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GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND

by

E. J. POLAK and P. E. MANN

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ILLUSTRATIONS.

ABSTRACT.

Geophysical investigations were made at the Koombooloomba Dam Site, Queensland to investigate foundation conditions.

Using the seismic refraction method the maximum depth to the bedrock was determined as approximately 148 feet. The dynamic elastic properties of the bedrock are given, as calculated from longitudinal and transverse wave velocities.

The bedrock consists of granite and porphyry and the boundaries between the formations were located using data from seismic refraction, resistivity and magnetic techniques. The possibility of the existence of three basalt dykes is indicated.

The overburden consists of soil, decomposed rock and weathered and jointed rock.

* *

I. INTRODUCTION

The output of the Kareeya Power Station near Ravenshoe, Queensland, which utilises the drop of the Tully River on and near Tully Falls, is affected by fluctuations of the water flow which has been recorded to vary between 30,000 cusecs (1927) and 10 cusecs (1946).

In order that the generation of power may be continuous the Department of Public Works of the Co-ordinator General's Office, Queensland, (referred to as C.O.G.) is about to construct the Koombooloomba Dam about seven miles upstream from Tully Falls (Plate 1).

The purpose of the dam is to store water to the extent of 21,000 million gallons during the summer and to release it at the required rate during the following winter. The area of the reservoir will be about 3,750 acres and the water level will be raised 115 ft. above the original river level. [illegible]

It is possible that corrective measures will have to be taken to prevent excessive leakage from the reservoir, especially at the points where a narrow ridge divides the reservoir from creeks.

In order to obtain a preliminary assessment of the need for such corrective measures the C.O.G. asked the Bureau of Mineral Resources, Geology and Geophysics, to determine by geophysical survey the depth to the unweathered rock along three critical sections of the storage area, namely:- (a) the left bank of the Tully River along the Monday Creek, (b) the right hand bank of the Tully River along the Campbell Creek, and (c) the Ridge Section where the Atherton Tableland drops down to the coastal plains.

The survey was carried out between 10/9/58 and 30/10/58 by a geophysical party consisting of E.J. Polak, party leader and P.E. Mann, geophysicist, with four field assistants provided by C.O.G. The C.O.G. also made a topographical survey along the traverse lines.

Seismic refraction, resistivity and magnetic methods were used.

It is desired to acknowledge help given by officers of the C.O.G. at Koombooloomba.

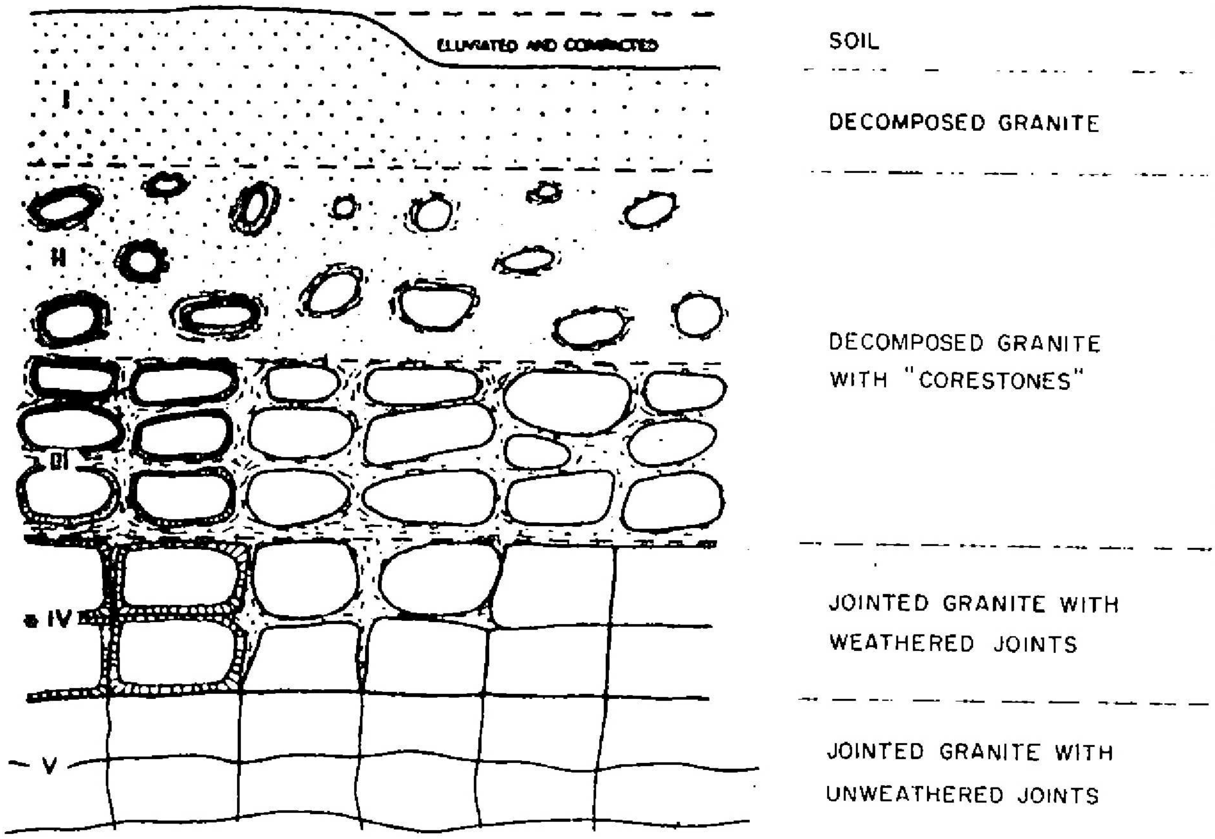

FIGURE 1. ILLUSTRATING THE WEATHERING OF GRANITE IN TROPICAL CLIMATE (RUXTON and BERRY, 1957)

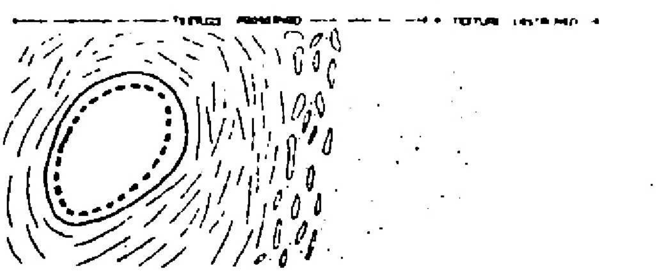

FIGURE 2: SHOWING THE WEATHERING OF GRANITE AS ILLUSTRATED BY FIG. 1, IN DETAIL (RUXTON and BERRY, 1957)

2. GEOLOGY

The geology of the Kareeya Power Station, Koombooloomba damsite catchment and storage areas is described by the following:-

(a) Denmead (1947 and 1949), who deals briefly with the geology of the proposed Kareeya power station, gives notes on the tunnel profiles of the project, and makes general remarks on the results of 29 test pits in the damsite area.

(b) Gloe (1950), who extends the geological investigation to the approaches of the damsite, and gives sections of 23 drill holes.

(c) Dunlop (1956), who describes rocks exposed by damsite excavations.

(d) Carter (1956), who examines 45 rock samples from the Tully River and Campbell Creek.

The catchment and storage area of the Koombooloomba Dam is covered by dense rain forest, which, together with a thick soil cover, makes a detailed geological investigation difficult.

Plate 2 shows the rock types, as far as are known, derived from the above mentioned geological investigations.

(i) Granite (see Plate 2).

Granite crops out along the Tully River in the vicinity of the dam. Granite outcrops were also observed in the Monday Creek (south-east of the dam). To the north-east granite was found along the forestry road, and in shotholes on traverses S and X, and near a water tower south-west of traverse S.

The granite in the vicinity of the dam is coarse-crystalline, and evenly grained. The main mineral constituents are quartz and felspar, with micas. Elsewhere the granite was found to be fine grained.

The granite is jointed and weathers easily, especially the coarse crystalline type. The maximum depth of weathering proved by drilling on the damsite was 131 ft. In weathering, the felspars are partly, or completely changed into kaolin.

In several places the granite is cut by aplite and pegmatite veins; the contacts of the veins with granite are not weathered.

In this report the terms "decomposed" granite (or rock) and "weathered" granite (or rock) are used. With "decomposed" granite is meant a weathered granite in which the original texture cannot be distinguished any more; with "weathered" granite the original texture can still be recognised although the minerals have been partly or completely changed by the weathering process.

Fig. 1 shows a profile commonly found with weathering granites in tropical climates. Ruxton and Berry (1957) distinguish four zones. Zone 1 consists of soil and/or decomposed granite and Zone IV of jointed granite with possibly minor weathering at the joints. Zones II and III form gradual transitions between Zones I and IV. The boundaries between zones are not sharp, and therefore somewhat arbitrary.

Fig. 2 show. enlarged details of Zone II.

(ii) Porphyry.

This rock crops out approximately 2000 ft. north-east of the dam, in the Tully River, and in Campbell Creek to the west of the dam. On the right hand saddle bank the presence of porphyry was proved by drillhole R.B.S.2. Outcrops of porphyry have been found along the forestry road, and porphyry was found in shotholes on traverses P and V.

The porphyries belong to the family of quartz diorites to tonalites (quartz diorite with less than 10 per centum of quartz) and hence have almost the same composition as granites except that the felspars do not contain orthoclase. Generally, the quartz diorite porphyry specimens showed a coarse crystalline ground mass, whereas the tonalite porphyry has a fine-crystalline ground mass.

(iii) Intrusive rocks.

(a) Basalt.

During the excavation for the dam a basalt dyke was uncovered, the basalt being highly weathered. Similar dykes were found in the quarry for the dam (south-west of the dam, along the road to Ravenshoe) and to the north of the right hand saddle bank along the forestry road.

(b) Trachyte.

A dyke of trachyte was found in one of the tributaries of the Campbell Creek west of the right hand saddle bank (see Plate 2).

3. METHODS AND EQUIPMENT

(i) Seismic Method.

The seismic refraction method of exploration depends on the contrast in the elastic properties of different rock formations and on discontinuities between these formations. Full details of the method have already been given in the report on the Barron Falls geophysical survey. (Polak and Mann, 1959).

In the Koombooloomba seismic survey great difficulty was experienced in transmitting enough energy into the ground to obtain a record on which the arrival times of the seismic wave were sufficiently distinct. It was therefore necessary to drill shot holes to 25 ft deep and to charge them with up to 50 lbs. of explosives. Where these shot-holes did not reach the water-table the explosives were tamped with water (400 gals. of water were often used in one hole). To limit the number of shot-holes which had to be drilled with a hand auger, shots were fired 250 ft. from each end of the traverse and repeated at the same shot-point as the geophone spread was moved along the traverse.

In the field work and calculations the "Method of Differences" was used. (Heiland, 1946; Polak et al., 1959).

Theoretically the velocity of longitudinal and transverse waves in elastic media is given by the following formulae (Loet, 1950):-

$$V_L = \frac{1}{12} \quad \frac{E}{\delta} \quad \frac{1 - \sigma}{(1 + \sigma)\ (1-2\sigma)}$$

$$V_t = \frac{1}{12} \quad \frac{E}{\delta} \quad \frac{1}{2\ (1 + \sigma)}$$

in which:

V_L = Longitudinal velocity in ft/sec.

V_t = Transverse velocity in ft/sec.

E = Young's Modulus in lb/sq. in.

σ = Poisson's Ratio

δ = Density lb. $sec^2 in^{-1} / in^3$

It is therefore possible to calculate all the other dynamical properties of rocks :-

G = Modulus of rigidity in lb/sq.in.

B = Bulk modulus in lb/sq.in.

$$\left(\frac{V_L}{V_t}\right)^2 = \frac{\sigma - 1}{\sigma - \frac{1}{2}}$$

$$E = 144 \; V_L^2 \; \delta \cdot \frac{(1 + \sigma)(1 - 2\sigma)}{1 - \sigma}$$

$$G = \frac{E}{2(1 + \sigma)}$$

$$B = \frac{E}{3(1 - 2\sigma)}$$

The seismic recording equipment used in the survey was a 12-channel reflection-refraction seismograph manufactured by the Midwestern Geophysical Laboratory, Tulsa, Oklahoma, with Midwestern geophones of natural frequency 8 c.p.s. to detect longitudinal waves and S.I.E. geophones with natural frequency of 6 c.p.s. to detect transverse waves.

(ii) Resistivity Traversing.

Differences in the structure and composition of the rocks produce variations in their electrical resistivity. Hard, non-porous and unweathered rocks as a rule have a high resistivity. Shearing and fracturing results in localised weathered zones which produce a decrease in resistivity because of the subsequent rise in the amount of saline water contained in them. In general, it may be said that the resistivity of the rock is inversely proportional to the product of its porosity and the salinity of the pore solutions.

A method of constant spacing resistivity traversing, similar to that used at the Barron Falls, was employed at Koombooloomba (Polak et al, 1959).

The equipment used was the Megger Earth Resistivity Tester manufactured by Evershed and Vignoles Ltd., London.

(iii) Magnetic Method.

The measured magnetic intensity at any point on the earth's surface is mainly the resultant of two vectors, an induced magnetic intensity vector in the approximate direction of the earth's magnetic field and a remanent magnetic intensity vector, which may lie in any direction, inherent to the rock. Magnetic measurements may indicate, in certain areas, such features as faults, and boundaries between near-surface formations, and it is sometimes possible also to obtain rough depth estimates from these measurements. The magnetic susceptibility of a rock is principally related to its magnetite content. In weathering the magnetite is changed into haematite or limonite, thus lowering the magnetic susceptibility of the rock. Hence, weathered dykes (e.g. a weathered basalt dyke) may show as a "low" on the magnetic profile.

A Watts vertical force variometer manufactured by Hilger and Watts Ltd., London, was used, with a 50 ft. interval between the stations.

(iv) Traverses.

The arrangement of all geophysical traverses surveyed at Koombooloomba is shown on Plate 2. These traverses may be grouped as follows:-

Left bank traverses. - Traverses A to G, Plates 3 to 6.
Right bank " - Traverses H to O, Plates 7 to 10.
Ridge traverses - Traverses P to X, Plates 11 to 14.

Table 1 gives the lengths of traverses surveyed by each geophysical method.

TABLE 1.

Section	Seismic (ft)	Resistivity (ft)	Magnetic (ft)
Left Bank	9150	-	9650
Right Bank	6950	2850	6950
Ridge	8500	-	8500
TOTAL	24600	2850	25100

4. RESULTS

(i) Density, Unit weight and porosity.

Table 2 gives the values of density, unit weight and porosity of granite and quartz-diorite porphyry from Koombooloomba. The values were obtained by measuring the weight of samples in air and in water.

TABLE 2.

Rock type	Density cgs units	Unit weight lb/in ft.	Porosity	No. of samples
Granite	2.62	164.00	1.13	11
Quartz-diorite porphyry	2.68	168.00	0.93	10

(ii) Velocities.

Although the principal objective of the seismic method is the determination of the depth to the elastic discontinuities, the seismic velocities are an indication of weathering, jointing and fracturing in shear-zone of the bedrock.

Fig. 1 (see chapter II, on geology) shows that in granites the intensity of weathering, and the amount of weathered material, decrease with increasing depth. The same feature is found for the quartz-diorite porphyry. (Suwa, Matsuzawa, Iida and Yamasaki 1958). From a study of Plates 3 to 5 and 7 to 14, it follows that the velocities may be grouped into seven groups, the lowest velocities corresponding to soil and decomposed rocks, the highest to unweathered rocks. Table 3 shows the above-mentioned seven groups, with a tentative interpretation of the velocities corresponding to certain rock types, into geological terms.

TABLE 3.

Group No.	Recorded velocities ft/sec.	Rock types
1	1000	Soil
2	1400 - 3000	Decomposed granite or porphyry unconsolidated rock.
3	3000 - 5000	Very weathered granite or porphyry.
4	6000 - 9000	Weathered granite or porphyry.
5	12000 - 15000	Jointed, fractured and/or sheared granite or porphyry; joints or fractures weathered.
6	15000 - 16500	Unweathered rock, probably granite, may be jointed and some joints may be slightly weathered.
7	16500 - 20000	Unweathered rock, mostly porphyry.

As a rough approximation, Zones I, II, III and IV of Figure 1 (see chapter II) may respectively be fitted into groups 2, 3, 4, and 5 of Table 3.

(iv) Elastic properties of rocks.

Table 4 shows the values of the elastic properties of the rocks and the data from which they were calculated. An apparent velocity value was used to calculate Poisson's Ratio. Apparent velocity is defined as the velocity obtained by dividing the distance between shot-point and geophone by the time taken for the wave to cover the distance.

The value of the Poisson's Ratio calculated from the apparent velocities may differ from the value calculated from true velocities. For the conditions met with at Koombooloomba the errors are small (4 to 10 per cent) as the errors decrease with increasing distance between the shot-point and the geophone.

Other elastic properties were calculated by the use of the formulae given in Part 3 of this report.

Experimental evidence shows that the values of all elastic properties of rocks obtained by dynamical methods (seismic wave propagation) are generally higher than those obtained statically (U.S. Bureau of Reclamation, 1953).

(v) Depth to the bedrock.

The results of the depth determination are shown on Plates 3 to 14 in the form of geological sections on the seismic traverses. The depth to the fresh rock was calculated, using an apparent velocity value obtained on weathering spreads. Recorded seismic velocities are shown on Table 3 Plates 3 to 14. On a short traverse one weathering spread was generally placed in the middle of the traverse; more than one weathering spread was placed on longer traverses. This method may introduce some error in depth determination as it assumes uniformity in the proportions of different zones in the vertical section. Thus in sections where the rock is more resistant to weathering and large "core stones" are left on/or near the surface, the thickness of the decomposed and weathered rock may be underestimated.

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The accuracy of depth determination may be lower on traverses A, B and part of C. Over this section the shots were only fired on one side of the spread; some in line, some broadside. With shots in one direction only it is necessary to assume the seismic velocity of the rock to calculate the thickness of the overlying rocks. A wrong assumption can cause errors in absolute depth to the fresh rock, but the error in relative depth from station to station along the traverse is likely to be much smaller and the profile shown for the surface of the fresh rock is expected to be quite accurate.

(vi) Type of the bedrock.

It has been mentioned before (Table 3) that the seismic velocity in granite is lower than in porphyry. On the left bank of the Tully River, where only granite appears to be present, the seismic velocity is 16,500 ft/sec or less (see Plates 3 to 6). Three drill-holes placed on the right hand saddle bank dam (see Plate 2 and Plate 8) proved the boundary between granite to the south and porphyry to the north. The seismic velocity in the unweathered rock south of the drill-hole RHB 2 is 16,500 ft/sec. or less (see Plates 7 and 8). The seismic velocity to the north of the right hand saddle bank dam up to Station 339, traverse O (Plate 10) is greater than 16,500 ft/sec. with one exception at Stations 301 to 310 (Plate 10) where it is 14,000 - 15,000 ft/sec.

This does not necessarily prove that all this area is underlain by porphyry, as the magnetic and resistivity profiles show great variations in intensity. The sudden decrease of the magnetic intensity on Station N 302 to N 306 (Plate 10) may be an indication of the existence of a very weathered basalt dyke, possibly along a boundary between two types of rooks, of lower resistivity and higher magnetic intensity to the south and of higher resistivity and lower magnetic susceptibility to the north. (See 3, (iii)).

Further north the magnetic profile is very disturbed, suggesting changes of rock type. The "low" in magnetic intensity on Stations N 309 and N 325 to N 327 may be an indication of the existence of other basaltic dykes in this area.

On Traverse O, north of the station O 338, the velocity drops below the value of 16,500 ft/sec. Probably the seismic traverse crosses a main boundary between porphyry to the south and granite to the north. The existence of this boundary was envisaged by geologists and is shown on Plate 2.

On the ridge section seismic velocities are generally lower than on the other sections. A maximum of 18,000 ft/sec. was recorded on the north end of Traverse P, where the porphyry is indicated on geological maps (see Plate 2). Further south the traverse passes over granite and the location of the boundary is not certain, but the seismic velocities are much lower. No increase in velocity was found on Traverse V (near station V 445 Plate 12) where highly weathered porphyry was located in a shot-hole. Further south the traverse crosses again over granites, as indicated on geological maps, and the seismic velocity there is at its minimum for the bedrock, 13,000 ft/sec. (on Traverse U, Plate 12).

5. CONCLUSIONS

The geophysical survey provided information on the depth to the bedrock along three critical sections of the edge of the reservoir. The overburden there consists of soil, and of highly weathered to jointed rock.

The bedrock consists of granite in areas of lower seismic velocity and of porphyry in areas where seismic velocity is over 16,500 ft/sec. The possibility of the existence of three basaltic dykes is indicated.

Poisson's Ratio of the unweathered bedrock, computed from longitudinal and transverse velocities is between 0.25 and 0.275.

The corresponding value of the Young's Modulus varies from 4.5×10^6 lb/in^2 to 11.6×10^6 lb/in^2.

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TABLE 4 - Dynamical properties of rocks calculated from apparent velocities.

Traverse	Station	Distance shot to geophone ft.	True Longitudinal velocity ft/sec.	Apparent velocity ft/sec. Long.	Apparent velocity ft/sec. Trans.	Poisson's Ratio	Young's Modulus E 10^6 lb/in^2	Young's Modulus E 10"dynes/in^2	Rigidity Modulus G 10^6 lb/in^2	Rigidity Modulus G 10"dynes/in^2	Bulk Modulus B 10^6 lb/in^2	Bulk Modulus B 10"dynes/in^2
A	1	1200	15000	14800	8900	.260	6.45	4.44	2.58	1.77	4.45	3.06
C	60	1950	16500	15600	8900	.258	6.10	4.20	2.44	1.68	4.14	2.85
D	88	1350	15000	10800	6200	.265	6.40	4.41	2.55	1.76	4.54	3.13
K	238	2300	15500	14000	8100	.254	6.90	4.75	2.76	1.90	4.62	3.18
L	260	2800	20000	17000	9900	.250	11.60	7.99	4.64	3.19	7.65	5.27
O	332	1520	17000	15900	9100	.260	8.30	5.71	3.32	2.28	5.72	3.93
P	360	2900	18000	17300	9800	.265	9.00	6.20	3.60	2.48	6.39	4.40
X	478	1320	13000	11400	6400	.275	4.50	3.10	1.40	1.24	3.33	2.29

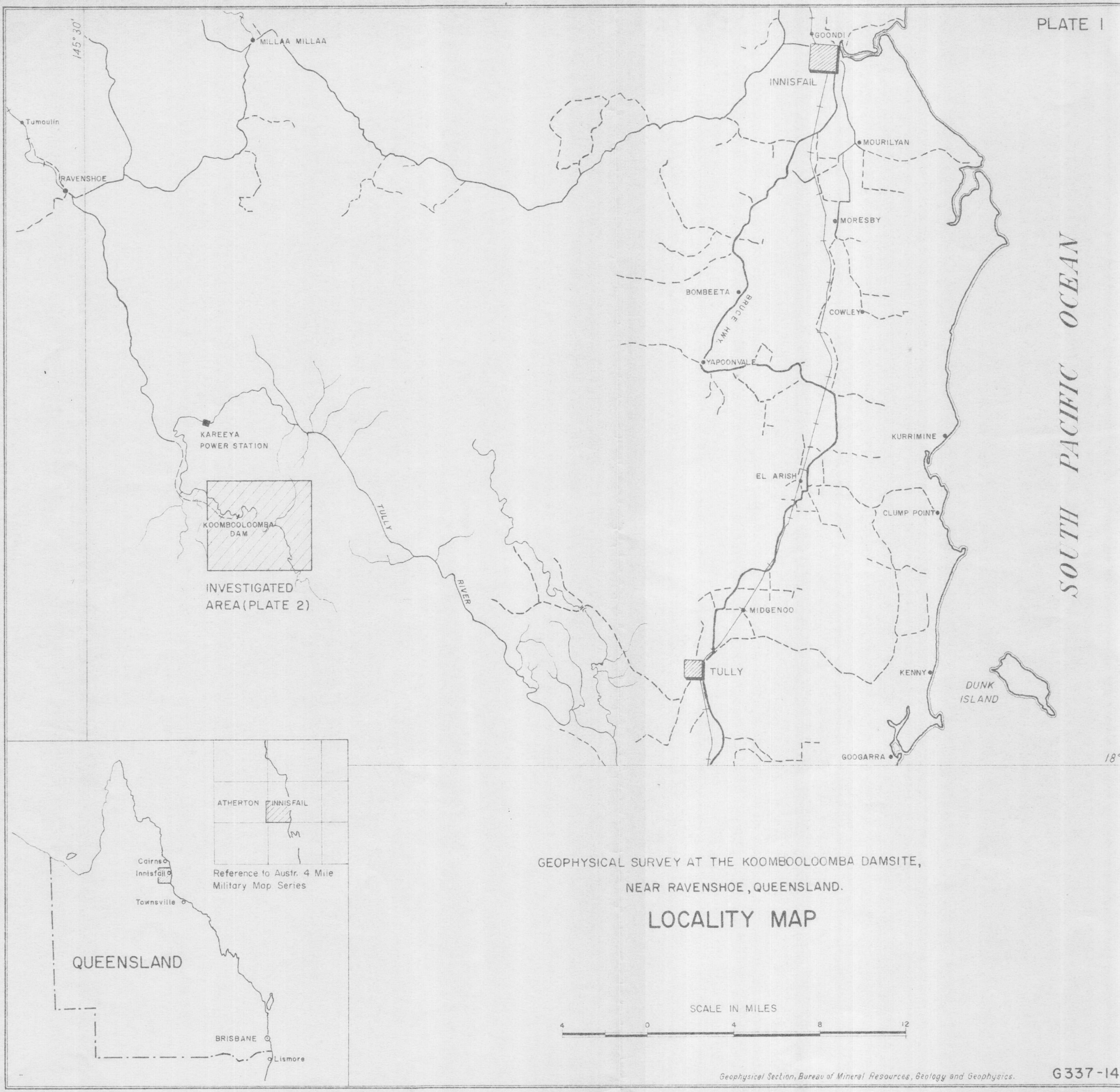

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PLATE 2

Forestry Rd.
Forestry Rd.
Campbell Ck.
Right Hand Saddle Bank
D.D. RBS2
D.D. RBS3
D.D. RBS1
Tully R.
Winton
Nitchie Ck.
DAM
Left Hand Saddle Bank
Monday
N
Granite
Porphyry
Intrusive Basalt
Intrusive Trachyte
Boundary Identified
" Assumed
Survey Line
Geophysical Traverse
Compiled from information from Geological Survey of Queensland and Coordinator General's office.
Geophysicist
GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND.
Scale 1" = 1000'
1000' 0 500' 1000' 1500' 2000'
G337-1
To Accompany Record 1959, No 120

— — — PONDED LEVEL
(5000) SEISMIC VELOCITY IN FT/SEC.
— 51' — DEPTH TO LAYER WITH DIFFERENT SEISMIC VELOCITY

Vertical and Horizontal Scales (in feet)
100 0 50 100 150 200

GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND.

SECTION ON GEOPHYSICAL TRAVERSES G AND F

Station No.	G183	G182	G181	G180	G179	G178	G177	G176	G175	G174	G173	G172	G171	G170	G169	G168	G167	G166	G165
Surface level	2609	2602	2591	2597	2593	2602	2604	2602	2596	2595	2601	2609	2616	2622	2627	2633	2639	2643	2642
Depth to fresh rock	109	100	108	98	87	87	84	84	70	74	84	90	100	112	78	90	104	116	90

Station No.	F165	F164	F163	F162	F161	F160	F159	F158	F157	F156	F155	F154	F153	F152	F151	F150	F149	F148	F147	F146	F145	F144	F143	F142	F141	F140	F139	F138	F137	F136	F135	F134	F133	F132	F131	F130	F129	F128
Surface level	2642	2635	2631	2623	2616	2608	2605	2600	2596	2587	2578	2573	2569	2567	2564	2560	2554	2546	2536	2527	2518	2511	2501	2503	2508	2510	2513	2519	2529	2541	2550	2558	2563	2567	2573	2578	2582	2587
Depth to fresh rock	90	88	90	88	88	67	67	76	78	78	67		75	78	85	93	102	95	93	72	64	55	61	56	52	52	52	85	88	104	98	126	119	100	97	100	95	108

E. J. Polak
Geophysicist

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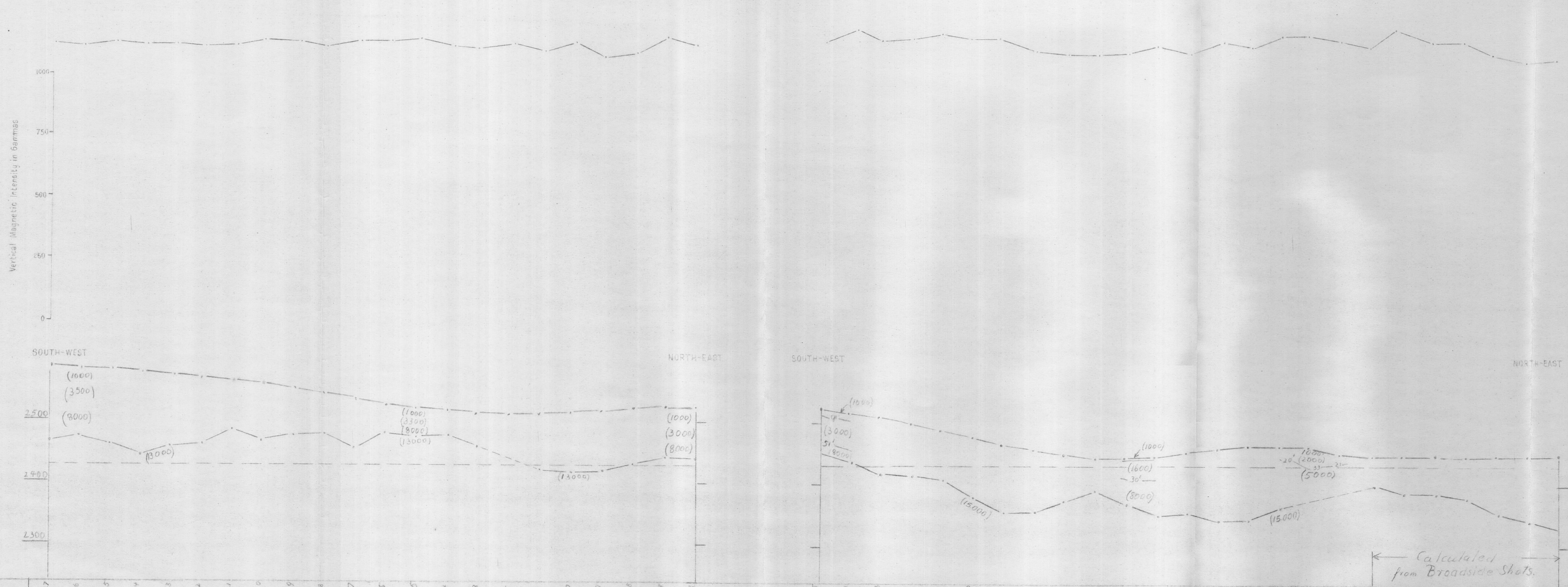
To Accompany Records 1958 No.160

PLATE: 4



STATION Nº	E127	E126	E125	E124	E123	E122	E121	E120	E119	E118	E117	E116	E115	E114	E113	E112	E111	E110	E109	E108	E107	E106
SURFACE LEVEL	2587	2586	2584	2579	2573	2568	2564	2561	2551	2544	2533	2527	2521	2519	2515	2513	2514	2516	2518	2522	2526	2524
DEPTH TO FRESH ROCK	120	108	116	132	117	102	77	90	72	62	76	46	44	37	50		88	93	95	85	80	79

STATION Nº	D105	D104	D103	D102	D101	D100	D99	D98	D97	D96	D95	D94	D93	D92	D91	D90	D89	D88	D87	D86	D85	D84	D83	D82	D81
SURFACE LEVEL	2524	2518	2511	2502	2490	2479	2468	2460	2452	2447	2446	2450	2455	2462	2466	2467	2465	2455	2449	2450	2451	2451	2451	2452	2452
DEPTH TO FRESH ROCK	71	78	93	85	78	99	106	102	78	56	80	96	99	118	124	102			46	67	64	68	96	108	120

---- PONDED LEVEL
(3000) SEISMIC VELOCITY IN FT./SEC.
-51'- DEPTH TO LAYER WITH DIFFERENT SEISMIC VELOCITY

HORIZONTAL AND VERTICAL SCALE (IN FEET)
100 0 50 100 150 200

GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND.

SECTIONS ON GEOPHYSICAL TRAVERSES E AND D

E J Polak
Geophysicist

G337-3

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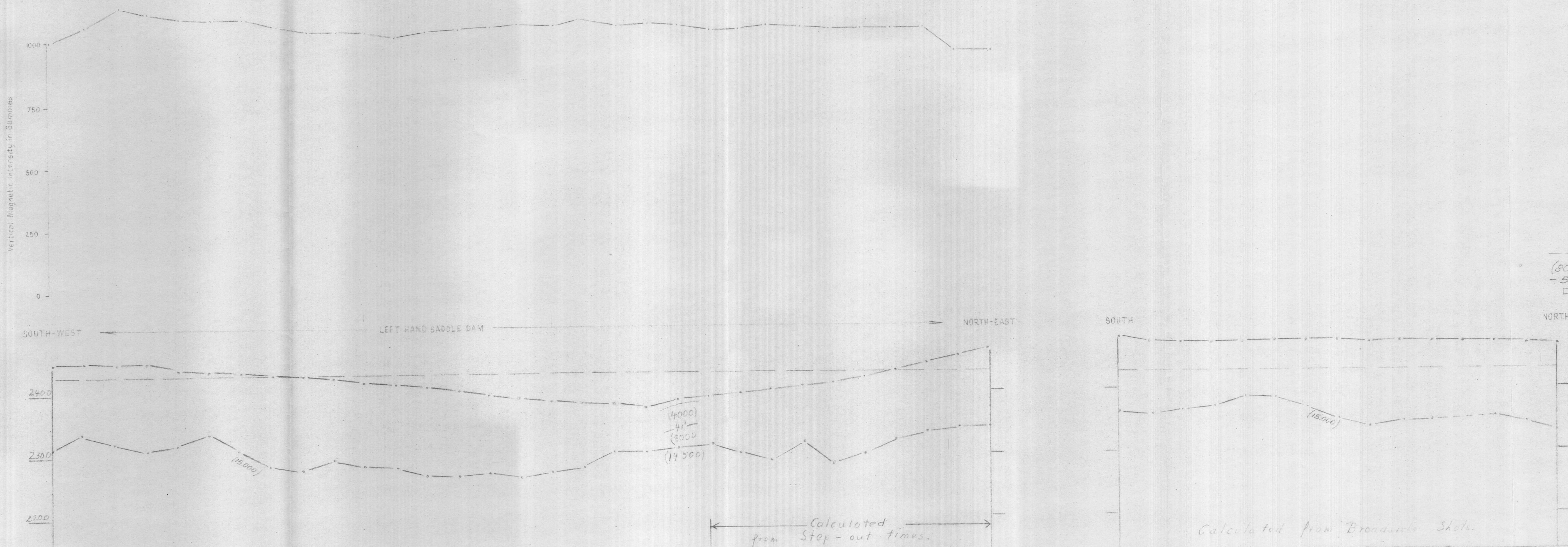
GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND

SECTIONS ON GEOPHYSICAL TRAVERSES C AND B



STATION No	C80	C79	C78	C77	C76	C75	C74	C73	C72	C71	C70	C69	C68	C67	C66	C65
SURFACE LEVEL	2452	2452	2452	2451	2441	2438	2435	2431	2428	2425	2419	2415	2411	2405	2395	2393
DEPTH TO FRESH ROCK	132	108	124	136	117	97	121	141	145	124	129	129	137	133	124	124

STATION No	C64	C63	C62	C61	C60	C59	C58	C57	C56	C55	C54	C53	C52	C51	C50
SURFACE LEVEL	2389	2384	2383	2385	2387	2393	2397	2402	2407	2412	2421	2432	2444	2458	2466
DEPTH TO FRESH ROCK	108	100	72	68	72	76	92	110	137	126	120	106	108	114	124

STATION No	B49	B48	B47	B46	B45	B44	B43	B42	B41	B40	B39	B38	B37	B36	B35
SURFACE LEVEL	2482	2475	2473	2474	2475	2475	2475	2475	2475	2475	2474	2474	2474	2472	2470
DEPTH TO FRESH ROCK	124	118	112	103	91	91	106	124	136	130	127		118	121	139

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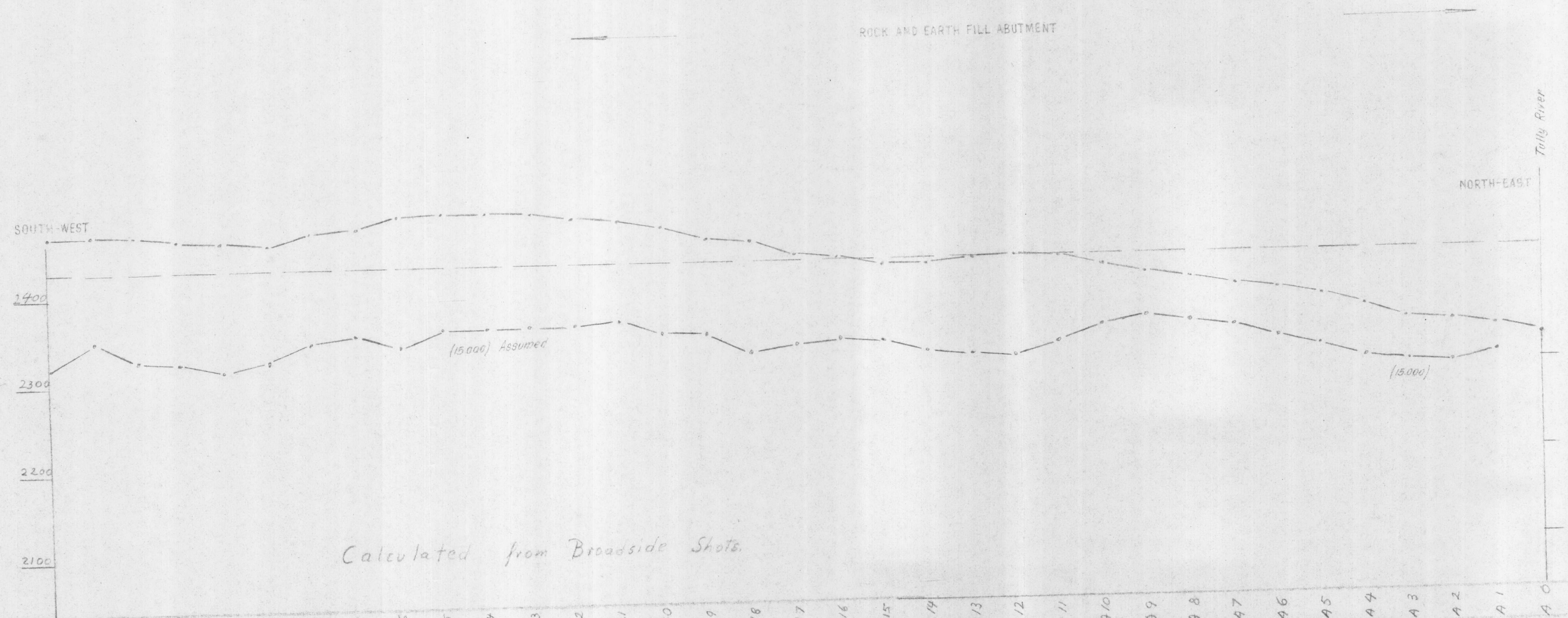

STATION Nº	A34	A33	A32	A31	A30	A29	A28	A27	A26	A25	A24	A23	A22	A21	A20	A19	A18	A17
SURFACE LEVEL	2471	2471	2470	2472	2472	2467	2469	2472	2488	2485	2488	2488	2482	2470	2469	2452	2450	2433
DEPTH TO FRESH ROCK	148	118	139	136	148	130	121	121	148	130	130	130	121	112	118	109	127	103

STATION Nº	A16	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
SURFACE LEVEL	2430	2423	2422	2426	2428	2424	2418	2408		2390	2385	2377	2364	2346	2344	2338	
DEPTH TO FRESH ROCK	97	85	97	106	115	97	69	57	47	47	54	55	56	36	41	23	

— — — PONDED LEVEL
(8000) SEISMIC VELOCITY IN FT/SEC.
–51'– DEPTH TO LAYER WITH DIFFERENT SEISMIC VELOCITY

HORIZONTAL AND VERTICAL SCALE (IN FEET)
100 0 50 100 150 200

GEOPHYSICAL SURVEY OF THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND

SECTION ON SEISMIC TRAVERSE A

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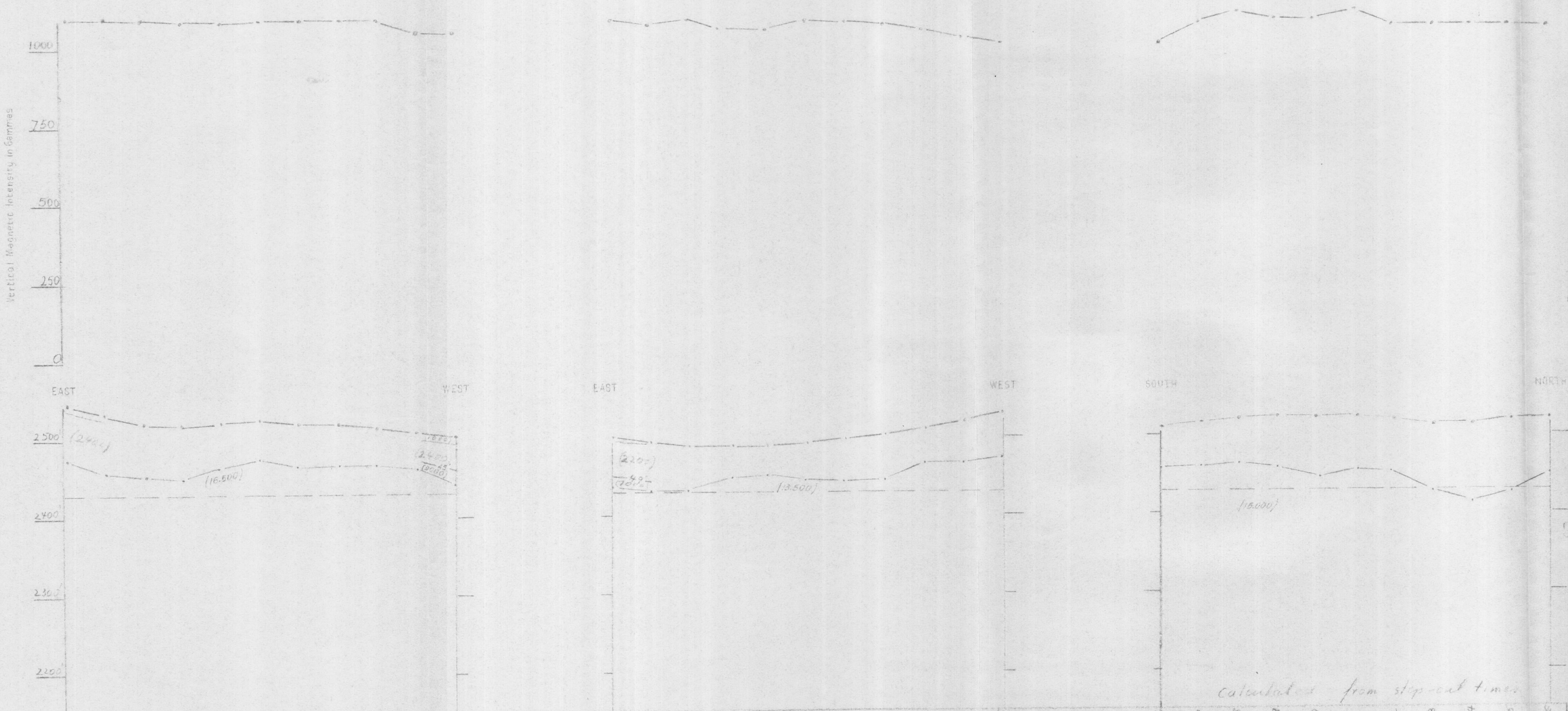
PLATE: 7.



--- BONDED LEVEL

(8000) SEISMIC VELOCITY IN FT/SEC.
-51- DEPTH TO LAYER WITH DIFFERENT SEISMIC VELOCITY

HORIZONTAL AND VERTICAL SCALE (IN FEET)
100 0 50 100 150 200

GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND

SECTIONS ON GEOPHYSICAL TRAVERSES H, I AND J

calculated from step-out times

STATION No	SURFACE LEVEL	DEPTH TO FRESH ROCK
H 184	2545	70
H 185	2533	75
H 186	2521	66
H 187	2519	68
H 188	2522	57
H 189	2524	50
H 190	2523	54
H 191	2522	51
H 192	2518	49
H 193	2512	46
H 194	2507	60
I 195	2503	64
I 196	2497	62
I 197	2492	58
I 198	2491	40
I 199	2491	37
I 200	2493	46
I 201	2498	54
I 202	2506	57
I 203	2510	44
I 204	2522	53
I 205	2531	55
J 206	2516	51
J 207	2519	56
J 208	2523	58
J 209	2525	67
J 210	2520	77
J 211	2525	70
J 212	2522	67
J 213	2516	86
J 214	2517	100
J 215	2520	93
J 216	2521	72

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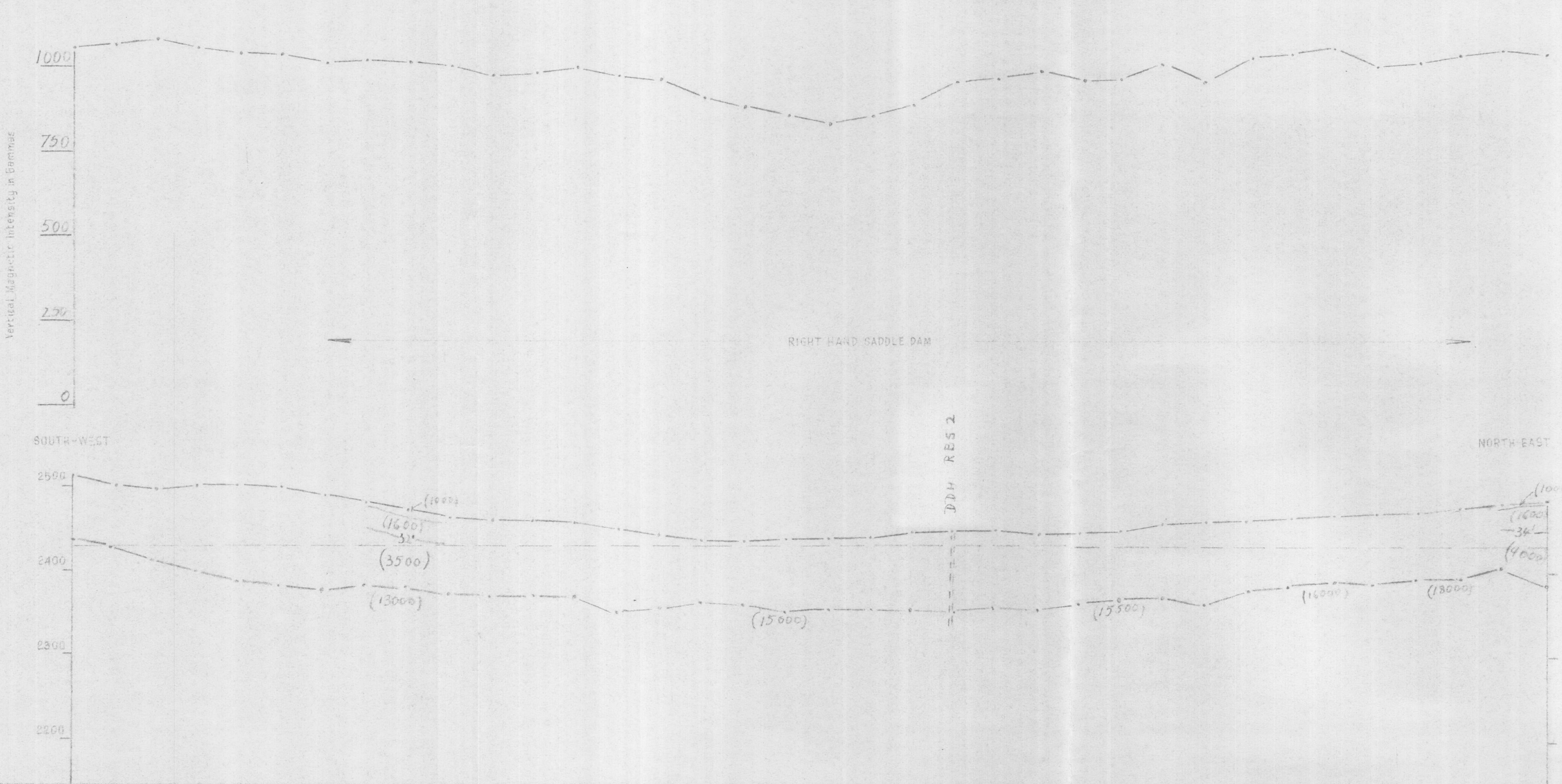

---- PONDED LEVEL
(8000) SEISMIC VELOCITY IN FT/SEC.
- 51' - DEPTH TO LAYER WITH DIFFERENT SEISMIC VELOCITY

HORIZONTAL AND VERTICAL SCALE (IN FEET)
100 0 50 100 150 200

GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND.

SECTION ON GEOPHYSICAL TRAVERSE K

STATION Nº	SURFACE LEVEL	DEPTH TO FRESH ROCK
K 217	2515	73
K 218	2505	70
K 219	2503	82
K 220	2505	102
K 221	2305	112
K 222	2502	116
K 223	2494	110
K 224	2481	99
K 225	2479	91
K 226	2469	84
K 227	2464	89
K 228	2464	89
K 229	2461	89
K 230	2456	97
K 231	2448	84
K 232	2442	72
K 233	2441	74
K 234	2443	84
K 235	2443	81
K 236	2443	84
K 237	2450	90
K 238	2451	91
K 239	2451	93
K 240	2449	90
K 241	2450	82
K 242	2451	80
K 243	2460	87
K 244	2451	99
K 245	2465	82
K 246	2468	81
K 247	2470	79
K 248	2471	81
K 249	2475	81
K 250	2479	82
K 251	2486	72
K 252	2481	97

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— — — PONDED LEVEL
(8000) SEISMIC VELOCITY IN FT./SEC.
-51'- DEPTH TO LAYER WITH DIFFERENT SEISMIC VELOCITY

HORIZONTAL AND VERTICAL SCALE (IN FEET)
100 0 50 100 150 200

GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE NEAR RAVENSHOE, QUEENSLAND

SECTIONS ON GEOPHYSICAL TRAVERSES L AND M

STATION No	SURFACE LEVEL	DEPTH TO FRESH ROCK
L 253	2488	94
L 254	2486	86
L 255	2487	86
L 256	2435	84
L 257	2483	85
L 258	2481	86
L 259	2483	86
L 260	2485	90
L 261	2487	90
L 262	2489	90
L 263	2490	87
L 264	2490	83
L 265	2490	80
L 266	2484	75
L 267	2486	68
L 268	2488	62
M 269	2487	75
M 270	2482	83
M 271	2482	70
M 272	2488	97
M 273	2493	74
M 274	2500	78
M 275	2509	91
M 276	2514	106
M 277	2518	104
M 278	2517	102
M 279	2513	104
M 280	2508	102
M 281	2502	107
M 282	2495	97
M 283	2468	94
M 284	2482	85
M 285	2478	94
M 286	2475	88
M 287	2478	82
M 288	2484	90

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To Accompany Record 1959, No. 126


PLATE 10.
MAGNETIC PROFILE
RESISTIVITY
Apparent Resistivity (Ohm-cm) X 10³
Vertical Magnetic Intensity - Gammas
SOUTH
NORTH
SOUTH-WEST
NORTH-EAST
PONDED LEVEL
(6000) SEISMIC VELOCITY IN FT./SEC.
-51'- DEPTH TO LAYER WITH DIFFERENT SEISMIC VELOCITY
HORIZONTAL AND VERTICAL SCALE (IN FEET)
100 0 50 100 150 200
GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND.
SECTIONS ON GEOPHYSICAL TRAVERSES N AND O
STATION No
SURFACE LEVEL
DEPTH TO FRESH ROCK
Geophysicist
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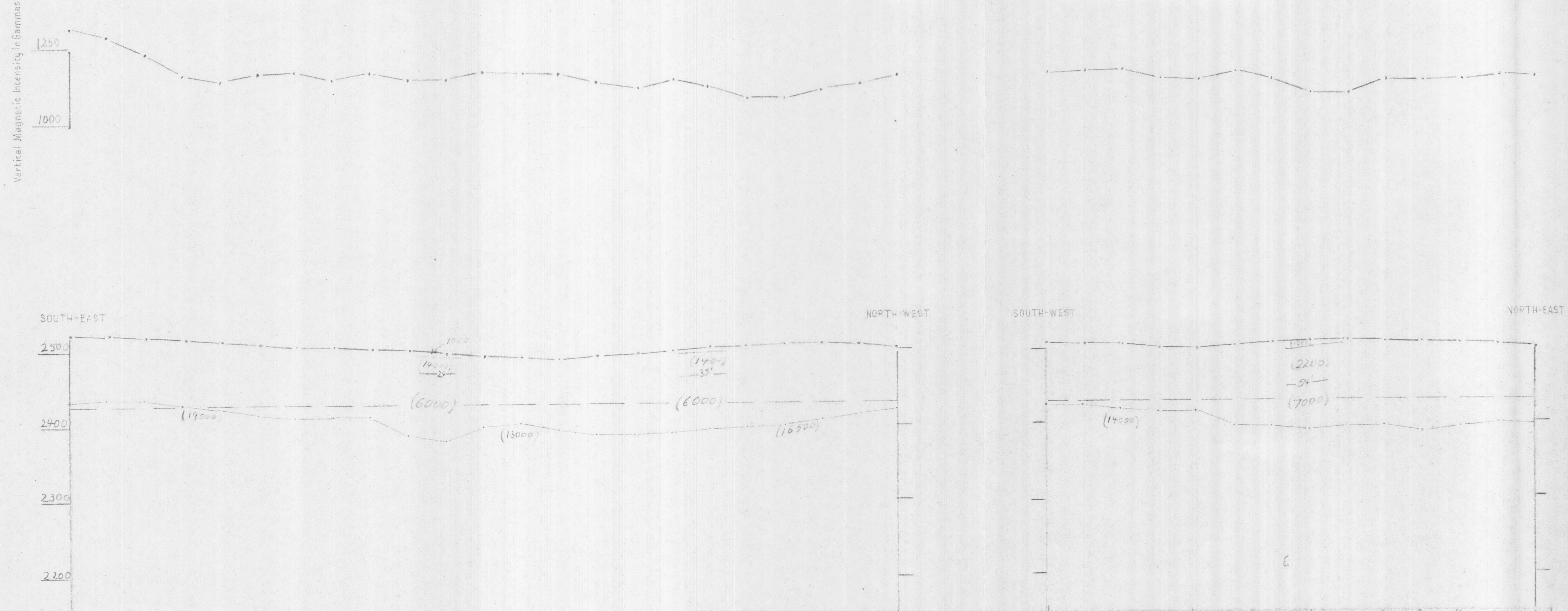
PLATE : 11.



STATION Nº	2522 X 492	2520 X 491	2517 X 490	2515 X 489	2511 X 488	2508 X 487	2506 X 486	2504 X 485	2502 X 484	2495 X 483	2496 X 482	2492 X 481
DEPTH TO FRESH ROCK	90	85	83	96	88	94	96	93	91	108	106	94

STATION Nº	2489 X 480	2488 X 479	2490 X 478	2495 X 477	2499 X 476	2502 X 475	2504 X 474	2506 X 473	2507 X 472	2507 X 471	2506 X 470
DEPTH TO FRESH ROCK	87	95	102	108	109	109	107	107	100	94	86

(Station Nº and Surface Level are written together in each column, as "Surface Level X Station".)

STATION Nº	W 469	W 468	W 467	W 466	W 465	W 464	W 463	W 462	W 461	W 460	W 459	W 458	W 457	W 456
SURFACE LEVEL	2503	2503	2500	2499	2498	2501	2505	2508	2507	2508	2506	2505	2502	2499
DEPTH TO FRESH ROCK	80	81	81	86	84	105	111	118	116	115	118	113	105	104

— — PONDED LEVEL

(8000) SEISMIC VELOCITY IN FT/SEC.
-51- DEPTH TO LAYER WITH DIFFERENT SEISMIC VELOCITY

HORIZONTAL AND VERTICAL SCALE (IN FEET)
100 0 50 100 150 200

GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND

SECTIONS ON GEOPHYSICAL TRAVERSES X AND W

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STATION Nº	SURFACE LEVEL	DEPTH TO FRESH ROCK
V 455	2494	96
V 454	2488	92
V 453	248[illegible]	81
V 452	2478	73
V 451	247[illegible]	66
V 450	2472	64
V 449	2470	62
V 448	2469	62
V 447	2469	69
V 446	2469	73
U 445	[illegible]	[illegible]
U 445	2461	77
U 444	2469	
U 443	2468	
U 442	2463	71
U 441	2465	91
U 440	2470	94
U 439	2473	91
U 438	2478	95
U 437	2488	109
U 436	2489	108
U 435	249[illegible]	104
U 434	2501	108
T 433	2507	119
T 432	[illegible]	105
T 431	[illegible]	101
T 430	2515	102
T 429	2509	86
T 428	2504	97
T 427	2499	80
T 426	2493	77
T 425	2489	86
T 424	2485	77
T 423	2482	73
T 422	2481	64
T 421	2485	74
T 420	2489	84
T 419	2493	84
T 418	2498	76
S 417	2501	85

GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND

SECTIONS ON GEOPHYSICAL TRAVERSES V, U AND T

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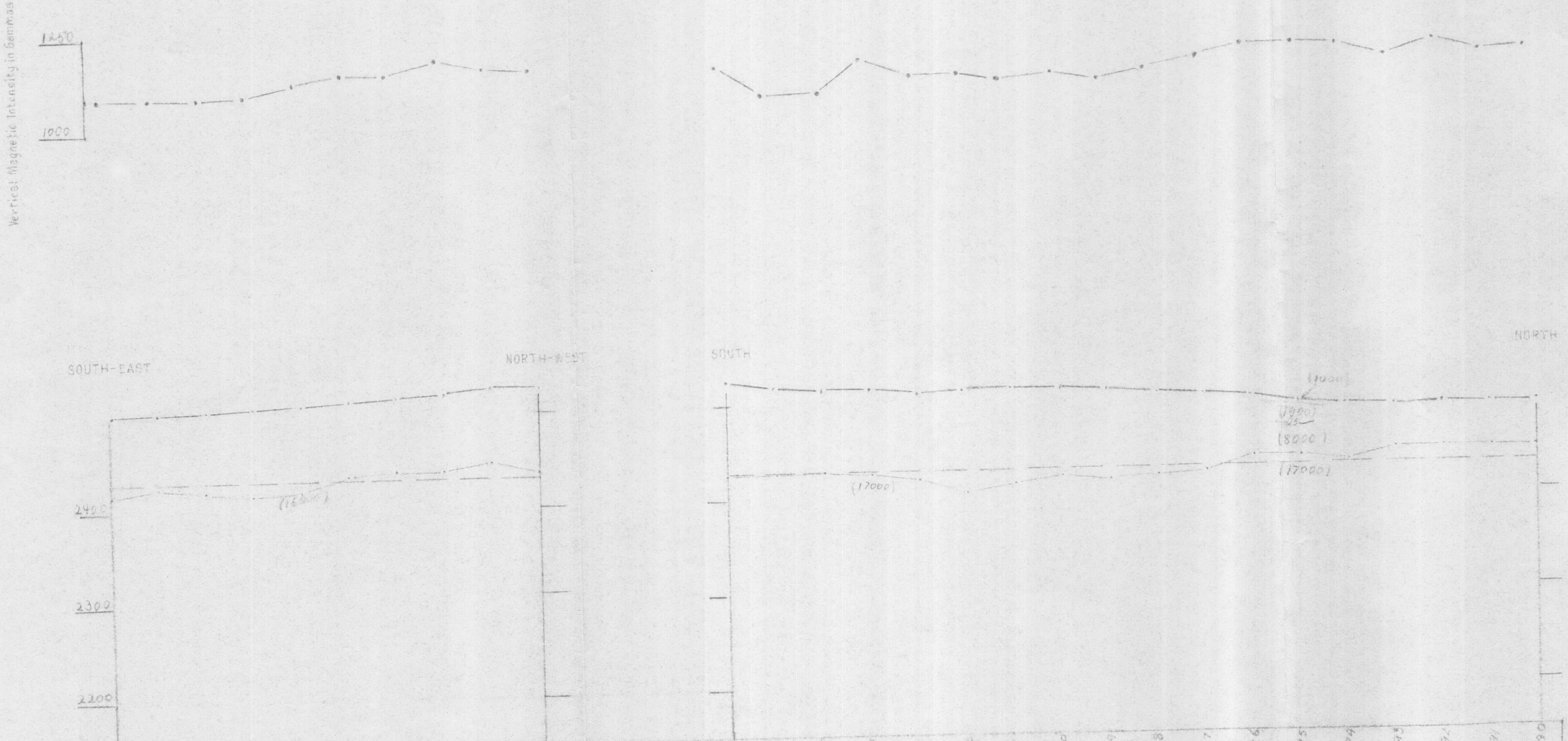
PLATE: 13



— — — PONDED LEVEL
(8000) SEISMIC VELOCITY IN FT./SEC.
~51~ DEPTH TO LAYER WITH DIFFERENT SEISMIC VELOCITY

HORIZONTAL AND VERTICAL SCALE (IN FEET)
100 0 50 100 150 200

GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND

SECTIONS ON GEOPHYSICAL TRAVERSES S AND R

STATION No	SURFACE LEVEL	DEPTH TO FRESH ROCK
S 417	2500	85
S 416	2503	81
S 415	2505	87
S 414	2507	91
S 413	2509	92
S 412	2512	80
S 411	2517	80
S 410	2521	91
S 409	2524	80
S 408	2526	93
R 407	2525	102
R 406	2519	94
R 405	2515	88
R 404	2513	90
R 403	2511	96
R 402	2512	110
R 401	2513	102
R 400	2516	92
R 399	2512	96
R 398	2509	90
R 397	2506	85
R 396	2501	64
R 395	2496	61
R 394	2493	61
R 393	2492	46
R 392	2492	45
R 391	2491	46
R 390	2492	47

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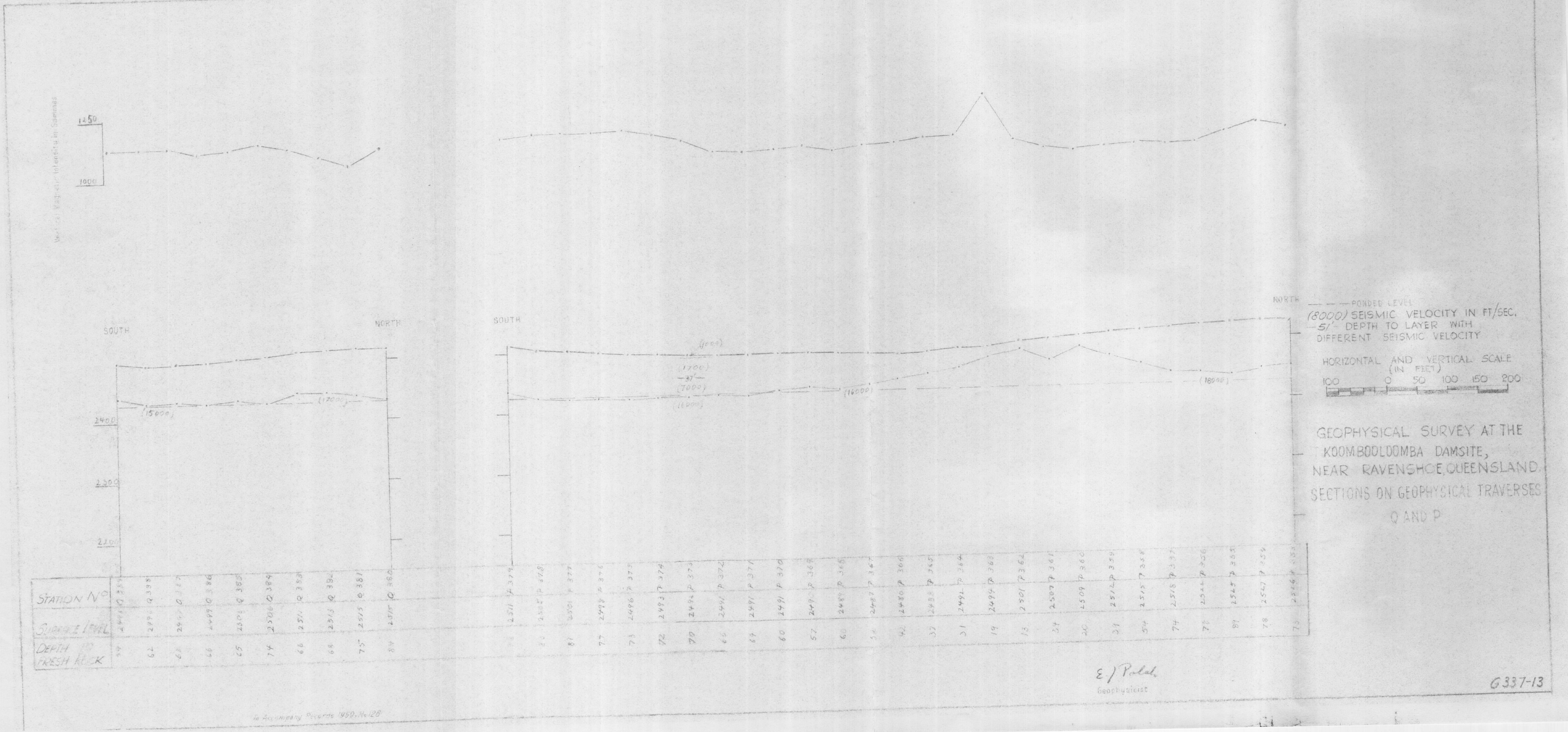
PLATE: 14.


SOUTH
NORTH
PONDED LEVEL
(8000) SEISMIC VELOCITY IN FT/SEC.
51' DEPTH TO LAYER WITH DIFFERENT SEISMIC VELOCITY
HORIZONTAL AND VERTICAL SCALE (IN FEET)
100 0 50 100 150 200
GEOPHYSICAL SURVEY AT THE KOOMBOOLOOMBA DAMSITE, NEAR RAVENSHOE, QUEENSLAND.
SECTIONS ON GEOPHYSICAL TRAVERSES Q AND P
STATION No
SURFACE LEVEL
DEPTH TO FRESH ROCK
Geophysicist
G337-13