

T/20P Part 6

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RELINQUISHMENT REPORT

FOR T20P

OFFSHORE OTWAY BASIN,

TASMANIA.

NOVEMBER, 1984.

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RELINQUISHMENT REPORT, T20P, OFFSHORE OTWAY BASIN, TASMANIAINTRODUCTION

Permit T20P covers 4900km<sup>2</sup> in the eastern part of the offshore Otway Basin, adjacent to T17P and bounded to the north by the Tasmanian - Victorian border (Fig. 1). Van Diemens Land Resources N.L. and other interests acquired the acreage in August 1980 and since then have extended preliminary investigations to include extra seismic coverage. More recently, detailed seismic re-interpretation has been done, and geochemical tests conducted on samples from several offshore wells in and adjacent to T17P and T20P. Results are generally discouraging, and we now regard T20P of low prospectivity.

This relinquishment report summarises the stratigraphy, structure, geochemistry and prospectivity of the eastern offshore Otway Basin in relation to T20P.

Summary of Exploration History, Offshore Otway Basin.

About 80 wells have been drilled in the Otway Basin, 14 of them offshore (Fig. 1). Results have been disappointing. Despite some encouraging onshore shows including one commercial carbon dioxide field, some small gas discoveries, and positive drill stem tests for gas in the offshore Pecten -1 and Crayfish -1 wells, the Basin has no proven plays. The main targets have been Upper Cretaceous plays, but most of these sediments are now regarded as thermally immature. Offshore drilling has therefore been located either in seaward extensions of known onshore hydrocarbon occurrences, or where the Upper Cretaceous is thickest (eg. Voluta Trough, Fig. 1). Several wells do not fit this pattern. Prawn - 1A, for example, drilled and abandoned in T17P, was partly a stratigraphic well which also tested an Upper Cretaceous play in a previously unexplored part of the basin, and Whelk -1 further south intersected basement at shallower depths.

STRATIGRAPHYGeneral

Otway Basin stratigraphy is summarised in Fig. 2 in relation to hydrocarbon shows and general prospectivity. Formation of the Otway, Bass and Gippsland basins was related to the Late Jurassic - Early Cretaceous separation of Australia from Antarctica. The Otway Group, deposited during initial

rifting and subsidence, comprises about 5000m. of mainly non-marine lithic sandstones, mudstones and greywackes. Several offshore wells terminated in the Upper Otway Group and some have encountered the Pretty Hill reservoir unit. In Whelk -1, the Otway Group was missing, and Upper Cretaceous Waarre Sandstone rested on PreCambrian basement. Most wells indicate the Early Cretaceous sediments to be strongly affected by diagenesis, and they now have very low primary porosity.

The Upper Cretaceous Sherbrook Group, a sequence of marine and non-marine sediments unconformably overlying the Otway Group is equivalent in part to the Eastern View in Bass and the Latrobe in Gippsland. It has been regarded as the most promising sequence in the Basin. A common play has been the Waarre sandstone at its base as reservoir, sourced from the overlying Belfast Mudstone (and possibly the underlying Eumeralla) and sealed by the Belfast. Other plays include Upper Otway Group (intra - Eumeralla), upper Sherbrook (Curdies and Paaratte), and base-Tertiary. The Lower Otway Group Pretty Hill Sandstone seems a promising reservoir onshore, but becomes shaley and deeply buried offshore, except at Crayfish - 1 in the Gambier Embayment.

East-west and north-south stratigraphic and structural cross sections between several offshore wells (Figures 3 and 4) have important implications for prospectivity:

- : the westward thickening of the source/seal Belfast Mudstone in the Voluta area (Figure 3).
- : the apparent thinning and deepening of the Belfast south through Prawn - A1 (Figure 4).
- : the southerly thickening and increased sandiness of the Sherbrook Group through Prawn - A1.

Prawn - 1A was a dry hole drilled to 3166m (10388') subsea (Fig. 1). The interpreted stratigraphy (Fig. 4) is

AGE	GROUP	FORMATION	THICKNESS (m)
Tertiary			1238
U. Cretaceous	Sherbrook	Curdies/Paaratte	910
		Belfast	52
		Flaxmans/Belfast	629
		Waarre	88
L. Cretaceous	Otway		249

The well tested a deep anticlinal structure originally thought to have been developed in pre-Sherbrook Group sediments, with possible minimal closure into the base Tertiary. It is now known that this structural picture is correct, the hole being located downdip on a Waarre high.

Prawn -1A was an important stratigraphic well with several implications for hydrocarbon prospectivity in T20P and the eastern Otway Basin. It attempted to assess various horizons which elsewhere in Otway are prospective or marginally prospective:

- : a Curdies reservoir sourced from the Upper Sherbrook and sealed by the base-Tertiary.
- : a lower Sherbrook play with the Waarre as reservoir, sourced by the Belfast and possibly the underlying Otway Group, and sealed by the Belfast, and
- : an intra-Eumeralla play sourced, sealed and reservoired in the Upper Otway Group.

and showed that :-

- : although the Sherbrook Group was unexpectedly thick, and good reservoirs were found in the Curdies, a source was not present. Also, the high permeability sands continued above the base-Tertiary uninterrupted by adequate seals. Structural closure did not extend above the top Sherbrook.
- : the Belfast as possible source and seal was unexpectedly thin, and appears to thin down-dip to the south (Figure 4). The undifferentiated Belfast/Flaxmans as possible reservoir was either too impermeable or water-saturated.
- : significantly, the Waarre Sandstone, regarded as prospective throughout the Otway Basin, proved to be a hard, siliceous, impermeable conglomerate
- : the Otway Group Eumeralla Formation below the Waarre has undergone extensive diagenesis and was hard and impermeable.
- : All post Otway Group sediments are either transitionally mature (Belfast) or immature.

#### STRUCTURE

Basins were produced by a Late-Jurassic to Eocene tensional, basin forming regime probably initiated by dextral and rotational displacement between Australia and Antarctica. Trends are influenced by earlier structural grains. Predominant E-W trends on the northern Otway swing SE-NW along the Bassian Rise, and south of T20P, trends are mainly NNW-SSE, related to structural features of the onshore Tasmanian Palaeozoic.

Most faults are normal in Otway Basin, delineating grabens and half-grabens downthrown to the south and southwest towards the continental margin. They range mostly from Late Jurassic to Eocene in age. The post Eocene regional compression which produced the anticlinal traps in the top-Eastern View and Latrobe Groups in Bass and Gippsland did not develop to the same extent in the Otway Basin. The regional compression of the Otway Ranges only just reached the northern part of T20P. Some small wrench features have been identified.

Figure 6 and 7 are structural reassessments of T20P and T17P based on recent re-interpretation of seismic lines. It was found possible to draw time structure maps on basement (pre-Otway Group) and near top-Waarre Sandstone (base Sherbrook Group).

The basement contour map (Fig. 6) shows a general southwest deepening to the continental margin, and predominant NW-SE normal fault orientation. South of Prawn - 1A, the faults trend more N-S, with a minor E-W component. No predominant basement structures are evident.

Structure at the top Waarre (Fig. 7) shows:

- : a SW deepening towards the continental shelf
- : a major NNW-SSE trending normal bounding fault, together with similar NW-SE and NNW-SSE trends on minor faults
- : probable widespread volcanic activity near base-Tertiary level
- : several possible structures near top-Waarre.

This re-interpretation suggests that Whelk -1 was drilled on a high caused by drape over basement, and that Prawn - 1A was probably located off-structure on a marginal, anticlinal feature complicated by normal faulting.

The Prawn structural trend probably continues NW and N and may be

related to the larger, Abalone structure (Fig. 8) mapped previously in Vic P16. Fig. 9 is a seismic section along line OMQ81-31 (from Fig. 8) through the Abalone prospect.

Of the several possible near top-Waarre structures indicated on Fig. 7, several are based on limited data. All are regarded as only marginally prospective.

### HYDROCARBON PROSPECTIVITY

#### General

Hydrocarbon shows in the basal Upper Cretaceous to Tertiary and pieces of bitumen on the beaches indicate that source rocks are present in the Otway Basin. However, the basin has been regarded as generally immature ( $R_o$  values are in the range 0.1 - 0.4, and average 0.2%, per km.). The most likely source rocks (Otway Group, Belfast Mudstone) have moderate but probably sufficient total organic carbon contents for commercial hydrocarbon generation. Thermal gradients range from 2.1 - 2.5°C/100m.

#### Basin Geohistory

In 1982, Van Diemens Land Resources commissioned a geohistory study of Otway Basin. Burial and thermal geohistory curves (Fig. 10) were prepared for each of 10 offshore wells, including Prawn - 1A and Whelk - 1. The study showed:-

- : Otway Group sediments were deposited during rapid subsidence in the initial stages of rift-valley formation. The sediments are arkosic, lithic and poorly sorted.
- : subsidence during Waarre times was very slow (in contrast to the tectonic regime during Otway Group sedimentation) and is probably related to incipient spreading of the Southern Ocean. Significantly, in Prawn - 1A, subsidence during the Waarre was very rapid, and conglomerates were deposited. These are now silicified, hard and impermeable, and probably non-prospective. The Waarre in Prawn - 1A may represent a fan-like deposit derived from the Precambrian quartzites of the Bassian Rise.
- : The Post-Waarre to Recent subsidence decreases exponentially with time for wells, with minor variations (reflecting changing oceanic crustal cooling rates) expressed as base and mid Tertiary unconformities.

- : major faulting during subsidence is generally pre-Tertiary
- : Belfast mudstone, regarded as the prime source for previous drilling, is only transitionally mature in nine wells. It was not present in Whelk -1, which intersected a coarse Waarre Sandstone draped over a basement high.

The Belfast is known to be thicker and mature in the Voluta Trough and it may also get mature W and SW of Prawn - A1 if it thickens towards the Continental Shelf. Plays with a Belfast source in T20P would then depend on eastwards up-dip migration across faults, and accumulation in suitable traps.

Accounts of stranded bitumenous material along the SE Australian coast may indicate that the Belfast or deeper horizons are presently generating hydrocarbons near the Continental Shelf, and that leakage up faults during up-dip migration eastwards has prevented commercial accumulation in T20P.

The Lower Cretaceous Otway Group is mature, and shows in several wells below the Base Sherbrook (Waarre) indicate some hydrocarbon generation. However, overall low prospectivity is indicated for the Otway Group because the rocks are usually hard and of very low primary porosity. Low, but locally high permeability can be expected from secondary fracture porosity. Porosity would further decrease with depth and Ro values suggest the Lower Otway may be gas prone.

#### Geochemistry

In a recent geochemical survey, 20 samples from five wells in the eastern Otway Basin were analysed to assess their hydrocarbon generating potential (See Fig. 11 for Ro values). TOC values exceeded 0.5% in 15 samples, and 5 showed fair source rock richness (>2 kg/tonne). Hydrogen indices showed the organic material ranged from humic Type III to inertinite IV. Four samples showed Type III kerogen, suggesting liquid generation. Supportive pyrolysis-gas chromatography of the same samples indicated high proportions of C<sub>15+</sub> hydrocarbons.

The geochemical study concluded that the Belfast and younger rocks were non-prospective, and that the Otway Group with its large volume of fair source rock richness and adequate Ro values, had a high

potential for generating waxy paraffinic crudes. However suitable migration, reservoirs and seals would need to exist.

#### SUMMARY

##### Source

Possible sources are the Otway Group and the Belfast Mudstone. The top-Otway in Prawn - 1A is fully mature ( $R_o$  approx. 0.9, average 0.6%, Fig. 11) and is possibly generating waxy crudes from a fair TOC.

The Belfast in Prawn - A1 (and T20P) is at best marginally mature. As a source it requires W or SW thickening and up-dip migration into the permit area.

Rocks younger than the lower-Sherbrook are immature.

##### Reservoir

Prawn - A1 intersected several good reservoirs. The Waarre is a suitable sand over much of Otway Basin, but in Prawn - A1 was a hard, impermeable conglomerate. Elsewhere in T17P it must therefore be regarded as suspect.

The top Sherbrook (Curdies/Paaratte) shows good (up to 29%) porosity and permeability, but porosity continues above the base Tertiary, and no suitable seals exist. In any case, Curdies as a reservoir relies on vertical migration from the Belfast or deeper sources and lower reservoirs in the Belfast and Flaxmans could be expected to fill first.

Intra-Otway Group sands are possible reservoirs, but previous drilling to the top-Eumeralla shows the sediments to be indurated and generally impermeable. Permeability from secondary (fracture) porosity will be variable and hydrocarbon yields low (as indicated by several onshore wells).

Where it has been intersected (usually onshore), the base-Otway Pretty Hill Sandstone is a good reservoir, but this is of variable thickness. Prospectivity relies on lateral migration through the Otway Group.

The sand is generally deep and impossible to map seismically on T20P.

### Seals

The Waarre at Prawn -1A was impermeable and it may locally act as a seal. The Belfast was sandy and thin at Prawn - A1, and generally suitable seals probably do not occur in the Sherbrook. Intra-Otway seals are possible.

### CONCLUSIONS

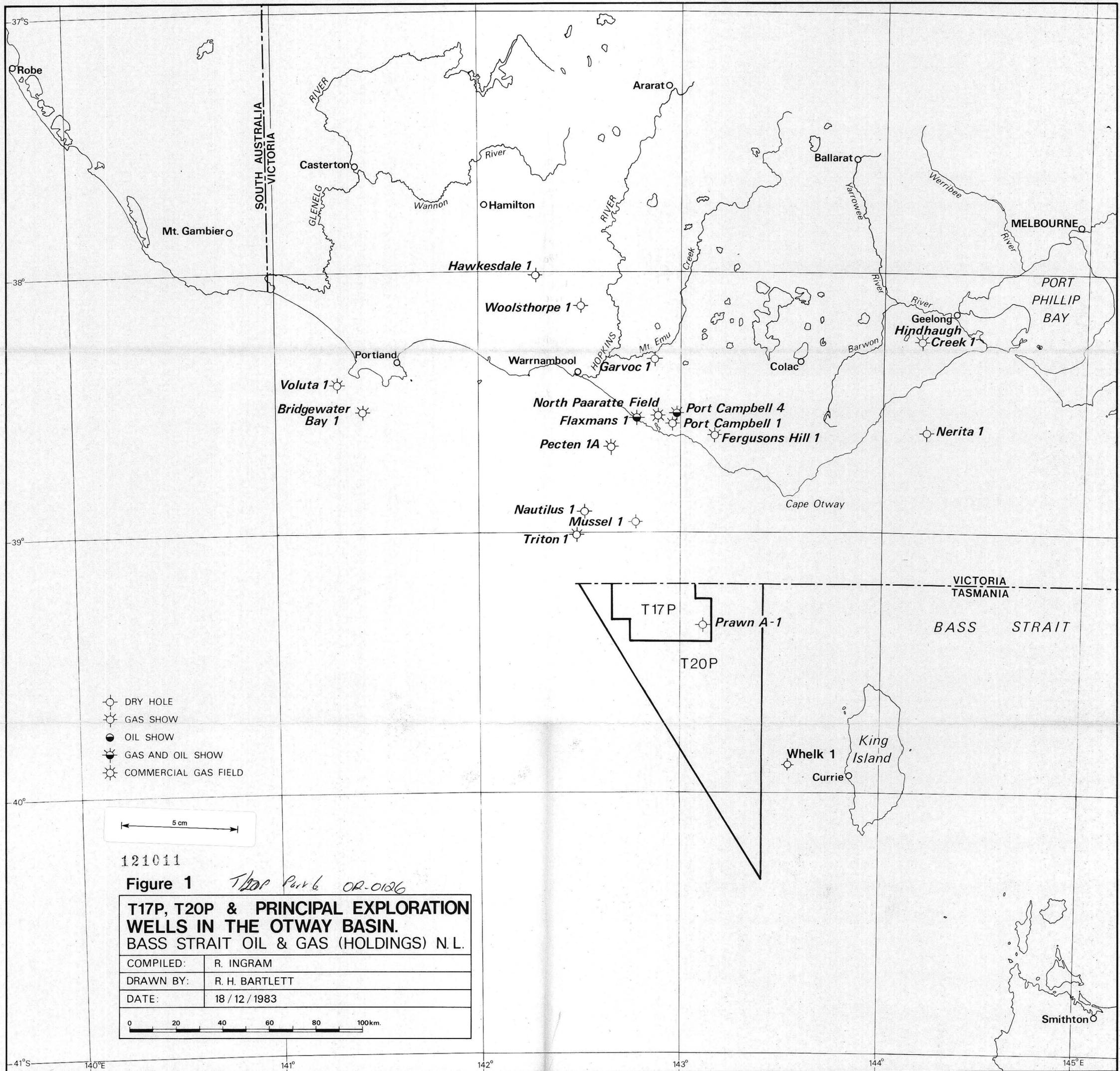
Source The Otway Group is presently generating hydrocarbons but may be gas prone. The Belfast Mudstone may be a source further offshore if it is deeper and thicker, but suitable migration paths into T20P are unlikely. In T20P it is transitionally mature, and all younger sediments are immature.

Seal In T20P, the top Otway Group and locally the Waare Sandstone may be suitable seal. The Belfast is thin and sandy.

Reservoir Several exist in the Sherbrook Group, and locally the Otway Group may contain non-commercial accumulations.

Structure No major prospective structures have been mapped at near top-Waarre, the most likely horizon.

The most likely play in T20P is sourced, sealed and reservoired intra-Otway, but hydrocarbons if present will probably be non-commercial. The permit is therefore regarded as non-prospective.



- DRY HOLE
- ☀ GAS SHOW
- OIL SHOW
- ☀ GAS AND OIL SHOW
- ☀ COMMERCIAL GAS FIELD

5 cm

121011

Figure 1 *T20P Part 6 OR-0126*

**T17P, T20P & PRINCIPAL EXPLORATION WELLS IN THE OTWAY BASIN.**  
 BASS STRAIT OIL & GAS (HOLDINGS) N.L.

COMPILED:	R. INGRAM
DRAWN BY:	R. H. BARTLETT
DATE:	18 / 12 / 1983

0 20 40 60 80 100km.

# OTWAY BASIN STRATIGRAPHY

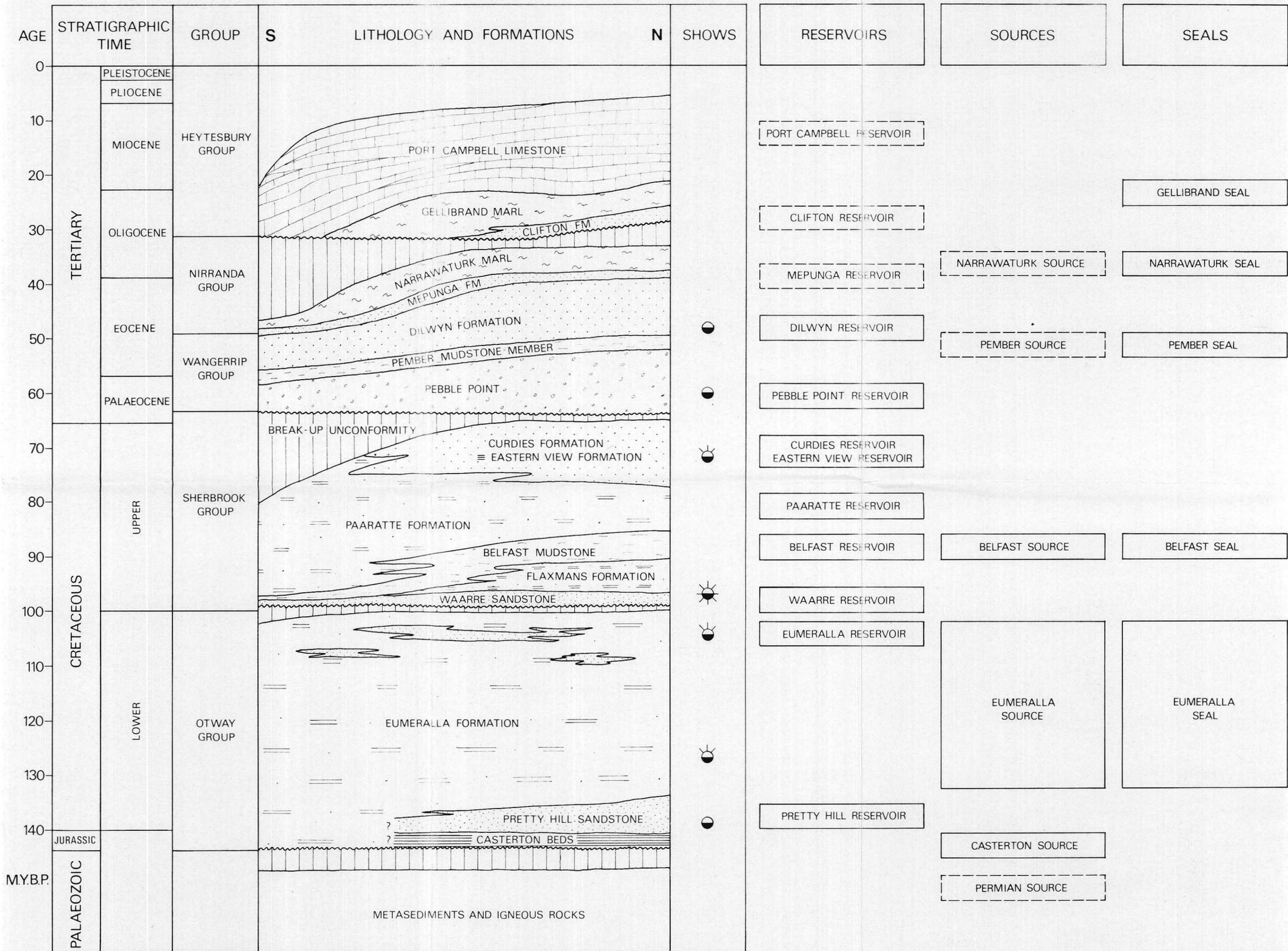
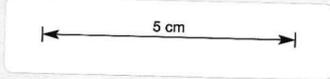
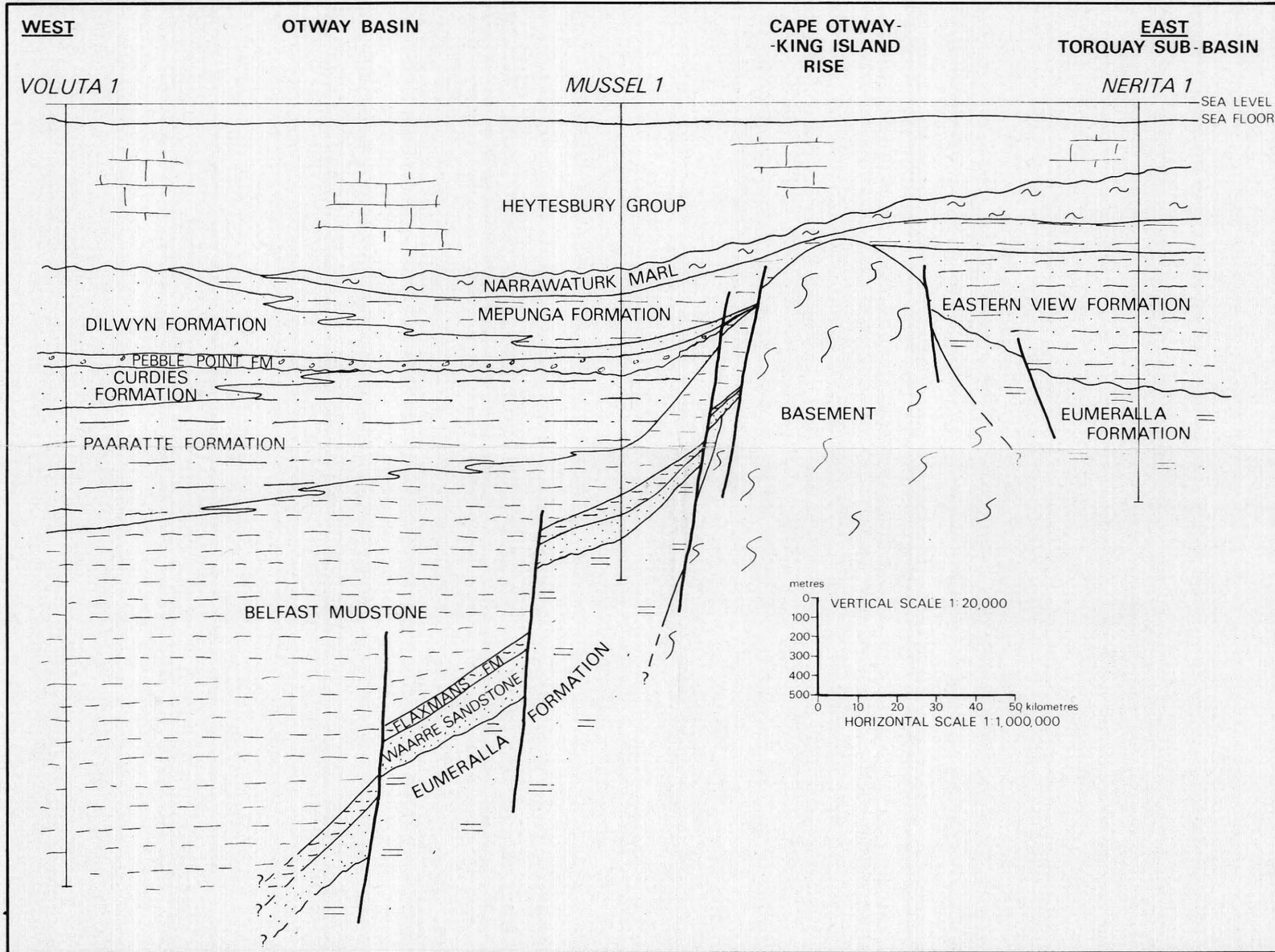


FIGURE 2 OR-0126

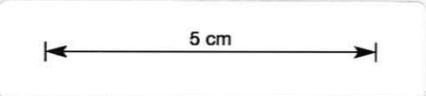
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121012



# CROSS SECTION WEST-EAST



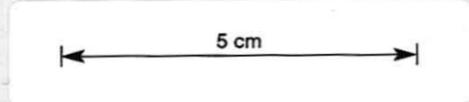
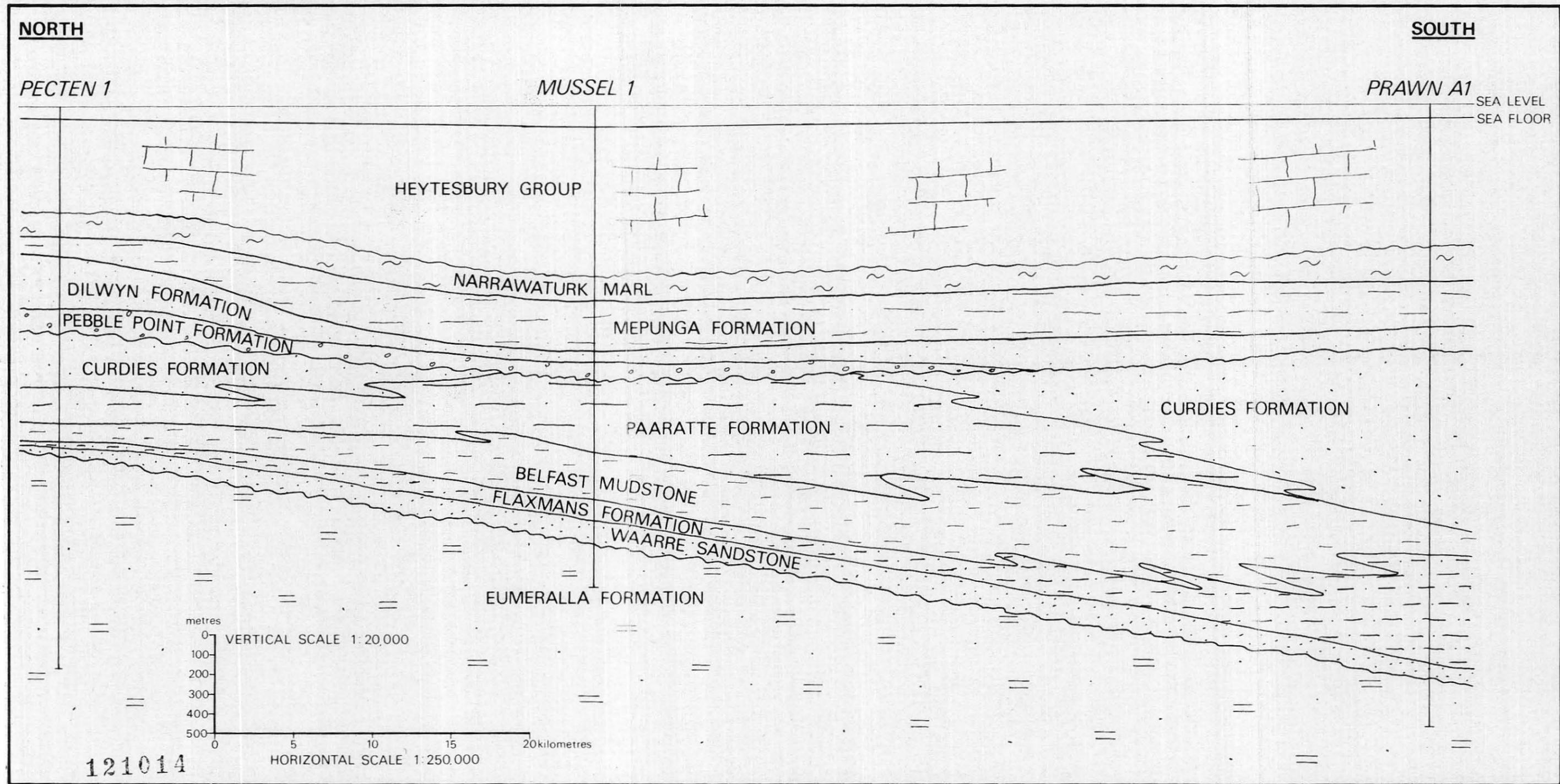
**FIGURE 3** *OR-0126*



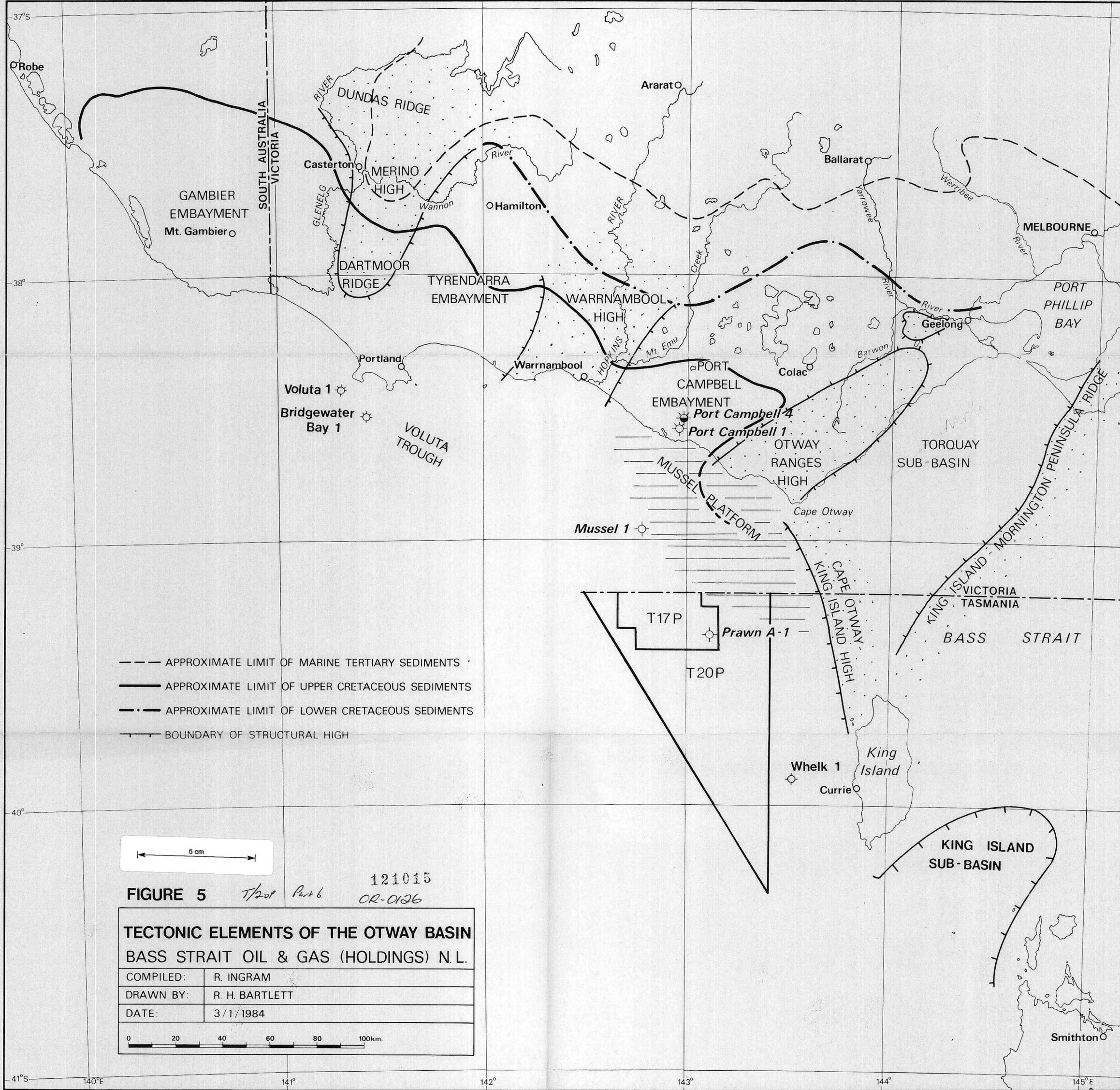
121013

*1/20 P Part 6*

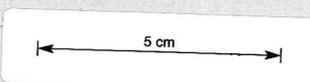
# CROSS SECTION NORTH-SOUTH



**FIGURE 4** *Thop Part 6 OR-0126*



- APPROXIMATE LIMIT OF MARINE TERTIARY SEDIMENTS
- APPROXIMATE LIMIT OF UPPER CRETACEOUS SEDIMENTS
- · - APPROXIMATE LIMIT OF LOWER CRETACEOUS SEDIMENTS
- | - BOUNDARY OF STRUCTURAL HIGH



121015  
 FIGURE 5 *T/201 Part 6* OR-0126

<b>TECTONIC ELEMENTS OF THE OTWAY BASIN</b>	
<b>BASS STRAIT OIL &amp; GAS (HOLDINGS) N. L.</b>	
COMPILED:	R. INGRAM
DRAWN BY:	R. H. BARTLETT
DATE:	3/1/1984



37°S 38° 39° 40° 41°S 140°E 141° 142° 143° 144° 145°E

# WICKHAM

ZONE - ZON1

1:250,000

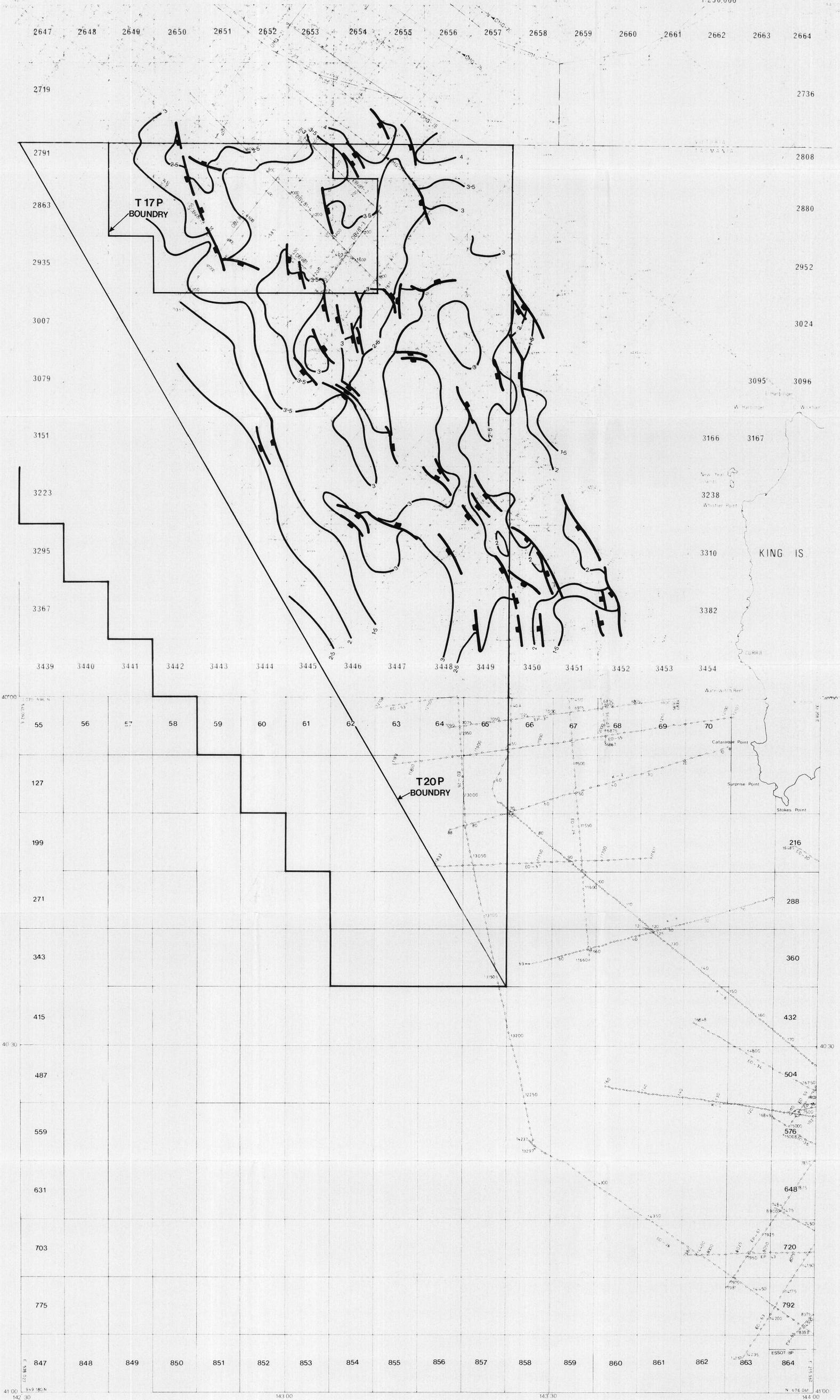


FIG. 6



PETRECON AUSTRALIA PTY. LTD.



T17P & T20P

84/1

TWO WAY TIME STRUCTURE  
CONTOURS ON PRE-OTWAY  
BASEMENT  
CONTOURS IN SECONDS

COMPILED	DEL
DRAWN	NR
DATE	Nov. 84
SCALE	
FIGURE	6

T/20P Arr 6

CR-066

121016

WICKHAM

1:250 000

2647 2648 2649 2650 2651 2652 2653 2654 2655 2656 2657 2658 2659 2660 2661 2662 2663 2664

2719 2736

2791 2808

2863 2880

2935 2952

3007 3024

3079 3096

3151 3166 3167

3223 3238

3295 3310 KING IS

3367 3382

3439 3440 3441 3442 3443 3444 3445 3446 3447 3448 3449 3450 3451 3452 3453 3454

55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70

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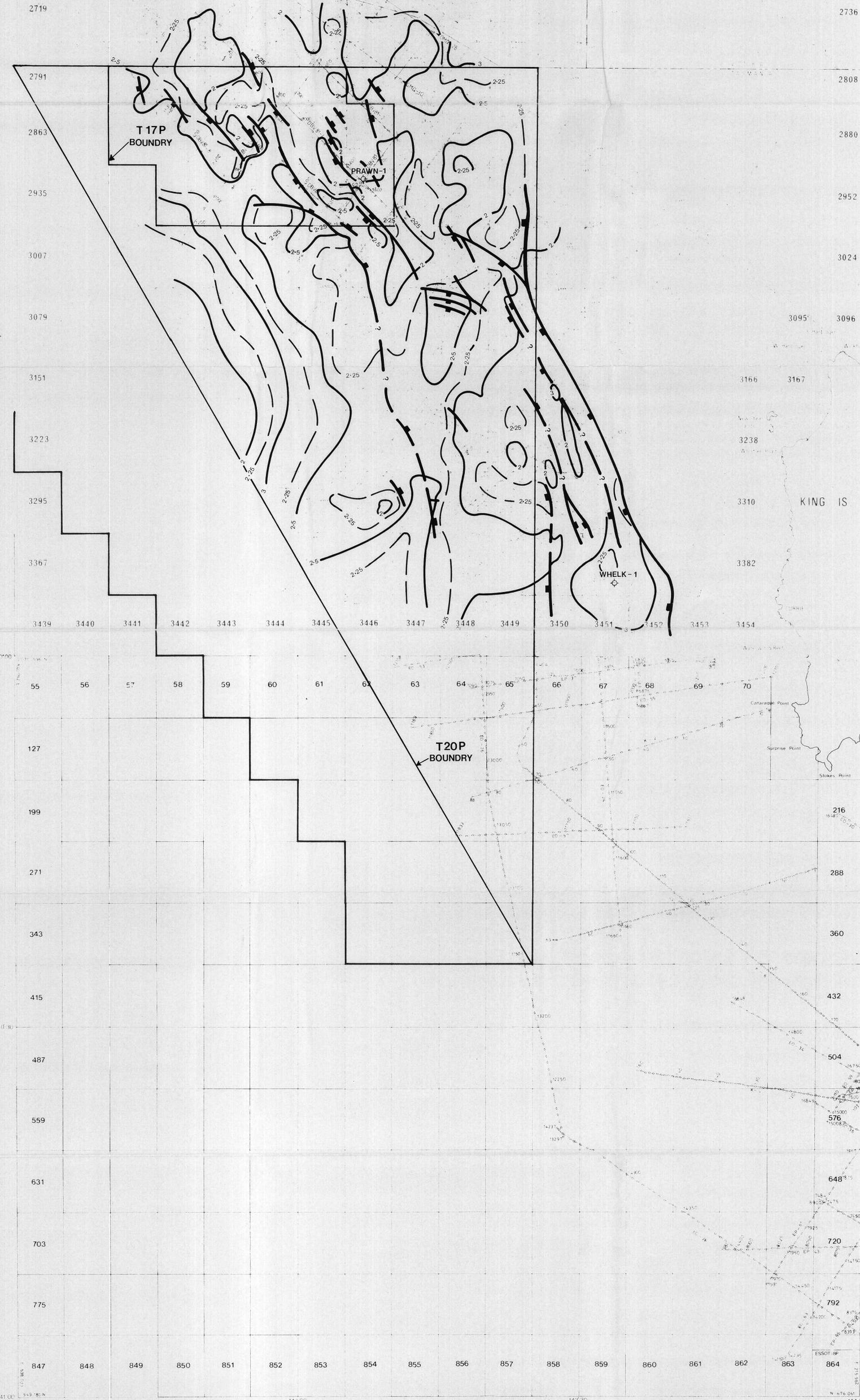


FIG. 7



PETRECON AUSTRALIA PTY. LTD.

T17P & T20P

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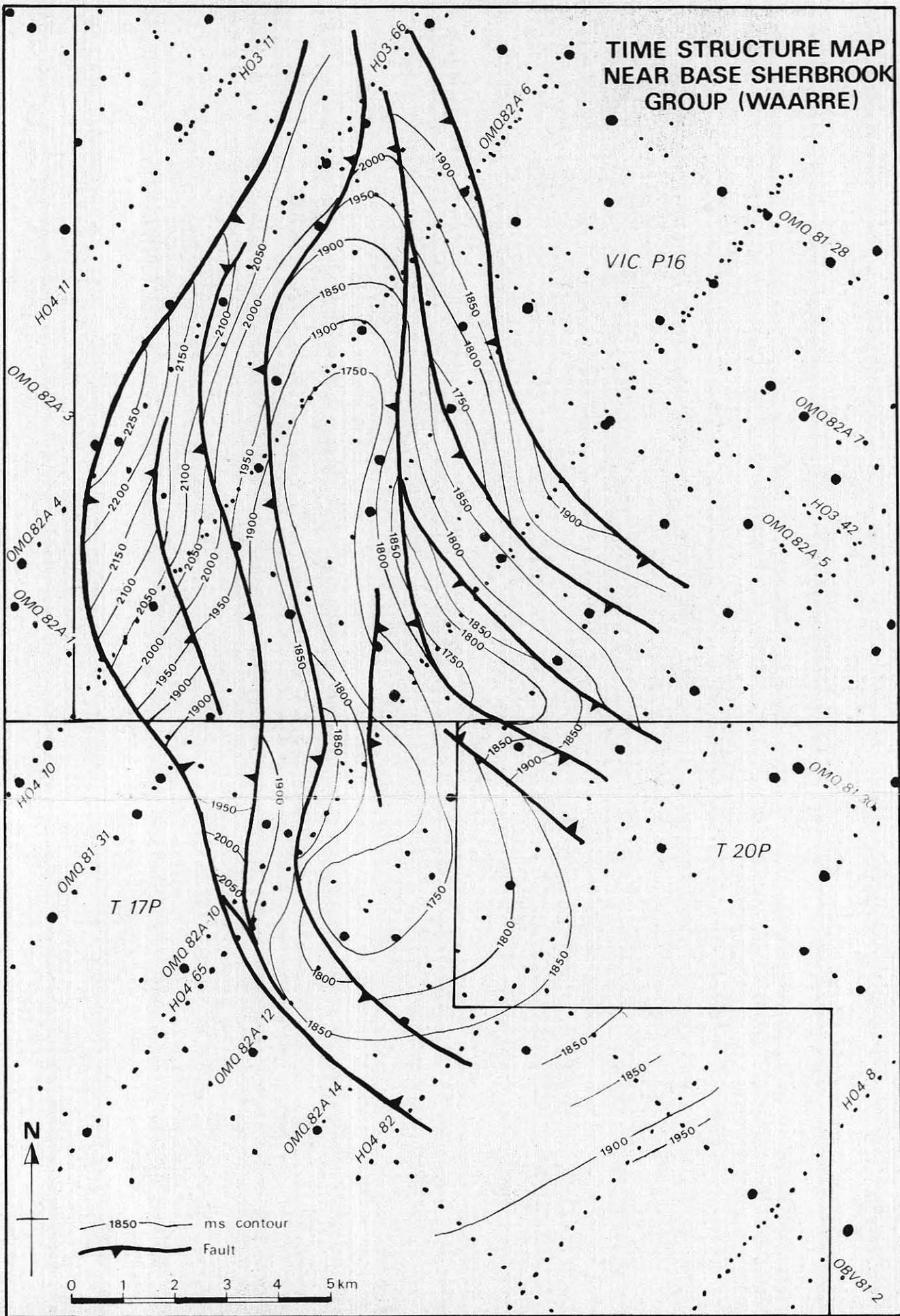
TWO WAY TIME STRUCTURE  
 CONTOURS AT TOP WAARRE  
 (BASE SHERBROOK GROUP)  
 CONTOURS IN SECONDS

COMPILED	DEL
DRAWN	N.R
DATE	Nov. 84
SCALE	
FIGURE	7

T/20P Part 6

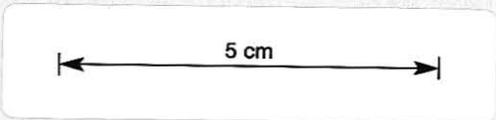
OR-0106

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**FIGURE 8**

*OR-0126*  
*T/20 P Part 6*



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# OMQ 81 - 31

## ABALONE PROSPECT

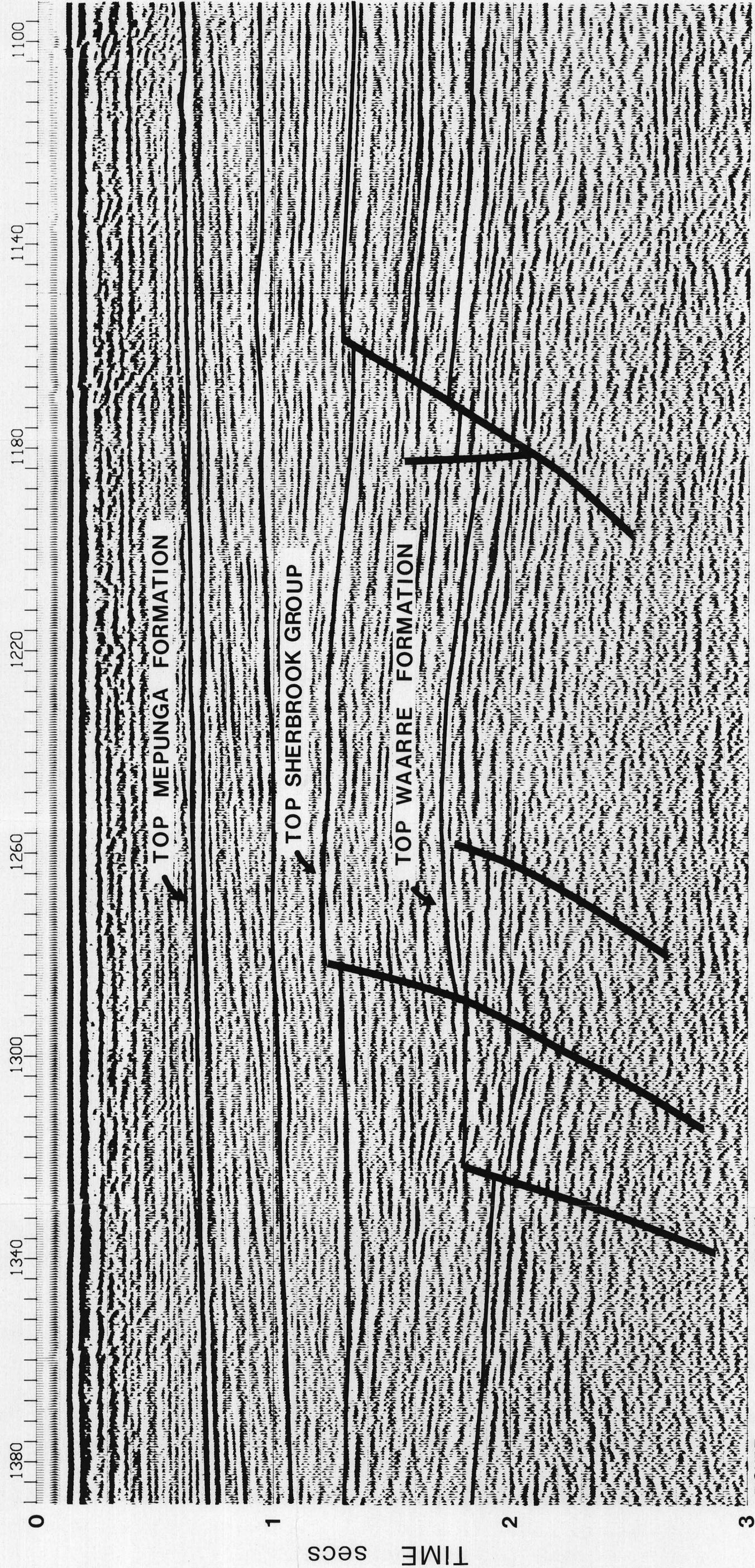
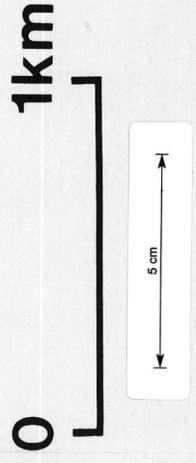
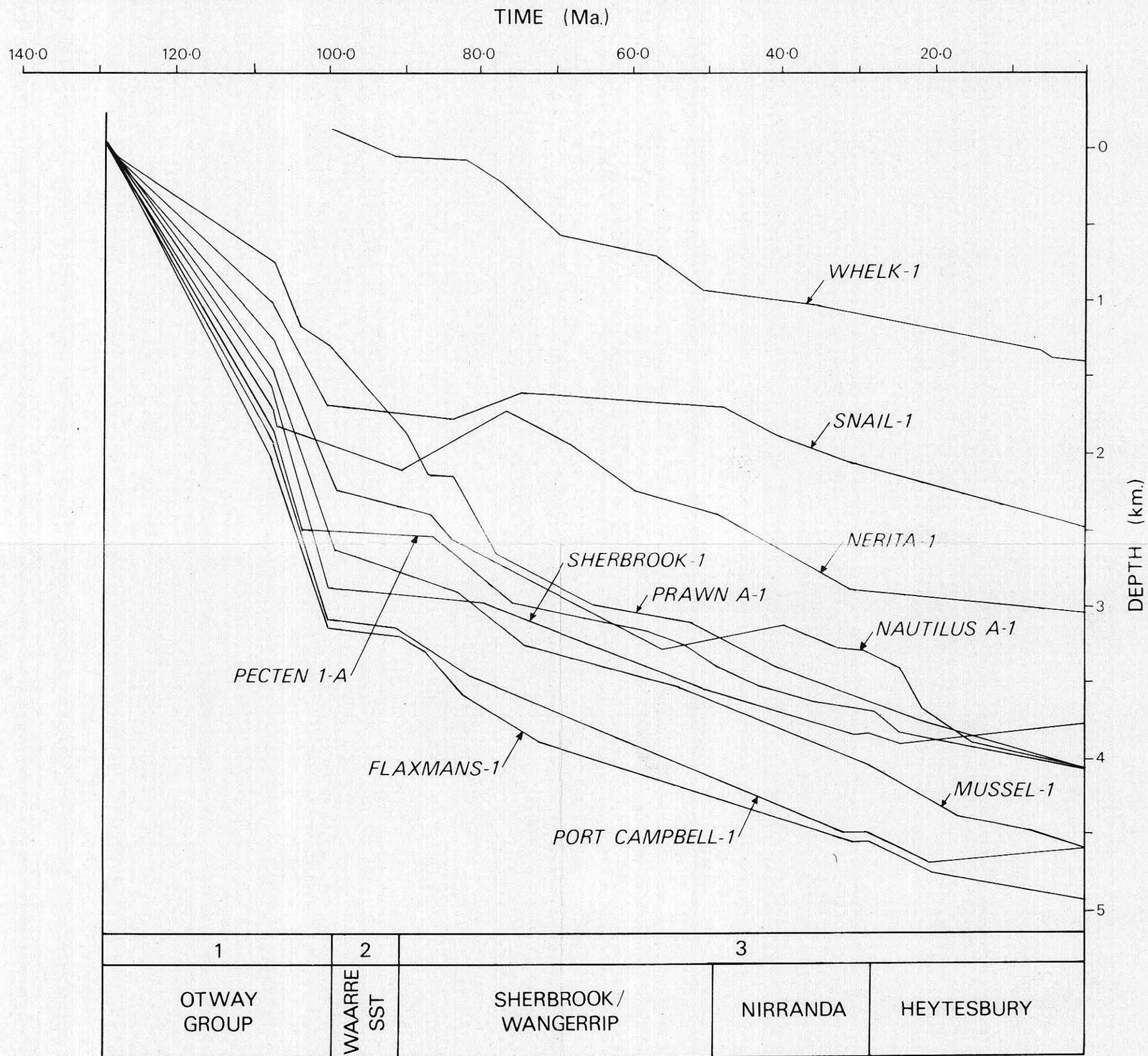


FIGURE 9 T/200 Pex 6 OR-026  
121019

# BASEMENT SUBSIDENCE CURVES

PALTECH REPORT 1982/27



**FIGURE 10** *OR-0126*

*T/20P Part 6*

121020

5 cm

# GRAPHS OF VITRINITE REFLECTANCE vs DEPTH FOR SELECTED WELLS IN THE OTWAY BASIN

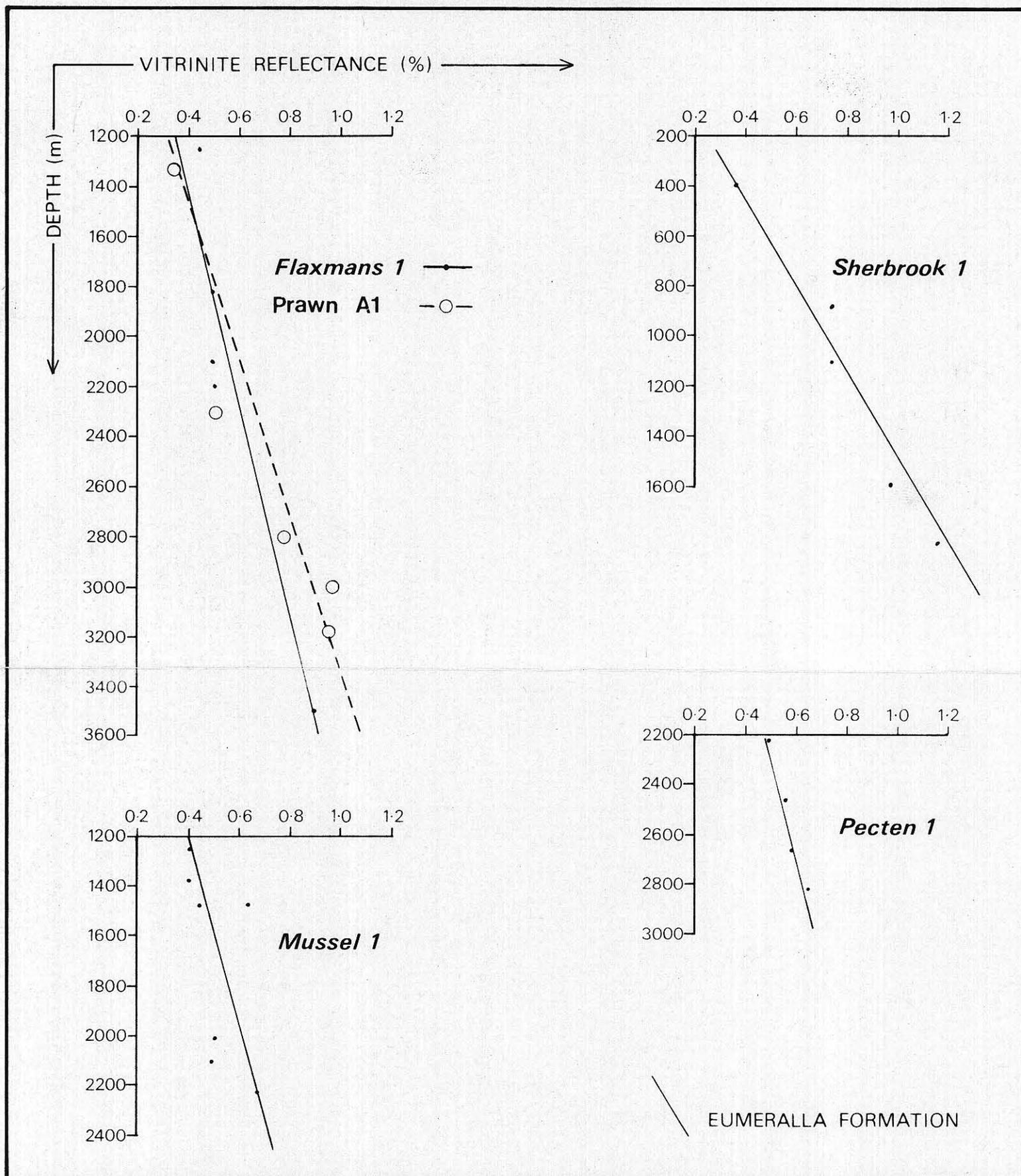


FIGURE 11 OR-0126

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