TREFOIL-1

WELL PROPOSAL

T/18P, BASS BASIN, TASMANIA

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Greenfields:\T-18P\BA018 - T Technical\Trefoil Well Proposal 2003

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EXECUTIVE SUMMARY

WELL NAME	*Trefoil-1*
LOCATION	Seismic: ORS01-13 SP 1492 Latitude: 39° 51' 41.58"S Longitude: 145° 22' 30.87"E Northing: 5 586 346 m N Easting: 361 028 m E (Datum = GDA94)
PERMIT	T/18P Offshore Bass Basin
INTEREST HOLDERS	Origin Energy Petroleum Pty Ltd (Operator) 41.4% AWE Petroleum Pty Ltd 22.6% CalEnergy Gas (Australia) Ltd 23.5% Wandoo Petroleum Pty Ltd 12.5%
TYPE OF WELL	Exploration
ANTICIPATED SPUD	Q2, 2004
ELEVATION	Water Depth: 68 m RT: 25 m (nominal)
PLAY TYPE	Anticline
PRIMARY OBJECTIVE	Palaeocene Eastern View Coal Measures
SECONDARY OBJECTIVE	Early Eocene & Late Cretaceous Eastern View Coal Measures

The Trefoil-1 exploration well will target sandstone reservoirs of the Eastern View Coal Measures (EVCM) within a four-way dip closure. Primary objectives are in the Palaeocene with secondary targets in the Early Eocene and Late Cretaceous. The proposed well location lies in the offshore Bass Basin approximately 37 km west of the Yolla gas field within permit T/18P.

Gas charge is assumed to be the most likely hydrocarbon type with lesser chance of oil and/or associated liquids. This is based on the predominantly gas charged pools in the Yolla and White Ibis fields.

Seven potential stacked reservoirs are recognised for the Trefoil Prospect. Of these, four are associated with seismic amplitude anomalies (P3, P1, E1 and C1 zones).

The total unrisked mean probabilistic OGIP estimate is 305 BCF.

The P3 and P1 zones are interpreted to have the highest chance of success due to the presence of amplitude anomalies and inferred thick, well-developed top seals. The P3 Zone is also one of the main gas-bearing reservoirs in the Yolla Field and in White Ibis-1. The P2 Zone is interpreted to have the lowest chance of success due to a combination of no amplitude anomaly and the very thin seal developed over the sand in each of the three control wells.

Probabilistic consolidation of the risked OGIP for the seven zones calculates a 73.2% chance of achieving the consolidated risked OGIP distribution. The mean of this consolidated risked OGIP distribution is 105 BCF (44.5% probability).

A preliminary economic truncation of 160 BCF indicates a chance of success of 14.1% to achieve a distribution with a mean of 211 BCF OGIP.

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1.0 INTRODUCTION

1.1 LOCATION

The proposed Trefoil-1 well is located in T/18P within the Bass Basin, approximately 37km west of the Yolla gas field (**Figure 1.1**). The nearest wells are Aroo-1 10 km to the northeast and White Ibis-1 and Bass-3 15 km and 17 km to the southwest respectively. The proposed drilling location is at SP 1492 on seismic line ORS01-13.

T/18P is located in Bass Strait between the south-eastern Australian mainland and Tasmania (**Figure 1.2**). The nearest population bases are Melbourne (Victoria), located 231 km NNW and Port Latta (Tasmania), situated 108 km to the south.

1.2 PERMIT DETAILS

T/18P was initially granted on July 23, 1980. After a series of farm-in agreements, withdrawals and company name changes, the current permit joint venture partners are: Origin Energy Petroleum Pty Ltd (41.4%, Operator), AWE Petroleum Pty Ltd (22.6%), CalEnergy Gas (Australia) Ltd (23.5%) and Wandoo Petroleum Pty Ltd (12.5%).

T/18P was renewed for a period of five years from 23 September 1999, based on an application submitted to the Designated Authority on 18 December 1998. Current approved permit obligations are set out in **Table 1.1** below.

Permit Year	Ending	Minimum Work Requirement	Indicative Expenditure
1	20/09/00	Geological & Geophysical Studies	$150,000
2	22/09/01	375 km Seismic Survey	$575,000
3	22/09/02	Geological & Geophysical Studies	$150,000
4	22/09/03	Geological & Geophysical Studies	$150,000
5	22/09/04	1 Well	$10,000,000

Table 1.1 - T/18P Permit Obligations, Renewed Permit Years 1 to 5

The Shelduck 2D Marine Seismic Survey was acquired in June 2001, which satisfied the seismic work obligations for Year 2 of the present permit term. Drilling of Trefoil-1 will satisfy the Year 5 work commitment.

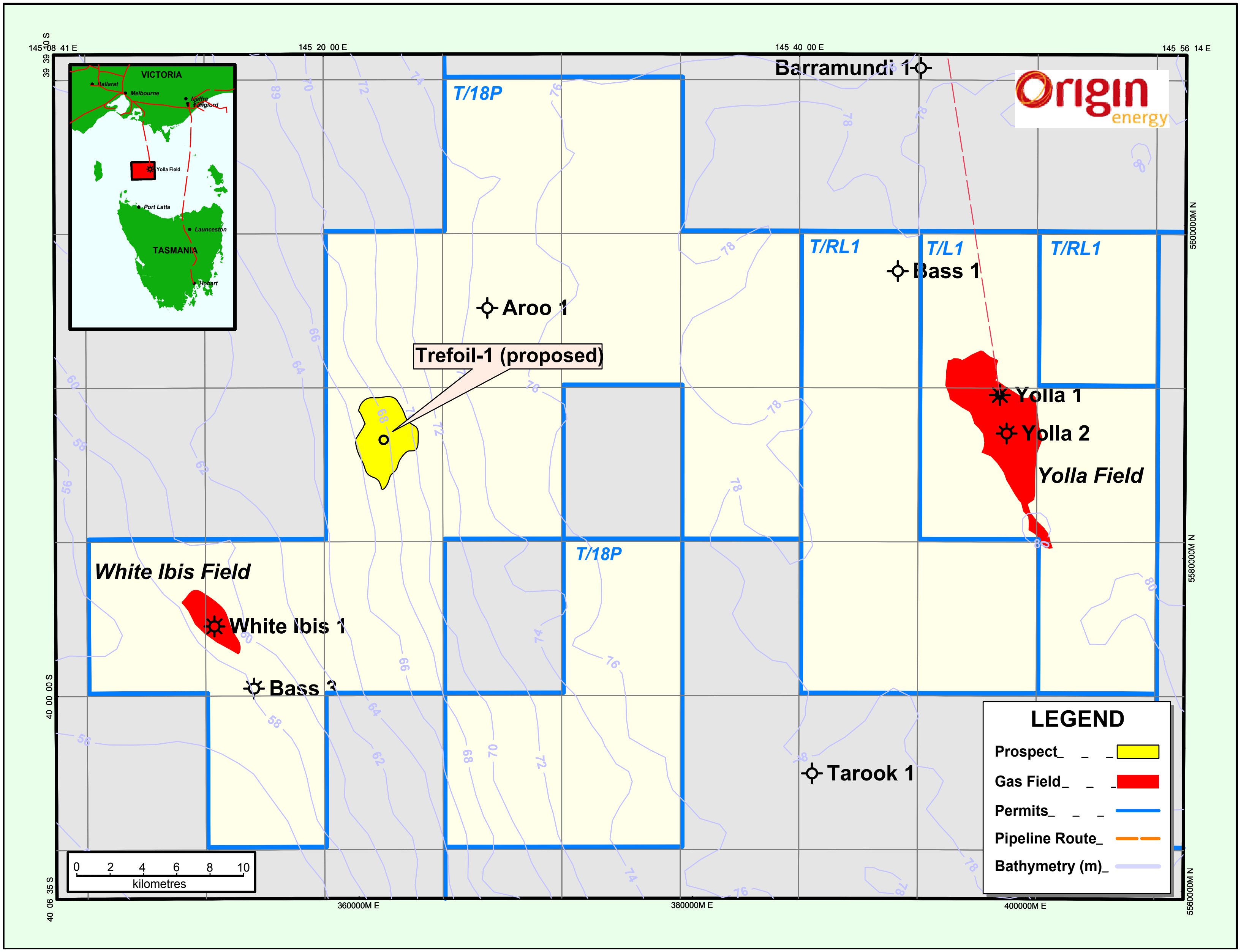


Figure 1.1 Trefoil-1 location. The proposed Trefoil-1 well is located in T/18P, 37 km west of the Yolla Gas Field.

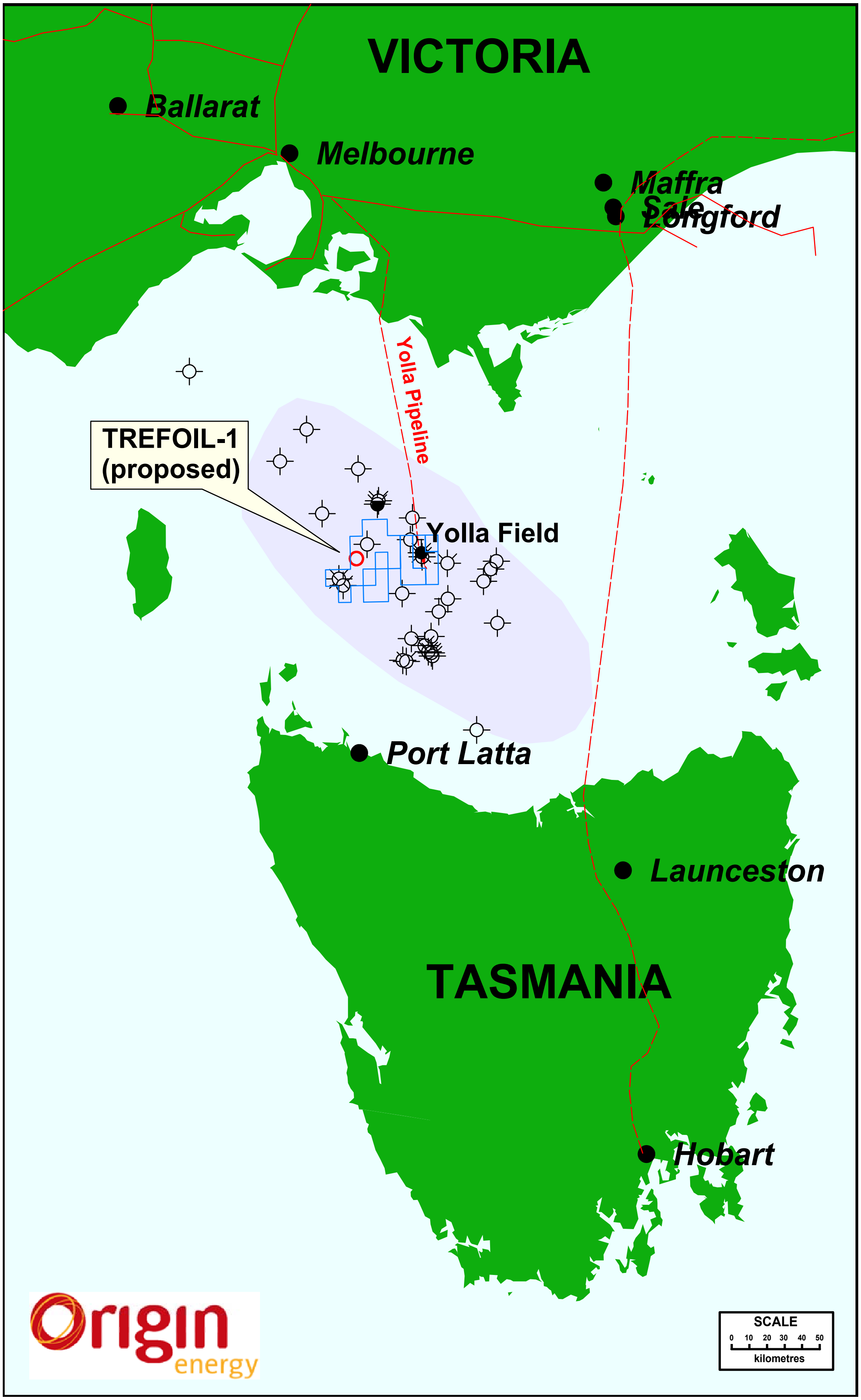


Figure 1.2: Bass Basin Location Map

2.0 EXPLORATION HISTORY

2.1 PREVIOUS EXPLORATION

Exploration within the area of T/18P commenced in 1963 with the acquisition of regional 2D seismic data (**Table 2.1**). Many subsequent seismic surveys have been recorded within the permit with the latest in 2001, the Shelduck 2D survey, bringing the total 2D seismic acquisition in the permit to 6,946.80 km.

Year	Survey Name		No Kilometres
1963	B		146.3
	B63		263.8
1965	EB		62.0
	EK		80.2
1966	ES		29.5
1969	B69B		100.0
1971	B71A		230.5
1972	B72A		582.5
1973	HB73A		297.3
1975	HB75A		440.5
1977	HB77A		318.75
1981	BBS81		419.75
	BCSS81		14.75
1982	82BMR		178.0
	BB82A		34.5
1984	TNK4		660.5
1985	TP05		304.25
	TQH5		1135.25
1990	BS90B		201.5
1994	SB94A (Rocky Cape)		541.0
1996	Hummock		569
2001	Shelduck		376
		TOTAL	**6,946.80**

Table 2.1 - Seismic Acquired within current T/18P permit boundaries

A total of 8 exploration wells have been drilled within the permit (**Table 2.2**). An uneconomic oil accumulation was discovered at Cormorant-1 in 1970. A two-metre oil column was identified from logs and a Formation Interval Test (FIT). Subsequent production testing was not performed. The King-1 well confirmed that the oil accumulation is uneconomic. White Ibis-1 discovered sub commercial quantities of gas.

The nearest and most relevant wells to the proposed Trefoil-1 are Aroo-1, White Ibis-1 and Bass-3, which are all located within the Yolla Trough (**Figure 2.1**).

Year	Well Name	Operator	Well Type	Target	Total Depth (m)	Result	Flow Rate/ Recovery
1967	Bass 3	ESSO	Expl	EVCM	2432	P&A	Gas Shows
1970	Cormorant 1	ESSO	Expl	Mid EVCM	3001	P&A	FIT Oil Recovery
1972	Tarook 1	ESSO	Expl	Top EVCM	2774	P&A	-
1974	Toolka 1A	ESSO	Expl	EVCM	2715	P&A	Shows Gas & Condensate
1974	Aroo 1	Hematite	Expl	Mid EVCM	3692	P&A	Shows Gas & Condensate
1985	Koorkah 1	AMOCO	Expl	Basal EVCM	3147	P&A	-
1992	King 1	SAGASCO	Expl	Upper EVCM	2223	P&A	Oil & Gas Shows
1998	White Ibis 1	BORAL (Premier)	Expl	Upper EVCM	2220	P&S	Sub comm. Gas disc

Table 2.2 - Wells Drilled within T/18P

Aroo-1 was drilled in 1974 as an exploration well on a then interpreted four-way dip closure. The well encountered strong gas and oil shows in the Lower *L. balmei* with minor gas and water recovered on testing. The poor reservoir quality and minor hydrocarbon recovery resulted in the well being plugged and abandoned. Remapping of the area indicates that no significant closure exists at Aroo-1 but the results of the well prove the migration of hydrocarbons into the area.

Bass-3 was drilled in 1967 as an exploration well on a fault-bounded closure on the southwestern margin of the Yolla Trough. Primary targets were sands in the intra-Eastern View Coal Measures (EVCM). A moderate gas peak in the upper Palaeocene was tested with a recovery of gas, condensate and water. A minor gas peak and fluorescence was also noted in the Late Cretaceous but not tested. The well was plugged and abandoned. The likely causes of failure are inadequate closure and/or fault seal breach.

White Ibis-1 was drilled in 1998 updip of Bass-3 in the adjacent fault block. Gas recoveries were made from sands in the Lower *L. balmei* and based on MDT and gas ratio data an oil leg is possible beneath the gas column. The well is currently suspended for possible future production.

2.2 REGIONAL GEOLOGY

2.2.1 Structure

The Bass Basin is located offshore in south-eastern Australia between Victoria and Tasmania. It is one of a series of sedimentary basins that were formed in response to rifting during the Late Jurassic to Early Cretaceous between Australia and Antarctica (Williamson et al, 1987). The Bass Basin covers approximately 65,000 km^2 and water depths range from 30 to 90 m.

The Bass Basin is a failed intra-cratonic rift basin with structural features which highlight three separate phases of evolution: 1) initial northeast-southwest extension during the early Cretaceous, 2) Late Cretaceous to Pliocene thermal subsidence and 3) Miocene compression. The rifting created a series of northwest-southeast oriented grabens offset by associated east-west wrench movement. The Pelican, Yolla and Cormorant Troughs comprise the major depocentres in the Bass Basin (**Figure 2.1**). The Trefoil structure is located on the flanks of the Yolla Trough. These depocentres are fault-bounded half-grabens that progressively developed via growth faulting during the active rifting and thermal subsidence phases of basin evolution. The dominant structural trend in the basin is northwest-southeast, highlighted by the orientation of the major faults and troughs.

2.2.2 Stratigraphy

The stratigraphic succession in the Bass Basin comprises sediments ranging in age from Early Cretaceous to Recent (**Figure 2.2**)

The Early Cretaceous Otway Group rests unconformably on pre-rift Palaeozoic black shales and quartzites and consists of clastic, volcaniclastic, fluvial and deltaic sediments ranging from coarse-grained sandstone to shale and coal. The Otway Group was deposited as a very thick sequence of sediments (*C. australiensis* to *C. paradoxus*) that have been intersected in the Bass Basin at only one locale, Durroon-1, in the extreme southeast.

Localised uplift and erosion then occurred on the basin margins as the initial rifting phase subsided (Middle Cretaceous). The Otway Drift phase then began along the southern margin of Australia, which was largely contemporaneous with the start of the Tasman Rifting event on the eastern edge of the southern margin. This recommenced rifting in the Bass Basin, which resulted in deposition of the prospective Early

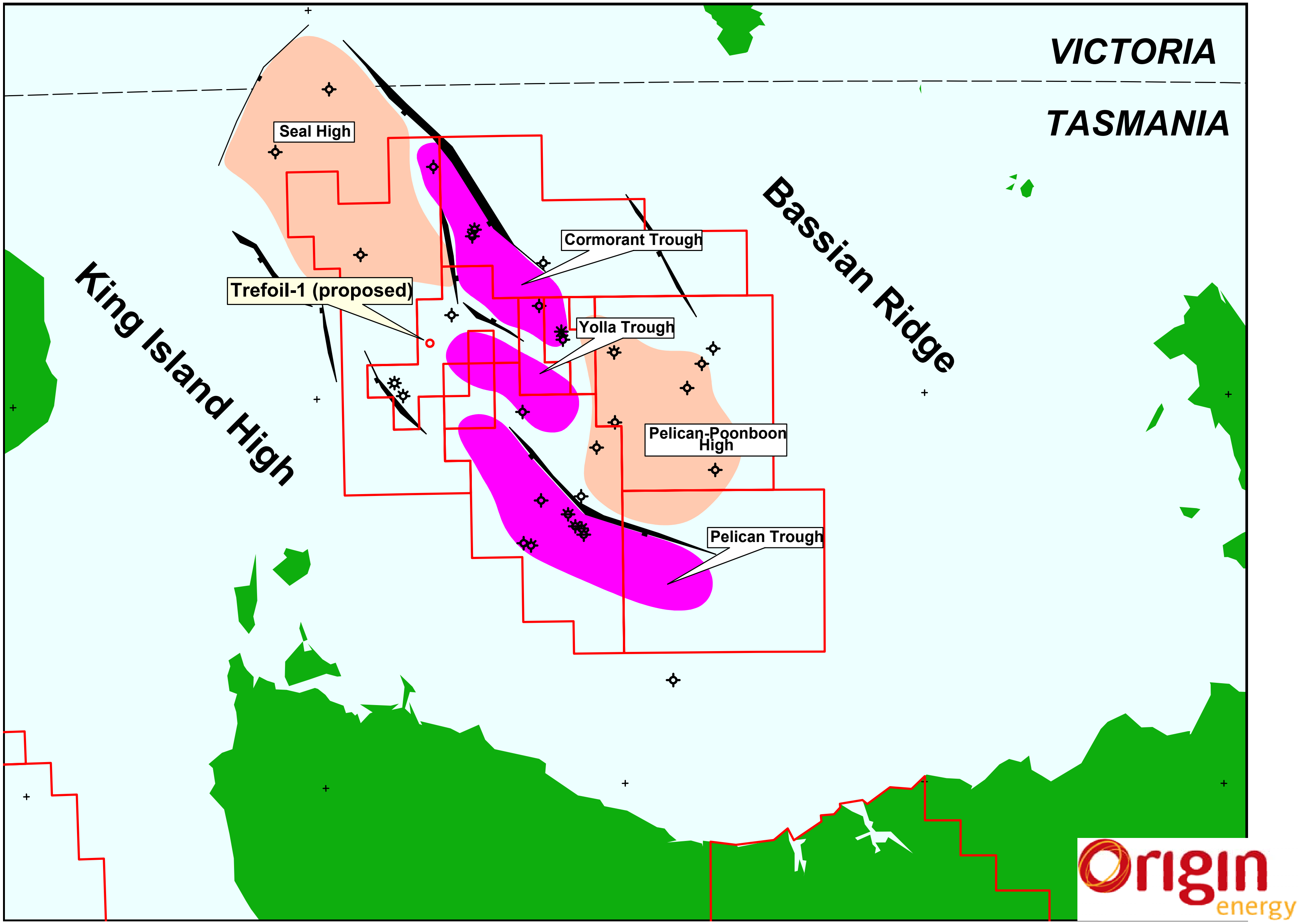


Figure 2.1 Bass Basin Structural Elements

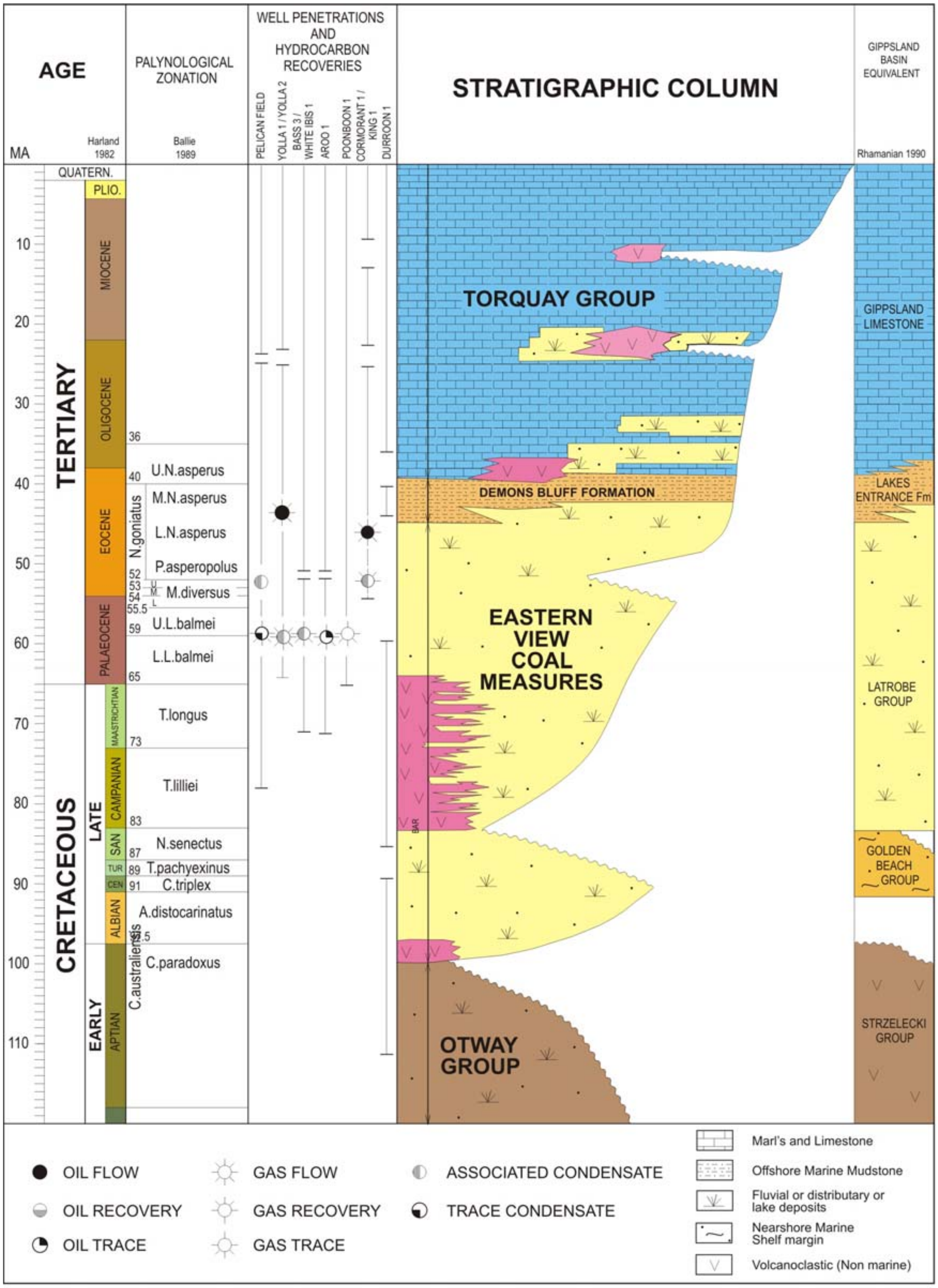


Figure 2.2 Stratigraphic Column, Bass Basin

Cretaceous to Late Eocene Eastern View Coal Measures (EVCM) which comprise a thick succession of sandstone, siltstone, shale and coal, deposited primarily within fluvial, deltaic and lacustrine depositional environments. Seismic data suggests that the EVCM is over 4000m thick in the Troughs. The EVCM thins markedly towards the basin margins and exhibits both onlap onto basement and erosional truncation. In a broad sense, the EVCM can be divided into three sequences separated by erosional unconformities. The middle sequence was penetrated in Bass-1 and Yolla-1 and –2 and contains the major gas accumulations in the Yolla Field. This sequence is bounded at the base by the *N. senectus* unconformity and at the top by the upper *M. diversus* unconformity.

The Lower Eastern View Coal Measures (EVCM) depositional sequence was deposited from Cenomanian to Santonian times (*A. distocrinatus* to *N. senectus*). These units have only been intersected in Durroon-1 in the southeast of the Bass Basin and are equivalent to the Golden Beach Group in the Gippsland Basin.

An angular unconformity is identified over localised highs on the basin margins at the top of the *N. senectus* zone. The boundary is marked in places by significant extrusive volcanism, similar to that observed in the Gippsland Basin. This event signals the termination of Tasman rifting, which was followed by sea floor spreading in conjunction with the already active drift in the Otway region. During this time, thermal subsidence dominated throughout the basin and thick, ubiquitous deposition of the Late Cretaceous to Palaeocene Lower EVCM occurred (*T. lillei* to Lower *M. diversus*/*P. asperopolus*).

The Late Cretaceous sediments are restricted mainly to the basin depocentres and axial reaches where accommodation space was sufficient for deposition and subsequent preservation. The section is missing on the basin margins due to sediment bypass. The Palaeocene section is extensive throughout with the greatest thickness of sediments in the basin depocentres and significant thinning towards the basin flanks, as a result of both condensing of the section and basement onlap.

The Late Cretaceous/Palaeocene Lower EVCM has been intersected in numerous wells in the basin, identifying it as a continuos sequence of late low stand sediments grading through a transgressive systems tract and finally capped by high stand sediments. Environments are gradational both laterally and temporally from alluvial through fluvio-deltaic and nearshore to deeper restricted lacustrine. Primary sediment input to the basin was from the southeast with minor localised input also deposited transversely from the flanks of the troughs. Extensive coal measures dominate the sedimentary sequence in the southeast of the basin (Pelican Trough) with increasingly thicker homogeneous shale units occurring through the Yolla and Cormorant Troughs.

The top of the Lower EVCM is identified by localised uplift and inversion of the pre-existing sedimentary sequence, caused by mild regional compression. The effects of this uplift are variable with the degree of erosion extending from the Mid *M. diversus* through to the *P. asperopolus* in places.

The Eocene upper EVCM (Mid *M. diversus/P. asperopolus* to Mid *N. asperus*) was then deposited under a regime of slower subsidence, resulting in more widespread, highly variable facies development. Fluctuating conditions of alluvial, fluvio-deltaic and shallow marine processes resulted with more extensive deposition of coal measure sediments. A regional marine transgression then occurred, resulting in the basin-wide deposition of the Demons Bluff, the base of which is marked by a locally very thick transgressive sand.

Conformably overlying the EVCM is the Late Eocene Demon's Bluff Formation. Lithologically this unit consists of a basal sequence of fine-grained carbonaceous shale and siltstone deposited in an open marine environment. The unit has an average thickness over the basin of approximately 120 m, but thins toward the basin margins. The Demon's Bluff Formation provides a regional top seal to hydrocarbons reservoired in the top-most sandstone units of the EVCM as demonstrated in Yolla-1.

The Demon's Bluff Formation is overlain by the Late Eocene to Pliocene age Torquay Group which broadly consists of a basal sequence of marls and calcareous shales which grade upwards into a succession of bioclastic limestones. The Torquay Group signifies continual deposition under pervasive marine conditions. The Torquay Group is punctuated in places by episodes of minor uplift and/or erosion accompanied by varying effects of volcanism. Large-scale extrusives (volcanoes) are observable on the seismic data with extensive sill and dyke networks also resulting from these events (Yolla-1, Cormorant-1 and Aroo-1).

3.0 TREFOIL PROSPECT EVALUATION

3.1 GEOPHYSICAL EVALUATION

3.1.1 Overview

The proposed well location of Trefoil-1 is positioned on seismic line ORS01-13 SP 1492 from the Shelduck 2D seismic survey (**Figure 3.1**). The structure is located 37 km west of the Yolla gas field in the Bass Basin in approximately 68 m water depth. The Trefoil Prospect is an Eastern View Coal Measure anticlinal play situated within the Yolla Trough.

Geophysical remapping and analysis of Trefoil was undertaken as part of the 2002 Trefoil prospect evaluation (Lonergan and Pauli, 2002). This work focused on producing accurate depth models for incorporation into subsequent volumetric and economic analyses, as well as detailed amplitude versus offset (AVO) analysis of the seismic data.

Key results of this work were :

- The Trefoil prospect was confirmed as a low relief, four-way dip closed anticline at prospective hydrocarbon-bearing levels within the Palaeocene and upper Cretaceous. Negligible closure was interpreted in the upper Eastern View Coal Measures (EVCM).

- AVO anomalies indicating possible gas-charged sands are recognised within the Palaeocene and top Cretaceous. These anomalies have a similar character to the AVO anomaly present for a 22 m thick gas sand intersected by White Ibis-1.

- An AVO anomaly is recognised in the early Eocene section indicating possible gas-charged sands at this level. The anomaly can be interpreted to possibly be due to hydrocarbons within a structural / stratigraphic trap.

- Depth conversion utilising HSVA produces depth maps with closures that are reasonably conformable with the recognised AVO anomalies. These maps were used for subsequent volumetric analysis.

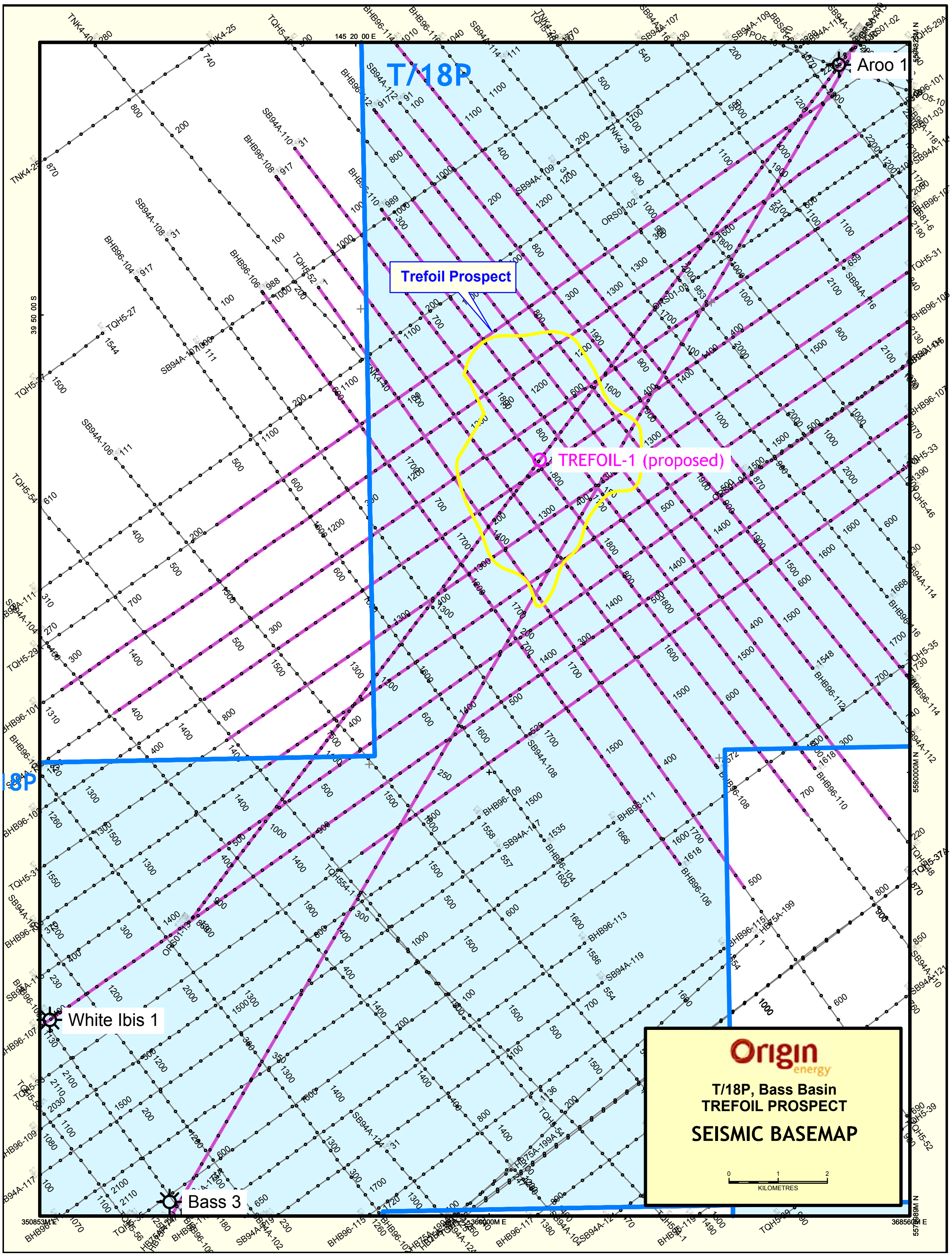


Figure 3.1 Trefoil Prospect 2002 Seismic Reprocessing Location

3.1.2 Reprocessing

Reprocessing of the existing 2D seismic grid over Trefoil was carried out in 2002 by CGG (Perth). The reprocessed seismic grid is shown in **Figure 3.1**. Further detail on the reprocessing is contained in Lonergan & Pauli (2001).

3.1.3 Interpretation and Mapping

The stratigraphy of the Bass Basin as summarised in **Figure 2.2** is adopted here for well correlations. Seismic ties to the key wells in the immediate vicinity to Trefoil were reviewed, namely White Ibis-1, Bass-3 and Aroo-1. Horizons interpreted within the prospective Eocene, Palaeocene and Cretaceous sections are summarised in **Table 3.1**.

Seismic Event	Reason for Picking	Event Quality
Top EVCM (Eocene)	**Secondary target; input to HSVA, AVO.**	**Fair**
P3 Marker (Palaeocene)	**Primary target; input to HSVA, AVO.**	**Fair**
P1 Marker (Palaeocene)	Primary target; Input to AVO.	Fair
C1 Marker (Cretaceous)	Primary target; Input to AVO.	Fair
Cretaceous Unconformity	**Secondary target; Input to HSVA, AVO.**	**Poor**

Table 3.1 – Key seismic markers interpreted in 2002 prospect evaluation. Mapped horizons were the Top EVCM, P3 Marker and Cretaceous Unconformity.

Note the horizon nomenclature has been revised compared to earlier geotechnical reports (Lonergan and Pauli, 2002, Doyle and Lonergan, 2003) and is now consistent with geological zonation viz. Palaeocene Marker 1 is now the P3 Marker, Palaeocene Marker 2 is now the P1 Marker and Cretaceous 1 Marker is now the C1 Marker.

Seismic lines through and near the proposed Trefoil-1 location are included as **Figures 3.2** and **3.3** showing interpreted horizons and data quality.

Mapped horizons were the Top EVCM, P3 Marker and Cretaceous Unconformity; these horizons were considered representative of structuring at possible Eocene, Palaeocene and Cretaceous reservoirs respectively. The P3 Marker is assumed to be relatively conformable with the P1 and C1 Marker levels.

3.1.4 Depth Conversion

The velocity field in T/18P, and throughout the Bass Basin, is complicated by volcanic intrusives and extrusives, which are generally characterised by "pull-up" on seismic time sections due to anomalously high velocities in the vicinity of the volcanics. The proximity to volcanics and the subtlety of the time closure at Trefoil (less than 20ms) therefore warranted a more rigorous approach than simply using average velocities derived from well time/depth relationships for depth conversion as might normally be applied.

The Horizon-based Stacking Velocity Analysis (HSVA) method of depth conversion utilises optimum stacking velocities derived from seismic for each target horizon. A stacking velocity map is created for each horizon and calibrated to average velocities for a given horizon at well locations. The calibrated average velocity map is then used to scale time migrated maps to depth.

Using Paradigm Geophysical's GeoDepth software, HSVA analysis was performed on the Top EVCM, P3 Marker and Cretaceous Unconformity for all seismic lines in the Trefoil grid, with ties into White Ibis-1, Aroo-1 and Bass-3.

Depth maps derived using HSVA for the Top EVCM, P3 Marker and Cretaceous Unconformity are included as **Figures 3.4, 3.5** and **3.6.**

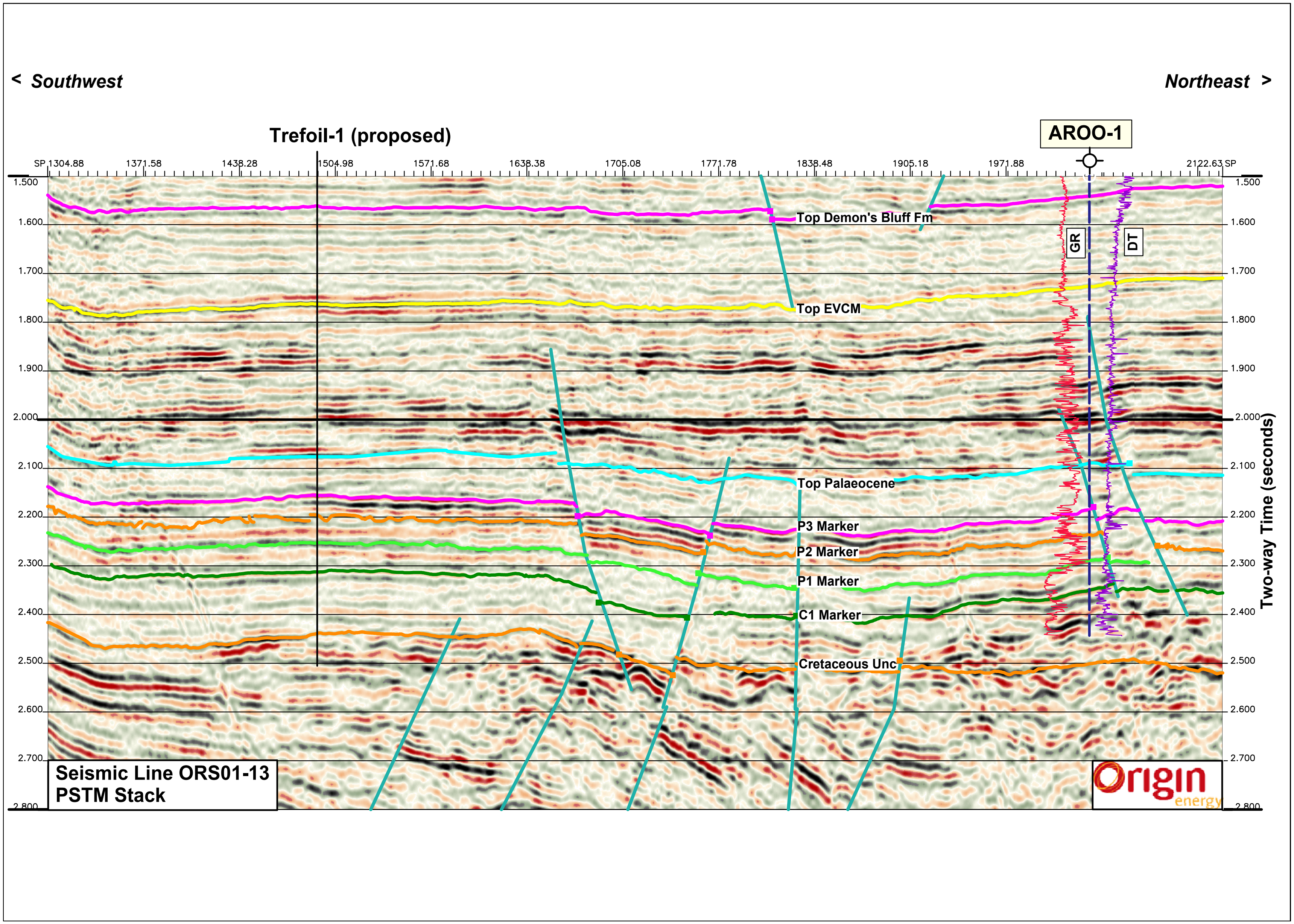


Figure 3.2 Seismic line ORS01-13 showing proposed Trefoil-1 location

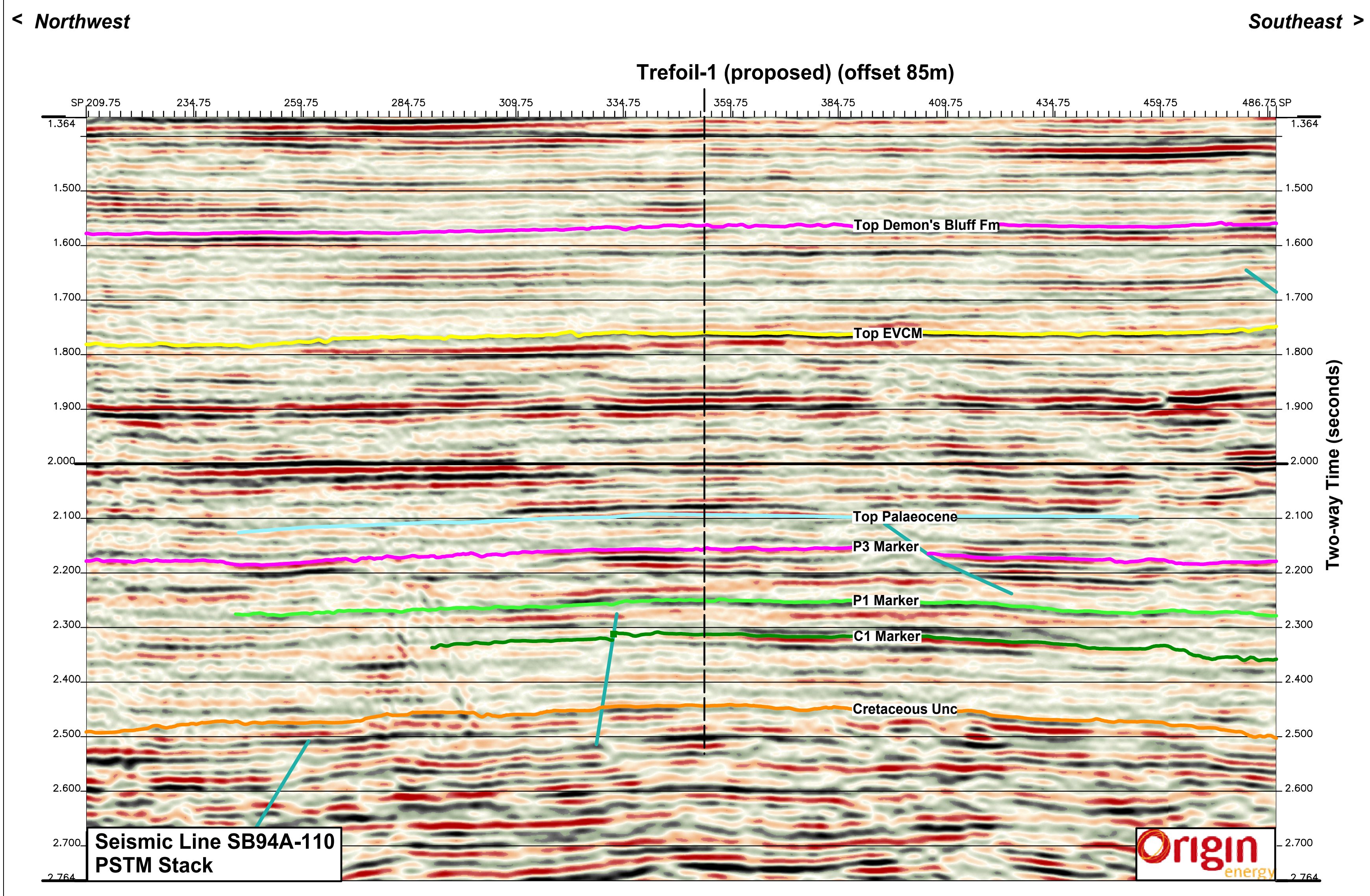


Figure 3.3 Seismic line SB94A-110 showing proposed Trefoil-1 location

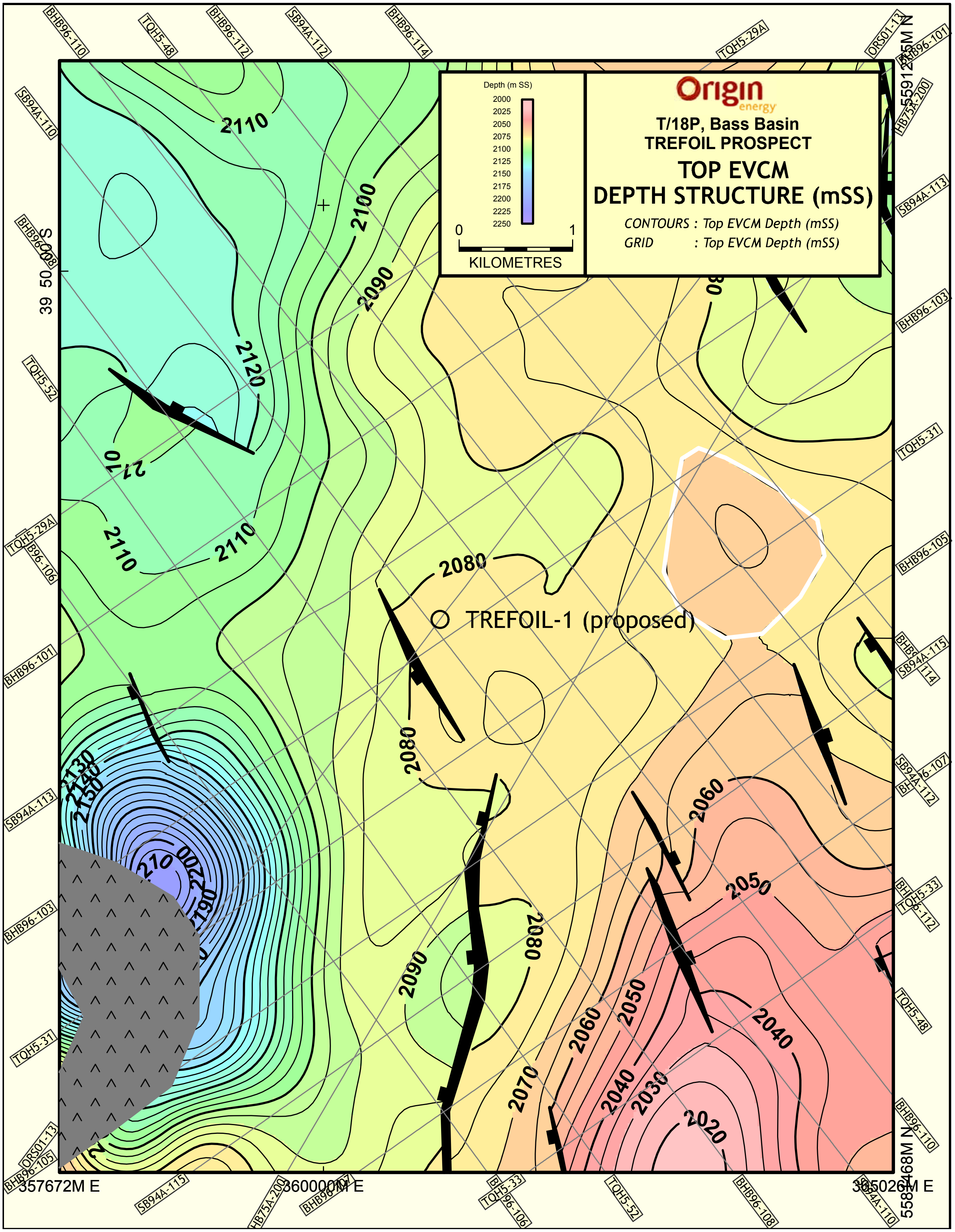


Figure 3.4 Top EVCM Depth Structure Map – Trefoil Prospect

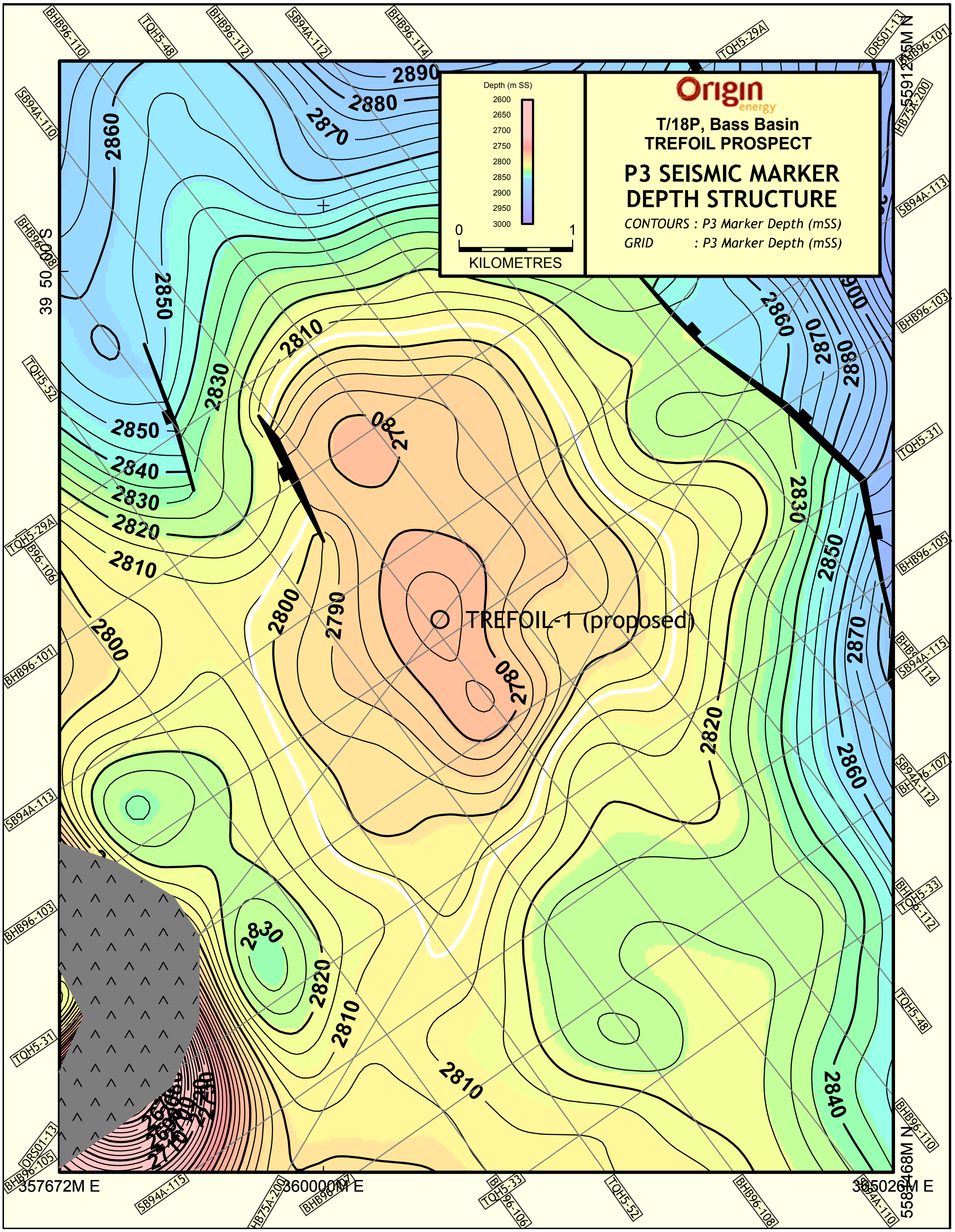


Figure 3.5 P3 Seismic Marker Depth Structure Map – Trefoil Prospect

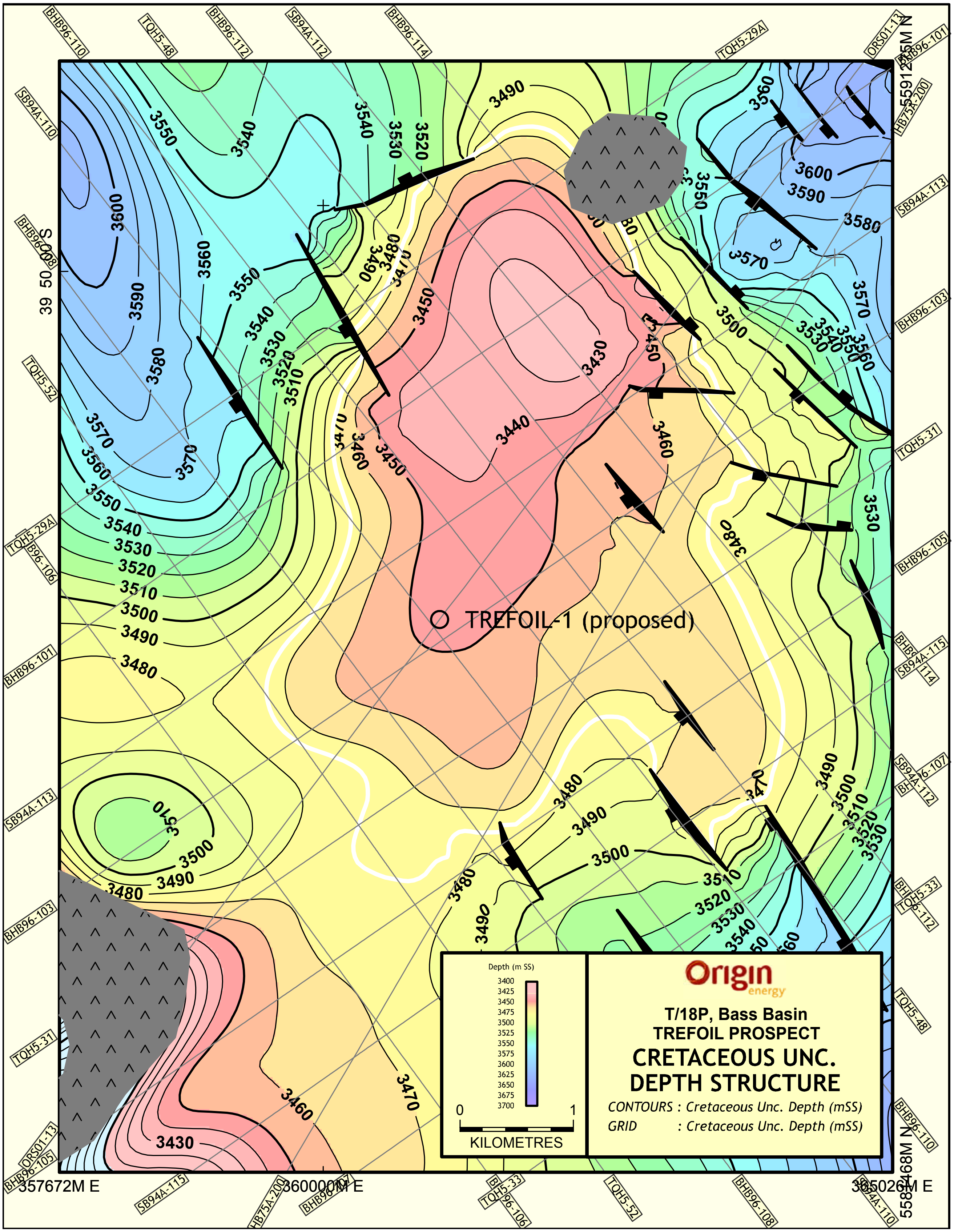


Figure 3.6 Cretaceous Unconformity Depth Structure Map – Trefoil Prospect

3.1.5 AVO Analysis

Hampson-Russell software was used to perform AVO analysis over Trefoil on all lines from the reprocessed grid, with the main focus on the Palaeocene section where AVO anomalies had previously been identified. A combination of AVO intercept (I), AVO gradient (G) and fluid factor sections were used, along with some modelling at White Ibis-1 to determine the thickness of gas required to produce a detectable AVO anomaly.

In order to gain a quantitative representation of the extent of the AVO anomalies, fluid factor sections were created for all seismic lines in the Trefoil grid. The fluid factor represents the deviation from the background, water saturated sand trend on an AVO intercept versus gradient crossplot. Reflections from gas sands are anomalous, and tend to plot away from the background trend. Unusual lithologies, such as the volcanics that are prevalent in the area, can also produce AVO anomalies, so care must be taken when interpreting the results.

Using the fluid factor sections, RMS amplitude maps were created using windows encompassing the following horizons:

- Top EVCM
- Top Palaeocene (*)
- P3 Marker (*)
- P1 Marker (*)
- C1 Marker (*)
- Cretaceous Unconformity

The fluid factor RMS amplitude maps are included in **Figure 3.7** for the horizons marked by an asterisk. The various AVO anomalies present at Trefoil and their match to depth mapping are summarised in **Table 3.2**.

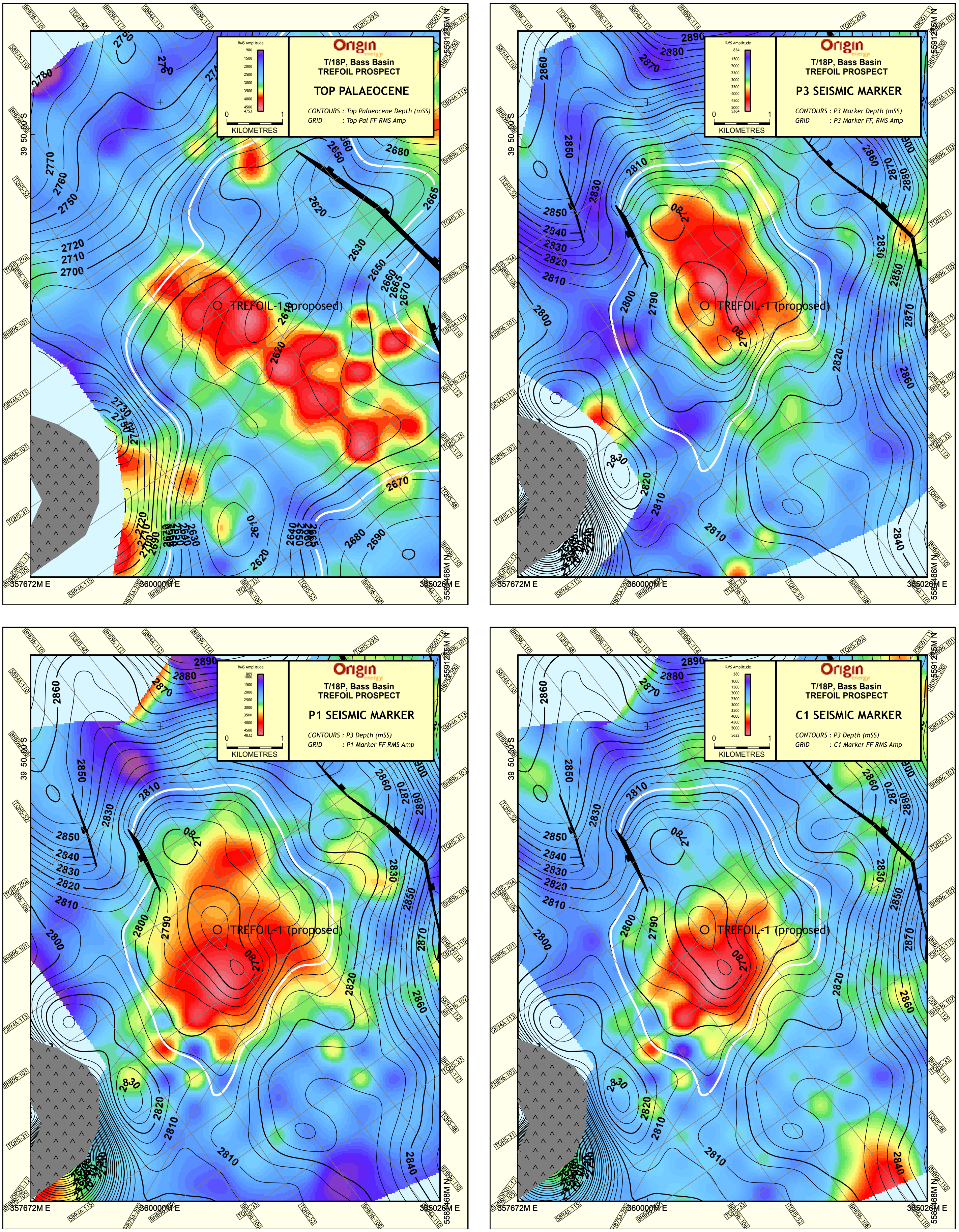


Figure 3.7 Fluid Factor RMS Amplitude Maps – Top Palaeocene, P3, P1 & C1 Markers

Table 3.2 - Comparison of AVO anomalies at Trefoil. Based on strong AVO anomalies that are relatively conformable with depth closure, the P3, P1 and C1 Markers are considered the most prospective horizons at Trefoil.

	Horizon	Structural Closure	AVO Anomaly	AVO match with depth closure
Top EVCM		**Negligible**	**Weak**	**No**
Top Palaeocene		**Yes**	**Moderate**	**No#**
Primary Targets	P3 Marker	**Yes**	**Strong**	**Yes**
	P1 Marker	**Yes**	**Strong**	**Yes**
	C1 Marker	**Yes**	**Strong**	**Yes**
Cretaceous Unconformity		**Yes**	**None***	**No**

Possible combined structural/stratigraphic trap.
* A localised strong anomaly is present, however this is interpreted to be caused by a high impedance unit, most probably volcanic.

For the P3, P1 and C1 Markers, there are clear AVO anomalies located over the Trefoil structure. These anomalies are closely conformable with the mapped depth closure (from HSVA) for the P3 Marker which is used to represent structure at P3, P1 and C1 Marker levels (**Figure 3.7).**

The P3 Marker horizon is at the same interpreted seismic level as a 22 m thick gas sand (2002m sand) that shows a distinct AVO anomaly at White Ibis-1. The fluid factor amplitudes for this level at Trefoil and White Ibis-1 are very similar (**Figure 3.8**), providing confidence the AVO anomalies at Trefoil are gas-related. The P3 Marker is also interpreted to be stratigraphically equivalent to a sand found at Aroo-1 (2897m sand) from which a minor gas recovery (1.4 ft^3 of gas and 1900 cm^3 of water) was made. It can be seen in **Figure 3.8** that there is no fluid factor anomaly for this horizon in the vicinity of Aroo-1.

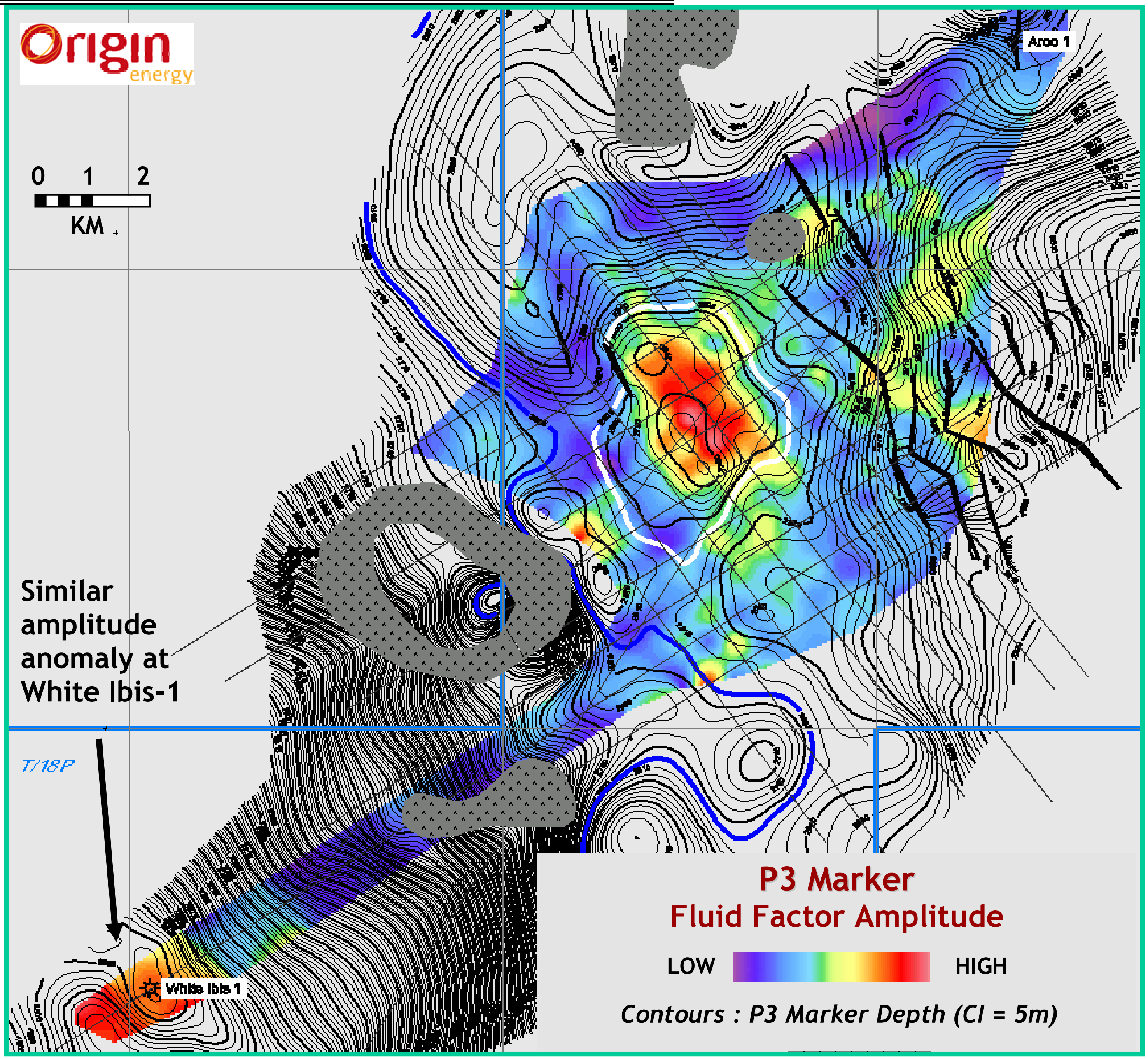


Figure 3.8 Fluid Factor RMS Amplitude Map – P3 Marker

Although the C1 Marker correlates seismically into the package of inter-bedded basalts and sands penetrated in the lower section of Aroo-1, based on seismic character it is considered unlikely to extend over the Trefoil structure, having been replaced with an extra sedimentary section. Indeed, the seismic and AVO response over Trefoil for the C1 Marker horizon appears to be consistent with a low impedance unit. With a valid fluid factor anomaly that lies within structural closure, the AVO anomaly observed at this horizon is interpreted to be gas-related.

The fluid factor map for the Top Palaeocene (**Figure 3.7**) reveals an interesting anomaly, with a band of high amplitudes trending NW-SE near Trefoil. Although this extends beyond the small mapped closure at the Top Palaeocene, there is a general high trending N-S, within which the amplitudes seem confined to the NW and SE. This raises the possibility of a laterally confined sand body running NW-SE, resulting in a combined stratigraphic/structural trap.

There is no extensive AVO anomaly for the Cretaceous Unconformity that indicates the presence of gas for this horizon and below. However, due to the lack of continuous events and poor data quality, AVO analysis may not be effective at the Cretaceous Unconformity and below.

The Top EVCM does not show a strong AVO anomaly consistent with the presence of structurally trapped hydrocarbons. There is a weak anomaly present, which may be due to a sharp lithological change at the boundary between the Demon's Bluff formation and Top EVCM.

AVO modelling was subsequently undertaken to determine whether anomalies observed at Trefoil are consistent with what might be expected from typical gas sands in the region, as well as establish thickness of gas sand required to produce a detectable AVO anomaly. The main gas sand in White Ibis-1 at the P3 Marker level (2000m sand) was chosen for the modelling tests.

Results of the modelling were :

- Observed AVO anomalies at Trefoil are consistent with low-impedance, low Poisson's ratio gas charged sands that have a negative intercept and a slight increase in amplitude with offset i.e. similar to 2002m sand in White Ibis-1.
- Anomalies observed from the modelling have the same character as the anomalies present in the real data.

- Modelling indicates a gas column and/or reservoir thickness of at least 15-20 m thickness is required to produce a recognisable AVO anomaly.

3.1.6 Depth Prognosis

Based on the preceding geophysical work, the depth prognosis for the proposed Trefoil-1 well is shown in Table 3.3.

Origin energy	OFFSET WELLS						TREFOIL-1	Seismic Line : ORS01-13, SP. 1492 Coords : 361028mE 5586346mS (GDA94) KB = 25 m ASL WATER DEPTH = -68m ASL			
	Aroo-1 (10 km NE)			White Ibis-1 (15 km SW)							
FORMATION	Depth (m ASL)	Depth (m KB)	Thickness (m)	Depth (m ASL)	Depth (m KB)	Thickness (m)	Two-way Time (msec)	Depth (m ASL)	Depth (m KB)	Thickness (m)	Depth Error (+/-) (m)
TORQUAY GROUP	-76	86	1738	-62	74	1357	-	**-68**	**93**	1712	5
Lower Miocene Marl	-825	835	-	-	-	-	-	**-817**	**842**	-	100
ANGAHOOK FORMATION	-1280	1290	534	-	-	-	-	**-1295**	**1320**	485	100
DEMON'S BLUFF FORMATION	-1814	1824	235	-1419	1431	172	1563	**-1780**	**1805**	297	50
EASTERN VIEW COAL MEASURES	-2049	2059	1147	-1591	1603	522	1760	**-2077**	**2102**	1027	30
E1 Reservoir Zone	-2582	2592	-	-1843	1855	-	-	**-2506**	**2531**	-	30
P5 Reservoir Zone	-2702	2712	-	-1930	1942	-	-	**-2627**	**2652**	-	30
P4 Reservoir Zone	-2783	2793	-	-1963	1975	-	-	**-2700**	**2725**	-	30
P3 Reservoir Zone	-2870	2880	-	-1990	2002	-	2152	**-2774**	**2799**	-	30
P2 Reservoir Zone	-2921	2931	-	-2033	2045	-	-	**-2825**	**2850**	-	30
P1 Reservoir Zone	-3061	3071	-	-2089	2101	-	-	**-2965**	**2990**	-	30
CRETACEOUS	-3196	3206	486+	-2113	2125	33		**-3104**	**3129**	343+	30
C1 Reservoir Zone	-3200	3210	-	-2116	2128	-	-	**-3104**	**3129**	-	30
TD-A (Trefoil)	-	-	-	-	-	-	-	**-3144**	**3169**	-	-
Cretaceous Unconformity	NP#	NP#	-	NP	NP	-	2440	**-3447**	**3472**	-	50
TD-B (Trefoil)	-	-	-	-	-	-	-	**-3487**	**3512**	-	-
BASEMENT	NP	NP	-	-2146	2158	-	-	**-**	**-**	-	-
TD	-3682.2	3692	-	-2208	2220	-	-	**-**	**-**	-	-

(NB : Depths at Trefoil-1 derived from seismic are highlighted, others prorata from well control)

Volcanic intrusives present at this level

Table 3.3 - Trefoil Depth Prognosis

3.2 GEOLOGICAL EVALUATION

3.2.1 Reservoir

The primary targets for the Trefoil Prospect are sandstone reservoirs in the Palaeocene section of the Eastern View Coal Measures (EVCM). These units are correlative to gas saturated sands in the Yolla and White Ibis Fields. Secondary targets are reservoirs in the Early Eocene and Late Cretaceous.

The Palaeocene reservoirs at Trefoil-1 are interpreted to be deposited in slightly more distal environments than the sandstones at Yolla-1 and White Ibis-1. Aroo-1 is along depositional strike from or is slightly more distal than the Trefoil structure (**Figure 3.9**) (IFP, 1999) and therefore is a good analogue for predicting the minimum expected reservoir quality (porosity and permeability) and distribution (net/gross) at Trefoil-1.

Regional correlations between White Ibis-1, Bass-3, Aroo-1 and Yolla-1 were used to define the vertical distribution of major reservoir and seal units (**Table 3.4**, Enclosure 1). Lateral continuity of individual sand units is poor as depositional processes varied both laterally and temporally through alluvial plain, fluvio-deltaic and shallow marine. Seven reservoir zones and associated top seal units were identified through the Early Eocene (*M. diversus)* to Late Cretaceous (*T. lillei*) sedimentary section (Encl 1). Due to the absence of significant mapped closure at the Top EVCM, no reservoir analyses were performed for that level.

Reservoir Zone (Trefoil)		Yolla-1	White Ibis-1
Eocene	E1	“2718” & “2755”	-
Palaeocene	P5	“2809”	-
	P4	-	-
	P3	“2952” & “2973”	“2002”
	P2	-	“2044”
	P1	-	-
Late Cretaceous	C1	-	“2128”

Table 3.4 - Correlation of Trefoil reservoir zones to known gas pools.

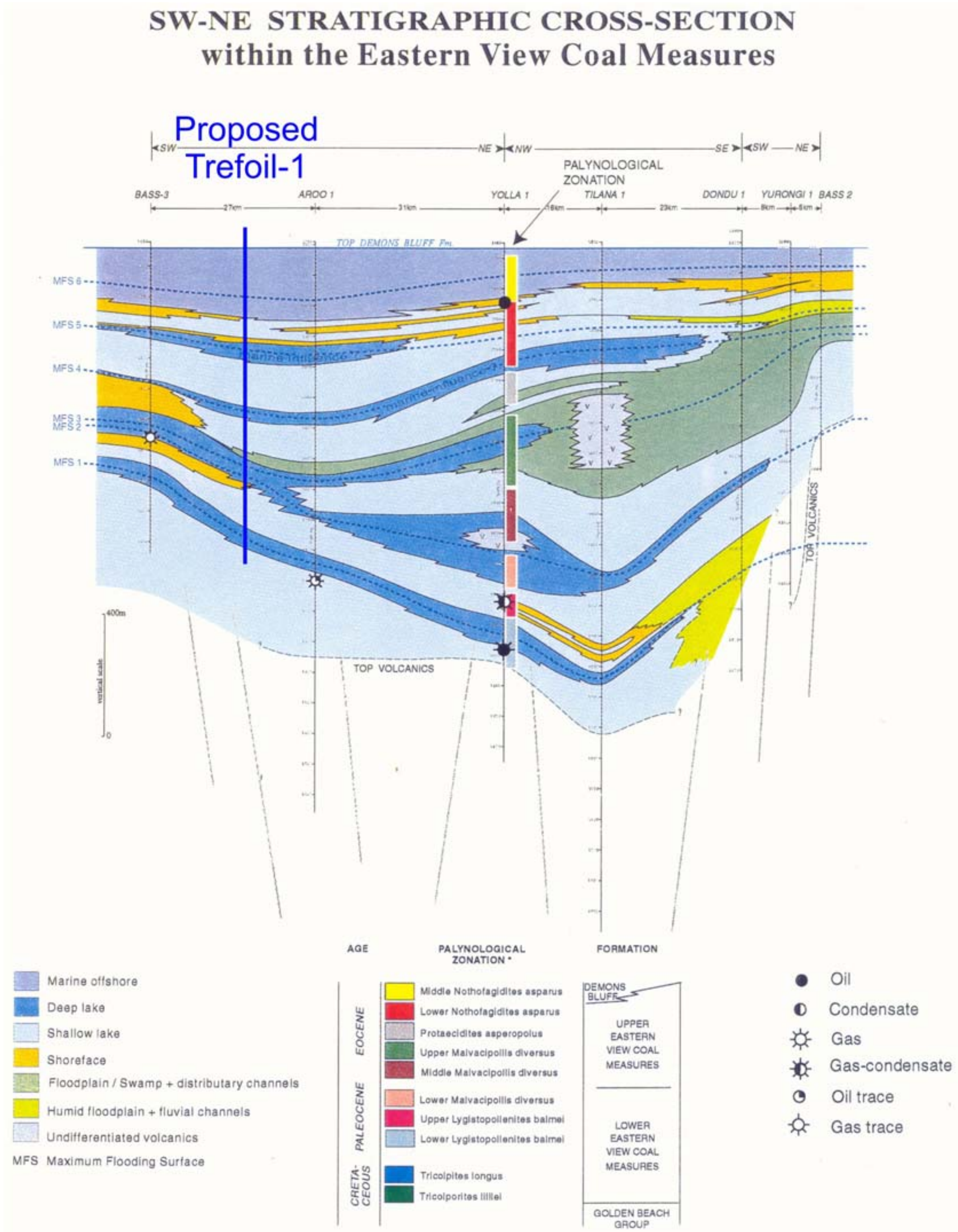


Figure 3.9 Facies Variation of the EVCM in the Yolla Trough (IFP 1999)

Detailed petrophysical analysis for the seven prospective EVCM reservoir units was undertaken on Aroo-1, White Ibis-1 and Bass-3. Average porosity for the EVCM varies between approximately 17% and 19% in these 3 wells with average porosity for the individual layers varying between 12% and 22%. The regional measured porosity vs depth plot shows that the expected total range of porosity at Trefoil (at 2774mSS) is between 10% and 22% (**Figure 3.10**). Minimum cut-off for porosity values to determine gas volumes at Trefoil is based on regional core derived permeability – porosity cross plots which indicate a correlation of approximately 13% porosity equates to 1mD of permeability (**Figure 3.11**). High side and low side porosity cut-offs were considered to be 16% and 10% respectively.

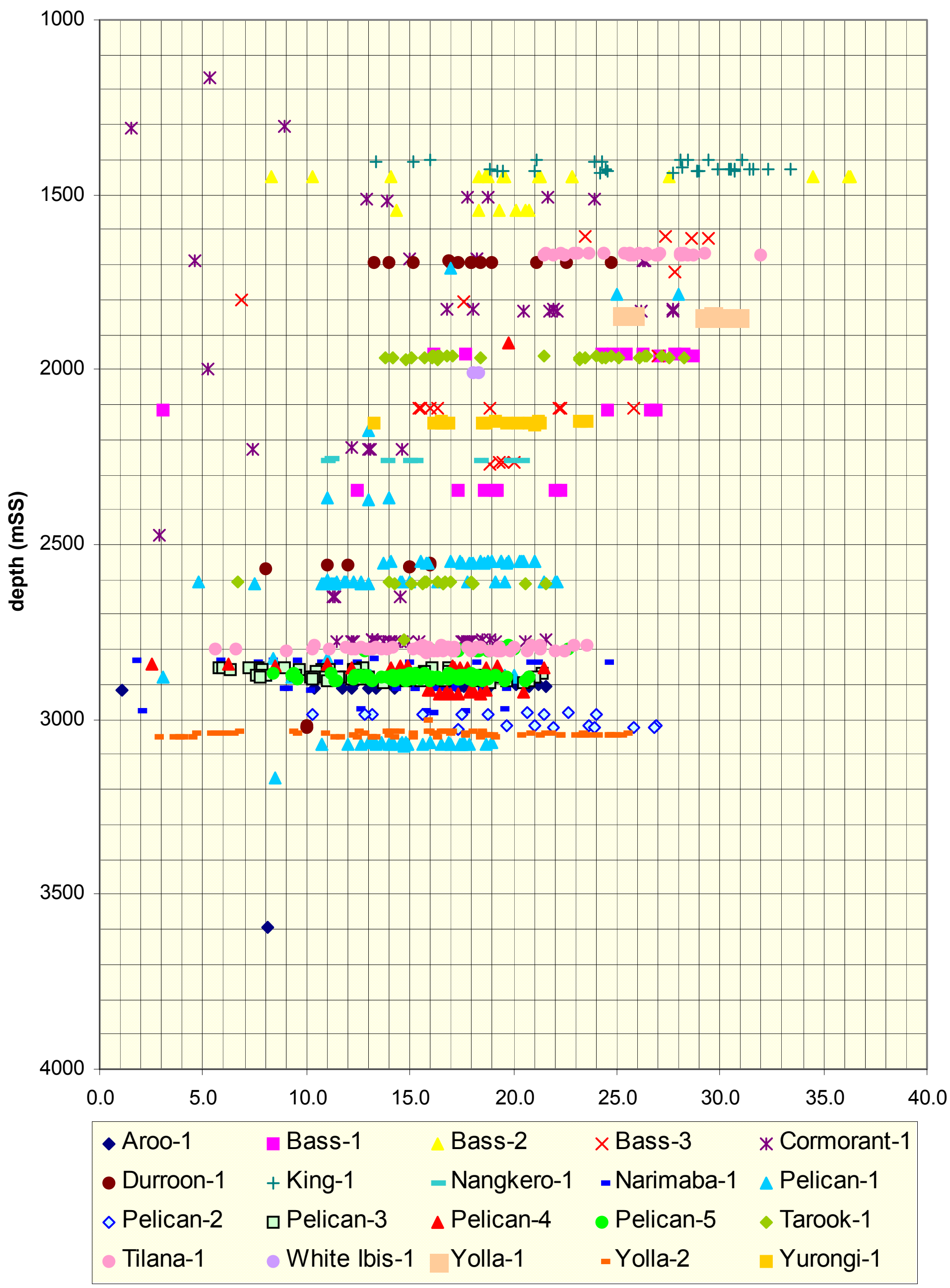


Figure 3.10 Bass Basin Measured Core Porosity vs Depth

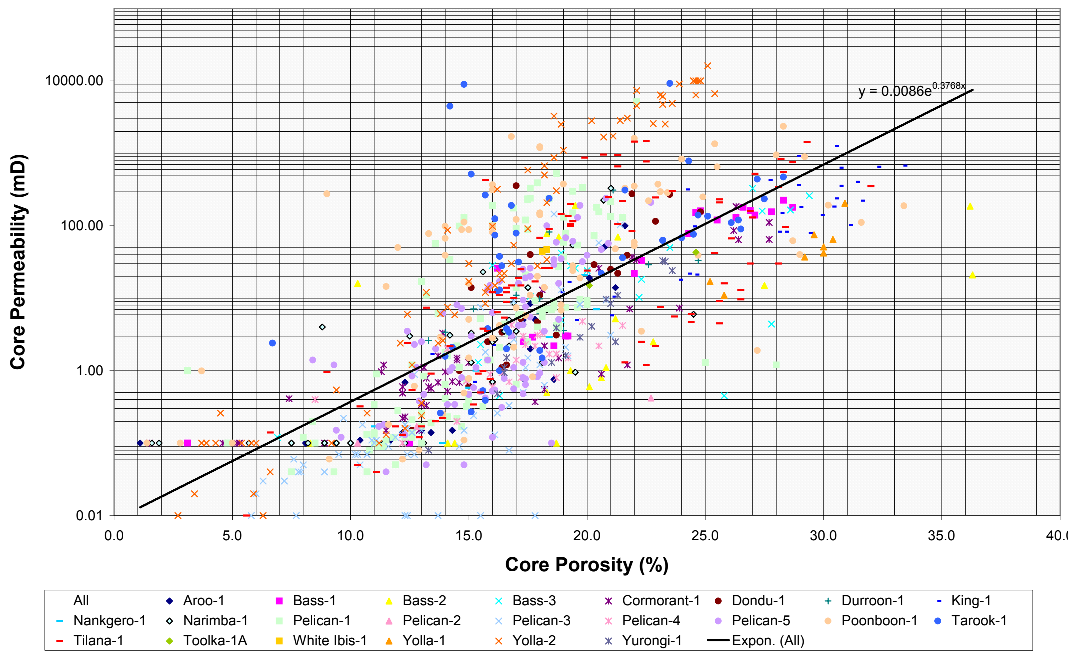


Figure 3.11 Bass Basin Measured Core Porosity vs Permeability

3.2.2 Seal

The vertical sealing capacity of multiple intra-formational seals within the Palaeocene aged part of the EVCM has been demonstrated by the stacked gas accumulations at Yolla and White Ibis. These seals extend over most of T/18P as mapped using wireline correlations (Enclosure 1) and seismic character ties. Confidence in the top seal capacity at Trefoil is enhanced by the presence of AVO anomalies that can be correlated to hydrocarbon bearing sands at White Ibis-1, which have a similar AVO response and are overlain by competent sealing shales.

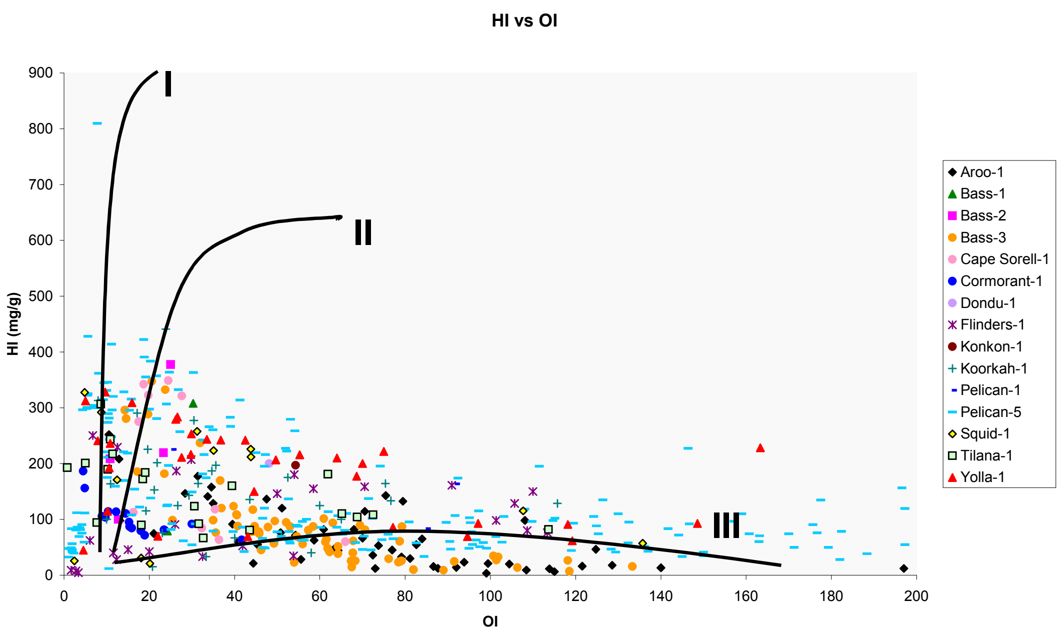
The Trefoil structure is not a fault dependant closure and therefore fault seal is not perceived to be a risk.

3.2.3 Source

3.2.3.1 Source Quality and Distribution

The recovery of gas and oil within the Bass Basin proves that a mature hydrocarbon source exists. Boreham et al (2003) have demonstrated the existence of a good oil-source correlation between the Yolla and Pelican crude oils and the coal facies of the EVCM. The best source potential occurs within the Palaeocene to Early Eocene (*L. balmei* to *M. diversus*) coals within the EVCM (Boreham et al 2003).

RockEval plots of the EVCM coals and claystones show that good quality terrestrial Type II and Type III kerogen is present in the basin (**Figure 3.12**). TOC values are generally over 1% and range up to over 80% in the coals. Regionally, good potential for gas and minor liquids is demonstrated in the range of HI values which are commonly over 100 and as high as 444. Wells on the western side of the basin (eg Aroo-1 and Bass-3) are poorer in organic matter than wells closer to depocentres (IFP 1999) but the presence of gas and minor oil at Yolla and White Ibis proves that the source facies is present in the Yolla Trough.



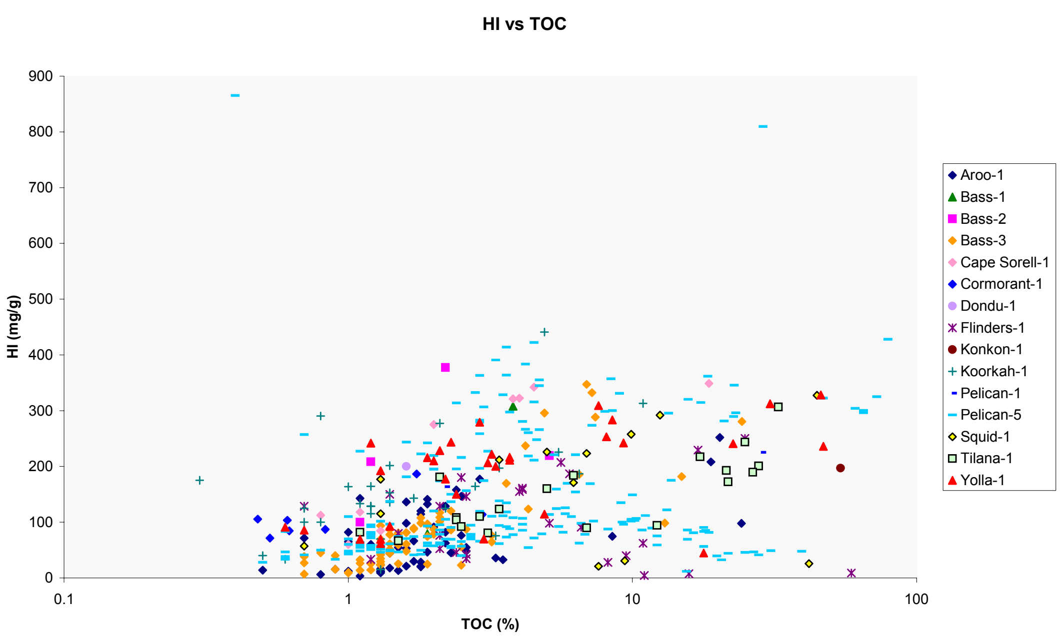


Figure 3.12 RockEval Plots of the EVCM source rocks in the Bass Basin

3.2.3.2 Maturation and Migration

The source rocks of the EVCM within the Yolla Trough have been modelled in 2D to determine the maturity in the drainage cell of the Trefoil Prospect (IFP 1999). The location of the model is shown in **Figure 3.13**. The model was calibrated to the present day temperature and pressure data taken from Aroo-1 and Vr data from Yolla-1 (**Figure 3.14**). Boreham et al (2003) speculate that the gases reservoired at Yolla and White Ibis-1 have been expelled from source rocks that are over a maturity of Vr 1.5%. The EVCM interval that surpasses this maturity present day within the Yolla Trough is shown on the 2D model in **Figure 3.15**. Using this maturity cut-off, the 2D model has predicted hydrocarbon accumulations at Yolla, Trefoil and White Ibis as represented by the hydrocarbon saturation plot (**Figure 3.16**).

To reduce uncertainty that this part of the trough lies within the Trefoil drainage cell, lateral migration pathways were plotted from the modeled gas mature depocentres on the regional structure maps representing the early gas expulsion and present day (**Figures 3.17 & 3.18**). In both cases the Trefoil structure can access laterally migrating hydrocarbons (assuming no loss up intervening faults). The White Ibis gas accumulation accesses the same parts of the present day mature Yolla Trough as Trefoil, supporting the theory that lateral migration will be an effective mechanism to charge the Trefoil closure.

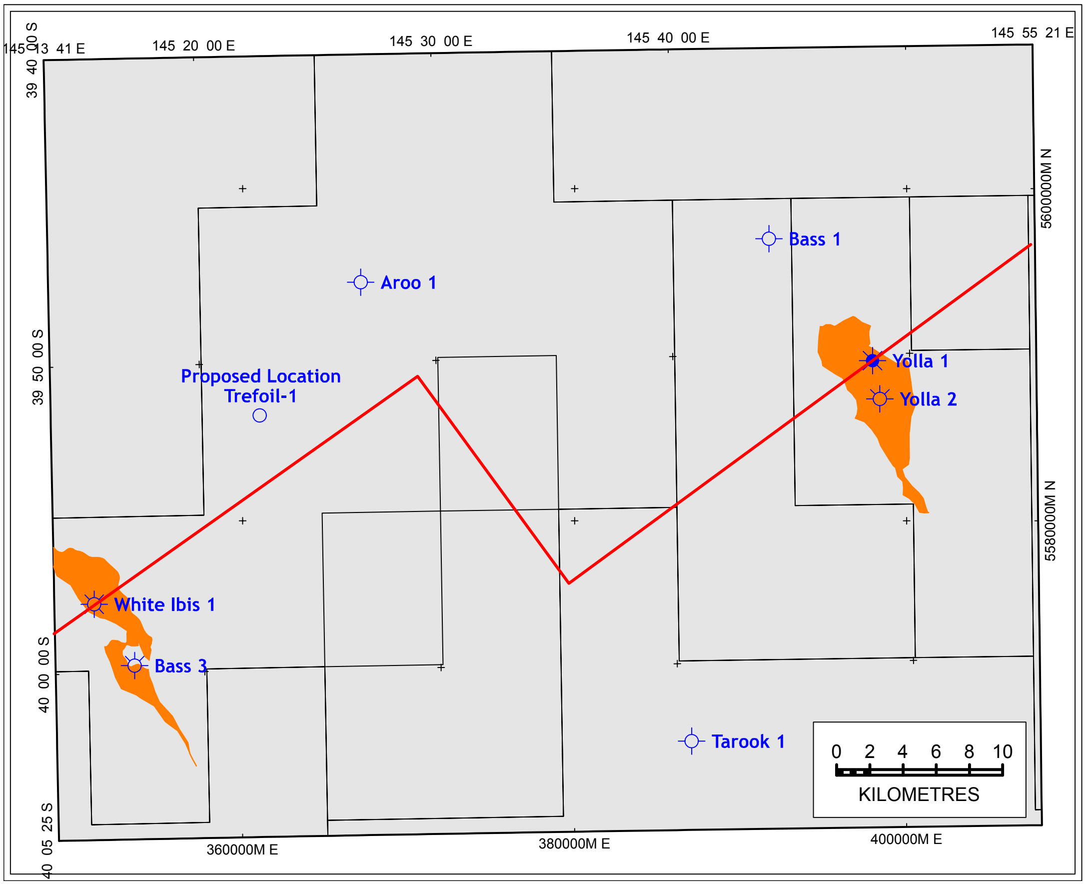


Figure 3.13 Location of Temis 2D basin model in Figures 3.21 & 3.22 shown in red

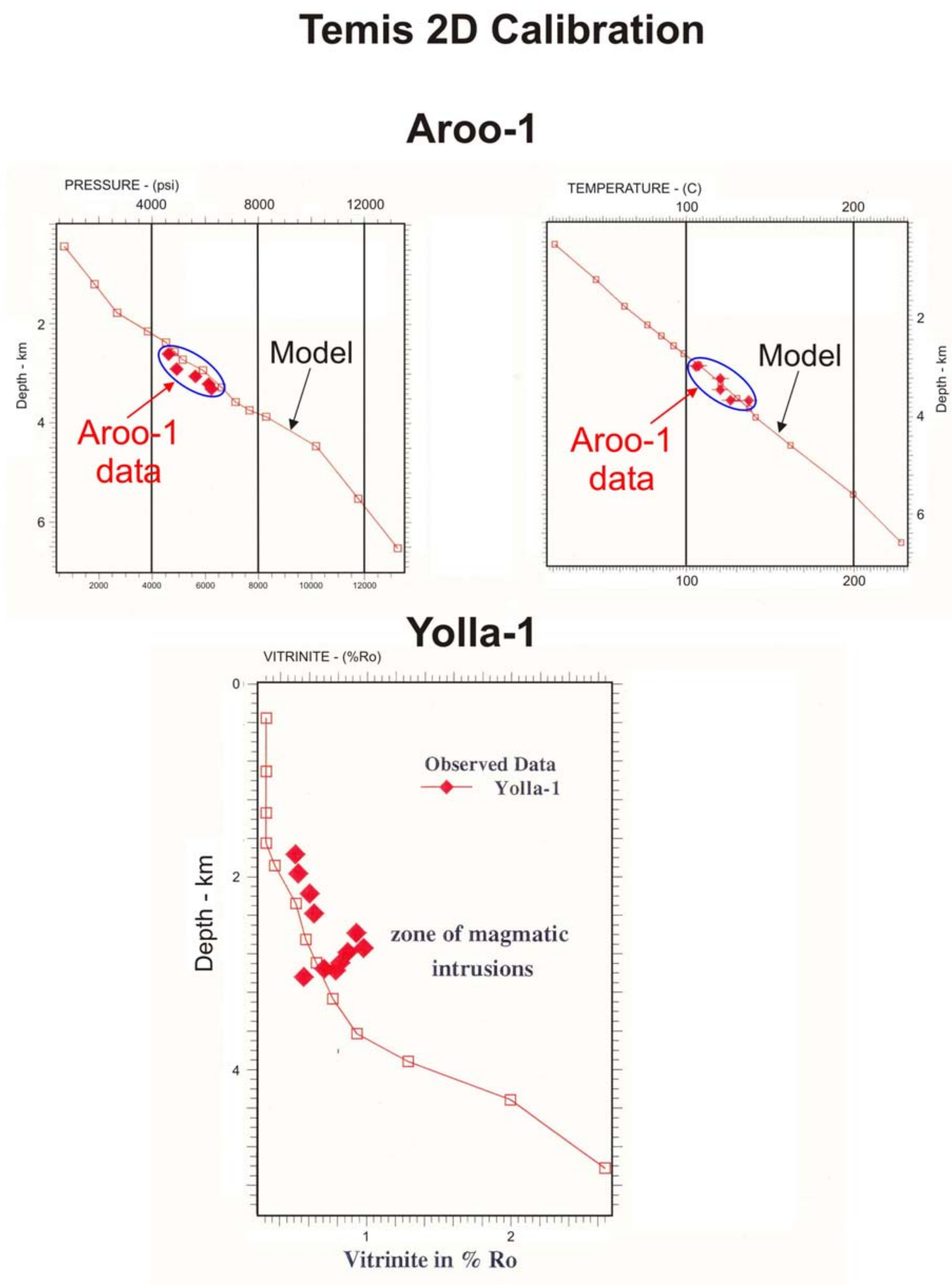


Figure 3.14 Calibration of Temis 2D basin model to Aroo-1 and Yolla-1 data (IFP 1999)

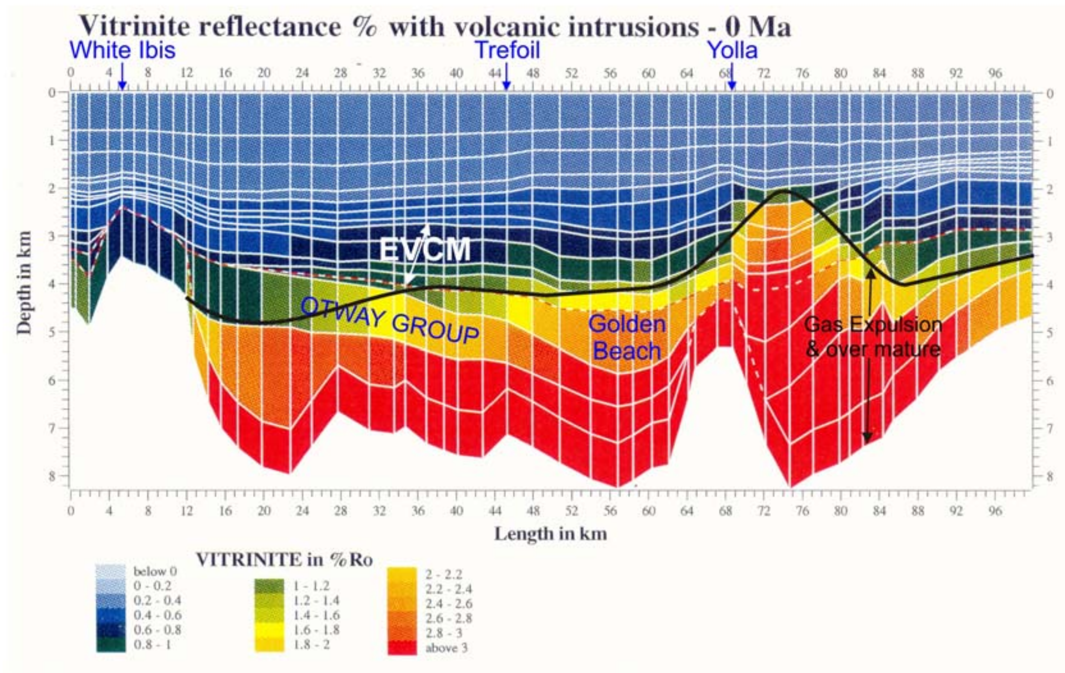


Figure 3.15 Temis 2D basin model showing predicted Vitrinite Reflectance maturity. The green cells represent the oil expulsion window. The yellow to orange cells are mature for gas expulsion. The red cells are overmature. (IFP 1999)

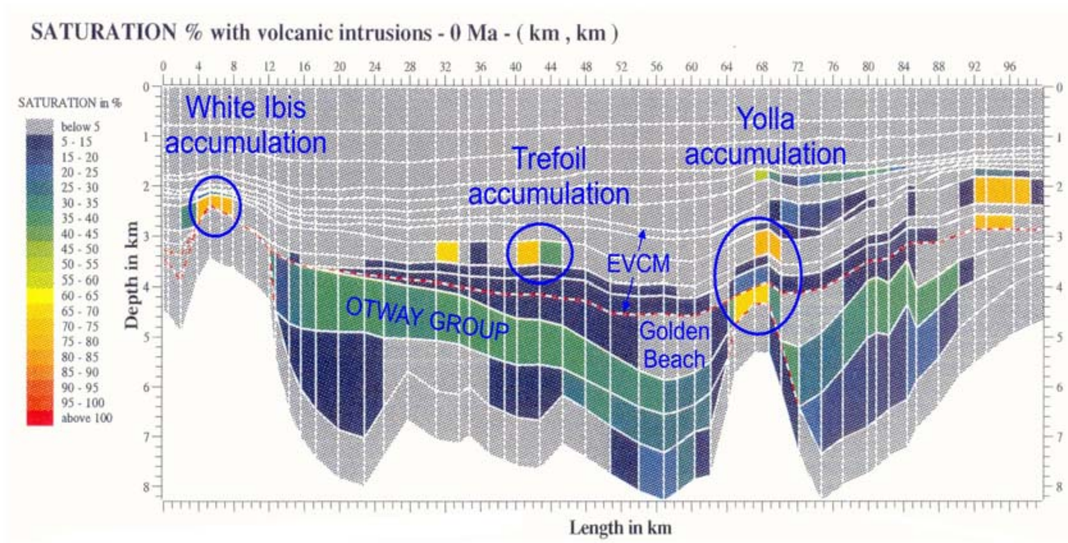


Figure 3.16 Temis 2D basin model showing predicted hydrocarbon saturation. Cells in yellow, orange and red represent migrated hydrocarbons in reservoir lithology. Cells coloured blue to green represent source rocks that may or may not have reached sufficient maturity to expel hydrocarbons. (IFP 1999)

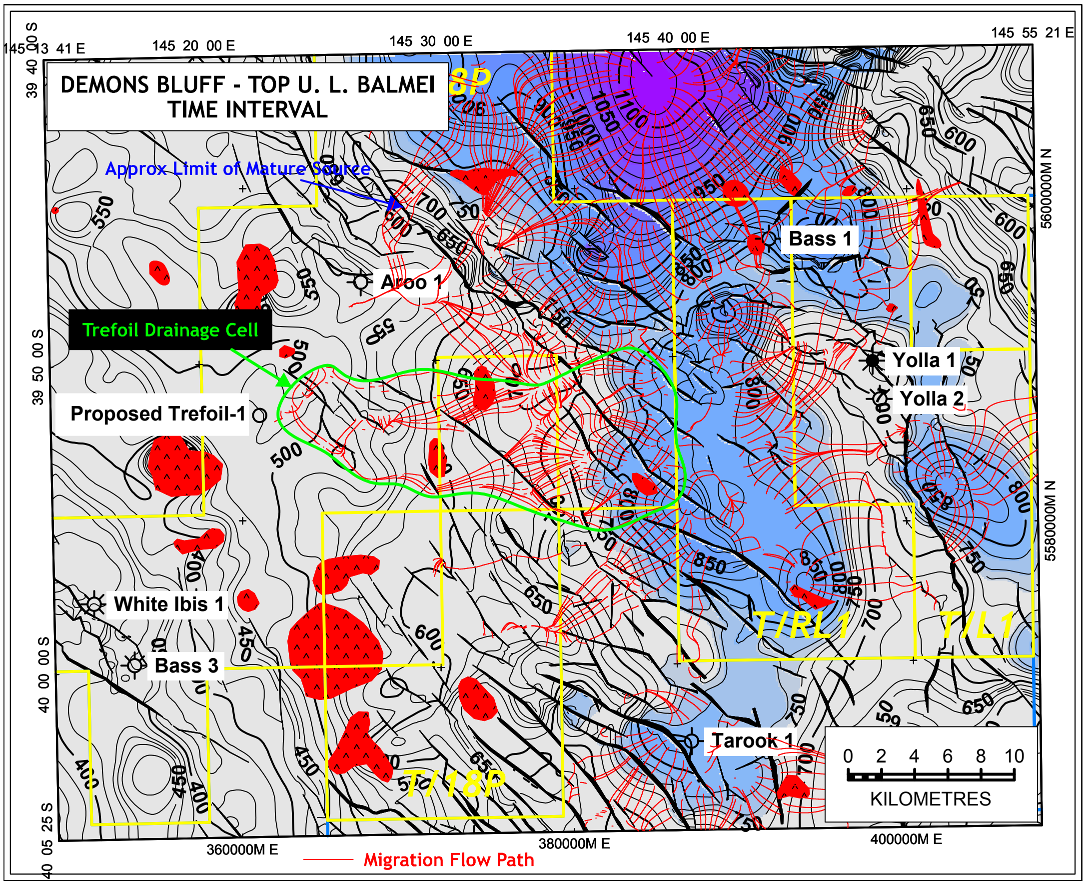


Figure 3.17 Lateral migration pathways of early gas expelled from the Yolla Trough at the end of Demons Bluff deposition (Late Eocene). Migration flow paths are shown in red. Predicted mature source kitchens are coloured in blue to purple.

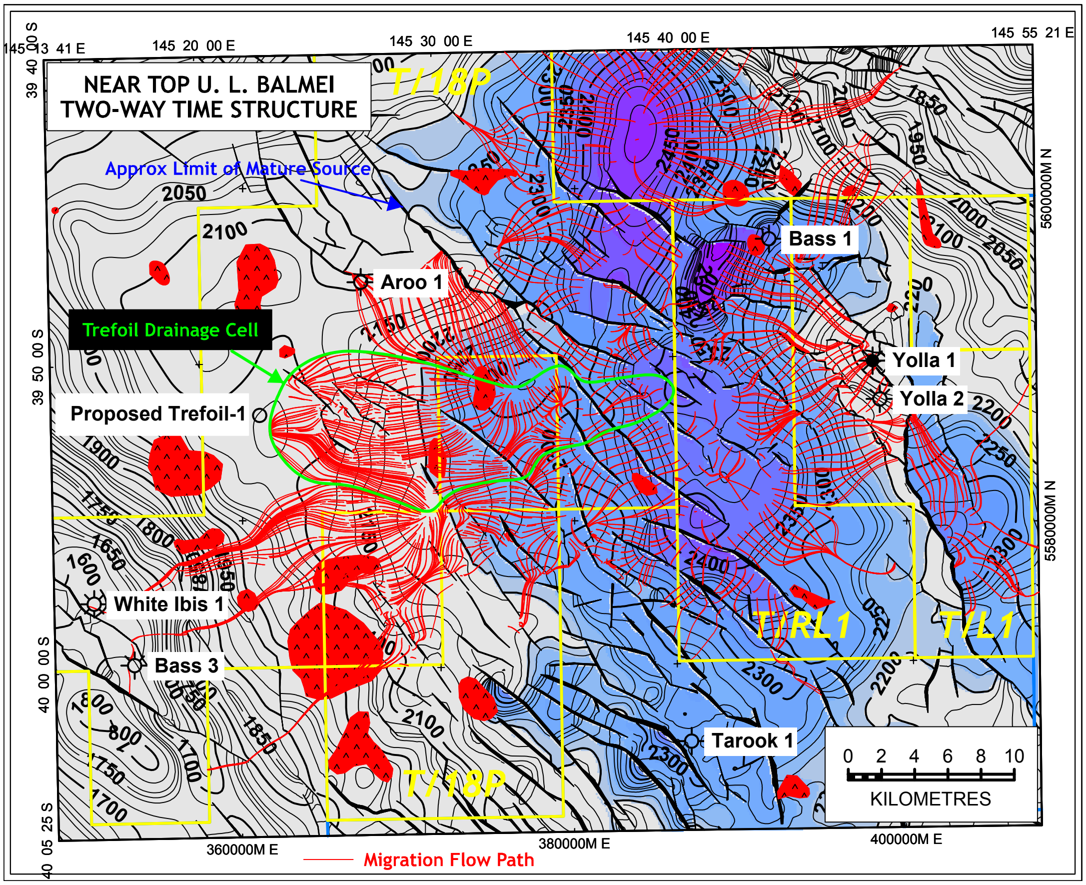


Figure 3.18 Present day lateral migration pathways of expelled gas from the Yolla Trough. Migration flow paths are shown in red. Predicted mature source kitchens are coloured in blue to purple.

4.0 PREDICTED OGIP

Volumetric estimates of the Trefoil Prospect for economic assessment have been calculated using probabilistic techniques. The reservoir units considered are in the Lower Eocene, Palaeocene and Late Cretaceous sections. Based on the predominantly gas charged fields of Yolla and White Ibis, oil and associated liquids were not considered in the calculations.

The Trefoil Prospect depth structure grids used in the volumetric determination are based on the previously described horizon stacking velocity analysis (HSVA) results. Regional correlation of discrete reservoir and seal zones was undertaken to define the individual layers to be modelled. The three control wells used were Aroo-1, White Ibis-1 and Bass-3.

Uncertainties on these volumes were then calculated allowing for variations in structural closure and reservoir quality affecting the net to gross of the various sands.

4.1 STRUCTURAL INPUT

The Trefoil Prospect is mapped as a four-way dip anticlinal closure with minor fault dependency. Significant closure was mapped at the P3 Marker and Cretaceous Unconformity levels with negligible relief at the Top EVCM (**Table 4.1**).

Seismic Horizon	Vertical Relief (m)	Areal Relief (km^2)
Top EVCM	5	1.7
P3 Marker	33	13.3
Cretaceous Unconformity	48	18.7

Table 4.1 - Mapped closures for Trefoil seismic horizons.

The most likely structural closure is based on the current mapping. The highside and lowside structural closure estimates were based on a possible +/- 1 % uncertainty in semblance picking in the vicinity of Trefoil and a similar +/- 1 % uncertainty in average velocities for depth conversion for the objective horizons.

4.2 RESERVOIR INPUT PARAMETERS

Probabilistic volumetrics were calculated for each individual reservoir zone as defined by the regional correlations (Encl 1). Triangular distributions were used for each of the parameters with P50 values based on petrophysical averages for Aroo-1, the closest analogue well for the Trefoil location. Highside parameters were taken from White Ibis-1 and Bass-3 (**Figure 4.1**). Water saturation was applied with a negative 90% dependency on porosity. Gas properties recorded in the Yolla Field were used to calculate Formation Volume Factor. The reservoirs were considered filled to structural spill.

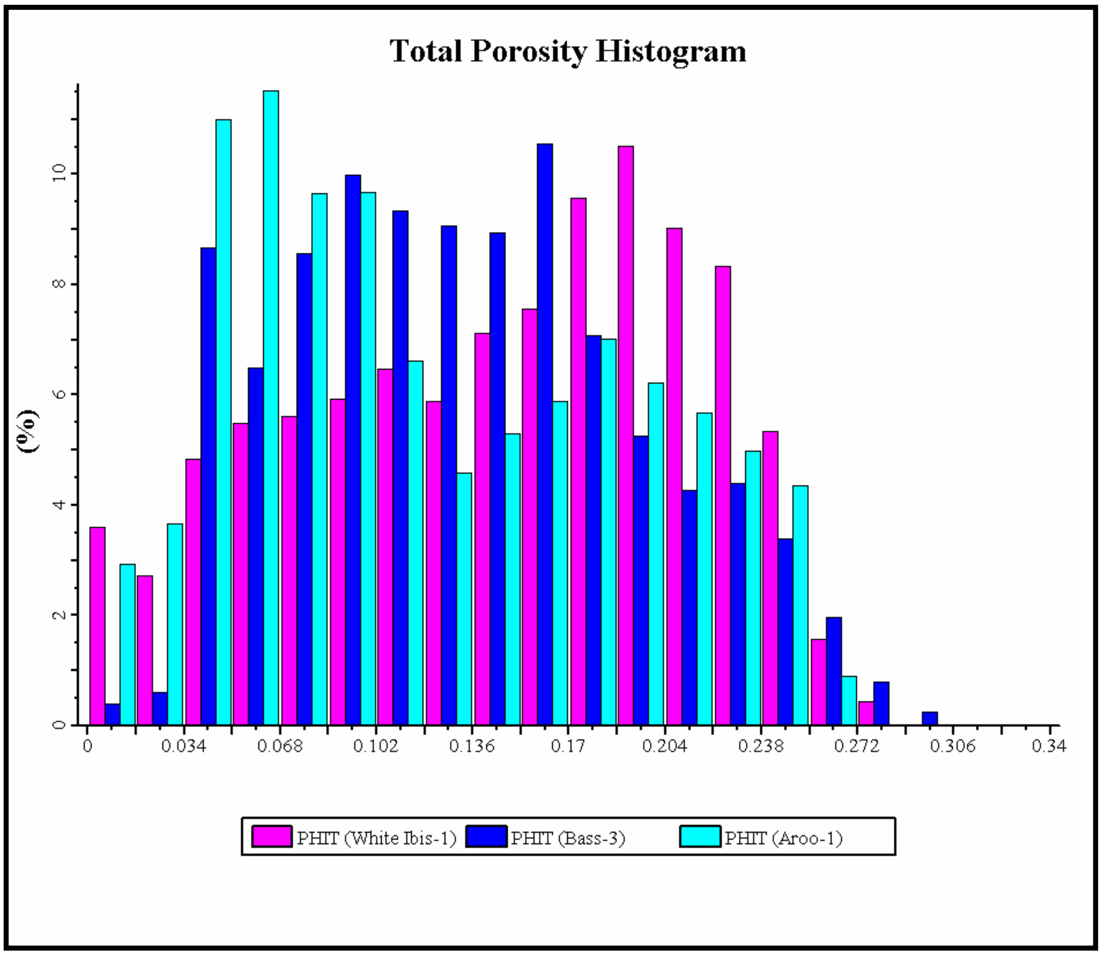


Figure 4.1 EVCM Total porosity histogram for White Ibis-1, Bass-3 & Aroo-1.

4.3 PROBABILISTIC OGIPs

The probabilistic estimates place the largest OGIP values in the C1 (86.3 BCF), P3 (65.2 BCF) and the E1 zones (33.6 BCF). The remaining four zones contain smaller portions of the total OGIP. Probabilistic consolidation of the seven zones (unrisked) estimates a P50 OGIP of 301 BCF (**Table 4.2**).

Reservoir Zone	Unrisked Probabilistic OGIP (BCF)			
	P10	Mean	P50	P90
E1*	72.5	38.1	33.6	9.0
P5	9.2	4.4	3.4	0.8
P4	11.5	5.8	5.0	1.2
P3*	107	68.8	65.2	35.5
P2	85.7	52.6	48.5	25.2
P1*	74.2	44.1	40.8	18.5
C1*[+]	146.0	91.8	86.3	45.1
Consolidated (all zones)	390	305	301	226

*Amplitude anomaly associated

Table 4.2. Probabilistic OGIPs.

5.0 GEOLOGICAL RISK ASSESSMENT

The influence of the AVO anomalies was considered when undertaking risk analyses. Adequacy of structural closure, reservoir quality, hydrocarbon charge, hydrocarbon source and seal integrity were all assessed for each of the seven reservoir zones individually (**Table 5.1**).

Zone	Chance of Adequacy for each Risk Parameter (%)					Geological Probability of Success (Pg)
	Closure (Pcl)	Reservoir (Prs)	Charge (Pch)	Source (Psc)	Seal (Psl)	
E1*	68	65	94	100	39	16
P5	77	65	88	100	56	25
P4	77	69	88	100	89	42
P3*	77	64	96	100	95	45
P2	73	65	88	100	2	1
P1*	73	73	98	100	86	45
C1*[+]	73	52	88	100	53	18

*Amplitude anomaly associated

NB. Red numbers highlight the key risk for each zone.

Table 5.1. Summary of final risk analysis.

The geological chance of success ranges from 45% (P3 and P1 zones) through to 1% (P2 Zone). The key risks for the various zones are interpreted to be reservoir and/or seal adequacy.

To combine the seven reservoir zones correctly, it was necessary to consider the dependency of the various risks. As Trefoil is a four-way dip closure containing stacked sands in the same basic structure, closure adequacy was deemed to be dependent between each of the seven zones. Hydrocarbon charge and source risks are also dependant as each zone relies on charge from essentially the same source rock kitchen.

Therefore, reservoir and seal risks are the only independent risks. Both the reservoir and seal units, whilst predominantly deposited under similar environmental conditions, occurred at temporally different intervals, subjecting them to independent depositional variables.

The consolidation procedure results in 73.2% chance of encountering at least one gas sand. The mean consolidated risked OGIP is estimated to be 105 BCF with a 44.5% probability (**Table 5.2**).

A preliminary economic truncation of 160 BCF indicates a chance of success of 14.1% to achieve a distribution with a mean of 211 BCF OGIP.

	Consolidated Risked Chance of Success			
	P90	P50	Mean*	P10
Consolidated Risked OGIP (BCF)	24.1	96.0	105	197

*Mean probability is 44.5% (Appendix 3)

NB. There is a 73.2% chance of the discovered OGIP achieving the consolidated distribution.

Table 5.2. Consolidated risked probabilistic OGIP distribution.

6.0 WELL LOCATION

The proposed Trefoil-1 well is located in the western portion of T/18P. The location is 36 km west of the Yolla Gas Field and 10 km southwest of Aroo-1, on 2D seismic line ORS01-13 SP 1492. The co-ordinates are 361 028 E and 5 586 436 N.

The location has been positioned on the mapped crest of the primary target (P3) and is also within the area of interpreted AVO anomalies at E1, P3, P1 and C1 horizons.

6.1 PRIMARY OBJECTIVES

The primary objectives for Trefoil-1 are the Palaeocene sandstones of the Eastern View Coal Measures. At least 5 stacked reservoirs may be present (termed P1 to P5). The P3 and P1 zones are interpreted to have the highest chance of success due to the presence of amplitude anomalies and thick, well-developed top seals. The P3 Zone is also one of the main gas-bearing reservoirs in the Yolla Field and in White Ibis-1. The P2 Zone is interpreted to have a very low chance of success due to a combination of no amplitude anomaly and the very thin seal developed over the sand in nearby wells.

6.2 SECONDARY OBJECTIVES

The secondary objectives for the well are sandstone units of Early Eocene (E1) and Late Cretaceous (C1) age, also within the Eastern View Coal Measures. Reservoir quality sands have been intersected within these intervals at White Ibis-1 and Bass-3. Aroo-1 also intersected minor sandstone within the E1. The E1 sands are gas bearing in Yolla-1.

6.3 PREDICTED TOTAL DEPTH

The proposed total depth (TD) for Trefoil-1 is designed to ensure the primary and secondary targets have been fully evaluated. The minimum TD is anticipated to be 3114 mSS. This depth is 40m below the predicted top of the Cretaceous and will allow appraisal of all well objectives. If the well is still within a live hydrocarbon column at this depth and sufficient encouragement of the existence of a commercial accumulation has been intersected, then the well should continue at least until 40m below the base of the hydrocarbon column has been penetrated. The deepest possible TD would then be 3487 mSS, which is 40m below the Cretaceous Unconformity. This will provide sufficient evaluation of the predicted Cretaceous reservoirs.

6.4 PREDICTED STRATIGRAPHY

A summary of the depth prognosis and predicted stratigraphy is included as Table 3.3 and **Figure 6.1** respectively. The lithological descriptions are based mainly on data from Aroo-1, with minor reference to White Ibis-1 and Bass-3. Note that all depths are in metres subsea (mSS).

Torquay Group (68 – 1295 mSS)

The Torquay Group is composed of an upper bioclastic limestone section and a lower marl section with the change in lithology being transitional at around 817 mSS. The upper section is expected to comprise white to mid-grey coarse to fine grained unconsolidated bioclastic calcarenite to calcirudite composed of friable and loosely cemented skeletal debris consisting of pelecypods, bryozoans, foraminifera and gastropods. Light grey to grey-brown siltstone will become significant below 770 mSS.

The lower part of the Torquay Group is dominated by marl. This will be light to mid-grey, very soft to firm, dense and contain abundant microfossils (mainly foraminifera) and minor dolomitic streaks. Near the basal 20m of this unit the marl will become silty.

Angahook Formation (1295 – 1780 mSS)

The Angahook Formation is a calcareous siltstone, which is described in Aroo-1 as dark grey to brown, soft to firm, slightly to very calcareous, grading to marl, glauconitic, pyritic in part, minor dolomitic streaks.

Demons Bluff Formation (1780 – 2077 mSS)

The boundary with the overlying Angahook Formation is gradational and indistinct but an increase in mica content could signal the top of the Demons Bluff Formation.

In Aroo-1, this formation comprises a micaceous, glauconitic, calcareous siltstone. The unit is finely interbedded, is dark grey to brown, soft to firm, slightly to very calcareous, grading to marl, micaceous, glauconitic, pyritic in part and contains minor dolomitic streaks.

In White Ibis-1 and Bass-3 this unit is siltstone interbedded with sandstone and claystone and it is possible that these interbedded lithologies may be developed at the Trefoil location as well. In these wells the siltstone is described as light brown to medium brown to dusky yellow brown, moderately firm to hard, occasionally soft, dispersive to amorphous, subblocky to blocky, occasionally subfissile, argillaceous in parts, moderately dolomitic cemented, common very fine grained quartz, grades to very fine grained sandstone in parts, trace glauconite, trace micromica, trace to common disseminated pyrite, trace pyrite nodules, trace fossil fragments.

Eastern View Coal Measures (2077 – 3144 mSS (TD))

The Eastern View Coal Measures (EVCM) within the wells surrounding Trefoil consist of interbedded sandstone, siltstone, claystone and trace coal. Within Aroo-1 the basal half of the formation contained thick basalt flows that are not expected in Trefoil-1. This assumption is based on seismic character.

The contact between the top of the EVCM and the overlying Demons Bluff Formation is lithologically gradational with siltstone gradually becoming more sandy downhole and eventually grading into very fine grained, moderately sorted to well sorted, quartz sandstone. The top may be picked from a change in the resistivity baseline and a slight decrease in gamma ray, as a response to the increase in sand into the system.

The top of the upper EVCM is expected to consist of 20 to 30m of siltstone grading to sandstone, underlain by a 50 m thick sequence of 2 coarsening upwards cycles of interbedded sandstone, siltstone and claystone. The siltstone is white to light brown, firm to soft and in part thinly interbedded with brown claystone that is soft and silty. The sandstone is greenish grey to light grey to dark brown, greenish in part, firm to hard, mostly very fine to medium grained, though very coarse in part, micaceous, variably glauconitic, in part calcareous and dolomitic, with minor coal which is black and silty.

The remainder of the upper EVCM is a thick succession of interbedded sandstone, siltstone, claystone and coal. The sandstone will be white to light brown, firm to hard, very fine to medium, occasionally coarse, sub angular to sub rounded, silty, micaceous, carbonaceous, trace pyrite, trace glauconite, rare red lithics, minor aggregrates with kaolin matrix, minor calcareous cement and poor visible porosity. Dolomite cement is present in the top half of the unit. This dolomite is tan, hard and coarsely crystalline. In the basal half of the unit the sandstone becomes argillaceous. Loose quartz sand grains are present throughout. The grains are clear to milky quartz, medium to coarse, subrounded to rounded. The siltstone is white to dark brown, firm to hard, micaceous, variably carbonaceous, grading to coal in part. The claystone beds will typically consist of light to dark brown clay, which is soft, silty, massive to sub blocky, micro micaceous and variably carbonaceous.

The top of the first target within the lower EVCM is the E1 sand at 2506 mSS. Overlying this sand a claystone unit approximately 20 to 40 m thick may be present. This unit will be firm, slightly fissile, silty and contain minor black sooty coal which is also slightly fissile and resinous. The E1 unit itself is a sandstone-dominated succession of fluvio-deltaic sandstone, siltstone, claystone and coal. This sandstone in surrounding wells differs from the upper EVCM with good visible porosity becoming evident. This sandstone will be tan to light brown, firm to hard, very fine to very coarse, poorly sorted, translucent to transparent quartz grains, sub rounded to angular, friable to loose, silty, partly friable, partly well cemented, trace disseminated mica, trace siderite, glauconitic, pyritic and argillaceous in part. Fluorescence was seen in this sandstone unit in Aroo-1. The siltstone associated with the E1 sandstone is dark brown, firm to hard, micaceous, variably carbonaceous, glauconitic in part. The claystone is described in Aroo-1 as chocolate brown to grey, soft to firm, fissile in part, micaceous. The interbedded coal is black, friable and sooty.

The Palaeocene section of the EVCM contains up to 5 objective sandstone units, with the top unit P5 expected around 2627 mSS. Thick-bedded lacustrine shales will separate these sandstone sequences. The sandstone units will consist of interbedded sandstone, siltstone, claystone and coal. The expected sandstone description will be cream to brown, soft to firm, medium to fine, carbonaceous in part, micaceous, argillaceous in part, well cemented to friable, slightly calcareous. The siltstone interbeds will be grey to light brown, firm and slightly calcareous. The lacustrine claystones may be grey to chocolate brown to grey green in part, soft to hard (conchoidal fracture), sub blocky to fissile in part, calcareous, silty in parts, trace pyrite, trace micromicaceous. Coals in the EVCM Palaeocene are black to dark brown black, dull to sub vitreous lustre, commonly silty, trace disseminated and nodule pyrite, interbedded in part, sub-conchoidal fracture, sub blocky to sub fissile, brittle to hard.

The top of the Cretaceous is predicted to be 3104 mSS. The C1 target sandstone forecast to be present at this depth will be a clear to cream to light grey, transparent to translucent grains, fine to medium, angular to sub rounded, moderately sorted, trace kaolinite matrix, trace pyrite, micaceous, argillaceous, well cemented in part, fair to good inferred porosity. The sandstone will be interbedded with siltstone and claystone. The siltstone is medium brown to dark grey brown in parts, firm to moderately hard, sub blocky to sub fissile, trace micro mica and pyrite, locally common carbonaceous/coaly fragments/laminae, arenaceous in parts and grading to very fine silty sandstone. Claystones will be light to medium brown, brown grey to grey green in parts, firm to moderately hard, blocky to sub fissile, slightly calcareous, micro micaceous, trace pyrite fragments, silty in part.

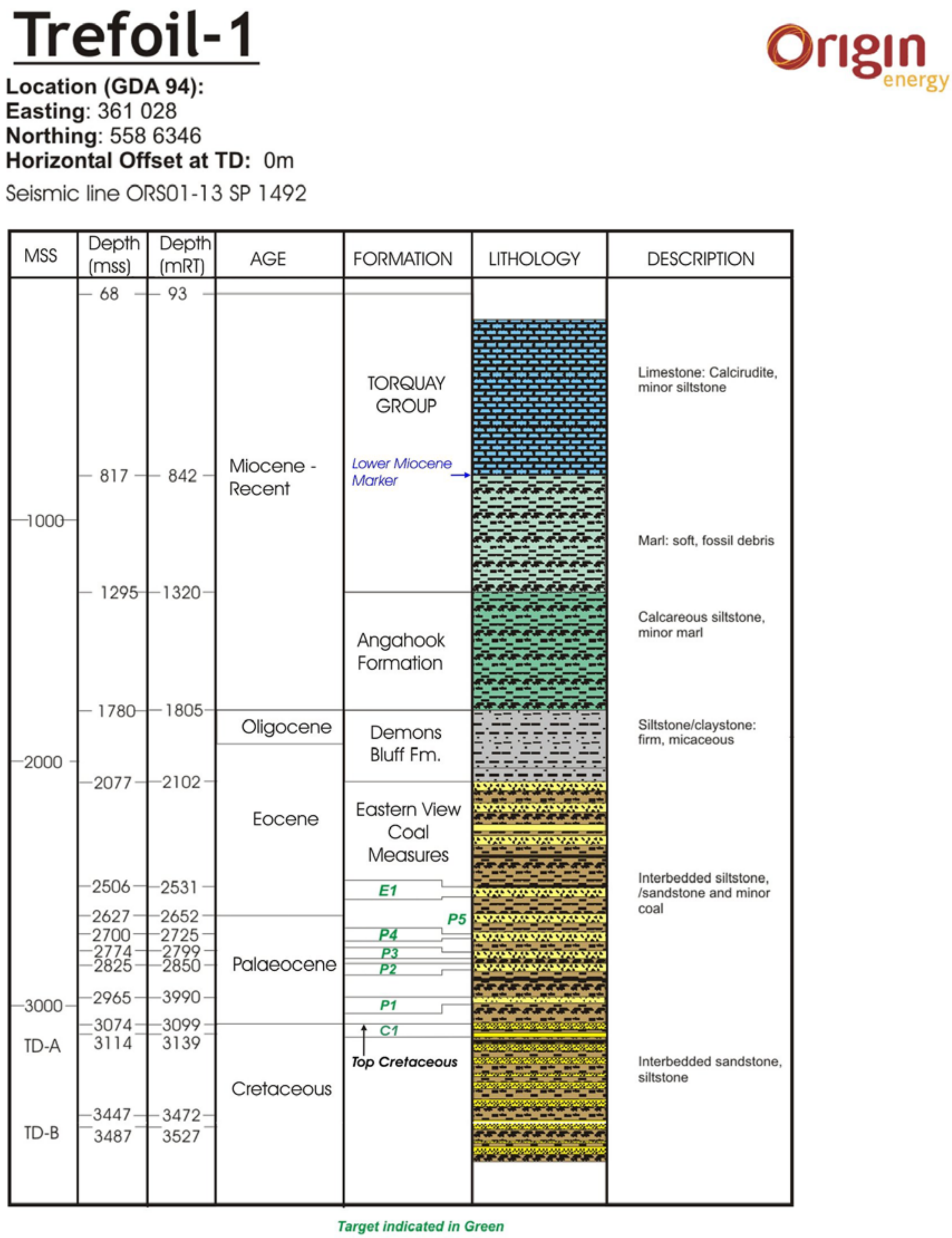


Figure 6.1 Predicted Stratigraphy for Trefoil-1

7.0 DRILLING EVALUATION

7.1 LOGGING & SAMPLING

The proposed logging program for Trefoil-1 is summarised in Table 7.1. It is proposed to run wireline logging tools over the 12 ¼" hole section in order to allow well synthetics to be constructed. No LWD is required for operational decisions in the 12¼" section of the well.

In the 8 ½" hole LWD (GR-RES) will be run to assist with the determination of core point and TD. Wireline PEX (HRLA)-DSI- SP (GR – DSI to surface) will be run 1 in the 8 ½" hole from TD to 9 5/8" casing shoe in the dry hole case and run 2 will be the VSP-GR which will be run from TD until loss of signal occurs. In a success case the 8 ½" hole run 1 wireline PEX configuration will be (HRLA)- HNGS-CMR-SP. Run 2 will be FMI-GR with GR – DSI to be logged up through casing until the DSI signal is lost. The MDT-GR will be run 3 and will involve pre-tests and be configured with 2x1-gallon PVT chambers to enable sampling if required (13x450cc samples). Run 4 (VSP) will be run until there is a loss of signal and run 5 (CST-GR) will attempt to acquire 60 sidewall samples.

Dry Hole Case	Success Case (Contingent upon hydrocarbons within reservoir)	Interval
Run 1: PEX (HRLA)-SP	Run 1: PEX (HRLA)-SP	Base of 12¼" section to 13 3/8" casing shoe Open hole wireline logs over 12¼" hole
Logging while Drilling (LWD) DGR-ARC5-directional	Logging while Drilling (LWD) DGR-ARC5-directional	13 3/8" casing shoe to TD
Run1: PEx(HRLA)-DSI-SP (GR – DSI to surface) (Standard Resolution) (30 metre rat-hole required)	Run 1: PEx(HRLA)-HNGS-CMR-SP (High Resolution) (45 metre rat-hole required)	TD – 9 5/8" casing Shoe
Run 2: VSP-GR (TD to loss of signal)	Run 2: FMI-DSI-GR (DSI-GR logged up through casing until DSI signal lost)	TD to approx 50 m above reservoir
	Run 3: MDT-GR (Pre-tests, 2x1-gallon PVT chambers, 13x450cc	TD to approx 50 m above reservoir

	samples)	
	Run 4: VSP-GR	TD to loss of signal
	Run 5: CST-GR (60 attempts) Palynology/reservoir quality data	Open Hole

Notes

Schlumberger/Anadrill Logging tool mnemonics assumed

PEx: Platform Express Tool
HRLA: High-resolution Laterolog Array Tool
SP: Spontaneous Potential Tool
DGR: Dual Gamma Ray LWD Tool
ARC5: Five Array Resistivity Compensated LWD Tool
HNGS: High resolution natural gamma-ray spectrometry Tool
CMR: Combinable Magnetic Resonance Tool
FMI: Formation Micro-scanner Tool
DSI: Dipole Sonic Imaging Tool
MDT: Modular Dynamic Testing Tool
VSP: Vertical Seismic Profile
CST: Core Sample Taking Tool

Table 7.1: Logging program for Trefoil-1

7.2 CORING

A core is viewed as crucial to obtain information on both reservoir quality and depositional facies. This information, combined with good test data will allow the economic feasibility of the prospect to be assessed. A core should only be obtained if hydrocarbons are present in the reservoir. Therefore the reservoir section must have been adequately penetrated to determine the presence of hydrocarbons via the MWD logging tools. One 54 m core is recommended to be obtained in either the P3, P1 or C1 zones depending on the presence of hydrocarbons. A second core may be taken if enough encouragement in the way of multiple or large hydrocarbon columns are intersected. The precise contingent decision criteria will be issued at a later date.

7.3 TESTING

At least one DST is to be undertaken in Trefoil-1 if a commercial hydrocarbon column is discovered. The test results will enable determination of reservoir and fluid properties and provide data required for a tie-in design to planned infrastructure. A chrome liner will be required for this testing programme. The details on test interval/s and contingent decision criteria will be issued at a later date.

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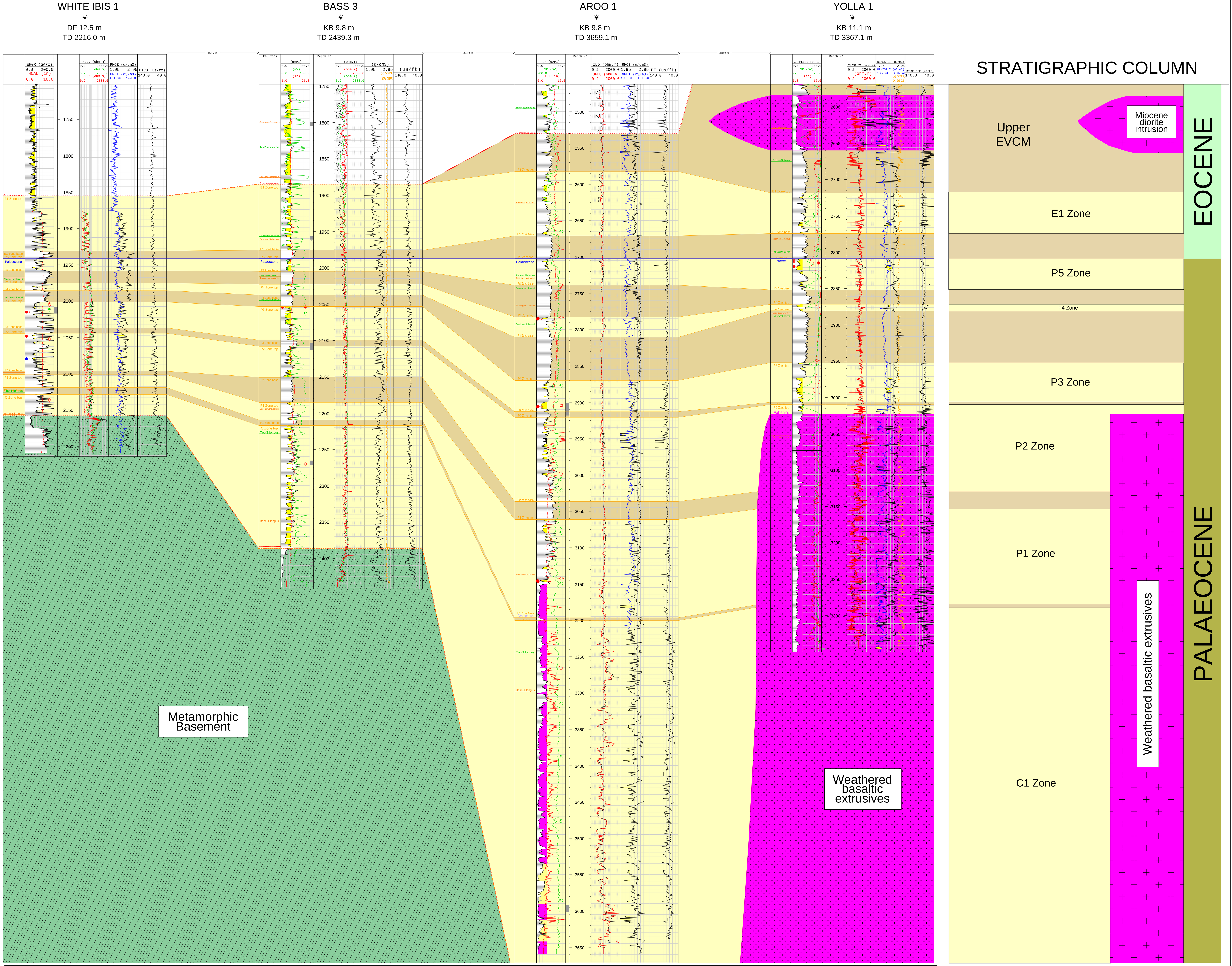
White Ibis-1 to Yolla-1 Lower EVCM Stratigraphic Cross-Section



MDTs

2015.2mKB Lower L. balmei.
Two one gallon gas samples.

2048.5mKB Lower L. balmei.
One gallon gas sample.

2079.4mKB Lower L. balmei.
One gallon water sample.

FITs

2054.4mKB Lower L. balmei
Rec 29ft3 gas, 800cc condensate & 12,250cc water.

1748.6mKB Lower N. asperus
Misrun. Tool plugged.
Rec 20,000 cc mud & filtrate.

1648.7mKB Mid N. asperus
Rec 20,000cc water.

1748.3mKB Lower N. asperus
Misrun.

FITs

2906mKB Lower L. balmei
Rec 1.4ft3 gas, trace oil & 9,000cc water.

2785mKB Lower L. balmei
Rec 1.9ft3 gas & 1,900cc water.

3146mKB Lower L. balmei
Rec 1.9ft3 gas & 8,600cc water.

2365mKB Lower N. asperus
No recovery. Impermeable.

3320mKB Late Cretaceous
Misrun.

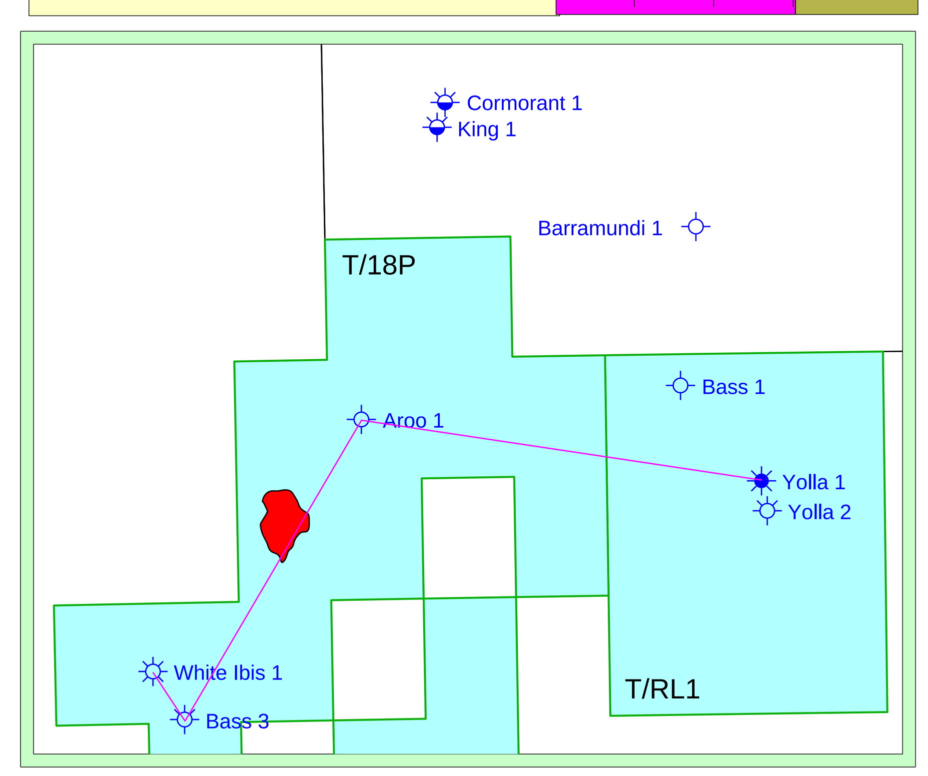
Cased-Hole Tests

CH1 2809.1-2814.2mKB
GTS @ 15.1 MMcfd plus condensate @ 580 BPD and minor water.

CH2 1830.0-1835.2mKB
GTS @ 3.4 MMcfd with minor condensate/oil and 1,675 BWPD (water channeling behind casing).

CH2a 1833.2-1833.8mKB
GTS @ 1.0 MMcfd plus 302 BPD condensate/oil.

CH3 1820.5-1840.5mKB
GTS @ 11.8 MMcfd plus 892 BPD condensate/oil (note: the originally reported depths are incorrect).



T/18P, BASS BASIN

White Ibis-1 to Yolla-1
Lower EVCM Stratigraphic
Cross-Section

Author: J. Doyle	Datum: Top Palaeocene	Encl No: 1
Date: 07/03/03	Contour Interval: NA	
Map File: Aroo-1_to_Yolla-1_Palaeocene_x-section.map		
Map Sheet: WHITE IBIS TO YOLLA X-SECTION		