in the weathered zone above 65 m.

The results of the in-phase field were filtered using a method described by Fraser (1969), and profiles of the filtered values are shown in Figure 9. The filtering process uses a difference operator which transforms the points of inflexion into peaks (for negative cross-overs) and troughs.

The filtered results show some peaks which can be traced to adjacent traverses, for example from 150 W traverse 600 N to 150 W traverse 300 N, and from 10 E traverse 975 N to 30 E traverse 825 N. However the complexity of the results and the fact that most peaks cannot be traced to adjacent traverses make the validity of assuming that conductors continue from traverse to traverse uncertain. The small peak occurring at 30 E on traverse 900 N and the peaks on adjacent traverses

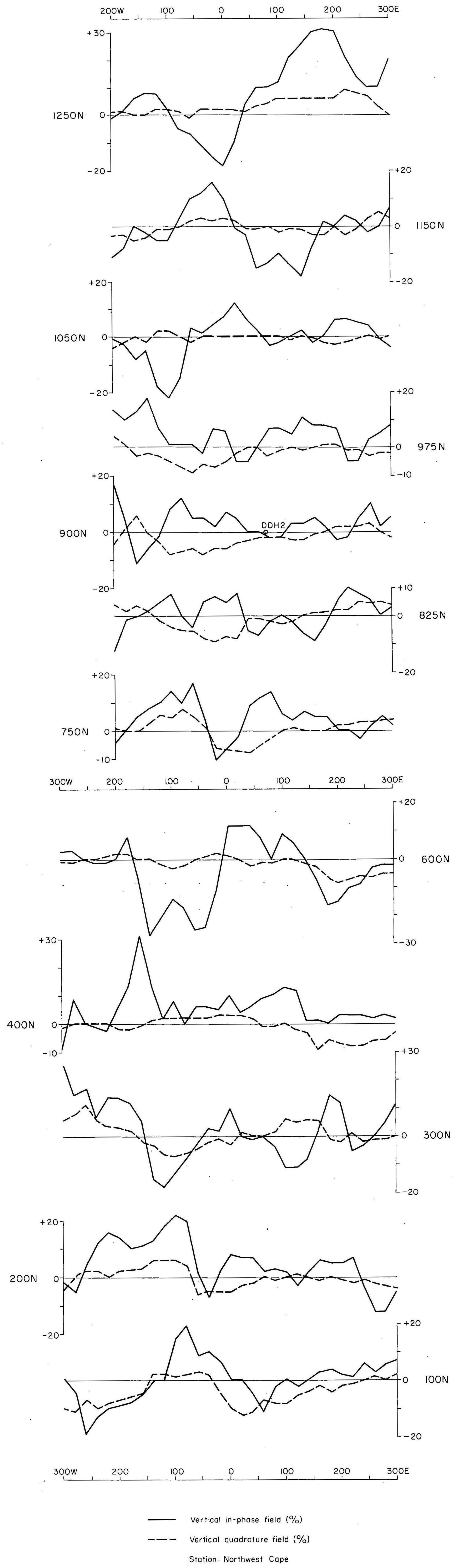

Fig.8 VLF profiles

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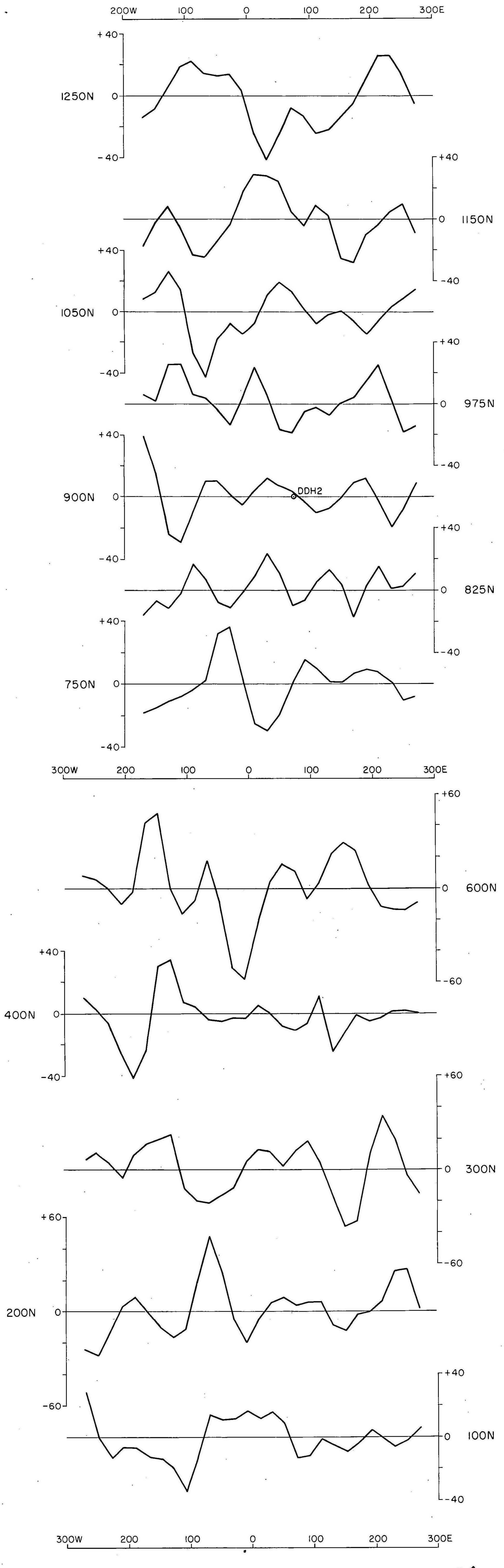

Fig.9 Filtered VLF profiles

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at 10 E, 975 N and 30 E, 825 N may be related to the mineralisation intersected by DDH 2. However these peaks are not obvious in the overall pattern.

There appears to be some correspondence between the Turam and VLF filtered data, for example at 250 E traverse 1150 N, around 250 E traverse 1050 N, 30 E traverse 825 N. However most VLF anomalies have no discernible associated Turam anomaly. This can be explained if the VLF response is mainly from the weathered zone and the Turam response is from deeper rocks.

Self-potential

Profiles are shown in Figure 7. No anomaly was found to occur over the alteration zone or the sulphide body intersected by DDH 2.

CONCLUSIONS

The chargeability contours and diamond drilling (Fig. 2) indicate that a narrow zone of minor disseminated sulphides is associated with the Jubilee Plunger lode over more than 1150 m. The maximum chargeability recorded on traverse 900 N rapidly decreases away from this traverse, indicating that massive sulphides intersected by DDH 2 have only a short strike length. Correlation of this sulphide intersection with surface geology and IP/resistivity data indicates that the massive sulphide lode dips at about 45°.

No significant EM, resistivity or gravity anomalies were recorded over the massive sulphides. The overall interpretation of the geophysical results is that the quantity of sulphides in the Jubilee Plunger lode is small and hence the lode has little economic potential.

The alteration zone in which the Jubilee Plunger lode occurs is not discernible from the geophysical results. Apparent resistivities are erratic, though high, reflecting the resistive nature of both the alteration zone and the granodiorite. On the eastern ends of the two extended traverses 600 N and 900 N, increases in chargeability and conductivity indicate a change within the Robin Hood Granodiorite. Apparent resistivities tend to increase with increasing n-spacing of the dipole-dipole array and indicate horizontal layering which may reflect fairly deep weathering of the Robin Hood Granodiorite.

The magnetic results show a complex and irregular pattern of anomalies which may be caused by alteration of iron-bearing minerals in the Robin Hood Granodiorite. The sulphides in the lode do not appear to be magnetic.

The gravity profiles have a strong regional gradient which reflects shallow crustal features rather than near surface local variations in geology.

It is important to note that for mineral exploration in the Georgetown area, the Jubilee Plunger lode is an ideal IP target, being in a resistive zone free of graphite. The fact that a Turam survey did not detect any significant anomaly is indicative of the small volume of massive sulphides present.

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