SOUTH AUSTRALIA

DEPARTMENT OF MINES AND ENERGY

OPEN FILE ENVELOPE NO. 5378

PEL 22

OTWAY BASIN

GEOLOGICAL SUMMARY REPORT, LICENCE DOCUMENT, MINISTERIAL MEMORANDA TO PETROLEUM REGISTER AND TENEMENT REPORTS FOR THE PERIOD 26/1/83 TO 14/11/84

Submitted by

Beach Petroleum NL
and SADME

1984

ENVELOPE 5378

TENEMENT: PEL 22; Otway Basin

TENEMENT HOLDER: Beach Petroleum NL (operator)

CONTENTS OF VOLUME ONE

		SADME NO.
REPORT:	**Harrison, M.R., 1984.** PEL 22 exploration guidelines and the prospects for locating hydrocarbons (March 1984).	**5378 R 1** Pgs 3-130
APPENDIX 1:	Extracts from source rock studies referred to in section 8 of this report.	Pgs 131-152

CONTENTS OF VOLUME TWO

PLANS

		Scale	Drwg no.	
Fig. 7-5	Interpretation of line TA, Tartwaup Seismic Survey (1973).			5378-1
Encl. 1	Isopach map - Dilwyn Formation.	1:250,000		5378-2
Encl. 2	Top Pember Mudstone Member.	1:250,000		5378-3
Encl. 3	Isopach map - Pember Mudstone Member.	1:250,000		5378-4
Encl. 4	Top Sherbrook Group, (Upper Cretaceous).	1:250,000		5378-5
Encl. 5	Isopach map - Sherbrook Group.	1:250,000		5378-6
Encl. 6	Top Belfast Mudstone Member.	1:250,000		5378-7
Encl. 7	Isopach map - Belfast Mudstone Member.	1:250,000		5378-8
Encl. 8	Top Waarre Formation.	1:250,000		5378-9
Encl. 9	Isopach map - Waarre Formation.	1:250,000		5378-10
Encl. 10	Top Otway Group.	1:250,000		5378-11
Encl. 11	Estimated depth to the top of the zone of significant oil generation (assumed to be Ro = 0.7%).	1:250,000		5378-12
Encl. 12	Seismic shotpoint plan.	1:100,000	OT 20375 (F)	5378-13

CONTENTS OF VOLUME THREE

PLANS

		Drwg no.	
Encl. 13	Dilwyn Formation correlation - Mt. Salt 1 to Kentgrove 1.		5378-14
Encl. 14	Dilwyn Formation correlation - Lake Bonney 1 to Douglas Point 1.		5378-15
Encl. 15	Lower Tertiary sonic-gamma ray log correlation; Caroline 1 - Douglas Point 1 - Kentgrove 1 - Lake Bonney 1 - Burrungule 1 - Kalangadoo 1.	OT 2007 (R)	5378-16
Encl. 16	Sherbrook Group correlation: Argonaut 1 - Lake Bonney 1 - Burrungule 1 - Kalangadoo 1.		5378-17
Encl. 17	Sherbrook Group correlation: Geltwood Beach 1 - Lake Bonney 1 - Mt. Salt 1 - Caroline 1 - Malanganee 4 (Victoria).		5378-18

CONTENTS OF VOLUME FOUR

END OF CONTENTS

Superseded

CONTENTS ENVELOPE 5378

TENEMENT: PEL 22 - The Gambier Embayment.

TENEMENT HOLDER: Beach Petroleum.

ENCLOSURES:

P.E.L. 22

EXPLORATION GUIDELINES AND THE PROSPECTS FOR LOCATING HYDROCARBONS

THE GAMBIER EMBAYMENT, SOUTH AUSTRALIA

BY

M.R. Harrison
Beach Petroleum NL
March 1984.

CONTENTS

CONTENTS - Continued

.../3

CONTENTS - Continued

APPENDIX NO. 1

Extracts from Source Rock Studies referred to in Section VIII. of this report.

FIGURES

FIGURES - Continued

TABLES

ENCLOSURES (Bound Separately)

ENCLOSURE NO.

1. Isopach Map - Dilwyn Formation
2. Top Pember Mudstone Member
3. Isopach Map - Pember Mudstone Member
4. Top Sherbrook Group
5. Isopach Map - Sherbrook Group
6. To Belfast Mudstone Member
7. Isopach Map - Belfast Mudstone Member
8. Top Waarre Formation
9. Isopach Map - Waarre Formation
10. Top Otway Group

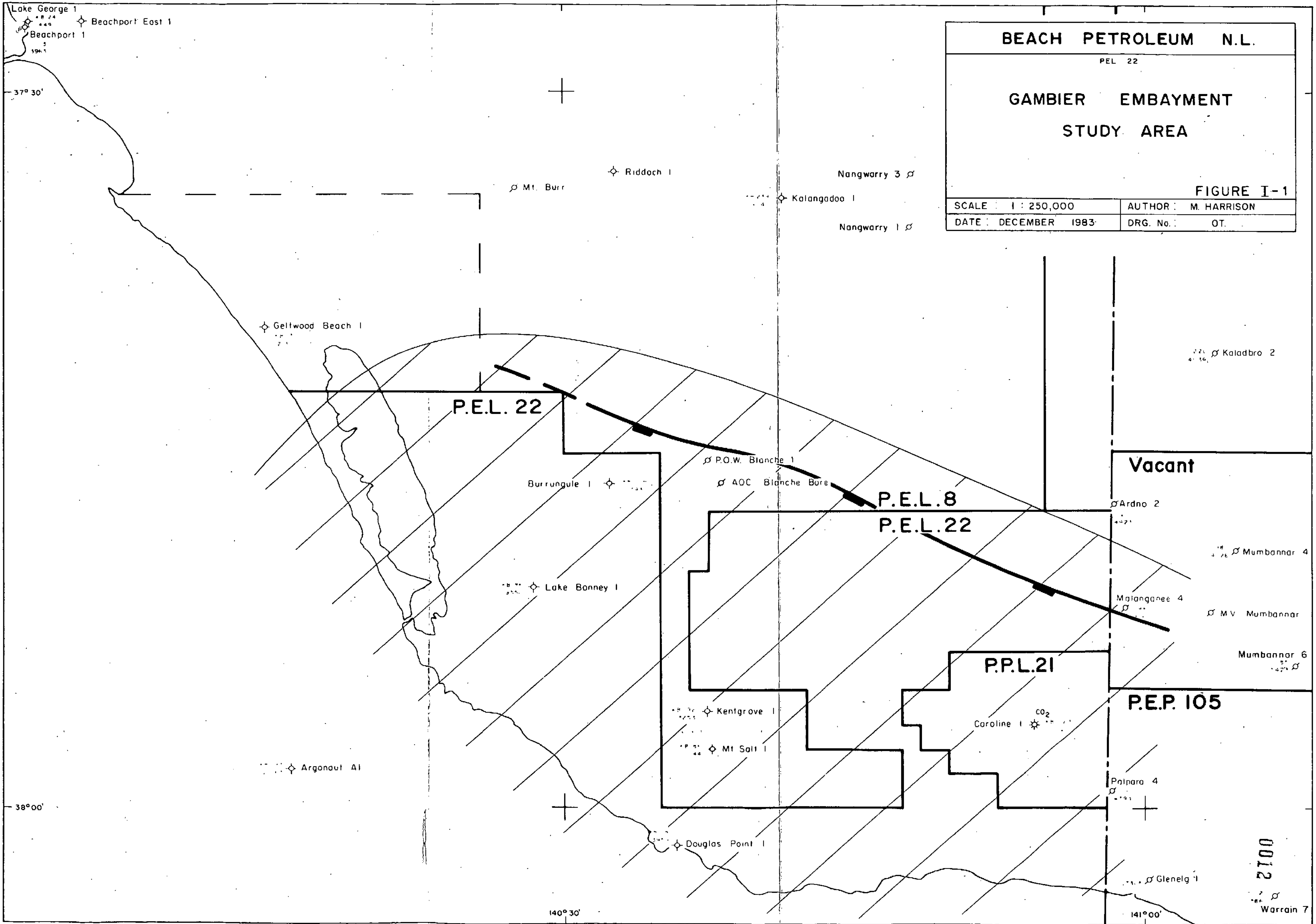
The preceeding enclosures were compiled from well data as listed in Table II-1 of this report.

11. Estimated Depth to the Top of the Zone of Significant Oil Generation (Assumed to be Ro = 0.7%).
12. Seismic Shotpoint Plan
13. Dilwyn Formation Correlation - Mt. Salt No. 1 to Kentgrove No. 1
14. Dilwyn Formation Correlation - Lake Bonney No. 1 to Douglas Point No. 1.
15. Lower Tertiary Sonic-Gamma Ray Correlation; Caroline No. 1 - Douglas Point No. 1 - Kentgrove No. 1- Lake Bonney No. 1 - Burrungule No. 1 - Kalangadoo No. 1.
16. Sherbrook Group Correlation: Argonaut No. 1 - Lake Bonney No. 1 - Burrungule No. 1 - Kalangadoo No. 1.
17. Sherbrook Group Correlation: Geltwood Beach No. 1 - Lake Bonney No. 1 - Mount Salt No. 1 - Caroline No. 1 - Malanganee No. 4.
18. Line TA, Tartwaup Seismic Survey (1973)
19. Line TQ, Tartwaup Seismic Survey (1973)
20. Interpretation of Line TC, Tartwaup Seismic Survey (1973)
21. Seismic Line UA82-31, Offshore Gambier Embayment.
22. 1973 Interpretation of the Tartwaup Seismic Survey; Structure at the "Base of Tertiary in Feet Below Sea Level".

I. INTRODUCTION

This report discusses the hydrocarbon potential of the Gambier Embayment of South Australia with particular reference to Petroleum Exploration Licence 22. The main study area is defined in Figure I-1.

The area selected for particular study contains prospective Upper Cretaceous, Sherbrook Group and Tertiary, Wangerrip Group sediments. It is not the intention of this report to discuss in detail the prospectivity of Lower Cretaceous Otway Group, in particular the principal play of that sequence, the Pretty Hill Sandstone play. Data assembled for the "Exploration Guidelines and the Prospects for Locating Hydrocarbons, Tyrendarra Embayment, A. Tabassi, 1984", was used to provide continuity with the Victorian Sector of the Otway Basin.



BEACH PETROLEUM N.L.
PEL 22
GAMBIER EMBAYMENT
STUDY AREA
FIGURE I-1
SCALE : 1 : 250,000
AUTHOR : M. HARRISON
DATE : DECEMBER 1983
DRG. No. : OT.
Lake George 1
Beachport East 1
Beachport 1
37° 30'
Riddoch 1
Mt. Burr
Nangwarry 3
Kalangadoo 1
Nangwarry 1
Gellwood Beach 1
Kaladbro 2
P.E.L. 22
P.O.W. Blanche 1
AOC Blanche Bore
Burrungule 1
P.E.L. 8
P.E.L. 22
Vacant
Ardno 2
Mumbannar 4
Lake Bonney 1
Malanganee 4
MV Mumbannar
Mumbannar 6
P.P.L. 21
P.E.P. 105
Kentgrove 1
CO_2
Caroline 1
Mt Salt 1
Argonaut A1
Palpara 4
38°00'
Douglas Point 1
Glenelg 1
Warrain 7
140°30'
141°00'
0012

0013

II. METHOD

The study concentrated initially on the correlation of lithostratigraphic units. (Note Table II-1.) A number of isopach and structure maps were prepared using this correlation. These are included as Enclosures 1 to 10.

A study of the likely source rock maturity pattern was made, and it suggested the Otway Group is likely to be mature for oil generation over the entire study area. Probable source rocks were then identified within the Otway Group.

The structure, seal and reservoir relationships in the area were considered; a high potential for hydrocarbon entrapment was recognised in the Lower Tertiary section and in the Waarre Formation.

.../4

TABLE II-1

WELL NAMES	ARGONAUT - 1			BURRUNGULE - 1			CAROLINE - 1		
ELEVATION: KB	93'/28.4m			104'/31.7m			123'/37.5m		
ELEVATION: GL				90'/27.4m			107'/32.6		
TOTAL DEPTH	12163'/3707.3m			7930'/2417.1m			11061'/3371.4m		
	TOP (KB) FT/M	TOP (MSL) FT/M	THICKNESS FT/m	TOP (KB) FT/M	TOP (MSL) FT/M	THICKNESS FT/M	TOP (KB) FT/M	TOP (MSL) FT/M	THICKNESS FT/M
NIRRANDA GROUP – NARRAWATURK FORMATION	1020/310.9	927/282.6	50/15.2	N.D.			N.D.		
NIRRANDA GROUP – MEPUNGA FORMATION	1070/326.1	977/297.8	92/28.0	N.D.			N.D.		
WANGERRIP GROUP – DILWYN FORMATION – BURRUNGULE MEMBER	1162/354.2	1069/325.8		390/118.9	286/87.2	227/69.2	660/201.2	537/163.7	359/109.4
WANGERRIP GROUP – DILWYN FORMATION – MIDDLE MEMBER – UNIT 4				617/188.1	513/156.4	136/41.5	1019/310.6	896/273.1	301/91.7
WANGERRIP GROUP – DILWYN FORMATION – MIDDLE MEMBER – UNIT 3		UNDIFFERENTIATED		753/229.5	649/197.8	245/74.7	1320/402.3	1197/364.9	255/77.7
WANGERRIP GROUP – DILWYN FORMATION – MIDDLE MEMBER – UNIT 2			1168/356.0	998/304.2	894/272.5	246/75.0	1575/480.1	1452/442.6	660/201.2
WANGERRIP GROUP – DILWYN FORMATION – MIDDLE MEMBER – UNIT 1				1244/379.2	1140/347.5	406/123.8	2235/681.2	2112/643.7	265/80.8
WANGERRIP GROUP – DILWYN FORMATION – PEMBER MUDSTONE MEMBER				1650/502.9	1546/471.2	408/124.4	2500/762.0	2377/724.5	540/164.6
SHERBROOK GROUP – PEBBLE POINT FORMATION	2330/710.2	2237/681.8	35/10.7	2058/627.3	1954/595.6	80/24.4	3040/926.6	2917/889.1	85/25.9
SHERBROOK GROUP – PAARATTE FORMATION – UNIT 3	2365/720.9	2272/692.5	3410/1039.4	2138/651.7	2034/620.0	611/186.2	3125/952.5	3002/915.0	705/214.9
SHERBROOK GROUP – PAARATTE FORMATION – UNIT 2	5775/1760.2	5682/1731.6	1827/556.9	2749/837.9	2645/806.2	1784/543.8	3830/1167.4	3707/1129.9	1875/571.5
SHERBROOK GROUP – PAARATTE FORMATION – UNIT 1	7602/7317.1	7509/2288.8	2448/746.2	4533/1381.7	4429/1350.0	1731/527.6	5705/1738.9	5582/1701.4	1365/416.1
SHERBROOK GROUP – PAARATTE FORMATION – BELFAST MUDSTONE MEMBER	10050/3063.3	9957/3034.9	1580/481.6	6264/1909.3	6160/1877.6	686/209.1	7070/2154.9	6947/2117.5	1010/308.0
SHERBROOK GROUP – FLAXMANS FORMATION	11630/3544.8	11537/3516.5	305/93.0	6950/2118.4	6846/2086.7	134/40.8	8080/2462.8	7957/2425.3	98/29.9
SHERBROOK GROUP – WAARRE FORMATION	11935/3637.8	11842/3609.5	PLUS 228/69.5	7084/2159.2	6980/2127.5	581/177.1	8178/2492.7	8055/2455.2	1322/403.0
OTWAY GROUP				7665/2336.3	7561/2304.6	PLUS 265/80.8	9500/2895.6	9377/2859.1	PLUS 1561/475.8

TABLE II-1

WELL NAMES		DOUGLAS POINT - 1			GELTWOOD BEACH - 1			KALANGADOO - 1		
ELEVATION: KB		18'/5.5m			30'/9.1m			239'/72.9m		
ELEVATION: GL		9.5'/2.9m			15'/4.6m			228'/69.5m		
TOTAL DEPTH		3959'/1206.7m			12300'/3749.1m			9040'/2755.0m		
		TOP (KB) FT/M	TOP (MSL) FT/M	THICKNESS FT/m	TOP (KB) FT/M	TOP (MSL) FT/M	THICKNESS FT/M	TOP (KB) FT/M	TOP (MSL) FT/M	THICKNESS FT/M
NIRRANDA GROUP	NARRAWATURK FORMATION	952/290.2	934/284.7	60/18.3	N.D.			N.D.		
NIRRANDA GROUP	MEPUNGA FORMATION	1012/308.5	994/303.0	51/15.5	N.D.			N.D.		
WANGERRIP GROUP – DILWYN FORMATION	BURRUNGULE MEMBER	1063/324.0	1045/318.5	354/107.9	945/288.0	915/278.9	210/64.0	316/96.3	77/23.5	↑
WANGERRIP GROUP – DILWYN FORMATION – MIDDLE MEMBER	UNIT 4	1417/431.9	1399/426.4	267/81.4	1155/352.0 ↓	1125/342.9	↑	UNDIFFERENTIATED		734/223.7
WANGERRIP GROUP – DILWYN FORMATION – MIDDLE MEMBER	UNIT 3	1684/513.3	1666/507.8	256/78.0			255/77.7	↓		↓
WANGERRIP GROUP – DILWYN FORMATION – MIDDLE MEMBER	UNIT 2	1940/591.3	1922/585.8	392/119.5	UNDIFFERENTIATED			1050/320.0	811/247.2	333/101.5
WANGERRIP GROUP – DILWYN FORMATION – MIDDLE MEMBER	UNIT 1	2332/710.8	2314/705.3	228/69.5	↓		↓	1383/421.5	1144/348.7	197/60.1
WANGERRIP GROUP – DILWYN FORMATION	PEMBER MUDSTONE MEMBER	2560/780.3	2542/774.8	713/217.3	1410/429.8	1380/420.6	400/121.9	1580/481.6	1341/408.7	380/115.8
SHERBROOK GROUP	PEBBLE POINT FORMATION	3273/997.6	3255/992.1	55/16,18	1810/551.7	1780/542.6	90/27.4	ABSENT		
SHERBROOK GROUP – PAARATTE FORMATION	UNIT 3	3328/1014.4	3310/1008.9	PLUS 631/192.3	1900/579.1	1870/570.0	465/141.7	1960/597.4	1721/524.6	548/167.0
SHERBROOK GROUP – PAARATTE FORMATION	UNIT 2				2365/720.9	2335/711.7	955/291.1	ABSENT		
SHERBROOK GROUP – PAARATTE FORMATION	UNIT 1				3320/1011.9	3290/1002.8	410/125.0	ABSENT		
SHERBROOK GROUP – PAARATTE FORMATION	BELFAST MUDSTONE MEMBER				3730/1136.9	3700/1127.8	142/43.3	2508/764.4	2269/691.6	52/15.9 ?
SHERBROOK GROUP	FLAXMANS FORMATION				3872/1180.2 ↓	3842/1171.0	↑ 113/34.4	ABSENT		
SHERBROOK GROUP	WAARRE FORMATION				UNDIFFERENTIATED		↓	ABSENT		
OTWAY GROUP					3985/1214.6	3955/1205.5	PLUS 8315/2534.4	2560/780	2321/707.4	4205/1281.7

TABLE II-1

WELL NAMES		KENTGROVE - 1			LAKE BONNEY 1			MALANGANEE 4		
ELEVATION: KB		91'/28.4 m			86'/26.2 m					
ELEVATION: GL		83'/25.3 m			70'/21.3 m			187'/57m		
TOTAL DEPTH		3252'/991.5m			9550'/2910.9			5641'/1719.3m		
		TOP (KB) FT/M	TOP (MSL) FT/M	THICKNESS FT/m	TOP (KB) FT/M	TOP (MSL) FT/M	THICKNESS FT/M	TOP (KB) FT/M	TOP (MSL) FT/M	THICKNESS FT/M
NIRRANDA GROUP	NARRAWATURK FORMATION	455/138.7	362/110.3	80/24.4	N.P.			N.D.		
NIRRANDA GROUP	MEPUNGA FORMATION	535/163.1	442/134.7	10/3.1	780/237.7	694/211.5	125/38.1	N.D.		
WANGERRIP GROUP – DILWYN FORMATION	BURRUNGULE MEMBER	545/166.1	452/132.8	278/84.7	905/275.8	819/249.6	300/91.4	748/228.0	561/171.0	183/55.8
WANGERRIP GROUP – DILWYN FORMATION – MIDDLE MEMBER	UNIT 4	823/250.9	730/222.5	176/53.6	1205/367.3	1119/341.1	188/57.3	931/283.8	744/226.8	266/81.1
WANGERRIP GROUP – DILWYN FORMATION – MIDDLE MEMBER	UNIT 3	999/304.5	906/276.2	321/97.8	1393/424.6	1307/398.4	307/93.6	1197/364.9	1010/307.9	245/74.77
WANGERRIP GROUP – DILWYN FORMATION – MIDDLE MEMBER	UNIT 2	1320/402.3	1227/374.0	490/149.4	1700/518.2	1614/492.0	180/54.9	1442/439.5	1255/382.5	478/145.7
WANGERRIP GROUP – DILWYN FORMATION – MIDDLE MEMBER	UNIT 1	1810/551.7	1717/523.3	176/53.6	1880/573.0	1794/546.8	265/80.8	1920/585.2	1733/528.2	247/75.3
WANGERRIP GROUP – DILWYN FORMATION	PEMBER MUDSTONE MEMBER	1986/605.3	1893/577.0	846/257.9	2145/653.8	2059/627.6	439/133.8	2167/660.5	1980/603.3	628/191.4
SHERBROOK GROUP	PEBBLE POINT FORMATION	2832/863.2	2739/834.9	59/18.0	2584/787.6	2498/761.4	47/14.3	2795/851.9	2608/794.9	85/25.9
SHERBROOK GROUP – PAARATTE FORMATION	UNIT 3	2891/881.2	2798/852.8	PLUS 361/110.0	2631/801.9	2545/775.7	743/226.5	2880/877.8	2693/820.8	460/140.2
SHERBROOK GROUP – PAARATTE FORMATION	UNIT 2				3374/1028.4	3288/1002.2	1949/594.1	3340/1018.0	3153/961.0	1548/471.8
SHERBROOK GROUP – PAARATTE FORMATION	UNIT 1				5323/1622.5	5237/1596.2	2317/706.2	NULLAWARRE GREENSAND FACIES ?		
SHERBROOK GROUP – PAARATTE FORMATION	BELFAST MUDSTONE MEMBER				7640/2328.7	7554/2302.5	676/206.1	4888/1489.9	4701/1432.9	176/53.6
SHERBROOK GROUP	FLAXMANS FORMATION				8316/2534.7	8230/2508.5	157/47.9	5064/1543.5	4877/1486.5	32/9.8
SHERBROOK GROUP	WAARRE FORMATION				8473/2582.6	8387/2556.4	452/137.8	5096/1553.3	4909/1496.3	235/71.6
OTWAY GROUP					8925/2720.4	8839/2694.0	PLUS 711/216.7	5331/1624.9	5144/1569.9	PLUS 310/94.5

TABLE II-1

Group	Formation	Member	Unit	WELL NAMES: MOUNT SALT NO. 1								
ELEVATION: KB				86'/26.2m								
ELEVATION: GL				70'/21.3m								
TOTAL DEPTH				10044'/3061.4m								
				TOP (KB) FT/M	TOP (MSL) FT/M	THICKNESS FT/m	TOP (KB) FT/M	TOP (MSL) FT/M	THICKNESS FT/M	TOP (KB) FT/M	TOP (MSL) FT/M	THICKNESS FT/M
NIRRANDA GROUP	NARRAWATURK FORMATION			480/146.3	394/120.1	48/14.6						
NIRRANDA GROUP	MEPUNGA FORMATION			528/160.9	442/134.7	62/18.9						
WANGERRIP GROUP	DILWYN FORMATION	BURRUNGULE MEMBER		590/179.8	504/153.6	303/92.4						
WANGERRIP GROUP	DILWYN FORMATION	MIDDLE MEMBER	UNIT 4	893/272.2	807/246.0	195/59.4						
WANGERRIP GROUP	DILWYN FORMATION	MIDDLE MEMBER	UNIT 3	1088/331.6	1002/305.4	347/105.8						
WANGERRIP GROUP	DILWYN FORMATION	MIDDLE MEMBER	UNIT 2	1435/432.4	1349/411.2	518/157.9						
WANGERRIP GROUP	DILWYN FORMATION	MIDDLE MEMBER	UNIT 1	1953/595.3	1867/596.1	237/72.2						
WANGERRIP GROUP	DILWYN FORMATION	PEMBER MUDSTONE MEMBER		2190/667.5	2104/641.3	960/292.6						
SHERBROOK GROUP	PEBBLE POINT FORMATION			3150/960.1	3064/933.9	93/28.4						
SHERBROOK GROUP	PAARATTE FORMATION		UNIT 3	3243/988.5	3157/962.3	963/293.5						
SHERBROOK GROUP	PAARATTE FORMATION		UNIT 2	4206/1282.0	4120/1255.8	3249/990.3						
SHERBROOK GROUP	PAARATTE FORMATION		UNIT 1	7455/2272.3	7369/2246.1	2255/687.3						
SHERBROOK GROUP	PAARATTE FORMATION	BELFAST MUDSTONE MEMBER		9710/2959.6	9624/2933.4	PLUS 334/101.8						
SHERBROOK GROUP	FLAXMANS FORMATION											
SHERBROOK GROUP	WAARRE FORMATION											
OTWAY GROUP												

III. LIMITATIONS OF THE PROJECT

The main limitation of the project is that the Gambier Embayment of South Australia is very sparsely explored. Drilling density of post-1960 exploration wells is only one well per 800 square kilometres. A few government water and stratigraphic wells provide further limited control of the shallow Tertiary section only.

To the north the modern exploration phase commenced in 1961 with the drilling of Penola No. 1. Seventeen exploration wells were drilled in this northern area to 1973. (Note Figure III-1.) The principal target was the Lower Cretaceous Pretty Hill Sandstone, a thickly bedded clean quartzose sandstone. Since 1973 only one exploration well has been drilled in the northern area; Banyula No. 1 drilled by Aquitaine in 1982.

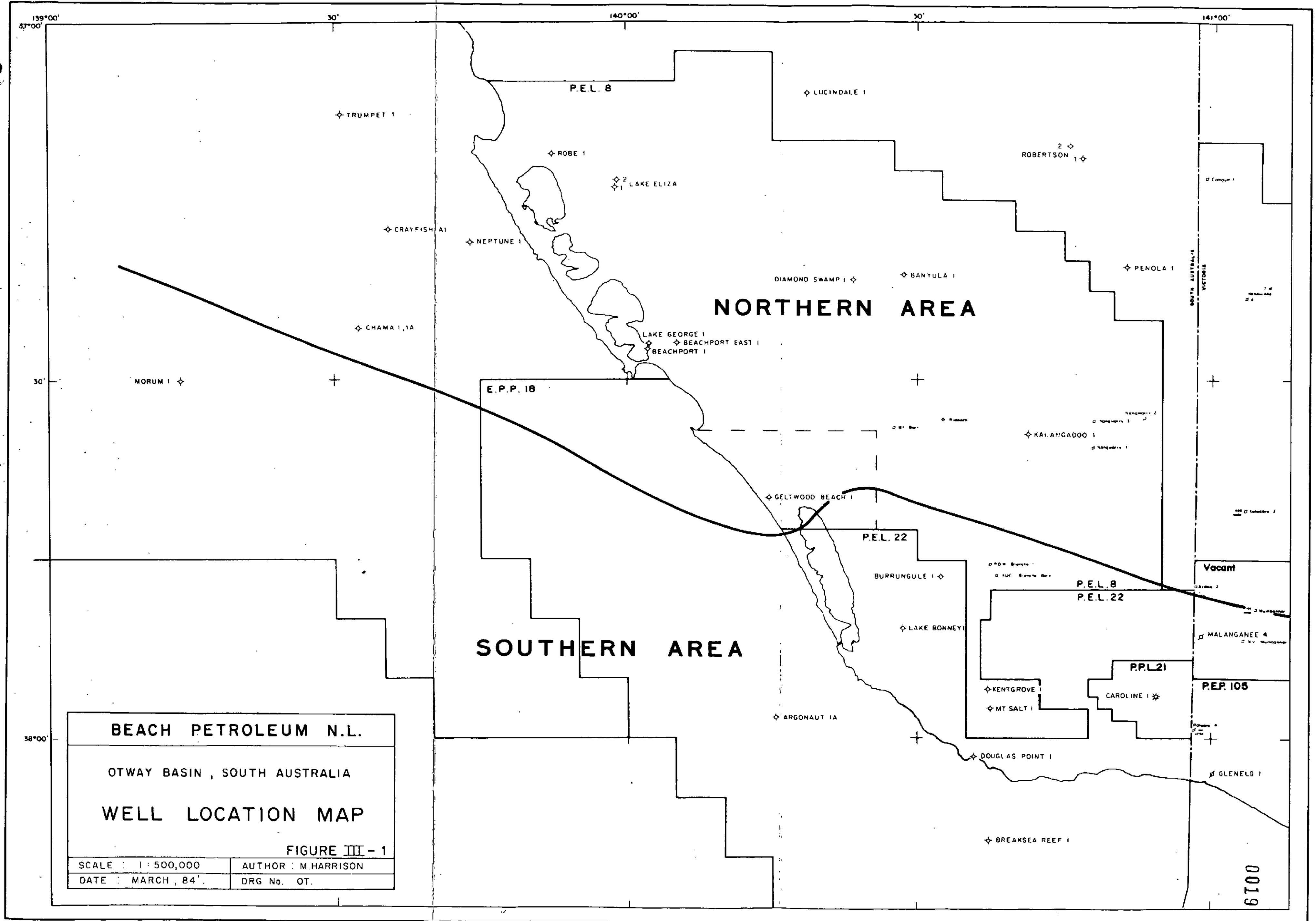
In the south, the main study area of this permit, significant late Cretaceous and Tertiary deposition occurred. Through the period 1962 to 1975 six exploration wells were drilled. Four of these wells were Upper Cretaceous/Tertiary tests and two wells had Lower Tertiary/Top Upper Cretaceous objectives.

Esso Australia Ltd. explored the offshore area where they drilled four wells in the northern area and two wells to the south (Moram-1 and Argonaut-1) through the period 1967 to 1975.

Onshore seismic control is very limited. (Note Enclosure No. 12, Seismic Base Map.) Only four prospects drilled in the northern area had moderate seismic control. All prospects drilled in the south had nil to very poor seismic control.

The Gambier Embayment is structurally complex relating to the rifting between and separation of the Australian and Antarctic continental plates. Thick Late Cretaceous fluvio-deltaic deposition occurred in the south.

With the limited subsurface control and complex geology the report seeks to isolate specific areas for more intensive exploration.



BEACH PETROLEUM N.L.

OTWAY BASIN, SOUTH AUSTRALIA

WELL LOCATION MAP

FIGURE III - 1

SCALE : 1:500,000	AUTHOR : M.HARRISON
DATE : MARCH, 84'.	DRG No. OT.

IV. CONCLUSIONS

The petroleum geology of the Gambier Embayment is complex with lack of success in the area to date attributed to lack of exploration. Exploration has however, reached a stage where the area can now be reasonably well understood. The prospectivity of the area studied in this report is rated as excellent for the following reasons.

1. Excellent seal - reservoir relationships in the Upper Cretaceous Sherbrook Group and Tertiary Wangerrip Group.

2. Excellent structure and structural timing condusive to hydrocarbon entrapment.

3. Mature oil prone source rocks occur at depth within the Lower Cretaceous Otway Group, particularly the Eumeralla Formation and the lower portion of the Crayfish Formation. Faulting is condusive to vertical migration into shallower objective reservoirs.

4. Definition of numerous prospects can be expected following recording of detailed modern seismic.

The major problems in the study area are:-

1. Lack of quality seismic
2. The occurrence of carbon dioxide; this appears to be a major problem in the south east of the study area.

V. RECOMMENDATIONS - P.E.L. 22

A. It is currently planned to record a regional/experimental seismic line in early 1984 (Note Figure V-1).

- extensive experimentation conducted prior to the recording of the 1970, Gambier Trough Seismic Survey and the 1973, Tartwaup Seismic Survey should be assessed prior to the recording of this 1984 experimental line.
- after recording of this line the 1973, Tartwaup Seismic Survey data should be reinterpreted with the objective of laying out a more detailed seismic grid. Reprocessing of Tartwaup Seismic Survey line TA is currently in progress and dependant on the results, further reprocessing should be contemplated.

B. The prospectivity of P.E.L. 22 is rated as excellent. The area warrants a detailed seismic program due to its complex structuring. Figure V-2 illustrates a recommended seismic program which is discussed in more detail in the section XIV titled "Exploration Objectives".

The program as drawn consists of 300 kilometres of seismic and should be recorded during the 1984/85 seismic season.

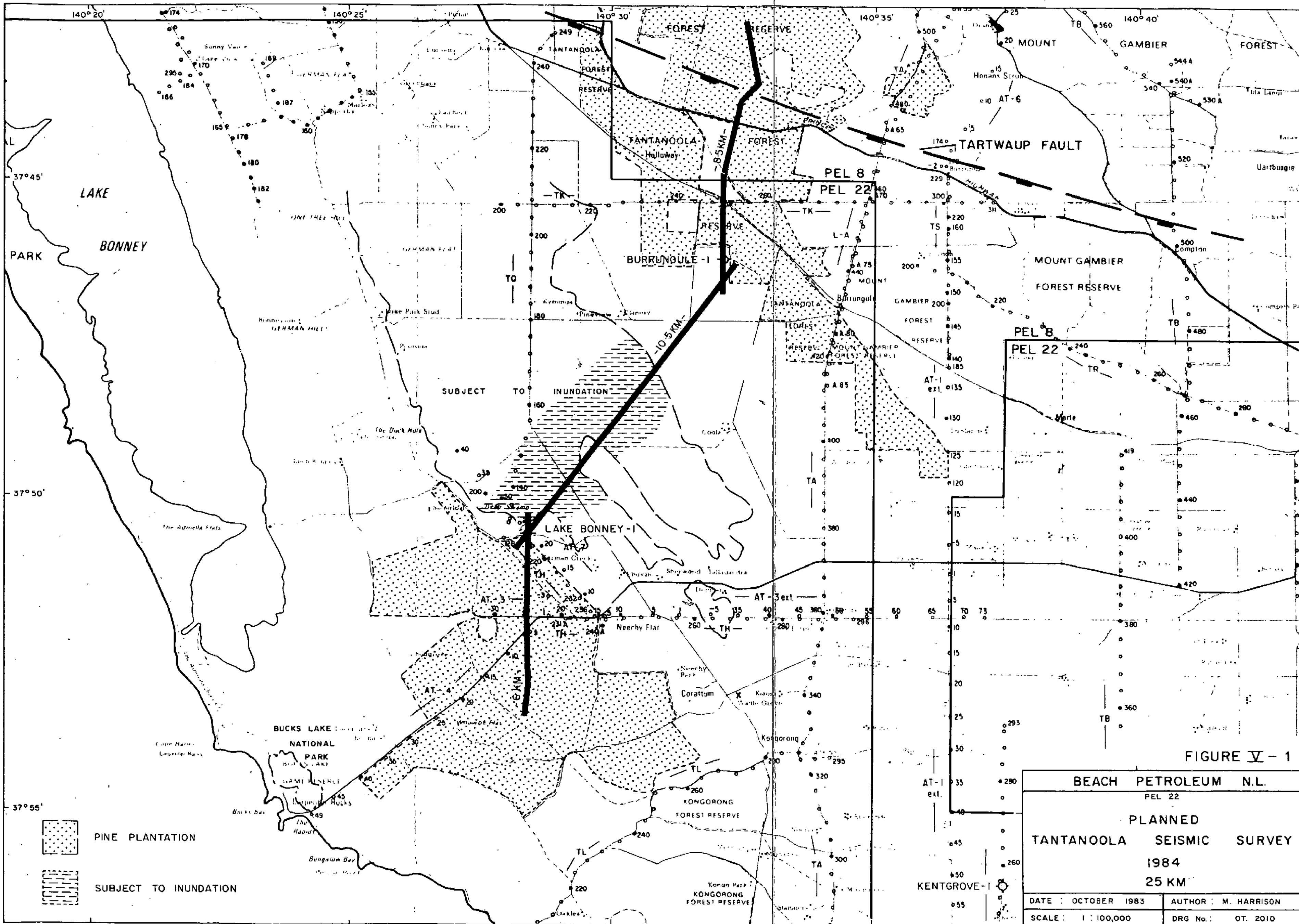
C. Dependant on seismic results an initial drilling program consisting of one deep well (2800 m) with Sherbrook Group targets and two shallow wells (1000 m) with Tertiary objectives should be contemplated. Follow up detail seismic will probably be required in late 1985 prior to drilling.

D. To further investigate Otway Group source rocks, particularly the promising intervals highlighted in the Geltwood Beach No. 1 and Kalangadoo No. 1 wells, as detailed in Section VIII of this report. Further source rock assessment should be made of the deeper section of Mount Salt No. 1.

V. RECOMMENDATIONS - P.E.L. 22 - Continued

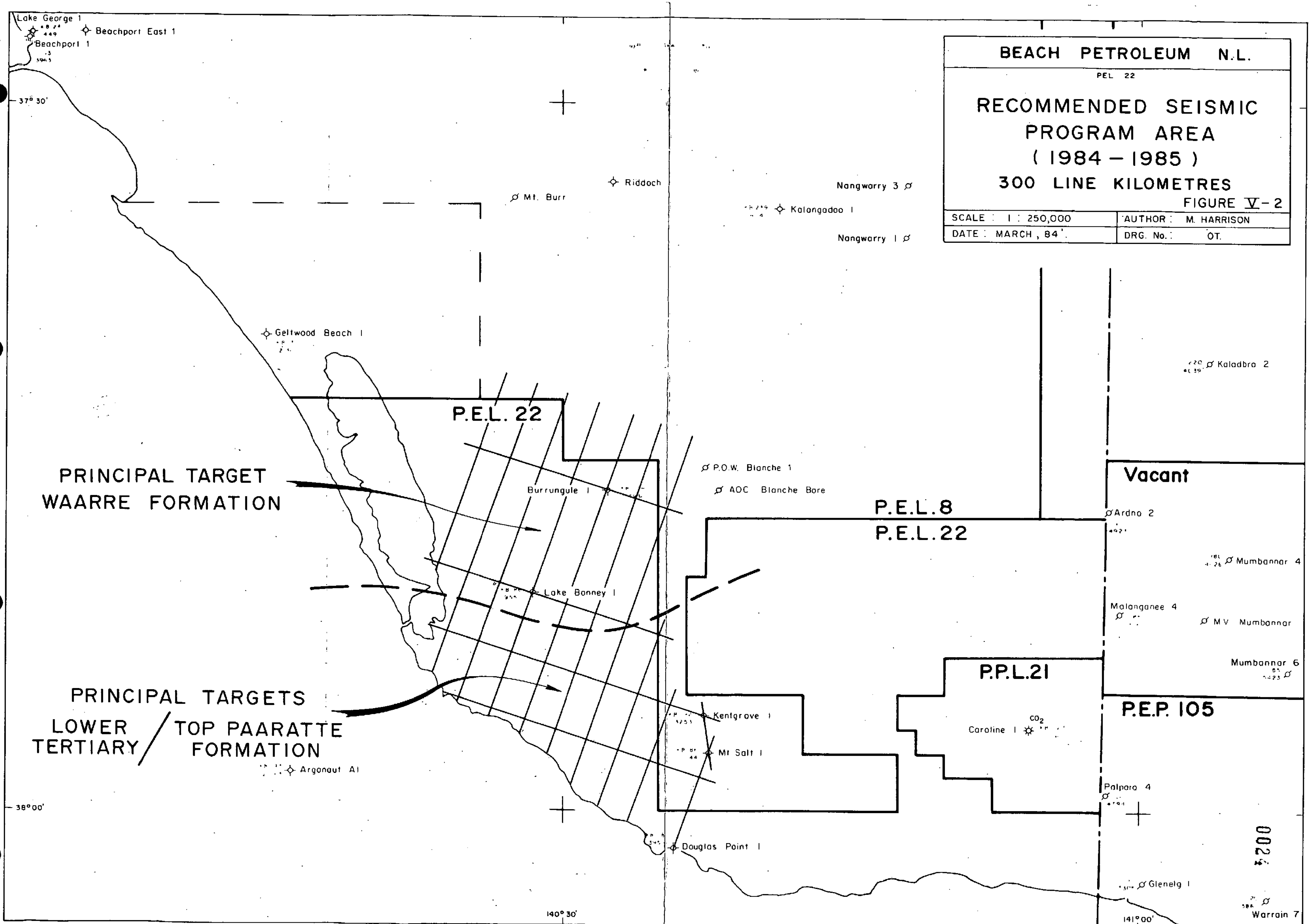
E. Landsat photography of the area should be acquired. An attempt should be made to pick recent/surface faulting which appears to have particular relevance to CO_2 occurrence.

F. Pebble Point facies variation should be studied in more detail integrating well and outcrop information from the Victorian sector of the Otway Basin adjacent to P.E.L. 22.



140° 20'
140° 25'
140° 30'
140° 35'
140° 40'
37° 45'
37° 50'
37° 55'
LAKE
BONNEY
PARK
FOREST RESERVE
TANTANOOLA FOREST RESERVE
TANTANOOLA
FOREST
MOUNT GAMBIER FOREST
TARTWAUP FAULT
PEL 8
PEL 22
BURRUNGULE-1
MOUNT GAMBIER
FOREST RESERVE
8.5 KM
10.5 KM
6 KM
SUBJECT TO INUNDATION
LAKE BONNEY-1
AT-6
AT-1 ext.
AT-3
AT-3 ext.
AT-4
AT-7
TK
TO
TS
TA
TB
TR
TH
TL
L-A
Neerchy Flat
Coratrum
Kongorong
KONGORONG FOREST RESERVE
BUCKS LAKE NATIONAL PARK
KENTGROVE-1
PINE PLANTATION
SUBJECT TO INUNDATION
FIGURE V - 1
BEACH PETROLEUM N.L.
PEL 22
PLANNED
TANTANOOLA SEISMIC SURVEY
1984
25 KM
DATE : OCTOBER 1983
AUTHOR : M. HARRISON
SCALE : 1 : 100,000
DRG No. : OT. 2010

0023


BEACH PETROLEUM N.L.
PEL 22
RECOMMENDED SEISMIC PROGRAM AREA (1984 – 1985) 300 LINE KILOMETRES
FIGURE V - 2
SCALE : 1 : 250,000
AUTHOR : M. HARRISON
DATE : MARCH , 84
DRG. No. : OT.
PRINCIPAL TARGET WAARRE FORMATION
PRINCIPAL TARGETS
LOWER TERTIARY / TOP PAARATTE FORMATION
P.E.L. 22
P.E.L. 8
P.E.L. 22
P.P.L. 21
P.E.P. 105
Vacant
Lake George 1
Beachport East 1
Beachport 1
37° 30'
38° 00'
140° 30'
141° 00'
Riddoch
Mt. Burr
Nangwarry 3
Kalangadoo 1
Nangwarry 1
Geltwood Beach 1
Kaladbro 2
P.O.W. Blanche 1
AOC Blanche Bore
Burrungule 1
Ardno 2
Mumbannar 4
Lake Bonney 1
Malanganee 4
MV Mumbannar
Mumbannar 6
Kentgrove 1
Caroline 1
CO_2
Mt Salt 1
Argonaut A1
Palpara 4
Douglas Point 1
Glenelg 1
Warrain 7
0024

VI. LITHOSTRATIGRAPHIC NOMENCLATURE

The lithostratigraphic nomenclature adopted by this report seeks to follow current useage and is biased towards nomenclature used in the Victorian Otway Basin where exploration and government study has been more active. Table VI-1 comments on the nomenclature used in this report and attempts to relate it to earlier terminology. The lithostratigraphic nomenclature used by the three principal Otway Basin studies undertaken in recent years, varies greatly. These studies are as follow:-

- "A Review of the Otway Basin", compiled M.A. Reynolds, 1971. B.M.R. Report No. 134.
- "The Otway Basin of Southeastern Australia" edited by H. Wopfner and J.G. Douglas, 1971. Special Bulletin No. 5. Geological Surveys of South Australia and Victoria.
- "Geology of Victoria", edited by J.G. Douglas and J.A. Ferguson, 1976. Geological Society of Australia, Special Publication No. 5.

As well control is limited this report resorts to simple correlative units which clearly, with better well control, will deserve more definition. For example at Argonaut No. 1 Unit 1 of the Paaratte sequence consists of a stacked sequence of cleaning upward sand bodies with shales at their bases which contrasts strongly with the Unit 1 lithology in the onshore wells such as at Burrungule No. 1. Another example would be the Paaratte sequence at Malanganee No. 4 which consists mainly of the Nullawarre Greensand Facies, which also has cleaning upward cycles. Significantly this well is located north of the Tartwaup Fault where significantly less Paaratte Formation has been deposited. It is not suggested that this sequence is necessarily genetically related to the Unit 1 in Argonaut No. 1. The correlation of the Otway Group between wells remains vague as does the correlation of subsurface occurrences with the Otway Group outcrops on the Merino High to the east in Victoria.

Stratigraphic tables which summarize the stratigraphy of the Tertiary sequence, Sherbrook Group and Otway Group are included as Tables VI-2, VI-3 and VI-4.

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TABLE VI-1

LITHOSTRATIGRAPHIC NOMENCLATURE

REPORT NOMENCLATURE	ALTERNATE NOMENCLATURE AND NOTES
HEYTESBURY GROUP	Glenelg Group
GAMBIER LIMESTONE	BMR Unit Bb; The Gambier Limestone is not divided further c.f. Port Campbell Embayment where the Heytesbury group is divided into the Port Campbell Limestone, Gellibrand Marl and Clifton Formations.
NIRRANDA GROUP	Included by the BMR in the Heytesbury Group; In general the group represents the transition from Paralic to Marine Transgressive sediments; variable facies and various terminology as follows: Buccleuch Group, BMR Units C & Bc; Compton Conglomerate (Part), Lacepede Formation; Kongorong Sandstone, Kingstone Greensand, Knight Formation, Browns Creek Group, Clifton Formation.
WANGERRIP GROUP	BMR Unit D., Knight Group.
DILWYN FORMATION	Dartmoor Formation, BMR Unit Db.
Burrungule Member	Knight Formation, Tartwaup Formation, BMR Unit Db, Hydrologists working in the Gambier Embayment restrict the use of this term to the top confining clay bed.
Middle Member	Informal unit used only in this report for descriptive purposes and divided into four correlative units.
Pember Mudstone	BMR Unit Db_2
PEBBLE POINT FORMATION	Bahallah Formation, BMR Unit Dd.

.../17

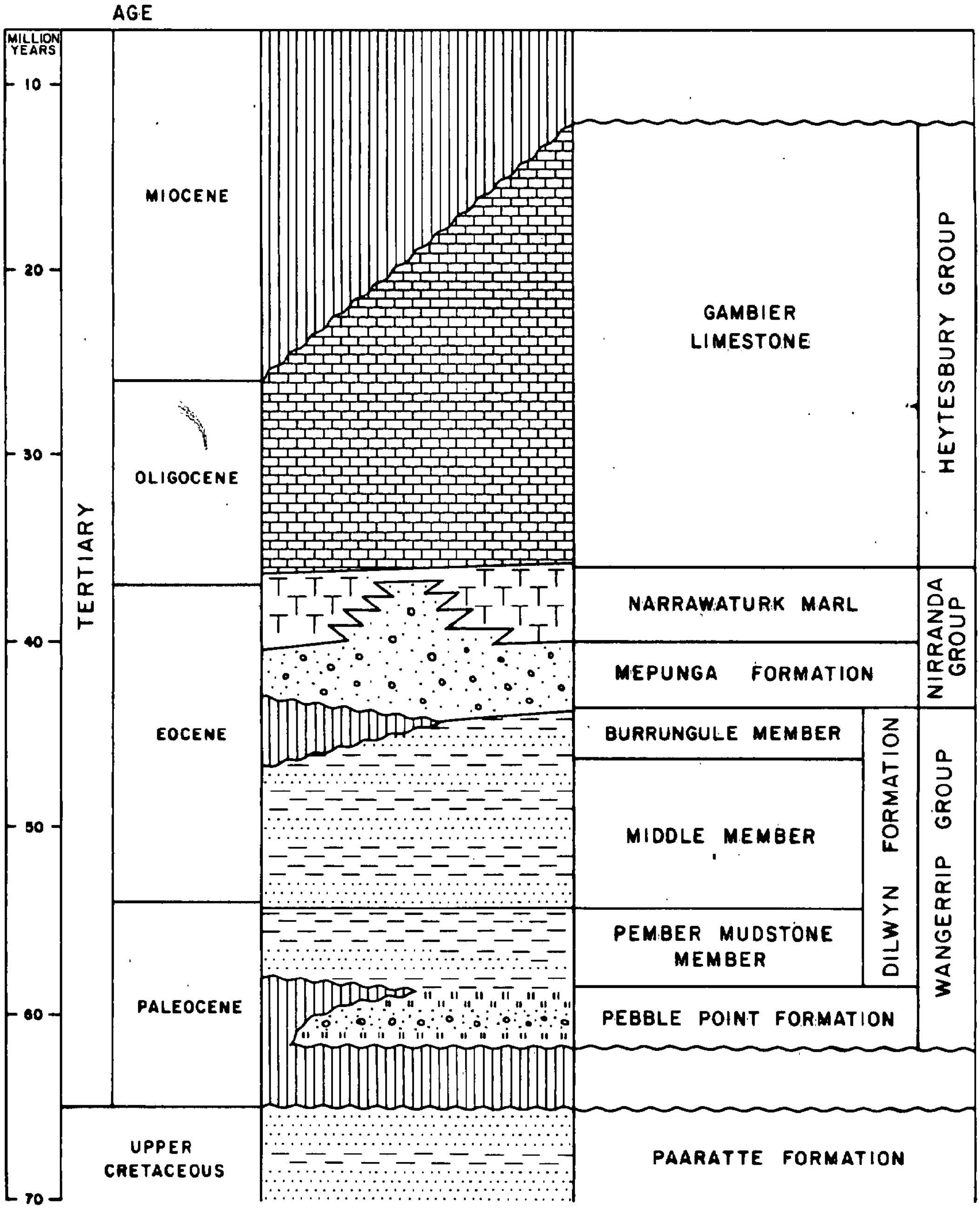
TABLE VI-1 - Continued

REPORT NOMENCLATURE	ALTERNATE NOMENCLATURE AND NOTES
SHERBROOK GROUP	Included within the Wangerrip Group by Glennie and others; BMR Unit G.
PAARATTE FORMATION	For descriptive purposes this formation has been divided into four numbered informal units in this report, including the Belfast Mudstone Member; BMR Units Gb, Gd, Gg and Gf.
Unit III	Curdies Formation, Timboon Sandstone Member of the Paaratte, BMR Unit Gb.
Unit II	Approximates the Macdonnel Member of the Paaratte Formation (Alliance Oil Development NL). Part of BMR Unit Gd.
Unit 1	Approximates the Caroline Member of the Paaratte Formation (Alliance Oil Development NL). Part of BMR Unit Gd.
Belfast Mudstone Member	BMR Unit Gf, The Mount Salt Formation of Esso and BMR (Unit Gg) is not recognised in this report.
WAARRE FORMATION	Included in the Sherbrook Group in this report, BMR units J and H, the Waarre Formation, This formation may require separate definition in the Gambier Embayment.
OTWAY GROUP	Merino Group, including the Runnymede Formation and Mocamboro Member are terms used in the past to describe Otway Group outcrops on the Merino Uplift and the Otway Group in earlier exploration wells.
EUMERALLA FORMATION	BMR Unit M
CRAYFISH FORMATION	A new term suggested by J. Gausden (1983) in his report to Australian Aquitaine (PEL.8). The term seeks to recognise that the porous Pretty Hill Sandstone is a local facies varient of the Geltwood Beach Member; Lower Otway Group.

.../18

TABLE VI - Continued

REPORT NOMENCLATURE	ALTERNATE NOMENCLATURE AND NOTES
OTWAY GROUP - Continued	
Geltwood Beach Member	BMR Unit P (Geltwood Beach Formation)
Pretty Hill Sandstone Member	BMR Unit R
CASTERTON FORMATION	BMR Unit T.

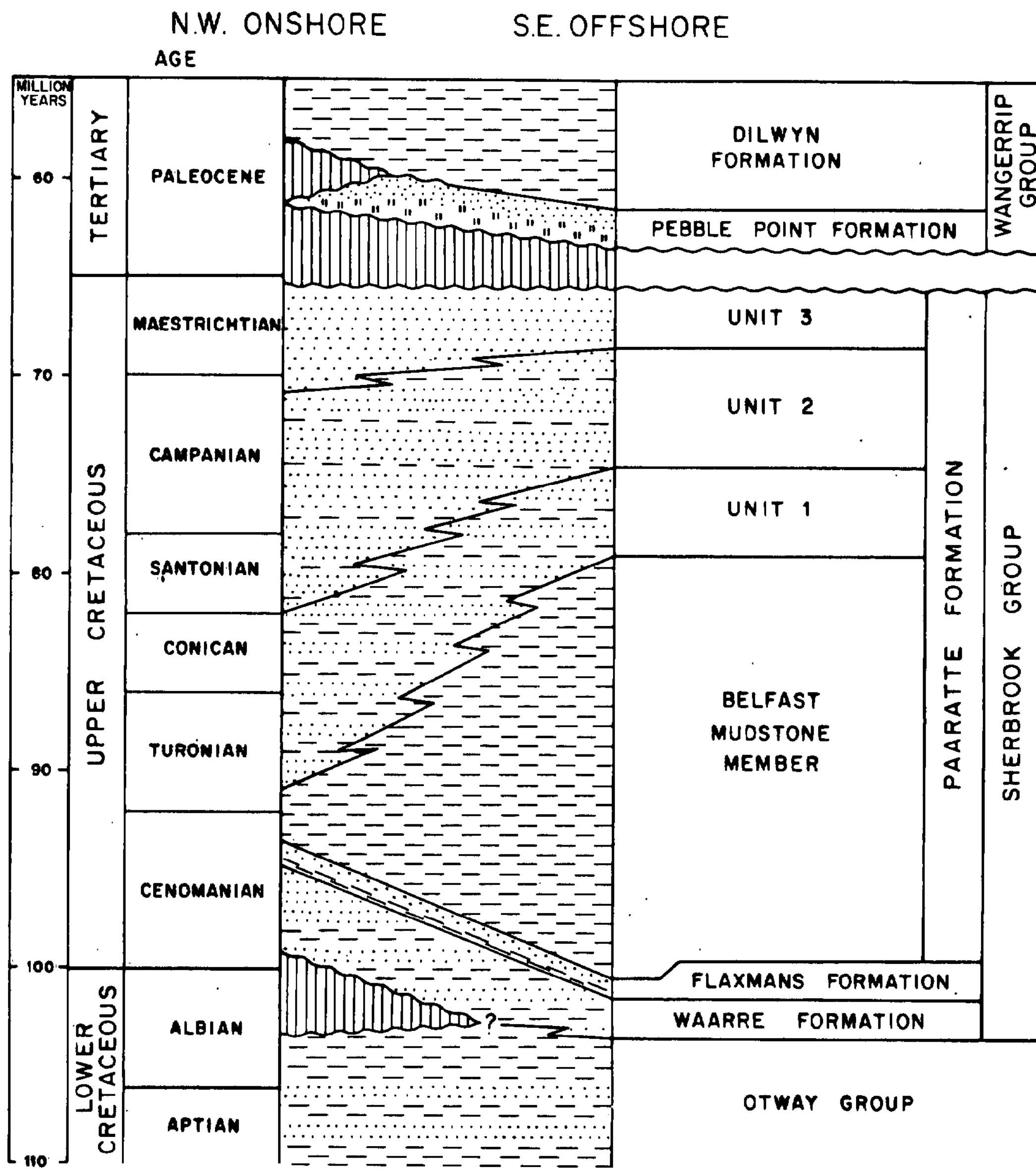


BEACH PETROLEUM N.L.

GAMBIER EMBAYMENT – SOUTH AUSTRALIA

TERTIARY STRATIGRAPHY

TABLE VI – 2

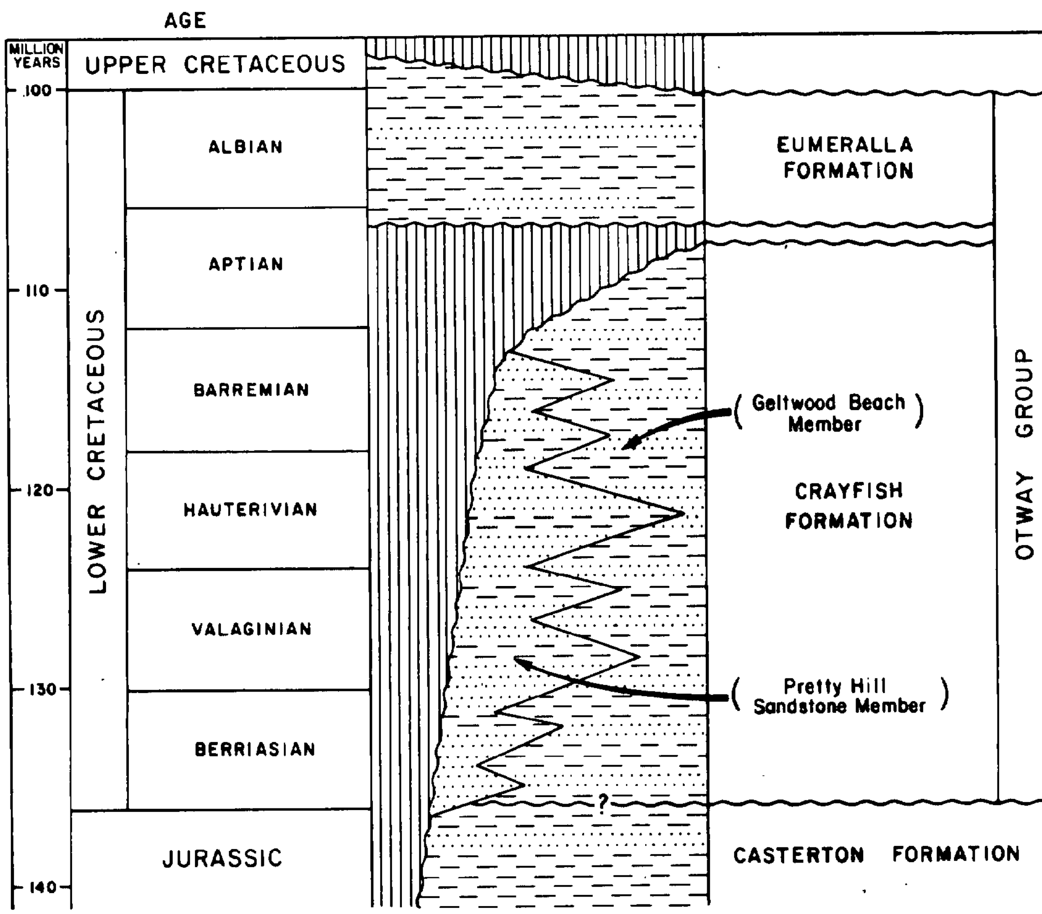


BEACH PETROLEUM N.L.

GAMBIER EMBAYMENT — SOUTH AUSTRALIA

SHERBROOK GROUP STRATIGRAPHY

TABLE VI – 3



BEACH PETROLEUM N.L.

GAMBIER EMBAYMENT — SOUTH AUSTRALIA

OTWAY GROUP STRATIGRAPHY

TABLE VI — 4

VII. STRUCTURE

The most important structural trend in the Gambier Embayment study area is the Burrungule Trend, an anticlinal trend on the downthrown side of the Tartwaup Fault. (Note Figure VII-1.) The Lake Bonney High Trend is an attractive structural trend which also warrants detailed study.

Both offer high potential for entrapment of hydrocarbons within the Tertiary Wangerrip Group and the Upper Cretaceous Sherbrook Group. In the deeper portion of the basin where Sherbrook Group targets become less attractive due to the depth of prospective horizons, structure of the lower portion of Wangerrip Group and at the Pebble Point Formation level is highly favourable for hydrocarbon entrapment.

Discussion of the regions structural history and structural elements follows.

Structural History

Initial rifting between the Australian and Antarctic continental plates commenced during the Jurassic period. By the Lower Cretaceous extensive rifting occurred between the two plates in general superimposing north east-southwest structural trends across the earlier Paleozoic north-south structural trends.

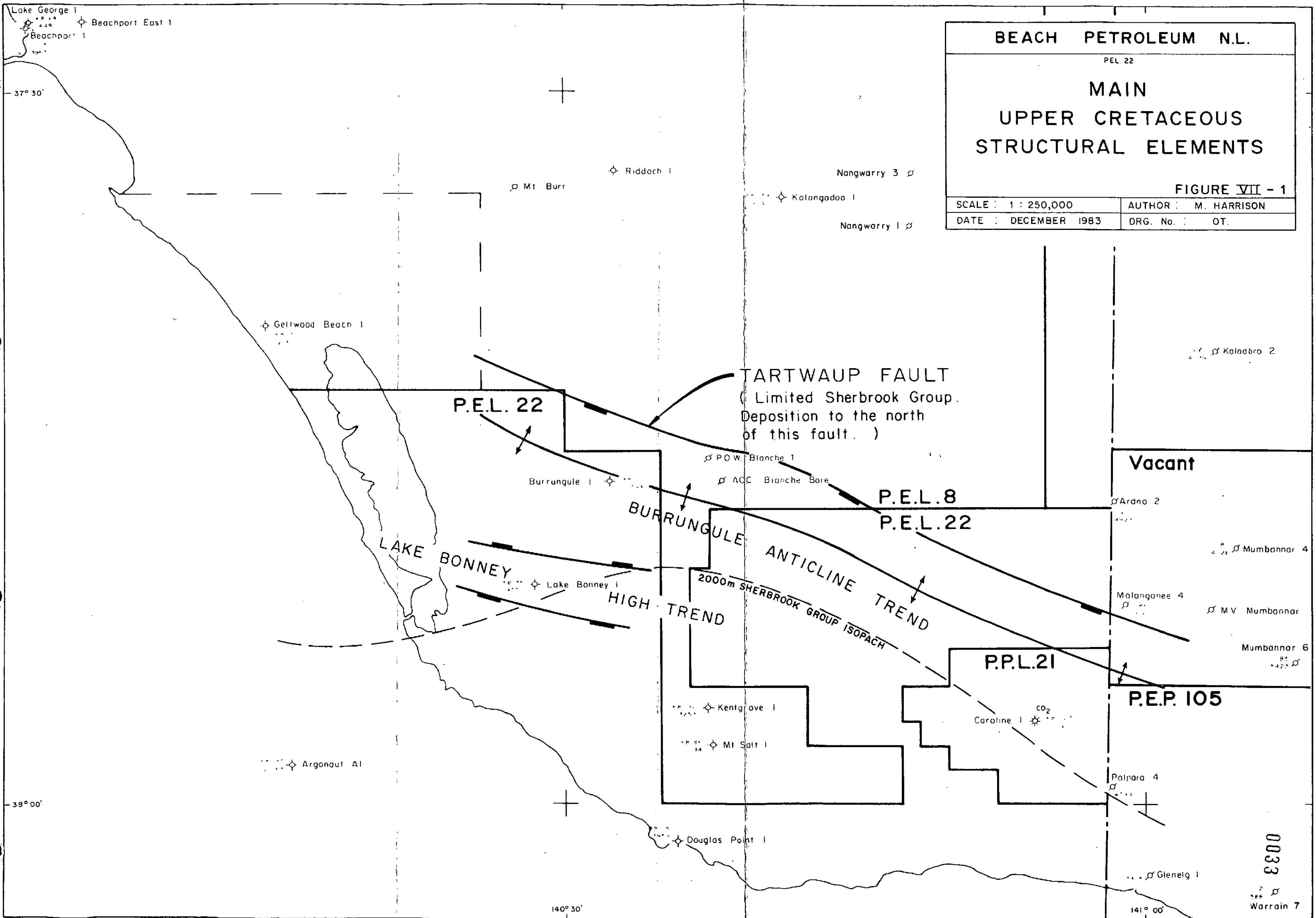
Three principal phases of rifting are recognised within the Gambier Embayment.

A. Jurassic-Lower Cretaceous Phase

The nature and extent of Jurassic sediments is not well known in the subsurface. It is practical to think of this initial rifting phase as being largely Lower Cretaceous when a thick section of fluvio-lacustrine sediments were deposited.

The Otway Group was deposited in an extensive basin. A series of grabens formed representing the initial phase of separation between the two continental plates. Volcanic derived sediments are common through this sequence.

.../23



BEACH PETROLEUM N.L.
PEL 22
MAIN
UPPER CRETACEOUS
STRUCTURAL ELEMENTS
FIGURE VII - 1
SCALE : 1 : 250,000
AUTHOR : M. HARRISON
DATE : DECEMBER 1983
DRG. No. : OT.
Lake George 1
Beachport East 1
Beachport 1
37° 30'
38° 00'
140° 30'
141° 00'
Riddoch 1
Mt Burr
Nangwarry 3
Kalangadoo 1
Nangwarry 1
Geltwood Beach 1
Kalabro 2
TARTWAUP FAULT
(Limited Sherbrook Group. Deposition to the north of this fault.)
P.E.L. 22
P.O.W. Blanche 1
Burrungule 1
AOC Blanche Bore
P.E.L. 8
P.E.L. 22
Vacant
Ardno 2
BURRUNGULE ANTICLINE TREND
LAKE BONNEY HIGH TREND
Lake Bonney 1
2000m SHERBROOK GROUP ISOPACH
Mumbannar 4
Malanganee 4
M.V. Mumbannar
Mumbannar 6
P.P.L. 21
P.E.P. 105
Kentgrove 1
Mt Salt 1
Caroline 1
CO_2
Argonaut A1
Palpara 4
Douglas Point 1
Glenelg 1
Warrain 7

0033

VII. STRUCTURE - Continued

Structural History - Continued

B. Upper Cretaceous Phase

After a period of extensive erosion at the end of the Lower Cretaceous, the Upper Cretaceous rifting phase commenced resulting in the deposition of the Sherbrook Group. This phase of rifting was less extensive than the earlier phase. Sherbrook Group onlap onto Otway Group sediments is evident both onshore and offshore. The phase commenced with a discrete period of marked tectonic activity. Right lateral wrenching may have been responsible for reactivation of the earlier palaeozoic north-south trends which became positive axes dividing the Otway Basin into several Upper Cretaceous Embayments: including the Gambier Embayment. No distinct post-rift unconformity has been recognised; deposition of the Sherbrook Group was apparently rapid and continuous during the rifting and consequent subsidence. In the Gambier Embayment this phase of rifting occurred in the main south of the major Tartwaup Fault. Structure immediately to the north of this fault is not well defined.

C. The Tertiary Phase

During the Tertiary, final separation of Australia and Antartica occurred. Generally Otway Basin tertiary faulting is less frequent than Upper Cretaceous and in general accommodates the collapse of the southern offshore margin of the basin. The Portland Trough is an exception to this style in that it appears to represent a rift in part independant of regional subsidence and southern basin margin collapse. This is important in that it creates structure in the basal tertiary sequence very condusive to the entrapment of hydrocarbons.

D. Recent Structuring

Faulting has continued to the present time although frequency and displacement of faults has diminished considerably. The Tartwaup Fault, Knight Fault and Nelson Faults can be mapped at the surface and appear to be associated with recent volcanism, in particular the volcanic vents at Mount Schank and Mount Gambier where ash has been dated as late as 1400 years before present.

.../25

VII. STRUCTURE - Continued

Major Lower Cretaceous Structural Elements

Figure VII-2 illustrates some of the major structural elements of the Lower Cretaceous. Figure VII-3 is an interpretation of the Lower Cretaceous graben development which underlies thick Upper Cretaceous Sherbrook Group sedimentation. This is important to consider as potential source rocks are likely to be deposited within these grabens. The major Lower Cretaceous features of the Gambier Embayment are discussed below:-

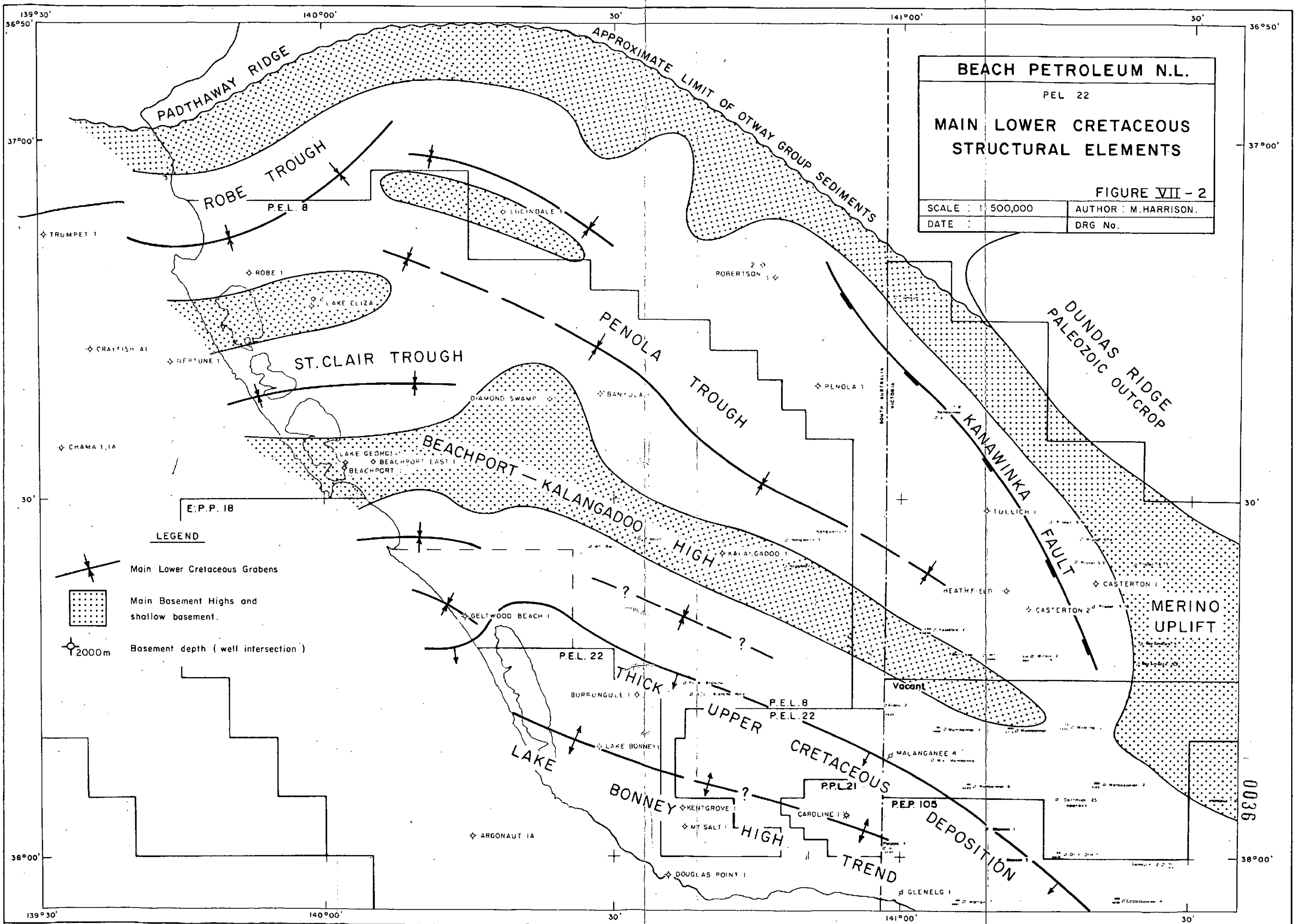
The Robe and Penola Troughs

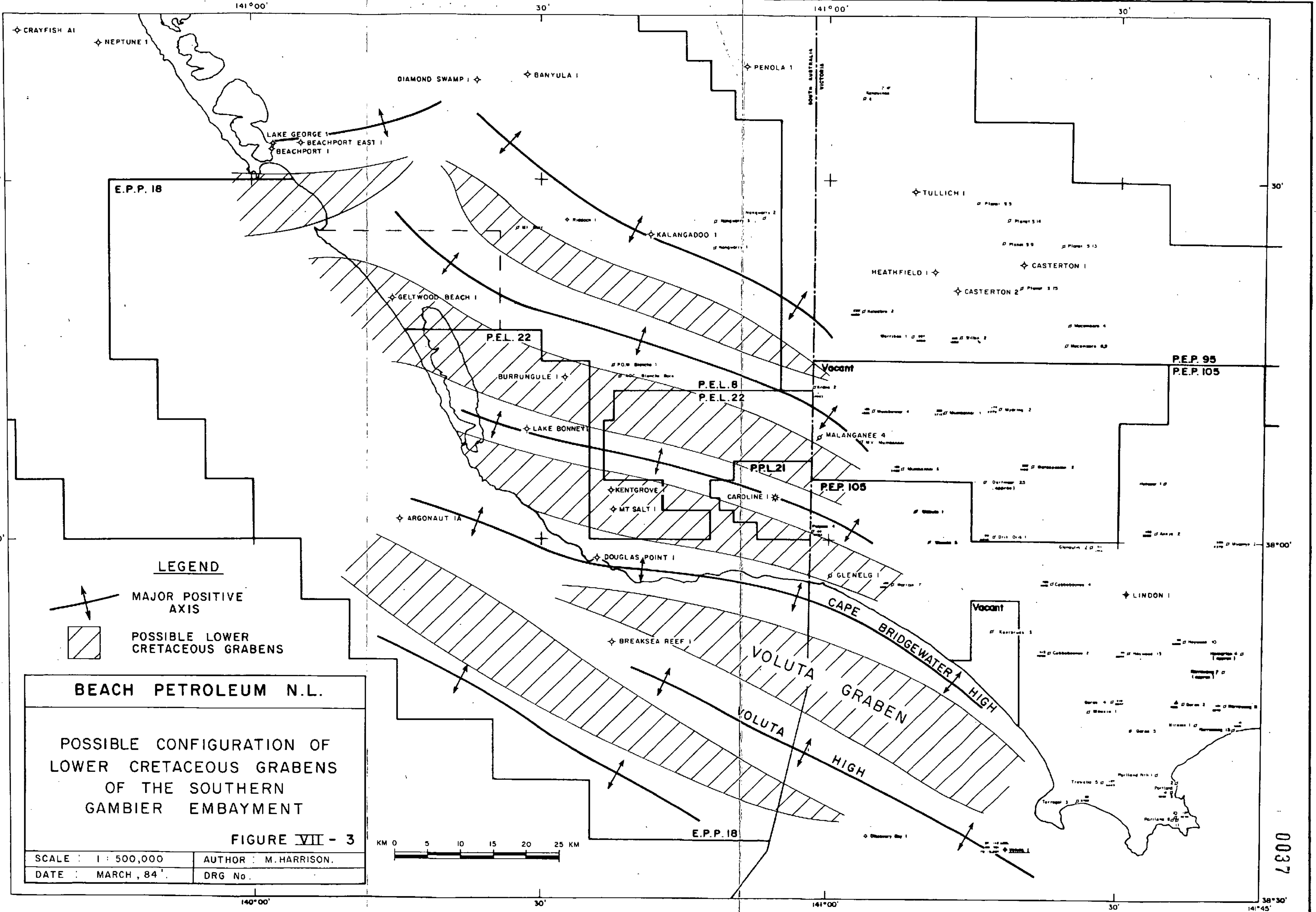
The Robe Trough directly abutts the Padthaway basement ridge which marks the northern boundary of the Gambier Embayment. The Penola Trough occurs further south of the margin and is best described as a half graben. Sediments north of the trough are relatively thin, generally less than 1500 m thick. Both troughs are filled with a thick Otway Group sequence, probably overlying Jurassic sediments and overlain by a thin Upper Cretaceous and Tertiary section. Both troughs appear to contain up to 5000 m of sediments in places. It is noteworthy that the axes of these troughs vary, the Penola Trough having a north west to south east trend while the Robe Trough has a west south west to east north east trend.

The Lake Eliza High

The Lake Eliza basement high bounds the southern flank of the Robe Trough. South of the high a further Lower Cretaceous trough has developed on trend with the Robe Trough. Lake Eliza No. 1 drilled on the high as mapped by the limited seismic intersected basement at 1378 m (MSL).

.../26


BEACH PETROLEUM N.L.
PEL 22
MAIN LOWER CRETACEOUS STRUCTURAL ELEMENTS
FIGURE VII - 2
SCALE : 1:500,000
AUTHOR : M.HARRISON.
DATE :
DRG No.
APPROXIMATE LIMIT OF OTWAY GROUP SEDIMENTS
PADTHAWAY RIDGE
ROBE TROUGH
P.E.L. 8
ST.CLAIR TROUGH
PENOLA TROUGH
BEACHPORT – KALANGADOO HIGH
KANAWINKA FAULT
DUNDAS RIDGE PALEOZOIC OUTCROP
MERINO UPLIFT
THICK UPPER CRETACEOUS DEPOSITION
LAKE BONNEY HIGH TREND
E.P.P. 18
P.E.L. 22
P.E.L. 8
P.E.L. 22
P.P.L. 21
P.E.P. 105
Vacant
SOUTH AUSTRALIA
VICTORIA
TRUMPET 1
ROBE 1
LAKE ELIZA
CRAYFISH A1
NEPTUNE 1
LUCINDALE 1
ROBERTSON 1
ROBERTSON 2
PENOLA 1
BANYULA
DIAMOND SWAMP
CHAMA 1,1A
LAKE GEORGE
BEACHPORT EAST 1
BEACHPORT
TULLICH 1
KALANGADOO 1
HEATHFIELD
CASTERTON 1
CASTERTON 2
GELTWOOD BEACH 1
BURRUNGULE 1
LAKE BONNEY 1
MALANGANEE 4
KENTGROVE
MT SALT 1
CAROLINE 1
ARGONAUT 1A
DOUGLAS POINT 1
GLENELG 1
LEGEND
Main Lower Cretaceous Grabens
Main Basement Highs and shallow basement.
2000m Basement depth (well intersection)
139°30'
140°00'
30'
141°00'
30'
36°50'
37°00'
30'
38°00'
0036



BEACH PETROLEUM N.L.

POSSIBLE CONFIGURATION OF LOWER CRETACEOUS GRABENS OF THE SOUTHERN GAMBIER EMBAYMENT

FIGURE VII - 3

SCALE : 1 : 500,000	AUTHOR : M. HARRISON.
DATE : MARCH, 84'.	DRG No.

0037

VII. STRUCTURE - Continued

Major Lower Cretaceous Structural Elements - Continued

The Beachport-Kalangadoo Basement High

As illustrated in Figure VII-2 this basement trend controls the southern flank of the Penola Trough and dog-legs to the east in a similar fashion to the change in trend observed between the Penola and Robe Troughs. The trend is significant in that the Upper Cretaceous Sherbrook Group thickens gradually off this high and the general shape of the trend has to a degree, been maintained by the thick Sherbrook Group deposition to the south.

The Lake Bonney High

This now deep-seated basement high appears to have been much more significant during Lower Cretaceous deposition than in present times as the presumed Lower Cretaceous graben adjacent to this trend is now deeply buried below a thick Upper Cretaceous and Tertiary pile. The trend shows up clearly on gravity and has exerted some control on Upper Cretaceous rifting. It seems possible that the Caroline gravity anomaly is on trend with the Lake Bonney High, with a thick Upper Cretaceous and Tertiary downwarp intervening. (Note Figure VII-4.)

Other Basement Highs

It appears that other now deep seated Lower Cretaceous horsts and corresponding intervening grabens occur along the coast on trend with the named Cape Bridgewater High of Victoria and the Voluta High further offshore as suggested by Figure VII-3.

Major Upper Cretaceous Structural Elements

The Tartwaup Fault

This fault is the major controlling feature of Upper Cretaceous sedimentation. It is a major growth fault and rollover into the fault is evident. It is suspected that Cretaceous sedimentation

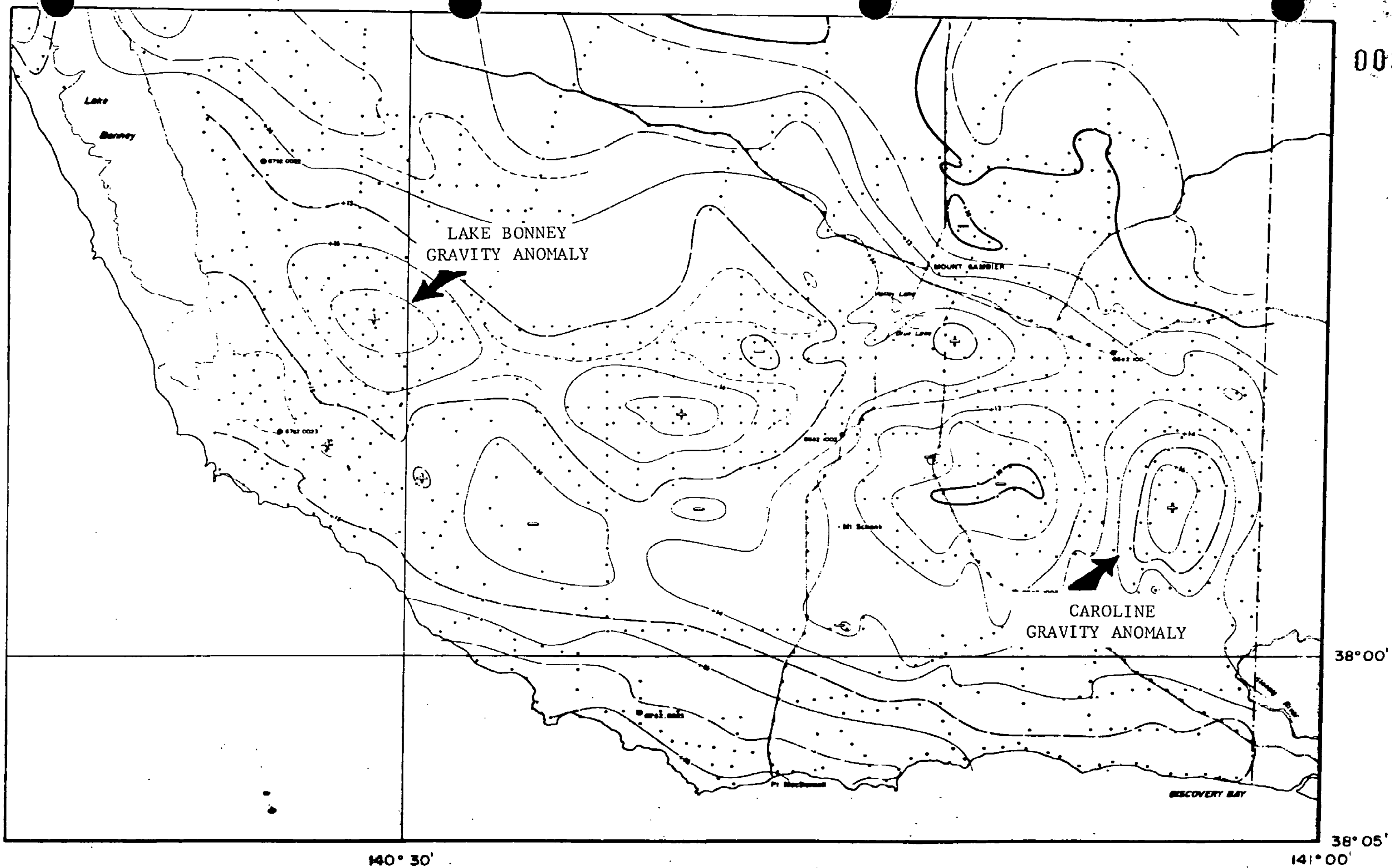


FIGURE VII-4 - PORTION OF BOUGUER ANOMALY MAP (S.A. MINES, 1981) SHOWING THE LAKE BONNEY AND CAROLINE GRAVITY ANOMALIES.

VII. STRUCTURE - Continued

Major Upper Cretaceous Structural Elements - Continued

The Tartwaup Fault - Continued

was continuous south of this fault. Planes of decollement probably occur within the Eumeralla Formation (Note Figures VII-5 and VII-6). Attractive structure also appears to be present on the upthrown side of this fault.

The Burrungule Anticline Trend

The Burrungule Anticline is used here to describe the persistent rollover adjacent to and on the downthrown side of the Tartwaup Fault, both in the South Australian and Victorian sectors of the Gambier Embayment. Only one poorly located well, Burrungule No. 1 was drilled on this anticline.

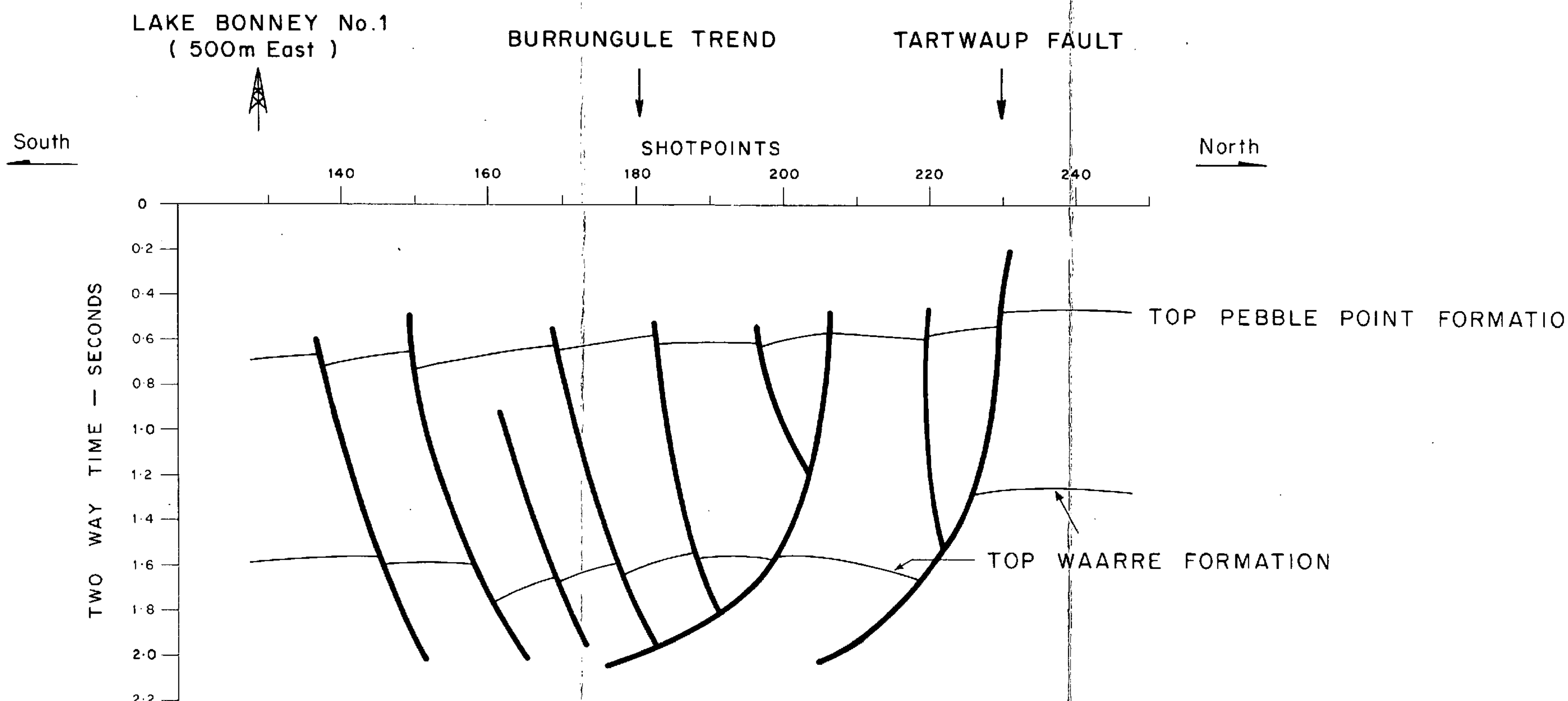
The Lake Bonney High

It appears that near vertical fault blocks can be expected along this trend. This is important to consider as such blocks would require minimal fault closure to the south and north. Fault independant closure is quite likely. As mentioned earlier the closed Caroline Structure appears to be on trend with the Lake Bonney High.

North Tilted Fault Block Trends

As one would expect the Upper Cretaceous rifting phase has resulted in fault blocks which have been rotated and the sediments now tilted to the north away from the basin centre. These blocks are relatively large in the onshore area and major faults are likely to extend for some distance uninterrupted. To the extreme south of the onshore area and in the offshore area the frequency of this faulting increases and structures are smaller.

.../31

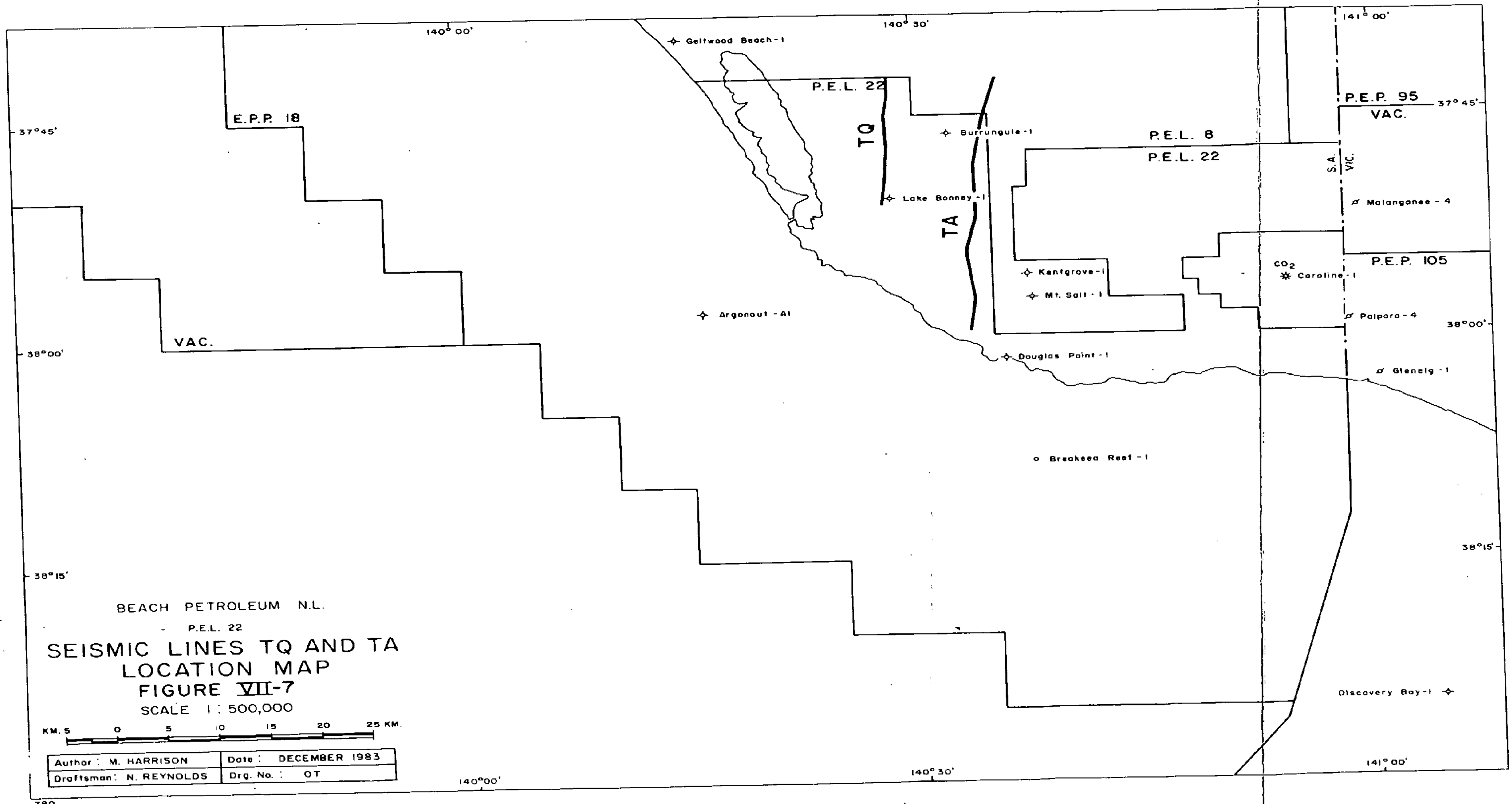


INTERPRETATION OF SEISMIC LINE No. TQ

TARTWAUP SEISMIC SURVEY (1973)

HORIZONTAL SCALE

KM 0 2 4 6 KM



BEACH PETROLEUM N.L.

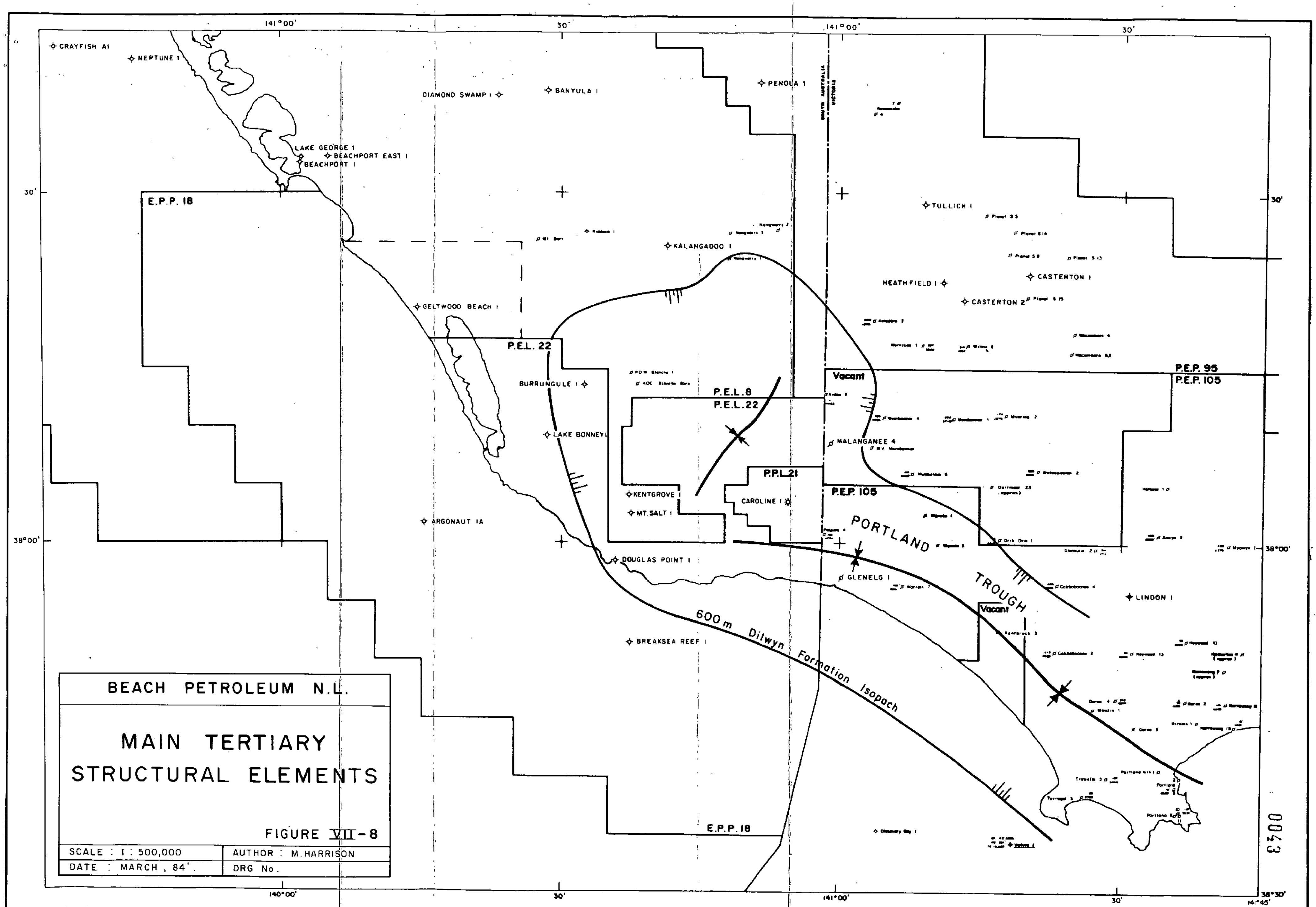
P.E.L. 22

SEISMIC LINES TQ AND TA LOCATION MAP

FIGURE VII-7

SCALE 1 : 500,000

Author : M. HARRISON	Date : DECEMBER 1983
Draftsman : N. REYNOLDS	Drg. No. : OT



BEACH PETROLEUM N.L.

MAIN TERTIARY STRUCTURAL ELEMENTS

FIGURE VII - 8

SCALE : 1 : 500,000	AUTHOR : M. HARRISON
DATE : MARCH, 84'.	DRG No.

VII. STRUCTURE - Continued

Major Tertiary Structural Elements

The Portland Trough

The major expression of this Tertiary rift occurs to the east in Victoria (Note Figure No. VII-8). The expression of the Portland Trough rifting is much broader in the Gambier Embayment (Note Enclosure 1) but its effect is significant on the deposition of the lower portion of the Dilwyn Formation. Synrift onlap onto the Pebble Point reflector is evident on some seismic sections, for example on line TC of the Tartwaup Seismic Survey (Enclosure 20). It is suggested that this structuring is important in that it enhances the prospectivity of the Lower Dilwyn Formation sands, in contrast, to many areas in the Otway Basin such as the Port Campbell Embayment where few faults cut into the Dilwyn sequence.

The existing mapping of the "Base Tertiary" (1974) is somewhat limited but does indicate the basic structural style (Note Enclosure 22).

0045

VIII. SOURCE ROCK POTENTIAL

Previous explorers have rated the Otway Basin sediments as having only a poor to fair hydrocarbon source potential and that, in the main, sourcing sediments are gas prone. This is contradictory to the most encouraging aspects of the basin which are that significant seeps of oil occur offshore and a high discovery rate from recent exploration (Port Campbell gas). Perhaps the major problem is the early explorer's dogma that hydrocarbons were only sourced from marine sediments and that the Sherbrook Group/Tertiary Group reservoirs would have to be sourced from the Paaratte Formation and in particular, the Belfast Mudstone.

By examining source rock data in detail, a picture emerges which suggests that important Otway Basin source rocks exist. In particular oil prone source rocks appear to be present within the Otway Group.

Tertiary subsidence, while not dramatic is significant enough to have allowed generation of liquid hydrocarbons by placing sourcing intervals with oil prone organics into the oil generating window. Similar generation must have occurred during the more dramatic Upper Cretaceous rifting phase.

SOURCE ROCK DATA

The following are source rock studies which are referred to in the discussion on the source rock potential of individual formations and are the principal references used.

- Geochemical Evaluation of the Otway Basin by Woodhouse, Alexander and Kagi, West Australian Institute of Technology (W.A.I.T.) for Phillips Australian Oil Co., 1980.

- Report AC 940/81. Australian Minerals Development Laboratories (AMDEL) for the Bureau of Mineral Resources, 1980.

- Organic Petrology of Samples from a set of six wells from the Otway Basin, South Australia by A.C. Cook for Phillips Australian Oil Co., 1980.

.../37

VIII. SOURCE ROCK DATA - Continued

- Source Rock Evaluation of Sediments Penetrated by Geltwood Beach-1, by G.W.M. Ruiter, Shell Technical Service Report, 1980.

- Discovery Bay-1 Well Completion Report, Appendix 8 and Appendix 9, Phillips Australia Oil Co., 1983.

The approach in source rock evaluation of the above reports varies. Key extracts are included as a source rock appendix at the end of this report.

SOURCE ROCK POTENTIAL OF SPECIFIC FORMATION INTERVALS

A. THE PAARATTE FORMATION

Fair source rocks have been encountered within this interval but they are primarily gas prone. In the deeper portion of the Paaratte Formation above the Belfast Mudstone, some oil sourcing potential is recognised. Sediments such as those intersected towards the base of the Mount Salt No. 1 well appear to have good oil source potential.

Comments on individual reports:-

WAIT for Phillips, 1980

10 samples in the Paaratte Formation were analysed geochemically. Total organic carbon content indicated moderate to good source rocks and soluble (extracted) organic matter indicated that poor to moderate source rocks were present, with one sample from 1830 m at Caroline No. 1 suggested to be a good source rock. Four samples were selected for further chromatography. The percentage of saturated compounds in these samples was low and indicated that the sourcing capabilities of these samples were poor. This is attributed in the main to the low level of maturity of all the samples except the 3061 m sample of Mount Salt No. 1 which had a moderate level of maturity.

.../38

VIII. SOURCE ROCK POTENTIAL OF SPECIFIC FORMATION INTERVALS - Continued

A. THE PAARATTE FORMATION - Continued

WAIT for Phillips, 1980 - Continued

The CT-CR Values (Total Insoluble Organic Carbon - Residual Carbon assessed to be incapable of generating hydrocarbons) indicates samples are good source rock which have failed to reach a suitable level of maturation for hydrocarbon generation.

The source of organic matter was assessed from analysis of the saturated compounds. The Argonaut No. 1 sample analysis at 3449 m (Belfast Mudstone) indicated organic matter present to be terrestrially derived. In contrast the Mount Salt No. 1 sample analysis at 3061 m indicated organic matter has a marine source.

Amdel, 1980

Four core samples from the Paaratte Formation were analysed from Argonaut No. 1. A shallow sample from 980 m, consisting of grey silty sandstone with carbonaceous laminae had a high total organic carbon content, 8.01 percent, and extracted organic matter of 5490 ppm, hydrocarbons. In the other samples total organic carbon content combined with the amount of extracted organic matter indicated moderate to good source rocks. Organic matter is assessed to be terrestrially derived.

Cook for Phillips, 1980

Maceral counts on samples reviewed by Cook in the Paaratte tended to be inconclusive as sandstone lithologies were examined. He suggested reworking and oxidation of organic matter had occurred in the samples examined.

Discovery Bay No. 1 Well Completion Report, 1983

This well did not penetrate the Belfast Mudstone. Rock-eval techniques were used on the samples in the Paaratte Formation both by Analabs and by Phillips, U.S.A.. Analabs identified gas prone organic rich sample intervals from 1215 m to 1370 m and 1655 m to 1930 m. A deeper interval within the Paaratte, 2295 m to 2770 m was assessed as having potential for generating moderate amounts

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0048

VIII. SOURCE ROCK POTENTIAL OF SPECIFIC FORMATION INTERVALS - Continued

A. THE PAARATTE FORMATION - Continued

Discovery Bay No. 1 Well Completion Report, 1983 - Continued

of oil and good amounts of gas. This assumption was based on a relative increase in the hydrogen index through this interval, which approached a figure of 100. No samples were thought to have entered the oil generating window. Phillips U.S.A. commented that of the 24 samples analysed, 18 were rich in total organic carbon, but only 6 samples had dominantly oil prone kerogen and that these tended to have a lower hydrogen index than one might expect, probably due to pre-burial oxidation. This conclusion relates well to the sandstone lithologies present. The report concludes that with greater maturity, the sediments examined would produce only dry gas of questionable significance because of the apparent pre-burial oxidation.

B. THE FLAXMANS/WAARRE FORMATIONS

Limited source rock sampling has been conducted in the Waarre/Flaxman Formation intervals. One sample each from Burrungule No. 1 and Lake Bonney No. 1 was analysed by WAIT and indicated moderate total organic carbon content. The Argonaut No. 1 core at around 3555 m in the Waarre Formation (?) was analysed by both WAIT and Amdel, both analyses indicating good levels of total organic carbon and moderate to good extracted organic matter respectively. Comments on the maceral content in the same core by Cook are not encouraging.

In general the source rocks qualities of these formations cannot be assessed with any degree of certainty at this stage.

C. THE EUMERALLA FORMATION

There is a high probability that a good portion of this formation has oil prone source rock potential.

Comments on individual reports:-

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0049

VIII. SOURCE ROCK POTENTIAL OF SPECIFIC FORMATION INTERVALS - Continued

C. THE EUMERALLA FORMATION - Continued

WAIT for Phillips, 1980

One sample analysis was conducted on the Eumeralla Formation in each of the Lake Bonney No. 1 and the Burrungule No. 1 wells; both indicated moderate total organic carbon content with the Lake Bonney No. 1 sample having a moderate level of soluble organic matter. At Kalangadoo No. 1 the two samples analysed showed moderate and high total organic carbon with a low level of maturity. Analysis was generally rudimentary.

Amdel, 1980

One sample was analysed in the Eumeralla Formation at 1468 m in Crayfish No. 1. Analysis of this grey to dark grey mudstone indicated a high total organic carbon content, 7.75% and high extracted organic matter content, 8329 ppm (good source rock in general 1,000 ppm plus). A very good source rock deserving further evaluation.

Cook for Phillips, 1980

Two samples examined by Cook in the Eumeralla Formation stand out as being potentially very significant. These were the 1455 m and 1719 m samples from Kalangadoo No. 1 described as shaley coal and carbonaceous shale, and silty carbonaceous shale respectively. All these lithologies contained abundant exinite, suggesting good oil prone source rocks.

Geltwood Beach No. 1 Well

As detailed in the dry hole analysis section of this report, a significant interval of gas shows and reported fluorescence occurred in the interval 1374 m to 1988 m within the Eumeralla Formation at Geltwood Beach No. 1. Gas analysis on DST samples shows some heavy hydrocarbons present. From vitrinite reflectance data we are able to assess that this interval is in a zone of the incipient oil generation. (Ro 0.5% - 0.7%) It is suggested that this interval is an important oil sourcing horizon and warrants further evaluation.

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VIII. SOURCE ROCK POTENTIAL OF SPECIFIC FORMATION INTERVALS - Continued

D. THE CRAYFISH FORMATION

The Upper portion of this formation does not appear to have good source rock potential. In contrast the lower portion appears to have very good oil source potential.

Comments on individual studies:-

Amdel, 1980

6 core samples from the Crayfish Formation were analysed from the Crayfish No. 1 well. The samples from 1663 metres and 1857 metres had poor source rock characteristics. The 2470 metre core sample has outstanding source rock characteristics. The sample consisted of carbonaceous mudstone with fine coally laminae, total organic carbon content was 15.88%, extracted organic matter was 21,560 ppm. The three deeper samples analysed had moderate to good source rock characteristics.

Geltwood Beach No. 1 Well

Within the Crayfish Formation at Geltwood Beach No. 1 gas shows were encountered between the intervals 2667 m to 2766 m and 2919 m to 2965 metres. In 1979 Shell conducted pyrolysis (sniffing) of 20 cuttings samples through the interval 2652 m and 2960 m. They determined that only one sample (2701 m to 2713 m) contained some source rock matter of mainly humic type. The deeper interval in this hole was not assessed by Shell. The Geltwood Beach No. 1 Well Completion Report notes that almost continuous fluorescence was present from the sandstones below 10,000 ft./3048 m, accompanied by minor gas shows. The fluorescence was dull gold and yielded a slow fluorescent cut in only one core sample.

E. THE CASTERTON FORMATION

The Casterton Formation is not expected to be a significant source horizon in the study area due to its probable great depth of burial.

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VIII. SOURCE ROCK POTENTIAL OF SPECIFIC FORMATION INTERVALS - Continued

MATURITY OF POTENTIAL SOURCING SEDIMENTS

Geothermal Gradient

Temperature data from wireline log readings was assessed. In general the derived temperature gradients are higher in areas where the basement is shallow in the north and decline to low gradient areas where thick Upper Cretaceous deltaic deposition has occurred. Lucindale No. 1, a well to the north of the Penola Trough, intersected basement at 3199/962 m and had a high geothermal gradient of 5.2°C/100 m in contrast to the Mount Salt No. 1 well which drilled a thick Upper Cretaceous section and had a geothermal gradient of less than 2.5°C/100 m. Estimation of true static borehole temperatures from most of the wells in the region is unreliable as generally only one reading was recorded per log suite.

- Vitrinite Reflectance

Vitrinite Reflectance data was collected for wells in the region (note: source rock appendix this section) and theoretical maturity profiles were constructed for each well. A map is attached showing the "depth to the assumed top of the zone of significant oil generation, Ro = 0.7%" (See Enclosure II.)

This map illustrates the same picture as the assessment made using temperature data. In the area of thick Upper Cretaceous deposition mature oil generating sediments occur at a greater depth. Comparison of this map with the Top Otway Group map (Enclosure 10) suggests that the most likely oil mature sourcing interval in the study area would be the Eumeralla Formation. The Crayfish Formation would vary from mature to post mature for oil generation in the study area. Towards the base of the Sherbrook Group in the south and offshore some mature generating sediments are likely. (Note the Mount Salt No. 1 well.)

Evidence suggests that the sediments in the study area have reached their maximum source rock maturity in recent times. Well log temperature data is not accurate enough to obtain reliable static bottom hole temperatures so sound geothermal history modelling cannot be undertaken with confidence.

0052

IX . POTENTIAL RESERVOIRS

Within the Gambier Embayment study area the main reservoir objectives are as follows:-

- The lower portion of the Dilwyn Formation including Pember Mudstone sands.
- The Pebble Point Formation.
- The eroded top of the Paaratte Formation.
- Unit 1 of the Paaratte Formation and sands within the Belfast Mudstone.
- The Waarre and Flaxman Formations.

The Mepunga Formation and upper portion of the Dilwyn Formation have limited potential in that they are shallow and remote from where we see the principal migration paths of hydrocarbons entering the Tertiary sequence, the syn-depositional faults of the Lower Tertiary. For completness however, these formations will be discussed.

THE MEPUNGA FORMATION

The Mepunga Formation is recognised as a confined acquifer within the Gambier Embayment although water is not generally produced because of its high iron content. The Mepunga consists of ferrigenous sands and gravels, as well as green sands in places. Porosity is variable due to variable matrix content. The interval represents the beginning of the last major transgressive phase in the basin. The potentially sealing Narrawaturk Marl thickens as the Mepunga Formation thins which suggests the possibility of stratigraphically sealed Mepunga sand bodies. The Narrawaturk Marl is often absent. Figure IX-1 is a correlation of two Mount Gambier town water supply bores which highlights some of the attributes and problems of the reservoir.

The Mepunga has low potential due to its shallow depth, a maximum of about 350 m in South Australia; biodegradation of any oil accumulations

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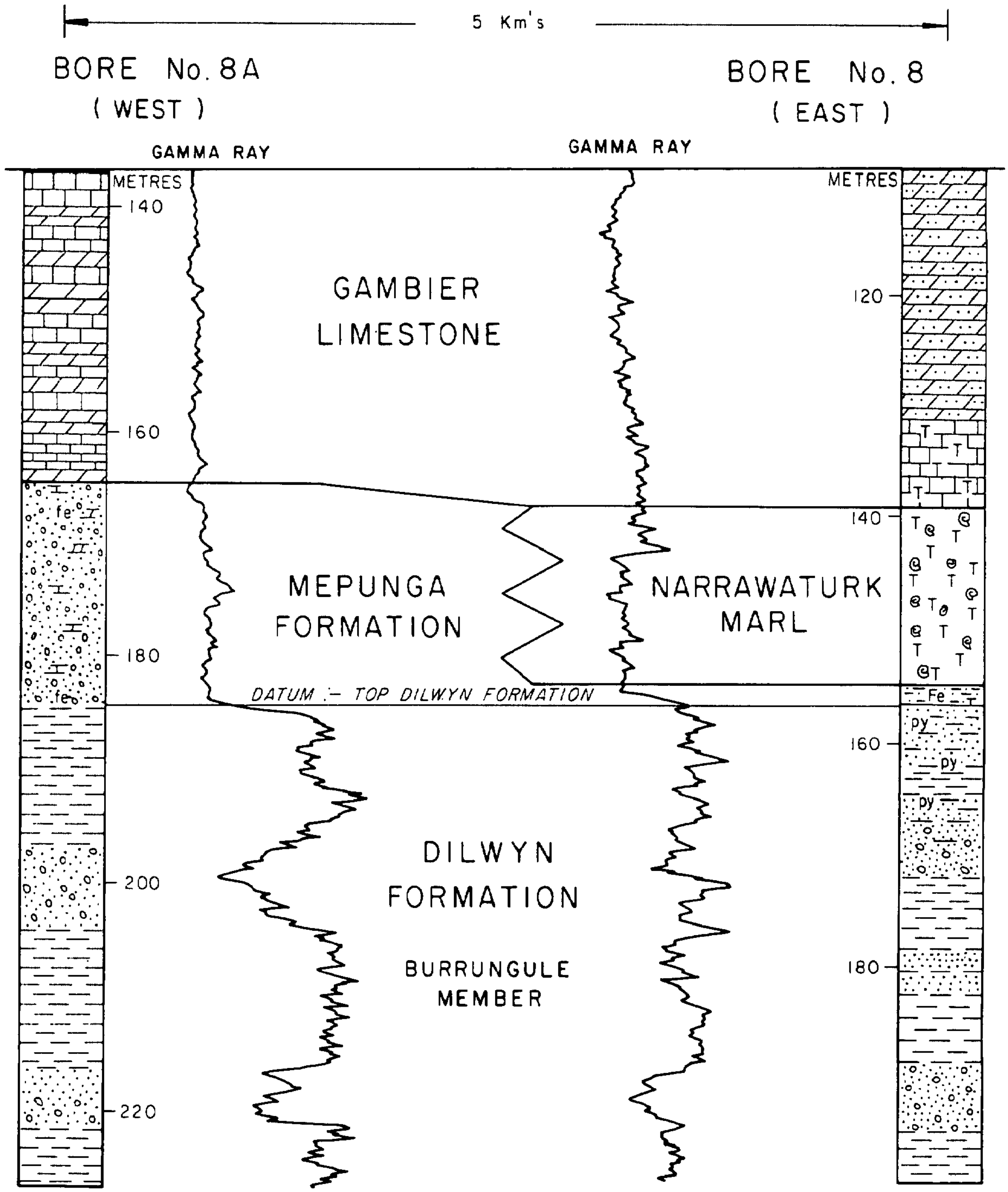

CORRELATION OF THE NIRRANDA GROUP BETWEEN TWO MOUNT GAMBIER TOWN WATER SUPPLY BORES

DEPTHS — METRES BELOW GROUND LEVEL

DATUM — TOP DILWYN FORMATION

FIGURE IX - 1

IX. POTENTIAL RESERVOIRS - Continued

THE MEPUNGA FORMATION - Continued

would therefore be very likely. It is also unlikely that oil has migrated through the conformable and relatively unfaulted Upper Dilwyn Formation.

THE DILWYN FORMATION

The Dilwyn Formation has excellent reservoir potential. In this area structuring of the lower portion of the Dilwyn Formation is condusive to hydrocarbon migration and entrapment. The three separate members of this formation are discussed below. Two correlations of this sequence, the first between Mount Salt No. 1 and Kentgrove No. 1 and the second between Douglas Point No. 1 and Lake Bonney No. 1 are included as Enclosures 13 and 14.

The Dilwyn Formation - Burrungule Member

Hydrologists in the region refer to the top clay bed of the Dilwyn Formation as the Burrungule Member. This report uses the term in a broader sense to describe the upper part of the Dilwyn Formation which consists largely of dark lignitic clays which are interbedded and mixed with fine to very coarse sands. The sands are increasingly utilized as town water supply acquifers as the prolific shallow unconfined acquifers of the Gambier Limestone have become polluted near townsites.

The basal portion of the Burrungule Member has some potential for hydrocarbon entrapment with its better sand development especially where associated with recent faulting. In general the unit should be considered a regional seal. Hydrocarbon accumulations would be prone to biodegradation in most areas because of the shallow depth of the sands and the active acquifer system. The underlying Dilwyn Middle Member is also an active acquifer. Considering these factors, Burrungule Member reservoirs are low priority objectives.

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IX. POTENTIAL RESERVOIRS - Continued

THE DILWYN FORMATION - Continued

The Dilwyn Formation - Middle Member

This member consists of a cyclic sand shale sequence. The sands would make excellent reservoirs in the onshore area where these cycles are discrete. Seven or more cycles of deltaic sedimentation have been recognised on well logs towards the Tertiary depocentre, each commencing with shale deposition grading upwards to a clean sandstone.
Holgate (1981) in his study of the Portland area of Victoria maintained there was evidence of marine sediments at the start of each cycle although no specific evidence for this has been assembled in the Gambier Study area.

The lower part of this sequence could be important. The sands have excellent reservoir properties and fault structuring, although active to present times, wained significantly during the deposition of the Middle Member. The lower sequence of the Middle Member could therefore be adequately deformed and migration of hydrocarbons up the larger faults can be expected. The best potential for traps within this sequence can be expected to be in the southern area where there is thicker Dilwyn deposition. The sandstones are active aquifers with intake areas to the north of the Tartwaup Fault and there is evidence that significant outflow occurs offshore. (Wopfner & Douglas, 1971, P.418; Sprigg, 1963).

The Dilwyn Formation Middle Member should be considered a secondary objective particularly in the south of the study area.

The Dilwyn Formation - Pember Mudstone Member

This unit is recognised as the major Tertiary sealing horizon. The active fresh water aquifers occur above this member. Although the unit is shale prone evidenece suggests there are two depositional cycles, at least in the Gambier Study Area. Isolated channel sand bodies do occur within the unit and may be hydrocarbon filled. However, the major sands within the Pember Mudstone occur towards the end of the first depositional cycle. Distribution of these sands throughout the Gambier Study area is variable and should be considered in detail because (i) they have excellent reservoir properties and (ii) in some prospects they would be detrimental

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IX. POTENTIAL RESERVOIRS - Continued

THE DILWYN FORMATION - Continued

The Dilwyn Formation - Pember Mudstone Member - Continued

to Pember Mudstone sealing properties. It is therefore worth commenting on their occurrence on a well to well basis to aid in prospect evaluation.

A. Kentgrove No. 1 and Mount Salt No. 1

The first depositional cycle of the Pember Mudstone is well developed in this area as subsidence was centred here during time of deposition. Enclosure 15, a Lower Tertiary Sonic-Gamma Ray correlation of several wells including Kentgrove No. 1 demonstrates this clearly. This correlation is confirmed by a detailed correlation of the Wangerrip Group as detailed in Table II-1 and particularly the correlation between Mount Salt No. 1 and Kentgrove No. 1 to Caroline No. 1. (Note Enclosure 13.)

The sands encountered in the Mount Salt/Kentgrove wells were medium to coarse, clean with excellent reservoir potential. It is interesting to note that in comparing these wells the sand development at Mount Salt thickens while the Pember Shale units thin despite the fact that Mount Salt is located on a downthrown block from Kentgrove. (Note Figure IX-2.)

B. Lake Bonney No. 1 and Burrungule No. 1

The initial depositional cycle in these wells is distinctive. The sands have a "Pebble Point" character in they have some siderite and limonite matrix although not as much as in the "Pebble Point" proper as defined in this report. The mudstone at the base of the unit may have been deposited in a lacustrine environment. The Lake Bonney thin of this unit is noteworthy as the well is located on a deep seated positive basement trend which is significant in controlling deposition.

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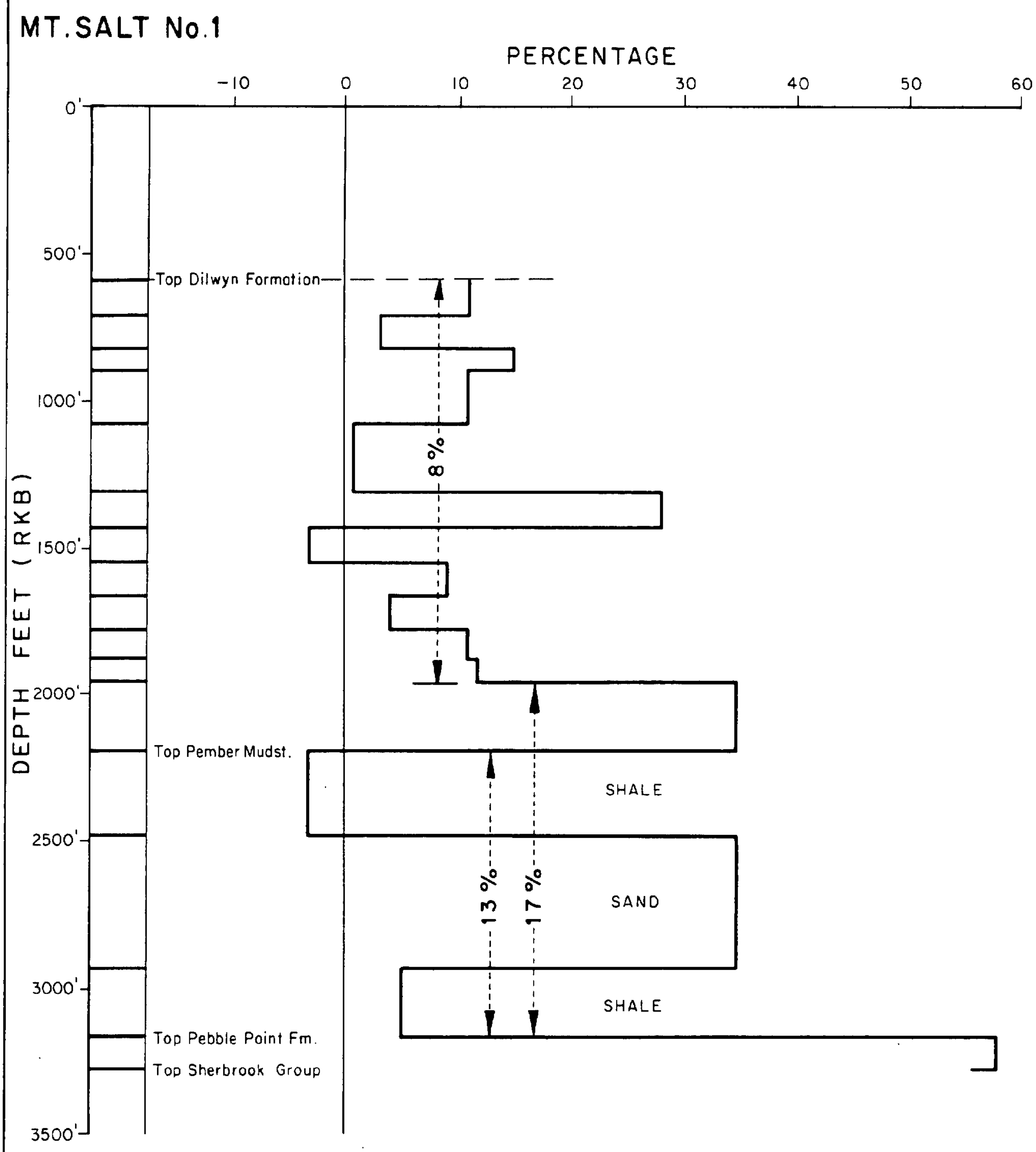

PERCENTAGE INCREASE IN FORMATION THICKNESS KENTGROVE No.1 TO MOUNT SALT No.1 THROUGH THE WANGERRIP GROUP.

FIGURE IX - 2

IX. POTENTIAL RESERVOIRS - Continued

THE DILWYN FORMATION - Continued

The Dilwyn Formation - Pember Mudstone Member - Continued

B. Lake Bonney No. 1 and Burrungule No. 1 - Continued

These sands were medium to very coarse grained, clean and have excellent reservoir potential.

C. Douglas Point No. 1 and Caroline No. 1

These wells appear to have been peripheral to to the main centre of subsidence during the initial cycle of Pember Mudstone deposition (Note Enclosure 3 and Enclosure 15). Marine influence appears to have been much greater in these wells.

At Caroline No. 1 both fine, dolomitic and medium to coarse sands are present. Forams were reported in the samples. At Douglas Point No. 1 the sands were fine to coarse with abundant glauconite. These sands have excellent reservoir potential. DST 2, 2936'-2961' at Caroline No. 1 was run over this unit and recovered a full string of fluid; good initial blow to fair in 10 mins. and died after 20 minutes; water salinity was 3500 ppm chlorides.

In conclusion the sandstones of the Pember Mudstone Member should be considered important objectives in any Basal Tertiary/Top Upper Cretaceous Play.

THE PEBBLE POINT FORMATION

The Pebble Point Formation has long been recognised as a major objective as it occurs directly below the Pember Mudstone. The Pebble Point Formation was deposited during a marine transgression which followed the

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IX. POTENTIAL RESERVOIRS - Continued

THE PEBBLE POINT FORMATION - Continued

breakup of the Australian and Antarctic continental plates. Facies transgression was apparently rapid, consisting of near shore marine sands and mudstones, paralic mudstones and pebble conglomerates. The presence of chamosite, greenalite and glauconite particularly as pellets and ooliths is commonly described in well samples.

Due to probable basin tilt as the basin sagged to the south, the Pebble Point Formation was apparently exposed in a landward direction prior to Dilwyn Formation deposition and chemical weathering with its resultant lateritic horizons is common.

The reservoir characteristics of the Pebble Point Formation are therefore very variable and log evaluation is difficult. A portion of the formation is generally porous and permeable in all wells in the Embayment. There is a need for a more complete study of the Pebble Point Formation in the study area and the incorporation of data from wells in the adjacent area of Victoria. Facies variation seaward and landward appears to differ.

One drill stem test has been conducted in this formation in the study area. This was (DST No. 1 3042'-3130', 927.2-954 m) at Caroline No. 1 where the Pebble Point Formation yielded a full string of fluid in under 21 minutes. Formation water was slightly saline (1600 ppm chloride equivalent, 3.2 OHMS at 80°F). Unfortunately the very top of the Paaratte Formation had been penetrated prior to testing.

While the Pebble Point has variable reservoir properties it should be considered a primary drilling target as at least a portion of the formation is always porous. Importantly the Pebble Point Formation is a good seismic reflector and drilling targets can be well defined.

.../51

IX. POTENTIAL RESERVOIRS - Continued

THE PAARATTE FORMATION

Rapid subsidence particularly south of the Tartwaup Fault has resulted in a very thick deltaic succession, the Paaratte Formation. The Paaratte has been tentatively divided into four lithostratigraphc units representing the transition from mud prone shelf deposition, to sandstone predominent alluvial deposition. (Note Enclosures 16 and 17.) Seal is the greater problem and unknown through this sequence. Reservoir properties are excellent at the top and from log and core data, sandstone porosities of 20% or more can be expected to occur up to a depth of about 9,000 ft./2750 metres. The only mechanically successful DST in the deeper sand/shale sequence was an open hole DST conducted at Mount Salt No. 1 between 9813 feet-9892 feet (2991-3015 metres) which recovered 4070 feet of muddy water cushion, 300 feet of salt water cut mud and 4070 feet of salt water (39,450 ppm Total Solids), a total fluid recovery of 8440 feet (2573 metres) during a total flow period of 90 minutes. The well was still steadily blowing at the completion of the test. Interestingly enough the test was not conducted over a particularly sand prone interval as suggested by wireline logs. Salinity increase of formation waters tends to indicate greater sealing of these reservoirs with depth.

THE FLAXMANS FORMATION

This formation has been tentatively correlated in the study area. Regionally the porosity of the upper sand unit is generally poor. Reservoir porosities within the sand unit in the study area appear to be excellent.

THE WAARRE FORMATION

South of the Tartwaup Fault where thick Sherbrook Group deposition has occurred only three wells have intersected the Waarre Formation with certainty; Burrungule No. 1, Lake Bonney No. 1 and Caroline No. 1.

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IX. POTENTIAL RESERVOIRS - Continued

THE WAARRE FORMATION - Continued

Whether the offshore well Argonaut No. 1 intersected the Waarre Formation remains in doubt, with sand quality in the supposed Waarre Formation in Argonaut No. 1 reported as being poor. Generally sand quality of the Waarre Formation contrasts sharply with sands encountered in the underlying Eumeralla Formation where sands present are tight. This is the main criteria for separating the Waarre Formation from the Eumeralla Formation in the Gambier Embayment where dipmeter logs are not available.

The Waarre Formation sands are clean and porous, although in this area some portions of the formation contain a high proportion of feldspar grains which may be detrimental to reservoir quality.

At the Caroline Structure the Waarre Formation is closed and a significant accumulation of carbon dioxide is trapped. The Waarre Formation at Caroline appears to exhibit 2 cycles of deposition, each displaying a gross cleaning upwards profile. There is one, possibly two gas water contacts in the upper cycle; sands towards the base of the lower cycle appear to be gas filled. DST No. 8 conducted over the interval 9154 feet - 9182 feet (2790.2 metres - 2798.7 metres) produced a stabilized flow of CO_2 of 2,730,000 cubic feet/day. Perhaps more importantly when considering reservoir quality, DST No. 5 8610' - 8730' (2624.3 m - 2660.0 m) recovered 279' (85 m) of gas cut watery mud and 6603' (2012.6 m) of gas-cut salt water. CO_2 flow was not sustained in this interval. Log calculated porosities through the Waarre Formation at Caroline No. 1 ranged from 15 to 21 percent.

At Lake Bonney No. 1 and Burrungule No. 1 only one cycle of deposition appears to be present. The Waarre Formation sands in these wells have excellent reservoir characteristics with a greater sand percentage.

The Waarre Formation is the primary Sherbrook Group objective as it is (i) overlayed by the Belfast Mudstone and (ii) is in close proximity to potential Otway Groups source beds. In the Gambier Embayment we can confidently expect to define numerous Waarre prospects with continued

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IX POTENTIAL RESERVOIRS - Continued

THE WAARRE FORMATION - Continued

exploration in the region. The Waarre Formation reservoirs contain high formation water salinities (exceeding 50,000 ppm) in places and are therefore considered to be regionally sealed.

THE OTWAY GROUP

Apart from the thin Heathfield Sandstone which occurs towards the base of the Eumeralla Formation, potential reservoirs are not recognised in the Eumeralla Formation and the underlying Geltwood Beach Member of the Crayfish Formation. The Pretty Hill Sandstone Member of the Crayfish Formation is broadly defined as the porous member of this Formation. The distribution of this porous member appears to be related to palaeogeography and perhaps provenance. Within the Gambier Embayment study area the Pretty Hill Sandstone Member is likely to be absent or at too great a depth.to be considered as a valid drilling objective.

PRE-CRETACEOUS RESERVOIRS

The Jurassic Casterton Beds and the Kalangadoo No. 1 type fractured basement reservoirs are not considered prospective in the study area.

X. POTENTIAL SEAL

Major seal potential is recognised in the Pember Mudstone of the Dilwyn Formation; the Belfast Mudstone Member of the Paaratte Formation and the Eumeralla Formation. In general sealing potential improves seaward and particularly in the Paaratte Formation towards the depocentre. Seal is not considered a problem in the study area, although prospects should be assessed with an appreciation of regional variation of seal quality and thickness.

THE DILWYN FORMATION

The cyclisity of individual stratigraphic units of the Dilwyn Formation leads us to believe that excellent reservoir seal-facies relationships will be consistent over a wide area. A detailed correlation of the wells in the study area (Note Table II-1) supports this contention.

The Dilwyn Formation - Burrungule Member

This member is the top seal or aquitard of the Dilwyn Formation confined aquifer system.

The Dilwyn Formation - Middle Member

As detailed in the section on potential reservoirs the hydrocarbon potential of this member increases towards the base. A persistent cleaning upward sand unit (Unit 1) is overlayed by a predominantly sealing unit (Unit 2) which exceeds 100 metres in thickness at Mount Salt No. 1, Kentgrove No. 1, Caroline No. 1 and Douglas Point No. 1. A detailed comparison of Unit 2 in Mount Salt No. 1 and Kentgrove No. 1 (Note Enclosure 13) indicates that individual siltstone - shale units can easily be correlated and therefore lateral sealing of this unit over prospects is likely.

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X. POTENTIAL SEAL - Continued

THE DILWYN FORMATION - Continued

The Dilwyn Formation - Pember Mudstone Member

This is an important regional seal. A general statement can be made that the Top Pember Mudstone separates the active freshwater aquifers of the Burrungule Member and Middle Member of the Dilwyn Formation from underlying reservoirs which exhibit higher formation water salinities. Enclosure 3 is an isopach of the Pember Mudstone and demonstrates that it thickens from the southwest and the north into the Portland Trough to the east. As noted in the section on reservoirs, two cycles of deposition are evident and that reservoir facies do occur within the member. In all wells within the study area seal is adequate. However, prospects towards the northwest are more prone to breaching of sealing facies and the prospectivity of individual structures in this area should be assessed with care. The Gamma-Ray log is excellent in assessing the presence of seal horizons. The comparison between the logs and core material at Caroline No. 1 supports this contention.

THE PEBBLE POINT FORMATION

Potential sealing facies in the Pebble Point Formation include mudstone and laterite which may provide intraformational seal and possible seal of the Top Paaratte unconformable surface. However, well to well variation is great and Pebble Point seal can only be expected to have sufficient lateral extent to trap hydrocarbons on a local or prospect level.

THE PAARATTE FORMATION

Unit 3 and Unit 2 of the Paaratte Formation are considered to have low sealing potential. The Gamma-Ray log again appears to be an excellent seal indicator.

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X. POTENTIAL SEAL - Continued

THE PAARATTE FORMATION - Continued

The Paaratte Formation - Unit 1

Enclosures 16 and 17 indicate that Unit 1 is a sand/shale sequence. Unfortunately such a sequence is prone to fault breaching and rapid facies changes. As an insitu hydrocarbon source is unlikely, faulting on the scale necessary to introduce hydrocarbons into this sequence is also likely to breach the seal. Towards the Upper Cretaceous depocentre progressive sealing of Unit 1 is indicated by gradually increasing water salinity with depth. (Note Mount Salt No. 1.) This unit may provide adequate seal where structures have roll-over independant of faults or where Unit 1 is juxtaposed against the Belfast Mudstone or Eumeralla Formation.

The Paaratte Formation - Belfast Mudstone Member

The Belfast Mudstone is the major regional seal of the Waarre Formation reservoirs. Formation waters below the Belfast Formation are often hypersaline, e.g. in Burrungule No. 1. Enclosure 7 is an isopach map of the Belfast Mudstone and indicates that throughout the area south of the Tartwaup Fault the Belfast Mudstone would be a reliable seal of fault traps. It is also important to recognise that significant structuring occurred during Belfast time resulting in its thicker deposition where seal is most critical, that is on the downthrown wide of fault blocks. It is questionable whether the Belfast Mudstone was intersected at Mount Salt No. 1. Earlier studies considered the lower portion of this well including Unit 1 as described in this report, as being the Mount Salt Formation, a facies equivalent of the Belfast Mudstone (Esso 1976.). This report rejects this concept and favours the more likely interpretation that the top of the Belfast Mudstone was intersected close to total depth at Mount Salt No. 1.

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X. POTENTIAL SEAL - Continued

THE FLAXMANS FORMATION

The lower portion of the Flaxmans Formation can be expected to contribute to the seal of the underlying Waarre Formation.

THE WAARRE FORMATION

Intraformational seal can be expected within the Waarre Formation. Within the Waarre Formation at Caroline No. 1 two principal horizons of CO_2 accumulation can be recognised. Drill Stem Tests of the entire interval indicated that the upper zone has a gas-water contact. Such intraformational seal at this level is less likely to the northwest, such as at Burrungule No. 1.

THE EUMERALLA FORMATION

The Eumeralla Formation deposition occurred during the last phase of Otway Group subsidence. The formation consists principally of shale facies and sands where developed are mainly tight. Generally the formation can be considered a blanket seal as even over major Lower Cretaceous horst-blocks the formation is well represented. Within the study area it should be recognised that the Eumeralla Formation could provide lateral seal for Sherbrook Group reservoirs which have been downthrown against the Eumeralla Formation.

XI. TIMING AND EVIDENCE OF HYDROCARBON MIGRATION

MIGRATION

As discussed in the Source Rock Section of this report the better source rocks are found in the Lower Cretaceous Otway Group and that maturity of these sourcing sediments is assured. Many of the productive basins of the world (some would argue most, Price 1980), rely on deep sourcing of oil and gas, with vertical migration of these fluids up major faults into shallower reservoirs. If this concept is accepted, the Gambier Embayment, in particular the area selected for detailed study, is a highly prospective province as major faulting is evident and deep source beds are present in the Otway Group.

Individual prospects and structural trends should be analysed carefully for possible migration routes related to major faulting. The limited amount of seismic in the area precludes detailed discussion relating to individual prospects.

TIMING OF MIGRATION

Significant downwarp has occurred in the Gambier Embayment study area during the Upper Cretaceous and Tertiary rifting phases. We must therefore assume that at least some of the underlying source rocks have reached their maximum maturity during the Tertiary phase of rifting. This is supported by the vitrinite reflectance profiles in wells where there has been reasonable Upper Cretaceous and Tertiary subsidence; there are no breaks in the reflectance profiles across the major unconformities.

Most structuring relevant to the entrapment of hydrocarbons in the study area occurred prior to the Eocene. Available maturity indicators confirm that hydrocarbons should be generated at the present time. We can therefore confidently predict that pre-Eocene structures are likely to have entrapped hydrocarbons in the Gambier Embayment study area.

As detailed in the Dry Hole Analysis Section of this report only one well, Caroline No. 1 in the study area has conclusively drilled a closed structure; this determined only by results (large CO_2 accumulation in the

.../59

XI. TIMING AND EVIDENCE OF HYDROCARBON MIGRATION - Continued

TIMING OF MIGRATION - Continued

Waarre Formation) rather than by seismic definition of the Prospect, which is extremely poor.

Beach Petroleum has had success in establishing gas reserves on the Port Campbell High of Victoria. (Note Figure XII-5) The Port Campbell High Gas Reserves are noteworthy in that the wells drilled in that area represent a high proportion of all wells drilled in the basin for Sherbrook Group objectives, on reliably defined structures.

Because of the limited number of wells in the study area, very few shows have been reliably documented. Furthermore, as detailed in the Dry Hole Analysis Section of this report one must question the on-site evaluation of some of these wells for shows (in particular the Mount Salt No. 1 and Lake Bonney wells). Early explorers expected to find oil at depth.

The oil show in Mount Salt No. 1, Core No. 1, 998' to 998'4" (304 m) is very significant. A strong fluorescent cut was obtained during evaluation of the core by the Bureau of Mineral Resources. It was not recorded during the drilling of the well.

Cook (1981) noted that in a number of samples he examined from the Gambier Embayment, Exsudatinite and bitumens are present in minor quantities. He notes that "Exsudatinite occurs in a number of coals and is of interest since its presence suggests that hydrocarbon mobilization and at least some migration has occurred within the coals". Unfortunately he was not specific as to which samples he was talking about (he examined Paaratte Formation, Waarre Formation and Eumeralla Formation samples).

In Caroline No. 1 in Core No. 10 in the Pebble Point Formation, the matrix was noted to contain "black bituminous material".

As discussed in detail below, the occurrence of oil seeps in the offshore area strongly suggests up-fault migration of oil from the basin deep to the surface is occurring. Only one report of an onshore oil seep is mentioned

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XI. TIMING AND EVIDENCE OF HYDROCARBON MIGRATION - Continued

TIMING OF MIGRATION - Continued

in the literature. The seep was reported at Haines Landing of the Glenelg River (Note Figure XI-4). Sprigg (1961b) refers to the report, but the original report has not been located by this author.

COASTAL BITUMEN STRANDINGS

Historically, the main encouragement for petroleum explorers in the Otway Basin has been the occurrence of bitumen strandings along the entire coastline adjacent to the Otway Basin. Reports of these strandings date back to the last century; thorough investigation of their occurrence was made in the early 1960's principally by Geosurvey's of Australia Ltd. It is most likely that the bitumen has been eroded from seafloor accumulations of bitumen on the continental shelf and slope and that these accumulations have occurred as a result of oil seepage up recent faults from deeper breached oil accumulation's or directly from lower Cretaceous source beds.

The occurrence of coastal bitumen strandings must indicate that there is a high probability of there being economic accumulations of oil in the Otway Basin sediments.

THE EARLY 1960'S INVESTIGATIONS

A concise review of bitumen strandings in the region and a series of detailed observations of their occurrence is written up in "Coastal Bitumen in South Australia with Special Reference to Observations at Geltwood Beach, South-East South Australia" by R.C. Sprigg and J. Wooley, 1961. (Published, Transactions of the Royal Society of South Australia, Volume 86, 1963.) Some further observations were included in "The South Australian Continental Shelf as a Habitat for Petroleum". Reg. C. Sprigg, (Apea J. 1964.).

.../61

XI. TIMING AND EVIDENCE OF HYDROCARBON MIGRATION - Continued

THE EARLY 1960'S INVESTIGATIONS - Continued

A summary of conclusions developed following the reading of these reports are:-

1. Recently stranded bitumen often has a moist sticky consistency ("consistency of treacle").

2. Frequency of bitumen strandings increases after winter storms and supports the idea of erosion of sea floor deposits of bitumen.

3. Following earthquake activity in 1948 large amounts of bitumen were stranded near Geltwood Beach. The epicentre of this quake was located offshore from the town of Beachport.

4. Co-incident with the occurrence of bitumen stranding's at Geltwood Beach, an area of frequent strandings, are the presence of offshore freshwater springs.

   The springs are active, with strong unwelling evident in the sea. The spring water is coloured yellow, sometimes black due to ligneous material in suspension.

5. The upper beds of the Dilwyn Formation (Burrungule Member) are typified by black ligneous claystones. It would appear that water from the Dilwyn Formation acquifers escapes in the coastal offshore zone probably at several localities similar to the Geltwood Beach area. (Note Wopfner & Douglas, 1971, P.418).

6. Sprigg and Wooley (1961) observed a "large block of black material in the centre of the brown (ligneous) scum", above a submarine spring. Unfortunately the block could not be sampled but was observed drifting until nightfall. The direction the block was drifting was assessed and the next day several large pieces of freshly stranded bitumen (that night) of half a pound or more were located above the high water mark on a beach located in the direction the block was drifting.

7. The high frequency of bitumen strandings at Geltwood Beach may relate to the close proximity to their source. It is possible that the breach of the Dilwyn Aquifers and occurrence of bitumen are related

.../62

XI. TIMING AND EVIDENCE OF HYDROCARBON MIGRATION - Continued

THE EARLY 1960'S INVESTIGATIONS - Continued

to the same phenomena, recent fault breaches of the Dilwyn Formation; Enclosure 21. Seismic Line UA82-31, has several faults which appear to reach the sea bed.

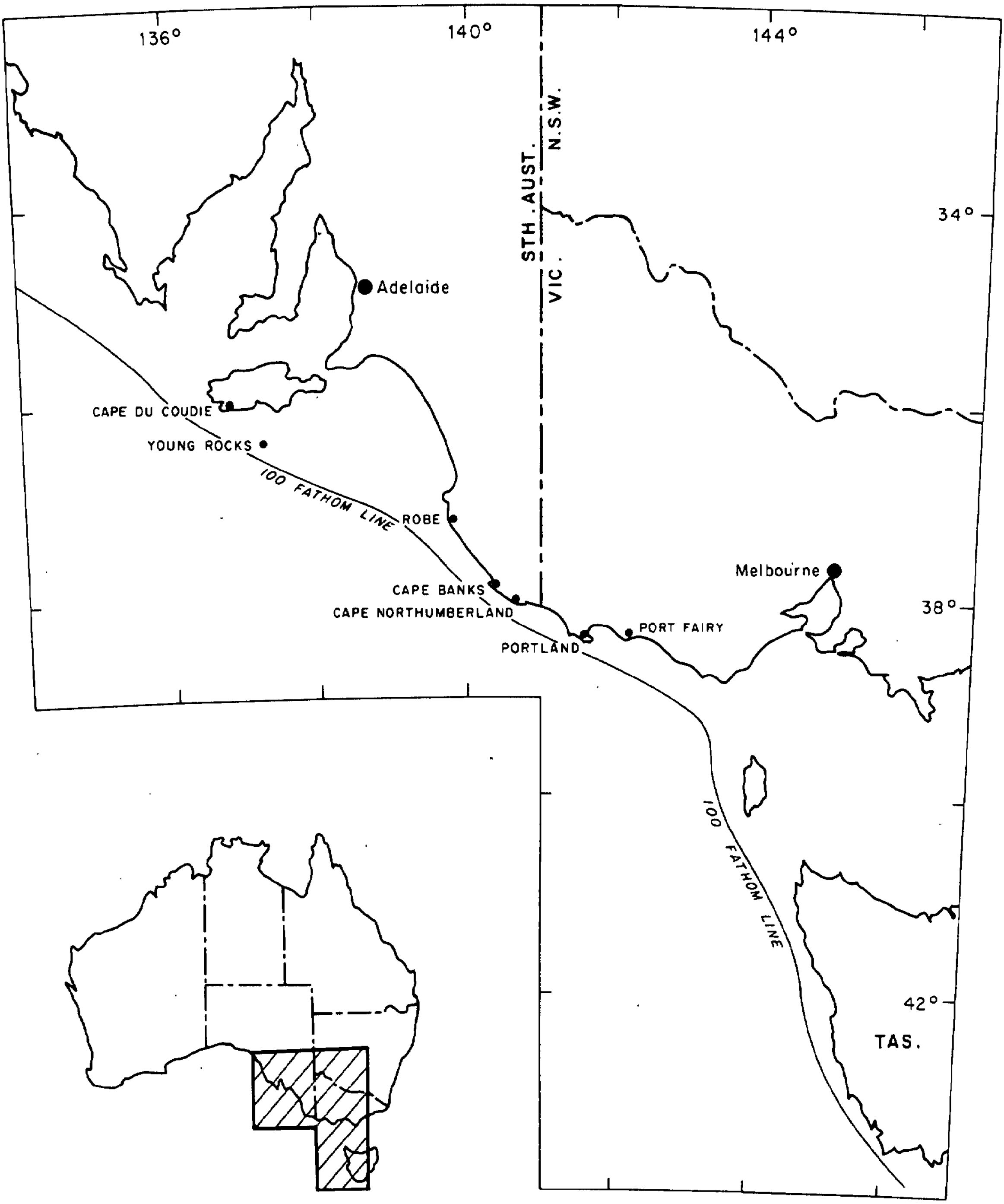
8. Drift bottle experiments (Sprigg, 1964) were carried out in the winter of 1963. Bottles were dropped South of Young Rocks and south west of Robe over the 100 Fathom line during a gale. (Figure XI-I) Bottles were retreived at Cape Northumberland and Cape Banks for the earlier release of bottles and the Robe released bottles were stranded at about Portland to Port Fairy.

   The bottles drifted better than 20 miles/32 kilometres per day. A summer release of bottles was made but no released bottles were retreived which is consistent with the lack of stranded bitumen during the summer. Suggestion was made that the bitumen may have been derived from Murray River Submarine Cayons (Note Figure XI-2) which are dramatic and prone to slumping and erosion.

ANALYSIS OF OTWAY BASIN COASTAL BITUMEN

The most comprehensive analysis of the Otway Basin coastal bitumen is summarized in "Geochemistry and Significance of Coastal Bitumen from Southern and Northern Australia", by D.M. McKirdy and Z. Harvath, B.M.R. (Apea J. 1976). Figure XI-3, is taken from this paper and illustrates the main localities where bitumen is stranded. The paper describes the bitumen samples as "inspissated waxy crudes of low sulphur content". Two types were described, the first Paraffinic to Naphthenic and the second (highly Paraffinic to Paraffinic), both of which occur along the coastline in the Gambier Embayment Study Area. The bitumens were also described as "products of the diagenesis of mostly continental vegetation" and were indicated to be of Cretaceous to Tertiary age.

.../63



BEACH PETROLEUM N.L.

LOCALITY MAP

DRIFT BOTTLE EXPERIMENTS

FIGURE XI – 1

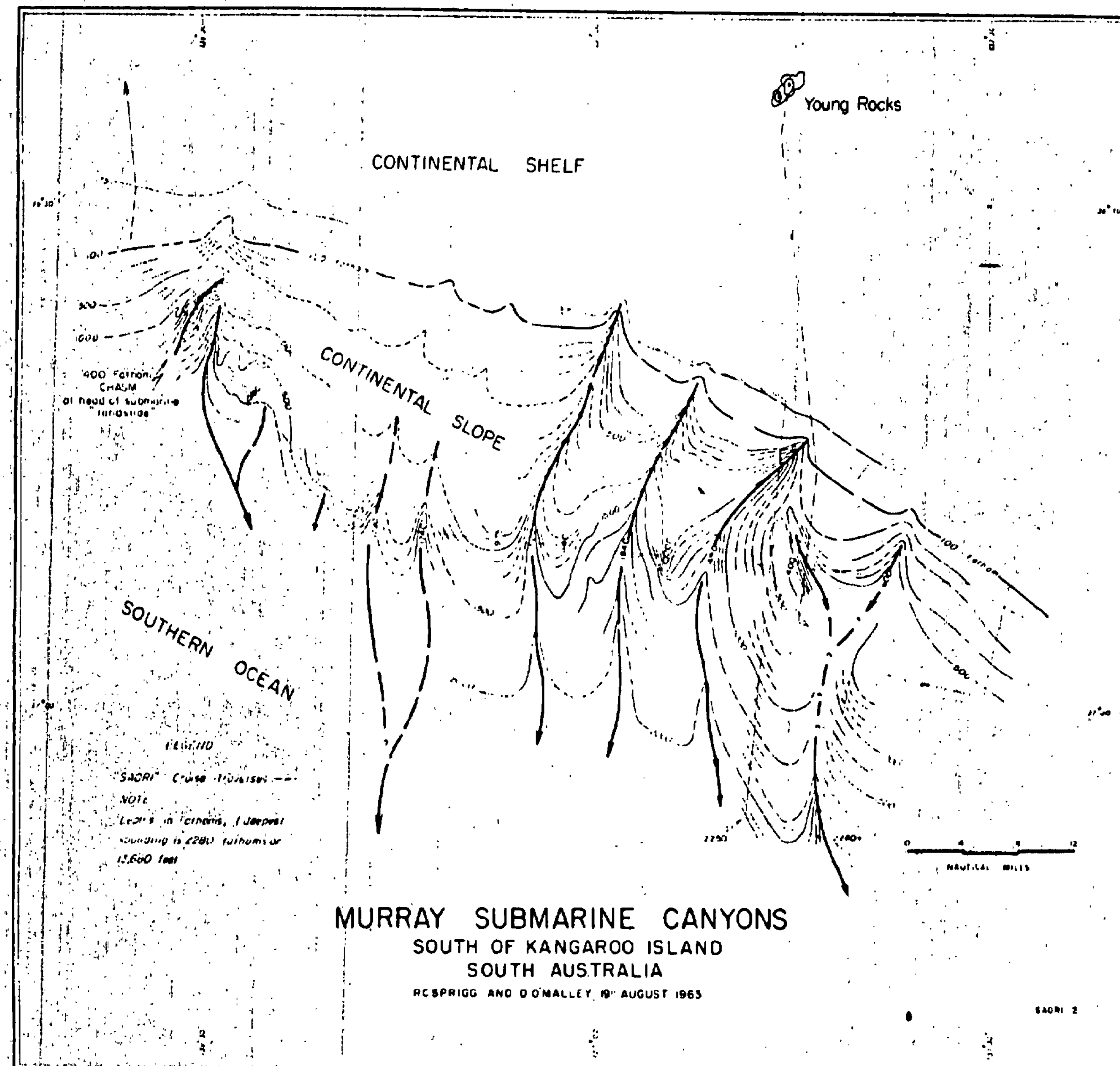


FIGURE XI-2

MURRAY RIVER CANYONS

(Sprigg, APEA J. 1964)

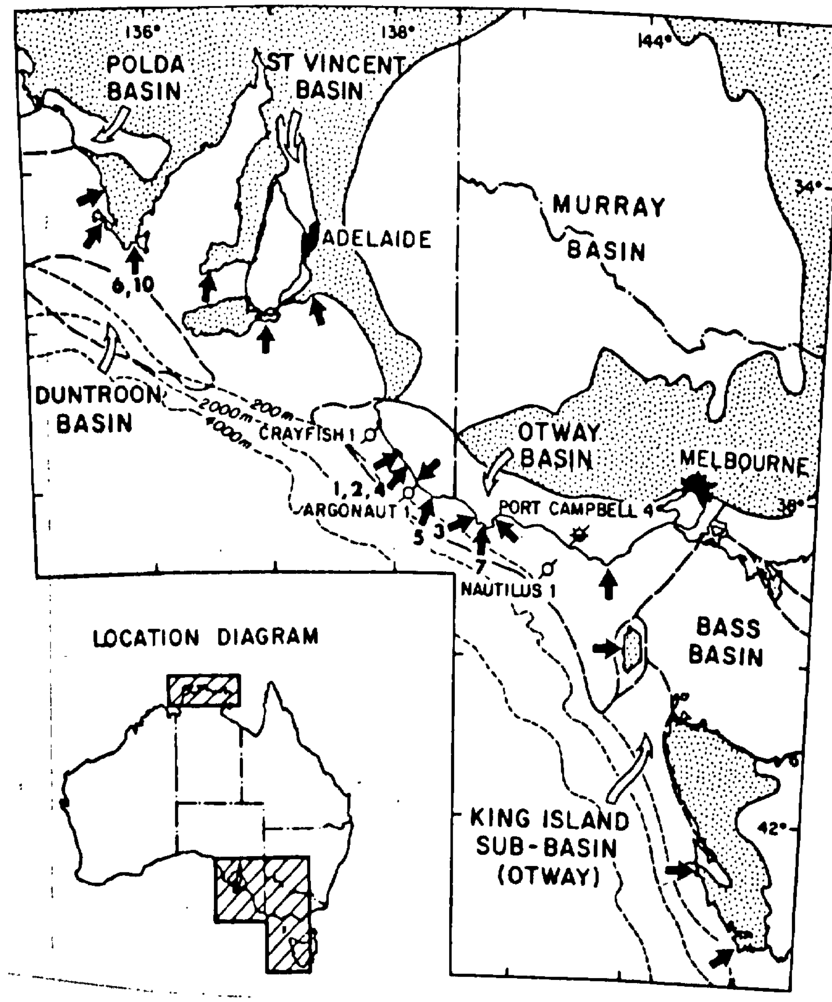


FIGURE XI-3

Main localities (arrowed) at which bitumen strands along the southern coast of Australia. Numbers refer to sites from which samples were analysed by McKirdy and Horvath (APEA J. 1976).

XI. TIMING AND EVIDENCE OF HYDROCARBON MIGRATION - Continued

ANALYSIS OF OTWAY BASIN COASTAL BITUMEN - Continued

The paper further suggests that the bitumen's "low Pristane/Phytane ratios (less than 2) suggests that the source organic matter underwent little thermal alteration". Recent literature Hunt (1979), Connan & Cassou (1980), and Snowden and Powell (1982) suggests that the Pristane/ Phytane ratio is more indicative of the nature of the source material than the degree of maturity of crude oil.

OFFSHORE SNIFFER SURVEY EPP.18

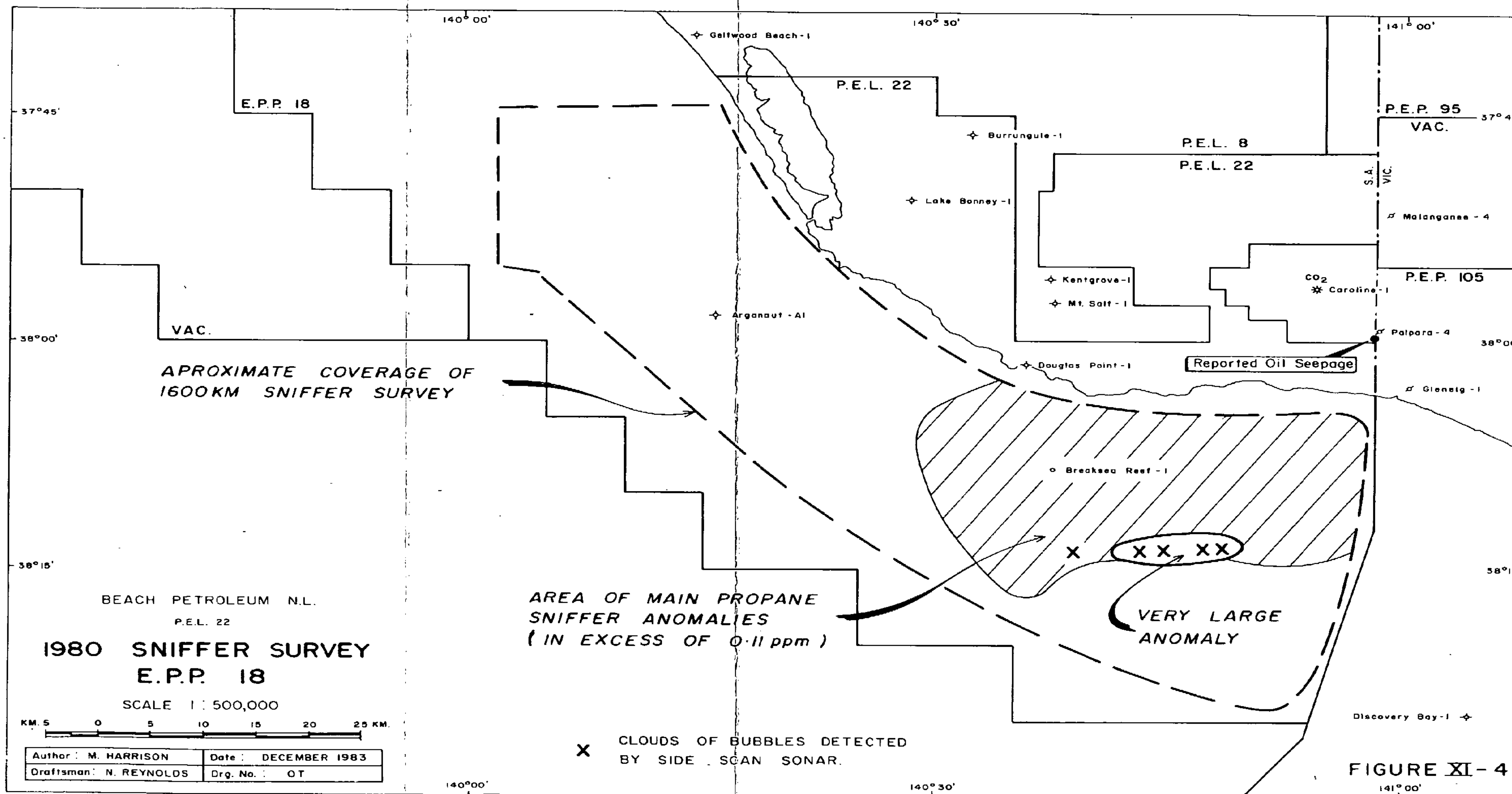
Shoreline Exploration Co. conducted a 1600 kilometre offshore sniffer survey to the south of the Gambier Embayment study area. (Note Figure XI-4.) Gas anomalies detected are indicated to be solution gas (from oil) with high Propane levels which is in accord with results one would expect from an oil province. The oil is likely to have been derived from a mature source by virtue of the normal - Butane and Iso-- Butane ratio's of the gas anomalies detected. (Shoreline Exploration Co. 1983.)

Main Observations Resulting from this Survey

A. Background levels of the gas components measured were very low. This was attributed to the consistent bottom current of ten to twenty kilometres per day ensuring constant gas free water replacement into the area.

B. One very large anomaly was detected and this was associated with clouds of gas bubbles detected below the survey vessel on the side scan sonor. This anomaly is thought to occur at the head of a late Tertiary Channel which breaches the Gambier Limestone and which has been subsequently filled by recent sediments. (Shoreline's Interpretation of data concurrently obtained from sparker and sidescan sonor.)

.../67


140° 00'
140° 30'
141° 00'
37° 45'
38° 00'
38° 15'
Geltwood Beach - 1
P.E.L. 22
E.P.P. 18
Burrungule - 1
P.E.L. 8
P.E.L. 22
P.E.P. 95
VAC.
S.A.
VIC.
Lake Bonney - 1
Malanganee - 4
Kentgrove - 1
Mt. Salt - 1
CO_2
Caroline - 1
P.E.P. 105
Arganaut - A1
VAC.
Palpara - 4
Douglas Point - 1
Reported Oil Seepage
Glenelg - 1
APROXIMATE COVERAGE OF 1600KM SNIFFER SURVEY
Breaksea Reef - 1
AREA OF MAIN PROPANE SNIFFER ANOMALIES (IN EXCESS OF 0·11 ppm)
VERY LARGE ANOMALY
BEACH PETROLEUM N.L.
P.E.L. 22
1980 SNIFFER SURVEY
E.P.P. 18
SCALE 1 : 500,000
KM. 5 0 5 10 15 20 25 KM.
Author: M. HARRISON
Date: DECEMBER 1983
Draftsman: N. REYNOLDS
Drg. No.: OT
X CLOUDS OF BUBBLES DETECTED BY SIDE SCAN SONAR.
Discovery Bay - 1
780
FIGURE XI - 4

XI. TIMING AND EVIDENCE OF HYDROCARBON MIGRATION - Continued

Main Observations Resulting from this Survey - Continued

C. Anomalies are discrete, the first cloud of bubbles was observed well before any anomaly was detected by the sniffer. (Note the first bubble cloud detected to the east of the very large anomaly, Figure XI-4.)

D. All anomalies had a relatively low level of Methane. Propane concentrations are nearly half those of Methane, which is a remarkedly high; a better result in fact than similar sniffer results in the Santa Barbara Channel, California which is an Oil Province. This should also be compared with sniffer results in the Gulf of California, a wet gas province, where Methane concentrations overwhelm Propane concentrations.

E. The relative amounts of Normal - Butane and Iso - Butane in the anomalies tends to suggest a mature source of the hydrocarbons.

Distribution of the Main Propane Anomalies

As summarized in Figure XI-4, there is a main area where propane anomalies were detected; propane anomalies outside of this area were present but were more scattered and of smaller concentrations. It is possible that large anomalies remained undetected outside the "main" anomalous area, however, if we accept the distribution in Figure XI-4 some relevant comments relating to structure and stratigraphy can be made which might explain this distribution:-

A. Argonaut No. 1 area. Lack of seal through most of the Paaratte Formation (Note Enclosure 16). Dilwyn Formation deposition appears to be more chaotic with successive progradation basinward onto the Base Tertiary horizon (Note Figure XIII-6). Faulting in the Argonaut No. 1 area is frequent with faulting commonly extending into the shallow Late Tertiary section. The Argonaut area has low potential for accumulation of hydrocarbons because of the above factors; generated hydrocarbons would remain dispersed as they migrate upward through the section.

.../69

XI. TIMING AND EVIDENCE OF HYDROCARBON MIGRATION - Continued

Distribution of the Main Propane Anomalies - Continued

B. Further north of Argonaut No. 1 the Cretaceous Section thins. The Eumeralla Formation, considered by this report to be the prime oil source would not be at a suitable depth for hydrocarbon generation. The deeper part of the Crayfish Formation, also recognised by this report as a significant source of oil would be sealed by a very thick Eumeralla Formation and Crayfish Formation Shale Sequence. (Note the Geltwood Beach No. 1 Otway Group Sequence.)

C. South of the main anomalous area the Belfast Mudstone is very thick as in Voluta No. 1. It is likely that the Belfast Mudstone is so thick that hydrocarbons generated in the underlying Eumeralla Formation would not migrate through the Belfast Mudstone despite the faulting through the sequence. The reason for the thick Belfast Mudstone relates not only to the thicker Sherbrook Group deposition in this area but also because of the persistent offshore paleogeography resulting in continuous Belfast Mudstone deposition for a proglonged period of time (Note Table VI-3). Waarre Formation reservoirs below this thick seal would be very deep.

D. The main anomalous area has positive attributes relating to hydrocarbon accumulation as follows:-

(a) greater seal potential on the Paaratte sequence overlying the Belfast Mudstone.

(b) Dilwyn Formation progradation is less chaotic and faulting into the Tertiary is less dramatic than in the Argonaut area.

(c) Upfault migration of Eumeralla Formation oil is not overly hindered by a thick Belfast Mudstone seal.

THE ONSHORE AREA

The lack of oil seeps onshore is not discouraging. Onshore the Dilwyn and Mepunga Formations are active confined aquifers. Their discharge areas appear to occur offshore probably up recent faults. The chemistry

XI. TIMING AND EVIDENCE OF HYDROCARBON MIGRATION - Continued

THE ONSHORE AREA - Continued

of these waters and those of the overlying Gambier Limestone aquifers differ and suggests that the Dilwyn Formation waters are sourced independently. The Gambier Limestone aquifers are in general unconfined. It is therefore concluded that the Dilwyn Formation aquifers are sufficiently confined over the onshore area to prevent migrated hydrocarbons reaching the surface in the great quantities that we see offshore. It is possible that at least a portion of the propane occurring offshore is derived from solution gas associated with Lower Dilwyn Formation aquifer discharge; this implying that sourcing of hydrocarbons is occurring at depth onshore.

XII. THE OCCURRENCE OF CARBON DIOXIDE IN THE GAMBIER EMBAYMENT

The occurrence of Carbon Dioxide in the Gambier Embayment represents a risk to exploration for hydrocarbons. It is suggested that Carbon Dioxide occurrence in reservoirs worldwide is in the main associated with volcanism, be it by volcanic emmissions or by volcanic intrusion into or near sediments with a carbon source. There were apparently two distinct phases of volcanism within the Gambier Embayment. The later Quarternary phase is of more importance in the study area and is limited in its extent. This phase of volcanism appears to relate to recent faulting. Exploration in the area can be designed to avoid CO_2 prone areas. Figure XII-1 summarises some of the important aspects of CO_2 occurrence.

COMMERCIAL ASPECTS OF CARBON DIOXIDE

In the United States of America established reserves of CO_2 are being increasingly utilized particularly with the development of enhanced oil recovery techniques (EOR), but also in other industries.

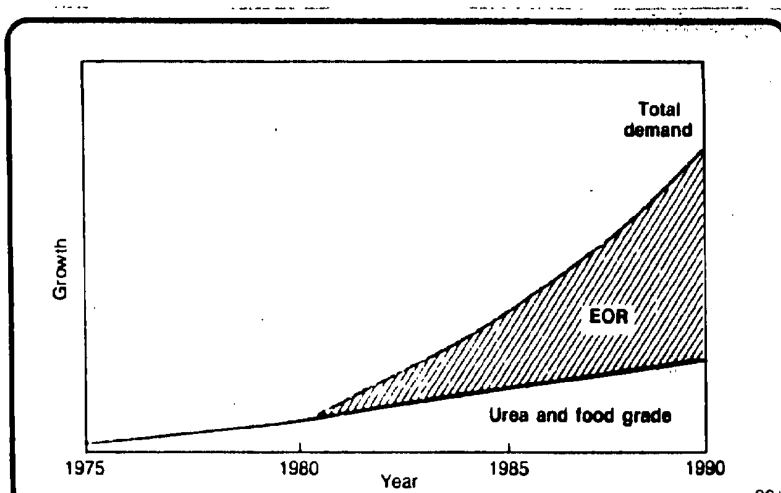
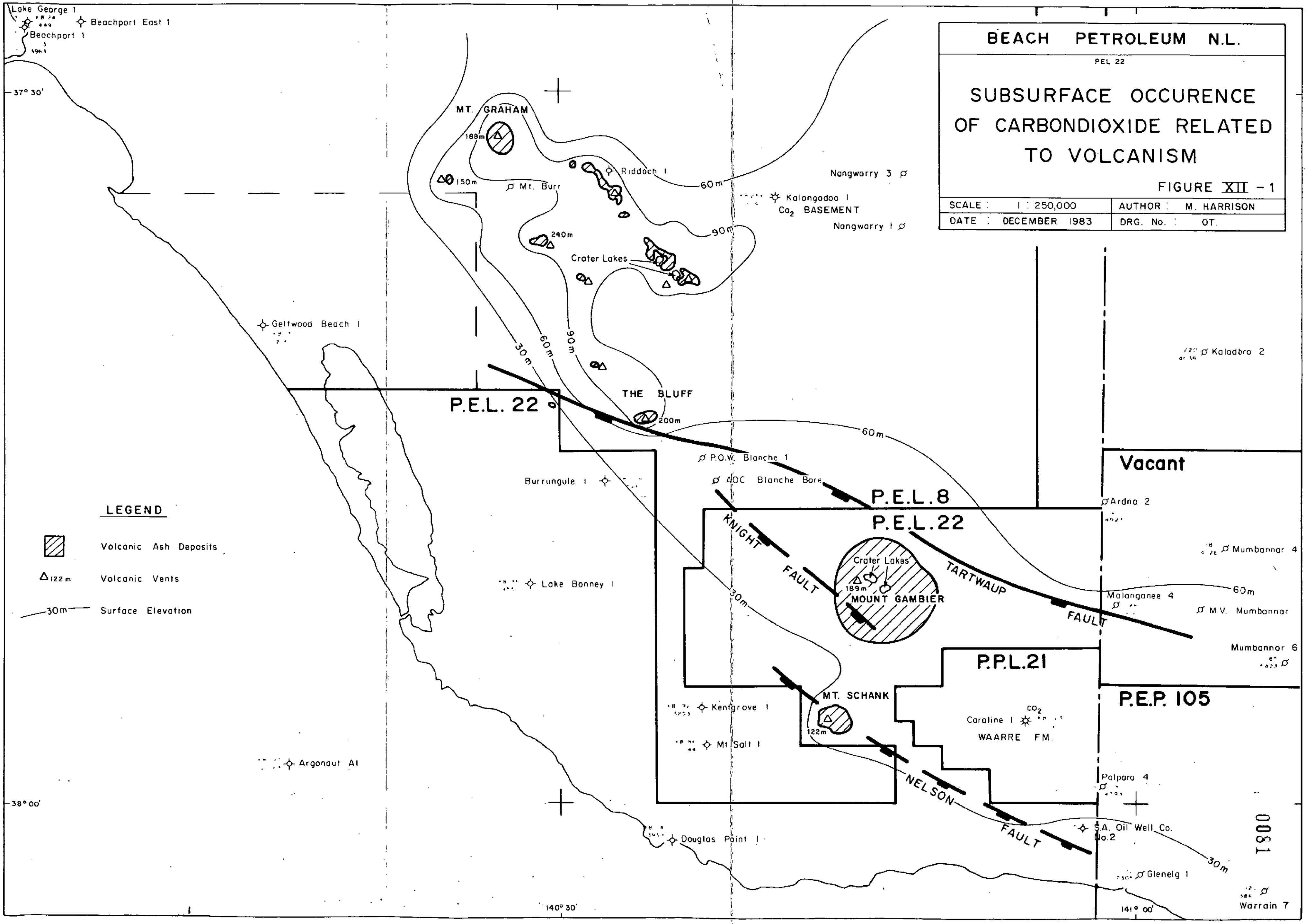


FIGURE XII-2

CO_2 Demand in the United States of America, OGJ. February 14, 1983.

With the CO_2 producing Caroline No. 1 well apparently satisfying the current market in the region it would obviously be premature to suggest exploring for CO_2. However, any significant reserves of CO_2 encountered



BEACH PETROLEUM N.L.
PEL 22
SUBSURFACE OCCURENCE OF CARBONDIOXIDE RELATED TO VOLCANISM
FIGURE XII - 1
SCALE : 1 : 250,000
AUTHOR : M. HARRISON
DATE : DECEMBER 1983
DRG. No. : OT.
LEGEND
Volcanic Ash Deposits
Volcanic Vents
Surface Elevation
Lake George 1
Beachport East 1
Beachport 1
37° 30'
38° 00'
140° 30'
141° 00'
MT. GRAHAM
188m
150m
Mt. Burr
Riddoch 1
60m
90m
240m
Crater Lakes
Nangwarry 3
Kalangadoo 1
CO_2 BASEMENT
Nangwarry 1
Geltwood Beach 1
30m
THE BLUFF
200m
P.E.L. 22
P.O.W. Blanche 1
AOC Blanche Bore
Burrungule 1
P.E.L. 8
P.E.L. 22
KNIGHT FAULT
TARTWAUP FAULT
MOUNT GAMBIER
189m
Vacant
Ardno 2
Kaladbro 2
Mumbannar 4
Malanganee 4
M.V. Mumbannar
Mumbannar 6
Lake Bonney 1
P.P.L. 21
P.E.P. 105
MT. SCHANK
122m
Kentgrove 1
Mt Salt 1
Caroline 1
CO_2
WAARRE FM.
Argonaut A1
Palpara 4
NELSON FAULT
S.A. Oil Well Co. No. 2
Douglas Point 1
Glenelg 1
Warrain 7
0081

XII. THE OCCURRENCE OF CARBON DIOXIDE IN THE GAMBIER EMBAYMENT - Continued

COMMERCIAL ASPECTS OF CARBON DIOXIDE - Continued

during drilling for hydrocarbons should be tested and the potential for future production should be assessed. Mud gas should be assessed for CO_2 content while drilling.

CURRENT CARBON DIOXIDE PRODUCTION FROM CAROLINE NO. 1

Caroline No. 1 currently produces 1.3 MMCFD of CO_2 from three perforated intervals within the Waarre Formation (8202'-8230', 9151'-9172' and 9303'-9321'). The well has been producing since early 1969 and production history to 1976 is summarised in Figure XII-3 (Mulready 1977).

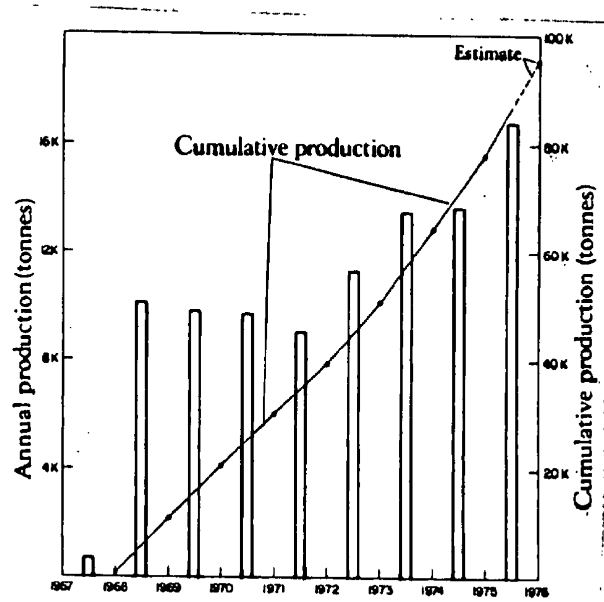


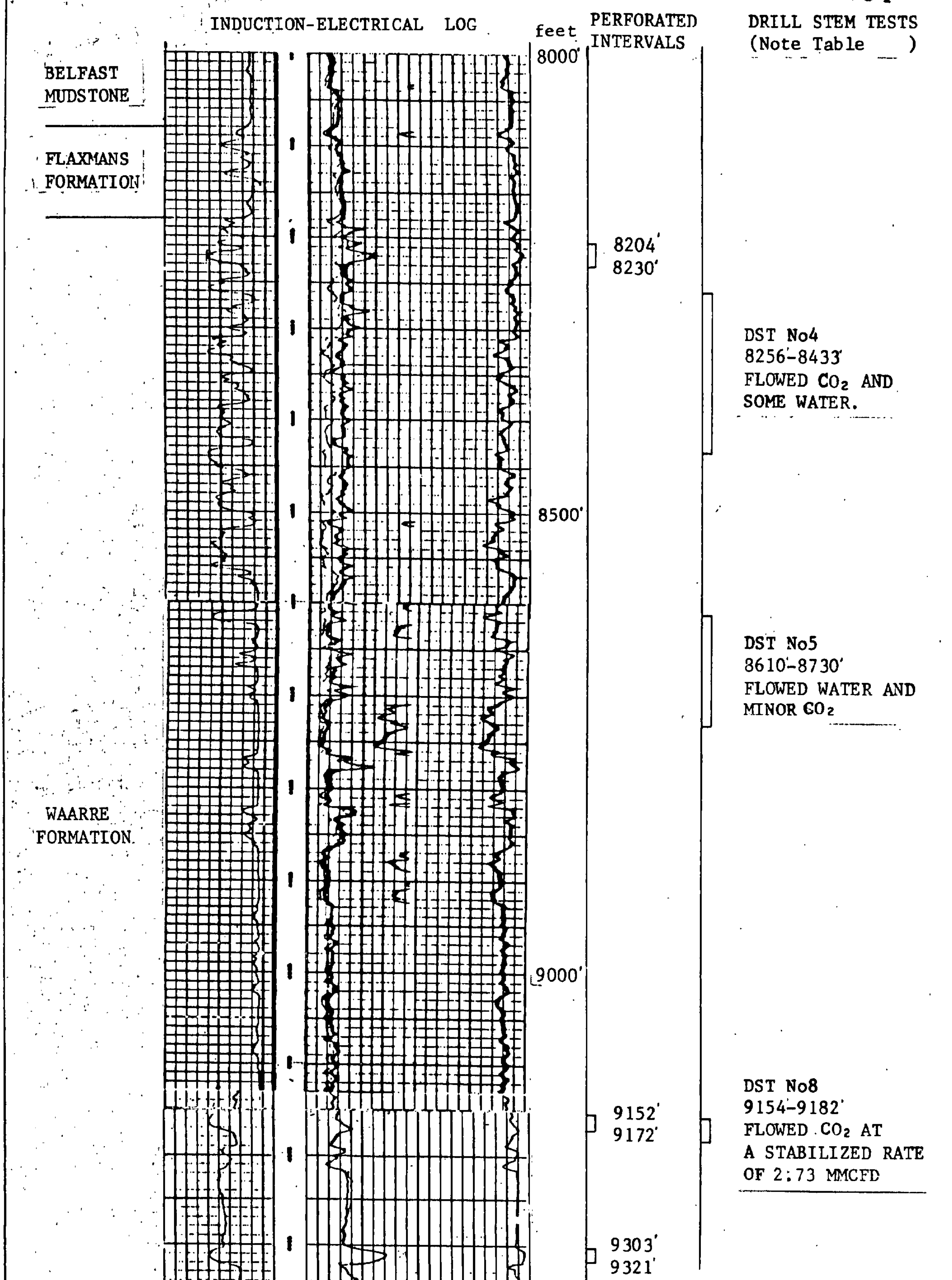
FIGURE XII-3 - PRODUCTION HISTORY, CAROLINE NO. 1

No measurable decline has been observed and corrosion problems have been minimal, presumably due to the lack of water produced with the CO_2. A summary log of the Caroline No. 1 CO_2 producing interval is included as Figure XII-4 and a summary of the original test results is included as Table XII-1.

TABLE XII-1

SUMMARY OF DRILL STEM TESTS - CAROLINE NO. 1

DST NO. 4	8,256 - 8,433 ft. Waarre Formation Unit 1	Non-combustible gas to surface in 7 mins RTSTM; flow increased to rate in excess of 800,000 CFD after 12 mins.; after 20 mins, gas was accompanied by slugs of mud and muddy salt water; after 40 mins. gas was accompanied by slugs of clean salt water. Flow rate estimated 2-3 MMCFD. Rec. 4,333 feet salt water separated by pockets of CO_2. Resistivity salt water 0.266 ohms at 68°F.
DST NO. 5	8,610 - 8,730 ft. Waarre Formation Unit 2	Non-combustible gas to surface in 20 mins at RTSTM; flow rate steady throughout first flow period. During 2nd flow period solution gas to surface immediately at 340,000 CFD, decreasing to 140,000 CFD after 5 mins. and TSTM after 7 mins. Recovered 279 feet gas-cut, watery mud and 6,603 feet gascut salt water (0.341 ohms at 58°F).
DST NO. 8	9,154 - 9,182 ft. Waarre Formation Unit 4	Non-combustible gas to surface in 2 mins at RTSTM. Flow rate increased to 1.54 MMCFD after 17 mins. and to 2.29 MMCFD at end of first flow period. During 2nd flow period gas stabilized at 2.73 MMCFD. Flow rates were then restricted to ¼, ½ and 3/4 of stabilized flow rate for periods of one hour. The well was then flowed without restriction for the duration of the test. During this period the flow rate stabilized at 2.495 MMCFD.



CAROLINE No.1

DRILL STEM TESTS AND PERFORATED INTERVALS

FIGURE XII - 4

XII. THE OCCURRENCE OF CARBON DIOXIDE IN THE GAMBIER EMBAYMENT - Continued

OTHER OCCURRENCES OF CARBON DIOXIDE IN THE GAMBIER EMBAYMENT

The other major occurrence of CO_2 within the Gambier Embayment was in the Kalangadoo No. 1 well drilled in 1965. The CO_2 occurred in fractured and sheared dolomitic sandstone and shale which are thought to be of Palaeozoic age and are considered to be basement. Nine Open Hole Drill Stem Tests were conducted through the interval, only two were successful due to the extensive fracturing and thus caving of the formation. The results of DST's. No. 7 and No. 14 are included as Table XII-2. The results of both these tests were not conclusive due to on-site problems. The conclusion reached, however, was that the reservoir was substantially depleted during testing.

An old shallow well, South Australia oil wells No. 2 drilled in 1915 was reported to have encountered inflameable gas at 1321 ft/403 m in the Dilwyn Formation.

OTHER OTWAY BASIN CARBON DIOXIDE OCCURRENCES

In the Port Campbell Embayment in the Eastern Otway Basin several wells have recorded CO_2 (Note Figure XII-5). Within the petroleum gas reserve established on the Port Campbell High a variable CO_2 content is present ranging from 0.28% at North Paaratte No. 1, 2% at Wallaby Creek No. 1, 14% at Port Campbell No. 1 and 51% at Grumby No. 1. North of this area, analysis of a gas sample collected from gas cut salt water recovered in DST No. 1 at Garvoc-1 was analysed as 96.7% CO_2. This test was in the Lower Cretaceous, Pretty Hill Sandstone. Near the town of Warrnambool in Victoria pump tests of aquifers in two government bores produced CO_2 cut water from the Pebble Point Formation at Wangoom-2 and from the Dilwyn Formation at Mepunga-7.

THE ORIGIN OF CARBON DIOXIDE IN THE GAMBIER EMBAYMENT

Aside from petroleum gas, CO_2 is the most common gas found to accumulate in subsurface traps. CO_2 can be formed by numerous methods in the subsurface.

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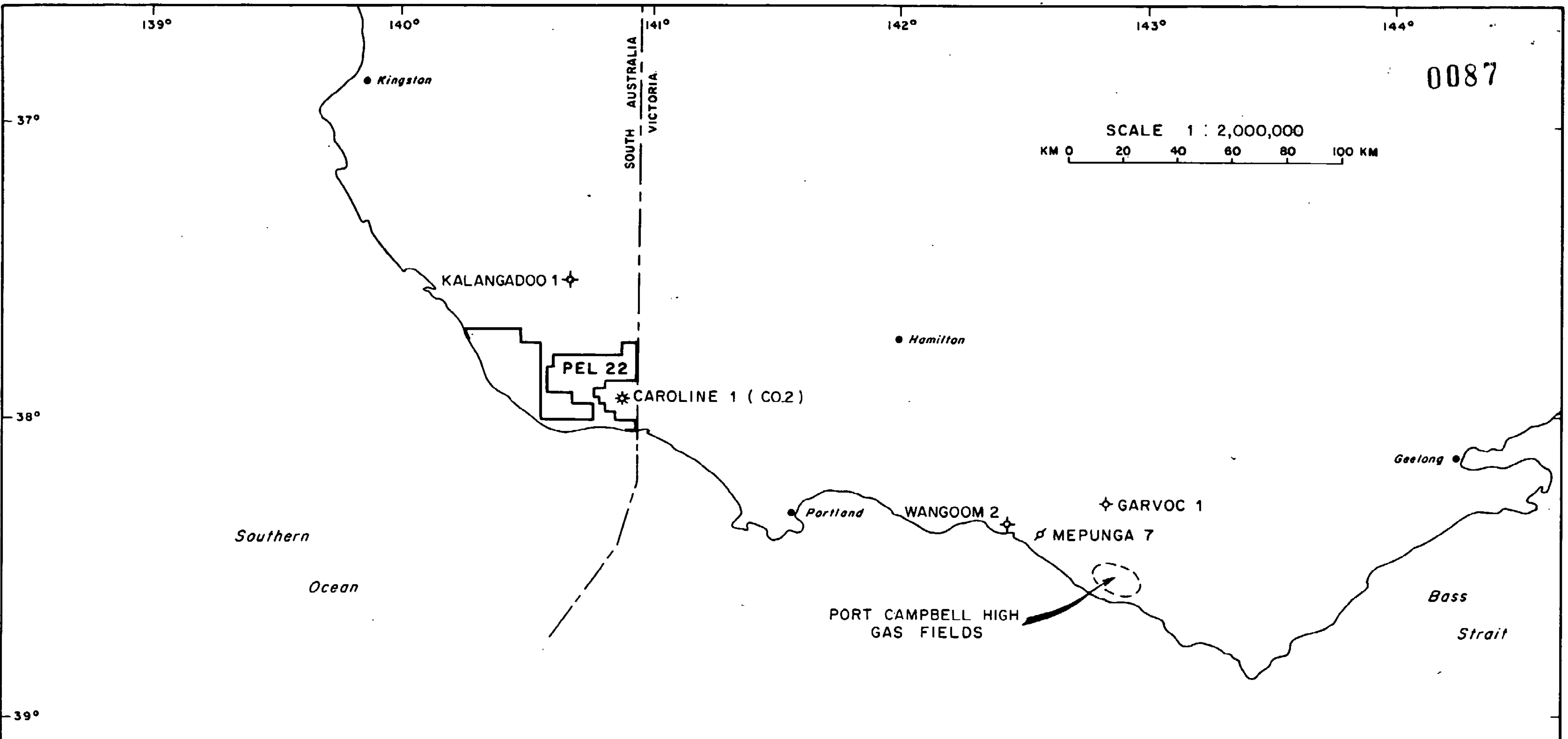
TABLE XII-2

KALANGADOO NO. 1

DST NO. 7	6,890 - 7,005 ft.	Non-combustible gas to surface in 6 mins at max. rate of 1.55 MMCFD. Packer began to fail after 10 mins. and flow rate decreased after 20 mins. Misrun. Test was of insufficient duration to permit collection of uncontaminated samples or to provide enough data for the determination of reservoir parameters.
DST NO. 14	6,730 - 7,010 ft.	Non-combustible gas to surface 43 mins after initial opening at max. rate of 686,000 CFD. testing head partly plugged. Obstruction was cleared and gas flow reached max. of 2.68 MMCFD (with mud slugs) during 2nd flow period.



BEACH PETROLEUM N.L.

OTWAY BASIN

LOCATION OF WELLS WITH SIGNIFICANT CO_2 SHOWS

FIGURE XII - 5

XII. THE OCCURRENCE OF CARBON DIOXIDE IN THE GAMBIER EMBAYMENT - Continued

THE ORIGIN OF CARBON DIOXIDE IN THE GAMBIER EMBAYMENT - Continued

The occurrence of relatively high proportions of CO_2 in natural gas (10% +) accumulations in the subsurface is in general related to the presence of volcanism in the area of such accumulations, whether it be that the CO_2 is derived from volcanic emanations or by the effect of heat on carbonates or perhaps organic material. That volcanic activity is recent in the Mount Gambier region and that CO_2 is a common occurrence through the entire stratigraphic sequence I believe go hand in hand.

VOLCANISM IN THE GAMBIER EMBAYMENT

Volcanism in the Gambier Embayment is of a similar age to that of the "Newer Volcanics" of Victoria where extensive lava flows and volcanic vents outcrop between the Portland area and Melbourne. This volcanism is mainly plio-pleistocene in age but there is a recent phase which appeared to terminate 1400 years BP. The Plio-Pleistocene and recent phases of volcanism are differentiated.

A. PLIOCENE (?) (See Figure XII-1)

This phase is represented by the volcanic vents which occur between Bluff and Mount Graham. This activity presumably resulted in the CO_2 at Kalangadoo No. 1. This group of vents has been affected the high sea level of the Pleistocene, and therefore this volcanism preceded this ingression (Filman 1969). An earlier shallow well, Riddock No. 1 encountered basalt in the Dilwyn Formation between 315'-459' which suggests the "Older Volcanics" of Victoria were also present in this area. It is important to recognise that this phase of volcanism occurs in an area updip from thicker Tertiary and Upper Cretaceous deposition and that these volcanics intruded up high angle north-west trending faults. It is therefore unlikely that this phase of volcanism has resulted in the accumulation of CO_2 within prospective Tertiary and Upper Cretaceous sediments to the south.

.../80

XII. THE OCCURRENCE OF CARBON DIOXIDE IN THE GAMBIER EMBAYMENT - Continued

VOLCANISM IN THE GAMBIER EMBAYMENT - Continued

B. RECENT

Two recent volcanic vents are located in the Gambier Embayment. These are the Mount Gambier and Mount Schank features, the former has crater lakes and the latter is a well preserved ash cone. Ash from Mount Gambier has been dated as 4700 years and 1400 years old (Filman, 1969). Sprigg (1959) described possible lava flows offshore from Beachport in the north which are located near the epicentres of earthquakes which occurred in 1897 and 1948.

The Mount Gambier and Mount Schank features occur in an area where a thick Upper Cretaceous and Tertiary section is present and through which these volcanics have intruded. These are ash cones with no significant lava flows.

The recent Knight and Nelson Faults, evident in outcrop, appear to relate to the Mount Gambier and Mount Schank features and the CO_2 accumulation at Caroline No. 1. The Bluff volcanic cone relates to recent faulting along the north of and associated with the Tartwaup Fault Zone so it appears that the pre-Pleistocene phase of volcanism is also related to late stage faulting.

CONCLUSION

Figure XII-6 illustrates the areas which are most likely to be CO_2 prone. The area of recent volcanism is more likely to be CO_2 prone as these volcanics have intruded through a thick pile of sediments. The earlier phase of volcanism to the north of the Tartwaup Fault is less likely to have generated large quantities of CO_2 as it intruded a thinner sedimentary pile and furthermore is located up-dip from a thick Upper Cretaceous section. The area to the east has more evidence of recent faulting which can be tied to recent volcanism. While the eastern area

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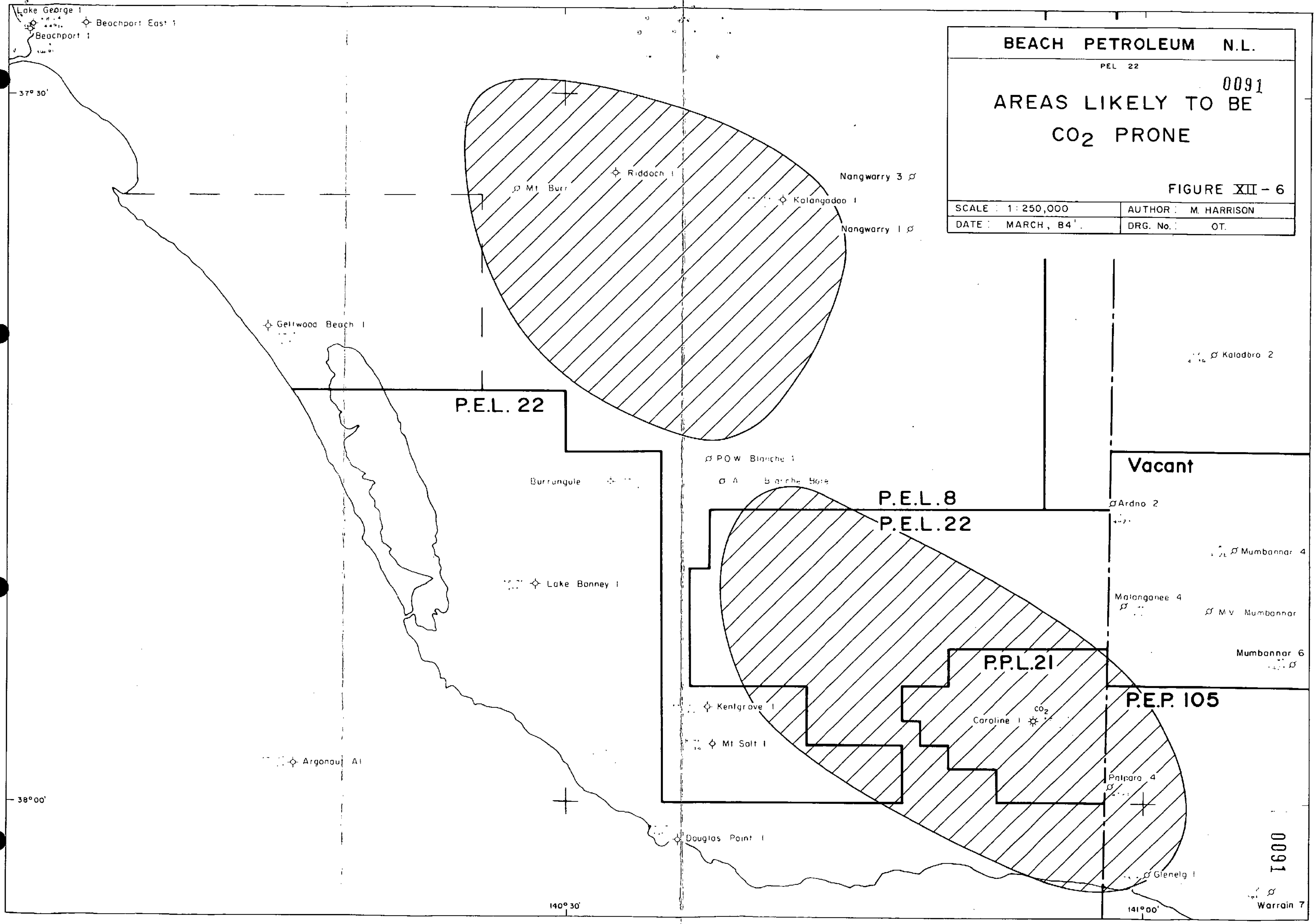
XII. THE OCCURRENCE OF CARBON DIOXIDE IN THE GAMBIER EMBAYMENT - Continued

CONCLUSION - Continued

of P.E.L. 22 must be considered to have a greater risk of CO_2 accumulation in traps, the concept that CO_2 injection into traps containing oil will tend to diplace such oil up-dip, should be given consideration.


BEACH PETROLEUM N.L.
PEL 22
0091
AREAS LIKELY TO BE
CO_2 PRONE
FIGURE XII - 6
SCALE : 1 : 250,000
AUTHOR : M. HARRISON
DATE : MARCH, 84'.
DRG. No. : OT.
Lake George 1
Beachport East 1
Beachport 1
37° 30'
38°00'
140° 30'
141°00'
Mt Burr
Riddoch 1
Kalangadoo 1
Nangwarry 3
Nangwarry 1
Geltwood Beach 1
P.E.L. 22
P.O.W. Blanche 1
Blanche Bore
Burrungule
P.E.L. 8
P.E.L. 22
Vacant
Ardno 2
Kalabro 2
Mumbannar 4
Malanganee 4
M.V. Mumbannar
Mumbannar 6
Lake Bonney 1
P.P.L. 21
P.E.P. 105
CO_2
Caroline 1
Kentgrove 1
Mt Salt 1
Argonaut A1
Palpara 4
Douglas Point 1
Glenelg 1
Warrain 7
0091

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA

Only six oil exploration wells have been drilled within the study area, all were dry and drilled between 1962 and 1976. This chapter looks at the reasons why these wells and wells adjacent to the study area were dry. Tabled below are some basic details of the wells discussed in this chapter. Figure XIII-1 illustrates the Gambier Embayment Study Area and well locations.

OPERATOR	WELL NAME	T.D. METRES	T.D. FORMATION	YEAR DRILLED
Oil Development	Mount Salt No. 1	3061	Waarre	1962
Beach	Geltwood Beach No. 1	3749	Crayfish	1963
Alliance	Kalangadoo No. 1	2758	Basement	1965
Alliance	Caroline No. 1	3371	Eumeralla	1967
Esso	Argonaut No. 1	3707	Waarre	1968
Alliance	Lake Bonney No. 1	2911	Eumeralla	1969
General Exploration	Douglas Point No. 1	1207	Paaratte	1973
Alliance	Burrungule No. 1	2438	Eumeralla	1975
Shoreline	Kentgrove No. 1	992	Paaratte	1976

Each of the above wells will be discussed under the following headings:-

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

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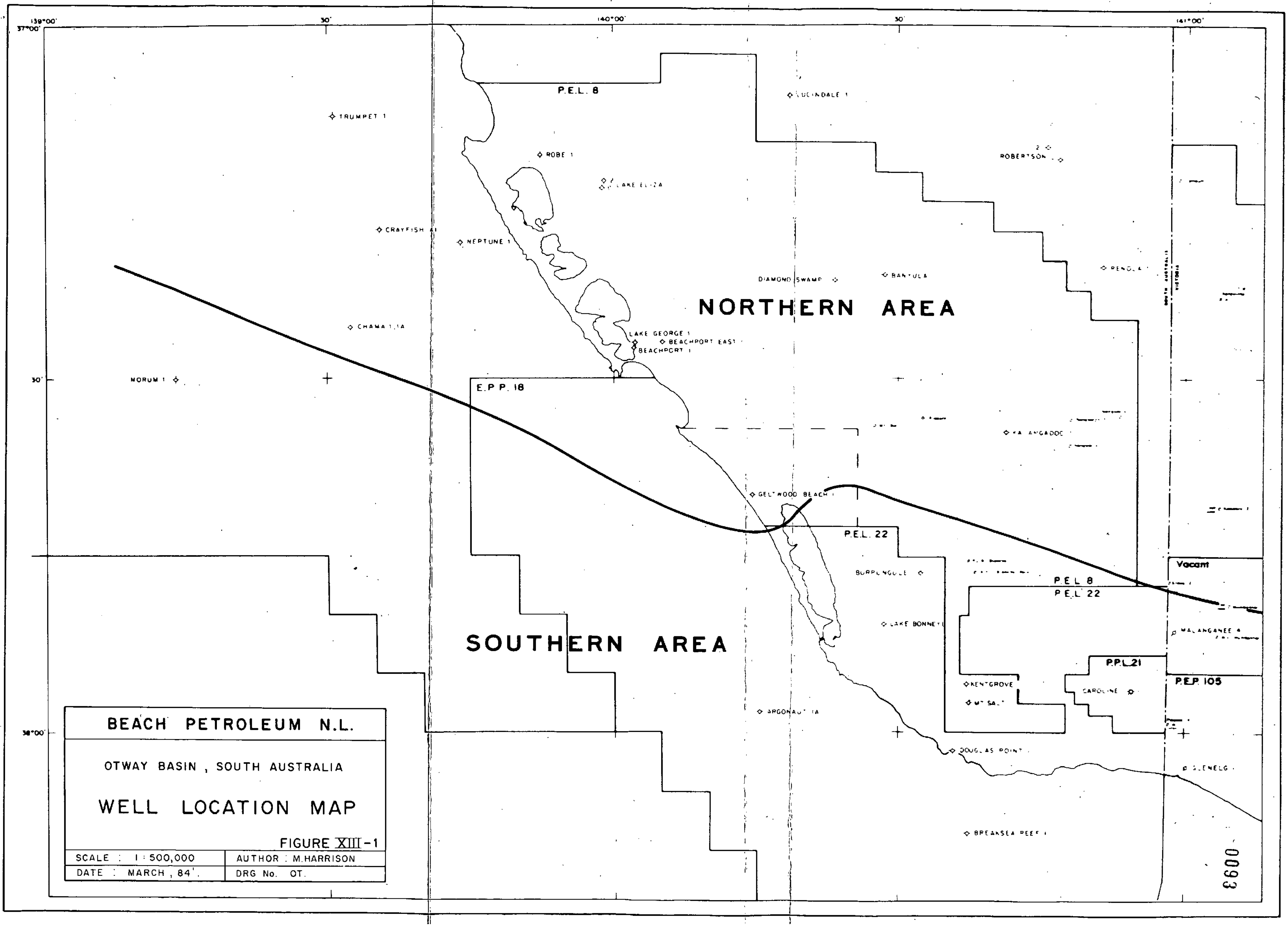

BEACH PETROLEUM N.L.

OTWAY BASIN , SOUTH AUSTRALIA

WELL LOCATION MAP

FIGURE XIII -1

SCALE : 1 : 500,000	AUTHOR : M.HARRISON
DATE : MARCH , 84'.	DRG No. OT.

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

MOUNT SALT PROSPECT

Seismic

No seismic was recorded prior to the drilling of this prospect in 1962. Line AT-1 of the 1970 Gambier Trough Seismic Survey and Line TC of the 1973 Tartwaup Seismic Survey were recorded through the Mount Salt Prospect.

Type of Structure

The Mount Salt structure was defined by the surface mapping of the Gambier Limestone which is exposed over the structure. A shallow drilling program of five 300 m wells tended to confirm a closed anticline at shallow depth. (Note Figure XIII-2.)

Results of Drilling

Mount Salt No. 1 penetrated a normal Tertiary section and a thick section of Upper Cretaceous sediments possibly reaching the Waarre Formation (?) at total depth. Some hydrocarbon indications were noted:-

(a) On-site, evaluation of the well does not appear to have been of high standard. The well was drilled overbalance with 10.3 - 10.6 lb/gal. mud. The "hydrogen flame gas detector" was apparently inoperative above 5,000 ft. (Willis, 1973. Appendix III.) Below this depth a minor gas show (0.35% total gas in air) was recorded during the cutting of Core 32. A DST over this interval (Open Hole, 9,813 - 9,892') recovered salt water (Total Salinity 39,450 ppm) which would have flowed to the surface had the tool remained open longer.

(b) The B.M.R. conducted acetone solvent tests on the cores cut. (W.C.R. Appendix 4) No description of their method is available but one result stands out as being very important. From 998' to 998'4", a portion of Core No. 1 was described as having a "strongly

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KNIGHT GROUP E-LOG MARKER

	STRUCTURE HOLE Nos.				
	1	2	3	4	5
ELEVATION OF ROTARY TABLE	+76	+75	+76	+75	+76
WELL DEPTH TO MARKER	735	560	840	655	808
SUBSEA DEPTH TO MARKER	-659	-485	-764	-582	-732

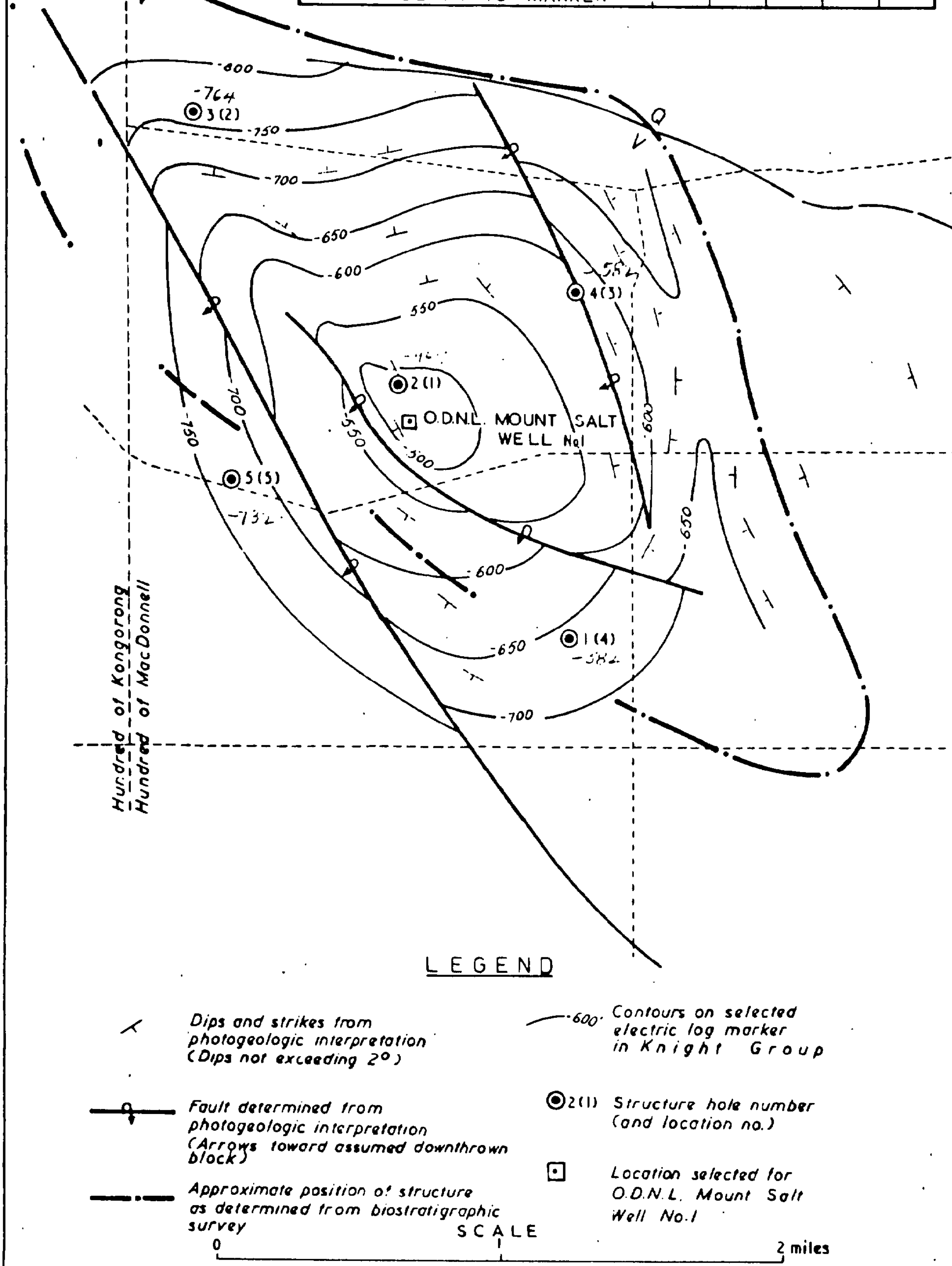

FIGURE XIII-2 - PRE-DRILL STRUCTURAL INTERPRETATION
MOUNT SALT NO. 1

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

MOUNT SALT PROSPECT - Continued

Results of Drilling - Continued

positive acetone test" (for oil), giving a "strong bluish white solvent fluorescence". This would indicate that oil has migrated into the Dilwyn Formation.

(c) The B.M.R. tests from Core 28, 7,942 - 7,942'3"; Core 29, 8,425 - 8,425'4" and Core 33, 9,951 - 9,851'4" were also reported as giving natural cut; "faint colour and slight bloom in solvent" and "green yellow in solvent". Inexplicably fluorescence of the extracts was not determined. Core 33 was cut directly below the gas show mentioned in point (a).

(d) An optimistic log interpretation of the Pebble Point Formation suggests that this interval was hydrocarbon bearing, however, this may be a matrix effect only.

Why Was Mount Salt No. 1 Dry?

The well was dry because indicated surface structure did not persist with depth. Line TC (Enclosure 20) shot 11 years after the drilling of the well clearly demonstrates that the indicated surface structure does not persist at depth.

GELTWOOD BEACH PROSPECT

Seismic

The Mayurra Seismic Survey conducted by Beach Petroleum in 1962 suggested the presence of an Anticline at the presumed Base Tertiary Horizon. (Note Figure XIII-3.) Seismic coverage was sparce and only shallow reflectors were mappable from the single fold wiggle trace records. Because of this nine structure holes were drilled to confirm the structure inferred from seismic. These wells were drilled into the upper portion of the Dilwyn Formation and a Base Gambier Limestone map was prepared (Note Figure XIII-4).

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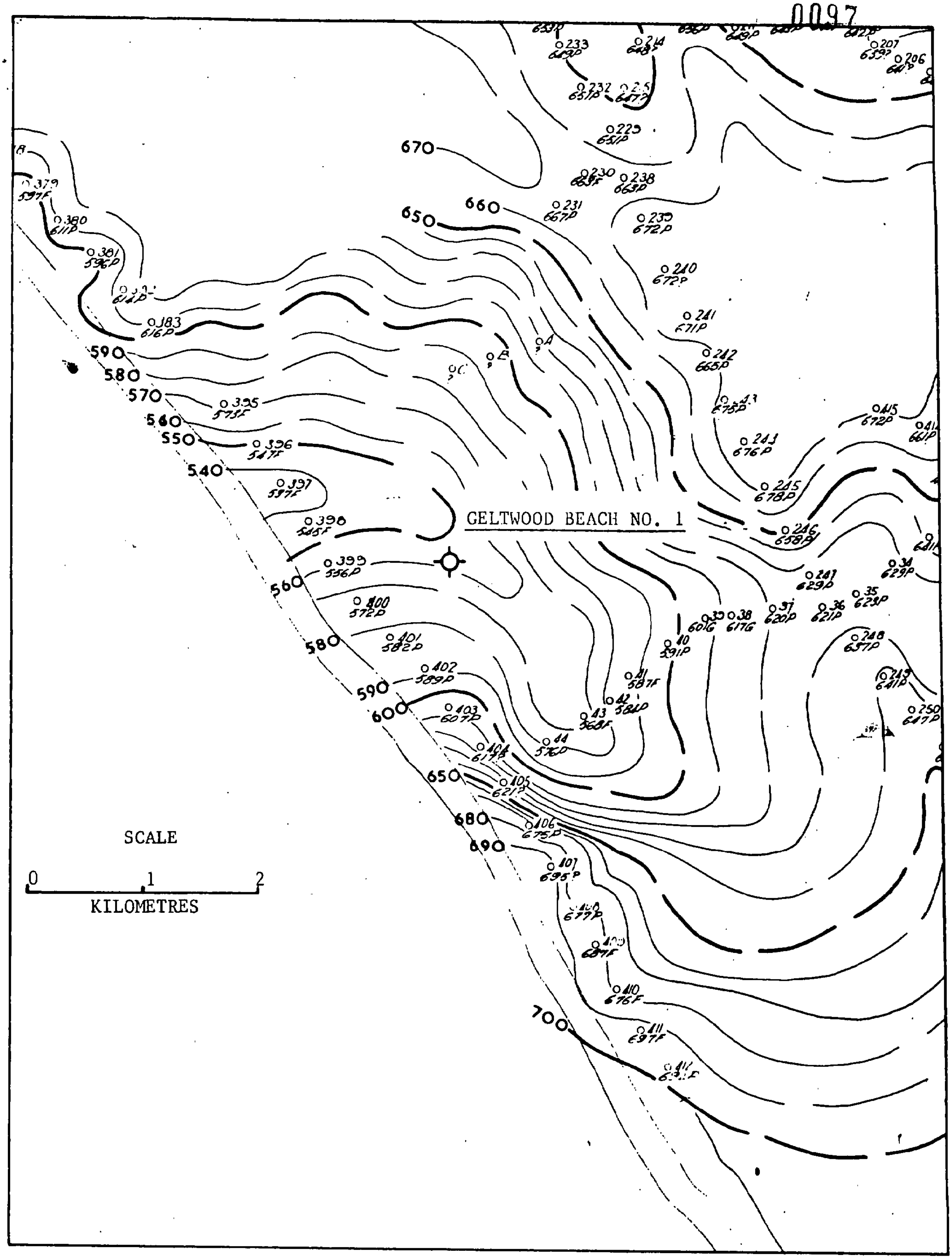

FIGURE XIII-3

GELTWOOD BEACH PROSPECT TIME STRUCTURE MAP
AT TENTATIVE BASE OF TERTIARY

August 1962

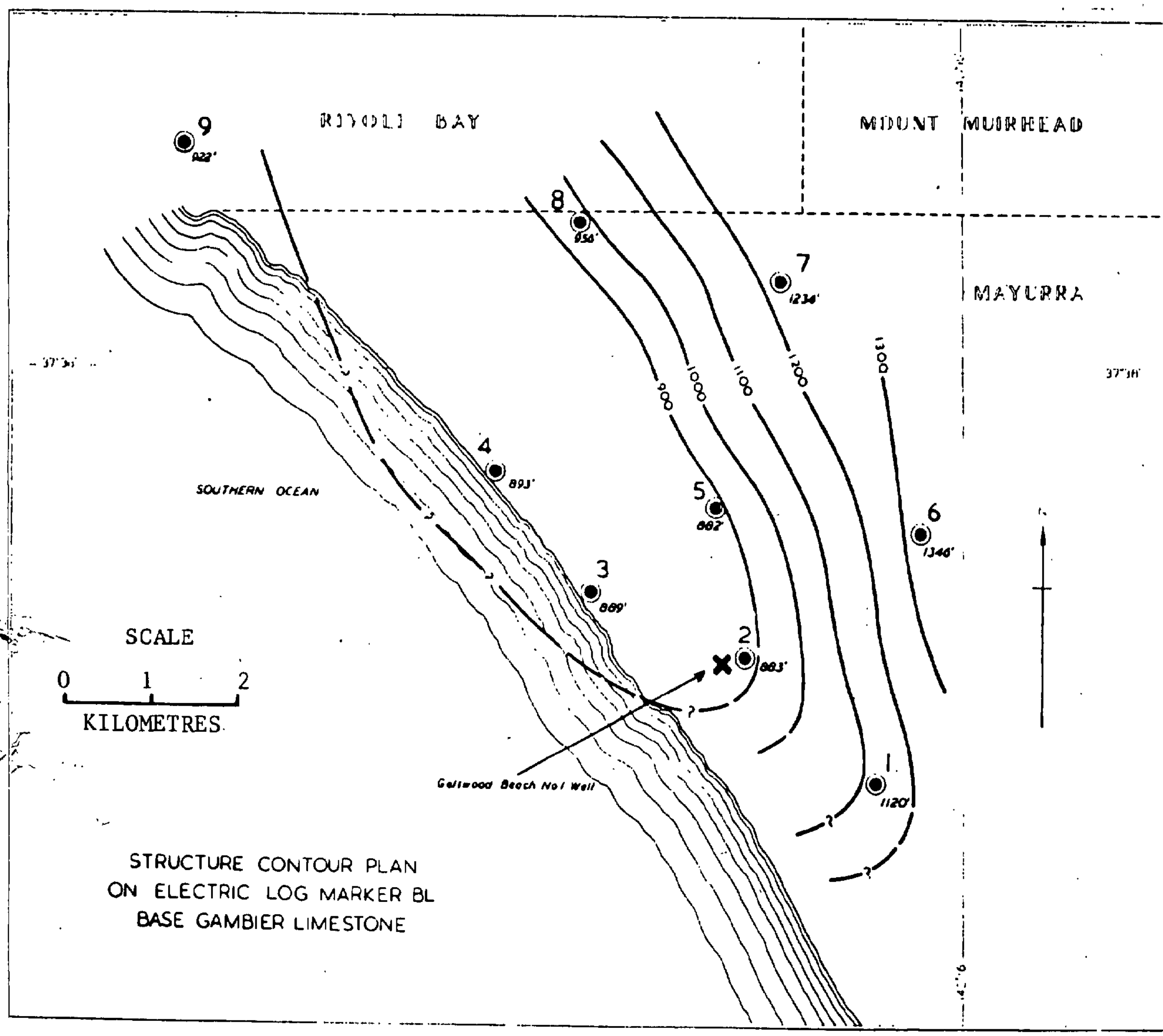

FIGURE XIII-4

GELTWOOD BEACH PROSPECT

STRUCTURE BASED ON STRUCTURE HOLE DRILLING PROGRAM

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

GELTWOOD BEACH PROSPECT - Continued

Type of Structure

The Geltwood Beach prospect was interpreted as an anticline at the Base of the Tertiary with a possible vertical closure of 100 ft/30 m. The anticline as mapped plunges to the south-east.

Results of Drilling

Geltwood Beach No. 1 intersected the Eumeralla Formation at 3,985'/ 1,215 m after drilling through a comparatively thin Upper Cretaceous and Tertiary section where excellent reservoirs were encountered. It is also noteworthy that there was excellent sealing potential within the Dilwyn Formation. Within the Eumeralla Formation a significant interval of shows occurred between 4,507' and 6,150' (1,373.7 m and 1,987.5 m) consisting of gas shows in the mud during drilling, gas cut fluid recovery from the three DST's conducted through the interval and minor dull gold fluorescence and "gas popping" in cores. Chromatographic analysis on a gas sample from DST No. 3, 4,982' - 5,054' (1,518.5 m - 1,540.5 m) was as follows; Air 5%, Methane 92.0%, Ethane 1.6%, Propane 1.4%, ISO Butane 45 ppm and Normal Butane 40 ppm. Another significant result was that DST No. 2, 4,708' to 4,780' (1,435.0 m - 1,457.0 m) recovered 3,330' (1,082 m) of fluid in 40 minutes from this generally tight formation. The Geltwood Beach Member of the Crayfish Formation was encountered from 8,955' (2,729.5 m) to a depth of 12,300' (3,449 m). Gas shows were encountered between 8,750' to 9,075' (2,667.0 m - 2,766.1 m) and 9,600' to 9,750' (2,919.4 m to 2,965 m). Below 10,000' (3,048 m) minor gas shows and dull fluorescence which yielded a slow cut were noted in the sandstones.

Why Was Geltwood Beach No. 1 Dry?

Even from various structure maps produced at the time of drilling there is a strong suggestion that the Geltwood Beach Prospect was not closed to the north west at the mappable shallow horizons. It was assumed before drilling that anticline mapped would persist and be enhanced

.../ 91

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

GELTWOOD BEACH PROSPECT - Continued

Why Was Geltwood Beach No. 1 Dry? - Continued

with depth, however it is now clear from our understanding of the area that folding in the shallow horizons relates to later wrenching and does not indicate comparable structuring in the deeper Cretaceous or even Tertiary horizons.

KALANGADOO PROSPECT

Seismic

Only one poor quality seismic line recorded during the 1964 Penola Seismic Survey traverses the prospect. Useable reflections were not obtained below 3,000'/900 m. Interpretation of this data and gravity data defined the prospect.

Type of Structure

The Kalangadoo Prospect is located on a large basement feature on a trend separating the Penola Trough to the north from the main basin development to the south.

Results of Drilling

Kalangadoo No. 1 penetrated the entire Tertiary - Cretaceous sequence which, except for the Tertiary section was relatively thin. Basement was encountered at 6,765'/2,062 m and consisted of steeply dipping sandstone with minor shales, apparently fractured extensively to a depth of 7,170'/2,185 m. Carbon dioxide flowed to the surface on DST in this interval. The results of the testing program were not accurate due to the down hole and mechanical problems. The conclusion reached was that the reservoir was largely depleted during testing. These results are further discussed in Section XII of this report.

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

KALANGADOO PROSPECT - Continued

Why Was Kalangadoo No. 1 Dry?

Closure of the shallow Tertiary and Upper Cretaceous sediments cannot be demonstrated with existing data. The apparent fractured basement reservoir containing CO_2 may be closed, but the distribution of presumed fault related fractures is unknown.

CAROLINE PROSPECT

Seismic

The Caroline Prospect was initially located by a detailed gravity survey, the Caroline-Killanoola Gravity Survey of 1966. Shortly thereafter, a seismic survey of the same name was recorded with most attention being placed on the Caroline Gravity Anomaly. Even by 1966 standards the quality of the single-fold data recorded over the prospect was poor.

Only one horizon was mapped, Phantom Horizon 'X' which approximates the Base of Tertiary (Note Figure XIII-5). The resultant mapped closure had a relief of 400 ft/120 m and an area of 23 square kilometres. Subsequently a single line TD of the Tartwaup Seismic Survey (1973) was recorded over the prospect, but again the data was of poor quality.

Type of Structure

Although the structure is mapped as a relatively simple dome, this is highly unlikely if you consider the regional structural setting. It is perhaps more likely that the structure is a large upthrown block. According to the 1966 Seismic interpretation it was relatively easy to establish dip to the east, west and north of the structure while southerly dip was difficult to establish. This may suggest closure of the Caroline structure is controlled to the south

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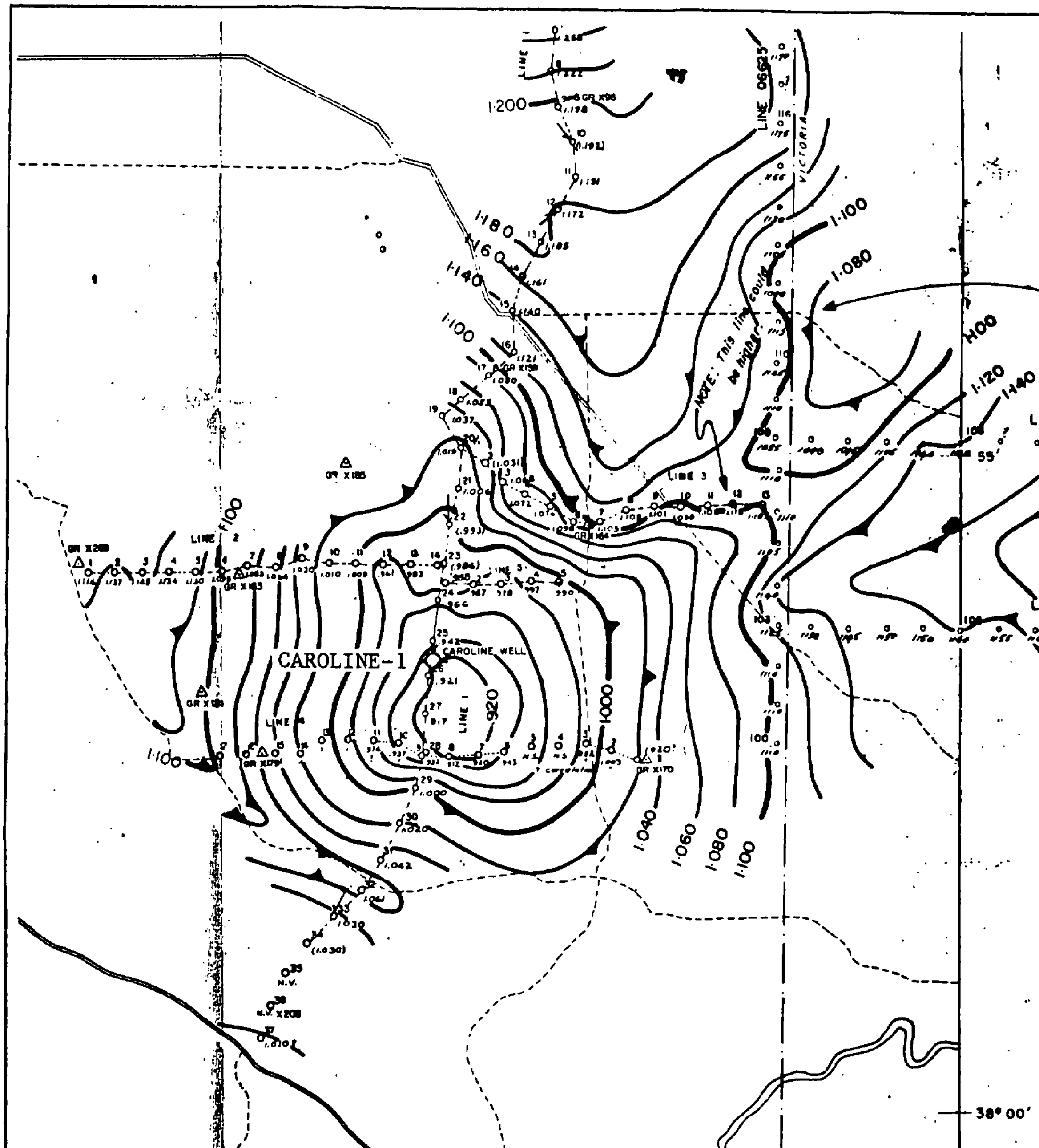

FIGURE XIII-5

CAROLINE PROSPECT

TIME STRUCTURE MAP ON PHANTOM HORIZON 'X'

NAMCO, 1966

SCALE - 1 inch : 2 miles

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

CAROLINE PROSPECT - Continued

Type of Structure - Continued

by a fault of significant throw. Gravity does indicate that basement is relatively shallow compared to the area adjacent to the Caroline Prospect. Structure specific to Waarre, Upper Cretaceous and Basal Tertiary traps can only be guessed at.

Results of Drilling

Caroline No. 1 penetrated a thick Tertiary and Upper Cretaceous Section and was drilled into the Lower Cretaceous Otway Group. The Waarre Formation was found to contain Carbon Dioxide in commercial quantities. The Carbon Dioxide was accompanied by minor quantities of hydrocarbon gas which averaged 1% of the total gas composition in the three gas samples analysed. (Note Table XIII-1.) Butane (C4) was detected in two of the samples. The relevance of the occurrence of Carbon Dioxide is discussed more fully in Section XII of this report.

No shows were recorded in the sediments above the Belfast Formation. Both the Transition Unit of the Dilwyn Formation and the Pebble Point Formation were tested and yielded brackish water.

TABLE XIII-1

CAROLINE NO. 1 - GAS SAMPLE EVALUATION

	PERCENTAGE COMPOSITION OF TOTAL GAS SAMPLE*		PERCENTAGE COMPOSITION OF HYDROCARBON FRACTION				
Gas Sample Collected	CO_2	HYDROCARBON	C1	C2	C3	IC4	NC4
DST #1, 8,256-8,433 ft.	97.5%	1.353%	96.82	2.22	0.81	0.074	0.074
DST #5, 8,610-8,730 ft.	99.1%	0.808%	91.58	4.83	2.72	0.37	0.50
DST #8 9,154-9,182 ft.	98.6%	0.939%	99.04	0.64		0.32	

* Balance includes traces of Nitrogen, Hydrogen and Helium.

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

CAROLINE PROSPECT - Continued

Why Was Caroline No. 1 Dry?

The occurrence of Carbon Dioxide in the Waarre Formation indicates that the Caroline structure is closed at this level. Carbon Dioxide may have displaced any entrapped hydrocarbons within the Waarre reservoir. Without reasonable seismic it is difficult to say whether the post Waarre Horizons were on structure.

ARGONAUT PROSPECT

Seismic

The Argonaut Prospect was defined by the seismic surveys recorded by Esso in 1967. The structure was well defined at the Base Tertiary level. In 1981 Shoreline recorded a single line through Argonaut A-1. This line SH-81-06 (Note Figure XIII-6) clearly illustrates to intensity of faulting in the Argonaut area.

Type of Structure

The Argonaut Prospect is a tilted fault block. Closure is controlled to the south by a down to the basin fault of significant throw. The pre-Tertiary sediments dip strongly to the north.

Results of Drilling

The Tertiary Dilwyn Formation encountered in this well is not easily correlated with the equivalent section onshore. It is apparent that the Dilwyn rapidly progrades seaward in this area and seismic shows that time lines within the Dilwyn Formation clinoform rapidly seaward. Sandstone predominated through the Curdies/Paaratte interval. The Belfast interval was thick (1,580'/482 m). The well bottomed in Waarre Formation, the sandstones of which were noted to be less porous and

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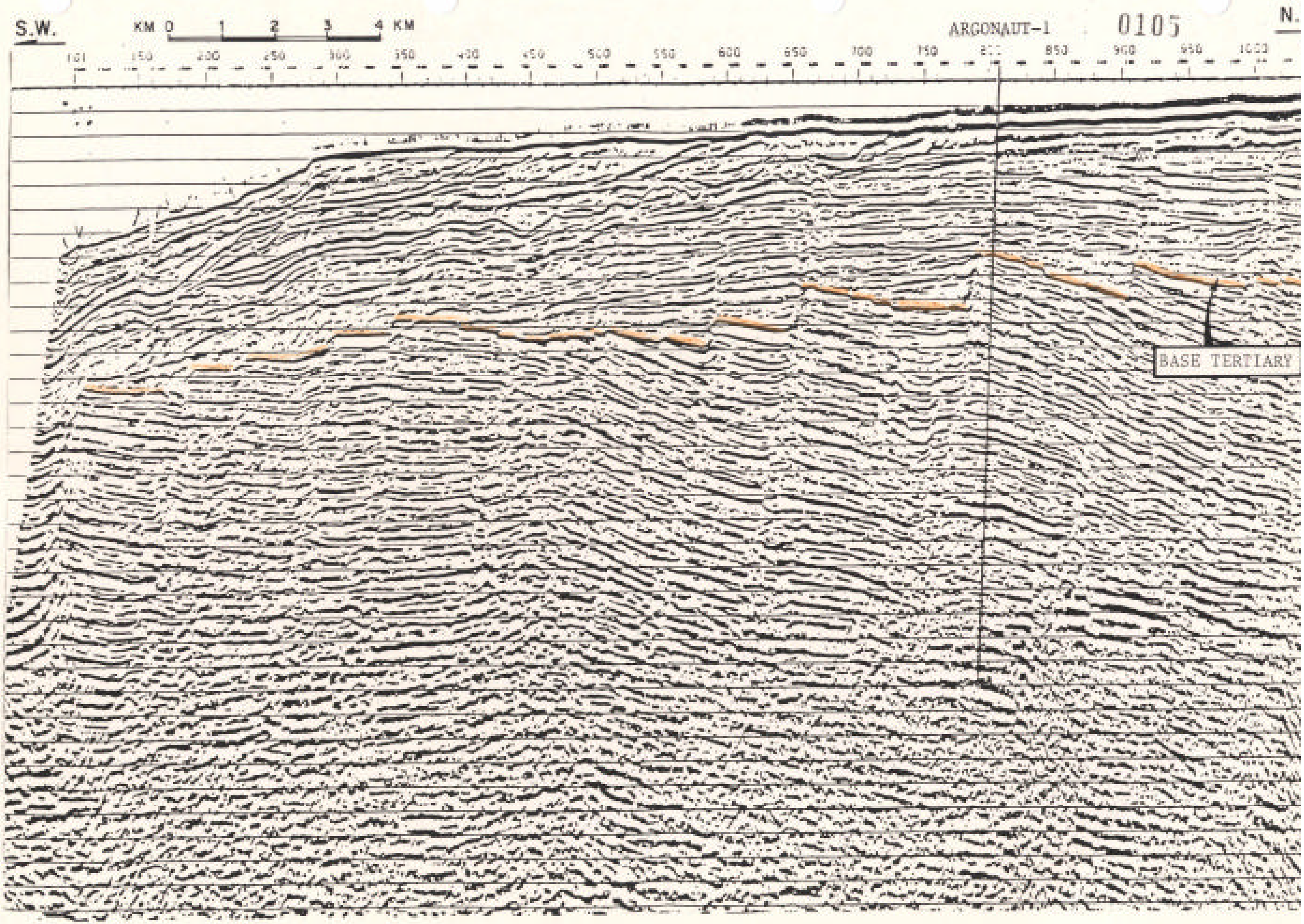

FIGURE XIII-6 - ARGONAUT PROSPECT. SEISMIC LINE SH-81-06

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

ARGONAUT PROSPECT - Continued

Results of Drilling - Continued

permeable than the onshore intersections. No hydrocarbon shows were encountered although the higher resistivity at the Base Tertiary (probable Pebble Point Formation; 2,350') and higher in the section at 1,162' may represent hydrocarbons (c.F. Mount Salt No. 1.).

Why Was Argonaut No. 1 Dry?

Argonaut No. 1 was located at the highest point of the structure at the Base Tertiary level. The structure was dry due to the great displacement of the fault which controls closure to the south coupled with insufficient seal development at this location to seal such a displacement. At the Base Tertiary level the fault has a throw of 220 ms/300 m. The Pember Mudstone seal may be present between 2,180'/664 m and 2,350'/716 m but would be juxtaposed against Dilwyn Formation sandstone.

Similarly, although the Belfast Mudstone is thick, evidence suggest that in addition to Tertiary structuring, Upper Cretaceous throw of these faults was great and consequently Belfast is juxtaposed against Paaratte Sandstones. It is also worth noting that with increased depth of penetration the well drilled increasingly off structures due to the tilted nature of the fault block.

LAKE BONNEY PROSPECT

Seismic

The well was located near the crest of the Lake Bonney Gravity High as mapped following the Kongorang Gravity Survey (Note Figure XIII-7). After its drilling two seismic surveys, the 1970 Gambier Trough Seismic Survey and the 1973 Tartwaup Seismic Survey tied into this well. The Gambier Trough data is very poor and that of the Tartwaup Survey is poor but useful in evaluating the prospect.

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XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

LAKE BONNEY PROSPECT - Continued

Type of Structure

In the north of the Embayment there is clear evidence that gravity accurately reflects the position of structurally closed highs (Pretty Hill Sandstone on Basement). Esso's Lucindale No. 1 and Lake Eliza No. 1 drilled such highs. In contrast the Lake Bonney area has a thick sequence of Tertiary and Upper Cretaceous sediments. The fault block on which Lake Bonney No. 1 is located does not show the same strong northerly dip of the fault blocks to the south.

Results of Drilling

The well penetrated the entire Tertiary and Upper Cretaceous sequence. The Lower Cretaceous Otway Group was intersected at 8,926'/2,721 m. Two DST's were conducted; DST NO. 2 between 8,590' - 8,652' (2,618 - 2,637.1 m) in the Waarre Formation was partially successful. DST NO. 2 recovered 1,800' of water cushion and 6,875' of muddy salt water. Partial packer seat failure was reported. No shows were recorded. The composite log notes that the gas trap was not functioning effectively above 6,700'. Below this depth the only significant readings encountered were trip gas (1-2%).

Why Was Lake Bonney No. 1 Dry?

The Lake Bonney Prospect is inadequately defined seismically. An examination of Line TQ of the Tartwaup Seismic Survey (Enclosure 19) would suggest that the well was drilled down-dip from the highest point of the fault block it drilled and it appears also that fault closure if present, is not adequately sealed as fault displacement is greater than the thickness of the Belfast Mudstone in Lake Bonney No. 1

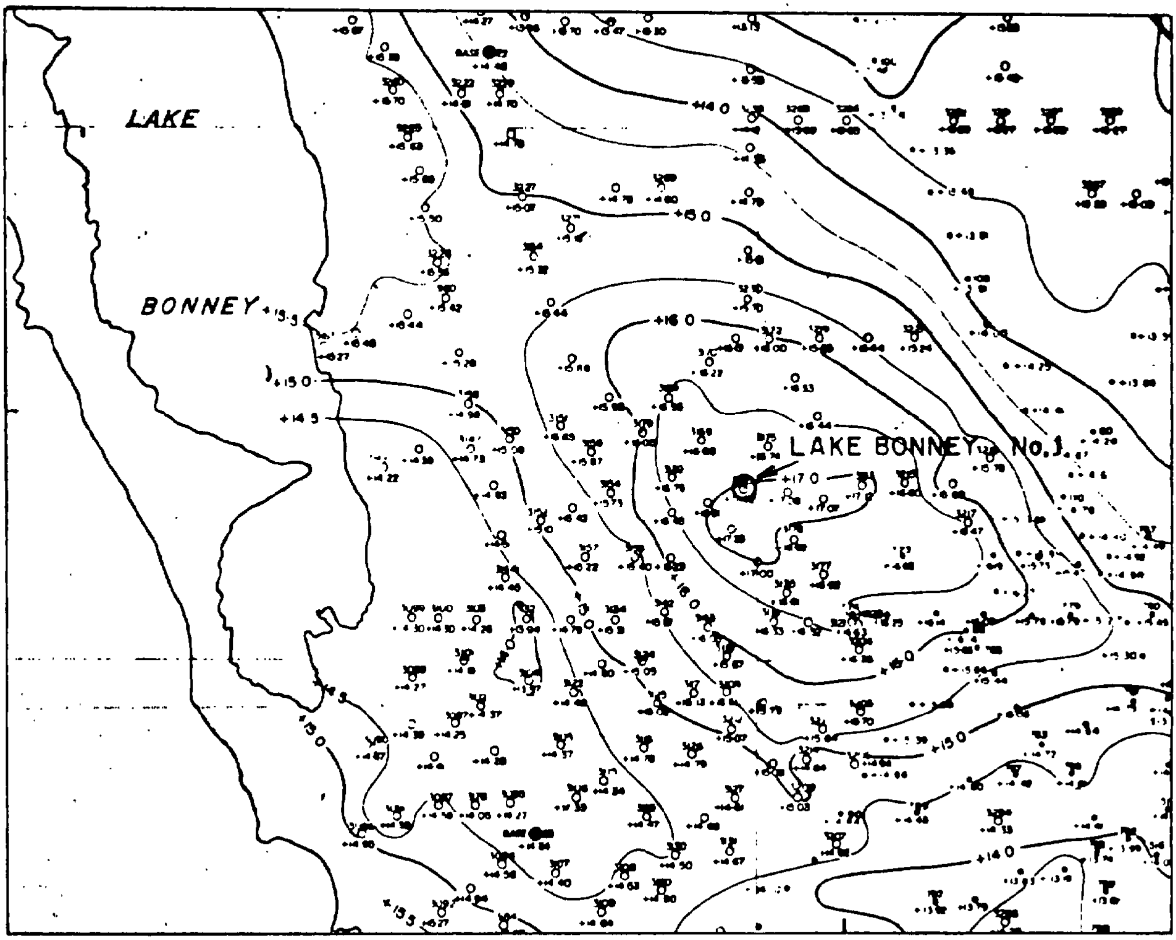

FIGURE XIII-7

LAKE BONNEY PROSPECT

Bouguer Anomaly Map
Kongorong Gravity Survey (1967)

Scale - 1 inch : 2 miles

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

DOUGLAS POINT PROSPECT

Seismic

Seismic control of the prospect is very limited. The well was located on the coast and both onshore and offshore data was utilized to produce a contour map. (Figure XIII-8.) Onshore, only one line controls the structure, Line AT-1 of the Gambier Trough Seismic Survey. Offshore control was provided by the Port Macdonnell Marine Seismic Survey (Alliance, 1972). Both sets of data are very poor.

Type of Structure

The Douglas Point Prospect was interpreted as a culmination on a regional anticline. This interpretation relied principally on an interpretation of the outcrop pattern of submarine exposures of the Gambier Limestone in Umpherstone Bay south west of the prospect and from the topography onshore.

Regional dip on the pre-Tertiary unconformity was determined using seismic Line AT-1 onshore and Port Macdonnell seismic offshore. The complexity of the Otway Basin faulting at the prospective horizons was not recognised at the time of drilling.

Results of Drilling

Douglas Point No. 1 penetrated the Tertiary sequence and about 660 ft/ 200 m of Upper Cretaceous Paaratte Formation. The pre-Tertiary unconformity (Base Pebble Point) was intersected 1,000 ft./300 m deeper than prognosed. No hydrocarbon shows were encountered.

Why Was Douglas Point No. 1 Dry?

There is no reason to believe Douglas Point No. 1 was drilled on structure. Subsequent seismic recorded in the region has shown that surface geology is of little value when assessing individual prospects.

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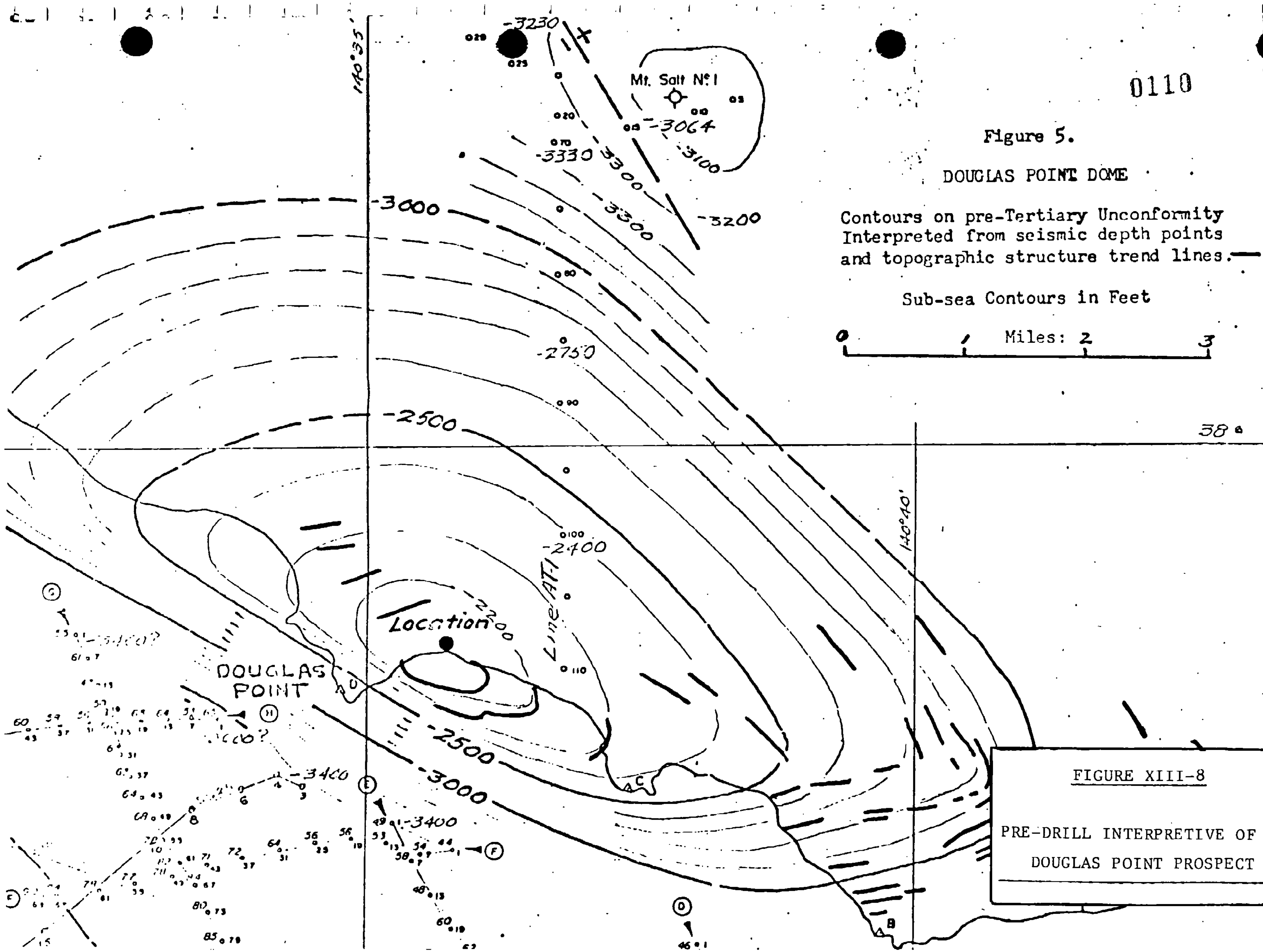

FIGURE XIII-8

PRE-DRILL INTERPRETIVE OF THE DOUGLAS POINT PROSPECT

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

BURRUNGULE PROSPECT

Seismic

The Burrungule Prospect was very poorly controlled seismically. The prospect was not located on a seismic line but was located on a structural high inferred from two north-south seismic lines 9 kilometres apart, tied by an east-west line 1½ kilometres north of the prospect. This seismic was recorded during the Tartwaup Seismic Survey (1973) and the quality of the data can be described as fair in contrast to much of the data recorded during this survey which is of poor quality. The definition of the Waarre horizon is however very poor.

Figure XIII-9 is the pre-drill interpretation of the Waarre Formation. Other markedly different interpretations were made by different companies involved with the prospect. The simplistic nature of the map as attached is completely unrealistic for Otway Basin structure.

Type of Structure

The Burrungule Prospect was invisaged to be the crest of a major anticline delineated by the Tartwaup Seismic Survey. In appearance the trend looks as if it has resulted from growth faulting which makes sense as the Tartwaup Fault is the major controlling fault of Sherbrook Group deposition. We need not however, need to infer growth faulting to explain such rollover into this major basin margin Fault (Upper Cretaceous margin).

Results of Drilling

The Base Tertiary was intersected 76 ft./23 m lower than predicted at 2,136 ft./651 m and the Top Waarre Formation was penetrated 1,345 ft/ 410 m lower than predicted at 7,085 ft/2,160 m. This reflects the lack of seismic definition of the Waarre Formation. The well drilled into the Eumeralla Formation and no hydrocarbons were reported.

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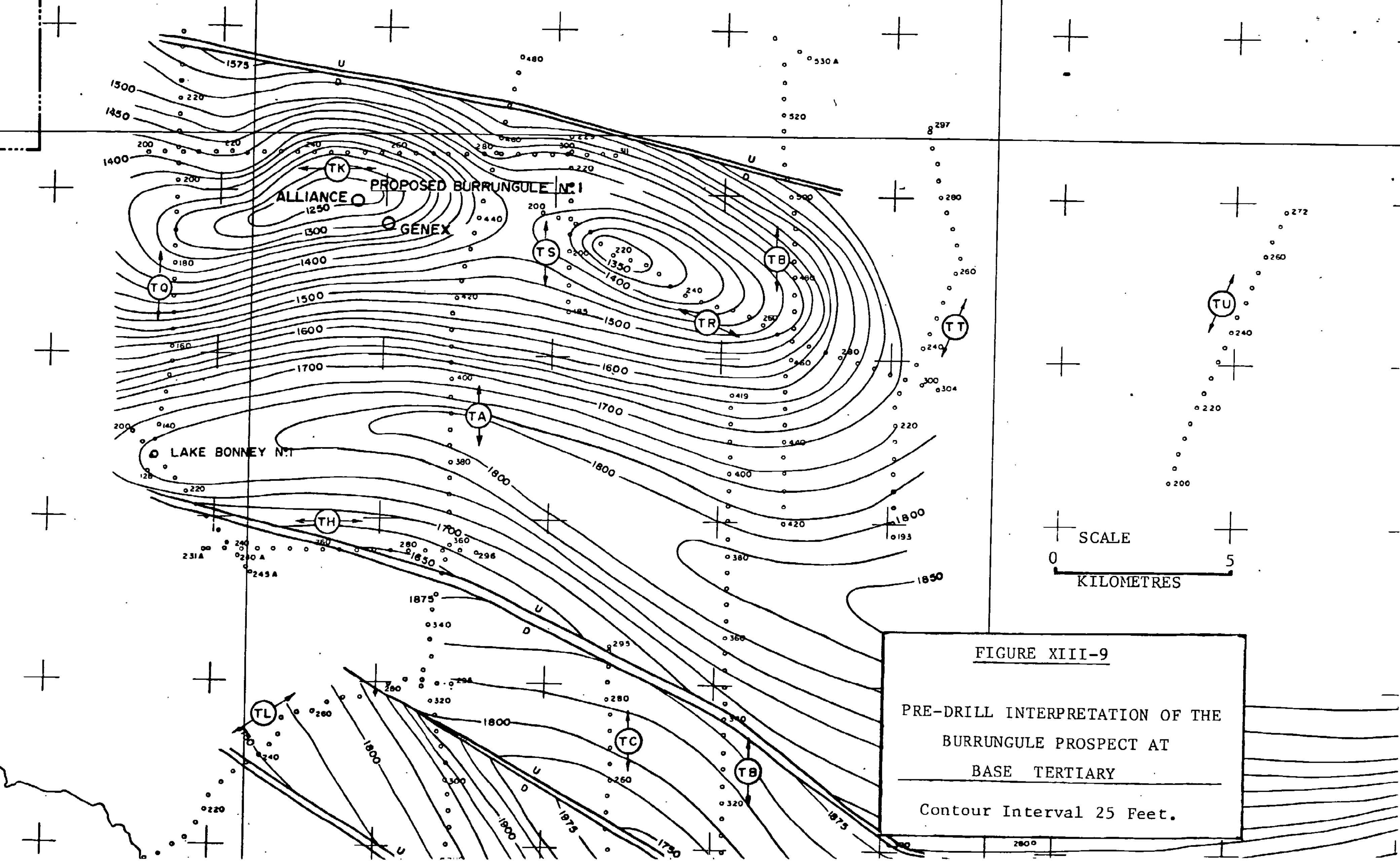


FIGURE XIII-9

PRE-DRILL INTERPRETATION OF THE BURRUNGULE PROSPECT AT BASE TERTIARY

Contour Interval 25 Feet.

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

BURRUNGULE PROSPECT - Continued

Why Was Burrungule No. 1 Dry?

Burrungule No. 1 was dry because seismic control was inadequate and therefore there is no reason to suppose that the well was drilled on structure. Pre-drill interpretation did not recognise the complexity of Otway Basin structure. The nearest seismic line to the prospect, line TK is a strike line which cuts obliquely through a significant fault. Well-Seismic ties within the area are inadequate to interpret the Upper Cretaceous section with the necessary degree of confidence.

KENTGROVE PROSPECT

Seismic

The Kentgrove Prospect was defined by the 1973 Tartwaup Seismic Survey. The prospect is poorly controlled seismically especially considering the structural style of the area (Note Enclosure 22). The well was drilled on Line TC. (Enclosure 20.) The seismic is of fair quality in this area at the Base Tertiary. Onlap onto the Pebble Point reflector is clear.

Type of Structure

The Kentgrove Structure is a north dipping tilted fault block which has a structural style typical of this area in the basin.

Results of Drilling

A typical Tertiary section was penetrated. The well was terminated in the top unit, Unit 3 of the Paaratte Formation. An open hole DST was made near T.D. but was unsuccessful due to caving sand problems. No significant shows were reported. There was a slight increase in methane in the mud from 40 to 400 ppm in the last 200 ft./60 m of hole. A very slight trace of CO_2 was suggested to be present with this

.../105

XIII. DRY HOLE ANALYSIS IN THE GAMBIER EMBAYMENT STUDY AREA - Continued

KENTGROVE PROSPECT - Continued

Results of Drilling - Continued

increase, presumably a slight negative kick following the methane kick on the chromatogram.

Why Was Kentgrove No. 1 Dry?

Kentgrove may or may not have been a closed structure. Seismic control and quality is not adequate. The lack of gas shows suggests that Kentgrove No. 1 was drilled off structure.

XIV. EXPLORATION OBJECTIVES - P.E.L. 22

The section will first highlight some initial seismic objectives as the area is very poorly endowed with quality seismic. This is discussed under the titles:-

(A) Seismic Exploration

and

(B) Seismic Interpretation.

Exploration plays will then be discussed dealing with:-

(C) The Sherbrook Group Plays

and

(D) The Tertiary Play,

Areas where exploration should be pursued will be highlighted when discussing these plays.

XIV. EXPLORATION OBJECTIVES - P.E.L. 22 - Continued

A. SEISMIC EXPLORATION

The study areas have a very low density of useable seismic (Note Enclosure 12, Seismic Base Map). Seismic recorded prior to 1973 is of limited value except perhaps portions of the Gambier Trough Seismic Survey recorded in 1970. Two projects are already underway which seek to tackle this problem.

1. Reprocessing of Line TA, Tartwaup Seismic Survey (1973)

   Attempts to locate the magnetic field tapes from the Tartwaup Seismic Survey have recently been successful and Line TA will be reprocessed. Further reprocessing will be considered if results warrant.

2. Experimental Seismic Line

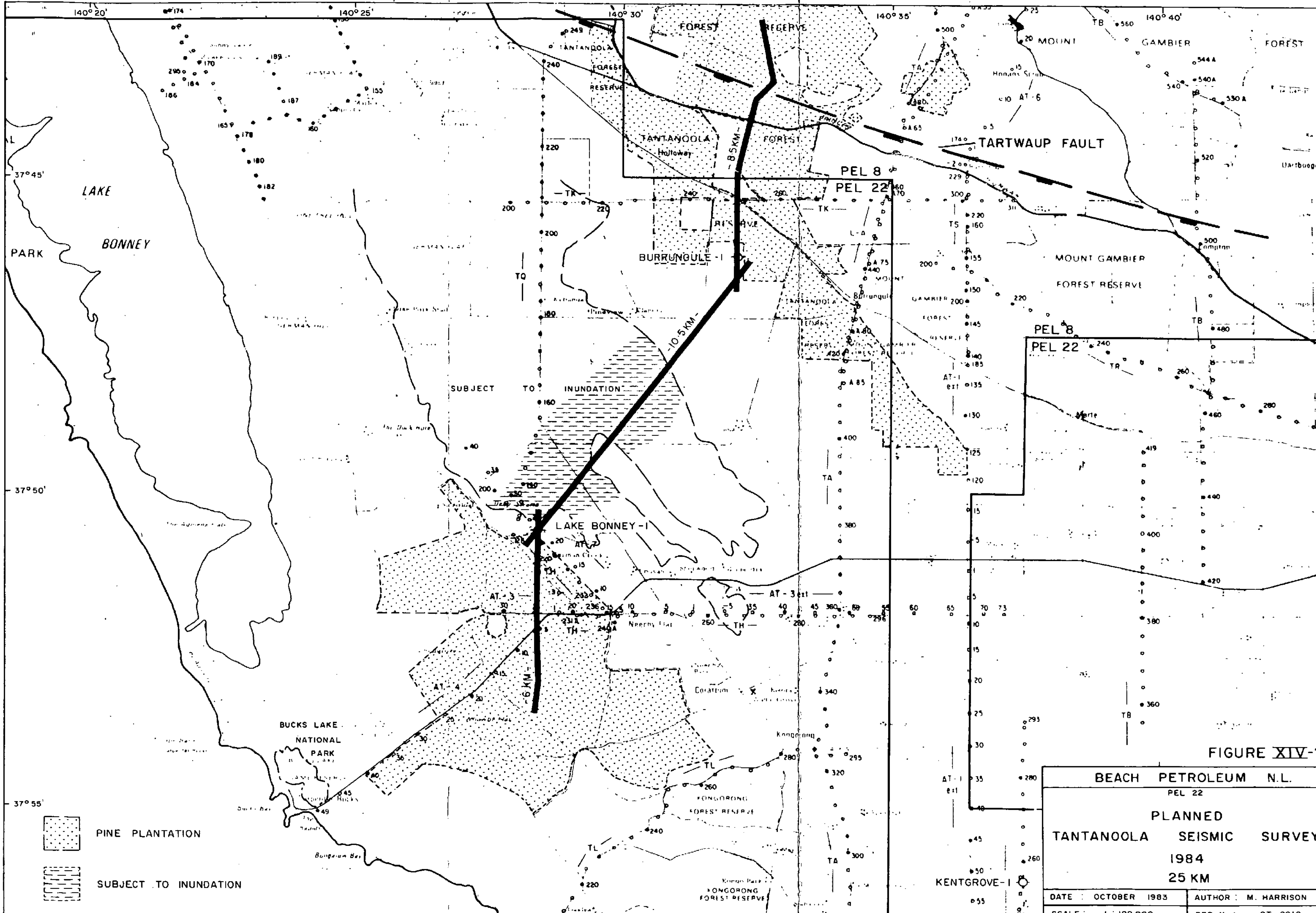
   It is planned to record the Tantanoola Seismic Survey, a 25 kilometre seismic traverse in permit P.E.L. 22 in early 1984 (Note Figure XIV-1). The objectives of this survey are as follows:-

   - tie the Lake Bonney No. 1 and Burrungule No. 1 wells.
   - investigate the Burrungule Trend and the Lake Bonney High Trend.
   - investigate acquisition problems in the area.

B. SEISMIC INTERPRETATION

Interpretation of the experimental line should be made in conjunction with a complete re-interpretation of the Tartwaup Survey data with the view of laying out a more extensive seismic program to be recorded during the 1984/1985 seismic season.

The existing interpretation of the Tartwaup Seismic Survey tends to be forced and it creates a much over-simplified picture not applicable to Otway Basin structure as we understand it at present. Enclosure 22 is the Base Tertiary Contour Map constructed following the survey and prior to the drilling of the Burrungule No. 1 well.


140° 20'
140° 25'
140° 30'
140° 35'
140° 40'
37° 45'
37° 50'
37° 55'
FOREST RESERVE
MOUNT GAMBIER FOREST
TARTWAUP FAULT
TANTANOOLA FOREST
TANTANOOLA FOREST RESERVE
PEL 8
PEL 22
BURRUNGULE - 1
MOUNT GAMBIER FOREST RESERVE
LAKE BONNEY
PARK
SUBJECT TO INUNDATION
~ 8.5 KM ~
~ 10.5 KM ~
~ 6 KM ~
LAKE BONNEY - 1
AT - 3
AT - 3 ext
AT - 4
AT - 6
AT - 1 ext
TH
TK
TQ
TA
TB
TL
TR
TS
BUCKS LAKE NATIONAL PARK
KONGORONG FOREST RESERVE
KENTGROVE - 1
PINE PLANTATION
SUBJECT TO INUNDATION
FIGURE XIV-1
BEACH PETROLEUM N.L.
PEL 22
PLANNED
TANTANOOLA SEISMIC SURVEY
1984
25 KM
DATE : OCTOBER 1983
AUTHOR : M. HARRISON
SCALE : 1 : 100,000
DRG No. : OT. 2010

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XIV. EXPLORATION OBJECTIVES - P.E.L. 22 - Continued

C. THE SHERBROOK GROUP PLAYS

1. The Waarre Formation Objective

As illustrated in Figures VII-5 and VII-6 interpretation of Lines TA and TQ of the Tartwaup Seismic Survey (1973) shows excellent structure present along the Lake Bonney High and Burrungule Trends. The Waarre Formation is considered to be at a suitable depth along these trends. Further south and east the Waarre Formation probably reaches a depth where the porosity and permeability of the formation may have deteriorated (Note Figure XIV-2) As detailed in Section XII the occurrence of CO_2 in the area places a limitation on where we might expect traps to contain hydrocarbons (Note Figure XII-6). The Belfast Mudstone is comparatively thin in this area related to its position in the basin (Note Enclosure 7). Fault closure should be assessed with care in order to minimize the risk of fault breaching.

The Burrungule Trend, an anticlinal trend on the downthrown side of the Tartwaup Fault is considered to offer the best potential for four way dip closure.

2. Lower Paaratte Formation Sandstones, Particularly Unit 1

Unit 1 of the Paaratte Formation and sand units within the Belfast Mudstone Member of the Paaratte Formation are considered to be prospective. This sequence at Mount Salt No. 1 is very attractive. The Mount Salt area is perhaps the most likely area where there appears to be strong interfingering of marine and terrestrial sediments.

What would be relied upon however, is that such prospects would require access to major faulting in order for vertical migration to have occurred through the Belfast Mudstone. At the same time the relatively tenuous seal of the interbedded sand-shale sequence

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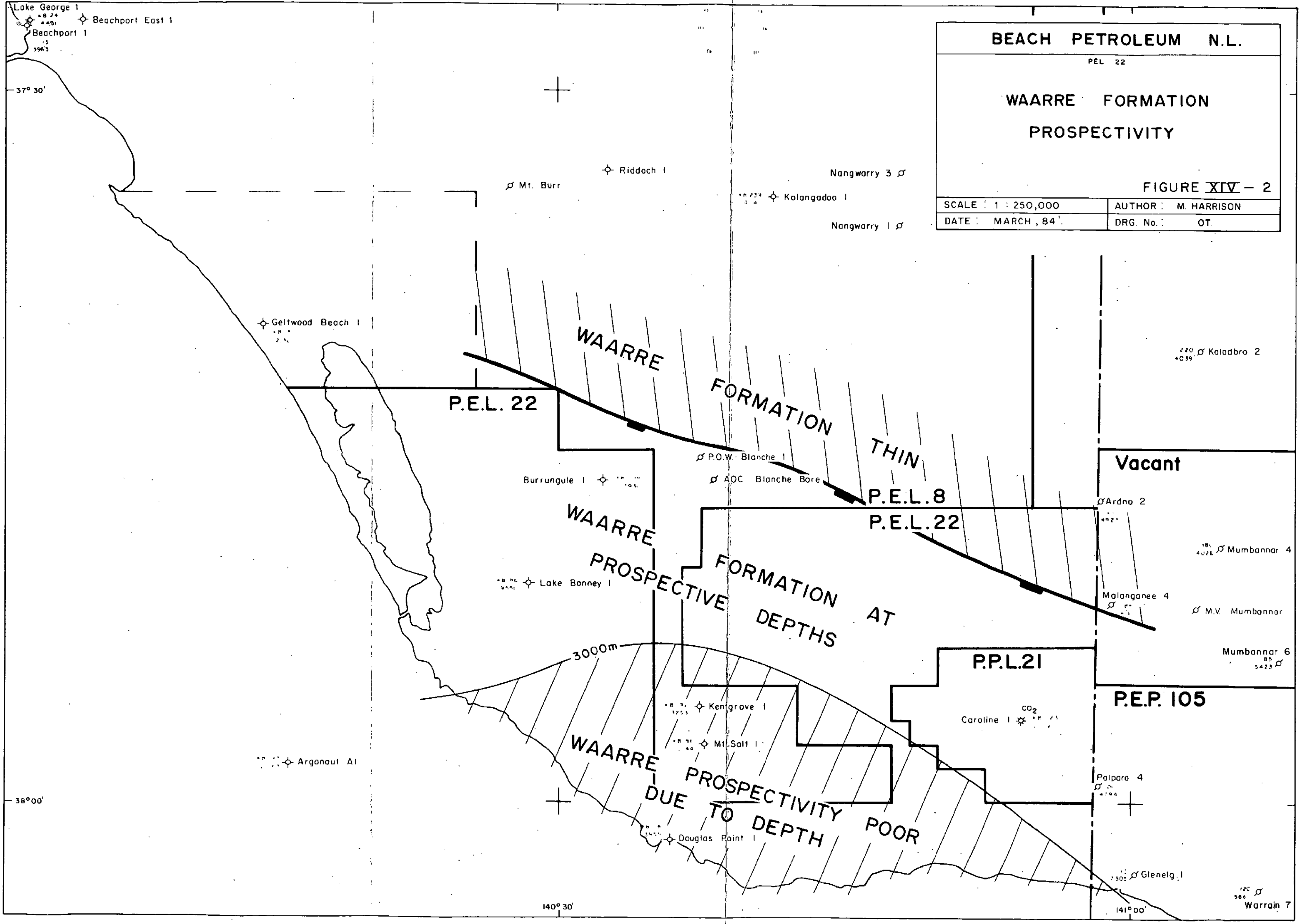

BEACH PETROLEUM N.L.
PEL 22
WAARRE FORMATION
PROSPECTIVITY
FIGURE XIV - 2
SCALE : 1 : 250,000
AUTHOR : M. HARRISON
DATE : MARCH, 84'.
DRG. No. : OT.
WAARRE FORMATION THIN
WAARRE FORMATION AT PROSPECTIVE DEPTHS
WAARRE PROSPECTIVITY POOR DUE TO DEPTH
3000m
P.E.L. 22
P.E.L. 8
P.E.L. 22
P.P.L. 21
P.E.P. 105
Vacant
Lake George 1
Beachport East 1
Beachport 1
37° 30'
38° 00'
140° 30'
141° 00'
Riddoch 1
Mt. Burr
Nangwarry 3
Kalangadoo 1
Nangwarry 1
Geltwood Beach 1
Kaladbro 2
P.O.W. Blanche 1
AOC Blanche Bore
Burrungule 1
Ardno 2
Mumbannar 4
Lake Bonney 1
Malanganee 4
M.V. Mumbannar
Mumbannar 6
Kentgrove 1
Caroline 1
CO_2
Mt. Salt 1
Argonaut A1
Palpara 4
Douglas Point 1
Glenelg 1
Warrain 7

0120

XIV. EXPLORATION OBJECTIVES - P.E.L. 22 - Continued

C. THE SHERBROOK GROUP PLAYS - Continued

2. Lower Paaratte Formation Sandstone, Particularly Unit 1 - Continued

should be maintained. Unit 1 prospects demonstrating closure independant of fault closure against the Belfast Mudstone can be expected to be uncommon due to the north tilting of major blocks. Southerly dip where present could be very important (Note Figure XIV-3).

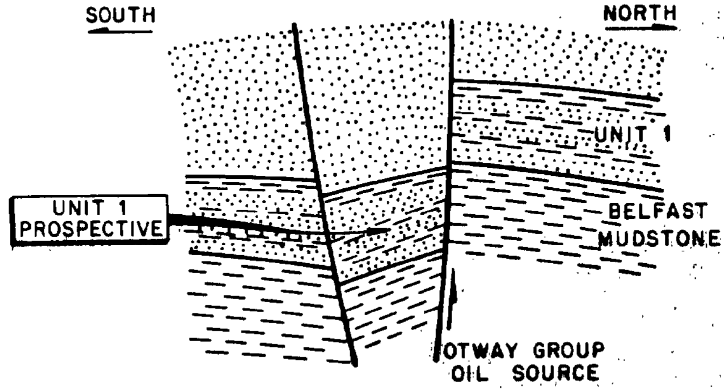


FIGURE XIV-3 - CONCEPTUAL PROSPECTIVITY OF UNIT 1, PAARATTE FORMATION FAULT STRUCTURES.

Unit 1 sands and Belfast Mudstone sand bodies should be considered secondary objectives and no specific exploration for these objectives is recommended at this stage.

D. THE TERTIARY PLAY

Prospective sands occur within the top of the Sherbrook Group Sequence (the Paaratte Formation, Unit 4), the Pebble Point Formation and the lower sands of the Dilwyn Formation. These objectives are discussed together as these objective reservoirs have all been structured at the same time, that is during the Tertiary phase of rifting. It should be anticipated that prime Tertiary prospects will not necessarily be centred over prime Sherbrook Group Prospects. It is recommended in

.../112

XIV. EXPLORATION OBJECTIVES - P.E.L. 22 - Continued

D. THE TERTIARY PLAY - Continued

the initial drilling phase that we should opt for a deep Sherbrook Group well and two shallow Tertiary wells, which would thus place emphasis of selecting prime targets at each of these levels rather than a compromise target half exploring both objectives.

The Top Paaratte Formation - Unit 4

The sands of this unit are excellent reservoirs and in places the lower portion of the Pebble Point Formation may seal. We are not however, looking at the classic unconformity trap where an unconformable surface is overlayed by marine shales, but are looking at a transgressive sequence of mixed lithology overlying Unit 4. Nevertheless sealing at the unconformity is possible.

The Pebble Point Formation

The Pebble Point Formation has variable reservoir characteristics but portions of the formation are porous. More well information would be required to define lithology variations and predict porous facies in a regional sense. One advantage of the Pebble Point Formation objective is that it can be reliable mapped seismically. There is a considerable difference in acoustic impedance between the base of the Dilwyn Formation and the Top of the Pebble Point Formation and strong Dilwyn Formation onlap is evident in places.

The Dilwyn Formation

Consideration of the facies variation of the Lower Dilwyn Formation, particularly the Pember Mudstone Member is of prime importance in considering the Tertiary Play. There are important variations in reservoir and sealing facies in this lowermost unit.

XIV. EXPLORATION OBJECTIVES - P.E.L. 22 - Continued

D. THE TERTIARY PLAY - Continued

The Dilwyn Formation - Continued

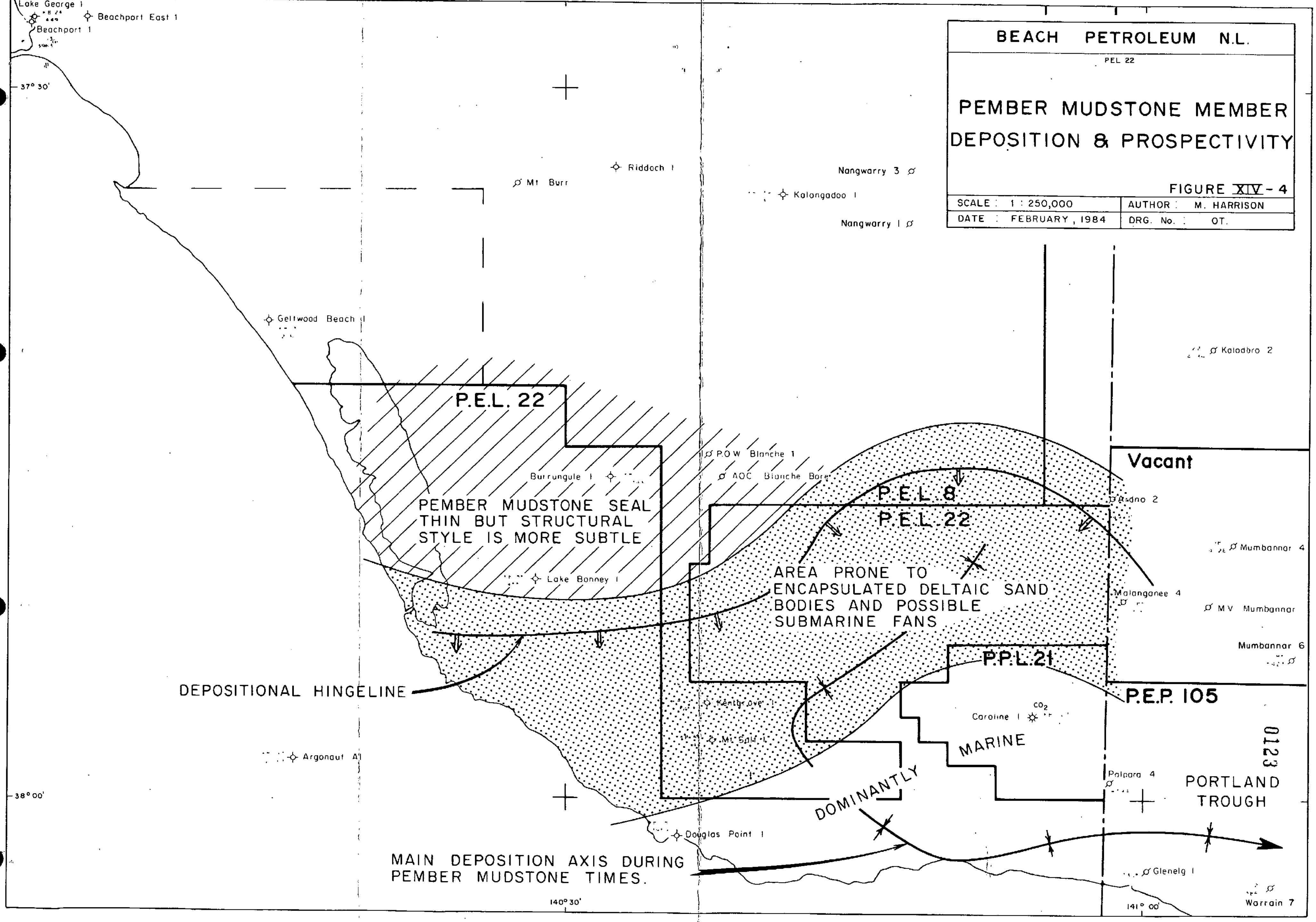
A description of facies variation between wells is given in the section on reservoir potential. Figure XIV-4 is a general summary of the main influences on Pember Mudstone deposition. It is clear from well information available that there is a strong marine influence on deposition from the southeast. The main Tertiary downwarp occurs on trend with the thick Tertiary Portland Trough of Victoria, its axis occurring onshore in the study area.

The most important aspect of Pember Mudstone Member deposition is that there are porous reservoir facies associated with sealing facies, both deposited during the main period of Tertiary structuring. This same fault structuring would allow migration of hydrocarbons into such a sequence.

It is important to recognise that hydrocarbons are likely to migrate towards the Tertiary Fault planes, There would thus be a point source of hydrocarbons eliminating the need for lateral migrating of oil into traps within the Dilwyn Formation. A variety of entrapment situations can be envisaged some with a strong stratigraphic component.

Stratigraphic Variation Within the Pember Mudstone

The correlation of the Pember Mudstone Member (Note Enclosure 15) illustrates that there is significant variation in facies from well to well. This report considers that the main prospective area for Pember Mudstone reservoirs is located along the trend where predominantly marine including pre-deltaic facies and predominantly terrestrial depositional facies meet.


BEACH PETROLEUM N.L.
PEL 22
PEMBER MUDSTONE MEMBER
DEPOSITION & PROSPECTIVITY
FIGURE XIV - 4
SCALE : 1 : 250,000
AUTHOR : M. HARRISON
DATE : FEBRUARY, 1984
DRG. No. : OT.
Lake George 1
Beachport East 1
Beachport 1
37° 30'
Riddoch 1
Mt Burr
Nangwarry 3
Kalangadoo 1
Nangwarry 1
Gellwood Beach 1
Kalodbro 2
P.E.L. 22
Vacant
P.O.W. Blanche 1
AOC Blanche Bore
Burrungule 1
P.E.L. 8
P.E.L. 22
Ardno 2
PEMBER MUDSTONE SEAL
THIN BUT STRUCTURAL
STYLE IS MORE SUBTLE
Mumbannar 4
Lake Bonney 1
AREA PRONE TO
ENCAPSULATED DELTAIC SAND
BODIES AND POSSIBLE
SUBMARINE FANS
Malanganee 4
M V Mumbannar
Mumbannar 6
P.P.L. 21
DEPOSITIONAL HINGELINE
P.E.P. 105
Kentgrove 1
Caroline 1
CO_2
MARINE
Mt Salt 1
Argonaut A1
Palpara 4
PORTLAND
TROUGH
38° 00'
DOMINANTLY
Douglas Point 1
MAIN DEPOSITION AXIS DURING
PEMBER MUDSTONE TIMES.
Glenelg 1
140° 30'
141° 00'
Warrain 7
0123

XIV. EXPLORATION OBJECTIVES - P.E.L. 22 - Continued

D. THE TERTIARY PLAY - Continued

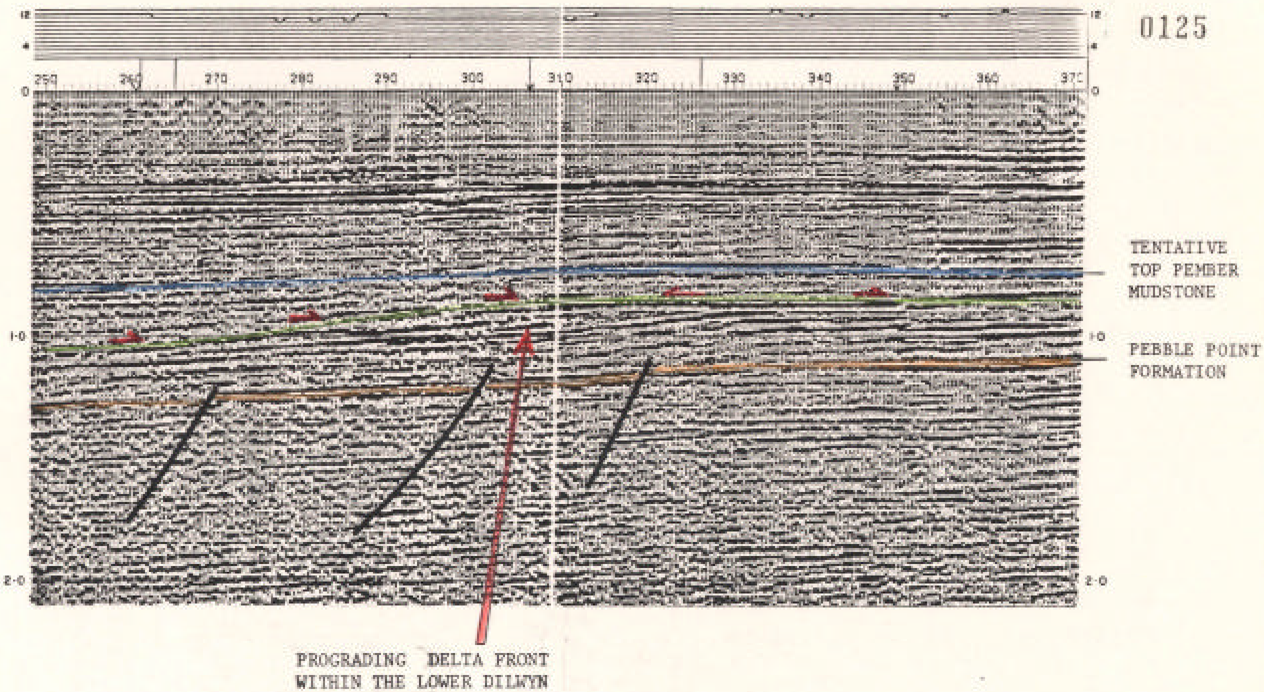
Stratigraphic Variation Within the Pember Mudstone - Continued

Well stratigraphy has its limitations in the understanding of this potential. One can imagine prograding deltas overstepped by renewed marine deposition but such a picture can only be developed after many wells have been drilled. Seismic stratigraphy may provide some valuable clues. Figure XIV-5 is a portion of a seismic section recorded on the northern flank of the Portland Trough. A prograding delta front is interpreted here within the Pember Mudstone Member. Such a body may have potential for stratigraphic traps. For example, forset and barrier sands near the top of the sequence sealed by onlapping shales.

On Line TA, Tartwaup Seismic Survey 1973 (Note Enclosure 18), between shot points 310 and 330; 700 and 800 ms there is some evidence of what could be a submarine fan? such a body would be very prospective if a suitable migration path from underlying source rocks can be demonstrated.

Line D226 (Beach, 1983)

0125



BEACH PETROLEUM N.L.

EXAMPLE SEISMIC SECTION

Portland Trough

Victoria

FIGURE XIV-5

0126

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APPENDIX NO. 1

SOURCE ROCK DATA - EXTRACTS FROM THE FOLLOWING REPORTS

Page No.

APPENDIX NO. 1

Extracts from:- "Geothermal Evaluation of the Otway Basin", Woodhouse, Alexander and Kagi.

TABULATED SUMMARY OF DATA INTERPRETATION

SAMPLE	SOURCE ROCK RICHNESS						MATURITY		SOURCE TYPE				DEPOSITIONAL/ ENVIRONMENT
	%TOC		%SOM		%SaOM	C_T-C_R	SOM/TOC	C_R/C_T	PRIST/ $n-C_{17}$	21+22/ 28+29	%SAT	n-ALKANES	PRISTANE/PHYTANE
ARGONAUT 1 1645m	***	u	**	u									
ARGONAUT 1 3449m	***		*		*	***	+	+	TER	TER	TER	MAR/TER	Oxidizing
ARGONAUT 1 3555m	***	u	**	u									
MOUNT SALT 1 3003m	***	u	**	u									
MOUNT SALT 1 3061m	**		*		*	**	++	++	MAR	MAR	MAR/TER	MAR	Reducing
CAROLINE 1 1830m	***	u	***	u									
CAROLINE 1 2426m	***		**		*	***	+	+	TER	MAR/TER	TER	MAR/TER	Reducing/Oxidizin;
CAROLINE 1 3069m	***	u	**	u									
KALANGADOO 1 765m	***	u	*	u									
KALANGADOO 1 896m	***	u	*	u									
KALANGADOO 1 1456m	**	u	*	u									
LAKE BONNEY 1 2332-2438m	**	u	*	u									
LAKE BONNEY 1 2438-2530m	**	u	*	u									
LAKE BONNEY 1 2719m	**	u	**	u									
LAKE BONNEY 1 2734-2835m	**	u	*	u									
URRUNGULE 1 1640-1713m	***		**		*	***	+	+	MAR/TER	MAR/TER	TER	MAR/TER	Reducing
URRUNGULE 1 2179-2341m	**	u	*	u									
URRUNGULE 1 2341-2438m	**	u	*	u									

KEY FOR "TABULATED SUMMARY OF DATA INTERPRETATION"

Source Rock Richness

*	Poor source rock
**	Moderate source rock
***	Good source rock
u	Data obtained from screening procedures

Maturity

+	Low level of maturity
++	Moderate level of maturity
+++	High level of maturity

Source Type

MAR	Dominantly marine source material
TER	Dominantly terrestrial source material
MAR/TER	Significant marine and terrestrial source input

APPENDIX NO. 1

Extracts from:- "Amdel Report AC 940/81".

amdel

Summary of Analytical Method

Total organic carbon was obtained by combustion after acid leaching of carbonate minerals. The finely pulverised sample was extracted with 87% chloroform - 13% methylalcohol and the extract evaporated to remove the solvent. Asphaltenes were removed from the extracted organic matter with petroleum ether and the asphaltene free fraction separated by liquid chromatography on 20 parts activated alumina under 80 parts activated silica gel. The saturates were eluted with petroleum ether, the aromatics with mixed solvent-benzene 15% in petroleum ether 85%, and the polar compounds with methanol containing approx. 10% benzene. Residual strongly polar compounds were not eluted.

Some of the samples yielded sulphur in the extracted organic matter and this was removed using active copper powder.

The saturate fractions were examined by gas chromatography using the following operating parameters:

Column SCOT 45 m x 0.5 mm diameter coated with OV101
Injection and detection temp 300°C
FID detection
Nitrogen carrier 4 mls/minute
Column temperature 60° for 3 mins. then programmed at 4° per minute to 180°C, held for 1 minute and reprogrammed at 3° per minute to 255°C and held for 60 minutes.
Alkane concentrations were obtained by measurement of peak areas above naphthenic hump.

SOURCE ROCK

SAMPLE NO:	7
WELL:	Crayfish 1 Otway Basin
SAMPLE IDENTIFICATION:	Core 22 Lower Cretaceous, Pretty Hill Sandstone equivalents
DEPTH:	8104' 7½" - 8105' 1½" (2470.29 - 2470.44 m)
TYPE OF SAMPLE:	Carbonaceous mudstone with fine coaly laminae
Total organic carbon (TOC)	15.88%
Weight of sample extracted	5.65gm
Extracted organic matter (EOM)	21560 ppm
EOM as fraction of TOC	135.8 mg/g
Wt. EOM	121.8 mg

Analysis of extracted organic matter:-

Asphaltenes	51.1 % (wt)
Saturates	5.7 %
Aromatics	5.0 %
Resins	24.4 %
Loss on column	13.8 %

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abund.	1.3	4.0	5.9	9.3	11.5	13.3	14.8	9.1	8.3	6.2	4.8
n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abund.	3.3	2.7	1.9	1.7	1.1	0.8	-	-	-	-	-

Isoprenoid distribution in saturates:

IP16	IP18	Pr	Ph
-	-	4.85	0.85

IP16/IP18	IP18/Pr	Pr/Ph	IP16/nC_{16}	IP18/nC_{18}	Pr/nC_{17}	Ph/nC_{18}
-	-	5.60	-	-	0.42	0.065

0138

SOURCE ROCK

SAMPLE NO:	8
WELL:	Crayfish 1 Otway Basin
SAMPLE IDENTIFICATION:	Core 26 Lower Cretaceous Pretty Hill Sandstone equivalents
DEPTH:	9545' 5" - 9545' 8" (2909.44 - 2909.52 m)
TYPE OF SAMPLE:	Fine grey silty sandstone with spars carbonaceous remains

Total organic carbon (TOC)	1.07	%
Weight of sample extracted	32.55	gm
Extracted organic matter (EOM)	728	ppm
EOM as fraction of TOC	68.0	mg/g
Wt. EOM	23.7	mg

Analysis of extracted organic matter:-

Asphaltenes	44.7	% (wt)
Saturates	8.9	%
Aromatics	6.8	%
Resins	31.2	%
Loss on column	8.4	%

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abund.	0.5	2.9	5.4	8.2	10.0	11.0	10.9	9.4	8.0	7.3	6.3
n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abund.	5.5	4.4	3.6	2.7	1.8	1.3	0.6	0.2	-	-	-

Isoprenoid distribution in saturates:

IP16	IP18	Pr	Ph
-	-	2.10	1.20

$\frac{IP16}{IP18}$	$\frac{IP18}{Pr}$	$\frac{Pr}{Ph}$	$\frac{IP16}{nC_{15}}$	$\frac{IP18}{nC_{16}}$	$\frac{Pr}{nC_{17}}$	$\frac{Ph}{nC_{18}}$
-	-	1.73	-	-	0.21	0.11

SOURCE ROCK

SAMPLE NO:	9
WELL:	Crayfish 1 Otway Basin
SAMPLE IDENTIFICATION:	Core 27 Lower Cretaceous Pretty Hill Sandstone equivalents
DEPTH:	9959' 0" - 9959' 7" (3035.50 - 3035.68 m)
TYPE OF SAMPLE:	Grey sandy mudstone

Total organic carbon (TOC)	1.00 %
Weight of sample extracted	30.15 gm
Extracted organic matter (EOM)	965 ppm
EOM as fraction of TOC	96.5 mg/g
Wt. EOM	29.1 mg

Analysis of extracted organic matter:-

Asphaltenes	55.0 % (wt)
Saturates	5.9 %
Aromatics	4.1 %
Resins	22.3 %
Loss on column	12.7 %

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abund.	0.4	2.6	5.1	7.9	9.6	10.1	9.3	7.9	7.7	8.6	8.0
n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abund.	7.0	5.0	3.8	2.6	1.8	1.3	0.6	0.5	0.2	-	-

Isoprenoid distribution in saturates:

IP16	IP18	Pr	Ph
-	-	1.40	1.20

IP16/IP18	IP18/Pr	Pr/Ph	IP16/nC_{14}	IP18/nC_{16}	Pr/nC_{17}	Ph/nC_{18}
-	-	1.17	-	-	0.14	0.12

0140

SOURCE ROCK

SAMPLE NO:	10
WELL:	Crayfish 1 Otway Basin
SAMPLE IDENTIFICATION:	Core 28 Lower Cretaceous Pretty Hill Sandstone Equivalents
DEPTH:	10482' 11" - 10483' 6" (3195.19 - 3195.37 m)
TYPE OF SAMPLE:	Dark grey silty mudstone

Total organic carbon (TOC)	1.60	%
Weight of sample extracted	27.5	gm
Extracted organic matter (EOM)	800	ppm
EOM as fraction of TOC	50.0	mg/g
Wt. EOM	22.0	mg

Analysis of extracted organic matter:-

Asphaltenes	27.3	% (wt)
Saturates	10.5	%
Aromatics	10.0	%
Resins	44.1	%
Loss on column	8.1	%

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abund.	0.5	2.9	5.7	9.4	13.3	14.8	12.9	9.5	7.4	6.5	5.6

n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abund.	4.5	3.1	1.9	1.0	0.7	0.3					

Isoprenoid distribution in saturates:

IP16	IP18	Pr	Ph
-	-	3.80	5.95

$\frac{IP16}{IP18}$	$\frac{IP18}{Pr}$	$\frac{Pr}{Ph}$	$\frac{IP16}{nC_{15}}$	$\frac{IP18}{nC_{16}}$	$\frac{Pr}{nC_{17}}$	$\frac{Ph}{nC_{18}}$
-	-	0.64	-	-	0.29	0.40

Page 12
AC 940701

0141

SOURCE ROCK

SAMPLE NO:	11
WELL:	Argonaut A1 Otway Basin
SAMPLE IDENTIFICATION:	Core 3 Upper Cretaceous Curdies - Paaratte Form
DEPTH:	3219' 10" - 3220' 3½" (981.40 - 981.54 m)
TYPE OF SAMPLE:	Grey silty sandstone with carbonaceou laminae

Total organic carbon (TOC)	8.01%
Weight of sample extracted	19.20gm
Extracted organic matter (EOM)	5490 ppm
EOM as fraction of TOC	68.5 mg/g
Wt. EOM	105.4 mg plus sulphur 46.9 mg

Analysis of extracted organic matter:-

Asphaltenes	72.8 % (wt)
Saturates	1.0 %
Aromatics	<0.1 %
Resins	15.3 %
Loss on column	10.8 %

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}	
Rel abund.	-	0.8	1.7	6.6	10.7	16.1	11.8	8.1	3.7	3.8	4.1	
n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}	C
Rel abund.	3.9	4.4	3.7	5.0	3.3	6.1	*	3.4	*	1.5	0.8	0

Isoprenoid distribution in saturates:

IP16	IP18	Pr	Ph
-	-	5.65	9.05

IP16/IP18	IP18/Pr	Pr/Ph	IP16/nC_{15}	IP18/nC_{16}	Pr/nC_{17}	Ph/nC_{18}
-	-	0.63	-	-	0.53	0.60

* - Identification of peak doubtful.

0142

SOURCE ROCK

SAMPLE NO:	12
WELL:	Argonaut A1 Otway Basin
SAMPLE IDENTIFICATION:	Core 6 Upper Cretaceous Curdies - Paaratte Form
DEPTH:	4832' 7" - 4833' 0½" (1472.97 - 1473.11 m)
TYPE OF SAMPLE:	Dark grey silty mudstone with very fi light grey sandstone laminae

Total organic carbon (TOC)	3.10	%
Weight of sample extracted	25.90	gm
Extracted organic matter (EOM)	595	ppm
EOM as fraction of TOC	19.2	mg/g
Wt. EOM	15.4	mg

Analysis of extracted organic matter:-

Asphaltenes	24.7	% (wt)
Saturates	11.0	%
Aromatics	1.3	%
Resins	23.4	%
Loss on column	39.6	%

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abund.	-	0.5	1.6	4.4	6.7	6.4	4.4	2.6	1.4	1.6	1.8
n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abund.	1.9	3.0	2.9	8.5	5.0	20.0	5.3	15.6	1.9	4.5	-

Isoprenoid distribution in saturates:

IP16	IP18	Pr	Ph
-	-	4.20	3.55

$\frac{IP16}{IP18}$	$\frac{IP18}{Pr}$	$\frac{Pr}{Ph}$	$\frac{IP16}{nC_{15}}$	$\frac{IP18}{nC_{16}}$	$\frac{Pr}{nC_{17}}$	$\frac{Ph}{nC_{18}}$
-	-	1.19	-	-	0.63	0.55

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SOURCE ROCK

0143

SAMPLE NO:	13
WELL:	Argonaut A1 Otway Basin
SAMPLE IDENTIFICATION:	Core 11 Upper Cretaceous Curdies - Paaratte Form
DEPTH:	8970' 2" - 8970' 7" (2734.11 - 2734.23 m)
TYPE OF SAMPLE:	Dark grey silty mudstone

Total organic carbon (TOC)	2.06	%
Weight of sample extracted	28.75	gm
Extracted organic matter (EOM)	1645	ppm
EOM as fraction of TOC	79.9	mg/g
Wt. EOM	47.3	mg

Analysis of extracted organic matter:-

Asphaltenes	51.6	% (wt)
Saturates	7.0	%
Aromatics	3.0	%
Resins	27.1	%
Loss on column	11.3	%

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abund.	-	-	1.5	3.1	5.0	5.6	5.8	5.1	3.3	3.7	3.9

n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abund.	3.5	4.5	4.6	7.2	6.2	12.2	5.2	11.9	2.8	4.9	-

Isoprenoid distribution in saturates:

IP16	IP18	Pr	Ph
-	-	14.35	5.50

$\frac{IP16}{IP18}$	$\frac{IP18}{Pr}$	$\frac{Pr}{Ph}$	$\frac{IP16}{nC_{15}}$	$\frac{IP18}{nC_{16}}$	$\frac{Pr}{nC_{17}}$	$\frac{Ph}{nC_{18}}$
-	-	2.62	-	-	2.88	0.98

0144

SOURCE ROCK

SAMPLE NO: 14

WELL: Argonaut A1 Otway Basin

SAMPLE IDENTIFICATION: Core 14 U. Cretaceous Belfast Mudston

DEPTH: 11315' 5" - 11315' 10"
(3448.94 - 344[illegible].06 m)

TYPE OF SAMPLE: Black carbonaceous shale

Total organic carbon (TOC)	1.09	%
Weight of sample extracted	40.05	gm
Extracted organic matter (EOM)	792	ppm
EOM as fraction of TOC	72.6	mg/g
Wt. EOM	31.7	mg

Analysis of extracted organic matter:-

Asphaltenes	56.8	% (wt)
Saturates	6.6	%
Aromatics	3.5	%
Resins	18.3	%
Loss on column	14.8	%

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abund.	-	1.0	2.5	4.9	7.0	8.0	7.7	6.5	6.2	5.9	6.2
n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abund.	6.0	6.1	5.5	6.8	5.2	5.9	3.5	3.2	1.0	0.9	-

Isoprenoid distribution in saturates:

IP16	IP18	Pr	Ph
-	-	14.95	4.05

IP16/IP18	IP18/Pr	Pr/Ph	IP16/nC_{14}	IP18/nC_{16}	Pr/nC_{17}	Ph/nC_{18}
-	-	3.69	-	-	2.12	0.54

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SOURCE ROCK

SAMPLE NO:	15
WELL:	Argonaut A1 Otway Basin
SAMPLE IDENTIFICATION:	Core 15 U. Cretaceous Waare Formation
DEPTH:	11677' 0" - 11677' 4" (3559.15 - 3559.25 m)
TYPE OF SAMPLE:	Fine sandstone with abundant carbonaceous matter

Total organic carbon (TOC)	1.14 %
Weight of sample extracted	22.0 gm
Extracted organic matter (EOM)	1422 ppm
EOM as fraction of TOC	124.8 mg/g
Wt. EOM	31.3 mg

Analysis of extracted organic matter:-

Asphaltenes	51.1 % (wt)
Saturates	7.7 %
Aromatics	5.1 %
Resins	26.2 %
Loss on column	9.9 %

n-Alkane distribution of saturates:-

n-Alkane	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}
Rel abund.	-	1.4	1.9	3.5	4.9	6.6	8.6	8.9	9.7	10.2	8.1
n-Alkane	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	C_{32}	C_{33}	C_{34}
Rel abund.	6.0	4.8	4.4	4.9	4.2	4.3	2.7	2.7	1.2	1.0	-

Isoprenoid distribution in saturates:

IP16	IP18	Pr	Ph
-	-	14.20	4.05

IP16/IP18	IP18/Pr	Pr/Ph	IP16/nC_{15}	IP18/nC_{16}	Pr/nC_{17}	Ph/nC_{18}
-	-	3.50	-	-	0.53	0.60

APPENDIX NO. 1

Extracts from:- "Organic Petrology of Samples from a set of six wells from the Otway Basin, South Australia", A.C. Cook.

0147

Argonaut No.1

U.Woll. No.	Depth (m)	$\bar{R}$%	Range	N	Exinite fluorescence (remarks)
9778	1305	<0.60	-	-	Sporinite rare, orange. (Massive inertinite abundant in silty pyritic ss. Probably no vitrinite present).
9779	1807	?0.38	0.26-0.44	5	Sporinite and cutinite sparse to common, orange. (Interbedded ss. and carb. shale with abundant semifusinite, vitrinite population not well-defined.
9780	2734	0.59	0.48-0.74	12	Liptodetrinite rare, yellow to orange, some ? suberinite, reddish-brown. (Clay-rich poorly sorted ss. with abundant I and rare V, shell fragments present).
9781	3448	0.69	0.62-0.75	3	Rare, bright yellow? dinoflagellates, orange liptodetrinite. (Sandy fine grained siltstone, d.o.m. common, chiefly fine-grained inertinite with a very poorly defined vitrinite population. Patches of bright yellow mineral fluorescence.)
9782	3554	0.75	0.55-0.92	17	Sparse to common cutinite, bright yellow, and liptodetrinite yellow orange. (Clay-rich ss. with a well-defined population of vitrinite, Inertinite dominant over vitrinite).

Burrungule No.1

U.Woll. No.	Depth (m)	$\bar{R}$%	Range	N	Exinite fluorescence (remarks)
9783	1441	0.55	0.45-0.65	14	Very rare liptodetrinite, orange. (Some carb. siltst. with sparse I and V, rare huminite grains).
9784	1488	0.52	0.48-0.54	3	Very rare sporinite, orange. (Dominantly sandstone, some silts rare vitrinite. Some carbonate grains which fluoresce orange).
9785	1677	0.50	0.41-0.58	25	Abundant, cutinite, sporinite and resinite, yellow to orange. (Coal 20%, vitrinite rich but I u to 40% and E 5-10%. Siltstone with common sporinite, orange, an resin, bright orange. Orange fluorescence prominent in carbonates.)
9786	1930	0.62	0.51-0.76	3	Rare sporinite, orange, in carb. shales and silst. (D.o.m. largely confined to carb. shales and silt stones, sparse and dominantly I, V is very rare.)
9787	2151	0.55	0.47-0.64	13	Sparse liptodetrinite, ?sporinite ?resin, yellow to orange in the sparse carb. shale. (Very rare massive vitrinite, some of it "fry-panned". Some orange fluorescing fusion carbonate crystals.
9788	2397	0.58	0.49-0.78	13	Similar to 9787 but no massive vitrinite is present.

Caroline No.1

U. Woll. No.	Depth (m)	R̄%	Range	N	Exinite fluorescence (remarks)
9773	1250	0.24	-	1	Cutinite, rare, orange, resinite, sparse, greenish yellow to brown. (Silty claystone with abundant I. most of it in the reflectance range 0.70% to 0.90%)
9774	1229	0.53	0.48-0.57	5	Liptodetrinite rare, orange. (Clay rich ss, rare shell fragment elongate vitrinite layers, with rim fluorescence on some quartz grains).
9775	2425	0.60	0.45-0.73	11	Sparse to common sporinite and liptodetrinite, orange, rare bright green fluorinite. (Claystone and clay rich ss, abundant vitrinite, typically pyritized, I>V>E.)
9776	3068	0.69	0.59-0.74	3	Sparse sporinite, cutinite and resinite, orange to yellow orange, (Siltstone with abundant mineral fluoresecnce, rare V, abundant I.)
9777	3369	0.97	0.56-1.17	13	Rare sporinite, orange. (Pale fine-grained sltst. with rare but extensive vitrinite layers, one, perpendicular to bedding, probably representing a root).

Kalangadoo No.1

U. Woll No.	Depth (m)	$\bar{R}$%	Range	N	Exinite fluorescence (remarks)
9793	611	0.33	-	1	Exinite rare, sporinite, cutinite, fluorinite, bright greenish yellow to orange. (Silty ss., d.o.m. common chiefly I, V is rare).
9794	764	0.35	0.26-0.45	12	Sparse sporinite and liptodetrinit and ?dinoflagellates, greenish yellow to orange. (Silty ss. d.o.m. common chiefly I, V is spar
9795	895	0.36	0.20-0.45	7	Exinite rare to sparse, cutinite sporinite and liptodetrinite, yell to orange and dull orange. (Sand siltst. with abundant organic matt chiefly I, large masses of pyrite are present).
9796	1455	0.42	0.34-0.46	7	Sporinite very abundant in shaly c dull orange but showing strong positive alteration to bright yel Brilliant greenish yellow to dull orange brown resin bodies. Cutin dull orange to brilliant yellow. (Shaly coal and carb. shale both abundant exinite and I but rare V. D.o.m. approx 20% overall and appr 10%E.)
9797	1719	0.45	0.39-0.52	18	Exinite common to abundant, sporin cutinite, and liptodetrinite, typically bright yellow to orange but some very dull orange. (Silt carb. shale with d.o.m. common. V abundant but in thin layers, son probably being *in situ* roots).
9798	2023	0.75	0.73-0.77	4	Common sporinite and shreds of cutinite, bright yellow to orange, rare resin, orange. (Sand siltst. d.o.m. chiefly E with thin layers of I and V, shell fragments presen
9799	2249				- No fluorescing exinite present. (Silst. with numerous fine laminae probably related to vitrinite but too thin to take a polish, pyritic

0151

Lake Bonney No.1

U. Woll No.	Depth (m)	$\bar{R}$%	Range	N	Exinite fluorescence (remarks)
9789	2375	0.63	0.48-0.81	14	Rare cutinite and sporinite yellow to orange. (Ss., silty, with abundant SF and rare V, shell fragments present).
9790	2563	0.53	0.45-0.60	7	Resinite yellow to orange, cutinite dull orange. (Sandy siltstone, rare massive vitrinite and I and E rich coal. Fluorescing carbonate common.)
9791	2718	0.61	0.54-0.70	10	Liptodetrinite common, sporinite derived, yellow to orange. (Sandy siltst. with abundant I and rare V. Carbonate with rare I and E).
9792	2908	0.55	0.48-0.68	20	Sparse to common sporinite, cutinite, liptodetrinite and ?dinoflegellates, bright yellow to orange. (Siltst. with rare pyrite, d.o.m. sparse chiefly I some V).

0152

Mount Salt No.1

U.Woll No.	Depth (m)	$\bar{R}$%	Range	N	Exinite fluorescence (remarks)
9819	1382	0.45	0.33-0.60	17	Sporinite, cutinite, brilliant yellow orange, sparse. (SS., siltst., and shaly coal, the ss. being extensively pyritized. The d.o.m. and the shaly coal are both dominated by inertinite, V is common and exinite sparse to rare in all lithologies).
9820	2419	0.46	0.30-0.60	10	Sparse to common liptodetrinite, sporinite and cutinite, yellow to orange. (Siltst. with abundant d.o.m., dominated by I. Pyrite and shell fragments present.)
9821	2567	0.47	0.39-0.67	8	Rare liptodetrinite, orange. (Pyritic silty ss., with shell fragments and sparse d.o.m., chiefly I.)
9822	3003	0.62	0.50-0.80	22	Sparse cutinite, sporinite and liptodetrinite, greenish yellow to orange. Some orange resinite present. (Pyritic coarse siltston with shell fragments and abundant d.o.m., but V is sparse I>V>E. Cutinite shows strong positive alteration).
9823	3060	0.74	0.57-0.83	14	As for 9822 but bright green fluorinite is also present in trace amounts.