COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS
1956, No.91

SEISMIC REFRACTION SURVEY AT BLACK BOB'S DAM SITE, NEAR OUSE, TASMANIA

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ABSTRACT

This report gives the results of a seismic refraction survey carried out by the Bureau of Mineral Resources for the Tasmanian Hydro-Electric Commission at the proposed site for Black Bob's Dam, which is part of the Commission's Derwent-Dee Development Scheme.

The survey disclosed the thickness of the overburden and indicated several shear zones. The following characteristic velocities in ft/sec were recorded : surface layer or soil, 1,100-2,100; gravel, 5,000±; weathered dolerite, 3,400 to 6,600; fractured or jointed dolerite, joints filled with clay, zeolites and calcite, 9,500-12,500; unweathered dolerite, slightly fractured to unfractured, 15,000-22,000.

Assuming a Poisson's ratio of 0.25 and a density of 2.7 for the 9,500 to 12,500 ft/sec layer, Young's modulus would be 2×10^{11} to 3×10^{11} dynes/cm^2 and the compressibility 0.8×10^{-11} to 0.5×10^{-11} cm^2/dyne. Such foundation rock may be considered by engineers as suitable for a dam

1. INTRODUCTION

Black Bob's Dam is part of the Derwent-Dee Power Development Scheme of the Tasmanian Hydro-Electric Commission. The proposed dam site is located in the valley of the Derwent river, 6 miles west of Ouse, (see Plate 1), and the approximate co-ordinates in relation to Tasmania's grid are N774000/E453400 yds, as shown on the Commission's photo mosaic of the Derwent-Dee Valley. The proposed dam site was selected in accordance with geological information.

The Commission asked the Bureau of Mineral Resources, Geology and Geophysics to undertake a seismic survey at the proposed site, with the object of determining the thickness and nature of the overburden and the nature of the bedrock.

The field work was done during April, 1955 by a geophysical party based at Wayatinah and consisting of D.F. Dyson (party leader) and M.J. O'Connor, geophysicists, and J.P. Pigott, field assistant.

The topographical survey was done by a survey party provided by the Hydro-Electric Commission.

It is desired to acknowledge the assistance of the staff of the Resident Engineer's office at Wayatinah.

2. GEOLOGY

No detailed geological report or plan was available from the Commission, but the following observations indicate the geological background of the problem.

In the area of the proposed dam site the bedrock consists of dolerite, which is fractured and jointed in places. The joints are filled with clay, calcite and zeolites. A layer of dolerite talus occurs along the northern side of the river and a layer of soil, with some talus occupies the southern side.

The aerial photo mosaic of the Derwent-Dee Valley shows a fracture pattern with two main trends, one easterly and one northerly, and a secondary trend 60 degrees east of north. The course of the Derwent River appears to be controlled by this fracture pattern.

At the time of the survey, 16 diamond drill holes had been put down in the area, but only a few are near enough to the seismic traverses to assist in the interpretation of the geophysical results.

In this report "bedrock" will be used to indicate unweathered dolerite and "overburden" to indicate soil, dolerite talus and weathered dolerite.

From the drilling data available, it appears that the overburden of weathered dolerite is thinnest (and in places non-existent) in the centre of the valley (i.e. in or near the river bed) and on the steeply sloping northern bank.

3. METHOD AND EQUIPMENT

The location of the dam site was fixed within a relatively small area and as the main purpose of the survey was to obtain information concerning the thickness of overburden, the seismic refraction technique was employed, using the "method of difference". Two traverses, each approximately 1,100 feet in length and three smaller cross-traverses were laid out on the northern bank. Three traverses, each approximately 1,000 feet in length and three smaller cross-traverses, were laid out on the southern bank (Plate 1). The total length of traverses surveyed was about 7,900 feet, the station interval along the traverses being 40 feet.

For normal spreads, shot distances of 20, 40 feet and about 200 feet were used. Five weathering spreads were shot with station intervals of 5 and 10 feet. It appeared later that, because of the large variations in the depth to bedrock and in the overburden velocity, the number of weathering spreads was insufficient.

The equipment used was a Century 12-channel portable seismograph, model 506.

4. RESULTS

The results are shown in the form of cross-sections on Plate 2. The thickness of the top soil is not shown. In a few places the interpretation of the seismic data is uncertain because:-

(a) The planting of geophones was often difficult because of the cover of coarse scree, and the coupling of the geophones with the ground was not always good. This caused noisy, irregular traces on the records and as a result, the velocity information in these cases was not reliable.

(b) In a valley with steeply sloping sides the nature of the overburden changes quickly from the side of the valley to the centre, causing rapid lateral changes in overburden velocity.

On traverse G-H, near station 1141 (Plate 2), the weathering shots gave velocities of 2,100 and 6,200 ft/sec. and the normal shots 12,300 and 18,000 ft/sec. for the deeper layers. To compute the depth to unweathered dolerite near station 1141, an average velocity of 11,000 ft/sec. was used.

Between stations H239 and 1184 on traverse K-L, the seismic data indicated an intermediate layer between the 4,000 and 15,000 ft/sec. layers. The velocity in this intermediate layer could not be accurately evaluated, and the depth estimates are therefore unreliable.

In cross-sections O-P, Q-R, and W-X, the lateral change in the nature of the overburden is well shown by the lateral change in the overburden velocity. Such changes render difficult the interpretation of the data.

The cross-sections show that the overburden thins out rapidly towards the centre of the valley and is probably non-existent in the river bed. It is possible that erosion is proceeding at the same rate as the weathering of the dolerite.

Shear or fault zones may be characterised by a thickening of the overburden, V-shaped bedrock profiles and lower seismic velocities in both overburden and bedrock.

Shearing in the dolerite is indicated on section A-B near station 984, on C-D near 1016 and 1020, on G-H west of 1150 and possibly between 1140 and 1142 and 1145 and 1149, on K-L west of 1188, on M-N near 1224 and on W-X between 1034 and 1039. The location of the sheared dolerite is shown by the shaded areas on Plate 1. On the northern bank both the seismic and drilling results suggest a main shear zone striking easterly and situated as shown on Plate 1.

TABLE 1

COMPARISON BETWEEN DRILLING AND GEOPHYSICAL RESULTS

Drill Hole No.	Location relative to nearest seismic station	Drilling log data	Thickness of overburden from geop. data at nearest seismic traverse (ft)	Seismic velocities (a) overburden (b) bedrock (ft/sec.)	Remarks
8604	10'N. of 980 (Traverse AB)	Broken dolerite to 9'; bedrock unbroken dolerite with calcite and zeolite veins	20	(a) 4700 (b) 19000	Broken dolerite is probably weathered
8607	20'N. of 1121 (Traverse EF)	Broken, weathered dolerite to 14'; bedrock unbroken dolerite	10	(a) 5000± (b) 18000	
8615	25'S. of 1019 (Traverse CD)	Broken, weathered dolerite to 13'; bedrock jointed dolerite, joints filled with zeolites and calcite	17±	(a) 5100±200 (b) 15000	
8609	25'S. of 1136 (Traverse GH)	Broken, weathered dolerite with clay seams to 45'; bedrock unbroken dolerite with calcite veins	48	(a) Av. 11000 (b) 18000	
8613	25'N. of 1102 (Traverse EF)	Gravel of waterworn dolerite boulders to 11'; bedrock unbroken dolerite with calcite and zeolite veins	15	(a) 5000± (b) 17000±	
8603		Weathered, broken dolerite to 16'; bedrock unbroken dolerite with calcite-filled joints			Drill hole located in shear zone
8602		Talus or weathered dolerite to 24'; bedrock broken dolerite			"
8616		Probably talus to 9'; unbroken dolerite to 37'; bedrock freshly broken dolerite with calcite-filled joints and veins			"

In Table 1 a comparison is made between some of the drilling and geophysical results. The comparison is not a direct one because none of the drill holes is located exactly on a seismic traverse. Nevertheless, the agreement between the results is satisfactory. The drill log data of D.H.8602, D.H.8603, and D.H.8616 have been added to the table because these three holes are located within the shear zone deduced from the geophysical results.

Table 2 shows the observed seismic velocities.

TABLE 2

Formation	Observed seismic velocity (ft/sec.)
Surface layer or soil	1100 - 2100
Gravel	5000±
Weathered dolerite	3400 - 6600
Fractured or jointed dolerite, joints filled with clay, zeolites and calcite	9500 - 12500
Unweathered dolerite, slightly fractured to unfractured	15000 - 22000

From Table 1 it can be concluded that the overall accuracy of depth determination by the geophysical method is not better than ±25 per cent.

It is shown in Table 2 that in fractured and jointed dolerite in which the joints have been filled with clay, zeolites and calcite, velocities range from 9,500 ft/sec. to 12,500 ft/sec. If Poisson's ratio for such rock is assumed to be 0.25 then:-

$$V_1 = \sqrt{1.2 \frac{E}{\delta}} \quad \text{------------------------(1)}$$

and $$K = \frac{E}{1.5} \quad \text{------------------------(2)}$$

where V_1 = seismic velocity of propagation

δ = density of dolerite

E = Young's modulus of elasticity

K = bulk modulus "

$\frac{1}{K}$ = compressibility

For V_1 = 9,500 ft/sec and $\delta = 2.7$.

$E = 1.9 \times 10^{11}$ dynes/cm^2

$K \doteqdot 1.3 \times 10^{11}$ " "

and $\frac{1}{K} \doteqdot 0.8 \times 10^{-11}$ cm^2/dyne.

For V_1 = 12,500 ft/sec and $\delta = 2.7$,

$E = 3.2 \times 10^{11}$ dynes/cm^2

$K \doteqdot 2 \times 10^{11}$ " "

and $\frac{1}{K} \doteqdot 0.5 \times 10^{-11}$ cm^2/dyne.

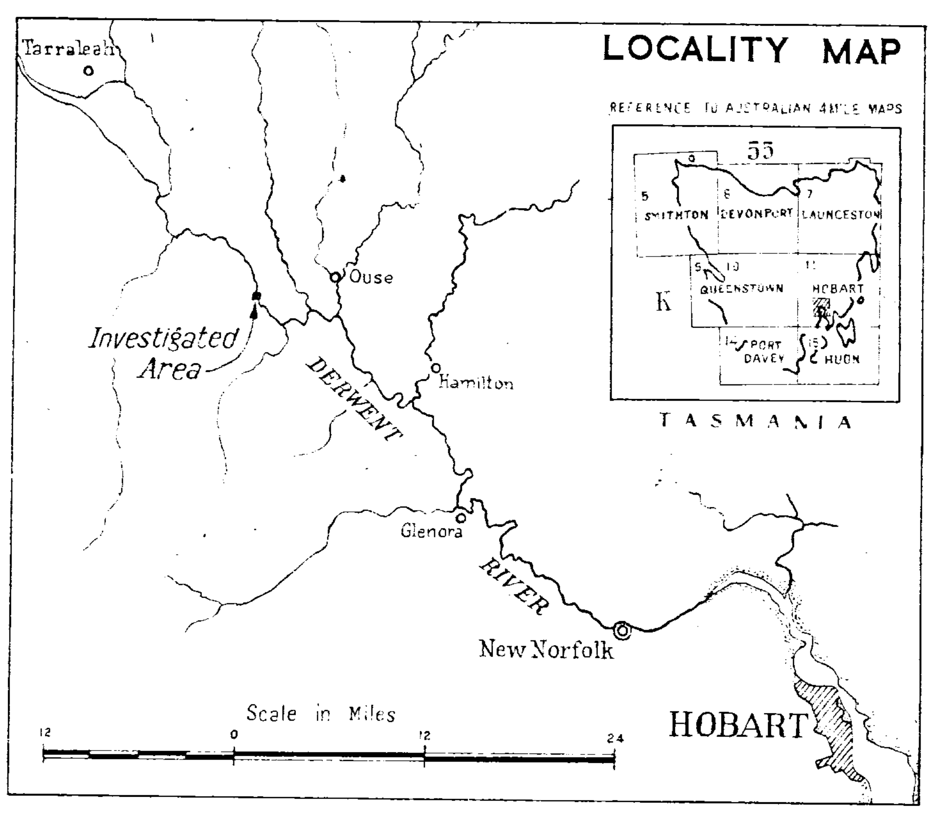
Engineers may consider bedrock with the above constants and compositions to be suitable for dam construction.

CONCLUSIONS

The seismic survey indicated the thickness of the overburden with a fair degree of reliability. Shearing in the dolerite was indicated in several places. On the northern bank there is evidence of a main shear zone, the strike of which is easterly and coincides with one of the main directions of shearing as shown by the photo mosaic.

In the area surveyed, the line Q-R-S-T may be favoured by engineers as the most likely site for a dam. Shearing appears to be unlikely along this line and the thickness of overburden is less than along MN and WX.

PLATE I



LEGEND

A —·— B TRAVERSE

D.H.8610 • DRILL HOLE

▨ AREAS IN WHICH SEISMIC RESULTS INDICATE SHEARING OR FRACTURING

SEISMIC REFRACTION SURVEY AT BLACK BOB'S DAMSITE, TASMANIA

LOCALITY MAP
LAY-OUT OF TRAVERSES

SCALE IN FEET

100 0 100 200 300 400

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics G 201-1

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LEGEND

STATIONS ON SECTION
VELOCITY IN FT/SEC
WEATHERED DOLERITE AND TALUS
SLIGHTLY WEATHERED AND FRACTURED DOLERITE
UNWEATHERED DOLERITE
SHEAR ZONES

SEISMIC REFRACTION SURVEY AT BLACK BOB'S DAMSITE, TASMANIA

SECTIONS

SCALE IN FEET

100 0 200 500

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G 201-2