

226001

D of M	A.O.	C.G.	E.O.	DEPT. OF MINES
D. DIR.	- 4 NOV 1985			E & IL
DEPT. OF MINES				
REF. No. 11,947/85				

Bass Basin

Tasmania

Australia

Year 4

Quarterly Report

Permit T-19-P

Third Quarter Report

September 27 to December 27, 1984

Submitted by:

Perthshire Petroleum Ltd  
14141 Southwest Freeway  
Houston, Texas 77478 USA

TPR

OR\_0211

Summary

No well has been drilled during this quarter and no geophysical data was acquired.

Given that several attractive leads have been identified through regional mapping of the permit area, the nearby wells have been studied in an attempt at establishing a stratigraphic framework for the permit area. The Konkon #1 well is the only well located within the permit T-19-P area.

Regional considerations indicate that rifting took place in the permit area and that wedge shape depressions and graben developed at various times. These are unconformably overlain by, in part marine, sediments of the basin interior sag stage.

Regional seismic time structure maps indicate that untested structural and stratigraphic leads are present in the Bass Basin.

Percentage sand maps of various palynological zone intervals show that in general the central portion of the basin contains less sand than its flank areas. Later studies indicate that this conclusion may in fact be true but that the percentage sand approach based on palynological zonation, without the help of structural considerations and adjustments for barren zones and preservation, is not really valid for reason that massive sandstone intervals typically contain little or no palynomorphs.

The thermal history of certain wells has been studied. The purpose of this study was to try to identify an oil window where conditions would be favorable for the generation, expulsion, and migration of hydrocarbons. Thermal cracking of the liquid hydrocarbons would take place at deeper levels and oil/condensate or only gas would be generated. This method did identify and define such a window, however it failed to explain the

stratigraphic and structural position of the known hydrocarbon occurrences. It therefore appears that the thermal history of the basin is such that hydrocarbon generation did take place, however, the relationship to present day location of those hydrocarbons is not readily indicated.

Three stratigraphic cross sections have been constructed using wells located in the western portion of the basin. Studies of individual wells indicate the presence of sedimentological cycles which consist of sequences of sandstone, shale and coal. These vary in thickness and in their proportion of each sediment type. These cycles are repeated in part or in whole in each of the wells and as such are correlatable.

Correlations have been established between the various wells and, given minor adjustments, the palynological zones can also be correlated. The indications of hydrocarbons found at the Cormorant and Pelican well locations are shown to be located in fault bounded depressions characterized by expanded sections. The Bass #3 well is located on the upthrown side of a major trough. Indications of hydrocarbons are located below a minor unconformity which may have drained and localized this occurrence. Although only partially documented, an apparent relationship appears to exist between structural depressions, incursions of marine conditions or development of lacustrine environments, and occurrences of hydrocarbons in mostly or completely immature sediments from a geothermal, source-rock/maturation, point of view.

Reprocessing of seismic line PB-82-25 has shown that advanced reprocessing methods provide improvement of the data but that basically standard methods of data processing, when applied correctly, do improve significantly the seismic resolution at depth.

226004

Table of Contents

	<u>Page</u>
Summary	1
Table of Contents	2
List of Figures	4
List of Enclosures	6
References	7
Introduction	9
Stratigraphy	
Basin Evolution	10
Regional Maps	13
Facies of Eastern View Coal Measures	16
Thermal History	22
Structural Cross-Sections	25
Stratigraphic Cross-Sections	25
Reprocessed Seismic Line	31

List of Figures

1. Stratigraphy of the Bass Basin
2. BMR Regional Seismic Lines - Location
3. BMR Seismic Lines 16/17/18/8-4/19/20
4. Fault Trends in the Bass Basin
5. Stages of the Bass Basin
6. Eocene Top Eastern View Coal Measures Depth Structure Map
7. Paleocene L. balmei Structure Map
8. Mid-Cretaceous Rift Unconformity Depth Structure Map
9. Pre-Rift (?) Jurassic Unconformity Depth Structure Map
10. Percentage Sand in Upper M. diversus Zone
11. Structure Contour Map Top Eastern View Coal Measures
12. Konkon #1 Stratigraphic Column
13. Toolka #1 Stratigraphic Column
14. Cormorant #1 Stratigraphic Column
15. Bass #1 Stratigraphic Column
16. Fault Trends in the Bass Basin, Same as Figure 4
17. Percentage Sand in Middle M. diversus Zone
18. Percentage Sand in Lower M. diversus Zone
19. Percentage Sand in Upper L. balmei Zone
20. Percentage Sand in Lower L. balmei Zone
21. Percentage Sand in T. longus Zone
22. Aggregate of Coal in Eastern View Coal Measures
23. Number of Coal Beds vs Palynological Zone
24. Thermal History Aroo #1
25. Thermal History Comorant #1
26. Thermal History Dondu #1

List of Figures (cont.)

27. Thermal History Narimba #1
28. Thermal History Pelican #1
29. Thermal History Pelican #3
30. Thermal History Poonboon #1
31. Thermal History Tarook #1
32. Cross-Section A-B-C showing oil window
33. Cross-Section D-B showing oil window
34. Cross-Section B-E showing oil window
35. Thickness of *M. diversus* within or below oil window
36. Thickness of *L. balmei* within or below oil window
37. Stratigraphic Cross-Section: Konkon, Toolka, Cormorant, Bass #1
38. Fault Trends in the Bass Basin: Same as Figures 4 & 16
39. Stratigraphic Cross Section: Nangkero, Poonboon, Pelican #3, Pelican #1.
40. Stratigraphic Cross Section: Bass #3, Aroo, Tarook, Narimba

226007

List of Enclosures

1. Seismic Line PB-82-25 4800% Final Stack (TVF,GAIN) (DMO)
2. Seismic Line PB-82-25 Migration (TVF,GAIN) (DMO)

References

- Williamson, P.E., Pigram, C.J., Colwell, J.B., Scherl, A.S., Lockwood, K.L., and Branson, J.C.

Pre-Eocene Stratigraphy, Structure, and Petroleum Potential of the Bass basin. The APEA Journal, 1985.

- Ethridge, M.A., Branson, J.C., Stuart-Smith, P.G.

Extensional Basin - Forming Structures in Bass Strait and their Importance for Hydrocarbon Exploration. The APEA Journal, 1985.

- Harding, T.P.

Graben Hydrocarbon Occurences and Structural Style, AAPG, Vol.68, No. 3 March 1984.

## Introduction

The Bass Basin is a polyphased rift depression area. Graben fill type accumulations of sediments are recognized in the Lower Cretaceous, Upper Cretaceous, Paleocene and Eocene. Each of these accumulation of sediments is separated by unconformities or major hiatus. The intra-Upper Cretaceous unconformity may possibly be the basin-wide break-up unconformity, a time when vertical movements are in part replaced by vertical and horizontal structural movements associated with expansion of the basin area. Rifting took place at different times in different geographic areas of the basin. In certain areas of the basin, the southeast, periods of rifting are stacked one upon another, thus causing the section to be very thick locally. Rift basin studies indicate that hydrocarbon accumulations are located in areas of active rifting, where the section is greatly expanded. Individual traps are associated with tilted fault blocks and are usually located at the unconformity surfaces where sealing is provided by the overlying and surrounding shales.

Regional mapping of the Bass Basin carried by the Bureau of Mineral Resources has revealed the presence of several untested prospective structures and stratigraphic leads. The untested structures are usually tilted blocks associated with normal faulting. The stratigraphic traps are located at the subcrop edges of the various map horizons.

A series of percentage sand maps have been constructed for various palynological zones. Given that occurrences of well preserved and reliably identified palynomorphs is strongly controlled by facies, these maps only serve to show what was easily predictable as they are based on existing well control only. At all levels studied, the percentage sand is shown to decrease basinward.

The thermal history at several well locations has been studied in order to evaluate the maturity of the source-rock sequence. To any practical purpose, this approach which is rather technically very advanced and capable, fails to account for the main indications of hydrocarbons found at the Cormorant, Pelican and Bass #3 well locations. It especially fails to explain a shallow occurrence of relatively heavy oil found at Cormorant in a completely immature section.

226010

Three stratigraphic cross-sections have been constructed using wells located in the western half of the Bass Basin. The datum is the top of the upper *N. aspersus* palynological zone.

The original purpose of this stratigraphic exercise was to try to illustrate lateral facies changes between wells located within a major structural or tectonic unit of the Bass Basin. These major units having been recognized and defined through seismic interpretation and mapping carried by the Bureau of Mineral Resources.

Correlations between wells are established on the basis of palynological zonation combined and adjusted with the boundaries of sedimentological cycles which consist of various proportions of sandstone, shale, and coal. Hydrocarbon occurrences are tentatively related to major but local cycles of rift fill accumulations of sediments, boundary unconformities, and rather ill-defined "marine" or "more marine" or "lacustrine" incursions of structurally depressed areas. Kerogen studies indicate that hydrocarbon occurrences are apparently associated with areas containing algal remains and are subject to timely structural conditions.

Results of the reprocessing of seismic line PB-82-25 are reported. The most advanced methods have been applied to this data in order to first collapse all the reflectors to the plane of the line. This was followed by filtering, stacking and remigration in an attempt to bring out the deeper reflectors in their correct space and time relationship. A series of tilted fault blocks are recognized below a major unconformity.

## Stratigraphy - Basin Evolution

226011

Sediments of the Bass Basin occur in a stacked succession of basins as a result of the development of a polyphased rift depression area.

Figure 1 displays the stratigraphic section found in the Bass basin.

Figure 2 shows the general outline of the Bass basin, the exploration permit, the major structural elements and the location of the BMR key seismic lines.

Figure 3 shows the key seismic lines, their interpretation, the location of the wedge depressions and grabens as well as major unconformities.

Figure 4 shows the wedge depressions and grabens, the direction of sediment thickening, the location of certain wells and the main transfer faults. It also shows a block diagram which illustrates the lateral termination and offset of various wedge depressions.

The uppermost sequence, or interior sag basin depression stage, contains largely marine sediments of the upper Eocene, Oligocene and younger sections. The sequence begins with the transgressive Eocene Shale, or Demons Bluff Formation, which is overlain by the basal Oligocene coarse clastics followed by claystones, additional coarse clastics of the mid-Oligocene, and then by claystones which grade upward and laterally into late Tertiary to Recent fine grained carbonates. Sediments accumulation in excess of 2000 meters thick took place in a northwest-southeast oriented saucer-shape depression with an area of more than 60,000 square kilometers characterized by little structural deformation. Tectonic disturbances took place during this stage of the basin as witnessed by occurrences of stratiform volcanics injected along fault planes.

226012

# Petroleum potential of the Bass Basin

E. Nicholas, K. L. Lockwood, A. R. Martin<sup>1</sup>, & K. S. Jackson

AGE (m.y.)	EPOCH	SERIES	SPORE-POLLEN ASSEMBLAGE ZONES	STRATIGRAPHY		
	MIOCENE-PLIOCENE			TORQUAY GROUP		
24	OLIGOCENE					
37.5			<i>Upper Nothofagidites asperus</i>	DEMONS BLUFF FORMATION		
40		Late	<i>Middle Nothofagidites asperus</i>			
45	EOCENE	Middle	<i>Nothofagidites goniatus</i>	'UPPER'	EASTERN	
						<i>Lower Nothofagidites asperus</i>
						<i>Proteacidites asperopolis</i>
50		Early	<i>Upper Malvacipollis diversus</i>	VIEW		
			<i>Lower Malvacipollis diversus</i>			
55	PALEOCENE	Late	<i>Upper Lygistepollenites balmei</i>	'LOWER'	COAL	
60		Middle	<i>Lower Lygistepollenites balmei</i>			
		Early				
65	LATE CRETACEOUS		<i>Tricolpites longus</i>	MEASURES		
98	EARLY CRETACEOUS			OTWAY GROUP		

Stratigraphy of the Bass Basin (after Brown, 1976; Partridge, 1976).

Figure 1

144°

146°

148°

226013

MELBOURNE

# WEAVER EXPLORATION PERMITS BASS STRAIT AREA

38° -

VICTORIA

GIPPSLAND BASIN

ESSO-B.H.P.

TORQUAY BASIN

MKE FAULT

OTWAY BASIN

BASSIAN RISE

VICTORIA

TASMANIA

KING ISLAND

FLINDERS ISLAND

PELICAN FIELD S.I.

LAUNCESTON

TASMANIA

40° -

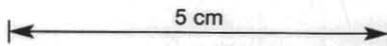
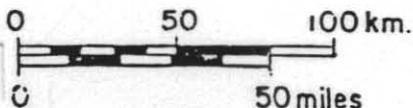
42° -

200m

200m

-  BMR Seismic
-  Oil Field
-  Gas/Cond. Field

SCALE



HOBART

Figure 2

226014

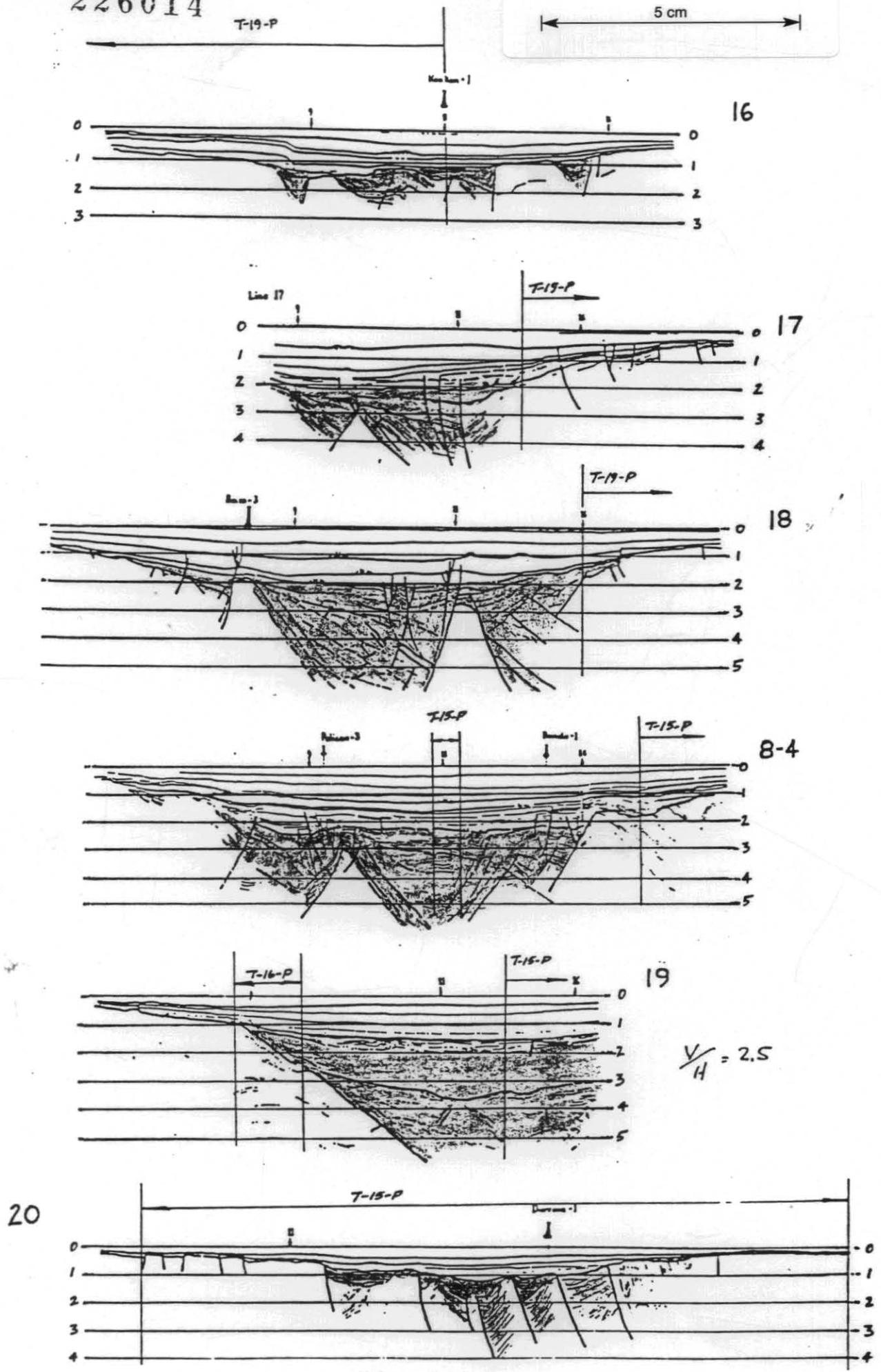
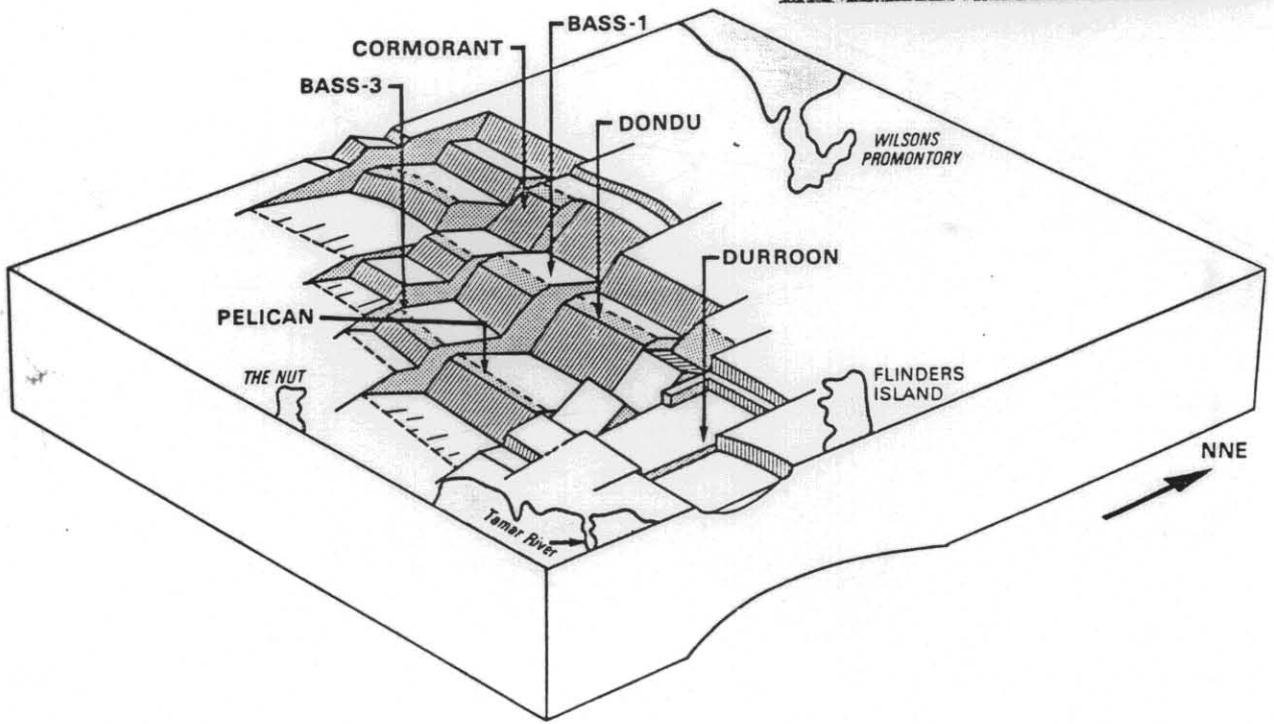
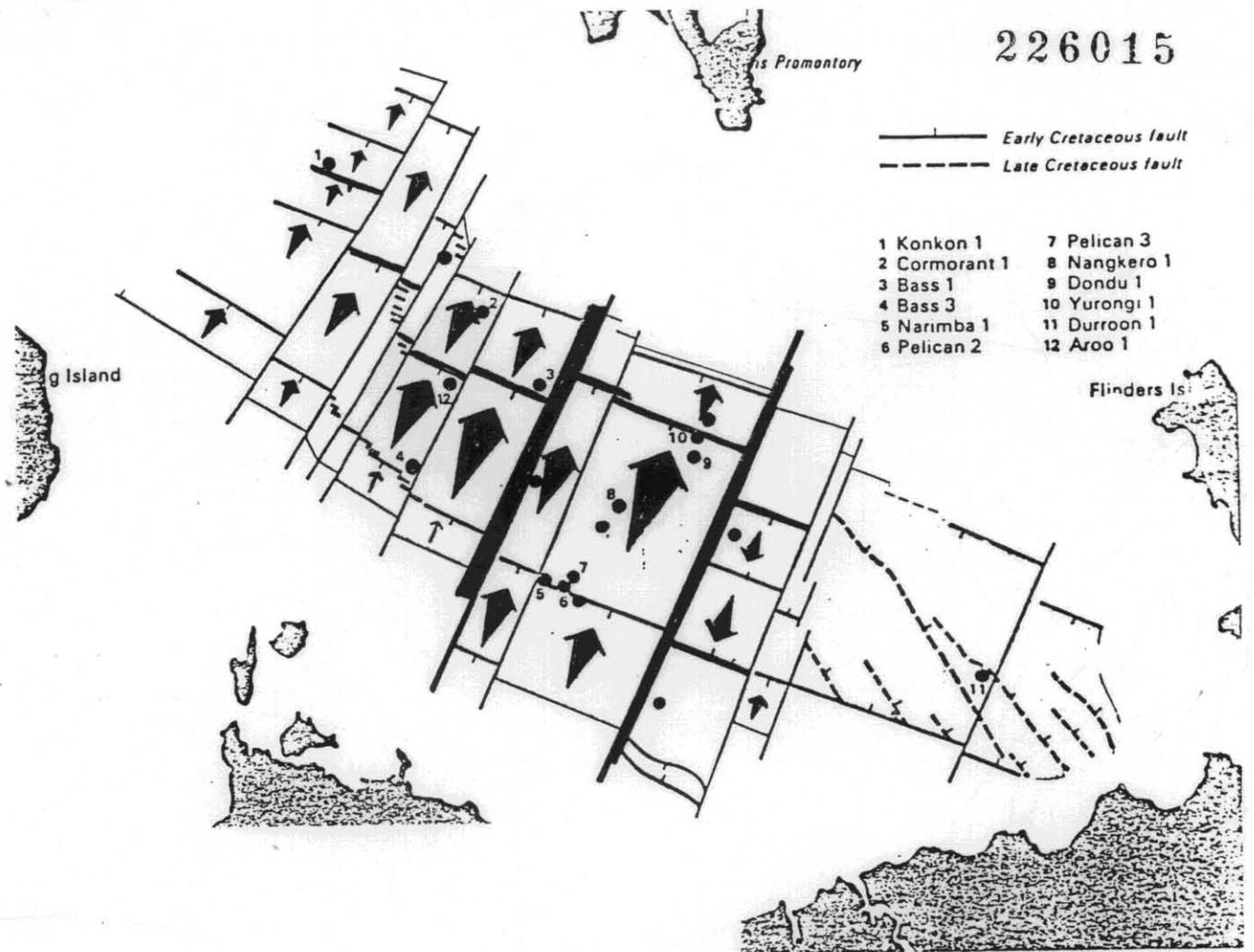


Figure 3



5 cm

Figure 4

The intermediate stage basins consist of the various graben fill type accumulations of sediments. Several different sequences are recognized and defined as to the extent of their geographic distribution.

In the southeast corner of the Bass basin, the possibly oldest graben fill sequence begins within the Lower Cretaceous or older section. This initial rift period is known to have retained and preserved a section of immature coarse clastics and volcanogenic debris below the mid-Cretaceous unconformity surface. This section has been drilled once in the Durroon #1 well. It may in-part represent a pre-rift sequence. The structural boundaries of the possibly oldest graben fill sequence consist of northwest-southeast trending basin forming faults, or rift boundary faults, which are offset by a series of northeast trending transfer faults. These structural boundaries defined the general geometry of the whole Bass basin through the following stages of its evolution.

A second graben fill accumulation of sediments is recognized in the southeast corner of the Bass basin. It ranges from the mid-Cretaceous unconformity to the intra-Upper Cretaceous unconformity and consist of coarse clastics, of potential reservoir quality, interbedded with mature source-rock shales, coals and minor volcanics. Its unconformable upper surface is very distinct on seismic lines as it marks the boundary between faulted and tilted beds below and drape features above.

The structural boundaries of this sequence have a general north-northwest orientation which is offset by east-northeast trending transfer faults. A series of north-northwest trending normal faults is recognized onshore Tasmania when a minor rift sequence is present. Individual graben or half graben depressions formed during this stage in the evolution of the

towards the south or southeast and abrupt termination against east-northeast trending transfer faults.

The intra-Upper Cretaceous Unconformity may in fact be the break-up unconformity of the Bass basin which represent the time when vertical movements along basin forming faults were in part replaced by spreading or lateral expansion of the basin.

A third graben fill accumulation of sediments is recognized in the central area of the basin. It ranges from the intra-Upper Cretaceous break-up unconformity to the intra-Lower M. diversus unconformity and consist of coarse reservoir clastics and source rock shales. An intra-L. balmei unconformity is recognized focally.

A fourth, and last, graben fill accumulation of sediments is recognized also in the central area of the Bass basin. It ranges from the intra-Lower M. diversus unconformity to the transgressive Eocene shale and consist of coarse clastics, shales and coals. A portion of this sequence could in fact be assigned to a locally developed interior sag basin depression stage.

These graben fill accumulations of sediments of the intermediate stage basins are collectively called the Eastern View Coal Measures, which ranges from the mid-Cretaceous unconformity to the Eocene shale and consist of a mixed fluvial-lacustrine sequence more than 3000 meters thick. A distinct lateral facies change from lacustrine shales in the northwest to coals with shales and channel sands in the center of the basin to fluvial sands in the southeast is recognized.

It should be kept in mind that this apparent lateral facies change is based on observations made in very few exploratory wells located on structures which may have controlled the environments of deposition to

a certain extent.

The lowest sequence, or pre-rift stage of the basin, consist of Lower Cretaceous and older sediments which at this time are not considered to be an objective section in the current exploration of the Bass basin.

Recognition of each member or stage of the stacked succession of basins which form the Bass basin is based on limited well data in addition to seismic data as well as marine magnetic and gravity data. As the basin forming faults and transfer faults displaced basement they, as such, are recognizable on the Total Magnetic Intensity map of the regional Aeromagnetic survey.

Regional magnetic intensity trends and interrupted trends with northwest, north-northwest, northeast, and east-northeast orientation are recognized and thought to reflect basin forming faults and transfer faults associated with each stage in the evolution of the Bass basin.

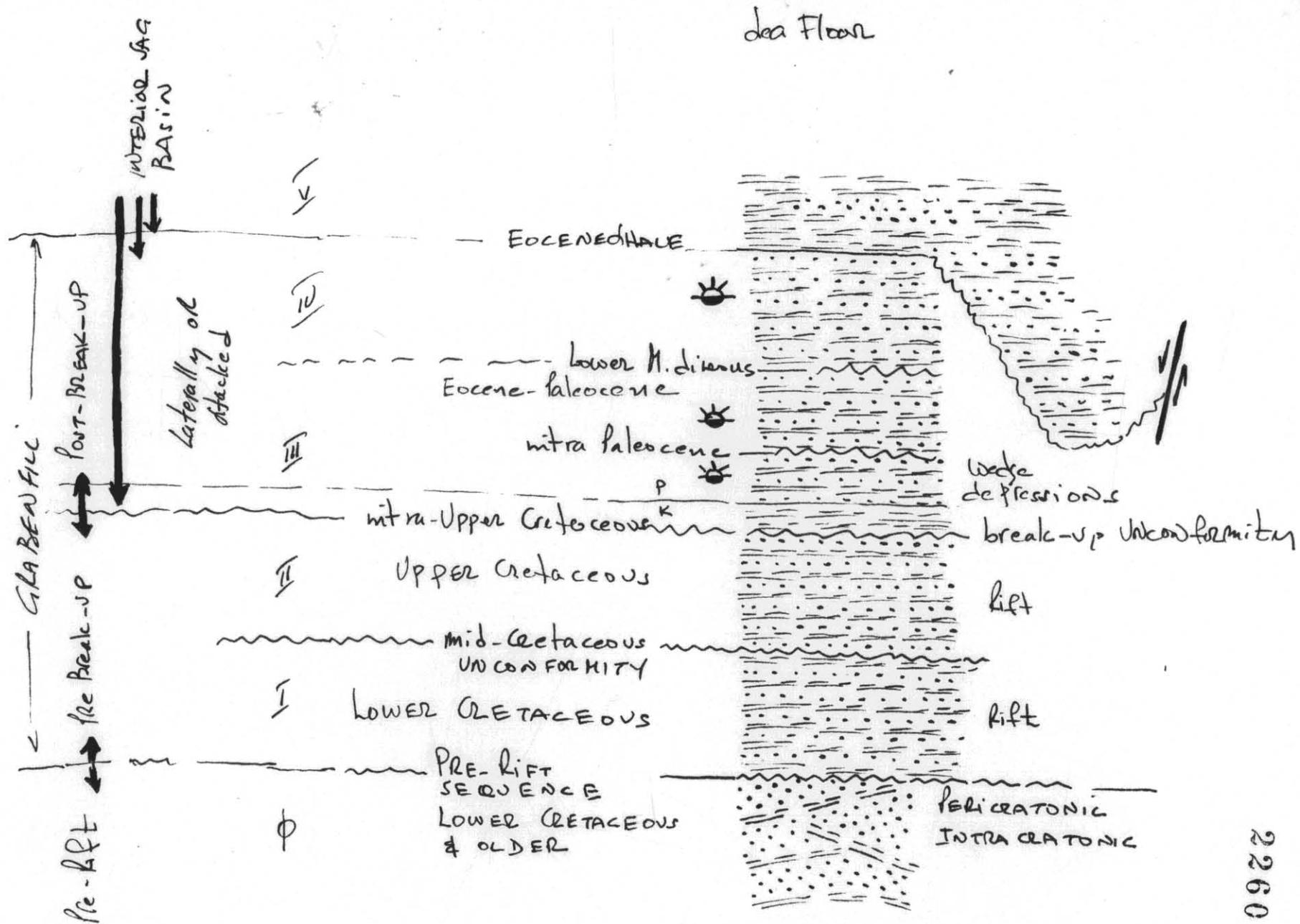
Indications of hydrocarbon have been found in the third graben fill accumulation of sediments which ranges from the intra-Upper Cretaceous break-up unconformity to the intra-Lower M. diversus unconformity.

Indications of hydrocarbon have also been found in the fourth graben fill accumulation of sediments which ranges from the intra-Lower M. diversus unconformity to the transgressive Eocene shale, Figure 5.

#### Regional Maps

Regional depth structure maps have been constructed for the Bass basin by the Bureau of Mineral Resources using data from the BMR 1982 regional seismic survey and infill recent industry data in conjunction with seismic stratigraphy and well data.

The shallowest structure map is at the top Eastern View Coal Measures



BOUNDARIES OF RIFTS AND OTHER DEPRESSIONS  
BASE BASIN

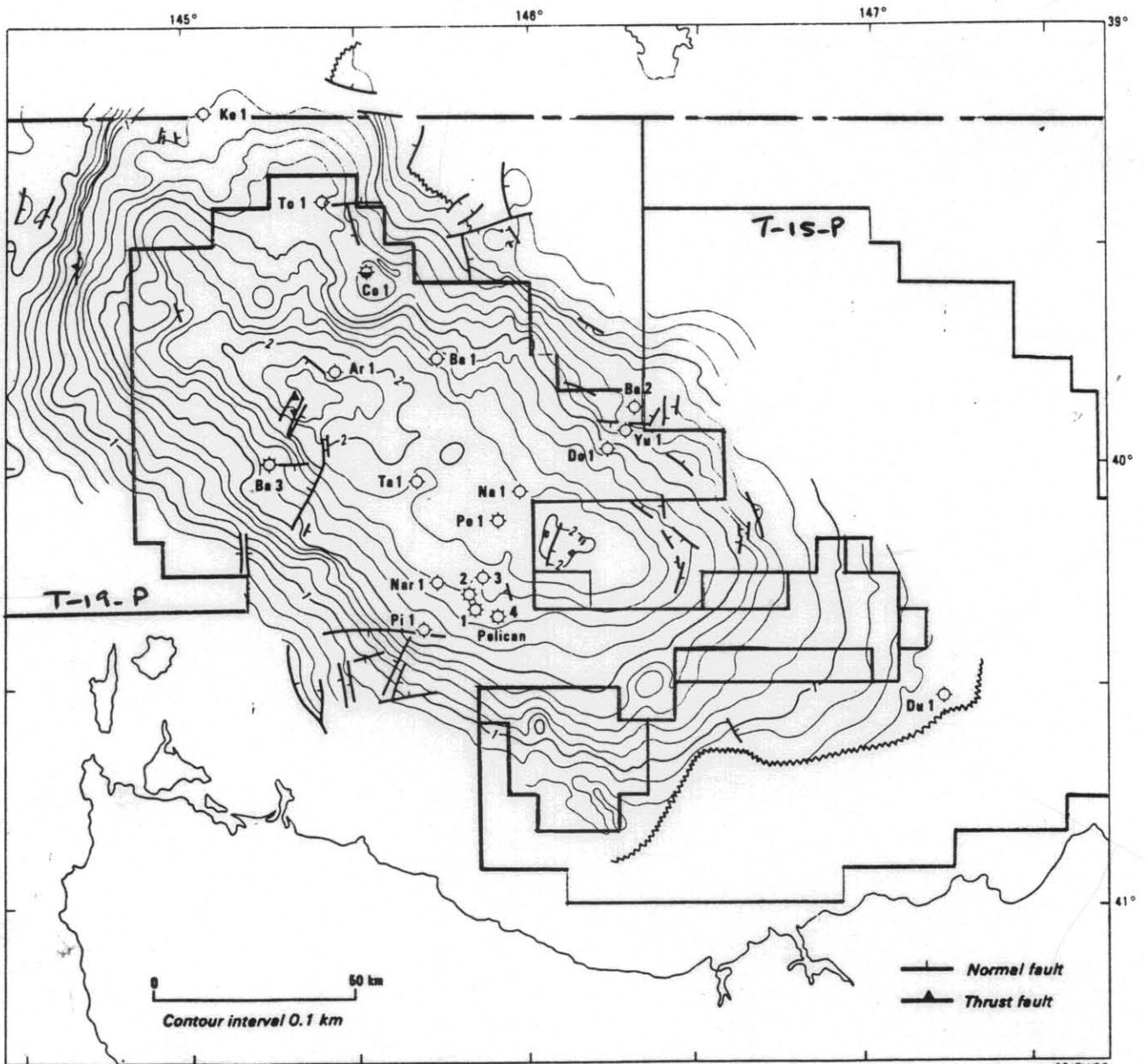
5 cm

Figure 5

226019

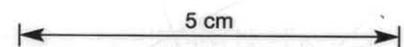
level. Figure 6. At this map level, the Bass basin is shown to be a simple northwest-southeast oriented depression characterized by minor faulting in various directions. Only the Cormorant well is shown to be located on a closed structure at this scale and contour interval. The outline of Perthshire Petroleum Limited Permit T-19-P and Weaver Oil and Gas Corporation, Australia Permit T-15-P and T-16-P are shown.

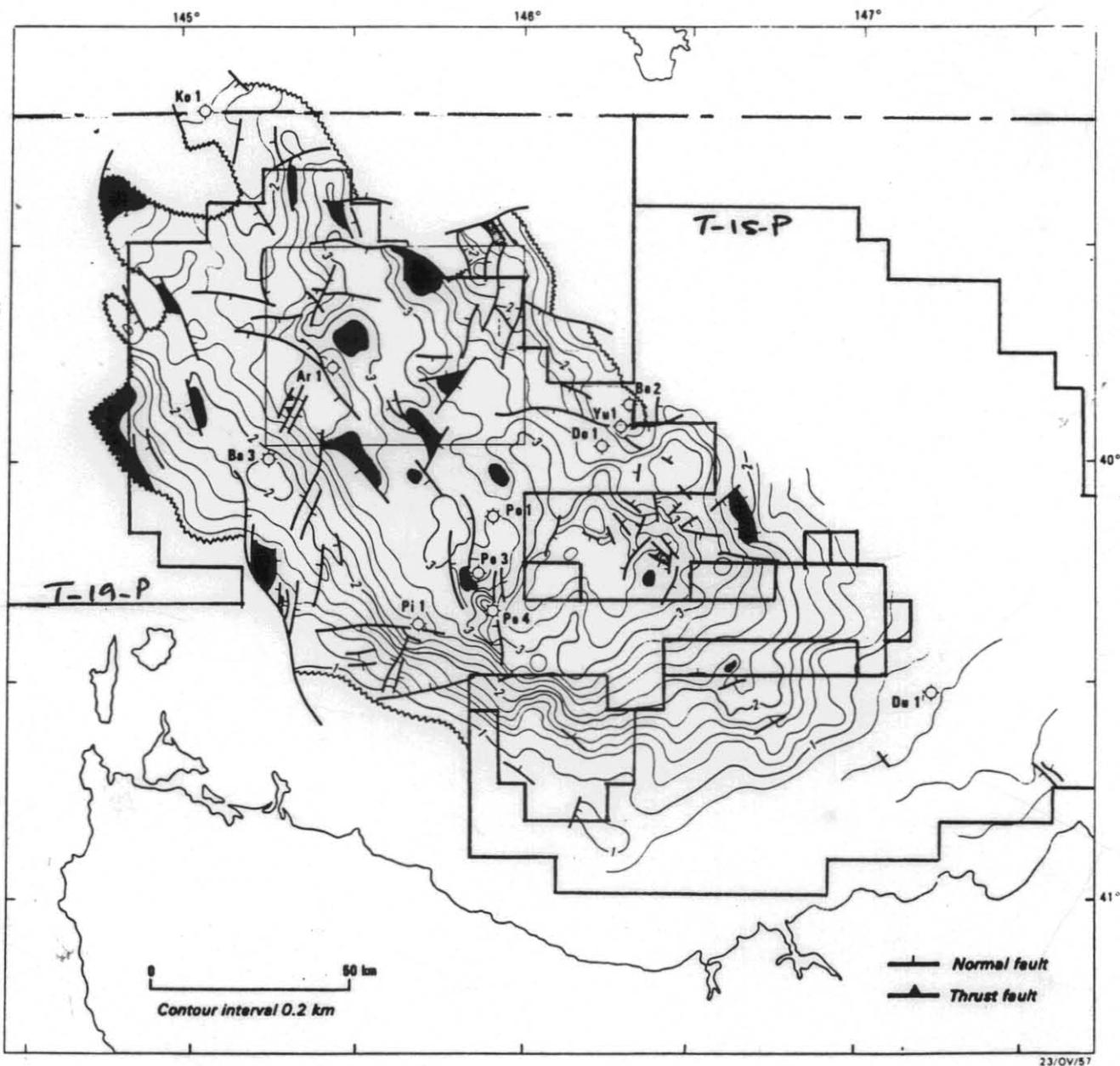
A depth structure map has been constructed at the Paleocene *L. balmei* palynological zone level. Figure 7. This map level is an unconformity, sometimes weak, which is mapped throughout the basin. It is tied to the top of the Lower *L. balmei* in the northern area and to the top of the Upper *L. balmei* in the southeastern area at the Durroon #1 well location. At this map level, significant fault controlled and anticlinal leads are observed mostly in the western half area of the basin. Prospective structures are controlled by faults associated with the rifting stage of the basin, drape features over deeper fault bounded structures, diapiric shales and possibly igneous intrusives. The Chat prospect located on Permit T-15-P is shown to consist of a southwestward tilted fault block controlled in its updip direction by a down to the east-northeast normal fault. The 81-21 prospect located on Permit T-16-P is also recognized as a simple four way closure at this map level. On permit T-19-P, the Manatee prospect area is shown to be a major reentrant with possible stratigraphic entrapment. Few of the existing wells tested valid closures at this map level. The Bass #3 well is shown to be located at the very edge of a simple closure area. It tested gas and condensate or light oil from the Lower *L. balmei* interval. The Tarook well tested a minor simple closure without finding any indication of hydrocarbons. The Pelican #3 and Poonboon wells tested a large upthrown fault closure and recovered gas.



Eocene Top Eastern View Coal Measures depth structure map.

Figure 6





Structural lead

Stratigraphic lead

Paleocene *L. balmei* depth structure map.

Figure 7

5 cm

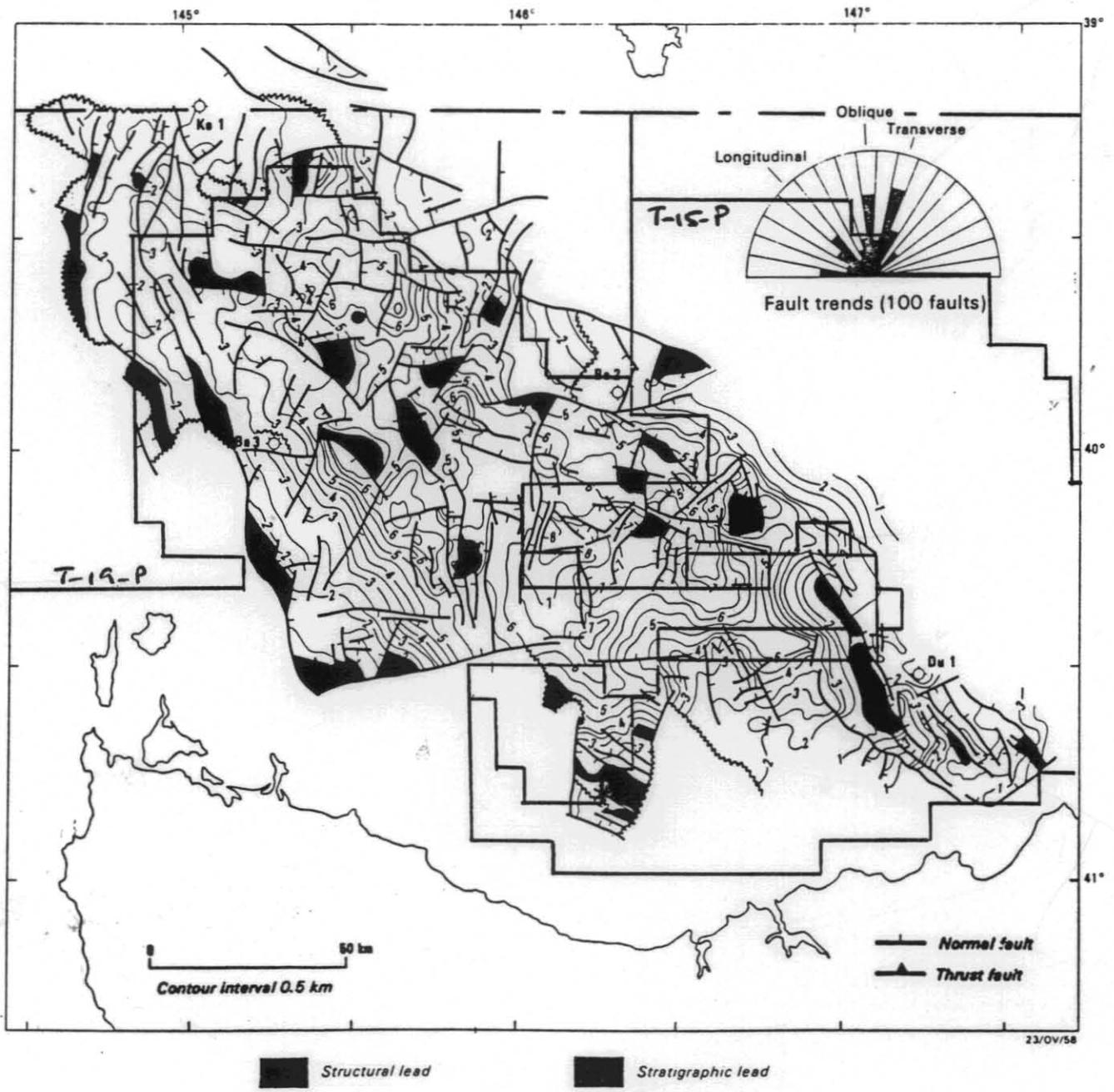
The Nangkero well tested a simple closure without finding any significant amounts of hydrocarbons.

The lithology of the Paleocene L. balmei interval consists of sandstones, shales and coal beds. The underlying Upper Cretaceous section is believed to have the best petroleum source potential in the Bass basin.

Structural relief is rather pronounced at the mid-Cretaceous unconformity level. Figure 8. Fault trends in the north portion of the basin are towards the west-northwest, while in the southeast portion of the basin, they are towards the north-northwest. These two fault orientations are related to distinct periods of faulting which took place on a regional basis during the Early Cretaceous, then on a local basis, in the southeast corner of the basin, during the Late Cretaceous. Structural closures are disseminated throughout the basin area. Stratigraphic leads occur at the basin margin and appear to be related to major downthrown fault areas. Lithology of the Upper and Lower Cretaceous is variable with sandstones, shales, minor coal beds, volcanics and possibly some lacustrine evaporites.

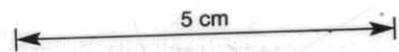
Figure 9 is a depth structure map constructed at a pre-rift unconformity level of possible Jurassic age. Lithology drilled on structural highs at this level consists of metamorphic basement. Seismic character indicates the possibility of sediments located off these high areas. Structural levels have been identified at the periphery of the basin.

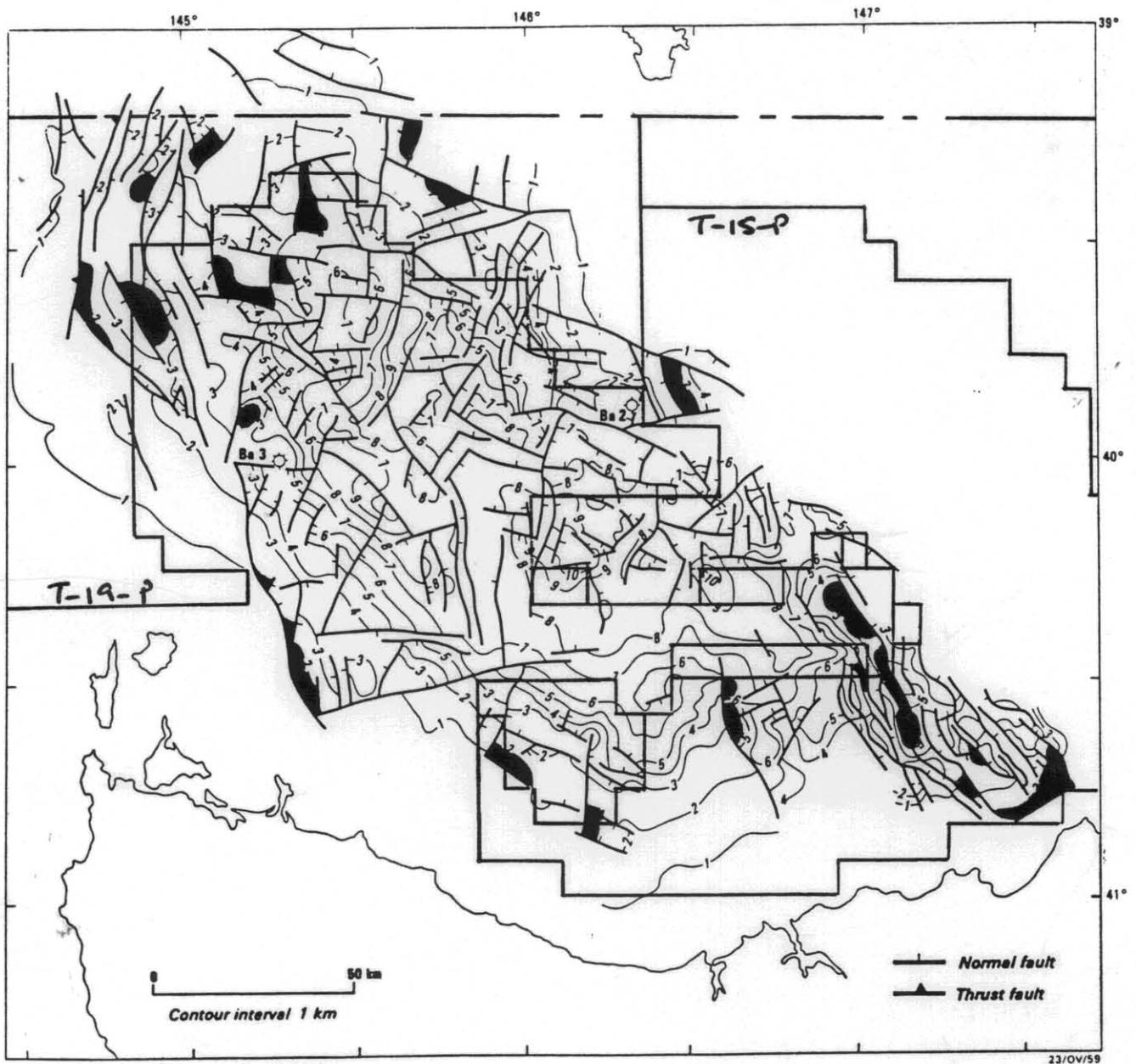
A structure map constructed by the BMR at the so-called basement level shows the northwest trending Early Cretaceous and north-northwest trending Late Cretaceous basin forming faults offset by the contemporaneous north-northeast trending transfer faults. This map was not drafted nor published by the Bureau of Mineral Resources.



Mid-Cretaceous Rift Unconformity depth structure map.

Figure 8





■ Structural lead

Pre-rift (?) Jurassic Unconformity depth structure map.

Figure 9

5 cm

### Facies of the Eastern View Coal Measures

There are no regionally recognizable marker beds within the Eastern View Coal Measures and subdivision is entirely based on palynological zonation which is subject to identification in widely spaced samples of sometimes poorly preserved or undiagnostic palynomorphs. Semi-regional correlations are based on loosely defined seismic markers contained within a coal bearing sequence where the majority of the high frequency energy is absorbed in the shallow action and resolution is lost in the deeper section.

For purposes of construction of facies maps, a combination palynological identification and seismic markers has been used to isolate mappable zones. The base is a structure map on top Eastern View Coal Measures to which percent sand contour lines per zone have been added. The top Eastern View Coal Measures is picked on electric logs as the first sand occurrence below the Eocene Shale. It is known to be somewhat diachronic. All the maps are obviously very much influenced by the location of the wells, as these are so few, and the age of structuration of each feature drilled as it did influence the local facies development.

All the zones analyzed belong to the intermediate stage basins which consists of the various graben fill type accumulation of sediments. However, it is known from studies of the basin evolution that some of these zones are recognized and correlatable as more or less time equivalent; but are in fact, different or unrelated, as they were deposited in structurally controlled and individualized depocenters. These differences cannot be resolved at this time due to the low density of data.

Figure 10 shows the structure contours at the top Eastern View Coal Measures, the well locations and the percentage sand values and contour lines for the upper M. diversus palynological zone. The wells are

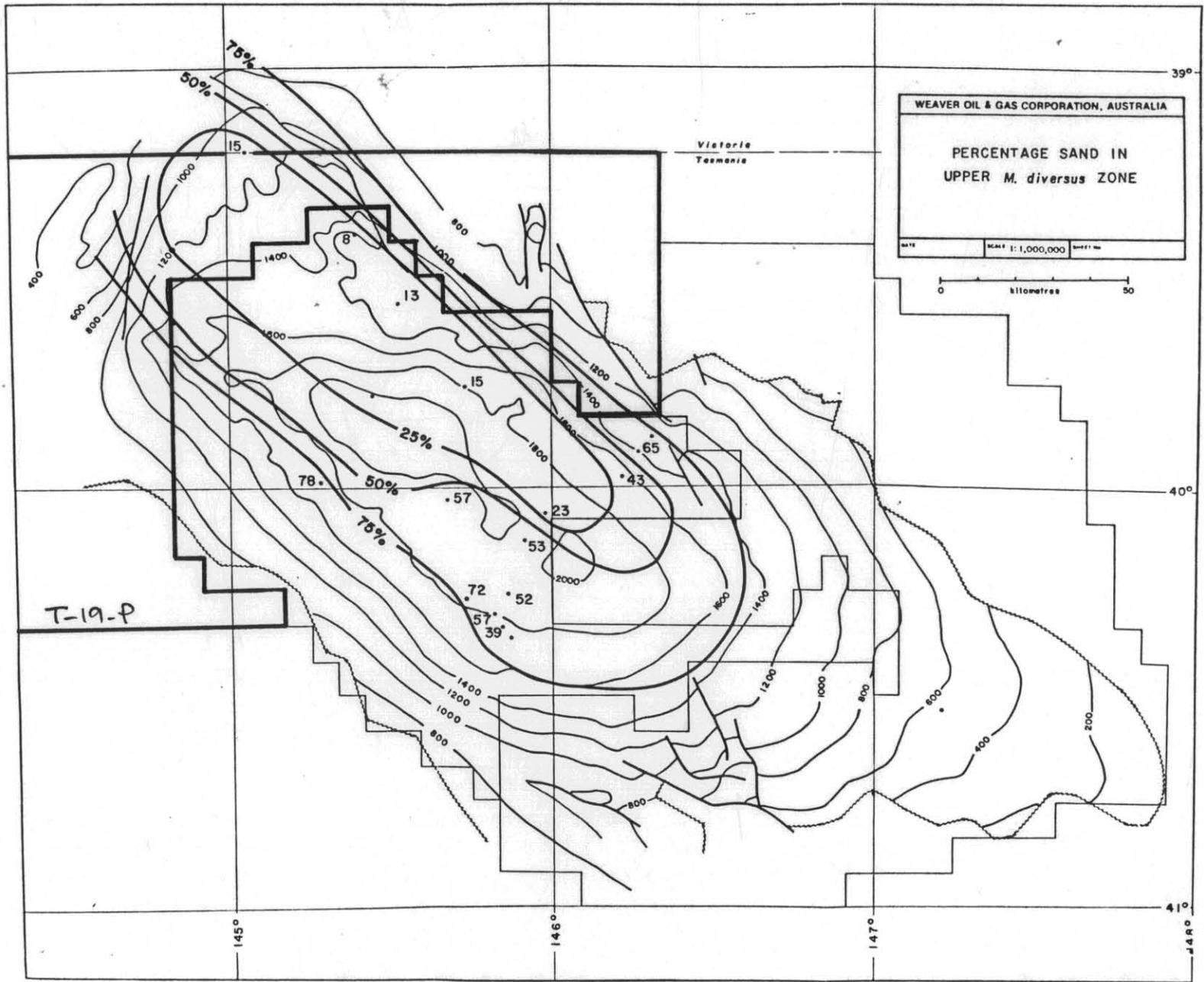


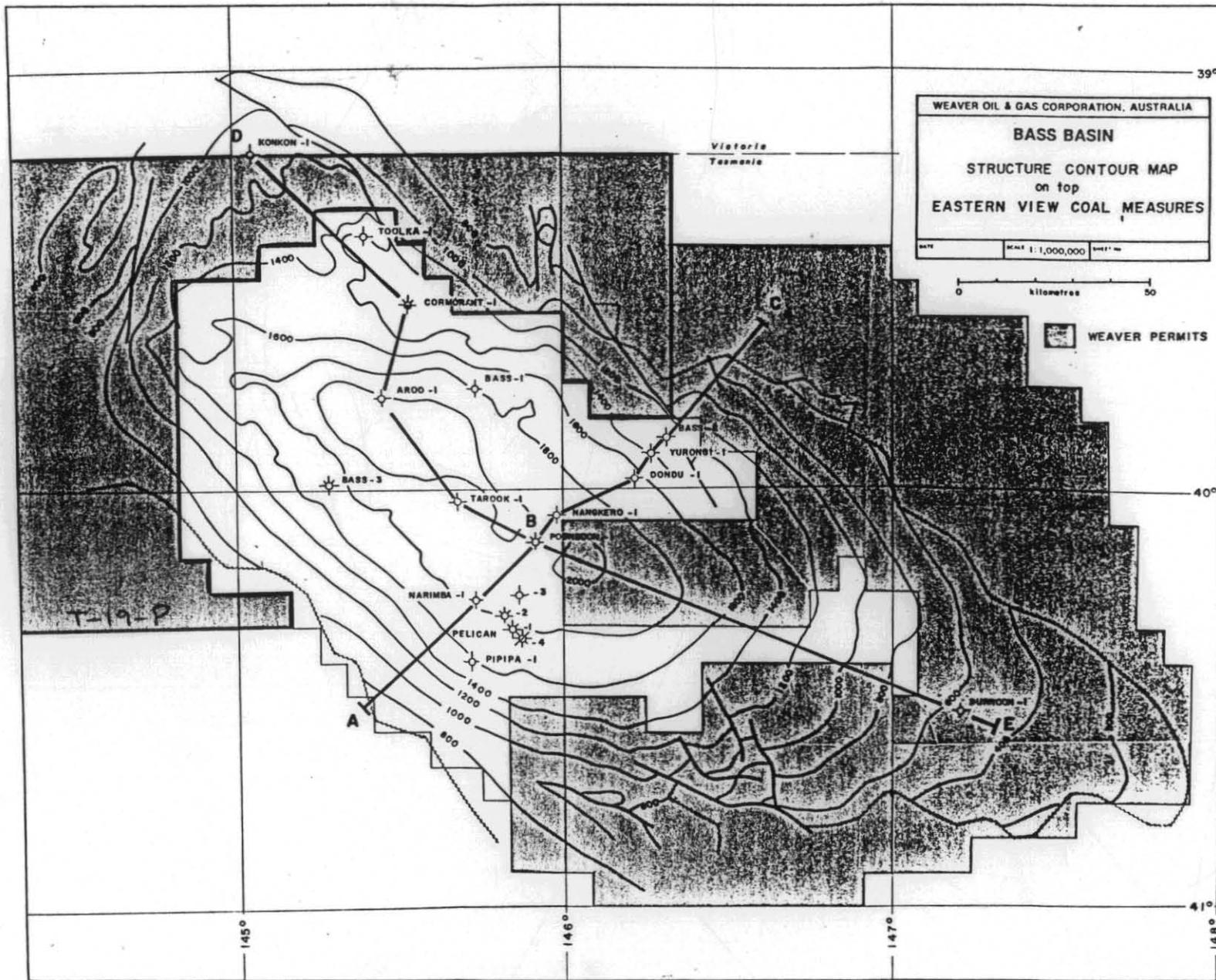
Figure 10

226027

identified on Figure 11. The eastern portion of permit T-19-P is shown and its boundaries are highlighted. The percentage sand is shown to decrease towards the central area of the basin. However, in detail it is obvious that this apparent decrease in percentage sand is controlled by determinations made in five wells. These are the Konkon well with 15%, the Toolka well with 8%, the Cormorant well with 13% and the Bass #1 well with 15%. Figures 12, 13, 14, 15.

Structural considerations indicate that these wells are all located outside the main rift at upper M. diversus time and that this low percentage sand facies is more representative of the generally quiescent and mostly atrauded interior sag basin depression stage than it is of the graben fill accumulation of sediments which characterize the intermediate stage basin. The Nangkero well with 23% sand is also somewhat anomalous in that it has a comparatively very thin, very condensed upper M. diversus section. Other wells indicate that the central basin area, graben fill accumulation of sediments, has a percentage sand in the order of 40 to 55% or so.

Figure 16 shows the early Cretaceous structures and sedimentary wedges with arrows indicating the direction of sediment thickening in the Bass basin. The block diagram is a schematic perspective view of post-early Cretaceous structures in the Bass basin showing the major fault bounded half-graben and the consistent right-lateral offset across transfer faults. Some of the wells are identified. These two illustrations show that the Konkon well is located in a sand impoverished area outside the main graben boundaries. The Toolka, Cormorant and Bass #1 wells are located in the areas of thickest sedimentary wedges of separate grabens where individual sand bodies are known to be thin and replaced laterally by shale facies. At this stratigraphic level, the Bass #1 well is located,



226029

Fig 11

Figure 11

KONKON No.1

K.B. 32'  
G.L. 245'

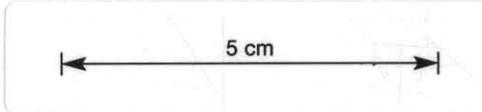
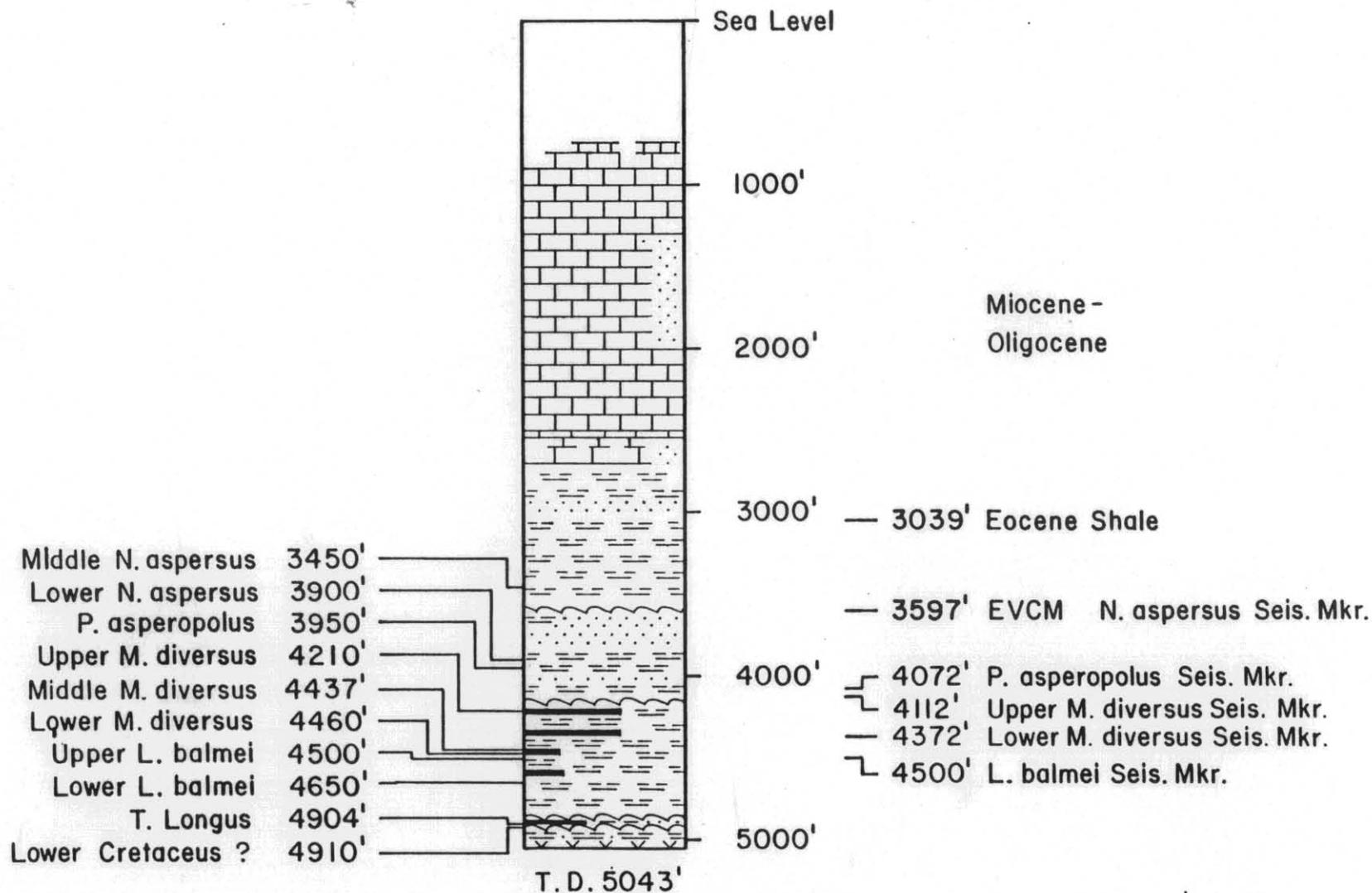


Figure 12

226030

TOOLKA No. 1-A

K.B. 32'  
G.L. 258' 226031

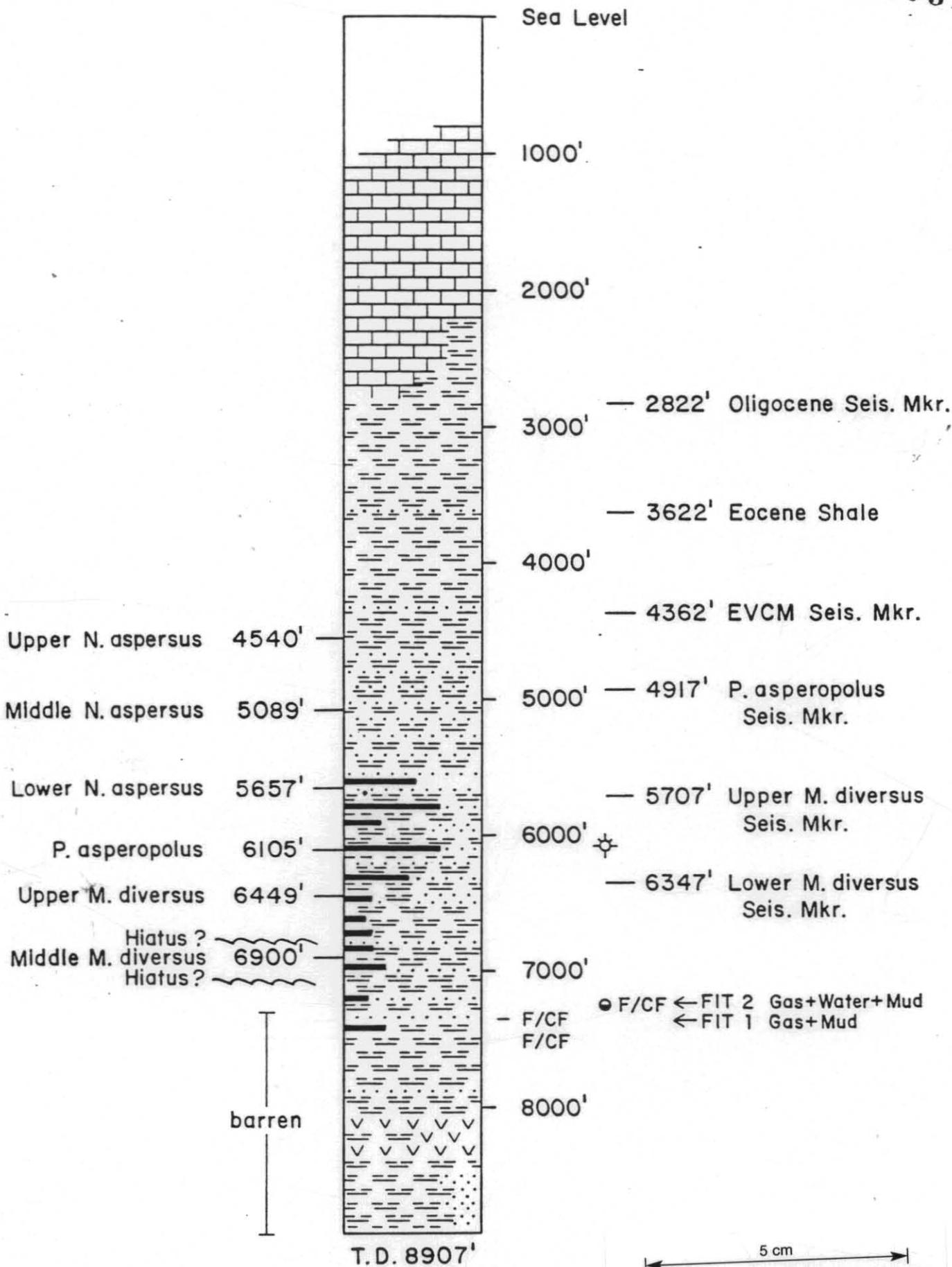


Figure 13

CORMORANT No. 1

226032

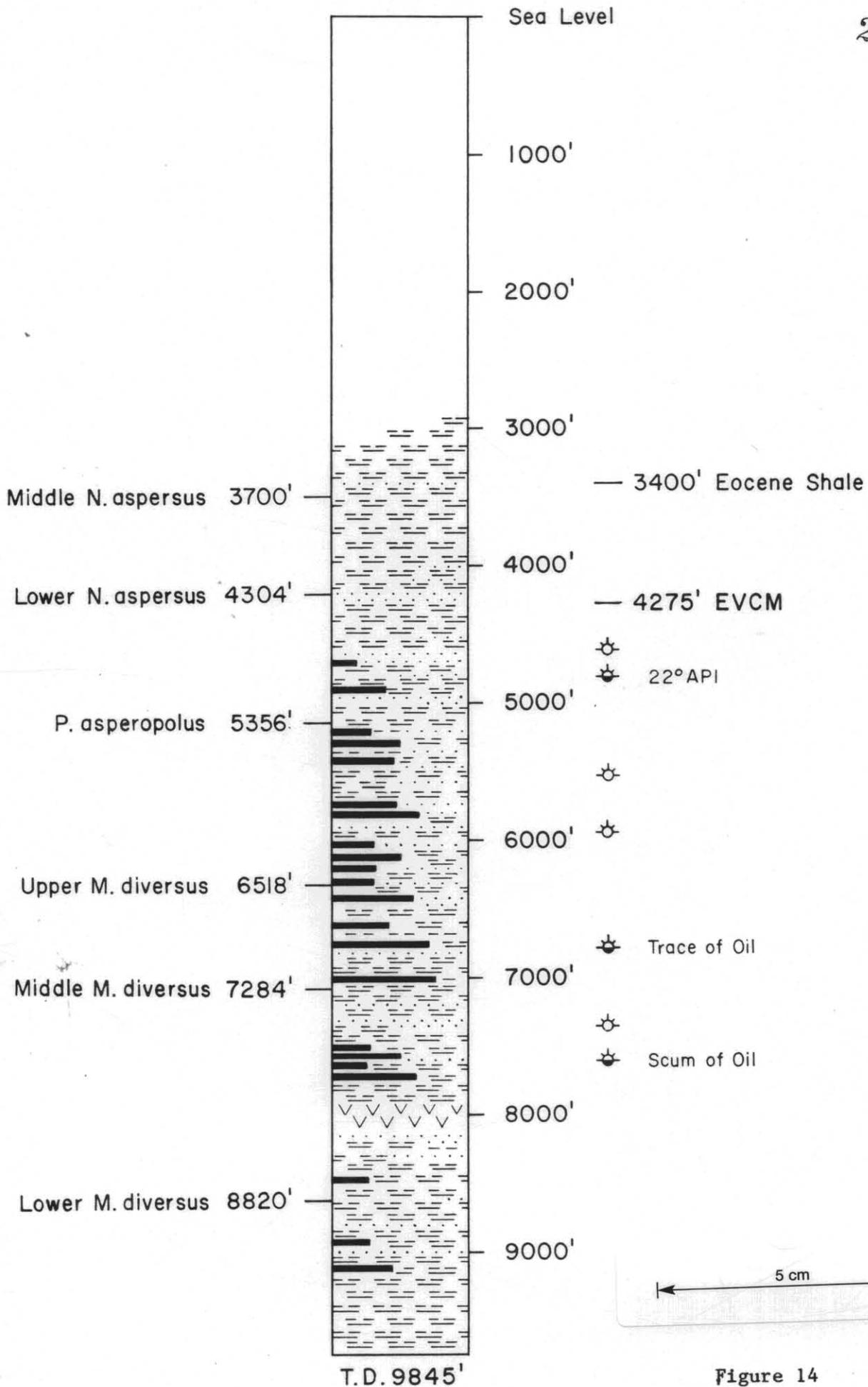
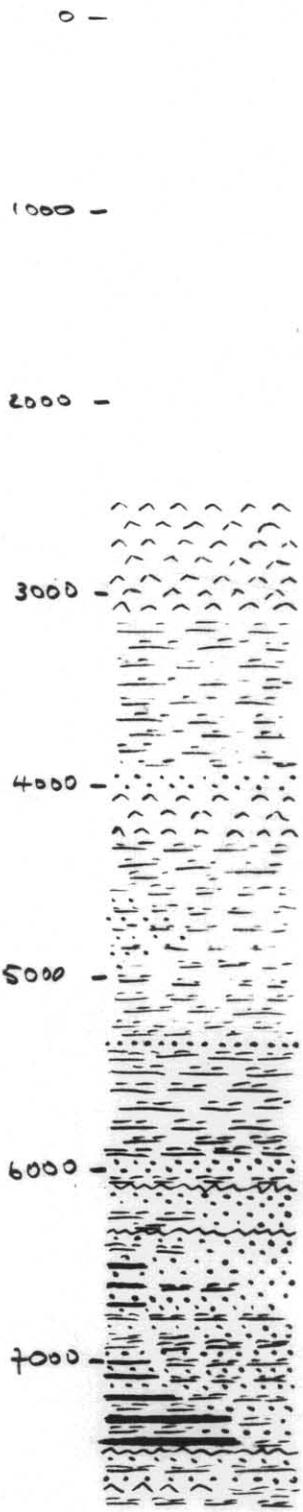


Figure 14

RAW #1

226033



DF 31'  
TD 7717' JALR

- 4873 U.N Asp.

5375 basal Oligoc. Eodh. - 5275 M.N Asp

5935

- 6162 L.N. Asp.

- 6780 P. Asp

Thick Coal 7310 - 7450 ±

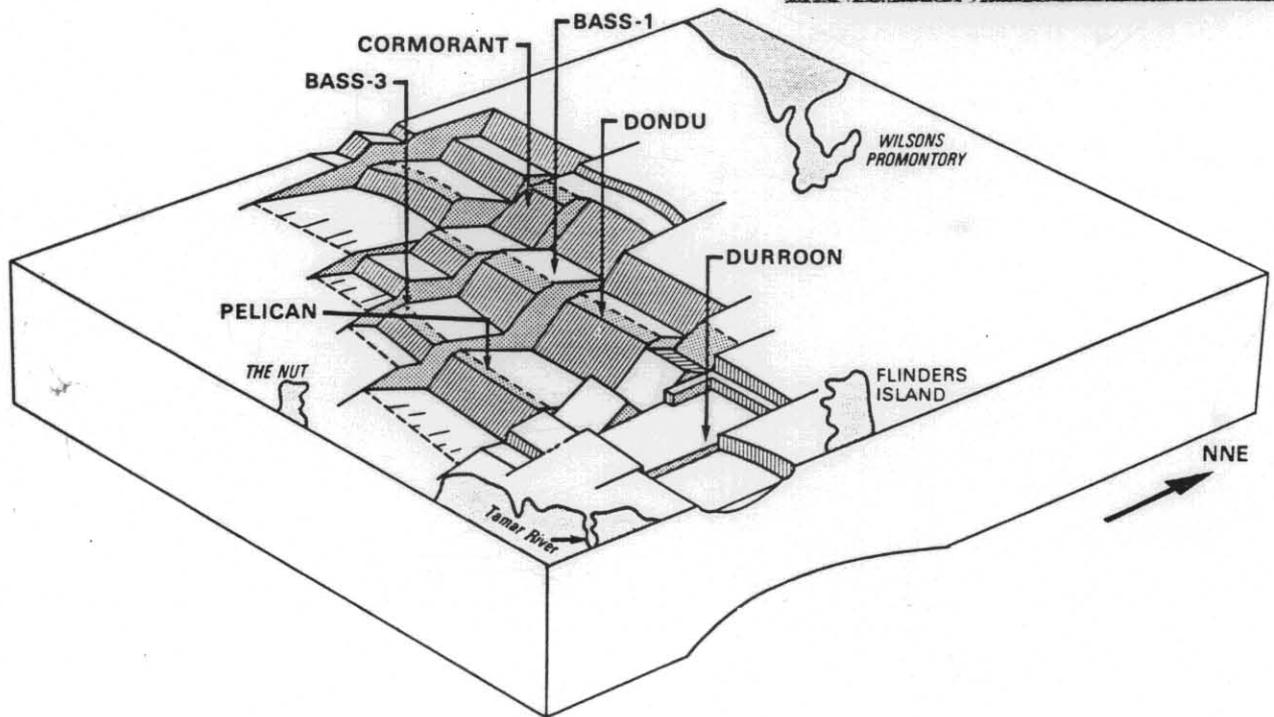
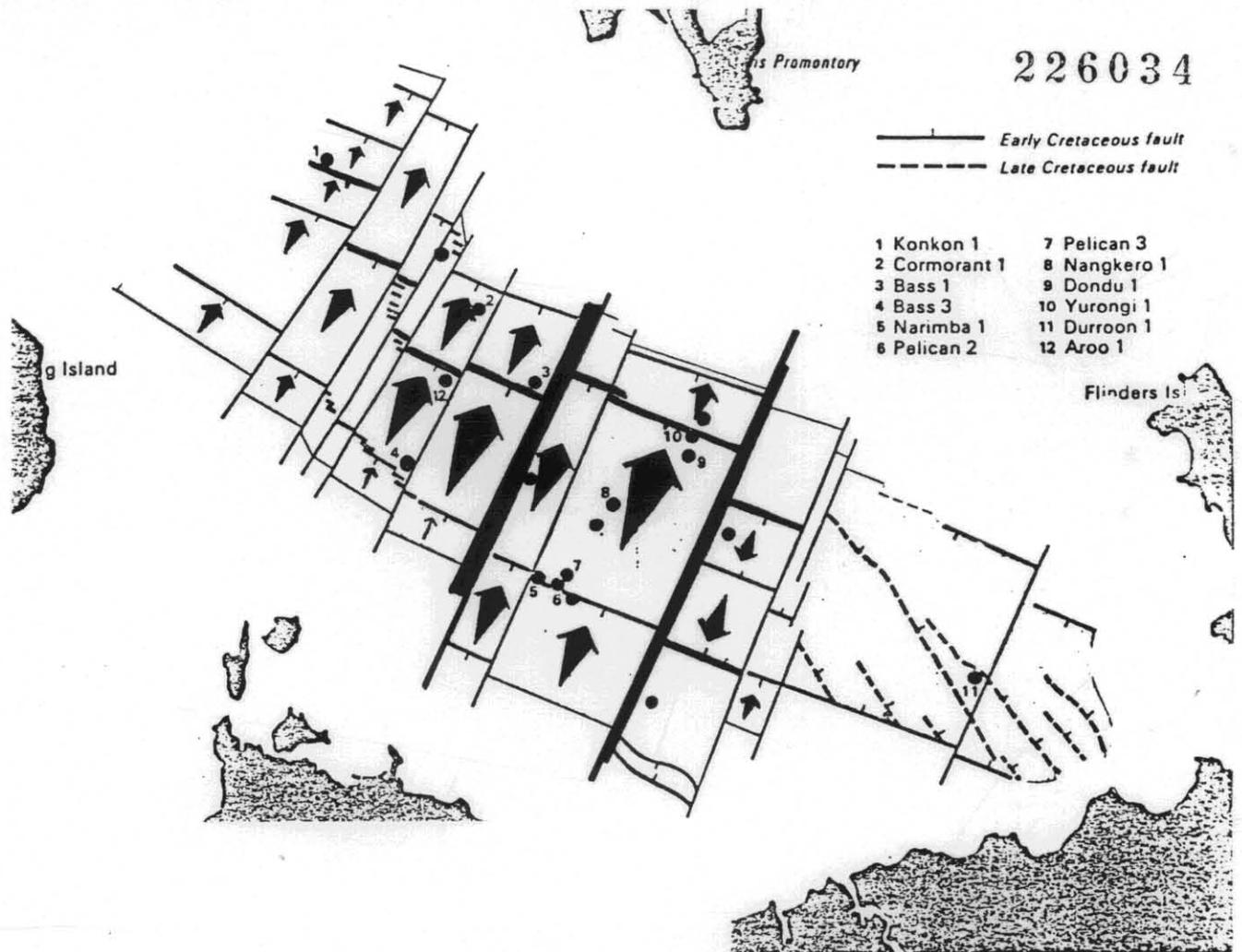
- 7543 U.N. div.

Alkali olivine basalt

7659-65  
or  
7659-75 } ± logs  
7661-63

5 cm

Figure 15



5 cm

Figure 16

through a fault plane projection, within the thick sedimentary wedge recognized to the southwest of the indicated surface location. The influence of the main transfer faults, indicated by heavy lines, is observed in the pattern of sedimentation.

Figure 17 shows the percentage sand values and contour lines for the middle *M. diversus* palynological zone. The percentage sand is shown to decrease towards the central area of the basin. However, it is obvious that this apparent trend is again controlled by few well determinations. At this stratigraphic level, the Konkon well is located outside the graben boundaries and a zero value is generated. The Toolka and Cormorant wells again generate low sand values because of their locations in thick sedimentary wedges. The Tarook well with 27% sand is also located in the thick portion of a sedimentary wedge. Other wells indicate that the central basin, graben fill accumulation of sediments, has a percentage sand in the order of 30 to 45% or so.

Figure 18 shows the percentage sand values and contour lines for the lower *M. diversus* palynological zone. The percentage sand is shown to decrease towards the central area of the basin. Again it is obvious that this apparent trend is influenced by few well determinations. The Konkon well with 18%, Toolka well with 3% and Cormorant well with 4% greatly influence the shape of the contour. The Aroo well with 11% sand is shown to be located in the thick portion of a sedimentary wedge. Other wells indicate that at this stratigraphic level, the central basin area, graben fill accumulation of sediments, has a percentage sand in the order of 30 to 40 percent. In this study, the lower *M. diversus* palynological zone has not been divided into two distinct zones on the basis of the intra-lower *M. diversus* unconformity recognized in certain

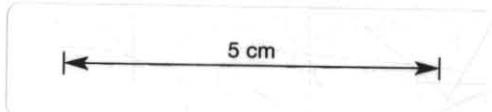
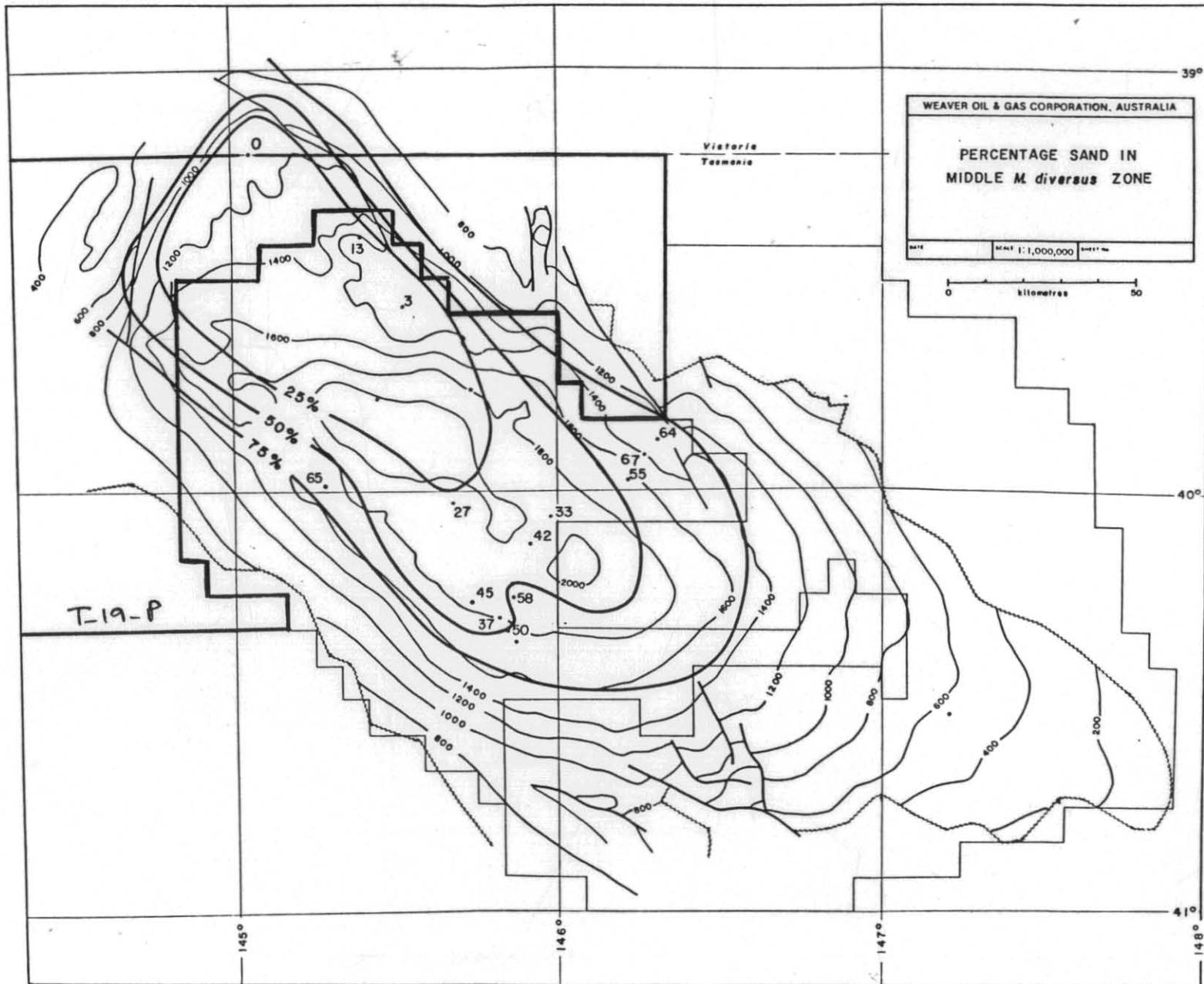


Figure 17

226036



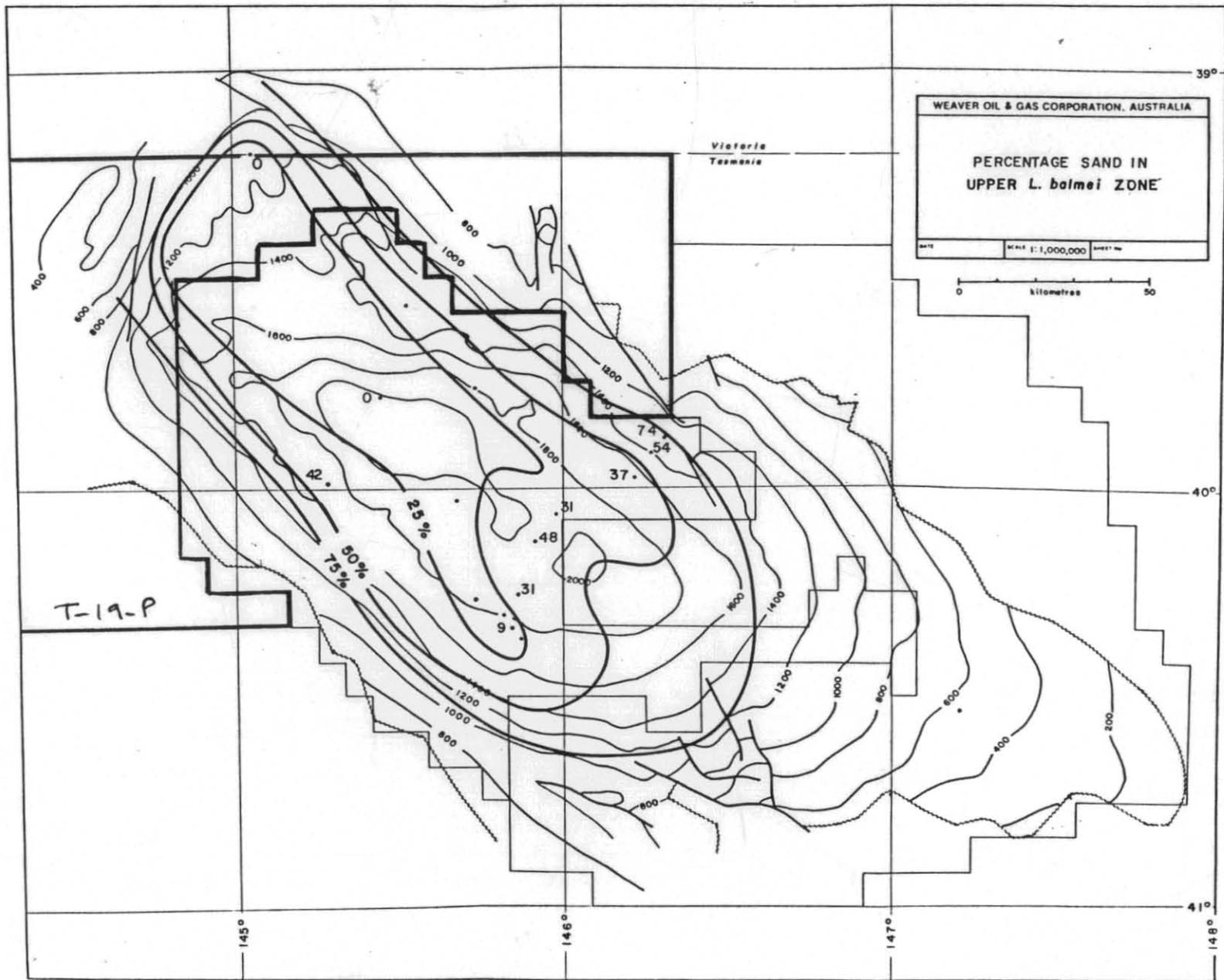
wells.

The lower *M. diversus* palynological zone, above the unconformity, the middle *M. diversus* and upper *M. diversus* as well as the not studied for percentage sand *P. asperopolus* and *N. aspersus* palynologic zone represent a graben fill cycle of accumulation of sediments in the Bass basin. Percentage sand studies illustrate the profound influence of the graben boundaries and attitude of the various half graben blocks on the patterns of sedimentations. Indications of hydrocarbons in this graben fill cycle have been recorded in the Cormorant, Aroo, Pelican 1,2, and 4 wells. Some significance is assigned to the small amount of low gravity oil and light oil or condensate tested in two separate and very thin sand bodies of the Cormorant well. These occurrences show that the basin is capable of generating liquid and gas phase hydrocarbons. The location of the Cormorant well, so close to a transfer fault, indicate that migration to an immature portion of the well section may have taken place from a deeper and mature generative section along the locally permeable plane of this near vertical transfer fault. Indications of hydrocarbons in this graben fill cycle of the Aroo well consist of fluorescence and wet gas identified in the drilling mud. The Aroo well is located on a thick wedge of sediments close to the same northeast trending transfer fault as the one near the Cormorant well. Again, generation,expulsion and migration from a deep and mature source may have taken place along this fault plane to the shallow and immature portion of the section tested by the Aroo well. Gas and light oil have been recovered in several wireline tests carried on separate intervals of this graben fill cycle portion of the section evaluated by the Pelican wells. Discrete

hydrocarbon bearing intervals are recognized on electrical logs. These are located in tilted beds below the intra-lower M. diversus unconformity. The deeper section is mildly over-pressured. Seismic mapping indicates the presence of a diapiric structure, probably shale, on the downthrown side of a major normal fault. The combination uplift, from greater depths, of a possibly more mature section, trapping below an unconformity, and proximity to a major fault may have contributed significantly to the accumulation of hydrocarbons at Pelican.

Figure 19 shows the percentage sand values and contour lines for the upper L. balmei palynologic zone. The percentage sand is shown to decrease towards the central area of the basin. The lowest percentage sand values are found in the Pelican #1 well with 9%, the Aroo well with 0% and the Konkon well with 0%. As observed previously, the Konkon well is located outside the main graben area and therefore, is probably not representative. The Aroo well has a very condensed shale section at this level and therefore, is also not very representative at the regional scale. The Pelican #1 well tested a mildly overpressured zone with low percentage sand as expected. Other wells indicate that at this stratigraphic level, the central basin area has a sand fraction in the order of 30 to 50 percent.

Figure 20 shows the percentage sand values and contour lines for the lower L. balmei palynologic zone. Aside from the Konkon well with 4%, the other wells indicate a gradual decrease in percentage sand towards the central area of the basin. The Aroo well shows a 31 percent sand fraction. This value is higher than the upper L. balmei zone, however, this apparent reversal in percentage sand may be more controlled by the thickness of the interval, as defined by palynology, then by a local resurgence of sand in the basin.



5 cm

Figure 19

226040

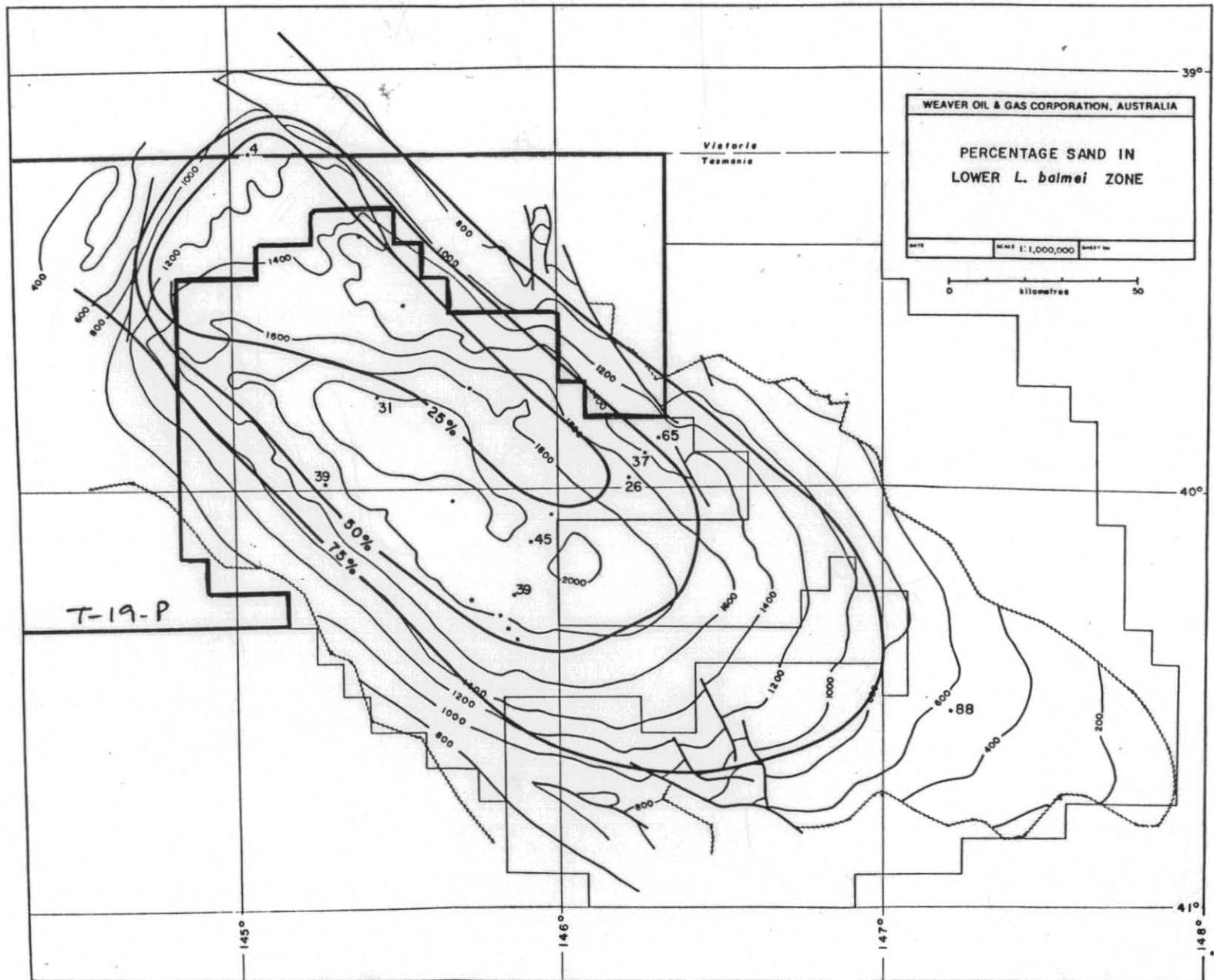


Figure 20

226041

Indications of hydrocarbons in the upper and lower *L. balmei* section of the Aroo, Poonboon, Bass #3, Pelican #3, and Dondu wells have been recorded. These indications consist of fluorescence and wet gas in the drilling mud in the Aroo well, fluorescence and cut in cores and cuttings in the Poonboon, Pelican #3, and Dondu wells, and light oil or condensate recorded in a wireline test conducted in the Bass #3 well.

Figure 21 shows the percentage sand values and contour lines for the *T. longus* palynologic zone of the Late Cretaceous. The percentage sand is shown to decrease towards the central area of the basin.

Figure 22 shows the aggregate percentage and thickness of coal found in the Eastern View Coal Measures section. These values are shown to vary rather rapidly over short distances. The Aroo and Bass #3 wells shows the lowest values. Palynological studies indicate the presence of possibly frequent marine incursions in the area of the basin where these two wells are located. Regional consideration indicates that encroachments of the sea would have come in from a westerly direction and would have been controlled by access ways provided the combination of half graben wedge shape depressions and compartments caused by transfer faults. Figure 16.

Marine shales and fine clastics as well as coals or interbedded coals and shales are considered potential source rocks for oil and gas in the Bass basin. Figure 22 shows that coal is developed best on the northeast and southwest flanks of the basin. The central basin area has less coal as it is replaced by in-part marine shales. Figure 23 shows that the proportion of coal is highest in the upper *M. diversus* palynologic zone and decreases in the older zones.

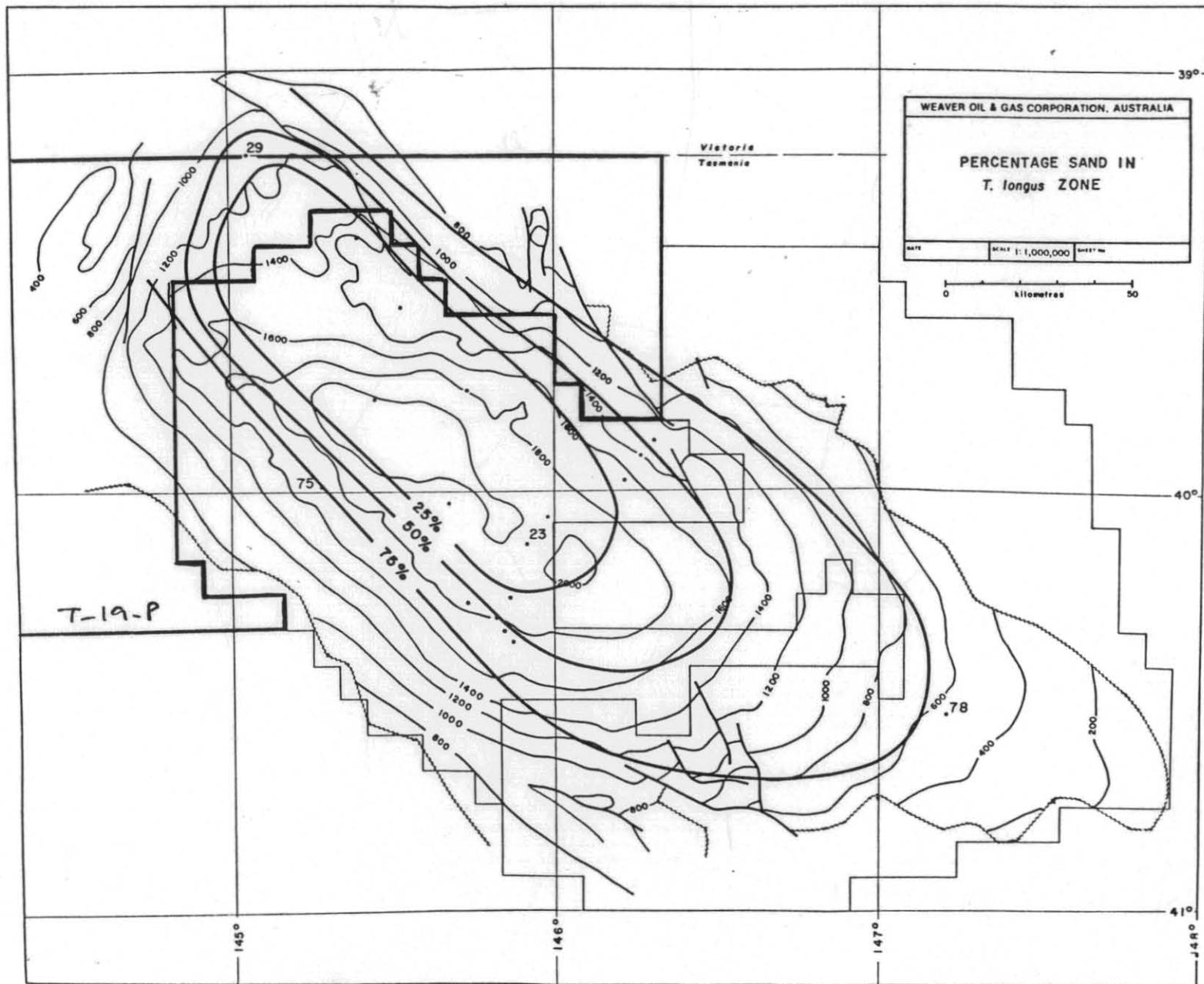


Figure 21

226043

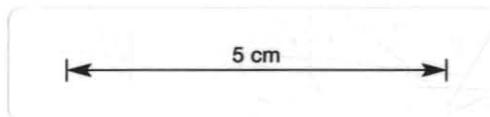
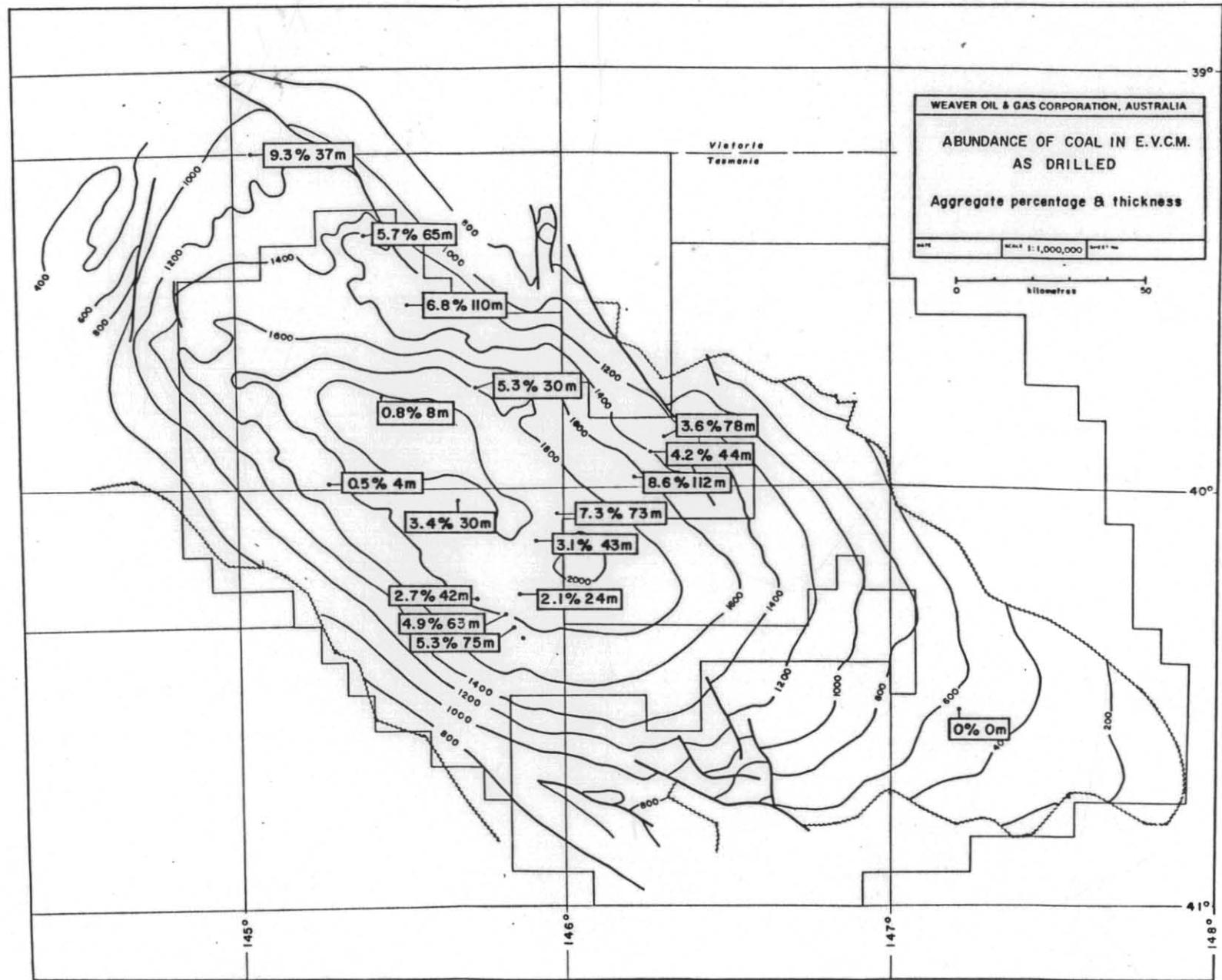
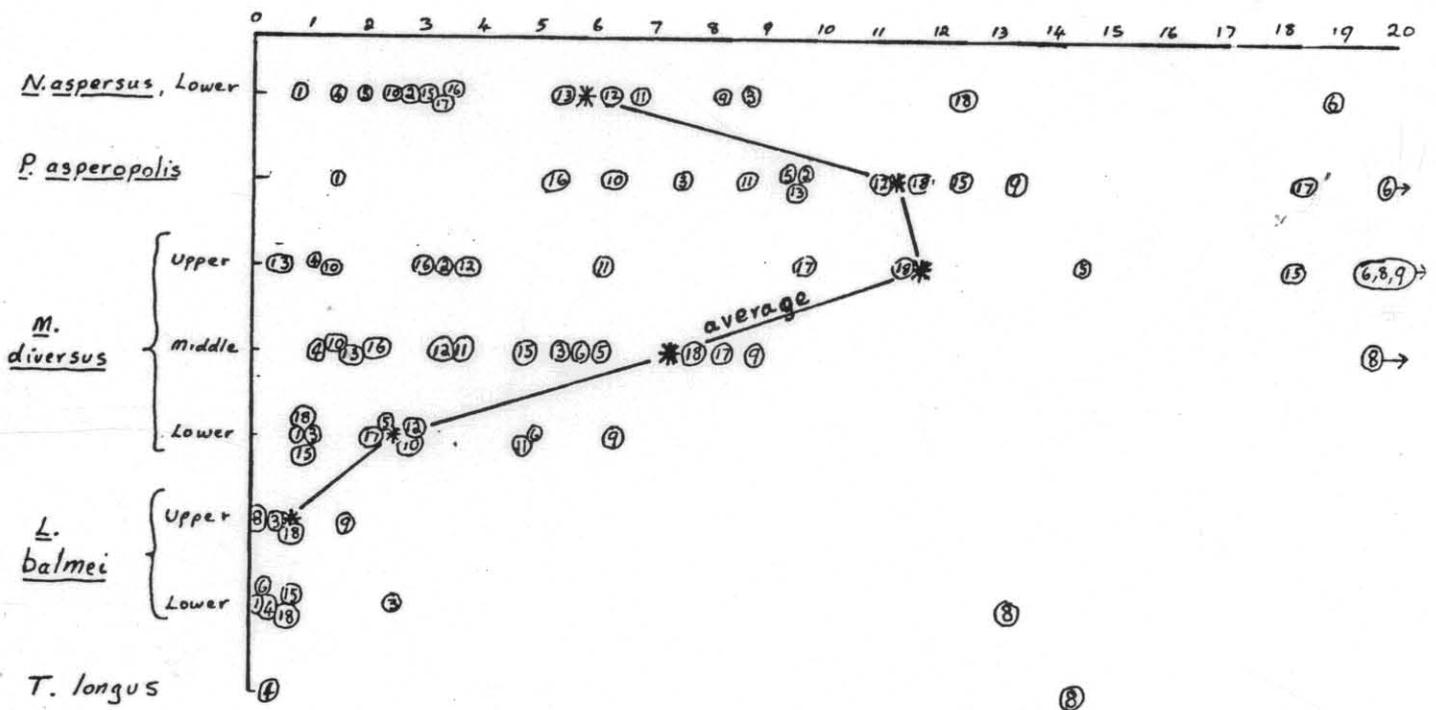


Figure 22

226044



KEY

- |               |              |
|---------------|--------------|
| ① Aroo -1     | ⑩ Narimba-1  |
| ② Bass-1      | ⑪ Pelican-1  |
| ③ Bass-2      | ⑫ Pelican-2  |
| ④ Bass-3      | ⑬ Pelican-3  |
| ⑤ Cormorant-1 | ⑭ Pelican-4  |
| ⑥ Donda-1     | ⑮ Poonboon-1 |
| ⑦ Durroon-1   | ⑯ Tarook-1   |
| ⑧ Konkon-1    | ⑰ Toolka-1a  |
| ⑨ Nangkero-1  | ⑱ Yurongi-1  |

Figure 23

5 cm

### Thermal History

Bottom hole temperature measurements have been collected in order to evaluate the thermal history of certain wells drilled in the Bass basin. These temperature readings, taken in the course of logging programs, have been corrected for the recovery period to maximum bottom hole temperature by taking account of the time since circulation stopped factor as well as the variations in rock thermal conductivity versus depth factor.

The Lopotin method for handling the chemical kinetics aspects of petroleum generation has been used. The corrected thermal profiles are plotted against the age, measured in millions of years, of the stratigraphic sequence found in a well. Available data is insufficient to study the in-time details of the structural evolution of the basin. Nevertheless, this method has been applied and Time Temperature Index (TTI) values have been generated. A value of 15 is generally considered to indicate the onset of oil generation, while a value of 1000 is considered to indicate the beginning of the thermal cracking of heavy hydrocarbon molecules. The Aroo, Cormorant, Dondu, Narimba, Pelican #1, Pelican #3, Poonboon, and Tarook wells have been studied.

The Time Temperature Index values indicate that the level of onset of the oil generation phase has been reached in the following wells evaluated in this study.

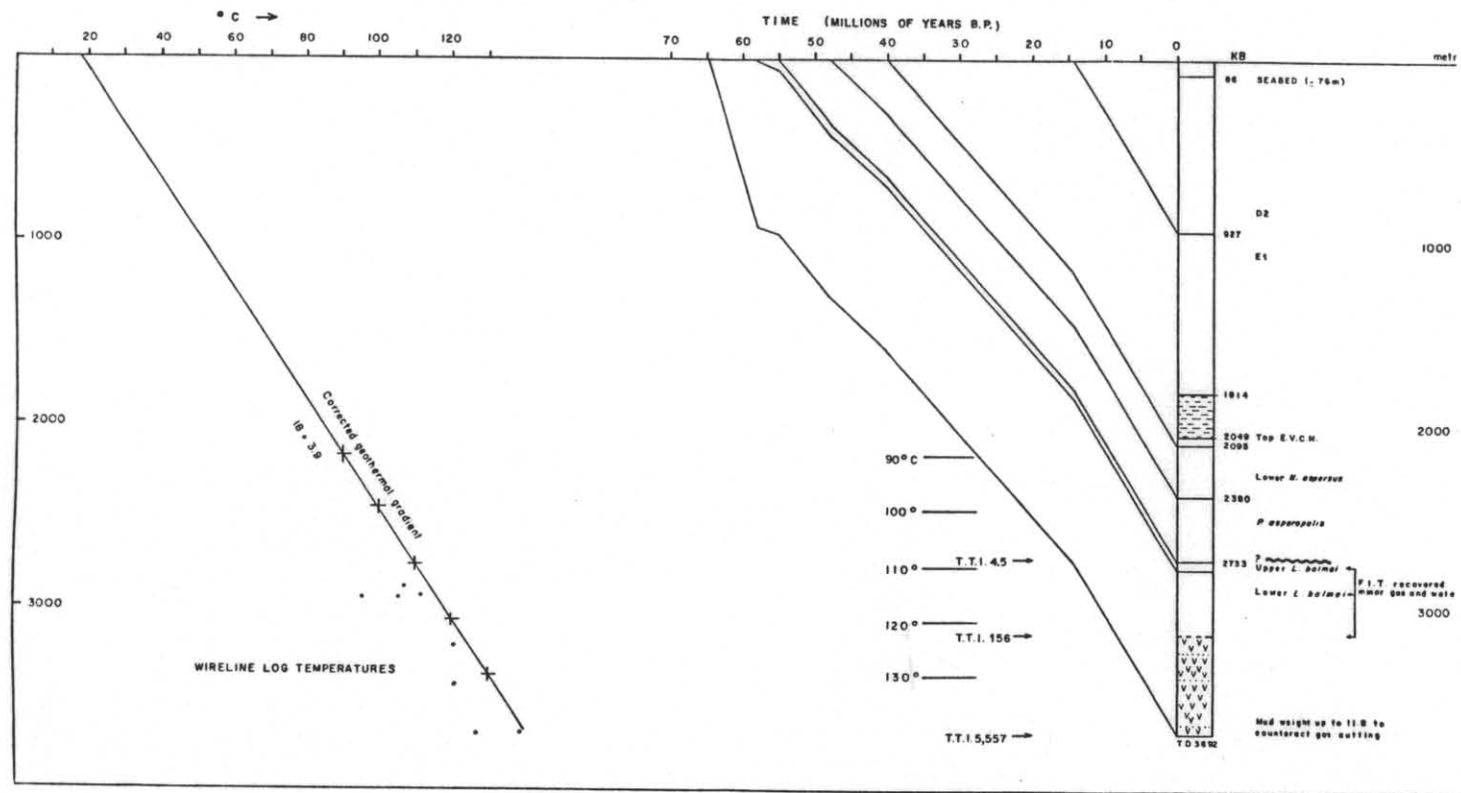
<u>WELL</u>	<u>DEPTH</u>	<u>PALYNOLOGIC ZONE</u>
Aroo	2900 m	L. L. balmei
Cormorant	2750 m	L. M. diversus
Dondu	2500 m	U. L. balmei
Narimba	2700 m	M. M. diversus
Pelican #1	3100 m	L. M. diversus
Poonboon	2950 m	L. L. balmei

Fluorescence, cut fluorescence and evidence of wet gas in the drilling mud was recorded in the Aroo well starting at a depth of 2100 meters. These indications persisted all the way down to 3634 meters. A sandstone at 3611 to 3634 meters, within the volcanic sequence found in this well, showed wet gas on the chromatograph. These recorded occurrences of hydrocarbon are located above the so-called oil generation phase window as well as within and below the level of thermal cracking of heavy molecules defined by the Lopotin method. These occurrences may indicate that migration took place to both the immature and overmature portions of the section. Figure 24.

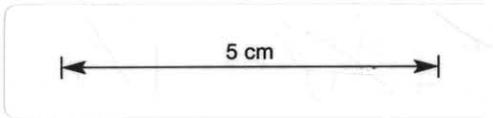
In the Cormorant well, the oil generation phase window has been reached at a depth of 2750 meters. The thermal cracking of heavy molecules level was not reached at total depth of 3002 meters in this well. Fluorescence and crushed cut fluorescence has been reported in sandstone intervals of conventional cores from a depth of 1300 meters down. Formation interval tests (FIT) recovered oil at 1500 meters, 2008 meters and 2345 meters. Other formation interval tests have recovered gas at various levels between 1416 meters and 2008 meters. Deeper interval, below the volcanics found in this well, were not tested. Conventional core descriptions and sample descriptions as well as mud log indications and formation interval tests carried in this well indicate that occurrences of liquid hydrocarbons occur at depths substantially shallower than the oil generation phase window defined by the Lopotin method. Migration into the immature portion of the well may have taken place. Figure 25.

In the Dondu well the oil generation phase level has been reached at a depth of 2500 meters. Indications of fluorescence and cut fluorescence have been reported starting at 2328 meters. Kerogen alteration studies indicate that the mature section begins at the same depth. Figure 26.

Figure 24

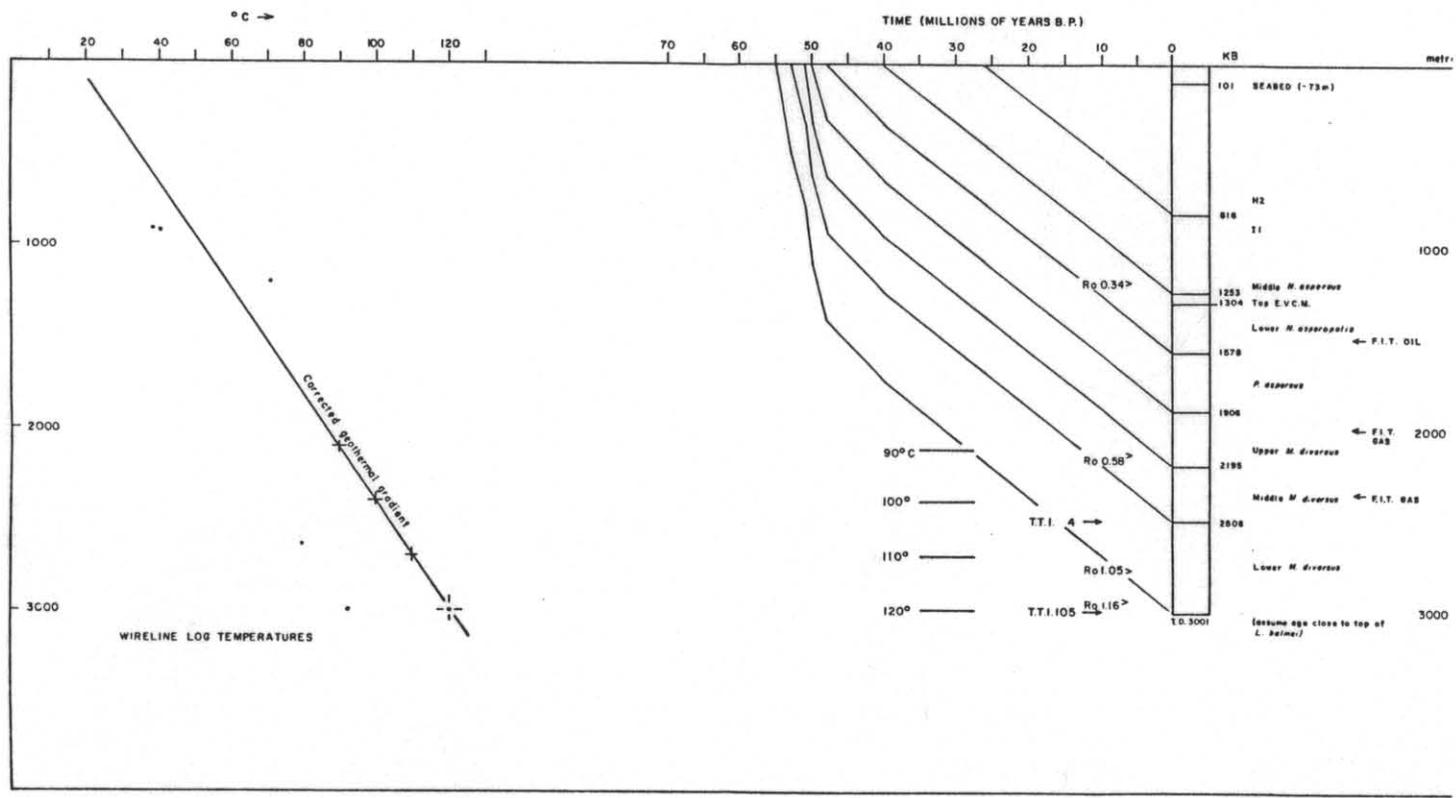


AR00-1 Thermal History

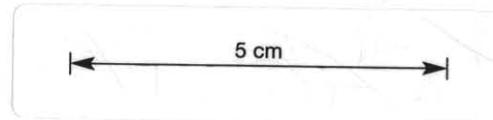


226048

Figure 25

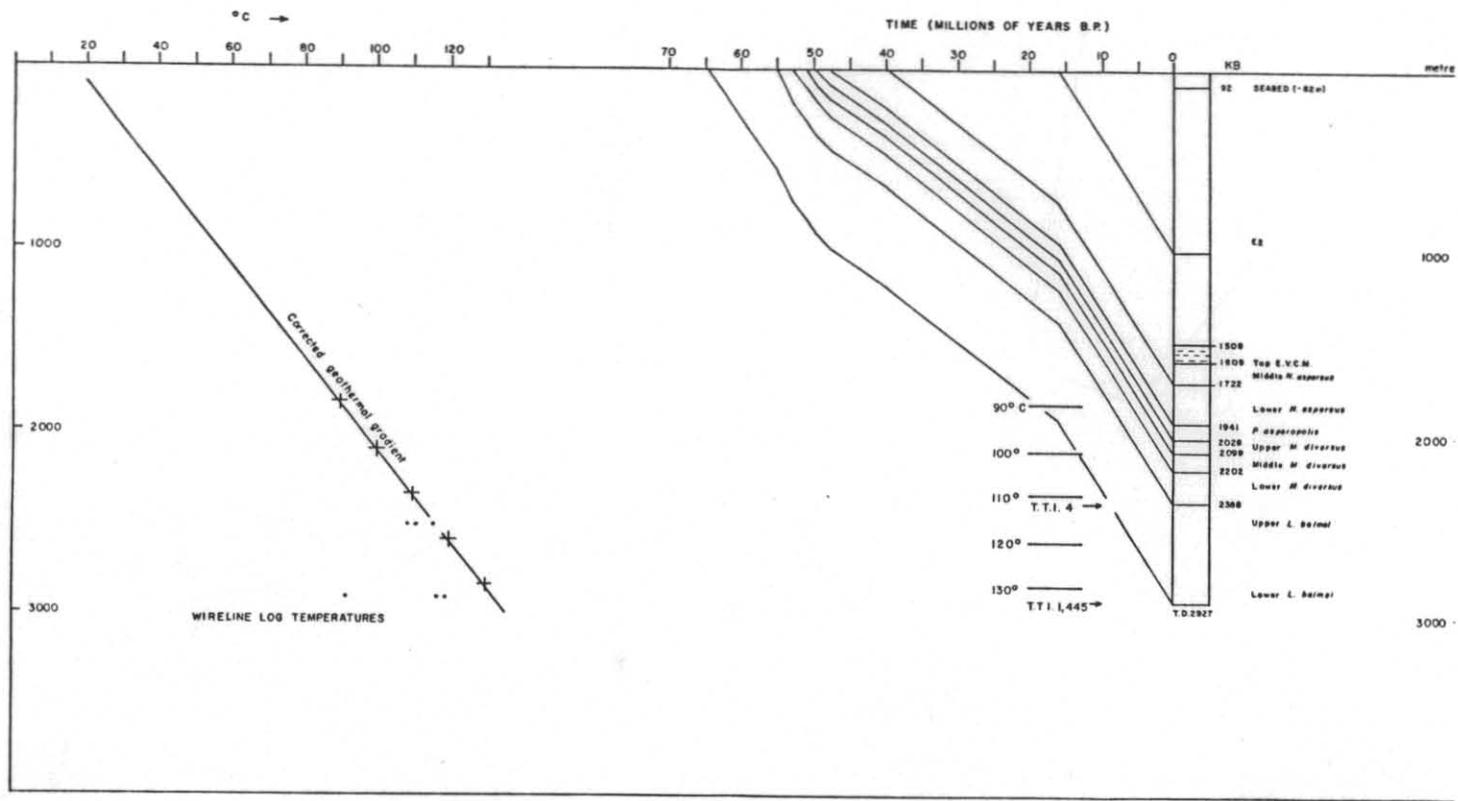


CORMORANT -1 Thermal History

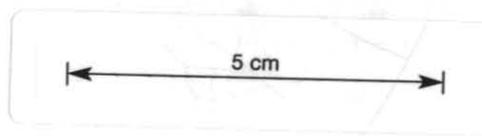


226049

Figure 26



DONDU -1 Thermal History



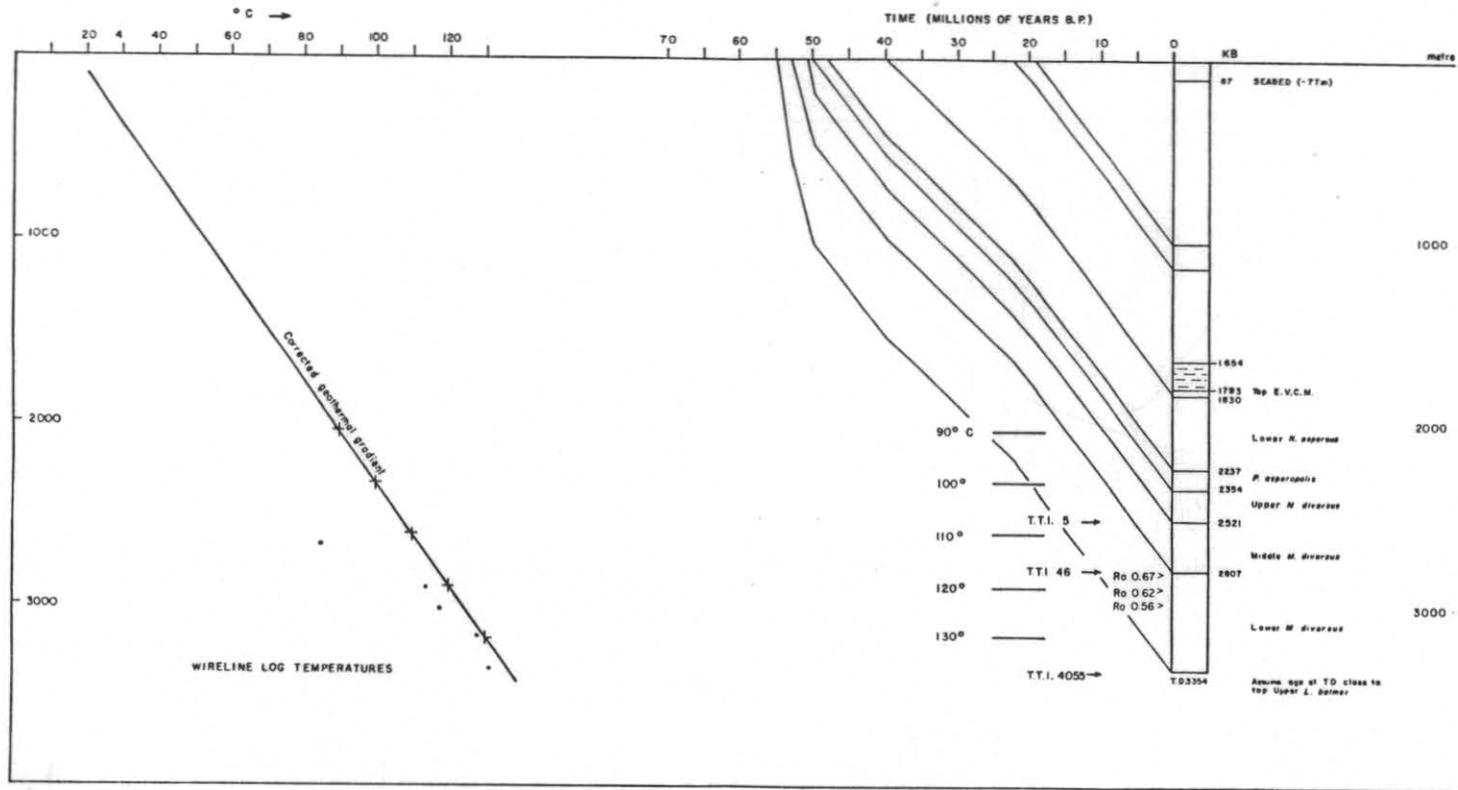
226050

In the Narimba well, the oil generation phase level has been reached at a depth of 2700 meters. The only indication of hydrocarbon in this well are from analysis of the gasoline fraction from canned cuttings. Consistently high values are found at 2804 meters and below, a fair degree of maturity is indicated. Figure 27.

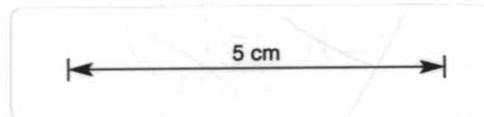
In the Pelican #1 well, the oil generation phase level has been reached at a depth of 3100 meters. Formation interval tests (FIT) indicate the presence of condensate or light oil and gas at depths of 2473 meters with 55° API, 2550 meters with 61° API, 2586 meters with 56.5° API and 3161 meters with 51° API. Other formation interval tests indicate the presence of gas only at intermediate depths. Discrete hydrocarbon bearing intervals are recognized in logs between 2472 meters and 2873 meters and possibly deeper. According to geophysical mapping, the Pelican #1 well is located on a diapiric structure downthrown from a major fault. Significant uplift of the general pay zone interval is indicated and mild overpressure of the section is reported to begin at a depth of 2880 meters. Figure 28.

In the Pelican #3 well, the oil generation phase was not reached by total depth of 2907 meters. This well encountered an older stratigraphic section than the Pelican #1 well. Indications of gas were recorded over the interval 2780 to 2820 meters. Mild overpressure was encountered at approximately 2570 meters. Petroleum odor as well as fluorescence and cut fluorescence were recorded in conventional cores at depths of 2851 meters, 2857 meters, 2864 meters, 2867 meters, 2872 meters, 2877 meters, 2879 meters, 2887 meters, and 2892 meters. Some mineral fluorescence is indicated. The Pelican #3 well is located on a tilted fault block with

Figure 27

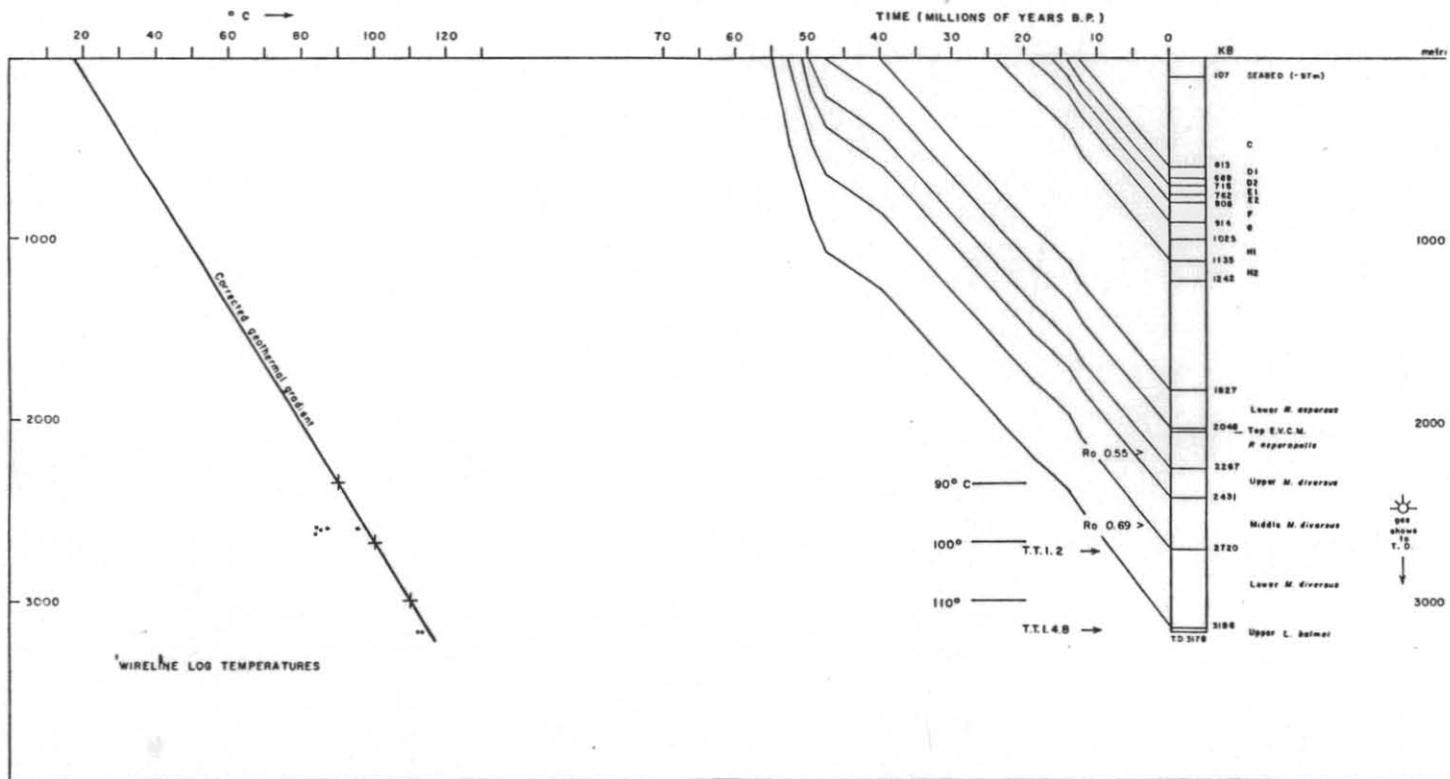


NARIMBA - I Thermal History

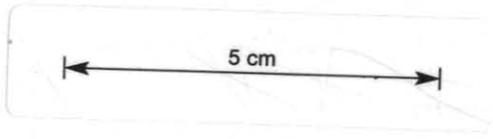


226052

Figure 28



PELICAN -1 Thermal History



226053

a condensed section. Most of the hydrocarbon bearing section found in the nearby Pelican #1 well is not present in the Pelican #3 well. Figure 29.

In the Poonboon well, the oil generation phase level has been reached at a depth of 2950 meters. Indications of fluorescence associated with dead oil or from mineral grains have been recorded sporadically beginning at a depth of 2746 meters. Abnormal high pressures were encountered at approximately 2835 meters. The well kicked at 3189 meters and was abandoned at 3266 meters due to an unsafe pressure imbalance condition. Kerogen alteration studies indicate that a mature section is present below 2713 meters.

Figure 30.

In the Tarook well the oil generation phase level was not reached by total depth of 2774 meters, figure 31.

#### Structural Cross-Sections

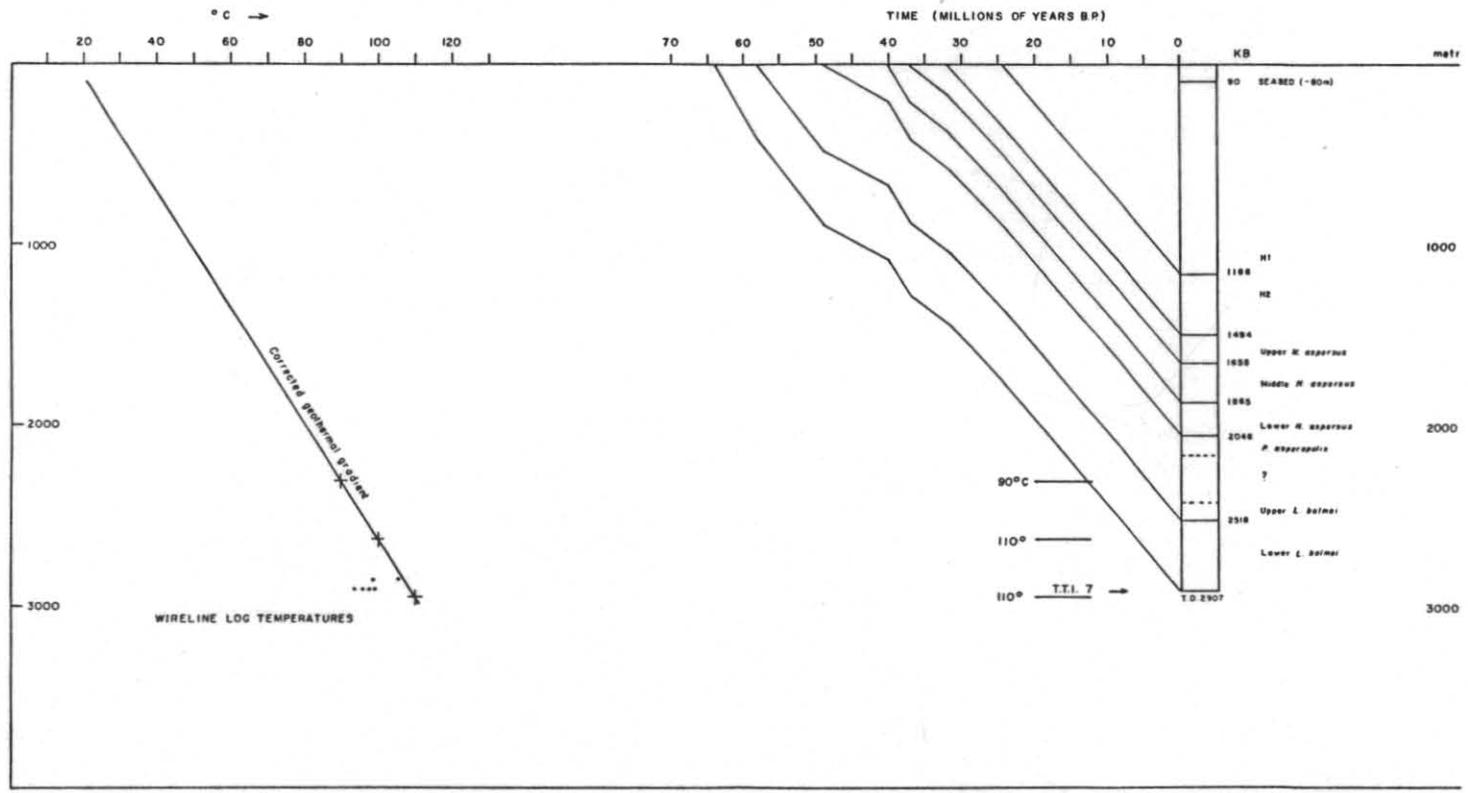
Structural cross sections A-B-C, D-B and B-E illustrate the very generalized geometry of the Bass basin along its transverse axis and longitudinal axis. The depths to the oil generation phase window and the thermal cracking level of heavy molecules is indicated. Figures 32,33, 34.

Figures 35 and 36 illustrate the spacial distribution of the *M. diversus* and *L. balmei* palynological zones sediments contained within or below the oil generation phase window of the Bass basin.

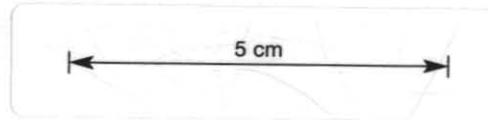
#### Stratigraphic Cross Sections

Three stratigraphic cross sections have been constructed in an attempt to show the lateral facies changes of the Eastern View Coal Measures in wells located in the western half of the Bass basin area. The original intent was to demonstrate the influence, on the spacial distribution of facies, of the wedges and troughs created by the basin forming faults and transfer faults as well as to illustrate the regional trends in sandstones,

Figure 29



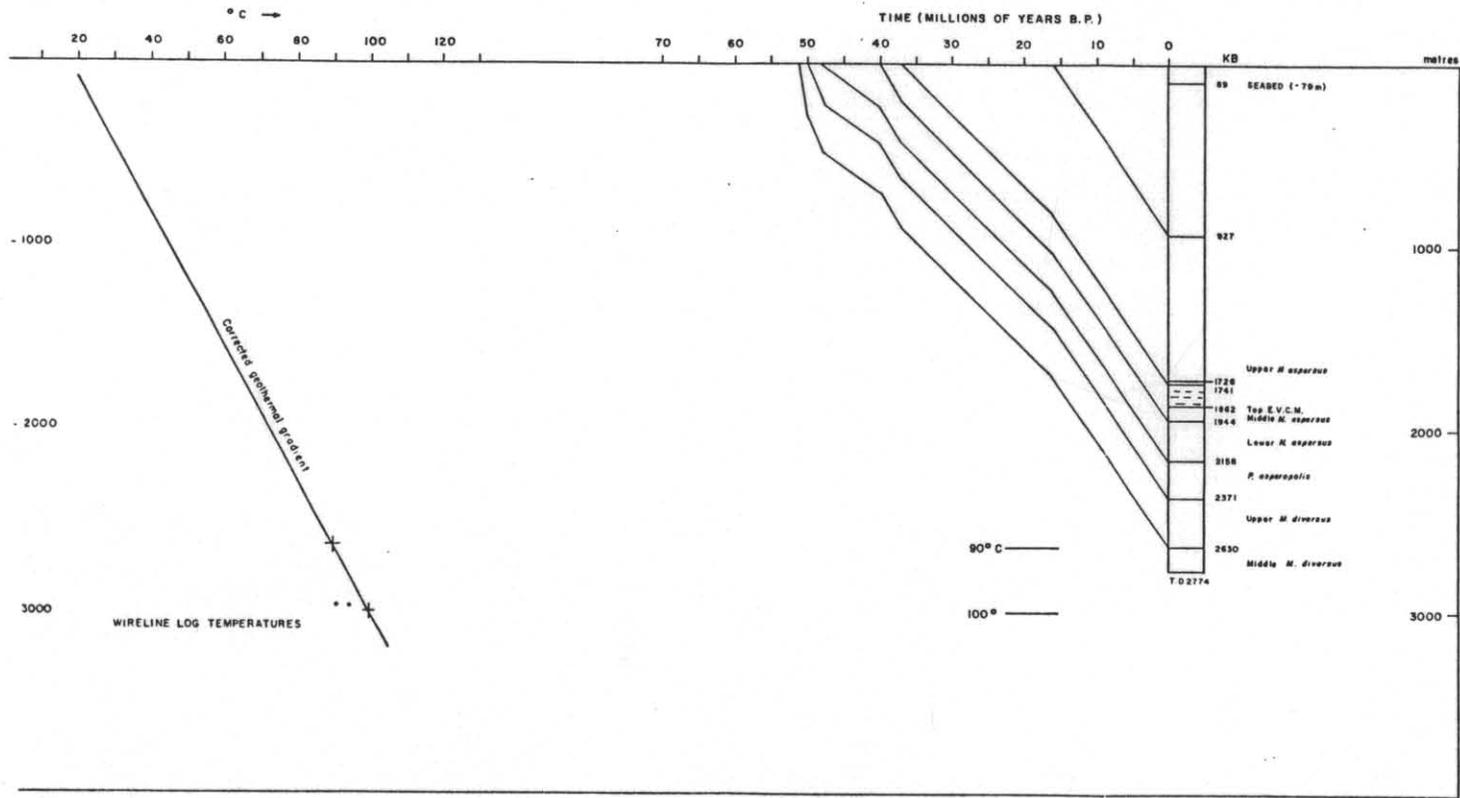
PELICAN -3 Thermal History



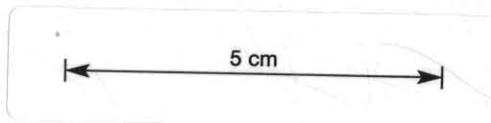
226055



Figure 31



TAROOK - I Thermal History



226057

CROSS SECTION A - B - C

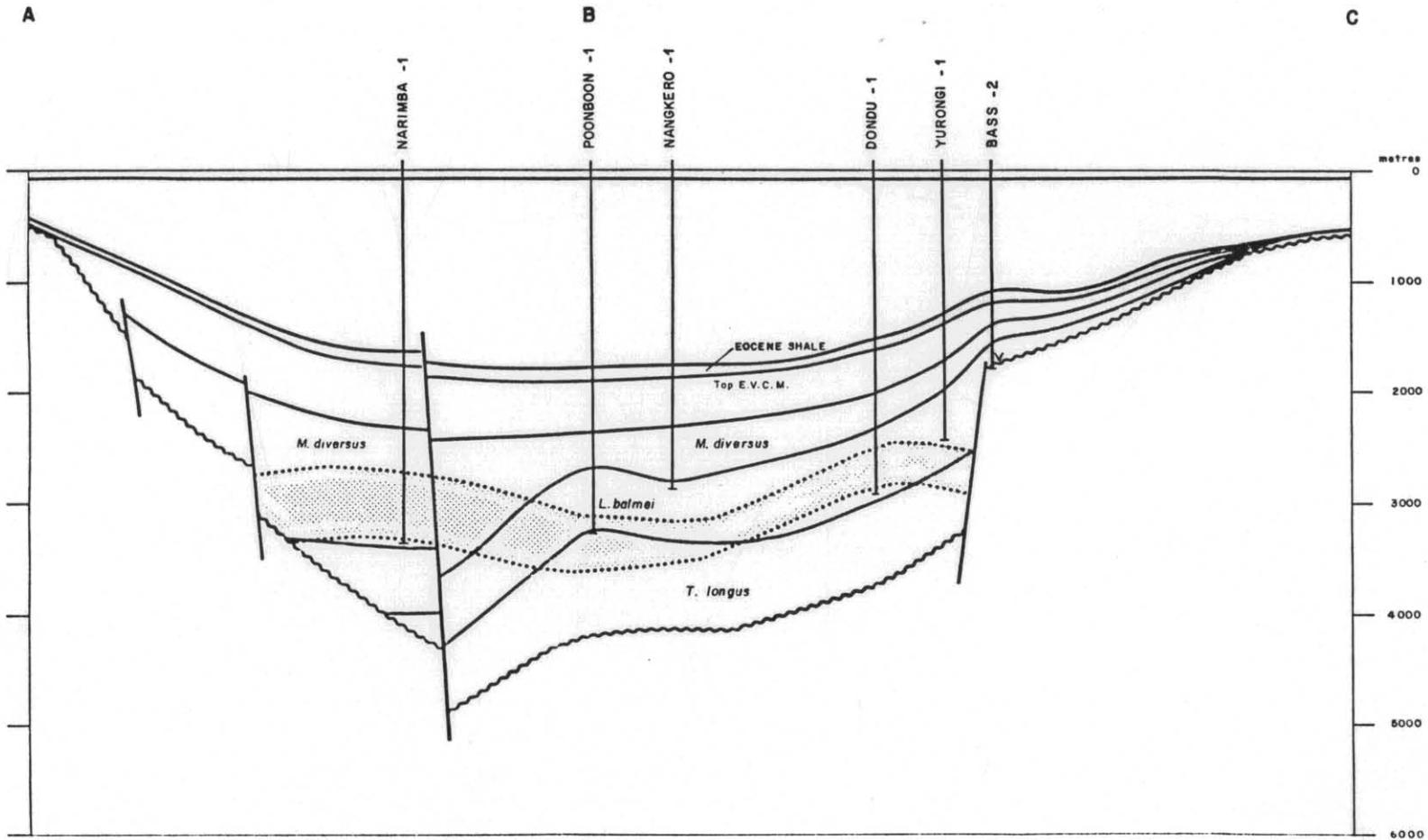


Figure 32

226058

CROSS SECTION D - B

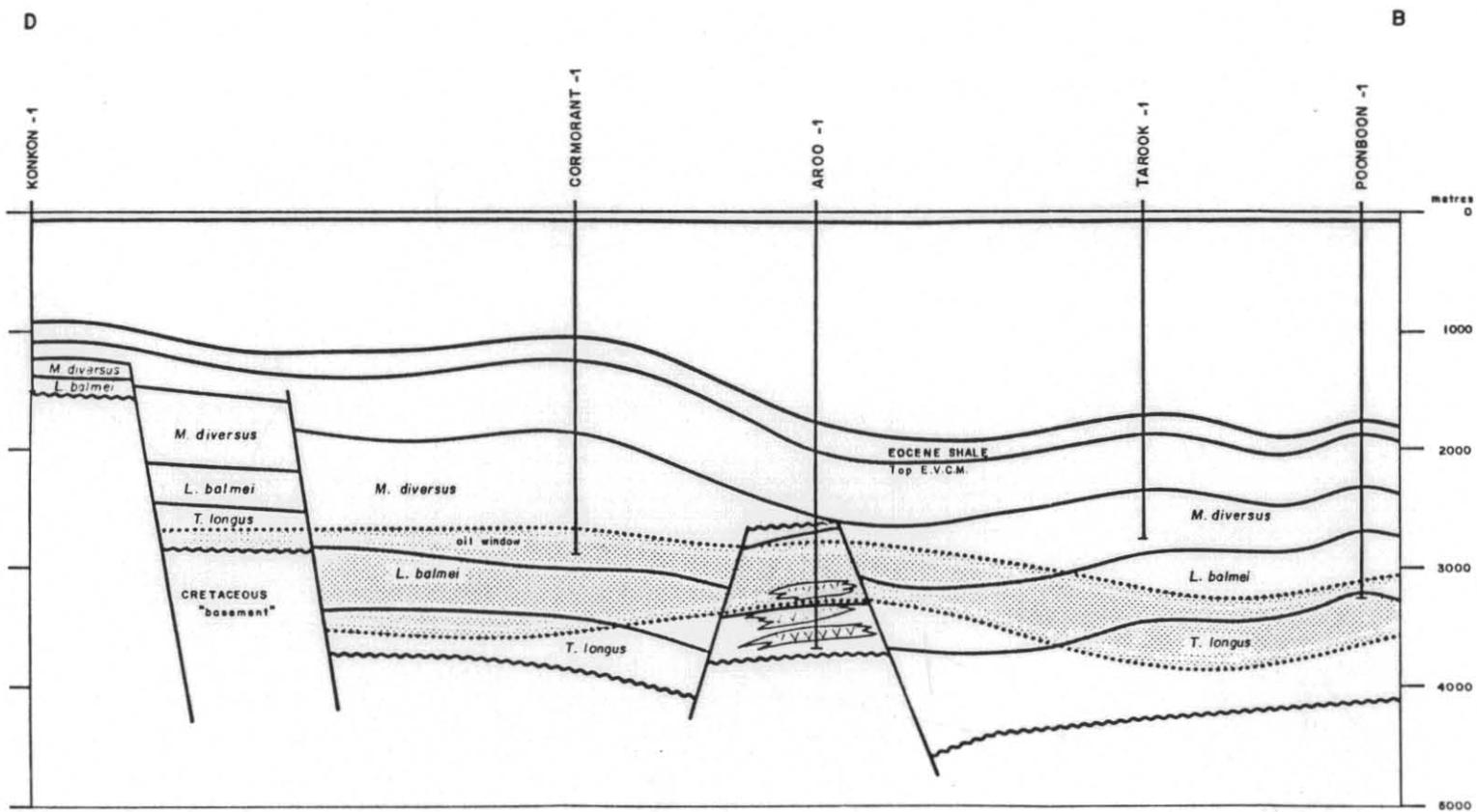


Figure 33

226059

CROSS SECTION B - E

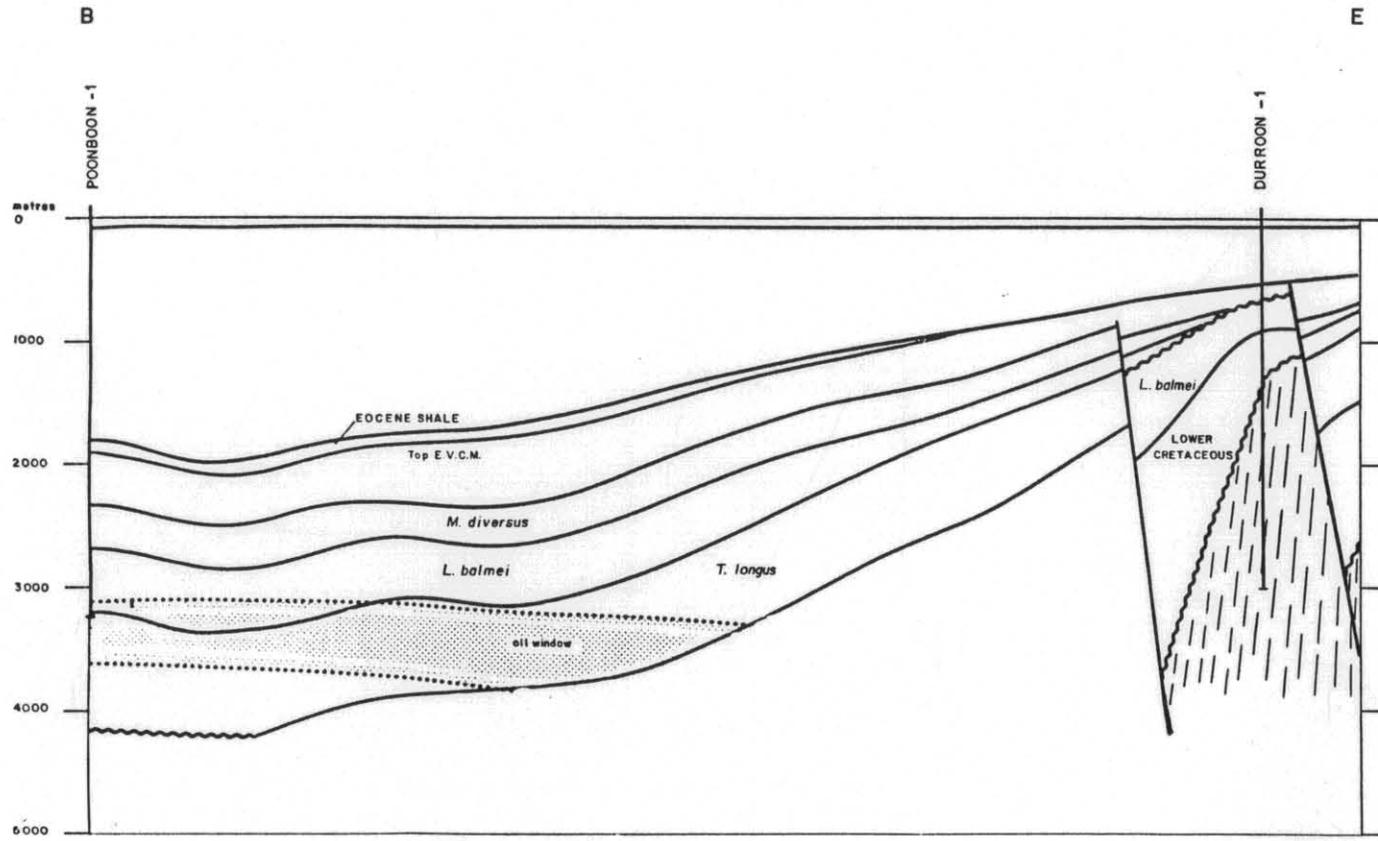
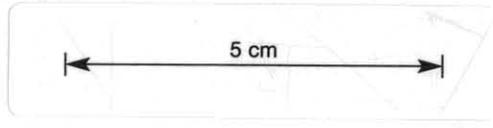
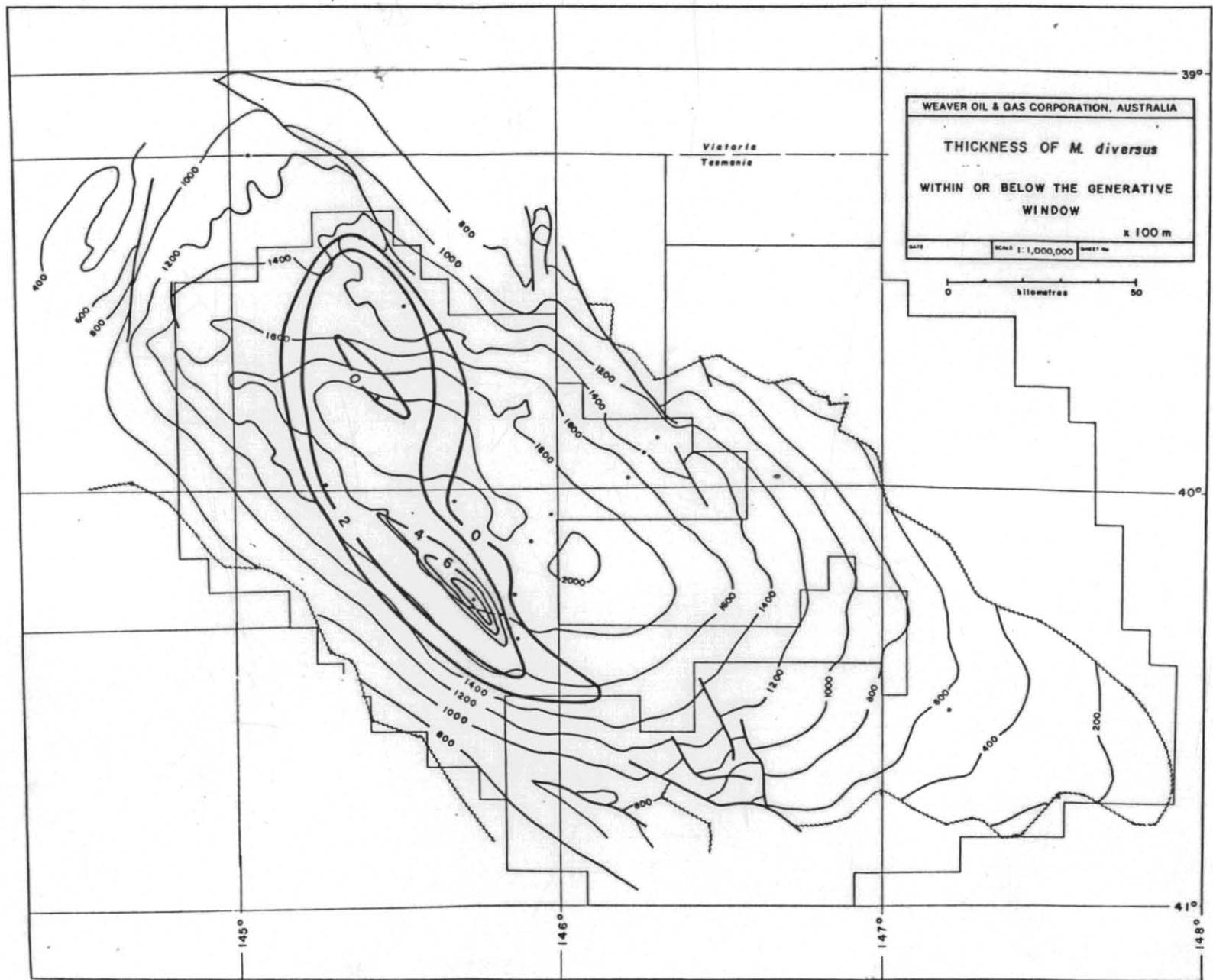


Figure 34



226060

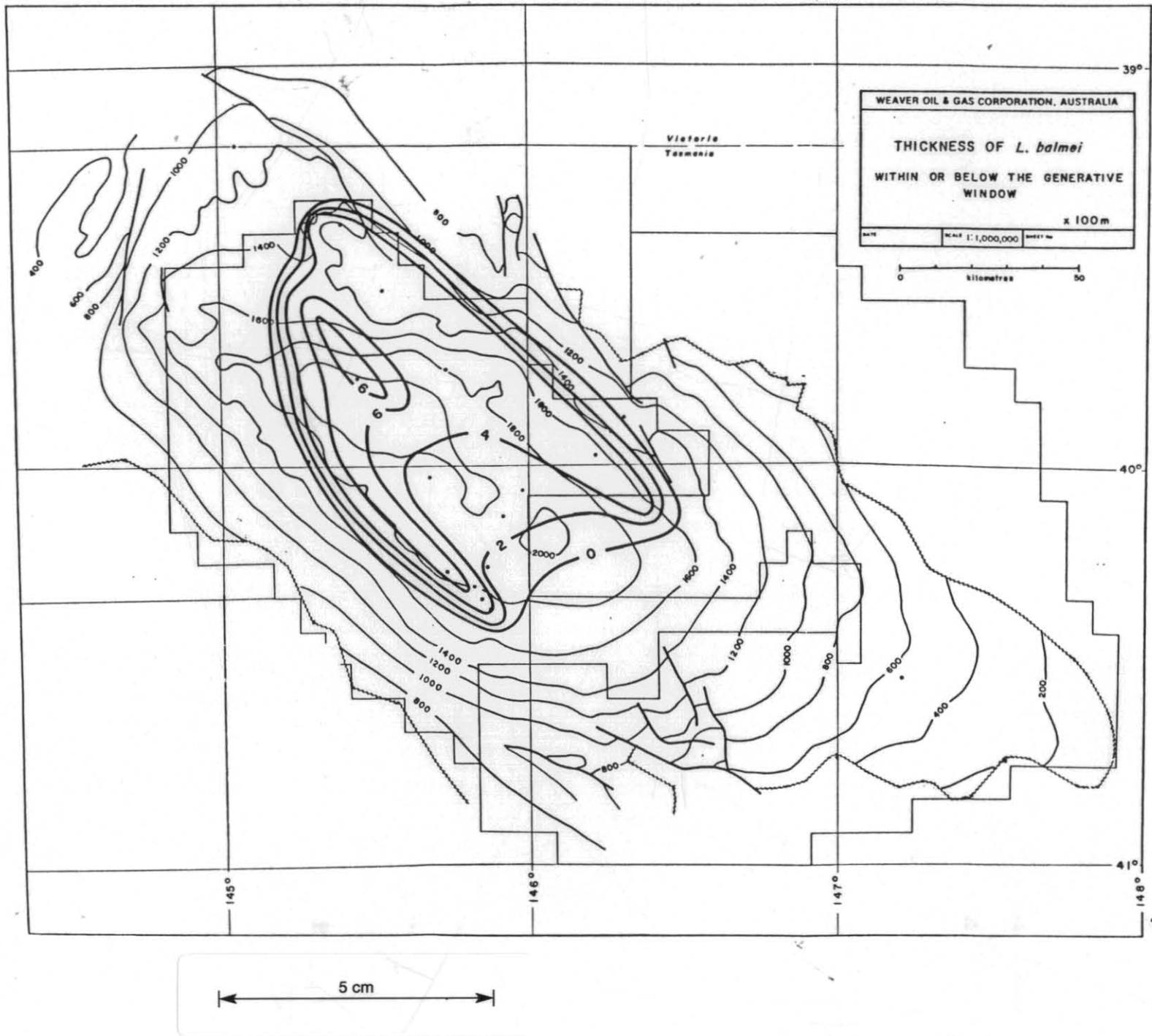
Figure 35



5 cm

226061

Figure 36



226062

shales and coal ditribution. Electric logs from each of the wells as well as samples, sidewall cores and conventional cores descriptions and palynological zonations have been used.

It has been observed that the electric log response to certain lithology changes is somewhat unusual. Taking into account that the wells were drilled and logged in the 60's and 70's and that the formation waters have highly variable and generally low salinities still does not account fully for certain departures from the usual standard log characteristics. The best documented cases of erratic behavior of certain log curves is found in wells where conventional cores have been taken, described, analyzed and plotted on the logs after correction for generally small depth discrepancies. In certain cases the spontaneous potential curves appears to be reading something else than sandstone versus shale or coal, relative cleanliness of the sandstone and fluid content. The gamma-ray curves also display unusual response in that the shaliness, or shale factor of the sandstones, known, described and analysed in conventional cores, is almost the same as that of the adjoining shales. The resistivity curves also display unusual responses. It may be of interest to cross plot certain log curves versus conventional core intervals in an effort to illustrate and possibly resolve these apparent departures from standard. Such an exercise may reveal the presence of a clay fraction, or other rock component, of a somewhat unusual nature.

The first cross section, Figure 37, relates the sections found in the Konkon, Toolka, Cormorant, and Bass #1 wells. These four wells are located on the north or northeast flank of the basin. Figure 38 shows that these wells are all located in northeast dipping wedge shaped depressions separated by transfer faults. The original intent was to



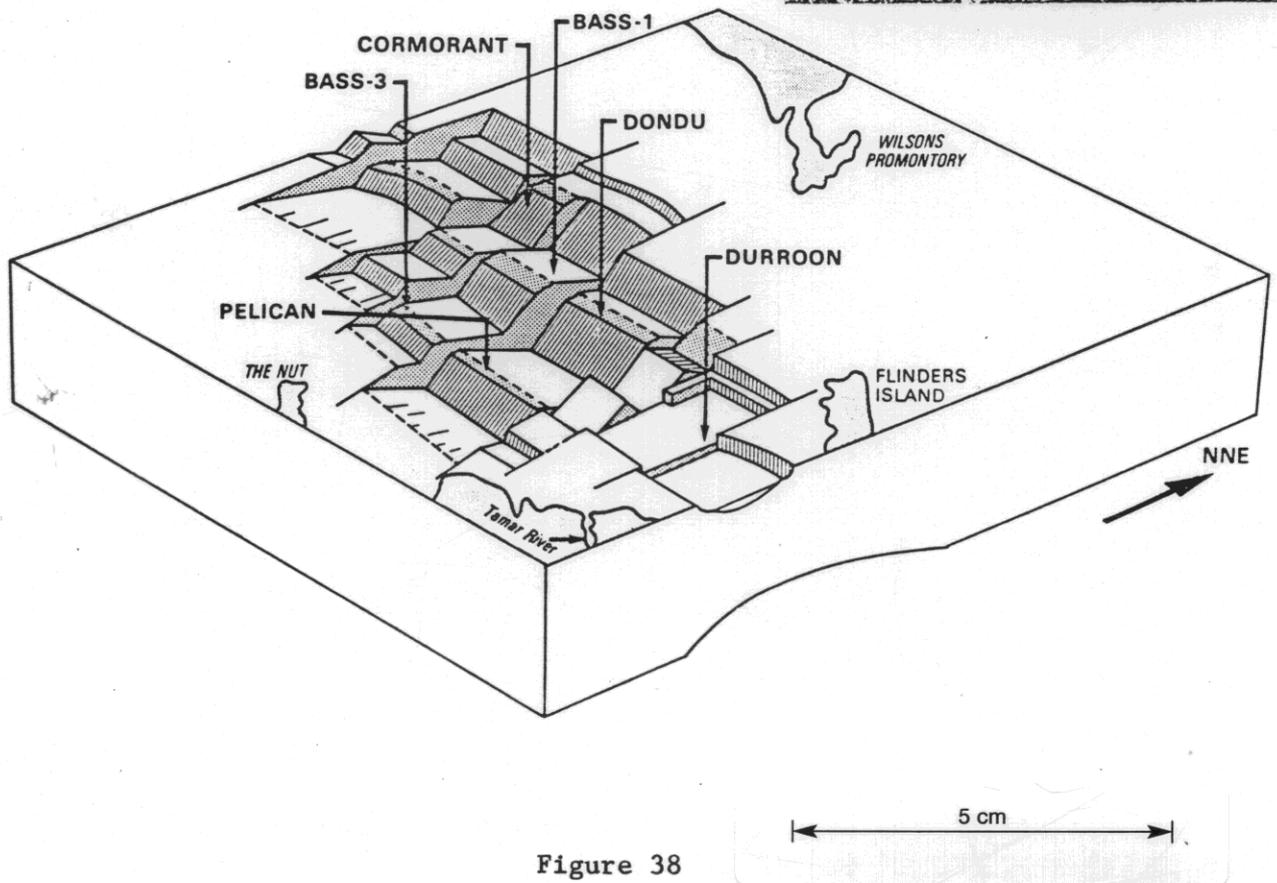
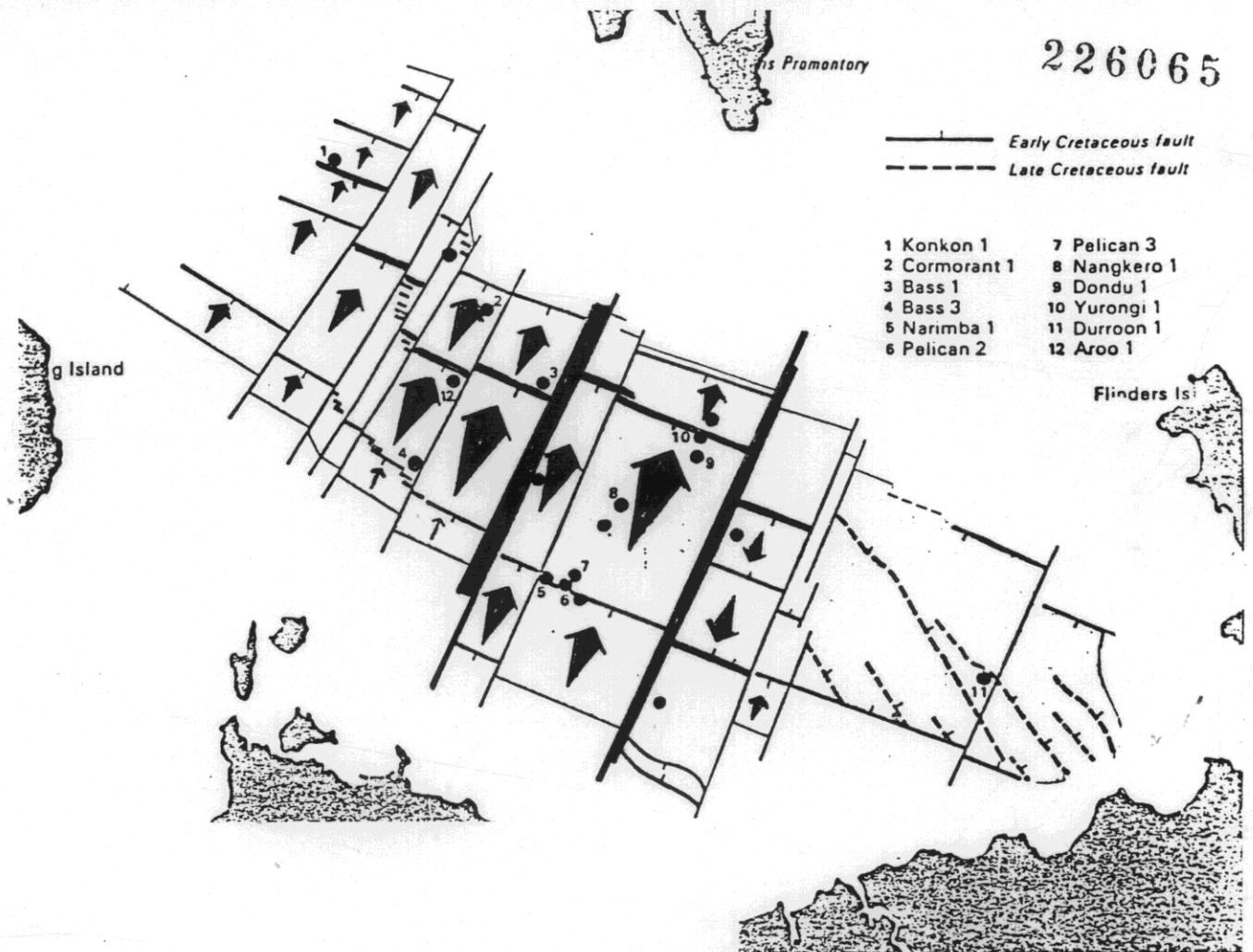


Figure 38

illustrate lateral facies changes controlled by the structural evolution of wedge shape depressions. The vertical scale is one inch equals one thousand feet. The horizontal scale is graphic. The lithologies are illustrated with standard symbols. The base line is the top Upper N. *aspersus* palynological zone. Correlations guided by the palynological zonation are easily established between the wells. Distinct sedimentological cycles are recognized and are used to adjust or complement the palynological zonations. This cross section shows that correlatable units are present in all four wells. The upper, middle, and lower N. *aspersus* zone are featureless except for a condensed section found in the Konkon well. An expanded section is found at Cormorant where the lower portion of the P. *asperopolus* zone is found to be thicker than in the nearby wells. The Toolka well displays a gradual expansion of the section throughout the P. *asperopolus* and older section. A typical sandstone to coal cycle with increasing depth is recognized in the P. *asperopolus* zone of the Bass #1 well. In this well the cycle begins at 6780 feet and extends down to 7450 feet. Typically the Upper M. *diversus* palynological zone begins right at the base of this coal cycle section. A similar and correlatable cycle is recognized in the Cormorant well where it begins at 5080 feet and extends down to 5910 feet. In this particular well a secondary cycle from 5910 feet to 6560 feet was deposited during the structural expansion period of this area.

The top of the Upper N. *aspersus* palynological zone displays a complex relationship with the first major occurrence of sandstone at the top of the Eastern View Coal Measures section. In the Cormorant well the Upper N. *aspersus* zone begins at 4260 feet. Above this depth a few ill-defined argillaceous sandstones are seen up to a depth of 4090 feet. Below this depth more argillaceous sandstones and shales are seen down to a depth of 4630 feet or so. This transition zone is not as well defined or

may in fact be absent in the Toolka well where the top lower *N. aspersus* correspond to the first sandstone occurrence. However, the first coal occurrence in the Toolka well is at 4910 feet while it is at 4770 feet in the Cormorant well. This may indicate that the transition from coal swamp to somewhat more "marine" condition occurred sooner in the Cormorant well than in the Toolka well. This may be witnessed by the occurrence of algal forms in the Kerogen fraction of the Cormorant well source-rock shale section. The local occurrence of oil or light oil/condensate in the Cormorant well has been tentatively explained, in various publications, by the local occurrence of marine source rocks. This could account for immature oil at shallow depths and lighter oil at greater depths. A transition zone is also observed in the Bass #1 well where the top of the Upper *N. aspersus* zone is at 6162 feet. Argillaceous sandstones are present all the way up to 5935 feet. A distinct log character response is also seen at 6335 feet. This interval is atypical of the top Eastern View Coal Measures section. In the Konkon well the top lower *N. aspersus* zone is at 3765 feet. Clean sandstones are seen all the way up to 3595 feet. This sandstone body is interpreted to replace the basal Eocene Shale section in a coarse clastics influx area.

This cross section shows the Konkon well to be located in an elevated, condensed section, coarse clastics, source area throughout the lower portion of the middle *N. aspersus* and the whole of the lower *N. aspersus* and *P. asperopolus* palynological zones. The upper and late middle *M. diversus* palynological zones show regional thicknesses. The Toolka well appears to be located in an area of mild expansion with more of the same being deposited. The Cormorant well

shows a greatly expanded section in an area which may have undergone marine incursions. The Bass #1 well displays regionally recognized cycles of deposition. Volcanic occurrences are recognized in the upper, middle and lower M. diversus palynological zones. This may possibly represent a single event where volcanics are intruded along transfer and basin forming faults and are injected in rocks of various ages across fault planes.

The second stratigraphic cross section was constructed for the specific purpose of observing the lateral facies relationships between wells located within the central basin area. The Nangkero, Poonboon, Pelican #3, and Pelican #1 wells form a northeast trending alignment. Figure 39. The Pelican #1 well is located in a downthrown position in relation to a major wedge shape depression within which the three other wells are located. All four wells display easy straight forward correlation of the section from Upper N. aspersus down to upper M. diversus palynological zone. Further, the Nangkero and Poonboon wells show easy correlations down to and including Lower L. balmei and the same would apply to the Pelican #3 well after removal of minor and local structuration. The Pelican #1 well displays an expanded section from upper M. diversus down and as in the Cormorant well, the expanded section is characterized by occurrences of hydrocarbons. Sandstone to coal with increasing depth cycles are recognized.

The third stratigraphic cross-section was constructed for the purpose of observing lateral facies relationships along the axis of the basin as well as along its southwest flank. The Narimba, Tarook and Aroo wells form a northwest alignment while the Aroo to Bass #3 wells form a northeast alignment. Figure 40. The Narimba well encountered a section closely similar to that found in the Pelican #1 well. These two wells are located closeby. The P. asperopolus palynological zone may have been identified a bit low in the Narimba well. Its relation to coal cycles shows that it





could be higher by a few hundreds of feet, thus permitting a closer comparison to the Pelican #1 well. Fluorescence and cut fluorescence and possibly dead oil is widely recognized in the Narimba well. The upper and middle M. diversus condensed section recognized in the Nangkero, Poonboon, Pelican #3, Aroo and Bass #3 wells is replaced by an expanded section the Pelican #1, Narimba, and Tarook wells. The Aroo well display an expanded Lower L. balmei section accompanied by indications of hydrocarbons which may also be, in part, controlled by structural movement. The general sequence does not show any drastic facies changes along the long axis of the basin. The section at Bass #3 is condensed as expected to be, in a well located on a structure of such magnitude.

These three stratigraphic cross sections show that with a modest amount of additional effort a rather simple sedimentological model could be constructed for the Bass basin. These show that sandstone percentage maps do not really show the sandstone distribution pattern on a regional scale as they are solely based on palynological zones which have not been adjusted to account for barren or reworked intervals. The significant occurrences of hydrocarbons are related to expanded stratigraphic sections where sediment accumulation took place under more "marine" or "deltaic" conditions. The pervasive coal swamp environment does not apparently provide for adequate generation, expulsion and migration of hydrocarbons. As in other rift systems, the main objective section consist of the sediments deposited during the various active rift fill stage cycles. The regionally correlatable and mostly uniform thickness sag stage sediments provides a cover and little else in terms of objective section for hydrocarbon exploration.

Reprocessed Seismic Line

Seismic line PB-82-25 was originally acquired by Perthshire Petroleum Limited in the course of the Octopus Marine Seismic Survey of 1982. The line has an east-west orientation and crosses the Manatee structural complex of tilted fault blocks located on Permit T-19-P.

This line was recommended for advanced reprocessing on an experimental basis. Reprocessing was performed by Western Geophysical in Houston, Texas USA. The objective of the reprocessing was to attempt to use new techniques or algorithms in an effort to enhance and extract data previously resistant to improvement by conventional processing methods.

The interval, shot point 61 to 617, was reprocessed using "DMO", a new pseudo pre-stack migration, followed by F-K filtering and finite-difference wave equation migration after stack in an attempt to bring out the deeper steeply dipping events. Results indicate that in this particular case, the "DMO" processing is of limited value especially in view of the time and expense involved. However, the finite difference migration and F-K filtering does help bring out the deeper events and put them in their correct space and time relationship.

Reprocessed seismic line PB-82-25 shot point 61-617 is displayed after 4800% final stack (TVF, GAIN) (DMO) Enclosure 1, and after migration (TVF, GAIN) (DMO) Enclosure 2.

Reprocessing work carried by GSI for the Bureau of Mineral Resources indicate that routine processing programs which were previously not applied, or incorrectly applied for our purposes, will in fact be adequate in most cases. A simple sliding gate AGC or multiple window trace balancing and scaling program will significantly enhance the deeper low

amplitude reflectors. This would significantly help in resolving the deeply buried structures of the main basin depocenter areas.

Reprocessing of certain lines on Permit T-19-P has been recommended and will be carried at the same time as the processing of the data to be acquired in the second quarter of 1985.