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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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SCANNED

RECORD No. 1962/66

BARRINGTON (DEVILS GATE) DAM AND POWER STATION SITE

SEISMIC REFRACTION SURVEY, TASMANIA 1961

BARRINGTON (DEVIL'S GATE) DAM & PR. STN. SITE

by

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E.J. Polak

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CONTENTS

		Page
	SUMMARY	
1.	INTRODUCTION	1
2.	GEOLOGY	1
3.	METHODS AND EQUIPMENT	1
4.	RESULTS, DAM SITE	3
5.	RESULTS, POWER STATION SITE	4
6.	CONCLUSIONS	4
7.	REFERENCES	5

ILLUSTRATIONS

Plate 1. Traverse layout, geology, and dynamic properties of rocks (Drawing No. G394-1)

Plate 2. Seismic cross-sections, power station site (G394-2)

SUMMARY

This Record describes a seismic refraction survey, on the site of the Barrington (Devils Gate) dam and power station, made for the Hydro-Electric Commission of Tasmania.

The survey showed that the overburden consists of a layer with a seismic velocity of 4000 ft/sec, representing very weathered rock with open dry joints, covered by a thin layer of soil. The bedrock consists of Precambrian chert with a velocity between 7000 and 12,000 ft/sec. The value of Young's modulus for the bedrock ranges between 1.2×10^6 and 3.5×10^6 lb/in^2.

1. INTRODUCTION

The Hydro-Electric Commission of Tasmania proposes to erect a power station on the Forth River near Barrington. A dam will be constructed in a narrow gorge, Devils Gate, about 12 miles south of Devonport. The approximate co-ordinates are 426908 on the Burnie sheet of the Australia 4-mile series.

The geology of the area was mapped by Paterson (1959). In addition, several holes were drilled, two adits were driven, and a static determination of Young's modulus was made in the adits. The Commission requested the Bureau of Mineral Resources, Geology and Geophysics to assist with the investigation, the main problem being the determination of the elastic properties of the foundation rock on the dam site and the depth to bedrock on the power station site.

A geophysical survey was done between 13th and 15th March 1961, by a party consisting of E.J. Polak (party leader), D.J. Harwood (geophysicist), and J.P. Pigott (geophysical assistant). The Commission provided additional assistants and did the topographical surveying.

2. GEOLOGY

Devils Gate is a gorge of the Forth River, where the river flows through a low plateau originally covered by basalt. In the surveyed area (Plate 1) the basalt has been eroded away. The rock is chert of ~~Precambrian~~ Cambrian age, strongly deformed by a series of wrench faults with northerly strike. Two sets of joints are recognized: the older, quartz-filled joints ~~with a north-north-westerly strike~~, and the open younger joints ~~with west-south-westerly strike~~. The latter joint system controls the course of the Forth River through the gorge. ~~The beds, with undetermined strike, dip between 70 and 90 degrees (Paterson, 1959).~~

Above statement not in accordance with report 644-172-1 [illegible]

3. METHODS AND EQUIPMENT

The seismic method of exploration depends on the contrast between the velocities of the seismic waves as they pass through different rock formations. Hard unweathered rocks have higher velocities than their weathered counterparts, and these in turn have higher velocities than soil and unconsolidated deposits. A detailed description of the method has been given by Polak and Moss (1959).

To determine the dynamic properties of the rock the velocities of the longitudinal and transverse waves were measured. A three-component geophone was placed on rock outcrops or on solid rock in the adit. Shots were fired at several distances and on different azimuths from the geophone. From these velocities the dynamic properties of the rocks were calculated (Polak and Moss, op. cit.)

The 'method of differences' was used for calculation of the depth to bedrock on the power-station site (Heiland, 1946; p. 548).

The equipment used in these surveys was a Midwestern 12-channel reflection/refraction seismograph with TIC vertical geophones of natural frequency about 20 c/s to record longitudinal waves and a TIC three-component geophone to record longitudinal and transverse waves.

TABLE 1

(1) Shot No.	(2) Position of geophone (see Plate 1)	(3) Position of shot	(4) Apparent velocity		(5) Phase velocity		(6) Poisson's ratio (App. vel.)	(7) Poisson's ratio (Phase vel.)	(8) Young's modulus ($\times 10^6$ lb/in^2) (App. vel.)	(9) Young's modulus ($\times 10^6$ lb/in^2) (Phase vel.)
			Longit.	Transv.	Longit.	Transv.				
1	A : outcrops near DH5554	50 ft down stream	7200	3800			0.24		1.5	
					10,400	6400		0.22		3.4
2	" "	100 ft down stream	8400	4800			0.25		2.1	
					12,000	7000		0.24		4.3
3	" "	150 ft down stream	9300	5400			0.25		2.6	
4	" "	50 ft up stream	8400	5000			0.23		2.1	
5	" "	In river, 110 ft from A	7800	4600			0.24		1.8	
6	B : outcrop near DH5562	100 ft up stream	9100	5300			0.23		2.5	
7	" "	50 ft down stream	8400	4600			0.26		2.1	
8	C : near left bank adit	50 ft down stream	7200	4200			0.24		1.5	
9	" "	100 ft down stream	8400	4800			0.26		2.1	
10	" "	150 ft down stream	10,600	6300			0.24		3.5	
11	D : 35 ft in left bank adit	On the track	6400	3500			0.28		1.2	
					15,500	9300		0.24		7.7
12	E : 60 ft in left bank adit	On the track	8600	4700			0.27		2.3	
					5300	3000		0.27		0.8
13	F : 110 ft in left bank adit	On the track	6800	3700			0.29		1.2	
14	F: "	200 ft down stream along the track	10,800	5900			0.28		3.3	

NOTE: Adit crosses major fault between E and F.

4. RESULTS, DAM SITE

Plate 1 shows the location of shots and geophones. Table 1 column 2 describes the location on Plate 1, columns 4 and 5 give the measurements of seismic velocity, columns 6 and 7 Poisson's ratio computed from columns 4 and 5, and column 8 and 9 give dynamical determinations of Young's modulus, computed from columns 4 to 7. Values of Young's modulus and Poisson's ratio are also shown on Plate 1.

In the computation of the apparent velocities (Table 1, Column 4) the distance between the shot and the geophone is divided by the time taken by the pulse to travel the distance. Hence, the apparent velocity is lower than the true velocity ('phase velocity') of the refractor because the path of the seismic pulse through the weathered layer is included in the computation. However, with thin weathered layers and long shot distances, as in the present survey, the errors in the computed values are expected to be small. Column 5 gives some phase velocities; these were computed where the shot locations were in line and at various distances from the recording 3-component geophone.

The longitudinal velocities in the bedrock are expected to be higher than the apparent velocities shown in column 2. For equal shot distances, higher apparent velocities indicate fresher, less jointed rock. The longitudinal phase velocities of column 5 range between 5300 and 15,500 ft/sec. The velocity of 5300 ft/sec was measured in an adit, across a major fault zone, and is consistent with jointed or fractured, weathered bedrock.

Longitudinal velocities of 10,000 to 12,000 ft/sec indicate moderately jointed bedrock, and velocities in excess of 15,000 ft/sec indicate unjointed fresh rock, or rock in which the joints are closed and cemented.

It is expected that the velocities in a direction across the open rock joints (which have west-south-westerly strike) are generally lower than the velocities parallel to these joints. This is illustrated by the observations close to geophone position A (Table 1, Shot Nos. 2 to 6).

In Table 1, columns 6 and 7 show that Poisson's ratio computed from apparent and phase velocities has values in the range of 0.25 $\pm$ 0.04.

Young's modulus from apparent velocities ranges between 1.2×10^6 lb/in^2 (column 8, Shot No. 13, apparent longitudinal velocity 6800 ft/sec) and 3.5×10^6 lb/in^2 (column 6, Shot No. 10, apparent longitudinal velocity 10,000 ft/sec). It is expected that these values of Young's modulus represent average values for bedrock. Column 9 shows that Young's modulus from phase velocities may be higher and lower than these average values from apparent velocities. Young's modulus of 0.8×10^6 lb/in^2 corresponds to a true longitudinal velocity of 5300 ft/sec for weathered rock in a shear zone; 3.4×10^6 and 4.3×10^6 lb/in^2 for moderately jointed rock whose velocity is 10,400 and 12,000 ft/sec, and 7.7×10^6 lb/in^2 for unweathered or cemented rock whose velocity is 15,500 ft/sec.

For the sake of comparison, Table 2 gives some data of measurements and results of laboratory determinations on drill hole cores, taken from Paterson (1959).

TABLE 2

Drill Hole No.	Depth of Sample (ft)	Longitudinal velocity (ft/sec)	Poisson's ratio Dynamic	Poisson's ratio Static	Young's modulus (10^6 lb/in^2) Dynamic	Young's modulus (10^6 lb/in^2) Static
5551	111	16,666	0.22		8.6	
5554	37	17,667	0.39		11.1	
5562	55	16,181	0.26		8.8	
5555	137	16,077		0.09		12.6 ± 1
5561	112	18,587		0.17		8.0

Paterson's report shows that the samples of drill holes 5555 and 5561, referred to in Table 2, showed compressive strengths of 15,200 and 3460 lb/in^2 respectively in a standard compression test. The low compressive strength of 3460 lb/in^2 is associated with a dense, fractured rock cemented by quartz veins. A 'jack test' with a hydraulic jack in the adit, near location D (Plate 1), gave values of Young's modulus ranging between 1.0×10^6 and 2.4×10^6 lb/in^2.

5. RESULTS, POWER STATION SITE

Plate 1 shows the traverse plan, and Plate 2 the results in the form of cross-sections.

The 'overburden' consists of a layer with a seismic velocity of 4000 ft/sec, representing very weathered rock with open, dry joints, covered by a thin layer of soil.

The bedrock consists of ~~Pre~~Cambrian chert with velocities ranging between 7000 and 12,000 ft/sec. The zone with lower velocities, representing bedrock with open and weathered joints, is indicated on Plate 1.

6. CONCLUSIONS

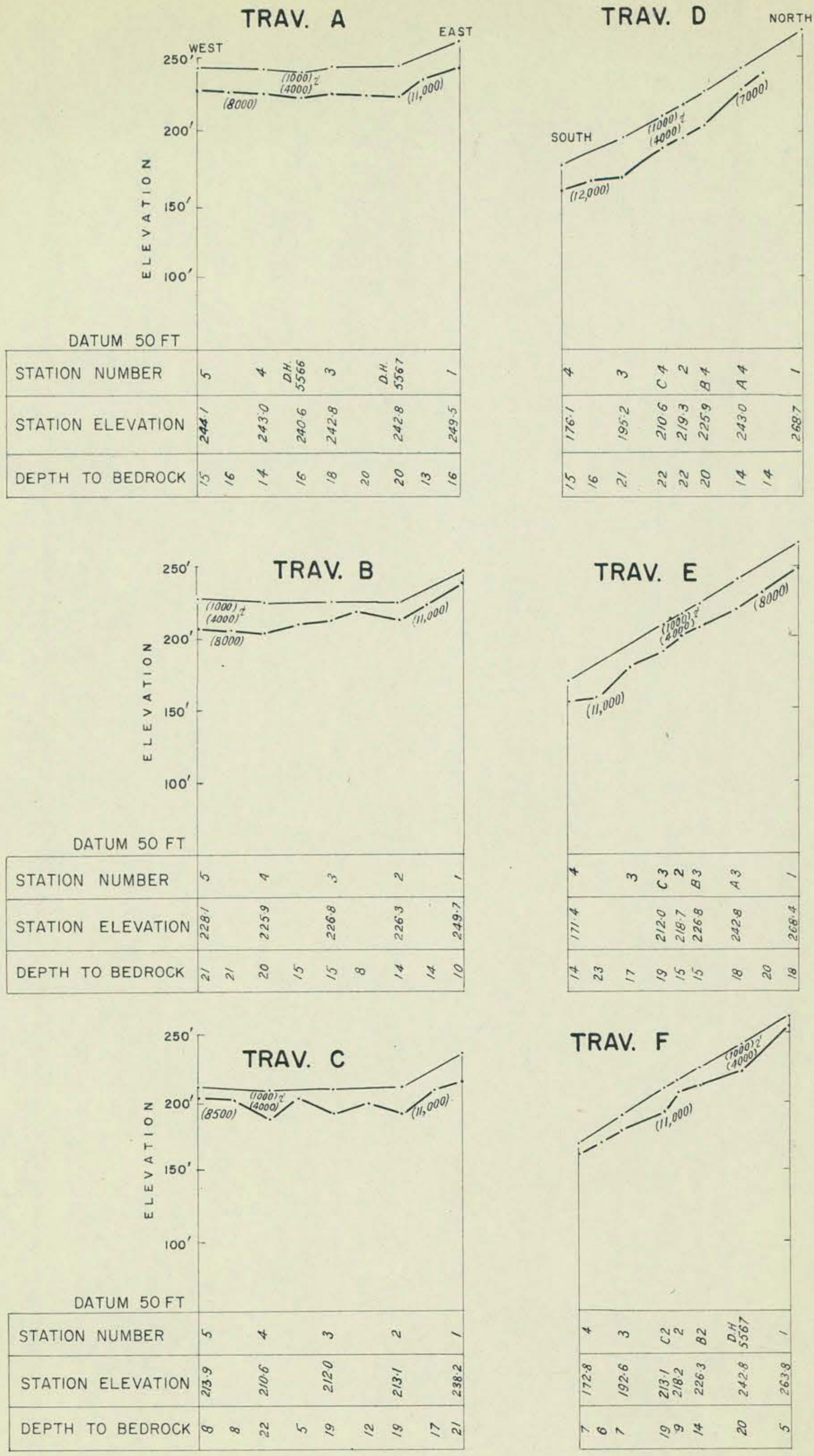
The geophysical survey provided information on the dynamic properties of rock on the dam site. The thickness of the overburden and the character of both overburden and bedrock was indicated on the power station site.

On the dam site, velocities measured parallel to the open joints were greater than those measured perpendicular to this direction. Poisson's ratio was found to be 0.25 ± 0.04, and Young's modulus of bedrock measured *in situ* from apparent velocities ranged between 1.2×10^6 and 3.5×10^6 lb/in^2. These values are roughly the same as the values found in a static test in adit No. 1, but are much lower than values found in laboratory investigations.

A zone of low velocities, associated with jointed rock, was found on the power station site.

7. REFERENCES

HEILAND, C.A.	1946	GEOPHYSICAL PROSPECTING. Prentice-Hall Inc., New York.
PATERSON, S.J.	1959	Mersey-Forth-Wilmot investigations. Geological Report G.44-172-1, Hydro-Electric Commission, Hobart.
POLAK, E.J., and MOSS, F.J.	1959	Geophysical survey at the Cluny dam site, Derwent River, Tasmania. Bur. Min. Res. Aust. Rec. 1959/87.



LEGEND

(7000) Formation with velocity 7000 ft/sec

—·— Unweathered bedrock

POWER STATION SITE CROSS-SECTIONS

HORIZONTAL AND VERTICAL SCALES IN FEET

100 0 100 200

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G394-2

TO ACCOMPANY RECORD No. 1962/66

DEVILS GATE, FORTH RIVER, TAS. 1961

PLATE 1

To Accompany Record No 1962/66