

Folio 29.

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**OIL AND GAS**

in the

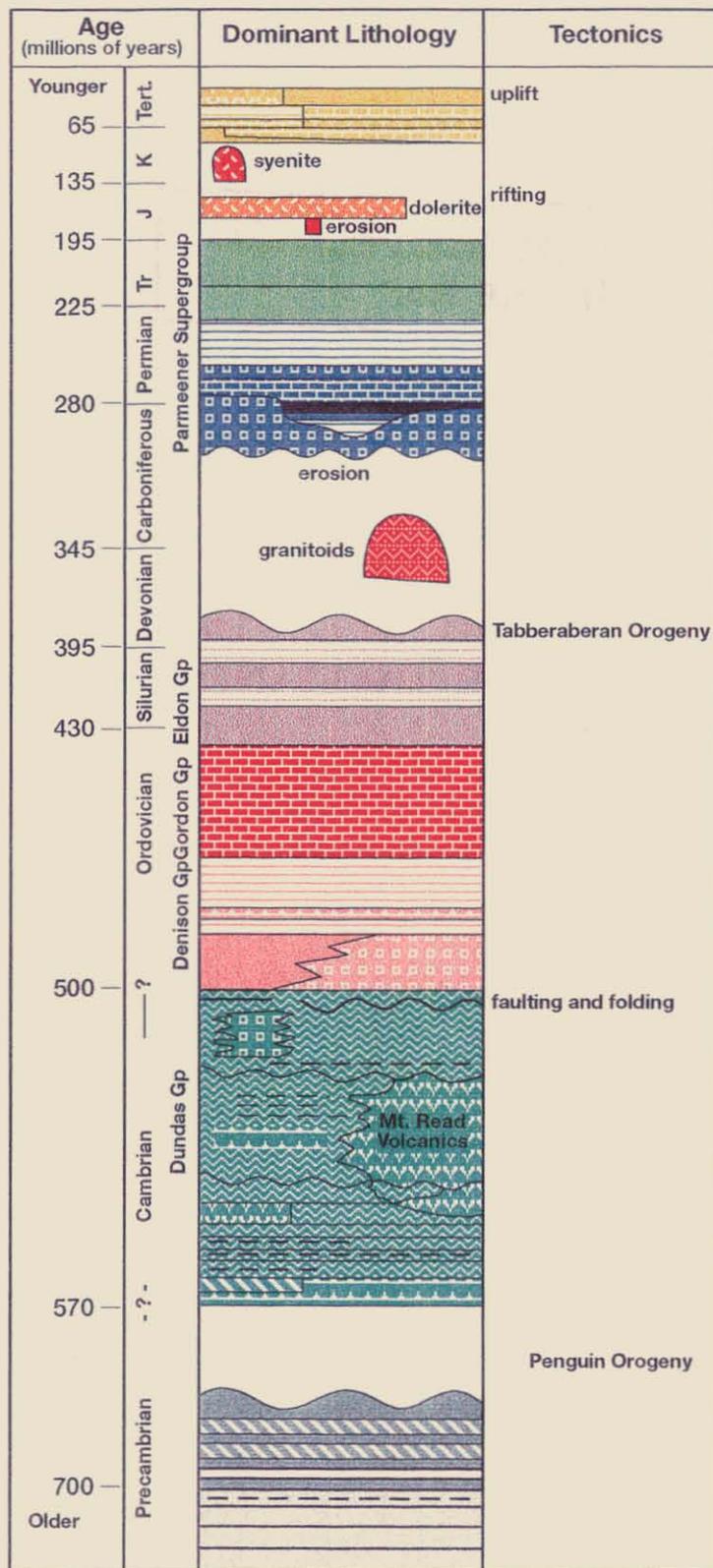
**ONSHORE TASMANIAN BASIN**

96-3934

EL 1/88 - OIL & GAS IN THE ONSHORE  
TASMANIAN BASIN - C BURRETT  
UNIVERSITY OF TASMANIA

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# Generalised Geological Column for Tasmania



Rock Types

- |  |   |  |
|--|---|--|
|  conglomerate   |  mudstone  |  volcanics                              |
|  siliciclastics |  limestone |  granitoids                             |
|  oil shale      |  dolomite  |  hypabyssal intrusions at shallow depth |
|  siltstone      |   |  |

## Abstract

At least four seep types have been characterised in Tasmania.

One seep type is identical geochemically to the Type I (oil prone) extremely TOC-rich Lower Permian Tasmanite Oil Shale. This excellent potential source rock oil shale is interbedded with fair to good TOC Type III (gas prone) shales of the Quamby and Woody Island Fms, is within the oil and gas windows over most of the Tasmanian Basin and is much more widespread than previously thought.

A sequence of middle Permian glaci-fluvial sandstones belonging to the Liffey and Faulkner Gps have good porosities and permeabilities and are found mainly in the north of the Basin. These sandstones thin towards the south where they interdigitate with glaci-marine sandstones of the Bundella Fm, which in the Shittim #1 stratigraphic well on Bruny Island also have good porosities and permeabilities. The 35m thick sandstones have a 10% porosity over much of the northern half of the Basin and can be compared with glaci-fluvial reservoir sandstones in Oman and the Cooper Basin.

The emplacement of thick and widespread Jurassic dolerite sills would have increased the regional geothermal gradient, increased the overburden on the source rocks by at least 250m, probably brought some sources to maturity over a wide area and on cooling would have produced very effective seals.

Maturation modelling suggests that some expulsion of oil and gas may have occurred after Jurassic and Cretaceous structuring. Tertiary reactivation of old faults and new faulting may have breached the dolerite seals but would have created new structures to receive the newly mobilised hydrocarbons.

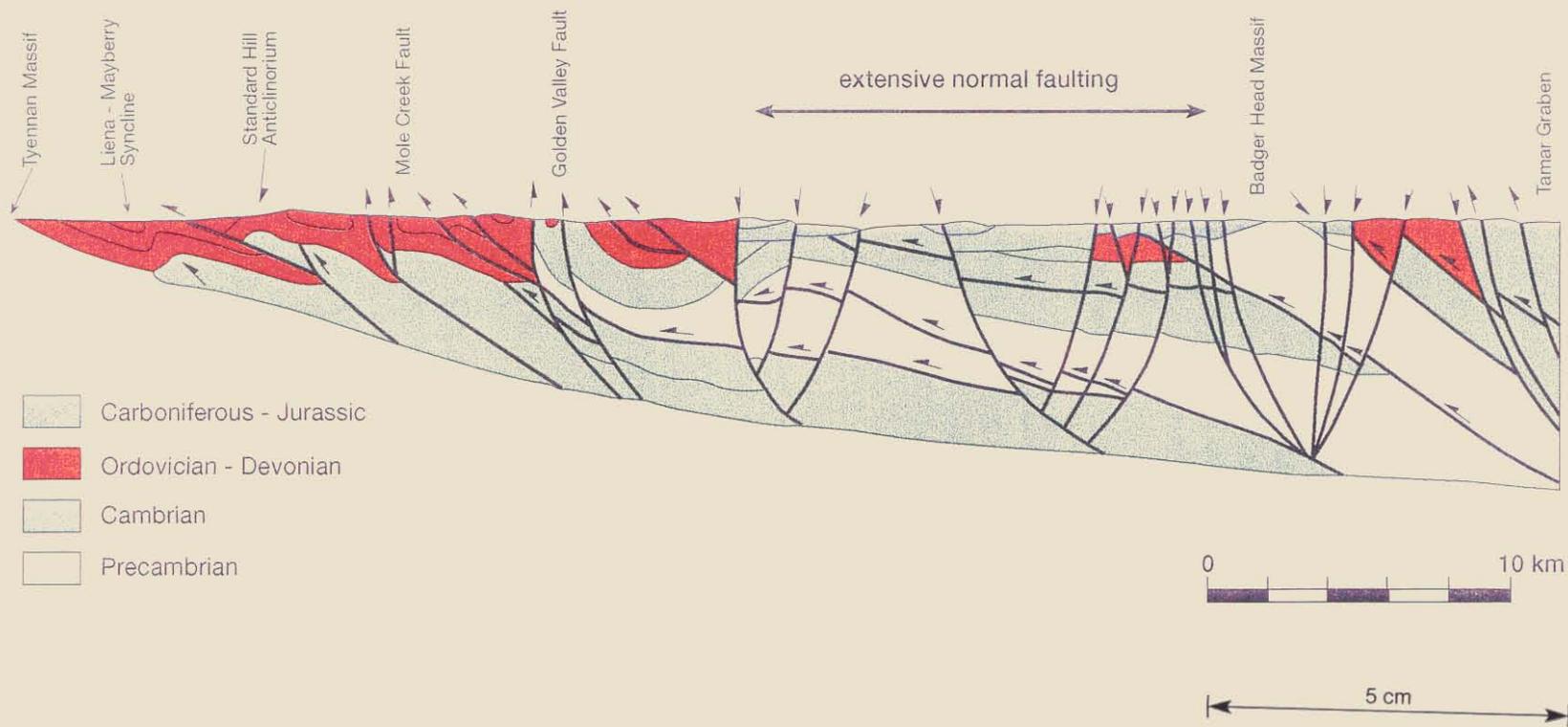
Non-biogenic methane with some ethane has been encountered continually but in varying quantities whilst coring the 1600m of Shittim #1 on Bruny Island. Highest values recorded are trip gas at 4% (in a lower dolerite sill at 1530m) with background values averaging about 1000 ppm. The source of this gas may be from below the mid-Devonian unconformity, possibly from Ordovician Gordon Gp limestones.

The recent recognition of widespread, potentially prolific Permian source rocks within the oil and gas windows which are stratigraphically under a good reservoir sequence, together with the demonstration by AGSO that seismic exploration is possible, enhances substantially the prospectivity of the Tasmanian Basin, particularly in the northern half.

# Results of Mid-Devonian Deformation (Tabberaberan orogeny) in Northern Tasmania (From Woodward et al 1993)

West

East



#961005-2/8

Figure 2

334001

## Introduction

Seeps of oil and gas have been reported in Tasmania for many years.

There were reports of oil being encountered in a shallow well on Bruny Island in southern Tasmania in 1929. The unsuccessful northern Tasmanian Mersey Valley 'oil boom' of the 1920's (Bacon, 1996) was based mainly on direct drilling of shallow occurrences of thermally immature Tasmanite Oil Shale ( $R_o = 0.5$ , Baillie, 1987).

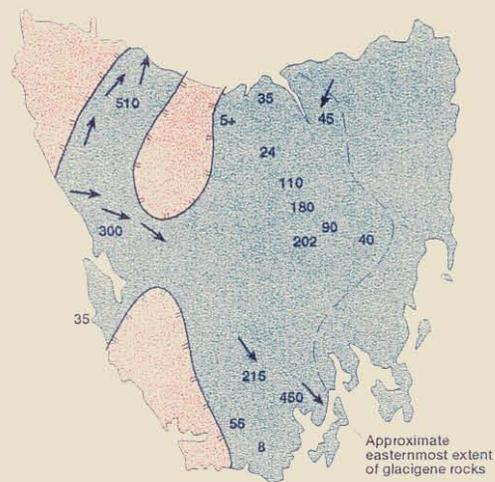
Since 1981 there has been a systematic investigation of the oil and gas potential of deeper parts of the onshore Tasmanian Basin carried out successively by Conga Pty Ltd, Condor Pty Ltd and since early 1995 by Great Southland Minerals Pty Ltd.

Geochemical, geophysical and geological data collected by these three companies are summarised herein. Also included are recent data and interpretations produced by the Australian Geological Survey Organisation (AGSO-formerly the Bureau of Mineral Resources-BMR), graduate students at the University of Tasmania, the Commonwealth Science and Industrial Research Organisation (CSIRO) and the Tasmanian Mines Department.

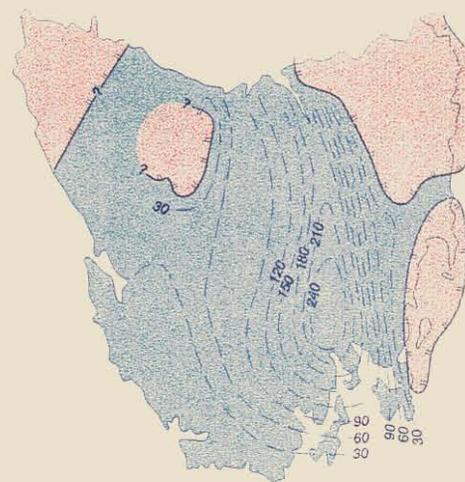
Recent geological, geochemical and geophysical results suggest that there is a valid hydrocarbon play in the Paleozoics of the Tasmanian Basin. This conclusion has been confirmed successively by three independent consultants (Carne, 1992; Mulready, 1995; Young, 1996).

# Paleogeographic development of the Tasmanian Basin from the Late Carboniferous to the Late Permian (from Clarke in Burrett and Martin 1989)

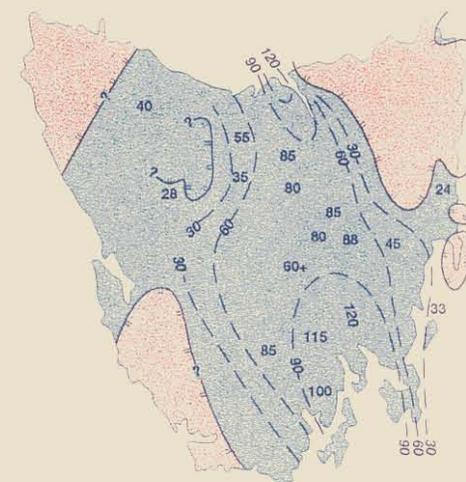
-  Land area
-  Isopach in metres
-  Direction of ice movement.  
Thickness of glaciogene rocks in metres
- C** Principle cool development
-  Successive brief, more open marine incursions
-  Maximum extent of marine Lower Bernacchian rocks
- 100 Total thickness of marine Bernacchian rocks in metres
-  Thickness of Upper Bernacchian rocks (m)
-  Southern limit of Bernacchian rocks due to Lymingtonian overstep



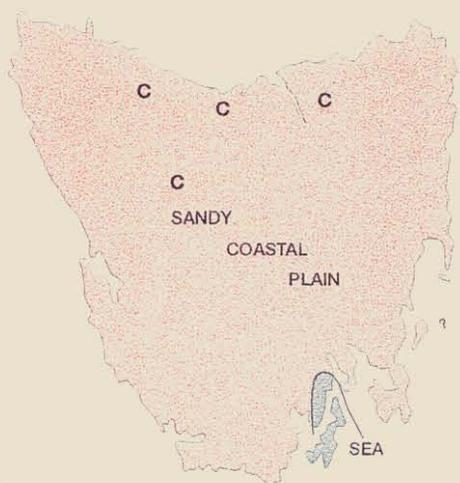
(a) Late Carboniferous glaciation



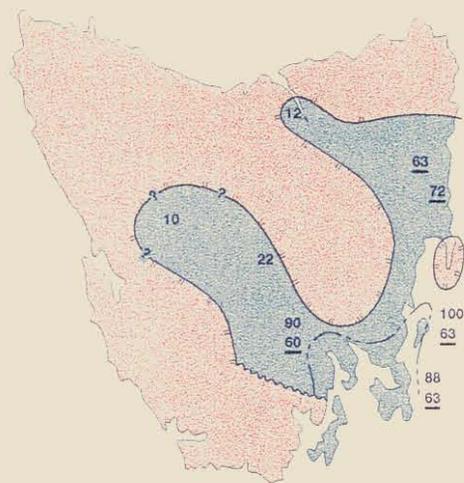
(b) Latest Carboniferous  
- earliest Permian/glaciomarine shales



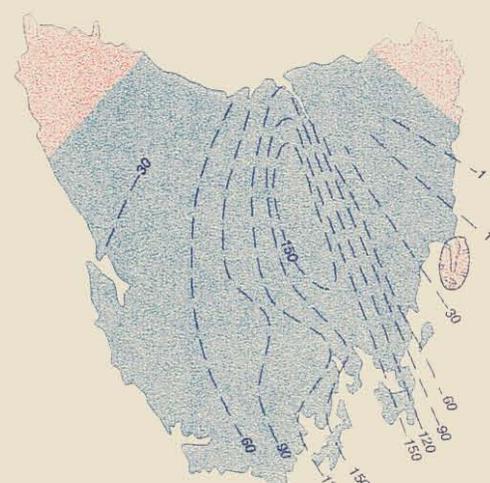
(c) Middle to Late Tamarian



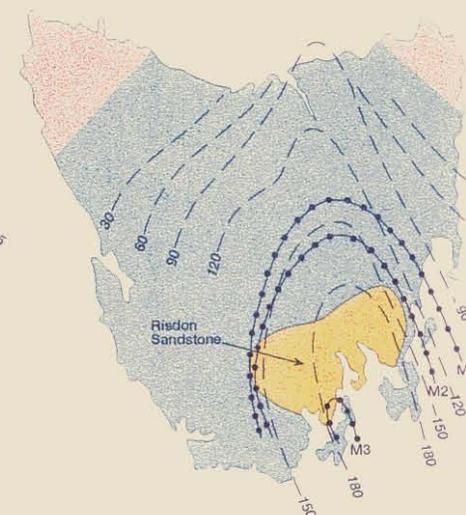
(d) Early Bernacchian non-marine interval  
("lower freshwater sequence")  
- potential reservoir sequence



(e) The main Bernacchian  
marine interval



(f) Early to Middle Lymingtonian



(g) Late Lymingtonian

## General Geology

The most recent summary of the geology of Tasmania is that edited by Burrett and Martin (1989).

The oldest rocks in Tasmania are Proterozoic schists and phyllites (see Fig.1) and occur in the Tyennan Region of central Tasmania and the Rocky Cape Region of northwest Tasmania. These are unconformably overlain by shallow water, often dolomitic, sequences of Late Proterozoic age. These Precambrian regions, originally thought to be autochthonous and acting as 'geanticlines' in the Cambrian are now known to be allochthonous.

The Cambrian sequences consist of the Mt Read Volcanic arc in the west interfingering westwards with basinal Dundas Gp siliciclastics. Cambrian volcanogenic sequences are probably found at depth under several parts of the Tasmanian Basin, including under north Hobart.

Deformation in the Late Cambrian led to the 'molasse' of the Owen Conglomerate, followed by the sandstones of the Moina Fm, the shales and silts of the Arenig Florentine Valley Fm and the 600-1500m thick tropical, fossiliferous, shallow-water limestones of the Middle-Upper Ordovician, known as the Gordon Gp. In parts the Gordon Gp carbonates are reefal forming a fringe to a miniplatform that deepens to the south and the east.

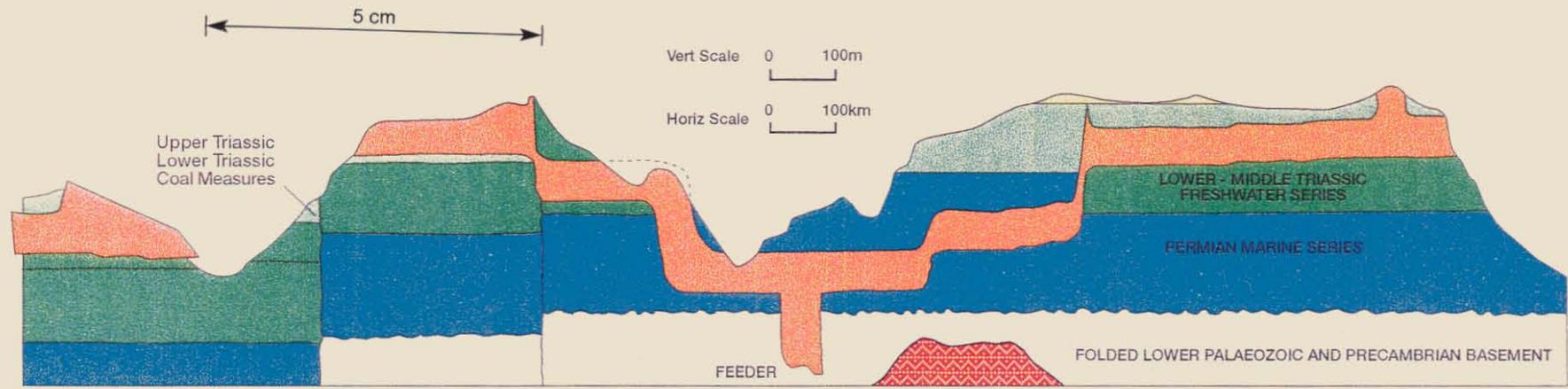
The Gordon Gp limestones are overlain conformably, and in places disconformably, by the siliciclastics of the the Upper Ordovician-Middle Devonian Eldon Gp in the west and the Tiger Range Gp in central Tasmania. These dominantly shallow water Ordovician to Devonian sediments deepen towards the eastern half of the state where the Ordovician to Middle Devonian is represented by the basinal turbidites of the Mathinna Gp.

These shallow water (in the west and central Tasmania) and basinal (in the east) Lower-Middle Paleozoics were deformed during the Middle Devonian Tabberaberan orogeny into a typical fold-thrust belt (see Fig.2) with the widespread intrusion of granitoids, particularly in the east and west.

The downwarping leading to the Tasmanian Basin was initiated in the Late Carboniferous with a depositional axis approximately coincident with the Early-Middle Paleozoic paleogeographic (and possibly structural) transition between western and eastern Tasmania (see Fig.3). Initiation of the Tasmanian Basin may be due to simple lithosphere stretching or to more complex stretching and widespread half-graben formation.

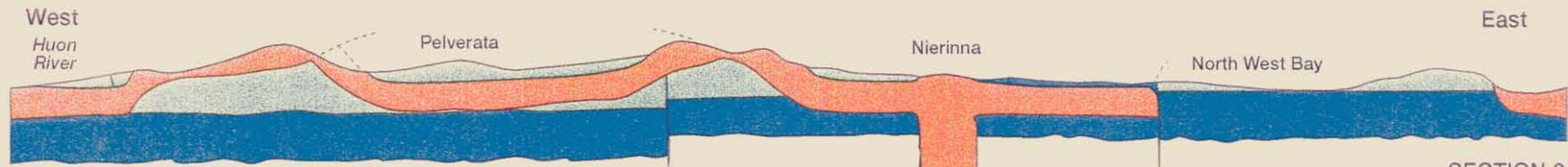
The sedimentary rocks of the Tasmanian Basin (see Fig.3b) are collectively known as the Parmeener Supergroup with the dominantly glacial-marine Upper Carboniferous-Permian comprising the thick Lower Parmeener (ave is 850m - range 645-981m) and the Triassic fluvial sandstones, coals and silts comprising the Upper Parmeener Supergroup (ave is 550m - range 365-655m) (Summons, 1981, p.5).

# Diagrammatic Summary of Dolerite Intrusion Forms and Structured Sections in the Southern Tasmanian Basin (from Leaman 1975)

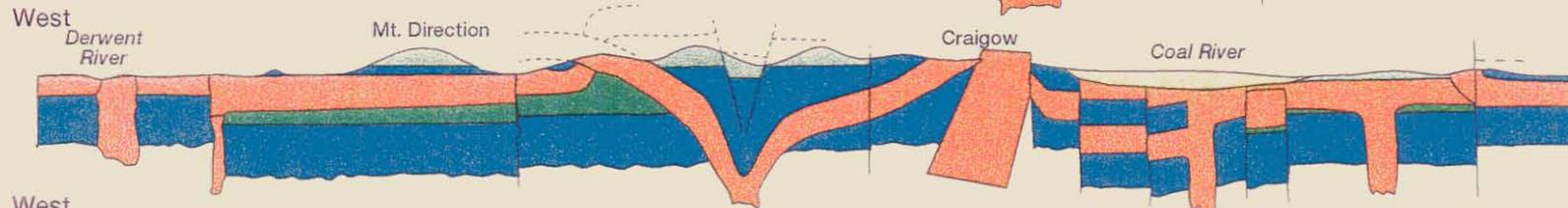


## INTRUSION FORMS

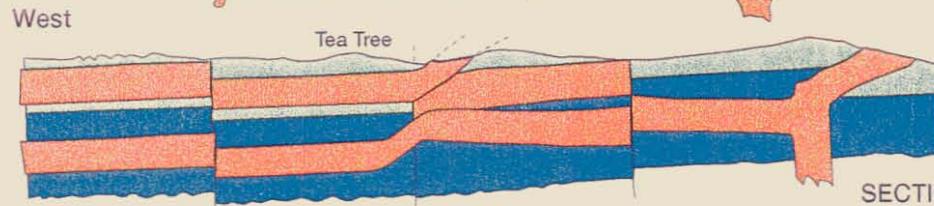
SECTION 1



SECTION 2



SECTION 3



SECTION 4



SECTION 5

## STRUCTURAL SECTIONS

0 1 2 3 km



The glacial marine Lower Parmeener includes a 60-100m thick sequence of mainly glacial fluvial sandstones which are known informally as the 'lower freshwater sequence' and formally as the *Liffey Gp* (in the north) and the *Faulkner Gp* (in the south) (see Fig 3d). These sandstones thicken from south to north and have been studied by Martini and Banks (1989). They are a good potential reservoir comparable to other Gondwana glacial fluvial sands such as those in the Cooper Basin of Australia (Maynard, 1996).

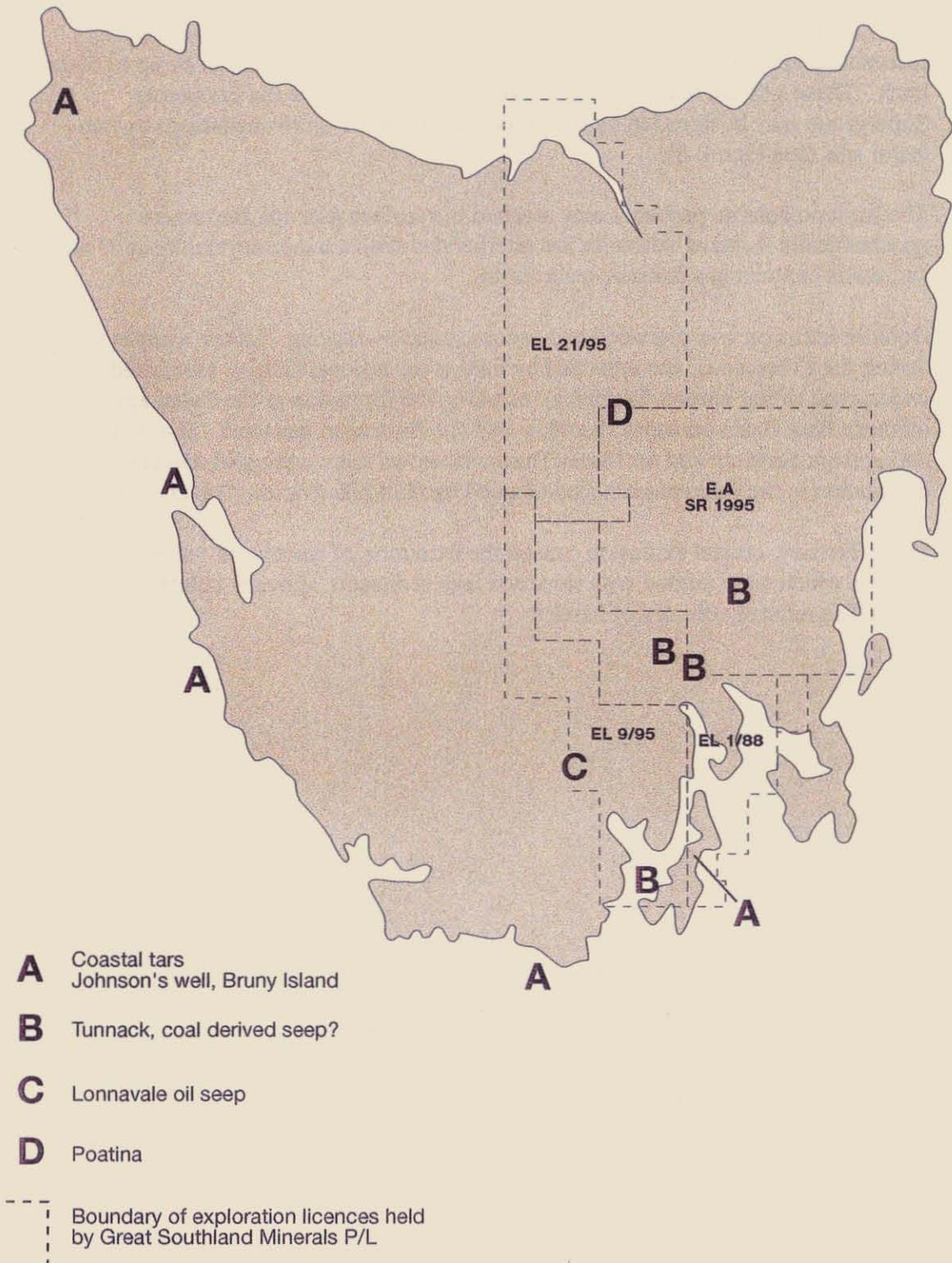
In the middle Jurassic (174 Ma), the Parmeener Supergroup was intruded by very extensive dolerite (diabase) sills, averaging 250m thick but which can be up to 600m thick. These sills are fed by narrow dykes. At any one place the Parmeener Supergroup may be intruded by one or (as at Shittim #1 on Bruny Island) by two major sills (see Figs. 4, 8).

The Jurassic dolerite probably only reached the surface near Ida Bay where geochemically identical volcanics are interbedded with a minor development of silts and sands containing a Jurassic macroflora.

Dolerite intrusion was preceded and accompanied by faulting. Minor syenites intruded during the Cretaceous, accompanied by further extensional faulting associated with widespread rifting around Tasmania, including the formation of the 'failed arm', offshore Bass Basin between Tasmania and the Australian mainland. Fission track dating from northern and northeast Tasmania shows there was uplift and considerable denudation in the Cenomanian accompanied by fault reactivation (Hill *et al*, 1995).

In the Tertiary, crustal extension caused the extension of narrow rift valleys and half grabens which were infilled with river and lake sediments. Locally volcanic centres erupted significant volumes of basalts.

## Distribution of Seep Types



## Seeps and Source Rocks

Three major types of Tasmanian seeps have been recognised geochemically (types A,B and C). A fourth (type D) may be a seep or an *in situ* oil (see Fig.5).

### SEEP TYPE A

#### ORDOVICIAN GORDON GP SOURCE

The first seep type is found as coastal bitumens and at Johnson's Well on Bruny Island.

The ratios of the two C<sub>27</sub> hopanes suggest that all of the coastal bitumens were generated at closely similar thermal maturities of about 0.6-0.7 R<sub>0</sub>. Geochemically, the Johnson's Well sample and the bitumens are very similar, although not identical, to the Ordovician Gordon Gp limestones (see Fig.7), and are characterised by abundant diasteranes (suggesting a clay-rich source), a predominance of C<sub>27</sub> steranes (typical of an algal source), and slightly lesser peaks for C<sub>28</sub> and C<sub>29</sub> steranes. Similar sterane ratios have been found in carbonate-derived oil from the Middle East and from Ordovician sedimentary rock found on mainland Australia (Volkman, in Bendall *et al* 1991, pp.78-79).

There is no geochemical similarity between this source/seep type and tasmanite, Gippsland crudes and the botryococcane-rich South Australian bitumens. However, the absence of methylhopanes is evidence against a shallow carbonate environment source.

Other possibilities for the source are the as-yet-unanalysed Proterozoic siltstones and Cambrian shales, the deep-water shales of the Ordovician (as at Surprise Bay on the South coast of Tasmania) or the Ordovician -Devonian Mathinna Gp shales.

### SEEP TYPE B

#### BRIDGEWATER AND TUNNACK

The second seep signature has been found in samples from five locations in southern Tasmania (e.g. Tunnack, south Bruny Island, Bridgewater) and is characterised by abundant C<sub>29</sub> steranes with C<sub>27</sub> and C<sub>28</sub> in equal amounts, with the major hopane being C<sub>30</sub>, slightly more abundant than C<sub>29</sub>. (Volkman and Holdworth, 1989a; Volkman and O'Leary, 1990). The samples are geochemically quite different to modern bitumens used for road making and this seep type has not, as yet, been matched to a known source rock.

One possible candidate is the Permian Preolenna Coal. The Preolenna Coal is developed as thin seams within the Liffey Gp in northern Tasmania (see Fig.3d), has high TOCs (av.=25%) and is oil prone terrestrial kerogen TypeII/III

"...not unlike the source for many of Australia's non-marine oils."  
(Powell, 1985).

The Preolenna Coal has not, however, been geochemically analysed in detail.

### Distribution of Tasmanite Oil Shale and abundant *Tasmanites* horizons plus Lonnavale seep

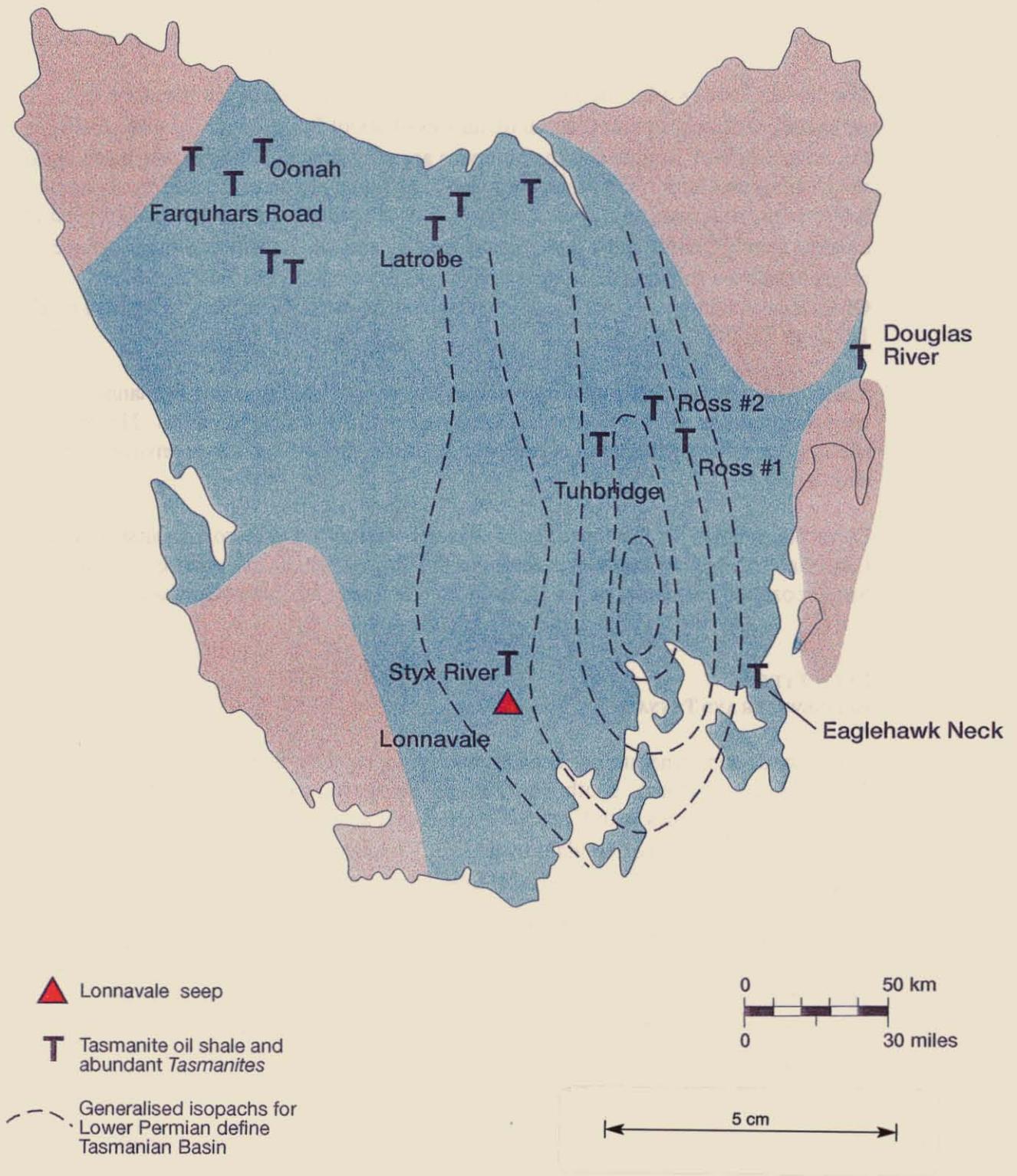


Figure 6

**SEEP TYPE C****QUAMBY/WOODY ISLAND FMS (INCLUDING TASMANITE OIL SHALE) SOURCE AND SEEP**

The third seep type has been found at one location in Tasmania, at Lonnvale (near Glen Huon in southern Tasmania)(see Figs.5, 6) and has the characteristic tricyclic triterpane signature of the Tasmanite Oil Shale (Revill *et al*, 1994).

This very organic-rich potential source rock (up to 28% TOC) is interbedded with generally lower (but still good) TOC shales in the Quamby Fm (the Woody Island Fm in the south) and correlates and is now known to be in the oil window over much of the basin.

The Tasmanite kerogen is Type I (oil prone) whilst the kerogen from the non-Tasmanite shales is type III (gas prone) (Banks *et al*, 1989). *In situ* reserves in the northern part of the state have been estimated at 43 million tonnes with a possible oil yield of 6 gigalitres (Banks *et al*, 1989). Similar figures may be calculated for the past oil production from the tasmanite within the deeper parts of the Tasmanian Basin where the oil shale is and was in the oil window.

An oil shale (consisting of the rock type tasmanite) is identified where the concentration of *Tasmanites* spores exceeds 10%. The geochemistry of the oil shale has been studied in detail by Baillie, (1987) and Revill *et al* (1994). In the north of the state, the main tasmanite seam is 1.57m thick and is sometimes associated with a subsidiary and thinner seam (James, 1950, p.9). The shale yields from 165 to 205 litres/tonne (Raphael & Saxby, 1980).

*Tasmanites*-abundant shale has now been recognised in several areas, including Farquhar's Road in NW Tasmania (Domack *et al*, 1993), the Douglas River on the east coast, (Revill *et al*, 1994), Eaglehawk Neck (Clarke, 1989 *in* Burrett and Martin, 1989) and in the Tunbridge, Ross #1 and Ross #2 boreholes in central Tasmania (Domack *et al*, 1993)(see Fig.6).

Domack *et al* (1993) and Campbell (1992) have analysed the TOC of the Quamby Fm in the Douglas River and the Ross #1 and Ross #2 boreholes. They found that most samples have a better than *fair* TOC (0.5-1.0), and that half of the samples of each section have a *good* TOC (between 1 and 2).

"Maximum TOC is associated with intervals of *Tasmanites* in cores both with levels of greater than 20% TOC found within the tasmanite in Douglas River, 17% in Ross #2 and greater than 2% in the *Tasmanites* zone in Ross #1 and Tunbridge" (Domack *et al*, 1993, p.478).

Thus in both the Ross #1 borehole and at Douglas River there is 56m of good source rock and in Ross #2 there is 125m of good and about 30m of fair source rock.

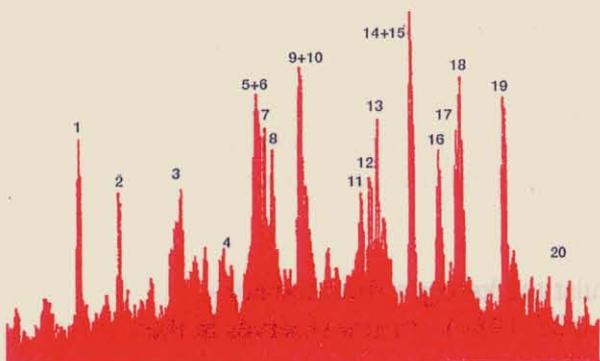
One band 0.37m thick occurs within the Woody Island Fm in the Styx River area near Maydena (BHP, 1981,1982) where it yields 6 litres per tonne. BHP analysed numerous samples from two borehole sections through 200m of the Woody Island Fm and found average yields of oil of about 2 litres per tonne with some samples yielding

# Seeps and Probable Source Rocks

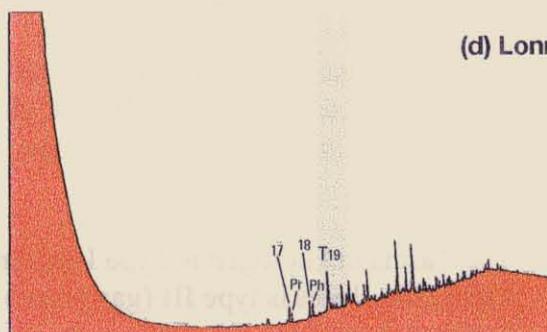
## Gordon Gp. signature

## Tamanite Oil Shale signature

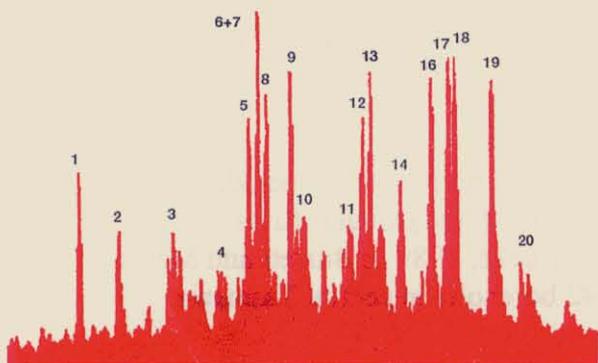
(a) Johnsons Well



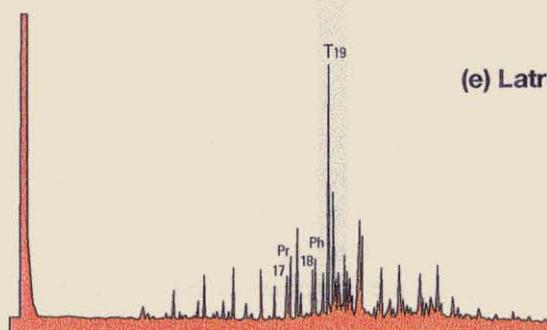
(d) Lonnvale



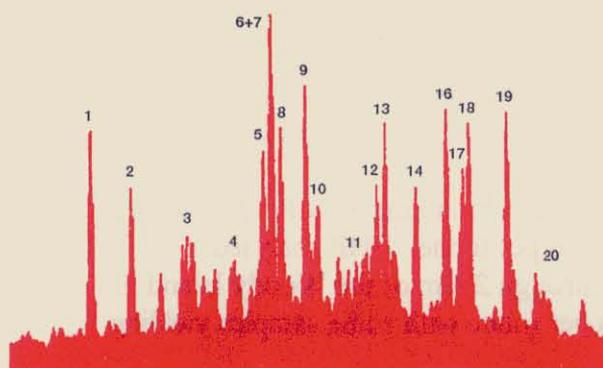
(b) Ida Bay Limestone



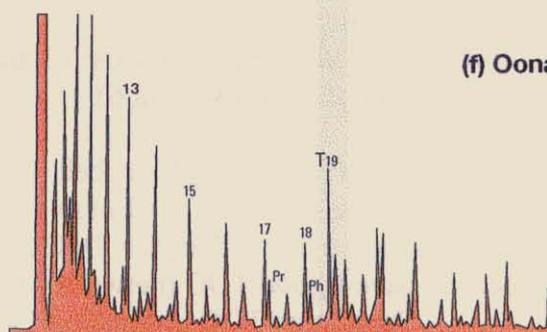
(e) Latrobe



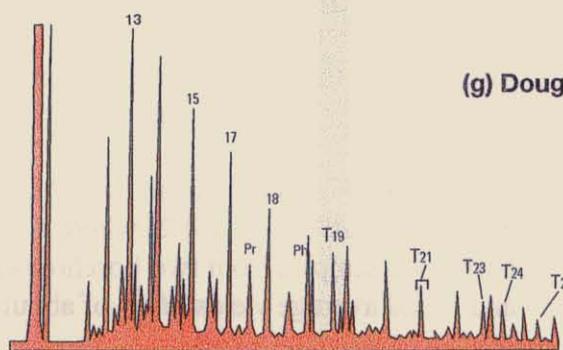
(c) Deep Creek Bitumen



(f) Oonah



(g) Douglas River



(m/z 217 Steranes and diasteranes)

(triterpanes)

Figure 7

up to 7 litres per tonne. They concluded that the Woody Island Fm "...may have served as an oil source rock in the past." (BHP, 1982, p.6).

In 1995 an oil seep was found within unusually strongly fractured Jurassic dolerite by Dr Ralph Bottrill of the Tasmanian Mines Department, about 15 km south of the Styx River locality at Lonnvale near Glen Huon. Dr Bottrill's samples were analysed by Dr A. Revill of the CSIRO (Revill, 1996).

Dr S. Wythe of AMDEL came to very similar conclusions as Revill based on samples collected by the writer. Wythe and Watson (1996) concluded that the Lonnvale seep is a lightly biodegraded, low sulphur, heavy crude that has undergone some migration from its source area. It is clearly derived from an anoxic shale rich in *Tasmanites*. Geochemical markers show that the seep derives from a source with a  $R_0$  of 0.8 equivalence (i.e. the middle of the oil window) (see Fig.7).

#### SEEP TYPE D POATINA

A sample of a Lower Permian mudstone from Poatina, in central Tasmania, contains n-alkanes and low molecular weight aromatics characteristic of a mature crude petroleum (Volkman and Holdsworth, 1989b). Methyl hopanes are very minor constituents (thereby excluding a carbonate source) and diasteranes, which are typical of a clay rich source, are abundant.

The methyl-phananthrene ratio and the aliphatic biomarkers suggest the petroleum was generated at a  $R_0$  equivalence of 0.75 (i.e. well into the oil window) and the presence of low abundances of tricyclic alkanes suggest that *Tasmanites* may have been a partial source. However, other n-alkanes are more abundant suggesting that the source is not rich in *Tasmanites* spores. This sample may be indigenous oil and perhaps this is the signature of the mainly gas-prone shales of the Quamby/Woody Island Fms.

#### Legend for Figure 7

Ordovician		Permian	
a	trace seep at Johnson's Well	d	heavy crude seep, Lonnvale
b	Ordovician Gordon Gp limestone, Ida Bay	e	Tasmanite Oil Shale, Latrobe
c	coastal tar from Deep Ck, nr Port Davey, SW Tasmania	f	Tasmanite Oil Shale, Oonah
		g	<i>Tasmanites</i> rich horizon, Douglas R. borehole, near Bicheno,

# Shittim #1 well log, North Bruny Island

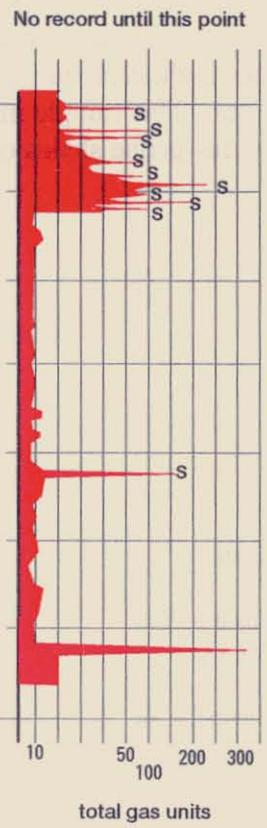
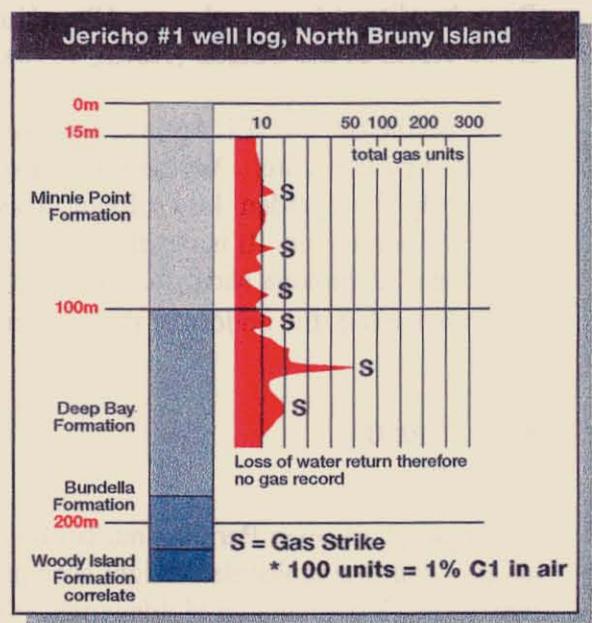
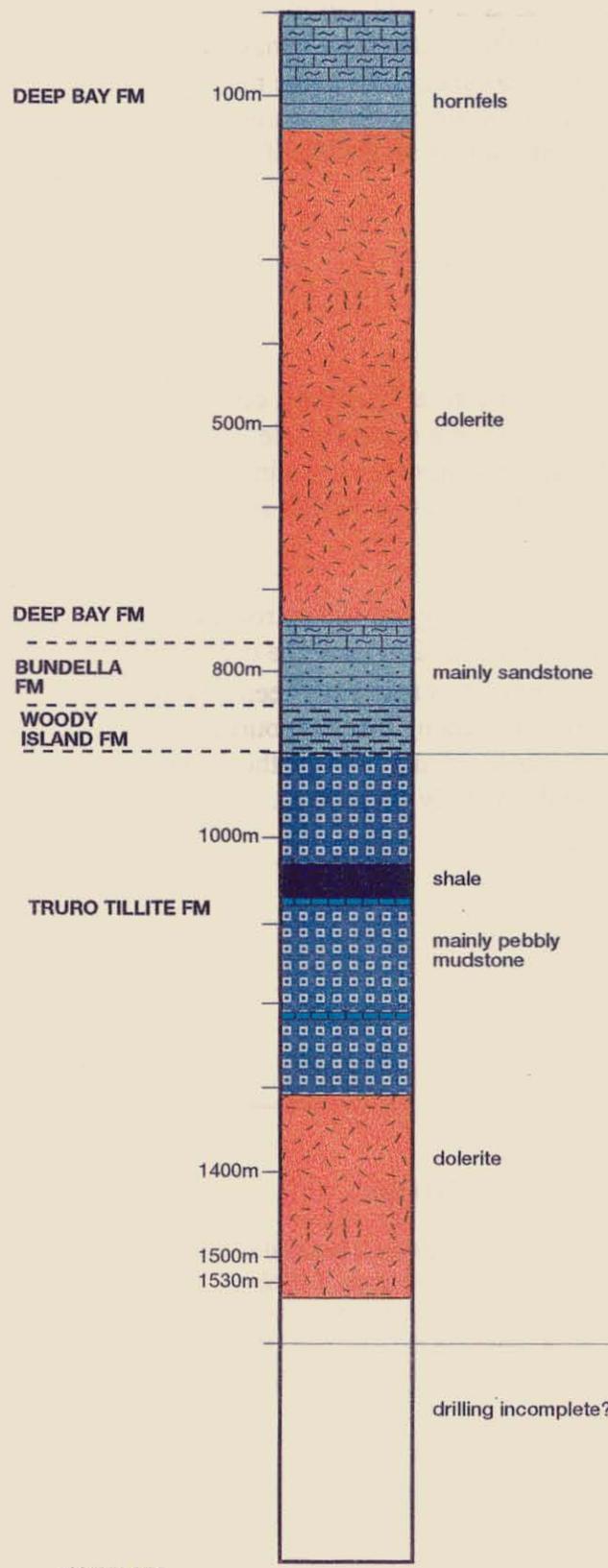


Figure 8

## Gas

Gas has been reported at several locations in Tasmania. For example, methane from Kimberley is of bacterial (biogenic) origin whereas methane from Smithton is of thermogenic origin (Baillie, 1992).

Gas encountered in the recent stratigraphic hole on Bruny Island (see Fig. 8) has been analysed by the Central Science Laboratory at the University of Tasmania (Davies, 1995, 1996) and by Cass at AMDEL (Cass, 1996). Hydrocarbons were found to be methane with a small amount of ethane ( $\approx 5$  ppm). The carbon isotope composition of the methane at  $-50.1\%$  PDB places it firmly in the middle of the "gas associated with oil generation" range (Feux, 1977).

Background methane readings ranged from a few hundred to a few thousand ppm. Higher levels associated with fractures were recorded with trip gas in the lower dolerite being 9000 ppm methane and 4 ppm ethane. Generally, background methane and ethane levels increased downwards through the lower sill and hydrogen decreased.

The source of this wet gas is not known. Its greater abundance when associated with fractures, particularly in the lower dolerite sill, suggests a pre-Parmeener source, either under the unconformity or with gas migrating along the unconformity.

# Summary of Vitrinite Equivalent and Vitrinite Measurements on Lower Parmeener Super Gp. Rocks

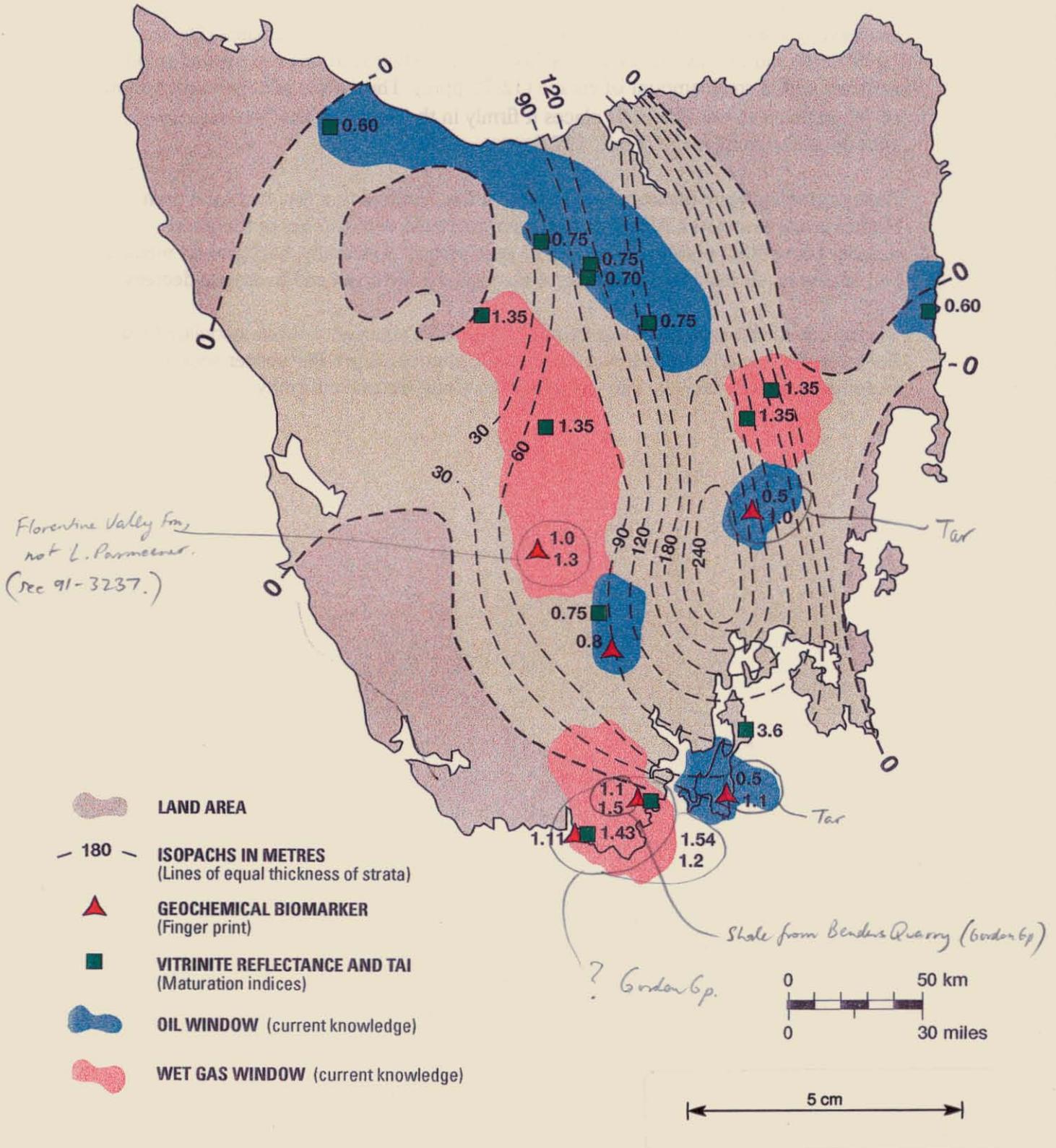


Figure 9

## Maturation

### Gordon Gp carbonates

A study of conodont color alteration indices (CAI) shows that the Gordon Gp limestones are overmature in western Tasmania but are in the oil and gas windows in central and southern Tasmania (Burrett, 1992). Oily residues and a petroliferous odour have commonly been reported by geologists (Prof. S.W. Carey *pers. comm.*) and paleontologists (Dr J. Laurie *pers. comm.*) studying the Gordon Gp carbonates in central Tasmania.

The common presence of pyrobitumens in vugs in the Eldon Gp sandstones of Zeehan in western Tasmania has been interpreted as oil generated from the Gordon Gp and destroyed *in situ* during the Devonian Tabberaberan orogeny. However, oil collected from Queenstown, in western Tasmania, where the Gordon Gp Limestones have a high CAI (more than 300°C) has a much lower vitrinite equivalence (Volkman, *in* Bendall *et al*, 1991).

This could be explained by juxtaposition of thrust slices with different maturities during the Tabberaberan orogeny. The Gordon Gp limestones almost certainly produced hydrocarbons and under parts of the Tasmanian Basin they are very probably in the oil and gas windows. They may well be the source of the wet gas in the Bruny Island hole. Because of the fold/thrust nature of the sub-Parmeener, such Gordon Gp subcrops may be difficult to locate (see Fig.2).

### Lower Parmeener Supergroup (including Tasmanite Oil Shale)

Several organic maturation indices are available for the Upper Carboniferous-Permian Lower Parmeener Supergroup. These are based on vitrinite reflectance, TAI and geochemical parameters and all available data is summarised as vitrinite reflectance ( $R_o$ ) equivalent values in Fig.9 (from Burrett & Bendall, 1996) and in Table I.

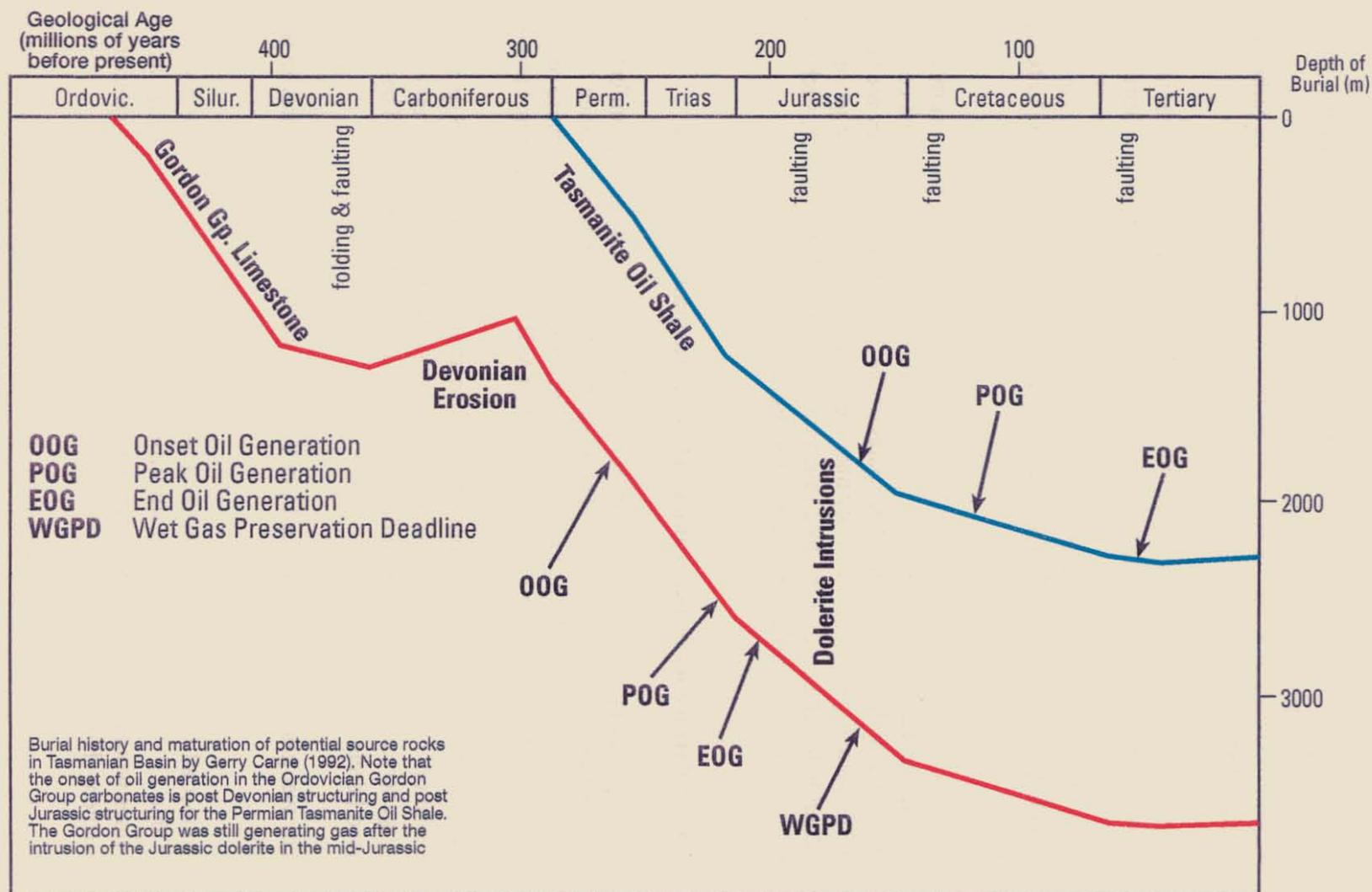
The oil window  $R_o$  ranges from about 0.5 to about 1.25 (Hunt, 1979, p.344) with maximum oil generation occurring at about 0.8. North (1985, p.65) takes the onset of oil generation as  $R_o = 0.65$ , and end of oil generation as  $R_o = 1.35$ . These values are used herein.

The wet gas window  $R_o$  ranges from 0.65 to 2 and the dry gas limit has an  $R_o$  of about 3.9.

Almost all Lower Parmeener Supergroup Tasmanian Basin values are in excess of 0.5 (Table 1). Such values are not surprising in the depocentre of the basin, as such  $R_o$  values would be expected with an overburden of 2km and a normal geothermal gradient (Hunt, 1979, p.344).

Two kilometers of overburden and an  $R_o$  of 0.6 on the Woody Island/Quamby Fms would be achieved by average thicknesses of Lower Parmeener (700m), Upper Parmeener (500m), dolerite (300m) and Tertiary (500m) (Table II).

# Thermal Maturation Estimate for Paleozoic Successions in Tasmania (from Carne 1992)



## Maturation Modelling

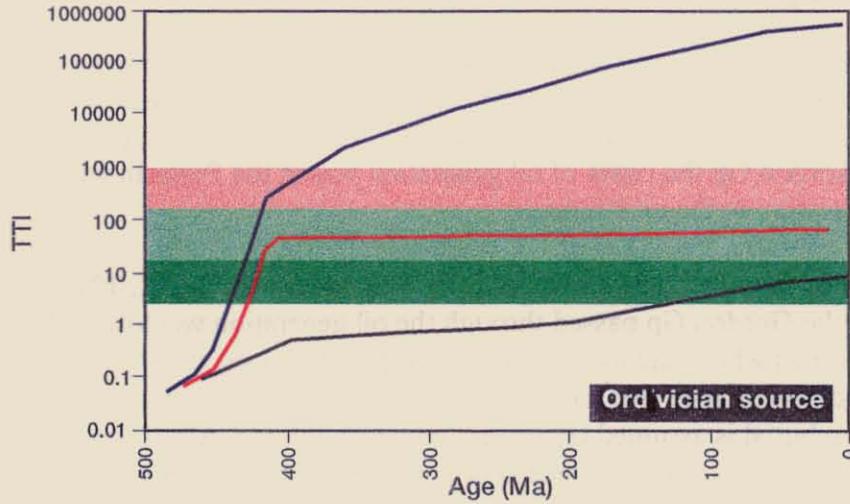
Several geologists have attempted maturation modelling of the putative source rocks in the Tasmanian Basin assuming various ranges of paleogeothermal gradients and depths of burial (e.g. Carne, 1992; Woods, 1995) (see Figs. 10,11,12). Carne (1992) showed that with the Gordon Gp the onset of oil generation was in the Permian with the end of wet gas generation in the mid-Jurassic.

A more intensive study by Woods (1995) using Lopatin diagrams (see Figs. 11, 12) shows that the base of the Gordon Gp passed through the oil generation window in the Silurian and Early Devonian when maximum burial is assumed (the west coast situation mentioned above) and may well have been generating oil in the Cretaceous and Tertiary if minimum burial is assumed (as suggested by conodont CAI's from central and southern Tasmania). On one scenario of burial/geothermal history, gas generation may have started in the Cretaceous and continued through the Tertiary.

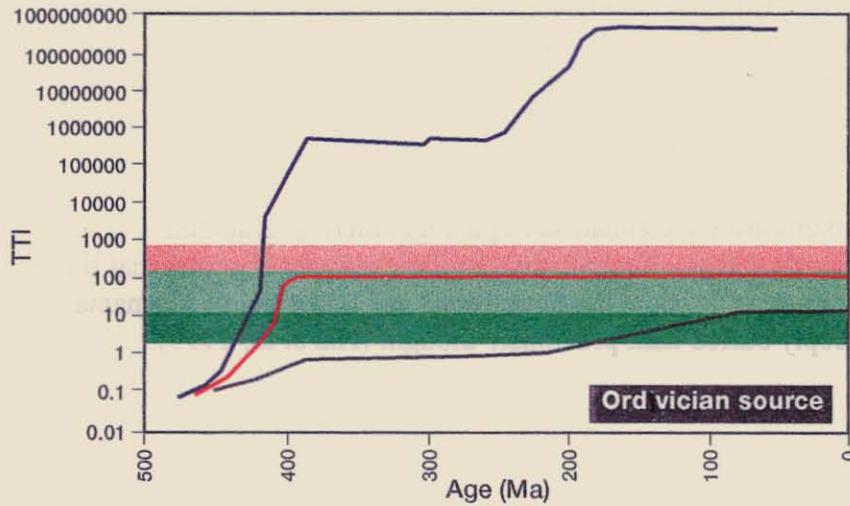
Simple modelling (see Fig. 11) of the Quamby Fm /Woody Island Fm, including the Tasmanite Oil Shale, suggests onset of oil generation in the Late Jurassic and end of oil generation in the Early Tertiary (Carne, 1992). Gas generation would continue through the Tertiary. Modelling by Woods (1995) suggests a range of timing of onset of oil generation from the Early Triassic through to the Quaternary (see Fig. 12).

Problems with these models are the estimation of paleogeothermal gradients and the estimation of overburden thickness. Recent work on fission tracks suggests that there has been a surprising amount of uplift in the Cretaceous and that parts of Tasmania may have been more deeply buried than previously thought (Hill *et al.*, 1995).

# Thermal Maturities



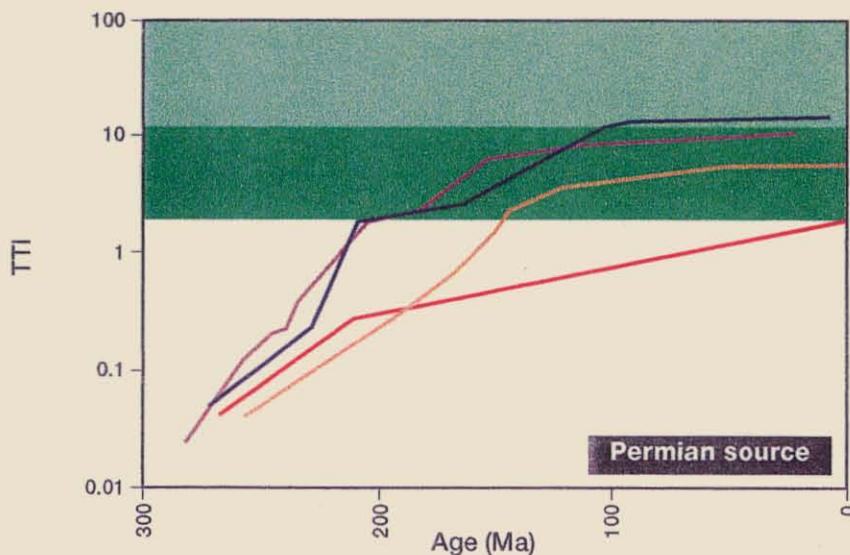
Thermal maturity versus time for the base of the Gordon Limestone. Simple geothermal history.



Thermal maturity versus time for the base of the Gordon Limestone. Maximum interpreted geothermal history.

- minimum burial
- intermediate burial
- maximum burial
- Gas Generation
- Oil Generation
- Oil generation from S-rich kerogen

Figure 11



Thermal maturity versus time for the base of the Woody Island Formation using various heating and burial scenarios. Illustrating the timing of oil generation from sulphur-rich kerogen and the conventional 'oil window'.

- minimum burial and geothermal history
- minimum burial, complex geothermal history
- maximum burial, simple geothermal history
- maximum burial and geothermal history
- Oil Generation
- Oil generation from S-rich kerogen

Figure 12

Liffey/Faulkner Group across the "Tasmania Basin"

N

S

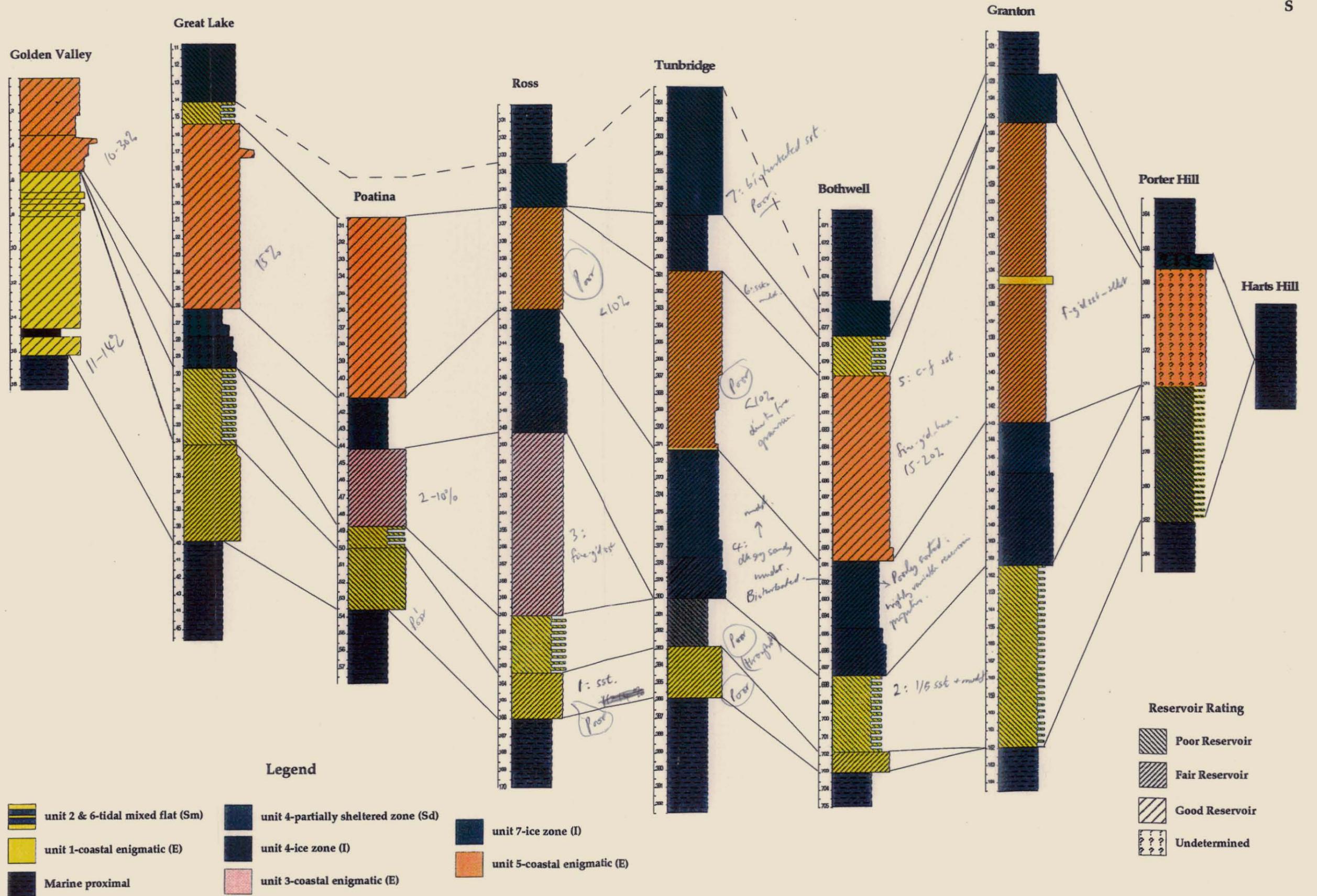


Figure : Reservoir rating of the Liffey/Faulkner Group

## Potential Reservoirs, Seals and Traps

### Reservoirs

Possible reservoirs occur in the Ordovician Gordon Gp limestones (as reefs and as paleokarst), in the siliciclastics of the Siluro-Devonian Eldon Gp (or Tiger Range Gp) and in the sandstones of the Triassic. However, the most likely reservoir is the 'lower freshwater sequence' comprising the Liffey and Faulkner Gps.

This thick (up to 100m) mid-Permian glaci-fluvial to marginal coastal sequence of sandstones and siltstones was deposited during a minor marine regression with an influx of sands from the north, east and west (Martini and Banks, 1989). There is a pronounced thinning towards the south of the Basin where it interdigitates with the mainly marine Bundella Fm. Only the marine Bundella Fm is found in the Shittim #1 stratigraphic hole on Bruny Island, where a pronounced gas show was reported and where (although contact metamorphosed) the porosity ranges from 11-12% and with corresponding horizontal permeabilities of 6.8 and 9.0 mdarcy.

The percentage of fluvial sandstones within the Liffey Gp increases from Bruny Island towards the north (see Figs.3d, 13). In a detailed study Maynard (1996) has shown that the 'coastal enigmatic' facies of Martini and Banks (1989) has especially good oil-reservoir potential. Overall Maynard (1996) has shown that several corehole sections have up to 35m thickness of fair to good reservoir (see Fig.13).

The glaci-fluvial sandstones of the Liffey and Faulkner Gps are comparable environmentally and compositionally to the glaci-fluvial Permo-Carboniferous reservoir sandstones of the producing Gondwana basins of Oman, South America and the Cooper Basin (Maynard, 1996, Chapter 6; Potter *et al*, 1995).

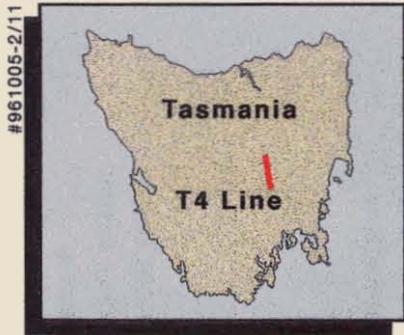
### Seals

Much of the Lower Parmeener Supergroup consists of poorly sorted siltstones and indurated mudstones. These have low intrinsic porosity and permeability and, except where intensely fractured, would make good seals.

Similarly the extensive and thick sills of Jurassic dolerite are also effective seals. These dolerite sheets have frequently metamorphosed the Parmeener sedimentary rocks to a hornfels which has an even lower porosity, except near the surface where weathering has preferentially removed calcareous shells.

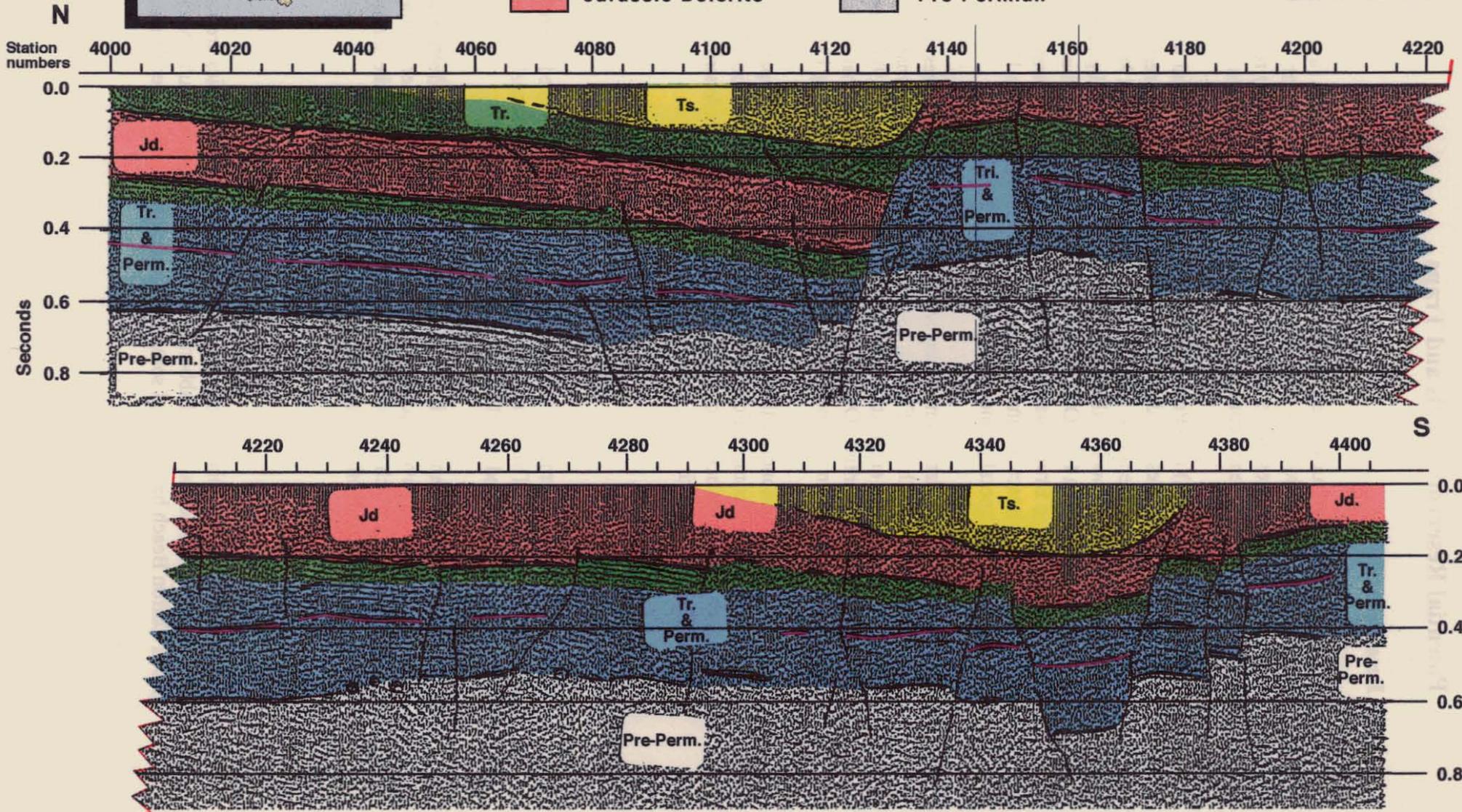
### Traps

Potential fold traps within the fold/thrust Lower-Middle Paleozoics are many but their identification beneath the Tabberaberan unconformity is difficult. A short seismic line at Clifton Beach has revealed some anticlinal closure in the older Paleozoics



# Interpretation of AGSO Seismic Line T4 (1995)

- |   |                   |   |                           |
|---|-------------------|---|---------------------------|
|  | Tertiary          |  | Permian                   |
|  | Triassic          |  | Lower Freshwater Sequence |
|  | Jurassic Dolerite |  | Pre-Permian               |



(Raw data reproduced with kind permission of AGSO - Interpretation by Leaman, for Great Southland Minerals P/L, 1996)

Figure 14

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unconformably beneath the Permo-Carboniferous Lower Parmeener Supergroup (Leaman, 1987).

Structures within the Parmeener Supergroup are mainly extensional faults. These are easily recognised on the AGSO seismic line (see Fig. 14).

It is well known that the Lower Parmeener is folded into gentle anticlines and synclines are well known near Maydena and several domal structures have been identified by field mapping such as those at Hunterston and Sorell. Seismic surveys across these domes are necessary in order to exclude the possibility of lopolith control, however unlikely that may be.

The most common type of trap is therefore likely to be a fault trap with minor traps based on domal structures within the Lower Parmeener.

Stratigraphic traps due to a pinch-out of Liffey Gp reservoir sandstones are also possible. Leaman (1995) has identified a reflector within the Lower Parmeener as the Liffey Gp (= 'lower freshwater sequence' on Fig. 14) and this is discontinuous on the seismic section, perhaps due to pinch-out.

## Conclusions

Two valid plays are represented in the Paleozoics. One is a source in the Ordovician Gordon Gp limestones reservoired in the Gordon/Eldon Gps or the Parmeener Supergroup. The wet gas found at Bruny Island may be part of this play. The second play is intra-Parmeener.

Matching of sources to seeps within the Tasmanian Basin suggests that the Gordon Gp carbonates and at least two horizons within the Lower Parmeener Supergroup are potential source rocks.

The widespread and extremely TOC-rich Tasmanite Oil Shale is an ideal source and has produced a migrated, low sulfur heavy crude seep near Glen Huon in southern Tasmania. Thermal maturation modelling and empirical data from outcrop and subcrop maturation indices suggests that the Tasmanite Oil Shale would have produced oil and gas both prior to and post deformation during the Jurassic, Cretaceous and early Tertiary.

Recent acquisition of seismic data by AGSO shows that ubiquitous dolerite sills are not impediments to seismic prospecting in the Tasmanian Basin. The AGSO seismic line shows that, contrary to most previous experience, both the upper and lower surfaces of the dolerite sill yield reflections and that structures and individual horizons within the Parmeener Supergroup, including the potential reservoir of the Liffey-Faulkner Gps, may be easily recognised.

Leaman (1987) has shown that structures beneath the Tabberaberan (mid-Devonian) unconformity can be discerned if the seismic acquisition parameters and processing are optimised. Thus, while the intra-Parmeener play concept is easier to plan an exploration program around, the older play of the Gordon Gp source and reservoir should not be discounted.

**Tables and References**

TABLE I

Maturity Indices of rocks and coastal tars in and around the Tasmanian Basin

Rock Type	Age	Locality	Method	R <sub>e</sub> equiv.	Maturity	Reference
oil (trace)	seep	Bruny Island		0.6-0.7	mature	Volkman 1987
mudstone with oil	in situ or seep Lwr Permian	Poatina	C27 hopane ratios	0.7	mature	Volkman & Holdsworth 1989
mudstone	Lwr Permian	Mersey R	TAI =3(brown)	1.0-2.0	very mature-gas	Summons 1981
mudstone	Lwr Permian	Bronte	TAI =3(brown)	1.0-2.0	very mature-gas	Summons 1981
siltstone (Woody Is)	Lwr Permian	Styx R	TAI=2(orange)	0.45-1.0	mature	Summons 1981
mudstone	Lwr Permian	Quamby Brook	TAI=2(orange)	0.45-1.0	mature	Summons 1981
mudstone	Lwr Permian	Poatina DDH5021 27m	TAI=2(orange)	0.45-1.0	mature	Summons 1981
mudstone	Lwr Permian	Poatina DDH5021 242m	TAI =3(brown)	1.0-2.0	mature	Summons 1981
Quamby/Woody Isl Fn	Lwr Permian	Preolenna	MP 1	0.6	mature	Bendall 1992
Quamby/Woody Isl Fn	Lwr Permian	Golden Valley	MP 1	0.7	mature	Bendall 1992
Quamby/Woody Isl Fn	Lwr Permian	Poatina	MP 1	0.75	mature	Bendall 1992
Quamby/Woody Isl Fn	Lwr Permian	Douglas R	MP 1	0.6	mature	Bendall 1992
Quamby/Woody Isl Fn	Lwr Permian	Ross #2	MP 1	1.35	gas	Bendall 1992
Quamby/Woody Isl Fn	Lwr Permian	Tunbridge	MP 1	1.35	gas	Bendall 1992
Quamby/Woody Isl Fn	Lwr Permian	Poatina	TAI=2	0.45-1.0	mature	Domack 1991, in Bendall 1992
Quamby/Woody Isl Fn	Lwr Permian	Tunbridge	TAI=3	1.0-2.0	very mature-gas	Domack 1991, in Bendall 1992
Quamby/Woody Isl Fn	Lwr Permian	Ross #1 & #2	TAI=3	1.0-2.0	very mature-gas	Domack 1991, in Bendall 1992
Quamby/Woody Isl Fn	Lwr Permian	Douglas R	TAI=2	0.45-1.0	mature	Domack 1991, in Bendall 1992
Tasmanite oil shale	Lwr Permian	Great Bend	C29	0.5	immature	Baillie 1987
Tasmanite oil shale	Lwr Permian	Mersey R	Vitrinite	0.4	immature	Russell, in Baillie 1987
bitumen	seep	Flinders Island	MPI/MPR	0.75	mature	Volkman & O'Leary 1990 (b)
bitumen	seep	Deep Ck	MPI/MPR	0.7	mature	Volkman & O'Leary 1990 (b)
bitumen	seep	Rocky Boat Hbr	MPI/MPR	0.74	mature	Volkman & O'Leary 1990 (b)
bitumen	seep	Surpnce Bay	MPI/MPR	0.73	mature	Volkman & O'Leary 1990 (b)
bitumen	seep	Pt Hibbs	MPI/MPR	0.76	mature	Volkman & O'Leary 1990 (b)
bitumen	seep	King Island	MPI/MPR	0.75	mature	Volkman & O'Leary 1990 (b)
bitumen	seep	New R	MPI/MPR	0.71	mature	Volkman & O'Leary 1990 (b)
bitumen	seep	Marawah	MPI/MPR	0.77	mature	Volkman & O'Leary 1990 (b)
Florentine V Fn	Lwr Ordovician	Florentine Valley	MPI/MPR	1.0-1.3	very mature	Volkman & O'Leary 1990 (b)
brittle tar	seep	Bruny Island	MPI/MPR	0.5(+1.1)	mature	Volkman & O'Leary 1990 (b)
sandstone	seep	Tunnack	MPI/MPR	0.7(0.8)	mature	Volkman & O'Leary 1990 (b)
tasmanite oil shale	Lwr Permian	Oonah	MPI/MPR	"immature"	immature	Revill <i>et al</i> 1994
tasmanite oil shale	Lwr Permian	Douglas R	MPI/MPR	"mature"	mature	Revill <i>et al</i> 1994
Lwr freshwater sequence coal	mid Permian	Fingal	direct vitrinite	0.55	immature	Powell 1985
Preolenna coal	mid Permian	Relapse Ck	direct vitrinite	0.48	immature	Powell 1985
Preolenna coal	mid Permian	Relapse Ck	direct vitrinite	0.49	immature	Powell 1985
Preolenna coal	mid Permian	Relapse Ck	direct vitrinite	0.49	immature	Powell 1985
Quamby mudstone	Lwr Permian	Golden Valley	golden yellow	0.4	immature	Powell 1985
Quamby mudstone	Lwr Permian	Andersons Ck	fluorescence exinite	0.4	immature	Powell 1985
tasmanite oil shale	Lwr Permian	Mersey Bend	dark orange	0.8	mature	Powell 1985
Quamby mudstone	Lwr Permian	Relapse Ck	deep orange	0.8	mature	Powell 1985
Lwr freshwater sequence	Mid Permian	Golden Valley	vitrinite	0.62	mature	Powell 1985
Lwr freshwater sequence	Mid Permian	Fingal	vitrinite	0.55	immature	Powell 1985
liquid crude	Lwr Permian	Lonnvale	aromatic maturity index	0.8	mature	Whyte & Watson 1996
mudstone	Lwr Permian	Bruny Island @ 900m	vitrinite	3.57	overmature	AMDEL,G31 in Woods 1995

TABLE II

Chart showing cumulative thickness of major units in Tasmanian Basin and resultant maturity levels assuming lowest, average and greatest thicknesses. Thickness estimates from Summons (1981) and definition of oil and gas windows from Hunt (1979) and North (1985). Geothermal gradient is assumed to be 27°C per km (=15° F per 1000 feet).

	THICKNESS		
	low	average	maximum
Tertiary	10m	500m	1000m
Jurassic dolerite	250m	300m	750m
Upper Parmeener SuperGp	365m	500m	655m
Lower Parmeener SuperGp	645m	700m	981m
total thicknesses	1270m	2000m	3386m
Vitrinite $R_0$	0.4	0.6	1.0
	immature	mature	very mature
		(oil window)	(oil window+wet gas)

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