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COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF NATIONAL DEVELOPMENT
BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

RECORDS 1956, No. 83

GEOPHYSICAL SURVEY OF THE DEE TUNNEL, LAKE ECHO POWER DEVELOPMENT SCHEME, TASMANIA

by

W. A. WIEBENGA, D. F. DYSON & L. V. HAWKINS

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ABSTRACT

The geophysical exploration of the Dee Tunnel, which is part of the Lake Echo power development scheme, was made in September and October, 1954, at the request of the Tasmanian Hydro-Electric Commission.

Electrical resistivity, seismic refraction and magnetic methods were used, and results from the three methods were in fairly good agreement with each other. Zones of probable shearing and/or weathering at tunnel level are indicated.

The magnetic survey disclosed a high, sharp anomaly for which no definite explanation is apparent.

1. INTRODUCTION

The Dee Tunnel is part of the Tasmanian Hydro-Electric Commission's Lake Echo power development scheme. It is approximately two miles in length and will connect Dee Lagoon and Brady's Lake (Plate 1).

A geophysical survey was made at the request of the Commission (after tunnelling operations had already commenced) to investigate possible variations in rock type and to locate zones of shearing or weathering which might extend down to tunnel level and thereby cause difficult tunnelling conditions.

The geophysical methods used were:-

(i) Resistivity.

(ii) Seismic refraction.

(iii) Magnetic.

Resistivity and magnetic methods were used along the tunnel line (traverse A), which runs approximately N112°E, and along a parallel line 500 feet to the north-east (traverse B). The seismic refraction survey was limited to the major part of traverse A.

Diamond drilling has been done by the Commission on traverse A near the two portals and also south of traverse A (see Plate 1).

The field work was carried out in September and October, 1954. The geophysical party consisted of D.F. Dyson, party leader, L.V. Hawkins, geophysicist, and six field assistants provided by the Commission.

It is desired to acknowledge the ready co-operation of the personnel of the Resident Engineer's offices at Bronte Park and Wayatinah, and the Investigations Branch of the Commission at Hobart.

2. GEOLOGY

The tunnel, connecting the Dee Lagoon (inlet) and Brady's Lake (outlet), is being driven through a flat-topped hill. Marshy conditions exist between stations 4498A and 7198A, i.e. along about one-quarter of the length of Traverse A.

The following rock types are present:

(a) Dolerite

This is amedium-grained to fine-grained crystalline rock which crops out on the hill near the flanks. The **hill** slopes are covered with dolerite scree, and boulders frequently occur within the soil of the marsh area. Evidence from drill cores and tunnelling shows that jointing is a common feature of the dolerite.

The dolerite is intrusive into sandstone. Drill holes DH7002, 7003, 7004, 7005 and 7006 (Plate 1) show that along the tunnel line dolerite may be expected at tunnel level.

(b) Sandstone

The sandstone is considered to be of Triassic age and is present at both inlet and outlet portals and also in Drill Hole 7014.

A high angle sandstone-dolerite contact occurs within the tunnel at the Brady's Lake end. In Drill Hole 7014 near the portal at Dee Lagoon, sandstone occurs above the dolerite.

3. METHODS

(a) General

The exploration of the area through which the proposed tunnel is to be driven was primarily concerned with:

(i) The location of any sheared and/or weathered zones extending down to tunnel level.

(ii) The rock types through which the tunnel is to be driven.

(b) Resistivity

The resistivity method is frequently used in determining shear zones, formation boundaries and horizontal discontinuities at depth.

In this survey the Wenner configuration was used for all resistivity work. Electrode spacings of 100 feet and 200 feet were used for continuous profiling, readings being taken every 50 feet and 100 feet respectively. The depth penetration of the measured resistivities is approximately equal to the electrode spacing in the Wenner configuration.

"Depth probing", using expanding electrode spacings, was done in three places for comparison with seismic results.

A Megger Earth Tester, which yields speedy and reliable results, was used for continuous profiling. A more accurate resistivity meter, designed and built by the Bureau of Mineral Resources, was used for the expanding electrode method.

(c) Seismic refraction

The "method of differences" was used in this survey. For a general description of the method and its application, see Heiland (1946, p. 548) and Edge and Laby (1931, p.339).

A geophone interval of 50 feet was used for normal geophone spreads, giving a spread coverage of 500 feet. Shot distances of 50 feet and 200 feet from both ends of the spread were used. "Weathering spreads", with geophones at intervals of 10 feet, were shot every 1,000 feet to give the velocity of the weathered layers and the thickness of the soil cover.

The seismic refraction method enables a quantitative estimate to be made of the depth to a high velocity medium which corresponds to unweathered rock. It also gives the velocity of a seismic wave in the rock through which it travels, thereby enabling an estimate to be made of the rock type and the degree of weathering. Over broad shear zones in unweathered dolerite for example, the seismic velocity is lower than normally observed over that rock.

The seismic survey was made along Traverse A as a check on the interpretation of the resistivity results. A Century 12-channel portable refraction unit, model 506, was used.

(d) Magnetic

This survey consisted of measuring the change in the vertical component of the earth's magnetic field from point to point.

For a description of the method and its application the reader is referred to any of the standard geophysical text books (Jakosky, 1940, pp 111-131).

Variations in magnetic intensity are caused largely by differences in the magnetite content of the rocks. Such changes may be due to:-

(i) Change of rock type, e.g. at a sandstone/dolerite contact.

(ii) Differential weathering. Magnetite and most other magnetic minerals lose their magnetic properties when weathered, and variations in the thickness of weathering over a magnetic body produce changes in the magnetic intensity.

(iii) Concentrations of magnetic minerals as in some ore bodies and mineralised shears.

(iv) Primary difference in magnetite content.

Readings were taken at 50-foot intervals on traverses A and B and on the detailed traverses shown on Plate 4.

The instrument used was a Watts vertical force variometer with a sensitivity of 42 gammas per scale division.

4. RESULTS

(a) General

Good agreement exists between the results of the three methods along the tunnel line (Traverse A) (See Plate 2). Zones of shearing and deep weathering on the seismic profile correspond to minima on the apparent resistivity and magnetic profiles. The exception is a prominent magnetic maximum over part of traverse A (See Plates 2 and 4). The cause of this magnetic maximum is not reflected in either the seismic or resistivity results.

Places where sheared or weathered rock is thought to extend to the tunnel level are shown on Plate 2, Fig. 1.

The presence of sandstone was not indicated along the tunnel line at the surface. The drilling results indicate that dolerite extends to tunnel level (see "Geology"). The magnetic and resistivity profiles along traverse B over the sandstone/dolerite contact showed a sharp contrast between the magnetic intensity and resistivity of the two formations (See Plate 3).

(b) Resistivity

(i) Continuous profiling

The resistivity of a rock depends mainly on its porosity, the degree of saturation and the salinity of the solutions. Loose dry gravel or soil and fresh crystalline rocks have a high resistivity. Moist, weathered zones have a low resistivity.

The marsh shows up as an area of low resistivity. This is due to the ground being saturated with water and the probable presence of weak organic acids. High resistivity values occur over the dolerite out-crops near the flanks of the hill, where fresh rock is shallower and drainage is good. These conditions control the general pattern of the resistivity profile.

Sheared and/or weathered zones are indicated by marked minima on the resistivity profile, superimposed on the general pattern.

Traverse A (see Plate 2, Fig.2)

The sharp rise in the profiles near station 10398A indicates a steeply dipping transition from weathered dolerite on the Dee portal side to fresh dolerite. This corresponds to the conditions found in the tunnel, where a transition to fresh jointed dolerite caused partial flooding of the tunnel.

The drop in the profiles near station 8498A is not as sharp. It represents deeper general weathering and indicates a probable transition into more weathered rock at tunnel level.

Marked minima occur near stations 2298A, 3198A, 3498A-3798A, 4098A, 4498A, 5398A, 7198A (edge of march), 7598A, 7898A, 8698A and 10498A (See Plate 2, Fig. 2).

The profile of unweathered dolerite obtained from the seismic survey shows that, in general, a thickening of weathered dolerite corresponds to a resistivity minimum. Corresponding magnetic minima could also confirm deeper weathering.

Traverse B (See Plate 3)

On the resistivity profile of traverse B, the contact between sandstone and dolerite is shown by the abrupt change in resistivity values near 698B. The position of the contact is confirmed by an abrupt change in the magnetic profile.

Between 698B and 2698B the high resistivity values indicate that unweathered dolerite is very close to the surface.

In the central portion of the traverse the marsh produces relatively low resistivity values and tends to mask the variations of resistivity within the dolerite.

The fairly broad minimum between 9098B and 10898B and several sharper minima elsewhere along the traverse indicate deeply weathered shear zones. It is not possible to establish a satisfactory correlation between the resistivity minima on the two traverses A and B, or to determine the strike of the shear zones from the resistivity profiles.

(ii) Depth probing (Plate 2, Fig. 3)

Depth determinations by the expanding electrode technique were made at stations 5698A, 6398A, and 7748A, giving depths to the high resistivity layer of 54 feet, 14 feet and 33 feet respectively. The corresponding values found by the seismic method were 55 feet, 33 feet and 45 feet respectively.

Depth determinations obtained by the resistivity method are not as accurate as those obtained by the seismic method and should be considered as qualitative only.

(c) Seismic refraction

The seismic survey extended along traverse A from station 2898A to station 8848A (Plate 2, Fig. 1).

The observed seismic velocities in the weathered dolerite range from 3,000 ft/sec. toward Dee Lagoon portal and 4,500 ft/sec. over the marsh to 7,500 ft/sec. towards Brady's Lake portal. The 7,500 ft/sec. velocity probably represents jointed dolerite, extensively weathered along the joints.

The unweathered dolerite has a velocity of 17,000 to 18,000 ft/sec. A velocity of 15,900 ft/sec. near station 5798A may represent a shear. It is near the centre of a large, positive magnetic anomaly (see below).

Indications of weathered zones from the seismic and resistivity results are in good agreement.

(d) Magnetic

The magnetic survey was made along traverses A and B and also along some detailed traverses shown on Plate 4.

Minima on the magnetic profiles may indicate deeper weathering, and in the present survey such indications are in agreement with those obtained by the other methods.

A prominent, positive magnetic anomaly with a maximum value of more than 4000 gammas exists between stations 4998A and 6498A (see Plate 2, Fig. 2 and the contour map on Plate 4). The anomaly takes the form of a double-peaked curve with the sharper gradient and highest values on the north-western side. The strike is approximately N25°E. The centre of the anomaly corresponds approximately with a lower seismic velocity of the unweathered rock of 15,900 ft/sec., and with two resistivity minima at stations 5398A and 5698A.

The anomaly may be due to a concentration of magnetic minerals in a body striking approximately between N25°E and north and dipping fairly steeply to the east.

The steepness of the magnetic gradients indicates that the cause of the anomaly is probably close to the surface. The above-mentioned lower seismic velocity indicates a broad zone of shearing. The two close resistivity minima and the double-peaked magnetic profile may indicate two main shears within the gneral shear zone. On the basis of this interpretation it was predicted that difficult tunnelling conditions could be encountered between stations 5198A and 5898A.

The position of zones of shearing and/or weathering deduced from the above results is shown on Fig. 1 of Plate 2.

After the tunnel had entered the zone indicated by the magnetic anomaly it was noted that the dolerite was of a different type. This change was very sudden along a plane with strike as mentioned above and dipping approximately 50° east.

A hand specimen from the tunnel below the area indicated by the magnetic anomaly showed coarse pyroxenes and fine-grained dark minerals which may be magnetite and pyrrhotite. A crude test with a hand magnet showed that the specimen was extremely magnetic, whereas the adjoining dolerite (which exhibits free quartz) showed no magnetic reaction in a similar test.

5. DRILLING RESULTS

The results obtained from diamond drilling on a line offset to the south of traverse A (see Plate 1) and prior to the geophysical survey yielded insufficient information to make reliable predictions concerning the nature of the rock.

The results of the drilling appeared to indicate a fairly steady increase in depth to unweathered dolerite from Brady's Lake to Dee Lagoon portals. This is not in agreement with the geophysical results.

6. ACCURACY

The accuracy of the quantitative results, such as the depth to unweathered rock, is relatively unimportant, as the proposed tunnel is considerably deeper than the unweathered rock profile.

The accuracy of the seismic depth determinations is about ± 15 per cent.

The error in magnetic readings is estimated as less than 10 gammas. This is insignificant when compared with the magnitude of the anomalies observed.

Poor electrode/earth contacts in dry rocky ground tend to give erratic values of apparent resistivity. This will have affected only the values obtained over the outcropping dolerite near the flanks of the hill. The results are qualitative and errors involved are small compared with the lateral variation.

7. CONCLUSIONS

The geophysical results indicate that the unweathered rock along the tunnel line (except for the portals) consists of dolerite and not of sandstone.

In general, the bottom of the weathered zone does not extend to tunnel level but some shear zones (Fig. 1, Plate 2), with attendant deep weathering, may do so.

8. REFERENCES

Edge, A.B. and Laby, T.H., 1931 - THE PRINCIPLES AND PRACTICE OF GEOPHYSICAL PROSPECTING, Cambridge University Press.

Heiland, C.A., 1946 - GEOPHYSICAL EXPLORATION, Prentice Hall, New York.

Jakosky, J.J., 1940 - EXPLORATION GEOPHYSICS, Times-Mirror Press, Los Angeles, Calif.

FIG.2 PLAN SHOWING TUNNEL LINE, DRILL HOLES AND GEOPHYSICAL TRAVERSES

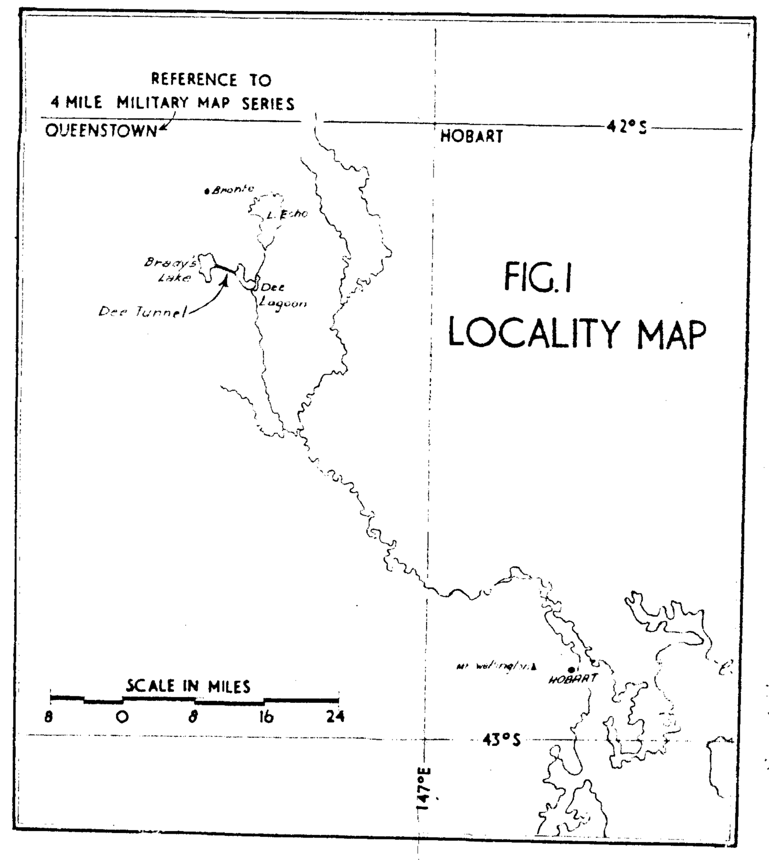

FIG.1 LOCALITY MAP

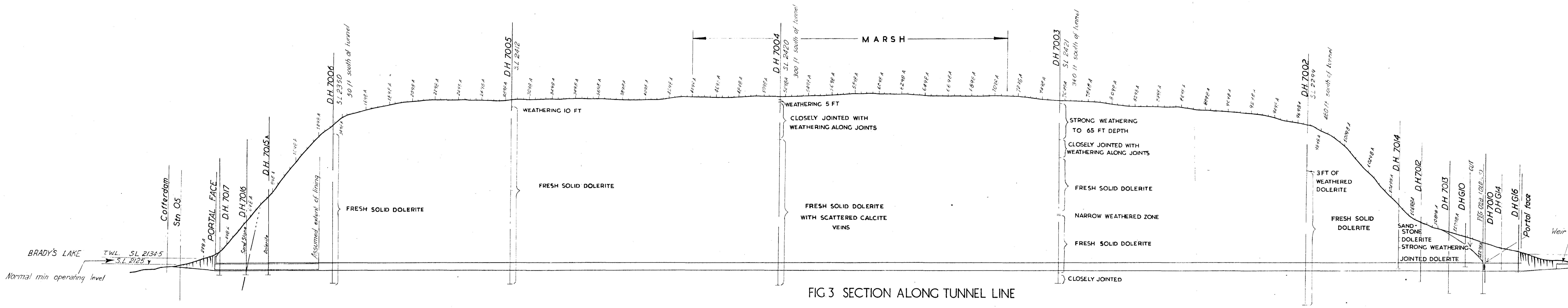

FIG 3 SECTION ALONG TUNNEL LINE

SCALE IN FEET

HORIZONTAL 400	0	400	800	1200	
VERTICAL 80	0	80	160	320	

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FIG. 1: TOPOGRAPHICAL AND SEISMIC PROFILES

FIG 2: MAGNETIC AND RESISTIVITY PROFILES

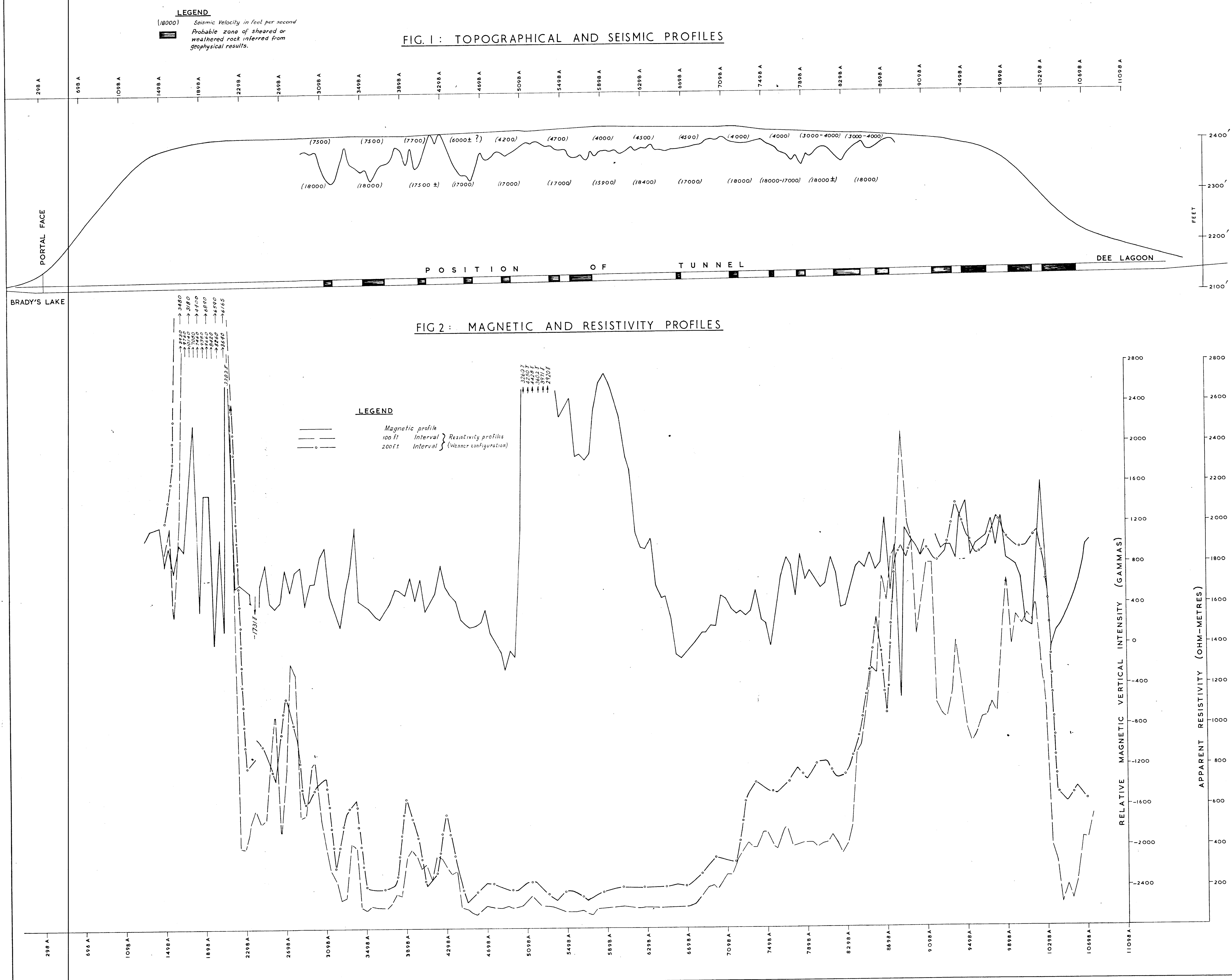
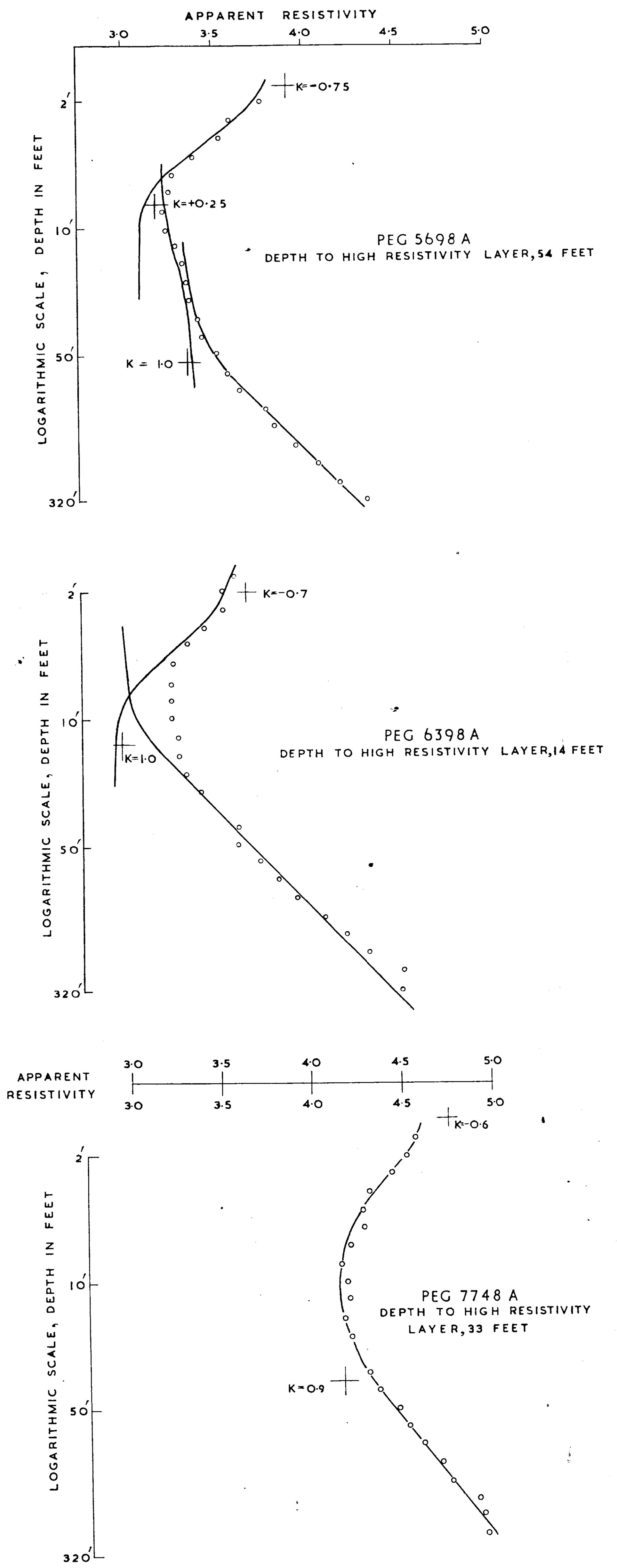


FIG. 3
EXPANDING ELECTRODE PROFILES, WENNER CONFIGURATION
GRAPHICAL INTERPRETATION.



GEOPHYSICAL SURVEY OF DEE TUNNEL, LAKE ECHO POWER DEVELOPMENT SCHEME, TASMANIA.
TRAVERSE A

STATION NUMBERS ARE INDICATED AS DISTANCES IN FEET FROM SURVEY PEG '00' NEAR BRADY'S LAKE PORTAL.

SCALE IN FEET
400 0 400 800 1200 1600 2000

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MAGNETIC AND APPARENT RESISTIVITY PROFILES, (TRAVERSE B)

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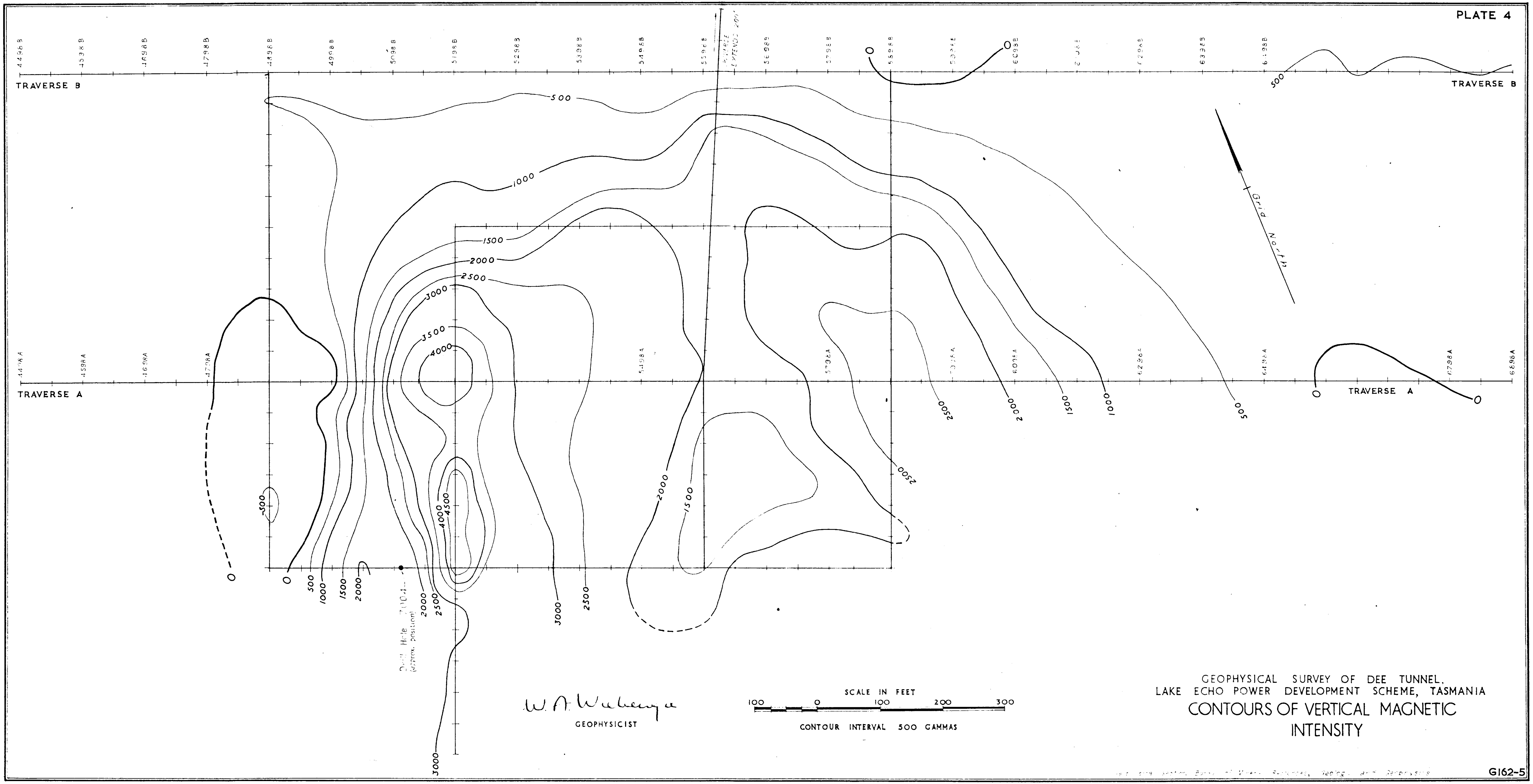
PLATE 4
TRAVERSE B
TRAVERSE A
Grid North
500
1000
1500
2000
2500
3000
3500
4000
4500
0
Drill Hole
(approx. position)
W. A. Wiebenga
GEOPHYSICIST
SCALE IN FEET
100 0 100 200 300
CONTOUR INTERVAL 500 GAMMAS
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CONTOURS OF VERTICAL MAGNETIC
INTENSITY
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