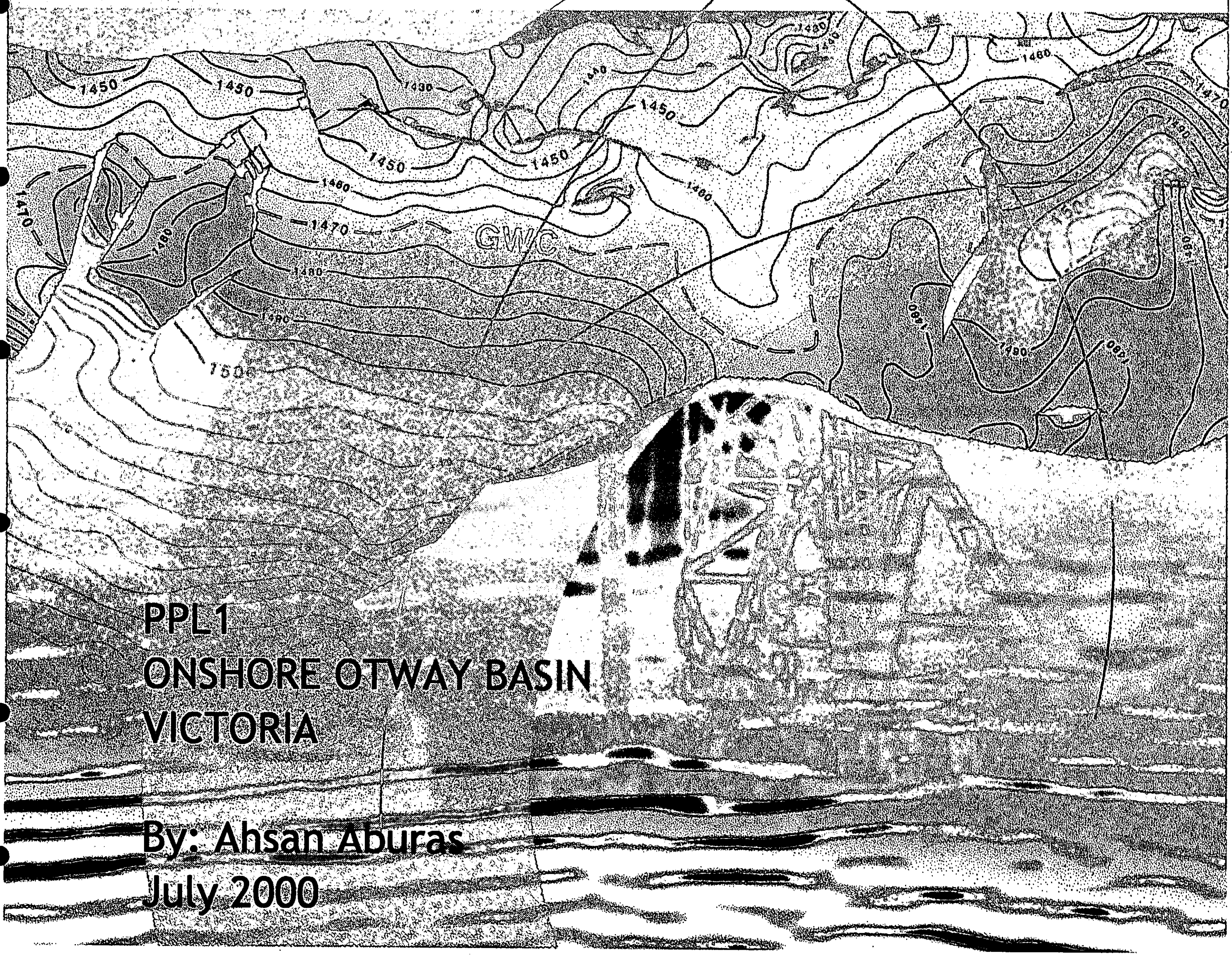
Origin energy

DUNBAR 1 DW1

WELL PROPOSAL



PPL1
ONSHORE OTWAY BASIN
VICTORIA

By: Ahsan Aburas
July 2000

909108 002

PROPOSAL TO DRILL

DUNBAR 1/DW1

PPL 1

OTWAY BASIN

VICTORIA

A.N.ABURAS
July 2000

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TABLE 1

PROSPECT SUMMARY

WELL NAME	Dunbar 1/DW1
LOCATION - Subsurface	Inline : 6470 CDP : 2620 Latitude : 038° 32' 50.73"S Longitude : 142° 54' 19.78"E Northing : 5731708.28 Easting : 666053.69
LOCATION – Surface	Northing : 5731612.3 Easting : 666132.4 Well azimuth : 320.646° Max well deviation : 30.710°
PERMIT	PPL 1, Otway Basin, Victoria
INTEREST HOLDERS	Origin Energy Petroleum Pty Ltd 100.0% (OPERATOR)
TYPE OF WELL	Development
ANTICIPATED SPUD	November 2000
ELEVATION	KB: 82.7 mASL GL: 77.2 mASL
PROPOSED TD	-1500 mTVDSS
PRIMARY OBJECTIVES	Waarre Formation Unit 'A' Sandstone, -1436 mTVDSS Waarre Formation Unit 'C' Sandstone, -1383 mTVDSS
SECONDARY OBJECTIVE	None prognosed

SUMMARY

1 INTRODUCTION

Dunbar 1/DW1 is proposed as a development well in PPL-1, onshore Otway Basin, Victoria. The well will develop the updip potential of the Dunbar structure. The primary objective for the well is the Waarre Sandstone member of the late Cretaceous Sherbrook Group. It is anticipated to spud in August 2000.

1.1 Geographical Location

The Dunbar structure is located approximately 8 km north north-west of Port Campbell in southeastern Victoria (Figure 1). The well will be directionally drilled using the surface location of Dunbar 1, which is about 125 m to the southeast of the target subsurface Waarre "A" location. The Waarre "A" subsurface location for the well is located on Inline 6470 and CDP 2620 of the Waarre 3D seismic survey.

TABLE 2 - Geographical Co-ordinates of the Waarre "A" Sst objective

EASTING	666053.69
NORTHING	5731708.28
LATITUDE	038° 32' 50.73"S
LONGITUDE	142° 54' 19.78"E
INLINE	6470
CDP	2620

1.2 Permit Details

Dunbar 1/DW1 is located in PPL 1 in the onshore Victorian Otway Basin (Figure 1). The North Paaratte 1 gas discovery well was drilled in the original PEP 93 by Beach Petroleum NL and subsequent discoveries (Grumby and Wallaby Creek) confirmed local prospectivity. The PPL 1 production lease was awarded on 1 March 1985, and PPL 2 was issued to Parker and Parsley Australasia following discovery of the Iona Field. The participating parties (Beach and PPA) sold their interests to GFCV in 1989 and interests were subsequently transferred to GFE. Basin Oil NL purchased the interests from GFE in 1996. Boral Energy assumed ownership of PPL 1 in 1998 with the acquisition of Otway Basin assets from Cultus Petroleum NL. Boral Energy became Origin Energy after the demerger from Boral in Feb 2000. Dunbar 1/DW1 will therefore be drilled by Origin Energy Petroleum Pty Ltd with 100% equity.

1.3 Previous Drilling

The Otway Basin has been recognized as a potential petroleum province since the 1860's. Salt Creek 1 in South Australia was the first exploration well in the

Otway Basin in 1866 (Sprigg, 1986). Since then, over 150 wells have been drilled in the Otway Basin, both onshore and offshore.

The first hydrocarbon discovery was made in 1959, when Frome-Broken Hill drilled Port Campbell 1 and flowed gas from the Late Cretaceous Waarre Formation at an initial rate of 1.5 mmcfd. However it was deemed non-commercial as the rate declined rapidly.

Shell initiated drilling offshore in the Victorian section of the Basin in 1967, followed closely by Esso, though there were no significant discoveries.

The first commerecial hydrocarbon discovery was in 1979 when North Paaratte-1 well was drilled by Beach Petroleum NL. The well was located on the southern flank of an elongate, east-west trending faulted anticline in the Port Campbell embayment of the Otway Basin and intersected gas in the Waarre Sandstone member of the Upper Cretaceous Sherbrook Group. Subsequent testing flowed GTS at rates up to 9.5 MMcfd and confirmed a new field discovery. North Paaratte-2 was drilled in 1981 approximately 1.6 km to the east and intersected a similar high-deliverability reservoir in the Waarre Sandstone. North Paaratte-3 was located further to the east but was drilled on a separate structure with no gas column.

Following the North Paaratte gas discovery, the Wallaby Creek and Grumby gas fields were discovered by Beach in 1981 (also Waarre Formation). Subsequent exploration resulted in the discovery, by Beach, of the Iona gas field in 1988, and the Boggy Creek CO_2 field, by GFE Resources, in late 1991.

The first offshore success was with BHP Petroleum's Minerva 1, in 1993, offshore from Port Campbell.

The Mylor gas and oil field was discovered in 1994 by Bridge/GFE, yielding the first recovery of oil from the Waarre Formation (Foster and Hodgson, 1995). The Langley gas field was also discovered (GFE) in 1994.

Dunbar 1 was drilled in 1995 by GFE and discovered gas from the Waarre formation.

In 1996 Skull Creek gas field was discovered by Basin Oil.

In 1999 the updip North Paaratte 4 and 5 wells were drilled by Boral Energy, and both wells proved the continuity of the gas accumulation in the Waarre Formation.

The most recent discovery in the area was made by Boral Energy in 1999 with the Wild Dog Road gas field (Waarre Formation).

1.4 Regional Geology

The Otway Basin is approximately 500 km long and extends both onshore and offshore west-northwest from the Victorian Mornington Peninsula in the east to

Cape Jaffa, South Australia, in the west. PPL 1 is located in the Victorian portion of the onshore Otway Basin approximately 50 km northwest of Cape Otway (Figure 2). PPL1 lies in the Port Campbell embayment which is bounded to the east by erosion along the emergent Otway Ranges and to the north and west by erosional thinning and pinch-out. The regional stratigraphy for the Victorian Otway Basin is shown in Figure 3 and includes informal nomenclature for the Sherbrook Group Waarre Sandstone based on work by Abele et al (1995).

The Formation of the Otway Basin commenced in the late Jurassic with the initiation of rifting between Australia and Antarctica. Depositional growth occurred as superimposed sedimentary sequences were laid down during different phases of the separation of the Antarctic continental landmass from Australia's southern margin. The oldest strata comprise the Early Cretaceous Crayfish subgroup and overlying Eumeralla Formation, the latter comprising lithic-rich, volcanogenic sandstones with generally poor reservoir potential. Following deposition of the Eumeralla Formation widespread uplift and erosion occurred and this has been interpreted to be due to the onset of sea floor spreading. The Sherbrook Group was deposited on the resulting unconformity as a condensed sandstone sequence further onshore, whilst offshore and near the coast it can be subdivided into formations representing the various facies of a delta system. The basal member, the Waarre Formation, comprises sands and shales with marine and shoreface facies. Buffin (1989) subdivided the Formation into four units and unit 'C' constitutes the main gas reservoir in the gas fields in PPL 1 and 2 with secondary gas occurring in the "A" unit. The Waarre Formation is overlain by the Belfast Mudstone, a sequence of massive siltstones interpreted to represent offshore pro-deltaic facies, and the time equivalent Nullawarre Greensand. The Skull Creek Mudstone and Paaratte Formation, an interbedded sand and shale sequence, comprise the upper members of the Sherbrook Group.

Fault movements during deposition of the Sherbrook Group are apparent in seismic sections but fault throws diminish above the Belfast Mudstone. The eventual large reduction in the number of faults by the top of the Paaratte Formation indicate relative quiescence by the end of the Cretaceous.

The earliest Tertiary section is defined by an unconformity with the Cretaceous and consists of sandstones and claystones of the Wangerrip Group probably deposited onshore in a fluvial-deltaic setting (Gravestock *et al.*, 1986). The basal transgressive sandstone unit is the Pebble Point Formation which comprises conglomeratic and commonly ferruginous sands. Pro-delta muds and silts of the Pember Mudstone Member grade into the overlying sands and shales of the Dilwyn Formation which represent a series of stacked transgressive-regressive deltaic cycles (Laing *et al*, 1989).

The rate of sea floor spreading appears to have increased markedly during the late Eocene resulting in a major marine transgression in the Otway Basin. The Tertiary sequence unconformably overlying the Dilwyn Formation is dominated by marine marls and limestones as a result of this inundation.

The tectonic framework of the Otway Basin is dominated by extensional processes which produced a series of normal fault blocks (Figure 4). Continued block faulting and subsidence during the early Cretaceous led to the development of an extensive rift valley system throughout southeast Australia. Pull-apart tectonics continued until the late Cretaceous and faulting, recognised as 'down to the basin' movement, represented reactivation of the initial rift system faults. By the Late Eocene drifting rates increased and a period of out-building occurred; subsidence was slow and tectonic activity became relatively quiet resulting in a relatively undeformed carbonate sequence.

During Late Cretaceous and possibly continuing to Early Tertiary times a right lateral couple was applied (Buffin 1989) resulting in the formation of a series of northeast-trending anticlines (e.g. Port Campbell Anticline). The structural grain generated as a result of this couple produced the combination fault and three-way dip closures targeted by drilling in the Port Campbell Embayment.

In the Middle Eocene, the rate of seafloor spreading south of Australia increased considerably. At this time there was also a strong pulse of northwest-southeast compression, resulting in northeasterly trending folds and faults, and reactivation of earlier structures in the Otway Ranges and nearby areas.

2. PROSPECT DESCRIPTION

2.1 Structure

The Dunbar structure was remapped following the acquisition by Boral Energy of the Cultus interest in PPL1. The seismic data base is the Waarre 3D seismic survey which was recorded in 1993.

The Dunbar structure is an elongate fault dependent closure. The main northern bounding fault of the prospect throws to the north thus juxtaposing the primary objective, the Waarre Sandstone, against the Belfast Mudstone (sealing formation) on the downthrown side of the fault. The closure to the south, east, and the west is by structural dip.

The Dunbar structure is illustrated on a seismic traverse oriented along the proposed well path (Figure 5). The well will be accessed from the Dunbar 1 well and then deviated to the northwest to hit an updip subsurface location at about 125 m offset from the surface location.

2.2 Source and Migration

The discovery of gas in Dunbar 1 confirms that generation and migration of hydrocarbons has occurred. The gas is most likely to have been generated deeper in the section, probably from basal coals in the Eumeralla Formation, and migrated along faults and sandstone layers to the Waarre Formation.

2.3 Reservoir and Seal

The Waarre Sandstones are interpreted to be an open marine facies deposited in the highest energy, shallow marine upper to middle shoreface environment and comprise medium to coarse grain size. The sequence of interbedded sand and shale has led to an informal sub-division of the Formation into the A (basal), B, C and D (top) units.

The Belfast Mudstone is a competent seal providing both vertical and cross-fault seal for the Waarre Sandstone reservoir. The juxtaposition of reservoir sands against mudstones across the fault is providing an adequate sealing mechanism.

3 SEISMIC

3.1 Seismic Data Base

Following the drilling of North Paaratte 1 and 2 and peripheral wells, a 3D seismic survey was carried out over an area including most of PPL 1 and part of PEP 108. The total area of the Waarre 3D survey is 108 km² with in-line and cross-line spacing of 12.5m x 12.5m.

3.2 Structural Mapping

The Waarre 3D seismic data were interpreted on a Sun workstation using IESX software from Geoquest, and picked horizons were mapped using the Petrosys software mapping package. The top Waarre 'C' horizon was picked and mapped over the whole PPL1 area at 1:20,000 scale. The Top Waarre "A" sandstone was picked and mapped locally over the Dunbar structure. A new Variance Cube technique from Geoquest was used to refine the location of the main Dunbar fault. Figure 5 shows a seismic traverse along the proposed well path in TWT. The top Belfast mudstone was picked locally over the structure, together with other marker horizons.

3.3 Depth Conversion

Depth conversion for the Waarre unit 'C' sandstone in PPL1 was performed using an average velocity map based on all available well data in the PPL1 area. These average velocities to the Top Waarre C Sandstone were hand contoured, and then digitized and input to the Petrosys mapping package where they were gridded and applied to the depth conversion. Figure 6 shows the depth structure map over the Dunbar Structure using the well average velocities.

The depth conversion for the Waarre "A" sandstone was performed using a constant well average velocity derived from the Dunbar 1 well velocity data.The result of this depth conversion is shown in figure 7.

4 WELL LOCATION AND PREDICTED SECTION

4.1 Choice of Location

The sub-surface location of Dunbar 1/DW1 on In-line 6470, CDP 2620 has been chosen in a near-crestal position on the time and depth structure maps. This location is about 13 to 15 meters updip of Dunbar 1.

The top of the Waarre "A" sandstone is prognosed at –1436 mTVDSS, and the Waarre "C" at –1383 mTVDSS.

4.2 Objectives

The primary objectives for Dunbar 1/DW1 are unit "A" and unit "C" sandstones of the Waarre Formation. The well is prognosed to penetrate in excess of 31-37 m of Waarre "A" reservoir thickness, and 22-28 m of the Waarre "C" reservoir thickness above the gas water contacts. The proposed TD of –1500 mTVDSS will allow sufficient rathole to perforate the reservoir and junk the perforating subs at the bottom of the hole.

4.3 Predicted Stratigraphic Sequence

The depth prognosis for Dunbar 1/DW1 is derived from the Waarre 3D seismic data using Dunbar 1 well velocity data, and depth conversion results from the well average velocities. The following prognosis is for a deviated well path to the subsurface location (Figure 5).

TABLE 3 – Prognosed Formation Tops

Formation	TVD SS (m)	Remarks
Port Campbell Limestone	+77.2	
Gellibrand Marl	-41.3	
Clifton Formation	-332.3	
Narrawaturk Marl	-343.3	
Mepunga Formation	-429.3	
Dilwyn Formation	-479.3	Formation Tops are taken from Dunbar 1 WCR and based on KB = 82.1 mASL (Port Campbell Limestone to Skull Creek Member)
Pember Mudstone	-679.3	
Pebble Point Formation	-739.3	
K-T Shale	-782.3	
Paaratte Formation	-796.3	
Skull Creek Member	-1152	
Nullawarre Greensand	Absent ?	
Belfast Formation / Fault	-1286	
Waarre Fm. (Unit 'C' sand)	-1383	
Waarre Fm. (Unit 'A' sand)	-1436	Dunbar 1/DW1 (Belfast Formation / Fault to T.D.)
Eumeralla Formation	-1451.6	
GWC Waarre "A" Sst	-1470	
T.D.	-1500	

The major bounding fault to the Dunbar structure is prognosed to be intersected in Dunbar 1/DW1 at -1286 m TVDSS.

The predicted stratigraphic sequence is shown in Figure 8.

A generalized lithological description of the sequence follows:

Heytesbury Group

Port Campbell Limestone

The Port Campbell Limestone consists of light grey to medium grey fine to very fine grained calcarenite, well sorted, common fossil fragments viz., crinoid stems, foraminifera, shell debris. Glauconite is present in trace quantities and pyrite occurs as grains or as replacement of fossils.

Gellibrand Marl

Medium grey, very soft to soft, fossiliferous and calcareous mudstone. Accessories include shell fragments, foraminifera, crinoid stems, carbonaceous material, glauconite and minor pyrite.

Clifton Formation

Ironstone grit, yellow to dark brown, firm to hard, angular with shell fragments. Glauconite is abundant interbedded with soft , light grey to green, glauconitic claystone.

Nirranda Group

Narrawaturk Marl

Marl, light brown to light grey, soft to very soft, shelly, strongly pyritic and glauconitic.

Mepunga Formation

Sandy Marl, light brown and brown green, unconsolidated, medium to coarse quartz grains, strongly glauconitic, richly fossiliferous, abundant pyrite.

Wangerrip Group

Dilwyn Formation

The Wangerrip Group can be subdivided into its formations, the Dilwyn Formation, the Pember Mudstone and the Pebble Point in this area. The Dilwyn Formation is a massive sandstone with very minor amounts of a silty clay matrix. The sandstone is predominantly clear to translucent, clean, unconsolidated, medium to predominantly coarse grained, angular to rounded, occasionally polished with trace to common pyrite and pyrite nodules. Trace dull brown to black, earthy, woody and pyritic lignite is expected in the lower part of the sequence, as well as brown or brown grey, soft dispersive claystone.

Pember Mudstone

The Pember Mudstone is composed of a massive claystone which is dark grey-brown, brown and yellow-brown in colour with glauconitic inclusions and trace lithics, lignite and ironstone. It is soft, very dispersive and grades to siltstone at depth.

Pebble Point Formation

The Pebble Point Formation is composed of sandstone and siltstone. The sandstone is clear to translucent, occasionally milky white and yellow, unconsolidated, coarse to very coarse grained, angular to subrounded, poorly sorted with common grey brown argillaceous matrix. There are abundant dark greenish black chloritic nodules, and minor pyrite nodules.

The siltstone is medium grey brown to dark greyish-green in colour, with occasional dark green chloritic inclusions. It is soft to firm, dispersive, grading to claystone in parts.

K-T Shale

The K-T Shale is composed of claystone and comprises medium to dark brown, silty, abundant quartz, soft, and depressive.

Sherbrook Group

Paaratte Formation

Medium to coarse grained sandstone, loosely consolidated, moderately sorted with interbedded black, carbonaceous shale, coal and chert. Towards the base of the Formation grain size decreases and lithology is dominated by clay-rich, medium grey siltstone with abundant carbonaceous flecks and minor glauconite.

Skull Creek Mudstone

Medium to dark grey, occasionally medium to dark brown grey, very silty, common dispersed very fine to fine quartz and partially altered feldspar grains, common pyrite, trace dolomite, carbonaceous flecks, and micromica, with minor interlaminated off white, very fine to fine sandstone, occasional medium to very coarse grains.

Belfast Mudstone

Medium grey, soft to firm siltstone and claystone, richly glauconitic in places with minor interbedded buff dolomite and dolomitic siltstone. Shell fragments increase towards the base.

Waarre Formation

The Waarre Formation has been sub-divided into four units as follow (Buffin 1989) :-

A) Unit A displays many lithological similarities to the underlying Eumeralla Formation being arenaceous with high lithic content. Reservoir quality is often poor due to the tight, well-cemented calcareous nature of the fine grained sandstones. However at Dunbar 1 the "A" sand is very fine to medium, occasional coarse to very coarse grains, dominantly fine to medium, angular to subangular, poor to moderate sorting, weak silica cement. The unit displays a typical fining-upward sequence on the gamma ray log.
B) Unit B is characterised by a high percentage of medium grey dispersive siltstone and claystone, glauconitic in part with occasional fine-grain dolomitic and calcareous sandstone.
C) Unit C has well developed quartz arenites and comprises the main reservoir facies in the Waarre Sandstone. Sands are typically medium to coarse, well sorted, clean, porous and permeable.
D) Unit D, the top most unit of the Waarre Formation, is equated with the Flaxmans Formation and is characterised by various lithologies including ironstone, siderite, glauconite, dolomite, sandstone, siltstone, shale and coals. The sediments are representative of back beach, lagoonal, shallow estuarine or inter-distributary bay environments.

Eumeralla Group

Eumeralla Formation

The Eumeralla Formation is a thick interval of siltstone and claystone with occasional thinly interbedded sandstones. The siltstones are light to dark grey, grey-green and grey-brown in part, argillaceous grading to claystone, occasionally arenaceous, non-calcareous with minor coal fragments. The claystone is expected to be light to medium grey, grey brown and occasionally pale green-grey, dispersive, and silty/arenaceous in part.

The sandstones are generally off-white to light grey and light brown, very fine to fine grained, moderately sorted with abundant calcareous cement and argillaceous matrix with poor visual porosity.

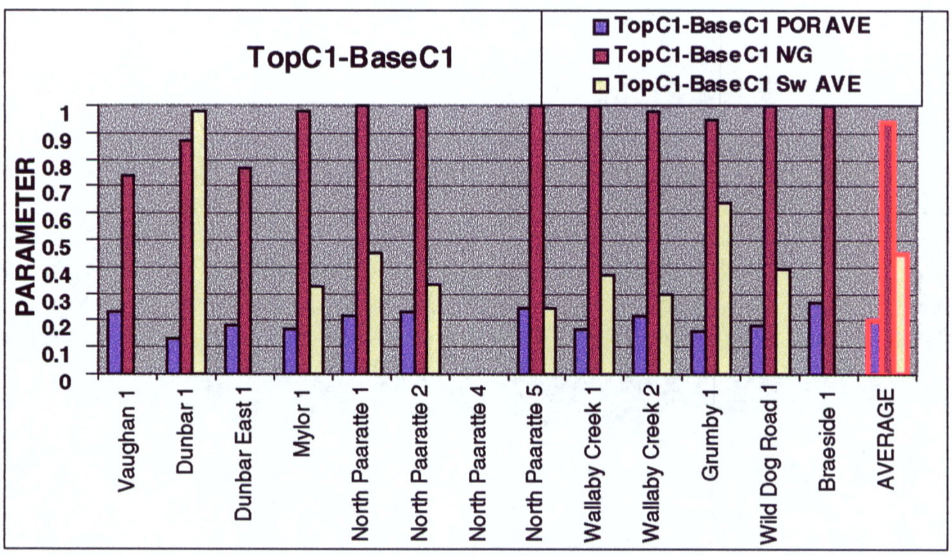
5. RESERVES

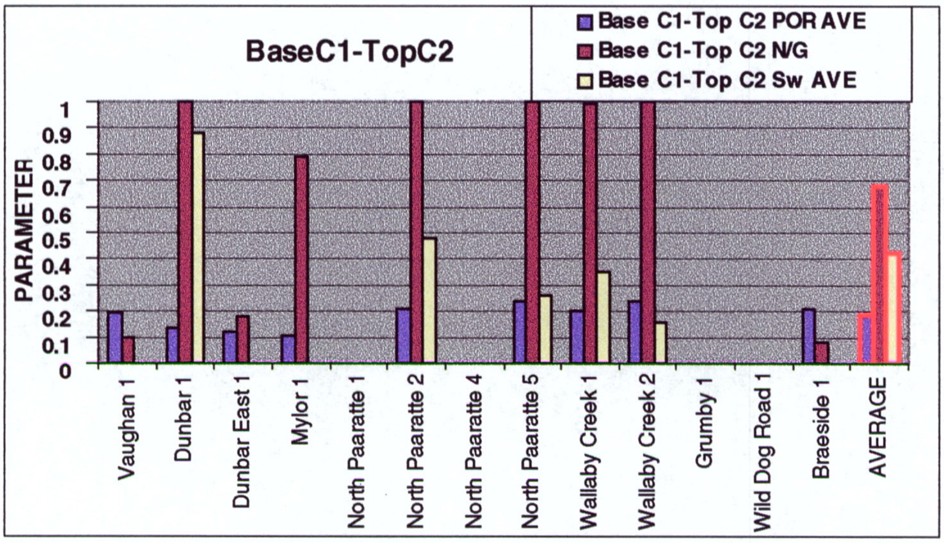
Reserves were calculated for the Waarre "A", "B" & "C" sandstones using the Reserve Estimation Program (REP) of Logicom Computer Services. A layered model using each of the sandstones (see Figure 9) was used to calculate reserves.

The petrophisical parameters were averaged for each layer using the following well data: Vaughan 1, Dunbar 1, Dunbar East 1, Mylor 1, Nth Paaratte 1, Nth Paaratte 2, Nth Paaratte 4, Nth Paaratte 5, Wallaby Creek 1, Wallaby Creek 2, Grumby 1, Wild Dog Road 1, and Braeside 1. The resulted figures and probabilities are shown below as Excel charts and on the REP reserve sheets.

The Recoverable Reserves within the Waarre Sst are:

DUNBAR1 DW1	VOLUME	REC BCF		
LAYERS	Vol (m3)	P90	MEAN	P10
TopC1-BaseC1	847324.88	0.014	0.0569	0.113
BaseC1-TopC2	111454.35	0.00185	0.00625	0.0119
TopC2-BaseC2	1643103.58	0.552	0.625	0.699
TopC3-TopB	415928.54	0.115	0.166	0.218
TopB-TopB1	61989.36	0	0	0
TopB1-BaseB1	11666.69	0.00265	0.00376	0.00489
TopA-EUM	10045542.4	1.74	2.25	2.81
TOTAL	13137009.8	2.4255	3.10791	3.85679

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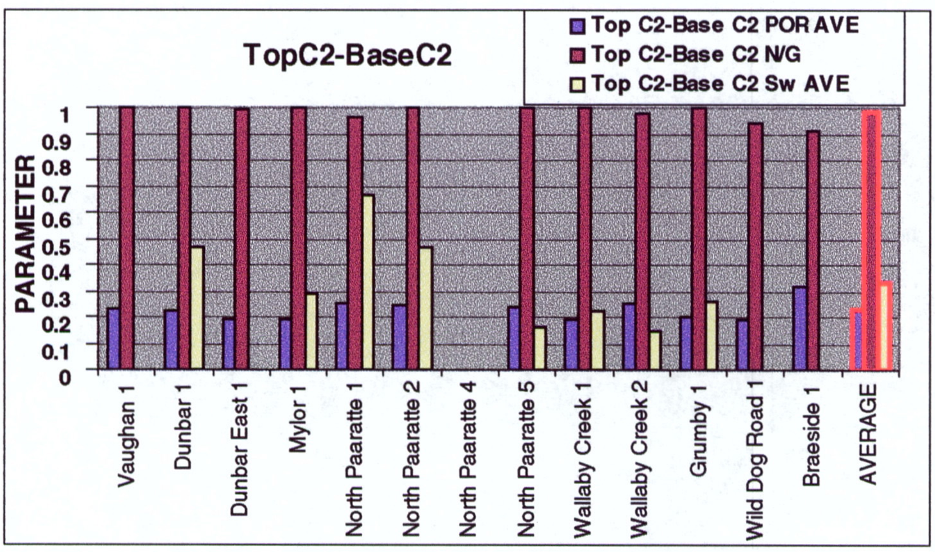
Dunbar 1
Dunbar East 1
Mylor 1
North Paaratte 1
North Paaratte 2
North Paaratte 4
North Paaratte 5
Wallaby Creek 1
Wallaby Creek 2
Grumby 1
Wild Dog Road 1
Braeside 1
AVERAGE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Dunbar 1
Dunbar East 1
Mylor 1
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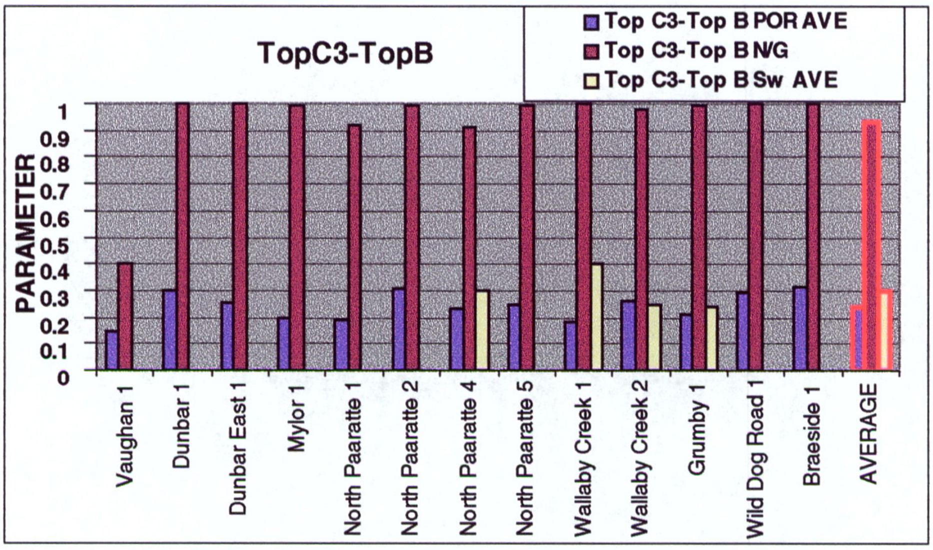
Wallaby Creek 1
Wallaby Creek 2
Grumby 1
Wild Dog Road 1
Braeside 1
AVERAGE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Dunbar 1
Dunbar East 1
Mylor 1
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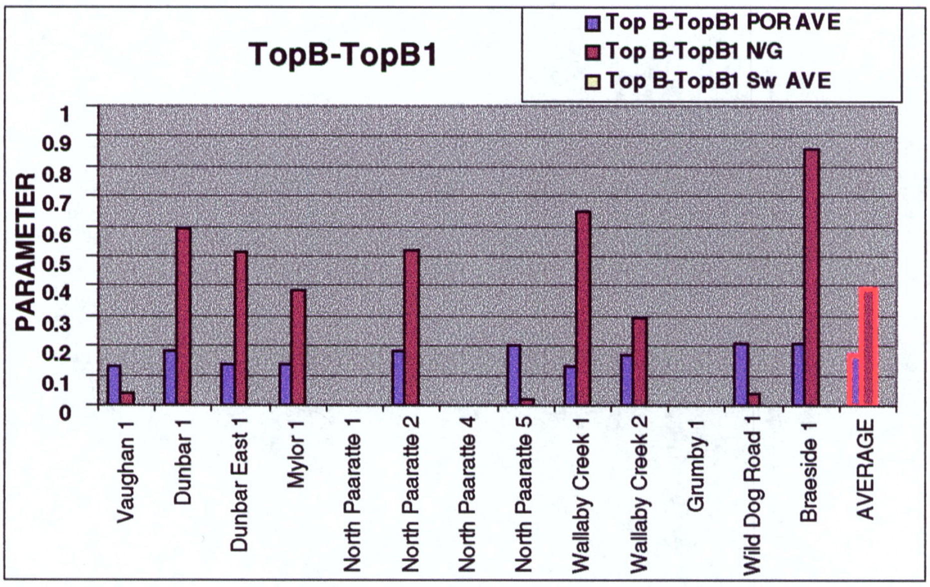
Grumby 1
Wild Dog Road 1
Braeside 1
AVERAGE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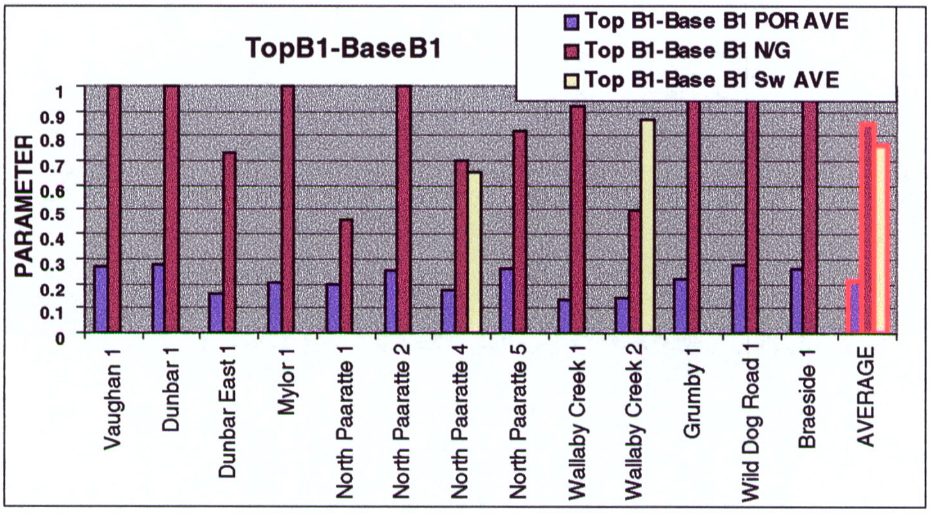
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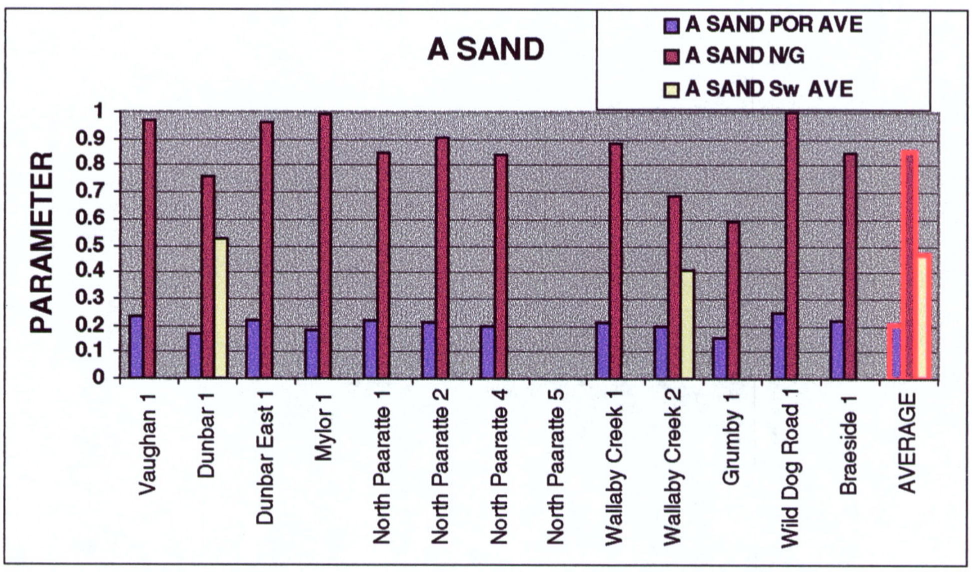
AVERAGE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North Paaratte 2
North Paaratte 4
North Paaratte 5
Wallaby Creek 1
Wallaby Creek 2
Grumby 1
Wild Dog Road 1
Braeside 1
AVERAGE

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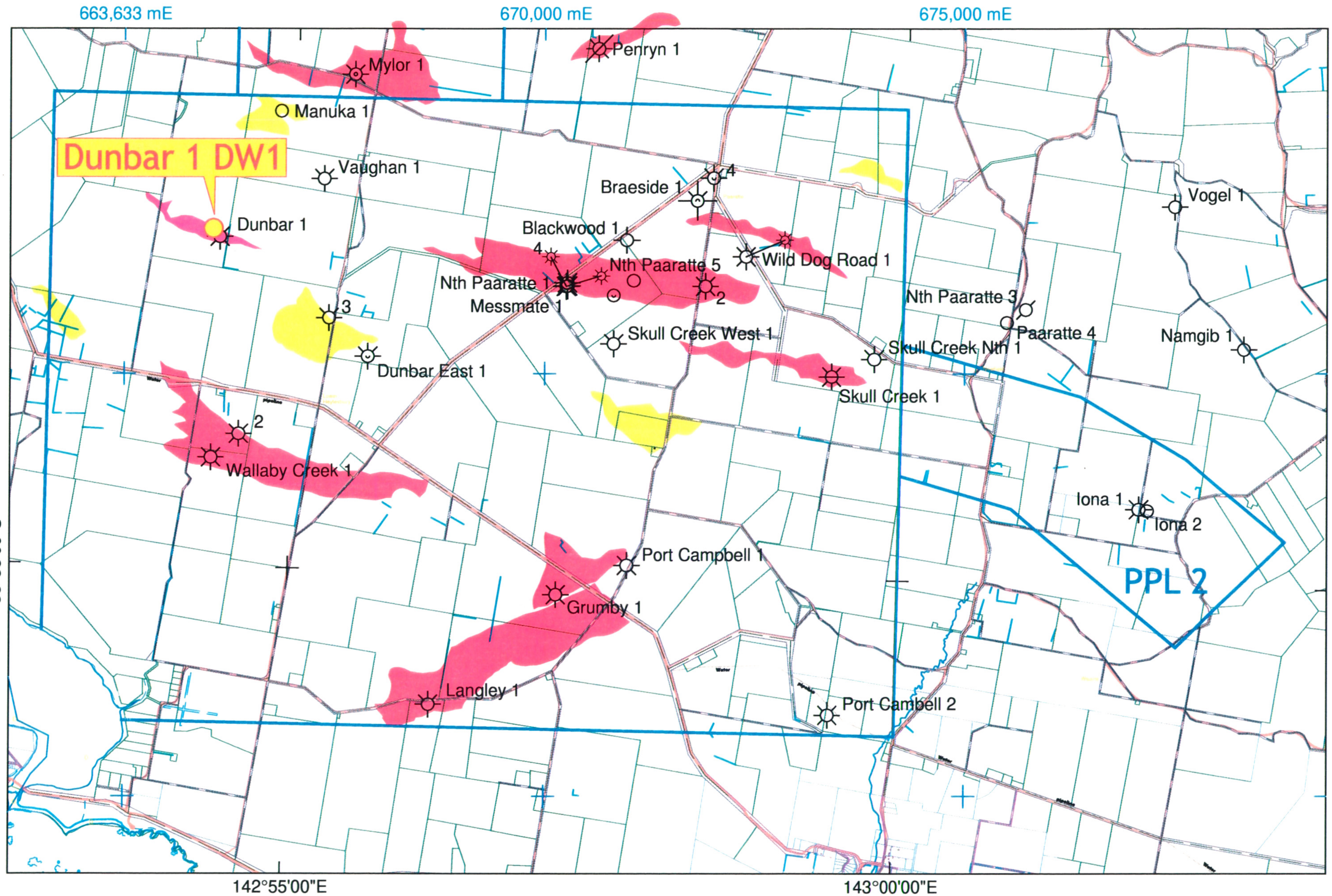


LOCATION MAP - Proposed Dunbar 1 DW1

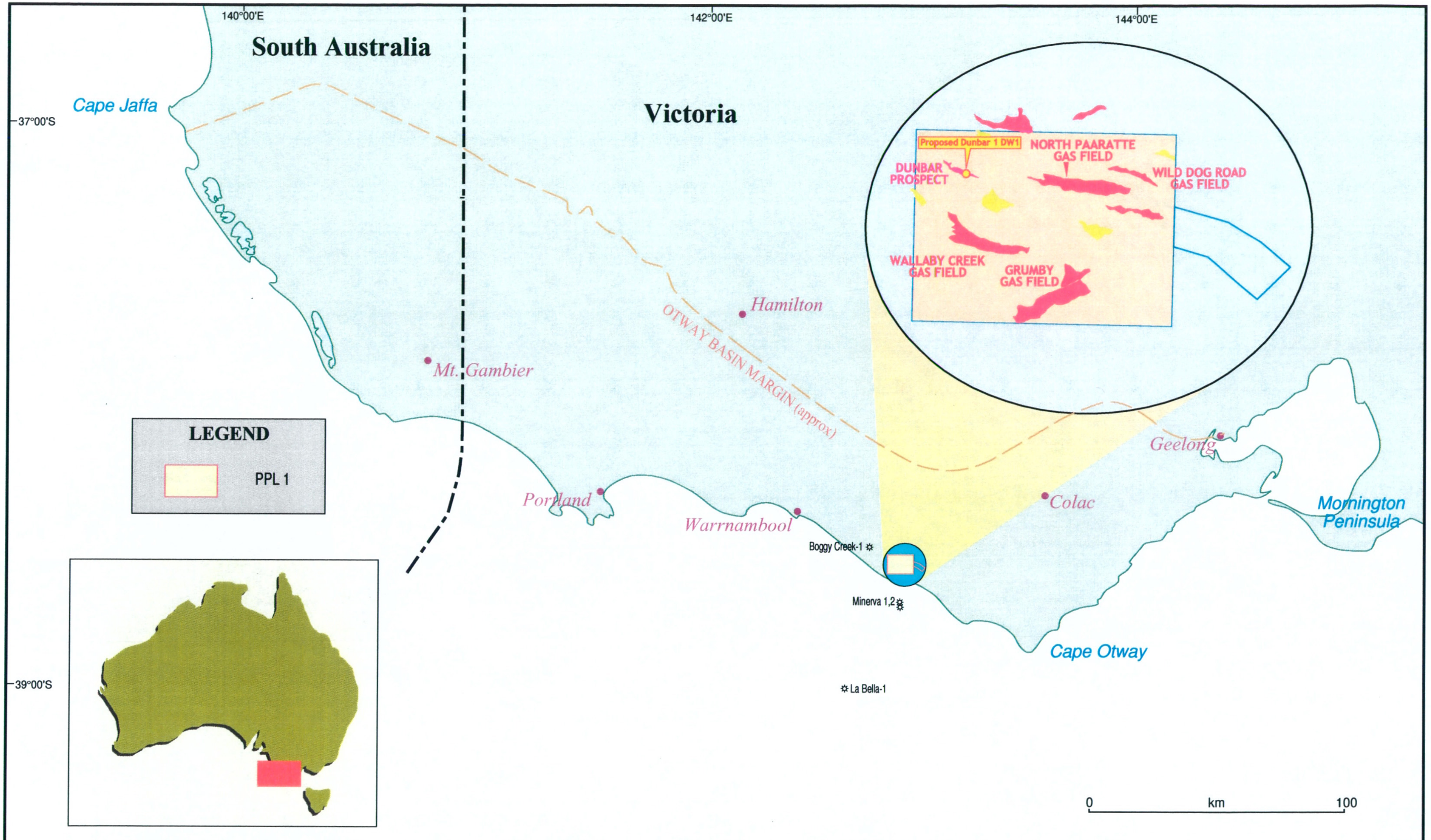
CPK

Origin energy

16277.072000 Fig.1

909108 020

PE909108-color005



OTWAY BASIN - PPL1 - LOCATION MAP

BDW/CPK

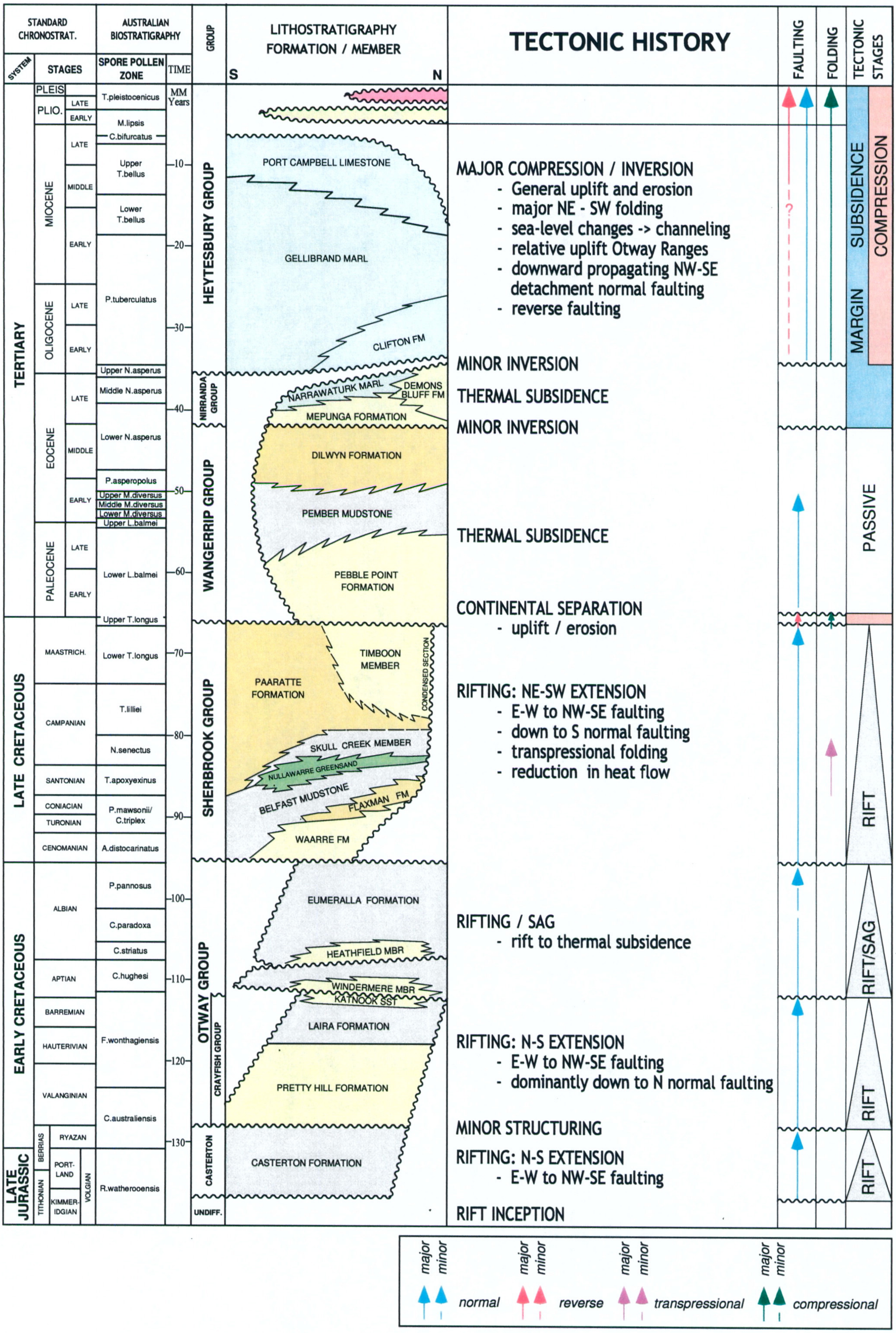
16278.072000 Fig.2

Origin energy

909108 021

PE909108-color006

903108 022 PE909108-color007

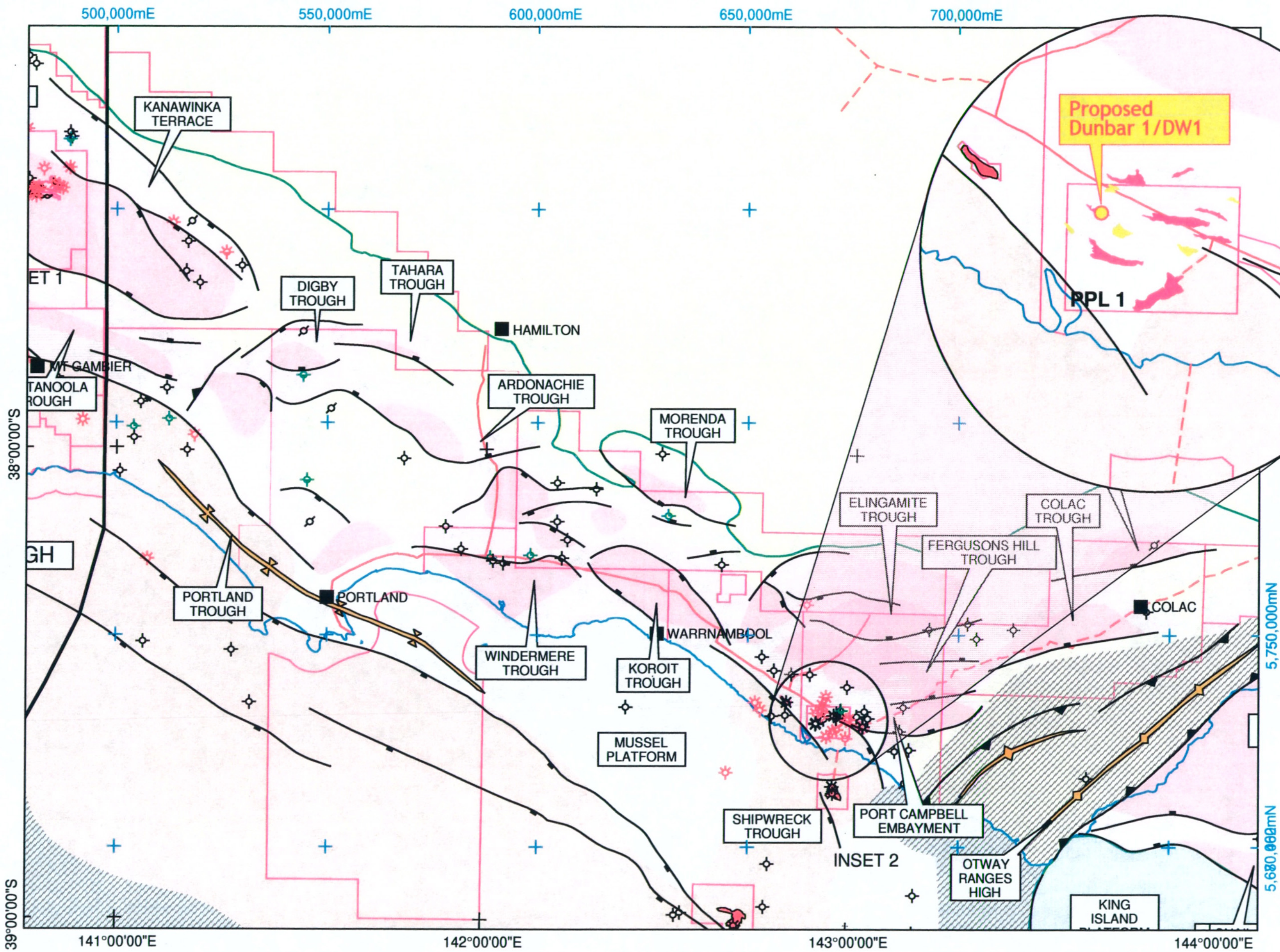


VICTORIAN OTWAY BASIN - STRATIGRAPHIC TABLE

REVISED October 1999 after ABELE et al 1995

16279.072000 Fig.3

Origin energy

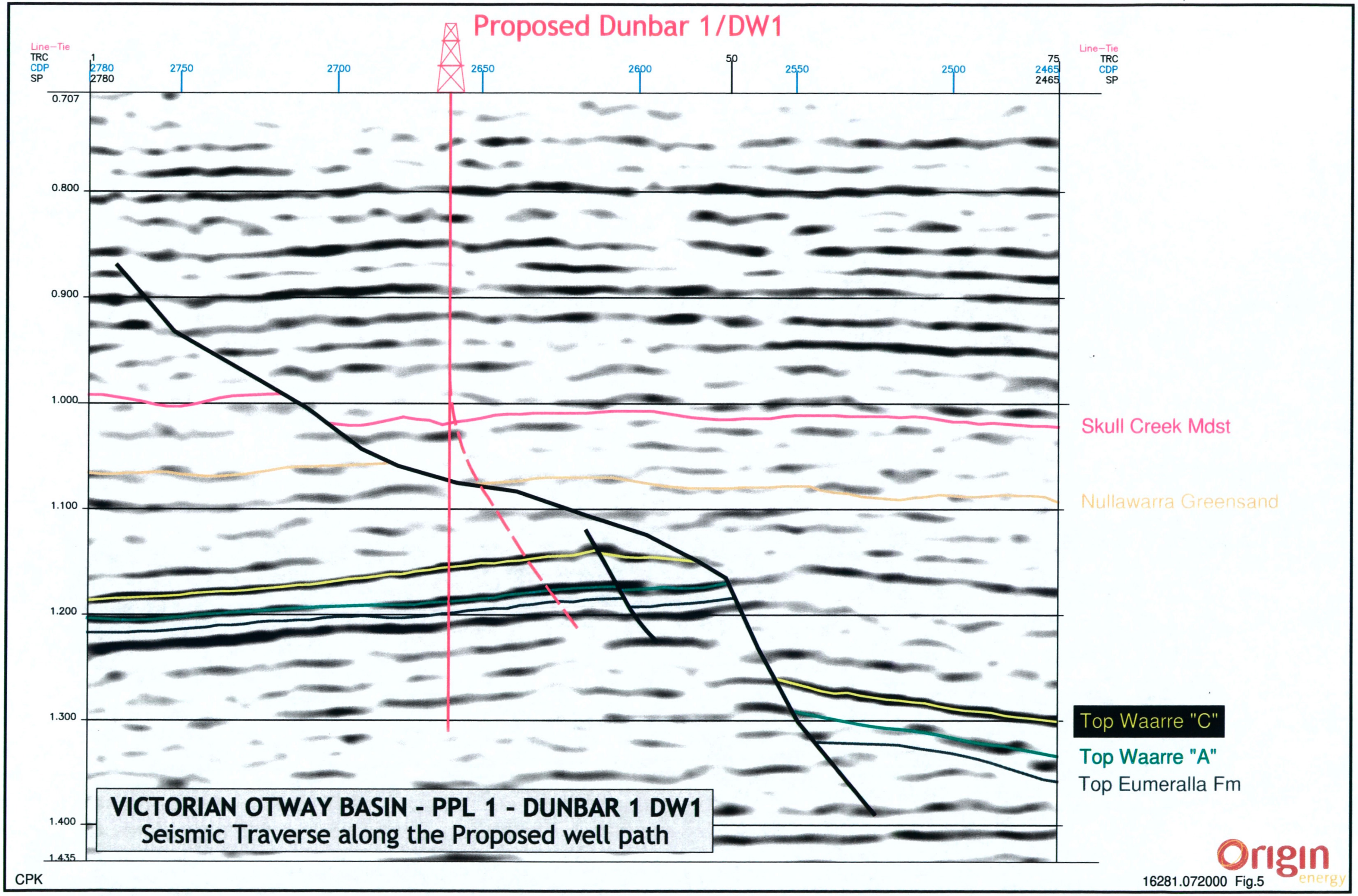


VICTORIAN OTWAY BASIN - TECTONIC ELEMENTS

After K.Mehin & A.E.Constantine (VIMP report 62 - June 1999)

Origin energy

16280.072000 Fig.4



VICTORIAN OTWAY BASIN - PPL 1 - DUNBAR 1 DW1
Seismic Traverse along the Proposed well path

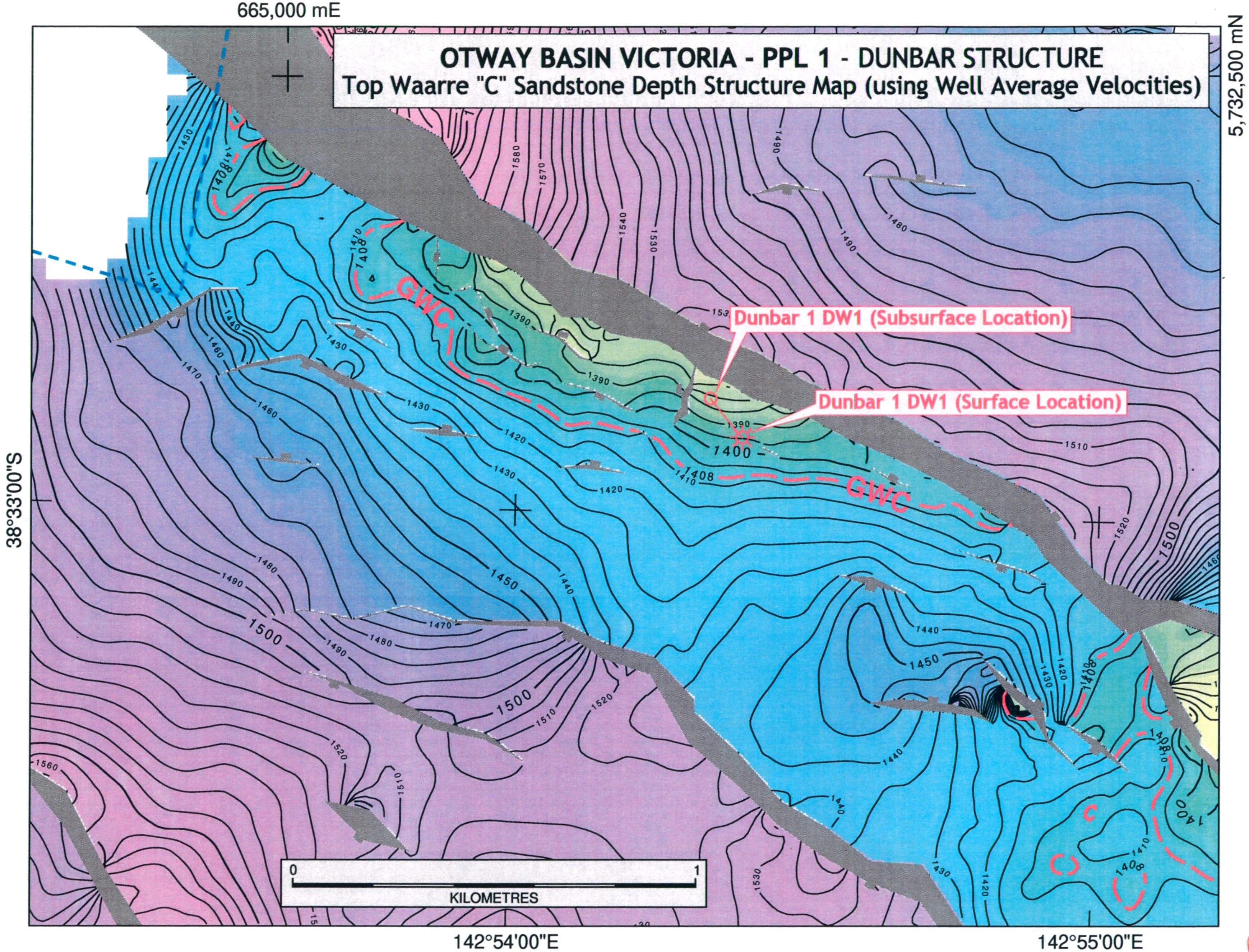
CPK

16281.072000 Fig.5

Origin energy

009108 024

PE909108-color009



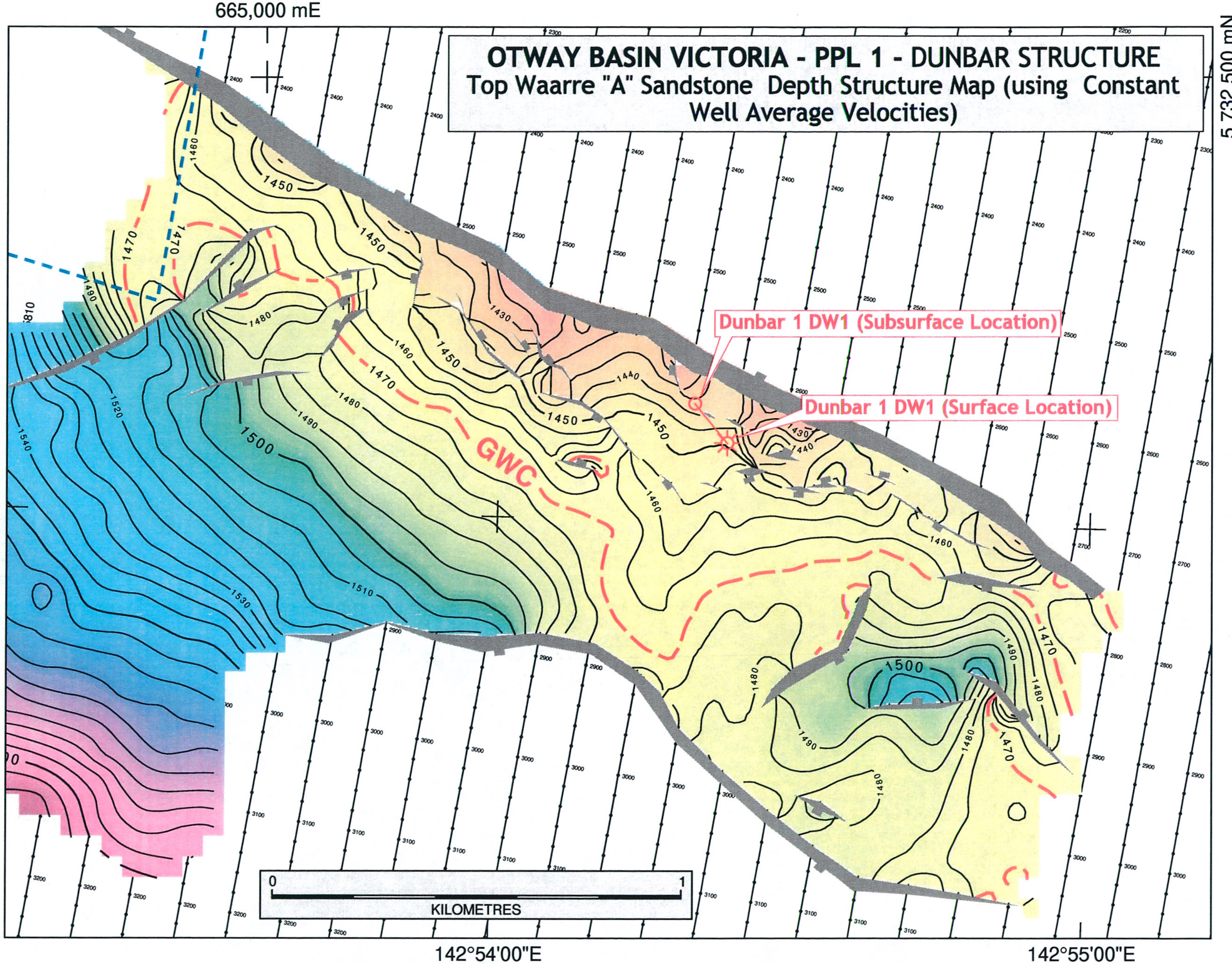
CPK

16282.072000 Fig.6

Origin energy

909108 025

PE909108-color010



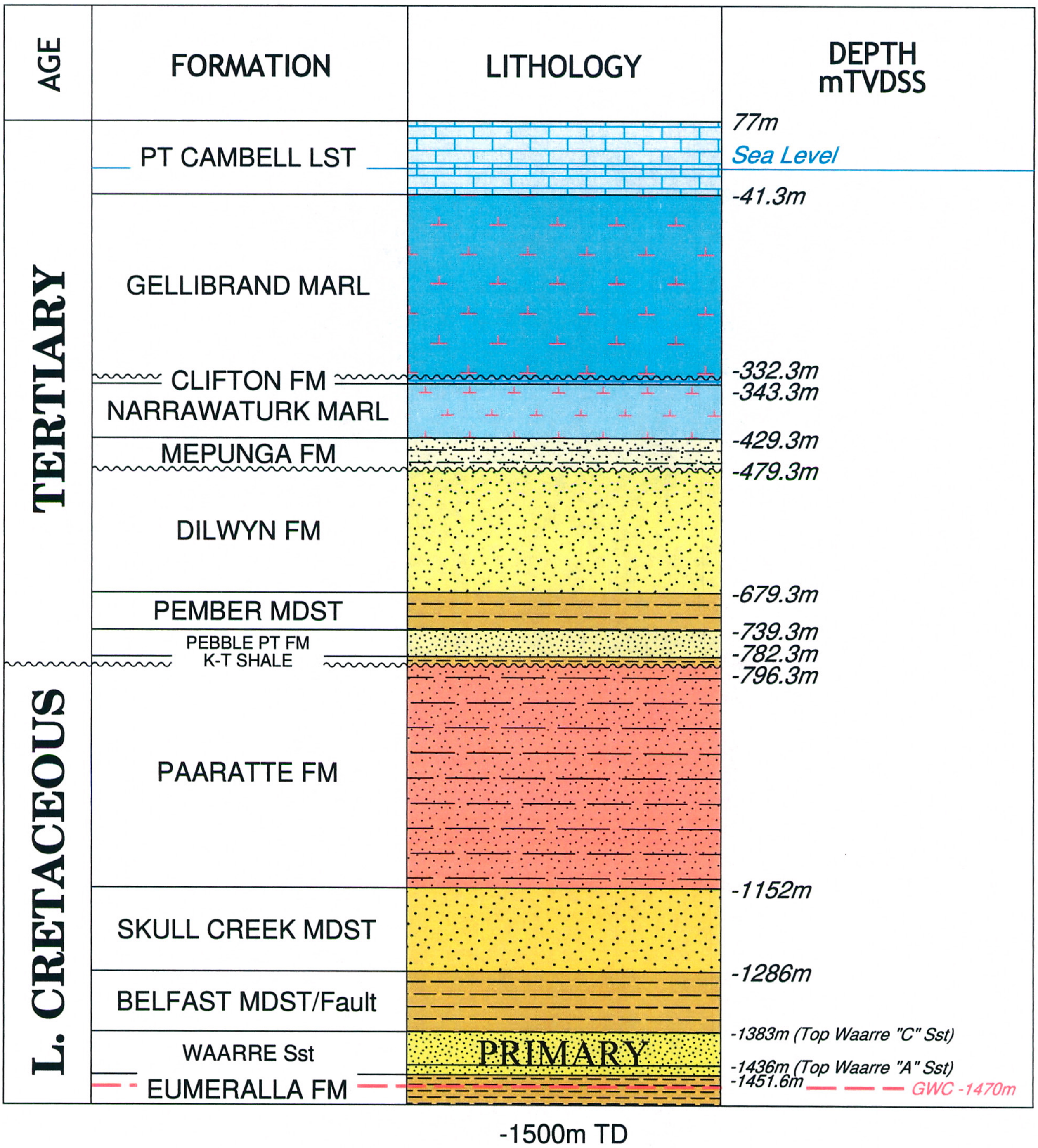
CPK

16283.072000 Fig.7

Origin energy

909108 026

PE909108-color011



OTWAY BASIN VICTORIA - PREDICTED SECTION
DUNBAR 1/DW1

CPK

16284.072000 Fig.8

Origin energy

909108 028

PE909108_color013