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MURCHISON-SOPHIA GEOPHYSICAL SURVEYS, UPPER PIEMAN HYDRO-ELECTRIC SCHEME,

TASMANIA 1963

by

P.E. MANN

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Plate 2. Seismic cross-sections and resistivity profiles (K55/B5-42)

SUMMARY

Seismic refraction and resistivity surveys were made along the proposed sites for the Murchison flume line and the Sophia tunnel line, parts of the Upper Pieman Power Development Scheme, of the Hydro-Electric Commission of Tasmania.

On the flume traverse, it is believed that weathered rock with seismic velocity greater than 6000 ft/s is strong enough for a foundation; weathered rock with a seismic velocity of less than 5000 ft/s is probably too weak. Additional seismic work may have to be done along some parts of the traverse where a seismic velocity greater than 6000 ft/s was not recorded.

The proposed tunnel line was found to pass through bedrock of varying quality; sections of the tunnel that would be cut through bedrock with a seismic velocity of 17,000 to 21,000 ft/s may not require lining. Owing to the presence of two zones of deep weathering, a new location is recommended for the entrance portal of the tunnel.

1. INTRODUCTION

The Hydro-Electric Commission of Tasmania (HEC) proposes to erect power stations to utilise the water resources of the Upper Pieman River system, which is formed by the Murchison and Mackintosh Rivers and their tributaries. Since about 1956, HEC has considered four dam sites on the Murchison River; geophysical surveys at two of these sites have been made by the Bureau of Mineral Resources (Polak, 1957 & 1962).

In the power scheme under investigation, the water impounded by a dam on the Murchison River (Plate 1) will flow along a flume and then pass through a tunnel to the Sophia River valley, where it will be used at power stations on the Mackintosh River.

In response to a request from HEC, the Bureau made a geophysical survey along the proposed flume and tunnel lines in April 1963. The object of the surveys was to determine the depth to bedrock and the nature of the bedrock and overburden. The seismic refraction method was used for the survey of the flume line, and the seismic refraction and resistivity methods were used for the survey of the tunnel line. The geophysical party consisted of P.E. Mann (party leader) and F. Jewell (HEC geophysicist). HEC supplied four field assistants and made the topographical survey along the traverse lines.

2. GEOLOGY

The proposed Murchison flume line extends from Murchison dam site No. 3 (Plate 1) along the right bank of the Murchison River for a distance of about 4000 ft. The geology of the area is described by Ward (1908) and Bradley (1954, 1956, 1957). HEC has completed reconnaissance surface mapping along the flume and tunnel lines (Mather, 1963). The geology of the area is shown in Plate 1. Along the flume line the bedrock consists of acid to intermediate igneous rocks. Bedrock crops out in several places and the steep sloping right bank is covered by talus material. Eight holes have been drilled, roughly on the flume line, to determine the depth to rock that would be suitable for the foundation of a flume. The greatest depth found was 33 ft in DDH6623 near station F44.

The proposed tunnel (about 2700 ft long) will be driven through a hill between the valleys of the Murchison and Sophia Rivers. The maximum thickness of rock above the tunnel will be about 220 ft. Surface mapping shows that the bedrock at the proposed inlet portal consists of igneous rock types. No rock crops out at the proposed outlet portal, but regional mapping suggests that the bedrock is the Owen Conglomerate. The regional mapping also indicates that a major fault with an easterly trend may intersect the proposed tunnel. Two horizontal holes, 600 and 1000 ft long respectively, have been drilled at the proposed inlet and outlet portal areas. The drill holes for the flume and tunnel lines were sited prior to the geophysical survey, but the horizontal hole at the proposed outlet portal was continued to 1000 ft as a result of the seismic survey.

3. METHODS AND EQUIPMENT

A detailed description of the seismic method has been given previously by Polak and Moss (1959). The seismic equipment was an SIE model P-19 portable refraction seismograph manufactured by South-western Industrial Electronics (SIE), Houston, Texas, including SIE model PRO-11-6 recording oscillograph, which was used with a 'Seismod' display unit manufactured by Electro-Tech Laboratories, Houston, Texas. Technical Instruments Co. geophones with a natural frequency of about 20 c/s were used.

In the Wenner method of resistivity traversing (Heiland, 1946), used in this survey, four electrodes equally spaced in a straight line (spacings 50 and 100 ft) were moved as a whole along a traverse and readings were taken at consecutive stations. In the interpretation, absolute values of resistivity are not so important as changes in resistivity,which generally indicate a change in rock type.

A YEW model L-10 earth resistance meter, manufactured by Yokogawa Electric Works Ltd (YEW), Tokyo, was used for the resistivity survey.

4. MURCHISON FLUME LINE

Seismic results

Plate 1 shows the layout of Traverse F for the seismic survey of the flume line. 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/s)	Rock Type
1000 to 2700	Soil and talus material
4000 to 5000	Highly weathered bedrock
5000 to 8000	Weathered bedrock
8000 to 16,500	Moderately to slightly weathered bedrock
16,500 to 18,500	Unweathered bedrock

The seismic results are shown as cross-sections in Plate 2. Table 2 compares the drilling and seismic data.

TABLE 2

DDH No. (Station No.)	DRILLING RESULTS		SEISMIC RESULTS		Remarks
	Rock Type	Depth (ft)	Depth (ft)	Velocity (ft/s)	
6618 (F82/83)	Talus	0-7	0-10	1000	DDH projected 10 ft
	Granitic rock with thin weathered joints	7-46+	10-29 29-95	4000 13,000	
6619 (F72/73)	Talus	0-3			DDH projected 30 ft
	Granitic rock with thin weathered joints	3-28+		?	
6621 (F66/67)	Talus	0-4?			
	Granitic rock with weathered joints and some sound rock	4?-11			
	Mainly sound granitic rock with some weathered joints	11-29+		?	
6622 (F51/52)	Talus	0-5	0-6	1000	DDH projected 20 ft
	Granitic rock with thin weathered joints	5-30+	6-41	6000	
6623 (F44/45)	Sandy brown clay	0-6	0-15	1000	DDH projected 20 ft
	Talus or weathered granitic rock	6-33	15-100	5000	
	Granitic rock with some thin weathered joints	33-49+			
6624 (F36)	Talus and weathered granitic rock	0-10	0-17	1000	DDH projected 20 ft
	Granitic rock with some thin weathered joints	10-35+	17-33	6000	
6625 (F21/22)	Talus	0-6	0-7	1000	
	Granitic rock with some thin weathered joints	6-31+	7-43	8000	
6626 (F14/15)	Talus	0-6	0-6	1000	
	Sound keratophyre with thin weathered joints	6-30+	6-28	8000	

From a comparison of the drilling and seismic results, it appeared that weathered rock with a seismic velocity of 6000 ft/s or greater would probably be suitable as a foundation rock for the flume. Weathered rock with a seismic velocity of 5000 to 6000 ft/s may or may not be suitable, and weathered rock with a seismic velocity of less than 5000 ft/s is considered to be too weak. In Plate 2 the estimated depth to rock that may be used as a foundation for the flume is indicated by a dashed line on the cross-section for Traverse F. The position of the line is based on geophysical, geological, and drilling data.

Conclusions

The seismic results show that the unweathered bedrock is probably deepest near F30 and F44. The latter is near DDH6623, where drilling indicates the greatest depth to suitable foundation rock. Additional information may be required between F28 and F35, between F59 and F67, and between F76 and F80, where no layer with a seismic velocity of 6000 to 8000 ft/s was detected above bedrock.

5. SOPHIA TUNNEL

Results

Plate 1 shows the layout of Traverse T for the survey of the Sophia tunnel line. Table 3 gives an interpretation of the recorded seismic velocities in geological terms, based on the geological logs of drill hole cores and experience in other areas.

TABLE 3

Seismic Velocity (ft/s)	Rock Type
1000 to 2100	Soil and talus material
5500 to 7500	Weathered igneous rock or weathered jointed conglomerate and quartzite
10,000 to 14,000	Moderately weathered igneous rock or conglomerate and quartzite
17,500 to 21,000	Unweathered igneous rock. Conglomerate and quartzite - Owen Conglomerate

The seismic cross-section of the tunnel line is shown in Plate 2. Generally the cross-section is self-explanatory but a few points will be discussed. The seismic velocity of the deepest refractor, interpreted as bedrock, is generally greater to the south-west of station T59 than to the north-east. The major fault found by regional mapping to the east of Traverse T may intersect the tunnel line near T59. Based partly on the evidence from seismic velocities computed during the survey, HEC decided to extend the drilling of DDH6627, at the proposed outlet portal, to 1000 ft horizontally, to sample the rock with seismic velocity 11,000 to 13,000 ft/s and to test the hypothesis that the change in seismic velocity of the bedrock near T59 indicates a fault zone. The drilling was stopped about 250 ft short of station T59 for technical reasons. The drill hole cores showed some minor faulting at the contact of the igneous rock and Owen Conglomerate at a distance of 290 ft in the drill hole. Table 4 compares the drilling and seismic results.

TABLE 4

	Drilling Results		Seismic Results	
DDH No.	Horizontal Distance (ft)	Rock Type	Station No.	Probable Seismic Velocity (ft/s)
6627	0-44	Talus		
	44-290	Hard siliceous conglomerate and quartzite - Owen Conglomerate. Weathered rock 158-171 ft, 243-245 ft, and 286-293 ft	T84-T81 T81-T78	13,000 18,000
	290-997	Mainly sound granitic rock. Weathered rock 561-562 ft, 645-650 ft, 712-717 ft, 744-746 ft, 796-801 ft, and 828-835 ft	T78-T64	11,000 to 13,000
6630	0-3	Talus		
6630	3-604	Mainly sound granitic rock. Weathered rock 3-6 ft, 85-87 ft, 334-345 ft, 443-452 ft, 494-498 ft, 532-539 ft, and 584-587 ft	F85-T38 T38-T42 T42-T46	18,000 14,000 12,500

Near the proposed outlet portal, the distribution of recorded bedrock velocities and the drilling data suggest the presence of a shear zone (Plate 1). Near the proposed inlet portal the seismic data indicate the presence of two zones of deep weathering (Plate 1).

The resistivity profiles (Plate 2) show low resistivity between stations T69 and T77, probably due to the marshy ground near station T75 rather than to a change of rock type at depth; the current is conducted in the uppermost layers and does not penetrate to any great depth. The high value of resistivity between stations T78 and T82 is probably due to the Owen Conglomerate, which the drill penetrated between 44 ft and 290 ft in DDH6627.

The seismic velocity gives an indication of the quality of a rock; unweathered rock without joints has a higher seismic velocity than weathered or jointed rock. Along the tunnel line the bedrock can be divided into zones based on the seismic velocity, viz. zones F85 to T38, T46 to T59, and T78 to T82 with a high seismic velocity of 17,500 to 21,000 ft/s; and zones T38 to T46, T59 to T78, and T82 to T84 with a relatively low seismic velocity of 11,000 to 14,000 ft/s.

Conclusions

The proposed tunnel will be excavated mostly in moderately weathered to unweathered igneous bedrock with seismic velocity ranging from 11,000 to 21,000 ft/s, and a small length in conglomerate and quartzite with velocity ranging from 13,000 to 18,000 ft/s. The different seismic velocities show that the quality of the rock varies along the tunnel line. Possibly the tunnel may not need to be lined in sections where the seismic velocity of the bedrock is 17,000 to 21,000 ft/s.

Because of the presence of two zones of deep weathering the entrance portal of the tunnel may be better located near F80 than near F85.

The log of drill hole DDH 6618 indicates a granite recemented with quartz and calcite. Recementing is probably the cause of the high seismic velocity of 18,000 ft/s between stations F85 and T38;

6. REFERENCES

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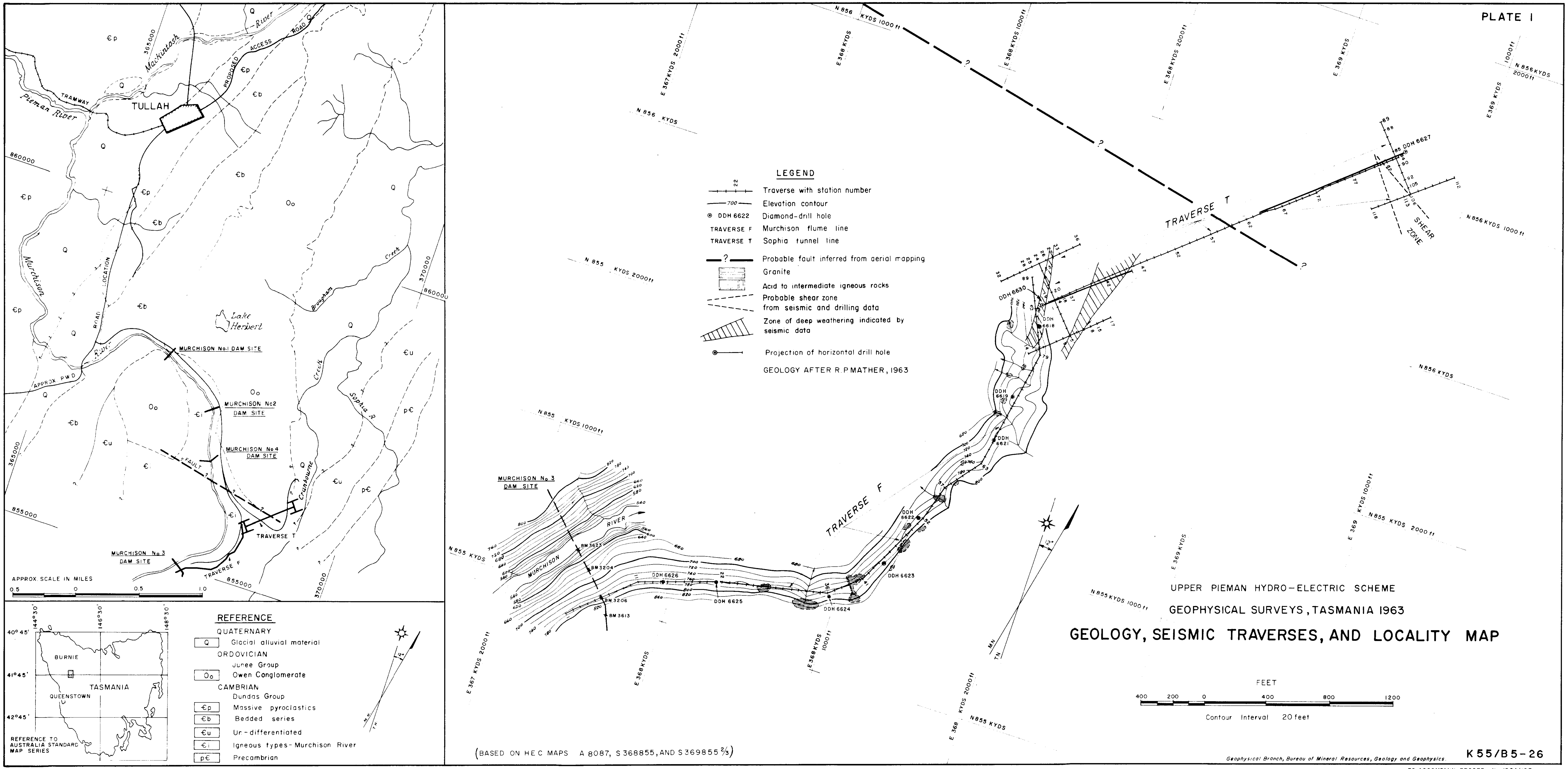

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PLATE 2

LEGEND

(8000)	Seismic velocity (ft/s) in formation
9′	Depth to formation with different seismic velocity
	Unweathered bedrock boundary
I.P.	Intersection point
DDH 6622	Diamond-drill hole No. 6622
(33)	Depth to suitable rock on flume line
---?---?--	Estimated boundary of suitable foundation rock for flume along Traverse F
	Talus
	Conglomerate and quartzite. Owen Conglomerate
	Granitic rock types

TRAVERSES F AND T

SEISMIC CROSS - SECTIONS AND RESISTIVITY PROFILES

BASED ON H.E.C. PLANS A10132, 10133 AND 10188

FEET 100 0 100 200 300

VERTICAL SCALES AS SHOWN

UPPER PIEMAN HYDRO-ELECTRIC SCHEME, 1963

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. K55/B5-42

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