H.M Sloop Investigator 1802

INVESTIGATOR 3D & 2D SEISMIC INTERPRETATION REPORT

OTWAY BASIN

VIC/P43
T/30P

FEBRUARY 2002

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Investigator 3D & 2D Seismic Interpretation Report

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PROLOGUE

HMS Investigator is the name of the ship, sailed under the command of Captain Matthew Flinders, which circumnavigated Australia in 1802-3. The Investigator 3D & 2D Seismic Surveys are situated offshore from the region known as the 'Shipwreck Coast'.

1 INTRODUCTION

The Investigator 3D & 2D Seismic Surveys were acquired in the first quarter of 2000 on the eastern margin of the Otway Basin. The 3D survey covers 986.4 km^2 and spans the border of both Petroleum Exploration Permits VIC/P43 and T/30P (Fig. 1). Investigator 3D was designed to delineate prospects identified along the Shipwreck Trough play fairway. The Investigator 2D consists of 115.95 km and lies solely within Tasmanian waters (T/30P).

There were three main prospects identified within the survey area prior to the acquisition of the Investigator 3D. VIC/P43 contains two of the prospects called Geographe and Glenaire. Other smaller prospects identified in VIC/P43 are Sentinel west of Geographe, and Roebuck north of Glenaire. T/30P contains the Thylacine Prospect, the southernmost prospect defined on the Shipwreck Trough play fairway (Fig. 2). The geological model produced incorporates the Investigator 3D survey, in conjunction with the Investigator 2D and existing 2D/reprocessed 2D.

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. The VIC/P43 joint venture consists of Woodside Energy Ltd (55%), Origin Energy Resources Ltd (30%) and CalEnergy Gas (UK) Ltd (15%).

T/30P was awarded to Benaris International NV on July 10, 1997 and subsequently farmed out to Origin Energy Resources Ltd and then Woodside Energy Ltd. The current T/30P joint venture consists of Woodside Energy Ltd (50%), Origin Energy Resources Ltd (30%) and Benaris International NV (20%). Prior to the acquisition of the Investigator 3D and 2D, T/30P contained only sparse, pre 1975 vintage, 2D seismic data.

Origin Energy Resources Ltd was operator of VIC/P43 and T/30P for the period ending 31 December 2001 and 16 February 2002 respectively, and undertook the interpretation described herein. Woodside Energy Ltd managed the acquisition and processing of the Investigator Surveys, and became operator of VIC/P43 and T/30P on 1 January 2002 and 17 February 2002 respectively.

2 REGIONAL GEOLOGY

The Investigator 3D is located in the eastern Otway Basin. Two rift phases have been identified in the Early and Late Cretaceous (Fig. 3) that formed in response to rifting between Australia and Antarctica. The main period of rifting occurred at the end of the Cenomanian and continued to the Campanian. A dominant feature identified in the eastern Otway margin is the Shipwreck Trough (Fig. 4) 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.

The Late Cretaceous interval within Shipwreck Trough is comprised of two distinct depositional sequences (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 and deposition and preservation is dependant on the palaeotopography of the basin. 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 younger 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.

Within the Shipwreck Trough Middle to Upper Late Cretaceous sediments of the Belfast and Paaratte Formations are distinct in that they form a continuous massive pro-delta shale seal. These sediments were deposited outside of the main northwest and eastern sediment provenances. Coarse clastics are observed to prograde from the eastern Otway margin but terminate at the Sorell Transfer Fault. Sinistral movement along the transfer fault is co-incident with the main Late Cretaceous rift episodes with the western plate being down shifted. Narrow trenches formed along the transfer axis in response to the transtensional forces.

Regional fold trends that plunge to the southwest are essential to defining prospectivity within the Shipwreck Trough. The Investigator 3D covers three main structures, which have been identified along the north – south orientated Shipwreck Trough play fairway. The 'Geographe Anticline', which plunges to the southwest, contains the Geographe and Thylacine prospects and is interpreted to control the migration of hydrocarbons from the source kitchens. The folding and stress field orientations are a composite of at least 3 different phases of deformation. The first phase began in the Albian/Cenomanian with the initial uplift of the Otway Ranges(crustal kink) in response to rift propagation from the west. Another fold episode is interpreted in the Santonian (influence of the Tasman Sea opening). The final transpressional episode occurred post rift in the mid to late Miocene (inertia of sea floor spreading after collision of Australian northern plate margin with the Banda Arc).

Major east-west trending rift faults occur along the Shipwreck Trough together with the transfer fault deformations. The Albian to Turonain east-west trending rift faults are inferred to be perpendicular to the direction of extension. The rift and post rift deformations mean that there are three main fault sets that dominate the Shipwreck Trough. Extensional tectonics are accentuated towards the shelf margin by gravitational effects. Features such as Thylacine occur over remnant resistant basement highs surrounded by intense deformation.

The northwest-southeast trending listric normal faulting commenced in the middle of the Late Cretaceous and terminated at the end of the Cretaceous with very little penetration above the Paleocene Pebble Point Formation. These faults commonly sole out on the earlier fault sets. Differences in fault orientations can be observed by comparing the Top Turonian structure map with the Near Base Tertiary Structure Map (Enclosures 6 & 7). Secondary synthetic and antithetic faulting and rollover anticline development is present. Inversion due to north-northwest transpression is inferred to have affected most structures in the eastern Otway, especially at Minerva (Jason et al, 2000).

A degraded north-south oriented wrench zone is present to the east of the Investigator 3D and is best shown on the variance cube data (Fig. 5). This wrenching, which is the result of crustal transtension, is manifest as a vertical north trending fault that splays vertically with keystone development. En echelon relay geometries are evident within the 3D, north of Geographe (Fig. 6). The complex structural geometry at Geographe is interpreted to be the product of wrench tectonics.

3 INVESTIGATOR 3D & 2D DATA SET

3.1 Acquisition

The Investigator 3D and 2D Seismic Surveys, operated by Woodside Energy Ltd., were conducted over the permits VIC/P43 and T/30P in the Otway Basin. The acquisition phase occurred during the period 13th December 1999 to 5th April 2000. The position of the Investigator seismic relative to other seismic data is shown on the basemaps provided (Fig. 7 & Encl. 1).

Western Geophysical, on behalf of Woodside, conducted the Investigator 3D and 2D surveys using the M/V Western Pride. Seismic data for the 3D was acquired using a 6 streamer dual source configuration covering approximately 986.4 km^2. An 8 streamer configuration was initially deployed but abandoned due to operational constraints. The program consisted of 88 sail lines with a total CMP distance at 42100.8 km (plus 2428.2 km run out). The shooting direction was 009/189 degrees.

The acquisition was terminated prior to completion and a portion to the northwest was not acquired. After 116 days on location Western had acquired 986.4 km2 (729.7 km2 VIC/P43, 256.7 km2 T/30P) of full fold 3D and 115.95 km of 2D seismic data.

Further details and technical specifications for the survey, including operational reports can be found in the following reports:

1. Investigator 2D & 3D MSS Final Operations Report, Western Geophysical
2. Investigator 2D & 3D MSS Report of Field Seismic Ops. Client report (ECA)

3.2 Processing

Processing for the Investigator 3D & 2D was conducted by Veritas. The processing flow is summarised as follows:

- Reformat; Edits: resample from 2ms to 4ms
- 4Hz 18dB/octave Low Cut Filter; Seismic & Navigation merge
- Tidal statics; 2km grid vel; Spherical divergence correction
- 1 km grid vel; Shot FK Filtering 2500 m/sec (job local NMO & AGC)
- Tau-P Decon 36 ms gap; 3D binning; Zero-phasing
- NMO 1 km grid vel; FLOOD; 3D Kirchoff DMO; INMO
- 0.5 km grid vel; NMO; Mute; Stack; FX crossline interp
- Omega-X mig; Q-comp; TVF; TVS

A full report of the Investigator 3D/2D processing has been provided by Veritas.

The Investigator 3D migration grid geometry is as follows:

Crossline (CDP) Spacing	:	12.5 m
Crossline (CDP) Increment	:	1.0
Inline Spacing	:	12.5 m
Inline Increment	:	1.0

3.3 Data Quality

The 3D data quality over the Investigator 3D is generally good. Excellent control on the spatial distribution of high density faulting was achieved. The Top Turonian objective was readily discernable over the prospect areas (Fig. 8). Amplitude anomalies were very distinctive, at Geographe and Thylacine, at the Top Turonian horizon. No amplitude anomalies were observed at the Glenaire Prospect but a feature further to the north, called Roebuck, has been highlighted by the presence of amplitudes.

Miocene canyoning present to the south of the 3D area affects the seismic data on the eastern margin of the Thylacine Prospect where events lose continuity and become diffuse (Fig. 9). To the northeast of the Thylacine Prospect, data quality deteriorates due to high fault frequency. The Top of Turonian in the eastern area between Geographe and Thylacine is not readily discernable due to the overlying highly reflective intra-Belfast Mudstone prograding facies reflectors (Fig. 9). Overall the data quality is more than adequate to accurately interpret down to the Base Waarre reflector.

The Investigator 2D and reprocessed seismic data were utilized to tie into the nearby wells outside of the 3D area. It was also used to extend the velocity grid into that area. Like the Investigator 3D, the Investigator 2D provided sufficient continuity and preservation of high frequency content allowing discrimination of various seismic facies and intervening horizons. These data were affected by the Miocene canyoning and also by the presence of high velocity volcanics that tend to locally obliterate the subjacent data (Fig. 10). Finally, a comparison of the 3D data versus the original 2D data (Fig. 11) shows that the original data typically lacks higher frequency data and poor continuity and character with depth. Reprocessing of the 2D proved sufficient to tie and interpret the primary horizons to the wells.

4 SEISMIC INTERPRETATION

4.1 Attribute Volumes

Additional attribute volumes were generated to assist the interpretation of the 3D seismic data. These included near and far offset volumes and Variance Cube™ volume (generated by Schlumberger's variance cube software).

The near and far offset volumes were produced to assist in the interpretation of hydrocarbon prospectivity and to derive some basic 3D AVO attributes. The variance cube volume highlights dissimilarities in the seismic data. Variance cube slices assist to provide accurate interpretation of fault/structural geometries. It also helps with the identification of geological features such as igneous bodies that are not as readily discernable on conventional seismic data. After interpreting the Top Turonian over the 3D a horizon slice was created from the variance cube volume (Fig. 12). The horizon slice provides a more accurate picture of the structuring at the interpreted horizon.

4.2 Well Ties

Synthetic seismograms were used to tie the seismic data and wells such as La Bella-1 (Fig. 13). The seismic ties are fair given that there are no wells within the 3D and the highly faulted nature of the area. Well ties are made by reprocessed vintage 2D data and, in T/30P, the Investigator 2D (Prawn A1). Composite seismic traverses between the wells and prospects shows the stratigraphic relationships by overlying the Gamma ray log on the seismic data.

4.3 Time Structure Mapping

Six horizons have been mapped throughout the Investigator 3D as listed in the table below. These horizons have been tied to the northern wells via the VIC/P43 2D interpretation and to the Prawn A1 well using the Investigator 2D lines. Picks for the main target horizons were interpreted on every 10th inline, and cross-lines were interpreted as required. The auto-pick tool was used to fill in the remaining areas in the 3D grid.

Interpreted Horizon	Polarity	Comments
Water Bottom (wb)	Strong Trough	Interval velocity Depth Conversion
Mid miocene (mioc)	Trough	Top Gellibrand Marl, Depth Conv.
Base Miocene (mgbm)	Peak	Interval velocity Depth Conversion
Top Mepunga (mpng)	Strong Peak	Base of carbonates, Depth Conv.
Near Base Tertiary (ppfm)	Trough	Interval velocity Depth Conversion
Top Turonian (ttur)	Trough	Prospectivity. Polarity reversal at Geographe & Thylacine

- **The Mid Miocene.** This event is an unconformity surface that is locally incised with canyons towards the shelf margin (southern part of the Investigator 3D). The reflector is a trough (on normal polarity). This event occurs at the base of the Port Campbell Limestone that locally, in seismic data, consists of thin moderate continuous reflectors interpreted as shelfal limestones. Canyon fill consists of bright steep downlapping and bright channel fill seismic facies consisting of locally derived bedload detritus. This and the Base Miocene have been locally interpreted to assist in mitigating the effect of local high velocities associated with canyon fill over the eastern extreme of the Thylacine Prospect.

- **The Base Miocene.** This event is an unconformity surface that is locally incised with submarine canyons. A peak (on normal polarity) has been arbitrarily chosen (Fig. 14). This event occurs towards the base of the Gellibrand Marl that locally, in seismic data, consists of thin moderate continuous reflectors interpreted as mid to outer shelfal marls. Canyon fill consists of occasionally bright steep downlapping and channel fill seismic facies interpreted as locally derived bedload detritus.

- **Top Mepunga Formation.** This event defines the top of the Paleocene coarse clastics in the northeast and rapidly converges towards the Pebble Point event in the southwest (Fig. 14). A strong amplitude peak (on normal polarity) has been chosen. Overlying this reflector is a thick succession of downlapping continuous reflectors with numerous incision and sedimentary fault surfaces including the Oligocene Unconformity. This succession is interpreted as outer shelf, slope and associated transients. The Top Mepunga Formation horizon has been locally interpreted to mitigate the effect of velocity gradients associated with rapidly thinning facies.

- **Near Base Tertiary.** This event is a major unconformity and is locally defined as a moderate to weak trough (on normal polarity) and often associated with subjacent angular terminations (Fig. 14). This horizon marks the cessation of major extensional tectonism. It defines the base, and locally the limit, of thick Paleocene prograding coarse clastics. These coarse clastics prograde from the north and terminate above the central northeastern area of the 3D. In this area, the Pebble Point reflector is coincident with or separated by a very thin interval from the base of the Tertiary (a poor to indistinct reflector).

- **Top Turonian.** This event defines the top of the main objective reservoir (Fig 15, Encl. 2). Throughout most of the 3D area the Top Turonian event consists of a moderate amplitude trough (on normal polarity). Over the Thylacine and Geographe prospects, a high amplitude peak (on normal polarity), presumably associated with gas charging, defines the horizon (Fig. 14). Over the Thylacine Prospect, the Top Turonian event defines the top of the Flaxman's Formation. Above this reflector is the thick bland interval of the Belfast Mudstone marine shales and siltstones. These show onlap onto the Top Turonian surface. To the immediate east, the Belfast Mudstone interval contains two prograding facies presumed to consist of coarse clastics. These prograding facies are confined to the east of the Thylacine and Geographe prospects and appear to be embedded in the marine shales and siltstones facies. They represent a basinward shift in sedimentation and are possibly lowstand shelf margin system tracts such as deltas or fan deltas.

5 DEPTH MAPPING

5.1 Depth Conversion

Single layer and multi layer depth conversion techniques were used on the interpreted TWT structure maps.

The single layer model uses average velocities from the water bottom to the Top Turonian horizon. A multi layer depth conversion model was constructed using Dix and / or stacking velocity inversion. The following intervals were utilized:

- Water Bottom to Mid Miocene
- Mid Miocene to Top Mepunga
- Top Mepunga to Near Base Tertiary
- Near Base Tertiary to Top Turonian

All velocity maps were calibrated to check-shot velocities in the wells. For each layer, the seismically derived velocities were scaled by a constant factor to approximately tie the check-shot velocities, then map-migrated to depth. Depth conversion using stacking velocities works well for robust features such as Thylacine. However, stacking velocities tend to be smoothed out in the gridding process. Smoothed stacking velocities affect features such as Geographe, where closure is controlled by a narrow trench to the east of the structure (Fig. 16).

5.2 Depth Maps

The Seafloor (Fig. 17 & Encl 3) is a smooth, gently dipping shelf, ranging from 50m SS in the northeast to 350 m SS in the southwest. There is no major sea floor channelling developed over the survey area that would affect the seismic data quality. The south western corner of the Investigator 3D extends just beyond the shelf margin but this area is not near the main prospects.

The Mid Miocene surface (Fig. 18 & Encl 4) is gently folded by the northeast trending 'Geographe Anticline', and represents outer shelfal grading to slope in the extreme southwest. The surface is incised by one canyon that trends south from the anticlinal area, and affects the eastern edge of the underlying Thylacine Prospect. This canyon is up to four kilometres wide and 200 metres deep. The canyon contains high velocity fill, presumably consisting of autochthonous carbonate detritus. This map has been constructed to account for the velocity effect of these features.

The Top of the Mepunga surface (Fig. 19 & Encl 5) is Late Eocene in age and defines the top of early Tertiary prograding coarse clastics. The Mepunga surface shows that the coarse clastics wedge out from the northeast proximal to the Thylacine Prospect. Incision of the underlying units is observed in the Geographe Prospect area and relates to the slope break / embayment observed. This surface defines a proto-outer shelf/slope to the south of the survey, converging with the overlying Oligocene global eustatic unconformity and the underlying Base Tertiary break-up unconformity.

The Near Base Tertiary surface (Fig. 20 & Encl 6) defines the base of the lower Tertiary prograding coarse clastics and culmination of active faulting. The surface is also an unconformity marking the change from ramp to shelfal geometry that plunges to the southwest. The wedging out of the overlying Palaeocene prograding coarse clastics is considered to produce a velocity gradient in the vicinity of the Thylacine Prospect but is thought to be generally consistent over the rest of the survey area.

The Top Turonian surface defines the top or near top of regional porosity (Fig. 21 & Encl 7) encompassing lower Late Cretaceous Flaxmans and Waarre Formations. The terrain consists of northeast trending low relief anticlinal ridges dissected into horsts and tilted normal fault blocks. The dominant faults are Lower Late Cretaceous east-west faults perpendicular to the direction of extension. Northwest-southeast, subarcuate normal listric faults dominate to the south near the shelf edge with the majority throwing down to the basin. A series of subordinate, synthetics and antithetics subparallel this trend. This fault trend terminates and forms composites with Early Cretaceous east-west trending normal rift faults to form the Thylacine horst. In the southeast a degraded transtensional wrench fault is dissected by Late Cretaceous east northeast trending listric normal faults. The Flaxmans Formation appears to thicken significantly in the depositional lows immediately below the Top Turonian event.

6 PROSPECTS & LEADS

Three main prospects, known as Glenaire, Geographe and Thylacine, were defined by the Investigator 3D. Several other prospects/leads have been defined/identified on the 3D dataset. These leads and prospects are classified according to the presence of closure and or the presence of seismic anomalies that indicate hydrocarbon accumulations.

6.1 VIC/P43

6.1.1 Prospects

6.1.1.1 Glenaire Prospect

The Glenaire Prospect is located 30 km offshore in the eastern Otway Basin in approximately 70 m water depth. The lead is located in the north of the Investigator 3D. The subsea depth to target for Glenaire is predicted at 1920 m.

Structure – Glenaire is a tilted fault block play in the Shipwreck Trough. There are two main culminations designated north and south (Figs. 22 & 23). The faults are Middle Late Cretaceous in age with some reactivation in the earliest Tertiary.

Reservoir – The primary target reservoir at Glenaire comprises the Flaxmans / Upper Waarre quartzose sandstone of Turonian age. The Flaxmans Formation consists of fine grained sandstones interbedded with shales. In stratigraphic terms the Waarre is divided into an Upper and Lower sequence based on the rift history. The Upper Waarre sequence thickens at the prospect location compared to wells drilled to the west, probably on the edge of a Late Cretaceous palaeo-valley.

Upper Waarre sands are excellent reservoirs with multi Darcy permeability and porosity averaging 18%. Glenaire is situated in the axis of deposition for the Late Cretaceous Waarre Formation. Reservoir conditions are expected to approach that encountered at Minerva and to be better than at Mussel-1, 20km to the west, because of the proximity to the axis of deposition (Fig. 24).

The Upper Waarre Formation reservoir is the main target with up to 200m of coarse clastic sandstones expected. Secondary reservoirs from the Flaxmans Formation are expected to overlie the Waarre Formation at the Glenaire Prospect.

Source - Upper Eumeralla Formation coals are the most likely source rock, situated directly beneath the main reservoir. Compared to the prospects to the south, the estimated generative area is a lot smaller for the Glenaire structure, which may lie in a migration shadow. This is supported by the lack of amplitudes on the far offset seismic data.

Seal - The Belfast Mudstone provides a regional seal to the Flaxmans / Waarre Formation. The Belfast Mudstone thickness is estimated to be greater than that found in La Bella-1 to the southwest. Additional seal is provided by the overlying Skull Creek Mudstone with Glenaire located just outside the limit of Nullawarre/Paaratte sand development. Due to the proximity of Glenaire to Conan-1 an element of fault seal risk has been identified.

6.1.1.2 Geographe Prospect

The Geographe Prospect is located 50 km offshore in the eastern Otway Basin in approximately 80m water depth. The prospect is contained within VIC/P43 situated in the middle of the Investigator 3D. The 3D data reveals the complexity of the Geographe structure (Fig. 25). Each culmination, designated north and south, displays vastly different characteristics. Geographe South has amplitude anomalies at the Top Turonian whereas Geographe North does not (Fig. 26). The amplitude anomalies are consistent with hydrocarbon entrapment at Geographe South only. The subsea depth to target for Geographe is 1780 m SS.

Structure – The Geographe Prospect is located on a southwest-trending, plunging anticline that extends from the Otway Ranges (Fig. 2). The structure is a complex, bicrestal feature with inferred Middle Late Cretaceous growth as defined by mapping at the Top Turonian (Fig. 25). Fault geometries at Geographe are complex with influence from the north-south trans-tensional movement along the Sorell Transfer Fault immediately to the east of the structure (Fig. 27).

Reservoir – The primary target reservoir in the Geographe-1 well comprises the Flaxmans / Upper Waarre quartzose sandstone of Turonian age. The Flaxmans Formation overlies the Waarre Formation but the thicknesses are hard to determine due to the long distance from the nearest wells. In stratigraphic terms the Waarre is divided into an Upper and Lower sequence based on the rift history. Two possible sequence boundaries are identified on seismic (Fig.28). The Flaxmans / Upper Waarre sequence thickens at the prospect location compared to wells drilled to the west. The axis of deposition within the Shipwreck Trough is proximal to the Geographe Prospect with the Latest Turonian strata probably deposited within a Late Cretaceous palaeo-valley (Fig. 28). The sequence immediately below the interpreted Top Turonian horizon (Flaxmans / Upper Waarre) appears to be progradational with a east to west direction of progradation (Fig. 29) This upper sequence is interpreted to pinch out from Geographe South to Geographe North (Fig. 30). This sequence is located in a palaeo valley situated along the Sorell Transform.

Upper Waarre sands are excellent reservoirs with multi Darcy permeability and porosity averaging 18%. Geographe is situated in the axis of deposition for the Late Cretaceous Waarre Formation. Reservoir conditions are expected to be better than at La Bella because of the proximity to the axis of deposition but not as good as at Minerva because of the distance from the sediment source. The Flaxmans / Upper Waarre Formation reservoirs are the main target with up to 200m of coarse clastic sandstones expected.

Source - The upper Eumeralla Formation is the predicted source rock, situated directly beneath the main reservoir. The La Bella and Minerva gas discoveries are full to spill which indicates relatively late charge for the area. The estimated generative area is potentially quite large as Geographe is situated near the shelf margin. Structure maps show a large area ramped up towards the Geographe Prospect with lowermost Waarre Formation postulated as having additional source potential.

Seal - The Belfast Mudstone provides a regional seal to the Flaxmans / Waarre Formations and its thickness (235m) is estimated to be greater than that found in La Bella-1 to the northwest. The overlying Paaratte Formation provides additional seal.

Top seal is not expected to be an issue at Geographe-1 where a continuous Late Cretaceous mudstone sequence is expected to overlie the main reservoir sequences. There is little or no seismic evidence for fault seal leakage at the South Geographe structure. Intra-Belfast sandstones prograde from the east but terminate at the edge of the Sorell Transfer Fault (Shipwreck Trench) before the Geographe structure.

6.1.2 Leads

Several other smaller features are identified within the Investigator 3D data set in VIC/P43. Most of these are considered satellite structures to the main leads.

6.1.2.1 Roebuck Lead

The Roebuck Lead is a small Waarre closure that lies directly north of the Glenaire Prospect (Fig. 22), near the axis of the Shipwreck Trough. Roebuck has been high graded by the 3D due to the presence of amplitudes at the target interval (Figs. 23 & 31). Roebuck is the only other structure besides Thylacine and Geographe to have amplitude anomalies contained in the far offset seismic data.

6.1.2.2 Sentinel Lead

The Sentinel Lead is a high side fault closure directly west of Geographe (Fig 29). The feature looks structurally robust but does not contain much closure and there are no amplitude anomalies associated with it.

6.1.2.3 Geographe East Lead

The Geographe East Lead is a highly faulted closure directly east of Geographe (Fig 28). The feature looks structurally robust but closure is not fully mapped by the 3D data. There are near offset amplitude anomalies associated with Geographe East.

6.2 T/30P

6.2.1 Prospects

6.2.1.1 Thylacine Prospect

The seismic anomalies associated with this Prospect are discussed in detail under the appropriate section below. The base of hydrocarbons is currently considered to be coincident with the seismic flat spot developed in the central portion of the structure at 2240m. Based on this assumption, the structure has an area of 25km^2 (Fig 32).

Structure. The Thylacine structure forms a composite horst developed on a NNE-SSW trending ridge. The horst is bounded by reactivated Early Cretaceous sub-vertical east-west trending normal faults coupled with Late Cretaceous northwest trending listric normal faults. The structure is fault-bounded to the north, east and south and pitches to the west (Fig 32). The primary faults often penetrate up to the base of the Tertiary. Ultimate structural closure is at 2380m SS. The Top of the Turonian is anticipated to be coincident with the top of the reservoir section. The crest of the structure is at the eastern edge of the feature at a depth of 2020m SS. A major amplitude anomaly is developed at the top of the Turonian over the bulk of the structure with development of a potential ‘flat spot’ in the central western area (Fig. 33).

A down-faulted block, SE Thylacine, is juxtaposed against the southeast side of the main horst. This fault block has been compressionally folded providing additional closure (Fig. 34). The presence of 'brightening' in seismic data implies a base of anticipated column at 2340m SS (lower than in the primary horst).

Reservoir. The potential reservoir is evident on seismic section as a WSW prograding facies (Fig. 35). Within this facies are two lobes, the upper one displaying high-angle internal reflectors. The high angle nature of these internal reflectors suggests that the lobe is sand-dominated. The base of the prograding facies climbs towards the east, above the seismic flatspot evident the central part of the horst.

Seismic data indicate a thick Lower Waarre Formation is present. The Lower Waarre appears as bland seismic reflectors suggesting little acoustic impedence contrast. Facies trends in the Shipwreck Trough axis support the Lower Waarre to contain fine-grained interbedded marine clastics. Based on ties to existing well data, there is a possibility that a thick non-marine coarse clastic section may be developed down to the base of the Lower Waarre Formation, immediately above the Top Eumeralla Formation event (Fig. 36). Any lower reservoir structures may breach into fault juxtaposed Upper Waarre Formation reservoir over part of the structure. Fault gouge may be sufficient to prevent this from occurring over much of the trap.

Seal. The Belfast Mudstone provides a regional seal to the Flaxmans / Waarre Formation and its thickness is estimated to be greater than that found in La Bella-1 to the northwest. The overlying Paaratte Formation provides additional seal. Top seal is not expected to be an issue at Thylacine-1 where a continuous Late Cretaceous mudstone sequence is expected to overlie the main Waarre reservoir. There is little evidence (only very minor brightening adjacent to faults in the eastern area) in seismic data of leakage into younger horizons.
In the case of a possible basal Lower Waarre Formation reservoir, juxtaposition with downfaulted Upper Waarre Formation over part of the structure is possible.

Migration. The presence of seismic 'flat spots' and 'bright spots' in the main horst and 'bright spots' in the southeast downthrown block suggests that gas has migrated into and become trapped in the structure. A very strong amplitude anomaly persists at the Top Turonian event as the horst plunges towards the west, well below mapped structural closure. It is suggested that this may represent migrated gas trapped in very low permeability reservoir that may have initially provided access into the Thylacine trap.

6.2.2 Leads

6.2.2.1 West Thylacine

A high amplitude peak defines the Top Turonian on the northern and southern flanks of the Thylacine horst in the west (Fig. 35). These are interpreted to result from gas trapped via cross fault seals. The reservoirs on the down thrown blocks should be better developed. No eastern updip structural closure is evident on these buttresses. The trapping may be effected towards the east by erosion of the reservoir. The seismic anomalies appear to amalgamate this lead with the main Thylacine structure into a much larger feature.

6.2.2.2 Southwest Thylacine

This play consists of a compressionally enhanced buttress and tilted fault blocks against the southwestern flank of the Thylacine horst (Fig. 37). Brightening and flat spot development is apparent, predominantly on the eastern flank. The anomalies occur below a seismically transparent zone interpreted as Flaxmans Formation sediments. The flat spots are multistorey, discontinuous and often terminated against secondary antithetic and synthetic normal faults. It is possible that these anomalies are associated with gas trapped in reservoirs with a complex stratigraphic geometry associated with the prograding facies identified on the Thylacine horst. Alternatively they may be associated with volcanics although their stratigraphic /structural configuration and polarity suggest a hydrocarbon origin. The discontinuous nature of the anomalies and their termination against secondary faults further indicates that the reservoir may contain a low net to gross ratio. The area of closure against the Thylacine horst is not extensive. This play needs to be interpreted at the Top Upper Waarre Reservoir to establish the degree of buttress faulting not evident at the Top of the Turonian.

7 CONCLUSIONS

The Investigator 3D and 2D surveys have increased the accuracy of interpretation and made it possible to evaluate one of the most structurally complex areas on the margin of the Australian continent. New generation 2D, coupled with reprocessing of vintage data, also allows for establishing the deeper geometries, however 3D or close spaced 2D is generally necessary for lead analysis. The use of the variance cube in conjunction with the conventional 3D cube provides very good constraints on the spatial attitude and distribution of the numerous faults.

The three main prospects Thylacine, Geographe and Glenaire are structural features that have been verified by the Investigator 3D. Seismic amplitude anomalies at Thylacine and Geographe are consistent with gas that has migrated into those structures. The nature of these anomalies would suggest that the reservoir quality is variable throughout the structure.

The stratigraphy in this area is not clearly understood due to the remoteness and more marine depositional setting. The geometry of the Flaxmans / Upper Waarre Formations indicate the presence of a reservoir previously not penetrated. The quality of the reservoir cannot be predicted however the prograding geometry suggests that good sandstones may be present.

Several leads are present in addition to the main features. Investigation at the Top Upper Waarre Formation is required because the current mapping at Top Turonian is at the top Flaxmans Formation which has considerable thickness and high variation across many of the structures.

8 REFERENCES

Jason, R.J. & Taylor, R.J., 2000. Minerva 3D: Interpretation Report. Origin Energy in-house report.

NOTE: The following reports will be provided as appendices with the digital copy of this report:

Investigator 2D & 3D MSS Final Operations Report, Western Geophysical

Investigator 2D & 3D MSS Report of Field Seismic Ops. Client report (ECA)

Investigator 3D/2D Processing Report, Veritas.