PEP 152/159
ONSHORE OTWAY BASIN
VICTORIA

REGIONAL
INTERPRETATION AND STRUCTURAL
MAPPING REPORT

INCORPORATING THE 2000
SPRING CREEK SEISMIC SURVEY

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1 INTRODUCTION

PEP 152 and PEP 159 are located in the eastern onshore Otway Basin in southwestern Victoria, approximately 60 km northeast of Portland (figure 1).

The Spring Creek seismic survey was recorded in March/April 2000 by Trace Terracorp, and was processed by Robertson Research Australia in July 2000. Ten lines were recorded with a total length of 99.5 kms in both permits (76.9 kms in PEP 159 and 22.6 kms in PEP 152) (figure 2).

This report incorporates the structural mapping of the Spring Creek seismic survey in both PEP 152 and PEP 159.

Different maps for different targets were produced for each permit.

In PEP 159, three maps were produced for three main targets: the Top Pretty Hill Sandstone, the Top Nullawarre Greensand over Findra prospect, and the Base Tertiary / Top Pebble Point Fm (enclosures 1, 2, & 3).

In PEP 152, two maps were produced for the following horizons: Top Pretty Hill Sandstone, and Top Waarre Sandstone (enclosures 1, & 4)

This report includes the updated prospect and lead maps for the key levels in both PEP 152 and PEP 159.

2 PERMIT SUMMARY

2.1 PEP 152

PEP 152 comprises 827 square kilometres of onshore area in the Victorian part of the Otway Basin.

The permit is in its second year of the current 5-year term, which commenced on 03/02/2000 and expires on 02/02/2005.

1340 kilometres of 2D seismic data were acquired since 1958 to the most recent Spring Creek Seismic Survey in 2000 (Table 1)

7 exploration wells have been drilled in the permit since 1959. Table 2 summarises the results of these wells.

The current participants in the permits are:

Origin Energy Petroleum Pty Ltd	50.51% (Operator)
Essential Petroleum Resources Ltd	33.9%
Lakes Oil NL	15.59%

Table 1. PEP 152 - Seismic Acquired

Year	Survey Name	No Km
1958	Portland & Pt Campbell	232
1962	Yambuck-Portland	47
1964	Koroit	13
1966	Port Fairy-Nelson	63
1969	Hawkesdale	10
1970	Portland-Macarthur	38
1971	Nelson-Koroit	56
1973	Coastal Strip	98
1985	Toolong	264
1985	Windermere to Port Fairy	59
1988	St Helens	100
1989	Shamrock	12
1990	Orford	50
1991	Moyne	10
1992	Otway Basin	16
1993	Kaloola	12
1994	Greenacres	14
1995	Tower Hill	112
1997	Cartcarrong	56
1998	Mumblin	57
2000	Spring Creek	23
	TOTAL	**1342 km**

Table 2. PEP 152 - Wells Drilled

Year	Well Name	Operator	Well Type	Target	Total Depth (MKB)	Result	Flow Rate/ Recovery
1959	Belfast 4	Vic Mines	Stratigraphic	None	1683	P&A	No tests
1960	Yangery 1	Vic Mines	Stratigraphic	None	1320	P&A	No tests
1961	Wangoom 1	Vic Mines	Stratigraphic	None	1195	P&A	No tests
1962	Eumeralla 1	Frome	Expl	Crayfish Gp	3142	P&A oil shows	4 DST's, rec'd muddy water
1987	Windermere 1	Minora	Expl	Pebble Pt/Eumeralla	1838	P&A, oil'rec'd from Heathfield Sst	5 DST's max rec 20.4bbls oil plus 11.3bbls gas cut oil
1989	Windermere 2	Minora	Expl	Heathfiled/ Windermere/ Crayfish Group	3595	P&A, oil shows in Windermere SS	3 DST's, rec'd muddy water & oil cut mud
1992	Shaw 1	Minora	Expl	Pebble Pt/ Eumeralla	960	P&A	No tests

2.2 PEP 159

PEP 159 comprises 2280 square kilometres in the Victorian part of the onshore Otway Basin.

The permit is in its first year of the current 5-year term, which commenced on 12/11/2000 and expires on 11/11/2005.

1933 kilometres of 2D seismic data were acquired since 1958 including most recent Spring Creek Seismic Survey in 2000 (Table 3)

9 exploration wells have been drilled in the permit since 1962. Table 4 summarises the results of these wells.

The current participants in the permits are:

Origin Energy Petroleum Pty Ltd 50.00% (Operator)
Essential Petroleum Resources Ltd 50.00%

Table 3. PEP 159 - Seismic Acquired

Year	Survey Name	No Km
1958	Portland & Pt Campbell	229
1964	Koroit	8
1966	Port Fairy-Nelson	17
1968	Port Fairy Nelson	53
1969	Hawkesdale	225
1970	Portland-Macarthur	37
1971	Nelson-Koroit	32
1973	Coastal Strip	47
1981	C81	21
1982	C82	173
1984	Terrang	171
1984	Greenslopes	54
1985	Toolong	34
1986	Ballangeich	122
1987	Woolsthorpe	56
1988	Tarrone	23
1988	St Helens	11
1989	Shamrock	95
1990	Moyne River	32
1991	Moyne	8
1992	Otway Basin	63
1993	Taralea	50
1993	Kaloola	3
1994	Merrylands	17
1995	Tower Hill	136
1996	Spiers	51
1997	Cartcarrong	8
1998	Mumblin	80
2000	Spring Creek	77
	TOTAL	**1933**

Table 4. PEP 159 - Wells Drilled

Year	Name	Operator	Well Type	Well Target	Total Depth (MKB)	Result	Flow Rate/ Recovery
1962	Pretty Hill 1	Frome	Expl	Early E Sst	2478	P&A Oil shows	1 DST Muddy water
1968	Woolsthorpe 1	Interstate Oil	Expl	Pretty Hill Fm	1971	P&A, fluor in cores	1 DST Muddy water
1968	Garvoc 1	Interstate Oil	Expl	Pretty Hill Fm	1533	P&A, fluor in cores	1 DST $C0_2$ cut Muddy water
1969	Moyne Falls 1	Shell	Expl	Basal Eumeralla	1008	P&A, no show	No tests
1969	Hawkesdale 1	Shell	Expl	Pretty Hill Fm	1774	P&A, fluor in cores	2 failed DSTs
1985	Greenslopes 1	Phoenix	Expl	Pretty Hill Fm	2608	P&A, faint fluor in cuttings	No tests
1987	Ballangeich 1	Phoenix	Expl	Pretty Hill Fm	1250	P&A, no show	No tests
1991	Killara 1	Phoenix	Expl	Basal Eumeralla Top Pretty Hill	2409	P&A, weak shows	2 DSTs rec'd Muddy water
1997	Taralea 1	Cultus	Expl	Intra Eumeralla	2800	P&A, no show	No tests

3 GEOLOGY AND HYDROCARBON PROSPECTIVITY

The main structural elements in PEP 152/159 (Figure 3) are:

1- The northwest trending Windermere Trough.
2- The northwest trending Koroit Trough.
3- The east-west trending Tyrendarra High.
4- The west-northwest trending Warrong Trough.
5- The northwest trending Moyne Falls High.
6- The northwest trending Morenda Trough.

The Tyrendarra fault forms the northern boundary of the Windermere Trough and the southern boundary of the Tyrendarra High (Figure 4).

Koroit Trough is controlled to the north by the Tower and Taurus main fault which separates it from Warrong Trough in PEP 159 (Figure 5).

The Windermere, Koroit and Warrong Troughs were initiated during the earliest phase of rifting in the Otway Basin in the Late Jurassic/ Early Cretaceous.

The stratigraphic column for the eastern Otway Basin is shown in Figure 6. More detailed description has been documented by different authors (Ryan et al, 1995, Mehin and Constantine, 1999, Paran and Khayou, 1999).

The best quality source rocks in the area are thought to be in the Casterton Formation and base of the Eumeralla Formation, which variably called the Geltwood Beach Formation or Killara Coals. The Pretty Hill Formation also has minor source potential. Maturation modelling indicates that the Casterton Formation sediments are over mature in the deep part of PEP 152 and the Base Eumeralla sediments are mature for hydrocarbon charge. A review of the petroleum maturity is given in P.J. Boult, 1999 maturity study report.

The main exploration targets for PEP 152 and PEP 159 are Intra-Crayfish Group Sandstones, Waarre Sandstones, Nullawarre Greensands, and Base Tertiary/Pebble Point Formation. Numerous seals exist within the Crayfish, Sherbrook, and Wangerrip Groups.

4 SEISMIC STRUCTURAL MAPPING

The structural mapping in this report is based on the integration of the Spring Creek seismic survey with the existing pre 2000 data sets and the reprocessed seismic data. All available well data were used to tie the formation tops with the seismic data.

The seismic data was interpreted on Sun workstations using IESX software from GeoQuest. The updated seismic picks were transferred to Petrosys, where the structure maps were produced.

The 2D seismic line spacing varies from 400 to 700 meters in the southern parts of PEP 152 and PEP 159, to over 3 kilometres in the eastern and western parts of the permits.

4.1 Time Structure Maps

Time structure maps were produced for the following horizons:

PEP 159 area:

1- Top Pretty Hill Sandstone (enclosure 1).
2- Top Nallawarre Greensand over Findra Prospect (enclosure 2).
3- Near Base Tertiary/Top Pebble Point Formation (enclosure 3).

PEP 152 area:

1- Top Pretty Hill Sandstone (enclosure 1).
2- Top Waarre Sandstone (enclosure 4).

The seismic data quality varies between fair and good, depending on the year processed, far offset distance, lithology, and depth.

In this report a general description of the maps will be discussed below.

4.1.1 Top Pretty Hill Sandstone: (Enclosure 1)

The Pretty Hill Sandstone is a proven reservoir in the western part of the Otway Basin in South Australia (Katnook, Redman, Haselgrove, Haselgrove South, and Ladbroke Grove gas fields). Despite hydrocarbon shows (Pretty Hill 1) no significant Pretty Hill Sandstone discovery has been made in the Victorian portion of the Otway Basin.

The top Pretty Hill Sandstone time structure map (enclosure 1) is the result of integrating the Spring Creek seismic survey to the existing pre 2000 seismic data.

The Pretty Hill Sandstone in the western Otway Basin is interpreted as being deposited in a low sinuosity, high energy, sand-rich river system (North, 1995). In the study area, it is believed to be similar to that in the western Otway Basin.

This sequence is dominated by east-west and northwest-southeast trending faults. The east-west trending faults are early faults formed during the initial rift phase.

As a result of the new seismic data, a new structural interpretation has been made which has a transfer zone oriented northeast-southwest located in-between the Tower and Taurus prospects. These extend northeast to set up new trapping geometries and to form series of new prospects in both PEP 152 and PEP 159 (Cartcarrong, Cartcarrong North, Cartcarrong South and Taurus South) (see enclosure 1).

Sun shaded gravity images of the central part of the Otway Basin in Victoria show a series of northwest-southeast basement highs separated by apparent northeast-southwest trending fracture zones (Figure 7). These images were overlaid by the Pretty Hill surface faults and showed that the transfer faults interpreted from the seismic data match those interpreted on the gravity images (enclosure 5).

Other evidence for the new structural interpretation model is from the interpretation of the Spring Creek seismic data. This interpretation shows an offset in fault correlation between the seismic lines OBE00A-09 and OBE00A-10 (Figure 8). Further work on the fault correlation was carried out by exporting the seismic interpretation to the fault analysis software package (FAPS). The fault analysis at the top Pretty Hill Sandstone level shows a displacement in the computed minimum and maximum fault strikes (Figure 9). The FAPS work has confirmed the offset in the fault correlation and the possibility of a transfer fault in-between seismic lines OBE00A-09 and OBE00A-10. This interpretation was then extended to the south to include the work previously done over Tower and Taurus prospects. The extension of the transfer fault to the southwest is perfectly correlated with the one interpreted in 1999 by P.J. Boult. The result of this integrated work is shown in figure 10 as a 3D image of the Top Pretty Hill Sandstone surface showing the location of the transfer fault.

The Top Pretty Hill Sandstone is deepest in the south of PEP 152, where the time value is more than 3150 milliseconds, and it becomes shallower to the north where the time value is less than 300 milliseconds.

4.1.2 Top Nallawarre Greensand: (Enclosure 2)

This horizon was picked over Findra prospect only. The reason was to confirm the 4-way dip closure of the Findra prospect which is seen at the Base Tertiary level. The time

structure map (enclosure 2) shows that the Findra prospect is an elongated four-way dip closure oriented east-west and dominated by small faults in the same orientation. The time values range from 570 milliseconds over the crestal part of the structure to more than 700 milliseconds to the east, south, and west.

4.1.3 Near Base Tertiary / Pebble Point Formation: (Enclosure 3)

The Near Base Tertiary level was mapped to reflect the structure of the Pebble Point Formation. The Pebble Point formation is a condensed sandstone which overlies the Tertiary sediments. Some oil shows have been recorded from the Pebble Point Formation in the adjacent areas of PEP 152 and PEP 159. Lindon 1 intersected a 3 metre column of 28.8º API oil with an average porosity of 20.8% and permeability of 45.3 md. Other oil shows have been recorded from Lindon 2, Fahley 1, Wilson 1 and Curdies1.

The time structure map at this level (Enclosure 3) shows 3 four-way dip closures in the west part of PEP 159 (Findra, Findra West, and Pleasant Park). This level is dominated by small faults oriented east-west.

The well data shows that the Pebble Point Formation pinches out toward the north. The Killara 1 well did not intersect any Pebble Point Formation, while the Taralea 1 well intersected about 30 metres.

The shallowest part of this level is in the northeast where the time values reach approximately 100 milliseconds, and the deepest is to the south and southwest where the time values reach more than 700 milliseconds.

4.1.4 Top Waarre Sandstone: (Enclosure 4)

The Waarre Sandstone is the main reservoir in the Port Campbell area of the Otway Basin in Victoria. It is developed in the southern part of the area to cover most of the PEP 152. This event is well imaged by the seismic and has a high amplitude character and is easy to pick.

The time structure map of this level (Enclosure 4) is the result of integrating the Spring Creek Seismic Survey to the existing grid. Three seismic lines were recorded in PEP 152 to cover the Port Fairy prospect which is a Waarre Sandstone play. The new interpretation has confirmed the prospect and mapped 5 new leads in the vicinity of Port Fairy area (Port Fairy North, Port Fairy South, Lead 1, Lead 2, and Lead 3) (see enclosure 4).

This surface is mainly dominated by east-west trending faults dipping to the south with some minor faults dipping to the north. The time values range from about 900 milliseconds in the northeast to more than 1250 milliseconds in the southeast part of the area.

5 ISOPACH AND EROSION

The basin modelling study of the area shows that the amount of erosion of the Upper Eumeralla Formation (Figure 11) has a significant implication on defining the orientation of folds and their location (Boult 1999b).

In order to calculate the amount of erosion, an isopach map of the upper Eumeralla Formation was created by dividing the Eumeralla Formation into upper and lower units separated by Heathfield Sandstone time line. Furthermore, knowing that the area was tectonically very stable during deposition of the upper Eumeralla Formation and that its deposition was uniformly widespread across most of the Gippsland Basin, Otway Basin and beyond (Veevers, 1984), it was assumed that the upper Eumeralla Formation was originally 1100 m thick, i.e. equivalent to its maximum thickness in the area near the present coast. Then the amount of erosion was calculated by subtracting the upper Eumeralla isopach from 1100 m (Boult 1999b).

Figure 11 clearly shows that the deformation of the Eumeralla Formation comprised tilting upwards in the northeast and northwest-southeast compression forming a series of northeast-southwest folds and probable block faulting.

6 CONCLUSIONS

The interpretation of the Spring Creek Seismic Survey and its integration with the gravity and the isopach mapping has led to the identification of a new component of the structural model in the Otway Basin. This component comprises left-lateral movement of high angle NNE-SSW striking faults possibly related to a rare onshore expression of early ocean floor spreading transfer faults.

The prospectivity was significantly improved by this model and included the recognition of a new play type controlled by these transfer faults (Cartcarrong, Cartcarrong North, Cartcarrong South, Taurus South, Taurus South 2).

In order to reduce the risk of the Cartcarrong structures, more seismic lines are being recorded over the structures in both dip and strike directions.

The seismic coverage over Tower and Taurus prospects includes different vintages with normal post stack migrated and non-migrated data. Reprocessing using a pre-stack time migration on one line has proved that the data can be significantly improved over the Pretty Hill Sandstone interval. Following the successful PSTM test over Tower prospect, a group of seismic lines over Taurus and Tower have been approved for reprocessing using the pre-stack time migration technique.

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