PALYNOLOGY OF

KOROIT WEST-1,

OTWAY BASIN, AUSTRALIA

BY

ROGER MORGAN

Prepared for

ORIGIN ENERGY

June, 2003

REF: OTW.KOROIT WEST-1 REPORT

PALYNOLOGY OF

KOROIT WEST-1,

OTWAY BASIN, AUSTRALIA

CONTENTS **PAGE**

1 SUMMARY

436.0 m (swc) : *N. asperus* Zone : Middle to Late Eocene : nearshore marine : Narrawaturk Marl equivalent

498.5 m swc – 545.0 m swc : upper *M. diversus-P. asperopolus* Zones : Early to Middle Eocene : very nearshore to marginal marine : Dilwyn Formation / Pember Mudstone equivalent

570.0 m (swc) – 608.0 m (swc) : middle to lower *M. diversus* Zone : Early Eocene : marginally marine : Pember Mudstone equivalent

623.0 m (swc) : *L. balmei* Zone : Paleocene : marginal marine : Pebble Point equivalent

632.5 m (swc) : upper *F. longus* Zone and upper *M. druggii* Dinoflagellate Zone : late Maastrichtian : shelfal marine : Massacre Shale / Timboon Sand equivalent

635.5 m (swc) : lean upper *F. longus* Zone and lower *M. drug*gii Dinoflagellate Zone : late Maastrichtian : marginal marine : Massacre Shale / Timboon Sand equivalent

751.0 m (swc) : lower *P. mawsonii* Zone (*H. trinalis* subzone of Partridge) and lower *P. infusorioides* Zone (*C. edwardsii* subzone of Partridge) : Turonian : very nearshore marine : Waare B equivalent

2 INTRODUCTION

The Cretaceous zonation used herein (Figure 1) is that of Morgan (2002) developed from extensive sample suites in the Thylacine-Geographe area, but kept within the framework of Helby, Morgan and Partridge (1987). Figure 2 compares the new zonation with that of Partridge (1998) and the lithostratigraphy of Partridge (1998, 2001). The Tertiary zonation used (Figure 3) is based on Partriddge (1976 and pers. comm.). Table 1 summarises the palynological details of the studied samples. Brief discussion of formation assignments is included in the text.

A total of 9 samples have been restudied from **Koroit West-1** for Origin Energy.

Maturity data were generated in the form of Spore Colour Index, and are plotted on Figure 2 Maturity Profile: Koroit West-1. The oil and gas windows on Figure 2 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), equivalent 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 m.

Species names are given in full when first mentioned in the text, but only the genus initial and full species name is given when subsequently mentioned.

Raw palynological data are included in Appendix 1. The data are based on a 100 specimen count from which an indication of marine microplankton to terrestrial palynomorph proportions can be derived. The microplankton percentages are listed in Table 1, which also summarizes other palynological details. Environmental assessments are derived from the palynomorph counts using content and diversity of saline taxa (dinoflagellates and spiny acritarchs), other microplankton (mostly freshwater algae), and terrestrial spores and pollen. The criteria for these assessments are defined in Table 1. However, dinoflagellate content and diversity in the Otway Basin are lower than might be expected from other data sources, especially sedimentology in the offshore marine shales. It may be that dinoflagellate productivity is suppressed by lowered salinity or restricted oceanic circulation caused by the enclosed nature of a long narrow marine gulf. Environments interpreted here may therefore underestimate marine influence in this section with environments really being more marine than interpreted here. In running text, frequency of taxa is discussed in the following intervals: Very rare = <1%, Rare = 1-3%, Frequent = 4-10%, Common = 11-29%, Abundant = 30-49%, Super-abundant = 50-100%.

TABLE 1

SUMMARY OF PALYNOLOGICAL DATA : KOROIT WEST-1

LOG DEPTH (m)	SAMPLE TYPE	MICROFOSSIL YIELD	PRESERVATION *1	PERCENTAGE				DIVERSITY *2		SPORE-POLLEN ZONE	DINOFLAGELLATE ZONE	ENVIRONMENT *3
				MICROPLANKTON			SPORE-POLLEN	MICROPLANKTON	SPORE-POLLEN			
				DINOFLAG.	SPINY AC.	OTHER	N.					
436.0	SWC	LOW	GOOD	14	0	<1	86	LOW	HIGH	N. ASPERUS		NEARSHORE
498.5	SWC	LOW	GOOD	6	0	1	93	EX LOW	V HIGH	P. ASPERO-UP M. DIVERUS		VERY NEARSHORE
545.0	SWC	MOD	GOOD	<1	0	2	98	EX LOW	V HIGH	P. ASPERO- UP M. DIVERUS		MARGINAL MARINE
570.0	SWC	MOD	GOOD	2	1	0	97	LOW	V HIGH	M. DIVERSUS, MID-LOW		MARGINAL MARINE
608.0	SWC	MOD	GOOD	<1	0	2	98	EX LOW	V HIGH	M. DIVERSUS, MID-LOW		MARGINAL MARINE
623.0	SWC	LOW	GOOD	<1	0	30	70	LOW	HIGH	L. BALMEI		MARGINAL MARINE
632.5	SWC	MOD	GOOD	<1	58	3	49	MOD	V HIGH	F. LONGUS	M. DRUGGII, UP	SHELFAL MARINE
635.5	SWC	VERY LOW	GOOD	2	0	6	92	EX LOW	HIGH	F. LONGUS	M. DRUGGII, LOW	MARGINAL MARINE
751.0	SWC	HIGH	GOOD	8	0	1	91	LOW	V HIGH	P. MAWSONII, LOW	P. INFUSORIDES, LOW	VERY NEARSHORE

*1 NOTE : PRESERVATION
(FRAGMENTATION INDEX)
1 = SUPERB
2 = EXCELLENT
3 = GOOD
4 = FAIR
5 = POOR

*2 DIVERSITY	
VERY HIGH	30+ SPECIES
HIGH	20-29 SPECIES
MODERATE	10-19 SPECIES
LOW	5-9 SPECIES
EX LOW	1-4 SPECIES

*3 ENVIRONMENTS	DINOFLAGELLATE CONTENT %	DINOFLAGELLATE DIVERSITY	FRESHWATER ALGAE CONTENT%
OFFSHORE MARINE	67 to 100	VERY HIGH	LOW
SHELFAL MARINE	34 to 66	HIGH	"
NEARSHORE MARINE	11 to 33	MODERATE	"
VERY NEARSHORE MARINE	5 to 10	MODERATE-LOW	"
MARGINAL MARINE	<1 to 4	LOW-VERY LOW	"
BRACKISH	0, SPINY ACRITARCHS ONLY	EXTREMELY LOW	"
NON-MARINE (UNDIFF)	0, NO SPINY ACRITARCHS	NIL	LOW <3
NON-MARINE (LACUSTRINE)	0, NO SPINY ACRITARCHS	NIL	MODERATE 3-10+

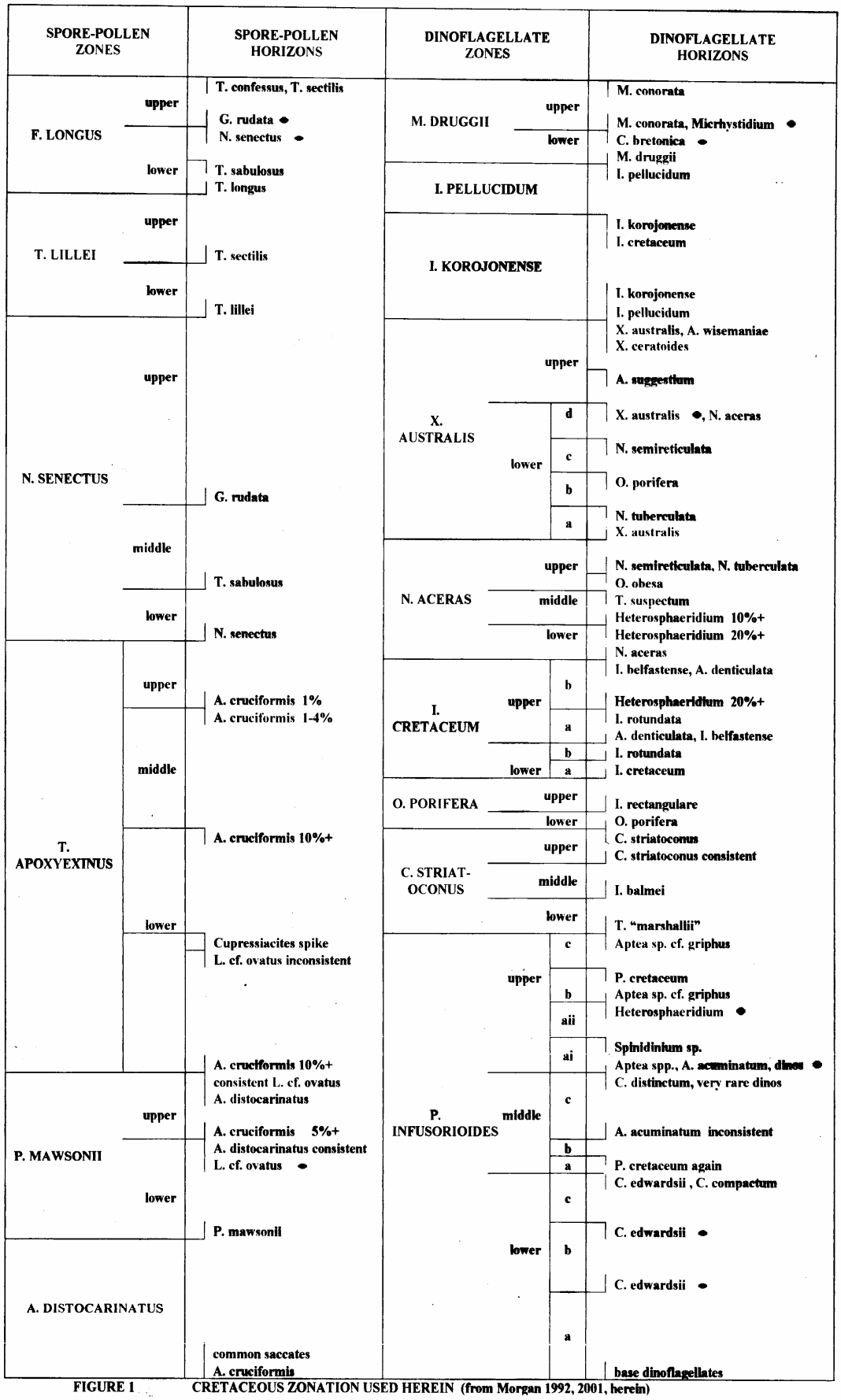


FIGURE 1 CRETACEOUS ZONATION USED HEREIN (from Morgan 1992, 2001, herein)

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

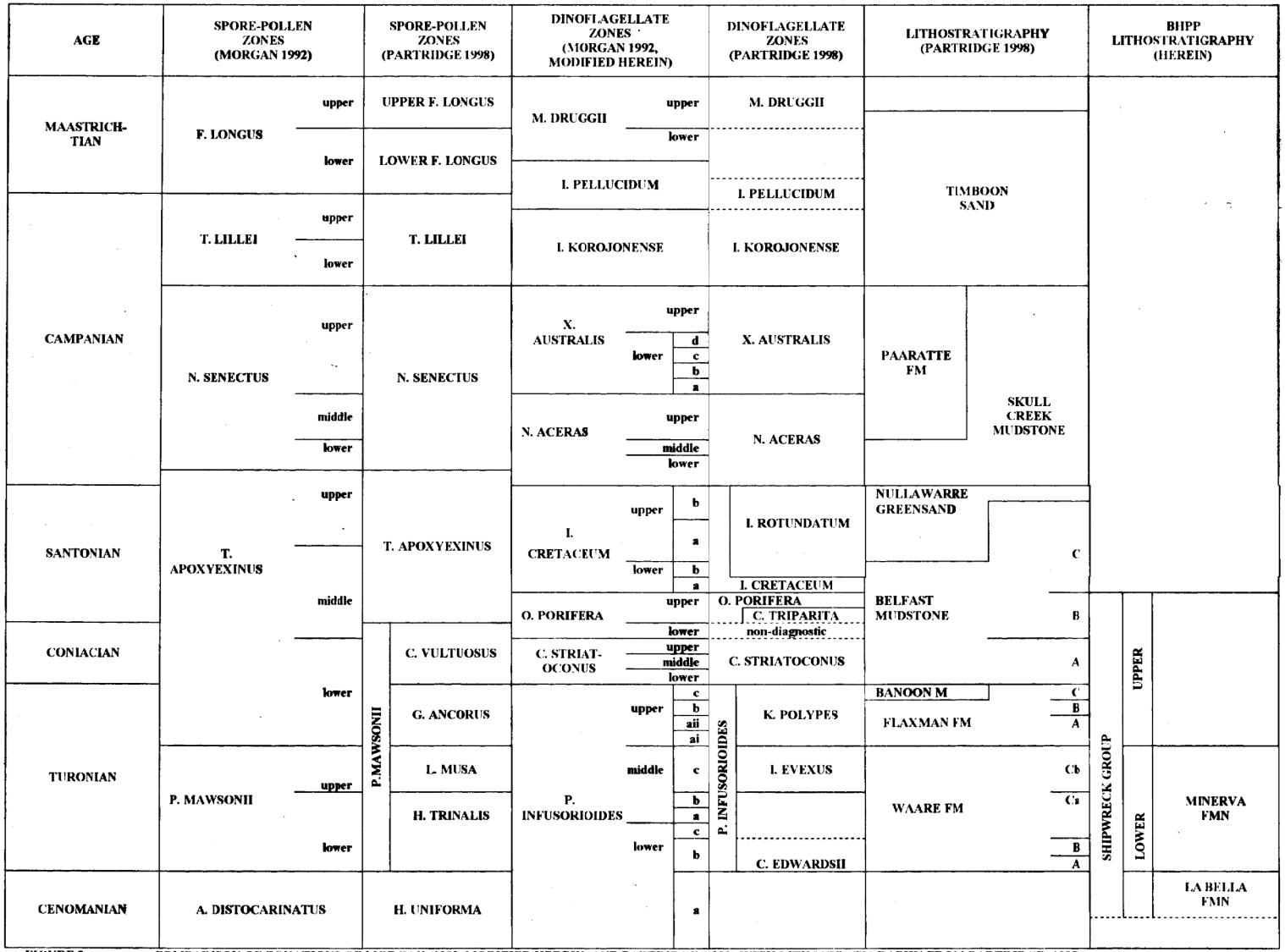


FIGURE 2 COMPARISON OF ZONATIONS OF MORGAN (1992, MODIFIED HEREIN) AND PARTRIDGE (1998) WITH LITHOSTRATIGRAPHY FROM PARTRIDGE (1998)

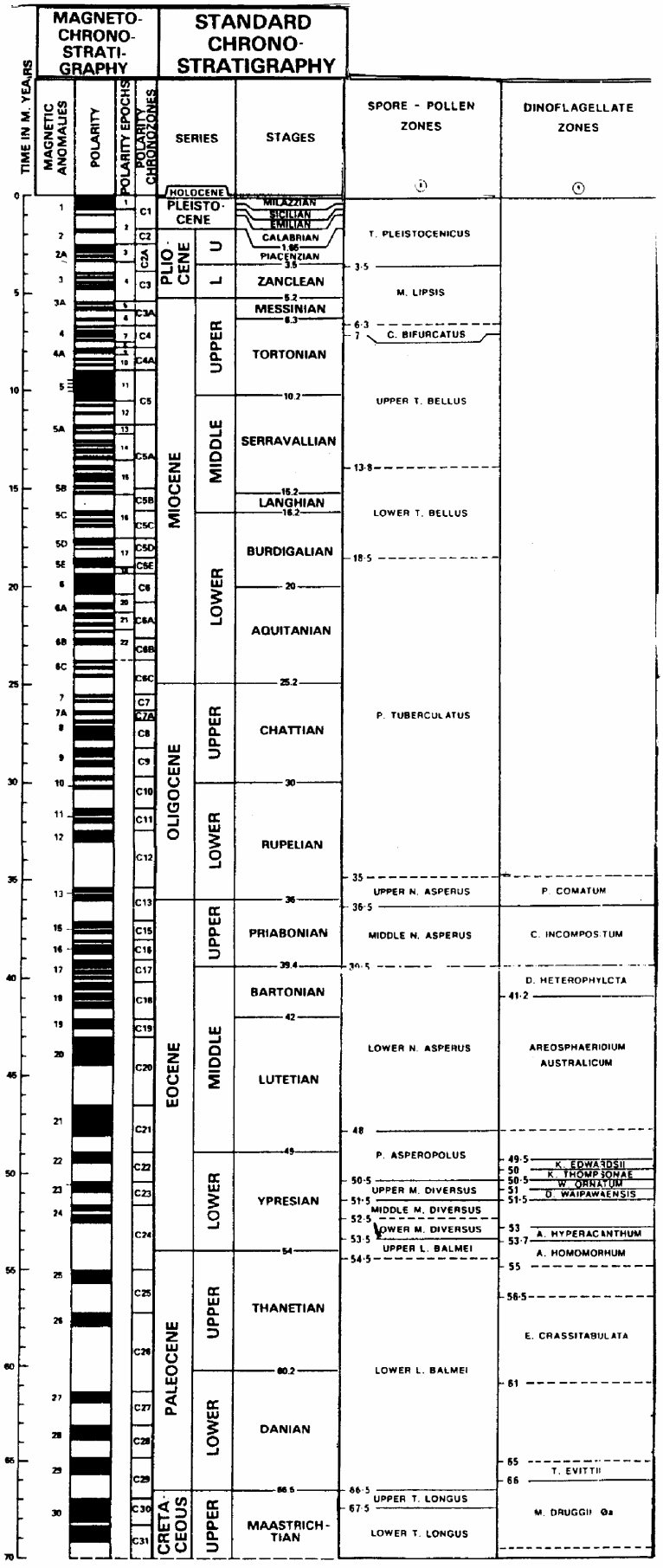
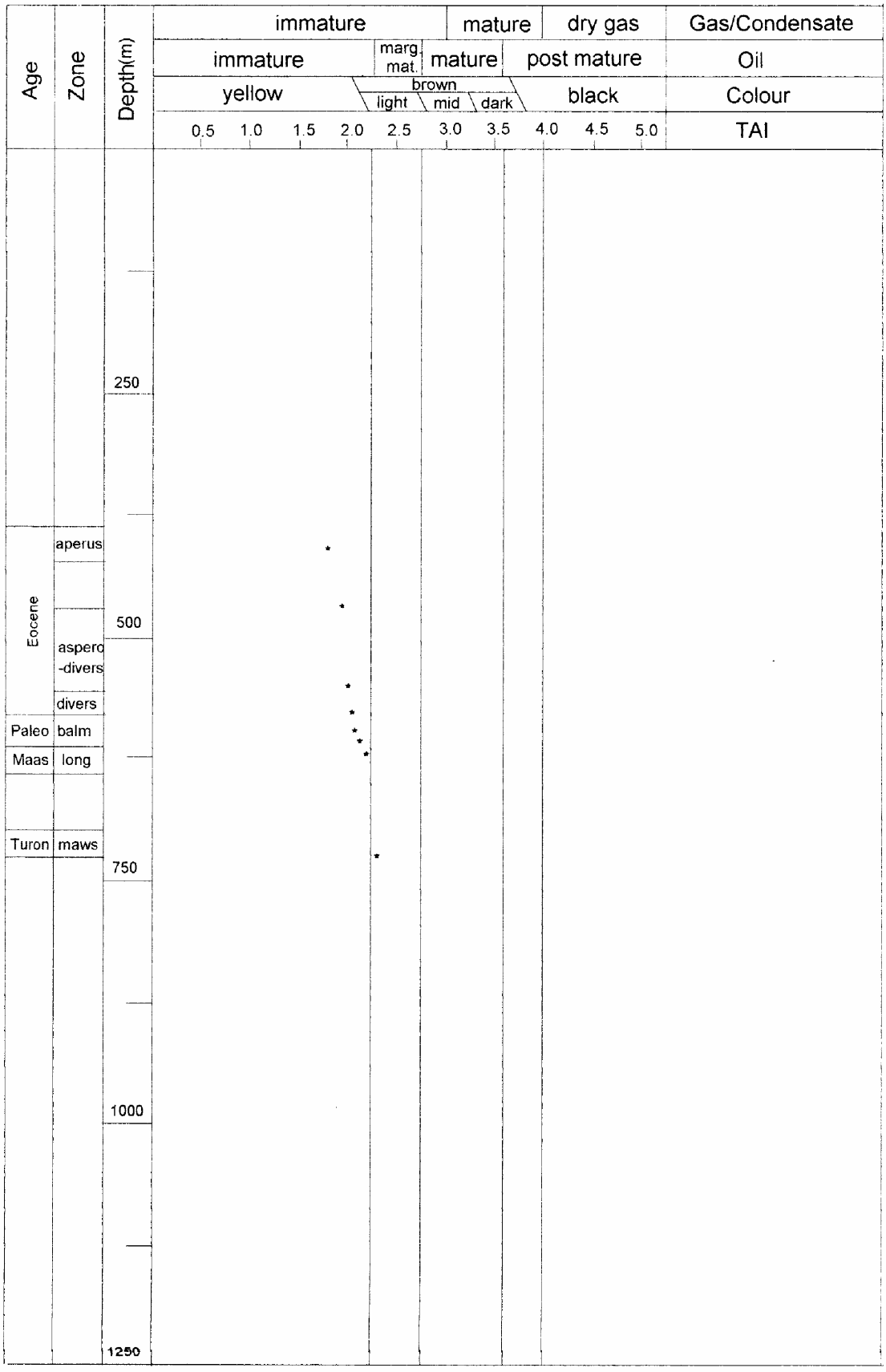


FIGURE 3 **TERTIARY ZONATION SCHEME (Partridge 1976 and pers. comm. using time scale of Haq et al)**

FIGURE 4 MATURITY PROFILE : KOROIT WEST-1



3 PALYNOSTRATIGRAPHY

3.1 436.0 m (swc) : *N. asperus* Zone

Assignment is indicated by the dominant *Nothofagidites* spp., especially common *N. emarcidus* and rare *N. falcata*. Subzonal assignment is not possible with this lean assemblage, but the presence of *Riccia* sp. suggests the middle subzone or younger. Overall, common are *Dilwynites granulatus* and *N. emarcidus* with frequent *Cyathidites minor, Falcisporites similis, Haloragacidites harrisii, Lygistepollenites florinii* and *Vitreisporites pallidus*. Rare elements include *Malvacipollis subtilis, N. falcata* and *Spinozonocolpites prominatus*.

Dinoflagellates are minor and not age diagnostic. *Spiniferites ramosus* is common with other elements rare.

Nearshore marine environments are indicated by the dominant and diverse spores and pollen and the minor low diversity dinoflagellates.

Colourless spore colours indicate immaturity for hydrocarbons.

3.2 498.5 m (swc) – 545.0 m (swc) : upper *M. diversus-P. asperopolus* Zones

Assignment is indicated by common *H. harrisii* at the top and oldest *Proteacidites pachypolus* at the base. Common are *C. minor, F. similis*, *H. harrisii* and *V. pallidus,* with frequent *Ericipites scabratus, Laevigatosporites ovatus, L. florinii, Microcachryidites antarcticus, Phyllocladidites mawsonii* and *Proteacidites* spp. Rare elements include *Anacolosidites acutullus, Cyathidites gigantis, Malvacipollis diversus, Periporopollenites demarcatus, P. pachypolus, Proteacidites grandis* and *Stereisporites punctatus*. Rare reworking was seen from the Permian and Early Cretaceous (*Coptospora paradoxa*, *Pilosisporites notensis*).

Dinoflagellates are very rare. *Muratodinium fimbriatum* at 498.5 m (swc) and *Deflandrea pachyoceros* at 545.0 m (swc) consistent with the spore-pollen assignment.

Marginal marine to very nearshore marine environments are indicated by the minor low diversity dinoflagellates amongst the dominant and diverse spores and pollen.

Colourless spore colours indicate immaturity for hydrocarbons.

3.3 570.0 m (swc) – 608.0 m (swc) : middle to lower *M. diversus* Zone

Assignment is indicated at the top by the absence of younger markers and confirmed by youngest *Tricolpites phillipsii*. At the base, the absence of older markers plus oldest *M. diversus* and *P. demarcatus* indicate the assignment. Common are *C. minor, D. granulatus, F. similis, Proteacidites* spp. and *V. pallidus*, with frequent *H. harrisii, L. ovatus, L. florinii, M. antarcticus* and *P. mawsonii*. Rare elements include *C. gigantis, M. diversus, M. subtilis, P. demarcatus, P. grandis, Proteacidites kopiensis* and *T. phillipsii*. Rare Permian reworking was seen.

Dinoflagellates are extremely rare but include *Apectodinium quinquelatum, D. pachyceros* and *Deflandrea truncata*, consistent with the spore-pollen assignment.

Marginal marine environments are indicated by the minor low diversity dinoflagellates amongst the dominant and diverse spores and pollen.

Colourless spore colours indicate immaturity for hydrocarbons.

3.4 623.0 m (swc) : *L. balmei* Zone

Assignment is indicated at the top by youngest *Lygistepollenites balmei* and at the base by the absence of older markers. In this lean assemblage, common are *F. similis* and *V. pallidus* with frequent *C. minor, M. antarcticus, P. mawsonii* and *Proteacidites* spp. Rare elements include *Australopollis obscurus, Herkosporites elliottii, L. balmei, Periporopollenites polyoratus, Peninsulapollis gillii* and *T. phillipsii.* The absence of *P. grandis* suggests the lower subzone. Rare Permian reworking was seen.

Dinoflagellates are rare but include *Cerodinium speciosum* and *Palaeoperidinium pyrophorum* consistent with the lower part of the *L. balmei* Zone. Other microplankton include frequent saline acritarchs (*Micrhystridium* spp.) and freshwater algae (common *Paralecaniella indentata* and frequent leiospheres).

Marginal marine environments are indicated by the frequent spiny acritarchs, rare dinoflagellates, common freshwater algae and dominant and diverse spores and pollen.

Yellow spore colours indicate immaturity for hydrocarbons.

3.5 632.5 m (swc) – 635.5 m (swc) : upper *F. longus* Zone and *M. druggii* Zone

Assignment is indicated at the top by youngest *Quadraplanus brossus* and *Tubuliflordites lillei* and at the base by oldest *S. punctatus*. *Gambierina rudata* is more frequent than *Nothofagidites endurus*. Common are *F. similis* and *Proteacidites* spp. with frequent *D. granulatus, M. antarcticus, O. wellmanii* and *V. pallidus.* Rare elements include *G. rudata, L. balmei, N. endurus, Q. brossus, S. punctatus* and *T. lillei*. At 635.5 m, a lean assemblage contains minor mud contamination from the upper *L. balmei* Zone including *H. harrisii, M. subtilis* and *P. grandis.*

Microplankton include *Manumiella conorata* in both samples, indicating the *M. druggii* Zone. At 632.5 m, *Micrhystridium* spp. are super-abundant, indicating the upper subzone. At 635.5 m (swc), *Micrhystridium* spp. are rare, indicating the lower subzone. Dinoflagellates are all rare but include *M. druggii, M. conorata* and *Palaeocystodinium australinum*.

Environments are shelfal marine at 632.5 m (indicated by subequal proportions of saline microplankton and terrestrial spores and pollen) and marginal marine at 635.5 m (indicated by minor low diversity saline microplankton and dominant and diverse spores and pollen).

Yellow spore colours indicate immaturity for hydrocarbons.

3.6 751.0 m (swc) : lower *P. mawsonii* Zone and lower *P. infusorioides* Zone

Spore-pollen assignment is indicated by youngest *Hoegisporis "trinalis"* at the top and oldest *P. mawsonii* at the base. Common are *C. minor, Cupressiacites* spp., *F. similis* and *M. antarcticus* with frequent *O. wellmanii, P. mawsonii, P. microsaccatus, S. antiquasporites* and *V. pallidus*. Rare elements include *Appendicisporites distocarinatus, Cicatricosisporites australiensis, Cicatricosisporites ludbrookiae* and *H." trinalis"*. Rare reworking includes the Early Cretaceous (*Foraminispors wonthaggiensis, P. notensis*) and Triassic.

Microplankton comprise rare dinoflagellates including consistent/frequent *Cribroperidinium edwardsii* indicating the dinoflagellate subzone. Other rare elements include *Amosopollis cruciformis, Chlamydophorella nyei, Cyclonephelium compactum* and *Palaeoperidinium cretaceum*.

Very nearshore marine environments are indicated by the minor moderately diverse dinoflagellates and the dominant and diverse spores and pollen.

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

4 REFERENCES

Helby, R., Morgan, R., & Partridge, A.D., (1987) A palynological zonation of the Australian Mesozoic. Mem. Assoc. Aust. Palaeontol. 4, 1-94.

Morgan, R.P., (2002) New palynology of LaBella-1, offshore Otway Basin, Australia unpubl rept. for Woodside Energy Ltd

Partridge, A.D. (1976) The geological expression of eustacy in the early Tertiary of the Gippsland Basin APEA J. 16 (1), 73-79

Partridge, A.D., (1998) Biostratigraphy and interpreted stratigraphy of Champion-1 and Conan-1 from open file basic data unpubl. rept. Biostrata 1998/02

Partridge, A.D., (2001) Revised stratigraphy of the Sherbrook Group, Otway Basin In Hill, K.C. and Bernecker, T. (Eds) Eastern Australian Basins Symposium, a refocused energy perspective for the future PESA spec. Publ. 455-464

Well Name : KOROIT WEST-1

Interval : 430m - 757m | **Palynological Data Chart**

Scale : 1:2000 | **% Abundance Histogram BASIC DATA VERSION**

Chart date: 19 June 2003 | **Roger Morgan**

KOROIT WEST-1

Morgan Palaeo Associates
Maitland, South Australia

Enclosure 1

Sampling
- Cutting
- Core
- Sidewall core

Text Keys
*1 % within discipline (40mm=100%)
*2 In-Situ occurrences

Depth | **Samples** (Samples in Discipline(s) : Paly)

Dinoflagellate Cysts — % within discipline (40mm=100%); In-Situ occurrences
- *Achomosphaera alcicornu*
- *Achomosphaera crassipellis*
- *Achomosphaera ramulifera*
- *Operculodinium centrocarpum*
- *Spiniferites ramosus*
- *Tectatodinium spp.*
- *Dapsilidinium pastielsii*
- *Diphes colligerum*
- *Muratodinium fimbriatum*
- *Thalassiphora pelagica*
- *Deflandrea pachyceros*
- *Deflandrea truncata*
- *Glaphyrocysta divaricata*
- *Heteraulacysta "paxilla"*
- *Apectodinium quinquelatum*
- *Cordosphaeridium inodes*
- *Cerodinium speciosum*
- *Impagidinium sp.*
- *Palaeoperidinium pyrophorum*
- *Paralecaniella indentata*
- *Trithyrodinium evittii*
- *Cassiculosphaeridia reticulata*
- *Circulodinium deflandrei*
- *Manumiella conorata*
- *Manumiella druggii*
- *Palaeocystodinium australinum*
- *Trithyrodinium spp.*
- *Fibrocysta bipolaris*
- *Canningia "reticulata"*
- *Chlamydophorella nyei*
- *Chiropteridium edwardsii*
- *Cyclonephelium compactum*
- *Exochosphaeridium phragmites*
- *Heterosphaeridium "solida"*
- *Microdinium "brentii"*
- *Odontochitina costata*
- *Odontochitina operculata*
- *Oligosphaeridium complex*
- *Palaeoperidinium cretaceum*

Acritarchs — *1 In-Situ occurrences
- *Amosopollis cruciformis*
- *Pterospermella australiensis*

AL

MP — *1 *2
- *Leiospheres*
- *Microforams*
- *Reworking - Permian*
- *Reworking - Triassic*

Spores And Pollen — % within discipline (40mm=100%); In-Situ occurrences
- *Araucariacites australis*
- *Australopollis obscurus*
- *Cyathidites minor*
- *Dilwynites granulatus*
- *Dilwynites tuberculatus*
- *Falcisporites similis*
- *Gleicheniidites spp.*
- *Haloragacidites harrisii*
- *Herkosporites elliottii*
- *Laevigatosporites ovatus*
- *Lygistepollenites florinii*
- *Malvacipollis subtilis*
- *Microcachryidites antarcticus*
- *Nothofagidites deminutus*
- *Nothofagidites emarcidus*
- *Nothofagidites falcatus*
- *Osmundacidites wellmanii*
- *Phyllocladidites mawsonii*
- *Proteacidites annularis*
- *Proteacidites incurvatus*
- *Proteacidites spp.*
- *Riccia sp.*
- *Spinozonocolpites prominatus*
- *Vitreisporites pallidus*
- *Anacolosidites acutullus*
- *Clavifera triplex*
- *Coptospora paradoxa*
- *Cyathidites australis*
- *Dictyophyllidites spp.*
- *Ericipites scabratus*
- *Falcisporites grandis*
- *Malvacipollis diversus*
- *Periporopollenites demarcatus*
- *Proteacidites grandis*
- *Retitriletes austroclavatidites*
- *Stereisporites punctatus*
- *Tricolpites spp.*
- *Tricolporites spp.*
- *Corollina torosa*
- *Cyathidites giganteus*
- *Foraminisporis asymmetricus*
- *Periporopollenites polyoratus*
- *Pilasiporites notensis*
- *Podosporites microsaccatus*
- *Proteacidites clarus*
- *Proteacidites pachypolus*
- *Retitriletes nodosus*
- *Verrucosisporites kopukuensis*
- *Foveotriletes parviretus*
- *Proteacidites "bun grandis"*
- *Proteacidites pseudomoides*
- *Tricolpites phillipsii*
- *Cyathidites splendens*
- *Proteacidites kopiensis*
- *Proteacidites scaboratus*
- *Tetracolporites "reticulatus"*
- *Triletes tuberculiformis*
- *Camerozonosporites ohaiensis*
- *Ceratosporites equalis*
- *Dictyotosporites complex*
- *Lygistepollenites balmei*
- *Peninsulapollis gillii*
- *Gambierina rudata*
- *Nothofagidites endurus*
- *Proteacidites "hapukui"*
- *Quadraplanus brossus*
- *Stereisporites regium*
- *Tubulifloridites cf. lilliei*
- *Tubulifloridites lilliei*
- *Appendicisporites distocarinatus*
- *Balmeisporites holodictyus*
- *Cicatricosisporites australiensis*
- *Cicatricosisporites ludbrookiae*
- *Convolutispora "magnifica"*
- *Cupressacites spp.*
- *Dilwynites "pusillum"*
- *Foraminisporis wonthaggiensis*
- *Hoegisporis "trinalis"*
- *Kuylisporites "zipperi"*
- *Perotriletes jubatus/morganii*

Samples (Samples in Discipline(s) : Paly)

Total Count — In-Situ occurrences; Total count: Total Count

% Category — In-Situ occurrences; Category %: % Category

AL
FU
AC
ALBO
MP
SP
DC

Depth	Samples
450m	436.0
500m	498.5
550m	545.0
570.0	570.0
600m	608.0
	623.0
	632.5
	635.5
650m	
700m	
750m	751.0

Well Name : KOROIT WEST-1

Interval : 430m - 757m | **Palynological Data Chart**

Scale : 1:2000 | **% Abundance Histogram**

Chart date: 19 June 2003 | **Roger Morgan**

KOROIT WEST-1

Morgan Palaeo Associates
Maitland, South Australia

Enclosure 1

Sampling
- Cutting
- Core
- Sidewall core

Text Keys
*1 Late Eocene - Middle Eocene
*2 % within discipline (40mm=100%)
*3 In-Situ occurrences