WELL COMPLETION REPORT

ANEMONE-1,1A

BASIC DATA

A P P E N D I X 2

PALYNOLOGY

PALYNOLOGY OF PETROFINA ANEMONE - 1

GIPPSLAND BASIN, AUSTRALIA

by

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FOR COMPLETION REPORT OCTOBER 1989

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CONTENTS

I SUMMARY

2574m : indeterminate : very lean.

2583m (swc) : probably upper N. asperus Zone (P. comatum Dinoflagellate Zone) : Late Eocene : offshore marine : immature.
HIATUS removing middle N. asperus Zone.

2595.4m (swc) - 2620m (swc) : lower N. asperus Zone (D. heterophlycta Dinoflagellate Zone) : Middle Eocene : offshore marine : immature.
HIATUS removing P. asperopolus to lower M. diversus Zones (early Eocene)

2650.8m (swc) - 2660m (swc) : upper L. balmei Zone (A. homomorphum Dinoflagellate Zone) : late Paleocene : offshore marine : immature.

2690m (swc) - 2728.5m (swc) : lower L. balmei Zone (E. crassitabulata Dinoflagellate Zone) : early to mid Paleocene : offshore marine : immature.

2750m (swc) - indeterminate (barren) : logs suggest Paleocene : POSSIBLE HIATUS removing early Paleocene (Danian) T. evittii Dinoflagellate Zone, or possibly represented by unfavourable lithologies.

2762m (swc) - 2809.5m (swc) : upper T. longus Zone (M. druggii Dinoflagellate Zone) : latest Maastrichtian : nearshore marine : immature.

2816m (swc) - 2825m (swc) : middle T. longus Zone : Maastrichtian : brackish : immature.

2838m (swc) - 3230m (cutts) : lower T. longus Zone : Maastrichtian : non-marine to brackish : immature.

3250m (cutts) - 3385m (cutts) : upper T. lilliei Zone (non-marine part) : Campanian : non-marine : immature.

3450m (cutts) - 3515m (cutts) : middle T. lilliei Zone (part I. korojonense Dinoflagellate zone) : Campanian : nearshore to brackish : immature.

3570m (cutts) - 3875m (cutts) : lower T. lilliei Zone : (part I. korojonense Dinoflagellate Zone) : Campanian : nearshore marine : immature.

3950m (cutts) - 4100m (cutts) upper N. senectus Zone (less marine part) : Campanian : marginally marine to non-marine : marginally mature for oil.

4159m (core catcher) - 4375m (cutts) (possibly 4285m) : lower N. senectus Zone (N. aceras Dinoflagellate Zone 4159 - 4285) : Campanian : nearshore marine to offshore marine : marginally mature for oil.

4400m (cutts) - 4775m (cutts) : T. pachyexinus Zone (I. cretacea - O. porifera Dinoflagellate Zones) : Santonian : offshore marine to nearshore marine ; marginally mature but containing fully mature specimens below 4570m. These may indicate penetration of an unconformity or contemporaneous volcanic activity.

II INTRODUCTION

Eighty five samples were submitted by Mark Tringham and Brian Thurley for palynology. Twenty eight were sidewall cores in the Maastrichtian to Eocene section. During the drilling of the older Cretaceous, several batches of urgent "hotshot" cuttings samples were examined, to provide age control before logging, comprising twelve samples. A further twenty seven cuttings samples plus one bit sample were submitted at well completion. Fillin samples to tighten up boundaries comprised the last sample group and numbered seventeen samples. All these samples are reported in detail herein. Raw data is presented in Appendix I.

The published palynostratigraphic framework for the Cretaceous of Australia is most recently reviewed by Helby, Morgan and Partridge (1987), but detailed modifications to this scheme for Petrofina were discussed by Morgan (1988). Until Anemone-1, dinoflagellates had been only rarely recorded from the Cretaceous of the Gippsland Basin, although Marshall (1988) provided taxonomic study of some Santonian dinoflagellates.

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 fig.1.

Organic maturity data was generated in the form of the Spore Colour Index and plotted on Fig. 2. The oil and gas windows follow the general consensus of geochemical literature. The oil window corresponds to spore colours of

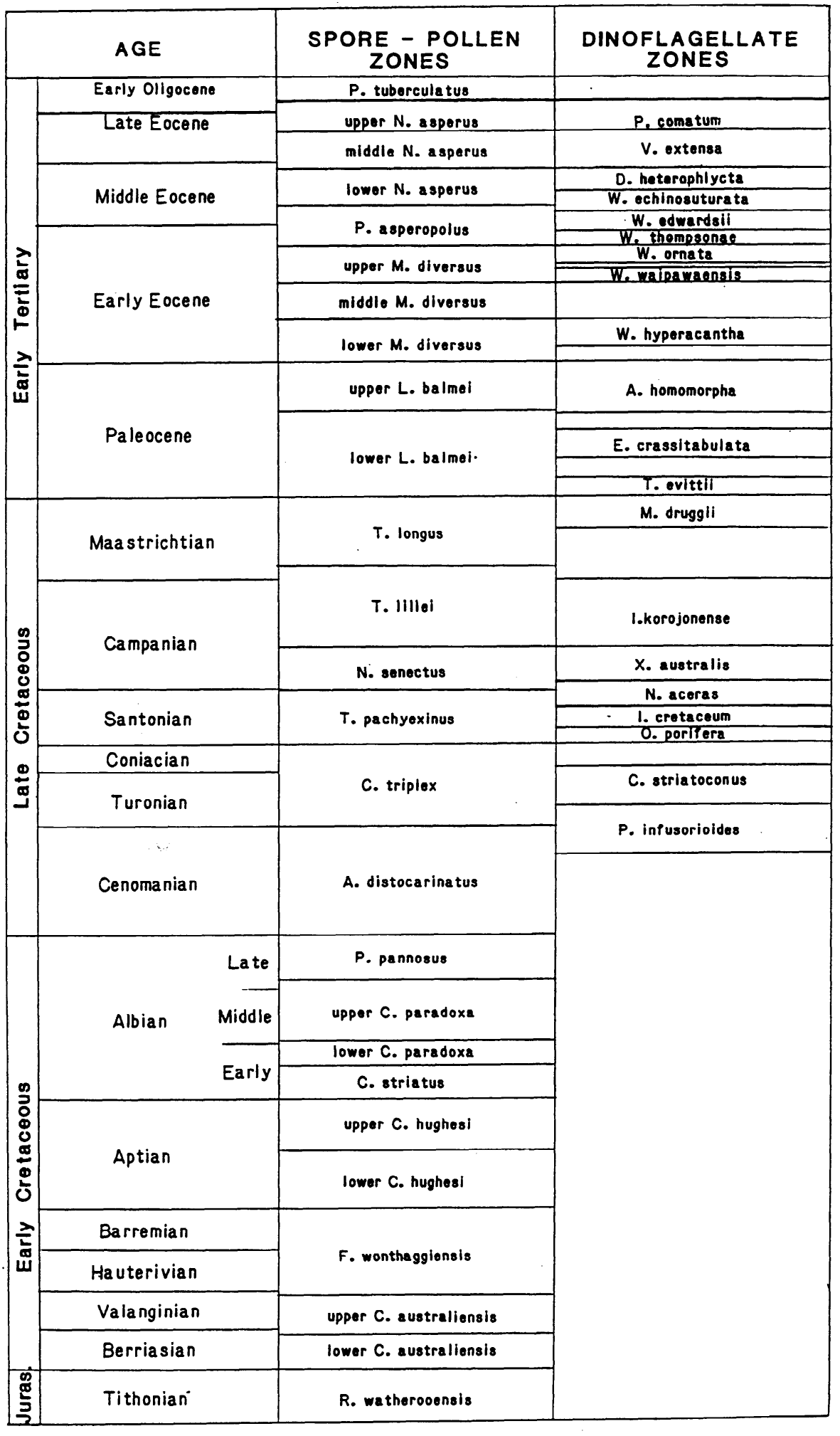

FIGURE 1 ZONATION FRAMEWORK

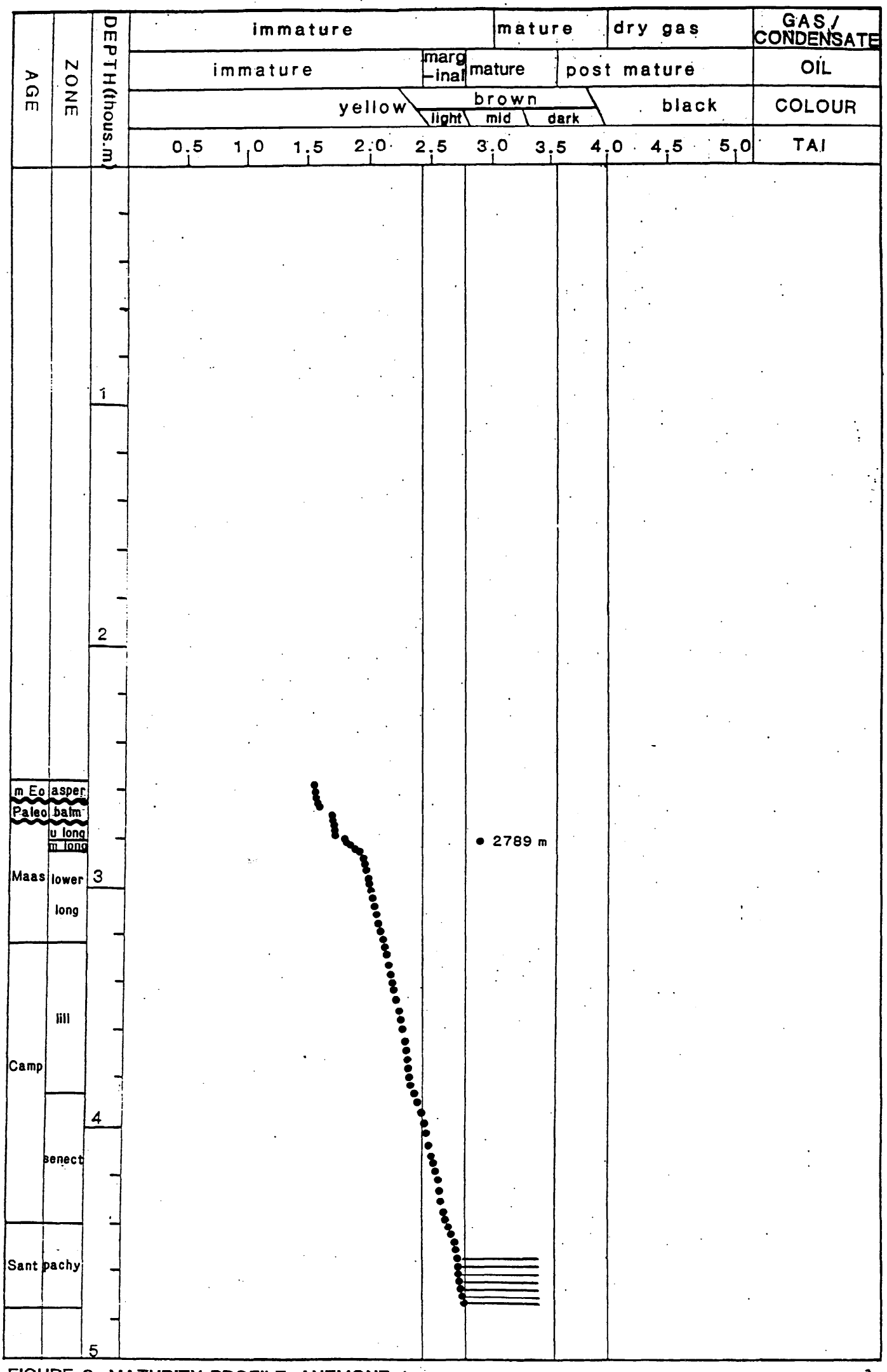

FIGURE 2 MATURITY PROFILE, ANEMONE 1

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.

III PALYNOSTRATIGRAPHY

A. 2574m (swc) : indeterminate

The yield was too poor for assignment. Nothofagidites spp. are the most frequent but only indicate an N. asperus or younger assignment. The dinoflagellates are not age diagnostic, but do indicate marine enviroments.

B. 2583m (swc) : probably upper N. asperus Zone (P comatum Dinoflagellate Zone)

This sidewall core is quite lean and so is not confidently assigned. The presence of frequent Nothofagidites spp including N. falcata indicates the N. asperus Zone or younger, and the absence of middle N. asperus Zone markers, plus the dinoflagellate evidence, favour the upper N. asperus Zone. Nothofagidites spp. dominate in a lean assemblage.

Frequent Phthanoperidinium comatum indicates the late Eocene P. comatum Dinoflagellate Zone. Operculodinium spp. are also frequent.

Offshore marine environments are indicated by the high content (50%) of dinoflagellates, despite their low diversity.

Colourless palynomorphs indicate immaturity for hydrocarbons.

C. Middle N. asperus Zone (V. extensa Dinoflagellate Zone)

This interval was not seen and is presumed absent by hiatus.

D. 2595.4m (swc) - 2620m (swc) : lower N. asperus Zone (D. heterophlycta Dinoflagellate Zone).

Zonal assignment is indicated at the top by youngest Santalumidites cainozoicus and Proteacidites pachypolus and at the base by oldest common Nothofagidites, and the dinoflagellate data. Nothofagidites and Proteacidites are common, and diversity is low in these environments.

Assignment to the D. heterophlycta Dinoflagellate Zone is indicated at the top by youngest Deflandrea heterophlycta, Tritonites pandus and T. inaequalis. At the base, oldest Rhombodinium glabrum and Achilleodinium biformoides are diagnostic. Oldest D. phosphoritica occurs at 2609m (swc). Cleistosphaeridium, Cordosphaeridium, Spiniferites and Corrudinium are frequent. Homotriblium tasmaniense at 2620m is probably reworked.

Offshore marine environments are indicated by the dominance of dinoflagellates over terrestrial palynomorphs and their moderate diversity.

Colourless palynomorphs indicated immaturity for hydrocarbons.

E. P. asperopolus to lower M. diversus Zones not seen.

Their absence indicates a significant hiatus removing all of the Early Eocene, and a part of the Middle Eocene.

F. 2650.8m (swc) - 2660m (swc) : upper L. balmei Zone (A. homomorphum Dinoflagellate Zone)

Zonal assignment is clearly indicated at the top by consistent Gambierina rudata and at the base by oldest Proteacidites grandis and P. incurvatus. Proteacidites, Dilwynites and Haloragacidites harrisii dominate the moderately diverse assemblages.

Dinoflagellates dominate (70% of palynomorphs) but are of moderate diversity. Zonal assignment is indicated at the top by the absence of younger indicators and at the base by oldest Apectodinium homomorphum. A. homomophum dominates the upper assemblage and Spiniferites dominates the lower one.

Offshore marine environments are indicated by the dominant and diverse dinoflagellates.

Colourless palynomorphs indicate immaturity for hydrocarbons.

G. 2690m (swc) - 2728.5m (swc) : lower L. balmei Zone (E. crassitabulata Dinoflagellate Zone).

Zonal assignment is indicated at the top by youngest Tetracolporites verrucosus and the absence of younger indicators, and at the base by oldest consistent Lygistepollenites balmei without older markers. Within the interval, Proteacidites, Phyllocladidites mawsonii and Cyathidites are frequent in moderately diverse assemblages.

Dinoflagellates are most frequent at the interval base (80%) and decrease rapidly to 5% at the interval top. Diversity decreases upward. Age diagnostic species include Isabelidinium bakeri (2728.5m) and Deflandrea medcalfii (2707m) without other markers. These

indicate the E. crassitabulata Zone. Areoligera medusettiformis dominates at 2728.5m.

Environments are offshore marine at the base, becoming more nearshore towards the top, as shown by dinoflagellate content and diversity.

Colourless to light yellow palynomorphs indicate immaturity for hydrocarbons.

H. 2750m (swc) : indeterminate.

This sample was almost barren, yielding only a few longranging species.

I. basal L. balmei Zone (T. evittii Dinoflagellate Zone) not seen.

The absence of this interval may be due to hiatus, or be represented by unfavourable lithologies such as that at 2750m.

J. 2762 (swc) - 2809.5m (swc) : upper T. longus Zone (M. druggii Dinoflagellate Zone).

Assignment is shown at the top by youngest Tricolpites confessus and T. longus supported by youngest T. waipawaensis at 2809.5m. At the base, oldest G. rudata dominance over N. endurus is diagnostic. Proteacidites spp., G. rudata and P. mawsonii dominate these assemblages.

Dinoflagellates are not common, but zonal assignment is clearly indicated in all samples by the presence of Manumiella conorata, associated at 2762m with M.

druggii. Cyclopsiella vieta is common at 2789m, and frequent Homotriblium tasmaniense at 2809.5m is presumed caved.

Environments are nearshore marine as shown by low dinoflagellate content and diversity.

Light yellow spore colours indicate immaturity for hydrocarbons. The sample at 2789m contains mid-brown colours, but these are anomolous in the section and are presumed to be caused by some staining effect peculiar to the environment of deposition.

K. 2816m (swc) - 2825m (swc) : middle T. longus Zone.

These samples are assigned by having G. rudata and N. endurus in equal quantities. In the upper T. longus Zone above, G. rudata dominates while in the lower T. longus Zone below, N. endurus dominates. Proteacidites spp. and P. mawsonii are frequent in this interval, and Triporopollenites sectilis is more common here then elsewhere in the section. T. lilliei is a consistent component and some larger spores (Aequitriradites Foraminisporis and Cicatricosisporites) are also seen here and may reflect the environment, as these are less able to be transported.

Dinoflagellates are absent, but the presence of very rare spiny acritarchs and the high cuticle content of residues indicate brackish environments.

Light yellow spore colours indicate immaturity for hydrocarbon generation.

L. 2838m (swc) - 3230m (cutts)(3063m in swc) : lower T.

longus Zone.

Assignment is indicated at the top by the dominance of N. endurus over G. rudata and at the base by oldest T. verrucosus. The zone base at 3230m is in cuttings and could be caved somewhat. At 3170m (cutts), several T. verrucosus specimens occur, but it is absent from assemblages at 3130m and 3120m (also cuttings). It is relatively frequent in cuttings at 3075m, and certainly in place in the swc at 3063m, supported by oldest T. longus at 3036m (swc). Thus the zone base is certain at 3075m possible at 3170m (cutts) but could be as low as 3230m. Within the zone, T. confessus is frequent at 2850m and common at 3063 - 3120m. Quadraplanus brossus occurs consistently down to 2865m. Proteacidites, P. mawsonii and N. endurus are frequent throughout. Cyathidites spp. are frequent in the intervals 2921-58m and 3170 - 3230m.

Trace dinoflagellates were seen at the top (2838m) and base (3063 - 75m) of the interval. Zonal assignment is not possible.

Mostly non-marine environments are indicated by the dominant and diverse spores and pollen, presence of Botryococcus, common cuticle and amorphous sapropel, and absence of marine indicators. Brackish incursions are shown at 2838m and 3063 - 75m as shown by scarce dinoflagellates.

Light yellow to yellow spore colours indicate immaturity for hydrocarbons.

M. 3250m (cutts) - 3385m (cutts) : upper T. lilliei Zone (non-marine part)

Zone assignment at the top is on the absence of younger indicators. As discussed above, the base of T. longus and therefore the top of T. lilliei may be slightly caved. The base of this upper T. lilliei subzone is based on the absence of the dinoflagellates seen below. As such, this reflects the marine/non-marine interface and is intrinsically time transgressive. Within the subzone, Proteacidites, P. mawsonii and N. endurus are consistently frequent. Towards the base (3350 - 85m) Cyathidites and Falcisporites are also frequent. Dilwynites spp. are occassionally frequent (3335 and 3385m). A single T. longus at 3385m is considered caved.

Dinoflagellates are totally absent from this interval and this, the common and diverse spores and pollen, frequent cuticle, tracheid and amorphous sapropel, indicate non-marine anoxic environments. Lakes, swamps and marshes seem likely.

Yellow spore colours indicate immaturity for hydrocarbons.

N. 3450m (cutts) - 3515m (cutts) : middle T. lilliei Zone (I. korojonense Zone)

This interval contains T. lilliei without younger or older indicators. Assignment to a middle subzone is based purely on dinoflagellate data. Amongst the spores and pollen, Proteacidites, P. mawsonii and Cyathidites spp. are frequent.

Amongst the dinoflagellates, I. cretaceum forms are common at 3480 and 3515m but show affinities to I. greenense of Marshall. Also present are I. pellucidum (greenense variety), Odontochitina prolata and

Chatangiella packhamii, indicating assignment to the I. korojonense Zone of Helby et al. (1987).

Dinoflagellates are rare at 3450m and 3515m indicating brackish environments, but comprise 30% of palynomorphs at 3480m, indicating nearshore marine environments. Given that these are all cuttings samples, the dinoflagellates at 3515m could all be caved from 3480m.

Yellow spore colours indicate immaturity for hydrocarbons.

O. 3570m (cutts) - 3875m (cutts) : lower T. lilliei Zone (I. korojonense Zone)

This interval is entirely within the recorded range of Tricolporites lilliei without younger or older indicators. The subdivision is dinoflagellate based. T. lilliei is, however, quite rare near its base range and in cuttings samples such as these, is clearly imprecise. Thus, although its oldest occurrence is at 3875m, it is inconsistent beneath 3780m, and could be caved beneath about that point. Amongst the pollen and spores, Proteacidites, P. mawsonii, N. endurus and G. rudata are the most frequent forms.

Yellow to light brown spore colours indicate immaturity but approaching marginal maturity for hydrocarbons.

Isabelidinium pellucidum (with affinities to I. greenense of Marshall) occurs throughout, but maybe partly caved. Typical I. pellucidum is also seen at 3575m and 3610m and indicates assignment to the I. korojonense Dinoflagellate Zone of Helby et al (1987).

Cyclopsiella is common below 3715m. Environments are within the nearshore to marginally marine range. Dinoflagellate content varies from 1% to 50% and diversity from 1 to 10 species.

P. 3950m (cutts) - 4100m (cutts) : upper N. senectus Zone (less marine part)

The subzone is defined at the top on the absence of younger indicators and at the base on the downhole influx of diverse dinoflagellates including Nelsoniella spp.. As discussed above, the zone top may be caved including Nelsoniella spp . Notably, T. sabulosus is consistent below 3715m and quite prominent at 3875 - 4100m. It may have potential as a top senectus marker. Overall, however, Proteacidites, N. endurus, N. senectus and P. mawsonii dominate most assemblages. N. senectus is most frequent at 3950 - 60m.

Dinoflagellates are quite rare, reaching a maximum 5% at 3960m. The assemblages are not easily characterized, comprising mostly nondescript Isabelidinium, Cyclopsiella and Trithyrodinium of the suspectum group. At 4100 only Cylopsiella was seen.

Environments range from non-marine at 4040 - 4100m, to marginally marine at 3950 - 60m, where low contents and low diversity of dinoflagellates occur with high proportions of plant debris and pollen and spores.

Light brown spore colours indicate marginal maturity for oil, but immaturity for gas/condensate.

Q. 4159m (bit sample) - 4375m (cutts) (possibly 4285m) :

lower N. senectus Zone (N. aceras Dinoflagellate Zone).

Zonal assignment at the top is on dinoflagellate data and coincides with a massive downhole influx of dinoflagellates (absent at 4100, 50% at 4159m). At the base, oldest consistent N. senectus and N. endurus are diagnostic, but could be caved in these cuttings samples. The base of the dinoflagellate N. aceras at 4285m may be a better base to the N. senectus Zone in this well. Amongst the subordinate spores and pollen, Proteacidites spp. dominate.

Dinoflagellates are dominant, comprising around 70% of palynomorphs. Nelsoniella spp. without younger indicators at 4159 - 4285 indicate assignment of that interval to the N. aceras Dinoflagellate Zone of Helby et al. 1987. Other common species include I. variabile, C. tripartita and Trithyrodinium. Beneath 4325m, no clear zonal assignment is possible.

Nearshore to offshore marine environments are indicated by the common but frequently moderate to low diversity dinoflagellates.

Light brown spore colours indicate marginal maturity for oil but immaturity for gas/condensate.

R. 4400m (cutts) - 4775m (cutts) : T. pachyexinus Zone (I. cretacea - O. porifera Dinoflagellate Zones).

Assignment to the Tricolpites pachyexinus Zone (= Tricolporites apoxyexinus Zone) is indicated at the top by the absence of younger indicators and at the base by oldest Tricolpites gillii at 4755m (although

this could be caved slightly). Within the interval, Proteacidites, Cyathidites and Falcisporites dominate the spores and pollen. A. cruciformsis is more consistent in this interval than above. Rare Nothofagidites and T. sabulosus are considered caved. T. confessus is consistent to 4510m and has potential to subdivide the interval.

Dinoflagellates occur in all samples and oldest Trithyrodinium spp. at 4775m and O. porifera at 4525m indicate a general correlation with the I. cretacea to O. porifera Zones interval of Helby et al. (1987). The individual zones cannot be identified due to the absence of the key species. Chatangiella spp, I. variabile and C. porosa are common.

Nearshore to offshore marine environments are indicated by the moderate to high (30% to 50%) proportion of dinoflagellates, and their moderate to high diversity.

These assemblages contain 90% palynomorphs of light brown colour indicating marginal maturity for oil. Below 4570m, 10% of the assemblage is dark brown to black, suggesting full maturity. This maybe caused by reworking, penetration of an unconformity, or contemporaneous volcanic activity. If contemporaneous volcanic activity is responsible, and the lower maturity may be an accurate measure of regional maturity at T.D.

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