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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS

1957, No.25

SEISMIC REFRACTION SURVEY OF No. 2 POWER STATION SITE, KIEWA, VICTORIA

by

D.F. Dyson and M.J.O'Connor

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ILLUSTRATIONS

ABSTRACT

In response to an application from the State Electricity Commission of Victoria, a seismic refraction survey was carried out by the Bureau of Mineral Resources over the site for the proposed No. 2 Power Station of the Kiewa Hydro-electric Power Development Scheme.

The object of the survey was to determine the depth to unweathered rock and to locate any major shear zones which may exist.

The results show a considerable range of seismic velocities in the various rock types present, and in order to compute depth values it was necessary to use average velocities for the sequence of zones extending from below the soil to the unweathered rock. The various rock types are also irregular in thickness and limited in lateral extent.

The depth to unweathered rock calculated from the seismic results is greater than the depth to unweathered rock indicated by diamond drilling, and it is suggested that the seismic results be used qualitatively rather than quantitatively.

1. INTRODUCTION

The proposed Kiewa No. 2 Power Station is part of the Kiewa Power Development Scheme planned by the State Electricity Commission of Victoria. The site for the proposed power station is near the junction of the Pretty Valley and Rocky Valley branches of the East Kiewa River (Plate 1), and has co-ordinates (in feet) of 1560000E/1375000N referred to the grid of the 4-mile military maps. The power station will be supplied with water from the proposed No. 2 (McKay) Dam via the No. 2 Headrace Tunnel and Penstock Line (Plate 1).

In response to an application by the Commission, a geophysical survey was carried out by the Bureau of Mineral Resources over an area selected by the Commission for the site of the proposed power station. The object of the survey was to determine the depth to unweathered rock and to locate any major shear zones which may exist. Such information would greatly reduce the amount of diamond drilling required and would assist the Commission in the design of the power station.

The seismic refraction method was employed, and five traverses were surveyed. The geophysical party consisted of M.J. O'Connor, party leader, and J.P. Pigott, field assistant. The Commission supplied additional assistants and carried out the topographic survey of the five traverse lines and stations shown on Plate 1. The field work was done in February, 1956.

As the seismic data was reduced, the results were freely discussed with the Commission's geologist.

2. GEOLOGY

The basement rock (granodiorite) is covered by alluvial deposits, weathered rock and talus. A geological investigation carried out by the Commission revealed two shear zones striking N70°E and east, with intrusive basic dykes. It is reasonable to assume, based on experience of similar problems in other areas, that the thickness of the weathered rock in or near fault and shear zones is greater than in places where faulting and shearing are absent.

3. METHODS

The method used for the survey was the seismic refraction technique, which depends on the degree of contrast between the elastic properties of the different zones of rock. An explosive charge detonated at, or near, the surface produces a train of seismic waves. In the normal refraction method the charge is in line with a series of detectors (geophones), known as a spread, and the first arrival times of the seismic waves are recorded at each geophone. A graph of first arrival times against distances from the shot point is known as a time-distance curve. Assuming that the interfaces at which the refractions take place are horizontal, the reciprocal values of the slopes of the time-distance curve indicate the velocities of the seismic longitudinal waves through the different zones.

For field work and calculations, the "method of differences" was used (Dyson and O'Connor, 1956; Heiland, 1946).

The following types of spread were shot :-

(i) Weathering Spreads. These are used to measure the seismic velocities and thickness of soil and near-surface layers. Geophones were spaced 10 feet apart and shot points were 10 feet, 50 feet and about 200 feet from each end of the spread. One weathering spread was shot on each of the five traverses.

(ii) Normal Spreads. Geophones were spaced 50 feet apart and shot points were at (or within) 50 feet and 200 to 300 feet from the end of the spread. One spread was shot along each traverse.

A 12-channel portable "Century" refraction seismograph (Model 506) was used, with Technical Instrument Company geophones of natural frequency about 19 cycles per second.

4. RESULTS

The results of the survey are shown in the cross-sections on Plate 2. Using available drilling data, the seismic velocities recorded are interpreted in terms of rock type in Table 1. For the purpose of this report, the term "overburden" refers to those rock types in which the

TABLE 1.

CORRELATION BETWEEN SEISMIC VELOCITIES AND ROCK TYPES

Seismic velocity (ft/sec.)	Rock type
1350 ± 450	Soil and talus
4400 ± 200	Consolidated talus
5000 ± 500	River gravels
3800 ± 700	Completely weathered granodiorite
5500 ± 1000	Sheared and weathered granodiorite
9000 ±	Sheared and slightly weathered granodiorite (detected only in weathering spreads)
15000 ± 1000	Fractured or jointed granodiorite
18000 ± 500	Unweathered granodiorite

seismic velocity is 9,000 ft/sec. or less and the term "bedrock" to those in which the seismic velocity is greater than 9,000 ft/sec (see Table 1). The 9,300 ft/sec material on Traverse EE' refers to the 9000 ft/sec group material and the "bedrock" is then synonymous with the "high velocity rock" shown on Plate 2. Use of the term "bedrock", as defined above, does not necessarily imply that only those rocks in which the seismic velocity is greater than 9,000 ft/sec. are suitable foundation rocks. It is quite possible that formations at shallower depth, with a seismic velocity of less than 9,000 ft/sec. would provide satisfactory foundations.

As the overburden in the area consists of several different layers, each varying in thickness and lateral extent, the seismic velocities within the overburden show considerable variation. The most satisfactory method of carrying out depth computations was to adopt average conversion factors to obtain an average apparent velocity within that part of the overburden which lies between the base of the surface layer and the top of the "bedrock". These average velocities, which are shown on the cross-sections on Plate 2, were obtained from normal time-distance curves, from detailed weathering spreads, and from results obtained by the application of the "curved ray" computation technique (Heiland, 1946, p. 540). More detailed information obtained from weathering spreads is shown on Traverses BB' (B6 to B8), EE' (E5 to E7) and FF' (F9 to F11).

Seismic velocities in the soil and unconsolidated talus range from 900 to 1800 ft/sec. Consolidated talus or debris, which has slipped down the hill, is found in the southern part of the area and seismic velocities of 4,200 to 4,600 ft/sec. were recorded in this material. Velocities of about 5,300 ft/sec. were recorded in gravels deposited along the river banks.

As stated earlier, sheared and fractured zones are usually accompanied by deeper weathering and have lower seismic velocities in both unweathered and weathered states than their unsheared and unfractured counterparts. It is usually possible, therefore, to detect such zones by means of a seismic survey, but it is not always possible to determine their boundaries accurately. The shear zones located in the present survey are shown on Plates 1 and 2. They occur on Traverse BB' between stations B3 and B6 and east of B8, on Traverse CC' between C6 and C10, on Traverse FF' between F4 and F8 and south-west of F10, and possibly on EE' near E4.

5. ACCURACY OF RESULTS

Of several diamond drill holes which have been put down in the area, some are very near the seismic traverses, and the graph in Fig. 1 shows the correlation between the depth to unweathered rock as identified by the Commission's geologist from drilling data and the depth to bedrock calculated from the seismic results. Where the bedrock is at shallow depth, as in drill holes 1271, 1272 and 1274, there is a discrepancy of about 20 feet between the depths obtained by the two methods. A possible reason for this is that jointed rocks (with relatively low seismic velocity) may have been identified from the drill logs as so slightly weathered as to be classed as foundation rock, whereas such rocks may not have been recorded by the seismic survey, possibly because the zone was too thin.

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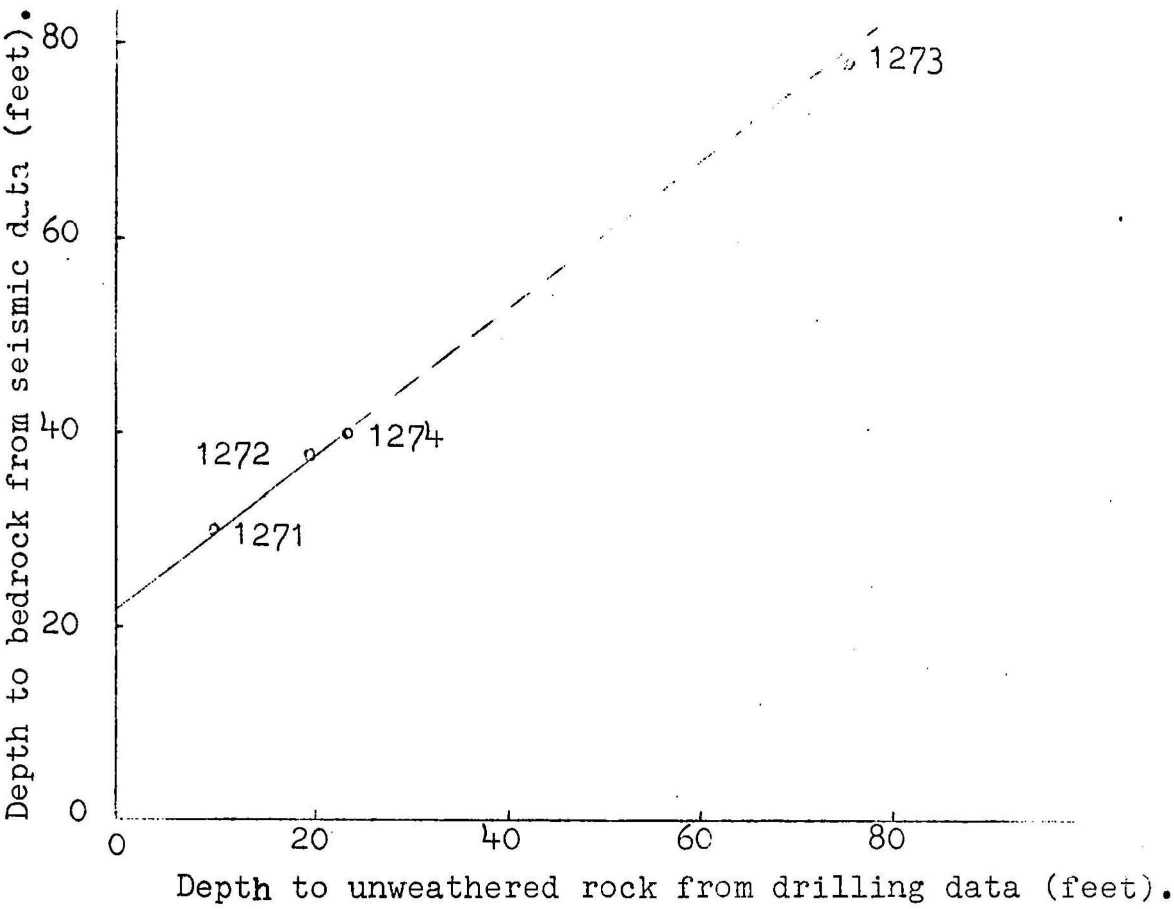


Fig. 1. Correlation of drilling and seismic results.

A satisfactory statistical analysis of the seismic depths to "bedrock" compared with unweathered rock as identified by drilling is not possible, as insufficient drilling data are available.

The seismic results should be considered as qualitative rather than quantitative, and should be used as a guide for further drilling investigations.

6. CONCLUSIONS

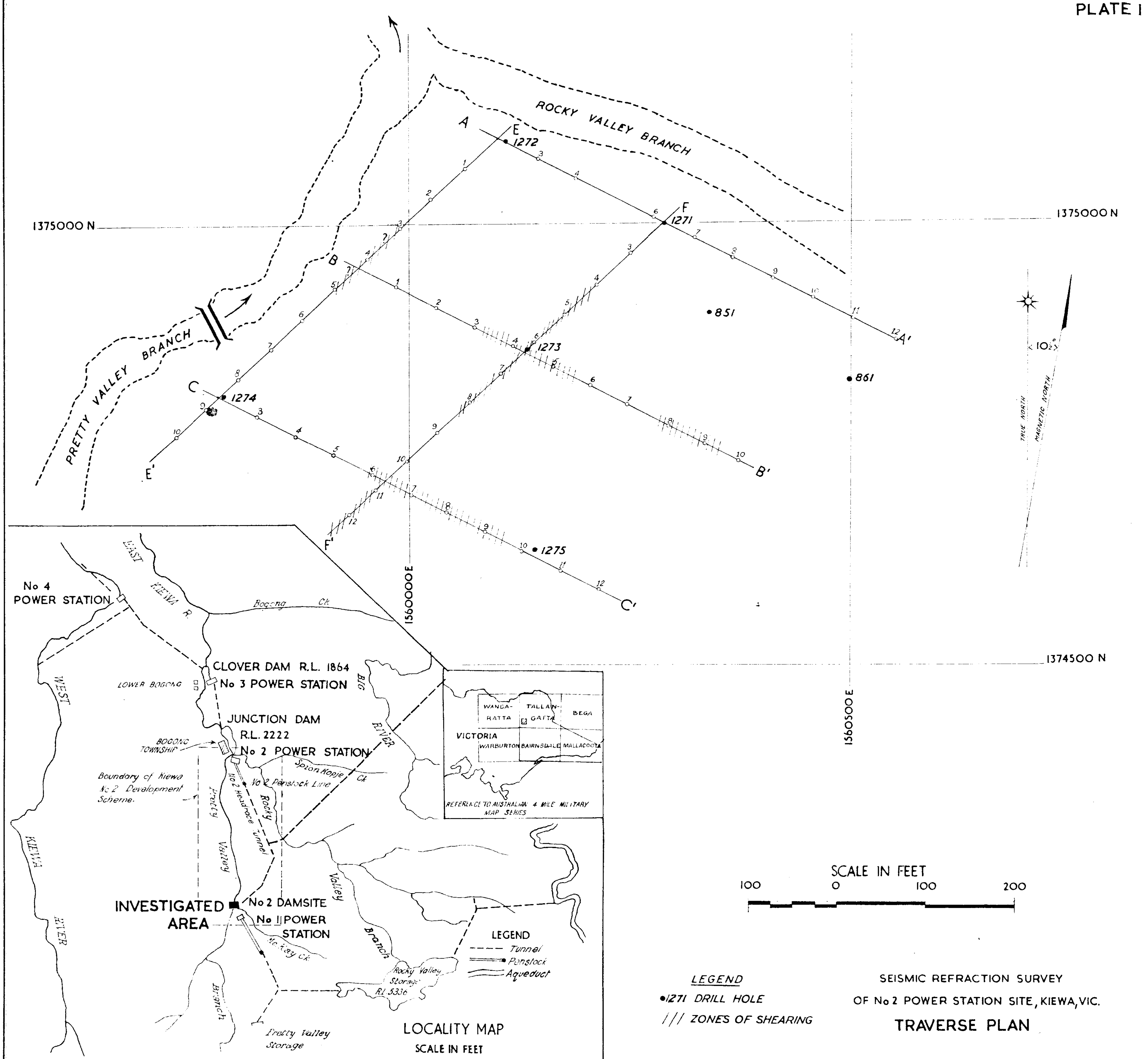
Plates 1 and 2 show that the area with shallow depth to "bedrock", other than that where shear zones exist, is to the north of a line joining stations E2 and A11, and is bounded to the north and north-west by the Rocky Valley and Pretty Valley Branches of the East Kiewa River respectively. It is probable that there is suitable foundation rock in this area at shallower depths than the seismically determined depths to "bedrock". The relatively high seismic velocities in the overburden along Traverse AA' support this conclusion, as it is possible that a thin zone of suitable foundation rock may exist between the identified overburden of 6,500 ft/sec. and the bedrock of 18,000 ft/sec.

7. REFERENCES

Dyson, D.F., and O'Connor M.J., 1956 — Seismic Refraction Survey of No. 1 Power Station Site, Kiewa, Victoria. Bur. Min. Resour. Aust., Records 1956, No. 136.

Heiland, C.A., 1946 — GEOPHYSICAL EXPLORATION, Prentice-Hall, New York.

PLATE I



LEGEND

•1271 DRILL HOLE

/// ZONES OF SHEARING

SEISMIC REFRACTION SURVEY OF No 2 POWER STATION SITE, KIEWA, VIC.

TRAVERSE PLAN

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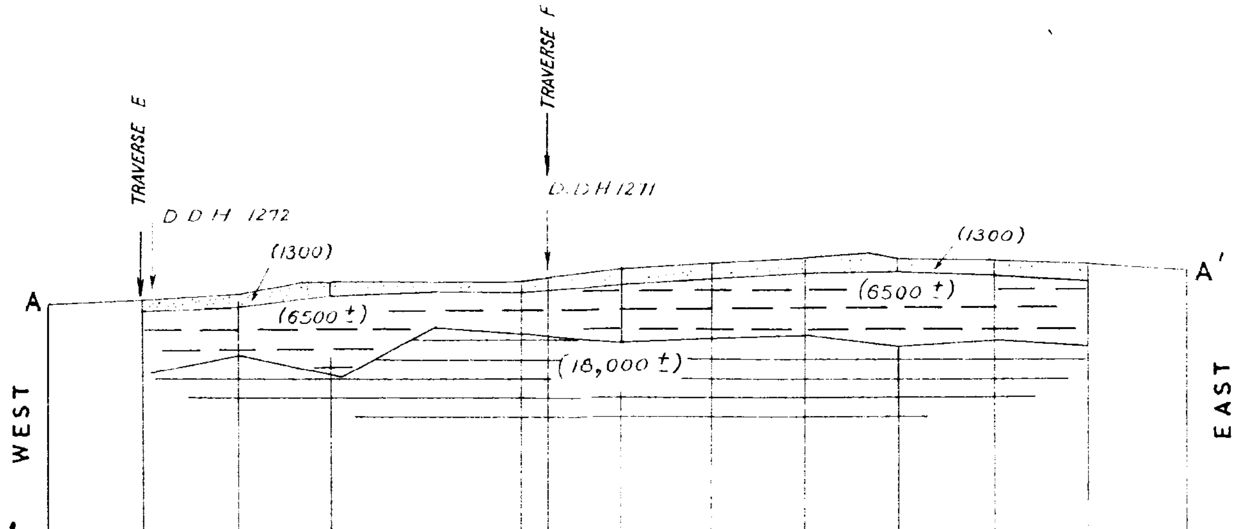
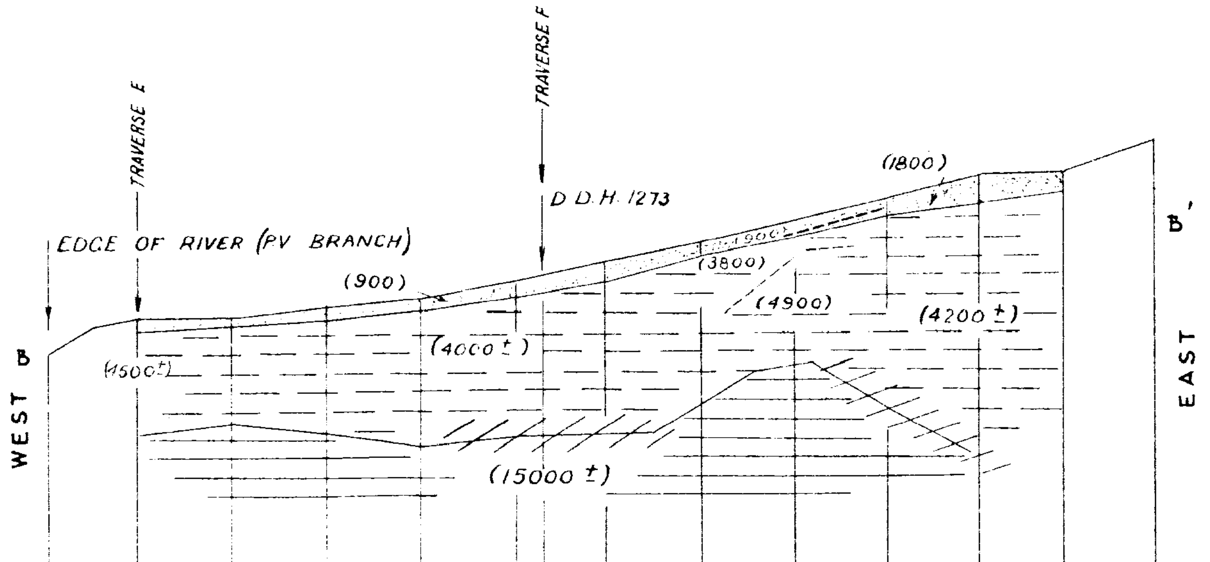
PLATE 2



DATUM RL 2100'

	E/A	A3	A4		A6	F/A	A7	A8	A9	A10	A11	A12
SURFACE R.L.	2230	2234	2240		2240		2245	2249	2252	2251	2251	2249
APPROXIMATE SOIL THICKNESS	5½	6	7	5	5		7	7	7	7	7	8
DEPTH TO BEDROCK	39	31	48	24	27		38	38	38	45	41	41

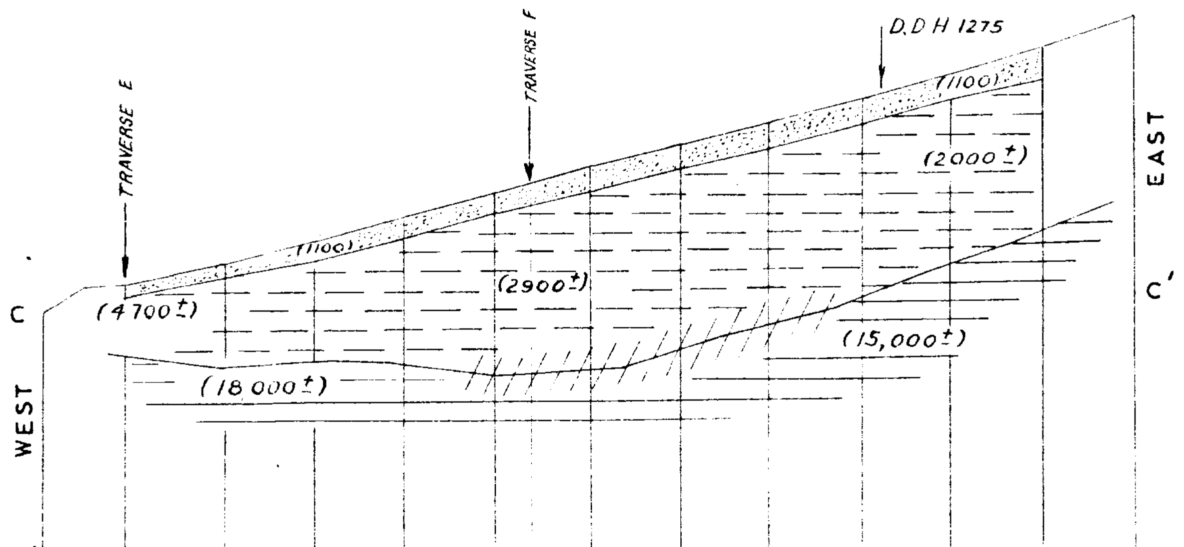
TRAVERSE AA'



DATUM RL 2100'

	E/B	B1	B2	B3	B4	F/B	B5	B6	B7	B8	B9	B10
SURFACE R.L.	2249	2249	2256	2260	2269		2279	2289	2301	2313	2324	2324
APPROXIMATE SOIL THICKNESS	7	5	6	7	9		12	8	8	9	14	9
DEPTH TO BEDROCK	61	55	67	78	80		88	72	72	93	130	153

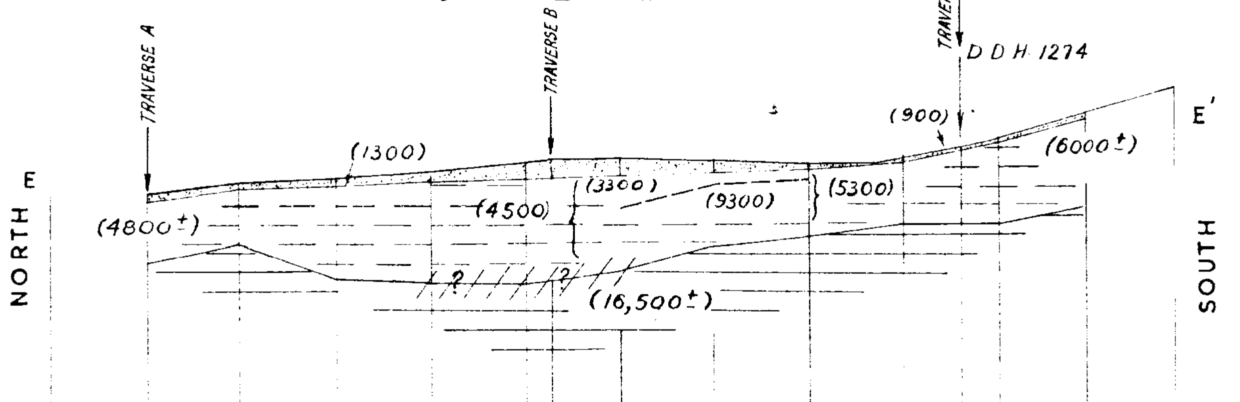
TRAVERSE BB'



DATUM RL 2100'

	E/C	C3	C4	C5	C6	F/C	C7	C8	C9	C10	C11	C12
SURFACE R.L.	2254	2264	2275	2288	2301	2307	2316	2326	2339	2351	2364	2378
APPROXIMATE SOIL THICKNESS	7	5	10	11	11		11	12	13	11	12	16
DEPTH TO BEDROCK	34	51	60	74	93		104	101	101	94	90	85

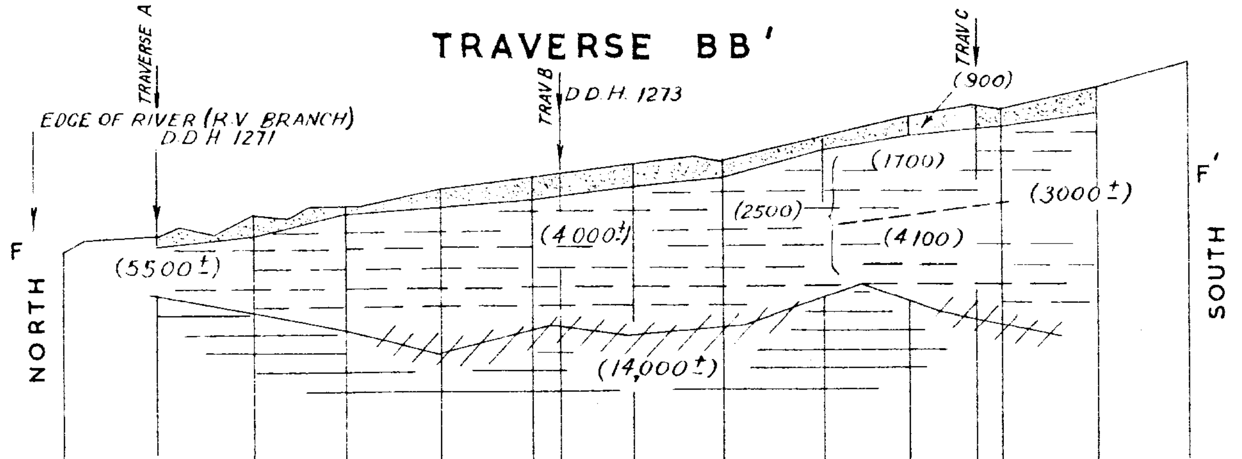
TRAVERSE CC'



DATUM RL 2100'

	A/E	E1	E2	E3	E4	B/E	E5	E6	E7	E8	C/E	E9	E10
SURFACE R.L.	2230	2238	2240	2244	2248		2251	2250	2248	2249		2259	2274
APPROXIMATE SOIL THICKNESS	5	4	5	6	7		7	5½	4	3		2	3
DEPTH TO BEDROCK	38	31	53	59	65		61	47	32	33		43	48

TRAVERSE EE'

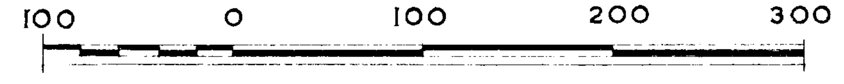


DATUM RL 2100'

	A/F	F3	F4	F5	F6	B/F	F7	F8	F9	F10	C/F	F11	F12
SURFACE R.L.	2240	2250	2253	2264	2270		2276	2279	2292	2302	2305		2317
APPROXIMATE SOIL THICKNESS	4	10	4	9	10		9	7	6	8	9		11
DEPTH TO BEDROCK	30	50	62	85	75		86	83	77	88	109		130

TRAVERSE FF'

HORIZONTAL AND VERTICAL SCALES IN FEET



LEGEND

- SOIL
- WEATHERED LOW VELOCITY ROCK
- HIGH VELOCITY ROCK
- (2900±) APPROXIMATE SEISMIC VELOCITY IN FEET PER SECOND
- D.D.H.1272 DIAMOND DRILL HOLE
- ZONES OF SHEARING

SEISMIC REFRACTION SURVEY OF No. 2 POWER STATION SITE, KIEWA, VICTORIA

INTERPRETATION OF SEISMIC DATA ALONG TRAVERSES

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics

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