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BIOSTRATIGRAPHIC ZONATION

GULF-IMPERIAL-SHELL TITALIK K-26

69° 05' 30" N. LAT., 135°06' 15" W. LONG.
NORTHWEST TERRITORIES

AUSTIN & CUMMING EXPLORATION CONSULTANTS
CALGARY, ALBERTA

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BIOSTRATIGRAPHIC ZONATION
GULF-IMPERIAL-SHELL TITALIK K-26

SUMMARY AND CONCLUSIONS

Biostratigraphy on Gulf-Imperial-Shell Titalik K-26 consists of palynostratigraphy and zonation by Dr. Geoffrey Norris and micropaleontological analysis by Dr. W. Braun.

One hundred and forty two prepared palynology slides, provided by Imperial Oil Limited and 82 slides obtained from the operator of the well, Gulf Oil Canada Limited, were examined in detail. In addition, Austin & Cumming had prepared palynology and micropaleontology slides from samples of conventional cores in the intervals 4830-4850 and 9046-9064 feet. Samples taken at 50 foot intervals from well cuttings provided by the Geological Survey of Canada were insufficient to conduct a useful investigation. Palynology and micropaleontology slides were prepared from the available material.

A continuous zonation based on microflora provides 8 recognizable zones (TI-1 to TI-8) ranging in age from Lower Paleogene at 12,580 feet (T.D.) to Quaternary at the surface. A continuous micropaleontological zonation could not be achieved because of barren intervals. However, 3 distinct microfaunal assemblages were identified, and are used in support of the palynological zonation and to assist in correlation between wells.

A zonation summary is as follows.

Summary of Zonation

<u>Age</u>	<u>Interval</u>	<u>Zonation</u>	
		<u>Palynology</u>	<u>Micropaleontology</u>
Quaternary	0'- 780'	Zone TI-1 (120-780')	Assemblage II (600-1,000')
Upper Neogene	780'- 1,762'	Zone TI-2 (900-1760')	
Middle Eocene-Older Paleogene	1762'-12,582'	Zone TI-3 (1820-2720') Zone TI-4 (2720-2840') Zone TI-5 (2960-5815') Zone TI-6 (5840-8500') Zone TI-7 (8570-11,408') Zone TI-8 (11,534-12,580')	Haplophragmoides Fauna (4450-6200') Cyclamina 70 Fauna (8340-8860') Cyclamina 71 Fauna (8860-10,200')

TOTAL DEPTH: 12,582'

PALYNOSTRATIGRAPHIC STUDY

BY

DR. GEOFFREY NORRIS

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PALYNOSTRATIGRAPHY
GULF-IMPERIAL-SHELL TITALIK K-26
BY
GEOFFREY NORRIS, PH.D.

INTRODUCTION

This report is the result of palynologic analysis of material supplied by Austin and Cumming Exploration Consultants, Calgary, on the Gulf-Imperial-Shell Titalik K-26 well drilled through putative Cenozoic sediments in the Mackenzie Delta region.

The objectives of the study are to establish a palynologic zonation to facilitate correlation between other wells in the region; to report on environments of deposition and paleoecology of the assemblages where possible; and to determine age relationships of the flora.

Emphasis will be placed on the local palynologic succession in each well, and a zonation will be established principally on the tops of ranges of species (successive disappearance zones of Vella). Palynofloral abundance data are notoriously variable and poorly understood - in part due to their dependence on sedimentation patterns - and impossible to assess meaningfully, other than in a general way, from cuttings samples. Staplin *et al.* (1975) have illustrated selected abundance curves of Neogene and Paleogene miospores from the Delta. Their data suggest a dominance of fungal spores in the lower Paleogene, a rise to dominance of monolete spores and fir pollen over other coniferous pollen in the upper Paleogene, and a change in abundance of bisaccate pollen and other types in the Neogene.

Although this method may have possibilities for crude stratigraphic correlation in the absence of index fossils, it requires heavy investment in time, personnel, statistical methods, and computer hardware and software. All are beyond the resources and time available for the present study. Consequently more effort has been expended in careful taxonomic study and identification of the material and comparative biostratigraphy amongst the wells to achieve a chronostratigraphic zonation based on species of restricted range and often of low abundance. This method is apparently used successfully by several companies operating in the Delta area (Staplin *et al.*, 1975).

Palynologic species are designated by either a published Latin binomial or by a generic name and number, e.g., *Taxodiaceaepollenites hiatus*, *Ulmus-1*, *Tricolporopollenites-3*, *Diconodinium-5*. In addition, these names are prefixed by a unique number for convenience of plotting data on paleo-logs, e.g., 1, 320, 373, and M219 respectively for the preceding species. All species are terrestrial spores and pollen except those with a unique number prefixed "M" to indicate microplankton (mostly marine dinoflagellates and acritarchs). A full numerical listing of unique numbers and their corresponding species names is provided in the Appendix. This is a comprehensive list comprising many Mesozoic-Cenozoic palynomorphs common in eastern, western, and arctic Canada. Not all will be referred to in this report.

SUMMARY

One hundred and forty-two samples from the subject well yielded 54 terrestrial and 3 marine palynomorph species as indicated on the accompanying chart. Zones, ages, and environments are summarized in the accompanying figure. (Table 1).

Two Neogene and 6 Paleogene zones are recognized. Upper Neogene is separated by a marked break from Lower Paleogene. The entire section is non-marine except for rare horizons containing possibly indigenous marine plankton in very low abundances. Organic maturation progresses from light yellow at the top of the well to black-brown at T.D., with a maturation reversal occurring at 8,270 feet.

ZONATION

Zone TI-1 (120-780 feet).

Reworked Carboniferous and Cretaceous material is common in this zone which is characterized by the presence of:

- 1 *Stereisporites antiquasporites*
- 2 *Taxodiaceae pollenites hiatus*

Some or all of the above species may also be reworked.

Zone TI-2 (900-1760 feet).

The following species occur in this zone:

- 34 *Laevigatosporites ovatus*
- 324 *Carpinus subtriangula*
- 395 *Corylus-1*
- 407 *Laevigatosporites-1*
- 326 *Pinus-1*

Several other temperate species occur sporadically and may be re-worked from older Tertiary:

- 282 *Caryapollenites paleocenicus*
- 323 *Pterocarya levis*
- 399 *Castanea-1*
- 287 *Alnipollenites-1*
- 370 *Tiliapollenites-1*
- 378 *Pluricellaesporites-1*
- 220 *Betulaceoipollenites-1*

GULF-IMPERIAL-SHELL TITALIK K-26

DEPTH	ZONES (PALYNOLOGY)	ENVIRONMENT	AGE
2000'	TI-1 780'	TERRESTRIAL (SOME POSSIBLE VERY RESTRICTED MARINE HORIZONS AT 7350', 8500', & 10,660')	QUATERNARY
	TI-2 1760'		UPPER NEOGENE
	TI-3 2720'		
	TI-4 2840'		MIDDLE
	TI-5 5815'		EOCENE
	TI-6 8500'		TO
	TI-7 11,408'		OLDER
	TI-8 T 12,582'		PALEOGENE
			LOWER PALEOCENE

TABLE 1

Zone TI-3 (1820-2720 feet).

The following species occur sporadically in Zone TI-3:

- 320 *Ulmus*-1
- 389 *Nyssapollenites*-1
- 392 *Granatisporites cotalis*
- 541 *Symplocoipollenites*-1
- 544 *Sapotaceae*-2
- 374 *Granatisporites*-1
- 22 *Cyathidites minor*
- 528 *Fusiformisporites*-1
- 539 *Acnepollis*-1
- 533 *Pluricellaesporites*-1
- 400 *Pesavis tagluensis*
- 552 *Stephanocolporopollenites*-1
- 284 *Cupuliferaepollenites*-1
- 411 *Abies*-1

Zone TI-4 (2840 feet).

A narrow zone characterized by 546 *Punctodiporites*-1.

Zone TI-5 (2960-5815 feet).

Several long-ranging species occur in this zone but the following are characteristic species and occur in restricted intervals in other wells:

- 549 *Pluricellaesporites*-3
- 391 *Striadiporites sanctaebarbarae*
- 362 *epiphyllous fungi*
- 325 *Aquilapollenites* cf. *reticulatus*
- 239 *Sequoiapollenites paleocenicus*
- 405 *Cicatricosisporites intersectus*
- 532 *Ctenosporites eskerensis*

Zone TI-6 (5840-8500 feet).

The following sporadic species define this zone:

- 553 *Pulcheripollenites* cf. *krempii*
- 369 *Cranwellia striata*
- 554 *Pesavis simplex*
- 555 *Ctenosporites wolfei*

374 *Granatisporites*-1 is also a common fungal spore in this zone although it ranges higher.

Zone TI-7 (8570-11,408 feet).

556 *Pesavis*-1 is restricted to this zone (and lower horizons).

5 *Alisporites bilaterlais* is a common but long-ranging element in this zone.

Zone TI-8 (11,534-12,580 feet).

This zone is characterized by a single occurrence of 522 *Leptolepidites cf. tenuis* in core, but about a dozen longer-ranging species also occur in this zone (in core also):

- 1 *Stereisporites antiquasporites*
- 2 *Taxodiaceaepollenites hiatus*
- 34 *Laevigatosporites ovatus*
- 378 *Pluricellaesporites-1*
- 22 *Cyathidites minor*
- 533 *Pluricellaesporites-2*
- 13 *Alisporites grandis*
- 7 *Gleicheniidites senonicus*
- 26 *Vitreisporites pallidus*
- 556 *Pesavis-1*

PALEOENVIRONMENTS

Reworked Cretaceous microplankton occurs throughout this well but the only possible indigenous acritarchs occur in Zone TI-6 and TI-7 as indicated on the chart. Even these two species, represented by single specimens in each sample, may be reworked.

Thus, the entire interval examined is non-marine, possibly coastal plain sediments being represented in TI-6 and TI-7 if the acritarchs mentioned above are truly indigenous.

AGE AND CORRELATION

TI-1:

Extremely impoverished assemblages and the presence of common reworked material in this interval suggests a Quaternary age for Zone TI-1.

TI-2:

The presence of 407 *Laevigatosporites-1* indicates a correlation with AD-1 and NT-1 and a Neogene age.

TI-3:

The following significant species in this zone are restricted to AD-6 or lower, suggesting a correlation with this lower Paleogene zone:

- 389 *Nyssapollenites-1*
- 392 *Granatisporites cotalis* (perhaps recycled in higher horizons in other wells)
- 541 *Symplocoipollenites-1*
- 544 *Sapotaceae-2*
- 539 *Acnepollis-1*
- 533 *Pluricellaesporites-1* (also in lower part of AD-5)
- 400 *Pesavis tagluensis* (also in lower part of AD-5)

A few species in this interval occur in lower zones as indicated:

- 528 *Fusiformisporites*-1 (AD-7, possibly reworked to AD-5)
552 *Stephanocolporopollenites*-1 (AD-8)

Other components of this zone are long-ranging types. The balance of evidence favours a correlation with AD-6.

TI-4:

The presence of 546 *Punctodiporites*-1 indicates a correlation with AD-7.

TI-5:

The following species of restricted range suggest a correlation with AD-8:

- 549 *Pluricellaesporites*-1
391 *Striadiporites sanctaebarbarae* (occurs higher in other wells)
13 *Alisporites grandis*
532 *Ctenosporites eskerensis*

TI-6:

The presence of 555 *Ctenosporites wolfei* in core from this interval suggests a middle or late Eocene age. This species occurs in the Eocene Kulthieth Formation of Alaska and the Middle Eocene of British Columbia (Elsik and Jansonius, 1974).

553 *Pulcheripollenites* cf. *krempii* and 369 *Cranwellia striata* are similar to Campanian-Maestrichtian species but possibly represent the tops of their ranges in the Paleogene. The latter species occurs elsewhere up to AD-6.

TI-7:

556 *Pesavis*-1 has been illustrated by Elsik and Jansonius (1974, Pl. 1, fig. 10 and possibly fig. 11) as "immature" specimens of *Pesavis tagluensis*. These specimens occur at 8,056 feet and 8,075 feet in IOE Taglu G-33 which on other evidence they bracket in the Paleocene-Eocene interval.

TI-8:

The presence of 522 *Leptolepidites* cf. *tenuis* suggests a correlation with KP-3 which is believed to be lower Paleocene.

556 *Pesavis*-1 continues its range down in core in this zone, indicating no hiatus between TI-7 and TI-8.

REFERENCES

- Elsik, W.C. and Jansonius, J., 1974. New genera of Paleogene fungal spores. Can. J. Bot., 52, 953-8.
- Hopkins, W.S., 1969. Palynology of the Eocene Kitsilano Formation, southwest British Columbia. Can. J. Bot., 47, 1101-31.
- Piel, K.M., 1971. Palynology of Oligocene sediments from central British Columbia. Can. J. Bot., 49, 1885-1920.
- Rouse, G.E. and Srivastava, S.K., 1970. Detailed morphology, taxonomy, and distribution of *Pistillipollenites mcgregorii*. Can. J. Bot., 48, 287-92.
- Staplin, F.L. et al., 1975. Tertiary biostratigraphy, Mackenzie Delta region, Canada. Text of a talk presented in Calgary.

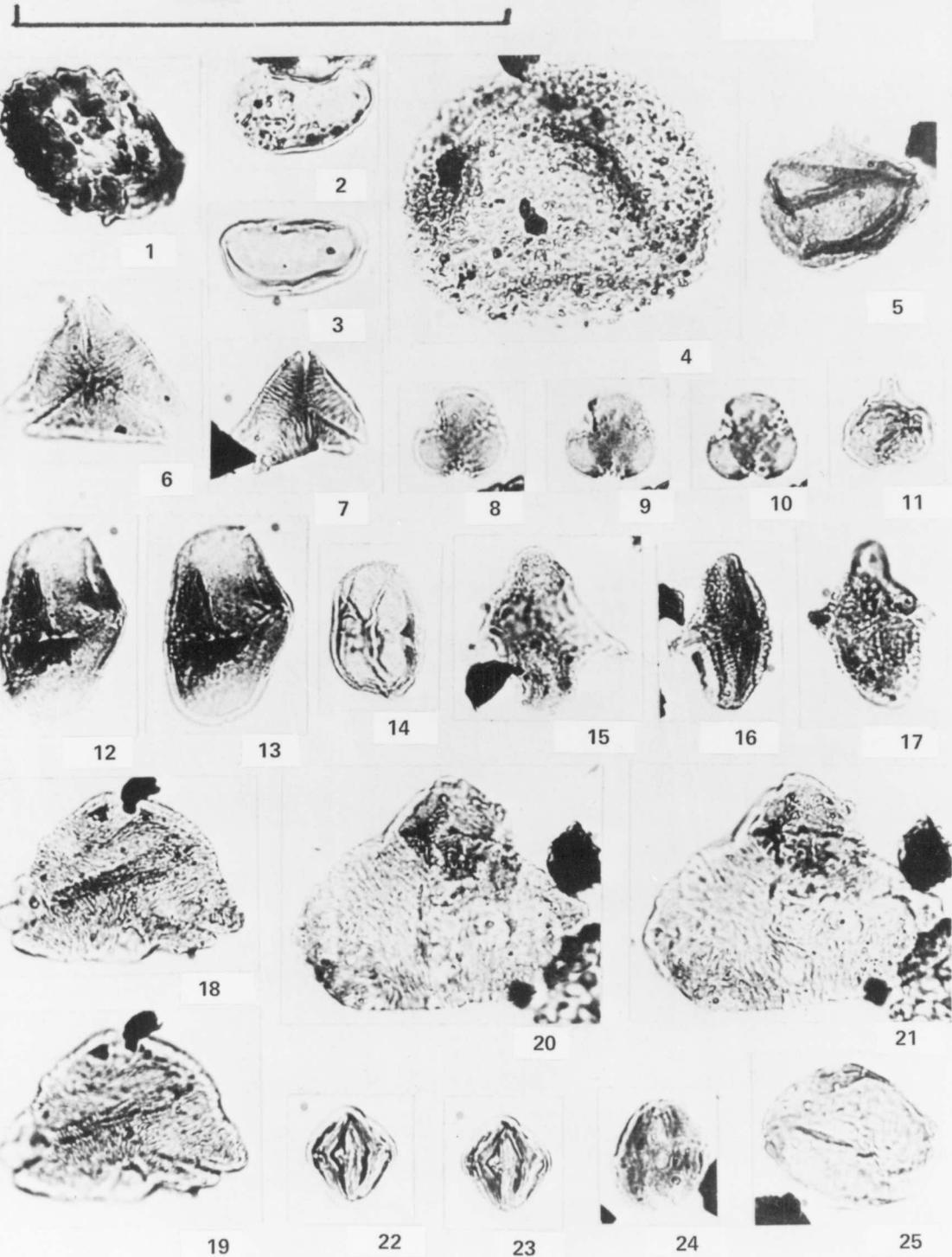
EXPLANATION OF PLATE #1GULF-IMPERIAL-SHELL TITALIK K-26

All figures approximately 750x. Scale in top left is 100 um.
All species new to this study are illustrated, togehter with some others
that require re-illustration.

PLATE 1

- | | | |
|--------|-----|---|
| 1. | 522 | <i>Leptolepidites</i> cf. <i>tenuis</i> |
| 2-3. | 407 | <i>Laevigatosporites</i> 1 |
| 4. | 371 | <i>Tsuga</i> 1 |
| 5. | 239 | <i>Sequoia pollenites paleocenicus</i> |
| 6-7. | 369 | <i>Cranwellia striata</i> |
| 8-10. | 539 | <i>Acnepollis</i> 1 |
| 11. | 239 | <i>Sequoia pollenites paleocenicus</i> |
| 12-14. | 544 | <i>Sapotaceae</i> 2 |
| 15-17. | 325 | <i>Aquila pollenites</i> cf. <i>reticulatus</i> |
| 18-21. | 553 | <i>Pulcheripollenites</i> cf. <i>krempfi</i> |
| 22-24. | 552 | <i>Stephanocolporopollenites</i> 1 |
| 25. | 320 | <i>Ulmus</i> 1 |

GULF - IMP - SHELL TITALIK K-26



EXPLANATION OF PLATE #2

GULF-IMPERIAL-SHELL TITALIK K-26

All figures approximately 750x. Scale in top left is 100 um.
All species new to this study are illustrated, together with some others
that require re-illustration.

PLATE 2

- | | | |
|--------|-----|---------------------------------|
| 26-28. | 400 | <i>Pesavis tagluensis</i> |
| 29-36. | 556 | <i>Pesavis</i> 1 |
| 37. | 554 | <i>Pesavis simplex</i> |
| 38-39. | 532 | <i>Ctenosporites eskerensis</i> |
| 40. | 555 | <i>Ctenosporites wolfei</i> |
| 41. | 549 | <i>Pluricellaesporites</i> 3 |
| 42. | 392 | <i>Granatisporites cotalis</i> |
| 43-44. | 528 | <i>Fusiformisporites</i> 1 |
| 45. | 546 | <i>Punctodiporites</i> 1 |
| 46-48. | 533 | <i>Pluricellaesporites</i> 2 |

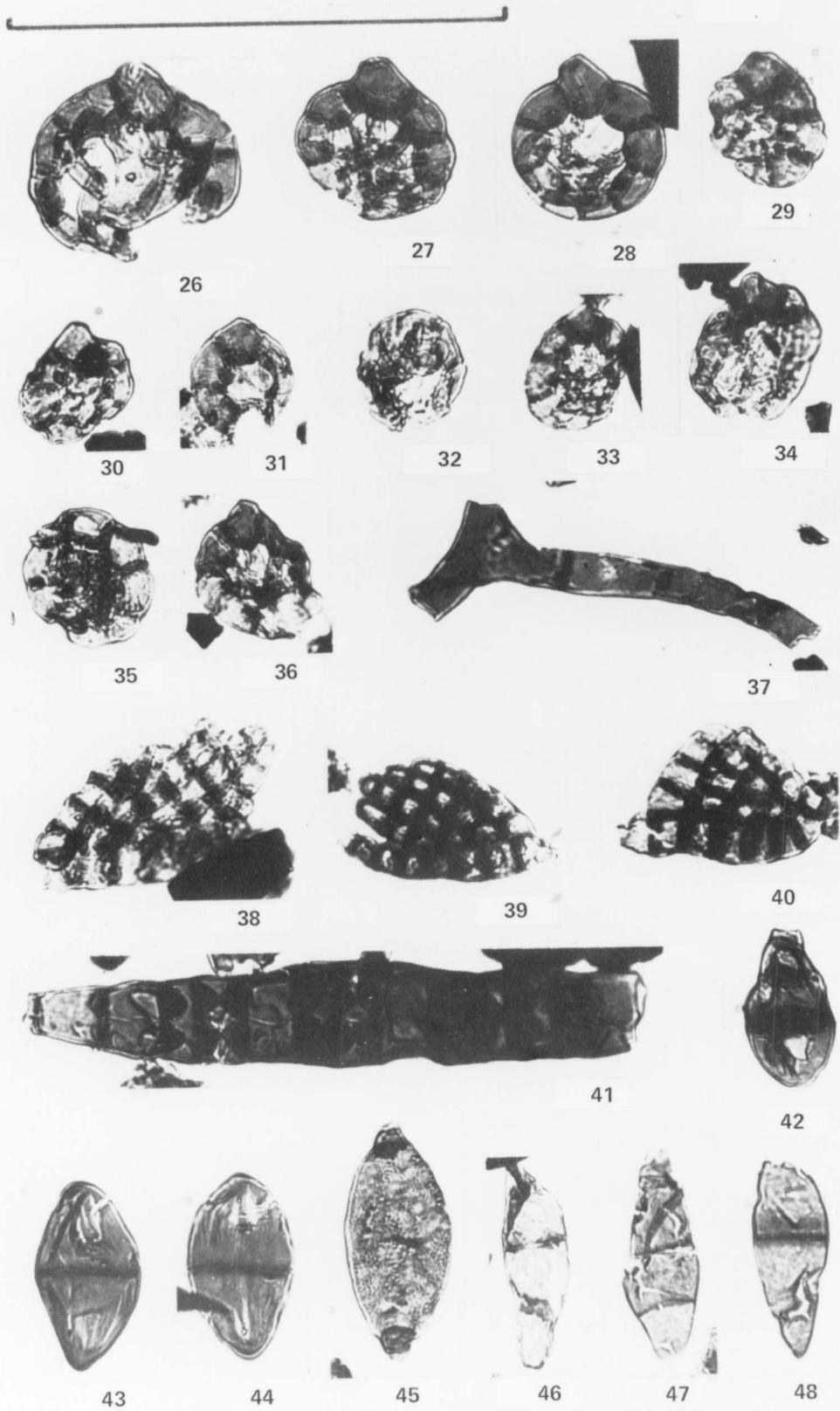


PLATE 2

FOSSIL APPENDIX

Numerical Listing of Unique Numbers
and Corresponding Palynomorph Species
Names Common in Eastern, Western, and
Arctic Canada.

Terrestrial palynomorphs

1. *Stereisporites antiquasporites* (Wilson and Webster) Dettmann
2. *Taxodiaceae pollenites Hiatus* (Potonie) Kremp
3. *Classopollis torosus* (Reissinger) Balme
4. *Cicatricosisporites hallei* Delcourt and Sprumont
5. *Alisporites bilaterialis* Rouse
6. *Cingutriletes clavus* (Balme) Dettmann
7. *Gleicheniidites senonicus* Ross
8. *Cedripites cretaceous* Pocock
9. *Cerebropollenites mesozoicus* (Couper) Nilsson
10. *Perinopollenites elatooides* Couper
11. *Concavissimisporites punctatus* (Delcourt and Sprumont) Brenner
12. Recycled Carboniferous-Devonian spores.
13. *Alisporites grandis* (Cookson) Dettmann
14. *Lycopodiumsporites marginatus* Singh
15. *Cicatricosisporites annulatus* Archangelski and Gamerro
16. *Deltoidospora hallei* Miner
17. *Cicatricosisporites cf. A. exilioides* (Maljavkina) Bolchovitina
18. *Tigrisporites scurrandus* Norris
19. *Osmundacidites wellmanii* Couper
20. *Cicatricosisporites australis* (Cookson) Potonie
21. *Cicatricosisporites hughesi* Dettmann
22. *Cyathidites minor* Couper
23. *Ginkgocycadophytus nitidus* (Balme) de Jersey
24. *Podocarpidites multisimus* (Bolchovitina) Pocock
25. Recycled Permo-Triassic pollen.
26. *Vitreisporites pallidus* (Reissinger) Potonie
27. *Ephedripites multicostatus* Brenner
28. *Neoraistrickia robusta* Brenner
29. *Cicatricosisporites augustus* Singh
30. *Phyllocladidites inchoatus* (Pierce) Norris
31. *Lycopodiumsporites austroclavatidites* (Cookson) Potonie
32. *Hymenozonotriletes cf. H. mesozoicus* Pocock
33. *Cyathidites australis* Couper
34. *Laevigatosporites ovatus* Wilson and Webster
35. *Cicatricosisporites pseudotripartitus* (Bolchovitina) Dettmann
36. *Lycopodiumsporites reticulumsporites* (Rouse) Dettmann
37. *Kuylisporites lunaris* Cookson and Dettmann
38. *Aequitriradites spinulosus* (Cookson and Dettmann) Cooks. and Dettmann
39. *Foraminisporis wonthaggiensis* (Cookson and Dettmann) Dettmann
40. *Sestrosporites pseudoalveolatus* (Couper) Dettmann
41. *Rouseisporites laevigatus* Pocock
42. *Araucariacites australis*
43. *Klukisporites pseudoreticulatus* Couper
44. *Polycingulatisporites reduncus* (Bolchovitina) Palyford and Dettmann
45. *Schizosporis parvus* Cookson and Dettmann
46. *Porvisaccites radiatus* Couper
47. *Classopollis minor* Pocock
48. *Circulina parva* Brenner
49. *Con verrucosisporites variverracatus* (Couper) Norris
50. *Coronatispora valdensis* (Couper) Dettmann

51. *Callialosporites* cf. *C. dampieri* (Balme) Dev
52. *Biretisporites potoniei* Delcourt and Sprumont
53. *Leptolepidites* cf. *L. psarosus* Norris
54. *Distaltriangulispores perplexus* (Singh) Singh
55. *Appendicisporites jansonii* Pocock
56. *Deltoidospora juncta* (Kara-Murza) Singh
57. *Trilobosporites* cf. *T. marylandensis* Brenner
58. *Trilobosporites trioreticulosus* Cookson and Dettmann
59. *Contignisporites multimuratus* Dettmann
60. *Rousesporites reticulatus* Pocock
61. *Eucommiidites troedssonii* Erdtman
62. *Exesipollenites tumulus* Balme
63. *Pilosisporites trichopapillosum* (Thiergart) Delcourt and Sprumont
64. *Tripartina* cf. *T. variabilis* Maljavkina
65. *Contignisporites glebulentus* Dettmann
66. *Trilobosporites* cf. *T. apiverrucatus* Couper
67. *Densoisporites microrugulatus* Brenner
68. *Concavissimisporites parkini* (Pocock) Singh
69. *Reticulispores* 1
70. *Contignisporites dorsostriatus* (Bolchovitina) Dettmann
71. *Todisporites major* Couper
72. *Callialasporites* 1
73. *Marattisporites scabrinatus* Couper
74. *Leptolepidites epacrornatus* Norris
75. *Perinopollenites* 1
76. *Cristatisporites* 1
77. *Contignisporites cooksoni* (Balme) Dettmann
78. *Podocarpidites* cf. *P. rousei* Pocock
79. *Antulsporites* 1
80. *Chasmatosprites* 1
81. *Ovalipollis canadensis* Pocock
82. *Dictyophyllidites harrisii* Couper
83. *Cirratriradites* cf. *Leiotriletes incertus* Bolchovitina
84. *Camarozonosporites* 1
85. *Acanthotriletes* 1
86. *Calamospora mesozoica* Couper
87. *Rubinella* 1
88. *Annulispores* 1
89. *Foraminisporis asymmetricus* (Cookson and Dettmann) Dettmann
90. *Protohaploxylinus chaloneri* Clarke
91. *Striatopodocarpidites* 1
92. *Alisporites* cf. *A. parvus* de Jersey
93. *Klausipollenites* 1
94. *Alisporites* 2
95. *Ovalipollis* 1
96. *Platysaccus* 1
97. *Taeniaesporites* 1
98. *Inaperturopollenites* 1
99. *Taeniaesporites novimundi* Jansonius
100. *Lueckisporites* 1
101. *Cordaitina* 1
102. *Protohaploxylinus* 2

- 103. *Cedripites* 2
- 104. *Cyclogranisporites* 1
- 105. *Lueckisporites* 2
- 106. *Guttulapollenites* 1
- 107. *Tsugaepollenites jonkeri* Jansonius
- 108. *Anaplanisporites* 1
- 109. *Cedripites* 1
- 110. *Sulcatisporites* cf. *S. institutus* Balme
- 111. *Stereisporites* 1
- 112. *Falcisporites nuthallensis* (Clarke) Balme
- 113. *Cycadopites follicularius* Wilson and Webster
- 114. *Densoisporites* cf. *D. nejburgi* (Schulz) Balme
- 115. *Protohaploxylinus samoilovitchi* (Jansonius) Hart
- 116. *Platysaccus* 2
- 117. *Taeniaesporites* 3
- 118. *Punctatisporites* 1
- 119. *Punctatosporites* cf. *P. minutus* Ibrahim
- 120. *Apiculatisporis* 1
- 121. *Alisporites* 3
- 122. *Illinites klausii* Clarke
- 123. *Taeniaesporites* cf. *T. labdacus* Klaus
- 124. *Taeniaesporites albertae* Jansonius
- 125. *Taeniaesporites hexagonalis* Jansonius
- 126. *Nevesisporites* 1
- 127. *Nevesisporites* 2
- 128. *Lundbladispora* 1
- 129. *Gnetaceaepollenites steevis* Jansonius
- 130. *Gnetaceaepollenites paenesaccatus* Jansonius
- 131. *Klausipollenites fastidiosus* Jansonius
- 132. *Kraueselisporites* 1
- 133. *Kraueselisporites* 2
- 134. *Raistrickia* 1
- 135. *Gnetaceaepollenites multistriatus* Jansonius
- 136. *Taeniaesporites* cf. *T. nubilis* (Leschik) Clarke
- 137. *Apiculatisporis* 2
- 138. *Grandispora* 1
- 139. *Gnetaceaepollenites scotti* Jansonius
- 140. *Schizosporis scissus* (Balme and Hennelly) Hart
- 141. *Taeniaesporites noviaulensis* Leschik
- 142. *Grandispora* 2
- 143. *Pretricolpypollenites* 1
- 144. *Ceratosporites* 1
- 145. *Lophotriletes* 1
- 146. *Endosporites* 1
- 147. *Aratrisporites* 1
- 148. *Endosporites* 2
- 149. *Striatites richteri* (Klaus) Jansonius
- 150. *Paravittatina* 1
- 151. *Pilosporites* 1
- 152. *Rugubivesiculites reductus* Pierce
- 153. *Camarozonosporites insignia* Norris
- 154. *Appendicisporites bilateralis* Singh

155. *Appendicisporites cristatus* (Markova) Pocock
 156. *Tricolpopollenites micromunus* Groot and Penny
 157. *Psilatricolpites parvulus* (Groot and Penny) Norris
 158. *Sequoia pollenites* sp.
 159. *Appendicisporites bifurcatus* Singh
 160. *Appendicisporites* cf. *jansonii* Pocock
 161. *Schizosporis grandis* Pocock
 162. *Penetetrapites mollis* Hedlund and Norris
 163. *Appendicisporites matesovai* (Bolchovitina) Norris
 164. *Cupuliferoipollenites minutus* (Brenner) Singh
 165. *Tricolpites sagax* Norris
 166. *Liliacidites dividuus* (Pierce) Brenner
 167. *Klukisporites foveolatus* Pocock
 168. *Costatoperforosporites foveolatus* Deak
 169. *Appendicisporites erdtmannii* Pocock
 170. *Schizosporis spriggi* Cookson and Dettmann
 171. *Rugubivesiculites rugosus* Pierce
 172. *Ornamentifera* cf. *echinata* (Bolchovitina) Bolchovitina
 173. *Todisporites minor* Couper
 174. *Foveotriletes subtriangularis* Brenner
 175. *Antulsporites distaverrucosus* (Brenner) Archangelsky and Gammero
 176. *Clavatipollenites minutus* Brenner
 177. *Cicatricosisporites* cf. *subrotundus* Brenner
 178. *Spheripollenites scabratus* Couper
 179. *Cicatricosisporites* cf. *hughesi* Dettmann
 180. *Trilobosporites marylandensis* Brenner
 181. *Cicatricosisporites subrotundus* Brenner
 182. *Cicatricosisporites potomacensis* Brenner
 183. *Baculatisporites comaumensis* (Cookson) Potonie
 184. *Appendicisporites tricornitatus* Weyland and Greifeld
 185. *Pilosporites verus* Delcourt and Sprumont
 186. *Appendicisporites potomacensis* Brenner
 187. *Acanthotriletes varispinosus* Pocock
 188. *Appendicisporites problematicus* (Burger) Singh
 189. *Cicatricosisporites* cf. *pseudotripartitus* (Bolch.) Dettmann
 190. *Appendicisporites* cf. *bilateralis* Singh
 191. *Trilobosporites* cf. *perverulentus* Dettmann
 192. *Pilosporites* cf. *trichopapillosum* (Thiergart) Del. and Sprumont
 193. *Contignisporites multimuratus* Dettmann
 194. *Contignisporites* cf. *multimuratus* Dettmann
 195. *Cicatricosisporites* cf. *australisensis* (Cookson) Potonie
 196. *Trilobosporites minor* Pockock
 197. *Deltoidospora psilostoma* Rouse
 198. *Sestrosporites* cf. *pseudoalveolatus* (Couper) Dettmann
 199. *Matonisporites phleopterooides* Couper
 200. *Callialasporites dampieri* (Balme) Sukh Dev
 201. *Trilobosporites apiverrucatus* Couper
 202. *Cicatricosisporites* cf. *potomacensis* Brenner
 203. *Taurocusporites segmentatus* Stover
 204. *Appendicisporites* cf. *A. macrorhiza* (Maljavična) Bolchovitina
 205. *Chomotriletes fragilis* Pocock
 206. *Cicatricosisporites purbeckensis* Norris

207. *Microreticulatisporites* cf. *uniformis* Singh
208. *Ischyosporites punctatus* Cookson and Dettmann
209. *Retitricolpites vulgaris* Pierce
210. *Reticulisperites elongatus* Singh
211. *Foveosporites canalis* Balme
212. *Striatopolis paraneus* (Norris) Singh
213. *Liliacidites textus* Norris
214. *Cirratriradites teter* Norris
215. *Lycopodiumsporites expansus* Singh
216. *Appendicisporites unicus* (Markova) Singh
217. *Quadrapolollenites* cf. *vagus* Stover
218. *Nyssapollenites albertensis* Singh
219. *Tricolpites fissilis* Couper
220. *Betulaceoipollenites* 1
221. *Proteacidites thalmanii* Anderson
222. *Liliacidites mirus* Srivastava
223. *Triorites inferius* Dutta and Sah
224. *Duplopollis carlquistii* Drugg
225. *Aquilapollenites calvus* Tschudy and Leopold
226. *Conclavipollis* 1
227. *Cicatricosisporites* cf. *ludbrookii* Dettmann
228. *Tricolporopollenites* 1
229. *Sigmopollis hispidus* Hedlund
230. *Neoraistrickia truncata* (Cookson) Potonie
231. *Loranthacites macrosolenoides* Mtchedlishvili
232. *Aquilapollenites trialatus* Rouse
233. *Aquilapollenites quadrilobus* Rouse
234. *Aquilapollenites catenireticulatus* Srivastava
235. *Ornamentifera baculata* Singh
236. *Schizosporis reticulatus* Cookson and Dettmann
237. *Syncolporites* cf. *lisamae* van der Hammen
238. *Aquilapollenites venustus* Srivastava
239. *Sequoiapollenites paleocenicus* Stanley
240. *Hazaria canadiana* Srivastava
241. *Triatriopollenites costatus* Norton
242. *Grewipollenites canadensis* Srivastava
243. *Proteacidites retusus* Anderson
244. *Foveotricolporites rhombohedralis* Pierce
245. *Sigmopollis* 1
246. *Aquilapollenites reductus* Norton
247. *Aquilapollenites attenuatus* Funkhouser
248. *Symplocoipollenites vestibulum* (Potonie) Potonie
249. *Aquilapollenites bertillonites* Funkhouser
250. *Foraminisporis* cf. *assymetricus* (Cookson and Dettmann) Dettmann
251. *Caryapollenites* cf. *veripites* Wilson and Webster
252. *Stereisporites australe* (Cookson)
253. *Cercidiphyllites brevicolpatus* Mtchedlishvili
254. *Tricolporopollenites* 2
255. *Zlivisporis* cf. *novamexicanum* (Anderson) Leffingwell
256. *Kuylisporites scutatus* Newman
257. *Aquilapollenites clarireticulatus* (Samoilovitch) Tschudy
258. *Aquilapollenites amygdalooides* Srivastava

259. *Umbosporites callosus* Newman
260. *Lusatiosporis dettmannae* Srivastava
261. *Aquilapollenites rigidus* Tschudy and Leopold
262. *Marcellopites basilicus* Srivastava
263. *Senipites drumhellerensis* Srivastava
264. *Liburnispiris adnacus* Srivastava
265. *Tricolpites reticulatus* Cookson
266. *Liliacidites morrinensis* Srivastava
267. *Tubulifloridites aedicula* Srivastava
268. *Cingulatisporites dakotaensis* Stanley
269. *Coriaripites cf. alienus* Srivastava
270. *Balmeisporites* 1
271. *Erdatmanipollis pachysandrodes* Krutzsch
272. *Kuylisporites* cf. *lunaris* Cookson and Dettmann
273. *Aquilapollenites turbidus* Tschudy and Leopold
274. *Faguspollenites granulatus* (Martin and Rouse) Srivastava
275. *Tetracolpites* 1
276. *Trudopollis meekeri* Newman
277. *Polyporina globosa* Sah
278. *Callistopollenites* 1
279. *Pulcheripollenites krempfi* Srivastava
280. *Symplocoipollenites morrinenses* Srivastava
281. *Proteacidites magnus* Samoilovitch
282. *Caryapollenites paleocenicus* (Stanley) Srivastava
283. *Triporopollenites* 1
284. *Cupuliferoidpollenites* 1
285. *Hazaria sheoperii* Srivastava
286. *Triporopollenites* 2
287. *Alnipollenites* 1
288. *Stereisporites regius* (Drozhastchich)
289. *Wodehousia spinata* Stanley
290. *Hamulatipollis* 1
291. *Tricolpites hians* Stanley
292. *Triporina globosa* Chlonova
293. *Triprojectus unicus* (Chlonova) Mtchedlishvili
294. *Syncolpites porosus* Mtchedlishvili
295. *Aquilapollenites senonicus* (Mtchedlishvili) Tschudy and Leopold
296. *Leiotriletes* 1
297. *Punctatisporites* 2
298. *Endosporites* 3
299. *Stenozonotriletes* 1
300. *Stenozonotriletes* 2
301. *Reticulatisporites* 1
302. *Densosporites* 1
303. *Cirratriradites* 1
304. *Inaperturopollenites* 2
305. *Stenozonotriletes* 3
306. *Hystricosporites* 1
307. *Acanthotriletes* 2
308. *Granulatisporites* 1
309. *Hymenozonotriletes* 1
310. *Calamospora* 1

- 311. *Retusotriletes* 1
- 312. *Perotrilites* 1
- 313. *Trilobosporites purverulentus* (Verbitskaya) Dettmann
- 314. *Cicatricosisporites spiralis* Singh
- 315. *Trilobosporites cf. obsitus* Norris
- 316. *Callialasporites trilobatus* (Balme)
- 317. *Trilobosporites cf. hannonicus* Delcourt and Sprumont
- 318. *Eucommiidites minor* Groot and Penny
- 319. *Fraxinoipollenites variabilis* Stanley
- 320. *Ulmus* 1
- 321. *Alnipollenites* 1
- 322. *Tilia danei* Anderson
- 323. *Pterocarya levis* Stanley
- 324. *Carpinus subtriangula* Stanley
- 325. *Aquilapollenites cf. reticulatus* Stanley
- 326. *Pinus* 1
- 327. *Podocarpus maximus* Stanley
- 328. *Ericipites* 1
- 329. *Pororeticulites* 1
- 330. *Pistillipollenites mcgregori* Rouse
- 331. *Triorites* 1
- 332. *Pediastrum* sp.
- 333. *Aquilapollenites spinulosus* Funkhouser
- 334. *Aquilapollenites cf. amygdalooides* Srivastava
- 335. *Costatoperforosporites fistulosus* Deak
- 336. *Cicatricosisporites auritus* Singh
- 337. *Rogalskisporites cicatricosus* (Rogalska) Danse, Corsin and Levin
- 338. *Foraminisporis daileyi*
- 339. *Taurocuspores cf. segmentatus*
- 340. *Januasporites spiniferus*
- 341. *Trilobosporites cf. minor*
- 342. *Hymenozonotriletes* 2
- 343. *Phyllocladidites* 1
- 344. *Cicatricosisporites annulatus*
- 345. *Couperisporites complexus*
- 346. *Cicatricosisporites angicanalis*
- 347. *Distalanulispores verrucosus*
- 348. *Podocarpidites arcticus*
- 349. *Pteruchipollenites microsaccus*
- 350. *Ceratosporites varispinosus*
- 351. *Circulina* 1
- 352. *Distalanulispores incertus*
- 353. *Corrugatisporites amplexiformis*
- 354. *Matthesisporites tumulosus*
- 355. *Staplinisporites jurassicus*
- 356. *Corrugatisporites anagrammensis*
- 357. *Concentrisporites pseudosulcatus*
- 358. *Apiculatisporites variabilis*
- 359. *Rhoipites pissinis*
- 360. *Alnus trina*
- 361. *Aquilapollenites cf. trialatus*
- 362. *Epiphyllous fungi fruiting body*

- 363. *Tricolpites parvus*
- 364. *Stephanoporites* 1
- 365. *Liliacidites leei* Anderson
- 366. *Rubinella major* (Couper) Norris
- 367. *Azolla* sp.
- 368. *Apilobium* 1
- 369. *Cranwellia striata*
- 370. *Tiliapollenites* 1
- 371. *Tsuga* 1
- 372. *Granatitricolpites* 1
- 373. *Tricolporopollenites* 3
- 374. *Granatisporites* 1
- 375. *Granatisporites* 2
- 376. *Triad* 1
- 377. *Ericaceae* 1
- 378. *Pluricellaesporites* 1
- 379. *Granatitricolpites* 2
- 380. *Tricolporopollenites* 4
- 381. *Psilatricolpites* 1
- 382. *Tricolporopollenites* 5
- 383. *Laricoidites* 1
- 384. *Retitricolpites* 1
- 385. *Rhoipites* 1
- 386. *Rhoipites* 2
- 387. *Tricolporopollenites* 6
- 388. *Tricolporopollenites* 7
- 389. *Nyssapollenites* 1
- 390. *Salix* 1
- 391. *Striadiporites sanctaebarbarae*
- 392. *Granatisporites cotalis*
- 393. *Tricolporopollenites* 8
- 394. *Corylus granilabrata*
- 395. *Corylus* 1
- 396. *Tiliapollenites* 2
- 397. *Tiliapollenites* 3
- 398. *Basopollis* 1
- 399. *Castanea* 1
- 400. *Pesavis tagluensis*
- 401. *Picea* 1
- 402. *Ginkgo* 1
- 403. *Aquilapollenites delicatus*
- 404. *Triprojectus* cf. *echinatus*
- 405. *Cicatricosisporites intersectus*
- 406. *Stephanocolpites* 1
- 407. *Laevigatosporites* 1
- 408. *Periporate* 1
- 409. *Stereisporites* 2
- 410. *Engelhardtia* 1
- 411. *Abies* 1
- 412. *Lycopodiumsporites* 1
- 413. *Stereisporites* 3
- 414. *Triatriopollenites* 1
- 415. *Aquilapollenites* cf. *murus* Stanley
- 416. *Osmundacidites* 1
- 417. *Contignisporites* cf. *fornicatus* Dettmann

- 418. *Polypodiisporites* 1
- 419. *tetrad* 1
- 420. *Laevigatosporites* 2
- 421. *Leptolepidites* 1
- 422. *Parviprojectus* 1
- 510. Recycled Cretaceous spores.
- 513. *Hamulatisporis* cf. *rugulatus* (Couper) Srivastava
- 518. *Trilobosporites* cf. *bernissartensis* (Delcourt and Sprumont)
- 522. *Leptolepidites* cf. *tenuis* Stanley
- 523. *Triquitrites* sp. indet.
- 524. *Ilexpollenites* 1
- 525. *Typha* 1
- 526. *Granatitricolpites* 3
- 527. *Liliacidites* 1
- 528. *Fusiformisporites* 1
- 529. *Tiliapollenites* 4
- 530. *Pachysandra* 1
- 531. *Momipites tenuipolis* Anderson
- 532. *Ctenosporites eskerensis* Elsik and Jansonius
- 533. *Pluricellaesporites* 2
- 534. *Nyssapollenites* 2
- 535. *Sapotaceae* 1
- 536. *Retitricolporopollenites* 1
- 537. *Polygoniaceae* 1
- 538. *Retitricolporopollenites* 2
- 539. *Acnepollis* 1
- 540. *Tricolpites* 2
- 541. *Symplocoipollenites* 1
- 542. *Foveosporites* 1
- 543. *periporate* 2
- 544. *Sapotaceae* 2
- 545. *Retitricolporopollenites* 3
- 546. *Punctodiporites* 1
- 547. *Punctodiporites* 2
- 548. *Fusiformisporites* 2
- 549. *Pluricellaesporites* 3
- 550. *Striadiaporites* 1
- 551. *Striadiaporites* 2
- 552. *Stephanocolporites* 1
- 553. *Pulcheripollenites* cf. *krempii* Srivastava
- 554. *Pesavis simplex* Elsik and Jansonius
- 555. *Ctenosporites wolfei* Elsik and Jansonius
- 556. *Pesavis* 1

Marine palynomorphs

- M1. *Oligosphaeridium complex* (White) Davey and Williams
- M2. *Astrocytula cretacea* (Pocock) Davey
- M3. *Micrhystridium* 1
- M4. *Odontochitina striatoperforata* Cookson and Eisenack
- M5. *Apteodinium cf. A. reticulatum* Singh
- M6. *Leiofusa bernesga* Cramer
- M7. *Hystrichosphaeridium cooksoni* Singh
- M8. *Gonyaulacysta tenuiceras* (Eisenack) Sarjeant
- M9. *Veryhachium europaeum* Stockmans and Williere
- M10. *Meiourogonyaulax cf. M. stoveri* Millioud
- M11. *Baltisphaeridium crameri* Singh
- M12. *Scriniodinium cf. S. eurypylum* Manum and Cookson
- M13. *Micrhystridium stellatum* Deflandre
- M14. *Pseudoceratium cf. P. regium* Singh
- M15. *Leiofusa jurassic* Cookson and Eisenack
- M16. *Chlamydophorella nyei* Cookson and Eisenack
- M17. *Palaeostomocystis* 1
- M18. *Cyclonephelium distinctum* Deflandre and Cookson
- M19. *Pseudoceratium pelliferum* Gocht
- M20. *Tanyosphaeridium* sp. Singh
- M21. *Canningia colliveri* Cookson and Eisenack
- M22. *cf. Aptea polymorpha* Eisenack
- M23. *Cleistosphaeridium polypes* (Cookson and Eisenack) Davey
- M24. *Baltisphaeridium whitei* (Deflandre and Courtville) Sarjeant
- M25. *Cribroperidinium orthoceras* (Eisenack) Davey
- M26. *Diplotesta angelica* Cookson and Hughes
- M27. *Gardodinium elongatum* Singh
- M28. *Oligosphaeridium anthophorum* (Cookson and Eisenack) Davey
- M29. *Hystrichosphaera cingulata* (Wetzel) Deflandre and Cookson
- M30. *Gonyaulacysta* sp. B Singh
- M31. *Gonyaulacysta cf. G. striata* Clarke and Verdier
- M32. *Carpodinium* 1
- M33. *Palaeoperidinium cf. P. ventriosum* (Wetzel) Deflandre
- M34. *Oligosphaeridium albertaine* Pocock
- M35. *Broomea jaegeri* Alberti
- M36. *Odontochitina operculata* (Wetzel) Deflandre
- M37. *Hystrichosphaera ramosa* (Ehrenberg) Wetzel
- M38. *Cyclonephelium cf. C. vannophorum* Davey
- M39. *Pseudoceratium cf. P. expolitum* Brideaux
- M40. *Apteodinium cf. A. granulatum* Eisenack
- M41. *Deflandrea pirnaensis* Alberti
- M42. *Pterospermopsis australiensis* Deflandre and Cookson
- M43. *Cantulodinium* 1
- M44. *Oligosphaeridium cf. O. diastema*
- M45. *Dingodinium cerviculum* Cookson and Eisenack
- M46. *Oligosphaeridium cf. O. pulcherrimum* (Deflandre and Cookson) Davey & Wetze
- M47. *Veryhachium reductum* (Deunff) de Jeckowski
- M48. *Palaeostomocystis fraglis* Cookson and Eisenack
- M49. *Botryococcus* 1
- M50. *Gardodinium eisenacki* Alberti

- M51. *Doidyx* 1
M52. *Sirmiodinium grossi* Alberti
M53. *Tasmanites suevicus* (Eisenack) Wall
M54. *Pareodinia ceratophora* Deflandre
M55. *Fromea amphora* Cookson and Eisenack
M56. *Cleistosphaeridium* cf. *C. ancoriferum* (Cookson and Eisenack) D.D.S.&W
M57. *Scriniodinium* 1
M58. *Ctenidodinium* 1
M59. *Endoscrinium* cf. *E. campanula* (Gocht)
M60. *Gonyaulacysta* cf. *G. jurassica* (Deflandre)
M61. *Tenua* 1
M62. *Baltisphaeridium* 1
M63. *Gonyaulacysta* 1
M64. *Meiourogonyaulax* 1
M65. *Wanaea digitata* Cookson and Eisenack
M66. *microforaminifera*
M67. *Pareodinia* 1
M68. *Gonyaulacysta* cf. *G. granuligera* (Klement)
M69. *Xenicodium* 1
M70. *Paleohystrichophora* cf. *P. multispina* Deflandre and Cookson
M71. *Diconodinium* 1
M72. *Diconodinium* 2
M73. *Baltisphaeridium* 2
M74. *Micrhystridium* cf. *inconspicuum*
M75. *Micrhystridium stipulatum*
M76. *Micrhystridium* 2
M77. chitinozoa
M78. *Micrhystridium* 3
M79. *Baltisphaeridium* 3
M80. *Deflandrea diebeli* Alberti
M81. *Oligosphaeridium pulcherrimum* (Deflandre and Cookson) D.D.S.&W
M82. *Canningia reticulata*
M83. *Areoligera* sp.
M84. *Deflandrea* cf. *victoriensis* Cookson and Manum
M85. *Cleistosphaeridium armatum* (Deflandre) Davey
M86. *Surculosphaeridium longifurcatum* (Firction) D.D.S.&W
M87. *Exochosphaeridium phragmites* D.D.S.&W
M88. *Pterodinium perforatum* (Clarke and Verdier) Davey and Verdier
M89. *Spinidinium vestitum* Brideaux
M90. *Gonyaulacysta* cf. *fetchamensis* D.D.S.&W
M91. *Hystrichodinium pulchrum* Deflandre
M92. *Baltisphaeridium multispinosum* Singh
M93. *Dinopterygium cladoides* Deflandre
M94. *Hystrichosphaeridium stellatum* Maier
M95. *Polysphaeridium laminaspinosum* D.D.S.&W
M96. *Exochosphaeridium* cf. *scitulum* Singh
M97. *Systematophora turonica* (Alberti)
M98. *Circulodinium* cf. *deflandrei* Alberti
M99. *Perisseiasphaeridium* sp.
M100. *Broomea pellifera* Alberti
M101. *Muderongia simplex* Alberti
M102. *Circulodinium* cf. *hirtellum* Alberti

- M103. *Surculosphaeridium* cf. *vestitum* (Deflandre) D.D.S.&W
 M104. *Gonyaulacysta* cf. *pachydermis* (Deflandre) D.D.S.&W
 M105. *Wanaea* cf. *spectabilis* Cookson and Eisenack
 M106. *Batisphaeridium stimuliferum* (Deflandre) Sarjeant
 M107. *Baltisphaeridium multifurcatum* (Deflandre) Klement
 M108. *Cyclonephelium* cf. *reticulatum*
 M109. *Systematophora schindelwolfi* (Alberti)
 M110. *Oligosphaeridium* cf. *albertense* Pocock
 M111. *Muderongia tetracantha* (Gocht) Alberti
 M112. *Ctenidodinium elegantulum* Millioud
 M113. *Dingodinium albertii* D.D.S.&W
 M114. *Oligosphaeridium* cf. *anthophorum* (Cookson and Eisenack) D.D.S.&W
 M115. *Systematophora* cf. *fasciculigera* Klement
 M116. *Hystrichosphaeridium* cf. *readi* D.D.S.&W
 M117. *Cannosphaeropsis aemula* (Deflandre) Deflandre
 M118. *Broomea exigua*
 M119. *Gonyaulacysta* cf. *longispinosa*
 M120. *Diconodinium arcticum* Manum and Cookson
 M121. *Deflandrea minor* Alberti
 M122. *Deflandrea cooksoni* Alberti
 M123. *Deflandrea* cf. *granulifera* Manum
 M124. *Tenua* 2
 M125. *Astrocysta* cf. *cretacea* (Pocock) Davey
 M126. *Fromea* 1
 M127. *Systematophora* cf. *turonica* (Alberti)
 M128. *Deflandrea* cf. *cooksoni* Alberti
 M129. *Deflandrea* cf. *magnifica* Stanley
 M130. *Diconodinium* 3
 M131. *Palambages* A
 M132. *Palambages* B
 M133. *Schizocystia levigata* Cookson and Eisenack
 M134. *Micrhystridium deflandrei*
 M135. *Hystrichosphaeridium recurvatum* (White) Lejeune-Carpentier
 M136. *Sirmiodinium* 1
 M137. *Deflandrea* 1
 M138. *Cannosphaeropsis* 1
 M139. *Deflandrea* 2
 M140. *Epilidosphaeridia* 1
 M141. *Deflandrea granulifera* Manum
 M142. *Chytroesphaeridia* 1
 M143. *Tenua* 3
 M144. *Canningia* cf. *senonica* Clarke and Verdier
 M145. *Apteodinium grande* Cookson and Hughes
 M146. *Cyclonephelium* cf. *paucispinum* Davey
 M147. *Pterospermopsis* 1
 M148. *Diconodinium pusillum* Singh
 M149. *Deflandrea* cf. *verrucosa* Manum
 M150. *Scolecodont*
 M151. *Ascodinium verrucosum* Cookson and Hughes
 M152. *Micrhystridium* cf. *piliferum* Deflandre
 M153. *Veryhachium* cf. *lairdi* (Deflandre) Deunff
 M154. *Pseudoceratium expolitum* Brideaux

- M155. *Hystrichosphaeridium* cf. *recurvatum* (White) Lejeune-Carpentier
M156. *Microdinium opacum* Brideaux
M157. *Deflandrea* cf. *pirnaensis* Alberti
M158. *Canningia* cf. *aspera* Singh
M159. *Diplotesta* cf. *bidigitata* Manum and Cookson
M160. *Broomea longicornuta* Alberti
M161. *Heliodinium voigti* Alberti
M162. *Cannosphaeropsis* 1
M163. *Muderongia staurota* Sarjeant
M164. *Wetzeliella* cf. *tabulata* Wilson
M165. *Deflandrea* cf. *microgranulata* Stanley
M166. *Deflandrea* cf. *cretacea* Cookson
M167. *Deflandrea* cf. *tenuera*
M168. *Cyclonephelium lemniscutatum* Stanley
M169. *Deflandrea scheii* Manum
M170. *Canningia* cf. *colliveri*
M171. *Pterodinium* cf. *cornutum*
M172. *Micrhystridium* cf. *stellatum*
M173. *Gonyaulacysta* cf. *Kostromiensis* Vozzhenikova
M174. *Gardodinium*-1
M175. *Imbatodinium villosum* Vozzhenikova
M176. *Muderongia* cf. *simplex* Alberti
M177. *Kalyptea monoceras* Cookson and Eisenack
M178. *Tenua hystrix* Eisenack
M179. *Prolixosphaeridium deirense*
M180. *Tubotuborella rhombiformis* Vozzhenikova
M181. *Doidyx anaphrissa* Sarjeant
M182. *Muderongia mcwhaei* Cookson and Eisenack
M183. *Pareodinia Albertii* Warren MS
M184. *Chytroesphaeridia pococki* Sarjeant
M185. *Gonyaulacysta hyalodermopsis* Cookson and Eisenack
M186. *Sirmiodinium* 2
M187. *Valensiella* 1
M188. *Scrinidinium crystallinum* (Deflandre) Klement
M189. *Chytroesphaeridia* 2
M190. *Gonyaulacysta jurassica*
M191. *Nannoceratopsis pellucida* Deflandre
M192. *Gonyaulacysta nealei* Sarjeant
M193. *Ellipsoidictym* 1
M194. *Hystrichosphaeridium pattei* Valensi
M195. *Ctenidodinium ornatum* (Deflandre) Sarjeant
M196. *Kalyptea* cf. *dicerca* Cookson and Eisenack
M197. *Gonyaulacysta* cf. *cladophora* (Deflandre)
M198. *Nannoceratopsis gracilis* Alberti
M199. *Palaeohystrichophora* 1
M200. *Nannoceratopsis* cf. *gracilis* Alberti
M201. *Crassosphaera* 1
M202. *Leiofusa deunffii* Pocock
M203. *Spinidinium* 1
M204. *Pterospermopsis eurypteris* Cookson and Eisenack
M205. *Xenicodinium* 2

- M207. *Adnatosphaeridium* cf. *vittatum* Williams and Downie
M208. *Exochosphaeridium* 1
M209. *Pseudoceratium* cf. *nudum* Gocht
M210. *WetzelIELLA* cf. *reticulata* Williams and Downie
M211. *Cannosphaeropsis* cf. *densiradiata* Cookson and Eisenack
M212. *Nelsoniella* 1
M213. *Deflandrea* cf. *micracantha*
M214. *Achomosphaera* cf. *ramulifera*
M215. *Diconodinium* 4
M216. *Ovoidinium scabrosum* (Cookson and Hughes)
M217. *Microdinium* cf. *setosum* Sarjeant
M218. *Cyclonephelium eisenacki*
M219. *Diconodinium* 5
M220. *Lejeunia* 1
M221. *Oligosphaeridium* 1
M222. *Ceratiopsis* 1
M223. *Multiplicisphaeridium* 1
M224. *Gonyaulacysta* 2
M225. *Deflandrea* 3
M226. *Diconodinium* 6
M227. *Cleistosphaeridium* 1
M228. *Veryhachium rhomboidinum* Downie
M229. *WetzelIELLA* cf. *hampdenensis* Wilson
M230. *Cannosphaeropsis* cf. *reticulensis* Pastiels
M231. *Hystrichosphaerina* cf. *turonica* Alberti
M232. *Hystrichosphaeridium* cf. *radiculatum*
M233. *Horologinella* 1
M234. *Palaeohystrichophora* 2
M235. *Diconodinium* 7
M236. *Diphyes colligerum* (Deflandre and Cookson)
M237. *Svalbardella* 1
M238. *Gonyaulacysta* cf. *orthoceras* (Eisenack)
M239. *Ophiobolus* 1
M240. *Deflandrea ditissima* McIntyre
M241. *Deflandrea* cf. *dakotaensis* Stanley
M242. *Korojonia* 1
M243. *Deflandrea* cf. *acutula* Wilson
M244. *Astrocytula* 1
M245. *Cordosphaeridium* cf. *diktyoplokus* (Klumpp)
M246. *Samlandia* 1
M247. *Baltisphaeridium* 4
M248. Recycled Cretaceous dinoflagellates
M249. *Deflandrea biapertura* McIntyre
M250. *Pareodinia osmingtonense* (Sarjeant) Wiggins
M251. *Deflandrea* cf. *wetzeli* Morgenroth
M252. *Deflandrea microgranulata* Stanley
M253. *Leptodinium* 1
M254. *Cannosphaeropsis* sp. indet.
M255. *WetzelIELLA homomorpha* *quinquelata* Williams and Downie
M256. *Ceratiopsis* 2
M257. *Rhombodinium* 1

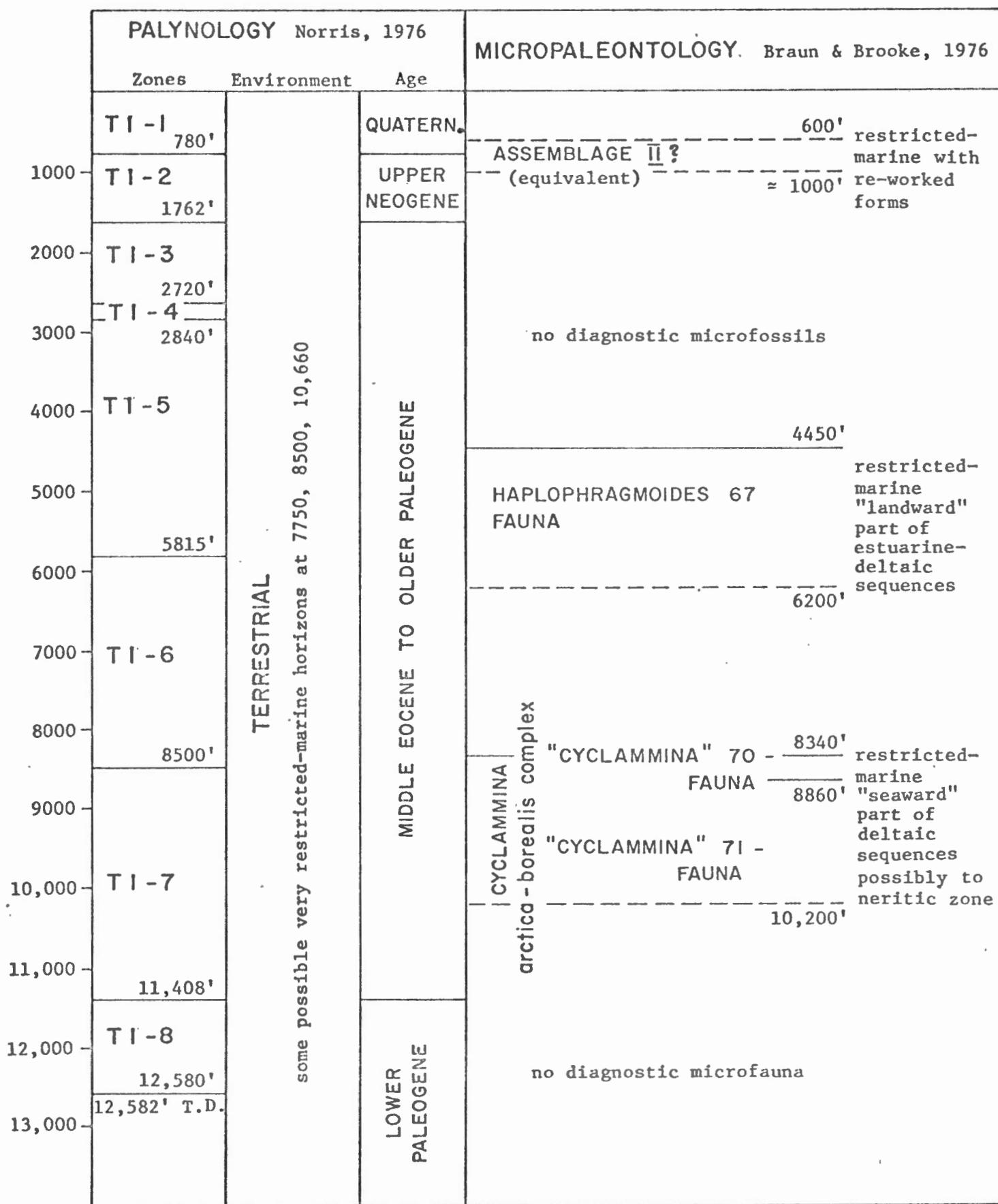
MICROPALÆONTOLOGICAL STUDY

BY

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Gulf - Imperial - Shell

TITALIK K-26



SUMMARY OF MICROPALEONTOLOGICAL STUDY

General Remarks

The following slides were available for micropaleontological study: 82 slides of drill samples covering 50' intervals for each 100' of section from 180' to 8300'. In addition, 13 core samples were disintegrated and analyzed. From 8300' to 12,586' and T.D., there were more than 400 slides of drill samples, covering 10' intervals.

All microfossils that could be identified, including certain characteristic fragments were provided with species numbers, and their sequence is shown on the chart. Whenever possible, the forms were identified to generic rank, or as close as possible, but no attempt has been made to search the "international" literature for identical or closely related forms. Only a thorough paleontological study, based on extensive collections would do justice to such an attempt. It would require also an intimate knowledge of the paleontological and stratigraphical problems, and bias, contained "in between the lines" in any published account. There is no obvious similarity to any fauna published from North America, except for the Cyclammina arctica - borealis fauna. Faunas from Siberia, however show closer relationship but literature search is made difficult for many reasons. So the microfauna of the Delta region has to be evaluated on its own merits first and for the time being, and there is nothing wrong with this procedure provided certain steps are taken in the right order.

One of the most critical requirements in any paleontological study is consistency in identification, and this consistency is best achieved by giving an adequate, visual impression of the taxa recovered, and document in detail their occurrences and distribution in individual distribution charts, summary range-charts, etc. Charts are usually given in reports or publications, but rarely are good photographs included. For this reason, emphasis was placed on photographic documentation of the key species, and also of many of the background fauna. Such documentation, it is hoped, will serve to unify the many existing number codes used by other investigators in speciation and which are at times hard to translate into ones own work, and which make even detailed studies rather confusing to interpret.

The micropaleontological data are plotted from "top to bottom", a standard procedure in subsurface studies. First occurrences are used to delineate the upper boundary of a faunal complex although, in reality, these are last occurrences. Lower boundaries are hard to define without the results from core samples but the "trailing" of specimens through the Titalik borehole seem to be minimal.

The usefulness as time indicators of the microfauna recovered is very limited, in fact it is non-existent. The lack of planktonic forms, the endemic nature of many of the benthonic forms discovered, the sporadic and erratic occurrence of the fauna being restricted essentially to a few more "marinish" horizons in an essentially terrestrial -deltaic sequence make it extremely hazardous to tie the microfauna into a proper time framework. The microfaunal assemblages are for this reason simply traced by number or name, without any age connotation attached. They can be used as such readily in correlating from one borehole to the other, provided the fauna, or part of it, is the same. Any references to stages and ages that are used are those adopted from palynological studies, and the micropaleontological data are summarized in the table with the palynological ones shown alongside.

Microfaunal Assemblages

Three distinct microfaunal assemblages were encountered which is surprising, for Norris' palynological evaluation indicates that the Titalik section was mainly terrestrial in origin, with only a very few, and "very" restricted marine horizons.

Assemblage II - Fauna (?)

Only two samples were available from the uppermost 600 feet which were barren of microfossils. Scattered specimens of a variety of agglutinated and calcareous Foraminifera appear throughout the 600 to 1300 - foot level of the borehole, and some of these forms are reminiscent of the Assemblage II - Fauna that underlies Assemblage I in other wells. The species recovered certainly do not belong to the rich Assemblage I, and the fauna is a relatively low diversity one which would indicate marine influences that were more pronounced than in older horizons, but not quite as open-marine as the Assemblage I of Niglintgak and other wells would indicate.

If the fauna is part of Assemblage II, and that is the question, it would be equivalent to the Asterigerina 501 Fauna of Staplin *et al.* that marks the lower part of the Neogene section and upper part of their T4 a-Zone in the Taglu C-42 borehole. However, the microfauna comes from an interval that spans part of Norris' T1 1 and T1 2 zones, with the latter being supposedly upper Neogene in age. If this age assignment could be confirmed, a different interpretation would have to be made and the fauna recovered then be regarded an impoverished and restricted-marine equivalent to the open-marine and freshwater fauna of Assemblage I.

Whichever interpretation is accepted, or whatever firm age assignment will be made in future, the fauna is too young to be at this time of any great help in oil exploration.

HAPLOPHRAGMOIDES 67 - Fauna

Haplophragmoides 67 occurs in abundance from 4450' of the Titalik borehole to about 6200 feet; the few specimens recovered from below this level probably are contaminants. This species is commonly associated with species of the genera Saccammina and Verneuilinoides, but only a Trochammina 68 occurs together, aside of caved forms and a few undiagnostic fragments.

The fauna spans an interval equivalent to parts of Norris' T1 5 and T1 6 zones which are assigned an Middle Eocene to older Paleogene age. Judging by the superposition of certain faunas, Haplophragmoides 67 should be equivalent to Staplin's et al. Haplophragmoides 4106 marker of the Taglu C-42 well which is supposedly of lower Paleogene age, an assignment compatible with Norris' findings.

A typical low diversity fauna, Haplophragmoides 67 and the few associated forms would indicate severe marine restrictions, as might be expected in the "landward" part of an estuary or delta where freshwater influences were considerable and marine influences weak.

"CYCLAMMINA" 70 and 71 - FAUNA (Cyclammina arctica-borealis complex)

One of the most diagnostic faunal units in the Mackenzie Delta region is the "Cyclammina" arctica-borealis complex, described by Petracca and mentioned by others. The fauna is here referred to as Cyclammina 70 and 71 - Fauna, as Petracca's species grouping is slightly modified.

"Cyclammina" 70 starts at about the 8340-foot level in the Titalik borehole and extends to about 10,000 feet; "Cyclammina" 71 however appears from about 9000 to 10,200 feet. There is a strong suggestion that both species have no overlapping ranges, and the few specimens of the 70-species in the 71-sub-assemblage may actually be cavings. However, only the results from core samples could substantiate or refute this assumption. In any way, their first occurrences and their abundancies do not coincide, and two sub-assemblages can be readily discriminated.

Whereas Cyclammina 70 seem to be the only species present in the upper sub-assemblage, there is a Bathysiphon 75 associated in the lower range of the "Cyclammina" 71 occurrences, aside of a few other forms.

The "Cyclammina" 70 and 71-Faunas span the lower part of Norris' T1 6-Zone and the upper part of his T1 7 unit, both considered of Middle Eocene to older Paleogene in age.

According to Staplin et al., the C.arctica-borealis complex occurs at or close to the base of the Taglu C-42 borehole in the lowermost Paleogene, and from there it is traced to the 9000-foot level in the Reindeer D-27 well from where Petracca and Chamney report the same species. The fauna seems to be equivalent, therefore, to Chamney's 11b unit of Reindeer, or his Middle Cyclammina (vitreous) horizon.

Chamney considers the Lower-Middle -and- Upper Cyclammina horizons to be of Danian age, "inferring more indicators of Maestrichtian than Paleocene age" and presents evidence for his conclusions. In contrast, Petracca shows weighted evidence for an early Tertiary age of the arctica-borealis complex. Clearly then, one and the same fauna carries a different age label.

It may be advisable at this time and state of our knowledge to overlook this discrepancy, and not use stage names in argumentation, but refer to the one fact only: the presence of a most valuable marker fauna that can be recognized widely, easily, and without mistake. As such, the fauna can be correlated from well to well and that is all what is needed.

The Cyclammina 70 and 71 - Fauna both are low diversity faunas, in contrast to the occurrences of modern forms of this group of Foraminifera. Restricted-marine conditions are therefore suggested to have been present at the time of their deposition, and not deeper water and open-marine ones as applies to many modern Cyclammina occurrences. Moreover, the generic placement may not be correct, for species of the genus Alveolophragmium exhibit similar characters and representatives of both could be readily confused.

UNDIAGNOSTIC FAUNA

An undiagnostic fauna with a few specimens of Ammobaculites 79 and spiroplectammina - 8 were found up to 200' below the arctica -borealis complex, but the rest of the samples to 12,580 feet (T.D.) proved to be barren.

References cited:

Chamney, T. P., 1973: Tuktoyaktuk Peninsula Tertiary and Mesozoic Biostratigraphy Correlations; Geol. Surv. Can., Paper 73-1, part B, p. 171-179, 3 figs., 1 table.

Loeblich, A.R. Jr., and Tappan H., 1953: Studies of Arctic Foraminifera; Smithsonian Miscellaneous Collections, Vol. 121, no. 7, p. 1-150, 24 plates.

Petracca, A.N., 1972: Tertiary microfauna, MacKenzie Delta area, Arctic Canada; Micropaleontology; v. 18, no. 3, p. 355-368

Staplin, F.L. et al : Tertiary Biostratigraphy, MacKenzie Delta Region, Canada; copy of manuscript of a joint oral presentation to C.S.P.G. by paleontological staffs of Gulf - Imperial-and Mobil Oil Canada. In press.

PLATES and PLATE EXPLANATIONS

All magnifications approximately X 35 to 40

* Forms listed on chart, but no photograph taken
(specimens too badly preserved).

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Plate I

* no photos for specimens too badly preserved

Miscellaneous Foraminifera forming "background fauna" throughout borehole, and including possible re-worked forms

Ammobaculites	63	8	Spiroplectammina
Ammobaculites	79	13	Saccammina
Ammodiscus	55	17	Hyperammina
Gaudryina	57	30	Trochammina
Glomospira	38	38	Glomospira
Glomospira	73	48	miliolid
Genus ind.	76	54	miliolid
Genus ind.	81	55	Ammodiscus
Hyperammina	17	57	Gaudryina
Lituotuba ?	69	63	Ammobaculites
miliolid	48	64	rotaliid (Epistomina?)
miliolid	54	66	polymorphinid
polymorphinid	66	68	Trochammina?
*Reophax	72	69	Lituotuba?
rotaliid (Epistomina?)	64	72	Reophax*
rotaliid (Eponides?)	78	73	Glomospira
Saccammina	13	76	Genus ind.
Spiroplectammina	8	77	Spirosigmoilinella*
*Spirosigmoilinella	77	78	rotaliid (Eponides?)
*Textularia	80	79	Ammobaculites
Trochammina	30	80	Textularia*
Trochammina?	68	81	Genus ind.

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Plate II

Main Faunal components of Haplophragmoides 67-Fauna and the
"Cyclammina" arctica-borealis complex (and a few related forms).

Bathysiphon	52
Bathysiphon	75
"Cyclammina"	70
"Cyclammina"	71
Haplophragmoides	53
Haplophragmoides	67
Haplophragmoides ?	65 (no photo, specimens too badly preserved)