Jurassic and Lower Cretaceous palynomorph assemblages from Cape Flora, Franz Josef Land, Arctic, USSR

MORTEN SMELROR

Smelror, M.: Jurassic and Lower Cretaceous palnyomorph assemblages from Cape Flora, Franz Josef Land, Arctic, USSR. *Norsk Geologisk Tidsskrift,* Vol. 66, pp. 107–119. Oslo 1986. ISSN 0029-196X.

Jurassic and Lower Cretaceous palynomorph assemblages are described from the Cape Flora Section and compared with assemblages recorded from Svalbard, East Greenland and Arctic Canada. The quantitative distribution of palynomorphs and palynodebris has also been estimated. Preservation is good, and from the six samples investigated, 41 species of dinoflagellate cysts, acritarchs, pollen and spores have been recorded. The stratigraphic range and occurrence of selected taxa support the earlier reported presence of Lower Cretaceous (probably Ryazanian – Barremian) and Middle Jurassic (Callovian) strata on Franz Josef Land.

M. Smelror, Paleontologisk Museum, Sars gate 1, 0562 Oslo 5, Norway. Present address: Institutt for kontinentalsokkelundersøkelser og petroleumsteknologi, Postboks 1883, N-7001 Trondheim, Norway.

This paper records palynomorph assemblages contained in six samples from Cape Flora on Northbrook Island, Arctic USSR. Northbrook Island is one of about 75 islands within the Franz Josef archipelago, and is situated at approximately 79°56′N and 49°40′E in the northeastern part of the Barents Sea. Cape Flora is the western extremity of the long and narrow peninsula which forms the southwestern part of the Northbrook Island (Figs. 1, 2).

The samples were collected during the Norwegian North Polar Expedition of 1893–96, led by Dr. Fridtjof Nansen on the polar vessel *Fram,* and were later deposited in the collections of the Paleontologisk Museum, Oslo. Dr. Nansen and his companion F. H. Johansen left *Fram* in March 1895 to make an advance on foot across the ice towards the North Pole. They were forced to stop at 86°14′N and 96°E, and make a return for Cape Fligely on Franz Josef Land. After spending the winter south of Jackson Island, they travelled southwards and came to Cape Flora, where they met the British Jackson-Harmsworth Expedition at Cample Elmwood in June 1896. Here Dr. Nansen, guided by the geologist Dr. Reginald Kættlitz, made a collection of fossils and rocks from the Cape Flora Section and other localities near by. The invertebrate fossils of this collection were described by Pompeckj (1900) and fossil plants by Nathorst (1900).

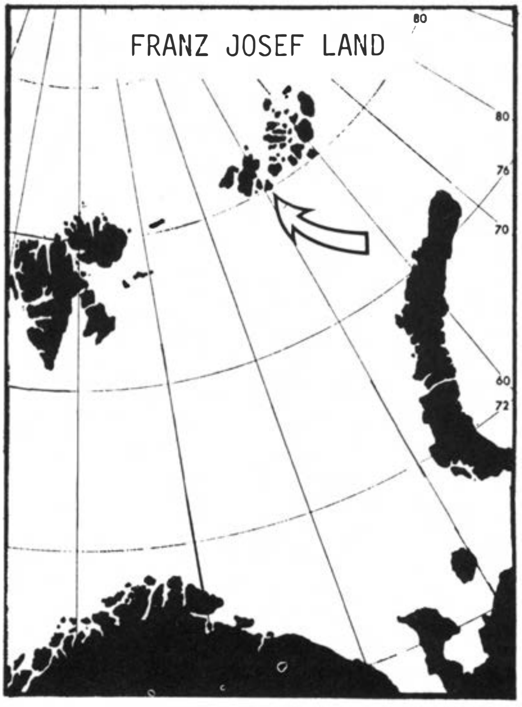


Fig. 1. Map of the Barents Sea. Location of Northbrook Island within the Franz Josef Land archipelago is indicated by arrow.

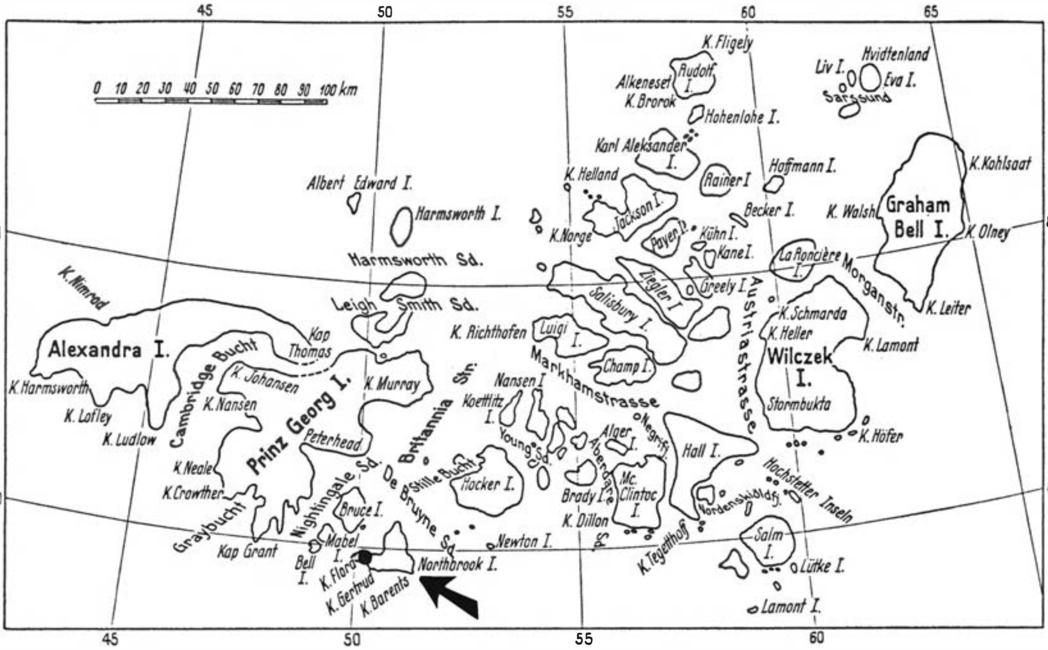


Fig. 2. Map of Franz Josef Land, showing the location of Cape Flora on the Northbrook Island (After Frebold 1935).

Geological setting

Pioneer work on the geology of Franz Josef Land was carried out during the Jackson-Harmsworth Expedition in 1895–98, and the results published by Newton & Teall (1897, 1898). Nansen (1900) and later Horn (1932) provided important data regarding the geology of the island group. A review of the early geological knowledge of Franz Josef Land is given by Frebold (1935). The island consists of approximately horizontal strata of Early Carboniferous to Early Cretaceous age, with a capping of basaltic lavas. The sedimentary sequence suggests relatively uniform Mesozoic conditions extending eastward from Kong Karls Land, Svalbard, and the lavas are contemporaneous with basalts from the same area (Harland 1973).

The Jurassic deposits are chiefly found in the southern part of the archipelago. At Cape Flora on Northbrook Island they reach an altitude of 170–200 m (Horn 1930). A sketch of the strata at Cape Flora (Fig. 3) is given by Nansen (1900), reviewed by Frebold (1935). The lowermost known unit consists of ?Upper Triassic sand, interbedded with minor coal bands. This is followed by 7–10 m of soft clay with nodules of sandy marl. Based on the recovery of *Pseudomonotis jacksoni, Lingula beanii* and *Discina reflexa* and other fossils, Pompeckj (1900) suggested a Lower Bajocian age for this unit. From about 10 to 113 m the section at Cape Flora is obscured, but the succeeding 24 m consists of thick, soft, stratified clay, with bands of calcareous nodules and phosphatic pebbles. This unit, containing the ammonites *Macrocephalites kaettlitzi, Macrocephalites pila* and *Cadoceras frearsi,* was placed in the Lower Callovian by Pompeckj (1900). The next

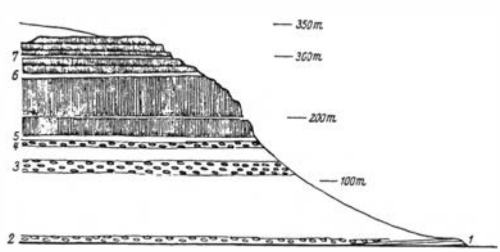


Fig. 3. Sketch of the Cape Flora section. 1: Thin alternating strata of sand with black carboniferous seams, 2: Lowest fossiliferous horizon of soft clay with nodules of sandy marl, 3: Middle fossiliferous horizon of soft stratified clay with bands of phosphatic and calcareous nodules, 4: Upper fossiliferous horizon of soft clay, with bands of nodules of clay-sandstone, 5: Horizon of soft clay, 6 and 7: Plant-bearing beds of shale and sandstone between the successive tiers of basalt (from Nansen 1900).

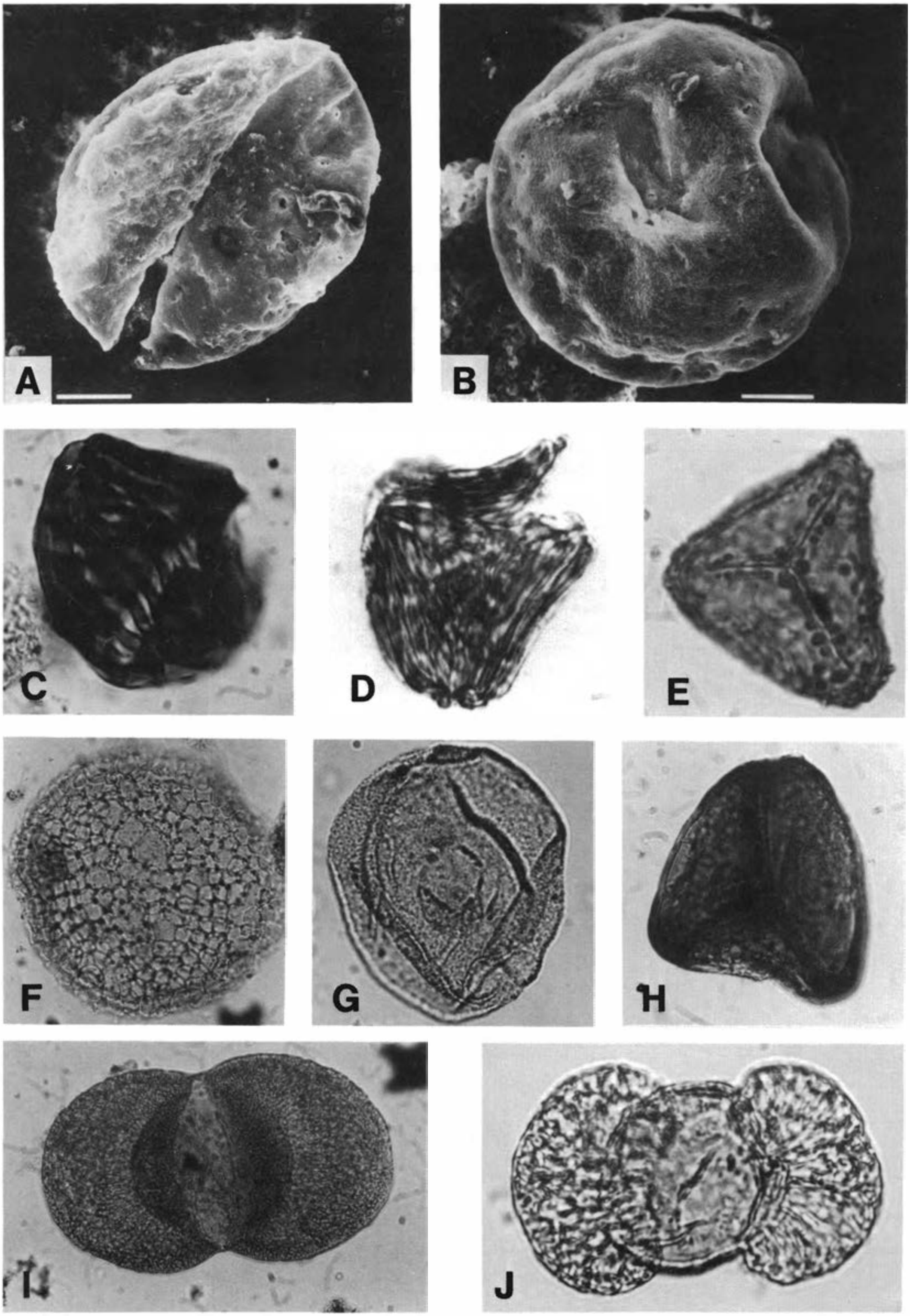
fossiliferous horizon has been recorded at 168 m. *Cadoceras tschefkini, Cadoceras stenolobum* and *Belemnites subextensus* among other recorded species, indicate a Middle Callovian age for these beds (Pompeckj 1900). Just beneath the lowermost basalts at about 175 m, there are two thin non-fossiliferous bands of black shale. A specimen of the Upper Callovian ammonite *Quenstedtoceras lamberti* was found enclosed in the basalt (Nansen 1900). The basalt capping the marine sedimentary deposits is interrupted by an about half a metre thick shale and sandstone at 210 m and at 280 m, respectively. These contain numerous fossil plant fragments. The flora described by Nathorst (1900) from these beds includes representatives of the genera *Cladophlebis, Sphenopteris, Pterophyllum, Ginkgo, Taxites, Phoenicopis, Pityophyllum* and *Abietites* among others. Nathorst (1900) could not give a precise age for these plant-bearing beds, but suggested that they could not be older than the fossil floras recorded from the Weald, England (i.e. Valanginian – Hauterivian age).

Material and methods

Table 1 provides data on the samples investigated. Between 15 to 25 grams of each sample were dissolved using standard palynological pro-

Table 1. Localities, lithology, microflora and kerogen data of the samples investigated from Northbrook Island.

Sample	Locality	Lithology	Microflora	Preservation	Maturation (TAI-values)	Kerogen	Correlations /Age
C.P.1	Windy Gully ca 210 m	Greyish shale	Dominated by bisaccate pollen, rare spores	Good	Moderate 2–2.5	Dominated by phyrogen	Lower Cretaceous
C.P.2	"	"	"	"	"	>50% phyrogen 15% hylogen 35% amorphogen	"
C.P.3	Found loose in talus at Cape Flora	Green-greyish mudstone	Dominated by bisaccate pollen, rare spores and dinoflagellate cysts	"	"	"	Lower Cretaceous (Ryazanian – Barremian)
C.P.4	"	Phosphorite pebble	Dominated by dinoflagellate cysts, minor pollen and spores	"	Slight <1.5	40% phyrogen 25% amorphogen 35% melanogen	Lower Kap Leslie Fm., *G. scarburghensis* zone of Piasecki 1980, Late Callovian-? Early Oxfordian
C.P.5	"	"	"	"	"	"	Retziusfjellet Member (?) (Janusfjellet Formation) Ass. D of Bjærke 1977 Callovian
C.P.6	"	"	"	"	"	5% phyrogen 95% melanogen	Callovian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cessing methods, including HC1 and HF treatment (see Barss & Williams 1973 for details). Floating separation methods were not employed nor was centrifugation. After acid treatment and during neutralization (water washing), the liquid was decanted. The residues were separated through 38 μm and 25 μm stell nets, and 10 μm nylon net sieves. For samples, C.P.1, C.P. 4 and C.P. 5 specimens for scanning electron microscopy were transferred to a stub in a drop of water. After the water had evaporated, specimens were coated with gold. Scanning electron photographs were taken using a Jeol JSM-35 instrument, and light photomicrographs using a Leitz Ortholux II Pol-Bk microscope. In order to get an approximate picture of palynomorph productivity and palynodebris distribution, additional strew mounts of unsieved residue were made for each sample.

All figured specimens (Figs. 4–7) are housed in the collections of the Paleontologisk Museum, Oslo, and referred to by preparation slide number (PA-number) or SEM-Stub number. The coordinates for strew slides refer to Leitz Ortholux Pol-Bk, NAVF reg. no. 8382.

Production and preservation

All samples yielded well-preserved palynomorphs. Sample C.P. 1 was very rich in pollen and spores, representing approximately 65% of the total organic matter. The rest of the organic material of sample C.P. 1 consisted of other phyrogen (following the definition of Bujak et al. 1977 for palynodebris), and a significant amount of translucent fragments of woody origin (hylogen). There was only a minor amount of structureless organic debris (amporphogen) and few black angular, fragments (melanogen) were present.

Samples C.P.2 and C.P.3 yielded relatively less palynomorphs and plant cuticle fragments, and the whole phyrogen fraction represents less than 50%. These samples contained approximately 15% hylogen and 35% amorphogen. As in sample C.P.1, few inertinite particles were present.

Samples C.P.1, C.P.2 and C.P.3 show moderate thermal alteration, with an orange to light brown colouration of single-walled palynomorphs indicating TAI-values of 2 to 2.5 (following TAI-indexes of Staplin 1969).

Samples C.P.4 and C.P.5 yielded fewer palynomorphs. The phyrogen material, which represents about 40% of the total organic matter, was dominated by dinoflagellate cysts, and contained minor amounts of terrestrial origin. Hylogen was barely present in these samples, while the amorphogen represents approximately 25%. The rest of the organic material in samples C.P.4 and C.P.5 was black carbonized particles (melanogen).

Sample C.P.6 contains more than 95% melanogen. This sample yielded only few (but well preserved) palynomorphs. Minor amounts of amorphogen were present, and few woody fragments have been recorded.

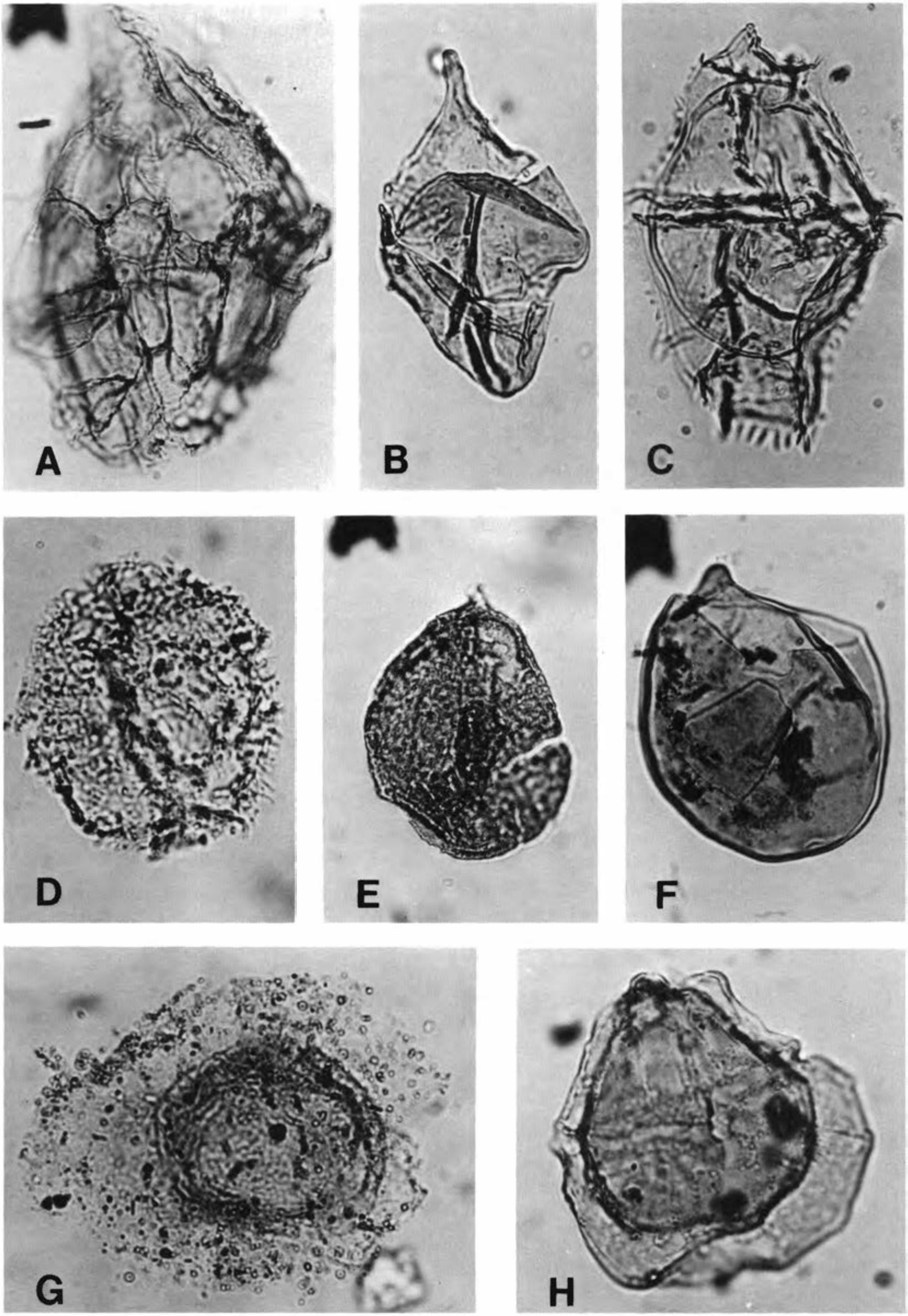
Palynomorphs from the samples C.P.4, C.P.5 and C.P.6 show mostly a pale yellow colouration, and some individuals are transparent. The palynomorphs give TAI-values of 1.5 or less, indicating immature deposits.

Palynomorph assemblages and correlations

Samples C.P.1 and C.P.2

These samples are dominated by bisaccate pollen, and species assignable to the genera *Alisporites, Brachysaccus* and *Podocarpidites* represent 80%-85% of the total microflora. Less common genera, but present in significant amounts (2–5%), are *Araucariacites, Cycadopites* and *Phyl-*

Fig. 4. Lower Cretaceous palynomorphs.
A: *Cycadopites* cf. *nitidus* (Balme) Pocock 1970. SEM-C.P.4.-II. Length 71 μm.
B: *Brachysaccus microsaccus* (Couper) Mädler 1964. SEM-C.P.1-I. Diameter 62 μm.
C: *Cicatricosisporites* sp. A. PA 4349: 106.8–46.3. Sample C.P.3. Diameter 36 μm.
D: *Cicatricosisporites australienses* (Cookson) Potonié 1956. PA 4340: 105.0–41.4. Sample C.P.3. Diameter 27 μm.
E: Spore type A. PA 4330: 107.0–45.2. Sample C.P.1 Diameter 38 μm.
F: *Schizosporis reticulatus* Cookson & Dettmann 1959. PA 4334: 97.2–36.1. Sample C.P.1. Diameter 56 μm.
G: *Araucariacites australis* Cookson 1947. PA 4341: 107.1–37.6. Sample C.P.2. Diameter 44 μm.
H: Spore indet. PA 4330: 99.5–39.0. Diameter 41 μm.
I: *Alisporites* sp. A. PA 4329: 102.0–37.7 Sample C.P.1. Length 81 μm.
J: *Podocarpidites biformis* Rouse 1957. PA 4333: 100.5–34.6. Sample C.P.1. Length 51 μm.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locladidites. Spores are rare, with only *Baculatisporites, Crybelosporites, Lycopodiumsporites* and two indeterminate species (Figs 4I and 5I) recorded. Nathorst (1900) suggested a Lower Cretaceous age for the upper plant-bearing beds at Cape Flora, and from the present palynological data it is not possible to give a more definite age.

Sample C.P.3

This sample is also dominated by bisaccate pollen. As within samples C.P.1 and C.P.2, *Alisporites, Brachysaccus* and *Podocarpidites* are the most prominent genera, representing approximately 75% of the total microflora. The acritarch *Schizosporis reticulatus,* which Pierce (1976) suggested might have been a fresh water species, occurs in low numbers, together with rare spores as *Cicatricosisporites* spp. The only marine species recorded is the dinoflagellate cyst *Chytroeisphaeridia cerastes* which is represented by a few individuals, and most probably reworked.

The presence of *Cicatricosisporites australiensis* and *Cicatricosisporites* sp. A, together with abundant bisaccate pollen, indicates that this assemblage is similar to those described as Association F from the Helvetiafjellet Formation (Hårfagrehaugen Member) on Kong Karls Land, Svalbard, by Bjærke (1977). A probable Barremian age was suggested for these assemblages (Bjærke 1977). Williams (1975) reported *Cicatricosisporites australiensis* to occur within the Kimmeridgian in wells from the Scotian Shelf, offshore Eastern Canada, but the genus *Cicatricosisporites* shows most prominent development during the Ryazanian and Valanginian (Dörhöfer 1977). A general Lower Cretaceous age (probable Ryazanian-Barremian) is here suggested for sample C.P.3.

Sample C.P.4

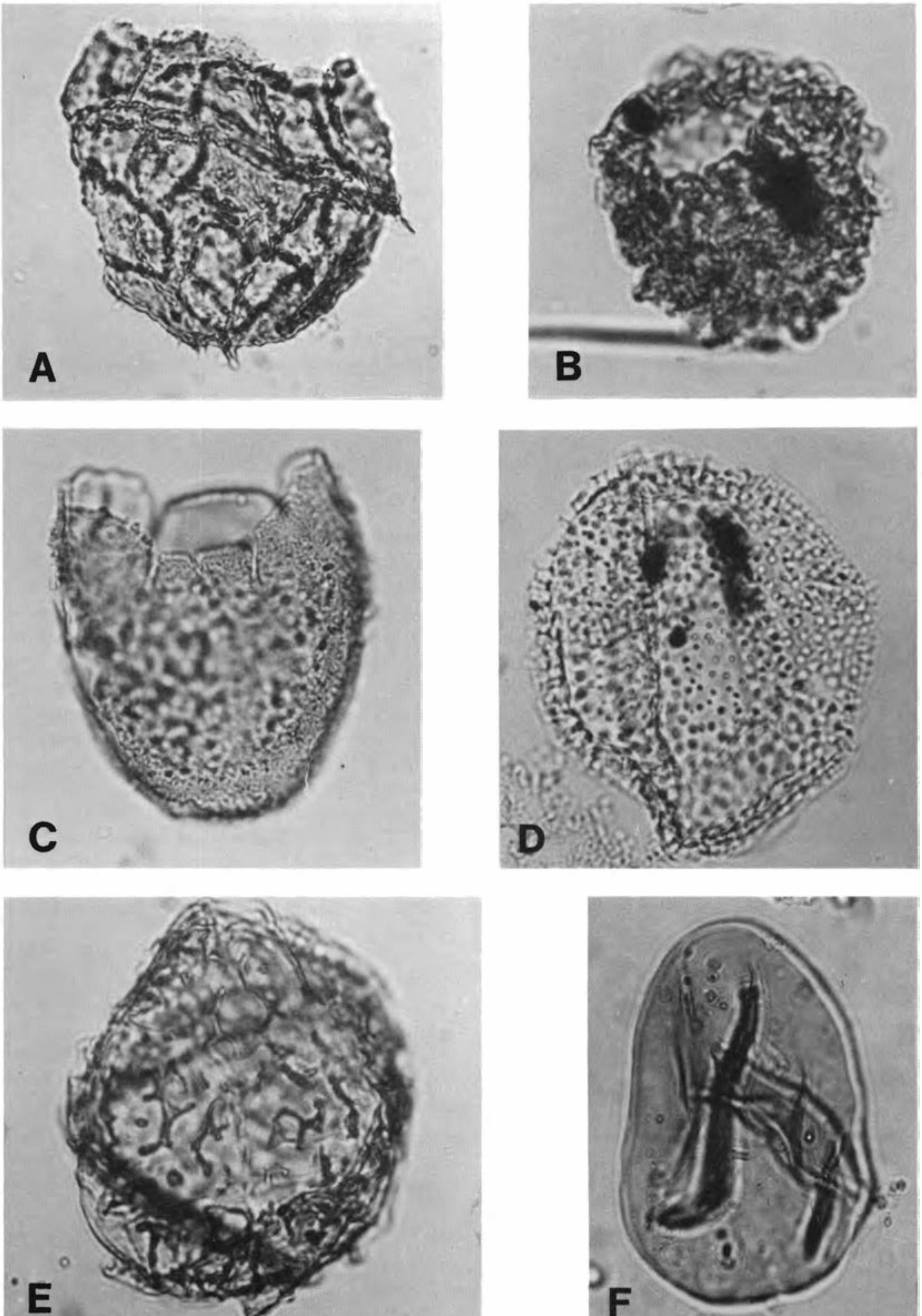
This sample is dominated by marine species, including the dinoflagellate cysts *Tenua verrucosa* and *Valensiella ovula,* each representing approximately 25% of the total assemblage. *Pareodinia ceratophora, Cleistophaeridium* sp. and *Tenua* sp. are also relatively common (8–10%), and *Tubotuberella eisenackii* and *Hystrichogonyaulax cladophora* are present in significant quantity (3–4%). The rest of the recorded dinoflagellate cysts represent each less than 2% of the total microflora. Pollen and spores are present in only minor amounts.

The presence of *Stephanelytron redcliffense* and *Lithodinia jurassica,* together with *Pareodinia ceratophora, Gonyaulacysta jurassica* (including var. *longicornis*), *Tubotuberella eisenackii* and *Hystrichogonyaulax cladophora,* indicates that the microflora from sample C.P.4 is comparable with assemblages recorded from Agardhfjellet Member (Zone 2), Janusfjellet Formation in Central Spitsbergen (Bjærke 1980). An ?Upper Bathonian-Callovian age was suggested for this unit.

In Arctic Canada a Toarcian – Tithonian dinoflagellate cyst zonation of the Savik Formation and lower part of the Awingak Formation was proposed by Johnson & Hills (1973). The assemblages recorded from the Upper Savik Member and Awingak Formation include several of the species from sample C.P.4 from Franz Josef Land. The species *Gonyaulacysta jurassica* var. *longicornis* and *Stephanelytron redcliffense,* together with *Tubotuberella eisenackii* present in sample C.P.4, have also been recorded within assemblages defining the Oppel – Zone H of Davies (1983) from the Sverdrup Basin, Arctic Canada. Based on the occurrence of *Cadoceras septentrionale* and *Buchia concentrica*, Davies (1983) proposed a Middle Callovian to Late Oxfordian age for his Oppel – Zone H.

The microflora from sample C.P.4 is also comparable with assemblages recorded from the Upper Vardeklöft (Sarjeant 1972) and Hareelv Formation (Fensome 1979) of Jameson Land, East Greenland. A more detailed dinoflagellate cyst stratigraphy for the Middle to Late Jurassic strata

Fig. 5. Middle Jurassic playnomorphs.
A: ? *Scriniodinium* sp. A. PA 4358: 106.1–37.1. Sample C.P.4. Length 92 μm.
B: *Pareodinia ceratophora* Deflandre 1947. PA 4356: 96.7–46.1. Sample C.P.5. Length 63 μm.
C: *Tubotuberella eisenackii* (Deflandre) Stover & Evitt 1978. PA 4358: 101.0–37.8. Sample C.P.4. Length 62 μm.
D: *Tenua* sp. B of Bjærke 1977. PA 4353: 102.6–38.5. Sample C.P.5. Diameter 42 μm.
E: *Pareodinia evittii* (Pocock) Wiggins 1975. PA 4355: 96.1–34.1. Sample C.P.5. Length 59 μm.
F: *Chytroeisphaeridia cerastes* PA 4339: 105.9–44.3. Sample C.P.3. Length 61 μm.
G: *Caddasphaera halosa* (Filatoff) Fenton, Neves & Piel 1980. PA 4354: 106.5–42.8. Sample C.P.5 Diameter (central body) 37 μm.
H: *Sirmiodinium grossii* (Alberti) Warren 1973. PA 4367: 103.5–36.0. Sample C.P.4. Length 60 μm.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on Milne Land and Jameson Land (East Greenland) has been worked out by Piasecki (1980), who correlated his dinocyst zones with the detailed subboreal to boreal ammonite biostratigraphy. Piasecki (1980) defined the *Gonyaulacysta scarburghensis* zone, recognized in the Kosmocerasdal Member on Milne Land and uppermost part of the Fossilbjerget Member at Ugleelv on Jameson Land. This zone he correlated with the lower part of assemblage Zone 2 of Bjærke (1980), Agardhfjellet Member in Central Spitsbergen. The *G. scarburghensis* zone of Piasecki (1980) is equivalent to the *athleta* and *lamberti* ammonite zones on Milne Land, and is found to be younger than the *coronatum* zone in the Olympen Formation at Olympen in Jameson Land. The dinocyst *Stephanelytron redcliffense* found at both Franz Josef Land and Central Spitsbergen was not recognized by Piasecki (1980) from East Greenland, but this species is known to range from the Middle Callovian (*jason* ammonite zone) through the Middle Oxfordian elsewhere in Northwest Europe (Riley & Fenton 1982). The key species of the *G. scarburghensis* zone have not been recognized in the samples from Franz Josef Land, but based on the known restricted stratigraphic distribution of *Gonyaulacysta jurassica* var. *longicornis, Lithodinia jurassica* and *Tubotuberella eisenackii,* it is suggested that sample C.P.4 from Franz Josef Land is of Late Callovian to Early Oxfordian (pre- *cordatum* zone) age.

Sample C.P.5

This sample is also dominated by marine species, and contains less than 6% pollen and spores. *Lithodinia jurassica* and *Pareodinia* spp. are most prominent (each representing approximately 25% of the total assemblage), but *Hystrichogonyaulax cladophora* is also common (12%). *Tenua* sp. and *Caddasphaera halosa* are present in significant amounts (9 and 7%), while the remaining dinoflagellate cysts species each represent less than 5%.

The presence of *Fromea* sp. A and *Pareodinia* sp. D of Bjærke (1977) may suggest that the microflora from sample C.P.5 is comparable with Association D of Bjærke (1977), described from near base of Retziusfjellet Member (?), Janusfjellet Formation, on Kong Karls Land. This unit has previously been dated as Callovian (Nathorst 1910). Other key species from Association D on Kong Karls Land (e.g. *Nannoceratopsis pellucida, Adnatosphaeridium caulleryi* and several species assignable to *Pareodinia*) are apparently missing in the Franz Josef Land sample C.P.5, and the suggested correlation is therefore most uncertain.

Pareodinia evittii is known from the *coronatum* and *athleta* ammonite zones in East Greenland, and the presence of this species may indicate a Middle to lower Upper Callovian age for sample C.P.5 from Franz Josef Land.

Sample C.P.6

This sample yielded few palynomorphs, and no attempt has been made to describe the assemblage from this sample. The presence of *Sirmiodinium grossii* indicates that this sample is not older than Bathonian, and the presence of *Valensiella ovula* indicates a pre-Lower Oxfordian age. As for sample C.P.5, *Pareodinia evittii* may suggest a Middle to lower Upper Callovian age.

Conclusions

Samples obtained from the Cape Flora Section on Northbrook Island, Franz Josef land, have produced good to excellently preserved palynomorph assemblages, with 41 species recorded from the six samples here investigated (see Table 2). Palynomorphs show in general low thermal alteration, with TAI-values (Staplin 1964) of 1.5 or less for the samples not affected by the Early Cretaceous basalt capping.

Two different palynomorph assemblages have been recognized. The youngest recorded assemblages of Early Cretaceous age (samples C.P.1, C.P.2, C.P.3) are dominated by pollen and

Fig. 6. Middle Jurassic palynomorphs
A: *Lithodinia jurassica* (Eisenack) Gocht 1975. PA 4356: 109.6–42.2. Sample C.P.5. Diamter 59 μm.
B: *Cerebropollenites mesozoicus* (Cookson) Potinié 1956. PA 4359: 106.5–42.6. Sample C.P.4. Diameter 30 μm.
C: *Tenua verrucosa* Sarjeant 1968. PA 4359: 109.0–31.0. Sample C.P.4. Length 52 μm.
D: *Cleistosphaeridium* sp. PA 4359: 105.2–42.3. Sample C.P.4. Diameter 30 μm.
E: *Valensiella ovula* (Deflandre) Eisenack 1963. PA 4358: 101.4–39.8. Sample C.P.4. Length 62 μm.
F: *Laevigatosporites* sp. PA 4357: 164.1–44.4. Sample C.P.5. Length 29 μm.

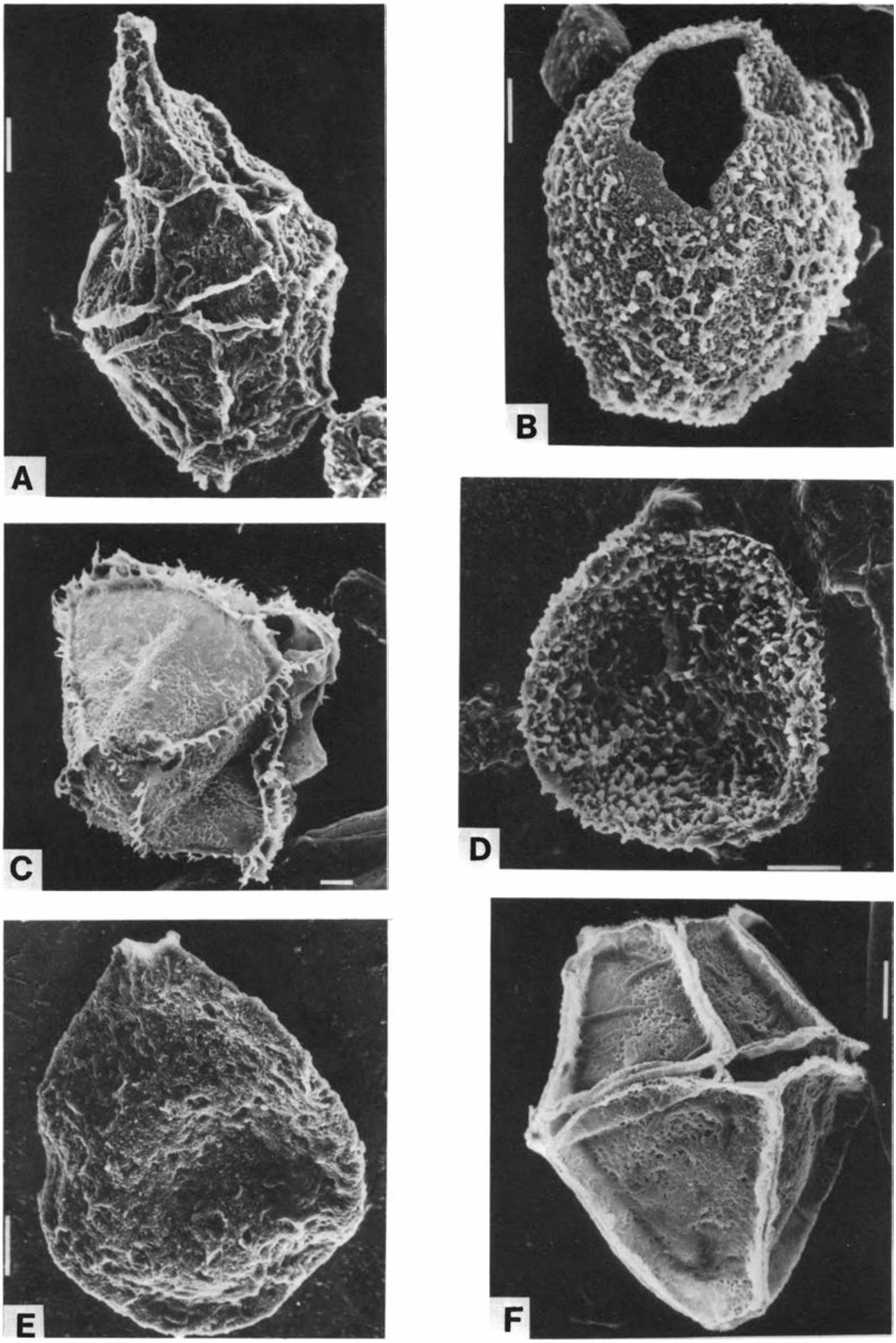
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Table 2. List of species recorded from Northbrook Island.

Taxa Samples	C.P.1	C.P.2	C.P.3	C.P.4	C.P.5	C.P.6
POLLEN AND SPORES:						
Alisporites grandis (Cookson) Dettmann 1963	×	×	×			
Alisporites sp. A	×	×				
Araucariacites australis Cookson 1947	×	×	×			
Baculatisporites comanensis (Cookson) Potonié 1956	×	×				
Brachysaccus microsaccus (Couper) Mädler 1964	×	×	×			
Cerebropollenites mesozoicus (Cookson) Potonié 1956				×		
Cerebropollenites cf. *macroverrucosus* (Thiergart) Ashultz 1967	×					
Cicatricosiporites australiensis (Cookson) Potonié 1956			×			
Cicatricosisporites sp. A			×			
Crybelosporites sp.	×					
Cyathidites australis Couper 1953	×	×	×			
Cycadopites cf. *nitidus* (Balme) Pocock 1970				×		
cf. *Fuldaesporites santonicus* Deák & Combaz 1967	×					
Laevigatosporites sp.					×	
Lycopodiumsporites sp.	×	×				
Perionopollenites sp.	×	×	×			
Phyllocladidites sp.	×	×	×			
Podocarpidites biformis Rouse 1957	×	×	×			
Verrucosisporites cheneyi Cornet & Traverse 1975					×	
DINOFLAGELLATE CYSTS AND ACRITARCHS						
? *Ambonosphaera* sp.				×		
Caddasphaera halosa (Filatoft) Fenton, Neves & Piel 1980				×	×	×
Cleistosphaeridium sp.				×		
Chytroeisphaeridia cerastes Davey 1979			×			
Cymatiosphaera cf. *parva* Sarjeant 1959					×	
Fromea sp.				×		
Gonyaulacysta jurassica (Deflandre) Norris & Sarjeant 1965				×		
Gonyaulacysta jurassica var. *longicornis* (Deflandre) Gitmetz 1970				×		
Hystrichogonyaulax cladophora (Deflandre) Storer & Evitt 1978				×	×	
Lithodinia jurassica (Eisenack) Gocht 1975				×	×	
Pareodinia ceratophora Deflandre 1947				×	×	×

Fig. 7. Middle Jurassic palynomorphs.
A: *Gonyaulacysta jurassica* var. *longicornis* (Deflandre) Gitmez 1970. SEM-C.P.4-I.
B: *Valensiella ovula* (Deflandre) Eisenack 1963. SEM-C.P.5.-II.
C: *Hystrichogonyaulax cladophora* (Deflandre) Stover & Evitt 1978. SEM-C.P.4.-I.
D: *Verrucosisporites cheneyi* Cornet & Traverse 1975. SEM-C.P.5.-II.
E: *Fromea* sp. SEM-C.P.5.-I.
F: ? *Ambonosphaera* sp. SEM-C.P.4.-II.

Pareodinia evittii (Pocock) Wiggins 1975				×	×
Pareodinia sp. D of Bjærke 1977				×	
Schizosporis parvus Cookson & Dettmann 1959	×				
Schizosporis reticulatus Cookson Dettmann 1959	×	×			
?Scriniodinium sp.			×		
Sirmiodinium grossii (Alberti) Warren 1973					×
Stephanelytron redcliffense Sarjeant 1961			×		
Tasmanites sp.	×				
Tenua verrucosa Sarjeant 1968				×	
Tenua sp. B of Bjærke 1977			×	×	×
Tubotuberella eisenackii (Deflandre) Storer & Evitt 1978			×		
Valensiella ovula (Deflandre) Eisenack 1963			×	×	×

spores, and only few marine palynomorphs are present. The Middle Jurassic assemblages from Cape Flora (samples C.P.4, C.P.5, C.P.6) are dominated by marine dinoflagellate cysts, with only minor terrestrial input.

Occurrence of Callovian strata at the Cape Flora Section as proposed by Pompeckj (1900) is confirmed by the presence of stratigraphically significant dinoflagellate cysts, and Lower Cretaceous strata as proposed by Nathorst (1900) are indicated by selected miospores. In addition to the ?Upper Triassic, Lower Bajocian, Lower to Middle Callovian and Lower Cretaceous deposits earlier reported, the presence of selected palynomorphs can indicate that strata of Upper Callovian to Lower Oxfordian age also may be present at Cape Flora.

Acknowledgements. – The author is grateful to Dr. J. B. Riding at British Geological Survey, Dr. D. Bruton at the Paleontologisk Museum, Oslo, and to N. Aarhus and J. Os Vigran at IKU for critically reading and suggesting improvements to this manuscript, which was typewritten by Ellen Solberg.

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