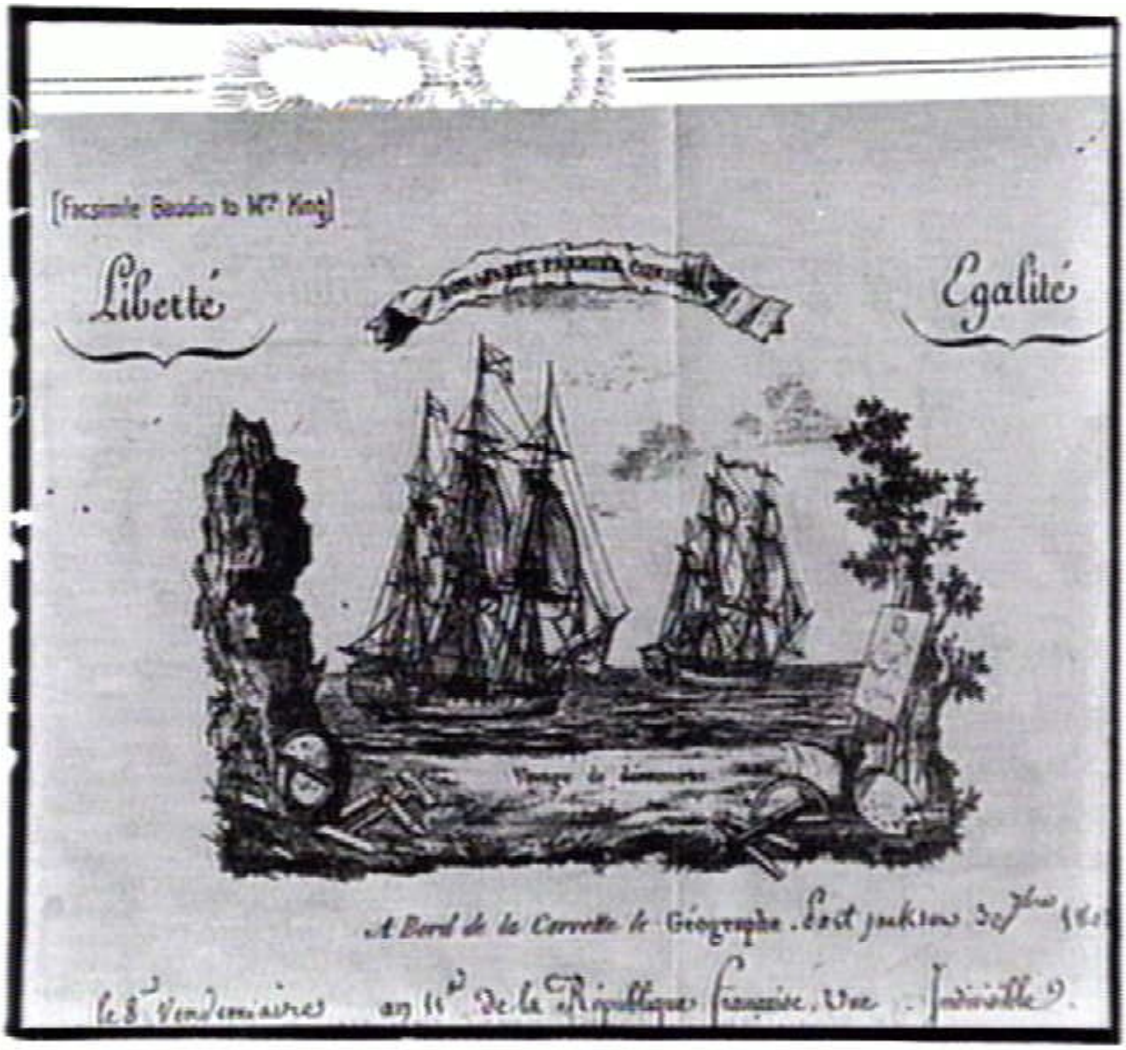
Geographe North 1

Well Proposal

Version 1.0



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Geographe North 1

Well Proposal

Version 1.0

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Approved:	Manager, Offshore Exploration	Date
Approved	General Manager, Exploration	Date

SUMMARY

WELL NAME	*Geographe North 1*
LOCATION	Seismic: Inline 840, CDP 2665 Latitude: 39°, 04', 31.5"S Longitude: 142°, 55', 15.1"E Northing: 5 673 084 m N Easting: 666 160 m E
PERMIT	VIC/P43 Offshore Otway Basin
INTEREST HOLDERS	Origin Energy Resources Ltd (Operator) 30% Woodside Energy Ltd 55% CalEnergy Gas (UK) Ltd 15%
TYPE OF WELL	Exploration
ANTICIPATED SPUD	August 2001
ELEVATION	Water Depth: 81 m RT: 25 m
PLAY TYPE	Faulted Anticline
OBJECTIVE	Flaxmans Formation (secondary) Waarre Formation

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1. INTRODUCTION

1.1 Location

The proposed Geographe North 1 exploration well is to be drilled in the offshore Otway Basin in petroleum exploration permit VIC/P43. The proposed location lies approximately 230 km southwest of Melbourne, 50 km south of Port Campbell and 145 km southeast of Portland (Fig. 1). Geographe North 1 is 4.2 km north of the Geographe 1 gas discovery, drilled in June 2001.

1.2 Permit Details

VIC/P43 was granted on August 11, 1999 to the current joint venture comprising Origin Energy Resources Limited (Operator), Woodside Energy Ltd, and CalEnergy Gas (UK) Ltd. Prior to drilling Geographe 1, Woodside and Origin both farmed in for 5% each of CalEnergy's equity, resulting in the following equity distribution:

Origin Energy Resources Limited	30% (Operator)
Woodside Energy Ltd	55%
CalEnergy Gas (UK) Ltd	15%

The work commitment for VIC/P43 is as follows:

Year 1:	200 km^2 3D seismic, 500 km 2D seismic, reprocessing, data review
Year 2:	Data evaluation
Year 3:	1 well, data review
Year 4:	400 km^2 3D seismic
Year 5:	Data assessment
Year 6:	1 well, data review

In early 2000, the VIC/P43 joint venture acquired 730 km^2 of 3D seismic data, which satisfied the seismic work obligations for both Year 1 and Year 4 of the present permit term. Geographe 1, spudded on May 28, 2001, is expected to satisfy the Year 3 work commitment.

The drilling operations for Geographe North 1 will be managed by Woodside Energy Ltd, under the terms of the VIC/P43 offshore operations services agreement with Origin Energy Resources Ltd.

Figure 1: Location of proposed Geographe North 1.

2.0 GEOLOGY & GEOPHYSICS

2.1 Previous Exploration

Frome-Broken Hill was the first company to carry out exploration in the Otway Basin with the drilling of an onshore well (Port Campbell 1) in 1959. Oil shows were encountered and a non-commercial gas flow was recorded from the Waarre Formation. Frome-Broken Hill was granted the first offshore permits, which covered almost the entire Victorian portion of the basin. The extent of the basin was delineated by an extensive aeromagnetic survey conducted by the consortium in 1959 and 1961, followed by the Southwest Victoria Survey acquired offshore in 1963.

Pecten 1A, the first offshore well, was drilled by Shell in 1967. Pecten 1A encountered a gross 17.5 m hydrocarbon column, which on test flowed gas at 145 mcfd from poorly developed Waarre Formation sandstones. Esso drilled Prawn A1 in 1967, Nautilus 1 in 1968 and Mussel 1 in 1969. These wells were all plugged and abandoned.

Seismic surveys were acquired within the Victorian offshore Otway Basin during 1980-82 by Esso and Phillips. Esso drilled Triton 1 in 1982 in VIC/P15. This well was also plugged and abandoned. All permits were relinquished between 1986 and 1990.

BHP Petroleum conducted the most recent offshore exploration in two exploration permits VIC/P30 and VIC/P31, awarded in 1990, which covered a large portion of the eastern offshore basin. In the following year BHP reprocessed 2,249 km of the 1980-82 Esso seismic data and recorded 2,284 km of new seismic data (OH91 series). Seven wells were drilled by BHP; La Bella 1, Eric the Red 1, Minerva 1, Minerva 2A, Loch Ard 1, Conan 1 and Champion 1. Minerva 1 and La Bella 1 were gas discoveries. Minerva 1 flowed gas during drill stem testing at a rig-limited rate of 28.8 mmcfd from excellent sandstones within the Waarre Formation. Gas-in-place is estimated at 575 bcf (Luxton et al., 1995). The La Bella gas discovery was evaluated by RFT (no DST was conducted). Gas-in-place was evaluated at 210 bcf (Luxton et al., 1995). BHP was granted Retention Leases over the discoveries in 1997/98. The exploration permits were surrendered and subsequently gazetted as V98-2, V98-3 and V98-4.

The exploration permit VIC/P43 was awarded on August 11, 1999 to the current joint venture based on a competitive work program bid for area V98-2 (Application for Area V98-2, 1998). Since the block was awarded 730 km^2 of 3D seismic data were acquired early in 2000. In May 2001. Thylacine 1 was drilled in T/30P, followed in June 2001 by Geographe 1 in VIC/P43. Both wells resulted in substantial gas discoveries. Geographe 1 intersected a 240 m gas column in interbedded sands and shales of the Flaxmans / Waarre Formation.

Well	Year	Operator	TD(m)	Status	Result
Pecten 1A	1967	Shell	2850	P&A	Gas shows,145 mcf from 17 m of tight Waarre
Prawn A1	1967	Esso	3193	P&A	No valid closure, good reservoir, poor seal
Nautilus 1A	1968	Esso	2011	P&A	Tertiary wedge play, no reservoir found
Mussel 1	1969	Esso	2450	P&A	Not drilled in crestal location
Whelk 1	1970	Esso	1466	P&A	No seal
Triton 1	1982	Esso	3545	P&A	Poor reservoir, no closure mapped to date
La Bella 1	1993	BHP	2710	GAS	Gas discovery, ~210 bcf OGIP
Minerva 1	1993	BHP	2425	GAS	Gas discovery, ~575 bcf OGIP
Eric the Red 1	1993	BHP	1875	P&A	No cross fault seal
Minerva 2A	1993	BHP	2170	GAS	Thick Waarre sand development
Loch Ard 1	1993	BHP	1397	P&A	No Top Seal for Waarre reservoir
Conan 1	1995	BHP	2175	P&A	Ineffective fault seal
Champion 1	1995	BHP	1882	P&A	Upper Waarre absent, no cross fault seal
Thylacine 1	2001	Origin	2710	GAS	Gas discovery, Flaxmans / Waarre
Geographe 1	2001	Origin	2430	GAS	Gas discovery, Flaxmans / Waarre

Table 1: Drilling history in the eastern offshore Otway Basin.

2.2 Regional Geology

The Otway Basin is part of the passive margin that formed in response to rifting between Australia and Antarctica. Two Early and Late Cretaceous stages of rifting have been identified. The main period of rifting occurred at the end of the Cenomanian and continued to the Campanian. A dominant feature of the eastern Otway is the Shipwreck Trough (Fig. 2) set up by sinistral transtension along the Sorell Transfer Fault. Significant thickening of Late Cretaceous sediments is observed towards the axis of the Shipwreck Trough.

Economic basement for the eastern offshore Otway Basin is represented by the Late Albian, upper Eumeralla Formation. The upper Eumeralla is also regarded as the main source interval for the overlying Late Cretaceous sediments within the Shipwreck Trough. Two distinct depositional sequences are interpreted in the overlying Late

Cretaceous interval (Fig. 3). The oldest sequence comprises the lower part of the Waarre Formation, deposited during the Cenomanian to Turonian. This sequence thickens significantly into the Trough. Sedimentation appears to have been focused west and south of the Cape Otway High. The rift climax of this sequence was associated with growth along the Mussel Fault Zone and the Tartwaup Hingeline and resulted in a shallow marine transgression across low areas of the basin. The base of the marine sequence marks a change from dominantly lithic to quartzose sediment provenance, which continues throughout the rest of the Late Cretaceous section. Potential reservoir facies exist in the lower and upper portions of this sequence.

A significant unconformity occurs within the Waarre Formation separating the upper and lower sequences. The best reservoir facies are intersected in the low stand tract at the base of this upper sequence (Fig. 4). Sedimentological analysis of the Minerva 2A core shows this section to comprise high-energy fluvial facies. Palaeotopography within the Shipwreck Trough is interpreted to be the primary control upon deposition. Quartzose sediments were sourced from the north and possibly lithic sediments from the east in the southern part of the Trough where predominantly non-marine facies have been intersected in Prawn A1, Eric the Red 1 and Loch Ard 1 on the Prawn Platform. The Flaxmans Formation overlies the Waarre Formation and displays a clear progradational, offlapping character in the Thylacine-Geographe area and comprises a series of coarsening-upward deltaic sequences.

The Flaxmans Formation is overlain by the Belfast Mudstone, which represents the maximum flooding of the Shipwreck Trough during the main phase of rift climax. The Belfast Mudstone is preserved at its thickest within the Trough and forms an effective regional seal for hydrocarbons trapped within the Waarre Formation. The Belfast Mudstone is overlain by the thick fluvio-deltaic Paaratte Formation, which represents the post-rift portion of the upper sequence. The Paaratte Formation, in the Shipwreck Trough, consists entirely of distal marine shales up to the Maastrichtian where minor regressive interbedded sands occur.

Above the Base Tertiary unconformity, Early Tertiary sediments consist of the progradational fluvio-deltaic Wangerrip Group. The Wangerrip Group is overlain by the transgressive marine sediments of the Nirranda Group. These sediments consist of coarse Mepunga Sandstone overlain by the Oligocene Narrawaturk Marl. Open marine carbonates of the Heytesbury Group overlie the Nirranda Group unconformably. The Gellibrand Marl consists of lower calcareous claystone/siltstone sequence overlain by marls and interbedded limestones. The Late Miocene to recent Port Campbell Limestone comprises the youngest sequence in the eastern offshore Otway Basin.

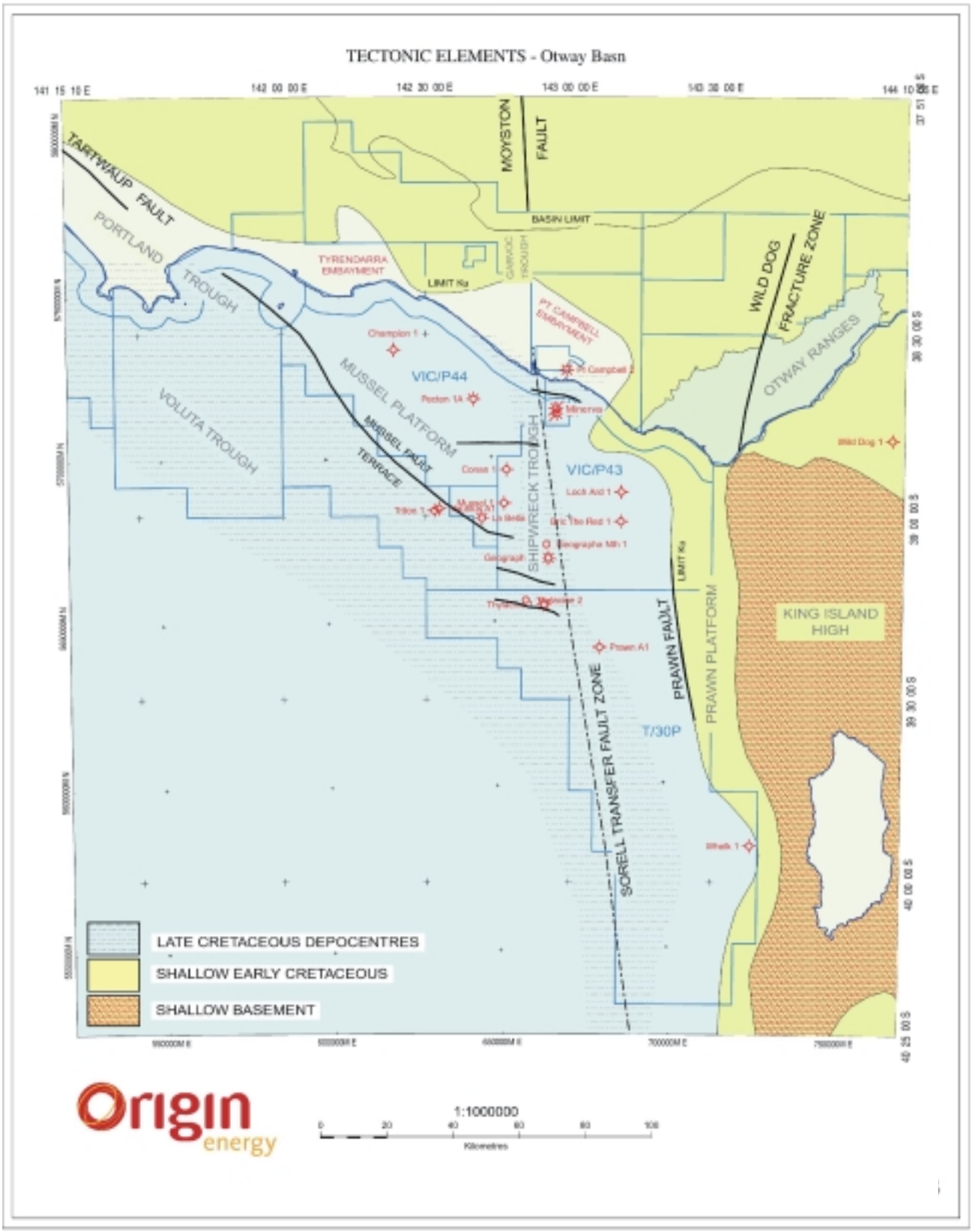


Figure 2: Tectonic elements of the Otway Basin.

OFFSHORE OTWAY BASIN
STRATIGRAPHIC COLUMN

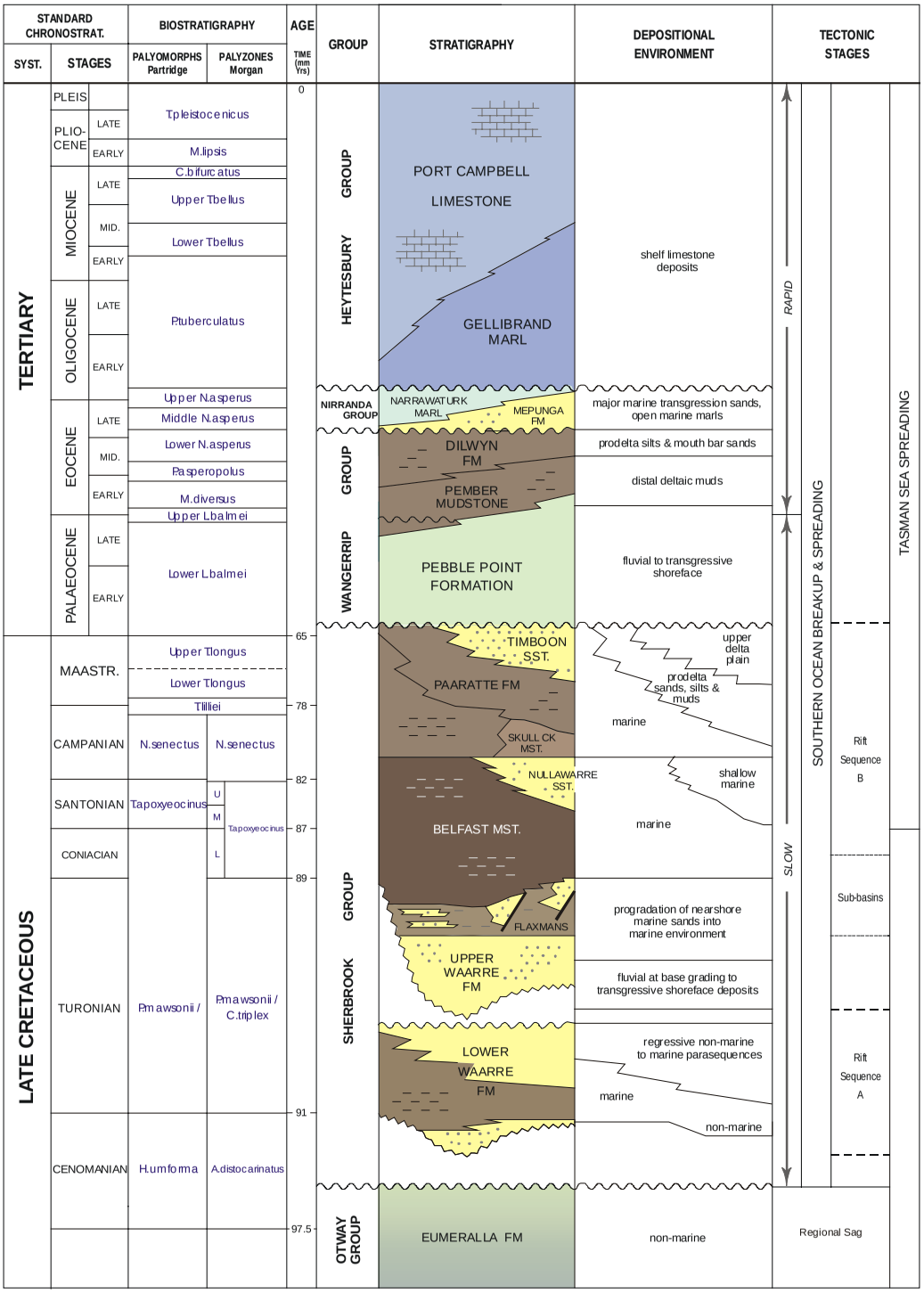


Figure 3

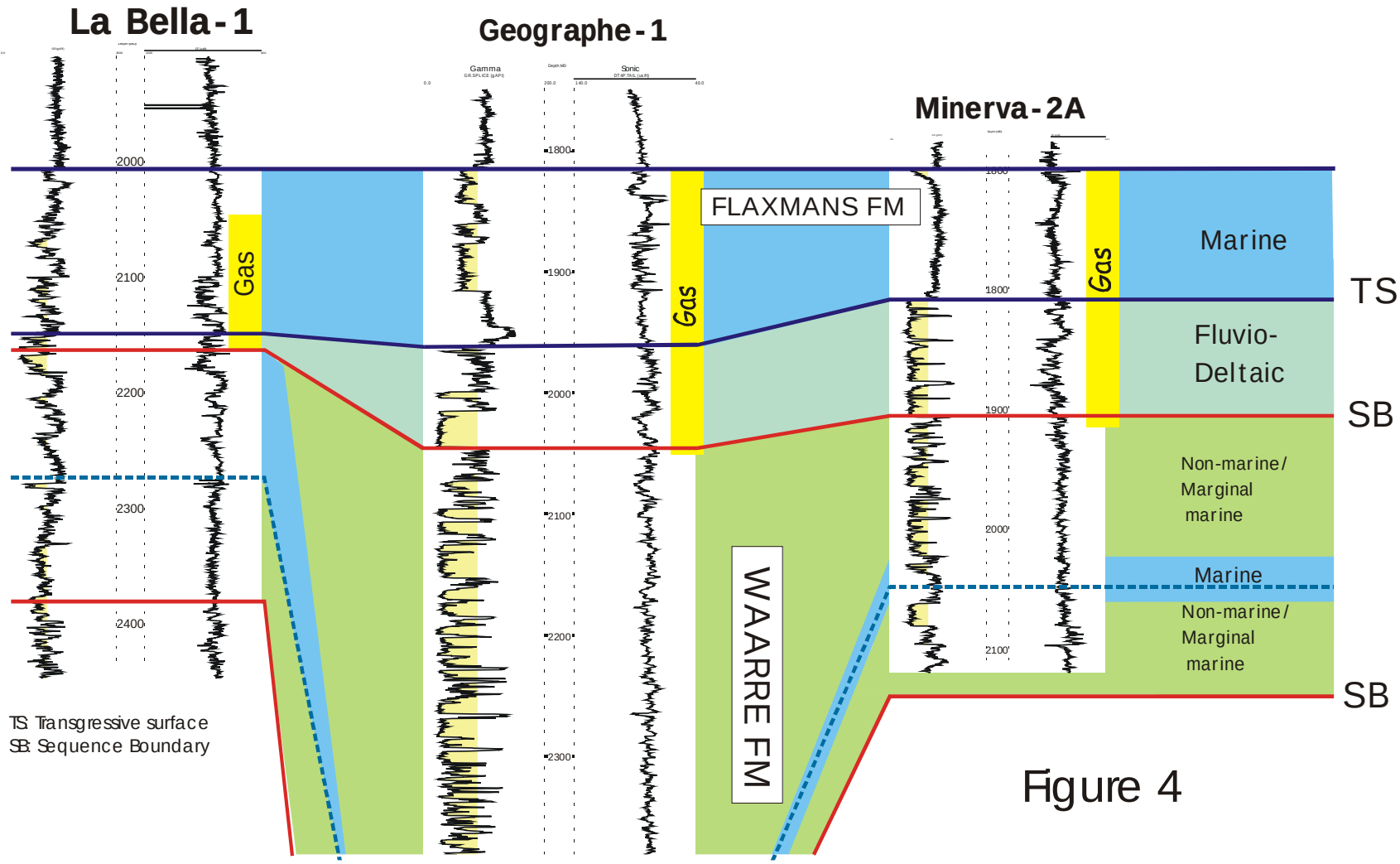

La Bella-1
Geographe-1
Minerva-2A
Gamma
Sonic
2000
2100
2200
2300
2400
1800
1900
2000
2100
2200
2300
1800'
1900'
2000'
2100'
Gas
Gas
Gas
FLAXMANS FM
WAARRE FM
Marine
Fluvio-
Deltaic
Non-marine/
Marginal
marine
Marine
Non-marine/
Marginal
marine
TS
SB
SB
TS: Transgressive surface
SB: Sequence Boundary

Figure 4

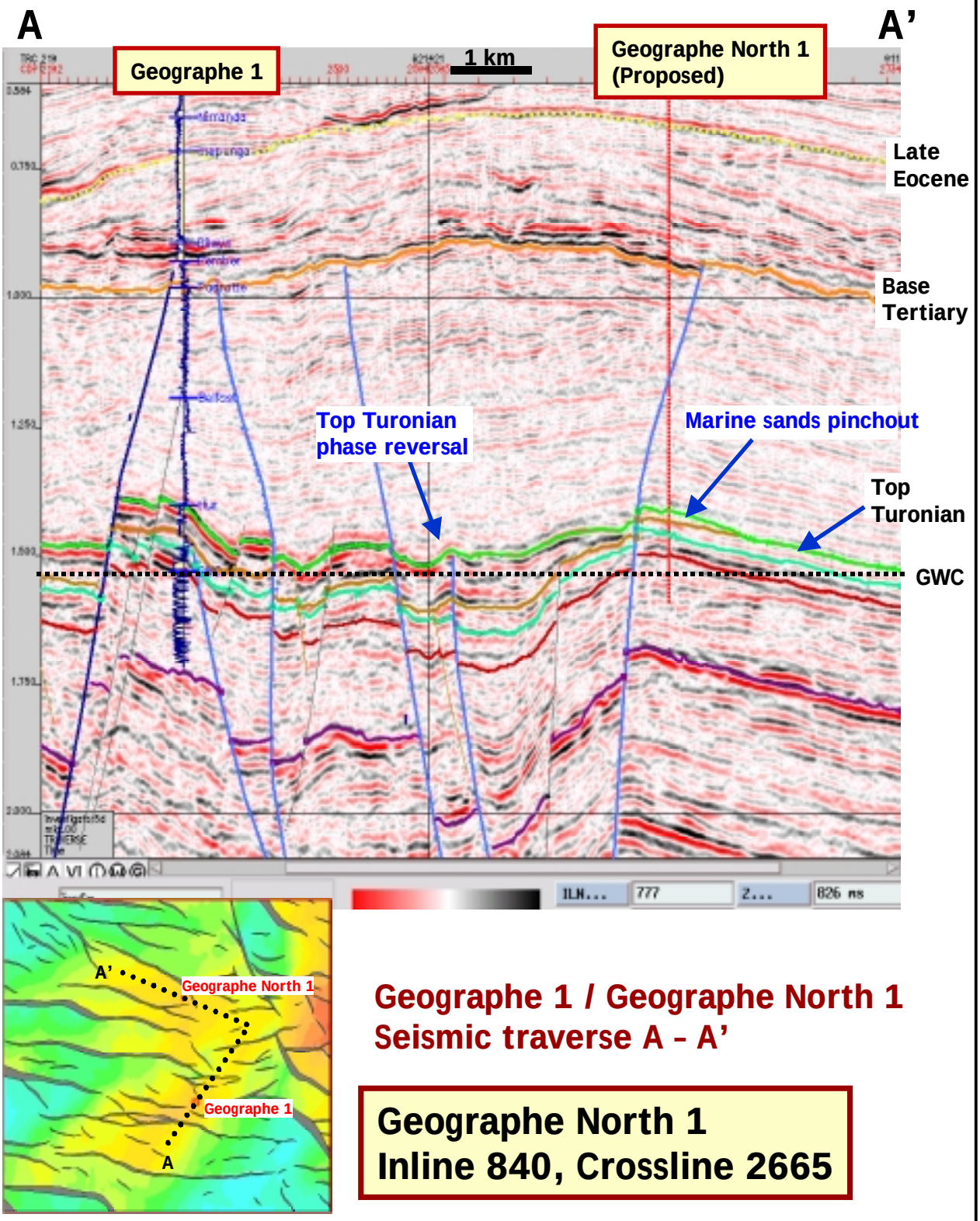
2.3 Seismic Interpretation

Seismic interpretation was carried out on the Investigator 3D cube acquired in 2000. 3D seismic data quality is generally good over the prospect and modern seismic attribute analyses have enabled accurate delineation of structure and amplitude anomalies. The Top Turonian objective is readily discernible over the Geographe North prospect area as a moderately bright trough. This is in contrast to the opposite phase 'soft kick' peak, which is observed within closure on the southern structure, drilled by Geographe 1 (Fig.5).

This change in character of the Top Turonian seismic event, is due at least in part to lithological variation. The progradational unit, which contains the Flaxmans sandstone reservoir intersected at Geographe 1, is interpreted to be largely absent at the Geographe North 1 location (Fig.5). The first 100m of sediments underlying the Top Turonian at Geographe North 1 are expected to be largely non-reservoir. This may explain the absence, in the northern structure, of seismic amplitudes attributed to gas saturation within the southern structure (Fig.6). It is this absence of amplitudes that gives rise to an associated moderate risk for hydrocarbon migration into Geographe North and hence the exploration classification for this well (Fig.7).

Seismic quality at the Top Waarre peak seismic event is good over the relatively unfaulted northern part of the Geographe structure (Fig.5). The Top Waarre event is poorly defined to the south and east due to the high degree of faulting within those parts of the Geographe structure. Correlation is difficult from Geographe 1 to Geographe North 1 as intra Waarre seismic events have to be interpreted through a highly faulted saddle between the two culminations of the structure (Fig. 6 & Fig.7). Geographe 1 and the proposed Geographe North 1 are similar distances from the axis of the Shipwreck Trough and the lower Waarre units are not interpreted to vary significantly in thickness between the two locations (Fig.6).

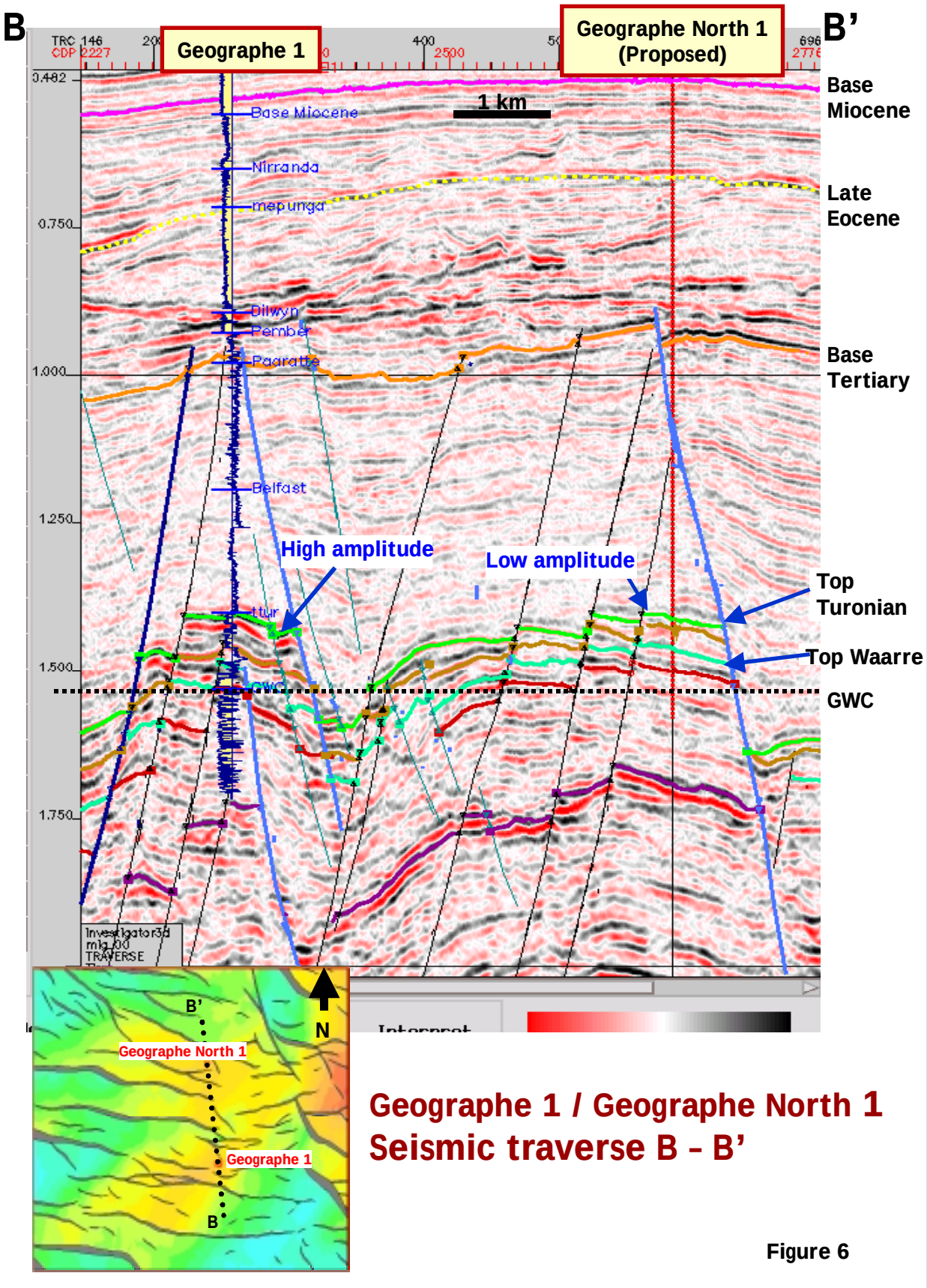
A depth map for the Near Base Tertiary shows the proposed location at that level (Fig.8). This map indicates that the well location is outside of any closure at the Base Tertiary level. The top Turonian depth structure map highlights the shape of the Geographe structure and shows structural spill to the northeast of the prospect (Fig 9). A preliminary interpretation of the Top Waarre has been conducted over the Geographe Field (Fig. 10). This horizon represents the interpreted boundary between the Flaxmans Formation transgressive unit and the fluvio-deltaic sands of the Waarre Formation. The map highlights the saddle between the north and south structures and the independence of the two structures at this level. Below the Top Waarre, the base of the "100' sand" has been recognised as a mappable event across the Geographe structure and is interpreted to represent the sequence boundary between the upper and lower Waarre (Fig. 7).



Geographe 1 / Geographe North 1
Seismic traverse A – A'

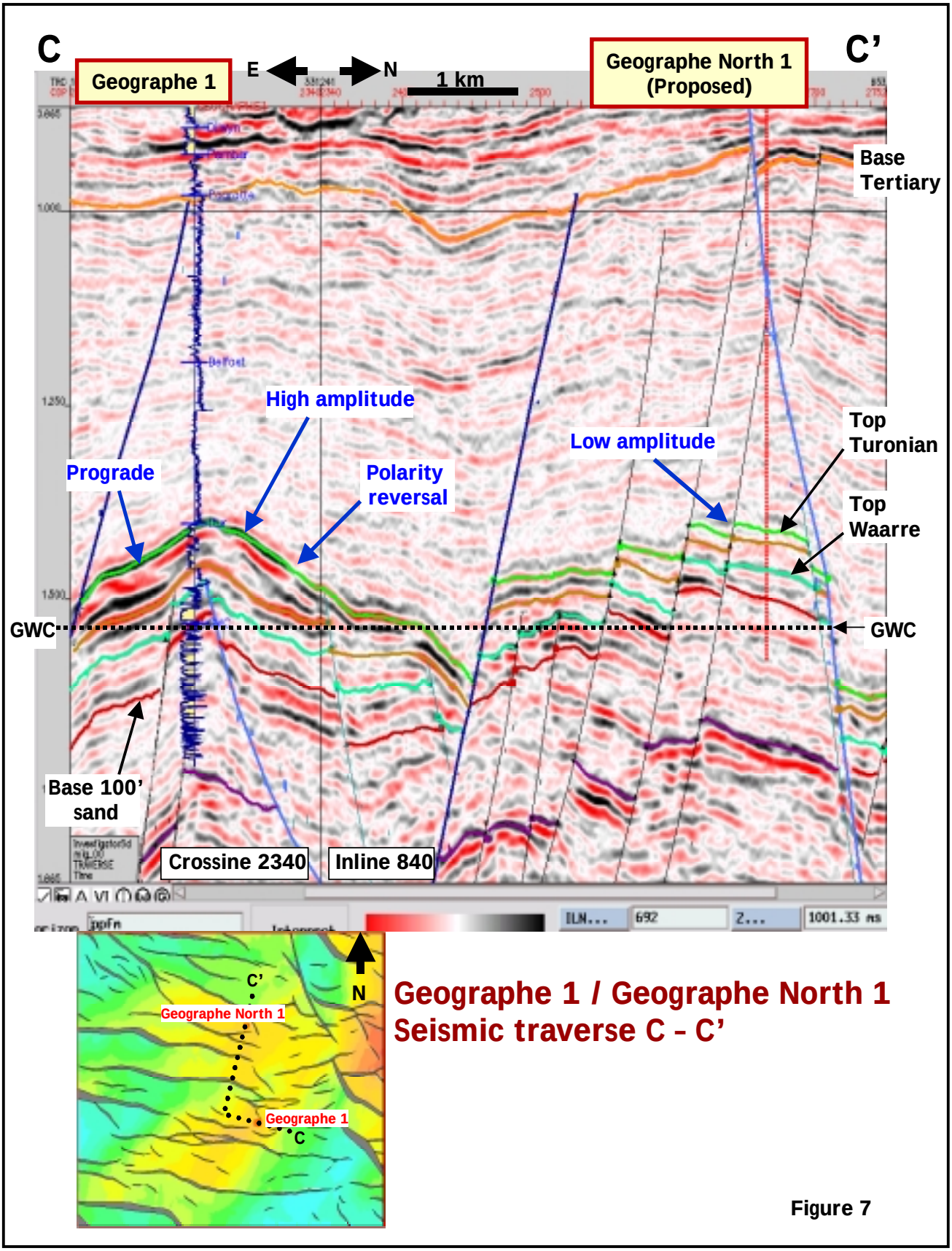
Geographe North 1
Inline 840, Crossline 2665

Figure 5



Geographe 1 / Geographe North 1
Seismic traverse B – B'

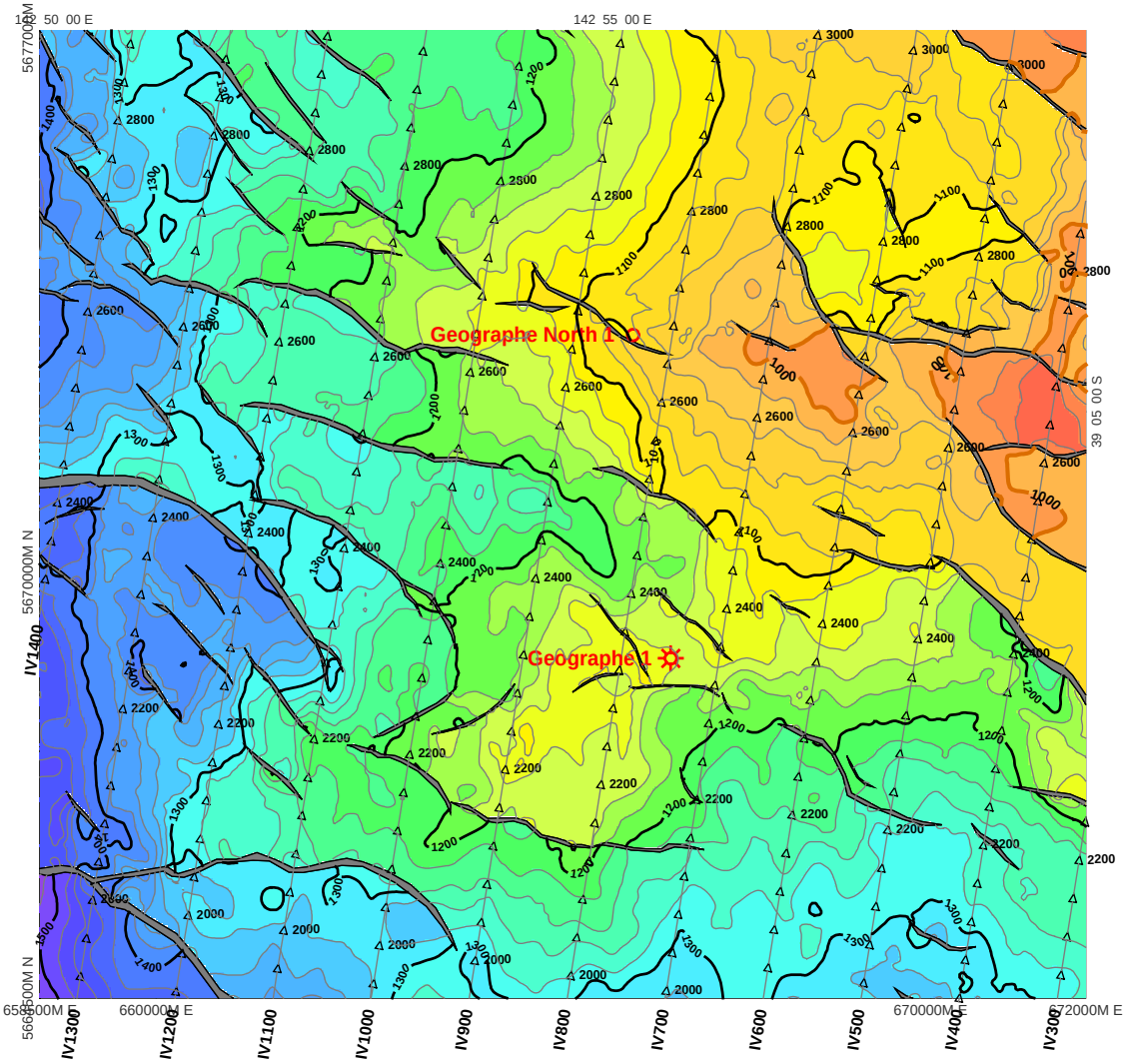
Figure 6

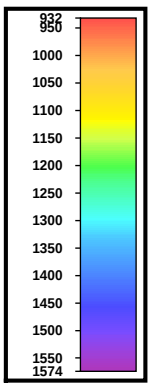


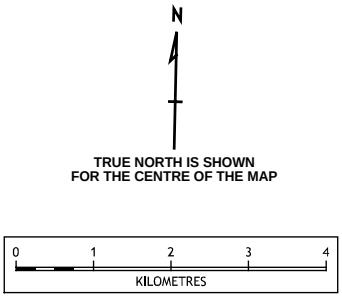
Geographe 1 / Geographe North 1
Seismic traverse C – C'

Figure 7

VIC/P43







Origin energy

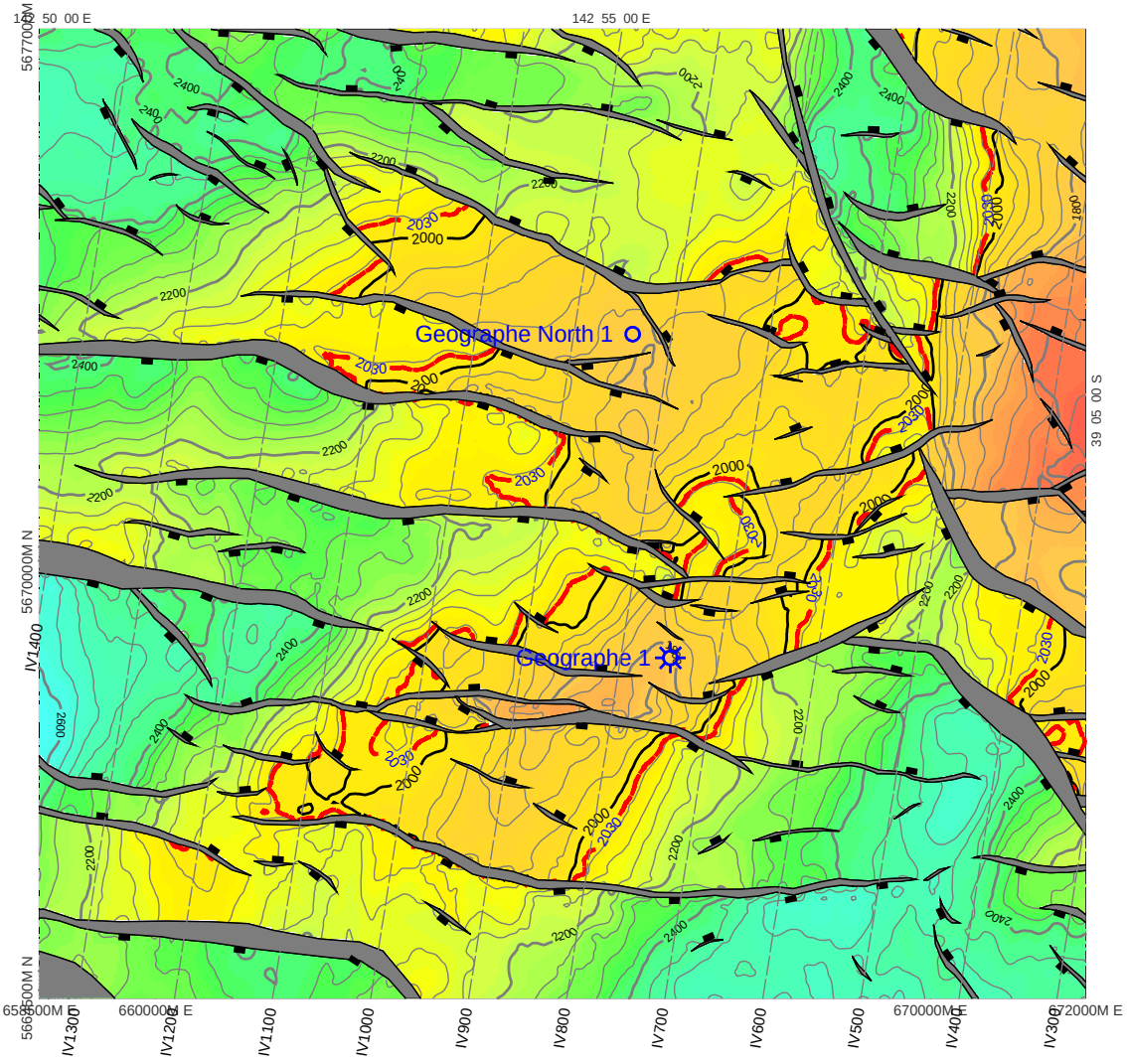
Eastern Otway Basin

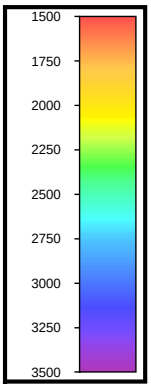
NEAR BASE TERTIARY
DEPTH STRUCTURE MAP
Geographe Gas field

Author: R. Jason	Datum: MSL	Encl No:
Date: 30/07/01	Contour Interval: 20m	
Map File:		
Map Sheet: GEOGRAPHE STH 50K PIC WELLPROP		

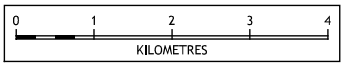
Figure 8

VIC/P43





TRUE NORTH IS SHOWN
FOR THE CENTRE OF THE MAP



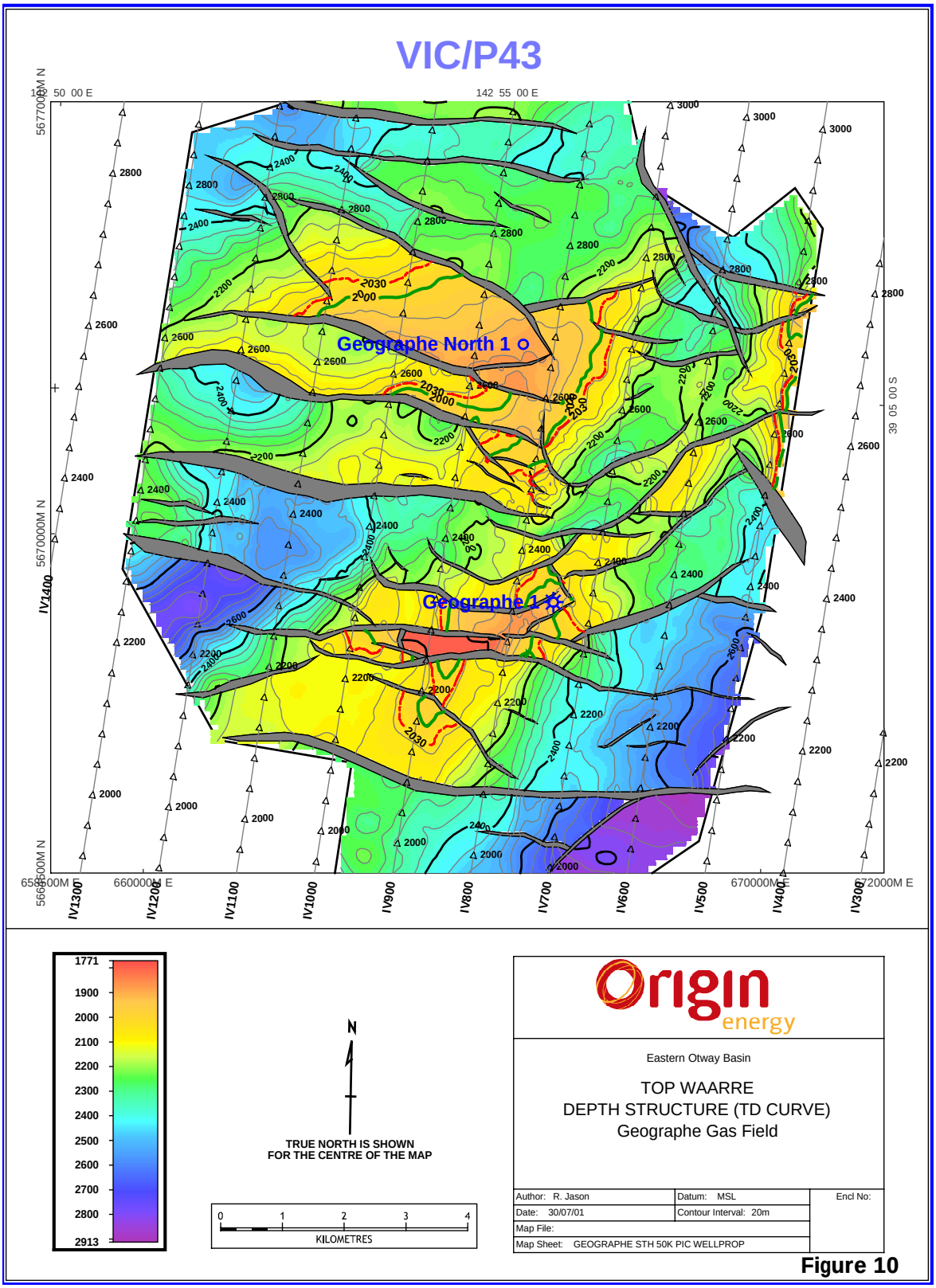
Origin energy

Eastern Otway Basin

TOP TURONIAN
Depth Map (TD Curve)
Geographe Gas Field

Author: R. Jason/R Taylor	Datum: MSL	Encl No:
Date: 30/07/01	Contour Interval: 20m	
Map File:		
Map Sheet: GEOGRAPHE STH 50K PIC WELLPROP		

Figure 9


VIC/P43
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Origin energy
Eastern Otway Basin
TOP WAARRE
DEPTH STRUCTURE (TD CURVE)
Geographe Gas Field
Author: R. Jason
Datum: MSL
Encl No:
Date: 30/07/01
Contour Interval: 20m
Map File:
Map Sheet: GEOGRAPHE STH 50K PIC WELLPROP

Figure 10

3. GEOGRAPHE FIELD

3.1 Introduction

The Geographe Gas Field is contained in a structural closure developed on a major regional north-northeast trending anticlinal ridge. Geographe 1 was drilled near the crest of the southern culmination of the structure. Geographe North 1 is proposed on the northern crest of the Geographe structure, 4.2 km north of Geographe 1. The well will target the Flaxmans / Waarre Formation where a gross target interval of 235m is predicted to be intersected. Water depth is 81 m.

3.2 Geographe North 1 Objectives

The objectives of the Geographe North 1 well are to:

1. Establish the presence of hydrocarbons in the northern culmination of the Geographe Anticline.
2. Determine the overall structural and stratigraphic relationship for the Geographe Gas Field, and implications for reservoir distribution/connectivity and development planning.
3. Establish the significance of seismic amplitude variation and provide more accurate field mapping and prospect risking.

3.3 Structure

The Geographe structure is a faulted anticline developed on a north-northwest trending anticlinal ridge. The structure is bi-crestal with Geographe 1 located near the southern crest and Geographe North 1 located on the northern crest.

The proposed well location lies on the crest defined by the Top Turonian seismic marker which, at Geographe North, represents units within the basal Flaxmans / upper Waarre Formation.

3.4 Reservoir

The reservoir section targeted by this well is the Flaxmans Formation (secondary) and upper/lower Waarre Formation (primary), predicted to be intersected at a depth of 1797 m SS and 1890 m SS respectively. These formations were intersected in Geographe 1 and a similar section is expected at Geographe North 1. Two distinctive reservoir sections are predicted (Fig. 4):

1. Flaxmans Formation (1797-1890 m SS): characterized by moderate to bland seismic events as opposed to the distinctive high amplitude progradational seismic character at Geographe 1 (Fig. 6). The Flaxmans is expected to be mostly non-reservoir due to a pinch out of sands on the flank of the Geographe North structure. Deposition at Geographe North 1 may have occurred in a more distal depositional environment than at the Geographe 1 location and more

fine-grained, sand-starved facies may be intersected. There is potential for the Flaxmans Formation to form a waste zone above the main Waarre reservoir section.

2. Upper/Lower Waarre Formation (1890 m SS -TD): characterized by continuous parallel reflectors and expected to comprise a series of intercalated coarse-grained channel and fine-grained, interdistributary bay facies indicative of a fluvio-deltaic depositional environment. In Geographe 1 the base of the upper Waarre contains the "100' sand", a thick blocky sandstone unit (Fig. 4, Geographe 1). The base of this sand is prognosed to be intersected in Geogrpahe North 1 at 1962 m SS. The remaining 70m (1962-2032 m SS) of the prognosed hydrocarbon column is predicted to comprise interbedded fluvial sandstone and siltstone of the lower Waarre Formation.

3.5 Seal

The Paaratte Formation and Belfast Mudstone provide a thick extensive top seal and lateral seal over the Geographe structure. The top of the Belfast Mudstone at this location is prognosed at 1443 m SS with a thickness of 354 m.

3.6 Depth Conversion

The depth conversion of the Geographe structure used the time versus depth curve (T-D curve) from Geographe 1. The curve was extrapolated below the total depth of the well using Thylacine 1 as a guide. This method of depth conversion provided a close match between the seismic amplitude distribution, the gas-water contact and the spill-point to the east. The methodology is also supported by the fact that the Thylacine 1 T-D curve is very similar to the Geographe 1 T-D curve, suggesting that the time-depth relationship along the axis of the Shipwreck Trough does not vary significantly. Hence it is considered to be a good representation of the closure trapping the gas column intersected at Geographe 1 (Fig.11)

Seismic stacking velocities were found to be a poor choice of velocity control for the Geographe Structure because they provided an average velocity map to the top Turonian that was too smooth and not representative of the T-D relationship off the flanks of the structure. Stacking velocities therefore could not provide an accurate representation of the saddle to the northeast that sets up the 240 m closure intersected at Geographe 1.

3.7 Spilling Mechanism Geographe South to Geographe North

A major risk at Geographe North is whether gas has spilled from Geographe to Geographe North. Seismic mapping indicates that at the top Turonian level, the structures should be in communication. However, the bright seismic amplitudes observed above the GWC at Geographe 1 do not fully extend to Geographe North (Fig.7 & Fig.12) and this may indicate a complex gas spill scenario, potentially bypassing

Geographe North. The primary unknown involves the sharp cut off of seismic amplitudes at the north-eastern end of the Geographe South structure, and the impact this has on gas spilling into Geographe North. AVO modelling and Acoustic Impedance inversion have been used to try and address these issues.

AVO/Fluid Replacement Modelling: AVO modelling has been used to determine if there is direct seismic evidence of hydrocarbons in Geographe North. A fluid replacement model shows that the seismic amplitudes in the Flaxmans Formation sands clearly result from gas saturation, (Fig 12). Hence, gas-bearing Flaxmans sands on the flanks of Geographe North should display bright seismic amplitudes. The fact that no such amplitudes occur does not preclude hydrocarbons from being present at Geographe North, but indicates that any such sands would need to have shaled-out across the structure.

AVO models for gas and water filled sands at the top Waarre sandstone have been produced. These models show that there is a weak AVO response, associated with the near top Waarre seismic peak: gas filled sands have a positive AVO gradient, whereas water filled sands show a weakly negative gradient. An approximate AVO gradient map for the top Waarre sandstone has been extracted from the Investigator 3D survey using the near and far offset volumes (Fig 13). This map shows positive gradient values around Geographe 1 and negative gradient values around Geographe North. While this not encouraging information, it is not regarded as definitive because the map also contains areas of positive AVO gradient in synclinal areas that could not be related to the presence of hydrocarbons. However, it does increase the risk associated with the presence of gas pore-filled reservoir in Geographe North 1.

Acoustic Impedance (AI) Inversion: An AI section has been generated from an interpreted seismic traverse from Geographe 1 to the proposed location of Geographe North 1 (Fig 14). The section appears to define the sand distribution within the Flaxmans Formation away from the well. Of note is the offsetting of sands across a fault, coinciding with the top Turonian amplitude cut-off at the north-eastern end of the Geographe structure (see arrow on Fig.14). The throw on this fault would place the Flaxmans sands below the GWC and hence could explain why the amplitudes cut-off so sharply. However it raises the question of whether there is sufficient shale on the low-side of the fault to seal the Flaxmans sands and prevent spillage into Geographe North.

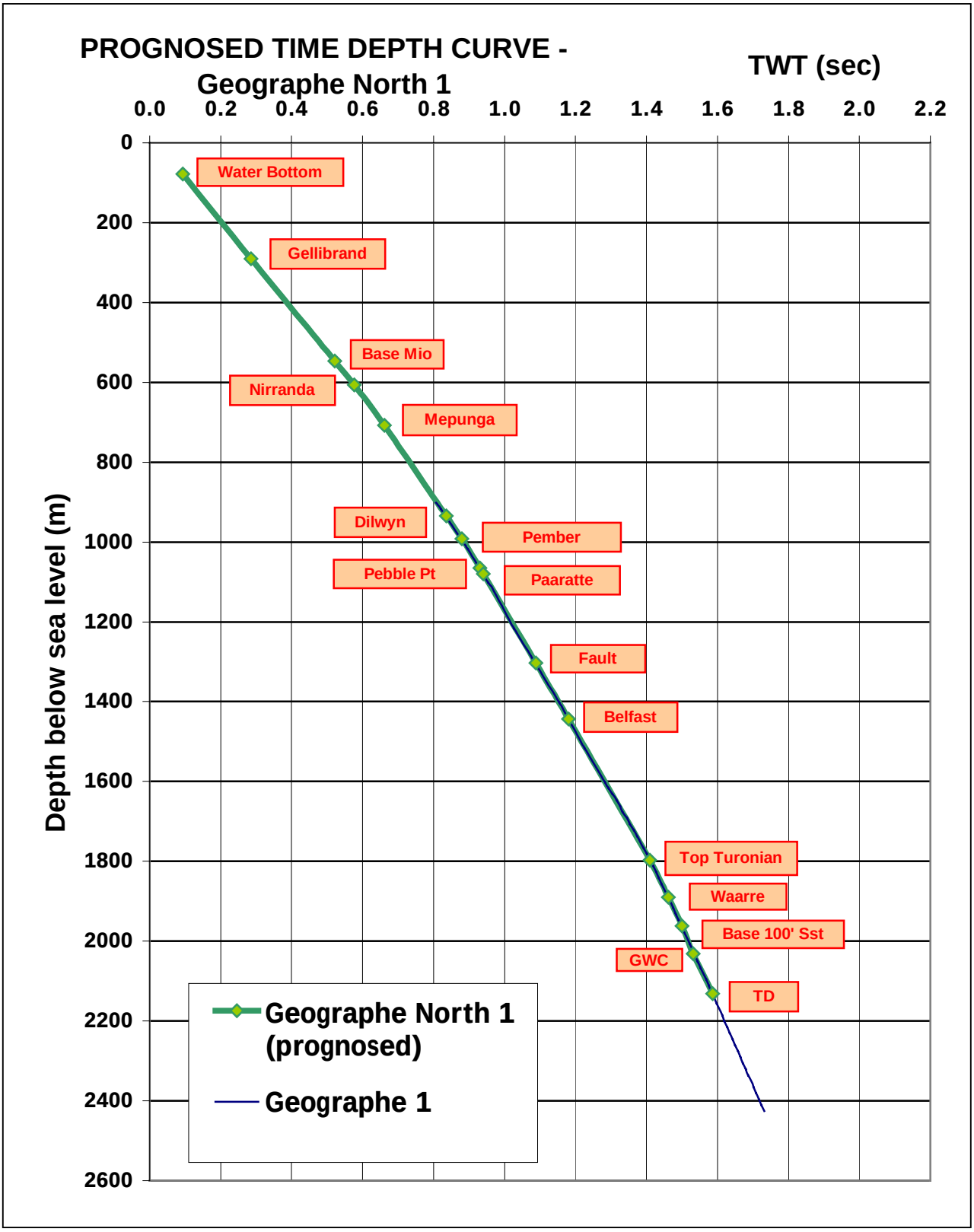
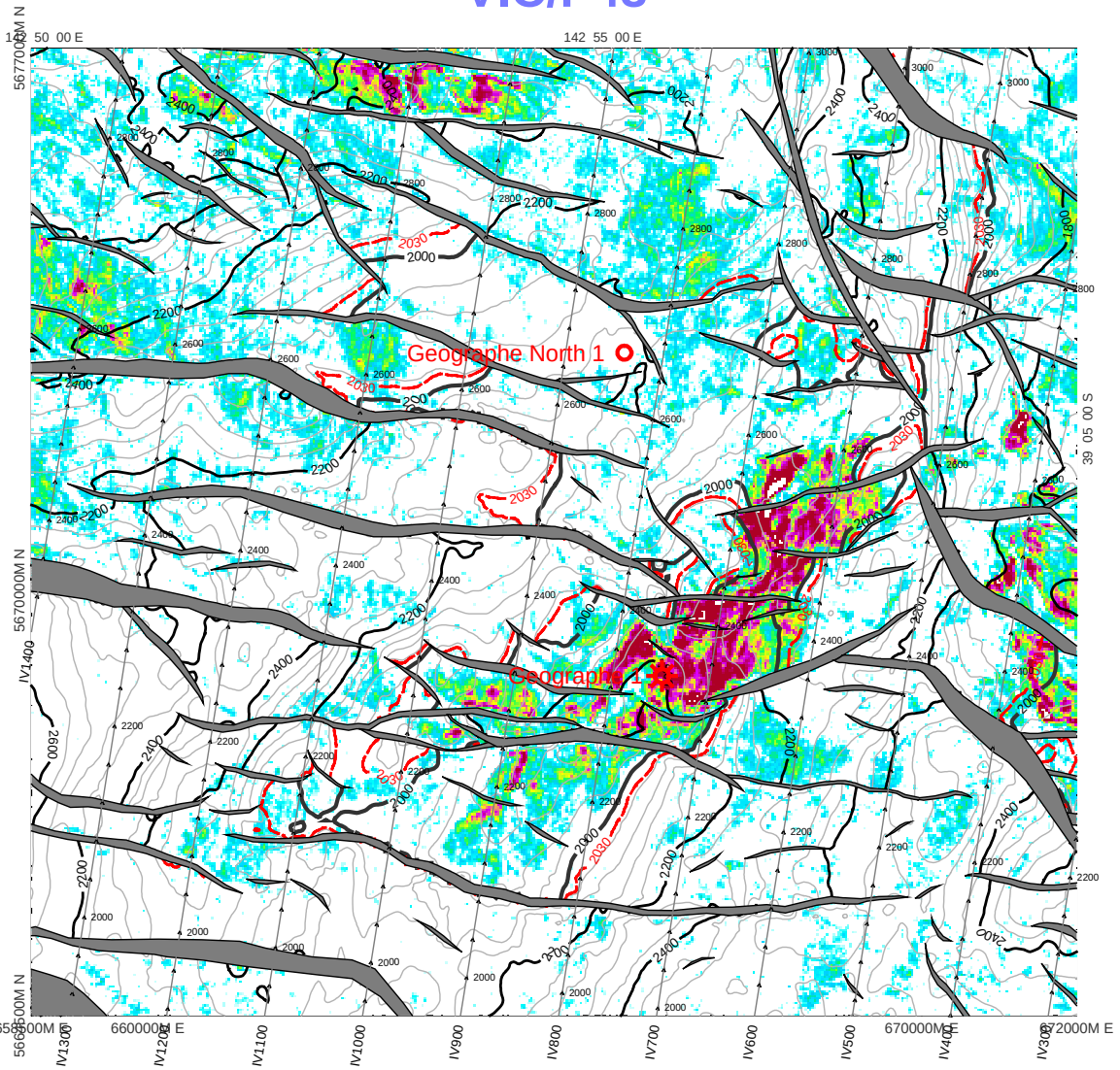
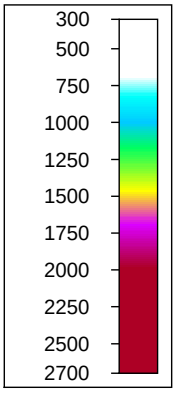
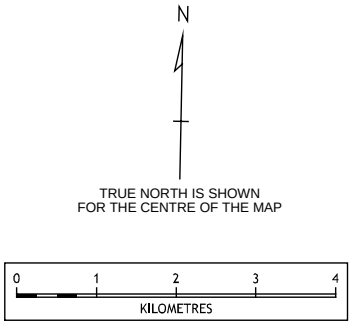


Figure 11: Time - depth curve for prognosis calculation

VIC/P43







Origin energy

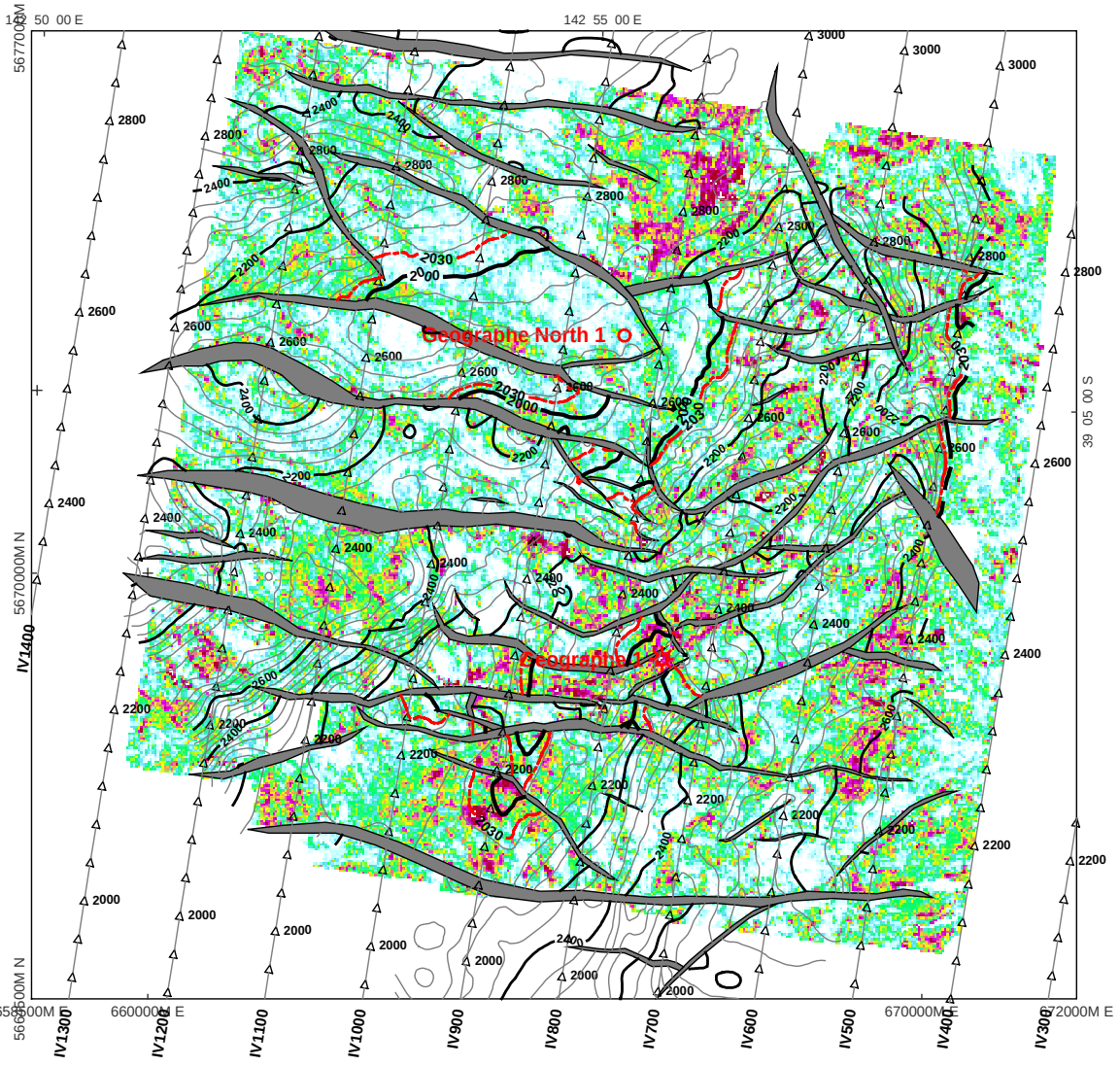
Eastern Otway Basin

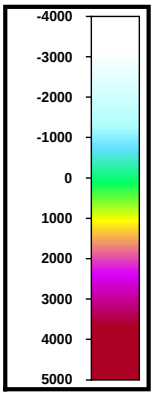
TOP TURONIAN
GEOGRAPHE GAS FIELD
RMS Amplitude(20ms above to 40ms below)
(TD curve Depth Contours)

Author:	Datum: MSL	Encl No:
Date: 30/07/01	Contour Interval: 40m	
Map File:		
Map Sheet: GEOGRAPHE STH 50K PIC WELLPROP		

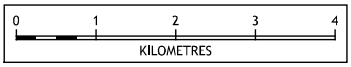
Figure 12

VIC/P43





TRUE NORTH IS SHOWN
FOR THE CENTRE OF THE MAP



Origin energy

Eastern Otway Basin

TOP WAARRE
Approximate AVO gradient
(far ampl. - near ampl. over +/- 10ms window)
(Depth contours from TD curve)

Author: R. Jason/R Taylor	Datum: MSL	Encl No:
Date: 30/07/01	Contour Interval: 20m	
Map File:		
Map Sheet: GEOGRAPHE STH 50K PIC WELLPROP		

Figure 13

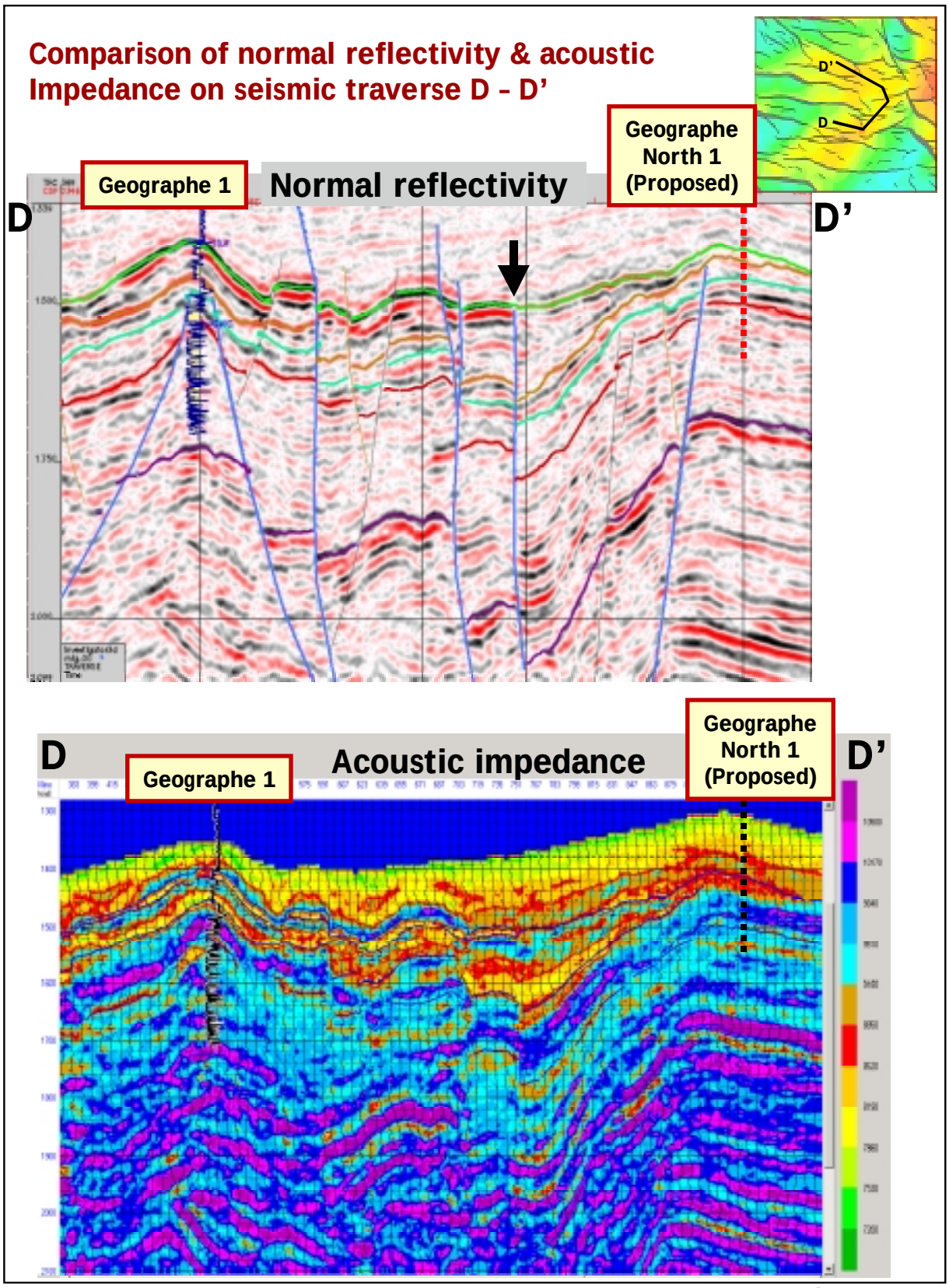

Comparison of normal reflectivity & acoustic Impedance on seismic traverse D – D'
D'
D
Geographe North 1 (Proposed)
Geographe 1
Normal reflectivity
D
D'
Geographe North 1 (Proposed)
Geographe 1
Acoustic impedance
D
D'

Figure 14

4. WELL LOCATION

Geographe North 1 is located towards the southwest of VIC/P43. The location, in reference to the Investigator 3D, is Inline 840 CDP 2655 and approximately 4.2 km north of Geographe 1. The co-ordinates are 666 160 E and 5 673 084 N, Zone 54.

4.1 Reservoir Objectives

The primary reservoir objective for Geographe North 1 is the Late Cretaceous Upper Waarre Formation. The Upper Waarre Formation directly underlies the secondary objective Flaxmans Formation, which, due to its lack of seismic amplitude, is not expected to contain significant net reservoir. The primary reservoir is expected to be intersected at a depth of 1890 m SS and to have a thickness above the GWC of 142 m.

4.2 Predicted TD

The minimum total depth (TD) for Geographe North 1 should be set at 2157mRT (2132m SS). This depth is 100m below the Geographe 1 GWC of 2032m SS and will allow enough rat hole for wireline log coverage. In the event of the GWC being deeper than 2082 m SS, a rat hole of 50 m below the GWC should be drilled to allow for wireline log coverage.

4.3 Predicted Stratigraphy

A summary of the prognosis and predicted stratigraphy is included as Table 2 and Figure 15 respectively. The prognosis was based on the TD curve from Geographe 1.

Port Campbell Limestone (78 – 290 m SS)

Calcarenites of the Port Campbell Limestone are expected in the upper part of the Heytesbury Group. The calcarenite consists of light grey to white, medium hard, fine to coarse grains with abundant fossils (corals, bryozoans, foraminifera) and trace to 3% glauconite.

Gellibrand Marl (290 – 606 m SS)

The Gellibrand Marl consists of calcareous mudstone with minor sandstone, claystone and calcilutite. The calcareous mudstone is light grey, soft, fossiliferous, pyritic and carbonaceous. The calcareous mudstone is interbedded with thin units of yellow to white skeletal limestone that is micritic to granular, non-porous and hard. The base Miocene seismic event defines the top of the lower Gellibrand Marl where calcareous claystones and siltstones are expected. This event is an unconformity surface that forms localised canyons. The claystone and siltstone are light grey to light tan or buff with trace coal, mica and trace fine-grained sandstone. The calcareous units are

interbedded with carbonaceous claystone and siltstone that are dark grey to brown, firm, non-calcareous and carbonaceous.

Nirranda Group (606 – 708 m SS)

The unit is dominated by calcilutite that is typically light grey, soft to firm with trace pyrite, glauconite and fossil fragments. The Niranda Group typically comprises both the Clifton Formation and Narrawaturk Marl.

Mepunga Formation (708 – 935 m SS)

The Mepunga Formation defines the top of prograding coarse clastic sequence in the Lower Tertiary. The Mepunga Formation consists of fine- to coarse-grained, poorly to well-sorted, sub-angular to well-rounded quartzose sandstone. The sandstone is unconsolidated with abundant calcareous fragments and up to 30% fossiliferous material. The sandstone has an argillaceous matrix, and poor porosity.

Dilwyn Formation (935 – 992 m SS)

The Dilwyn Formation represents the upper part of the Wangerrip Group. The Dilwyn Formation consists of greyish brown to light grey fine to coarse-grained quartzose sandstone, sub-rounded, poorly sorted and brown to green claystone. The sandstone has trace pyrite, glauconite and poor visible porosity.

Pember Mudstone (992 – 1065 m SS)

Medium grey to dark grey silty claystone with minor bands of calcilutite.

Pebble Point Formation (1065 – 1080 m SS)

The Pebble Point consists of highly variable lithologies ranging from medium to coarse-grained, subangular to rounded, well sorted quartz sandstone to dark brown, poorly-sorted, laterite like conglomeratic claystone (KT Shale) and argillaceous conglomerate, friable, unconsolidated with poor visible porosity.

Paaratte Formation (1080 – 1443 m SS)

The Paaratte Formation forms the upper part of the Sherbrook Group and the lower section herein includes the Skull Creek Mudstone. Dominantly claystone lithology is expected but may be interbedded with sandstone in the uppermost section. The claystone is dark to greenish grey and brownish grey, soft, dispersive and contains trace glauconite and pyrite. Minor sandstone units interbedded with the claystone are typically quartzose, light grey coloured, very fine to medium-grained with scattered coarse grains.

Belfast Mudstone (1443 – 1797 m SS)

The Belfast Mudstone is a monotonous section of light to dark grey shale. It contains rare glauconite and pyrite non calcareous.

Flaxmans Formation (1797- 1890m SS)

This unit was intersected in Geographe 1 and comprises 3 approximately 10-40m thick argillaceous sandstone units. The sandstone is light grey to white, quartzose, friable, sub angular to subrounded, poorly to moderately sorted, siliceous-cemented, very fine to medium grained with an argillaceous matrix. Core 1 (1814 – 1850 m RT) in Geographe-1 also showed that these units were highly bioturbated. Intervening shales (5 – 15m thick) are dark grey, bioturbated with trace glauconite and pyrite. The base of the Flaxmans Formation is marked by a 46m thick dark shale. This shale is dark grey to grey and contains minor glauconite and pyrite. The Flaxmans Formation is interpreted to be in a more distal depositional environment at Geographe North 1 and therefore the section is predicted to be dominated by fine-grained facies. There may be no net reservoir within this Formation.

Upper Waarre Formation (1890 – 1962 m SS)

This section was intersected in Geographe 1 where it comprises an interpreted fluvio-deltaic sequence. The section directly underlying the Flaxmans Formation in Geographe 1 (1956 – 2015 m RT) comprises interbedded sandstone, siltstone and claystone. The base of the Upper Waarre is marked by a 30m thick medium to coarse grained, friable, moderately sorted quartzose blocky sandstone. A similar section to that intersected at Geographe 1 is expected at Geographe North 1.

Lower Waarre Formation (1962 m SS – TD)

At the stage of writing this proposal the stratigraphic position of the contact between the Upper and Lower Waarre had not been confirmed. The correlative section in Geographe 1 is dominated by thick sandstone units up to 30m thick with thin (< 5m) intervening silstone/mudstone. The sandstone is fine to coarse grained, quartzose, moderately sorted, friable with trace pyrite. A 70m thick section of the Lower Waarre Formation is prognosed to be intersected above the GWC at Geographe North 1.

Upper Eumeralla Formation

The Eumeralla Formation is not expected to be reached in Geographe North 1.

The predicted stratigraphy for Geographe North 1 is shown in Table 2 and Figure 12.

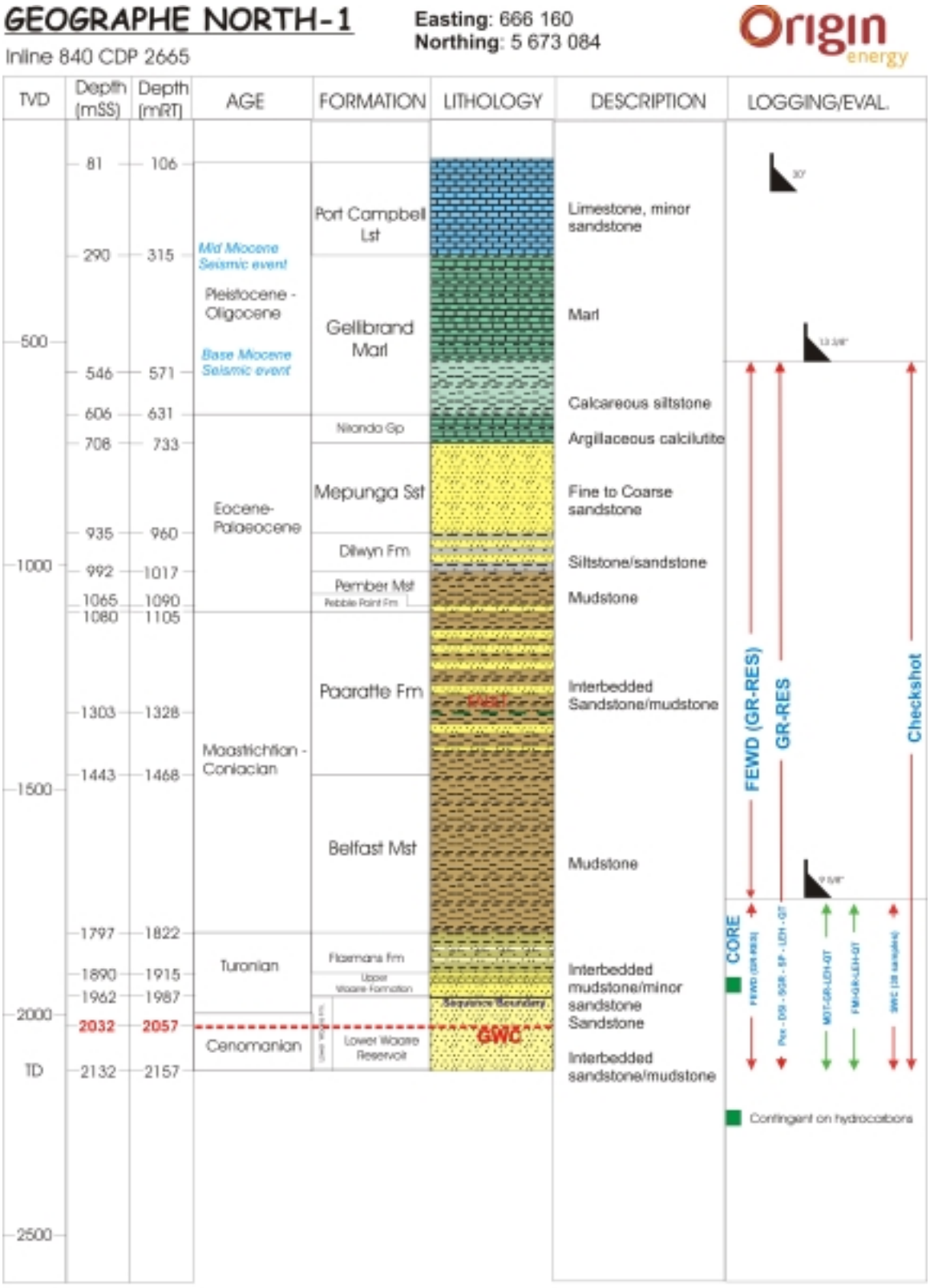


Figure 15: Predicted stratigraphy for Geographe North-1

	Well	**Geographe North-1**		Origin energy		
	Water Depth	**81**		Inline 840 CDP 2665		
	RT	**25 m ASL**	**Predicted Tops**			
	Formation	**Two-way time (ms)**	**Depth (RKB)**	**Depth (SS)**	**Thickness**	**Expected Lithology**
TERTIARY	***Seabed/Port Campbell Lst***	**94**	**103.0**	**78.0**	**212.0**	Limestone, minor sandstone
	Mid Miocene/Gellibrand Marl	**286**	**315.0**	**290.0**	**256.0**	Marl
	Mid Gellibrand Marl	**521**	**571.0**	**546.0**	**60.0**	Calcareous Siltstone
	Niranda Group	**576**	**631.0**	**606.0**	**102.0**	Calcilutite, Marl
	Mepunga Formation	**662**	**733.0**	**708.0**	**227.0**	Sandstone
	Dilwyn Formation	**836**	**960.0**	**935.0**	**57.0**	Siltstone/Sandstone
	Pember Mudstone	**880**	**1017.0**	**992.0**	**73.0**	Shale
	Pebble Point Formation	**930**	**1090.0**	**1065.0**	**15.0**	Sandstone
CRETACEOUS	***Base Tertiary/Paaratte Formation***	**940**	**1105.0**	**1080.0**	**223.0**	Shale with some minor Sandstone near Base Tertiary
	Fault	**1088**	**1328.0**	**1303.0**	**N/A**	
	Belfast Mudstone	**1180**	**1468.0**	**1443.0**	**354.0**	
	Flaxmans Formation	**1410**	**1822.0**	**1797.0**	**93.0**	Dominantly Mudstone
Waarre	***Waarre Formation***	**1462**	**1915.0**	**1890.0**	**242.0**	Sandstone/Siltstone
	Base 100ft sand	**1500**	**1987.0**	**1962.0**	**N/A**	Coarse Sandstone
	GWC	**1670**	**2057.0**	**2032.0**	**N/A**	Proven at Geographe-1
	TD	**1587**	**2157.0**	**2132.0**	**N/A**	100m below GWC
	Italics **= Interpreted Horizon**					

Table 2: Geographe North 1 Prognosis

5. RISKING

Detailed risk assessment has been undertaken for the Geographe North Prospect. There is a moderate chance of success (50%) attributed to the well. The success of Geographe 1 and its intersection of a significant gas column (240m) has significantly improved the chance of success from the pre-Geographe 1 estimate for the Geographe North structure. The large thickness of reservoir section expected above the predicted GWC at Geographe North 1 indicates that the potential success of the well is not sensitive to changes in depth conversion and mapping.

The main risk is the potential for Geographe North to lie within a migration shadow. The migration risk is related to the lack of seismic amplitudes observed over the Geographe North structure and the potential for the saddle between the two structures to act as a seal. There is also a large portion of non-net 'waste zone', interpreted as basal Flaxmans Formation, expected at the proposed location. The underlying higher net/gross, fluvio-deltaic Waarre Formation is expected to contain the bulk of productive section over the Geographe north structure.

6. EVALUATION

6.1 Logging and Sampling

The proposed logging program for Geographe North 1 is summarised in Table 4. As the FEWD tool will be run in the 12¼" section no open hole logs will be obtained over this part of the well.

	Tools	Interval	Comments
logging	FEWD (GR-RES)	13 3/8" casing shoe to TD	Replaces open hole wireline logs over 12¼" hole.
	Run 1: PEX-DSI-SGR-SP-LEH-QT	TD – Surface Casing Shoe	GR-DSI only in cased hole section.
	Run 2: MDT-GR-LEH-QT	TD to approx 50 m above reservoir	Contingent on hydrocarbons
	Run 3:FMI-GR-LEH-QT	TD to approx 50 m above reservoir	Contingent on hydrocarbons
Wireline program	Run 4: Checkshot	TD to loss of signal	
	Run 5: SWC (30 samples)	Open Hole	Palynology/reservoir quality data

Table 4: Logging program for Geographe North 1

6.2 Coring

The objective of the coring programme is to obtain reservoir within the hydrocarbon column from the Upper Waarre Formation. This will complement the core already taken from the upper part of the Flaxmans Formation in Geographe 1.

It is proposed to cut 1 X 54m core from the Upper Waarre Formation. The following criteria have been set to a) avoid cutting a core in the overlying Flaxmans Formation and b) maximise recovery of reservoir useful for engineering and geological evaluation.

- Drill to a depth of 1930 m RT.
- Intersection of 3m of sandstone confirmed on FEWD with < 60 API units on GR and > 10ohm/m on RES.

At this point bottoms should be circulated to surface to confirm sand quality and presence of gas. If these criteria are met the core should be taken.

6.3 Testing

DST equipment will be made available for testing at Geographe North 1. A DST would be conducted to investigate the deliverability of hydrocarbon bearing reservoirs in the objective intervals outlined previously in this report. The decision to test is contingent on hydrocarbons and will be based on wireline log data.

7. REFERENCES

LUXTON, C.W., HORAN, S.T., PICKAVANCE, D.L. & DURHAM, M'.S., 1995. The La Bella and Minerva gas discoveries, offshore Otway Basin. *Australian Petroleum Exploration Association Journal* **35(1)**, pp.405-417.

Application for Area V98-2, February 1999. Submitted by Boral Energy Resources Limited, Woodside Energy Ltd & CalEnergy Gas (UK) Ltd to the Commonwealth of Australia under the Petroleum (submerged Lands) Act 1967.