COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

RECORDS 1956, No. 137

SEISMIC REFRACTION SURVEY OF No. 2 DAM SITE AREA, KIEWA, VICTORIA

by

W. A. WIEBENGA, D. F. DYSON and M. J. O'CONNOR

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ABSTRACT

In response to an application from the State Electricity Commission of Victoria, a seismic survey was carried out over the Kiewa No. 2 Dam Site area to assist in finding the best location for a dam. The results of the seismic survey did not indicate any major faults in the dam site area, but showed that in places the depth of weathering exceeds one hundred feet. Based on the results of both seismic and drilling data, a recommendation is made as to the most suitable location for a dam site.

1. INTRODUCTION.

In response to an application from the State Electricity Commission of Victoria, a seismic refraction survey was made by the Geophysical Section of the Bureau of Mineral Resources over the Kiewa No. 2 Dam Site area.

The Kiewa No. 2 Development Scheme (Plate 1) consists of :-

(i) No. 2 Dam, which will be supplied with water from the Pretty Valley Branch of the East Kiewa River, McKay Creek and the tail-race of No. 1 Power Station.

(ii) No. 2 Head Race Tunnel, about 3½ miles long, to divert this water to

(iii) No. 2 Penstock Line, which leads to

(iv) No. 2 Power Station to be built near the junction of the Pretty Valley and Rocky Valley Branches of the East Kiewa River at Bogong. The drop in water level from No. 2 Dam Site to No. 2 Power Station is about 1,300 feet.

No. 2 Dam Site area is located immediately below the junction of McKay Creek and the Pretty Valley Branch (Plate 1). The approximate co-ordinates of the centre of the area are 1358000N, 1560500E, on the grid of the 4-mile military map series.

In this report the term overburden is used to indicate material of low seismic velocity, This includes the weathered layer of the granodiorite or gneiss, alluvial deposits, soil and loose hill-side material.

The purpose of the survey was to find the most suitable location for a dam within the area. This necessitates an estimate of the thickness of the overburden, the location of any shear and fault zones and river terraces and, if possible, the determination of the nature of the overburden and of the unweathered rock.

The geophysical party consisted of D. F. Dyson, (party leader) and M. J. O'Connor, geophysicists, and J. P. Piggott, field assistant. Additional field assistants were supplied by the Commission. The field work was done during November and December, 1955 and March, 1956.

2. GEOLOGY.

Granodiorite crops out in, and adjacent to, the stream bed in the southern part of the area, as indicated on Plate 1. In the northern part of the area, landslips occur on both banks of the river and the stream bed widens into flats, composed of alluvium and slip debris.

The unweathered granodiorite is closely jointed, the majority of the joints being nearly vertical. The predominant strike of the joints is northerly, which coincides with the direction of the stream in the dam site area.

Isolated outcrops of gneiss occur. Where the gneiss is intersected in drill holes, the contact with the granodiorite is transitional.

Downstream from where the 3,470 foot contour cuts the river, alluvial deposits overlie the basement rock (unweathered granodiorite) on the western side of the valley. The alluvial deposits are 25 feet thick in drill hole 877 (see Plates 2 and 4). In drill hole 879, 5 feet of alluvial deposits underlie hill side debris.

No major faults have been found in the area investigated, although the major "Frying Pan Fault" crops out immediately downstream. Many minor faults with a predominantly easterly strike have been found (Beavis, 1956).

3. METHOD AND FIELD WORK.

The seismic refraction method of survey was selected because from the results estimates of overburden thickness which are sufficiently accurate to be of practical use for engineering purposes, can be made.

The "method of differences" was used to calculate vertical travel times to the unweathered rock (Heiland, 1946 and Dyson, 1956). Difficulties were experienced in measuring reliable seismic velocities in the overburden. Vertical travel times calculated at points near diamond drill holes were therefore used to obtain apparent velocities in the overburden. The vertical travel time at each geophone, multiplied by the apparent velocity in the overburden at that point gives the depth to unweathered rock perpendicular to the surface at the geophone. In this manner the diamond drill hole information was used as a control for the seismic survey and not as a check on the accuracy of the seismic results.

A 12-channel Century 506 portable refraction seismograph was used, with T.I.C. geophones of natural frequency 20 c.p.s. Explosive charges with a maximum of 15 lbs. of 75 per cent gelignite were used, the exact amount depending on the depth of overburden at the shot point and on the distance to the geophone at the reciprocal shot-point.

The traverses, five in number, were cleared and surveyed by the Commission's Survey Section. Nine normal spreads and five weathering spreads were shot in the following manner:

(a) Normal Spreads: Eleven geophones were spaced at fifty-foot intervals along the slope of the ground, with shot points at the ends of the spread and at points sufficiently removed from each end of the spread to record refractions from the unweathered rock over the entire length of the spread.

(b) Weathering Spreads: Eleven geophones were spaced at ten-foot intervals along the slope of the ground, with shot points at 10,50,100 and 250 feet from either end of the spread.

4. RESULTS.

Profiles showing the seismic velocities recorded and the depth to unweathered rock calculated from the seismic results, are reproduced on Plate 2. The depths are plotted perpendicular to the ground surface.

The profile of the unweathered rock along traverse T-T' suggests the presence of terraces cut in the granodiorite between T15 and T22, and west of T28. This could not be confirmed from the drilling logs, however, as no cores were recovered from the upper portions of the drill holes in this vicinity.

The profiles along traverses P-P', Q-Q' and R-R' indicate a general increase in the thickness of the overburden towards the north.

Seismic velocities usually give a fairly good indication of rock type, but to make a definite interpretation a certain amount of geological control is needed. Usually, it is possible to compare drill log descriptions of rock type with the seismic velocities, but in the present survey the descriptions on the drill logs were not always adequate.

Table 1 gives a probable interpretation of the seismic velocities recorded, in terms of rock type.

TABLE 1.

Velocity of Longitudinal Waves (ft/sec.)	Rock Type
1,200 - 1,700	Soil
2,900 - 4,500	Completely weathered granodiorite or gneiss and perhaps alluvial deposits.
5,000 - 7,400	Weathered and fractured granodiorite or gneiss.
10,000 -11,000	Sheared or fractured granodiorite or gneiss, probably slightly weathered along fractures.
15,000 -17,500	Unweathered granodiorite or gneiss, probably slightly jointed or fractured.
19,000 -22,000	Unweathered, unbroken granodiorite or gneiss.

Plate 3 is a contour map of the unweathered rock, compiled from the profiles shown on Plate 2 and the available drill hole information. The main features of the map are:-

(i) A pronounced ridge of unweathered rock with north-easterly strike on the western bank of the Pretty Valley Branch, near Q15.

(ii) A depression in the unweathered rock, with an easterly strike, between P6 and Q4, which could be interpreted as a shear zone. This may explain why, when shooting from the southern end of traverse P-P', the transmission of energy of the sound wave through the ground was poor towards the north.

(iii) A depression in the southern part of the area, coinciding roughly with the Pretty Valley Branch, is indicated by contours 3480 to 3520.

(iv) On the eastern bank, the contours indicate a depression in the unweathered rock near S11. The presence of a nearby creek, flowing in the same direction as the strike of the depression, suggests that this feature may possibly be interpreted as a former gully (now in-filled) formed on a shear zone.

(v) The closure of the contours round station T20 may possibly be interpreted as an indication of the remnants of a river terrace or a small "hill" on the general slope.

Plate 4 is an isopach plan showing the thickness of the overburden, as calculated from seismic and drilling data. The plan clearly shows that the overburden thickness decreases towards the river and may even be zero in the river bed.

5. ACCURACY OF RESULTS.

Errors are introduced into z, the calculated depth to fresh rock, by errors in the apparent velocity (v) and the vertical travel time (t).

$$z = v.t.$$

Let the error in v and t be Δv and Δt respectively. Then the error, Δz, in z is given by :-

$$\Delta z = (v+\Delta v)(t+\Delta t) - v t$$

$$= t\Delta v + v\Delta t + \Delta v \Delta t.$$

The third term, $\Delta v \Delta t$, is of a small order of magnitude and hence may be neglected.

$$\therefore \Delta z = t\Delta v + v\Delta t$$

$$\text{i.e.} \frac{\Delta z}{z} = \frac{\Delta v}{v} + \frac{\Delta t}{t}$$

From velocity and drill hole data the term $\frac{\Delta v}{v}$ is estimated to be within $\pm$ 20 per cent.

The time measurements on the records indicate that, for an average depth of about 50 feet, the term $\frac{\Delta t}{t}$ does not exceed $\pm$ 5 per cent.

Hence the total accuracy of the depth measurements is within $\pm$ 25 per cent.

However, where the seismic traverses pass through drill hole sites, depths obtained from the seismic survey have been adjusted to depths obtained by drilling, and in such instances the accuracy of the depths indicated on the profiles (Plate 2) and isopach map (Plate 4) is considered to be much better than $\pm$ 25 per cent.

6. CONCLUSIONS.

Seismic and drilling data show that the depth to unweathered rock is less along traverse T-T' than it is to the north and south of T-T'.

The seismic velocities in the unweathered rock between stations T6 and T14 indicate the presence of a shear zone within these limits.

It is considered that the information obtained from the seismic survey will be of assistance in the selection of a dam site, and, should a site be selected within the area surveyed, may be useful in assisting with the design of the dam.

7. REFERENCES.

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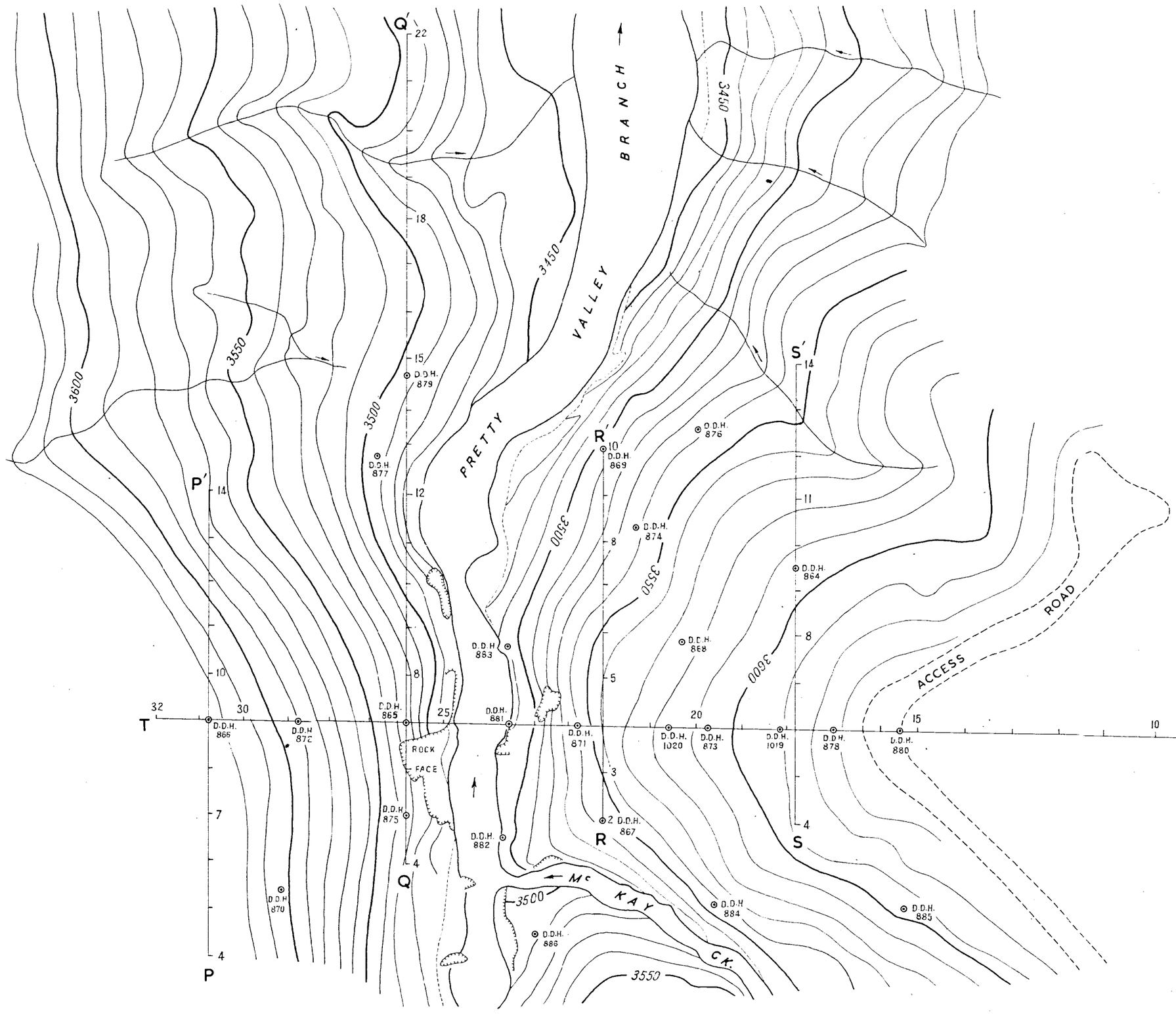
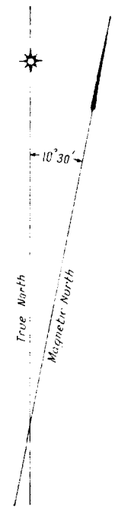
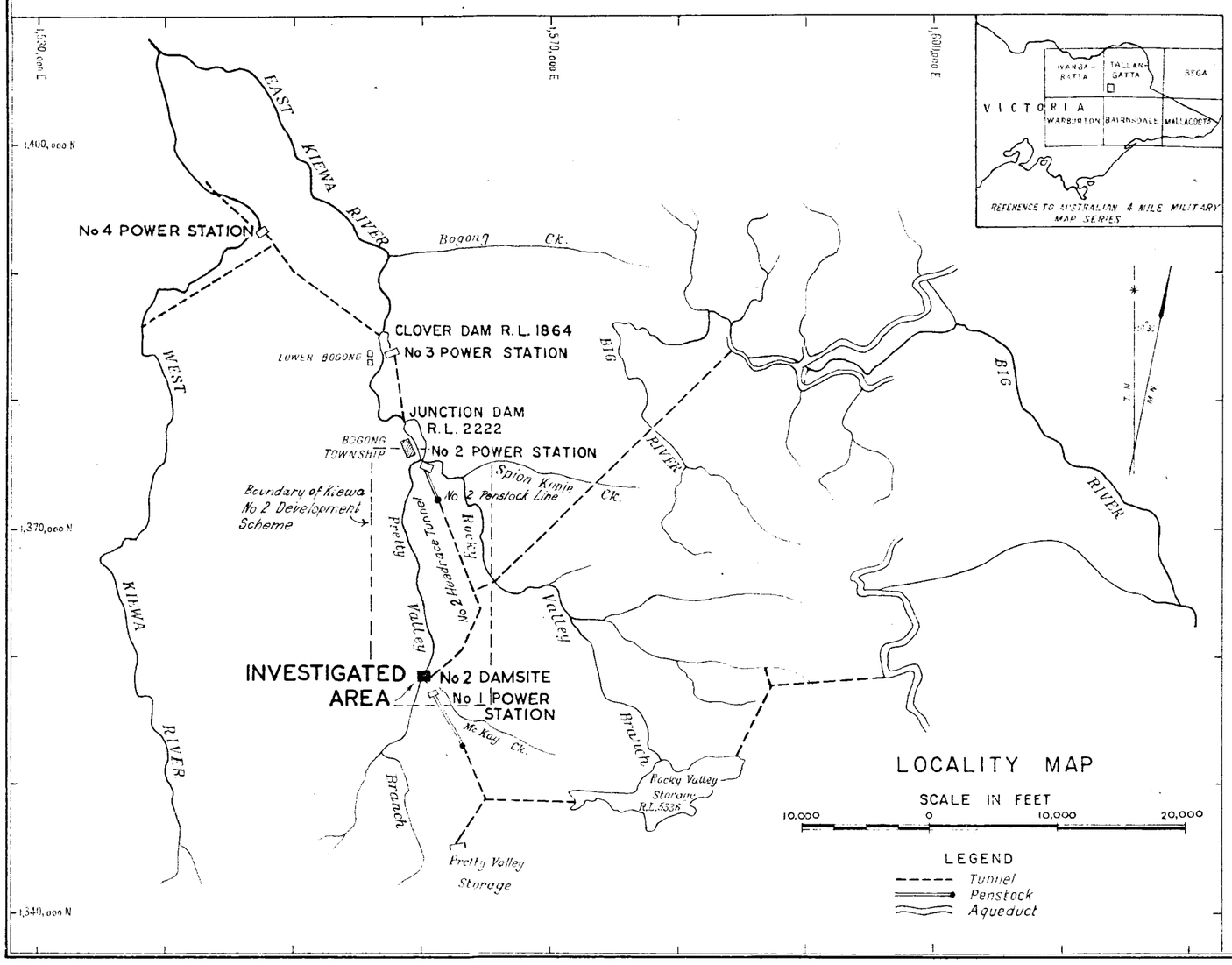
Heiland, C.A., 1946 - GEOPHYSICAL EXPLORATION. Prentice Hall, New York.







LOCALITY MAP

SCALE IN FEET

10,000 0 10,000 20,000

LEGEND

Tunnel
Penstock
Aqueduct

LEGEND

10 Traverse with stations
3500 Surface contours (R L in feet)
Granodiorite outcrop
Main stream
Small creek
Top of river bank
Road
D.D.H. 874 Diamond drill hole

SEISMIC REFRACTION SURVEY OF No 2 DAMSITE AREA. KIEWA, VICTORIA

TRAVERSE PLAN AND TOPOGRAPHY

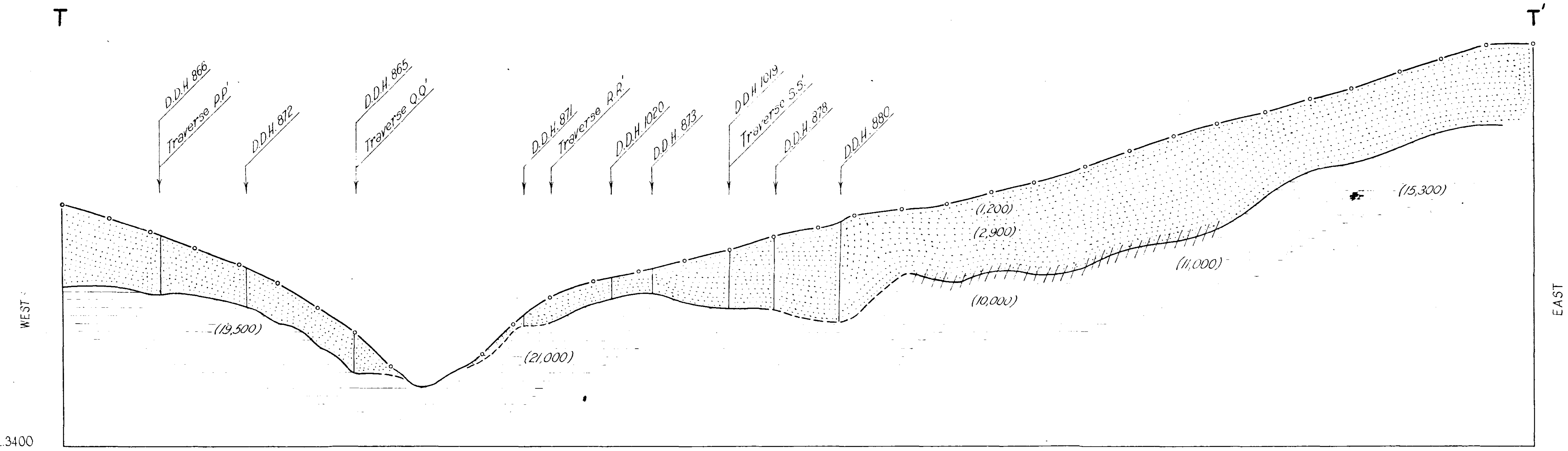
SCALE IN FEET

100 0 100 200 300 400

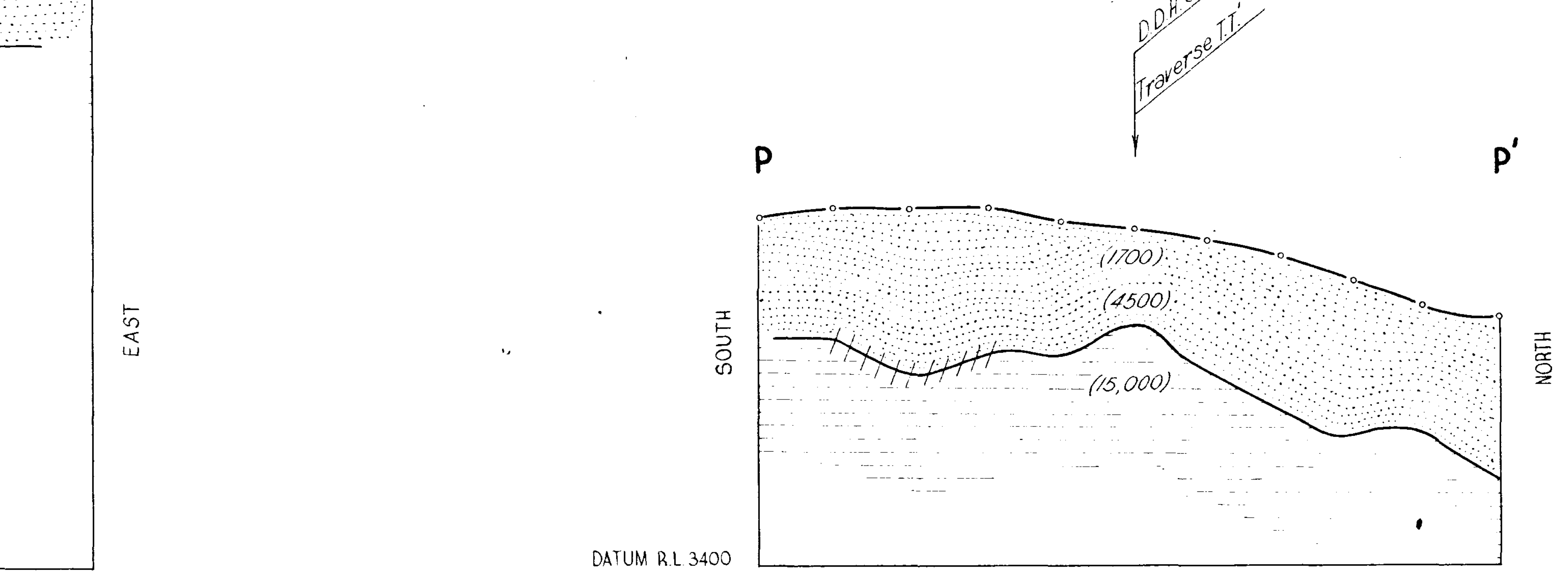
CONTOUR INTERVAL 10 FEET

D. F. Dyson
GEOPHYSICIST

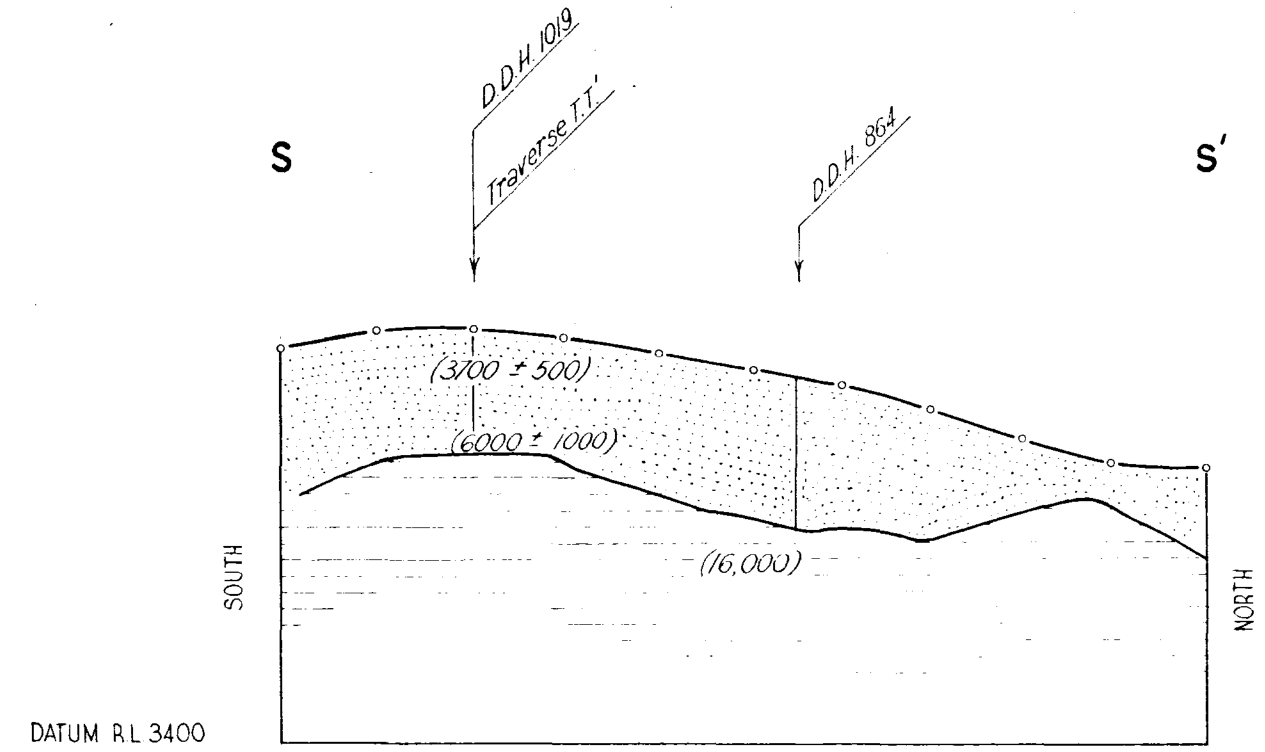
Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics G 232-7



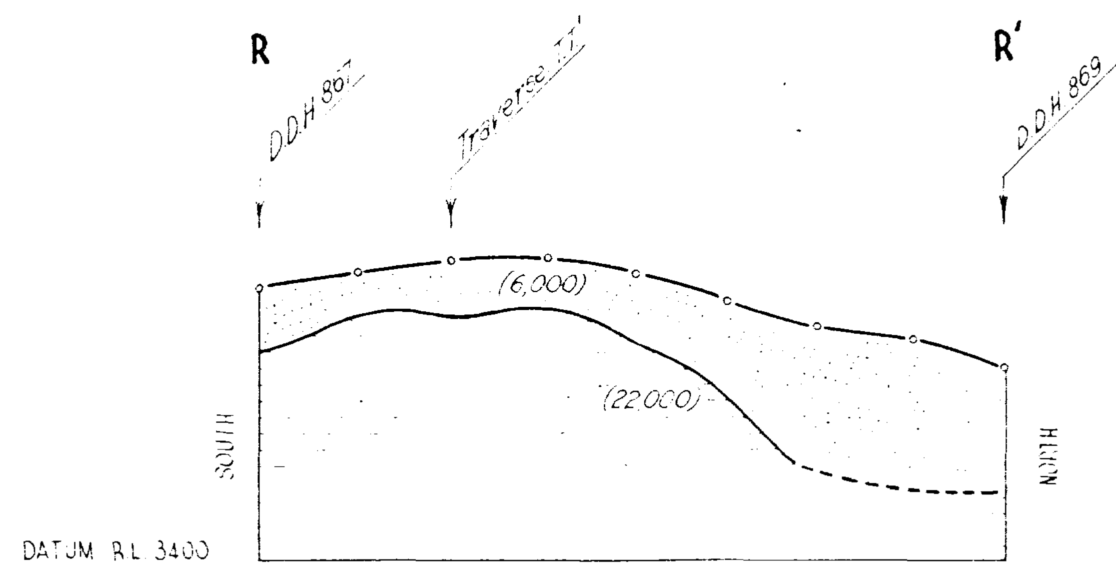
STATION No.	T33	T32	T31 (P/T)	T30	T29	T28	T27	T26 (Q/T)	T25	T22 (R/T)	T21	T20	T19	T18 (S/T)	T17	T16	T15	T14	T13	T12	T11	T10	T9	T8	T7	T6	T5	T4	T3	T2	T1	I.P. No.2 H.R. Line
SURFACE R.L. (FEET)	3663	3649	3632	3615	3597	3576	3552	3525	3488	3560	3578	3590	3602	3614	3626	3638	3650	3657	3662	3673	3683	3699	3715	3731	3745	3756	3770	3782	3798	3813	3827	
DEPTH TO UNWEATHERED ROCK	90	79	62	52	43	35	29	30	11	29	25	29	48	64	76	100	106	69	87	84	102	101	102	109	106	80	74	76	77	74	85	



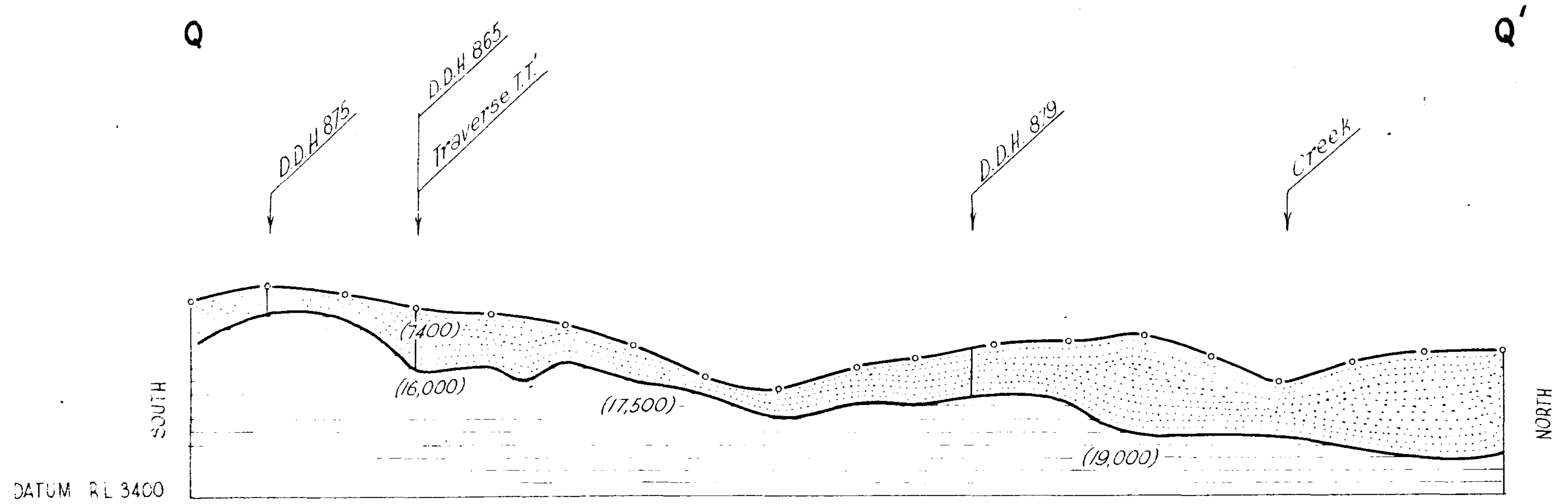
STATION No.	P4	P5	P6	P7	P8	P/T	P10	P11	P12	P13	P14
SURFACE R.L. (FEET)	3637	3643	3642	3643	3633	3627	3621	3612	3594	3578	3571
DEPTH TO UNWEATHERED ROCK	75	79	105	88	83	54	76	93	94	73	100



STATION No.	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
SURFACE R.L. (FEET)	3607	3614	3615	3610	3602	3595	3587	3575	3561	3548	3544
DEPTH TO UNWEATHERED ROCK	74	64	64	63	72	75, 80	72	70	40	18	15



STATION No.	[illegible]	[illegible]	R/T	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SURFACE R.L. (FEET)	[illegible]	[illegible]	3560	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DEPTH TO UNWEATHERED ROCK	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



STATION No.	Q4	Q5	Q6	Q/T	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22
SURFACE R.L. (FEET)	3530	3540	3535	3525	3523	3514	3498	3478	3469	3483	3490	3499	3503	3503	3493	3475	3488	3493	3494
DEPTH TO UNWEATHERED ROCK	28	19	8	40, 35	38, 49	24	28	13	20	23	34	37	45	63	53	40	60	69	66

LEGEND

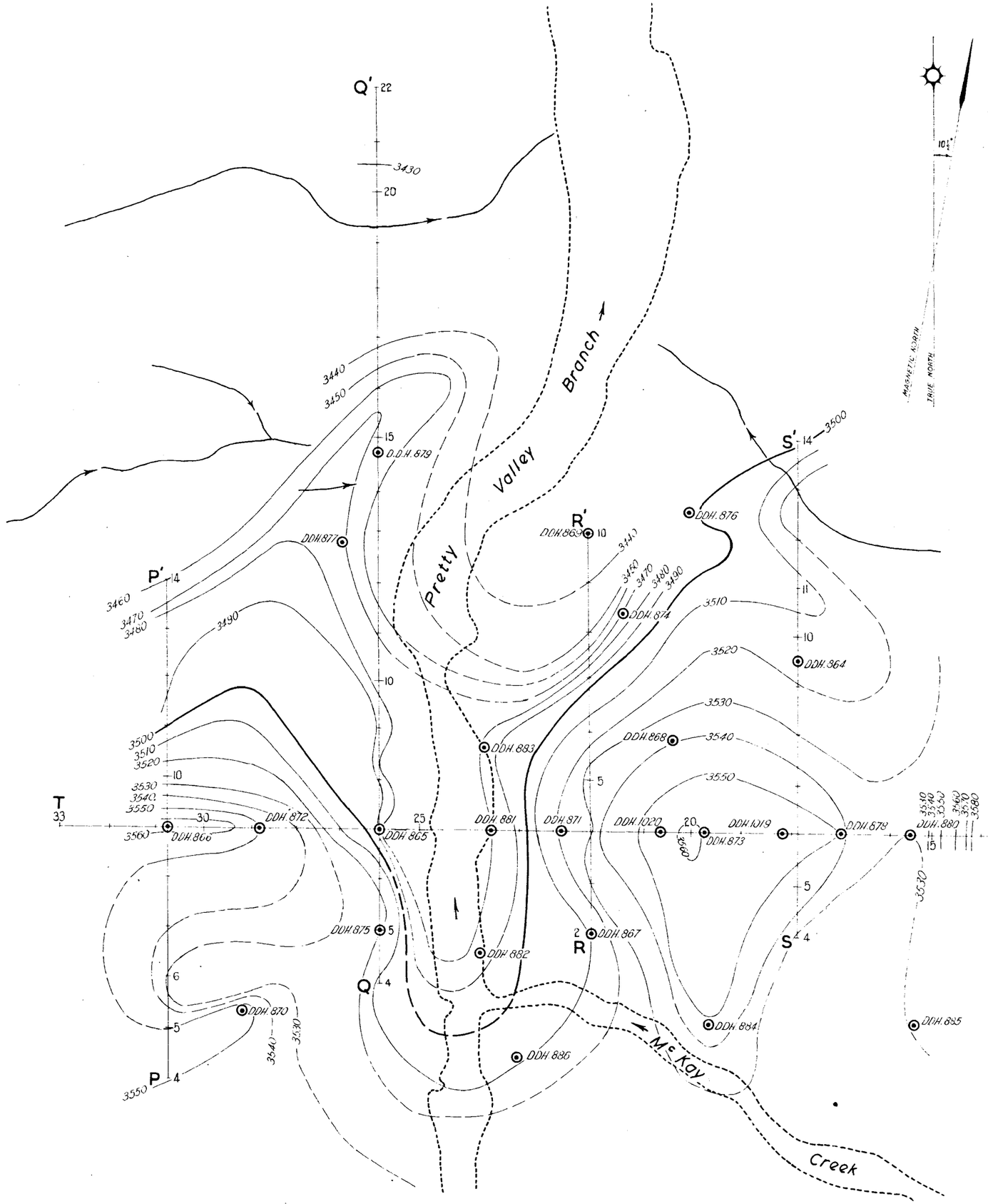
- Overburden
- Unweathered Rock
- //// Shear Zone
- DDH Diamond Drill Hole
- (6000) Approx. Seismic Velocity in feet per second
- I.P. Intersection point

SEISMIC REFRACTION SURVEY OF No.2 DAMSITE AREA,
KIEWA, VICTORIA.

PROFILES SHOWING DEPTHS TO UNWEATHERED ROCK

(DEPTHS ARE MEASURED PERPENDICULAR TO SURFACE)

D.F. Dyson. GEOPHYSICIST



SEISMIC REFRACTION SURVEY OF No. 2 DAMSITE AREA,
KIEWA, VICTORIA.

"UNWEATHERED ROCK" CONTOUR MAP

CONTOUR INTERVAL, 10 FEET.
FROM SEISMIC DATA AND DIAMOND DRILL HOLE INFORMATION.

SCALE IN FEET

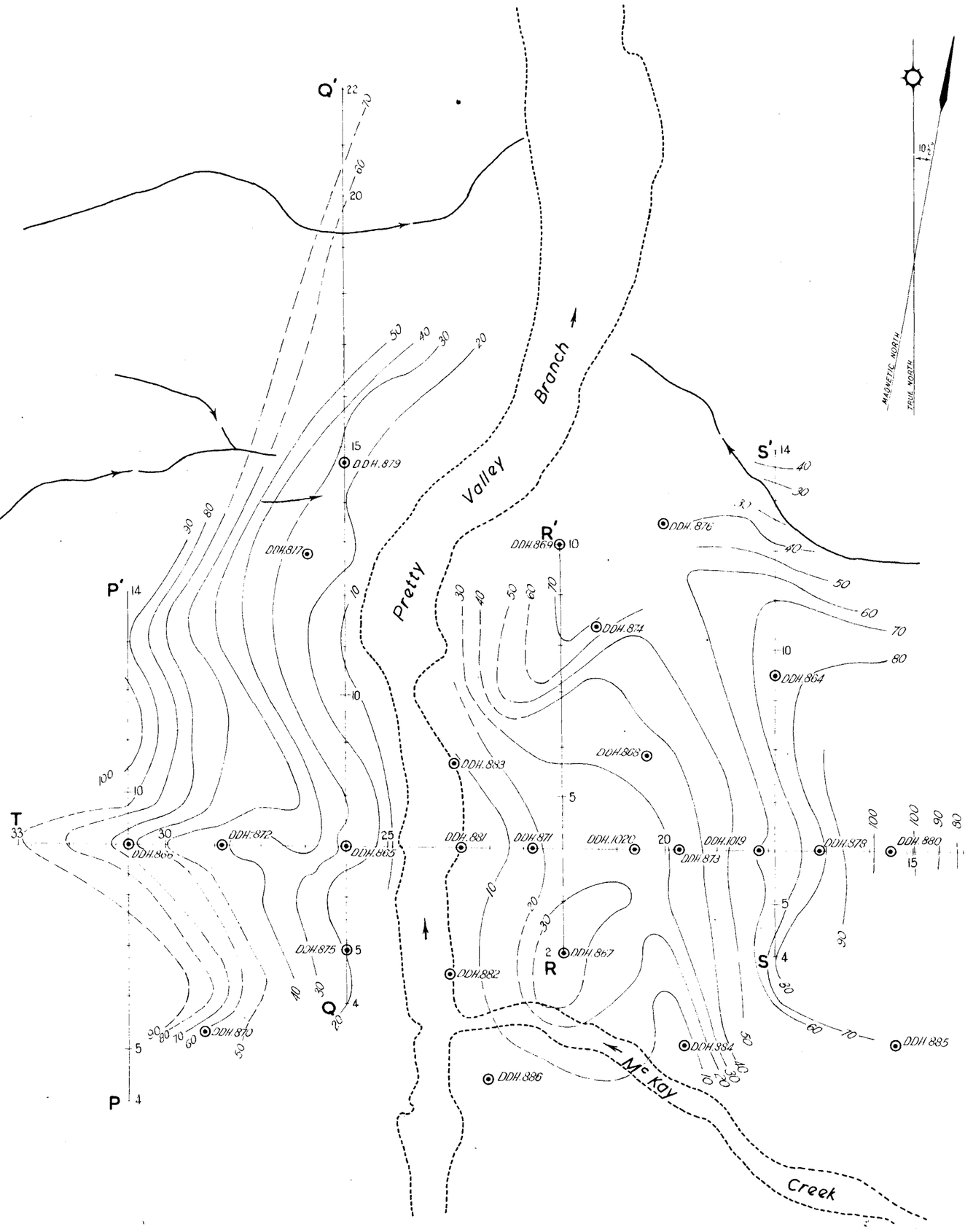
100 0 100 200 300

LEGEND

- 3500 / 3510 — "Fresh Rock" contour
- 3500 / 3510 — " " " , position indefinite
- 5 — Traverse, with stations numbered
- Main streams
- Small creeks
- ⊙ DDH.871 — Diamond drill hole

L. P. Dyson.

GEOPHYSICIST



SEISMIC REFRACTION SURVEY OF No.2 DAMSITE AREA, KIEWA, VICTORIA.

ISOPACH MAP

SHOWING THICKNESS IN FEET OF OVERBURDEN.

ISOPACH INTERVAL, 10 FEET.

FROM SEISMIC DATA AND DIAMOND DRILL HOLE INFORMATION.

SCALE IN FEET

100 0 100 200 300

LEGEND

50	Isopach
50	" , position indefinite
5	Traverse, with stations numbered
	Main stream
	Small creek
⊙ DDH.871	Diamond drill hole
I.P	Intersection point

I.P
T1 No2 Headrace tunnel line

GEOPHYSICIST