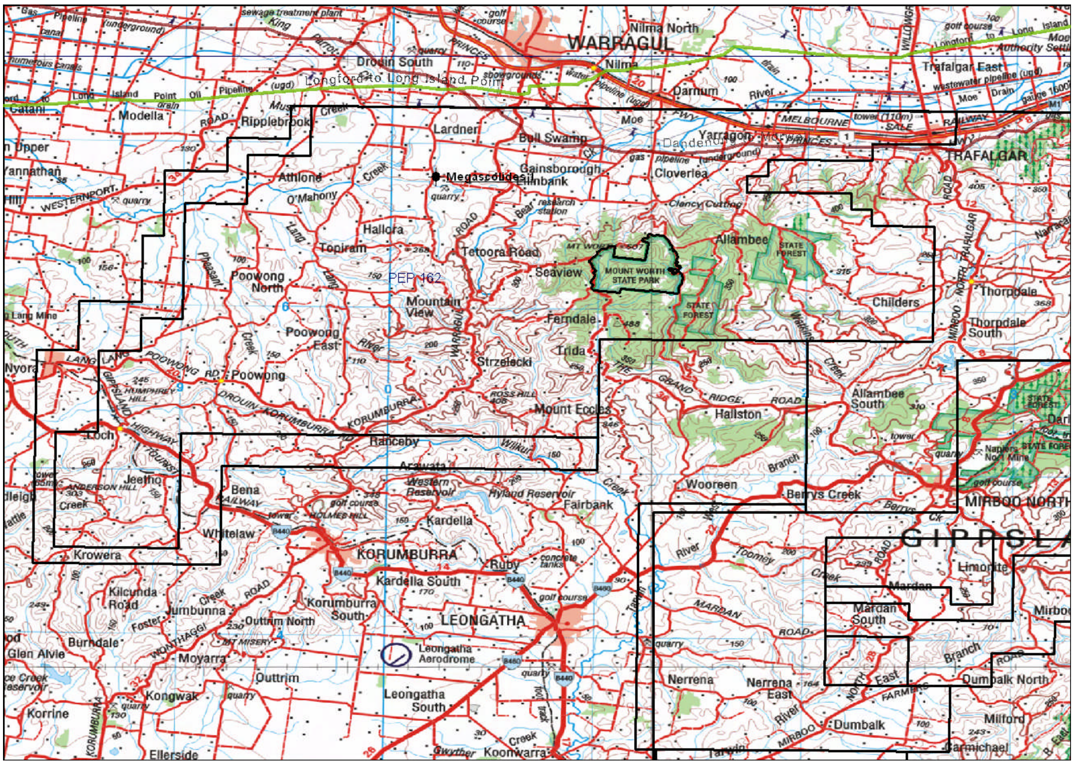

Megascolides-1

Well Completion Report
Volume 2
Interpretative Report

Karoon Gas Ltd
Onshore Gippsland Basin
Australia

Executive Summary

The well Megascolides 1 is located on the Northern Terrace of the Narracan Trough which forms part of the northwestern edge of onshore Gippsland Basin (Figure 3). It was the first deep, modern exploration well to be drilled in the EL4537 and PEP162 permits targeting lower Strzelecki coal deposits for Coal Bed Methane (CBM) exploration and Crayfish Group equivalent alluvial fan sands for conventional oil and gas accumulations that had been interpreted by previous seismic mapping (Blackburn, 2002).

Seismic mapping had indicated that the coals should occur at an optimum depth range (750 -800m based on analogous CBM basin depths and permeabilities) with low structural deformation for prospective coal seam methane exploration.

For CBM exploration, the results of the well proved the presence of gas bearing black coal across the Narracan Trough within Wonthaggi Coal Measure (Strzelecki Group) sediments. However, only a total thickness of 15m of black coal with a gas content of 100SCF per tonne and approximate gas saturation of 30% (one core sample analysed) was penetrated. It was therefore considered to be non-commercial at this location.

For oil and gas exploration, mapping had interpreted that basal Strzelecki Group (probably Rintoul Creek Formation) alluvial fan sands were well developed over the eastern portion of the seismic survey shot in the EL4537 license area. It was also interpreted that trap seal integrity would be higher to the west where there has been less Tertiary structural deformation. Megascolides 1 was drilled on a saddle bounded at the south by a fault identified by depth mapping at the Top Crayfish Group Equivalent surface.

The well penetrated 3 to 5 metres of net porous, permeable sands with good bright white-yellow fluorescence and high mud gas readings within the Rintoul Creek Fm (Top Crayfish Group equivalent). Geochemical analysis of the extracted oil shows that it is a waxy oil. Petrophysical analysis of the sands show up to 60% oil saturation and a porosity range between 12% and 15%.

The data from the well provides a sound basis for further CBM and conventional oil exploration. The existing seismic grid is insufficient to define Crayfish Group equivalent oil zone structural closures or to map the extent of the coals. A further seismic program is being planned.

1: Contributors & Controls

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Document Distribution

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2: Previous Investigations

More than 2500 coal and water bores have been drilled within PEP162/EL4537. Most are less than 100m in depth. To the south and east of the permit, a number of wells were drilled by the ARCO-Woodside Oil Co. partnership in the 1960s along the Gippsland coastline.

In 1965, Tarwin Meadows 1 was drilled 55km south of Megascolides 1 by Alliance Oil Development to a total depth of 1203m. At 945m the well encountered strong gas shows in Aptian age Strzelecki sediments. High trip gas readings were encountered at 487m, 786m, 945m, and 1202m.

To the east, Duck Bay 1 penetrated a relatively thin Strzelecki section, 149m thick, underlain by 289.2m of volcanics and Permian metasediments.

Sixty kilometers to the east of Megascolides 1, Loy Yang 1A, (1994, Capital Energy NL) drilled to a total depth of 1736m. The objective of the well was to test a structural play of basal Cretaceous sediments (Rintoul Creek Sandstone and Tyers Conglomerate) beneath the Tertiary Loy Yang Dome. This dome had been well mapped using brown coal exploration data obtained from the neighbouring open cut coal mine. The dome has a thin Tertiary cover which allowed a thick Cretaceous sequence to be easily intersected. Both the target sediments (Rintoul Creek Sandstone and Tyers Conglomerate) have low porosities and contain dolomite cement. Other authors such as Blackburn (2002) have questioned whether they in fact reached the target as recorded in the WCR or whether only the top of the upper portion of the Crayfish Group equivalent sediments were penetrated.

Two wells that penetrated a thick Strzelecki Group sequence, useful for regional correlation, are Woodside South 1 (1955) which had an oil show in the mud at 1777 m KB in the middle of the Strzelecki sediments, and Sunday Island 1 (1965) which showed light blue fluorescence in shallow Strzelecki sediments. Sunday Island 1 also intersected Granite basement at TD.

In the past few years, Lakes Oil has drilled a number of wells to the southeast of Megascolides 1 with gas accumulated within the thick Strzelecki sequences at the Wombat and Trifon Fields. In Wombat 2, two successful open hole DSTs flowed at a rate of 0.5 mmcfpd. An interval between 1470-1476 metres was hydraulically fractured and the stabilised gas flow rate was measured at 1,200,000 mmcfpd. This fell to a rate of 600,000 mmcfpd after a week of shut in.

Echidna High 1, further to the west, also encountered gas within Strzelecki Group sediments at 1591m however on testing no gas came to the surface. Lakes Oil interpret that the gas recorded came from open fractures associated with a reverse fault they encountered while drilling.

3: Regional Geology

3.1 Geological Setting

The two overlying licenses PEP162/EL4537 lie within the Late Jurassic –Early Cretaceous Strzelecki rift basin (Figure 1). The EL4537 license covers an area of (approx 635 km^2) and is generally characterised by extensive outcrop of Early Cretaceous age Strzelecki Group. The larger (approx 2950 km^2) PEP 162 oil and gas exploration permit area extends to the south coast and Western Port Bay (Figure 2). Both licenses lie on the western edge of the section of Neoproterozoic–Cambrian crust called the Selwyn Block. This underlying Block forms a structure that controls the modern topography and ‘closely reflect[s] the northeast magnetic fabric’ (Cayley et al., 2002). This has been supported by detailed mapping over the rest of the Gippsland basin that has shown that the magnetic lows ‘generally correspond to the deepest parts of the Top Strzelecki’ surface (Moore and Wong, 2001, p 43).

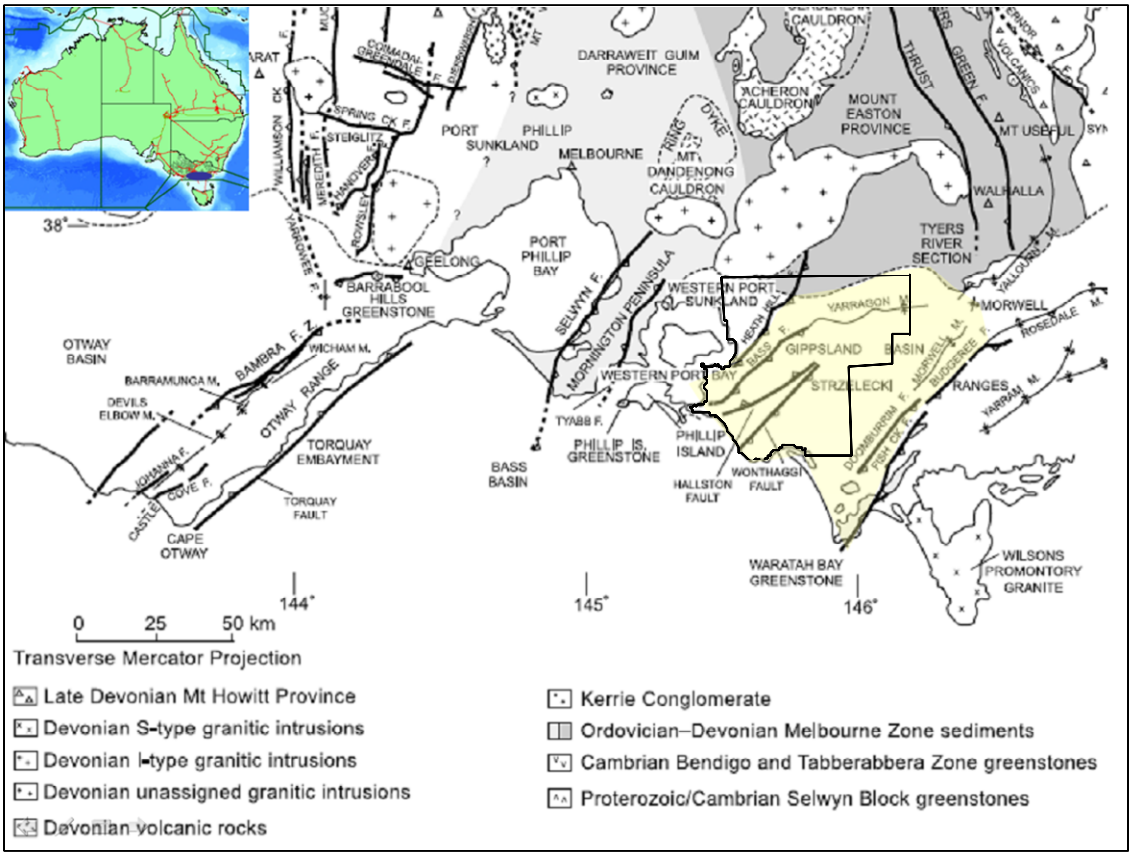

Figure 1. Main stratigraphic and structural zones of Southern Victoria modified from Cayley et al. 2002

Thin intervals of Tertiary sediments and volcanics partially overlie the Strzelecki Group. In restricted areas around the margins of the Early Cretaceous grabens Paleozoic rocks outcrop or lie beneath the thin Tertiary section.

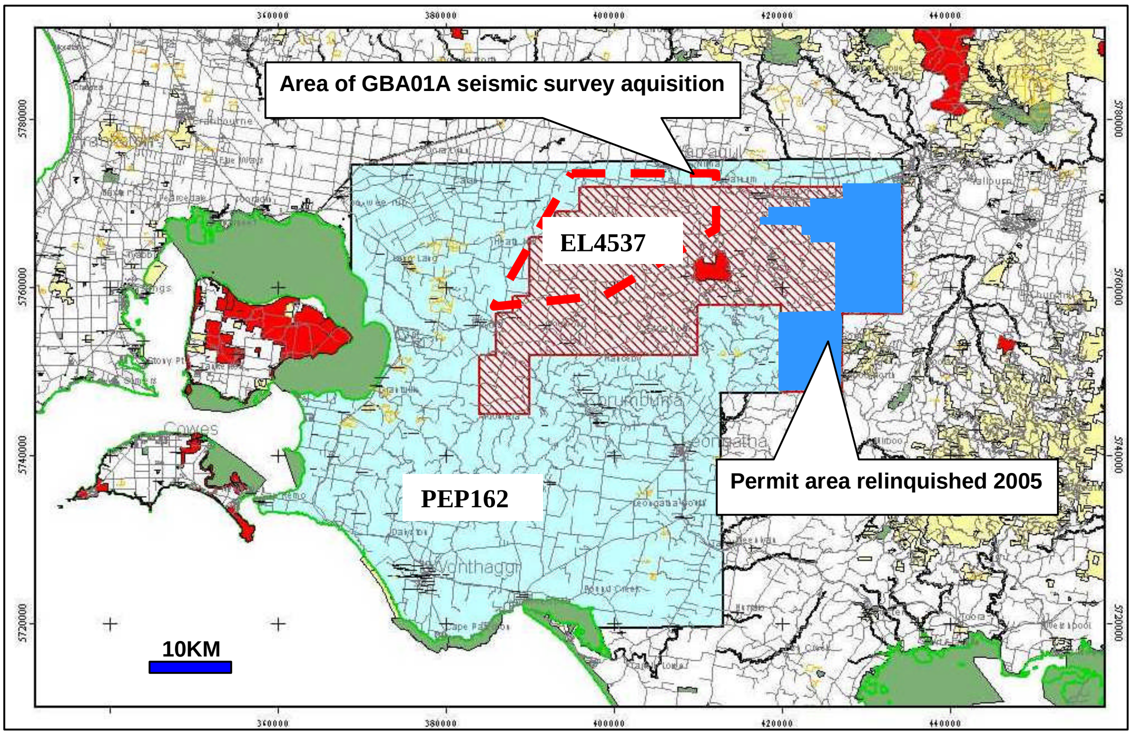

Figure 2. Location map, PEP162 and EL4537.

2.2 Structural and Thermal History

The structural history of the Narracan Trough (formerly the Narracan Block) and surrounds is complex. At least four Mesozoic to Recent tectonic episodes have modified the basement cover in this area. These regimes were; the Australia/ Antarctica rift and continental break-up tectonics, the Australia/Norfolk rise rift and continental break-up tectonics, the Australia/Antarctica West Tasmania wrench margin development and the Australia/ Indonesian archipelago collision. The net structural effect in the permit area was the early development of a major graben then episodic Late Cretaceous and Tertiary inversion and uplift. The timing and magnitude of the later of these events is locally indicated by the deformation seen in the late Tertiary coals of the Latrobe valley which are underlain by similar Strzelecki Group filled grabens. It has been estimated that as much as 5 km of Strzelecki sediments were deposited within the Narracan trough with up to 1500m of section removed during the late Tertiary inversion.

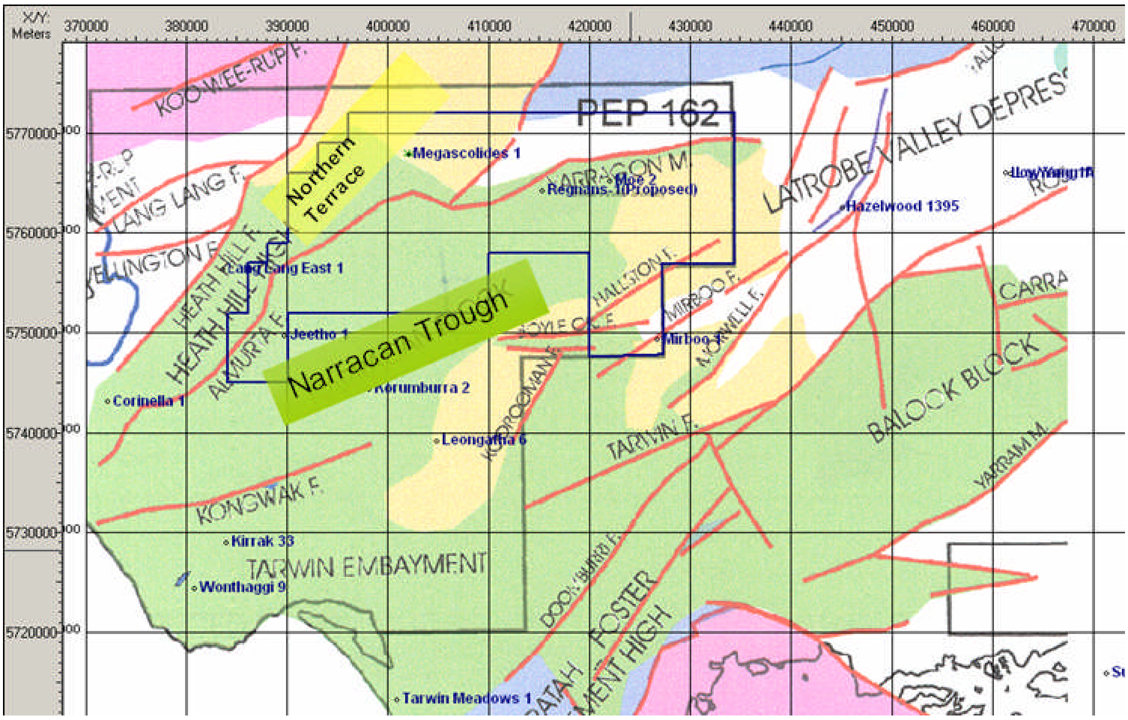

Figure 3. Major structural elements over the permit area.

Local and regional thermal history studies have consistently interpreted a major heating event before the mid Cretaceous and prior to the initial period of deformation/uplift. It is interpreted that prior to the mid Cretaceous, that the rocks within the Strzelecki grabens were likely to have matured and generated oil and gas. This is supported by coal maturity data from the Megascolides 1 well and the Wonthaggi and Korumburra coal fields which are preserved at maturity levels that can produce oil and gas. These coalfields are situated adjacent to the main depocenter of the Narracan Trough.

2.3 Regional Stratigraphy

Extensive accounts of the geology of the basin, including a detailed discussion of regional stratigraphy, can be found in Haskell (1972), Hocking (1976), James and Evans (1971), Douglas and Ferguson (1976;1988), Blake (1980), Thompson (1986), Lowry (1987; 1988), Lowry and Longley (1991), Abele *et al.* (1988), Rahmanian *et al.* (1990), Featherstone *et al.* (1991), Partridge (1994), Bernecker *et al.* (1997), Tosolini *et al.* (1999), Woollands (2003), Birch (2003), Holgate (2005), Bryan *et al.*(1997), and Morath and White (2004) . The following figures summarise the conventional lithostratigraphy of the Strzelecki Basin (Figure 4) and a detailed chronostratigraphy of the Strzelecki Group (Figure 5) as defined by previous authors. The lithostratigraphy column shows that over the onshore areas there has been major uplift and erosion, removing in excess of 1000m of rock section of the coal bearing Strzelecki Group.

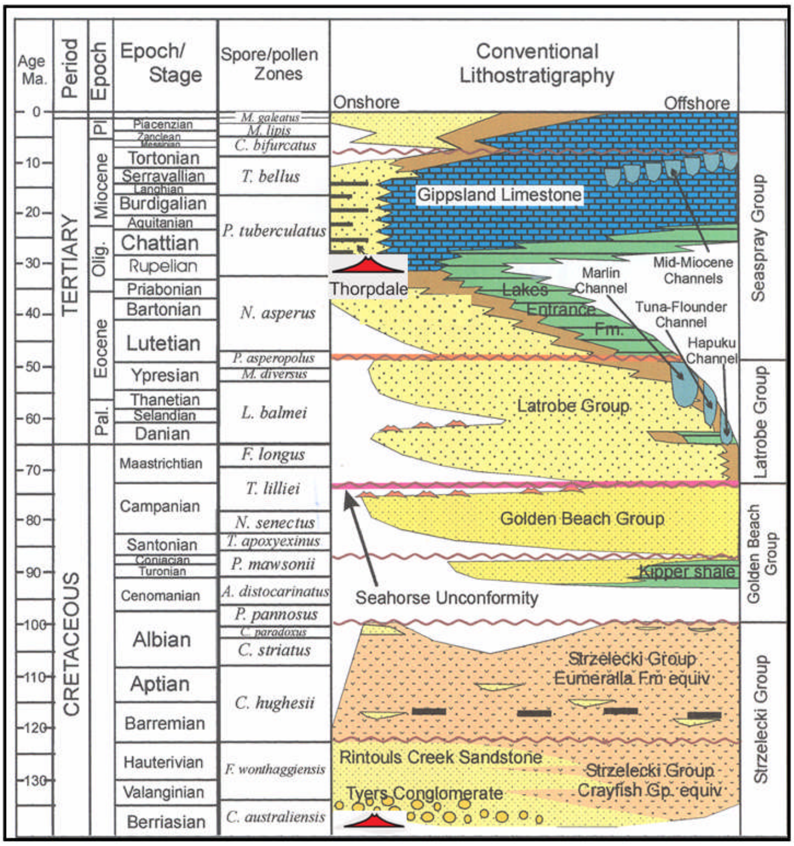

Figure 4. Lithostratigraphy of the Gippsland and Strzelecki Basins modified from Blackburn, 2002.

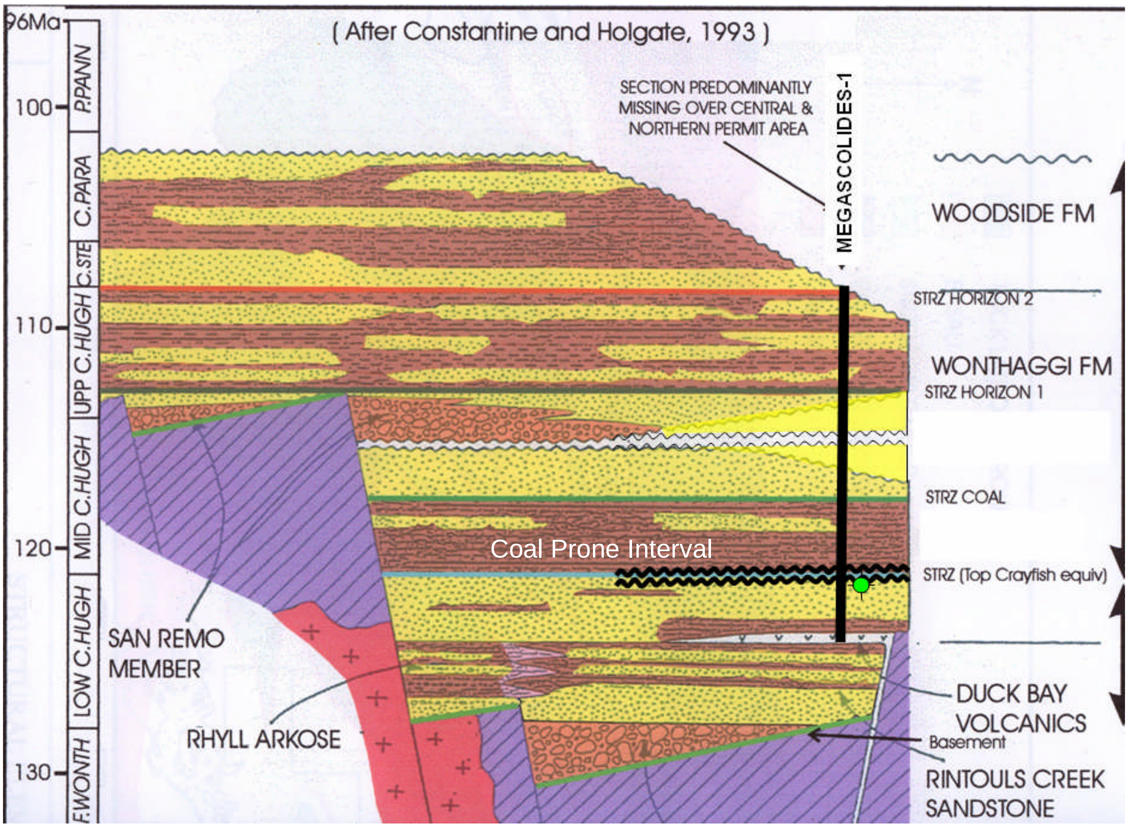

Figure 5. Chronostratigraphy of the Strzelecki Group modified from Blackburn, 2002 (After Constantine and Holdgate, 1993). *Note this stratigraphic column gives only a guide to the stratigraphic succession, as age dates recovered from Megascolides 1 suggest an earlier date of deposition and a more significant erosional break at the top of the Top Crayfish Group. This report has also treated the Kilcunda and Wonthaggi Formation as the Wonthaggi Formation as there has been little detailed stratigraphic discussion of the Kilcunda Formation in other publications and well completion reports.*

The closest petroleum wells to the PEP162 permit for stratigraphic correlation are Tarwin Meadow 1 to the south and Loy Yang 1A to the east. Both wells do not have complete Strzelecki Group sections so Woodside South 1 and Sunday Island 1 well were also considered when estimating predrill stratigraphic thickness. Sunday Island 1 intersected the thickest section of the Crayfish Group Equivalent (which includes the Chitts and Tyers Conglomerate and Rintouls Creek sandstone units). Paleogeographic mapping of the Early Neocomian main depositional systems by Chiupka (1996) interpreted the limit of the Tyers Conglomerate (Figure 6).

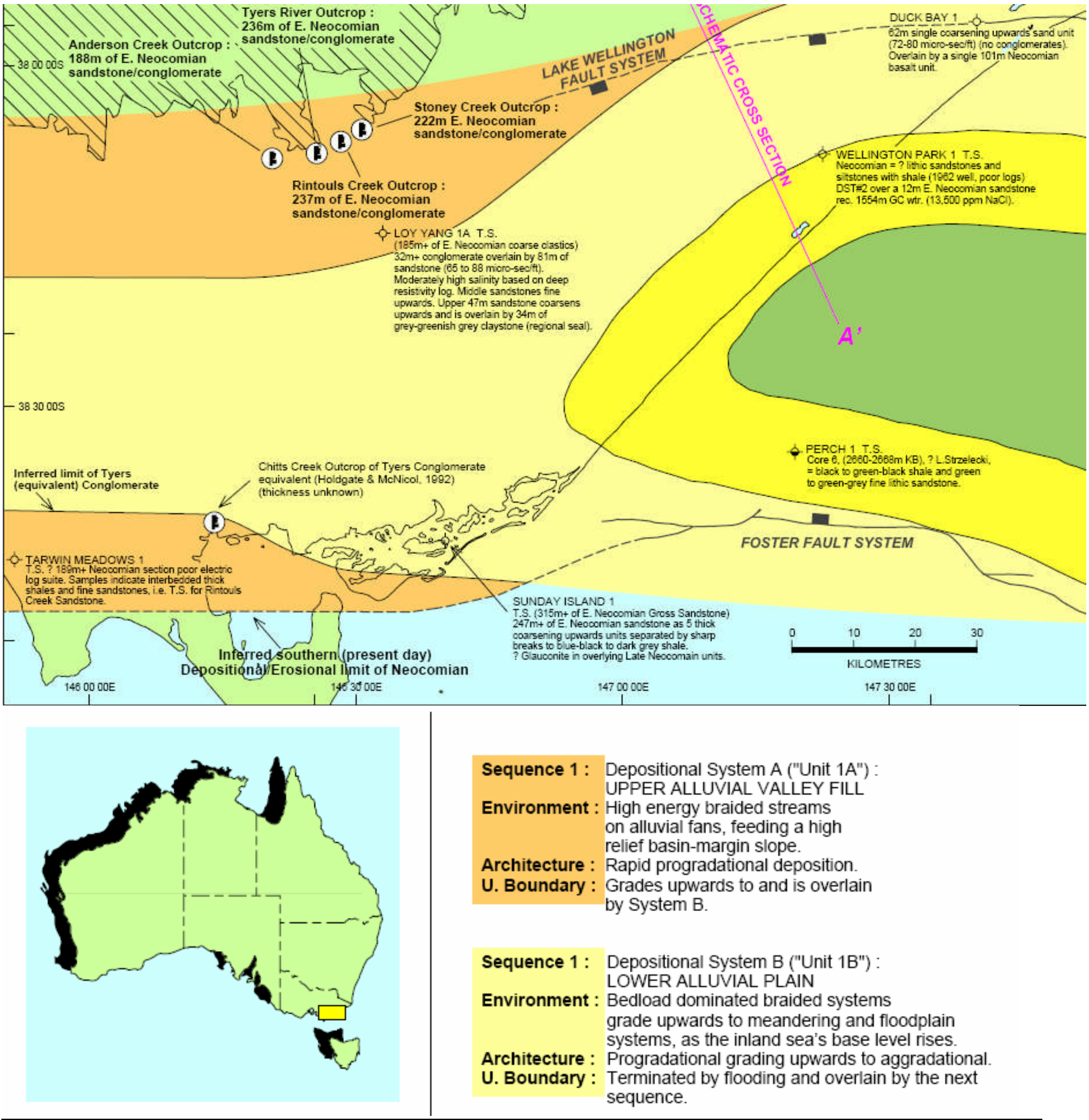

Figure 6. Early Neocomian Paleogeography trend map by Chiupka, 1996.

2.3.1 Paleozoic Basement

The basement Paleozoic rocks outcrop at Wonthaggi and Longwak within the PEP162. These are metasediments primarily of Ordovician, Devonian and Silurian age that belong to the north-south orientated Tasman Fold Belt (Scheibner, 1978). Cambrian altered basic rocks (Constantine, 1993) and Devonian granites have also been recorded within the study area.

2.3.2 Cretaceous (Strzelecki Group)

During the late Jurassic to Early Cretaceous the Strzelecki Basin formed in response to NW-SE left lateral oblique extensional rifting (Wilcox et al., 1992). These Strzelecki Group sediments, sourced from cratonic highlands to the north and gradually accumulated within a number of generally northeast to southwest trending grabens and half grabens (Griffiths, 1971). The graben system extends to the east and underlies the giant oil and gas fields of Bass Strait. The same system also extends to the west at least as far as the western end of the Otway Basin in South Australia.

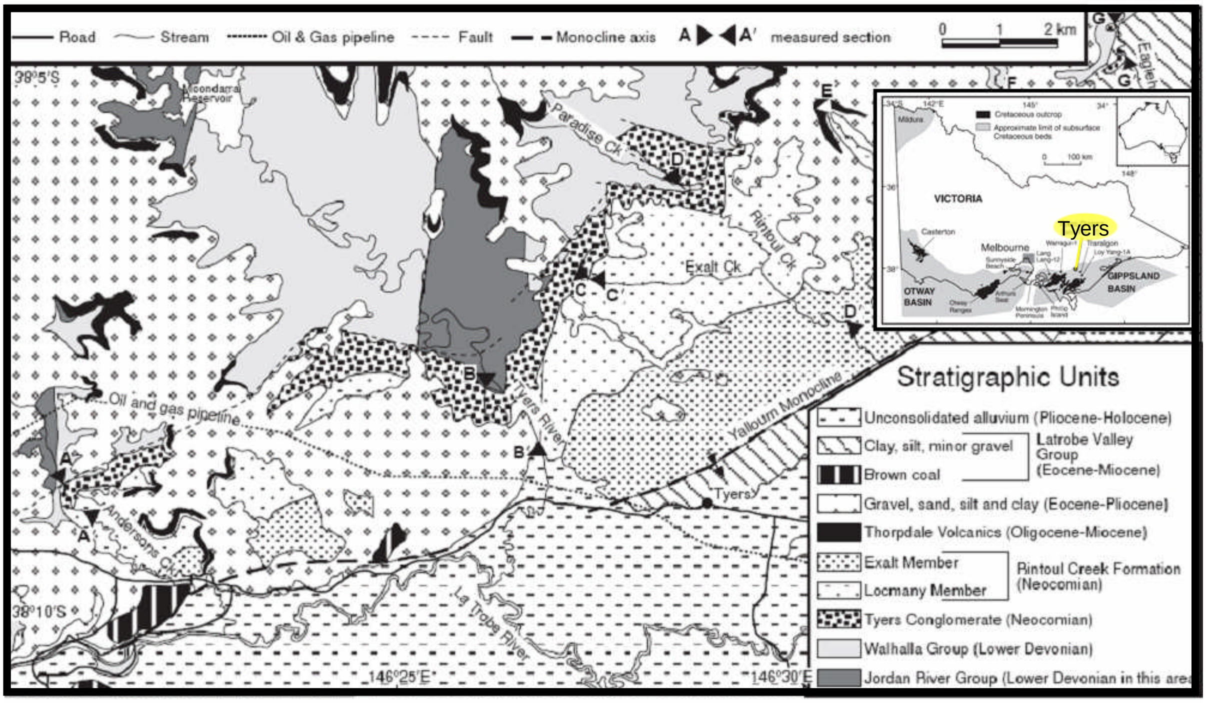

Figure 7. Tyers river district showing distribution of the Tyers River Subgroup (defined here as Top Crayfish Group equivalent) as mapped by Tosolini *et al.* (1999). The map shows the preserved outcrop of the conglomerates associated with alluvial fan development along the Paleozoic highlands in the north.

Initial graben fill was derived from the uplifted Paleozoic terrain dominated by continentally derived, quartzose, non-marine sandstones and minor coals, mudstones and carbonaceous shales. It is analogous to the Crayfish subgroup, prospective for oil and gas in the Otway Basin. These predominantly braided river sequences filled the rapidly subsiding alluvial plain within incised valleys cut into the underlying Paleozoic metasediments of the Lachlan Fold Belt. A lithologic and paleocurrent study (Figure 7) of the Tyers conglomerate has revealed that these lower Strzelecki Group rivers had a southeasterly paleocurrent direction with a likely northwestern cratonic sediment source (Tosolini *et al.*,1999).These early graben fill sediments (including the Tyers Conglomerate and Rintoul Creek Sandstone) have been described in detail by McNicol and Holdgate (1992) and Tosolini *et al.* (1999). This interval may correlate to the Loy Yang 1A 1551-1647m quartz sand rich interval located to the Tyers type section exposed in the north.

Overlying these Early Neocomian quartz rich sediments are the lithologically distinctive Kilcunda and Wonthaggi Formation sediments rich in volcanogenic sediments derived from an eastern extrabasinal andesitic/dacitic source depleted in quartz. The section is characterized by stacked fluvial sands, fine-grained overbank deposits and coal rich intervals, best developed near the base of the interval (Wonthaggi coals). According to Douglas (1976) the claystones and sandstones contain quartz, biotite, hornblende, oligoclase, orthoclase, perthite, microcline, andesite and calcite. However the claystones are dominantly potassic whereas the sandstones are dominantly sodic. The depositional pattern is regionally persistent with indications of marine influences only detected in the far west of the Otway Basin (e.g. Troas-1 well). This is supported by recent paleoenvironmental modeling by Morath and White (2004) that suggests a marine influence during the late Aptian.

The components of cratonic hinterland derived claystones, quartzose sands and metamorphics is generally less than 20%, except in the basal units, compared with over 85% in the lower Strzelecki. According to a predrill study by Blackburn (2002, p9) the spatial distribution of the Paleozoics along the northern margin of the Strzelecki basin suggests ‘that arkoses may be present within the west, while fan conglomerates and sandstones are more likely in the central and eastern part’ of the PEP162 permit. These sediments were predominantly deposited by rivers along the rift valley in braided streams, alluvial fans, over flood plains and into deltas and swamps (Figure 8). According to Bryan *et al.* (1997) sedimentation is controlled by westerly directed paleocurrents.

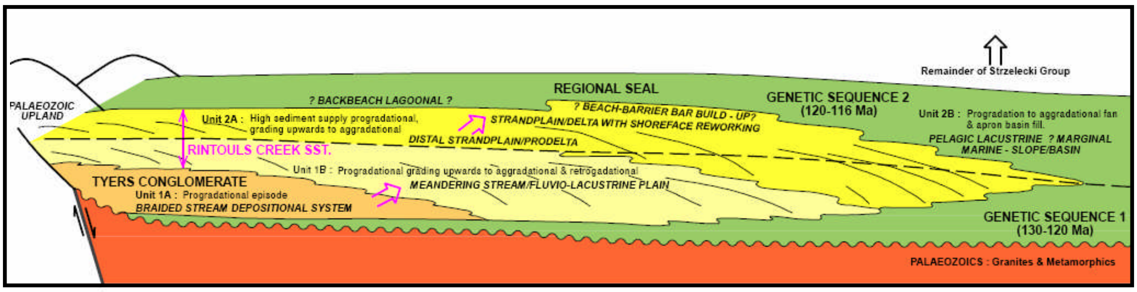

Figure 8. Generalised Early Neocomian Stratigraphic section by Chiupka,1996.

During the start of the Late Cretaceous, the Bass Strait early rifting failed and a northwest-southeast zone of strike-slip faulting to the west of Tasmania, absorbed the motion related to the continuing east-west rifting. This rifting eventually separated the continents of Australia and Antarctica from each other. During the period, the sea began to flood into the rift from the west marking the start of the opening of the Southern Ocean and the Tasman Sea. A phase of compressional uplift was also associated with the continental breakup and is considered to have compensated for rift valley sag caused by the crustal loading of volcanogenic derived sediments sourced from the east. By the end of the Cretaceous a passive margin was formed along the southern coast of Victoria. The Woodside Formation Strzelecki Group sediments that are absent in the Megascolides 1 indicate substantial inversion and erosion of the Northern Terrace area at this time (Figure 4). This Upper Strzelecki Group section is penetrated in a number of onshore wells close to the Permits such as Loy Yang 1A, Sunday Island 1 and Wellington Park 1 onshore wells. The stratigraphy is primarily interbedded volcano-lithic sandstones, siltstones and shales with minor coal units. (Chiupka, 1996).

The top of the Group is an unconformable surface that corresponds to the opening up of the Southern Ocean at the end of the Albian stage (Hill *et al.* 1995).

2.3.3 Tertiary

Overlying the Strzelecki Group onshore is the Latrobe Group (Figure 9). In the northwest region of the basin, over the PEP162 permit area, it has been divided into five Formations that relate to several main phases of positive structural inversion that occurred from early Late Cretaceous to the present day (Veevers, 1984; Duddy & Green, 1992). The first major deformation activity occurred during the Middle to Late Eocene time as northeast-southwest compressional anticlines formed and volcanism initiated along the western margin of the basin. Another major event occurred in Late Miocene reactivating the formation of anticlinal structures. The last tectonic event was the "Kosciusko" Uplift during Late Pliocene to Early Pleistocene which caused a basinward tilting of the sediments (Douglas & Ferguson, 1976). In the Megascolides 1 well only a thin Tertiary section of fluvial-paludal coarse grain quartz sandstone was encountered overlain by the basaltic lavas of the Thorpdale Volcanics. These volcanic flows have been tentatively placed at Late Eocene –Early Oligocene age by Mehin and Bock in the onshore Gippsland Basin (1998). To the south at Woodside 1 these Tertiary alluvial valley sediments thicken recorded by a recovered section of 47m.

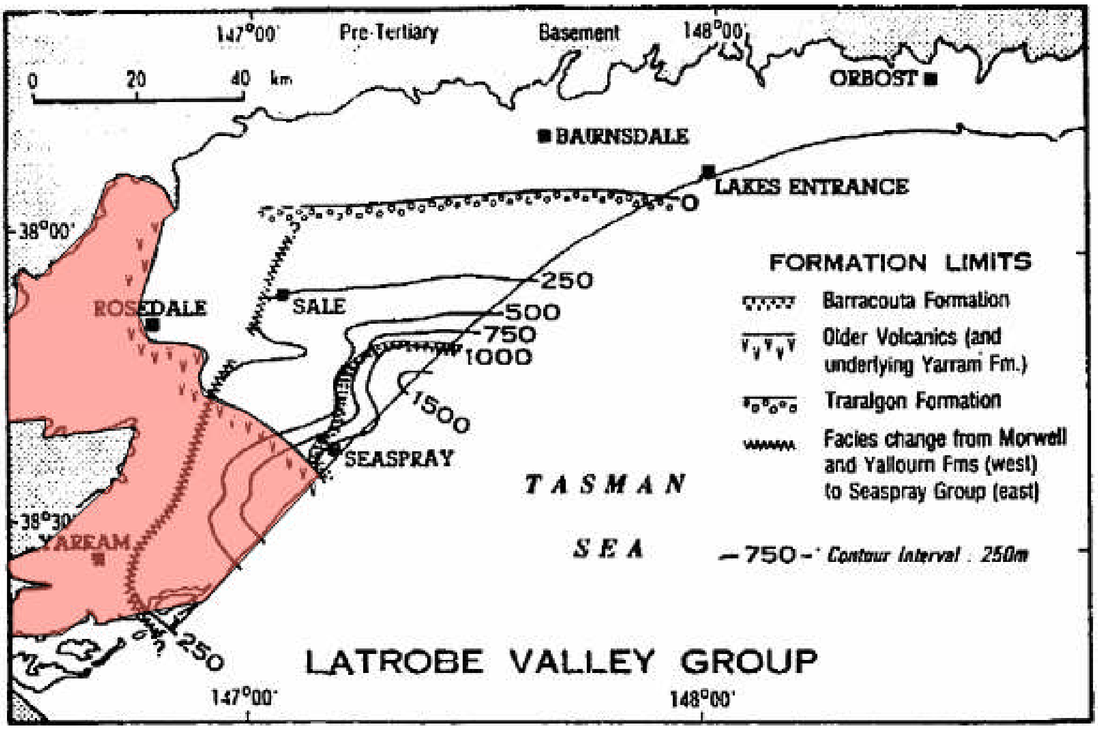

Figure 9. Tertiary Isopachs showing extent of Thorpdale (Older) Volcanics and Yarram Fm (Childers) mapped by Hocking, 1976.

Paleogeographic mapping of the Tertiary sequence over the Gippsland Basin has shown multiple transgressions and regressions of the coastal plain and barrier settings during the Late Paleocene to Early Oligocene (Fielding, 1992) with paleoshorelines orientated southwest to northeast and located around the modern Blackback field (Rahmanian and others, 1990; Fielding, 1992; Megallaa, 1993; Moore and others, 1992; Gross, 1993). Progressive westward marine transgression backstepped a wide zone of shoreline environments to finally onlap the terraces to the northwest of the basin followed by alternate eastward stepping regressions. These shorelines were backed by an extensive coastal plain surrounded by alluvial and fluvial settings controlled by large regional faulting (Douglas, 1976; Fielding, 1992). Continental clastic sediments were sourced from the north, the Bassian Rise Southern Platform to the southwest, south of the basin and from the west along the basin axis.

3: Megascolides-1 Results & Evaluation

Megascolides-1 was drilled in the northern reaches of the Northern Terrace of the Narracan Trough (Figure 3), a major depocenter within this Strzelecki rift basin that has since been inverted and eroded from the late Eocene (Constantine, 1993). It is bounded on the west by the major Heath Hill Fault (A southeast dipping reverse fault or Fault Zone (Tickle, 1978) and to the east by the Almurta Fault. Previous seismic mapping (Blackburn, 2002) has identified a number of features indicating rift basin inversion.

3.1 Stratigraphic Summary

Megascolides 1 penetrated a sedimentary sequence dated by palynological analysis to range in age from Early to Late Oligocene (Thorpdale Volcanics) at the surface to Early Cretaceous (*F. wonthaggiensis* Zone) at the well TD (Table 2).

The Thorpdale Volcanics have been dated over the Moe Swamp and Narracan Trough by radiometric dating (Wellman, 1974). The Volcanics at the base of the well (1942m to 2000m) are postulated to be the Duck Bay Volcanics that mark the onset of rapid extension from the end of the Tithonian to the Early Cretaceous. For a detailed description of the lithology please refer to the enclosed wellsite Lithological Log (Well Completion Report: Basic Data, End of Well Report within enclosure section 'Drilling Data').

The predicted versus actual formation tops are summarised in Table 1 (Figure 10). The primary main coal objective (Top Main Coals) was encountered approximately 16 m deeper than the prognosis. The secondary conventional oil and gas play objective comprised moderate quality sands of a gross thickness of 7m, 170m low to prognosis. The well reached a total depth at 2000 m RT (driller's depths) as planned after penetrating 58m of unweathered basalts at the base of the well.

Formation Tops:	Prognosed (mRT)	Actual (mRT)	Actual (mSS)
Thorpdale Volcanics	Surface	Surface	+101
Childers Formation	34	37	+68
Strzelecki Formation	104	61	+44
Top Upper Coals	287	278	-173
Top Bland Zone	560	n/p	n/p
Top Main Coals	699	715	-610
Top Crayfish Equivalent	1713	1883	-1778
Volcanics	n/p	1942	-1837

Table 1. **Prognosed and Actual Formation Tops.**

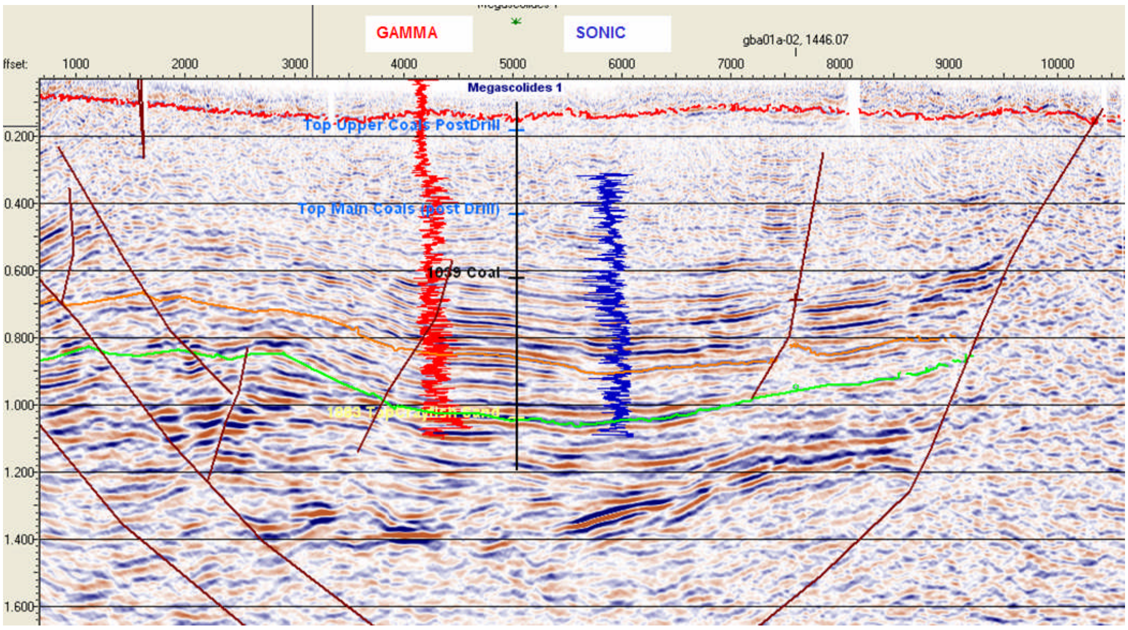

Figure 10. Time seismic section across Megascolides 1 location showing reservoir section in yellow and main coal in black.

The following lithologic descriptions combine the results of ditch cuttings and conventional core descriptions. The complete ditch cuttings and core descriptions are available in Megascolides-1, Well Completion Report: Basic Data. All depth measurements are referenced to the rotary table.

The formation assignments are based on drilling parameters, geologic sampling, wireline logs, biostratigraphic data and correlation to offset wells.

Age	Formation	MD	TVDSS	Thickness
Major Unconformity				
?Oligocene	Thorpdale Volcanics	0mRT	-129.27	37m
?Oligocene	Barracouta Formation (Childers Formation)	37mRT	-166.27	24m
Major Unconformity				
?Early Albian	Wonthaggi Formation (Strzelecki Group)	61mRT	-190.27	656m
Major Unconformity				
Hauterivian	Rintoul Creek Formation (Top Crayfish Group Equivalent)	1883mRT	-2011.72	59m
Unconformity?				
Hauterivian	Top Crayfish Group Equivalent	1890mRT	-2019.27	52m
Hauterivian	Duck Bay Volcanics?	1942mRT	-2091.27	58m
Total Drillers Depth: 2000 mRT Total Loggers Depth: 2001.8 mRT				

Table 2. **Megascolides 1 Stratigraphic Table.**

3.1.1 Thorpdale Volcanics

Top: 0 m RT
Base: 39 m RT
Age: ?Oligocene
Upper boundary pick: Outcrops at surface.
Lithology: Weathered basalt at top with boulders and very coarse sands to unweathered black basalt at base.
Shows: None.

3.1.2 Barracouta Formation (formerly known as Childers Formation)

Top: 37 m RT
Base: 61 m RT
Age: ?Oligocene

Upper boundary pick: The top of the onshore extent of the Barracouta Formation (known locally as the Childers Formation) is based on a lithology change from the overlying Thorpdale Volcanics basalt to paleosol and coal, to massive quartz sandstone, shown by the associated increase in rate of penetration and the shift in gamma ray from the MDT-GR logging suite.
Lithology: Light orange, massive very coarse, poorly sorted quartz sandstone with minor pyrite grading to grey claystone at the base.
Shows: None.
Depositional Setting: Braided river system underlain by swamp-dominated floodplain. The very coarse quartz sandstone grains suggest a proximal sediment source.
Note: This formation has also been previously interpreted as the alluvial valley sands of the Yarram Formation (Hocking, 1976). In 1971 Partridge determined that the Formation is younger, Oligocene, in the Narracan Trough than the Middle-Late Paleocene date of the Childers Fm sediments seen at Woodside-1 well and elsewhere.

3.1.3 Strzelecki Group (Wonthaggi Formation)

Top: 61 m RT
Base: 1883 m RT
Age: Cretaceous (*?C.striatus* to *F.wonthaggiensis* zone*)*
Upper boundary pick: The top of the formation comprises weathered claystone overlying an argillaceous green-grey volcanogenic sandstone distinguished from the overlying faster drilling rate of the Barracouta (Childers) Formation by its lower rate of penetration.
Lithology: The Strzelecki formation consisted of interbedded claystone and volcanolithic sandstones with thin interbedded coal seams. The Sandstone in the upper part of the section is light green-grey, dominantly very fine, angular to subangular, very poorly sorted with abundant medium grey argillaceous matrix. No visible cement, quartzose, friable, very poor visual porosity.
Coals: Gas desorption analysis was carried out on a single 87cm long 50mm diameter wireline retrieved coal core sample that was collected between 1039.25 and 1040.12m. The total methane generation potential of the sample was 3.37m3/tonne Dissolved Air Flotation.
Shows:

1644-1655	Oil Show Complex fault/fracture zone with live medium gravity oil saturation but with no significant associated gas
1730-1783	Oil Show Trace solid bright yellow fluorescence giving a weak yellow white crush cut, trace film residue not associated with any observable drill rate fluctuation or gas increase.
1816-1850	Oil Show 40% solid bright yellow fluorescence giving a weak yellow white crush cut, thin film residue. No drill rate increase or mud losses were observed. A slight total gas increase to 0.02% was observed (C1 75.5%, C2 14.0%, C3 3.5%, C4 7.0%, C5 0).
1865-1866	Oil Show Slickensided coaly material has 1% solid bright yellow fluorescence giving a weak pale yellow white slow streaming to crush cut. The thin film residue suggests that some oil is along the slide sufaces within the coal, however total volume is assessed as being too low for significant recovery.

Depositional Setting: The range of very fine to medium sandstones with poor to moderate sorting, and common fine overbank deposits suggest a fairly quiescent meandering fluvial environment throughout the Strzelecki Group section. This would suggest that there was a low channel gradient and the presence of only thin coals hints at a fairly high sediment supply. As seen in Loy Yang 1A the Aptian sediments are finer grained and darker green-grey than the overlying grey Albian sandstones seen in wells to the south. The green grey colouration is due to the presence of septichlorite within the matrix cement. This phyllosilicate is a common alteration phase of metabasalts.

In this area, the rate of sedimentation appears to closely match graben development as rifting slowed throughout the Otway and Gippsland margin.

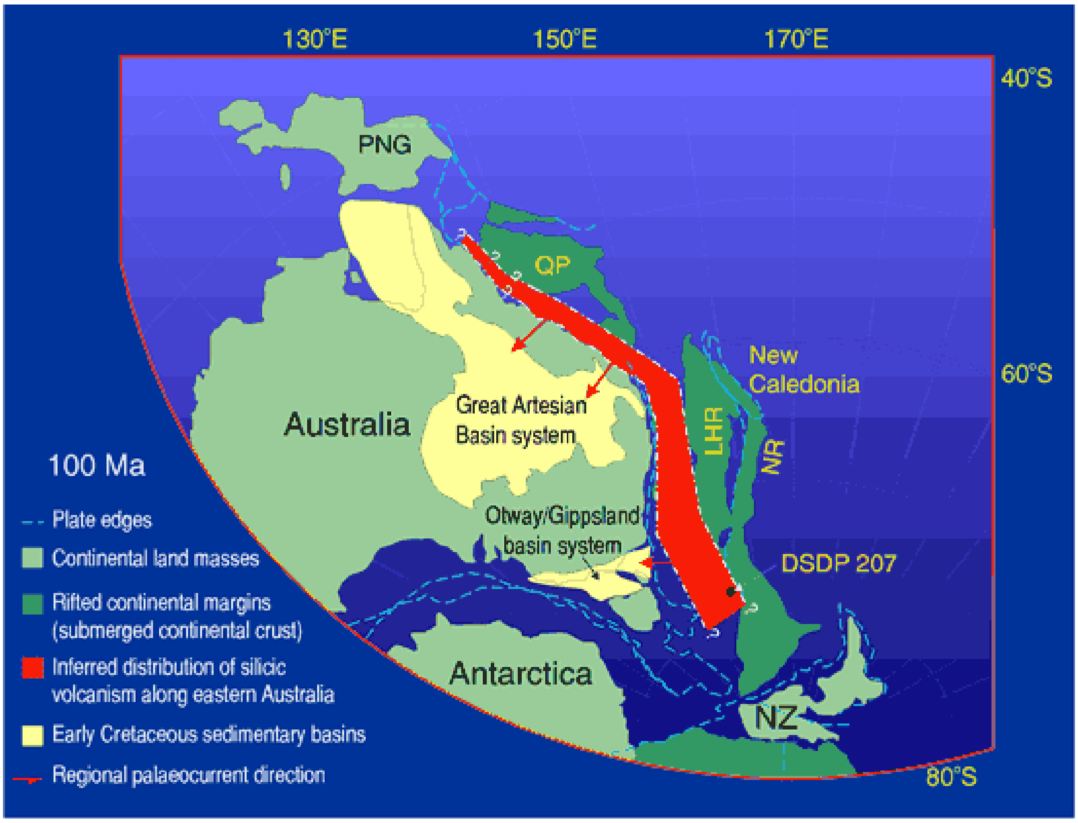

Figure 11. **Map of the SW Pacific reconstructed at cessation of volcanic activity 100 Ma (Yan & Kroenke, 1993), showing the inferred distribution of the Early Cretaceous silicic pyroclastic volcanic belt along the eastern Australian plate margin**: the proposed *source of Aptian-Albian volcanogenic sedimentary rocks in the Great Artesian and Otway/Gippsland basin systems. Volcanogenic sediment was shed westwards (arrows) into the basin systems.*

3.1.4 Strzelecki Group (Crayfish Group Equivalent sand)

Top: 1883 m RT
Base: 1890 m RT
Age: Cretaceous (*?F.wonthaggiensis* zone*)*
Upper boundary pick: The top pick is based on a lithology change from the overlying Wonthaggi Formation laminated claystone and coal, to massive argillaceous, quartz sandstone. There was an associated increase in rate of penetration, a shift in gamma ray from the MDT-GR logging suite and increase in mud gas readings (Table 3).
Lithology: The upper part of the formation at 1883m consists of predominantly coarse sandstone. The quartzose sandstone is light to medium grey, very fine to very coarse. It has subangular to subrounded grains which are very poorly sorted. It also has a white argillaceous matrix and is strongly silica cemented and moderately calcareous cemented. The sandstone has trace dark grey and red brown lithics and black coaly detritus.
Shows:

1883-1890	Oil Show The upper 3m is tight due to unconformity alteration and depositional products. A remnant tarry product is present in this upper 3m and extends up into the base of the Strzelecki. The gas readings in the upper 3m range around 0.05%. Below 1886m (1886-1890m) the total gas readings rise to 0.267%, correspondingly the oil fluorescence increased from 1% of sample to 50%. Visually this sandstone appears to have low to very low porosity - confirmed in part by the low drill rate and fluorescence. Best assessment is for this interval to be oil saturated with a medium to heavy gravity oil with a low GOR and very poor intergranular porosity.

Depth M	Tgas %	C1 ppm	C2 ppm	C3 ppm	iC4 ppm	nC4 ppm	iC5/nC5 ppm
1511.0	0.03	95	13	1	7	0	0
1535.9 coal stringer	0.051	50	18	15	15		
1633	0.045	74	0	13	8	0	4/4
1660	0.021	56	2	5	2	0	0
1690	0.016	45	2	4	0	0	0
1692	0.023	58	2	6	3	0	0
1694	0.031	105	6	9	3	0	0
1703.82	0.031	113	7	10	3	0	0
1708.75	0.038	124	8	11	4	0	0
1733	0.034	29	1	4	1	0	0
1788	0.019	33	2	3	0	3	0
1803 (Drill Break)	0.024	62	3	3	0	3	0
1810	0.024	68	7	4	0	3	
1823	0.021	49	4	4	3	0	0
1825	0.022	65	4	4	3	0	
1836	0.028	80	11	7	0	0	0
1841	0.031	70	11	9	2	0	0
1854	0.41	98	23	17	4	0	0
1865	0.05	72	19	18	6	0	5
1884.4	0.131	154	38	47	22	34	23/19
1889	0.267	218	67	88	49	62	56/42

Table 3. **Gas readings across Strzelecki Group 1511 – 1889m interval.** The values at the base show the large mud gas kick.

Depositional Setting: It was deposited in a high energy environment, perhaps a lower (distal) alluvial fan to braided fluvial setting, before the late Neocomian volcanic pulse that provided volcanogenic sediment to the overlying Wonthaggi Fm. The lower alluvial fan setting is similar to a braided fluvial system however it has smaller channels and less dense braiding. Deposits are largely sheetflood sand and silt showing evidence of low angle cross stratification, with thin conglomerate layers. These conglomerates are seen in the east at Loy Yang 1 and at outcrop at Tyers where they are more proximal to the highland source. It is possible that a bajada (coalescing alluvial fans) ran a distance at the base of the highlands to the north making stratigraphic correlation of these fan conglomerates and sands problematic. The thin development of the fan sediments at Megascolides 1 suggest that the Northern Terrace may have been an area of higher relief than anticipated at this time or erosion may have removed later fan sands.

Note: This sandstone has also been classified as part of the Early Cretaceous Lower Strzelecki Group or Boola Fm (Bernecker, 2001).

3.1.5 Strzelecki Group (Crayfish Group Equivalent shale)

Top: 1890 m RT
Base: 1942 m RT
Age: Cretaceous (*?F.wonthaggiensis* zone*)*
Upper boundary pick: The top pick is based on a sharp lithology change from the overlying sandstone to very dark grey shale. There was a corresponding shift in the gamma ray and density curves from the MDT-GR logging suite.
Lithology: Shale with thin interbedded sandstones. The shale is very dark grey, slightly to moderately silty, occasional diffuse and intermixed with very finely arenaceous laminae. It is also moderately to very carbonaceous with minor high angle mineralized fractures and common micromica.

The thin interbedded sandstones are generally light grey, very fine to occasionally fine, and subangular to subrounded. They have a white argillaceous matrix with trace grey lithics and black coal. It also has trace micromica and is hard with very poor visual porosity and no oil fluorescence.
Depositional Setting: The carbonaceous shale was deposited in a low energy environment, possibly a lacustrine to fluvial overbank setting similar to the Laira Fm in the Otway Basin. The thin interbedded sandstones may represent flood/stormbeds or crevasse splay deposits as suggested by the presence of rip-up clasts.

The calcite layers parallel to bedding (anoxic environments are favourable for preserving solid calcite) may have been biologically precipitated by cyanobacterium during warmer periods in an oligotrophic to mesotrophic lake as thermal stratification created algal blooms and increased calcite production. This process has been observed in such oligotrophic lakes such as Cayuga Lake in New York, USA (Mullins, 1998).

Shows:

1916-1942	Oil Show The vein infill material has trace dull patchy yellow fluorescence giving a very weak dull yellow white crush cut, trace residue. However no significant fracture intervals were observed during drilling, no mud losses recorded, no drill rate increases or gas increases observed. Possibly live oil saturation is present in open fracture spaces, however the number of open fracture volume is low and it is unlikely that there is communication between fractures.

3.1.6 ?Duck Bay Volcanics

Top: 1942 m RT
Base: 2000 m RT
Age: ?Early Cretaceous (*?F.wonthaggiensis* zone*)*
Upper boundary pick: The top pick is based on a lithology change from the overlying shale to weathered volcanics shown by the shift in gamma ray, neutron-porosity and density logs from the MDT-GR logging suite and increase in mud gas readings.
Lithology: Weathered basalts and green volcanics. The weathered volcanics had a cryptocrystalline texture with remnant flow banding, and common small vesicular infill. At the base it was hard, brittle, bright green in colour, and cryptocrystalline. There was also some calcite veining, and chloritic alteration.
Shows:

1944-2000 (TD)	Oil Show The vein infill material has trace dull to rarely moderately bright patchy yellow fluorescence giving a very weak dull yellow white crush cut, trace residue increasing with depth to 1% of sample with 20% dull to occasionally bright solid to patchy yellow fluorescence giving a weak yellow white crush cut, thin yellow ring residue. No drill rate or mud losses occurred through this interval. Total gas readings rose from a background of 0.02% to 0.07%. Best interpretation based on available data is for the presence of minor open spaces in the fracture planes with oil saturation, but with insufficient open volume and interconnectivity for recovery.	

Depositional setting: This volcanism may be similar to the Casterton Formation related volcanism seen in the Otway basin. In the Otway basin flows are associated with organic rich lacustrine shales that overlie the basement floor.
Note: This older volcanism in the Gippsland basin is thought to be possibly associated with dykes along the Lake Wellington Fault Zone (Moore and Wong, 2002). At the Duck Bay 1 well located at the eastern margin of the basin, Constantine (2001) dated the flows to the *R. watherooensis* Zone (around 150 Ma). This is much older than the tentative Early Cretaceous date recorded for this

well. However, in the Otway Basin volcanism has been recorded throughout the ?Tithonian (*R. watherooensis)* to Berriasian (lower *R.australiensis*) during the early extensional phase of the rift formation (Krassay et al. 2004).

3.2 Palynology

A palynological analysis was undertaken to determine the specific age, depositional environment and maturity of the Cretaceous and Tertiary sediments. Age dating was not diagnostic because all of the samples analysed relied heavily on the oldest occurrences of species. Strong events were not easily visible due to down hole contamination.

A summary of the results is presented in Table 4 and the complete report is available in Associated Report 1.

Sample depth	Biozone
75m	*Cyclosporites hughesii* Zone, possibly *Crybelosporites striatus* Zone
295m	*Cyclosporites hughesii* Zone
550-1005m	Possible *Cyclosporites hughesii* Zone
1235-1550m	Upper *Foraminisporis wonthaggiensis* Zone
1895m - 1780m	*Foraminisporis wonthaggiensis* Zone, possibly upper part of zone
2000m	Early Cretaceous?

Table 4. **Palynological zonation.**

3.3 Seal

The top of the Crayfish Group Equivalent sandstone was encountered 170m low to prognosis. The presence of a gas kick in the mud gas readings from 0.05% at 1883m to 0.267% at 1886m, and a large increase in oil fluorescence from 1% to 50% over the same interval indicates some trapping, structural or stratigraphic is or has been present. The top seal is the overbank quartzose-feldspathic claystone at the base of the Wonthaggi Fm sediments and may be enhanced by the weathered alteration at the unconformity surface at the top of the Crayfish Group Equivalent sandstone. It is anticipated that there may be both structural and stratigraphic traps at other locations in the basin where updip pinchouts of the sandstone interfinger overbank and paludal sediments.

3.4 Source

Previous onshore wells encountered potential Strzelecki source rocks with a range from 0.21 to 26.83 wt% TOC, with vitrinite reflectance in oil (R_o) values of 0.35-1.04 % and HI values from 23-179 mg hydrocarbon (HC)/g TOC (Mehin and Bock, 1998).

Seven samples from Megascolides 1 were collected and source rock richness analysis and rock-eval pyrolysis were performed. The abundant shallow Wonthaggi coals provide good source potential. The top (240-1104m) of the Wonthaggi section is oil mature (Type II and Type III) and makes a relatively rapid rise to late mature by 1104.2m. The potential reservoir rocks that are interbedded with these coals and organic rich shales have low permeability and porosity.

The Megascolides 1 hydrocarbon show at 1889m falls within the range recorded for Strzelecki source rocks with a R_o value of 0.83%, TOC of 1.54 wt% (1920m), and a HI of 72 mg (1920m). It is therefore likely to have had a complicated migration path history. Sediment compaction due to loading may have caused hydrocarbons to follow a fluid potential vertically downwards, moving from the relative high hydrostatic pressure, porosity low of the Wonthaggi Fm source sediments to the relative porosity high of the top Crayfish Group equivalent sandstone. The weathered Barremian unconformity surface or secondary tectonic porosity (joints, faults, fractures, or microfractures) may have provided a pathway for oil migration to this underlying reservoir.

Geochemical analysis of the 1889m core sample oil extract suggests a sub-oxic environment with predominantly land plant derived organic matter and a small component of aquatically derived algal matter. Equivalent vitrinite reflectance values suggest an early oil window maturity and comparisons with the recorded vitrinite reflectance value for the sample support the oil migrated from a local source. The oil window (0.6 – 1.3 Ro) falls between 400m with the entrance to the wet gas interval postulated to be at 2300m depth.

The shallow depth of the oil generative window has led to an estimate that there has been almost 2500 meters of uplift in the Northern Terrace area. The peak time for maturation and expulsion of the oil was the mid Cretaceous.

There may also be another downdip source component from the underlying lacustrine Crayfish Group shale or from even deeper lacustrine shales associated with the volcanism during early the rifting in the Basin as observed in the Otway Basin (Padley *et al.*, 1985; Edwards *et al.*, 1999). It is possible however that Crayfish Group equivalent source rocks may no longer be oil-generative as maturation and hydrocarbon expulsion from these lacustrine sediments may have occurred before the episodic uplift over the Late Cretaceous and Tertiary. This may create a strong preservation risk.

3.4 Maturity

Hydrocarbon generation and expulsion modeling from onshore wells in the Seaspray Depression and on the Northern Strzelecki Terrace near Lake Wellington indicate that there was one widespread expulsion event in this area at 115-95 Ma (Mehin and Bock, 1998).

Geothermal modeling of Megascolides 1 has suggested a number of possibly valid thermal history reconstructions. The most complex history corresponds to thermal history modeling characteristic of Australia's Mesozoic-Tertiary southern margin sedimentary basins (Duddy, 1997). In the well, this history is based on a paleogeothermal gradient increasing from of 29.5°C/km at 135Ma to 55°C/km at 95 Ma and declining to 29.5°C/km at 80 Ma. This gradient remains stable until 1 Ma then increases to 43.3°C/km until the present. An additional 750 m of Strzelecki Group sediments is deposited between 107 and 95 Ma, 250 m of which is eroded between 95 and 90 Ma, followed by deposition of 2000 m of Late Cretaceous section between 90 and 80 Ma with 2500 of section eroded between 80 and 35 Ma. This can be paralleled to the Loy Yang 1A model that saw dramatic uplift between 92 to 88 Ma after which subsidence slowed to 6Ma followed by gradual uplift until the present (Mehin and Bock, 1998).
The major erosional event recorded in the Strzelecki Group initiated at 95Ma is likely to be associated with the compressional realignment of the major blocks during the breakup of Gondwana suggested by Duff *et al.* (1991).

5: Reservoir Evaluation

The 3-5 meters of net reservoir sandstone penetrated between 1883 and 1890m is interpreted to be a braided fluvial or sheet flood sand in a lower alluvial fan setting (Figure 11). It contains young, very poorly sorted, subangular to subrounded quartz sands that coarsen upwards. These young clastics were analysed using mud logs, wireline logs and conventional cores. Complete core analysis, description, photos and petrology reports are included within Megascolides-1, Well Completion Report: Basic Data.

Predrill interpretation had anticipated that reservoir development would be good in this area along the northern Strzelecki Basin margin (Blackburn, 2002). It was also considered that there was a risk that deep burial and erosion above the base of the *C. hughesii* interval could reduce porosity and permeability. However wells such as Duck Bay 1 indicate that there are sandstones below this interval with porosities up to 23%. Megascolides 1 showed that the sandstone at the top Crayfish Group Equivalent was thinner than anticipated, being located on the lower alluvial fan and displays a lower effective porosity of 12.29 to 13.39 % (Table 5). The gas peak at 1889m however shows that permeability is fair and reservoir quality may improve towards the main braided channel fill/upper alluvial fan. Chiupka (1996) suggests that higher porosities may be also be expected in hydrocarbon zones which have received early hydrocarbon charging.

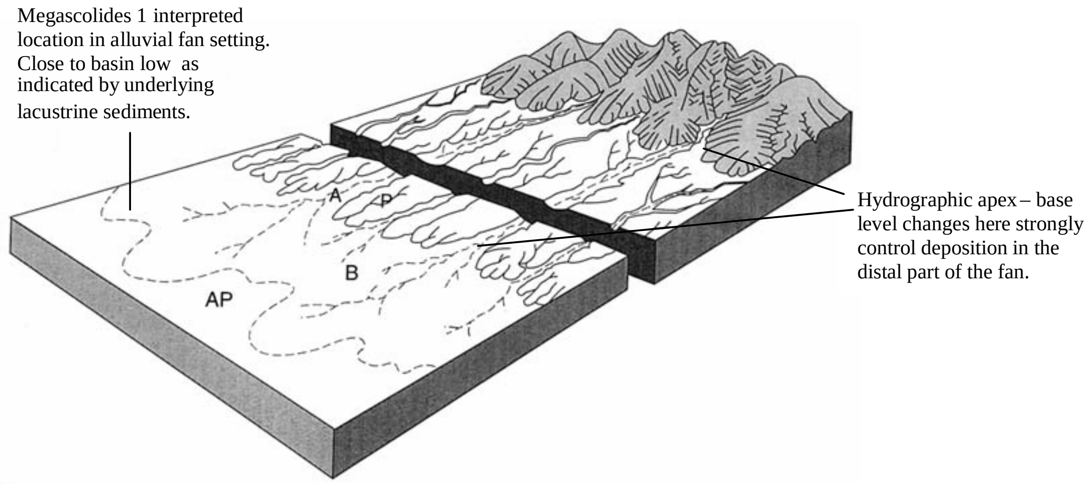

Figure 12. A bajada (B) incising a piedmont (P) showing stream flow alluvial fans (A) merging with an alluvial plain (AP). (Peterson ,1981).

5.1 Petrophysical Evaluation

The complete petrophysical evaluation of Megsacolides-1 is available as Associated Report 2. A brief summary of the results is presented below in Table 5 and Figure 12. Figure 12 clearly shows the overlying shale with poor porosity and the two good reservoir Crayfish Group equivalent sands with high water saturation (SW).

Interval	PHIE cut-off %	Gross m	Net m	PHIE av %	Vcl av %	Swe av %
1883-1886	12.0	3.00	0.66	13.39	16.75	63.96
1888-1891	12.0	2.00	0.10	12.29	25.12	49.25

Table 5. **Megascolides-1 Reservoir Summary.** Cut-off used: Vcl <50%, PHIE >12.0%.

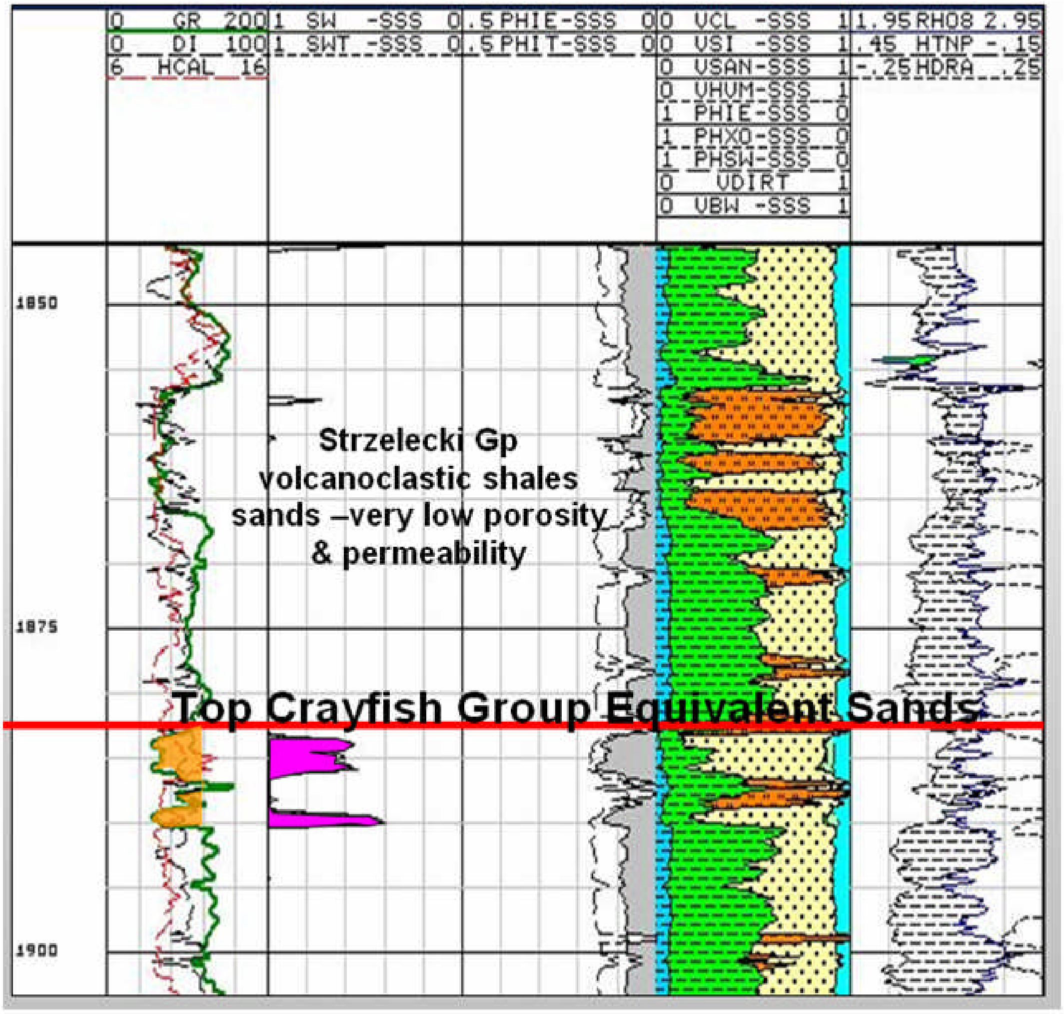

Figure 13. Top Crayfish Group equivalent reservoir interval (Rintoul Creek Fm) showing effective porosity overlain by volcaniclastic sediments with very low porosity and permeability.

6: Coal Bed Methane

The onshore Gippsland Basin is a historical coal mining region with up to 3m thick bituminous coal seams mined in the Wonthaggi Coal Measures at the town of Wonthaggi (Ward, 1995). Authors (Planet Gas, 2005) have likened the Wonthaggi coal deposits to the economic deposits of the San Juan Basin which produces from 1m thick back-barrier coal deposits (0.8% VR). Megascolides 1 is the first coal bed methane well to be drilled in the northern part of the Strzelecki basin, and the first to test the Wonthaggi coal bed methane potential in the Narracan trough. It intersected a total thickness of 12.2m black coals (from a

Petrophysical log analysis using RHOB, NPHI, DT and RT) over the interval 700 to 1100m.

The seams are generally thin and their thickness, occurrence, and geometry have been strongly influenced by depositional environment. On the Northern Terrace (Figure 13), coals were deposited during a regionally quiescent period of Strzelecki Basin development at the top of the Barremian stage. At the Wonthaggi mine, the coals are banded bituminous with medium moisture level content and volatile hydrocarbon content. The rank and prospectivity of the coals recovered at Megascolides 1 is discussed below.

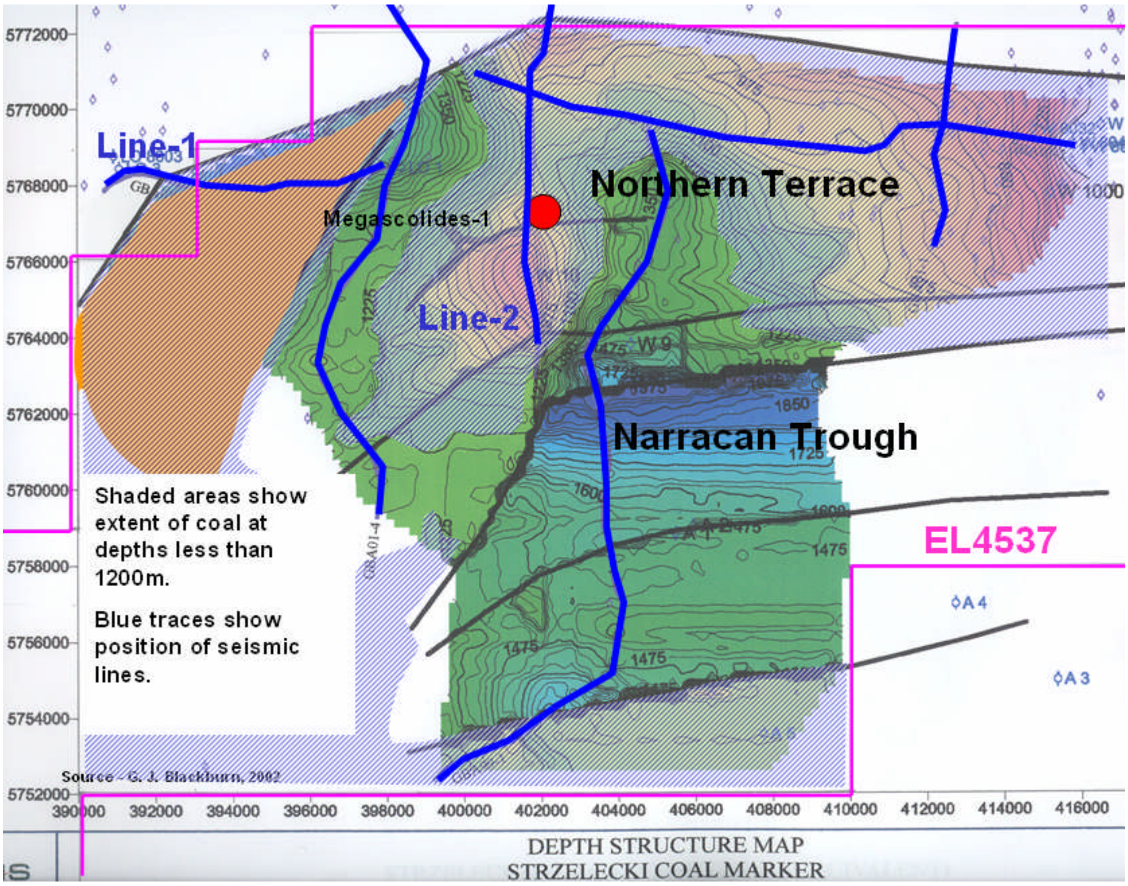

Figure 14. Predrill Depth Structure Map of the Strzelecki Coal Marker (Blackburn, 2002) showing coals at depth less than 1200m.

6.1 Coal Bed Methane geological considerations

There are six considerations for successful coal bed methane exploration (Scott, 2004) and these will be discussed in relation to the results from the well:

1. Tectonic and structural setting
2. Depositional systems and coal system
3. Coal rank and gas generation

4. Gas Content
5. Permeability
6. Hydrodynamics

1. Tectonic and structural setting

Where not excessive, structural deformation and faulting can greatly enhance coal permeability through the development of fracturing and close-spaced cleat development. The Northern Terrace area is a large area with a lightly structured and folded sequence. Structural deformation is low with only a few faults cutting the sequence. Current day tectonic activity has produced a compressional regime in the area that results in reverse fault movement on the main faults that control the Narracan Trough. This activity has resulted in the uplift of Mount Worth and other high features in the area of the Karoon Leases.

Historical studies have showed that compressional regimes can enhance coal permeability increasing the viability of the fields. Coal cleats can form, as well as inclined fractures that result from shearing by structural slip. Cleats can also form as the result of dehydration, devolatilisation, tectonic activity, and overburden unloading. The face cleat set is the dominant set and forms parallel to maximum compressive stress. High ash, low rank coals such as the coals seen around 1005-1050m usually display less cleat development. The thick coal desorption sample (MS1ED005) at 1039.25m-1040.12m was examined for cleat and fracture surfaces in the Megascolides 1 coals. Most of the thin coal seams did not have developed butt cleats however face cleats were commonly seen with spacing ranging in size from 7mm to 25mm. Rare fracture surfaces were also recorded. Butt cleats are strain-release fractures that form parallel to fold axes and their absence indicates a lack of structural deformation.

Coalification is interpreted to be before structural development (pre-tectonic) as there is little or no correlation between coal rank and structure. High gas levels at shallow depths are unlikely because the low permeability interfingering volcanogenic fluvial sandstones prevent vertical thermogenic gas movement.

2. Depositional systems and coal system

As discussed above, the Wonthaggi Coal Measures (Medwell, 1954) occurred within a meandering fluvial depositional system as suspended load, mixed load or bed load deposits in swamps, overplain or flood plain settings. This is also born out by the presence of vitrinite rich coals indicative of fluvial environments and siderite bands indicative of low salinity, low energy, and anoxic swamp environments. In a fluvial system the thickest seams usually occur between the channel axes. In Megascolides 1 the common presence of thin seams throughout the section and high ash content could be indicative of coal seam splitting towards a major distributary channel. The coals are likely to be dip elongate and trend parallel to the westerly/southwesterly paleocurrent direction.

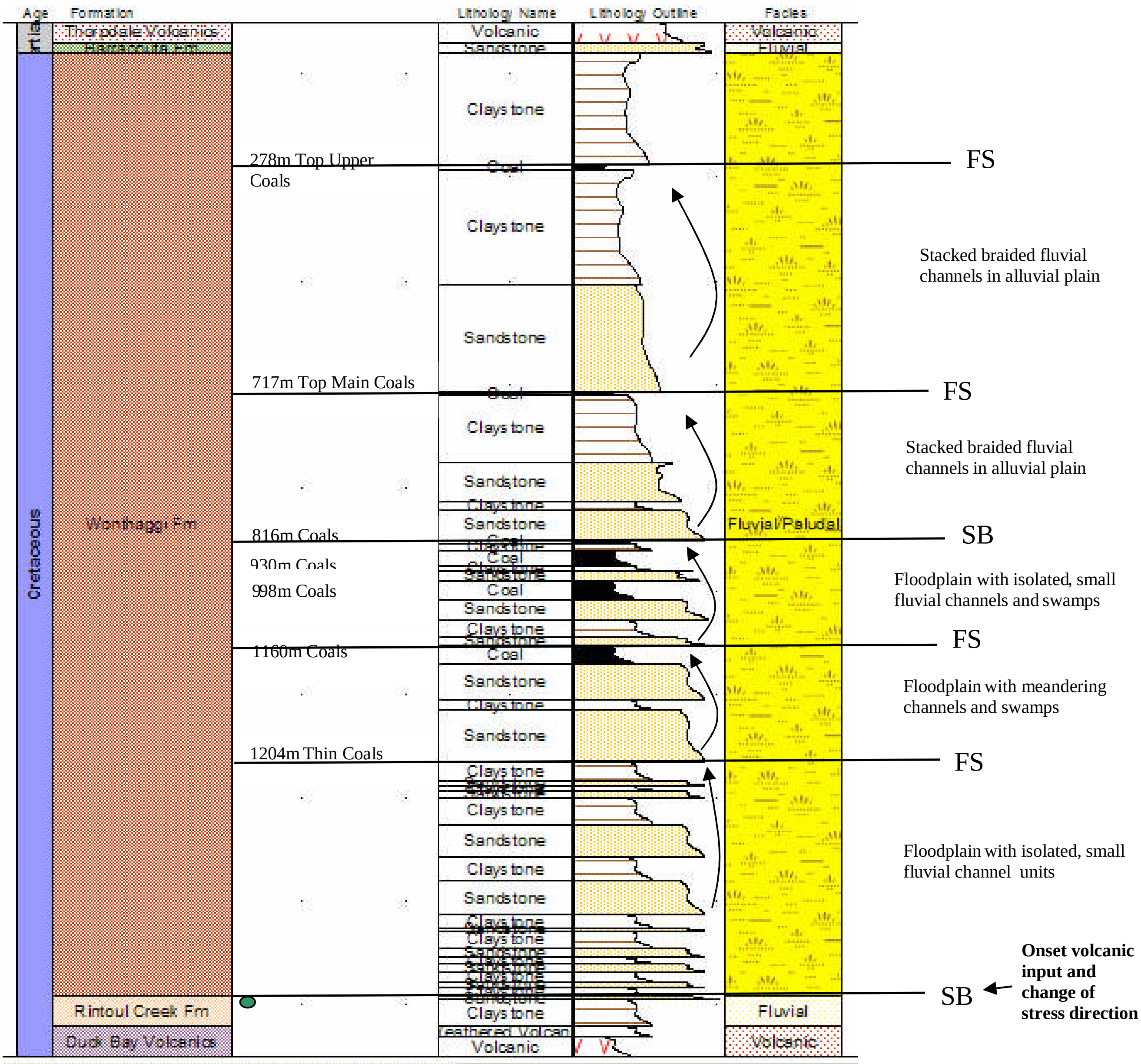

Figure 15. Generalised Megascolides 1 lithology column showing coal rich, claystone rich and sandstone rich facies. FS=Flooding surface, SB =Sequence Boundary

Figure 14 shows the main coal rich intervals. The whole column shows a phase of fluvial progradation during of a period of episodic base level rise. At the base of the Wonthaggi Fm penetrated the rapid creation of space on the rift floor created isolated thin channels preserved in thick accumulations of flood plain fine sediments. The poorly drained soils and high sediment supply created rare, patchy, high ash coals. As the accommodation space filled the channels amalgamated and deposition slowed as sand deposition bypassed to the coast. The streams became more sinuous and the coal swamps on the overbanks and fluvial plain thickened as sediment supply to these areas halted. This was followed by a drop in baselevel and an increase in sediment supply. This created a stack of higher energy braided channel fluvial sands, floodplain claystones with little or no coal.

3. Coal rank and gas generation

The desorption coal sample had air dried moisture content of 2.9%, ash of 47.4%, volatile matter of 23.7% and fixed carbon of 26.0%. It also had a VR range between 0.64 - 0.89 (within the optimum range).This would put it within the subbituminous to high volatile B bituminous coal rank (see Table 6 below). The optimum coal rank is low to medium volatile bituminous therefore the sample analysed is of lower rank than the ideal. The high ash content is also higher than the target of 20% (air dry). Predrill studies had shown that the documented ash content from mines and bores in the Narracan Trough range between 4.9% and 14.2%. These percentages are lower than those encountered in the well.

The content of the small macerals in coal have a large effect on gas content in coal beds. The inertinte group, commonly seen in the samples, has relatively little hydrocarbon generating potential, though they have the greatest capacity for storage of methane.

Rank Stages	%carbon (daf)	%volatile matter (daf)	specific energy (gross in MJ/kg)	% in situ moisture	% vitrinite reflectance	% vitrinite reflectance
					random	max
wood	50	>65	-	-	-	-
peat	60	>60	14.7	75	0.2	0.2
brown coal	71	52	23	30	0.4	0.42
sub-bituminous	80	40	33.5	5	0.6	0.63
high volatile bituminous coal	86	31	35.6	3	0.97	1.03
medium volatile bituminous coal	90	22	36	<1	1.47	1.58
low volatile bituminous coal	91	14	36.4	1	1.85	1.97
semi-anthracite	92	8	36	1	2.65	2.83
anthracite	95	2	35.2	2	6.55	7

Table 6. **Coal rank stages by Diessel (1992).**

4. Gas Content

The gas content was measured using an inverted, water filled measuring cylinder for a core sample taken between 1039.25 and 1040.12m. The desorption gas content was 3.37 m^3/tonne DAF over 2.45 days. The gas composition was 100% C1 with a very low (0.01 Mol%) CO_2 component. By comparison the San Juan basin averages gases that contain 10-12 Mol% CO_2.

The gas is a wet (alkane rich) gas in an immature, low rank coal with a VR value that falls within the maximum wet gas generation stage.

5. Permeability

No permeability analysis was undertaken for this well.

6. Hydrodynamics

The presence of the large relative volumes of volcanoclastic material in the Upper Strzelecki Wonthaggi Fm (coal bearing interval) is very important for CBM production. The volcanoclastic dominated sandstones alter rapidly with burial creating very low porosity and permeability rocks that are as such, very unlikely to provide a water source during production related dewatering of the coals.

7: Contributions to the Evaluation of Hydrocarbon Potential of the Area

The drilling of Megascolides-1 has contributed the following information to the understanding of the Narracan Trough and the Strzelecki Group within the northern reaches of the onshore Gippsland Basin:

- Proved existence of good source coal and claystone rocks in the Wonthaggi Formation of the Strzelecki Group. Analysis of hydrocarbons shows within the Crayfish Group Equivalent sandstone also show there is a lacustrine source rock at the base of the Group that is syn-sedimentary with equivalent lacustrine sediments observed in the Otway Basin.
- Proved Ozimic et al.'s (1987) supposition that the Northern Terrace of the Narracan Trough contain Strzelecki Group sediments in the oil window.
- Proved the trap at the top of the Crayfish Group Equivalent sandstone is valid. This provides a compelling argument for further exploration in prospective areas along the flanks of the Heath Hill High.
- Proved that there are reservoir sandstones (3 to 5 metres of net porous, permeable sands showing good fluorescence and high mud gas readings) within the Rintoul Creek Fm (Top Crayfish Group equivalent).
- Provided essential stratigraphic control for the existing 1998 GBA01A seismic survey. Further seismic will provide more information on basin geometry.
- Mafic volcanics had been suspected to be below the Stzelecki (Moore and Wong, 2002) in the onshore Gippsland Basin however none had previously been encountered.

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