Stratigraphy and palynology of the Lower Carboniferous Sortebakker Formation, Wandel Sea Basin, eastern North Greenland

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Two palynological assemblages of Early Carboniferous age have been recorded from the upper parts of the non-marine, fluvial-dominated Sortebakker Formation in the Wandel Sea Basin. The stratigraphically lower assemblage includes poorly preserved *Cingulizonates* spp., *Densosporites* spp., *Lycospora* spp. and *Schulzospora* spp. whereas the upper assemblage contains a more diversified microflora including the stratigraphically important *Tripartites distinctus*, *Potoniespores delicatus* and *Savitrisporites* spp. The microflora enables correlation and dating of the succession to the late Viséan Perotrilites tessellatus – Schulzospora campyloptera (TC) and Raistrickia nigra – Triquitrites marginatus (NM) miospore Biozones of western Europe. The depositional facies correspond to those seen in time equivalent deposits from East Greenland, Svalbard, Bjørnøya and the Barents Sea.

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The Sortebakker Formation in North Greenland and the roughly time equivalent non-marine deposits in East Greenland, Svalbard, Bjørnøya and the offshore areas of the Barents Sea form a distinctive depositional event related to initial rifting in the region (Stemmerik & Worsley 1989; Stemmerik *et al.* 1991). Deposition started in East Greenland and on Svalbard during the latest Devonian (Strunian part of the Famennian) and throughout the region fluvial sedimentation continued into the Viséan (Stemmerik *et al.* 1991; Bugge *et al.* 1995; Vigran *et al.* 1999). So far, dating of the Sortebakker Formation has been based on a poorly preserved macroflora that suggests a general Early Carboniferous age for these deposits (Nathorst 1911; Stemmerik & Håkansson 1989). This broad age assignment has hampered detailed correlation of this thick succession of mainly fluviatile deposits with the time equivalent Billefjorden Group of Svalbard and Traill Ø Group of East Greenland.

The Sortebakker Formation is geographically limited to the south coast of Holm Land in eastern North Greenland (see Fig. 1) where it overlies Caledonian-affected basement and is unconformably overlain by Upper Carboniferous (Moscovian) marine deposits of the Kap Jungersen Formation (Håkansson *et al.* 1981; Stemmerik *et al.* 1995a). The Sortebakker Formation deposits were faulted and thermally affected prior to deposition of the Kap Jungersen Formation (Håkansson *et al.* 1981; Christiansen *et al.* 1991), and previous attempts at dating of the formation by miospores have failed due to thermal destruction of the organic material in the sampled sections. However, following renewed field work in 1994, miospores were obtained from shales in the uppermost part of the formation in outcrops located to the west of the previous study areas (Fig. 1; Stemmerik *et al.* 1995b). The miospores, although poorly preserved, define two stratigraphically significant Viséan assemblages that enable, for the first time, relative age assignment of, at least, the upper part of the formation and a more reliable correlation with comparable deposits in East Greenland, Svalbard and Bjørnøya (Fig. 2).

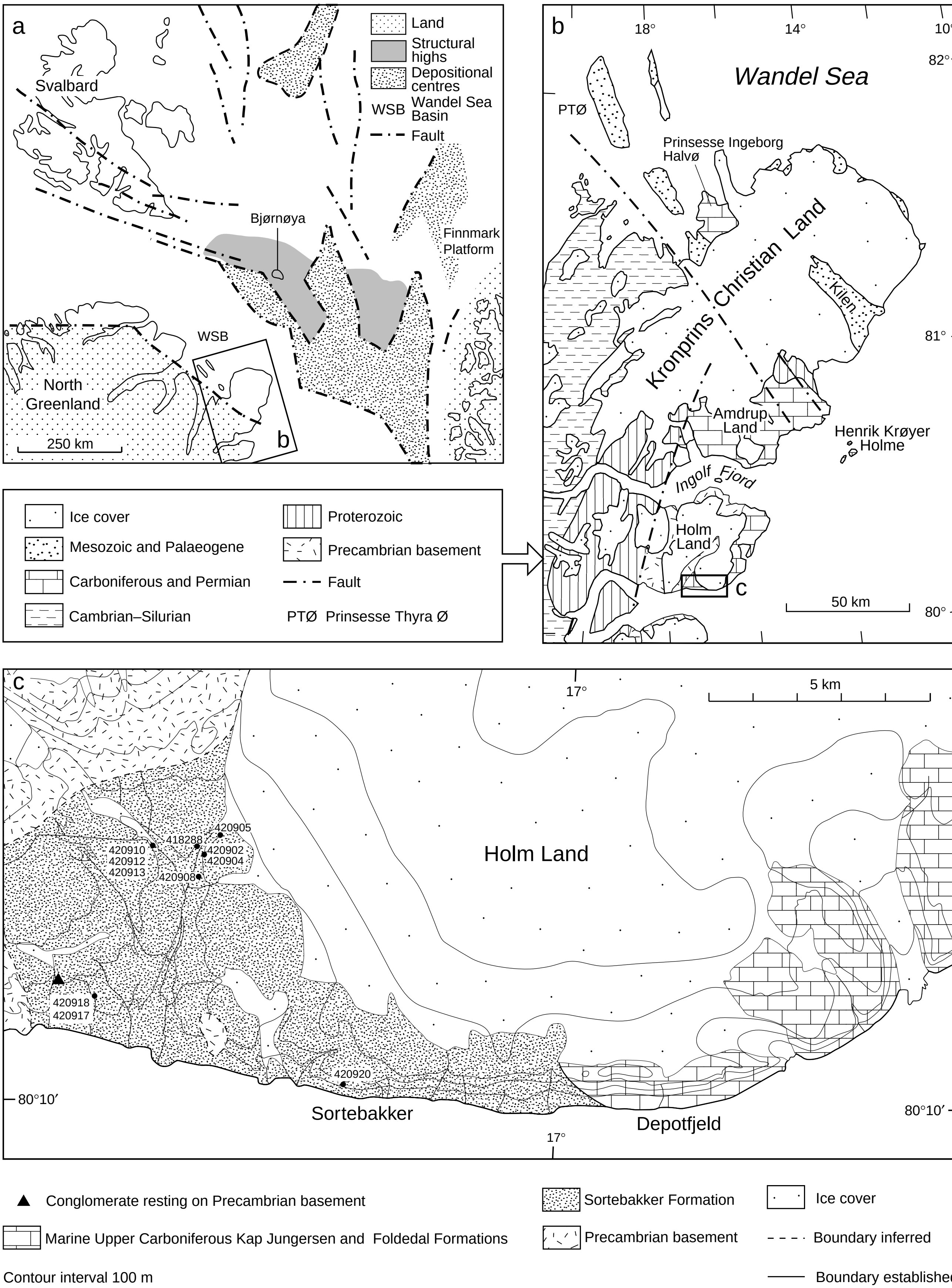
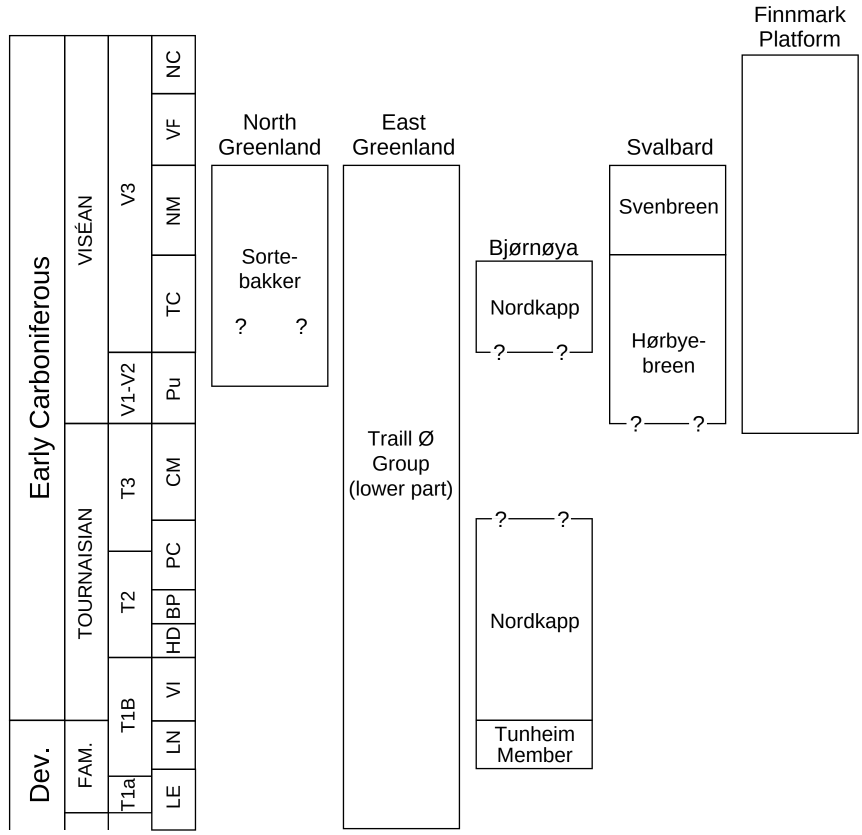

a
Land
Structural highs
Depositional centres
WSB Wandel Sea Basin
Fault
Svalbard
Bjørnøya
Finnmark Platform
WSB
North Greenland
250 km
b
Ice cover
Mesozoic and Palaeogene
Carboniferous and Permian
Cambrian–Silurian
Proterozoic
Precambrian basement
Fault
PTØ Prinsesse Thyra Ø
18°
14°
10°
82°
81°
80°
Wandel Sea
PTØ
Prinsesse Ingeborg Halvø
Kronprins Christian Land
Kilen
Amdrup Land
Henrik Krøyer Holme
Ingolf Fjord
Holm Land
c
50 km
17°
5 km
Holm Land
420905
418288
420910
420912
420913
420902
420904
420908
420918
420917
420920
80°10′
Sortebakker
Depotfjeld
Conglomerate resting on Precambrian basement
Marine Upper Carboniferous Kap Jungersen and Foldedal Formations
Contour interval 100 m
Sortebakker Formation
Precambrian basement
Ice cover
Boundary inferred
Boundary established

Fig. 2. Stratigraphic scheme showing proposed correlation of Lower Carboniferous sediments in eastern North Greenland, Bjørnøya, Svalbard and the Barents Sea. **FAM**: Famennian (Strunian). **LE–NC** miospore Biozones of Clayton *et al.* (1977) and Higgs *et al.* (1988).



This paper describes the miospore assemblages found in the upper part of the Sortebakker Formation (Fig. 3). Dating of these assemblages is based on correlation with miospore assemblages from East Greenland and western Europe (Neves *et al.* 1973; Clayton *et al.* 1977; Higgs *et al.* 1988; Vigran *et al.* 1999).

Lithology

The Sortebakker Formation comprises a succession of non-marine, mainly fluviatile sediments exposed along the south coast of Holm Land in eastern North Greenland (Stemmerik & Håkansson 1989). The formation was originally proposed to be approximately 600 m thick but reliable thickness estimates were difficult due to structural disturbance of the section, and lack of outcrops of the base of the formation. During field work in 1995, the base of the formation was found in the western part of the outcrop area (Fig. 1). There, unusually coarse-grained facies rest directly on Caledonian-affected basement. Based on these new observations and correlation of detailed sedimentological sections from the coastal cliffs and river sections, the formation is now estimated to be *c.* 1000 m thick (Fig. 4). The formation is dominated by stacked fining-upward cycles of fluvial sandstones and shales with some lacustrine shale deposits towards the top (Fig. 5). Individual cycles can be traced laterally for at least 1–2 km, the limiting factor in most cases being the amount of exposure. The formation is divided by a low-angle disconformity into a lower unit of shale-dominated cycles and an upper unit of sandstone-dominated cycles (Fig. 4).

The succession consists of six lithofacies associations. Five of these characterise different parts of a meandering river system; the sixth represents a lacustrine system. Details of the sedimentology are given in

Fig. 1. **a**: Map with major structural outline and palaeogeographic reconstruction of the Wandel Sea and Barents Sea regions. Modified from Stemmerik & Worsley (1995). **b**: Simplified geological map of Kronprins Christian Land and environs showing the distribution of Upper Palaeozoic sediments. Modified from Stemmerik *et al.* (1994). For location, see Fig. 1a. **c**: Geological map of the southern part of Holm Land showing the distribution of the Sortebakker Formation and sample localities mentioned in the text. For location, see Fig. 1b.

Fig. 3. Interbedded fine-grained sandstones (**SS**) and shales (**Sh**) from the topmost part of the Sortebakker Formation yielding palynomorphs in sample GGU 418288. Exposed section is *c.* 15 m high. For location, see Fig. 1c.

Dalhoff & Stemmerik (2000, this volume) and a summary of the sedimentary associations are given in Table 1. All miospores are found in the overbank fines association described in more detail below.

Overbank fines association

This facies association comprises up to 10 m thick units of laminated to weakly laminated shale and siltstone separated by thin partings of massive sandstone and parallel laminated silty sandstone. In the lowermost part of the formation, rare very thin coal partings occur. The overbank fines association has a transitional or planar to irregular base and comprises mainly fining-upward units with flaser and lenticular bedding, though coarsening-upward units are observed locally. The sandstone partings are 2–10 cm thick with wavy or planar lower and upper boundaries. Sediments from the overbank fines association usually overlie sand-

Table 1. Summary of facies associations in the Sortebakker Formation

Facies association	Thickness	Dominant lithology	Characteristics
Channel	0.5–4 m (lower part) 10–13 m (upper part)	Upward-fining units of medium- to fine-grained sandstone	Sharp, erosive bases, mudflake clasts, pebbly lags, cross-bedding
Overbank fines	< 10 m	Laminated to weakly laminated shale and siltstone. Silty sandstone	Flaser and lenticular bedding
Crevasse splay	< 5 m	Medium- to fine-grained sandstone	Composite less than 1.5 m thick beds. Cross-bedding
Levee	Multistory, up to 10 m	Heterolithic units of weakly laminated clay and silt and medium- to fine-grained sandstone	
Lake	< 28 m	Laminated and non-laminated shale and siltstone	Rare, thin silty sandstones with ripple lamination
Swamp	< 1 m	Coal and shaly coal	Vertical tree stumps in growth position

For details, see Dalhoff & Stemmerik (2000, this volume)

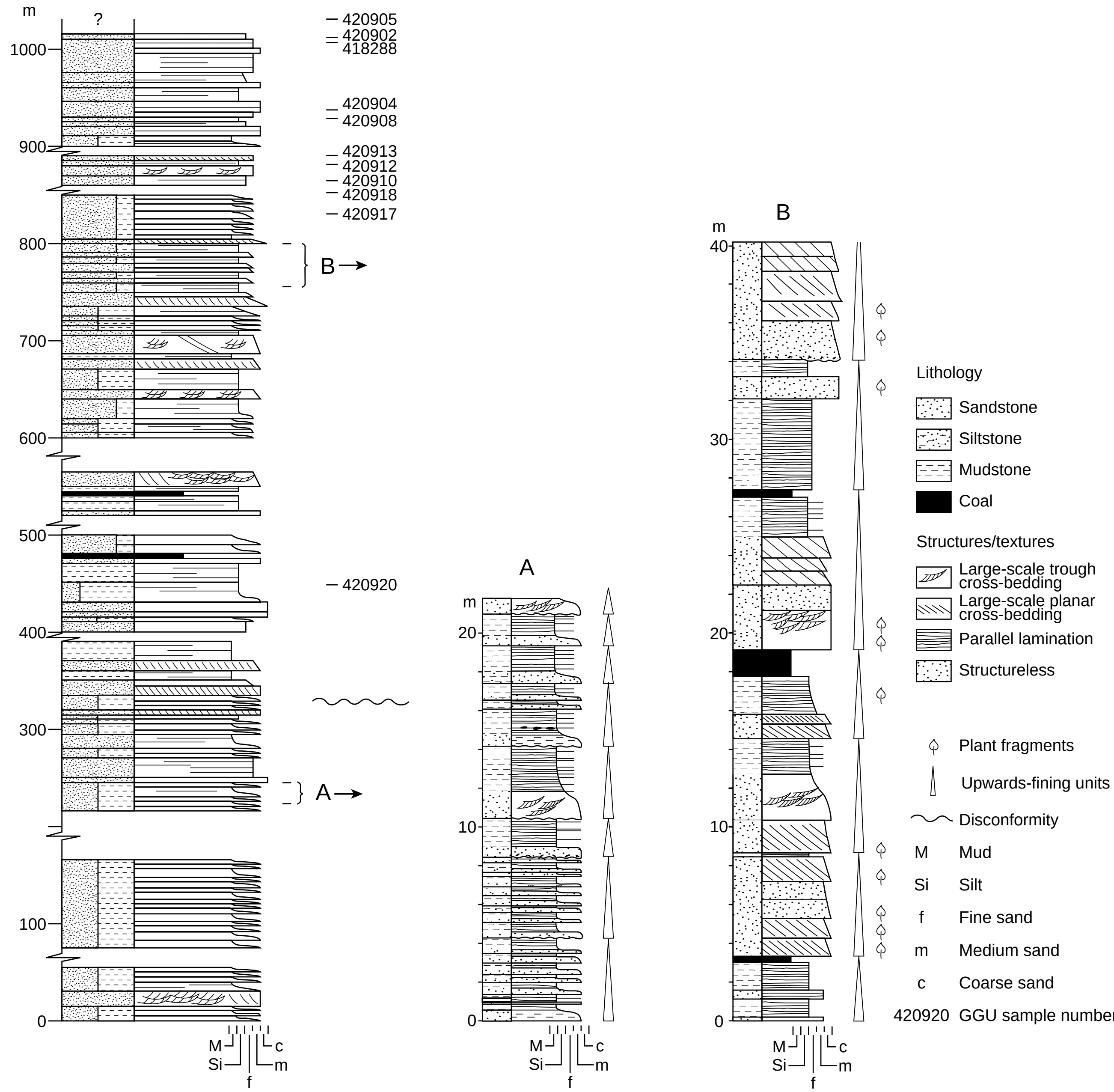


Fig. 4. Composite and detailed sedimentological logs of the Sortebakker Formation. The detailed logs show typical stacking patterns in the lower shale-dominated unit (**A**) and the upper sand-dominated unit (**B**). The total thickness is estimated to exceed 1000 m. Palynological sample localities are also shown.

stones from the channel association with a gradual transition (Fig. 6). Poorly preserved plant fragments are the only macrofossils recorded in this association. The facies association can be traced laterally for more than 1000 m.

Depositional evolution

The formation consists of stacked floodplain deposits that in the uppermost part pass into a succession of mixed fluvial and lacustrine deposits. The overall pattern shows a transition from thin shale-dominated cycles to thick sand-dominated cycles. This change is suggested to reflect a shift from a broad distal floodplain, where the meandering stream channels had limited influence on sedimentation, to a more proximal or laterally confined floodplain where channel sedimentation dominated. The final shift towards mixed lacustrine and fluvial deposition reflects a change in base level possibly due to increased rates of subsidence. The uppermost fluvial channels appear to be of the same size as those seen below in the upper flood-plain succession, but are laterally confined, and rather than forming tabular sand bodies they form isolated lenticular sand bodies.

Miospore correlation

The palynological investigation of the Lower Carboniferous Sortebakker Formation of North Greenland has shown the presence of two miospore assemblages. These can be correlated with the western European standard Carboniferous miospore zones of Clayton *et al.* (1977) and Higgs *et al.* (1988) which allows dating of the succession (Fig. 2; Tables 2, 3). There is also resemblance to assemblages described from East Greenland by Vigran *et al.* (1999). The organic residues are generally of poor but variable preservation. Processing procedures developed at the former Geological Survey of Greenland (GGU) have been adapted to enrich the palynomorph content (Hansen & Gudmundsson 1979). Different fractions of the residues were isolated according to their specific weight and floating properties. Smear slides mounted in Eukitt® represent the different fractions and show a variable relative palynological composition. The 'semiquantitative data' expressed rather briefly in the distribution chart represent estimates based on one or more slides (Table 2).

Two palynological assemblages (described below) are recognised on the basis of selected palynomorphs. The assemblages are numbered according to their stratigraphic position in the sections and their ages refer to the western European Miospore Biozones with modifications based on material from other Arctic areas (Playford 1962, 1963; Kaiser 1970; Bugge *et al.* 1995; Vigran *et al.* 1999).

Assemblage 1

Definition. The miospores encountered are *Cingulizonates* spp., *Densosporites* spp. and *Lycospora* spp. together with rare specimens of *Schulzospora* spp.

Palynofacies. The residues contain dominantly angular black fragments and only very rare miospores. The

Fig. 5. Cliff exposure of the upper sand-dominated unit. Note the thick laterally persistent cycles of interbedded channel sandstones (light) and overbank fines. Eastern Sortebakker, southern Holm Land. The cliff is approximately 350 m high.

Table 2. Distribution of miospores in the Sortebakker Formation

Taxa	GGU 420905	GGU 420902	GGU 418288	GGU 420904	GGU 420908	GGU 420913	GGU 420912	GGU 420910	GGU 420918	GGU 420917	GGU 420920
Densosporites spp.	3	1	3	3	3	2	3	3	2	1	1
Lycospora spp.	1		1	1	2	1	1	1	1	1	2
Schulzospora spp.	1	1	1	1	1		1	1	1	1	1
Cingulizonates spp.	1		1	1	1		1	1		1	
Discernisporites micromanifestus (Hacquebard & Barss) Sabry & Neves 1971			1				1	1		1	
Knoxisporites triradiatus Hoffmeister Staplin & Malloy 1955	1						1			1	
Lycospora pusilla (Ibrahim) Schopf, Wilson & Bentall 1944			1	1	1		1			1	
Punctatisporites pseudobesus Playford 1962										1	
Reticulatisporites variolatus Playford 1962	1		1	1	1	1	1	1		1	
Spelaeotriletes spp.			1							1	
Calamospora spp.				1			1	1			
Cingulizonates bialatus (Waltz) Smith & Butterworth 1967	1	2	1	1	1		1	1			
Cirratriradites spp.				1			1	1			
Convolutispora labiata Playford 1962			1					1			
Corbulispora cancellata (Waltz) Bharadwaj & Venkatachala 1961	1	1	1	1	1	1	1	1			
Densosporites spitsbergensis Playford 1963	1		1	1	1	1	1	1			
Diatomozonotriletes fragilis Clayton *in* Neves *et al.* 1973	1	1					1	1			
Diatomozonotriletes saetosus (Hacquebard & Barss) Hughes & Playford 1961		1			1	1	1	1			
Diatomozonotriletes spp.	1	1	1		1			1			
Knoxisporites dissidius Neves 1961			1					1			
Platyptera incisotriloba (Naumova) Braman & Hills 1977	1	1					1	1			
Punctatisporites spp.	1	1	1	1	1		1	2			
Raistrickia spp.	1		1			1	1	1			
Reticulatisporites peltatus Playford 1962			1			1		1			
Tricidarisporites arcuatus Neville *in* Neves *et al.* 1973	1	1				1		1			
Tricidarisporites rarus (Playford) Neville 1971	1	1	1				1	1			
Velamisporites spp.				1				1			
Verrucosisporites spp.		1					1	1			
Walzispora planiangulata Sullivan 1964	1	1					1	1			
Ahrensisporites duplicatus Neves *in* Neves *et al.* 1973	1						1				
Bisaccate pollen (indeterminate)		1		1			1				
Cingulizonates brevispinosus (Hoffmeister, Staplin & Malloy) n. comb.	1			1	1		1				
Endosporites spp.			1		1		1				
Knoxisporites stephanephorus Love 1960							1				
Microreticulatisporites spp.	1				1		1				
Murospora aurita (Waltz) Playford 1962							1				
Phyllothecotriletes rigidus Playford 1962							1				
Platyptera complanata (Staplin) Ravn 1991		1					1				
Raistrickia nigra Love 1960							1				
Savitrisporites nux (Butterworth & Williams) Smith & Butterworth 1967							1				
Savitrisporites spp.			1		1	1	1				
Simozonotriletes intortus (Waltz) Potonié & Kremp 1954							1				
Tetraporina horologia (Staplin) Playford 1963							1				
Triquitrites batillatus Hughes & Playford 1961	1		1		1	1	1				
Tumulispora variverrucata (Playford) Staplin & Jansonius 1964							1				
Cristatisporites bellus Bharadwaj & Venkatachala 1961	1					1					
Tripartites distinctus Williams *in* Neves *et al.* 1973		1	1			1					
Verrucosisporites eximius Playford 1962						1					
Schulzospora campyloptera (Waltz) Hoffmeister, Staplin & Malloy 1955		1	1	1							
Densosporites diatretus Playford 1963			1								
Laevigatosporites spp.			1								
Latosporites spp.			1								
Lophozonotriletes spp.			1								
Rugospora spp.			1								
Potoniespores delicatus Playford 1963		1									
Acanthotriletes cf. *A. haquebardii* Playford 1964	1										
Discernisporites macromanifestus (Hacquebard) Utting 1987	1										
Palynological Assemblage Zone	NM								TC		
Age	Late Viséan										

Frequency is illustrated by the numbers 1, 2 and 3 (highest)
For sample description, see Table 3
NM: Raistrickia nigra – Triquitrites marginatus Biozone
TC: Perotrilites tessellatus – Schulzospora campyloptera Biozone

Fig. 6. Typical fining-upward unit from the upper part of Sortebakker Formation. Fluvial sandstones erosively overlie the overbank fines from the preceding unit and pass upwards into new overbank fines. The exposed section is approximately 60 m thick and located at Sortebakker on the southern coast of Holm Land just east of sample locality 420920. For location, see Fig. 1.

productive samples all represent the overbank fines association.

Distribution. The assemblage is recorded in GGU 420917, 420918 and 420920 from two sub-sections in the upper part of the Sortebakker Formation. The samples occur stratigraphically below those containing the more diverse Assemblage 2.

Age. The presence of *Schulzospora* spp. indicates that the assemblage is no older than the Perotrilites tessellatus – Schulzospora campyloptera (TC) miospore Biozone of western Europe (Neves *et al.* 1973; Clayton *et al.* 1977). Similar low diversity assemblages have been recorded as Biozone 1 on the Finnmark Platform (Bugge *et al.* 1995). The deposits there represent a braided river system developing into a local floodplain and they are considered as representing the Nordkapp Formation (see Fig. 2).

Table 3. Description of eleven samples from the Sortebakker Formation (see Table 2)

GGU No.	Description
420905	Spore-dominated, sapropelised residue
420902	Spore-dominated, sapropelised residue
418288	Spore-dominated, sapropelised residue, some coal fragments
420904	Coal fragments and spores dominate sapropelised residue
420908	Spore-dominated, sapropelised residue, some coal fragments
420913	Coal fragments dominate the residue
420912	Coal fragments and fairly well-preserved spores dominate
420910	Spore-dominated, sapropelised residue, some coal fragments
420918	Coal fragments dominate the residue
420917	Coal fragments dominate the residue
420920	Coal fragments dominate the residue

Comment. The low diversity assemblage is suggested to represent a palynofacies different from the interval above rather than a distinctive stratigraphic level within the late Viséan. However, both assemblages come from the same lithofacies, the overbank fines.

Assemblage 2
Figs 7, 8

Definition. This assemblage includes *Cingulizonates* spp., *C. bialatus, Corbulispora cancellata, Densosporites* spp., *D. spitsbergensis, Diatomozonotriletes fragilis, D. saetosus, Discernisporites* spp., *D. micromanifestus, Knoxisporites dissidius, K. stephanephorus, K. triradiatus, Laevigatosporites* spp., *Lycospora pusilla, Murospora aurita, Platyptera complanata, P. incisotriloba, Potoniespores delicatus* (the highest sample), *Punctatisporites* sp., *Raistricka* spp., *R. nigra, Reticulatisporites variolatus, Savitrisporites* spp., *S. nux, Schulzospora* spp., *S. campyloptera, Tricidarisporites arcuatus, T. rarus* and *Tripartites distinctus.* Indeterminate alete bisaccate pollen occurs sporadically.

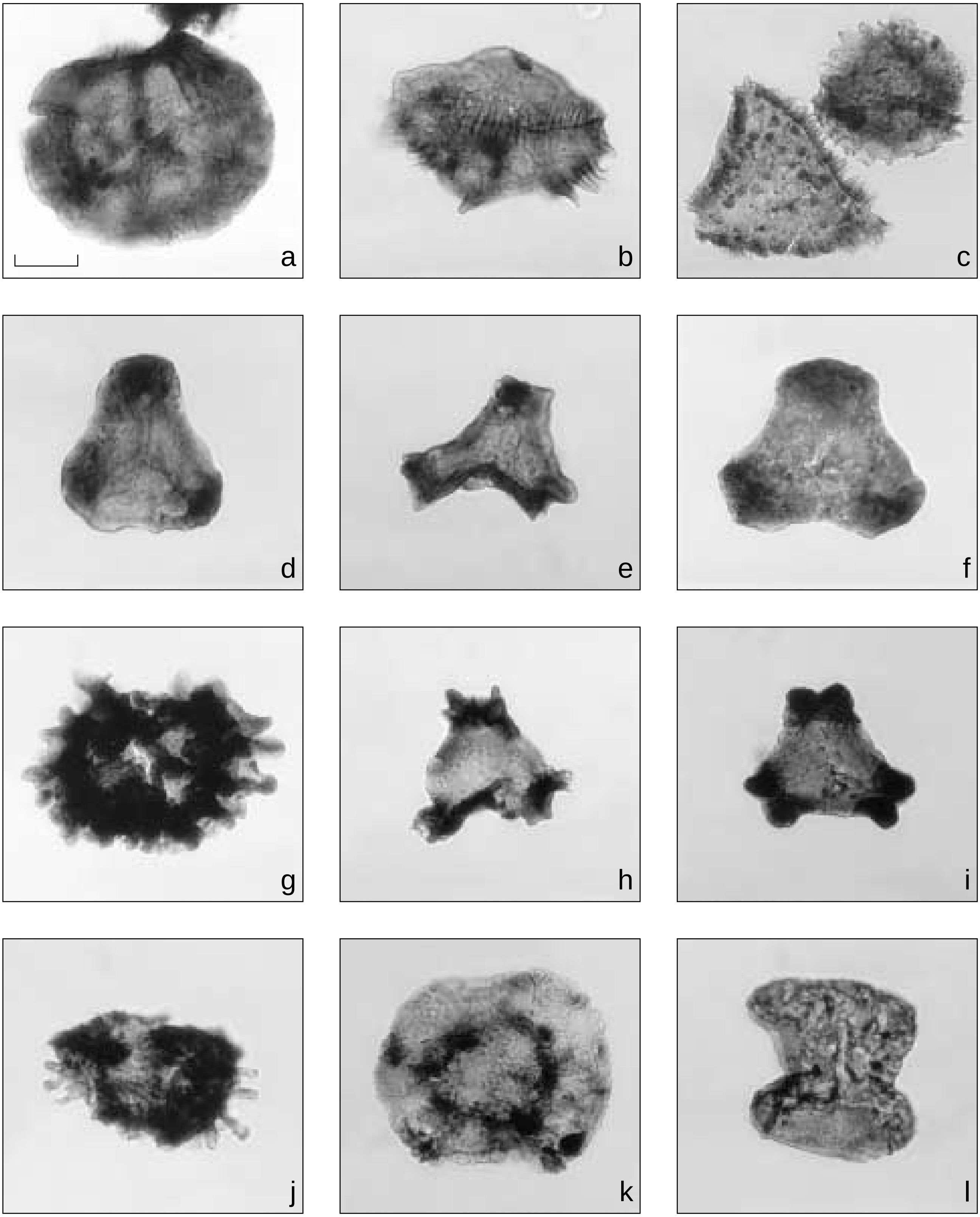


Fig. 7. Palynomorphs from Assemblage 2 in the Sortebakker Formation in southern Holm Land. Scale bar is 10 µm; all figures are the same size. **a**: *Schulzospora campyloptera*, MGUH 24807 from GGU 418288-5; **b**: *Diatomozonotriletes saetosus*, MGUH 24808 from GGU 420912-3; **c**: *Diatomozonotriletes fragilis*, MGUH 24809 from GGU 420912-3; **d**: *Triquitrites batillatus*, MGUH 24810 from GGU 420912-3; **e**: *Ahrensisporites duplicatus*, MGUH 24811 from GGU 420912-3; **f**: *Platyptera complanata*, MGUH 24812 from GGU 420912-3; **g**: *Reticulatisporites peltatus*, MGUH 24813 from GGU 418288-5; **h**: *Platyptera incisotriloba*, MGUH 24814 from GGU 420902-2; **i**: *Tripartites distinctus*, MGUH 24815 from GGU 420912-3; **j**: *Raistrickia* sp. cf. *Raistrickia corynoges*, MGUH 24816 from GGU 420912-3; **k**: *Endosporites* spp., MGUH 24817 from GGU 420908-3; **l**: *Tetraporina horologia*, MGUH 24818 from GGU 420912-3.

Palynofacies. Black angular fragments and miospores, of which *Lycospora* spp., *Densosporites* spp. and morphologically related genera are most common, dominate the residues. The diversity and composition of the assemblage varies within the studied material and possibly relates to variations in the lithofacies. The strong sapropelisation in some samples suggests material from more swampy areas. The variably dark colour of miospores within individual samples is most likely the result of post-depositional chemical processes, presumably related to circulation of hot water during a post-depositional mid-Carboniferous tectonic event (e.g. Stemmerik *et al.* 1998).

Age. The palynoflora of Assemblage 2 is correlated to the Raistrickia nigra – Triquitrites marginatus NM Biozone (Fig. 2). *Tripartites distinctus* and *Potoniespores delicatus* are among the taxa characterising the NM Biozone of western Europe (Neves *et al.* 1973). Assemblage 2 clearly is related to the *aurita* Assemblage from the upper part of the Billefjorden Group of Svalbard (Playford 1962, 1963). This diverse assemblage, although different in composition to the western European assemblages, may be correlated with the TC and NM Biozones, although *Raistrickia nigra* seems to be missing. The diverse assemblages from the Finnmark Platform that are characterised by *P. delicatus* and dominated by *Lycospora* spp. have been correlated with the NM Zone (Bugge *et al.* 1995; Fig. 2), and in East Greenland a *Lycospora*-dominated assemblage with *Schulzospora* and *Diatomozonotriletes saetosus* is correlated with the TC–NM Biozones (Vigran *et al.* 1999).

Sullivan (1965) showed that Lower Carboniferous palynofloras were distributed according to latitudinal control. The Sortebakker Formation microflora, together with the *aurita* Assemblage from Svalbard, belongs to the *Monilospora* suite which covered northern Europe and Canada between approximately 20º and 50º northern palaeo-latitude. Further to the south in the Early Carboniferous, close to the equatorial areas of western Europe, this microflora was replaced by a *Grandispora* suite. This latitudinal control on the palynoflora may explain why Assemblage 2 also includes some miospores that have their first appearance in younger Carboniferous miospore biozones in western Europe. They include *Diatomozonotriletes saetosus* and *Savitrisporites nux* which have their first appearance in the Tripartites vetustus – Rotaspora fracta (VF) Biozone, *Laevigatosporites* spp. which have their first appearance in the Lycospora subtriquetra – Kraeuselisporites ornatus (SO) Biozone and indeterminate bisaccate pollen which first appear in the Radiizonates aligerens (RA) Biozone of western Europe.

Distribution. The assemblage although recorded from different subsections is limited to lake and swamp deposits in the uppermost part of the Sortebakker Formation. The variation in composition and preservation reflects that deposition of the miospores took place more or less contemporaneously, but in different depositional environments. The dominance of *Densosporites* and related genera is in accordance with observations by Playford (1963) in coal samples from the upper part of the Billefjorden Group of Svalbard.

Regional implications

The miospore assemblages obtained in this study date the upper part of the Sortebakker Formation as late Viséan. Deposition took place within a time interval equivalent to the TC and NM Biozones of the western European miospore zonation (Fig. 2). Age equivalent deposits in East Greenland are restricted to Geographical Society Ø (72°30′N) where they consist of stacked floodplain cycles of trough cross-bedded medium-grained sandstones and coaly shales, occasionally capped by thin coal beds (Stemmerik *et al.* 1993; Vigran *et al.* 1999). These 2–15 m thick fining-upward cycles are associated with thicker lacustrine shales and the overall depositional environment resembles that inferred for the upper part of the Sortebakker Formation.

Age equivalent deposits on Bjørnøya belong to the upper part of the Nordkapp Formation (Fig. 2; Kaiser 1970). These sediments consist of lacustrine shales and interbedded sandstones, conglomerates and shales deposited in a braided-stream-dominated floodplain environment (Gjelberg 1981). The miospore assemblages of the upper Hørbyebreen Formation and the Svenbreen Formation of the Billefjorden Group of Svalbard were originally described by Playford (1963). These assemblages are here assigned to the TC and NM Biozones (Fig. 2). The sediments were deposited on broad, humid floodplains and towards the basin margins pass into more coarse-grained alluvial deposits (Steel & Worsley 1984). In contrast to the North Greenland deposits, these sediments include thick coal beds. In the offshore areas of the Finnmark Platform thick floodplain deposits with a miospore flora assigned to the TC and NM Biozones have been recorded (Fig. 2; Bugge *et al.* 1995). The depositional environments

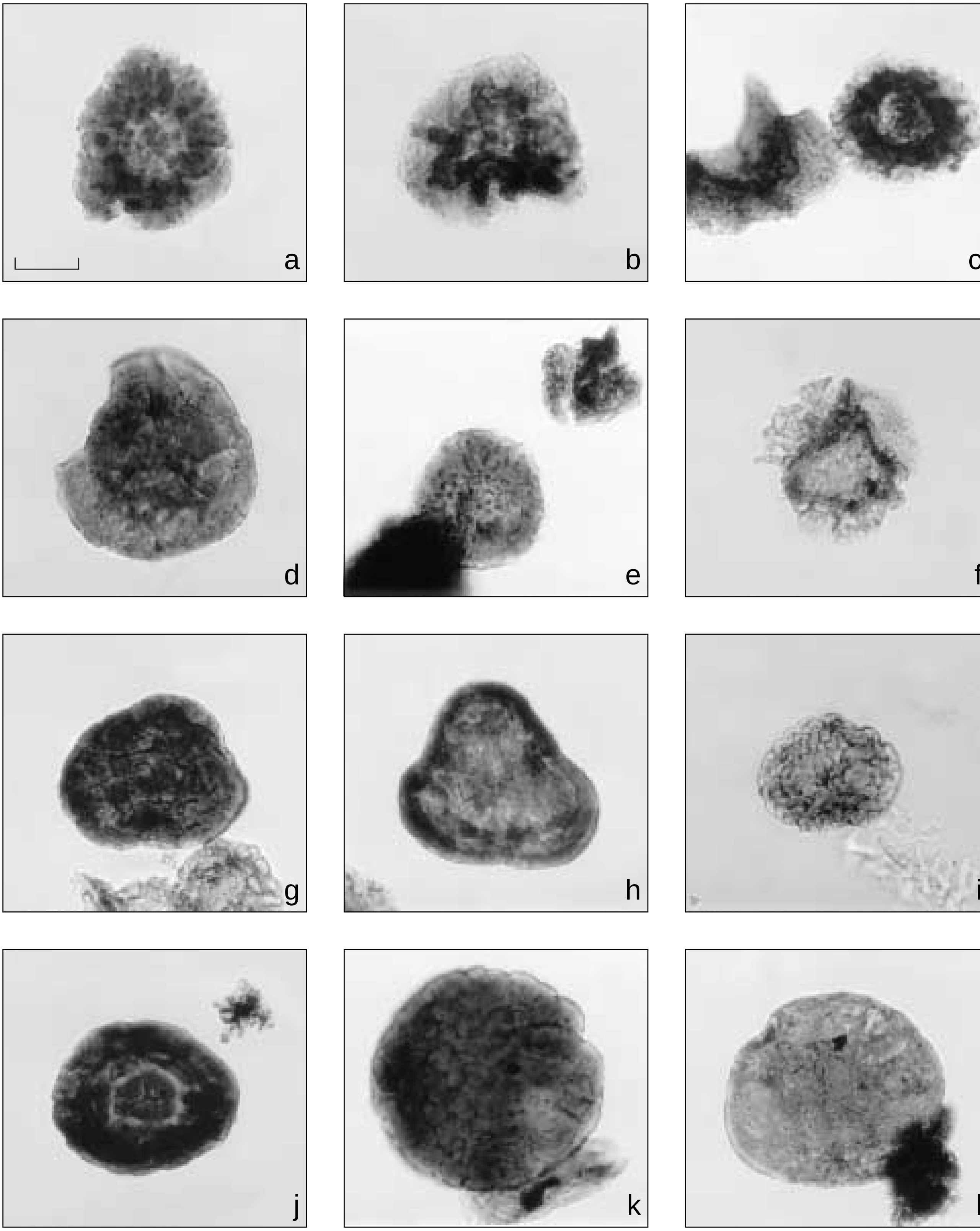


Fig. 8. Palynomorphs from Assemblage 2 in the Sortebakker Formation in southern Holm Land. Scale bar is 10 µm; all figures are the same size. **a**: *Densosporites spitsbergensis*, MGUH 24819 from GGU 420912-3; **b**: *Cristatisporites bellus*, MGUH 24820 from GGU 420912-3; **c**: *Cingulizonates brevispinosus*, MGUH 24821 from GGU 420912-2; **d**: *Discernisporites* spp., MGUH 24822 from GGU 420912-2; **e**: *Densosporites* sp. A, MGUH 24823 from GGU 420912-3; **f**: *Cingulizonates* sp., corroded specimen, MGUH 24824 from GGU 420912-3; **g**: *Tumulispora variverrucata*, MGUH 24825 from GGU 420912-3; **h**: *Simozonotriletes intortus*, MGUH 24826 from GGU 420912-3; **i**: *Rugospora minuta*, MGUH 24827 from GGU 420902-2; **j**: *Knoxisporites stephanephorus*, MGUH 24828 from GGU 420912-3; **k**: *Verrucosisporites eximius*, MGUH 24829 from GGU 420913-3; **l**: *Phyllothecotriletes rigidus*, MGUH 24830 from GGU 420912-2.

inferred for the upper parts of the Sortebakker Formation thus confirm that the region during the late Viséan formed a vast, humid lowland where sedimentation was dominated by meandering river deposits except for local areas along active fault blocks. The north-eastward flow directions recorded on Holm Land are comparable to palaeocurrent data from the Finnmark Platform (Bugge *et al.* 1995) which suggests the rivers had their sources in the Greenland Shield and Baltic Shield, respectively. During the late Viséan (NM Biozone time) the Finnmark Platform was transgressed (Bugge *et al.* 1995). So far, evidence of marine deposits has not been recorded from Bjørnøya, Svalbard, North Greenland and East Greenland. However, the relative rise in sea level recorded on the Finnmark Platform may correlate with the shift from uniform floodplain sedimentation to more lacustrine-dominated environments near the top of the Sortebakker Formation.

The biostratigraphic data confirm that the youngest sediments, belonging to the Early Carboniferous rift sequence in North Greenland, are of late Viséan age and are roughly age equivalent to the uppermost parts of the lower Traill Ø Group in East Greenland (*sensu* Vigran *et al.* 1999) and the Billefjorden Group of Svalbard and Bjørnøya (Fig. 2). This strongly suggests that the hiatus between the Sortebakker Formation and the overlying Upper Carboniferous sediments of the Kap Jungersen Formation in North Greenland spans roughly the same time interval as the mid-Carboniferous hiatus in East Greenland and on Svalbard (Stemmerik *et al.* 1991), and was most likely caused by the same regional uplift. The intense faulting of the Sortebakker Formation and migration of hot water through the sediments prior to deposition of the overlying Upper Carboniferous sediments may imply movements along the East Greenland fault zone during this event.

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