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Australian Petroleum Accumulations Report 6

Otway Basin, South Australia, Victoria and Tasmania.

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FOREWORD

This is the sixth report in a series prepared by the Petroleum Resource Assessment Branch of the Bureau of Mineral Resources, Geology and Geophysics (BMR) that outlines the locations, character and general quality of Australia's identified petroleum resources in particular sedimentary basins. The series is a product of continuing BMR effort to develop and maintain an inventory of the petroleum resources identified by exploration and development. Each report is intended as a reference for use by petroleum explorationists, government policy makers, researchers, resource analysts and the public, to assist in understanding the nature and extent of Australia's identified petroleum resources.

This report covers the identified petroleum and non-petroleum gas resources in the Otway Basin which, although not large, are strategically located near major population centres along the southeast margin of the Australian mainland. Previous reports in the series cover the petroleum resources of the Amadeus, Bass, Gippsland, Adavale and Bonaparte Basins. Reports on the Browse, Bowen-Surat, Cooper-Eromanga, Carnarvon and Perth Basins are in preparation.

The Australian Petroleum Accumulations Report series is a major product of the work coordinated by the BMR Reservoir Geology Group, established under the leadership of the late Dr Stanley Ozimic. The APA series was initiated by Dr Ozimic and is a tribute to his efforts and foresight.

C.S. Robertson
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5 April 1990

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ABSTRACT

As at 31 December 1989 the Otway Basin, which is located along the southeast margin of the Australian mainland, was known to contain a total of seven economic and six subeconomic petroleum and non-petroleum gas accumulations. All have been discovered since the late 1950s as a result of petroleum exploration drilling.

Three accumulations have been or could be used as a source of petroleum natural gas or carbon dioxide: the North Paaratte gas accumulation in Victoria and the Caroline carbon dioxide accumulation in South Australia, both of which are currently being exploited, and the Wallaby Creek gas accumulation in Victoria, which has been identified by permit holders as an accumulation likely to be developed in the future (1992-1994). In addition, the Katnook and Ladbroke Grove gas accumulations in South Australia are being considered for development in the near future.

The initial petroleum reserves of the Otway Basin as at 31 December 1988 are estimated to be 0.483 billion cubic metres of sales gas and 0.002 million kilolitres of condensate (not including the reserves of the Katnook and Ladbroke Grove accumulations). Production from the Caroline carbon dioxide accumulation commenced in 1968, and this field continues to supply this commodity much of the South Australian and Victorian markets. Production of natural gas from the North Paaratte accumulation commenced in August 1986. This field supplies domestic and industrial users in Warrnambool, Victoria.

INTRODUCTION

This report summarises technical information on the petroleum and non-petroleum accumulations found in the Otway Basin up to 31 December 1989. The report contains a brief overview of the geology of the Otway Basin and describes the location and significance of all known petroleum and other strategic non-petroleum gas accumulations.

The nature of the Otway Basin sequence, and the petroleum accumulations found to date, indicate that additional petroleum resources are likely to be discovered. An unusual feature of the known accumulations is that several comprise carbon dioxide, while some of the petroleum accumulations have significant concentrations of nitrogen and helium, in addition to carbon dioxide. The petroleum and non-petroleum gas found to date highlight the potential of the basin to satisfy some of the energy and industrial resource needs of regional population centres in southeastern Australia.

BASIN SUMMARY

Basin setting

The Otway Basin extends west-northwestwards for over 500 kilometres along the southern Australian mainland coast, and is one of several extensional and transitional basins along this margin of the Australian continent.

The limits of the Otway Basin (Fig. l) are taken as the 4500 metre isobath in the southwest, and King Island in the southeast (Exon & Lee, 1987; Robertson & others, 1978). In the north and northwest, the boundary of the Otway basin is taken as the limit of Cretaceous sedimentation.

In the east, the Otway Basin is separated from the Bass Basin by the King Island-Mornington Peninsula basement ridge. Between this ridge and the Cape Otway-King Island High lies the Torquay Basin, which has a similar early rifting history to that of the Otway Basin, but which developed separately in the Late Cretaceous (Robertson & others, 1978). In the southeast, the Otway Basin grades into the Sorell Basin, which extends down

the west coast of Tasmania for 500 kilometres and averages 100 kilometres in width.

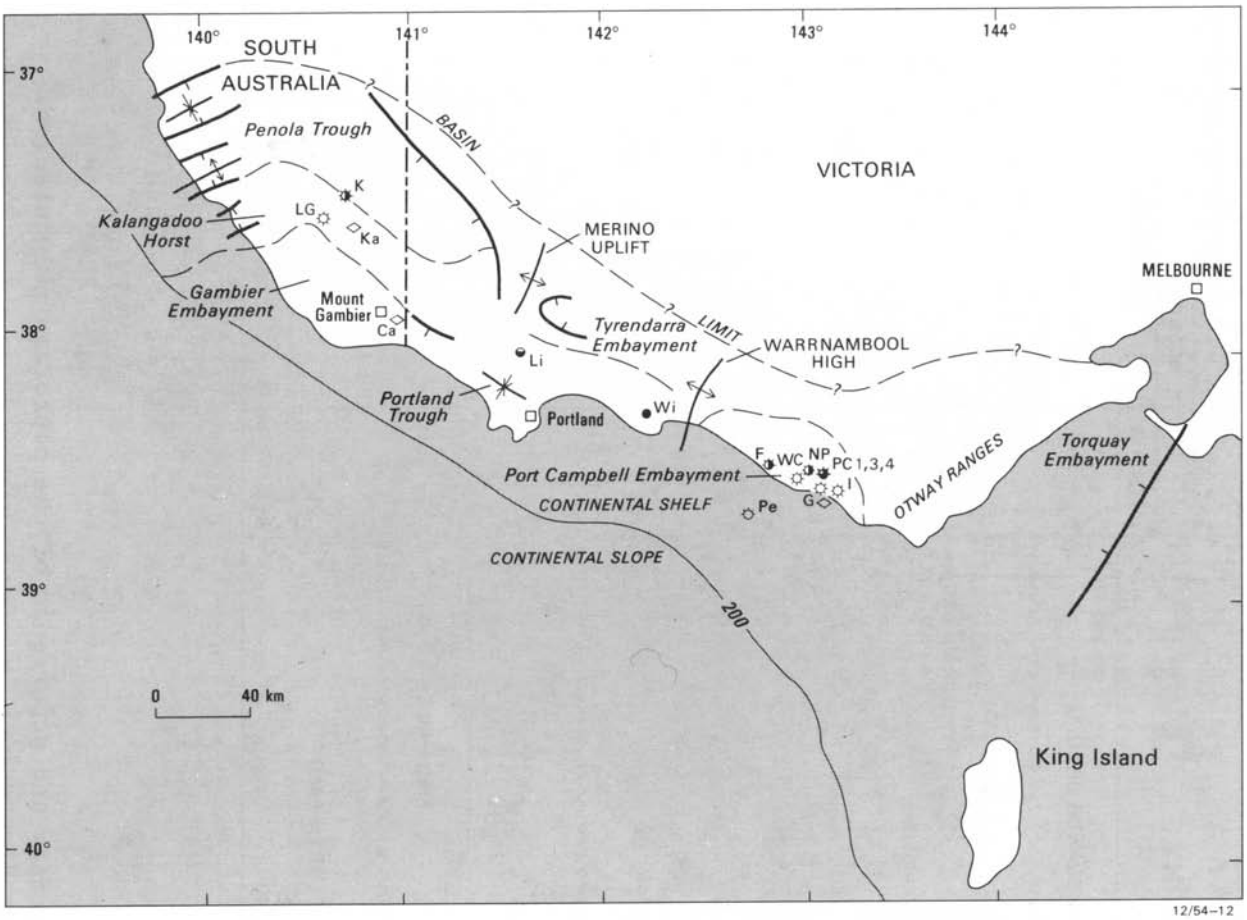
Basin development and stratigraphy

The Otway Basin was formed by both rift and wrench-related tectonics (Williamson & others, 1988) (Fig. 1) but is largely interpreted to be a rifted margin whose structural grain is dominated by west-northwest-trending down-to-basin faults. This fault pattern appears to have been initiated in the Early Cretaceous, but was far more evident in the Late Cretaceous to early Tertiary as sea floor spreading occurred (Weissel & Hayes, 1972). Following the initiation of sea floor spreading, north-northeast-trending horst and graben structures developed in the Late Cretaceous and the outer part of the continental shelf was the site of subsidence.

Four major sedimentary sequences have been recognised in the Otway Basin (Felton & Jackson, 1987) (Fig. 2). The Upper Jurassic to Lower Cretaceous Otway Group (Fig. 2), consists of up to 4500 metres of continental sandstone, siltstone, shale and coal with some volcanoclastic sediments and volcanics. Much of the sequence was deposited by fluvio-lacustrine (Eumeralla Formation) to fluvial (Pretty Hill Sandstone) sedimentation in troughs formed during initial rifting of the basin. By the Late Cretaceous, rifting was followed by spreading and subsidence, so that the basin began to take its present shape (Exon & Lee, 1987). South and west of the Mussel Platform, rapid subsidence occurred during the deposition of the Sherbrook Group, forming the northwest-trending Voluta Trough which is filled with up to 5000 m of clastic sediments. The Upper Cretaceous sequence was deposited during a major transgressive-regressive cycle. Holdgate and others (1986) suggested that the Sherbrook Group was deposited as a thick deltaic sequence, sourced from the north and west of the basin with its major depocentre in the Voluta Trough (Fig. 3).

At the end of the Cretaceous the Sherbrook Group was truncated by local erosion. A rise in sea level in the Paleocene resulted in transgression over the other sequences where they were exposed around major basement highs. Some of the material eroded from older sequences is preserved in restricted shallow marine deposits of the Pebble Point Formation, which is one of the earliest Tertiary units (Fig. 2). Overlying sediments comprise the clastic-dominated deltaic Dilwyn Formation and Pember Mudstone Member, which were deposited in rapidly subsiding areas

Figure 1. Location map of the Otway Basin showing simplified onshore structural elements and petroleum accumulations. See Plates 1 and 2 for details of each accumulation and Figure 3 for a detailed structural elements map.



No.	PETROLEUM ACCUMULATIONS		
1	North Paaratte	NP	
2	Caroline	Ca	
3	Wallaby Creek	WC	
4	Katnook	K	
5	Ladbroke Grove	LG	
6	Iona	I	
7	Grumby	G	
8	Lindon	Li	
9	Windermere	Wi	
10	Kalangadoo	Ka	
11	Flaxmans	F	
12,13,14	Port Campbell 1, 3, 4	PC	
15	Pecten	Pe	

Oil
Oil show
Gas
Gas show
Condensate
CO_2
— 200 — Bathymetric contour (m)

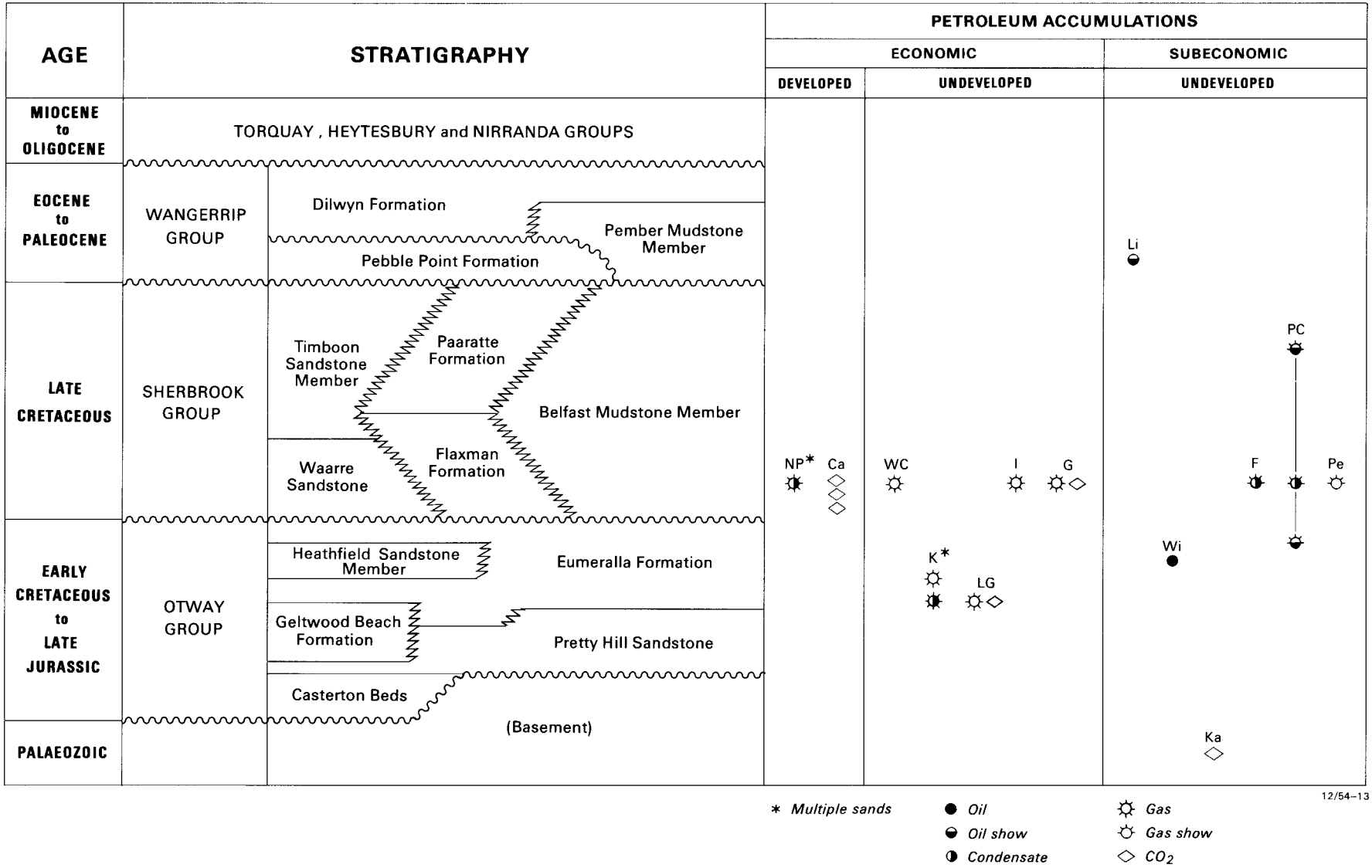
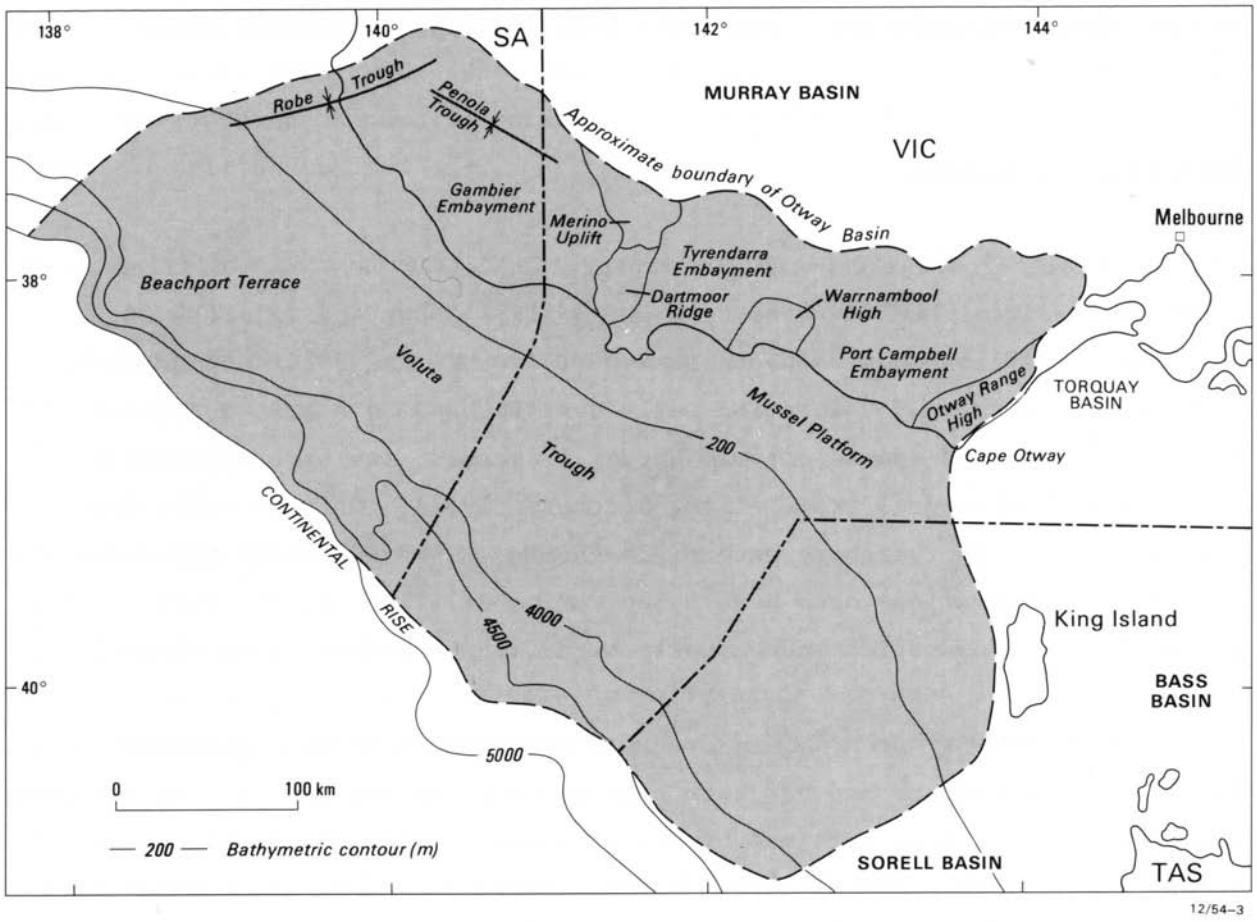

AGE
STRATIGRAPHY
PETROLEUM ACCUMULATIONS
ECONOMIC
SUBECONOMIC
DEVELOPED
UNDEVELOPED
UNDEVELOPED
MIOCENE to OLIGOCENE
TORQUAY , HEYTESBURY and NIRRANDA GROUPS
EOCENE to PALEOCENE
WANGERRIP GROUP
Dilwyn Formation
Pember Mudstone Member
Pebble Point Formation
LATE CRETACEOUS
SHERBROOK GROUP
Timboon Sandstone Member
Paaratte Formation
Belfast Mudstone Member
Waarre Sandstone
Flaxman Formation
EARLY CRETACEOUS to LATE JURASSIC
OTWAY GROUP
Heathfield Sandstone Member
Eumeralla Formation
Geltwood Beach Formation
Pretty Hill Sandstone
Casterton Beds
PALAEOZOIC
(Basement)
NP*
Ca
WC
I
G
K*
LG
Li
PC
F
Pe
Wi
Ka
12/54–13
* Multiple sands
Oil
Oil show
Condensate
Gas
Gas show
CO2

Figure 3. Location and structural elements of the Otway Basin, southeastern Australia.



around Portland Trough where the early Tertiary sequence reaches a thickness of 500 metres (Holdgate & others, 1986). The clastic sequences of the Wangerrip Group are succeeded by extensive carbonate sequences comprising the Nirranda and Heytesbury Groups. Open marine conditions prevailed during deposition of these sequences, as is indicated by the prolific growth of filter-feeding invertebrates (Holdgate & others, 1986). Since the Pliocene regression, karst has formed in coastal regions while characteristic red soils have developed in inland areas.

Petroleum exploration

A total of over 120 petroleum exploration wells have been drilled in the Otway Basin since the 19th century (Sprigg, 1986), but the majority of exploration drilling has been undertaken since the late 1950s (Appendix 1). Many of the petroleum exploration wells were located by a combination of surface geology and sparse seismic survey traverses; few have apparently tested valid structural traps (Laing & others, 1989). Only 19 wells have been drilled in the offshore part of the basin. Numerous minor hydrocarbon 'shows' and indications have been noted during drilling (Smith, 1988), yet few wells have identified economically significant accumulations (Fig. 2).

The results of exploration in the Otway Basin have been discussed in detail by many authors and has been summarised by Sprigg (1986). More recent developments have been outlined by Felton & Jackson (1987), Williamson & others (1987, 1988), Smith (1988), Buffin (1989) and Laing and others (1989). Previous exploration, both seismic and drilling activity, has largely been aimed at determining the extent and content of potential reservoirs within the Waarre and Pretty Hill Sandstones and the Eumeralla Formation.

The initial major discovery of petroleum occurred in 1959 when the Port Campbell 1 well intersected gas in the Upper Cretaceous Waarre Sandstone (Fig. 2). Subsequently, the Port Campbell 4 (1962) well recovered waxy paraffinic oil (28-35^{o}API gravity) from the upper part of the Eumeralla Formation. Additional drilling in the Port Campbell area in the late 1970s and early 1980s resulted in the discovery of several gas (and some condensate or carbon dioxide) accumulations including North Paaratte, Wallaby Creek and Grumby. All of these accumulations are reservoired in the Waarre Sandstone.

The Lower Cretaceous sequence (Eumeralla Formation) has provided some encouragement as it contains recently-discovered and undeveloped accumulations. Windermere 1 well, drilled in 1987, recovered oil from the sandy upper part of this sequence. Testing indicated that the oil- bearing unit had low productivity and exhibited pressure decline in the reservoir section but the well was significant in that it increased the basin's onshore oil prospectiveness (Smith, 1988). The Windermere 2 well, drilled in 1989, encountered minor gas shows. The Katnook 1 well, drilled in 1987, and the Katnook 2 well, drilled in 1989, apparently intersected gas and condensate reservoir(s) in the Eumeralla Formation, as did the Ladbroke Grove 1 well, which was drilled in 1989.

The recovery of several barrels of oil from the Pebble Point Formation in the Lindon 1 well in 1983 highlighted the possibility of long-range vertical migration of petroleum from a deep, mature sequence into shallow, immature parts of the Tertiary sequence (Tabassi & Davey, 1986).

Petroleum and non-petroleum gas accumulations

The petroleum and other accumulations discovered to date are, or are potentially, strategic sources of supply for natural carbon dioxide and petroleum gas (and some condensate) for the Victorian and South Australian markets.

One gas accumulation and one carbon dioxide accumulation have been identified by companies as economic accumulations and have been developed for use. These are as follows:

Economic and developed accumulations

Accumulation	**Discovery well**	**Year drilled**
Caroline (carbon dioxide)	Caroline 1	1967
North Paaratte (gas/condensate)	North Paaratte 1	1979

These accumulations have been brought on-stream and their products are used by domestic or industrial users in parts of Victoria and South Australia. A number of other accumulations have been identified as potentially economic but as yet have not been developed for use. They include the following:

Economic and undeveloped accumulations

Accumulation	Discovery well	Year drilled
Wallaby Creek (gas)	Wallaby Creek 1	1981
Katnook (gas/condensate)	Katnook 1 & 2	1987, 1988
Ladbroke Grove (gas/carbon dioxide)	Ladbroke Grove 1	1989
Iona (gas)	Iona 1	1988
Grumby (gas/carbon dioxide)	Grumby 1	1981

Several other accumulations comprise smaller or less extensive resources which currently are considered subeconomic and remain undeveloped. They include:

Subeconomic and undeveloped accumulations

Accumulation	Discovery well	Year drilled
Lindon (oil)	Lindon 1	1983
Windermere (oil)	Windermere 1	1987
Kalangadoo (carbon dioxide)	Kalangadoo 1	1965
Flaxmans (gas/condensate)	Flaxmans 1	1961
Port Campbell 1) (oil/	Port Campbell 1	1959
Port Campbell 3) gas/	Port Campbell 3	1963
Port Campbell 4) condensate)	Port Campbell 4	1965
Pecten (gas)	Pecten 1A	1967

The number of traps and the petroleum-bearing units in which these accumulations from the three categories outlined above are shown in Plates 1 and 2. Detailed technical data on each accumulation are tabulated in the 'Petroleum and non-petroleum gas accumulations summaries' section of this report. The stratigraphic position of each accumulation is shown in Figure 2.

Structure and petroleum traps

The Otway Basin was developed in the Late Jurassic as a northwest-trending trough which formed as a result of rifting between Australia and Antarctica (Williamson & others, 1988). As a result, tensional and wrench fault planes dip both towards the continent (northeast) and towards the open ocean (southwest), and the dips on these normal faults vary from one part of the basin to another. On the continental slope, rotational normal faults dip more consistently towards the ocean; these faults and some associated wrench-related 'flower structures' appear to be somewhat younger than the faults on the shelf (Fig. 3).

Rapid subsidence of the basin during the Late Cretaceous resulted in extensive synsedimentary deformation of some sequences, forming slumps and gravitational slides (Gravestock & others, 1986). By the end of the Cretaceous, reactivation of the earlier rift-faults resulted in the development of numerous fault-related closures in younger sequences, after which major faulting ceased (Robertson & others, 1978; Felton & Jackson, 1987). The tensional faulting and slumping which characterise the continental slope sequence probably continued to occur, although by about 45 Ma (million years before the present) blocks of continental crust ceased sliding to abyssal depths and the basin reached its present configuration (Robertson & others, 1978; Felton & Jackson, 1987).

The potential traps in the basin which have not yet been drilled consist of tilted-fault blocks, four-way dip closures on the upthrown side of normal faults, horsts, and folded structures associated with wrenching (Megallaa, 1986). On the other hand, the majority of structures tested by drilling are associated with syndepositional down-to-basin normal faults and include simple fault traps where reservoir rock is faulted against cap-rock seal or sealed by impermeable fault zones, and four-way dip-closed traps ('rollovers'). Both stratigraphic pinchout and unconformity traps are potential plays throughout the basin (Felton & Jackson, 1987).

Coastal bitumen strandings of oil indicate that some as yet unknown offshore accumulations may have been breached allowing hydrocarbons to escape (McKirdy & Horvath, 1976; McKirdy & others, 1986; Felton & Jackson, 1987).

Reservoir sequences

Potential reservoir rocks have been identified throughout the Otway Basin sequence from the Early Cretaceous to Paleocene, and in some cases weathered and fractured Palaeozoic basement (the Kalangadoo 1 well) (Sprigg, 1986). The Pretty Hill Sandstone, Eumeralla Formation and Waarre Sandstone have, however, been the major petroleum exploration drilling targets.

Figure 4 shows the variation in permeability and porosity readings from core material (over 150 core plugs) tested by the BMR Petrophysical Laboratory (from over 20 wells drilled between 1964 and 1986) in a variety of lithologies. BMR will release the results of all testing undertaken in this laboratory in a comprehensive data set for sale to industry and the public. It is evident from the data that, while many of the samples have

porosities in excess of 10 percent, less than a third exhibit permeability in excess of 100 millidarcys. This is a common trend in many of the potential reservoir rocks; permeability is generally unrelated to porosity and is a major limiting factor affecting the quality of potential reservoir rocks in the Otway Basin sequence.

Pretty Hill Sandstone

The Cretaceous Pretty Hill Sandstone exhibits features typical of most major reservoir units in the Otway Basin sequence (Fig. 5). The core plugs tested by BMR (Petrophysical Laboratory) reveal a range of core porosity readings, many as high as 35 percent. However, permeability readings from the same plugs were less than 100 millidarcys in at least half of the plugs, indicating that permeability does not correlate well with porosity even when the latter is high. Where the Pretty Hill Sandstone has been buried, its porosity and permeability are generally markedly reduced. However the patchy nature of permeability is clearly illustrated by the data in Crayfish 1 between 2000-3000 m and Woolsthorpe 1 between 100-2000 m.

According to Smith (1988), the Pretty Hill Sandstone is a major potential reservoir of interest for petroleum exploration and consists of fine to coarse-grained, relatively clean sandstone, but mineralogy varies widely, depending on local provenance. Plutonic-sourced sandstones (subarkose and sublitharenite) are generally more porous, whereas sandstones containing metasedimentary and volcanic-sourced clasts are prone to significant loss of permeability and porosity due to diagenetic changes.

Eumeralla Formation

Porosity and permeability changes similar to that evident in the Pretty Hill Sandstone are also evident in the Eumeralla Formation. The lower part of the Eumeralla Formation contains fine-grained sandstone deposited in lacustrine and floodplain environments but the upper part contains braided-stream sandstone which has a high proportion of clean, coarse-grained channel units. According to Smith (1988), sandstones throughout the formation are feldspathic litharenites, with a matrix comprising clay, zeolite, carbonate, silica, and broken framework grains. The reservoir potential of the Eumeralla Formation is, however, severely reduced by diagenesis. One exception is the Heathfield Sandstone Member

Figure 4. Plot of porosity and permeability from over 150 core plugs obtained from 20 wells drilled in the Otway Basin. Data obtained from material tested by the BMR Petrophysical Laboratory.

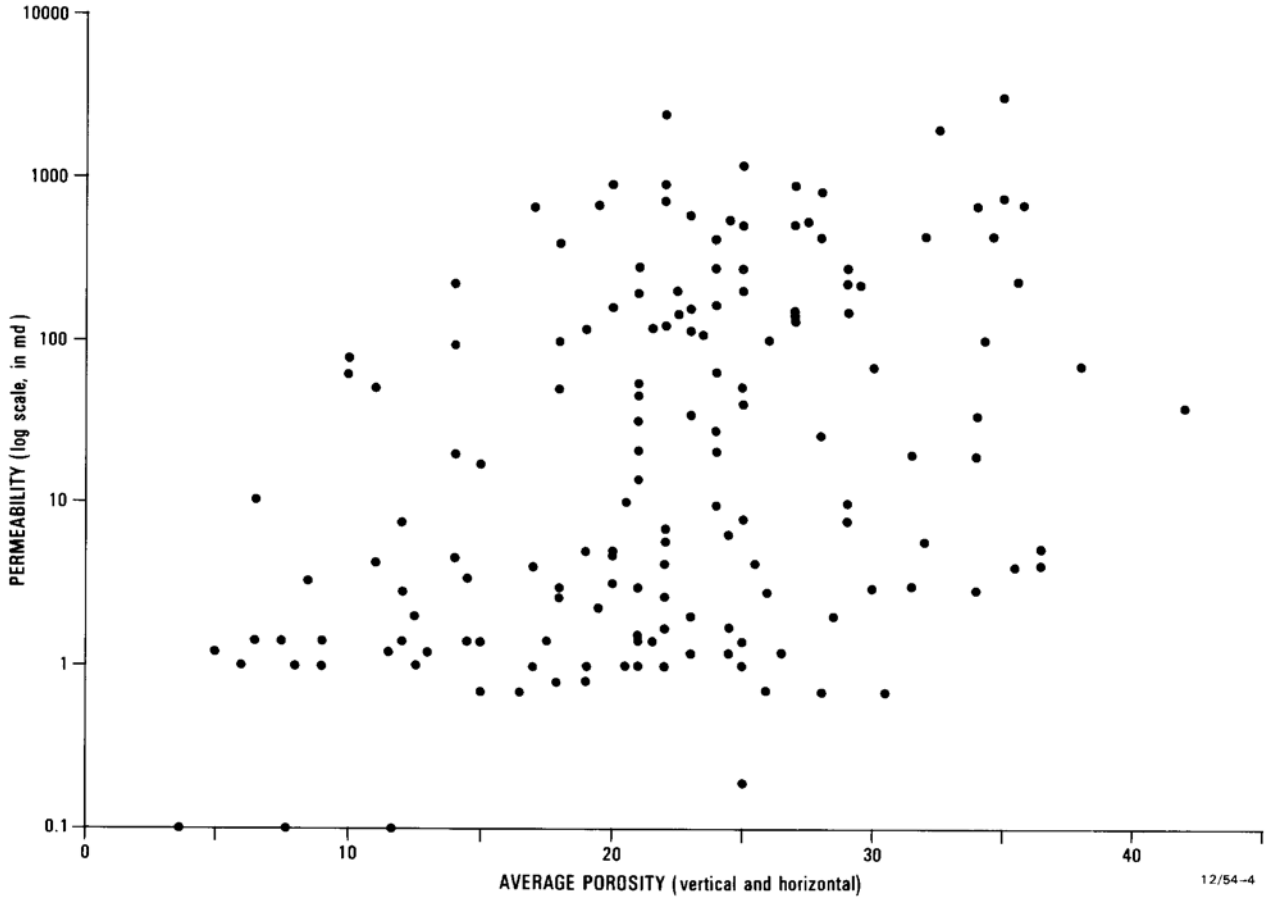
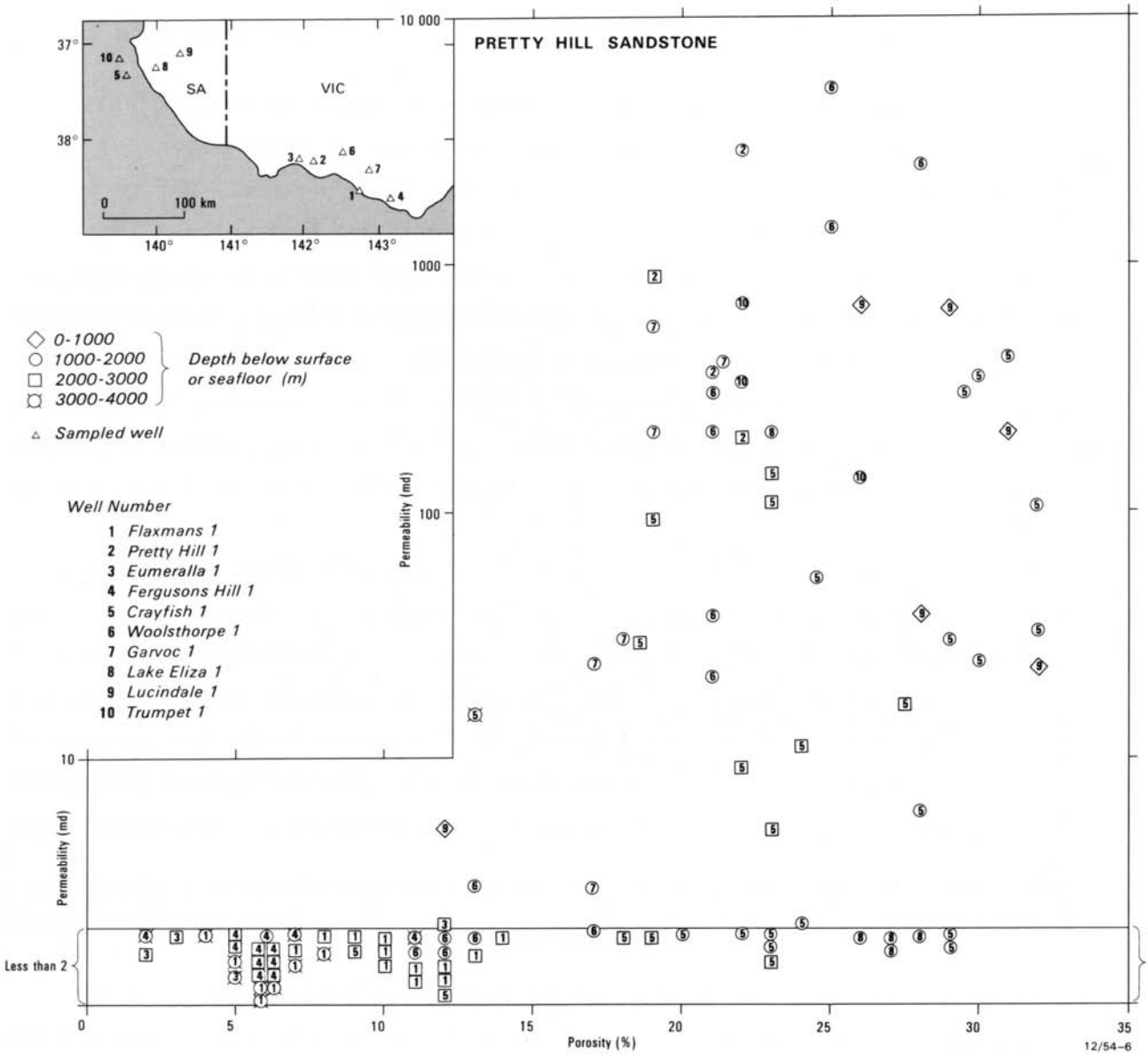


Figure 5. Porosity and permeability in the Pretty Hill Sandstone, measured from core plugs obtained from 10 Otway Basin wells by the BMR Petrophysical Laboratory.



which can display excellent porosity with good permeability but this unit is apparently restricted to the northeastern margin of the basin and trough areas (Laing & others, 1989).

The results evident during drilling of the Katnook 1 and 2 wells in South Australia suggest that additional gas accumulations could be discovered in the Eumeralla Formation. The flow rates measured during the tests of these wells suggest that the reservoir quality of the formation and the Pretty Hill Sandstone is higher than could have been expected from information available prior to drilling of these wells.

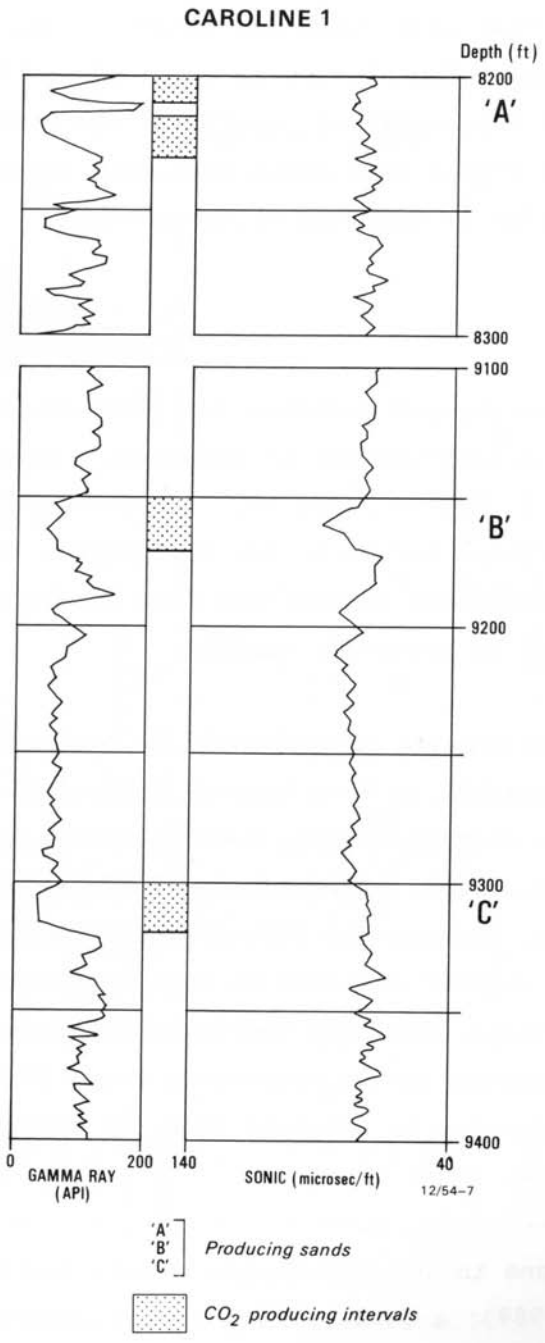
Waarre Sandstone

The Upper Cretaceous Waarre Sandstone has good reservoir properties in some areas and contains a large number of the basin's known petroleum accumulations (Appendix 1; Plates 1 and 2). It is commonly non-marine at its base and passes into marginal marine at the top (Smith, 1988) with accompanying change in sandstone composition from lithic to quartzose and a corresponding improvement in reservoir quality.

The Caroline carbon dioxide accumulation is reservoired in a sequence that Mulready (1977) considers to be a lateral equivalent of the Waarre Sandstone. Three carbon dioxide-bearing intervals were identified on wireline log data within deltaic or reworked deltaic sandstone reservoirs (Fig. 6). The sandstone, interbedded with siltstone and shale, is very poorly-sorted, friable, angular and fine to coarse-grained. Cement in the sandstone consists of silica with some kaolinite and rare siderite. Log-derived porosity readings in the reservoirs range from 13 to 21 percent. Most carbon dioxide production is obtained from the uppermost 'reworked' sand in the sequence (Mulready, 1977).

The Waarre Sandstone in the Port Campbell area has been subdivided into four units by Buffin (1989): a basal fining-upward sequence; a medial siltstone with interbedded calcareous sandstone; a coarse-grained porous, beach-barrier sandstone with good permeability (the primary gas reservoir); and the 'Flaxman Formation' - a ferruginous siltstone/sandstone sequence. The two upper units comprise a beach barrier island complex with associated tidal inlet delta channel complexes, deposited in an elongate linear fashion (Buffin, 1989).

Figure 6. Carbon dioxide-bearing reservoirs in the Caroline 1 well, after Mulready (1977).



Other potential reservoir units

The Paaratte Formation is typically a clean orthoquartzite to sublitharenite, with some chlorite and glauconite. The formation contains evidences of progradation by several deltaic systems, as well as offshore, shoreface, estuarine and lagoonal sediments (Smith, 1988). Landward parts of the sequence consist of distributary channel, coastal-plain and alluvial sequences. While onshore reservoirs of the Paaratte Formation appear to be flushed by meteoric water they may be a viable exploration target in the offshore part of the basin (Laing & others, 1989).

The Paleocene Pebble Point Formation consists of conglomeratic sandstone with a clay matrix of limonite and chamosite as well with minor goethite and hematite. In the eastern part of the basin, this unit is a potential reservoir as it is more arenaceous (Laing & others, 1989).

Source rocks and maturation

The petroleum source potential of the Otway Basin sequence has been examined by Felton and Jackson (1987), and their analytical results for total organic carbon (TOC) are shown in Table 1. Most stratigraphic units sampled contained an average of more than 0.5 percent of TOC, which is generally considered the minimum for sourcing a significant quantity of hydrocarbons. Most units had more than necessary to source hydrocarbons, the Dilwyn and Paaratte Formations being the richest. The Eumeralla Formation and Pretty Hill Sandstone, although not rich in organic material, have some rich intervals in the Crayfish lA well (Felton & Jackson, 1987).

More detailed qualitative information is revealed by saturated and aromatic hydrocarbon contents of each unit compared to the amount of organic carbon. The Dilwyn Formation is potentially a fair to very good source for both oil and gas. Both the Upper and Lower Cretaceous sequences are identified as fair hydrocarbon sources, largely for gas, as the organic matter is dominated by vitrinite and inertinite macerals. The Eumeralla Formation has a significantly higher vitrinite-to-exinite ratio than any other unit. Overall, the exinite content of the Cretaceous sequence is generally low (3%) and highest concentrations are found in the Paaratte Formation. Felton and Jackson (1987) concluded that the Paaratte Formation and Belfast Mudstone have the best hydrocarbon source potential, where

these units are mature, but that they are likely to generate gas, owing to the vitrinite-rich nature of the preserved organic matter.

Table 1. Organic richness of Otway Basin stratigraphic units.

Formation	TOC % range	Average TOC %	No. of samples
Dilwyn Formation	1.87 - 3.00	2.23	4
Pebble Point Formation	1.65 - 2.23	1.89	2
Paaratte Formation	1.49 - 3.10	2.26	-
Belfast Mudstone	0.86 - 2.59	1.50	13
Waarre Sandstone	1.14	-	1
Eumeralla Formation	0.25 - 7.75	0.62	10
Pretty Hill Sandstone	0.26 - 15-9	0.83	-

(After Felton & Jackson, 1987).

Available vitrinite reflectance data for the entire basin, collected from analytical results submitted by exploration companies to BMR's Core and Cuttings Laboratory (Fig. 7), indicate that much of the sequence drilled is immature. Less than half of the available readings are in the range of 0.7 to 1.2 percent (the oil window). Most samples which exceed 0.7 percent are from well depths in excess of 2000 metres (Fig. 7), mainly in the Cretaceous section. The results indicate that the top of the oil window is not likely to be encountered at depths shallower than 2500 metres. The present subsurface temperature data for the basin, derived from the bottom hole measurement of exploration wells, show a gradient of 2.8^{o}C/100 metres (Fig. 7) which is in accord with the likely depth-oil-maturity trends evident from the vitrinite reflectance data.

A geohistory analysis of the Voluta 1, Crayfish lA and Prawn lA wells by Williamson and others (1988) provides additional indication of the history, maturity and prospectivity of the Otway Basin sequence. Subsidence data presented by Williamson and others (1987 & 1988) indicate that major rifting from 144 Ma through to the point of continental break-up at 94 Ma, was the major influence on structuring and maturation.

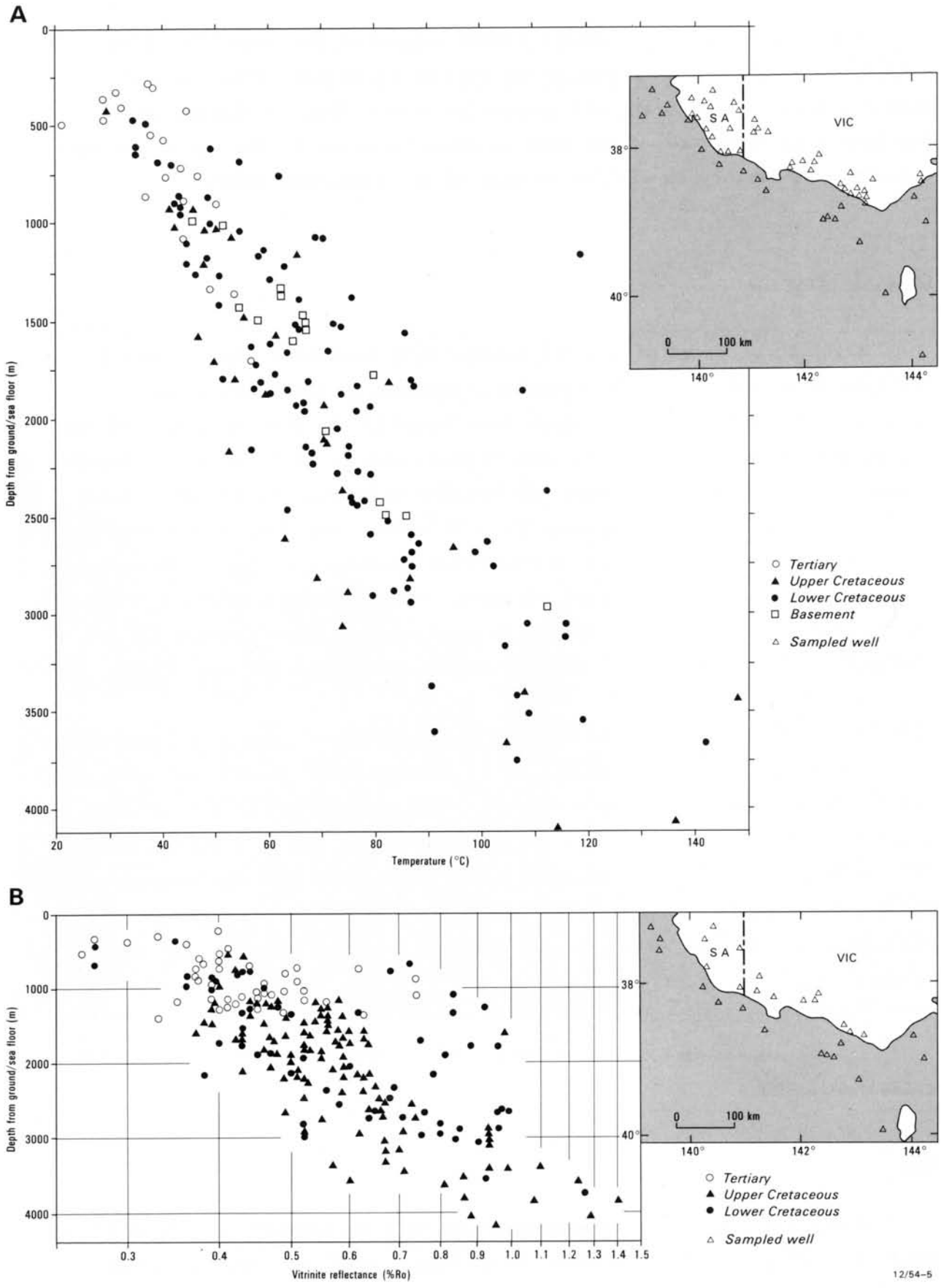


Figure 7. Temperature (A) and vitrinite reflectance (B) profiles from over 50 wells drilled in the Otway Basin. Based on data submitted to the BMR Core and Cuttings Laboratory.

However, Holdgate and others (1986) suggested that rapid Tertiary subsidence in the Portland region has buried the Belfast Mudstone and Paaratte Formation into the oil generation zone. They considered the Portland area to be one of the most prospective areas in the basin, as its depositional history is similar to that of the Gippsland Basin.

Coastal bitumens

Eight occurrences of coastal bitumen have been described in detail (McKirdy & Horvath, 1976) from coastal locations in the Otway Basin (Fig. 8). The bitumen samples have been found in the form of lumps, blocks and sheets, ranging from black, semi-liquid crude to light brown weathered flakes. As a result of exposure the bitumen is heavier (< 29^{o}API) than most Australian crude oils (generally > 35^{o}API). Pour points are high (> 10^{o}C) indicating a high wax content characteristic of crude oil derived from debris of non-marine plants (Hedberg, 1968; McKirdy & Horvath, 1976). The samples have a high wax and low sulphur content; this feature is consistent with a terrestrial organic source (McKirdy & Horvath, 1976).

A comparison of analytical data from the bitumen samples and paraffinic crude oil from the Port Campbell 4 well, shows a close resemblance between the stranded bitumens and the crude oil. The composition of the bitumens shows that they are abnormally rich in asphaltenes, and to a lesser extent, ONS compounds. McKirdy and Horvath (1976) considered that the composition of the bitumen samples are within the limits which could be expected from biodegradation and weathering of oil of similar composition to the Port Campbell oil.

Petroleum types

Gas

Otway Basin natural gas accumulations vary in composition, as shown in Table 2, from gas rich in methane (96%) with a small content of carbon dioxide (as little as 0.15%) to gas with much lower methane content (63-70%) and a high proportion of carbon dioxide (15-23%).

Figure 8. Principal sites of bitumen stranding along the Otway Basin coast (after McKirdy & Horvath, 1976).

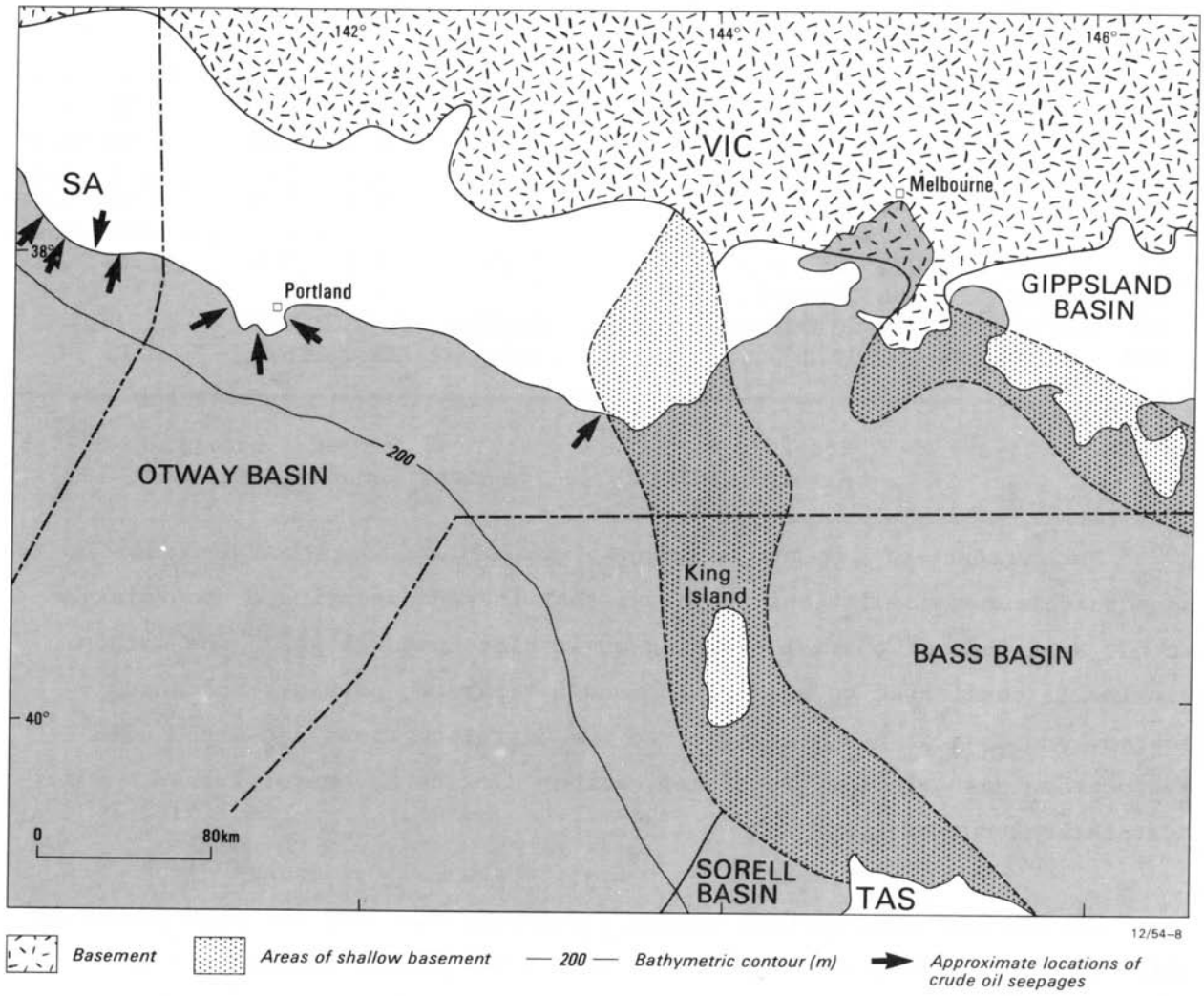


Table 2. Analysis of natural gases in Otway Basin accumulations.

	Caroline-1 Waarre Sst			Flaxmans -1 Otway Gp	Pecten-1A Waarre Sst	Port Campbell-1 Waarre Sst		Port Campbell-4 Otway Gp	
Depth (m)	2516 to 2570	2624 to 2661	2790 to 2799	3305 to 3514	1771 to 1775	1723 to 1743	1724 to 1728	1813 to 1820	1790 to 1799
C1	1.31	0.74	0.93	76.9	96.3	63.2	71.6	86.5	74.4
C2	0.03	0.039	0.006	13.2	1.85	5.4	4.8	5.25	7.3
C3	0.01	0.022	0.001	6.9	0.41	2.7	2.6	3.04	3.8
C4	0.001	0.003	0.001	1.5	0.064	0.14	1.7	1.79	1.19
C5	0.001	0.004	0.001	-	0.024	0.2	0.2	0.66	1.05
N2	0.42	0.094	-	*	1.03	3.3	3.5	2.33	-
H2	0.04	0.054	0.0023	-	-	-	-	-	-
He	0.008	0.0026	0.0071	-	0.005	-	-	-	-
CO2	97.5	99.1	99.8	-	0.04	23.0	15.6	0.15	-

* Oxygen + nitrogen = 3.9%
(After Konecki and Blair, 1970).

The presence of wet-gas fractions, in addition to carbon dioxide, in some petroleum accumulations indicates that the accompanying carbon dioxide is not a product of thermal cracking of in-place natural gas. The carbon dioxide is considered to be derived from a separate, possibly volcanic source, and that it has migrated into the petroleum traps and mixed with hydrocarbon gas. In some instances, carbon dioxide may have flushed hydrocarbons out of traps.

Oil-cut mud samples from Lindon 1 indicate that the oil intersected by this well is a mature crude generated from terrigeneous organic matter, possibly of algal origin (Tabassi & Davey, 1986). Water-washing of the crude is evident from a high wax content, as well as the depletion of benzene and toluene. The crude has a high pour point (33^{o}C) and a relatively low gravity (28^{o}API). Oil samples recovered from the Port Campbell 4 well (1789-1799 m RT) have a similar high wax content but a higher gravity (35^{o}API). The Port Campbell crude comprises 83.1 percent saturates and 9.5 percent aromatic compounds, and has a high gasoline content (38 vol %) (McKirdy & Horvath, 1976). According to McKirdy and Heggie (1987) the Lindon-1 oil (Pebble Point Formation), Port Campbell-4 oil (Eumeralla Formation) and North Paaratte-1 condensate (Waarre Sandstone) were probably all sourced from the Eumeralla Formation.

Gas which flowed during testing of the Katnook 2 well was accompanied by a flow of 109 barrels per day of condensate from a thick 69 metres depth interval (Milne, 1988).

Non-petroleum gas accumulations

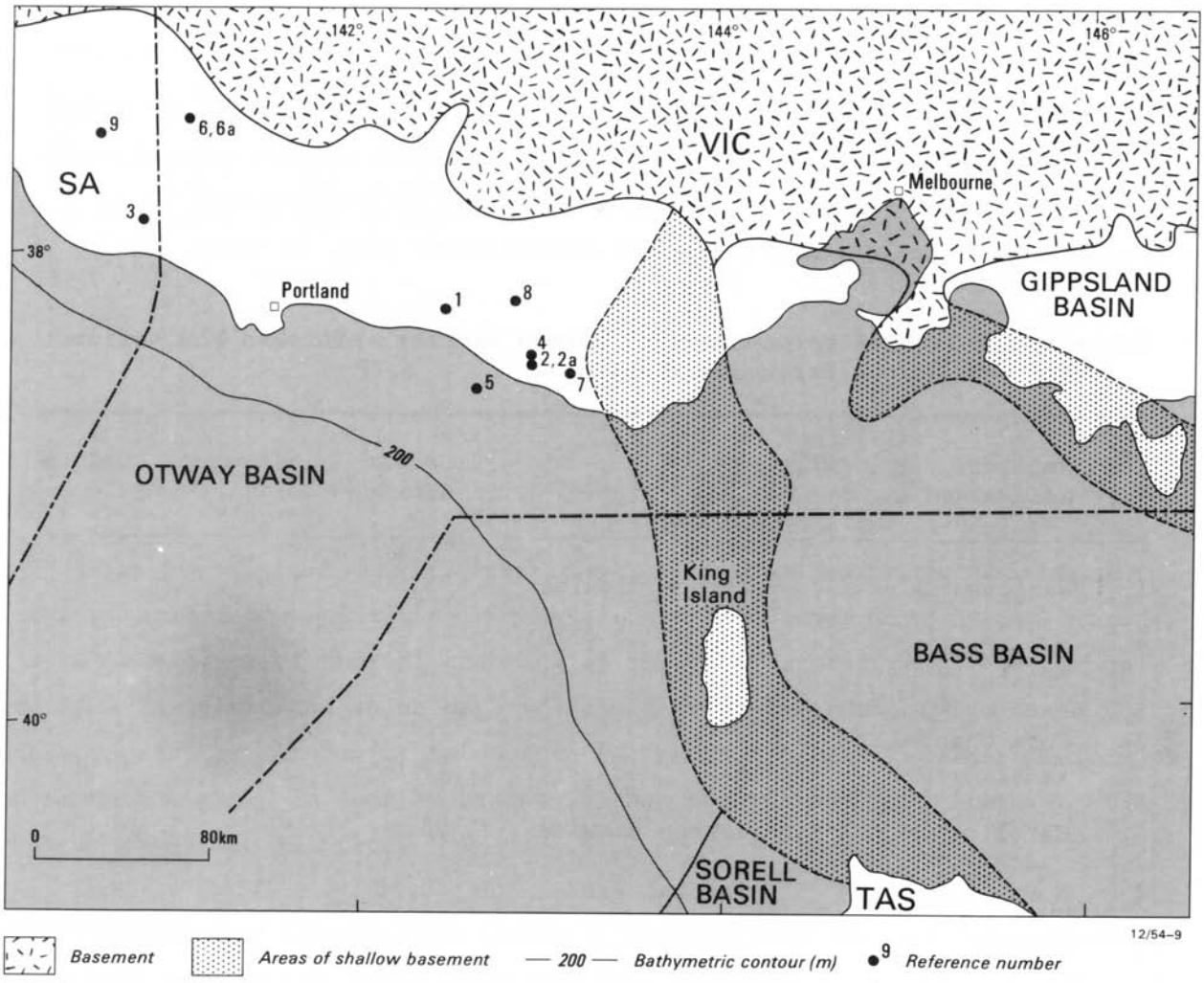
Gas and liquid hydrocarbons containing measurable quantities of carbon dioxide, nitrogen and helium, have been recovered from several accumulations. These compounds have economic significance as well as contributing to an understanding of petroleum genesis and accumulation (Fig. 9; Table 3).

Table 3. Molecular percentages of carbon dioxide, nitrogen and helium in Otway Basin gas samples.

Ref No.	Well or Accumulation	Type	Carbon dioxide	Nitrogen	Helium
1	Wangoom	carbon dioxide	95.00	-	-
2	Port Campbell (Paaratte Fm)	oil	0.5	-	-
2A	Port Campbell (Waarre Fm)	oil	23.00	6.80	0.05
3	Caroline	carbon dioxide	98.6	-	0.07
4	North Paaratte	natural gas	0.28	1.45	-
5	Pecten	natural gas	0.04	1.6	-
6	Tullich (Eumeralla Fm)	natural gas	-	18.5	-
6A	Tullich (Pretty Hill Sst)	natural gas	-	32.62	-
7	Ferguson Hill	natural gas	-	12.0	-
8	Garvoc	carbon dioxide	96.7	-	-
9	Kalangadoo	carbon dioxide	88.0	12.60	0.029

(The locations of the accumulations are shown in Figure 9.)
[After Konecki & Blair (1970) and Ozimic (1986).]

Figure 9. Regional distribution of non-petroleum gas accumulations. (Reference numbers 1 to 9 inclusive are listed in Table 3.)



Carbon dioxide

A significant accumulation of carbon dioxide was discovered in 1967 during drilling of the Caroline 1 well in South Australia (Mulready, 1977; Sprigg, 1986). The carbon dioxide in this accumulation is 98.9 percent pure. Since 1968, when production from the accumulation commenced, a total of over 250 000 tonnes of carbon dioxide has been produced for the South Australian and Victorian markets.

Apart from the Caroline accumulation, a number of other accumulations have been identified with concentrations of carbon dioxide ranging from less than 1.0 percent to over 99.0 percent.

Wopfner and Thornton (1971) concluded from their study of carbon dioxide in the Caroline 1 and Kalangadoo 1 wells that it was derived from sources below the Otway Group, rather than in-situ decay of organic matter. The migration of the carbon dioxide into present-day traps probably took place during the Cainozoic. In contrast, sources of carbon dioxide in the Bass and Gippsland Basins are likely to be organic, but with some contribution from igneous sources (Stainforth, 1984; Ozimic, 1986). The Caroline-1 'volcanic' carbon dioxide is accompanied by a small amount of aromatic petroleum (15^{O}API with 0.2% sulphur) apparently stripped from poor-quality inertinitic organic matter dispersed throughout the Waarre Sandstone reservoir (McKirdy & Heggie, 1987).

The genesis of carbon dioxide in petroleum basins has been discussed in detail by Farmer (1965), Hunt (1969) and Bray and Foster (1980) who consider that potential sources include the thermocatalytic decomposition of organic matter, hydrocarbons, or thermal decomposition of carbonates, as well as the action of some anaerobic bacteria on hydrocarbons (Ozimic, 1986).

Nitrogen

Nitrogen is present in a number of Otway Basin accumulations in concentrations ranging from 1.0 to 33.0 percent (Table 3). Thermal alteration of organic matter is a common source of nitrogen (Lutz & others, 1975). A possible source is the degassing of basement rocks, a view supported by the observation that gases included in igneous rocks have a high nitrogen content, and that the nitrogen concentration in some natural gas accumulations increases towards basement (Beebe & Curtis, 1986).

Ozimic (1986) considered that the nitrogen recorded in the Otway Basin may have originated by degassing of basement.

Helium

Low concentrations of helium have been recorded in several accumulations (Table 3); any accumulations containing over 0.5 percent helium may have commercial potential (Ozimic, 1986). Terrestrially-derived helium is generally a by-product of the disintegration of radioactive elements. While the concentration of such elements may be low in plutonic and volcanic rocks, they are the most likely source of helium in petroleum accumulations (Hunt, 1979). Ozimic (1986) suggested an igneous source for helium in the Otway Basin.

Petroleum and carbon dioxide reserves and developments

The initial total commercial and non-commercial reserves (as at 31 December 1988) for all gas accumulations in the Otway Basin are estimated at 0.483 billion cubic metres of sales gas and 0.002 million kilolitres of condensate (BMR, 1989). This does not include the Katnook and Ladbroke Grove reserves, which are currently being assessed by the permit holders. Of these reserves approximately 0.025 billion cubic metres of gas have been extracted.

North Paaratte/Wallaby Creek

In mid-1984 an agreement was reached between Beach Petroleum and the Gas and Fuel Corporation of Victoria for the supply of natural gas to Warrnambool from the North Paaratte and Wallaby Creek gas accumulations, via a production facility and pipeline (Figs. 10 & 11). The agreement required that 14 billion cubic feet (0.4 billion cubic metres) of gas be supplied over a 20 year period at flow rates up to a maximum of 8 million cubic feet per day (VDITR, 1988).

Beach Petroleum (1986) estimated the initial gas reserves in the North Paaratte accumulation to be 0.207 billion cubic metres; Wallaby Creek, 0.228 billion cubic metres; and Grumby, 0.048 billion cubic metres. Included in these accumulations are small quantities of condensate.

Figure 10. Location map of the North Paaratte gas production facility, surrounding wells and petroleum accumulations, after Beach Petroleum (1986).

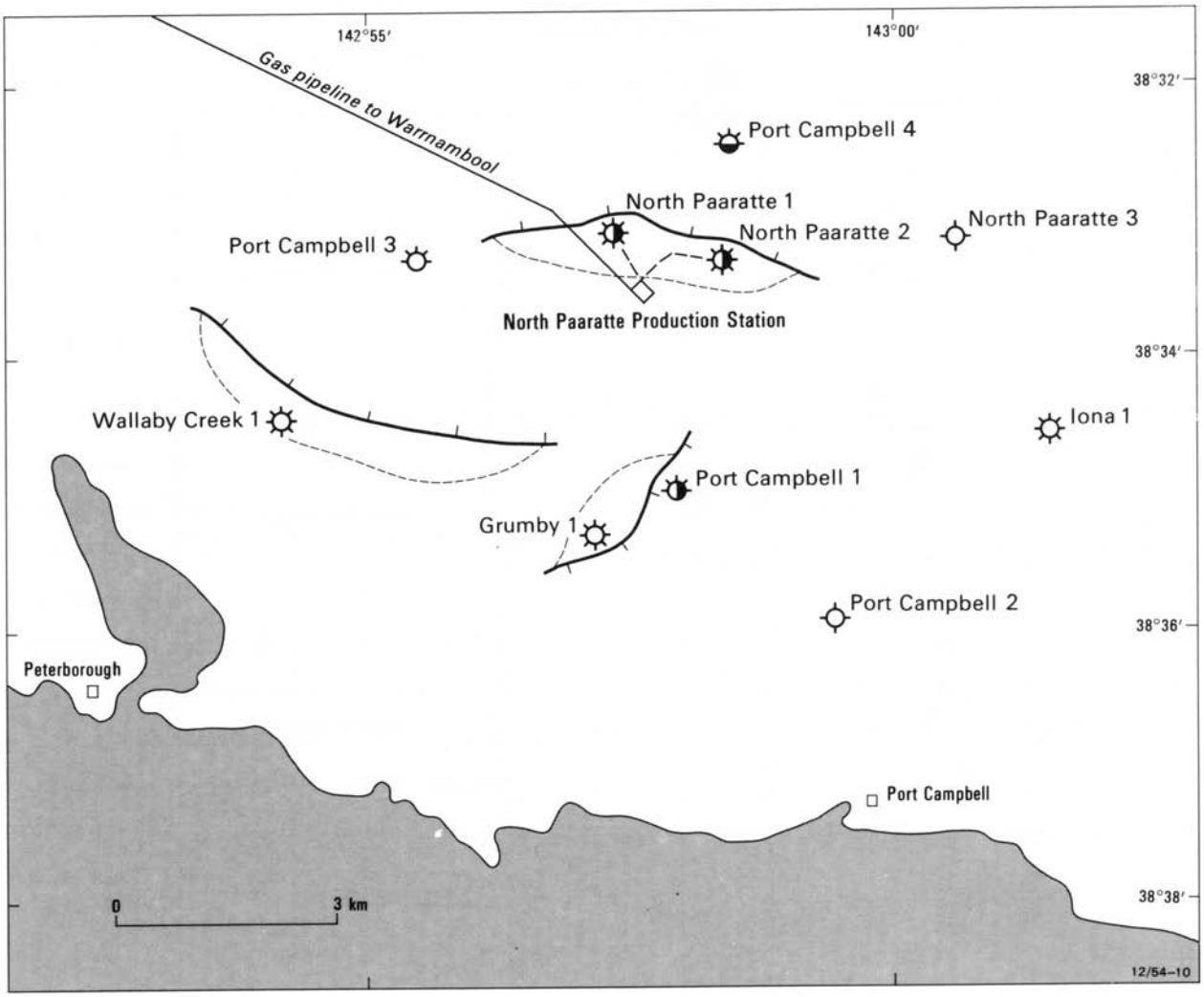
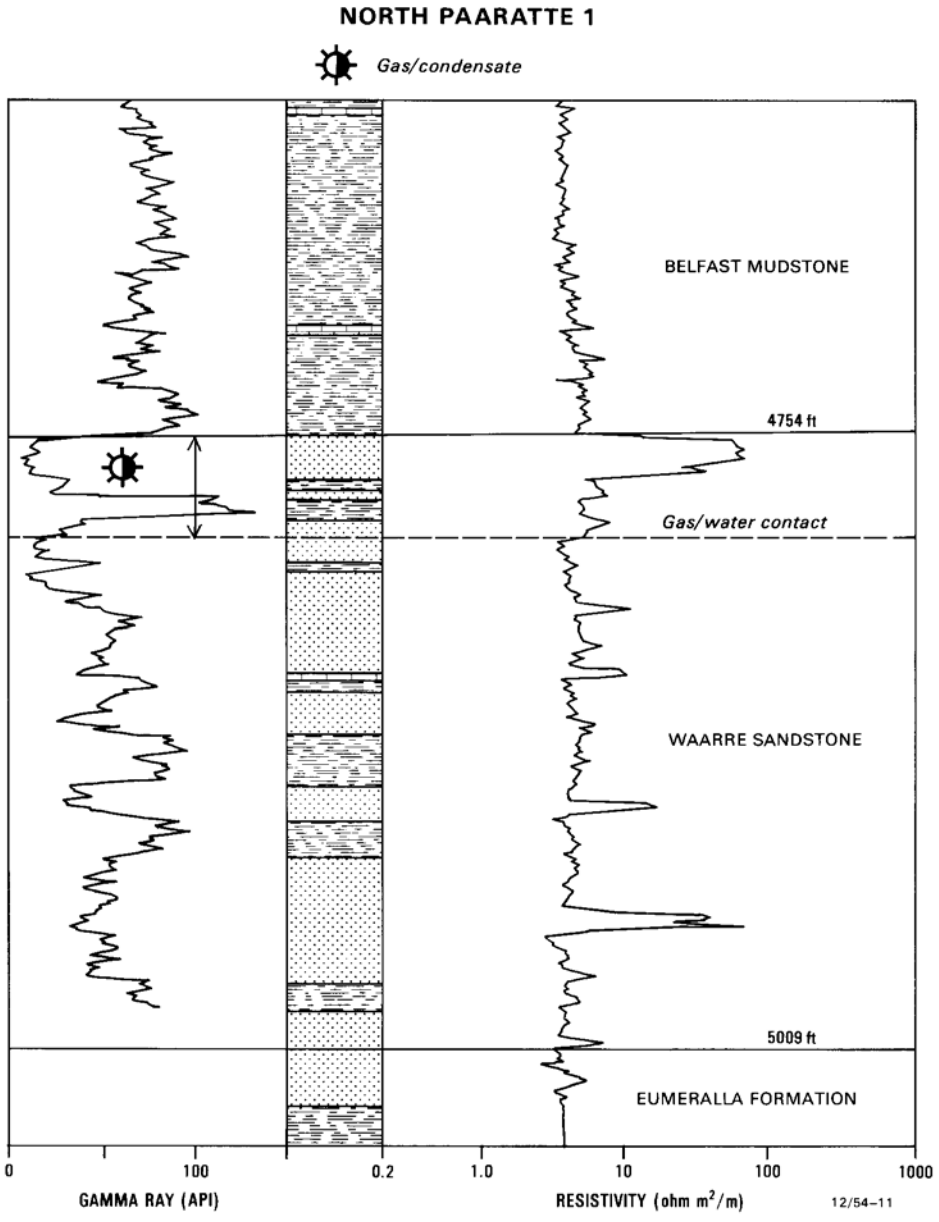


Figure 11. Wireline log data and extent of gas accumulation in part of the sequence intersected in the North Paaratte 1 well, after McPhee & others (1981).



Development of the North Paaratte gas accumulation(s) involved two stages. The initial stage, completed in August 1986 (VDITR, 1988), coupled the North Paaratte 1 and 2 wells, and an associated processing and production facility, into a 34 km-long and 168 mm-diameter pipeline to Warrnambool. The second stage involves development of the Wallaby Creek accumulation and is expected to be completed by 1992 to 1994 (Beach Petroleum, 1986).

The North Paaratte gas processing plant was commissioned in April 1986, and full conversion of the Warrnambool gas market to natural gas was completed in August 1986. Water and condensate are removed at the processing plant; the water is disposed of in an evaporation pit and the condensate stored for use (Beach Petroleum, 1986).

Caroline

The Caroline carbon dioxide accumulation in South Australia has been producing since 1968 at a rate of around 15 000 tonnes per annum of liquefied carbon dioxide. The maximum daily production rate is approximately 79 tonnes of raw gas. The raw gas is purified at a processing plant to remove small quantities of methane, water and hydrogen sulphide and the refined product is shipped to Melbourne and Adelaide in pressurised road tankers (Mulready, 1977). Reservoir conditions (pressure and temperature) in the accumulation are well above the critical point for carbon dioxide; some liquid carbon dioxide does, however, form as the gas passes through the well column to the surface. As a result both liquid and gaseous carbon dioxide are produced at the well head.

Resource potential

The quality of Otway Basin reservoirs and the size of potential traps have been highlighted by Smith (1988) and Williamson and others (1988) as major constraints on the resource potential of the sequence. The Pretty Hill Sandstone remains a major potential target in onshore areas, particularly for fault-dependent closures (Smith, 1988). The Eumeralla Formation generally lacks good-quality reservoir, due to the presence of a high proportion of labile constituents which are susceptible to diagenetic change. The formation has reservoir potential for gas accumulations in areas where immature or unstable constituents are absent.

According to Smith (1988), the Waarre Sandstone represents the best reservoir target for future exploration, for marine transgressive sandstones in particular, less so in the case of fluvial sandstones which have reduced porosity and permeability. In the Port Campbell area the marine sandstones have good porosity at depths of up to 1500 metres, as well as the advantage of good water drive. The Paaratte Formation is considered to have its best reservoir potential in the top of prograding shoreface units, and which could be good potential targets in offshore locations (Smith, 1988).

The Late Cretaceous and older parts of the Otway Basin sequence (pre-Belfast Mudstone) are possibly the most prospective because of favourable burial history and source rock maturity (Smith, 1988). In addition, any hydrocarbons present above the Belfast Mudstone are likely to be in small accumulations rather than large discrete ones (Smith, 1988). While potential reservoirs and traps are present in the Tertiary sequence the development of a freshwater aquifer system in this sequence could cause rapid biodegradation of any oil which has migrated from deeper mature sediments (for example, the Lindon 1 well).

More detailed modern seismic coverage and well control will be required before the basin's resource potential can be assessed with greater certainty (Smith, 1988). Many of the offshore wells failed to reach their target, or were off-structure, and no detailed modern seismic coverage exists over much of the offshore parts of the basin (Williamson & others, 1988; Smith, 1988). All of these factors suggest that considerable scope exists for further and more detailed exploration, as well as possible successful development of additional resources.

PETROLEUM AND NON-PETROLEUM GAS ACCUMULATIONS SUMMARIES

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: North Paaratte

COMPILATION DATE: 01/11/89

TYPE: gas/condensate

COMMERCIAL STATUS: economic and developed

LOCATION: 200 km WSW of Melbourne; 34 km SE of Warrnambool

STATE: Victoria

PETROLEUM TITLE(S): PPL 1

OPERATOR: Gas and Fuel Corp of Victoria

FIRST DISCOVERY WELL: North Paaratte 1
- latitude: 38°33'10" - longitude: 142°57'15"
- discovery: gas/condensate
- total depth: 1545 m
- date total depth reached: 21/11/79

NUMBER OF WELLS DRILLED: - exploration & appraisal: 3, including one producer
- development: nil

STRUCTURE: a discrete fault block within a faulted high
- areal closure: 2.3 sq. km
- vertical closure: 13.4 m

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 1

NUMBER AND TYPE OF PRODUCING ZONES: - gas: nil - gas/condensate: 1
- gas/oil: nil - oil: nil

DRIVE MECHANISM: water drive

PRODUCTION COMMENCED: April 1986

PRODUCTION INFRASTRUCTURE: the gas is piped 34 km to Warrnambool

REFERENCE(S): McPhee & others, 1981; Beach Petroleum, 1986

TRAP

TRAP 1: Waarre Sandstone

DISCOVERY WELL(S): North Paaratte 1

CONTENTS: gas/condensate

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: top of Waarre Sandstone

PETROLEUM CONTENTS: gas with a small amount of condensate

PRODUCTION STATUS: producing

FORMATION: Waarre Sandstone

AGE: Late Cretaceous

LITHOLOGY: sandstone: white to very light grey; medium to coarse grained; subround to subangular; moderately sorted; loosely consolidated; fluvial channel and point-bar

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 1449 m KB (1353 m SS)

POROSITY: 23%

PERMEABILITY: 2000 md

RESERVOIR TEMPERATURE: not available

RESERVOIR PRESSURE: 13 618 kPa at 1454 m KB

NON-PETROLEUM GAS ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Caroline

COMPILATION DATE: 01/11/89

TYPE: carbon dioxide

COMMERCIAL STATUS: economic and developed

LOCATION: 400 km SE of Adelaide

STATE: South Australia

PETROLEUM TITLE(S): PPL 21

OPERATOR: Liquid Air Australia Ltd

FIRST DISCOVERY WELL: Caroline 1
- latitude: 37°56'30" - longitude: 140°54'30"
- discovery: carbon dioxide
- total depth: 3371 m
- date total depth reached: 29/1/67

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 1 (producer)
- development: nil

STRUCTURE: a tilted fault block
- areal closure: not available
- vertical closure: 365 m

SUBDIVISION OF ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 3

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: 3
- gas/condensate: nil
- gas/oil: nil
- oil: nil

DRIVE MECHANISM: water drive (?)

PRODUCTION COMMENCED: November 1968

PRODUCTION INFRASTRUCTURE: Raw gas is purified at the treatment plant adjacent to the wellhead. The purified gas is transported in liquid form in pressured road tankers.

REFERENCE(S): Wopfner & Douglas, 1971; Mulready, 1977

TRAP

TRAP 1: Waarre Sandstone

DISCOVERY WELL(S): Caroline 1

CONTENTS: carbon dioxide

CARBON DIOXIDE-BEARING UNIT(S)

CARBON DIOXIDE-BEARING UNIT 1: "A" sand

CONTENTS: carbon dioxide

PRODUCTION STATUS: producing

FORMATION: Waarre Sandstone

AGE: Late Cretaceous

LITHOLOGY: sandstone: poorly sorted, friable, angular and very fine to very coarse; slightly cemented

TRAPPING MECHANISM: structural

DEPTH TO TOP OF CARBON DIOXIDE-BEARING UNIT: 2499 m KB (2462 m SS)

POROSITY: 14-17%

PERMEABILITY: not available

RESERVOIR TEMPERATURE: not available

RESERVOIR PRESSURE: not available

CARBON DIOXIDE-BEARING UNIT 2: "B" sand

CONTENTS: carbon dioxide

PRODUCTION STATUS: producing

FORMATION: Waarre Sandstone

AGE: Late Cretaceous

LITHOLOGY: sandstone: poorly sorted, friable, angular and very fine to very coarse; slightly cemented

TRAPPING MECHANISM: structural

DEPTH TO TOP OF CARBON DIOXIDE-BEARING UNIT: 2789 m KB (2751 m SS)

POROSITY: 18-21%

PERMEABILITY: not available

RESERVOIR TEMPERATURE: not available

RESERVOIR PRESSURE: 28 435 kPa at 2790 m KB

CARBON DIOXIDE-BEARING UNIT 3: "C" sand

CONTENTS: carbon dioxide

PRODUCTION STATUS: producing

FORMATION: Waarre Sandstone

AGE: Late Cretaceous

LITHOLOGY: sandstone: poorly sorted, friable, angular and very fine to very coarse; slightly cemented

TRAPPING MECHANISM: structural

DEPTH TO TOP OF CARBON DIOXIDE-BEARING UNIT: 2835 m KB (2798 m SS)

POROSITY: 11%

PERMEABILITY: not available

RESERVOIR TEMPERATURE: 86^{O}C

RESERVOIR PRESSURE: not available

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Wallaby Creek

COMPILATION DATE: 1/11/89

TYPE: gas/condensate

COMMERCIAL STATUS: economic and undeveloped

LOCATION: 200 km WSW of Melbourne; 30 km SE of Warrnambool

STATE: Victoria

PETROLEUM TITLE(S): PPL 1

OPERATOR: Gas and Fuel Corp of Victoria

FIRST DISCOVERY WELL: Wallaby Creek 1
- latitude: 38°34'18" - longitude: 142°54'19"
- discovery: gas/condensate
- total depth: 1763 m
- date total depth reached: 29/3/81

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 1
- development: nil

STRUCTURE:
- areal closure: 3.0 sq. km
- vertical closure: not available

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 1

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil - gas/condensate: nil
- gas/oil: nil - oil: nil

DRIVE MECHANISM: not known

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: 4 km distant from the North Paaratte-Warrnambool gas pipeline

REFERENCE(S): Beach Petroleum, 1986

TRAP

TRAP 1: Waarre Sandstone

DISCOVERY WELL(S): Wallaby Creek 1

CONTENTS: gas/condensate

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: top of Waarre Sandstone

PETROLEUM CONTENTS: gas with a small amount of condensate

PRODUCTION STATUS: nil (suspended)

FORMATION: Waarre Sandstone

AGE: Late Cretaceous

LITHOLOGY: sandstone

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 1516 m KB (1472 m SS)

POROSITY: not available

PERMEABILITY: not available

RESERVOIR TEMPERATURE: not available

RESERVOIR PRESSURE: not available

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Katnook

COMPILATION DATE: 12/12/89

TYPE: gas/condensate

COMMERCIAL STATUS: economic and undeveloped

LOCATION: 300 km SE of Adelaide; 40 km north of Mount Gambier

STATE: South Australia

PETROLEUM TITLE(S): PEL 32

OPERATOR: Ultramar Australia Ltd

FIRST DISCOVERY WELL: Katnook 1
- latitude: 37°27'11" - longitude: 140°46'53"
- discovery: gas/condensate
- total depth: 2520 m
- date total depth reached: 31/12/87

SECOND DISCOVERY WELL: Katnook 2
- latitude: 37°27'02" - longitude: 140°47'19"
- discovery: gas/condensate
- total depth: 3478.2 m KB
- date total depth reached: 8/2/89

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 2
- development: nil

STRUCTURE: a faulted anticline
- areal closure: not available
- vertical closure: not available

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 3
- number of petroleum-bearing units: 3

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil
- gas/condensate: nil
- gas/oil: nil
- oil: nil

DRIVE MECHANISM: water drive

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: nil

REFERENCE(S):

TRAP

TRAP 1: Eumeralla Formation

DISCOVERY WELL(S): Katnook 1

CONTENTS: gas/condensate

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: basal sand of Eumeralla Formation

PETROLEUM CONTENTS: gas/condensate

PRODUCTION STATUS: completed as potential producing interval

FORMATION: Eumeralla Formation

AGE: Early Cretaceous

LITHOLOGY: sandstone

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 1882 m KB (-1814 m SS)

POROSITY: 20%

PERMEABILITY: 2000 m.d.

RESERVOIR TEMPERATURE: 85^{O}C

RESERVOIR PRESSURE: 2684 psia

TRAP

TRAP 2: Pretty Hill Sandstone

DISCOVERY WELL(S): Katnook 2

CONTENTS: gas/condensate

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: Pretty Hill Sandstone

PETROLEUM CONTENTS: gas/condensate

PRODUCTION STATUS: completed

FORMATION: Pretty Hill Sandstone

AGE: Early Cretaceous

LITHOLOGY: sandstone

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 2863.5 m KB (-2794.7 m SS)

POROSITY: not available

PERMEABILITY: not available

RESERVOIR TEMPERATURE: not available

RESERVOIR PRESSURE: not available

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Ladbroke Grove

COMPILATION DATE: 1/11/89

TYPE: gas

COMMERCIAL STATUS: economic and undeveloped

LOCATION: 300 km southeast of Adelaide; 40 km north of Mount Gambier

STATE: South Australia

PETROLEUM TITLE(S): PEL 32

OPERATOR: Ultramar Australia Ltd

FIRST DISCOVERY WELL: Ladbroke Grove 1
- latitude: 37°28'06" - longitude: 140°46'52"
- discovery: gas
- total depth: 3442 m
- date total depth reached: 24/4/89

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 1
- development: nil

STRUCTURE:
- areal closure: not available
- vertical closure: not available

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 1

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil - gas/condensate: nil
- gas/oil: nil - oil: nil

DRIVE MECHANISM: water drive

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: nil

REFERENCE(S):

TRAP

TRAP 1: Pretty Hill Sandstone

DISCOVERY WELL(S): Ladbroke Grove 1

CONTENTS: gas

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: Pretty Hill Sandstone

PETROLEUM CONTENTS: gas (high CO_2 content)

PRODUCTION STATUS:

FORMATION: Pretty Hill Sandstone

AGE: Early Cretaceous

LITHOLOGY: sandstone

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: not available

POROSITY: not available

PERMEABILITY: not available

RESERVOIR TEMPERATURE: not available

RESERVOIR PRESSURE: not available

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Iona

COMPILATION DATE: 1/11/89

TYPE: gas

COMMERCIAL STATUS: economic and undeveloped

LOCATION: 200 km WSW of Melbourne; 40 km SE of Warrnambool

STATE: Victoria

PETROLEUM TITLE(S): PEP 108

OPERATOR: Gas and Fuel Corporation of Victoria

FIRST DISCOVERY WELL: Iona 1
- latitude: 38°34'30" - longitude: 143°01'57"
- discovery: gas
- total depth: 1487 m
- date total depth reached: 17/3/88

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 1 (suspended)
- development: nil

STRUCTURE:
- areal closure: 2.86 sq. km
- vertical closure: 30 m

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 1

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil - gas/condensate: nil
- gas/oil: nil - oil: nil

DRIVE MECHANISM: bottom water or edge water drive

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: 6 km east of the North Paaratte gas plant

REFERENCE(S): Buffin, 1989; Laing & others, 1989

TRAP

TRAP 1: Waarre Sandstone

DISCOVERY WELL(S): Iona 1

CONTENTS: gas

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: Waarre Sandstone

PETROLEUM CONTENTS: Waarre Sandstone

PRODUCTION STATUS: nil (suspended)

FORMATION: Waarre Sandstone

AGE: Late Cretaceous

LITHOLOGY: sandstone

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 1293 m KB

POROSITY: 27%

PERMEABILITY: in excess of 8000 md

TEMPERATURE: 56^{O}C @ 1487 m KB

RESERVOIR PRESSURE:

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Grumby

COMPILATION DATE: 1/11/89

TYPE: gas

COMMERCIAL STATUS: economic and undeveloped

LOCATION: 200 km WSW of Melbourne; 35 km SE of Warrnambool

STATE: Victoria

PETROLEUM TITLE(S): PPL 1

OPERATOR: Gas and Fuel Corp of Victoria

FIRST DISCOVERY WELL: Iona 1
- latitude: 38°35'08" - longitude: 142°57'11"
- discovery: gas
- total depth: 1811 m
- date total depth reached: 10/3/81

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 1
- development: nil

STRUCTURE:
- areal closure: 0.9 sq. km
- vertical closure: not available

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 1

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil - gas/condensate: nil
- gas/oil: nil - oil: nil

DRIVE MECHANISM: not available

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: 3 km south of the North Paaratte gas plant

REFERENCE(S): Beach Petroleum, 1986

TRAP

TRAP 1: Waarre Sandstone

DISCOVERY WELL(S): Grumby 1

CONTENTS: gas

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: Waarre Sandstone

PETROLEUM CONTENTS: gas containing 50% of carbon dioxide

PRODUCTION STATUS: nil (suspended)

FORMATION: Waarre Sandstone

AGE: Late Cretaceous

LITHOLOGY: sandstone

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 1665 m KB (1574 m SS)

POROSITY: not available

PERMEABILITY: not available

RESERVOIR TEMPERATURE: not available

RESERVOIR PRESSURE: not available

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Lindon

COMPILATION DATE: 1/11/89

TYPE: oil show

COMMERCIAL STATUS: uneconomic

LOCATION: 370 km west of Melbourne; 30 km north of Portland

STATE: Victoria

PETROLEUM TITLE(S): PEP 105

OPERATOR: Beach Petroleum NL

FIRST DISCOVERY WELL: Lindon 1
- latitude: 38°04'05" - longitude: 141°30'55"
- discovery: oil show
- total depth:
- date total depth reached:

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 1
- development: nil

STRUCTURE: a NW-trending horst block
- areal closure: 3.1 sq. km
- vertical closure: not available

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 1

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil - gas/condensate: nil
- gas/oil: nil - oil: nil

DRIVE MECHANISM: (show only)

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: nil (plugged and abandoned)

REFERENCE(S): Tabbasi & Davey, 1986

TRAP

TRAP 1: Pebble Point Formation

DISCOVERY WELL(S): Lindon 1

CONTENTS: (oil show)

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: top of Pebble Point Formation

PETROLEUM CONTENTS: (oil show)

PRODUCTION STATUS: nil (plugged and abandoned)

FORMATION: Pebble Point Formation

AGE: Tertiary

LITHOLOGY: sandstone: medium to dark green-grey, friable to firm, very fine to very coarse grained, rounded and poorly sorted; inter bedded with silty claystone; lateritic

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 910 m KB

POROSITY: up to 20%; average 5%

PERMEABILITY: low

RESERVOIR TEMPERATURE: not available

RESERVOIR PRESSURE: not available

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Windermere

COMPILATION DATE: 1/11/89

TYPE: oil

COMMERCIAL STATUS: subeconomic

LOCATION: 250 km west of Melbourne; 30 km NW of Port Fairy

STATE: Victoria

PETROLEUM TITLE(S): PEP 111

OPERATOR: Minora Resources NL

FIRST DISCOVERY WELL: Windermere 1
- latitude: 38°13'45" - longitude: 142°10'52"
- discovery: oil
- total depth: 1852 m
- date total depth reached: 8/4/87

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 2
- development: nil

STRUCTURE: a faulted anticline
- areal closure: not available
- vertical closure: not available

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps:
- number of petroleum-bearing units:

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil - gas/condensate: nil
- gas/oil: nil - oil: nil

DRIVE MECHANISM: not available

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: nil

REFERENCE(S):

TRAP

TRAP 1: Eumeralla Formation

DISCOVERY WELL(S): Windermere 1

CONTENTS: oil

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: Heathfield Member

PETROLEUM CONTENTS: oil

PRODUCTION STATUS: nil (suspended)

FORMATION: Eumeralla Formation

AGE: Early Cretaceous

LITHOLOGY: sandstone

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 1790 m KB (1739 m SS)

POROSITY: not available

PERMEABILITY: not available

RESERVOIR TEMPERATURE: not available

RESERVOIR PRESSURE: not available

NON-PETROLEUM GAS ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Kalangadoo

COMPILATION DATE: 1/11/89

TYPE: carbon dioxide

COMMERCIAL STATUS: uneconomic

LOCATION: 120 km SE of Adelaide; 30 km north of Mount Gambier

STATE: South Australia

PETROLEUM TITLE(S): PEL 32

OPERATOR: Ultramar Australia Ltd

FIRST DISCOVERY WELL: Kalangadoo 1
- latitude: 37°34'32" - longitude: 140°42'10"
- discovery: carbon dioxide
- total depth: 2755 m
- date total depth reached: 31/8/65

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 1
- development: nil

STRUCTURE: an upthrust block of Palaeozoic basement
- areal closure: not known
- vertical closure: not known

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 1

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil - gas/condensate: nil
- gas/oil: nil - oil: nil

DRIVE MECHANISM: not known

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: nil (plugged and abandoned)

REFERENCE(S):

TRAP

TRAP 1: Palaeozoic basement

DISCOVERY WELL(S): Kalangadoo 1

CONTENTS: carbon dioxide

CARBON DIOXIDE-BEARING UNIT(S)

CARBON DIOXIDE-BEARING UNIT 1: Palaeozoic basement

PETROLEUM CONTENTS: carbon dioxide

PRODUCTION STATUS: nil (plugged and abandoned)

FORMATION: basement

AGE: Palaeozoic (? Devonian)

LITHOLOGY: sandstone: dolomitic with shale; sheared and fractured; weathered

TRAPPING MECHANISM: structural

DEPTH TO TOP OF CARBON DIOXIDE-BEARING UNIT: 2059 m RT (1986 m SS)

POROSITY: low

PERMEABILITY: not available

RESERVOIR TEMPERATURE: not available

RESERVOIR PRESSURE: not available

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Flaxmans

COMPILATION DATE: 1/11/89

TYPE: gas/condensate show

COMMERCIAL STATUS: uneconomic

LOCATION: 200 km WSW of Melbourne; 30 km SE of Warrnambool

STATE: Victoria

PETROLEUM TITLE(S): PEP 104

OPERATOR: Beach Petroleum NL

FIRST DISCOVERY WELL: Flaxmans 1
- latitude: 38°33' - longitude: 142°46'
- discovery: (gas/condensate show)
- total depth: 3514 m
- date total depth reached: 25/8/61

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 1
- development: nil

STRUCTURE: a faulted NE-trending high
- areal closure: not available
- vertical closure: not available

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 1

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil - gas/condensate: nil
- gas/oil: nil - oil: nil

DRIVE MECHANISM:

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: nil (plugged and abandoned)

REFERENCE(S): BMR, 1965

TRAP

TRAP 1: Eumeralla Formation

DISCOVERY WELL(S): Flaxmans 1

CONTENTS: (gas/condensate show)

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: Eumeralla Formation

PETROLEUM CONTENTS: (gas/condensate show)

PRODUCTION STATUS: nil (plugged and abandoned)

FORMATION: Eumeralla Formation

AGE: Early Cretaceous

LITHOLOGY: sandstone: grey, very fine grained and cross-bedded; grading into siltstone and mudstone

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 3305 m RT (3237 m SS)

POROSITY: low

PERMEABILITY: low

RESERVOIR TEMPERATURE: 103^{o}C

RESERVOIR PRESSURE: not available

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Port Campbell 1

COMPILATION DATE: 1/11/89

TYPE: gas/condensate

COMMERCIAL STATUS: uneconomic

LOCATION: 200 km WSW of Melbourne; 36 km SE of Warrnambool

STATE: Victoria

PETROLEUM TITLE(S): PPL 1

OPERATOR: Gas and Fuel Corp of Victoria

FIRST DISCOVERY WELL: Port Campbell 1
- latitude: 38°34'57" - longitude: 142°57'50"
- discovery: gas/condensate
- total depth: 1818 m
- date total depth reached: 9/12/59

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 1
- development: nil

STRUCTURE: a faulted block on the downthrown side of a fault
- areal closure: not available
- vertical closure: not available

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 1

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil - gas/condensate: nil
- gas/oil: nil - oil: nil

DRIVE MECHANISM:

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: (plugged and abandoned); 3km east of the North Paaratte gas production station

REFERENCE(S): BMR, 1964

TRAP

TRAP 1: Waarre Sandstone

DISCOVERY WELL(S): Port Campbell No. 1

CONTENTS: gas/condensate

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: top of Waarre Sandstone

PETROLEUM CONTENTS: gas/condensate

PRODUCTION STATUS: nil (plugged and abandoned)

FORMATION: Waarre Sandstone

AGE: Late Cretaceous

LITHOLOGY: sandstone: light grey to white; clean and friable; pebble conglomerate at the top; pyrite and coal lenses; slightly calcareous in parts

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 1724 m RT (1618 m SS)

POROSITY: 24-26.5%

PERMEABILITY: 170-2990 md

RESERVOIR TEMPERATURE: 79^{o}C

RESERVOIR PRESSURE: 14 500 kPa at 1739 m RT (DST 4)

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Port Campbell 3

COMPILATION DATE: 1/11/89

TYPE: gas show

COMMERCIAL STATUS: uneconomic

LOCATION: 200 km WSW of Melbourne; 32 km SE of Warrnambool

STATE: Victoria

PETROLEUM TITLE(S): PPL 1

OPERATOR: Gas and Fuel Corp of Victoria

FIRST DISCOVERY WELL: Port Campbell 3
- latitude: 38°33' - longitude: 142°55'
- discovery: (gas show)
- total depth: 1686 m
- date total depth reached:

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 1
- development: nil

STRUCTURE:
- areal closure: not available
- vertical closure: not available

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 1

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil - gas/condensate: nil
- gas/oil: nil - oil: nil

DRIVE MECHANISM: not available

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: (plugged and abandoned); 3km distant from the North Paaratte gas production station

REFERENCE(S):

TRAP

TRAP 1: Eumeralla Formation

DISCOVERY WELL(S): Port Campbell No. 3

CONTENTS: (gas show)

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: Eumeralla Formation

PETROLEUM CONTENTS: (gas show)

PRODUCTION STATUS: (plugged and abandoned)

FORMATION: Eumeralla Formation

AGE: Early Cretaceous

LITHOLOGY: sandstone

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 1511 m RT

POROSITY: not available

PERMEABILITY: not available

RESERVOIR TEMPERATURE: not available

RESERVOIR PRESSURE: not available

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Port Campbell 4

COMPILATION DATE: 1/11/89

TYPE: oil and gas

COMMERCIAL STATUS: uneconomic

LOCATION: 200 km WSW of Melbourne; 34 km SE of Warrnambool

STATE: Victoria

PETROLEUM TITLE(S): PPL 1

OPERATOR: Gas and Fuel Corp of Victoria

FIRST DISCOVERY WELL: Port Campbell 4
- latitude: 38°32'30" - longitude: 142°58'30"
- discovery: oil and gas
- total depth: 2597 m
- date total depth reached: 12/7/64

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 1
- development: nil

STRUCTURE:
- areal closure: not available
- vertical closure: not available

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 1

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil
- gas/condensate: nil
- gas/oil: nil
- oil: nil

DRIVE MECHANISM: not available

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: (plugged and abandoned); 3km distant from the North Paaratte gas production station

REFERENCE(S):

TRAP

TRAP 1: Eumeralla Formation

DISCOVERY WELL(S): Port Campbell 4

CONTENTS: oil and gas

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: intra-unit 2

PETROLEUM CONTENTS: oil and gas

PRODUCTION STATUS: (plugged and abandoned)

FORMATION: Eumeralla Formation

AGE: Early Cretaceous

LITHOLOGY: sandstone: light grey to green-grey; mottled; feldspathic with dark rock grains and minor quartz; interbedded with siltstone and mudstone

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 1789 m RT (1655 m SS)

POROSITY: 10.4-14.3%

PERMEABILITY: very low

RESERVOIR TEMPERATURE: 62^{o}C

RESERVOIR PRESSURE: 16 410 kPa at 1783 m RT

PETROLEUM ACCUMULATIONS SUMMARY SHEET

ACCUMULATION: Pecten

COMPILATION DATE: 1/11/89

TYPE: gas

COMMERCIAL STATUS: uneconomic

LOCATION: 215 km WSW of Melbourne; 15 km offshore

STATE: Victoria

PETROLEUM TITLE(S): vacant

OPERATOR:

FIRST DISCOVERY WELL: Pecten 1A
- latitude: 38°40'41" - longitude: 142°39'56"
- discovery: gas
- total depth: 2850 m
- date total depth reached: 3/6/67

NUMBER OF WELLS DRILLED:
- exploration & appraisal: 1
- development: nil

STRUCTURE: ANE-trending anticline
- areal closure: 73 sq. km
- vertical closure: 107 m

SUBDIVISION OF PETROLEUM ACCUMULATION:
- number of traps: 1
- number of petroleum-bearing units: 1

NUMBER AND TYPE OF PRODUCING ZONES:
- gas: nil - gas/condensate: nil
- gas/oil: nil - oil: nil

DRIVE MECHANISM: not available

PRODUCTION COMMENCED:

PRODUCTION INFRASTRUCTURE: nil (plugged and abandoned)

REFERENCE(S):

TRAP

TRAP 1: Waarre Sandstone

DISCOVERY WELL(S): Pecten No. 1A

CONTENTS: gas

PETROLEUM-BEARING UNIT(S)

PETROLEUM-BEARING UNIT 1: top of Waarre Sandstone

PETROLEUM CONTENTS: gas

PRODUCTION STATUS: nil (plugged and abandoned)

FORMATION: Waarre Sandstone

AGE: Late Cretaceous

LITHOLOGY: sandstone: well sorted; interbedded with mudstone

TRAPPING MECHANISM: structural

DEPTH TO TOP OF PETROLEUM-BEARING UNIT: 1771 m RT (1737 m SS)

POROSITY: 17-25%

PERMEABILITY: 19-30 md

RESERVOIR TEMPERATURE: 63^{O}C

RESERVOIR PRESSURE: 16 740 kPa at 1722 m DF

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APPENDIX LIST OF PETROLEUM EXPLORATION WELLS DRILLED IN THE OTWAY BASIN

WELL NAME	OPERATOR	LATITUDE (S)	LONGITUDE (E)	STAT	TD DATE	LEGIS	WELL STATUS	TD (m)	GL WD (m)	DATUM (m)	BHTEMP (degC)
Anglesea 1	Oil Development	38.4072	144.1981	Vic	07-NOV-62	PSSA	abandoned	3068	20.0	24.0	116
Argonaut 1A	Esso	37.9716	140.2647	SA	29-JUN-68	PSSA	abandoned	3707	-77.1	28.3	91
BMR Penola 31	BMR	37.8333	140.8833	Vic	77		abandoned				
BMR Queencliff 1	BMR	38.2264	144.4342	Vic	67		abandoned				
Ballongeich 1	Phoenix	38.2368	142.6413	Vic	23-JUL-87		abandoned	1255	75.0	81.0	
Banyula 1	Aquitaine	37.3574	140.4742	SA	28-JUL-82		abandoned	2789	41.0	45.0	
Barton Corner 1	Beach	38.4314	142.7550	Vic	17-APR-85		abandoned	2100	58.0	63.0	
Beachport 1	South East Oil	37.4486	140.0375	SA	28-DEC-61	PSSA	abandoned	1208	4.0	5.0	63
Beachport East 1	John Henry	37.4500	140.0860	SA	24-AUG-73	PSSA	abandoned	1429	12.0	17.0	54
Bool Lagoon 1	Hartogen	37.1464	140.6323	SA	15-NOV-89		abandoned	782	164.0	168.5	
Braeside 1	Beach	38.5425	142.9725	Vic	26-APR-82		abandoned	2300	62.0	67.0	
Breaksea Reef 1	Ultramar	38.1586	140.6123	SA	18-MAY-84	PSLA	abandoned	4468	-67.0	22.0	
Bridgewater Bay 1	Phillips	38.5405	141.3633	Vic	02-DEC-83	PSLA	abandoned	4200	-109.0	21.0	123
Burrungule 1	Alliance	37.7711	140.5383	SA	12-JUL-75		abandoned	2438	27.4	31.8	
Callista 1	Beach	38.4667	142.8368	Vic	07-APR-88		abandoned	1800	77.0		
Camelback 1	Hartogen	37.1047	140.1881	SA	21-APR-87		abandoned	1783	42.0	45.0	
Caroline 1	Alliance	37.9417	140.9083	SA	29-JAN-67	PSSA	CO2 gas	3371	33.0	38.0	91
Casterton 1	Planet	37.6150	141.3350	Vic	28-APR-65	PSSA	abandoned	2494	140.0	144.0	82
Casterton 2	Planet	37.6514	141.2222	Vic	29-OCT-67	PSSA	abandoned	1526	66.0	70.0	66
Chama 1	Esso	37.4267	139.5419	SA	24-JAN-70	PSLA	abandoned	1288	-85.0	28.0	
Chama 1A	Esso	37.4269	139.5435	SA	27-FEB-70	PSLA	abandoned	2748	-83.0	28.0	92
Copa 1	Cultus	37.6884	139.7558	SA	17-JAN-90	PSLA	abandoned	3850			
Crayfish 1A	Esso	37.2894	139.5972	SA	20-DEC-67	PSSA	abandoned	3199	-49.0	28.0	
Curdie 1	Beach	38.5539	142.8220	Vic	27-MAR-82		abandoned	2618	36.0	39.0	

WELL NAME	OPERATOR	LATITUDE (S)	LONGITUDE (E)	STAT	TD DATE	LEGIS	WELL STATUS	TD (m)	GL WD (m)	DATUM (m)	BHTEMP (degC)
Curdievale 1	Beach	38.5553	142.7839	Vic	27-MAR-83		abandoned	1176	53.0	56.0	
Diamond Swamp 1	John Henry	37.3626	140.3898	SA	07-AUG-73	PSSA	abandoned	1595	11.0	15.0	64
Discovery Bay 1	Phillips	38.4119	141.0725	Vic	12-OCT-82	PSLA	abandoned	2776	-97.0	23.0	82
Douglas Point 1	General Exp'tion	38.0258	140.5956	SA	18-JUN-73	PSSA	abandoned	1207	3.0	6.0	48
Eumeralla 1	Frome	38.2119	141.9336	Vic	05-JAN-63	PSSA	abandoned	3142	47.0	51.0	97
Fahley 1	Beach	37.9561	141.0467	Vic	29-JUN-85		abandoned	3211	39.0	44.0	
Fahley 2	Beach	37.9792	141.0464	Vic	20-AUG-87		abandoned	1300	27.0	31.0	
Fergusons Hill 1	Frome	38.6222	143.1614	Vic	06-MAY-64	PSSA	abandoned	3546	194.0	198.0	119
Flaxmans 1	Frome	38.5500	142.7667	Vic	25-AUG-61	PSSA	abandoned	3514	63.0	67.0	
Garvoc 1	Interstate	38.3192	142.8758	Vic	06-JUL-68	PSSA	abandoned	1533	107.0	111.0	67
Geelong Flow 1	Geelong Flow Oil	28.3042	144.3389	Vic	49		abandoned	486			
Geltwood Beach 1	Beach	37.6622	140.2431	SA	10-NOV-63	PSSA	abandoned	3749	5.0	9.0	
Geltwood Beach SH 1	Beach	37.6706	140.2522	SA	05-AUG-62	PSSA	abandoned	442	32.0	33.0	
Geltwood Beach SH 2	Beach	37.6642	140.2367	SA	17-AUG-62	PSSA	abandoned	369	35.0	36.0	
Geltwood Beach SH 3	Beach	37.6550	140.2158	SA	02-SEP-62	PSSA	abandoned	369	34.0	35.0	
Geltwood Beach SH 4	Beach	37.6433	140.2033	SA	12-SEP-62	PSSA	abandoned	369	34.0	35.0	
Geltwood Beach SH 5	Beach	37.6467	140.2333	SA	25-SEP-62	PSSA	abandoned	369	40.0	41.0	
Geltwood Beach SH 6	Beach	37.6481	140.2600	SA	16-NOV-62	PSSA	abandoned	431	34.0	35.0	
Geltwood Beach SH 7	Beach	37.6222	140.2417	SA	28-OCT-62	PSSA	abandoned	491	33.0	34.0	
Geltwood Beach SH 8	Beach	37.6178	140.2150	SA	28-FEB-63	PSSA	abandoned	412	44.0	45.0	31
Geltwood Beach SH 9	Beach	37.6104	140.1644	SA	21-MAR-63	PSSA	abandoned	424	34.0	35.0	36
Green Banks 1	Beach	38.0206	141.7755	Vic	14-APR-83		abandoned	1226	105.0		
Greenslopes 1	Phoenix	38.1514	142.1939	Vic	09-JAN-86		abandoned	2608	82.0	88.0	
Grumby 1	Beach	38.5856	142.9531	Vic	10-MAR-81		gas suspd	1811	88.0	91.0	
Hawkesdale 1	Shell	38.0814	142.2983	Vic	28-DEC-69	PSSA	abandoned	1774	135.0	139.0	58

WELL NAME	OPERATOR	LATITUDE (S)	LONGITUDE (E)	STAT	TD DATE	LEGIS	WELL STATUS	TD (m)	GL WD (m)	DATUM (m)	BHTEMP (degC)
Heathfield 1	Planet	37.6272	141.1856	Vic	21-APR-64	PSSA	abandoned	2286	70.0	74.0	79
Henke 1	Beach	38.0067	141.1914	Vic	06-JUL-87		abandoned	1435			
Hindhaugh Creek 1	Pursuit	38.2786	144.2019	Vic	31-OCT-69	PSSA	abandoned	2372	71.0	75.0	102
Iona 1	Beach	38.5751	143.0326	Vic	17-MAR-88		gas suspd	1490	126.5	132.5	
Kalangadoo 1	Alliance	37.5777	140.6945	SA	28-AUG-65	PSSA	abandoned	2755	67.0	73.0	87
Katnook 1	Ultramar	37.4533	140.7817	SA	31-DEC-87		gas suspd	2520	63.1		
Katnook 2	Ultramar	37.4506	140.7886	SA	09-FEB-89		gas suspd	3478	63.0		
Katnook 3	Ultramar	37.1164	140.7743	SA	23-JAN-90			3098	63.4	69.2	
Kentgrove 1	Shoreline	37.9347	140.6236	SA	01-DEC-76		abandoned	991	26.4	28.2	
Killarney 1	Hartogen	37.1011	140.3058	SA	30-APR-87		abandoned	817	32.0	35.0	
Knights Dome 2	Oil Search	37.9889	140.6833	SA	01-JAN-30		abandoned	613			
Ladbroke Grove 1	Ultramar	37.4683	140.7811	SA	16-JUN-89		gas suspd	3442			
Laira 1	Ultramar	37.2535	140.4024	SA	18-DEC-89		abandoned	3003	62.8	68.6	
Lake Bonney 1	Alliance	37.8442	140.4725	SA	25-AUG-67	PSSA	abandoned	2908	21.0	26.0	79
Lake Eliza 1	Esso	37.2322	139.9850	SA	22-SEP-69	PSSA	abandoned	1473	9.0	12.0	70
Lake Eliza 2	General Exp'tion	37.2203	139.9856	SA	10-SEP-73		abandoned	1158	9.1	13.4	
Lake George 1	Esso	37.4525	140.0431	SA	15-OCT-69	PSSA	abandoned	1369	4.0	7.0	67
Lake Hawdon 1	Hartogen	37.1988	139.9900	SA	26-NOV-88		abandoned	2083	10.4	16.5	
Latrobe 1		38.6953	143.1433	Vic	14-FEB-64	PSSA	water	618		34.0	
Lindon 1	Beach	38.0683	141.5153	Vic	02-JAN-84		abandoned	3011	63.0	70.0	
Lucindale 1	Esso	37.0989	140.3117	SA	08-NOV-69	PSSA	abandoned	976	47.0	51.0	57
McEachern 1	Gas and Fuel	37.5642	141.1904	Vic	09-JAN-90		abandoned	2384	76.3	5.6	
McNamara 1	Beach	37.8372	140.6294	SA	31-MAR-87		abandoned	680	32.0	36.0	
Morum 1	Esso	37.5025	139.2355	SA	02-JUN-75	PSLA	abandoned	2439	-277.3	8.5	57
Mount Salt 1	Oil Development	37.9569	140.6286	SA	21-SEP-62	PSSA	abandoned	3061	21.0	26.0	73

WELL NAME	OPERATOR	LATITUDE (S)	LONGITUDE (E)	STAT	TD DATE	LEGIS	WELL STATUS	TD (m)	GL WD (m)	DATUM (m)	BHTEMP (degC)
Mount Salt SH 1	Oil Development	37.9686	140.6400	SA	24-JAN-62	PSSA	abandoned	307	22.0	27.0	
Mount Salt SH 2	Oil Development	37.9561	140.6281	SA	03-FEB-62	PSSA	abandoned	304	22.0	27.0	
Mount Salt SH 3	Oil Development	37.9431	140.6150	SA	10-FEB-62	PSSA	abandoned	304	22.0	27.0	
Mount Salt SH 4	Oil Development	37.9508	140.6400	SA	17-FEB-62	PSSA	abandoned	304	21.0	26.0	
Mount Salt SH 5	Oil Development	37.9608	140.6178	SA	01-MAR-62	PSSA	abandoned	304	22.0	27.0	
Moyne Falls 1	Shell	38.0692	142.1931	Vic	26-NOV-69	PSSA	abandoned	1008	146.0	150.0	50
Mumbannar 1	Mersey Valley	37.8528	141.0444	Vic	25		abandoned	335			
Mussel 1	Esso	38.9628	142.7727	Vic	07-SEP-69	PSSA	abandoned	2450	-85.0	30.0	68
Najaba 1	Beach	37.9025	142.0644	Vic	14-APR-86		abandoned	212	52.0	57.0	
Najaba 1A	Beach	37.9036	141.0639	Vic	22-JUN-86		abandoned	3411	52.0	57.0	
Nautilus 1A	Esso	38.9780	142.5460	Vic	05-MAY-68	PSSA	abandoned	2011	-100.0	28.0	59
Neptune 1	Esso	37.3036	139.7358	SA	08-JAN-74	PSLA	abandoned	2436	-35.0	10.0	
Nerita 1	Shell	38.6287	144.2291	Vic	30-JUL-67	PSSA	abandoned	2042	-75.0	34.0	66
Normanby 1	BP	38.2365	141.0842	Vic	15-APR-86	PSLA	abandoned	3306	-48.8	26.8	
North Eumeralla 1	Shell	38.1642	141.8917	Vic	21-JAN-73	PSSA	abandoned	2968	55.0	63.0	110
North Paaratte 1	Beach	38.5528	142.9542	Vic	21-NOV-79		gas	1545	92.6	96.0	
North Paaratte 2	Beach	38.5519	142.9720	Vic	09-FEB-81		gas	1603	46.0	49.0	
North Paaratte 3	Beach	38.5531	142.9394	Vic	16-JUN-80		abandoned	1516	78.0	81.0	
Palpara 1	Point Addis	37.9917	140.9972	Vic	25		abandoned	356			
Pecten 1A	Shell	38.6781	142.6656	Vic	03-APR-67	PSSA	abandoned	2850	-63.0	34.0	
Penola 1	Oil Development	37.3439	140.8764	SA	18-APR-61	PSSA	abandoned	1519	62.0	64.0	63
Port Campbell 1	Frome	38.5825	142.9639	Vic	09-DEC-59	PSSA	gas suspd	1819	103.0	106.0	82
Port Campbell 2	Frome	38.5967	142.9917	Vic	01-DEC-60	PSSA	water	2696	81.0	86.0	87
Port Campbell 3	Frome	38.5500	142.9167	Vic	04-MAR-61		abandoned	1686			
Port Campbell 4	Frome	38.5417	142.9750	Vic	12-JUL-64	PSSA	abandoned	2597	130.0	134.0	79

WELL NAME	OPERATOR	LATITUDE (S)	LONGITUDE (E)	STAT	TD DATE	LEGIS	WELL STATUS	TD (m)	GL WD (m)	DATUM (m)	BHTEMP (degC)
Prawn 1A	Esso	39.3565	143.1116	Tas	30-MAR-68	PSSA	abandoned	3193	-109.7	27.0	109
Pretty Hill 1	Frome	38.2250	142.1250	Vic	13-OCT-62	PSSA	abandoned	2476	58.0	62.0	86
Princes 1	Beach	38.4922	142.9889	Vic	03-APR-86		abandoned	1150	107.0	113.0	
Purrumbete 1	Interstate	38.3656	143.2075	Vic	30-JUL-68	PSSA	abandoned	1829	145.0	148.0	77
Riddoch 1	Adelaide Oil	37.5556	140.5444	SA	15		abandoned	318			
Robe 1	SA Oil Wells	37.1833	139.8736	SA	15		abandoned	1372			
Robertson 1	Alliance	37.1897	140.7797	SA	14-MAR-67	PSSA	abandoned	1789	52.0	57.0	87
Robertson 2	Alliance	37.1722	140.7611	SA	07-MAY-67	PSSA	abandoned	1506	52.0	57.0	67
Ross Creek 1	Shell	38.5325	143.1428	Vic	28-APR-74	PSSA	abandoned	3659	152.0	161.0	114
Rowans 1	Shell	38.4597	142.7887	Vic	02-MAY-72	PSSA	abandoned	1798	66.0	71.0	67
Seaview 1	Beach	38.5833	143.1333	Vic	12-APR-81		abandoned	1235	94.0	98.0	
Sherbrook 1	Frome	38.6258	143.1211	Vic	18-DEC-63	PSSA	abandoned	1656	142.0	146.0	71
Snail 1	Hematite	38.8972	144.3006	Vic	07-DEC-72	PSSA	abandoned	1235	-81.0	10.0	59
Squatter 1	Beach	37.8742	141.1344	Vic	05-AUG-87		abandoned	1500	57.0	61.0	
Stonyford 1	Gas and Fuel	38.3517	143.3131	Vic	30-JAN-84		abandoned	1203	142.0	148.0	
Tirrengowa 1	Hartogen	38.3831	143.3392	Vic	21-MAR-87		abandoned	1273	139.0		
Triton 1	Esso	38.9833	142.5303	Vic	17-APR-82	PSLA	abandoned	3545	-100.0	21.0	121
Trumpet 1	Esso	37.0965	139.4118	SA	22-DEC-73	PSLA	abandoned	2256	-49.0	10.0	89
Tullich 1	Planet	37.5167	141.1500	Vic	02-SEP-64	PSSA	abandoned	1635	79.0	83.0	57
Voluta 1	Shell	38.4296	141.3132	Vic	08-DEC-67	PSSA	abandoned	3974	-92.0	34.0	104
Wallaby Creek 1	Beach	38.5714	142.9053	Vic	29-MAR-81		gas suspd	1763	41.0	44.0	
Westgate 1	Beach	38.4669	142.8867	Vic	14-MAR-86		abandoned	1918	88.0	94.0	
Whelk 1	Esso	39.8994	143.5558	Tas	17-MAR-70	PSLA	abandoned	1466	-103.0	30.4	
Wilson 1	Beach	37.8729	141.1422	Vic	23-JUL-87		abandoned	1317	52.6	56.0	
Windermere 1	Minora	38.2292	142.0144	Vic	08-APR-87		oil suspd	1852	49.0	51.0	

WELL NAME	OPERATOR	LATITUDE (S)	LONGITUDE (E)	STAT	TD DATE	LEGIS	WELL STATUS	TD (m)	GL WD (m)	DATUM (m)	BHTEMP (degC)
Windermere 2	Minora	38.2363	142.0222	Vic	13-APR-89		abandoned	3595	49.0	54.5	
Woolsthorpe 1	Interstate	38.1356	142.4964	Vic	12-JUN-68	PSSA	abandoned	1971	122.0	125.0	76

PLATE 1

AUSTRALIAN PETROLEUM AND CARBON DIOXIDE ACCUMULATIONS

OTWAY BASIN

DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY

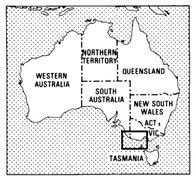
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

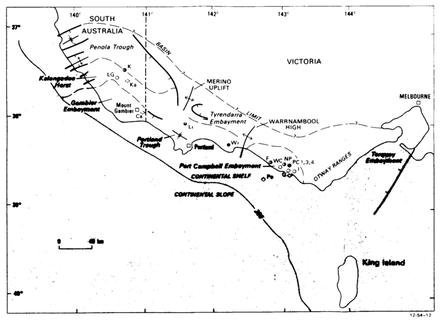
COMPILED BY S. MIYAZAKI, L. PAIN AND I. H. LAVERING

BIBLIOGRAPHIC CITATION: MIYAZAKI, S., LAVERING, I. H., STEPHENSON, A. E., AND PAIN, L., 1990 — Otway Basin, South Australia, Victoria and Tasmania. *Bureau of Mineral Resources, Australia. Australian Petroleum Accumulation Report 6*

STATUS	ECONOMIC AND DEVELOPED	ECONOMIC AND UNDEVELOPED					UNECONOMIC AND UNDEVELOPED			
LOCALITY MAP NUMBER	1	2	3	4	5	6	7	8	9	10	11
ACCUMULATION	NORTH PAARATTE	CAROLINE	WALLABY CREEK *	KATNOOK	LADBROKE GROVE *	IONA	GRUMBY	LINDON	WINDERMERE	KALANGADOO	FLAXMANS *
TRAP	Waarre Sandstone	Waarre Sandstone	Waarre Sandstone	Eumeralla Formation; Pretty Hill Sandstone	Pretty Hill Sandstone	Waarre Sandstone	Waarre Sandstone	Pebble Point Formation	Eumeralla Formation	Palaeozoic	Eumeralla Formation
PETROLEUM BEARING UNIT	U. Waarre Sst *	Sand 'A'; Sand 'B'; Sand 'C'	U. Waarre Sst	L. Eumeralla Fm*; Pretty Hill Sst	Pretty Hill Sst	Waarre Sst	Waarre Sst	Pebble Point Fm	Heathfield Mbr	Basement	Eumeralla Fm
PETROLEUM CONTENT	* Multiple sands; Carbon dioxide	Carbon dioxide	Carbon dioxide	Gas	Gas/Condensate; Carbon dioxide	Oil show	Carbon dioxide	Oil	Gas/Condensate show	CO_2	Gas

LOCALITY MAP



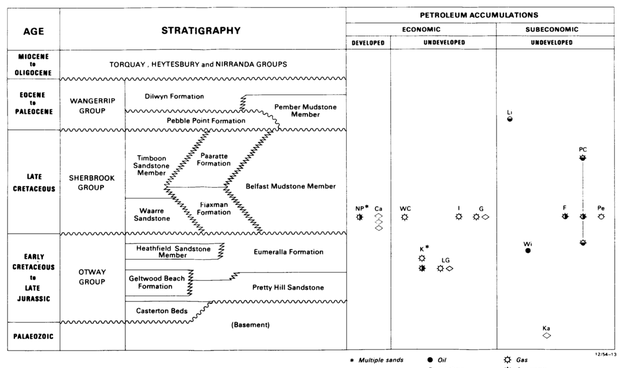


- Discovery well
- Fault (U / D)
- −3000− Contour interval (metres) below sea level
- −1 000− Contour interval (seconds) below ground level
- NOTE: ★ Structure map not available

No.	PETROLEUM ACCUMULATIONS		
1	North Paaratte	NP	
2	Caroline	Ca	
3	Wallaby Creek	WC	
4	Katnook	K	
5	Ladbroke Grove	LG	
6	Iona	I	
7	Grumby	G	
8	Lindon	Li	
9	Windermere	Wi	
10	Kalangadoo	Ka	
11	Flaxmans	F	
12,13,14	Port Campbell 1, 3, 4	PC	
15	Pecten	Pe	

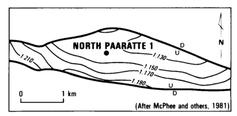
- Oil
- Oil show
- Gas
- Gas show
- Condensate
- CO_2
- — 200 — Bathymetric contour (m)

STRATIGRAPHY



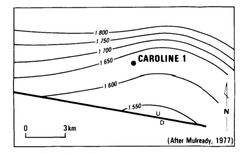
STRUCTURES

NORTH PAARATTE



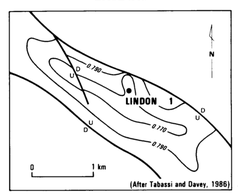
TWO WAY TIME CONTOURS ON TOP OF WAARRE SANDSTONE (seconds)

CAROLINE



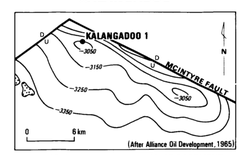
TWO WAY TIME CONTOURS ON TOP OF WAARRE SANDSTONE (seconds)

LINDON



TWO WAY TIME CONTOURS ON TOP OF PEBBLE POINT FORMATION (seconds)

KALANGADOO



STRUCTURE CONTOURS ON TOP OF BASEMENT

PETROLEUM RESERVES AND PRODUCTION

(The estimates listed below are for the whole of the basin and not for the accumulations shown on this Plate)

REMAINING RECOVERABLE RESERVES	as at	30	06	88
Gas (Sales)	$0.458 \times 10^9 m^3$			
LPG				
Condensate	$0.002 \times 10^9 m^3$			
Oil				
CUMULATIVE PRODUCTION	as at	30	06	88
Gas (Sales)	$0.025 \times 10^9 m^3$			
LPG				
Condensate				
Oil				

Comments

Carbon dioxide has been produced from the Caroline accumulation since 1968 and the output has been sufficient to satisfy CO_2 demand in South Australia and Victoria for the last 21 years.

DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY

COMPILED BY S. MIYAZAKI, L. PAIN AND I. H. LAVERING

BIBLIOGRAPHIC CITATION: MIYAZAKI, S., LAVERING, I. H., STEPHENSON, A. E., AND PAIN, L., 1990 — Otway Basin, South Australia, Victoria and Tasmania *Bureau of Mineral Resources, Australia, Australian Petroleum Accumulation Report 6*

AUSTRALIAN PETROLEUM ACCUMULATIONS

OTWAY BASIN

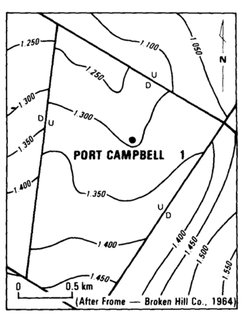
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

STATUS: UNECONOMIC AND UNDEVELOPED

LOCALITY MAP NUMBER	12	13	14	15
ACCUMULATION	PORT CAMPBELL 1	PORT CAMPBELL 3	PORT CAMPBELL 4	★PECTEN
TRAP	Paaratte Formation; Waarre Sandstone	Paaratte Formation; Eumeralla Formation	Eumeralla Formation	Waarre Sandstone
PETROLEUM BEARING UNIT	Paaratte Fm; Waarre Sst	Parratte Fm; Eumeralla Fm	Eumeralla Fm	U. Waarre Sst
PETROLEUM CONTENT	Oil show	Gas/Condensate show	Gas show	Gas/Oil show

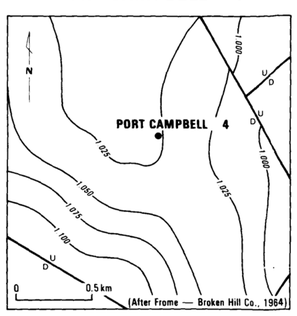
STRUCTURES

PORT CAMPBELL 1



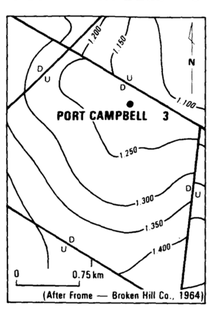
TWO WAY TIME CONTOURS ON TOP OF WAARRE SANDSTONE (seconds)

PORT CAMPBELL 4



TWO WAY TIME CONTOURS ON TOP OF WAARRE SANDSTONE (seconds)

PORT CAMPBELL 3

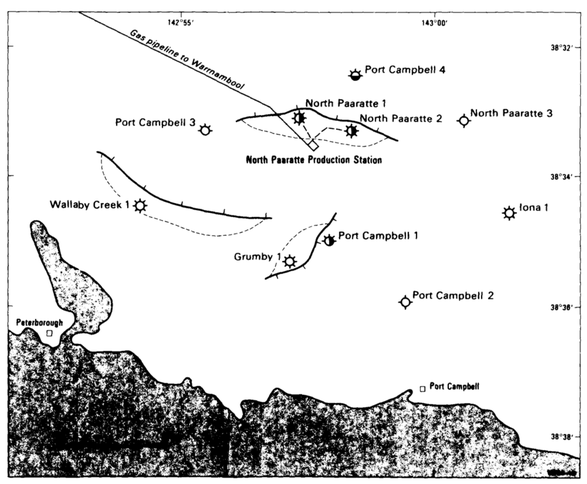


TWO WAY TIME CONTOURS ON TOP OF WAARRE SANDSTONE (seconds)

- ● *Discovery well*
- U/D *Fault*
- —3000— *Contour interval (metres) below sea level*
- —1.000— *Contour interval (seconds) below ground level*

NOTE: ★ *Structure map not available*

PETROLEUM PRODUCTION SYSTEMS



PETROLEUM RESERVES AND PRODUCTION

(The estimates listed below are for the whole of the basin and not for the accumulations shown on this Plate)

REMAINING RECOVERABLE RESERVES	as of	30	06	88
Gas (Sales)	$0.458 \times 10^9 m^3$			
LPG				
Condensate	$0.002 \times 10^6 m^3$			
Oil				
CUMULATIVE PRODUCTION	as of	30	06	88
Gas (Sales)	$0.025 \times 10^9 m^3$			
LPG				
Condensate				
Oil				

Comments