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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1964/148

GRAVEYARD DEEP LEAD GEOPHYSICAL SURVEYS, EMMAVILLE, NSW 1960-1961

by

M.J. O'CONNOR

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SUMMARY

Geophysical surveys were made in the Graveyard deep lead area near Emmaville, NSW in 1960 and 1961 at the request of the Department of Mines, NSW. The main purpose of the surveys was to trace the downstream extension of the deep lead using seismic refraction, magnetic, and resistivity methods.

The seismic method indicated a westward extension of the lead and also another lead in the north-western part of the area. The magnetic and resistivity methods did not prove applicable to the problem of tracing deep leads in the Graveyard area.

Four shaft sites were recommended to test the seismic results. At one recommended site a shaft was sunk by the Company interested in the area; it reached bedrock at 109 feet after going through four feet of wash, and confirmed the results of the seismic survey. Drives and cross-cuts from the shaft showed, however, that the tin values were only 1 to $1\frac{1}{2}$ lb/yd^3.

1. INTRODUCTION

The Graveyard lead runs roughly east-west about two miles south of the township of Emmaville, NSW.

Tin was first discovered in the Emmaville area in 1872. Between 1873 and 1955 a total of 73,474 tons of tin concentrates was produced in the Emmaville district (BMR,1957). Of this total, 48,255 tons was produced between 1873 and 1894. Both alluvial and primary deposits were worked but the main production came from the alluvial deposits, which were worked by dredging, sluicing, and mining. The main production of alluvial tin was from the Vegetable Creek and Graveyard leads. The course of the Graveyard deep lead has been defined by sluicing and mining operations for about three miles west of its origin south-east of Emmaville.

Previous geophysical investigations for tin in the Emmaville district were made by Rayner (1937 a and b), who used the magnetic method over the basalt-covered Vegetable Creek and Stannum deep leads. He maintained that the magnetic method was suitable for delineating the course of these basalt-covered leads. Probably because of the expense of drilling through basalt, his recommendation to drill lines of test bores was not acted on.

The geophysical surveys described in this Record were requested by the Department of Mines, NSW. At the time of the surveys the Broken Hill Pty Co. Ltd (BHP) held authoritiies to prospect over most of the Graveyard lead area and was conducting a prospecting programme consisting mainly of re-opening old shafts, extending drives from these shafts, and sampling for tin content.

The main objects of the surveys were: (a) to determine the geophysical methods most applicable to the problem of locating deep leads in the Graveyard area, and (b) to use these methods to trace the deep leads from where their positions were known from previous mining work into areas where their positions were not known. The geophysical field work in 1960 occupied 14 weeks from 25th August to 2nd December. The field party consisted of M.J. O'Connor (party leader), E.N. Eadie and J.J. Hussin (geophysicists), and four field assistants. Southerly extensions to Traverses 100E, 65E, 60E, 55E, and 50E, and velocity-logging of four shafts were made from 30th May to 13th June 1961. In this work O'Connor was assisted by geophysicist R.J. Smith and five field assistants. In both years topographical surveys of the area were carried out by surveyor K.W. Watson of the Department of the Interior, Sydney; he was assisted by two chainmen.

2. GEOLOGY

The geology of the Vegetable Creek (Emmaville) tin-mining district has been described by Carne (1911). The primary tin deposits occur in coarse-grained intrusive granite and quartz porphyry and also in Permo-Carboniferous claystone. Stream action denuded these rocks and carried the tin along the courses of the old Vegetable and Graveyard Creeks. Basins were eroded in the softer rocks of the stream beds, especially during great floods. This led to the formation of a series of ponds connected by narrow defiles through the harder rocks. The heavy tin particles tended to accumulate in these ponds, where the stream velocity diminished. Considerable thickness of sand, retained by the basin rim, frequently completed the basin filling. In time of partial drought, fine suspended clay and organic matter settled to form the pipe clay and carbonaceous clay overlying the lead drifts. Over these clays, lesser floods deposited sands and coarser drifts between periods of clay deposition.

A flow of basalt water filled the channel containing the deep lead and partially filled the valley. Later streams flowed over this basalt, eroding channels, into which stanniferous detritus gravitated from the watershed. Thus the shallow leads were formed. This basalt-flow coming from the west along the Graveyard valley probably did not extend east of about Traverse 80E, as basalt was reported in Hurley's shaft (approximately 65E/10N) but not in the 130-ft shaft (approximately 85E/12N) to the east (Carne, 1911, p.116). A later basalt-flow filled the Graveyard valley. This has been highly decomposed and eroded, leaving in its place lateritic and bauxitic deposits. The eastern limit of the main bauxitic cover occurs about Traverse 105E, but extended outliers continue farther east towards the head of the valley.

Plate 2 shows the geology of the Graveyard and adjoining areas. It was taken from a map provided by BHP and is based on the work of Carne (1911).

3. METHODS AND EQUIPMENT

There is no known geophysical method that can be used to detect directly the small amounts of tin in a deep lead. However, there are several methods that may give an indication of the position and depth of the lead by determining the depths to bedrock. The methods used in this survey were seismic refraction, magnetic, and resistivity.

Seismic refraction

The seismic refraction method of exploration depends on the contrast between velocities of propagation of elastic waves in different geological formations. The velocities are greater in the hard, unweathered rocks of the bedrock than in the unconsolidated sediments of the overburden of the lead.

In the 'method of differences' (Heiland, 1946) used in this survey, if A is the shot-point at one end of a linear spread of geophones, then the time taken for the refracted energy to reach a geophone at a point C within the spread is t_1 and the time taken to reach a geophone at a point B beyond the spread is t_3. Similarly when shooting from B, the time for the energy to travel from B to C is t_2 and the time from B to A is again t_3, since the energy paths A to B and B to A are identical; the identical times are known as 'reciprocal times'.

In the two-layer case, in which the velocities of the elastic wave in the upper and lower layers are V_1 and V_2 respectively, and i is the critical angle of incidence, $\sin i = V_1/V_2$.

The times t_1, t_2, and t_3 can be measured from the seismic records. The velocities V_1 and V_2 can be determined from the time/distance curves. The depth h to the second layer is then given by

$$h = \tfrac{1}{2}\,(t_1 + t_2 - t_3)V_1/\cos i$$

If more than two layers are involved, their thicknesses can be determined at each shot-point from the intercept times of the time/distance curves, and conversion factors can be calculated to replace the term $V_1/\cos i$. Depth to bedrock is then given by

$$h = \frac{1}{2}(t_1 + t_2 - t_3) \times \text{conversion factor}$$

Between shot-points the values of the conversion factors can be obtained by interpolation.

The term $\frac{1}{2}(t_1 + t_2 - t_3)$ is called the vertical travel time (VTT) from surface to bedrock. At some places in a surveyed area there may be shafts or drill-holes down to bedrock, in which shots may be fired to find the average vertical velocity through the overburden. The product of the VTT and the average vertical velocity will give the depth to bedrock at each geophone placing.

The equipment used in 1960 consisted of a Century 12-channel refraction seismograph Model 506, and Technical Instrument Co. (TIC) geophones of natural frequency 6 c/s. These were replaced during the survey by a South-western Industrial Electronics Co. (SIE) portable refraction seismograph and by TIC geophones of natural frequency 20 c/s. The SIE seismograph was much more satisfactory than the Century model; most of the traverses were surveyed using the SIE equipment. In 1961 a Midwestern 12-channel shallow reflection/refraction seismograph was used.

Magnetic

The magnetic method can be used to explore for deep leads in the following cases:

(a) Where there is a highly-magnetic material, *e.g.* magnetite, present in the lead. This will show up as a positive magnetic anomaly if the overburden and bedrock are non-magnetic. However, unless the lead is a shallow one, it is very unlikely that it can be delineated by the magnetic method owing to the small amount of magnetic material usually present.

(b) Where the overburden consists of magnetic material, the lead will show up as a positive magnetic anomaly caused by the greater thickness of magnetic material above the lead. A basalt-covered lead will fall into this classification. The magnetic method was used by Rayner (1937 a and b) over the Vegetable Creek and Stannum deep leads. The success of the magnetic method in tracing basalt-covered leads depends on the degree of weathering of the basalt, the irregularities in the upper surface of the basalt, and the presence of any magnetic material in the soil above the weathered basalt. The weathering of a basalt decreases its magnetic susceptibility because some of the magnetite in the basalt is oxidised to haematite or limonite, which are non-magnetic. If the upper surface of the basalt is irregular, it will cause changes in the measured magnetic field that will mask any anomaly caused by the deepening of the bottom surface of the basalt, as occurs over a lead. Magnetic material in the near-surface layers also causes irregularities in the magnetic field and will mask the influence of the deep lead. This appears to have been the case in the Graveyard area.

(c) Where the bedrock has a greater magnetic susceptibility than the overburden, in which case the lead will be associated with a magnetic 'low'.

The magnetic survey in the Graveyard area was made with an ABEM torsion magnetometer Model MZ-4 (Serial No.4503), which measured changes in the vertical magnetic field.

Resistivity

Different rock types have different electrical resistivities, mainly owing to variations in the porosity and the electrolyte content of the rock. In general the hard, non-porous, unweathered rocks of the bedrock, such as the quartz porphyry in the Graveyard area, have high resistivities. Weathered rocks and the more-recent sediments, which are more porous, have lower resistivities if they are filled with water or are clayey.

In the Wenner method, which was used in the Graveyard area, four electrodes equally spaced in a straight line are moved along as a whole and resistivity measurements are made between the inner (potential) electrodes at consecutive stations. The spacing of the potential electrodes is about equal to the depth of the earth materials affecting the resistivity. Changes in resistivity indicate boundaries between formations of different resistivity at a depth roughly equal to the electrode spacing. The most significant changes of resistivity are generally between overburden and bedrock. Resistivity profiles measured with various electrode spacings can indicate approximately where the boundary between bedrock and overburden occurs at that depth (or electrode spacing). Spacings of 50, 100, and 150 ft were used in the resistivity survey. The resistivity work was carried out with an Evershed and Vignoles Geophysical Megger.

4. FIELD WORK AND RESULTS

Seismic

The main work consisted of sixteen parallel north-south traverses, spaced 500 ft apart and of lengths ranging from 950 ft to 3700 ft. The traverses are shown in Plates 2 and 5. Two intermediate traverses were surveyed, one 2750 ft long at 82.5E and the other 250ft long at 98.64E near some shafts that had been cleaned out by BHP. Two traverses 500-ft long were run at right angles to the main traverses, between 80E and 85E along 17N and 24N. The total length of traverses surveyed by the seismic method was a little over eight miles. The following types of geophone-spreads were used:

Weathering spreads. These were used to obtain the seismic velocities in the soil and near-surface layers, and also to measure the thickness of the soil. Eleven geophones were spaced 5 and 10 ft apart and a geophone was placed at the reciprocal shot-point; shot-points were at distances of 5 ft and 50 ft (sometimes farther than 50 ft) from both ends of the spread and in line with it.

Normal spreads. These were used to measure the velocities in the formations beneath the soil and in the bedrock, and also to calculate the time taken for the waves to travel from the bedrock to the surface. Eleven geophones were spaced 50 ft apart and a geophone was placed at the reciprocal shot-point. Shot-points were placed at distances of 25 ft and 200 ft or more from both ends of the spread and in line with it, and also one shot-point was placed in the middle of the spread to obtain additional information relating to the near-surface formations.

The weathering spreads were in general spaced about 1000 ft apart along the traverses. Additional weathering spreads were placed where there appeared to be marked changes in the seismic velocities in the overburden. Normal spreads generally overlapped by 50 ft (2 geophones) in order to facilitate the computing of a continuous seismic cross-section along the traverse.

Vertical travel times (VTT) were computed at each geophone station for normal spreads by using the 'method of differences'. These VTT were converted to depths to the bedrock by two different methods (see 'Interpretation of results'). Plates 3 and 4 show the seismic cross-sections. Plate 6 shows the bedrock contours computed using conversion factors. Velocities were measured in eleven shafts located between traverses 90E and 125E (see Plate 6).

Magnetic

Magnetic readings were made along nine traverses in the Graveyard area between 55E and 100E. The main reason for using the magnetic method in this area was to see if it could indicate the buried basalt flow. In the western extension of the Graveyard lead area eleven traverses (Plate 2) were surveyed with the magnetometer to see if the magnetic method could be used to trace the Graveyard deep lead beneath the basalt.

A magnetic traverse was also surveyed near Reid's shaft (Plate 1) on the Vegetable Creek deep lead, within the area previously surveyed with a magnetometer by Rayner (1937a). The readings were made to compare them with the magnetic readings over the Graveyard lead.

Selected magnetic profiles over the Graveyard, Graveyard western extension, and Vegetable Creek areas are shown in Plate 7.

Resistivity

Eight traverses were surveyed by the resistivity method, using the Wenner configuration of electrodes with an electrode spacing of 50 ft. Four traverses were repeated using an electrode spacing of 100 ft and two of these with an electrode spacing of 150 ft. Plate 8 shows the resistivity profiles (resistivity plotted on a logarithmic scale) for electrode spacings of 100 and 150 ft along Traverses 80E and 85E.

5. INTERPRETATION OF RESULTS

Seismic refraction

The bedrock profiles shown in Plates 3 and 4 were computed from the seismic data by using two different velocity distributions; hence the seismic cross-sections show very similar features but differ mainly in the calculated depth to bedrock. In most places the indicated positions of bedrock depressions coincide in plan but the depth to the bedrock calculated by the conversion-factor method is in general greater than that calculated from shaft-shooting data.

The reasons for the difference in calculated depths to bedrock is that, for each point on the bedrock profile, the measured VTT has been multiplied by two separate factors :

(a) A conversion factor, calculated from the time/distance curves and intercept times at each shot-point. It is assumed that there is no velocity reversal, i.e. the velocity in each layer is greater than the velocity in the layer above it. If velocity reversal does occur in the overburden beneath a shot-point, then the conversion factor calculated from the time/distance curves and intercept times at that shot-point will be too large and the depth to bedrock will be over-estimated.

(b) An average vertical velocity in the overburden, determined directly by shooting at the bottom of a shaft and measuring the time for the seismic wave to reach the ground surface. In practice, measurements were made in eleven shafts (Plate 6). The average velocity did not vary appreciably in the different shafts. A value of 2200 ft/sec was adopted, and was then applied to the VTT to calculate the depth to bedrock over most of the area, except on the westernmost traverses, where the time/distance curves indicated a larger thickness of low-velocity surface soil than in the rest of the area. Along these traverses a lower average velocity in the overburden was used.

The conversion-factor method is considered to give the more realistic approximation to the actual velocity distribution because :

(a) The VTT measured refer to a 12,000 to 20,000-ft/sec layer, which must be relatively-unweathered bedrock. It can be assumed that there will be a thickness of weathered bedrock above the fresh bedrock and that the seismic velocity in the weathered bedrock will be considerably less than in the bedrock. As the conversion factor is effectively a measure of the average velocity in the formations down to the unweathered bedrock, it is the appropriate multiplier to be applied to the VTT to obtain the depth to unweathered bedrock.

(b) The average velocity obtained from the shaft-shooting is that for the formations in the geological cross-section above the lead, which will be situated either on the upper surface of weathered bedrock or above it. None of the shafts in the Graveyard area has been put down to unweathered bedrock. It can be reasonably assumed that the seismic velocity in the weathered bedrock will be greater than that in the overburden above it; hence the value of the average vertical velocity in the overburden will be less than the average vertical velocity in the overburden plus weathered bedrock.

Another disadvantage of applying the average velocity from shaft-shooting is that no suitable shafts were available in the area west of 90E. The shafts used were therefore not representative of the whole area, and the average velocity in the overburden in the area west of 90E may be significantly different from the figure obtained from the shaft-shooting.

Thus it may be said that the conversion-factor method indicates the depth to unweathered bedrock, which will be at some depth below the weathered bedrock surface on which the deep lead will lie. If the thickness of weathered bedrock is uniform, the depressions in the unweathered bedrock will be situated vertically below the deep lead.

The two bedrock profiles are shown in Plates 3 and 4, to illustrate the difference made to the results when the two velocity distributions are applied. Where the conversion-factor method indicates a much greater depth to bedrock than the shaft-shooting method, it is likely that a velocity reversal exists in the overburden and that the bedrock will probably be closer to that indicated by the shallower profile, e.g. at 80E/20.5N (Plate 3) and 90E/8.5N (Plate 4).

The main features of interest in the bedrock contours (Plate 6) are: (a) the sudden changes in direction of the course of the deep lead at 105E/13.5N and 100E/17.5N. These two sharp bends imply that there was a barrier to the old Graveyard Creek along Traverse 100E to the south of 17N; (b) the sudden drop in level of the lead between 95E/12.5N and 90E/8.5N, and the rise to the west of 90E to form a 'pool' in the bedrock; (c) a tributary lead, which was first detected on the northern end of Traverse 85E, and which takes a sharp swing to the west at about 82.5E/21N.

Magnetic

The unsuitability of the magnetic method to the problem of detecting the course of the Graveyard deep lead can be realised by examining the selected magnetic profiles in Plate 7. There is a marked difference between the profiles over the Graveyard lead and the one over the Vegetable Creek lead.

In his report on the geophysical survey of Vegetable Creek lead, Rayner (1937a) stated that the basalt filling the old river channel had very pronounced magnetic properties and caused regular magnetic anomalies. The magnetic profile over the Vegetable Creek lead along the traverse near Reid's shaft (Plate 7) is fairly smooth and there is a broad negative anomaly of roughly 200 gammas centred near 15S. From this profile it would be inferred that the Vegetable Creek deep lead is located in the vicinity of 15S.

In comparison, however, the magnetic profiles in the Graveyard area and its western extension show many large fluctuations, both positive and negative. Some of the large fluctuations in the magnetic field were proved to be caused by near-surface bodies; when readings were repeated with the magnetometer at elevations approximately two feet lower than generally used, these anomalies increased by from 30 to 80 percent, thus indicating that the bodies causing the anomalies are quite close to the surface. Large fluctuations such as these make it impossible to detect the much smaller anomalies that may be associated with a basalt-covered deep lead. In the Graveyard area the effect of magnetic minerals in the laterite and bauxite completely masks the anomalies due to the deeper basalt covering the lead. The magnetic profiles in the Graveyard area are similar to those in its western extension, where it is known that basalt occurs underneath the bauxite. Thus the magnetic method failed to indicate the extent of the buried basalt covering the Graveyard lead.

The contrast between the magnetic results over the two leads can be explained by the absence of surface laterite or bauxite over the Vegetable Creek lead.

Resistivity

With the Wenner configuration of electrodes used on this survey, the depth penetration of the electric current may be regarded as roughly equal to the electrode separation. A decrease in resistivity over portion of a traverse surveyed with constant electrode-separation indicates a probable deepending of the bedrock because of the extra thickness of lower-resistivity overburden. The resistivity profiles shown in Plate 8 have many irregular features, some of which are probably due to high contact resistance at the electrodes. However, on each traverse there is a general similarity between the profiles for both 100 and 150-ft spacings. Resistivity 'lows' were recorded on Traverse 85E near 11N and from 20N to 23N, and on Traverse 80E from 10N to 14N. Owing to the irregular nature of the profiles, however, it was not possible, from the resistivity work, to infer the position of the deep lead with sufficient accuracy to aid the prospecting campaign; the resistivity work was therefore discontinued in the Graveyard area.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the survey show that, of the three geophysical methods used in the area, only the seismic refraction method was suited to aid in prospecting for the Graveyard deep lead. This method has given indications of bedrock depressions, which may reasonably be expected to be associated with the Graveyard deep lead, and has indicated the probable course of the deep lead. However, the calculated depth to the lead must be regarded as somewhat uncertain owing to the incomplete information relating to the seismic velocities in the overburden. The magnetic and resistivity methods were not successful in prospecting for the deep lead.

Indications of another lead were given by the seismic method in the north-western part of the area.

Recommended shafts to test the results of the seismic survey are shown in Plate 6. A vertical shaft was recommended at 90E/8.5N, directly above the indicated lead, to give preliminary information to the geologists of BHP. Shaft No.20 was sunk on the recommended site and bottomed on weathered quartz porphyry at 109 ft after passing through white sand and clay to 58 ft and grey 'pipe clay' to 105 ft. The wash between 105 ft and 109 ft, which contained 1 to 1.5 lb/yd^3 of coarse cassiterite, consisted of boulders of claystone, waterworn quartz pebbles and cobbles, and sand and clay.

A southerly drive from the shaft bottom continued in wash for 35 ft, to which point the thickness had steadily diminished to 15 in. Between 40 and 50 ft from the shaft, the grey pipe clay rested directly on bedrock. At 60 ft the wash was 38 in thick and consisted mainly of sand with small pebbles and a little fine cassiterite. A northerly drive was excavated for a distance of 130 ft, where the wash was 70 in thick with poor tin values (Rowell, pers. comm.).

Although the tin values found at the shaft are too low to be of economic interest and although the geophysical results cannot give any information about the metal content in the deep leads, one shaft site can hardly be considered sufficient for the testing of a deep-lead system of such large dimensions. A few more shaft sites are recommended if the exploration should be continued. Reasons for a continuation of exploration include:

(a) The cassiterite found at the shaft was coarse, which means that fine tin should be found farther downstream.

(b) Shaft No.20 is situated on a rather straight course of the lead, but tin enrichments are usually found near bends in the lead or where the old river-bed flattened and the water stagnated.

(c) The bedrock was found at a depth of 109 ft, a depth which still allows dredging and sluicing operations.

(d) The seismic survey gave no evidence of a tributary near Shaft No.20. Tributaries often increase the metal content of the lead near the junction.

Reasons against a continuation of exploration include:

(a) The seismic results indicate an increasing depth of overburden farther downstream.

(b) Basalt, known to occur in the overburden in the western part of the area, would complicate dredging and sluicing operations, especially if it were hard and not decomposed.

(c) The absence of layers of wash and false bottoms above the bottom wash found at 105 ft.

The recommended shaft sites are:

On the main lead:	On tributaries:
60E/1.5S	50E/18N
70E/3N	55E/14.5N
75E/6N	80E/20.5N
95E/12N	
100E/17.5N	

Geological considerations and information from old records of the area might add weight to, or exclude, some of the recommendations.

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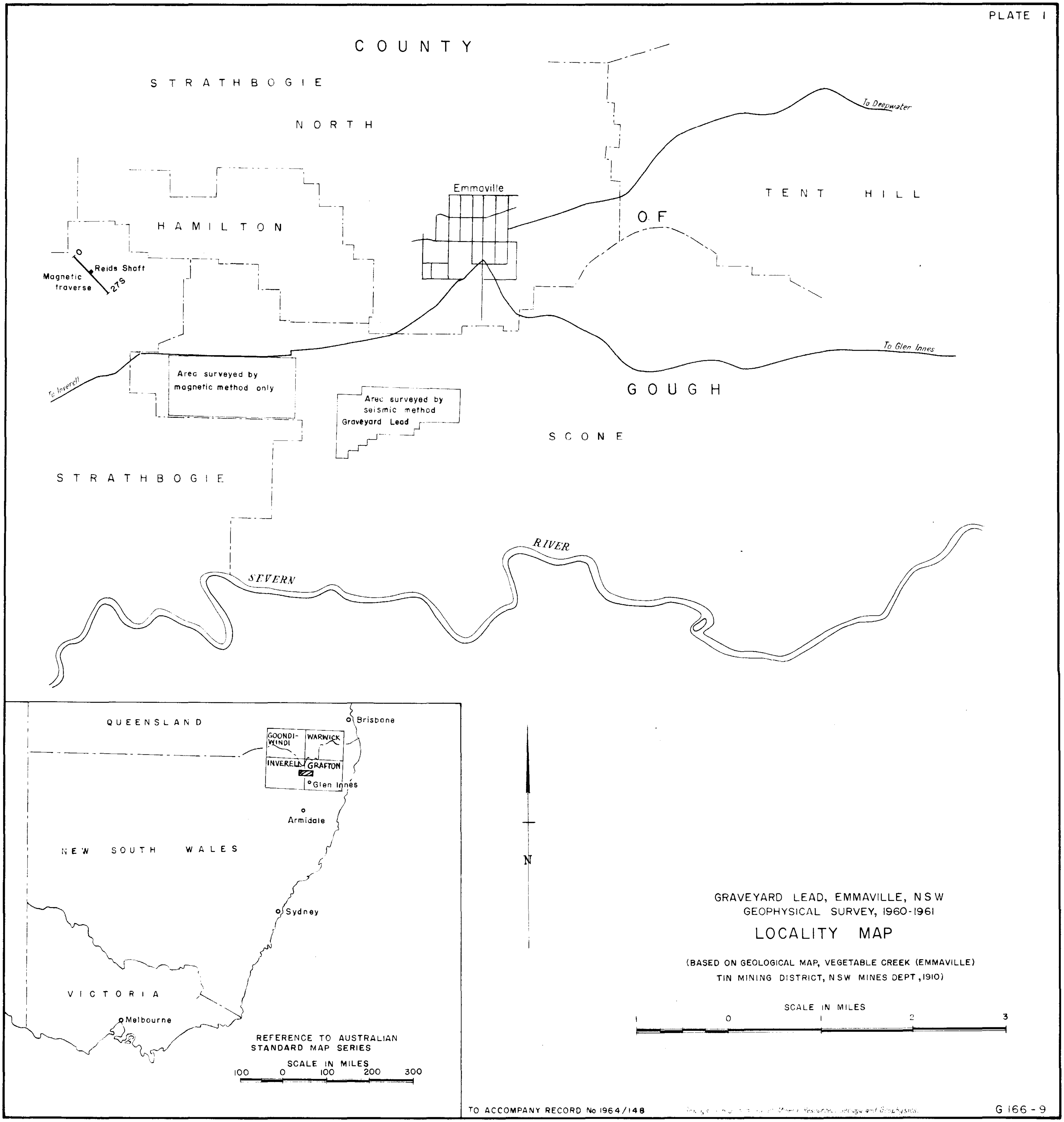
RAYNER, J.M. 1937b Geophysical survey of Stannum deep lead. Ibid.



GRAVEYARD LEAD, EMMAVILLE, NSW
GEOPHYSICAL SURVEY, 1960-1961

LOCALITY MAP

(BASED ON GEOLOGICAL MAP, VEGETABLE CREEK (EMMAVILLE) TIN MINING DISTRICT, NSW MINES DEPT, 1910)

TO ACCOMPANY RECORD No 1964/148

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GRAVEYARD DEEP LEAD

GEOLOGY AND LAYOUT OF TRAVERSES

GEOLOGY AFTER CARNE (1911)

TO ACCOMPANY RECORD No. 1964/148

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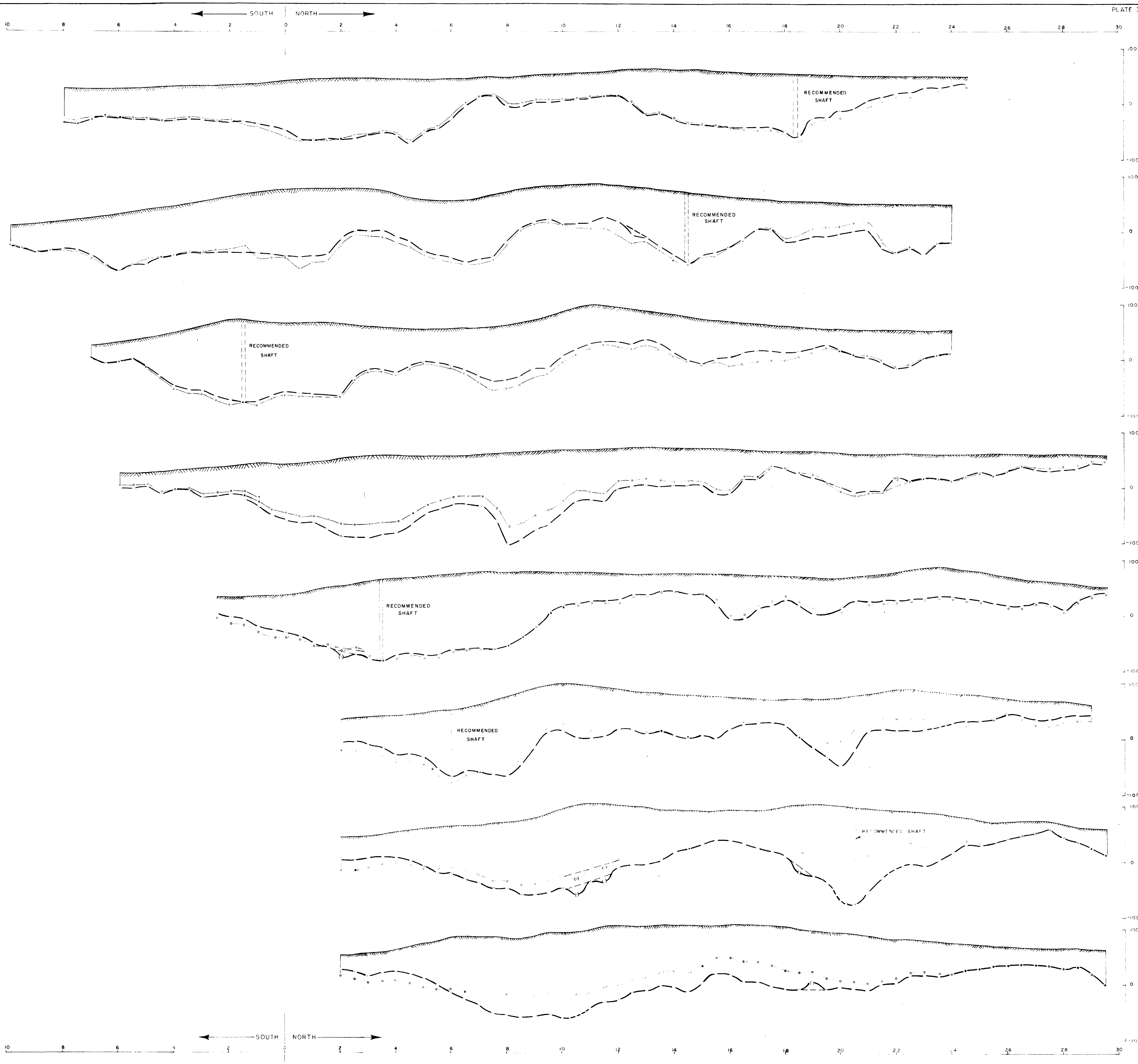


GEOPHYSICAL SURVEY AT GRAVEYARD DEEP LEAD,
NEAR EMMAVILLE, N.S.W., 1960-1961

SURFACE AND BEDROCK PROFILES (FROM SEISMIC DATA)

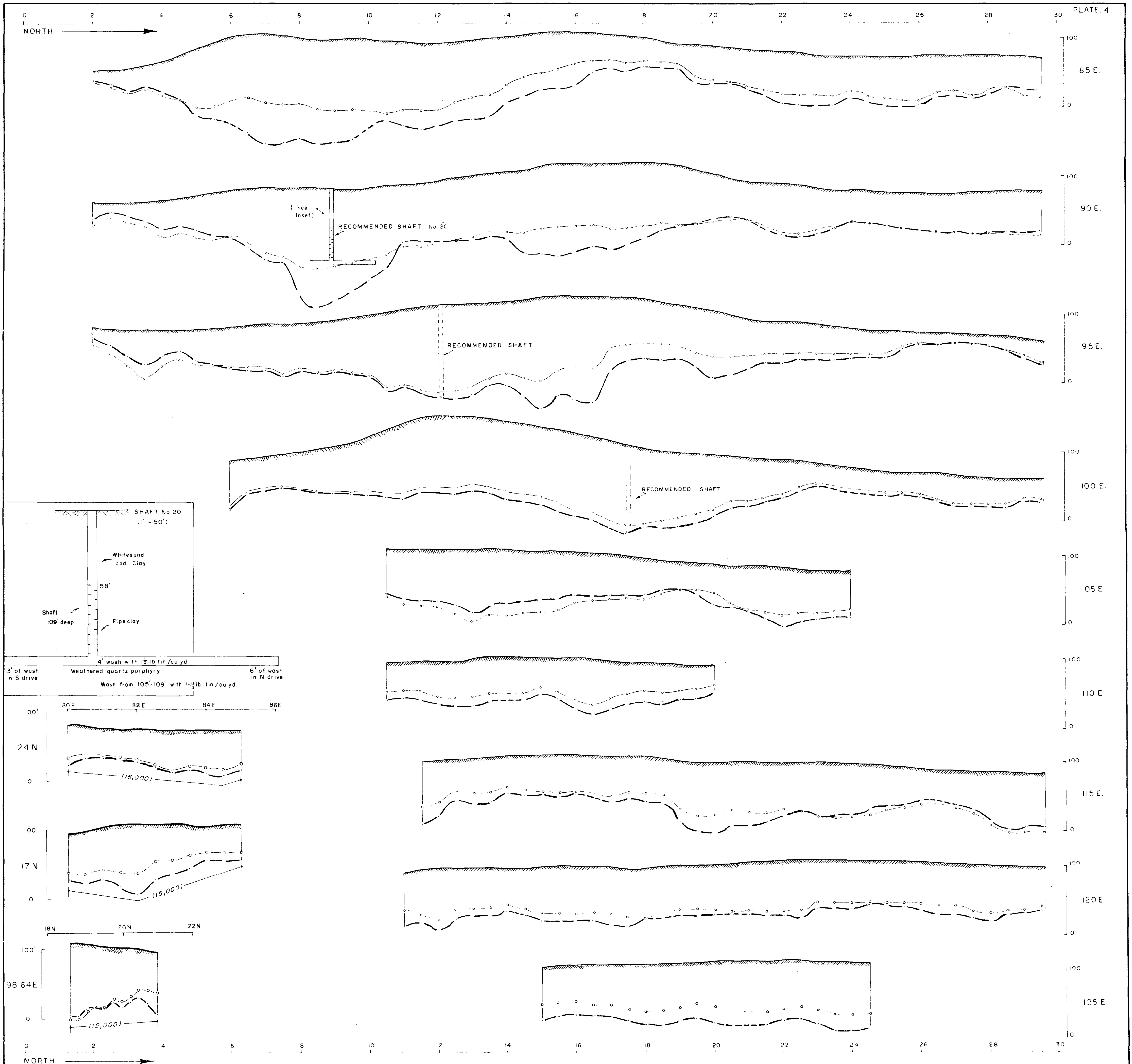
SCALES IN FEET

VERTICAL 100 0 50 100 200 300
HORIZONTAL 200 100 0 100 200 400 600

SURFACE PROFILE
BEDROCK PROFILE (COMPUTED USING CONVERSION FACTORS)
BEDROCK PROFILE (COMPUTED USING AVERAGE VELOCITY FROM SHAFT-SHOOTING)

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

G 166-7-1



GEOPHYSICAL SURVEY AT GRAVEYARD DEEP LEAD,
NEAR EMMAVILLE, N.S.W. 1960-1961

SURFACE AND BEDROCK PROFILES (FROM SEISMIC DATA.)

SCALES IN FEET

VERTICAL 100 0 50 100 200 300
HORIZONTAL 200 100 0 100 200 400 600

SURFACE PROFILE
BEDROCK PROFILE (COMPUTED USING CONVERSION FACTORS)
BEDROCK PROFILE (COMPUTED USING AVERAGE VELOCITY FROM SHAFT-SHOOTINGS)

TO ACCOMPANY RECORD No 1964/148

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G166-8


PLATE 5
TRAVERSE PLAN AND SURFACE CONTOURS
ELEVATION DATUM: PEG 100E 20N SURFACE ASSUMED TO BE 100FT
SCALE IN FEET
200 0 200 400 600
CONTOUR INTERVAL 10 FT.
LEGEND
SURFACE CONTOURS
GEOPHYSICAL TRAVERSE
M.L. 18 MINERAL LEASE
SHAFT
SURVEY PEG
NOTE: MAGNETIC AND TRUE NORTH DIRECTIONS TAKEN FROM INFORMATION ON DEPARTMENT OF THE INTERIOR PLAN (SURVEYOR K.W. WATSON)
NEG No 11911 N.S.W. 1961
M.L. 18
SHAFT 4
SHAFT 5
SHAFT 6
SHAFT 7
SHAFT 9
SHAFT 10
SHAFT 11
SHAFT 13
SHAFT 14
SHAFT 15
SHAFT 17
SHAFT 18
SHAFT 19 (not bottomed)
SHAFT 20
50E
55E
60E
65E
70E
75E
80E
82.5E
85E
90E
95E
98.64E
100E
105E
110E
115E
120E
125E
30N
25N
24N
20N
17N
15N
10N
5N
0
5S
10S
12S
TO ACCOMPANY RECORD No 1964/148
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
G166-10-1

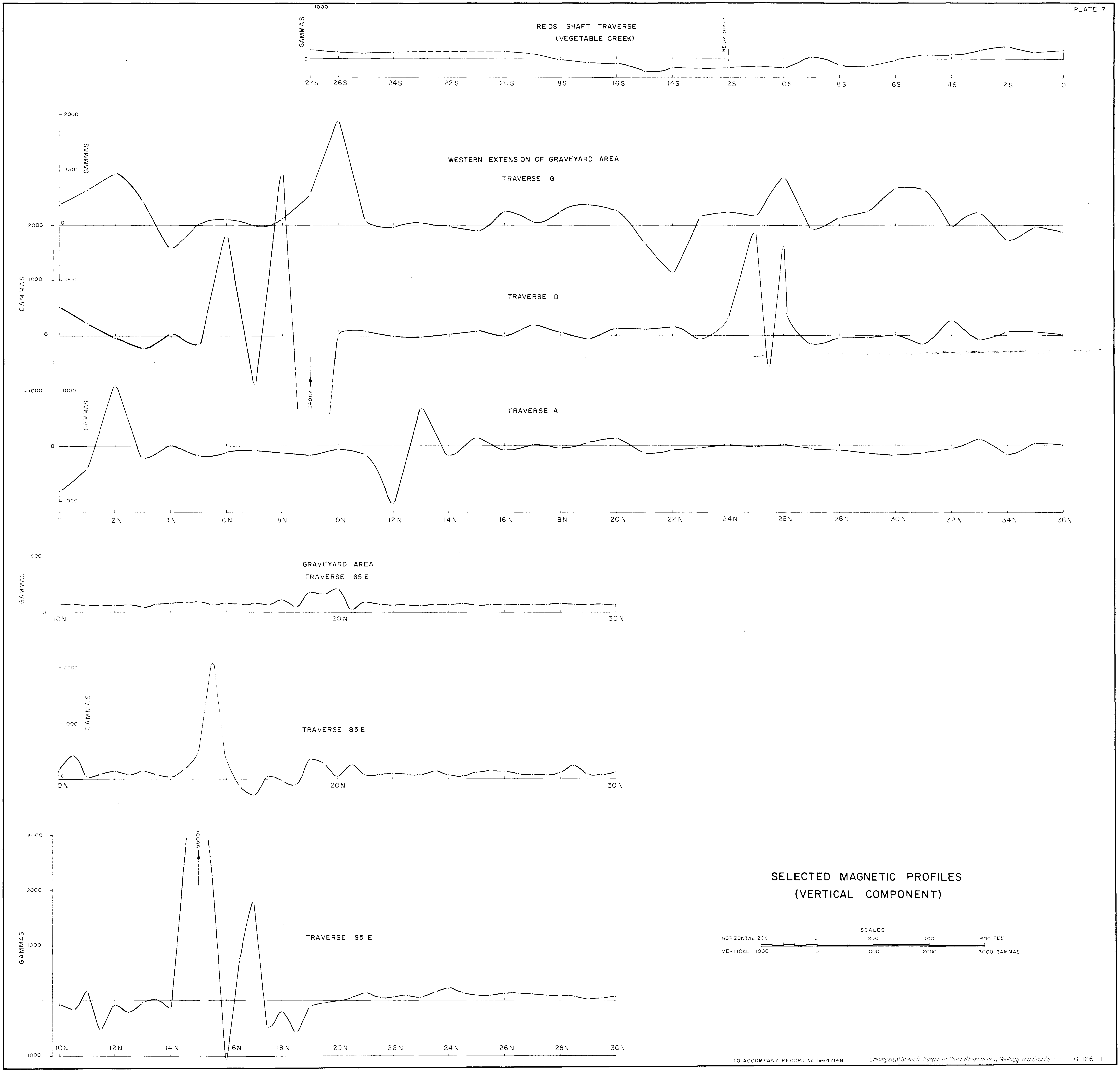
EMMAVILLE GEOPHYSICAL SURVEY, N S W, 1960 – 1961

GRAVEYARD DEEP LEAD AREA

TRAVERSE PLAN AND BEDROCK CONTOURS

COMPUTED FROM REFRACTION SEISMIC DATA (USING CONVERSION FACTORS CALCULATED FROM CONVENTIONAL SURFACE SPREADS). CONTOUR INTERVAL 10 FEET. BEDROCK CONTOURS BASED ON ASSUMED DATUM FOR LEVELS.

TO ACCOMPANY RECORD No. 1964/148 GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS G166-5-1



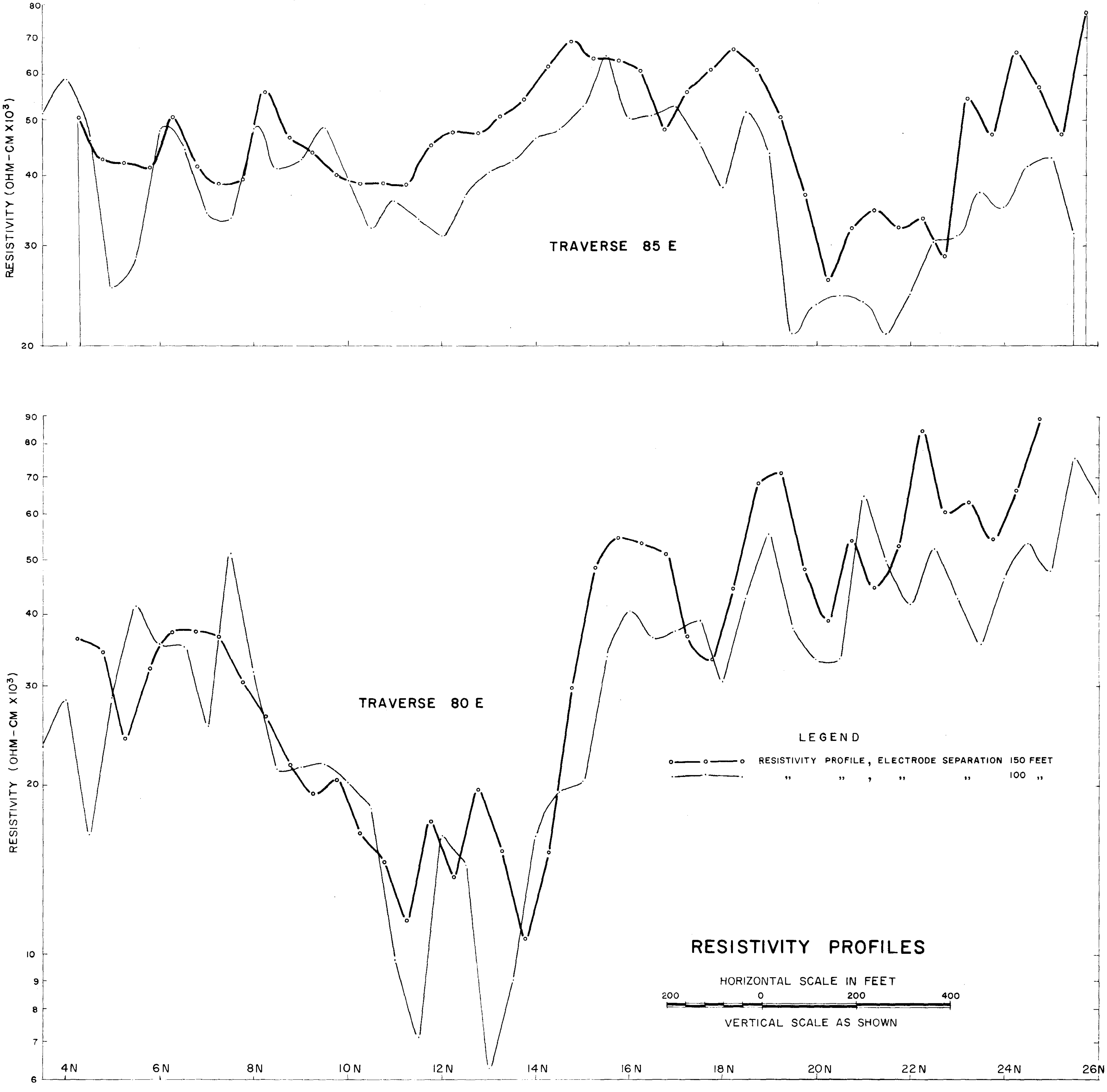
SELECTED MAGNETIC PROFILES
(VERTICAL COMPONENT)

TO ACCOMPANY RECORD No 1964/148

G 166-11

EMMAVILLE N.S.W.

PLATE 8


TRAVERSE 85 E
RESISTIVITY (OHM-CM X 10³)
80
70
60
50
40
30
20
TRAVERSE 80 E
RESISTIVITY (OHM-CM X 10³)
90
80
70
60
50
40
30
20
10
9
8
7
6
4N
6N
8N
10N
12N
14N
16N
18N
20N
22N
24N
26N
LEGEND
RESISTIVITY PROFILE, ELECTRODE SEPARATION 150 FEET
" " , " " 100 "
RESISTIVITY PROFILES
HORIZONTAL SCALE IN FEET
200
0
200
400
VERTICAL SCALE AS SHOWN