File 208 T/1 17.0.
Folios. 60/61.

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES.

GEOLOGY AND GEOPHYSICS

RECORD No. 1961-92

GREAT LAKE POWER DEVELOPMENT GEOPHYSICAL SURVEYS,

TASMANIA 1957-59

by

W. A. WIEBENGA and E. J. POLAK

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES,

GEOLOGY AND GEOPHYSICS

RECORD No. 1961-92

GREAT LAKE POWER DEVELOPMENT GEOPHYSICAL SURVEYS,

TASMANIA 1957-59

by

W. A. WIEBENGA and E. J. POLAK

CONTENTS

ILLUSTRATIONS

ABSTRACT

Results are given of two geophysical surveys carried out by the Bureau of Mineral Resources for the proposed Great Lake Power Development on behalf of the Hydro-Electric Commission of Tasmania.

In the 1957-58 survey seismic reflection, seismic refraction, resistivity, gravity, and magnetic methods were used. Although no reflections were recorded from the bottom of the dolerite sill, the magnetic and seismic surveys provide supporting evidence for features indicated by the interpretation of a gravity survey in 1951.

In the 1959 survey a new tunnel line was investigated with seismic refraction, gravity, magnetic, and resistivity methods. Estimates are made of the thickness of scree material, glacial deposits or weathered layers. Some shear zones were located and information was obtained on the nearly vertical subsurface boundary between sediments and dolerite.

1. INTRODUCTION

The Hydro-Electric Commission of Tasmania is constructing a power station near Blackwood Creek which will use water from the Great Lake. The scheme, referred to as Great Lake Power Development, consists of an intake tunnel, penstock lines, a vertical pressure shaft, an underground power station, and a tail-race tunnel (Plate 1).

The area has been mapped geologically by the Commission (McKellar, 1956), and test holes have been drilled. Four geophysical surveys have now been carried out.

The first geophysical survey consisted of gravity traverses along the intake tunnel (Chamberlain, 1952).

On the second geophysical survey the first 5500 ft of the intake tunnel, the penstock lines, and the tail-race tunnel were surveyed with seismic refraction, magnetic, and resistivity methods; the gravity data previously obtained were re-interpreted using new drilling evidence (Wiebenga and Polak, 1957). Following this survey diamond-drill holes DDH 5083, DDH 5084, and DDH 5086 were drilled; they proved that the dolerite varies in thickness as suggested by the re-interpretation of the gravity data (Plate 1).

Later the Commission asked the Bureau to make a geophysical survey over the intake tunnel between 5500 ft and 19,300 ft; that is, the section omitted in the second survey. This led to the third survey, which was made between December 1957 and February 1958 by a geophysical party consisting of E. J. Polak (party leader) and F. J. Moss, geophysicists. The purpose of this third geophysical survey was to determine the thickness of the dolerite and the character of the base of the dolerite, and if possible, to locate the positions of any faults.

In 1959 the Commission changed the route of the planned intake tunnel. Accordingly a fourth geophysical survey was carried out in December 1959 to cover the first 6000 ft of the new intake tunnel.

The party on this fourth survey consisted of E.J. Polak (party leader), M. J. Duggin, and D. J. Harwood, geophysicists.

The present Record gives the results of the third and fourth geophysical surveys. The traverse surveyed in 1957-58 will be referred to as the old tunnel line, and that surveyed in 1959 as the new tunnel line.

It is desired to acknowledge the assistance and co-operation of the Commission's survey and administrative staff both at Poatina and at the Head Office in Hobart.

NOTE:-

In the topographical survey the zero point of the old tunnel line was arbitrarily chosen at a point in the Great Lake by the H.E.C. Survey Branch; on the new tunnel line the zero point (Station No. 50) was chosen on the shore of the Great Lake.

2. GEOLOGY

The geology of the area (McKellar, 1956) is shown on Plate 1, and was fully discussed by Wiebenga and Polak (1957). Data obtained from subsequent drilling are included in Table 1 and shown on Plate 1.

TABLE 1

Drill hole	Elevation of collar in ft	Thickness of dolerite in ft	Elevation of the base of dolerite in ft	Elevation change of dolerite base in ft
DDH 5042	3612	104	3508	-45
DDH 5041	3646	183	3463	+81
DDH 5040	3716	172	3544	+119
DDH 5002	3835	172	3663	-10
DDH 5087	3883	230	3653	-82
DDH 5083	4340	769	3571	-512
DDH 5084	4239	1180	3059	-171
DDH 5086	3908	1020*	2888	-6
DDH 5085	3693	817*	2882	+35
DDH 5033	3495	578	2917	

* drill hole not vertical; thickness of dolerite corrected to vertical.

The last column of Table 1 shows that the elevation of the base of the dolerite has considerable relief between DDH 5042 and DDH 5033. This can be explained in two ways :-

(a) Faulting could have produced differences in elevation of the dolerite/sediments contact; this suggests that the original dolerite/sediments contact followed the bedding planes of the sediments, which are nearly horizontal.

(b) Dolerite could have been injected along an irregular surface across the bedding planes of the sediments.

A combination of (a) and (b) is possible.

3. METHODS AND EQUIPMENT

Geophysical methods used were magnetic, micro-magnetic, resistivity, resistivity drill hole logging, seismic refraction, seismic reflection, and gravity.

Magnetic method

Wiebenga and Polak (1957, p.4) have described the magnetic method. Magnetic stations were spaced 50 ft apart along the traverses. The measurements were corrected for diurnal variation by observations at half-hourly intervals at base stations.

Micro-magnetic method

A micro-magnetic method (Lauterbach, 1953-1954; Wiebenga, 1958) was used. In this method magnetic measurements are made in a dense observation grid in small sample areas or panels on rocks with a thin weathered layer. Micro-magnetic features may be correlated with the strike of jointing or shearing planes; they may indicate the original direction of flow in plutonic rock; they may correlate features of sediments with sedimentation; and they may reveal subsurface vertical boundaries between different formations.

Two micro-magnetic panels of 88 stations with a station interval of 10 ft were made in the Great Lake area (Plate 4). A Watts vertical variometer was used.

Resistivity method

Wiebenga and Polak (1957, p. 4) have described the resistivity method. On the resistivity traverses, two different electrode spacings were used, 50 ft and 100 ft. The measurements were made at 50-ft intervals along the traverses. The results of resistivity traverses on thick scree material were not reliable and the method was confined to areas free from scree material.

Parts of three drill holes (DDH 5001, DDH 5002, and DDH 5084) were logged with a two-electrode assembly (Plate 2). Heiland (1946, p. 826-831) describes the method used. The assembly consists of a current and a potential electrode 10 in. apart; this is lowered in a drill hole which contains fluid. The other current and potential electrodes are earthed at the surface and are connected to the terminals of a Megger Earth Tester (resistivity meter); an apparent resistivity is measured in the drill hole at depth intervals of one foot. The variations in apparent resistivity indicate variations in the resistivity of the wall rock of the drill hole. If the salinity of the solutions in the rock pores remains about the same over the logged section, then variations in apparent resistivity indicate variations in rock porosity, and hence in rock type. High-porosity rock has a low resistivity and low-porosity rock has a high resistivity.

Seismic method

The seismic method of exploration depends on the difference in the velocity of propagation of elastic waves through different rock formations. When an explosive charge is detonated in the ground, seismic waves propagate in all directions. The waves are of three types: longitudinal, transverse, and surface (Polak and Moss, 1959). Longitudinal and transverse waves are refracted or reflected after they reach the boundary between rocks of different characteristics.

The seismographs used were a Midwestern reflection-refraction seismograph and a T.I.C. reflection seismograph. The geophones were T.I.C. geophones with a natural frequency of about 20 c/s.

(a) Refraction

The seismic refraction method uses the waves which are refracted at the boundary between rock types. These waves then travel in the lower rock layer with a higher seismic velocity and send waves to the surface (Plate 3, Fig. 1). This method requires the lower layer to have a higher seismic velocity than the upper layer. In the Great Lake area it was possible to determine the depth of weathering, but it was impossible to obtain refraction from the top of sediments under dolerite because the velocity in dolerite is 16,000 to 18,000 ft/sec, whereas in sediments it is only 8000 to 10,000 ft/sec (Wiebenga and Polak, 1957, p.3). At the Great Lake survey the geophones were placed along the traverse at 50-ft intervals. The shots were fired 50 ft and 350 ft beyond both ends of the spread and in line with the spread. The "method of differences" was used for depth calculations (Heiland, 1946, pp.548-9).

(b) Reflection

In the seismic reflection method (Heiland, 1946, pp. 549-579), the recorded waves from an explosion are reflected from a subsurface layer. The geophones are usually placed in line with and not far from the shot-point; the geophone interval is kept relatively small compared with the depth of the reflecting horizon (Plate 3, Fig. 2). Direct waves and shallow refraction waves arrive at the geophones early and with relatively large phase differences. Reflected waves arrive at the geophones later and with only small phase differences because the differences in the paths travelled are relatively small. This makes it possible to recognise reflections on the records even if the traces are disturbed by other events.

To decrease the background noise of the traces and to make the reflections stand out as clear events, several techniques were used:-

(1) Pattern shooting, with four, nine, and sixteen shots in a pattern (Parr and Mayne, 1955).

(2) Air shooting, with shots placed six feet above the ground; the air acts as an additional layer with filtering properties (Poulter, 1950).

(3) Mixing of the geophone traces with geophones spaced at 16,25, and 50 ft (Parr and Mayne, 1955).

(4) A geophone pattern with 6 geophones per trace; the geophones were up to 32 ft apart (Parr and Mayne, 1955).

try to

In the 1957-58 survey the seismic reflection technique was used to determine the thickness of the dolerite between stations 5500 ft and 9500 ft, and between stations 12,500 ft and 17,500 ft. Despite the use of the techniques mentioned above, no readable reflections were recorded to indicate the thickness of the dolerite layer; hence the seismic reflection technique yielded no results.

Several explanations for the failure to obtain reflections can be suggested.

(a) The Midwestern seismograph had a frequency range of 75 to 400 c/s, and the T.I.C. seismograph had a frequency range of 5 to 45 c/s. Reflections possibly occurred in the frequency range 45 to 75 c/s, but as this range is outside the filter setting ranges of both seismographs these reflections would not be recorded. A ground roll with a velocity of about 9000 ft/sec and a frequency of 60 to 65 c/s was recorded on refraction settings, and probably would have overshadowed the reflection events in the 45 to 75-c/s range even if this filter range had been available.

(b) The dolerite is probably layered and fractured. Possibly the seismic energy was completely dispersed within the dolerite.

Gravity method

Heiland (1946 pp. 67-70) describes the gravity method. In the present survey a Worden gravity meter was used. Stations were spaced along the traverses at 50-ft intervals; the elevations were determined with an accuracy of ± 0.1 ft.

4. ROCK PROPERTIES

Magnetic properties

Cores from DDH 5001 give high but variable values of magnetic susceptibility for dolerite (Jaeger and Joplin, 1955):-

Magnetic susceptibility : 0.55×10^{-3} to 3.0×10^{-3} c.g.s.e.m.u.

Remanent magnetism : 0.24×10^{-3} to 4.0×10^{-3} c.g.s.e.m.u.

Faults, shears, or fractures may be indicated on the magnetic profile by a decrease in vertical magnetic intensity because weathering causes demagnetisation of the magnetite in the dolerite. This evidence, and evidence from gravity, resistivity, and seismic data, were used to interpret the magnetic profiles. Decrease in the magnetic intensity may also be caused by variations in magnetic susceptibility or by variations in the direction of the remanent magnetisation vector; but past experience of surveys on dolerite has shown that these factors play only a minor part in the interpretation of magnetic data.

Resistivity

The weathered layer in a shear zone is usually thicker than it is outside the shear zone, because sheared rock provides better access to surface solutions than fresh solid rock; also, the porosity of weathered rock is higher than that of unweathered rock, and the salinity of the pore solutions in weathered rock is higher than the salinity usually found in ground water. Therefore, shear zones are indicated as low-resistivity zones. Low resistivity however, does not necessarily indicate a shear zone; for instance, small pockets of clay near the potential electrodes may cause low resistivity. The resistivity of the solid dolerite is very high.

The resistivity log of DDH 5002 (Plate 2) shows that the resistivity of dolerite is not uniform and that occasional beds of very high resistivity occur (up to 250,000 ohm cm). The average value is about 80,000 ohm cm. Lower resistivity values probably indicate the positions of weathered joints; the high values indicate unweathered dolerite. The resistivity of the underlying Newton Coal Measures is only 8000 ohm cm.

Seismic velocities

Seismic velocities recorded in the Great Lake area have been discussed by Wiebenga and Polak (1957). Table 2 lists the velocities used in the interpretation of the results.

TABLE 2

Rock type	Seismic velocity in ft/sec
Soil	1000 to 2000
Scree material and completely weathered dolerite	2000 to 5000
Glacial deposits	5000 to 6000
Weathered to jointed dolerite	5000 to 11,000
Jointed to unweathered dolerite	11,000 to 18,000

Specific gravity

In the interpretation of the gravity data the specific gravity for unweathered dolerite was taken as 2.95 (Jaeger and Joplin, 1955); for the underlying sediments the specific gravity was taken as between 2.5 and 2.6. For the computation of Bouguer and terrain corrections the specific gravity of dolerite (2.95) was used.

5. RESULTS

Plate 4 shows two micro-magnetic panels at Stations 3850 ft and 15,900 ft. Following Lauterbach's procedure (Wiebenga, 1958) a frequency analysis of the direction of the contours at each station was made; the results are plotted in histograms (Plate 4) and are summarised in Table 3.

TABLE 3

Station	Range of predominant strikes	Frequency as percentage of total	Range of predominant strikes	Frequency as percentage of total
	25° to 55°	28	35° to 40°	9
3850 ft	270° to 275°	8	270° to 275°	8
	355° to 10°	26	355° to 10°	26
	45° to 70°	44	45° to 50°	25
15,900 ft	270° to 275°	6	270° to 275°	6
	315° to 330°	27	315° to 330°	27
	335° to 10°	17	355° to 360°	13

Both histograms suggest the presence of faults or fractures with northerly, north-easterly, and westerly strikes. Trends with a north-westerly strike, strongly represented at Station 15,900 ft, are missing at Station 3850 ft. On the other hand the three trends mentioned for Station 3850 ft are somewhat overshadowed by other trends which possibly represent cooling joints. This would indicate that the dolerite in this locality is close to the contact; this is confirmed by Jaeger and Green (1958, pp. 34-36) and by the discovery of Permian rocks close to Station 2000 ft (Clothier, 1960).

Plates 5 and 6 show the results along the old and new tunnel lines. The two tunnel lines are between zero and 500 ft apart and so some important features found on one tunnel line are also found on the other. Plates 7 and 8 show in more detail the data on Plate 6. Plate 9 illustrates the conclusions reached from the combined evidence of all the surveys carried out.

One of the important results of these surveys is the location of faults and shear zones and the determination of their strikes. A fault with a small vertical throw is characterised by a small negative local gravity anomaly, by a low apparent resistivity, by a small negative magnetic anomaly, and from seismic methods by a locally thick weathered layer. Considered separately none of this evidence is very conclusive that a fault or shear zone exists, but considered together the evidence is strong.

Old tunnel line (Plate 5)

The steep gravity gradient shown between Stations 5500 ft and 8000 ft indicates a sudden decrease in dolerite thickness. F1 is the position where a fault was indicated in a previous survey (Wiebenga and Polak, 1957). The position of the fault has now been shifted to Station 8300 ft from seismic, gravity, and magnetic evidence.

The negative gravity and magnetic anomaly at Station 10,200 ft is interpreted as a local thickening of scree material at the side of dolerite cliffs and is possibly associated with a fault. Dolerite cliffs crop out at Station 10,700 ft where a steep rise to the east in vertical magnetic intensity is evident. F2 is the position of a fault as indicated by Wiebenga and Polak (1957). The present evidence indicates F2 to be between Stations 14,000 ft and 14,200 ft.

The magnetic and seismic evidence suggests the possibility of a fault at 15,400 ft and at 16,000 ft (F3).

The thickening of the weathered layer and the negative magnetic anomaly at Station 17,000 ft may represent a fault. All the features mentioned above are indicated by the letter A on Plates 5 and 9.

An estimate of the density contrast can be made from the gravity stations near DDH 5083 and DDH 5084 at the centre of the ridge. Correcting for the weathered layer, the gravity difference between the two stations is 1.21 + 0.14 = 1.35 mgal. The elevation difference of the lower dolerite contact is 512 ft. The density contrast is obtained from the formula derived from Dobrin (1960, p. 175).

$$\Delta g = 12.77 \Delta \delta L /1000$$

in which Δg is gravity difference, L the thickness of a layer in feet, and $\Delta \delta$ the density contrast. The density contrast is 0.21 and is about half the density contrast originally used in interpreting the gravity survey; hence variations in dolerite thickness may be up to twice the amount originally computed from the gravity results.

The dolerite is more than 400 ft thick at DDH 5073, about 104 ft thick at DDH 5042, and thins abruptly close to Station 5600 ft. The Bouguer gravity interval between Stations 400 ft and 6400 ft is about 12 mgal. If the original value of 0.4 is assumed for the density contrast then the dolerite thickness west of Station 5600 ft is about 2300 ft; but if a density contrast of 0.2 is assumed, then the dolerite thickness is about 4600 ft. These two estimates can be used as limits.

New tunnel line (Plate 6)

The data on the traverses along the new tunnel line were interpreted in the same way as the data on the old tunnel line. The positions of faults or shears are indicated diagrammatically underneath the resistivity profiles on Plate 6.

The gravity profile of the new tunnel line closely resembles that of the old tunnel line. A comparison suggests that the dolerite thins abruptly near Station 140 (4500 ft). Also, a Bouguer gravity interval of 12 mgal between Stations 60 and 160 indicates a thickness of dolerite at the western end of the tunnel line of between 2300 and 4600 ft; this is the same as the thickness estimated for the old tunnel line.

Comparison between old and new tunnel lines

A tracing of the gravity profile of the old tunnel line was superimposed on the gravity profile of the new tunnel line. When corresponding features were plotted along the old and new tunnel lines, the strike of these features appeared to be about 96° and to cut the tunnel line at an acute angle of about 25° (Plate 9).

It follows that the edge of the zone where the dolerite thins abruptly also has a strike of 96°, and that the faults or shears located on the new tunnel line near Station 135 and at Stations 154, 175, and 204 are also parallel to the edge of this zone, and also have a strike of 96°. The strike of these features coincides with a major trend shown by the histograms of the micro-magnetic panels (Plate 4).

6. CONCLUSIONS

The earlier gravity work along the old tunnel line was supplemented by additional magnetic and seismic refraction work. Most of the features indicated by the earlier work (Wiebenga and Polak, 1957) were confirmed. Some of the faults were shifted slightly and some additional faults, shears, or fractures were found. On Plates 5 and 9 these features are indicated by the letter A. The strikes of the features are not known but they probably coincide with the major trends indicated by the histogram of the micro-magnetic panel at Station 15,900 ft (Plate 4).

Along the new tunnel line (Plates 6 and 9) the gravity, seismic refraction, magnetic, and resistivity data indicate the boundary between thick and thin dolerite; the data also indicate the positions of many faults or shears. A comparison between the data of the old and the new tunnel lines shows a great similarity between the data, and indicates that the edge between thick and thin dolerite is parallel to the faults or shears and has a strike of about 96°. This strike is also indicated as a trend on the histograms of the micro-magnetic panels on Stations 3850 ft and 15,900 ft of the old tunnel line (Plate 4).

It is concluded from the gravity data that the dolerite sill at the western end of the tunnel lines at the lake shore is between 2300 and 4600 ft thick.

7. REFERENCES

CHAMBERLAIN, N. G.	1952	Unpublished gravity data. Bur. Min. Resour. Aust.
CLOTHIER, E. A. W.,	1960	Personal communication.
DOBRIN, M. B.	1960	INTRODUCTION TO GEOPHYSICAL PROSPECTING. McGraw-Hill, New York.
HEILAND, C. A.	1946	GEOPHYSICAL EXPLORATION. Prentice-Hall, New York.
JAEGER, J. C. and JOPLIN, G.,	1955	Rock magnetism and the differentiation of a dolerite sill. J. geol. Soc. Aust. 2.
JAEGER, J. C. and GREEN, R.,	1958	A cross section of a tholeiite sill. DOLERITE - A SYMPOSIUM. University of Tasmania, Hobart.

McKELLAR, J. B. A., 1956 Internal report. Hydro-Electric Commission, Tasmania.

LAUTERBACH, R., 1953-54 Mikromagnetik, ein Hilfsmittel geologischer Erkundung. Wiss. Z. der Karl-Marx. Universitat, Leipzig. 3 (3), 223.

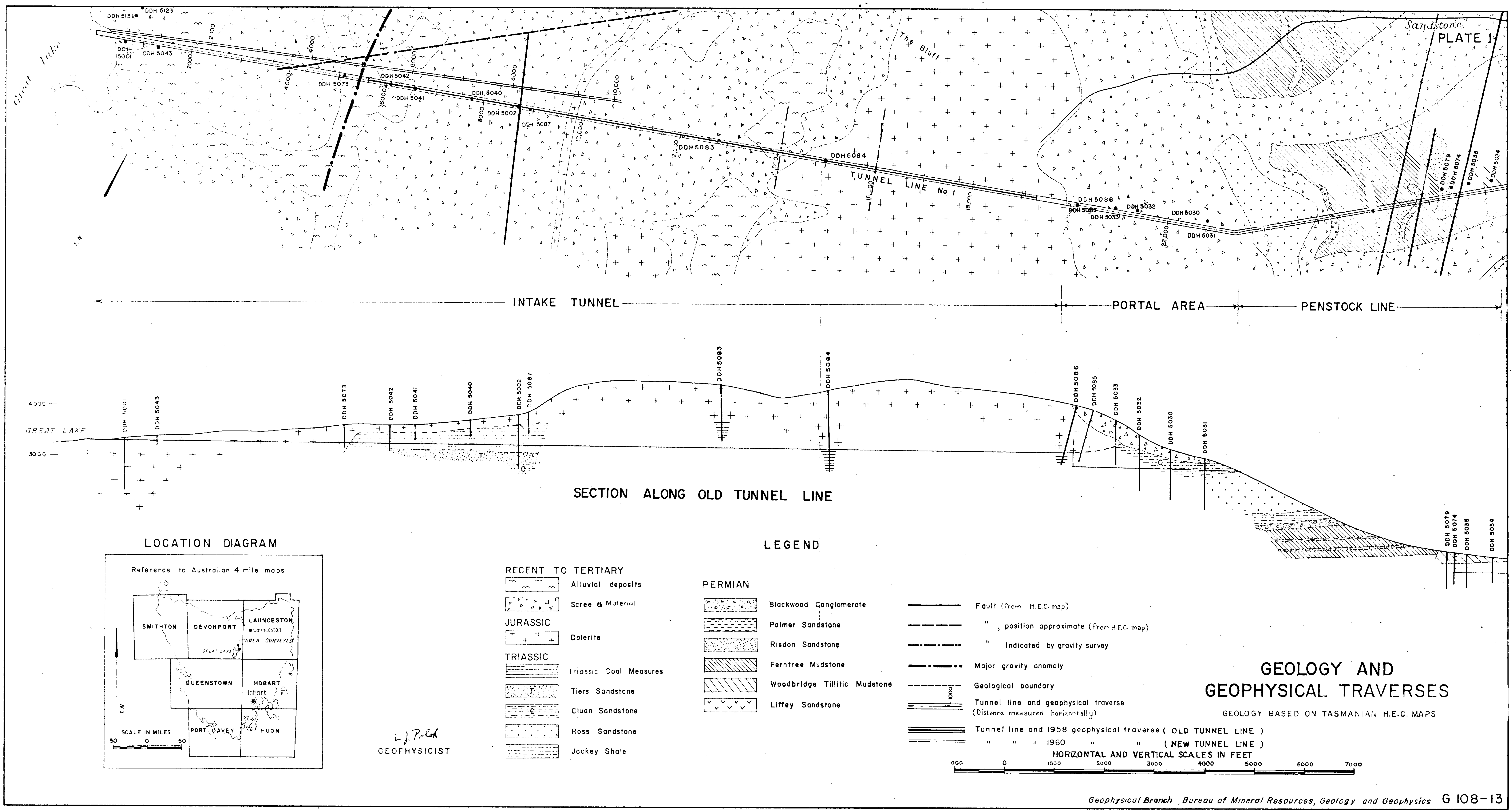
PARR, J. O. and MAYNE, W.H. 1955 A new method of pattern shooting. Geophysics, 20 (3), 539.

POLAK, E. J., and MOSS, F.J. 1959 Geophysical survey at the Cluny damsite, Derwent River, Tasmania. Bur. Min. Res. Aust. Rec. 1959/87.

POULTER, T. C. 1950 The Poulter seismic method of geophysical exploration. Geophysics, 15, 181-207.

WIEBENGA, W.A. and POLAK, E.J. 1957 Geophysical survey of the Great Lake North area, Tasmania. Bur. Min. Res. Aust. Rec. 1957/44.

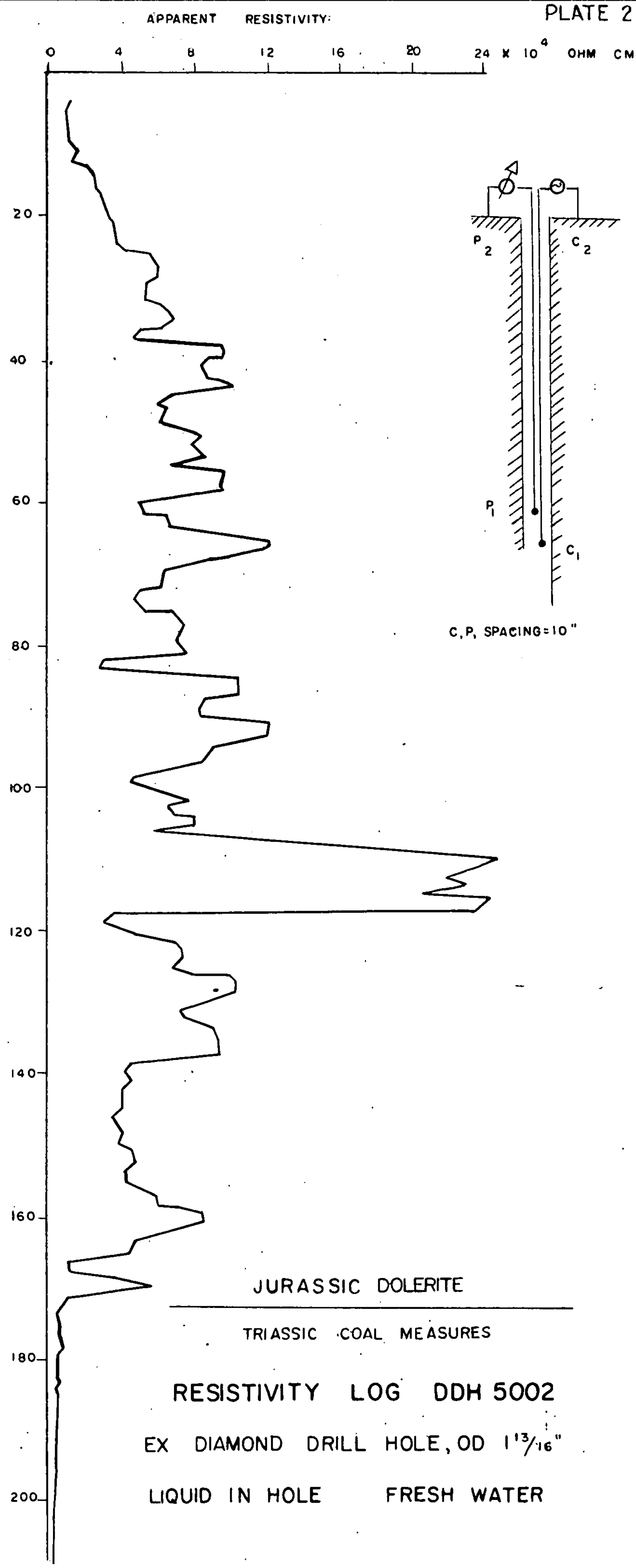
WIEBENGA, W.A., 1958 Exploration geophysics applied to the dolerites of Tasmania. DOLERITE - A SYMPOSIUM. University of Tasmania, Hobart.



GREAT LAKES, TASMANIA 1960.

To Accompany Record No 1961-92

PLATE 2



RESISTIVITY LOG DDH 5002

EX DIAMOND DRILL HOLE, OD 1 13/16"

LIQUID IN HOLE FRESH WATER

GREAT LAKE, TASMANIA, 1960

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS G 108 — 14

TO ACCOMPANY RECORD No 1961-92

PLATE 3

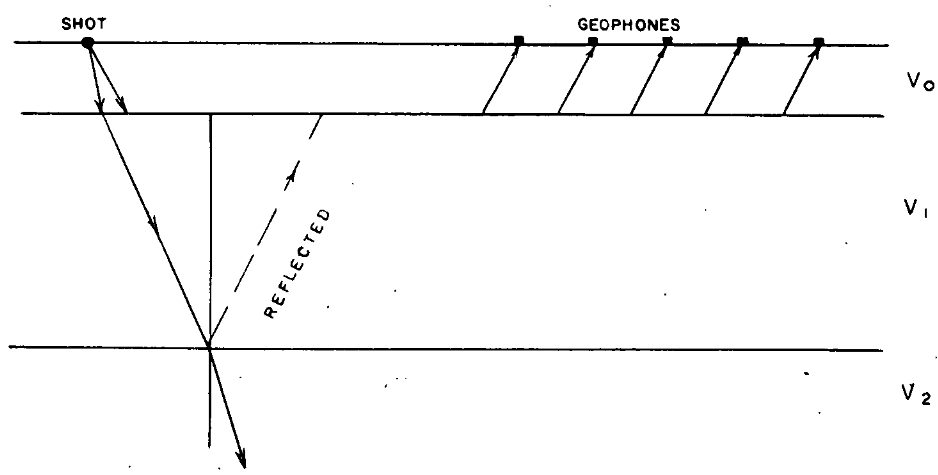


FIG. 1 Refracted waves in area where velocity in second layer V_1 is higher than in first and third layers

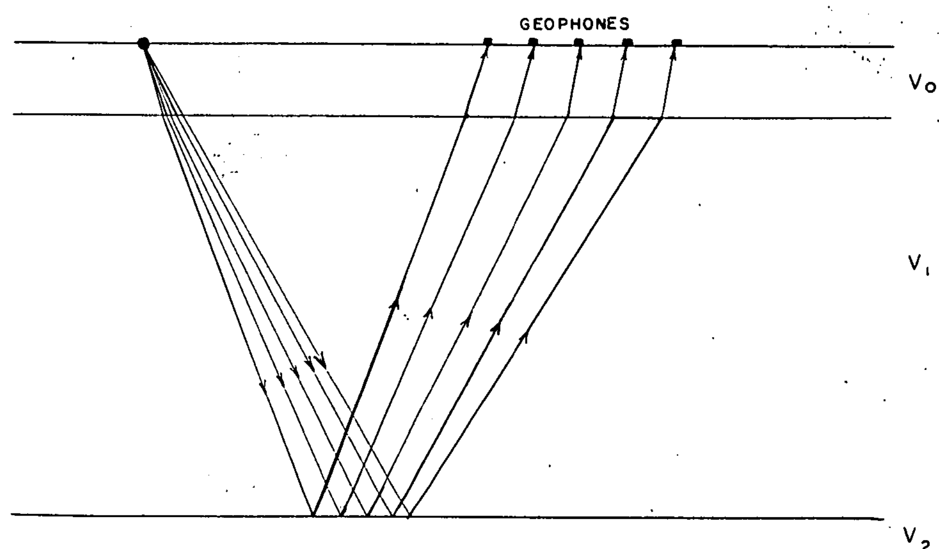
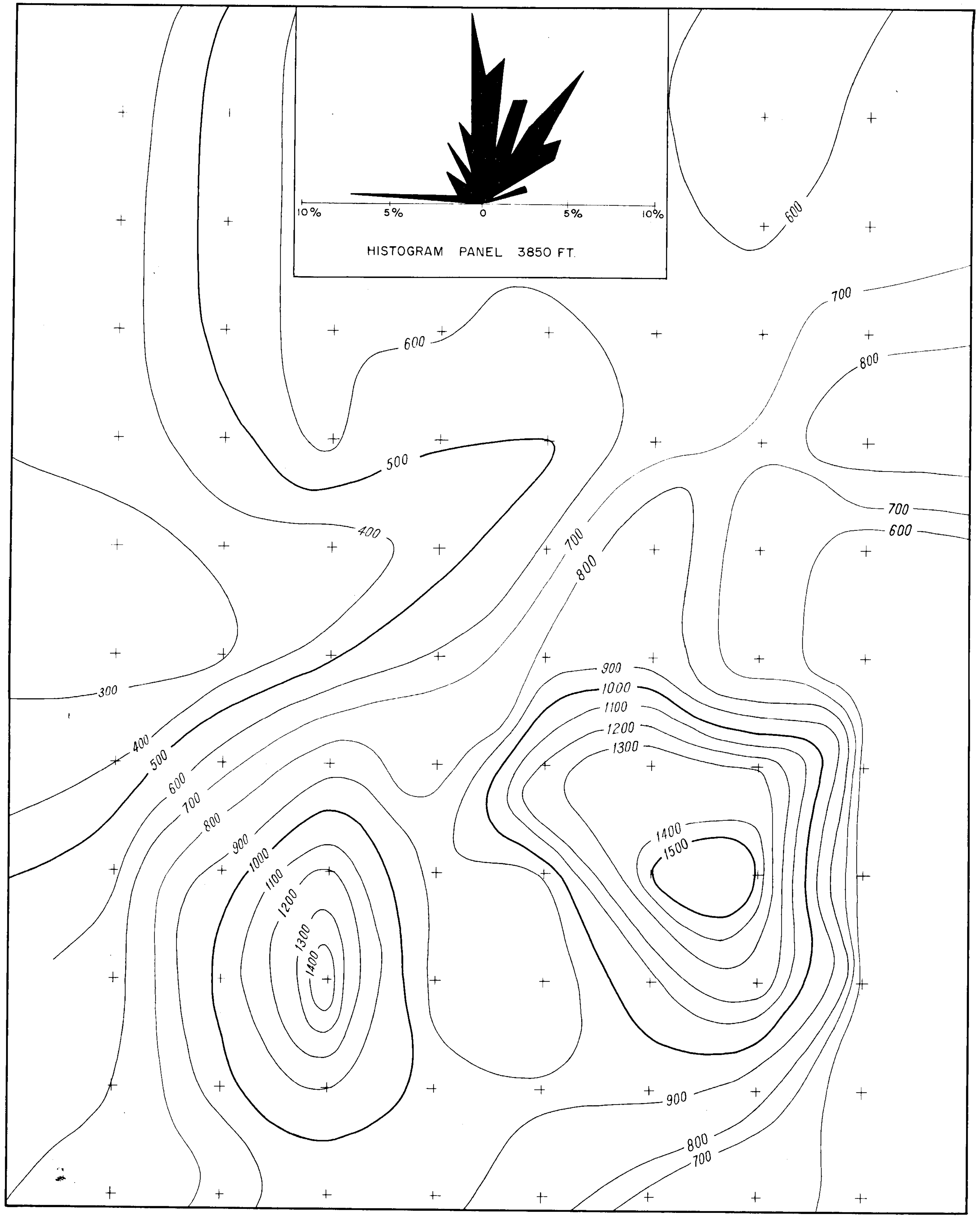
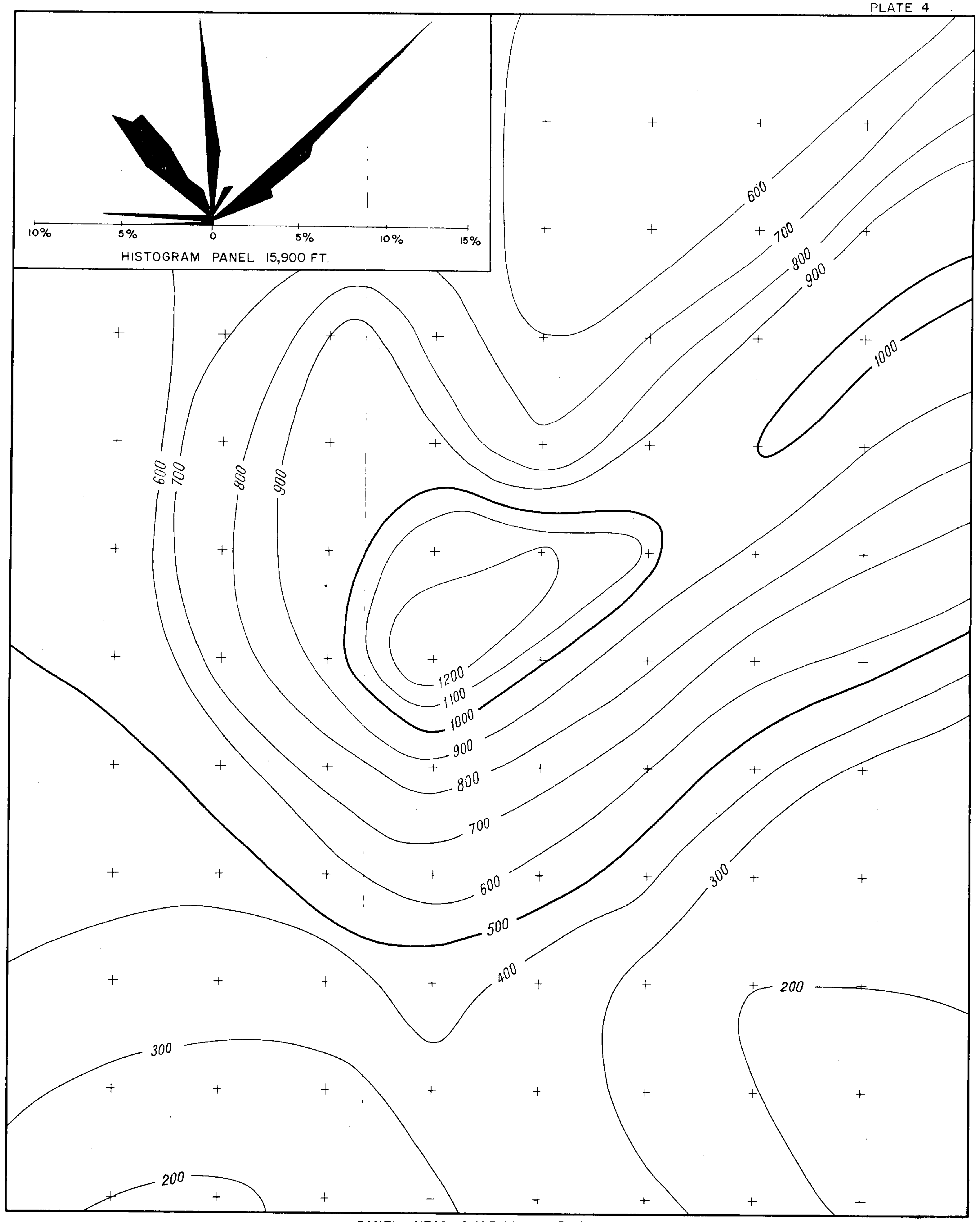


FIG. 2 Reflected waves

ILLUSTRATING SEISMIC METHODS



PANEL NEAR STATION No 3850 FT.



PANEL NEAR STATION No 15,900 FT.

LEGEND

\+ MAGNETIC STATION

1000 / 900 MAGNETIC CONTOURS IN GAMMAS

MICROMAGNETIC PANELS

SCALE IN FEET

10 0 10 20 30

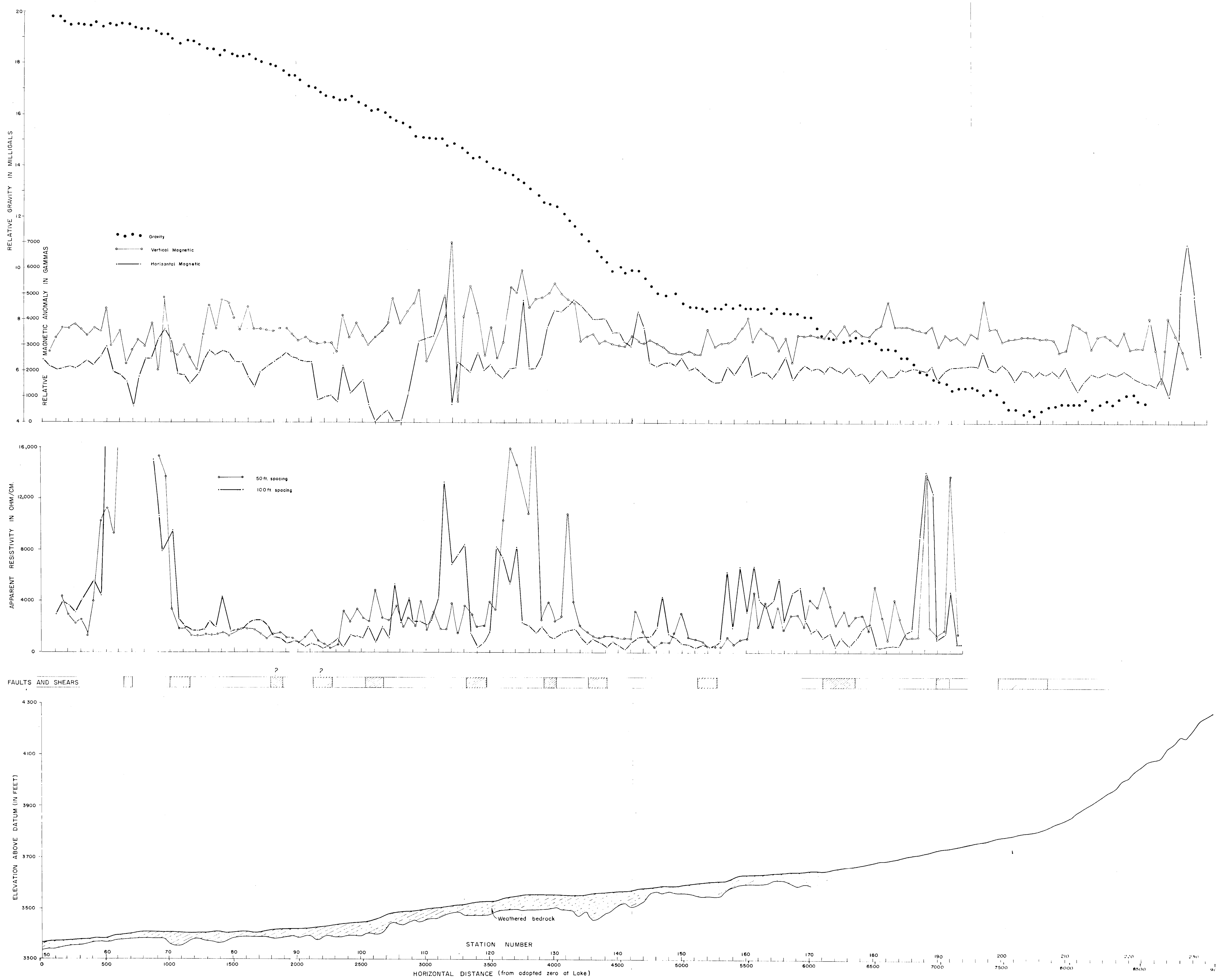
Geophysical Branch, Bureau of Mineral Resources, Geology & Geophysics. G108-15

TO ACCOMPANY RECORD No 1961-92

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G 108 - 19

TO ACCOMPANY RECORD No 1961 - 92

GREAT LAKE POWER DEVELOPMENT, TAS. 1960



NEW TUNNEL LINE
GRAVITY, MAGNETIC, RESISTIVITY AND SEISMIC REFRACTION PROFILES

HORIZONTAL SCALE IN FEET

500 0 500 1000

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G108-20

TO ACCOMPANY RECORD No 1961-92

PLATE. 7.

DATUM 3200 FT

Peg Number	S.L. Natural Surface	Horizontal Distance (Feet)	Depth To Bedrock
Peg 750	3372	00	
751	3377	48	30
BM2762	3378.43	83	
752	3379	99	31
753	3381	150	28
754	3382	197	27
755	3383	249	25
756	3385	300	23
757	3386	350	21
758	3388	399	19
759	3389	447	16
760	3400	498	13
IP "A"	3401	533	
761	3401	549	10
762	3404	599	13
763	3408	648	16
764	3413	697	19
765	3417	748	22
IP "B"	3418	779	
766	3418	795	22
767	3417	846	27
768	3416	896	27
769	3413	946	38
770	3408	996	45
771	3408	1046	43
772	3408	1096	36
773	3408	1146	26
774	3408	1196	35
775	3408	1247	35
776	3410	1297	36
777	3412	1348	41
778	3414	1397	24
779	3413	1447	20
780	3414	1497	16
781	3415	1547	20
782	3418	1597	20
783	3416	1647	18
784	3417	1697	18
785	3418	1747	20
786	3419	1797	36
787	3421	1847	36
IP "C"	3422	1868	
788	3422	1896	33
789	3424	1946	32
790	3426	1997	36
791	3428	2046	[illegible]
792	3429	2096	39
793	3432	2146	44
794	3434	2196	29
795	3437	2245	31
796	3439	2295	45
797	3443	2345	50
IP "D"	3445	2362	
798	3447	2394	48
799	3453	2444	53
7100	3456	2493	61
7101	3461	2543	56
7102	3465	2592	54
7103	3476	2640	56
IP "E" 7104	3483	2689	50
7105	3486	2738	63
7106	3490	2789	61
7107	3493	2838	63
7108	3497	2888	63
7109	3501	2938	59
IP "F" 7110	3504	2990	49
7111	3507	3039	36
7112	3510	3089	41
7113	3513	3139	45
7114	3517	3187	35
7115	3519	3238	35
7116	3524	3288	53
7117	3527	3338	57
7118	3529	3387	49
7119	3533	3437	49
7120	3536	3487	53
7121	3540	3536	47
7122	3544	3586	42

NEW TUNNEL LINE-STATION 50 to 122

GRAVITY, MAGNETIC, RESISTIVITY AND SEISMIC REFRACTION PROFILES

100 0 100 200

HORIZONTAL SCALE IN FEET

Stadia Bk. P49,53.

GEOPHYSICAL TRAVERSE

LONGITUDINAL SECTION Ch00' - Ch3586'

100' to 1" A104 - 300 - 6

Natural

G108-16

GREAT LAKE TAS. 1960

TO ACCOMPANY RECORD No. 1961/92

PLATE 8

DATUM 3300

Peg Number	Peg 7122	7123	7124	"IPG" 7125	7126	7127	7128	7129	7130	7131	7132	7133	7133	7134	7135	7136	7137	7138	7139

Peg Number	Peg 7122	7123	7124	"IPG" 7125	7126	7127	7128	7129	7130	7131	7132	7133	7134	7135	7136	7137	7138	7139
SL. Natural Surface	3544	3548	3552	3557	3559	3559	3559	3558	3557	3557	3557	3557	3558	3557	3561	3563	3565	3567
Horizontal Distance (Feet)	3586	3636	3686	3736	3787	3836	3886	3936	3986	4036	4086	4137	4187	4236	4286	4336	4386	4436
Depth to Bedrock	42	46	46	55	58	58	58	58	46	51	57	57	71	61	94	98	77	79

Peg Number	7140	7141	7142	7143	7144	7145	7146	7147	7148	7149	7150	7151	7152	I.P."H"	7153	7154	7155	7156	7157
SL. Natural Surface	3569	3572	3579	3584	3583	3583	3586	3589	3593	3595	3598	3601	3603	3606	3606	3608	3612	3614	3616
Horizontal Distance (Feet)	4487	4536	4585	4635	4685	4735	4785	4835	4885	4935	4985	5034	5084	5122	5134	5185	5235	5285	5335
Depth to Bedrock	45	44	63	71	50	13	8	23	13	23	25	30			57	57	57	59	23

Peg Number	7158	7159	7160	IP"I"	7161	7162	7163	7164	7165	7166	7167	7168	7169	7170	7171	7172	7173	IP"J"	7174
SL. Natural Surface	3626	3633	3636	3636	3636	3637	3638	3639	3643	3644	3645	3647	3647	3648	3650	3653	3655	3656	3659
Horizontal Distance (Feet)	5382	5434	5482	5488	5533	5583	5633	5683	5733	5783	5833	5884	5933	5984	6033	6084	6134	6140	6183
Depth to Bedrock	32	32	34			30	34	23	27	31	42	52	48	57					

Peg Number	7175	7176	7177	7178	7179	7180	7181	7182	7183	7184	7185	7186	7187	7188	7189	7190	7191	7192	7193
SL. Natural Surface	3662	3666	3671	3674	3679	3683	3687	3691	3696	3700	3706	3711	3715	3719	3723	3730	3735	3740	3745
Horizontal Distance (Feet)	6231	6282	6332	6381	6431	6481	6531	6581	6632	6680	6731	6779	6829	6879	6928	6978	7028	7078	7127
Depth to Bedrock																			

NEW TUNNEL LINE- STATION 122 to 193

MAGNETIC RESISTIVITY AND SEISMIC REFRACTION PROFILES

100 0 100 200

HORIZONTAL SCALE IN FEET

Sdo Bk PM P53

GEOPHYSICAL TRAVERSE

LONGITUDINAL SECTION CH3586' - CH7127'

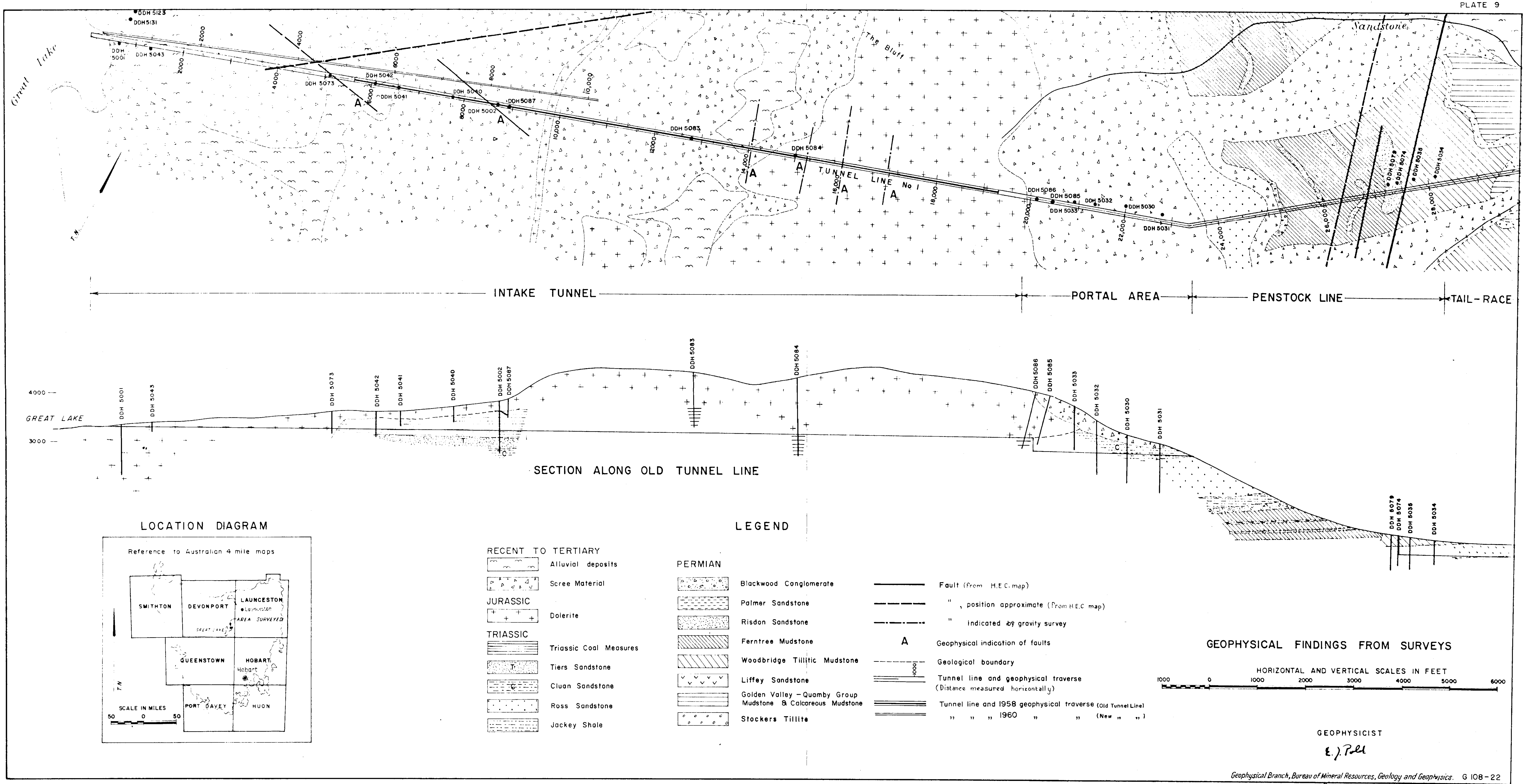
P.I.3 100 to 1" A104 - 300 - 7

B.W. NATURAL G108-17

GREAT LAKE TAS 1960

TO ACCOMPANY RECORD No 1961-92

PLATE 9



To accompany Record No 1961-92

GREAT LAKE TAS, 1960