P.E.P. 105

OTWAY BASIN STUDY
TYRENDARRA EMBAYMENT

PART 1 (TEXT)

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INTRODUCTION

This report discusses the prospects for locating hydrocarbons in the Tyrendarra Embayment of the Otway Basin. It deals with all aspects relevant to petroleum exploration, elaborating on the structure and the stratigraphy of the basin only as they apply to hydrocarbons. The report also discusses:-

- source rock potential
- reservoir potential
- cap rocks and migration pathways
- timing of hydrocarbon generation, and
- timing of structural development.

A data base of well cards and logs has been used as a basis for this study. A series of maps, log correlation cross-section etc. have been prepared from this data base.

As Lindon-1 was drilled during the final stage of report preparation, only its preliminary results were adopted in this study.

THE OBJECTIVES

The paucity of detailed petroleum exploration data in the Tyrendarra Embayment prevents this report providing detailed objectives. However a significant number of water bores have been drilled and results from these do provide some exploration concepts and recommendations.

Very limited palynological studies are available from exploration as well as stratigraphic/water wells. These, where possible, were extrapolated by correlations between limited logged wells to give formation tops. The results presented in this report are the basic information for future exploration in the Tyrendarra Embayment. This when combined with the recommended additional data acquisition, will provide the principal tools to achieve a more detailed knowledge of the Embayment.

CONCLUSIONS

The Tyrendarra Embayment of the Otway Basin has an excellent chance of containing economic accumulation of hydrocarbons. Results of the recent exploration activities would suggest a greater probability of finding oil than gas.

The Eumeralla Formation is recognised as the major source rock. This formation is mature and liquid hydrocarbon has been, and probably is being, generated over much of the area. It is possible that gas has also been generated from this formation in the centre of the Portland Trough.

Because of the depth of burial, the Belfast Mudstone Member, in the centre of the Portland Trough, may be considered a gas-prone latent source rock.

Potential Reservoirs are recognised in:-

- The sand units of the lower cycles of the Dilwyn Formation
- The Pebble Point Formation
- The Timboon Sand Member of the Paaratte Formation
- The sand units of the undifferentiated Paaratte Formation (including the Nullawarre Greensand equivalent)
- The Waarre Formation
- The Pretty Hill Sandstone Facies of the Crayfish Formation.

Structural and stratigraphic hydrocarbon entrapments could exist in:-

(a) The Crayfish Formation;
   - pinchout on basement high's flank
   - truncation at unconformity surface

(b) The Waarre Formation
   - pinchout at basin margin
   - structural traps south of the Tartwaup Fault

(c) The Paaratte Formation (undifferentiated sand units)
   - structural traps south of the Tartwaup Fault, where structure independent of faulting is recognised.

CONCLUSIONS - Continued

(d) The Timboon Sand Member and Pebble Point Formation
- structural traps in the central part of the Portland Trough.

Because of the relatively high oil price, the geographical location of the Embayment (between Melbourne and Adelaide) and the growing demand for oil, even relatively small accumulation could be considered commercial.

RECOMMENDATIONS

Mapping

The following maps should be prepared/completed for the Tyrendarra Embayment (in order of priority).

(i) For any seismic program always map Top Pebble Point Formation and Top Waarre Formation,

(ii) Fault Maps (faults rupturing the Belfast and Pember Mudstone Members),

(iii) Attempt, where possible, to map Top Crayfish Formation and Top Basement. The latter particularly along the basin margin.

Source Rock Studies

(i) Complete a 100 metre sampling interval source rock study of the Eumeralla Formation and/or Geltwood Beach Facies of the Crayfish Formation in the following wells:-

- Casterton No. 1
- Eumeralla No. 1
- Heathfield No. 1
- Lindon No. 1
- Malanganee No. 4
- North Eumeralla No. 1

(ii) Samples of the Belfast Mudstone and Pember Mudstone Members should be collected for source rock related studies from all future wells in the centre of the Portland Trough.

(iii) Attempt source rock/oil correlations between oil sample recovered from DST No. 1 and samples from Eumeralla Formation in Lindon No. 1.

(iv) Attempt source rock/oil correlations between Lindon No. 1 oil and selected samples of the Eumeralla Formation in Eumeralla No. 1 and North Eumeralla No. 1.

(v) Attempt source rock/oil correlations between Lindon No. 1 oil and Port Campbell No. 4 oil.

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RECOMMENDATIONS - Continued

Petrological Studies

(i) Attempt a detailed petrological study on core samples from the Pebble Point Formation in Lindon No. 1. The study should include:-

- mineral identification using both transmitted light microscopy and x-ray diffraction techniques.
- define the grain-matrix-cement relationship.
- point-counting and microphotography.

(ii) Attempt lithological logging on cutting and core samples from the Pebble Point Formation in selected wells in the Tyrendarra Embayment. The study will define the extent of different lithofacies of this formation.

Seismic Acquisition

(i) Acquire further seismic to complete the, now extended, 1983 Denhelm Seismic Survey (Wanwin-Gorae Seismic Survey). A minimum of two lines should be located over the Lindon Structure in an attempt to define the highest point of this structure. Dynamite should be used in places, particularly where relatively thick surface volcanics are present in an attempt to improve the data quality.

(ii) Reprocess selected lines from the 1971 and 1972 Shell-Dartmoor Survey.

(iii) Acquire a 'new Permit' north of the Tartwaup Fault extending from the north western border of the P.E.P. 105 to the South Australia border. Once the permit is granted seismic should be acquired to the south of the Tartwaup Fault as well as immediately north of the fault to examine both the Upper and Lower Cretaceous reservoirs.

(iv) Complete a relatively detailed regional seismic grid over the entire area of P.E.P. 105 south of the Tartwaup Fault and extending to the coast on the Glenelg National Park.

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RECOMMENDATIONS - Continued

Drilling

(i) The priority is given to the leads already defined between Lindon No. 1 and the centre of the Portland Trough. Any leads defined by the Wanwin-Gorae Survey are potential drilling targets. In all cases the Pebble Point Formation is the primary target.

(ii) All the future V.D.M.E. wells should be monitored. If wells are to intersect Pebble Point Formation, it is strongly recommended to monitor the progress from the wellsite.

CURRENT STATUS OF EXPLORATION IN P.E.P. 105

The study area comprises over 9,000 kilometres^2 of which 3,700 kilometres^2 is occupied by P.E.P. 105. Within the study area 16 exploration wells have been drilled by various petroleum exploration companies and over 100 stratigraphic/water bores have been drilled by the Victorian Department of Minerals and Energy (VDME). Shallow stratigraphic wells drilled by various exploration companies in this area were not taken into consideration in this study.

The VDME bores range in depth between less than 50 metres to around 1850 metres. Data from 69 comparatively deep bores were used in this study (See Figure 1).

The well density is shown in the following table:-

		Study Area	P.E.P. 105
Oil Industry Wells	1 Per	643 km^2(562 km^{2**})	740 km^2(1233 km^{2*})
VDME Wells	1 Per	130 km^2	123 km^2
Total Number of Wells	1 Per	108 km^2	106 km^2

* Figure in bracket shows exploration well density in P.E.P. 105 if Mirams-1 and Portland North-1 are not taken into account, see text.

**Including two offshore (Discovery Bay-1 and Voluta-1) wells.

Only five of the exploration wells were drilled in P.E.P. 105. Mirams-1 and Portland North-1 are very shallow and penetrated only the upper part of the Tertiary sequence. There is very little data available in these wells, consequently they do not contribute to the understanding of the geology and prospectivity of the permit.

The only exploration well which is well-documented and its entire data can be adopted for this study is Green Banks-1. The other exploration wells concentrated on two area; five wells on and west of the Warrnambool High and four wells on the extreme north west of the study area (See Figure 2).

CURRENT STATUS OF EXPLORATION IN P.E.P. 105 - Continued

Within the study area no commercially successful well was drilled. Most wells were drilled either off structure and/or did not reach their targets. Green Banks-1 was drilled on structure but the Pretty Hill Sandstone Facies, the primary target was not developed on the basement high.

More than two thirds of seismic available (approximately 1,700 kilometres) in the study area concentrated over P.E.P. 105 (See Part 1, Enclosure 1) and further seismic is planned for the permit.

Exploration in P.E.P. 105 is at an extremely immature stage.

LIMITATIONS OF THE PROJECT

Despite the comparatively high total number of wells drilled in the Tyrendarra Embayment, the majority of them (more then 80%) are water/stratigraphic bores. This means that detailed data is scarce and is limited to a very small number of well-documented wells. A significant number of wells drilled by the VDME over a number of years have only electrical logs, some of which were acceptable for this study only to a certain degree. Just recently the VDME has used more advanced logging tools and consequently a variety of logs rather than just the relatively primitive electrical logs are present in some bores.

As found in the Port Campbell Embayment, the intense tectonic activities within the Tyrendarra Embaymenthave resulted in rapid changes in formation thickness. Furthermore, comparatively rapid lateral facies changes from north to south and more gradual changes from east to west also occur.

The above-mentioned factors downgrade reliability of any prediction based on the geological data alone. Likewise not all the theories and predictions expressed here may stand up to future drillings.

STRATIGRAPHY

The Stratigraphic Table sets out common nomenclature in the Tyrendarra Embayment. The general time scale is included only for reference.

Although the nomenclature used in this table is the most accepted terminology in the Victorian part of the Otway Basin, the following are worthwhile to note:-

1. The Burrungule Mudstone Member of the Dilwyn Formation is mainly recognised south of Tartwaup Fault (See Figure No. 4). It is completely absent in the Port Campbell Embayment, but it is present locally in South Australia.

2. Older Volcanics are also locally present at the top of the Dilwyn Formation in the study area only. Their presence is not reported in South Australia. In the Port Campbell Embayment the Older Volcanics were reported in one well only (Seaview-1).

3. Due to the limited available data and/or poor development of the Flaxman and Waarre Formations drilled only at the northern margin of the Embayment, differentiation of these two formations was found hazardous. Thus throughout this report they will not be separated.

4. The Crayfish Formation is here applied to the section confined between overlying Eumeralla Formation and underlying Casterton Formation. The unconformity between the Eumeralla and Crayfish Formations was previously regarded as an intraformational unconformity within the Eumeralla Formation. The Crayfish Formation is here considered as a non-marine clastic sequence of interbedded sandstones, siltstones and mudstones, with minor coals. The dominantly porous, well sorted, quartz arenite with garnet as the dominant accessory, is referred to as the "Pretty Hill Sandstone Facies". The moderately sorted, chloritic-smectitic clayey sandstone with abundant multi-sourced lithics, which is usually impermeable and resembles the previously called "Geltwood Beach Formation" is here referred to as the "Geltwood Beach Sandstone Facies".

   After a detailed examination of all intersections of Otway Group sediments this particular classification is seen to be the most logical.

STRATIGRAPHIC TABLE
TYRENDARRA EMBAYMENT

General Time Scale: Period	General Time Scale: Age	Group	Formation	Member	General Lithology	Other Terminology
Q.		POST-HEYTESBURY	NEWER VOLCANIC WHALERS BLUFF FM., ETC.		NEWER VOLCANIC	
TERTIARY	Pliocene	POST-HEYTESBURY	NEWER VOLCANIC WHALERS BLUFF FM., ETC.			
TERTIARY	Miocene	HEYTESBURY	PORT CAMPBELL			GAMBIER LIMESTONE
TERTIARY	Oligocene	HEYTESBURY	GELLIBRAND			GAMBIER LIMESTONE
TERTIARY	Oligocene	HEYTESBURY	CLIFTON		Fe	GAMBIER LIMESTONE
TERTIARY	Eocene	NIRRANDA	NARRAWATURK			
TERTIARY	Eocene	NIRRANDA	MEPUNGA		Fe	
TERTIARY	Eocene	WANGERRIP	DILWYN	Burrungule	OLDER VOLCANIC	
TERTIARY	Palaeocene	WANGERRIP	DILWYN	Pember		
TERTIARY	Palaeocene	WANGERRIP	? PEBBLE POINT	?	? Fe	
CRETACEOUS UPPER	Maastrichtian	SHERBROOK	PAARATTE	Timboon Sand		
CRETACEOUS UPPER	Campanian	SHERBROOK	PAARATTE	Undifferentiated part		
CRETACEOUS UPPER	Santonian	SHERBROOK	PAARATTE	Skull Creek Mudstone and Nullawarre Greensand		
CRETACEOUS UPPER	Coniacian	SHERBROOK	PAARATTE	Belfast		
CRETACEOUS UPPER	Turonian	SHERBROOK	FLAXMAN		L Fe	
CRETACEOUS UPPER	Cenomanian	SHERBROOK	WAARRE		Fe	
CRETACEOUS LOWER	Albian	OTWAY	EUMERALLA	Heathfield		
CRETACEOUS LOWER	Aptian	OTWAY	EUMERALLA			
CRETACEOUS LOWER	Neocamian	OTWAY	? CRAYFISH	? Geltwood Beach; Pretty Hill		
JURASSIC	Late	? —	? CASTERTON	?	? BASAL VOLCANIC	
JURASSIC	Middle	—	CASTERTON		BASAL VOLCANIC	
PALAEOZOIC		BASEMENT				

STRATIGRAPHY - Continued

5. The term "Casterton Formation" is adopted here to replace Casterton Beds which were intersected in Casterton-1, Woolthorpe-1, Hawkesdale-1 and Moyne Falls-1 all located in the study area.

In the last well only the volcanic section (basal Volcanic) of the Casterton Formation was present.

This Casterton Formation is a Middle to Late Jurassic sequence of non-marine clastics, consisting dominantly of mudstones and siltstones with some carbonaceous detritus. It is locally interbedded with olivine basalt and trachyte flows. Isolated sand units may be present within the sedimentary portion. Casterton Formation where seen rests unconformably on Palaeozoic basement rocks.

The depths and formation thicknesses of all wells drilled in the study area and isopach/top formation maps are presented in Part 2 as Appendix No. 1 and Enclosures 1 to 11 respectively.

STRUCTURAL ELEMENTS

The Otway Basin was initiated in the Late Jurassic-Early Cretaceous evolving from a series of sedimentary and syndepositional tectonic events preceding and accompanying the rifting of the Australo-Antarctic palaeo-continent. The basin is a W-NW trending Mesozoic to Tertiary sedimentary trough, extending from Cape Jaffa in South Australia to the Mornington Peninsula in Victoria. The northern margin of the basin has been defined by outcrop and seismic as well as well data. The southern margin is not clearly defined since it lies at or beyond the continental shelf margin.

The structural elements of the basin are generally complex because of several phases of severe tectonic activities:

(a) The basin was initially developed as a pull-apart basin, with the development of a series of rift valleys in which the Late Jurassic-Early Cretaceous sediments were deposited.

It is believed that the Late Jurassic-Early Cretaceous sequences were deposited initially on a low relief surface in a subsiding rift valley along a west northwest axis. Sediments were derived from either the northern or southern flanks of a "postulated" initial dome (which normally preceeds the rift valley stage of continental breakup). After the deposition of the Crayfish Formation within the rifts, this provenance provided a large volume of volcano-clastic material which was deposited as the Eumeralla Formation.

(b) A pause in the early pull-apart tectonism during the beginning of the Upper Cretaceous caused a period of deformation, non-deposition and/or erosion. This, in turn, was followed by subsidence in the Late Cretaceous, with deposition of thick sequences of fluvio-deltaic and restricted marine sediments (Sherbrook Group).

(c) The pull-apart tectonism recommenced during the deposition of the Belfast Mudstone and continued till the late Upper Cretaceous. This would have been due principally to re-activated of faults active during the initial pull-apart.

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STRUCTURAL ELEMENTS - Continued

(d) The final stage in the basin development is a sequence of post breakup Tertiary sediments, which were initially of paralic to marine origin, overlain by open marine carbonates. Gentle faulting and flexing, with localised volcanism further accompanied uplift from Pliocene to Recent.

A brief discussion on the major structural elements within the Tyrendarra Embayment as a function of the period of their development is given below:-

STRUCTURAL ELEMENTS - LATE JURASSIC/EARLY CRETACEOUS (See Figure No. 3)

All the structural features listed below are believed to have resulted from movements during the initial rifting or Late Jurassic/Early Cretaceous stage.

Ardonachie Trough

This half-graben is located in the northeast of both P.E.P. 105 and the study area.

It is controlled by a NW-SE trending normal, down-to-the north-northeast major fault commencing approximately north of Hotspur-1 and probably continues to the vicinity of the Warrnambool High.

Ardonachie-2 is the only VDME bore drilled in this trough and it penetrated only 111 metres of the Otway Group. Seismic data, which is tied to the Green Banks No. 1 well, indicates a substantial section of Lower Cretaceous sediments on the downthrown side of the fault. The presence of the Crayfish Formation is expected within the trough.

The hydrocarbon prospectivity of this trough is yet to be determined.

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Lake Condah High

The Lake Condah High is located to the south of the central part of the Ardonachie Trough, a down-to-the-north, normal fault forming its northern boundary. The elevation of basement caused erosion or non-deposition of the Crayfish Formation. Seismic indicated a large structure on which Green Banks No. 1 was drilled. The lack of shows in this well is considered solely a result of the absence of any worthwhile reservoir, not absence of structure.

Petroleum prospects of the Lake Condah High are extremely doubtful and would be associated only with the pinch-out of sand units within or below the Eumeralla Formation.

Branxholme High

The Branxholme High is located northeast of the Ardonachie Trough. The southern limit of this high is a down-to-the-southwest, normal fault trending northwest-southeast. Two relatively shallow bores, Branxholme-1 and Byambynee-2, were drilled by the VDME on this high, neither of which intersected the basement. The entire Upper Cretaceous and early Tertiary sediments were absent in these wells, i.e. the Dilwyn Formation unconformably overlies the Otway Group.

Merino Uplift

The Merino Uplift is a prominent feature in the northwest of P.E.P. 105. It is an area of moderately elevated and dissected tablelands which is delineated by a series of faults. The structures listed below is that proposed by Douglas & Ferguson, 1976 and Wopfner & Douglas, 1971.

A. KANAWINKA FAULT is a north-northwest trending normal, down-to-the-southwest fault. Several movements including some reversals in direction have taken place on this fault during Cainozoic time (See Figure No. 5).

Merino Uplift - Continued

B. CAROLINE FAULT limits the northern boundary of the Merino Uplift. This is a west-northwest trending normal fault which is downthrown to the south-southwest. The eastern end of this fault bends and its trend becomes north-northeasterly with its downthrown side to the southeast.

C. MIAKITE CREEK FAULT is a northwest striking, down-to-the-southwest fault. It passes through the middle of the Merino Uplift, about 4 kilometres east of Casterton township and displaces the tableland surface, the top of the Otway Group, by about 25 metres. Movements of this fault appear to have been related to movements of the Kanawinka Fault.

The Merino Uplift has later, in Cainozoic time, been affected by the development, to the south and southeast of the Hotspur and the Grassdale-Wannon monoclines respectively (See Figure No. 5).

An isolated, relatively small, "gravity high", defined by an early gravity survey, is located at the southern extremity of the Kanawinka Fault. It appears that this "High" either terminates very locally or faded away rather gradually southward. This is what was previously called the "Dartmoor High". Available data does not indicate any substantial early Cretaceous movement in this area. Consequently in this report, the Dartmoor High would not be considered as a structural element in the Early Cretaceous time.

However, movement of the Kanawinka-Swan Lakes Bridgewater fault system in Cainozoic time elevated this area. Thus, this report will consider the "Dartmoor High" only as a Late Tertiary feature (see later discussion and Figure No. 5).

Only one exploration well, Casterton No. 1, was drilled on the Merino Uplift and VDME bores are very widely spaced. There is no modern seismic available.

Penola Trough

The Penola Trough is, like the Ardonachie Trough, a half-graben with a major, northwest-southeast trending, down to the northeast fault. The axis of the trough, runs parallel to this fault, commencing at around Heathfield-1 and Casterton-2 exploration wells and continuing in a northwesterly direction into South Australia.

A substantial sedimentary sequence, possibly initiated with the Jurassic aged Casterton Formation, has accumulated in this trough. A lack of any apparent Tertiary movement is the only apparent difference between this and the Ardonachie Trough.

Since a large portion of the Penola Trough is located in the South Australian part of the Otway Basin and only a small southeastern portion of it extends into Victoria, i.e. into the study area, its structural development will not be discussed in any detail in this report.

Discussion

As shown in Figure No. 3 structural elements of Early Cretaceous age are the result of the initial pull-apart tectonism. These are generally northwest trending "Troughs" and "Highs", extending from the vicinity of the Warrnambool High (See Figure No. 4) to the extreme northwest of the study area and continuing with the same trend into South Australia.

Available data suggests that similar structures will be present further south both onshore and offshore but are covered by substantial Tertiary and Upper Cretaceous sediments. Further seismic and drilling in P.E.P. 105 will provide the necessary information to define these structures more clearly.

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STRUCTURAL ELEMENTS - LATE CRETACEOUS/EARLY TERTIARY (See Figure No. 4)

Warrnambool High

The Warrnambool High marks the eastern boundary of the study area. It also separates the Port Campbell Embayment from the Tyrendarra Embayment.

This subsurface but prominent feature has been defined by gravity, seismic surveys and drilling. The absence of the basal Upper Cretaceous sandstone, the Waarre Formation, on this high suggests substantial movement at this time and the development of potential Waarre Sandstone stratigraphic targets along the flank of the high.

The Pretty Hill Sandstone Facies of the Crayfish Formation is another possible drilling target on this high. Data available does not indicate whether development of this high also occurred earlier during the deposition of the Crayfish Formation.

Ardonachie Trough

It is apparent, from limited drilling data, that the Ardonachie Trough was tectonically active during the Early Tertiary time. This is indicated by the thickness of the Tertiary sediments in the Ardonachie-2 VDME bore. A detailed account of this trough was given in the early discussion (See Page 14).

Stable Homerton Platform

The Stable Homerton Platform is the area south of the Ardonachie Trough and northeast of the Tartwaup Fault or its eastern extension. Available data suggests that apparently there has been relatively small scale tectonic activity in this area. As a result the Stable Homerton Platform is a zone of relatively minor structural complexity although large numbers of small fault blocks occur. Varying thicknesses of the Pember Mudstone Member suggest that substantial fault movement occurred during the basal Tertiary. Prior to the drilling of Lindon No. 1 it was assumed that this thick mudstone sequence would act as a reliable seal to hydrocarbons trapped below. Results from the well suggest that this may not be the case.

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Tartwaup Fault

This is a major west-northwest trending fault extending from South Australia to western Victoria. It can be seen at the surface near Compton in South Australia but it has not been recognised at the surface in Victoria. The Tartwaup Fault is downthrown to the southwest and extends in subsurface in Victoria to the south of Heywood-13 VDME bore. The movements of this fault caused thickening of the Late Cretaceous - Early Tertiary sediments to the south as is displayed in the respective isopach maps (See Part 2 - Appendix No.2).

On the downthrown side of this fault structural turnover is often present in all pre-Tertiary sediments. With such turnover, rare in the Otway Basin sediments, structures along the southern side of the Tartwaup Fault appear extremely prospective.

Portland Trough

This is a synclinal trough whose axis trends northwest-southeast from north of Warrain-7 to east of the Portland township. The extent of this trough to the east, i.e. offshore, is not clearly defined by available data. It is now believed that the northeastern flank of the Portland Trough is bounded by the Tartwaup Fault or its extension whilst the southwestern flank is limited by the Cape Bridgewater High.

The Portland Trough appears to have developed in the Late Upper Cretaceous - Early Tertiary time and has an accumulation of more than 2500 metres of Tertiary sediments at its depocentre.

On its northern flank, most faulting is normal and down-to-the-north (Lindon No. 1). On its southern flank faulting is again normal but generally down-to-the-south.

Cape Bridgewater High

The Cape Bridgewater High is a poorly-defined fault bounded feature covered by early, very poor quality seismic. The Portland Trough lies immediately north of this high. The Cape Bridgewater High runs parallel to the coast

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STRUCTURAL ELEMENTS - LATE CRETACEOUS/EARLY TERTIARY - Continued

Cape Bridgewater High - Continued

at Discovery Bay and possibly extends both into South Australia to the northwest and south of Cape Duquesne to the southeast.

The fault constituting the southwestern limit of the Cape Bridgewater High is a major, down-to-the-southwest, northwest trending fault. Seismic interpretation has revealed that the movement of this fault was restricted to the Lower Tertiary and has no effect on the Upper Tertiary sequences.

Other Structures

As seen on Upper Cretaceous isopach maps, a trough of this age is located immediately offshore trending parallel to the Portland Trough. The extent and magnitude of this trough cannot be defined because no wells have drilled the entire Upper Cretaceous section. However, its northeastern flank appears to lie onshore beneath the Portland Trough.

The major structural developments within this trough are believed to have occurred at the late Upper Cretaceous stage. These structures are:-

- Cape Bridgewater High (see above)
- South Voluta High, located south of the Cape Bridgewater High. It is a poorly-defined fault bounded feature
- Voluta Graben, bounded by the Cape Bridgewater and South Voluta Faults.

It is believed that the two offshore exploration wells, Voluta-1 and Discovery Bay-1 are located in the Voluta Graben and on the South Voluta High respectively. The deeply-buried Waarre Formation was not intersected in either well.

Discussion

As can be seen from Figure No. 4, with the exception of the Warrnambool High, all the structural elements formed during the Late Cretaceous - Early

STRUCTURAL ELEMENTS - LATE CRETACEOUS/EARLY TERTIARY - Continued

Discussion - Continued

Tertiary time are similar to those of the Lower Cretaceous, i.e. northwest trending fault controlled "Highs" and "Troughs". Some of these features are the result of the reactivation of the faults of the early pull-apart tectonism. A large number of relatively minor faults are scattered in the study area both onshore and offshore.

These do have distinctive and potentially important differences. Most such faults north of the Portland Trough are down-to-the-north. South of the Portland Trough they are down-to-the-south. In the area immediately east of the South Australian border where the Portland Trough has died out, all faulting appears to be down to the south.

Lindon No. 1 was located on a down-to-the-north fault and only a small quantity of oil found to be trapped. The next stage of drilling must include a structure in which faulting is downthrown to the south.

The anticlinal structures developed immediately of the downthrown side of the Tartwaup Fault are also of significant interest.

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STRUCTURAL ELEMENTS - LATE TERTIARY (See Figure No. 5)

Kanawinka Fault

The Kanawinka Fault which was first active in the Lower Cretaceous time (See Page 15) is believed to have been reactivated in Cainozoic time. The presence of a fault escarpment today supports this concept. As it was mentioned earlier some of the movements were reversals in direction. (Wopfner & Douglas, 1971 and Douglas & Ferguson, 1976.)

Weecurra Fault

The Weecurra Fault is a north-south trending normal fault which is downthrown to the west. The northern extremity of this fault bends and extends a few kilometres eastwards. There is also a prominent escarpment along this fault linking the Kanawinka escarpment with the escarpment along the Dartmoor High.

Drik Drik, Jones Ridge, Moleside, Kentbruck, Swan Lake and Bridgewater Faults

These are a series of intersecting faults originating at around the southern end of the Weecurra Fault to the north and terminating at around the south-eastern end of the coast of the Discovery Bay.

The Drik Drik, Jones Ridge and Kentbruck Faults trend northeasterly with their downthrown sides to the northwest, whilst the down-to-the-southwest Moleside and Swan Lake-Bridgewater Faults trend northwesterly.

It is believed that several movements have occurred along these faults during Pre-Syn & Post Pleistocene with the youngest displacements being of greatest magnitude in the south. Escarpments along most of these faults have also been reported.

Dartmoor High

The Dartmoor High is a palaeogeographic feature commencing at around the southwestern end of the Hotspur Monocline, which extends in a southwesterly direction to the intersection of the Kentbruck and Swan Lake-Bridgewater Faults. The abrupt edge of this high being the Drik Drik-Kentbruck Faults

STRUCTURAL ELEMENTS - LATE TERTIARY

Dartmoor High - Continued

system to the northwest whilst its gentle flank extends to the southeast towards the centre of the Portland Trough.

The origin of the Dartmoor High has been debated by several authors. The lengthy discussion on the origin of this high is beyond the scope of this report. However, the opinion of this report will be highlighted as follows:-

> "In contrast to what was believed previously, the Dartmoor High is a relatively young structure. The constant thicknesses of the Tertiary sequences (shown in Isopach maps, Enclosure No's 1 to 5) and the depth of the Top of the Pebble Point Formation (See Enclosure No. 10) over this high support this hypothesis. The presence of a basement high, defined by a gravity survey, south of the Merino Uplift is an independant feature and has no effect on the "Dartmoor High". However, this apparently low relief basement high is not a prominent feature in this area and its location, parallel to the "Dartmoor High" is purely coincidental.
>
> The Dartmoor High is the product of the movements of the Drik Drik, Swan Lake-Bridgewater Faults system at different stages. Hence its abrupt, monocline-like, flank along these faults and its gentle flank to the southeast".

Other Structures

Minor structural elements in the Late Tertiary - Quarternary time include Wannon, Grassdale, Hotspur and Wanwin Monoclines. These monoclines along with their low escarpments are the product of gentle flexures at the completion stage of the Otway Basin's development. They are generally low relief surface features and have minor effect on subsurface strata.

As it was mentioned earlier, the Grassdale-Wannon and Hotspur Monoclines are bounding the Merino Uplift on the southeast and south respectively.

STRUCTURAL ELEMENTS - LATE TERTIARY - Continued

Discussion

As can be seen from Figure No. 5 , the major structural elements in the Late Tertiary - Quarternary time have occurred from north to south along the Kanawinka-Swan Lake-Bridgewater Faults. The rest of Tyrendarra Embayment, and the study area as a whole, appears to have been tectonically stable at this time. Based on this assumption, the petroleum prospects of the study area is summarised as follows:-

A. Any structure produced prior to Late Tertiary time could be considered mature enough to accumulate migrating hydrocarbons, if its seal has remained unbroken.

B. Leads associated with the young movements but originally developed prior to these movements should be treated with great caution, simply because the seal might have been broken with a resulting escape of hydrocarbons.

C. Any lead purely originating from the young structural elements should be considered immature and be initially discarded from the exploration programs.

SOURCE ROCK POTENTIAL

GENERAL

The Otway Basin section is now known to contain both oil and gas prone source rocks. The degree in which these generate hydrocarbons is not confirmed, but further drilling and source rock studies will determine the source rock potential of these sediments both quantitatively and qualitatively.

The presence of commercially produceable gas (North Paaratte No's 1 and 2, Wallaby Creek No. 1 and Grumby No. 1), an uncommercial quantity of oil (Port Campbell No. 4) in the Port Campbell Embayment as well as CO_2 (now in production at Caroline No. 1) in the Gambier Embayment together with the numerous oil and gas shows seen in the whole basin provide part of the support for the positive source rock statements. Table-1 shows the reported hydrocarbon shows in the Tyrendarra Embayment. Eight out of the fourteen exploration wells (excluding Portland North No. 1 and Mirams No. 1) drilled both onshore and offshore in the study area recorded hydrocarbon shows.

GEOTHERMAL GRADIENT

The geothermal gradient in the Tyrendarra Embayment is generally low. Insufficient data were available to present a full account on geothermal gradient of the Tyrendarra Embayment. However the following are worthwhile to note:-

- geothermal gradients for the following wells were calculated:

1.	GREEN BANKS-1	3.75°C/100 m
2.	HAWKESDALE-1	3.46 "
3.	MOYNE FALLS-1	3.28 "
4.	LINDON-1	3.24 "
5.	CASTERTON-2	3.12 "
6.	NORTH EUMERALLA-1	3.10 "
7.	TULLICH-1	3.05 "
8.	WOOLSTHORPE-1	2.95 "
9.	PRETTY HILL-1	2.73 "
10.	HEATHFIELD-1	2.66 "
11.	DISCOVERY BAY-1	2.61 "
12.	CASTERTON-1	2.55 "
13.	EUMERALLA-1	2.50 "
14.	VOLUTA-1	2.50 "

TABLE 1

HYDROCARBON SHOWS IN THE TYRENDARRA EMBAYMENT, OTWAY BASIN

WELL NAME AND NUMBER	DEPTH OF SHOW	LITHOLOGY	GROUP FORMATION	NATURE OF HYDROCARBON SHOW	ANALYSES/ TESTS
Eumeralla No. 1	Cores and Cuttings 3,810′ - 9,890′	Tight Sandstone, siltstone and mudstone	Otway Group	Slight to strong solvent cut and fluorescence but only traces of oil detected. Bubbles of gas (?CH4) from carbonaceous intervals.	-
Green Banks No. 1	All the sand units below 1008.0 m	Tight fine-grained sandstone	Eumeralla Formation	10%-15% patchy, very dull to dull-yellow-orange fluorescence in cuttings.	-
Hawkesdale No. 1	Core 1 3,568′ - 3,596′	Sandstone, porosity 20-30%, permeability moderate to very high.	Pretty Hill Sandstone	Pin points and patches in pale, yellow brown fluorescence, mainly on core surface. Gas/oil smell in places.	-
Heathfield No. 1	DST 2 4,078′ - 4,144′	Sand	Otway Group ("Heathfield Sandstone")	Gas cut salt water and muddy salt water	CH_4 72.0%, N_2 24.2%
Lindon No. 1	DST 1 891.0 - 912.5 m	Sandstone with low porosity and permeability	Pebble Point Formation	Oil, oil and gas cut mud, slightly gas cut mud.	Oil show i a mature non-marine waxy crude which has undergone some insit water-washing
	Core 1 912.5 - 917.0 m	Sandstone with low porosity and permeability	Pebble Point Formation	Oil saturated sandstone	
	1945 - 1948 m	Tight fine-grained sandstone	Eumeralla Formation	5% patchy to pinpoint bright pale yellow-white natural fluorescence giving a slow streaming moderately bright milky white cut fluorescence in cuttings.	

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TABLE 1 - Continued

HYDROCARBON SHOWS IN THE TYRENDARRA EMBAYMENT, OTWAY BASIN

WELL NAME AND NUMBER	DEPTH OF SHOW	LITHOLOGY	GROUP FORMATION	NATURE OF HYDROCARBON SHOW	ANALYSES/ TESTS
Lindon No. 1 (Continued)	All the sand units between 2360 to 2950 m	Tight fine-grained sandstone	Eumeralla Formation	30%-100% even to patchy dull to moderately bright yellow-gold to orange natural fluorescence with cut in cuttings. Rare oil staining.	-
	2950 - 3011 m (T.D.)	Tight fine-grained sandstone	Crayfish Formation	Up to 80% patchy blue green dull natural fluorescence with cut in part in cuttings.	-
V.M.D. Mepunga No. 7	Pumping 2,370'	?	Dilwyn Formation?	Groundwater cut by non-combustible gas. Salinity 4,573 ppm, temp. 116°F. Pumped at 24,000 - 39,000 g.p.h.	CO_2, N_2
Nelson Bore (Glenelg No. 1)	Approx. 4,045'	Sand	Paaratte Formation?	Gas cut mud carrying a few globules of oil.	-
Tullich No. 1	DST 3 2,947 - 2,982'	Sandstone	Otway Group (upper part)	Gas cut salt water	CH_4 79.3% N_2 18.7%
	DST 4 3,721 - 3,786'	Sandstone	Otway Group (lower part)	Gas cut salt water	CH_4 91.0%
	DST 6 4,815 - 4,880'	Sandstone	Otway Group (lower part)	Gas cut salt water	CH_4 56.6% N_2 32.3%
	DST 7 4,980 - 5,045'	Sandstone	Otway Group (lower part)	Gas cut salt water	N_2 62.0% CH_4 22.2%
Voluta No. 1	7,100 - 12,290' (T.D.)	?	Belfast Mudstone equivalent	Minor CH_4 shows in mud gas. Traces of C_2H_6 and C_3H_8 below 10,850 ft.	-

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TABLE 1 - Continued

HYDROCARBON SHOWS IN THE TYRENDARRA EMBAYMENT, OTWAY BASIN

WELL NAME AND NUMBER	DEPTH OF SHOW	LITHOLOGY	GROUP FORMATION	NATURE OF HYDROCARBON SHOW	ANALYSES/ TESTS
V.M.D. Wangoom No. 2	Pumping 2,413 - 3,197'	?	Pebble Point Formation to Paaratte Formation	Non-combustible gas and gas cut water. Salinity 4,478 ppm, temperature 113°F. Pumped at 35,000 to 40,000 g.p.h.	-
Woolsthorpe No. 1	4,868', 4,875' - 4,975' and 5,708' - 5,727' (Core 3)	Sandstone with fair to good porosity and permeability	Pretty Hill Sandstone	Patchy to spotty blue-white to yellow fluorescence in cuttings and core.	-

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SOURCE ROCK POTENTIAL - Continued

- it is generally expected that wells drilled on basement highs which penetrated basement have a higher geothermal gradient. This is true with Green Banks-1, North Eumeralla-1, Moyne Falls-1 and Hawkesdale-1, but Pretty Hill-1 has a relatively lower value.

MATURATION

A number of studies on maturation modelling in the Otway Basin have been carried out, the most recent of which is the work by Middleton and Falvey (1983). They have proposed a model by which the stages of hydrocarbon maturity of sediments can be postulated. They also suggest that depositional history can be determined from geohistory analysis and thermal history depends on the subsidence mechanism applied to the basin (see "Structural Elements"). They believe that the pre-breakup subsidence may have been produced by either lithospheric stretching or deep crustal metamorphism. These mechanisms have identifiable thermal history. A palaeo-heat-flow history derived from the deep crustal metamorphism model of subsidence for Voluta-1 is shown in Figure No. 6. This model presents a maturation profile with depth which is consistent with observed vitrinite reflectance data. They concluded that the 0.5% vitrinite reflectance level is reached at about 2,000 metres. This may be true in part of the basin but limited data available to this report suggests that the 0.5% Ro figure is reached at a depth as shallow as 1,200 metres onshore (See Figure No's. 7, 8 and 9).

Similarily the 1.0% vitrinite reflectance level which is reached at around 3,000 metres offshore, is probably reached at slightly shallower depth onshore. The Ro = 1.0% level is probably very much shallower still in the areas where sediments were deposited on basement highs. This is evident in Woolsthorpe-1 where an extrapolated value for Ro = 1.0% was reached at around 2,300 to 2,400 metres (See Figure No. 9).

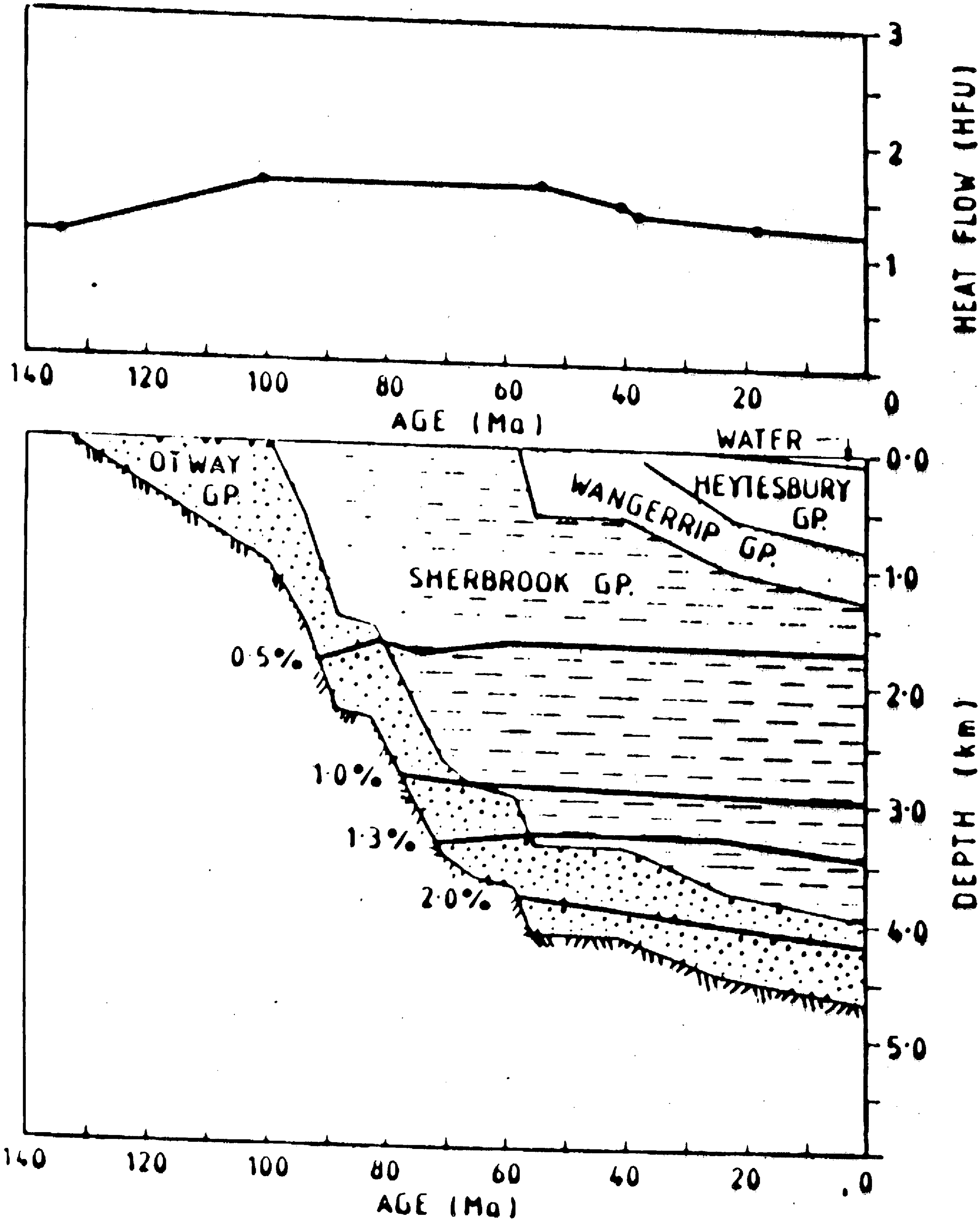
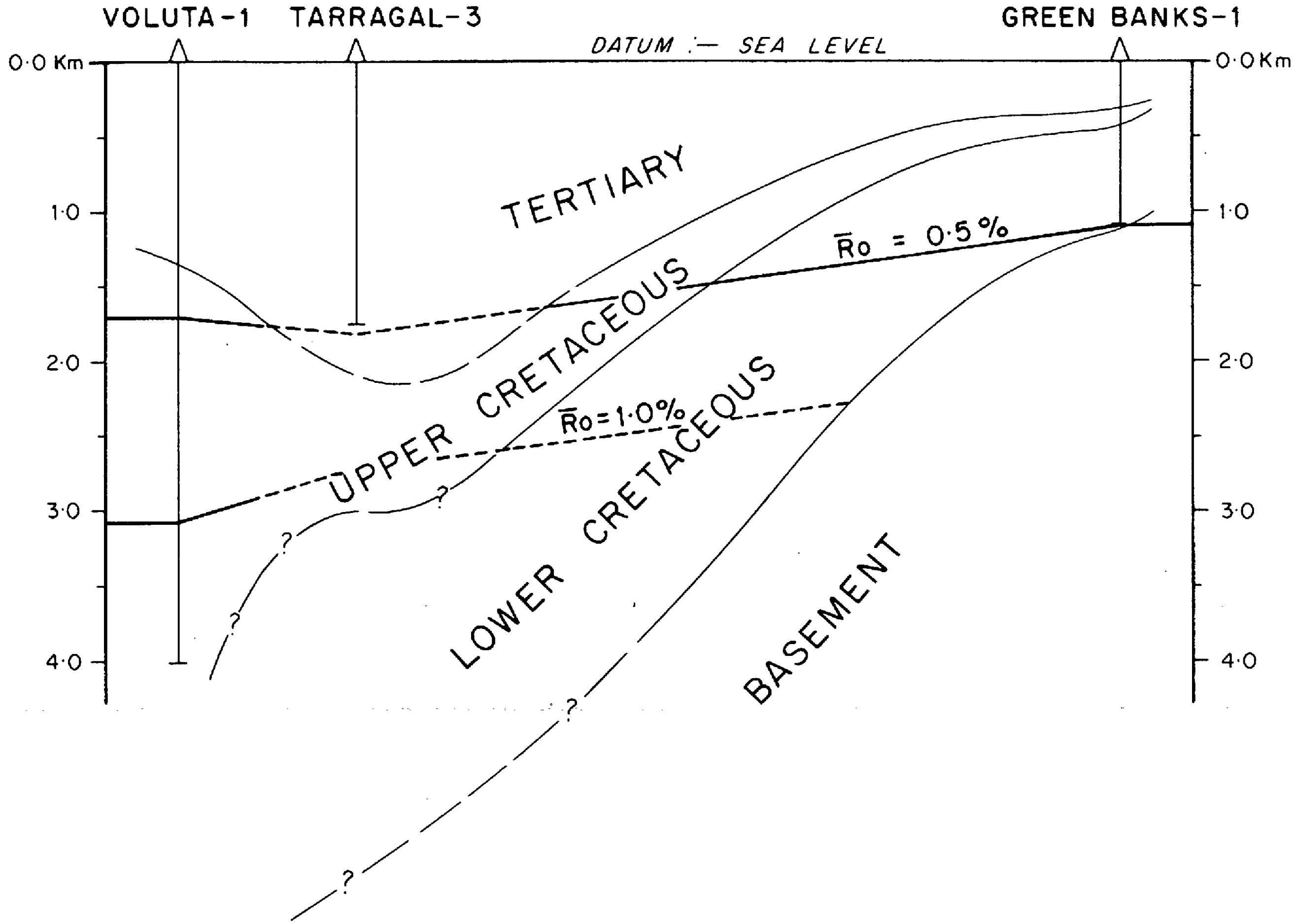


FIGURE 6 - Geohistory analysis for Voluta-1, and heat flow versus age based on the deep crustal metamorphism model, (after Middleton and Falvey, 1983).



VITRINITE REFLECTANCE CORRELATION BETWEEN VOLUTA-1, TARRAGAL-3 AND GREEN BANKS-1

(Dashed lines are extrapolated value of Ro %)

FIGURE 7

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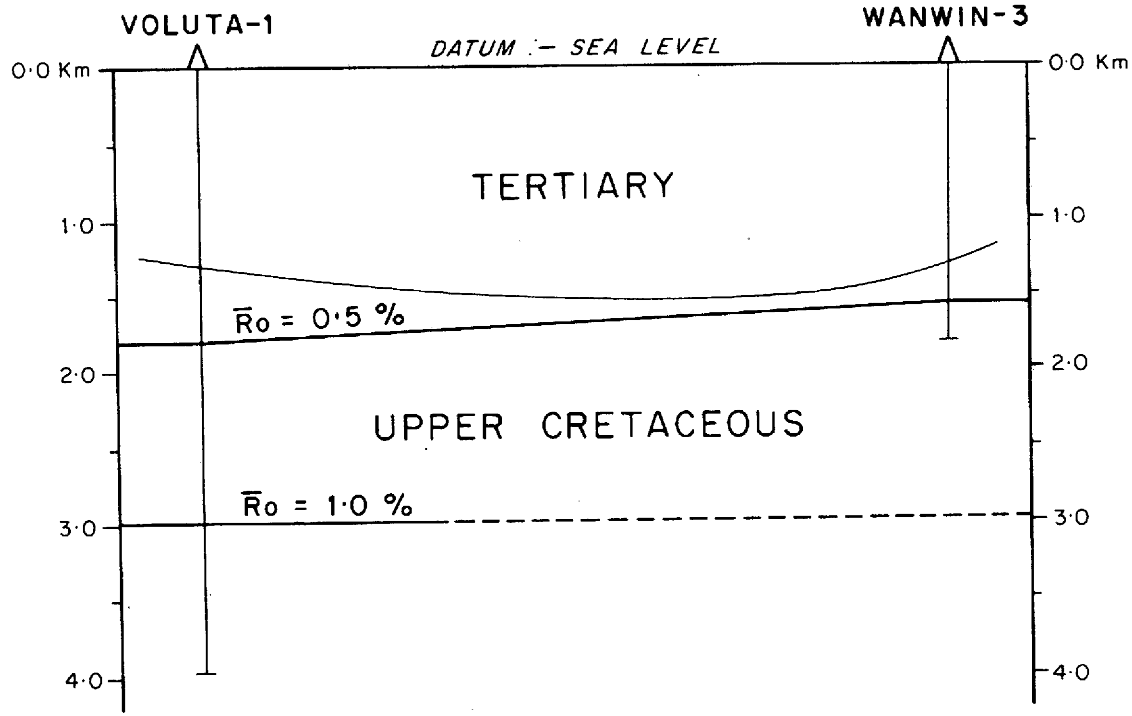

VITRINITE REFLECTANCE CORRELATION BETWEEN
VOLUTA-1 AND WANWIN-1
(Dashed line is extrapolated value of Ro %)

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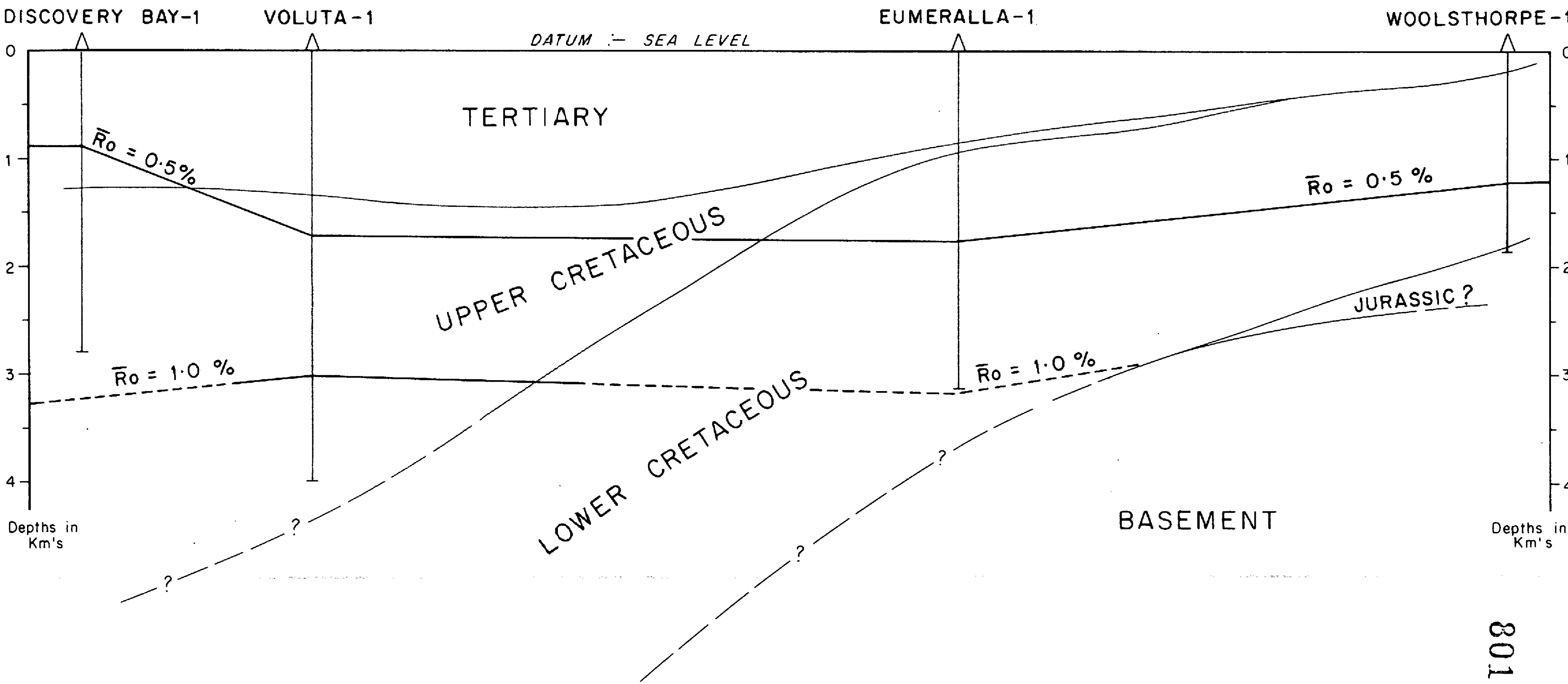
FIGURE 8



VITRINITE REFLECTANCE CORRELATION BETWEEN
DISCOVERY BAY-1, VOLUTA-1, EUMERALLA-1 AND WOOLSTHORPE-1
(Dashed lines are extrapolated value of Ro %)

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FIGURE 9

SOURCE ROCK POTENTIAL - Continued

RESULTS OF SOURCE ROCK STUDIES

Source rock studies are not available from most wells in the Tyrendarra Embayment. Results from a few wells examined (the majority of which have been completed by Beach Petroleum/GFE) are presented as Appendix No. 4.

PRE-OTWAY GROUP

Casterton Formation

The sedimentary portion of this formation was intersected only in Casterton-1 and Woolsthorpe-1 and only two samples from the latter well were studied for source rock potential. There is not therefore, sufficient data to evaluate the source rock potential of this formation. In the main areas of interest it will be, if present, at great depth and only gas generative. However, in future studies it may be worthwhile investigating its hydrocarbon potential.

Results of the source rock work suggest an oil/gas prone source rock. In South Australian wells it is reported as a good potential gas source. The following facts concerning this formation are significant:-

(A) Lithology; non-marine clastics, dominantly mudstones and siltstones and including carbonaceous lithologies.

(B) Abundance of Conifer material (reported from Casterton-1 Cores) which is believed to have potential for generating light waxy crudes within the Surat Basin (Gausden, 1983).

(C) Overlying the basement, hence its higher geothermal gradient, consequently reaching maturity at relatively shallower depth.

(D) Its association with the basal volcanic in part could have provided local higher heat flow, resulting in rapid maturation.

SOURCE ROCK POTENTIAL - Continued

PRE-OTWAY GROUP - Continued

Casterton Formation - Continued

Therefore if exploration does extend into areas where this formation is found at a relatively shallow depth, it could be considered a potential source.

OTWAY GROUP

Crayfish Formation

This formation, which includes both Pretty Hill Sandstone and Geltwood Beach Facies, has not been studied as a potential source rock. Only two samples of this formation (from Woolsthorpe-1) were studied. Both samples contain abundant T.O.C. (1.76 to 2.7%) while Ro = 0.67% at 1417 m. There is no information available concerning the type of organic material present.

It is appropriate to suggest at this stage that the shaley sections of this formation may be a fair quality source with the type of hydrocarbons generated unknown .

Eumeralla Formation

The shaley interval of the Eumeralla Formation is generally accepted as the main source rock in other areas of the Otway Basin.

T.O.C.'s of the limited number of samples analysed in the study area are generally greater than 0.5% but range from 0.24 - 4.45%. Vitrinite reflectance of these samples ranges from $\bar{R}o$ max. = 0.35% at 527 m (Green Banks-1) to $\bar{R}o$ max. = 0.5% at 1184 m (Wangoom-6).

Early data from the Lindon No. 1 gives the following figures:-

- at 1340 m Ro = 0.43%
- at 2900 m Ro = 0.87%

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SOURCE ROCK POTENTIAL - Continued

OTWAY GROUP - Continued

Eumeralla Formation - Continued

The substantial fluorescence and C_3 to C_5 gas shows while drilling this formation below 2300 metres in Lindon No. 1 tends to support the Eumeralla Formation oil and gas generative properties.

Once again this report suffers from a lack of sufficient data. Hence it is not possible to present a full account on the source rock potential of this formation. However the detailed work to be completed on Lindon No. 1 samples will be of considerable value. As it was recommended (See "Recommendations"), wells in which a significant section of Eumeralla Formation was intersected should be studied for their source rock potential. Once this is completed, a more comprehensive picture of the maturity profile of this formation can be drawn.

The following conclusions are based on the available data:-

- this formation can be regarded as a fair to good gas and oil prone source rock.
- hydrocarbon liquids appear to be generated at a reflectance level of 2,300 m (first C_3) or 2,600 m (first C_4). This formation reaches an $\bar{R}omax$ = 1.0% at around 3,000 metres.
- by extrapolation, $\bar{R}o$ max = 1.2% would be reached at approximately 4,200 m. (As extrapolated in both Green Banks No. 1 and Lindon No. 1.)

SHERBROOK GROUP

Flaxman-Waarre Formations

These formations cannot be regarded as a potential source rock in the Tyrendarra Embayment at this stage. As shown in the

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SOURCE ROCK POTENTIAL - Continued

SHERBROOK GROUP - Continued

Flaxman-Waarre Formations - Continued

Part 2 - Appendix No. 1, the majority of the wells drilled in the study area either lacked these formations or did not reach them. The remainder intersected extremely thin Flaxman-Waarre Formations.

Belfast Mudstone Member

The hydrocarbon generative potential of this unit has been discussed by several exploration companies and individual researchers (Shell Development Australia 1971, Beach Petroleum N.L. 1977, C.S.I.R.O. 1977, Amdel 1980). It was initially considered to be a significant oil and gas source. This has been found incorrect elsewhere and this probably also applies in the Tyrendarra Embayment. In Voluta No. 1 some gas generative organics were present.

Samples from four wells were analysed for source rock related studies. Only one sample from each of the following wells was chosen:-

Green Banks-1	@	527.0 m	$\bar{R}o$ max = 0.28%	T.O.C. = 1.66%
Wangoom-6	@	952.0 m	$\bar{R}o$ max = 0.44%	T.O.C. = 1.45%
Eumeralla-1	@	952.0 m	$\bar{R}o$ max = 0.46%	T.O.C. = ?

The only well in which source rock related studies was carried out in more details is Voluta-1. T.O.C.'s of the Belfast Mudstone in this well range from 0.67% to 1.55%. A Bureau of Mineral Resources report indicates much higher figures. Examination of the Kerogen concentrate of several samples revealed that they all contain humic, land-drived material which could be defined as a mixture of vitrinite and inertinite. Exinite was observed in smaller quantity and it appears to decrease with depth. The maturity of $\bar{R}o$ max=0.62% and $\bar{R}o$ max=0.93% were reached at 2459.9 m and 3323.9 m respectively. This clearly

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SOURCE ROCK POTENTIAL - Continued

SHERBROOK GROUP - Continued

Belfast Mudstone Member - Continued

indicates that the lower section of Belfast Mudstone in Voluta-1 is approaching the zone of gas generation only for humic matter in the sediments.

The above data confirms that very little, if any, of the Belfast Section will generate onshore. It is not considered a potential source rock for the Tyrendarra Embayment.

Paaratte Formation

The source rock potential of this formation is not yet clearly defined in the Tyrendarra Embayment. The depth of burial and thickness of this formation greatly varies from place to place. For example, in Green Banks-1 Paaratte Formation was intersected at the depth of 407.0 m and was 109.0 m thick whilst in Discovery Bay-1 it was intersected at the depth of 1279.0 m and its thickness was greater than 1497.0 m (T.D. at 2776.0 m in Paaratte Formation). Furthermore, the sand/shale ratio of this formation is much greater than the Belfast Mudstone or Eumeralla Formation.

The above mentioned variables downgrade the hydrocarbon generative potential of the Paaratte Formation to a substantial degree and it is generally felt that at this stage of exploration it cannot be considered a potential source.

There is however, limited data available to this report. One sample from Green Banks-1 and three samples from Wanwin-3 were analysed for source rock related studies. T.O.C.'s of these samples range from 0.9% to 2.30% and $\bar{R}o$ max = 0.54% was gained at the depth of 1851.0 m in Wanwin-3. In both wells this formation is considered a poor gas source. Offshore, the source rock potential of the Paaratte Formation was comprehensively analysed in Discovery Bay-1. Here, T.O.C. ranges from 0.33% to 2.97% with the maximum $\bar{R}o$ max = 0.66% at 2776.0 m (T.D.). It is generally believed that at a higher level of thermal maturity,

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SOURCE ROCK POTENTIAL - Continued

SHERBROOK GROUP - Continued

Paaratte Formation - Continued

moderate to good quantities of gas and minor to moderate quantities of oil could have been generated and expelled into available reservoirs.

Four samples from the Paaratte Formation in Voluta-1, were analysed. The maximum $\bar{R}o$ max = 0.59% was reached at the depth of 2039.2 m.

At the present stage of exploration it must be accepted that the Paaratte Formation could be a fair potential source rock with a tendency to produce more gas than oil if the formation is buried deep enough to reach thermal maturity. This criteria could be met beneath the centre of the Portland Trough as well as the offshore section of the Tyrendarra Embayment.

WANGERRIP GROUP

Pember Mudstone Member

The Pember Mudstone Member has not yet been considered as a potential source rock in the Otway Basin. Although it is not the intention of this report to promote the hydrocarbon generative potential of this unit, the following facts derived from the in-house studies on samples from V.D.M.E.'s Wanwin-3 and Tarragal-3 are worthwhile to note:-

A. The Pember Mudstone appears to have a relatively high T.O.C. (T.O.C.'s in Wanwin-3 range from 0.71% to 3.68% and in Tarragal-3 from 2.26% to 3.66%);

B. $\bar{R}o$ max = 0.49% was reached at the depth of 1377.0 m in Wanwin-3. By extrapolation, $\bar{R}o$ = 1.0% would be located at approximately 2,500 metres;

C. $\bar{R}o$ max = 0.56% was reported at 1560.9 m in the centre of the Portland Trough (A.J. Kantsler, Pers. Comm. Quoted in G.R. Holgate, 1981).

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SOURCE ROCK POTENTIAL - Continued

WANGERRIP GROUP - Continued

Pember Mudstone Member - Continued

D. Vitrinite is the dominant maceral in most analysed samples with exinite as a secondary maceral in some.

It is therefore, recommended that samples be collected for source rock analysis from all future wells intersecting this unit. It is not suggested at this time that a study of all wells drilled through this unit to date be initiated.

It is the opinion of this report that, with some reservation, the Pember Mudstone could be a fair to good gas prone source rock at sufficient depth within the embayment. This includes the depocentre of the Portland Trough and possibly most offshore parts of the Tyrendarra Embayment.

Younger Units

These sediments are invariable buried at insufficient depth, therefore they would not be considered a potential source rock in the study area.

GENERAL REVIEW

There is now no doubt that significant volumes of hydrocarbon have been or are being generated in the Otway Basin. Unfortunately shortage of data dictates that the generative capabilities of the Tyrendarra Embayment can only be assumed to compare with the more heavily explored areas. CO_2 is produced in the South Australian portion of the basin and gas will soon be produced from the Port Campbell area. Uncommercial volumes of oil were produced in the same area. In addition numerous bitumen strandings have been found along the South Australian and Victorian coastlines.

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SOURCE ROCK POTENTIAL - Continued

GENERAL REVIEW - Continued

However, the most encouraging evidence for the Tyrendarra Embayment is the recent oil discovery in the Lindon No. 1 well. Although complete detail from this well is not yet collected, data now available permits the following limited conclusions:-

(a) oil is being generated in the Embayment. It is believed that this is in relatively significant volumes;

(b) this oil is derived from land plants;

(c) the principal generative area is more towards the centre of the Portland Trough;

(d) relatively long range migration is suggested by the significant water washing noted for the oil;

(e) liquid hydrocarbon generation is occurring within the Eumeralla Formation and commences at approximately 2,300 m where a reflectance of 0.70% is noted.

As will be discussed later on, the majority of the wells drilled in the study area were either not located on valid closed structures or the major targets were not reached. Structural complexity of this area, which apparently was undetected to the relatively primitive exploration tools, seems to have aggravated the problem of locating hydrocarbons at the time.

It is believed that hydrocarbon generation within the Otway Basin as a whole has occurred relatively more slowly than that of the Gippsland and Bass Basins. This slow hydrocarbon generation process is unlikely to have had an unfavourable influence over the balance between accumulation into, and loss from, potential reservoirs (A.C. Cook, 1979).

The other different feature in the Tyrendarra Embayment is the presence of relatively widespread "Older Volcanics". This together with the "Newer Volcanics" could have locally heated the section causing early maturation of the source rocks. If this had happened, then, in some part of the embayment, a mature source rock would be expected at relatively shallow depth.

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SOURCE ROCK POTENTIAL - Continued

GENERAL REVIEW - Continued

In conclusion, hydrocarbons seem to have been generated in this embayment and statistically the chance of locating oil is as great as that of gas despite the previous assumption which considered these sediments as gas prone only.

POTENTIAL RESERVOIRS

Within the Tyrendarra Embayment the following potential reservoirs are recognised:-

- Mepunga Formation
- Dilwyn Formation
- Pebble Point Formation
- Paaratte Formation
- Flaxman-Waarre Formations
- Eumeralla Formation
- Crayfish Formation

Although recognized as potential reservoir, the Mepunga Formation will not be discussed any further in this report as it is invariably shallow and no shows have been reported from it so far.

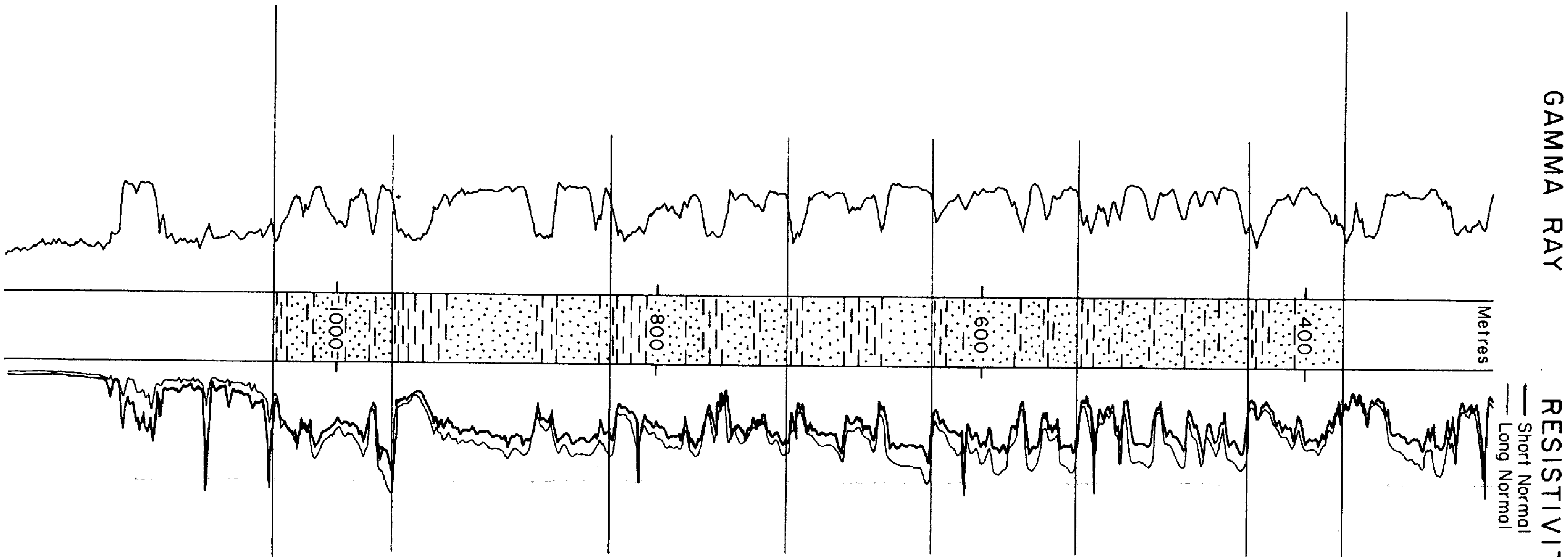
WANGERRIP GROUP

Dilwyn Formation (See Part 2, Enclosure 3)

The isopach map for Dilwyn Formation shows its widespread distribution. Its maximum thickness is reached along the axis of the Portland Trough. It was not previously regarded as a potential reservoir, mainly because of its shallow depth of burial and its apparent exposure to fresh water flushing. This may be true in some parts of the onshore Tyrendarra Embayment, but in the centre of the Portland Trough as well as the offshore portion of the embayment, the thick Dilwyn Formation is buried sufficiently to be safe from flushing.

In the Tyrendarra Embayment, the Dilwyn Formation appears to comprise up to seven stacked deltaic cycles (See Figure No. 10). Each cycle begins with marine shales followed by barrier bar and delta front channel sands. Each cycle is terminated abruptly by a renewed marine transgression. The shale at the base of each cycle provides an excellent seal for the sand unit below. The effect of these shales are particularly important as they protect the sand portion of the lower cycles from flushing.

DILWYN FORMATION



PEMBER MUDSTONE MEMBER

TYPICAL CYCLIC SEQUENCES OF THE UNDIFFERENTIATED DILWYN FORMATION

BURRUNGULE MEMBER

801302 051

WANWIN No.1

WIRELINE LOG CHARACTERISTICS OF THE DILWYN FORMATION

FIGURE 10

POTENTIAL RESERVOIRS - Continued

WANGERRIP GROUP - Continued

Dilwyn Formation - Continued

The sandy portions of the undifferentiated Dilwyn Formation have porosities in excess of 30%. Based on the data obtained from V.D.M.E., permeabilities could be as high as 1 darcy. It is worthwhile to note that an oil show was recorded from the core at a depth of 304.2 m in the Dilwyn Formation at Mount Salt-1 in the South Australian portion of the Otway Basin.

Pebble Point Formation (See Part 2, Enclosures 5 and 10)

The isopach map prepared for this formation demonstrates its widespread distribution. Its maximum thickness of 59 metres was reached in Ardonachie-2. In other parts of the study area the thickness of this formation is relatively uniform and rarely exceeds 30 metres. The extra thickness of Pebble Point Formation in Ardonachie-2 appears to have been due to the reactivation of the Ardonachie Fault during the Early Tertiary (See "Structural Elements"). Although no well in the centre of Portland Trough was sufficiently deep to intersect this formation, a relatively thinner Pebble Point Formation would be expected there.

The Pebble Point Formation is a conglomeratic sandstone whose lithology appears to be quite different in the Tyrendarra Embayment to the more completely explored Port Campbell Embayment. It is generally capped by "bottom-slope" and/or in-situ laterite. Although the thickness of the lateritic zone varies from well to well, in the Tyrendarra Embayment it is generally thicker than that found in the Port Campbell Embayment. In the Tyrendarra Embayment the section underlying the lateritic "cap" varies lithologically from relatively porous and permeable coarse sand (See Figure No.11) to chloritic-clay sandstone. In the latter case the permeability has been reduced dramatically. The presence of more "bottom-slope" type lateritic material and/or change of provenance appears to have been responsible for this lithofacies change.

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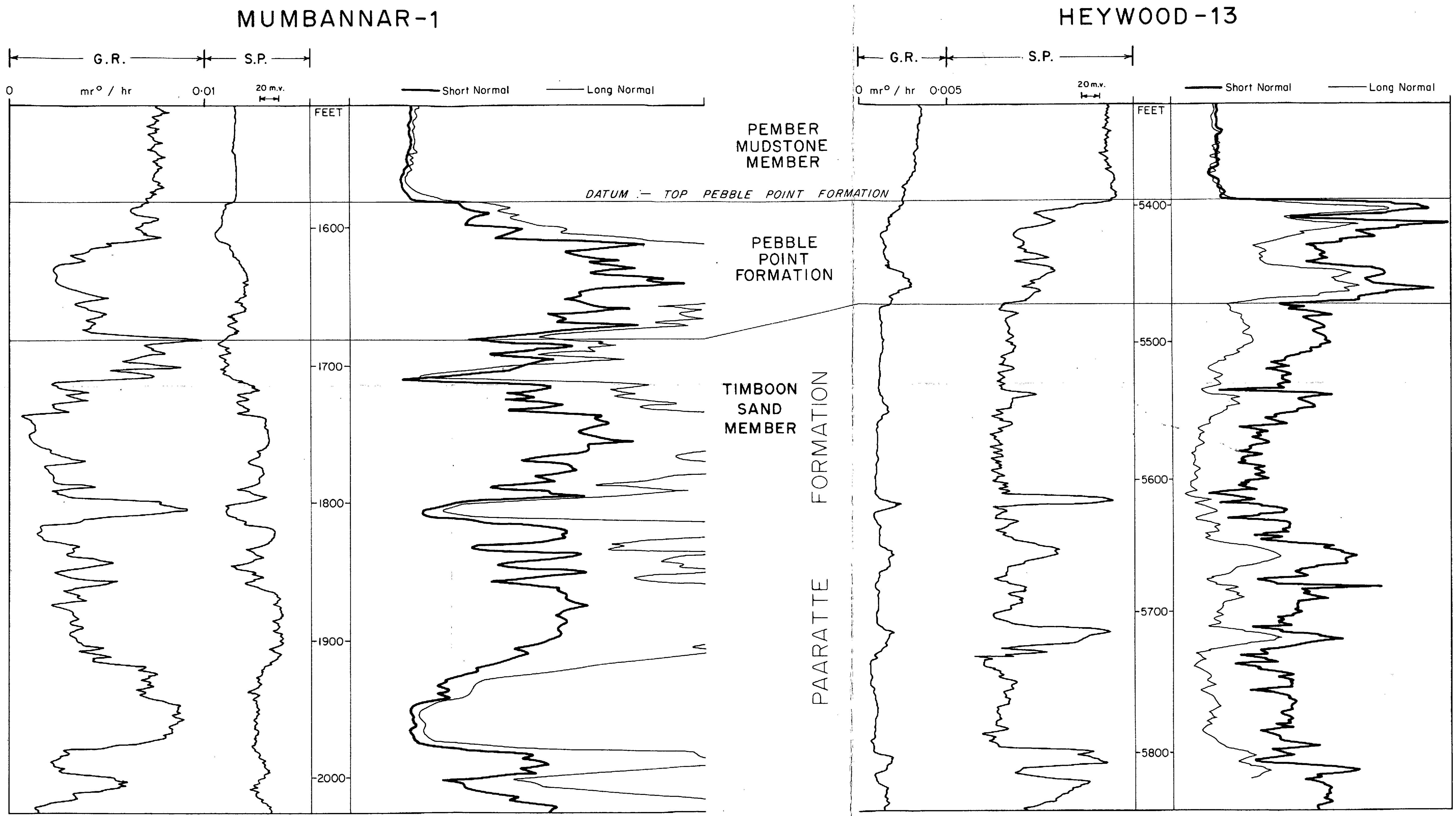

LOG CORRELATION

PEBBLE POINT FORMATION
AND
TIMBOON SAND MEMBER

MUMBANNAR No.1 — HEYWOOD No.13

FIGURE 11

POTENTIAL RESERVOIRS - Continued

WANGERRIP GROUP - Continued

Pebble Point Formation - Continued

In the majority of wells drilled in the study area, it was noted that this formation overlies the porous Timboon Sand Member of the Paaratte Formation (See next section).

In conclusion the following variables make the Pebble Point Formation a worthwhile target reservoir:-

- it has a consistant seismic character, therefore it can be mapped confidently;
- it is sandwiched between a relatively unknown, locally detected, unconformity at its top and a widely believed unconformity at the top of the Upper Cretaceous at its base;
- where the section beneath the lateritic cap is a clean sand, its porosity exceeds 25-30%.

In many or even most instances the Pebble Point Formation will be a reservoir in which part or all of it will require some type of stimulation. Therefore it is necessary to highlight areas where
(a) the Pebble Point sandstones tend to be cleaner and/or
(b) the Pebble Point Formation is relatively thin.

Item (b) has been attempted with an attached isopach map (See Part 2, Enclosure 5) while (a) can only be attempted in the future when more adequately logged drill holes have penetrated it.

SHERBROOK GROUP

Undifferentiated Paaratte Formation (See Part 2, Enclosure 6)

Due to insufficient data and/or poor development of the Nullawarre Greensand Member, with the exception of Belfast Mudstone Member, no attempt could be made to differentiate members of this formation. The isopach map prepared for the Paaratte Formation includes the Timboon Sand Member, Skull Creek Mudstone Member and Nullawarre Greensand Member. A separate isopach map was prepared for the Belfast Mudstone Member (See Part 2, Enclosure 7).

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POTENTIAL RESERVOIRS - Continued

SHERBROOK GROUP - Continued

Undifferentiated Paaratte Formation (See Part 2, Enclosure 6)

Increased thicknesses of this formation are found on the north eastern flank of the offshore Voluta Grabon and on the downthrown side of the Tartwaup Fault to a lesser extent. A tentative direction of thickening as shown in the isopach map (See Part 2, Enclosure 6) is towards Discovery Bay-1 where the maximum thickness of this formation was penetrated (1497^{+}m).

The Paaratte Formation thins over the Warrnambool High, the eastern end of the Stable Homerton Platform - Lake Condah High and probably pinches out around the southern and western margins of the Merino Uplift. Major subsidence seems to have occurred along the Tartwaup Fault at the time of deposition of this formation.

The upper part of the Paaratte Formation (Timboon Sand Member) has excellent poroperm characteristics. Porosities and permeabilities in excess of 30% and 1 darcy respectively are expected in most parts of the embayment. It underlies the Pebble Point Formation (See Figure No. 11) and in some cases a thin tight bed separate these two reservoirs. In Lindon No. 1 this bed has an extremely high density and chemically combined water content (chlorite?).

As was discussed previously the Pebble Point Formation provides a fair reservoir within the embayment. If it thins or if the hydrocarbon column is great enough to include the Timboon Sand Member the potential of such a prospect is greatly enhanced. This implies that, even in the case of fault dependent structure the Pember Mudstone is still a valid and reliable seal for a Timboon Sand reservoir.

The lower section of the Paaratte Formation consists of interbedded shales and sands. It includes the Nullawarre Greensand and Skull Creek Mudstone Members which are not as well developed as in the

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POTENTIAL RESERVOIRS - Continued

SHERBROOK GROUP - Continued

Undifferentiated Paaratte Formation - Continued

Port Campbell Embayment. However their presence in some of the wells drilled in the study area is evident.

The sands in the lower portion of the Paaratte Formation (with or without Nullawarre Greensand Member) retain their poroperm characteristics, making them attractive reservoir objectives. In comparison, these sands have relatively higher clay content than the Timboon sands and lower porosities and permeabilities are therefore expected. These sands are still considered to be good to excellent reservoir targets.

Although these sands are capped by overlying shales, the predominance of limited to nil structural turnover (predominantly fault closures) means that Lower Paaratte Sandstones are not often in a position to trap hydrocarbons. If structural turnover is present, it is possible that all individual sandstones could be part of a stacked hydrocarbon accumulation. This is discussed in more detail in the section under "Cap Rocks".

Flaxman-Waarre Formation (See Part 2, Enclosure 8)

None of the wells drilled in the Portland Trough reached these formations. Therefore the Flaxman-Waarre isopach map prepared clearly demonstrates their distribution only in the northern onshore area studied.

The Flaxman-Waarre Formations are absent over the Warrnambool High. They pinch-out on either side of a narrow strip extending from Eumeralla-1 to North Eumeralla-1 and Green Banks-1 and also along the south and western margins of the Merino Uplift. They are relatively uniform and thin over the Stable Homerton Platform.

There is moderate thickening towards and possibly into the Penola Trough as well as the south-eastern extension of the Ardonachie Trough.

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POTENTIAL RESERVOIRS - Continued

SHERBROOK GROUP - Continued

Flaxman-Waarre Formation (See Part 2, Enclosure 8)

Minor isolated thickening occurs around Myamyn-2 and a number of minor thinnings in the northwest of the study area are believed to be because the Waarre Formation, or the Flaxman Formation in the absence of the former, filled limited depressions on the peneplained surface of the Lower Cretaceous Eumeralla Formation.

It is strongly believed that the Voluta Graben was active at the time of deposition of these formations and that a thick Flaxman/ Waarre sequence will be present offshore (See Part 2, Enclosure 8). Furthermore, with better development of these formations, separation both lithologically as well as on wireline log characteristics, is also expected.

Figure No. 12 shows the log characteristics of Flaxman and Waarre Formation in Glenaulin-2. Core and cutting descriptions indicate that the lower sand intersected in this well is the Waarre Formation.

It is generally expected that a thin Waarre Sandstone will be developed over much of the area and that porosity will be as good as lower sandstone within the Paaratte Formation. Although sealed by the Belfast Mudstone, the Waarre/Flaxman has potential only where structural turnover is present, particularly across the Stable Homerton Platform.

As will be demonstrated later (See "Exploration Objectives") the most attractive portion of Waarre Formation is located where no well has penetrated deep enough so far.

Although the Waarre Formation will be relatively deep in the centre of the Portland Trough, it is anticipated that it would be reached (at least in onshore) shallower than 2300 metres. This is the porosity cut-off level proposed for Port Campbell Embayment. However, at this stage of exploration it would appear unwise to apply a porosity cut-off level derived elsewhere to this area.

Potential is also seen where this unit pinches out along the flanks of the Stable Homerton Platform.

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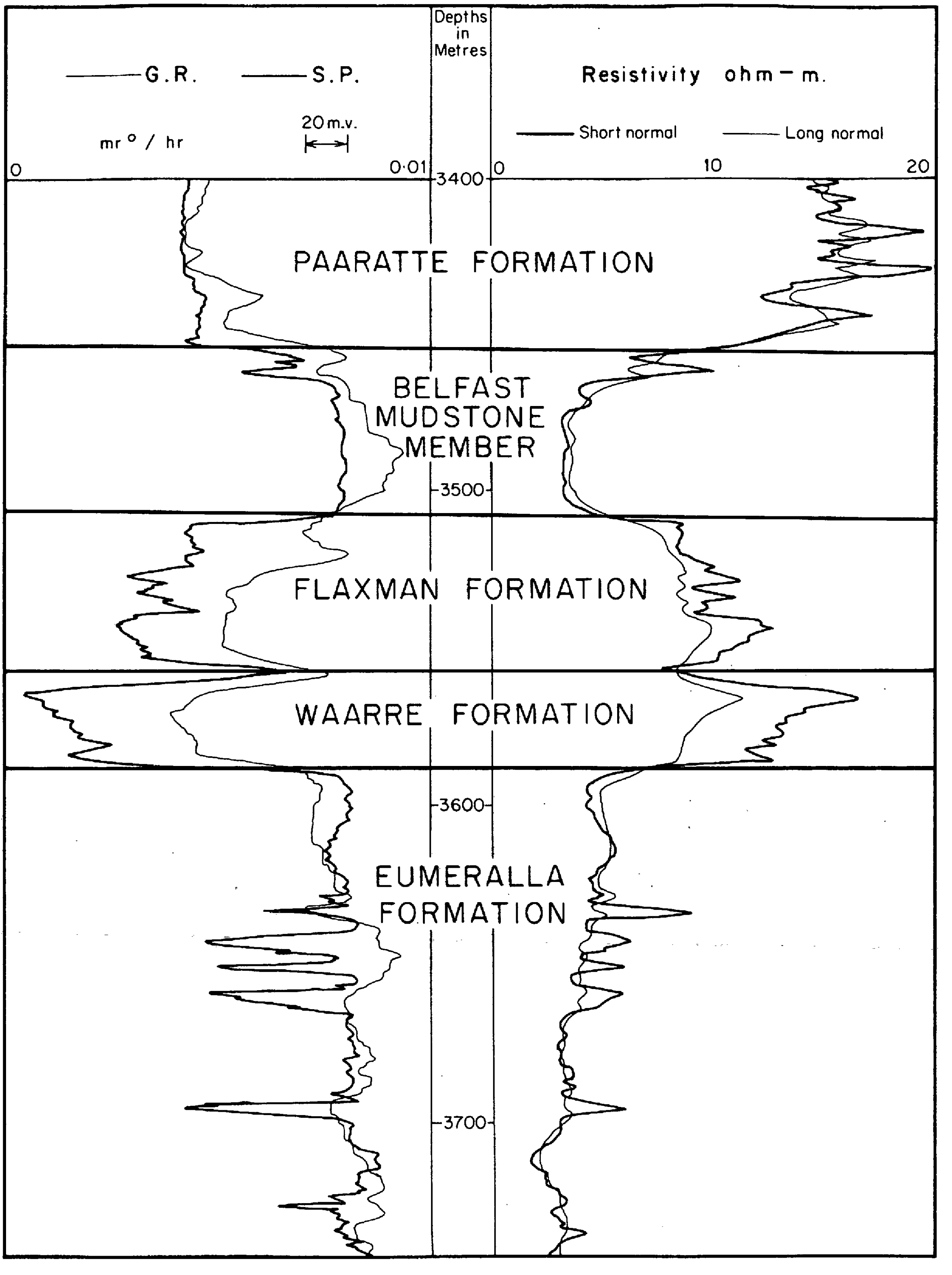

GLENAULIN No. 2

WIRELINE LOG CHARACTERISTICS OF THE FLAXMAN-WAARRE FORMATIONS

FIGURE 12

801302 059

POTENTIAL RESERVOIRS - Continued

OTWAY GROUP (See Part 2, Enclosures 9 and 11)

Eumeralla Formation

Shales appear to be the dominant lithology within this formation. Minor sand units are recognised throughout the study area, chief of which is the Heathfield Sand Member recorded only in three wells. These wells (Heathfield-1, Casterton-1 and Tullich-1) are all located in the extreme northwest of the study area, at around the southeastern extension of the Penola Trough. The Heathfield Sandstone Member is an unconsolidated to loosely consolidated quartz sandstone with excellent poroperm characteristics. The following data about this sand member are available:-

Well	Thickness	Porosity (log)	Inferred Perm.
Heathfield-1	16.8 m	27%	Excellent (DST-2)
Casterton-1	20.0 m	27%	Good (DST-1)
Tullich-1	24.4 m	29%	Good-Excellent (DST-3)

It should be also noted that the DST-2 in Heathfield-1 recovered 122 m of gas cut muddy salt water and 1085 m of gas cut salt water. The DST-3 in Tullich-1 recovered 457 m of gas cut salt water. Samples from both tests contained 72% - 79% hydrocarbon gas.

Despite all these promising facts, the Heathfield Sand Member is not regarded as an objective reservoir because:-

(a) its distribution is limited (it might have been developed in part of the Penola Trough only); it was not present in either Green Banks-1 or Lindon-1.

(b) it lacks a recognisable seismic character.

In the Eumeralla Formation there are other numerous sand units. They are generally thin, discontinuous and have poorer poroperm characteristics than the Heathfield Sand Member. These sands are usually fine grained and extremely tight. However, wireline logs of a number of wells drilled in this area show a relatively thicker sand unit at the upperpart of the formation with fair to moderate poroperm characteristics. (e.g. Annya-2 and Glenaulin-2).

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POTENTIAL RESERVOIRS - Continued

OTWAY GROUP - Continued

Eumeralla Formation - Continued

Although (at this stage of exploration) it is not recommended to seek any target within this formation, as it is the most active source rock, any intraformational sandstone is extremely well placed.

Crayfish Formation

As was discussed earlier (See "Stratigraphy") the Crayfish Formation includes the "Pretty Hill Sandstone Facies" (clean sand) and the "Geltwood Beach Sandstone Facies" (tight sand). This formation appears to be present everywhere within the embayment except on basement highs. This is supported by:-

(a) the lack of this formation in Green Banks-1 and Moyne Falls-1, and

(b) its presence in Casterton-1, Eumeralla-1, Heathfield-1, Hotspur-1, North Eumeralla-1, Pretty Hill-1, Tullich-1, Woolsthorpe-1 and Lindon-1.

With the exception of Heathfield-1, North Eumeralla-1, Tullich-1 and Lindon-1, the other above mentioned wells penetrated the entire section of the Otway Group. No other wells drilled in the study area, away from basement highs, were deep enough to intersect the Crayfish Formation.

The position of lithofacies changes in this formation will have a significant influence over the location of exploration in this embayment. Figure No. 13 clearly demonstrates this lithofacies change. In Woolsthorpe-1 both, Geltwood Beach Sandstone Facies and Pretty Hill Sandstone Facies are present. In Hawkesdale-1 only Pretty Hill Sandstone Facies was reported and apparently the formation pinches out completely somewhere between Hawkesdale-1 and Moyne Falls-1. The Pretty Hill Sandstone Facies is fully developed in Pretty Hill-1. It appears that on the downthrown side of the Eumeralla Fault the facies changes and in both Eumeralla-1 and North Eumeralla-1 only Geltwood Beach Sandstone Facies of the Crayfish Formation is present.

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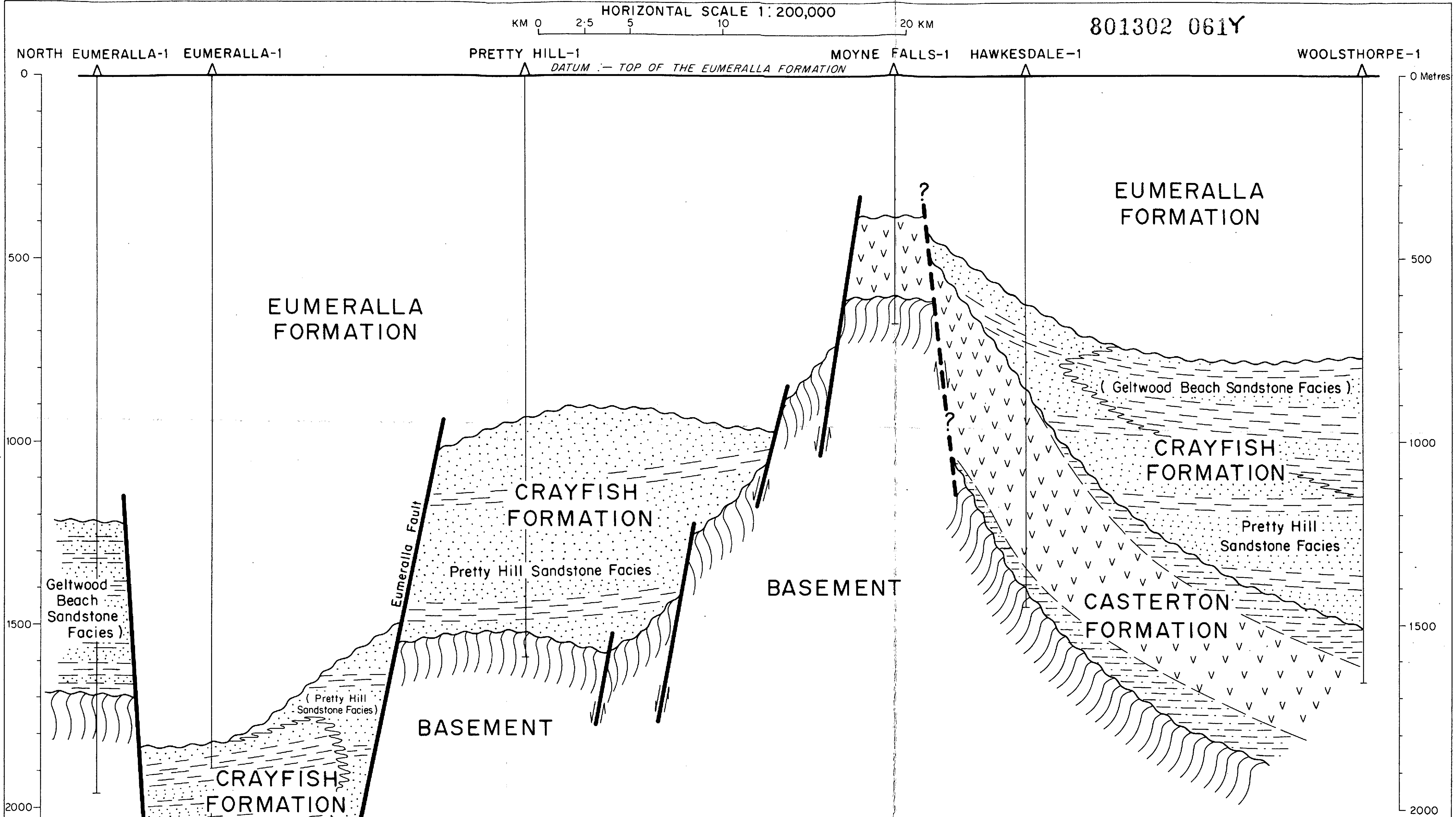

BEACH PETROLEUM N.L.

PEP 105

TYRENDARRA EMBAYMENT

DIAGRAMMATIC CROSS SECTION SHOWING LITHOFACIES CHANGES OF THE CRAYFISH FORMATION

FIGURE 13

POTENTIAL RESERVOIRS - Continued

OTWAY GROUP - Continued

Crayfish Formation - Continued

At the moment, sufficient data is not available to define the extent of each facies. Where and how this lithofacies change occurs within the embayment is not understood. Further exploration particularly drilling, in this embayment would hopefully answer these questions.

In all wells where the Pretty Hills Sandstones facies has been intersected it has overlain pre-Otway Group section. Therefore in any area where it is possible to locate the Crayfish Formation truncation, exploration directed towards the updip truncation edge may be successful in locating the clean sandstone facies.

The known variables of the Crayfish Formation are summarised below:-

(a) it appears to be widespread in the embayment except on the basement highs (any substantial high developed prior to deposition of Crayfish Formation),

(b) it has two lithofacies; Pretty Hill Sandstone Facies and Geltwood Beach Sandstone Facies,

(c) the Pretty Hill Sandstone Facies exhibits excellent reservoir characteristics,

(d) the Geltwood Beach Sandstone Facies, has a "dirty" nature, and lacks reservoir potential,

(e) the formation has comparatively recognisable seismic character being a strong event below the Top Eumeralla horizon.

If it was possible to locate Pretty Hill Sandstone Facies within the embayment, this report would not hesitate to consider it as one of the excellent reservoir objectives since it has an average porosity of 25% with a maximum recorded porosity of 37% (in Woolsthorpe-1, based on log analysis) and permeability up to 2756 m.d. (in Pretty Hill-1, based on core analysis). Furthermore, although this lithofacies

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POTENTIAL RESERVOIRS - Continued

OTWAY GROUP - Continued

Crayfish Formation - Continued

has not been intersected below 2000 metres in the Tyrendarra Embayment the depth seems to have no influence over its porosities in the Gambier Embayment to the west. Therefore, at least at the present time, this report can only emphasise the excellence of the reservoir characteristic of the Pretty Hill Sandstone Facies and highlights the difficulty of attempting to locate it.

801302 064

CAP ROCKS AND HYDROCARBON MIGRATION PATHS

The major cap rocks within the Tyrendarra Embayment are:-

(a) Pember Mudstone Member, capping both the Pebble Point Formation and Timboon Sand Member of the Paaratte Formation;

(b) Belfast Mudstone Member, capping the Waarre Formation

(c) Internal shales and silts of the Eumeralla Formation, capping the Heathfield Sand Member and/or other sand units in the Eumeralla Formation.

(d) Internal shales and silts of the Crayfish Formation, capping the Pretty Hill and Geltwood Beach Sandstone Facies.

A. Pember Mudstone Member (See Part 2, Enclosure 4)

In contrast to that in the Port Campbell Embayment, the Pember Mudstone Member is considerably thicker in the Tyrendarra Embayment. The isopach map prepared for this unit demonstrates its widespread distribution. The maximum thickness of 500+ metres was encountered along the axis of the Portland Trough. It thins gradually on both flanks to the north and south with a thin of 27 m at Voluta-1. At Cobboboonee-2, along the axis of the trough, a relatively minor, isolated thin (214 m) seems to exist. This was also noticed in the Dilwyn Formation isopach map (See Part 2, Enclosure 3). Away from the Portland Trough, the amount of deposition appears to have varied only in the area of the Ardonachie Fault. A relative thickening occurs on the downthrown side of this fault in the Ardonachie Trough. Structural movements in the early Tertiary appear to be responsible for the isolated thins around Bootahpool-2, Lindon-1 as well as a number of other seismically mapped highs in the Heywood Area.

The Pember Mudstone Member consists principally of claystone. From the top it commences with a relatively sandy claystone. The sand/shale ratio gradually decreases with depth with the bottom half claystone only. Analysis of the various logs proves the presence of a minor number of thin sand units in a number of wells within the Pember Mudstone. When present these sand units are encountered at the top section of this member with the deepest one being deposited considerably shallower than the base of Pember Mudstone. This means that a relatively thick section of Pember

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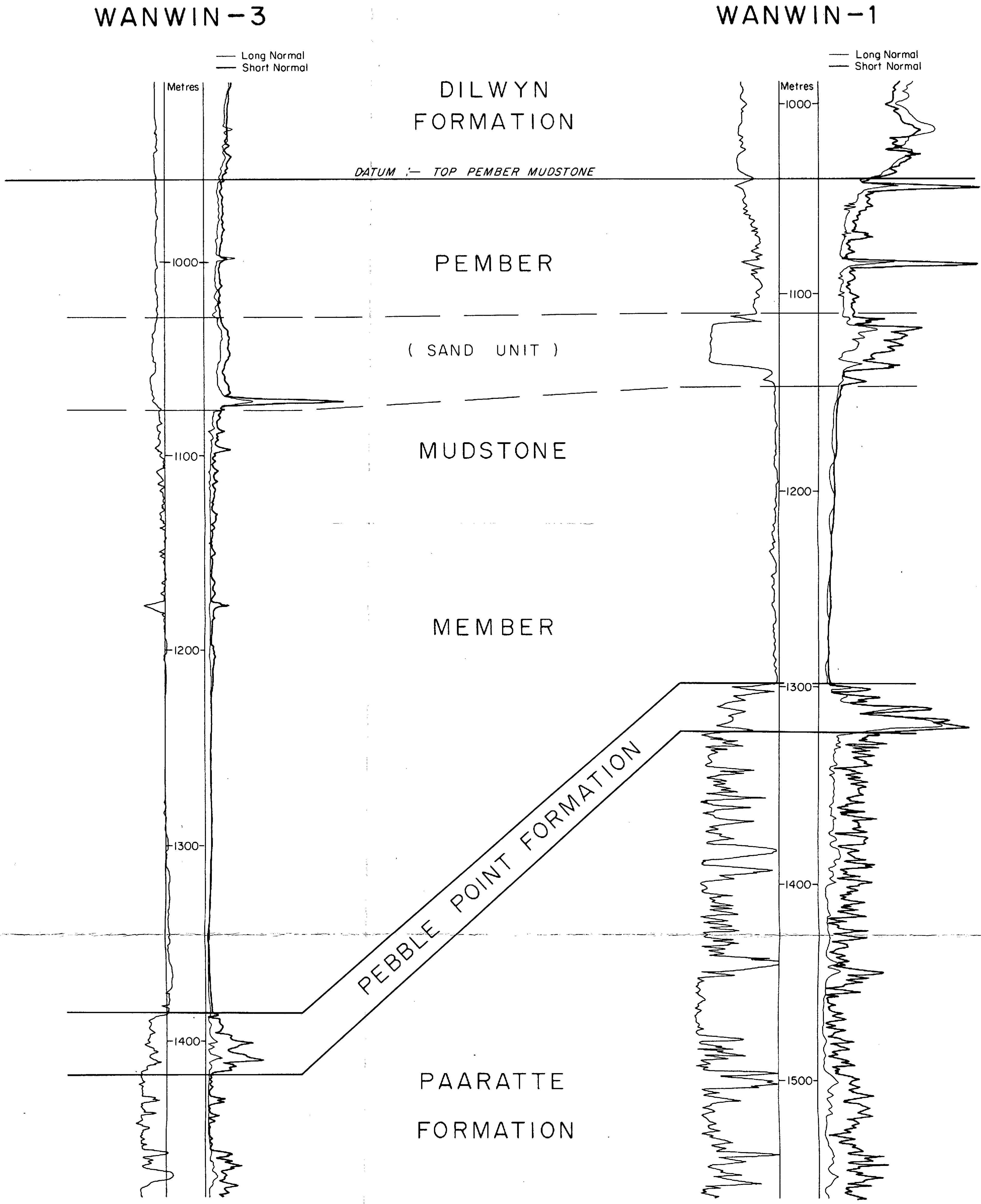

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LOG CORRELATIONS

PEMBER MUDSTONE MEMBER

WANWIN No.3 — WANWIN No.1

Legend

— — — Tentative Correlations

FIGURE 14

CAP ROCKS AND HYDROCARBON MIGRATION PATHS - Continued

A. Pember Mudstone Member - Continued

Mudstone can be considered a reliable cap for the Pebble Point Formation and/or Timboon Sand Member.

Towards the centre of the Portland Trough, where the Pember Mudstone Member is fully developed, the bottom, shaley section (with no major sand interruption) would exceed 300 metres thickness (See Figure 14).

Where the intermediate sand unit(s) is expected the sealing properties of the Pember Mudstone Member would, however, be downgraded when the throw of the fault (in the case of fault depending structure) exceeds the predicted thickness of the bottom shaley section.

As was noted earlier, the lateritic cap of the Pebble Point Formation would increase the sealing reliability of the Pember Mudstone.

B. Belfast Mudstone Member (See Part 2, Enclosure 7)

The deposition of the Belfast Mudstone is virtually centred only in the "Voluta Graben". This is supported by the gradual, and rather smooth, thinning from the northern margin of the Voluta Graben to the north and the relatively rapid thickening of this member on the northeastern flank of the trough offshore.

No well drilled in the southern part of the P.E.P. 105 has reached this regional blanket seal. Voluta-1, drilled offshore, which did not reach the base of the Belfast Mudstone, penetrated 1810+ metres of this unit. A rough calculation based on the available data suggests that the thickness of the Belfast Mudstone increases offshore by the rate of approximately 35 metres per kilometre. On this assumption a relatively thick Belfast Mudstone, perhaps between 600 metres to 1000 metres, could be expected in the unexplored southern part of the P.E.P. 105. If this thick Belfast Mudstone is unbroken by faulting then it provides a vertical barrier to the migration of hydrocarbons from the Eumeralla Formation below. Both the thickness and faulting of the Belfast Mudstone are extremely important to the exploration programs in P.E.P. 105.

CAP ROCKS AND HYDROCARBON MIGRATION PATHS - Continued

B. Belfast Mudstone Member - Continued

The Belfast Mudstone Member caps the Waarre Formation. As it was suggested earlier (See "Potential Reservoirs") the Waarre Formation is better developed and more porous basinwards. This better developed Waarre Sandstone coincides with the thickening of the Belfast Mudstone Member which in turn upgrades the available plays within this part of the embayment.

C. Eumeralla Formation (See Part 2, Enclosures 9 and 11)

Numerous shale and silt units are known to exist within the Eumeralla Formation. These units provide effective seals for the porous and permeable Heathfield Sand Member as well as other porous sand Members within the Eumeralla Formation. This formation is relatively thick and has a widespread distribution within the embayment.

In the section entitled "Structural Elements" it was noted that the Otway Group, in general, was affected by severe tectonism. The resulting faulting together with the erosional surface at the top of the Eumeralla Formation provided numerous migration paths. Hydrocarbons generated within the Otway Group would have migrated along the unconformity surface and/or fault plane to the overlying Waarre Formation. Migration of hydrocarbons to the shallower reservoirs, e.g. Paaratte/Pebble Point Formations would also occur because much of the faulting terminates at the top of the Pebble Point Formation.

The Eumeralla Formation also caps the Pretty Hill Sandstone Facies or Geltwood Beach Sandstone Facies of the Crayfish Formation, depending on which one underlies the Eumeralla Formation.

D. Crayfish Formation

The shale and silt units within the Geltwood Beach Sandstone Facies probably encapsulate the sand units within this lithofacies. To a lesser

D. Crayfish Formation - Continued

extent, this may also be true for the Pretty Hill Sandstone Facies. However, the Geltwood Beach Sandstone Facies would appear to provide an adequate seal for the Pretty Hill Sandstone Facies where the former overlies the latter.

Hydrocarbons generated within the Crayfish Formation would migrate along the lithofacies boundaries as well as the unconformity surface at the top of the formation providing both lateral and vertical migration. Face-loading mechanism would also occur where porous sandstones were brought in contact with more shaley zones by faulting.

E. Other Formations

There are a number of thin potentially sealing shales within the Paaratte and Dilwyn Formations. The shale units within the Paaratte Formation would provide seals for the sand units other than Timboon Sand Member. Where the Nullawarre Greensand Member is present the Skull Creek Member could seal the former effectively.

In the case of the Dilwyn Formation, the shale at the base of each cycle (See Figure No.10) generally caps the sand portion of the underlying one. This shale in some places, can be up to 100 metres thick, providing a relatively valid seal for the sand unit. In other cases it can be removed by deep channel cutting with a resulting loss of seal.

Because both the Paaratte and Dilwyn Formations appear to lack sourcing capabilities, substantial deep seated faulting is necessary to allow hydrocarbon migration from the underlying Eumeralla Formation.

TIMING OF HYDROCARBON MIGRATION AND ENTRAPMENT

There was not sufficient data available to this report to accurately assess the timing of hydrocarbon generation, migration and entrapment within the Tyrendarra Embayment. Detailed analysis of the oil shows within the sourcing capabilities of various formations in Lindon No. 1 may provide a clearer picture.

It has been recommended that samples from a number of wells within the study area should be analysed for their source rock related properties. Once this is done, it may then be possible to draw a clearer picture of the timing of hydrocarbon generation, migration and entrapment. However, a simplified model, based on the available data including seismic is proposed here.

In the section entitled "Source Rock Potential" it was noted that:-

- the Eumeralla Formation in Green Banks-1 was at an early stage of maturation, i.e. $\bar{R}o$ max - 0.5% at around 1200 metres (this was supported by the presence of in-situ oil shows).
- it is also suggested that the oil window in the Tyrendarra Embayment could be between $\bar{R}o$ max = 0.5 to $\bar{R}o$ max = 1.0%.

By extrapolation, using Green Banks-1 data, the peak of hydrocarbon generation of $\bar{R}o$ max = 0.7%, or the optimum depth of maturation would be located at around 2300 metres. This is supported by preliminary results from Lindon No. 1 which also suggest a depth of 4200 m where only gas is being generated regardless of the type of organic material present.

Based on the above criteria and assuming that the geothermal gradient is relatively constant, 4 distinctive areas are recognised within the Tyrendarra Embayment (See Figure No. 15):-

- Area (A) occupies a large portion of the Ardonachie Trough. Here part or all of the sediments of the Otway Group are buried at a depth below 2300 metres. On the north eastern margin, the base of Otway Group is at or below this depth. The depth increases in a south westerly direction so that on the southwestern margin, i.e. the deepest section of the Ardonachie Trough, most of the upper section of Otway Group is also located below this 2300 m depth.

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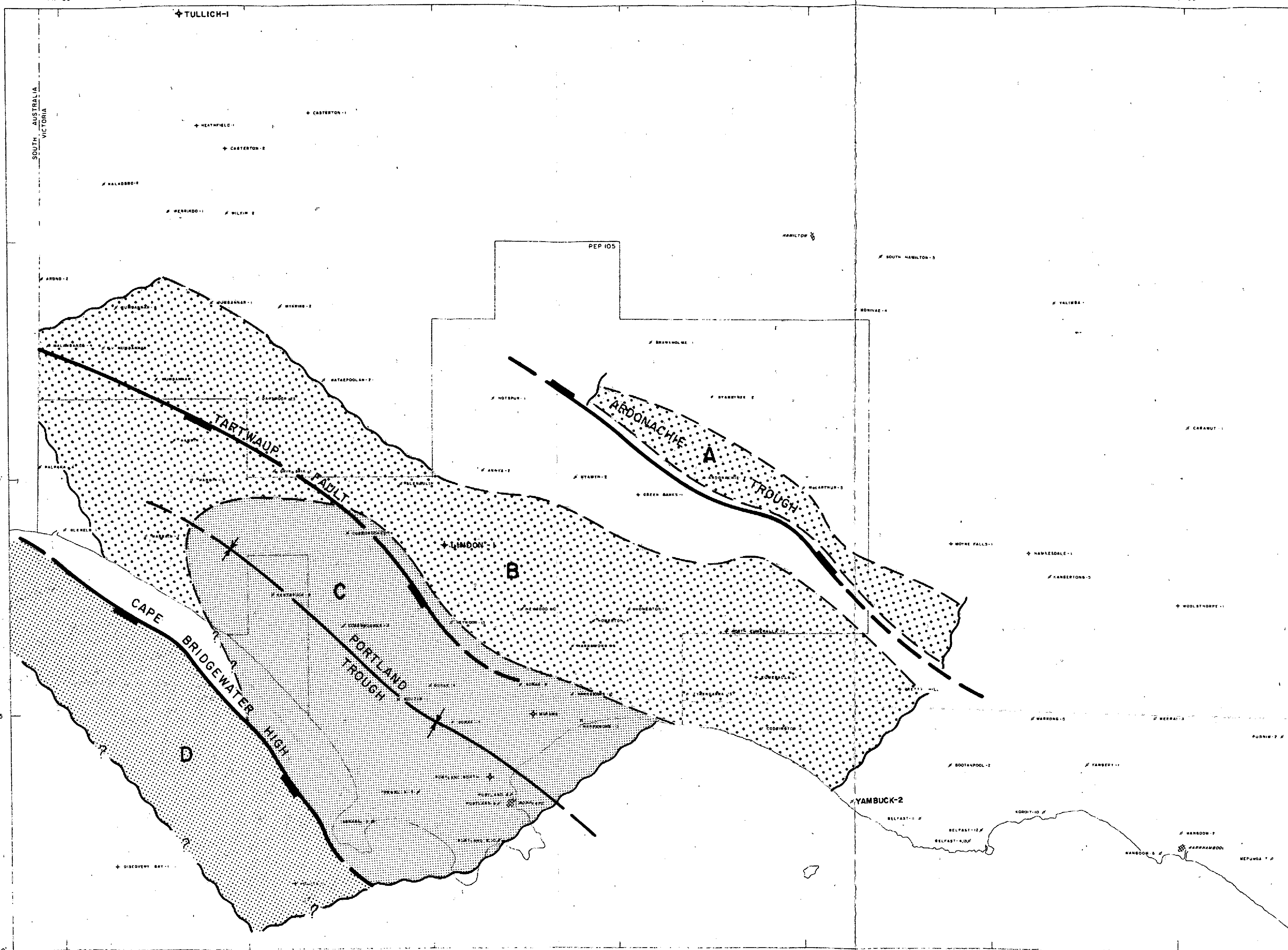

Area with insufficient data

Otway Group Sediments

Sherbrook Group Sediments

Areas where intervals of the Otway Group and Sherbrook Group Sediments are buried at or below the assumed depth of maturation. (i.e. below 2300 metres).

Areas where the Otway Group Sediments are overmature but intervals of the Sherbrook Group sediments are mature.

A, B, C, D. (see text.)

LEGEND

- PROPOSED WELL
- V.D.M.E. BORE
- ABANDONED DRY HOLE

SCALE 1 : 500,000

FIGURE 15

BEACH PETROLEUM N.L.

PEP 105

TYRENDARRA EMBAYMENT

OTWAY BASIN

OPTIMUM MATURATION DEPTH

SCALE 1 : 500,000		AUTHOR	A TABASSI
DATE NOV, 83'.	DRAWN N Reynolds	DRG No OT.2023-F	

TIMING OF HYDROCARBON MIGRATION AND ENTRAPMENT - Continued

- Area (B) is located on the north east, north and north west of the Portland Trough. Over this entire area at least part of the Otway Group sediments are mature, i.e. below 2300 m. In a large portion of this area (area on the upthrown side of the Tartwaup Fault) the base of the Otway Group sediments are buried at or below 2300 m on the eastern margin whilst the upper section of those sediments are buried at the same depth at around the Tartwaup Fault. Although the pattern of the depth of burial of the Otway Group sediments is somehow different in the remaining portion of this area, a large section of these sediments are located below 2300 metres.

- Area (C) virtually covers the entire Portland Trough. Beneath this trough and on the northern flank of the Voluta Graben the entire Eumeralla Formation and also part of the Sherbrook Group Sediments are buried below 2300 metres. Some of the Eumeralla Formation is buried below 4200 m and may therefore be generating minor gas volumes.

- Area (D) where oil and gas generated is prevented from migration into the Portland Trough by the Cape Bridgewater High.

It appears that any hydrocarbons present in the onshore area of the Tyrendarra Embayment would have been and are being generated within areas A, B and C. Only limited amounts of Eumeralla sediments in Areas A and B are located within the oil window, therefore limited volumes of oil and gas have been generated sometime after the Otway Group sediments were deposited. Area C is therefore preferable because the entire Otway Group section is mature and migration paths to the principal reservoirs are much more direct.

Area D, where rapid subsidence of the Voluta Graben occurred during the Lower Cretaceous, is probably now generating significant volumes of gas. However the Cape Bridgewater High is probably acting as a barrier to this gas, preventing it from moving north into the Portland Trough.

If the parameters used are correct, it would not then be unjust to suggest that the Area (C), the Portland Trough, is the most promising source of liquid hydrocarbons within the Tyrendarra Embayment.

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TIMING OF HYDROCARBON MIGRATION AND ENTRAPMENT - Continued

A relatively rapid subsidence during the early and Mid Tertiary caused the deepening of the sediments where they would reach the maturation depth fairly rapidly. Furthermore, numerous faults which occurred simultaneously and later has provided good paths for hydrocarbons to migrate both vertically and laterally.

Area (B) is considered the second best source area of hydrocarbons. Smaller volumes of liquid hydrocarbon is the most probable product here with minor gas/condensate in the area where the Eumeralla Formation sediments are buried below 4200 ? metres. As in Area (C) the numerous faults across this area have provided routes for hydrocarbons to migrate to the entrapments within and north of this area. Any structure developed during the Late Upper Cretaceous to Early Tertiary in these areas would be well placed to accumulate hydrocarbons from both Areas C and B.

Area (A) is relatively less important since it occupies a smaller area and consequently produces less hydrocarbons. No migration is expected from this area to B and C (and vice versa) as the down-to-the-north east Ardonachie Fault has developed both vertical and lateral barriers by bringing the Basement in contact with a large portion of the Otway Group sediments.

The north eastern flank of the Ardonachie Trough, in contrast, has a different structural history. A series of, relatively minor, down-to-the-south west step faults has provided migration paths to the entrapments in the north east, and north west of the Area (A). Oil shows observed in cuttings and cores of the Pretty Hill Sandstone Facies in Woolsthorpe-1 (See "Source Rock Potential", Table 1), may be considered as a marginal support to this hypothesis?

The gas chromatograms of the two deepest cores in Voluta-1 (See Figures 16 and 17) indicate that at least the lower section of the Belfast Mudstone Member has reached the optimum maturation. This is to say that hydrocarbons are being generated in the Belfast Mudstone Member offshore, but one would not expect these hydrocarbons to migrate through major highs (e.g. Cape Bridgewater High). Hence, hydrocarbons generated in the sediments situated south west of the Cape Bridgewater High (Area (D)) would not contribute to the presence of hydrocarbons onshore.

.../

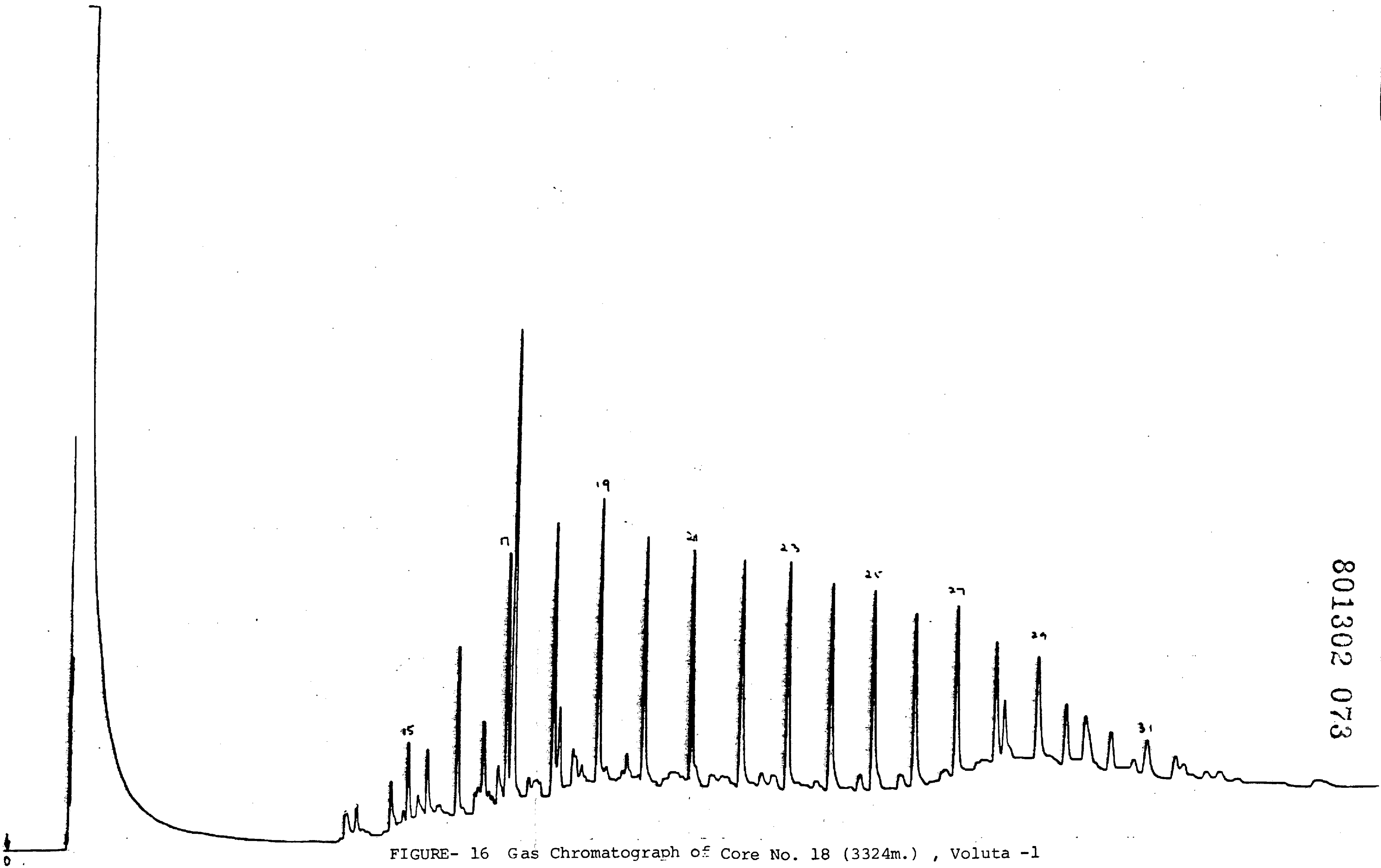

FIGURE- 16 Gas Chromatograph of Core No. 18 (3324m.) , Voluta -1

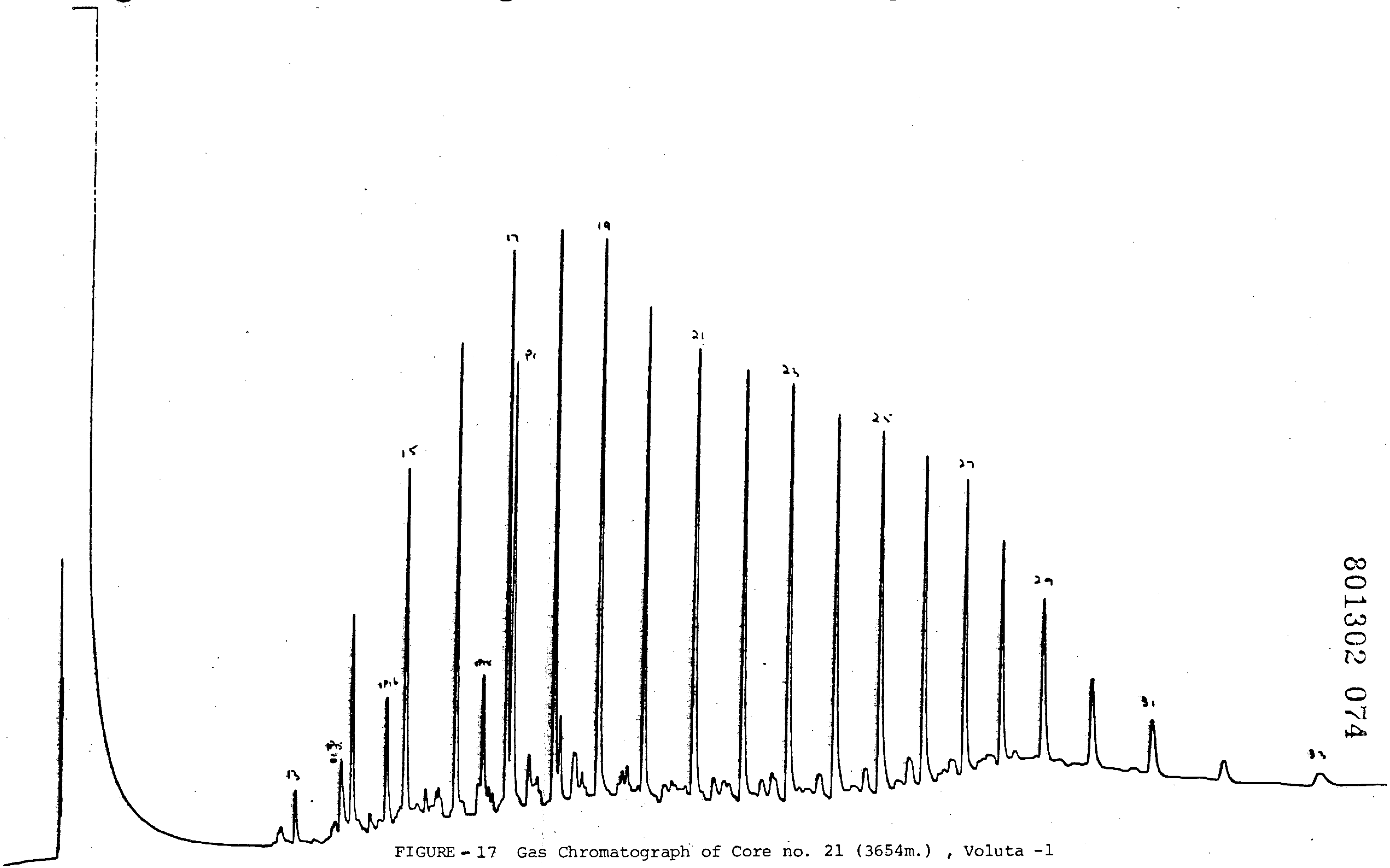

FIGURE - 17 Gas Chromatograph of Core no. 21 (3654m.) , Voluta -1

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To summarise the foregoing discussion it can be said that:-

- hydrocarbons have been, and are being, generated within the Tyrendarra Embayment.

- Area (C), (See Figure No.15) is where the greatest volume of hydrocarbon is or has been generated. This should be oil and gas.

- Area (B) generation is occurring but only from part of the available source rock.

- Area (A) is a relatively less important source of oil in this area.

There is now no doubt that significant volumes of hydrocarbons are being generated in the Otway Basin. Unfortunately limited data means that the generative capabilities of the Tyrendarra Embayment can only be assumed to compare with the more heavily explored areas of the basin.

Although detail from the recently drilled Lindon No. 1 well is not yet available, data now to hand is extremely encouraging.

The following limited conclusions can be reached from data derived from this well:-

(a) oil is being generated in the Embayment.

(b) the oil is generated from plant material.

(c) available reflectance data suggests that the principal generative area is deeper into the Portland Trough to the south.

(d) relatively long range migration is suggested by the significant water-washing of the oil.

(e) liquid hydrocarbon generation commences at 2300 m which has a reflection of approx. $\bar{R}o$ max = 0.70%.

DRY HOLE ANALYSIS

This section discusses the results of the exploration wells only (See Figure No. 2). The V.D.M.E. wells (See Figure No. 1) will not be discussed because:-

- they were not targeted for locating hydrocarbons
- seismic control is nil to scarce
- the drilling results were not monitored continuously
- poor quality wireline logs.

The exploration wells will be discussed under the following headings:-

- Seismic Control
- Type of Structure
- Results of Drilling
- Why was the Prospect Dry?

A. CASTERTON NO. 1 PROSPECT

- Seismic

Casterton No. 1 was located at the crest of a structure defined by a structure drilling program. No seismic control was involved in locating the well.

- Type of Structure

Based on a shallow hole program in the Casterton Area, a large surface structure probably of Tertiary age was outlined. Vertical closure was estimated to be approximately 91.5 m. Results of the dipmeter and analyses of 24 cores cut in this well could not positively verify the presence of any structure.

- Results of Drilling

Casterton No. 1 well intersected the Eumeralla Formation (including 20 metres of the Heathfield Sand Member) after penetrating a thin section

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A. CASTERTON NO. 1 PROSPECT - Continued

- Results of Drilling - Continued

of recent sediments at the surface. It then penetrated the Geltwood Beach Sandstone Facies of the Crayfish Formation, and the entire Casterton Formation before reaching T.D. in the basement.

From nine Drill Stem Tests carried out in the well only one recovered hydrocarbons. DST No. 1 (594.7 - 614.5 m) recovered 61 m salt water, water cut mud and 442 m muddy very slightly gassy salt water. The quantity of gas was too small to measure. The other DST's proved that reservoirs are either water wet or tight. No oil fluorescence or trace of oil staining was recorded.

- Why was Casterton No. 1 Dry?

No valid trap can be confirmed at Casterton No. 1 location.

B. CASTERTON NO. 2 PROSPECT

- Seismic

The Casterton No. 2 Prospect, located 11 kilometres from Casterton No. 1, was defined by six seismic lines of a 1967 seismic survey. The lines formed an irregular pattern over the prospect. Data quality at the level of the Heathfield Sandstone Member is reported to range from fair to good.

- Type of Structure

The feature was mapped as an anticlinal structure on the downthrown side of two arcuate north westerly trending faults (See Figure No. 18).

- Results of Drilling

The Casterton No. 2 well intersected a normal Otway Basin sequence to reach T.D. in the Eumeralla Formation. The Heathfield Sand Member was not present.

No formation testing was carried out in this well.

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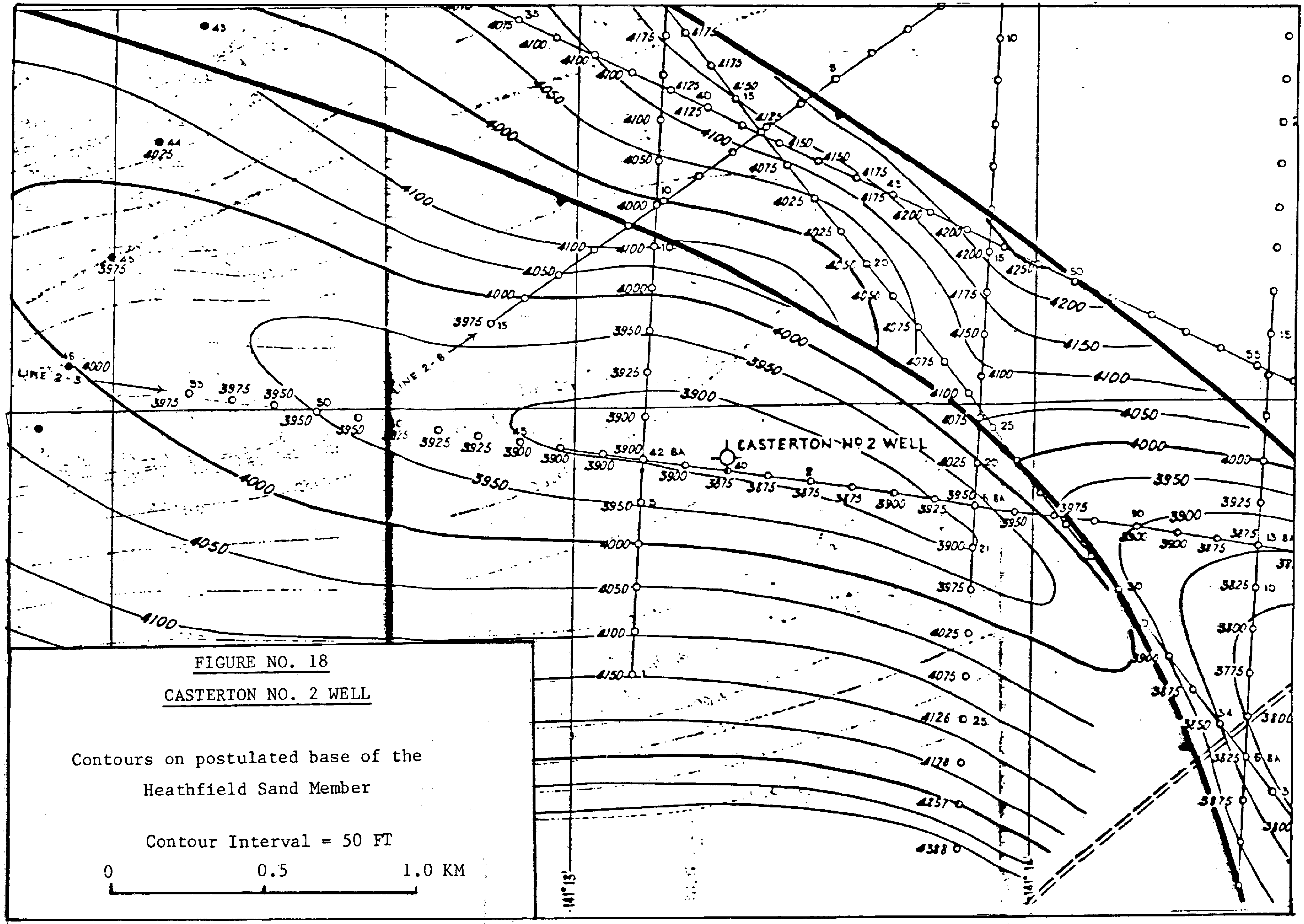

FIGURE NO. 18

CASTERTON NO. 2 WELL

Contours on postulated base of the Heathfield Sand Member

Contour Interval = 50 FT

0 0.5 1.0 KM

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B. CASTERTON NO. 2 PROSPECT - Continued

- Why Was Casterton No. 2 Dry?

Casterton No. 2 was a dry hole because the target horizon, the Heathfield Sand Member, was absent.

C. DISCOVERY BAY PROSPECT

- Seismic

The Discovery Bay Prospect was defined by 8 seismic lines of the OP-80 Seismic Survey. Seismic data ranged from fair to good at both the Timboon Sand Member and the undifferentiated Paaratte Formation horizons.

- Type of Structure

The Discovery Bay Prospect located on the major South Voluta High complex was mapped as an entirely fault dependent structure, on both horizons. The shallower structure is closed over an area of 59.7 kilometres^2 with a maximum vertical closure of 56 metres. Areal closure of the deeper structure is 35.3 kilometres^2 with a maximum vertical closure of 108 metres (See Figure No.'s 19 and 20).

- Results of Drilling

The Discovery Bay No. 1 well intersected a sequence similar to that found in wells onshore. However, the absence of the Pebble Point Formation in this well is worthwhile to note. No hydrocarbon indications were noted in the well but subsequent head space analyses carried out on canned geochemical samples over a number of intervals indicated minor amounts of methane, ethane, propane, n-butane and iso-butane.

- Why Was Discovery Bay No. 1 Dry?

Discovery Bay No. 1 was dry because the sealing unit immediately above the Upper Cretaceous sediments was thin and interbedded with sandstone units.

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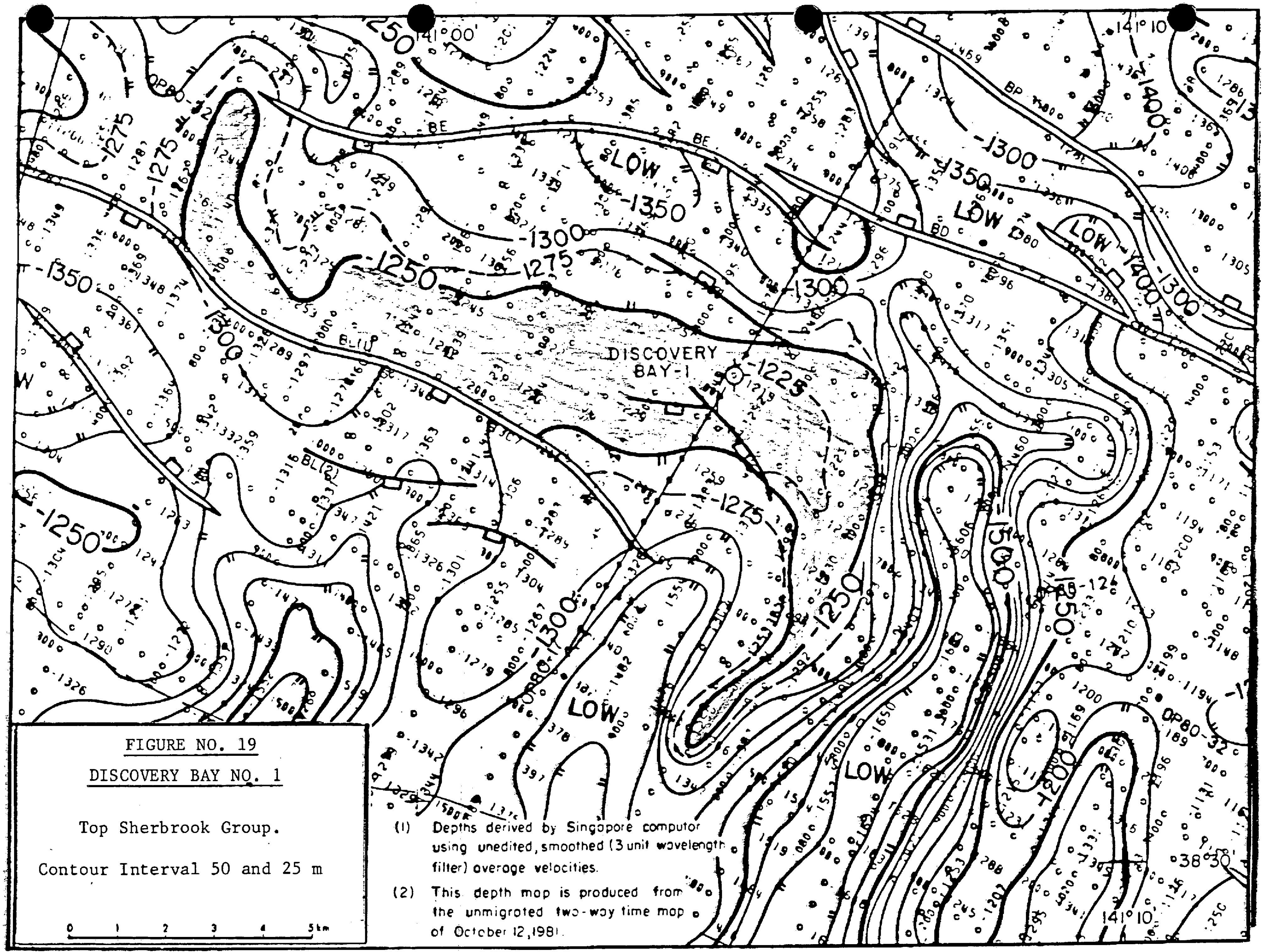

FIGURE NO. 19

DISCOVERY BAY NO. 1

Top Sherbrook Group.

Contour Interval 50 and 25 m

0 1 2 3 4 5 km

(1) Depths derived by Singapore computor using unedited, smoothed (3 unit wavelength filter) average velocities.

(2) This depth map is produced from the unmigrated two-way time map of October 12, 1981.

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D. EUMERALLA PROSPECT

- Seismic

The Eumeralla Prospect was defined by a seismic survey of pre-1962 vintage. This seismic data was not available for this report.

- Type of Structure

The mapped target horizon within the Eumeralla Formation is reported to have north closure independent of faulting. It is believed that the mapped deeper reflector, depended on the faulting for northern closure, is the Top of the Crayfish Formation.

- Results of Drilling

The Eumeralla No. 1 well intersected a normal Otway Basin sequence to reach T.D. in the Geltwood Beach Sandstone Facies of the Crayfish Formation. The Flaxman/Waarre Formation was not present. The Pretty Hill Sandstone Facies of the Crayfish Formation, the primary target, was not penetrated. This could be due to either lack of development or its development below the T.D. of the well. Oil fluorescence and cut were reported over a number of intervals in the Otway Group sediments but results of the formation testing proved these intervals tight.

- Why Was Eumeralla No. 1 Dry?

Although there was no data available to justify the validity of any structure at this location, the absence of any worthwhile reservoir greatly contributed to the lack of discovery in this well.

E. GREEN BANKS PROSPECT

- Seismic

The Green Banks Prospect was defined by 7 seismic lines across the feature. Seismic data ranged from fair to good at the Top Basement mapping horizon.

.../

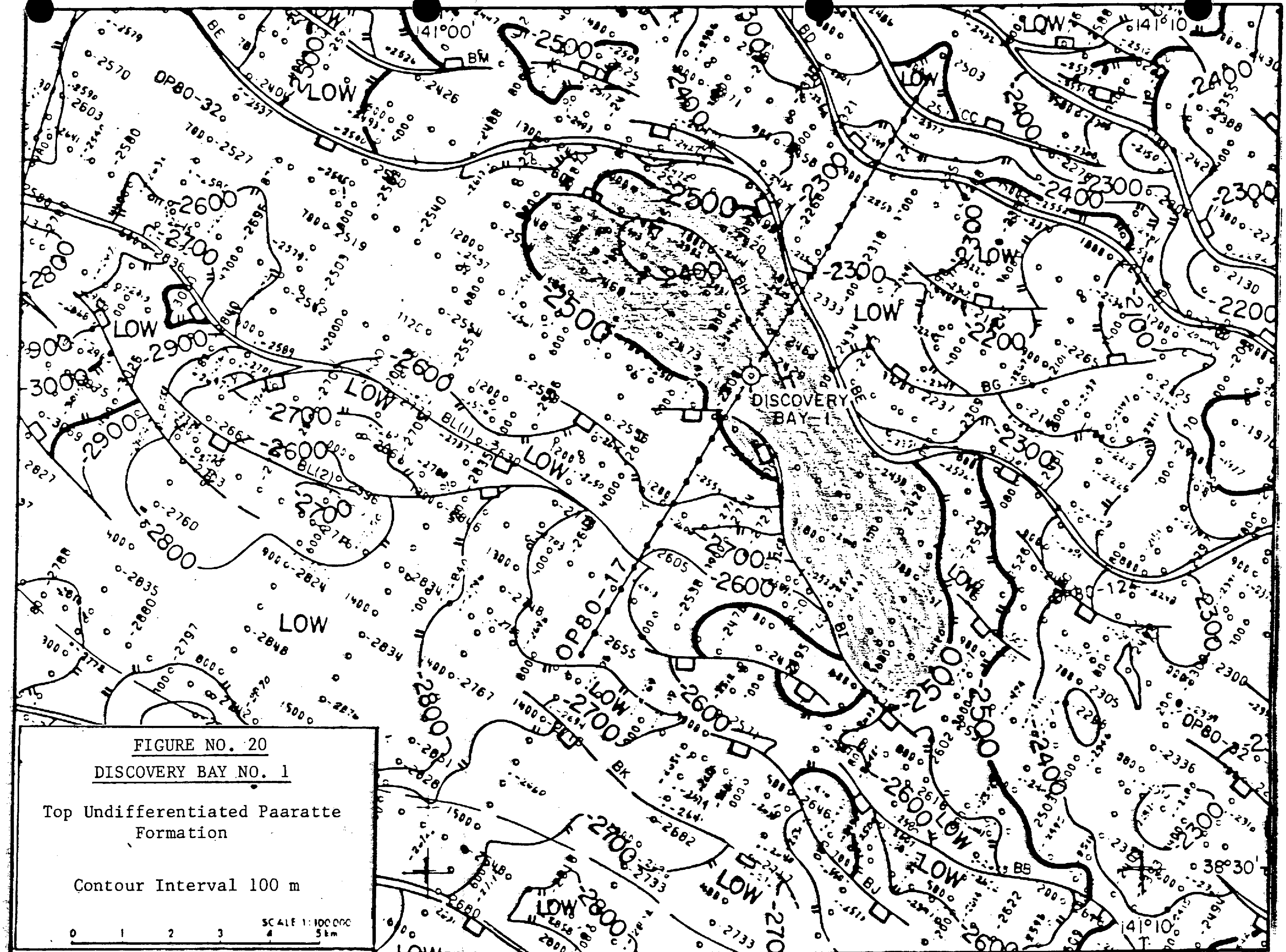

FIGURE NO. 20

DISCOVERY BAY NO. 1

Top Undifferentiated Paaratte Formation

Contour Interval 100 m

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E. GREEN BANKS PROSPECT - Continued

- Type of Structure

The Lake Condah High at the Basement level of the prospect was mapped as a plunging anticline, dipping to the south. To the north this anticline is generally controlled by a northwest down-to-the-north normal fault. It is believed that the fault was active prior to any Lower Cretaceous deposition. The structure at basement level is closed over an area of 63.5 kilometres^2 with a maximum vertical closure of 405 metres (See Figure No. 21 and 22).

- Results of Drilling

With the exception of the Nirranda Group, Flaxman/Waarre Formation and the Crayfish Formation (the primary target), the entire Tertiary Upper and Lower Cretaceous sequences were penetrated. Minor oil fluorescence and cut were noted in all the thin sandstone beds from 1008 m, in the Eumeralla Formation, down to the top of the basement. The poroperm characteristics of these thin sandstone beds were extremely low.

- Why Was Green Banks No. 1 Dry?

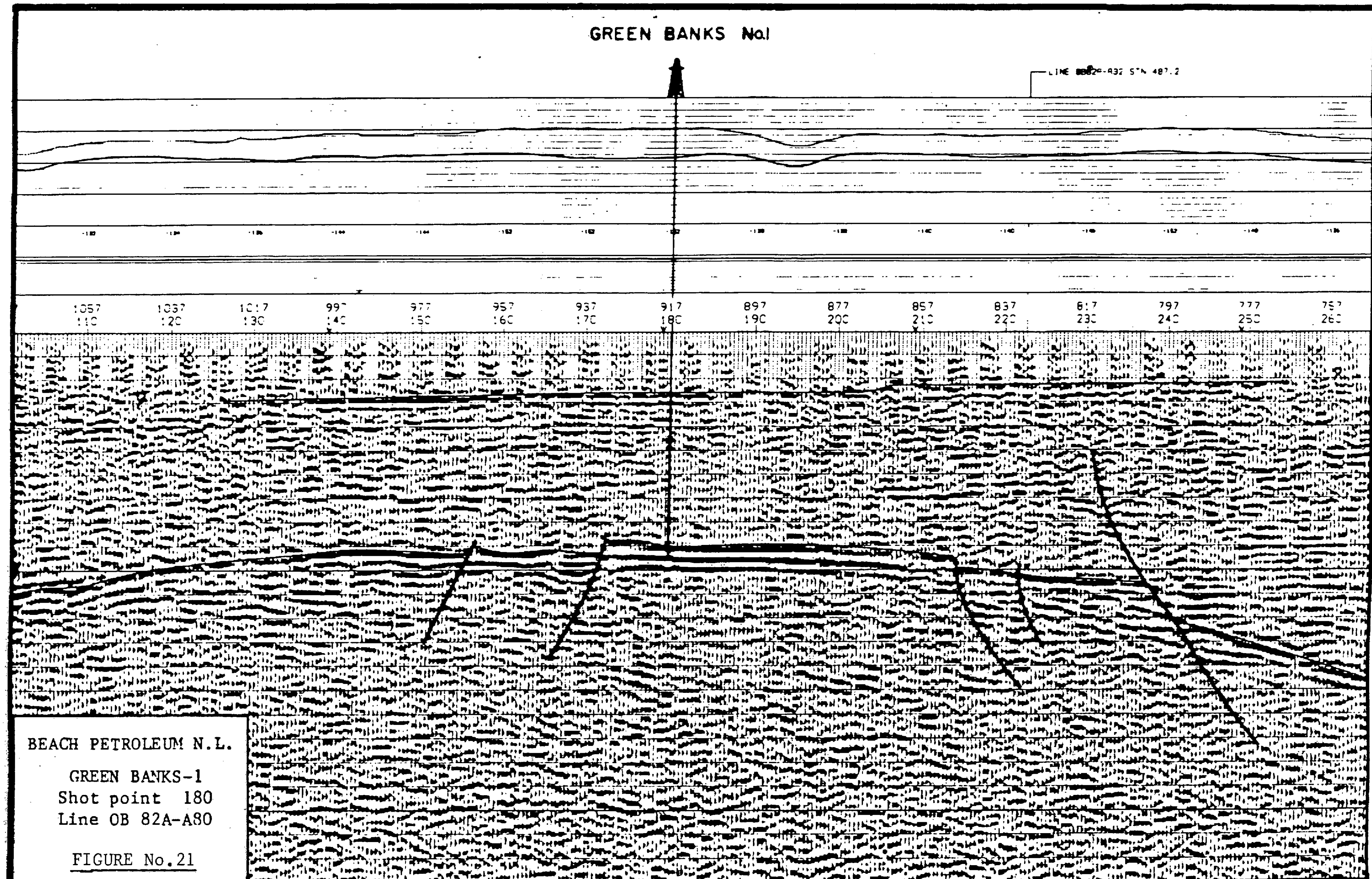
The well was dry because the Pretty Hill Sandstone Facies, the target reservoir was absent at this location. Recent studies have suggested that the presence of the Crayfish Formation and particularly the Pretty Hills Sandstone cannot be expected on the major basement highs.

F. HAWKESDALE PROSPECT

- Seismic

The geophysical program to define this prospect was initiated by a gravity survey and followed by a geochemical survey in selected areas. The Hawkesdale Prospect was finally outlined by a subsequent seismic survey (Shell 1969 Seismic Survey). The well was drilled one kilometre west of the seismic line 069-08, shot point 126.5.

.../62



BEACH PETROLEUM N.L.

GREEN BANKS-1
Shot point 180
Line OB 82A-A80

FIGURE No.21

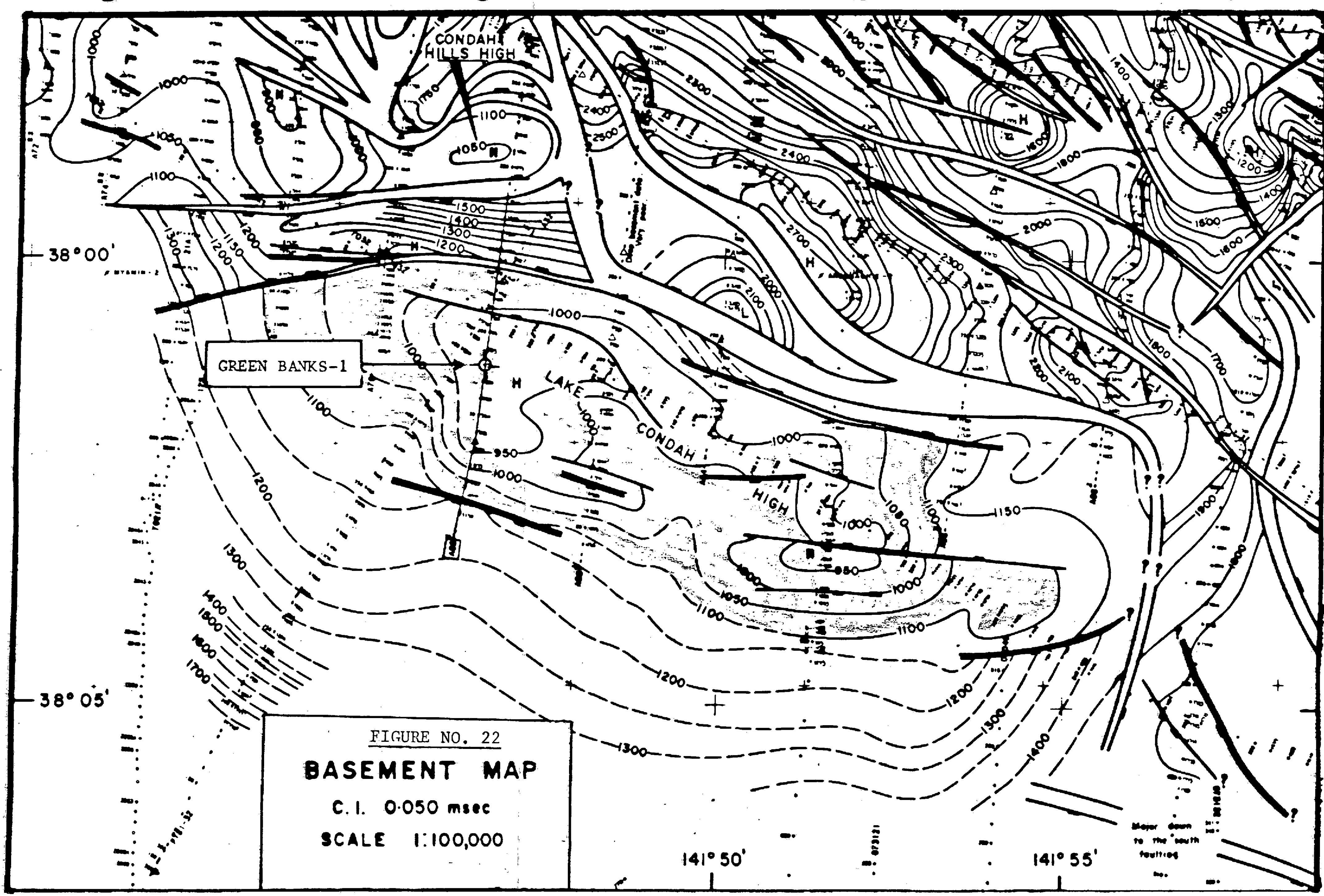


FIGURE NO. 22

BASEMENT MAP

C.I. 0·050 msec

SCALE 1:100,000

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F. HAWKESDALE PROSPECT - Continued

- Type of Structure

Although the gravity survey revealed three pronounced positive anomalies, seismic interpretation indicated that the Crayfish Formation was absent on these basement highs. However, a small pinch-out/fault trap was mapped at the Crayfish Formation level. The structure, located on the eastern flank of the Hawkesdale high, is controlled by a normal, down-to-the south, northwest trending fault located to the north and northeast of the well. Closure also relies on a wedging out of the Crayfish Formation on basement towards the west (See Figure No. 23).

- Results of Drilling

The Hawkesdale No. 1 well intersected an abbreviated late Tertiary sequence typical for the northern margin of the Otway Basin. The Nirranda and Wangerrip Groups of early Tertiary age and the entire Upper Cretaceous section were absent. The well then penetrated the Eumeralla Formation and Pretty Hill Sandstone Facies of the Crayfish Formation. The total depth of 1774 m was reached in basement after penetrating the Casterton Formation. 213 metres of the 251 metres thick Pretty Hill Sandstone Facies, the target reservoir had excellent poroperm characteristics. Oil fluorescence and cut were noted on core surfaces and in cuttings. Two attempted DST's failed because no adequate packer seat was obtained.

- Why Was Hawkesdale No. 1 Dry?

Available data cannot confirm a closed structure at the Hawkesdale No. 1 location. The well was also inadequately tested.

G. HEATHFIELD PROSPECT

- Seismic

The Heathfield Prospect was defined by seismic surveys carried out by the Planet Exploration Company in 1962 and 1963.

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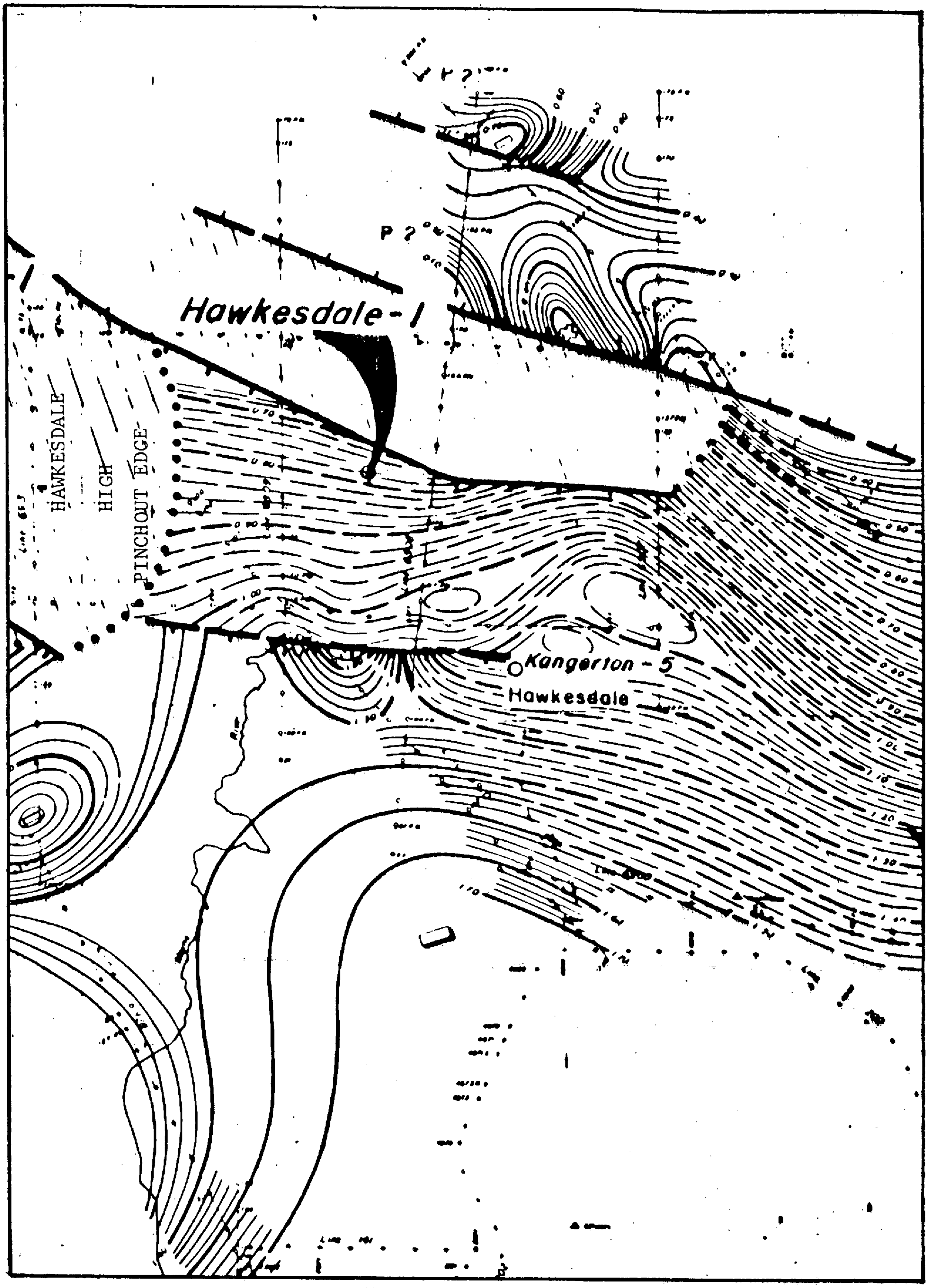

FIGURE NO. 23

HAWKESDALE PROSPECT

Top Crayfish Formation

Scale 1:100,000

Contour Interval 20 millisecs

G. HEATHFIELD PROSPECT - Continued

- Type of Structure

The feature was mapped as a major anticlinal structure on the downthrown side of the Kanawinka Fault at the level which was thought to be the Top of the Eumeralla Formation.

- Results of Drilling

The Heathfield No. 1 well spudded in the Whaler's Bluff Formation. It intersected Wangerrip Group and Sherbrook Group. The Heytesbury Group of late Tertiary was absent. The well then penetrated the Eumeralla Formation including 16.8 metres of the Heathfield Sand Member, the first time it had been drilled in Otway Basin. The total depth was reached in the Geltwood Beach Sandstone Facies of the Crayfish Formation. The only indication of hydrocarbons was obtained from DST No. 2 over the interval which includes the Heathfield Sand Member. The DST No. 2 recovered 122 metres of muddy gassy salt water and 1085 metres of gassy salt water. The gas was analysed and found to consist of 75% combustible gas, dominantly methane, with small amounts of ethane, propane, isobutane, normal butane, neopentane, isopentane, normal pentane and hexane.

- Why Was the Heathfield No. 1 Dry?

Although none of the original seismic data was available, absence of a closed structure at the Heathfield Sand Member level is suspected to be responsible for the lack of an accumulation of hydrocarbons at this prospect.

H. LINDON PROSPECT

- Seismic

The Lindon Prospect was defined by 4 seismic lines of the 1983 Denhelm Seismic Survey (acquired by Beach Petroleum NL) and 2 reprocessed seismic lines of 1972 Shell Survey (See Figure No. 24).

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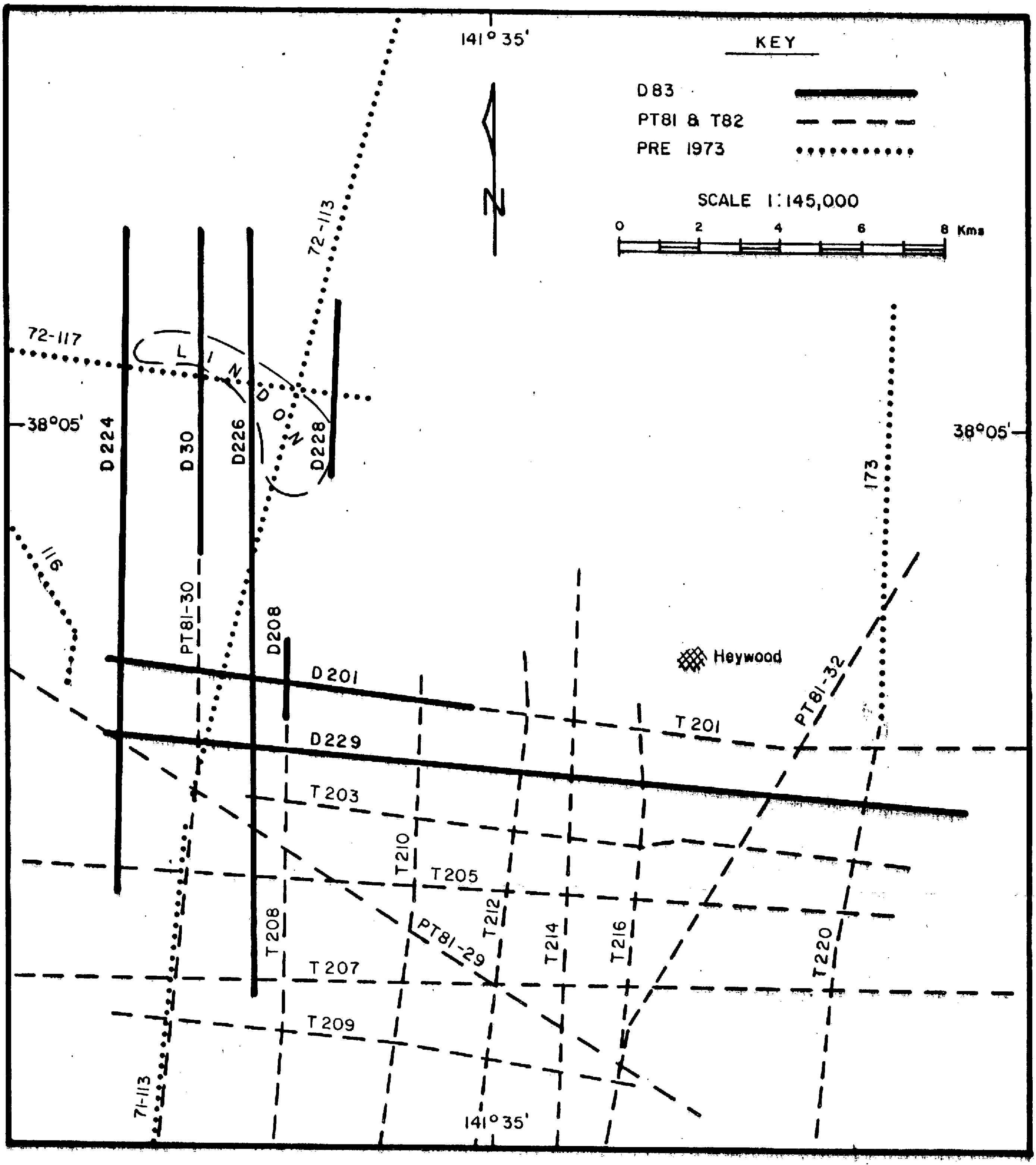

FIGURE NO. 24

DENHELM

SEISMIC PROGRAM MAP

H. LINDON PROSPECT - Continued

- Seismic - Continued

Seismic data quality of the Denhelm Survey is excellent at the Near Top Upper Cretaceous level, fair to quite good at Near Base Upper Cretaceous level and poor to fair at the Near Base Lower Cretaceous level. Data quality of the 1972 Shell lines was noticeably improved by reprocessing. The Lindon No. 1 well was located on the Denhelm Line D226 at Shot Point 532.5 (See Figure No. 25).

- Type of Structure

The Lindon Prospect was mapped as a closed elongate structure at Near Top Upper Cretaceous level (See Figure No. 26) with its structural axis trending northwest to southeast. It is essentially a horst-block type structure which shows very limited if any rollover into the north bounding fault. The maximum area of closure at the Near Top Upper Cretaceous is estimated to be 3.4 km^2 with maximum vertical relief of 97 metres at the well location.

The feature was also mapped at Near Base Upper Cretaceous level as a close structure (See Figure No. 27). It is similar to the Near Top Upper Cretaceous structure in shape but appears to have turnover into the northern fault. The structure has a maximum areal closure of 4.54 km^2 with a maximum vertical closure of 180 metres.

Based on the seismic interpretation, a third closed structure was mapped at the level which was thought to be Near Base Lower Cretaceous. The results of Lindon-1 drilling revealed that this horizon is the base of the Eumeralla Formation/Top Crayfish Formation.

- Results of Drilling

Although the Lindon-1 well intersected the full sedimentary sequence predicted, the following is worthwhile to note:-

- The Pebble Point Formation was thicker than anticipated;
- The Belfast Mudstone Member was considerably thinner than it was prognosed;

.../65

FIGURE NO. 25

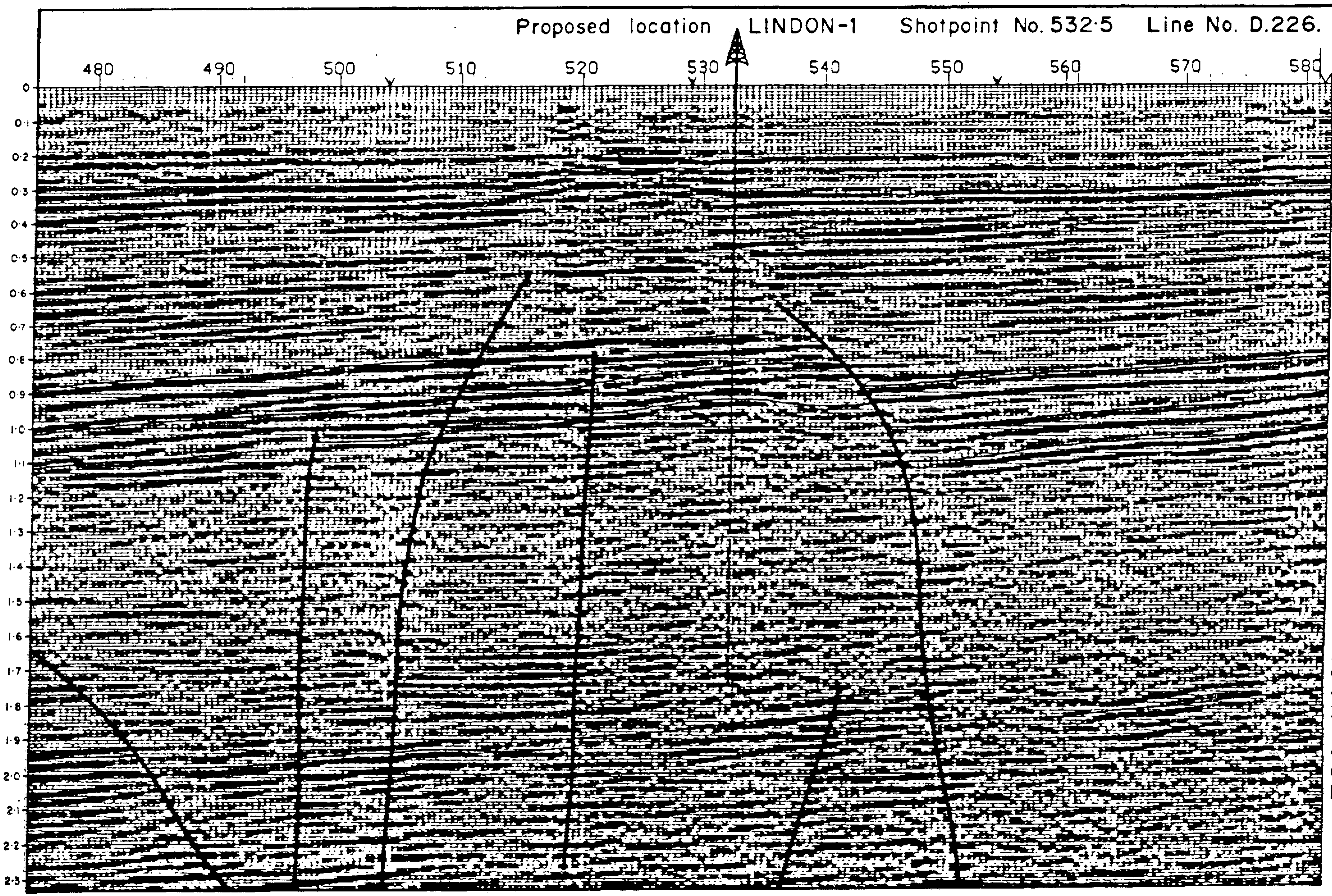

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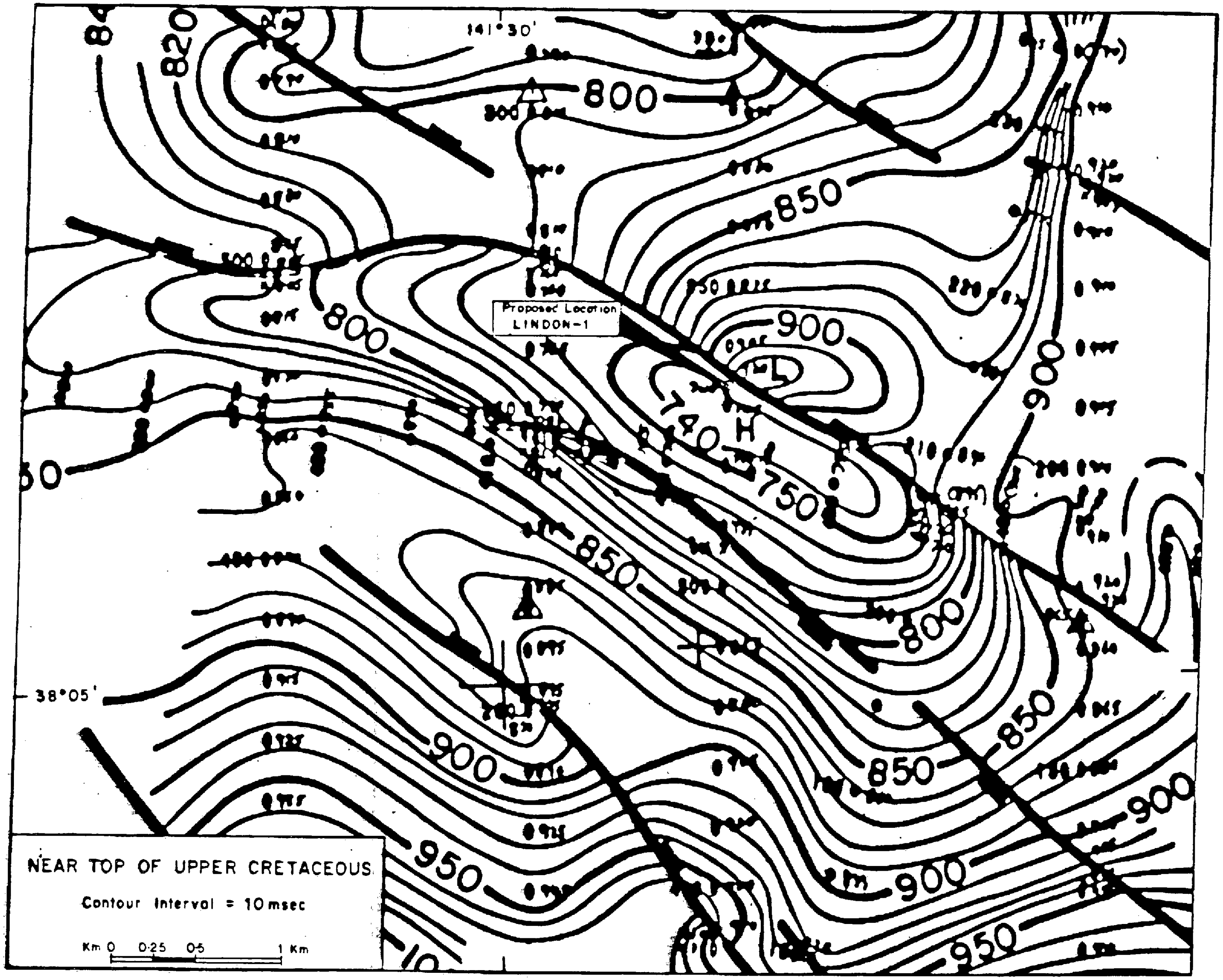
FIGURE NO. 26



NEAR TOP OF UPPER CRETACEOUS

Contour Interval = 10 msec

Km 0 0·25 0·5 1 Km

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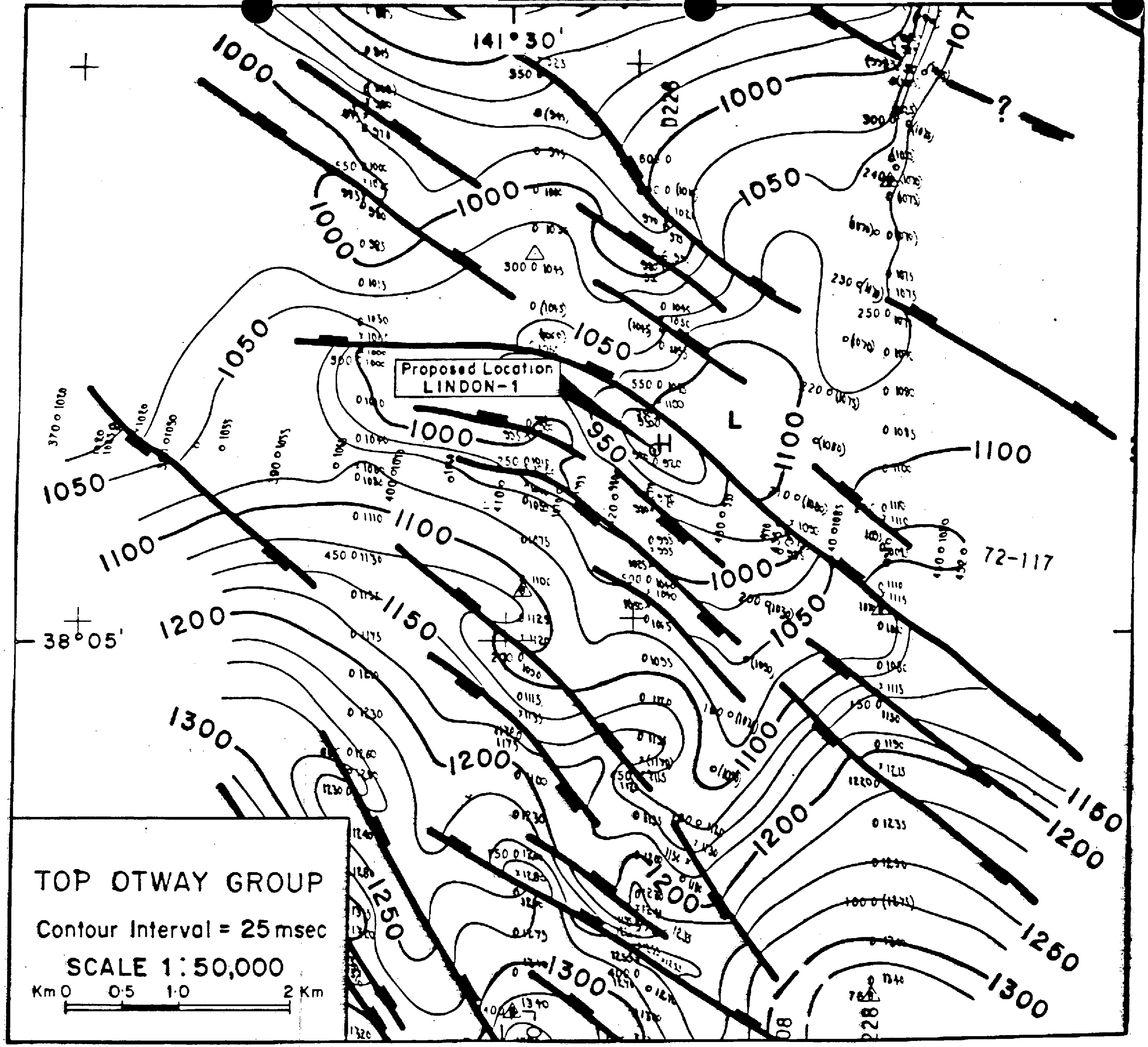
FIGURE NO. 27



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H. LINDON PROSPECT - Continued

- Results of Drilling - Continued

  - The Waarre Formation was very thin, poorly developed and with virtually no porosity;
  - The Eumeralla Formation was much thicker than predicted with no sand units with worthwhile reservoir properties present;
  - The total depth was reached in the Geltwood Beach Sandstone Facies of the Crayfish Formation.

The first and major indication of hydrocarbons was encountered at the top of the Pebble Point Formation where increased mud, gas, oil fluorescence, cut and oil staining were noted. The DST No. 1 over the interval 891.0 m - 912.5 m recovered 18.29 metres of heavily oil cut and gas cut mud, 27.43 metres of slightly gas cut mud and 18.29 metres of mud. The preliminary geochemical analysis of the oil sample indicates that the oil show is a mature non-marine waxy crude which has undergone water-washing. Core No. 1 cut over the interval 912.5 m - 917.0 m (4.0 m recovery) consisted of 4.0 metres of sandstone with irregularly distributed porosity of up to 26% with oil saturation noted through most of the core.

DST No. 2 over the interval 888.0 m - 927.0 m recovered 351.0 metres of muddy water only.

The first oil fluorescence and cut noted in the Lower Cretaceous section was at the interval 1946.0 m - 1948.0 m. A stronger oil show was encountered at 2392.0 m and cutting fluorescence was continuously present all the way down to T.D.

DST No. 3, run over the interval 2979.0 m - 3011.0 m (T.D.), recovered 70.0 metres of mud only.

The well was plugged and abandoned.

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H. LINDON PROSPECT - Continued

- Why was Lindon Prospect Not Full to Mapped Closure?

As it was discussed earlier, the Lindon Structure is generally controlled to both north and south by two faults. Seismic interpretation indicates that the last movement of these faults took place during the deposition of the Pember Mudstone Member. This is supported by the estimated thickness of the Pember Mudstone on the downthrown side of the faults. Based on this interpretation, the structure is believed to be securely sealed against these faults, leaving no doubt on validity of a closed structure.

Why Lindon Prospect was not filled to mapped spill-point at the base Tertiary level is a lengthy discussion and beyond the scope of this study. Nevertheless a brief account, based on the preliminary interpretation, is given below:-

"Seismic data suggests that closure exists well beyond the oil/water contact, as drilled, i.e. an oil column less than 8 m thick was present in the base Tertiary reservoir. This is substantially less than the mapped 97 m of closure. The only logical reason to be given for this anomaly, at present appears to be the distance between the source and reservoir rocks. Long distance migration would dramatically reduce the rate of hydrocarbon accumulation in the reservoir. This means that the accumulation process at this reservoir is in an early stage and probably still continuing at a very slow rate. If this is the case the lower zone of the oil column, i.e. oil/water contact, is in contact with formation water at any given time considerably longer than that of an accumulation, closer to the oil source.

Also, if the Eumeralla Formation is considered the source of hydrocarbon, oil generated from this formation has to migrate through porous, water filled, Upper Cretaceous sediments. Association of this oil with water would be lengthened if migration occurs laterally. The lengthy contact of oil with water would cause the change in composition of the oil noted.

.../67

H. LINDON PROSPECT - Continued

- Why was Lindon Prospect Not Full to Mapped Closure? - Continued

The degradation processes, the water-washing, appear to have resulted in the removal of a considerable quantity of the light hydrocarbons up to C15. The sample recovered from DST No. 1 which is described as low-pour-point waxy crude, is the remainder of the original oil".

At the deeper horizon, the Belfast Mudstone Member was considerably thinner than anticipated. Therefore structure at Waarre Formation level is not sealed at the downthrown side of the north and south bounding faults.

No sand body with reasonable reservoir properties was intersected within the Lower Cretaceous Eumeralla and Crayfish Formations.

I. MOYNE FALLS PROSPECT

- Seismic

The Moyne Falls No. 1 was defined using both gravity and seismic acquired by Shell and Frome Broken Hill. The well was located on seismic line 069-14 shot point 167.

- Type of Structure

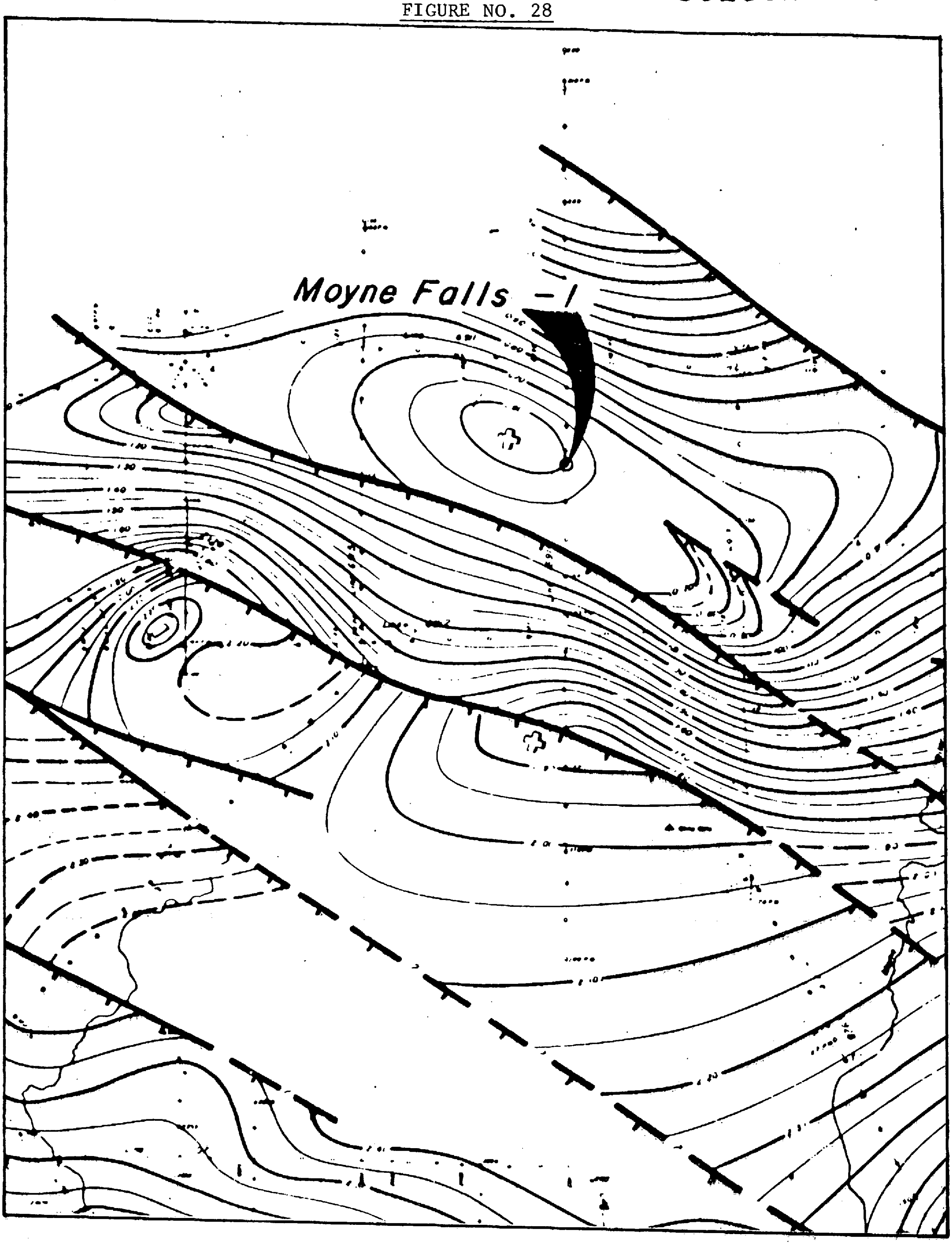
The initial gravity survey indicated the presence of a basement high (See Figure No. 28). The subsequent seismic survey revealed an anticlinal structure with areal closure of 38 kilometres^2 and vertical closure of 305 metres at the Top Basement level. To the south this anticline is generally affected by a normal down-to-the-south northwest trending fault. It is believed that fault movement first occurred during Late Jurassic-Early Cretaceous.

- Results of Drilling

The Moyne Falls No. 1 well was spudded in the Newer Volcanics. The well intersected the Heytesbury Group which unconformably overlie the Eumeralla Formation. It then penetrated the Casterton Formation

.../68

FIGURE NO. 28



MOYNE FALLS NO. 1

Top Basement Map

Contour Interval: 50 millisecs

Scale 1:100,000

I. MOYNE FALLS PROSPECT - Continued

- Results of Drilling - Continued

before reaching T.D. in the Basement. The Pretty Hill Sandstone Facies of the Crayfish Formation, the primary target which was thought to have been deposited as a basal wash overlying the basement, was not present. It was also thought that hydrocarbons could accumulate in weathered or fractured basement. The basement appeared to be neither weathered nor fractured.

- Why was the Moyne Falls No. 1 Dry?

The Moyne Falls No. 1 was dry because no significant reservoir rocks were encountered.

J. NORTH EUMERALLA PROSPECT

- Seismic

The North Eumeralla Prospect was mapped using four seismic lines from 1970 and 1973 Seismic Surveys acquired by Shell Development of Australia.

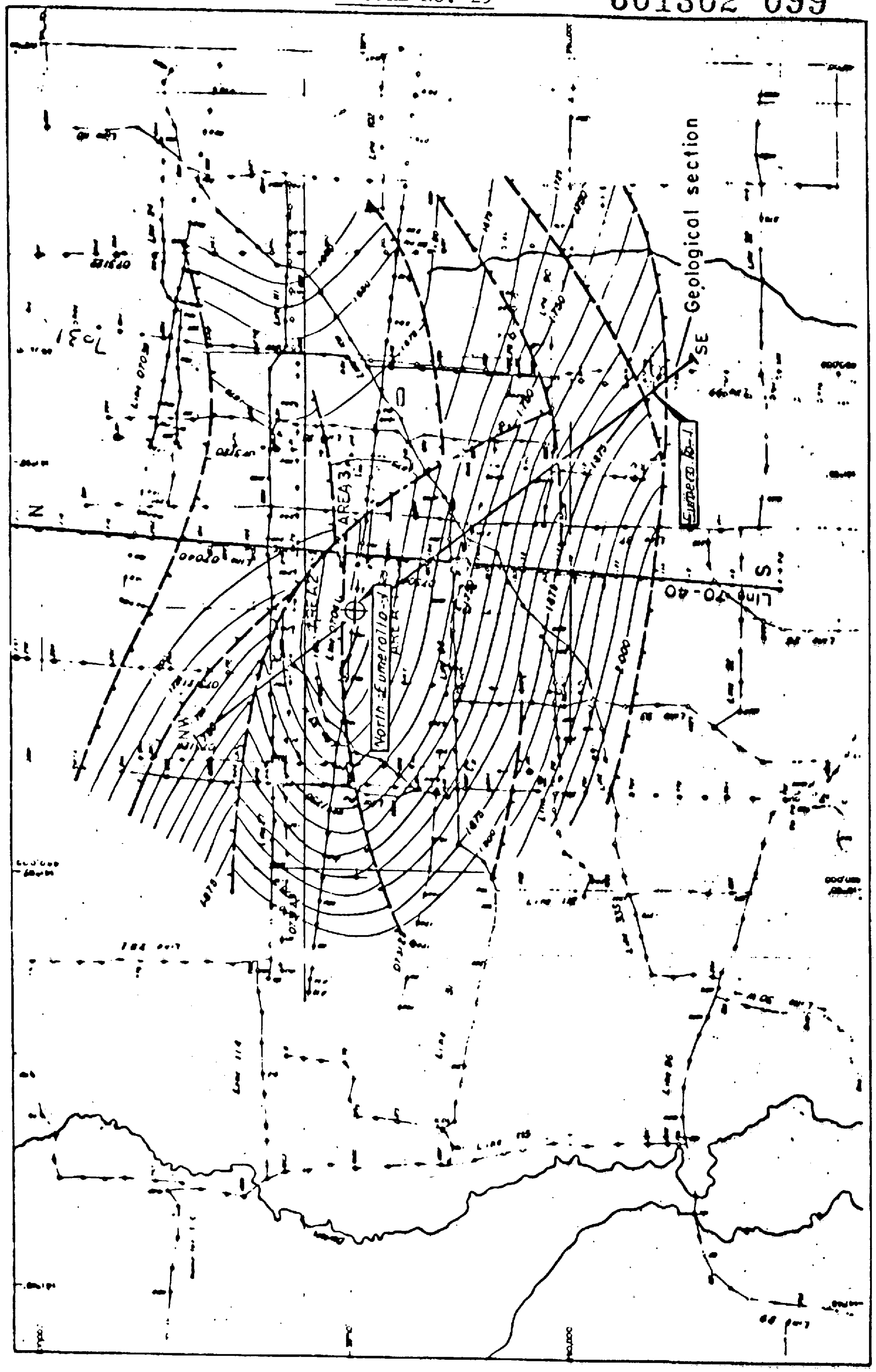
- Type of Structure

The structure was mapped as a dip-fault combination trap at the Intra-Eumeralla horizon (See Figure No. 29). To the north it is generally controlled by a normal down-to-the north northeast trending fault. The structure was thought to be closed from the Intra-Eumeralla horizon down to the Top of the Basement.

- Results of Drilling

The North Eumeralla No. 1 well intersected a normal sedimentary sequence except that the Nirranda Group and Flaxman/Waarre Formation were not present in this well. Only the Geltwood Beach Sandstone Facies of the Crayfish Formation was penetrated and the total depth was reached in basement. No hydrocarbons were noted in this well.

.../69



NORTH EUMERALLA NO. 1

Top Intra-Eumeralla Horizon

Contour Interval = 25 millisecs

Scale 1:100,000

J. NORTH EUMERALLA PROSPECT - Continued

- Why was North Eumeralla No. 1 Dry?

Although it is believed that the North Eumeralla No. 1 well was located on a fault closed structure, lack of hydrocarbons in this well can be attributed to the combination of the following facts:-

- lack of reservoir rock development
- lack of suitable source rocks in the area
- if suitable source rocks do exist, structural development has occurred after hydrocarbon generation and migration.

K. PRETTY HILL PROSPECT

- Seismic

The Pretty Hill Prospect was defined by Pre-1962 (Wriggley Trace) seismic data acquired by Frome Broken Hill.

- Type of Structure

The Pretty Hill No. 1 well was located on the crest of the structure interpreted for the deep seismic reflector which turned out to be basement. The structure was mapped as a dip-fault combination trap (See Figure No. 30). To the south it is controlled by a normal down-to-the-south, west northwest trending fault.

The structure is generally dipping to the north with a general east-west strike. Regional dip through the Pretty Hill Sandstone Facies section is not clearly defined but it is believed to be probably less than 15^{o} towards the northwest.

- Results of Drilling

The Pretty Hill No. 1 well intersected a normal, albeit abbreviated in part, Otway Basin sequence to reach T.D. in the Basement. For the first time, the Pretty Hill Sandstone Facies of the Crayfish Formation (previously called "basal sand") was recognised in this

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FIGURE NO. 30

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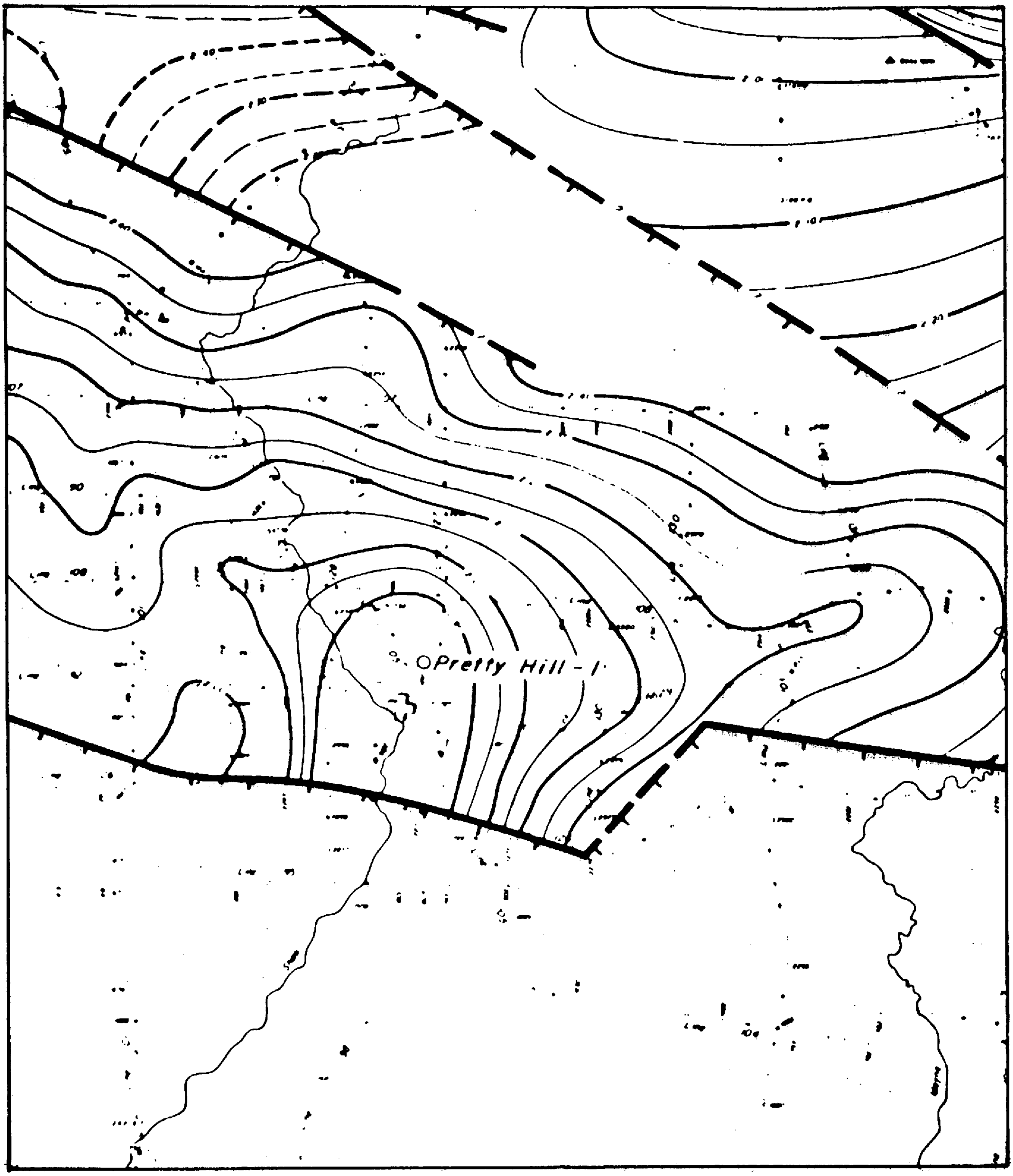

PRETTY HILL NO. 1

Top Basement

Contour Interval = 50 millisecs

Scale 1:100,000

K. PRETTY HILL PROSPECT - Continued

- Results of Drilling - Continued

well. No significant hydrocarbon shows were noted and the DST results over an interval of the Pretty Hill Sandstone Facies indicated that the reservoir is 100% water saturated with water salinity of 14,000 ppm.Cl. The core analysis revealed that the Pretty Hill Sandstone facies exhibits excellent reservoir characteristics with porosity and permeability up to 25% and 2756 millidarcy respectively.

- Why was Pretty Hill No. 1 Dry?

The feature which was originally mapped as top of the reservoir turned out to be the Top of the Basement. Sections above the basement are believed to have their culmination offset to the south. In addition no north component of dip can be confirmed in cores, cuttings or dipmeter log at the Pretty Hill Sandstone Facies level.
The Pretty Hill No. 1 was dry because the well was not located on structure.

L. TULLICH PROSPECT

- Seismic

The Tullich Prospect was defined by a seismic survey acquired by Planet Exploration in 1962/63.

- Type of Structure

The feature was mapped as a closed anticlinal structure in the Tullich area. The structure was thought to have a vertical closure of 76 metres covering an area about 8.9 kilometres long and 2.0 kilometres wide, its structural axis trending in a north-west-southeast direction. The well was drilled on a culmination at the southeast end of this structure.

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L. TULLICH PROSPECT - Continued

- Results of Drilling

The Tullich No. 1 well was spudded in a thin veneer of the Whaler's Bluff Formation before intersecting a relatively thin Wangerrip Group. The Heytesbury and Sherbrook Groups were also absent. It then penetrated a thick Eumeralla Formation, including 24 metres of the porous Heathfield Sand Member, to reach T.D. in the Geltwood Beach Sandstone Facies of the Crayfish Formation.

No fluorescence due to hydrocarbons was detected in any of the samples or cores. Formation tests over a number of intervals in the lower section of the Eumeralla Formation (including one DST in the Heathfield Sand Member) and Geltwood Beach Sandstone Facies recovered gas cut salt water. The dominant gas was methane and ranged from 22% to 91% (see section entitled "Source Rock Potential").

- Why was Tullich No. 1 Dry?

Although relatively good reservoir characteristics were exhibited in a number of intervals in the Eumeralla and Crayfish Formations, no significant quantity of hydrocarbons were found in this well. It can only be assumed at this time that the 1962/63 seismic data was not of sufficient quality to satisfactorily define a closed structure.

M. VOLUTA PROSPECT

- Seismic

The Voluta Prospect was defined by seismic data acquired by Shell Development (Australia) in 1966 .

- Type of Structure

The feature was mapped as a broad gentle closed anticlinal structure at a level in the Upper Cretaceous Sherbrook Group. At this level seismic data indicated a closed area of about 51.8 kilometres^2 and a vertical closure of approximately 305 metres.

M. VOLUTA PROSPECT - Continued

- Results of Drilling

The Voluta No. 1 well intersected a normal sedimentary sequence down to the base of the Paaratte Formation. It then penetrated a thick section of the Belfast Mudstone Member, i.e. 1810 metres, before it was plugged and abandoned due to mechanical problems. As a result, the well failed to achieve its objectives. The Waarre Formation, the primary target, was not reached and no sand body with reasonable reservoir properties was present in the lower section of the Sherbrook Group.

No hydrocarbon indications were noted from cuttings or cores, but minor shows of methane were recorded from the mud over a number of intervals in the Belfast Mudstone Member. Below 3300 metres, traces of ethane and propane were also recorded.

- Why was Voluta No. 1 Dry?

No seismic data were available to this report to analyse the presence of a closed structure at this location. However, the Voluta No. 1 Well Completion Report claims that "there can be little doubt that the well was drilled on a closed anticlinal feature" at the Sherbrook Group level (S.D.A. 1968). On the other hand results of the source rock related studies indicate that the lower section of the Belfast Mudstone Member is approaching the zone of gas generation in the Voluta No. 1 well (See "Source Rock Potential").

However, the absence of any worthwhile reservoir rock within the known closure is responsible for the lack of a hydrocarbon accumulation in this prospect.

N. WOOLSTHORPE PROSPECT

- Seismic

The Woolsthorpe Prospect was defined by pre-1970 seismic acquired by Shell Development (Australia) Ltd.

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N. WOOLSTHORPE PROSPECT - Continued

- Type of Structure

The prospect was located at the intersection of the northern extension of the Warrnambool High and the inferred pinch-out of Lower Cretaceous sediments along the northern hinge-line of the Port Campbell Embayment. Figure No. 31 and 32 show the contour maps of the base of Eumeralla Formation and Top of the Basement respectively.

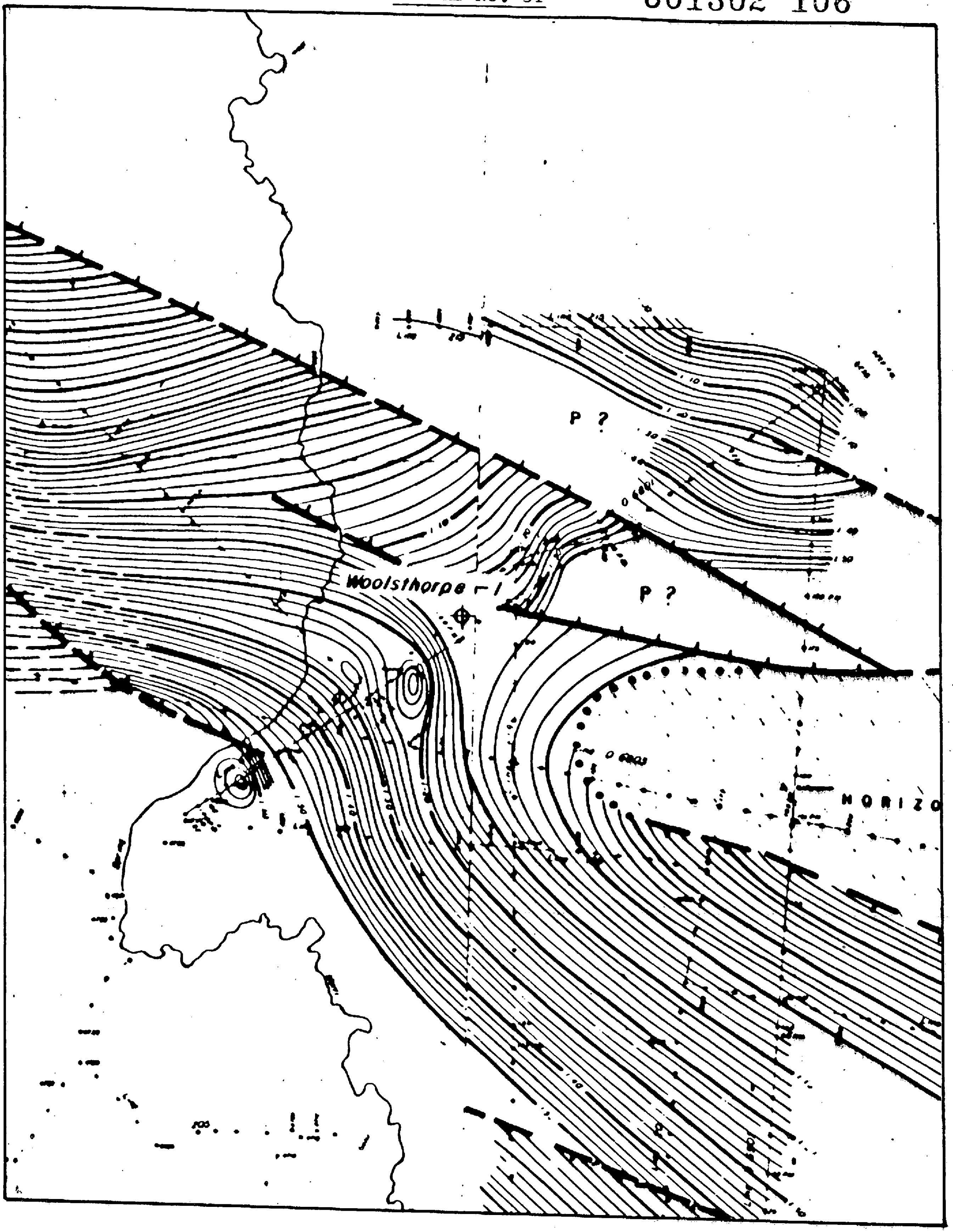
- Results of Drilling

The Woolsthorpe No. 1 well intersected Post-Heytesbury and Heytesbury Groups before penetrating the Eumeralla and Crayfish Formation. The total depth was reached in the volcanic section of the Casterton Formation. The Crayfish Formation included both the Geltwood Beach Sandstone Facies and the Pretty Hill Sandstone Facies. The former was underlain by the latter.

The only hydrocarbon indication was minor oil fluorescence noted in the Pretty Hill Sandstone Facies. Although the excellent poroperm characteristics of this reservoir were confirmed by DST, it was also proved that the reservoir was water-wet with 21,000 ppm NaCl water.

- Why was Woolsthorpe No. 1 Dry?

No valid closed structure can be confirmed at this location.



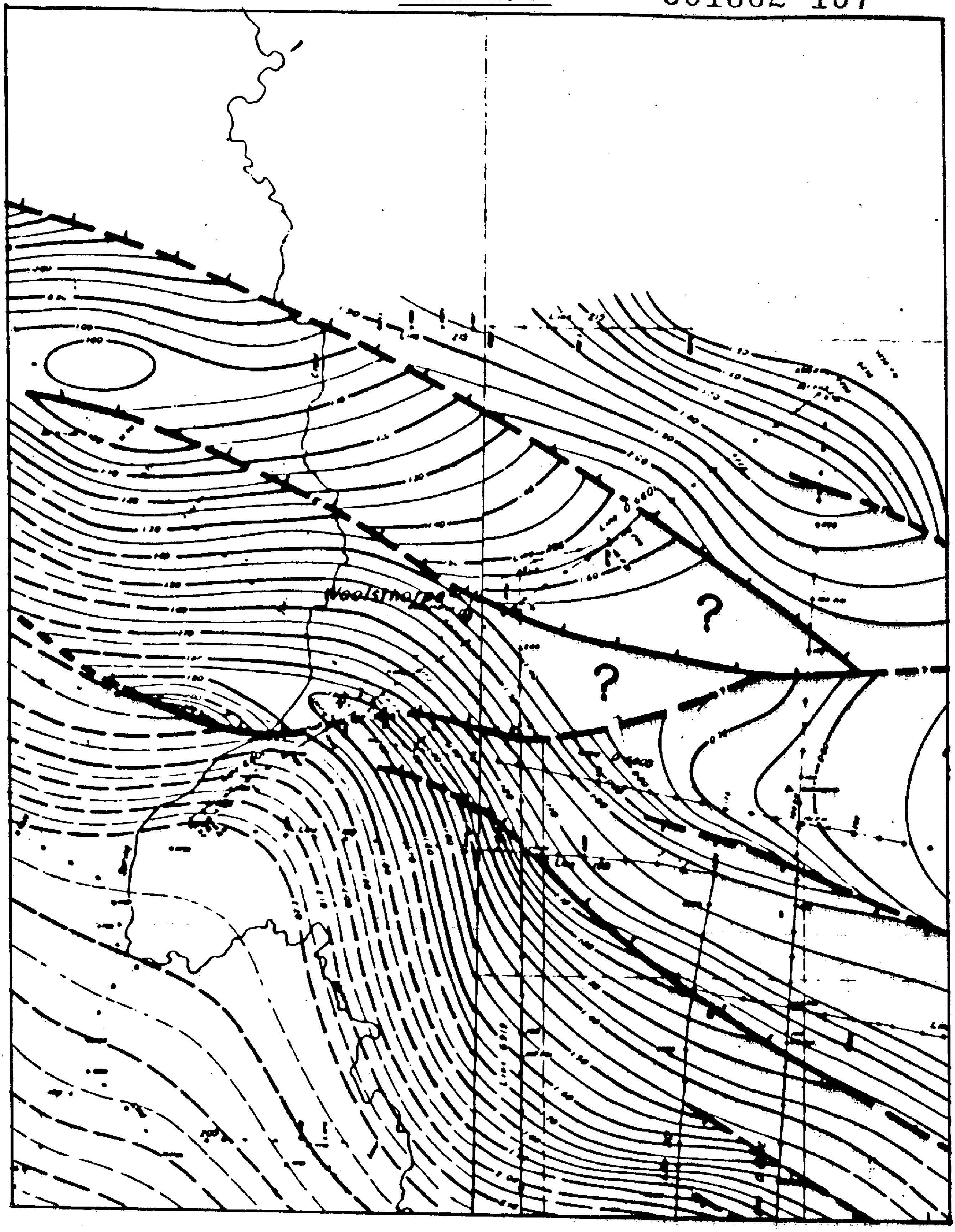
WOOLSTHORPE NO. 1

Base Eumeralla Formation

Contour Interval = 20 millisecs

Scale 1:100,000

FIGURE NO. 32



WOOLSTHORPE NO. 1

Top Basement

Contour Interval = 50 millisecs

Scale 1:100,000

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EXPLORATION OBJECTIVES

The Tyrendarra Embayment, like the remainder of the Otway Basin, has been subjected to several phases of tectonic movements. A number of potential reservoirs are known and when related to these periods of structural development form significant exploration objectives.

This section will discuss the various reservoir units in relationship to the structural frame-work. Where sufficient data is available, a "Specific Work Program" for each exploration objective will be discussed. This will highlight the proposed future work activity.

The exploration objectives will be discussed under the following headings:-

(a) Crayfish Formation
(b) Eumeralla Formation
(c) Waarre Formation
(d) Paaratte Formation
(e) Timboon Sand Member/Pebble Point Formation
(f) Dilwyn Formation

(a) Crayfish Formation

In the section entitled "Stratigraphy" it was noted that the Crayfish Formation consists of two end-member; the Pretty Hill Sandstone Facies and the Geltwood Beach Sandstone Facies. At the present time insufficient data is available to explian the mechanism(s) with which the facies changes occur. It is also impossible to recognise the Pretty Hill Sandstone Facies on seismic. This downgrades the potential of this reservoir.

One possible explanation for this lithofacies change is that the Pretty Hill Sandstone Facies was developed by reworking the Geltwood Beach sediments. This is partially supported by the following typical Pretty Hill facies properties.

i. Concentration of heavy minerals, e.g. garnet
ii. Increase in quartz sand content.

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EXPLORATION OBJECTIVES - Continued

(a) Crayfish Formation - Continued

iii. Decrease in clay and other light minerals susceptible to reworking processes.

iv. General improvement in roundness, sorting and coarsening of quartz.

Wherever the Pretty Hill Sandstone Facies is present it is capped by the Geltwood Beach and/or Eumeralla Formation sediments. The cap rock sequence is normally in excess of 1000 m thick.

Considering the overlying Eumeralla Formation as the main source rock in this area, the depth of the Crayfish Formation as a reservoir is critical. On relatively high uplifted fault blocks, hydrocarbons could be face-loaded into the Crayfish Formation by source rocks across the fault.

Based on the interpretation of the limited available seismic data a number of truncation edge/stratigraphic traps could exist on the southern flank of the Lake Condah basement high complex (See Figure No. 33). In this case hydrocarbons could migrate into the Crayfish Formation across the unconformity.

The only shows reported from the Pretty Hill Sandstone Facies of the Crayfish Formation were in Hawkesdale-1 and Woolsthorpe-1 where fluorescence and cut were noted.

Specific Work Program

Although the potential of the Crayfish Formation is downgraded by the fact that its different lithofacies are not recognisable on seismic, this report considers it a medium to high ranking exploration objective, because:-

(a) the excellent reservoir characteristics of its Pretty Hill Sandstone Facies.

(b) its location within the embayment where stratigraphic and/or fault depended traps seem to exist.

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EXPLORATION OBJECTIVES - Continued

(a) Crayfish Formation - Continued

Specific Work Program - Continued

Based on the above criteria, the area with Crayfish Formation exploration objectives are divided in three different exploration programs (See Figure No. 34):-

i. Area With Crayfish Formation Immediate Exploration Objective

This is an area south of the basement high complex within P.E.P. 105. Preliminary interpretation of the available seismic data indicates the presence of a wedging out or truncation of the Crayfish Formation. This will place the basal sandstone or potential Pretty Hill Sandstone Facies along the southern flank of the basement high directly below the Eumeralla siltstone (See Figure No. 33). Additional seismic is required to highlight any roll-over in the east west direction.

In addition, the down-to-the-south, east west trending normal faults present in this area would provide fault dependent structures. On the upthrown side of the faults the Crayfish Formation is well located to receive hydrocarbons from the source rock by face-loading mechanism across the fault.

The depth of Crayfish Formation in this marked area is less than 3000 m and it is believed that the porosity is not affected by depth. An immediate regional seismic program is strongly recommended over part of this area close to the one line crossing it at present.

ii. Area With Crayfish Formation Follow-Up Exploration Objective

This is the continuation of the area discussed above which extends to the South Australian border and located in the north western extremities of P.E.P. 105. It is also located on the upthrown side of the Tartwaup Faults where again face-loading mechanism of hydrocarbons from source rock is expected. A number of pinch-out traps are also recognised on the northern margin of this area.

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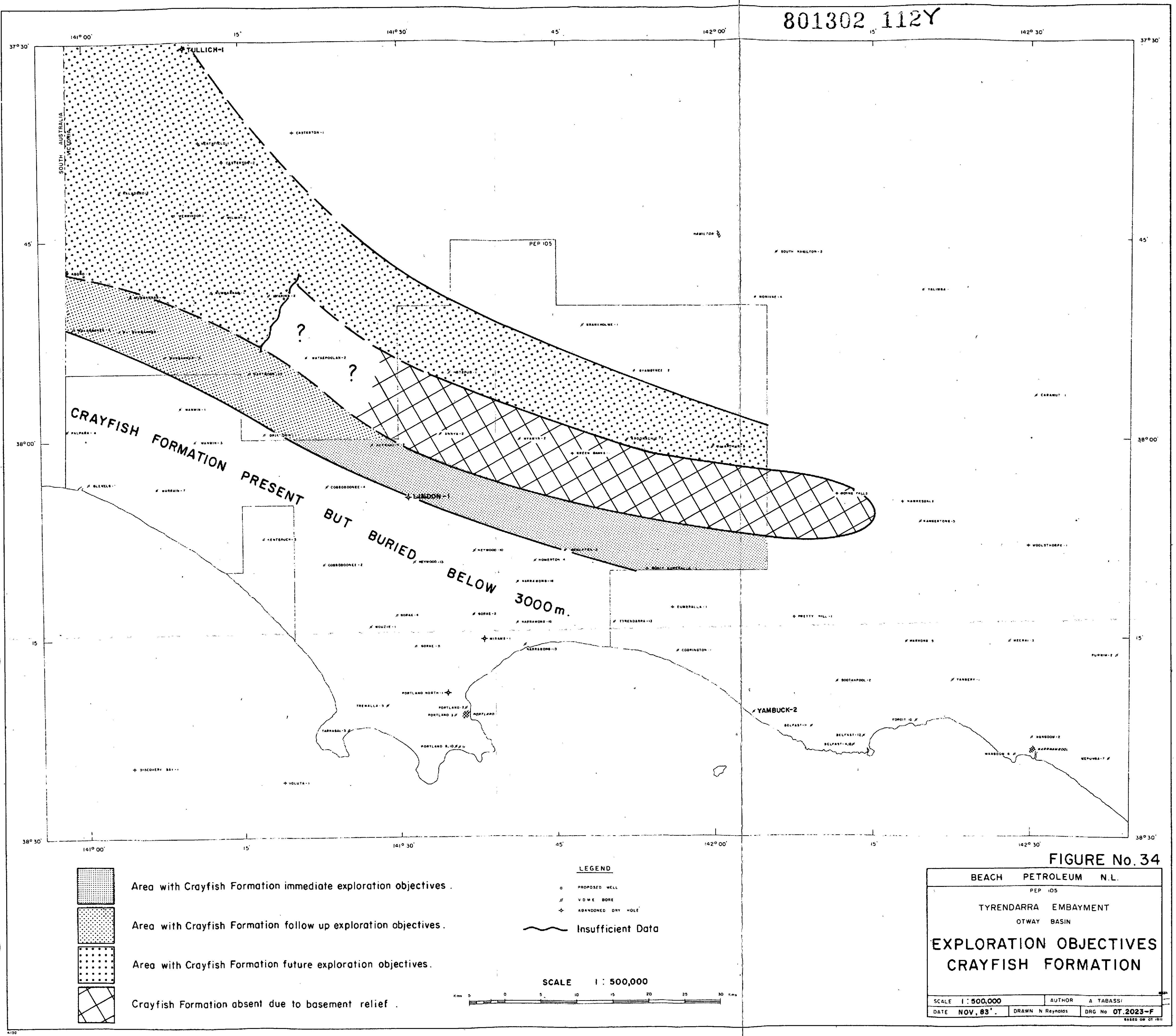
801302 112Y
TULLICH-1
SOUTH AUSTRALIA
VICTORIA
PEP 105
HAMILTON
?
?
CRAYFISH FORMATION PRESENT BUT BURIED BELOW 3000m.
LINDON-1
YAMBUCK-2
PORTLAND
141° 00'
15'
141° 30'
45'
142° 00'
142° 30'
37° 30'
38° 00'
38° 30'
FIGURE No. 34
LEGEND
Area with Crayfish Formation immediate exploration objectives.
Area with Crayfish Formation follow up exploration objectives.
Area with Crayfish Formation future exploration objectives.
Crayfish Formation absent due to basement relief.
PROPOSED WELL
VDME BORE
ABANDONED DRY HOLE
Insufficient Data
SCALE 1 : 500,000
BEACH PETROLEUM N.L.
PEP 105
TYRENDARRA EMBAYMENT
OTWAY BASIN
EXPLORATION OBJECTIVES
CRAYFISH FORMATION
SCALE 1 : 500,000
AUTHOR A. TABASSI
DATE NOV. 83'.
DRAWN N. Reynolds
DRG No OT.2023-F

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EXPLORATION OBJECTIVES - Continued

(a) Crayfish Formation - Continued

Specific Work Program - Continued

ii. Continued

Much of this area lies outside the area of P.E.P. 105 and it is recommended that attempts be made to gain title as soon as possible.

The potential significance of the Crayfish Formation and lack of sufficient seismic data highlights the need for a seismic program for this area once the new permit is acquired.

iii. Area With Crayfish Formation Future Exploration Objective

This area is located to the north of the Lake Condah basement high complex and Area II. Although pinch-out traps are suspected in the Ardonachie Trough, the presence of numerous down-to-the south, west-east trending faults are indicative of possible development of fault dependent structures. However, faulting is complex and common and until some encouragement is found in areas I and II, no further work is recommended in this area.

(b) Eumeralla Formation

Available data suggests that no sand unit with acceptable reservoir characteristics is recognisable from seismic in this formation. Sporadic reports on the presence of a relatively porous sand unit in the Eumeralla Formation are available although its correlation from well to well across the embayment is not possible. The Heathfield Sandstone Member, which is reported to have excellent reservoir characteristics, was intersected only in three exploration wells in the extreme northwestern portion of the study area. The Heathfield Sandstone Member has not been reported elsewhere in the Victorian portion of the Otway Basin. The above-mentioned facts downgrade the potential of the Eumeralla Formation dramatically.

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EXPLORATION OBJECTIVES - Continued

(b) Eumeralla Formation - Continued

On the other hand, more hydrocarbon shows have been reported in this formation than any other formation within the Tyrendarra Embayment. These include gas cut salt water to oil fluorescence and cut (See Table No. 1). In addition available source rock study results clearly indicate that this formation has reached the optimum stage of maturation and hydrocarbons have been, and are being, generated at or below a depth of approximately 2300 m. (See Figure No. 15). As it was discussed earlier, the hydrocarbon generative potential of the Eumeralla Formation greatly upgrades the exploration potential of any sand unit with reasonable properm characteristics within this formation.

This is because hydrocarbons would have only very limited or short range migration.

Any Eumeralla Formation Sandstone requires no significant migration mechanism and hydrocarbons would not be subjected to any loss of components which is generally believed to occur during migration processes. To summarize the foregoing discussion it can be said:-

- it is a good, oil prone source rock.
- no continuous sand unit with the optimum reservoir characteristics is recognised within the embayment.
- if sand is present, it is a lenticular body, hence it would be a reliable trap and accumulation of hydrocarbon does not require complex migration mechanisms.

Specific Work Program

Because of the absence of any worthwhile Eumeralla Formation Sandstone in Lindon-1 and an inability to locate any such sand on seismic, no immediate exploration program is recommended for this formation. When drilling for Crayfish Formation objectives, Eumeralla Formation Sandstone should not be completely overlooked.

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PE801303

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EXPLORATION OBJECTIVES - Continued

(c) Waarre Formation

In the section entitled "Potential Reservoirs" it was noted that the offshore Voluta Graben is the major controlling factor of the rate of deposition of the Waarre Formation. No well drilled in the centre of the Voluta Graben or indeed the Portland Trough intersected this formation but available seismic data suggests considerable thickening of Waarre Formation towards the axis of the trough. It is believed that thickening could be accompanied by improvement of Waarre Formation reservoir characteristics.

It is therefore, suggested that exploration targets should be within the shaded areas in Figure No. 35, because:-

i. Thickness and poroperm should be developed in the Waarre Sandstone in this area.

ii. Proximity of the reservoir to the source rock, i.e. in the Portland Trough the entire section of the Eumeralla Formation is buried below the optimum depth of maturation (See Figure No. 15).

iii. Thickening of the Belfast Mudstone Member basinwards provides a more reliable seal.

iv. Seismic interpretation revealed a number of fault dependent structures at Waarre level in this area, particularly north-west of the Portland Trough on the downthrown side of the Tartwaup Fault, some of which are expected to be associated with structural turnover. It should be emphasised that structures that have only fault closure are probably not prospective.

v. Numerous faults developed since Upper Cretaceous time have provided migration paths on either flank of the trough, hence vertical as well as lateral migration of hydrocarbons has occurred.

vi. The Waarre Formation is known to pinch-out along the northern edge in the onshore area of the major trough. This would bring about the development of traps along any N-S trending structural ridges.

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EXPLORATION OBJECTIVES - Continued

(c) Waarre Formation - Continued

Specific Work Program

The immediate work priority should be to attempt mapping of:-

(a) Waarre Formation, or;

(b) The underlying "Top Eumeralla Formation".

Any structure developed as a result of (a) which has clear four way roll-over, is a potential drilling target.

(d) Paaratte Formation (exluding Timboon Sand Member)

The undifferentiated part of the Paaratte Formation consists of an interbedded shale and sand sequence. As was discussed earlier (See "Potential Reservoirs") because of poor development of the Nullawarre Greensand and Skull Creek Mudstone Members it was not possible to differentiate them.

However, available wireline logs indicate the presence of porous sand units within the interval between base of the Timboon Sand Member and Top of the Belfast Mudstone Member. It is believed that the thickening and improvement of the reservoir characteristics of these sand units occurs towards the centre of the Portland Trough. The same condition as outlined for the Waarre Formation will apply in that potential for hydrocarbon development is possible in these sandstones only if turnover as against fault closure is present. In such a situation it is possible to have a stacked reservoir sequence.

The Skull Creek Mudstone Member generally caps these sand units but its thickness is questionable when a structure is fault dependent.

Specific Work Program

This report recognises the potential of the sand units (Nullawarre Greensand or its equivalent) within the Paaratte Formation. Figure No. 36 illustrates the area where undifferentiated Paaratte Formation objectives could be present if suitable traps can be mapped.

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EXPLORATION OBJECTIVES - Continued

(e) Timboon Sand Member/Pebble Point Formation

The first oil show in the Pebble Point Formation in the Tyrendarra Embayment (See Lindon-1 Well Completion Report, under preparation) promoted this formation to a prime potential exploration target. The "dirty" nature, hence low permeability of the Pebble Point in Lindon-1 supports the idea of considering this formation and the immediately underlying Timboon Sand Member as a combined reservoir.

Figure No. 37 illustrates the area where both primary and secondary Sand Member objectives could be present. The following points were taken into account on highlighting these areas:-

(a) proximity of the reservoir to the source rock.
(b) possible thinning of Pebble Point Formation.
(c) thickness of the Pember Mudstone Member, the caprock..
(d) depth of reservoir against possible flushing.
(e) available seismic interpretation results.
(f) potential structural turnover along the downthrown side of the Tartwaup Fault.

Specific Work Program

A semi-detailed seismic program is recommended for the area highlighted in Figure No. 37. Fault dependent structural development could be reliable since the thickness of Pember Mudstone, is in excess of 500 m in the centre of the Portland Trough. Furthermore, early Tertiary movements in the trough have developed multiple structures.

(f) Dilwyn Formation

As was noted earlier (See "Potential Reservoirs"), the Dilwyn Formation consists of up to seven stacked deltaic cycles. Each cycle begins with shale followed by barrier bar and delta front channel sands. These sand units have excellent reservoir characteristics and are normally capped by the shales of the above cycle. In the centre of Portland Trough, the basal cycles could be as deep as 1500 m. At this depth, the reservoir is adequately protected from flushing.

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EXPLORATION OBJECTIVES - Continued

(f) Dilwyn Formation - Continued

Specific Work Program

Although no specific work program is suggested for this formation, this report, for the first time in the exploration history of the Otway Basin, considers it as an exploration objective. Figure No. 38 illustrates the area where the Dilwyn Formation objectives could be present if suitable structural development can be mapped. Similar to that of the undifferentiated Paaratte Formation, preference is given to the structures independent of faults. In addition any drilling target sought in the shaded area of Figure No. 38 should consist of more than one reservoir target. This is purely a safeguard against our lack of understanding of the hydrocarbon potential of the Dilwyn Formation.

PE801306

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GENERAL DISCUSSION

The foregoing discussion has clearly revealed the presence of two structural trends of significance. These are:-

(A) Portland Trough

(B) Tartwaup Fault

All the elements required for locating hydrocarbons are present in these areas:-

- source rock is abundant and proven to be mature
- different phases of tectonics including relatively rapid subsidence have occurred resulting in:-

  (a) considerably rapid deepening of the sediments (consequently source rock maturity achieved in a shorter time space).

  (b) providing both vertical and lateral migration paths.

  (c) extensive faulting (though complicating the exploration programs) together with gentle and low amplitude foldings to develop numerous structures, some with possible multiple plays.

- potential reservoirs are widespread and seem to have a tendency to quality and quantity improvement towards the centre of the trough.

These areas are virtually unexplored and Lindon-1 drilled on the northern margin of the Portland Trough proved the significance potential of this trough.

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PE801307

This is an enclosure indicator page.
The enclosure PE801307 is enclosed within the container PE801302 at this location in this document.

The enclosure PE801307 has the following characteristics:

ITEM_BARCODE = PE801307
CONTAINER_BARCODE = PE801302
NAME = PEP 105, Tyrendarra Embayment Study Area
BASIN = OTWAY
ONSHORE? = Y
DATA_TYPE = TITLE
DATA_SUB_TYPE = PERMIT_MAP
DESCRIPTION = PEP 105, Study Area Map, Figure 1 Otway Basin Study Tyrendarra Embayment, Part 1 (Text), By A.Tabassi, Beach Petroleum, Nov 1983.
REMARKS =
DATE_WRITTEN = 30-NOV-1983
DATE_PROCESSED =
DATE_RECEIVED = 28-JUN-1984
RECEIVED_FROM = Beach Petroleum NL
WELL_NAME =
CONTRACTOR =
AUTHOR =
ORIGINATOR =
TOP_DEPTH =
BOTTOM_DEPTH =
ROW_CREATED_BY = MK11_SW

(Inserted by DNRE - Vic Govt Mines Dept)

PE801308

This is an enclosure indicator page.
The enclosure PE801308 is enclosed within the container PE801302 at this location in this document.

The enclosure PE801308 has the following characteristics:

ITEM_BARCODE = PE801308
CONTAINER_BARCODE = PE801302
NAME = PEP 105, Location of Exploration Wells
BASIN = OTWAY
ONSHORE? = Y
DATA_TYPE = TITLE
DATA_SUB_TYPE = PERMIT_MAP
DESCRIPTION = PEP 105, Location of Exploration Wells Map, Figure 2 within Otway Basin Study Tyrendarra Embayment, Part 1 (Text), By A.Tabassi, Beach Petroleum, Nov 1983.
REMARKS =
DATE_WRITTEN = 30-NOV-1983
DATE_PROCESSED =
DATE_RECEIVED = 28-JUN-1984
RECEIVED_FROM = Beach Petroleum NL
WELL_NAME = Woolsthorpe-1
CONTRACTOR =
AUTHOR =
ORIGINATOR =
TOP_DEPTH =
BOTTOM_DEPTH =
ROW_CREATED_BY = MK11_SW

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PE801309

This is an enclosure indicator page.
The enclosure PE801309 is enclosed within the container PE801302 at this location in this document.

The enclosure PE801309 has the following characteristics:

ITEM_BARCODE = PE801309
CONTAINER_BARCODE = PE801302
NAME = PEP 105, Early Cretaceous Map
BASIN = OTWAY
ONSHORE? = Y
DATA_TYPE = OTHER_SRVY
DATA_SUB_TYPE = STRUCTURE_MAP
DESCRIPTION = PEP 105, Structural Elements Early Cretaceous Map, Figure 3 within Otway Basin Study Tyrendarra Embayment, Part 1 (Text), By A.Tabassi, Beach Petroleum, November 1983.
REMARKS =
DATE_WRITTEN = 30-NOV-1983
DATE_PROCESSED =
DATE_RECEIVED = 28-JUN-1984
RECEIVED_FROM = Beach Petroleum NL
WELL_NAME =
CONTRACTOR =
AUTHOR =
ORIGINATOR =
TOP_DEPTH =
BOTTOM_DEPTH =
ROW_CREATED_BY = MK11_SW

(Inserted by DNRE - Vic Govt Mines Dept)

PE801310

This is an enclosure indicator page.
The enclosure PE801310 is enclosed within the container PE801302 at this location in this document.

The enclosure PE801310 has the following characteristics:

ITEM_BARCODE = PE801310
CONTAINER_BARCODE = PE801302
NAME = PEP 105, Late Cretaceous Map
BASIN = OTWAY
ONSHORE? = Y
DATA_TYPE = OTHER_SRVY
DATA_SUB_TYPE = STRUCTURE_MAP
DESCRIPTION = PEP 105, Structural Elements Late Cretaceous Map, Figure 4 within Otway Basin Study Tyrendarra Embayment, Part 1 (Text), By A.Tabassi, Beach Petroleum, Nov 1983.
REMARKS =
DATE_WRITTEN = 30-NOV-1983
DATE_PROCESSED =
DATE_RECEIVED = 28-JUN-1984
RECEIVED_FROM = Beach Petroleum NL
WELL_NAME =
CONTRACTOR =
AUTHOR =
ORIGINATOR =
TOP_DEPTH =
BOTTOM_DEPTH =
ROW_CREATED_BY = MK11_SW

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PE801311

This is an enclosure indicator page.
The enclosure PE801311 is enclosed within the container PE801302 at this location in this document.

The enclosure PE801311 has the following characteristics:

ITEM_BARCODE =	PE801311
CONTAINER_BARCODE =	PE801302
NAME =	PEP 105, Late Tertiary - Quaternary Map
BASIN =	OTWAY
ONSHORE? =	Y
DATA_TYPE =	OTHER_SRVY
DATA_SUB_TYPE =	STRUCTURE_MAP
DESCRIPTION =	PEP 105, Structural Elements Late Tertiary - Quaternary Map, Figure 5 within Otway Basin Study Tyrendarra Embayment, Part 1 (Text), By A.Tabassi, Beach Petroleum, Nov 1983.
REMARKS =	
DATE_WRITTEN =	30-NOV-1983
DATE_PROCESSED =	
DATE_RECEIVED =	28-JUN-1984
RECEIVED_FROM =	Beach Petroleum NL
WELL_NAME =	
CONTRACTOR =	
AUTHOR =	
ORIGINATOR =	
TOP_DEPTH =	
BOTTOM_DEPTH =	
ROW_CREATED_BY =	MK11_SW

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PE801312

This is an enclosure indicator page.
The enclosure PE801312 is enclosed within the container PE801302 at this location in this document.

The enclosure PE801312 has the following characteristics:

ITEM_BARCODE = PE801312
CONTAINER_BARCODE = PE801302
NAME = PEP 105, Seismic Line Location Map
BASIN = OTWAY
ONSHORE? = Y
DATA_TYPE = SEISMIC
DATA_SUB_TYPE = LOCATION_MAP
DESCRIPTION = PEP 105, Seismic Line Location Map, Enclosure 1 within Otway Basin Study Tyrendarra Embayment, Part 1 (Text), By A.Tabassi, Beach Petroleum, Jan 1984.
REMARKS =
DATE_WRITTEN = 31-JAN-1984
DATE_PROCESSED =
DATE_RECEIVED = 28-JUN-1984
RECEIVED_FROM = Beach Petroleum NL
WELL_NAME = Windermere-2
CONTRACTOR =
AUTHOR =
ORIGINATOR =
TOP_DEPTH = 0
BOTTOM_DEPTH = 0
ROW_CREATED_BY = MK11_SW

(Inserted by DNRE - Vic Govt Mines Dept)