DEPARTMENT OF MINES
SOUTH AUSTRALIA

REFRACTION SEISMIC SURVEY IN THE NORTHERN ST. VINCENT BASIN

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PLAN NO.	TITLE	SCALE
77-243	Northern St. Vincent Basin Seismic Investigation: Seismic shot point locations.	1:100 000
77-242	Northern St. Vincent Basin Seismic Investigation: Interpreted sections.	1:25 000 horiz

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ABSTRACT

A refraction seismic survey was employed to determine depths to bedrock in the northern St. Vincent Basin. The aim was to assist siting drill-holes of a coal exploration programme within a down faulted trough.

Time-distance curves did not directly delineate the sedimentary - weathered bedrock interface, due to the presence of undetectable intermediate velocity zones. However, using "blind-zone" calculations in association with the few weathered bedrock velocities recorded, troughs in the weathered bedrock were indicated.

Results from the seismic survey compare well with drill logs from the subsequent drilling programme.

INTRODUCTION

To assist planning for a proposed power station in the northern St. Vincent Gulf area, it is necessary to have adequate information on the available coal resources in the area. Preliminary coal reserves have been estimated from current and past investigations (Meyer, 1976) but the proving of additional reserves of usable coal could considerably influence the final proposals.

A reconnaissance drilling programme was planned to determine the existence and quality of any additional exploitable coal. It was reasoned that the thicker sections of coal were most likely to be associated with bedrock depressions, and that the seismic refraction method could be used to locate such depressions, thereby assisting in the selection of suitable drilling sites.

It was considered unlikely that the low metamorphic grade coals likely to be found would provide sufficient velocity contrast with the overlying beds to enable them to be detected as separate refractors, and the primary aim of the seismic work would therefore be restricted to mapping basement.

METHOD USED

Forty-four kilometres of seismic traverse along five lines BS, BSA, BSB, BSC and BSD (Dwg. 77-243) were carried out during October, 1976 between Watchman Plain east of Whitwarta, and Condowie Plains west of Brinkworth. A 7 km gap in the coverage south-southwest of Boowillia was due to the inability of the shot hole drill to penetrate the near surface calcrete.

The recording equipment for this survey consisted of an SIE, PT 100, 24 channel amplifier bank and an SIE ERC6, electrostatic oscillograph. Standard refraction geophones were employed.

For most of the survey, seismic spreads consisted of 24 geophones spaced 200 ft (60.9 m) apart (total spread length 4600 ft (1402 m)) with a shot detonated in a hole approximately 3 m deep at the centre of the spread. After each shot six geophones and one length of cable were transferred from one end of the spread to the other and the shot point moved to the new spread centre 1200 ft (365.7 m) along the traverse. Velocity and depth information was obtainable at points 1200 ft apart and reciprocal shot information enabled almost continuous "time depth" cover for the high velocity bedrock.

On line BSB, however, the depth to the high velocity layer increased so that the first arrival times at less than six geophones on each half spread indicated that energy reaching the geophones had travelled through the high-velocity bedrock layer. In these circumstances, to give continuous cover for the high-velocity bedrock, shots were detonated 100 ft (30.6 m) from each end of the 24 geophone spread. One half of the geophone spread was then moved 4800 ft (1464 m) to the other end of the spread and shots again fired off each end of the new spread. To obtain adequate records from the most distant geophones, larger charges necessitating deep shot holes had to be fired. The time taken to drill these deep (7 m) holes was much greater than for the shallower (3 m) holes and progress along the traverse was severely reduced.

In order to obtain more accurate determinations of typical near-surface layer thicknesses and velocities, "weathering" spreads of 24 geophones placed at increasing intervals, ranging from 2.5 m to 70 m from the centre shot point, were employed at 3km intervals along the survey route. Thirteen such spreads were used with charges placed approximately 0.15 m below the ground surface.

All seismic records were timed for the first detectable arrival of energy at each geophone position and results were then plotted as time-distance curves. Conventional seismic refraction interpretation techniques were used to determine velocities and thicknesses of the various refracting layers. Reciprocal analysis as reviewed by Hawkins (1961) was used where possible to obtain bedrock velocities.

RESULTS

Shot point locations are shown on Dwg. 77-243 and interpreted sections for the traversed lines on Dwg 77-242. The velocities and thicknesses of the near-surface layers were derived from "weathering" spreads which were shot at intervals of about 3 km, hence their apparent uniformity over considerable distances.

The near surface layer, which is approximately 1 m thick, exhibits velocities between 140 m/s and 350 m/s and most probably consists of loose sand in the southern part of the traverse, where sand dunes occur, loose flaggy calcrete immediately to the north of the sands, and sandy clay for the remainder of the traverse.

A second layer with velocities between 700 m/s and 1000 m/s and a maximum thickness of 7 m below BSB5, occurs over most of the traverse.

This layer probably consists of similar material to the first layer, but is more consolidated. Between BSB34 and BSB46, this layer was not detected, either because it is too thin to be "seen" on the time-distance curves, or is in this area sufficiently water saturated to raise its velocity to a value comparable with the underlying material.

At the northern end of line BSB and the southern end of line BSD a layer with a velocity of 1250 m/s with a maximum thickness below BSB61 of 21 m was interpreted. Information from drillholes intersecting this seismic layer does not show any lithological change. However, the drillhole logs in this section were from cuttings and the change in velocity may be related to a change in moisture content or compaction.

The next layer on all lines exhibits velocities between 1600 m/s and 1830 m/s and is considered to contain Tertiary non-marine sediments. Estimation of the thickness of this layer is difficult because of the rigid requirements of the refraction method that (a) velocities must increase with depth and (b) the layer thickness must exceed a minimum value before it can be distinguished on the time-distance curves as a separate layer with a measurable velocity.

A preliminary section was compiled using the high velocity layer (4000 m/s to 8300 m/s) as bedrock underlying the 1600 m/s to 1830 m/s layer. However there were signs of another layer with velocities between 2300 m/s and 4150 m/s overlying the high velocity basement in the southern half of the area where the non-marine sediments are thinner. This intermediate velocity material is thought to be weathered bedrock. It most probably exists throughout the area, but is only detectable when close to the surface, i.e. at the edge of the troughs. Where the overlying section is thicker, the weathered layer is probably thinner than the minimum value which can be recorded by the refraction method. However, the maximum depth and thickness of a zone with velocities of this order, which would not be detected on the time-distance plots, was calculated for each shot point by the method described by L.V. Hawkins and D. Maggs (1961).

Plotting the section to incorporate this maximum thickness of the hidden layer gives a minimum depth limit for the weathered basement and a maximum limit for the depth to the unweathered basement. The velocities used in these calculations were derived where possible by interpolating from points at which weathered basement velocity measurements were obtainable. Drill holes Blyth 4 and 5 drilled adjacent to such points gave intersections of weathered basement at depths within 5% of the calculated minimum depth. Where such information was not available an assumed velocity of 3050 m/s (10 000 ft/second) gave a minimum depth to weathered bedrock within 8.5% of the drill intersections at Blyth 3 and 6. Use of a higher velocity for the hidden zone would have given a closer result.

On line BSD where no experimental velocity data was available, the reverse process was adopted. This necessitates finding the minimum velocities from which depth calculations of the upper boundary of the hidden zone will correspond with the actual weathered basement intersections. The average velocity found gave depths to weathered basement in Blyth 1 and 2 within 2% and was then applied to the remainder of the section.

From the calculated weathered basement profiles, it may be concluded that in general the overlying sedimentary layer apparently increases in thickness to the north, but that the base of the layer is broadly undulating along the survey route.

Shallow troughs exist below BS3, between BS11 and BS15 and between BSB9 and BSB20. A deeper trough lies between BSB 25 and BSB 55 with a maximum depth of 120 m below BSB 48. This latter trough is terminated by a ridge passing through BSB 58 with another depression having its maximum depth of 120 m at BSB 61 lying north of the ridge.

An increase in thickness of sediments at each end of line

BSD, with the thickest section of 146 m at the northern end, is probably indicative of troughs at these locations. The depth of sediments also increases to the west along line BSC.

Insufficient time for a complete seismic interpretation was allowed before a test drilling programme commenced, and the test holes were sited by geologists in the Fossil Fuels Division using the initial interpretation (i.e., before blind zone calculations were used to delineate the weathered bedrock) and geological information obtained from holes previously drilled. Table I below shows the relations between estimated and actual depths to weathered bedrock together with some information on coal seams detected during drilling.

TABLE I

Drill Hole Blyth Nos.	Seismic spread No.	Depth to weathered bedrock		Total thickness of coal seams	depth to base of coal seams
		from drill log	from seismic interpretation		
1	BSD 2	121.9 m	124 m	7.8 m	98.1 m
2	BSD 16	150 m	146 m	6.0 m	141.2 m
3	BSB 48	125.5 m	118 m	5.6 m	94.6 m
4	BSB 18	76.3 m	80 m	0.6 m	55.7 m
5	BS 17	51.7 m	53 m	0.5 m	35.6 m
6	BSB 64	119.8 m	108 m	7.7 m	113.4 m

CONCLUSIONS AND RECOMMENDATIONS

Preliminary interpretation without allowing for a hidden layer gave a profile which indicated general basement trends in the area, but gave depths to bedrock considerably deeper than those at which weathered bedrock was actually intersected. Allowing for an intermediate velocity layer, by using blind zone calculations, permitted mapping of a weathered basement profile and the location of troughs with much greater accuracy. These calculations were possible because the intermediate layer velocity is measurable at isolated locations, and could be extrapolated to areas where the blind zone is less than the optimum thickness required for measurement. It is also implied that the blind zone remains near this optimum thickness over much of the area investigated.

The following comments are applicable to the drilling actually carried out.

Blyth 5 sited at BS17 was not drilled in a trough and would have been better situated at BS 12 or 13 which is in the centre of a trough that has a calculated thickness of sediments of 90 m.

Blyth 4 situated at BSB18 was positioned in the deepest part of one of the troughs but the sedimentary section was only 76 m thick and little coal was found. However, appreciable intersections of coal were found in drillholes to the north where thicker sections of sediments were intersected, and it may be possible to establish a relationship between the thicknesses of coal and sediments.

If further drilling is planned, it is recommended that some sites be located on seismic interpretation. This would entail further field operations followed by a sufficient period of time to carry out a considered interpretation of the data.

15th April, 1977
BJT:AGT

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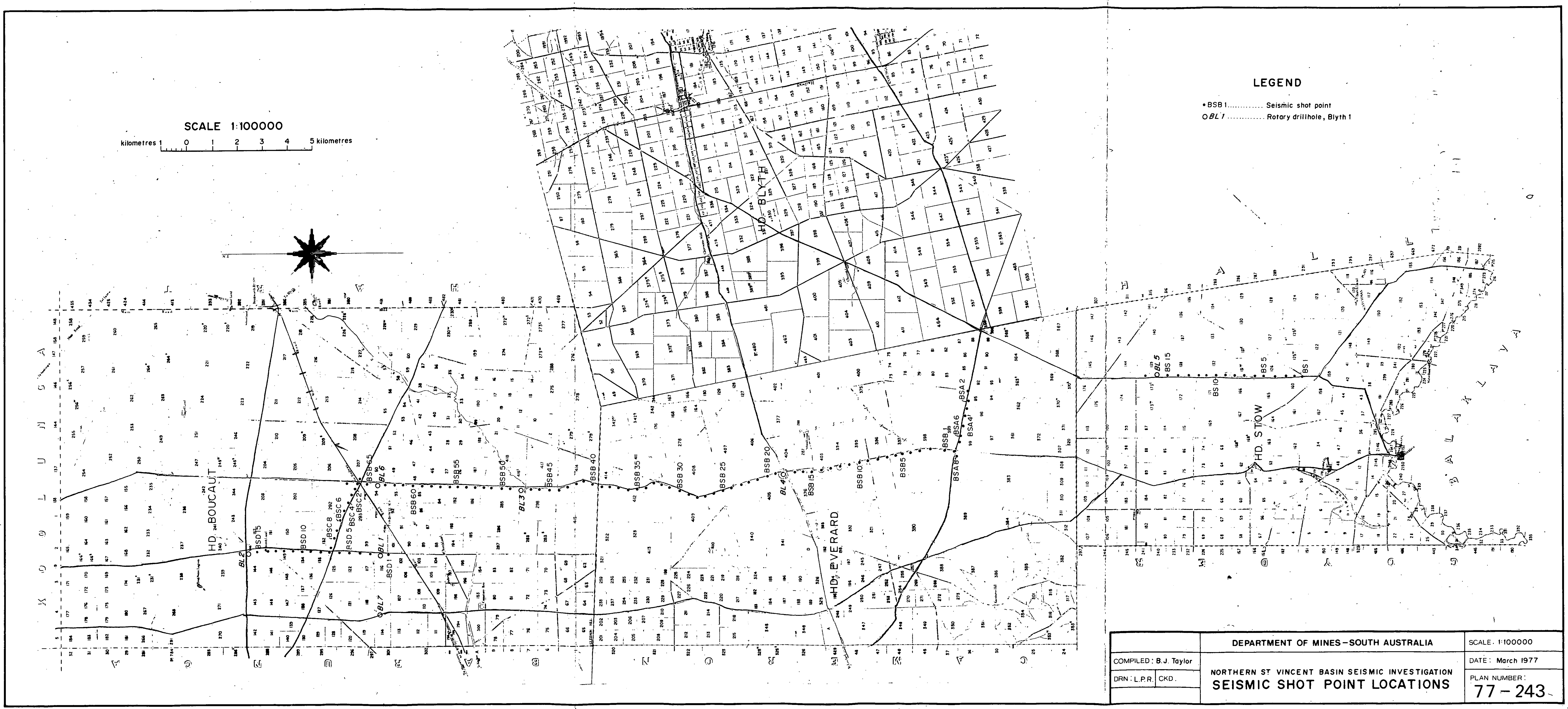
SCALE 1:100000
kilometres 1 0 1 2 3 4 5 kilometres
LEGEND
• BSB 1 .... Seismic shot point
○ BL 1 .... Rotary drillhole, Blyth 1
HD. BLYTH
HD. BOUCAUT
HD. EVERARD
HD. STOW
DEPARTMENT OF MINES – SOUTH AUSTRALIA
SCALE: 1:100000
COMPILED: B.J. Taylor
DATE: March 1977
DRN: L.P.R.
CKD.
NORTHERN ST VINCENT BASIN SEISMIC INVESTIGATION
SEISMIC SHOT POINT LOCATIONS
PLAN NUMBER:
77 – 243


LINE BSB
S
N
Upper layer velocity 227 m/s 1 metre thick
2nd " " 1000 m/s
Upper layer velocity 312 m/s 0.8 metres thick
2nd " " 900 m/s
Velocity of 1st layer 207 m/s 1 metre thick
" " 2nd layer 826 m/s
Velocity of 1st layer 294 m/s 1 metre thick
" " 2nd layer 950 m/s
Velocity of upper layer 208 m/s
Upper Velocity 207 m/s 1 metre thick
2nd layer velocity 975 m/s
Upper layer velocity 140 m/s 1 metre thick
2nd layer velocity 975 m/s
BLYTH 4
BLYTH 3
BLYTH 6
SEDIMENTS
WEATHERED BEDROCK
END OF HOLE
BLIND ZONE
ELEVATION IN METRES
1829 m/s
1781 m/s
1693 m/s
1770 m/s
1799 m/s
1729 m/s
1716 m/s
1250 m/s
3658 m/s
3460 m/s
2712 m/s
3050 m/s
5500 m/s
6850 m/s
5680 m/s
4690 m/s
5765 m/s
5500 m/s
5560 m/s
5840 m/s
6100 m/s
6650 m/s
5600 m/s
7200 m/s
5400 m/s
4830 m/s
5212 m/s
5640 m/s
EXPLANATORY SECTION
Shot point location
Surface profile
Seismic velocity interface
Blind zone
LINE BSA
Upper Velocity 277 m/s 1 - 2 metres thick
Second Velocity 990 m/s
W
E
990 m/s
1820 m/s
4150 m/s
BLIND ZONE
5300 m/s
4020 m/s
5500 m/s
4480 m/s
LINE BSC
Upper layer velocity 250 m/s
2nd " " 400 m/s
1st layer velocity 140 m/s
2nd " " 975 m/s
1684 m/s
1720 m/s
1623 m/s
3050 m/s
4960 m/s
LINE BSD
Velocity 1st layer 250 m/s 1 metre thick
" 2nd layer 400 m/s
" 3rd layer 1250 m/s
Velocity 1st layer 206 m/s 1 metre thick
" 2nd layer 529 m/s
BLYTH 1
BLYTH 2
1770 m/s
2740 m/s
5540 m/s
LINE BS
1st layer velocity 260 m/s 1 metre thick
1st layer velocity 350 m/s 2·7 metres thick
BLYTH 5
814 m/s
701 m/s
1613 m/s
1701 m/s
2316 m/s
3596 m/s
3383 m/s
5656 m/s
6306 m/s
5290 m/s
5096 m/s
5416 m/s
4979 m/s
8226 m/s
5460 m/s
6416 m/s
HORIZONTAL SCALE 1:25000
metres 50 0 50 100 150 200 metres
DEPARTMENT OF MINES—SOUTH AUSTRALIA
COMPILED: B.J. Taylor
DRN: L.P.R.
CKD. A.F.
NORTHERN ST VINCENT BASIN SEISMIC INVESTIGATION
INTERPRETED SECTIONS
SCALE. 1:25000 horiz.
DATE: March 1977
PLAN NUMBER:
77-242 R