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# RIVERSIDE EXPRESSWAY SEISMIC REFRACTION SURVEY,

BRISBANE 1966

*by*

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## CONTENTS



## ILLUSTRATIONS



## SUMMARY


At the request of the Co-ordinator-General's Department a seismic refraction survey was made to determine the depth and character of the bedrock and overburden in the area of the proposed Riverside Expressway in Brisbane. Bedrock is shallowest upstream from Victoria Bridge. Also, the quality of the bedrock is generally much better there than downstream from Victoria Bridge.

# 1. INTRODUCTION

The Co-ordinator-General's Department, Queensland is preparing plans for the Riverside Expressway, which will take north-south traffic across the Brisbane River. The expressway (Plate 1) will start near Grey Street Bridge, follow the left bank of the river, and cross the river to the Old Coal Wharf.

In response to a request from the Co-ordinator-General's Department the Bureau of Mineral Resources, Geology & Geophysics made a geophysical survey to determine the depth to bedrock and the nature of the bedrock and overburden along the axis of the proposed route. The seismic refraction method was used. The work was done between 6th and 20th January 1966, by a party consisting of E.J. Polak, M. Wainwright, and A. Radeski.

It is desired to acknowledge the assistance given by the Co-ordinator-General's Department in providing the personnel, a boat, explosives, and surveying.

As used in this Record, the term 'bedrock' refers to the deepest refractor with the highest recorded seismic velocity. The term 'overburden' refers to soil, mud, gravel, sand, and completely to partly weathered bedrock.

# 2. GEOLOGY

The geology of the area has been described by Bryan and Jones (1951) and has been discussed in a previous report (Polak, 1965).

The bedrock in the area of survey consists of metamorphosed sandstone, siltstone, and mudstone of the St. Lucia Polymetamorphics and Neranleigh-Fernvale Group, both of which belong to the Brisbane Metamorphics of Precambrian to Silurian age. The rocks are jointed.

In part of the area under investigation the Brisbane Metamorphics are covered with beds of hard clay, elsewhere with sand, gravel, and mud. Several holes were drilled to determine the thickness of the overburden and the condition of the bedrock.

In the vicinity of Victoria Bridge, old drill holes indicate mud, sand, and gravel overlying the Brisbane Metamorphics (Polak, loc. cit.). Ten new holes (numbered 101 to 110) were drilled between Botanical Gardens and the Old Coal Wharf (Plate 1). They penetrated thick layers of sand, gravel, and clay above the Brisbane Metamorphics.

# 3. METHODS AND EQUIPMENT

The seismic refraction method was used. The method has been described in several reports on geophysical surveys in Queensland (e.g. Polak & Mann, 1959).

On the river part of the survey, floating geophones were used, spaced 25 feet apart. Shots were fired in line with the geophone spreads. For the calculation of the results the 'reciprocal geophone method' (Heiland, 1940) was used.

On several locations it was impossible to place shots at the ends of the spread, owing to the proximity of buildings and structures; therefore the shots were displaced at right angles to the direction of the spreads. This technique is referred to as 'broadside shooting' (Polak & Hawkins, 1956).

On the land part of the survey, geophones were spaced 50 feet apart and shots were fired at both ends of, and in line with, the geophone spread.

The equipment consisted of a 24-channel refraction seismograph manufactured by South-western Industrial Electonics, T.I.C. land geophones with a natural frequency of 20 c/s, and floating pressure geophones with a frequency response range of 1 to 200 c/s.

The presence of buildings, engineering plants, and anchored ships and river traffic imposed severe restrictions on the size of the charges and on the positions of the shots. Therefore the first arrival events on the records are not very clear, and the accuracy of results is lower than usual. Moreover the depth of the water along part of the left bank of the river was not sufficient for normal operation of the floating geophones; as a result the geophone plates became blocked with mud and the geophones became sluggish.

## 4. RESULTS

Plate 1 shows the positions of the seismic spreads and the interpretation of the results.

### Seismic velocities

The seismic velocities recorded in the area (Polak & Mann, 1959) may be assigned to three groups, as follows:

(1) A water layer with a velocity of 5000 ft/s.

(2) A second layer of unconsolidated deposits with velocities of 5000 to 5300 ft/s. These velocities were determined during the Victoria Bridge survey (Polak, 1965) using the 'Sonar Boomer' as a vibration source and S.I.E. equipment as a recorder. On a land traverse a velocity of 5300 ft/s was found with an engineering seismograph. These velocities agree with the velocities found at Hamilton Crossing (Polak, 1965).

(c) A bottom layer (bedrock) with velocities of 7000 to 19,000 ft/s. These velocities were determined by shooting from both ends of the spreads and therefore are true velocities. No separate layer of weathered bedrock was recorded. The variation in seismic velocities of the bedrock is related to rock type and jointing or faulting. The drilling results and geological information suggest that seismic velocities in phyllite, shale, or clay schist of the Neranleigh-Fernvale Group range from 7000 to 8700 ft/s, in quartzite of the St. Lucia Polymetamorphics are about 19,000 ft/s, and in schist of the St. Lucia Polymetamorphics are from 9000 to 13,000 ft/sec. At various places the interpretation of velocities in geological terms is uncertain, but the above relation may be taken as a guide. According to the Co-ordinator-

General's Department engineers, water penetrating into the joints of the low-velocity shales or clay schists causes swelling of the rock.

Depth to bedrock and character of bedrock

Grey Street Bridge to Victoria Bridge. The traverses in this section are placed close to the steep bank of the river. Hence the indicated depths on the profiles must be interpretated as the shortest distance to the bedrock, and not necessarily as the depth in vertical direction.

The traverses in this section were shot from both ends of the spreads; therefore accurate determination of seismic velocities was possible. The velocities in the bedrock range between 7000 and 19,000 ft/s. The velocities are generally lower than the velocities found during the Victoria Bridge survey (Polak, 1965). In the present survey the traverses cross several rock boundaries, while in the Victoria Bridge survey the main traverses were roughly parallel to the strike of the beds.

Victoria Bridge to Margaret Street (B2 to B5). Two sesimic refraction methods were used: the reciprocal geophone method for traverses B2, B3, and B4, and a 'step-out-time' method for traverse B5. The latter method was used because of limitations on the choice of location of shot-points; with this method, the velocity in bedrock or overburden cannot be determined, and must be deduced from neighbouring measurements. As the formula for calculating depth to bedrock involves velocities of both bedrock and overburden, incorrect assumptions about the velocities may lead to incorrect depths. The velocity in the water-saturated overburden does not change significantly along the traverse but the apparent rise in bedrock shown under traverse B5 may be caused partly by a change in velocity. However, this could not explain a rise of such magnitude completely. Another possibility is that the seismic records have been affected by large blocks of concrete, which are known to have been dumped in this area.

Sand and Gravel Wharf to Old Coal Wharf (B7 to B20). Traverses B8, B9, B10, B12, B15 and B18 were seismically investigated with the reciprocal geophone method, B13, B16, B17, and B19 with the broadside shooting method.

The surface of the bedrock along this section is very uneven. The bedrock rise on traverse B7 may be the result of concrete foundations and piles of the Sand and Gravel Wharf. Farther downstream, near B9 and B10, a deep valley in the bedrock may represent the old Brisbane River bed at the time when the sea level was much lower. This interpretation is supported by the presence of sand and gravel in drill holes 101 to 106. Farther downstream, drill holes 107 and 108 indicate a bed of clay.

Except at B6 and B10, bedrock velocities are low (7000 to 8000 ft/s.).

Young's modulus of bedrock

Young's modulus has been determined from the longitudinal seismic velocities using an empirical formula similar to that given by Polak (1963). The formula is:

$$E = 0.76V_L \times 10^{-3} - 4.3 \pm 0.15$$

where E is Young's modulus in $lb/in^2 \times 10^6$, $V_L$ is the longitudinal seismic velocity in ft/s, and the figure 0.15 represents the standard deviation. For rocks with seismic velocities of 7000 and 12,000 ft/s, Young's modulus derived from this formula is 1.1 and 4.9 x $10^6$ respectively.

## 5. CONCLUSIONS

On the site of the proposed expressway, seismic work indicates that bedrock is shallowest upstream from Victoria Bridge. Also, the quality of the bedrock as judged from seismic velocity is much better there than downstream from Victoria Bridge.

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PLATE 1
BRISBANE RIVER
SHALES AND SCHISTS OF NERANLEIGH–FERNVALE GROUP
DUMPED CONCRETE BLOCKS
POSSIBLY CLAY SCHIST
QUARTZITES
SCHISTS OF ST LUCIA GROUP
LEGEND
AXIS OF THE EXPRESSWAY
(5100) SEISMIC VELOCITY FT/S
DIAMOND-DRILL HOLE No.104
"SONAR BOOMER" TRAVERSE
RECIPROCAL GEOPHONE SPREAD
BROADSIDE SPREAD
LOCALITY MAP
SEISMIC TRAVERSES
SCALE 0 4 8 12 16 CHAINS
SEISMIC REFRACTION SURVEY, 1966
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