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APPENDIX

PALYNOLOGICAL ANALYSIS OF BASKER SOUTH-1
(GIPPSLAND BASIN, PERMIT VIC/P19)

by

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1. SUMMARY

Depth (m)	Dinoflagellate Zones	Spore-Pollen Zones	Age
2240-2257	A. HYPERACANTHUM	Lower M.DIVERSUS	Late PALEOCENE Early EOCENE
2316-2467	Upper T.EVITTII/ E.CRASSITABULATA	Lower L.BALMEI	Early-Mid PALEOCENE
2498-2525	T.EVITTII	Lower L.BALMEI	Early PALEOCENE
2568	-	prob. T.LONGUS	MAASTRICHTIAN
2713-2940	-	T.LONGUS	MAASTRICHTIAN
2719	I.DRUGGII	-	MAASTRICHTIAN
2985	-	? T.LONGUS	?MAASTRICHTIAN
3138-3412	-	T.LILLIEI	CAMPANIAN

(3420m TD)

SPORE COLOUR/DEGREE OF ORGANIC MATURITY (D.O.M.)/SOURCE ROCK QUALITY

Transmitted (white) light: from pale yellow (2240m) to yellow (3412m)
Incident U.V. light: from light yellow to golden yellow or orange
D.O.M.: probably immature to T.D.
Source rock quality: 2240-2530m: poor; 2568-3412m: poor to good.

ENVIRONMENT OF DEPOSITION (Palynofacies)

2240-2525m: marine, near shore
2568-2716m, 2734-3316m and 3412m: non-marine (swamp, lake or fluvial deposits)
2719m and 3330-3344m: marginal marine

2. INTRODUCTION AND METHODS

The interval examined palynologically ranged from 2240m down to 3412m (TD is at 3420m, bdf). A total of 28 sidewall cores were selected on the basis of lithology. Grey to black, fine-grained sediments (mudstones, shales) are generally richer in palynomorphs than sediments such as silts and sands deposited in higher-energy environments. Where mudstones or shale samples were not available, siltstone samples were prepared. The quality of the sidewall cores was poor to fair. Sampling gaps are fairly large in the Cretaceous section.

Samples were prepared in Perth by Exploration Consultants Ltd (ECL) using the "standard" technique for siliciclastic sediments, i.e. hydrochloric and hydrofluoric acid treatment followed by heavy-liquid separation to remove mineral matter; controlled oxidation with nitric acid to reduce unwanted organic constituents and thus concentrate the palynomorphs; and finally washing with sodium hydroxide to remove humic acids. The resulting acid-insoluble residue was mounted in Elvacite to produce permanent microscope preparations. A slide of the non-oxidised residue was used for palynomaceral studies.

All samples yielded an organic fraction and almost all were productive, although one (at 2734m) proved to be barren of palynomorphs and several were too poor to be of much value. Preservation was excellent to reasonable in most samples. Diversity of assemblages varied but was generally good in the Tertiary to poor in the Cretaceous part of the examined section.

The palynomorphs were recorded semi-quantitatively. To provide continuity with the work of Harris, 1983, the stratigraphic interpretation of assemblages follows the zonal characteristics given in his "Biostratigraphic Summary" (Harris, undated). The range charts in this "Summary" are largely based on published and unpublished work of Stover and Evans (1974), Stover and Partridge (1973), Partridge (1975) and Partridge (1976).

Reworked palynomorphs were regularly found, mostly as single occurrences only. Most were Permio-Triassic and Jurassic in age.

It is not clear how to classify the regular occurrences of early and mid Cretaceous spores. They could be reworked, but, although found in younger sediments than their published ranges would indicate they may in fact belong.

Contamination from the mud was present in some samples. Although all samples were carefully cleaned before preparation, a fractured or broken-up sidewall sample cannot always be fully trusted as some contamination with palynomorphs from the mud is unavoidable.

3. ANALYSIS OF ZONES

A. DINOFLAGELLATE ZONES

2240-2257m (3 SWS): A.HYPERACANTHUM Zone, Early EOCENE

Based on the presence of Ceratiopsis dartmooria, Hafniasphaera septata and a single specimen of Muratodinium fimbriatum. A fragmented Glaphyrocysta retiintexta was present as well. Assemblages were poor in specimens and diversity. Apart from the markers mentioned only Apectodinium homomorphum, Palaeocystodinium sp. and some chorate cysts were present.

2316-2467m (5 SWS): Upper T.EVITTII/E.CRASSITABULATA Zone, Early/Mid PALEOCENE

Based on the presence of Isabelidinium bakeri, Ceratiopsis speciosa, Glaphyrocysta retiintexta, Senegalinium dilwynensis and one fragmented Eisenackia crassitabulata. Palaeocystodinium sp. was fairly common and a few chorate cysts were present as well, but assemblages were poor both in species and in specimens.

2498-2525m (2 SWS): T.EVITTII Zone, Early PALEOCENE

Again, assemblages are not diverse. Apart from the nominate species the following markers were present: Palaeoperidinium pyrophorum (fragments only) and Ceratiopsis speciosa. Spiny cysts of the Spinidinium/Vozzhennikovia-type were quite common. Also present were Paralecaniella indentata, Palaeocystodinium sp., Glaphyrocysta retiintexta, chorate cysts and a few indet. Deflandrea sp.

2719m (1 SWS): I.DRUGGII Zone, Late MAASTRICHTIAN

Apart from the nominate species only a single specimen of Palaeocystodinium sp. was present.

3330-3344m (3 SWS): (dinoflagellate zone unknown) prob. CAMPANIAN

A number of specimens of an as yet unidentified Isabelidinium and several specimens of a Chatangiella sp. were present in these samples. A single specimen of Odontochitina cf. operculata may or may not belong as its preservation and colour is somewhat different from the other dinoflagellates.

The interval cannot be assigned to one of the established zones because of lack of markers.

B. SPORE POLLEN ZONES

2240-2257m (3 SWS): Lower M.DIVERSUS Zone, Late PALEOCENE/ Early EOCENE

The presence of Proteacidites grandis, P. incurvatus, Verrucosisporites kopukuensis and Intratriporopollenites notabilis indicate an age not older than Lower M.DIVERSUS. Top of the interval is characterised on negative evidence, i.e. the absence of markers for the overlying Upper M.DIVERSUS Zone. Such markers were not found. Evidence from dinoflagellates (see 3A) supports the interpretation.

2316-2525m (7 SWS): Lower L.BALMEI Zone, Early to Mid PALEOCENE

The combined presence of Australopollis obscurus, Baculatisporites mallatus, Polycolpites langstonii, Proteacidites angulatus and Tricolpites phillipsii indicate the lower L.BALMEI Zone. Also found, a.o.: Herkosporites elliotii, Gambierina rudata, Lygistepollenites balmei, Nothofagidites spp., Proteacidites spp., Stereisporites (Tripunctisporis) sp. and more.

2568 (1 SWS): probably T.LONGUS Zone, MAASTRICHTIAN

The presence of Camarozonosporites amplus, Proteacidites "reticuloconcavus", P. "otwayensis" and P. "clinei" in this sample has been taken to indicate the top of the T.LONGUS Zone as the nominate species itself is absent. Small Proteacidites spp. and Gambierina rudata were quite common, Nothofagidites spp. much less so.

(Sampling gap of 145m to next sample down).

2713-2940m (6 SWS): T.LONGUS Zone, MAASTRICHTIAN

The nominate species is present in the highest sample (at 2713m). Of the 4 sidewall cores available between 2713 and 2734m one (at 2734m) is barren of palynomorphs and one (at 2716m) too poor to be of any use. Next sample down is at 2877m, leaving a gap of about 160m. The assemblages at 2877m and 2940m are rich in specimens and although not diverse contain some typical T.LONGUS Zone markers. Present, a.o., were Tricolpites longus, Triporopollenites sectilis, Tricolpites lilliei, common Gambierina rudata and less common Nothofagidites spp., Proteacidites angulatus, P. "reticuloconcavus", P. "clinei", P. palisadus, P. "otwayensis", P. "scaboratus", Stereisporites regium, Quadraplanus brossus, "Grapnelispora evansii" (one fragmented specimen), and more.

2595m (1 SWS): ? T.LONGUS Zone, ? MAASTRICHTIAN

This sample is difficult to place with certainty in either the T.LILLIEI Zone or the T.LONGUS Zone although on balance the latter is the more likely. Proteacidites angulatus is present as doubtful specimens only; the ratio between Nothofagidites and Gambierina is about even and no other markers could be found. Pollen types present, such as Triporopollenites sectilis, Camarozonosporites amplus, Gephyrapollenites wahooensis, Stereisporites regium, Proteacidites "clinei" and P. "reticuloconcavus" can occur in either zone. Baculatisporites sp. is unusually common at 2985m.

3138-3412m (9 SWS): T.LILLIEI Zone, CAMPANIAN

The ratio of Nothofagidites/Gambierina is clearly in favour of the former at 3138m and this has been taken as the top of the T.LILLIEI Zone. Markers for the overlying T.LONGUS Zone are absent. Assemblages are poor and not diverse, consisting mainly of Nothofagidites spp., small Proteacidites spp., Triporopollenites sectilis, Tricolpites lilliei, Lygistepollenites balmei, Ceratospora sp., Gephyrapollenites wahooensis, Proteacidites amolosexinus, P. scaboratus, P. "reticuloconcavus", Tricolpites confessus, T. gillii and other sporomorphs, present in the overlying T.LONGUS Zone as well.

The presence of T.lilliei, T.sectilis, G.wahooensis and N.endurus indicate that the underlying N.SENECTUS Zone was not reached and that the well bottomed in the T.LILLIEI Zone.

4. SPOROMORPH COLOUR, DEGREE OF ORGANIC METAMORPHISM (D.O.M.) AND SOURCE ROCK POTENTIAL

The colour of palynomorphs changes when subjected to the increasing or prolonged temperatures such as occur during burial. These changes in colour are irreversible and therefore indicate the maximum level of maturity reached. The different stages, yellow to golden-yellow through orange and brown to black can be correlated with changes in chemical composition as hydrocarbons are generated from the organic matter (see Fuchs, 1969; Standard Legend, 23.5.10). The sporomorph colour scale is more subjective than the more commonly used vitrinite reflectance scale. Ideally, a long-ranging sporomorph type should be selected as different types of sporomorph within the same sedimentary section show variations in colour. As observed in transmitted white light the change in colour from light yellow to golden-yellow or orange corresponds with the onset of oil generation, whereas the onset of gas generation is associated with a change in colour from orange to brown. Post-mature source rocks contain black sporomorphs and organic fragments only.

In incident ultraviolet light palynomorphs (and some palynomacerals) exhibit fluorescence colours that not only help in their identification but also increase and decrease according to rank. Fluorescence is maximal at the threshold of the "oil window", decreases with increasing rank and disappears at the end of the "oil window" (1-1.3% R_o, see Robert, 1981).

In Basker South-1 sporomorph-colour in transmitted light ranged from pale-yellow at 2240m to yellow at 3412m. Over the same interval fluorescence colours of sporomorphs ranged from light yellow to golden yellow or orange. Both estimates seem to indicate immature conditions over most if not all of the section studied.

Palynomaceral determination was carried out on a sieved, non-oxidised preparation. The sieving (with a 10 micrometer mesh sieve) was necessary to concentrate the large palynomacerals that otherwise would be diluted by fine, amorphous organic matter. This fine fraction is undoubtedly important for source rock characterisation but its nature and origin cannot be determined by ordinary means.

In Basker South-1 a rough estimate during preparation showed that between 2240m and 2530m total organic matter varied from 0.1 to 0.5 millilitre per 10 grams of sample, and from 2568m to 3412m from 0.1 to 2.0 millilitre per 10 grams of sample. It should be remembered that these estimates may not reflect the true picture, as they are based on an inadequately sampled section, using only the samples selected for palynology (e.g. disregarding coarser grained sediments and coals).

The interval 2240m to 2530m is rich in inertinite while plant tissues, pollen, spores and dinoflagellates are present in various amounts, but the very low figures for total amount of organic matter per 10 grams of sample classifies them as poor source rocks. The interval 2568m to 3412m (again, considering the palynological samples only) has better amounts of organic matter, mostly consisting of plant tissues (woody and epidermal) with palynomorphs a minor percentage only.

5. ENVIRONMENT OF DEPOSITION/PALYNOFACIES

The relationship between organic matter and grainsize of the sediments has been well-documented and is used to deduce depositional environment (palynofacies) from the type of palynomorphs and palynomacerals present.

The palynomorphs can be divided into marine organisms such as dinoflagellates and Tasmanites (both algae) and foraminiferal test linings; fresh and brackish water organisms such as Botryococcus and Acritarchs; and land derived pollen and spores (Sporomorphs).

Breakdown products of plants (woody fragments, epidermal tissues, cork cells, resin), algal and bacterial remains, animal tissue and many inderterminate organic fragments are collectively known as palynomacerals.

Although wind transport is an important aspect of the initial dispersal of sporomorphs, water transport then carries the sporomorphs and palynomacerals until they settle out of the water column. A continuous process of mechanical abrasion, biological degradation and wve and current action sorts and grades the particles during this transportation phase. Less buoyant, heavy or larger organic particles tend to characterise environments close to source while lighter, more buoyant and smaller particles are carried further afield. Very low sporomorph diversity indicates authochthonous environments (marsh, swamps); allochthonous environments are characterised by more diverse assemblages. Marine microplankton diversity increases in an offshore direction (Whitaker, 1979).

In Basker South-1 the interval 2240-2525m is clearly marine because dinoflagellates, reasonably diverse, are present in all samples; a fairly rich and diverse pollen flora, together with plant tissues indicate an environment near a source of land-derived organic matter. Between 2568m and 3412m only two intervals contain marine indicators: at 2719m and at 3330-3344m. Both are dominated by one species of dinoflagellate only. This is generally interpreted as indicating a marginal marine environment. Leiospheres of the Nummus type were common at 3330m. Its environmental significance is not clear. Morgan

(1975) considered his Nummus monoculatus to be part of a marine assemblage. They are, however, present singly or as a few specimens in assemblages within the T.LONGUS and T.LILLIEI Zones, classified as non-marine. The other assemblages in the interval 2568-3412m lacked marine indicators. Furthermore, the variety and size range of the plant tissues suggests limited water transport such as can be expected in swamp, lake or some fluvial deposits.

REFERENCES

HARRIS, W.K. (undated)	: Gippsland Basin Early Tertiary and Late Cretaceous Palynology: Biostratigraphic Summary (Internal Report)
HARRIS, W.K. (1983)	: Gippsland Basin Early Tertiary and Late Cretaceous Palynology: Summary of Results from 22 Selected Wells (Internal Report)
FUCHS, H.P. (1969)	: D.O.M. Determination by Geologists and Palynologists (Shell Proprietary Report - Confidential)
MORGAN, R. (1975)	: Some Early Cretaceous organic-walled microplankton from the Geat Artesian Basin, Australia (Journal and Proceedings of the Royal Society of New South Wales, 108: 157-167)
ROBERT, Paul (1981)	: Classification of Organic Matter by Means of Fluorescence: Application to Hydrocarbon Source Rocks (International Journal of Coal Geology, Vol.1, pp. 101-137)
PARTRIDGE, A.D. (1975)	: Palynological Zonal Scheme for the Tertiary of the Bass Strait Basins (Handout: Symposium on Bass Strait Geology, Melbourne 1975)
PARTRIDGE, A.D. (1976)	: The Geological Expression of Eustacy in the Early Tertiary of the Gippsland Basin (J. AUST. Petrol. Expl. Assoc., 16: pp. 73-79)
STANDARD LEGEND (1976)	: (Shell Proprietary Report - Confidential)