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MARY RIVER AREA GEOPHYSICAL SURVEY, NORTHERN TERRITORY, 1972

by

F.N. Michail

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SUMMARY

Between 1967 and 1971, the Bureau of Mineral Resources made a series of brief geophysical surveys in Government Mining Reserve No. 275 in the Mary River area, Northern Territory. In 1972 an attempt was made to rationalize earlier work with a new concerted approach. A detailed low-level aeromagnetic survey was flown, and ground geophysical surveys were made in two areas selected from the aeromagnetic data and in two areas where lead-zinc mineralization was known to occur. Magnetic, gravity, electromagnetic, and self-potential methods were used to establish the response from known mineralization and to make reconnaissance surveys in the areas where aeromagnetic data suggested that favourable structural control might host sulphide mineralization.

The results indicate that gravity is the only method which can detect the mineralization in the Mary River area but the usefulness of the method is severely restricted by the unfavourable terrain.

Good correlation was established between geophysical anomalies and geology. The electromagnetic anomalies can be attributed to carbonaceous rock units. Magnetic anomalies indicate areas of metamorphism due to the neighbouring Cullen Granite. The mineralization at the Gubberah gossan is associated with a discontinuity in electromagnetic anomalies attributed to a fissure and, possibly, resistive sulphide mineralization.

Drilling is recommended on an electromagnetic anomaly with an associated magnetic high to establish the common source of both anomalies.

1. INTRODUCTION

In 1966 geologists from the Northern Territory Resident Geological Section of the Bureau of Mineral Resources discovered a gossanous outcrop 7.5 km northwest of the Minglo mine in the Pine Creek 1:250 000 Sheet area. Samples from this outcrop (the Gubberah gossan) assayed anomalously high in lead, zinc, and copper; as a result Government Mining Reserve No. 275 of 64 km^2 was placed over the area.

In the ensuing period to late 1971, spasmodic geological, geochemical, and geophysical investigations were carried out in the Reserve. The results of these investigations failed to yield additional areas of economic interest beyond that of the initial discovery at the Gubberah gossan. Two holes drilled to establish the significance of the gossan beneath the oxidized zone proved lead-zinc mineralization in a small quartz-filled fracture zone.

An attempt was made in 1972 to rationalize all earlier geophysical work with a new concerted approach to geophysical surveys in the Reserve as shown in Plate 2. A detailed low-level aeromagnetic survey was first flown in the area shown in Plates 1 and 2 to clearly establish anomalous magnetic features.

In the period July to October 1972, ground follow-up geophysical surveys were carried out with two major objectives. The first was to establish the nature of geophysical responses which could be attributed to known mineralization at the Gubberah gossan locality; the second objective was to undertake reconnaissance surveys in areas where aeromagnetic data suggested that favourable structural control might be present to host sulphide mineralization.

Geophysical methods used were magnetic, gravity, electro-magnetic (Slingram, Turam, and MPPO-1 transient-EM), and self-potential. Attempts were made to geophysically log drill holes at the Gubberah gossan. Unfortunately sidewall collapse prevented this.

The field party consisted of F.N. Michail (party leader), E. Wronski (geophysicist), N. Ashmore (technical assistant), and three fieldhands. J. Major, P.B. Bullock, and B. Spies (geophysicists), and W. Burns and J. Williams (technical officers) were involved part-time in specific aspects of the work which included transient-EM surveys. Traverses were surveyed and pegged by contractor to Department of Interior, R.S. Jones, Flint, and Pike of Brisbane.

2. GEOLOGY

The geology of the Mining Reserve 275 and its immediate surrounds is shown in Plate 2 based on data contained in the Ban Ban and Goodparla North 1:63 360 geological Sheets. Hays (1960) described the geology relevant to the western side of this area, which in essence is similar to that in the east.

Outcrop in the Reserve is poor; sedimentary rocks exposed belong to the Masson Formation, a unit of the Goodparla Group of Lower Proterozoic age. These sediments consist of interbedded quartzite, greywacke, sandstone, siltstone, and carbonaceous shale which strike northwest and dip steeply to the west. To the south, Cullen Granite intrudes these sediments. Composition of the Cullen Granite varies from granite to adamellite and is generally coarse-grained, massive, or gneissic in character. The boundary of the granite is thought to be extensively faulted (Hays, 1960, p. 10), however in the Reserve, alluvial and ferricrete cover generally conceals the nature of the sediment-granite contact.

Known sulphide mineralization within the Reserve is restricted to zinc-lead intersected by two drill holes at the Gubberah gossan and silver-lead recovered from minor workings at the Minglo mine. At Mount Harris, 8 km west of the Reserve, tin occurs as cassiterite in quartz-hematite breccia within rocks of the Masson Formation adjacent to the Cullen Granite. Similar lodes occur at Mount Masson and at Jessops Lode about 15 km west of the Reserve; at these localities, sulphides are present as accessory minerals (Walpole & Crohn, 1965).

In the region of the Gubberah gossan grid, carbonaceous shale and siltstone were intersected by two diamond-drill holes DDH-2 and DDH-3 in addition to the sulphide mineralization previously mentioned (Daly, 1971). These rocks are not seen in outcrop. Rather, sediments which crop out are restricted to sandstone exposed on ridges. Faulting and shearing occur along two main directions which approximate northwest and northeast. The Gubberah gossan is associated with one such northeast trending fault, the outcrop being lenticular and about 240 m long.

South of the Gubberah gossan grid, gossany quartz hematite and sandstone rubble are associated with low ridges. Diamond-drill hole DDH-1, drilled to test the significance of a geochemical anomaly in this region, demonstrated that black soil plains which enclose these ridges are commonly underlain by shale.

3. PREVIOUS GEOPHYSICAL WORK

As a result of an aeromagnetic reconnaissance survey flown in the Darwin/Pine Creek region of the Northern Territory in 1963 (Goodeve, 1966) a zone of strong magnetic disturbance was delineated adjacent to the boundary of the intrusive Cullen Granite. An area of major interest was defined around the Mount Harris tin field extending eastwards to the Mary River. This was subsequently surveyed by a more detailed aeromagnetic survey in 1965 (Tipper & Finney, 1966).

It was concluded from the latter survey that magnetic highs recorded over rocks of the Masson Formation adjacent to the granite resulted from a process of low-grade thermal metamorphism and metasomatism produced by shallow-lying granite. It was suggested that the positions of magnetic highs represented the more favourable locations for tin mineralization, and certain anomalies were accordingly recommended for ground follow-up investigations.

Following the discovery of the Gubberah gossan in 1966 (Shields and Taube, 1967) a geochemical survey was completed in this area (Shields, 1969). Results from this work indicated a large zone of anomalous lead and zinc values.

A geophysical survey was carried out over the geochemical grid in 1967 (Duckworth, 1969) with the objectives of determining whether sulphide mineralization existed at depth beneath the gossan and of ascertaining what significance could be placed on the anomalous geochemical zone. Duckworth concluded that sulphides did underlie the gossan and that such mineralization possibly extended to the south. Support for this hypothesis arose from the delineation of a Slingram anomaly which trended approximately north 500 m south of the Gubberah gossan, and from the indication that a decrease of 400 mV in self-potential existed from the black soil plain up to the gossan.

Another well defined Slingram anomaly was recorded to the west of the gossan. This was interpreted however as due to a steeply dipping graphitic shale bed.

Work was continued in 1970 over geochemical anomalies in the area immediately south of the Gubberah gossan (Williams, 1971). Little correlation could be established between Slingram and geochemical anomalies. However, Turam results indicated a conducting zone comprising two or which did bear some similarity to the anomalous geochemical zone. Little correlation was apparent in fine detail and interpretation of the electromagnetic anomalies favoured carbonaceous rock sources.

A detailed self-potential survey subsequently completed over the same area (Bullock, 1972) revealed no response indicative of sulphide mineralization. Again, anomalies recorded were attributed to carbonaceous shale.

Before the ground work dealt with in this Record, it was recognized that inadequate aeromagnetic coverage existed to the east of the Mary River. A detailed low-level aeromagnetic survey was accordingly flown in June 1972 the results from which are shown in Plate 2. Magnetic features defined in the areas now designated Minglo-1 and Minglo-2 were selected for reconnaissance ground survey to determine whether they bore any significance to sulphide mineralization or structure as might be detectable by ground geophysical methods.

4. GEOPHYSICAL METHODS

Geophysical work completed in 1972 was designed to form a basis for reviewing and integrating the results of earlier geophysical surveys. Accordingly methods used included magnetic, self-potential, electromagnetic, and gravity. Induced polarization work was also attempted. However instrumentation problems resulted in no useful data being recorded.

Magnetic surveys were undertaken both to ensure that the survey grids laid out covered aeromagnetic targets selected and to provide greater definition of them. For such work, a McPhar M700 fluxgate magnetometer was used which limited survey accuracy to $\pm$ 10 gammas.

A Sharpe VP-6 instrument was used for self-potential surveys, three potential values being recorded at each station occupied. Where extensive self-potential coverage was obtained, data have been reduced to contour form using a contour interval of 50 mV.

Electromagnetic methods used included the Slingram moving transmitter-moving receiver configuration operated at a frequency of 1760 Hz with a coil separation of 60 m; the Turam fixed transmitter - moving receiver configuration operated at frequencies of 220 Hz and 660 Hz involving either grounded cables or loops as primary energy sources;

a Ronka EM-16 VLF instrument utilizing the North West Cape communications transmitters (N.W.C.) in Western Australia at a 22.3 kHz primary energy source; and the Russian built MPPO-1 equipment for transient-EM surveys. Spies (in press) has provided a detailed account of the usage of the latter equipment in a series of test surveys including that at the Mary River locality. As such, it is sufficient to note that loop sizes used were 150 m and 60 m, and data displayed in this Record are for delay times between 1.1 ms and 15.3 ms.

Gravity measurements were carried out using a Worden gravimeter (W-260) with scale factor 0.109 mGal per dial division. Data have been corrected for latitude, elevation, and terrain effects. For terrain effects the correction is approximate, a density factor of 2.30 g/cm^3 being applied.

5. DISCUSSION OF RESULTS

5.1 Gubberah gossan area

Magnetic: Aeromagnetic data displayed in Plate 2 show that the most outstanding feature in the Gubberah gossan area is a positive gradient with magnetic field increasing to the northeast. Short-wavelength anomalies attributable to near-surface sources are also evident in the vertical field data shown in Plate 3. It is apparent that no anomaly is associated with the Gubberah gossan or the underlying sulphide mineralization intersected by DDH-3. Furthermore, there does not appear to be any pattern discernible in the short-wavelength magnetic anomalies, which suggests that geology is not reflected by these features.

Such results are compatible with laboratory measurements of susceptibility on drill core from DDH-2 and DDH-3 which showed that all rock units and mineralization tested were non-magnetic (see Appendix).

Self-potential: The quality of self-potential data recorded in the Gubberah gossan area is considered to be average for a hilly region where topographic relief exceeds 40 m. Data presented in Plate 4 have been contoured at an interval of 50 mV to suppress noise apparent of $\pm$ 20 mV. Self-potential values obtained on the project drilled section 14N are also shown in profile form in Plate 9 together with associated geological and geophysical data.

It is readily apparent from both Plates 8 and 9 that the sulphide mineralization intersected by DDH-3 beneath the gossan does not produce a diagnostic anomaly.

Rather, the strong anomaly with north-northwest trend (A) located at the southern end of the gossan is clearly related to carbonaceous shale intersected predominantly above the mineralized zone.

A second composite anomalous feature, anomalies B_1/B_2, appears to extend from 19N/108E to 15N/148E sub-paralleling anomaly A and the known geological strike. This composite anomaly occurs in a region where the terrain is particularly hilly. Although the anomaly source is not known from mapping, it must be inferred that carbonaceous rocks are again the source. The presence of a strong rise in the magnetic field to the immediate north suggests that such rocks may have been subjected to metamorphism.

Turam: Measurements of field ratio and phase difference were made at frequencies of 220 Hz and 660 Hz using primary energy sources located both to the southeast and to the southwest of the Gubberah gossan grid. Phase difference contours shown in Plate 5 are for the 660 Hz signal response from loops of 600m by 800m with near sides placed along 152E (loop 1) and 136E (loop 2). Similar results shown in Plate 6 are for a loop with near side located along 10N (loop 3).

The locations of loops 1 and 2 were designed to enable traverses to be run at right angles to the Gubberah gossan to ascertain whether the known sulphide mineralization produced a recordable anomaly. It can be seen from Plate 5 that no such anomaly is present that parallels the gossan. Instead, a number of anomalies (A, A_1, B_1, and B_2) were recorded whose trend closely parallels the geological strike and self-potential features as shown in Plate 7. As such it is concluded that these anomalies indicate the presence of conductive carbonaceous rocks. These findings are supported by laboratory measurements of conductivity made on drill core (see Appendix), which showed that massive sphalerite mineralization was resistive in comparison to conductive carbonaceous shale.

Although the angle between traverse direction and anomaly trends is acute and therefore indicative of unfavourable geometry for the primary energy source and the conductors resolved, results from loops 1 and 2 show satisfactory agreement. Nevertheless, to improve anomaly resolution, loop 3 to the southwest was used. The anomaly so recorded between 104E and 120E (Plate 6) has large ratio and moderate phase difference components indicative of a strong conductor. Furthermore, study of the ratio data indicates that two current axes are present, one of which is offset to the west of the axis of the negative phase difference closure and the other which closely approximates the location of a gully.

Analysis of anomaly form indicates that the conductors have a minimum strike length of 180m, dip to the east, and have their upper surfaces within 30m of ground level. Referring to Plate 5, it is apparent that the strike length can be increased to 350m and the two anomalies along and to the west of the gully (A and A_1) are quite well reflected, as minor anomalies in phase difference when the primary energy source is to the southeast.

A very weak conductor C is also evident from the phase contours (Plates 5 and 7). This feature extends from 112E/17N to 146E/10N and over its entire length it is coincident with a self-potential high.

Transient-EM: Results from transient-EM measurements at Mary River have been dealt with in detail by Spies (in press). It is adequate to draw attention to the results displayed in Plates 8 and 9 for the purpose of this Record. These were obtained in the immediate vicinity of the Gubberah gossan using 60m loops.

It is apparent from both Plates 8 and 9 that no response was recorded that could be attributed to known sulphide mineralization. It is equally apparent that the carbonaceous shale unit intersected in the upper section of DDH-3, which was interpreted to be the source of conductor axes resolved by the Turam work, produces a well defined transient-EM anomaly at the t = 2.3 ms delay time (Plate 8).

The discontinuity in anomalous response evident along 122E is of particular significance. Rock properties referred to previously clearly evidence the conductive nature of the carbonaceous shale in contrast to the resistive nature of the massive sphalerite mineralization. Accordingly the discontinuity apparent at the intersection of the gossan and the axis of the electromagnetic anomalies is interpreted to be due to fissure filling by quartz and/or sphalerite.

Gravity: Surveys carried out were designed to determine whether the sulphide mineralization intersected by DDH-3 was indicative of a major deposit whose surface expression was reflected by the Gubberah gossan. It was originally estimated that a density contrast of approximately 1.0 g/cm^3 would exist between the mineralization and the enclosing sandstone and carbonaceous shale, a hypothesis subsequently proven by laboratory measurements on drill core (see Appendix).

Results obtained from readings made on the projected drilled section 14N are shown in Plate 9 together with the calculated response for a model designed to represent mineralization confined to an inclined tabular lode of 12m width, 46m depth to upper surface, and 506m depth to lower surface. This model was choosen from the limited control afforded by drilling.

It is apparent that the raw Bouguer gravity values uncorrected for terrain do show the presence of an anomaly of about 0.2 mGal at the location of the outcropping gossan, suggesting that the mineralization has significant vertical and lateral extent. Correction of Bouguer values for terrains effects retains the presence of the observed anomaly even though the corrections themselves are large.

To confirm the finding from traverse 14N, measurements were made on adjacent traverses 13N and 15N, but no similar anomaly could be clearly resolved; hence it must be concluded that either mineralization is of minor proportions near these traverses, or alternatively that anomaly resolution is impaired by indeterminable effects involving variation in the weathering oxidation profile and/or poorly controlled terrain corrections.

As a result of the geophysical orientation surveys made over the known sulphide intersection at the Gubberah gossan shown in Plate 9, and laboratory measurements on drill core, it must be concluded that neither electrical nor magnetic surveys can be expected to result in the direct detection of such mineralization. Carbonaceous rock units produce diagnostic electromagnetic and self-potential responses which facilitate their mapping. Such rocks are interpreted as the source of the anomalies designated A, A_1, B_1, and B_2 in Plate 7. The absence of a pronounced self-potential low coincident with the strong conductor A_1 is interpreted as an effect produced by a very shallow water-table, a conclusion which seems reasonable on topographic evidence.

The value of gravity work remains in doubt in terms of the resolution of anomalies produced by mineralization in a high-noise background generated primarily by topography.

5.2 <u>Minglo-1</u>

The survey of Minglo 1 was specifically designed to yield ground geophysical data to assist the interpretation of the aeromagnetic anomaly whose axis is approximately coincident with the southern boundary of the grid shown in Plate 2. The anomaly delineates a west-northwest trending magnetic unit less than 200m wide. Referring to the regional geology shown in Plate 2, it is apparent that the unit occurs in an area mapped as predominantly siltstone of the Masson Formation. The northern boundary of this rock type closely approximates that of the magnetic unit.

Ground magnetic data shown in Plate 10 indicate numerous short-wavelength anomalies superimposed on the regional anomaly. Although many anomalies appear to have significant strike extension parallel to the regional anomaly no one anomaly is outstanding. This suggests that although the sources of the short-wavelength anomalies are shallow, probably within the zone of oxidation, they nevertheless reflect in some manner the underlying geology.

Profiles of Turam field ratios and phase differences presented in Plate 10 show that the magnetic unit is associated with numerous complex conductor axes. The trends of the most significant axes parallel those of the shallow-seated magnetic anomalies and a direct relation seems to exist between many magnetic and electromagnetic anomalies or groups of anomalies, suggesting common source rocks.

Less complex conductors are apparent from the Turam data in the extreme northeast corner of the survey area where there is no pronounced association of magnetic anomalies with the axes of the electromagnetic anomalies. However, strike projections of the electromagnetic anomalies to the east would pass through the area which immediately surrounds the Minglo mine.

Self-potential data acquired over the entire survey grid are displayed in contour form in Plate 10. Data quality is good, noise generally being less than ± 20 mV. It is apparent that numerous self-potential positive and negative centres do not in general correlate well with individual Turam anomalies. The more intense, localized self-potential anomalies occur in those parts of the grid containing Turam anomalies and are probably related to the presence of carbonaceous rock units.

It must be concluded that the ground geophysical reconnaissance work at Minglo-1 has not resulted in the delineation of any outstanding feature which indicates sulphide mineralization. The extensive areas containing electromagnetic anomalies are evidence for the presence of carbonaceous rock units. The magnetic anomalies can only be interpreted at this time as evidence of metamorphism.

5.3 Minglo-2

The area surveyed at Minglo-2 was selected to investigate the northern flank of a prominent aeromagnetic anomaly west-northwest trend as shown in Plate 2. The baseline for the grid was accordingly positioned to approximate the line of maximum anomaly gradient. Much of the area enclosed within the grid is flat and covered by alluvium as indicated by the regional geology shown in Plate 2. The limited outcrop, as in the southern corner of the survey area, is predominantly sandstone; Cullen Granite however crops out extensively about 0.5 km to the south of the grid.

Ground magnetic data in the form of contours of vertical intensity are shown in Plate 11. As in the Minglo-1 area, correlation between airborne and ground data is excellent in terms of the regional anomalies delineated. Two major anomalies or anomalous zones AA' and B clearly define the boundaries of magnetic units. The southernmost unit AA' is characterized by both a large regional anomaly and more intense short-wavelength anomalies whose trends parallel the northern boundary of the magnetic unit.

Anomaly form is simpler and anomaly amplitude is lower for zone B. A third ill defined anomalous zone (C) of minor magnetic relief is evident in the northernmost part of the grid in the region of overlap with Minglo-1.

After the successful application of the transient-EM equipment in the Gubberah gossan area, it was decided to use the system in a reconnaissance mode over the entire Minglo-2 grid. Loop sizes of 150m were used. The results obtained at delay times of 1.1 ms and 15.3 ms are shown in Plate 12.

It is apparent that the alluvium is conductive over most of the survey area as evidenced by the rapid decay of the large signals recorded at early delay times. Three anomalies which persist to the 15.3 ms delay time indicate the presence of strong conductors centred at 90W/30S, 60E/6S, and 130E/18N. More detailed work was carried out over the 90W/30S anomaly using 60m loops. The results more accurately defined the location of the anomaly as being centred at 87W/33S and suggested a west-northwest elongation for it.

The paucity of rock outcrop in Minglo-2 precludes direct correlation of any of these anomalous features with their geological source. Accordingly, an orientation survey using 150m loops was completed at the neighbouring Minglo mine which is in an area of carbonaceous shale. Similar responses to those referred to above were recorded at this location, but no anomalous response could be uniquely attributed to the sulphide mineralization (Spies, in press).

In accordance with this result, it must be inferred that the strong anomalies recorded in Minglo-2 are produced by carbonaceous shale. The association of a distinct magnetic high with the anomaly at 87W/33S suggests rock alteration attributable to the neighbouring Cullen Granite. The anomaly has been studied by Spies (pers. comm.) who interpreted the source to be of about 200m strike length, 80m width, less than 30m depth, and 0.7 mho/m conductivity.

The flat nature of the terrain in Minglo-2 permitted the extensive use of Slingram. Accordingly a reconnaissance survey was carried out the results of which are shown in profile form in Plate 13. It is apparent from the data displayed that numerous complex conductors have been outlined by the survey. Anomalies tend to be more pronounced in the real component than in the imaginary, indicating that their sources are moderate conductors. Such conductors are most probably contained within the zone of oxidation as at the frequency used (1760 Hz), an 'overburden' conductivity of 1 to 0.1 mhos/m would restrict effective penetration to depths of 10 to 30m.

An obvious overall trend of the anomalies is oriented northwest in the western part of the grid but swings to west-northwest in the east. An attempt has been made to establish the continuity of the more significant anomalies as shown, but the reader must recognize that the axes selected from within the complex anomalies are speculative.

The most outstanding feature revealed by the Slingram results is the lack of anomalous response associated with the simple magnetic anomalies which constitute the magnetic units designated B and C. By contrast, complex Slingram anomalies are associated with the magnetic unit AA'. Locally, the conductor axes resolved not only parallel the short-wavelength magnetic anomalies but to a limited extent coincide with them. This is a result similar to that previously observed in the Minglo-1 area. The transient-EM anomaly located at 87W/33S is seen to be contained within the zone of complex conductors. However, this locality is in no way uniquely defined by the Slingram data.

Less complex anomalies with clearly defined elongation are located between the magnetic units AA' and B. Between the units AA' and C is a zone of complex anomalies about which little can be said other than it contains two of the transient-EM anomalies previously referred to.

Turam surveys using loops of 800 to 600m were carried out over the locations of the transient-EM anomalies at 87W/33S and 60E/6S. Results from this work did not contribute any additional information of significance, hence the data acquired are not displayed. In the vicinity of 60E/6S, profiles of Turam reduced ratio and phase difference closely resemble those of the Slingram real and imaginary components.

VLF and self-potential data were obtained on selected traverses to determine whether more extensive surveys were warranted. Neither method yielded distinctive anomalies or results which could be sensibly correlated between adjacent traverses or with other geophysical data. Accordingly, no further work was undertaken.

Finally, gravity traverses were read along 15E and 60E. No anomalies were resolved adjacent to, or coincident with, electromagnetic conductors and no further work was carried out.

It would appear from the results described that carbonaceous shale and alluvium derived there from such rocks represent the sources of the extensive electromagnetic anomalies apparent in Minglo-2. The greater resolution of conductor axes obtainable from the Slingram and Turam data over that evident from the transient-EM work reflects a disadvantage in the use of large reconnaissance loops applied without overlap in the latter case. Smaller loops (30 to 60m) used with overlap in excess of 50% might be expected to yield similar information to that obtained from the Slingram survey. However, it might be argued that the transient-EM reconnaissance survey has been successful in resolving the more significant anomalies, representative of conductive fresh rock, from those anomalies produced by superficial conducting material located in the zone of oxidation.

6. CONCLUSIONS AND RECOMMENDATIONS

It must be concluded from the fieldwork completed at the Gubberah gossan and Minglo mine localities plus laboratory measurements of the physical properties of rock samples from DDH-2 and DDH-3 that the only detectable geophysical response which might be expected from sulphide mineralization in the Mary River area is that of gravity. Unfortunately the successful application of gravity surveys in this region is severely restricted by the unfavourable topographic relief.

Good correlation has been established between geophysical anomalies and geology at both the regional and local scales. Well defined aeromagnetic anomalies of north-northwest trend are seen to be associated with Masson Formation siltstone which appears to be highly responsive to either metamorphic or metasomatic alteration by the neighbouring Cullen Granite. Diagnostic electromagnetic anomalies are also commonly associated with these rocks. At one locality in Minglo 2 (87W/33S), the coincidence of the most significant electromagnetic anomaly with a local magnetic high necessitates drilling to establish the common source of both anomalies.

Mineralization at Gubberah gossan and at Minglo mine appears to be associated with carbonaceous siltstone and shale of extremely low magnetic susceptibility. It has been suggested by W. Roberts (pers. comm.) that favourable structures, e.g. fissures, in such rocks have locally concentrated sulphide mineralization from a rock unit which basically has only a low metal content.

Transient-EM work has proved to be of interest in revealing a response attributable to the fissure and possibly to the resistive sulphide mineralization contained therein at Gubberah gossan area. This response manifests itself as a discontinuity of the conductivity high associated with inferred carbonaceous rocks coincident with the gossan. It appears that the receiver/transmitter loop configuration of the transient-EM method has afforded greater resolution of this feature than that obtainable from the Turam method. It is not practical to carry out a Slingram survey at this locality owing to rapid changes in terrain elevation; hence complementary data from this electromagnetic survey technique which used receiver and transmitter loops in close proximity is precluded.

The analysis of the 1972 geophysical data adequately demonstrates that the electromagnetic and self-potential anomalies previously reported by Duckworth (1969) and Williams (1971) are of a type attributable to carbonaceous rocks. There is no justification to assume that lead-zinc sulphide mineralization in any way contributed to these anomalies.

It would appear that the most prospective rocks are non-magnetic. However, confirmation of this hypothesis will have to await the results of the required drill test in Minglo 2.

It would be worthwhile to carry out more detailed transient-EM work at Gubberah gossan and Minglo 2 to optimize the value of drill-hole data. In the former area an extension of coverage northwards to 19N/124E would be of value to determine whether structural dislocations of electrical anomalies occur along the strike extension of the gossan.

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APPENDIX

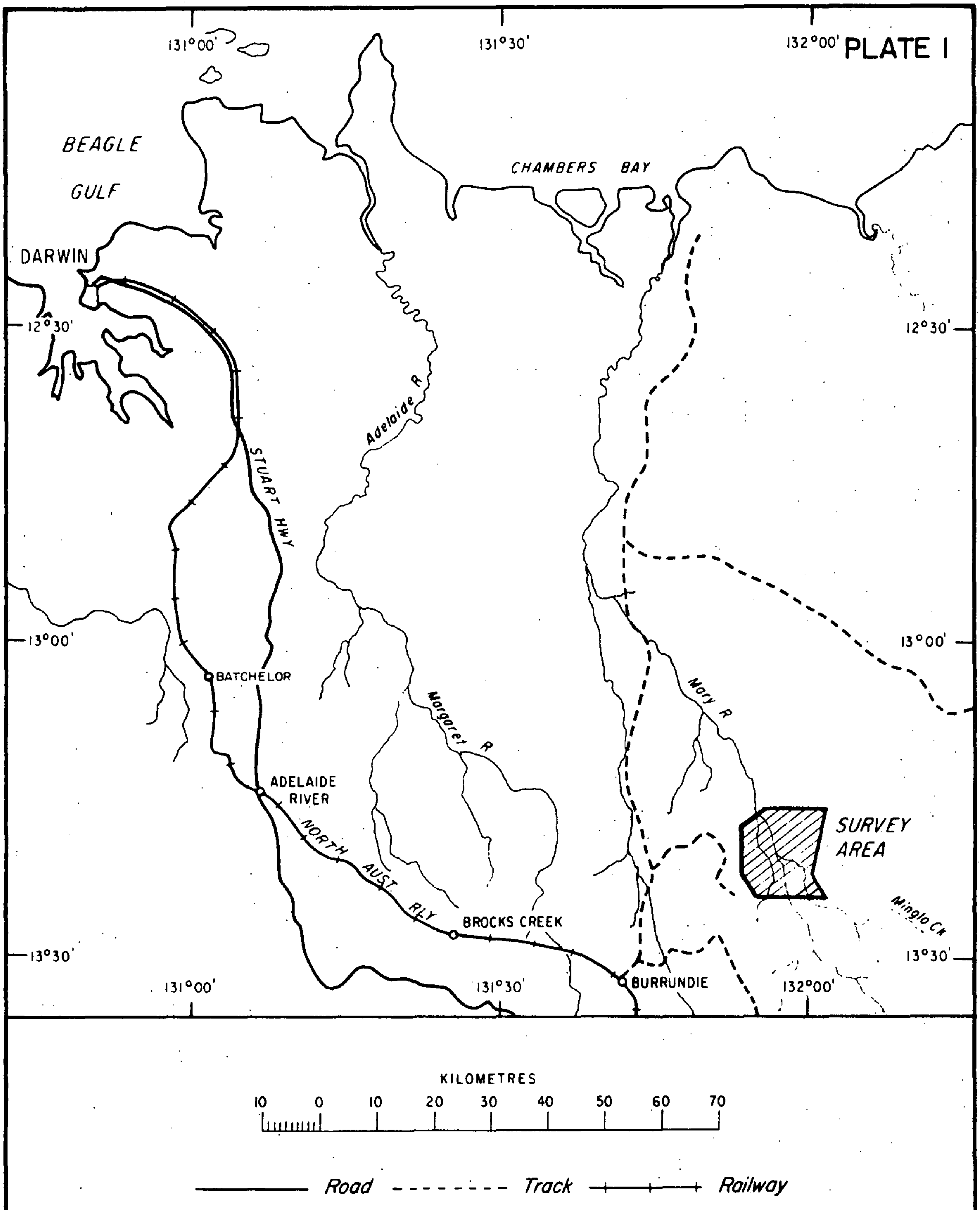
Laboratory measurements on drill core from Gubbera gossan area

Lab. No.	Drill Hole	Depth (metres)	Geological description	Susceptibility c.g.s. x 10^{-6}	Specific gravity dry	Specific gravity saturated	Porosity %	Resistivity (ohm-m) at 650 Hz	Resistivity (ohm-m) at 3 Hz	Frequency effect %
73/48	2	45.4	Carbonaceous shale, siltstone	less than 5	2.27	2.45	18	11	16	9
73/49	2	105.8	Carbonaceous shale, siltstone	70	2.48	2.60	12	95	120	7
73/50	3	51.2	Carbonaceous shale, siltstone in oxidized zone	less than 5	2.10	2.34	24	200	220	0
73/51	3	55.2	Carbonaceous shale, siltstone	less than 5	2.24	2.43	18	4	6	22
73/52	3	68.9	Carbonaceous shale, siltstone	less than 5	2.38	2.52	15	0.1	0.4	14
73/54	3	92.7	Quartz, pyrite, sphalerite	not measured	2.66	2.68	2	2	5	40
73/55	3	94.5	Massive sphalerite	60	3.86	3.86	0	380	450	2

Notes: For resistivity and frequency effect measurements, specimens were saturated under vacuum with saline solution of conductivity approximately 5000 micro-mho/cm at 20°C.

Frequency effect is $100\,({}_{0.3} - {}_{3.0})/{}_{3.0}$

Measurement temperature was 21°C



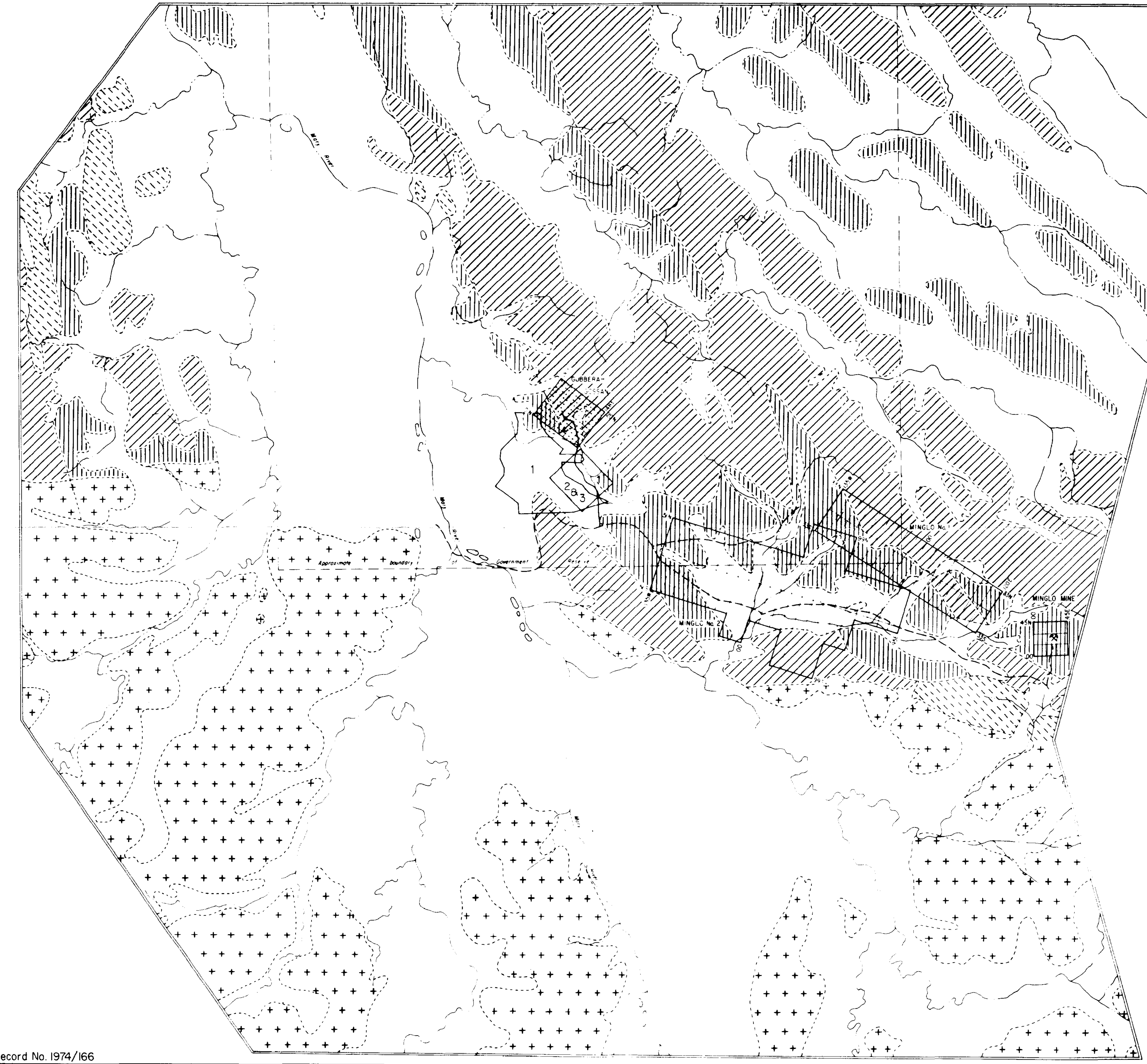
MARY RIVER, GEOPHYSICAL SURVEY NT,1972

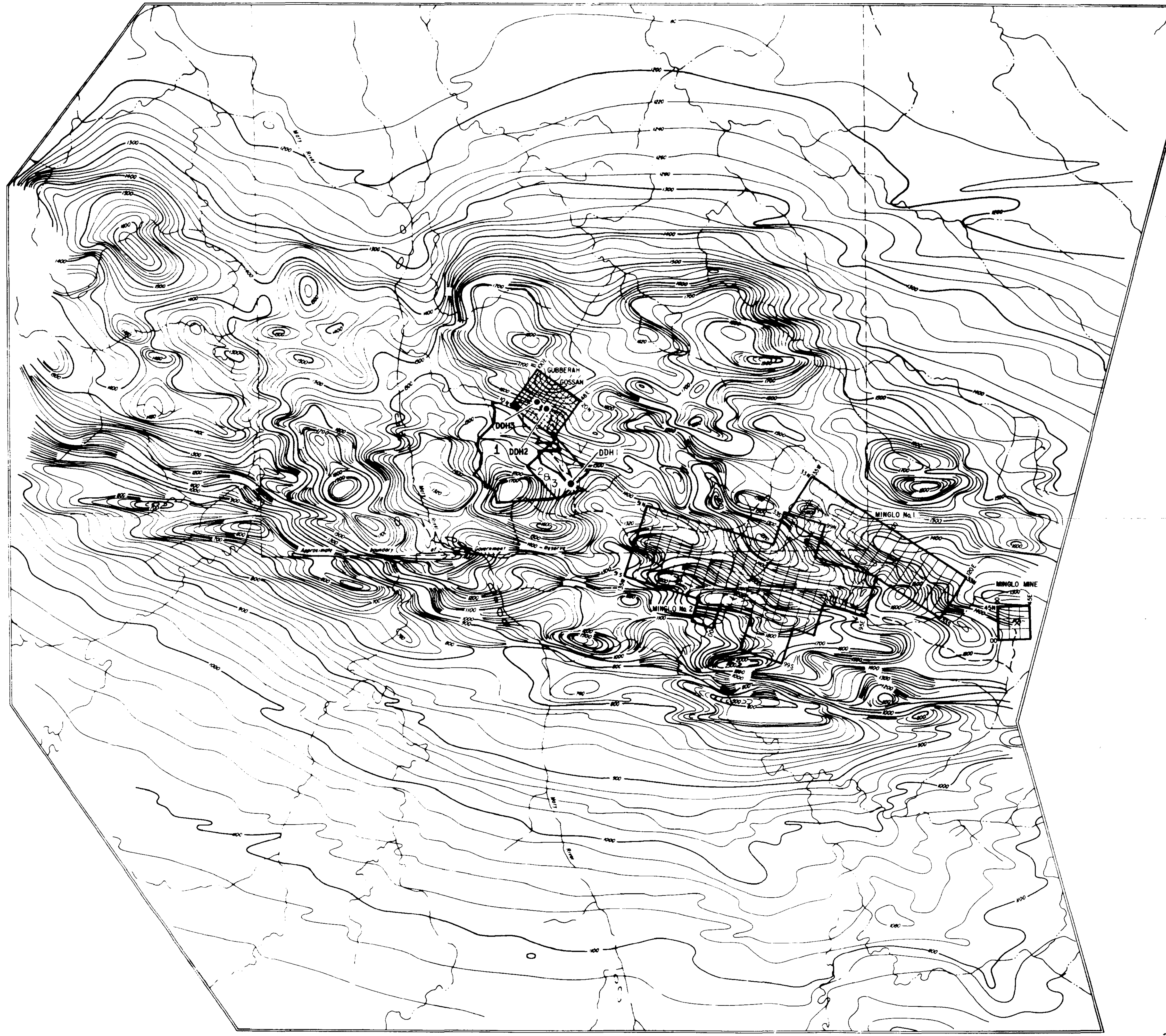
LOCALITY MAP

(BASED ON ICAO CHART) Record No 1974/166

D52/B7-639A

PLATE 2





Boundary of area surveyed by ground geophysics prior to 1972

1. *Duckworth (1969)*
2. *Williams (1971)*
3. *Bullock (1972)*

Road or track

River or stream

Airborne survey boundary

1200 / 1300 *Total magnetic intensity contours*

45N / 00 *Geophysical grid*

GEOLOGY

Geological boundary

QUATERNARY

Soil and alluvium, ferruginous cemented detritus

LOWER PROTEROZOIC

Cullen Granite

Biotite hornblende granite

Masson Formation

Quartz greywacke, quartz conglomerate, sandstone, siltstone, carbonaceous siltstone, banded siltstone

Quartz greywacke

Siltstone predominant

KILOMETRES

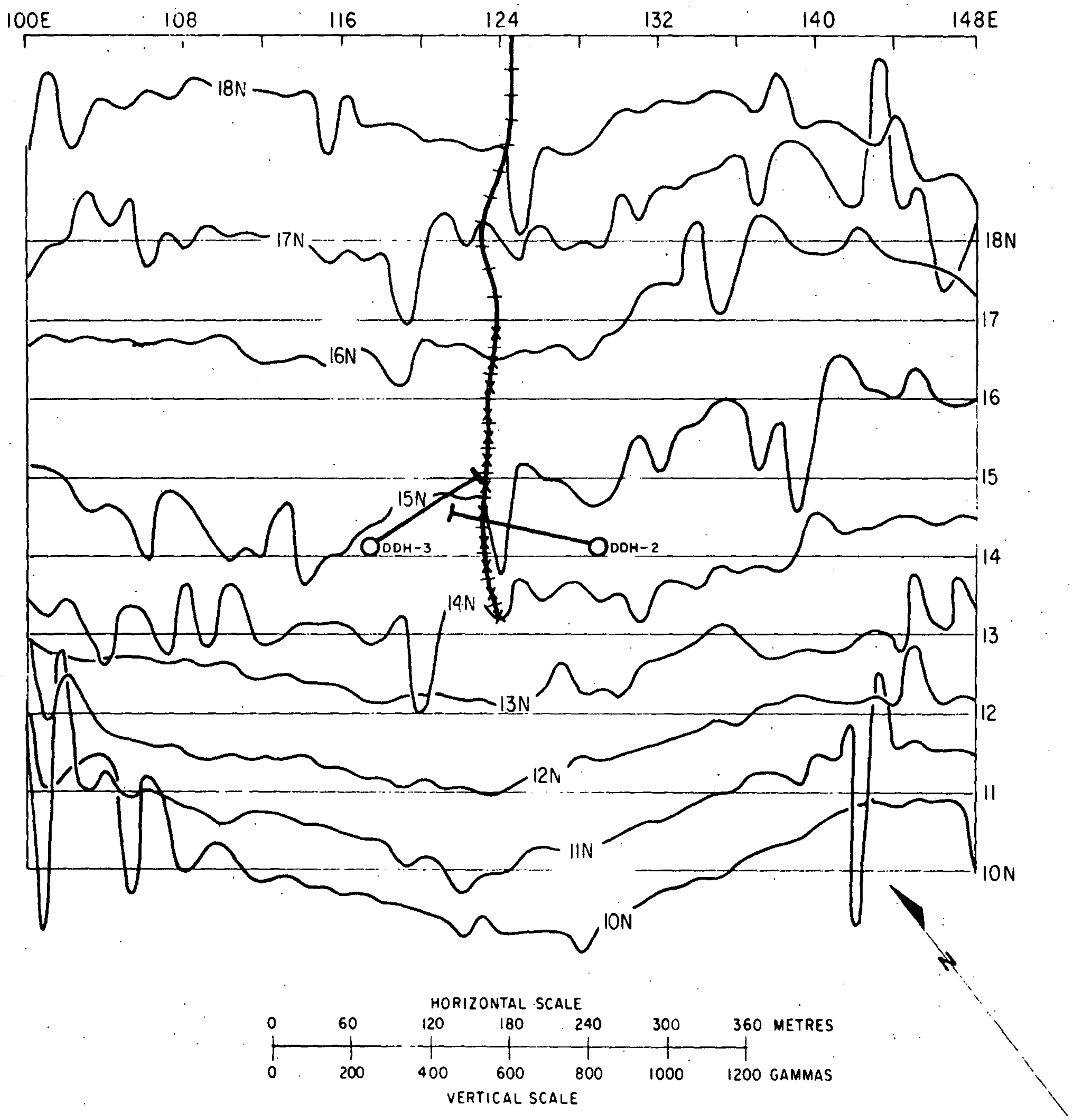
1 0 1 2 3 4 5

AEROMAGNETIC CONTOURS AND GEOLOGY

Record No. 1974/166

D52/B7-620

PLATE 3



LEGEND

Ridge - rock outcrop

Diamond-drill hole

Gossan

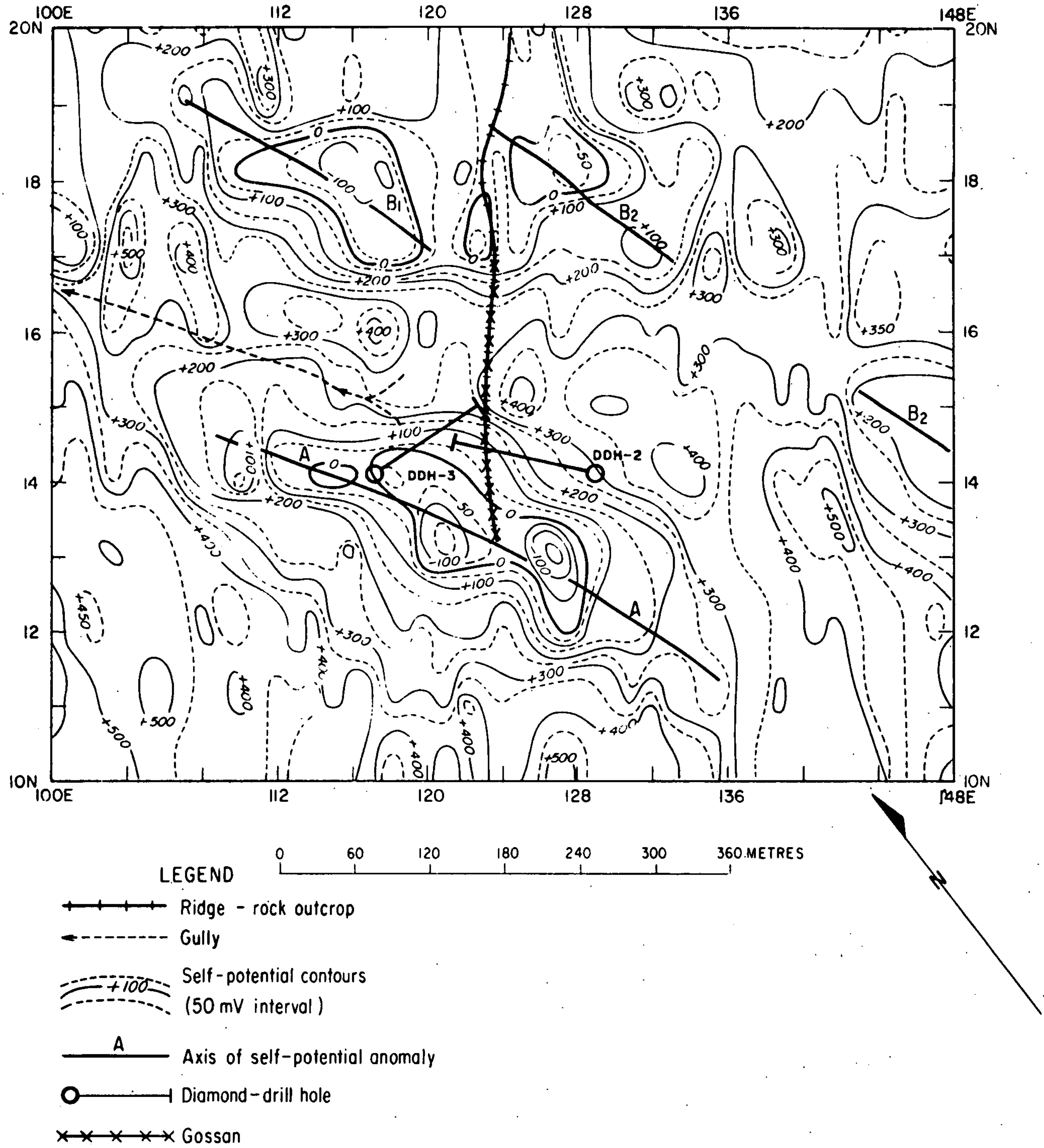
VERTICAL MAGNETIC INTENSITY PROFILES

GUBBERAH GOSSAN AREA

Record Nº 1974/166

D52/B7-633A

PLATE 4



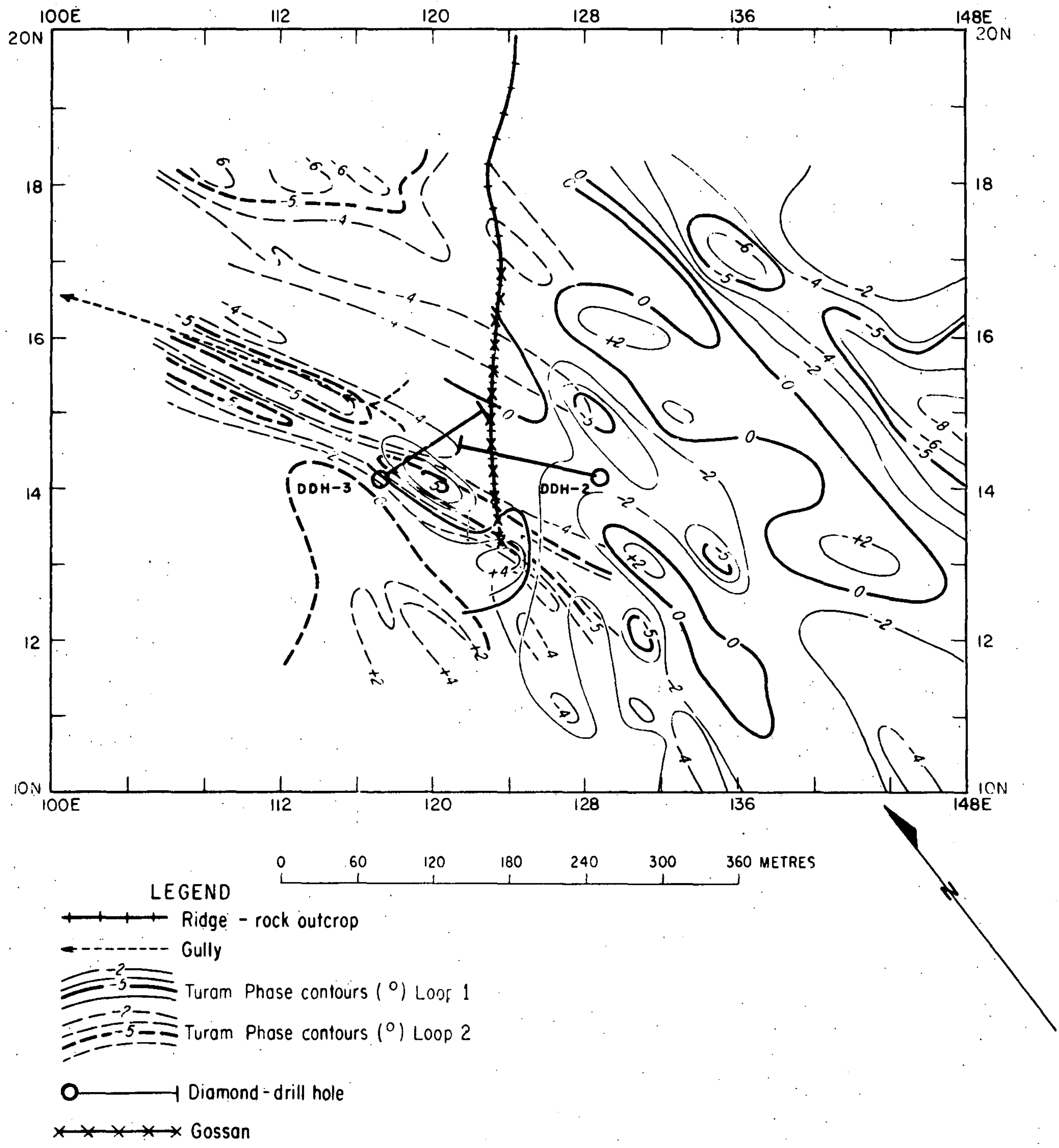
SELF-POTENTIAL CONTOURS

GUBBERAH GOSSAN AREA

Record Nº 1974/166

D52/B7-634A

PLATE 5



LOOP 1: near side along 152E
LOOP 2: near side along 136E

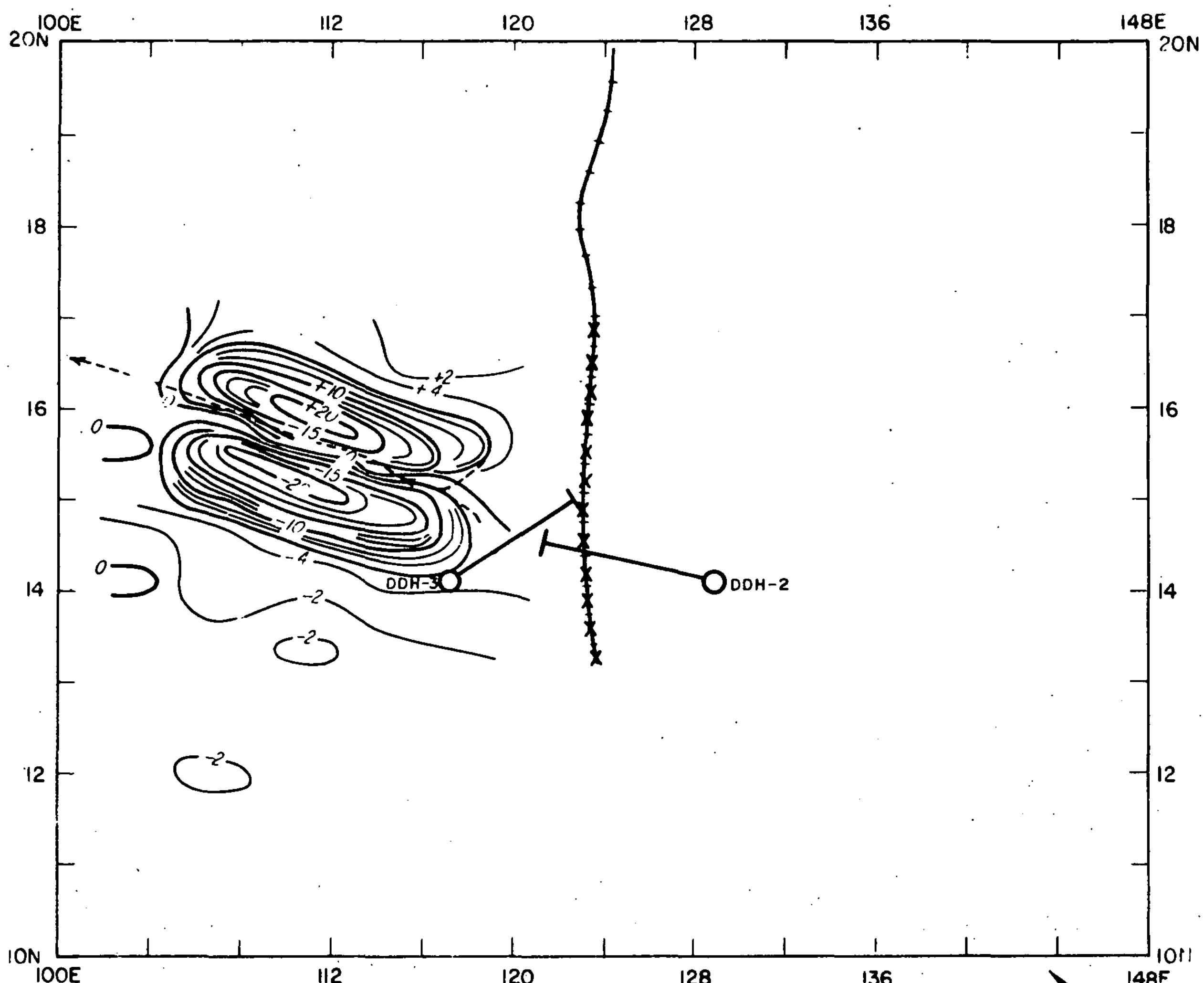
TURAM PHASE DIFFERENCE CONTOURS (660Hz) LOOPS 1 and 2

GUBBERAH GOSSAN AREA

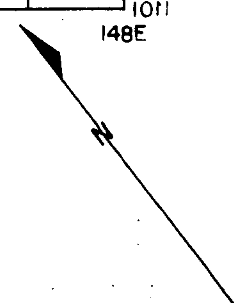
Record No. 1974/166

D52/B7-635A

PLATE 6



0 60 120 180 240 300 360 METRES



LEGEND

Ridge - rock outcrop

Gully

-20 Turam Phase contours (°)

Diamond-drill hole

Gossan

LOOP 3: near side along 10N

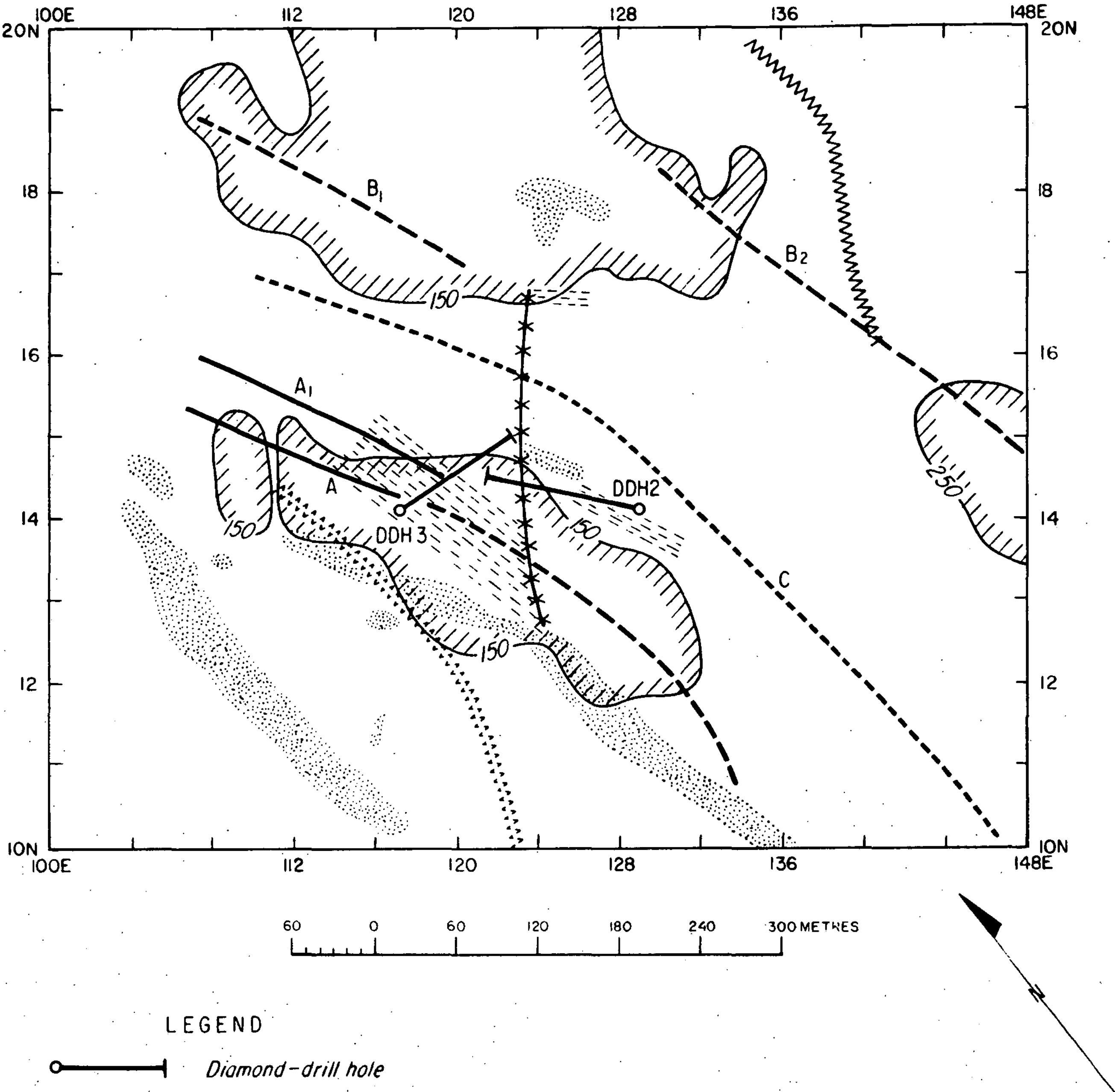
TURAM PHASE DIFFERENCE CONTOURS (660 Hz) LOOP 3

GUBBERAH GOSSAN AREA

Record Nº 1974/166

D52/B7-636A

PLATE 7



LEGEND

Diamond-drill hole

Gossan

S-P anomaly 'low' : voltage shown in mV

Sandstone

Shale

Magnetic anomaly axis

'High'

'Low'

Turam anomaly conductor axis

Strong

Medium

Weak

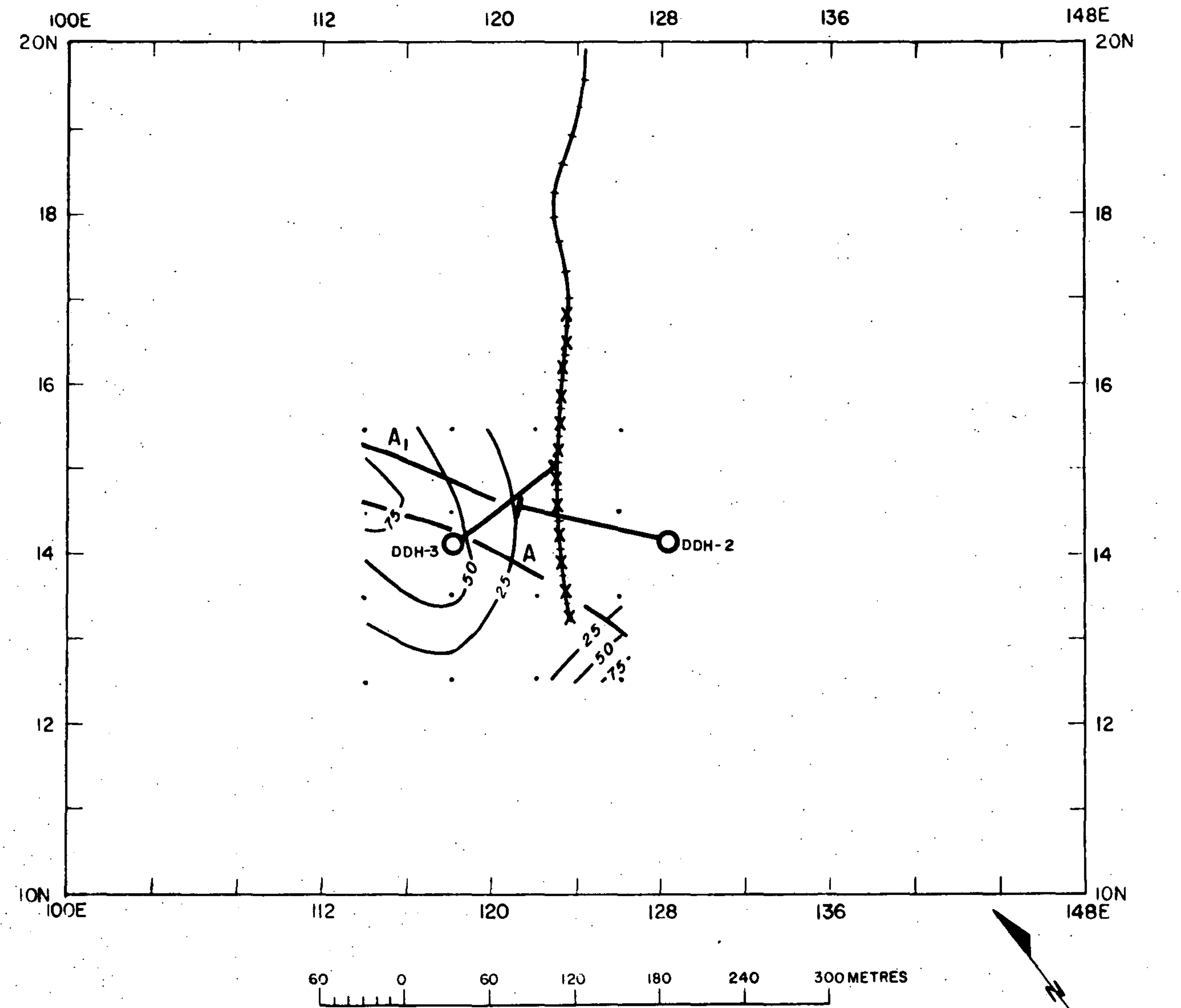
GEOPHYSICAL ANOMALIES

GUBBERAH GOSSAN AREA

Record Nº 1974/166

D52/B7-605A

PLATE 8



LEGEND

Ridge - rock outcrop

Gully

Centres of 60m loops

Contours of response $\frac{\text{microvolts}}{\text{amps}}$ $(\frac{\mu V}{A})$

Turam anomaly axis

Diamond-drill hole

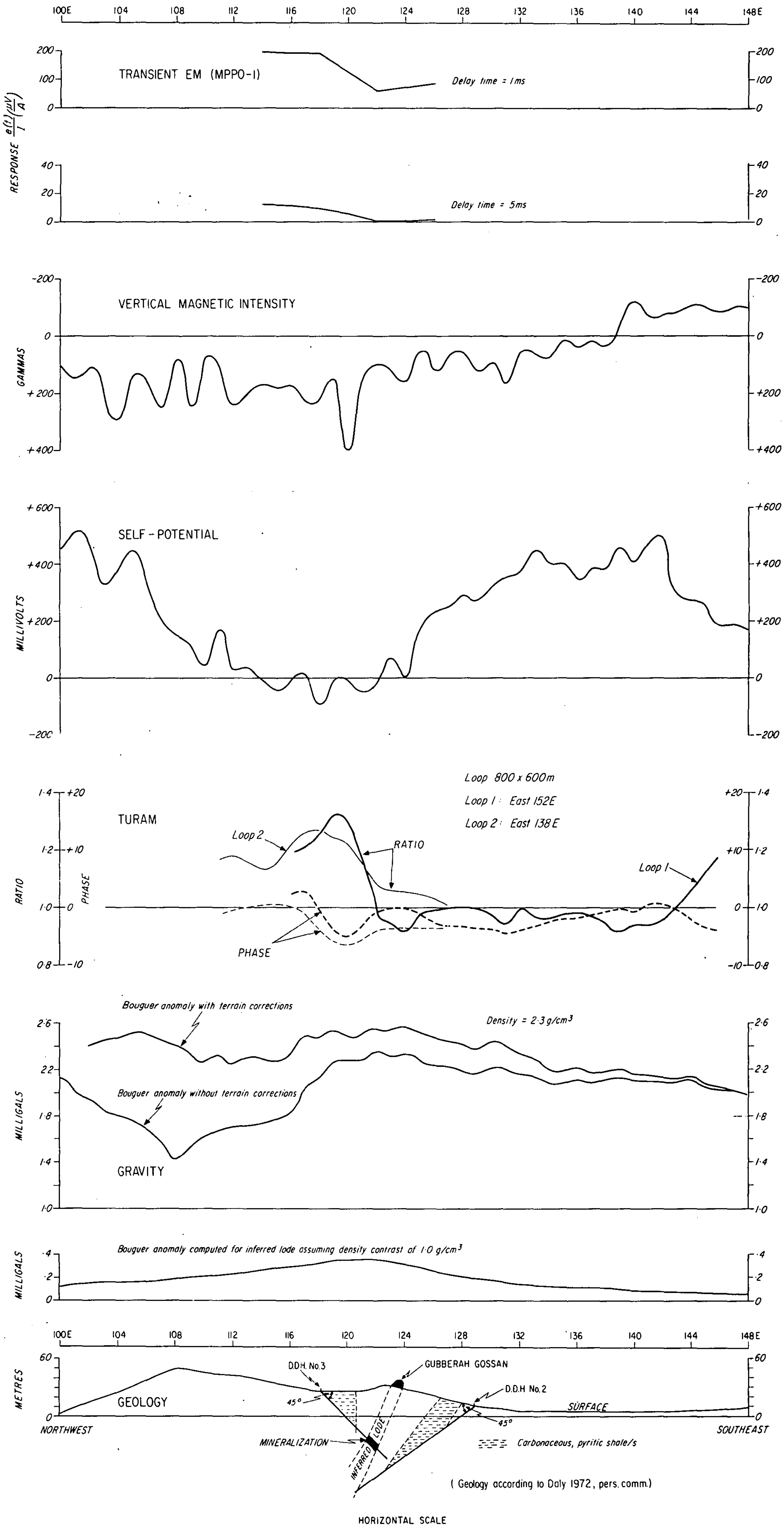
Gossan

TRANSIENT EM CONTOURS 2·3ms DELAY

GUBBERAH GOSSAN AREA

Record Nº 1974/166

D52/B5—640A

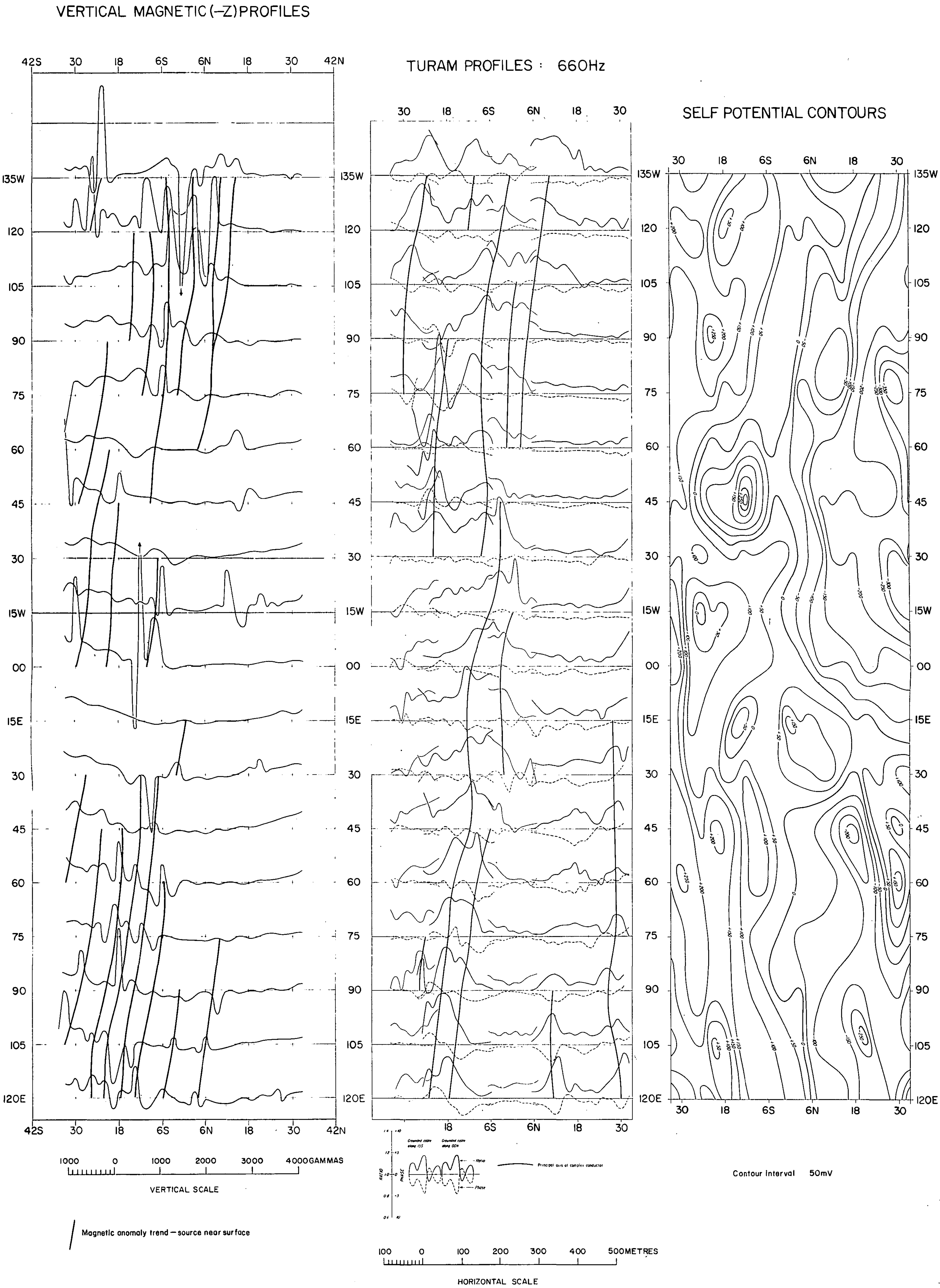


GEOPHYSICAL AND DRILLING RESULTS, TRAVERSE 14N

GUBBERAH GOSSAN AREA

PLATE 9

Record No. 1974/166

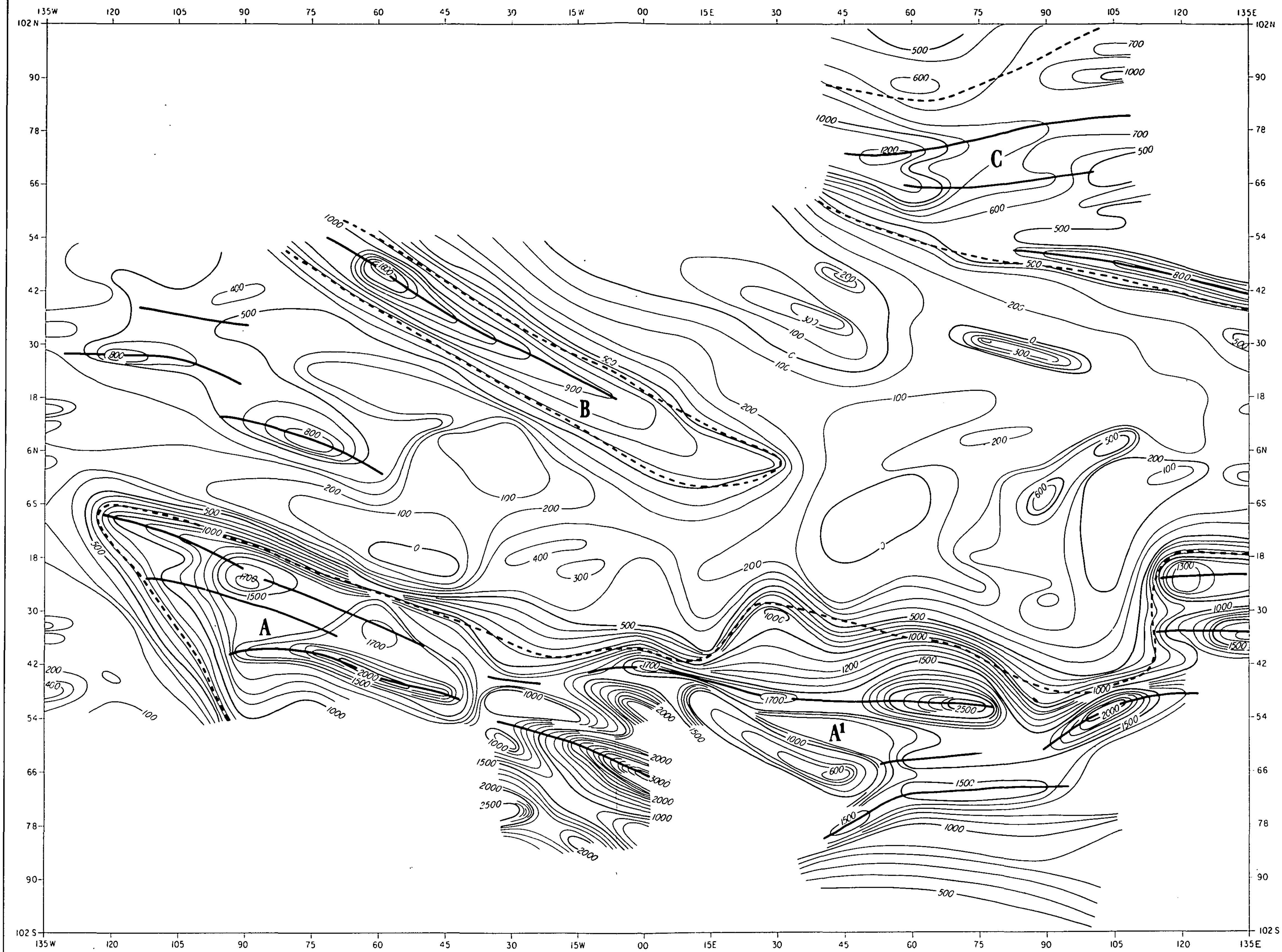


RESULTS OF VERTICAL MAGNETIC, TURAM & SELF POTENTIAL SURVEYS

MINGLO I

PLATE 10

D52/B7–649



LEGEND

AXIS OF MAGNETIC ANOMALY

MAGNETIC ROCK UNIT

SCALE

100 0 100 200 300 400 500 METRES

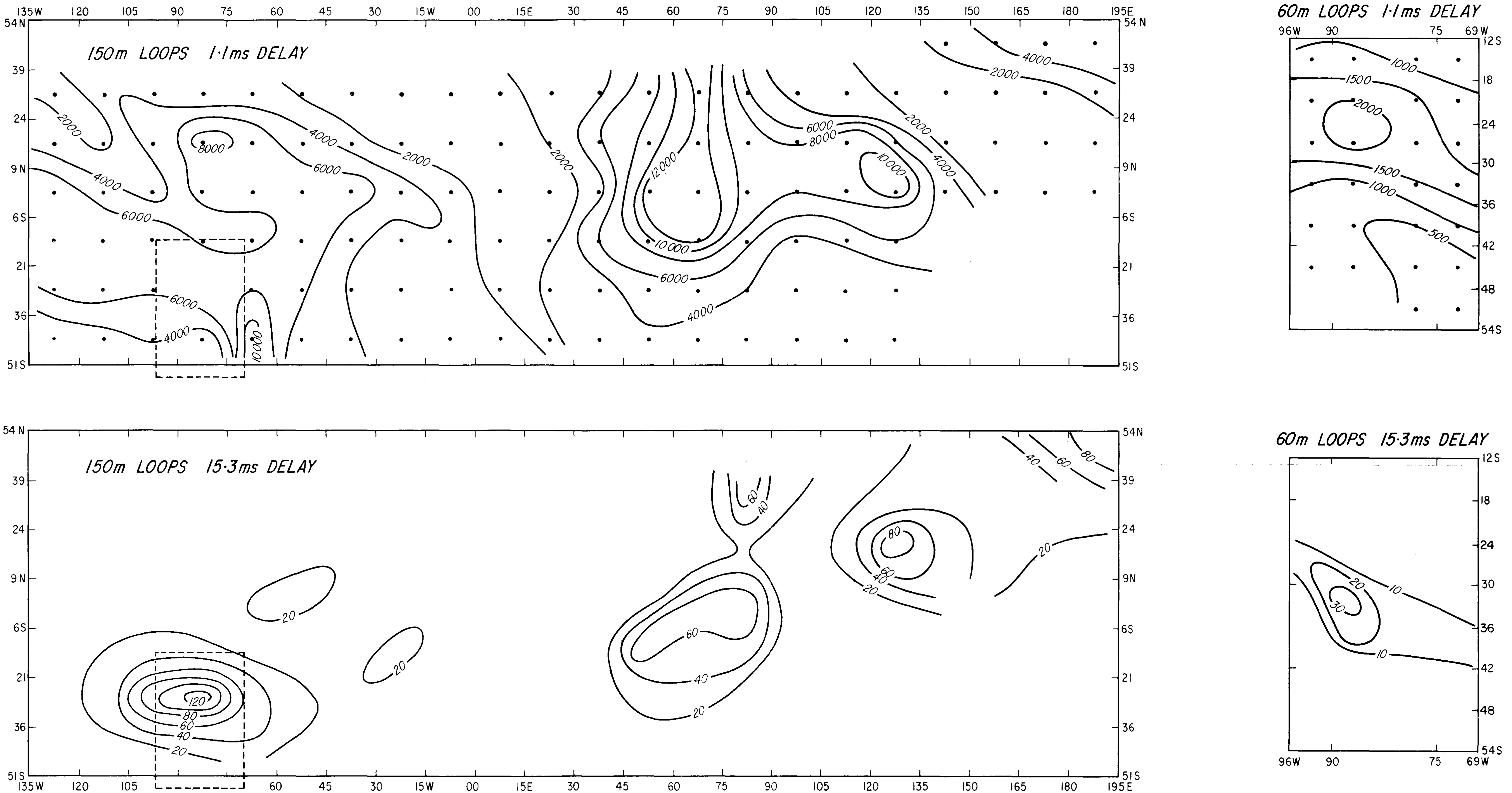
CONTOUR INTERVAL 100 GAMMAS (-Z)

VERTICAL MAGNETIC INTENSITY CONTOURS

MINGLO 2

Record No 1974/166

D52/B7-619



LEGEND

• Centre of loops

Area surveyed with 60 metre loops

Contours of response $\frac{e(t)}{I}$ in $\frac{\mu V}{A}$

SCALE

100 0 200 400 600 800 1000 METRES

SCALE

50 0 50 100 150 200 METRES

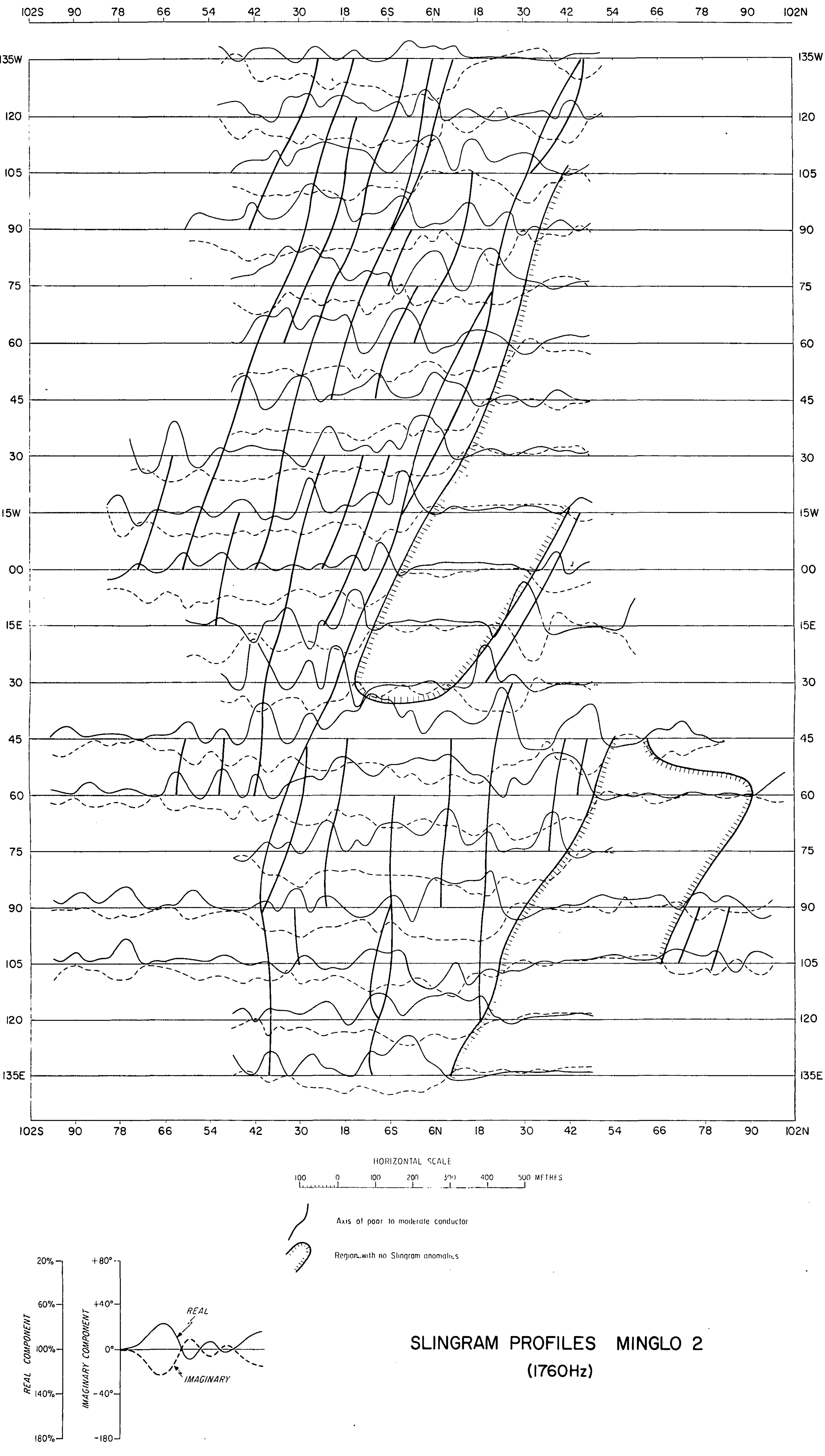
TRANSIENT EM CONTOURS

MINGLO 2

Record No 1974/166

D52/B7—604

Record No. 1974/166



SLINGRAM PROFILES MINGLO 2

(1760Hz)

D52/B7-602

PLATE 13