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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1964/101

WILMOT POWER DEVELOPMENT

GEOPHYSICAL SURVEY.

TASMANIA 1963

by

P.E. MANN

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CONTENTS

ILLUSTRATIONS

SUMMARY

A seismic refraction survey along the Wilmot tunnel line, which is part of the Mersey-Forth-Wilmot Power Development scheme, was made in order to determine the conditions in the bedrock along the proposed tunnel level.

The 'method of differences' and 'step-out times' procedures were used for interpretation.

The results indicate that the tunnel level is within bedrock (seismic velocity 11,000 to 17,500 ft/sec) for considerable lengths of the traverse. The tunnel level is in, or close to, Tertiary clay and sand at the centre of the traverse between M70 and M108. This part should be investigated further by drilling.

A shear zone in which the seismic velocity is 7000 ft/sec is indicated between Stations M165 and M167.

1. INTRODUCTION

The Wilmot Power Development is part of the Mersey-Forth-Wilmot Power Development Scheme of the Hydro-Electric Commission of Tasmania. The Wilmot tunnel will carry water impounded by a dam on the Wilmot River just below the confluence of the Iris and Lea Rivers to a power station on the Forth River. The water will be used again at several power stations at the Cethana, Barrington, and Paloona dam sites along the Forth River.

The results of a geophysical survey by the Bureau of Mineral Resources at the Wilmot dam site, inlet and outlet portal of the proposed tunnel, and the penstock line are given by Polak (1962). The survey showed deep weathering of rock in the inlet portal area. To avoid poor tunnelling conditions at the inlet portal the Commission proposed a new tunnel line which was expected to be in sound rock along the whole length. The tunnel will be about 14,000 ft long and the depth below the surface will range from about 200 ft to 600 ft.

In response to a request by the Commission, the Bureau made a seismic refraction survey in February 1963 to determine the presence of shear or fault zones and the depth of weathering along the tunnel line, and to enable conclusions to be made about the quality of the rock at tunnel level. The geophysical party consisted of P.E. Mann (party leader and geophysicist) and F. Jewell (the Commission's geophysicist). The Commission supplied four field assistants and supervised the topographical survey of the traverse bores by a contract surveyor.

When about 9000 ft of traverse had been surveyed using the 'method of differences', the party moved out after arranging for Mr Jewell to survey required sections at a later date.

Further seismic work on the tunnel line was done in June 1963 by F. Jewell using the 'step-out times' technique. The results were checked and recomputed by P.E. Mann.

2. GEOLOGY

Plate 1 shows the proposed tunnel line, which was mapped geologically by Patterson (pers. comm.).

The general geology and stratigraphy of the area (also after Patterson) is summarised by Polak (1962).

Two holes, viz. DDH 4558 and 4559, have been drilled in Bell Valley close to the proposed tunnel line. The log of DDH 4559 indicates 20 ft of alluvial sand, clay, and gravel overlying nearly 80 ft of volcanic breccia and agglomerate. Underneath this layer 40 ft of Tertiary clay and sand were drilled through before the drillhole reached the sandstone of the Moina Formation at a depth of 137 ft.

3. METHODS AND EQUIPMENT

A detailed description of the seismic refraction method using the method of differences (Heiland 1946, p.548) has been given by Polak and Moss (1959). Continuous traversing with 50-ft geophone spacing and shot-points at 25 and 200 ft from the nearest geophone were used on Traverses A, B, C, and D, and between Stations 1 and 181 on Traverse M. On Traverses A and B, and between Stations 61 and 101 on Traverse M, extra shots were fired at 400 ft from the nearest geophone. Between M87 and M155 extra geophone spreads of 1100-ft length were used with 100-ft geophone spacing and shot-points 100 and 1100 ft from the nearest geophone. For an 1100-ft spread between M65 and M87 and a 550-ft spread between M155 and M166, the shot distances used were 100 ft at each end and a single shot at 1100 ft from the nearest geophone. The arrangement of shot-point and spread adopted meant that the close (100-ft) shot-point of one spread was the long-distance (1100-ft) shot-point for an adjacent spread. Between M87 and M155 the reciprocal time was obtained by extrapolating the time/distance curves of the long-distance shot. Between M65 and M87 and between M155 and 166, the depth to the highest-velocity refractor was calculated by the method of 'step-out times' (Barthelmes, 1946).

The seismic equipment used in February 1963 was a portable SIE 12-channel P-19 refraction seismograph. An SIE 24-channel PRO-11-6 camera was used with an Electro-Tech seismod display unit to give conventional and variable-density records.

TIC geophones with a natural frequency of about 20 c/s were used. In June 1963 the seismic survey was made with similar equipment and Electro-Tech geophones with a natural frequency of about 15 c/s.

4. RESULTS

Plate 1 shows the layout of the seismic traverse. Table 1 gives an interpretation of the seismic velocities in geological terms based on the geological mapping, logs of drill-hole cores, and experience in other areas.

TABLE 1

Seismic velocity (ft/sec)	Rock type
1000	Soil and talus material
3000 to 6000	Weathered volcanic breccia
7000 to 8500	Partly-weathered volcanic breccia; partly-weathered, jointed Moina sandstone
9000 to 13,000	Jointed Moina sandstone; unweathered volcanic breccia
14,000 to 17,000±	Unweathered Moina sandstone

The seismic cross-section of the tunnel-line traverse and cross traverses are shown in Plates 2 to 6.

At the western end of Traverse M (Plate 2) a bed in which the velocity is 12,500 ft/sec is located underneath a bed of weathered rock in which the seismic velocity is 7000 ft/sec. Near Station M52 the bed of weathered rock becomes thin. A deeper refractor (seismic velocity 15,000 ft/sec) has been recorded below a 10,500 to 11,500-ft/sec layer between Stations M31 and M45.

Farther east between Stations M71 and M157 (Plates 2, 3, and 4) an intermediate layer of 9000 to 13,000-ft/sec velocity was recorded between the 7000-ft/sec weathered surface layer and the deepest refractor, in which the velocity is between 14,000 and 17,000-ft/sec in this zone.

The logs of drill holes DDH 4558 and 4559 (see Plate 3) show Tertiary sands and clays sandwiched between the volcanic breccia and agglomerate and the Moina Formation. Seismic velocities in the Tertiary sands and clays are expected to be lower than in the volcanic breccia and agglomerate (9000 - 13,000-ft/sec at Wilmot). This velocity reversal prevents an accurate depth determination of the deepest refractor, the Moina sandstone and quartzite. Therefore, average velocities were computed on the basis of two alternative hypotheses. Seismic profiles A and B were calculated using these average velocities and are plotted in Plates 3 and 4. The true depth should be between those two extreme indications.

Profile A was obtained by assuming that the boundary located in DDH 4559 at the depth of 140 ft is the top of the 16,000-ft/sec refractor. The average velocity above the refractor was obtained by dividing 140 ft by the time-depth from seismic results. The depth to the refractor was then calculated using this value.

Profile B was calculated by assuming that no velocity reversal occurs, i.e. the refractor in which the intermediate velocity was recorded (on seismic spreads with 50-ft geophone spacing) extends downwards to the deepest refractor (recorded with 100-ft geophone spacing).

Between M71 and M99 Profile B is about 40 ft deeper than Profile A. Generally the difference is less than 20 ft between Stations M99 and M131, indicating that Tertiary clays and sand are thinner or perhaps non-existent.

On the seismic cross-section between M131 and M156 (Plates 3 and 4) the velocity in the intermediate layer is 8500-ft/sec and only Profile B was computed and plotted.

East of Station M157 to the end of the surveyed traverse (M182 in Plate 4) the 8500-ft/sec layer is no longer observed. The seismic velocity of 11,000 to 14,000 ft/sec in the bedrock is interpreted as belonging to the Moina Formation. A low seismic velocity of 7000-ft/sec in bedrock between Stations M165 and M167 may represent a shear zone.

On Traverses A, B, C, and D (Plates 5 and 6) the layer of volcanic breccia and agglomerate was recorded with short shot-distances. With long shot-distances the deepest refractor was recorded in which the seismic velocities are 11,000 to 17,500 ft/sec, representing Moina Formation.

5. CONCLUSIONS

Between Station M1 and M71, M111 and about M165, and M167 and M181, the tunnel will probably be in the Moina Formation, represented by good-quality rock in which the velocity is 12,000 to 17,500 ft/sec.

Between Stations M70 and M108 the proposed tunnel is close to, or in, the intermediate layer above the deepest refractor, indicating that Tertiary clays and sands may be met during tunnelling operations because these were found underneath the volcanic breccia and agglomerate in drill holes 4558 and 4559.

A shear zone is indicated between M165 and M167, but it may not be vertically below these stations at the tunnel level.

Additional drill holes on the tunnel line are recommended between M69 and M111 to check the extent of the sand and clay beneath the volcanic breccia and agglomerate.

6. REFERENCES

BARTHELMES, A.J.	1946	Application of continuous profiling to refraction shooting. Geophysics 11 (1), 24-42.
HEILAND, C.A.	1946	GEOPHYSICAL PROSPECTING. New York, Prentice Hall Inc.
POLAK, E.J.	1962	Wilmot Power Development geophysical survey, Tasmania 1961. Bur. Min. Resour. Aust. Rec. 1962/96 (unpubl.)
POLAK, E.J. and MOSS, F.J.	1959	Geophysical survey at the Cluny dam site, Derwent River, Tasmania. Bur. Min. Resour. Aust. Rec. 1959/87 (unpubl.)

PLATE I

CONTROL DATA

HORIZONTAL:

State Triangulation

VERTICAL

Standard level datum

Lands and Survey BM L30 S.L. 18·141

Reference: BM 2574 S.L. 1569·59

Compiled from aerial photographs

Photograph Nos T 364 / 14 to 19, Run 1

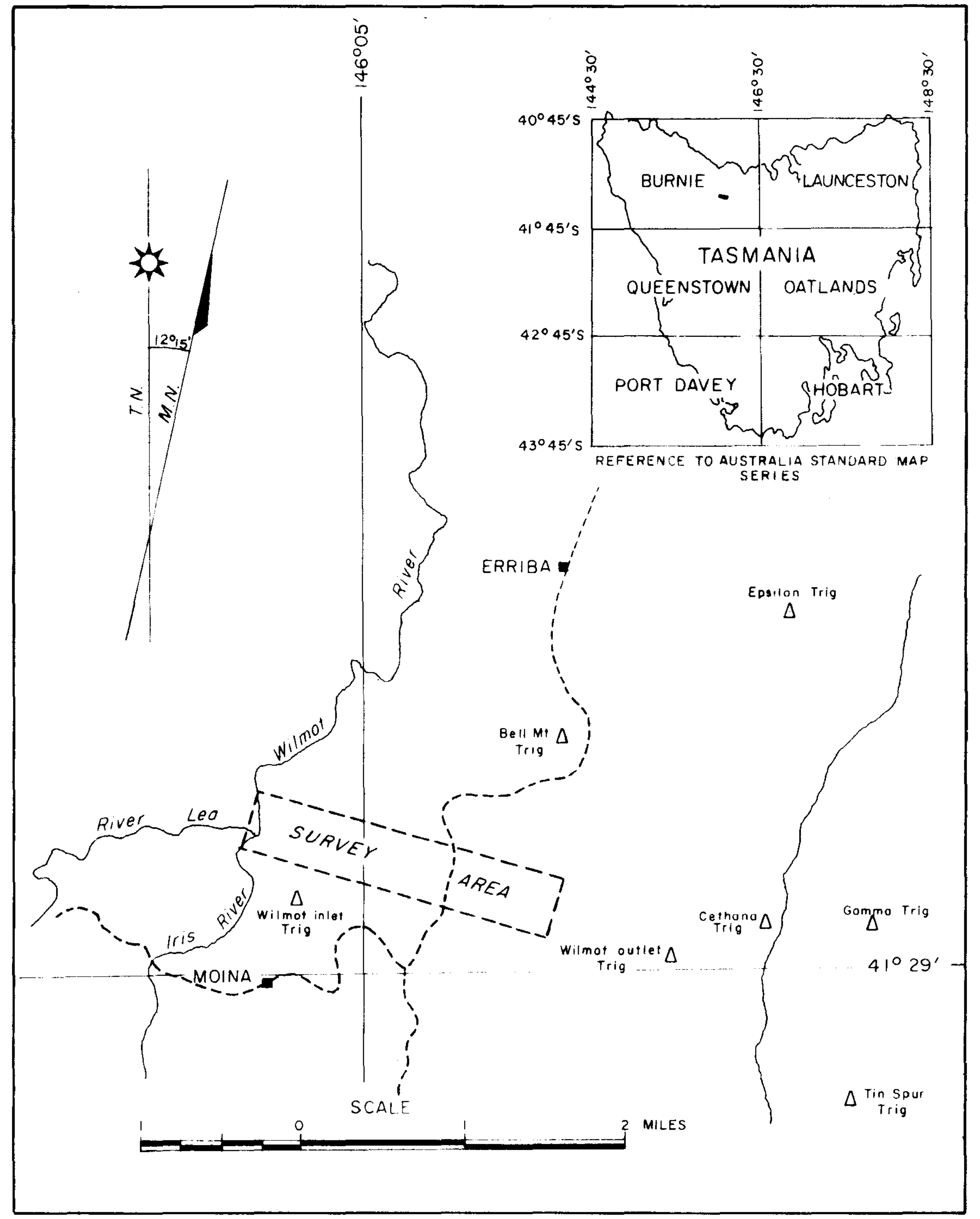
STATION	CO-ORDINATES				LEVEL
	EAST	EAST	NORTH	NORTH	
	K YARDS	FEET	K YARDS	FEET	
BM 2574	406	1901·8	892	2722·6	1569·59
BM 3268	406	1550·2	892	2104·7	1480·652
BM 3269	406	1481·1	892	2654·1	1572·36
BM 3270	406	1703·6	892	2318·0	1475·119
BM 3272	406	1709·3	892	2688·7	1472·973
BM 3273	406	1637·0	893	0454·8	1490·62
BM 3274	406	1329·2	892	2603·6	1512·49
BM 3276	406	1652·5	892	2991·1	1469·43
BM 3729					1893·379

LEGEND

DH — Drill hole

BM — Bench mark

M126 — Geophysical traverse with station number



MERSEY-FORTH-WILMOT INVESTIGATIONS

WILMOT DAM SITE ENVIRONS

TRAVERSE PLAN AND LOCALITY MAP

TO ACCOMPANY RECORD No 1964/101 Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics K55/B5-62

WILMOT - MERSEY FORTH AREA, TASMANIA 1963

PLATE 2

LEGEND

(14,000) Seismic velocity (ft/sec) in formation

—8' Depth to formation with different seismic velocity

Unweathered bedrock boundary

Interpolated unweathered bedrock boundary

FEET

100 50 0 100 200 300 400

(Horizontal and Vertical)

STATION NUMBER	WT1	M1				M5					M10				
STATION ELEVATION	1532	1555	1581	1606	1629	1652	1676	1701	1724	1743	1754	1774	1784	1789	1785
DEPTH TO DEEPEST REFRACTOR	00	7	15	23	54	61	75	44	67	58	64	75	78	100	116

STATION NUMBER	M15					M20					M25				
STATION ELEVATION	1779	1776	1772	1769	1767	1764	1768	1774	1784	1794	1804	1811	1814	1816	1817
DEPTH TO DEEPEST REFRACTOR	90	75	83	84	85	55	60	67	57	56	63	48	76	59	71

STATION NUMBER	M30					M35					M40				
STATION ELEVATION	1815	1813	1807	1802	1795	1789	1786	1782	1782	1783	1784	1787	1790	1794	1796
DEPTH TO DEEPEST REFRACTOR	65	52	59	78	75	73	83	97	70	75	68	64	64	83	64

STATION NUMBER	M45					M50					M55				
STATION ELEVATION	1799	1799	1794	1788	1782	1781	1783	1789	1794	1797	1802	1808	1808	1811	1811
DEPTH TO DEEPEST REFRACTOR	84	110	90	77			(93)	(86)	(81)	(68)	(64)	(96)	(88)	(85)	(103)

STATION NUMBER	M60					M65					M70			M73
STATION ELEVATION	1805	1803	1792	1779	1767	1753	1741	1733	1722	1725	1717	1712	1708	1705
DEPTH TO DEEPEST REFRACTOR	(82)	(92)	(72)	(74)	(76)	(84)	(86)	(130)	(123)	(142)	(150)	(116)	(106)	(91)
DEPTH TO REFRACTOR PROFILE A												152	180	207
DEPTH TO REFRACTOR PROFILE B						130	120	115	130	158	205	249	272	291

M1 to M73

SEISMIC CROSS-SECTION

MERSEY-FORTH - WILMOT AREA, TASMANIA, 1963

TO ACCOMPANY RECORD No. 1964/101

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

K55/B5-63

STATION NUMBER	M73		M75					M80					M85					M90
STATION ELEVATION	1705	1703	1702	1702	1703	1704	1699	1702	1704	1704	1708	1711	1713	1715	1716	1720	1725	1731
DEPTH TO DEEPEST REFRACTOR	(91)	(91)	(76)	(63)	(59)	(58)	(38)	(30)	(35)	(31)	(41)	(57)	(64)	(51)	(60)	(52)	(64)	(64)
DEPTH TO PROFILE A	206		106		128		108		120		156		194		240		264	
DEPTH TO PROFILE B	292		192		206		163		178		220		282		306		320	

STATION NUMBER					M95					M100					M105			
STATION ELEVATION	1736	1742	1748	1755	1762	1768	1771	1774	1779	1784	1791	1796	1804	1809	1814	1819	1823	1828
DEPTH TO DEEPEST REFRACTOR	(64)	(38)	(59)	(41)	(43)	(38)	(34)	(41)	(43)	(39)	(31)	(14)	(28)	(18)	(14)	(20)	(46)	(58)
DEPTH TO PROFILE A	239		279		248		289		313		271		278		254		296	
DEPTH TO PROFILE B	280		348		296		337		358		271		281		262		305	

STATION NUMBER		M110					M115					M120					M125	
STATION ELEVATION	1835	1841	1848	1857	1868	1878	1885	1894	1900	1907	1915	1921	1928	1941	1950	1959	1965	1965
DEPTH TO DEEPEST REFRACTOR	(67)	(53)	(56)	(43)	(50)	(24)	(17)	(14)	(22)	(36)	(26)	(22)	(25)	(27)	(14)	(14)	(15)	(23)
DEPTH TO PROFILE A	242		206		140		147		182		216		195		134		185	
DEPTH TO PROFILE B	267		219		148		158		195		282		211		145		199	

STATION NUMBER				M130					M135					M140				M144 WT21
STATION ELEVATION	1969	1971	1973	1975	1978	1978	1977	1977	1976	1971	1964	1961	1952	1943	1937	1931	1925	1925
DEPTH TO DEEPEST REFRACTOR	(25)	(25)	(37)	(26)	(25)	(34)	(27)	(26)	(26)	(19)	(18)	(33)	(36)	(34)	(33)	(15)	(46)	(45)
DEPTH TO PROFILE A	165		142		105													
DEPTH TO PROFILE B	177		161		133		258		232		249		243		260		209	

LEGEND

(7500)	Seismic velocity (ft/sec) in formation
—8'	Depth to formation with different seismic velocity
•—•—•	Unweathered bedrock boundary
DDH	Diamond-drill hole
(20')	Depth (feet) of geological boundary from log of drill hole
A	Alluvial material
V	Volcanic breccia
C+S	Clay and sand
S+Q	Sandstone and quartzite
⊥ 252'	Depth (feet) of drill hole

FEET
100 50 0 100 200 300 400
(Horizontal and Vertical)

M73 to M144

SEISMIC CROSS-SECTION

TO ACCOMPANY RECORD No. 1964/101

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

K55/B5-64

PLATE 4

STATION NUMBER	WT21 M145					M150					M155			
STATION ELEVATION	1919	1912	1901	1893	1883	1870	1860	1849	1841	1836	1833	1830	1826	1816
DEPTH TO DEEPEST REFRACTOR	(62)	(58)	(56)	(61)	(59)	(68)	(66)	(73)	(73)	(74)	(81)	(66)	(50)	48?
DEPTH TO PROFILE B	200		224		181		163		156		122		82	

STATION NUMBER		M160					M165					M170		
STATION ELEVATION	1811	1797	1780	1763	1745	1732	1727	1722	1715	1731	1745	1759	1780	1796
DEPTH TO DEEPEST REFRACTOR	66?	55	31	30	36	37	41	39	56	57	39	38	52	30
DEPTH TO PROFILE B	70													

STATION NUMBER			M175					M180					M185
STATION ELEVATION	1816	1834	1853	1872	1885	1903	1919	1936	1948	1961	1974	1987	1992
DEPTH TO DEEPEST REFRACTOR	48	52	49	36	34	36	28	26	18				
DEPTH TO PROFILE B													

M145 to M185

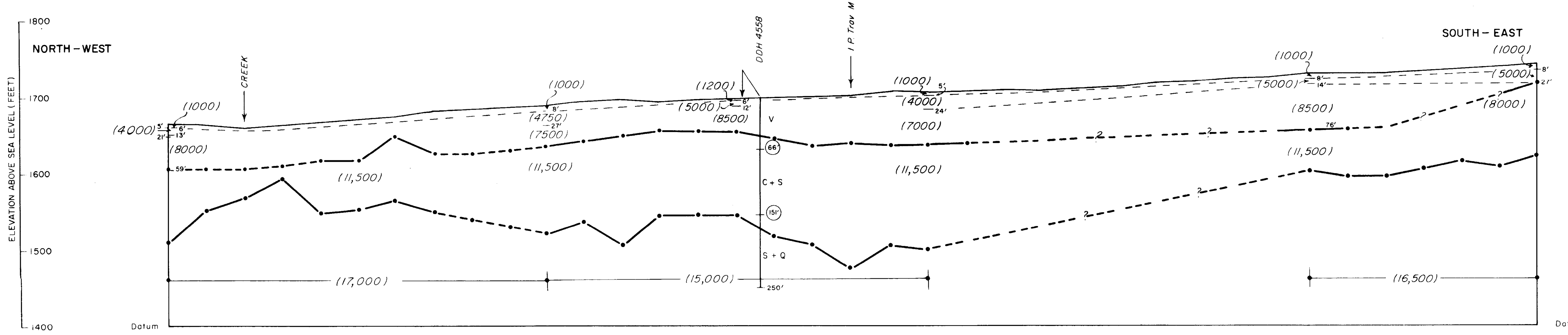
SEISMIC CROSS-SECTION

TO ACCOMPANY RECORD No. 1964/101

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

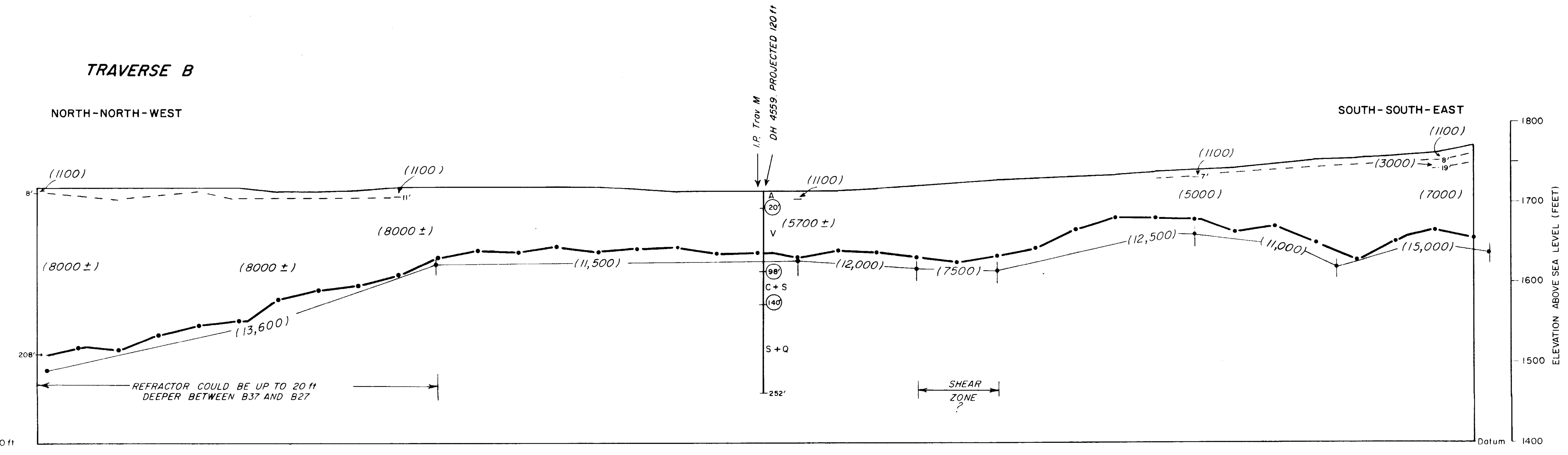
K55/B5-65

TRAVERSE A



STATION NUMBER	STATION ELEVATION	DEPTH TO SHALLOW REFRACTOR	DEPTH TO DEEPEST REFRACTOR
A 37	1662	59	156
	1662		112
A 35	1658		92
	1661		68
	1666	50	120
	1670	54	120
	1673	26	108
A 30	1681	54	132
	1683		
	1687		
	1689	57	168
	1694	55	156
A 25	1695	49	192
	1693	44	148
	1696	43	152
	1698	45	152
	1699	56	182
A 20	1700	67	196
	1702	63	228
	1706	69	200
	1705	68	204
	1708		
A 15	1708		
	1707		
	1712		
	1714		
	1718		
A 10	1721		
	1724		
	1726		
	1729	76	128
	1729		136
A 5	1730		136
	1733		132
	1735		120
	1738		128
A 1	1741		120

TRAVERSE B



STATION NUMBER	STATION ELEVATION	DEPTH TO SHALLOW REFRACTOR	DEPTH TO DEEPEST REFRACTOR
B 37	1719		208
	1718		199
B 35	1719		202
	1720		183
	1720		171
	1719		166
	1714		130
B 30	1714		120
	1715		117
	1718		108
	1719		87
	1719		80
B 25	1720		82
	1719		74
	1718		79
	1717		72
	1711		70
B 20	1712		78
	1712		74
	1713		79
	1714		72
	1715		79
B 15	1720		90
	1723		100
	1726		93
	1727		82
	1730		61
B 10	1732		53
	1735		57
	1737		60
	1739		76
	1744		76
B 5	1744		105
	1750		128
	1752		98
	1757		94
B 1	1764		118

LEGEND

(11,000)	Seismic velocity (ft/sec) in formation
—8'	Depth to formation with different seismic velocity
⊥252'	Depth (feet) of drill hole
•—•—•	Unweathered bedrock boundary
DDH	Diamond-drill hole
(20')	Depth (feet) of geological boundary from log of drill hole
A	Alluvial material
V	Volcanic breccia
C + S	Clay and sand
S + Q	Sandstone and quartzite
I.P.	Intersection point

FEET

100 0 100 200 300 400

(Horizontal and Vertical)

TRAVERSES A and B

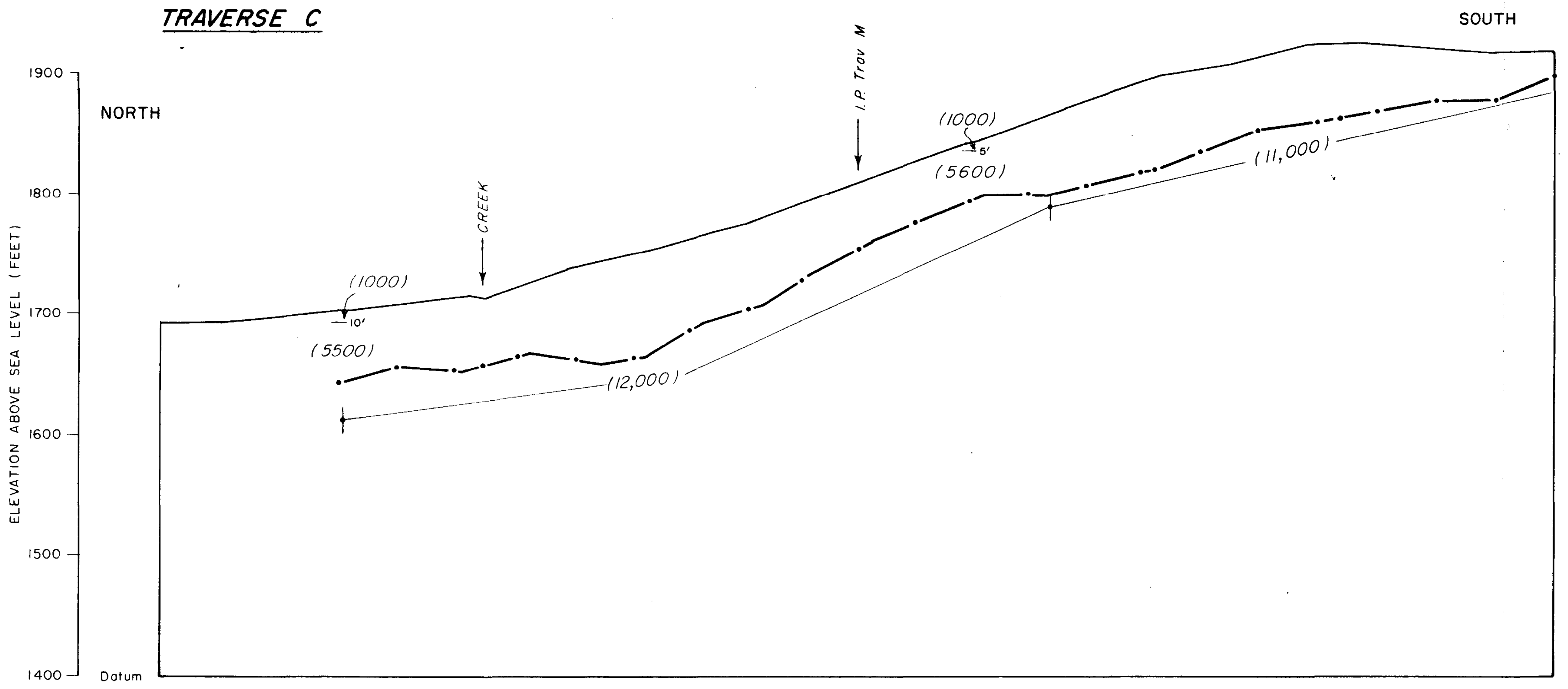
SEISMIC CROSS-SECTIONS

MERSEY FORTH - WILMOT AREA, TASMANIA, 1963

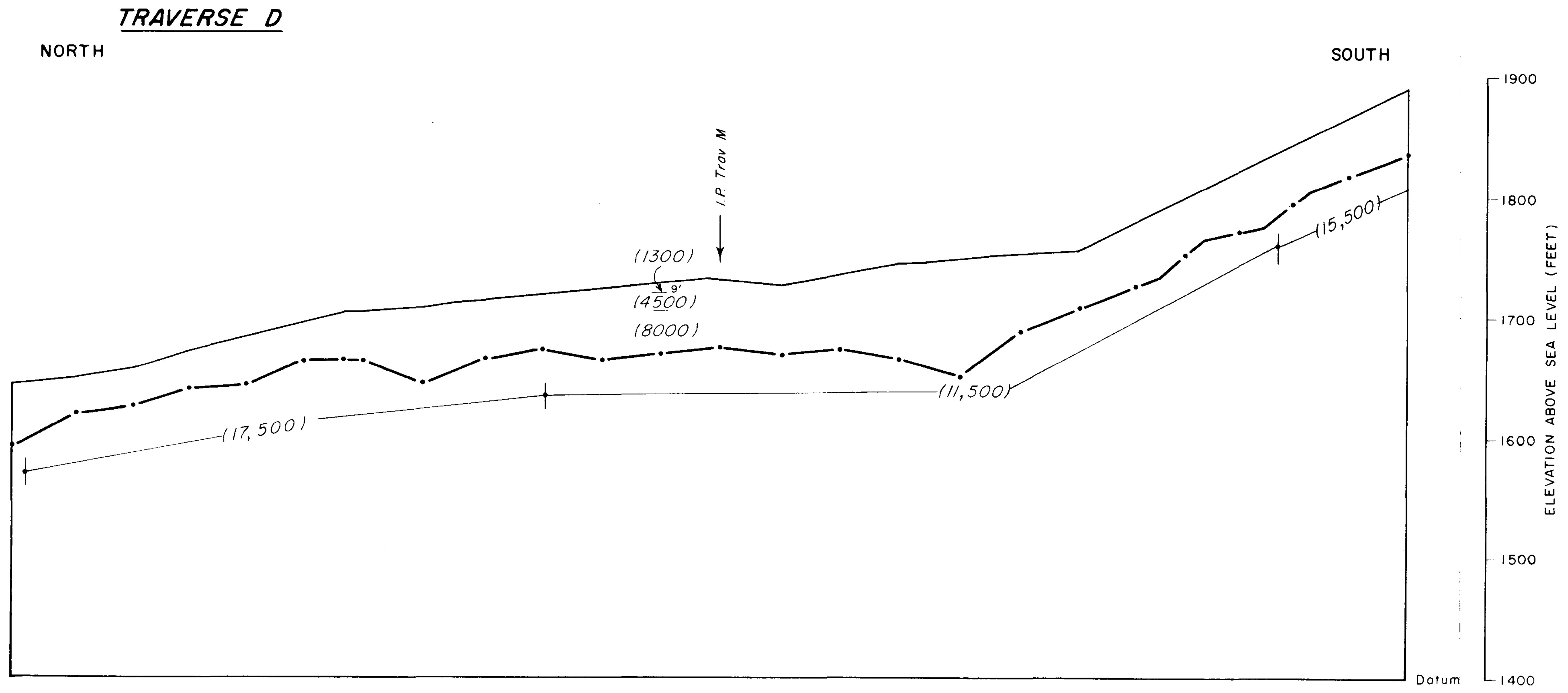
TO ACCOMPANY RECORD No. 1964/101

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

PLATE 6



STATION NUMBER	STATION ELEVATION	DEPTH TO DEEPEST REFRACTOR
C28	1694	
	1694	
	1699	
C25	1703	60
	1711	51
	1718	
	1718	65
	1724	54
C20	1742	83
	1753	85
	1765	70
	1776	66
	1797	57
C15	1812	48
	1830	48
	1847	44
	1863	62
	1882	69
C10	1898	76
	1903	65
	1910	59
	1922	71
C5	1929	
	1930	63
	1931	55
	1926	42
	1923	38
C1	1923	18



STATION NUMBER	STATION ELEVATION	DEPTH TO DEEPEST REFRACTOR
D26	1652	52
D25	1658	28
	1667	32
	1682	32
	1693	42
	1706	30
D20	1714	
	1714	40
	1720	66
	1724	48
	1728	46
D15	1733	58
	1739	60
	1740	54
	1738	58
	1745	61
D10	1755	80
	1757	100
	1761	62
	1765	46
	1790	52
D5	1811	38
	1832	52
	1854	42
	1877	50
D1	1898	50

LEGEND

- Unweathered bedrock boundary
- (11,500) Seismic velocity (ft/sec) in formation
- I.P. Intersection point

FEET
100 50 0 100 200 300 400
(Horizontal and Vertical)

TRAVERSES C and D

SEISMIC CROSS-SECTION

MERSEY FORTH - WILMOT, TASMANIA, 1963

TO ACCOMPANY RECORD No. 1964/101

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics K55/B5 - 61