DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

80/132

Rept.Bk.No. 80/132

REDCLIFF POINT SEISMIC SURVEY

GEOLOGICAL SURVEY

By

Bruce Finlayson
GEOPHYSICS SECTION

DME No.: 438/79

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DEPARTMENT OF MINES AND ENERGY
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REDCLIFF POINT SEISMIC SURVEY

ABSTRACT

A seismic refraction survey at Redcliff Point on Spencer Gulf has confirmed the existence of a trough up to 450 m deep and 3.5 km wide, oriented north-south beneath the western portion of the promontory. Two internal refracting horizons have been identified within this trough.

A drillhole to identify the infill material of the trough has been recommended.

INTRODUCTION

Redcliff Point is a coastal promontory in northern Spencer Gulf, on the eastern shore about 40 km south of Port Augusta. At this site the construction of a petrochemical plant with associated facilities was proposed.

From a previous gravity survey (80A1, Finlayson, 1980a), a gravity low had been discovered beneath the western part of the promontory and a fault had been postulated adjacent to the plant site. A buried valley, infilled with at least 250 m of low density material, appeared to be incised against this fault. The seismic survey was planned to:

1. clarify the subsurface topography of this valley;

2. field test the newly acquired 24 channel Nimbus ES 1210 seismograph.

Bad weather and limited time curtailed the programme. As a result, an expanding spread to examine seismic reflection responses was not made.

However, refraction coverage was completed between two drillholes Port Augusta No. 1 and Redcliff No. 2 (fig. 1). Field procedure tests were also completed.

GEOLOGICAL SETTING

The gravity low, which was the subject of this seismic investigation (fig. 1), is situated geologically within the complex Torrens Hinge Zone (Thomson, 1969). Upper Proterozoic rocks, which are represented by the Wilpena Group (ABC Range Quartzite) within the area of investigation, form a basement to Quaternary sediments of the Northern Spencer Basin, particularly the Lower Pleistocene Hindmarsh Clay and the Holocene St. Kilda Formation (Firman, 1969). Sediments of Tertiary age are inferred to exist within the area (Ludbrook, 1969) but none have been identified from the existing drillholes.

OPERATIONS

Twenty-four detectors were laid at 50 m intervals in-line with the energy source, with information gathered in forward and reverse directions by means of detonations at the end of each spread. Twelve detectors were then moved forward and the procedure repeated. Gelignite AN60 was used for the explosive source, commonly in 1.6 kg chargessalthough other sizes were tried.

As one experiment, multiple 0.16 kg charges were detonated to test a system for working which sought to:

1. improve record quality by "stacking" data from repeated shots at a shotpoint as a cumulative sum recorded in the memory of the "Nimbus" seismograph;

2. minimize ground surface damage by using smaller detonations;

3. minimize time and hence also costs of drilling shotholes with a motorized hand auger.

The results of this experiment were variable and depended largely on the soil or rock type in which the charges were placed (the 'shooting medium').

Two types of shooting media were encountered. In shotholes 0, 1, 5, 6 and 7, shelly marine muds, saturated with water, were found. These provided an excellent shooting medium. Small charges gave excellent records and took only minutes to place at sufficient depth for minimal surface damage.

In shotholes 2, 3 and 4, hard clays occurred immediately below surface. Shotholes here took considerable time and effort to drill. Drilling with water was required to penetrate more than 0.5m m below surface and a 2 m hole took about 1½ hours to prepare. This was too shallow to avoid the 4 m diameter crater which resulted with either 1.6 kg or repeated 0.16 kg charges. The necessity to repeat detonations with "stacking" of the smaller charges made it unacceptable in time and hence cost terms to adopt this approach.

To reduce time and hence cost, the shothole 4 was drilled to the top of the hard clay (0.5 m) and a single 1.6 kg charge fired. This resulted in a record of poor but marginally acceptable quality and similar surface damage to the previous shots.

As a result of these experiments it is concluded that where similar hard clays are present, a more powerful drilling unit is necessary to place charges at depths where cratering can be avoided and record quality maintained.

SEISMIC COMPUTING

"Time-distance" curves were constructed by plotting arrival times at individual detectors against their distance from the shotpoint (fig. 2). Where information from forward and reverse directions for a refractor was available the 'reciprocal method' of Hawkins (1961) was used to give accurate depth to refractors and to calculate their true velocities. Elsewhere, approximate depths to refractors were calculated using plane layer theory (Telford et. al., 1976). From the resulting section inverse "time-distance" curves were calculated by ray path analysis (Dix, 1952). The results were then compared with field data and adjustments made where necessary to give a closer fit. The time-distance curves are stored in the Geophysics Section together with the basic data.

RESULTS

Control of the interpretation was afforded by two drillholes, Port Augusta No. 1 and Redcliff No. 2, and the gravity survey 80A1 (see Table 1).

Several refractors were encountered.

1. Surface material up to 10 m thick at shotholes 0, 1, 5, 6 and 7 has a velocity of 1.25 km/s and correlates with water saturated shelly marine muds. At shotholes 2, 3 and 4 the surface material is indurated sandy clay and has a lower velocity of 0.56 km/s. This thin layer has been omitted from fig. 3 for ease of presentation.
2. Subsurface material is correlated with Hindmarsh Clay. This has a velocity which gradually increases from 1.8 km/s near the coast at shotpoints 6 and 7 to 2.3 km/s at shotpoints 0 and 1.
3. Within the "trough" two layers exist. These consist of:
   (a) material whose velocity averages 2.65 km/s and whose thickness is approximately 100 m;

   and

   (b) beneath this, in the deeper portion of the trough, material with velocity 3.1 km/s and thickness up to 250 m.
4. Two horizons have been identified as Proterozoic horizons.
   (a) Between shotpoints 0 and 2 a refractor occurs with a velocity of 3.45 km/s. This horizon apparently thickens to the east from zero thickness beneath shotpoint 2, to an inferred thickness of 280 m below shotpoint 0. At Port Augusta No. 1

drillhole, this refractor correlates with ABC Range Quartzite (Table 1, fig. 3).

(b) The second horizon which has a velocity of 4.9 km/s occurs to the west of and beneath the "trough". It then continues east beneath the 3.45 km/s refractor. Its thickness is undetermined. At Redcliff No. 2 drillhole, this refractor correlates with ABC Range Quartzite (Table 1, fig. 3).

No evidence can be found of a geological difference occurring between the quartzite intersected at Port Augusta No. 1 and the quartzite intersected at Redcliff No. 2 which might explain the different velocities observed in each case.

TABLE 1

Control wells. Comparison of seismic and geological horizons

	Formation	Depth	Seismic layer vel.	Depth
Port Augusta No. 1	St. Kilda Formation	0-4 m	1.25 km/s	0-7 m
	Hindmarsh Clay	4-20 m	2.3 km/s	7-21 m
	ABC Range Quartzite	20 m+	3.45 km/s	21 m+
Redcliff No. 2	St. Kilda Formation	0-5 m	1.25 km/s	0-7 m
	Hindmarsh Clay	6-65 m	1.85 km/s	7-67 m
	ABC Range Quartzite	65 m+	4.9 km/s	67m+

COMPARISON WITH GRAVITY RESULTS

Approximate density correlations for the seismic velocities (from Drake in Grant & West, 1965 p. 200) are given in Table 2 and fig. 3.

These values were used to calculate the gravity response of the seismic model and compare it with the Bouguer gravity values measured in survey 80A1 (fig. 3).

Close agreement occurs between the theoretical and observed gravity values with the mean difference of 1 μ Galileos and a maximum of 3 μ Galileos. Assuming that model values are correct, these represent possible mean uncertainties in depth estimates of 5 m and a possible maximum of 14 m to the

4.9 km/s refractor. Such variations are within the accuracy of the refraction seismic analysis.

TABLE 2

Correlation of seismic velocities with densities

Refracting Layer	Velocity (km/s)	Density (t/m^3)	Geol. correlation
2	1.8	1.9	Hindmarsh Clay
3a	2.65	2.10	?
3b	3.10	2.20	?
4a	3.45	2.25	ABC Range Quartzit
4b	4.90	2.60	ABC Range Quartzit

DISCUSSION

In the previous gravity investigation (Finlayson, 1980a), a narrow "trough" filled with at least 250 m of low density (1.9 t/m^3) sediments was interpreted to exist incised against a fault at Redcliff Point. The seismic information has confirmed the existence of low velocity (correlated with low density) material occurring within a trough-shaped depression. The width of this depression is estimated to be 3.5 km, between shotpoints 7 and 1. It now has an interpreted maximum depth of 450 m beneath shotpoint. The uppermost layer, beneath thin surface material, is up to 100 m thick over the "trough" and has an inferred density of 1.9 t/m^3. Beneath this, within the "trough", are two layers (layers 3a and 3b) of inferred densities 2.1 t/m^3 and 2.2 t/m^3 with respective maximum thicknesses of 100 m and 250 m. There are at least two different explanations to account for these seismic layers:

(1) They could arise from horizons within sedimentary deposits filling an erosional valley. The velocities and inferred densities are within the expected range for sediments of Permian and Tertiary age.

(2) Weathering of Proterozoic rocks along fault zones has produced strongly leached zones elsewhere with a similar gravity response and depth extent (Finlayson, 1980b). The refractors within the "trough" could represent weathering profiles in a leached zone adjacent to a fault at Redcliff Point.

Each of these explanations has a different set of consequences for consideration in planning of the site.

RECOMMENDATIONS

A drillhole has been recommended at gravity point 80A1.1.800 (fig. 3) and the probable formation intersections at this site are shown below. Depths are relative to surface.

Prognosis	Depth (m)	Seismic refraction velocity (km/s)
Hard sandy clays	0-7	1.20
Hindmarsh clay	7-90	1.90
unknown	90-200	2.65
unknown	200-300	3.1
ABC Range quartzite	300+	4.9

Either or both of the unknown horizons may also be aquifers. As underground water supplies are very poor within the locality, discovery of water bearing horizons would be of additional significant benefit.

No new information has been gained in this survey adding to the previous gravity interpretation of a north-south fault existing west of Mt. Grainger. In view of the possible consequences of such a fault occurring, further gravity work in that area is recommended.

BF: G. Urbancic

B. FINLAYSON
Geophysicist

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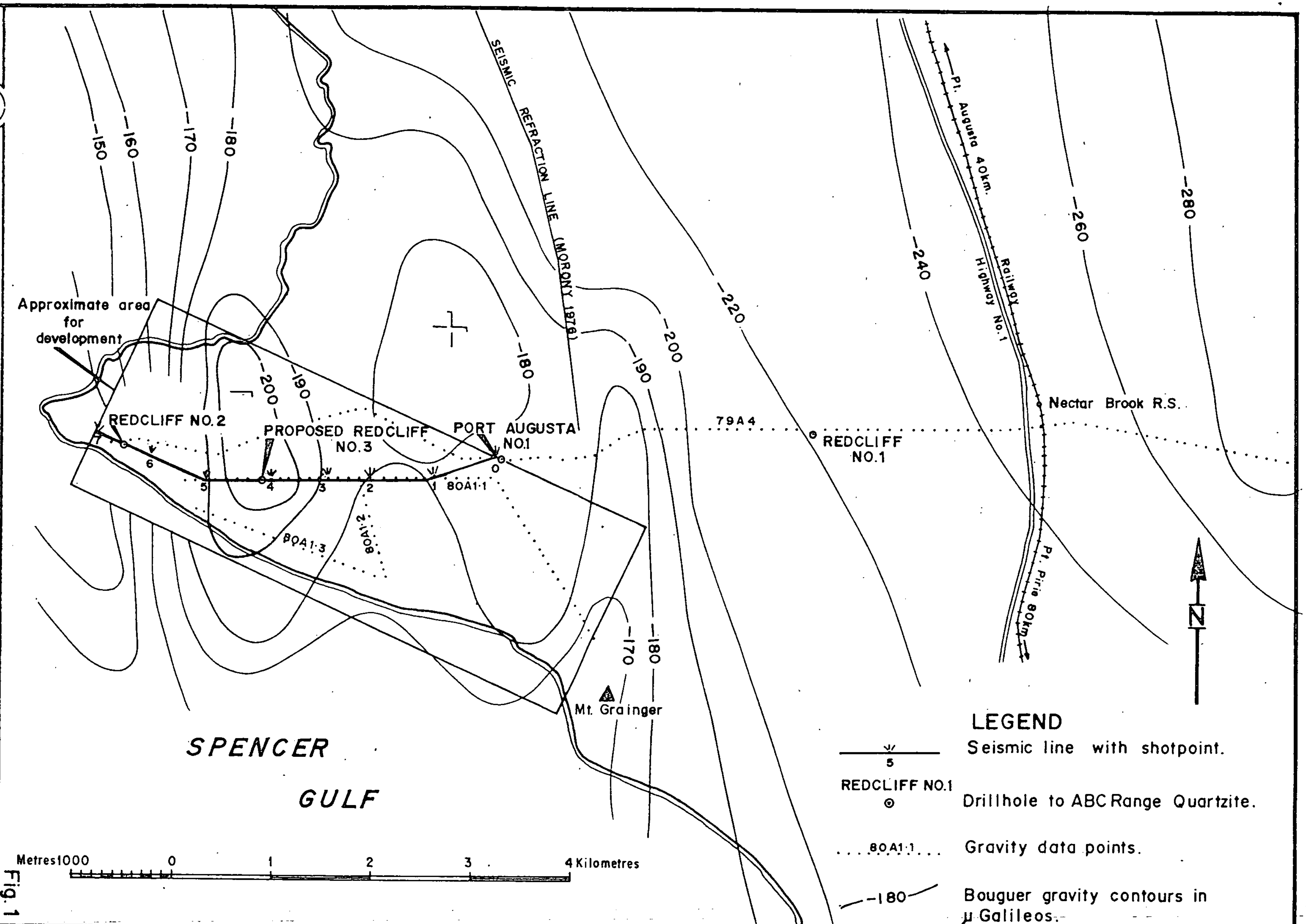

Fig. 1

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RED CLIFF POINT SEISMIC SURVEY
LOCATION OF SEISMIC LINES

COMPILED B.F.	C.D.O. DATE
DRAWN S.R.	SCALE 50 000
DATE 26/9/80 CHECKED	PLAN NUMBER S15033

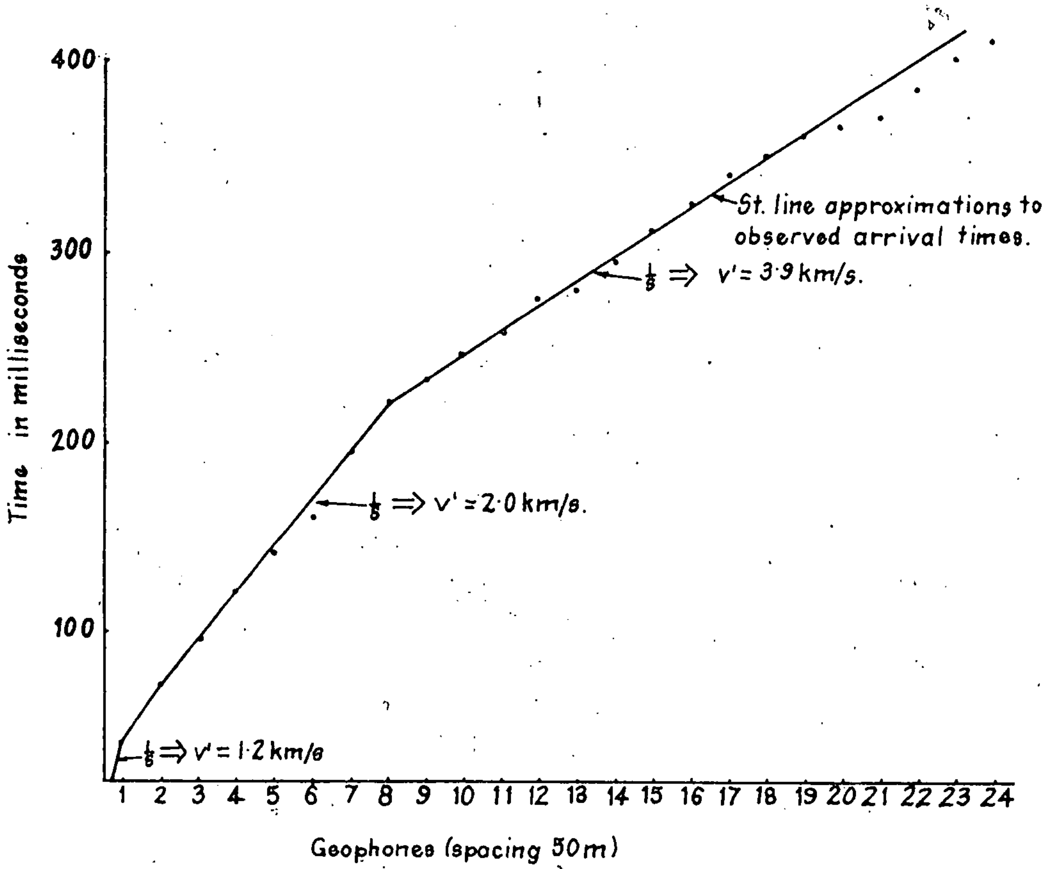

FIG. 2

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RED CLIFF POINT SEISMIC SURVEY
"TIME–DISTANCE" CURVE SPREAD3

COMPILED B.F.	C.D.O.	DATE
DRAWN S.R.	SCALE 1:10000	
DATE 28-8-80	PLAN NUMBER	
CHECKED	S15034	

2141

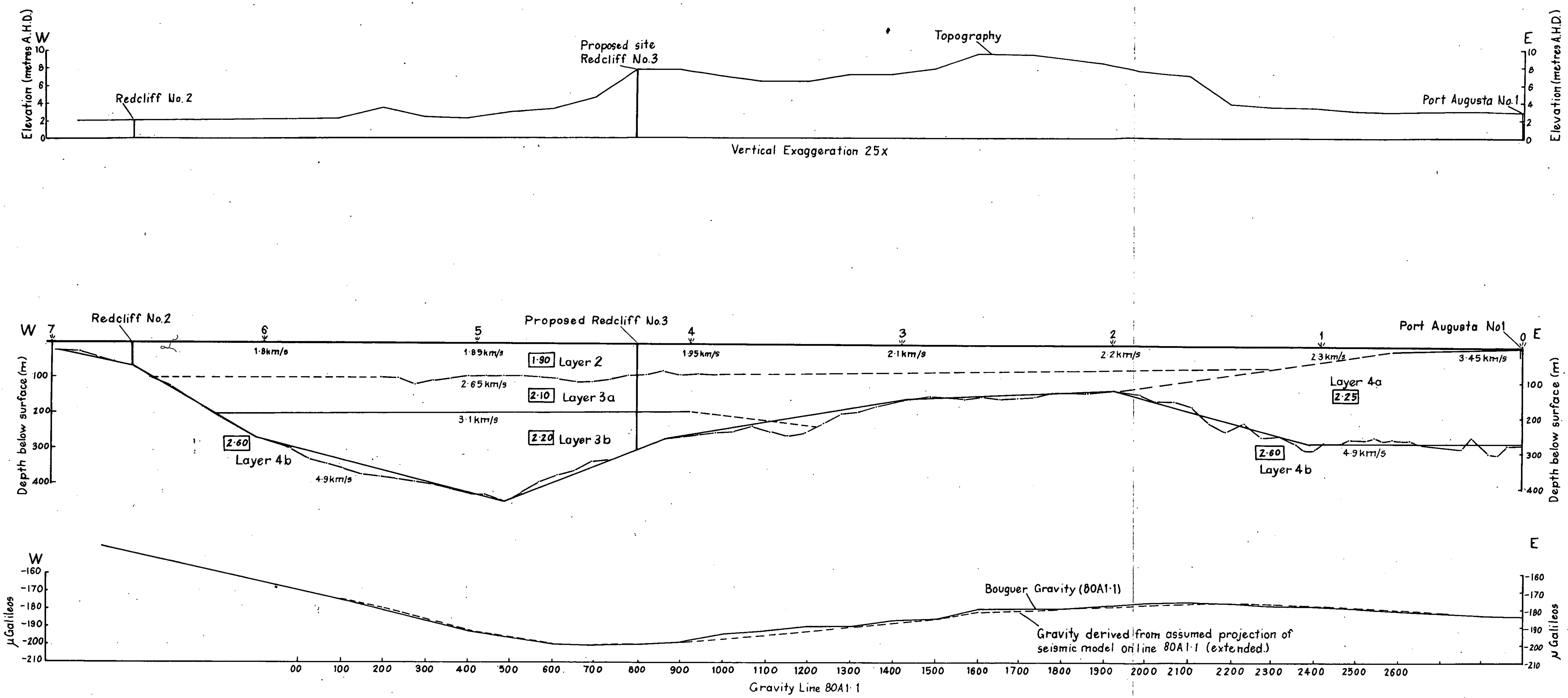

FIG. 3

LEGEND

5	Seismic Shotpoint.
2·65km/s	Refractor, velocity in km/s.
	Boundaries used for gravity model.
2·60	Density (t/m³)
Port Augusta No.1	Drillhole intersecting A B C Range Quartzite at Total depth.

Metres 200 0 200 400 600 800 1000 Metres

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SOUTH AUSTRALIA

RED CLIFF POINT SEISMIC SURVEY

SEISMIC SECTION LINE 80A1·1

COMPILED B.F.	C.D.O.	DATE 11·11·80
DRAWN S.R.	SCALE 1:10 000	
DATE 1/9/80	PLAN NUMBER	
CHECKED	80–592	

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