# SHELL AUSTRALIA
# UPSTREAM OIL AND NATURAL GAS

SDA 1090



# SEISMIC INTERPRETATION REPORT

## VIC/P28, TORQUAY SUB-BASIN



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## TABLE OF CONTENTS



## LIST OF FIGURES



## LIST OF APPENDICES

# 1. INTRODUCTION

In 1988 Shell acquired the 1554km regional OS88A seismic survey across the entire area of exploration permit VIC/P28 on a 5km x 10km grid (Figs. 1, 2). The data confirmed the presence of a significant sub-basin within the permit and enabled the main tectonic elements to be defined. Two areas likely to have good exploration potential were identified and the 1186km OS90A infill survey was acquired in March 1990, providing a 1km x 3km grid over two target areas. Mapping of this data uncovered the Wild Dog Prospect.

# 2. SEISMIC INTERPRETATION

## 2.1 Seismic Data

The 1988 data was acquired by the GSI (now HGS) vessel M/V Magnificent Creek using 37.5 litre sleeve airgun array and a 300 channel, 3750 m digital fibre optic cable. This data was processed by GSI in Sydney using basically a "hands off" processing stream incorporating DMO. The 1990 infill grid was acquired by the M/V Pacific Titan with the same acquisition configuration as that of the 1988 data.

The 1990 data was processed by Digicon in Brisbane with a similar processing sequence to that used for the 1988 data, but also included the PMULT multiple suppression technique in an attempt to remove the strong multiples which obscure primary reflections in both the shallow Tertiary section and the deeper Lower Cretaceous section. The results of the Digicon processing were disappointing with the final product showing significant degradation of the primary energy (relative to the 1988 product) and a lack of coherent lateral continuity.

In-house processing tests including weighted stacking and a rigorous approach to velocity picking produced a significant improvement in data quality. Multiple energy was attenuated without significant loss of primary signal, resulting in an improvement in the resolution of the structure at depth (Figs. 3 ,4). Reprocessing of the majority of the 1988 and 1990 data (1825 km, Fig. 2) was completed in late May, 1991.

Despite the reprocessing improvements, the quality of the data within the Otway Group section is generally poor. The Otway Group sediments are predominantly of fluvial and alluvial sediments which typically produce discontinuous, low amplitude reflections. Strong reflections are usually associated with volcanics and packages of thin coals which have only limited lateral continuity. Thick coals within the overlying Eastern View Group attenuate the deeper seismic signal. The absence of a thick Eastern View Group on the Snail Terrace may explain the improved data quality in that area. Locally, lenses of igneous rocks (both extrusive volcanics and intrusive sills) completely mask the section below them. This is especially the case in the southwest of the permit.

### 2.2 Interpretation

The interpretation was focussed on the areas highlighted previously as most prospective. Six horizons were mapped regionally with confidence:

- (i) Intra-Torquay Group Marker
- (ii) Near Top Jan Juc Formation (Fig. 5)
- (iii) Top Anglesea Siltstone (Fig. 6)
- (iv) Top Boonah Formation (Fig. 7)
- (v) Top Eastern View Group (Fig. 8)
- (vi) Top Otway Group (Fig. 9)

A description of the seismic character of these events and the synthetic seismogram well ties are given in Appendix A. An attempt has been made to interpret the top of basement where possible (Fig. 10). In the basin deep this reflection is highly unreliable and is used for indicative depth to basement purposes only. On the Snail Terrace, the top of basement and a probable Top Casterton Beds reflection can be mapped with confidence.

Several intra-Otway Group events were interpreted with confidence in the western Snail Terrace region but could not be correlated across the Terrace bounding fault into the basin deep. Elsewhere, intra-Otway Group events were carried locally to provide structural form and to delineate potential intra-Otway Group closures.

### 2.3 Depth Conversion

The average velocity to each mapped horizon was derived from horizon-consistent stacking velocities and calibrated against Snail-1 and Nerita-1.

Stacking velocities had been carefully picked in-house during the reprocessing, and required only minor editing before calibration with the two wells. An examination of interval velocity maps showed only minor lateral velocity variations as can be seen from the average velocity map to Top Boonah (Fig. 11).

Below the top of the Otway Group, velocities are less consistent and stacking velocities were deliberately picked high in order to give better multiple suppression. A linear velocity-depth function, $V = 2300 + 0.45*Z$, derived from Snail-1, Nerita-1 and Hindhaugh

Creek-1, was used to depth convert from the top of the Otway Group to deeper levels.

## 2.4 Structural Interpretation

The structural geology of the region is complex. The Basin Deep in particular is intensely faulted; faults have elements of both extension, compression and strike slip movement. Fault character may change rapidly from line to line making fault correlation difficult. Therefore, the many minor faults have not been correlated in detail and interpretational effort has been directed to resolving the significant structural elements. The interpretation was made using a Landmark workstation where the fault interpretation options proved extremely valuable.

The Basin Deep contains the thickest development of the Otway Group and the Eastern View Group. The dominant fault trend is the NW-SE to W-E, normal throw and in places faults are closely spaced. Except on the Snail Terrace, these faults mainly throw down to the north (Fig. 9). There is clear evidence of folding within the Otway Group, which pre-dates the Miocene transpressional folds. The folding is limited mainly to the northeastern area. The folds are interpreted to be wrench-induced structures; along their axes they become tighter and more highly faulted until they have the appearance of flower structures (e.g. Fig. 12). The timing of wrenching is possibly mid-Cretaceous and corresponds with the early uplift of the Otway Ranges.

A NW-SE fault through the western part of the Basin Deep bounds the area of significant Eastern View Group development (Fig. 8). The Eastern View Group is either thin or absent across much of the Snail Terrace where Boonah Formation lies directly on the Top Otway Group unconformity. In the axis of the half graben and on the hanging wall block of the Snail Terrace bounding fault there are possible strike-valley fills which may contain Eastern View Group sediments (e.g. Fig. 13).

The Cretaceous structure is increasingly overprinted by Miocene transpression towards the northwest. This produced reactivation of the E-W normal faults in the western part of the Basin Deep, close to the Otway Ranges, and more broad open folds in the north (Fig. 7). These anticlines strike NE-SW, parallel to the Otway Ranges and other anticlines seen both onshore and offshore in the Gippsland Basin to the east.

The Snail Terrace, which is separated from the Basin Deep by a major, approximately E-W striking, fault complex can be further subdivided into two distinct structural elements. In the west the Snail

Terrace is a relatively simple half graben dipping to the SW. Subsequent tilting has resulted in erosion of the leading edge of the fault block producing an angular unconformity across what appears to be a wrench-related hinge line. East of the hinge, sediments dip to the northeast (Fig. 10). The Terrace is strongly dissected by a series of domino-style faults (Figs. 9) which strike sub-parallel to the faulting in the Basin Deep. They appear to detach at basement, and have complex geometries that cannot be resolved with the current seismic line spacing.

The structural mapping identified one drillable prospect called Wild Dog-1, after a creek near Apollo Bay. The Wild Dog Prospect (Fig. 14) is a simple, fault bound anticline on the edge of the Snail Terrace. The prospect is well defined at the top of the Boonah Formation and is well placed to have received charge from the Basin Deep prior to inversion. Its location at the leading edge of the Snail Terrace provides good access to any charge being generated from deeper in the Terrace.

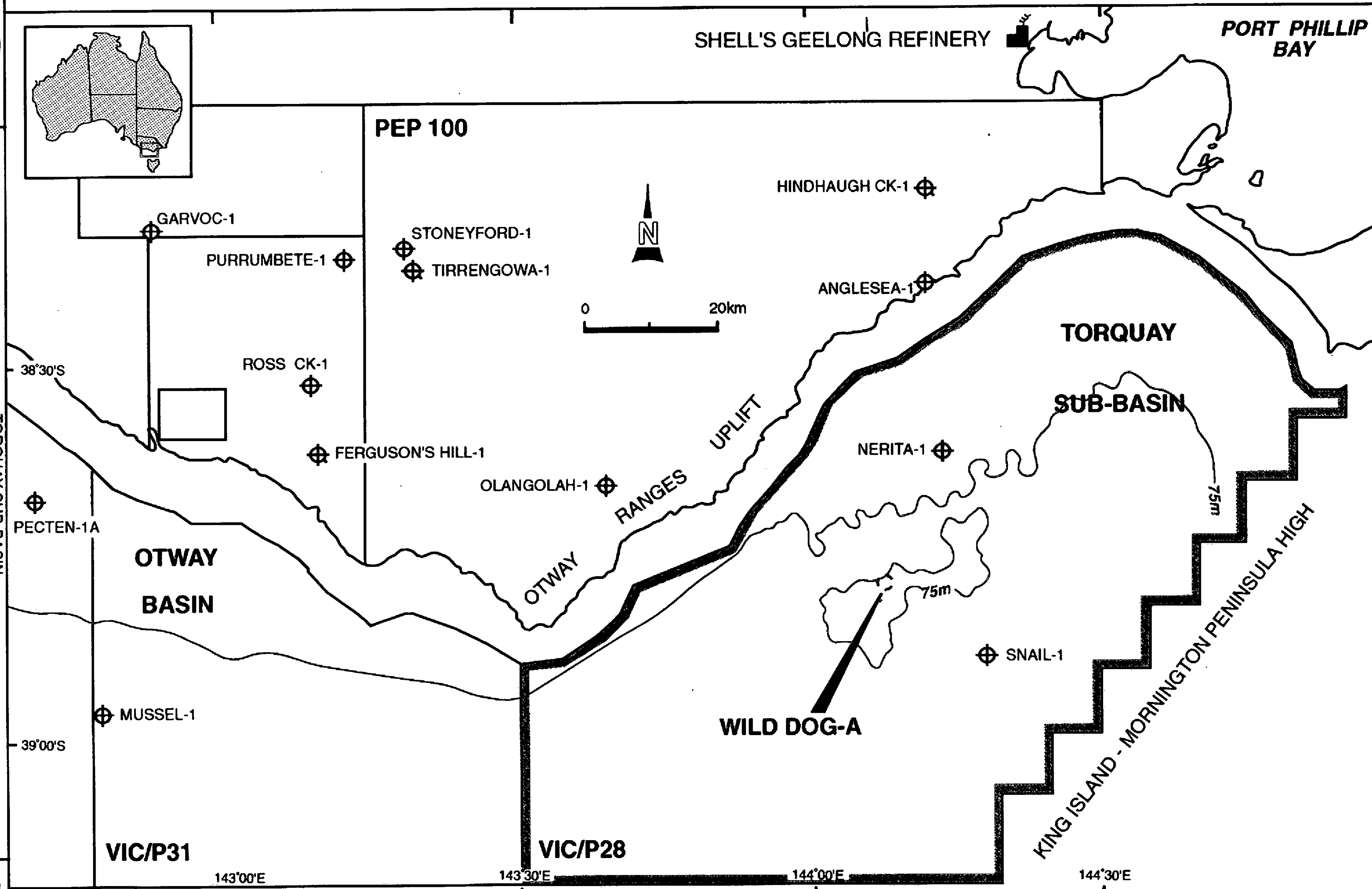
## 3. THE WILD DOG PROSPECT

Wild Dog represents a previously untested play in the basin. It is an asymmetric faulted anticline at the top of the Boonah Formation, which formed during the Oligocene in response to localised movement on the Snail Terrace bounding fault (Fig. 13).

The structure is seismically mature. It is defined by 8 true dip lines and 4 strike lines on a 1 km x 3 km grid. The average velocity to top reservoir increases northwards across the reservoir which depresses the northern flank of the prospect thereby reducing the area of closure in depth by 30% (Figs. 11, 14, 15). The southern limit of the structure is defined by a fault formed by reactivation of the Snail Terrace bounding fault. This fault cuts the highest point of the structure, hence the leak point may be as high as the culmination of the structure. The dip dependant depth closure (spill point = 1000-1005m) has an area of 17 $km^2$, and a vertical closure of 105m, but if the fault is sealing the spill point may be as deep as 1030m, hence the vertical closure would increase to 130 m and the area to 33 $km^2$. The trap culmination is at 900 m.

The timing of trap development is constrained by the local erosional unconformity in the Jan Juc Formation over the structure (Fig. 13). The trap is considered to have been effective at 28 Mabp, when the Anglesea Siltstone was sufficiently deep (>500m) to have been an effective seal.

The Anglesea Siltstone, which has been determined to be a good potential seal is 160 m thick over the prospect (Fig. 16). To the south of the fault on the Snail Terrace the seal is 120 m thick. The throw on the fault is slightly greater than half the seal thickness on lines OS88A-13 and OS90A-11, but over the rest of the structure the seal is displaced by less than half its thickness. On most dip lines the deformation of the seal appears to have been ductile rather than brittle. Nowhere on the structure is the sealing unit breached.

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Author: EXO

Report No.: SDA 1090

Date: NOVEMBER 1991

Drawing No.: 27439 C

**LOCATION MAP**

TORQUAY SUB-BASIN

Figure 1

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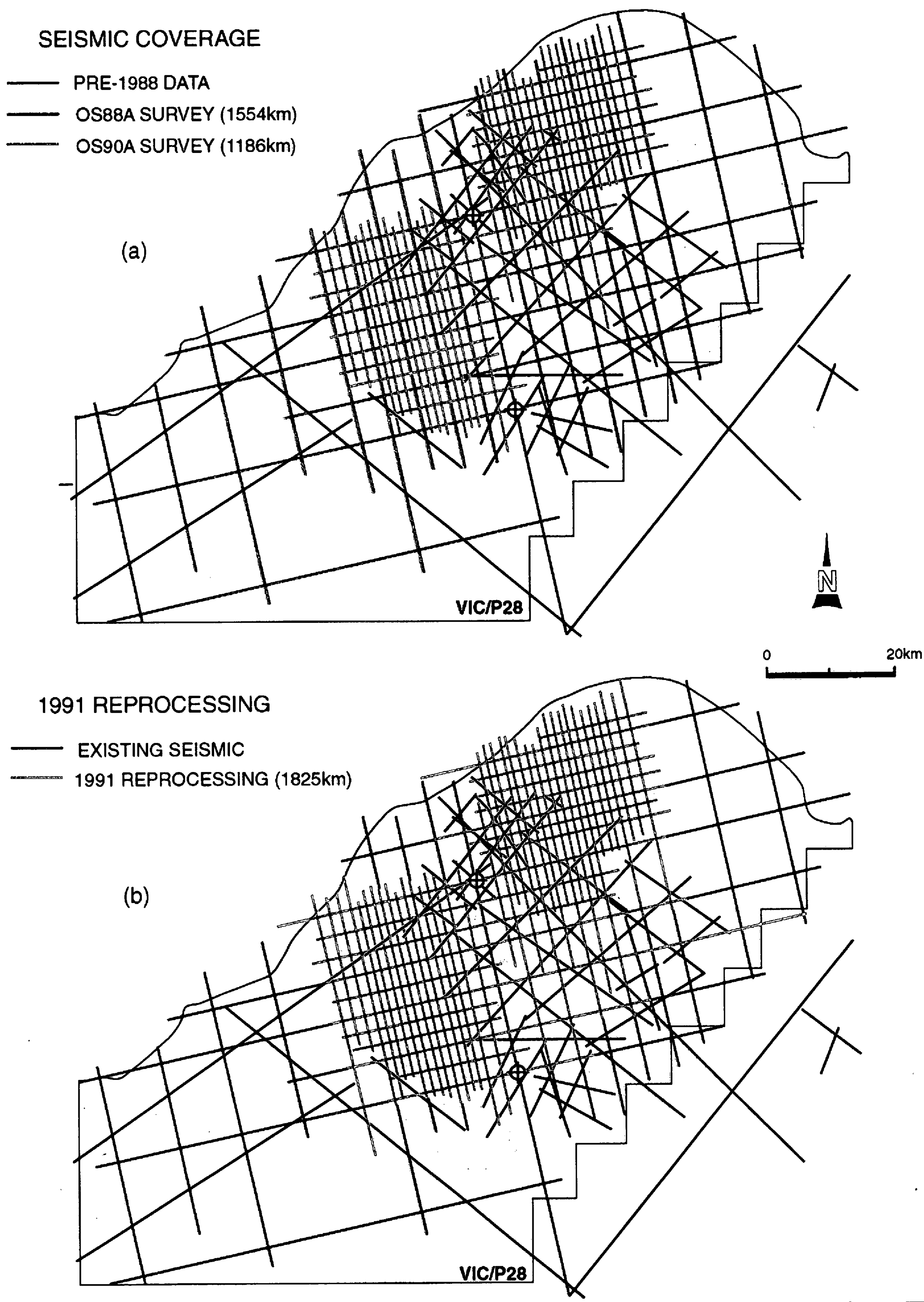


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OTWAY BASIN

**SEISMIC COVERAGE**

Author: EXO | Report No.: SDA 1090 | Date: NOVEMBER 1991 | Drawing No.: 27442C

Figure 2

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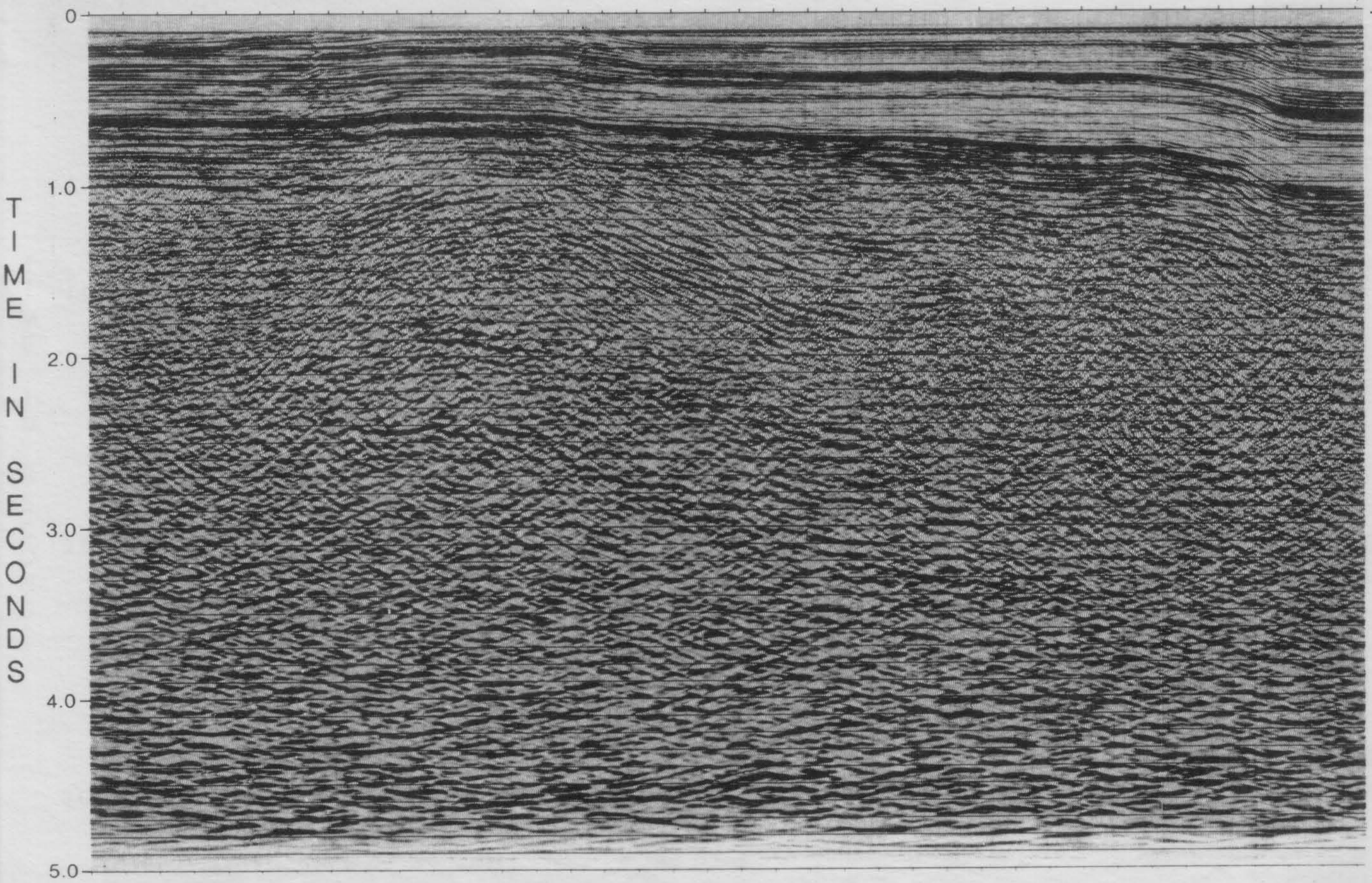


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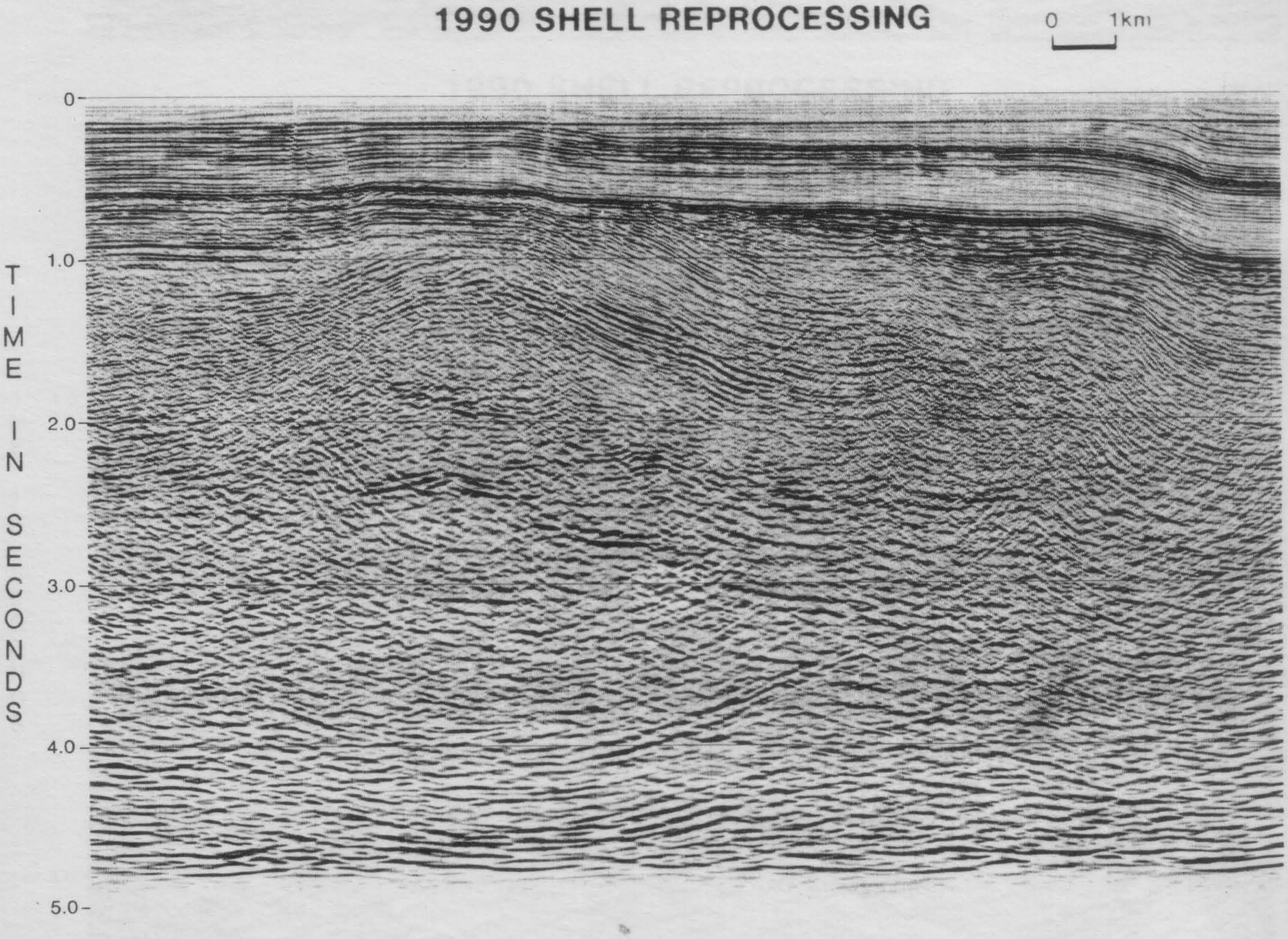


| SHELL-AUSTRALIA E.& P. OIL AND GAS | OTWAY BASIN | | | Figure |
|---|---|---|---|---|
| | REPROCESSING COMPARISON - OS90A-41 | | | 3 |
| | Author: EXO | Report No.: SDA 990 | Date: NOV 1991 | Drawing No.: 27458 |

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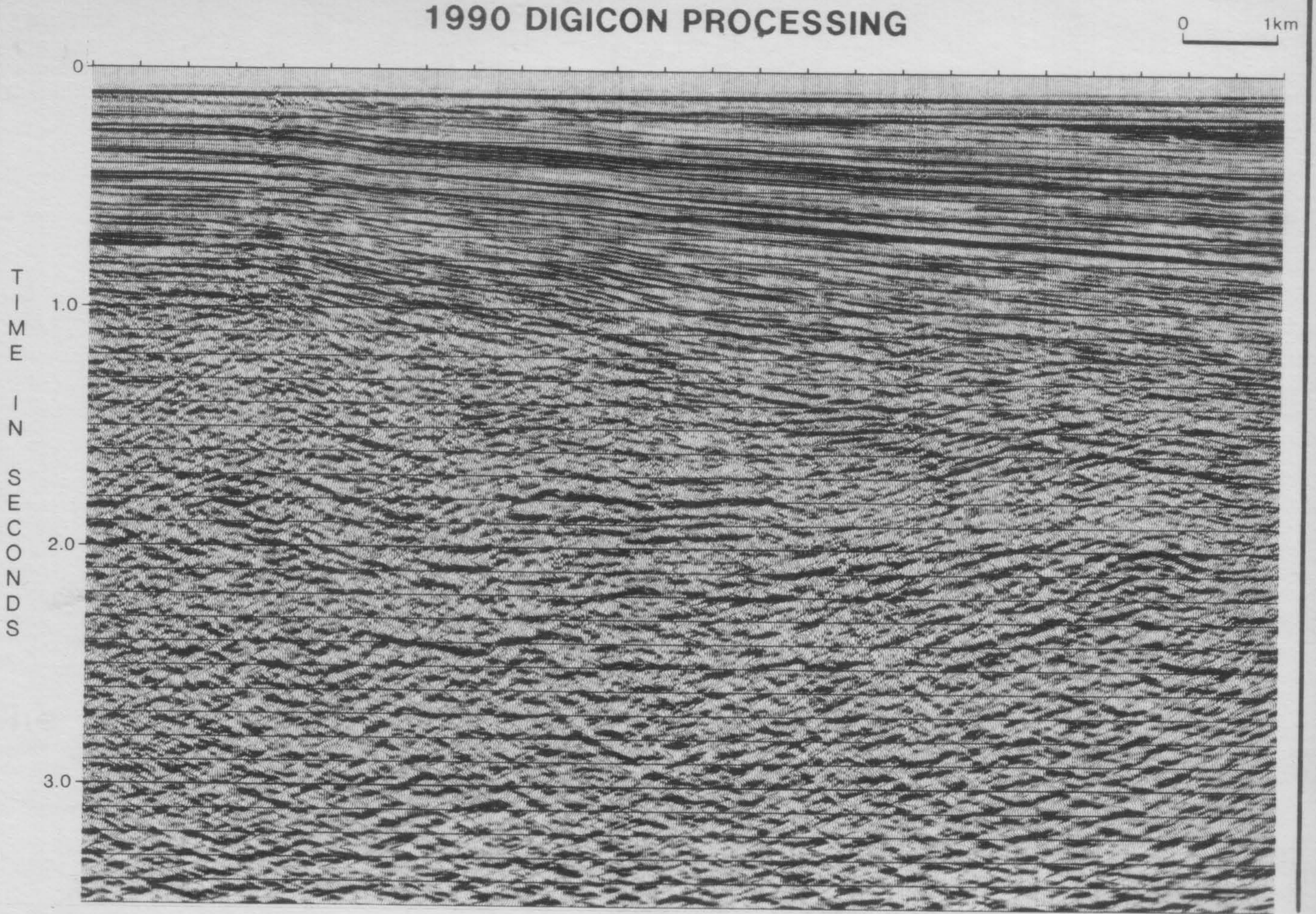


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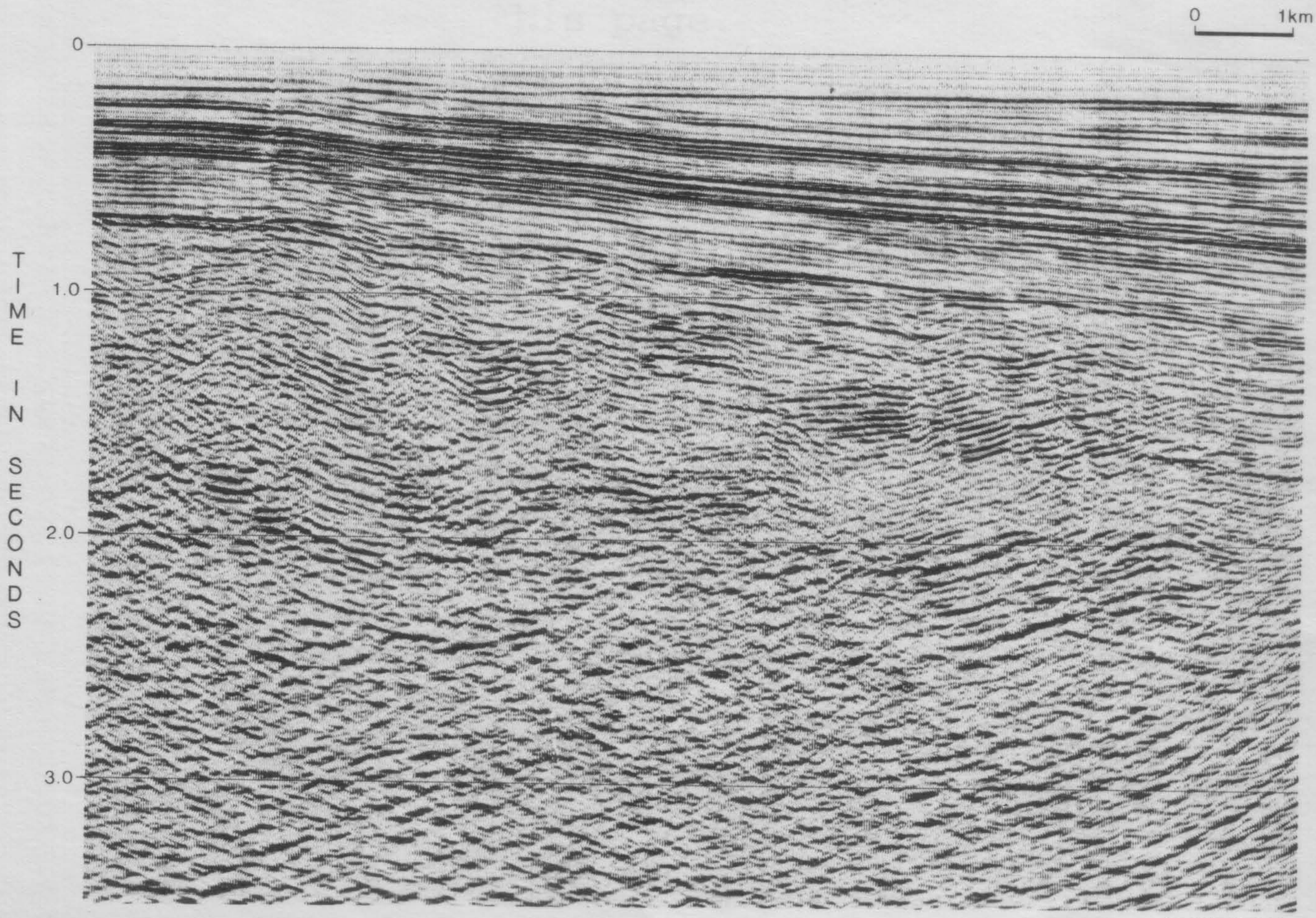


OCTOBER 1990

| | | | | |
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| SHELL-AUSTRALIA E.& P. OIL AND GAS | OTWAY BASIN<br>**REPROCESSING COMPARISON - OS90A-57** | | | Figure 4 |
| | Author: EXO | Report No.: SDA 1090 | Date: OCT 1990 | Drawing No.: 26467 |

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**APPENDIX A.** SEISMIC PICKS AND WELL TIES

The seismic data is zero-phase and has been displayed with a trough representing a positive acoustic impedance interface. The well ties for Nerita-1 and Snail-1 are shown as Figures A-1 and A-2. Neither of the two wells are optimally located for good well ties. At both locations, localised variations in geology affect the seismic response such that the correlation of reflections away from the wells is not straightforward.

The **intra-Torquay Group Marker** is not intersected by Nerita-1. It crops out at sea floor both to the north and south of the well. In Snail-1, it is intersected above the top of logs and there is no synthetic seismic data to tie. The intra-Torquay Marker is a continuous black loop (negative acoustic impedance contrast) of variable but generally high amplitude. The Marker was interpreted to assist with depth conversion and for stratigraphic control in basin history and maturity modelling.

The **Top Jan Juc** reflection marks a sharp increase in acoustic impedance and is typically a continuous strong white loop. The tie to Nerita-1 and Snail-1 is good.

The **Top Anglesea Siltstone** reflection is mapped as a variable but usually strong, continuous black loop. To the north of the Snail Terrace, above the Wild Dog Prospect, a localised unconformity exists which is the product of reactivation of the Snail Terrace bounding fault. The Anglesea Siltstone unit is seismically quiet and the transition to the underlying Boonah Formation is marked by an increase in acoustic response.

The **Top Boonah Formation** in Snail-1 is a slight acoustic impedance increase which produces a weak trough below which there is a strong black peak. In Nerita-1, the tie is also a weak trough above a stronger peak. Away from the wells, the white trough varies in strength but can be mapped with confidence. The unconformity at the top of the **Eastern View Group** is the most obvious seismic event on most lines. The unconformity is often quite angular and when this is not the case, it is normally a strong black loop. On parts of the Snail Terrace near Snail-1, the Top Eastern View Group is a trough. The Eastern View Group is either very thin or absent over much of the Snail Terrace. In the Basin Deep, it is characterised by a package of higher amplitude, laterally continuous reflections with consistent character that allows correlation across faults. These strong events emanate from the thick Eastern View coals and coaly shales.

In both Snail-1 and Nerita-1, the top of the **Otway Group** is a rather indistinct peak. In the Basin Deep, the top of the Otway Group is not an angular unconformity. It is recognisable as the change in character from the strong, coherent reflections of the Eastern View Group to the discontinuous, lower frequency character of the Otway Group. It was largely on this differentiation of character that the top of the Otway Group was mapped. On the Snail Terrace, the Top Otway Group is more readily recognised as an angular unconformity at the base of the Boonah Formation or Eastern View Group.

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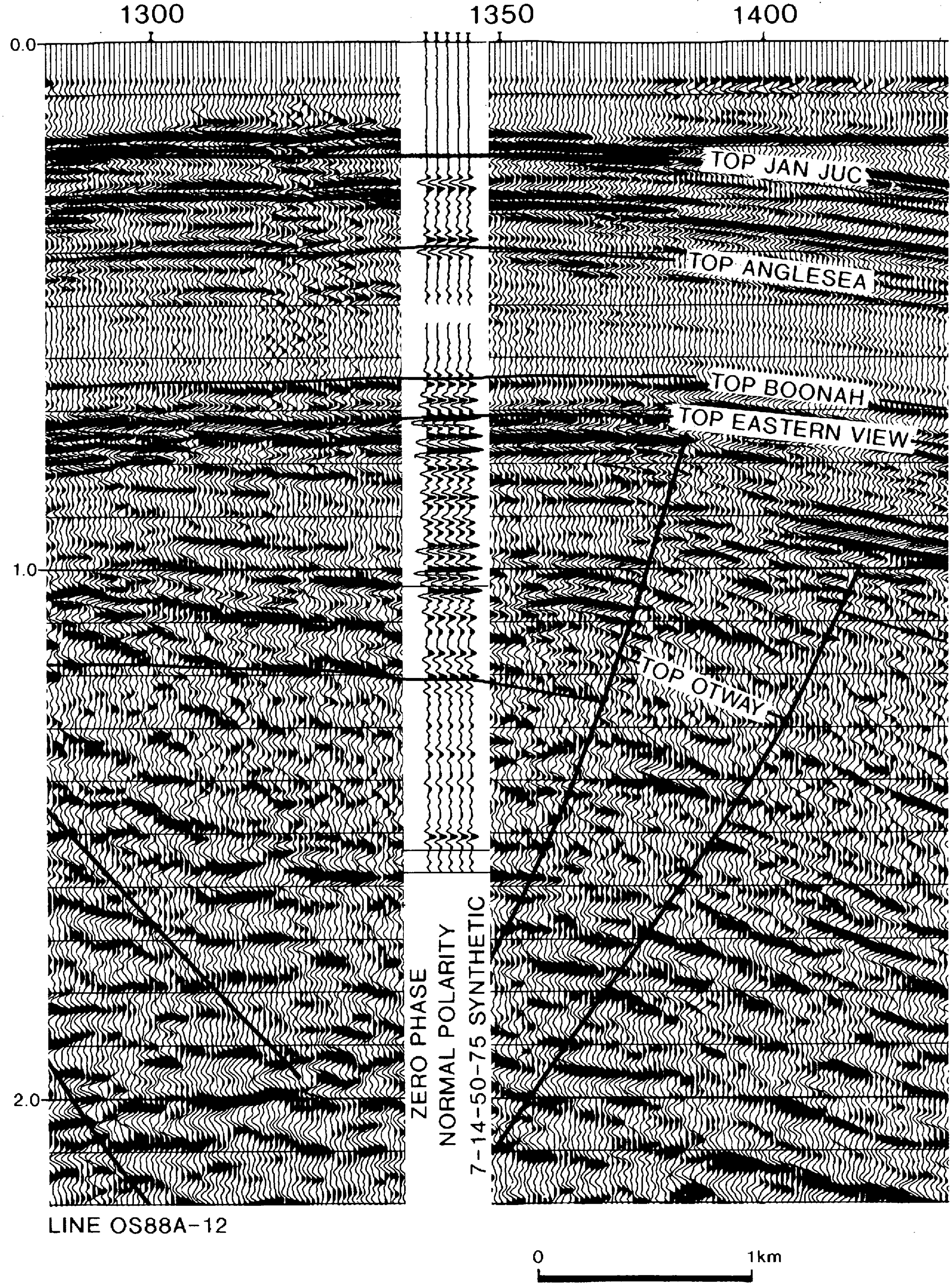
NERITA-1

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| OTWAY BASIN | | | | Figure A-1 |
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| **SEISMIC -WELL TIE NERITA-1** | | | | |
| Author: EXO | Report No.: SDA 1090 | Date: NOV.1991 | Drawing No.: 27501 | |

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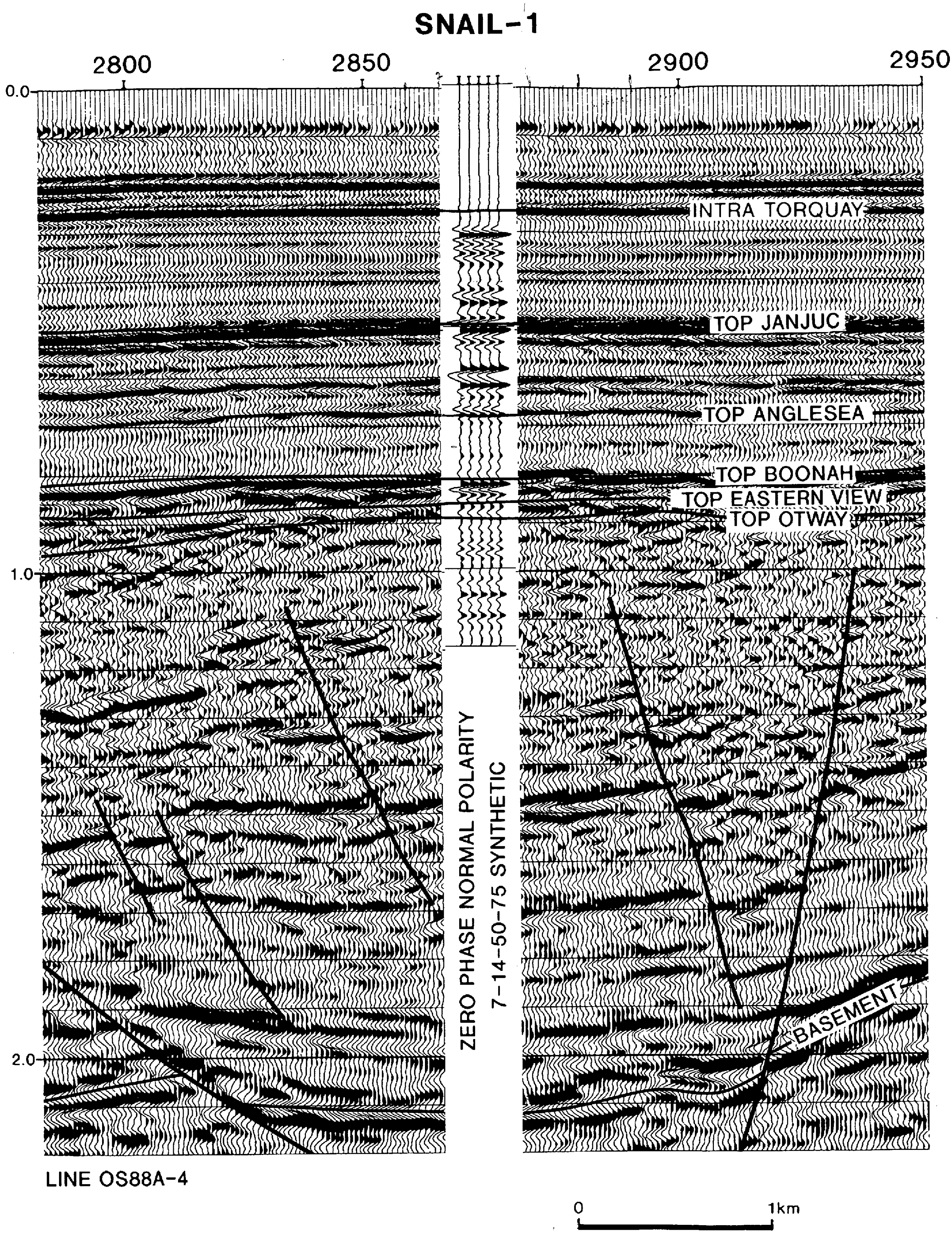


| SHELL-AUSTRALIA E.& P. OIL AND GAS | OTWAY BASIN | | | Figure |
|---|---|---|---|---|
| | SEISMIC-WELL TIE SNAIL-1 | | | A-2 |
| | Author: EXO | Report No.: SDA 1090 | Date: NOV.1991 | Drawing No.: 27499 |