# Spikey Beach-1

## WELL COMPLETION REPORT

## INTERPRETIVE DATA

## T/38P

**Bass Basin, Offshore Northern Tasmania**


Beach Energy Limited
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## ENCLOSURES

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| | | |
|---|---|---|
| SEISMIC LOCATION: | Survey: | Amoco Bass Basin |
| | Line: | TNK4-99 |
| | SP: | 772 |

| | | |
|---|---|---|
| PERMIT: | T/38P | |
| BASIN: | Offshore Bass Basin | |
| PARTICIPANTS: | Beach Energy Ltd (Op.) | 80% |
| | Galveston Mining Corp Pty Ltd | 10% |
| | Exoil Ltd | 10% |

| | | |
|---|---|---|
| SURFACE LOCATION: | Latitude: | 40º 28' 53.879" S |
| | Longitude: | 145º 52' 24.706" E |
| | Easting: | 404 522.80m |
| | Northing: | 5 518 174.63m |
| | Datum: | GDA94 |
| | Spheroid: | GRS80 |
| | Map Grid: | MGA 94 |
| | Projection: | UTM Zone 55, CM 147 |

| | |
|---|---|
| WELL DESIGNATION: | Exploration |
| STATUS: | Plugged and Abandoned |
| STRUCTURE TYPE: | Anticline |
| RIG NAME AND TYPE: | Ocean Patriot<br>Semi-Submersible MODU |
| RIG CONTRACTOR: | Diamond Offshore Drilling Inc |

| TOTAL DEPTH: | (mMD) | (mTVDSS) |
|---|---|---|
| Driller: | 2100.0 | 2078.5 |
| Logger: | N/A | |
| ELEVATION: | Datum: | MSL |
| | RT-ASL (MSL): | 21.5m |
| | WD (MSL): | 74.0m |
| | RT-ML: | 95.5m |

| HOLE SIZES: | Size | Interval (mMD) |
|---|---|---|
| | 914mm (36") | 95.5 - 155.0m |
| | 445mm (17 ½") | 155.0 - 816.0m |
| | 311mm (12 ¼") | 816.0 - 2100.0m |
| CASING: | Size | Shoe (mMD) |
| | 762x508mm (30x20") | 151.4 |
| | 340mm (13 ⅜") | 805.8 |
| SPUD DATE: | 21:00hrs | 5/09/2009 |
| REACHED TD: | 09:00hrs | 13/09/2009 |
| RIG RELEASED: | 14:30hrs | 19/09/2009 |

**LWD LOGS**

| DATE | HOLE SIZE | RUN NUMBER | MEASUREMENT | INTERVAL |
|---|---|---|---|---|
| 7-8/09/2009 | 445mm (17 ½") | 1 | GR-DT_Shear DT_Comp-D&I | 149.4 – 816.0m |
| 10-14/09/2009 | 311mm (12 ¼") | 2 | GR-APWD-D&I-Resistivity-Shear DT-Comp DT-Density-Neutron-Caliper | 816.0 – 2100.0m |

**WIRELINE LOGS – No wireline logs were run**

| LOG TYPE | SUITE/RUN | INTERVAL mRT | BHT/TIME |
|---|---|---|---|
| | | | |

**DRILL STEM TESTING - No drill stem testing was undertaken**

| TEST | TEST INTERVAL | FLOW RATE | CHOKE | FWHP |
|---|---|---|---|---|
| | | | | |

**CEMENT PLUGS**

| PLUG | INTERVAL | CEMENT TYPE | CEMENT VOLUME |
|---|---|---|---|
| 1 | 1385 – 1520m | Abandonment | 822 sacks |
| 2 | 650 – 850m | Abandonment | 404 sacks |
| 3 | 115 – 215m | Abandonment | 235 sacks |

| WELL INDEX SHEET | Spikey Beach-1 | Page 2 of 2 |
|---|---|---|

| FORMATION | PROGNOSED DEPTHS | | ACTUAL DEPTHS | | Difference. |
|---|---|---|---|---|---|
| | mMDRT | mTVDSS | mMDRT | mTVDSS | High/Low |
| Recent Carbonates | 101.5 | -80.0 | 95.5 | -74.0 | 6.0m H |
| Torquay Group (Reefal Carbonate) | 121.5 | -100.0 | 131.0 | -109.5 | 9.5m L |
| Torquay Group (Lower) | 701.5 | -680.0 | 715.0 | -693.5 | 13.5m L |
| Demons Bluff Fm | 1381.5 | -1360.0 | 1392.2 | -1370.7 | 10.7m L |
| Upper Eastern View Group | 1461.5 | -1440.0 | 1480.5 | -1459.0 | 19.0m L |
| Middle Eastern View Group | 1851.5 | -1830.0 | 1874.7 | -1853.2 | 23.2m L |
| Total Depth | 2061.5 | -2040.0 | 2100.0 | -2078.5 | 38.5m L |

# 1 WELL SUMMARY

The Spikey Beach-1 exploration well is located in the Bass Basin, approximately 40km from the north coast of Tasmania in 74 metres of water **(Figure 1)**. It was proposed to test a simple, robust, anticlinal structure located on the south-eastern margin of the Pelican Trough in the south central Bass Basin.

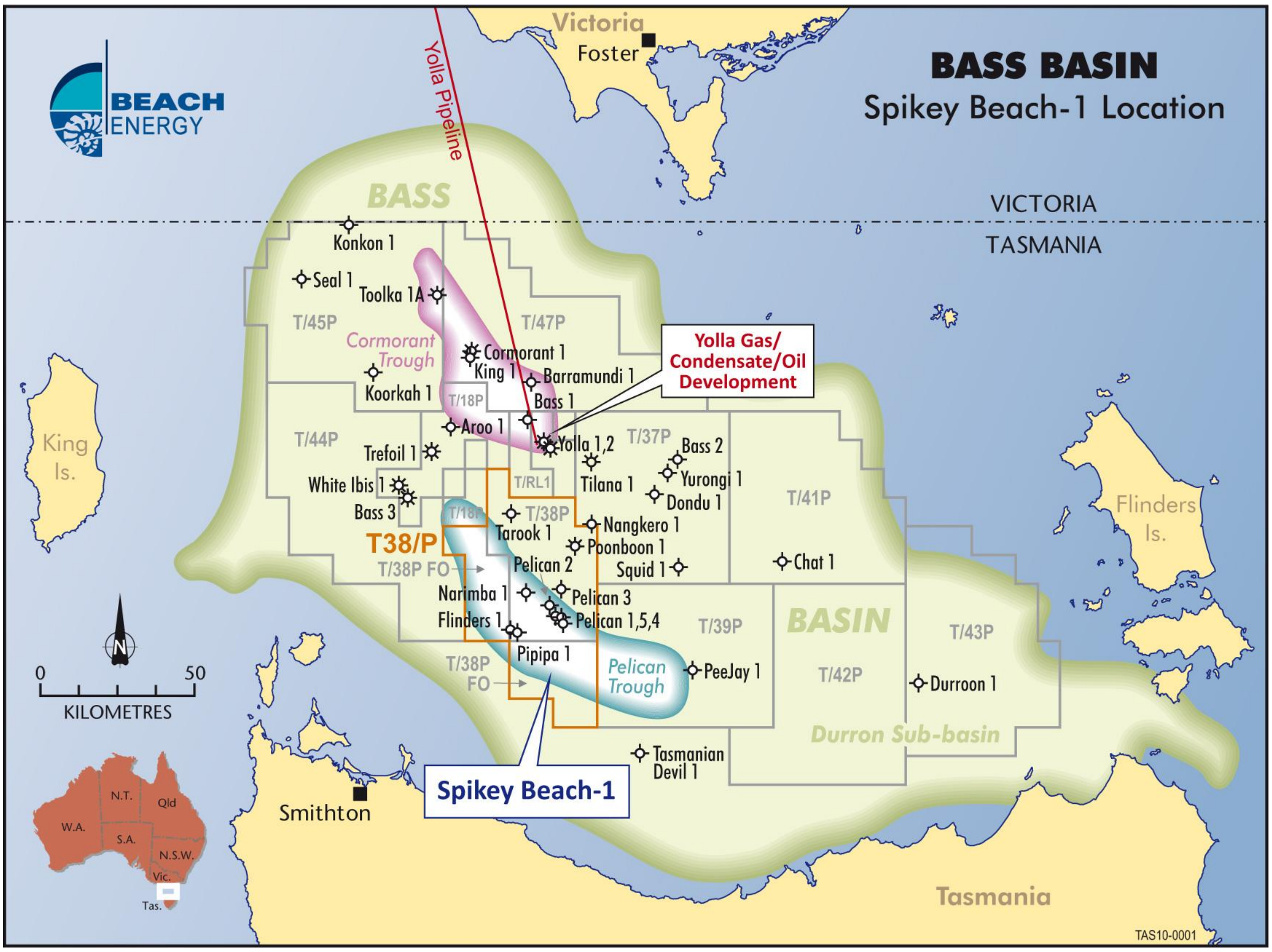


**Figure 1: Location T/38P and Spikey Beach-1 Petroleum Exploration Well**

The well was designed as a vertical well targeting oil in the Early to Middle Eocene age Upper Eastern View Group as its primary objective. Excellent reservoir quality sandstones at this level are present at Cormorant-1 and Yolla-1 where they are described as being fine to coarse grained. Yolla-1 intersected a 10 metre oil leg underlying a 20 metre gas cap in the Upper Eastern View Group.

The secondary objective was oil or condensate rich gas in the Late Cretaceous to Early Eocene Middle Eastern View Group. This has been the main target for exploration in the basin, hosting commercial or potentially commercial volumes of liquids rich gas at Yolla, White Ibis and Trefoil and sub-commercial accumulations at Cormorant and Pelican.

Seismic mapping at near top Upper Eastern View Group indicated that the Spikey Beach structure has approximately 35 metres of structural relief and encloses an area of $12km^2$. Seal was considered a key risk element with the presence of two faults cross cutting the structure. Maximum fault displacement on the primary fault is in the order of 20 metres. The other fault is small with minimal displacement and is an antithetic to the main fault and the two faults penetrate the entire Eastern View Group, dying out in the younger Lower Torquay Group. Charge was also considered a key risk for the well. To date, with the possible exception of Yolla, and this not on a stand alone basis, no commercial hydrocarbons have been encountered in sands of the Upper Eastern View Group and no commercial oil accumulations have been encountered in the basin. Yolla-1 did encounter nine metres of light oil underlying ten metres of gas saturated sands in the Upper Eastern View, which would contribute to the commerciality of the field.

The Ocean Patriot drilling rig came on contract to Beach Energy for the tow to Spikey Beach-1 at 12:30hrs on the 2nd of September 2009 and was towed 185nm to the well location. Anchor running operations commenced at 06:30hrs on 4th September 2009, and were completed at 11:30hrs on 5 September 2009.

The well was spudded at 21:00hrs on 5th September 2009 and 36" hole was drilled to section TD at 155mMDRT before the PGB and 30" conductor was run and cemented with the float shoe at 151.4mMDRT.

A 17 ½" BHA with MWD was made up and used to drill to section TD of 816m, and 13 ⅜" casing was run and cemented at 805.8mMDRT.

The BOP's and riser were run, latched to the wellhead and the connector tested before a 12 ¼" BHA with MWD was made up and used to drill to final TD at 2100mMDRT.

No wireline logging was conducted as it was considered sufficient information was available from the real time and recorded LWD data.

Reservoir quality throughout the Upper Eastern View Group from 1525.0mMD to 1875.0MD is interpreted to be good. Logs indicate average porosities of sands to be 22 percent. No zones of significant hydrocarbons were identified, this being confirmed by the lack of significant shows on the mudlog. The reservoir quality of the Middle Eastern View Group from 1870.0mMD to 2085.0mMD is interpreted to be moderate to good with average porosities of sands 19 percent. Log evaluation indicates no moveable hydrocarbons are evident **(Appendix 1)**.

The well was plugged and abandoned with three (3) cement plugs and the surface casing strings cut at 97.1m (1.6m below the seabed) and recovered to surface. The PGB (Permanent Guide Base) and wellhead were successfully retrieved to surface and a seabed clearance survey was completed with the ROV (Remote Operating Vehicle) prior to commencing rig move operations.

After de-ballasting, anchor retrieval operations were completed and the rig then towed to Western Port Bay where it went off contract to Beach Energy Ltd at 14:30hrs on 19 September 2009.

# 2 GEOLOGICAL DISCUSSION

## 2.1 Previous Exploration

The Bass Basin is a moderately explored basin with 37 wells (Including Spikey Beach-1) drilled since 1965 with a density of one well per approximately 1200 $km^2$. Exploration of the basin commenced in the early 1960s with permits awarded to Hematite Petroleum Pty Ltd (BHP) and ESSO Exploration and Production Australia Ltd. ESSO drilled the first well in the Basin, Bass-1, in 1965, and from 1966 to 1974 drilled an additional 15 wells without achieving commercial success. Non commercial gas and condensate accumulations were discovered at Pelican-1 and Pelican-2, and gas shows were recorded at Bass-3, Cormorant-1, Pelican-3, Poonboon-1, Toolka-1A, and Aroo-1.

The drilling of Yolla-1 by Amoco Australia in 1985 resulted in the first commercially significant discovery in the Basin. This well encountered approximately 30 metres of net gas pay in stacked sands over a 278 metre depth interval in the Middle Eastern View Group. The well also penetrated a gross column of 31 metres of hydrocarbon (20.4 metre gas cap overlying a 10.1 metre light oil leg) in the Upper Eastern View Group.

In 1998, Boral Energy Resources Ltd and its Joint Venture Partners drilled two wells in the central Bass Basin – Yolla-2 and White Ibis-1. Yolla-2 confirmed a commercial gas resource at Yolla and White Ibis-1, a crestal test over a large basement high up-dip of Bass-3, encountered a smaller gas accumulation with a thin oil rim. Yolla wells - 3 and -4 were subsequently drilled during field development in 2003.

Prior to drilling Spikey Beach-1, Trefoil-1 was the most recent exploration well drilled in the basin, discovering a modest gas - condensate accumulation in 2004.

Development of the Yolla gas field by Origin Energy and JV partners between 2003 and 2006 represents the initial phase of the BassGas Project which also includes plans for developing the White Ibis (1998) and Trefoil gas – condensate fields. First production of hydrocarbons from Yolla was in late 2005.

Details of the closest offset wells to Spikey Beach-1 are listed in **Table 1** below.

**Table 1: Nearest Offset Wells**

| Well | Distance from Spikey Beach-1 | Direction |
|---|---|---|
| Pelican-4 | 10km | North |
| Pipipa-1 | 15km | Northwest |
| Flinders-1 | 15km | Northwest |
| Tasmanian Devil-1 | 40km | Southeast |
| PeeJay-1 | 41km | Northwest |
| Yolla-1 to -4 | 75km | North |

## 2.2 Structural History of the Bass Basin

The Bass Basin was initially formed as a failed arm of the Southern Margin Rift System that developed through the opening of the Southern Ocean (separation of Antarctica from Australia) and the opening of the Tasman Sea (separation of the Lord Howe Rise Complex from Australia).

The basin is underlain by a series of north-west to south-east half-grabens that have undergone varying amounts of extension. Five major tectonic events are recognised by Cummings et al (2004):

1. A Late Jurassic - Early Cretaceous (Barremian) Southern Ocean Rifting Phase associated with Southern Ocean rifting (initial separation of Antarctica from Australia);

2. A Late Cretaceous (Turonian - Campanian) Tasman Rifting Phase (separation of the Lord Howe Rise Complex from Australia);

3. Campanian - Maastrichtian oblique extension associated with the continuing separation of Antarctica from Australia;

4. Paleocene - Middle Eocene oblique rifting mainly affecting the north-eastern part of the Basin, and
5. Oligocene - Miocene compressional reactivation dominated by right-lateral wrench deformation and localised inversion (mainly in the north of the Basin) of Cretaceous - Middle Eocene rift structures.

Uplift with localised inversion related to Oligocene-Miocene reactivation appears to be restricted to the northern part of the Basin. Oligocene-Miocene deformation in the southern (T/38P) part of the Basin is evident as right lateral strike slip reactivation of deep seated basement involved structures. Seal and trap integrity risk can in places be attributed to structures that have undergone inversion.

In the Yolla and White Ibis fields, access to mature source rocks is interpreted to be provided by large displacement faults that linked the Upper Eastern View Coal Measure Group reservoirs with deeper mature source rocks.

## 2.3 Regional Geology

The Bass Basin contains sediments that range in age from Early Cretaceous and possibly Latest Jurassic to Recent **(Figure 2)** that rest unconformably on pre-rift Mesozoic and Palaeozoic rocks.

Several stratigraphic nomenclature schemes have been proposed for the Basin, one of the more recent of these integrating biostratigraphy, sequence and seismic stratigraphy to identify accommodation cycles (Cummings et al, 2002). The stratigraphy of the basin remains to be standardised amongst explorers in the basin. A. D. Partridge (Biostrata Pty Ltd) has proposed a subdivision of the Bass Basin's stratigraphic succession that is significantly more 'detailed' and 'useful' than that currently being used by explorers.

The discussion below follows the more commonly used lithostratigraphic nomenclature.

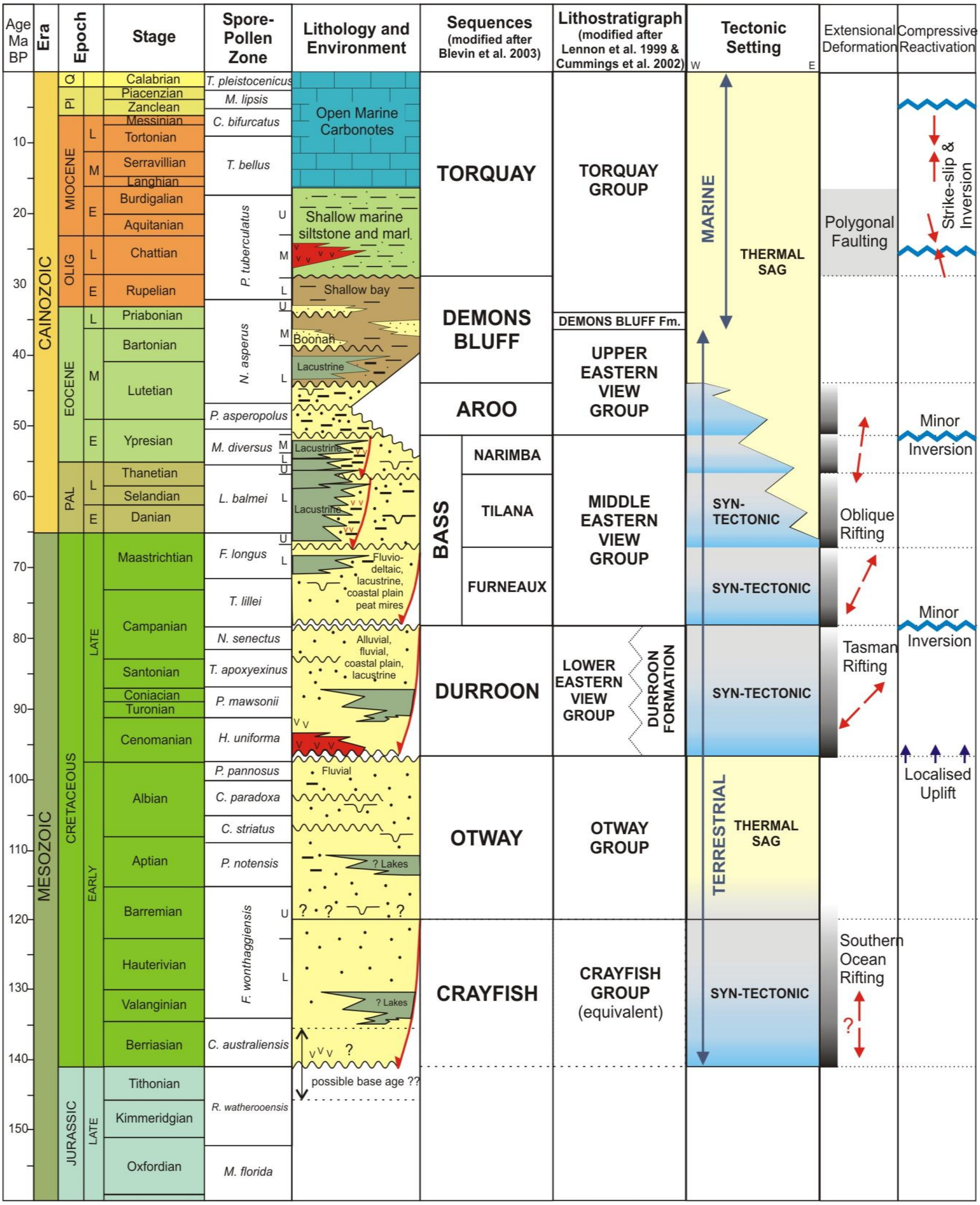


**Figure 2: Generalised Stratigraphy of the Bass Basin (Cummings et al 2004)**

**Eastern View Group (Early Cretaceous- Middle Eocene)**

A threefold stratigraphic subdivision of the Eastern View Group (also referred to as the Eastern View Coal Measures) is recognized, the units being poorly defined and identified predominantly by a relative abundance of coal, and by age.

Differentiation of the Eastern View Group into Members or more ideally Formations has historically proven difficult throughout the Bass Basin. Variation within the Group is gradational, with no well defined departures in lithology. Work undertaken by Cummings et al (2004) and Partridge (2002) is leading towards formalisation of a more appropriate, more definitive and more useful breakdown of the stratigraphic succession of the Bass Basin and the Eastern View Group in particular. A report detailing the Palynological Analysis that was undertaken by Biostrata Pty Ltd is included in this report as **Appendix 2**.

The Eastern View Group is thickest in the centres of the main troughs, reaching a total thickness of in excess of 5500 metres, but thins markedly towards the basin margins. The Lower Eastern View Group remains largely unexplored and consequently unknown due to its depth of burial.

The Eastern View Group comprises interbedded sandstone, siltstone, claystone and coal, the coals being sparse in the Upper Eastern View, but becoming more abundant towards and in the Middle Eastern View Group *M. diversus* and *L. balmei* zones. In earlier wells, the 'picked' contact between the top of the Eastern View Group and the overlying Demons Bluff Formation is lithologically gradational with siltstone gradually becoming sandier towards the base of the Demons Bluff Formation and eventually grading into very fine to coarse grained, moderately to well sorted, quartz sandstones. In Spikey Beach-1, the contact is sharp and clear with claystone of the demons Bluff Formation overlying coarser grained sandstone and siltstone.

Sandstones of the upper Eastern View Group are proven petroleum-bearing units, having been tested by the Cormorant-1 and Yolla-1 wells where the unit comprises very fine to coarse-grained sandstones with minor clay matrix. Nevertheless, the unit has not been seen as a conventional reservoir target in the basin due to a general lack of structure at this level. Porosity in the Upper Eastern View Group sands ranges up to 30 per cent; permeabilities average about 75mD and can exceed a Darcy.

The Middle Eastern View Group and in particular *L.balmei* zone has been the primary reservoir target in the basin, hosting commercial volumes of liquids rich gas at Yolla, potentially commercial volumes of liquids rich gas at White Ibis and Trefoil, significant but non-commercial accumulations at Cormorant and Pelican and abundant shows in several other wells including Bass-1, Aroo-1 and Ponboon-1. Where well developed, sandstones in both the Upper and Middle members reach 10- 50 metres in thickness and tend to be predominantly medium to coarse grained, with moderately good sphericity and sorting. The sandstones are mainly siliceous, but in places have moderate calcareous or dolocalcareous cement. Glauconite (often abundant), thin dolomitic streaks and micropyrite are inherent to the Group.

Eastern View sediments were deposited in a variety of terrestrial, paralic and shallow marine environments, the area covered by T/38P receiving sediment input from both Tasmania and the Australian mainland. The Eastern View Group underlying T/38P is interpreted by Alan Partridge as being "remote from the marine influence entering the basin in the north-west, the group comprising a mixed succession of coal measures, fluvial, lacustrine and lagoonal sediments. The sequence is seen as being non-marine in the Late Cretaceous and through most of the Paleocene (Middle Eastern View Group), gradually becoming more marine through the latest Paleocene and Eocene (Upper Eastern View Group) with estuarine and deltaic facies also present.

**Demons Bluff Formation (Middle - Late Eocene)**

The Demons Bluff Formation is an overall transgressive-regressive succession that was deposited during a phase of thermal subsidence. The formation ranges in thickness up to 130 metres. The Demons Bluff Formation is an important regional seal for the Eastern View Group.

At Flinders-1 and Pipipa-1, the formation comprises argillaceous, dark brown, pyritic siltstones and shales that are slightly carbonaceous and occasionally calcareous. At Pelican-5, the formation consists of moderately calcareous, dark brownish claystone which grades to shale in part, with minor interbedded limestone, siltstones and silty sandstones. The boundary with the overlying Torquay Group across the Basin is gradational and indistinct as is the boundary with the underlying Eastern View Group. The Demons Bluff at Spikey Beach is similar to that described at Pelican-5.

**Torquay Group (Middle Eocene to Recent)**

The Torquay Group sequence consists of a lower argillaceous succession of marine mudstones and marls up to 650 m thick, overlain by a calcarenite-dominated succession up to 900 metres thick that were probably deposited as reefal detritus in a shelfal, back reef environment. Volcanics, both intrusives and extrusives, are common in the lower unit.

At nearby wells Flinders-1 and Pipipa-1, the upper part of the Torquay Group is 900 metres thick and comprises predominantly skeletal limestone, largely unconsolidated, interbedded with minor calcareous siltstone and marl. The limestone varies from white to grey, and is predominantly a calcarenite but occasionally grades to calcilutite, in particular towards the base of the interval. The unit consists mainly of bryozoan and foraminiferal fragments with occasional pelecypod and echinoid fragments and minor quartz. The calcilutite is grey green and glauconitic. The marl is grey, very silty in part and friable. At Pelican-5, up to 25 percent of intergranular calcite cement is present.

The lower interval of the Torquay Group, referred to by some as the Angahook Formation, is 400 metres in thickness at Pipipa-1 and nearly 500 metres in thickness at Pelican-5. At Pipipa-1, the unit is dominated by siltstone interbedded with minor shale and rare light brown dolomite. The siltstones are argillaceous and occasionally carbonaceous. There is a general increase in the proportion of clay and silt towards the base of this interval. At Pelican 5, the unit comprises calcareous claystones with minor thin beds of bioclastic limestones.

At Spikey Beach, the upper Torquay Group comprises predominantly calcarenite with thinly interbedded calcareous siltstones and claystones. This upper interval is underlain by a thick (250 metre) interval of calcareous claystone. The basal 55 metres of the Torquay Group comprises siltstone with prominent sandstone interbeds

## 2.4 Predicted vs Actual

**Table 2** below summaries the predicted versus actual formation tops for Spikey Beach-1. RT is 21.5m above mean sea level.

**Table 2: Spikey Beach-1 Predicted vs Actual Formation Summary**

| FORMATION | PROGNOSED DEPTHS | | ACTUAL DEPTHS | | Difference |
|---|---|---|---|---|---|
| | mMDRT | mTVDSS | mMDRT | mTVDSS | High/Low |
| Recent Carbonates | 101.5 | -80 | 95.5 | -74.0 | -6.0 |
| Torquay Group (Reefal Carbonate) | 121.5 | -100 | 131.0 | -109.5 | 9.5 |
| Torquay Group (Marl) | 701.5 | -680 | 715.0 | -693.5 | 13.5 |
| Demons Bluff Formation | 1381.5 | -1360 | 1392.2 | -1370.7 | 10.7 |
| Upper Eastern View Group | 1461.5 | -1440 | 1480.5 | -1459.0 | 19.0 |
| Middle Eastern View Group | 1851.5 | -1830 | 1874.7 | -1853.2 | 23.2 |
| Total Depth | 2061.5 | -2040 | 2100.0 | -2078.5 | 38.5 |

## 2.5 Stratigraphic Summary

The stratigraphic section encountered in Spikey Beach-1 is summarised below and tops are shown in Table 2 above. Cuttings descriptions are included in Appendix 5 of the Basic Data Well Completion Report, as well as below.

For reference, a generalised Bass Basin stratigraphic column is provided as **Figure 2**. The detailed lithological description of the section encountered is also contained in the Spikey Beach-1 Basic Data Report.

Differentiation of the Eastern View Group into 'Members' or more ideally 'Formations' has proven difficult throughout the Bass Basin. Variation within the Group is gradational and with no well defined departures in lithology. Work undertaken by Cummings et al (2004) and Partridge (2002) is leading towards formalisation of a more definitive and appropriate breakdown of the stratigraphic succession of the Bass Basin and the Eastern View Group in particular. A report detailing the Palynological Analysis that was undertaken by Biostrata Pty Ltd is included in this Report as **Appendix 2**.

All depths reported in this Well Completion Report are measured depth relative to the Rotary Table (MDRT) unless otherwise stated.

### 2.5.1 Recent Carbonates

Depth: 95.5 to 131.0mMDRT (-74.0 to -109.5mTVDSS)

Thickness: 35.5 m

Age: Oligocene to Recent

Depositional Environment: Marine

Returns to seabed from 95.5 to 816.0m.

### 2.5.2 Torquay Group (Reefal Carbonates)

Depth: 131.0 to 715.0mMDRT (-109.5 to -693.5mTVDSS)

Thickness: 584.0 m

Age: Middle Eocene to Oligocene

Depositional Environment: Marine

Returns to seabed from 95.5 to 816.0m.

### 2.5.3 Torquay Group (Lower)

Depth: 715.0 to 1392.2mMDRT (-693.5 to -1370.7mTVDSS)

Thickness: 677.2 m

Age: Middle Eocene to Oligocene

Depositional Environment: Marine

Returns to seabed from 95.5 to 816.0m.

Interbedded CALCARENITE and CALCAREOUS CLAYSTONE with minor CALCAREOUS SILTSTONE from 816.0 to 1064.5m.

CALCARENITE: light grey to white, light blue grey, abundant fossils (coral, byozoa, ammonoids), common very fine to fine grains of quartz, rare siderite, firm to moderately hard, sub-blocky to blocky.

CALCAREOUS CLAYSTONE: light to medium grey, light brown to brown grey, light to medium olive grey, medium dark grey, trace carbonaceous specks and micro-laminations, trace very fine glauconite grains, trace fossil fragments, firm to moderately hard, blocky.

CALCAREOUS SILTSTONE: medium to dark grey, medium olive grey, medium brown grey, argillaceous, grading to Arenaceous Claystone, trace to common fossil fragments, trace carbonaceous specks, trace glauconite, firm, sub-blocky to blocky.

CLAYSTONE from 1064.5 to 1250.0m: light to medium grey, light brown to brown grey, medium olive grey, medium dark grey, calcareous, trace carbonaceous specks and micro-laminations, trace to abundant disseminated and nodular pyrite, trace very fine glauconite grains, trace fossil fragments, rare micro mica, firm to moderately hard, sub-blocky to blocky.

SILSTONE with minor CLAYSTONE interbeds from 1250.0 to 1270.0m.

SILTSTONE: light to medium brown, light to medium brown grey, common very fine sand grains, grading to a very fine Sandstone, nil to weakly calcareous, trace to common micro mica and glauconite, trace disseminated pyrite, trace carbonaceous specks, soft to firm, sub-blocky to blocky.

CLAYSTONE: medium to dark grey, medium olive grey, medium brown grey, moderately calcareous, trace to common nodular pyrite, common carbonaceous specks, trace micro mica and glauconite, firm to moderately hard, sub-blocky to blocky.

SILTSTONE with SANDSTONE and CLAYSTONE interbeds from 1270.0 to 1344.0m.

SILTSTONE: light to medium brown, light to medium brown grey, common very fine sand grains, grading to a very fine Sandstone, nil to weakly calcareous, trace to common micro mica and glauconite, trace disseminated pyrite, trace carbonaceous specks, soft to firm, sub-blocky to blocky.

SANDSTONE: light brown to brown grey, clear to translucent, very fine grained, moderately sorted, sub-angular to sub-rounded, moderate siliceous cement, moderate to strong calcareous (dolomitic) cement, common to abundant argillaceous to silty matrix, in part grading to a Sandy Siltstone, trace carbonaceous specks and glauconite, trace siderite, friable to moderately hard, very poor inferred porosity, no fluorescence.

CLAYSTONE: medium to dark brown grey, medium olive grey, weak to moderately calcareous, trace to common nodular pyrite, common carbonaceous specks, trace micro mica and glauconite, firm to moderately hard, sub-blocky to blocky.

SILTSTONE with minor SANDSTONE and LIMESTONE interbeds from 1344.0 to 1392.2m.

SILTSTONE: light to medium brown, medium to dark brown grey, common very fine sand grains, grading to a very fine Sandstone, nil to moderately calcareous, trace to common micro mica and glauconite, trace disseminated and nodular pyrite, rare to minor carbonaceous material, soft to firm, sub-blocky to blocky.

SANDSTONE: light brown to brown grey, clear to translucent, very fine grained, moderately sorted, sub-angular to sub-round, moderate siliceous cement, moderate to strong calcareous (dolomitic) cement, common to abundant argillaceous to silty matrix, in part grading to a Sandy Siltstone, trace carbonaceous specks and glauconite, trace siderite, friable to moderately hard, very poor inferred porosity, no fluorescence.

LIMESTONE: light brown to moderate brown, microcrystalline, sandy in part, dolomitic in part, angular cuttings, moderate hard to hard.

### 2.5.4 Demons Bluff Formation

Depth: 1392.2 to 1480.5mMDRT (-1370.7 to -1291.0mTVDSS)

Thickness: 88.3 m

Age: Middle to Late Eocene

Depositional Environment: Marine

CLAYSTONE with rare LIMESTONE laminations.

CLAYSTONE (1): dark grey, brownish grey to brownish black, non to slightly calcareous, carbonaceous, rare disseminated very fine pyrite, trace nodular pyrite, rare micro-mica, soft to firm, sub-blocky to sub-fissile.

CLAYSTONE (2): very light grey to light grey, light brownish grey, grading to SILTSTONE, non to moderate calcareous, soft to firm, sub-blocky to blocky.

LIMESTONE: light brown to moderate brown, trace bluish grey, predominantly microcrystalline, trace bioclastic, sandy in part, dolomitic in part, angular cuttings, moderate hard to hard.

### 2.5.5 Upper Eastern View Group

Depth: 1480.5 to 1874.7mMDRT (-1459.0 to -1853.2mTVDSS)

Thickness: 394.2 m

Age: Middle Eocene

Depositional Environment: Terrestrial to Shallow Marine

Interbedded CLAYSTONE, SILTSTONE and SANDSTONE from 1480.5 to 1560.0m.

CLAYSTONE: olive grey, brownish grey, yellowish grey, non to slightly calcareous, rare micro mica, rare very fine quartz, trace carbonaceous material, trace very fine disseminated pyrite, soft, amorphous to sub-blocky, grading to SILTSTONE.

GLAUCONITIC SANDSTONE: moderate to dark yellowish green, very fine, well sorted, sub rounded, siliceous cement, pervasive glauconitic staining, grading to glauconitic Siltstone, friable, tight to poor visible porosity, no fluorescence.

SILTSTONE: olive grey, light brownish grey, non to slightly calcareous, rare micro mica, trace carbonaceous laminae and material, trace nodular pyrite, trace coarse embedded quartz grains, trace black Coal fragments and laminae, soft to firm, sub-blocky, grading to and interlaminated with very fine SANDSTONE.

SANDSTONE: translucent, transparent, frosted in part, fine to coarse, poor sorted, sub rounded to rounded, loose, good inferred porosity, no fluorescence.

Interbedded SILTSTONE and SANDSTONE with minor COAL seams from 1560.0 to 1595.0m.

SANDSTONE: light grey, light olive grey, moderate yellowish green, translucent, transparent, predominantly very fine to fine well sorted aggregates, 5% fine to coarse moderate sorted loose, sub angular to sub rounded, siliceous cement, trace argillaceous matrix, trace carbonaceous specks, rare very fine glauconite, interlaminated with and grading to SILTSTONE, loose to friable, fair to tight visible porosity, good inferred porosity, no fluorescence.

SILTSTONE: olive grey, light brownish grey, non to slightly calcareous, rare micro mica, trace carbonaceous laminae and material, trace nodular pyrite, trace coarse embedded quartz grains, trace black Coal fragments and laminae, soft to firm, sub-blocky, grading to and interlaminated with very fine SANDSTONE.

COAL: black, brownish black, earthy to sub vitreous, rare vitreous, lignitic, soft to brittle, angular, grading to carbonaceous Claystone.

SANDSTONE interbedded with minor SILTSTONE and COAL seams from 1595.0 to 1645.0m.

SANDSTONE: clear to translucent, minor opaque grains, fine to medium grained, minor coarse grains, poorly sorted, sub-angular to sub-rounded, moderate siliceous cement, weak calcareous cement, rare pyritic cement, trace silty matrix, common quartz overgrowths, trace to common nodular pyrite, rare lithics fragments, predominantly loose, minor moderately hard to hard aggregates, fair visible porosity, fair inferred porosity, no fluorescence.

SANDSTONE: clear to translucent, minor opaque grains, fine to coarse grained, predominantly medium grained, moderately sorted, angular to sub-rounded, weak to moderate siliceous cement mainly as quartz overgrowths, rare pyritic cement, rare light grey to white argillaceous to silty matrix, trace to rare nodular pyrite, trace lithics, common quartz overgrowths, loose, trace moderately hard aggregates, fair to poor visible and inferred porosity, no fluorescence.

SILTSTONE: light to medium brown, light brown grey, light olive grey, common disseminated and nodular pyrite, rare pyrite veins, trace carbonaceous specks, common micro mica, soft to firm, sub-blocky to blocky.

COAL: black, brownish black, sub vitreous, rare vitreous, soft to brittle, angular to sub-blocky, sub-conchoidal.

Interbedded SANDSTONE, SILTSTONE with minor CARBONACEOUS CLAYSTONE and COAL seams from 1645.0 to 1747.0m.

SANDSTONE: clear to translucent, fine to coarse grained, predominantly fine to medium grained, poorly sorted, sub-angular to sub-rounded, moderate siliceous cement, trace pyritic cement, common to abundant white argillaceous to silty matrix (kaolinitic), common nodular pyrite, trace lithics and carbonaceous material, loose, minor friable aggregates, poor inferred porosity, no fluorescence.

SILTSTONE: medium brown to brown grey, light to medium olive grey, sandy and in part grading to a very fine Sandstone, trace common disseminated and nodular pyrite, trace carbonaceous specks, common micro mica, soft to firm, sub-blocky to blocky.

CARBONACEOUS CLAYSTONE: dark brown to dark brown grey, dark grey to grey black, dark olive grey, trace to common disseminated pyrite, common micro-micaceous, moderately hard, sub-fissile to sub-blocky.

COAL: black to grey black, dark brown, dull to earthy luster, in part sub-vitreous, angular to sub-conchoidal fracture.

Interbedded SILTSTONE and SANDSTONE from 1747.0 to 1820.0m.

SILTSTONE: medium to dark brown grey, medium olive grey, medium to dark grey, sandy and in part grading to a very fine Sandstone, carbonaceous, trace common disseminated and nodular pyrite, common micro mica, firm to moderately hard, in part very hard, sub-blocky to blocky.

SANDSTONE: white to light grey, clear to translucent, very fine to fine grained, predominantly fine grained, poorly sorted, sub-angular to sub-rounded, weak siliceous cement, minor pyritic cement, common to abundant silty matrix, common disseminated and nodular pyrite, trace carbonaceous specks, rare lithics, predominantly loose, common friable aggregates, poor inferred and visible porosity, no fluorescence.

SANDSTONE: clear to translucent, fine to medium grained, moderately sorted, sub-angular to sub-rounded, weak siliceous cement, common argillaceous to silty matrix, common nodular pyrite, trace carbonaceous specks, rare lithics, loose, minor moderately hard to hard aggregates, poor inferred and visible porosity, no fluorescence.

Interbedded SANDSTONE and SILTSTONE with minor COALS from 1820.0 to 1874.7m.

COAL: black to brownish black, dark brown, dull to earthy lustre, in part sub-vitreous, angular to sub-conchoidal fracture, grading to carbonaceous shale.

SANDSTONE: translucent, transparent, very light grey, very fine to fine, well sorted, sub angular to sub rounded, weak siliceous cement, localised pyritic cement, abundant white clay matrix, rare carbonaceous material, trace nodular pyrite, grades to sandy SILTSTONE, predominantly disaggregated, minor loose, poor visible porosity, no fluorescence.

SILTSTONE: pale brown, light olive grey to olive grey, brownish grey, argillaceous to arenaceous, sandy and in part grading to a very fine Sandstone, minor to very carbonaceous in part, common micro mica, soft to firm, sub-blocky to blocky, fissile in part.

### 2.5.6 Middle Eastern View Group

| | |
|---|---|
| Depth: | 1874.7 to 2100mMDRT (-1853.2 to -2078.5mTVDSS) |
| Thickness: | 225.3 m |
| Age: | Late Cretaceous to Middle Eocene |
| Depositional Environment: | Terrestrial to Shallow Marine |

Interbedded SANDSTONE and SILTSTONE with minor Coals from 1874.7 to 1959.0m.

COAL: black, occasional brownish black, sub vitreous, minor earthy, firm, brittle in part, sub conchoidal to angular fracture, grading to carbonaceous Claystone.

SANDSTONE: very light grey to light grey, translucent, transparent, very fine to fine, well sorted, sub angular to sub rounded, minor aggregates with weak siliceous cement, abundant slightly calcareous white clay matrix, trace lithics, trace pyrite, grading to arenaceous SILTSTONE, predominantly dissagregated to friable, fair visible porosity, no fluorescence.

SILTSTONE: light brownish grey, light olive grey, arenaceous, minor carbonaceous material / laminae, rare micro-mica, weakly dolomitic in part, firm, sub-blocky to blocky.

SANDSTONE from 1959.0 to 1990.0m: translucent, transparent, very light grey to light grey, light olive grey, very fine to fine, well sorted, sub rounded, rare aggregates with siliceous cement, trace to abundant white clay matrix, slightly calcareous in part, trace dark lithics, trace carbonaceous material, predominantly loose, rare friable to moderate hard aggregates, good inferred porosity, fair to good visible porosity, no fluorescence.

Interbedded SANDSTONE and SILTSTONE with minor COAL seams from 1990.0 to 2100.0m.

SANDSTONE: clear to translucent, fine to medium grains, predominantly fine grains, moderately sorted, sub-angular to rounded, moderate siliceous cement mainly as quartz overgrowths, minor moderate calcareous cement in part, common argillaceous to silty matrix, trace carbonaceous specks, trace lithics, minor moderately hard aggregates, predominantly loose, poor inferred porosity, no fluorescence.

SILTSTONE: medium brown to brown grey, medium dark brown, sandy, in part grading to a very fine Sandstone, carbonaceous, common carbonaceous micro laminations, common micro-micaceous, firm to in part moderately hard, sub-blocky to blocky.

COAL: black, sub-vitreous to vitreous, earthy in part, argillaceous and grading to carbonaceous Claystone in part, moderate hard, uneven to angular fracture.

**Total Depth: 2100.0mMDRT**

# 3 HYDROCARBONS

Hydrocarbon detection via gas chromatograph and cuttings descriptions commenced from the beginning of the 12 ¼" hole at 816mMDRT.

There were no recorded hydrocarbon shows in Spikey Beach-1 (refer Spikey Beach-1 Mudlog and cuttings descriptions, Well Completion Report Basic Data).

Formation evaluation consisted of mudlogging and Logging While Drilling (LWD). No wireline logs were run at Total Depth. Log Interpretation (Appendix 1 and Enclosure 1) indicates no moveable hydrocarbons are present in Spikey Beach-1.

# 4 GEOPHYSICAL DISCUSSION

## 4.1 Pre-Drill Mapping

The Spikey Beach-1 prospect was interpreted as a simple four-way dip closed anticline defined by modern 2D seismic data **(Figure 3)**.

At the top of the Upper Eastern View Group (the primary objective of the well) the lowest closing contour for the structure was interpreted at 1467 mss, defining 8.7 $km^2$ of closure with 27 metres of vertical relief. A greater closure of 12 sq km and 35 metres of relief could be mapped by extending the primary fault significantly to the south, but such an extension was considered unlikely. The Spikey Beach-1 well is located in a crestal position on the south west, foot-wall side of a NNW - SSE trending fault that cuts through and in part defines the north western part of the structure. The fault is one of two faults mapped in the northern part of the structure, the second being a smaller, antithetic fault that exhibits only minimal vertical displacement. The two faults penetrate the entire Eastern View Group, dying out in the younger Lower Torquay Group. Maximum fault displacement on the primary fault is interpreted to be is in the order of 20 metres.

The Spikey Beach structure exhibits an early growth history forming soon after deposition of the Demons Bluff Formation **(Figures 4 and 5)**.

Spikey Beach-1 provided a key test of a well defined, high relief, structural roll-over at the level of the Upper Eastern View Group. Few wells drilled in the basin have tested anticlinal closure at the Upper Eastern View level, and the lack of hydrocarbon success to date is perhaps more due to lack of targeting closures at this level than any other factor.

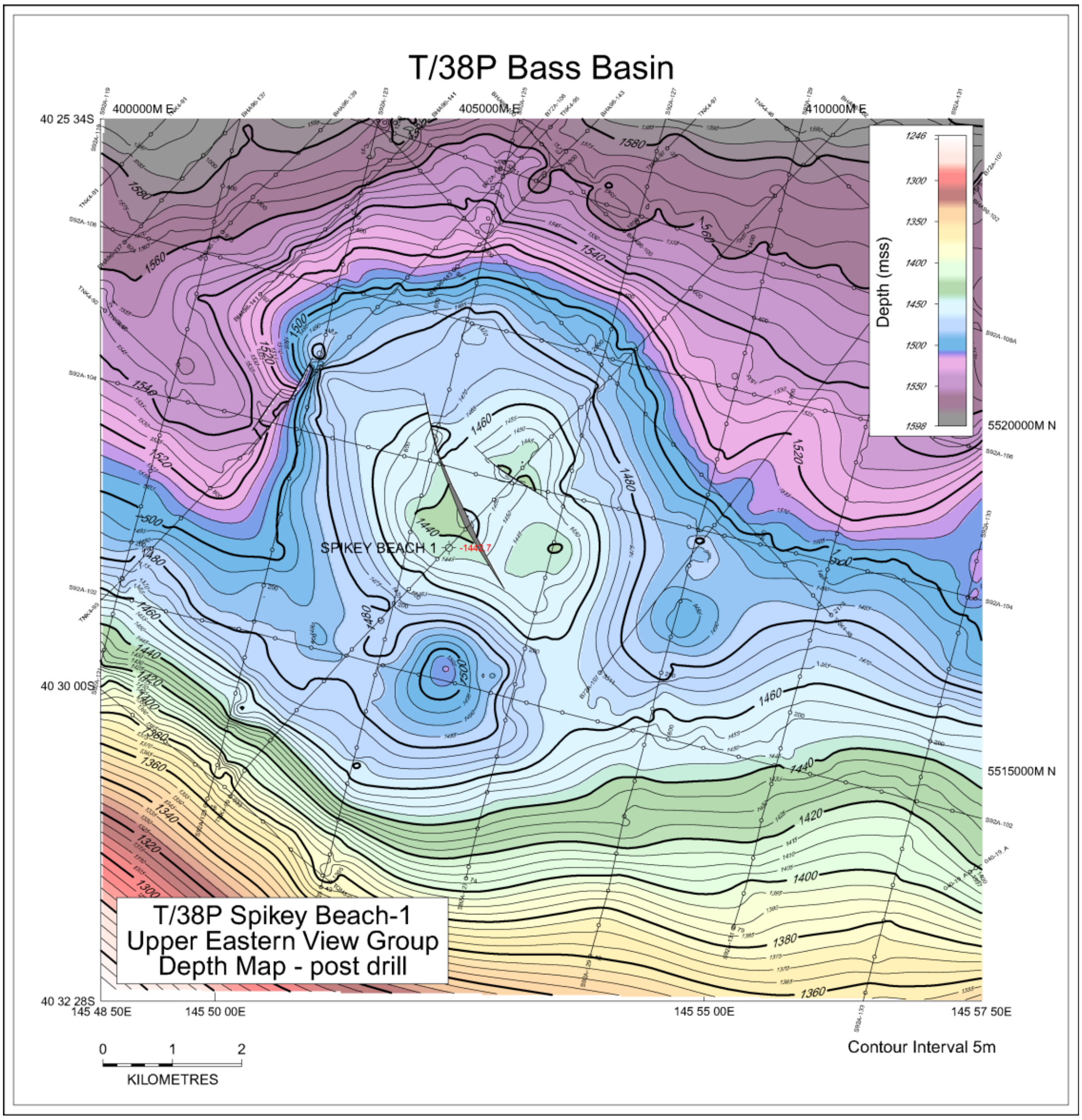


**Figure 3: Spikey Beach-1 post-drill Depth Structure at Near Top Eastern View Group**

## 4.2 Post-Drill Mapping

Spikey Beach-1 intersected the Demons Bluff Formation 11 metres deep to prediction, the Upper Eastern View Group 19 metres deep to prediction and the Middle Eastern View Group 23 metres high to prediction. Other than elevation, the interpreted structural configuration of the Spikey Beach-1 feature post the drilling of the well remains essentially unchanged from the pre-drill interpretation. The Spikey Beach-1 feature remains as a large, closed, anticlinal structure and is still seen to provide a competent trapping mechanism **(Figures 3, 4 and 5)**. The interpretation of pre-drill fault intersections remains unchanged.

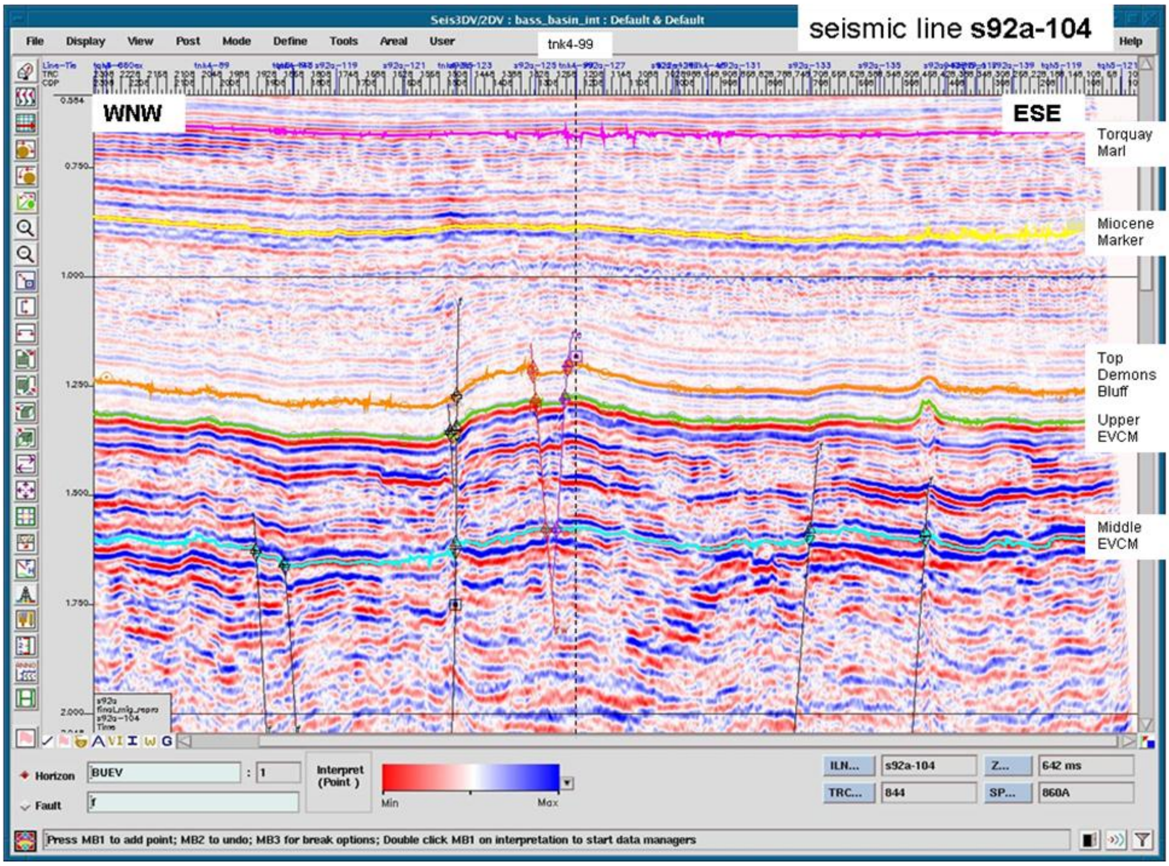


**Figure 4: Northwest to Southeast Seismic Cross Section s92a-104 across Spikey Beach**

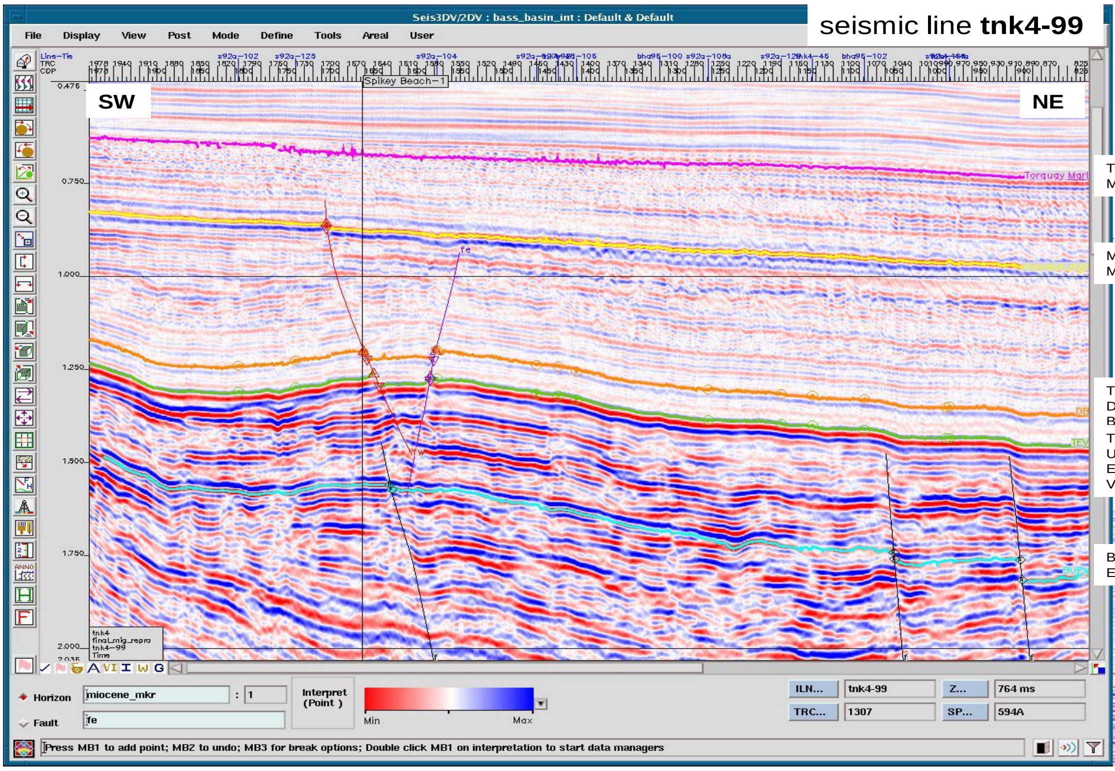


**Figure 5: Southwest to Northeast Seismic Cross Section tnk4-99 across Spikey Beach**

# 5 CONTRIBUTIONS TO GEOLOGICAL CONCEPTS AND CONCLUSIONS

## 5.1 Reservoir

The fluvio-deltaic sandstones of the Upper Member of the Eastern View Group provided the primary reservoir objective for Spikey Beach-1. Over much of the Bass Basin, reservoir properties of sands in the Upper Eastern View are similar to those of sands of the Middle Eastern View, the stratigraphic unit historically considered as the primary reservoir target for the basin. Sands for both the Middle and Upper Eastern View Members are interpreted to have been deposited in a variety of terrestrial, paralic and shallow marine environments.

Yolla-1 penetrated a gross hydrocarbon column of 31 metres comprising a wet gas cap of 20.4 metres overlying a 10.6 metre oil leg in “excellent porous sands” of the uppermost Upper Eastern View Group succession. Log derived porosities within the interval vary between 17 percent and 30 percent, and high permeabilities are indicated.

The Upper Eastern View Member at Spikey Beach-1 proved to be a sandstone dominated sequence with interbedded siltstones and minor coals (up to 5 metres thick). Porosities within the sands reach 30 percent and average circa 22 percent. Several sandstone intervals reach 15-20 metres in thickness (refer to **Section 3.2.5** and Composite Log - **Enclosure 2**).

Sandstones of the Upper Member of the Eastern View Group at Spikey Beach-1 are quartzose, generally 'blocky', fine to medium grained but in part very fine and coarse to very coarse grained, subangular to subround and commonly spherical. Trace pyrite and silica cements occur throughout the Upper Eastern View.

The upper part of the Middle Member of the Eastern View Group at Spikey Beach-1 is also dominated by sandstones, with interbedded siltstones and minor coals (refer to **Section 3.2.6** and Enclosed Composite Log - **Enclosure 2**).

The interval penetrated in the well comprises several fining upwards sequences and is predominantly finer grained towards the base of the unit. The sands exhibit lower porosities and permeabilities than in the Upper Eastern View. Average calculated porosity for the sequence is 19 percent.

Sandstones of the Middle Eastern View Group at Spikey Beach-1 are quartzose, very fine to fine grained, subangular to subrounded, moderately to poorly sorted with some argillaceous matrix. Commonly, the sandstones have a weak calcareous cement.

Hydrocarbon indications recorded during drilling operations consisted of very minor elevated mud gas readings from 1900 metres and no hydrocarbon fluorescence shows. Petrophysical analysis (**Appendix 1**) indicates all of the sands in both the Upper Eastern View and the Middle Eastern View to be water saturated. No moveable hydrocarbon zones were intersected by the well.

## 5.2 Source and Migration

A primary risk for Spikey Beach-1 pre-drilling was assessed to be charge. To date, with possibly the exception of Yolla, and this not on a stand alone basis, no commercial hydrocarbon accumulations have been encountered within sands the Upper Eastern View Group and no commercial oil accumulations have been encountered within this unit in the Basin. Commercial volumes of gas have been encountered at Yolla and potentially at Trefoil and White Ibis in the Middle Eastern View Group and a 9 metre column of light oil below a 10 metre gas cap is present in the Upper Eastern View at Yolla.

In the Yolla and White Ibis fields, access to mature source rocks is interpreted to be provided by large displacement faults that linked the 'shallower' Eastern View Coal Measure Member reservoirs with deeper mature source rocks, the intersected Eastern View Group sediments being immature at Yolla (Yolla-1). The maximum measured Vitrinite Reflectance ($R^o$) value at Yolla-1 was 1.06% (mean 0.97) at a depth of 2731mMD, but this is near the base of a massive dolerite intrusion. The Vitrinite Reflectance ($R_o$) mean at 3028m is 0.56% (maximum reading 0.63%). Total Depth for Yolla-1 is 3351 mMD.

Gas has previously been considered the primary hydrocarbon target for the basin, but Spikey Beach was considered by Beach to represent one of the best opportunities in the basin for a commercial oil accumulation.

Very minor elevated mud gas readings were recorded within both the lower Upper Eastern View Group and upper Middle Eastern View Group at Spikey Beach-1. No hydrocarbon fluorescence was noted.

The primary source rocks in the Bass Basin are interpreted to lie within the Palaeocene Middle Eastern View Group and consist of interbedded coals (up to 25 metres thick), and fluvio-deltaic and lacustrine shales. Geochemical analyses have shown that these source rocks have generated both gaseous and liquid hydrocarbons. Deeper sediments of the Otway Group may also contribute, but little is known about this Group and they are not generally considered a primary candidate for hydrocarbon generation.

The Eastern View Group (Upper, Middle and Lower) is interpreted to reach a total thickness of in excess of 5500 metres in the centre of the basin, but thins markedly towards the basin margins. The Lower Eastern View Group remains largely unexplored and consequently unknown due to its depth of burial, but is expected to provide additional and perhaps the primary source potential for the Basin.

In undertaking a palynological analysis of the Spikey Beach-1 cuttings samples, Dr Alan Partridge (Biostrata Pty Ltd) noticed that the assemblages recovered from five samples within the Lower *N.asperus* zone (Middle Eastern View Group), were 'moderately carbonised', indicating "either the presence of a nearby igneous intrusion or the migration of superheated fluids through the Eastern View Group" (report included as **Appendix 2**). It is unlikely that the degree and extent of the abnormal heating seen within this 195 metre interval at Spikey Beach would have led to the generation of significant volumes of oil. If it had, oil shows would most likely have been noted within the upper Eastern View Group.

Neither Vitrinite Reflectance analysis nor other quantitative maturity studies were undertaken for the Spikey Beach-1 cuttings samples.

The maximum temperature recorded for Spikey Beach-1 was 65$^{O}$C at 2100m (TD). This temperature is not considered a true bottom hole temperature,

Geochemical analysis and modelling has determined that the basin-wide onset of oil generation occurs at depths of between 2500 to 3300 metres; peak generation and expulsion at deeper depths.

Mature, oil generative, Eastern View Group sediments are present within the Spikey Beach drainage area, but long distance migration, both lateral and vertical, is required to charge the Upper Eastern View sands within the Spikey Beach anticline.

In the deeper parts of the basin, Middle and Upper Eastern View Group coals are interpreted to have entered the oil generation window at the time of and following deposition of the sealing Demons Bluff Formation., i.e. after major trap forming structural events of the Late Cretaceous and Early Eocene. In shallower parts of the basin these source rock units continued to enter the oil expulsion window during and after Miocene structural reactivation events. Spikey Beach is interpreted as being a relatively late structure (Miocene), but effective trap closure would have been in place sufficiently early to capture hydrocarbons that may have migrated out of the Pelican Trough to the east.

### 5.3 Seals

Shaly facies within the Demons Bluff Formation and the overlying Torquay Group should provide a competent seal for the Upper Eastern View Group reservoirs at Spikey Beach-1. The Demons Bluff Formation comprises 88 metres of claystone which is calcareous in part. Intraformational shales within the Upper Eastern View Group and upper Middle Eastern View Group are not as well developed as were expected, but nevertheless, competent intraformational seals are interpreted to be present.

Seal was considered a primary risk for Spikey Beach-1 with two faults interpreted to be cutting through the structure, penetrating the entire Eastern View Group and dying out in the younger Lower Torquay Group. Maximum fault displacement on the primary fault is in the order of 20 metres. Small crestal faults may be more pervasive than seismic indicates and may have allowed leakage of hydrocarbons from Upper and Middle Eastern View reservoirs.

Given the complete lack of significant hydrocarbon shows and what is interpreted to be a highly competent overlying seal (Demons Bluff Formation) this is not believed to be the case, and charge remains the most plausible reason for hydrocarbons not being present at Spikey Beach.

### 5.4 Palynology

Palynological analysis was conducted on fifteen cuttings samples of the lower 865 metres of the section penetrated by Spikey Beach-1. The samples yielded moderate to high density spore - pollen assemblages from which were recorded a continuous succession of zones between the Early Oligocene and Early Eocene. Assemblages recovered from five samples within the Lower *N.asperus* zone, are of particular interest in that they were "moderately carbonised indicating either the presence of a nearby igneous intrusion of some magnitude or the migration of superheated fluids through the Eastern View Group". The report on the Palynological Analysis that was undertaken by Biostrata Pty Ltd is included in this Well Completion Report as Appendix 2.

# 6 TEMPERATURE

No wireline temperature surveys were run in Spikey Beach-1. However MWD/LWD logs recorded the following maximum temperatures:

**Table 3: Maximum Recorded Temperatures**

| Logging Tool String | Max Depth (m) | Max Temp (deg C) | Circulating Hours |
|---|---|---|---|
| ArcVision9-TeleScope-SonicVision9 | 816.0 | 23 | 19.0 |
| ArcVISION-SonicVISION-SadnVISION | 2100.0 | 65 | 48.9 |

## REFERENCES:

Blevin, J. E. (compiler) 2003. Petroleum Geology of the Bass Basin - Interpretation Report. Geoscience Australia Record 2003/19.

Cummings, A. M., Hillis, R. R. and Tingate, P. R, 2004. New perspectives on the structural evolution of the Bass Basin: implications for petroleum prospectivity. PESA Eastern Australasian Basins Symposium II, Adelaide. 133-149.

Ozimic, S., Nicholas, E., and Pain, L., 1987. Bass Basin, Tasmania and Victoria; Australian Petroleum Accumulations Report 2. Bureau of Mineral Resources.

Partridge, A.D.., 2002. Bass Basin Palynological Project. Unravelling a Late Cretaceous to Eocene geological history of large palaeolakes, coastal lagoons and marine bays. Biostrata report 2002/13 in Petroleum Geology of the Bass - Basin Interpretation Report, An Output of the Western Tasmanian Regional Minerals Program, by J.E. Blevin (Compiler), Geoscience Australia Record 2003/19.

# Appendix 1: Petrophysical Summary

# Formation Evaluation Quick Look

| | |
|---|---|
| Products: | • Interactive Petrophysics* |
| Company: | • Beach Petroleum Ltd |
| Well(s): | • Spikey Beach-1 |
| Analysis Interval: | • 1525 – 2085 m |
| Analysis Date: | • 18-September-2009 |
| Logging Date: | • 10-September-2009 (LWD) |
| Location: | • Schlumberger Data Services Centre<br>• Perth, Western Australia |
| Analyst(s): | • Peter Miklavs |
| Logging Engineer: | • Marganda Hasiholan Sihite |

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# Executive Summary

- The FEQL for Spikey Beach-1 indicates no hydrocarbon pay zones over the interpreted interval. Below is the detailed summary of the FEQL using LWD log data between 1525 – 2085m.

CUTOFF SUMMARY REPORT

Well : SPIKEY BEACH-1
Date : 09/20/2009 17:44:12

Reservoir SUMMARY

| Zn # | Zone Name | Top | Bottom | Gross | Net | N/G | Av Phi | Av Sw | Av Vcl | Phi*H | PhiSo*H |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Upper Eastern View | 1525.00 | 1870.00 | 345.00 | 270.60 | 0.784 | 0.216 | 1.000 | 0.282 | 58.51 | 0.01 |
| 2 | Middle Eastern View | 1870.00 | 2085.00 | 215.00 | 114.65 | 0.533 | 0.193 | 0.997 | 0.253 | 22.11 | 0.07 |
| | All Zones | 1525.00 | 2085.00 | 560.00 | 385.25 | 0.688 | 0.209 | 0.999 | 0.273 | 80.62 | 0.08 |

Pay SUMMARY

| Zn # | Zone Name | Top | Bottom | Gross | Net | N/G | Av Phi | Av Sw | Av Vcl | Phi*H | PhiSo*H |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Upper Eastern View | 1525.00 | 1870.00 | 345.00 | 0.00 | 0.000 | --- | --- | --- | --- | --- |
| 2 | Middle Eastern View | 1870.00 | 2085.00 | 215.00 | 0.00 | 0.000 | --- | --- | --- | --- | --- |
| | All Zones | 1525.00 | 2085.00 | 560.00 | 0.00 | 0.000 | --- | --- | --- | --- | --- |

CUTOFFS USED

| Zn # | Zone Name | Top | Bottom | Min. Height | Phi PHIE | Sw SW | Vcl VWCL |
|---|---|---|---|---|---|---|---|
| | Reservoir | | | | | | |
| 1 | Upper Eastern View | 1525.00 | 1870.00 | 0. | >= 0.1 | | <= 0.6 |
| 2 | Middle Eastern View | 1870.00 | 2085.00 | 0. | >= 0.1 | | <= 0.6 |
| | Pay | | | | | | |
| 1 | Upper Eastern View | 1525.00 | 1870.00 | 0. | >= 0.1 | <= 0.6 | <= 0.6 |
| 2 | Middle Eastern View | 1870.00 | 2085.00 | 0. | >= 0.1 | <= 0.6 | <= 0.6 |

Depth Units : m

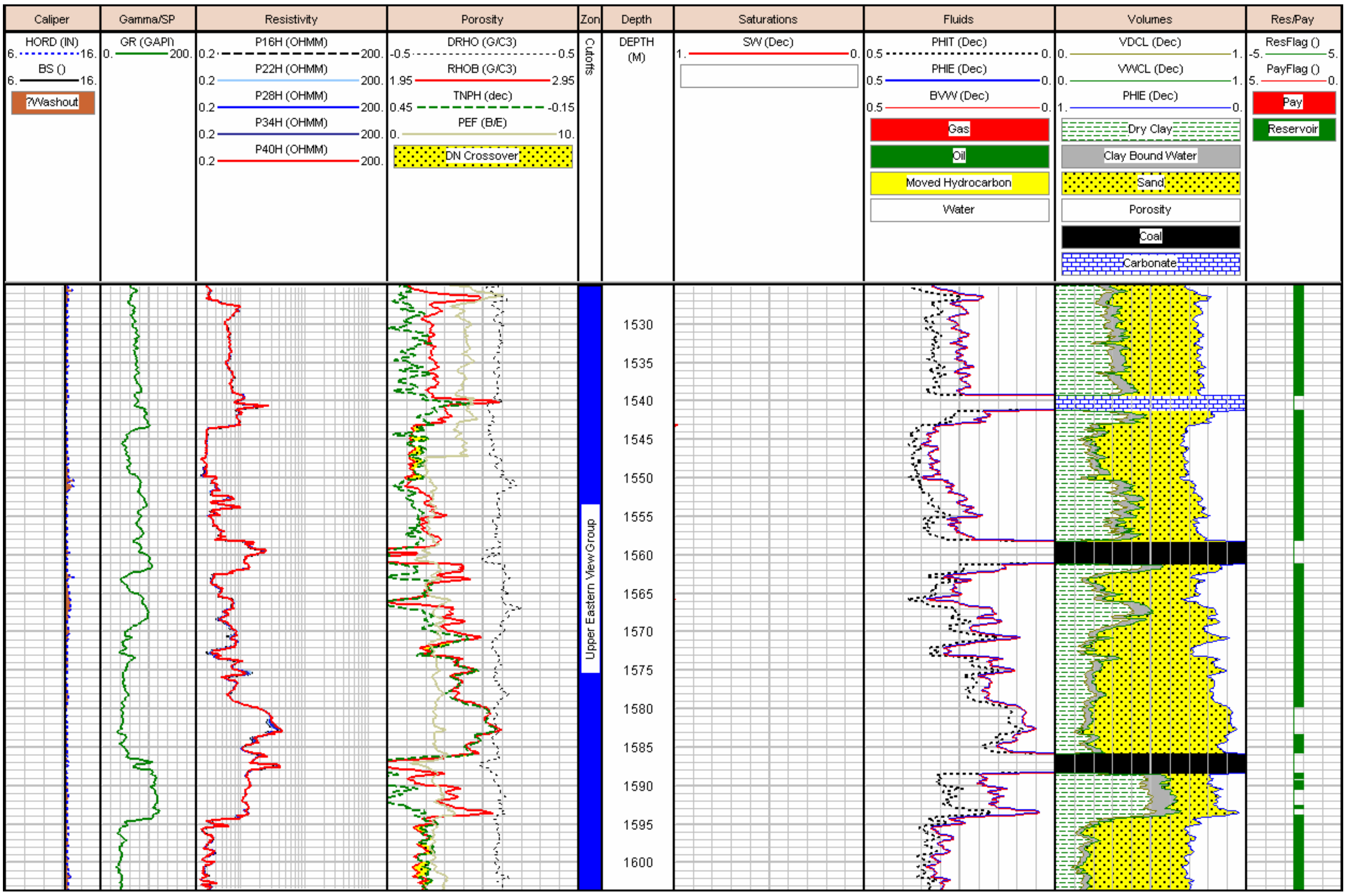


Figure 1 : Evaluation results 1525 – 1603m.

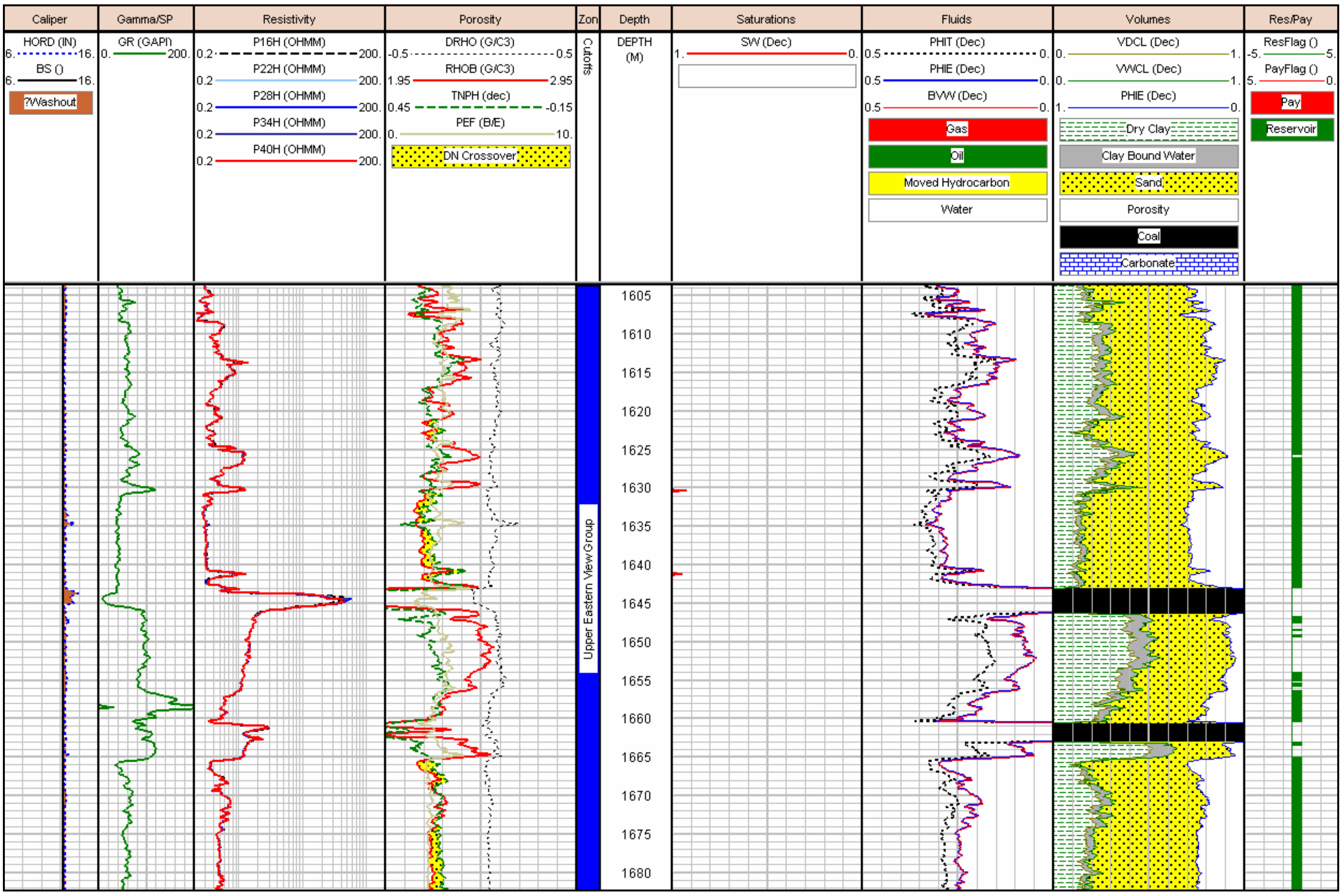

Figure 2 : Evaluation results 1604 – 1682m.

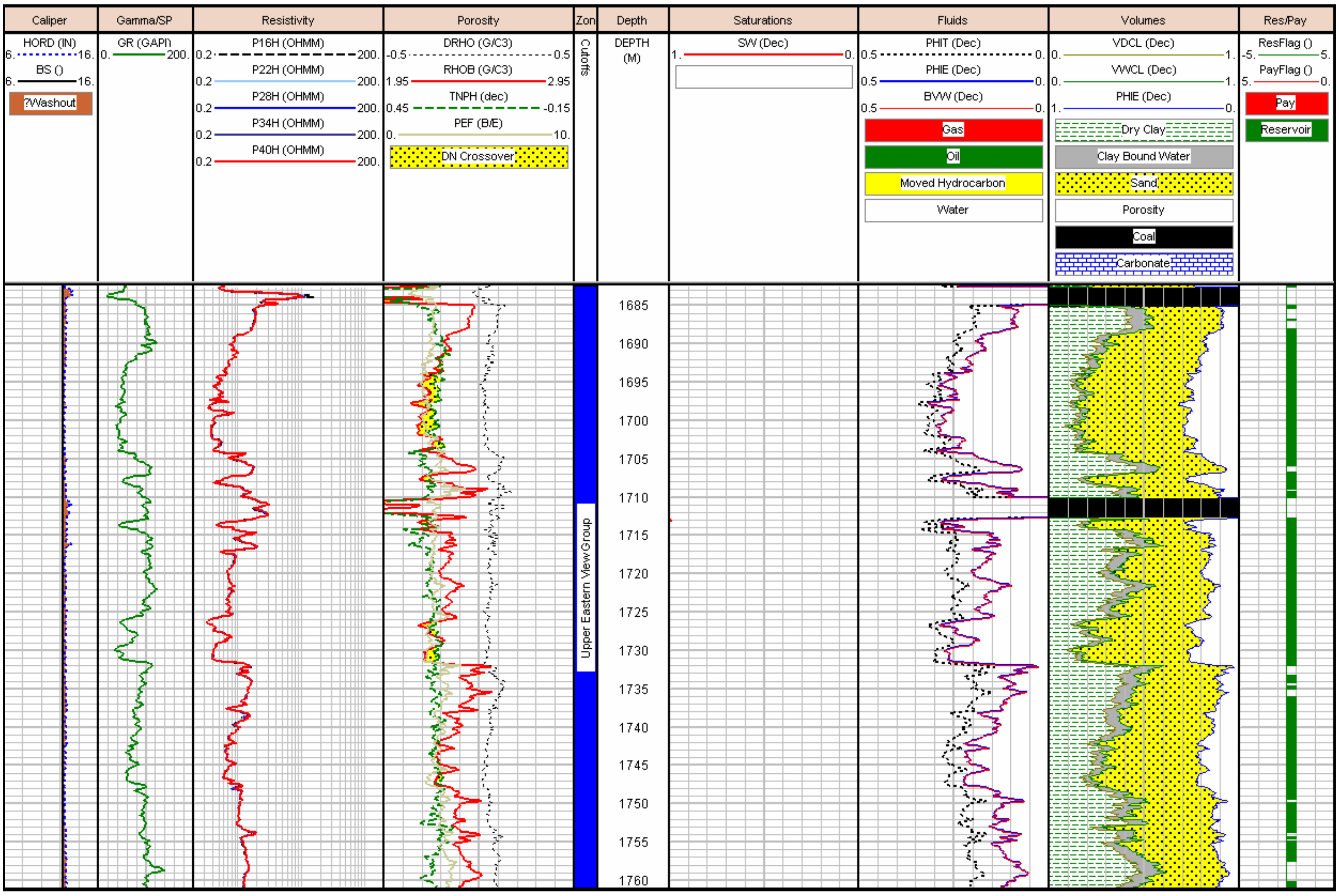

Figure 3 : Evaluation results 1682 – 1761m.

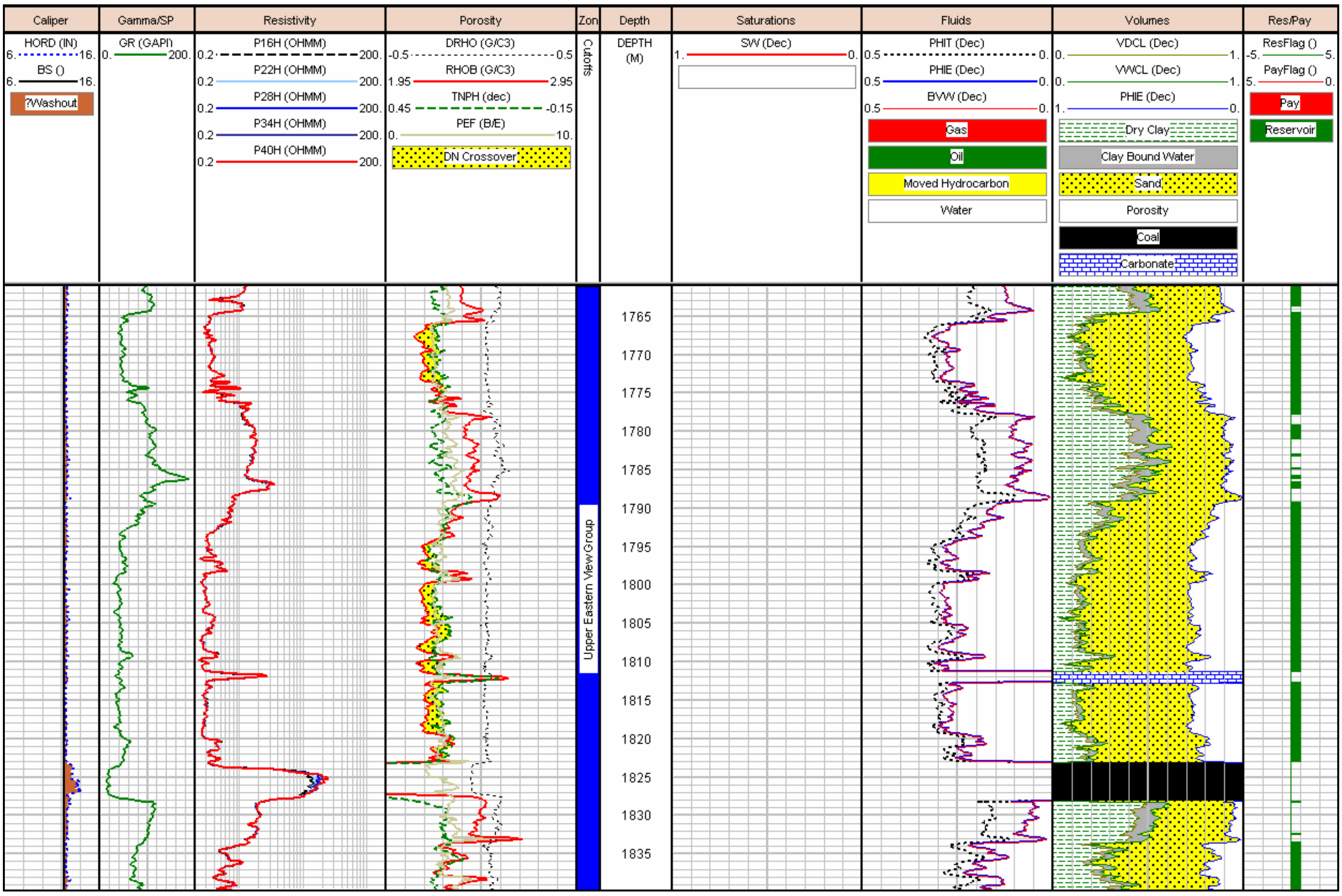

Figure 4 : Evaluation results 1761 – 1840m.

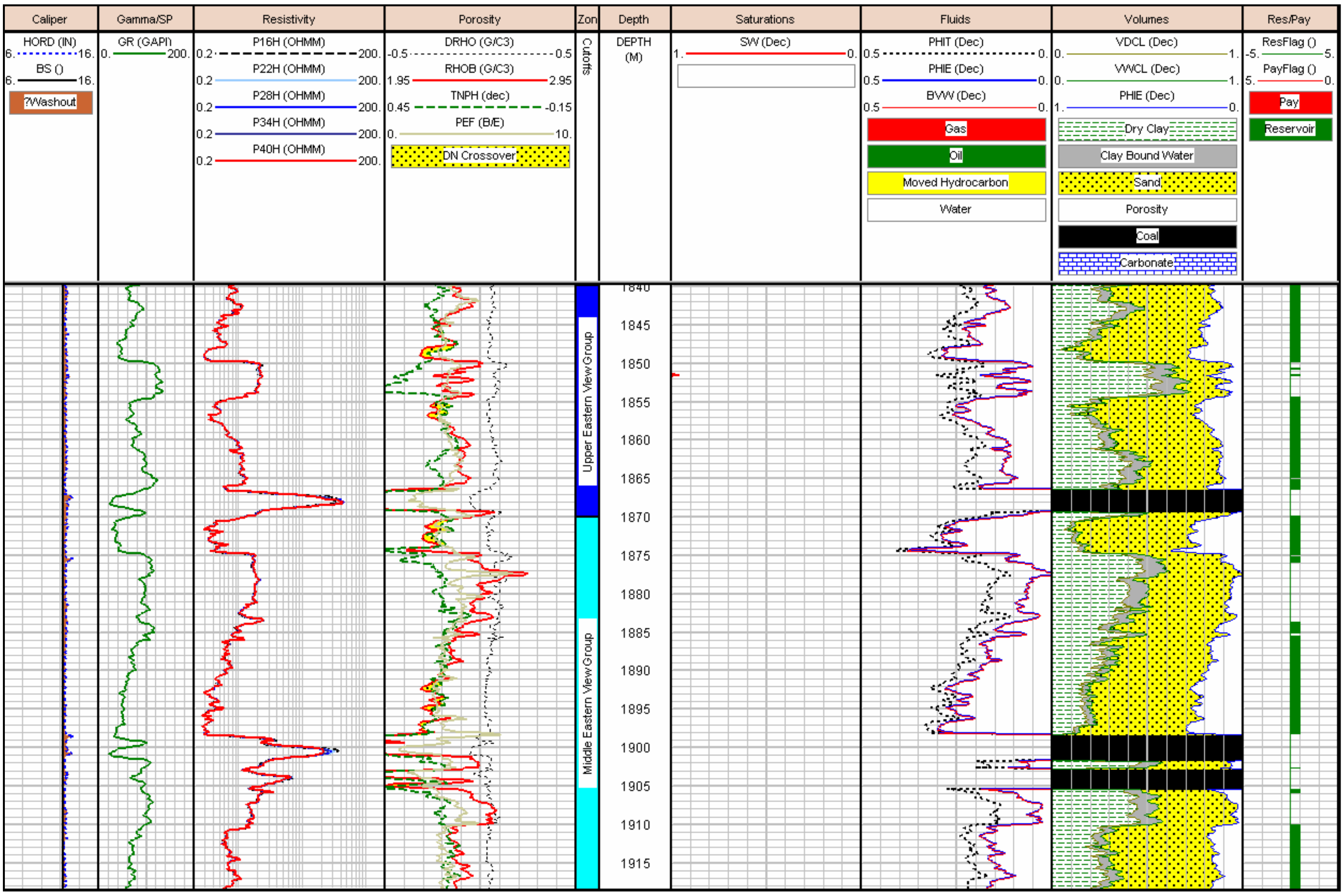


Figure 5 : Evaluation results 1840 – 1918m.

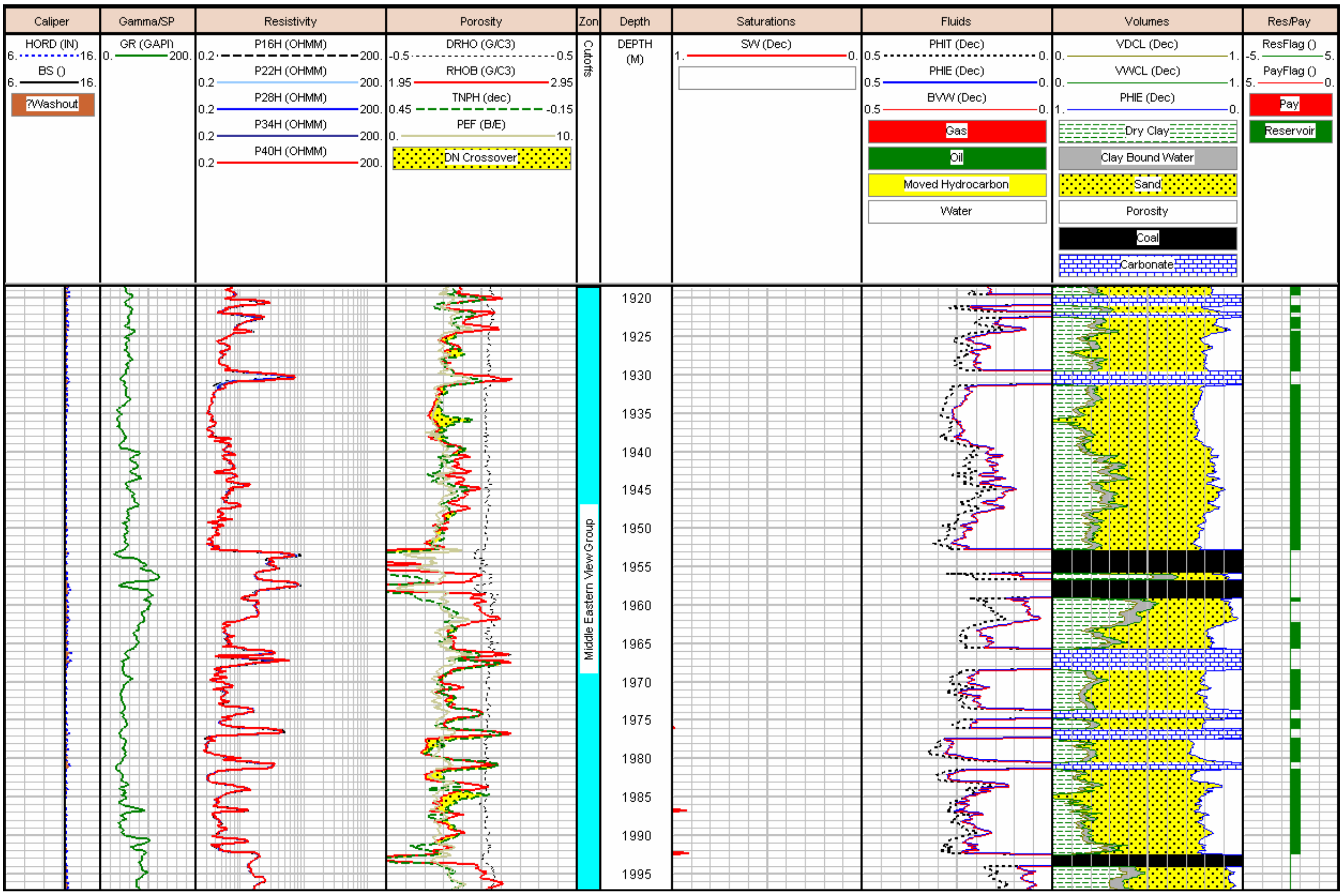

Figure 6 : Evaluation results 1918 – 1997m.

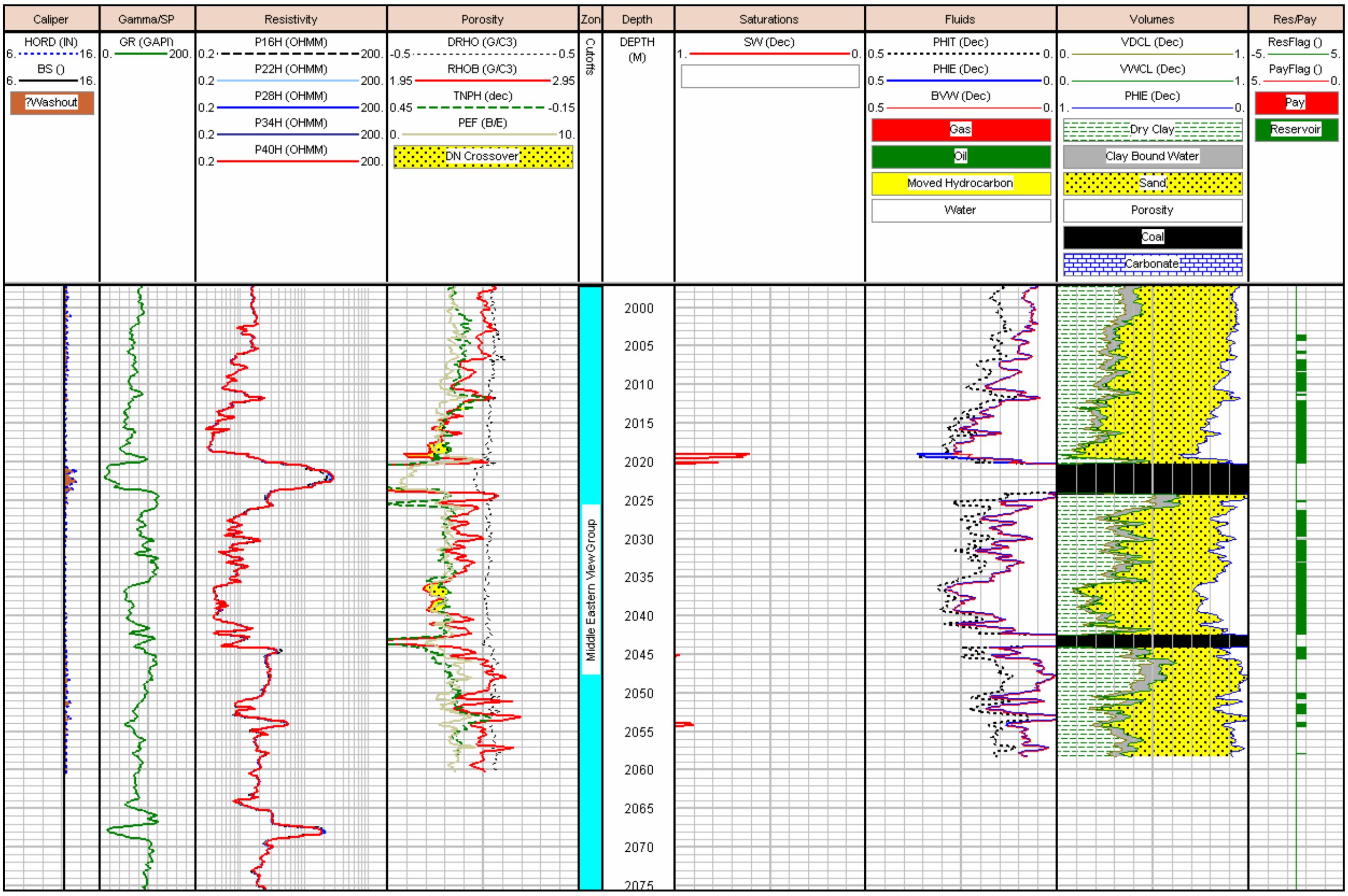

Figure 7 : Evaluation results 1997 – 2075m.

# Table of Contents

# Methodology

"Logging While Drilling" recorded mode data was used for the FEQL for Spikey Beach-1. The LWD data was analysed using the Schlumberger evaluation package, Interactive Petrophysics (IP*). This graphically interactive package uses deterministic methods to quickly evaluate acquired log data.

# Results

The FEQL for Spikey Beach-1 indicates no hydrocarbon pay zones over the interpreted interval between 1525 – 2085m.

Please refer to the "Executive Summary" or the Evaluation Graphics file (GIF format) for the plot of the entire evaluation interval.

## *General Information*

The following general information and parameters were taken from field logs and data files:

### Well Data

| | | | |
|---|---|---|---|
| Company Name | Beach Petroleum Ltd | | CN |
| Well Name | Spikey Beach-1 | | WN |
| Field Name | Exploration | | FN |
| Rig: | Ocean Patriot | | CLAB, COUN |
| State: | Tasmania | | SLAB, STAT |
| Nation | Australia | | NATI |
| Field Location | Exploration | | FL |
| Longitude | 145 52' 24.71"E | | LONG |
| Latitude | 40 28' 53.90"S | | LATI |
| Elevation of Drill Floor | 21.5 | | EKB |
| Elevation of Ground Level | -74.0 | | EGL |
| Permanent Datum | MSL | Elevation of Permanent Datum 0.0 (m) | PDAT, EPD |
| Log Measured From | DF | Above Permanent Datum 21.5 (m) | LMF, APD |
| Drilling Measured From | DF | | DMF |

Absent Valued Parameters: CN1, CONT, FL1, FL2, SECT, TOWN, RANG, APIN, SON, EDF

### Job Data

| | | |
|---|---|---|
| Date as Month-Day-Year | 10-Sept-2009 | DATE |
| Run Number | 2 | RUN |
| Total Depth - Driller | 2100.4 (m) | TDD |
| Total Depth - Logger | 2100.4 (m) | TDL |
| Bottom Log Interval | 2085.0 (m) | BLI |
| Top Log Interval | 803.0 (m) | TLI |
| Casing Outer Diam. | 13.4 (in) | CSIZ |
| Bit Size | 12.25 (in) | BS |

| | | | |
|---|---|---|---|
| End Log Date | 13-Sept-2009 | | |
| Logging Unit No. | OLU-KC-0702 | | |
| Engineer's Name | Marganda Hasiholan Sihite | | ENGI |

Absent Valued Parameters: CDF, CADT, CASG, BSDF, BSDT, SON , RMB, RMFB

### Mud Data

| | | | |
|---|---|---|---|
| Drilling Fluid Type | WBM Polymer | | DFT |
| Drilling Fluid Density | 9.0 (lbm/gal) | Drilling Fluid Viscosity 43.0 (s) | DFD, DFV |
| Drilling Fluid PH | 9.0 | | DFL, DFPH |
| Mud Sample Source | Active Tank | | MSS |
| Resistivity of Mud Sample | 0.07 (ohm.m) | Mud Sample Temperature 22.4 (degC) | RMS, MST |
| Resistivity of Mud Filtrate Sample | 0.69 (ohm.m) | Mud Filtrate Sample Temperature 22.8 (degC) | RMFS, MFST |
| Resistivity of Mud Cake Sample | 0.08 (ohm.m) | Mud Cake Sample Temperature 20.1 (degC) | RMCS, MCST |
| Resistivity of Mud - BHT | 0.03 (ohm.m) | | RMB |
| Resistivity of Mud Filtrate - BHT | 0.03 (ohm.m) | | RMFB |
| Maximum Recorded Temperature | 68.0 (degC) | | MRT |

Absent Valued Parameters: MRT2, MRT3

## *Log Quality*

The LWD logs over the zones of interest are of good quality. The caliper used in the final presentation is only for qualitative use.

## *Environmental Corrections*

Gamma Ray is corrected for mud weight, tool size and bit size.

All corrections for neutron were done in the field, excluding formation salinity. This was computed inside the evaluation software (IP), as it is dependent on saturations.

Borehole corrections were done in the field for the ARC resistivity measurements. Shoulder bed corrections were not done.

## *Rt Determination*

ARC phase shift resistivity 40 inch spacing at 2Mhz (P40H) was used for true resistivity (Rt) in Spikey Beach-1.

## Rw Determination

The Rw's were interpreted from the logs.

## Vclay Determination

Vclay was determined from the minimum of GR and Density-Neutron indicators.

```
CLAY VOLUME PARAMETERS

Well :  SPIKEY BEACH-1
Date :  09/20/2009 17:44:03

   Input Curves
Gamma Ray          : GR                        Neu/Den Density    : RHOB
Neu/Den Neutron    : TNPH
   Output Curves
Vclay Gamma Ray    : VCLGR                     Vclay Neu/Den      : VCLND
Vclay minimum      : VCL                       Vclay average      : VCLAV

   Zone number 1   Top :  1525.00  Bottom :  1870.00
Gr Use          : Yes         Gr Clean        : 15.         Gr Clay         : 180.
Gr Method       : Linear      ND Use          : Yes         ND Neu Clay     : 0.433
ND Den Clay     : 2.443       ND Den Clean1   : 2.65        ND Den Clean2   : 2.009
ND Neu Clean1   : -0.04       ND Neu Clean2   : 0.298       Link PhiSw Clay : Yes

   Zone number 2    Top :  1870.00  Bottom :  2085.00
Gr Use          : Yes         Gr Clean        : 15.         Gr Clay         : 180.
Gr Method       : Linear      ND Use          : Yes         ND Neu Clay     : 0.433
ND Den Clay     : 2.443       ND Den Clean1   : 2.65        ND Den Clean2   : 2.009
ND Neu Clean1   : -0.04       ND Neu Clean2   : 0.298       Link PhiSw Clay : Yes
```

## Lithology Determination

Lithology was assumed to be sand and clay, using the parameters above.

Carbonates were interpreted manually in zones where the density and PEF goes high, neutron porosity goes low, resistivity goes high and compressional slowness decreases.

Coal was manually interpreted in zones where the density goes low, neutron and DT goes high and Resistivity goes high.

## Saturation

Saturation was calculated using the Archie equation:

1/Rt = Phi**m.Sw**n / (a.Rw)

Cementation exponent "m" is the Shell equation in the IP software. "m" increases with decreasing PHIE.  The saturation exponent "n" is 1.9.

## Porosity

Porosity is calculated using the neutron-density in the IP software.

## Cutoff

Cutoffs used for net pay are:

Vclay < 60%, PHIE > 10% and Sw < 60% was used

### *Assumptions*

1. Mineral model of sand, clay.
2. m is assumed to be variable and n assumed to be 1.9

# Deliverables

## Main Outputs

The following main outputs were delivered with the digital data:

```
#MNEM          UNIT      API CODE   Description
#---------- --------- ----------   -----------
 DEPTH     .M                    :
 BVW       .Dec                  : Bulk Volume water (Phie x SW)
 BVWSXO    .Dec                  : Bulk Volume water Invaded Zone (Phie x Sxo)
 PayFlag   .                     : Pay Flag
 PayH      .                     : Pay Height
 PHIE      .Dec                  : Effective Porosity
 PHIT      .Dec                  : Total Porosity
 ResFlag   .                     : Reservoir Flag
 ResH      .                     : Reservoir Height
 SW        .Dec                  : Water Saturation
 SWT       .Dec                  : Total Water Saturation
 SXO       .Dec                  : Saturation Invaded Zone
 SXOT      .Dec                  : Total Saturation Invaded Zone
 VCL       .Dec                  : Clay Volume
```

The following deliverables are produced from this processing:

1. Evaluation report (PDF)
2. Evaluation graphics, 1:500 (GIF),
3. LAS outputs of evaluation
4. Cutoffs and evaluation parameters (TXT)

# Evaluation Parameters

The following parameters were used for the interpretation:

```
POROSITY WATER SATURATION PARAMETERS

Well :  SPIKEY BEACH-1
Date :  09/20/2009 17:44:08

   Input Curves
Neutron          : TNPH                      Density          : RHOB
PEF              : PEF                       Clay Volume      : VCL
Rt               : P40H                      Temperature      : Temp
Non Calc. flag   : NO_PAY_US2
   Output Curves
Phi Total        : PHIT                      Phi effective    : PHIE
Sw               : SW                        Sw unlimited     : SWU
Sw total         : SWT                       Sw total unlim   : SWTU
Sxo total        : SXOT                      Sxo total unlim  : SXOTU
Bulk vol water   : BVW                       Wet clay volume  : VWCL
Dry Clay volume  : VDCL                      Bound water sat  : SWB
Volume silt      : VSILT                     Logic flag       : PHIFLAG
Matrix density   : RHOMA                     Coal Volume      : VCOAL
Salt volume      : VSALT                     Hydrocarbon den  : RHOHY
```

| | | | |
|---|---|---|---|
| Mineral 1 Volume | VSand | Mineral 2 Volume | VLime |
| Mineral 3 Volume | VDol | Rho Mat apparent | RHOMAPP |
| U Mat apparent | UMAPP | Kill Anal. Flag | KillFlag |

Multi-mineral analysis
3 mineral used : Sand Lime Dol

Zone number 1 Top : 1525.00 Bottom : 1870.00

| | | | | | |
|---|---|---|---|---|---|
| Rw | 0.0762 | Rw Temp | 68. | Rmf | 0.0694 |
| Rmf Temp | 22.8 | Rho Sxo zone | | Salin Sxo zone | |
| Rho Wet Clay | 2.443 | Rho Dry Clay | 2.78 | Neu Wet Clay | 0.433 |
| Hc Den | 0.8 | Neu Hc HI | | Den Hc app | |
| GD source | Mlt-Mins | Rho GD | 2.65 | Rho GD max | 2.95 |
| Rho GD min | 2.51 | Neu Form Sal | Yes | Neu Log Cont | Schlumb |
| Neu Tool Type | CNL | Porosity Method | Neu Den | Variable Hc Den | No |
| Variable GD | Yes | Variable Vcl | No | Mineral Model | ss/ls/dol |
| OBM ? | No | Phi max | 0.3 | Delta Phi max | 0.15 |
| m vari wth Vcl | No | Vcl cutoff | 0.6 | Sat Equation | Archie |
| a factor | 1. | m exponent | 1.8 | n exponent | 1.9 |
| Invasion factor | 2. | Sxo Method | Inv Fac | m source | Shell |
| n source | Param | Coal Logic | No | Salt Logic | No |
| PhiT Clay | | Model Type | Sand | Sand Umat | 4.8 |
| Lime Umat | 13.8 | Dol Umat | 9. | Sand RhoMat | 2.65 |
| Lime RhoMat | 2.71 | Dol RhoMat | 2.85 | Sand Rho True | 2.65 |
| Lime Rho True | 2.71 | Dol Rho True | 2.85 | Clay Corr Input | Yes |
| Sand Clay ? | No | Lime Clay ? | No | Dol Clay ? | No |
| Pef Clay | 3. | Phie Sw Limit | 0. | Phie Limit | 0. |
| Vcl Limit | 1. | Kill Logic | No | Link Clay Vol | Yes |
| Swi Limit | 0. | | | | |

Zone number 2 Top : 1870.00 Bottom : 2085.00

| | | | | | |
|---|---|---|---|---|---|
| Rw | 0.0762 | Rw Temp | 68. | Rmf | 0.0694 |
| Rmf Temp | 22.8 | Rho Sxo zone | | Salin Sxo zone | |
| Rho Wet Clay | 2.443 | Rho Dry Clay | 2.78 | Neu Wet Clay | 0.433 |
| Hc Den | 0.8 | Neu Hc HI | | Den Hc app | |
| GD source | Mlt-Mins | Rho GD | 2.65 | Rho GD max | 2.95 |
| Rho GD min | 2.51 | Neu Form Sal | Yes | Neu Log Cont | Schlumb |
| Neu Tool Type | CNL | Porosity Method | Neu Den | Variable Hc Den | No |
| Variable GD | Yes | Variable Vcl | No | Mineral Model | ss/ls/dol |
| OBM ? | No | Phi max | 0.3 | Delta Phi max | 0.15 |
| m vari wth Vcl | No | Vcl cutoff | 0.6 | Sat Equation | Archie |
| a factor | 1. | m exponent | 1.8 | n exponent | 1.9 |
| Invasion factor | 2. | Sxo Method | Inv Fac | m source | Shell |
| n source | Param | Coal Logic | No | Salt Logic | No |
| PhiT Clay | | Model Type | Sand | Sand Umat | 4.8 |
| Lime Umat | 13.8 | Dol Umat | 9. | Sand RhoMat | 2.65 |
| Lime RhoMat | 2.71 | Dol RhoMat | 2.85 | Sand Rho True | 2.65 |
| Lime Rho True | 2.71 | Dol Rho True | 2.85 | Clay Corr Input | Yes |
| Sand Clay ? | No | Lime Clay ? | No | Dol Clay ? | No |
| Pef Clay | 3. | Phie Sw Limit | 0. | Phie Limit | 0. |
| Vcl Limit | 1. | Kill Logic | No | Link Clay Vol | Yes |
| Swi Limit | 0. | | | | |

# Appendix 2: Palynological Analysis of cuttings samples

# INTERPRETATIVE DATA.

# Palynological analysis of cuttings samples between 1236-48 and 2079-85 metres in Spikey Beach-1, Bass Basin.

**by**

**Alan D. Partridge**

**Biostrata Pty Ltd**

**A.B.N. 39 053 800 945**

**Biostrata Report 2010/01A**

**12th January 2010**

# INTERPRETATIVE DATA.
# Palynological analysis of cuttings samples between 1236-48 and 2079-85 metres in Spikey Beach-1, Bass Basin.

**by Alan D. Partridge**

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# INTERPRETATIVE DATA.
# Palynological analysis of cuttings samples between 1236-48 and 2079-85 metres in Spikey Beach-1, Bass Basin.

**by Alan D. Partridge**

## Summary

Fifteen cuttings samples have been analysed from the bottom 864 metres penetrated in the offshore Spikey Beach-1 well drilled by Beach Petroleum Ltd in permit T/38P in the Bass Basin. The samples gave moderate to high diversity spore-pollen assemblages from which were identified a continuous succession of spore-pollen zones between the Early Oligocene and Early Eocene, with the shallowest sample no younger than the Lower *Proteacidites tuberculatus* Zone and the deepest no older than the Middle *Malvacipollis diversus* Zone. Moderate diversity microplankton assemblages were recorded through the Demons Bluff Group, with the *Fromea leos* Zone, *Phthanoperidinium comatum* Acme, *Stoveracysta kakanuiensis* Zone and *Deflandrea heterophlycta* Zone identified. In contrast, *in situ* microplankton are rare through the older Eastern View Group and only the *Homotryblium tasmaniense* Zone was identified near the base of the well. These palynological results are merged with the cuttings lithologies and electric logs to subdivide the succession according to the latest stratigraphic terminology (Table 1). Assemblages recovered from the five samples between 1590 and 1785m are noteworthy as the spore-pollen are moderately carbonized suggesting either the presence of a nearby igneous intrusion, or migration of superheated fluids through the Eastern View Group. Spore-pollen recovered from the underlying samples between 1851 and 2085m are not carbonized and this deeper interval is immature.

**Table 1. Summary of palynological zones and stratigraphy in Spikey Beach-1.**

| Age | STRATIGRAPHY<br>Lennon *et al.* (1999) | STRATIGRAPHY<br>Partridge (2002c) | | Spore-Pollen Zones (Microplankton Zones) | Depths mKB |
|---|---|---|---|---|---|
| **Early Oligocene** | **TORQUAY GROUP** | **DEMONS BLUFF GROUP** | **Angahook Formation**<br>1070 to 1343m | Lower *P. tuberculatus* Zone<br>(*F. leos* Zone) | at 1236-48m†<br>(at 1236-48m†) |
| **Early Oligocene** | | | **Squid Sandstone**<br>1343 to 1392m | Upper *N. asperus* Zone<br>(*P. comatum* Acme) | at 1353-62m†<br>(at 1353-62m†) |
| **Late Eocene** | **Demons Bluff Formation** | | **Anglesea Formation**<br>1392 to 1478m | Middle *N. asperus* Zone<br>(*S. kakanuiensis* Zone) | 1407 to 1470m<br>at 1407-16m† |
| **Late Eocene** | **Upper EASTERN VIEW COAL MEASURES** | | **Boonah Formation**<br>1478 to 1549.5m | Lower *N. asperus* Zone<br>(*D. heterophlycta* Zone) | at 1533-36m†<br>(at 1533-36m†) |
| **Middle Eocene** | | **EASTERN VIEW GROUP** | **Poonboon Formation**<br>1549.5 to 1704m | Lower *N. asperus* Zone | 1590 to 1713m |
| **Early Eocene** | | | **Cormorant Formation**<br>1704 to 2100mTD | *P. asperopolus* Zone<br>Indeterminate samples<br>*P. asperopolus* to Upper *M. diversus* Zones<br>Upper *M. diversus* to Middle *M. diversus* Zones<br>(*H. tasmaniense* Zone) | at 1710-13m†<br>1761 to 1785m<br>1851 to 1953m<br>2037 to 2085m<br>(at 2037-43m†) |

† Depths cited are the top & base of single cuttings samples.

# Introduction

Palynological analysis has been conducted on fifteen cuttings samples over the bottom 864 metres of the Cenozoic succession penetrated in the Spikey Beach-1 well drilled by Beach Petroleum Ltd in permit T/38P in the offshore Bass Basin. The objective of the study was to provide age dating of the succession penetrated using palynology.

A summary of the palynological zones, stratigraphic formations and ages determined in Spikey Beach-1 is provided in Table 1. Zones assignments, zone confidence ratings, and zone identification criteria for individual samples are provided in Table 2. Basic assemblage data comprising the visual yields and palynomorph concentrations on the slides, the preservation of the palynomorphs, and the number of species of spore-pollen and microplankton recorded from individual samples are given in Table 3. Basic sample data comprising the lithologies and weights of samples processed are provided in Table 4. All palynological slides prepared are listed in Table 5. Finally, the distribution of all species identified are plotted on the accompanying StrataBugs™ range chart.

***Materials and Methods:*** The cuttings samples analysed were selected and forwarded by geologists at Beach Petroleum Ltd directly to Core Laboratories Australia Pty Ltd, in Perth, for laboratory processing. The prepared palynological slides were received by the author on 15$^{th}$ December 2009. Initial results of their microscope analysis were provided in a Provisional Palynological Report issued on the 28$^{th}$ December 2009.

The Spikey Beach-1 well was drilled using the KCl-PHPA-Polymer drilling mud additive, and because this additive has previously caused difficulties with the laboratory extraction of the palynomorphs (resulting in low concentrations and poor palynomorph preservation on the microscope slides), some modifications to the industry standard processing procedure have been employed. Firstly, larger quantities of sample (51 to 53 grams) were selected and then subjected to an initial soaking and washing in a detergent/solvent to dilute and remove the polymer mud additive. Secondly, as an extra precaution, the samples were all processed using a modification of the standard processing stream whereby the dispersed organic-matter (kerogen) and any undissolved mineral matter remaining after the initial dissolution of the samples in hydrofluoric acid are oxidised with nitric acid **before** the density separation using zinc bromide solution. This modified procedure was specified to counteract processing difficulties caused by the impregnation of the palynomorphs with micron-size pyrite crystals, and any residual effects of the polymer drilling mud additive. Finally, based on experience gained from the recent analysis of other recent wells the amount of oxidation given to the residues was increased, with 3:00 minutes duration given to the shallowest seven samples, and 4:00 minutes applied to the deepest eight samples.

The microscope analysis consisted of an initial count of approximately 150 palynomorphs to determine the proportion of spores and pollen to all types of organic-walled microplankton, as well as the relative proportions of spores, gymnosperm pollen and angiosperm pollen, within this count. Once these initial proportions were established and separately recorded, the slides were further scanned to record rare species, and some extra counts made of the microplankton species.

***Results:*** An average of 52 grams per sample was processed to give moderate to high organic-residue yields. The concentration of the palynomorphs in the residues, based on examination of the prepared slides, is mostly moderate to high, with the carbonized samples containing the lowest palynomorph concentrations. The preservation of palynomorphs is variable on most slides, typically poor to fair, to occasionally poor to good. Most palynomorphs recovered from the five samples between 1590 and 1785m are carbonized with poor to very poor preservation. Across all samples the diversity of spores and pollen was moderate to high ranging from 18 to 66 species per sample (average 38+ species). In contrast, the diversity of *in situ* microplankton is low to high from the five shallowest samples from the Demons Bluff Group (range 4 to 26 species, average 14 species), but very low in the ten samples from the Eastern View Group (zero to 2 species). However, all samples from the latter group contain Oligocene to Miocene microplankton species interpreted to be caved from the uppermost Demons Bluff and Torquay groups.

***Description of Range Chart:*** The palynomorphs identified in the samples are documented on the accompanying StrataBugs™ range chart which displays the recorded species proportional to the sample depths, and in terms of either their percentage or absolute abundances. The palynomorphs recorded are also split between different groups. The first biostratigraphic panel on the chart is for the categories of spore-pollen, comprising the sum of all angiosperm-pollen, gymnosperm-pollen, and spores in the initial count. The next three panels labelled Spores, Gymnosperms Pollen and Angiosperm Pollen display the percentage abundances of the individual species within these three categories. The following panel for categories of microplankton (labelled MP%) displays the percentage abundance of selected groups of organic-walled microplankton, and is followed by a panel for individual Microplankton species. The latter are expressed as absolute abundance as many MP specimen counts are too low to meaningfully display this data as percentage abundance. The final panel is for all Other palynomorph categories and species, and these are expressed as their percentage abundance of the total Spore-Pollen and all Other palynomorphs in the count. The following codes or abbreviations apply to the individual species occurrences and abundances on the range chart:

| | | |
|---|---|---|
| Numbers | = | Percentage or Absolute abundances |
| + | = | Species outside of count |
| C | = | Caved species |
| R | = | Reworked species |
| ? | = | Questionable identification of species. |

Author citations for most of the recorded spore-pollen species can be sourced from the papers by Dettmann (1963), Dettmann & Playford (1968), Helby *et al.* (1987), Macphail (1999), Partridge (1973) and Stover & Partridge (1973), while the author citations for the microplankton species can be sourced from the indexes for dinocysts and other organic-walled microplankton prepared by Fensome *et al.* (1990) and Williams *et al.* (1998). Manuscript species names and combinations are indicated by “sp. nov.” or “comb. nov.” on the range charts.

Additional panels on the left side of the chart provide a depth scale, columns for the suggested stratigraphy according to Lennon *et al.* (1999) and Partridge (2002c), a lithological profile, selected electric logs, and the identified spore-pollen and microplankton zones. Picks for the palynological zone boundaries are wherever possible the actual samples analysed, but sometimes arbitrary log depths need to be added between samples so there is sufficient space available in the columns for the zone names to be legibly printed on the charts. The lithological profile is plotted in terms of the percentages of "coal", "shale", "silt", and "sand" derived from the detailed cuttings descriptions. This display uses the electric log plotting function within the StrataBugs™ program, which only allows four curves (ie. lithologies) to be plotted in a single panel, and only provides a restricted selection of colours. Notwithstanding these limitations the resultant panel displays an approximate sand**:**shale ratio, which are far more informative than what can be achieved by using the program’s standard graphical procedure for displaying lithologies. Note also that the "shale" category represents the sum of all the fine-grained mudstone, claystone, and carbonate lithologies in the cuttings descriptions over the interval displayed.

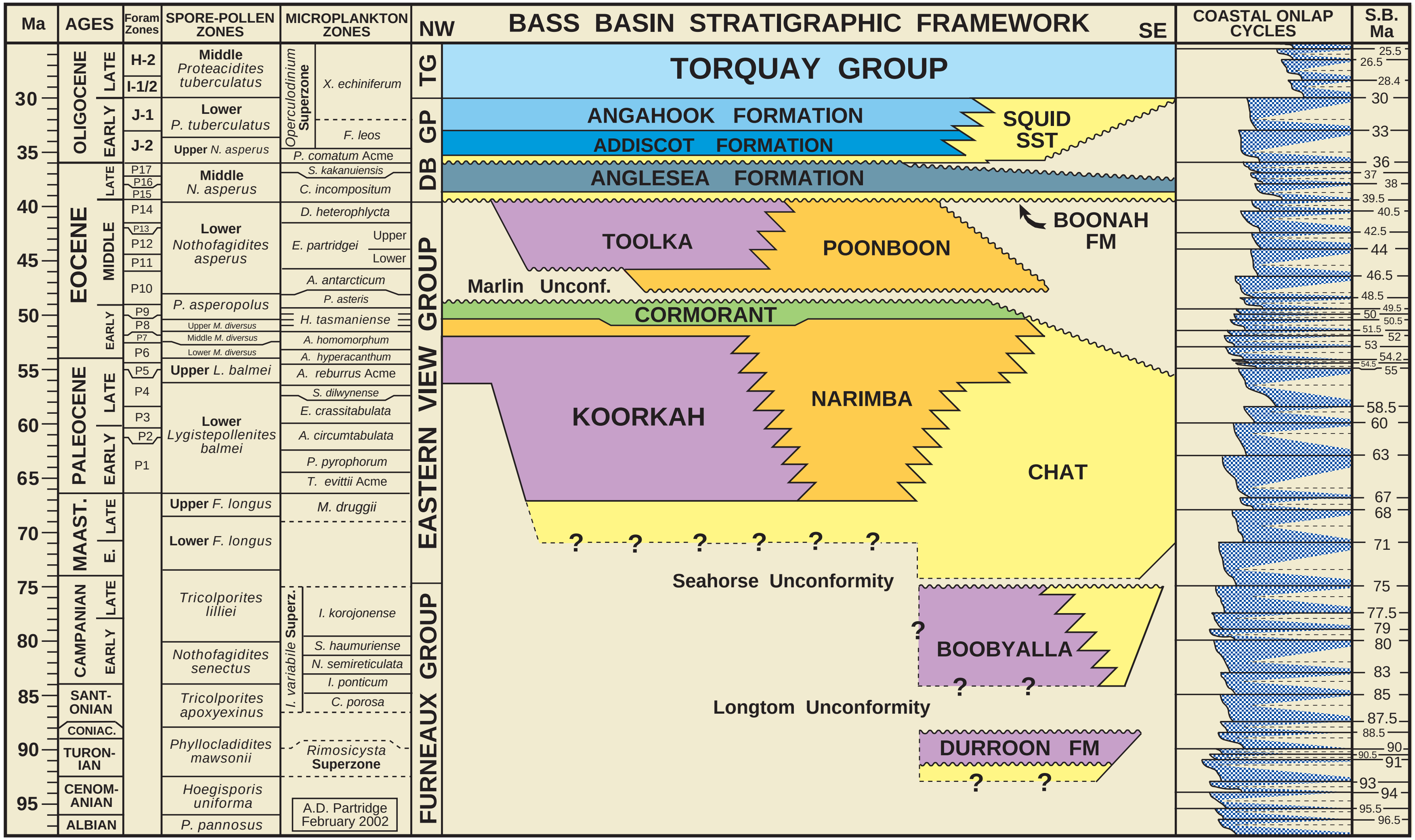


**Figure 1.** Stratigraphic framework for Bass Basin proposed by Partridge (2002c). Palynological and foraminiferal zones correlated to timescale of Haq *et al*. (1987). Demons Bluff Group abbreviated to DB GP, and Torquay Group to TG. Except for those labelled as formations new unit names are informal, as is Furneaux Group.

## Geological Comments

The section analysed in Spikey Beach-1 extends from below the marine carbonates to the TD of the well at 2100mMD. Table 1 provides a stratigraphic subdivision of this nearly 1000 metres of open hole section according to both the generalised terminology of Lennon *et al.* (1999; fig.3), and the more recent and detailed stratigraphy proposed by Partridge (2002c; fig.3). The latter scheme is outlined in Figure 1. This stratigraphic diagram was first published as figure 4.3 *in* Blevin (2003). In the following discussion the stratigraphic units recognised in Spikey Beach-1 are described in descending stratigraphic order, according to the new group and formation nomenclature advocated by Partridge (2002c), with reference made to the earlier scheme of Lennon *et al.* (1999) where that is appropriate.

### TORQUAY GROUP

The Torquay Group, in the sense originally proposed by Raggatt & Crespin (1955) and adopted by Partridge (2002c), can be identified from the cuttings descriptions available from Spikey Beach-1 as the interval of calcarenites and calcareous siltstones and claystones extending from the base of the 13-3/8 casing shoe at ~806m to about 1070m. This part of the open hole section was not analysed for palynomorphs, but based on caved fossils recovered in deeper cuttings it is presumed to be Late Oligocene to Early Miocene in age.

It needs to be acknowledged that this concept of the Torquay Group differs from common usage in the Bass Basin, as exemplified by the stratigraphic nomenclature of Lennon *et al.* (1999). Under the latter concept the Torquay Group includes the Bass Basin equivalents of the Angahook and Addiscot members of the underlying Demons Bluff Formation as defined by Raggatt & Crespin (1955). In Spikey Beach-1, the equivalent section is identified as the Angahook Formation and Squid Sandstone and is included in the Demons Bluff Group.

### DEMONS BLUFF GROUP

Originally defined as the Demons Bluff Formation by Raggatt & Crespin (1955) in the coastal outcrops in the Torquay Sub-basin, this unit was later raised to the rank of group by Holdgate *et al.* (2001), and extended to incorporate the underlying Boonah Formation. The latter terminology was then adopted and extended to the much larger Bass Basin by Partridge (2002c). Four formation are identified in this group in Spikey Beach-1 and these are discussed below in order of increasing stratigraphic age. The "Demons Bluff Formation" as recognised by Lennon *et al.* (1999) is equivalent to just the Anglesea Formation (Table 1).

***Angahook Formation — 1070 to 1343 metres:*** The top of this formation is picked at the change from calcareous claystones and calcarenites, to brown to dark grey claystones and siltstones, occurring at 1070m in the cuttings descriptions. Unfortunately, there is no obvious equivalent change or break on the electric logs. The base of the unit would normally be placed at the incoming or top of the brown-grey sandstones in the cuttings descriptions at 1290m. However, in Spikey Beach-1 his lower boundary has been moved down to 1343m to tie with a more significant break on both the gamma ray and density/porosity electric logs. The one cuttings sample analysed from the Angahook Formation at 1236-48m gave a good Early Oligocene assemblage assigned to the Lower *P. tuberculatus* spore-pollen Zone and *Fromea leos* microplankton Zone. This age is consistent with this author’s understanding of the onshore type section of the formation and the ages obtained from equivalent sections in other wells. This unit could grade into the older Addiscot Formation, but as no clear lithological break can be identified in the cuttings descriptions it is considered more appropriate to equate the latter unit with the underlying Squid Sandstone.

***Squid Sandstone — 1343 to 1392 metres:*** The Squid Sandstone is identified in Spikey Beach-1 as an interval of lower gamma ray readings, reduced separation on the density/porosity logs, and 15 to 25% brown-grey sandstones in the cuttings descriptions. The cuttings at 1353-62m from this unit gave a good Early Oligocene assemblage assigned to the Upper *N. asperus* spore-pollen Zone and *Phthanoperidinium comatum* microplankton Acme.

***Anglesea Formation — 1392 to 1478 metres:*** The interval of predominantly brownish-black claystones in the cuttings descriptions between 1398 and 1476m (adjusted to 1392 to 1478m on the electric logs) is considered typical of the Anglesea Formation. Most previous papers on the basin, including Lennon *et al.* (1999), would equate this interval with the entire Demons Bluff Formation, in the Torquay Sub-basin. The two samples analysed from this formation gave poorly preserved assemblages that are assigned to the Middle *N. asperus* Zone with very low confidence. This is consistent with the results from other wells in the basin, as this organic-rich facies often gives poor results. The *Stoveracysta kakanuiensis* microplankton Zone identified in the shallower sample at 1407-16m has previously been found at the top of the Anglesea Formation in Squid-1 (Partridge, 2002b; 2002c, fig.11).

***Boonah Formation — 1478 to 1549.5 metres:*** The return to predominantly sandstone lithologies in the cuttings at 1473-76m and 1476-79m marks the top of the Boonah Formation. This unit has been considered part of the "Eastern View Coal Measures" by Lennon *et al* (1999) and most earlier authors, but is now treated as a formation within the Demons Bluff Group following the work of Holdgate *et al.* (2001). The formation is distinguished from sediments of the Eastern View Group by a lack of coals and the fairly consistently presence of marine dinocysts. The deposition setting is interpreted to represent a restricted marine environment typical of a large estuarine bay, analogous to those described from Permian and Early Cretaceous by Haig (2004). The base of the unit in other wells in the basin has either been picked at the base of the predominant sandstone lithology, or at the best log break immediately above the shallowest coal. In Spikey Beach-1 the first coals recorded in the cuttings descriptions occur at 1560-63m, while the best log break is at the bottom of the next shallowest sand at 1549.5m.

The single sample analysed from near the base of this formation at 1533-36m yielded a very high diversity spore-pollen assemblage which lies close to the boundary between the Lower and Middle *N. asperus* Zones. The associated microplankton are only moderately abundant and diverse but can be assigned to the *Deflandrea heterophlycta* Zone with low confidence based on the presence of a single endocyst of the eponymous species.

It is noted that the cuttings descriptions through the Boonah Formation describe the interval from 1494 to 1509m as containing between 5 to 20% glauconitic sandstone. This lithology is consistent with the depositional environment envisaged for the unit, and the interval would be a worthy target for further palynological analysis to improve the age dating of the formation.

### EASTERN VIEW GROUP

The Eastern View Group in the Bass Basin has been interpreted by Partridge (2002c) as a mixed succession of coal measures and lacustrine sediments. The latter are either be represented by thick shaly successions depauperate in coals, which are interpreted to have been deposited in large palaeolakes with a long-duration (eg. Koorkah and Toolka formations), or thinly bedded paralic lagoonal facies interbedded with the coal measures typical of palaeolagoons with a short-duration and/or constantly shifting palaeogeography (eg. Cormorant Formation). The palaeolakes identified are non-marine in the Late Cretaceous and through most of the Paleocene but gradually become more marine through the latest Paleocene and Eocene. The environmental setting of the younger palaeolakes is best thought of as "restricted" marine or lagoonal as the basin did not have a permanent connection to the open ocean until the deposition of the Demons Bluff Group in the Late Eocene. Based on the identification of these palaeolake facies and the coeval fringing deltaic and fluvial facies the Eastern View Group has been subdivided into a number of informal formations by Partridge (2002c) which are summarised in Figure 1. The formations are notionally "time-rock" or allostratigraphic units[1] and therefore do not strictly conform to the *Australian Code of Stratigraphic Nomenclature 1964*. In contrast, under the stratigraphic terminology used by Lennon *et al.* (1999) the portion of the Eastern View Group drilled in Spikey Beach-1 is interpreted to be equivalent to just the Upper member of the Eastern View Coal Measures.

Identification of the formations in the Eastern View Group, is based on a combination of the ages and palaeoenvironments determined from the palynology, and a comparison of the lithological succession in Spikey Beach-1 with nearby surrounding wells, as summarised in Text-tables 1 & 2. The results of this review suggest that only the uppermost Poonboon and Cormorant formations of the Eastern View Group have been penetrated in Spikey Beach-1.

**Text-table 1: Formations Tops in selected wells in south-central Bass Basin.**

| **TOPS** (metres MD) | Spikey Beach-1 | Narimba-1 | Pelican-1 | Pelican-2 | Pelican-3 | Poonboon-1 | Squid-1 |
|---|---|---|---|---|---|---|---|
| Squid Sandstone | 1343 | 1643 | 1619 | 1653 | 1649 | 1730 | 1549 |
| Anglesea Formation | 1392 | 1652 | 1635 | 1673 | 1668 | 1755 | 1785 |
| Boonah Formation | 1478 | 1793 | 1755 | 1797 | 1789 | 1892 | 1852 |
| Poonboon Formation | 1549.5 | 1857 | 1897 | 1899 | 1907 | 1994 | 1927 |
| Cormorant Formation | 1704 | 2044 | 2161 | 2179 | 2047 | 2197 | 2205 |
| Narimba Formation† | ? | 2580 | 2491 | 2563 | 2289 | 2495 | 2576 |

† Upper portion of Narimba Formation belonging to Early Eocene *M. diversus* Zone.

**Text-table 2: Thickness of formations in selected wells in south-central Bass Basin.**

| **THICKNESS (metres)** | Spikey Beach-1 | Narimba-1 | Pelican-1 | Pelican-2 | Pelican-3 | Poonboon-1 | Squid-1 |
|---|---|---|---|---|---|---|---|
| Squid Sandstone | 49 | 9 | 16 | 20 | 19 | 25 | 236 |
| Anglesea Formation | 86 | 141 | 120 | 124 | 121 | 137 | 67 |
| Boonah Formation | 71.5 | 64 | 142 | 102 | 118 | 102 | 75 |
| Poonboon Formation | 154.5 | 187 | 264 | 280 | 140 | 203 | 278 |
| Cormorant Formation | 396+ | 536 | 330 | 384 | 242 | 298 | 371 |
| Narimba Formation† | ? | 778 | 576 | 429 | 129 | 175 | 203 |

† Upper Narimba Formation belonging to Early Eocene Lower and Middle *M. diversus* Zones.

An interesting feature of the Eastern View Group encountered in Spikey Beach-1 is that the assemblages recovered from the five shallowest samples between 1590-93m and 1782-85m are dominated by carbonized spore-pollen with estimated TAI (Thermal Alteration Index) values between 2.2 and 2.5 on the empirical scale of Staplin (1969, 1977). These readings would suggest

[1] **Allostratigraphic unit:** Defined in *Third Edition — Glossary of Geology* (Bates & Jackson, 1987, p.17) as a mappable stratiform body of sedimentary rocks that is defined and identified on the basis of its bounding discontinuities.

that the uppermost Eastern View Group is ***transitional to mature*** for the generation of liquid hydrocarbons. However, this is can only be a local maturation of just part of succession in Spikey Beach-1 as the five deeper samples from the bottom 250 metres penetrated in the well contain *in situ* light-yellow coloured spore-pollen assemblages with TAI values of <2.0. These lower TAI values clearly indicate that the deeper part of the well is ***immature*** with respect to the generation of hydrocarbons. Possible explanations for the presence of this ~200 metre thick carbonized interval in Spikey Beach-1 is the presence of a nearby igneous intrusion, or migration of superheated fluids through the uppermost Eastern View Group. A potential source of the latter fluids could be from the igneous intrusions which are postulated to occur at a similar stratigraphic level in the Pipipa-1 and Flinders-1 wells approximately 15 kms to the west (Stacy *et al.*, 1982; Partridge & Morgan, 1993).

***Poonboon Formation — 1549.5 to 1704 metres:*** The interval from the shallowest coal to the base of the predominantly sandstone interval in the cuttings descriptions is assigned to the Poonboon Formation. The two samples analysed from this unit yielded carbonized spore-pollen assemblages in which the relatively minor lighter-coloured palynomorphs can be easily distinguished as caved. The samples are assigned to the Lower *N. asperus* Zone based on *Nothofagidites* pollen being significantly more abundant in the assemblages relative to *Haloragacidites harrisii*. The deeper sample lacks any *in situ* microplankton, but the shallower sample at 1590-93m contains restricted marine to brackish lagoonal microplankton similar to an assemblage previously been recorded from the conventional cores from the base of the Toolka Formation in the King-1 well (Partridge, 2002a; Partridge, 2002c, fig.10). This suggests the shale bed identified from 1588 to 1594.5m on the electric logs could represent a tongue of the Toolka lagoonal facies extending into the far south of the Bass Basin as this is the most southerly known occurrence of this facies.

***Cormorant Formation — 1704 to 2100 metres:*** The bottom ~400 metres in the well is assigned to the Cormorant Formation and can be subdivided into a silty upper unit from 1704 to 1793m, which conspicuously lacks any coals, but yields carbonized spore-pollen assemblages, at thick sandstone from 1793 to 1823m which was not sampled for palynology, and a lower coal measures succession with twelve coals seams between 0.5 and 4 metres thick making up ~8% of the succession. The upper boundary between the Poonboon and Cormorant formations is believed to correlate with the Marlin Channel unconformity in the Gippsland Basin (Figure 1). The palynology and cuttings lithologies (but not necessarily the electric logs) suggest the best pick for this boundary is at 1704m at the base of a consistently sandy interval and immediately above the shallowest *P. asperopolus* Zone sample.

The rare presence of marine dinocysts within the Cormorant Formation (ie. *Diphyes colligerum* at 1851-54m and *Homotryblium tasmaniense* at 2037-43m) and the record of a single specimen of the mangrove pollen *Spinizonocolpites prominatus* at 2037-43m suggests that the lagoonal facies considered typical of this formation have reached this southerly portion of the basin.

## Biostratigraphy

The samples analysed in Spikey Beach-1 are primarily classified according to the spore-pollen zonation scheme originally established for the Gippsland Basin by Stover & Evans (1974) and Stover & Partridge (1973). This scheme was also partly developed from and tested on the early exploration wells drilled in the Bass Basin. A summary of the application of the scheme to these early wells is provided in the report by Partridge (1973). The parallel microplankton zonation was originally outlined by Partridge (1975, 1976), but has never been formally published. The most accessible published summaries of both zonations schemes are provided in Chapter 22.4.2 of the latest edition of the *Geology of Victoria* (Partridge & Dettmann, 2003). Additional information on the zones and their correlation with latest Geologic Time Scale of Gradstein *et al.* (2004) can be found on the chart prepared by Partridge (2006).

**Lower *Proteacidites tuberculatus* spore-pollen Zone, and**
***Fromea leos* microplankton Zone**
**Sample at: 1236-48 metres**
**Age: Early Oligocene.**

The shallowest sample processed gave high diversity spore-pollen (SP) and microplankton (MP) assemblages. The microplankton represent 28% of the combined SP + MP count, with *Spiniferites* spp. constituting 39% of the MP count. The SP count is dominated by angiosperm pollen (65%), with *Nothofagidites* spp. at 52% the dominant angiosperm category followed by *Haloragacidites harrisii* at 8%. The gymnosperm pollen in the assemblage are dominated by *Podocarpidites* spp. at 10%, and the spores by *Cyathidites* spp. at 8%. All other spore-pollen species in the assemblage have abundances of <5%.

The recorded spore-pollen assemblage is confidently assigned to the Lower *P. tuberculatus* Zone based on the presence of the *Cyatheacidites annulatus* and *Foveotriletes crater* and the absence of *Foveotriletes lacunosus* and *Cyathidites subtilis* whose oldest occurrences mark the base of the overlying Middle *P. tuberculatus* Zone. Secondary index species supportive of the zone assignment are the presence of *Aglaoreidia qualumis*, *Proteacidites rectomarginis* and *Verrucosisporites cristatus*. Unusual early occurrences in the zone are the presence of *Malvacipollis spinyspora* and *Striasyncolpites laxus*.

The recorded microplankton assemblage is confidently assigned to the *Operculodinium* Superzone based on the dominance of *Spiniferites* spp., and to the basal *Fromea leos* Zone of the superzone based on the LAD (Last Appearance Datum) of *Fromea leos* ms. Other species recorded that are not considered to range above this zone are *Cooksonidium capricornum* and *Glyphanodinium facetum*, and possibly *Selenopemphix brevispinosa* and *S. nephroides*. An unusual youngest occurrence in the zone is the presence of poor specimens of *Deflandrea heterophlycta* (characterised by very subdued tubercules on the endocyst), while the rare presence of the fresh-water colonial algae *Pediastrum* sp. is of potential environmental significance.

**Upper *Nothofagidites asperus* spore-pollen Zone, and**
***Phthanoperidinium comatum* microplankton Acme**
**Sample at: 1353-62 metres**
**Age: Early Oligocene.**

The definition of the Upper *N. asperus* Zone is based on negative criteria. It lies above the youngest occurrences of species that become extinct at the top of the older Middle *N. asperus* Zone, and below the oldest occurrences of species whose first appearances mark the base of the younger *P. tuberculatus* Zone. The sample at 1353-62m meets these criteria, as is lies above the LAD of *Proteacidites adenanthoides* (a marker for the top of the Middle *N. asperus* Zone) and below the FAD (First Appearance Datum) of *Cyatheacidites annulatus*. Like the overlying sample the SP count is dominated by angiosperm pollen (78%) and *Nothofagidites* pollen (73%), with only minor other abundances of *Haloragacidites harrisii* (4%), *Podocarpidites* spp. (9%) and *Cyathidites* spp. (7%). All other species in the assemblage have abundances of <2%.

The samples also conform to the *P. comatum* Acme, based on the LAD and common occurrence of the eponymous species *Phthanoperidinium comatum* in the low MP count. The assemblage appears to be dominated by *Paralecaniella indentata*, but this is difficult to confirm as the preservation of that species is notably poorer than the other microplankton. The only other noteworthy species in the assemblage are the LAD of *Heteraulacacysta paxilla* ms, and the continued presence of the fresh-water colonial algae *Pediastrum* sp. All other species recorded could potentially be caved.

**Middle *Nothofagidites asperus* spore-pollen Zone**
**Samples at: 1407-16 to 1467-70 metres**
**Age: Late Eocene.**

These two samples are no younger than the Middle *N. asperus* Zone based on the LADs of the angiosperm pollen *Proteacidites adenanthoides* at 1407-16m and *Proteacidites pachypolus* at 1467-70m, as neither species ranges above this zone, or above the top of the Eocene. Although, no species with FADs falling within the zone were recorded the FAD of *Tricolpites thomasii* in the next deepest sample at 1533-36m is supportive of the zone assignment as the latter species has been recorded by Partridge (1973) as only ranging into the top of the underlying Lower *N. asperus* Zone. Both assemblages are poorly preserved and only contain moderate concentrations and diversities of palynomorphs. This is considered typical of the Anglesea Formation, as the laboratory processing of samples from this unit can be difficult.

The SP counts are dominated by angiosperm pollen (average 58%), with *Nothofagidites* spp. (average 32%) the dominant angiosperm category followed by *Haloragacidites harrisii* (average 13%). The gymnosperm pollen in the counts are dominated by *Podocarpidites* spp. (average 9%) and the spores by *Cyathidites* spp. (average 11%). The only other noteworthy abundance is *Lygistepollenites florinii* (6% at 1407-16m). All other spore-pollen species in the assemblages have abundances of <5%.

Microplankton abundance in the two samples average 8%, but only the top sample contains diagnostic zone species which allow the identification of the *S. kakanuiensis* Zone. The other sample only contains long-ranging species, or specimens that could be caved. Note also that the two samples contain rare occurrences of the fresh-water colonial algae *Pediastrum* sp.

***Stoveracysta kakanuiensis* microplankton Zone**
**Sample at: 1407-16 metres**
**Age: Late Eocene.**

The sample at 1407-16m from near the top of the Anglesea Formation can be assigned to this zone based on the presence of poor specimens of the dinocyst *Stoveracysta kakanuiensis* (which does not range below this zone) and a single specimen of the acritarch *Paucilobimorpha* (al. *Tritonites*) *spinosus* (which does not range above this zone). The dominant dinocyst in the assemblage is *Lingulodinium machaerophorum*.

**Lower *Nothofagidites asperus* spore-pollen Zone**
**Interval: 1533-36 to 1659-62 metres**
**Age: Middle Eocene.**

Of the three samples assigned to the Lower *N. asperus* Zone the palynomorphs recovered from the shallowest at 1533-36m are light-yellow coloured, while those recovered from the deeper samples at 1590-93m and 1659-62m are amber-brown coloured and therefore are interpreted to be carbonized. Although kerogen slides were not prepared for any of these three samples, the colour of the carbonized palynomorphs on the oxidised slides is consistent with TAI (Thermal Alteration Index) values between 2.2 and 2.5 on the empirical scale of Staplin (1969, 1977), and this would suggest that the portion of the Eastern View Group containing these two deeper samples is ***transitional to mature*** for the generation of hydrocarbons. A side effect of this carbonization of the palynomorphs is that it allows easy identification of the presence of caved specimens in the assemblages as the latter are distinctly lighter in colour.

The sample at 1533-36m contains a highly diverse assemblage of 66+ species in which the FAD of *Tricolpites thomasii* without any younger index species suggests a position near the top of the

Lower *N. asperus* Zone based on the ranges documented by Partridge (1973). The SP count from this sample is dominated by angiosperm pollen (75%) with *Nothofagidites* pollen (24%) equal in abundance to *Haloragacidites harrisii* (25%), and *Proteacidites* spp. prominent (17%). In contrast the gymnosperm pollen *Podocarpidites* spp. become rare (2%), while the spores of *Cyathidites* spp. continue to be common (8%). All other species in the assemblage have abundances of <5%.

Due of the carbonization the two deeper samples are very poorly preserved and difficult to work, and furthermore they lack all index species used to define the base of the zone (ie. *Nothofagidites falcatus*, *Tricolpites simatus* and *Tricolporites leuros*). Fortunately, the overall composition of these assemblages, with *Nothofagidites* pollen (average 31%) significantly greater than *Haloragacidites harrisii* (average 11%), plus the common occurrence of *Phyllocladidites mawsonii* (average 13%) and *Nothofagidites flemingii* (average 10%), is considered characteristic of the zone. Negative evidence supporting this conclusion is the absence of the index species whose last occurrences (extinctions) mark the top of the next older *P. asperopolus* Zone (eg. *Intratriporopollenites notabilis, Myrtaceidites tenuis* and *Proteacidites ornatus*).

As discussed below the shallowest sample at 1533-36m contains a marine microplankton assemblage, the middle sample at 1590-93m a distinctive restricted marine to brackish lagoonal microplankton assemblage, while the bottom sample at 1659-62m lacks *in situ* microplankton.

***Deflandrea heterophlycta* microplankton Zone**
**Sample at: 1533-36 metres**
**Age: late Middle Eocene.**

The moderately abundant and diverse microplankton assemblage from the cuttings at 1533-36m is assigned to the *D. heterophlycta* Zone with low confidence based on the presence of a single endocyst of the eponymous species, which is identified by its distinctive tuberculate ornament. This species has a recorded disjunct range occurring at the top of the Lower *N. asperus* Zone being absent or exceptionally rare throughout the Middle *N. asperus* Zone, then reappearing again with some frequency in the Upper *N. asperus* Zone.

**Lacustrine microplankton zone**
**Sample at: 1590-93 metres**
**Age: Middle Eocene.**

The cuttings at 1590-93m contains restricted marine to brackish lagoonal microplankton that are indisputably *in situ* based on their identical carbonization to that of the associated spore-pollen. The assemblage is comprised of two undescribed dinocyst species referred to as *Morkallacysta* sp. and *Ceratertius* gen. et sp. nov. The latter species has previously been recorded from the conventional cores from the base of the Toolka Formation in the King-1 well (Partridge, 2002a; Partridge, 2002c, fig.10). This suggests the shale bed from 1588 to 1594.5m represents a tongue of the Toolka lagoonal facies extending into the Spikey Beach-1 well. Currently this assemblage does not have a formal zone name.

***Proteacidites asperopolus* spore-pollen Zone**
**Sample at: 1710-13 metres**
**Age: Early Eocene.**

The very poorly preserved and carbonized spore-pollen recovered at 1710-13m were mistakenly assigned to the Lower *N. asperus* Zone in the initial Provisional Report due to the lack of index species diagnostic of the *P. asperopolus* Zone. But, subsequent microscope analysis has found rare specimens of *Proteacidites asperopolus* and *P. ornatus* which favour the older zone. The SP count supports this assignment in that the assemblage is dominated by angiosperm pollen (75%) with

*Haloragacidites harrisii* (23%) significantly more abundant than *Nothofagidites* spp. (14%). Pollen assigned to *Proteacidites* was also very abundant at 35%, and this includes common *Proteacidites leightonii* at 7%. The secondary gymnosperm pollen (22%) are dominated by *Podocarpidites* spp. (10%) and *Phyllocladidites mawsonii* (9%), while all spores are rare to frequent (3%).

Microplankton are rare, and consist of the *in situ* non-marine algal-cyst *Circulisporites parvus* and light-coloured marine dinocysts which are clearly caved from higher in the well.

**Indeterminate zone**
**Samples at: 1761-64 and 1782-85 metres**
**Age: Early? Eocene.**

These two samples are contain ~50% carbonized spore-pollen and ~50% light-yellow coloured and thermally ***immature*** spore-pollen. It is not clear however, whether the assemblages represent a return to immature sediments with all the carbonized specimens caved, or if the assemblages are from a carbonized part of the section, with all the light-yellow coloured specimens caved! The latter alternative is highly likely as the assemblage counts contain 14 to 57% microplankton that are all light-yellow coloured and obviously caved from the younger Demons Bluff and Torquay groups.

Irrespective of which fraction of the spore-pollen are caved the two assemblages are most like assemblages from the Lower *N. asperus* Zone as specimens of *Nothofagidites* pollen (average 25%) are more abundant than *Haloragacidites harrisii* (average 16%). Unfortunately, there were no index species recorded that could be considered diagnostic of either the Lower *N. asperus* Zone or the *P. asperopolus* Zone. Furthermore, no *in situ* microplankton are identified in the samples.

***Proteacidites asperopolus* to Upper *Malvacipollis diversus* spore-pollen Zones**
**Interval: 1851-54 to 1947-53 metres**
**Age: Early Eocene.**

The three samples between 1851 to 1953m are clearly no younger than the *P. asperopolus* Zone based on the rare but consistent occurrence of *Intratriporopollenites notabilis* and no older than the Upper *M. diversus* Zone based on the frequent to common occurrence of *Proteacidites pachypolus.* But deciding which of these two zone the individual samples belong to is not clear as all the other key species are rare and/or their occurrences confusing. The deepest sample at 1947-53m is potentially the most diagnostic as it contains the highest abundance of *P. pachypolus* (9%), rare *Myrtaceidites tenuis* (which does not range above the *P. asperopolus* Zone) and single specimens of *Proteacidites asperopolus*, and *Conbaculatisporites apiculatus* ms (which do not range below the *P. asperopolus* Zone). Unfortunately, it is possible that the latter two specimens could either be caved, or that the one or more of the samples might have be swapped, as the two shallower samples at 1851-54m and 1902-05m do not contain any species that would support an age younger than the older Upper *M. diversus* Zone. As no sensible boundary can be distinguished between these two adjacent zones the only recourse is assign the interval to both zones until such time that additional cuttings samples are analysed to resolve this conflict.

The SP counts are dominated by angiosperm pollen (average 71%), with *Haloragacidites harrisii* (average 23%) and *Proteacidites* spp. (average 20%) both more abundant than *Nothofagidites* spp. (average 10%). Gymnosperm pollen are next most abundant (average 18%), with *Podocarpidites* spp. (average 10 %) the dominant category. Spores average 11% in the assemblages and are characterised by smooth monolete spores (*Laevigatosporites ovatus* at average of 5%), being more common than smooth trilete spores (*Cyathidites* spp. at average of 2%). The only other noteworthy abundances are *Proteacidites pachypolus* (average 6%), and *Dicotetradites clavatus* (5% at 1902-05m).

Microplankton are uncommon in the samples, and with the exception of the non-marine algal-cyst *Circulisporites parvus* and the somewhat questionable identification of the dinocyst *Diphyes colligerum* at 1851-54m, all appear to be caved from the younger Demons Bluff and Torquay groups.

**Upper to Middle *Malvacipollis diversus* spore-pollen Zones**
**Interval: 2037-43 to 2079-85 metres**
**Age: Early Eocene.**

The deepest two cuttings analysed are best assigned to the time interval representing the Middle to Upper *M. diversus* Zones. These assemblages lack the three principal index species for the Middle subzone (ie. *Proteacidites ornatus, P. tuberculiformis* and *P. xestoformis* ms), as well as the two key index species for the Upper subzone (ie. *Proteacidites pachypolus* and *Myrtaceidites tenuis*) which have their FADs in these zones. But they also lack the elevated abundances of the species *Proteacidites grandis* and *Malvacipollis diversus* and/or *M. subtilis* which are characteristic of the Lower *M. diversus* Zone. Instead, the identification of the zone interval depends on the FADs of the secondary index species *Polycolporopollenites esobalteus* and *Proteacidites nasus*[2] based on their established ranges in the Bass Basin (Partridge, 1973). Supporting these species occurrences is the composition of the shallower cuttings assemblage which is dominated by *Haloragacidites harrisii* (40%), with secondary *Nothofagidites* spp. (13%). The composition of the deeper cuttings is less informative as the sample is badly contaminated by species interpreted to be caved from the shallow Torquay Group. In this assemblage *Nothofagidites* spp. at 25%, is significantly more abundant than *H. harrisii* at 15%. However, the fact that the caved microplankton are estimated to represent >25% of the combined SP + MP count suggests that a large proportion of the spore-pollen could also be caved. The best that can be said of this assemblage is that it is unlikely to be any older than the Middle *M. diversus* Zone because it does not display any of the species abundances considered typical of the Lower *M. diversus* Zone.

***Homotryblium tasmaniense* microplankton Zone**
**Sample at: 2037-43 metres**
**Age: Late Eocene.**

The recovery of frequent specimens of the dinocyst *Homotryblium tasmaniense* in an essentially monospecific marine assemblage from the cuttings at 2037-43m is considered diagnostic of the *H. tasmaniense* Zone. This range-zone was originally described from the Otway Basin by Harris (1985) where it was equated to only the *P. asperopolus* Zone, but the eponymous species has subsequently been demonstrated to have a range extending to the base of the Upper *M. diversus* Zone (Partridge, 2006). The only other *in situ* microplankton in the assemblages is the non-marine algal-cyst *Circulisporites parvus*. All the other marine dinocysts are all interpreted to be caved.

[2] *Proteacidites nasus* Truswell & Owen 1988 is valid name for manuscript species *Proteacidites plemmelus*.

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# Table 2. Interpretative palynological data from Spikey Beach-1, Bass Basin.

| Sample Type | Depth metres | Spore-Pollen Subzones (Microplankton Subzones) | *CR | Comments and Key Species Present |
|---|---|---|---|---|
| Cuttings | 1236-1248 | Lower *P. tuberculatus* Zone (*Fromea leos* Zone) | D1 D1 | MP are 28% of combined SP + MP count. FAD of *Cyatheacidites annulatus* and LADs of *Fromea leos* ms and *Glyphanodinium facetum.* |
| Cuttings | 1353-1362 | Upper *N. asperus* Zone (*P. comatum* Acme) | D4 D3 | MP 12%, with common *Phthanoperidinium comatum*. SP assemblage typically non-descript. |
| Cuttings | 1407-1416 | Middle *N. asperus* Zone (*S. kakanuiensis* Zone) | D3 D3 | MP 12%, with LADs of *Stoveracysta kakanuiensis* and *Paucilobimorpha spinosus*. SP assemblage with LAD of *Proteacidites adenanthoides*. |
| Cuttings | 1467-1470 | Middle *N. asperus* Zone | D4 | MP <5%, but assemblage not zone diagnostic. SP suite with LAD of *Proteacidites pachypolus.* |
| Cuttings | 1533-1536 | Lower *N. asperus* Zone (*D. heterophylcta* Zone | D1 D3 | MP 10%, with FAD of *Deflandrea heterophylcta* SP suite with FAD of *Tricolpites thomasii.* |
| Cuttings | 1590-1593 | Lower *N. asperus* Zone | D4 | Carbonized and rather non-descript SP assemblage, associated with restricted marine to lagoonal MP assemblage representing 18% of combined count. |
| Cuttings | 1659-1662 | Lower *N. asperus* Zone | D4 | Carbonized SP assemblage dominated by gymnosperm pollen. No *in situ* MP recorded. |
| Cuttings | 1710-1713 | *P. asperopolus* Zone | D4 | Carbonized and angiosperm pollen dominated SP assemblage with LADs of *Proteacidites ornatus* and *P. asperopolus*. MP rare ~1% and mostly CAVED. |
| Cuttings | 1761-1764 | Indeterminate | | Mixed SP assemblage with ~60% specimens carbonized and ~40% lighter coloured (immature). MP 57% of combined count and all CAVED. |
| Cuttings | 1782-1785 | Indeterminate | | Mixed SP assemblage with ~45% specimens carbonized and ~55% lighter coloured (immature). MP 14% of combined count and all CAVED. |
| Cuttings | 1851-1854 | *P. asperopolus* to Upper *M. diversus* Zones | D1 | Return to light-coloured or immature SP with LADs of *Intratriporopollenites notabilis* and common *Proteacidites pachypolus*. MP ~3% some *in situ*. |
| Cuttings | 1902-1905 | *P. asperopolus* to Upper *M. diversus* Zones | D1 | *Proteacidites pachypolus* 6% in assemblage dominated by *Haloragacidites harrisii* 30%. MP 6% and all CAVED. |
| Cuttings | 1947-1953 | *P. asperopolus* to Upper *M. diversus* Zones | D1 | *Proteacidites pachypolus* 9% in assemblage with FAD of *Myrtaceidites tenuis* and single poor specimen of *Proteacidites asperopolus*. MP <1%. |
| Cuttings | 2037-2043 | Upper *M. diversus* to Middle *M. diversus* Zones (*H. tasmaniense* Zone) | D4 D3 | FADs of *Polycolporopollenites esobalteus* and *Proteacidites nasus* in assemblage dominated by *Haloragacidites harrisii* ~40%. MP at 5% contains important index species *Homotryblium tasmaniense*. |
| Cuttings | 2079-2085 | No older than the Middle *M. diversus* Zone | D5 | Poor assemblage with all the MP and probably half of the SP caved. Nothing presence to indicate that assemblage is any older than Middle subzone. |

*CR = Confidence Ratings (as summarised below)
FAD & LAD = First and Last Appearance Datums.
SP & MP = Spore-Pollen and Microplankton

**CR = Confidence Ratings used in STRATDAT database and applied to Table 2.**

| **Alpha codes:** Linked to sample | | **Numeric codes:** Linked to fossil assemblage | | |
|---|---|---|---|---|
| **A** | Core | **1** | **Excellent confidence:** | High diversity assemblage recorded with key zone species. |
| **B** | Sidewall core | **2** | **Good confidence:** | Moderately diverse assemblage with key zone species. |
| **C** | Coal cuttings | **3** | **Fair confidence:** | Low diversity assemblage recorded with key zone species. |
| **D** | Ditch cuttings | **4** | **Poor confidence:** | Moderate to high diversity assemblage without key zone species. |
| **E** | Junk basket | **5** | **Very low confidence:** | Low diversity assemblage without key zone species. |

## Table 3. Basic palynological assemblage data for Spikey Beach-1, Bass Basin.

| Sample Type | Depth metres | Visual Yield | Palynomorph Concentration | Palynomorph Preservation | No. SP Species | No. MP Species† |
|---|---|---|---|---|---|---|
| Cuttings | 1236-1248 | Moderate | High | Poor-Good | 54+ | 26+ |
| Cuttings | 1353-1362 | Moderate | Moderate | Poor-Good | 30+ | 15+ |
| Cuttings | 1407-1416 | Moderate | Moderate | Poor | 39+ | 16+ |
| Cuttings | 1467-1470 | High | Low | Very Poor | 30+ | 4+ |
| Cuttings | 1533-1536 | High | Very High | Poor-Good | 66+ | 12+ |
| Cuttings | 1590-1593 | Moderate | Low | Very Poor (carbonized) | 22+ | 2+ (2+) |
| Cuttings | 1659-1662 | High | High | Very Poor (carbonized) | 32+ | (2+) |
| Cuttings | 1710-1713 | High | High | Very Poor (carbonized) | 41+ | 1+ (2+) |
| Cuttings | 1761-1764 | Moderate | Low | Poor (60% carbonized) | 18+ | (7+) |
| Cuttings | 1782-1785 | Moderate | Moderate | Poor (45% carbonized) | 37+ | (9+) |
| Cuttings | 1851-1854 | High | Moderate | Poor-Fair | 48+ | 2+ (4+) |
| Cuttings | 1902-1905 | Moderate | High | Poor-Fair | 35+ | (3+) |
| Cuttings | 1947-1953 | High | High | Poor-Fair | 46+ | 1+ (1+) |
| Cuttings | 2037-2043 | High | High | Poor-Fair | 37+ | 2+ (5+) |
| Cuttings | 2079-2085 | Moderate | Moderate | Poor-Fair | 34+ | (10+) |
| | | | | **Average:** | **38+** | **8+** |

†**Note:** Microplankton species numbers shown in brackets are interpreted to be carved species.

# Table 4. Basic sample data for Spikey Beach-1, offshore Bass Basin.

| Sample Type | Depth metres | Lithology | Weight grams |
|---|---|---|---|
| Cuttings | 1236-1248 | **Claystone 95%**: olive to brown grey, moderately calcareous, common pyrite & carbonaceous specks, trace mica & glaucony. **Calcarenite 5%**: Light brown-grey. | 51.0 |
| Cuttings | 1353-1362 | **Siltstone 85%:** Lt-med brown-grey, weakly calcareous, tr.-common mica & glaucony, tr. pyrite & carbonaceous specks. **Sandstone 15%:** Light brown to grey, very fine to fine, tr. glaucony. | 52.0 |
| Cuttings | 1407-1416 | **Claystone 94%:** Dark brownish grey to black, carbonaceous, tr. pyrite & mica, non-calcareous. **Siltstone 5%:** Lt-brownish grey. **Limestone 1%:** Light brown, fairly hard. | 51.1 |
| Cuttings | 1467-1470 | **Claystone 95%:** Brown-grey to black, micaceous carbonaceous, tr. pyrite. **Limestone 5%:** White to brownish grey, grading to marl. | 51.4 |
| Cuttings | 1533-1536 | **Siltstone 90%:** Olive to brownish grey, trs coal laminae, pyrite & crs quartz, non calcareous. **Sandstone 10%:** Light olive-grey, vf-f, tr. carbonaceous specks & glaucony. | 52.4 |
| Cuttings | 1590-1593 | **Siltstone 80%:** Dark brown-grey to black, carbonaceous, common pyrite, common large shards. **Sandstone 20%:** Light grey, vf to f-grained. | 51.8 |
| Cuttings | 1659-1662 | **Carbonaceous Claystone 50%:** Dark brown-grey–black, common pyrite & mica. **Sandstone 40%:** Translucent, vf-f grained. **Siltstone 10%:** Med brown-grey, grading to fine sandstone. | 51.2 |
| Cuttings | 1710-1713 | **Carbonaceous Claystone 75%:** Grey-black grading to **Coal 5%:** Earthy to sub-vitreous. **Sandstone 20%:** Translucent, fine to coarse grained. | 51.1 |
| Cuttings | 1761-1764 | **Siltstone 100%:** Medium to dark, brown to grey, carbonaceous, common mica, tr. pyrite. | 52.1 |
| Cuttings | 1782-1785 | **Siltstone 85%:** Dark brown grey, carbonaceous, common mica, tr. pyrite. **Sandstone 15%:** Light grey to white, vf. to f. grained. | 52.5 |
| Cuttings | 1851-1854 | **Siltstone 70%:** Olive grey, common carbonaceous, laminae. **Sandstone 30%:** Translucent to light grey, vf. to f. grained, grading to sandy siltstone. | 51.2 |
| Cuttings | 1902-1905 | **Sandstone 60%:** Light grey to translucent, vf. to f. grained, grading to sandy **Siltstone 39%:** Light olive grey. **Coal 1%:** Black, sub-vitreous. | 52.3 |
| Cuttings | 1947-1953 | **Siltstone 70%:** Brownish grey-black, carbonaceous. **Coal 20%:** Black, sub-vitreous. **Sandstone 10%:** Translucent to light grey, vf. to f. grained. | 52.5 |
| Cuttings | 2037-2043 | **Carbonaceous Claystone 90%:** Grey-black to olive-grey. **Sandstone 10%:** Light grey fine-med grained. | 52.7 |
| Cuttings | 2079-2085 | **Sandstone 75%:** Light grey to translucent, vf. to f. grained. **Siltstone 25%:** Med brown, slightly calc. matrix. | 51.1 |

**Average Sample Weight Processed: 51.8**

**Note:** The Weight in grams column gives the sample weights recorded by the processing laboratory.

## Table 5. Palynological slides from Spikey Beach-1, offshore Bass Basin.

| No. | Depth Metres | Sample Type | Catalogue Number | Core Lab. Prep. No. | Description |
|---|---|---|---|---|---|
| 1 | 1236-1248 | Cuttings | | 12204 | Oxidised Slide 1 |
| 2 | 1236-1248 | Cuttings | | 12204 | Oxidised Slide 2 |
| 3 | 1236-1248 | Cuttings | | 12204 | Oxidised Slide 3 |
| 4 | 1353-1362 | Cuttings | | 12205 | Oxidised Slide 1 |
| 5 | 1353-1362 | Cuttings | | 12205 | Oxidised Slide 2 |
| 6 | 1353-1362 | Cuttings | | 12205 | Oxidised Slide 3 |
| 7 | 1407-1416 | Cuttings | | 12206 | Oxidised Slide 1 |
| 8 | 1407-1416 | Cuttings | | 12206 | Oxidised Slide 2 |
| 9 | 1407-1416 | Cuttings | | 12206 | Oxidised Slide 3 |
| 10 | 1467-1470 | Cuttings | | 12207 | Oxidised Slide 1 |
| 11 | 1467-1470 | Cuttings | | 12207 | Oxidised Slide 2 |
| 12 | 1467-1470 | Cuttings | | 12207 | Oxidised Slide 3 |
| 13 | 1533-1536 | Cuttings | | 12208 | Oxidised Slide 1 |
| 14 | 1533-1536 | Cuttings | | 12208 | Oxidised Slide 2 |
| 15 | 1533-1536 | Cuttings | | 12208 | Oxidised Slide 3 |
| 16 | 1590-1593 | Cuttings | | 12209 | Oxidised Slide 1 |
| 17 | 1590-1593 | Cuttings | | 12209 | Oxidised Slide 2 |
| 18 | 1590-1593 | Cuttings | | 12209 | Oxidised Slide 3 |
| 19 | 1659-1662 | Cuttings | | 12210 | Oxidised Slide 1 |
| 20 | 1659-1662 | Cuttings | | 12210 | Oxidised Slide 2 |
| 21 | 1659-1662 | Cuttings | | 12210 | Oxidised Slide 3 |
| 22 | 1710-1713 | Cuttings | | 12211 | Oxidised Slide 1 |
| 23 | 1710-1713 | Cuttings | | 12211 | Oxidised Slide 2 |
| 24 | 1710-1713 | Cuttings | | 12211 | Oxidised Slide 3 |
| 25 | 1761-1764 | Cuttings | | 12212 | Oxidised Slide 1 |
| 26 | 1761-1764 | Cuttings | | 12212 | Oxidised Slide 2 |
| 27 | 1761-1764 | Cuttings | | 12212 | Oxidised Slide 3 |
| 28 | 1782-1785 | Cuttings | | 12213 | Oxidised Slide 1 |
| 29 | 1782-1785 | Cuttings | | 12213 | Oxidised Slide 2 |
| 30 | 1782-1785 | Cuttings | | 12213 | Oxidised Slide 3 |
| 31 | 1851-1854 | Cuttings | | 12214 | Oxidised Slide 1 |
| 32 | 1851-1854 | Cuttings | | 12214 | Oxidised Slide 2 |
| 33 | 1851-1854 | Cuttings | | 12214 | Oxidised Slide 3 |
| 34 | 1902-1905 | Cuttings | | 12215 | Oxidised Slide 1 |
| 35 | 1902-1905 | Cuttings | | 12215 | Oxidised Slide 2 |
| 36 | 1902-1905 | Cuttings | | 12215 | Oxidised Slide 3 |
| 37 | 1947-1953 | Cuttings | | 12216 | Oxidised Slide 1 |
| 38 | 1947-1953 | Cuttings | | 12216 | Oxidised Slide 2 |
| 39 | 1947-1953 | Cuttings | | 12216 | Oxidised Slide 3 |
| 40 | 2037-2043 | Cuttings | | 12217 | Oxidised Slide 1 |
| 41 | 2037-2043 | Cuttings | | 12217 | Oxidised Slide 2 |
| 42 | 2037-2043 | Cuttings | | 12217 | Oxidised Slide 3 |
| 43 | 2079-2085 | Cuttings | | 12218 | Oxidised Slide 1 |
| 44 | 2079-2085 | Cuttings | | 12218 | Oxidised Slide 2 |
| 45 | 2079-2085 | Cuttings | | 12218 | Oxidised Slide 3 |

**Well Name : Spikey Beach-1**

Operator : Beach Petroleum — Spudded : 05 September 2009
Well Code : SPIKEYBEACH-1 — Completed : 19 September 2009
Lat/Long : 40°28' 53.88"S 145°52' 24.71"E
Interval : 1220m - 2120m — INTERPRETATIVE Range Chart
Scale : 1:4000 — Sample interval 1236-48m to 2079-85m
Chart date: 12 January 2010 — Microscope analysis by Alan D. Partridge

# Spikey Beach-1

Biostrata Pty Ltd
AUSTRALIA

Attachment to Biostrata Report 2010/01A