

**New Palynological and Geochemical Data, Durroon-1  
Bridge Oil Limited**

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Implications for Expulsion of Oil from Lacustrine Facies in Post-Otway, Cenomanian  
Depocentres in T15P

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Well Durnomi  
Well Boobyomi

Attachment 3 - New Palynology of the Durroon Mudstone

7 May 1991  
521/117/bag

To: KS/RP/DE/PTB

From: BAG *for [signature]*

RE: GEOTHERMICS AND SENSITIVITY OF MATOIL MODELS FOR DURROON-1 AND IMPLICATIONS FOR EXPULSION OF OIL FROM LACUSTRINE FACIES IN POST-OTWAY, CENOMANIAN DEPOCENTRES IN T15P (whew!)

A review of thermal and maturity gradients in Durroon-1 is now complete, post-receipt of new palynologic and pyrolytic studies of Roger Morgan and Dave McKirdy (AMDEL) respectively. This review was cause to subtly adjust prior MATOIL models for Durroon-1 and the Cenomanian depocentre recognised at sp 300 on WB82-40. Key conclusions drawn from the Morgan/McKirdy review (appended) and revised MATOIL models follow:

- (a) The organo-facies contained in the Durroon Mudstone in Durroon-1 are submature and in parts, dominated by lacustrine algal palynomorphs. Based on MATOIL models of Cenomanian depocentres, equivalent aged Type I OM buried to >2930 m subsea will have reached a level of organic maturity corresponding to >0.7 Rv% or >15% TR (transformation ratio). Type I organic matter (~ lacustrine algae) in basal Cenomanian strata now buried to ~4050 m reached ~ 1.0 Rv% equivalent (~ 95% TR) ~ 36 MYA (at the start of Oligocene time). The TWT equivalent to the top of the oil generative window for lacustrine algae at ~2930 m subsea will vary with velocities. It corresponds to ~ 2.1 sec TWT (based on stacking velocities) in the vicinity of sp 1843 on line BB90-191.
- (b) The average temperature gradient observed in Durroon-1 has been reanalysed. The previous review concluded an average gradient of 28.4 C/km was a reasonable basis on which to calibrate present-day heatflow estimates at Durroon-1. A detailed reaccount of that estimate is provided (attachment 1) and concludes subtly higher gradients (29.4 to 31.6 C/km) better characterise the extrapolated (to static) BHT's in Durroon-1. The extrapolated static BHT's at 3 depths (corresponding to the 3 wireline log suites) in Durroon-1 were used as a basis to calibrate the present-day heatflow for Durroon-1. That calibrated value is ~ 60 mwatt/sq m.
- (c) A variable heatflow (over time) model has been developed that parallels thermal decline (sediment accumulation and subsidence maximas) and thermal "bulge" (exhumation) of Durroon-1's stratigraphy and is the basis for reconciling observed (measured) and theoretical (MATOIL) maturity gradients for Durroon-1. Graphic MATOIL plots are appended.

**DURROON-1**

log	depth(ft)	depth(m)	bht (f)	T time since circ(hr)	t time(hr) circ'd	rig operating time(hr)	T/T+t
isf/sonic	-3063	-933.6	96	7	1		0.88
n-d	-3063	-933.6	99	12	1	4	0.92
rft	-6030	-1838.0	147	16	1		0.94
n-d	-6030	-1838.0	147	10.5	1	4.5	0.91
isf/sonic	-6030	-1838.0	145	5	1		0.83
isf/sonic	-9913	-3021.5	176	5	1		0.83
n-d	-9913	-3021.5	196	11	1	5	0.92
seabotto	-225	-68.6	-	-	-	-	-

depth(ft)	depth(m)	extrap bht (f)	extrap bht (c)	T(f)/Z(ft) gradient to next BHT	t(c)/z(km) gradient to next BHT	T(f)/Z(ft) gradient BHT to s.f.	t(c)/z(km) gradient BHT to s.f.
-3063	-933.6	113	45.00	0.0165	30.10	0.0161	29.37
-3063	-933.6	113	45.00	0.0165	30.10	0.0161	29.37
-6030	-1838.0	162	72.22	0.0175	31.92	0.0163	29.72
-6030	-1838.0	162	72.22	0.0175	31.92	0.0163	29.72
-6030	-1838.0	162	72.22	0.0175	31.92	0.0163	29.72
-9913	-3021.5	230	110.00	n.a	n.a	0.0168	30.56
-9913	-3021.5	230	110.00	n.a	n.a	0.0168	30.56
-225	-68.6	60	15.56	0.0187	34.04	n.a	n.a

nb. Time since circ not given with n-d logs.

Assumed time since circ for ISF plus operating time  
for n-d plus 1 hr - time since circ for n-d.

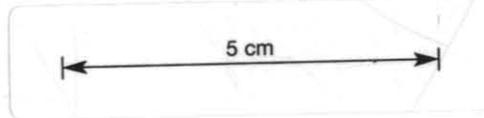
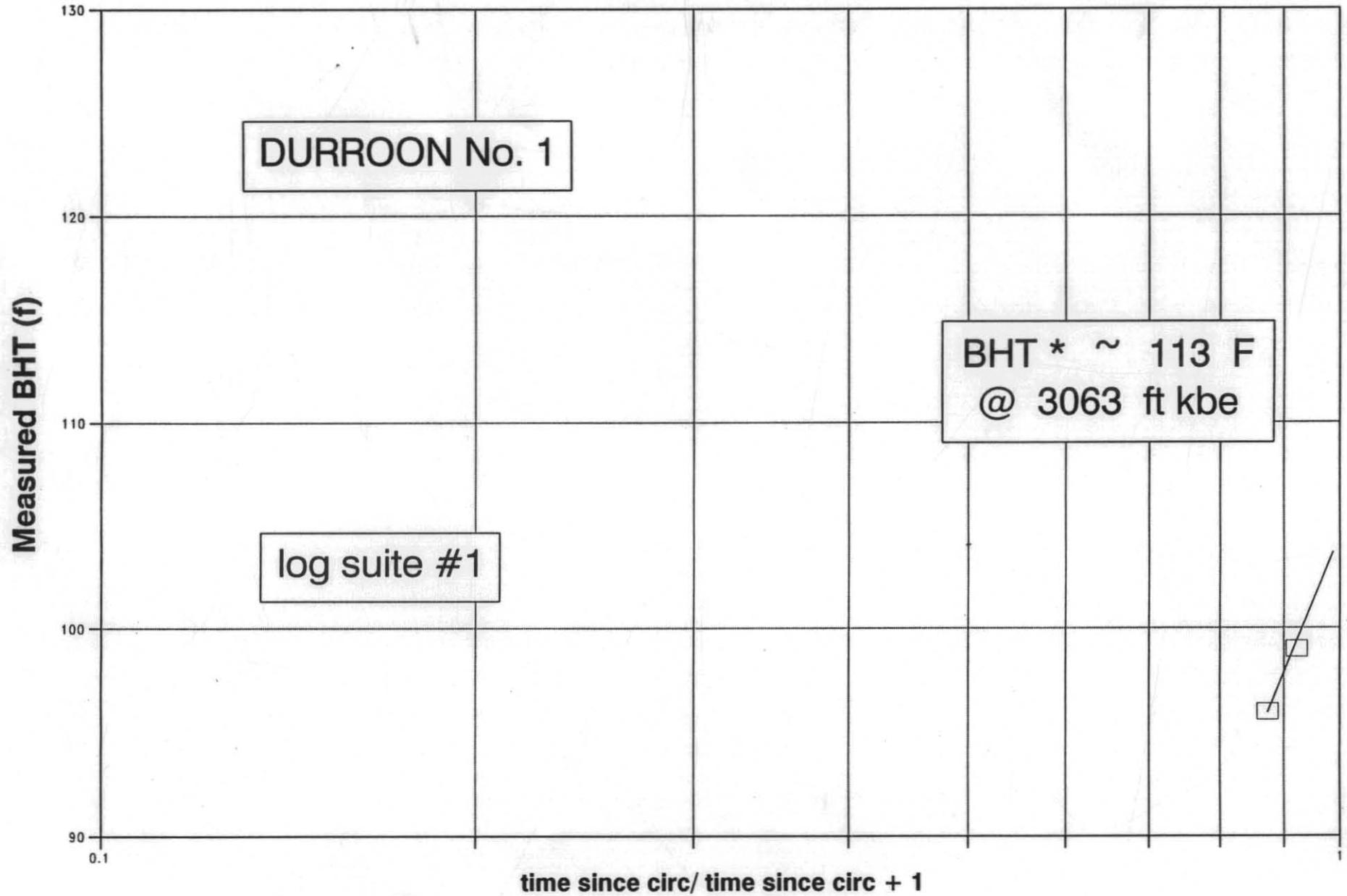
nb. BHT's at 6132 (n-d) and 6153 (isf-sonic) are  
posted at the depth of the rft survey (6030).

This leaves the crossplot "clean" without consequential  
manipulation of the data set.

367003

Attachment 1  
page 1 of 4

# Temperature Extrapolation

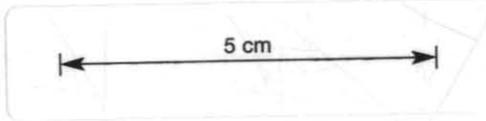
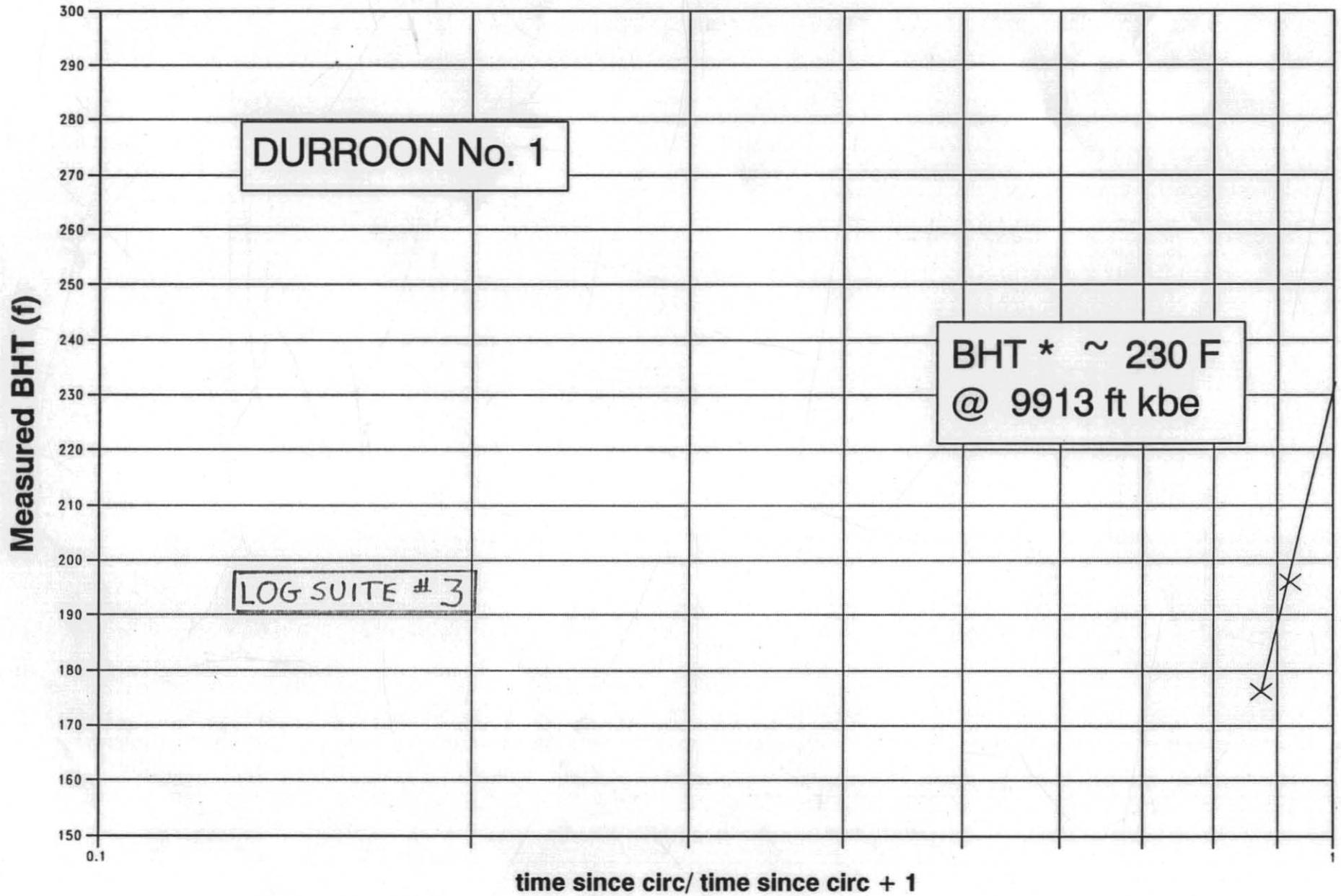


□ depth kbe

367004

Attached 1  
page 2 of 4

# Temperature Extrapolation

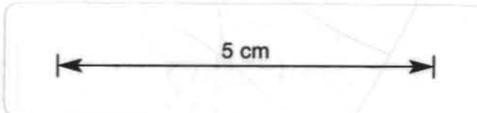
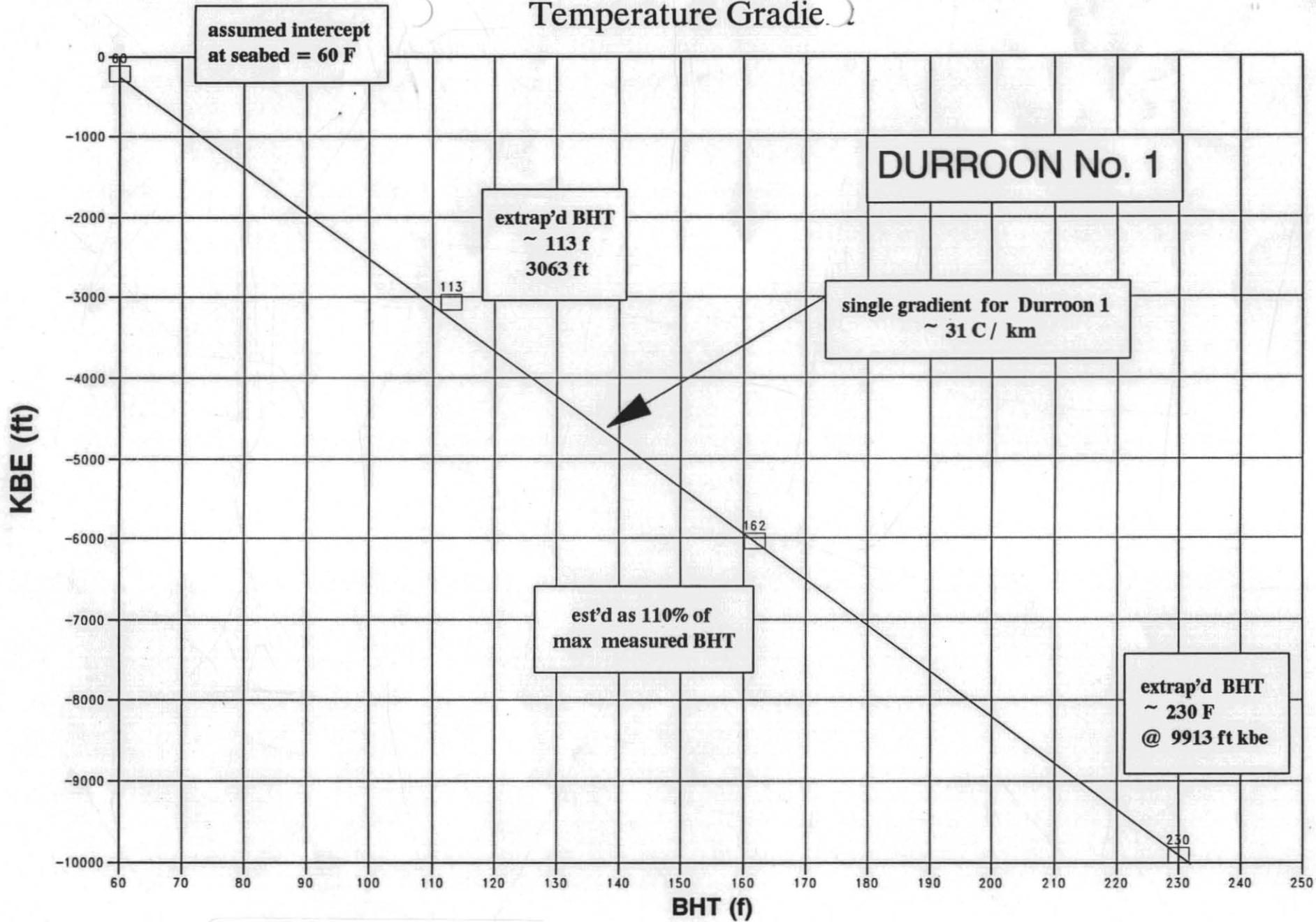


x depth kbe

367005

Attachment 1  
page 3 of 4

# Temperature Gradient



□ BHT\*

367006

## Attachment 2

Variable heatflow used in revised MATOIL models:

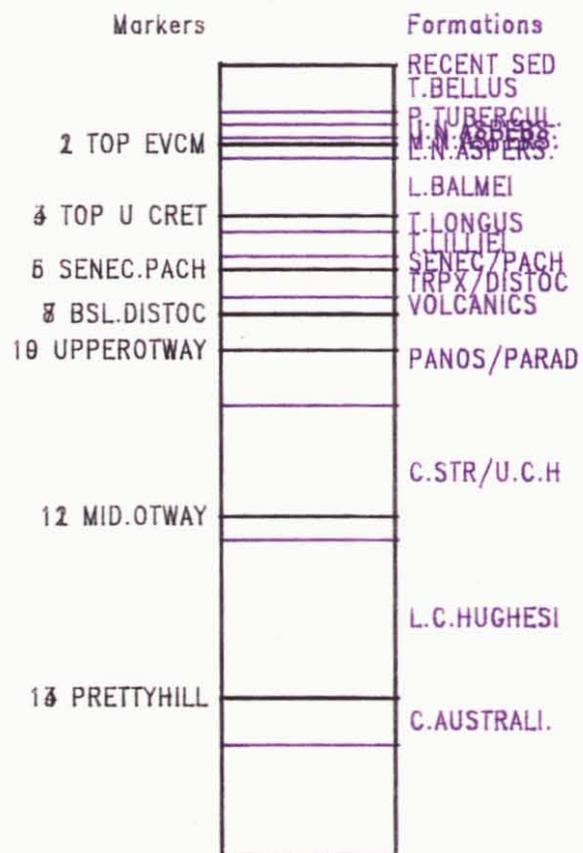
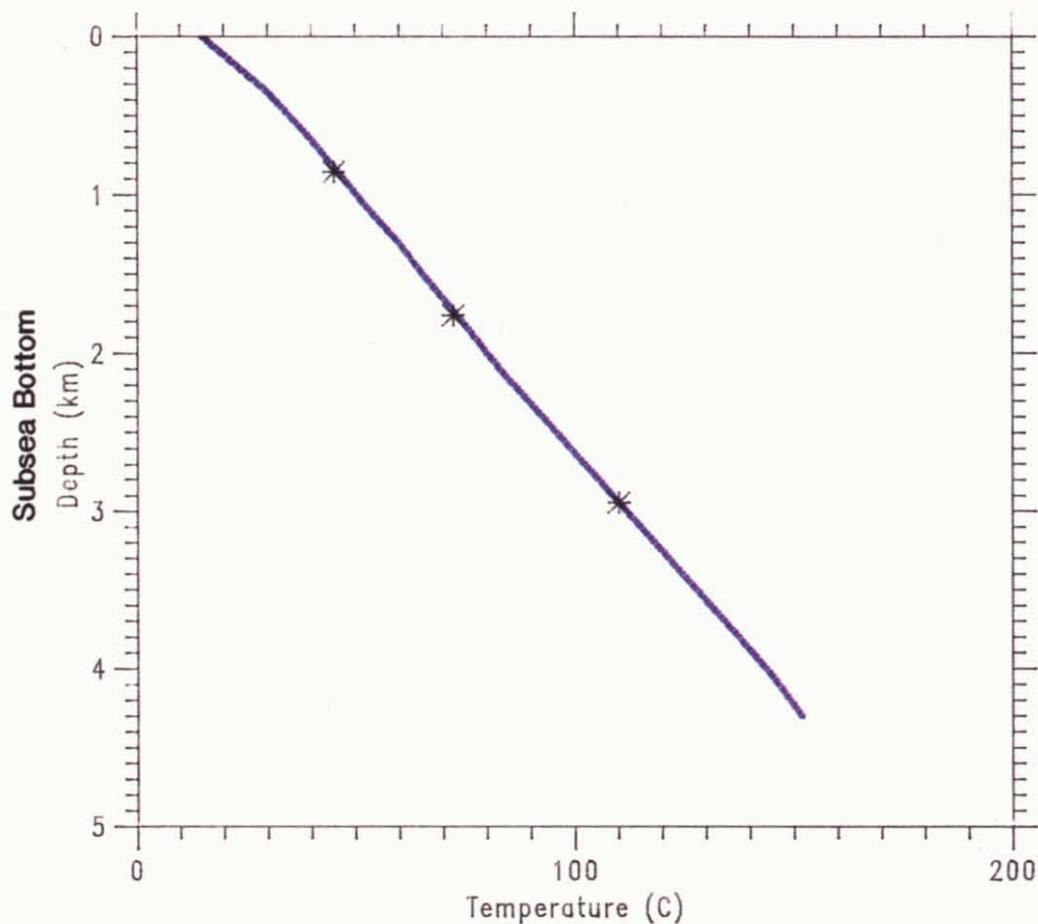
DURRNBHT & DURRNOMI		BOOBYOMI	
time	HF	time	HF
mya	(wmatt/sq m)	mya	(mwatt/sq m)
145	55	145	55
110	55	110	55
101	65	101	65
88	55	88	55
51	65	51	65
0	60	0	55

OMI models assume lacustrine algae (organic matter type I) as the standard organic matter. BHT models assume vitrinite as the standard organic matter. All are "calibrated" models. The difference in these HF models is only in the present-day HF value determined by MATOIL ( at Durroon-1 vs. the Cenomanian depocentre ).

5 cm

CALIBRATED WITH DURROON-1 BHT's  
PRESENT TEMPERATURE

Well DURRN BHT  
WD 68m



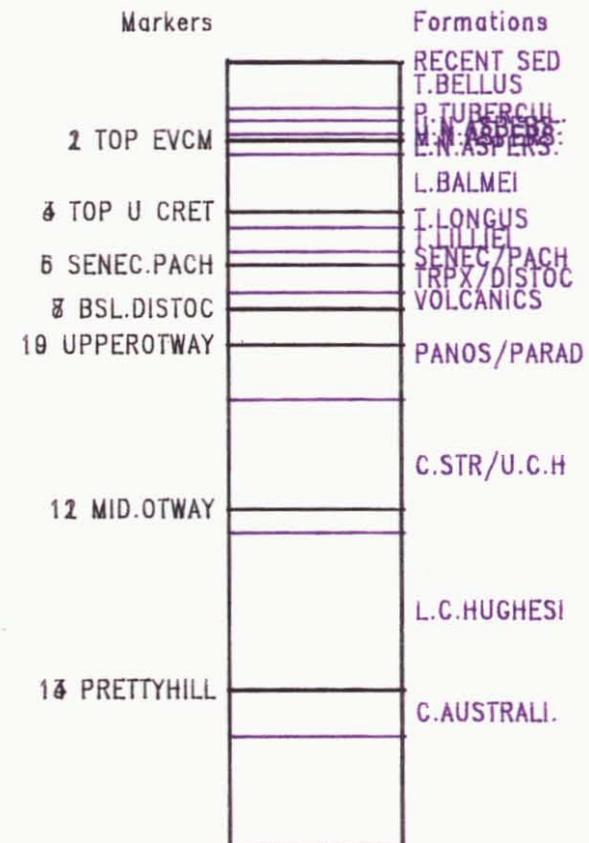
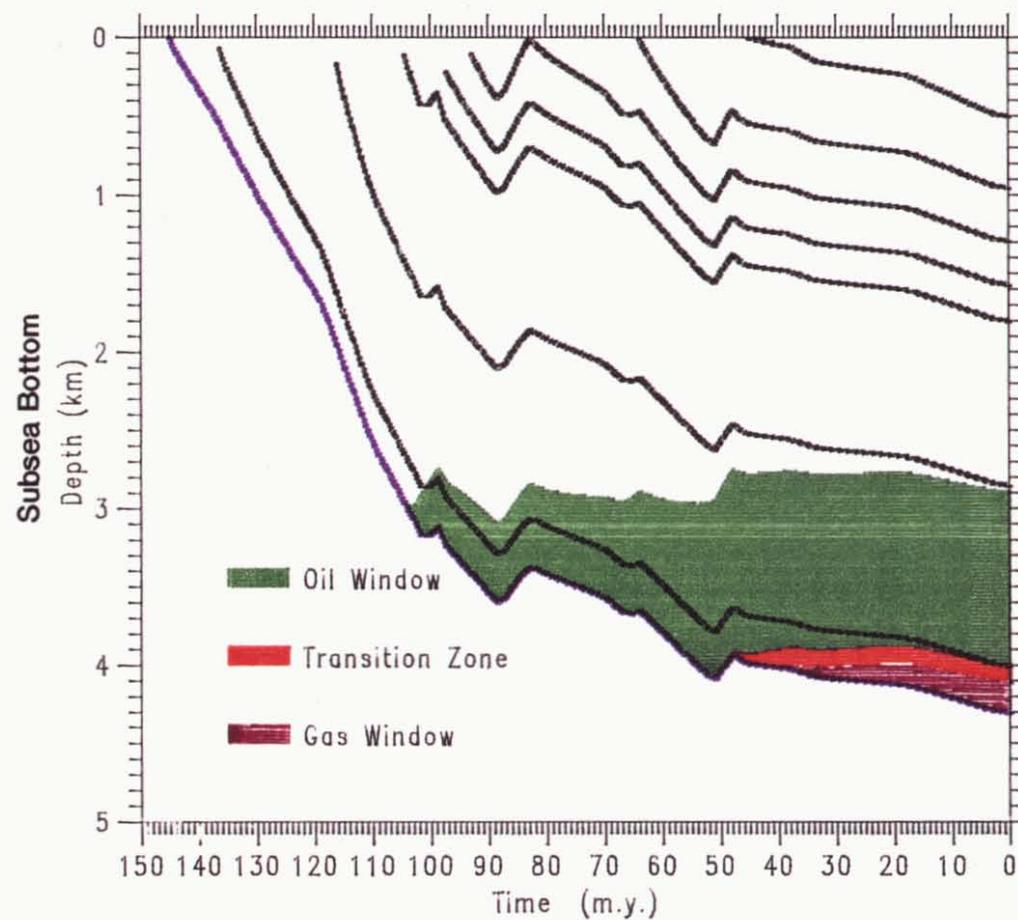
5 cm

## OIL WINDOW EVOLUTION

ORGANIC MATTER no. 4 (Vitrinite)

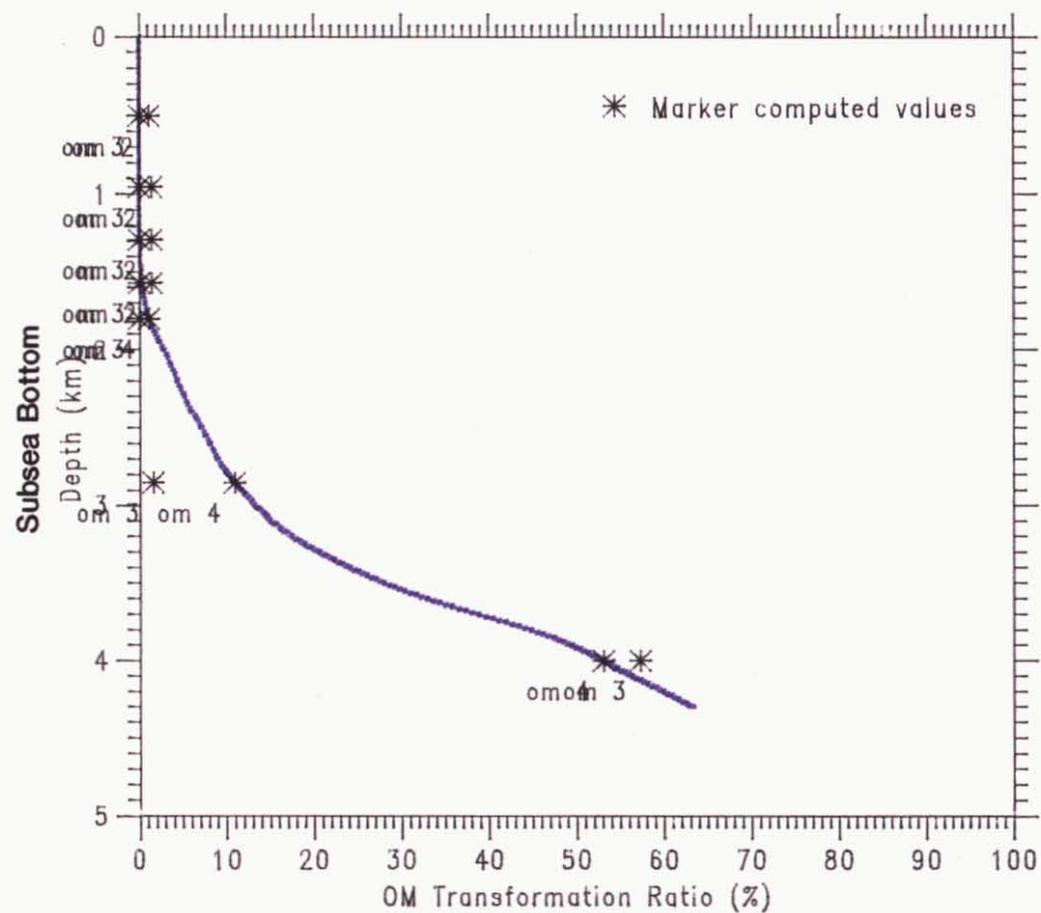
Well DURRBHT

WD 68m

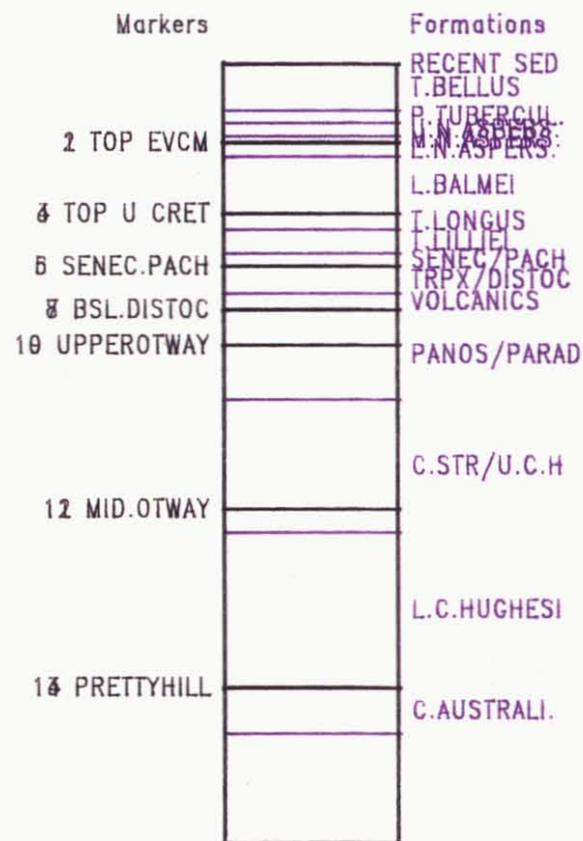


5 cm

PRESENT TRANSFORMATION RATIO  
ORGANIC MATTER no. 4 (Vitrinite)



Well DURRBHT  
WD 68m



← 5 cm →

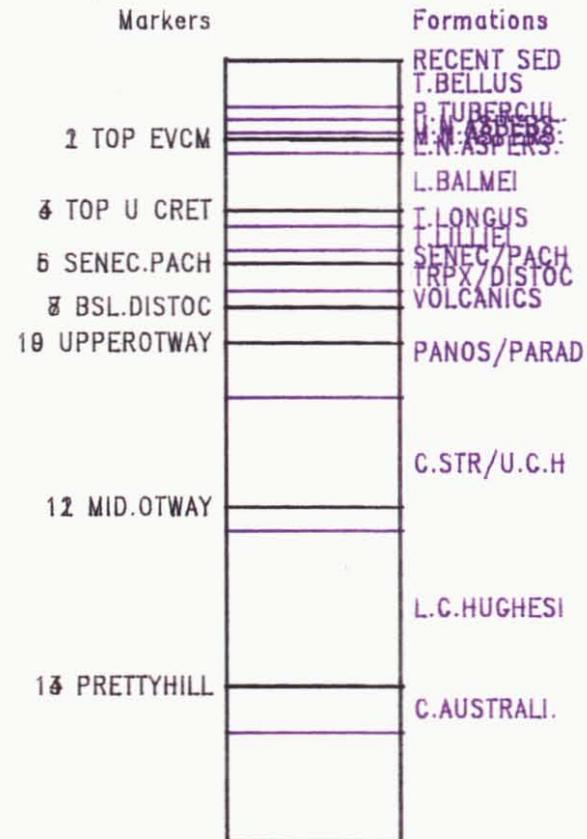
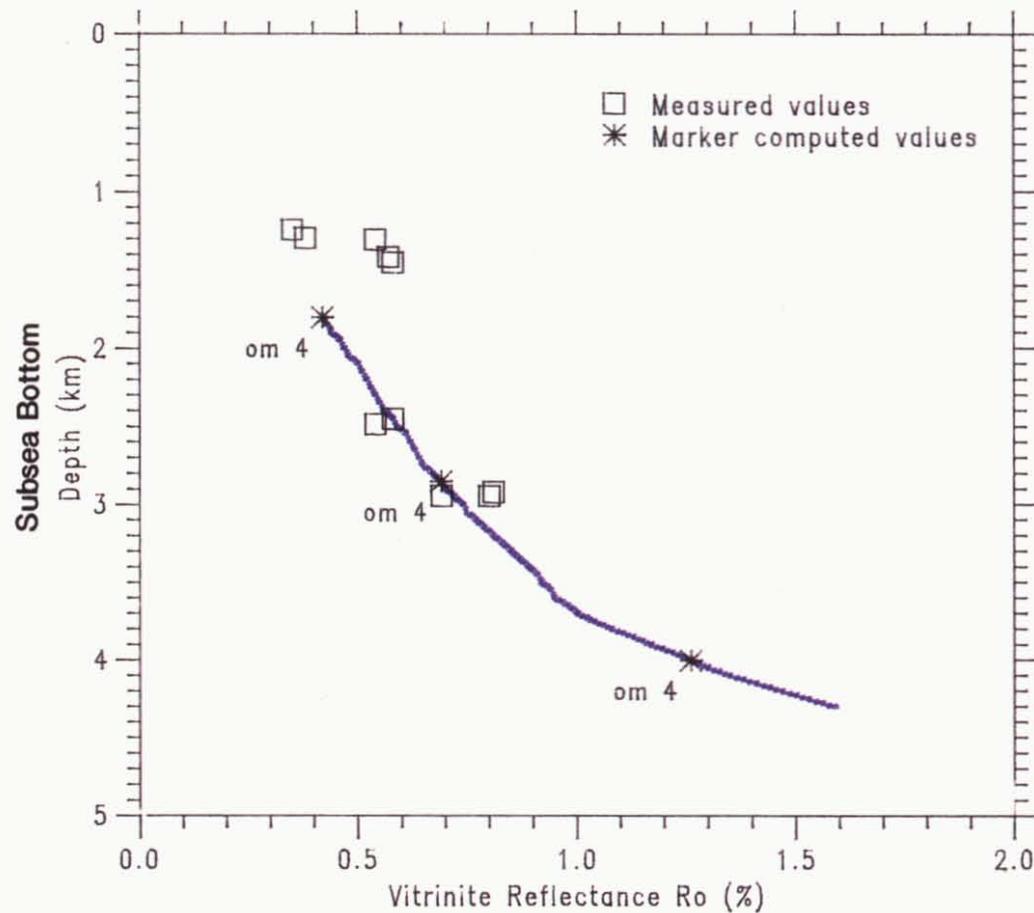
**Conservative Heat Flow MATOIL Model that Reconciles Minimum Maturity Gradient in Durroon-1**

PRESENT VITRINITE REFLECTANCE

Well DURRNBT

ORGANIC MATTER no. 4

WD 68m



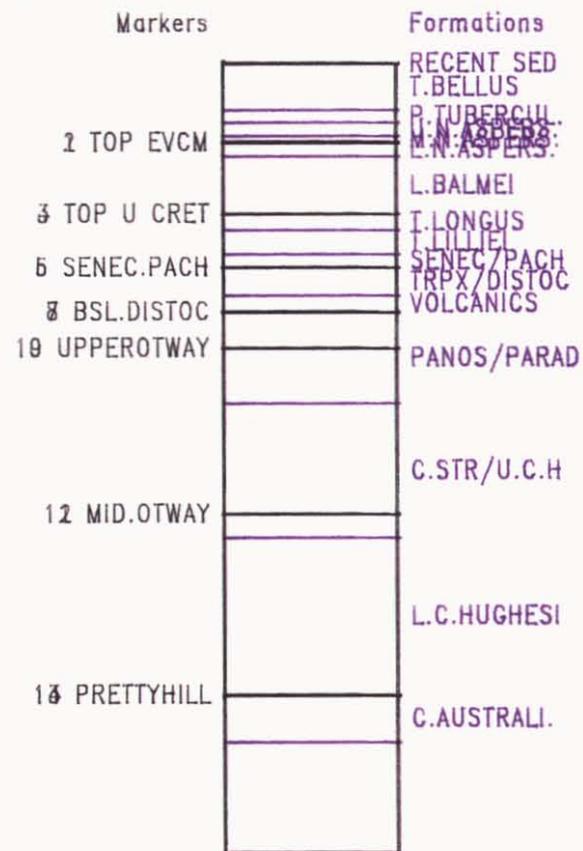
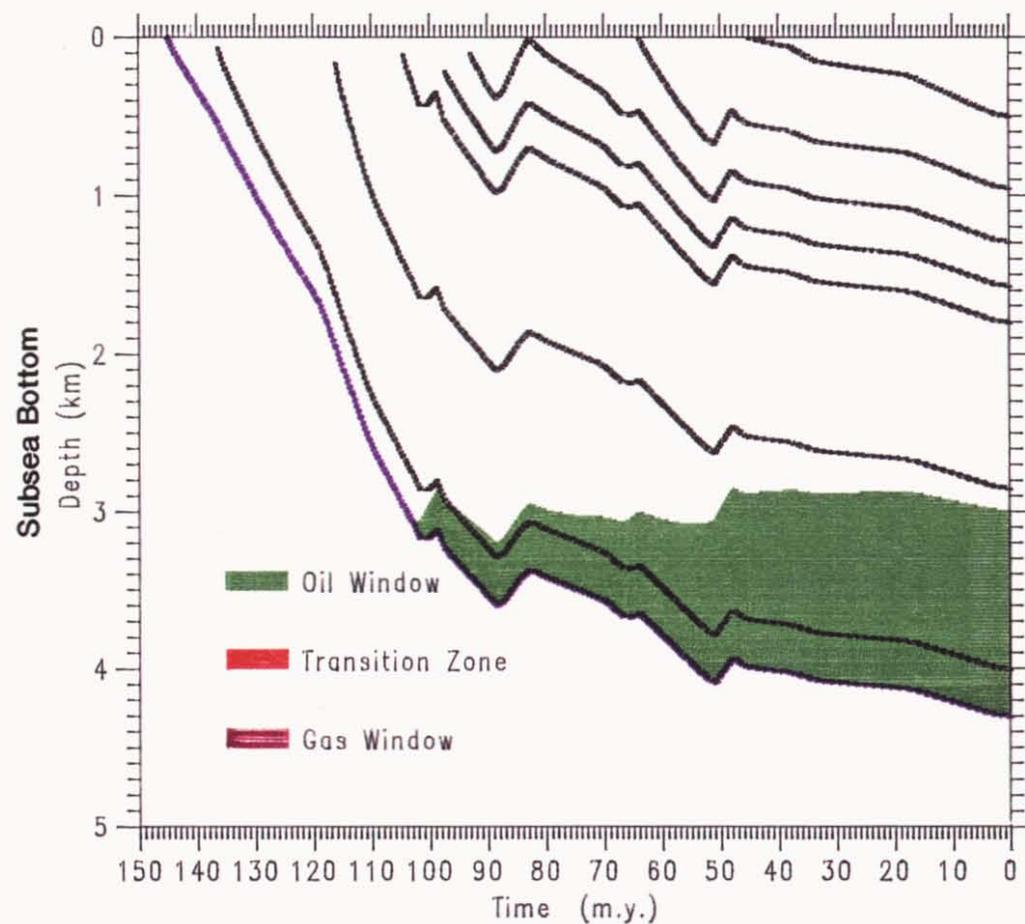
5 cm

# OIL WINDOW EVOLUTION

ORGANIC MATTER no. 1 (Lacustrine Algae)

Well DURRNOM1

WD 68m



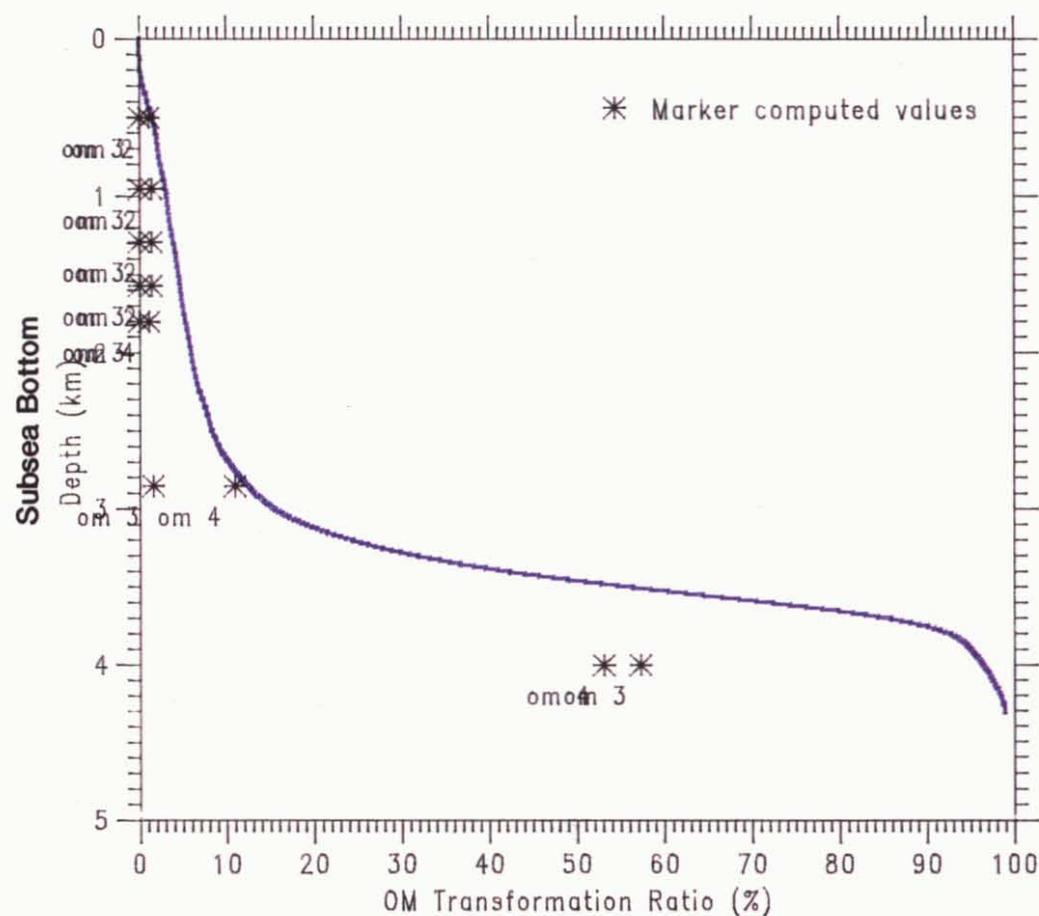
5 cm

## PRESENT TRANSFORMATION RATIO

ORGANIC MATTER no. 1 (Lacustrine Algae)

Well DURRNOM1

WD 68m



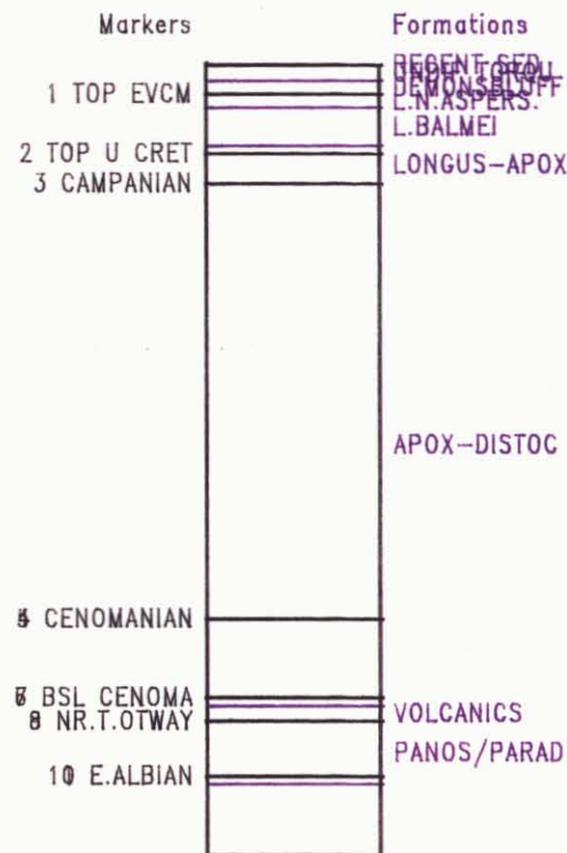
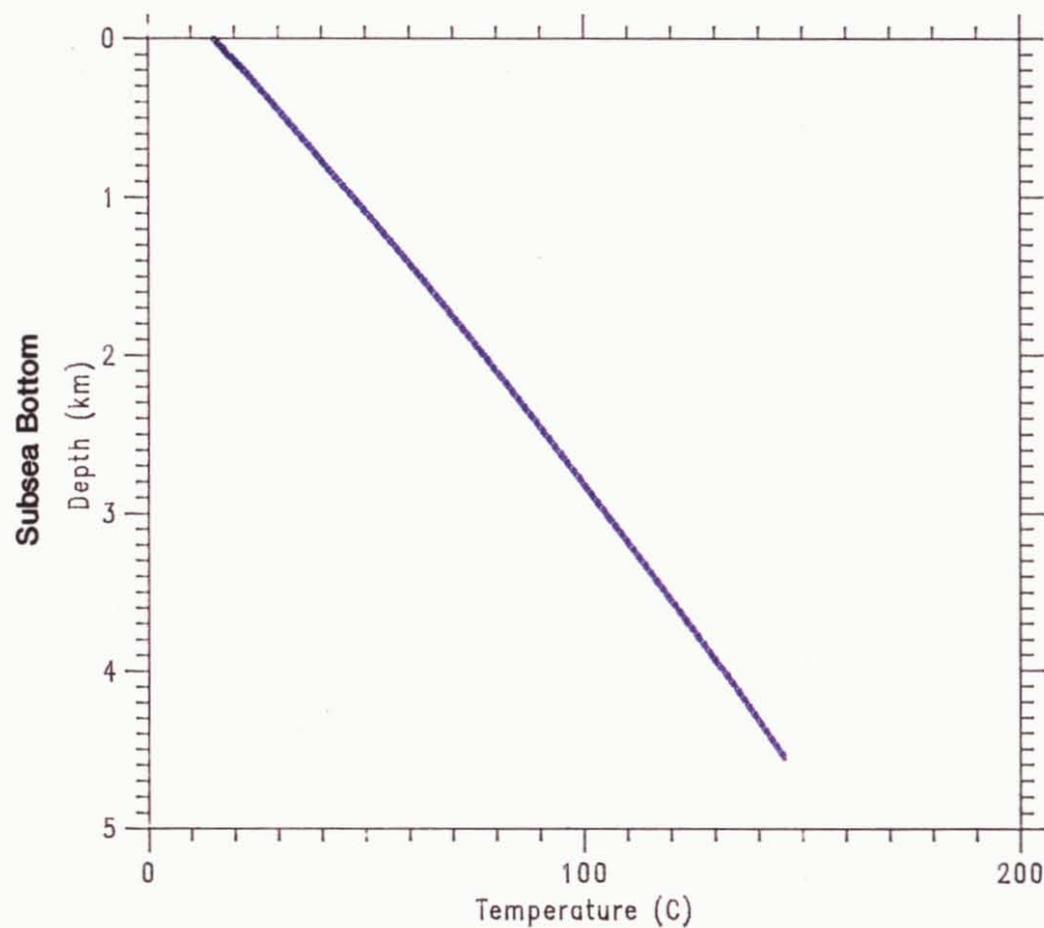
5 cm

Cenomanian Depocentre Line WB82-40 SP300 (30°C/km gradient)

PRESENT TEMPERATURE

Well BOOBYOMI

WD 51m



5 cm

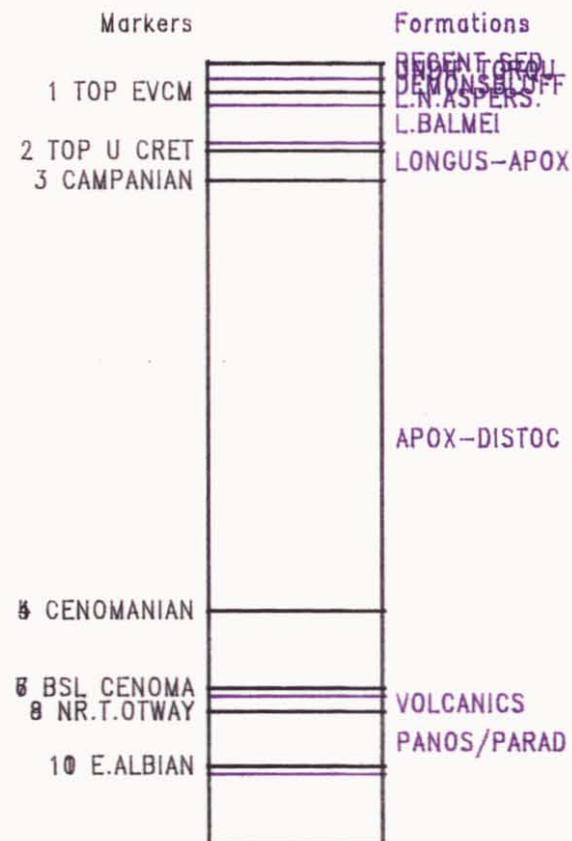
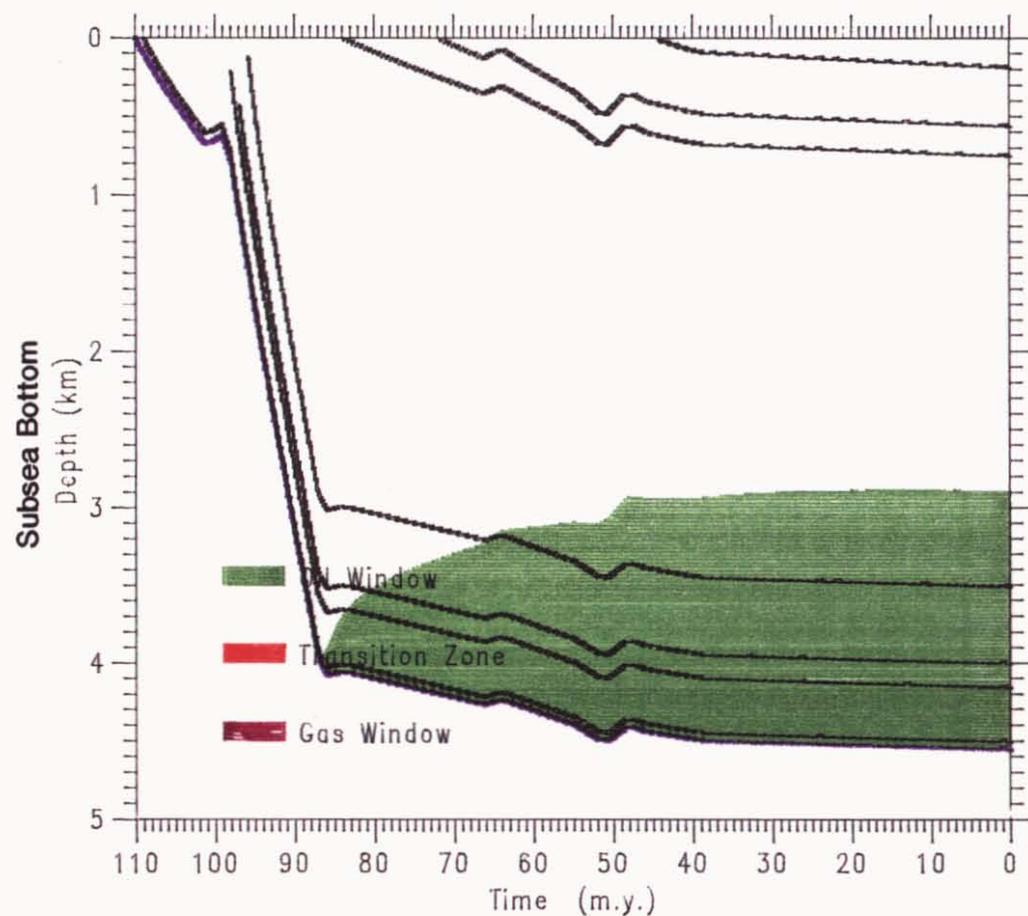
Cenomanian Depocentre WB82-40 SP300

OIL WINDOW EVOLUTION

ORGANIC MATTER no. 1 (Lacustrine Algae)

Well BOOBYOMI

WD 51m



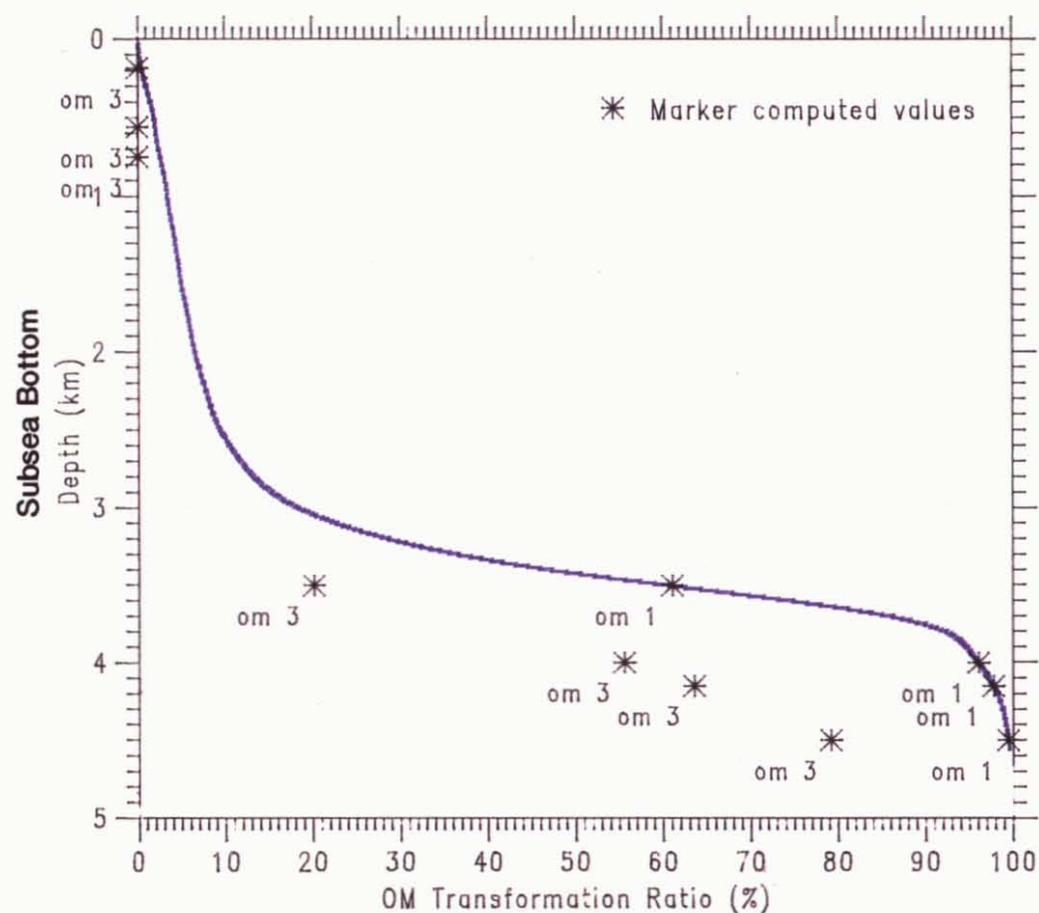
5 cm

## PRESENT TRANSFORMATION RATIO

ORGANIC MATTER no. 1 (Lacustrine Algae)

Well BOOBYOMI

WD 51m



Markers

Formations

- 1 TOP EVCM
- 2 TOP U CRET
- 3 CAMPANIAN
- 5 CENOMANIAN
- 6 BSL CENOMA
- 8 NR.T.OTWAY
- 10 E.ALBIAN

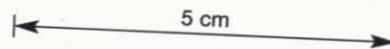
RECENT SED.  
DEMONS BLUFF  
L.N.ASPERS.  
L.BALMEI

LONGUS-APOX

APOX-DISTOC

VOLCANICS

PANOS/PARAD

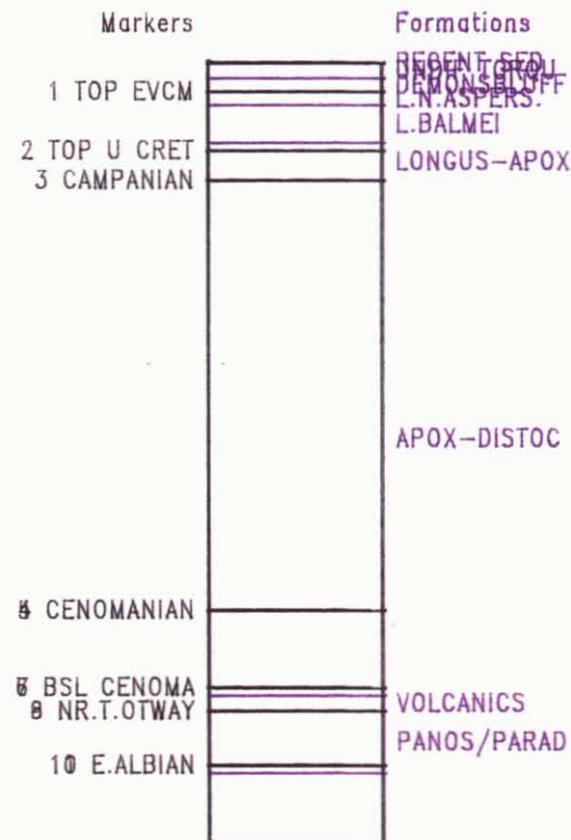
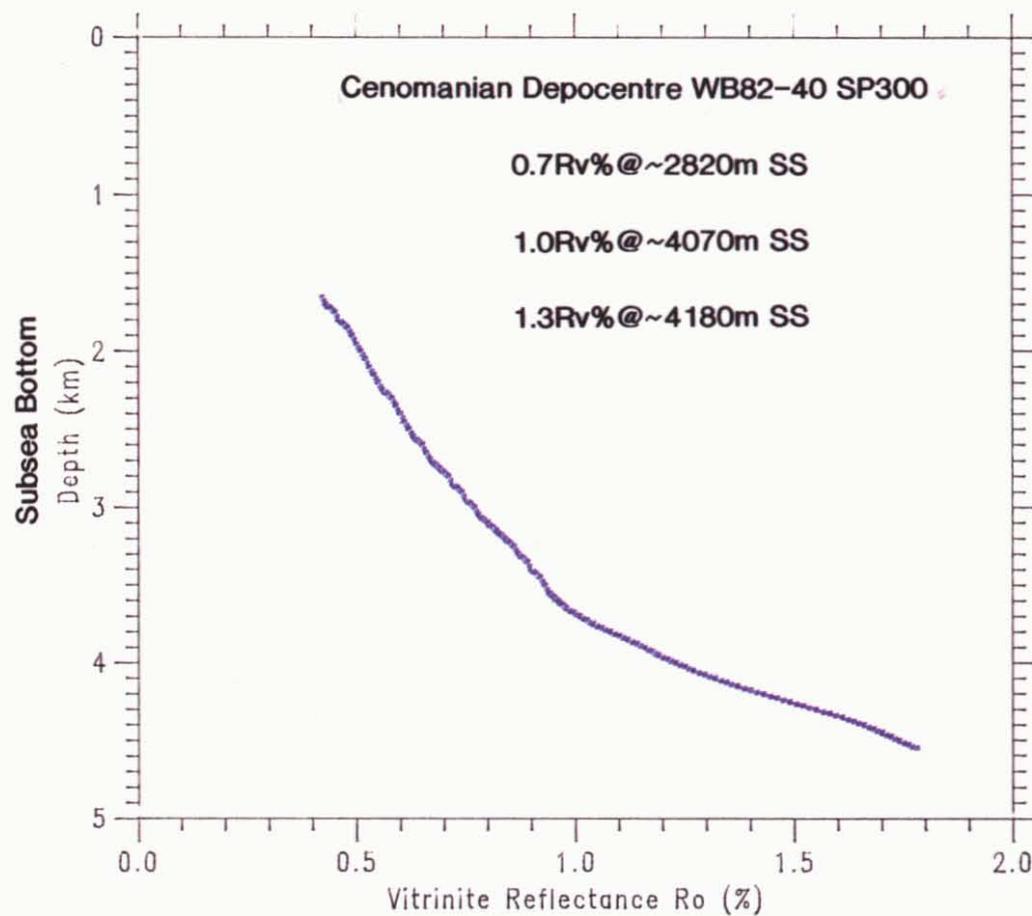


## PRESENT VITRINITE REFLECTANCE

ORGANIC MATTER no. 4

Well BOOBYOM4

WD 51m



5 cm

## HYDROCARBON GENERATION HISTORY

Well BOOBYOMI

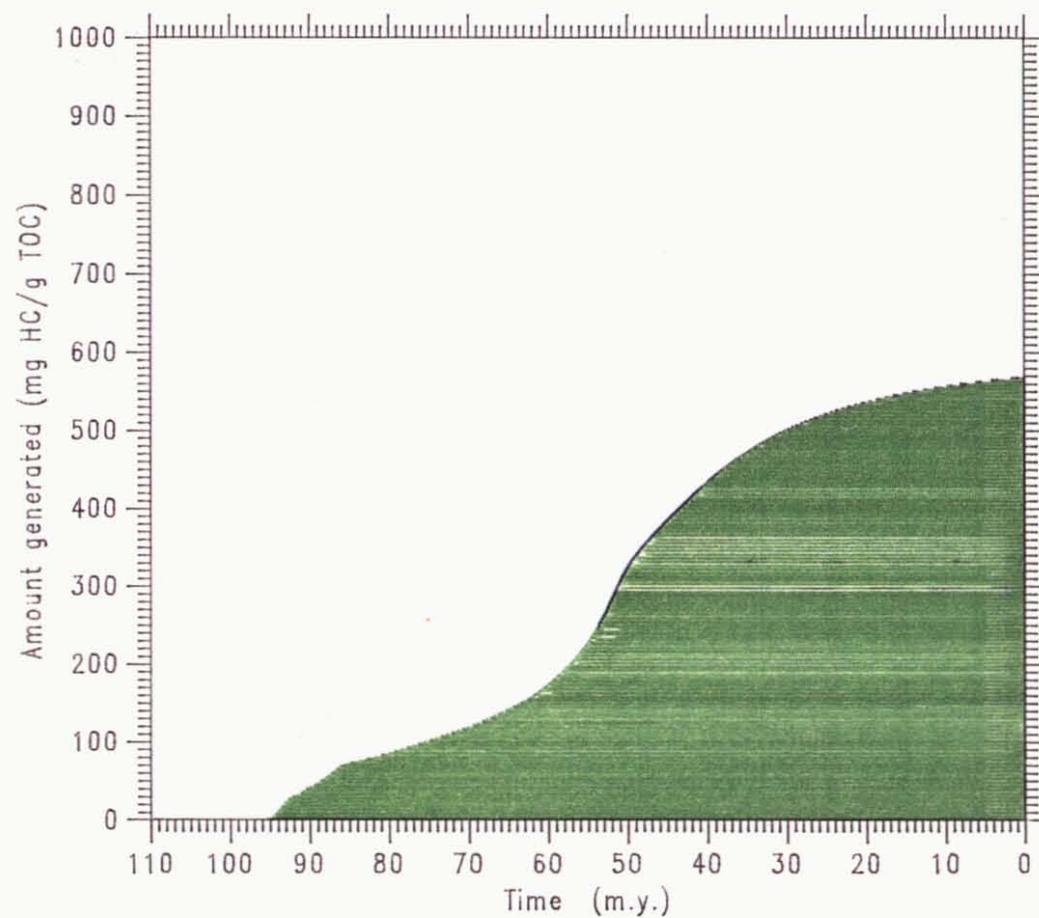
SOURCE ROCK NO. 5

Cenomanian Depocentre WB82-40 SP300

Lacustrine Algae in Uppermost Cenomanian

Marker CENOMANIAN

Organic matter no. 1



Residue

Gas

Oil

5 cm

# HYDROCARBON GENERATION HISTORY

SOURCE ROCK NO. 6

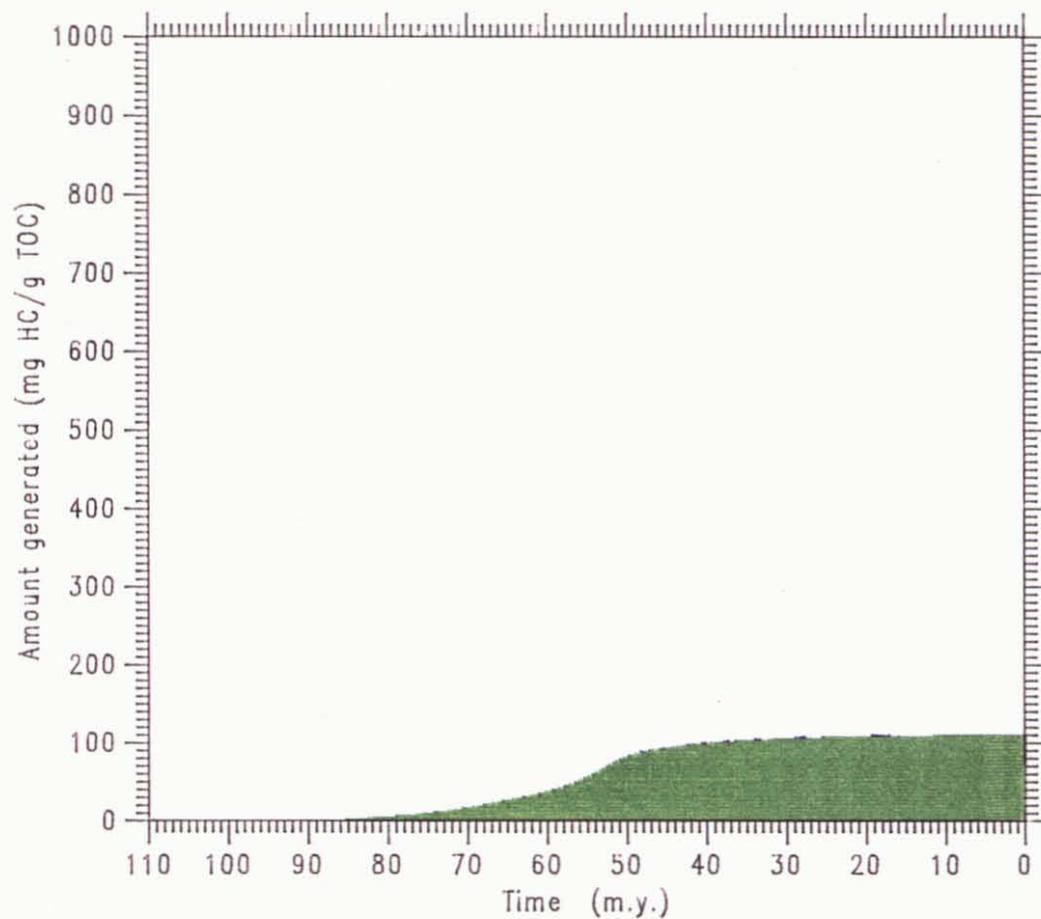
Well BOOBYOMI

Cenomanian Depocentre WB82-40 SP300

Terrestrial Organic Matter  
in Deepest Cenomanian

Marker BSL CENOMA

Organic matter no. 3



Residue

Gas

Oil

5 cm

# HYDROCARBON GENERATION HISTORY

SOURCE ROCK NO. 7

Well BOOBYOMI

**Cenomanian Depocentre WB82-40 SP300**

**Lacustrine Algae in Deepest Cenomanian**

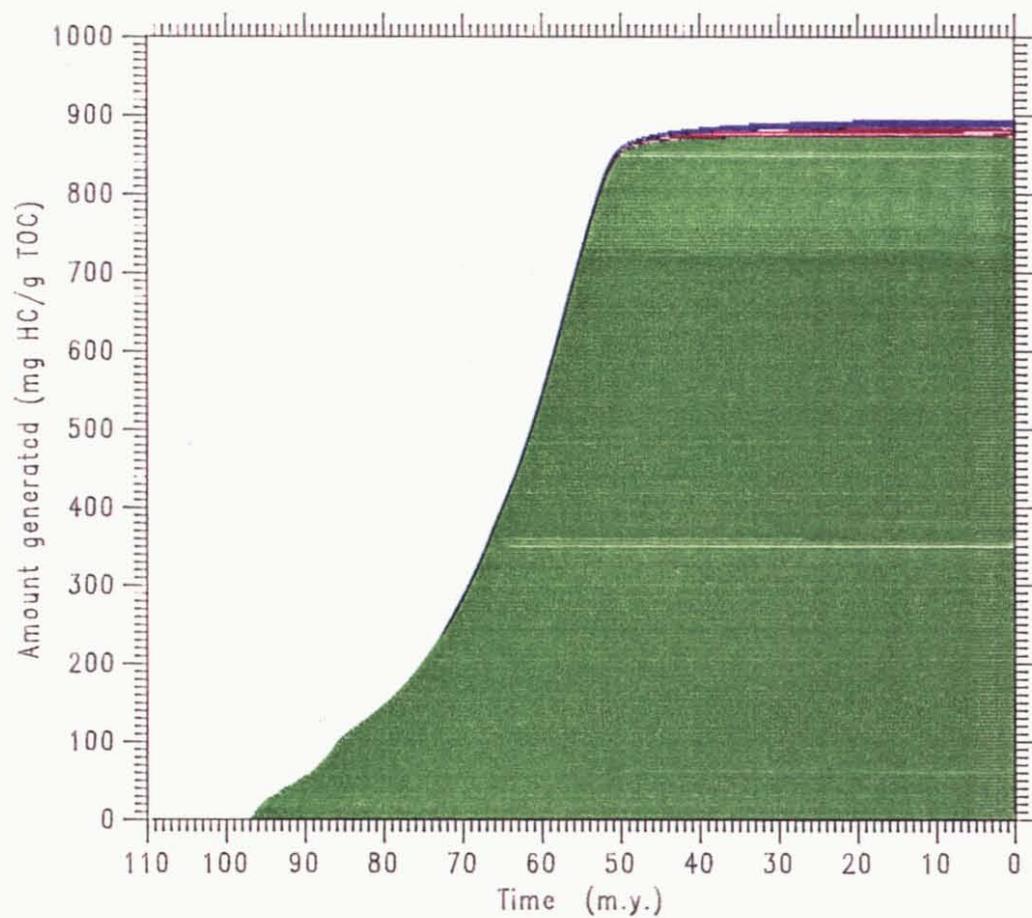
Marker BSL CENOMA

Organic matter no. 1

Residue

Gas

Oil

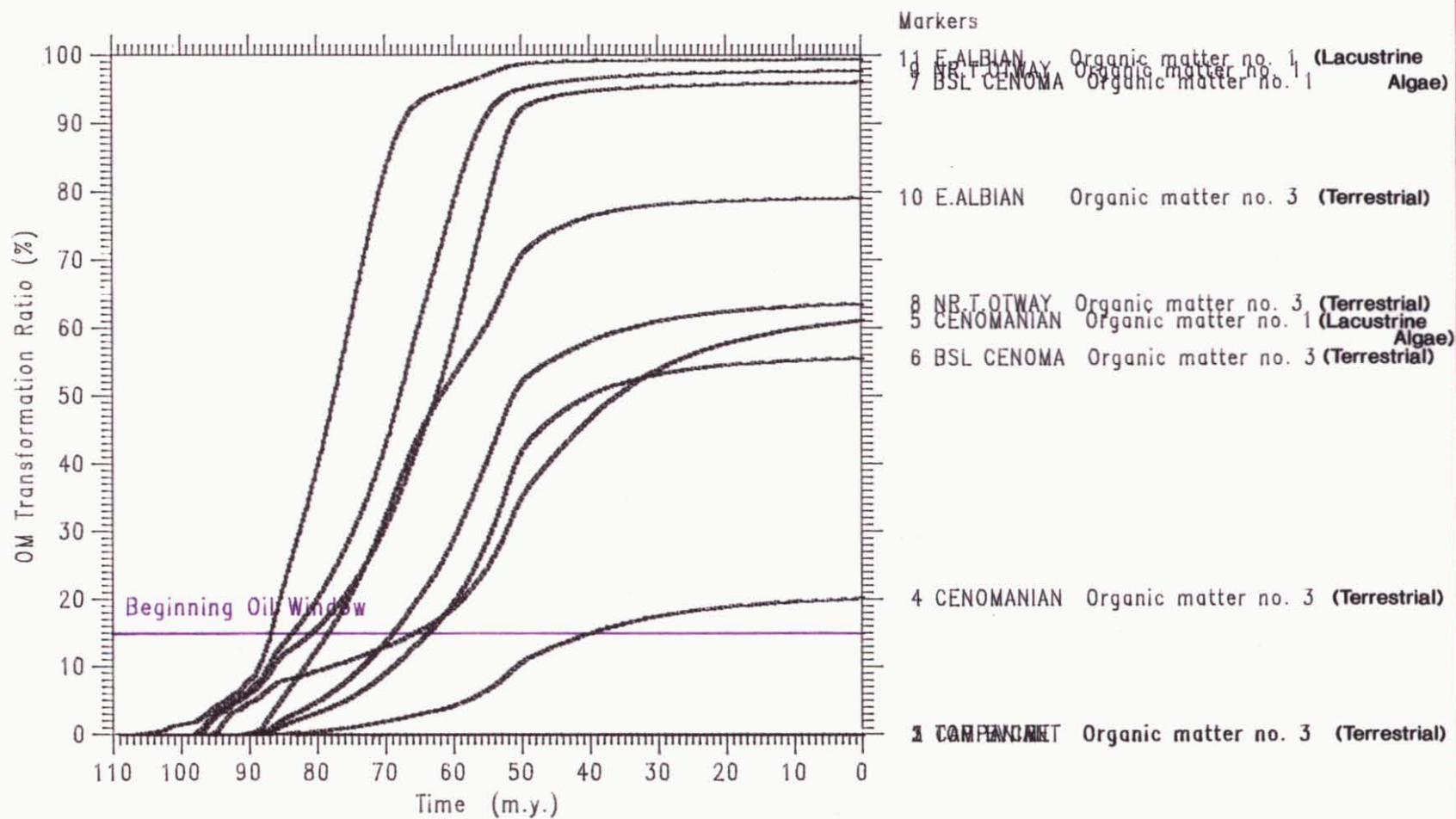


5 cm

## Cenomanian Depocentre Line WB82-40 SP300

## TRANSFORMATION RATIO OF SOURCE ROCKS

Well BOOBYOMI



NEW PALYNOLOGY OF THE DURROON MUDSTONE,

DURROON-1, BASS BASIN

BY

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for BRIDGE OIL

February, 1991

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I SUMMARY

New study of 19 swc and cuttings and restudy/review of 13 previous cuttings in the Durroon Mudstone and encasing units is complete. The unexpected availability of swc material has expanded the project somewhat, but increased precision. The principal conclusions are

The Durroon Mudstone 1360m (4462ft) - 1660m (5446ft) appears to be entirely of C. triplex zone Coniacian (87.5my) - Turonian (91.5my) age, bounded above by 5my Tasman Sea breakup unconformity, and below by a 9.5my Southern Ocean breakup unconformity.

The upper Durroon Mudstone contains some striking algal assemblages expected to have encouraging oil source characteristics. These contain dominant (50-60% of palynomorphs) algal and dinoflagellate assemblages (4510ft swc, 4550ft swc, 4630-60ft cutts and 4900ft swc) and probably represent extensive lake systems developed during eustatic highstands. Many of these elements were recently described by Marshall (1989) from Kipper-1 and Sunfish-1 in the Gippsland Basin. There they occur only in the Golden Beach Formation equivalents and occur interbedded with the gas reservoir at Kipper-1. Notably, they are richer here than in the Gippland Basin.

Vail sea level charts show a total of around six cycles in the time span of the triplex zone. The best algal developments are likely to correspond to maximum lake development during highstands, and the logs suggest at least three cycles in the upper Durroon Mudstone, and perhaps three in the lower volcanic part.

Spore colour suggests marginal maturity on structure and full maturity below 2000m. However, the high algal content

may mature earlier.

The potential for new section offstructure as the unconformities diminish is intriguing. If sandy, it may provide reservoir. If shaley, it may provide more source rocks. Offstructure, the upper Durroon Mudstone itself may be in deeper lake environments, and become more algal rich.

The present work has only enhanced the petroleum possibilities of the Durroon Mudstone. Instrumental geochemistry on the algal rich samples is the acid test.

## II INTRODUCTION

Barry Goldstein of Bridge Oil initiated a project to concisely define the age, environment and organic prospectivity of the Durroon Mudstone interval. Swc samples and selected cuttings were made available by Peter Baillie of the Tasmanian Geological Survey and studied herein. Raw data is presented in Appendix 1.

The published palynostratigraphic framework for the Cretaceous of Australia is most recently reviewed by Helby, Morgan and Partridge (1987). Until now, Cretaceous dinoflagellates had not been recorded from the Bass Basin and from the Gippsland Basin, although Marshall (1988) provided taxonomic study of some Santonian dinoflagellates. In unpublished work, Marshall (1987a) describes dinoflagellates from new cuttings samples in Pisces-1, Marshall (1987b) describes taxonomy and some stratigraphy of Campanian dinoflagellates and in (1987c) describes some Turonian - Campanian algal cysts. These latter algal forms are recorded here, but the younger dinoflagellates are still unrecorded from the Bass Basin. The Helby et al Zonal Scheme is shown in Figure 1.

In the Tertiary, the Gippsland zonal scheme was most recently published by Partridge (1976), but the scheme is essentially similar to that for New Zealand for which substantial new data is available in Wilson (1988). Significant new Gippsland data is available in unpublished and privately circulated material, Harris (1985), Morgan (1988) and Marshall and Partridge (1988). The zonal framework of Partridge (1976) is shown in Figure 1, and can be used in the Bass Basin. Figure 2 shows the geological framework recently published for the Gippsland Basin by Lowry (1987) and relevant here.

Organic maturity data was generated in the form of the Spore Colour Index and plotted on Figure 3. The oil and gas windows follow the general consensus of geochemical literature. The oil window corresponds to spore colours of light-mid brown (2.7) to dark brown (3.6). This would correspond to Vitrinite Reflectance values of 0.6% to 1.3%. However, factors such as detailed kerogen type, basin type, basin history and heating curves all affect precise interpretation, and analytical machine-based maturity parameters are probably more reliable.

367027

AGE		SPORE - POLLEN ZONES	DINOFLAGELLATE ZONES	
Early Tertiary	Early Oligocene	<i>P. tuberculatus</i>		
	Late Eocene	upper <i>N. asperus</i>	<i>P. comatum</i>	
		middle <i>N. asperus</i>	<i>V. extensa</i>	
	Middle Eocene	lower <i>N. asperus</i>	<i>D. heterophlycta</i>	
			<i>W. echinosuturata</i>	
	Early Eocene		<i>P. asperopolus</i>	<i>W. edwardsii</i>
			upper <i>M. diversus</i>	<i>W. thompsonae</i>
				<i>W. ornata</i>
			middle <i>M. diversus</i>	<i>W. waidwagensis</i>
			lower <i>M. diversus</i>	<i>W. hyperacantha</i>
	Paleocene	upper <i>L. balmei</i>		<i>A. homomorpha</i>
lower <i>L. balmei</i>			<i>E. crassitabulata</i>	
Late Cretaceous	Maastrichtian		<i>T. evittii</i>	
		<i>T. longus</i>	<i>M. druggii</i>	
	Campanian			
		<i>T. illiei</i>	<i>I. korojonense</i>	
	Santonian		<i>N. senectus</i>	<i>X. australis</i>
		<i>T. pachyexinus</i>		<i>N. aceras</i>
	Coniacian			<i>I. cretaceum</i>
	Turonian			<i>C. poriferz</i>
		<i>C. triplex</i>		<i>C. striatoconus</i>
	Cenomanian			<i>P. infusorioides</i>
<i>A. distocarinatus</i>				
Early Cretaceous	Albian	Late	<i>P. pannosus</i>	
		Middle	upper <i>C. paradoxa</i>	
		Early	lower <i>C. paradoxa</i>	
	Aptian		<i>C. striatus</i>	
		upper <i>C. hughesi</i>		
		lower <i>C. hughesi</i>		
	Barremian			
	Hauterivian		<i>F. wonthaggiensis</i>	
	Valanginian			
	Berriasian		upper <i>C. australiensis</i>	
		lower <i>C. australiensis</i>		
Juras	Tithonian		<i>R. watheroensis</i>	

FIGURE 1 ZONATION FRAMEWORK

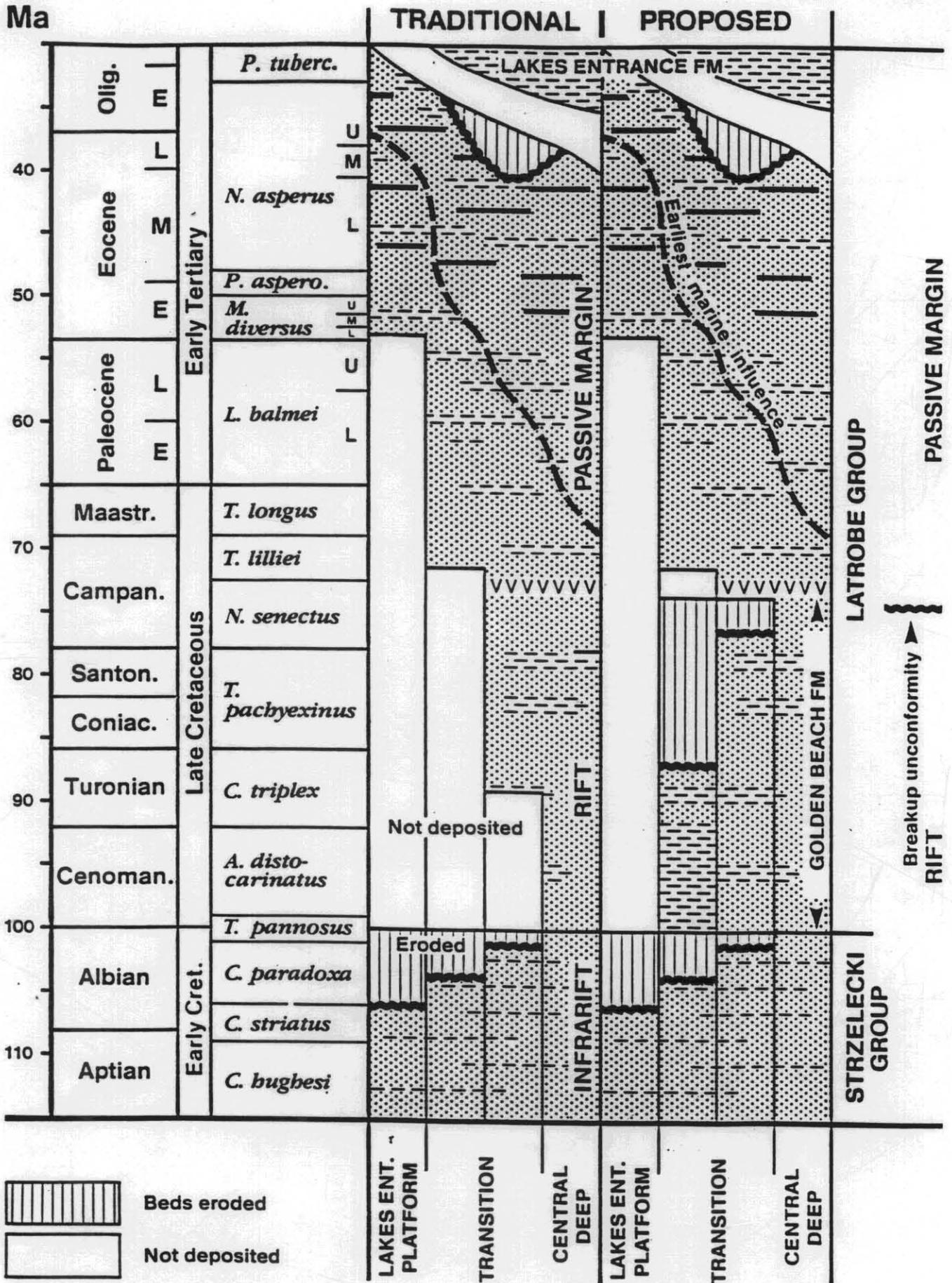
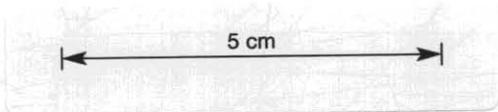


Figure 2 — Time-space diagram generalised for Cretaceous to Eocene in the offshore Gippsland Basin.



III PALYNOSTRATIGRAPHYA 4223ft swc (=1287m) : T. lillei zone

Assignment to the Tricolporites lillei zone is indicated at the top by the absence of younger indicators and at the base by oldest common Gambierina rudata and Nothofagidites senectus. Common species include N. senectus, N. endurus, Phyllocladidites mawsonii and G. rudata.

This is in accord with the zonal assignment in Partridge (1979).

Non-marine probably fluvial environments are suggested by the absence of algae or acritarchs and common cuticle with pollen and spores.

Yellow to light brown spore colours suggest early marginal maturity for oil.

B 4300ft swc (=1311m) - 4450ft swc (=1356m) : upper N. senectus zone.

Assignment to the upper part of the Nothofagidites senectus zone is indicated at the top by frequent N. endurus without G. rudata and at the base by oldest frequent N. endurus, N. senectus and Tricolpites sabulosus. Within the interval, common forms include P. mawsonii, N. endurus and Cyathidites minor.

This swc based data is in accord with the zonal assignments of Partridge (1979) and is superior to the slightly younger assignment of Morgan (1985a), which was cuttings based.

Non-marine probably fluvial environments are indicated by the absence of saline or lacustrine indicators, and the rich and diverse spores and pollen.

Light brown to yellow spores indicate early marginal maturity for oil.

- C lower N. senectus to T. pachyexinus zones : not seen.

This usually distinctive interval was not seen and is presumed absent by hiatus. The zones are probably present offstructure in the basin, as they are clearly present in the deeper parts of both the Gippsland and Otway Basins. To my knowledge they have not yet been recognized in the Bass Basin.

- D 4510ft swc (=1375m) - 5190ft swc (=1582m) (5400ft cutts =1646m) : C. triplex zone

Assignment to the old Clavifera triplex zone (now renamed the P. mawsonii zone) is indicated at the top by the absence of younger indicators and at the base by oldest P. mawsonii. The interval is further characterized along the northern margin of the Gippsland Basin and herein by a marked dominance of Dilwynites granulatus, and at the top by youngest Coptospora "pileosa". The algal associates are also distinctive. Amongst the pollen and spores, Dilwynites and Falcisporites dominate down to 5030ft (=1533m), with Cyathidites dominant below. Assignment is firm to the oldest P. mawsonii in swc at 5190ft, but rather more tentative below where it could be caved into the cuttings. Notably older indicators such as Appendicisporites distocarinatus, Hoegisporis spp and Trilobosporites trioreticulatus were not seen, and so the entire interval is assigned to the triplex zone,

and the distocarinatus zone is interpreted as missing. Within the unit, an upper interval (4510ft =1375m to 4955ft =1510m) can be distinguished from a lower interval (5030ft =1533m to 5400ft =1646m) which contains first downhole Crybelosporites striatus, Foraminisporis asymmetricus and Cicatricosporites cuneiformis.

This assignment is slightly different to that of Partridge (1979) but identical to that of Morgan (1985a).

The algal/microplankton content of the interval is very striking, and comprises from 1% to 60% of palynomorphs. Rimosicysta spp, and Morkallacysta spp occur in almost every sample, but their abundances and occurrences enable detailed subdivision of the unit. These subdivisions may be of only local significance, although their association with distinct log units suggestive of sequence stratigraphic sequences, suggests significant correlative potential.

At the top, (4510ft swc =1375m) microplankton comprise 60% of palynomorphs with Morkallacysta "verrucosa" dominant, Rimosicysta kipperi subordinate and Morkallacysta "psilata" rare. I call this the "verrucosa" acme zone. M. verrucosa only occurs rarely below this point and then only in cuttings where it may be caved. Next (4550ft swc =1387m and 4660ft cutts =1420m), microplankton comprise 50-60% of palynomorphs with M. "psilata" dominant and R. kipperi and M. "verrucosa" rare. The lower sample is in cuttings and could be caved from above the log break at 1399m. I call this the "psilata" acme zone. These zones together represent an algal maximum and are probably associated with maximum algal productivity during

maximum lake development. This usually occurs during highstand when paleoslope is reduced and drainage systems back up. Next (4800ft =1463m), microplankton comprise only 1% of palynomorphs and Rimosicysta eversa first occurs downhole with rare R. kipperi and M. "verrucosum". I call this the R. eversa partial range zone. Next (4900ft swc =1494m), microplankton again comprise 60% of palynomorphs with abundant R. eversa and a varied assemblage including spiny acritarchs (Micrhystridium) and the distinctive Wuroia spp for the first time downhole. The spiny acritarchs suggest slight saline influence. I call this the eversa acme zone. The next interval (4930ft cutts =1503m to 5030ft swc =1533m) contains rare microplankton with R. kipperi prominent throughout and Micrhystridium present. At the top (4930ft swc =1503m) R. eversa is present, but may be caved in these cuttings. Micrhystridium suggests slight saline influence, and I call this the kipperi partial range zone. This group of zones may represent eustatic rise with saline influence at the base (kipperi zone) passing to maximum lake development still with saline influence (eversa acme zone) succeeded by shallowing (eversa partial range zone). The associated logs suggest an upward coarsening sequence stratigraphic unit over this interval 1540m - 1457m.

At the base (5190ft swc = 1582m to 5400ft cutts = 1646m), microplankton are again very rare (less than 1% of palynomorphs) and comprise Botryococcus, Rimosicysta spp and Morkallacysta spp with Micrhystridium at 5190ft only. The cuttings sample may be partly or wholly caved and so I have not attempted to subdivide this interval which may be essentially similar to the kipperi unit above.

Environments clearly alternate within this interval, but are essentially within the range of fluvial to lacustrine, with intermittent minor saline influence.

Light brown spore colours indicate marginal maturity for oil generation. The high algal content suggests excellent oil source characteristics and that maturity may be higher than first appears.

- E 5410ft swc (=1649m) - 5460ft cutts (=1664m) :  
indeterminate.

These two samples are essentially barren, containing only trace quantities of long ranging Mesozoic taxa. They therefore cannot be assigned to any zone. Local heating from the volcanics may have destroyed in situ palynomorphs.

- F A. distocarinatus to P. pannosus zones : not seen.

These zones have not yet been recognized in the Bass Basin, but their distinctive and common occurrence in the Otway Basin suggests that they should be distinctive when penetrated here, on first downhole occurrences of taxa such as Hoegisporis uniforma, Appendicisporites distocarinatus, Trilobosporites trioreticulatus and perhaps rare Coptospora paradoxa. Their absence indicates an unconformity probably located at or near 1650m.

- G 5500ft swc (1676m) - 7236ft swc (=2206m) this study :  
C. paradoxa zone.

Assignment to the Coptospora paradoxa zone is indicated at the top by top consistent C. paradoxa without younger indicators, coincident with a downhole influx

of C. striatus and F. asymmetricus. At the base, oldest C. paradoxa is diagnostic. Previous work extends below the samples studied here and places the lower boundary at 7236ft swc (=2206m). Cyathidites, Falcisporites and Microcachryidites are common with spores such as Aequitriradites spinulosus, Foraminisporis dailyi and C. striatus frequent.

Non-marine fluvial environments are indicated by the absence of lacustrine or saline indicators, and the abundant and diverse spores and pollen.

Spore colours of light brown above about 2000m indicate marginal maturity, while colours of light to mid brown below 2000m indicate maturity for oil generation.







## SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

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INDEX NUMBER	SPECIES
28	AEGUITRIRADITES SPINULOSUS
29	AEGUITRIRADITES TILCHAENESIS
50	AEGUITRIRADITES VERRUCOSUS
80	AMOSOPOLLIS CRUCIFORMIS
85	APPENDICISPORITES DISTOCARINATUS
51	ARAUCARIACITES AUSTRALIS
52	ARCELLISPORITRES SP.
83	AUSTRALOPOLLIS OBSCURUS
10	AVELLODINIUM SP.
53	BALMEISPORITES HOLODICTYUS
1	BOTRYOCOCCUS
54	CERATOSPORITES EQUALIS
30	CICATRICOSISPORITES AUSTRALIENSIS
58	CICATRICOSISPORITES CUNEIFORMIS
31	CICATRICOSISPORITES HUGHESI
76	CICATRICOSISPORITES LUDBROOKIAE
32	CINGUTRILETES CLAVUS
59	CONTIGNISPORITES COOKSONIAE
79	COPTOSPORA "PILEOSA"
33	COPTOSPORA PARADOXA
21	COROLLINA TOROSUS
34	COUPERISPORITES TABULATUS
35	CRYBELOSPORITES STRIATUS
22	CYATHIDITES AUSTRALIS
23	CYATHIDITES MINOR
60	CYCADOPITES FOLLICULARIS
73	CYCLOSPORITES HUGHESI
11	CYMATIOSPHAERA SP.
1	DACRYCARPITES AUSTRALIENSIS
1	DICTOPHYLLIDITES SPP
36	DICTYOTOSPORITES COMPLEX
37	DICTYOTOSPORITES SPECIOSUS
63	DILWYNITES GRANULATUS
24	FALCISPORITES GRANDIS
25	FALCISPORITES SIMILIS
38	FORAMINISPORIS ASYMMETRICUS
39	FORAMINISPORIS DAILYI
74	FORAMINISPORIS WONTHAGGIENSIS
40	FOVEOTRILETES PARVIRETUS
81	GAMBIERINA RUDATA
41	GLEICHENIIDITES
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26	MICROCACHRYIDITES ANTARCTICUS
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13	RIMOSICYSTA ASPERA
14	RIMOSICYSTA CONCAVA
4	RIMOSICYSTA EVERSA
5	RIMOSICYSTA KIPPERI
2	SCHIZOSPORIS PARVUS
16	SCHIZOSPORIS PSILATUS
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88	TRICOLPITES SABULOSUS
91	TRICOLPITES SP
71	TRICOLPORITES SP.
47	TRIPOROLETES RADIATUS
48	TRIPOROLETES RETICULATUS
49	VELOSPORITES TRIQUETRUS
6	MURDIA CORRUBATA

IV CONCLUSIONS

- A The zonal breakdown indicates that the Durroon Mudstone appears to be entirely of C. triplex zone age, deposited during the Turonian to Coniacian (91.5 - 87.5m according to the time scale of Haq et al).
- B At the top, the absence of the lower N. senectus to T. pachyexinus zones indicates a Santonian to lower Campanian time gap of about 5my (87.5-82my). This corresponds to the intra senectus Tasman Sea breakup unconformity of Lowry (1987).
- C At the base, the absence of the A. distocarinatus and P. pannosus zones indicates a latest Albian to Cenomanian time gap of about 9.5my (91.5m to 101my). This corresponds to the pannosus Southern Ocean breakup unconformity of Lowry (1987).
- D These age relationships indicate that the Durroon Mudstone is age equivalent to the Golden Beach Formation in the Gippsland Basin, as discussed by Lowry (1987). This affinity is closely seen in the associated distinctive suite of algal cysts described from the Golden Beach Formation of Kipper-1 (2296.5 - 2839m) and Sunfish-1 (2480.7 - 2485m) as well as some Bass Canyon dredge sites by Marshall (1989).

Notably, these algal cysts occur interbedded with the reservoir section in Kipper-1. However, they are much more common in the Durroon Mudstone than in the Gippsland Basin samples. These algal cysts are expected to be excellent oil source material, if present in sufficient quantities. They reach 50-60% of palynomorphs in two distinct and distinctive horizons, and are likely to indicate times of maximum algal

productivity in large lake systems formed during highstands. The rare spiny acritarchs suggest, but do not definitely indicate, minor and intermittent saline penetration into the system. The low algal percentages probably represent lowstand intervals with greater palaeoslope and so more fluvial rather than lacustrine influence.

- E Vail sea level charts show a total of around six cycles during the time span of the triplex zone. Within the upper Durroon Mudstone, at least three distinct cycles are evident on the logs. The oldest (1540m to 1455m) shows coarsening up and corresponds to transgression with slight saline influence at the base (kipperi zone herein) passing to maximum lake development and an algal acme (eversa acme zone) then decreased algal production with shallowing (eversa partial range zone).

The second cycle (1455m to 1398m) shows good shale developments at top and base, but is essentially unsampled palynologically, (if 4660ft cutts = 1420m is entirely caved).

The third cycle (1398m to 1369m) shows maximum algal production throughout (psilata to verrucosa zones).

In the lower (volcanic) part of the unit, shale peaks at 1648m 1627, and 1603m may represent flooding shales, but correlation to sea levels is doubtful due to poor lithologies for palynology, and the volcanic influence which could easily mask depositional features.

Conceptually, all of these sequence stratigraphic boundaries are unconformities and can thicken up into new section laterally. Detecting the extent of the

break is beyond the resolution of the palynology at the present state of knowledge. Extensive drilling in the area would be necessary to develop such detail.

F Spore colour suggests marginal maturity for the Durroon Mudstone, although burial below 2000m offstructure should bring it within the oil window. Algal kerogens however, tend to mature at slightly lower spore colours, and so the section may be early mature on structure. Instrumental geochemistry should yield more accurate estimates.

G Clearly the potential exists for new section to be developed offstructure, as the major bounding unconformities diminish, and as the sequence stratigraphic unconformities are traced laterally. If these result in sand development, then reservoir potential may be enhanced. If these result in shale development, additional source rocks may enhance the hydrocarbon potential. Also, the Durroon Mudstone itself offstructure may become even more algal rich with increasing water depth into the lowlying lake systems, filling the developing rifts.

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