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RUM JUNGLE EAST TEST GEOPHYSICAL SURVEYS,

NORTHERN TERRITORY 1966 - 1967

by

K. DUCKWORTH, B.B. FARROW and J.E.F. GARDENER

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SUMMARY

Turam, self-potential, induced polarisation, and gravity surveys were made between June 1966 and January 1967 over parts of the Rum Jungle East area to test the usefulness of these methods in the area and particularly to determine their effectiveness in locating orebodies of the L5 type in deep weathering.

The known mineralisation in the Woodcutters L5 Prospect was not detected by the induced polarisation and electromagnetic methods because of the high conductivity of the slates in which the lode occurs. Gravity and self-potential anomalies were revealed close to the position of the lode and may be related to it. The lode produced no magnetic effects.

In the L3 area, electromagnetic and induced polarisation anomalies coincide with the position of previous geochemical anomalies. In the Coomalie Gap West and Huandot North areas, several induced polarisation anomalies were outlined coinciding with electromagnetic anomalies.

Several drill holes are recommended to test the geophysical results.

1. INTRODUCTION

The Rum Jungle East area is situated between fifty and sixty miles south of Darwin and immediately west of the Stuart Highway. It includes Woodcutters, Huandot, and Coomalie Gap West areas, the locations of which are shown in Plate 1.

In 1964 a reconnaissance geochemical survey in the Woodcutters area revealed lead anomalies. These were relocated and surveyed in detail in 1965 and 1966. Diamond-drilling of several of these anomalies commenced in 1966 and continued in 1967. Extensive drilling of the L5 lead anomaly (located between 36E to 40E and 186S to 232S) revealed lead and zinc mineralisation. The geochemical surveys and drilling results have been described by Dodson and Shatwell (1965), Shatwell (1966), and Semple (1967).

In 1964 a reconnaissance Slingram survey was made of the Rum Jungle East area, which outlined strong anomalies in the Huandot North and Coomalie Gap West areas. These areas were then surveyed in detail with Turam and Slingram later in 1964. The Woodcutters area was surveyed with Slingram in 1965 on the close grid established for the geochemical work; a few minor anomalies were located but there was no indication of the presence of mineralisation. The geophysical surveys are described by Duckworth (1966a and b).

The present surveys were designed to test other geophysical methods in the Rum Jungle East area, and particularly to determine whether any method could be used to detect orebodies of the L5 type situated in an environment of deep weathering.

Induced polarisation, Turam, and self-potential surveys were conducted in the Woodcutters area and induced polarisation traverses were read in the Huandot North and Coomalie Gap West areas during the period June to September 1966 by B.B. Farrow. A gravity survey in the Woodcutters area was conducted in September and October 1966 by K. Duckworth. Self-potential, single-point resistance, and radiometric logs of all diamond-drillholes completed in the Woodcutters area in 1966 were made by J.E.F. Gardener during 1966 and early 1967.

Early in 1967 an extended self-potential survey was carried out in the Woodcutters area by J.E.F. Gardener. The results of this work are included in the present report as it is convenient to consider them in relation to the results of the 1966 surveys.

2. GEOLOGY

The geology of the Rum Jungle East area has been described in detail by Dodson and Shatwell (1965) and Shatwell (1966). The geological units present in the area are Golden Dyke Formation and Coomalie Dolomite, both of Lower Proterozoic age. The geology of the Woodcutters area is illustrated in Plate 2.

The Coomalie Dolomite includes coarse-textured biohermal limestone and medium to fine-textured dark grey calcilutite. The calcilutite includes up to ten percent of clay minerals and contains patchy sulphide mineralisation including pyrite, pyrrhotite, and rarely chalcopyrite. Occasionally bands of silicified tremolite schist occur close to the top of the dolomite and are frequently associated with laterite.

The Golden Dyke Formation overlies the Coomalie Dolomite and consists of variable blue-grey siltstone, quartzite, and shale, locally mineralised with sulphides. Abrupt facies changes and lenticularity of bedding occur throughout the area and lenses of impure limestone are locally present as minor intercalations.

In the Woodcutters area, the Golden Dyke Formation is folded into an anticline, which pitches north in the L5 area. There is a reversal of pitch to the north and **at L1 the pitch is to the south.** A nose of Coomalie Dolomite appears in the core of the anticline in the extreme north (L3 area). In the Coomalie Gap West area the rocks dip east at 45° to 75°, with Coomalie Dolomite occurring to the west. Some tight folding and overturning are apparent in exposures of shale and siltstone in the south.

Several faults have been inferred in the Rum Jungle East area. Most of them trend north-east to east-north-east, sub-parallel to the Giants Reef Fault, which lies north-west of the area.

3. FIELD WORK

Surveying

The Rum Jungle East grid was originally pegged in 1964 for the BMR by a contract surveyor employed by the Department of the Interior. A baseline was surveyed at a bearing of $359^{\circ}00'$ from true north and traverses were set off at right angles to it at 2400-ft intervals. The relationship between the Rum Jungle East grid and the TEP mine grid is given by Shatwell (1966, Appendix 2). Geophysical work was done later on traverses 400 ft apart. The traverses in the Huandot North and Coomalie Gap West areas were pegged in 1964 by the geophysical party and the traverses in the Wooductters and L3 areas were pegged in 1965 and 1966 by a surveyor supplied by the Department of the Interior. In the L3 area, grid north had a bearing of $337^{\circ}02'30''$ from true north, and the point 50E/50N on the grid corresponded to 60E/70S on the Rum Jungle East grid.

The locations of the areas are shown in Plate 1.

Induced polarisation

Frequency domain IP measurements were taken with McPhar HPIP equipment with the dipole-dipole electrode configuration and a dipole length of 100 ft, using buried sheets of aluminium foil as current electrodes. Readings were taken with frequencies of 5.0 and 0.3 c/s. Selected traverses were surveyed with the IP method in the L3, L5, Huandot North, and Coomalie Gap West areas (Plate 1).

Electromagnetic

Slingram surveys were done over the Huandot North and Coomalie Gap West areas in 1964 (Duckworth 1966a) and over the Woodcutters area in 1964 and 1965 (Duckworth 1966a and b). ABEM Slingram equipment was used with horizontal co-planar coils 200 ft apart, and with a frequency of 1760 c/s. Readings were taken every 50 ft along traverses.

Turam surveys were done over the Huandot North and Coomalie Gap West areas in 1964 (Duckworth 1966a and b) using ABEM Turam type 1182 equipment. The sources of the primary fields were large horizontal rectangular loops, and the frequency of excitation was 440 c/s. Readings were taken every 50 ft along traverses using horizontal co-planar receiving coils 50 ft apart.

The results from these electromagnetic surveys have been used to assist in the interpretation of the 1966 IP results.

Turam surveys were also done in the L3 and L5 areas during the 1966 test surveys using ABEM Turam type 2S equipment. The sources of primary fields were long grounded cables and frequencies of 220 and 660 c/s were used.

Self-potential

Self-potential readings were first taken during the dry season of 1966 in the L5 area, but were erratic because of poor ground contacts. The work was repeated early in 1967, at the end of the wet season, and reliable readings were easily obtained. The self-potential survey was then extended to cover the L1 area and most of the L5 area. Two or more readings were taken every 50 ft along traverses using a Sharpe ground voltmeter type VP-6 and non-polarising electrodes. Values were considered to be reliable when readings at the same station agreed within 3 millivolts.

Potential differences were reduced relative to a base station at 44E/204S for the southern half of the L5 area, at 48E/200S for the northern half of the L5 area, and at 40E/134S for the L1 area.

Gravity

The gravity work was done using a Worden Gravimeter (serial number W260A) and readings were taken at stations every 100 ft along traverses. The altitudes of stations were determined to within 0.1 ft by means of an optical level. The forward looping technique was used in taking gravity readings, drift checks being made every hour and corrections applied linearly. However, excessive drift and poor closures occasionally occurred.

A bench-mark on the side of the Stuart Highway was selected as the base station for the whole survey. The bench-mark is designated BM51 by the Northern Territory Lands and Survey Branch and datum was selected as 100 ft below its elevation. A density of

2.3 gm/cc was used in the elevation correction.

Geophysical logging of drillholes

Drillholes in the Woodcutters area were probed with a Widco 1000-ft logger, which gave logs of gamma ray activity (using a scintillometer as detector), self-potential, and single-point resistance. Because the Widco logger became temporarily inoperative, drillhole DDH 66-2 was logged for gamma ray activity with a Harwell 1417A logger, which uses a single geiger tube as detector.

4. RESULTS AND INTERPRETATION

Woodcutters L3 area

Turam. Turam work was done over the local grid with a grounded cable along 44N as the source of the primary field. Reduced ratio contours at 220 c/s are shown in Plate 3. Two anomalies, striking across the traverses, occur in the area; the western anomaly is the stronger and closely follows the boundary between the Coomalie Dolomite and the Golden Dyke Formation. The contours are disturbed at the northern end of traverse 50E where the geological map (Plate 4) shows a fault. Reduced ratio values greater than 1.3 occur at the northern end of traverse 54E over the Coomalie Dolomite and may be associated with the faulting. The eastern anomaly is much weaker but quite definite, and, although it displays roughly the same strike as the western anomaly, it is displaced to the south. Estimates based on anomaly half-widths indicate a depth of about 250 ft to the current concentrations that are causing the two anomalies. The low amplitude of the corresponding phase difference anomalies suggests that the sources are highly conducting.

Induced polarisation. Traverses 46E and 58E were read with the IP method and were extended to the north and south for that purpose. The resulting profiles are shown in Plate 3.

The resistivity profile on traverse 46E shows anomalous resistivity 'lows' at 45N and 49N, the second of which corresponds in depth and position to the source of the Turam anomaly. The northern part of the profile shows contours typical of those caused by a steeply dipping contact between rocks of contrasting resistivity; in this case between conductive slate of the Golden Dyke Formation to the south and resistive Coomalie Dolomite to the north. Geological evidence suggests that the contact dips south at about 45° where it crosses the traverse. Frequency effect anomalies with values up to 10% accompany both resistivity anomalies, indicating the presence of metallic mineralisation.

On traverse 58E the resistivity profile shows a broad low resistivity anomaly centred at about 49N, which is the approximate position of the source of the Turam anomaly, and it extends at depth to about 55N. Duckworth (1966b) outlined a Slingram anomaly at this location (Plate 4). Frequency effects up to 9% occur at about 55N but values are lower elsewhere. The metal factor profile however shows anomalies centred at 48N, 51N, and at depth on 55N. The anomalies are attributed to disseminated sulphide mineralisation.

Woodcutters L5 area

Electromagnetic. Eight traverses (200S to 228S) were surveyed using the Turam method with a straight grounded cable along 30E as the source of the primary field. Readings were taken using frequencies of 220 and 660 c/s, and the profiles at 220 c/s are shown in Plate 5. The results are interpreted as indicating an extensive horizontal conductor at depth, with variations in composition which cause minor anomalies. A very low resistivity for the conductor is indicated by the low values for the phase differences.

The L5 area was surveyed with Slingram in 1965 (Duckworth, 1966b). The profiles reproduced in Plate 5 show high real component values over most of the area. Comparison with model experiments shows that this would be caused by a horizontal conductor at a depth of about 150 ft.

The conductor indicated by the electromagnetic results is presumed to be the top of the unweathered, highly conducting slate. Geophysical logging of diamond-drill holes in the Woodcutters area has shown that the slates are highly conducting, and also that the difference in conductivity between the slates and the high-grade mineralisation is very small. The logs of DDH 66-3 (collar 33E/220S; depression 60°E) reproduced in Plate 6 clearly demonstrate this. Electromagnetic methods generally would therefore be influenced by the slates alone, and it is considered that these methods are of no use in defining mineralisation in this environment.

Induced polarisation. Readings were taken on traverses 204S, 208S, and 220S where diamond-drilling had been completed at the time of the survey. The IP and drilling results are shown in Plate 7.

The apparent resistivity profiles indicate a marked decrease in resistivity with increasing depth. Values higher than 250 ohm-metres occur near the surface but decrease to less than 10 ohm-metres at larger dipole separations. There is also a tendency for the lower resistivities to appear closer to the surface at the western ends of the profiles, which is attributed to a decrease in the depth of weathering.

The frequency effect profiles show a generally high frequency effect background with localised regions of higher values. The anomalous regions do not correlate well with the known mineralisation and it is probable that the small effects that mineralisation would produce are masked by the strong effects produced by amphibolite and pyritic carbonaceous slate.

Self-potential. The S-P work revealed anomalies over the length of the area surveyed (Plate 8). Between 200S and 208S the positions of the negative centres coincide with the geochemical lead anomaly, but are slightly east of the known mineralisation. South of 212S the negative centres are west of the geochemical anomaly but coincide with it again on 228S. At about 232S the geochemical and

S-P anomalies follow a more westerly trend.

The promimity of the S-P anomalies to the mineralisation suggests that the source of the S-P anomalies may be the high-grade sulphides. On traverse 208S the S-P anomaly increases very sharply close to an outcrop of gossan, but deeper sources are indicated on other traverses. The true nature of the anomaly sources, however, is still in doubt and further work, both exploration and analytical, is required.

Magnetic. To test if the high-grade sulphide zone could be detected directly using magnetic methods a short magnetic traverse was read over DDH 66-3 (traverse 220S), using an Askania vertical field torsion magnetometer. The profile (Plate 7) shows that the only magnetic anomalies detected were caused by near-surface sources and were not associated with the sulphide zone. The drill core from DDH 66-3 over the mineralised section was later placed, foot by foot, directly under the magnetometer, but was found to be non-magnetic. Six aeromagnetic traverses were flown across the area but these also showed no response over the mineralisation, but gave large anomalies over amphibolite to the west.

Gravity. The gravity results are shown as profiles in Plate 9 and as contours in Plate 10, where the main anomalies are denoted by A, B, C, D, and E. The results have not been corrected for terrain effect, which is generally negligible.

Sample densities were determined of sections of core from drill holes in the L5 area by a water displacement method. Densities for porous, weathered rocks are difficult to assess because of the indeterminate amount of water they contain in situ. The laboratory measurements show that, in general, the mineralised sections have a density of about 4.0 g/cc and the country rock has a mean density of about 3.0 g/cc.

The gravity contours show a strong northerly trend, which agrees with the known geological strike and the trend of the known mineralisation. The edges of the trough separating anomalies C and E correspond with faulting postulated from geological investigations, and it is possible that this same faulting separates the sources of anomalies A and D, which might otherwise be one continuous feature.

Anomaly A corresponds closely to the position of the L5 geochemical lead anomaly and to the position of the lode intersected in the drill holes. Drill hole DDH 66-3 on traverse 220S intersected a wide zone (79 ft) of high density zinc and lead mineralisation at a vertical depth of 430 ft below 36E, that is, below the gravity anomaly on that traverse. The peak of the gravity anomaly occurs on traverse 216S where it has an amplitude of about 0.4 mgal and a half-width of about 400 ft. The anomaly on this traverse is consistent with that due to a near-vertical tabular body with density contrast of 1.0 gm/cc and width of 50 to 100 ft, which does not approach closer than 200 ft to the surface. The assumed density contrast is that between the lode material and country rock as determined from laboratory measurements. In this area, weathering is found by drilling to extend to a depth of more than 200 ft, limiting primary sulphides to below that depth.

Drill hole DDH 66-6 on traverse 216S intersected the lode vertically below the peak of the gravity anomaly. The lode intersected was 20 ft wide and at a vertical depth of 385 ft and from comparison with the assumed theoretical body is not sufficient to fully account for the gravity anomaly.

Further north, on traverses 204S and 208S, where the geochemical anomaly is most pronounced, the gravity anomaly is much weaker but corresponds to a strong S-P anomaly. Drilling on these traverses revealed a sulphide lode with some lead and zinc, which was more weathered than the country rock to a depth of 400 ft. Weathering would preferentially reduce the density of lode material and could account for the weaker gravity anomaly.

On traverse 208S a gossan crops out, which has a higher density than the normal weathered country rock and probably contributes to the steeper gradient shown by the profile along that traverse.

Anomaly D does not correspond to any significant geochemical anomaly, but is associated with an S-P anomaly which covers approximately the same area and has a similar shape. DDH 66-5 (Collared at 37E/192S; depression 60°E) was drilled south of the gravity anomaly but within the S-P anomaly, and intersected 21 ft of pyrite mineralisation at a vertical depth of about 350 ft.

Anomaly B corresponds to neither a geochemical lead anomaly nor to an S-P anomaly, although an S-P anomaly occurs between it and anomaly A. The absence of associated geochemical lead and S-P anomalies does not necessarily rule out the possibility that gravity anomaly B is caused by mineralisation. The mineralisation intersected in DDH 66-3 on traverse 220S is largely zinc sulphide and if anomaly B is caused by a predominantly zinc body, no geochemical lead or S-P anomaly would be expected.

Anomalies C and E also have no associated geochemical lead anomalies. They have not yet been surveyed with the S-P method.

Although anomaly A agrees closely in position with the known lode, there is not sufficient evidence to conclude that this and the other gravity anomalies should be ascribed to mineralisation. The anomalies are of small amplitude and could be caused simply by changes in depth to unweathered rock, and preferential weathering caused by lithological variations. There are, for example, well-defined Slingram anomalies in the region of anomaly B, which would not be expected unless the depth of weathering were shallow. Further drilling would be required to test the significance of these gravity anomalies. If it is assumed that anomalies A and B are caused by bodies of density 4.0 g/cc set in country rock of density 3.0 g/cc, the total masses of the bodies can be calculated using a method described by Parasnis (1966). The calculations indicate that the body causing anomaly A would have a total mass of about 1,800,000 tons and that causing anomaly B 2,800,000 tons. These values apply regardless of the shape of the bodies.

Woodcutters L1 area

An S-P anomaly (Plate 11) was outlined to the south of the geochemical anomaly. A southerly plunge of the anticline has been inferred here from geological considerations, so that, if the S-P source is at the water table, the anomaly would possibly be displaced south of the geochemical anomaly. There is some outcrop in the vicinity and the source of the geochemical anomaly could be well above the water table.

Huandot North area

The IP test survey was confined to traverse 252S (16W to 4W) and traverse 248S (4E to 17E). The results are shown in Plate 12 together with electromagnetic results from previous surveys (Duckworth, 1966a).

From 14W to 9W on traverse 252S, apparent resistivities are all very low at n=2, and less than 1 ohm-metre at n=3 and are associated with a strong frequency effect anomaly. A highly conducting body or series of bodies close to the surface is indicated, which agrees with the interpretation of the electromagnetic results (Duckworth 1966a, p4.) Under these resistivity conditions frequency effects caused by inductive coupling become large; a brief assessment of the effects of inductive coupling here and elsewhere in the Rum Jungle East area is given in an appendix to this report.

Detailed geochemistry and geology have been done on traverse 252S (Shatwell, 1966). No geochemical lead or copper anomaly was found. The outcrops are mapped as limestone west of 9W with slate to the east (Plate 2). The source of the strongest IP anomaly could be sulphides within the limestone or, alternatively, intruded magnetitic basic rocks or pyritic carbonaceous shales within the area mapped as limestone.

On traverse 248S low apparent resistivities are associated with electromagnetic anomalies between 6E and 10E. The apparent resistivity values become lower with increasing dipole separation and are about 2 ohm-metres at n =3. This suggests that the conducting bodies are not as close to the surface as those between 14W and 9W on traverse 252S. Duckworth (1966a) has estimated that the electromagnetic anomalies on traverse 248S are caused by conductors at a depth of between 100 and 150 ft below the surface. Frequency effects are generally high over the traverse with higher values corresponding to lower resistivities.

Detailed geochemistry and geology on this section of the traverse show that the conductors occur in carbonaceous shales of the Golden Dyke Formation, and a minor geochemical lead anomaly occurs at 6E. An outcrop of amphibolite is located to the north and approaches to within 100 ft of the traverse at about 5E. The amphibolite was shown to be magnetic by the airborne survey, and magnetic amphibolites have been shown previously to give high IP effects due to contained magnetite and pyrite (Farrow, 1967). The high frequency effects on the western half of the IP traverse can be partly attributed to this source. IP anomalies could also be expected from the shales and from possible sulphide mineralisation. Duckworth (1966a) has shown that the electromagnetic anomalies persist north and south of the traverse surveyed with IP, and it can be expected that the IP anomalies would do the same.

Coomalie Gap West area

Induced polarisation readings were taken on traverse 348S between 17E and 46E. The resulting profiles are shown in Plate 13 with electromagnetic results from previous surveys.

At the extreme west of the traverse the apparent resistivity profile shows the effect of the contact (at about 18E) between the resistive Coomalie Dolomite and the conductive Golden Dyke Formation. Immediately east of this contact are two electromagnetic anomalies which are attributed to two nearly parallel tabular bodies dipping east at about 50° (Duckworth, 1966a). The IP profiles show low apparent resistivities at the same locations with frequency effects up to 14% indicating metallic mineralisation. The IP and Turam profiles over the contact on this traverse and on traverse 46E in the Woodcutters L3 area (Plate 3) closely resemble those over the Browns orebody (Eadie, 1964, Plate 4), which is itself at a similar contact.

East of 28E the IP profiles show decreasing resistivity with depth, together with increasing frequency effects. The electromagnetic work indicates a series of conductors and the IP results are attributed to a number of steeply dipping beds of conducting shale. The high frequency effects suggest considerable amounts of metallic mineralisation which could be mainly of pyrite or graphite but might also contain concentrations of base metal sulphides.

The electromagnetic anomalies in the area show a strong north-south trend and the IP results are probably representative of most of the area.

Reconnaissance gravity traverses

Three long gravity traverses were read across the Woodcutters area and the resulting profiles are shown in Plate 14.

The profiles show a general decrease in gravity towards the Rum Jungle Granite in the west, but the granite has little effect on the gravity results in the Woodcutters area. Traverses 72S and 120S cross respectively the Woodcutters L1 and L3 geochemical lead anomalies, but there are no well-defined gravity anomalies that could be attributed to massive mineralisation. The results appear to reflect mainly stratigraphic and structural features, and more extensive gravity work may give valuable information on the geological structure in the Rum Jungle East area.

5. CONCLUSIONS AND RECOMMENDATIONS

Woodcutters L3 area

There appear to be two bodies in this area, the one to the west is on the Coomalie Dolomite - Golden Dyke Formation boundary and is in an environment similar to that of Browns orebody. The other body is further from the contact and is set in the Golden Dyke Formation. Three diamond-drill holes are recommended to test these bodies. The locations of the holes are shown in Plate 3 and details are set out below.

Hole	Collar	Direction	Depression	Length
DDH 1	46E/46N	Grid North	60°	500 ft (or to Coomalie Dolomite)
DDH 2	46E/43.3N	" "	60°	450 ft
DDH 3	58E/46.5N	" "	60°	500 ft

Woodcutters L5 area

The electromagnetic, IP, and magnetic methods all failed to detect the mineralisation which had been found by drilling. The S-P method outlined good anomalies but it is not certain that they can be directly attributed to the mineralisation, and further S-P work in the area is desirable. The gravity method can possibly detect sulphide bodies of the type encountered in this area, but other agencies can be responsible for anomalies of the same magnitude. One diamond-drill hole (DDH4) is recommended to test the source of anomaly B and is shown in Plate 10. It should be collared at 28E/224S and drilled at a depression of 60° to the east to a depth of about 500 ft.

Huandot North area

The strong IP anomaly on traverse 252S occurs on limestone of the Golden Dyke Formation and suggests a high degree of metallic mineralisation. A second strong IP anomaly occurs on traverse 248S together with a small goechemical lead anomaly. Both anomalies should be tested by drilling. Details of the recommended drill holes are set out below and their positions are shown in Plate 12.

Hole	Collar	Direction	Depression	Length
DDH 5	9W/252S	West	60°	450 ft
DDH 6	11E/248S	West	60°	450 ft

Further IP work in the area is recommended as the electromagnetic results suggest that the zones of interest have a considerable north-south extent.

Coomalie Gap West area

A series of near-surface conductors with associated IP frequency effect anomalies occur on traverse 348S. The most promising anomalies are those close to the Coomalie Dolomite - Golden Dyke Formation boundary at the western end of the traverse and closely resemble anomalies over Browns orebody. There are, however, no associated geochemical anomalies but the following drill holes are recommended to test the geophysical indications (Plate 13).

Hole	Collar	Direction	Depression	Length
DDH 7	25E/348S	West	60°	500 ft
DDH 8	22E/348S	West	60°	500 ft

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APPENDIX

THE INFLUENCE OF INDUCTIVE COUPLING ON INDUCED POLARISATION MEASUREMENTS IN THE RUM JUNGLE EAST AREA

by B.B. Farrow

The low resistivities encountered in parts of the Rum Jungle East area make it necessary to attempt an assessment of errors in induced polarisation measurements due to inductive coupling between the transmitting and receiving circuits. This coupling results in a frequency dependence in the measurement of resistivity, leading to frequency effects not due to polarisation in the earth.

Madden and Cantwell (1967) have published an approximate formula for the calculation of inductive coupling values for the dipole-dipole configuration on a uniform half space:

Percentage coupling,

$$C_f = \frac{|kl|^3}{6\sqrt{2}} n (n^2 - 1). 100$$

where $k^2 = i\mu\omega/\rho$

l = dipole length (metres)

nl = centre to centre dipole separation (metres)

μ = permeability of medium, assumed to be that of free space

f = frequency (c/s)

ω = $2\pi f$ radians sec^{-1}

ρ = d.c. resistivity (ohm-metres)

The formula is claimed to be valid for the range

$$|knl| < 0.7$$

and where displacement currents are negligible.

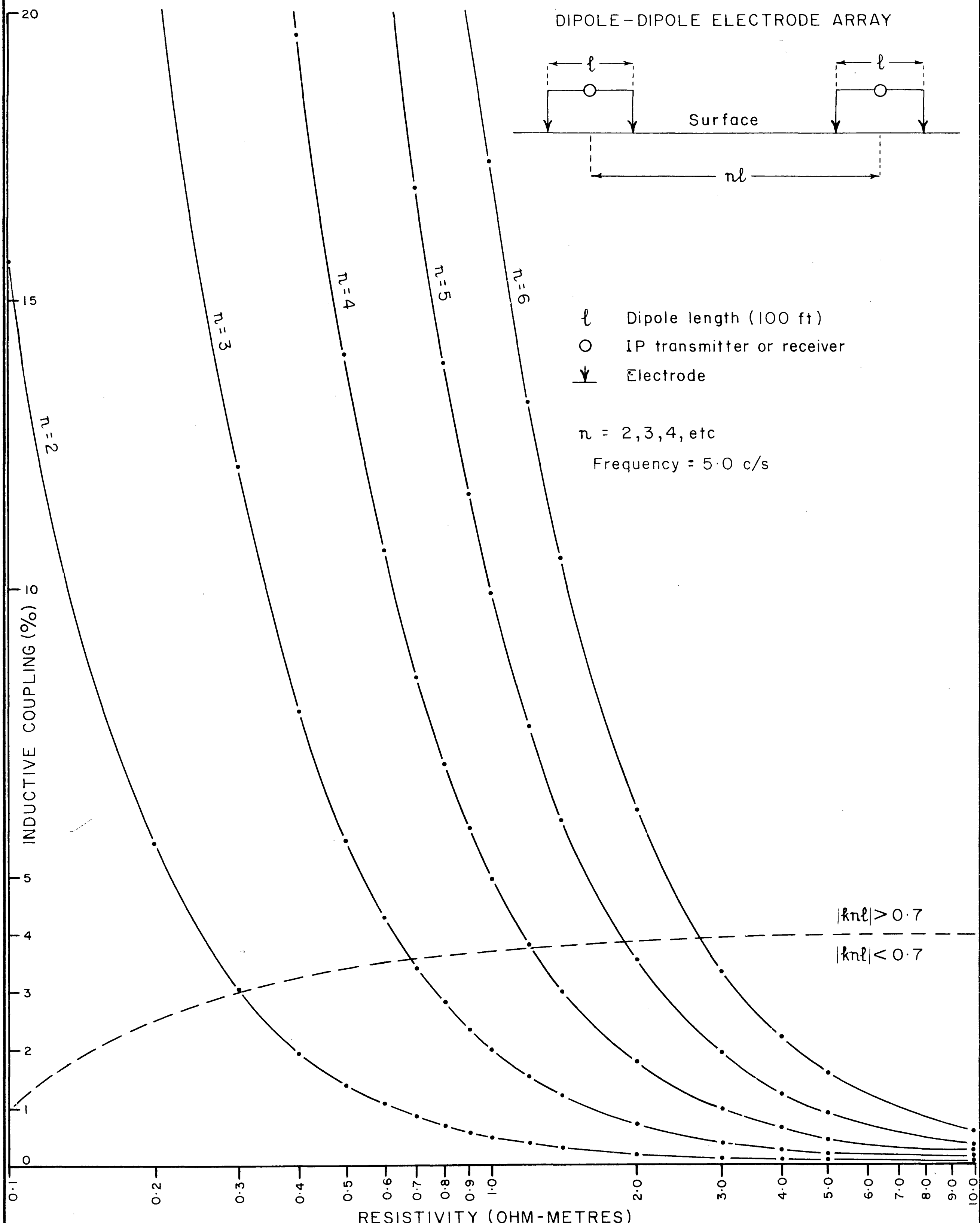
Using a CDC 3600 computer, J. Haigh (pers. comm.) has tabulated values of the percentage coupling as a function of resistivity and n-value for various dipole lengths and frequencies. Part of these tables was used to construct the curves in Figure 1 which apply to the work in the Rum Jungle East area, where a dipole length of 100 ft and a higher frequency of 5.0 c/s were used throughout. Percentage coupling is plotted against resistivity in ohm-metres for various n-values and the region of validity is clearly marked.

The lower frequency was 0.3 c/s and the ratio of the coupling at the two frequencies can be readily calculated:

$$C_{5.0} : C_{0.3} = (5.0)^{3/2} : (0.3)^{3/2}$$
$$\doteqdot 66:1$$

(Facing page 12)

FIG. 1



INDUCTIVE COUPLING CURVES

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RUM JUNGLE EAST, NT, 1966

This means that the coupling at the lower frequency amounts to only 1½% of that at the higher frequency and may be neglected.

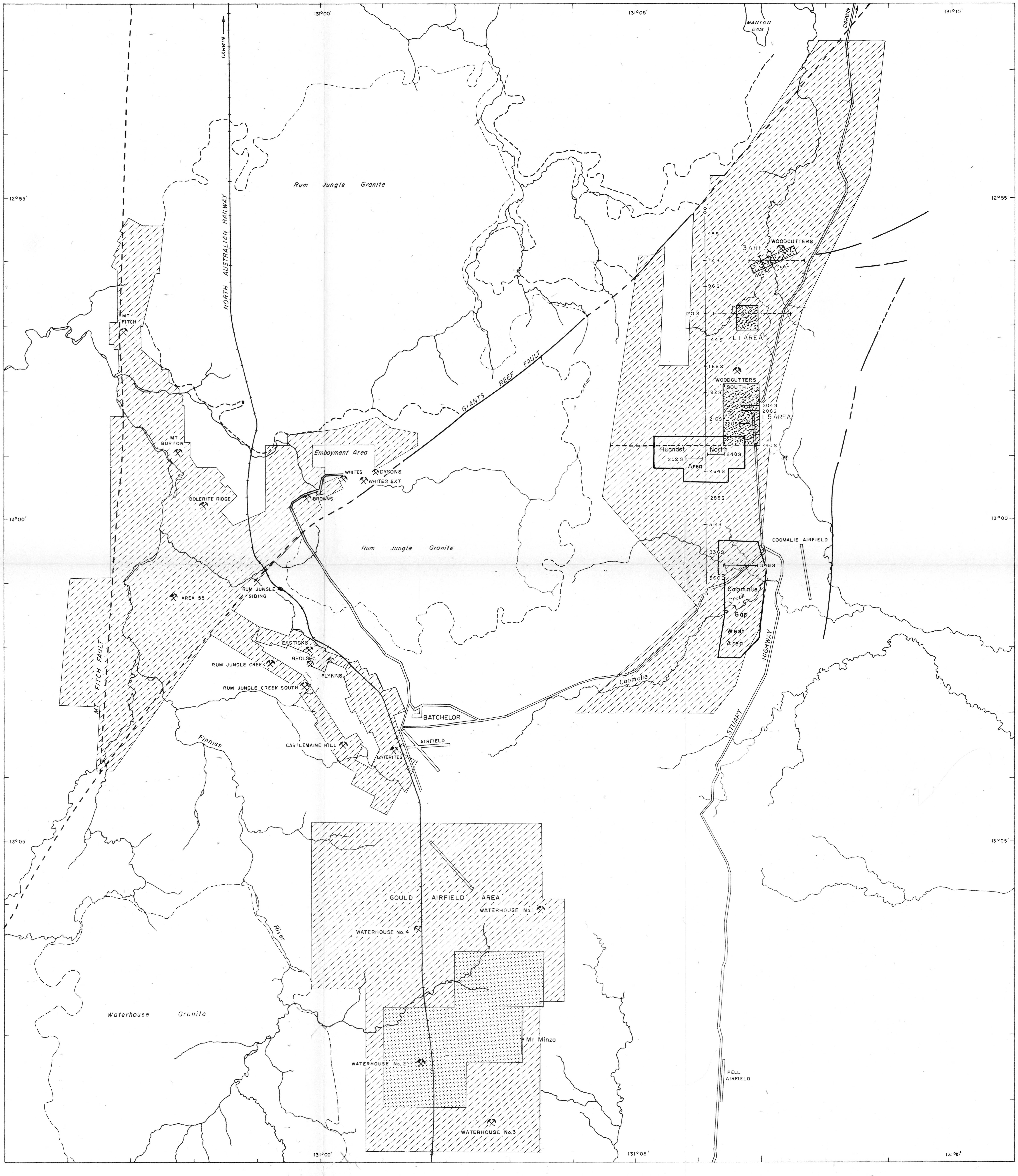
The calculations show that in this case coupling effects are insignificant for resistivities greater than 10 ohm-metres, but it can be seen from the curves that they increase rapidly as the resistivity decreases. Because of the approximate nature of the formula used and the fact that in practice the earth is not uniform, values taken from the curve are regarded only as a guide to the order of magnitude of coupling to be expected for a given apparent resistivity, and cannot be used to correct the field measurements except in special circumstances.

In the Rum Jungle East area apparent resistivities of less than 10 ohm-metres are frequently encountered. In the L3 and L5 areas, coupling effects due to low resistivities are all less than 1% for n-values up to 5 and for most readings at n = 6 and are everywhere less than 2%. Evidently, in these areas coupling effects have not seriously affected the induced polarisation readings. However, in parts of the Coomalie Gap West area, apparent resistivities as low as 1.3 ohm-metres are encountered, and coupling becomes more significant, with magnitudes approaching 5%. But because instances where they rise above 2½% are relatively few, coupling effects alter the results only to a minor extent. In the profiles shown in Plate 13, frequency effect values are shown in parentheses where estimated coupling effects exceed 2½%. Similar conditions occur on traverse 248S in the Huandot North area, and high coupling effects are shown in the same way on the profiles in Plate 12. However, on traverse 252S, the lowest apparent resistivities recorded in the Rum Jungle East area are encountered, being less than 0.5 ohm-metres. Coupling effects are expected to be large, and reference to the curves indicates values as high as 10%.

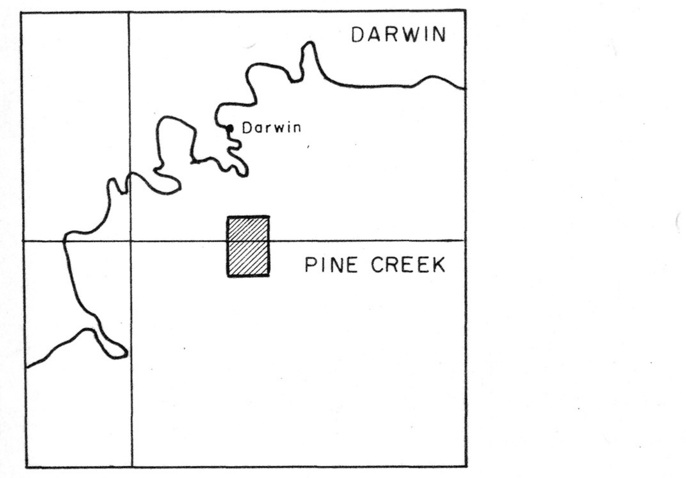
In this case, field readings are not very reliable, but there is little doubt that there is a substantial frequency effect anomaly present on this traverse, because, even when coupling effects are low at n = 2, high values are recorded. In order to obtain more satisfactory results in these conditions, it would be necessary to lower the two frequencies at which measurements are made, for example, if the upper frequency were reduced to 1.0 c/s, maximum coupling at n = 3 would be less than 2%. This would be sufficient because, with such low resistivities, it would be impossible to take readings at higher n-values owing to the limitations of the equipment.

It can be concluded, therefore, that errors in induced polarisation measurements caused by inductive coupling in the Rum Jungle East area are generally not serious inasmuch as they do not render the interpretation of anomalies invalid, but it is important to realise that these errors exist, and to make some assessment of their magnitude.

PLATE I



LOCALITY MAP



REFERENCE TO AUSTRALIA 1:250,000 STANDARD MAP SERIES

LEGEND

- HIGHWAY
- RAILWAY
- FAULT
- MINE OR PROSPECT
- GEOLOGICAL BOUNDARY
- RIVER OR STREAM
- GEOCHEMICAL AND GEOPHYSICAL SURVEY AREAS UP TO 1965
- MOUNT MINZA - GOULD GEOPHYSICAL SURVEY AREA 1966
- RUM JUNGLE EAST TEST SURVEY AREAS 1966
- INDUCED POLARISATION TRAVERSE
- GRAVITY TRAVERSE

SCALE

1 0 1 2 MILES

RUM JUNGLE EAST
TEST GEOPHYSICAL SURVEYS
NORTHERN TERRITORY 1966-1967
LOCALITY MAP

BASED ON D52/B7-191 and 215

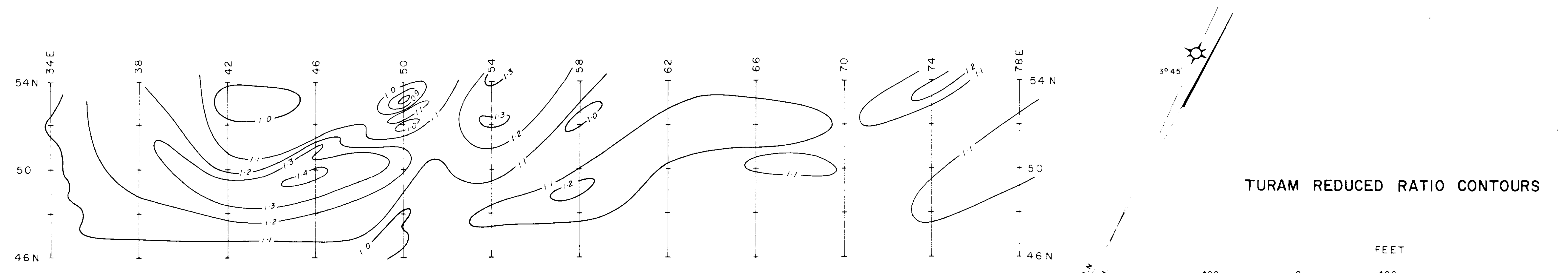
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

To Accompany Record No. 1968/45

D52/B7-225

Plate 2

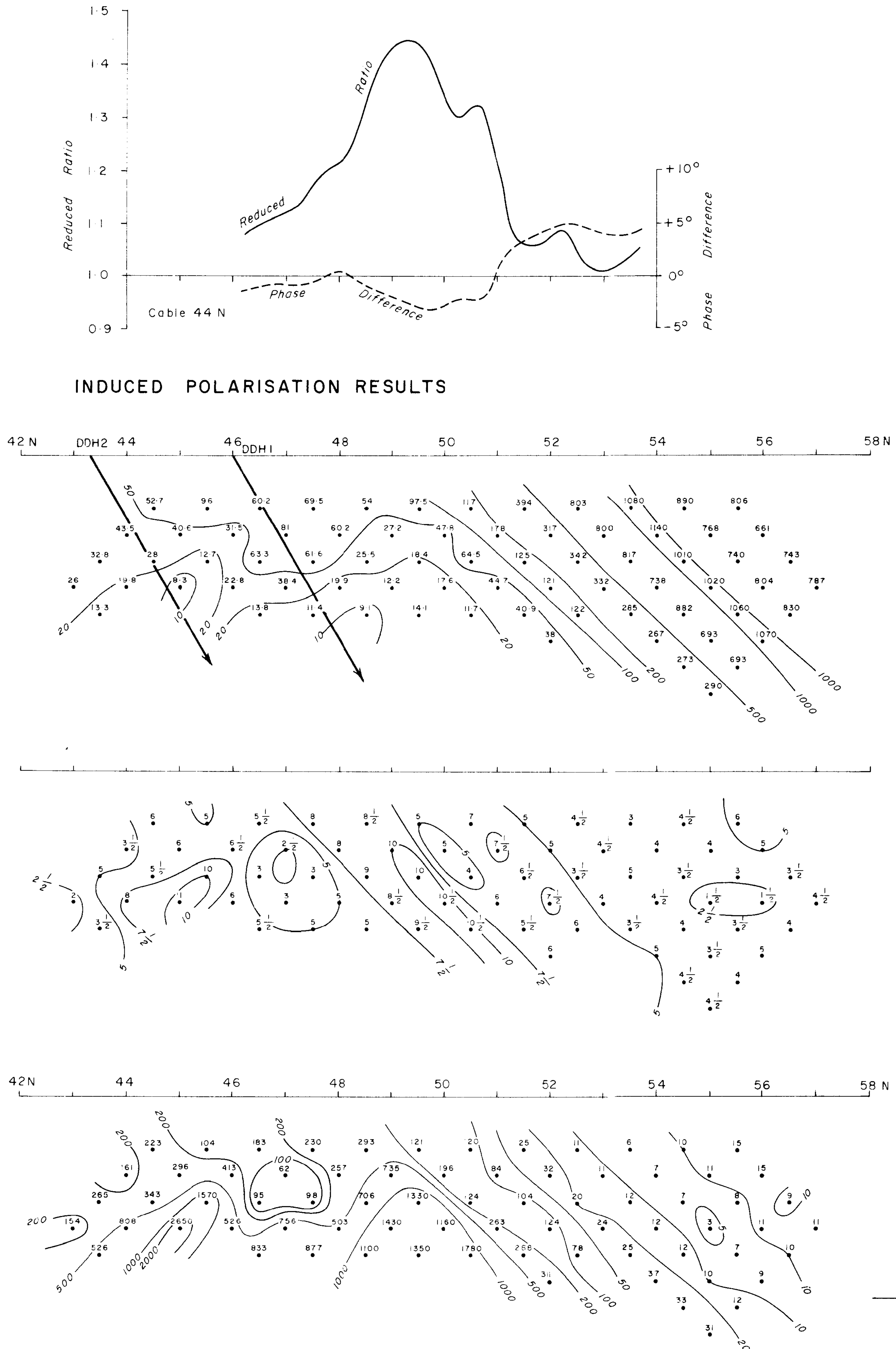
WOODCUTTERS AREA, NT
GEOLOGY, ELECTROMAGNETIC AXES, GEOCHEMICAL ANOMALIES AND RADIOMETRIC CONTOURS
Reference
Laterite
LOWER PROTEROZOIC
Golden Dyke Formation
Pld
Black shale
Amphibolite and chloritic schist
Pyritic quartzitic sandstone
Siltstone
Limestone
Coomalie Dolomite
Plo
Lithological boundary
Outcrop boundary
Fault · broken line position approximate
Quartz vein
Gossan
Dip and strike of bedding
Costean
Vehicle track
Slingram anomaly axis (1965)
Turam anomaly axis (1964)
Lead contours at 100, 200, 400 ppm.
Copper contours at 150, 300 ppm
Auger samples
Radiometric contours at ·025, 030 mR/hr
(Maximum values in auger holes)
66-7
Diamond-drill hole
SCALE
400 0 400 800 1200 FEET
Rifle Range
Woodcutter's Track
Woodcutter's South Track
STUART HIGHWAY
Pyrite
Cerussite
Under cultivation
Port Hueddol North Grid 1964
L1
L2
L3
L4
L5
L6
R1
R2
R3
R4
C1
To Accompany Record No. 1968/45
D52/B7—359
(BASED ON D52/A/72)



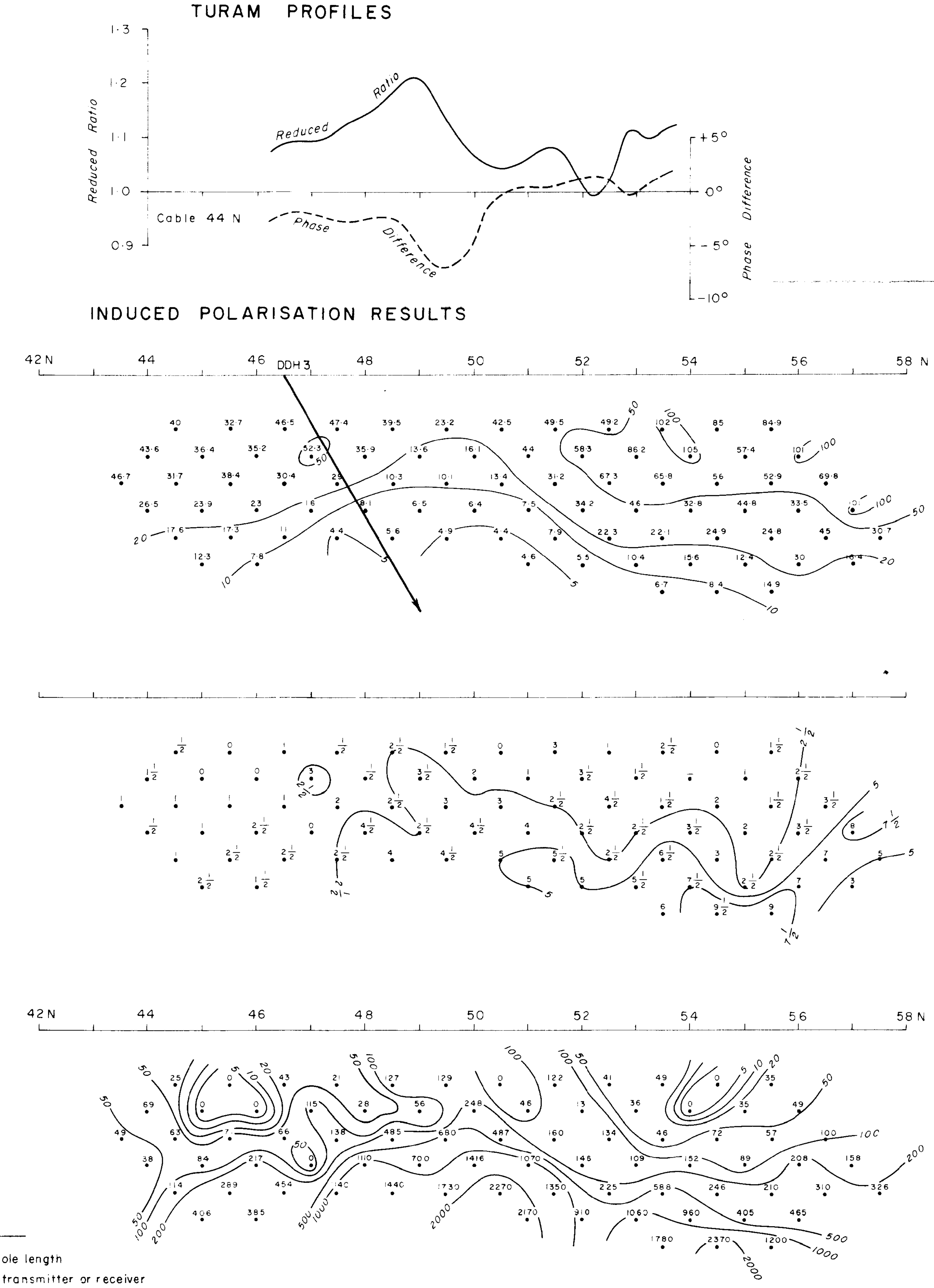
TURAM REDUCED RATIO CONTOURS

FEET 400 0 400 800 1200

TRAVERSE 46 E



TRAVERSE 58 E

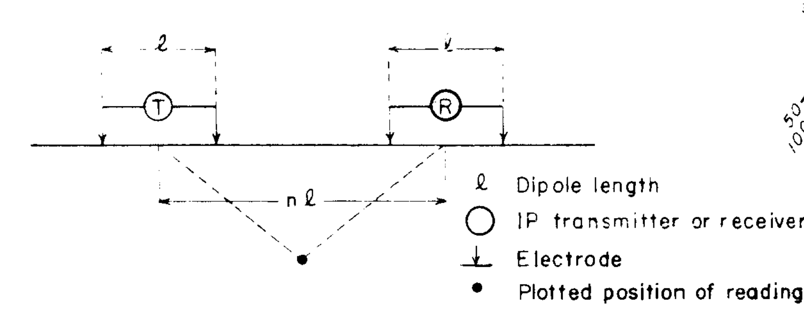


APPARENT RESISTIVITY
(ohm - metres)

FREQUENCY EFFECT
(%)

METAL FACTOR

DIPOLE-DIPOLE ELECTRODE ARRAY



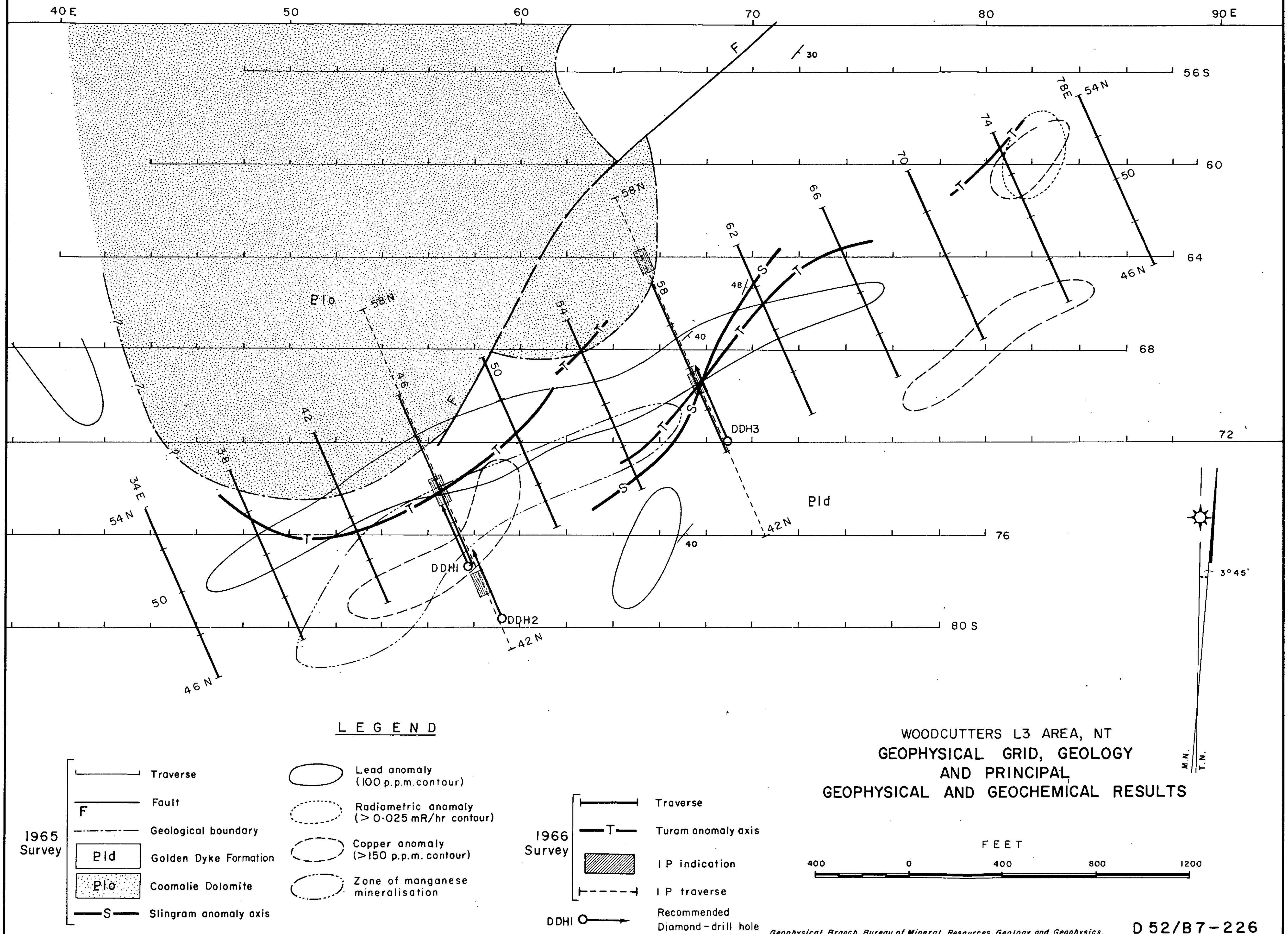
FEET 200 0 200 400 600

LEGEND

TURAM : Frequency 220 c/s, coil separation 50 ft, primary field cable 44 N
I P : Dipole length 100 ft, frequencies 0·3 c/s and 5 c/s
DDH3 ⟶ Recommended Diamond-drill hole

WOODCUTTERS L3 AREA, NT
TRAVERSES 46E AND 58E
TURAM REDUCED RATIO CONTOURS AND PROFILES, AND IP RESULTS

PLATE 4



WOODCUTTERS L3 AREA, NT

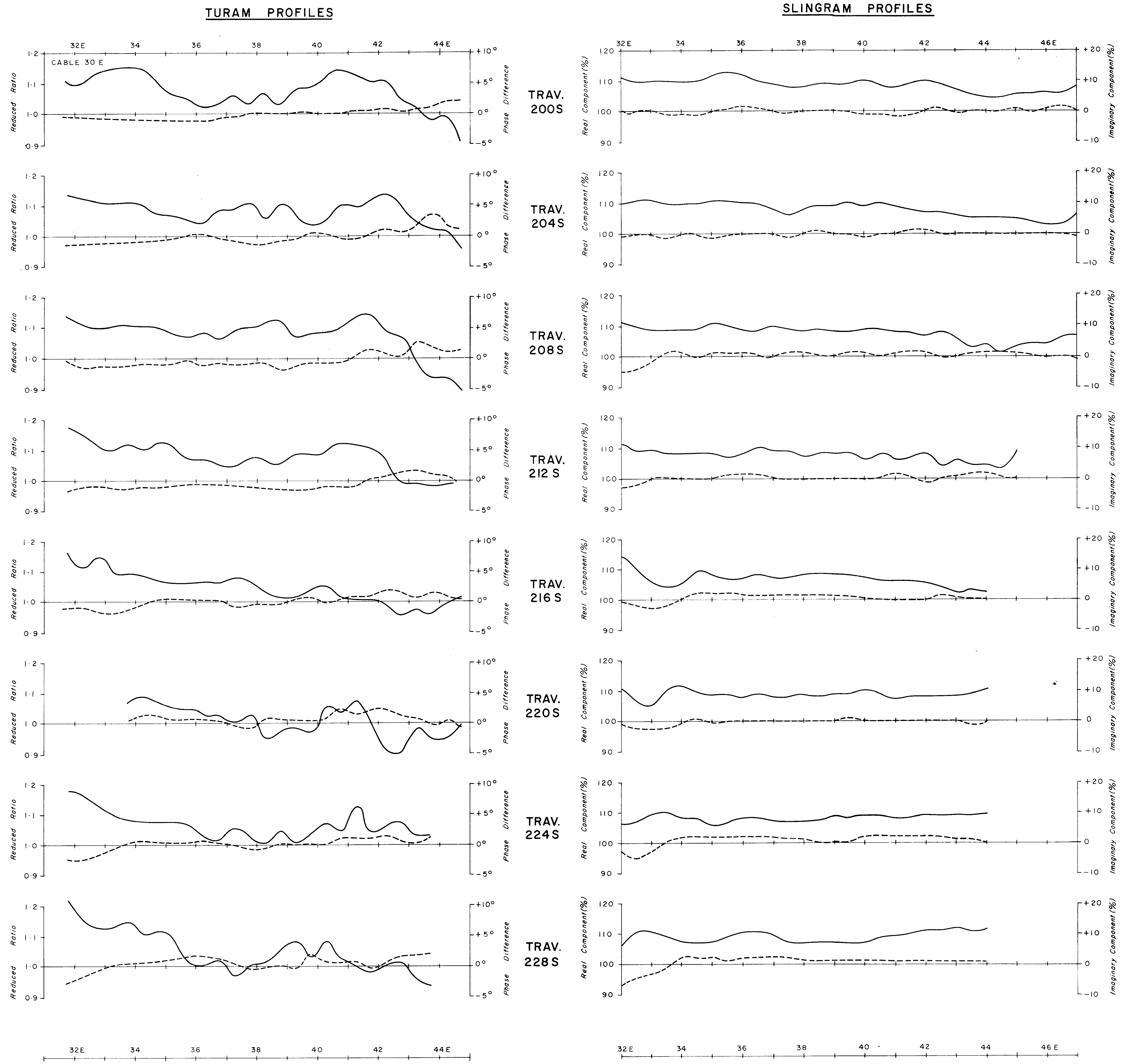
GEOPHYSICAL GRID, GEOLOGY AND PRINCIPAL GEOPHYSICAL AND GEOCHEMICAL RESULTS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

D 52/B7-226

To Accompany Record No. 1968/45

Rum Jungle East Test, Geophysical Surveys 1966. N.T.



LEGEND

———— Reduced Ratio or Real Component

- - - - - Phase Difference or Imaginary Component

TURAM : 220 c/s, 50 ft coil separation. Primary Field Cable 30 E

SLINGRAM : 1760 c/s, 200 ft coil separation

WOODCUTTERS L5 AREA, N.T.
TURAM & SLINGRAM PROFILES

FEET

200 0 200 400 600

To Accompany Record No. 1968/45

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

D 52/B7-229

PLATE 6

WOODCUTTERS L5 AREA, NT
RESISTANCE & RADIOMETRIC LOGS
OF DDH 66-3

Scales: As shown

To Accompany Record No. 1968/45 *Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.* D52/B7-230

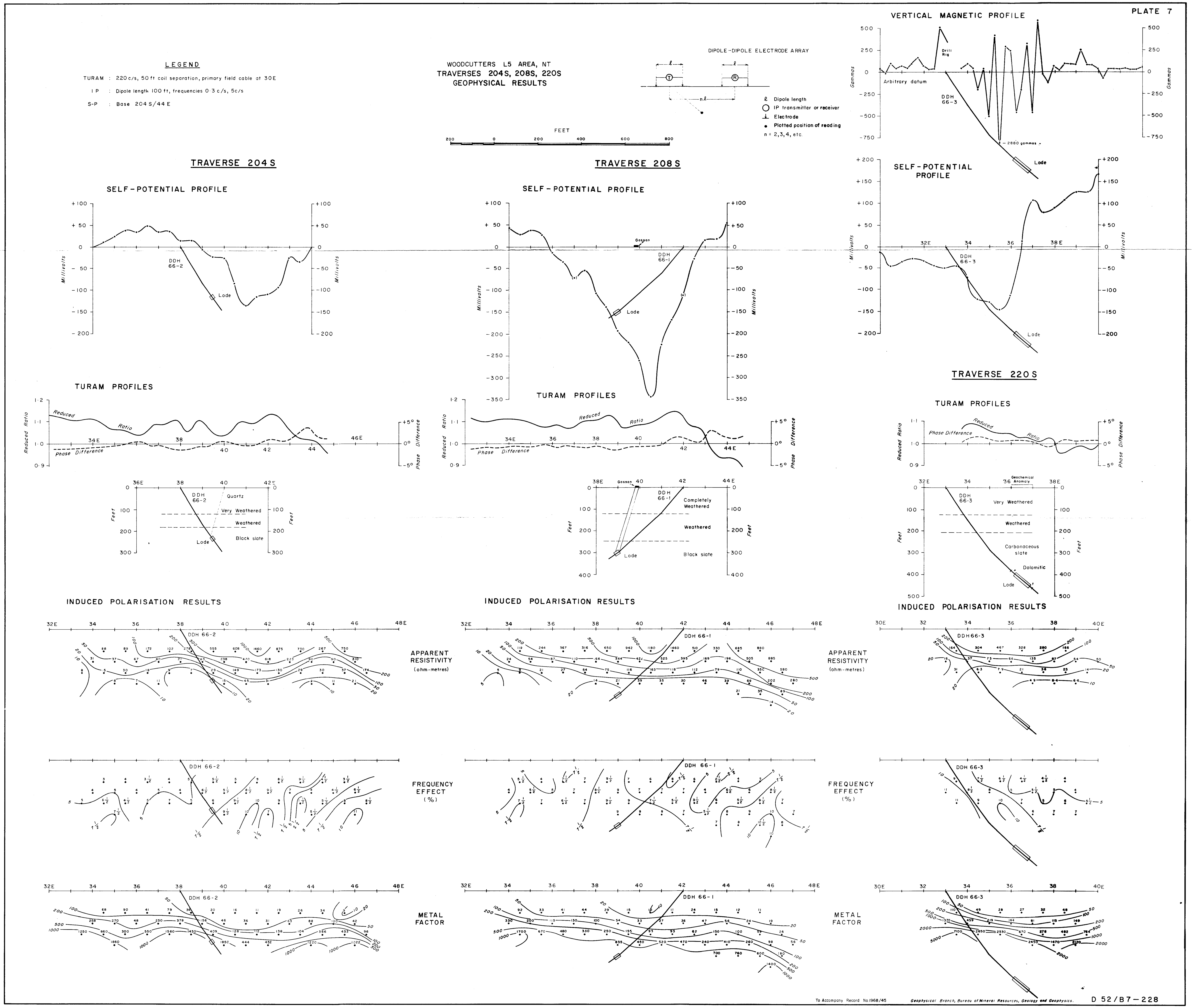
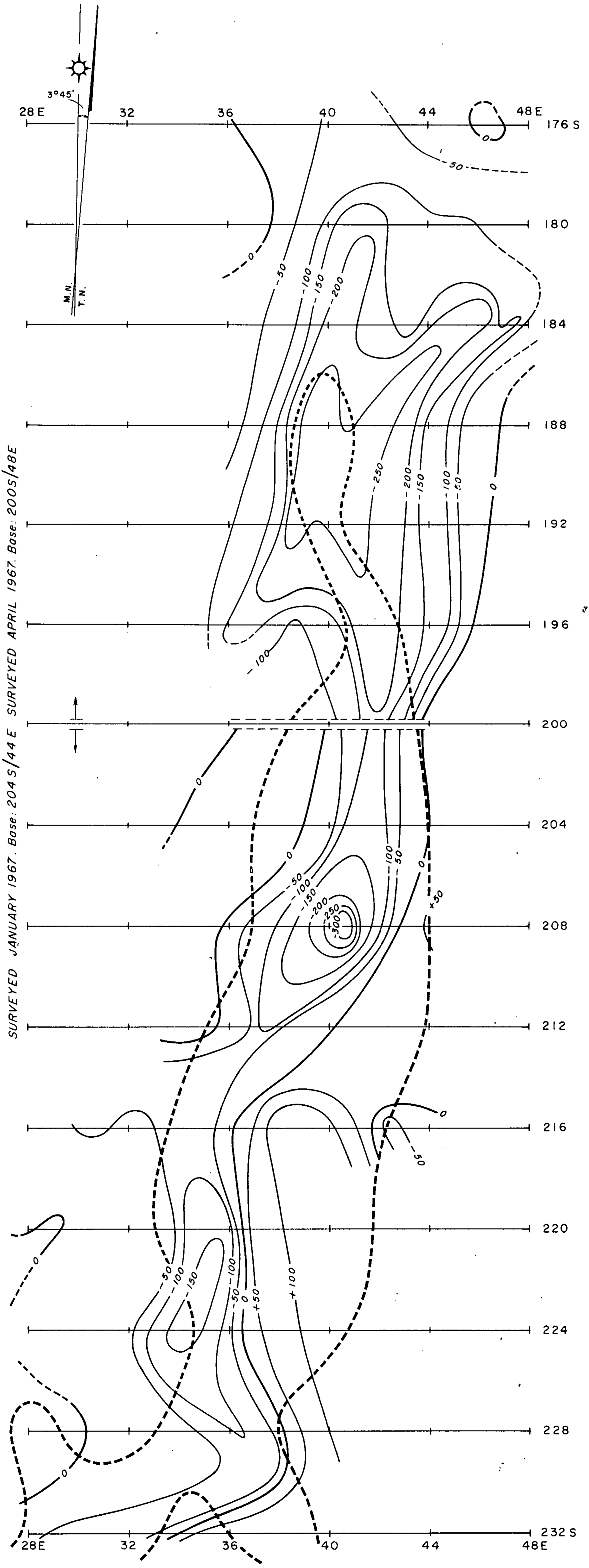


PLATE 7
LEGEND
TURAM : 220 c/s, 50 ft coil separation, primary field cable at 30E
IP : Dipole length 100 ft, frequencies 0·3 c/s, 5c/s
S-P : Base 204 S/44 E
WOODCUTTERS L5 AREA, NT
TRAVERSES 204S, 208S, 220S
GEOPHYSICAL RESULTS
DIPOLE-DIPOLE ELECTRODE ARRAY
ℓ Dipole length
IP transmitter or receiver
Electrode
Plotted position of reading
n = 2, 3, 4, etc.
FEET
VERTICAL MAGNETIC PROFILE
Arbitrary datum
Drill Rig
Gammas
TRAVERSE 204 S
TRAVERSE 208 S
TRAVERSE 220 S
SELF-POTENTIAL PROFILE
Millivolts
Gossan
DDH 66-1
DDH 66-2
DDH 66-3
Lode
TURAM PROFILES
Reduced Ratio
Phase Difference
Quartz
Very Weathered
Weathered
Black slate
Completely Weathered
Carbonaceous slate
Dolomitic
Geochemical Anomaly
Feet
INDUCED POLARISATION RESULTS
APPARENT RESISTIVITY (ohm-metres)
FREQUENCY EFFECT (%)
METAL FACTOR
To Accompany Record No. 1968/45
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.
D 52/B7-228



WOODCUTTERS L5 AREA, NT
SELF-POTENTIAL CONTOURS

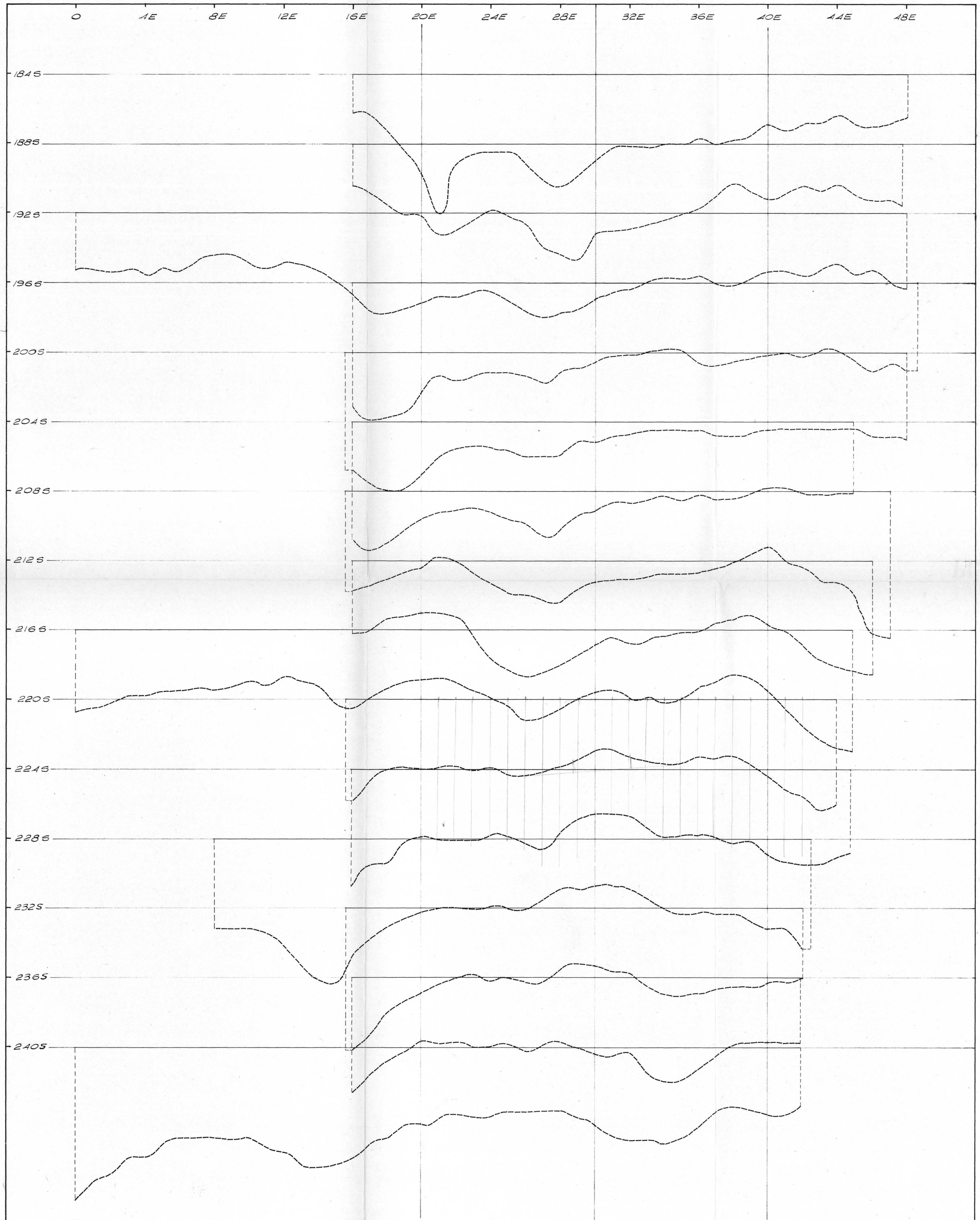
FEET
400 0 400 800 1200

Contour interval 50 millivolts

100 p.p.m geochemical lead contour (after Shatwell, 1966)

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. D52/B7-231

To Accompany Record No. 1968/45



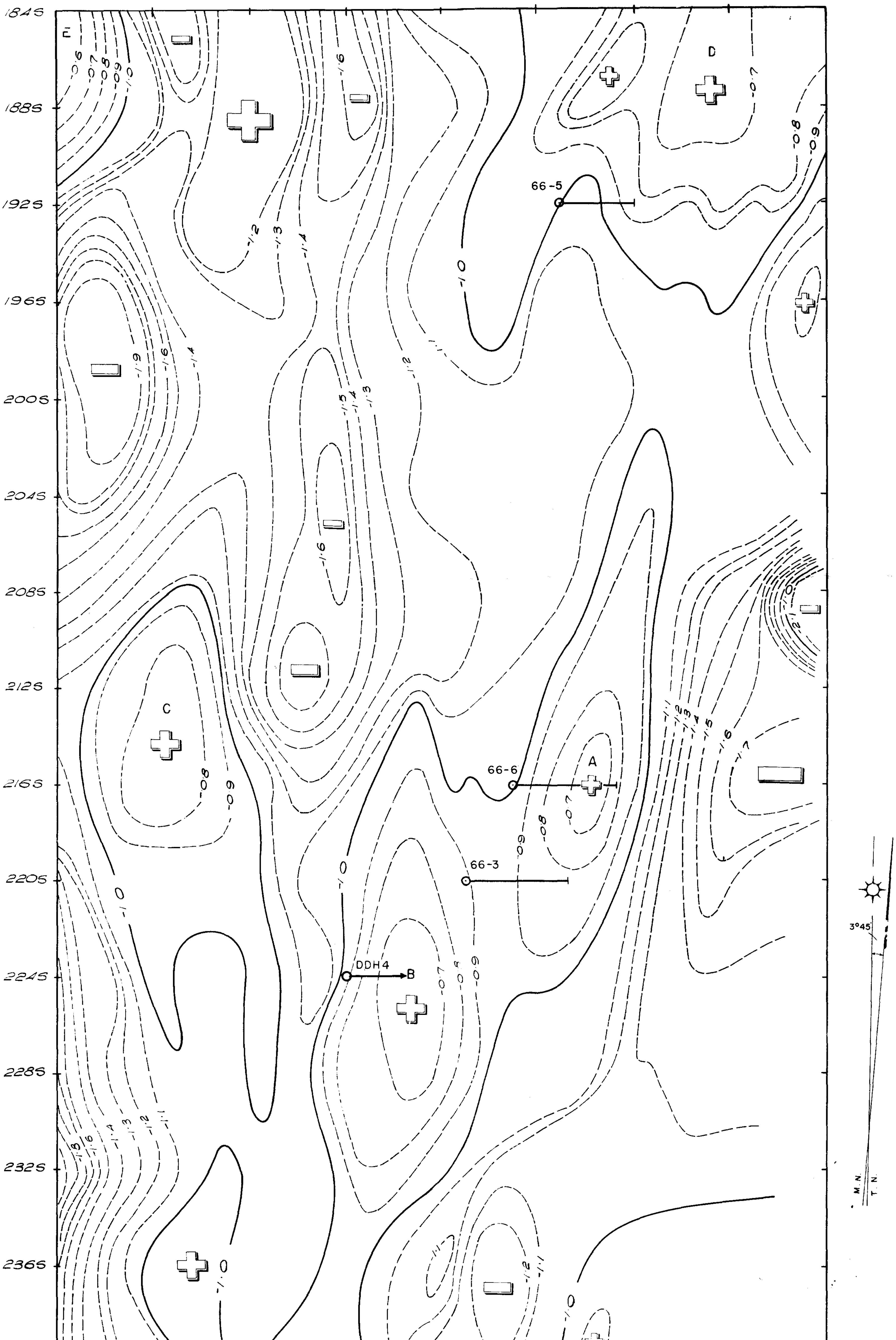
WOODCUTTERS L5 AREA, NT
GRAVITY PROFILES

Horizontal 400 0 400 800 1200 1600 Feet
Vertical 1 0 1 2 3 4 Milligals

To Accompany Record No.1968/45

Bureau of Mineral Resources, Geology and Geophysics, Darwin, October 1966

D 52/B7-233



"High" anomaly

"Low" anomaly

DDH4 Recommended Diamond-drill hole

66-3 Existing Diamond-drill hole

WOODCUTTERS L5 AREA, NT

GRAVITY CONTOURS

FEET

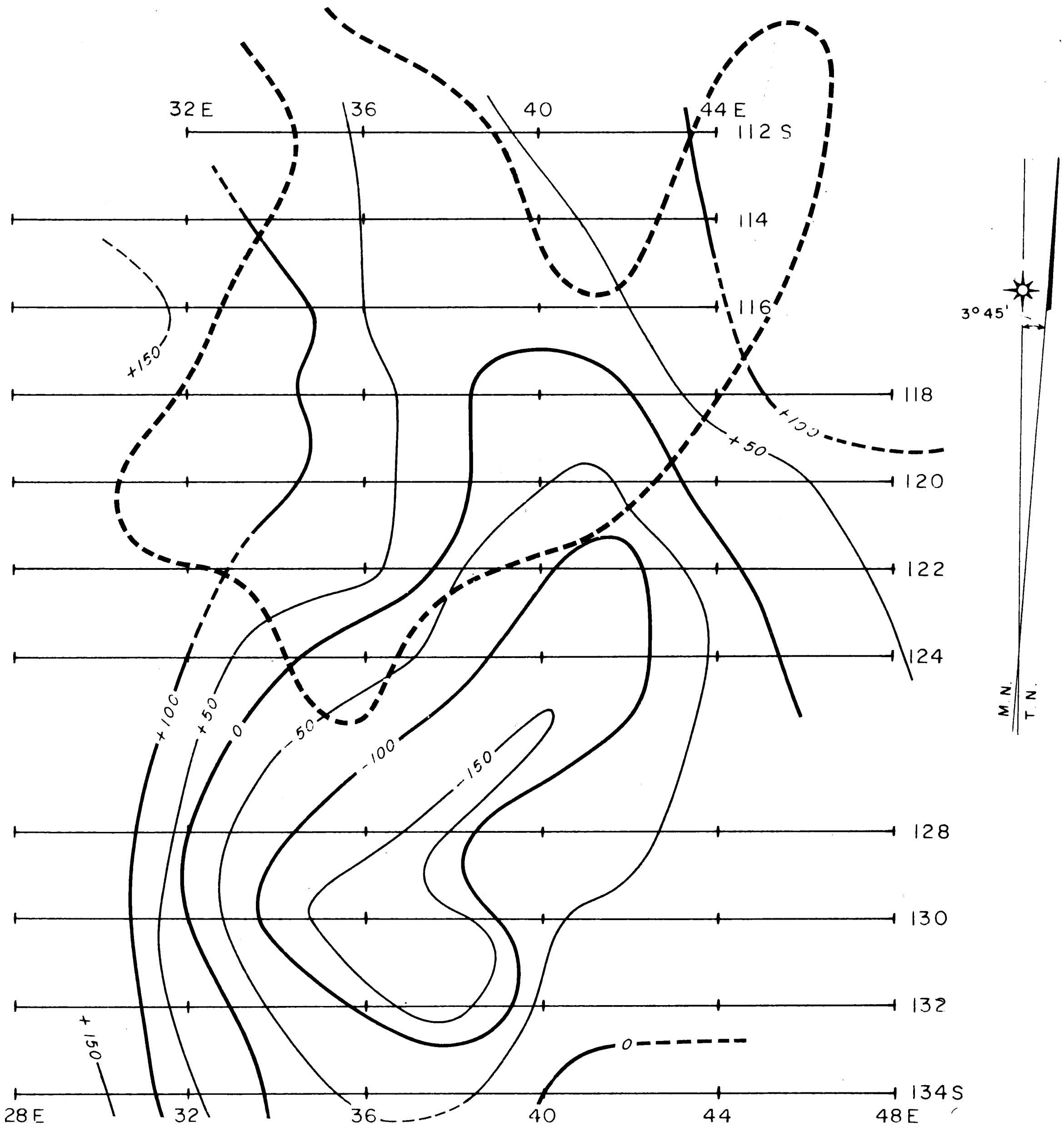
400 0 400 800 1200

Contour interval 0·1 milligal

To Accompany Record No. 1968/45 Bureau of Mineral Resources, Geology and Geophysics. Darwin October 1966.

D 52/B 7-235

PLATE II



WOODCUTTERS L1 AREA, NT

SELF-POTENTIAL CONTOURS

BASE: 134S/40E

FEET

400 0 400 800 1200

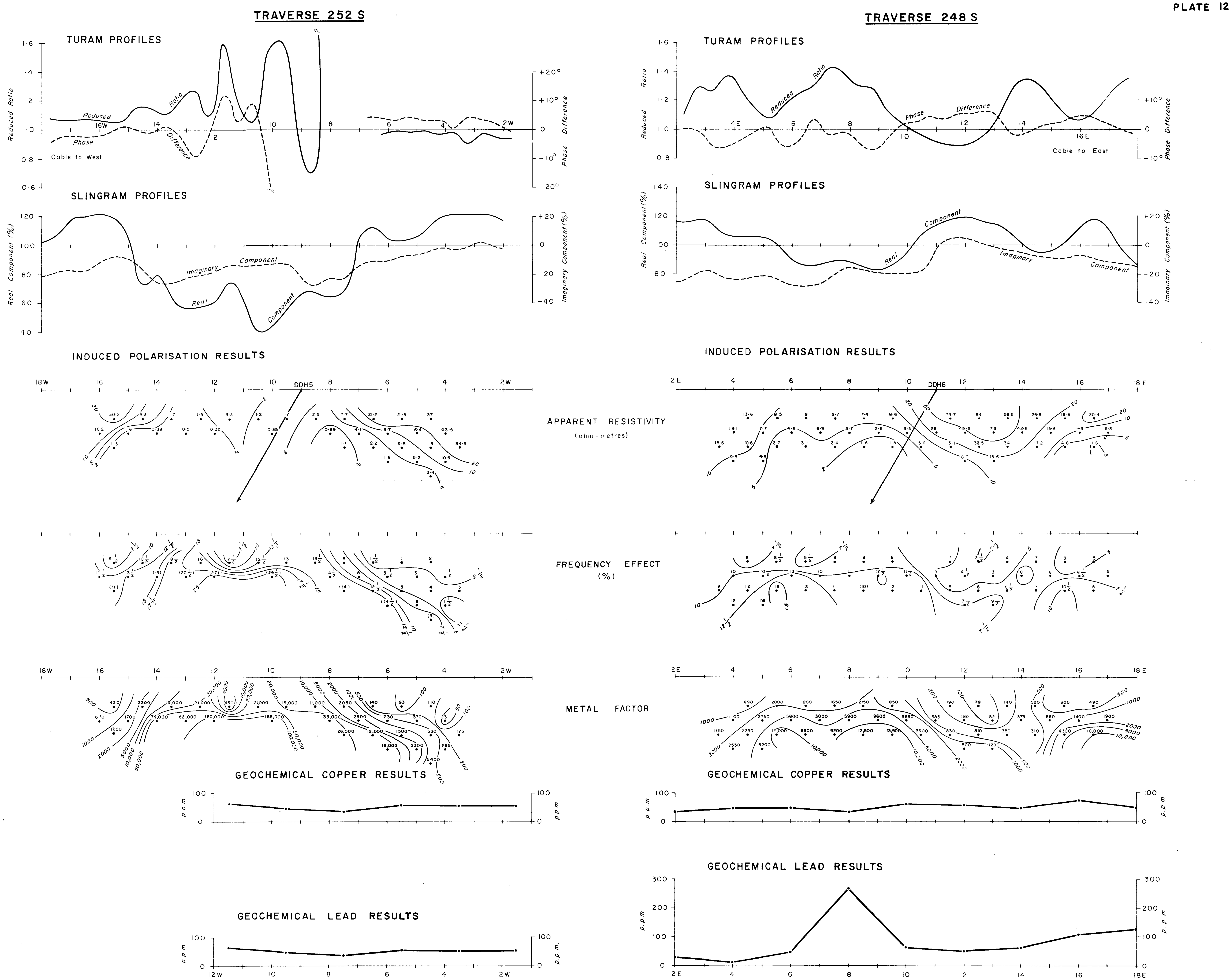
Contour interval 50 millivolts

100 p.p.m. geochemical lead contour (after Shatwell, 1966)

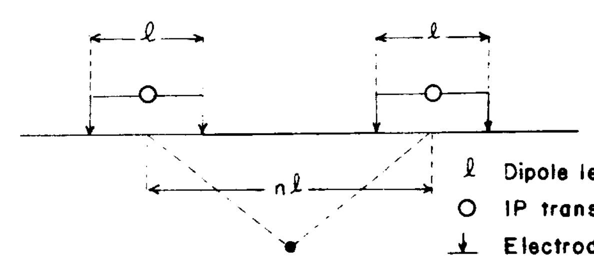
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B7-232

To Accompany Record No. 1968/45

PLATE 12



DIPOLE-DIPOLE ELECTRODE ARRAY



ℓ Dipole length
O IP transmitter or receiver
Electrode
• Plotted position of reading
n = 2, 3, 4, etc.

HUANDOT NORTH AREA, NT
GEOPHYSICAL AND GEOCHEMICAL PROFILES

FEET
200 0 200 400 600

LEGEND

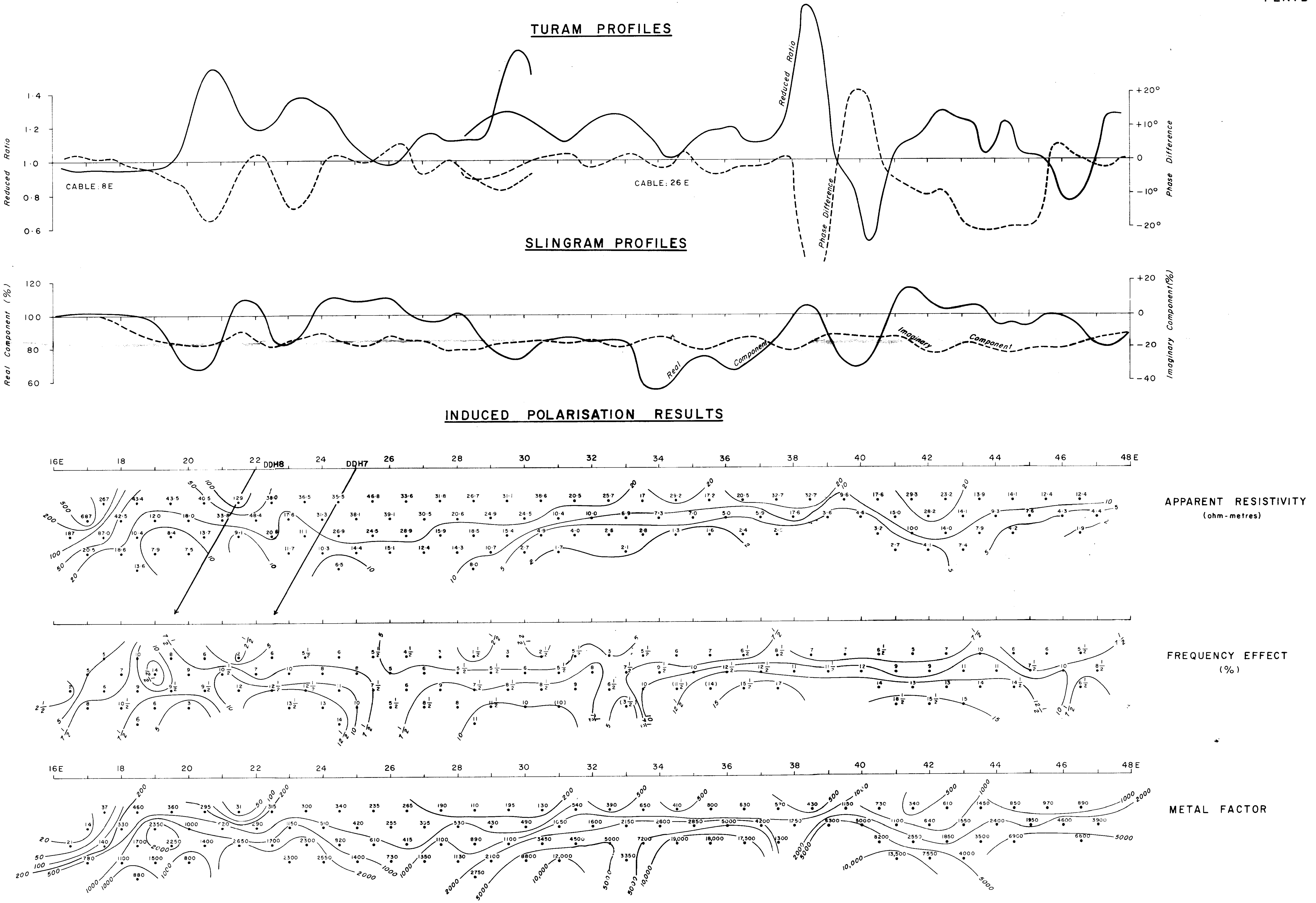
(15) • : Estimated coupling effects greater than $2\frac{1}{2}$ %
TURAM : Frequency 440 c/s, coil separation 50 ft
SLINGRAM : Frequency 1760 c/s, coil separation 200 ft
I P : Dipole length 100 ft, frequencies 0·3 c/s and 5 c/s
DDH5 → : Recommended Diamond-drill hole

To Accompany Record No. 1968/45

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

D 52/B7-237

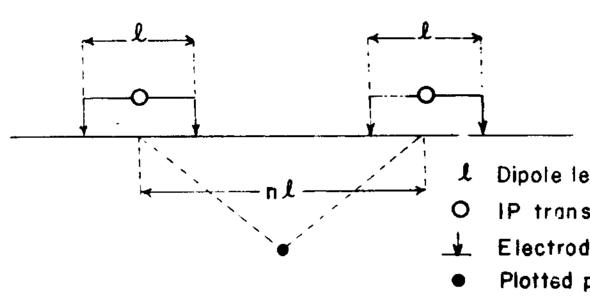
Rum Jungle East Test, Geophysical Survey 1966, N.T.



LEGEND

- (10) • : Estimated coupling effects greater than $2\frac{1}{2}$ %
- TURAM : Frequency 440 c/s, coil separation 50 ft, primary field cables 8E and 26E
- SLINGRAM : Frequency 1760 c/s, coil separation 200 ft
- I P : Dipole length 100 ft, frequencies 0·3 c/s and 5 c/s
- DDH ⟶ : Recommended Diamond-drill hole

DIPOLE–DIPOLE ELECTRODE ARRAY



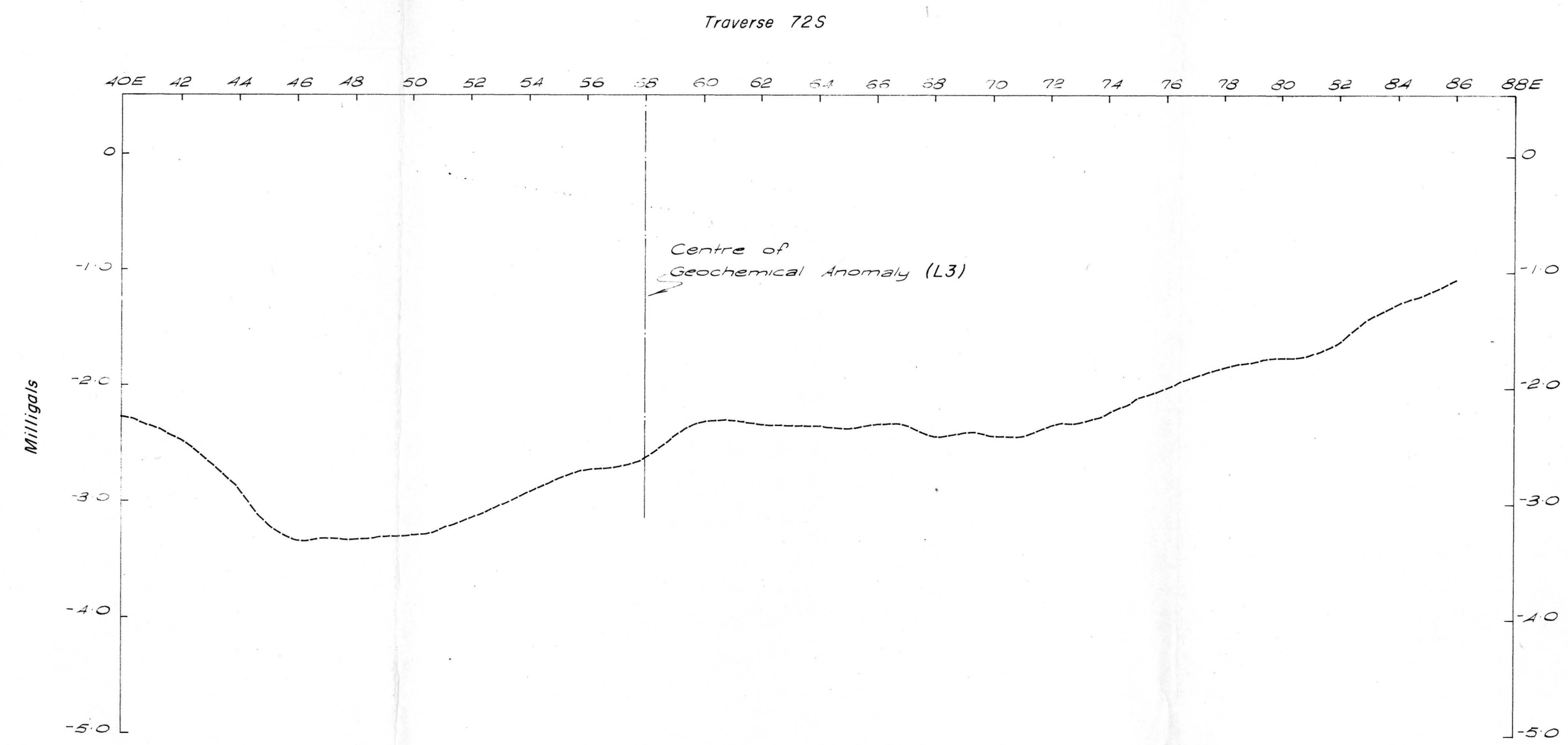
- ℓ Dipole length
- O IP transmitter or receiver
- Electrode
- • Plotted position of reading
- n = 2, 3, 4, etc.

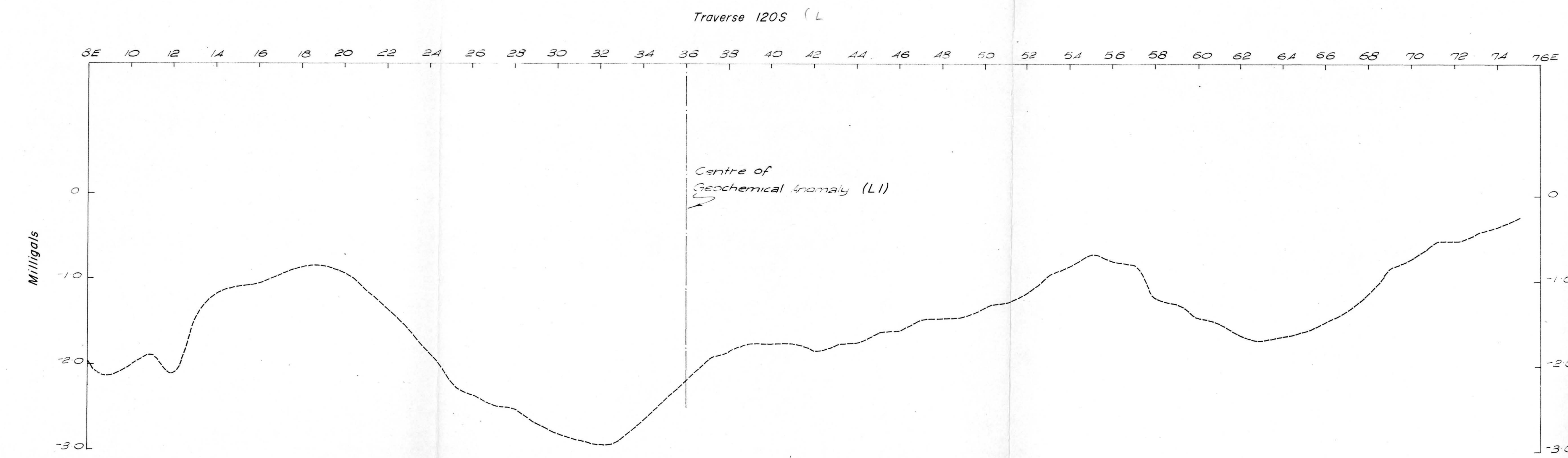
COOMALIE GAP WEST AREA, NT

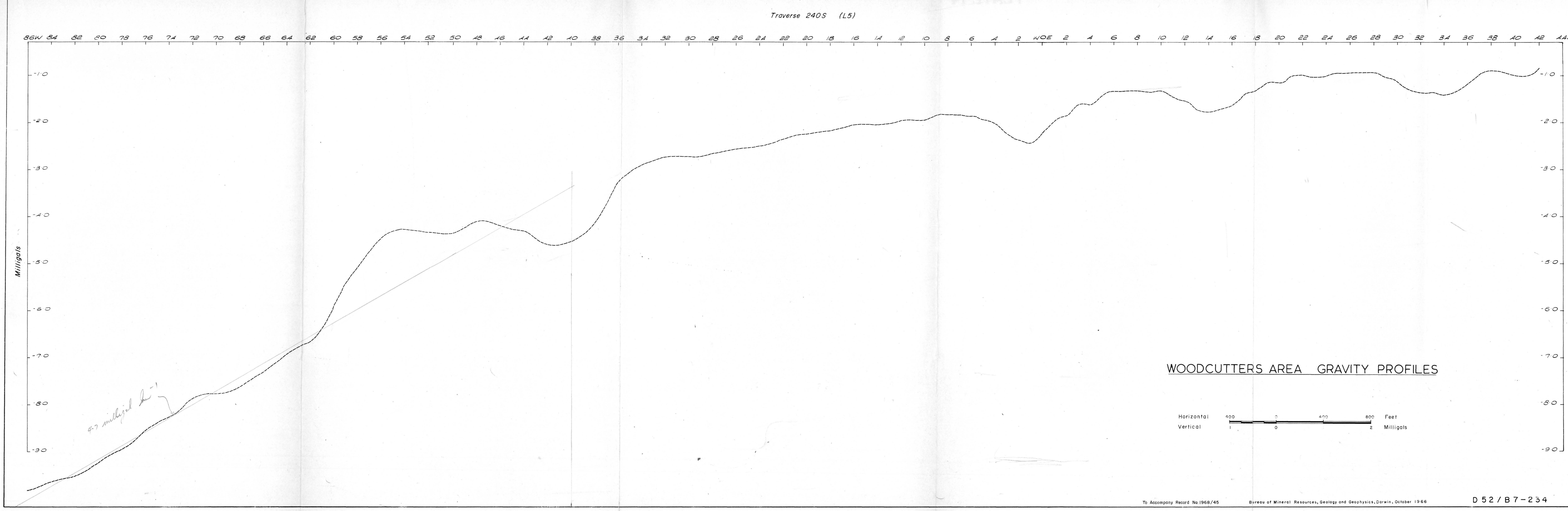
TRAVERSE 348S GEOPHYSICAL RESULTS

FEET

200 0 200 400 600







WOODCUTTERS AREA GRAVITY PROFILES

Horizontal 400 0 400 800 Feet
Vertical 1 0 2 Milligals