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PALYNOLOGY OF BHPP CONAN-1,

OFFSHORE OTWAY BASIN,

VICTORIA, AUSTRALIA

BY

ROGER MORGAN

for **BHP PETROLEUM**

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I SUMMARY

1250m(cutts) : *lillei* Zone (*korojonense* Dino Zone) : Campanian : very nearshore marine : immature : usually Sherbrook Group

1300m(cutts) - 1450m(cutts) : upper *senectus* Zone (1300-1350m upper *australis* Dino Zone, 1450m lower *australis* Dino Zone) : Campanian : nearshore to brackish: immature ; usually Sherbrook Group

1500m(cutts) - 1575.5m(swc) : middle *senectus* Zone (upper *aceras* Dino Zone) : Campanian : nearshore : immature : usually Sherbrook Group

1601.5m(swcs) - 1640m(cutts) : lower *senectus* Zone (middle *aceras* Dino Zone) : Campanian : nearshore marine : immature : usually lower Belfast Mudstone of the Sherbrook Group

1649.0m(swc) - 1704.0m(swc) : upper *apoxyexinus* Zone (1649.0m lower *aceras* Dino Zone, 1678.0-1700m upper *cretacea* Dino Zone, 1704.0m lower *cretacea* Dino Zone) : Santonian : nearshore marine : immature : usually basal Belfast Mudstone of the Sherbrook Group

1715.0m(swc) : middle *apoxyexinus* Zone : Santonian : nearshore marine : immature : usually Napier Formation

lower *apoxyexinus* and upper *mawsonii* Zone not seen

1719.0m(swc) : *mawsonii* Zone (?lower) : Turonian-Coniacian : nearshore marine : marginally mature : usually Minerva Formation

1770m(cutts) - 1800m(cutts) : lower *mawsonii* Zone : (1775.0-1800m *infusorioides* Dino Zone) : Turonian : nearshore marine : marginally mature : usually Minerva Formation

1805.0m(swc) - 1830m(cutts) : *distocarinatus* Zone (1824.0m swc and ?1830m cutts *infusorioides* Dino Zone) : non-marine to marginal marine : marginally mature : usually La Bella Formation

1861.0m(swc) - 1867.0m(swc) : indeterminate barren

1872.0m(swc) - 1875.0m(swc) : *paradoxa* Zone : Albian : non-marine to brackish : marginally mature :usually Eumeralla Formation

1965m(cutts) : indeterminate caved material.

Depth (m)	Sample	Spore-Pollen Zone	Dinoflagellate Zone	Dino %	Environment
1250	cutts	lillei	korojonense	(3)	very nearshore
1300	cutts	upper senectus	upper australis	(<1)	marginal marine
1350	cutts	upper senectus	upper australis	(<1)	brackish
1400	cutts	upper senectus	lower australis	2	very nearshore
1450	cutts	upper senectus	lower australis	(13)	nearshore
1500	cutts	middle senectus	upper aceras	(8)	nearshore
1539.0	swc	middle senectus	upper aceras	8	nearshore
1575.5	swc	middle senectus	upper aceras	9	nearshore
1601.5	swc	lower senectus	middle aceras	6	nearshore
1610	cutts	lower senectus	middle aceras	(6%)	nearshore
1640	cutts	lower senectus	middle aceras	(25%)	nearshore
1649.0	swc	upper apoxyexinus	lower aceras	22	nearshore
1678.0	swc	upper apoxyexinus	upper cretacea	20	nearshore
1700	cutts	upper apoxyexinus	upper cretacea	(26)	nearshore
1704.0	swc	upper apoxyexinus	lower cretacea	15	nearshore
1715.0	swc	middle apoxyexinus	-	7	nearshore
1719.0	swc	?lower mawsonii	-	5	nearshore
1770	cutts	lower mawsonii	-	(28)	nearshore
1775.0	swc	lower mawsonii	infusorioides	11	nearshore
1790	cutts	lower mawsonii	infusorioides	(23)	nearshore
1795.0	swc	lower mawsonii	infusorioides	6	nearshore
1800	cutts	lower mawsonii	infusorioides	(14)	nearshore
1805.0	swc	distocarinatus	-	3	very nearshore
1824.0	swc	distocarinatus	infusorioides	2	marginal marine
1829.0	swc	distocarinatus	-	0	non-marine
1830	cutts	distocarinatus	(?infusorioides)	(7)	?non-marine
1861.0	swc	indeterminate	-	-	-
1867.0	swc	indeterminate	-	-	-
1872.0	swc	paradoxa	-	0	non-marine
1875.0	swc	paradoxa	-	1	brackish
1965	cutts	indeterminate	-	-	-

TABLE 1 : INDIVIDUAL SAMPLE SUMMARY : CONAN-1

II INTRODUCTION

Twelve cuttings samples were studied during drilling on an urgent basis, and reported by fax, at the request of Jim Preston. After well completion, two batches of samples were submitted for detailed study. The first comprised twelve sidewall cores. The second comprised six cuttings and five swcs. All these results are summarised herein.

Palynomorph occurrence data are shown as Appendix I and form the basis for the assignment of the samples to nine spore-pollen and nine dinoflagellate units of Campanian to Albian age.

Specimen counts were made on all assemblages and expressed in the raw data as percentages. In the summary table, percentages from cuttings are bracketed (5%) to show that they may be inaccurate due to caving.

The Cretaceous spore-pollen zonation is essentially that of Dettmann and Playford (1969), but has been significantly modified and improved by various authors since, and most recently discussed in Helby et al (1987), as shown on Figure 1. The Late Cretaceous zonation has been modified by Morgan (1992) in project work for BHPP (Figure 2).

Maturity data was generated in the form of Spore Colour Index, and is plotted on Figure 3 Maturity Profile of Conan-1. The oil and gas windows on Figure 3 follow the general consensus of geochemical literature. The oil window corresponds to spore colours of light-mid brown (Staplin Spore Colour Index of 2.7) to dark brown (3.6). These correspond to vitrinite reflectance values of 0.6% to 1.3%. Geochemists argue variations on kerogen type, basin type and basin history. The maturity interpretation is thus open to reinterpretation using the basic colour observations as raw data. However, the range of interpretation philosophies is not great, and probably would not move the oil window by more than 200 metres.

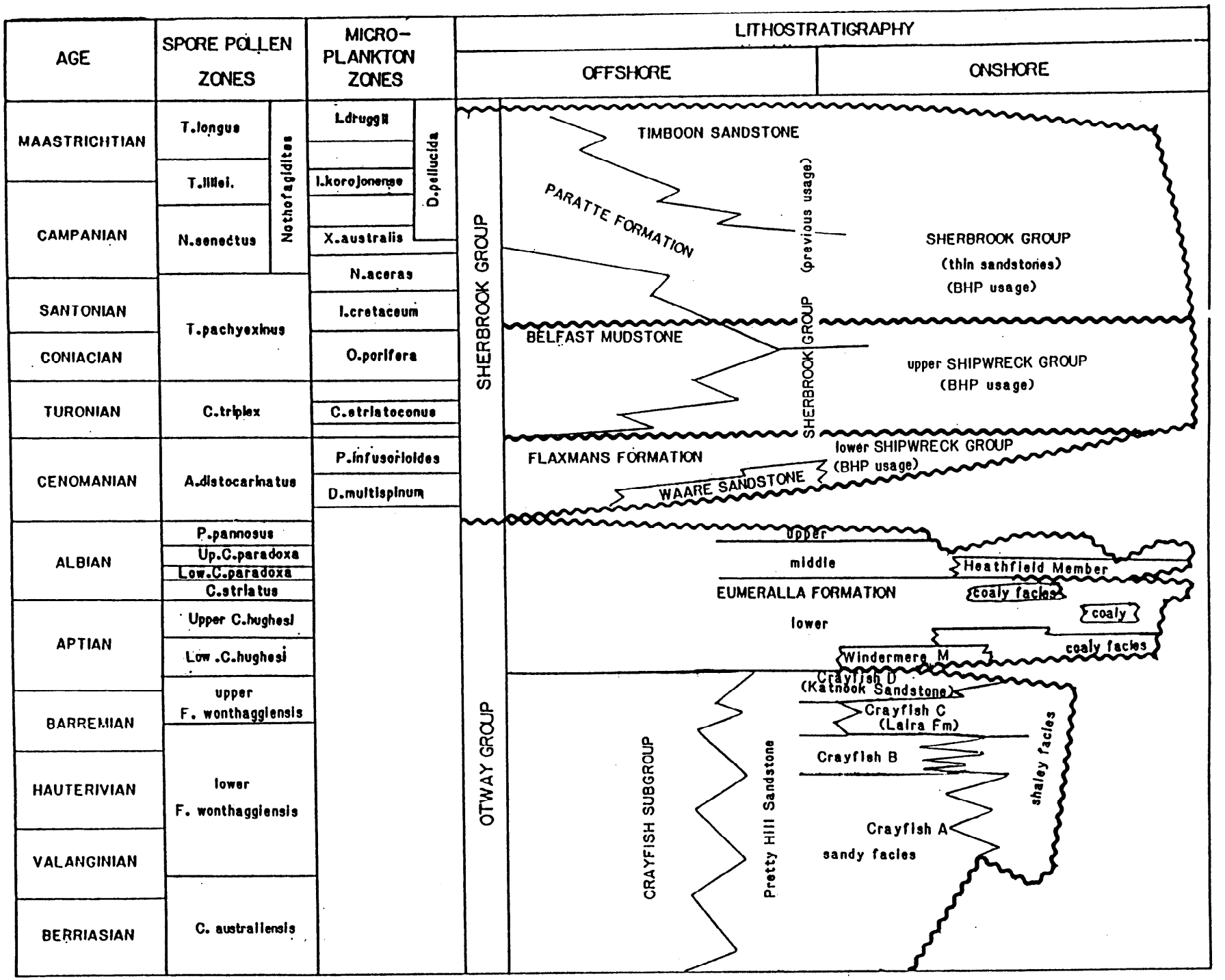

FIGURE 1. CRETACEOUS REGIONAL FRAMEWORK, OTWAY BASIN

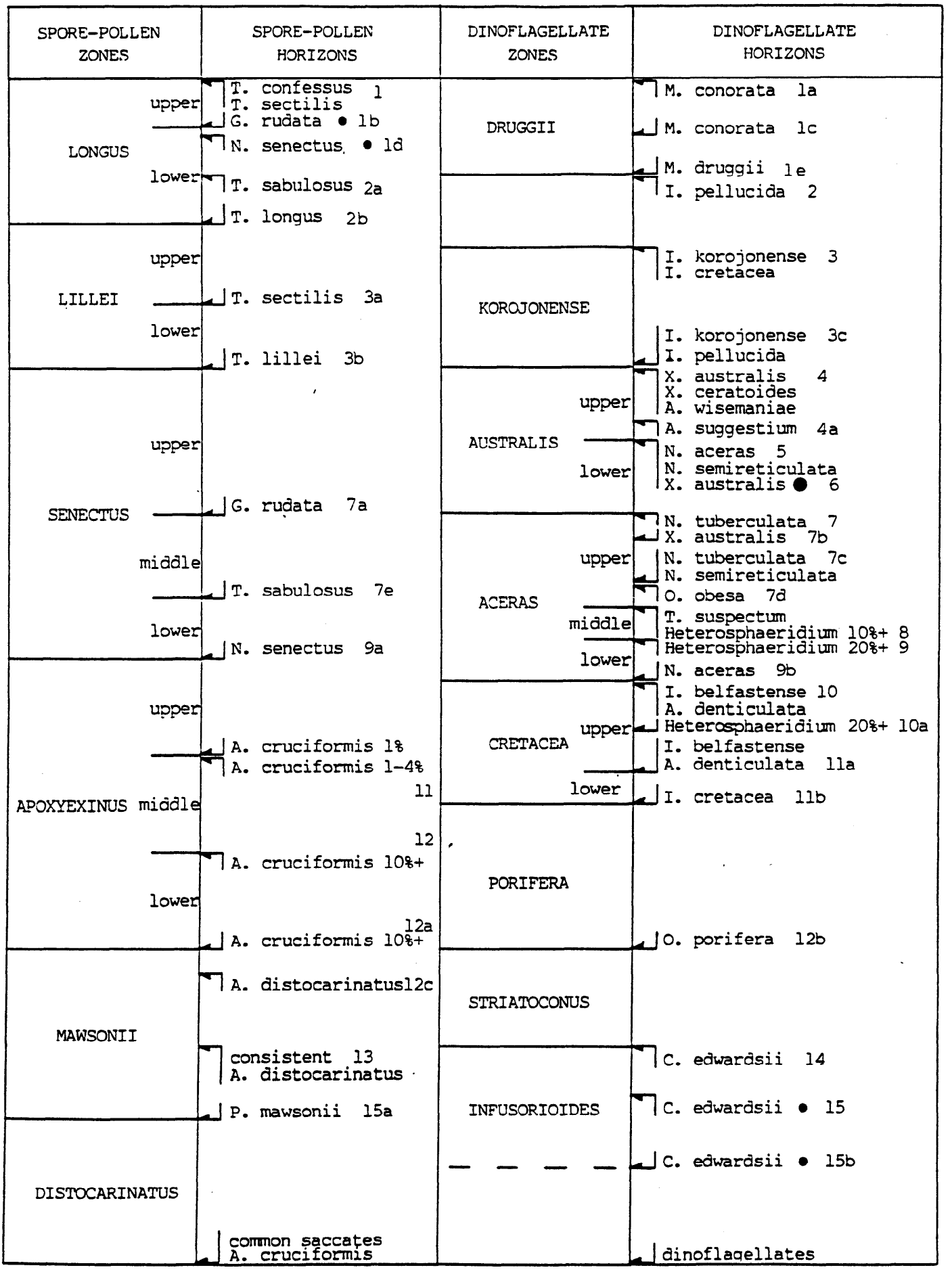

FIGURE 2 ZONATION USED HEREIN SHOWING THE NUMBERED HORIZONS AGAINST THE EXISTING FORMAL ZONATION.

• =frequent (4-10%) ● =common (11-30%)

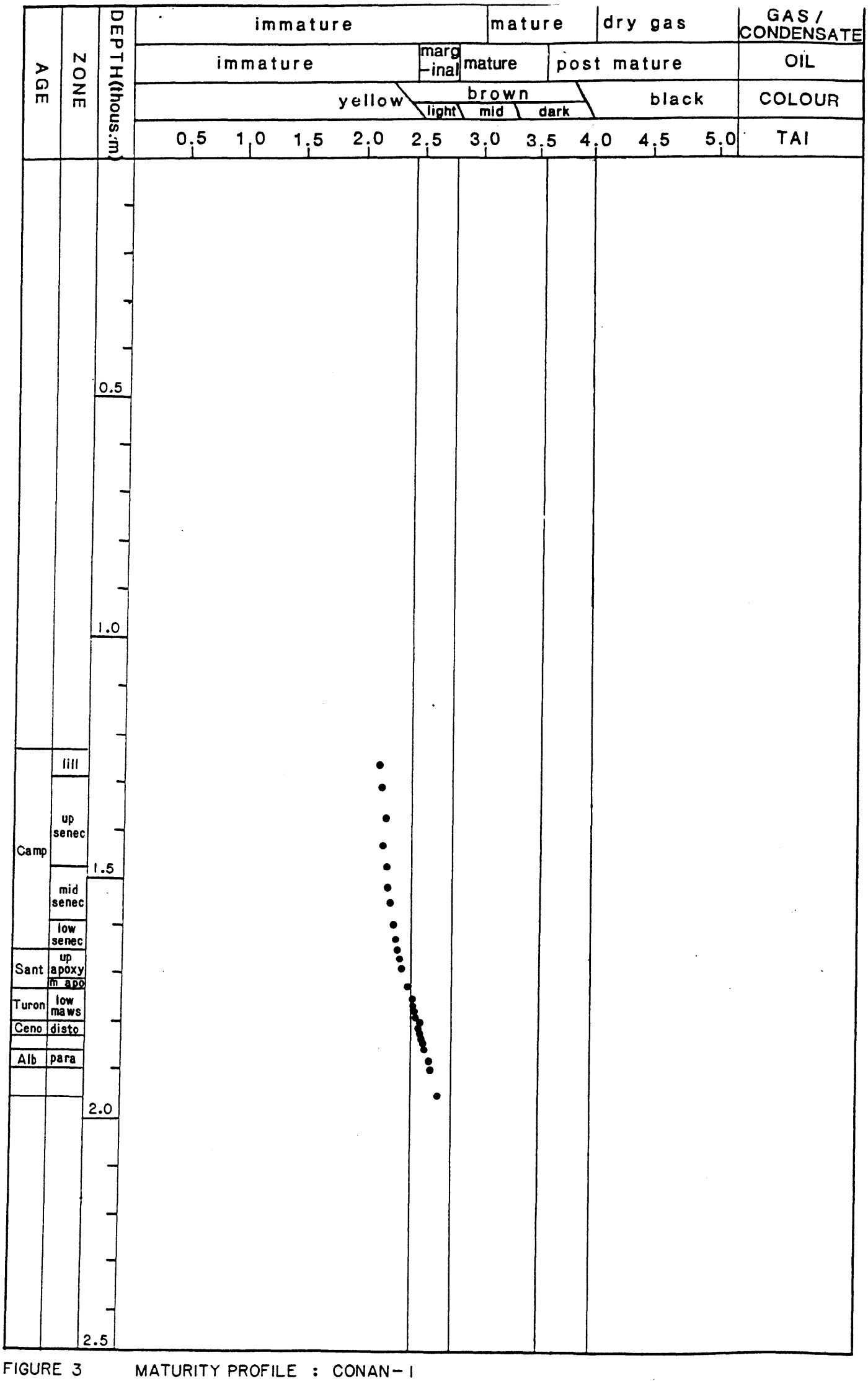

FIGURE 3 MATURITY PROFILE : CONAN-1

III PALYNOSTRATIGRAPHY

A 1250m(cutts) : *lillei* Zone (*korojonense* Dino Zone)

Assignment to the *Tricolporites lillei* Zone of Campanian age is indicated by the absence of younger markers at the top, and oldest *Triporopollenites sectilis* at the base, and is confirmed by the dinoflagellates. *Proteacidites* is common with *Cyathidites minor*, *Nothofagidites endurus* and *Vitreisporites pallidus* frequent. Rare elements include *Gambierina rudata*, *Lygistepollenites balmei*, *Tricolpites confessus*, *Tricolporites apoxyexinus* and *T. sectilis*. Rare Permian reworking was seen.

Amongst the scarce dinoflagellates, youngest *Isabelidinium cretacea* without older markers indicates the *Isabelidinium korojonense* Dino Zone, correlative with the *lillei* Spore-Pollen Zone.

Very nearshore marine environments are indicated by the scarce dinoflagellates and their low diversity, the abundant and diverse spores and pollen, and common freshwater algae (*Botryococcus*).

Yellow spore colours indicate immaturity for hydrocarbons.

These features are usually seen in the Sherbrook Group.

B 1300m(cutts) - 1450m(cutts) : upper *senectus* Zone (upper and lower *australis* Dino Zones)

Assignment to the upper *Nothofagidites senectus* Zone of Campanian age is indicated at the top by the absence of younger markers and confirmed by the dinoflagellates and at the base by oldest *Gambierina rudata*. Within the interval, *Falcisporites similis*, *Proteacidites* and *Vitreisporites pallidus* are common, with *C. minor*, *N. endurus*, *Microcachryidites antarcticus* and *Phyllocladidites mawsonii* frequent. Rare elements include *G. rudata*, *L. balmei*, *T. confessus* and *T. sabulosus*. Rare Permian and Triassic reworking were seen.

Amongst the dinoflagellates, *Xenikoon australis* without older markers indicates the upper *australis* Dino Zone at 1300-1350m, where all taxa are extremely rare. *Nelsoniella semireticulata* and *N. aceras* without older

markers indicate the lower *australis* Dino Zone at 1400-1450m, where dinoflagellates are more frequent, with *X. australis* the most persistent, and frequent (8%) at 1450m. *Areosphaeridium suggestium* and the *Nelsoniella* spp are rare throughout.

Environments shallow uphole from nearshore at the base (with 13% low diversity dinoflagellates) to brackish marine at the top (with <1% very low diversity dinoflagellates). Pollen and spores are abundant and diverse throughout, with freshwater algae (*Botryococcus*) frequent throughout around 5%.

Yellow spore colours indicate immaturity for hydrocarbons.

These features are normally seen in the Sherbrook Group.

C 1500m(cutts) - 1575.5m(swc) : middle *senectus* Zone (upper *aceras* Dino Zone)

Assignment to the middle *N. senectus* Zone of Campanian age is indicated at the top by the absence of younger markers and confirmed by the dinoflagellates, and at the base by oldest *T. sabulosus*. Within the interval, *F. similis* is common, with *Proteacidites* very frequent (less than above), *Dilwynites granulatus* frequent (more than above), and C. minor, *M. antarcticus*, *P. microsaccatus* and *V. pallidus* frequent (as above). Rare elements are *Australopollis obscurus*, *N. endurus* (less than above), *T. confessus* and *T. gilli* (both to 1539.0m) and *T. sabulosus*. Very rare Permian reworking was seen.

Amongst the rare dinoflagellates, *Nelsoniella tuberculata* throughout and oldest *X. australis* at 1539.0m indicate the upper *Nelsoniella aceras* Dino Zone. *X. australis* is frequent at 1500m and 1539.0m with all other dinoflagellates rare. *Canningia giant*, *N. aceras* and *Heterosphaeridium heterocanthum* are rare but consistent. *Eucladinium madurense*, *Isabelidinium cretacea*, *Odontochitina porifera* and *O. triangularis* are rare and inconsistent.

Nearshore marine environments are indicated by the low dinoflagellate content and diversity, with pollen and spores abundant and diverse. Freshwater algae are minor (3%) except at 1539.0m, where they are common (10%).

Yellow spore colours indicate immaturity for hydrocarbons.

These features are normally seen in the Sherbrook Group.

D 1601.5m(swc) - 1640m(cutts) : lower *senectus* Zone (middle *aceras* Dino Zone)

Assignment to the lower *Nothofagidites senectus* Spore-Pollen Zone is indicated by oldest *Nothofagidites endurus* at the base, in the absence of younger indicators, and confirmed by the dinoflagellates. Of the spore-pollen, *Dilwynites granulatus*, *Falcisporites similis*, *Proteacidites* spp and *Vitreisporites pallidus* are common, with rare but significant elements including *Australopollis obscurus*, *Amosopollis cruciformis*, *Clavifera triplex*, *Ornamentifera sentosa* and *Phyllocladidites mawsonii*. Caved is *Tetracolporites verrucosus*. Permian reworking is rare.

Of the dinoflagellates, *Heterosphaeridium* spp are the most frequent, increasing downhole (2%, 4% and 10%). Zonal assignment is on *Nelsoniella aceras* with moderate *Heterosphaeridium* spp without younger or older markers. Top ranges include *Trithyrodinium glabrum*, at 1601.5m, and *Odontochitina obesa* at 1640m. *Odontochitina porifera*, *O. cribropoda*, *G. hymenophora* and *Isabelidinium cretacea* are rare and inconsistent.

Nearshore marine environments are indicated by the low dinoflagellate content and diversity amongst dominant and diverse spores and pollen. At 1640m, diversity is moderate.

Yellow spore colours indicate immaturity for hydrocarbons.

These features are normally seen in the Sherbrook Group in the lower Belfast Mudstone in this area.

E 1649.0m(swc) - 1704.0m(swc) : upper *apoxyexinus* Zone (1649.0m lower *aceras* Dino Zone, 1678.0-1700m upper *cretacea* Dino Zone, 1704.0m lower *cretacea* Dino Zone)

Assignment to the upper *Tricolporites apoxyexinus* Spore-Pollen Zone of latest Santonian age is indicated by very rare *A. cruciformis* in the absence of younger or older markers. Common are *F. similis*, *Gleicheniidites* and

Microcachryidites antarcticus. Frequent are *Proteacidites* spp and *V. pallidus*. Rare but significant are *A. obscurus*, *A. cruciformis* and *P. mawsonii*. No caving was visible in the cuttings sample. Minor Permian and Triassic reworking were seen.

The lower *N. aceras* Dino Zone is indicated by the major downhole acme of *Heterosphaeridium* spp (19% at 1649.0m). Rare are *Areosphaeridium suggestium*, *N. aceras*, *O. obesa* and *O. cribropoda*.

The upper *Isabelidinium cretacea* Dino Zone is indicated by *Isabelidinium belfastense* at 1678.0m and 1700m, and by *Chatangiella victoriensis* at 1678.0(swc) and *Amphidiadema denticulata* at 1700m(cutts). *Heterosphaeridium* spp especially *H. solida* are the dominant dinoflagellate taxa, with others rare. *Botryococcus* is common at 1678.0m only.

At 1704m, the lower *I. cretacea* Dino Zone is indicated by *I. cretacea* without younger markers. *Spiniferites* spp are frequent with *Botryococcus* also frequent.

Nearshore marine environments are indicated by the low dinoflagellate content and moderate to low diversity. Spores and pollen are dominant and diverse.

Yellow spore colours indicate immaturity for hydrocarbons.

These features are normally seen in the basal Belfast Mudstone of the Sherbrook Group.

F 1715.0m(swc) : middle *apoxyexinus* Zone

Assignment to the middle *T. apoxyexinus* Spore-Pollen Zone of Santonian age is indicated by the downhole influx of frequent *A. cruciformis* (4%) without older markers. A single *Appendicisporites distocarinatus* is considered reworked. Amongst the spore-pollen, *F. similis* and *M. antarcticus* are common, with *A. cruciformis*, *Dilwynites granulatus*, *Gleicheniidites* and *P. microsaccatus* frequent. *P. mawsonii* is rare and *Proteacidites* spp were not seen.

Amongst the dinoflagellates, no zone diagnostic taxa were seen. However, youngest *Circulodinium deflandrei* is consistent with the middle *apoxyexinus* Spore-Pollen Zone.

Nearshore marine environments are indicated by the low dinoflagellate content and diversity. Spores and pollen are dominant and diverse, and there is abundant cuticle.

Yellow spore colours indicate immaturity for hydrocarbons.

These features are normally seen in the Napier Formation, which may be present in the higher resistivity log interval 1707-18m.

G 1719.0m(swc) : *mawsonii* Zone (?lower)

Assignment to the *P. mawsonii* Spore-Pollen Zone of Coniacian-Turonian age is indicated by *P. mawsonii* without younger markers. *F. similis*, *D. granulatus*, *M. antarcticus* and *P. microsaccatus* are common, with *Cyathidites* and *Gleicheniidites* frequent. Rare are *P. mawsonii* and *Phimopollenites pannosus*. A single *Gambierina rudata* is considered caved as mud contamination. The lower *mawsonii* Zone is implied by the absence of *A. cruciformis*.

Dinoflagellates are rare and not age diagnostic.

Environments are very nearshore marine with low dinoflagellate content and very low diversity. Significant lake influence is shown with freshwater algae (*Botryococcus*) frequent. Pollen and spores are dominant and diverse.

Light brown spore colours indicate marginal maturity for hydrocarbons.

These features are normally seen in the Minerva Formation.

H 1770m(cutts) - 1800m(cutts) : lower *mawsonii* Zone (1775.0-1800m *infusorioides* Dino Zone)

Assignment to the lower *P. mawsonii* Zone of Turonian age is indicated by youngest *A. distocarinatus* without *A. cruciformis* at the top, and oldest *in situ* *P. mawsonii* at the base. This is confirmed by the swc at 1795.0m. Frequent

to common are *Cyathidites minor*, *F. similis*, *Gleicheniidites* and *M. antarcticus*. Rare but significant are *A. distocarinatus*, *P. mawsonii* and *Trilobosporites trioreticulosus*. Significant caving is seen in the cuttings, marked especially by frequent *Proteacidites* and the dinoflagellates.

Amongst the dinoflagellates, *Heterosphaeridium* spp are the most frequent. Youngest *Cribroperidinium edwardsii* at 1775.0m indicates the *Palaeohystrichophora infusorioides* Dinoflagellate Zone of early Turonian to Cenomanian age. *P. infusorioides* is rare but consistent in the swcs. Other taxa are not zone diagnostic. The two cuttings samples show caving from the Campanian *X. australis* and *N. aceras* Dinoflagellate Zones.

Nearshore marine environments are indicated by the low dinoflagellate content and diversity especially in the swcs. Dinoflagellate content in the cuttings is considered unreliable due to caving. Pollen and spores are dominant and diverse.

Light brown spore colours indicate marginal maturity for hydrocarbons.

These features are normally seen in the Minerva Formation in this area.

I **1805.0m(swc) - 1830m(cutts) : *distocarinatus* Zone (1824.0m swc and ?1830m cutts *infusorioides* Dino Zone)**

Assignment to the *A. distocarinatus* Spore-Pollen Zone of Cenomanian age is indicated by *A. distocarinatus* without younger or older markers. Common are *F. similis*, *M. antarcticus* and *P. microsaccatus*. Frequent are *Cyathidites* and *V. pallidus*. *A. distocarinatus* and *Triporoletes* spp are rare but consistent. *P. mawsonii* occurs in the cuttings only and is considered caved. *Phyllocladidites eunuchus* occurs in swcs and cuttings and is considered in place. Rare Permian and Early Cretaceous reworking was noted.

Environments are marginal marine to non-marine, with the swcs yielding extremely few (1824.0m) to no (1829.0m) dinoflagellates. The cuttings are contaminated by caving. The *P. infusorioides* Zone is indicated at 1824.0m swc and suggested at 1830m cutts by the presence of *C. edwardsii*. At 1830m(cutts), it could be caved. Significant lake influence is indicated by frequent freshwater algae (*Botryococcus*). Spores and pollen are abundant and diverse.

These features are usually seen in the La Bella Formation in this area.

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

J 1861.0m(swc) - 1867.0m(swc) : indeterminate

These two samples were almost barren of palynomorphs due to their sandy lithologies. The few taxa recovered were mostly long ranging spores and pollen. A single dinoflagellate (*Maduradinium pentagonum* at 1867.0m) is clearly mud contamination from the Sherbrook Group.

K 1872.0m(swc) - 1875.0m(swc) : *paradoxa* Zone

Assignment to the *Copto*spora paradoxa Zone of Albian age is indicated by youngest *in situ C. paradoxa* (1875.0m), *Crybelosporites striatus* (1872.0m) and the downhole influx of *Cicatricosisporites australiensis* and *Foraminisporis asymmetricus*. Abundant to very common is *F. similis*, with common *Cyathidites* and frequent *C. australiensis*, *M. antarcticus* and *Retitriletes austroclavatidites*.

Extremely rare dinoflagellates are clearly caved and present as mud contamination. Extremely rare spiny acritarchs at 1875.0m are considered in place and indicate brackish environments. Significant lake influence is indicated by the freshwater algae (*Botryococcus* and *Schizosporis*).

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

These features are normally seen in the Eumeralla Formation.

L 1965m(cutts) : indeterminate

This assemblage is clearly caved with spores and pollen most similar to the Santonian upper *apoxyexinus* Zone, and the dinoflagellates most similar to the Campanian *australis* and *aceras* Dino Zones. Very few taxa could be regarded as in place, suggesting caved Sherbrook Group into barren Eumeralla Formation.

IV CONCLUSIONS

Palynology suggests a normal Belfast Mudstone, complete to the base in upper *apoxyexinus* Zone. Beneath this, a thin and incomplete Napier Formation appears to be present and includes only the middle *apoxyexinus* Zone with the lower *apoxyexinus* Zone lost by unconformity. Beneath, the Minerva Formation may be truncated, as no upper *mawsonii* Zone was seen. Alternatively, it may be barren, as the Minerva Sand is exceptionally clean and so lacks claystone interbeds for swcs. Beneath, the La Bella Formation is present but yields are variable as usual in this interval. At the base, the Eumeralla Formation is indicated on swc data although some swcs and the cuttings are inconclusive.

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