CORE PALYNOLOGY OF DRIK DRIK-1, GLENAULIN-2 KALADBEO-2, PALAPARA-1, PRETTY HILL-1, WANGOOM-2, ONSHORE OTWAY BASIN, VICTORIA, AUSTRALIA

ROGER MORGAN

UNPUBLISHED REPORT 1994/13

MORGAN PALAEO ASSOCIATES
PALYNOLOGICAL/PETROLEUM GEOLOGICAL CONSULTANTS

POSTAL ADDRESS: Box 161, Maitland, South Australia 5573
DELIVERIES: 1 Shannon Tce, Maitland, South Australia 5573
Phone (088) 32 2795 Fax (088) 32 2798

CORE PALYNOLOGY OF DRIK DRIK-1, GLENAULIN-2, KALADBRO-2, PALPARA-1, PRETTY HILL-1, WANGOON-2, ONSHORE OTWAY BASIN, VICTORIA, AUSTRALIA

BY

ROGER MORGAN

for Victorian DME

June 1994

REF:OTW.RPDRIK

CORE PALYNOLOGY OF DRIK DRIK-1, GLENAULIN-2, KALADBRO-2, PALPARA-1, PRETTY HILL-1, WANGOON-2, ONSHORE OTWAY BASIN, VICTORIA, AUSTRALIA

BY

ROGER MORGAN

CONTENTS **PAGE**

I SUMMARY

Drik Drik-1 : 616-21m(CORE) : middle *senectus* Zone (uppermost *aceras* Dino Zone) : Campanian : marginally marine : usually Paaratte Formation (not Pebble Point)

Glenaulin-2 : 1091-97m(CORE) : lower *apoxyexinus* Zone : early Santonian : marginally marine : usually Flaxmans Formation or Belfast Mudstone

Kaladbro-2 : 1112-3m(CORE) : *distocarinatus* Zone (*infusorioides* Dino Zone) : Cenomanian : very nearshore marine : usually Flaxmans Formation or Waare Sandstone

Palpara-4 : 1126.8-32(CORE) : *longus* Zone (*druggii* Dino Zone) : Maastrichtian : marginally marine : usually topmost Paaratte Formation or Timboon Sandstone

Pretty Hill-1 : 726-32m(CORE) : upper *apoxyexinus* Zone : latest Santonian : usually lower Paaratte Formation or Belfast Mudstone : marginally marine

Wangoon-2 : 808-14m(CORE) : *longus* Zone (*druggii* Dino Zone) : Maastrichtian : nearshore marine : usually topmost Paaratte Formation or Timboon Sandstone.

II INTRODUCTION

Steve Ryan, Geologist from the Basin Studies Group of the Victorian Geological Survey, submitted 9 samples for palynology, to detect the presence or absence of condensed Late Cretaceous Sherbrook Group.

Palynomorph occurrence data are shown as Appendix I and form the basis for the assignment of the samples to zones of Cretaceous age. Specimen counts were made on all assemblages and expressed in the raw data as percentages.

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.

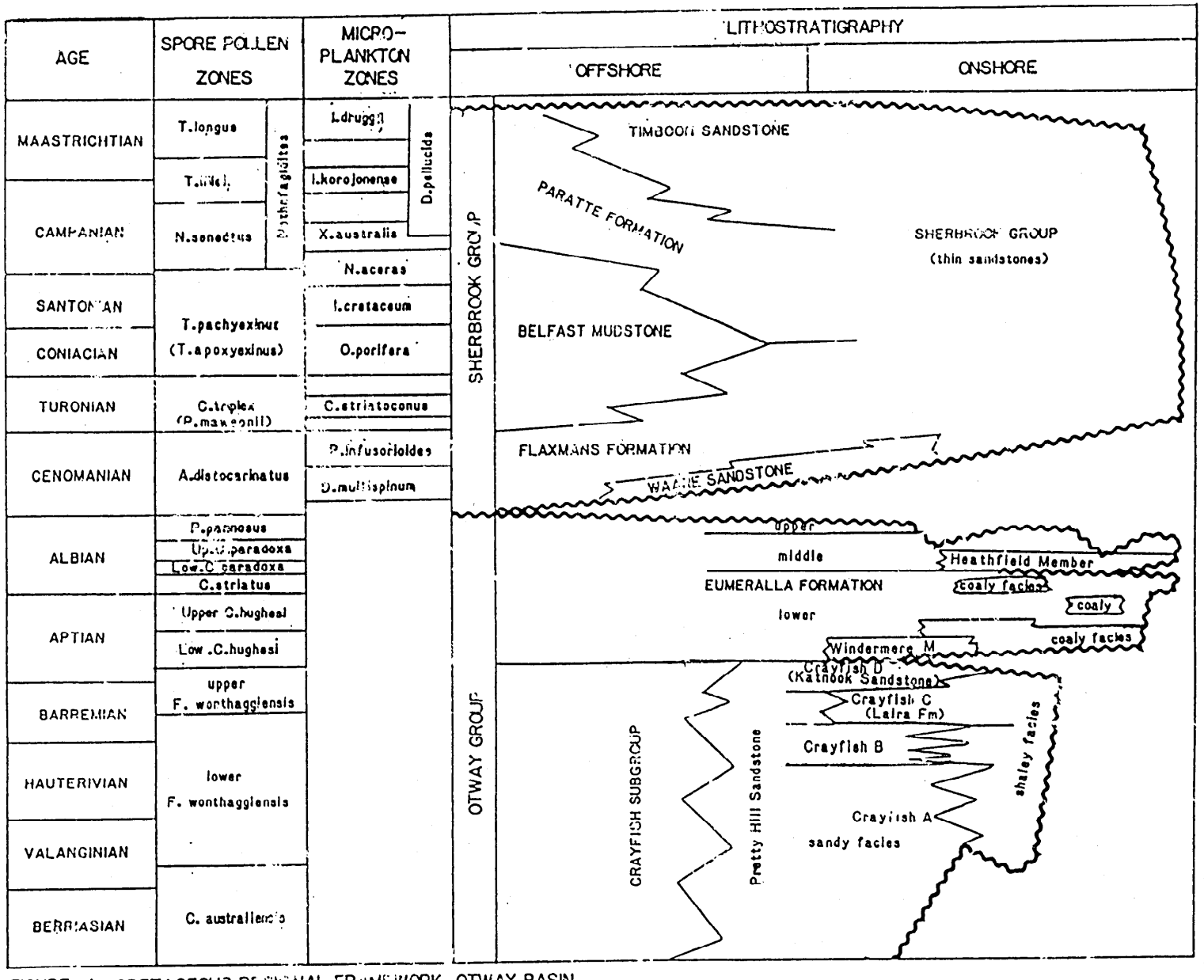

FIGURE 1. CRETACEOUS REGIONAL FRAMEWORK, OTWAY BASIN

III PALYNOSTRATIGRAPHY

A Drik Drik-1, 616-21m(CORE) : middle *senectus* Zone (uppermost *aceras* Dino Zone)

Assignment to the middle *Nothofagidites senectus* Zone of Campanian age is indicated at the top by the absence of younger markers, and at the base by oldest *Tricolpites sabulosus*. *Falcisporites similis* is common, with *Proteacidites* and *Microcachryidites* very frequent and *Australopollis obscurus*, *Cyathidites minor*, *Dilwynites granulatus*, *Nothofagidites senectus*, *Podosporites microsaccatus* and *Tricolpites sabulosus* frequent. Trace Permian reworking was seen.

Dinoflagellates are extremely scarce but the uppermost *Nelsoniella aceras* Dino Zone is indicated at the top by the spore pollen assignment with youngest *Nelsoniella semireticulata* and *N. aceras* and at the base by oldest *Xenikoon australis*.

Environments are marginally marine as shown by the very low dinoflagellate content (2%) and diversity. Spores and pollen are dominant and diverse and rare freshwater algae (*Botryococcus*) indicate minor lacustrine influence.

These features are normally seen in the Paaratte Formation or topmost Belfast Mudstone.

B Glenaulin-2, 1091-97m(CORE) : lower *apoxyexinus* Zone

Assignment to the lower *Tricolporites apoxyexinus* Zone of early Santonian age is indicated at the top by youngest very frequent *Amosopollis cruciformis*, and at the base by oldest very frequent *A. cruciformis* and the absence of older markers. *Falcisporites similis* and *Microcachryidites antarcticus* are common, with *Cyathidites*, *Podosporites minosaccatus* and *Phyllocladidites mawsonii* frequent.

Dinoflagellates are extremely scarce and not age diagnostic.

Environments are marginally marine as shown by the extremely rare dinoflagellates (<1%) and their very low diversity. Spores and pollen are abundant and diverse. Freshwater algae are rare.

These features are normally seen in the Flaxmans Formation or Belfast Mudstone.

C Kaladbro-2, 1112-3m(CORE) : *distocarinatus* Zone (*infusorioides* Dino Zone)

Assignment to the *Appendicisporites distocarinatus* Zone of Cenomanian age is indicated at the top by the absence of younger markers (and confirmed by the dinoflagellates) and at the base by oldest *A. distocarinatus* without older markers. Common are *Cyathidites*, *Dilwynites granulatus*, *Falcisporites similis* and *Microcachryidites*. Rare elements include *A. distocarinatus*, *A. tricornitatus*, *Coptospora pileosa* *Hoegisporis triradius* and *Phyllocladidites eunuchus*. Rare Permian reworking was seen.

Dinoflagellates are scarce but include the age diagnostic *Cribroperidinium edwardsii* and *Cyclonephelium membraniphorum*, indicating the *Palaeohystrichophora infusorioides* Dinoflagellate Zone.

Environments are very nearshore marine, as shown by the low dinoflagellate content (8%) and their moderate diversity. Freshwater algae (8% *Botryococcus*) suggest large freshwater lake influence. Spores and pollen are abundant and diverse. Overall, estaurine or coastal tidal lagoons seem likely.

These features are normally seen the the lower Flaxmans Formation or Waare Sandstone.

D Palpara-4, 1126-32m(CORE) : *longus* Zone (*druggii* Dino Zone)

Assignment to the *Tricolpites longus* Zone of Maastrichtian age is indicated at the top and base by youngest and oldest *T. longus* respectively. Coincident with the zone top are *Tricolpites waipawaensis*, *Tricolporites lillei* and *Triporopollenites sectilis*. Very common are *Gambierina rudata* and *Proteacidites* spp with frequent *Nothofagidites endurus*. Minor Permian reworking was seen.

Dinoflagellates are rare but include *Canninginopsis bretonica*, *Manumiella coronata* and *M. druggii*, indicating the *Manumiella druggii* Dinoflagellate Zone.

Marginally marine environments are indicated by the very rare (2%) dinoflagellates, their very low diversity, frequent freshwater algae (*Botryococcus*) and abundant and diverse spores and pollen.

These features are normally seen in the topmost Paaratte Formation or Timboon Sandstone.

E Pretty Hill-1, 726-32m(CORE) : upper *apoxyexinus* Zone

Assignment to the upper *Tricolporites apoxyexinus* Zone of latest Santonian age is indicated at the top by very rare *A. cruciformis* without younger markers, and at the base by the absence of older markers, and the frequency of *Proteacidites* spp (6%). Overall, *Falcisporites similis* is very common, with common *Cyathidites* and frequent *Dilwynites granulatus*, *Microcachryidites*, *Phyllocladidites mawsonii*, *Podosporites microsaccatus* and *Proteacidites*. Rare but distincitive are *A. cruciformis*, *Clavifera triplex* and *T. apoxyexinus*. Rare Permian reworking was seen.

Dinoflagellates are rare and not age diagnostic.

Marginally marine environments are indicated by the rare low diverstiy dinoflagellates, significant freshwater algae (3% *Botryococcus*) and the abundant and diverse spores and pollen.

These features are normally seen in the lower Paaratte Formation or Belfast Mudstone.

F Wangoon-2, 808-14m(CORE) : *longus* Zone (*druggii* Dino Zone)

Assignment to the *Tricolpites longus* Zone of Maastrichtian age is indicated at top by youngest *T. longus*, and at the base by oldest *T. longus* and *Tetracolporites verrucosus*. Consistent with the zone top are youngest *Tricolpites confessus* and *Triporopollenites sectilis*. Common is *F. similis* with frequent *Cyathidites*, *G. rudata*, *N. endurus*, *P. mawsonii* and *Proteacidites*. *G. rudata* (8%) outnumbers *N. endurus* (4%).

Dinoflagellates are subordinate but include *C. bretonica* and *M. druggii*, indicating the *Manumiella druggii* Dinoflagellate Zone. *Heterospiraeridium heteracanthum* is common, with other taxa rare.

Environments are nearshore marine with subordinate (23%) dinoflagellates of low to moderate diversity, minor freshwater algae (2%), and abundant and diverse spores and pollen.

These features are normally seen in the topmost Paaratte Formation or Timboon Sandstone.

IV CONCLUSIONS

All six samples are clearly Late Cretaceous Sherbrook Group. One (Kaladbro-2, 1112-3m) is from the base of the Group in Waare Sandstone or Flaxmans Formation equivalents (Ceromanian *distocarinatus* Zone). Two are from the mid sequence Belfast Mudstone correlatives (Santonian *apoxyexinus* Zone). One is from the upper part of the sequence in lower Paaratte Formation equivalents (Campanian *senectus* Zone). Two are from the very youngest Sherbrook Group from topmost Paaratte Formation or Timboon Sandstone equivalents (Maastrichtian *longus* Zone).

V REFERENCES

Dettmann ME and Playford G (1969) Palynology of the Australian Cretaceous : a review **In** Stratigraphy and Palaeontology. Essays in honour of Dorothy Hill, **KSW Campbell ED.** ANU Press, Canberra 174-210

Helby RJ, Morgan RP and Partridge AD (1987) A palynological zonation of the Australian Mesozoic **In** Studies in Australian Mesozoic Palynology **Assoc. Australas. Palaeontols. Mem 4** 1-94.

DRIK DRIK, GLENAULIN, KALADBRO, PALPARA, PRETTYHILL, WANGOON

MORGAN PALAEO ASSOCIATES
BOX 161, MAITLAND, SOUTH AUSTRLALIA, 5573
PHONE: (088) 322795 FAX: (088) 322798

CLIENT: VICTORIAN DEPT ENERGY AND MINERALS
WELL: DRIK DRIK#1, GLENAULIN#2, KALADBRO#2, PALPARA#1, PHILL#1, WANGN
FIELD / AREA: ONSHORE OTWAY BASIN, VICTORIA
SECTION: _____ TOWNSHIP: _____ RANGE: _____

KB ELEVATION: _____ TOTAL DEPTH: _____
ANALYST: ROGER MORGAN DATE : JULY 1994
NOTES: ALL DEPTHS IN METRES. ALL FIGURES ARE PERCENTAGES.
X MEANS THAT SPECIES IS VERY RARE AND OCCURRED OUTSIDE GRAIN COUNT.

RANGE CHART OF OCCURRENCES BY ALPHABETICAL LIST WITHIN GROUP

DRIK DRIK #1 0616-21 CORE	GLENAULIN #2 1091-97 CORE	K.LADBRO #2 1112-3 CORE	PALPARA #1 1126.8-52CORE	PRETTY HILL#1 0726-32 CORE	WANGOON #2 0808-14 CORE		
2.	1.	8.	4.	3.	2.	1	BOTRYOCOCCUS
.	.	X	.	.	.	2	ASCODINIUM PARVUM
.	.	.	.	.	1	3	AVELLODINIUM FALSIFICUM
.	.	.	.	.	.	4	CANNINGIA SP
.	.	.	X	.	2	5	CANNINGINOPSIS BRETONICA
.	.	.	.	X	.	6	CHATANGIELLA SVERDROPIANA
.	.	1	.	.	.	7	CIRCULODINIUM DEFLANDREI
.	X	.	.	.	.	8	CIRCULODINIUM SOLIDA
.	.	X	.	.	.	9	CRIBROPERIDINIUM EDWARDSII
.	.	1	.	.	.	10	CYCLONEPHELIUM MEMBRANIPHORUM
.	.	.	.	.	1	11	EXOCHOSPHAERIDIUM PHRAGMITES
X	.	1	.	4	16	12	HETEROSPHAERIDIUM HETEROCANTHUM
.	.	.	.	.	X	13	ISABELDINIUM DRUGGII
.	.	.	X	.	X	14	ISABELDINIUM PELLUCIDUM CF
.	.	.	1	.	.	15	MANUMIELLA CORONATA
.	.	.	1	.	2	16	MANUMIELLA DRUGGII
.	.	X	.	.	.	17	NELSONIELLA ACERAS
.	.	1	.	.	.	18	NELSONIELLA SEMIRETICULATA
.	.	X	.	X	.	19	NUMMUS SP
.	.	1	.	.	.	20	OLIGOSPHAERIDIUM COMPLEX
.	.	.	.	.	1	21	PALAEOHYSTRICHOSPHORA INFUSORIOIDES
.	1	.	.	.	.	22	SCHIZOSPORIS PARVUS
X	.	3	.	1	X	23	SPINIFERITES FURCATUS RAMOSUS
.	.	X	.	.	.	24	XENASCUS CERATOIDESS
.	.	.	.	.	X	25	XENIKOON AUSTRALIS
.	.	.	.	X	.	26	AEQUITRIRADITES SP. A
.	.	.	.	X	.	27	AEQUITRIRADITES TILCHAENESIS
X	8.	X	.	X	2.	28	AMOSOPOLLIS CRUCIFORMIS
.	.	X	.	.	.	29	APPENDICISPORITES DISTOCARINATUS
.	.	X	.	.	.	30	APPENDICISPORITES TRICORNITATUS
1.	1.	2.	.	1.	1.	31	ARAUCARIACITES AUSTRALIS
2.	1.	3.	1.	2.	4.	32	AUSTRALOPOLLIS OBSCURIS
.	1	.	.	1	.	33	CALLIALASPORITES DAMPIERI
.	.	.	2	X	.	34	CANEROZONOSPORITES OHAIENSIS
2.	.	1.	.	3.	3.	35	CERATOSPORITES EQUALIS
.	.	1	.	.	.	36	CHLAMYDOPHORELLA NYEI
.	.	.	.	1	X	37	CINGUTRILETES CLAVUS
.	X	1	.	.	1	38	CLAVIFERA TRIPLEX

	DRIK DRIK #1	0616-21 CORE	GLENAULIN #2	1091-97 CORE	KALADBRO #2	1112-3 CORE	PALPARA #1	1126.8-52CORE	PRETTY HILL#1	0726-32 CORE	WANGOON #2	0308-14 CORE		
39	.	.	.	.	.	X	X	.	.	.	.	.		COPTOSPORA PILEOSA
40	.	1	.	.	.	X	X	.	.	1	.	.		COROLLINA TOROSUS
41	.	1	5	.	.	5	2	.	2	2	.	2		CYATHIDITES AUSTRALIS
42	.	5	.	13	.	15	2	.	8	12	.	10		CYATHIDITES MINOR
43	.	.	.	.	.	.	.	.	.	1	.	.		CYCADOPITES FOLLICULARIS
44	.	.	.	.	.	.	.	X	.	.	.	.		CYCLOSPORITES HUGHESI
45	.	5	.	3	.	13	.	.	.	5	.	1		DILWYNITES GRANULATUS
46	.	.	.	1	.	.	.	.	.	.	.	.		DILWYNITES TUBERCULATUS
47	.	.	.	.	.	.	.	X	.	.	.	.		ERICIPITES "VERRUCATUS"
48	.	.	.	.	.	.	.	.	.	.	.	X		ERICIPITES SCABRATUS
49	.	2	.	4	.	1	.	1	.	3	.	1		FALCISPORITES GRANDIS
50	.	21	1	25	.	13	.	1	.	25	.	14		FALCISPORITES SIMILIS
51	.	1	.	.	.	.	.	.	.	1	.	.		FORAMINISPORIS DAILYI
52	.	.	.	.	.	.	.	21	.	.	.	8		GAMBIERINA RUDATA
53	.	.	.	.	.	.	.	1	.	.	.	.		GEPHYRAPOLLENITES WAHOOENSIS
54	.	2	.	1	.	4	.	1	.	3	.	2		GLEICHENIIDITES
55	.	.	.	.	.	X	.	4	.	.	.	.		HOEGISPORIS TRIRADIS
56	.	1	.	.	.	2	.	2	.	.	.	2		LAEVIGATOSPORITES OVATUS
57	.	X	.	.	.	.	.	1	.	X	.	.		LEPTOLEPIDITES VERRUCATUS
58	.	.	.	.	.	X	.	.	.	.	.	.		LILIACIDITES KAITANGATAENSIS
59	.	.	.	.	.	.	.	2	.	.	.	.		LYCOSTIPOLLENITES BALMEI
60	.	8	.	18	.	10	.	2	.	5	.	1		MICROCACHRYIDITES ANTARCTICUS
61	.	1	5	.	.	.	.	5	.	.	.	4		NOTHOFAGIDITES ENDURUS
62	.	5	1	.	.	.	.	1	.	.	.	.		NOTHOFAGIDITES SENECTUS
63	.	2	.	1	.	3	.	1	.	3	.	3		OSMUNDACIDITES WELLMANII
64	.	1	.	.	.	.	.	.	.	.	.	.		PEROTRILETES JUBATUS MORGANII
65	.	.	.	.	.	1	.	.	.	.	.	.		PEROTRILETES MAJUS
66	.	.	.	1	.	.	.	.	.	.	.	2		PHIMOPOLLENITES PANNOSUS
67	.	.	.	1	.	.	.	.	.	.	.	.		PHYLLOCLADIDITES EUNUCHUS
68	.	4	6	.	.	.	3	.	6	.	5	.		PHYLLOCLADIDITES MAWSONII
69	.	5	8	.	.	4	.	.	5	6	3	.		PODOSPORITES MICROSACCATUS
70	.	8	.	.	.	.	22	.	6	.	8	.		PROTEACIDITES
71	.	.	2	.	.	.	2	.	.	.	X	.		PROTEACIDITES MAPUKUI
72	.	1	2	.	.	.	2	X	.	.	.	.		PROTEACIDITES LARGE
73	.	.	1	.	.	.	1	.	.	.	X	.		PROTEACIDITES PALISADUS
74	.	2	1	2	.	2	3	.	2	.	2	.		RETITRILETES AUSTROCLAVATIDITES
75	.	1	2	.	.	X	X	4	.	2	.	.		REWORKING - PERMIAN
76	.	2	.	2	.	.	X	.	X	.	X	.		STERIESPORITES ANTIQUASPORITES

	DRIK DRIK #1	0616-21 CORE	GLENAULIN #2	1091-97 CORE	KALADBRO #2	1112-3 CORE	PALPARA #1	1126.8-52CORE	PRETTY HILL#1	0726-32 CORE	WANGOON #2	0808-14 CORE
77 TETRACOLPORITES VERRUCOSUS	.	.	.	.	.	.	.	.	.	.	.	X
78 TRICOLPITES CONFESSUS	.	.	.	.	.	.	.	.	.	3	.	X
79 TRICOLPITES LONGUS	.	.	.	.	.	.	.	2	.	.	.	1
80 TRICOLPITES SABULOSUS	.	5	.	.	.	.	.	.	.	.	.	.
81 TRICOLPITES WAIPAWAENSIS	.	.	.	.	.	.	.	1	.	.	.	.
82 TRICOLPORITES APOXYEXINUS	.	.	.	.	.	.	.	.	.	X	.	.
83 TRICOLPORITES LILLIEI	.	.	.	.	.	.	.	X	.	.	.	.
84 TRIPOROLETES RETICULATUS	.	.	.	.	.	X	.	.	.	.	.	.
85 TRIPOROPOLLENITES SECTILIS	.	.	.	.	.	.	.	2	.	.	.	1
86 VITREISPORITES PALLIDUS	.	2	.	.	.	2	.	.	.	2	.	.

DRIK DRIK #1
0616-21 CORE
GLENAULIN #2
1091-97 CORE
KALADBRO #2
1112-3 CORE
PALFARA #1
1126.8-52CORE
PRETTY HILL#1
0726-32 CORE
WANGOON #2
0808-14 CORE

SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
26	AEQUITRIRADITES SP. A
27	AEQUITRIRADITES TILCHAENESIS
28	AMOSOPOLLIS CRUCIFORMIS
29	APPENDICISPORITES DISTOCARINATUS
30	APPENDICISPORITES TRICORNITATUS
31	ARAUCARIACITES AUSTRALIS
2	ASCODINIUM PARVUM
32	AUSTRALOPOLLIS OBSCURIS
3	AVELLODINIUM FALSIFICUM
1	BOTRYOCOCCUS
33	CALLIALASPORITES DAMPIERI
34	CAMEROZONOSPORITES OHAIENSIS
4	CANNINGIA SP
5	CANNINGINOPSIS BRETONICA
35	CERATOSPORITES EQUALIS
6	CHATANGIELLA SVERDROPIANA
36	CHLAMYDOPHORELLA NYEI
37	CINGUTRILETES CLAVUS
7	CIRCULODINIUM DEFLANDREI
8	CIRCULODINIUM SOLIDA
38	CLAVIFERA TRIPLEX
39	COPTOSPORA PILEOSA
40	COROLLINA TOROSUS
9	CRIBROPERIDINIUM EDWARDSII
41	CYATHIDITES AUSTRALIS
42	CYATHIDITES MINOR
43	CYCADOPITES FOLLICULARIS
10	CYCLONEPHELIUM MEMBRANIPHORUM
44	CYCLOSPORITES HUGHESI
45	DILWYNITES GRANULATUS
46	DILWYNITES TUBERCULATUS
47	ERICIPITES "VERRUCATUS"
48	ERICIPITES SCABRATUS
11	EXOCHOSPHAERIDIUM PHRAGMITES
49	FALCISPORITES GRANDIS
50	FALCISPORITES SIMILIS
51	FORAMINISPORIS DAILYI
52	GAMBIERINA RUDATA
53	GEPHYRAPOLLENITES WAHOOENSIS
54	GLEICHENIIDITES
12	HETEROSPHAERIDIUM HETEROCANTHUM
55	HOEGISPORIS TRIRADIS
13	ISABELDINIUM DRUGGII
14	ISABELDINIUM PELLUCIDUM CF
56	LAEVIGATOSPORITES OVATUS
57	LEPTOLEPIDITES VERRUCATUS
58	LILIACIDITES KAITANGATAENSIS
59	LYGISTIPOLLENITES BALMEI
15	MANUMIELLA CORONATA
16	MANUMIELLA DRUGGII
60	MICROCACHRYIDITES ANTARCTICUS
17	NELSONIELLA ACERAS
18	NELSONIELLA SEMIRETICULATA
61	NOTHOFAGIDITES ENDURUS
62	NOTHOFAGIDITES SENECTUS
19	NUMMUS SP
20	OLIGOSPHAERIDIUM COMPLEX
63	OSMUNDACIDITES WELLMANII
21	PALAEOHYSTRICHOSPHORA INFUSORIOIDES
64	PEROTRILETES JUDATUS/MORGANII
65	PEROTRILETES MAJUS
66	PHIMOPOLLENITES PANNOSUS
67	PHYLLOCLADIDITES EUNUCHUS
68	PHYLLOCLADIDITES MAWSONII
69	PODOSPORITES MICROSACCATUS
70	PROTEACIDITES
71	PROTEACIDITES HAPUKUI
72	PROTEACIDITES LARGE
73	PROTEACIDITES PALISADUS
74	RETITRILETES AUSTROCLAVATIDITES
75	REWORKING - PERMIAN
22	SCHIZOSPORIS PARVUS
23	SPINIFERITES FURCATUS/RAMOSUS
76	STERIESPORITES ANTIQUASPORITES
77	TETRACOLPORITES VERRUCOSUS
78	TRICOLPITES CONFESSUS
79	TRICOLPITES LONGUS
80	TRICOLPITES SABULOSUS
81	TRICOLPITES WAIPAWAENSIS
82	TRICOLPORITES APOXYEXINUS
83	TRICOLPORITES LILLIEI
84	TRIPOROLETES RETICULATUS
85	TRIPOROPOLLENITES SECTILIS
86	VITREISPORITES PALLIDUS
24	XENASCUS CERATOIDES?
25	XENIKOON AUSTRALIS