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BIOSTRATIGRAPHIC ZONATION

IOE NUKTAK C-22

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AUSTIN & CUMMING EXPLORATION CONSULTANTS  
CALGARY, ALBERTA

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# BIOSTRATIGRAPHIC ZONATION

IOE NUKTAK C-22

## SUMMARY AND CONCLUSIONS

The biostratigraphic analysis on IOE Nuktak C-22 includes a palynostratigraphic study by Dr. G. Norris, and a micropaleontological investigation by Dr. W. Braun.

One hundred and thirty two prepared palynology slides and 206 micropaleontology samples were made available by the operator of the well, providing good coverage for both faunal and floral examination. No conventional core material was obtained on this well.

A continuous zonation spanning the interval from Middle-Upper Eocene to Neogene was established utilizing 8 recognizable microflora zones, from total depth (12,600 feet) to near surface.

Microfaunal assemblages are limited to marine, lagoonal and near-shore occurrences in a generally terrestrial-deltaic sequence, and because of sporadic occurrences have limited value for absolute age determination. Assemblages are, however, useful in supporting the palynological zonation, and for 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>
Neogene	0'- 2,370'	NT-1 (30-1110')	Assemblage I (0-950')
		NT-2 (1200-2370')	Assemblage II (950-1900')
Oligocene	2370'- 4,310'	NT-3 (2550-4310')	
Middle-Upper Eocene	4310'-12,600'	NT-4 (4353-5280')	
		NT-5 (5370-7590')	Haplophragmoides 53 Bathysiphon 52
		NT-6 (7682-8590')	Fauna (6960-11,600')
		NT-7 (8695-10,980')	
		NT-8 (11,160-12,600')	Astrorhizid Fauna (11,600-12,600')
			TOTAL DEPTH: 12,600

PALYNOSTRATIGRAPHIC STUDY

BY

DR. GEOFFREY NORRIS

## PALYNOSTRATIGRAPHY

IOE NUKTAK C-22

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 IOE Nuktak C-22 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., *Taxodiaceapollenites 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 thirty-two samples from the subject well yielded 95 terrestrial and 37 marine palynomorph species as indicated in Figure 1. Certain species are illustrated in Plates 1-3. Table 1 summarizes zones, ages assignments and depositional environments.

Eight zones are recognized, spanning the Upper Eocene and Oligocene between T.D. and 2370 feet and with Neogene occupying the top 2,000 feet approximately of the subject well. The only clearly defined marine interval occurs between 11,160 feet and 12,600 feet (T.D.).

## ZONATION

### Zone NT-1 (30-1110 feet).

Characterized by the common occurrence of:

- ✓ 2 *Taxodiaceapollenites hiatus*
- ✓ 7 *Gleicheniidites senonicus*
- ✓ 12 Recycled Carboniferous
- ✓ 42 *Araucariacites australis*
- ✓ 1 *Stereisporites antiquasporites*
- ✓ 5 *Alisporites bilateralis*
- ✓ 22 *Cyathidites minor*

In addition, the following species occur sporadically:

- 326 *Pinus-1*
- ✓ 34 *Laevigatosporites ovatus*
- ✓ 16 *Deltoidospora hallei*
- ✓ 54 *Distaltriangulisporites perplexus*
- 239 *Sequoiapollenites paleocenicus*
- 287 *Alnipollenites-1*
- 323 *Pterocarya levis*
- 324 *Carpinus subtriangula*
- 377 *Ericaceae-1* (probably recycled)
- 381 *Psilatricolpites-1*
- ✓ 3 *Classopollis torosus*
- ✓ 4 *Cicatricosisporites hallei*
- ✓ 36 *Lycopodiumsporites reticulumsporites*
- 25 Recycled Permo-Triassic
- 390 *Salix-1*
- 318 *Eucommiidites minor*
- ✓ 26 *Vitreisporites pallidus*
- ✓ 48 *Circulina parva*
- ✓ 20 *Trilobosporites apiverrucatus*
- 396 *Tiliapollenites-2*
- 407 *Laevigatosporites-1*
- ✓ 214 *Cirratriradites teter*
- 229 *Sigmopollis hispidus*

# IOE NOKTAK C-22

DEPTH	ZONES (PALYNOLOGY)	ENVIRONMENT	AGE
0	NT-1 1110'	NON-MARINE  WITH RARE,  SCATTERED  THIN MARINE  INTERVALS	NEOGENE
2000'	NT-2 2370'		OLIGOCENE
4000'	NT-3 4310'		
	NT-4 5280'		MIDDLE &  UPPER  EOCENE  (POSSIBLY  OLIGOCENE  IN PART)
6000'	NT-5 7590'		
8000'	NT-6 8590'		
10,000'	NT-7 10,980'		
12,000' T.D. 12,600'	NT-8	NEAR-SHORE MARINE	

TABLE 1

- 236 *Schizosporis reticulatus*
- 10 *Perinopollenites elatoides*
- 284 *Cupuliferoideaepollenites-*
- 19 *Osmundacidites wellmanii*
- 33 *Cyathidites australis*

Some of the above species are recycled from the Paleozoic, Cretaceous, and lower Tertiary. Of particular significance is the presence of 407 *laevigatosporites-1* and 229 *Sigmopollis hispidus* which are short-ranging Neogene species characterizing this interval. M237 *Svalbardella-1* is the only possible marine palynomorph that is indigenous to this zone.

#### Zone NT-2 (1200-2370 feet).

Characterized by the common occurrence of:

- 220 *Betulaceaepollenites-1*
- 408 *periporate-1*

Sporadic species include:

- 360 *Alnus trina*
- 46 *Parvisaccites radiatus*
- 9 *Cerebropollenites mesozoicus*
- 45 *Schizosporis parvus*
- 378 *Pluricellaesporites-*
- 6 *Cingutritetes clavus*
- 335 *Costatoperforosporites fistulosus*
- 369 *Cranwellia striata*

All except the first of these sporadic species are probably recycled Cretaceous and Tertiary elements.

Nineteen species of marine microplankton are present in Zone NT-2 but all are recycled Lower and Upper Cretaceous species.

#### Zone NT-3 (2550-4310 feet).

Characterized by the common occurrence of 395 *Corylus-1* and 371 *Tsuga-1* and the less frequent occurrence of 399 *Castanea-1*.

Occasional marine plankton species occur in this interval as indicated in Figure 3 but all are recycled Cretaceous specimens.

#### Zone NT-4 (4353-5280 feet).

The following species occur in this zone but none are common except *Ericaceae-1*:

- 214 *Cirratriradites teter*
- 377 *Ericaceae-1*
- 320 *Ulmus-1* (possibly recycled)
- 313 *Trilobosporites purverulentus*



- 411 *Abies*-1
- 409 *Stereisporites*-2
- 410 *Engelhardtia*-1
- 387 *Tricolporopollenites*-6

*Ericaceae*-1, *Abies*-1, and *Stereisporites*-2 are taken to characterize this zone.

M233 *Horologinella*-1 characterizes this zone and Zone NT-5 below. Although grouped with marine plankton in this study, it is possibly a freshwater algal cyst allied to the desmids.

Apart from recycled Cretaceous microplankton, no other indigenous marine plankton species occur.

Zone NT-5 (5370-7590 feet).

The top of the range of 412 *Lycopodiumsporites*-1 is clearly defined in this zone. In addition, rarer species also characterize the interval:

- 413 *Stereisporites*-3
- 247 *Aquilapollenites attenuatus*
- 50 *Coronatisporites valdensis*
- 373 *Tricolporopollenites*-
- 31 *Lycopodiumsporites austroclavatidites*
- 414 *Triatriopollenites*-
- 291 *Tricolpites hians*
- 183 *Baculatisporites comaumensis*

Apart from recycled Cretaceous marine microplankton, the only possible indigenous marine type is M242 *Korojonia*-1 near the bottom of Zone NT-5.

Zone NT-6 (7682-8590 feet).

416 *Osmundacidites*-1 has a well-defined range in this zone. In addition, the following also occur but are probably recycled, other than the first:

- 405 *Cicatricosisporites intersectus*
- 415 *Aquilapollenites* cf. *murus*
- 417 *Contignisporites* cf. *fornicatus*

No unequivocally indigenous marine plankton species are present in Zone NT-6.

Zone NT-7 (8695-10,980 feet).

Common species characterizing this interval include:

- 419 *tetrad*-1
- 421 *Leptolepidites*-1

Rarer terrestrial species include:

- 418 *Polypodiisporites*-1
- 420 *Laevigatosporites*-2
- 362 *epiphyllous fungi*
- 422 *Parviprojectus*-1
- 402 *Ginkgo*-1
- 282 *Caryapollenites paleocenicus*
- 398 *Basopollis*-1
- 381 *Psilatricolpites*-1
- 372 *Granatitricolpites*-1

Weak marine influence is indicated 540 feet above the base of Zone NT-7 by the presence of M244 *Astrocysta*-1. Sporadic recycled marine Cretaceous palynomorphs also occur in this zone.

Zone NT-8 (11,160-12,600 feet).

This zone is characterized by the following frequently occurring species:

- 374 *Granatisporites*-1
- 367 *Azolla*
- 400 *Pesavis tagluensis*
- 391 *Striadiporites sanctaebabarbarae*

The following species occur more rarely:

- 325 *Aquilapollenites* cf. *reticulatus*
- 384 *Retitricolpites*-1
- 370 *Titiapollenites*-1
- 24 *Podocarpidites multisimus*
- 375 *Granatisporites*-2
- 330 *Pistillipollenites mcgregorii*
- 392 *Granatisporites cotalis*
- 30 *Phyllocladidites inchoatus*

A well-defined marine assemblage also characterizes this interval and comprises the following species:

- M244 *Astrocysta*-1
- M235 *Diconodinium*-7
- M229 *Wetzeliiella* cf. *hampdenensis*
- M245 *Cordosphaeridium* cf. *diktyoplokus*
- M246 *Samlandia*-1
- M230 *Cannosphaeropsis* cf. *reticulensis*

## PALEOENVIRONMENTS

The only clearly defined marine interval occupies Zone NT-8 between 10,980 feet and 12,600 feet with a possible extension upwards to 10,440 feet based on the occurrence of *Astrocysta*-1 at this horizon. The limited number of marine species and relative abundance and diversity of terrestrial species suggests near-shore conditions of deposition in this interval.

The entire section above the marine interval is terrestrial (with occasional recycled Cretaceous microplankton) apart from the following probably indigenous species at the horizons indicated:

M237 *Svalbardella*-1 1110 feet.  
 M242 *Korojonia*-1 7050 feet.  
 M233 *Horologinella*-1 7682-4518 feet.

*Svalbardella*-1 and *Korojonia*-1 indicate very limited marine incursions at their respective horizons.

The environmental significance of *Horologinella*-1 is less certain. It may be marine but could also be a freshwater algal cyst.

## MATURATION

Degree of maturation of palynomorphs in this well ranges from light yellow-dark yellow (1-3) through the upper 8100 feet, yellow-amber (2-4) through the interval 8210-11,700 feet, and dark yellow-brown through the lowermost interval 11,790 to 12,600 (T.D.). (See Figure 1)

## CORRELATION

Palynostratigraphic correlations between IOE Nuktak C-22 and Shell Niglintgak H-30 are summarized as follows. The successive disappearance zones are prefixed NI for the Niglintgak well and NT for the Nuktak well.

### NT-8:

Zone NT-8 is firmly correlated with Zone NI-4 on the basis of the common occurrence of 400 *Pesavis tagluensis*, 391 *Striadiporites sanctae-barbarae*, 367 *Azolla*, and 325 *Aquilapollenites* cf. *reticulatus*. The Paleocene-Middle Eocene species 330 *Pistillipollenites mcgregorii* occurs near the NI-5/NI-4 boundary but at the top of NT-8. Little precise correlative significance, however, can be placed on these single occurrences.

The marine phase near the top of NT-8 characterized principally by M229 *Wetzeliella* cf. *hampdenensis*, M244 *Astrocysta*-1, M245 *Cordosphaeridium* cf. *diktyoplokus*, M246 *Samlandia*-1, and M230 *Cannosphaeropsis* cf. *reticulensis* correlates with a similar marine assemblage at the top of NI-4.

The marine phase characterizing NI-3 and the lower part of NI-2 is not recognized in the Nuktak well. This phase has the following species, none of which occur in any Nuktak zone:

M220 *Lejeunia*-1  
 M222 *Ceratiopsis*-1  
 M223 *Multiplicisphaeridium*-1  
 M227 *Cleistosphaeridium*-1  
 M226 *Diconodinium*-6  
 M225 *Deflandrea*-3

Its time equivalence in the Nuktak well is not certain at present because terrestrial palynomorph correlations in the intervals spanned by NI-2 and NI-3, on the one hand, and NT-7, NT-6, and NT-5 on the other are not clear. Two limiting possibilities exist for the *Lejeunia*-1, *Ceratiopsis*-1, etc. marine phase:

- (i) it directly succeeds the M229 *Wetzeliella* cf. *hampdenensis*, *Astrocysta*-1, etc. marine phase, correlating with much of upper NT-8, NT-7, NT-6, and possibly some NT-5.
- (ii) it is principally a biofacies controlled by an over-riding ecologic factor such as salinity or depth, and thus essentially synchronous with NT-8.

There is no doubt, however, that the *Lejeunia*-1, etc. marine phase is definitely post-*Pesavis tagluensis*-*Striadiporites sanctaebarbarae* zone in age; the question remains just how much of the succeeding Nuktak interval correlates with NT-3 and NI-2 or whether there may be a hiatus at this horizon in the Nuktak well.

NT-7 to NT-4:

This thick interval in the Nuktak well is well-characterized by sequential miospore compositional changes but is difficult to correlate with the Niglintgak well, except at the top where *Ericaceae*-1 disappears in both wells and several other species in the Nuktak well.

Several species occurring in the NI-2 and NI-3 interval also occur in the NT-4 to NT-7 interval but none are sufficiently characteristic in their distribution to allow correlation between these two wells. The Nuktak zones NT-5 and NT-6 are based on species not occurring in the Niglintgak well.

The frequent occurrence of 320 *Ulmus*-1 near the NT-5/NT-6 boundary may indicate a correlation with a similar frequent recurrence within NI-3.

*Horologinella*-1 occupies most of Zones NT-4 and NT-5 but has an apparently lower range in the Niglintgak well. It may be partially facies controlled, if it is an algal - possibly freshwater - cyst. The probable correlative zone in the Niglintgak well (parts of NI-3 or NI-2) is marine.

## NT-3:

The presence of 371 *Tsuga*-1 characterizes this zone in the Nuktak well and Zone NI-1 in the Niglintgak well. However, 395 *Corylus*-1 has a lower range in Niglintgak compared with the Nuktak well, as does 399 *Castanea*-1 which also occurs in NT-3 (the latter may be recycled from below). Other long-ranging species occur frequently in both wells in these zones (220 *Betulaceaepollenites*-1, 287 *Alnipollenites*-1, 324 *Carpinus subtriangula*) but other species have disparate distributions.

## NT-2 to NT-1:

Correlation of these zones with the Niglintgak well is impossible since the probably correlative horizons were not examined in the Niglintgak well.

NT-1 contains 229 *Sigmopollis hispidus* which also occurs in the upper horizons of the Niglintgak well.

AGE RELATIONSHIPS

Age relationships are summarized in Table I and are principally based on correlations with Shell Niglintgak H-30.

The Nuktak well bottoms in Zone NT-8 which is Middle or Upper Eocene.

The Eocene-Oligocene boundary may be taken at the highest occurrence of *Tiliapollenites*, as discussed on page of this report. In the Nuktak well, this genus occurs near the top of Zone NT-4 (up to 4,518 feet), apart from a probable recycled specimen in Zone NT-1. This would place the base of the Oligocene relatively higher in the Nuktak well compared with the Niglintgak well. The correlative Oligocene-Eocene boundary from the Niglintgak well probably occurs in Zone NT-8 of the Nuktak well, thus indicating that the well may bottom in Oligocene. However, this would conflict badly with a Middle Eocene age (at the latest) for the Horizon at 11,610 feet which contains 330 *Pistillipollenites mcgregorii*. In addition, a specimen on the operator's slides from 5626 feet SWC has been circled and annotated "PJ-1" which corresponds presumably with *Parviprojectus* PJ-1 of Imperial Oil Ltd. (Staplin et al., 1975). This species is believed to be late Eocene in age by the Imperial staff. The species is badly torn, however, and the present writer could not confirm its presumed triprojectate pollen structure on that specimen alone. It seems more likely that the Eocene-Oligocene boundary occurs near the NT-3/NT-4 boundary. If 422 *Parviprojectus*-1, which occurs as a single specimen at 9270 feet in the subject well, is conspecific with PJ-1, the Middle -Upper Eocene boundary presumably occurs below this and above definite Middle Eocene at 11,610 feet.

The top of the Paleogene is placed at the highest occurrence of *Corylus*-1, *Castanea*-1, and *Tsuga*-1 at the top of NT-3, which correlates with a similar event at the top of NI-1.

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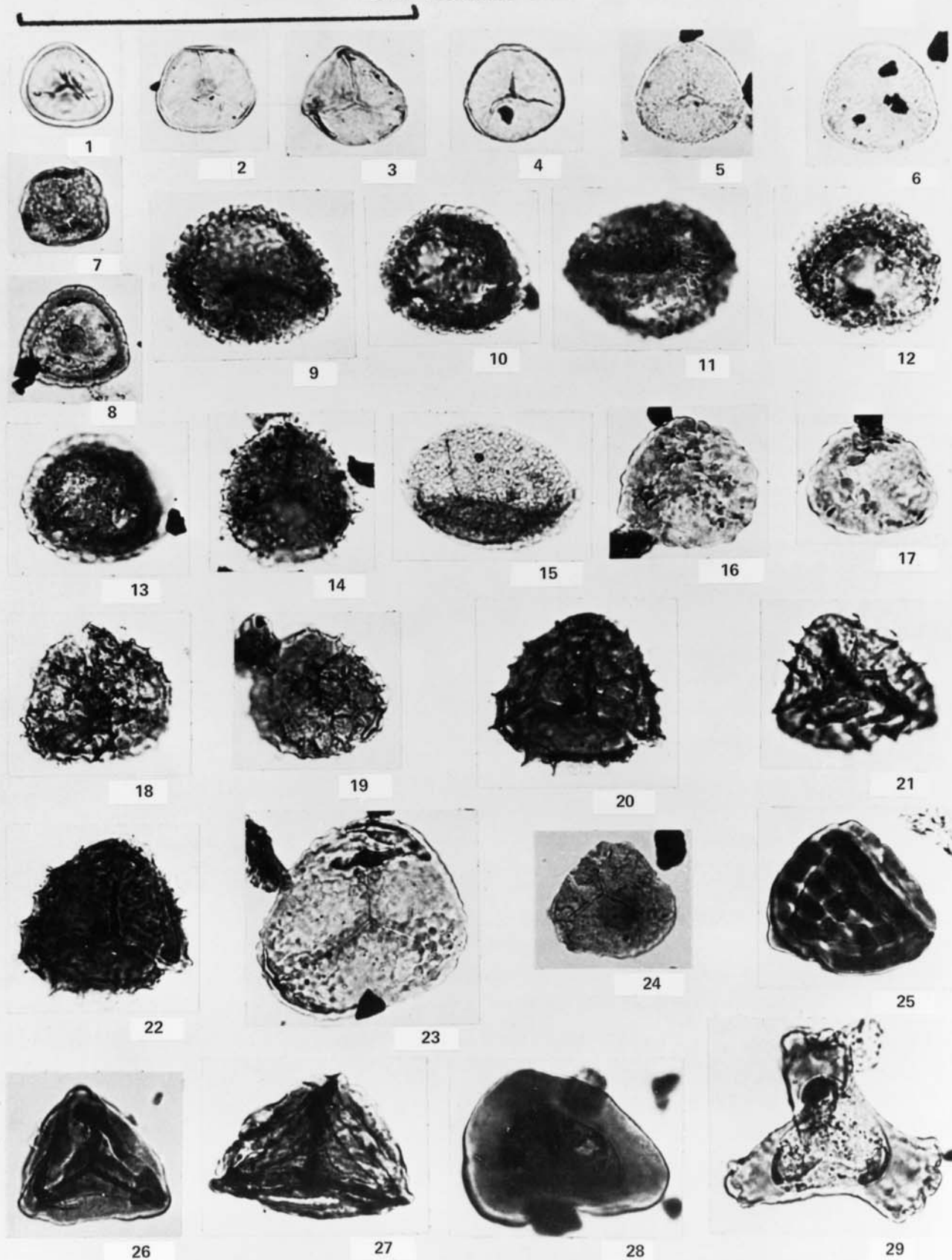
EXPLANATION OF PLATE #1

IOE NUKTAK C-22

All figures approximately 750x. (Scale in top left represents 100 u).

PLATE 1

1.	1	<i>Stereisporites antiquasporites</i>
204.	409	<i>Stereisporites</i> 2
5-7.	413	<i>Stereisporites</i> 3
8.	6	<i>Cingutriletes clavus</i>
9-13.	416	<i>Osmundacidites</i> 1
14.	183	<i>Baculatisporites comaumensis</i>
15.	19	<i>Osmundacidites wellmanii</i>
16-17.	421	<i>Leptolepidites</i> 1
18-19.	36	<i>Lycopodiumsporites reticulumsporites</i>
20-22.	412	<i>Lycopodiumsporites</i> 1
23.	313	<i>Trilobosporites purverulentus</i>
24.	18	<i>Tigrisporites scurrandus</i>
25.	417	<i>Contignisporites</i> cf. <i>fornicatus</i>
26.	54	<i>Distaltrianulisporites perplexus</i>
27.	186	<i>Appendicisporites potomacensis</i>
28-29.	12	Recycled Carboniferous





EXPLANATION OF PLATE #2

IOE NUKTAK C-22

All figures approximately 750x. (Scale in top left represents 100 u).

PLATE 2

30-31.	12	Recycled Carboniferous
32-33.	407	<i>Laevigatosporites</i> 1
34.	12	Recycled Carboniferous
35-36.	391	<i>Striadiporites sanctaebarae</i>
37.	12	Recycled Carboniferous
38-39.	400	<i>Pesavis tagluensis</i>
40-41.	420	<i>Laevigatosporites</i> 2
42-43.	418	<i>Polypodiisporites</i> 1
44.	45	<i>Schizosporis parvus</i>
45.	362	<i>Epiphyllous fungi</i>
46.	367	<i>Azolla</i>



30



31



32



33



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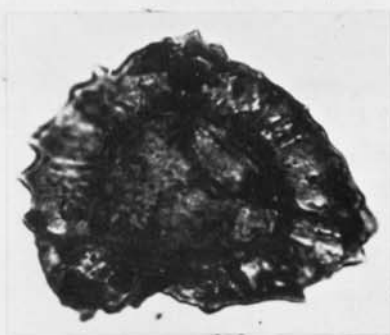
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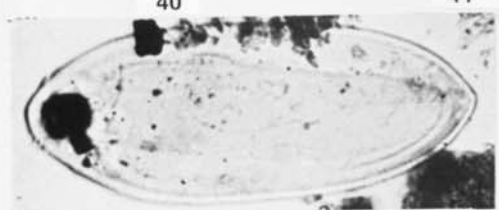
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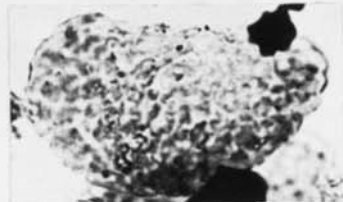
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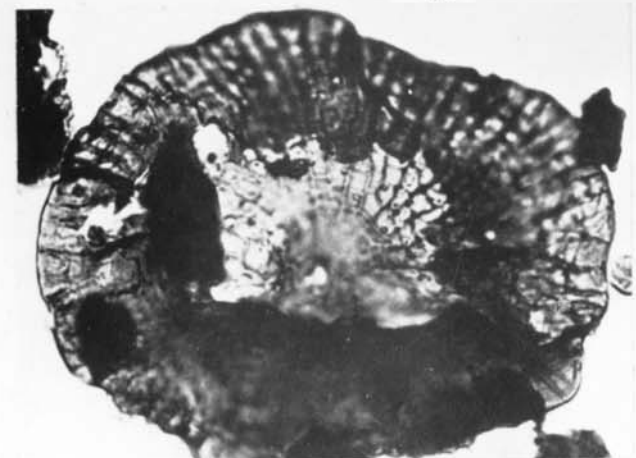
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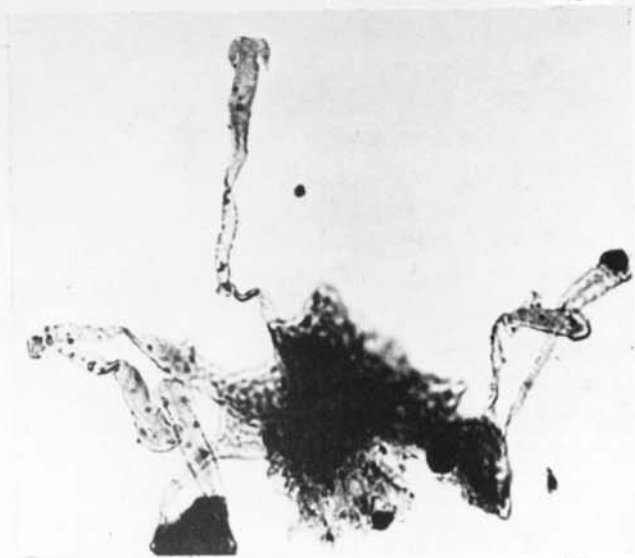
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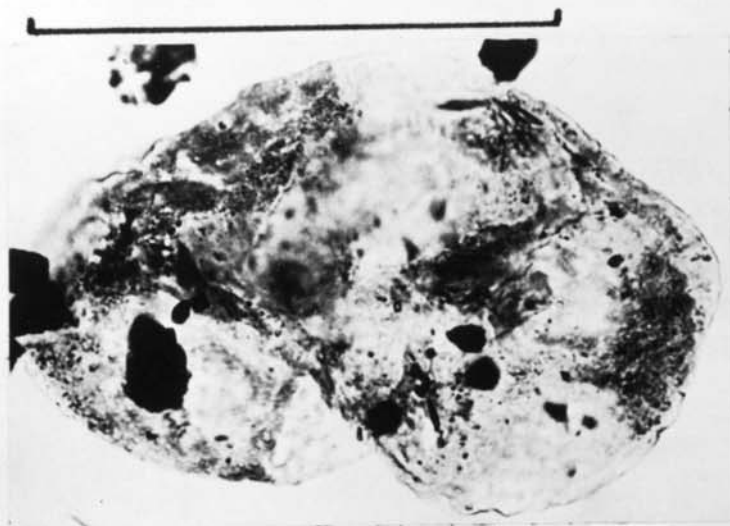
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EXPLANATION OF PLATE #3IOE NUKTAK C-22

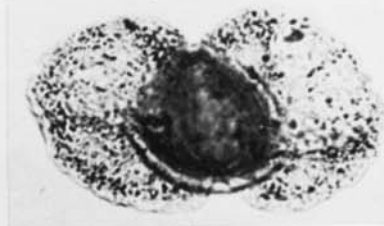
All figures approximately 750x. (Scale in top left represents 100u).

PLATE 3

47-49.	411	<i>Abies</i> 1
50.	24	<i>Podocarpidites multisimus</i>
51.	318	<i>Eucommiidites minor</i>
52.	247	<i>Aquilapollenites attenuatus</i>
53-54.	415	<i>Aquilapollenites</i> cf. <i>murus</i>
55.	361	<i>Aquilapollenites</i> cf. <i>trialatus</i>
56.	325	<i>Aquilapollenites</i> cf. <i>reticulatus</i>
57.	422	<i>Parviprojectus</i> 1
58-59.	369	<i>Cranwellia striata</i>
60-61.	398	<i>Basopollis</i> 1



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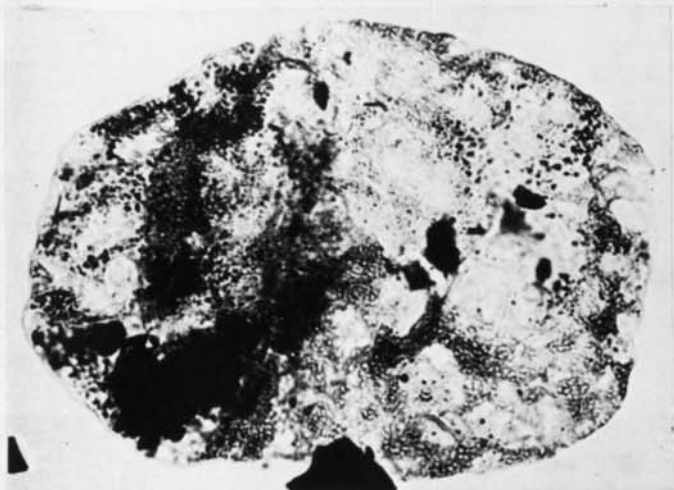
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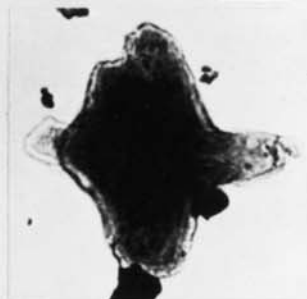
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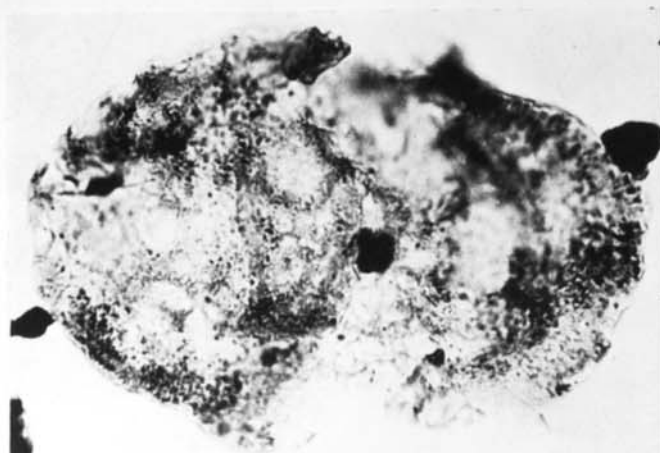
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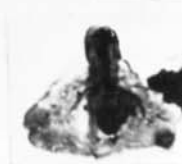
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## FOSSIL APPENDIX

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. *Taxodiaceapollenites Hiatus* (Potonie) Kremp
3. *Classopollis torosus* (Reissinger) Balme
4. *Cicatricosisporites hallei* Delcourt and Sprumont
5. *Alisporites bilateralis* Rouse
6. *Cingutritetes clavus* (Balme) Dettmann
7. *Gleicheniidites senonicus* Ross
8. *Cedripites cretaceous* Pocock
9. *Cerebropollenites mesozoicus* (Couper) Nilsson
10. *Perinopollenites elatoides* 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 Gamarro
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. *Hymenozonotritetes* 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. *Converrucosisporites 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. *Distaltriangulisporites 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. *Pilososporites trichopapillosus* (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. *Reticulisporites* 1
70. *Contignisporites dorsostriatus* (Bolchovitina) Dettmann
71. *Todisporites major* Couper
72. *Callialasporites* 1
73. *Marattisporites scabratus* Couper
74. *Leptolepidites epacornatus* 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. *Cirratiradites* cf. *Leiotriletes incertus* Bolchovitina
84. *Camarozonosporites* 1
85. *Acanthotriletes* 1
86. *Calamospora mesozoica* Couper
87. *Rubinella* 1
88. *Annulispora* 1
89. *Foraminisporis asymmetricus* (Cookson and Dettmann) Dettmann
90. *Protohaploxypinus 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. *Protohaploxypinus* 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. institatus* 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. *Pretricolpipollenites* 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. *Pilosisporites* 1
152. *Rugubivesiculites reductus* Pierce
153. *Camazonosporites 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. *Sequoiapollenites* 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 dividiuus* (Pierce) Brenner
167. *Klukisporites foveolatus* Pocock
168. *Costatoperforosporites foveolatus* Deak
169. *Appendicisporites erdtmanii* Pocock
170. *Schizosporis spriggi* Cookson and Dettmann
171. *Rugubivesiculites rugosus* Pierce
172. *Ornamentifera* cf. *echinata* (Bolchovitina) Bolchovitina
173. *Todisporites minor* Couper
174. *Foveotrilletes 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. *Acanthotrilletes 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. *trichopapillosus* (Thiergart) Del. and Sprumont
193. *Contignisporites multimuratus* Dettmann
194. *Contignisporites* cf. *multimuratus* Dettmann
195. *Cicatricosisporites* cf. *australisensis* (Cookson) Potonie
196. *Trilobosporites minor* Pocock
197. *Deltoidospora psilostoma* Rouse
198. *Sestrosporites* cf. *pseudoalveolatus* (Couper) Dettmann
199. *Matonisporites phlebopteroides* Couper
200. *Callialasporites dampieri* (Balme) Sukh Dev.
201. *Trilobosporites apiverrucatus* Couper
202. *Cicatricosisporites* cf. *potomacensis* Brenner
203. *Tauocusporites segmentatus* Stover
204. *Appendicisporites* cf. *A. macrorhiza* (Maljavkina) Bolchovitina
205. *Chomotrilletes fragilis* Pocock
206. *Cicatricosisporites purbeckensis* Norris

207. *Microreticulatisporites* cf. *uniformis* Singh
208. *Ischyosporites punctatus* Cookson and Dettmann
209. *Retitricolpites vulgaris* Pierce
210. *Reticulisporites elongatus* Singh
211. *Foveosporites canalis* Balme
212. *Striatopollis paraneus* (Norris) Singh
213. *Liliacidites textus* Norris
214. *Cirratriradites teter* Norris
215. *Lycopodiumsporites expansus* Singh
216. *Appendicisporites unicus* (Markova) Singh
217. *Quadrapollenites* 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* Mchedlishvili
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. *assymmetricus* (Cookson and Dettmann) Dettmann
251. *Caryapollenites* cf. *veripites* Wilson and Webster
252. *Stereisporites australe* (Cookson)
253. *Cercidiphyllites brevicolpatus* Mchedlishvili
254. *Tricolporopollenites* 2
255. *Zlivisporis* cf. *novamexicanum* (Anderson) Leffingwell
256. *Kuylisporites scutatus* Newman
257. *Aquilapollenites clarireticulatus* (Samoilovitch) Tschudy
258. *Aquilapollenites amygdaloides* Srivastava

259. *Umbosporites callosus* Newman
260. *Lusatisporis dettmannae* Srivastava
261. *Aquilapollenites rigidus* Tschudy and Leopold
262. *Marcelloporites basilicus* Srivastava
263. *Senipites drumhellerensis* Srivastava
264. *Liburnispiris adnacus* Srivastava
265. *Tricolpites reticulatus* Cookson
266. *Liliacidites morrinensis* Srivastava
267. *Tubulifloridites aedacula* Srivastava
268. *Cingulatisporites dakotaensis* Stanley
269. *Coriariopites* cf. *alienus* Srivastava
270. *Balmeisporites* 1
271. *Erdtmanipollis pachysandroides* 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. *Pulcheripollentia krempi* 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* (Drozhaschich)
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. *Cirratiradites* 1
304. *Inaperturopollenites* 2
305. *Stenozonotriletes* 3
306. *Hystricosporites* 1
307. *Acanthotriletes* 2
308. *Granulatisporites* 1
309. *Hymenozonotriletes* 1
310. *Calamospira* 1

311. *Retusotriletes* 1
312. *Perotriletes* 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. *Fraxinopollenites 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. *amygdaloides* Srivastava
335. *Costatoperforosporites fistulosus* Deak
336. *Cicatricosisporites auritus* Singh
337. *Rogalskisporites cicatricosus* (Rogalska) Danse, Corsin and Levin
338. *Foraminisporis daileyi*
339. *Taurocusporites* cf. *segmentatus*
340. *Tanuasporites spiniferus*
341. *Trilobosporites* cf. *minor*
342. *Hymenozonotriletes* 2
343. *Phyllocladidites* 1
344. *Cicatricosisporites annulatus*
345. *Couperisporites complexus*
346. *Cicatricosisporites angicanalis*
347. *Distalanulisporites verrucosus*
348. *Podocarpidites arcticus*
349. *Pteruchipollenites microsaccus*
350. *Ceratosporites varispinosus*
351. *Circulina* 1
352. *Distalanulisporites 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 sanctaebabarbarae*
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 delicatulus*
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. *Striadiporites* 1
- 551. *Striadiporites* 2
- 552. *Stephanocolporites* 1
- 553. *Pulcheripollenites* cf. *krempi* 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. *Astrocysta cretacea* (Pocock) Davey
- M3. *Micrhystridium* 1
- M4. *Odontochitina striatoperforata* Cookson and Eisenack
- M5. *Apteodinium* cf. *A. reticulatum* Singh
- M6. *Leiofusa bernesa* Cramer
- M7. *Hystriosphæridium cooksoni* Singh
- M8. *Gonyaulacysta tenuiceras* (Eisenack) Sarjeant
- M9. *Veryhachium europæum* Stockmans and Williere
- M10. *Meiourogonyaulax* cf. *M. stoveri* Millioud
- M11. *Baltisphaeridium crameri* Singh
- M12. *Scrinioidinium* 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 pelliiferum* 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. *Cribooperidinium orthoceras* (Eisenack) Davey
- M26. *Diplotesta angelica* Cookson and Hughes
- M27. *Gardodinium elongatum* Singh
- M28. *Oligosphaeridium anthophorum* (Cookson and Eisenack) Davey
- M29. *Hystriosphæra 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 albertense* Pocock
- M35. *Broomea jaegeri* Alberti
- M36. *Odontochitina operculata* (Wetzel) Deflandre
- M37. *Hystriosphæra ramosa* (Ehrenberg) Wetzel
- M38. *Cyclonephelium* cf. *C. vannophorum* Davey
- M39. *Pseudoceratium* cf. *P. expolitus* Brideaux
- M40. *Apteodinium* cf. *A. granulosum* 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 & Wetzel
- M47. *Veryhachium reductum* (Deunff) de Jeckowski
- M48. *Palaeostomocystis fragilis* 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. *Meiourogonaulax* 1
- M65. *Wanaea digitata* Cookson and Eisenack
- M66. *microforaminifera*
- M67. *Pareodinia* 1
- M68. *Gonyaulacysta* cf. *G. granuligera* (Klement)
- M69. *Xenicodinium* 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* (Firtion) 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 pelliifera* 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* *schindelwolffi* (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. *piliiferum* 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. *Wetzeliiella* cf. *tabulata* Wilson  
M165. *Deflandrea* cf. *microgranulata* Stanley  
M166. *Deflandrea* cf. *cretacea* Cookson  
M167. *Deflandrea* cf. *tenera*  
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. *Kalypte* *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. *Kalypte* cf. *diceras* 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* *deunffi* 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. *Wetzeliiella* 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* *rhomboidinium* Downie
- M229. *Wetzeliiella* 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. *Astrocysta* 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. *wetzelii* Morgenroth
- M252. *Deflandrea* *microgranulata* Stanley
- M253. *Leptodinium* 1
- M254. *Cannosphaeropsis* sp. indet.
- M255. *Wetzeliiella* *homomorpha* *quinquelata* Williams and Downie
- M256. *Ceratiopsis* 2
- M257. *Rhombodinium* 1

MICROPALEONTOLOGICAL STUDY

BY

DR. W. BRAUN

## SUMMARY OF MICROPALAEONTOLOGICAL STUDY

## General Remarks

206 slides were available for micropaleontological study. The uppermost 1050 feet of the section were covered by samples spaced about 100' apart; from this level to about 12,500', spacing was either 50' or 60' apart, narrowing to 30-foot intervals in the lowermost 120' of the borehole.

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 fauna of the youngest and pre-Recent assemblage in the uppermost part of this borehole. 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 phototgraphic 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

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PALYNOLOGY    Norris, 1976			MICROPALAEONTOLOGY    Braun & Brooke, 1976	
	Zones	Environment	Age	
	NT-1	non-marine with rare, scattered, thin marine intervals	NEOGENE	open, shallow-marine, near-shore to lagoonal
1000	1110'			ASSEMBLAGE I
2000	NT-2		(equivalent)	1900' restricted-marine
3000	NT-3		OLIGOCENE	
4000	4310'			
5000	NT-4	MIDDLE - UPPER EOCENE (possibly Oligocene in part)		no diagnostic microfauna
6000	5280'			
7000	NT-5			6960'
8000	7590'			
9000	NT-6			53 52
10,000	8590'			restricted-marine
11,000	NT-7			
	10,980'			
12,000	NT-8	near-shore marine		
	12,600' T.D.			
				ASTRORRHIZID ? - FAUNA
				severely restricted - marine?

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 Nuktuk borehole seem to be not too excessive.

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 occurrences 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 stage and ages that are used are those adopted from palynological studies, and the micropaleontological data are summarized in a table with the palynological ones shown alongside.

#### Microfaunal Assemblages

Two major microfaunal complexes and two minor assemblages were encountered although the section was considered to be mainly of non-marine origin with rare, scattered, thin marine intervals by Norris, and based on palynological evidence.

#### ASSEMBLAGE I

The widespread and characteristic Assemblage I - Fauna was encountered from about 90' to 950' of the uppermost section of the borehole. Elphidiid and miliolid Foraminifera, and a few shallow-water, marine ostracods are prevailing in the 90 to 690 - foot interval; freshwater ostracods replace this fauna down to the 950-foot level. Clearly then, the fauna seems to be of shallow-marine origin in the upper, and of freshwater origin in the lower part of this assemblage interval. In other wells, the freshwater and marine components are more mixed, indicating a more complex pattern of intergrading facies.

Miliolid Foraminifera and heavily sculptured cythereid ostracods, with typically well-developed hinges are characteristic of open-marine, shallow and near-shore environments, whereas the elphidiids occur also in lagoons and embayments. Characteristic for these assemblages, including Assemblage I, is the dominance of calcareous forms and the scarcity, if not absence of the agglutinated Foraminifera indicating that freshwater influences and restrictive conditions

were minimal to absent.

In contrast, the freshwater ostracods with such typical representatives as the genera Candona, Iliocypris and Limnocythere are unmistakable indicators of lacustrine environments, and a major shift in the environment of deposition must have taken place at about the 690-foot mark.

Assemblage I is referred to as the "Sigmodontis-Ostracod-Elphidium-Assemblage" in Staplin's (et al.) summary, and is shown on their correlation chart to occupy the highest part of the Neogene section and zone T4 c. in Taglu C-42. Chamney shows a relatively thick Pleistocene to Recent section (unit 1 and 2) in the Reindeer D-27 borehole which contains ostracods and chara. This section seems to be particularly thick in the Tuk F-18 well and was found in many other boreholes according to his cross-section. Norris' NT1 -Zone of Neogene age spans about the same sample interval as does Assemblage I.

#### ASSEMBLAGE II ( ? equivalent )

A few badly preserved specimens of some Foraminiferal species and a few ostracods are spread erratically over the 950 to 1900-foot interval. Agglutinated Foraminifera dominate in this "shadow-fauna" indicating restricted to severely restricted marine conditions. Some of these forms, if not all, may be even re-worked.

For these reasons, the fauna cannot be exactly placed in its proper stratigraphic position. It may be a restricted-marine equivalent of Assemblage I, or it may be such an equivalent of the underlying Assemblage II, as is suggested tentatively and until more precise age dates are available.

The Assemblage II-fauna is commonly composed of many rotaliid and miliolid Foraminifera, without the elphidiids and marine ostracods; as such it would indicate that it developed "seaward" of the Assemblage I - fauna.

Assemblage II is equivalent to Staplin's (et al.) Asterigerina 501-Fauna that marks the lower part of their Neogene section and the upper part of their T4 a - Zone in the Taglu C-42 borehole. Norris' NT 2-Zone of Neogene age spans the same interval at Nuktuk as does the "undiagnostic or shadow fauna".

#### HAPLOPHRAGMOIDES 53 and BATHYSIPHON 153 - FAUNA

This assemblage is dominated by two abundant and quite characteristic species groups: the Haplophragmoides 53 and 154, and the Bathysiphon 52 and 153 group.



As the study proceeded it was found necessary to split the original species in order to accomodate some distinctive variations.

This fauna appears at the 6960' level at Nuktuk and continues nearly uninterrupted to about 11,600 feet of the section. Both groups are abundantly represented. How much of contamination is involved cannot be ascertained without the results from core samples, but it is assumed that this fauna covers a rather long interval, and indicating that restricted, but restricted-marine conditions prevailed, as may have been present in the landward part of an estuarine setting where freshwater influences were strong and marine influences relatively weak.

There is no diagnostic fauna above or below this interval to place it in its proper stratigraphic framework, and it has to stand on its own for this reason. Norris gives a Middle and Upper Eocene, possible Oligocene (in part) age assignment for this interval, spanning the lower part of his NT 9 - Zone and the upper part of his NT 6 to 7 sequence. Such evidence, therefore, would place this fauna relatively high in the Tertiary succession.

#### Undiagnostic Fauna

The base of the section, from 11,600' to 12,600' T.D. contains obscure but nevertheless characteristic fragments which are questionably referred to a very primitive foraminiferal group, the Astrorhizidae, but which might be of any other origin. These fragments are associated also with many plant remains. A severely restricted-marine environment is suggested, but cannot be proven without finding any more diagnostic, associated faunal elements.

#### 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.

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

Assemblage I - ostracods

\* Freshwater forms; all others of open-marine, shallow-water origin.

Ostracod	2*
	3*
	5
	6
	7
	8
	9
	11*
	14
	15

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Plate II

Assemblage I - Foraminifera (calcareous forms)

Bolivina	45	
Cyclogyra	33	
Elphidium	25	
Elphidium	26	
miliolid	32	
miliolid	43	
miliolid	47	
miliolid	48	
miliolid	54	
Orbitoides ?	39	
polymorphinid	44	
polymorphinid	51	(specimen reverse)
rotaliid (Nonion?)	42	
Vaginulinopsis	50	

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Plate III

Miscellaneous agglutinated Foraminifera

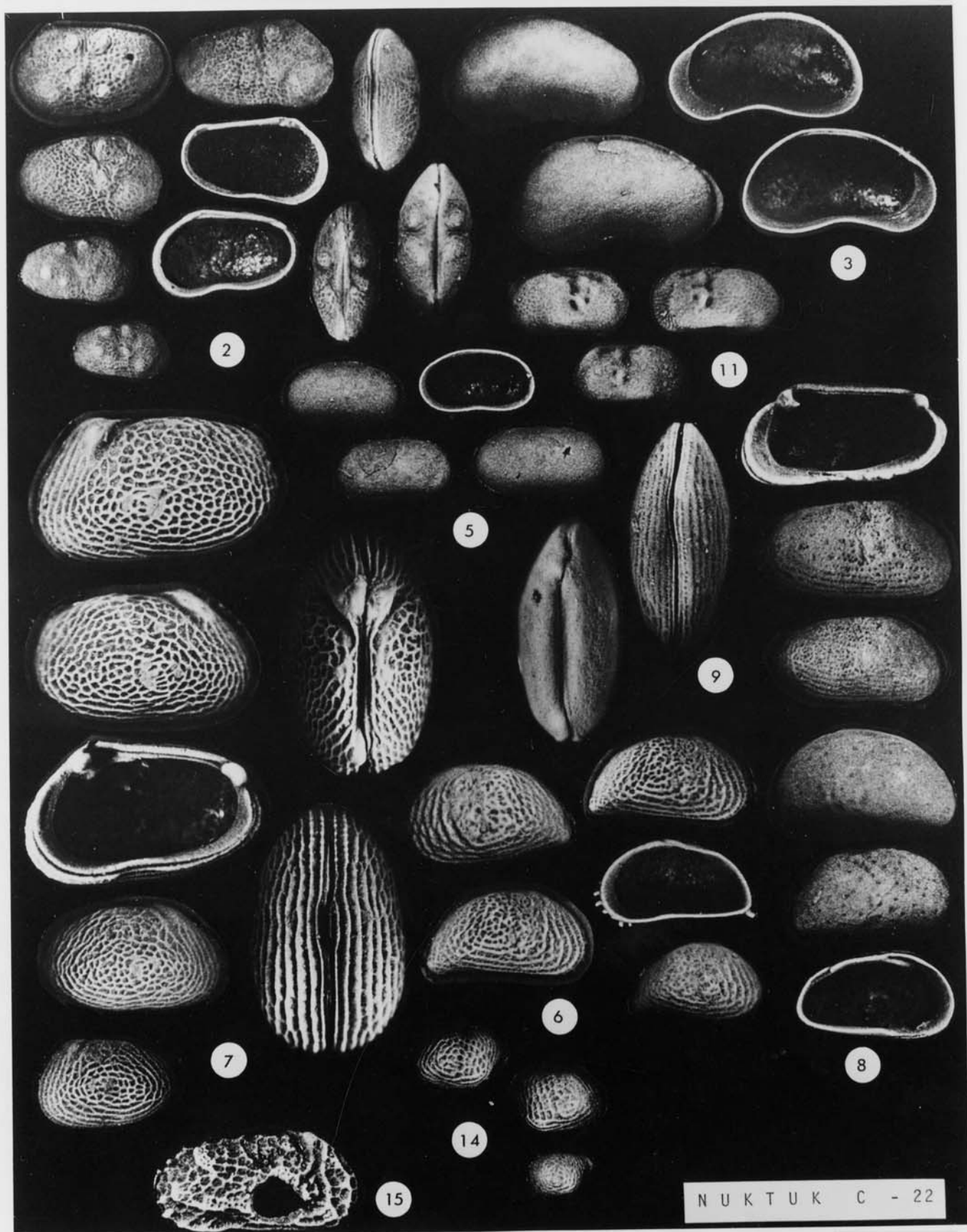
Ammobaculites	46
Ammodiscus	55
astrorhizid ?	61
Bathysiphon	40
Bathysiphon	52
Bathysiphon	153
Gaudryina	57
Glomospira	38
Reophax ?	59
Textularia	49

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Plate IV

Miscellaneous agglutinated Foraminifera

"Cyclammina"	cf	71
Haplophragmoides		1
Haplophragmoides		27
Haplophragmoides		53
Haplophragmoides		154
Trochammina		56
Trochammina		60



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