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Palynomorph biostratigraphy of Eocene samples from the Sagavanirktok Formation at Franklin Bluffs, North Slope of Alaska

By

Norman O. Frederiksen[1], Lucy E. Edwards[1], Thomas D. Fouch[2], L. David Carter[3], and Timothy S. Collett[2]

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[1]Reston, Virginia
[2]Denver, Colorado
[3]Anchorage, Alaska

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ABSTRACT

This report discusses the palynomorph (dinocyst, pollen, fungal spore) analyses of 20 samples from four stratigraphic sections in the Sagavanirktok Formation at Franklin Bluffs, North Slope of Alaska. The analyses were performed to obtain information about the ages, environments of deposition, and provenance of the sediments as well as the nature of the terrestrial paleoclimate during the time of deposition.

Sections 1 and 2, in the southern part of the Franklin Bluffs area, are composed mainly of laminated mudrock and sandstone and belong to the Franklin Bluffs Member of the Sagavanirktok Formation but appear to be the temporal equivalent of the Mikkelsen Tongue of the Canning Formation. The lowest part of Section 1 is early early Eocene in age; the remainder of the section is probably early Eocene or may be as young as middle Eocene at the top. Section 2 is approximately the same age as Section 1, the lower part of the section being early Eocene and the upper part probably being early or middle Eocene. Section 3 is very close geographically and lithologically to Sections 1 and 2 but has not been examined for palynomorphs.

Sections 4 and 5 are at the southern end of Franklin Bluffs. Section 4 is a thin coaly interval that apparently forms the top of the Sagwon Member of the Sagavanirktok Formation; the coaly beds are probably early Eocene in age. Section 5, a thin silty and clayey exposure less than 10 m topographically above Section 4, is early (but not earliest) Eocene or middle Eocene in age and belongs to the Franklin Bluffs Member.

In all samples that contained reasonably well preserved dinocyst assemblages, the environment of deposition was nearshore marine or estuarine. Reworked late Paleozoic and early Mesozoic(?) spores, Campanian and Maastrichtian pollen grains, and Cretaceous dinocysts were found in many samples and reflect at least in part the provenance of the sediments. The terrestrial paleoclimate was probably subtropical or possibly temperate.

INTRODUCTION

This report concerns the palynological examination of 25 outcrop samples from Franklin Bluffs, North Slope of Alaska (figs. 1, 2; table 1). Samples were analyzed to determine their ages and to infer some information about the environments of deposition of the sediments, the provenance of the sediments (based on reworked palynomorphs), and the nature of the terrestrial paleoclimate. Twenty of the samples contained reasonably well preserved palynomorph (dinocyst, pollen, and fungal spore) assemblages. The samples were collected by Frederiksen in August, 1992, from four localities (in this paper, termed Sections 1, 2, 4, and 5) along the Franklin Bluffs (figs. 1, 2). The Franklin Bluffs extend along the east side of the Sagavanirktok River from sec. 17, T. 6 N., R. 14 E., to sec. 27,

T. 5 N., R. 14 E., Sagavanirktok (D-3) 1:63,360 quadrangle (fig. 2).

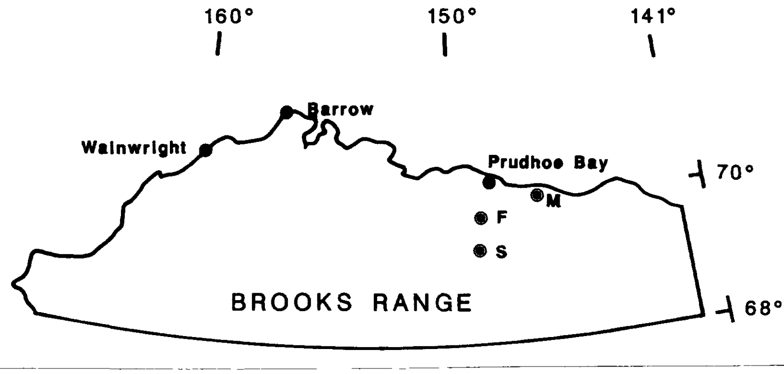

Figure 1. Index map showing location of Franklin Bluffs (F), Sagwon Bluff (S), and the Mobil Oil Corporation West Staines State no. 2 well (M) in northern Alaska.

STRATIGRAPHY AND PREVIOUS AGE DETERMINATIONS

Samples discussed in this paper are from the Sagavanirktok Formation (tables 1, 2), whose type locality is at Franklin Bluffs (Gryc and others, 1951) as is the type section of the Franklin Bluffs Member of the Sagavanirktok (table 2; fig. 2, Section A; Detterman and others, 1975).

Detterman and others (1975) stated (p. 38) that "the contact [of the Franklin Bluffs Member] with the underlying Sagwon Member [also of the Sagavanirktok Formation] is probably conformable, although not visible in these poorly exposed sections." These authors (1975, fig. 13, Section 22) did not see the coal bed at the south end of Franklin Bluffs (Section 4 of this paper). Because they (p. 38) defined the Sagwon Member as "the coal-bearing sequence of the Tertiary in northeastern Alaska," Section 4 of this paper appears to represent the uppermost part of the Sagwon Member.

Sections 1 and 2 are 52 m and 61 m thick, respectively, and Sections 4 and 5 are each less than 5 m thick (fig. 3). Detterman and others (1975) estimated that the Franklin Bluffs Member is at least 900 m and perhaps as much as 1,500 m thick; therefore, the strata sampled for palynomorphs represent only a small fraction of the total thickness of the member, and probably only the lowermost part. However, Ager and others (1986) sampled and dated silty strata to the north of our sections (fig. 2, Section A), and if their samples are from considerably higher in the member than ours, then it would be possible to state that

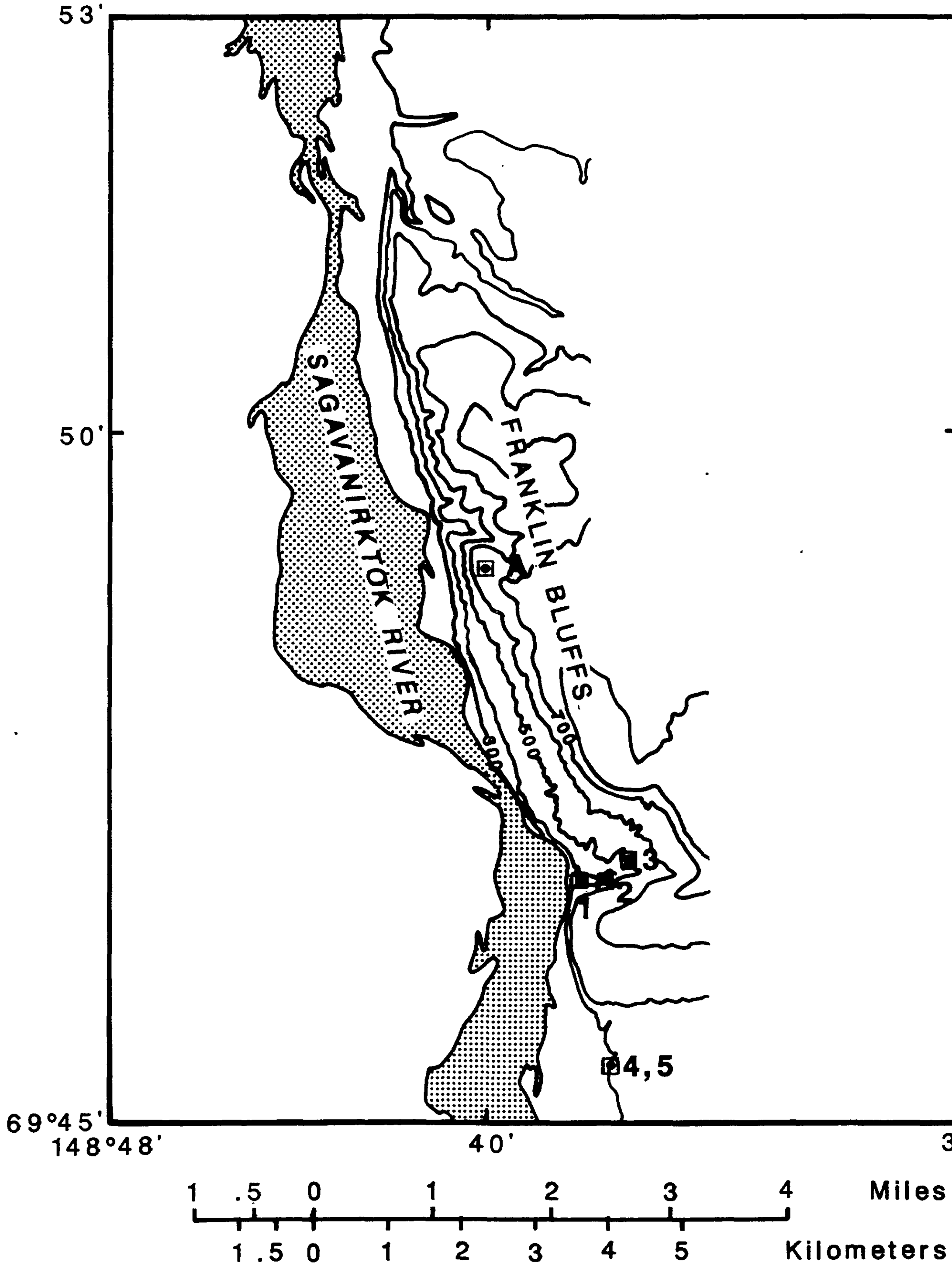

Figure 2. Location of stratigraphic sections at Franklin Bluffs. 1-5, sections described in this paper. A, type area of the Franklin Bluffs Member of the Sagavanirktok Formation, and the area sampled by Ager and others (1986).

Table 1. Samples examined for palynomorphs. Samples of the R4717 and R4718 series are from Sections 1 and 2, respectively; samples R4713 C-F and R4713 G-I are from Sections 4 and 5, respectively.
Summary of palynological analyses: P, pollen analysis completed; R, pollen present but rare; B, barren of palynomorphs; D, indigenous dinocysts found.

Paly-nology number	Field number	Stratigraphic position (above (+) or below (-) base of measured section for samples of the R4717 and 4718 series)	Lithology	Palyno-logical analysis
R4717A	NF92AK 1	-0.5 m	Shale, medium-gray, silty	P,D
B	2	+0.7 m	Shale and sandstone, interlaminated, clay-rich, medium-gray	B
G	7	+15.9 m	Shale, medium-dark-gray	R,D
H	8	+19 m	Mudrock, medium-gray, laminated, 3 1"-thick beds	P
L	12	+29 m	Mudrock, medium- to medium-dark-gray, with fine-grained sandstone laminae	P,D
N	14	+33 m	Similar to sample 12	P,D
P	15	+34 m	Similar to sample 12, but sandier	P,D
X	23	+47 m	Mostly sand, beds <1" thick, with interbeds of clay, medium-gray	P
Y	24	+48 m	Similar to sample 23	P,D
Z	25	+50 m	Mudrock, dark-gray, 1" bed in light-gray mudrock-sandstone sequence	R
R4718 A	27	+1 m	Mudrock, medium-gray, soft, laminated	P
B	28	+3 m	Similar to sample 27	P
E	31	+11.7 m	Mostly mudrock, medium-gray, laminated	P,D
G	33	+20 m	Mudrock, medium-dark-gray, bed <1" thick within brown mudrock	P
I	35	+26.1	Mudrock, medium-dark-gray, laminated, within sand-mudrock interval	P
L	38	+32.6 m	Mudrock, medium-gray, interbedded with sandstone, weathered	P
M	39	+39 m	Mudrock, medium- to medium-dark-gray, with sandstone interbeds	R,D

R4718 P	41	+41.5 m	Claystone and mudrock, medium- to medium-dark-gray	P
R4713 C	43	Top of coal bed, which is overlain by Quaternary(?) gravel	Coal	R
D	44	Middle of coal bed	Coal	R
E	45	Lower part of coal bed	Coal	R
F	46	Basal part of coaly sequence	Muddy coal or coaly mudrock	P
G	47	Base of exposure	Sandstone, muddy, fine-grained, weathered	P,D
H	48	Middle of exposure	Clay, medium-brownish-gray, sandy, somewhat weathered	P,D
I	49	Top of exposure	Siltstone, medium-light-brown	R,D

Table 2. Members of the Sagavanirktok Formation (in descending order; Detterman and others, 1975; Ager and others, 1986; this report).

Member	Lithology	Age
Nuwok Member	Mainly sand, mudrock, and siltstone	Late Tertiary
Franklin Bluffs Member	Laminated mudrock, fine-grained sandstone, silt, and clay, overlain by sand, gravel, and volcanic ash	Eocene, Oligocene(?), and Miocene(?)
Sagwon Member	Shale, sandstone, conglomerate, and coal	Paleocene and Eocene

perhaps the lower half of the member has now been reasonably well dated.

Detterman and others (1975, p. 37, 39) thought that "the beds at Franklin Bluffs are younger than Eocene" and that the Franklin Bluffs Member of the Sagavanirktok Formation "represents at least the Oligocene(?) and Miocene(?) strata, and may possibly include more of the Tertiary sequence," but these authors had no fossils from the Franklin Bluffs Member on which to base this determination. Furthermore, Detterman and others (1975, p. 39) suggested on the basis of lithology that the Franklin Bluffs

Member might represent "semiarid conditions in which varved silt and clay beds were deposited in large shallow lakes." In contrast, Ager and others (1986, p. 243) demonstrated on the basis of pollen and dinocysts that (1) the laminated silty and clayey deposits of the Franklin Bluffs Member at its type locality (Section A, fig. 2) are early to middle Eocene in age, and (2) the strata are likely to be at least in part of marine origin. Sedimentologic studies by Fouch and Carter (Fouch and others, 1993, p. 2) have shown that the laminated mudrock and fine-grained sandstone of Sections 1-3 (fig. 2), some 4.5 km south-southeast of the type area of the Franklin Bluffs Member, were deposited in "shallow marine to estuarine? sites." An apparent lateral equivalent of the laminated silty deposits of the Franklin Bluffs Member is mentioned in the "Comparison and Summary" part of this report.

The Sagwon Member of the Sagavanirktok Formation has been dated at its type locality (fig. 1), by means of very low-diversity pollen assemblages, as Paleocene, apparently early Paleocene (T. A. Ager, in Carey and others, 1988, and in Spicer and Parrish, 1990).

SAMPLE LOCALITIES

Five stratigraphic sections along the southern part of the Franklin Bluffs have been described by Fouch and Carter (fig. 3), and, as stated, four of them were sampled for palynomorphs.

Section 1 is located at the mouth of a small west-flowing unnamed stream entering the Sagavanirktok River at NE$^1/_4$ NE$^1/_4$ sec. 21, T. 5 N., R. 14 E. (lat. 69°46.72′ N., long. 148°38.17′ W.). The lowermost 10 m of Section 1 are exposed on the north side of the stream at its mouth but most of the section was measured along the faces of the westernmost gully that is developed on the south side of the stream.

Sections 2 and 3 are east of Section 1 but in the same unnamed stream drainage. Section 2 is located in SE$^1/_4$ NW$^1/_4$ NW$^1/_4$ sec. 22, T. 5 N., R. 14 E. (lat. 69°46.70′ N., long. 148°37.57′ W.); it follows a small gully developed in the south side of the stream. Section 3 was measured along the main course of the unnamed stream and is in NE$^1/_4$ NW$^1/_4$ sec. 22, T. 5 N., R. 14 E. (lat. 69°46.94′ N., long. 148°37.09′ W.).

Sections 1-3 are composed mainly of noncalcareous mudrock and very-fine-grained sandstone. The lithology of samples examined for palynomorphs is given in table 1; palynomorph samples were not collected from Section 3.

Sections 4 and 5 are at the south end of Franklin Bluffs, about 2.4 km south of Sections 1 and 2, in the SE$^1/_4$ NW$^1/_4$ SW$^1/_4$ sec. 27, T. 5 N., R. 14 E. (lat. 69°45.39′ N., long. 148°47.42′ W.). Section 4 exposes a coal bed about 1 m thick composed mainly of thick lignitized wood fragments but with a few siltstone interbeds as much as 1 cm thick; at the base of the exposure is dirty coal or coaly mudrock. The coal bed is overlain by Quaternary(?) gravel. In 1984, T. A. Ager (written

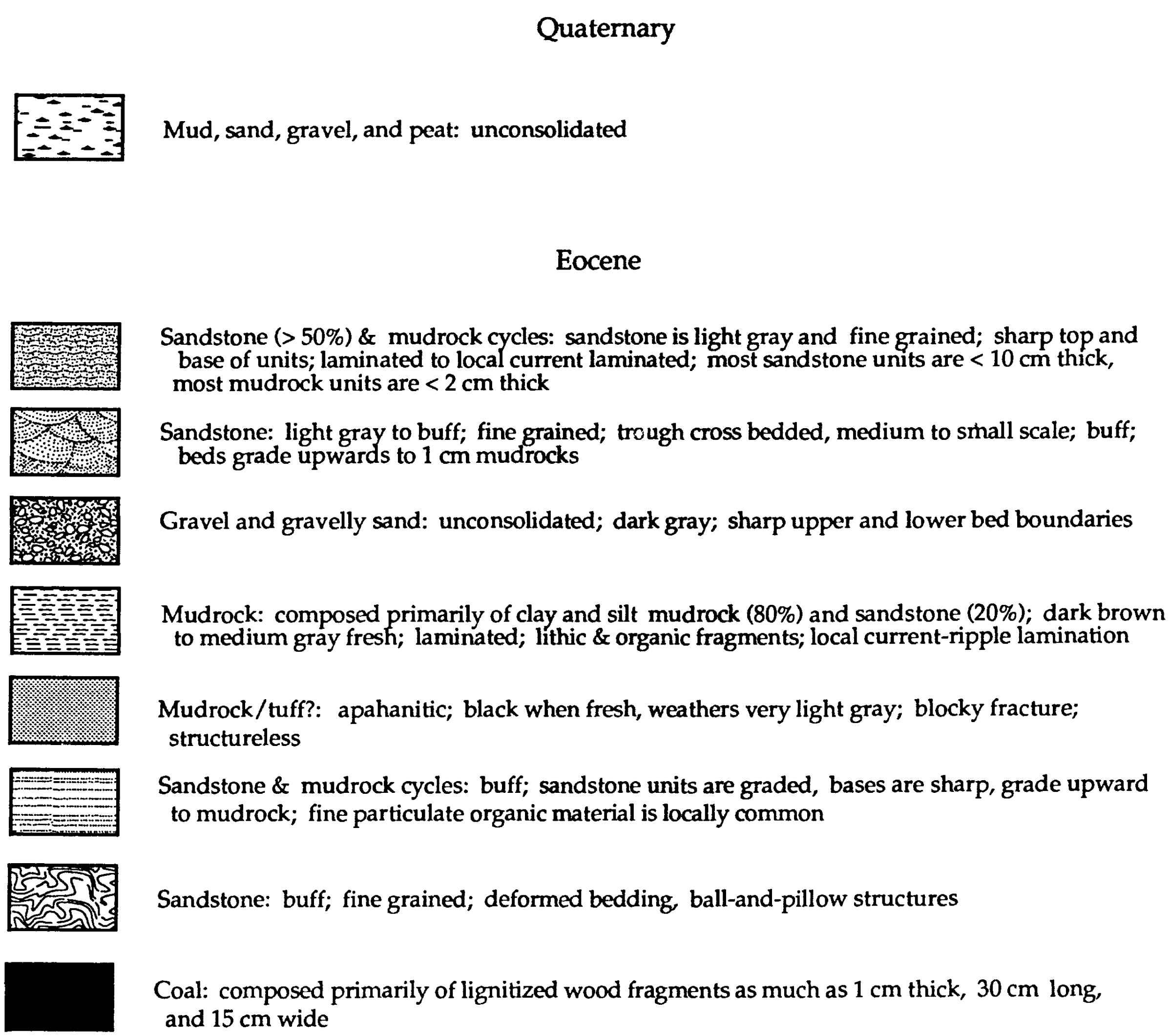

Figure 3a. Lithology of Eocene and Quaternary strata in sections 1-5, southern Franklin Bluffs, North Slope Borough, Alaska; symbols used in the diagrams.

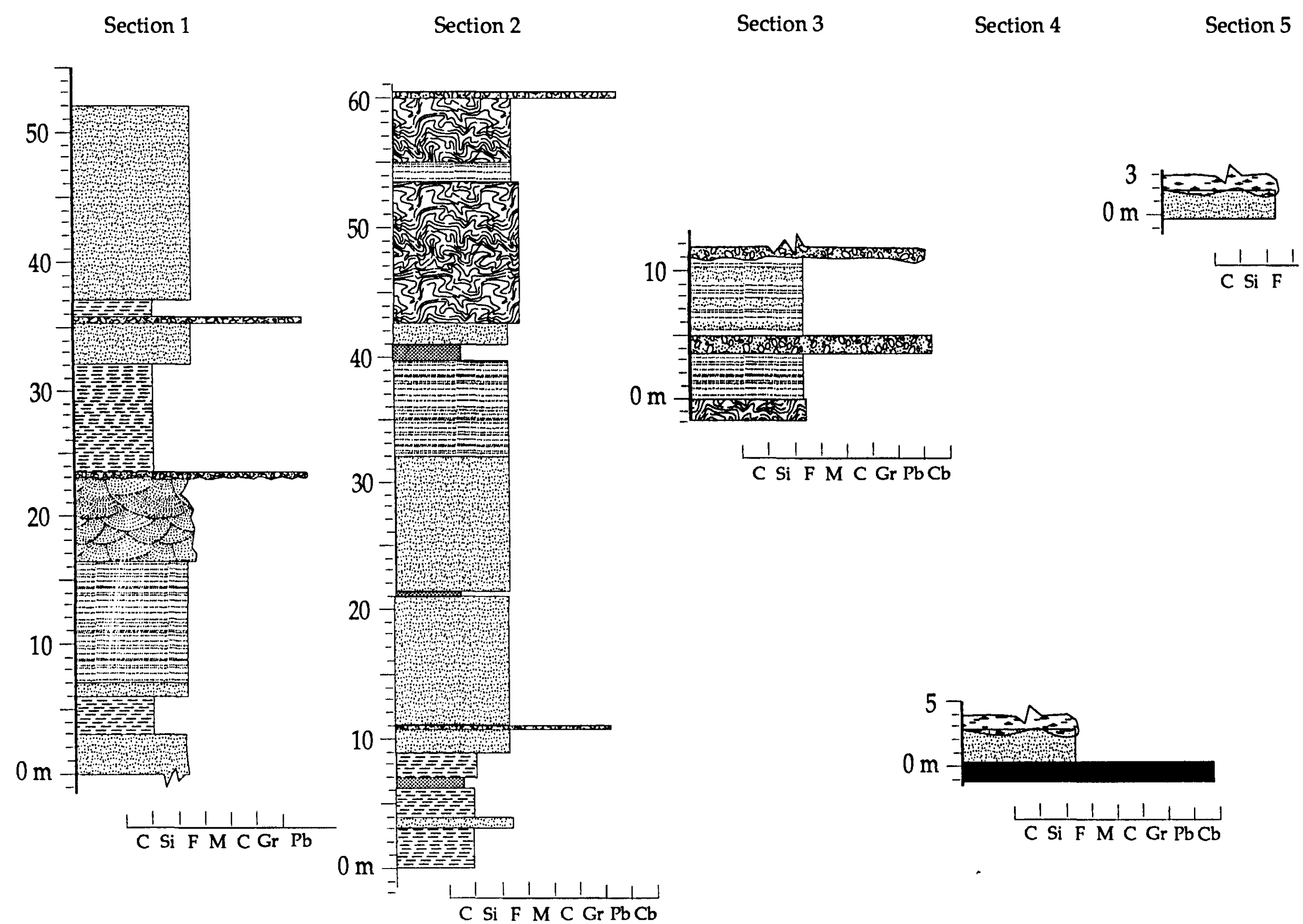

Figure 3b. Lithology of Eocene and Quaternary strata in sections 1-5, southern Franklin Bluffs, North Slope Borough, Alaska; section diagrams. Placement of the sections on this diagram does not imply biostratigraphic or stratigraphic correlation.

commun., 1984) collected palynomorph samples at the south end of Franklin Bluffs from a thin coal-bearing exposure that probably is the same as Section 4 of this paper (fig. 2). However, Ager and others (1986) did not include data on this exposure in their report on the palynology of their Franklin Bluffs samples. Section 5 is about 50-70 m north of and less than 10 m topographically above Section 4; Section 5 is exposed in the wall of the first east-west gully north of Section 4. At Section 5, 2.5 m of mudrock, muddy sandstone, and sandy clay are exposed.

Dips of strata in the sampled area are low, generally 4° or less to the north or south. However, the strata are cut by normal faults, and one of these, a southeast trending down-to-the-east fault in NE$^1/_4$ NE$^1/_4$ sec. 21, T. 5 N., R. 14 E., lies between Sections 1 and 2. Sections 1 and 2 are lithologically different from each other (fig. 3); therefore, based on lithologic data, Section 2 appears to have been downdropped at least 60 m relative to Section 1 and appears to represent younger strata than in Section 1. However, as will be explained in the next part of this report, Sections 1 and 2 are biostratigraphically coeval (fig. 4).

PALYNOLOGY

Published palynological investigations of strata at Franklin Bluffs began with collection of samples there in 1984 by T. A. Ager. He sampled two localities, one in the central area of the bluffs, here termed Section A, and one at the south end of the bluffs, a thin coal-bearing exposure that probably is the same as Section 4 of this paper (fig. 2).

In this report, we discuss pollen, fungal spore, and dinocyst assemblages from 20 samples, as follows:

Section	Number of samples
1	8
2	8
4	1
5	3

Section 1

Dinocysts

Six samples were examined from this section (table 3). The lowest sample examined is of early early Eocene age (approximately correlative to calcareous nannofossil zone NP10). *Apectodinium parvum* has a reported range of late Paleocene to early Eocene (NP9-NP10). The genus *Wetzeliella* has its lowest occurrence in the lower Eocene; *W. articulata* has its lowest occurrence in "mid" NP10.

Table 3. Distribution of dinocyst taxa in samples of sample series R4717, from Section 1. Samples run from oldest on the left to youngest on the right. X signifies that the taxon is present.

Taxon	Sample A	G	L	N	P	Y
Apectodinium parvum	X					
Areoligera sp.	X					
Diphyes colligerum	X					
Hystrichokolpoma sp.	X					
Operculodinium centrocarpum	X					
small, peridinioid	X		X	X		X
Spiniferites spp.	X		X	X		
Wetzelliella cf. *W. articulata*	X			X		
Phthanoperidinium echinatum		X				
Charlesdowniea stellata				X	X	
Cretaceous forms						
Chatangiella spp.	X	X		X		
Other	X	X		X		

Sample R4717G contains poorly preserved dinocysts, including *Phthanoperidinium echinatum*. This species has its lowest occurrence in lower but not lowermost lower Eocene (NP11). The sample could be as young as middle Eocene; none of the species present is very helpful in setting a minimum age.

Sample R4717N contains specimens of *Charlesdowniea stellata* (this is the same form that was recorded by McIntyre (1985) as *Kisselovia tenuivirgula* and Brideaux (1976) as *Wetzeliella articulata conopia*). This species has been reported from rocks dated as early or middle Eocene.

Thus, the best interpretation of the age of these samples is the early part of the early Eocene, with the section ranging in age from approximately "mid" NP10 to NP11. However, if the section is not continuous, the higher samples could be as young as middle Eocene.

The environment of deposition was nearshore marine or estuarine. Reworked Cretaceous dinocysts are conspicuously present.

Pollen and fungal spores

Many pollen taxa were found in the seven samples examined from Section 1 that contained well preserved palynomorphs (table 4). These samples are Eocene in age, particularly because of the

Table 4. Distribution of pollen taxa and fungal spores in samples of sample series R4717, from Section 1. Samples run from oldest on the left to youngest on the right. X, present; P, identification probable; ?, identification possible; A = aff., meaning the specimen is very similar to and may belong to the taxon; C = cf., meaning the specimen is similar to but probably does not belong to the taxon.

Taxon	Sample						
	A	H	L	N	P	X	Y
Triatriopollenites sp. 1					X		X
Triatriopollenites spp.	X	X		X	X	X	X
Triporopollenites megagranifer type					X	X	
Triporopollenites mullensis	X				X	X	
Paraalnipollenites confusus type H							X
Paraalnipollenites confusus type Z							X
Trivestibulopollenites spp.						X	
Betulaepollenites spp.	X			X			
Carya <29 µm	X		X		X	X	X
Caryapollenites prodromus group, type 1	X			X		X	
Caryapollenites prodromus group, type 2	X	X	X		X	X	X
Plicatopollis sp.							X
Pistillipollenites mcgregorii	X			X	X	X	P
Corsinipollenites sp.		X					
Ulmipollenites tricostatus	X	X	X			?	
Ulmipollenites undulosus	X	X	X	X	X	X	X
Alnipollenites verus	X			X	X	X	X
Pterocarya spp., 5- to 8-porate	X	X	X	X	X	X	X
Liquidambar type 1					X		
Liquidambar type 2						X	
Eucommia sp.						X	
Ilexpollenites spp.							?
Horniella sp. 1							C
Rhoipites latus type of Rouse (1977)	X				X		X
Rhoipites angustus type					X		
Nyssapollenites sp. 1	X						
Nyssapollenites sp. 2						X	
Lanagiopollis spp.				X			X
Bombacacidites paulus type			X			X	X
Intratriporopollenites sp. 1			X	X	A		X
Intratriporopollenites sp. 2	X		A	X	X	X	X
Pompeckjoidaepollenites subhercynicus	X						
Novemprojectus sp.	X			P			
Ericipites spp.	X		X	X	X		
Pasavis tagluensis			X				

presence of *Pompeckjoidaepollenites subhercynicus*, which migrated from western Europe to North America very early in the Eocene. Finding a specimen of *P. subhercynicus* in the Arctic was very significant; previously, the highest-latitude known specimens were from Massachusetts (Frederiksen, 1984), and although the migration of the species from Europe by way of Greenland could be inferred from paleogeographic and geologic range data, it is important to have confirmation that the species indeed could live at very high latitude.

The long list of tricolporate insect-pollinated taxa (from *Ilexpollenites* sp. to *Intratriporopollenites* sp. 2 in table 4) is certainly also indicative of an Eocene or younger age.

Novemprojectus sp., found in Sections 1 and 2, is interesting because most species of the triprojectate pollen group became extinct at the end of the Cretaceous. *Novemprojectus* has previously been known only from the middle Eocene of the Canadian Arctic (Choi, 1984). McIntyre and Ricketts (1989) summarized the known occurrences of a similar species, *Aquilapollenites tumanganicus* (see table 11), in China, easternmost Siberia, and northern Canada, and noted that the geologic range of *A. tumanganicus* seems to be upper Paleocene to lower Eocene. However, because of a scarcity of photomicrographic documentation of *Novemprojectus* and *Aquilapollenites tumanganicus* from the Canadian Arctic, the range base of *Novemprojectus* in that region is poorly known.

McIntyre (1985, p. 45) reported that in the Paleocene to middle Eocene of the Beaufort-Mackenzie Basin, northwest Canada, "fungal spores [including] *Pesavis tagluensis* are often common to abundant." However, *Pesavis* is rare in Paleocene samples from the Colville River area of northern Alaska (Frederiksen and others, 1988) and also in the present samples from Franklin Bluffs, where only one specimen of *P. tagluensis* was found, in Section 1.

Section 2

Dinocysts

Two samples from this section were examined for dinocysts (table 5). These are approximately the same age as the samples in Section 1. The lower sample (R4718E) could be as old as late Paleocene or as young as early Eocene. The upper sample (R4718M) is most likely of early or middle Eocene age.

The environment of deposition was nearshore marine or estuarine. Reworked Cretaceous dinocysts are conspicuously present.

Pollen

As in Section 1, many pollen taxa were found in the seven samples examined from Section 2 (table 6). These samples are

Table 5. Distribution of dinocyst taxa in samples of sample series R4718, from Section 2. Samples run from older on the left to younger on the right. X signifies taxon is present.

Taxon	Sample E	Sample M
Adnatosphaeridium sp.	X	
Apectodinium homomorphum group	X	
Operculodinium spp.	X	
Phelodinium magnificum group	X	
small, peridinioid	X	X
Spinidinium densispinatum	X	
Spinidinium microceratum		X
Wetzelliella cf. *W. articulata*		X
Cretaceous forms		
Chatangiella spp.	X	X
other	X	X

also Eocene in age, particularly on the presence of *Ilex-pollenites*, and again a long list of tricolporate insect-pollinated taxa.

Section 4

Pollen

Of the four samples collected from Section 4 in 1992, only one (R4713F) contained enough pollen to make an analysis possible (table 7). Only 13 taxa were found in this sample, perhaps partly because coaly sediments bearing autochthonous pollen assemblages typically have lower diversities than detrital sediments receiving many pollen species from the whole region. Some of the taxa in sample R4713F are known from strata as old as Maastrichtian or early Paleocene, although they range up into the Eocene, for example *Triatriopollenites* spp., *Triporopollenites megagranifer* type, *Ulmipollenites tricostatus*, *U. undulosus*, *Alnipollenites verus*, and *Ericipites* spp. However, *Pistilli-pollenites mcgregorii* does not range lower than the upper Paleocene in North America including Arctic Canada (Rouse, 1977). *Rhoipites angustus* type apparently has not previously been reported from the Arctic, but in the Gulf Coast it is very rare below the upper Paleocene and is common throughout the Eocene. *Pterocarya* spp., 5- to 8-porate, was not found in this sample, but the assemblage does include an intriguing specimen of what is here termed 4-porate *Pterocarya* which might be interpreted as a primitive form of the genus. On the other hand, Doerenkamp and others (1976) and McIntyre (1989; 1991b; McIntyre and Ricketts, 1989) have found *Pterocarya*, presumably of the 5- to 8-porate

Table 6. Distribution of pollen taxa in samples of sample series R4718, from Section 2. Samples run from oldest on the left to youngest on the right. X, present; A = aff., meaning the specimen is very similar to and may belong to the taxon.

Taxon	Sample						
	A	B	E	G	I	L	P
Triatriopollenites sp. 1			X				
Triatriopollenites spp.	X		X	X		X	X
Triporopollenites mullensis			X	X	X		X
Paraalnipollenites confusus type Z			X	X			
Trivestibulopollenites spp.	X			X			
Betulaepollenites spp.				X			
Carya <29 µm	X	X	X	X	X		X
Caryapollenites prodromus group, type 1		X	X	X	X	X	X
Caryapollenites prodromus group, type 2	X	X	X	X	X		X
Platycaryapollenites sp.						X	
Pistillipollenites mcgregorii		X		X			
Ulmipollenites krempii			X				
Ulmipollenites undulosus	X	X	X	X			X
Alnipollenites verus	X	X	X	X		X	X
Pterocarya spp., 5- to 8-porate	X	X	X	X			X
Liquidambar type 1		X	X	X			X
Liquidambar type 2						X	
Eucommia sp.		X		X			
Ilexpollenites spp.						X	
Horniella sp. 1							X
Rhoipites latus type of Rouse (1977)		A	X	X			
Cf. *Rhoipites latus* type	X	X					
Rhoipites angustus type					X		
Tricolporopollenites A of Rouse (1977)		X	X				
Nyssapollenites sp. 1			X				
Nyssapollenites sp. 2	X		X				
Lanagiopollis spp.	X						
Bombacacidites paulus type	X			X	X		X
Intratriporopollenites sp. 1	X		X	X			
Intratriporopollenites sp. 2		X	X	X	X		
Intratriporopollenites sp. 3	X	X	X				
Pseudoplicapollis sp.							X
Novemprojectus sp.				X			
Ericipites spp.	X	X	X	X	X		

Table 7. Distribution of pollen taxa in samples R4713F and R4713 G-H, from Sections 4 and 5, respectively. Samples run from oldest on the left to youngest on the right. X, present; A = aff., meaning the specimen is very similar to and may belong to the taxon.

	Section		
	4	5	
Taxon	Sample		
	F	G	H
Triatriopollenites spp.	X	X	X
Triporopollenites megagranifer type	A		
Triporopollenites mullensis		A	X
Trivestibulopollenites spp.		X	X
Carya <29 µm		X	X
Caryapollenites prodromus group, type 1		X	
Caryapollenites prodromus group, type 2		X	X
Plicatopollis/Platycaryapollenites sp.			X
Pistillipollenites mcgregorii	X		X
Ulmipollenites krempii		X	X
Ulmipollenites tricostatus	X		
Ulmipollenites undulosus	X	X	X
Alnipollenites verus	X		X
Pterocarya spp., 4-porate	X		
Pterocarya spp., 5- to 8-porate		X	X
Ilexpollenites spp.			X
Horniella sp. 1	X		
Cf. *Rhoipites latus* type	X		
Rhoipites angustus type	X		X
Tricolporopollenites A of Rouse (1977)	X		
Nyssapollenites sp. 1	X		
Intratriporopollenites sp. 1			X
Intratriporopollenites sp. 2		X	X
Ericipites spp.	X		

variety, in samples from the Canadian Arctic that they considered to be Paleocene, and Ioannides and McIntyre (1980, pl. 31.4, fig.2) illustrated a grain -- similar to "4-porate *Pterocarya*" of this paper -- which they considered to be a 4-pored specimen of *Caryapollenites*, a common Paleocene species.

Rouse (1977) recorded *Nyssapollenites* sp. 1 only from the lower to middle Eocene and *Tricolporopollenites* A only from the upper Eocene of Arctic Canada. The geologic ranges of *Horniella* sp. 1 and Cf. *Rhoipites latus* type are unknown, but these species are morphologically closely related to *Rhoipites latus* type of Rouse (1977), which is known in the Arctic only in the lower to middle Eocene.

In his coal samples probably from the same locality as Section 4 of this paper, T. A. Ager found rich pollen assemblages that included *Novemprojectus* (written commun., 1994).

In short, sample R4713F is certainly no older than late Paleocene, but it does not contain any taxa confined to the Paleocene. The sample contains several taxa that are thought to be only Eocene or younger, but it lacks many Eocene taxa that are found in Sections 1, 2, and 5; however, it is possible that this low diversity is caused by paleoecological factors and not by age. Therefore, the sample could be from close to the Paleocene-Eocene boundary, although probably from the Eocene side of the boundary, or it could even be from well up in the lower Eocene; the evidence for a definite age determination is sparse.

Section 5

Dinocysts

All three samples collected from this section contained dinocysts (table 8). All three assemblages included *Charlesdowniea stellata* and thus are early (but not earliest) Eocene or middle Eocene in age. The assemblages in these samples are quite similar to that in R4717N in Section 1. The environment of deposition was nearshore marine or estuarine. Reworked Cretaceous dinocysts are conspicuously present.

Pollen

Two of the three samples collected from Section 5 could be analyzed for pollen (R4713 G, H; table 7). These samples contain many long-ranging taxa but only a few that have more restricted ranges. One of these is *Plicatopollis/Platycaryapollenites* sp., of which one specimen was found. The migration of *Platycaryapollenites* from Europe to North America probably took place at the end of the Paleocene (Frederiksen, in press), but, at least in Virginia where a nearly complete sequence of upper Paleocene to lower Eocene strata is present, pollen of this genus is sparse to rare until the beginning of the Eocene (Brenner and others, 1979; Frederiksen, 1979). McIntyre (1991b, p. 69) considered the presence of "extremely rare" *Platycaryapollenites* to indicate a

Table 8. Distribution of dinocyst taxa in samples of sample series R4713, from Section 5. Samples run from oldest on the left to youngest on the right. X, present; ?, identification uncertain.

Taxon	Sample G	Sample H	Sample I
small, peridinioid	X	X	X
Wetzelliella cf. *W. articulata*	X	X	X
Charlesdowniea stellata	X	X	X
Deflandrea phosphoritica		X	X
Spiniferites spp.		X	
Apectodinium homomorphum			?
Cretaceous forms			
Chatangiella spp.	X	X	
other			X

late Paleocene age in the Arctic. On the other hand, in samples from the Gulf and Atlantic Coastal Plains, Frederiksen (unpublished) has seen forms transitional between *Plicatopollis* and *Platycaryapollenites* only in the lower and middle Eocene. *Ilexpollenites* spp. probably first appeared on the Gulf Coast in the Eocene (Frederiksen, unpublished data), and the same also seems to be true in the Arctic (Doerenkamp and others, 1976; McIntyre and Ricketts, 1989).

As noted in the discussion of pollen from Section 4, *Rhoipites angustus* type apparently has not previously been reported from the Arctic, but in the Gulf Coast it is very rare below the upper Paleocene; it is common throughout the Eocene of the Gulf Coast.

Intratriporopollenites sp. 2 is similar morphologically to certain finely reticulate pollen grains that authors assign variously to *Tilia* (basswood, linden), *Tiliaepollenites*, and *Intratriporopollenites*. McIntyre (1991b) summarized evidence showing that in the Arctic this species is almost entirely found in strata of Eocene and younger age, but that rare specimens may occur in the upper Paleocene.

Caryapollenites prodromus group, type 2, and *Intratriporopollenites* sp. 1 do not seem to have been recognized by previous authors as separate species; therefore, their geologic ranges are unknown.

In summary, the two samples examined for pollen from Section 5 are undoubtedly Eocene, particularly because of the presence of *Plicatopollis/Platycaryapollenites* sp. and *Ilexpollenites* spp.

COMPARISON AND SUMMARY

Tables 9 and 10 summarize the lists of palynomorph taxa in samples from Sections 1, 2, 4, and 5, and figure 4 is a chronostratigraphic comparison of these sections based on the ages of recovered palynomorphs.

As noted previously, Section 1 appears to be older than Section 2 from structural and stratigraphic evidence. However, dinocyst data do not support this conclusion. These fossils indicate that the lowest part of Section 1 is early early Eocene in age (approximately correlative to calcareous nannofossil zone NP10). The remainder of the section is probably early Eocene or may be as young as middle Eocene at the top. According to dinocysts, Section 2 is approximately the same age as Section 1, the lower part of the section being late Paleocene or early Eocene, and the upper part probably being early or middle Eocene. In short, the lower parts of Sections 1 and 2 are probably about the same early Eocene age, whereas the upper parts of each section appear to be younger, late early or middle Eocene.

Section 4 is a thin coaly sequence at the south end of Franklin Bluffs that has a pollen assemblage probably early Eocene in age. Section 5, a thin silty and clayey exposure less than 10 m topographically above Section 4, is early (but not earliest) Eocene or middle Eocene in age on the basis of dinocysts, that is, it appears to be younger than the bases of Sections 1 and 2. Pollen assemblages also indicate that Section 5 is Eocene, but it does contain significantly fewer Eocene pollen species than Sections 1 and 2 (table 10). Comparison of the pollen assemblages of Sections 4 and 5 is difficult because one is coaly and the other is composed of detrital material.

The lower part of the Franklin Bluffs Member of the Sagavanirktok Formation, composed of mudrock and sandstone, is known from this study and from that of Ager and others (1986) to be lower to middle Eocene. Thus, these strata are temporal equivalents of the Mikkelsen Tongue of the Canning Formation, whose type locality is the Mobil Oil Corporation West Staines State no. 2 well, approximately 90 km to the east-northeast (fig. 1, loc. M; Molenaar and others, 1987). The Sagwon Member of the Sagavanirktok Formation, defined as being coal bearing, has been dated as Paleocene at its type locality, which is about 55-60 km south of our Franklin Bluffs sections (fig. 1, loc. S). However, the top of the Sagwon Member (Section 4 of this report) is almost certainly Eocene.

In all samples that contained usable dinocyst assemblages (table 1), the environment of deposition was nearshore marine or estuarine.

Ager and others (1986, p. 243) stated on the basis of pollen from Eocene laminated silty and clayey strata of the Franklin Bluffs Member at and near its type locality (fig. 2, Section A) that "the fossil pollen assemblages suggest a warm-temperate, moist climate, and a forest cover composed primarily of deciduous broadleaf tree taxa." The terrestrial paleoclimate cannot be

Table 9. Summary of dinocyst taxon distributions in samples from Sections 1, 2, and 5. All three sections appear to be about the same age on the basis of dinocyst evidence. X, present; ?, identification uncertain.

Taxon	Section 1	Section 2	Section 5
Adnatosphaeridium sp.		X	
Apectodinium homomorphum			?
Apectodinium homomorphum group		X	
Apectodinium parvum	X		
Areoligera sp.	X		
Charlesdowniea stellata	X		X
Deflandrea phosphoritica			X
Diphyes colligerum	X		
Hystrichokolpoma sp.	X		
Operculodinium centrocarpum	X		
Operculodinium spp.		X	
Phelodinium magnificum group		X	
Phthanoperidinium echinatum	X		
Spinidinium densispinatum		X	
Spinidinium microceratum		X	
Spiniferites spp.	X		X
Wetzelliella cf. *W. articulata*	X	X	X
small, peridinioid	X	X	X

determined with great accuracy based on the lists of pollen floras (table 10) from Sections 1, 2, 4, and 5 (fig. 2), but the best evidence may be offered by the four pollen species of the Bombacaceae-Sterculiaceae-Tiliaceae family group (fossil pollen genera *Bombacacidites* and *Intratriporopollenites*) which were found mainly in sections 1 and 2. Tiliaceae range from tropical to temperate climates (linden or basswood is a common temperate representative); on the other hand, Bombacaceae and Sterculiaceae are typically subtropical to tropical in their modern distributions but may possibly have extended into temperate regions in the early Tertiary (climatic clsssification of Wolfe, 1979).

Reworked Cretaceous dinocysts are common in most of our samples. Reworked late Paleozoic and early Mesozoic(?) spores as well as Campanian and Maastrichtian pollen grains were also found in many samples.

Table 10. Summary of pollen taxon distributions in samples from Sections 1, 2, 4, and 5. Section 4 is presumably the oldest, but Sections 1, 2, and 5 appear to be about the same age on the basis of dinocyst evidence. X, present; ?, identification possible; A = aff., meaning the specimen is very similar to and may belong to the taxon; C = cf., meaning the specimen is similar to but probably does not belong to the taxon.

Taxon	Section			
	1	2	4	5
Triatriopollenites sp. 1	X	X		
Triatriopollenites spp.	X	X	X	X
Triporopollenites megagranifer type	X		A	
Triporopollenites mullensis	X	X		X
Paraalnipollenites confusus type H	X			
Paraalnipollenites confusus type Z	X	X		
Trivestibulopollenites spp.	X	X		X
Betulaepollenites spp.	X	X		
Carya <29 µm	X	X		X
Caryapollenites prodromus group, type 1	X	X		X
Caryapollenites prodromus group, type 2	X	X		X
Platycaryapollenites sp.		X		
Plicatopollis sp.	X			
Plicatopollis/Platycaryapollenites sp.				X
Pistillipollenites mcgregorii	X	X	X	X
Corsinipollenites sp.	X			
Ulmipollenites krempii		X		X
Ulmipollenites tricostatus	X		X	
Ulmipollenites undulosus	X	X	X	X
Alnipollenites verus	X	X	X	X
Pterocarya spp., 4-porate			X	
Pterocarya spp., 5- to 8-porate	X	X		X
Liquidambar type 1	X	X		
Liquidambar type 2	X	X		
Eucommia sp.	X	X		
Ilexpollenites spp.	?	X		X
Horniella sp. 1	C	X	X	
Rhoipites latus type of Rouse (1977)	X	X		
Cf. *Rhoipites latus* type		X	X	
Rhoipites angustus type	X	X	X	X
Tricolporopollenites A of Rouse (1977)		X	X	
Nyssapollenites sp. 1	X	X	X	
Nyssapollenites sp. 2	X	X		
Lanagiopollis spp.	X	X		
Bombacacidites paulus type	X	X		
Intratriporopollenites sp. 1	X	X		X

Table 10 (continued).

Taxon	Section 1	2	4	5
Intratriporopollenites sp. 2	X	X		X
Intratriporopollenites sp. 3		X		
Pompeckjoidaepollenites subhercynicus	X			
Pseudoplicapollis sp.		X		
Novemprojectus sp.	X	X		
Ericipites spp.	X	X	X	
Pasavis tagluensis	X			

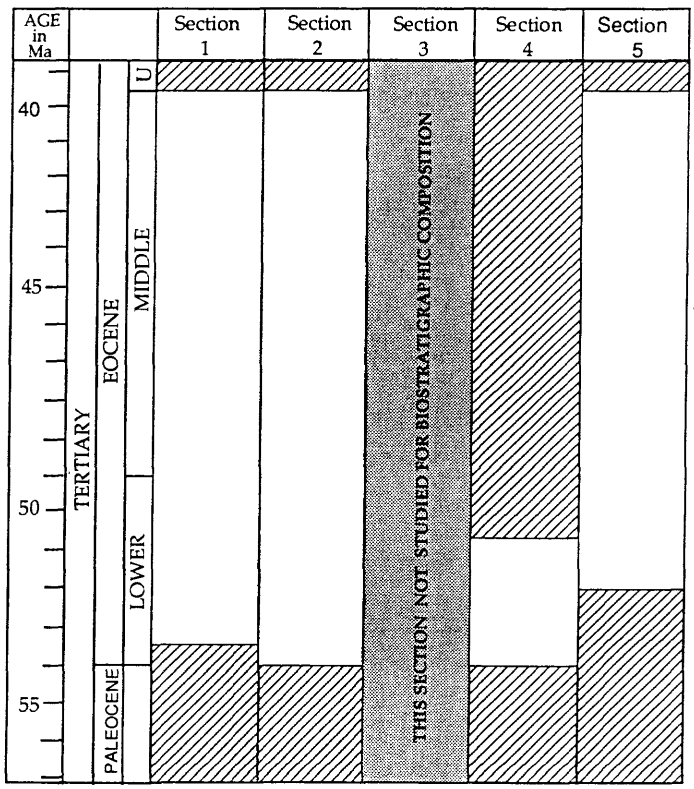

Figure 4. Chronostratigraphic diagram showing probable ranges of biostratigraphic ages (white areas) of Eocene sections discussed in this paper. Diagonally striped areas show ages for which no strata have been identified. Time scale boundaries are from Haq and others (1987).

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TAXONOMY

Table 11 presents a list of pollen and fungal spore taxa identified in the samples from Franklin Bluffs. For the most part, the taxonomy of triporate taxa follows that of Frederiksen and others (1988). It is not possible to provide useful photomicrographs of the pollen specimens in this open-file report, but references are given to photomicrographs of similar specimens in the literature mainly from Arctic Canada and Alaska. Such references are not given for species that are particularly well known.

Table 11. Pollen and fungal spore taxa identified by Frederiksen in the samples from Franklin Bluffs. References are not given to published photomicrographs of some well-known taxa.

Triatriopollenites sp. 1. Atrium rather indistinct; sides gently convex; corners of grain narrowly rounded; labrum and annulus not well developed.

Triatriopollenites spp. These specimens have a distinct atrium; most of them have a labrum and commonly at least a small annulus or tumescence. Distinct columellae are generally lacking except, in some cases, at the atrium.

- *Triporopollenites bituitus* (Potoné) Elsik 1968. Doerenkamp and others, 1976, pl. 1, figs. 8, 10.
- *Carpinites ancipites* (Wodehouse) Srivastava 1966. Wilson, 1978, pl. 10, fig. 2.
- *Myrica annulites* Martin & Rouse 1966. Wilson, 1978, pl. 10, fig. 24.
- *Triatriopollenites* sp. Frederiksen and others, 1988, pl. 1, fig. 7.
- *Corylus* sp. McIntyre, 1991a, pl. 2, fig. 9.
- *Betula* [sp.] of McIntyre (1985, pl. 1, fig. 13) may belong here.

Triporopollenites megagranifer (Potonié) Thomson & Pflug 1953 type.

- *Triporopollenites megagranifer* type. Frederiksen and others, 1988, pl. 1, figs. 3-6.

Table 11 (continued).

Triporopollenites mullensis (Simpson) Rouse & Srivastava 1972.
- *Triporopollenites bituitus* (Potoné) Elsik 1968. Doerenkamp and others, 1976, pl. 1, figs. 11-12.
- *Triporopollenites mullensis*. Rouse, 1977, pl. 1, fig. 3; McIntyre, 1985, pl. 1, fig. 12; Dietrich and others, 1989, pl. 3, fig. 5; McIntyre, 1989, pl. 2, fig. 11; Frederiksen and others, 1988, pl. 1, fig. 2.
- *Annutriporites tripollenites* (Rouse) Norris 1986, pl. 10, figs. 20-23.

Paraalnipollenites confusus (Zaklinskaya) Hills & Wallace 1969, type H. These specimens have distinct arcus-like folds.
- *Paraalnipollenites confusus*. Rouse, 1977, pl. 1, fig. 2; Wilson, 1978, pl. 10, fig. 25.
- *Betula claripites* Wodehouse 1933. Wilson, 1978, pl. 10, fig. 14.
- *Paraalnipollenites confusus* type H. Frederiksen and others, 1988, pl. 1, fig. 9.
- *Paraalnipollenites alterniporus* (Simpson) Srivastava 1975. Ioannides and McIntyre, 1980, pl. 31.4, fig. 17; Dietrich and others, 1989, pl. 3, figs. 1-2; McIntyre, 1989, pl. 2, fig. 5; Kalgutkar and McIntyre, 1991, pl. 2, fig. 11.

Paraalnipollenites confusus type Z. These specimens have a distinct, abrupt annulus and an atrium, but they lack distinct arcus-like folds.
- *Paraalnipollenites confusus* type Z. Frederiksen and others, 1988, pl. 1, fig. 7.

Trivestibulopollenites spp.
- *Trivestibulopollenites betuloides* Pflug in Thomson & Pflug 1953. Norris, 1986, pl. 10, figs. 38-42.
- *Trivestibulopollenites claripites* (Wodehouse) Norris 1986, pl. 10, figs. 47-49.
- *Trivestibulopollenites* spp. Frederiksen and others, 1988, pl. 1, fig. 10.

Betulaepollenites spp.
- *Betulaepollenites* spp. Frederiksen and others, 1988, pl. 1, fig. 11.

Carya <29 µm. Most specimens lack a polar ring of thin exine.

Caryapollenites prodromus group, type 1. Type 1 includes *Caryapollenites imparalis* Nichols & Ott 1978 (which lacks a polar ring of thin exine) and *C. prodromus* Nichols & Ott 1978 (which has such a ring). In the present material, most specimens lack a ring.
- *Caryapollenites* sp. Doerenkamp and others, 1976, pl. 1, fig. 7.
- *Caryapollenites imparalis*. McIntyre, 1989, pl. 2, fig. 7; Kalgutkar and McIntyre, 1991, pl. 2, fig. 20.

Table 11 (continued).

Caryapollenites prodromus group, type 2. In this species, 1-2 pores are at the equator whereas the other pore(s) are shifted slightly to one hemisphere; tumescence is present around the pores. The atrium is distinctly granulate, but the remainder of the exine is not distinctly columellate as in *Subtriporopollenites*. A ring of thin exine is lacking at the pole.

Carya viridifluminipites Wodehouse 1933. Rouse and Mathews, 1979, fig. 3K.

Platycaryapollenites sp. The only specimen of this genus found in the present material has somewhat irregular pseudoplicae.

McIntyre (1985, pl. 1, fig. 7; in Dietrich and others, 1989, pl. 2, figs. 12-13) illustrated specimens probably referable to *Platycaryapollenites platycaryoides* (Roche) Kedves 1982.

Plicatopollis sp.

Plicatopollis/Platycaryapollenites sp.

Pistillipollenites mcgregorii Rouse 1962.

Corsinipollenites sp. One specimen seen, having a small, rather pointed annulus.

Several other specimens of *Corsinipollenites* have been illustrated in papers on Canadian Arctic palynology, but they belong to different species: *Jussiaea champlainensis* Traverse 1955 of Doerenkamp and others (1976, pl. 1, figs. 13-14); *Jussiaea* sp. of Rouse (1977, pl. 1, fig. 15); *Corsinipollenites triangulatus* (Zaklinskaya) Sung et al. 1978 of Norris (1986, pl. 10, figs. 54-56).

Ulmipollenites krempii (Anderson) Frederiksen 1979.

Ulmipollenites sp. Ioannides and McIntyre, 1980, pl. 31.4, fig. 13.

Ulmipollenites krempii. Frederiksen and others, 1988, pl. 1, fig. 12.

Ulmus sp. (*Ulmipollenites undulosus*). Kalgutkar and McIntyre, 1991, pl. 2, fig. 14.

Ulmus sp. McIntyre, 1991a, pl. 3, fig. 9.

Ulmipollenites tricostatus (Anderson) Frederiksen 1980.

Alnipollenites trina (Stanley) Norton 1969. Wilson, 1978, pl. 10, fig. 15.

Ulmipollenites undulosus Wolff 1934. Ioannides and McIntyre, 1980, pl. 31.4, fig. 14.

Ulmoideipites tricostatus Anderson 1960. Norris, 1986, pl. 11, figs. 1-2.

Ulmipollenites tricostatus. Frederiksen and others, 1988, pl. 1, fig. 13.

Ulmus sp. Dietrich and others, 1989, pl. 3, fig. 13; McIntyre, 1989, pl. 1, fig. 10; McIntyre, 1991a, pl. 3, fig. 9.

Table 11 (continued).

Ulmipollenites undulosus Wolff 1934.
Pterocaryapollenites stellatus (Potonié) Raatz 1937. Wilson, 1978, pl. 10, fig. 13.
Ulmus sp. Staplin, 1976, pl. 2, fig. 4; McIntyre, 1985, pl. 1, fig. 20; Dietrich and others, 1989, pl. 3, fig. 12.
Ulmipollenites undulosus. Ioannides and McIntyre, 1980, pl. 31.4, fig. 15; Norris, 1986, pl. 11, figs. 8-9; Frederiksen and others, 1988, pl. 1, fig. 14.
Alnipollenites verus Potonié 1931.
Pterocarya spp., 4-porate.
Caryapollenites sp. A. Ioannides and McIntyre, 1980, pl. 31.4, fig. 2.
Pterocarya spp., 5- 8-porate.
Pterocarya sp. Staplin, 1976, pl. 2, fig. 5; Ioannides and McIntyre, 1980, pl. 31.4, fig. 6; McIntyre, 1989, pl. 2, fig. 9; Kalgutkar and McIntyre, 1991, pl. 2, fig. 10; McIntyre, 1991a, pl. 3, fig. 2.
Polyatriopollenites stellatus (Potonié) Pflug 1953. Norris, 1986, pl. 11, figs. 5-7.
Liquidambar type 1. Medium-sized pores.
Liquidambar sp. 1. Piel, 1977, pl. 2, fig. 6.
Liquidambar sp. 1 of Piel. Rouse and Mathews, 1979, fig. 3N.
Liquidambar [sp.]. McIntyre, 1985, pl. 1, fig. 16.
Liquidambar sp. of McIntyre (1989, pl. 1, fig. 13; 1991a, pl. 3, fig. 18) has much larger pores.
Liquidambar type 2. Small pores.
Liquidambar sp. Ioannides and McIntyre, 1980, pl. 31.4, fig. 18.
Liquidambar sp. of Dietrich and others (1989, pl. 3, fig. 11) has larger pores.
Eucommia sp. In the present material, all specimens are tricolporate.
Ilexpollenites spp. These are small-clavate specimens. Specimens illustrated by Doerenkamp and others (1976, pl. 1, figs. 29, 35) and Ioannides and McIntyre (1980, pl. 31.4, figs. 19-20) have larger clavae; those illustrated by McIntyre (1991a, pl. 3, figs. 16-17) have much larger clavae.
Horniella sp. 1. Very fine reticulum, lumina varying from ± square or round to elongate but extremely narrow; grain prolate, nearly perprolate.
Rhoipites latus type of Rouse (1977, pl. 2, fig. 36). This high-latitude species has a slightly finer reticulum, and the lumina are generally more elongate, than in *R. latus* Frederiksen 1980 (Eocene, Gulf Coast).
Cf. *Rhoipites latus* type. This species has a reticulum that is intermediate between those of *Horniella* sp. 1 and *Rhoipites latus* type of Rouse; prolate, but nearly subprolate.
Rhoipites angustus Frederiksen 1980 type.

Table 11 (continued).

Tricolporopollenites A of Rouse (1977, pl. 2, fig. 37).
Nyssapollenites sp. 1. This species has a fine reticulum.
Holkopollenites A. Rouse, 1977, pl. 2, figs. 28-29.
Nyssapollenites sp. 2. This species is so finely reticulate that it could be considered punctate.
Margocolporites stenosus Ke & Shi in Sung et al. 1978. Norris, 1986, pl. 10, figs. 3-4. The reticulum in the Chinese type specimen of this species is similar to that of the Canadian specimen of Norris (1986) and to the specimens from Franklin Bluffs, but the ora of the Chinese specimen appear to be different.
Nyssa sp. McIntyre, 1991a, pl. 4, figs. 18-19.
Lanagiopollis spp.
Tricolporopollenites kruschii (Potonié) Thomson & Pflug 1953 of Doerenkamp and others (1976, pl. 1, figs. 27-28) and of McIntyre (1985, pl. 1, fig. 6) probably belong to *Lanagiopollis*, and they probably belong to the same species as some of the specimens in the present material.
Bombacacidites paulus Frederiksen 1989 type.
Tiliapollenites-Bombacacidites complex. Ioannides and McIntyre, 1980, pl. 31.4, fig. 11.
Tilia crassipites Wodehouse 1933. McIntyre, 1985, pl. 1, fig. 4).
Tilia sp. Dietrich and others, 1989, pl. 3, fig. 6.
"Bombacaceae" sp. of Staplin (1976, pl. 2, fig. 20) is more triangular.
Intratriporopollenites sp. 1. This species has approximately the shape of *Tiliaepollenites* sp. of Doerenkamp and others (1976, pl. 1, fig. 15), *Tilia vescipites* Wodehouse 1933 of McIntyre (1985, pl. 1, fig. 9), and *Tilia* sp. (*T. vescipites*) of Kalgutkar and McIntyre (1991, pl. 2, figs. 15-16), that is, it is intermediate in shape between *Intratriporopollenites* spp. 2 and 3. However, the distinctive feature of *Intratriporopollenites* sp. 1 is that one pole has a distinctly coarser reticulum than the other pole, in the manner of modern pollen of *Tilia cordata* Mill., some species of *Fremontodendron*, and *Chiranthodendron* (the latter two genera assigned questionably to Bombacaceae or Sterculiaceae; see discussion of the heteropolar reticulum in these taxa in Frederiksen, 1983, p. 80).
Intratriporopollenites sp. 2, ± round, only slightly triangular, finely reticulate.
Tiliaepollenites sp. Staplin, 1976, pl. 2, fig. 19.
Tilia crassipites Wodehouse 1933. Rouse, 1977, pl. 1, fig. 11.
Intratriporopollenites crassipites (Wodehouse) Norris 1986, pl. 10, figs. 43-45, 50.
Tilia sp. McIntyre, 1991a, pl. 3, figs. 12-13.

Table 11 (continued).

Intratriporopollenites sp. 3. Outline triangular; fine reticulum.
Pompeckjoidaepollenites subhercynicus (Krutzsch) Krutzsch in Góczán et al. 1967.
Pseudoplicapollis sp. *Pseudoplicapollis limitatus* Frederiksen 1978 is similar to this species but has narrower and more distinct plicae.
Novemprojectus sp. This is probably a new species because it lacks the very pronounced polar flaps present in *N. traversii* Choi 1984. Most specimens do have distinct if small flaps at the poles; thus, by definition they belong to *Novemprojectus*. In its general shape, this species is very similar to *Aquilapollenites tumanganicus* Bolotnikova 1973, but the morphology of *A. tumanganicus* is not well understood. The photomicrograph of the holotype of this species (Bolotnikova, 1973, pl. 25, fig. 1) is difficult to interpret; it may be that this specimen does have polar flaps and therefore belongs to *Novemprojectus*. However, McIntyre and Ricketts (1989) assigned specimens to *A. tumanganicus* that do not have polar flaps (e.g., *Aquilapollenites* sp. of Staplin, 1976, pl. 2, fig. 25; *Aquilapollenites spinulosus* Funkhouser 1961 of Sung and others, 1978).
Ericipites spp.
Pasavis tagluensis Elsik & Jansonius 1974.

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