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Bell Bay Railway — Seismic refraction interpretation

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Introduction

A limited amount of seismic refraction work was undertaken along the proposed route of the Bell Bay railway line by Compagnie Generale de Geophysique (CGG) in August 1971. Under a contract to Maunsell and Partners, consulting engineers, CGG was to provide records suitable for interpretation by representatives of the engineering consultants and by the Department of Mines as an external agency.

Copies of records transmitted to the Department of Mines have been interpreted as detailed below. The interpretations are not presented in graphical form as any such plot would be meaningless without a reliable surface shape (see special comments below). The table provides the detail of layer thicknesses required.

Note: All units are metric; depth in metres, velocity in metres/second.

Interpretation — General

The following comments made with reference to each spread are expressed in general terms as this interpreter is not aware of the exact location of many of the spreads or of the detailed logging of associated drill cores, as these have not been inspected in detail. Mr W. Peck of Maunsell and Partners has supplied a brief log of cores. The problems of correlation of drill cores and seismic surveys was discussed by Leaman (1973).

The locality maps supplied by the consulting engineers were found to be a quite inadequate aid to the location of the spreads. While not essential to the interpretation it is useful knowledge. These maps should show a conventional State grid system, or if some other it should be defined on the map, and all necessary identifying features such as power lines and roads should be shown. The random orientation of print is disturbing and these maps are a poor example of engineering drafting.

In the following discussion L1, for example, refers to the first layer.

Spread 3

L1 — Fractured and weathered dolerite. Deep weathering.

L2 — Massive and fresh dolerite. Non-rippable, explosives only means of excavation.

Spread 3A

L1 — Fractured and weathered dolerite. It is possible that this material is dolerite talus (comment applies to spread 3 also).

L2 — Fractured and weathered dolerite. Junction L1 to L2 transitional at the south end. Non-rippable without some use of explosives.

Spread 7

L1 — Soil and talus.

L2 — Deeply weathered dolerite.

L3 — Fresh, relatively massive dolerite.

Compare with locality 10 (Leaman, 1973).

Spread 8

Insufficient information to give a reliable interpretation. Two conflicting interpretations are possible, one as presented in the interpretation table and another which would imply D2 is approximately 20 metres.

L1 — Soil and talus.

L2 — Deeply weathered dolerite.

L3 — Jointed, non-rippable dolerite.

Spread 9

Generally inadequate information. Centre shot an absolute necessity in such spreads. As was the case with spread 8 more than one interpretation is possible.

L1 — Soil and talus.

L2 — Deeply weathered dolerite.

L3 — Fresh, massive dolerite.

The supplied log of borehole 614 (situated about the centre of spreads 8 and 9) would suggest six metres of clay and a further six metres of dolerite boulders and weathered dolerite. The interpretation of spreads 8 and 9 would imply far more material of poor quality than has been drilled. The variability of L3 velocity suggests that the dolerite is strongly jointed in an east–west direction. The variation in D1 estimates (although based on very little data) implies deep and erratic surface weathering which may well be channelled. There are insufficient spreads in this region to establish the whole structure. An additional problem here is the non-orthogonal nature of spread 9 to the alignment as along-line components of velocity are detected as well.

Spread 10

L1 — Soil and talus.

L2 — Deeply weathered dolerite.

L3 — Relatively fresh but jointed dolerite.

Spread 11

L1 — Soil and talus.

L2 — Jointed and weathered dolerite with limited rippability.

L3 — Massive unweathered dolerite.

The records are difficult to interpret due to inadequate shot extensions and heterogeneous materials. The interface between L1 and L2 appears to parallel the surface but that between L2 and L3 slopes upward from north to south. There is a distinct velocity change at geophone 7 on all records which suggests the presence of a vertical discontinuity. The material north of geophone 7, while showing the same profile, is condensed. A centre shot would have been crucial to the solution of this spread.

Spread 13

This spread presented many difficulties in interpretation. As there is a vertical discontinuity present beneath geophone 7 and the profile contains only two layers south of this, but three layers north of it, double columns are given in the table. The step in high velocity material (Dl to the south, D2 to the north) is apparent. The reliability of this interpretation is unknown as the critical centre shot was omitted, there is no cross shot, and no surface levelling. As this spread straddled a hill spur, as indicated in the operator's sketch, topographic factors could be significant.

South end L1 — Soil.

South end L2 — Relatively fresh but fractured dolerite.

North end L1 — Soil and talus.

North end L2 — Weathered dolerite (rippable).

North end L3 — Relatively fresh but fractured dolerite.

Spread 14

L1 — Soil and surface fragments.

L2 — Very deeply weathered dolerite or Tertiary sediment (sand and clay). Compare with locality 1 (Leaman, 1973).

L3 — Relatively fresh but fractured dolerite. The transition from L2 to L3 is very abrupt.

Spread 15

A centre shot would have been useful. This is a cross spread to spread 14. Layers as for spread 14. The very much higher velocity of L3 suggests that the dolerite in this region has a strong joint anisotropy. The implication is that east–west jointing is either more frequent or more weathered than north–south jointing. In view of the high velocity (7,000 m/sec) it would appear that the former is the case.

Spread 16

Comments as for spread 14.

Spread 17

L1 — Soil and talus.

L2 — Slightly weathered and fractured dolerite.

L3 — Relatively fresh but jointed dolerite. It is unlikely that any part of L2 or L3 would be rippable without prior use of explosives.

Spread 18

As for spread 17.

Spread 22

L1 — Soil and talus.

L2 — Fractured dolerite, with massive dolerite blocks separated by marked zones of weathering (compare with locality 9, Leaman, 1973).

Spread 23

As for spread 22. Anisotropy of fracturing and weathering is implied by the range of velocities in L2, and north–south jointing is presumed to predominate.

Spread 24

In the depth table this spread has been divided into two parts. Although covered by the most detailed shooting the area covered by spreads 24 and 25 is complicated by many variations in the dolerite present. A significant vertical discontinuity is present in the region of geophone 19 (7 of 24b). Five distinct layers are apparent in the time distance graphs for spread 24 and all but one velocity appears in spread 25.

L1 — Soil and surface fragments. This material appears to be discontinuous across the surface, especially in 24a.

L2 — Possibly deeply weathered dolerite and (or) clay. See spread 25.

L3 — Less deeply weathered and rippable dolerite.

L4 — Relatively fresh but jointed dolerite.

L5 — Massive and fresh dolerite.

There is generally an abrupt change from L4 to L5 and the depth to massive rock is some 20+ metres. However the jointed and relatively solid (probably non-rippable) dolerite occurs at about 10–15 metres generally.

Spread 25

Cross spread — L1, L2, L3 as for spread 24. There appears to be no equivalent for L4. The approximate depth of D3 is some 19 metres. This figure correlates reasonably with spread 24.

Spreads 24 and 25 are close to spreads 17, 18 and borehole 8. There is little similarity in results between spreads 17, 18 and 24, 25. Borehole 8 correlates well with spreads 17 and 18.

The form of the travel-time curves for spreads 24 and 23 suggests that the profile is not dolerite produced. Although the above profile is possible, a more favoured interpretation would be L1, L4 and L5 as above, but with L2 and L3 Tertiary sand and clay. A problem with this interpretation is the location of the spreads which are east of the transmission line, according to the field notes, and therefore more likely to be in dolerite. The west end of spread 25 is towards the river.

Interpretation — Detail

The tables of depths, geophones and velocities for the various spreads follow. Gaps in the figures reflect inadequate or insufficient information. Every effort has been made to extract as much information as possible and a variety of interpretation methods have been used. For estimates of rippability, rock quality and value of boreholes see Leaman (1973). Some boreholes are sited on seismic spreads and the drilling results are directly useful. Where the borehole is more than 20 to 30 m from the spread its value is strictly limited for correlation purposes due to rock variability.

All geophone spacings were at 7.6 m.

Spread no.	*3*	*3A*	*7*		*8*		*9*		*10*	
Geophone no.	*D1*	*D1*	*D1*	*D2*	*D1*	*D2*	*D1*	*D2*	*D1*	*D2*
Depth (m)										
1	4.3	3.0	1.5	12.8	0.8				1.5	22.5
2	2.4	4.9					13.4			23.5
3	1.2	4.9		10.0	(2.4)					18.3
4	1.8	6.7		10.0						19.5
5	3.6	5.5		11.9	(4.8)					17.0
6	4.3	3.0		8.5		39.6			1.0	20.4
7	3.0	3.6		15.2	(7.2)	39.3		33.5		19.2
8	5.5					40.1		33.5		14.3
9	5.5	4.9		14.6	(10.0)	41.1				14.3
10	3.0	2.4		13.7		42.1	12.5			15.5
11	2.4	3.6		15.2						17.7
12	5.5	2.4	1.5	10.0	11.0				0.7	15.2
						±25%		±25%		
Velocity (averages):										
Layer 1:	1220	1220	610		670		760		670	
Layer 2:	5200	3700	1680		1220		1380		1130	
Layer 3:			4900		3000+		7000		4250	
Direction:										
Geophone 1	north	north	north		east		north		west	

D1 = depth to base layer 1 in metres.
Velocity in metres/second.
Bracketed numbers are inferred.

Comments

Spread 8 is along the alignment while spread 9 is acute. Junction of the two spreads approximates borehole 614.
Geophone 7 (9) corresponds to geophone 6 (8).
Note normal limit of rippability is at 2750 m/sec.

Spread no.	*11*		*13*			*14*		*15*	
Geophone no.	*D1*	*D2*	*D1*	*D1*	*D2*	*D1*	*D2*	*D1*	*D2*
Depth (m)									
1	3.9		2.1			2.4		2.3	17.0
2			1.5						17.0
3			3.0						19.2
4			2.4			2.4	22.5		21.6
5			3.3			2.4	23.1		
6			2.1			2.5	20.7		
7		22.9	3.0			2.4	18.6		19.2
8		20.4		(1.8)	20.2	2.4	18.6		22.9
9					16.8		14.6		21.9
10				(1.8)	16.8		12.5		23.1
11							11.6		21.9
12	4.1			1.8		2.4	10.7	2.3	
		±25%							
Velocity (averages):									
Layer 1:	900		440	850		450		520	
Layer 2:	2290		3750	1500		1000		1520	
Layer 3:	7000			3750		3900		7000	
Direction:									
Geophone 1	north		south			south		east	

Comments

Geophone 12 of spreads 14 and 16 are separated by 11.4 m.
Geophone 3 of spread 15 is approximately coincident with geophone 9 of spread 14.
Note: D1 = depth to base of layer 1 in metres.

Spread no.	*16*		*17*		*18*		*22*	*23*
Geophone no.	*D1*	*D2*	*D1*	*D2*	*D1*	*D2*	*D1*	*D1*
Depth (m)								
1	1.7-		3.0	19.5	2.0	18.6	2.4	4.6
2		22.2		23.2		18.6	3.0	6.4
3		21.3		19.2		18.6	3.0	6.4
4		20.4		13.7		17.4	3.0	4.6
5		19.5		13.7		14.3	3.0	1.8
6	2.5	15.8		19.2		15.8	3.6	2.7
7		15.8		22.9		15.8	3.6	3.6
8		16.1		22.5		14.6	3.0	6.4
9		16.1		26.2		14.6	3.6	
10		16.1		15.2		11.9	1.8	
11		16.5		15.2		9.7	2.4	
12	3.2	16.8	2.5	13.4	3.5	10.7	2.4	6.4
Velocity (averages):								
Layer 1:	700		760		900		790	760
Layer 2:	1125		3050		2750		5500	2200
Layer 3	4250		4700		4500			
Direction:								
Geophone 1	north		east		west		south	west

Comment

Geophone 1 of spreads 17 and 18 is common.
Spread 23 is perpendicular to spread 22, crossing point geophone 6 (23) and geophone 11 (22).
D1 = depth to base layer 1 in metres.

Spread no.	*24a*				*24b*				*25*		
Geophone no.	*D1*	*D2*	*D3*	*D4*	*D1*	*D2*	*D3*	*D4*	*D1*	*D2*	*D3*
Depth (m)											
1	0.0	2.1	6.7		1.7		8.7	36.5	0.0	1.2	
2					1.0			24.4			
3			9.7		2.3			18.3			
4		(3.0)	15.2		1.7			19.8			
5			16.7		3.0			16.8			
6			18.9		3.0			16.8			
7		(4.0)	23.5		1.3		16.0	22.9			19.0
8				28.0	1.6		16.4				19.0
9	(1.0)				3.0						20.0
10					3.3						
11		5.5			4.0	11.0				3.4	
12	1.3				3.0				2.4		
				±15%				±20%			
Velocity (averages):											
Layer 1:	760				760				600		
Layer 2:	1050				1050				1050		
Layer 3:	1525				1525				1525		
Layer 4:	3000				3000				6000+		
Layer 5:	6000+				6000+						
Direction:											
Geophone 1	north				north				west		

Comments

Geophone 2/3 (spread 25) is the approximate position of geophone 16/17 (spread 24). Spreads 24, 25 are perpendicular.
Geophone 1, spread 24b is geophone 13 spread 24a. Spreads 24a + 24b are one spread.
D1 = depth to base layer 1 in metres.

Conclusions

Several serious problems have arisen in regard to this survey and its interpretation which limit its value. The equipment used for the survey was not wholly suitable and the records in several cases leave much to be desired. Much of the lack of clarity in the records is due to shallow shot depths and over-sensitive equipment. The survey itself was poorly planned and the separation and lack of correlation between spreads has inhibited the production of a reliable interpretation in several cases. Most of the technical inadequacies of the survey have been caused by lack of proper instruction to CGG prior to the survey, by the limited funds made available and the patchy coverage undertaken. Overall, CGG produced acceptable results limited in value by deficiencies beyond their control. The major deficiency in this survey is its partial non-applicability to the alignment due to design shifts. Due to the variability of dolerite a 15 m shift may be sufficient to render drilling or geophysical interpretations invalid. In some spreads, for example spreads 9, 13, 15, 18 and 24, geophone positions and shot points should have been levelled in order to provide a wholly reliable and useful interpretation.

This type of survey should not be undertaken until the route is finalised and pegged. As a result of the above deficiencies full responsibility cannot be accepted for the implications of the somewhat limited interpretation presented. When the alignment is fixed, further work is recommended if reasonable estimates are to be expected. It should not be assumed that adjacent cuttings will contain similar materials.

Reference

LEAMAN, D. E. 1973. The engineering properties of Tasmanian dolerite, with particular reference to the route of the Bell Bay Railway. *Technical Reports Department of Mines Tasmania* 16:148–163

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