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DOBBYN AREA GEOPHYSICAL SURVEY, QUEENSLAND 1963

by

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SUMMARY

A geophysical survey was made from July to November 1963 in the Dobbyn area, about 70 miles north-west of Cloncurry, Queensland. The object of the survey was to extend the exploration into the primary zone of mineralisation in the hope of finding larger copper deposits than have hitherto been found in the Dobbyn area.

The methods used were electromagnetic, induced polarisation, gravity, and magnetic. The electromagnetic results showed a large number of long narrow anomalies, of which many are attributable to electrolytic conductors in shear and fault zones but some, on the basis of the induced polarisation results, appear to be associated with mineralisation. The gravity method was found to be unsuitable for direct detection of orebodies but was useful in revealing the more important geological structures, particularly fault zones. The magnetic results showed the area to be generally disturbed magnetically. The known mineralisation appeared to produce no recognisable magnetic effects.

The induced polarisation survey revealed strong anomalies over several mines in the area and two of these, the Crusader and the Dinkum Digger, could warrant further investigation.

The combined results of the electromagnetic and induced polarisation methods have drawn attention to several localities of possible mineralisation where further geophysical and geological work would be useful. Two of these are new prospects.

1. INTRODUCTION

Between 29th July and 9th November 1963, the Bureau of Mineral Resources made a geophysical survey in the Dobbyn area, about 70 miles north-north-west of Cloncurry, Queensland.

Throughout the Cloncurry and Mount Isa mineral fields, mineral deposits appear to be confined to zones of structural deformation, particularly shears and faults. The occurrence of extensive faulting, shown by geological mapping, and the existence of numerous copper shows make the Dobbyn area a favourable one in which to explore for new copper deposits. The aim of the geophysical survey was to test the suitability of various methods in the area and to search for evidence of hitherto unknown mineralisation. In particular the aim was to look for copper deposits in the primary zone.

The only previous geophysical work in the area was a survey made in 1935 by the Aerial, Geological, and Geophysical Survey of Northern Australia (Rayner & Nye, 1936). This survey did not give very definite results as regards location of new orebodies, but indicated possible extensions of known orebodies.

In addition to the survey described in this Record, the Bureau made gravity and aeromagnetic surveys over an area of about 40 miles by 25 miles in the Mount Cuthbert/Dobbyn area to determine major structural features. The gravity results are described by Smith (in preparation) and the aeromagnetic results by Dockery and Tipper (1964).

Electromagnetic and induced polarisation (IP) methods were used in the present survey; the electromagnetic method used was Turam. Self-potential (S-P) was tried but the results were not very satisfactory, mainly because the extremely dry surface did not permit good ground contacts. Magnetic and gravity methods were also used on a few traverses.

Geological mapping over part of the geophysical grid was done by Dr. D.O. Zimmerman of the Bureau's Geological Branch.

Geophysicists who took part in the survey were J.E. Gardener (party leader), J.E. Haigh, A. Howland-Rose, and R.J. Smith.

2. GEOLOGY

The geology of the surveyed area is described by Carter, Brooks, and Walker (1961).

The geophysical grid (Plate 2) covers parts of the Leichhardt Metamorphics, the Argylla and the Corella Formations (all Precambrian), and the Kalkadoon Granite, which is Proterozoic or Archaean.

Geological mapping on the grid showed quartzite, siltstone, calc-silicate rock, acid volcanics, and tuff in the eastern part. Rhyolite, dacite, and sheared basic rocks (amphibolite) are dominant in the western parts. The regional trend is strike roughly north-south and dip 85° east. Boundaries between the Corella Formation, Argylla Formation, and Leichhardt Metamorphics as marked on the Dobbyn 4-mile geological series sheet are somewhat questionable. The Corella Formation can be distinguished because it contains calc-silicates and because of its relative paucity of acid and intermediate volcanics, but the Argylla Formation and Leichhardt Metamorphics are not easily distinguishable. (Zimmerman, pers. comm.).

Kalkadoon Granite crops out in the extreme western part of Traverse 0. The Kalkadoon granite is mainly a granodiorite in a composite mass and is usually coarse-grained with a porphyritic appearance. (Carter et al, 1961, p 143).

Leichhardt Metamorphics crop out between Kalkadoon Granite in the west and the Argylla Formation in the east. They are essentially highly to moderately metamorphosed acid lavas, for the most part originally dacite and rhyolite. Associated metamorphics include migmatite, gneiss, mica schist, quartzite, calc-silicate rocks, and hornblende schists and amphibolite, which were probably originally mainly basic igneous intrusives. (Carter et al, 1961, p 60).

The Argylla Formation is described as metamorphosed rhyolite and metadacite, with smaller quantities of quartzite, arkose, calc-silicate rocks, conglomerate, slate, schist, and gneiss (Carter et al, 1961, p 62).

The Corella Formation covers the eastern part of the grid. The rocks are described as characteristically thin-bedded. The formation appears to consist of fine- to coarse-grained calc-silicate hornfels, gneiss, and granulite, with thinly interbedded pelitic and psammitic rocks. In the Dobbyn 4-mile geological series sheet area, quartzite appears to form a greater proportion of the succession than is usual, especially in the eastern part of the surveyed area. (Carter et al, 1961, p 86-7).

Copper mineralisation occurs in practically all the Lower Proterozoic units in the north-west of the Mount Isa and Cloncurry mineral fields. In general, however, the factors controlling the occurrence of copper mineralisation appear to be lithological rather than stratigraphical. Acid lavas (and their metamorphic derivatives) and quartzite appear to be unfavourable as host rocks. The deposits that occur in the Leichhardt Metamorphics and Argylla Formation are generally related to faults and shear zones close to, or in, basic igneous rocks or schists. (Carter et al, 1961, p 205).

The calc-silicate rocks of the Corella Formation appear to have been unfavourable to ore deposition. Many of the copper bodies in the Corella Formation have calcitic gangue. Most orebodies of this type are low-grade, but the best prospects for large orebodies in the Corella Formation probably lie in calcitic bodies. (Carter et al, 1961, p 206).

Throughout the Cloncurry and Mount Isa mineral fields basic igneous rocks and copper mineralisation are closely associated. Sparse chalcopyrite and pyrite crystals are common in the basic rocks, but mineral deposits appear to be confined to zones of structural deformation. Almost without exception the copper deposits of the region are within, or very close to, fault zones or shears. Not all faults, or fault systems, appear to be equally favourable to ore localisation. The major strike-slip faults, particularly the north-east component, are not associated with many important deposits; but off-shoots from some of the north-east faults contain deposits. (Carter et al, 1961, p 206-7).

The geology of several mines in the area is referred to later in the Record in connection with the discussion of the geophysical results.

3. METHODS

The methods used in the survey were induced polarisation (IP), electromagnetic, self-potential (S-P), magnetic, and gravity.

Induced polarisation occurs when electric current is passed through a volume of rock that contains an electronic conductor. If a direct current is applied to the ground by means of two current electrodes and is then cut off, the voltage observed between two potential electrodes does not drop to zero instantaneously, but is found to decay for a finite time starting from an initial voltage, which is a fraction of the voltage existing when the current was flowing. This phenomenon is called over-voltage or induced polarisation. If an alternating current is used instead of direct current, the conductivity of the ground is found to be dependent on the frequency, because of the induced polarisation effect.

In the method used in this survey, the IP effect measured was the percentage change in apparent resistivity of the ground when the frequency was changed from 3 c/s to 0.05 c/s. This is called the frequency effect. An increase in frequency effect indicates the presence of electronic conductors such as metallic sulphides, graphite, and magnetite. Other parameters obtained from the survey results are the apparent resistivity in ohm-metres at 3 c/s and the metal factor, which is defined as the ratio of the frequency effect to the apparent resistivity at 3 c/s, multiplied by a constant.

The electrode configuration used was the dipole-dipole one with 200-ft dipoles and with dipole separations of 2, 3, and 4 times the dipole length. This set-up is shown diagrammatically in Plate 5. Theoretical depth penetration using this set-up is one dipole length for $n = 2$, one and a half for $n = 3$, and two dipole lengths for $n = 4$. In practice the penetration is somewhat less.

In the electromagnetic (Turam) method as used in the survey, an electromagnetic field is produced by passing alternating current through a long straight cable grounded at each end. This primary field causes currents to flow in subsurface conductors and these currents in turn give rise to secondary electromagnetic fields. In general, the resultant field will differ from the primary field in intensity, phase, and direction and will reveal the presence of conductors.

Two search coils 100 ft apart were carried along traverses at right-angles to the primary cable and readings were made every 50 ft. The quantities measured were the ratio of the amplitudes of the vertical electromagnetic field at the two search coils, and the phase difference of the field between the two coils. The ratios are corrected for the variation of the primary field with the distance from the cable. Corrected ratios greater than unity, together with negative phase differences, characterise conductors.

The strengths of the amplitude and phase anomalies depend upon the depth and conductivity of the body causing the anomaly.

In the S-P method, the natural potential differences between any two points on the ground are measured. Negative potentials are characteristic of sulphide bodies undergoing oxidation. The S-P results were not satisfactory in the Dobbyn area and the method was abandoned after a time.

The magnetic method used in the survey consisted of measuring variations in the vertical component of the Earth's magnetic field with an AB Electrisk Malmletning (ABEM) torsion magnetometer.

Gravity readings were made with a Sharpe gravity meter (Serial No.145). The readings were corrected for instrumental drift, elevation (using a density of 2.67 g/cm^3), and latitude. The corrected gravity reading is called the Bouguer anomaly. Its variations are attributed to variations in rock density.

4. WORK DONE

The locality map is shown in Plate 1 and the geophysical grid in Plate 2. The traverses have a true bearing of 90° 19' 30" and were pegged every 50 ft, except for Traverse 0 between 5000W and 10,000W, which was pegged every 100 ft. The north-south lines shown on the grid were used for Turam primary cables.

The first part of the survey was devoted to testing the various methods. The S-P results were not satisfactory, partly because the anomalies were small and tended to be obscured by random variations, but mainly because of poor grounding conditions for the electrodes. Eventually it was decided to concentrate on a combination of Turam and IP methods. The IP method is slower and more expensive to use than Turam, and was used only on selected traverses.

No Turam or IP work was done on the grid between 24,500E and 34,000E. The country here is very hilly and consists almost entirely of outcrop, which made electrode grounding very difficult. Because of the extensive outcrops, it is unlikely that ordinary prospecting would have overlooked any evidence of mineralisation in this part of the survey area. Turam work was done over the rest of the grid (Plate 2) except between 4500W and 10,000W on Traverse 0 and between 34,000E and 40,000E on Traverse 1500N.

IP work was done on the following traverses:

Traverse 0, from 2000E to 10,000W

Traverse 400N, from 0 to 24,500E and from 34,000E to 45,000E

Traverse 1500N, from 0 to 24,500E and from 35,000E to 46,000E

Traverse 2500N, from 0 to 24,500E

Traverse 4100N, from 8200E to 11,000E

In addition, one east-west IP traverse, 2600 ft long, was made over each of the Mount Cuthbert, Crusader, Kohinoor, and Dinkum Digger mines.

Gravity work was done on Traverses 0 and 800N with readings every 100 ft, and magnetic work was done on selected parts of some traverses.

5. DISCUSSION OF RESULTS

Turam and IP methods

On most of the grid, only scattered Turam anomalies were found and these tended to be short and narrow and not associated with IP anomalies. However, in four areas Turam anomalies tended to persist from traverse to traverse in a north-south direction, and were associated with IP anomalies. These four areas lie between 0 and 3600E, 8600E and 11,000E, 12,800E and 15,000E, and 44,000E and 46,600E.

Area 0-3600E. The Turam and IP results in this area, which includes the Dobbyn mine, are shown in Plates 3, 4, and 5.

The Dobbyn main shaft is at 1000E on Traverse 0. In the mine, mineralisation is localised in a north-trending shear in schists on the contact with altered rhyolites. The shear dips east at 75° (Plate 16). The orebody was worked only in the oxidised zone and the ore consisted of copper carbonates and oxides with some chalcocite in a gangue of quartz. The primary ore mineral is chalcopyrite. The deposit was developed over a maximum length of 440 ft, a width of 3 to 12 ft and a depth of 330 ft. At the time of closure, the operating company estimated that 41,000 tons of 5% sulphide ore remained. (Carter et al, 1961, p 214). At the 200-ft level the lode is 60 ft east of the main shaft, and at the 330-ft level 100 ft east (Plate 16). The proper lode is about 10 to 17 ft wide and dips east. Pyritic formations occur west of the lode and probably extend west of the main shaft.

The Turam results on Traverse 0 over the Dobbyn mine show the mineralised shear to be a very good conductor. The Turam anomaly extends north and south of the mine as far as and probably beyond the limits of the grid, indicating that the shear persists through the area as a definite tectonic feature. The shear is presumably more porous and consequently contains more saline water than the country rock, a factor which increases its conductivity relative to the country rock. The occurrence of sulphide minerals in the shear will contribute directly to its conductivity, and also indirectly by increasing the electrolyte content of the water.

Most of the Turam anomalies marked in Plate 3, with the exception of the one over the Dobbyn mine, are caused by moderate conductors. Several anomalies extend for considerable distances roughly parallel to the Dobbyn anomaly. These are probably also due to tectonic features such as shears. The anomalies that occur only on single traverses may be due to strong decomposition and weathering of certain areas, or to other surface features that cause increased electrical conductivity.

The IP work, which was confined to Traverses 0, 400N, 1500N, and 2500N, shows IP effects associated with the Dobbyn Turam anomaly. The IP anomaly on Traverse 0 over the mine extends on both sides of the main shaft with its centre slightly east of the shaft. The resistivity 'low' is on both sides of the shaft but the lowest values are to the west. This may be due to the pyritic formations which occur west of the lode. The main part of the IP anomaly is presumably due to the 5% sulphide ore that remains in the mine. At the largest dipole-separation, corresponding to a theoretical depth of penetration of about 400 ft, the metal-factor values are low, which may mean that the grade of the primary ore at depth is poor.

The resistivity, frequency-effect, and metal-factor anomalies are all quite strong on Traverse 0 but become weaker at 400N (Plate 5), where the Turam anomaly suggests lower conductivity (Plate 4). On Traverse 1500N at 950E, where the Turam results again indicate only moderate conductivity, the IP results show only a weak frequency effect and no appreciable resistivity or metal-factor anomaly. On Traverse 2500N the Turam and IP frequency-effect anomalies become slightly stronger and weak resistivity and metal-factor anomalies are present.

The interpretation is that the Dobbyn mine is in a mineralised shear that extends north and south past the limits of the grid. The mineralisation is strongest at the Dobbyn mine. This is indicated by both the Turam and IP results. The strength of mineralisation weakens rapidly north and south of the mine. The Turam results suggest that on Traverse 500S some mineralisation is present in a narrow zone, but dies out to the south. To the north of the mine, the Turam results suggest first a weakening and then a slight strengthening in mineralisation on Traverses 2000N and 2500N, but then getting weaker again further north. The IP results show mineralisation on all the traverses surveyed with this method, but the mineralisation appears weak.

East of the Dobbyn anomaly, two other Turam anomalies with associated IP anomalies, can be traced for considerable distances. One extends from 1880E/3500N southwards to 1850E/800N, where it appears to die out. The other, about 150 ft further east extends from Traverse 1500N to the southern limit of the grid at 1680E/1000S and probably continues further south. These anomalies indicate only moderate conductors, but on Traverses 500S and 1000S the phase differences are relatively small in comparison with the amplitude ratios and indicate a somewhat higher conductivity.

On Traverse 1500N, the two Turam anomalies coincide with an IP anomaly centred at about 1900E. The IP results show fairly strong resistivity, frequency-effect, and metal-factor anomalies. On Traverses 2500N and 400N the frequency effects are distinct but the resistivity and metal-factor anomalies are very weak. These results are interpreted as being due to a mineralised shear extending from about 1880E/3500N to south of Traverse 1000S. The mineralisation appears to be weaker than in the Dobbyn mine.

Area 8600E - 11,000E. The Turam and IP results in this area, which includes the Orphan mine, are shown in Plates 6, 7, and 8.

The Orphan main shaft is about 50 ft north of 9600E/4100N. The mine is in a fault which bifurcates to the north-west of the mine. The fault dips to the south-west at 70° and the orebody pitches steeply south-east. The country rocks are hornblende schist and altered porphyritic rhyolite. The ore consisted of malachite, cuprite, chalcocite, and azurite in the oxidised zone and chalcopyrite and pyrite in the primary zone. The gangue consists of quartz and siderite. The deposit was mined over a length of 300 ft, a width of 5 to 9 ft, and a depth of 175 ft. The orebody widens to 15 ft at the junction of the fault branches. The ore reserves were not exhausted at the time of closure, but have not been estimated. (Carter et al, 1961, p 214).

As in the case of the Turam anomalies in the region of the Dobbyn mine, the long, almost-straight lines of Turam anomalies suggest tectonic features such as shears. The Turam anomaly at 9600E on Traverse 4100N (Plate 6) is over the eastern lode of the Orphan mine, near the junction of the eastern and western lodes. The Turam anomaly is most pronounced on Traverse 4100N and decreases rapidly on Traverses 3700N and 3300N. The present survey did not extend north of Traverse 4100N. However, the results of a previous geophysical survey (Rayner & Nye, 1936, Plate 7) show that the electromagnetic anomaly over the Orphan mine can be followed at least 2500 ft north of Traverse 4100N.

IP on this part of the grid was confined to Traverses 400N, 1500N, 2500N, and 4100N. The IP results (Plate 8) show strong resistivity, frequency-effect, and metal-factor anomalies over the Orphan mine at 9600E/4100N. The traverse crosses the Orphan mine over the junction of the eastern and western lodes. Stronger anomalies may have been obtained had the traverse been over the main workings. The width of copper mineralisation is about the same as in the Dobbyn mine, and the 250 value metal-factor contours of the Orphan and Dobbyn mines are very similar. The resistivity anomaly is slightly stronger in the Orphan mine than in the Dobbyn mine, but the frequency-effect anomaly is weaker. The metal-factor values again are low at the largest dipole-separation (n = 4), suggesting that the mineralisation becomes weaker at depth. On Traverses 2500N and 1500N there are only broad, weak, frequency-effect anomalies and these seem to be associated with the Turam anomaly extending from 10,350E/2500N to 10,180E/0.

From the Turam and IP results of the present survey and from the previous electromagnetic survey results, it appears that the Orphan mine is on the southern part of a mineralised shear, which extends a considerable distance north of the grid but terminates to the south between Traverses 3300N and 2900N. The Turam anomaly that extends from 10,350E/2500N to 10,180E/0 is accompanied by weak frequency-effect anomalies and may indicate a slightly mineralised shear.

Area 12,800E - 15,000E. The Turam and IP results in this area are shown in Plates 9, 10, and 11. The anomalies recorded are in or near a major fault zone. A ridge with a haematite outcrop occurs in this area and its position is shown in Plate 9 as a rocky outcrop. The haematite outcrop was found to by highly magnetic by an aeromagnetic survey (Dockery & Tipper, 1964). The magnetic anomalies extend to the south only to about the middle of the grid around Traverse 1500N but continue north of the grid for about 3000 ft. Another aeromagnetic anomaly starts about 1000 ft south of 12,000E/0 and continues south for several thousand feet. The cause of it is not known.

The IP anomalies shown in Plate 11 are weak, and on Traverses 1500N and 2500N they seem to be related to the haematite outcrop and the corresponding Turam anomalies.

Area 44,000E - 46,600E. The geophysical results in this area are shown in Plates 12, 13, and 14. The IP method was confined to Traverses 1500N and 400N. Although the main discussion of the gravity and magnetic surveys is given in later sections, it is convenient here to consider the gravity and magnetic results in this area together with the Turam and IP results. Gravity readings were made on Traverses 0 and 800N and magnetic readings on Traverse 400N from 44,000E to 46,000E.

On Traverse 400N the Turam results show a strong anomaly, characteristic of a good conductor. The IP anomalies on this traverse are fairly strong but not so strong as over the Dobbyn and Orphan mines. A magnetic anomaly with amplitude of about 200 gammas and width about 200 ft occurs over the IP anomaly and east of the main Turam anomaly on Traverse 400N. A weak gravity anomaly of about $\frac{1}{4}$ milligal occurs on Traverses 800N and 0 to the north and south of this magnetic anomaly.

On Traverse 1500N, the IP results show a strong resistivity anomaly but the frequency-effect and metal-factor anomalies have become weak. The Turam anomaly can be traced to the north and south of 400N to the limits of the grid.

All these anomalies occur over alluvium between a quartzite ridge about 300 ft to the west and the Leichhardt River to the east. The alluvial plain narrows to the north and widens to the south of the area. Zimmerman (pers. comm.) observed siltstones with some thin carbonaceous shales on the west side of the quartzite ridge and considered that siltstones probably occur under soil cover immediately west of the Leichhardt River and north of the grid. On Traverse 400N from 43,300E to 44,100E, he noted quartzite (strike 340°, dip 75° east); from 44,100E to 44,300E, quartzite rubble; and from 44,300E to 46,600E, alluvium, mainly over siltstone(?), probably with some quartzite towards the eastern end between 45,500E to 46,200E. On Traverse 0 from 41,800E to 43,300E, he noted buff quartzite with average strike 345° and dip 80° east; from 43,300E to 46,600E, alluvium, probably underlain by quartzite and grey siltstones.

The anomalies may be due to mineralisation or to carbonaceous sediments.

IP tests over selected mines

One IP traverse was surveyed over each of the Mount Cuthbert, Crusader, Kohinoor, and Dinkum Digger mines. The results are considered here together with the geology of the mines. Each of the traverses was laid in an east-west direction; the profiles are shown in Plate 15.

Mount Cuthbert mine. The Mount Cuthbert deposit occurs in a northerly-trending shear zone in schist and slate near the contact with acid volcanics and metadolerites. The dip is to the east and the pitch is alsmot vertical. The shear zone is up to 300 ft wide, but the mineralisation is mainly confined to ore-shoots over a 100-ft section on the hangingwall and to a lesser extent near the footwall of the shear zone. The ore-shoots had a maximum width of 30 ft. The ore consisted of chalcocite, 'tile ore', cuprite, and azurite in a gangue of quartz, siderite, and calcite. Chalcopyrite ore was reached in the lower levels but little of it was mined. The mine was worked over a length ranging from 300 ft at the surface to 650 ft on the 350-ft level. It was estimated that at least 200,000 tons of 5% oxidised ore remained in the mine. (Carter et al, 1961, p 213).

The IP results over the Mount Cuthbert mine (Plate 15) show well-defined resistivity and metal-factor anomalies, and frequency effects of up to 12%, which is high. The Mount Cuthbert shear is much wider than the Dobbyn shear and this is reflected in the much wider areas within the 7½% frequency-effect contour and the 250-value metal-factor contour.

The main shaft is about 100 ft east of the easterly-dipping hangingwall. The metal-factor anomaly agrees in position with the mineralisation but, with a spacing of 200 ft between readings, the width of the anomaly cannot be strictly compared with the width of the mineralisation. The metal-factor values decrease and the resistivity values increase with increasing dipole separation, indicating a lower grade of mineralisation at depth; this is consistent with lower-grade chalcopyrite being encountered in the lower levels of the mine. The ore remaining in the mine is stated to be 5% ore and presumably the main part of the metal-factor anomaly is due to this ore. Metal-factor values with $n = 4$ are about as high as those with $n = 2$ over the Dobbyn and Orphan mines (Plates 5 and 8), and it is probable that mineralisation persists at depth with reasonable strength.

Crusader mine. The Crusader mine occurs in a quartz porphyry that is intrusive into hornblende schist. The porphyry is mineralised along a fissure zone that trends north-north-west and dips 70° east-north-east, with hornblende schist forming the hangingwall of the orebody. The mineralised porphyry has been sericitised and kaolinised, but beyond the limits of copper mineralisation it has been thoroughly silicified. The silicification also extends into the porphyry wall rock. Copper mineralisation occurs over a length of 800 ft and a width of up to 70 ft centrally, but tapers out towards either end. Near the surface the ore consists of malachite and cuprite. As the base of oxidation is approached, considerable amounts of chalcocite are found disseminated throughout the orebody.

Concentrations of more than 5% copper are distributed irregularly, the largest one being 180 ft long and 3 ft to 5 ft wide. The whole mineralised zone would carry less than 3% copper. Primary sulphide ore has not been penetrated by the workings, which extend only to a depth of 74 ft. The zone of secondary enrichment is of limited size near the groundwater table and has no appreciable vertical extent. (Hall, 1953).

The IP results over the Crusader mine (Plate 15) show a strong resistivity anomaly and a strong metal-factor anomaly. The anomalies are narrow, being about the same width as the anomalies over the Dobbyn and Orphan mines, and are situated slightly west of the main shaft. The values obtained for n = 2 are from a theoretical depth of 200 ft, which is considerably deeper than the workings. The Crusader mine lies in an area that was found by an aeromagnetic survey to be highly magnetic; however, the magnetically disturbed area is many thousands of feet wide in an east-west direction and is not associated directly with the mine (Dockery & Tipper, 1964). It is difficult to draw conclusions from one isolated IP traverse with no external control, but the results suggest that good mineralisation could be present at depth.

Kohinoor mine. The Kohinoor mine occurs in a schist belt enclosed on both sides by porphyry. The contact between the schist and the porphyry shows signs of contact metamorphism with contact minerals and hornfels. The orebody occurs in the zone of maximum shearing, which contains bands of ferruginous and of milky quartz. The gangue material is mainly crystalline calcite. (Rayner & Nye, 1936, p 4). The lode is generally narrow and the greatest recorded width of ore is only 7 ft (Carter, 1959).

The previous geophysical work (Rayner & Nye, 1936) showed a strong electromagnetic anomaly coinciding with the Kohinoor workings and continuing to the north. However, the IP results in the present survey (Plate 15) were disappointing. No appreciable resistivity or metal factor was found. A weak frequency-effect anomaly occurs over the workings and another even weaker one about 800 ft to the west. The workings are known to be narrow and shallow and it is possible that with n = 2, the depth penetration (theoretically 200 ft) was already below the strongly mineralised zone.

Dinkum Digger mine. The Dinkum Digger mine is located on relatively flat country with poor exposures. The ore occurs in a quartz-filled fracture in calc-silicate rocks adjacent to amphibolite. Surface expression apparently consisted of some minor copper carbonate stains, some very small and unimpressive looking gossans, and the copper flower. Sulphides occur within a few feet of the surface and consist mainly of chalcopyrite and lesser pyrite. Mineralisation occurs over a width of at least 100 ft. The mine is situated near a major north-south fault zone. Primary mineralisation may extend for several thousands of feet. (Zimmerman, pers. comm.).

The IP results over the Dinkum Digger mine (Plate 15) show strong resistivity and metal-factor anomalies that are narrow, but seem to persist in depth. The workings in the mine are much shallower than the depth penetration of the IP results.

Magnetic results

The magnetic survey was confined to selected parts of some traverses. Readings were taken every 50 ft on Traverse 0 from 0 to 2000E, Traverse 400N from 0 to 18,000E, Traverse 800N from 0 to 1950E (Plate 18), and Traverse 400N from 44,000E to 46,000E (Plate 14). Readings were taken every 10 ft on Traverse 0 from 26,200E to 27,600E and Traverse 2500N from 5950E to 7500E (Plate 17) to obtain a more detailed comparison between the magnetic profiles and surface geology.

The surface geology indicated in Plates 17 and 18 shows fairly good correlation with the magnetic profiles. Most of the basic rocks appear to produce strong anomalies. In general these anomalies have steeper gradients on the western side, indicating an easterly dip, which agrees with the regional trend. On the detailed profiles on Traverses 0 and 2500N the strongly magnetic basic volcanics can be distinguished from the less magnetic rhyolite.

Not all the magnetic anomalies are necessarily due to the basic rocks. For instance, on Traverse 400N, the high values around 650E may be related to magnetic material in a nearby fault zone. High values around 3550E may be due to magnetite in river gravels; this area is on the west bank of Coppermine Creek and there is an abundant source of magnetite in the areas of basic rocks drained by Coppermine Creek. Coarse-grained quartz felspar porphyry near 16,500E is apparently more magnetic than rhyolite or quartzite. Magnetic anomalies were obtained over some tuffaceous quartzites, for instance at 27,250E on Traverse 0 (Plate 17). These may be due to layers of detrital magnetite in the quartzite.

In the area of the Dobbyn mine, small peaks in the magnetic profile at 950E/0, 970E/400N, and 800E/800N (Plate 18) coincide with the Turam anomaly that passes through the Dobbyn mine. The peaks are probably due to hornblende biotite schist. A similar cause is attributed to the peaks at 1800E/0, 1950E/400N, and near 1950E/800N.

In general it is difficult to correlate the magnetic anomalies with the mineralised zones indicated by the Turam and IP surveys, as any magnetic features possibly attributable to the mineralised zones are relatively minor compared with the numerous strong anomalies associated with the surrounding rocks.

Gravity results

The gravity profiles on Traverses 0 and 800N are shown in Plates 18, 19, and 20. The surface geology shown along Traverse 0 is from mapping carried out by Zimmerman (pers. comm.).

The table below, giving the average densities of rock samples collected in the Dobbyn area, shows that the acid volcanics and granite, and the quartzites and calc-silicates have densities that are, in general, lower than those of the basic rocks.

Rock type	Average density (g/cm^3)
siltstone	2.44
granite	2.61
rhyolite	2.63
calc-silicates	2.66
felspar porphyry	2.68
dacite	2.69
quartzite	2.70
gneiss	2.77
amphibolite	3.01

On the basis of these average rock densities, there appears to be good correlation between the surface geology and the gravity profile along Traverse 0.

Between 10,000W (the western end of the traverse) and 0, the gravity values show a small general rise (Plate 20). The area is mainly rhyolite, but basic rock (dolerite or amphibolite) occurs at 9000W, corresponding to a small gravity 'high', and between 8780W and 7800W granite outcrops as a 50-ft hill corresponding to a sharp gravity 'low'. Small local gravity 'highs' near 6800W and between 1150W and 650W appear to be caused by amphibolite.

The gravity values rise more rapidly east of 0 and reach a maximum of about 12 milligals near 4400E (Plate 18). Amphibolite and rhyolite alternate between 2600E and 6400E and the gravity 'high' suggests that the area here is underlain mainly by basic rocks. Rhyolite predominates between 6400E and 12,400E corresponding to a broad gravity 'low'. Amphibolite occurs between 12,000E and 14,000E and the gravity 'high' here suggests the presence of mainly basic rocks.

A major fault zone mapped between 14,300E and 14,450E divides the area into two parts, one of generally low gravity on the east and the other of generally higher gravity on the west. The fault zone coincides with a fairly steep gradient on the gravity profile.

Between 15,900E and 19,200E (Plates 18 & 19) the geology shows amphibolite and quartzite. The decrease in the gravity values is probably due to a decreasing proportion of basic rocks. The broad gravity 'low' between 19,200E and 21,900E corresponds to an area consisting mainly of quartzite and granite. Amphibolite and quartzite were mapped between 21,900E and 25,400E and the profile shows a broad gravity 'high', which may be due to basic rocks.

From 25,400E to 28,000E the rocks are predominantly quartzite with small areas of granite and amphibolite; the gravity values show a gradual decrease.

The gravity results between 27,000E and 31,000E are influenced by terrain effects but further east between 31,000E and 33,000E there appears to be a broad gravity 'low' corresponding to an area of mainly quartzite, acid volcanics, and granite.

The gravity 'high' of about 1 milligal between 33,000E and 35,000E occurs over predominantly calc-silicate rocks. Two rock samples from this locality gave higher densities than other calc-silicates in the area and the gravity 'high' may be due to this higher density.

The eastern part of the traverse from about 35,000E to 46,600E crosses an area covered mostly by alluvium. The steep gravity gradient on the eastern end of the traverse continues to the east of 46,600E and gravity values reach a minimum east of the Leichhardt River and then increase rapidly (Smith, in preparation). This gravity anomaly is evidently related to a pronounced fault east of the Leichhardt River.

The similarity between the gravity profiles on Traverses 0 and 800N indicate that the main gravity features in the area of the geophysical grid trend north-south. The two large gravity 'highs' (one at 4400E and the other at 13,000E) both extend for a considerable distance to the north. The eastern 'high' also extends to the south (Smith, in preparation). The flanks of both these 'highs' are associated with several copper shows, both on the east and west, and seem to indicate a general relation between gravity anomalies and mineralisation. However, neither the Dobbyn deposit (as is evident from Plate 18) nor the Orphan deposit appear to produce recognisable gravity anomalies.

6. CONCLUSIONS

The IP and Turam methods proved the most useful tools in the exploration for copper deposits in the Dobbyn area. The Turam method, however, gave many anomalies caused mainly by shears and fault zones because the groundwater in this area is largely saline. The shears and fault zones act as good conductors because of their high porosity and the concentration of water in them. IP results, however, are not affected by electrolytic conductors if there is no mineralisation present and most of the good conductors shown in the Turam results can be eliminated through the use of the IP method. Because large dipole lengths (200 and 300 ft) are used in IP surveys little detailed information can be obtained about size, position, dip, and shape of the orebodies; this information is better obtained from a Turam survey. The combination of both methods must be regarded as a step forward in the search for base-metal deposits because it allows drilling targets to be selected with greater discrimination and therefore greatly reduces the amount of drilling.

The IP work done on the main geophysical grid included traverses over the Dobbyn and Orphan mines. In addition one IP traverse was surveyed over each of the Crusader, Dinkum Digger, Mount Cuthbert, and Kohinoor mines. With the exception of the Kohinoor deposit, where only weak IP effects were observed, each of these deposits showed up as definite IP anomalies. The IP anomalies observed elsewhere in the area must therefore be regarded as possible indications of mineralisation.

Although only a limited area was covered by the survey, a few possible prospects can be recognised in the results. These are:

(a) extension of the Dobbyn deposit to the north and south,

(b) a zone of mineralisation about 1000 ft to the east of the Dobbyn mine and continuing north from about 1500N,

(c) extension of the Orphan deposit,

(d) the fault zone near 14,400E, and

(e) the alluvial area at about 45,000E where the results indicate a mineralised or graphitic zone.

Of these, (b) and (e) are two new areas of possible mineralisation found by the survey. Further detailed geophysical investigation of the above prospects will be required to determine the full extent of the anomalies and to select drilling targets if the anomalies warrant investigation by drilling.

The results of the gravity survey revealed a correlation with the known geology. In general the gravity 'highs' correspond to the areas of predominantly basic rocks and the 'lows' to the more acid rocks. The copper deposits appear to be situated on the flanks of the gravity 'highs' but the deposits themselves do not show up as gravity anomalies. Gravity surveys therefore do not seem suitable in direct search for the orebodies but are better suited for reconnaissance to reveal the more important geological structures, expecially fault zones.

The magnetic survey showed a large number of magnetic anomalies reflecting the different magnetic properties of the various rock types in the area, but the known mineralisation does not appear to produce any recognisable magnetic effects.

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DOCKERY, B.A. and TIPPER, D.B.	1964	Mount Cuthbert/Dobbyn aeromagnetic survey, Queensland 1963. Bur. Min. Resour. Aust. Rec. 1964/146.
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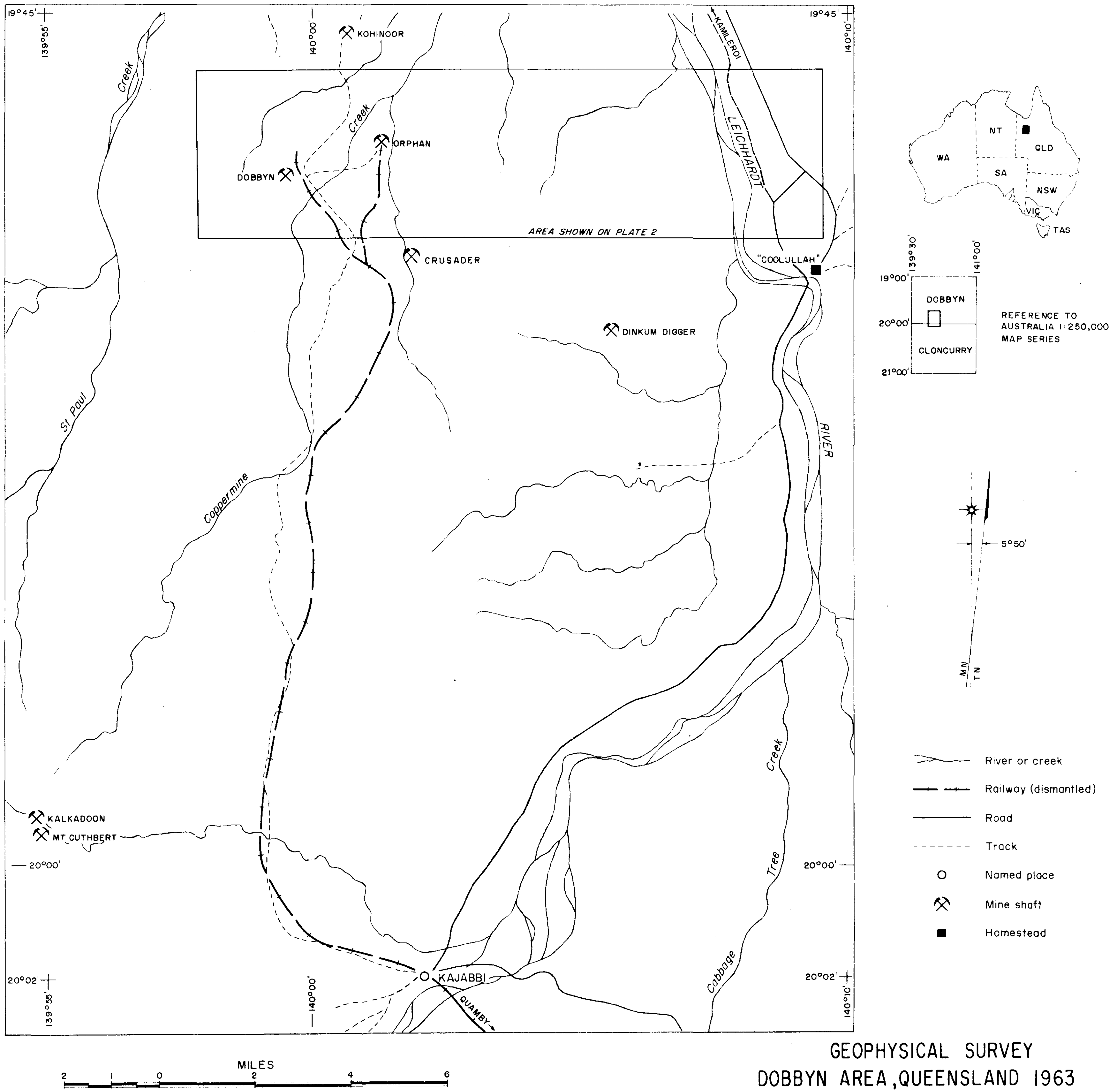
PLATE I



GEOPHYSICAL SURVEY
DOBBYN AREA, QUEENSLAND 1963
LOCALITY MAP

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E54/B7-1

TO ACCOMPANY RECORD No. 1964/187

(BASED ON E 54/B1-17)

PLANIMETRY

PLANIMETRIC DETAIL FROM AN UNCONTROLLED PHOTO COMPILATION USING F.24 PHOTOGRAPHS TAKEN BY BMR AIRCRAFT, SEPTEMBER 1963

SCALES

1 0 1 2 MILES

2000 1000 0 2000 4000 6000 8000 FEET

1 0 1 2 3 KILOMETRES

True North
Magnetic North
5°50'

DOBBYN AREA, QUEENSLAND 1963
GEOPHYSICAL GRID

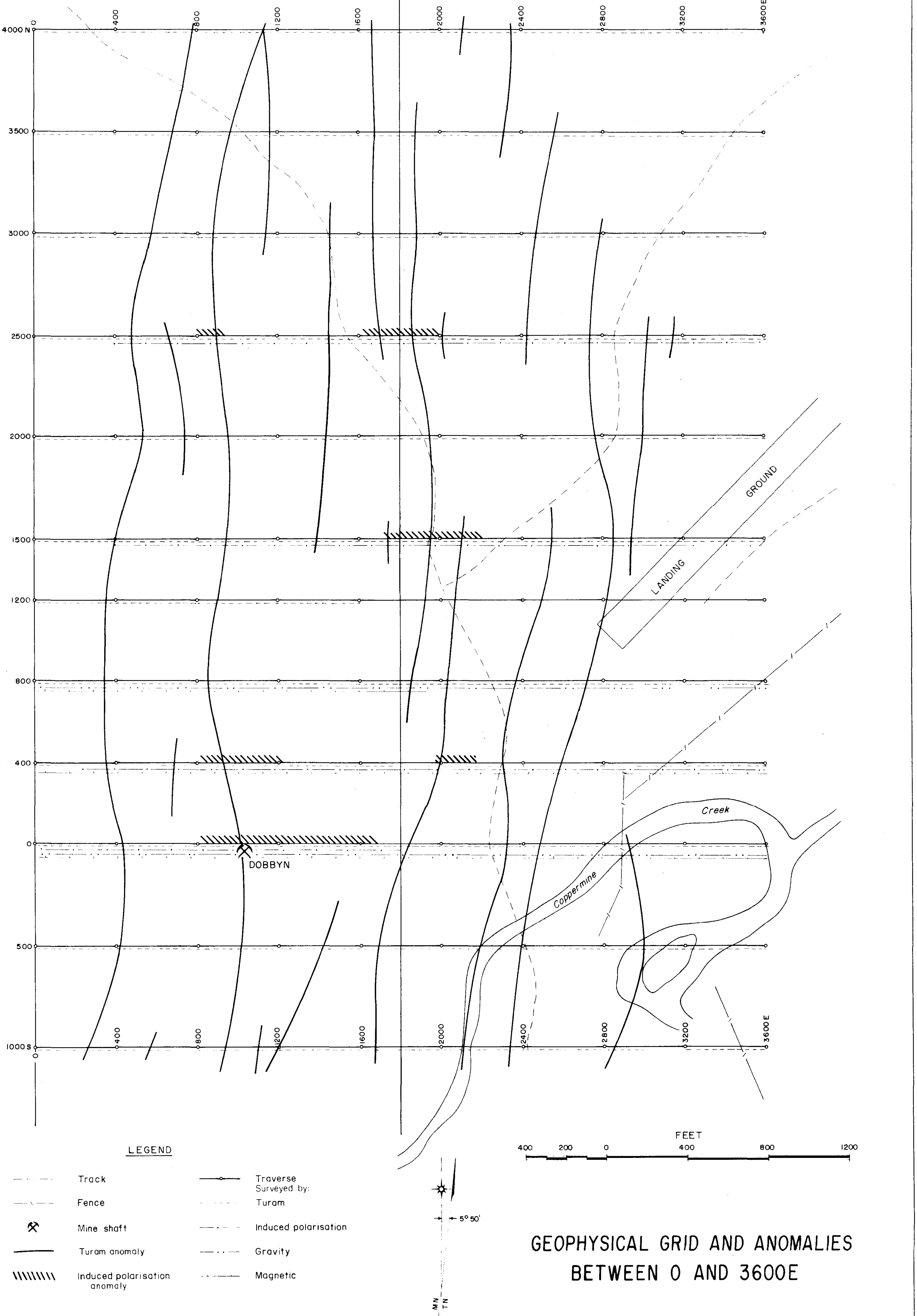
LEGEND

- River or creek
- Road
- Railway
- Track
- Fence
- Building or shed
- Mine shaft
- Geophysical traverse

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics E54/B7-2

TO ACCOMPANY RECORD No. 1964/187

PLATE 3



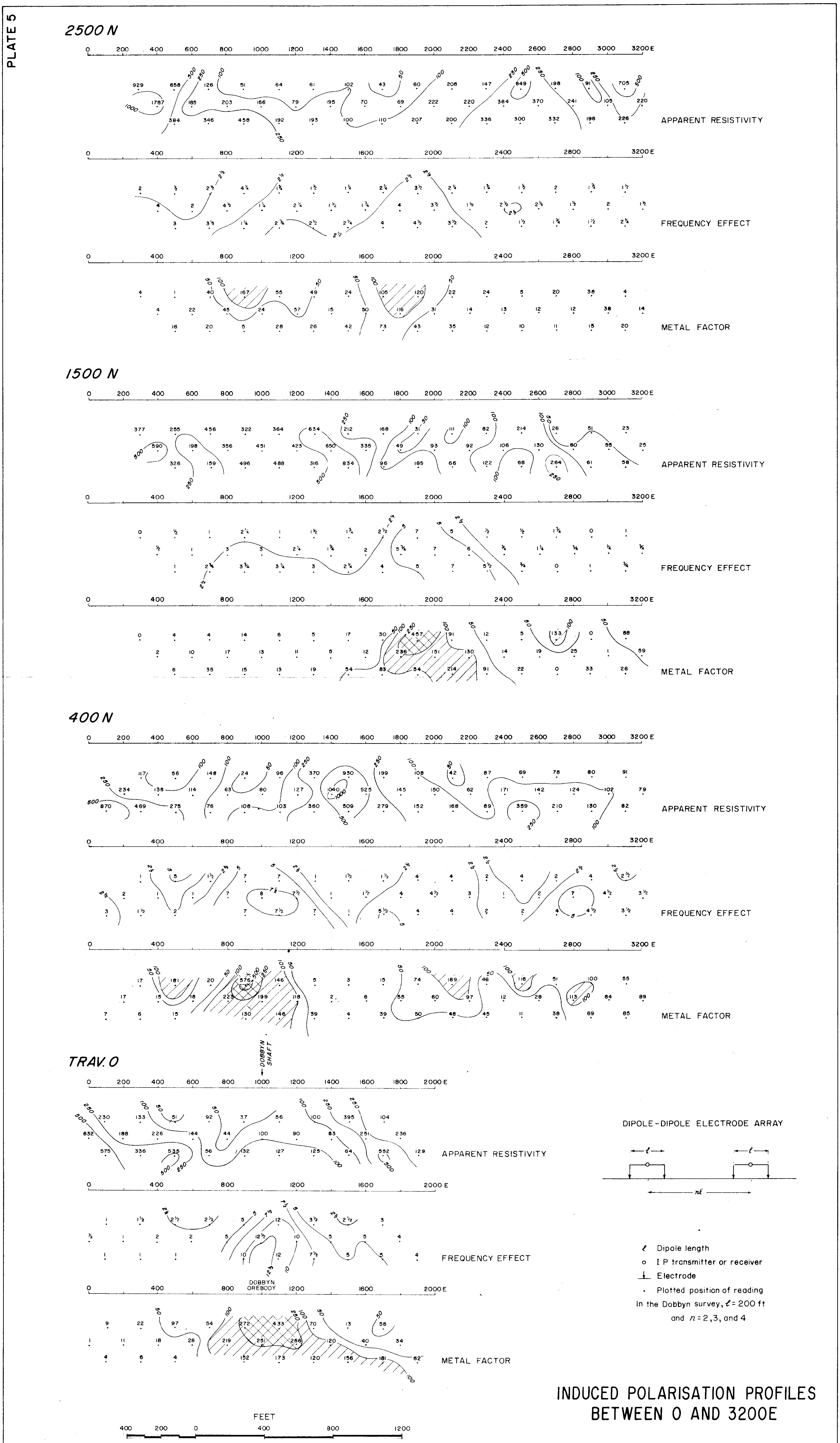
GEOPHYSICAL GRID AND ANOMALIES BETWEEN 0 AND 3600E

PLATE 4

TURAM REDUCED RATIO AND PHASE DIFFERENCE PROFILES BETWEEN 0 AND 3600E

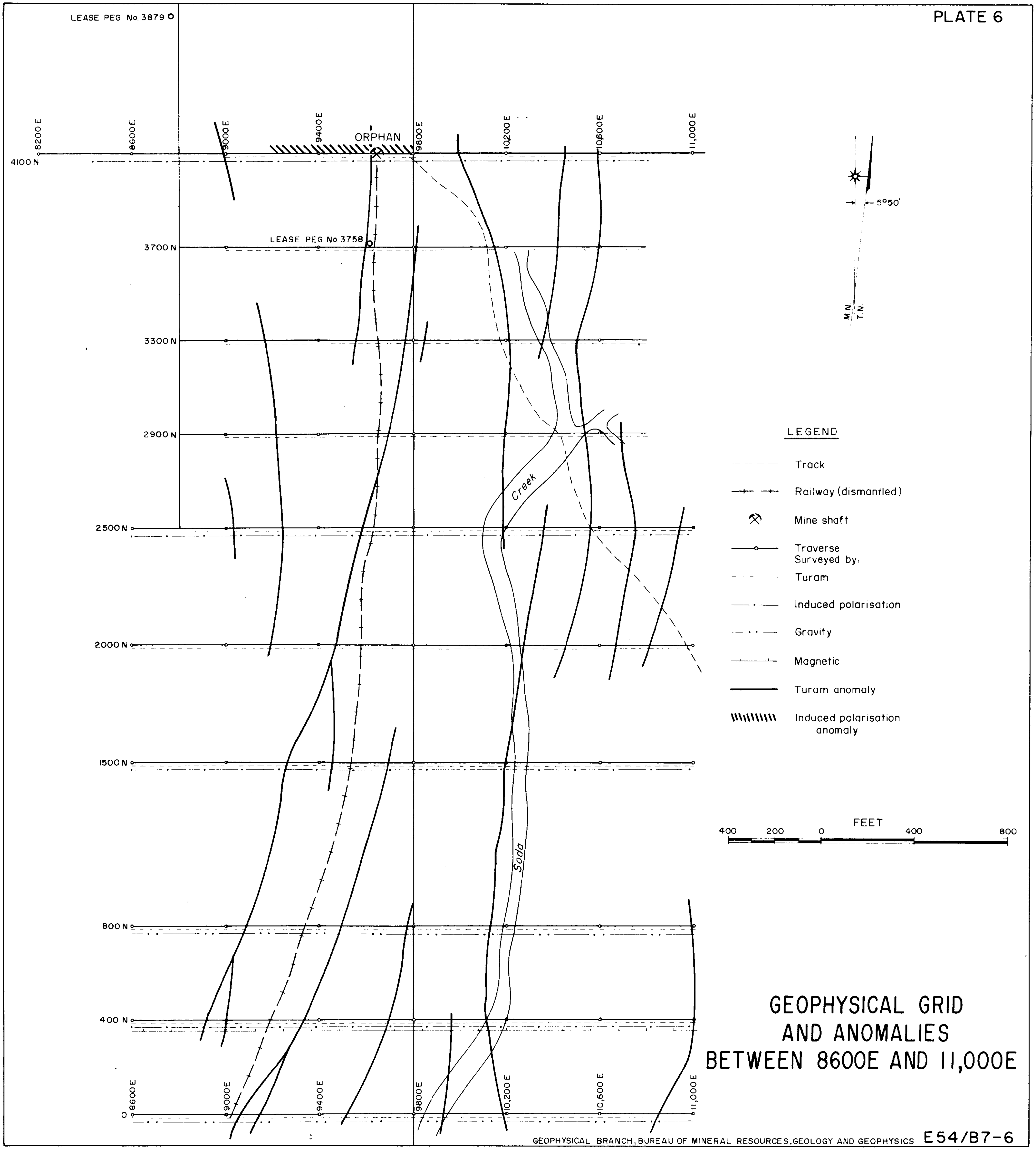
GROUNDED CABLE, CABLELINE 3800E
COIL SEPARATION 100 FT, FREQUENCY 660 c/s

TO ACCOMPANY RECORD No. 1964/187 GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E54/B7-4



INDUCED POLARISATION PROFILES BETWEEN 0 AND 3200E

DOBBYN AREA, QLD, 1963

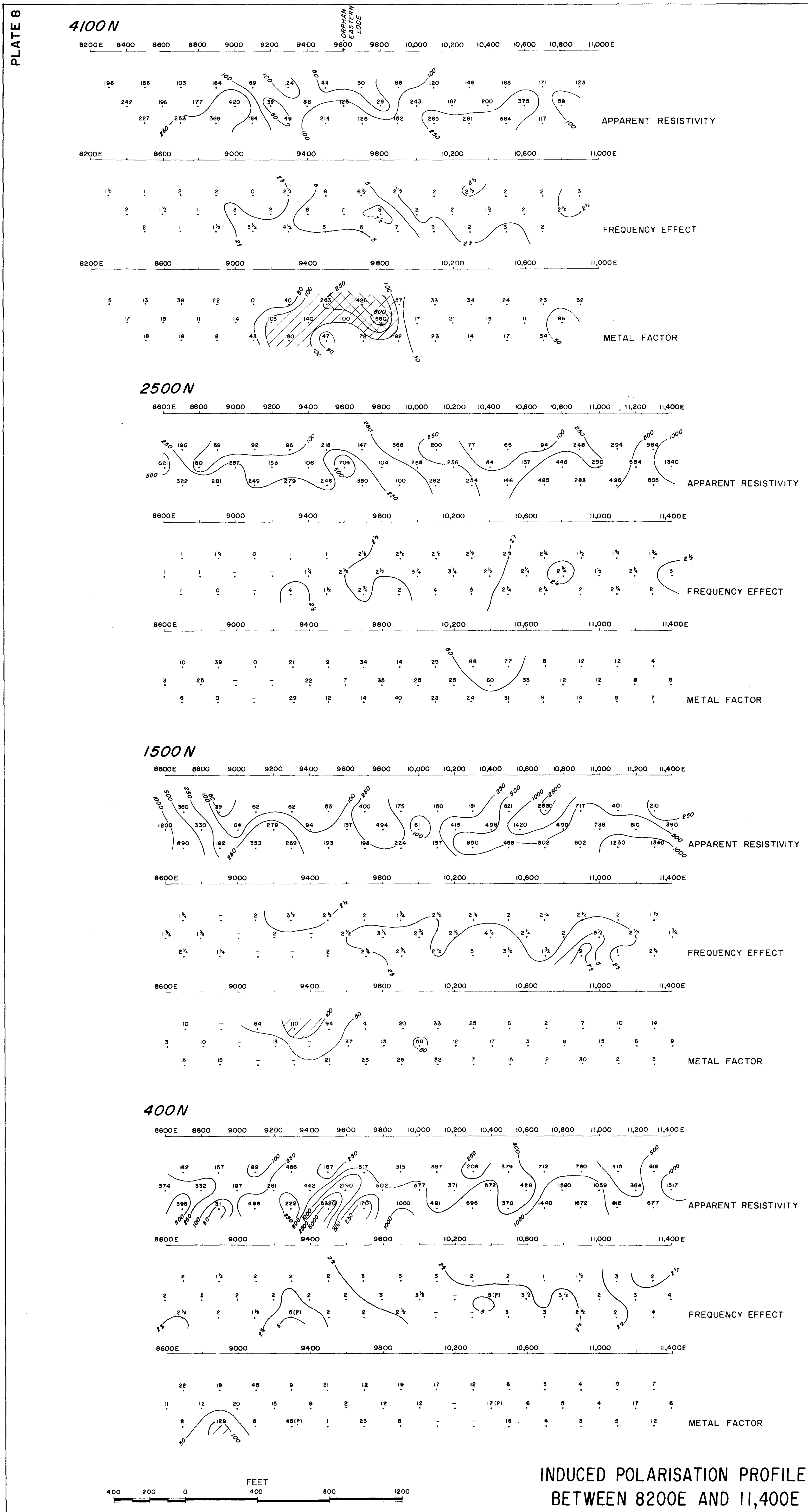


TO ACCOMPANY RECORD No 1964/187

PLATE 7

TURAM REDUCED RATIO AND PHASE DIFFERENCE PROFILES BETWEEN 8600E AND 11,000E

GROUNDED CABLE, CABLELINES 7800E, 9800E
COIL SEPARATION 100 FT, FREQUENCY 660%

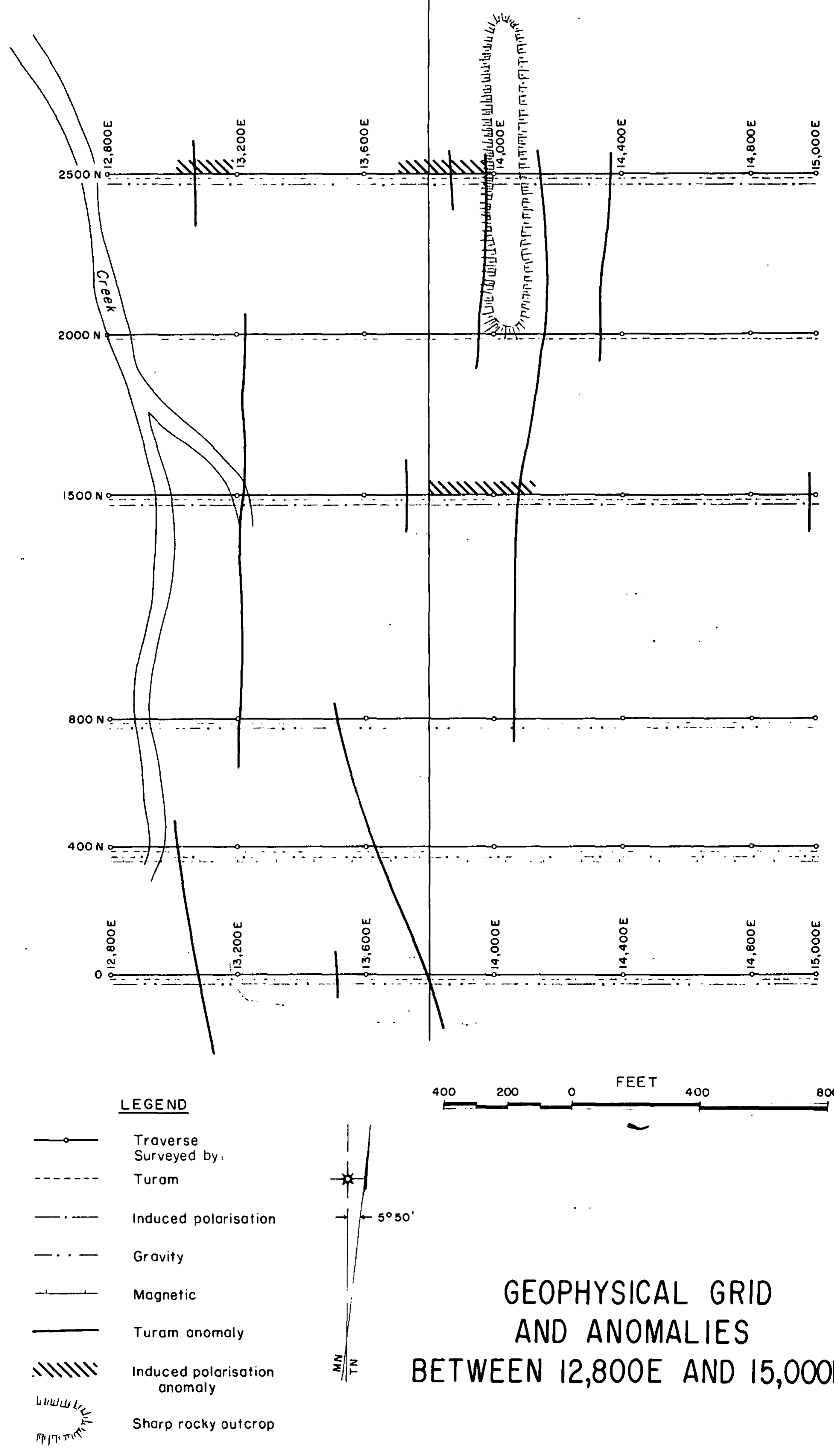


INDUCED POLARISATION PROFILES
BETWEEN 8200E AND 11,400E

TO ACCOMPANY RECORD No. 1964/187

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E54/B7-8

PLATE 9



GEOPHYSICAL GRID AND ANOMALIES BETWEEN 12,800E AND 15,000E

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

E54/B7-9

TO ACCOMPANY RECORD No. 1964/187

DOBRYN AREA, QLD. 1963

PLATE 10

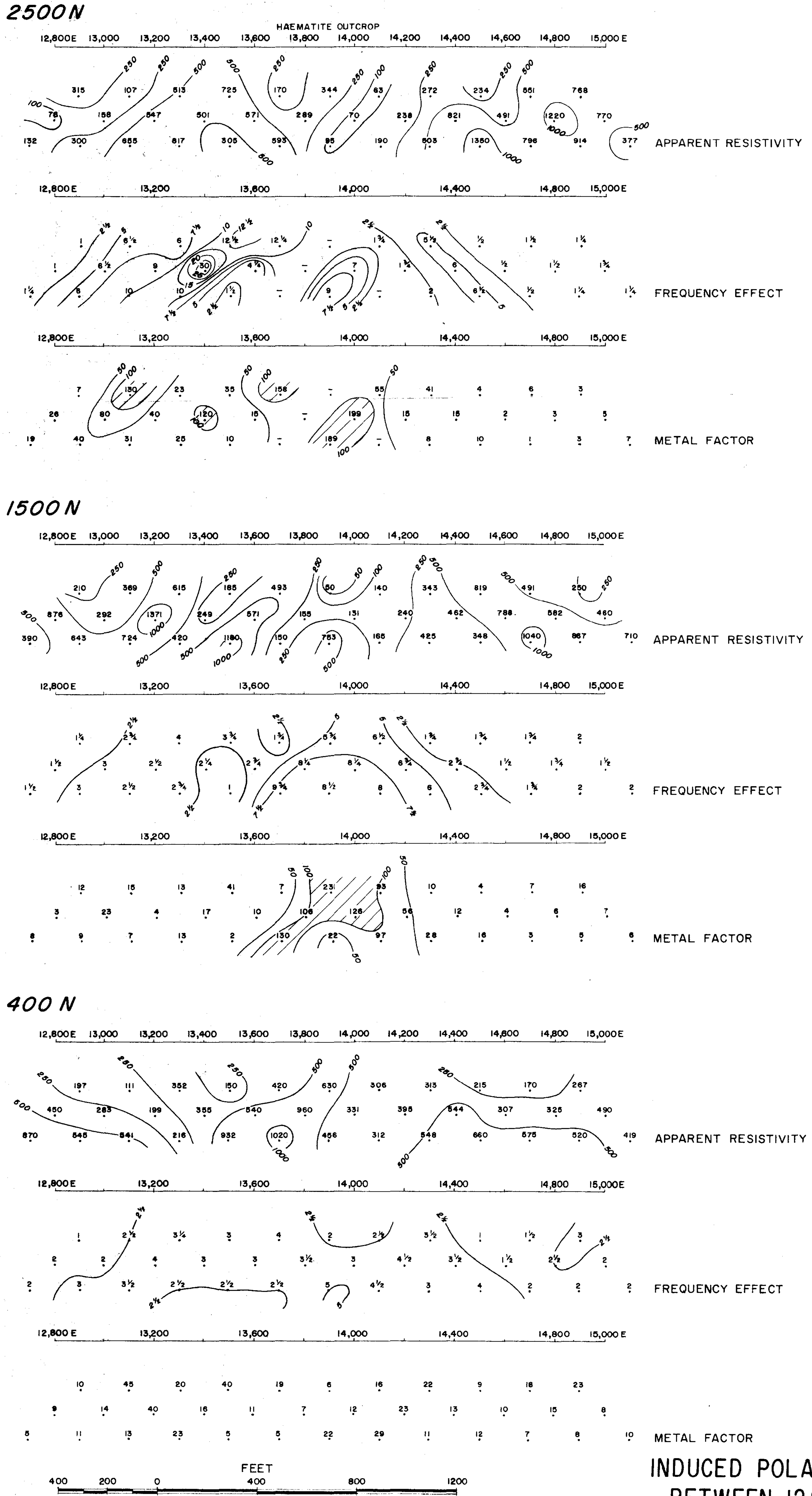
TURAM REDUCED RATIO AND PHASE DIFFERENCE PROFILES BETWEEN 12,800E AND 15,000E

GROUNDED CABLE, CABLELINE AT 11,800E
COIL SEPARATION 100 FT, FREQUENCY 660%

TO ACCOMPANY RECORD No. 1964/187   GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS   E54/B7-10

DOBBYN AREA, QLD, 1963

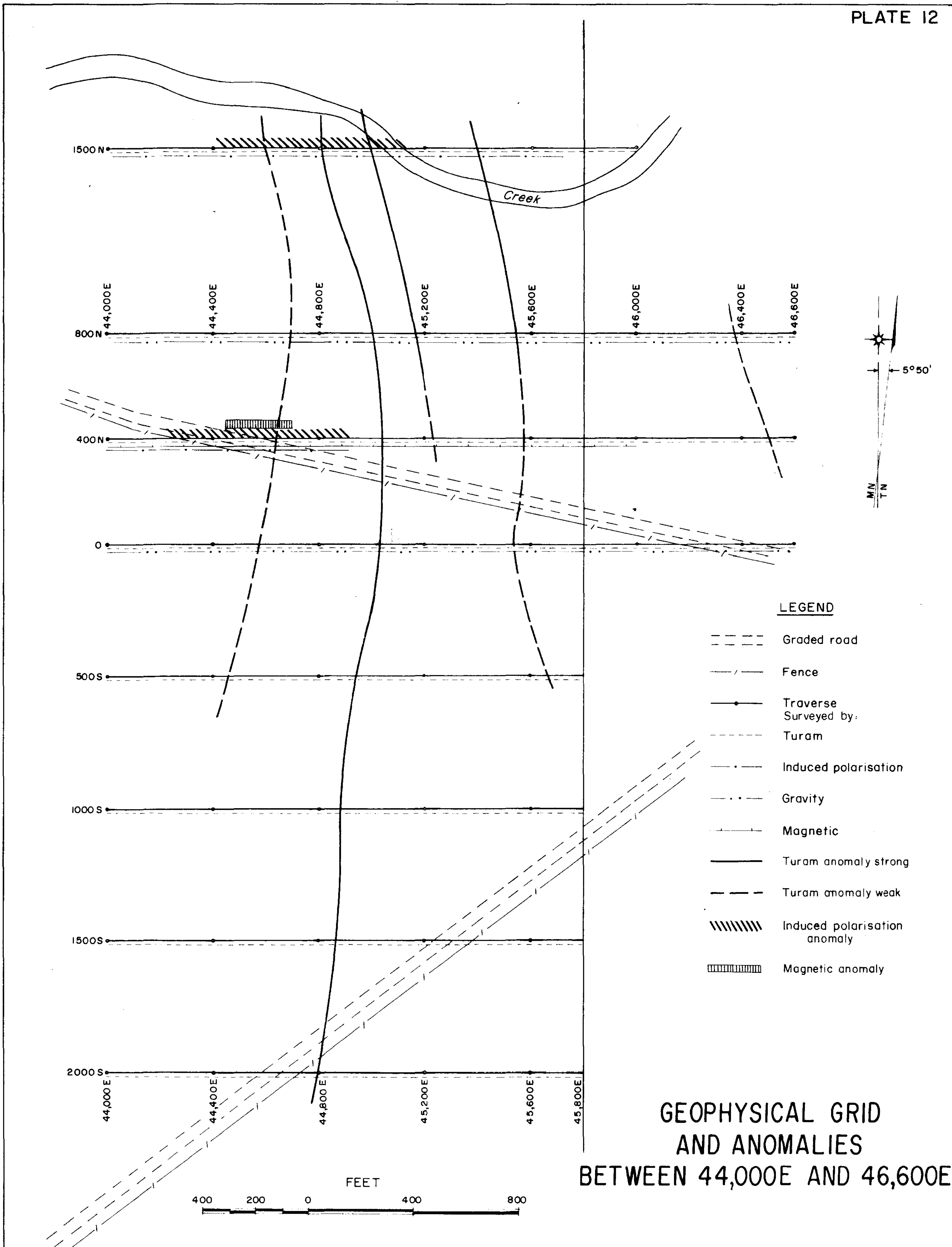
PLATE II



INDUCED POLARISATION PROFILES BETWEEN 12,800E AND 15,000E

TO ACCOMPANY RECORD No. 1964/187 GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E54/B7-11

PLATE 12



GEOPHYSICAL GRID AND ANOMALIES BETWEEN 44,000E AND 46,600E

TO ACCOMPANY RECORD No. 1964/187

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

E54/B7-12

DOBBYN AREA, QLD. 1963

PLATE 13

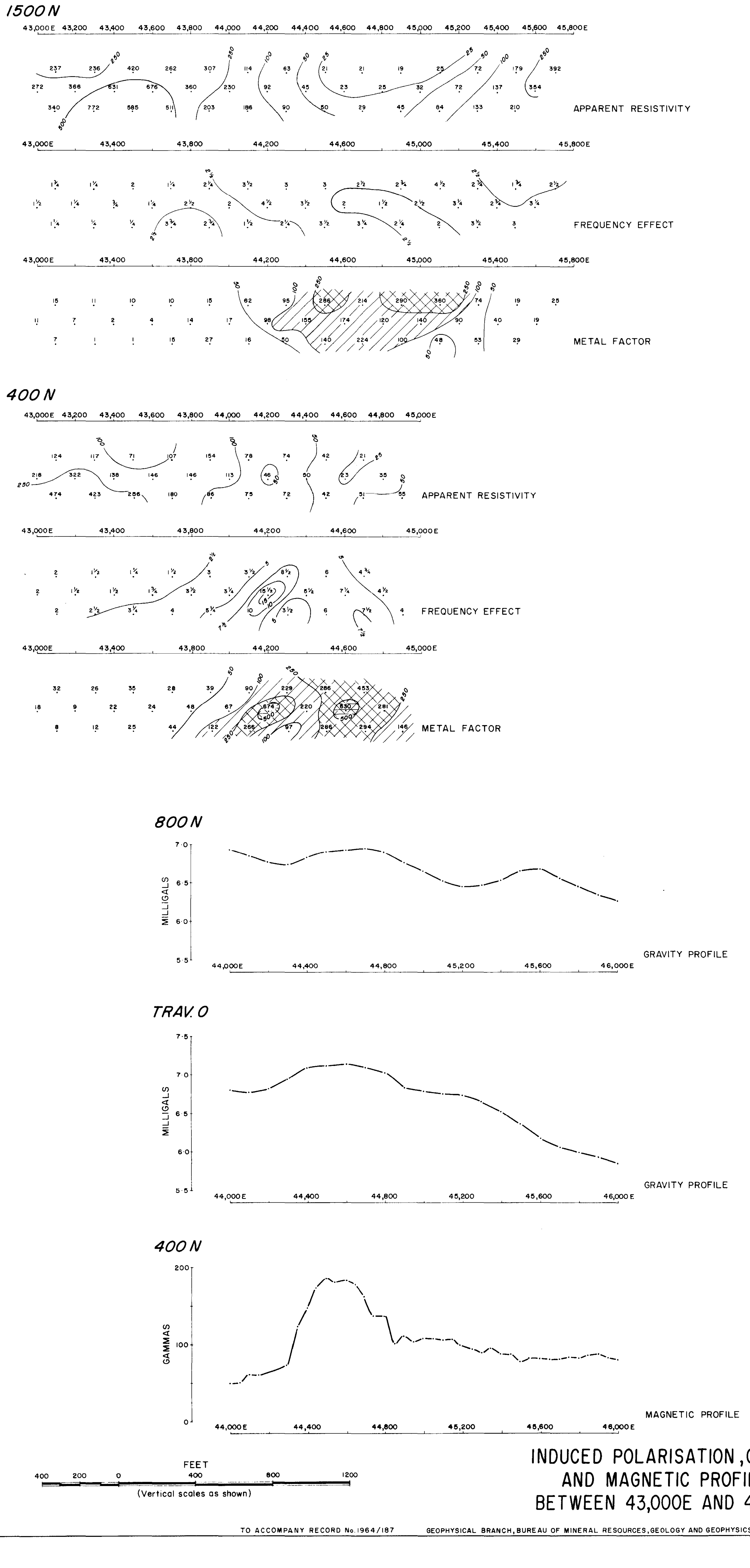
TURAM REDUCED RATIO AND PHASE DIFFERENCE PROFILES BETWEEN 44,000E AND 46,600E

GROUNDED CABLE, CABLELINE AT 43,800 E
COIL SEPARATION 100 FT, FREQUENCY 660 c/s

TO ACCOMPANY RECORD No. 1964/187

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E54/B7-13

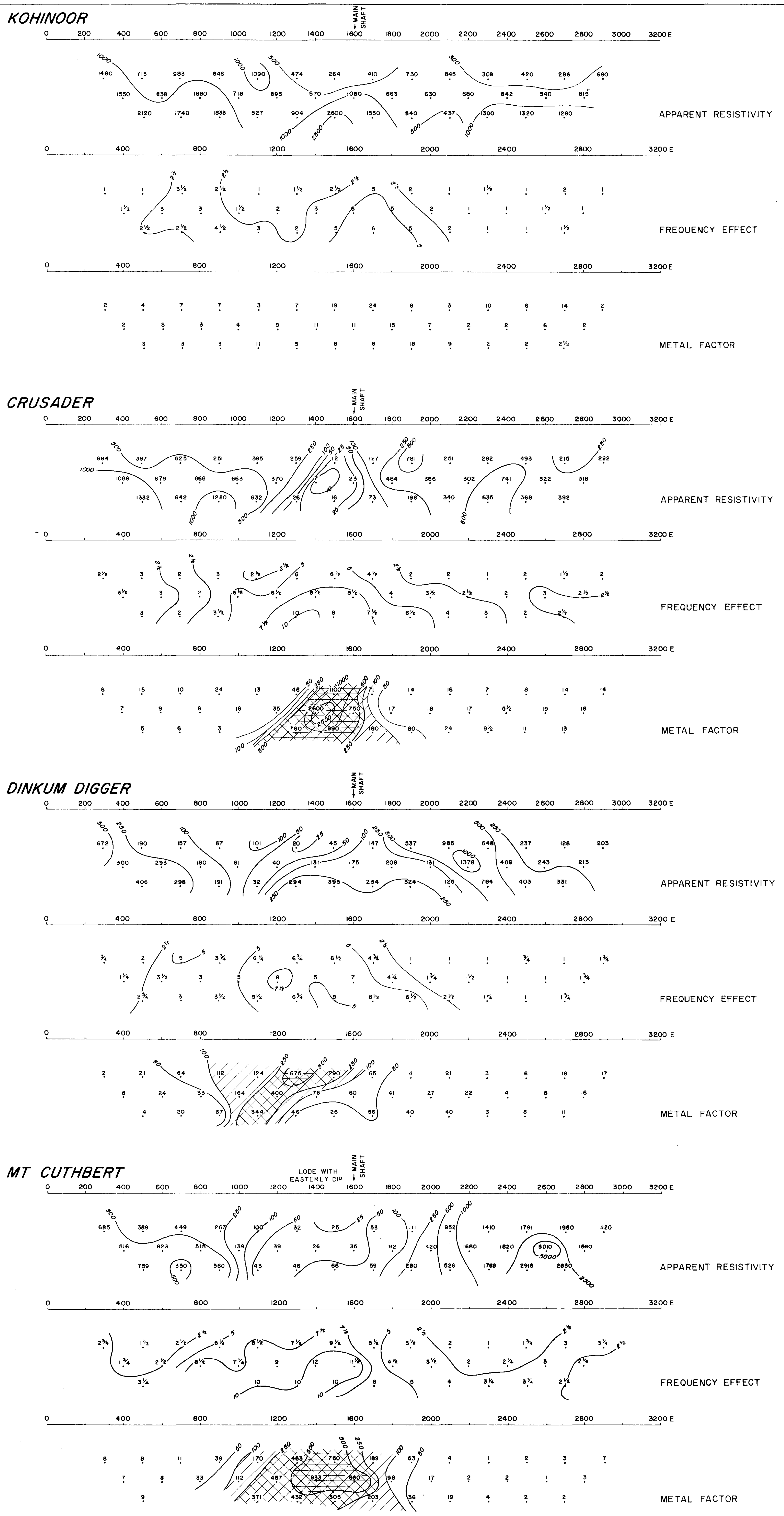
PLATE 14



INDUCED POLARISATION, GRAVITY, AND MAGNETIC PROFILES BETWEEN 43,000E AND 46,000E

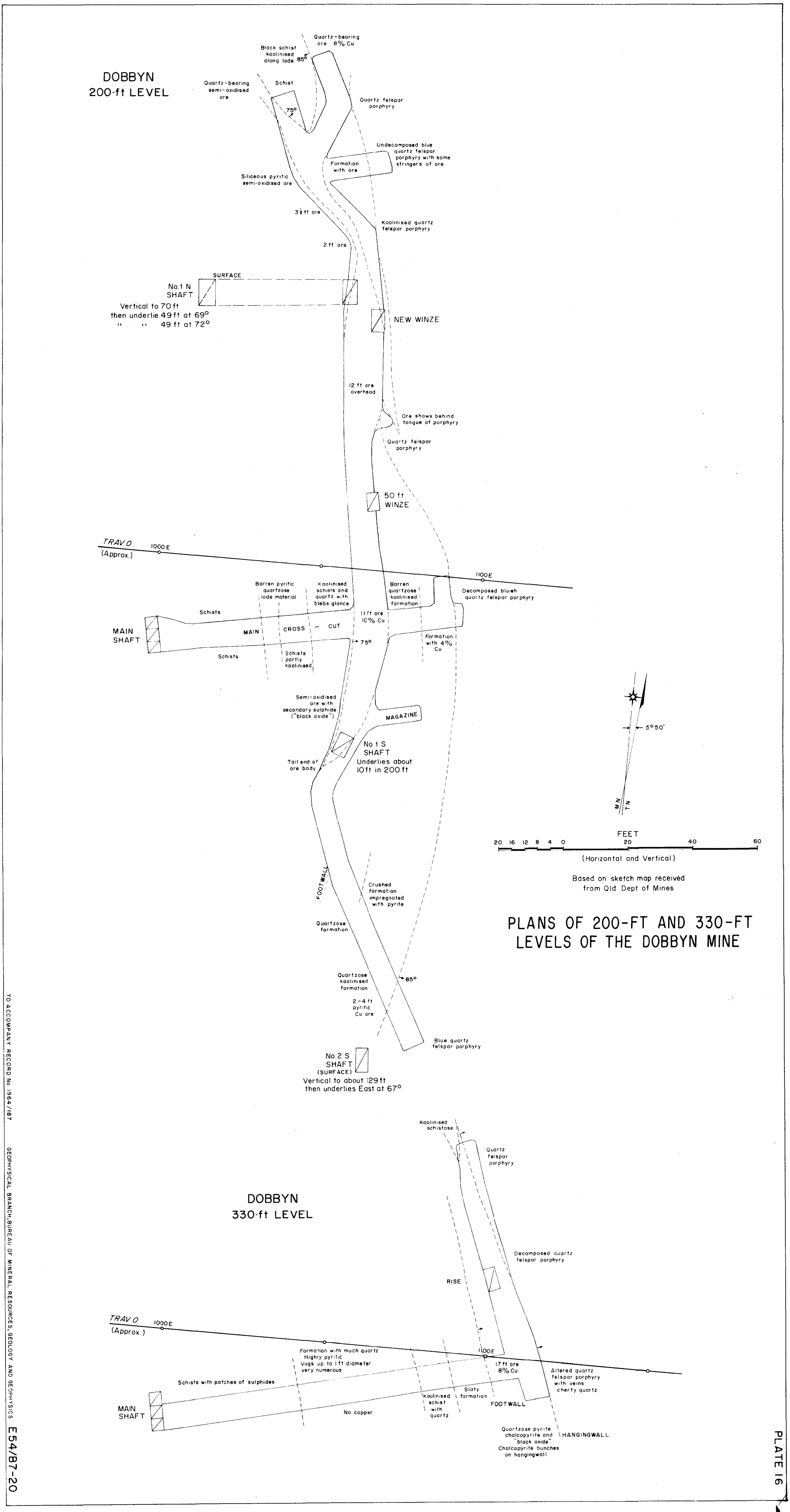
TO ACCOMPANY RECORD No. 1964/187 GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E54/B7-14

PLATE 15



INDUCED POLARISATION PROFILES OVER KOHINOOR, CRUSADER, DINKUM DIGGER AND MT CUTHBERT MINES

TO ACCOMPANY RECORD No. 1964/187 GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS E54/B7-15



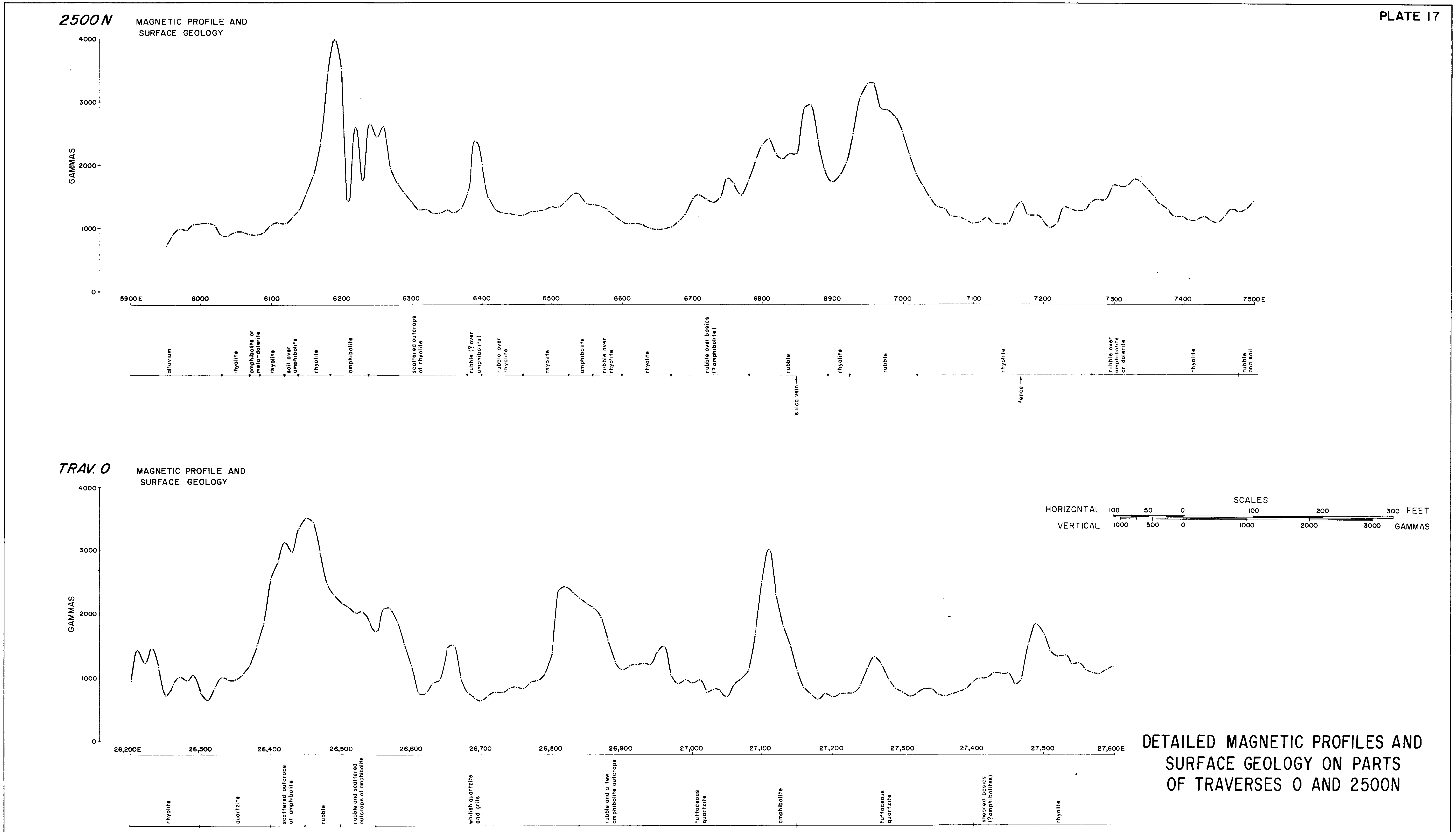
PLANS OF 200-FT AND 330-FT LEVELS OF THE DOBBYN MINE

TO ACCOMPANY RECORD No 1964/187

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

E54/B7-20

PLATE 16



DETAILED MAGNETIC PROFILES AND SURFACE GEOLOGY ON PARTS OF TRAVERSES 0 AND 2500N

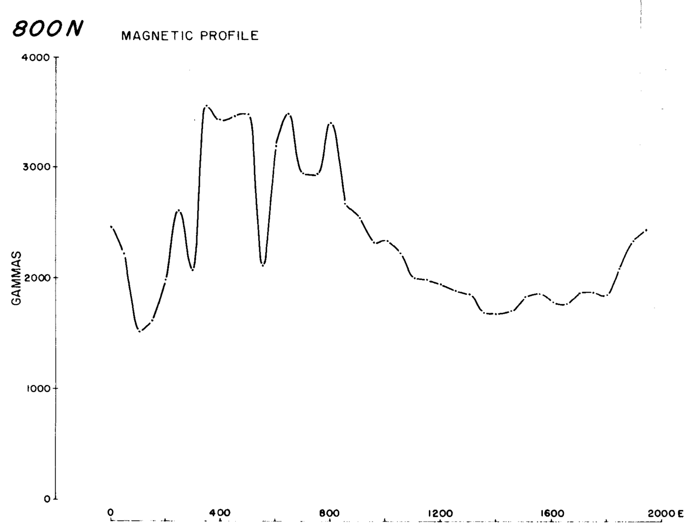
TO ACCOMPANY RECORD No 1964/187

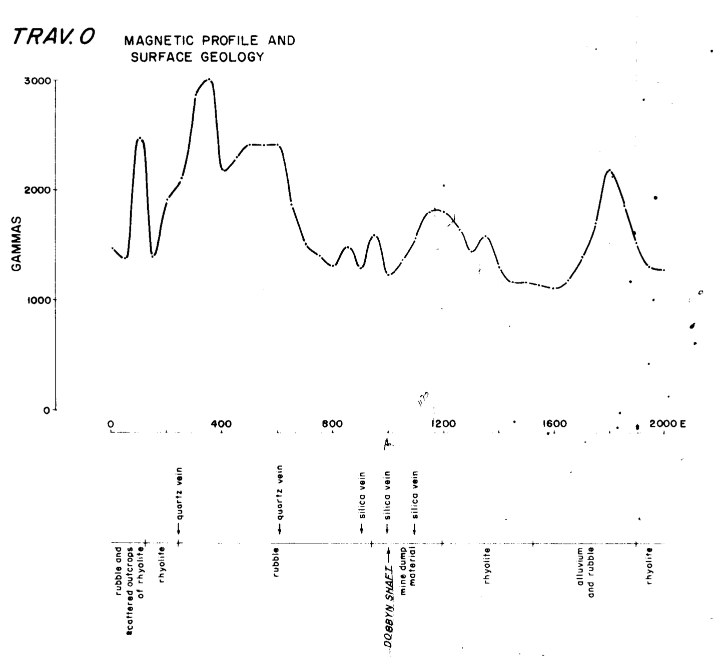
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

E54/B7-16

OBBYN AREA, QLD, 1963

PLATE 18





FEET

400 200 0 400 800 1200

(Vertical scales as shown)

GRAVITY, SURFACE ELEVATION, AND MAGNETIC PROFILES, AND SURFACE GEOLOGY BETWEEN 0 AND 18,000E

TO ACCOMPANY RECORD No. 1964/187

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

E54/B7-18

GRAVITY AND SURFACE ELEVATION PROFILES AND SURFACE GEOLOGY BETWEEN 10,000W AND 0