

A REVIEW OF THE EXPLORATION,  
PETROLEUM GEOLOGY AND PROSPECTS  
IN T/13P, OFFSHORE TASMANIA  
AUSTRALIA

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#### **PLANS**

**Offshore Tasmania Block T/13P – Prospects**

## I. INTRODUCTION

This report reviews the exploration history of the area now covered by T/13P prior to Union Texas involvement in 1982, and details the work conducted by Union Texas to the present date. The geology and petroleum potential of the permit area are described and leads/prospects reviewed in the light of the recently completed seismic interpretation and various geophysical and geological studies.

## II. LOCATION

Permit T/13P covers an area of 3,644,000 acres (14,750 km<sup>2</sup>) east of the Furneaux Islands, northeast of Tasmania.

Most of the permit covers a southern extension of the Southern Platform which borders the Central Deep of the Gippsland Basin. This platform forms the continental shelf of northeast Tasmania. A shelf break occurs along the eastern part of the permit. Water depths range from 50m to 200m on the shelf to over 1,000m on the continental slope.

The permit adjoins Union Texas' Vic P/12 permit to the north. This boundary coincides with the Tasmania/Victoria border.

## III. EXPLORATION HISTORY

The T/13P Permit was awarded to a group led by Otter Exploration N.L. on April 4th, 1979, for a six year exploration period. The permit covered areas previously held by Magellan Petroleum in the east, and Esso/BHP in the west. Prior to the award of the current permit, the area had been explored by several seismic surveys and three wells.

Seismic surveys were shot during the period 1965- 73. These were concentrated mainly in the north of the permit and resulted in a moderately detailed grid, but the data was generally of poor quality. A comprehensive survey along the northeastern platform margin was acquired for Planet in 1970. Most of the southern half of the permit had not been explored.

The Mullet-1 and Bluebone-1 wells, located in the northwest of the permit, were drilled by Esso in 1969 to test stratigraphic plays on the Southern Platform. The plays were pinchouts of Latrobe Group reservoir sands on Devonian granite or sediments with top seal provided by marls and mudstones of the transgressive Lakes Entrance Formation. Both wells were abandoned without shows. The lack of hydrocarbons may be attributed to inadequate sealing capabilities of the basal Lakes Entrance Formation near the Latrobe pinchout edge, or excessive distance from mature source rocks in the deep Gippsland Basin.

Sailfish-1 was drilled by N.S.W. Oil and Gas in 1971. This well, located in the northeast of the permit, was drilled to evaluate a large isolated seismic feature believed to be a biohermal reef of Oligocene - early Miocene age. The feature was found to consist of weathered vesicular basalts and the well was plugged and abandoned without shows.

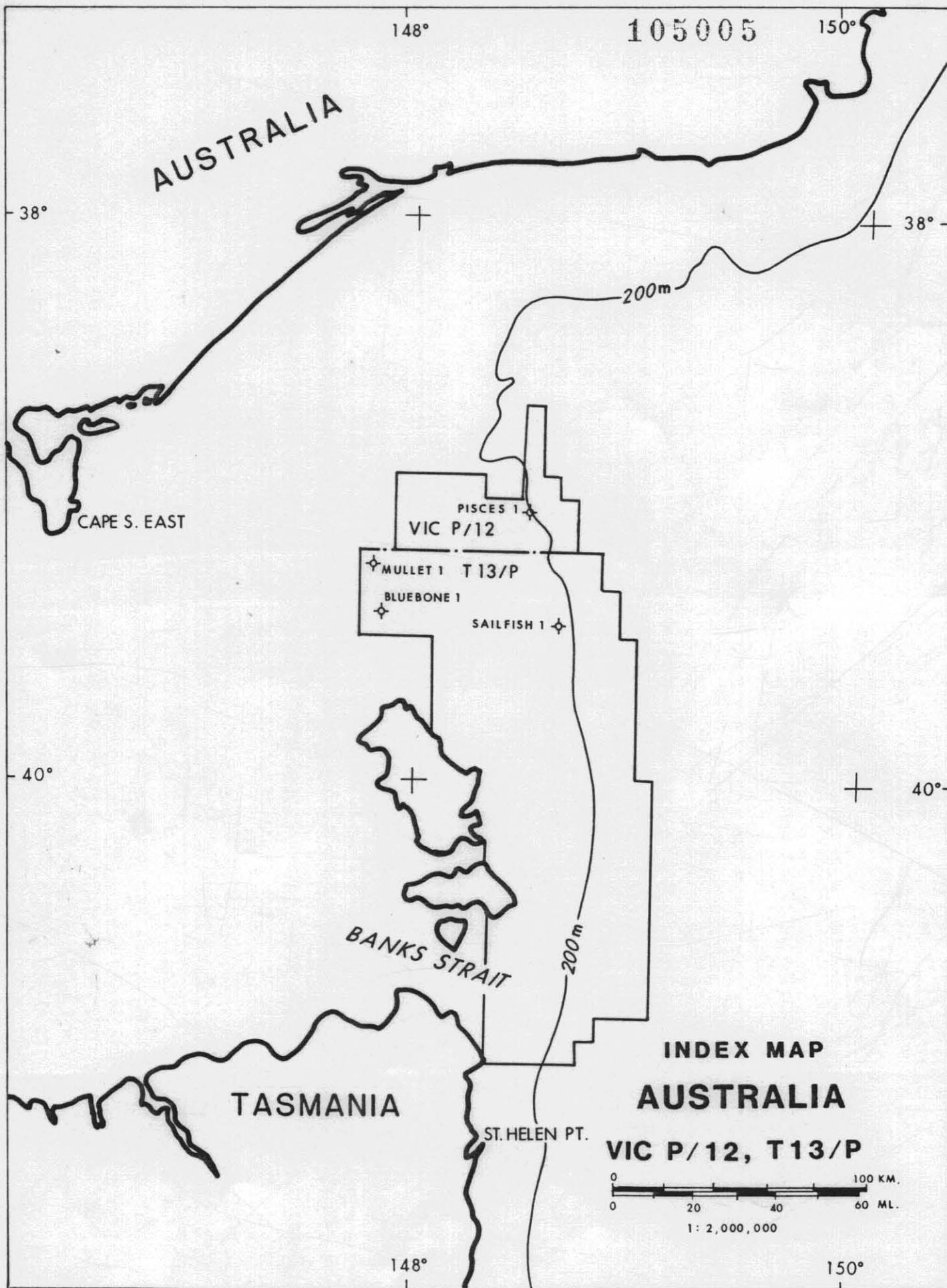


FIGURE 1.

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In May 1980, the Otter Group (Otter Petroleum, Meridian Oil, Valiant & Ocita) acquired 400 km of data in the Flinders Seismic Survey (designated 80F-) shot by G.S.I. This program was a reconnaissance survey along the margin of the Southern Platform. The survey was an open zig-zag of lines with only one loop closure. This design was selected to maximise the stratigraphic information obtained, especially over the southern part of the permit. The data was tied to the dense grid of old surveys in the north. The interpretation of the Flinders survey data relied heavily on the Planet Oil, 1970 G-Series lines for control. Several of these lines were reprocessed in 1980, along with many of the M-lines originally shot for Magellan in 1969.

Details of the Flinders Seismic Survey data acquisition, processing and interpretation are contained in the "Final Interpretive Report, 1980 Flinders Seismic Survey and Prior Data, Tasmania Permit - T/13P" prepared for Otter Exploration N.L. by Al Sabitay Consultants. The interpretation revealed several small structural and stratigraphic closures in the Latrobe Group. It was recommended that additional seismic be shot to better define four of these structures located southeast of Sailfish-1, and identified as "Furieux", "Flinders", "Muttonbird" and "South Muttonbird".

The Cultus Pacific group, then operator for Permit Vic P/12 to the north, extended their 1981 seismic survey (designated GC81-) into the northern part of T/13P to acquire 82 line km of good quality data. Interpretation of this data was incorporated in their evaluation of Vic P/12.

In May 1982, Union Texas and its joint venture partners in Vic P/12, entered into a seismic option/farmout agreement with the T/13P permittees. Under that agreement, the Union Texas group had an option to drill a well to earn 75% interest in the permit in return for conducting a 183 km seismic program. The seismic was acquired in November-December 1982 and the option was allowed to expire unexercised on December 31st, 1982.

Union Texas and the joint venture partners in Vic P/12 (with the exception of Tri-Arc) entered into a new Heads of Agreement covering T/13P in December 1982. Under the terms of the new agreement the Union Texas group earned a 50% interest in the permit by conducting a geophysical and geological evaluation of the permit in 1983. In addition, the Union Texas group had an option to earn an additional 25% interest by paying for the original permittees 50% share of one well. This option was allowed to expire unexercised on March 4th, 1984.

The results of the 1982 seismic program (designated UTP82-) indicated several leads in the northern part of the permit but none were considered mature enough for drilling. Consequently, on December 15th 1982, Union Texas, acting on behalf of its joint venture partners and representing Otter Petroleum and Meridian Oil, submitted to the Tasmanian Mines Department an application for a variation of the fifth year work program. The submission requested that the two exploratory wells required in the original permit work program for the fifth year be deferred until the sixth year, and that a comprehensive geophysical and geological study be substituted. This variant work program was approved on January 13th, 1983. Details of the proposed studies are contained in the letter submitted to the government.

During the fifth permit year, Union Texas conducted detailed geophysical and geological studies which included the acquisition of a further 236 line km of seismic data. To enable satisfactory completion of the seismic interpretation and evaluation of the results of other studies, this work was extended into the first half of the sixth and final permit year and a commitment to drill two wells was deferred until October 4th, 1984. This deferral was contained in a proposed sixth year work program submitted by Union Texas on March 14th, 1984, and approved by the Director of the Tasmania Mines Department on April 3rd, 1984.

The geophysical and geological studies have been completed. The results of these studies and their contribution to our understanding of the petroleum potential of T/13P follows.

#### IV. RECENT STUDIES AND INTERPRETATION

##### A. GEOPHYSICS

Geophysical studies have involved the acquisition, processing and interpretation of seismic and magnetic data, magnetic and seismic modelling, and acquisition and interpretation of relevant trade seismic data.

##### 1. 1982 Seismic Survey (UTP 82-)

In November-December, 1982, Union Texas conducted a seismic survey over the northeastern part of T/13P. The survey acquired 182.5 line km of good quality, 96 trace, 48 fold data. The survey was shot and processed by G.S.I.

This program was designed to identify plays which had previously been recognised in the adjoining Vic P/12 permit to the north. The data was interpreted and integrated with data from older surveys. Two play types were recognised:-

- (i) a stratigraphic/structural play associated with a Miocene sand wedge trending southeast from Vic P/12, and
- (ii) a top Latrobe and possibly intra-Latrobe play associated with basement highs along the southern flank of the Gippsland Basin.

##### 2. 1983 Seismic Survey (GUT83P- )

A second seismic survey was shot during late March - early April 1983. A total of 236 line km was acquired using a high resolution multiplex 240 channel streamer. Acquisition and processing were performed by G.S.I. The data was processed 30 fold using time variant filtering and scaling. The entire 236 line km of data was migrated. Velscan analyses were done on average 1 per 3 km. Processing was completed in November 1983.

The survey was designed to better define plays previously identified in the northeast part of the permit.

### 3. Seismic Interpretation

The recently completed seismic interpretation and mapping used all the Union Texas UTP 82A- and GUT 83P- data integrated with data from many of the earlier surveys including GC80-, GC81-, 80F-, G-, G69A-, M-, EC- and EH-. A total of 1251 line km was interpreted. Data from the early surveys was generally of poor quality and was only used when necessary to provide regional coverage or detail over previously identified leads.

Five horizons have been mapped in the area of T/13P. They are identified as follows :-

- (i) Purple - Water Bottom
- (ii) Orange - Intra Lakes Entrance Formation
- (iii) Green - Top Latrobe Clastics
- (iv) Blue - Intra Latrobe Group
- (v) Red - Basement (Paleozoic)

With the exception of the Blue Horizon, which is confined to the east and northeast and the Green Horizon, which is locally absent through erosion on the Southern Platform, these horizons have been picked across the area of T/13P.

In the north of the permit where the seismic grid is reasonably dense, mapping has been done on <sup>THREE</sup> two 1 : 50,000 sheets. The southern part of the permit, where only reconnaissance lines exist, has been covered by a 1 : 100,000 map sheet.

The following maps have been generated:-

- (a) Two Way Time Structure
  - (i) Intra-Lakes Entrance Formation
  - (ii) Top Latrobe Clastics
  - (iii) Intra-Latrobe Group
  - (iv) Basement (Paleozoic)
- (b) Average Velocity
  - (i) Sea Level to Intra-Lakes Entrance Formation
  - (ii) Sea Level to Top Latrobe Clastics
  - (iii) Sea Level to Intra-Latrobe Group
  - (iv) Sea Level to Basement (Paleozoic)
- (c) Depth Structure
  - (i) Water Bottom
  - (ii) Intra-Lakes Entrance Formation
  - (iii) Top Latrobe Clastics
  - (iv) Intra-Latrobe Group
  - (v) Basement (Paleozoic)

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## (d) Isopach

- (i) Intra-Lakes Entrance Formation - Top Latrobe  
Clastics. (1 PLATE MISSING #3.)
- (ii) Top Latrobe Clastics - Intra-Latrobe Group
- (iii) Intra-Latrobe Group - Basement (Paleozoic)
- (iv) Top Latrobe Clastics - Basement (Paleozoic)

## 4. Magnetic Interpretation

Magnetic data was acquired during the shooting of the 1983 seismic program. This data was processed by Exploration Consultants Ltd in Perth, Western Australia. The processing was complicated by significant line misties believed to have been the result of acquisition problems, inadequate diurnal control, and/or magnetic storm activity. Because of the distortion of anomalies on the map introduced by smoothing out misties, the usefulness of the data for quantitative interpretation is limited to line profiles.

Processing details are contained in the "Report on Processing of Marine Magnetic Data from Vic P/12 and T/13P" - E.C.L. November 1983, together with a Raw Magnetic Data Map (1:200,000) and a Total Intensity Magnetic Contour Map (1:100,000).

The processed magnetic data were modelled by Aero Service in Denver, Colorado, in an attempt to determine if various small anomalies seen during the seismic interpretation over the Southern Platform were of volcanic or clastic origin. Details of this study are contained in the report "The Evaluation of Magnetic Anomalies over Anomalous Seismic Reflectors in a Portion of the Gippsland Basin, Offshore Southeastern Australia" - Aero Service, March 1984.

Four anomalies were studied. Three occur within the area of T/13P, and the other is located in Vic P/12 close to the boundary with T/13P. The features can be seen on the following seismic line locations :-

- (i) Line GUT83A- 49, S.P. 1001 - 1100 (Vic P/12)
- (ii) Line GUT83P- 26, S.P. 1200 - 1339
- (iii) Line GUT83P- 20A, S.P. 1685 - 1765, and
- (iv) Line GUT83P- 17, S.P. 1130 - 1020

Modelling over features (i) and (ii) suggests the buildups may be of a relatively non-magnetic, sedimentary origin whereas features (iii) and (iv) could be modelled as weakly to moderately magnetic volcanic flows. However, extreme caution should be exercised in reviewing these results because the acquisition and reduction problems previously mentioned limit the confidence in quantitative interpretation.

## 5. Seismic Modelling

This seismic anomaly observed on line GUT83A-49 (and best seen on line GC80-11A) was the subject of a seismic modelling study in an attempt to determine the fluid content of the feature. This line was modelled because it conveniently ties to the Pisces-1 well and the previous magnetic modelling indicated the anomaly was likely to be a non-magnetic feature. The study was done by Union Texas Petroleum in Houston, Texas, and is documented in a "Report on the Magnetic and Seismic Modelling of Intra-Latrobe Features" - J D Underwood, March 20th 1984.

The seismic modelling was not able to confirm the sedimentary or volcanic lithology of the feature. The weathered, vesicular basalts seen in the Salfish-1 well have a low velocity and bulk density so the impedance contrast between volcanics and clastics may be very low.

The modelling study was able to demonstrate that the buildup is unlikely to contain gas because there is no associated amplitude anomaly. However it is not possible to determine whether postulated sand reservoirs are oil - or water-bearing.

## 6. Acquisition and Interpretation of Trade Seismic Data

Union Texas has exchanged approximately 1,000 line km of seismic data from Vic P/12 for the same from Phillips' Vic P/18, Shell's Vic P/19, and Aquitaine's Vic P/17. A similar trade with Hudbay for Vic P/11 is still being negotiated.

This data has been acquired to establish a broad database for interpretation of the Gippsland Basin and to put Vic P/12 in a regional context.

The Phillips and Shell data has been especially useful in tying the Vic P/12 Seismic interpretation to wells outside the permit, either by direct ties or by seismic character.

Union Texas has also purchased the BMR 1982 regional seismic data for the Gippsland Basin area. Six lines transverse the basin and tie 11 wells, providing additional control for regional interpretation.

The acquisition and interpretation of this seismic data has greatly assisted in the evaluation of the T/13P permit. By first of all evaluating the structure and stratigraphy of Vic P/12 it has been possible then to extrapolate the geology south into the adjacent T/13P area which is otherwise remote from the Gippsland Basin proper.

## B. GEOLOGY

Geological studies have involved digitising well log data, paleoenvironmental interpretation of well data, geochemical analyses, detailed well correlations, well data trades, regional and local stratigraphic, paleogeographic analyses, and prospect evaluation.

### 1. Digitising Well Logs

To facilitate detailed well log correlations, logs from available wells were digitised and the data stored on magnetic tape. This enables playback of logs at any specified scale.

Logs were obtained for 44 wells in locations scattered throughout the Gippsland Basin. Sonic and Gamma Ray logs were digitised from just above the Latrobe Group to T.D. This work was performed by G. S. I. in Singapore.

## 2. Paleoenvironmental Interpretation

An interpretation of data from 51 wells, widely distributed throughout the Gippsland Basin, was conducted for Union Texas by Paltech Pty Ltd, in Sydney. The aim of the study was to provide a standardised database for well correlation within the offshore Gippsland Basin.

Age and paleoenvironmental information were presented in the form of a strip log for each well. This provided a framework for a subsequent detailed geological well correlation and can also be used for interpolative seismic stratigraphy.

The results and details of study techniques employed are presented in the report "Age and Paleoenvironmental Assessment of Fifty One Selected Well Sequences : Offshore Gippsland Basin", - Paltech Pty Ltd, June 23rd 1983.

## 3. Geochemical Analyses

To further evaluate the source potential of the sediments encountered in Pisces-1, and to compare these results with other wells in the Gippsland Basin, geochemical analyses were carried out on cuttings and SWC samples from Pisces-1 and 9 other wells. The analyses were performed by Gearhart Pty Ltd.

The study included pyro-analysis, total organic carbon content and residual organic carbon measurements, spore colouration, vitrinite reflectance and kerogen type analyses. The results are presented in a comprehensive report - "Geochemical Analyses of Wells from the Gippsland Basin, Australia" - S Sengupta, S Hindmarsh and P J Bigg, January 1984.

The results of this study have been incorporated in the detailed geologic well correlation study by Tom de Windt, and written up in his "Interim Report Geology", March 1984.

Of the ten wells studied, Pisces-1 was considered by Gearhart to be the most promising well with respect to oil generation. Their results indicate the section is capable of generating poor to moderate amounts of oil and gas at its present state of maturity. The section is partially mature and contains good quality amorphous (oil-prone) kerogen but the source is poor. The T.O.C. levels in most of the Latrobe section are well below the average for the basin (less than 1% compared to 6%). Even though the section does contain good, oil-prone kerogen, the low T.O.C. levels and the presence of moderate to common amounts of inertinite (very little potential) have limited the oil generating potential of the section.

The observation that the Pisces-1 well was the most promising for oil generation probably reflects the fact that the Latrobe section is mature at a shallower depth than in the other wells studied because of its proximity to the basin margin. It has been established that the geothermal gradient is higher towards the edges of the Gippsland Basin. This explains why the section at Pisces-1 is partially mature at 2300m whereas in the Central Deep Basin the oil window probably starts at depths exceeding 3500m.

The section below 2500m in Pisces-1 contained more organic matter (T.O.C. levels up to 4.37%) but the vitrinitic and inertinitic character of the kerogen limits the potential for generation of large volumes of oil.

#### 4. Detailed Well Correlations

To better understand the stratigraphy of the Latrobe Group in the Gippsland Basin, and to relate this to the geology of Vic P/12 and T/13P, a detailed geological well correlation study was undertaken. Fifty-four wells from throughout the basin were lithologically correlated using well logs, and these results integrated with the previously obtained chronostratigraphic information and geochemical analyses to give a comprehensive picture of basin geology. Details of this work by Tom de Windt are contained in his - "Interim Report Geology, Vic P/12 Variant Work Program, Offshore Gippsland Basin, Australia" - March 1984.

The 54 wells were correlated using logs, and the Latrobe Group section was subdivided into three broad facies on the basis of sand/shale ratios, sand percentages and coal percentages. The facies recognised were delta-plain, delta-front and pro-delta. Results from the geochemical analyses on 10 wells were then related to these facies.

The results of this study are displayed on six regional cross-sections across the basin; four east-west and two north-south. The cross-sections show correlation points, Latrobe Group facies, chronostratigraphic correlations, hydrocarbon test/show intervals, sandy zones within the pro-delta Latrobe Group and the Lakes Entrance Formation, and sand development within the Gippsland Formation.

The study indicated that the delta-front facies of the Latrobe Group is the best reservoir objective in the basin with an average sand/shale ratio of 3.65 and average sand percentage of 67%. The delta-plain facies is of secondary importance as reservoir with an average sand/shale ratio of 2.97 and average sand percentage of 62%. All Latrobe Group facies were found to be time-transgressive as is the Lakes Entrance - Gippsland Limestone formational boundary. Sandstone development/preservation within the Gurnard Formation was found to be highly variable across the basin. With respect to oil source potential it was found that the delta-front facies of the Latrobe Group contains the highest average total organic carbon (7.85%) and volatile organic carbon (1.79%) of the samples analysed.

Correlation to Pisces-1 has allowed the identification of the three paleo-environment related facies recognised regionally. However, the sand content and T.O.C. content of all three intervals differ markedly from the corresponding averages for the basin. The Latrobe Group section in Pisces-1 appears to have been deposited under different environmental constraints than the major portion of the Gippsland Basin. This observation supports the geophysically based structural interpretation that this well was drilled in a sub-basin on the margin of the main Gippsland Basin.

#### 5. Well Data Trades

To add to Union Texas' Gippsland Basin well database and to provide a control for traded seismic data, Union Texas has traded well data from Pisces-1 for the same from Shell's Hammerhead-1, Vic P/19, Phillips' Helios-1, Vic P/18, and Aquitaine's Edina-1, Vic P/17. A similar exchange is being negotiated for one of the Huidbay wells in Vic P/11.

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The Helios-1 well information has been particularly useful for tying to the Vic P/12 interpretation, and thence to the area of T/13P.

#### 6. Regional Geological Analyses

The regional geology of the Gippsland Basin has been well published and will not be discussed in detail in this report.

Union Texas' efforts have added to the understanding of the regional geology by the various studies mentioned above. The work done by Tom de Windt on regional well correlations is a detailed review of the stratigraphy of the basin. This work has been continued with the preparation of regional paleogeographic maps for the Latrobe Group and immediate post-Latrobe Group sections. These maps and the results from that study are contained in a separate report.

Local geological analyses of the T/13P area and a review of prospects follow as separate sections.

### V. GEOLOGY OF T/13P

#### A. INTRODUCTION

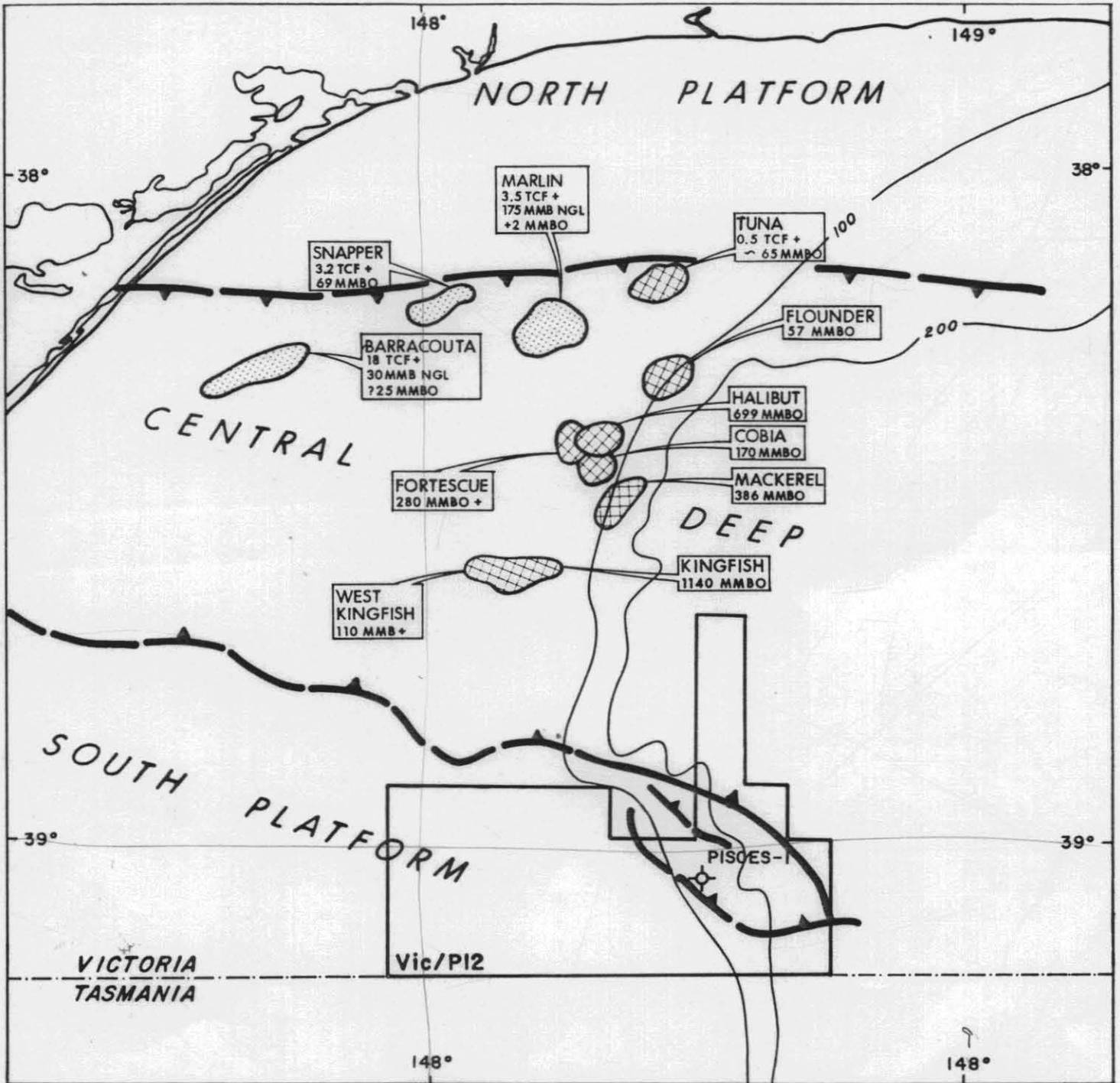
The T/13P permit is located south of the main Gippsland Basin. Most of the Cretaceous - Tertiary sediments comprising this basin are contained in an east-west trending graben bounded to the north by the Rosedale Fault system, and to the south by the Foster Fault System. A greatly reduced sedimentary section extends northwards onto the Northern Platform, and an even thinner cover extends south onto the Southern Platform.

The graben developed during late Jurassic to Late Cretaceous rifting associated with the separation of the Lord Howe Rise and New Zealand from Eastern Australia. The predominantly northwest - oriented normal fault system was established during this time. The oldest sediments deposited were continental, rift-fill greywackes of the Lower Cretaceous Strzelecki Group. As rifting continued and the graben opened to the east, these sediments were overlain by an overall transgressive sequence of quartzose, continental to marginal marine clastics belonging to the Upper Cretaceous to Eocene Latrobe Group. This section contains the source and reservoir for the main oil and gas accumulations in the basin.

A major unconformity occurs at the top of the Latrobe Group. Erosion and subsequent transgression of the Latrobe coarse clastics may have been related to the breakup of Antarctica from Australia and the opening of the Southern Ocean.

An early Tertiary phase of folding, probably related to convergent wrench movement along the major faults, gave rise to northeast - southwest aligned fold structures which contain the major fields of the Gippsland Basin.

During the Late Oligocene - Early Miocene, the basin subsided rapidly and marine mudstones and marls of the Lakes Entrance Formation were deposited in an inner shelf environment. With continued subsidence, bioclastic marls and carbonates of the Miocene-Pliocene Gippsland Limestone were laid down in an outer shelf environment.



--- FAULT



COMMERCIAL OIL FIELD



COMMERCIAL GAS FIELD



GIPPSLAND BASIN

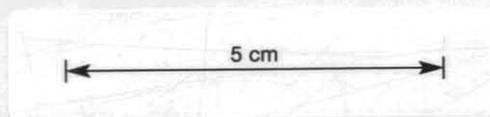
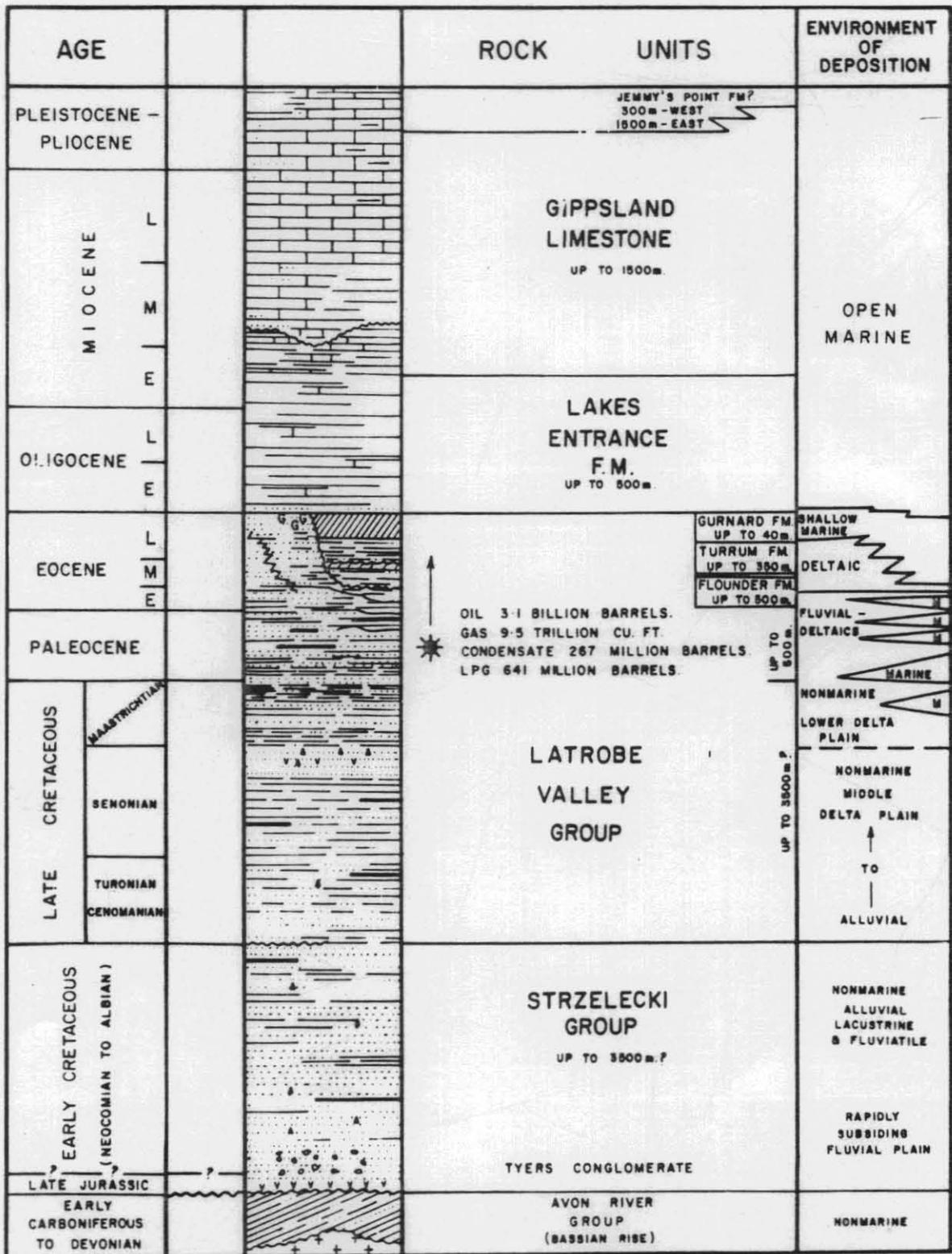


FIGURE 2.



STRATIGRAPHY OF THE OFFSHORE GIPPSLAND BASIN

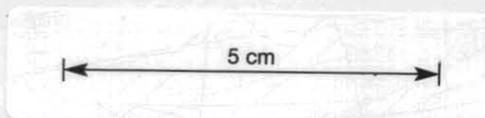


FIGURE 3

## B. REGIONAL SETTING

Permit T/13P covers the southeastern part of the Southern Platform and the Furneaux Islands - northeast Tasmania continental shelf and slope. The northern boundary of the permit is approximately 30km south of the Foster Fault system which forms the southern margin of the deep Gippsland Basin.

The geology of the area is different to that known from the Gippsland Basin. This basin was a rift-graben which received predominantly continental and fluvio-deltaic sediments throughout most of the Cretaceous and early Tertiary before the major marine transgression during the Oligocene. Only the southeastern part of the basin was subjected to marginal and shallow marine conditions since the Late Cretaceous as the basin opened to the east.

In the area of T/13P no such basin was developed. The equivalent Cretaceous to early Tertiary sediments were deposited along a rifted continental margin where the influence of marine conditions is likely to have been more predominant. Small grabens were formed along the edge of the shelf but most of the structuring gave rise to tilted fault blocks dropping basement down to the northeast.

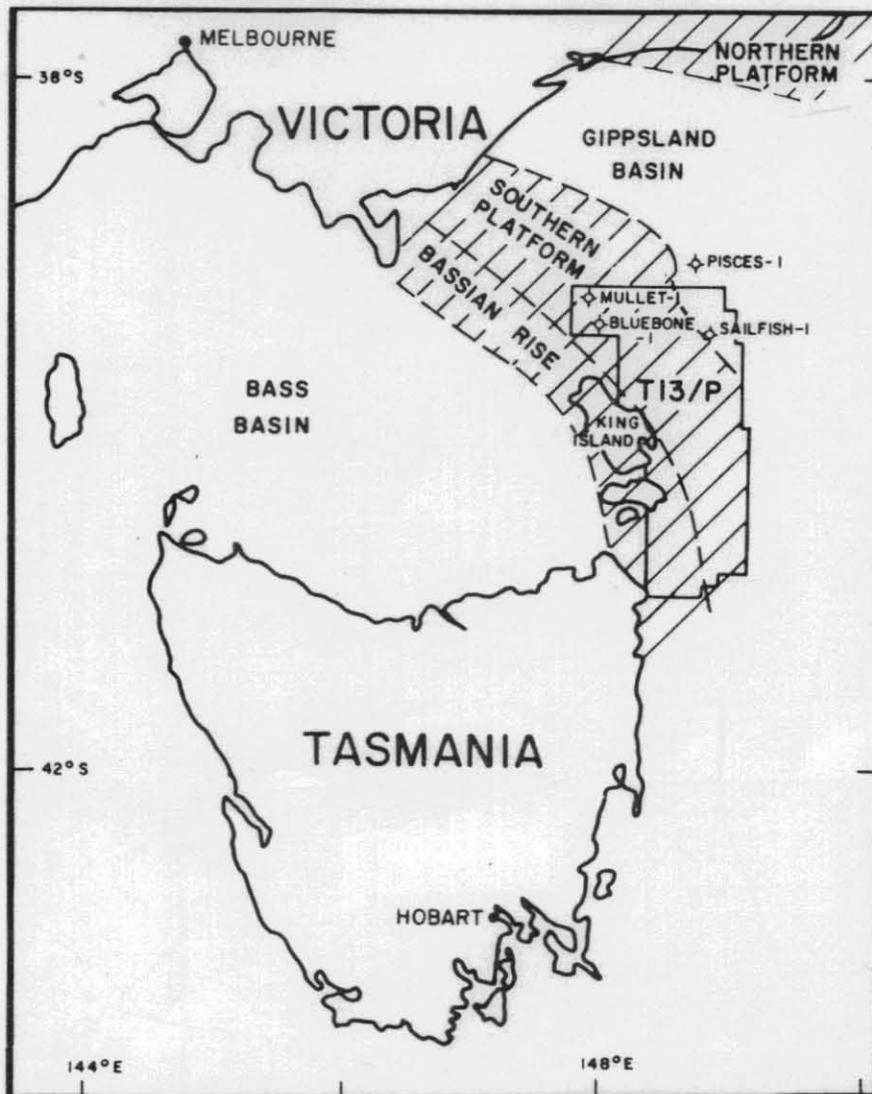
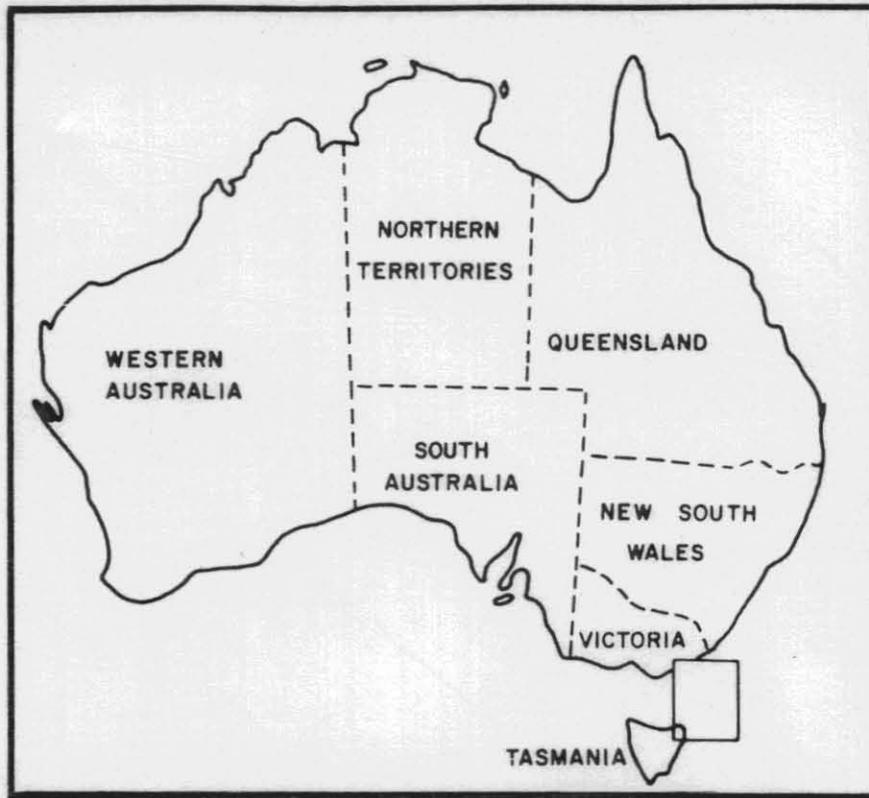
## C. STRUCTURE

The western two-thirds of the permit covers the Southern Platform - shelf feature. This is an extensive area of shallow basement covered by a relatively thin Tertiary section. Basement has been penetrated in four wells drilled on the platform and found to consist of granite in Groper-1, Mullet-1 and Bluebone-1, and siltstones of assumed Devonian-Carboniferous age in Groper-2. Basement rises gradually to the west and southwest where it forms the Bassian Rise which crops out as granite and metamorphosed Paleozoic sediments from Wilson's Promontory to the Flinders and Cape Barren Islands in the Furneaux Group on the western edge of T/13P.

Exposed basement west of the permit area has been an important source for the clastics deposited along the shelf edge. The predominance of granite in the provenance area is important for the supply of quartz sands which are likely to comprise the potential reservoirs in the Latrobe Group.

To the east and northeast the shelf is bounded by a series of north to northwest trending faults which progressively drop basement down to the east, and northeast. These structural lineaments are expressed on the shelf as minor faults and shallow grabens but most of the shelf area has been rather stable.

Scattered volcanics are known to occur in places across the shelf. The Sailfish-1 well encountered basalts, and similar features are observed elsewhere on seismic sections. The feeders for these volcanics have not been observed but their occurrence may be related to deep-seated basement faults.



**PERMIT T13/P, OFFSHORE TASMANIA**  
**LOCATION MAP**

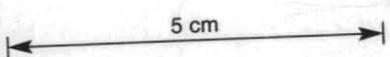


FIGURE 4.

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Basement faulting along the shelf edge is complex. Interpretation of basement structure has been difficult because of this complexity, and because of poor seismic resolution and data quality, and insufficient seismic coverage, particularly over the southern part of the permit.

Two main trends are evident in the mapping of basement faults. The first is aligned NW-SE and is most pronounced in the northeast and inner shelf areas. The second is aligned more N-S and is predominant in the east and along the edge of the shelf to the south.

The NW-SE lineaments are sub-parallel to the Foster and Pisces Fault systems which form the southern margin of the Gippsland Basin. Normal faults dip mainly to the northeast and form several grabens similar to the Pisces Sub-Basin. These depressions open to the southeast. As the Latrobe section thickens to the east and northeast there is some drape of the section over preserved high basement fault blocks. The NW-SE structure appears to be related to the extensional tectonics which formed the Gippsland Basin graben. Most of the extension took place between the Rosedale Fault System in the north and the Foster Fault System in the south but zones of weakness extended into the Southern Platform.

The N-S lineaments on the other hand are probably related to the separation of Tasmanian and the Campbell Plateau. This extension was directed more E-W and gave rise to the tilted basement fault blocks which occur along the margin of the Tasmanian continental shelf. The area in the northeast of T/13P and southeast of Vic P/12 was at the apex of these two rifts and so the complex structuring observed is understandable.

The faulting of basement began in the late Jurassic to early Cretaceous and has continued in some places until the Miocene. The N-S trend seems to post-date the NW-SE trend and overprint it. The style of faulting observed is consistent with a predominantly extensional stress field but there may have been a later component of left-lateral movement during the Tertiary at the same time as movement which has been documented in the Gippsland Basin. An early Tertiary phase of folding, probably related to convergent wrench movement along the major faults, gave rise to northeast - southwest aligned fold structures which contain the major fields of the Gippsland Basin. In the T/13P area fold structures are not so evident. Latrobe structure is mainly related to basement fault blocks.

#### D. STRATIGRAPHY

##### 1. Introduction

Control for the interpretation of stratigraphy in T/13P is very limited. The Mullet-1 and Bluebone-1 wells penetrated the Gippsland Limestone Formation, the Lakes Entrance Formation and a thin Latrobe Group overlying basement on the Southern Platform. Sailfish-1 penetrated Gippsland Limestone Formation and then volcanics at which stage the well was plugged and abandoned. The results from drilling in the permit area to date have provided very little information on the prospective Latrobe Group. The thin Latrobe section tested on the platform is certainly not representative of the section, seen on seismic, which thickens across the outer shelf and shelf edge.

Pisces-1 well, to the north of the permit, is the only well in the vicinity to have drilled a thick section of Latrobe Group. By correlation to this well and from assumptions on the geological history of the area relative to that known from the Gippsland Basin, it is possible to propose a model for the stratigraphy of the area. Much of the geological interpretation is based on the seismic interpretation by Ian Browne.

## 2. Results of previous drilling

Three wells have been drilled in the T/13P permit :- Mullet-1, Bluebone-1, and Sailfish-1.

The results from these wells, and from the Pisces-1 well, are presented below.

### Mullet-1

The first well drilled in the area now covered by permit T/13P was Mullet-1 located in the northwest corner of the block. The well was drilled by Esso in 1969 as the second (the first being Groper-1) of a two well program to evaluate the hydrocarbon potential of a stratigraphic play along what was called the Groper-Mullet trend. The play consisted of a stratigraphic pinchout of Latrobe sands on Devonian granites, with top seal provided by mudstones and marls of the overlying Lakes Entrance Formation. Both wells were plugged and abandoned without shows.

At 702m K.B. Mullet-1 encountered 36m of Eocene sands overlying granitic basement. The upper 20m of this section may represent a sandy equivalent of the Gurnard Formation. The Eocene section was overlain by the Lakes Entrance Formation which was sandy at the base. The absence of hydrocarbons may be attributed to lack of seal at top Latrobe or excessive distance from source rocks.

### Bluebone-1

Following the drilling of Groper-1 and Mullet-1, further work led to the seismic definition of further stratigraphic plays updip and geographically distant from the first two wells. Groper-2 was drilled first followed by Bluebone-1.

Bluebone-1 was proposed to evaluate a large play that was mapped to the south of Mullet-1 in a separate Latrobe embayment. It was hoped that a large hydrocarbon reservoir existed updip from Mullet-1 in the Bluebone location.

The anticipated Latrobe pay consisted of 69m of silty sandstones and mudstones (the top 7m from 522-529m K.B. may be equivalent to the Gurnard Formation). The sands were found to be medium to coarse-grained, poorly to moderately sorted, in part conglomeratic and pebbly, unconsolidated, with clay matrix.

Log derived porosities are in the range 25- 30%, but the Gamma Ray log indicates the sands are silty. Permeability was considered to be poor.

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No hydrocarbons were present. The formation was flushed with water having salinities less than 15,000 p.p.m. The Latrobe section overlaid granite and was overlain by a sandy Lakes Entrance Formation.

The Latrobe sediments were interpreted to represent braided stream sequence with the interbedded silts deposited in overbank or marsh environments. Dipmeter results indicate that sedimentation during Latrobe time at Bluebone-1 tended to the northwest.

As for the previous wells on the Southern Platform, Bluebone-1 was dry because of either inadequate top seal or, more likely, lack of access to migrating hydrocarbons.

#### Sailfish-1

Seismic work completed early in 1971 by NSW Oil and Gas Company N.L. identified a group of seismic anomalies which were interpreted to be reefs forming a trend 50 km long and 10km wide. The Sailfish area was believed to be in a seaward position on a shelf edge during Oligocene to early Miocene time - a condition conducive to reef development.

Sailfish-1 was drilled in 1971 to test one of the isolated seismic anomalies believed to be a porous biohermal reef. The well was located in the northeast part of T/13P. The "reef" was found to comprise porous, non-permeable volcanics. After drilling Gippsland Limestone, weathered basic volcanics were penetrated from 1237m to 1271m K.B., followed by predominantly dark green volcanics to 1422m. Petrographic analyses indicated the rocks to be basic/intermediate lava with a trachytic basalt/ trachytic andesite composition.

It was tentatively suggested that the lavas were formed as a result of both sub-aerial and sub-aqueous extrusion involving relatively rapid cooling.

By stratigraphic position the volcanics are assumed to be of Oligocene to Miocene age.

No hydrocarbons were encountered. Without deeper objectives, the well was plugged and abandoned. The Lakes Entrance Formation and Latrobe Group were not reached.

#### Pisces 1

The Pisces-1 well in Vic P/12 provides the nearest control for stratigraphic interpretation of the Latrobe Group in T/13P. The well was drilled by Union Texas in 1982.

Pisces-1 was designed to test a complex structural/stratigraphic trap in Latrobe Group sediments near the boundary fault of the Southern Platform, within the Pisces Sub-Basin. The Latrobe section was found to consist of late Campanian-Maestrichtian marginal marine and fluvio-deltaic sands and shales, overlying a Campanian section of continental clastics. The upper section (1826m - 2486 K.B.) contained thick, potential reservoir sands but was organically lean and immature for hydrocarbon generation.

The lower Campanian section (2486m-2580m K.B. Total Depth) contained poor reservoir sands but organically rich interbedded shales (T.O.C.'s to 4.37%) which were at the early stages of maturity for oil generation at T.D. Subsequent geochemical analyses indicate that the section below the T.D. of the well may be mature, but the kerogen type identified in samples from the well was not favourable for the generation of large volumes of oil.

As originally proposed, the trap at Pisces-1 relied on vertical seal by the Lakes Entrance Formation. In the event, the Latrobe potential reservoir was found to be overlain by 31m of transgressive marine sands of possible Gurnard, and lower Lakes Entrance Formation. The presence of these sands was thought to have destroyed the integrity of the prospect.

It is now considered that the permeability of these post-Latrobe sands is very questionable and the absence of any oil staining in this section (which would be expected in any low permeability samples if the section had acted as a conduit for oil migrating out of the Latrobe Group at Pisces-1), and above 2200m in the underlying Latrobe Group section, indicates that the area has not seen migrating hydrocarbons, or at least oil. Assuming that the complex structure and stratigraphy did indeed provide lateral seal to the prospect, the preferred explanation for the failure of the test is the lack of access to a significant volume of mature, oil-prone source rocks.

### 3. T/13P Regional Stratigraphy

With only limited well control in the vicinity of T/13P the interpretation of stratigraphy is based largely on seismic interpretation. Mapped seismic events have been tied to the wells to provide some age control. The top Latrobe Group is clearly defined on seismic throughout most of the Gippsland Basin area and has been mapped with confidence in T/13P. Intra-Latrobe and ? Basement events are much more difficult to resolve and stratigraphic ages are speculative. Seismic character has been used as a guide in interpretation of both structure and stratigraphy.

#### i) Basement

The basement lithology is likely to comprise Devonian granite and Paleozoic metasediments. Both lithologies are known from wells drilled on the Southern Platform, and from outcrop on Flinders and Cape Barren Islands which form the central western border of the permit.

Groper-2 penetrated 33m of red siltstones and sandstones considered to be Devonian-Carboniferous in age. The top 16m of siltstone was weathered to plastic clay. Groper-1, Mullet-1 and Bluebone-1 all penetrated granitic basement. By way of example, the granite at Bluebone-1 was described as speckled grey, black and dark green, massive, crystalloblastic and weakly fractured. The top 3m was weathered. The granite is impermeable and would afford an excellent base seal for any stratigraphic traps.

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Seismic resolution of basement is difficult in many areas. It is clearly defined on the platform but cannot easily be recognised where it has been faulted to greater depths. On some seismic lines this can be partly attributed to poor data quality but elsewhere there does not appear to be a marked velocity contrast between basement and the overlying sediments. This may be the result of varying basement lithology and degree of weathering.

The mapped "Red Horizon" is an attempt to define structure at the level of top Paleozoic Basement.

ii) ? Permo-Triassic

Permo-Triassic rocks have not been encountered in the Gippsland Basin but they do occur in eastern Tasmania. Sediments of this age may infill early basement depressions formed prior to the Late Jurassic - early Cretaceous rifting along the northeast Tasmanian continental margin.

iii) ?Late Jurassic - early Late Cretaceous.

Overlying (?) basement is a poorly defined unit interpreted to represent early rift sediments. The unit is best developed along the shelf edge (eg. Line 80F-2) and in the graben in the northeast (eg. Line UTP82-5). The section is characterised by irregular, discontinuous seismic events and a hummocky top surface (eg. Line GUT83P-2A). This surface represents an erosional unconformity which may correlate with the top Lower Cretaceous (Strzelecki Group) unconformity of the Gippsland Basin. Seismic resolution of the boundary with underlying basement is not clear.

This unit may comprise sediments of Late Jurassic to early Late Cretaceous age. An equivalent section was recognised in the Pisces Sub-Basin but it was not reached by the Pisces-1 well. The interval may include rocks of the Strzelecki Formation or equivalent.

The lithology of this section is likely to be similar to that described for the Strzelecki or Otway Groups elsewhere ie. predominantly non-marine greywackes, shales and minor coals. There may also be volcanics associated with the rifting. The lithologies are not likely to include good reservoirs but potential source rocks may be present in coals and lacustrine shales.

iv) Early Campanian

Overlying and infilling the erosional surface on the previous unit is an interval characterised on seismic by fewer but somewhat more continuous events. The top of this unit has been mapped by the 'Blue-Horizon' which in places, particularly in the northeast (eg. Line UTP82-1A), has strong seismic character but is generally only poorly defined. The 'Blue Horizon' has been picked in an attempt Intra-Latrobe structure in the T/13P area. The event has been loosely tied on character to the Vic P/12 interpretation where control from Pisces-1 dates the unit as Early Campanian.

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In the Pisces Sub-Basin this interval could be mapped confidently over a wide area. The top of the interval was penetrated in Pisces-1 and found to consist of predominantly siltstones and claystones with thin interbeds of sandstone and minor coal. The interpreted environment of deposition at Pisces-1 is continental. On the basis of a change in seismic character and in consideration of the interpreted marine environment of deposition for the overlying Late Campanian-Maestrichtian section, it was proposed that the Early Campanian section may be of a marginal marine environment in outer areas of the sub-basin.

The Early Campanian sediments are confined to the east and northeast of the permit area where basement was faulted down to form the shelf edge, and grabens in the adjacent platform. The interval thins onto underlying high basement or older sediments such that in places the 'Blue Horizon' may mark the top of the Lower Cretaceous - early Upper Cretaceous sediments (eg. Line UTP82-3). The top of the Early Campanian appears to be marked locally by an angular unconformity (eg. Line UTP82-5).

As in the Pisces Sub-Basin, the Early Campanian sediments in T/13P were probably deposited in a range of environments from continental to marine. The lowermost sediments, and those in locations proximal to the clastics source on the platform, were probably deposited in continental to marginal marine environments, but elsewhere it is believed marine conditions prevailed. In the east this interval contains few seismic reflectors and may well consist of marine sediments. This early marine environment is considered to be a feature of the Latrobe Group geology in T/13P.

Latrobe clastics would have been derived from exposed basement to the west and southwest. In the troughs adjacent to the platform it is probable that coarse clastics were deposited, interbedded with shales and siltstones. From seismic evidence it appears that the section to the east loses this interbedded character to become more homogeneous, a character consistent with a more marine environment.

Sands within this interval may constitute reservoirs. In Pisces-1, the Early Campanian sands were thin (2-3m) and contained abundant matrix material and could not be considered potential reservoirs. In a more favourable depositional environment however, the reservoir quality of the sands may be improved.

The source potential of this interval may be significant if the lithology in the east comprises marine shales. It is, however, unlikely that these rocks have undergone sufficient maturation for significant hydrocarbon generation.

#### v) Late Campanian - Maestrichtian

By analogy with the Pisces Sub-Basin in Vic P/12 and the control provided by the Pisces-1 well, the upper Latrobe Group section in the east and northeast of T/13P is believed to be mostly Late Campanian-Maestrichtian in age. Direct ties to the Pisces Sub-Basin are not possible because of an intervening basement high over which the Latrobe Group is absent, but it is considered unlikely that the geology differs markedly.

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The Late Campanian-Maestrichtian interval is bounded by the "Blue Horizon" and the "Green Horizon" which marks the top of the Latrobe Group. The section occurs in the grabens in the northeast and along the continental margin.

The unit thins to the northwest in the northern graben and displays slight thinning over high basement areas (eg. Line GUT83P-18A).

In most places the interval is characterised by few internal seismic reflections. A more interbedded character is evident in the grabens developed in the northeast.

In the grabens and areas adjacent to the platform, the Late Campanian-Maestrichtian section probably contains a high percentage of sand deposited in marginal marine and shallow marine environments. An equivalent facies was recognised for rocks of the same age in Pisces-1. These facies may change rapidly to more marine eastwards, as indicated by seismic character.

There is some evidence for a possible buildup of sediment at the top of the Latrobe Group near the shelf edge in the north of the permit. This can be seen on Line GUT83P-17A, and intersecting Lines UTP82-1A, GUT83P-9 and -10. A mounded feature is evident immediately beneath the Latrobe unconformity. The overlying Lakes Entrance Formation onlaps it. The mound may be a buildup of sand deposited in a coastal environment (eg. barrier bar) or it could be volcanics. Although the seismic character of the feature does not have the obvious appearance of volcanics, its geometry tends to indicate this possibility.

vi) Paleocene - Eocene

Tertiary Latrobe sediments were not penetrated in Pisces-1 and seismic correlation indicates they are absent throughout the Pisces Sub-Basin. By analogy, the same may be true for the Latrobe section in the northeast and east of the T/13P area, but the possibility of Tertiary Latrobe cannot be discounted.

Eocene Latrobe sediments are known to occur on the Southern Platform. Mullet-1 penetrated 67m of Eocene Latrobe Group and Bluebone-1 penetrated 21m of the same. At Mullet-1, the lithology was mainly sandstone of a granite wash nature. At Bluebone-1 the section consisted of silty sandstones and mudstones interpreted as being a braided stream sequence with the silts representing overbank or marsh deposits. Dipmeter interpretation indicates that sedimentation during Latrobe time tended to the northwest.

The Latrobe Group is thin on the platform and locally absent over high basement relief. Along the northern border of the permit, the section was eroded off a large area adjacent to the southern edge of the Pisces Sub-Basin. The regional pinchout edge of the Latrobe Group passes through the western part of the permit.

Eocene sediments probably occur overlying the Latrobe coarse clastics. In Pisces-1, the Late Maestrichtian section is unconformably overlain by 31m of glauconitic sands. The lower part of this interval is believed to be Gurnard Formation of (?) Eocene age, deposited as shallow seas transgressed the Latrobe surface, reworking the older sediments.

An equivalent section may occur in the T/13P area. As in the Pisces Sub-Basin, the unit is confined to topographically low areas on the Latrobe surface. Lines GUT83P-18A and -25 illustrate such a section above the Latrobe Group, thickening basinward.

In much of the Gippsland Basin the Gurnard Formation consists of glauconitic siltstones and shales which form part of the seal over the Latrobe Coarse Clastics. The sandy nature of the formation at Pisces-1 may indicate proximity to a clastic source, probably Latrobe Group and basement eroding off the Southern Platform.

Although the Gurnard Formation at Pisces-1 is sandy, it is not considered to be potential reservoir. Sidewall cores from the interval recovered sandstone - very fine to very coarse grained, very poorly sorted, with abundant red clay matrix, mica and glauconite - which would seem to have low porosity and permeability.

#### vii) Early Oligocene

At Pisces-1 the greensand of the Gurnard Formation is unconformably overlain by another greensand unit interpreted to be the Lakes Entrance Greensand of Early Oligocene age. The sands are fine to very coarse grained, with abundant glauconite and pyrite. The finer sands grade to siltstones. This unit represents another marine transgression.

As for the Gurnard Formation, the Lakes Entrance Greensand is probably preserved only in paleotopographic lows. The section may be included in the interval demonstrated on the southeastern ends of Lines GUT83P-18A and -25.

The unit is not considered to have reservoir potential in the Pisces Sub-Basin but it may reduce the sealing capacity of the Lakes Entrance Formation over the Latrobe Group on the Southern Platform.

#### ix) Early Miocene

In the northeast and east of T/13P the Early Miocene Lakes Entrance Formation and overlying Miocene-Pleistocene Gippsland Limestone are of no interest for petroleum geology other than they provide vertical seal for top Latrobe Group structures. On the Southern Platform, however, it is possible that Early Miocene progradational sands constitute potential reservoir.

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The equivalent section of interest occurs in Pisces-1 well between 1681.5m and 1794.5m (K.B.). The top of this section coincides with the "Orange Horizon" which has been mapped on seismic throughout the permit. The section consists of predominantly siltstone grading to shale with thin beds ( 2m) of fine grained sandstone becoming less common towards the base. This lithology may represent the distal deposits of a higher energy progradational wedge for which there is seismic evidence on the Southern Platform.

Seismic interpretation over the Southern Platform in Vic P/12 and the northern part of T/13P indicates a large progradational feature exists along an axis trending northwest. Progradation, as indicated by high amplitude, continuous, downlapping events, (See line GC-11A S.P. 400 east) was directed normal to this axis, ie., to the northeast. The feature is interpreted to be a wedge of sediments prograding across the Southern Platform shelf environment, parallel to a paleoshoreline and source area further to the southwest. The distal edge of this wedge is the section seen in the Pisces-1 well.

The component of coarser clastics in the section may have increased nearer the source but the high amplitude seismic events in the lower Miocene interval do not necessarily indicate sandstone/shale interbeds.

Southwest of the major progradational wedge, and parallel to it, is a massive linear slump zone which was early recognised by Esso and which can be traced seismically over 130 km. The explanation proposed for this feature is that marls and limestones prograding from the southwest formed an unstable sediment wedge which slumped down the paleoslope when structural movements during the Miocene reactivated the Foster Fault.

## E. PETROLEUM GEOLOGY

### 1. Source Rocks

The oil in the Gippsland Basin has been derived mainly from Upper Cretaceous to Paleocene non-marine source rocks. Carbonaceous shales and coals from this interval are very rich in organic matter. The kerogen is terrigenous in origin and comprises predominantly vitrinite, but a high component of exinite enables these land-plant source rocks to generate oil as well as gas.

Various studies indicate that the main phase of oil generation, as measured by vitrinite reflectance of 0.7, occurs at depths exceeding 3500m in the central part of the basin. As the geothermal gradient increases towards the margins of the basin, the depth to this level of maturity becomes less such that at Pisces-1, near the southern margin of the basin, the Vr=0.7 level is indicated to occur at about 2800m.

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The area of interest in T/13P occupies a position similar to the Pisces Sub-Basin. It is suggested that potential source rocks in the area need to be buried to depths of at least 2800m for them to have generated significant volumes of hydrocarbons.

At Pisces-1 the Latrobe Group organic matter was found to consist of Type III kerogen with a predominance of vitrinite and inertinite, which has limited potential for generating oil. Organic matter of similar composition may be expected in the grabens located in the northeast of permit T/13P but elsewhere, along the edge of the shelf, it is suggested that the kerogen in the Upper Cretaceous sediments may be more of the Type I (Alginitic) and Type II (Liptinitic - Exinitic) associated with marine environments. This type of source material is not common in the Gippsland Basin but it is believed that the shelf edge has been subject to marine conditions for the major part of Latrobe Group deposition. Consequently, the source potential of the Latrobe sediments in this area may be high.

The source potential of the underlying ? Jurassic - early Upper Cretaceous rift sediments is not rated as highly. The sediments are likely to be continental and may have some potential if lower alluvial plain coal swamps or lakes existed.

Unfortunately the predicted high potential of the Upper Cretaceous source rocks has probably not been realised in much of the area because of insufficient maturation.

## 2. Reservoir

The fluvial and deltaic sandstone reservoirs typical of the Latrobe Group in the Gippsland Basin are not expected in the eastern, most prospective part of T/13P. Instead, it is predicted that coastal or shallow marine sands are present and seismic evidence indicates these may be best developed near the top of the Latrobe section, adjacent to the edge of the Platform.

The main source for the Latrobe Group clastics in T/13P was exposed basement to the west along the Southern Platform and Bassian Rise where the abundance of granite would have provided a good source for quartzose sands. In the far north of the permit the sediments were locally derived from the basement high which separates the area from the Pisces Sub-Basin. The graben to the south of this high received sediments eroded off it (eg. Line UTP 82-5).

Eocene Latrobe sands on the Southern Platform were tested by Mullet-1 and Bluebone-1. The sands were porous, but poorly to moderately sorted, and silty with low permeability.

The reservoir potential of the ? Jurassic - early Upper Cretaceous section is considered to be poor. The sands are probably mostly immature with low permeabilities.

## 3. Seal

As is the case in the Gippsland Basin, shales of the Oligocene Lakes Entrance Formation may be expected to provide a regional seal to top Latrobe reservoirs. Results from Bluebone-1 and Mullet-1 indicate that on the platform, closer to a presumed clastics source, the lower part of the Lakes Entrance Formation is more sand prone and its sealing capabilities are less assured.

Intra-Latrobe shales may provide seal for deeper reservoirs.

4. Traps

Both stratigraphic and structural traps have been identified in the area of T/13P.

i) Stratigraphic traps

Mullet-1 and Bluebone-1 tested stratigraphic plays along the pinchout edge of the Latrobe Group on basement. This edge occurs in the western part of the permit. The recent seismic programs have been concentrated over areas in the northeast and east of the permit where the Latrobe Group is known to be thicker, so the mapping of traps along the pinchout edge has not been possible. Negative results from the Mullet-1 and Bluebone-1 wells, and from the Groper-1 and -2 wells which tested similar plays, downgrade the potential for accumulations along the Latrobe regional pinchout.

Geophysical studies prior to the drilling of Pisces-1 in Vic P/12, suggested the existence of a very large intra-Lakes Entrance Formation stratigraphic trap trending northwest - southeast across the Southern Platform in the western part of the Vic P/12 and into T/13P. A slightly sandy interval towards the base of the Lakes Entrance Formation in Pisces-1 may represent distal deposits of a clastic wedge prograding across the shelf. The possibility remains that the mapped complex consists of Early Miocene sands deposited in a shelf environment and a trap exists involving structural closure to the north and east, and stratigraphic truncation or facies changes to the south and west.

ii) Structural Traps

Structural traps consist of simple four-way dip closures and fault-bounded closures.

The first type are generally formed by drape of Latrobe Group sediments over older highs, usually basement fault blocks. There is some evidence for structure at top Latrobe related to depositional buildup in the upper part of the Latrobe section (eg. at the intersection of Lines GUT83P-17A and UTP82-1).

The second type of structural trap is formed by north or northwest-trending faults intersecting east or northeast - plunging structural noses such that Latrobe Group sediments are offset against other sediments or basement.

VI REVIEW OF LEADS

The key horizon for mapping prospects in T/13P is the top of the Latrobe Group (Green Horizon). The recently completed seismic interpretation and mapping has identified numerous small closures but few which are large enough to be significant. A description of each lead follows.

Lead 1

Lead 1 is a fault-bounded closure centred about the intersection of lines G-33 and G-39A. The structure is along the southern edge of a graben containing Latrobe and probable Lower Cretaceous sediments. Closure is effected by local dip of top Latrobe section to the northeast into the axis of the graben, and seal across the fault to the southwest against basement of the Southern Platform. A thin Latrobe section probably extends onto the platform. Critical closure is to the northwest along the fault.

Seal against the fault is a risk. Sands in the Latrobe section on the platform, or at the base of the overlying Lakes Entrance Formation, may be in communication with the section within closure and intra-latrobe seals may be jeopardised by a high percentage of sandy clastics adjacent to the fault.

The reservoir potential of the upper Latrobe Group is expected to be good. The setting at Lead-1 is in many ways similar to that of the Pisces-1 location where good reservoir sands comprised 70% of the section.

The main risk for an accumulation at this location is considered to be source. The potential source rock intervals of the Upper Cretaceous (and to a lesser extent Lower Cretaceous) section are locally thin and not likely to have experienced the thermal maturation required for the generation of a significant volume of hydrocarbons.

Area	-	5.95 km <sup>2</sup> (1,470 acres)
Relief	-	52m (170 ft)
Bulk Volume-		130,720 acre ft
Net pay	-	70%
Porosity	-	22%
1 - Sw	-	75%

Oil in place - 117 MMBO

Recoverable reserves 34 - 49 - 63 MMBO  
(Recovery Factor .35 - .50 - .60, Formation Volume Factor 1.2)

Water Depth - 145m (475 ft)  
Depth to reservoir - 1300m (4265 ft)  
T.D. 1830m (6,000 ft)

Lead 2

This is a simple four-way dip-closed structure located on Line GUT83P-26 between Lines UTP82-6A and G-35. The structure mapped at top Latrobe is a roughly equidimensional mound resting on basement near the edge of the Southern Platform. The Latrobe section thins away from the crest in all directions. The overlying Lakes Entrance Formation onlaps the feature and is draped over it. Mapped areal closure is  $4 \text{ km}^2$  (1,000 acres) and relief is 75m (230 ft).

The geometry of this feature is indicative of a volcanic buildup. The anomaly was one of four studied by magnetics modelling in an effort to determine the volcanic or sedimentary nature of the buildup. No magnetic response was associated with the feature and it was suggested that it may be sedimentary in origin. If the latter was the case, there should be some sort of linear trend associated with it. This is not observed. Surrounding lines confirm that the feature is restricted to a small area. It is therefore believed to be volcanic in origin and not prospective.

Similar features have been mapped elsewhere in the permit. In most cases these have a distinctive "ropy" seismic character associated with the mounding, and they overlie the Latrobe unconformity. The pick of the top Latrobe Group seismic event is difficult near these features and it may be that all of them are younger than the Latrobe unconformity, ie. Oligocene - early Miocene.

Sailfish-1 drilled into a pile of Oligocene-Miocene volcanics.

Lead 3

A structure is indicated on lines G-27 and -25 between lines G-37 and -38. The structure relates to very slight relief on basement fault blocks near the edge of the platform. A top Latrobe event has been mapped over this area but the Latrobe section is very thin, if present at all.

The feature does not warrant further investigation.

Lead 4

This is a very small closure ( $1 \text{ km}^2$ , 250 acres) on Line UTP82-2 between Lines GUT83P-18A and UTP82-7A. The structure is the only culmination on a major, broad nose which plunges gently to the east, in response to complex structuring in the underlying basement. The Latrobe Group section thins over high basement. Volcanics appear to overlie the Latrobe surface at the crest of the structure.

The previously identified "Scorpio Prospect" was located in this area. The latest interpretation has failed to confirm the existence of a large top Latrobe closure over the broad basement nose. With the exception of the small mapped closure, the Latrobe section is open up-dip to the west.

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Lead 5

A top Latrobe structure has been mapped at the intersection of Lines UTP82-1A and GUT83P-20A. The structure overlies a high on ? Lower Cretaceous sediments. Minor faults cut the Latrobe surface on Line UPT82-1A but closure is not dependent on the faults.

The Upper Cretaceous section in this area is relatively thin and may not have the same reservoir potential as areas closer to the platform to the west. From a regional analysis it is believed the Latrobe Group in the east of the permit may comprise predominantly marine shales.

The potential source rock section in the area is thin and not deeply buried. It is considered unlikely that significant volumes of hydrocarbons have been generated.

Area	-	2.4 km <sup>2</sup> (590 acres)
Relief	-	20m (65 ft)
Bulk Volume	-	19,600 acre ft
Net pay	-	50%
Porosity	-	22%
1- Sw	-	75%
Oil in Place	-	12.5 MMBO

Lead 6

A top Latrobe structure has been mapped on Line GUT83P-17A between Lines UTP82-1 and GUT83P-9. A thickening of section is evident at the top of the Latrobe Group coincident with the mapped structure. The overlying lower Lakes Entrance Formation onlaps the feature.

As with Lead 2, the geometry of the mapped closure is consistent with the buildup being of volcanic, rather than sedimentary origin. However, in this case, although the prominent relief is local, adjacent seismic lines display evidence of a buildup over a broader area. There is a possibility that the feature is a buildup of coarse clastics deposited in a coastal environment, eg., a barrier bar. Such an environment is consistent with the model for Latrobe Group deposition in the area.

Should the feature comprise a coarse clastic buildup it is well placed to receive hydrocarbons which may have been generated from potential source rocks to the east, but the maturity of these source rocks is doubtful.

In any case, the structure is small (2.6 km<sup>2</sup> 640 acres) and unlikely to be mapped any larger with additional control.

Area	-	2.6 km <sup>2</sup> (640 acres)
Relief	-	46m (150 ft)
Bulk Volume	-	51,480 acre ft
Net pay	-	70%
Porosity	-	22%
1-Sw	-	75%
Oil in place	-	46 MMBO

Recoverable reserves 13 - 19 - 25 MMBO.  
(Recovery Factors .35 - .50 x .65, Formation Volume Factor 1.2)

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Water depth - 130m (425 ft)  
 Depth to reservoir - 1550m (5100 ft)  
 T.D. 1830m (6,000 ft)

Lead 7

A small dip-closed structure at top Latrobe occurs on Line GUT83P-25, southeast of Line GUT83P-24. The mapped area of closure is less than 1 km<sup>2</sup> (250 acres).

Lead 8

A closure of approximately 1 km<sup>2</sup> (250 acres) has been mapped centred about Line G-15 between G-37 and -39. The Latrobe section thins and is draped over a basement horst. The interpretation is complicated by an interval of volcanics overlying the Latrobe surface above the structure.

Lead 9

This lead is located on Lines G-11 and -12, intersecting Line G-37. Top Latrobe structure is related to basement fault blocks and possibly gentle folding. A north-south trending simple closure has been mapped with a maximum area of approximately 4 km<sup>2</sup>. Relief on the structure is 20m.

The structure is well placed to receive hydrocarbons possibly generated in a thicker Latrobe Group section to the east. The location close to the platform should ensure adequate sandstone reservoirs in the section.

Area - 3.8 km<sup>2</sup> (940 acres)  
 Relief - 20m  
 Bulk Volume - 35,720 acre ft  
 Net Pay - 70%  
 Porosity - 22%  
 1 - Sw - 75%  
 Oil in Place - 32 MMBO

Recoverable Reserves 9 - 13 - 17 MMBO  
 (Recovery Factors .35 - .50 - .65, Formation Volume Factor 1.2).

Water Depth - 113m (370 ft)  
 Depth to reservoir - 1475m (4840 ft)  
 T.D. - 1585m 5200 ft

This lead is the Furneaux Play recognised previously by Al Sabitay Consultants in an interpretation for Pan Pacific Petroleum N.L. The previous interpretation had relief on the structure of 65m (compared with 20m in the recent interpretation) which resulted in a greater volume for the structure and higher estimate of 39 MMBO for recoverable reserves.

The nearby Flinders Play to the southeast has only slight expression on the recent interpretation (Line G-10 West of Line G-39).

Lead 10

A small closure is indicated at the intersection of Lines 80F-3, G-35 and -9, where a thin Latrobe section is draped over a high, faulted basement block. Critical closure is to the west and cannot be confirmed because of lack of seismic line control. Closure is unlikely to exceed 2 km<sup>2</sup>. (500 acres).

Lead 11

Another small closure (1 km<sup>2</sup>) has been mapped at the intersection of Lines 80F-4 and G-37. The coverage of seismic lines interpreted has not allowed detailed definition of this lead.

Lead 12

Some indication of a structure is evident on Line G-37 between Lines 80F-5 and G-4. A broad rollover of Latrobe section is evident at that location and closure may exist updip to the west against a north-northwest trending fault. Critical closure is in the northerly direction along this fault and although the seismic grid is sparse, it appears that much of the closure is lost in this direction.

The maximum area of closure can only be a couple of square kilometres. Closure seems to be fault dependent and is by no means assured in view of the fact that Latrobe section is faulted against Latrobe, and a high sand percentage may be expected.

This feature was previously mapped by Al Sabitay Consultants as the Mutton Bird Play. They estimated the structure could contain recoverable reserves of 41.6 MMBO. The recent interpretation has used the same limited seismic coverage and verified the possibility of a structure at the same location but it is not considered to be as large as previously mapped.

Intra-Miocene Lead (Gemini)

The Gemini feature extends from the western part of Vic P/12 into the central northern part of T/13P. It was originally mapped by Cultus Pacific, and remapped by Union Texas in 1982.

The recently completed interpretation has not changed the concept of the Gemini prospect as previously proposed. In Vic P/12, no significant closed structures were mapped over the feature. In T/13P it appears that structural closure may exist but it is poorly controlled. Reservoir and source/migration are considered to be high risk.

The Gemini lead is a prominent northwest - southeast aligned isopach thick within the Lakes Entrance Formation. The top of the feature is defined by the Orange Horizon mapped on seismic. The isopach thick is thought to represent a wedge of clastic sediments which prograded to the northeast across the Southern Platform and may have been reworked by longshore currents.

In the absence of significant closed structures over the isopach thick the prospect was dependent on a combination of stratigraphic seal to the south and west, and regional dip to the north and east. Strong seismic events below the Orange Horizon are truncated to the southwest and a well-defined Miocene slump zone lies sub-parallel along the western margin of the bulldip. This combination of structure and stratigraphy may contain a trap of major proportions.

The mapping of a structural closure on the feature provides a trap independent of stratigraphic seal.

The equivalent section of stratigraphic interest at Gemini, ie., from Intra-Lakes Entrance Formation (Orange Horizon) to Top Latrobe Coarse Clastics (Green Horizon), was penetrated in Pisces-1 between 1681.5m and 1794.5m (K.B.). In the well this section consisted of predominantly siltstone, grading to shale, with thin beds (2m) of fine-grained sandstone becoming less common towards the base. At Pisces-1 this section probably represents the distal edge of a higher energy prograding wedge observed on seismic as the Gemini feature. The section has previously been subdivided on the basis of a decrease in sand and silt in the lower part. It has been suggested that a basal shale unit below 1757m (K.B.) was overlain by a coarser unit (to 1681.5m K.B.) which prograded northeastward. Equivalents of these units can be correlated on seismic to the Gemini location.

It is probable that the component of coarser clastic material did increase to the southwest towards the presumed source for the Lakes Entrance Formation clastics but it cannot be certain that the bright seismic events at the top of the Gemini feature represent thick, coarse sandstones.

The basal shale unit in Pisces-1 is truncated at the Orange Horizon along the western edge of the Gemini buildup, indicating that a possible overlying sand pile remains, either shaled out or truncated towards the southwest.

Reworked marginal marine to shallow marine sands are postulated to provide potential reservoirs. The quality and thickness of these sands is unknown.

The sands in the Gemini Prospect would be confined by mudstones of the overlying Gippsland Limestone Formation and a basal Oligocene shale. Strong reflectors within the upper part of the feature may represent an interbedded sand/shale sequence. Such shales may provide extensive intra-formational seals.

The main source area for the Gemini prospect is the Central Deep of the Gippsland Basin to the north. The isopach thick of the Gemini trend extends across the Foster Fault north of the Vic P/12 permit boundary.

In the Gippsland Basin proper, oil has been generated at depths exceeding 3,500m and has migrated vertically to traps at the Top Latrobe unconformity surface. It has been suggested that the sands at Gemini are in communication with hydrocarbons migrating to the Top Latrobe, but it is now considered unlikely that such pathways exist.

It has also been suggested that mature sediments of Late Cretaceous age, encountered within the Pisces Sub-Basin in Pisces-1, may have provided a secondary source for hydrocarbons migrating into the Gemini feature. From a re-evaluation of the Pisces-1 results and seismic this is also considered to be unlikely.

Access to migrating hydrocarbons is considered to be the main risk for the Gemini prospect. None of the wells drilled on the Southern Platform have encountered even a show of hydrocarbons indicating that long distance lateral migration has not occurred in the area.

## VII. SUMMARY OF POTENTIAL

The northern half of permit T/13P has the best potential for petroleum prospects. The southern half, south of 40 degrees S, is covered by only a few reconnaissance seismic lines (mainly from the 80F - survey) but they are sufficient to demonstrate that the Latrobe Group section is poorly developed in the area. The section appears to thin towards the south on rising basement. The reconnaissance survey is sufficient to discount the possibility of deep sedimentary basins in the area.

In the north, the northeast corner of the permit has been covered by a dense seismic grid. Much of this coverage comprises good quality seismic data acquired since 1980 in the 80F-, GC80-, GC81-, UTP82- and GUT83P- surveys. This data has enabled detailed mapping of structure at the top of the prospective Latrobe Group. This mapping has failed to identify geologically attractive traps large enough to justify further exploration. The structures are typically 1 - 4 km<sup>2</sup> in area and could contain recoverable reserves of only 10-20 MMBO. The largest structure has a mapped areal closure against a fault of 6 km<sup>2</sup>. If the structure is sealed, and there has been access to a sufficient volume of mature, oil-prone source rocks, the trap could contain recoverable reserves of 50 MMBO. Both seal and source, however, are high risk.

One region remains of possible interest for further exploration. South of the recent detailed grid, and north of latitude 40 degrees S, the existing data indicates two areas where structure may exist updip from areas of thicker Latrobe Group.

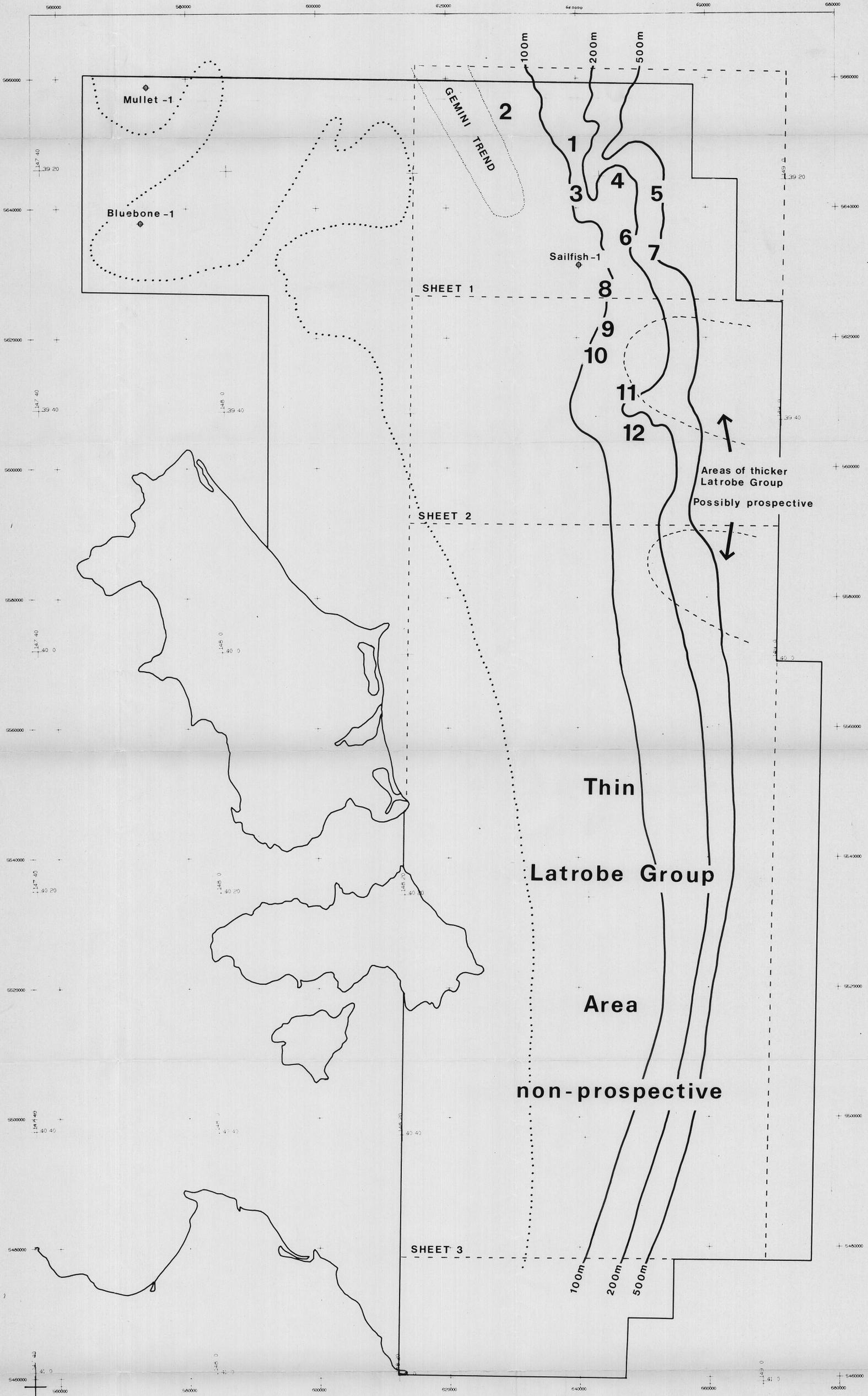
The first area is between lines 80F-2 and -5. Line 80F-4 indicates a broad structure at top Latrobe level. This structure has been mapped as a major basement nose plunging to the east. The grid of G-lines indicates that Latrobe structure generally opens updip to the west but the quality of this data is poor and interpretation is difficult. Also, simple or fault-bound closures may occur further east than the area presently mapped, but still within accessible water depths.

The 80F-2 and -5 lines, and the nearby BMR 82- / line suggest possible thickening of the Latrobe Group section to the east. However, seismic recognition of base Latrobe is difficult and it is uncertain as to whether the section is either sufficiently thick, or deeply buried, for the generation of a significant volume of hydrocarbon from potential source rocks.

The second area of interest is illustrated on the northeastern end of line 80F-8. A reasonably thick Latrobe section is evident in this location, separated from the previous area by elevated basement. The presence of this section is confirmed on Line M-24. Structuring at top Latrobe appears to be minor but intra-Latrobe events indicate more structure at depth. As for the previous area, there are doubts as to the adequacy of the Latrobe Group for hydrocarbon generation.

The exploration potential of the permit may be summarised as follows :-

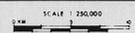
- (i) The southern half of the permit is non-prospective due to the absence of a sufficient Latrobe Group section.
- (ii) The western two-thirds of the northern half of the permit is likewise non-prospective.
- (iii) The northeast corner of the permit has moderate potential but lacks significant structures at the important top Latrobe level. Source is considered to be doubtful.
- (iv) A relatively poorly explored region between the detailed seismic grid in the north-east and about latitude 40 degrees S is of some interest but the potential is not considered sufficient to justify further exploration in the permit.



-  APPROXIMATE LATROBE EDGE
-  LEAD LOCATION
-  WATER DEPTH

Union Texas Petroleum Corporation  
An **ALLIED** Company

**AUSTRALIA  
OFFSHORE TASMANIA  
BLOCK T/13P  
PROSPECTS**  
(See 1:50,000 map sheets for details)

C 1	SCALE 1:250,000	REV. DATE
DATE <b>AUG. 1988</b>		DRAFTED BY
AUTHOR <b>ATKINS</b>		FILE NO.



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02-0110