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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No.1962/73

DELVILLE SADDLE DAM SITE GEOPHYSICAL SURVEY, TASMANIA 1961

by

E.J.Polak

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SUMMARY

This Record describes a seismic refraction survey on the Delville Saddle dam site on the west coast of Tasmania, carried out at the request of the Hydro-Electric Commission of Tasmania.

The overburden of decomposed basalt and unconsolidated sediments is up to 270 ft thick. The seismic wave velocity in the decomposed basalt is 3500 ft/sec or less; the velocity in the unconsolidated sediments is 5000 to 6000 ft/sec.

Correlation between seismic velocities and porosity for the Savage Dolomites suggests that some of the dolomites are very porous, and hence are likely to be permeable.

1. INTRODUCTION

The Hydro-Electric Commission of Tasmania proposes to build a power station on the lower reaches of the Pieman River.

Several schemes have been proposed and geophysical surveys have been made at two of them (Polak and Moss, 1959a; Polak, in preparation). With any of the schemes a dam will be required to prevent impounded water overflowing through the Delville Saddle into Newdegate Creek (Plate 1). This report gives the results of a geophysical survey by the Bureau of Mineral Resources, Geology and Geophysics, on a site for the Delville Saddle dam. The objects of the survey were to measure the depths to bedrock, and to evaluate the nature of bedrock and overburden, with special reference to the possibility of water-leakage through the bedrock.

The approximate co-ordinates of the centre of the site are 310864, referring to the Smithton sheet of the Australia four-mile series.

The field work was done between 18th April and 8th May 1961, and the geophysical party consisted of E.J. Polak, party leader, D.J. Harwood, geophysicist, and J.P. Pigott, geophysical assistant. Field assistants were provided by the Commission, which also carried out the topographical survey of the traverses.

2. GEOLOGY

The Delville Saddle is situated on the divide between Newdegate Creek and the mature valley of Delville Creek about four miles south-west of the Pieman River. The Newdegate Creek flows from there in a south-westerly direction to the sea, about two miles away.

The geology of the area was mapped by Spry (1960). The detailed geology (see Plate 1) was given by Commission geologist Mather (1960).

The stratigraphy of the area is described in Table 1 and the notes that follow the table:

TABLE 1

Age	Reference	Formation
Tertiary	(a)	Basalt
	(b)	Sediments
Precambrian	(c)	Savage Dolomite and Delville Chert
	(d)	Bernafai Volcanics and Corinna Slates
	(e)	Donaldson Group

(a) Basalt. The investigated area is blanketed with basalt. The basalt is highly decomposed; the maximum measured thickness of basaltic clay is 122 ft in DDH 6382.

(b) Tertiary Sediments of varying thickness were proved in most drill holes. Quartz sand and yellow clay were brought to the surface in the drilling sludge, with chert fragments from the base of the sediments. The sediments are not present everywhere underneath the basalt cover; e.g. no sediments were found in DDH 6385.

(c) The Savage Dolomite and Delville Chert. In the centre of the investigated area the bedrock consists of Savage Dolomite and Delville Chert. These beds are considered as one stratigraphic unit. The chert is a silicified slate at the base of the Savage Dolomite (Spry, 1960).

Savage Dolomite is a very fine-grained dolomite. The dolomite found in drill holes DDH 6385 near B22, and DDH 6381 near A52, is jointed and contains many caverns filled with clay.

(d) The Bernafai Volcanics and Corinna Slates . In the south-eastern part of the area (south-east from A13 and B12) the bedrock consists of Bernafai Volcanics. The Bernafai Volcanics overlie the Corinna Slates, which were not found however within the investigated area. The Bernafai Volcanics show a slaty cleavage (Spry, 1960).

Bernafai Volcanics were found at a depth of 162 ft in DDH 6382 near A10. The formation is referred to as argillite and slate (see log on Plate 4).

(e) Donaldson Group This consists of white quartzite and slate with interbedded conglomerate (Polak and Moss, 1959a). The formation crops out near station B97.

Towards the north-west of the area the traverses cross a major fault named the Delville Fault (Spry, 1960) which has a vertical down-throw of the eastern side of at least 3000 ft, bringing the Donaldson Group in contact with the Savage Dolomite.

All the beds in the area dip north-west (Spry, 1960). Mather (1960) considers that there may be a synclinal structure with its axis close and approximately parallel to Traverse E.

Plate 4 shows the drill-hole sections and the results of the water-loss tests carried out in DDH 6381 and DDH 6385.

The water-pressure tests in drill holes indicate that both the clay, which is derived from basalt in situ, and the sediments below the clay, are of very low permeability; on the other hand, chert and dolomite show considerable water-loss in some horizons.

As used in this report, the term 'bedrock' refers to unweathered rock, including jointed rock, in the deepest observed seismic refractor. The term 'overburden' refers to basaltic clay, sediments, and weathered rock, all with a seismic wave velocity of 6000 ft/sec or less.

3. METHODS AND EQUIPMENT

The seismic refraction method was used in the investigation. Detailed description of the method was given by Polak and Moss (1959b). The 'method of differences' used for calculation of the thickness of overburden has been described in several records forwarded previously to the Commission.

The equipment used in the survey was an SIE 12-channel refraction seismograph with TIC geophones having a natural frequency of about 20 c/s.

Short tests were carried out using resistivity constant-spacing traversing and magnetic methods. As these tests did not provide any useful information, they were discontinued.

4. RESULTS

The results of the seismic survey are shown on Plates 2 to 4.

Seismic velocities

Longitudinal wave velocities for the various rock types at the Delville Saddle dam site are shown in Table 2 and in logs on Plate 4.

TABLE 2

Seismic velocity (ft/sec)	See Notes	Rock Type
1000 - 3000	(a)	Soil and clay derived from basalt *in situ*
5000 - 6000	(b)	Sub-basaltic sediments
3500 - 6000	(c)	Dolomite with caverns
7000 - 11,000	(d)	Bernafai Volcanics, weathered to slightly weathered
8000 - 18,000	(o)	Leached dolomite with caverns, to fresh dolomite
9000 - 11,000	(e)	Quartzite and slate of the Donaldson Group.

Notes to Table 2

(a) The velocity is low in soil and in clay derived from basalt. Water testing (see Plate 4) shows the clay to be practically impermeable.

(b) Water testing of the sub-basaltic sediments which were recovered in drilling as quartz sand and clay in sludge, show these sediments to be practically impermeable. These sediments are water-saturated.

(c) The velocity of 3500 ft/sec, shown by the upper part of the dolomite near drill hole DDH 6385, may indicate that the dolomite contains many caverns that are not filled with water. The velocity of 6000 ft/sec indicates that the rock is below the water table.

The velocity in the dolomite bedrock ranges between 8000 and 18,000 ft/sec, indicating a porous dolomite with caverns (lower ranges of velocities), to a non-porous dolomite without caverns (high velocity). No higher-velocity bed was recorded below the 8000-ft/sec refractor. This indicates that this low-velocity refractor continues to a substantial depth and could be a steeply dipping, or nearly vertical formation.

(d) A velocity of 8000 to 11,000 ft/sec in the Bernafai Volcanics near A10 and B8 indicates fractured and jointed rocks, probably partially weathered.

(e) The relatively low velocity in the Donaldson Group may be explained by a large content of slate (Spry, 1960) and by considerable jointing and distortion due to the Delville fault. A velocity of 11,000 ft/sec was found in the Interview Slate and Quartzite on the Donaldson dam site (Polak, in preparation).

On Plate 4 the velocities in the deepest refractor (i.e. the bedrock) plotted along Traverses A and B show a zonal arrangement; e.g. a lower velocity at A36 corresponds with a lower velocity at B28, a higher velocity at A43 corresponds with higher velocity at B34, etc. The boundaries between the velocity zones are shown by dashed lines. The velocity zones are almost symmetrical about the zone that includes Traverse D. A possible interpretation is that the structure represents a syncline (Section 2, Geology) with its axis approximating to Traverse D instead of Traverse E as suggested in the geological report.

Depth determination

The depth to the highest-velocity refractor was calculated using apparent velocities derived from weathering spreads and the intercept times of normal spreads (Polak and Moss, 1959b). Plates 2 and 3 show the interpretation of the seismic results in the form of cross-sections.

Comparison of the depth from seismic interpretation with the depth to the lower-permeability rock (see water tests in drill holes on Plate 4) indicates that the seismic depth is under-estimated in DDH 6381 by 2 per cent and in DDH 6385 by 12 per cent.

Rock porosities from seismic velocities

The major factor affecting the wave velocity in a porous medium is porosity. Other factors include composition, compaction, cementation, hydrostatic and directional pressure, and fluid saturation.

An inset on Plate 4 shows a set of curves showing the relation between velocity and porosity for various carbonate rocks.

Curve No. 1 has been calculated from the empirical formula (Wyllie, Gregory and Gardiner, 1956):-

$$1/V = P/V_A + (1 - P)/V_B \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \qquad (1)$$

where

P = fractional porosity

V = average velocity (ft/sec)

V_A = velocity in interstitial liquid

V_B = velocity in solid rock

In the calculation of Curve No. 1 the values V_B = 22,000 ft/sec for dolomite and V_A = 5000 ft/sec for water filling the pores were used.

Curve No. 2 gives the porosity/velocity relation for a Lower Palæozoic dolomite (Sarmiento, 1961). Velocity logs were made by continuously recording the velocity of seismic waves over a certain depth range in drill holes. The porosity data were measured in drill-hole cores or were calculated from micrologs. Micrologs give an accurate record of rock-resistivity variation as a function of depth in a drill hole. The author states that the porosity/velocity relation is uncertain for rocks with fractional porosity higher than 0.12.

Curve No. 3 gives the porosity/velocity relation for a Cretaceous dolomite (Berry, 1959). The data for the plot were obtained from velocity logging over a distance of 190 ft at a depth of 6000 ft, and from porosity measurements on cores.

Berry's porosity/velocity relation is derived for a depth of 6000 ft; hence the seismic velocities corresponding to certain porosity values as indicated by Curve No. 3 must be considered as maximum values. Kisslinger (1953) pointed out that generally carbonate rocks have higher velocities and lower porosities at depth than near the surface.

The graphs of Plate 4 should be used to indicate qualitatively from the seismic velocities measured in the area, the variations in porosity.

5. CONCLUSIONS

The overburden consists of two layers; the upper one being completely-decomposed basalt without water (seismic velocity about 3000 ft/sec or less), the lower one being water-saturated, poorly consolidated sediments (seismic velocities 5000 to 6000 ft/sec). The maximum thickness of overburden indicated by seismic results is 270 ft, near station B29.

The bedrock consists of Bernafai Volcanics in the south-east, Savage Dolomites in the centre of the area, and quartzite and slate of the Donaldson Group to the west of the Delville Fault.

The Savage Dolomites bedrock may be divided into velocity zones, and these zones possibly represent a synclinal structure. Correlation between seismic velocity and porosity for the Savage Dolomites suggests that some of the dolomites may be very porous, and hence they are also likely to be very permeable. Water-loss tests in drill holes show the dolomite to be cavernous; the core consists of dense dolomite, closely jointed.

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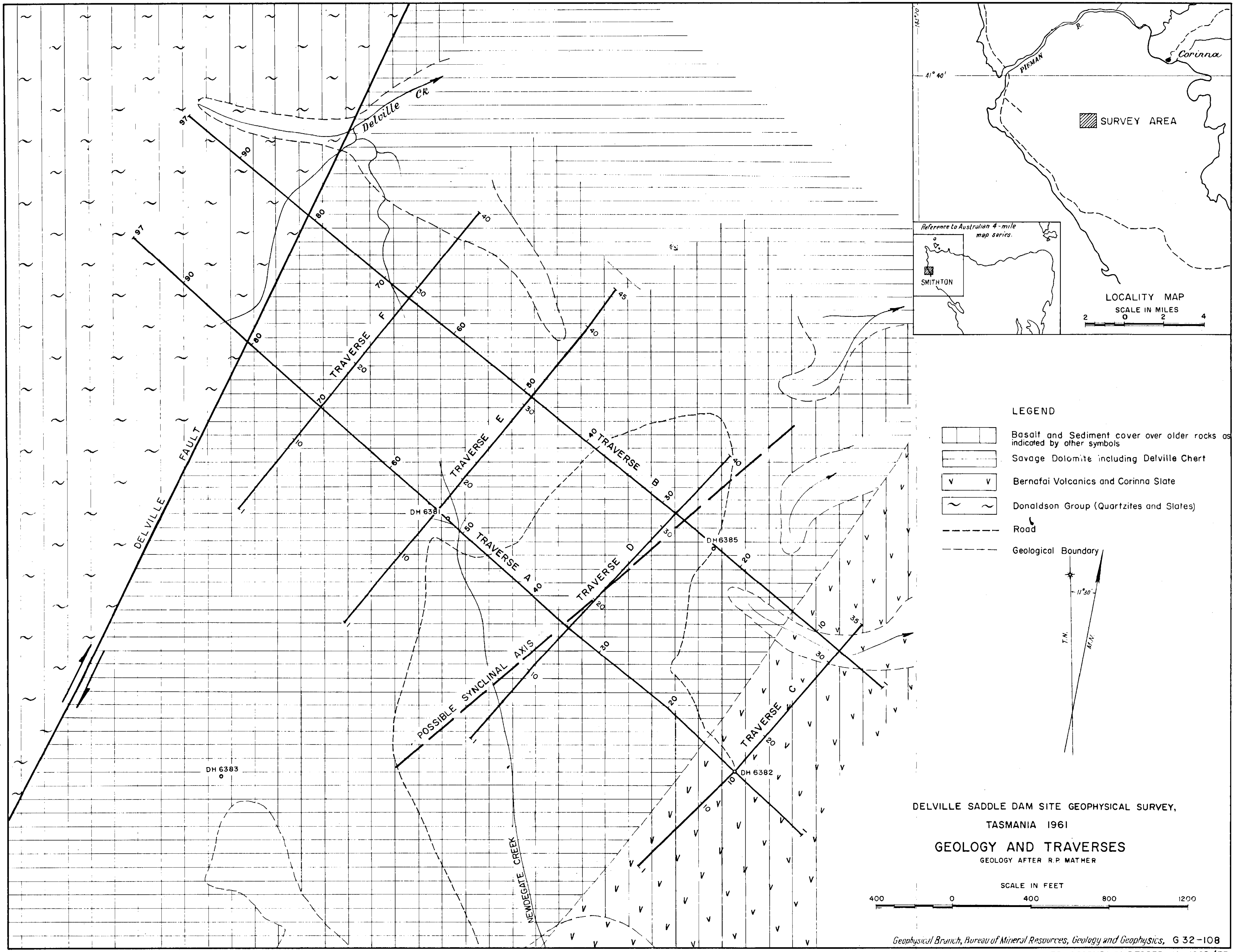

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TRAVERSES A AND B

CROSS-SECTIONS

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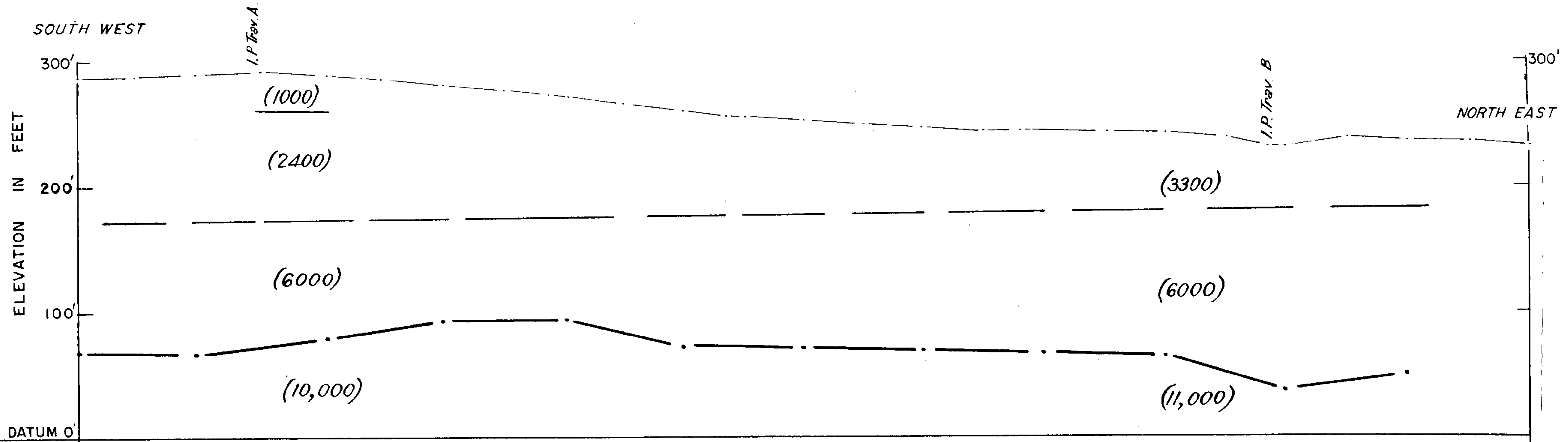
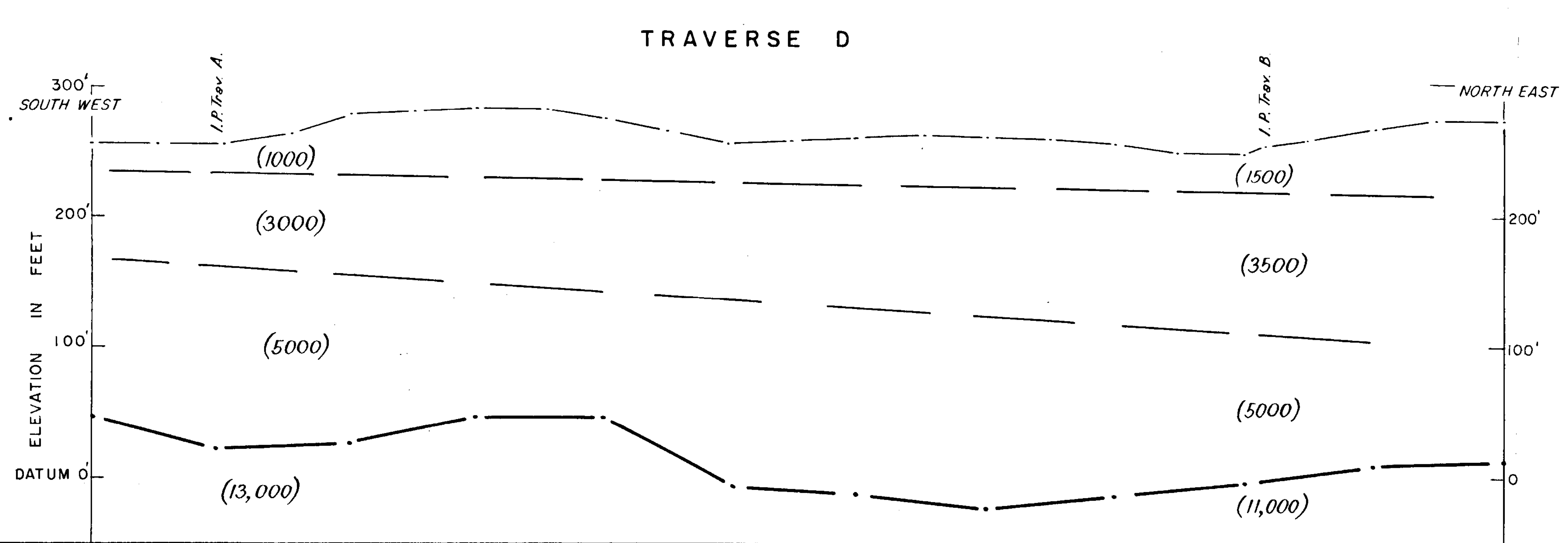
SADDLE DAM SITE

TRAVERSE C



STATION NUMBER	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
STATION ELEVATION	286	287	290	293	289	286	281	277	272	266	260	256	252	249	246	245	244	243	243	239	232	239	236	236	231
DEPTH TO BEDROCK	220		220		208		186		180		186		176		180		180		180		190		186		

TRAVERSE D

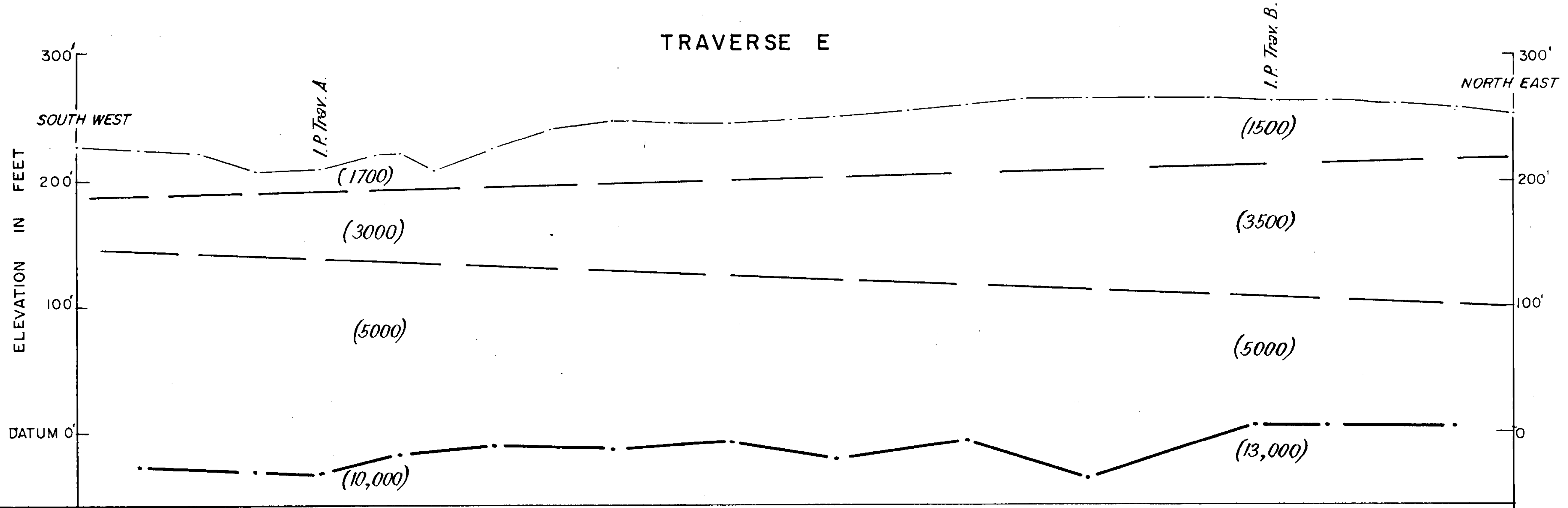


STATION NUMBER	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
STATION ELEVATION	256	256	256	264	278	281	283		275	266	258	259	261	263	261	260	256	250	249	260	268	274	273
DEPTH TO BEDROCK	205		235		250		234		225		266		275		285		270		250		255		260

LEGEND

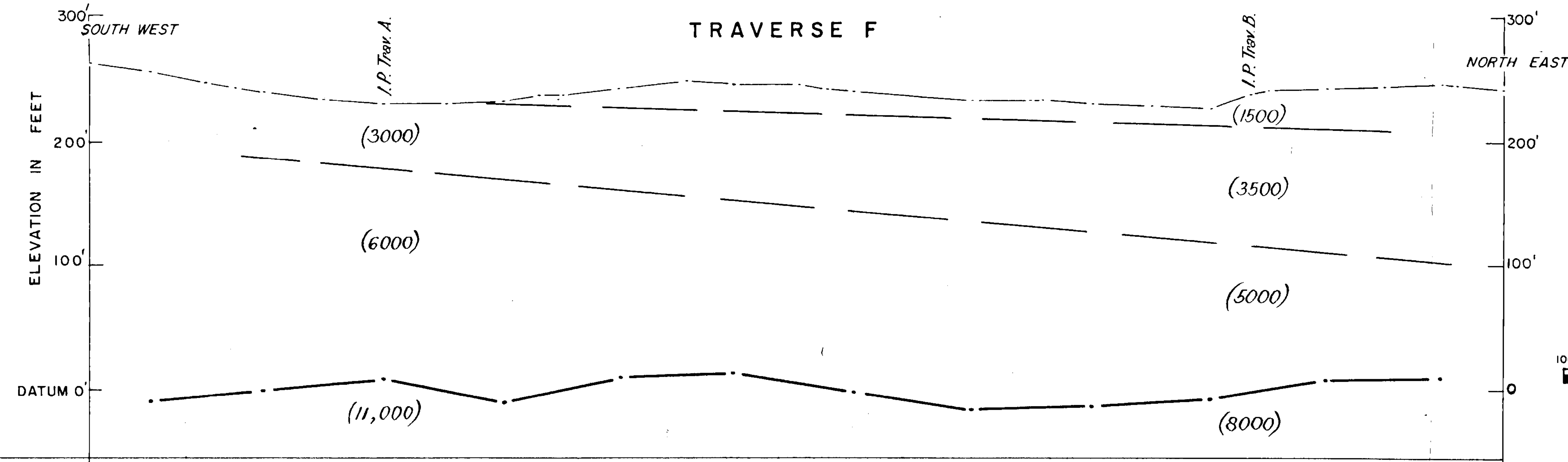
- BOUNDARY BETWEE SEISMIC REFRACTORS
- (12,000) FORMATION WITH SEISMIC VELOCITY 12,000 FT/SEC.
- I.P. Trav. C. INTERSECTION POINT
- UNWEATHERED BEDROCK BOUNDARY

TRAVERSE E



STATION NUMBER	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
STATION ELEVATION	224	221	207	209	221	208	226	241	247	246	246	249	251	255	261	265	265	266	265	263	264	262	259
DEPTH TO BEDROCK	254		240	240	240		240		260		255		268		268		300		276		260		255

TRAVERSE F



STATION NUMBER	10	11	12	13	14	15	16	17	18	19	21	22	23	25	26	27	28	29	30	31	32	33	34
STATION ELEVATION	264	257	249	241	234	230	231	234	238	243	247	246	241	234	235	232	229	228	243	244	245	247	242
DEPTH TO BEDROCK		260		240		220		240		235	233		245	250		245		232		235		235	

TRAVERSES C, D, E AND F
CROSS—SECTIONS

HORIZONTAL AND VERTICAL SCALES IN FEET

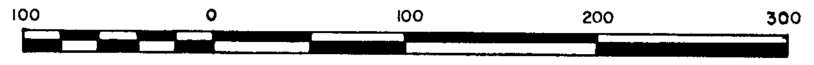


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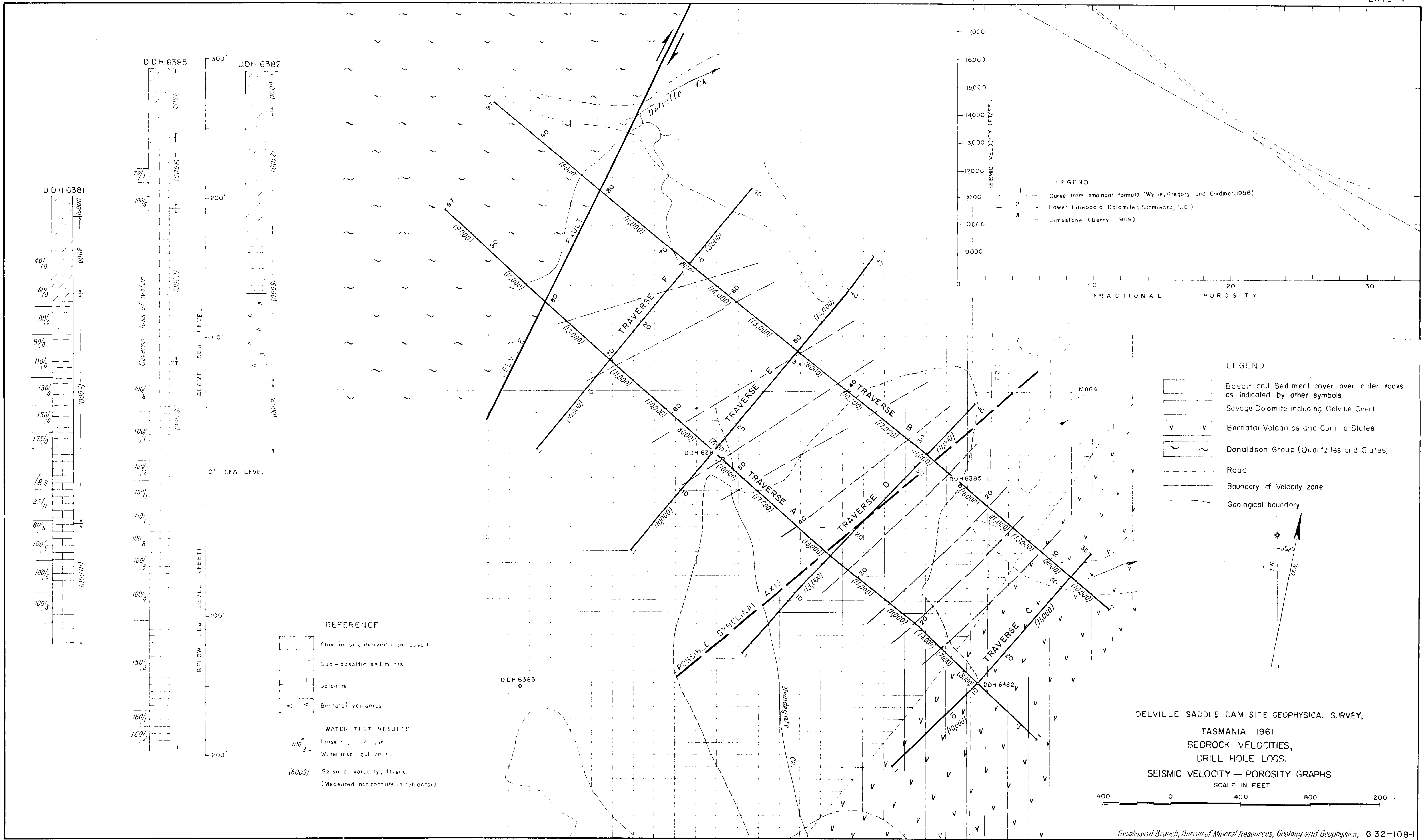
PLATE 4



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