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Cretaceous and Cenozoic dinoflagellate cysts and other palynomorphs from the western and eastern margins of the Labrador–Baffin Seaway

Robert A. Fensome, Henrik Nøhr-Hansen
& Graham L. Williams

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Keywords
Biostratigraphy, Cretaceous, Cenozoic, dinocysts, systematics, Baffin Margin, Labrador Margin, Mesozoic, offshore West Greenland

Cover illustration
Selected palynomorphs from the subsurface of the Labrador–Baffin Seaway; for details, see Plates 1, 3, 4, 6, 7, 12, 15, 17, 18.
Top left to bottom right: **Dinoflagellates** – *Chiropteridium gilbertii* sp. nov., *Chatangiella tripartite*, *Cleistosphaeridium palmatum* sp. nov., *Diphyes brevispinum*, *Ginginodinium*? *flexidentatum* sp. nov., *Adnatosphaeridium vittatum*, *Piladinium columna*, *Thalassiphora pelagica*, *Eocladopyxis peniculata*; **Miospores** – *Aquilapollenites quadrilobus*, *Cicatricososporites eocenicus*, *Baculatisporites crenulatus* sp. nov.

Frontispiece: facing page
The Canadian icebreaker *Amundsen* off Beechey Island in the Canadian Arctic in the autumn of 2013. Geological research in the Arctic is entirely dependent on such professional logistic support, whether by sea or air. Photo: Kate Jarrett (GSC).

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Phone: +45 38 14 20 00, fax: +45 38 14 20 50, e-mail: geus@geus.dk

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Contents

Abstract

Fensome, R.A., Nøhr-Hansen, H., & Williams. G.L. 2016: Cretaceous and Cenozoic dinoflagellate cysts and other palynomorphs from the western and eastern margins of the Labrador–Baffin Seaway.
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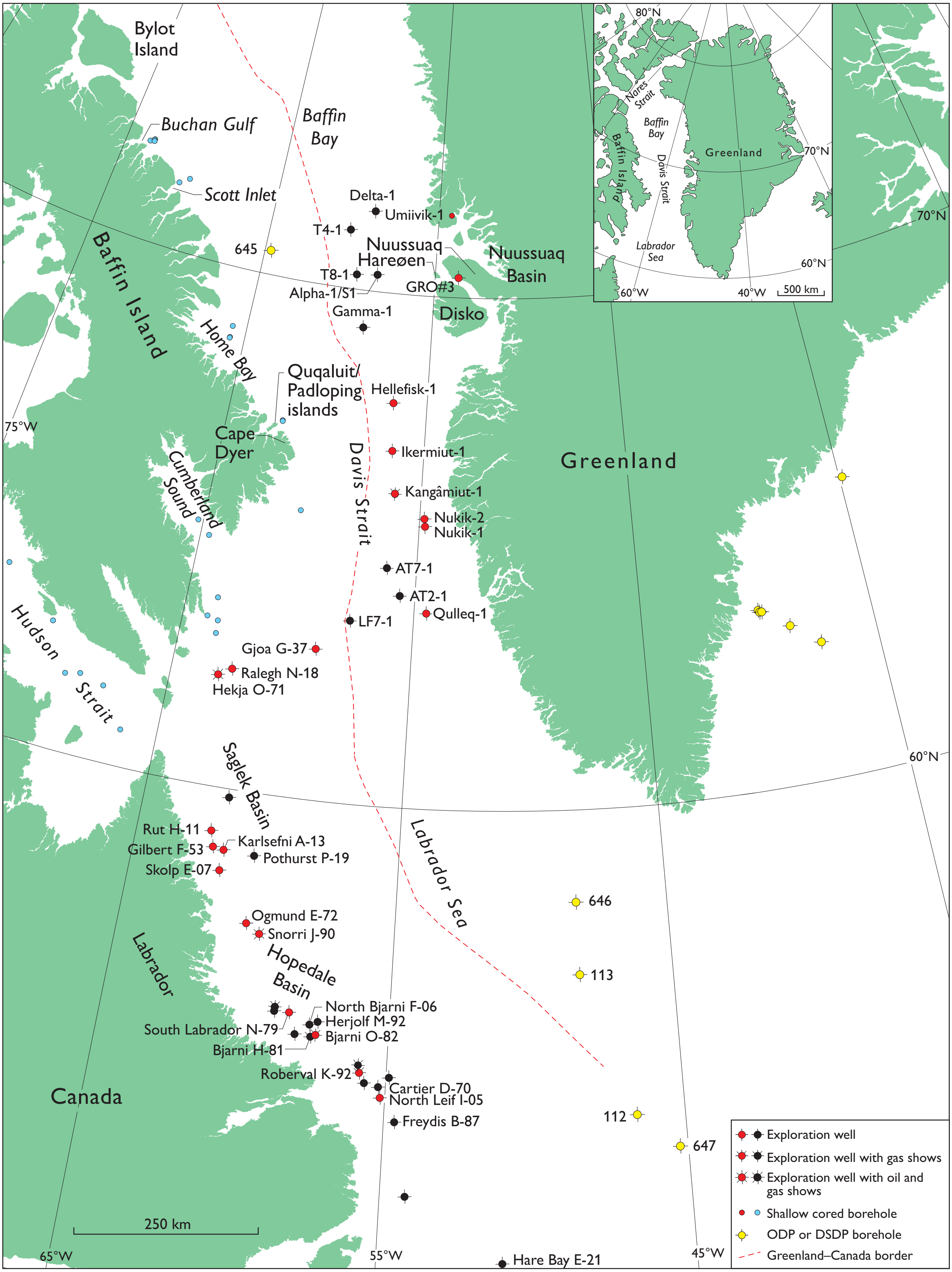
New palynological analysis of samples from 13 offshore wells on the Canadian Margin and six wells on the West Greenland Margin has led to a new event biostratigraphic framework for Cretaceous–Cenozoic strata of the Labrador Sea – Davis Strait – Baffin Bay (Labrador–Baffin Seaway) region. This framework is based on about 150 dinoflagellate cyst taxa and 30 acritarch, algal, fungal and plant microfossil (mostly miospore) taxa. In the systematics we include three new genera of dinocysts (*Scalenodinium, Simplicidinium and Taurodinium*), 16 new species of dinocysts (*Chiropteridium gilbertii*, *Chytroeisphaeridia hadra*, *Cleistosphaeridium elegantulum*, *Cleistosphaeridium palmatum*, *Dapsilidinium pseudoinsertum*, *Deflandrea borealis*, *Evittosphaerula*? *foraminosa, Ginginodinium*? *flexidentatum*, *Hystrichosphaeridium quadratum*, *Hystrichostrogylon digitus*, *Impletosphaeridium apodastum*, *Scalenodinium scalenum*, *Surculosphaeridium convocatum*, *Talladinium pellis*, *Taurodinium granulatum and Trithyrodinium*? *conservatum*), four emendations of dinocyst genera (*Alterbidinium*, *Chatangiella*, *Chiropteridium* and *Surculosphaeridium*), six new combinations for dinocyst species (*Alterbidinium biaperturum*, *Deflandrea majae*, *Kleithriasphaeridium mantellii*, *Simplicidinium insolitum*, *Spongodinium grossum*, *Spongodinium obscurum*), one new acritarch species (*Fromea quadrangularis)*, one new miospore species (*Baculatisporites crenulatus*) and one new combination for miospores (*Tiliaepollenites crassipites*). Most of the taxa included provide age information, almost exclusively last occurrences (range 'tops'), but some are useful mainly for environmental interpretations. Collectively, they provide a powerful tool for helping to establish the geological history of the Labrador–Baffin Seaway.

Authors' addresses

R.A.F. & G.L.W., *Geological Survey of Canada (Atlantic), Natural Resources Canada, PO Box 1006, 1 Challenger Drive, Dartmouth, Nova Scotia B2Y 4A2, Canada.* E-mail: *rob.fensome@canada.ca*

H.N.-H., *Geological Survey of Denmark and Greenland, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark.*



Bylot Island
Buchan Gulf
Scott Inlet
Baffin Bay
Baffin Island
Home Bay
Quqaluit/ Padloping islands
Cape Dyer
Cumberland Sound
Hudson Strait
Davis Strait
Greenland
Nuussuaq
Hareøen
Nuussuaq Basin
Disko
Delta-1
Umiivik-1
T4-1
645
T8-1
Alpha-1/S1
GRO#3
Gamma-1
Hellefisk-1
Ikermiut-1
Kangâmiut-1
Nukik-2
Nukik-1
AT7-1
AT2-1
Qulleq-1
LF7-1
Gjoa G-37
Ralegh N-18
Hekja O-71
Saglek Basin
Labrador Sea
Rut H-11
Gilbert F-53
Karlsefni A-13
Pothurst P-19
Skolp E-07
Ogmund E-72
Snorri J-90
Hopedale Basin
Labrador
North Bjarni F-06
Herjolf M-92
Bjarni O-82
South Labrador N-79
Bjarni H-81
Roberval K-92
Cartier D-70
North Leif I-05
Freydis B-87
Hare Bay E-21
Canada
646
113
112
647
250 km
65°W
55°W
45°W
75°W
70°N
60°N
80°N
Nares Strait
Baffin Island
Davis Strait
Labrador Sea
60°W
40°W
500 km
Exploration well
Exploration well with gas shows
Exploration well with oil and gas shows
Shallow cored borehole
ODP or DSDP borehole
Greenland–Canada border

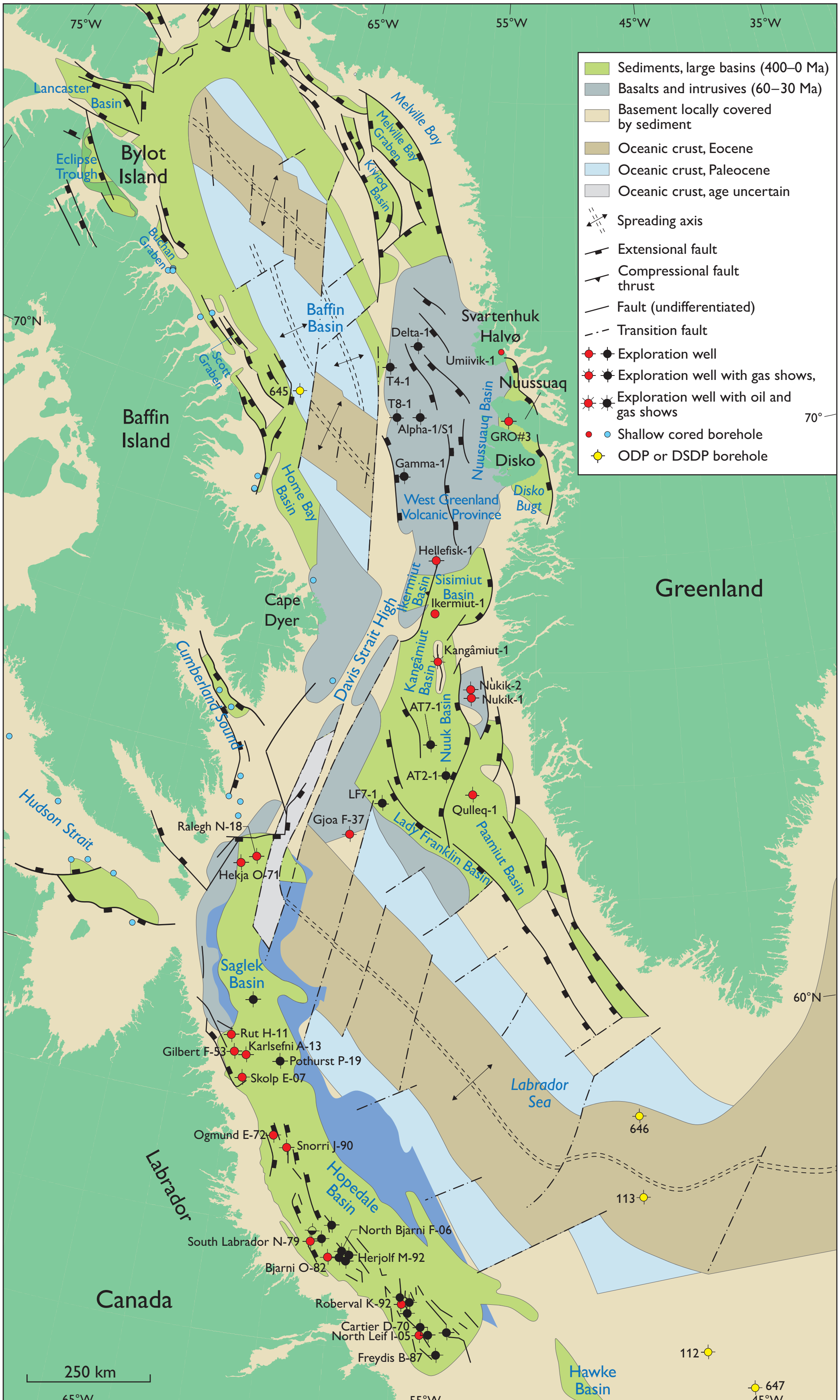
Introduction

Canada and Greenland are separated, from south to north, by the Labrador Sea, the Davis Strait, Baffin Bay (which we call collectively the Labrador–Baffin Seaway), and the narrow Nares Strait (Fig. 1). The Labrador–Baffin Seaway stretches from about 52°N on to 75°N, a distance of roughly 2500 km. Timing for the geological evolution of the seaway's margin is based primarily on biostratigraphic analyses from exploration wells drilled between 1971 and 2000 on the Labrador Margin, off West Greenland and in the Davis Strait, and from some shallow cored boreholes drilled in Baffin Bay in the 1980s (Figs 1, 2). These drilling activities revealed thick successions of Mesozoic–Cenozoic sediments on both sides of the seaway, and the lithostratigraphy of these has developed in tandem with the biostratigraphy. Additional information comes from numerous Cretaceous–Cenozoic outcrop sections in the Nuussuaq Basin in West Greenland, a few onshore sections in Labrador and on Baffin and Bylot islands (Figs 1, 2), and from ODP Leg 105, hole 645 in Baffin Bay (Fig. 1). Although previous work on these materials has provided a good stratigraphic foundation for the Cretaceous–Cenozoic of the region (Fig. 3), renewed petroleum exploration interest in recent years has revealed gaps in our knowledge and a need to correlate the western and eastern margins of the seaway. Consequently, for the past decade, the Geological Survey of Denmark and Greenland (GEUS) and the Geological Survey of Canada (Atlantic) (GSCA) have undertaken an exhaustive palynological study, based on palynological analysis of more than 2000 well samples. The objectives of this work have been to refine age control and palaeoenvironmental interpretations on a regional scale, with the ultimate goal of contributing fundamentally to an understanding of the geological history of the seaway and its petroleum systems. A significant finding has been that the orderly story of five regional unconformities (Fig. 3) is not as clear-cut as has been previously thought (see Fig. 4 and Nøhr-Hansen *et al*. 2016 for details).

Dinoflagellate cysts (dinocysts) are the primary palynomorph group evaluated, but spores and pollen (miospores), a fern microspore massula (*Azolla*), algal microfossils and acritarchs have also been used. Our new age determinations (Figs 5, 6, in pocket; see Nøhr-Hansen *et al*. 2016 for further details) are more precise than those of previous studies because of advances made in refining stratigraphic ranges, especially of dinocysts (e.g. Williams *et al*. 2004). Moreover, the number of species for which we have detailed stratigraphic information has increased immeasurably since early studies in the region in the 1970s.

This paper focuses on the systematic treatment of palynomorphs observed in the study, thereby underpinning the results presented in the companion bulletin (Nøhr-Hansen *et al.* 2016), but also facilitating future work in the region and further afield.

Facing page:
Fig. 1. Map of the Labrador–Baffin Seaway showing the location of relevant wells, boreholes and onshore localities; wells and boreholes shown in red were used in this study. The cored borehole GGU 400712 is 2 km ENE of Umiivik-1; Annertuneq is on the north coast of Nuussuaq. Inset map shows the regional context of the Labrador–Baffin Seaway between Canada and Greenland.



75°W
65°W
55°W
45°W
35°W
Sediments, large basins (400–0 Ma)
Basalts and intrusives (60–30 Ma)
Basement locally covered by sediment
Oceanic crust, Eocene
Oceanic crust, Paleocene
Oceanic crust, age uncertain
Spreading axis
Extensional fault
Compressional fault thrust
Fault (undifferentiated)
Transition fault
Exploration well
Exploration well with gas shows,
Exploration well with oil and gas shows
Shallow cored borehole
ODP or DSDP borehole
Lancaster Basin
Eclipse Trough
Bylot Island
Melville Bay
Melville Bay Graben
Kivioq Basin
Buchan Graben
Scott Graben
Baffin Basin
70°N
Svartenhuk Halvø
Delta-1
Umiivik-1
T4-1
T8-1
Alpha-1/S1
645
Nuussuaq
Nuussuaq Basin
GRO#3
70°
Baffin Island
Gamma-1
Disko
Disko Bugt
Home Bay Basin
West Greenland Volcanic Province
Hellefisk-1
Ikermiut Basin
Sisimiut Basin
Ikermiut-1
Greenland
Cape Dyer
Davis Strait High
Kangâmiut-1
Kangâmiut Basin
Cumberland Sound
Nukik-2
Nukik-1
AT7-1
Nuuk Basin
AT2-1
Hudson Strait
LF7-1
Qulleq-1
Gjoa F-37
Ralegh N-18
Lady Franklin Basin
Paamiut Basin
Hekja O-71
Saglek Basin
60°N
Rut H-11
Karlsefni A-13
Gilbert F-53
Pothurst P-19
Skolp E-07
Labrador Sea
646
Ogmund E-72
Snorri J-90
Hopedale Basin
Labrador
113
North Bjarni F-06
South Labrador N-79
Herjolf M-92
Bjarni O-82
Canada
Roberval K-92
Cartier D-70
North Leif I-05
Freydis B-87
112
250 km
Hawke Basin
647
65°W
55°W
45°W

Methodology

The study is based on samples from ditch cuttings, sidewall cores and conventional cores from onshore and offshore wells and boreholes, and on outcrop samples (Figs 1, 2). Most of the samples were processed for palynology between 1990 and 2006, using standard techniques for concentrating palynomorphs. However, many of the sidewall-core samples are represented only by oil-company slides produced in the late 1970s to 1980s and are of variable quality.

Using transmitted light microscopy, qualitative and quantitative analyses were carried out of the dinocysts, acritarchs and pollen and spores, the results and implications of which are detailed in Nøhr-Hansen *et al.* (2016). The systematic section below is accompanied by plates; sample number, slide number and England Finder coordinates for each specimen are provided. The slides from the six offshore West Greenland wells, Hellefisk-1, Ikermiut-1, Kangâmiut-1, Nukik-1, Nukik-2 and Qulleq-1 are kept at GEUS. GEUS also processed samples from six offshore Canadian wells, Gjoa G-37, Hekja O-71, North Leif I-05, Ogmund E-72, Ralegh N-18 and Skolp E-07. One set of palynology slides from Gjoa G-37, Hekja O-71 and Ralegh N-18 is housed at GEUS (Copenhagen) and one set is housed at the Geological Survey of Canada (Atlantic), Dartmouth, Nova Scotia, Canada. A set from each well is also curated at the Canada–Nova Scotia Offshore Petroleum Board, Dartmouth, Nova Scotia. The Geological Survey of Canada has processed samples from all the Labrador Margin wells, which include Bjarni O-82, Gilbert F-53, Kalsefni A-13, Roberval K-92, Rut H-11, Snorri J-90 and South Labrador N-79. One set of palynology slides from these wells is housed at the Geological Survey of Canada (Atlantic), Dartmouth, Nova Scotia. Another set is curated at the Canada – Newfoundland and Labrador Offshore Petroleum Board (CNLOPB) in St. Johns, Newfoundland. Also on file with CNLOPB are sets of GEUS-prepared slides from North Leif I-05, Ogmund E-72 and Skolp E-07.

Facing page:
Fig. 2. Map of the basic geology of the Labrador–Baffin Seaway, showing the main structural features and relevant well/borehole locations; wells and boreholes shown in red were used in this study. Modified from Henriksen *et al.* (2009) and Oakey & Chalmers (2012).

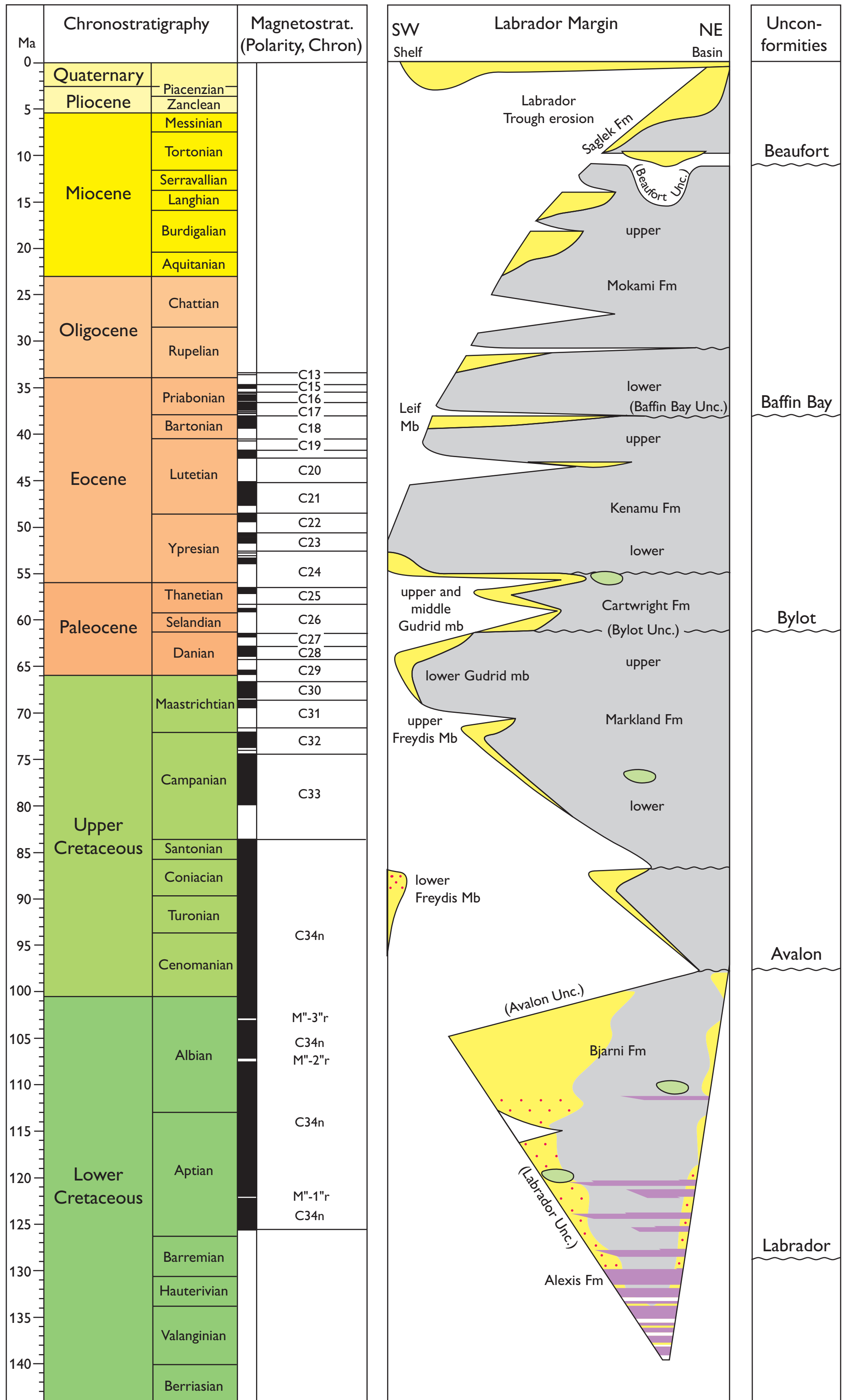
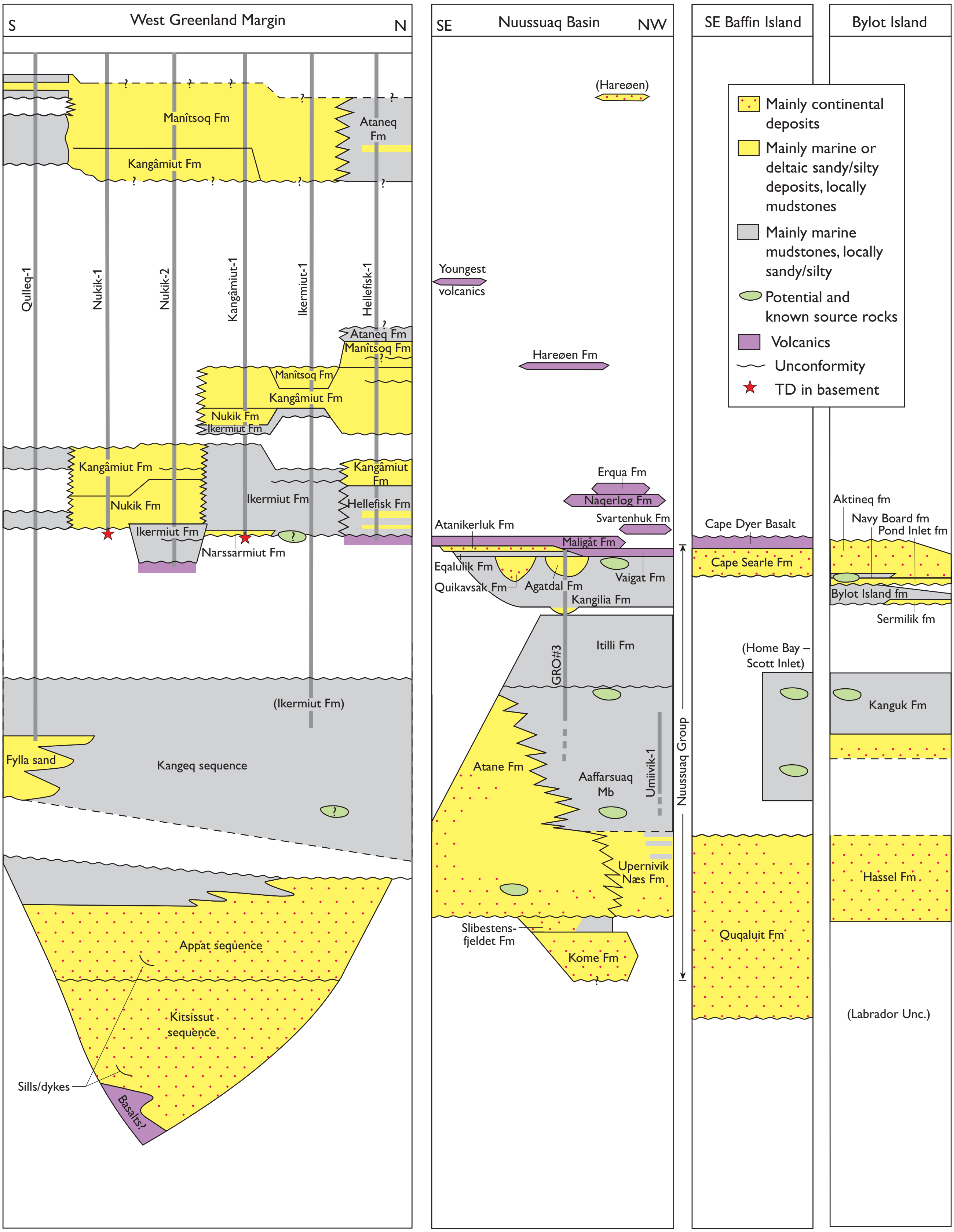
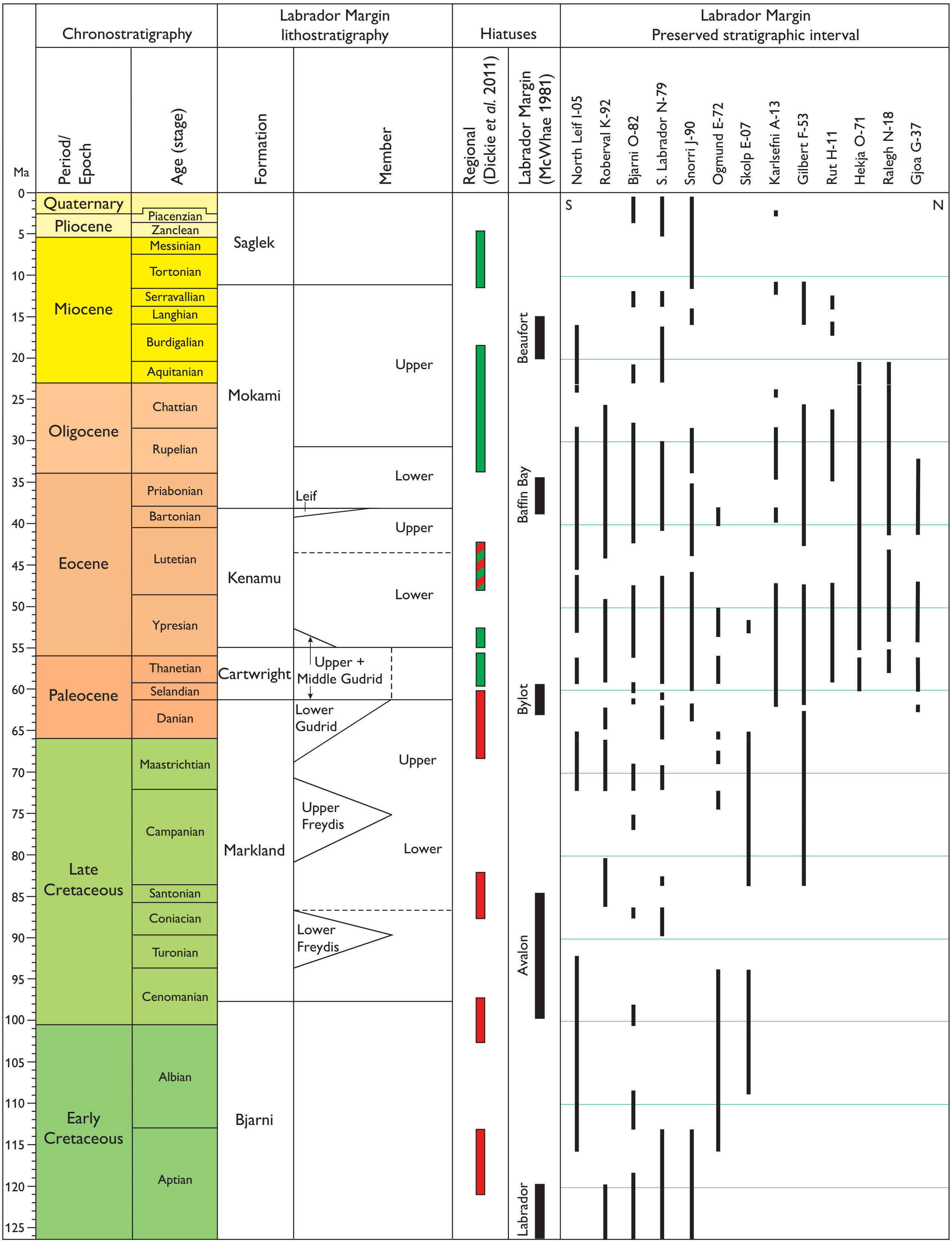


Fig. 3. Stratigraphic framework of the Mesozoic–Cenozoic rocks of the Labrador and West Greenland margins and adjacent onshore sections; modified from Gregersen *et al.* (2013). The Labrador Margin stratigraphy is from Dickie *et al.* (2011), with unconformities from McWhae (1981). The West Greenland Margin stratigraphy is based on well stratigraphic studies by Rolle (1985), Nøhr-Hansen (2003) and Sønderholm *et al.* (2003); the deeper sub-well section is based on Chalmers *et al.* (1993), Chalmers & Pulvertaft (2001) and Sørensen (2006). The Nuussuaq Basin stratigraphy is from Storey *et al.* (1998), Dam *et al.* (2009), Pedersen & Nøhr-Hansen (2014) and Larsen *et al.* (2015); these papers and this study are the source of the inferred ages. The southeast Baffin Island stratigraphy is from Burden & Langille (1990) and Pedersen *et al.* (2002), the Home Bay and Scott Inlet seabed samples from MacLean *et al.* (2014) and the north Baffin Island stratigraphy is based on Jackson *et al.* (1978) and McWhae (1981). The Bylot Island stratigraphy is from Miall (1986), Waterfield (1989), and Harrison *et al.* (1999). The timescale (Ma) and magnetostratigraphy are from Gradstein *et al.* (2012). **Fm**: Formation (formal). **fm**: formation (informal). **Mb**: Member (formal). **mb**: member (informal). **Unc.**: unconformity.


S
West Greenland Margin
N
SE
Nuussuaq Basin
NW
SE Baffin Island
Bylot Island
Manîtsoq Fm
Ataneq Fm
Kangâmiut Fm
Qulleq-1
Nukik-1
Nukik-2
Kangâmiut-1
Ikermiut-1
Hellefisk-1
Ataneq Fm
Manîtsoq Fm
Manîtsoq Fm
Kangâmiut Fm
Nukik Fm
Ikermiut Fm
Kangâmiut Fm
Nukik Fm
Ikermiut Fm
Kangâmiut Fm
Hellefisk Fm
Ikermiut Fm
Narssarmiut Fm
(Ikermiut Fm)
Fylla sand
Kangeq sequence
Appat sequence
Kitsissut sequence
Sills/dykes
Basalts?
(Hareøen)
Youngest volcanics
Hareøen Fm
Erqua Fm
Naqerlog Fm
Svartenhuk Fm
Atanikerluk Fm
Maligât Fm
Eqalulik Fm
Quikavsak Fm
Agatdal Fm
Vaigat Fm
Kangilia Fm
Itilli Fm
GRO#3
Atane Fm
Aaffarsuaq Mb
Umiivik-1
Nuussuaq Group
Upernivik Næs Fm
Slibestens-fjeldet Fm
Kome Fm
Cape Dyer Basalt
Cape Searle Fm
(Home Bay – Scott Inlet)
Quqaluit Fm
Aktineq fm
Navy Board fm
Pond Inlet fm
Bylot Island fm
Sermilik fm
Kanguk Fm
Hassel Fm
(Labrador Unc.)
Mainly continental deposits
Mainly marine or deltaic sandy/silty deposits, locally mudstones
Mainly marine mudstones, locally sandy/silty
Potential and known source rocks
Volcanics
Unconformity
TD in basement



Chronostratigraphy
Labrador Margin lithostratigraphy
Hiatuses
Labrador Margin Preserved stratigraphic interval
Ma
Period/ Epoch
Age (stage)
Formation
Member
Regional (Dickie et al. 2011)
Labrador Margin (McWhae 1981)
North Leif I-05
Roberval K-92
Bjarni O-82
S. Labrador N-79
Snorri J-90
Ogmund E-72
Skolp E-07
Karlsefni A-13
Gilbert F-53
Rut H-11
Hekja O-71
Ralegh N-18
Gjoa G-37
S
N
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
Quaternary
Pliocene
Miocene
Oligocene
Eocene
Paleocene
Late Cretaceous
Early Cretaceous
Piacenzian
Zanclean
Messinian
Tortonian
Serravallian
Langhian
Burdigalian
Aquitanian
Chattian
Rupelian
Priabonian
Bartonian
Lutetian
Ypresian
Thanetian
Selandian
Danian
Maastrichtian
Campanian
Santonian
Coniacian
Turonian
Cenomanian
Albian
Aptian
Saglek
Mokami
Kenamu
Cartwright
Markland
Bjarni
Upper
Lower
Leif
Upper
Lower
Upper + Middle Gudrid
Lower Gudrid
Upper
Upper Freydis
Lower
Lower Freydis
Beaufort
Baffin Bay
Bylot
Avalon
Labrador

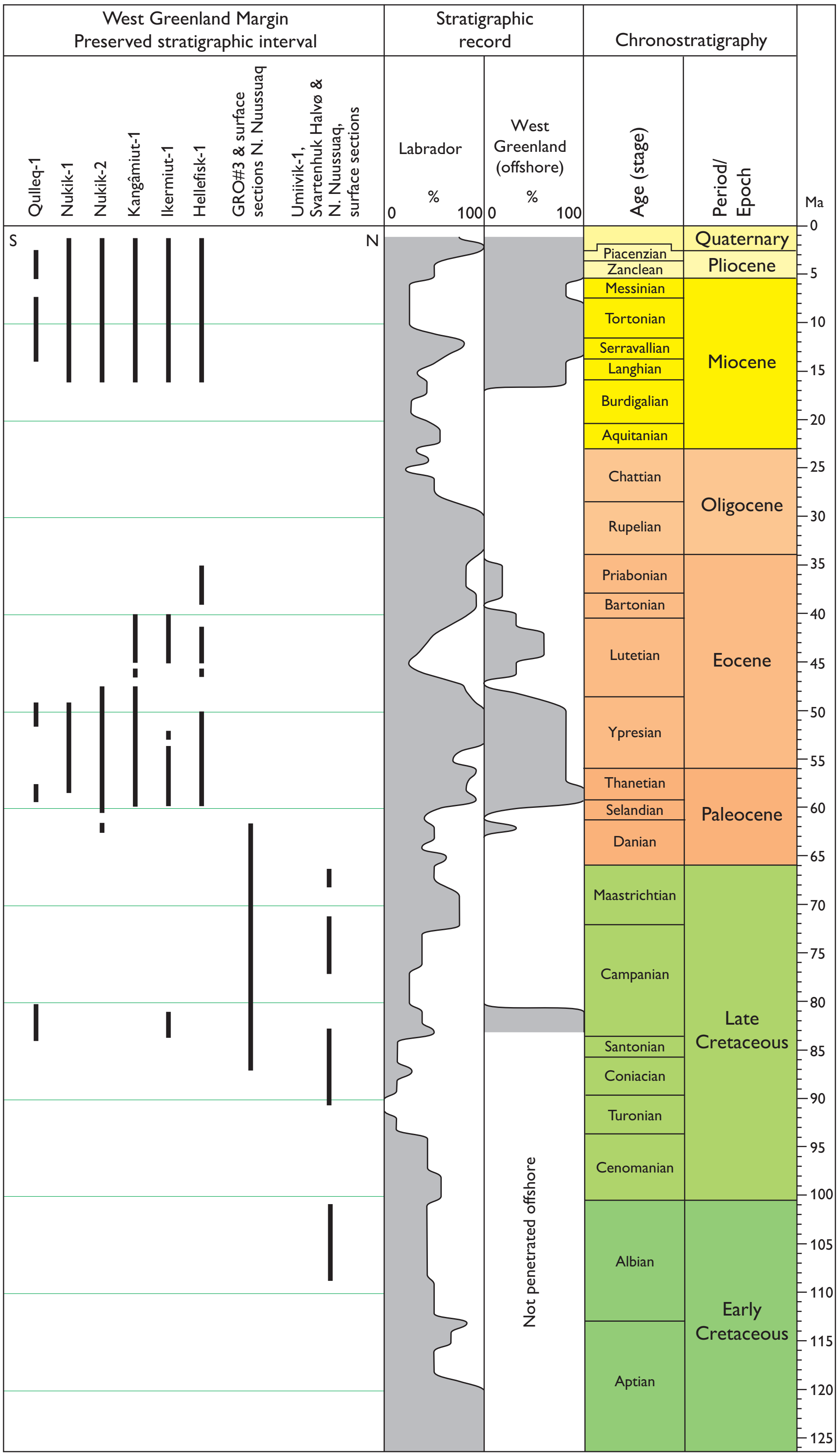


Fig. 4. Ages of strata preserved in wells on the Labrador, Baffin and Greenland Margins, compared with the hiatuses linked to unconformities reported in the literature. Dickie *et al.* (2011) recognised a number of unconformities in two or more of three regions – the Southwest Greenland Shelf, the Labrador Shelf and the Jeanne d'Arc Basin, offshore Newfoundland (red, all three regions; green, two regions). McWhae (1981) named five unconformities on the Labrador Margin; the hiatuses associated with these unconformities indicated here are estimates by McWhae (1981) based on an unspecified timescale and thus should be considered approximate. The 'cumulative preservation' plots (right) depict schematically the proportion of wells that contain sediments of a specified age, based on one million-year slots; note that these calculations only include wells that extend down to/beyond the relevant stratigraphic level.

	Suborder	Family	Subfamily	Genera
Order Gonyaulacales	Rhaetogonyaulacineae	Rhaetogonyaulacaceae		
	Cladopyxiineae	Cladopyxiaceae		*Gillinia, Histiocysta*
		Pareodiniaceae	Pareodinioideae	
			Broomeoideae	*Batioladinium*
	Gonyaulacineae	Gonyaulacaceae	Leptodinioideae	*Eatonicysta, Kleithriasphaeridium, Oligosphaeridium*
			Cribroperidinioideae	*Achilleodinium, Apteodinium, Cordosphaeridium, Cribroperidinium, Dapsilidinium, Diphyes, Disphaerogena, Hapsocysta, Hystrichokolpoma, Lingulodinium, Operculodinium, Spongodinium, Thalassiphora*
			Gonyaulacoideae	*Cannosphaeropsis, Evittosphaerula, Hystrichosphaeropsis, Hystrichostrogylon, Impagidinium, Rottnestia, Spiniferites,*
			Uncertain	*Callaiosphaeridium, Cerebrocysta, Chytroeisphaeridia, Fibrocysta, Habibacysta, Kiokansium, Surculosphaeridium, Trichodinium*
		Ceratocoryaceae		
		Areoligeraceae		*Adnatosphaeridium, Areoligera, Areosphaeridium, Chiropteridium, Cleistosphaeridium, Enneadocysta, Glaphyrocysta, Heterosphaeridium, Licracysta Palynodinium, Schematophora, Senonaisphaera, Tenua*
	Ceratiineae	Ceratiaceae		*Aptea, Nyktericysta, Odontochitina, Pseudoceratium, Taurodinium, Vesperopsis, Xenascus*
	Goniodomineae	Goniodomaceae	Goniodomoideae	*Heteraulacacysta*
			Gambierdiscoideae	
			Helgolandinioideae	*Tuberculodinium*
			Pyrodinioideae	*Alisocysta, Eocladopyxis, Homotryblium Hystrichosphaeridium*
			Uncertain	
		Pyrocystaceae		
	Uncertain	Heterodiniaceae		
		Crypthecodiniaceae		
		Uncertain		*Atopodinium, Batiacasphaera, Chlamydophorella, Impletosphaeridium?, Raphidodinium, Reticulatosphaera, Simplicidinium, Tanyosphaeridium, Wallodinium*
Order Peridinales	Heterocapsineae	Heterocapsaceae		
	Glenodiniineae	Glenodiniaceae		
	Peridiniineae	Peridiniaceae	Palaeoperidinioideae	*Ginginodinium?, Laciniadinium, Palaeoperidinium, Phthanoperidinium? Subtilisphaera*
			Deflandreoideae	*Alterbidinium, Cerodinium, Chatangiella, Deflandrea, Isabelidinium, Lentinia, Palaeocystodinium, Scalenodinium?, Senegalinium, Spinidinium, Trithyrodinium*
			Calciodinelloideae	
			Ovoidinioideae	
			Wetzelielloideae	*Apectodinium,Axiodinium, Charlesdowniea, Petalodinium, Piladinium, Rhombodinium, Sophismatia, Stichodinium, Talladinium, Wetzeliella*
			Lithoperidinioideae	
			Peridinioideae	
		Protoperidinioideae	Protoperidinioideae	*Phelodinium*
			Diplopsalioideae	
		Podolampaceae		

Fig. 7. Suprageneric affiliation of peridiniphycidean genera treated systematically in the present study. The only non-peridiniphycidean dinocyst genus treated in this study is *Dinogymnium*, which belongs to the subclass Gymnodiniophycidae, order Ptychodiscales, family Ptychodiscaceae, subfamily Dinogymnioideae.

Systematics – general

Presentation of the systematic taxonomic descriptions includes subsections on dinocysts, acritarchs and other algae, miospores, and fungi. For pragmatic reasons, genera are arranged alphabetically within each section. For the dinocysts, a tabulation of suprageneric affinities is provided (Fig. 7). Under individual taxa, all synonyms are listed but those already indicated and credited to earlier works in Fensome *et al.* (2008) are generally not discussed further. The term 'synopsis' is used for a statement of what we consider the essential defining features of the genus. Unless otherwise clearly indicated, the synopses given herein should not be understood to represent emendations. Only those emendations that we agree with or consider helpful are cited.

All ages refer to their definition in the latest revision of the geological timescale (Gradstein *et al.* 2012). For most species, an age is indicated for significant events in its stratigraphical range, usually a range top or 'Last Occurrence' (LO). The statement 'not plotted' refers to the fact that a particular taxon was not plotted in the summary event charts (Figs 5, 6, in pocket); the reasons for not plotting some taxa include a taxon's sparsity or long and unhelpful range (though it may be helpful palaeoenvironmentally. Because the data are based mainly on cuttings samples, a taxon's range bottom or 'First Occurrence' (FO) is rarely used. We occasionally refer to the LAD of a species, its 'Last Appearance Datum', which refers to its youngest global occurrence.

Systematics – dinoflagellates

Division Dinoflagellata (Bütschli 1885) Fensome *et al.* 1993
Class Dinophyceae Pascher 1914

Genus *Achilleodinium* Eaton 1976
Type. Eisenack 1954, plate 11, fig. 18, as *Hystrichosphaeridium biformoides*.

1976 *Achilleodinium* Eaton, p. 234.

Remarks. We follow the synopsis of Fensome *et al.* (2009, p. 11) for this genus.

***Achilleodinium biformoides* (Eisenack 1954) Eaton 1976**
(Plate 1, figs 1–3)

1954 *Hystrichosphaeridium biformoides* Eisenack, p. 68, plate 11, figs 16–20.
1965 *Baltisphaeridium biformoides* (Eisenack) – Downie & Sarjeant, p. 87.
1965 *Hystrichokolpoma biformoides* (Eisenack) – Rozen, p. 308.
1976 *Achilleodinium biformoides* (Eisenack) – Eaton, p. 234.
1980 *Florentinia biformoides* (Eisenack) – Duxbury, p. 121.

Age. LO: Ypresian.

Genus *Adnatosphaeridium* Williams & Downie 1966a
Type. Williams & Downie 1966a, plate 24, fig. 7, text-fig. 56, as *Adnatosphaeridium vittatum*.

1966a *Adnatosphaeridium* Williams & Downie, p. 215.

Remarks. Stancliffe & Sarjeant (1990, p. 199–200) emended the diagnosis of *Adnatosphaeridium* but did not change the concept of the generic circumscription. Here, we follow the synopsis provided by Fensome *et al.* (2009, p. 11).

***Adnatosphaeridium vittatum* Williams & Downie 1966a**
(Plate 1, figs 4, 8)

1966a *Adnatosphaeridium vittatum* Williams & Downie, p. 15, plate 24, fig. 7; text-fig. 56.
1966a *Adnatosphaeridium multispinosum* Williams & Downie, p. 216, 217, plate 24, fig. 5; text-fig. 57.

Age. LO: late Bartonian. Not plotted.

Remarks. Following Fensome *et al.* (2009, p. 13), the species *Adnatosphaeridium multispinosum* is considered a taxonomic synonym of *Adnatosphaeridium vittatum*.

Genus *Alisocysta* Stover & Evitt 1978
Type. Drugg 1967, plate 1, fig. 12, as *Eisenackia circumtabulata.*

1978 *Alisocysta* Stover & Evitt, p. 15, 16.
1979a *Agerasphaera* Harland, p. 28, 29; illegitimate name, having the same type as *Alisocysta*.

Synopsis. Goniodomacean (pyrodinioid) cysts that are proximate and subspherical. The tabulation is reflected by penitabular ridges or septa that delineate the plates, including the cingulars and some or all of the sulcals. The archaeopyle is apical, with the formula $A_{(1\text{–}4')}$; operculum free.

Remarks. Quattrocchio & Sarjeant (2003, p. 144) considered *Alisocysta* to be a taxonomic junior synonym of *Eisenackia*. However, as stated by Stover & Evitt (1978, p. 42) "*Alisocysta* has parasutural [i.e. penitabular] ridges or septa rather than depressions as in *Eisenackia*" and *Alisocysta* is thus retained here as a separate genus, including both the type, *Alisocysta circumtabulata,* and *Alisocysta margarita*.

***Alisocysta circumtabulata* (Drugg 1967) Stover & Evitt 1978**
(Plate 1, figs 6, 7)

1967 *Eisenackia circumtabulata* Drugg, p. 15, plate 1, figs 12, 13.
1978 *Hystrichokolpoma circumtabulatum* (Drugg) – Schumacker-Lambry, p. 42.
1978 *Alisocysta circumtabulata* (Drugg) – Stover & Evitt, p. 16.
1979a *Agerasphaera circumtabulata* (Drugg) – Harland, p. 29; illegitimate combination as the generic name *Agerasphaera* is illegitimate.
2003 *Eisenackia circumtabulata* (Drugg) – Quattrocchio & Sarjeant, p. 146.

Age. LO: earliest Thanetian.

***Alisocysta margarita* (Harland 1979a) Harland 1979a**
(Plate 1, figs 5, 9)

1979a *Agerasphaera margarita* Harland, p. 29, 31, 33, plate 1, figs 1–12; plate 2, figs 1–10.
1979a *Alisocysta margarita* (Harland) – Harland, p. 35.
2003 *Eisenackia margarita* (Harland) – Quattrocchio & Sarjeant, p. 146.

Age. LO: earliest Thanetian.

Genus *Alterbidinium* Lentin & Williams 1985 emend. nov.
Type. Vozzhennikova 1967, plate 77, fig. 2, as *Albertia recticornis*.

1967 *Albertia* Vozzhennikova, p. 150, 151; illegitimate name.
1976 *Alterbia* Lentin & Williams, p. 47, 48; illegitimate name.
1985 *Alterbidinium* Lentin & Williams, p. 14.

Emended description. Peridiniacean (deflandreoid) cysts that are proximate and peridinioid, usually elongate, in outline. The antapical horns are always asymmetrically arranged, the left horn being larger. Bicavate. The pericyst surface is generally atabulate, smooth, or with low ornament; the cingulum is commonly indicated, if only marginally. The periarchaeopyle is intercalary or combination intercalary–precingular; always involving an iso- to stenodeltaform hexa plate 2a and commonly plate 4′′, the operculum remaining attached posteriorly; archaeopyle I_{2a} @ or $(I_{2a}P_{4''})$@.

Remarks. In their emendation of *Alterbidinium,* Khowaja-Ateequzzaman *et al.* (1991, p. 38) stated: "archaeopyle intercalary, independently developed on periphragm and endophragm, dissimilar in shape; periarchaeopyle hexa 2a, steno/iso-deltaform, perioperculum free or adnate; endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate." However, they did not base their emendation on the type of the genus. Thus, in the emendation proposed here, the synopsis of Fensome *et al.* (2009, p. 13) is largely repeated: it emphasised the nature of the archaeopyle, which is formed from the iso- to stenodeltaform hexa plate 2a, but may also involve plate 4´´. Almost invariably, the operculum remains attached posteriorly.

Genera with similar morphologies to *Alterbidinium* include *Spinidinium*, *Diconodinium*, *Cerodinium*, *Chatangiella* and *Isabelidinium*. *Spinidinium* and *Diconodinium* differ from *Alterbidinium* in having a spinate periphragm. *Cerodinium* has a large isodeltaform periarchaeopyle, an endoarchaeopyle formed from the loss of one to three anterior intercalary plates, and generally long apical and antapical horns. *Chatangiella* is distinguished by its generally omegaform 2a and partite cingulum, although Fensome *et al.* (2009, p. 19) stated that the archaeopyle could vary between isodeltaform and iso-omegaform. We now consider that *Chatangiella* should be restricted to taxa that possess an iso- or lati-omegaform archaeopyle. Similarly, *Isabelidinium* is restricted to taxa with an iso- to latiomegaform 2a plate and archaeopyle. However, some species presently included in *Isabelidinium* can have thetaform or isodeltaform 2a plates and archaeopyles.

The present morphological differences used to separate the deflandreoid genera are in large part unsatisfactory. Perhaps a more effective approach would be to adopt the methodological approach used by Williams *et al.* (2015) in their reclassification of the wetzelielloideans. Following this example, the deflandroidean genera would be differentiated primarily on the nature of the archaeopyle, since this reflects differences in tabulation pattern. This then follows the categories recognised by Lentin & Williams (1976) and expanded by Bujak & Davies (1983). These are omegaform, thetaform and deltaform modes, with steno-, iso- and lati- subcategories. Such an approach would not be a perfect solution as there are clearly gradations, but it would make the generic distinctions more meaningful, and is considered here the best solution.

In the spirit of this approach, herein we informally use *Isabelidinium* for forms having a lati- to iso-omegaform archaeopyle. A formal revision would require many of the species now included in that genus to be transferred to other existing or new genera. Indeed, a re-appraisal of all deflandreoidean taxa is deemed necessary, but is beyond the scope of the present paper, although as an initial step emendations are proposed for *Alterbidinium* and *Chatangiella*.

Alterbidinium acutulum **(Wilson 1967a) Lentin & Williams 1985**
(Plate 1, figs 10, 11)

1967a *Deflandrea acutula* Wilson, p. 225, 226, figs 11, 12.
1967 *Albertia curvicornis* Vozzhennikova, p. 151, plate 76, figs 1–4.
1967 *Albertia recticornis* Vozzhennikova, p. 151, 152, plate 77, figs 1–4; plate 78, figs 1–3; plate 79, figs 1, 2.
1976 *Alterbia acutula* (Wilson) – Lentin & Williams, p. 48.
1976 *Alterbia curvicornis* (Vozzhennikova) – Lentin & Williams, p. 49.
1976 *Alterbia recticornis* (Vozzhennikova) – Lentin & Williams, p. 47.
1985 *Alterbidinium acutulum* (Wilson) – Lentin & Williams, p. 14.

Age. LO: early Maastrichtian.

Remarks. Fensome & Williams (2005, p. 9) recorded this species, in part, under the informal name '*Alterbidinium fleximorphum*' because of the great variation shown by this species. It is now recognised that this variability should be encompassed within *Alterbidinium acutulum*.

Alterbidinium biaperturum **(McIntyre 1975) comb. nov.**
(Plate 1, figs 12–14)

1975 *Deflandrea biapertura* McIntyre, p. 66, plate 3, figs 5–8.
1976 *Chatangiella*? *biapertura* (McIntyre) – Lentin & Williams, p. 53.

Age. LO: late Maastrichtian.

Remarks. This species is distinguished by an opening in the pericyst between the antapical horns. From the illustrations of the holotype in McIntyre (1975, plate 3, figs 5, 6), *Alterbidinium* (as *Chatangiella*?) *biaperturum* appears to possess a cingulum delineated by continuous ridges; the periarchaeopyle is extremely unusual, being distinctly deltaform on one lateral margin but, as M. Pearce (personal communication 2015) has noted, possibly thetaform on the other lateral margin. Whether such asymmetry occurs in other specimens of this species is unknown. But regardless, the species is thus not assignable to *Chatangiella*. Lentin & Williams (1976) were aware of these differences when provisionally including this taxon in *Chatangiella,* but did not consider assigning it to *Alterbidinium*. We herein transfer the species to *Alterbidinium* to more accurately reflect its morphology.

***Alterbidinium*? *bicellulum* (Islam 1983a) Lentin & Williams 1985**
(Plate 1, figs 15, 16)

1983a *Alterbia*? *bicellula* Islam, p. 335, 336, plate 1, figs 6, 7.
1985 *Alterbidinium*? *bicellulum* (Islam) – Lentin & Williams, p. 14.

Age. LO: Lutetian, with a peak occurrence in the Ypresian.

Remarks. In the diagnosis for *Alterbidinium*? *bicellulum* (as *Alterbia*? *bicellula*), Islam (1983a, p. 336) stated that the archaeopyle was "… intercalary type I/I with standard hexa style operculum attached". This implies that the archaeopyle is isodeltaform, but it is not possible to confirm this from his illustrations (Islam 1983a, plate 1, figs 6, 7, 10, 11). Islam (1983a) questionably assigned this species to *Alterbia* (now *Alterbidinium*) "because the epipericoel is not always communicative to the exterior, and its degree of cavation and the archaeopyle index do not match those prescribed for the genus. The degree of cavation and the archaeopyle index of this species also do not match those of other peridinioid genera that are differentiated on the basis of these features by Lentin & Williams (1976)." Taxa with an isodeltaform archaeopyle and an attached operculum are rare, especially in the Cenozoic. Thus we leave the species questionably in *Alberbidinium*.

***Alterbidinium ioannidesii* Pearce 2010**
(Plate 1, Fig. 17)

1986 Dinoflagellate type E of Ioannides, p. 42, plate 23, figs 13–16.
2010 *Alterbidinium ioannidesii* Pearce, p. 66, 67, plate 1, figs 1–6.

Age. LO: early Campanian.

Remarks: This is an unusual species of *Alterbidinium* in displaying tabulation on the pericyst.

***Alterbidinium varium* Kirsch 1991**
(Plate 1, figs 18, 19)

1991 *Alterbidinium varium* Kirsch, p. 98, 99, plate 19, figs 1–10; text-figs 46a–h, 47a, b.

Age. LO: Campanian.

Genus *Apectodinium* (Costa & Downie 1976) Lentin & Williams 1977a emend. Williams, Damassa, Fensome & Guerstein in Fensome *et al.* 2009
Type. Deflandre & Cookson 1955, plate 5, fig. 7, as *Wetzeliella homomorpha.*

1976 *Wetzeliella* subgenus *Apectodinium* Costa & Downie, p. 608.
1977a *Apectodinium* (Costa & Downie 1976) – Lentin & Williams, p. 8.
2009 *Apectodinium* (Costa & Downie) – emend. Williams, Damassa, Fensome & Guerstein in Fensome *et al.*, p. 13, 14.

Remarks. The emended diagnosis in Fensome *et al.* (2009, p. 13, 14) is followed here; this emphasised archaeopyle type and variability and the general absence of a pericoel except in the vicinity of the horns.

***Apectodinium homomorphum* (Deflandre & Cookson 1955) Lentin & Williams 1977a**
(Plate 1, fig. 20)

1955 *Wetzeliella homomorpha* Deflandre & Cookson, p. 254, plate 5, fig. 7; text-fig. 19.
1974 *Hystrichosphaeridium caiobense* Regali *et al.*, p. 290, plate 24, fig. 4.
1977a *Apectodinium homomorphum* (Deflandre & Cookson) – Lentin & Williams, p. 8.
1981 *Apectodinium caiobense* (Regali *et al.*) – Lentin & Williams, p. 14.
1983a *Apectodinium folliculum* Islam, p. 336, 337, plate 1, figs 8, 9.

Age. Peak: early Ypresian.

Remarks. Harland (1979b, p. 64) emended the diagnosis of this species, as *Wetzeliella* (*Apectodinium*) *homomorphum*, to "take into account the nature of the archaeopyle, cingular and sulcal details". A characteristic feature of *Apectodinium homomorphum* is the absence of horns, although Harland noted that incipient horns may be developed in the apical, lateral and antapical areas.

***Apectodinium parvum* (Alberti 1961) Lentin & Williams 1977a**
(Plate 2, figs 1–3)

1961 *Wetzeliella parva* Alberti, p. 8, 9, plate 1, figs 14–18; plate 12, figs 10–12.

1976 *Wetzeliella* subgenus *Apectodinium parva* (Alberti) – Costa & Downie, p. 608.
1977a *Apectodinium parvum* (Alberti) – Lentin & Williams, p. 9.

Age. LO: earliest Ypresian.

Remarks. In his emendation of *Apectodinium parvum*, Harland (1979b, p. 65, 66) noted that lateral horns are absent and the processes may be intratabular or sutural. In his description he stated that "The horn development, prominent at the antapex, is variously developed with relation to the apical horn, which may or may not be present." The Labrador Margin specimens usually have an apical horn, but show considerable variation in length and width. Some of the Labrador Margin specimens have longer processes than those illustrated by Harland (1979b), with those of one specimen being 21 µm. When longer, the processes are extremely delicate. However, forms with more robust processes also occur.

***Apectodinium quinquelatum* (Williams & Downie 1966b) Costa & Downie 1979**
(Plate 2, fig. 4)

1948 *Hystrichosphaeridium geometricum* Pastiels, p. 41, plate 4, figs 1–5, 7–10, non *Hystrichosphaeridium geometricum* Deflandre 1942.
1966b *Wetzeliella homomorphum* var. *quinquelata* Williams & Downie, p. 191, 192, plate 18, fig. 7.
1977a *Wetzeliella homomorpha* subsp. *quinquelata* (Williams & Downie) – Lentin & Williams, p. 8.
1979b *Wetzeliella (Apectodinium) quinquelata* (Williams & Downie) – Harland, p. 67.
1979 *Apectodinium quinquelatum* (Williams & Downie) – Costa & Downie, p. 43.

Age. LO: Ypresian. Not plotted.

Genus *Aptea* Eisenack 1958
Type. Eisenack 1958, plate 22, fig. 5, as *Aptea polymorpha*.

1958 *Aptea* Eisenack, p. 393.
1966a *Doidyx* Sarjeant, p. 205.

***Aptea polymorpha* Eisenack 1958**
(Plate 2, fig. 5)

1958 *Aptea polymorpha* Eisenack, p. 394, plate 22, figs 5–12; plate 24, fig. 5.
1986 *Pseudoceratium polymorphum* (Eisenack 1958) – Bint, p.145.

Age. LO: Aptian.

Remarks. The ornamentation of this species is variable, ranging from coarsely reticulate to irregularly spinate.

Genus *Apteodinium* Eisenack 1958
Type. Eisenack 1958, plate 23, fig. 9, as *Apteodinium granulatum.*

1958 *Apteodinium* Eisenack, p. 385.
1961 *Emslandia* Gerlach, p. 171.
1971 *Coniferatium* Burgess, p. 80, 81.

Remarks. The synopsis for *Apteodinium* followed here is that provided in Fensome *et al.* (2009, p. 14), which noted that tabulation may sometimes be weakly reflected on the cyst wall.

***Apteodinium australiense* (Deflandre & Cookson 1955) Williams 1978**
(Plate 2, fig. 6)

1955 *Gymnodinium australiense* Deflandre & Cookson, p. 248, plate 5, fig. 1.
1961 *Gonyaulax tenuitabulata* Gerlach, p. 159, plate 25, figs 10, 11; text-figs 1–3.
1965 *Emslandia australiensis* (Deflandre & Cookson) – Nagy, p. 202; combination not validly published.
1965a *Scriniodinium australiense* (Deflandre & Cookson) – Cookson & Eisenack, p. 122.
1969 *Gonyaulacysta tenuitabulata* (Gerlach) – de Coninck, p. 23.
1978 *Apteodinium australiense* (Deflandre & Cookson) – Williams, p. 794.
1978 *Millioudodinium tenuitabulatum* (Gerlach) – Stover & Evitt, p. 174.
1981 *Emslandia crassimurata* Benedek & Sarjeant, p. 320, 322, fig. 1, nos 2, 4.
1984 *Cribroperidinium tenuitabulatum* (Gerlach) – Helenes, p. 124.
1984a *Rhynchodiniopsis tenuitabulata* (Gerlach) – Sarjeant, p. 76.

Age. LO: Rupelian.

Remarks. *Apteodinium australiense* has a spongy wall, as does the holotype of *Cribroperidinium tenuitabulatum*. Moreover, the latter has at best weakly developed and barely discernible parasutural ridges. Hence, we consider *Cribroperidinium tenuitabulatum* to be a junior synonym of *Apteodinium australiense*.

***Apteodinium spiridoides* Benedek 1972**
(Plate 2, figs 7, 8)

1972 *Apteodinium spiridoides* Benedek, p. 5, plate 2, fig. 1a, b; plate 15, figs 1–6.
1981 *Emslandia spiridoides* (Benedek) – Benedek & Sarjeant, p. 318.

Age. LO: earliest Serravallian.

Remarks. In their emendation of *Apteodinium spiridoides*, Benedek & Sarjeant (1981, p. 318, 319) noted the presence of an apical horn, the two-layered nature of the wall and the archaeopyle type. Jan du Chêne *et al.* (1986, p. 48) retained the species in *Apteodinium*.

Genus *Areoligera* Lejeune-Carpentier 1938
Type. Lejeune-Carpentier 1938, text-fig. 2, as *Areoligera senonensis*.

1938 *Areoligera* Lejeune-Carpentier, p. B164.

Remarks. We agree with the synopsis for *Areoligera* provided by Fensome *et al.* (2009, p. 14) and their observations under remarks. Included in *Areoligera* are several species with overlapping morphology. This is primarily manifested in the shape and distribution of the process complexes and the complexity of the linkages between processes within an individual complex. Fensome *et al.* (2009, p. 15) introduced two terms for the distribution of the process complexes. The encircling condition is when complexes are, "…arcuate to annulate and occur on all the pre- and postcingular plates." In the disjunct condition, "…annulate to arcuate complexes are restricted to the dorsal surface, there is lateral development of linear complexes and the ventral surface (i.e. 6′′ and 6′′′) is devoid of complexes." Fensome *et al.* (2009, p. 15) define *Areoligera gippingensis* as a species with "encircling complex arrangement and predominantly trabecular connections." Following the specific differences recognised for species of *Areoligera* by these authors, it is concluded that all specimens with this general morphology studied here should be assigned to *Areoligera gippingensis*.

The genera *Chiropteridium* and *Glaphyrocysta* superficially resemble *Areoligera*, but neither *Chiropteridium* nor *Glapyrocysta* have distinct annulate or arcuate process complexes with basal ridges that delineate tabulation. However, *Chiropteridium gilbertii* does have intratabular processes or complexes. *Chiropteridium* differs from *Areoligera* primarily in having neither mid-dorsal nor mid-ventral processes or membranes. *Glaphyrocysta* has non-tabular or indistinctly contabular processes.

***Areoligera circumsenonensis* Fensome *et al.* 2009**
(Plate 2, fig. 9)

1966a *Areoligera* cf. *senonensis* of Williams & Downie, p. 230, 231; text-fig. 64 A–C (not plate 25, fig 6, typographically mislabelled plate 26, fig. 6).
1969 *Areoligera senonensis* Lejeune-Carpentier – Gocht, p. 56, plate 8, fig. 4a, b (?not figs 5–9); text-figs 40a, b, ?40c, d (not fig. 40e, f).
2009 *Areoligera circumsenonensis* Fensome *et al.*, p. 15, plate 1, fig. m.

Age. LO: early Lutetian. Not plotted.

Remarks. *Areoligera circumsenonensis* has processes like those of *Areoligera senonensis* but the process complexes are annular to arcuate on the large pre- and postcingular plates. In *Areoligera gippingensis*, the processes are interconnected along their length within, and occasionally between, complexes.

***Areoligera gippingensis* Jolley 1992**
(Plate 2, figs 10, 11)

1966a *Areoligera* cf. *medusettiformis* of Williams & Downie, p. 229, plate 25, fig. 4.
1976 *Areoligera* cf. *medusettiformis* of Eaton, p. 246, plate 3, fig. 7.
1992 *Areoligera gippingensis* Jolley, p. 26, 28, 30, 31, plate 1, figs 1–6; plate 2, figs 1–6; text-figs 2a–d, 3.

Age. LO: late Ypresian. Peak: early Thanetian.

Remarks. Specimens of *Areoligera gippingensis* in Labrador Margin samples show considerable variability in the delineation of the process complexes. We have found that this species is gradational with *Glaphyrocysta divaricata*. The species can be common in the late Thanetian, but generally peaks in the early Thanetian.

Genus *Areosphaeridium* Eaton 1971
Type. Klumpp 1953, plate 18, figs 3, 4, as *Hystrichosphaeridium dictyoplokum*.

1971 *Areosphaeridium* Eaton, p. 357, 358.

Synopsis. Chorate gonyaulacinean cysts with subspherical central body. Acavate. Processes mesotabular, solid, commonly fibroid, expanded clypeate and fenestrate to reticulate distally. The number of cingular processes is variable. Archaeopyle apical, with formula $A_{(1-4')}$, operculum free.

Remarks. The synopsis is based on the emendation of *Areosphaeridium* by Stover & Williams (1995, p. 100). Following Fensome *et al.* (2007), *Areosphaeridium* is considered an areoligeracean cyst related to *Enneadocysta*.

***Areosphaeridium diktyoplokum* (Klumpp 1953) Eaton 1971**
(Plate 2, fig. 12)

1953 *Hystrichosphaeridium diktyoplokum* Klumpp, p. 392, plate 18, figs 3–7 (not plate 18, figs 8–10, which are now *Cordosphaeridium latum*).
1963a *Cordosphaeridium diktyoplokum* (Klumpp) – Eisenack, p. 262.
1971 *Areosphaeridium diktyoplokum* (Klumpp) – Eaton, p. 358, 359.

Age. LO: latest Priabonian.

Genus *Atopodinium* Drugg 1978
Type. Drugg 1978, plate 1, fig. 1, as *Atopodinium prostatum*.

1978 *Atopodinium* Drugg, p. 62.
1981 *Maghrebinia* Below, p. 22.
1987 *Bejuia* Stover & Williams, p. 37.

Remarks. Masure (1991, p. 64) demonstrated that *Atopodinium* has a gonyaulacacean tabulation and that the archaeopyle of the type is apical, with the formula $A_{1-4'}$, and with precingular accessory sutures; the operculum is attached.

***Atopodinium* cf. *haromense* Thomas & Cox 1988**
(Plate 2, fig. 13)

cf. 1988 *Atopodinium haromense* Thomas & Cox, p. 319–321, 323, plate 1, figs 1–6; text-fig. 4.

Age. LO: late Campanian.

Remarks. The Cretaceous forms found in the present study tend to have slightly more pronounced ornamentation than that of the Jurassic holotype of *Atopodinium haromense* (Thomas & Cox 1988, plate 1, figs 1, 2).

Genus *Axiodinium* Williams, Damassa, Fensome & Guerstein in Fensome *et al.* 2009
Type. Williams & Downie 1966b, plate 18, fig. 1, as *Wetzeliella articulata*; now *Axiodinium prearticulatum*.

2009 *Axiodinium* Williams, Damassa, Fensome & Guerstein in Fensome *et al.*, p. 16.

Remarks. Both *Axiodinium* and *Apectodinium* are wetzelielloidean genera with an equiepeliform archaeopyle (Williams *et al.* 2015), but *Axiodinium* is clearly cavate and *Apectodinium* does not have a clear or consistent separation of the endophragm and periphragm.

***Axiodinium augustum* (Harland 1979b) Williams *et al.* 2015**
(Plate 2, figs 14, 15)

1979b *Wetzeliella (Apectodinium) augusta* Harland, p. 63, plate 2, figs 13–15.
1981 *Apectodinium augustum* (Harland) – Lentin & Williams, p. 14.
2015 *Axiodinium augustum* (Harland) – Williams *et al.*, p. 301.

Age. LO: basal Ypresian.

Genus *Batiacasphaera* Drugg 1970
Type. Drugg 1970, fig. 6A–B, as *Batiacasphaera compta.*

1970 *Batiacasphaera* Drugg, p. 813.

Remarks. We adhere to the synopsis presented in Fensome *et al.* (2009, p. 17), which specifies that the apical archaeopyle has an outline lacking or with weakly developed accessory sutures between precingular plates and a free operculum.

***Batiacasphaera micropapillata* Stover 1977**
(Plate 2, fig. 16)

1977 *Batiacasphaera micropapillata* Stover, p. 73, plate 1, figs 7, 8.

Age. LO (not confirmed in present study) Gelasian on Scotian Margin (Fensome *et al.* 2009). Not plotted.

Remarks. This is a species of *Batiacasphaera* with a granulate to microreticulate ornamentation.

Genus *Batioladinium* Brideaux 1975
Type. Alberti 1961, plate 5, fig. 2, as *Broomea jaegeri*.

1975 *Batioladinium* Brideaux, p. 124.
1975 *Necrobroomea* Wiggins, p. 111.

Synopsis. An elongate pareodiniacean cyst, drawn out into one apical and two generally equal antapical horns. Acavate. Wall consisting of autophragm. Archaeopyle apical, with formula $A_{(1-2')}$, formed from the loss of the two apical plates.

Remarks. The synopsis is based on the interpretation of the archaeopyle presented in Wharton (1988, text-fig. 4.13) and Fensome *et al.* (1993, p. 77, 78). The antapical horns, though equal on a single specimen, are of variable length from specimen to specimen.

***Batioladinium jaegeri* (Alberti 1961) Brideaux 1975**
(Plate 2, fig. 17)

1961 *Broomea jaergeri* Alberti, p. 26, plate 5, figs 1–7.
1975 *Batioladinium jaegeri* (Alberti) – Brideaux, p. 1240.
1975 *Necrobroomea jaegeri* (Alberti) – Wiggins, p. 111.
1980 *Imbatodinium jaegeri* (Alberti) – Dörhöfer & Davies, p. 37.
1981 *Pseudoceratium hansgochtii* Lentin & Williams, p. 236.

Age. LO: Campanian.

Remarks. Most records of this species are from the Early Cretaceous, but it appears to have an extended range up to the Campanian in western and northern North America (e.g. Harker *et al.* 1990).

Genus *Callaiosphaeridium* Davey & Williams 1966a
Type. Deflandre & Courteville 1939, plate 4, fig. 1, as *Hystrichosphaeridium asymmetricum*.

1966a *Callaiosphaeridium* Davey & Williams, p. 103.
1967 *Hexasphaera* Clarke & Verdier, p. 42; name illegitimate.

Remarks. *Callaiosphaeridium* is a chorate gonyaulacacean genus that has large, tubular mesotabular or gonal processes on the cingulum and may have slender gonal processes elsewhere. The archaeopyle is epicystal, with the formula ($A_{1-4'}$, $P_{1-6''}$) and a simple operculum.

***Callaiosphaeridium asymmetricum* (Deflandre & Courteville 1939) Davey & Williams 1966a**
(Plate 2, fig. 18)

1939 *Hystrichosphaeridium asymmetricum* Deflandre & Courteville, p. 100, 101, plate 4, figs 1, 2.
1966a *Callaiosphaeridium asymmetricum* (Deflandre & Courteville) – Davey & Williams, p. 104.
1967 *Hexasphaera asymmetrica* (Deflandre & Courteville) – Clarke & Verdier, p. 43; combination illegitimate.

Age. LO: Campanian.

Genus *Cannosphaeropsis* Wetzel 1933a
Type. Wetzel 1933a, plate 3, fig. 9a, b, as *Cannosphaeropsis utinensis.*

1932 *Cannosphaeropsis* Wetzel, p. 136; name not validly published.
1933a *Cannosphaeropsis* Wetzel, p. 6.

Synopsis. Chorate gonyaulacacean (gonyaulacoidean) cysts with a subspherical to ellipsoidal central body. Tabulation on the central body delineated by gonal processes, which can be restricted to the cingular plates, and sometimes also intergonal processes, which distally are united by trabecula that also reflect the tabulation. The gonal processes are trifurcate distally, the intergonal processes are bifurcate distally. Archaeopyle precingular, with formula $P_{3''}$; operculum free.

***Cannosphaeropsis passio* de Verteuil & Norris 1996**
(Plate 3, fig. 5)

1996 *Cannosphaeropsis passio* de Verteuil & Norris, p. 130, 132, 134, 136, plate 7, figs 1–8; plate 8, figs 1–6; plate 17, figs 1, 3–5; text-fig. 33.

Age. LO: Serravallian (based on Piasecki 2003).

Remarks. De Verteuil & Norris (1996) described *Cannosphaeropsis passio* as having cingular processes only, even though the trabecula delineate the complete tabulation.

Genus *Cerebrocysta* Bujak in Bujak *et al.* 1980
Type. Bujak *et al.* 1980, plate 13, figs 4–5, as *Cerebrocysta bartonensis*.

1980 *Cerebrocysta* Bujak in Bujak *et al.*, p. 42.

Remarks. The synopsis for *Cerebrocysta* provided by Fensome *et al.* (2009, p. 18) covers all the salient details of the morphology of this genus. These authors also noted that it is difficult to separate *Cerebrocysta* from *Pyxidinopsis*. The only distinctions are in the possible variability in the number of precingular plates lost in archaeopyle formation in *Cerebrocysta* and perhaps different wall structures. Regardless, we follow Fensome *et al.* (2009) in assigning Cenozoic taxa with the general morphology of *Cerebrocysta* and *Pyxidinopsis* to *Cerebrocysta*.

***Cerebrocysta bartonensis* Bujak in Bujak *et al.* 1980**
(Plate 2, figs 19, 20)

1980 *Cerebrocysta bartonensis* Bujak in Bujak *et al.*, p. 42, plate 13, figs 4–7.

Age. LO: Bartonian.

***Cerebrocysta magna* Bujak 1994**
(Plate 3, fig. 6)

1994 *Cerebrocysta magna* Bujak, p. 121, plate 2, figs 10, 11.

Age. LO: Lutetian.

Genus *Cerodinium* Vozzhennikova 1963
Type. Vozzhennikova 1963, text-fig. 9, as *Cerodinium sibiricum.*

1963 *Cerodinium* Vozzhennikova, p. 181.
1963 *Ceratiopsis* Vozzhennikova, p. 181; name illegitimate.

Remarks. Fensome *et al.* (2009, p. 18) noted that *Cerodinium* is characterised by having an isodeltaform to isothetaform 2a plate, a free perioperculum and a symmetrical antapex. The endoarchaeopyle may involve all three anterior intercalary plates. At present it does not seem practicable to separate into distinct species forms that lose the 2a plate only from those that lose the 1a, 2a and 3a plates individually from the endocyst. However, such a separation seems to have some stratigraphic value as forms occurring in younger rocks all seem to lose the 2a plate only; earlier forms may lose all three anterior intercalaries.

***Cerodinium diebelii* (Alberti 1959) Lentin & Williams 1987**
(Plate 3, figs 1–4)

1959 *Deflandrea diebelii* Alberti, p. 99, 100, plate 9, figs 18–21.
1967 *Ceratiopsis diebelii* (Alberti) – Vozzhennikova, p. 159; combination illegitimate.
1987 *Cerodinium diebelii* (Alberti) – Lentin & Williams, p. 114.

Age. LO: latest Danian.

***Cerodinium glabrum* (Gocht 1969) Fensome *et al.* 2009**
(Plate 3, figs 7, 8)

1969 *Deflandrea speciosa* forma *glabra* Gocht, p. 10, text-fig. 3.
1973 *Deflandrea speciosa* subsp. *glabra* (Gocht) – Lentin & Williams, p. 45.
1977a *Ceratiopsis speciosa* subsp. *glabra* (Gocht) – Lentin & Williams, p. 21 (combination illegitimate).
1987 *Cerodinium speciosum* subsp. *glabrum* (Gocht) – Lentin & Williams, p. 115.
2009 *Cerodinium glabrum* (Gocht) – Fensome *et al*, p. 19.

Age. LO: latest Thanetian (Late Paleocene).

***Cerodinium kangiliense* Nøhr-Hansen & Heilmann-Clausen 2001**
(Plate 3, figs 9, 10)

2001 Nøhr-Hansen & Heilmann-Clausen, p. 158, 160, 162–164, fig. 4, nos 1–9, fig. 5, nos 1–9.

Age. LO: Selandian.

***Cerodinium speciosum* (Alberti 1959) Lentin & Williams 1987**
(Plate 3, fig. 13)

1959 *Deflandrea speciosa* Alberti, p. 97, plate 9, figs 12, 13.
1977a *Ceratiopsis speciosa* (Alberti) – Lentin & Williams, p. 21; combination illegitimate.
1987 *Cerodinium speciosum* (Alberti) – Lentin &Williams, p. 115.

Age. LO: latest Thanetian.

***Cerodinium striatum* (Drugg 1967) Lentin & Williams 1987**
(Plate 3, figs 11, 12)

1967 *Deflandrea striata* Drugg, p. 18, plate 2, figs 13, 14.
1977a *Ceratiopsis striata* (Drugg) – Lentin & Williams, p. 21; combination illegitimate.
1987 *Cerodinium striatum* (Drugg) – Lentin & Williams, p. 115.

Age. LO Thanetian. Not plotted.

Remarks. *Cerodinium striatum* has a distinct development of more or less parallel folds. The folds should not be confused with the plications of *Cerodinium diebelii* (which is distinctly elongate) or the linearly aligned granules or denticles in *Cerodinium speciosum.*

Genus *Charlesdowniea* Lentin & Vozzhennikova 1989 emend. Williams *et al.* 2015
Type. Williams & Downie 1966b, plate 18, fig. 8, text-fig. 47, as *Wetzeliella coleothrypta*, and Bujak *et al.* 1980, plate 12, figs 7, 8, as *Kisselevia coleothrypta.*

1989 *Charlesdowniea* Lentin & Vozzhennikova, p. 225, 227.

Remarks. The emended diagnosis of Williams *et al.* (2015) is followed; this emphasises the archaeopyle type and the nature of the pericystal ornamentation. The archaeopyle of *Charlesdowniea* is equiepeliform and the processes are intratabular and sometimes also penitabular. Distally, the processes on individual plates are united by membranes.

***Charlesdowniea coleothrypta* (Williams & Downie 1966b) Lentin & Vozzhennikova 1989**
(Plate 4, fig. 9)

1966b *Wetzeliella coleothrypta* Williams & Downie, p. 185, 186, plate 18, figs 8, 9; text-fig. 47.
1976 *Kisselevia coleothrypta* (Williams & Downie) – Lentin & Williams, p. 136.
1989 *Charlesdowniea coleothrypta* (Williams & Downie) – Lentin & Vozzhennikova, p. 225.

Age. LO: Ypresian. Not plotted.

Remarks. In the Labrador Margin samples, *Charlesdowniea coleothrypta* has its LO just below that of *Scalenodinium scalenum*, but is not common.

Genus *Chatangiella* Vozzhennikova 1967 emend. nov.
Type. Vozzhennikova 1967, plate 56, fig. 1; plate 57, fig. 1, as *Chatangiella niiga*.

1967 *Chatangiella* Vozzhennikova, p. 128, 129.
1967 *Australiella* Vozzhennikova, p. 129, 130.
1967 *Cooksoniella* Vozzhennikova, p. 183, 184.

Emended description. Peridiniacean (deflandreoid) cysts that are proximate, dorsoventrally compressed and peridinioid in outline, with epicystal ‘shoulders’ and asymmetrical antapex, the left side being larger. Circumcavate to, generally, bicavate. Surface generally atabulate to weakly paratabulate, but cingulum clearly reflected by ridges, commonly serrated, reflecting the positions of pre- and postcingular plates. Periarchaeopyle intercalary, with formula I_{2a}, operculum free or attached; plate 2a is lati- to iso-omegaform hexa; endoarchaeopyle with formula I_{2a} or $I_{1a+2a+3a}$.

Remarks. Fensome *et al.* (2009, p. 19) provided a synopsis for *Chatangiella* that encompasses all its salient morphologic features. As part of their synopsis, these authors stated: “Periarchaeopyle intercalary, with formula I_{2a}, operculum free or attached; plate 2a is isodeltaform to (typically) iso-omegaform hexa; endoarchaeopyle with formula I_{2a} or $I_{1a+2a+3a}$.” We disagree with the synopsis of Fensome *et al.* (2009) in two important respects. Firstly, only taxa with omegaform 2a plates should be included in *Chatangiella*; and, secondly, taxa with 2a plates that are lati-omegaform must be included since the type of *Chatangiella* (Vozzhennikova 1967, plate 56, fig. 1; plate 57, fig. 1) has such an archaeopyle. Thus it is proposed here that a characteristic feature of *Chatangiella* be the possession of a lati- or iso-omegaform hexa 2a plate.

In their emendation of *Chatangiella*, Lentin & Williams (1976, p. 51, 52) emphasised the omegaform shape of the pericystal 2a plate and its common attachment posteriorly. Unfortunately, the critical shape and relationship of this plate have been overlooked in many subsequent papers. To correct this concern, the omegaform shape of the operculum is re-emphasised in the emended description above. Although epicystal shoulders, a distinctive characteristic of this genus, appear to almost always be related to the presence of an omegaform periarchaeopyle, which feature came first is open to debate.

As noted under *Alterbidinium*, the morphological differences used to separate the deflandreoid genera are in large part unsatisfactory. This criticism applies to *Chatangiella*: to bring stability to the genus, we propose that any peridiniacean forms with a partite cingulum that do not have an omegaform periarchaeopyle should be re-assigned.

Chatangiella decorosa **(McIntyre 1975) Lentin & Williams 1976**

1975 *Deflandrea decorosa* McIntyre, p. 63, 64, plate 2, figs 1–4.
1976 *Chatangiella decorosa* (McIntyre) – Lentin & Williams, p. 54.

Age. LO: early Campanian.

Remarks. McIntyre (1975, p. 64) noted that *Chatangiella decorosa* differs from *Chatangiella ditissima* in being larger. The size of *Chatangiella ditissima* overlaps that of *Chatangiella tripartita*. *Chatangiella decorosa* also has more pustules than *Chatangiella ditissima*.

Chatangiella madura **Lentin & Williams 1976**
(Plate 3, figs 14, 15)

1970b *Deflandrea manumii* Cookson & Eisenack, p. 141, 142, plate 11, figs 10, 11.
1976 *Chatangiella manumii* (Cookson & Eisenack) – Lentin & Williams, p. 54; name illegitimate.
1976 *Chatangiella madura* (Cookson & Eisenack) – Lentin & Williams, p. 54.

Age. LO: Campanian.

Chatangiella tripartita **(Cookson & Eisenack 1960a) Lentin & Williams 1976**
(Plate 3, figs 16, 20)

1960a *Deflandrea tripartita* Cookson & Eisenack, p. 2, 3, plate 1, fig. 10.
1967 *Australiella tripartita* (Cookson & Eisenack) – Vozzhennikova, p. 134, 135.
1976 *Chatangiella tripartita* (Cookson & Eisenack) – Lentin & Williams, p. 55.

Age. LO: Campanian (Late Cretaceous). Not plotted.

Remarks. There is considerable confusion concerning the morphology of *Chatangiella tripartita* and the related form *Chatangiella victoriensis*. Both are surprisingly large. According to Cookson & Eisenack (1960a, p. 3), the pericyst of *Chatangiella tripartita* ranges from 100 to 120 µm in length and 59 to 71 µm in width. Cookson & Manum (1964) stated that in *Chatangiella victoriensis*, the pericyst was 76 to 116 µm in length and 49–73 µm in width. Comparison of the sizes of the above two species with one of the higher latitude (Arctic) species of *Chatangiella*, *Chatangiella ditissima,* shows that there is some overlap, especially in width. McIntyre (1975, p. 63) noted that the pericyst in *Chatangiella ditissima* could be 115–150 µm long and 60–90 µm wide. The similar but even larger, higher latitude species *Chatangiella decorosa* has a pericyst that can be 130–175 µm long and 80–110 µm wide.

Our conclusion from comparison of several *Chatangiella* species is that size is not a reliable characteristic when separating species. But size has some significance: for example specimens of *Chatangiella* found on the Grand Banks of Newfoundland are generally much smaller than those from the high Arctic. Gigantism is a common feature of life in higher latitudes, so it is no surprise to find it among dinoflagellates.

Differences in the expression of the cingulum and the surface ornamentation of the pericyst are perhaps more diagnostic. Cookson & Manum (1964, p. 521, 522) noted that the cingulum of the holotype of *Chatangiella tripartita* is denoted by two pairs of ill-defined short, offset, low parallel ridges on the ventral surface and a fold-like line on the dorsal surface. The ridges are not serrate or denticulate, a feature of many specimens placed in *Chatangiella tripartita*. Regarding the cingulum of *Chatangiella victoriensis*, Cookson & Manum (1964) stated that it "is bordered by conspicuous ridges or by linearly arranged wart-like thickenings of varying size and shape". McIntyre (1975, p. 62, 63) described *Chatangiella ditissima* as having a cingulum delineated by "discontinuous ridges consisting of rows of pustules that may join to form narrow grooves". That author recognised seven and five ridges on the anterior and posterior margins respectively of the cingulum, which represent the difference in number of plates between the pre- and postcingular series. These two series of plates can also have penitabular pustules mirroring the plate outlines.

Cookson & Manum (1964, p. 522) gave a thickness of 1.0–1.7 µm for the periphragm (as the thecal wall) of *Chatangiella victoriensis* and noted that it is "ornamented with fairly evenly scattered rod-like projections *c.* 0.5–1.5 µm long; in surface view the rods appear as dots usually between 0.5 and 1.0 µm in diameter but a few smaller and larger ones are usually present". In *Chatangiella tripartita*, the periphragm is finely granular. McIntyre (1975) described the periphragm of *Chatangiella ditissima* as smooth, except for the pustules delineating the tabulation and occasional pits.

What is the conclusion to be drawn from the above and from our observations on the specimens from the offshore wells? The most compelling is the extreme variability in the size of the taxa and the degree of expressions of tabulation. In this paper, all the 'smaller' forms are assigned to *Chatangiella tripartita* if they lack pustules other than on the cingulum. We would like to include those smaller forms with pustules defining the pre- and postcingular plates in a new species but do not have enough specimens to do that here.

Genus *Chiropteridium* Gocht 1960 emend. nov.
Type. Gocht 1960, plate 17, fig. 1, as *Chiropteridium lobospinosum*.

1959 *Galea* Maier, p. 305; name illegitimate.
1960 *Chiropteridium* Gocht, p. 221.

Emended diagnosis. Areoligeracean cysts that are proximochorate to chorate, with subrounded to lenticular central body that may be asymmetrical antapically. Cavate or acavate; if cavate, with cavation mainly restricted to scalloped marginal wings; when acavate there may be marginal wings and/or processes. Mid-ventral and mid-dorsal areas devoid of processes or having processes of a reduced size. Surface atabulate or with intratabular processes. Archaeopyle apical, with formula $A_{(1-4')}$ and free operculum; sulcal notch offset to the left.

Remarks. *Chiropteridium* has not been emended previously. However, Stover & Evitt (1978) provided a synopsis and modified description and Fensome *et al.* (2009, p. 21) gave a synopsis. In their synopsis of *Chiropteridium*, Stover & Evitt (1978, p. 27) stated: "Cysts skolochorate, body lenticular; processes isolated or connected proximally and absent or greatly reduced in size and number on ventral surface; archaeopyle apical, Type tA; parasulcal notch offset." In their modified description, the same authors noted that processes could be isolated or partly connected in longitudinal rows, with the connections being proximal. Also they stated that processes are absent or reduced in size and numbers ventrally. Fensome *et al.* (2009, p. 21) were more specific in providing the following synopsis for *Chiropteridium*: "Areoligeracean cysts that are proximochorate to chorate, with lenticular central body that may be asymmetrical antapically. Cavate or acavate; if cavate, with cavation mainly restricted marginally to 'wings' and scalloped; if acavate, marginate wings formed from longitudinal crests or from longitudinally taeniate processes. Surface atabulate. Archaeopyle apical, with formula $A_{(1-4')}$, operculum free; sulcal notch offset to the left."

Fensome *et al.* (2009, p. 21) stated that "*Chiropteridium* is characterised by lateral extensions or 'wings' that may be cavate; these wings are typically scalloped to varying degrees or formed by taeniate processes. In *Membranophoridium*, processes are absent and the 'wings' are continuous pericoelar sacs." Although correct for species included to date in *Chiropteridium*, forms are recorded here that possess only processes that are not connected proximally or along their length and which denote the tabulation. These are accommodated in the above emended diagnosis for *Chiropteridium*.

***Chiropteridium galea* (Maier 1959) Sarjeant 1983**
(Plate 3, figs 17–19)

1959 *Galea galea* Maier, p. 306, plate 29, fig. 4; text-fig. 2.
1959 *Galea levis* Maier, p. 308, plate 30, figs 1, 2.
1959 *Galea mespilana* Maier, p. 306, 307, plate 29, figs 5, 6.
1960 *Chiropteridium dispersum* Gocht, p. 227, plate 18, figs 1–16; text-figs 16–27.
1961 *Membranophoridium multispinatum* Gerlach, p. 203, 204, plate 29, fig. 5.
1961 *Membranophoridium partispinatum* Gerlach, p. 201, plate 29, fig. 6.
1963 *Chiropteridium partispinatum* (Gerlach) – Brosius, p. 48.
1964 *Baltisphaeridium leve* (Maier) – Sarjeant, p. 176.
1964 *Baltisphaeridium mespilanum* (Maier) – Sarjeant, p. 176.
1969 *Cleistosphaeridium leve* (Maier) – Davey *et al.*, p. 16.
1973 *Chiropteridium mespilanum* (Maier) – Lentin & Williams, p. 26.

1975 *Hystrichosphaeridium mespilanum* (Maier) – Eisenack & Kjellström, p. 233, 234.
1983 *Chiropteridium galea* (Maier) – Sarjeant, p. 108.

Age. LO: Chattian.

***Chiropteridium gilbertii* sp. nov.**
(Plate 4, figs 1–4)

Holotype. Plate 4, fig. 4, from a cuttings sample at 1600–1610 m in Gilbert F-53, GSC type collection no.137976, sample P39466, slide 01, co-ordinates 17.4 × 106.0, England Finder R36/3. Overall length 83 µm, width 87 µm; central body, length 57 µm, width 52 µm; maximum length of processes 20 µm, width varies from less than 1 to 10 µm. The age determined for the sample from which the holotype was recovered is basal Bartonian.

Etymology. The epithet is derived from the name of the Gilbert F-53 offshore exploration well, in which the species is abundant.

Diagnosis. A species of *Chiropteridium* in which the processes or process complexes delineate the tabulation and there are no interconnections between processes representing adjacent plates.

Description. The processes delineate the tabulation, though none are interconnected. Processes on the mid-ventral and mid-dorsal surfaces are reduced in width or absent: this is especially true of the 3′′ process that, if present, is very slender. Commonly, processes are basally trumpet-shaped, then tubular or parallel-sided. Processes are also of variable size depending on which plate series they are reflecting, with cingular processes being invariably slender, precingular processes broader, and postcingular processes being broader still, and the antapical process being broadest of all. Many of the processes are perforate.

Size. Overall maximum diameter 87 µm; maximum diameter of central body 57 µm; maximum length of processes 25 µm, maximum width 17 µm; seven specimens measured.

Age. LO: Bartonian.

Remarks. In *Chiropteridium gilbertii*, the central body, which is granulate, commonly has a prominent antapical protuberance. All of the processes, which are intratabular, have a circular cross-section proximally and distally are closed and commonly branch into short bifurcations or aculeae. Proximally, the processes tend to be conical then become tubular about halfway along their length before flaring distally. The processes are often fibrous and/or perforate, especially the antapical process, which sometimes subdivides to form a process complex. Recognition of the antapical process, if the archaeopyle is not obvious, is facilitated by the extreme width and the perforations, which may form arches in the process wall. Cingular processes are invariably slender, some less than 1 µm wide, rarely exceed four in number, and are restricted to the ambital region of the central body. Apical processes show variation in width on different specimens. Precingular processes are always narrower than the postcingular processes. Although the sulcal notch is offset, this is not always obvious.

Chiropteridium gilbertii differs from *Chiropteridium galea* in having processes or process complexes that are restricted to individual plates. *Licracysta semicirculata* has processes that are restricted to the ambitus and tend to form arcuate complexes. The processes of *Chiropteridium gilbertii* vary in size according to the plate they represent, and are often fibrous and/or perforate. *Chiropteridium conispinum* also has membranous processes, but these are restricted to the dorsal surface, with two linear membranes running apically–antapically on the ventral surface.

Genus *Chlamydophorella* Cookson & Eisenack 1958
Type. Cookson & Eisenack 1958, plate 11, fig. 1, as *Chlamydophorella nyei*.

1958 *Chlamydophorella* Cookson & Eisenack, p. 56.

Remarks. As Fensome *et al.* (2009, p. 21) noted in their synopsis for *Chlamydophorella*, the genus is characterised by being proximate, holocavate, with short, solid processes forming buttresses between the autophragm and ectophragm, an apical horn formed from the ectophragm, and an apical archaeopyle. The tabulation is gonyaulacacean, but whether it shows neutral or dextral torsion is not known. *Sepispinula* differs from *Chlamydophorella* in lacking an ectophragm.

***Chlamydophorella nyei* Cookson & Eisenack 1958**
(Plate 4, fig. 5)

1958 *Chlamydophorella nyei* Cookson & Eisenack, p. 56, plate 11, figs 1–3.
1970b *Chlamydophorella apiculata* Cookson & Eisenack, p. 150, 151, plate 13, fig. 3.
1970b *Chlamydophorella lagena* Cookson & Eisenack, p. 151, plate 13, fig. 4.

Age. LO: Coniacian (Late Cretaceous).

***Chlamydophorella* cf. *nyei* Cookson & Eisenack 1958**
(Plate 4, figs 6–8)

Age. LO : Campanian. Not plotted.

Remarks. This form includes specimens similar to *Chlamydophorella nyei* but which lack an evident apical horn.

Genus *Chytroeisphaeridia* (Sarjeant 1962) Downie & Sarjeant 1965
Type. Sarjeant 1962, plate 70, fig. 13, as *Leiosphaeridia* subgenus *Chytroeisphaeridia chytroeides.*

1962 *Leiosphaeridia* subgenus *Chytroeisphaeridia* Sarjeant, p. 492.
1965 *Chytroeisphaeridia* Downie & Sarjeant, p. 102.

***Chytroeisphaeridia hadra* sp. nov.**
(Plate 4, figs 17, 18)

Holotype. Plate 4, fig. 18 from a cuttings sample at 3120–3140 m in Roberval K-92, GSC type collection no. 137902, sample P17728, slide 01, co-ordinates 19.5 × 109.8, England Finder U40/1. Overall length 79 µm, width 81 µm; wall thickness 5 µm, archaeopyle length 37 µm, width 33 µm. The age determined for the sample from which the holotype was recovered is Late Cretaceous (the specimen is caved).

Etymology. The epithet is from the Greek *hadros* meaning well-developed, bulky, stout, strong, great, in reference to the thick, sturdy wall.

Diagnosis. A species of *Chytroeisphaeridia* with a thick wall that has a subdued rugulate, sometimes lightly striated surface. The archaeopyle is large, apparently resulting from the loss of the 3´´ plate only.

Size. Overall length 69–82 µm; width 64–81 µm. Six specimens measured.

Age. LO: Bartonian.

Remarks. Some specimens of *Chytroeisphaeridia hadra* have parallel striations on the wall but these are irregular and discontinuous. The archaeopyle is large, suggesting that more than a single plate may be involved.

Genus *Cleistosphaeridium* Davey *et al.* 1966
Type. Davey *et al.* 1966, plate 10, fig. 7, as *Cleistosphaeridium diversispinosum*.

1966 *Cleistosphaeridium* Davey *et al.*, p. 166.

Remarks. We concur with the retention and emendation of *Cleistosphaeridium* as proposed by Eaton *et al.* (2001, p. 176, 177) and the synopsis provided by Fensome *et al.* (2009, p. 22). Following Fensome *et al.* (2007, p. 408), *Cleistosphaeridium* is considered to be areoligeracean because of the asymmetry in some specimens of the antapex and sulcal notch, and also because it forms a morphological plexus with other areoligeracean genera, including *Glaphyrocysta*, *Enneadocysta*, *Licracysta* and *Cooksonidium.* We include in the genus species in which adjacent processes are medially and distally interconnected.

***Cleistosphaeridium diversispinosum* Davey *et al.* 1966**
(Plate 4, figs 19, 20)

1966 *Cleistosphaeridium diversispinosum* Davey *et al.*, p. 167, plate 10, fig. 7.
1993 *Systematophora diversispinosa* (Davey *et al.*) – Islam, p. 88.

Age. LO: Serravallian.

Remarks. Following Fensome *et al.* (2009, p. 22), *Cleistosphaeridium diversispinosum* and *Cleistosphaeridium ancyreum* are not considered synonyms.

***Cleistosphaeridium elegantulum* sp. nov.**
(Plate 4, figs 10–12)

Holotype. Plate 4, fig. 12, from a cuttings sample at 2286.03 to 2295.17 m in Karlsefni A-13, GSC type collection no. 138033, sample P39600, slide 01, co-ordinates 17.9 × 101.7, England Finder S44.2. Central body maximum diameter 50 µm, maximum length of processes about 25 µm. The age determined for the sample from which the holotype was recovered is Lutetian–Bartonian.

Etymology. From the Latin *elegantulus* (very fine), in reference to the narrow, long processes.

Diagnosis. A species of *Cleistosphaeridium* with numerous long, fine, flexible, unconnected processes, some to many of which are dolabrate distally. The length of many of the processes equals about one half of the central body diameter. Proximal ridges are absent to weakly developed.

Size. Central body diameter 30−57 µm; maximum length of processes up to half maximum diameter of central body; three specimens measured.

Age. LO: Lutetian−Bartonian. Not plotted.

Remarks. This species differs from other species of *Cleistosphaeridium* in its long, fine, flexible processes.

Cleistosphaeridium palmatum **sp. nov.**
(Plate 4, figs 13–16)

Holotype. Plate 4, figs 13, 14 from a cuttings sample at 2450–2460 m in Roberval K-92: GSC type collection no. 137897, sample P17706, slide 01, co-ordinates 6.9 × 100.6, England Finder G30/0−2. Maximum overall diameter 87 µm, maximum diameter of central body 50 µm, maximum length of processes 25 µm. The age determined for the sample from which the holotype was recovered is early Ypresian.

Etymology. The epithet is from the Latin *palmatus*, meaning marked or shaped like the palm of the hand, in reference to the shape of the distal terminations of the processes.

Diagnosis. A species of *Cleistosphaeridium* in which the solid processes are of irregular width, varying from 1–7 µm and distally slender to splayed, with some adjacent processes interconnected distally, commonly so that they form arches.

Description. The processes are of irregular width, distally slender to splayed, with some adjacent processes interconnected distally. They are predominantly dolobrate, but some are bifid. The wall of the central body is generally less than 1 µm thick. Archaeopyle apical, with formula $A_{(1–4')}$, operculum attached or free. Other aspects of the tabulation cannot be determined, as specimens possess more than one process per plate, sometimes in complexes. Where present, the complexes appear to occur on the precingular, postcingular and antapical plates.

Size. Maximum diameter of central body 48 µm, length of processes 10–25 µm, four specimens measured.

Age. LO: late Ypresian.

Remarks. The processes of specimens belonging to this species show similarities to those found in *Adnatosphaeridium*, *Enneadocysta, Licracysta* and other species of *Cleistosphaeridium*. Although the distal branches of processes can sometimes be interconnected, the general absence of trabecula uniting processes precludes assignment of the species to *Adnatosphaeridium*. *Cleistosphaeridium palmatum* differs from species of *Enneadocysta* because the number of processes per plate (where discernible as being related to tabulation) invariably exceeds one, and distally processes are dolobrate rather than licrate or clypeate. Moreover, the antapex of *Cleistosphaeridium palmatum* is not characterised by two processes (see Fensome *et al.* 2007, p. 394). *Cleistosphaeridium diversispinosum* differs in not having branched processes in which the branches often meet along their length or distally and in not having spatulate endings. Specimens of the species *Cleistosphaeridium polypetellum* are slender and are not spatulate or branched distally; species of *Licracysta* have proximal and ventral surfaces on which processes are absent or reduced.

Cleistosphaeridium polypetellum **(Islam 1983b) Stover & Williams 1995**
(Plate 5, figs 1, 2)

1983b *Areosphaeridium polypetellum* Islam, p. 82, 84, plate 2, figs 1–6.
1995 C*leistosphaeridium polypetellum* (Islam) – Stover & Williams, p. 102.

Age. LO: Ypresian.

Remarks. Some connections occur between adjacent processes, differentiating this species from *Cleistosphaeridium diversispinosum* and *Cleistosphaeridium ancyreum*. Processes in *Cleistosphaeridium polypetellum* are less variable and the species lacks the thick processes of *Cleistosphaeridium palmatum*. Distally, most processes of *Cleistosphaeridium polypetellum* are strongly dolabrate and sometimes licrate. However, a few simple bifid processes occur.

Genus *Cordosphaeridium* Eisenack 1963a
Type. Klumpp 1953, plate 18, figs 1, 2, as *Hystrichosphaeridium inodes*.

1963a *Cordosphaeridium* Eisenack, p. 261.
1981 *Tityrosphaeridium* Sarjeant, p. 120.

Remarks. We concur with the synopsis for *Cordosphaeridium* provided by Fensome *et al.* (2009, p. 22). The characteristic features of the genus are the spheroidal central body, the precingular ($P_{3''}$) archaeopyle and the fibrous wall and processes. The processes, which are commonly cylindrical and restricted to one per plate, are generally of approximately equal length but can show considerable variation in width.

***Cordosphaeridium cantharellus* (Brosius 1963) Gocht 1969**
(Plate 5, fig. 7)

1963 *Hystrichosphaeridium cantharellus* Brosius, p. 40, 41, plate 6, fig. 1; text-fig. 2, nos 11a–c.
1969 *Cordosphaeridium cantharellus* (Brosius) – Gocht, p. 45.
1981 *Tityrosphaeridium cantharellus* (Brosius) – Sarjeant, p. 120.

Age. LO: Burdigalian.

Remarks. As in the holotype, the process width in the Labrador Margin specimens of *Cordosphaeridium cantharellus* shows considerable variation. The species was retained in *Cordosphaeridium* by Edwards (2001, p. G19).

***Cordosphaeridium delimurum* Fensome *et al.* 2009**
(Plate 5, figs 3, 4)

2009 *Cordosphaeridium delimurum* Fensome *et al.*, p. 23, plate 2, figs l–q.

Age. LO: early Lutetian. Not plotted.

Remarks. As its name implies, *Cordosphaeridium delimurum* differs from *Cordosphaeridium inodes* and *Cordosphaeridium gracile* in having a much thinner central body wall. Unlike *Cordosphaeridium fibrospinosum, Cordosphaeridium delimurum* has solid rather than perforate process walls.

***Cordosphaeridium fibrospinosum* Davey & Williams 1966a**
(Plate 5, figs 5, 6)

1966a *Cordosphaeridium fibrospinosum* Davey & Williams, p. 86, plate 5, fig. 5.
1966a *Cordosphaeridium exilimurum* Davey & Williams, p. 87, 88, plate 11, fig. 2.
1970 *Achomosphaera valianta* Sah *et al.*, p. 145, plate 1, figs 8, 9.
1978 *Cordosphaeridium valiantum* (Sah *et al.*) – Stover & Evitt, p. 147.
1981 *Hystrichosphaerina*? *exilimura* (Davey &Williams) – Sarjeant, p. 122.
1981 *Emmetrocysta*? *fibrospinosa* (Davey & Williams) – Sarjeant, p. 123.
1986 *Tityrosphaeridium*? *exilimurum* (Davey & Williams) – Jain & Garg, p. 120.
1986 *Tityrosphaeridium*? *fibrospinosum* (Davey & Williams) – Jain & Garg, p. 121.

Age. LO: late Rupelian. Not plotted.

Remarks. As noted above, *Cordosphaeridium fibrospinosum* has processes with fibrous, perforate walls. We agree with Fensome *et al*. (2009) that *Cordosphaeridium exilimurum* and its long-recognised synonym *Achomosphaera valianta* cannot be meaningfully differentiated from *Cordosphaeridium fibrospinosum*. Although this species has an Oligocene LO, at least in offshore eastern Canada, it tends to be most common in the Paleocene.

***Cordosphaeridium funiculatum* Morgenroth 1966a**
(Plate 5, fig. 8)

1966a *Cordosphaeridium funiculatum* Morgenroth, p. 22, 23, plate 6, figs 2–3.
1981 *Tityrosphaeridium funiculatum* (Morgenroth) – Sarjeant, p. 121.

Age. LO: Priabonian.

***Cordosphaeridium gracile* (Eisenack 1954) Davey & Williams 1966a**
(Plate 5, fig. 9)

1954 *Hystrichosphaeridium inodes* subsp. *gracile* Eisenack, p. 66, plate 8, fig. 17; plate 10, figs 3–8; plate 12, figs 7, 21.
1963a *Cordosphaeridium inodes* subsp. *gracile* (Eisenack) – Eisenack, p. 261.

1966a *Cordosphaeridium gracile* (Eisenack) – Davey & Williams, p. 84.
1981 *Tityrosphaeridium gracile* (Eisenack) – Sarjeant, p. 121.

Age. LO: early Lutetian.

Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963a
(Plate 5, fig. 10)

1953 *Hystrichosphaeridium inodes* Klumpp, p. 391, plate 18, figs 1, 2.
1963a *Cordosphaeridium inodes* (Klumpp) – Eisenack, p. 261.

Age. LO: consistent occurrence early Lutetian. Not plotted.

Remarks. The holotype of *Cordosphaeridium inodes* (Klumpp 1953, plate 18, figs 1, 2) shows considerable variation in the width of the processes, some being remarkably similar to those of *Cordosphaeridium gracile*. It is this variability in width, however, that is the distinguishing characteristic of *Cordosphaeridium inodes*.

Genus _Cribroperidinium_ Neale & Sarjeant 1962
Type. Neale & Sarjeant 1962, plate 19, fig. 4, text-fig. 3a, b, as *Cribroperidinium sepimentum.*

1962 *Cribroperidinium* Neale & Sarjeant, p. 443.
1968 *Acanthaulax* Sarjeant, p. 227.
1978 *Millioudodinium* Stover & Evitt, p. 173.
1984b *Meristaulax* Sarjeant, p. 160.
1988 *Meristaulax* Brenner, p. 65.

Synopsis. Gonyaulacacean (cribroperidinioid) cysts that are proximate, with spheroidal to more commonly ovoidal central body, usually surmounted by an apical horn. Acavate or cornucavate. Tabulation strongly delineated by sutural and penitabular ornamentation. Archaeopyle precingular, with formula $P_{3''}$, operculum free.

Cribroperidinium giuseppei (Morgenroth 1966a) Helenes 1984

1966a *Gonyaulax giuseppei* Morgenroth: 5, plate 2, figs 3–6.
1969 *Gonyaulacysta giuseppei* (Morgenroth) – Sarjeant, p. 9.
1978 *Millioudodinium*? *giuseppei* (Morgenroth) – Stover & Evitt, p. 174.
1982 *Rhynchodiniopsis*? *giuseppei* (Morgenroth) – Sarjeant, p. 36.
1984 *Cribroperidinium giuseppei* (Morgenroth) – Helenes, p. 121.

Age. Local acme: Priabonian.

Remarks. *Cribroperidinium giuseppei* is a species of *Cribroperidinium* with a small, button-like apical horn, a spongy wall, distinctly reflected paratabulation and a low, coarse reticulum superimposed on the paraplates. This includes many forms assigned in the literature to *Cribroperidinium tenuitabulatum*, but the latter species is now considered to be a junior synonym of *Apteodinium australiense*. Helenes (1984, p. 122) noted that the sutural ridges in *Cribroperidinium giuseppei* are smooth and that the penitabular ridges are more commonly found on the hypocyst.

Genus _Cyclonephelium_ Deflandre & Cookson 1955
Type. Deflandre & Cookson 1955, plate 2, fig. 12, as *Cyclonephelium compactum.*

1955 *Cyclonephelium* Deflandre & Cookson, p. 285.
1961 *Circulodinium* Alberti, p. 28.

Remarks. We follow the synopsis for this genus proposed by Fensome *et al.* (2009, p. 24), and agree with those authors in considering *Circulodinium* to be a junior synonym of *Cyclonephelium*.

Cyclonephelium distinctum (Deflandre & Cookson 1955) Jansonius 1986
(Plate 6, fig. 10)

1955 *Cyclonephelium distinctum* Deflandre & Cookson, p. 285, 286, plate 2, fig. 14; text-figs 47, 48.
1961 *Circulodinium hirtellum* Alberti, p. 28, 29, plate 4, fig. 20.
1969 *Canningia hirtella* (Alberti) – Millioud, p. 425.
1978 *Cyclonephelium hirtellum* (Alberti) – Davey, p. 894.
1986 *Circulodinium distinctum* (Deflandre & Cookson) – Jansonius, p. 204.

Age. LO: latest Maastrichtian.

Genus *Dapsilidinium* Bujak *et al.* 1980
Type. Davey & Williams 1966a, plate 4, fig. 10, as *Polysphaeridium pastielsii.*

1980 *Dapsilidinium* Bujak *et al.*, p. 27, 28.

Remarks. For this genus, the concept of Fensome *et al.* (2009, p. 26) is followed.

***Dapsilidinium pseudocolligerum* (Stover 1977) Bujak *et al.* 1980**
(Plate 5, fig. 13)

1977 *Polysphaeridium pseudocolligerum* Stover, p. 74, 75, plate 1, figs 14–19.
1980 *Dapsilidinium pseudocolligerum* (Stover) – Bujak *et al.*, p. 28.

Age. LO: Tortonian.

Remarks. As Fensome *et al.* (2009) observed, *Dapsilidinium pastielsii* and *Dapsilidinium pseudocolligerum* differ primarily in the proximal morphology of the processes. In *Dapsilidinium pastielsii*, the processes are initially broad before tapering gradually, whereas in *Dapsilidinium pseudocolligerum* they are more or less cylindrical proximally, tapering gradually to the distal opening.

***Dapsilidinium pseudoinsertum* sp. nov.**
(Plate 5, figs 11, 12)

Holotype. Plate 5, fig. 12 from a cuttings sample at 2825−2835 m in Rut H-11, GSC type collection no. 137957, sample P39388, slide 01, co-ordinates 19.6 × 105.1, England Finder U48/1−2. Central body maximum diameter 32 µm; length of processes up to about 15 µm. The age determined for the sample from which the holotype was recovered is Ypresian.

Etymology. The epithet is in reference to the similarity of this species to *Hystrichokolpoma*? *incertum* Michoux 1985.

Diagnosis. A species of *Dapsilidinium* in which some, but not all, of the processes are significantly broader than others, though the position of the broader processes appears not to be consistent.

Size. Central body maximum diameter 30−32 µm; length of processes up to about 15 µm; two specimens measured.

Age. LO: late Lutetian.

Remarks. This species is distinctive in having a more or less bimodal variation in process widths, with a few being distinctly broader than the others. The position and number of broad processes vary from specimen to specimen. One or more of the broader processes on each specimen may be bifurcate distally down to about midlength. In *Hystrichokolpoma*? *incertum*, the larger processes are consistently the precingulars and the antapical. In other species of *Dapsilidinium*, such as *Dapsilidinium pseudocolligerum* and *Dapsilidinium simplex*, the processes are more or less uniformly developed. In species of *Diphyes*, only the antapical process is relatively large.

***Dapsilidinium simplex* (White 1842) Bujak *et al.* 1980**
(Plate 5, fig. 14)

1842 *Xanthidium tubiferum* var. *simplex* White, p. 38, plate 4, fig. 10.
1946 *Hystrichosphaeridium simplex* (White) – Deflandre, card 934.
1969 *Polysphaeridium*? *simplex* (White) – Davey & Williams, p. 7.
1980 *Dapsilidinium simplex* (White) – Bujak *et al.*, p. 28.

Age. LO: Bartonian. Not plotted.

Genus *Deflandrea* Eisenack 1938
Type. Eisenack 1938, text-fig. 6, as *Deflandrea phosphoritica*.

1938 *Deflandrea* Eisenack, p. 187.

Remarks. *Deflandrea* is a peridiniacean cyst that is characterised by its latideltaform intercalary (I_{2a}) archaeopyle. The broad shape is a consistently striking feature of the periarchaeopyle, but not always of the endoarchaeopyle.

***Deflandrea borealis* sp. nov.**
(Plate 5, figs 17–20)

Holotype. Plate 5, fig. 19 from a cuttings sample at 3095−3105 m in Rut H-11, GSC type collection no. 137964, sample P39397, slide 01, co-ordinates 18.9 × 98.6, England Finder T41/2. Length (including horns) 57 µm, width 55 µm. The age determined for the sample from which the holotype was recovered is Thanetian (Late Paleocene).

Etymology. The epithet is from the Latin *borealis* (northern) in reference to the northern occurrence of at least the type material of this species.

Diagnosis. A relatively small, squat and generally rounded species of *Deflandrea* with a scabrate to granulate wall and a latiform archaeopyle, the operculum of which commonly remains attached posteriorly.

Size. Length (including horns) 46–59 µm, width 46–55 µm; three specimens measured.

Age. LO: latest Priabonian.

Deflandrea denticulata **Alberti 1959**
(Plate 5, figs 15, 16)

1959 *Deflandrea denticulata* Alberti, p. 102, 103, text-fig. 1.

Age. LO: Ypresian. Not plotted.

Remarks. *Deflandrea denticulata* (Alberti 1959, text-fig. 1) is unusual for a species of this genus in having a pericyst with long slender apical and antapical horns. The periphragm is covered with small, slender spines. Although the archaeopyle appears to be latideltaform, it is impossible to be definite without examining the holotype. Alberti (1959) recorded *Deflandrea denticulata* from Lower Eocene sediments of Volgograd, Russia, the Oebisfelde Borehole in Germany, and possibly from Belgium. His observations fit the predicted LO in this study for a taxon with a morphology intermediate between *Cerodinium* and *Deflandrea.*

Deflandrea galeata **(Lejeune-Carpentier 1942) Lentin & Williams 1973**
(Plate 6, fig. 1)

1942 *Peridinium galeata* Lejeune-Carpentier, p. B186–B188, figs 15–20.
1973 *Deflandrea galeata* (Lejeune-Carpentier) – Lentin & Williams, p. 41.

Age. LO: Maastrichtian.

Remarks. The line-drawing of the dorsal view of the holotype of *Deflandrea galeata* (Lejeune-Carpentier 1942, fig. 15) clearly shows a latideltaform hexa 2a archaeopyle. This interpretation is confirmed in Lejeune-Carpentier & Sarjeant (1981, p. 18, 19, who refer to the archaeopyle as "single-plate intercalary (type I/I) of broad-hexa type and formed by the loss of paraplate 2a". In every other respect, the species has the typical morphology of *Cerodinium*. It is unusual to find forms with a latideltaform 2a in rocks of this age.

Deflandrea majae **(Schiøler 1993) comb. nov.**
(Plate 6, fig. 2)

1993 *Isabelidinium majae* Schiøler, p. 108, 110, plate 1, figs 1–6; text-fig. 4a, b.

Age. LO: latest Maastrichtian.

Remarks. Schiøler (1993) noted that this species has a latideltaform archaeopyle with a transverse archaeopyle index (TAI) considerably higher than 0.5. Schiøler (1993, p. 110) stated that although these characters are "… typical of the genus *Deflandrea* … as the new species lacks any signs of a paracingulum, referral to the latter genus is precluded." In our view, archaeopyle shape is critical in diagnosing *Deflandrea* and similar genera and that the presence or absence of a cingulum is not significant. Therefore, this species is transferred herein to *Deflandrea*. However, M. Pearce (personal communication 2015) has pointed out that the archaeopyles of specimens otherwise attributable to this species show a wide variation in archaeopyle shape. For example he has observed specimens of *Deflandrea majae* with stenodeltaform archaeopyles; we would recommend that such forms be included in another genus. As noted under *Alterbidinium*, a detailed re-evaluation of archaeopyle shapes in *Deflandrea* and similar genera in relation to the taxonomy of the group is clearly needed but beyond the scope of the present work.

Deflandrea oebisfeldensis **Alberti 1959**
(Plate 6, fig. 3)

1959 *Deflandrea oebisfeldensis* Alberti, p. 95, 96, plate 8, figs 10–13.

Age. LO: early Ypresian.

Remarks. The antapical margin of the pericyst in *Deflandrea oebisfeldensis* is broad, with the left and right antapical horns being at the intersection with the posterior lateral sides and thus broadly separated.

Deflandrea phosphoritica **Eisenack 1938**
(Plate 6, fig. 4)

1938 *Deflandrea phosphoritica* Eisenack, p. 187, text-fig. 6.

1965b *Deflandrea granulosa* Cookson & Eisenack, p. 122, plate 11, figs 8, 9.
1965 *Deflandrea heterophlycta* forma *pusulosa* Rozen, p. 293, 294, plate 1, figs 3, 4; text-fig. 2.
1966 *Deflandrea menendezii* Pöthe de Baldis, p. 223, plate 2, fig. a.
1973 *Deflandrea heterophlycta* subsp. *pusulosa* (Rozen) – Lentin & Williams, p. 41.

Age. LO: latest Chattian.

Genus *Dinogymnium* Evitt *et al.* 1967
Type. Evitt *et al.* 1967, plate 1, figs 21–23, plate 2, fig. 5, text-figs 16–18, as *Dinogymnium acuminatum*.

1967 *Dinogymnium* Evitt *et al.*, p. 4–8.

Remarks. Lentin & Vozzhennikova (1990) subdivided the dinogymnioids into genera that are separated on overall outline, relative size of the episome and hyposome, and surface ornamentation. As a consequence, these authors transferred several species previously included in *Dinogymnium* into the new genera. Fensome *et al.* (2009, p. 27) provided a synopsis for *Dinogymnium* that is followed here.

***Dinogymnium longicorne* (Vozzhennikova 1967) Harland 1973**
(Plate 6, fig. 11)

1967 *Gymnodinium longicorne* Vozzhennikova, p. 46, plate 1, fig. 8; plate 3, fig. 6; plate 4, figs 6a, b, 7.
1967 *Gymnodinium curvatum* Vozzhennikova, p. 43, plate 1, figs 10–12; plate 4, figs 2, 3.
1973 *Dinogymnium longicorne* (Vozzhennikova) – Harland, p. 678.

Age. LO: early Campanian.

Remarks. *Dinogymnium longicorne* is elongate, with an episome that is considerably longer than the hyposome. According to Lentin & Vozzhennikova (1990, p. 19), the length varies between 62 and 91 μm, the width between 21 and 38 μm.

Genus *Diphyes* Cookson 1965 nom. cons.
Type. Deflandre & Cookson 1955, plate 7, fig. 3, as *Hystrichosphaeridium colligerum*.

1965 *Diphyes* Cookson, p. 85; name illegitimate.
1970 *Lingulasphaera* Drugg, p. 817.
2000 *Diphyes* Cookson nom. prop. cons. Harris & Fensome, p. 281, 282.

Remarks. The conservation proposal of the name *Diphyes* Cookson (Harris & Fensome 2000) was ratified at the 2005 Botanical Congress. We agree with the synopsis of *Diphyes* in Fensome *et al.* (2009, p. 28), with one exception regarding the processes. Some specimens show an intratabular organisation, with about four processes on each pre- and postcingular plate.

***Diphyes brevispinum* Bujak 1994**
(Plate 6, figs 5, 6)

1994 *Diphyes brevispinum* Bujak, p. 121, 123, plate 2, figs 4–6.

Age. LO: Ypresian.

Remarks. *Diphyes brevispinum* has short conical to subconical, rarely tapering processes and an inflated antapical process that is similar to that of *Diphyes ficusoides*.

***Diphyes colligerum* (Deflandre & Cookson 1955) Cookson 1965**
(Plate 6, fig. 12)

1955 *Hystrichosphaeridium colligerum* Deflandre & Cookson, p. 278, 279, plate 7, fig. 3.
1965 *Baltisphaeridium colligerum* (Deflandre & Cookson) – Downie & Sarjeant, p. 88.
1994 *Diphyes pseudoficusoides* Bujak, p. 123, 125, plate 2, figs 2, 3.

Age. LO: Lutetian.

Remarks. Following Fensome *et al.* (2009, p. 30), *Diphyes pseudocolligerum* should be considered a junior synonym of *Diphyes colligerum* because the size of the antapical process is similar in both holotypes.

***Diphyes ficusoides* Islam 1983a**
(Plate 6, figs 7, 8)

1983a *Diphyes ficusoides* Islam, p. 338, plate 2, figs 8, 9.

Age. LO: middle Lutetian.

Genus *Disphaerogena* Wetzel 1933a
Type. Wetzel 1933a, plate 4, fig. 34, as *Disphaerogena carposphaeropsis.*

1933a *Disphaerogena* Wetzel, p. 51.
1976 *Cyclapophysis* Benson, p. 192.
1981 *Plethysyrinx* Sarjeant, p. 106.

Remarks. The synopsis of *Disphaerogena* provided in Fensome *et al.* (2009, p. 30) is accepted, including that *Cyclapophysis* is a taxonomic junior synonym of the genus.

***Disphaerogena carposphaeropsis* Wetzel 1933a**
(Plate 6, fig. 9)

1933a *Disphaerogena carposphaeropsis* Wetzel, p. 51, plate 4, fig. 34.
1976 *Cyclapophysis monmouthensis* Benson, p. 183, plate 1, figs 9–12; plate 2, fig. 1.

Age. LO: latest Maastrichtian.

Remarks. When Sarjeant (1985a, p. 141, 142) emended the diagnosis of *Disphaerogena carposphaeropsis*, he considered *Cyclapophysis monmouthensis* to be a taxonomic junior synonym of the species.

Genus *Eatonicysta* Stover & Evitt 1978
Type. Morgenroth 1966a, plate 3, fig. 11, as *Cannosphaeropsis ursulae.*

1978 *Eatonicysta* Stover & Evitt, p. 41.

Synopsis. Gonyaulacacean (leptodinioid) cysts that are chorate, with a spheroidal central body. Holocavate. Central body bearing 17 to 23 hollow or solid, fibroid mesotabular processes, which are distally connected by a fenestrate to reticulate to irregular open-mesh, net-like ectophragm. Archaeopyle apical, with formula $A_{(1–4')}$, operculum free.

Description. The holocavate cyst has an autophragm bearing mesotabular processes with expanded distal extremities that merge to form a perforate membranous to reticulate to trabeculate ectophragm. The size of the mesh or perforations shows considerable variation. A leptodinioid tabulation of 3–4′, 6′′′′, 0–6c, 5′′′, 1′′′′, 0s is indicated by the processes. Based on process size, plate 1′′ would be wider than 6′′.

Remarks. *Eatonicysta* is characterised by a membranous ectophragm that may be reticulate or broken down to form a trabeculate network.

***Eatonicysta furensis* (Heilmann-Clausen in Heilmann-Clausen & Costa 1989) Stover & Williams 1995**
(Plate 6, fig. 13)

1989 *Eatonicysta ursulae* subsp. *furensis* Heilmann-Clausen in Heilmann-Clausen & Costa, p. 466, plate 11, figs 3, 5, 7.
1995 *Eatonicysta furensis* (Heilmann-Clausen in Heilmann-Clausen & Costa) – Stover & Williams, p. 104.

Age. LO: late Ypresian.

Remarks. *Eatonicysta furensis* has much shorter, usually broader, funnel-shaped processes than *Eatonicysta ursulae*. Also, the processes grade imperceptibly into the ectophragm, which is divided into areas reflecting the individual plates, rather than forming a continuous network.

***Eatonicysta ursulae* (Morgenroth 1966a) Stover & Evitt 1978**
(Plate 6, fig. 14)

1966a *Eatonicysta ursulae* Morgenroth, p. 20, plate 3, figs 11, 12.
1966a *Membranilarnacia reticulata* Williams & Downie, p. 220, 221, plate 24, figs 4, 6; text-fig. 59.
1967 *Membranilarnacia dictyophora* Agelopoulos, p. 49, 50, plate 12, figs 3, 4, 6.
1969 *Membranilarnacia ursulae* (Morgenroth) – de Coninck, p. 43.
1978 *Eatonicysta ursulae* (Morgenroth) – Stover & Evitt, p. 41.

Age. LO: earliest Lutetian.

Remarks. Williams & Downie (1966a) recorded two variants of *Eatonicysta ursulae* (as *Membranilarnacia reticulata*, a synonym of *Eatonicysta ursulae*) from the Ypresian London Clay from southern England. One lacked cingular processes, the other had four cingular processes. Whether or not this variation is stratigraphically significant remains to be confirmed.

Genus *Enneadocysta* Stover & Williams 1995
Type. Gerlach 1961, plate 28, fig. 14, as *Baltisphaeridium pectiniforme.*

1994 *Enneadocysta* Stover & Williams in Bujak, p. 119; name not validly published.
1995 *Enneadocysta* Stover & Williams, p. 108, 109.
2007 *Enneadocysta* Stover & Williams – emend. Fensome *et al.*, p. 394.

Remarks. We follow the emendation of Fensome *et al.* (2007, p. 394) in our concept for this genus and agree that it is areoligeracean.

***Enneadocysta magna* Fensome *et al.* 2007**
(Plate 7, figs 1, 2)

2007 *Enneadocysta magna* Fensome *et al.*, p. 394, 396, plate 1, figs 1–20; plate 2, figs 1–19; text-figs 5A, B, 6A–E.

Age. LO: latest Rupelian.

Remarks. Labrador Margin specimens of *Enneadocysta magna* can have process clusters on individual plates.

Genus *Eocladopyxis* Morgenroth 1966a
Type. Morgenroth 1966a, plate 3, figs 2, 3, as *Eocladopyxis peniculata*.

1966a *Eocladopyxis* Morgenroth, p. 7.

Remarks. The synopsis provided by Fensome *et al.* (2009, p. 31) takes into account that *Eocladopyxis* is a goniodomacean (pyrodinioid) cyst and identifies all the plates involved in the formation of the archaeopyle.

***Eocladopyxis peniculata* Morgenroth 1966a**
(Plate 7, fig. 3)

1966a *Eocladopyxis peniculata* Morgenroth, p. 7, 8, plate 3, figs 2, 3.

Age. LO: late Ypresian.

Genus *Evittosphaerula* Manum 1979 emend. Damassa 1997
Type. Manum 1979, plate 2, figs 3, 4, as *Evittosphaerula paratabulata*.

1979 *Evittosphaerula* Manum, p. 242, 243.
1997 *Evittosphaerula* Manum – emend. Damassa, p. 161–163.

***Evittosphaerula*? *foraminosa* sp. nov.**
(Plate 6, figs 15–20)

Holotype. Plate 6, figs 19, 20 from a cuttings sample at 2130–2140 m in North Leif I-05, GSC type collection no. 138159, sample YD17600, slide 03, co-ordinates 44.9 × 15.5, England Finder M43/0. Pericyst length 82.5 µm, width 90 µm. The age determined for the sample from which the holotype was recovered is Ypresian.

Etymology. From the Latin *foraminosus*, meaning 'full of holes'.

Description. A species of gonyaulacalean cysts in which only broad strips of membrane representing the sutures are preserved. The tabulation appears to be goniodomaceans, with a five-sided antapical plate reflecting a quinqueform hypocystal tabulation. At the apex, sutural strips come together to form a short apical horn.

Size. Diameter 68–90 µm; four specimens in dorsoventral orientation measured, but excluding the holotype as it is oriented apically–antapically.

Age. LO: Ypresian.

Remarks. This species has a very distinctive structure, represented by strips of membrane reflecting the sutures only; the internal area of each plate is represented by a hole. Thus the species is reminiscent of the late Oligocene to early Miocene species *Evittospaherula paratabulata*, but differs superficially in having an apical horn, an apparently much narrower cingulum, and broader sutural membranes. More fundamentally, one specimen (Plate 6, fig. 18) appears to have a five-sided antapical plate, suggesting a goniodomacean affinity (Fensome *et al.* 1993). The tabulation described by Manum (1979) for *Evittosphaerula paratabulata*, the type of the genus, is clearly gonyaulacacean. As this new species is strikingly similar, albeit perhaps superficially, to Manum's species, and there is not sufficient material to describe its tabulation in full, it is questionably assigned to *Evittosphaerula*. The new species is also strikingly similar to both *Hapsocysta susanae*, described by Duxbury (2002) from the Albian of the central North Sea, and *Chaenosphaerula magnifica*, described by Damassa (1997) from the late Oligocene of the Norwegian Sea. However, the tabulation of both those species is clearly sexiform, and neither has horns.

Genus *Fibrocysta* Stover & Evitt 1978
Type. Cookson & Eisenack 1965b, plate 16, fig. 8, as *Cordosphaeridium bipolare.*

1978 *Fibrocysta* Stover & Evitt, p. 155.

Synopsis. Gonyaulacacean (cribroperidinioid) cysts that are chorate, with a longitudinally elongate ovoidal central body, with a protrusion at the apical and antapical poles. Acavate or cornucavate, with a fibrous wall. Processes numerous, nontabular to indistinctly tabular; they are hollow and fibrous or solid and generally of uniform size. Archaeopyle precingular, with formula $P_{3''}$, operculum free.

Remarks. In wall structure and archaeopyle type, *Fibrocysta* is very similar to *Turbiosphaera*. However, processes in *Turbiosphaera* are wider, especially apically and antapically, and in *Turbiosphaera*, the cingulum is marked by a membrane. The remarkable similarities between the two genera suggest that *Fibrocysta*, like *Turbiosphaera*, has a cribroperidinioid tabulation.

***Fibrocysta bipolaris* (Cookson & Eisenack 1965a) Stover & Evitt 1978**
(Plate 7, fig. 4)

1965a *Cordosphaeridium bipolare* Cookson & Eisenack, p. 135, plate 16, figs 7, 8.
1969 *Lanternosphaeridium bipolare* (Cookson & Eisenack) – de Coninck, p. 38.
1969c *Amphorosphaeridium bipolare* (Cookson & Eisenack) – Davey, p. 35.
1978 *Fibrocysta bipolaris* (Cookson & Eisenack) – Stover & Evitt, p. 155.

Age. Local acme early Ypresian.

Remarks. The cingulum of the holotype of *Fibrocysta bipolaris* (Cookson & Eisenack 1965a, plate 16, fig. 8) appears to be delineated by a single row of processes.

Genus *Gillinia* Cookson & Eisenack 1960a
Type. Cookson & Eisenack 1960a, plate 3, fig. 4, as *Gillinia hymenophora.*

1960a *Gillinia* Cookson & Eisenack, p. 11, 12.

Synopsis. Small, proximate, slightly elongate cysts with two membranous wings, one on each side of the apical archaeopyle. Tabulation partially delineated by ridges, which commonly define the cingulum and a sulcal area that is considerably broader posteriorly.

Remarks. Following Fensome *et al.* (1993, p. 73), *Gillinia* probably has a cladopyxiacean tabulation.

***Gillinia hymenophora* Cookson & Eisenack 1960a**
(Plate 7, fig. 12)

1960a *Gillinia hymenophora* Cookson & Eisenack, p. 12, plate 3, figs 4–6; text-fig. 5.

Age. LO: late Campanian.

Genus *Ginginodinium* Cookson & Eisenack 1960a
Type. Cookson & Eisenack 1960a, plate 2, fig. 9, as *Ginginodinium spinulosum.*

1960a *Ginginodinium* Cookson & Eisenack, p. 7.

Remarks. In their emendation of *Ginginodinium*, Lentin & Williams (1976, p. 95, 96) noted that the archaeopyle is compound, involving the three anterior intercalary plates and three of the precingular plates (3′′–5′′). However, the archaeopyle may be formed from loss of only the three anterior intercalary plates. There may also be a series of successive stages, until all three intercalaries are lost and three of the precingulars remain attached to the main cyst solely along the cingular margin. This variability in archaeopyle type often makes assignment of species to the genus difficult.

***Ginginodinium*? *flexidentatum* sp. nov.**
(Plate 7, figs 5–11)

Holotype. Plate 7, fig. 11, from a cuttings sample at 1815–1825 m in Bjarni O-82, GSC type collection no. 138070, sample P39715, slide 01, co-ordinates 3.6 × 102.8, England Finder C32/4. Pericyst length 84 µm, width 73 µm, endocyst length 61 µm, width 67 µm, length of processes up to 2.5 µm. The age determined for the sample from which the holotype was recovered is early Ypresian.

Etymology. The epithet is from the Latin *flexibilis,* meaning bendable and *dentatus*, meaning toothed or pointed.

Diagnosis. A species of *Ginginodinium* with one or more lateral horns or bulges, a flexible folded wall, and no clearly demarked cingulum. The ornament is variable but typically denticulate.

Description. Pericyst outline pentagonal, with a well-developed apical and two antapical horns, one of which is slightly shorter than the other, and two lateral protuberances. Generally cornucavate but can, in part or whole, be circumcavate. The endocyst is pentagonal. Pericyst ornamentation varies from finely perforate to verrucate to bearing processes. The archaeopyle involves the loss of the 2a plate, which remains attached to the 4´´ plate, and sometimes the partial detachment of the 1a and 3a plates. One margin of the cingulum is commonly indicated by a fold.

Size. Pericyst length 61–87 µm (mean 73 µm), pericyst width 56–73 µm (mean 63 µm), endocyst length 43–61 µm (mean 51 µm), width 49– 67 µm (mean 53 µm), process length up to about 2.5 µm.

Age. LO: late Ypresian.

Remarks. The shapes of the pericyst and endocyst are relatively stable in *Ginginodinium*? *flexidentatum*, but there are differences between specimens in degree of cavation, which can range from cornucavate to narrowly circumcavate. There are also variations in the shape of the horns, especially the apical: this is generally rounded distally but may be acuminate. The antapical horns are acuminate to rounded distally; the lateral horns are primarily just protuberances. Pericyst ornamentation is variable, sometimes even on the same specimen. The periphragm can be perforated and ornamented with small verrucae and processes, the latter of variable length. Processes are slender and distally bifid. This species is included in *Ginginodinium* only provisionally because of the uncertainty over the archaeopyle.

Genus *Glaphyrocysta* Stover & Evitt 1978
Type. Cookson 1965, plate 11, fig. 4, as *Cyclonephelium retiintextum*.

1978 *Glaphyrocysta* Stover & Evitt, p. 49, 50.

Remarks. The generic concept of *Glaphyrocysta*, as expressed in the emendation by Fensome *et al.* (2009, p. 32), is followed here. The genus is sometimes abundant in middle Eocene sections in Labrador Margin wells.

***Glaphyrocysta divaricata* (Williams & Downie 1966a) Stover & Evitt 1978**
(Plate 7, figs 15, 16)

1966a *Cyclonephelium divaricatum* Williams & Downie, p. 223, 224, plate 25, fig. 1; text-fig. 60.
1978 *Glaphyrocysta divaricata* (Williams & Downie) – Stover & Evitt, p. 50.

Age. LO: earliest Lutetian. See also Remarks.

Remarks. A species of *Glaphyrocysta* with numerous processes variously interconnected along their length, but with a preponderance of distal free ends. In *Glaphyrocysta divaricata*, unlike in *Glaphyrocysta ordinata* and *Glaphyrocysta retiintexta*, the processes do not form distinct complexes. Although this taxon has a Lutetian LO, it is most abundant in the Paleocene and is often very common to dominant in assemblages from that epoch.

***Glaphyrocysta exuberans* (Deflandre & Cookson 1955 ex Eaton 1976) Stover & Evitt 1978**
(Plate 7, fig. 14)

1955 *Cyclonephelium exuberans* Deflandre & Cookson, p. 255; name not validly published.
1976 *Cyclonephelium exuberans* Deflandre & Cookson ex Eaton, p. 255, 256.
1978 *Glaphyrocysta exuberans* (Deflandre & Cookson ex Eaton) – Stover & Evitt, p. 50.

Age. LO: Priabonian.

Remarks. *Glaphyrocysta exuberans* has a well-developed, often perforate, marginate ectophragm, supported by solid, slender processes.

***Glaphyrocysta retiintexta* (Cookson 1965) Stover & Evitt 1978**
(Plate 7, fig. 17)

1965 *Cyclonephelium retiintextum* Cookson, p. 88, plate 11, fig. 4.
1978 *Glaphyrocysta retiintexta* (Cookson) – Stover & Evitt, p. 50.

Age. LO: Priabonian.

Remarks. *Glaphyrocysta retiintexta* shows an ambital development of distal trabecula but has minimal membrane development. The general absence of membranes and the distal connections between plate complexes distinguish this species from *Glaphyrocysta intricata*. Fensome *et al.* (2009, p. 34) noted that the morphology of *Glaphyrocysta retiintexta* was very similar to that shown in the drawing of the holotype of *Glaphyrocysta pastielsii* (Deflandre & Cookson 1955) Stover & Evitt 1978 by Pastiels (1948, plate 5, fig. 15). But Fensome *et al.* (2009) also stated that photographs of the holotype of *Glaphyrocysta pastielsii* appeared to possess a morphology more like that of *Glaphyrocysta divaricata*. Accordingly they recommended restricting the name *Glaphyrocysta pastielsii* to the holotype, a proposal followed here.

Glaphyrocysta texta **(Bujak 1976) Stover & Evitt 1978**
(Plate 8, fig. 1)

1976 *Cyclonephelium texta* Bujak, p. 110, plate 3, figs 6–11; text-fig. 3G, H.
1978 *Glaphyrocysta texta* (Bujak) – Stover & Evitt, p. 50.

Age. LO: Priabonian.

Remarks. *Glaphyrocysta texta* has distinctive process complexes on most of the pre- and postcingular plates, and apparently one broader complex on the single antapical plate. The contabular complexes consist of slender intratabular processes, distally united to form clypeate platforms that have ragged margins. The 3′′ and 3′′′ plates sometimes have a single process rather than a process complex. Adjacent process complexes are connected distally by trabecula.

Glaphyrocysta vicina **(Eaton 1976) Stover & Evitt 1978**
(Plate 8, fig. 2)

1976 *Cyclonephelium vicinum* Eaton, p. 260, 261, plate 8, figs 4, 5; text-fig. 13.
1978 *Glaphyrocysta vicina* (Eaton) – Stover & Evitt, p. 50.

Age. LO: Lutetian.

Remarks. *Glaphyrocysta vicina* has a marginal, perforate pericoel, with the periphragm remaining close to the endophragm. Both features are unusual in species of *Glaphyrocysta*. Species of *Membranophoridium* lack processes supporting the periphragm.

Genus *Habibacysta* Head *et al.* 1989
Type. Head *et al.* 1989, plate 4, figs 1, 2, 5, 6, as *Habibacysta tectata*.

1989 *Habibacysta* Head *et al.*, p. 457, 458.

Synopsis. Proximate spheroidal gonyaulacean cysts. Atabulate. Autophragm bearing short columns that distally are sometimes united by an entire, perforate or reticulate layer. Archaeopyle precingular, with formula $P_{3''}$, operculum free.

Remarks. Head (1994, text-fig. 3) showed how the nature of the autophragm differentiates *Habibacysta* from *Bitectatodinium*, *Filisphaera* and *Tectatodinium*. All four genera are proximate, atabulate gonyaulacacean cysts with precingular archaeopyles.

Habibacysta tectata **Head *et al.* 1989**
(Plate 7, fig. 13)

1989 *Habibacysta tectata* Head *et al.*, p. 458, plate 4, figs 1–6, 9, 10.

Age. LO: earliest Zanclean.

Genus *Hapsocysta* Davey 1979
Type. Eisenack & Cookson 1960, plate 3, fig. 6, as *Cannosphaeropsis peridictya.*

1979 *Hapsocysta* Davey, p. 556.

Synopsis. A chorate to camocavate gonyaulacacean (gonyaulacoidean) cyst, with a subrounded to ovoidal central body, which is surrounded by a periphragm that may be trabeculate, forming an open network, or filled by a perforate membrane. Tabulation indicated by the trabecula, which on membranous taxa occur as ridges. Archaeopyle precingular, with formula $P_{3''}$, operculum free.

Remarks. Fensome *et al.* (1993, p. 89) considered *Hapsocysta* to have a cribroperidinioid tabulation. However, Nøhr-Hansen (1993, p. 71, 72) showed that the taxon, which he named *Hapsocysta*? *benteae*, had gonyaulacoidean tabulation. Nøhr-Hansen (1993) provisionally included the species in *Hapsocysta*, because of the presence of the thin-walled periphragm.

Hapsocysta*? *benteae **Nøhr-Hansen 1993**
(Plate 8, fig. 12)

1993 *Hapsocysta*? *benteae* Nøhr-Hansen, p. 71, 72, plate 25, figs 11, 12; text-figs 10a, b, 11a, b.

Age. LO: Cenomanian.

Genus *Heteraulacacysta* Drugg & Loeblich Jr. 1967

Type. Drugg & Loeblich Jr. 1967, plate 1, fig. 8a–c, as *Heteraulacacysta campanula*.

1967 *Heteraulacacysta* Drugg & Loeblich Jr., p. 183.

Remarks. The synopsis for *Heteraulacacysta* by Fensome *et al.* (2009, p. 35) is followed.

***Heteraulacacysta porosa* Bujak in Bujak *et al.* 1980**
(Plate 8, fig. 16)

1980 *Heteraulacacysta porosa* Bujak in Bujak *et al.*, p. 62, plate 15, figs 10–13; text-fig. 14B, C.

Age. LO: Priabonian.

Remarks. Considerable uncertainty has prevailed over the distinction between *Heteraulacacysta leptalea* Eaton 1976 and *Heteraulacacysta porosa*. In his diagnosis for *Heteraulacacysta leptalea*, Eaton (1976, p. 305) stated: "Circular fenestrations frequently developed in the proximal area of the cingular crests, along with fine elongate fenestrations aligned at right-angles to the margin of the cyst body." Under 'Remarks', Eaton commented that small perforations occurred in the periphragm, comparable to those in the proximal area of the cingular crests, and commonly gave a punctate appearance to the wall. In the succeeding sentence, Eaton (1976, p. 305) differentiated *Heteraulacacysta leptalea* from *Heteraulacacysta campanula* on the basis of its "…frequently punctuate rather than positively ornamented surface to the cyst body, and in exhibiting circular and elongate fenestrations in the cingular crests."

Bujak in Bujak *et al.* (1980, p. 62) differentiated *Heteraulacacysta porosa* "… from all other described species of *Heteraulacacysta* by its perforate periphragm." The illustrations of the holotype and another specimen of *Heteraulacacysta leptalea* in Eaton (1976, plate 21, figs 1, 2) clearly show perforations. Consequently, the only consistent difference appears to be the presence of elongate perforations on the cingular crests in *Heteraulacacysta leptalea*. We do not know, however, whether this feature is stratigraphically significant.

Genus *Heterosphaeridium* Cookson & Eisenack 1968

Type. Cookson & Eisenack 1968, text-fig. 4H, as *Heterosphaeridium conjunctum*.

1968 *Heterosphaeridium* Cookson & Eisenack, p 115.

Remarks. In their synopsis for *Heterosphaeridium*, Fensome *et al.* (2009, p. 35) recognised that it is an areoligeracean cyst with a spheroidal to broadly ovoidal central body. Yun Hyesu (1981, p. 45, 46) provided an emended diagnosis that broadened the circumscription mainly to include forms with hollow, open processes as well as solid processes. Some of the specimens of *Heterosphaeridium difficile* observed in the present study have processes that are perforated or circular (annulate) process complexes that can be connected at various locations along their length.

***Heterosphaeridium bellii* Radmacher *et al.* 2014**
(Plate 8, figs 3, 4)

2014 *Heterosphaeridium bellii* Radmacher *et al.*, p. 31–33, plate 1, figs 1–9.

Age. LO: late Campanian.

Remarks. *Heterosphaeridium bellii* differs from *Heterosphaeridium heteracanthum* in having dolabrate processes that are not branching. The processes in *Heterosphaeridium bellii* may be connected proximally but are never branched along their length. Radmacher *et al.* (2014) considered the LO of *Heterosphaeridium bellii* to be late Campanian to early Maastrichtian in the southwestern Barents Sea.

***Heterosphaeridium difficile* (Manum & Cookson 1964) Ioannides 1986**
(Plate 8, fig. 8)

1964 *Hystrichosphaeridium difficile* Manum & Cookson, p. 12–14, plate 3, figs 1–3, 7.
1986 *Heterosphaeridium difficile* (Manum & Cookson) – Ioannides, p. 24.

Age. LO: early Santonian.

Remarks. Labrador Margin specimens of *Heterosphaeridium difficile* show extreme variation in the nature of the processes. Some are perforate along their length or arched so that the process walls merge distally. Others, as noted under 'Remarks' for the genus, have process complexes on the pre- and postcingular plates that are connected by circular proximal membranes, as in *Systematophora*. In the latter specimens, the cingular plates have linear process complexes. In some specimens, the apical plates commonly show a characteristic X-shaped crest as observed by M. Pearce (personal communication 2015) and also appear to have annulate process complexes. The antapical plate is marked by an annulate complex that is broader than those on the pre- and postcingular plates. The wall of the central body is microreticulate.

Genus *Histiocysta* Davey 1969a
Type. Davey 1969a, plate 1, fig. 5, text-fig. 14A, B, as *Histiocysta palla.*

1969a *Histiocysta* Davey, p. 138.

Remarks. This genus is similar to *Corrudinium* in its shape and ornamentation, but tends to be smaller and has an apical archaeopyle.

***Histiocysta palla* Davey 1969a**
(Plate 7, figs 18–20)

1969a *Histiocysta palla* Davey, p. 138–140, plate 1, figs 5, 6; text-fig. 14A, B.

Age. LO: late Campanian.

Genus *Homotryblium* Davey & Williams 1966a
Type. Davey & Williams 1966a, plate 12, fig. 5, as *Homotryblium tenuispinosum.*

1966a *Homotryblium* Davey & Williams, p. 100.

Remarks. The synopsis provided by Fensome *et al.* (2009, p. 35, 36) covers all the key morphological attributes of *Homotryblium*.

***Homotryblium abbreviatum* Eaton 1976**
(Plate 8, figs 9, 10)

1976 *Homotryblium abbreviatum* Eaton, p. 267, 268, plate 10, figs 2–4.

Age. LO: late Ypresian. Not plotted.

Remarks. As in the type material, the Labrador Margin specimens of *Homotryblium abbreviatum* have short and wide processes, but the surface ornamentation of the central body can be smooth as well as granulate. This species is not as common as *Homotryblium tenuispinosum* in the samples studied here.

***Homotryblium tenuispinosum* Davey & Williams 1966a**
(Plate 8, figs 5–7)

1966a *Homotryblium tenuispinosum* Davey & Williams, p. 101, 102, plate 4, fig. 11; plate 12, figs 1, 5, 7; text-fig. 21.
1966a *Homotryblium pallidum* Davey & Williams, p. 102, 103, plate 12, figs 4, 6; text-fig. 22.

Age. LO: Bartonian; peak: latest Ypresian.

Genus *Hystrichokolpoma* Klumpp 1953
Type. Klumpp 1953, plate 17, figs 3, 5a, as *Hystrichokolpoma cinctum.*

1953 *Hystrichokolpoma* Klumpp, p. 388.

Remarks. Fensome *et al.* (2009, p. 36) provided a detailed synopsis for *Hystrichokolpoma,* which stipulated among other morphologic attributes, that the genus must have cingular processes.

***Hystrichokolpoma cinctum* Klumpp 1953**
(Plate 8, fig. 11)

1953 *Hystrichokolpoma cinctum* Klumpp, p. 389, plate 17, figs 3, 4, 5a–d.

Age. LO: Burdigalean according to Williams *et al.* (2004), but we consider that the age range of this species needs to be better constrained. Not plotted.

Remarks. A species of *Hystrichokolpoma* in which the pre- and postcingular processes fill plates and have small tubular extensions. There are generally two processes per cingular paraplate.

***Hystrichokolpoma globulus* Michoux 1985**
(Plate 8, figs 13–15)

1985 *Hystrichokolpoma globulus* Michoux, p. 143, plate 1, figs 1–4, 12; text-fig. 2A, B.

Age. LO: late Ypresian. Not plotted.

Remarks. Michoux (1985, p. 143) compared *Hystrichokolpoma globulus* to *Hystrichokolpoma cinctum* Klumpp 1953, from which it differs by having a much shorter antapical process relative to the length of the cyst and pre- and postcingular processes that do not branch into tubules distally. Also, the cingular and sulcal processes are conical and there are three to five on each cingular plate. The Labrador Margin specimens of *Hystrichokolpoma globulus* differ from the type material in not having conical cingular plates and in there being only three or less on each plate.

Genus *Hystrichosphaeridium* Deflandre 1937
Type. Ehrenberg 1838, plate 1, fig. 16, as *Xanthidium tubiferum*.

1937 *Hystrichosphaeridium* Deflandre, p. 68.

Remarks. We concur with the synopsis provided by Fensome *et al.* (2009, p. 38) except to note that individual processes proximally do not cover most of the underlying plate and that the cingular and sulcal processes are slender. The apical processes also tend to be slender, especially the first and fourth. Variation in process dimensions in *Hystrichosphaeridium* does not approach the strong variation that is distinctive of *Hystrichokolpoma*.

***Hystrichosphaeridium quadratum* sp. nov.**
(Plate 8, figs 17–19)

Holotype. Plate 8, figs 17, 18, from a cuttings sample at 2770–2780 m in Gilbert F-53, GSC type collection no. 137988, sample P39505, slide 01, co-ordinates 11.3 × 99.2, England Finder L29/3. Diameter of central body 44 µm, length of processes up to about 37 µm. The age determined for the sample from which the holotype was recovered is early Ypresian.

Etymology. From the Latin *quadratus* (four-cornered), in reference to the rectangular distal endings of the processes in this species.

Diagnosis. A species of *Hystrichosphaeridium* in which the distal process endings are slightly flared and polygonal, generally rectangular and commonly perforate. The process bases are mesotabular and circular.

Size. Width of central body 36−48 µm, length of central body (when operculum in place) 46−63 µm; processes up to 39 µm long. Six specimens measured.

Age. LO: Selandian. Not plotted.

Remarks. This species differs from *Hystrichosphaeridium tubiferum* in having rectangular endings to its processes. It also resembles *Hystrichokolpoma proprium*, but the holotype of that species has rounded polygonal process bases that largely fill the plate (see Fauconnier & Masure 2004, plate 40, figs 1–3), as is typical of the genus *Hystrichokolpoma*. *Hystrichosphaeridium salpingophorum* differs in lacking perforations in the distal endings of the processes.

***Hystrichosphaeridium tubiferum* (Ehrenberg 1838) Deflandre 1937**
(Plate 8, fig. 20)

1838 *Xanthidium tubiferum* Ehrenberg, plate 1, fig. 16.
1937 *Hystrichosphaeridium tubiferum* (Ehrenberg) – Deflandre, p. 68.

Age. LO: Lutetian.

Genus *Hystrichosphaeropsis* Deflandre 1935
Type. Deflandre 1935, plate 8, fig. 11, as *Hystrichosphaeropsis ovum*.

1935 *Hystrichosphaeropsis* Deflandre, p. 232.
1937 *Hystrichosphaera* subgenus *Hystrichosphaeropsis* (Deflandre) Deflandre, p. 67.

Remarks. Eisenack (1963b, p. 118) retained *Hystrichosphaeropsis* at generic rank. Fensome *et al.* (2009, p. 38) provided a synopsis that allows for the inclusion of circumcavate forms in *Hystrichosphaeropsis*.

***Hystrichosphaeropsis perforata* Schiøler 1993**
(Plate 9, fig. 4)

1993 *Hystrichosphaeropsis perforata* Schiøler, p. 106, plate 2, figs 4–8; text-fig. 3.

Age. LO: late Maastrichtian.

***Hystrichosphaeropsis quasicribrata* (Wetzel 1961) Gocht 1976**
(Plate 9, fig. 12)

1961 *Triblastula quasicribrata* Wetzel, p. 340, plate 2, fig. 3.
1976 *Hystrichosphaeropsis quasicribrata* (Wetzel) – Gocht, p. 322.

Age. LO: late Maastrichtian.

Genus *Hystrichostrogylon* Agelopoulos 1964
Type. Agelopoulos 1967, text-figs 1, 2, as *Hystrichostrogylon membraniphorum*.

1964 *Hystrichostrogylon* Agelopoulos, p. 673, 674.

***Hystrichostrogylon digitus* sp. nov.**
(Plate 9, figs 1–3)

Holotype. Plate 9, fig. 3, from a cuttings sample at 2435−2445 m in Rut H-11, GSC type collection no. 137952, sample P39375, slide 01, co-ordinates 15.8 × 105.0, England Finder Q48/1. Length of central body (excluding cavation) 45 µm, width of central body (excluding cavation) 38 µm; overall length of cyst 73 µm, overall width of cyst 72 µm. The age determined for the sample from which the holotype was recovered is Lutetian Priabonian.

Etymology. From the Latin *digitus* (finger), in reference to the long extensions at the process endings. The epithet is a noun in apposition.

Diagnosis. A species of *Hystrichostrogylon* in which the bi- and trifurcations of the processes constitute long, fine, cylindrical distal branches generally one-third to one half the length of the process stem. The distal branches tend to be perpendicular to the process stem.

Size. Length of central body (excluding cavation) 40−45 µm, width of central body (excluding cavation) 33−40 µm; overall length of cyst 73−82 µm, overall width of cyst 66−79 µm; 3 specimens measured.

Age. LO: Bartonian−Priabonian. Not plotted.

Remarks. This species differs from other species of *Hystrichostrogylon* in having remarkably long, fine branches at the ends of the processes.

Genus *Impagidinium* Stover & Evitt 1978
Type. Cookson & Eisenack 1965b, plate 12, figs 5–6, as *Leptodinium dispertitum.*

1978 *Impagidinium* Stover & Evitt, p. 165, 166.

Synopsis. Proximate gonyaulacaceans with the S-type ventral organisation; in dorso-ventral view they are subspheroidal to ellipsoidal. Tabulation clearly defined by sutural septa or thickenings, although sometimes these features are missing between plates bordering the sulcus or the cingulum. Sometimes the septum or thickening between the 3′ and 4′ plates is reduced or absent. Cingulum and sulcus clearly defined. Archaeopyle precingular, with formula $P_{3''}$, operculum free.

Remarks. The inclusion of *Impagidinium* in the subfamily Gonyaulacoideae by Fensome *et al.* (1993, p. 92) reflects an appreciation of the commonly triangular shape of the 6′′ plate. If a separate reflected plate, the 4′ is generally not in contact with the anterior sulcal plate.

***Impagidinium victorianum* (Cookson & Eisenack 1965b) Stover & Evitt 1978**
(Plate 9, figs 9–11, 13, 14)

1965b *Leptodinium victorianum* Cookson & Eisenack, p. 123, plate 12, figs 8, 9.
1978 *Impagidinium victorianum* (Cookson & Eisenack) – Stover & Evitt, p. 166.

Age. LO: intra late Maastrichtian.

Remarks. Cookson & Eisenack (1965b, p. 123) noted that *Impagidinium victorianum* described from the Late Eocene differs from *Impagidinium dispertitum* in its "larger size, spherical form, and the constant absence of the transverse dividing between the upper two plates of the ventral field…." Where the anterior ventral side of the specimens in this study can be observed, *Impagidinium victorianum* also lacks the suture between what are purportedly the upper two plates of the sulcus. However, Labrador Sea specimens of *Impagidinium victorianum* are generally smaller than the type material, which ranges from 80 to 120 µm in length and 80 to 123 µm in width. In contrast, the Labrador Sea specimens vary from 60 to 71 µm in length and 56 to 80 µm in width. Distal and proximal ends of the cingulum are offset by approximately a cingulum width. The sutural features may be ridges or septa but are consistent within an individual specimen. Maximum height of the sutural ridges or septa is 5 µm. In some specimens the septa are perforated, the perforations aligned in single rows. Whether those forms with perforations should be included in a new species is dependent upon finding more specimens.

An intriguing aspect of the occurrence of *Impagidinium victorianum* in the Labrador Sea is that its LO is consistently within the Maastrichtian. This may reflect changing environments from deep-water to shallower conditions, but this does not explain the absence of the species in deeper water parts of the Palaeogene. One explanation advanced by M. Pearce (personal communication 2015) is that *Impagidinium victorianum* is a warmer-water species that migrated south during cooler climatic conditions. If so, it is odd that it did not migrate back during Paleocene warming, unless opening of the Labrador–Baffin Seaway had already generated a proto-Labrador Current.

Genus *Impletosphaeridium* Morgenroth 1966a
Type. Morgenroth 1966a, plate 10, fig. 5, as *Impletosphaeridium transfodum*.

1966a *Impletosphaeridium* Morgenroth, p. 32.
1971 *Ciliosphaeridium* Grigorovich, p. 94.
1984c *Laticavodinium* Wilson & Sarjeant in Sarjeant, p. 127.

Remarks. In their remarks on *Impletosphaeridium*, Fensome *et al.* (2009, p. 38) agreed with Islam (1993, p. 84, 85) that the archaeopyle of the paratype of *Impletosphaeridium transfodum*, the 'type species', is probably apical. But the morphology of the holotype remains uncertain. To quote Fensome *et al.* (2009, p. 38): "This genus is useful, if of dubious status, since it serves as a repository for chorate forms whose general morphology accords with a gonyaulacacean dinoflagellate affinity, but whose archaeopyle is uncertain."

***Impletosphaeridium apodastum* sp. nov.**
(Plate 9, figs 5–8)

Holotype. Plate 9, fig. 5, from a cuttings sample at 4565–4575 m in Hekja O-71, GSC type collection no. 137903, sample P18737, slide 01, co-ordinates 13.3 × 108.0, England Finder N37/3. Central body length 30 µm, width 26 µm; length of processes up to 17 µm, width less than 1 µm. The age determined for the sample from which the holotype was recovered is late Danian.

Etymology. The epithet is from the Greek *apodastos*, meaning separated or apportioned, in reference to the bifurcations of the processes distally.

Diagnosis. A species of *Impletosphaeridium* with solid delicate processes that divide distally into two relatively long branches. The branches are bifurcate at the tips and usually curve back towards the central body.

Description. This species has a rounded, small central body that is granulate. Distally, the solid delicate processes divide into two, relatively long branches, each of which is bifurcate at its tip. These distal branches usually curve back towards the central body. The initial bifurcations are generally one-quarter to one-third as long as the main stem of the process but can be as much as a half or as little as a quarter the length. There are about 50 processes per specimen.

Size. Central body length 20–33 µm, width 18–27 µm, length of processes 10–18 µm; six specimens measured.

Age. LO: Selandian.

Remarks. *Impletosphaeridium apodastum* is characterised by the high number of processes and their distinctive distal extremities, which branch. Tips of the two branches are usually bifid. Occasional processes have three branches. Because of the unknown nature of the archaeopyle, this species is included in *Impletosphaeridium*.

Genus *Isabelidinium* Lentin & Williams 1977b
Type. Cookson & Eisenack 1958, plate 4, fig. 10, as *Deflandrea korojonensis*.

1976 *Isabelia* Lentin & Williams, p. 56 (name illegitimate).
1977b *Isabelidinium* Lentin & Williams, p. 167.
2009 *Isabelidinium* Lentin & Williams – emend. Fensome *et al.*, p. 39.

Remarks. In recent decades, there has been much debate about the definition of *Isabelidinium* and similar genera such as *Manumiella* and *Chatangiella*, all of which have an isodeltaform, isothetaform and/or iso-omegaform 2a plate whose partial or complete detachment forms the archaeopyle. Species now included in *Chatangiella* and *Isabelidinium* can have an isodelataform, isothetaform or iso-omegaform 2a plate, but *Manumiella* almost always has an isodeltaform 2a plate. Much confusion remains regarding generic circumscriptions, but a resolution as to how these should be dealt with is beyond the scope of the present study. In our view, generic distinctions should be based mainly on variations in the shape and dimensions of the hexa 2a plate and secondarily on other expressions of tabulation such as the cingulum and on the ornamentation.

Chatangiella is clearly distinguished from *Isabelidinium* by its partite cingulum. Fensome *et al.* (2009) emended *Manumiella*, restricting it to forms with one symmetrically disposed antapical prominence. However, the antapex of the holotype of the type of the genus, *Manumiella* (originally *Broomea*) *seelandica* (Lange 1969, plate 3, fig. 3), is partly obscured so that its precise morphology cannot be determined; and the paratype (Lange 1969, plate 2, fig. 10) clearly has two protuberances. Thorn *et al.* (2009) emended the diagnosis of *Manumiella* to allow for inclusion of a mesophragm, which we would consider a non-diagnostic feature at generic rank. However, these authors did indicate that *Manumiella* was distinctive in being circumcavate, with *Isabelidinium* being bicavate. For further comparisons, see under *Alterbidinium*.

***Isabelidinium cooksoniae* (Alberti 1959) Lentin & Williams 1977b**

1959 *Deflandrea cooksoniae* Alberti, p. 97, plate 9, figs 1–6.
1961b *Isabelidinium belfastense* Cookson & Eisenack, p. 71, plate 11, figs 4–6.
1967 *Australiella cooksoniae* (Alberti) – Vozzhennikova, p. 132.
1976 *Isabelia cooksoniae* (Alberti) – Lentin & Williams, p. 57.
1976 *Isabelia belfastensis* (Cookson & Eisenack) – Lentin & Williams, p. 57.
1977b *Isabelidinium cooksoniae* (Alberti) – Lentin & Williams, p. 167.
1977b *Isabelidinium belfastense* (Cookson & Eisenack) – Lentin & Williams, p. 167.
1992 *Isabelidinium bujakii* Marheinecke, p. 86, 87, plate 18, figs 1–3; text-fig. 16.

Age. LO: Maastrichtian.

Remarks. See Fensome *et al.* (2009, p. 39) for a discussion of this species.

***Isabelidinium cretaceum* (Cookson 1956) Lentin & Williams 1977b**
(Plate 9, figs 15, 16)

1956 *Deflandrea cretacea* Cookson, p. 184, 185, plate 1, figs 1–4 (only).
1976 *Isabelia cretacea* (Cookson) – Lentin & Williams, p. 57.
1977b *Isabelidinium cretaceum* (Cookson) – Lentin & Williams, p. 167.
1983 *Manumiella*? *cretacea* (Cookson) – Bujak & Davies, p. 161.

Age. LO: Maastrichtian.

Remarks. The holotype of this species (Cookson 1956, plate 1, fig. 1 and Helby *et al.* 1987, fig. 42L) and some of the other specimens illustrated in the protologue (Cookson (1956, plate 1, figs 2–4) are all bicavate, with an endocyst that is broader than long. This bicavation, together with a general rounding of the apical and antapical regions, are considered here to be characteristic for *Isabelidinium cretaceum*. However, the presence of a very short horn on two specimens (Cookson 1956, plate 1, figs 3, 4), neither of which is the holotype, does not exclude their retention in this species. This species is retained in *Isabelidinium* because it is bicavate (see discussion above under *Isabelidinium*).

***Isabelidinium microarmum* (McIntyre 1975) Lentin & Williams 1977b**
(Plate 9, fig. 17)

1975 *Deflandrea microarma* McIntyre, p. 65, plate l, figs 5–8.
1976 *Isabelia microarma* (McIntyre) – Lentin & Williams, p. 58.
1977b *Isabelidinium microarmum* (McIntyre) – Lentin & Williams, p. 168.

Age. LO: early Campanian.

Remarks. The holotype of *Isabelidinium microarmum* (McIntyre 1975, plate 1, figs 5, 6) has a deltaform archaeopyle as do all the other specimens (McIntyre 1975, plate 1, figs 6–8).

Genus *Kiokansium* Stover & Evitt 1978
Type. Tasch *et al.* 1964, plate 3, fig. 8, as *Hystrichosphaeridium unituberculatum*.

1978 *Kiokansium* Stover & Evitt, p. 167.
1979 *Bacchidinium* Davey, p. 555.

Remarks. Characteristic features of *Kiokansium* are the precingular archaeopyle, which is formed from the loss of plates 3′′ and 4′′, and the dirigate to cauliflorate distal terminations of the numerous solid processes.

***Kiokansium williamsii* Singh 1983**

1983 *Kiokansium williamsii* Singh, p. 150, plate 54, figs 3–6.

Age. LO: Cenomanian.

Genus *Kleithriasphaeridium* Davey 1974
Type. Davey 1974, plate 5, figs 1, 2, text-fig. 3, as *Kleithriasphaeridium corrugatum*.

1974 *Kleithriasphaeridium* Davey, p. 55, 56.
1976 *Diversispinosa* Benson, p. 184.

Age. LO: Coniacian.

Remarks. Fensome *et al.* (2009, p. 40) emended the diagnosis of *Kleithriasphaeridium* to include forms with mesotabular, tubular processes that are open or closed distally and "to circumscribe forms with a combination precingular–apical archaeopyle, a type of opening that occurs as an intraspecific variant of some species." These authors also stressed that *Kleithriasphaeridium* does not have fibrous processes, thus differentiating it from *Cordosphaeridium*.

***Kleithriasphaeridium mantellii* (Davey & Williams 1966a) comb. nov.**
(Plate 9, fig. 18)

1966a *Hystrichosphaeridium mantellii* Davey & Williams, p. 66, plate 6, fig. 6.
1973 *Florentinia mantellii* (Davey & Williams) – Davey & Verdier, p. 191.

Age. LO: Coniacian.

Remarks. Davey & Williams (1966a, p. 66) stated that "The periphragm of processes [is] slightly fibrous." On the same page they further noted that "… the periphragm of the central body appears to be fairly heavily granular but on closer examination the granules apparently result from a fine reticulation" and that "An apical archaeopyle appears always to be present." Davey & Verdier (1973, plate 4, figs 1, 3) re-illustrated the holotype of *Kleithriasphaeridium* (as *Florentinia*) *mantellii* and concluded that the archaeopyle is precingular, resulting from the loss of the 3′′ plate. Although the processes may be slightly fibrous, it is not obvious in the photographs. Thus the characteristic feature of the species appears to be the ornamentation of the main body. Fensome & Williams (2005, p. 48) noted that *Florentinia* includes "forms with simple tubular processes such as *Florentinia aculeata* and *Florentinia cooksoniae*, as well as more 'classic' *Florentinia* types, such as *Florentinia laciniata* and *Florentinia ferox*, with more complicated processes." They recommended that taxa with simple tubular processes and precingular rather than combination archaeopyles, such as *Florentinia cooksoniae*, should be transferred to *Kleithriasphaeridium*. Thus the new combination *Kleithriasphaeridium mantellii* is proposed here.

Genus *Laciniadinium* McIntyre 1975
Type. McIntyre 1975, plate 4, figs 12, 13, as *Laciniadinium orbiculatum.*

1975 *Laciniadinium* McIntyre, p. 70.
1984 *Sinocysta* He Chengquan, p. 769, 773.

Synopsis. A proximate peridiniacean (palaeoperidinioidean) cyst that is subspherical to biconical and compressed dorso-laterally; when biconical, single horns are developed at the apical and antapical poles. Acavate. Autophragm smooth or ornamented with granules or echinae. Cingulum indicated by low ridges. Archaeopyle combination intercalary-precingular, with formula $IP_{(1\text{–}3a\ +\ 3\text{–}5'')}$, operculum simple, attached along the anterior margin of the cingulum.

Remarks. *Laciniadinium* differs from *Palaeoperidinium* in having one rather than two antapical horns, and an archaeopyle involving intercalary and precingular plates only.

***Laciniadinium arcticum* (Manum & Cookson 1964) Lentin & Williams 1980**
(Plate 9, figs 19, 20)

1964 *Diconodinium arcticum* Manum & Cookson, p. 18, 19, plate 6, figs 1–4.
1980 *Laciniadinium arcticum* (Manum & Cookson) – Lentin & Williams, p. 41.
1986 *Laciniadinium williamsii* Ioannides, p. 28, plate 10, figs 1–6; plate 11, fig. 5.

Age. LO: late Maastrichtian.

Remarks. In their description of *Laciniadinium* (as *Diconodinium*) *arcticum*, Manum & Cookson (1964) stated that the autophragm was ornamented with minute granules up to 0.5 μm in diameter. The size range of the species was: length 50–73 μm, breadth 32–53 μm. Ioannides (1986) erected the species *Laciniadinium williamsii*, which can have a smooth to finely ornamented autophragm; *Laciniadinium williamsii* varies from 39 to 54 μm in length and 31 to 43 μm in width. Unfortunately, Ioannides (1986) did not compare *Laciniadinium williamsii* to *Laciniadinium arcti-*

cum, although he did differentiate it from *Laciniadinium orbiculatum* McIntyre 1975 and *Laciniadinium biconiculum* McIntyre 1975. The only difference that we can determine for separating *Laciniadinium arcticum* and *Laciniadinium williamsii* is on the size, but this overlaps as demonstrated above. Accordingly, we herein consider *Laciniadinium williamsii* to be a taxonomic junior synonym of *Laciniadinium arcticum*.

Genus *Lentinia* Bujak in Bujak *et al.* 1980
Type. Bujak *et al.* 1980, plate 18, figs 7–9, text-fig. 18A–F, as *Lentinia serrata*.

1980 *Lentinia* Bujak in Bujak *et al.*, p. 69.

Remarks. Fensome *et al.* (2009, p. 42) provided a comprehensive synopsis for *Lentinia* that includes reference to the large 2a isodeltaform archaeopyle, which dominates the dorsal epicystal area of the pericyst.

***Lentinia serrata* Bujak in Bujak *et al.* 1980**
(Plate 10, fig. 9)

1980 *Lentinia serrata* Bujak in Bujak *et al.*, p. 71, 72, plate 18, figs 7–12; text-figs 18A–F, 19.

Age. LO: latest Priabonian.

Genus *Licracysta* Fensome *et al.* 2007
Type. Fensome *et al.* 2007, plate 4, figs 9–12, as *Licracysta corymbus*.

2007 *Licracysta* Fensome *et al.*, p. 400, 402.

Remarks. *Licracysta* is an areoligeracean cyst with nontabular to penitabular processes, many dolabrate to moderately licrate, that are absent from the dorsoventral region. In *Glaphyrocysta*, the processes are not licrate or dolobrate distally. Also, processes tend to be longer relative to the size of the central body than in *Licracysta*. A synopsis for *Licracysta* is provided by Fensome *et al.* (2009, p. 42).

***Licracysta corymbus* Fensome *et al.* 2007**
(Plate 10, fig. 16)

2007 *Licracysta corymbus* Fensome *et al.*, p. 402, 404, 406, 408; plate 4, figs 5, 6, 9–20; plate 5, figs 1–8, 12, 16, 20.

Age. LO: Rupelian.

***Licracysta*? *semicirculata* (Morgenroth 1966b) Fensome *et al.* 2007**

1966b *Cyclonephelium semicirculatum* Morgenroth, p. 9, 10, plate 2, figs 3, 4.
1978 *Areoligera semicirculata* (Morgenroth) – Stover & Evitt, p. 18.
2007 *Licracysta*? *semicirculata* (Morgenroth) – Fensome *et al.*, p. 408.

Age. LO: latest Rupelian.

Remarks. The distribution of the process complexes in *Licracysta*? *semicirculata* is reminiscent of the Late Cretaceous forms of *Areoligera*, in which the mid-ventral surface lacks ornamentation, ventral processes being restricted to ambital linear complexes.

Genus *Lingulodinium* Wall 1967
Type. Deflandre & Cookson 1955, plate 9, fig. 6, as *Hystrichosphaeridium machaerophorum.*

1967 *Lingulodinium* Wall, p. 109.

Synopsis. A chorate gonyaulacacean (cribroperidinioid) cyst with a subspherical central body. Acavate. The central body is smooth or ornamented with features of low relief and bears numerous simple, hollow, apparently nontabular processes that are variable in length and distal ending. Archaeopyle precingular, resulting from loss of a variable number of precingular plates (one to five), or epicystal. When the archaeopyle is precingular, the opercular pieces are usually free and separate.

Remarks. We do not know if the variation in archaeopyle development among specimens of *Lingulodinium* bears any relationship to age or palaeoenvironment.

***Lingulodinium funginum* (Morgenroth 1966a) Islam 1983a**
(Plate 10, figs 1, 2)

1966a *Baltisphaeridium funginum* Morgenroth, p. 17, 18, plate 3, figs 7, 8.
1983a *Lingulodinium funginum* (Morgenroth) – Islam, p. 341.

Age. Peak of *Lingulodinium* spp. inconsistent within Eocene – it probably has greater palaeoenvironmental than biostratigraphic significance.

Remarks. According to Morgenroth (1966a), *Lingulodinium funginum* is characterised by having a variable number of processes that are distally bulbose, in contrast to species such as *Lingulodinium machaerophorum* that have acuminate process endings. Specimens of *Lingulodinium* with bulbose process endings are common in some samples from Labrador Margin wells and these are included here in *Lingulodinium funginum*. However, there is a caveat. Kokinos & Anderson (1995), in laboratory experiments, noted that the length and nature of the processes of resting cysts of the extant *Lingulodinium polyedrum* show considerable variation. The processes of the cysts, more familiarly known to palynologists as *Lingulodinium machaerophorum*, could be distally acuminate, bulbose, smooth or with small granules or spines; process length could vary up to a maximum of 10–12 µm. Based on their findings, Kokinos & Anderson (1995) considered *Lingulodinium funginum, Lingulodinium sadoense* and *Lingulodinium brevispinosum* to be taxonomic junior synonyms of *Lingulodinium machaerophorum*. Because morphological types included here in *Lingulodinium funginum* occur only in the Eocene in the study material, we propose to retain the species as defined in Morgenroth (1966a) and prefer to avoid the use of infraspecific ranks (e.g. variety). Retention may also provide useful information on palaeoenvironments.

Lingulodinium machaerophorum **(Deflandre & Cookson 1955) Wall 1967**
(Plate 10, figs 3, 4)

1955 *Hystrichosphaeridium machaerophorum* Deflandre & Cookson, p. 274, plate 9, figs 4, 8.
1961 *Baltisphaeridium machaerophorum* (Deflandre & Cookson) – Gerlach, p. 191, 192.
1966 *Cleistosphaeridium machaerophorum* (Deflandre & Cookson) – Davey *et al.*, p. 170; combination not validly published.
1967 *Lingulodinium machaerophorum* (Deflandre & Cookson) – Wall, p. 109.

Age. LO not confirmed in the study area, but globally the species extends to the present day.

Genus *Nyktericysta* Bint 1986
Type. Bint 1986, plate 4, figs 1, 2, 5, 6, text-fig. 3A, B, as *Nyktericysta davisii*.

1986 *Nyktericysta* Bint, p. 148, 149.
1986 *Balmula* Bint, p. 158.
1999 *Quantouendinium* Mao Shaozhi *et al.*, p. 155, 156.

Remarks. Fensome *et al.* (2009, p. 46) emended the generic diagnosis of *Nyktericysta* and considered the two wall layers to be the endophragm and ectophragm, to better facilitate comparison with closely similar genera. The ectophragm is finely perforate. According to the emendation, *Nyktericysta* always has one apical and two antapical horns. In addition, one or two lateral equatorial horns commonly occur, and these may have pre- and postcingular extensions. The archaeopyle is apical, with the formula $A_{(1-4')}$ and the operculum usually remains attached. Fensome *et al.* (2009, p. 46) noted that *Vesperopsis* differs from *Nyktericysta* in not having an ectophragm, and that *Endoceratium* and *Pseudoceratium* differ in having only an apical, postcingular and antapical horn rather than two antapical horns.

Mao Shaozhi *et al.* (1999, p. 156) differentiated *Quantouendinium* from *Nyktericysta* Bint 1986 and *Vesperopsis* Bint 1986 on the number and nature of the horns. Fensome *et al.* (2009, p. 46) in their emendation of *Nyktericysta* stated that it always has two antapical horns and commonly can have one or two lateral, equatorial horns. This indicates that the main distinction between *Quantouendinium* and *Nyktericysta* is that the former has one postcingular horn. However, from Mao Shaozhi *et al.* (1999, fig. 4), the location of both posterior horns appears to be antapical. We thus consider *Quantouendinium* to be a taxonomic junior synonym of *Nyktericysta*.

Nyktericysta davisii **Bint 1986**
(Plate 10, figs 5, 6)

1986 *Nyktericysta davisii* Bint, p. 149, 150, 152, 153, plate 4, figs 1–12; plate 8, figs 1–6; text-figs 3A–C, 4A, B, 10A, B.

Age. LO: late Albian.

Remarks. *Nyktericysta davisii* is characterised by the presence of five horns, of which the two lateral equatorial have pre- and postcingular extensions. The ectophragm is perforate. Tabulation may be indicated by low sutural ridges.

Nyktericysta dictyophora **He Chengquan *et al.* 1992**
(Plate 10, figs 7, 8)

1992 *Nyktericysta dictyophora* He Chengquan *et al.*, p. 184, 190, 191, plate 1, figs 1–9.
1992 *Nyktericysta dictyophora* subsp. *circularis* He Chengquan *et al.*, p. 185, 191, plate 1, figs 7–9.
1992 *Nyktericysta fusiformis* He Chengquan *et al.*, p. 185, 191, 192, plate 1, fig. 16; plate 2, figs 1–3.
1999 *Quantouendinium dictyophorum* (He Chengquan *et al.*) – Mao Shaozhi *et al.*, p. 156.

Age. LO: Cenomanian.

Remarks. Mao Shaozhi *et al.* (1999, p. 157) considered *Nyktericysta dictyophor*a subsp. *circularis* to be a junior synonym of *Quantouendinium dictyophorum* (that is, with the autonym). They also considered *Nyktericysta fusiformis* to be taxonomic junior synonyms of this species.

***Nyktericysta tripenta* (Bint 1986) Fensome *et al.* 2009**
(Plate 10, figs 11, 12)

1986 *Balmula tripenta* Bint, p. 158, 160, plate 6, figs 9–17; plate 7, fig. 8; text-fig. 6A, B.
2009 *Nyktericysta tripenta* (Bint) – Fensome *et al.*, p. 46.

Age. LO: Albian.

Remarks. Fensome *et al.* (2009, p. 46) noted that *Nyktericysta tripenta* has a coarse autophragmal reticulum, with muri being up to 10 μm wide.

Genus *Odontochitina* Deflandre 1937
Type. Deflandre 1937, plate 18 (also labelled plate 15), fig. 8, as *Odontochitina silicorum.*

1937 *Odontochitina* Deflandre, p. 94.

Remarks. The synopsis provided for *Odontochitina* by Fensome *et al.* (2009, p. 46) does not allow for the inclusion of forms with abbreviated horns.

***Odontochitina ancala* Bint 1986**
(Plate 10, fig. 14)

1986 *Odontochitina ancala* Bint, p. 139, 140, plate 1, figs 2–8; plate 7, figs 1, 2; text-fig. 2A.

Age. LO: Cenomanian.

Remarks. According to Bint (1986, p. 140), "*Odontochitina ancala* differs from *O. operculata* by having an elbow and cingular notch in the right lateral horn, localised perforations about midway along the horns, and an elongate ventral extension of the antapical pericoel."

***Odontochitina costata* Alberti 1961**
(Plate 10, fig. 15)

1961 *Odontochitina costata* Alberti, p. 31, plate 6, figs 10–13.
1962 *Odontochitina striatoperforata* Cookson & Eisenack, p. 490, plate 3, figs 14–19.

Age. LO: latest Campanian.

Remarks. *Odontochitina costata* was emended by Clarke & Verdier (1967, p. 58, 59), who considered *Odontochitina striatoperforata* to be intergradational with, and a taxonomic junior synonym of, *Odontochitina costata.*

***Odontochitina porifera* Cookson 1956**
(Plate 10, fig. 13)

1956 *Odontochitina porifera* Cookson, p. 188, plate 1, fig. 7.

Age. LO: Santonian.

Remarks. In the Scotian Margin wells, the LO of *Odontochitina porifera* is also Santonian (Fensome *et al.* 2009, p. 47).

Genus *Oligosphaeridium* Davey & Williams 1966a
Type. White 1842, plate 4, fig. 11, as *Xanthidium tubiferum* var. *complex*.

1966a *Oligosphaeridium* Davey & Williams, p. 70, 71.

Remarks. In their synopsis for *Oligosphaeridium*, Fensome *et al.* (2009, p. 47) stated: "processes more or less equal in size and general shape." There are two exceptions, the first and fourth apical (1′, 4′) are generally slender compared to the other apicals, although all the apicals tend to be slender.

***Oligosphaeridium albertense* (Pocock 1962) Davey & Williams 1969**
(Plate 10, fig. 17)

1962 *Hystrichosphaeridium albertense* Pocock, p. 82, plate 15, figs 226, 227.
1962 *Hystrichosphaeridium irregulare* Pocock, p. 82, plate 15, figs 228, 229.
1964 *Hystrichosphaeridium coelenteratum* Tasch in Tasch *et al.*, p. 195, plate 2, fig. 11.
1964 *Hystrichosphaeridium dispare* Tasch in Tasch *et al.*, p. 195, plate 2, fig. 8
1964 *Hystrichosphaeridium reniforme* Tasch in Tasch *et al.*, p. 193, plate 2, fig. 6.
1969 *Oligosphaeridium albertense* (Pocock) – Davey & Williams, p. 5.

Age. LO: early Cenomanian.

Remarks. In his emendation of *Oligosphaeridium albertense*, Brideaux (1977, p. 27, 28) described the processes as hollow, flared to tubiform, with the open distal margins being "variably secate, occasionally aculeate or serrate; the distal third of some processes variably fenestrate …." Jansonius (1986, p. 213) described the holotype of *Oligosphaeridium albertense*, which he re-illustrated (his plate 4, figs 4, 5), as having processes that were proximally nearly cylindrical but widened, and were strongly flared distally. The distal margins of the processes were "occasionally scalloped, carrying numerous coarse to fine, slender spinules." Jansonius (1986) considered *Hystrichosphaeridium* (as *Oligosphaeridium*) *irregulare* to be a taxonomic junior synonym of *Oligosphaeridium albertense*. Stover & Evitt (1978, p. 68, 69) regarded *Hystrichosphaeridium* (as *Oligosphaeridium*) *coelenteratum*, *Hystrichosphaeridium* (as *Oligosphaeridium*) *dispare* and *Hystrichosphaeridium* (as *Oligosphaeridium*) *reniforme* as taxonomic junior synonyms of *Oligosphaeridium irregulare*. Thus, by implication, *Oligosphaeridium coelenteratum*, *Oligosphaeridium dispare* and *Oligosphaeridium reniforme* are all taxonomic junior synonyms of *Oligosphaeridium albertense*.

Oligosphaeridium pulcherrimum **(Deflandre & Cookson 1955) Davey & Williams 1966a**
(Plate 10, figs 18, 19)

1955 *Hystrichosphaeridium pulcherrimum* Deflandre & Cookson, p. 270, 271, plate 1, fig. 8; text-figs 21, 22.
1966a *Oligosphaeridium pulcherrimum* (Deflandre & Cookson) – Davey & Williams, p. 75, 76.

Age. LO: regional – Santonian; LAD – Danian. Not plotted.

Remarks. Included here in *Oligosphaeridium pulcherrimum* are those forms that have a mixture of perforated and unperforated processes. *Oligosphaeridium complex* has no perforated processes.

Oligosphaeridium totum **Brideaux 1971**
(Plate 10, fig. 20)

1971 *Oligosphaeridium totum* Brideaux, p. 88, 89, plate 25, figs 53–55, 57.
1971 *Oligosphaeridium diastema* Singh, p. 337, plate 55, figs 4, 5; plate 56, figs 1, 2.

Age. LO: early Cenomanian.

Remarks. Based on nannofossil control, Fensome *et al.* (2009) considered the last occurrence for *Oligosphaeridium totum* to be in the early Cenomanian.

Genus *Operculodinium* Wall 1967
Type. Deflandre & Cookson 1955, plate 8, figs 3, 4, as *Hystrichosphaeridium centrocarpum*.

1967 *Operculodinium* Wall, p. 110, 111.

Remarks. *Operculodinium* is a chorate gonyaulacacean (criboperidinioidean) cyst with a spheroidal to slightly ovoidal central body with a reticulate wall. The central body bears numerous nontabular to contabular processes. Processes are generally solid, of the same size in individual species and distally bifid to aculeate. The archaeopyle is precingular, with the formula $P_{3''}$; the operculum is free. Fensome *et al.* (2009, p. 48) discussed the differences between *Operculodinium* and the closely similar genus *Exochosphaeridium*.

Operculodinium centrocarpum **(Deflandre & Cookson 1955) Wall 1967**
(Plate 11, figs 5, 6)

1955 *Hystrichosphaeridium centrocarpum* Deflandre & Cookson, p. 272, 273, plate 8, figs 3, 4.
1961 *Baltisphaeridium centrocarpum* (Deflandre & Cookson) – Gerlach, p. 192,193.
1965 *Cordosphaeridium centrocarpum* (Deflandre & Cookson) – de Coninck, p. 33.
1966a *Cordosphaeridium tiara* subsp. *centrocarpum* (Deflandre & Cookson) – Morgenroth, p. 26.
1967 *Operculodinium centrocarpum* (Deflandre & Cookson) – Wall, p. 111.

1969 *Cordosphaeridium*? *microtriainum* subsp. *centrocarpum* (Deflandre & Cookson) – de Coninck, p. 32.
1978 *Cleistosphaeridium centrocarpum* (Deflandre & Cookson) – Jiabo, p. 61.
1983 *Operculodinium echigoense* Matsuoka, p. 126, plate 7, figs 1, 2a, b, 3–5, 8.
1987 *Operculodinium*? *echigoense* Matsuoka – Mudie, p. 804.

Age. LO: Tortonian.

Genus *Palaeocystodinium* Alberti 1961
Type. Alberti 1961, plate 7, fig. 12, as *Palaeocystodinium golzowense*.

1961 *Palaeocystodinium* Alberti, p. 20.
1963 *Cystodiniopsis* Vozzhennikova, p. 185.

Remarks. In their emendation of *Palaeocystodinium*, Fensome *et al.* (2009, p. 48) stated that they are "Peridiniacean (deflandreoid) cysts that are fusiform in shape, with single prominent pointed horns apically and antapically; the horns are generally long and there may be a short accessory antapical horn." Fensome *et al.* (2009) differentiated *Palaeocystodinium* from the genus *Svalbardella* Manum 1960 on the nature of the horns distally; the latter has bluntly rounded apical and antapical horns.

***Palaeocystodinium bulliforme* Ioannides 1986**
(Plate 11, figs 1, 2)

1986 *Palaeocystodinium bulliforme* Ioannides, p. 31, plate 17, figs 2–5.

Age. LO: Selandian.

***Palaeocystodinium golzowense* Alberti 1961**
(Plate 10, fig. 10)

1961 *Palaeocystodinium golzowense* Alberti, p. 20, plate 7, figs 10–12; plate 12, fig. 16.

Age. LO: late Tortonian (Late Miocene).

***Palaeocystodinium teespinosum* Fensome *et al.* 2009**
(Plate 11, fig. 3)

2009 *Palaeocystodinium teespinosum* Fensome *et al.*, p. 50, plate 8, figs m–p.

Age. LO: early Rupelian.

Remarks. *Palaeocystodinium teespinosum* differs from *Palaeocystodinium golzowense* in having delicate T-shaped spinelets that are about 2 µm long and are especially common on the apical and antapical horns.

Genus *Palaeohystrichophora* Deflandre 1935
Type. Deflandre 1935, plate 8, fig. 4, as *Palaeohystrichophora infusorioides.*

1935 *Palaeohystrichophora* Deflandre, p. 230.

Remarks. In their remarks for this genus, Fensome *et al.* (2009, p. 50) compared *Palaeohystrichophora* to *Subtilisphaera* Jain & Millepied 1973. Both genera lack an obvious archaeopyle, but Harker (1979, p. 374, fig. 1) observed a combination archaeopyle with the formula $3I3P_{(1-3a\ +\ 3-5'')}$ in *Palaeohystrichophora infusorioides*; according to Harker, the operculum remains attached along the posterior or cingular margin. Bujak & Davies (1983, p. 62, text-fig. 4) observed an archaeopyle, which they termed the transverse archaeopyle, in some species assigned to *Subtilisphaera*. This archaeopyle resulted from the development of sutures between the apicals and three anterior intercalary plates and between the anterior lateral margins of the intercalaries. The major observable difference between the two genera is the presence of processes on the pericyst of *Palaeohystrichophora*. Forms with processes that are presently included in *Subtilisphaera* should probably be included in *Palaeohystrichophora*.

***Palaeohystrichophora infusorioides* Deflandre 1935**
(Plate 11, fig. 4)

1935 *Palaeohystrichophora infusorioides* Deflandre, p. 230, 231, plate 8, fig. 4.
1943 *Palaeohystrichophora paucisetosa* Deflandre, p. 507, 508, text-fig. 26.

Age. LO: Campanian.

Genus *Palaeoperidinium* Deflandre 1934 ex Sarjeant 1967
Type. Ehrenberg 1838, plate 1, fig. 4, as *Peridinium pyrophorum.*

1934 *Palaeoperidinium* Deflandre, p. 968; name not validly published.
1963 *Pentagonum* Vozzhennikova, p. 183; name not validly published.

1967 *Palaeoperidinium* Deflandre ex Sarjeant, p. 246, 247.
1967 *Pentagonum* Vozzhennikova ex Vozzhennikova, p. 106; name illegitimate.
1970 *Astrocysta* Davey, p. 359.

Remarks. The synopses of *Palaeoperidinium* provided by Stover & Evitt (1978, p. 217) and Fensome *et al.* (2009, p. 51) are very similar. In their remarks, Fensome *et al.* (2009) took into account the emendation of *Palaeoperidinium* by Evitt *et al.* (1998, p. 46, 48), who noted that the most commonly preserved wall of the cyst is an exophragm, which is unusual in having been formed outside but in contact with the exterior surface of the theca.

***Palaeoperidinium pyrophorum* (Ehrenberg 1838 ex Wetzel 1933b) Sarjeant 1967**
(Plate 11, figs 7, 8)

1838 *Peridinium pyrophorum* Ehrenberg, plate 1, figs 1, 4; name not validly published.
1933b *Peridinium pyrophorum* Ehrenberg ex Wetzel, p. 164, 165.
1967 *Palaeoperidinium pyrophorum* (Ehrenberg ex Wetzel) – Sarjeant, p. 246.
1967 *Peridinium basilium* Drugg, p. 13, plate 1, figs 9–11; plate 9, fig. 1a, b.
1967 *Pentagonum marginatum* Vozzhennikova, p. 107, plate 46, figs 1, 3, 4, 6; generic name illegitimate.
1967 *Pentagonum sibiricum* Vozzhennikova, p. 106, 107, plate 46, figs 2, 5.
1967 *Peridinium conicum* var. *larjakiense* Vozzhennikova, p. 71, 72, plate 16, figs 1a, b, 2a, b.
1973 *Palaeoperidinium deflandrei* Lentin & Williams, p. 105.
1981 *Palaeoperidinium larjakiense* (Vozzhennikova) – Lentin & Williams, p. 210.

Age. LO: Selandian; peak: early Danian.

Remarks. Gocht & Netzel (1976, p. 403–405) and Evitt *et al.* (1998, p. 48, 49) provided comprehensive, concise emendations of *Palaeoperidinium pyrophorum*, and resolved its relationship to the thecate equivalent.

Genus *Palynodinium* Gocht 1970
Type. Gocht 1970, fig. 4, nos 1a–c, as *Palynodinium grallator*.

1970 *Palynodinium* Gocht, p. 135, 137, 138, 140.

***Palynodinium grallator* Gocht 1970**
(Plate 11, figs 9, 10)

1970 *Palynodinium grallator* Gocht, p. 135, 137, 138, 140, fig. 2a–e; fig. 4, nos 1a–c, 2a, b, 3a, b, 4a, b, 5a, b, 6a, b, 7, 8; fig. 5, nos 1, 2a, b.

Age. LO: latest Maastrichtian.

Genus *Petalodinium* Williams *et al.* 2015
Type. Williams & Downie 1966b, plate 20, figs 1, 2, as *Wetzeliella condylos*.

2015 *Petalodinium* Williams *et al.*, p. 307.

Remarks. Williams *et al.* (2015) erected the genus *Petalodinium* for wetzelielloidean dinocysts with a latiepeliform archaeopyle and a pericyst that is smooth or ornamented with features of low relief.

***Petalodinium condylos* (Williams & Downie 1966b) Williams *et al.* 2015**
(Plate 11, figs 11, 12)

1966b *Wetzeliella condylos* Williams & Downie, p. 193, 194, plate 20, figs 1, 2.
1976 *Rhombodinium condylos* (Williams & Downie) – Lentin & Williams, p. 128.
1979 *Dracodinium condylos* (Williams & Downie) – Costa & Downie, p. 43.
2015 *Petalodinium condylos* (Williams & Downie) – Williams *et al.*, p. 308.

Age. LO: Ypresian.

Remarks. As Williams *et al.* (2015) have demonstrated, the holotype of *Petalodinium condylos* (Williams & Downie 1966b, plate 20, fig. 1, as *Wetzeliella condylos*), which is the type of *Petalodinium*, has a latiepeliform archaeopyle. Apparently related to the latiepeliform archaeopyle is the nature of the apical horn, which in *Petalodinium condylos* is reduced or absent, the apex being rounded. The pericyst is verrucate to tuberculate. Often, the intratabular ornamentation delineates the tabulation: other verrucae or tubercles are penitabular. Both peri- and endophragm are thick, about 3 μm. Some specimens observed in the Labrador Margin samples are devoid of ornamentation, but are otherwise identical.

Genus *Phelodinium* Stover & Evitt 1978
Type. Corradini 1973, plate 28, fig. 3, as *Deflandrea pentagonalis*.

1978 *Phelodinium* Stover & Evitt, p. 117, 118.

Synopsis. A dorso-ventrally compressed, proximate protoperidiniacean (protoperidinioidean) cyst with one apical and two antapical horns. The cyst is pentagonal with convex to concave lateral sides. It is produced into one apical and two antapical horns that can be of variable length, are usually acuminate distally, and may have solid tips. Cornucavate where two wall layers can be discerned. Cingulum sometimes present. Endocyst, where observable, and pericyst smooth or ornamented with features of low relief. Archaeopyle intercalary, with formula $I_{(2a)}$, the second anterior intercalary plate is deltaform; operculum usually free.

Remarks. The emendation of *Phelodinium* by Mao Shaozhi & Norris (1988, p. 51, 52) related to the archaeopyle index, given in the original diagnosis as 0.3 to 0.4 by Stover & Evitt (1978, p. 117). Mao Shaozhi & Norris (1988) expanded the index to between 0.3 and 0.6; these authors also classified the archaeopyle as standard hexa 2a. One difficulty with *Phelodinium* is determining if it has one or two wall layers. According to Stover & Evitt (1978, p. 118) "*Phelodinium* differs from *Lejeunia* in being cavate and in having a peridinioid outline with straight to concave sides. *Lejeunia* has an autophragm only, and its lateral margins are normally convex." That there are two wall layers in *Phelodinium* is often extremely difficult to discern and the outline of the cyst in the two genera appears to be variable.

***Phelodinium kozlowskii* (Górka 1963) Lindgren 1984**
(Plate 12, figs 1–3)

1963 *Lejeunia kozlowskii* Górka, p. 41, plate 5, fig. 4.
1970 *Astrocysta kozlowskii* (Górka) – Davey, p. 369.
1977 *Senegalinium kozlowskii* (Górka) – Harland, p. 189.
1984 *Phelodinium kozlowskii* (Górka) – Lindgren, p. 181.

Age. LO: Danian.

Remarks. Harland (1973, p. 673) and Harker & Sarjeant (1975, p. 223) considered *Phelodinium kozlowskii* to be a taxonomic junior synonym of *Phelodinium tricuspe*. In their emendation of *Phelodinium tricuspe*, Lejeune-Carpentier & Sarjeant (1981, p. 20) stated that the "Phragma [is] apparently composed of a single layer (autophragm)." These authors also observed that in the holotype of *Phelodinium* (as *Lejeunecysta*) *tricuspe* only one wall layer could be discerned: this observation explains why these authors accepted the transfer of the species to *Lejeunecysta* by Artzner & Dörhöfer (1978). Lindgren (1984, p. 181–183) recorded two wall layers in *Phelodinium kozlowskii*, with the endophragm being closely appressed to the periphragm except at the tips of the horns. Some of the specimens of *Phelodinium kozlowskii* encountered in this study show a similar morphology, which is why the species is retained in *Phelodinium* and separated from *Phelodinium tricuspe*; assuming that the holotype of the latter species has a single wall layer, it should be included in *Lejeunecysta*.

Genus *Phthanoperidinium* Drugg & Loeblich Jr. 1967
Type. Drugg & Loeblich Jr. 1967, plate 1, fig. 4, as *Phthanoperidinium amoenum*.

1967 *Phthanoperidinium* Drugg & Loeblich Jr., p. 182.

Remarks. Fensome *et al.* (2009, p. 54) provided a comprehensive synopsis of *Phthanoperidinium*, which included the findings by Edwards & Bebout (1981, p. 36) and Islam (1982, p. 306) on the variability and complexity of the archaeopyle. Although the variability has not been noted rigorously, if the trend is similar to that in other peridiniaceans, it is probable that the various types have different stratigraphic ranges. This has already been demonstrated in *Phthanoperidinium geminatum* and *Phthanoperidinium regale*, whose only difference is in the nature of the archaeopyle.

***Phthanoperidinium coreoides* (Benedek 1972) Lentin & Williams 1976**
(Plate 11, figs 13, 14)

1972 *Hystrichogonyaulax coreoides* Benedek, p. 20, plate 9, fig. 4a–c.
1976 *Phthanoperidinium coreoides* (Benedek) – Lentin & Williams, p. 76.
1976 *Phthanoperidinium tritonium* Eaton, p. 299, 300, plate 17, figs 2, 3, 6, 7; text-figs 23C, 24A, B.

Age. LO: Rupelian.

Remarks. Following Fensome *et al.* (2009, p. 55), *Phthanoperidinium coreoides* and *Phthanoperidinium comatum* are separate species, distinguished on the relative length of the processes. In *Phthanoperidinium coreoides*, the processes are about one third the diameter of the central body; in *Phthanoperidinium comatum*, the processes are about one half the diameter of the central body.

***Phthanoperidinium levimurum* Bujak in Bujak *et al.* 1980**
(Plate 11, fig. 15)

1980 *Phthanoperidinium levimurum* Bujak in Bujak *et al.*, p. 74, plate 19, figs 13–16; text-figs 20E, 22B.

Age. LO: Priabonian.

Remarks. *Phthanoperidinium levimurum* is characterised by having the tabulation delineated by membranes, which are usually smooth distally but may sometimes be denticulate.

***Phthanoperidinium multispinum* Bujak in Bujak *et al.* 1980**
(Plate 11, figs 16, 17)

1980 *Phthanoperidinium multispinum* Bujak in Bujak *et al.*, p. 74, plate 19, figs 17–19; text-fig. 20F.

Age. LO: latest Priabonian.

***Phthanoperidinium regale* Bujak 1994**
(Plate 11, figs 18, 19)

1994 *Phthanoperidinium regale* Bujak, p. 130, plate 4, figs 4–6.

Age. LO: Lutetian.

Remarks. *Phthanoperidinium regale* has ornamentation similar to *Phthanoperidinium geminatum* Bujak in Bujak *et al.* 1980, but differs in having a combination archaeopyle, with the formula $IP_{(2a+4'')}$. *Phanoperidinium geminatum* has the more usual archaeopyle type for the genus, losing the 2a plate only. In *Phthanoperidinium regale,* the operculum is free.

***Phthanoperidinium stockmansii* (de Coninck 1975) Lentin & Williams 1977a**
(Plate 11, fig. 20)

1975 *Peridinium stockmansii* de Coninck, p. 97, 98, plate 17, figs 18–37.
1977a *Phthanoperidinium stockmansii* (de Coninck) – Lentin & Williams, p. 131.
1976 *Phthanoperidinium echinatum* Eaton, p. 298, 299, plate 17, figs 8, 9, 12; text-fig. 23B.
1980 *Phthanoperidinium*? *pseudoechinatum* Bujak in Bujak *et al.*, p. 75, 76, plate 19, fig. 20; text-fig. 20C.

Age. LO: Priabonian.

Remarks. *Phthanoperidinium stockmansii* has penitabular rows of small processes that distally are clavate. Rows of processes usually occur in parallel pairs, somewhat like railway tracks. De Coninck (1977, p. 40) considered *Phthanoperidinium echinatum* to be a junior taxonomic synonym of *Phthanoperidinium stockmansii*. Islam (1982, p. 315) agreed with this synonymy, but mistakenly thought that *Phthanoperidinium echinatum* was the senior name. Accepting Islam's synonymy of *Phthanoperidinium pseudoechinatum* with *Phthanoperidinium echinatum*, the former thus becomes a junior taxonomic synonym of *Phthanoperidinium stockmansii.*

Genus *Piladinium* Williams *et al.* 2015
Type. Michoux 1988, plate 1, figs 2, 3, as *Kisselovia columna.*

2015 *Piladinium* Williams *et al.*, p. 308, 309.

Remarks. *Piladinium* is a wetzelielloidean genus with a latiepeliform archaeopyle and processes connected by an ectophragmal membrane. For comparison with other wetzelielloidean genera, see Williams *et al.* (2015).

***Piladinium columna* (Michoux 1988) Williams *et al.* 2015**
(Plate 12, figs 5, 6)

1988 *Kisselevia columna* Michoux, p. 28, 30, plate 1, figs 2, 3, 5, 6; plate 2, figs 3–5; text-fig. 7A, B.
1989 *Charlesdowniea columna* (Michoux) – Lentin & Vozzhennikova, p. 74.
2015 *Piladinium columna* (Michoux) – Williams *et al.*, p. 309.

Age. LO: Ypresian.

Remarks. Several of the observed Labrador Margin specimens of *Piladinium columna* have reduced numbers of processes on the mid-ventral and mid-dorsal regions. The morphology of these specimens is thus approaching that of *Piladinium edwardsii*.

***Piladinium edwardsii* (Wilson 1967b) Williams *et al.* 2015**
(Plate 12, figs 7, 8)

1967b *Wetzeliella edwardsii* Wilson, p. 477, figs 8, 9.
1978 *Kisselevia edwardsii* (Wilson) – Stover & Evitt, p. 111.
1989 *Charlesdowniea edwardsii* (Wilson) – Lentin & Vozzhennikovia, p. 227.
2015 *Piladinium edwardsii* (Wilson) – Williams *et al.*, p. 309.

Age. LO: early Ypresian. Not plotted.

Genus *Pseudoceratium* Gocht 1957
Type. Gocht 1957, plate 18, fig. 1, as *Pseudoceratium pelliferum.*

1957 *Pseudoceratium* Gocht, p. 166.
1962 *Eopseudoceratium* Neale & Sarjeant, p. 446.
1966a *Doidyx* Sarjeant, p. 205.

Synopsis. A dorso-ventrally compressed, proximate ceratiacean cyst with single apical, postcingular and antapical horns. Wall formed of one or two layers. If two-layered, there can be endophragm and periphragm or endophragm and ectophragm. Tabulation often indicated by ornamentation if present. Ornamentation may be absent or it may be granular or consist of short processes, which may be trabeculate. Cingulum sometimes obvious. Archaeopyle apical, with formula $A_{(1–4')}$, operculum free; sulcal notch offset to the left.

***Pseudoceratium* sp.**
(Plate 12, fig. 4)

Remarks. Our specimens of *Pseudoceratium* differ from *Pseudoceratium pelliferum* in having longer processes and in generally lacking a lateral horn.

Genus *Raphidodinium* Deflandre 1936
Type. Deflandre 1936, plate 10, figs 1, 2, 7, *Raphidodinium fucatum.*

1936 *Raphidodinium* Deflandre, p. 184, 185.

Synopsis. Chorate cyst with ovoidal central body and a clearly defined cingulum. The cingulum can subdivide the central body into equal epi- and hypocysts or be anteriorly located, dividing the cyst into a short epicyst and much longer hypocyst. Tabulation marked by membranes or ridges and long, slender processes that are clustered along the cingulum and to a lesser extent in the antapical area. Processes are distally blunt to multifurcate. Archaeopyle indeterminate.

Remarks. Marheinecke (1992, p. 79) considered the archaeopyle of *Raphidodinium fucatum* subsp. *compactum* Marheinecke 1992 to be possibly precingular.

***Raphidodinium fucatum* Deflandre 1936**
(Plate 12, figs 9, 10)

1936 *Raphidodinium fucatum* Deflandre, p. 185, 186, plate 10, figs 1–7.

Age. LO: Campanian.

Remarks. The unequal sizes of the epi- and hypocysts suggest that *Raphidodinium fucatum* could be a cladopyxiacean.

Genus *Reticulosphaera* Matsuoka 1983
Type. Matsuoka 1983, plate 4, fig. 8, as *Reticulatosphaera stellata*.

1983 *Reticulatosphaera* Matsuoka, p. 116.

***Reticulatosphaera actinocoronata* (Benedek 1972) Bujak & Matsuoka 1986**
(Plate 12, figs 11, 12)

1972 *Cleistosphaeridium actinocoronatum* Benedek, p. 34, plate 12, fig. 13; text-fig. 12.
1978 *Areosphaeridium*? *actinocoronatum* (Benedek) – Stover & Evitt, p. 20.
1983 *Reticulatosphaera stellata* Matsuoka, p. 116, 117, plate 4, figs 8–11; text-fig. 10.
1986 *Reticulatosphaera actinocoronata* (Benedek 1972) – emend. Bujak & Matsuoka 1986, p. 238.

Age. LO: earliest Zanclian. Not plotted.

Genus *Rhombodinium* Gocht 1955 emend. Williams, Damassa, Fensome & Guerstein in Fensome *et al.* 2009

Type. Gocht 1955, text-fig. 1c, as *Rhombodinium draco*.

1955 *Rhombodinium* Gocht, p. 85.
1961 *Wetzeliella* subgenus *Rhombodinium* (Gocht) – Alberti, p. 9.
2009 *Rhombodinium* Gocht 1955 emend. Williams, Damassa, Fensome & Guerstein in Fensome *et al.*, p. 57.

Remarks. We fully concur with the emendation in Fensome *et al.* (2009), which emphasises the generic significance of the archaeopyle. According to the emended diagnosis, species of *Rhombodinium* must have a soleiform archaeopyle, which always has an operculum that is attached apically. *Rhombodinium* was retained at generic rank by Lentin & Williams (1977a, p. 139).

***Rhombodinium draco* Gocht 1955**
(Plate 12, figs 13, 14)

1955 *Rhombodinium draco* Gocht, p. 86, text-fig. 1a–c.
1961 *Wetzeliella* subgenus *Rhombodinium draco* (Gocht) – Alberti, p. 8.

Age. LO: Priabonian.

Remarks. Vozzhennikova (1967, p. 168) retained this taxon in *Rhombodinium*.

***Rhombodinium porosum* Bujak 1979**

1979 *Rhombodinium porosum* Bujak, p. 314, 315, plate 1, figs 3, 5–8; plate 2, fig. 11; text-fig. 8C.

Age. LO: Bartonian.

Genus *Rottnestia* Cookson & Eisenack 1961a

Type. Eisenack 1954, plate 9, fig. 5, as *Hystrichosphaera borussica*.

1961a *Rottnestia* Cookson & Eisenack, p. 40, 42.

***Rottnestia borussica* (Eisenack 1954) Cookson & Eisenack 1961a**
(Plate 13, fig. 1)

1954 *Hystrichosphaera borussica* Eisenack, p. 62, plate 9, figs 5a, b, 6, 7.
1961a *Rottnestia borussica* (Eisenack) – Cookson & Eisenack, p. 42.
1966a *Triblastula borussica* (Eisenack) – Morgenroth, p. 15, 16.
1966b *Hystrichosphaeropsis borussica* (Eisenack) – Sarjeant, p. 139; combination not validly published.

Age. LO: Lutetian. Not plotted.

Genus *Scalenodinium* gen. nov.

Type. Plate 12, fig. 15, as *Scalenodinium scalatum*.

Etymology. The name is from the Latin *scalenus*, meaning unequal, uneven, odd, in reference to the unequal variation in apical and antapical development.

Description. Pericoel elongate, with an apical horn that is acuminate to rounded distally and generally a rounded antapex, although the latter may be extended into a short protuberance. When the endocyst is present, the cyst is bicavate. Cingulum present or faintly expressed. Periarchaeopyle intercalary, generally with formula I_{2a}, and with a free operculum. The hexa 2a plate is stenodeltaform. In some specimens, the apparent loss of the apical area (Plate 12, figs 16–19) or of other intercalary plates besides the 2a (Plate 12, fig. 15) indicates a compound and/or combination archaeopyle.

Remarks. *Scalenodinium* differs from *Isabelidinium* in having a stenodeltaform, rather than a lati- to iso-omegaform 2a plate. *Palaeocystodinium*, which like *Scalenodinium* has a stenodeltaform 2a plate, differs from the latter genus in always having more or less apical and antapical horns and a periarchaeopyle that is always formed from the loss of a single plate, the 2a plate, rather than several plates as in *Scalenodinium*.

***Scalenodinium scalenum* sp. nov.**
(Plate 12, figs 15–20)

Holotype. Plate 12, fig. 15, from a cuttings sample at 2135–2145 m in Gilbert F-53, GSC type collection no. 137916, sample P39484, slide 01, co-ordinates 19.3 × 106.5, England Finder T37/4. Pericyst length 81 µm, width 31 µm. The age determined for the sample from which the holotype was recovered is Ypresian.

Etymology. The name is from the Latin *scalenus*, meaning unequal, uneven, odd, in reference to the unequal variation in apical and antapical development.

Description. A species of *Scalenodinium* with an elongate pericoel that has an apex bearing a well-developed, distally acuminate to rounded apical horn and an antapex that is generally rounded, though an antapical protuberance may occasionally be developed. When an endocyst is present, the cyst is bicavate. The pericyst is verrucate to granulate in the mid-dorsal and mid-ventral regions. A cingulum is rarely developed. Both pericyst and endocyst have walls that are, at the most, 1 μm thick. Periarchaeopyle intercalary, generally with formula I_{2a}, operculum free. The hexa 2a plate is stenodeltaform. In some specimens, the apparent loss of the apical area (Plate 12, figs 16–19) or of other intercalary plates besides the 2a (Plate 12, fig. 15) indicates a compound and/or combination archaeopyle.

Size. Pericyst length 77–86 μm, pericyst width 38–56 μm, apical horn length 18–27 μm, apical horn maximum breadth 11–14 μm.

Age. LO: Ypresian.

Remarks. *Scalenodinium scalenum* shows some variation in the antapical region: although generally rounded antapically, some specimens have a prominent antapical horn that is more or less centrally located. The pericyst invariably has folds running across its surface. It is difficult to be specific about the nature of the archaeopyle since there is a common tendency for the apical polar area to break up. Thus this breakup could be interpreted to denote a compound or combination archaeopyle. Width and shape of the distal terminations of the horn or horns vary considerably.

Genus *Schematophora* Deflandre & Cookson 1955
Type. Deflandre & Cookson 1955, plate 6, figs 11, 12, as *Schematophora speciosa*.

1954 *Schematophora* Deflandre & Cookson, p. 1237 (name not validly published).
1955 *Schematophora* Deflandre & Cookson, p. 262.

Remarks. The synopsis provided by Fensome *et al.* (2009) covers all the salient points regarding the morphology of *Schematophora*.

***Schematophora speciosa* Deflandre & Cookson 1955**
(Plate 13, fig. 2)

1955 *Schematophora speciosa* Deflandre & Cookson, p. 262, 263, plate 6, figs 11–13; plate 7, fig. 11.

Age. LO: Priabonian.

Genus *Senegalinium* Jain & Millepied 1973
Type. Jain & Millepied 1973, plate 1, figs 1–3, as *Senegalinium bicavatum.*

1973 *Senegalinium* Jain & Millepied, p. 22, 23.

Synopsis. Peridiniacean (deflandreoid) cysts with a peridinioid, usually elongate pericyst and two antapical horns that are more or less of equal length. Bicavate with a circular to pentagonal endocyst. Pericyst surface smooth or with low ornament, sometimes with cingulum indicated. Periarchaeopyle intercalary, resulting from the loss of the iso- to stenodeltaform deltaform 2a plate; the operculum commonly remains attached along the posterior margin.

Remarks. *Alterbidinium* differs from *Senegalinium* in having two antapical horns that are of unequal length. Since *Alterbidinium* contains species that may have a combination intercalary–precingular archaeopyle resulting from the loss of the 2a and 4′′ plate, it would not be surprising to find the same variability in *Senegalinium*.

***Senegalinium iterlaaense* Nøhr-Hansen & Heilmann-Clausen 2001**
(Plate 13, figs 3, 4)

2001 *Senegalinium iterlaaense* Nøhr-Hansen & Heilmann-Clausen, p. 164, 166–168, fig. 6, nos 1–6.

Age. LO: Selandian.

Remarks. *Senegalinium iterlaaense* differs from *Isabelidinium viborgense* in having a striate periphragm.

Genus *Senoniasphaera* Clarke & Verdier 1967
Type. Clarke & Verdier 1967, plate 14, fig. 8, as *Senoniasphaera protrusa*.

1967 *Senoniasphaera* Clarke & Verdier, p. 61.

Remarks. The cavate cysts included in *Senoniasphaera* have the typical offset sulcal notch of areoligeraceans. The operculum of the apical archaeopyle is always free.

***Senoniasphaera inornata* (Drugg 1970) Stover & Evitt 1978**
(Plate 13, fig. 5)

1970 *Chiropteridium inornatum* Drugg, p. 811, 812, fig. 3C–F.
1978 *Senoniasphaera inornata* (Drugg) – Stover & Evitt, p. 80.

Age. LO: Danian.

Remarks. Brinkhuis & Schiøler (1996) recorded *Senoniasphaera inornata* from the early Danian of the Geulhemmerberg Cretaceous–Palaeogene boundary section in Limburg, south-eastern Netherlands. This observation accords with the age of this species in sections at Stevns Klint (Denmark) and Alabama as recorded by Hansen *et al.* (1986) and Habib (1994) respectively. *Senoniasphaera inornata* therefore appears to be a good Danian index species. Williams *et al.* (2004) placed the LO of the species close to the top of the Danian.

***Senoniasphaera microreticulata* Brideaux & McIntyre 1975**
(Plate 13, fig. 6)

1975 *Senoniasphaera microreticulata* Brideaux & McIntyre, p. 35, plate 11, figs 7–12; plate 12, figs 1–8.
1981 *Canningia microreticulata* (Brideaux & McIntyre) – Below, p. 31.

Age. LO: Cenomanian.

Remarks. Lentin & Williams (1981, p. 33) retained this species in *Senoniasphaera*.

***Senoniasphaera rotundata* Clarke & Verdier 1967**
(Plate 13, fig. 7)

1967 *Senoniasphaera rotundata* Clarke & Verdier, p. 62, 63, plate 14, figs 1–3; text-fig. 25.

Age. LO: latest Campanian.

Remarks. In *Senoniasphaera rotundata*, the endocyst does not protrude into the antapical horns.

Genus *Simplicidinium* gen. nov.
Type. Eaton 1976, plate 21, fig. 5, as *Impletosphaeridium insolitum*.

Etymology. The name derives from the Latin *simplicis*, meaning simplicity, in reference to the relatively simple morphology of the cyst, comprising a spiny ball with an apical archaeopyle.

Diagnosis. Proximochorate to chorate dinoflagellate cysts with a more or less symmetrical spheroidal to ovoidal central body. Spines or processes numerous, isolated and non-tabulate, distally closed, with symmetrical distal terminations. Archaeopyle apical, type $4A_{1'-4'}$, operculum attached or detached.

Remarks. There seems to be considerable confusion currently surrounding the generic assignment of chorate species with non-tabulate spines/processes and a cryptic, or not clearly discernible or consistent archaeopyle. Forms with a consistent apical archaeopyle and at least some asymmetrical processes are assignable to *Cleistosphaeridium* (Eaton *et al*. 2001). Islam (1993) proposed *Downiesphaeridium*, purportedly for forms with an apical archaeopyle and simple non-tabulate processes. The processes of the type of *Downiesphaeridium* are typical of *Lingulodinium,* and the archaeopyle in the type of *Downiesphaeridium* looks precingular; it is thus suggested here that *Downiesphaeridium* may be a taxonomic junior synonym of *Lingulodinium*, but at least should not be used beyond the type. Many authors have assigned species that they consider to be chorate dinoflagellates but show no evidence of an archaeopyle to *Impletosphaeridium*, the type of that genus being suitably cryptic in its archaeopyle type. Similar species deemed not to be dinoflagellates are assignable to the acritarch genus *Baltisphaeridium*.

***Simplicidinium insolitum* (Eaton 1976) comb. nov.**
(Plate 13, figs 9, 10)

1976 *Impletosphaeridium insolitum* Eaton, p. 308, plate 21, figs 5, 8; text-fig. 25B.
1978 *Cleistosphaeridium*? *insolitum* (Eaton) – Stover & Evitt, p. 31.

Age. Local peak: earliest Bartonian.

Remarks. Eaton (1976, p. 308) commented on the presence of a polygonal opening in some of the specimens of *Simplicidinium* (as *Impletosphaeridium*) *insolitum*; such openings are readily apparent in his accompanying illustrations (Eaton 1976, plate 21, figs 5, 8). We thus assign this species, as type, to *Simplicidinium* on the basis of the morphology of the holotype and because several of the specimens in this study also have an apical archaeopyle.

Genus *Sophismatia* Williams *et al.* 2015
Type. Williams & Downie 1966a, plate 20, figs 2, 4, text-fig. 49, as *Wetzeliella tenuivirgula*.

2015 *Sophismatia* Williams *et al.*, p. 312, 313.

Remarks. Williams *et al.* (2015) are followed here in restricting *Sophismatia* to wetzelielloideans with an equiepeliform 2a archaeopyle and trabeculate processes.

***Sophismatia tenuivirgula* (Williams & Downie 1966b) Williams *et al.* 2015**
(Plate 13, fig. 8)

1966b *Wetzeliella tenuivirgula* Williams & Downie, p. 188, 189, plate 19, figs 1, 2, 4, 5, 7; text-figs 49, 50.
1976 *Kisselevia tenuivirgula* (Williams & Downie) – Lentin & Williams, p. 136.
1989 *Charlesdowniea tenuivirgula* (Williams & Downie) – Lentin & Vozzhennikova, p. 227.
2015 *Sophismatia tenuivirgula* (Williams & Downie) – Williams *et al.*, p. 313.

Age. LO: Lutetian.

Remarks. The holotype of *Sophismatia tenuivirgula* (Williams & Downie 1966b, plate 19, figs 2–4; text-fig. 49) clearly shows an equiepeliform archaeopyle, with the endo- and periarchaeopyle being of almost identical size. The only difference is anteriorly, where the periarchaeopyle extends slightly beyond the endoarchaeopyle.

Genus *Spinidinium* Cookson & Eisenack 1962
Type. Cookson & Eisenack 1962, plate 1, figs 1, 2, as *Spinidinium styloniferum*.

1962 *Spinidinium* Cookson & Eisenack, p. 489.
2003 *Magallanesium* Quattrocchio & Sarjeant, p. 138, 140.
2003 *Volkheimeridium* Quattrocchio & Sarjeant, p. 136, 138.

Remarks. In their extensive review of *Spinidinium*, *Vozzhennikovia* and related genera, Sluijs *et al.* (2009) emended the diagnosis of *Spinidinium*. They restricted the genus to peridiniacean taxa with proximosutural spines, a steno- to isodeltaform 2a plate and an I_{2a} archaeopyle, with the operculum typically attached posteriorly.

***Spinidinium echinoideum* (Cookson & Eisenack 1960a) Lentin & Williams 1976**
(Plate 13, figs 11, 12)

1960a *Deflandrea echinoidea* Cookson & Eisenack, p. 2, plate 1, figs 5, 6.
1976 *Spinidinium echinoideum* (Cookson & Eisenack) – Lentin & Williams, p. 64.
1978 *Vozzhennikovia echinoideum* (Cookson & Eisenack) – Stover & Evitt, p. 130.
2003 *Spinidinium*? *echinoideum* (Cookson & Eisenack) – Quattrocchio & Sarjeant, p. 136.

Age. LO: Selandian.

Remarks. Sluijs *et al.* (2009, p. 47) noted: "Both the holotype (Cookson & Eisenack 1960a, plate 1, Fig. 5) and specimens illustrated in Sverdlove & Habib (1974, plate 1, figs 3, 5, 6; text–fig. 1) show the 2a plate is isodeltaform to isothetaform. The 2a also remains attached to the 4′′ plate. Further the ornamentation is predominantly proximosutural. For the above reasons we include this species in *Spinidinium* without question."

Genus *Spiniferites* Mantell 1850
Type. Ehrenberg 1838, plate 1, fig. 5, as *Xanthidium ramosum*, designated by Davey & Williams (1966b, p. 32), as lectotype of *Hystrichosphaera ramosa*.

1850 *Spiniferites* Mantell, p. 191.
1933b *Hystrichosphaera* Wetzel, p. 33; name not validly published.
1937 *Hystrichosphaera* Wetzel ex Deflandre, p. 61.
1953 *Hystrichokibotium* Klumpp, p. 387.

Remarks. *Spiniferites* is characterised by having its gonyaulacoidean tabulation expressed by sutural ridges or membranes as well as gonal and sometimes sutural processes. Distally, the gonal processes are always trifurcate, and the sutural processes are always bifurcate. The archaeopyle is precingular, with formula $P_{3''}$, with a free operculum.

***Spiniferites ovatus* Matsuoka 1983**
(Plate 13, fig. 13)

1983 *Spiniferites ovatus* Matsuoka, p. 134, 135, plate 3, figs 1a–c, 2, 3a, b, 4a, b; text-fig. 19A, B.
non 1984 *Spiniferites ovatus* Bujak, p. 192, plate 3, figs 15–18; illegitimate junior homonym.

Age. LO: Messinian.

Remarks. *Spiniferites ovatus* differs from *Spiniferites pseudofurcatus* in having much shorter processes with shorter terminations.

***Spiniferites pseudofurcatus* (Klumpp 1953) Sarjeant 1970**
(Plate 13, fig. 14)

1953 *Hystrichokibotium pseudofurcatum* Klumpp, p. 388, plate 16, figs 12, 14.
1960 *Hystrichosphaera tertiaria* Eisenack & Gocht, p. 515; text-fig. 4.
1966b *Hystrichosphaera buccina* Davey & Williams, p. 42, 43, plate 4, fig. 1; text-figs 10, 11.
1969 *Hystrichosphaera pseudofurcata* (Klumpp) – Gocht, p. 32.
1970 *Spiniferites pseudofurcatus* (Klumpp) – Sarjeant, p. 76.

Age. LO in present study: late Serravalian. LO according to Piasecki (2003): Tortonian.

Remarks. *Spiniferites pseudofurcatus* differs from *Achomosphaera alcicornu* only in having the tabulation clearly expressed by ridges. Although so similar, the stratigraphic ranges of the two species differ considerably, with *Spiniferites pseudofurcatus* having a much younger LO.

***Spiniferites scabrosus* (Clarke & Verdier 1967) Lentin & Williams 1975**
(Plate 13, fig. 15)

1967 *Hystrichosphaera scabrosus* Clarke & Verdier, p. 49, 50, plate 9, figs 7–10; text-fig. 21.
1975 *Spiniferites scabrosus* (Clarke & Verdier) – Lentin & Williams, p. 2155.

Age. LO: Maastrichtian.

Remarks. The central body of *Spiniferites scabrosus* has a distinctive scabrate to granulate wall and bears long, slender processes. In some specimens, the sutural ridges or membranes are not obvious, but such forms are retained here in *Spiniferites scabrosus*.

Genus *Spongodinium* Deflandre 1936
Type. Ehrenberg 1838, plate 1, figs 1, 6, as *Peridinium delitiense*.

1936 *Spongodinium* Deflandre, p. 169, 170.

Synopsis. Gonyaulacacean (cribroperidinioid) cysts that are proximate, spheroidal to subpolyhedral, with a rounded antapex and usually an apical protrusion or horn. Acavate. The wall is complexly reticulate to vesiculate, and its total thickness is sometimes greater along the cingulum and at the poles. Wall atabulate or with structure/ornament arranged to reflect or suggest tabulation. Archaeopyle precingular, with formula $P_{3''}$, operculum free.

Remarks. The synopsis is similar to that provided by Fensome *et al.* (2009, p. 60). An ectophragm is not developed but may be partially simulated on the cyst outline by the outer margins of membranes that constitute the wall. The genus *Samlandia* is very similar in appearance to *Spongodinium*, but the precise morphology of the type is not clear from available illustrations (Eisenack 1954, plate 11, figs 12–15). However, an SEM micrograph of a specimen identified as *Samlandia chlamydophora* by one of the authors shows that an occasionally perforate ectophragm connects processes in all but the sutural areas. Such a morphology supports our interpretation that *Samlandia* can thus be differentiated from *Spongodinium*.

***Spongodinium delitiense* (Ehrenberg 1838) Deflandre 1936**
(Plate 13, figs 16, 20)

1838 *Peridinium delitiense* Ehrenberg, p. 110, plate 1, figs 1, 6.
1936 *Spongodinium delitiense* (Ehrenberg) – Deflandre, p. 170, 171.

Age. LO: early Danian.

Remarks. The Labrador Margin specimens of *Spongodinium delitiense* show considerable variation in size. The larger specimens have an LO in the Maastrichtian and the smaller ones range up into the Danian.

***Spongodinium grossum* (Manum & Cookson 1964) comb. nov.**
(Plate 14, figs 1–4)

1964 *Chlamydophorella grossa* Manum & Cookson, p. 17, 18, plate 5, figs 1, 2.
1986 *Chlamydophorella*? *grossa* Ioannides, p. 16.

Age. LO: Campanian.

Remarks. In a description of *Spongodinium* (as *Chlamydophorella*) *grossum*, Ioannides (1986, p. 16) stated: "Archaeopyle of dubious position, possibly precingular, type P (or 2P). Paracingulum often indicated by aligned processes, which may be joined proximally…." It is confirmed here that the archaeopyle is precingular, resulting from the loss of the 3′′ plate. The operculum is free. *Chlamydophorella* has an apical archaeopyle, so this species is transferred to *Spongodinium.*

M. Pearce (personal communication 2015) has drawn our attention to the similarity between *Spongodinium grossum* and *Isabelidinium*? *extremum*. The latter species has a precingular archaeopyle and an outer wall or periphragm that forms an apical horn and a discontinuous pericyst. Thus, this species should be retained as *Spongodinium*? *extremum*, a combination originally proposed by Lentin & Williams (1976). *Spongodinium grossum* and *Spongodinium*? *extremum* may be synonymous; the only obvious difference seems to be in the nature of the pericyst, which is more continuous and less perforate in *Spongodinium grossum.*

***Spongodinium obscurum* (Manum & Cookson 1964) comb. nov.**
(Plate 13, fig. 19)

1964 *Scriniodinium obscurum* Manum & Cookson, p. 21, 22, plate 4, figs 5, 6.
1978 *Scriniodinium*? *obscurum* (Manum & Cookson) – Stover & Evitt, p. 188.
2003 *Endoscrinium obscurum* (Manum & Cookson) – Riding & Fensome, p. 23.

Age. LO: Santonian.

Remarks. As demonstrated by Ioannides (1986, plates 5–8), intergradation exists between *Spongodinium (as Endoscrinium) obscurum, Spongodinium grossum* (as *Chlamydophorella grossa)* and a taxon that he called *Spongodinium* sp. In their description of *Endoscrinium obscurum*, Manum & Cookson (1964, p. 21) stated: "There are no distinct connections running between the capsule and the theca, but fine, irregular lines, the true nature of which is obscured by the many folds, may possibly represent supporting fibrils. The wall of the capsule is up to 1 μm thick and sometimes indistinctly dotted." The comments of Manum & Cookson (1964) and Ioannides (1986), together with observations in this study, indicate that the species should be assigned to *Spongodinium*, and that the wall is best considered a complex autophragm, rather than being holocavate.

Genus *Stichodinium* Williams *et al.* 2015
Type. He Chengquan & Wang Kede 1990, plate 2, fig. 3, as *Wilsonidium subtile.*

2015 *Stichodinium* Williams *et al.*, p. 314.

Remarks. Williams *et al.* (2015) erected the genus *Stichodinium* for wetzelielloidean cysts with a latiepeliform archaeopyle and sutural or penitabular ornamentation that may be features of low relief or processes that are distally free.

***Stichodinium lineidentatum* (Deflandre & Cookson 1955) Williams *et al.* 2015**
(Plate 13, figs 17, 18)

1955 *Wetzeliella lineidentata* Deflandre & Cookson, p. 253, 254, plate 5, fig. 5; text-figs 17, 18.
1976 *Wilsonidium lineidentatum* (Deflandre & Cookson) – Lentin & Williams, p. 139.
2015 *Stichodinium lineidentatum* (Deflandre & Cookson) – Williams *et al.*, p. 314.

Age. LO: Lutetian.

Remarks. The holotype of *Stichodinium lineidentatum* (Deflandre & Cookson 1955, plate 5, fig. 5) clearly shows a latiepeliform archaeopyle.

Genus *Subtilisphaera* Jain & Millepied 1973
Type. Jain & Millepied 1973, plate 3, fig. 31, as *Subtilisphaera senegalensis*.

1973 *Subtilisphaera* Jain & Millepied, p. 26, 27.

Remarks. Our concept of the genus *Subtilisphaera* adheres to the synopsis presented in Fensome *et al.* (2009), who acknowledged uncertainty in interpreting the archaeopyle. Lentin & Williams (1976, p. 118) considered that, where observable, *Subtilisphaera* has a combination archaeopyle, with the formula AIP$_{(3'+1-3a+3-5'')}$, the operculum remaining attached along the posterior margin. Stover & Evitt (1978, p. 238) considered the archaeopyle of *Subtilisphaera* to be "presumably intercalary". Bujak & Davies (1983, p. 62) observed specimens from the Early Cretaceous of offshore eastern Canada, which they attributed to *Subtilisphaera*, with complete or incomplete archaeopyle sutures between the following plates: 2′/1a, 3′/1a, 3′/2a, 3′/3a. 4′/3a and with complete or incomplete archaeopyle sutures between individual intercalary plates. These authors termed this a transverse archaeopyle.

***Subtilisphaera perlucida* (Alberti 1959) Jain & Millepied 1973**
(Plate 14, fig. 5)

1959 *Deflandrea perlucida* Alberti, p. 102, plate 9, figs 16, 17.
1959 *Deflandrea pirnaensis* Alberti, p. 100, plate 8, figs 1, 5.
1960 *Scriniodinium cooksoniae* Anderson, p. 30, plate 9, figs 1–3.
1973 *Subtilisphaera perlucida* (Alberti) – Jain & Millepied, p. 27.
1973 *Subtilisphaera pirnaensis* (Alberti) – Jain & Millepied, p. 27.
1990 *Subtilisphaera*? *pirnaensis* (Alberti) – Harker & Sarjeant in Harker *et al.*, p. 133.

Age. LO: Albian.

Remarks. Fensome *et al.* (2009, p. 61, 62) considered *Subtilisphaera pirnaensis* to be a taxonomic junior synonym of *Subtilisphaera perlucida*.

Genus *Surculosphaeridium* Davey *et al.* 1966 emend. nov.
Type. Sarjeant 1960, plate 6, fig. 2, as *Hystrichosphaeridium cribrotubiferum*.

1966 *Surculosphaeridium* Davey *et al.*, p. 160, 161.

Emended diagnosis. Chorate gonyaulacacean cysts with spheroidal central bodies. Acavate. Processes are solid and branched and/or distally furcate. There may be one to four processes per plate, sometimes forming complexes in cases where there is more than one process per plate. Archaeopyle apical, with the formula A$_{(1-4')}$; operculum free.

Remarks. *Surculosphaeridium* is emended to allow inclusion of forms with more than one process per plate. However, there must be processes or process complexes on all the plates, including the precingulars.

***Surculosphaeridium convocatum* sp. nov.**
(Plate 14, figs 6–8)

Holotype. Plate 14, fig. 7, from a cuttings sample at 3510–3520 m in South Labrador N-19, GSC type collection no. 138128, sample P39834, slide 01, coordinates 7.8 × 99.1, England Finder G29/3−H28/2. Central body length (without apical operculum) 30 µm, central body width 38 µm, processes up to about 12 µm. The sample from which the holotype derives is dated as Barremian−Aptian, indicating that the specimen represents caving.

Etymology. The epithet is from the Latin *convocatum*, to call together or assemble, in reference to the grouping of several processes per plate common in this species.

Diagnosis. A species of *Surculosphaeridium* in which at least the larger plates have more than one and up to four processes per plate. Processes may branch along their length and are always furcate distally.

Size. Central body length (without apical operculum) 29−34 µm, central body width 30−38 µm, processes up to about 15 µm; three specimens measured.

Age. LO: early Campanian. Not plotted.

Remarks. Some plates, especially smaller ones such as cingulars, sulcals and apicals, may have only one process per plate, but others have two to four. Processes are characteristically furcate distally. *Surculosphaeridium longifurcatum* has one process per plate.

Genus *Talladinium* Williams, Damassa, Fensome & Guerstein in Fensome *et al.* 2009
Type. Mao Shaozi & Norris 1988, plate 13, fig. 6, as *Charlesdowniea wulagense.*

2009 *Talladinium* Williams, Damassa, Fensome & Guerstein in Fensome *et al.*, p. 61, 62.

Remarks. Williams, Damassa, Fensome & Guerstein in Fensome *et al.* (2009) erected the genus *Talladinium* for wetzelielloidean cysts with a soleiform archaeopyle and processes that are distally united by ectophragmal membranes that delineate the tabulation.

***Talladinium*? *clathratum* (Eisenack 1938) Williams, Damassa, Fensome & Guerstein in Fensome *et al.* 2009**
(Plate 14, figs 9, 10)

1938 *Wetzeliella clathrata* Eisenack, p. 187; text-fig. 5.
1976 *Kisselevia*? *clathrata* (Eisenack) – Lentin & Williams, p. 136.
1989 *Charlesdowniea clathrata* (Eisenack) – Lentin & Vozzhennikova, p. 227.
2009 *Talladinium*? *clathratum* (Eisenack) – Williams, Damassa, Fensome & Guerstein in Fensome *et al.*, p. 62.

Age. LO: latest Bartonian. Not plotted.

Remarks. As noted in Fensome *et al.* (2009, p. 62), the nature of the peri- and endoarchaeopyles in *Talladinium*? *clathratum* can not be ascertained from the original description of Eisenack (1938) or the expanded description of Eisenack (1954). From the late Eocene to early Oligocene age of the type material, however, it seems reasonable to deduce that this species has a soleiform archaeopyle. This explains why the species is questionably included in *Talladinium*.

***Talladinium pellis* sp. nov.**
(Plate 14, figs 11, 12, 16)

Holotype. Plate 14, figs 11, 12, from a cuttings sample at 1840 m in Gjoa O-37, GSC type collection no. 138082, sample YD16082, slide 03, coordinates 050 × 0907, England Finder E20/3. Size: pericyst length 94 µm, width 76 µm; endocyst length 61 µm, width 57 µm. The age determined for the sample from which the holotype was recovered is late Ypresian.

Etymology. The epithet is from the Latin *pellis*, meaning skin, in reference to the ectophragm, which surrounds most of the pericyst. It is a noun in apposition.

Diagnosis. A species of *Talladinium* in which processes of individual plates are distally united by a membrane that mimics the outline of the underlying plate. The ectophragm may be irregularly or regularly perforate.

Size. Pericyst length 89−94 µm, width 76−81 µm; endocyst length 61 µm (both specimens), width 57−64 µm; two specimens measured.

Age. LO: Priabonian.

Remarks. The ectophragmal membranes in *Talladinium pellis* form linear complexes that mirror the outline of the reflected plates, rather than forming a shield-like covering as in *Talladinium*? *clathratum.* This difference is not always easy to determine. *Charlesdowniea coleothrypta* has identical ornamentation but differs in having an equiepeliform archaeopyle.

Genus *Tanyosphaeridium* Davey & Williams 1966a
Type. Davey & Williams 1966a, plate 6, fig. 7, text-fig. 20, as *Tanyosphaeridium variecalamum*.

1966a *Tanyosphaeridium* Davey & Williams, p. 98.

Remarks. *Tanyosphaeridium* is characterised by an elongate ellipsoidal central body, slender open processes and an apical archaeopyle. The processes number about 30 or more and cannot be readily related to tabulation.

***Tanyosphaeridium xanthiopyxides* (Wetzel 1933a ex Deflandre 1937) Stover & Evitt 1978**
(Plate 15, fig. 7)

1933a *Hystrichosphaera xanthiopyxides* Wetzel, p. 44, 45, plate 4, fig. 25 (name not validly published).
1937 *Hystrichosphaeridium xanthiopyxides* Wetzel ex Deflandre, p. 77.
1965 *Baltisphaeridium xanthiopyxides* (Wetzel ex Deflandre) – Downie & Sarjeant, p. 98.
1968 *Hystrichosphaeridium*? *xanthiopyxides* (Wetzel ex Deflandre) – Morgenroth, p. 556.
1969 *Prolixosphaeridium*? *xanthiopyxides* (Wetzel ex Deflandre) – Davey *et al.*, p. 17.
1978 *Tanyosphaeridium xanthiopyxides* (Wetzel ex Deflandre) – Stover & Evitt, p. 85.

Age. LO: Danian.

Remarks. Fensome *et al.* (2009, p. 62) is followed here in using the earliest proposed name, *Tanyosphaeridium xanthiopyxides*, for all the Late Cretaceous – Paleocene forms of *Tanyosphaeridium*.

Genus *Taurodinium* gen. nov.
Type. Plate 14, fig. 13, as *Taurodinium granulatum.*

Etymology. The name derives from the Latin *taurus,* meaning bull, in reference to the two prominent apical horns.

Description. Dorso-ventrally compressed ceratiacean cysts with an autocyst having six horns: two apical, two lateral and two antapical, all with closed, acuminate to slightly rounded terminations. Autophragm smooth to finely granulate or perforate and very thin. Paratabulation not expressed. Cingulum may be indicated above the two lateral horns but there is no indication of a sulcus. Archaeopyle apical with a straight to weakly angular margin; operculum usually attached.

Remarks. *Nyktericysta* and *Vesperopsis* have the same thin and fragile appearance as *Taurodinium*, but have only a single apical horn. *Satyrodinium* Lentin & Manum 1986, has two to three apical and one or more antapical horns, but is a peridiniacean cyst with an intercalary archaeopyle, lacks lateral horns, and is cavate. The acritarch genus *Limbicysta* Marshall 1989, from Upper Cretaceous nonmarine to nearshore environments, has an elongate split protrusion at one end that shows some resemblance to the apical horns of *Taurodinium* but *Limbicysta* lacks a regular opening and other protrusions.

***Taurodinium granulatum* sp. nov.**
(Plate 14, figs 13–15, 17, 18)

1992 Gen. et sp. indet. Piasecki *et al.*, fig. 6L, M.
1995 *Nyktericysta* sp. Gregory & Hart, plate 7, figs 6, 7.
2011 Gen. et sp. indet. Piasecki *et al.* 1992 – Nøhr-Hansen *et al.*, figs 3, 4.
2012 Gen. et sp. indet. Piasecki *et al.* 1992 – Nøhr-Hansen, plate X, figs 12–19.

Holotype. Plate 14, fig. 13, from a cuttings sample at 2340 m in Ikermiut-1, offshore West Greenland, MGHU no. 31333, sample Ikermiut 2289, slide s-261-3, England Finder T19-1. Size: overall length 105 μm, length of body 54 μm, body width 35 μm, length of apical horns up to 30 μm, length of lateral horns 13 μm, length of antapical horns 22 μm, wall less than 1 μm thick. The age determined for the sample from which the holotype was recovered is late Thanetian.

Etymology. The epithet is from the Greek *granulatum* meaning granulate, in reference to the surface ornamentation.

Description. A species of *Taurodinium* with two apical horns of approximately equal length, two short lateral horns and two antapical horns of unequal length with the left being the longer. The antapical horns narrow at about one-third along their length. Autophragm smooth to finely granulate, thin, hyaline and often wrinkled. The apical horns appear to be oriented in a plane perpendicular to that of the other horns, giving the cyst a twisted look.

Size. Overall length 75–105 μm, length of body 40–70 μm, body width 28–60 μm, length of apical horns 15–25 μm, length of lateral horns 7–17 μm, length of antapical horns 10–32 μm; seven specimens measured.

Age. LO: Bartonian; peak early Ypresian.

Remarks. *Taurodinium granulatum* was originally recorded as 'Gen. et sp. indet.' by Piasecki *et al.* (1992) from a miospore-dominated palynological assemblage devoid of other dinocysts. The assemblage was from a silty shale clast in subaqueous volcanic breccias from the lower Rinks Dal Member, Maligât Formation, West Greenland; the basalts were radiometrically dated as 61.2 ± 0.4 Ma, and thus of Selandian age (Larsen *et al.* 2015). Gregory & Hart (1995) recorded a specimen of *Nyktericysta* sp. that may be assignable to *Taurodinium granulatum* from sediments dated as Thanetian. Nøhr-Hansen *et al.* (2011) recorded Gen. et sp. indet. of Piasecki *et al.* (1992) from Thanetian – lower? Ypresian non-marine or marginal marine deposits of north-eastern Greenland. Recently, this species has been found to be common in the Thanetian−Ypresian non-marine or marginal marine Kulhøje Member in the Kangerlussuaq Basin, south-eastern Greenland (Nøhr-Hansen 2012). In the present study, *Taurodinium granulatum* was encountered in wells on the West Greenland continental margin in samples together with the Late Paleocene marker *Axiodinium augustum*, as well as in samples of Ypresian age from the Saglek Basin. However, the species has been mostly recorded from spore-dominated or marginal marine, algae-dominated assemblages. We thus follow Nøhr-Hansen (2012) in regarding it as a freshwater to brackish-water indicator.

Genus *Tenua* Eisenack 1958
Type. Eisenack 1958, plate 23, fig. 1, as *Tenua hystrix.*

1958 *Tenua* Eisenack, p. 410.
1981 *Cerbia* Below, p. 8.

Remarks. The genus is distinguished from *Cyclonephelium* (incorporating *Circulodinium*) by having some processes showing alignment in penitabular rows. *Aptea* differs in having three horns – an apical, an antapical, and a third, probably postcingular – of variable development; the probable postcingular horn is always reduced. *Cerbia* is considered here to be a taxonomic junior synonym of *Tenua.*

***Tenua hystrix* Eisenack 1958**
(Plate 14, figs 19, 20)

1958 *Tenua hystrix* Eisenack, p. 410, plate 23, figs 1–4; text-fig. 10.
1972 *Tenua hystricella* Eisenack & Kjellström, p. 1039.
1978 *Cyclonephelium hystrix* (Eisenack) – Davey, p. 894.

Age. LO: late Aptian.

Remarks. Sarjeant (1985b, p. 94, 95) retained this species in *Tenua*. The distribution of processes in this species is variable. The material in this study includes forms in which processes are largely absent on mid-ventral and mid-dorsal surfaces (for example that shown in Plate 14, fig. 19).

Genus *Thalassiphora* Eisenack & Gocht 1960
Type. Eisenack 1954, plate 12, fig. 17, as *Pterospermopsis pelagica.*

1960 *Thalassiphora* Eisenack & Gocht, p. 513.
1966a *Erikania* Morgenroth, p. 27.
1980 *Subathua* Khanna & Singh, p. 307, 308.

Remarks. Fensome *et al.* (2009, p. 62) provided a comprehensive synopsis for *Thalassiphora* based on the emendations of the genus by Williams & Downie (1966a, p. 234), Gocht (1968, p. 153) and Benedek & Gocht (1981, p. 59).

***Thalassiphora delicata* Williams & Downie 1966a**
(Plate 15, fig. 1)

1966a *Thalassiphora delicata* Williams & Downie, p. 235, plate 26, fig. 8.
1973 *Disphaeria delicata* Norvick, p. 43.

Age. LO: middle Bartonian. Not plotted.

Remarks. Lentin & Williams (1977a, p. 54) retained this species in *Thalassiphora*.

***Thalassiphora fenestrata* Liengjarern *et al.* 1980**
(Plate 15, figs 2–4)

1980 *Thalassiphora fenestrata* Liengjarern *et al.*, p. 489, plate 54, fig. 1.

Age. LO: earliest Rupelian.

Remarks. *Thalassiphora fenestrata* has large fenestrations, which are restricted to lateral and ventral areas of the pericyst. Liengjarern *et al.* (1980, p. 489) considered its stratigraphic range to be late Eocene to early? Oligocene.

***Thalassiphora pelagica* (Eisenack 1954) Eisenack & Gocht 1960**
(Plate 15, figs 5, 6)

1954 *Pterospermopsis pelagica* Eisenack, p. 71, plate 12, figs 17, 18.
1960 *Thalassiphora pelagica* (Eisenack) – Eisenack & Gocht, p. 513, 514.
1966 *Thalassiphora sueroi* Pöthe de Baldis, p. 224, 225, plate 2, fig. d.
1973 *Disphaeria pelagica* (Eisenack) – Norvick, p. 46.
1981 *Disphaeria sueroi* (Pöthe de Baldis) – Yun Hyesu, p. 70.

Age. LO: Chattian.

Remarks. Lentin & Williams (1977a, p. 54) retained this species in *Thalassiphora*.

Genus *Trichodinium* Eisenack & Cookson 1960
Type. Eisenack & Cookson 1960, plate 2, fig. 4, as *Trichodinium pellitum*.

1960 *Trichodinium* Eisenack & Cookson, p. 5.

Remarks. *Trichodinium* is a spheroidal to ovoidal proximate gonyaulacacean cyst that apically can have a horn or several spines. The autophragm may be tabulate, as determined from the alignment of some of the numerous short spines or bifid processes. Its surface has been described as fibro-pitted (see Fensome *et al.* 2009, p. 64). The archaeopyle is precingular, with the formula $P_{3''}$; the operculum is free. Fensome *et al.* (2009, p. 64) discussed the morphological similarity between *Trichodinium* and *Xenicodinium* Klement 1960. They recommended that *Xenicodinium* should be restricted to its type material and all forms with the appropriate morphology should be included in *Trichodinium*.

Trichodinium castanea **Deflandre 1935 ex Clarke & Verdier 1967**
(Plate 15, fig. 8)

1935 *Palaeoperidinium castanea* Deflandre, p. 229, plate 6, fig. 8; name not validly published.
1967 *Trichodinium castanea* (Deflandre) – Clarke & Verdier, p. 19, 20.

Age. LO: Campanian.

Remarks. Some tabulation can usually be discerned on *Trichodinium castanea*, which is also distinguished by its dense covering of short, acuminate to bifid spines.

Genus *Trithyrodinium* Drugg 1967
Type. Drugg 1967, plate 3, fig. 2, as *Trithyrodinium evittii.*

1967 *Trithyrodinium* Drugg, p. 20.

Synopsis. Peridiniacean (deflandreoid) cysts that are proximate and rounded to peridinioid in shape, with an antapex that is rounded, symmetrical or, more usually weakly to strongly asymmetrical, the left side being larger; endophragm rounded pentagonal to subcircular in dorso-ventral outline. Cavate; endocyst sometimes strongly developed with a fragile or thin-walled periphragm that is easily lost. Archaeopyle intercalary, with formula $I_{(1–3a)}$; operculum free, compound. Plate 2a is always iso- to stenodeltaform.

Remarks. The synopsis is largely a repeat of that provided by Fensome *et al.* (2009, p. 64), though with the concept broadened to include rounded forms and to recognise that the pericyst may be durable. The 2a plate, which is revealed through archaeopyle development, can show some variation in width but is always deltaform. The genus *Pierceites* also has a 3I archaeopyle but the endocyst is absent or weakly developed.

Trithyrodinium*? *conservatum **sp. nov.**
(Plate 15, figs 9–14)

2003 *Deflandrea* sp.1 Nøhr-Hansen, plate 3, figs 4–6.

Holotype. Plate 15, fig. 12 and Nøhr-Hansen (2003, plate 3, fig. 6), from a sidewall-core sample at 1155 m in Ikermiut 1, MGHU no. 26502, sample 04E006504, slide 2, co-ordinates 36.0 × 97.1, England Finder U36/1. Pericyst length 60 µm, width 63 µm, endocyst length 44 µm, width 52 µm. The age determined for the sample from which the holotype was recovered is Lutetian.

Etymology. The epithet is from the Latin *conservatus*, meaning retain or conserve, in reference to the constant presence of the pericyst.

Description. A species of *Trithyrodinium* with a commonly rounded but sometimes ovoidal pericyst that is always present. The endocyst generally mimics the shape of the pericyst. As a rule the cyst is circumcavate, but the endocyst may occasionally be in partial contact with the pericyst. The periphragm and endophragm are both thin, at the most slightly over 1 µm thick. The periphragm varies from laevigate (the usual condition), to faintly granulate or verrucate. The I to 3I archaeopyle is formed from the loss of one to three intercalary plates individually, any of which can remain attached posteriorly.

Size. Pericyst length 48–60 µm, width 49–65 µm, endocyst length 44–51 µm, width 43–56 µm; seven specimens measured.

Age. LO: Lutetian. Not plotted.

Remarks. *Trithyrodinium*? *conservatum* is unusual in that the pericyst is always preserved. When the pericyst has a subdued granulate or verrucate ornamentation, this tends to be restricted to the mid-dorsal and mid-ventral regions. Folds are consistently present on the pericyst but appear to be random. The exact nature of the archaeopyle is unclear. In some specimens its polygonal shape appears to indicate that multiple plates are missing, but in others it appears to reflect loss of a single intercalary plate. Because of the uncertainty regarding the archaeopyle, the species is only assigned questionably to *Trithyrodinium*.

Trithyrodinium evittii **Drugg 1967**
(Plate 15, figs 17–19)

1967 *Trithyrodinium evittii* Drugg, p. 20, plate 3, figs 2, 3; plate 9, fig. 2.
1969b *Trithyrodinium fragile* Davey, p. 11, plate 3, figs 6, 9.

Age. LO: Danian.

***Trithyrodinium quinqueangulare* Marheinecke 1992**
(Plate 15, fig. 16)

1992 *Trithyrodinium quinqueangulare* Marheinecke, p. 95, plate 19, figs 9–11.

Age. LO: Maastrichtian.

Remarks. *Trithyrodinium quinqueangulare* has a pericyst and endocyst, which are sometimes closely appressed. Both pericyst and endocyst are pentagonal and have two more or less equal antapical protuberances. The cingulum is clearly delineated. Plate 4´´ is reduced in an anterior–posterior direction. Some of the Labrador Margin specimens have a verrucate endophragm.

***Trithyrodinium suspectum* (Manum & Cookson 1964) Davey 1969b**
(Plate 15, fig. 15)

1964 *Hexagonifera suspectum* Manum & Cookson, p. 9, 10, plate 1, figs 9–13.
1969b *Trithyrodinium suspectum* (Manum & Cookson) – Davey, p. 12.

Age. LO: Campanian.

Remarks. *Trithyrodinium suspectum* has a thick granular endophragm, which appears to be tectate. The archaeopyle may form from the detachment of the 1a and 3a plates, whereas the 2a plate can remain attached posteriorly, along its boundary with the 4´´ plate. One specimen of *Trithyrodinium suspectum* illustrated in Manum & Cookson (1964, plate 1, fig. 11) has a stenodeltaform 2a plate rather than the more commonly observed isodeltaform 2a.

Genus *Tuberculodinium* Wall 1967
Type. Rossignol 1962, plate 2, fig. 1, as *Pterospermopsis*? *vancampoae.*

1967 *Tuberculodinium* Wall, p. 114.

Synopsis. Goniodomacean (gambierdiscoid) cysts proximate, preicyst and endocyst both discoidal to subspheroidal. Holocavate. Numerous intratabular pillar- to barrel-shaped processes support an ectophragm. Archaeopyle antapical, involving usually 2–3 paraplates, operculum free, compound.

Remarks. *Tuberculodinium* represents the cysts of *Pyrophacus*, with its multiplate tabulation; the ectophragmal supports (processes), although numerous, can be readily interpreted as intratabulate.

***Tuberculodinium vancampoae* (Rossignol 1962) Wall 1967**
(Plate 15, fig. 20)

1962 *Pterospermopsis*? *vancampoae* Rossignol, p. 134, plate 2, fig. 1.
1967 *Tuberculodinium vancampoae* (Rossignol) – Wall, p. 114, 115.
1971 *Pyrophacus vancampoae* (Rossignol) – Wall & Dale, p. 234.

Age. LO: Tortonian?

Remarks. Head (1996, p. 1232) retained this species in *Tuberculodinium*.

Genus *Vesperopsis* Bint 1986
Type. Bint 1986, plate 5, figs 9, 12–13; text-fig. 5, as *Vesperopsis mayii*.

1986 *Vesperopsis* Bint, p. 156.

Remarks. *Vesperopsis* is a proximate ceratiacean cyst with an autophragm that has at least three horns – one apical and two antapical. Commonly, it may also have equatorial horns with or without pre- and postcingular branches. The archaeopyle is apical, with the formula $A_{(1–4')}$; the operculum is usually attached. *Vesperopsis* was emended by Qiao Xiuyun *et al.* (1992, p. 32, 33, 36, 37), Wan Chuanbiao & Qiao Xiuyun (1994, p. 503) and Mao Shaozhi *et al.* (1999, p. 149, 150). However, we adhere to the synopsis of Fensome *et al.* (2009, p. 65).

***Vesperopsis longicornis* (Batten & Lister 1988) Harding 1990**
(Plate 16, figs 1, 2)

1988 *Australisphaera longicornis* Batten & Lister, p. 340, 341, fig. 1b–e, g.
1990 *Vesperopsis longicornis* (Batten & Lister) – Harding, p. 21.

Age. LO: Albian.

Remarks. Harding (1990, p. 21) emended the diagnosis of *Vesperopsis longicornis*, based on it having an autophragm and an attached operculum. According to Harding, an unusual aspect of *Vesperopsis longicornis* is that the operculum appears to be attached dorsally; operculum attachment in ceratiacian cysts, where present, is almost always ventral.

Genus *Wallodinium* Loeblich Jr. & Loeblich III 1968
Type. Cookson & Eisenack 1960b, plate 39, fig. 4, as *Diplotesta glaessneri.*

1960b *Diplotesta* Cookson & Eisenack, p. 256; name illegitimate.
1968 *Wallodinium* Loeblich Jr. & Loeblich III, p. 212.

Synopsis. Proximate gonyaulacalean cyst, elongate crescent-shaped to subcylindrical. Bicavate, circumcavate or epicavate. Pericyst much longer than endocyst; both bodies generally rounded apically and antapically, although the endocyst may have short horns. Tabulation indicated by apical archaeopyle, with inferred formula of $A_{(1-4')}$; peri- and endoarchaeopyle free or attached. Sometimes an equatorial constriction or ornamentation alignment marks a cingulum. Wall smooth or with ornamentation of low relief.

Remarks. *Wallodinium* was considered to be an acritarch by Duxbury (1983, p. 68) and Fensome *et al.* (1990, p. 535). However, Riding (1994, p. 17, 18) emended the diagnosis to include reference to the indications of gonyaulacalean tabulation and the presence of an apical archaeopyle; the above synopsis is based on Riding's emendation.

***Wallodinium luna* (Cookson & Eisenack 1960a) Lentin & Williams 1973**
(Plate 16, fig. 5)

1960a *Diplotesta luna* Cookson & Eisenack, p. 10, 11, plate 3, fig. 21.
1973 *Wallodinium luna* (Cookson & Eisenack) – Lentin & Williams, p. 140.
Age. LO: Campanian.

Genus *Wetzeliella* Eisenack 1938 emend. Williams, Damassa, Fensome & Guerstein in Fensome *et al.* 2009
Type. Eisenack 1938, fig. 4, as *Wetzeliella articulata*.

1938 *Wetzeliella* Eisenack, p. 187.
1979 *Gochtodinium* Bujak, p. 310–312.
2009 *Wetzeliella* Eisenack – emend. Williams, Damassa, Fensome & Guerstein in Fensome *et al.*, p. 65.

Synopsis. Wetzelielloidean cysts with a soleiform archaeopyle and processes that are predominantly nontabular, although they can show some alignment, and are distally free.

***Wetzeliella articulata* Wetzel in Eisenack 1938 emend. Williams, Damassa, Fensome & Guerstein in Fensome *et al.* 2009**
(Plate 16, figs 3, 4)

1938 *Wetzeliella articulata* Wetzel in Eisenack, p. 187, text fig.4.
1938 *Palaeoperidinium articulatum* Wetzel in Eisenack, p. 187 (name not validly published).
1948 *Hystrichosphaeridium articulatum* (Wetzel in Eisenack) – Pastiels, p. 42.
1960 *Wetzeliella echinulata* Vozzhennikova, plate 3, fig. 3 (name not validly published).
1967 *Rhombodinium coronatum* Vozzhennikova, p. 170, 171, plate 89, figs 1–3, 5; plate 90, figs 1–5.
1967 *Wetzeliella echinulata* Vozzhennikova, p. 164, 165.
1975 *Wetzeliella horrida* Jan du Chêne & Châteauneuf, p. 28, 30, plate 1, figs 1–7; plate 3, figs 1–6.
1976 *Wetzeliella coronata* (Vozzhennikova) – Lentin & Williams, p. 131.

Age. LO: Rupelian. Not plotted.

Remarks. According to the literature, *Wetzeliella articulata* has a stratigraphic range of Eocene–Oligocene. But when the species is restricted to wetzeleilloideans with a soleiform archaeopyle, intratabular processes and five horns, its stratigraphic range is more restricted, being Bartonian to Rupelian.

Genus *Xenascus* Cookson & Eisenack 1969
Type. Cookson & Eisenack 1969, fig. 1I, J, as *Xenascus australensis*.

1969 *Xenascus* Cookson & Eisenack, p. 7.

Remarks. Fensome *et al.* (2009, p. 67) provided a comprehensive synopsis of *Xenascus* in which they referred to lateral rather than postcingular, horn(s) because they seem to emanate from the cingulum as well as postcingular areas. Fensome *et al.* (2009) also discussed the emendations of Yun Hyesu (1981, p. 60) and Stover & Helby (1987, p. 128).

Xenascus ceratioides **(Deflandre 1937) Lentin &Williams 1973**
(Plate 16, figs 9, 10)

1937 *Hystrichosphaera ceratioides* Deflandre, p. 66, 67, plate 12 (also labelled as plate 9), figs 7, 8.
1967 *Pseudoceratium ceratioides* (Deflandre) – Clarke & Verdier, p. 60.
1970 *Spiniferites ceratioides* (Deflandre) – Sarjeant, p. 76.
1971 *Phoberocysta ceratioides* (Deflandre) – Davey & Verdier, p. 26.

Age. LO: Campanian.

Remarks. *Xenascus ceratioides* has three horns: one apical, one lateral and one antapical. The horns are not perforated.

Xenascus wetzelii **Slimani 1996 ex Slimani 2001a**
(Plate 16, figs 6–8)

1985 *Odontochitina wetzelii* Wilson in Foucher in Robaszynski *et al.*, p. 33, plate 10, figs 9–12; name not validly published.
1996 *Xenascus wetzelii* Slimani, p. 380, 381, plate 3, figs F, G; plate 4, figs A, B; text-fig. 7A, B; name not validly published.
2001a *Xenascus wetzelii* Slimani 1996 ex Slimani, p. 9, plate 2, figs 3, 4.

Age. LO: Campanian.

Remarks. *Xenascus wetzelii* is cornucavate to circumcavate. It has a long postcingular horn and a long antapical horn, both of which are perforate distally and can be acuminate or bifurcate at their extremities. Tabulation is clearly shown by parasutural crests and gonal processes, the latter being acuminate, bifurcate or trifurcate. Slimani (2001a, p. 9; 2001b, p. 194) considered *Odontochitina wetzelii* to be a taxonomic junior synonym of *Xenascus wetzelii*.

Systematics – acritarchs and other algae

Genus *Fromea* (Cookson & Eisenack 1958) Yun Hyesu 1981
Type. Cookson & Eisenack 1958, plate 5, fig. 10, as *Fromea amphora.*

1958 *Fromea* Cookson & Eisenack, p. 55.
1973 *Xenascus ceratioides* (Deflandre) – Lentin & Williams, p. 144.

Remarks. Although many workers assign *Fromea* to the dinoflagellates, some (e.g. Duxbury 1980, p. 134; Fensome *et al.* 1990, p. 227; Fensome & Williams 2004, p. 742) consider it to lack unequivocal morphological indications of dinoflagellate affinity and thus prefer to consider it an acritarch.

Fromea nicosia **Jansonius 1989**
(Plate 16, fig. 19)

1989 *Fromea nicosia* Jansonius, p. 67, plate 1, figs 2–7; text-fig. 1.

Age. LO: early Campanian.

Fromea quadrangularis **sp. nov.**
(Plate 16, figs 11, 12, 15, 16)

Holotype. Plate 16, fig. 16, from a cuttings sample at 2375 m in Skolp E-07, MGUH no. 31352, sample YD15665, slide 04, co-ordinates 30.9 × 111.9, England Finder D31-1. Overall length 88 µm; maximum width 35 µm; minimum width 27 µm; wall thickness 1 µm.

The age determined for the sample from which the holotype was recovered is early Campanian, Late Cretaceous.

Etymology. The epithet is from the Latin words *quadra,* meaning four and *angularis*, having angles, in reference to the quadrangular shape of specimens of this species.

Diagnosis. A slender elongate rectangular species of *Fromea* with a thin smooth wall and generally two longitudinal folds. Where present, the folds start at the antapex and continue along the body to the circular 'apical' opening. No accessory opening sutures or equatorial 'girdle' have been observed.

Size. Overall length 77–101 µm; maximum width 30–45 µm; minimum width 27–37 µm; seven specimens measured.

Age. LO: early Campanian.

Remarks. Some specimens of *Fromea quadrangularis* are twisted, resulting in an elongate jar-like shape with longitudinal folds; other specimens have been slightly compressed, resulting in a weak equatorial extension and a splitting of the elongate folds.

Genus *Microsphaeridium* Benedek 1972
Type. Benedek 1972, plate 12, fig. 3a, b, as *Microsphaeridium ancistroides*.

1972 *Microsphaeridium* Benedek, p. 46, 47.

Remarks. Benedek & Sarjeant (1981, p. 346, 347) interpreted *Microsphaeridium ancistroides* as "the detached opercula of skolochorate dinoflagellate cysts." Pending further investigation, we prefer to consider *Microsphaeridium* to be an acritarch.

***Microsphaeridium ancistroides* Benedek 1972**
(Plate 16, figs 13, 14, 17, 18)

1972 *Microsphaeridium ancistroides* Benedek, p. 47, plate 12, fig. 3a, b; text-fig. 21.
Age. LO: middle Miocene or younger; not well constrained. Not plotted.

Genus *Palambages* Wetzel 1961
Type. Wetzel 1961, plate 1, fig. 11, as *Palambages morulosa*.

1961 *Palambages* Wetzel, p. 338.

Remarks. Wetzel (1961) noted that the microfossils assigned to *Palambages* are identical to forms recorded as "Morulosae" in Wetzel (1933a, p. 23, 24, plate 4, figs 1–5). Wetzel (1933a) had compared these fossils with certain colonial algae, but noted their likeness to the egg-balls of planktonic crustaceans. Manum & Cookson (1964, p. 23) considered them to represent colonies of green algae.

***Palambages* spp.**
(Plate 16, fig. 20)

Age. Range not determined. Not plotted.

Genus *Paralecaniella* Cookson & Eisenack 1970a
Type. Deflandre & Cookson 1955, plate 9, fig. 6, as *Epicephalopyxis indentata*.

1970a *Paralecaniella* Cookson & Eisenack, p. 323.

Remarks. Understanding of this genus, which is abundant in what seem to be shallow-water environments, is tenuous. Elsik (1977, p. 96), who emended the diagnosis of the genus and the type, considered *Paralecaniella* to be a dinocyst. We agree with Fensome *et al.* (2009, p. 67) that it is probably an algal cyst of non-dinoflagellate affinity.

***Paralecaniella indentata* (Deflandre & Cookson 1955) Cookson & Eisenack 1970a**
(Plate 17, figs 1, 2)

1955 *Epicepholopyxis indentata* Deflandre & Cookson, p. 292, plate 9, figs 5–7; text-fig. 56.
1970a *Paralecaniella indentata* (Deflandre & Cookson) – Cookson & Eisenack, p. 323.
1973 *Scriniodinium*? *nilsii* Kjellström, p. 42, fig. 35.

Age. Peak occurrence within the earliest Ypresian.

Remarks. The peak occurrence of *Paralecaniella indentata* is close to the Paleocene–Eocene boundary.

Genus *Pediastrum* Meyen 1829
Type. Meyen 1829, plate 43, figs 6–20, as *Pediastrum duplex*.

1829 *Pediastrum* Meyen, p. 772.

Remarks. *Pediastrum* is a nonmotile coenobial green alga that is found in freshwater environments.

***Pediastrum* spp.**
(Plate 17, figs 3, 4)

Age. Range not determined. Not plotted. The range of the genus extends from Early Cretaceous to Recent (Batten 1996).

Remarks. The presence of *Pediastrum* spp. in some of the samples from marine deposits in the offshore wells is indicative of offshore transport of freshwater elements.

Genus *Tetraporina* Naumova 1939
Type. *Tetraporina antiqua* Naumova 1950, designated by Potonié (1960, p. 130).

1939 *Tetraporina* Naumova, p. 357.
1956 *Tetrapidites* Klaus in Meyer, p. 107.
1960 *Tetraporopollenites* Frantz, p. 559.
1963 *Balmeella* Pant & Mehra, p. 116.
1980 *Tetraporina* Naumova – emend. Lindgren, p. 346.

Synopsis. Acid resistant, unicellular, tetrahedral or parallelepipedal microfossils with or without obvious pore or other dehiscence mechanism. Wall single or double layered.

Remarks. Described originally as representing pollen, Hemer & Nygreen (1967) considered *Tetraporina* to be an algal genus, and it has been considered generally to represent the acritarchs or algae since then. The above synopsis largely follows the emended diagnosis of Lindgren (1980). Recognition of *Tetaporina* is based mainly on its distinctive tetrahedral or parallelepipedal shape (a parallelepiped is a geometric figure with six faces, all parallelograms and all opposite faces being similar and parallel). Although most commonly related to modern zygospores of the Zygnemataceae, Lindgren (1980) considered *Teraporina* to be polyphyletic and difficult to match with particular modern algae because of its simple shape, rigours of preservation and ontogenetic factors. Most algae to which *Tetraporina* can be related are freshwater. The stratigraphic range of the genus extends from Carboniferous to Quaternary.

There has been considerable debate about the nomenclatural status of *Tetraporina*. Jansonius & Hills (1981, card 3917) considered that the name was not validly published in Naumova (1939) because it was proposed in anticipation of future acceptance of the name (see McNeill *et al.* 2012, Article 36.2). However, the case for this has not proved compelling for other authors (Lindgren 1980; Farr & Zijlstra 1996). Although both sets of arguments have merit, for pragmatic reasons, here we accept *Tetraporina* as valid in Naumova (1939).

***Tetraporina* sp. A**
(Plate 17, figs 5–7)

Description. A form of *Tetraporina* with a tetrahedral outline and indentations at the apices, although these are not clearly perforated by pores. The apices have no, or only short, extensions. The wall surface is smooth or has subdued ornament such as small verrucae. This form may correspond with one or more of the species described by Lindgren (1980), but morphological overlap, preservation and flexibility of the wall, and the quality of Lindgren's illustrations make comparison difficult.

Age. LO: earliest Rupelian.

***Tetraporina*? sp. B**
(Plate 17, figs 8–12)

Description. A form with broad truncated extensions at each of the four apices. The extensions may be relatively short and converge on a central rhombic area, or they may just converge centrally without the development of a central rhombic area, in which case the entire specimen is essentially a cross-like structure. *Tetraporina* does not typically have extensions, so this form is only tentatively associated with that genus.

Age. Not plotted.

Systematics – miospores and fungal elements

Miospores

Genus *Afropollis* Doyle *et al.* 1982
Type. Brenner 1968, plate 10, fig. 5, as *Reticulatosporites jardinus*.

1982 *Afropollis* Doyle *et al.*, p. 44.

***Afropollis* sp.**
(Plate 17, figs 18, 19)

Remarks. This form is assigned to *Afropollis* because of its possession of a network of reticulate to regulate muri separated from the nexine. The grains are apparently inaperturate. No ring furrow was discerned. The network of muri is considerably coarser than that exhibited by *Afropollis jardinus*, *Afropollis operculatus* and *Afropollis zonatus*.

Age. LO: Cenomanian.

Genus *Appendicisporites* Weyland & Krieger 1953
Type. Weyland & Krieger 1953, plate 11, fig. 54, as *Appendicisporites tricuspidatus.*

1953 *Appendicisporites* Weyland & Krieger, p. 12.

***Appendicisporites potomacensis* Brenner 1963**
(Plate 17, fig. 20)

1963 *Appendicisporites potomacensis* Brenner, p. 46, plate 6, figs 4, 5.
1985 *Plicatella potomacensis* (Brenner) – Davies, p. A49.

Age. LO: mid-Cretaceous, but not well constrained. Not plotted.

Remarks. This species is retained in *Appendicisporites,* following Burden & Hills (1989, p. 100) and Nichols & Sweet (1993, p. 548).

***Appendicisporites unicus* (Markova in Ivanova & Markova 1961) Singh 1964**
(Plate 18, fig. 1)

1961 *Anemia unica* Markova in Ivanova & Markova, p. 53, plate 20, fig. 3a, b.
1964 *Appendicisporites unicus* (Markova in Ivanova & Markova) – Singh, p. 53.
1985 *Plicatella unica* (Markova in Ivanova & Markova) – Davies, p. A 53.

Age. LO: mid-Cretaceous, but not well constrained. Not plotted.

Remarks. This species is retained in *Appendicisporites*, following Burden & Hills (1989, p. 100).

Genus *Aquilapollenites* Rouse 1957 emend. Braman 2013
Type. Radforth & Rouse 1954, plate 1, fig. 14, as "N_2". Holotype lost; lectotype (possibly the holotype) selected from restored type slide by Tschudy & Leopold (1971, plate 2, fig. 1); neotype designated by Srivastava & Rouse (1970, plate 1, figs 4–7); all as *Aquilapollenites quadrilobus*.

1957 *Aquilapollenites* Rouse, p. 370.
1970 *Hemicorpus* Krutzsch, p. 107.
2013 *Aquilapollenites* Rouse – emend. Braman, p.14.

Remarks. Braman (2013) is followed here in considering *Aquilapollenites* to comprise triprojectate pollen that are heteropolar and have isolated sculptural elements. Other triprojectate pollen found in this study are assignable to *Parviprojectus* and *Translucentipollis*.

***Aquilapollenites quadrilobus* Rouse 1957**
(Plate 17, figs 14, 15, 17)

1957 *Aquilapollenites quadrilobus* Rouse, p. 371, plate 2, figs 8, 9.
1961 *Aquilapollenites polaris* Funkhouser, p. 198, plate 1, figs 1, 2.
1961 *Aquilapollenites pulcher* Funkhouser, p. 198, plate 1, fig. 7a–c.
1970 *Mancicorpus polaris* (Funkhouser) – Stanley, p. 30.
1970 *Hemicorpus polaris* (Funkhouser) – Krutzsch, p. 107.
1970 *Hemicorpus pulcher* (Funkhouser) – Krutzsch, p. 107.
1970 *Mancicorpus pulcher* (Funkhouser) – Srivastava, p. 697.

1970 *Aquilapollenites quadrilobus* Rouse – emend. Srivastava & Rouse, p. 1597.

Remarks. The synonymy above follows that in Braman (2013, p. 28). This widely recorded species is characterised by heteropolar grains with prominent spinate sculpture. According to Braman (2013) and A. Sweet (personal communication 2015), this species has a Late Cretaceous range, so the specimens recorded from the Labrador–Baffin Seaway are assumed to be reworked.

Age. LO: middle? Eocene (reworked?).

Genus *Azolla* Lamarck in Lamarck *et al.* 1783
Type. *Azolla filiculoides* Lamarck *et al.* 1783.

1783 *Azolla* Lamarck in Lamarck *et al.*, p. 343.

***Azolla* spp.**
(Plate 18, figs 2–4)

Age. LO: ?Bartonian. Frequent in late Ypresian.

Remarks. *Azolla* is a small moss-like, free-floating freshwater fern that occurs today in warm climates; it is famous for its nitrogen-fixing capability. Given the right combination of time and temperature, sediment rich in *Azolla* could represent major sources of oil. *Azolla* had coeval blooms in some Arctic and northern temperate areas during the Early to earliest Middle Eocene (e.g. Barke *et al.* 2011, 2012). Barke *et al.* (2012) concluded that the presence of the blooms accords with high-precipitation conditions modelled for the Early Eocene and implies the presence of extensive wetlands bordering the regional landmasses. They further suggested that *Azolla* blooms in the Arctic and Norwegian Sea basins may indicate widespread fresh ocean surface waters due to unprecedented discharge of water from the land and the semi-enclosed nature of those two basins. The occurrences of *Azolla* in Labrador Sea – Davis Strait wells are mostly restricted to a narrow time interval at the top of the Ypresian. *Azolla* has not been recorded in the offshore West Greenland wells. Evidence of extensive blooms of *Azolla* in the Labrador–Baffin Seaway was not encountered in this study, perhaps indicating that this marine basin was broadly open to the south and had limited or no connection to the Arctic basin (see Barke *et al.* 2012, fig. 4 and Nøhr-Hansen *et al.* 2016).

The poor preservation and limited frequency of *Azolla* specimens in our study have precluded specific assigments, but several species are probably represented (see Barke *et al.* 2012). Previous studies suggest an LO of *Azolla* species in the earliest Lutetian.

Genus *Baculatisporites* Pflug & Thomson in Thomson & Pflug 1953
Type. Wolff 1934, plate 5, fig. 8, as *Sporites priarius*.

1953 *Baculatisporites* Pflug & Thomson in Thomson & Pflug.

Synopsis. Trilete spores, with a subcircular ambitus; the laesurae are of variable length, sometimes reaching to the equator. The ornamentation of the exine is predominantly of bacula, although other types of element may be present. Distally, the bacula can be flat to multicrowned.

Remarks. In our synopsis for *Baculatisporites*, we allow for variation in both the width relative to the height of the baculae, so that the width may exceed the height, and in the nature of their distal terminations.

***Baculatisporites crenulatus* sp. nov.**
(Plate 18, figs 6–8)

Holotype. Plate 18, fig. 8, from a cuttings sample at 1790–1800 m in Roberval K-92, GSC type collection no. 137889, sample P17684, slide 01, co-ordinates 10.6 × 104.8, England Finder L34/2. Maximum overall diameter 65 µm. The age determined for the sample from which the holotype was recovered is Bartonian.

Etymology. The epithet is from the Latin *crenulatus*, meaning minutely crenulate, in reference to the toothed distal margin of the bacula.

Diagnosis. A species of *Baculatisporites* with sculptural elements that have variable distal terminations, ranging from blunt to rounded to crenulate. There is considerable variation in the nature of the distal terminations, and also in the length-to-width ratio of the elements: many are of greater length than width and hence true bacula, but others are of greater width than length.

Size. Diameter 52–65 µm. Length of laesurae 15–18 µm. Bacula height 3–12 µm, width 3–7 µm. Wall thickness 2–3 µm.

Age. LO: Bartonian. Not plotted.

Remarks. The ratio of the width to height of the baculae and their distal variability from blunt to crenulated, distinguishes *Baculatisporites crenulatus* from other species of the genus.

Genus *Callialasporites* Dev 1961
Type. Balme 1957, plate 8, fig. 91, as *Zonalapollenites trilobatus*.

1961 *Callialasporites* Dev, p. 48.
1961 *Applanopsis* Döring, p. 112.
1961 *Triangulopsis* Döring, p. 113.
1962 *Pflugipollenites* Pocock, p. 72.
1964 *Applanopsipollenites* Levet-Carette, p. 107.
1970 *Singhiapollis* Kar & Sah, p. 107.

Synopsis. Cavate, proximo-distally compressed miospores with a roughly circular to triangular or trilobate amb. The two wall layers are mostly appressed proximally and distally, but ambitally and sub-ambitally the wall layers are variously separated to produce a hollow zona that may be continuous or constricted to few (commonly three) to multiple vesicles and/or be radially plicated. The central body may be circular, triangular, or irregularly shaped. A proximal, non-functional triradiate mark may be present.

Remarks. The above description is condensed from a version provided by Fensome (1983), who gave an extensive review of this genus and its synonymy.

***Callialasporites dampieri* (Balme 1957) Dev 1961**
(Plate 18, fig. 16)

1957 *Zonalapollenites dampieri* Balme, p. 32, plate 8, figs 88–90.
1961 *Callialasporites dampieri* (Balme) – Dev, p. 48.
1961 *Applanopsis dampieri* (Balme) – Döring, p. 113.
1962 *Pflugipollenites dampieri* (Balme) – Pocock, p. 72.
1963 *Tsugaepollenites dampieri* (Balme) – Dettmann, p. 100.

Remarks. Singh (1971, p. 175) retained this species in *Callialasporites*.

Age. LO: Aptian.

***Callialasporites obrutus* Norris 1969**

1969 *Callialasporites obrutus* Norris, p. 597, plate 110, figs 6, 7.

Age. LO: Aptian.

Genus *Caryapollenites* Raatz 1938 ex Potonié 1960
Type. Potonié 1931, fig. 2, as *Pollenites simplex.*

1934 *Caryae?-pollenites* Potonié & Venitz, p. 21; name not validly published.
1938 *Caryapollenites* Raatz, p. 19; name not validly published.
1960 *Caryapollenites* Potonié, p. 123.

Remarks. As Nichols & Ott (1978) noted, the nomenclatural history of fossil pollen similar to the modern genus *Carya* is difficult to unravel. This is also true of species within *Caryapollenites.* Nichols & Ott (1978) developed a biostratigraphic scheme for species of *Caryapollenites* and the closely related *Momipites* for Paleocene strata of the Wind River Basin of Wyoming. However, we have found species of these two genera widely distributed in Paleocene to Miocene sediments, and our observations do not conform to the tight Paleocene-restricted ranges proposed by Nichols & Ott (1978). In our experience, firm ranges for individual species of these two genera have yet to be determined, though in the Labrador–Baffin Seaway, *Caryapollenites* generally has an LO in the latest Serravallian.

***Caryapollenites inelegans* Nichols & Ott 1978**
(Plate 18, figs 9, 10)

1978 *Caryapollenites inelegans* Nichols & Ott, p. 105, 106, plate 2, figs 7, 8.

Age. See 'Remarks' under the generic entry for *Caryapollenites*. Not plotted.

***Caryapollenites veripites* (Wilson & Webster 1946) Nichols & Ott 1978**
(Plate 18, figs 11, 12)

1946 *Carya veripites* Wilson & Webster, p. 276, fig. 14.
1978 *Caryapollenites veripites* (Wilson & Webster) – Nichols & Ott, p. 106.

Age. See 'Remarks' under the generic entry for *Caryapollenites*. Not plotted.

Genus *Cerebropollenites* Nilsson 1958
Type. Couper 1958, plate 30, fig. 8, as *Tsugaepollenites mesozoicus*.

1958 *Cerebropollenites* Nilsson, p. 72.

***Cerebropollenites mesozoicus* (Couper 1958) Nilsson 1958**

1958 *Tsugaepollenites mesozoicus* Couper, p. 155, plate 30, figs 8–10.
1958 *Cerebropollenites mesozoicus* (Couper) – Nilsson, p. 72.

Age. LO: Aptian.

Genus *Chenopodipollis* Krutzsch 1966
Type. Weyland & Pflug 1957, plate 22, figs 18, 19, as *Periporopollenites multiplex*.

1966 *Chenopodipollis* Krutzsch, p. 35.

***Chenopodipollis* sp.**
(Plate 18, fig. 17)

Age. LO: Miocene?

Genus *Cicatricosisporites* Potonié & Gelletich 1933
Type. Potonié & Gelletich 1933, plate 1, fig. 1, as *Cicatricosisporites dorogensis*, designated by Potonié (1956, p. 47).

1933 *Cicatricosisporites* Potonié & Gelletich, p. 522.
1950 *Mohrioidites* Thiergart, p. 84 (name not validly published).
1951 *Mohrioisporites* Potonié, p. 144.

Remarks. Emendations for *Cicatricosisporites* have been proposed by Potonié (1966, p. 58) and Dettmann & Clifford (1992, p. 289–291).

***Cicatricosisporites minutaestriatus* (Bolkhovitina 1961) Pocock 1964**

1961 *Pelletieria minutaestriata* Bolkhovitina, p. 68, plate 20, fig. 1a–f; plate 21, fig. 3a–g.
1964 *Cicatricosisporites minutaestriatus* (Bolkhovitina) – Pocock, p. 159.
1971 *Cicatricosisporites augustus* Singh, p. 68, plate 7, figs 3–11; text-fig. 7M.

Age. LO: early Turonian.

***Cicatricosisporites ornatus* Srivastava 1972**
(Plate 19, figs 1–4)

1972 *Cicatricosisporites ornatus* Srivastava, p. 9, plate 5, figs 3−11; plate 6, figs 1−4.

Age. LO: Priabonian.

Remarks. The forms studied here are very similar to the type material, described by Srivastava (1972) from the Maastrichtian of Alberta.

Genus *Cicatricososporites* Pflug & Thomson in Thomson & Pflug 1953
Type. Selling 1944, plate 4, fig. 44, as *Schizaea*? *eocenica*.

1953 *Cicatricososporites* Thomson & Pflug, p. 61.
1959 *Schizaeoisporites* Krutzsch, p. 226.

Remarks. Jansonius & Hills (1976) did not agree with Davies (1985) that *Cicatricososporites* was a junior homonym of *Cicatricosisporites* and retained the former as a separate genus.

***Cicatricososporites eocenicus* (Selling 1944) Jansonius & Hills 1976**
(Plate 18, fig. 5)

1944 *Schizaea*? *eocenica* Selling, p. 66, plate 4, fig. 44.
1950 *Sporites pseudodorogensis* Potonié – Thiergart, p. 84; name not validly published.
1951 *Schizaeolsporites pseudodorogensis* (Potonié) – Potonié, p. 144, plate 20, fig. 19; generic name not validly proposed.
1953 *Cicatricososporites pseudodorogensis* (Potonié) – Thomson & Pflug, p. 61.
1976 *Cicatricososporites eocenicus* (Selling) – Jansonius & Hills, card 468.

Age. LO: middle Bartonian.

Remarks. Burden & Hills (1989) recorded *Cicatricososporites eocenicus* from the Early Cretaceous, but the species is most common in the early Cenozoic and especially the Eocene.

Genus *Compositoipollenites* Potonié 1951 ex Potonié 1960
Type. Potonié 1934, plate 5, fig. 25, as *Pollenites rhizophorus*.

1951 *Compositoipollenites* Potonié, p. 138; name not validly published.
1960 *Compositoipollenites* Potonié, p. 105.

***Compositoipollenites* sp. B of Williams & Brideaux 1975**
(Plate 18, fig. 18)

1975 *Compositoipollenites* sp. B Williams & Brideaux, plate 43, fig. 15.

Age. LO: Gelasian.

Remarks. *Compositoipollenites* sp. B of Williams & Brideaux (1975) is very similar to the pollen of the extant genus *Ambrosia,* being tricolporate and ornamented with short (up to about 2 μm) conate spines that are distally pointed.

Genus *Corsinipollenites* Nakoman 1965
Type. Thiergart 1940, plate 7, fig. 1 as *Pollenites oculus noctis*.

***Corsinipollenites oculusnoctis* (Thiergart 1940) Nakoman 1965**
(Plate 18, figs 19, 20)

1940 *Pollenites oculus noctis* Thiergart, p. 47.
1965 *Corsinipollenites oculusnoctis* (Thiergart) – Nakoman, p. 156.

Age. LO: Bartonian.

Remarks. Fossil pollen with this morphology have also been described under the modern plant name *Jusseia*.

Genus *Extratriporopollenites* Pflug in Thomson & Pflug 1952 ex Pflug in Thomson & Pflug 1953
Type. Pflug in Thomson & Pflug 1953, plate 6, fig. 2, as *Extratriporopollenites fractus.*

1952 *Extratriporopollenites* Pflug in Thomson & Pflug, p. 14, 16; name not validly published.
1953 *Extratriporopollenites* Pflug in Thomson & Pflug 1952 ex Pflug in Thomson & Pflug, p. 69.

***Extratriporopollenites* spp.**
(Plate 19, figs 5–9)

Age. LO: Bartonian.

Genus *Graminidites* Cookson 1947 ex Potonié 1960
Type. Cookson 1947, plate 15, fig. 41, as *Monoporites (Graminidites) media.*

1947 *Graminidites* Cookson, p. 134; name not validly published.
1960 *Graminidites* Cookson ex Potonié, p. 111.

***Graminidites* sp. A. of Williams & Brideaux 1975**
(Plate 19, fig. 12)

1975 *Graminidites* spp. Williams & Brideaux, plate 47, figs 9, 10.

Age. LO: latest Gelasian.

Genus *Momipites* Wodehouse 1933
Type. *Momipites coryloides* Wodehouse 1933, fig. 43.

1933 *Momipites* Wodehouse, p. 511.

Remarks. See 'Remarks' under the generic entry for *Caryapollenites*.

***Momipites annellus* Nichols & Ott 1978**
(Plate 18, figs 13, 14)

1978 *Momipites annelus* Nichols & Ott, p. 103, plate 1, figs 22–25.

Age. See 'Remarks' under the generic entry for *Caryapollenites*. Not plotted.

***Momipites coryloides* Wodehouse 1933**
(Plate 18, fig. 15)

1933 *Momipites coryloides* Wodehouse, p. 511, fig. 43.

Age. See 'Remarks' under the generic entry for *Caryapollenites*. Not plotted.

Genus *Osmundacidites* Couper 1953
Type. Couper 1953, plate 1, fig. 5, as *Osmundacidites wellmanii.*

1953 *Osmundacidites* Couper, p. 20.

Remarks. *Osmundacidites* is characterised by having a granulate to finely verrucate exine that is commonly irregularly organised.

***Osmundacidites wellmannii* Couper 1953**
(Plate 20, fig. 1)

1953 *Osmundacidites wellmannii* Couper, p. 20, plate 1, fig. 5.
1959 *Baculatisporites wellmannii* (Couper) – Krutzsch, p. 142.
1964 *Osmundacidisporites wellmannii* (Couper) – Levet-Carette, p. 98.
1968 *Todisporites granulatus* Tralau, p. 67, plate 7, fig. 1.
1972 *Osmundacidites araucanus* Volkheimer, p. 120, plate 6, figs 47−49.
1986 *Osmunda* sp. in Williams, p. 83, plate 1, fig. 2.

Age. LO: Burdigalian.

Remarks. This species has a long range, starting in the Mesozoic, but its LO appears to be useful in the Labrador–Baffin Seaway region. We have established a Burdigalian LO; Williams (1986) considered that *Osmunda* sp. (= *Osmundacidites wellmannii*) has an LO in the middle to late Miocene. For a full synonymy listing of *Osmundacidites wellmannii*, see Fensome (1983, p. 323, 324).

Genus *Parviprojectus* Mtchedlishvili in Samoilovitch & Mtchedlishvili 1961 emend. Braman 2013
Type. Samoilovitch & Mtchedlishvili 1961, plate 73, fig. 2, as *Parviprojectus reticulatus*.

1961 *Parviprojectus* Mtchedlishvili in Samoilovitch & Mtchedlishvili, p. 225.
2013 *Parviprojectus* Mtchedlishvili in Samoilovitch & Mtchedlishvili – emend. Braman, p. 129.

Remarks. Following Braman (2013), *Parviprojectus* is considered to comprise triprojectate pollen that are isopolar and have a reticulate wall.

***Parviprojectus reticulatus* Mtchedlishvili in Samoilovitch & Mtchedlishvili 1961**
(Plate 17, fig. 16)

1961 *Parviprojectus reticulatus* Mtchedlishvili in Samoilovitch & Mtchedlishvili, p. 226, 227, plate 73, figs 2, 3.
1961 *Aquilapollenites reticulatus* Stanley, p. 348, 349, plate 8, figs 1–12.
1970 *Integricorpus reticulatus* (Mtchedlishvili) – Stanley, p. 29.
1970 *Aquilapollenites* (*Parviprojectus*) *reticulatus* (Mtchedlishvili) – Kedves & Király, p. 67.

Remarks. This species is characterised by its fine reticulate ornament. The above synonymy follows that of Braman (2013, p. 148), with only nomenclaturally significant entries included.

Age. LO: not determined; not plotted. The illustrated specimen is from late Paleocene strata in Rut H-11. According to Braman (2013), this species ranges from the Campanian to early Paleocene, with a ‘provisional’ occurrence in the late Eocene. The latter may be reworked, as could be the present occurrence.

Genus *Parvisaccites* Couper 1958
Type: Couper 1958, plate 29, figs 5, 6, as *Parvisaccites radiatus*.

1958 *Parvisaccites* Couper, p. 154.

***Parvisaccites amplus* Brenner 1963**

1963 *Parvisaccites amplus* Brenner, p. 78, 79, plate 28, fig. 1a, b; plate 29, fig. 1a, b.

Age. LO: Aptian.

***Parvisaccites radiatus* Couper 1958**

1958 *Parvisaccites radiatus* Couper, p. 154, plate 29, figs 5–8; plate 30, figs 1, 2.

Age. LO: Aptian.

Genus *Periporopollenites* Pflug & Thomson in Thomson & Pflug 1953
Type. Potonié 1931, plate 2, fig. 1, as *Pollenites stigmosus.*

1953 *Periporopollenites* Pflug & Thomson in Thomson & Pflug, p. 111.
1960 *Liquidambarpollenites* Raatz 1937 ex Potonié, p. 134.

***Periporopollenites* sp.**
(Plate 19, figs 10, 11)

Age. LO: early? Miocene. Not plotted.

Genus *Pistillipollenites* Rouse 1962
Type. Rouse 1962, plate 1, figs 10, 12, as *Pistillipollenites macgregorii.*

1962 *Pistillipollenites* Rouse, p. 206.

Remarks. The distinctive characteristic of this triporate pollen grain is the pistil-like or bulbose ornamentation that covers the exine.

***Pistillipollenites macgregorii* Rouse 1962**
(Plate 19, figs 13, 14)

1962 *Pistillipollenites macgregorii* Rouse, p. 206, plate 1, figs 8–12.

Age. LO: Bartonian.

Genus *Quercoidites* Potonié *et al.* 1950 ex Potonié 1960
Type. Potonié 1931, plate 2, fig. 19, as *Pollenites henrici*.

1950 *Quercoidites* Potonié *et al*., p. 54; name not validly published.
1960 *Quercoidites* Potonié *et al*. ex Potonié, p. 92.

Remarks. The exine of this ovoidal, tricolpate pollen grain is usually granulate to scabrate. The colpi reach almost to the poles.

***Quercoidites* sp.**
(Plate 19, figs 15, 16)

1986 *Quercus* form A of Williams, p. 83, plate 1, fig. 8.

Age. LO: Frequent in latest Messinian.

Remarks. This is a finely granular form of *Quercoidites*, also found by Williams (1986) and called *Quercus* form A. Williams found that the LO of this form was in her *Fagus granulata* Zone, which she dated as early Miocene. *Quercoidites* sp. differs from *Quercoidites* sp. A of Williams & Brideaux (1975) (equivalent to *Quercus* form B of Williams 1986) in its much finer ornament.

Genus *Rugubivesiculites* Pierce 1961
Type. Pierce 1961, plate 2, fig. 57, as *Rugubivesiculites convolutes.*

1961 *Rugubivesiculites* Pierce, p. 39.

Remarks. *Rugubivesiculites* is a bivesiculate pollen with a distinctive rugulate ornamentation on the proximal surface of the central body.

***Rugubivesiculites* spp.**
(Plate 20, fig. 2)

Age. LO: Turonian.

Remarks. No attempt was made to speciate the specimens of *Rugubivesiculites* seen in the Labrador Margin and offshore West Greenland samples.

Genus *Tiliaepollenites* Potonié 1931
Type. Potonié 1931, fig. 14, as *Tiliaepollenites indupitabilis*.

1931 *Tiliaepollenites* Potonié, p. 4.
1938 *Tiliaepollenites* Raatz, p. 27.
1953 *Intratriporopollenites* Pflug & Thomson in Thomson & Pflug, p. 87.

***Tiliaepollenites crassipites* (Wodehouse 1933) comb. nov.**
(Plate 19, figs 17, 18)

1933 *Tilia crassipites* Wodehouse, p. 515, fig. 48.
1969 *Tilliaepollenites crassipites* (Wodehouse) – Penny, p. 355 (combination not validly published, basionym not fully referenced).
1975 *Bombacacidites* sp. A Williams & Brideaux, plate 46, fig. 10.
1986 *Tilia crassipites* Williams, plate 2, fig. 1.

Age. LO: Serravallian.

Remarks. A search of the Palynodata database (Palynodata Inc. & White 2008) provided no indication of a previous formal transfer of this species to *Tiliaepollenites.*

***Tiliaepollenites* sp. A**
(Plate 19, figs 19, 20)

Description. This form is distinctive in its possession of a pad-like thickening at the inner end of each colpus.

Age. LO: early? Miocene (not well constrained). Not plotted.

Genus *Translucentipollis* Khlonova 1961
Type. Khlonova 1961, plate 16, fig. 121, as *Aquilapollenites plicatilis.*

1961 *Translucentipollis* Khlonova, p. 89.
1966 *Translucentipollis* Khlonova – Srivastava, p. 546.

Remarks. Following Braman (2013, p. 13), *Translucentipollis* is considered to comprise isopolar triprojectate pollen with reduced polar projections and a more or less smooth surface.

***Translucentipollis contiguus* (Tschudy 1969) Braman 2013**
(Plate 17, fig. 13)

Remarks. The specimen illustrated has very fine granulae to short and delicate rugulae that are barely discernible in optical section. We consider that this wall surface fits within the granular to scabrate range of *Translucentipollis contiguous.*

Age. LO: not determined. Not plotted.

Genus *Wodehouseia* Stanley 1961
Type. Stanley 1961, plate 1, figs 1–3, as *Wodehouseia spinata*.

1961 *Wodehouseia* Stanley, p. 157.

Remarks. *Wodehouseia* is included in the 'oculata' pollen, which Khlonova (1962, p. 306) defined as pollen grains with two pairs of apertures that are located close to the tips of the two long sides. Wiggins (1976) gave a thorough review of various genera in the group, including *Wodehouseia*.

***Wodehouseia spinata* Stanley 1961**
(Plate 20, fig. 3)

1961 *Wodehouseia spinata* Stanley, p. 157, 158, 160, plate 1, figs 1–12.

Age. LO: latest Maastrichtian.

Genus *Zlivisporis* Pacltová 1961
Type. Pacltová 1961, plate 2, figs 1–3, as *Zlivisporis blanensis.*

1961 *Zlivisporis* Pacltová, p. 40.
1961 *Seductisporites* Khlonova, p. 56.
1962 *Rouseisporites* Pocock, p. 52.

Remarks. The reticulum developed on the distal surface is never fine and is often incomplete.

***Zlivisporis* spp.**
(Plate 20, figs 4–8)

Age. LO: early Rupelian.

Remarks. Specimens of *Zlivisporis* from the Labrador–Baffin Seaway region are variable, especially in the nature of the surface reticulum, and are thus difficult to speciate.

Genus *Zonalapollenites* Pflug in Thomson & Pflug 1953
Type. Potonié 1931, fig. 2, as *Sporonites igniculus*.

1934 *Tsugaepollenites* Potonié & Venitz, p. 17; name not validly published.
1958 *Zonalapollenites* Pflug in Thomson & Pflug, p. 66.
1958 *Tsugaepollenites* Potonié & Venitz ex Potonié, p. 48.

Remarks. This genus is characterised by the numerous small, distinct equatorial sacs or vesiculae. Sometimes the polar regions may be covered with greatly reduced sacs. Jansonius & Hills (1976, card 3265) recognised that *Tsugaepollenites* is an obligate junior synonym of *Zonalapollenites*.

***Zonalapollenites igniculus* (Potonié 1931) Thomson & Pflug 1953**
(Plate 20, figs 9–11)

1931 *Sporonites igniculus* Potonié, p. 556, fig. 2.
1934 *Tsugaepollenites igniculus* (Potonié) – Potonié & Venitz, p. 17; name not validly published.
1953 *Zonalapollenites igniculus* (Potonié ex Pflug) – Thomson & Pflug, p. 66.

Age. LO: latest Gelasian.

Fungal elements

Remarks. All fungal spores are grouped together but several different morphologies are recorded, including those shown in the accompanying illustrations (Plate 20, figs 12–20). Fungal spores occur sporadically throughout the sections studied, but peaks were noted in the Lutetian and Ypresian.

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Plates

Scale

The scale bar represents 20 µm in all plates.

Explanation

In the following plates, details concerning the figured specimens are presented in a standardised, abbreviated form grouped in four categories:

Location

- Locality: mainly offshore wells, but also onshore boreholes and outcrop sections.
- Sample depth (in metres) in wells and boreholes; sample number in outcrop sections, unless specified otherwise.

Sample

- Type: **cs**: cuttings sample. **os**: outcrop section sample. **sw**: sidewall core sample. **cc**: conventional core sample.
- Sample number or processing number: All 'P numbers' (e.g. P39553) nos are sample numbers from Canadian wells processed in Canada; the remainder are GGU/GEUS processing numbers of both Canadian and Greenlandic material.
- Slide number/letter.

Optical parameters

- Microscope identification (relating to following Vernier scale coordinates): **A**: Leitz Dialux 22 microscope 512 742/057691 at the Geological Survey of Denmark and Greenland (GEUS). **B**: Leica DM 2000 331596-092011 at GEUS. **C**: Zeiss Axioplan 2 microscope, serial no. 310243 at GSC Atlantic, Dartmouth, Nova Scotia. **D**: Zeiss Photomicroscope, serial no. 67750 at GSC Atlantic, Dartmouth, Nova Scotia. **E**: Leitz DM RB (RS232C) at GEUS.
- Vernier coordinates.
- England Finder coordinates.
- Lens magnification and type: **bf**: bright field. **pc**: phase contrast.

Repositories

- **CNLOPB**: slide curated in the collection of the Canada – Newfoundland and Labrador Offshore Petroleum Board, St. John's, Newfoundland, Canada (no numbers).
- **CNSOPB**: slide curated in the collection of the Canada – Nova Scotia Offshore Petroleum Board, Dartmouth, Nova Scotia, Canada (no numbers).
- **MGUH**: slide curated in the type collection of the Geological Museum of the University of Copenhagen (at the time of writing, this material is on long-term loan to GEUS, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark).
- **GSC**: slide curated in the National Collection of Type Invertebrate and Plant Fossils, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada K1A 0E8 (at the time of writing, this material is on long-term loan to GSC Atlantic, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada B2Y 4A2).
- **Statoil**: slides are stored at the offices of the Statoil petroleum company in Stavanger, Norway (no numbers).
- All nomenclatural types are curated at either the Geological Museum of the University of Copenhagen or at the Geological Survey of Canada, as indicated above.

Previous publication

The following figures were previously published (in black-and-white) in Nøhr-Hansen (2003): Plate 2, fig. 12; Plate 11, figs 18,19; Plate 15, figs 9–12; Plate 17, fig. 2. In addition, Plate 6, fig. 1 was previously published in colour in Nøhr-Hansen (1996).

Plate 1

Fig. 1. *Achilleodinium biformoides*, optical section.
Location: North Leif I-05, 2040–2050 m. **Sample**: cs, YD17597, 3.
Optical parameters: E, 34.6 × 17.7, K33/1, × 60 bf.
Repository: GSC 138151.

Fig. 2. *Achilleodinium biformoides*, same specimen as fig. 1, focussed on ventral surface.
Location: North Leif I-05, 2040–2050 m. **Sample**: cs, YD17597, 3.
Optical parameters: E, 34.6 × 17.7, K33/1, × 60 bf.
Repository: GSC 138152.

Fig. 3. *Achilleodinium biformoides*, dorsal surface.
Location: South Labrador N-79, 1920–1930 m. **Sample**: cs, P39782, 1.
Optical parameters: C, 192 × 1020, T31/4, × 50 bf.
Repository: GSC 138115.

Fig. 4. *Adnatosphaeridium vittatum*, dorsal surface.
Location: Karlsefni A-13, 1627.65–1636.80 m. **Sample**: cs, P39577, 1.
Optical parameters: D, 179 × 866, R29/3, × 40 pc.
Repository: GSC 138013.

Fig. 5. *Alisocysta margarita*, dorsal surface.
Location: North Leif I-05, 2310–2320 m. **Sample**: cs, YD17606, 2.
Optical parameters: E, 28.5 × 6.9, U27/3, × 60 bf.
Repository: MGUH 31266.

Fig. 6. *Alisocysta circumtabulata*, ventral view of ventral surface.
Location: South Labrador N-79, 3060–3070 m. **Sample**: cs, P39819, 1.
Optical parameters: C, 166 × 1026, R32/0–2, × 50 bf.
Repository: GSC 138124.

Fig. 7. *Alisocysta circumtabulata*, same specimen as fig. 6, focussed on dorsal surface.
Location: South Labrador N-79, 3060–3070 m. **Sample**: cs, P39819, 1.
Optical parameters: C, 166 × 1026, R32/0–2, × 50 bf.
Repository: GSC 138124

Fig. 8. *Adnatosphaeridium vittatum*, apical view.
Location: South Labrador N-79, 2310–2320 m. **Sample**: cs, P39795, 1.
Optical parameters: C, 184 × 1028, S32/4, × 50 bf.
Repository: GSC 138120.

Fig. 9. *Alisocysta margarita*, dorsal view.
Location: North Leif I-05, 2370–2380 m. **Sample**: cs, YD17608, 4.
Optical parameters: E, 38.9 × 13.6, O37/2, × 60 bf.
Repository: GSC 138161.

Fig. 10. *Alterbidinium acutulum*, dorsal view of dorsal surface.
Location: Karlsefni A-13, 1106.44–1115.58 m. **Sample**: cs, P39558, 1.
Optical parameters: D, 192 × 918, T34/2, × 40 pc.
Repository: GSC 138010.

Fig. 11. *Alterbidinium acutulum*, dorsal surface.
Location: Skolp E-07, 1295 m. **Sample**: cs, YD15594, 3.
Optical parameters: A, 49.0 × 113.2, C50/1, × 60 bf.
Repository: MGUH 31267.

Fig. 12. *Alterbidinium biaperturum*, dorsal view of dorsal surface.
Location: Skolp E-07, 1070 m. **Sample**: cs, YD15580, 3.
Optical parameters: A, 19.6 × 96.4, U19/2, × 60 bf.
Repository: MGUH 31268.

Fig. 13. *Alterbidinium biaperturum*, same specimen as fig. 12, dorsal view of ventral surface.
Location: Skolp E-07, 1070 m. **Sample**: cs, YD15580, 3.
Optical parameters: A, 19.6 × 96.4, U19/2, × 60 bf.
Repository: MGUH 31268.

Fig. 14. *Alterbidinium biaperturum*, dorsal view of ventral surface.
Location: Skolp E-07, 1250 m. **Sample**: cs, YD15592, 3.
Optical parameters: A, 25.2 × 98.0, S25/3, × 60 bf.
Repository: MGUH 31269.

Fig. 15. *Alterbidinium*? *bicellulum*, ventral view.
Location: Gjoa O-37, 1620 m. **Sample**: cs, YD16074, 2.
Optical parameters: A, 16.2 × 100.0, R16/1, × 60 bf.
Repository: MGUH 31270.

Fig. 16. *Alterbidinium*? *bicellulum*, ventral view.
Location: Gjoa O-37, 1620 m. **Sample**: cs, YD16074, 2.
Optical parameters: A, 29.2 × 93.0, Y29/0, × 60 bf.
Repository: MGUH 31271.

Fig. 17. *Alterbidinium ioannidesii*, dorsal view of ventral surface.
Location: Skolp E-07, 2390 m. **Sample**: cs, YD15666, 2.
Optical parameters: A, 20.1 × 113.2, B20/3, × 60 bf.
Repository: MGUH 31272.

Fig. 18. *Alterbidinium varium*, ventral view.
Location: Skolp E-07, 1715 m. **Sample**: cs, JEH15622, 3.
Optical parameters: A, 40.0 × 103.7, M40/4, × 60 bf.
Repository: MGUH 31273.

Fig. 19. *Alterbidinium varium*, dorsal view.
Location: Skolp E-07, 1715 m. **Sample**: cs, JEH15622, 5.
Optical parameters: A, 26.0 × 101.6, P26/3, × 60 bf.
Repository: CNLOPB.

Fig. 20. *Apectodinium homomorphum*, dorsal view.
Location: North Leif I-05, 2010–2020 m. **Sample**: cs, YD17596, 2.
Optical parameters: E, 34.1 × 12.8, O33/3, × 60 bf.
Repository: MGUH 31274.

Plate 1

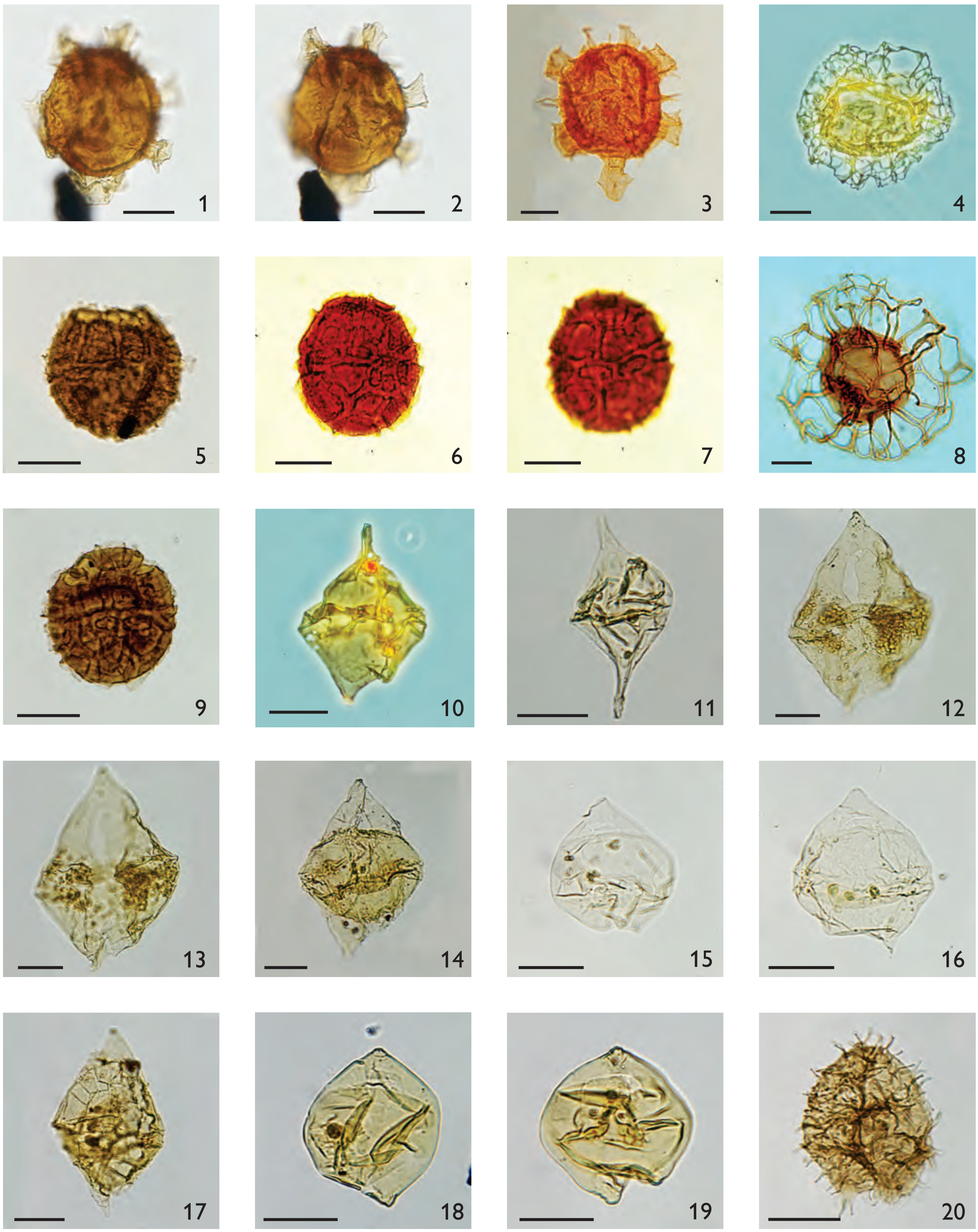

Plate 2

Fig. 1. *Apectodinium parvum*, ventral view.
Location: North Leif I-05, 2100–2110 m. **Sample**: cs, YD17599, 3.
Optical parameters: E, 22.6× 16.8, K20/4, × 60 bf.
Repository: GSC 138154.

Fig. 2. *Apectodinium parvum*, dorsal view.
Location: North Leif I-05, 2070–2080 m. **Sample**: cs, YD17598, 4.
Optical parameters: E, 20.3 × 23.3, D18/0, × 60 bf.
Repository: MGUH 31275.

Fig. 3. *Apectodinium parvum*, dorsal view of dorsal surface.
Location: Rut H-11, 3335–3345 m. **Sample**: cs, P39405, 1.
Optical parameters: D, 121 × 1034, M46/2, × 40 pc.
Repository: GSC 137967.

Fig. 4. *Apectodinium quinquelatum*, dorsal view of ventral surface.
Location: North Leif I-05, 2250–2260 m. **Sample**: cs, YD17604, 3.
Optical parameters: E, 55.2 × 18.9, G54/4, × 60 bf.
Repository: MGUH 31276.

Fig. 5. *Aptea polymorpha*, dorsal view.
Location: Roberval K-92, 3160–3170 m. **Sample**: cs, P2008177, 1.
Optical parameters: C, 79 × 980, H27/7, × 50 bf.
Repository: GSC 137910.

Fig. 6. *Apteodinium australiense*, dorso-ventral view.
Location: Karlsefni A-13, 969.28–978.42 m. **Sample**: cs, P39553, 1.
Optical parameters: D, 167 × 898, Q32/4, × 40 pc.
Repository: GSC 138005.

Fig. 7. *Apteodinium spiridoides*, right lateral view.
Location: Karlsefni A-13, 2505.49–2514.63 m. **Sample**: cs, P39608, 1.
Optical parameters: D, 171 × 990, R42/0, × 40 pc.
Repository: GSC 138037.

Fig. 8. *Apteodinium spiridoides*, right lateral view.
Location: Rut H-11, 725–735 m. **Sample**: cs, P39318, 1.
Optical parameters: D, 78 × 913, G34/0–3, × 40 pc.
Repository: GSC 137919.

Fig. 9. *Areoligera circumsenonensis*, ventral view of dorsal surface.
Location: Karlsefni A-13, 2615.22–2624.36 m. **Sample**: cs, P39612, 1.
Optical parameters: D, 183 × 990, S42/1–3, × 40 pc.
Repository: GSC 138040.

Fig. 10. *Areoligera gippingensis*, dorso-ventral view.
Location: Karlsefni A-13, 3822.24–3831.38 m. **Sample**: cs, P39655, 1.
Optical parameters: D, 143 × 930, O36/1, × 40 pc.
Repository: GSC 138054.

Fig. 11. *Areoligera gippingensis*, dorso-ventral view.
Location: Gjoa O-37, 2240 m. **Sample**: cs, YD16095, 2.
Optical parameters: E, 52.3 × 14.2, M51/4, × 60 bf.
Repository: MGUH 31277.

Fig. 12. *Areosphaeridium diktyoplokum*, dorso-ventral view.
Location: Hellefisk-1, 723 m. **Sample**: sw, YD13709, 2.
Optical parameters: A, 38.9 × 108.4, H39/4, × 60 bf.
Repository: MGUH 26473.

Fig. 13. *Atopodinium* cf. *haromense*, dorso-ventral view.
Location: Skolp E-07, 1550 m. **Sample**: cs, JEH15611, 5.
Optical parameters: A, 35.0 × 95.5, V35/1, × 60 bf.
Repository: MGUH 31278.

Fig. 14. *Axiodinium augustum*, dorso-ventral view.
Location: North Leif I-05, 2250–2260 m. **Sample**: cs, YD17604, 3.
Optical parameters: E, 43.0 × 21.6, E42/1, × 60 bf.
Repository: MGUH 31279.

Fig. 15. *Axiodinium augustum*, dorso-ventral view, same specimen as fig. 14, focussed on antapical part.
Location: North Leif I-05, 2250–2260 m. **Sample**: cs, YD17604, 3.
Optical parameters: E, 43.0 × 21.6, E42/1, × 60 bf.
Repository: MGUH 31279.

Fig. 16. *Batiacasphaera micropapillata*, dorso-ventral view.
Location: Rut H-11, 845–855 m. **Sample**: cs, P39322, 1.
Optical parameters: D, 93 × 1020, J45/0, × 40 pc.
Repository: GSC 137924.

Fig. 17. *Batioladinium jaegeri*, ventral view of ventral surface.
Location: Skolp E-07, 1655 m. **Sample**: cs, JEH15618, 3.
Optical parameters: A, 45.7 × 107.9, H46/4, × 60 bf.
Repository: MGUH 31281.

Fig. 18. *Callaiosphaeridium asymmetricum*, apical-antapical view.
Location: Skolp E-07, 1535 m. **Sample**: cs, JEH15610, 3.
Optical parameters: A, 33.7 × 98.8, R34/3, × 60 bf.
Repository: MGUH 31282.

Fig. 19. *Cerebrocysta bartonensis*, left lateral view.
Location: Ogmund E-72, 1336 m. **Sample**: sw, JEH15552, 2.
Optical parameters: A, 39.8 × 107.7, H40/4, × 60 bf.
Repository: MGUH 31283.

Fig. 20. *Cerebrocysta bartonensis*, left lateral view, same specimen as fig. 19, focussed on operculum, within cyst.
Location: Ogmund E-72, 1336 m. **Sample**: sw, JEH15552, 2.
Optical parameters: A, 39.8 × 107.7, H40/4, × 60 bf.
Repository: MGUH 31283.

Plate 2

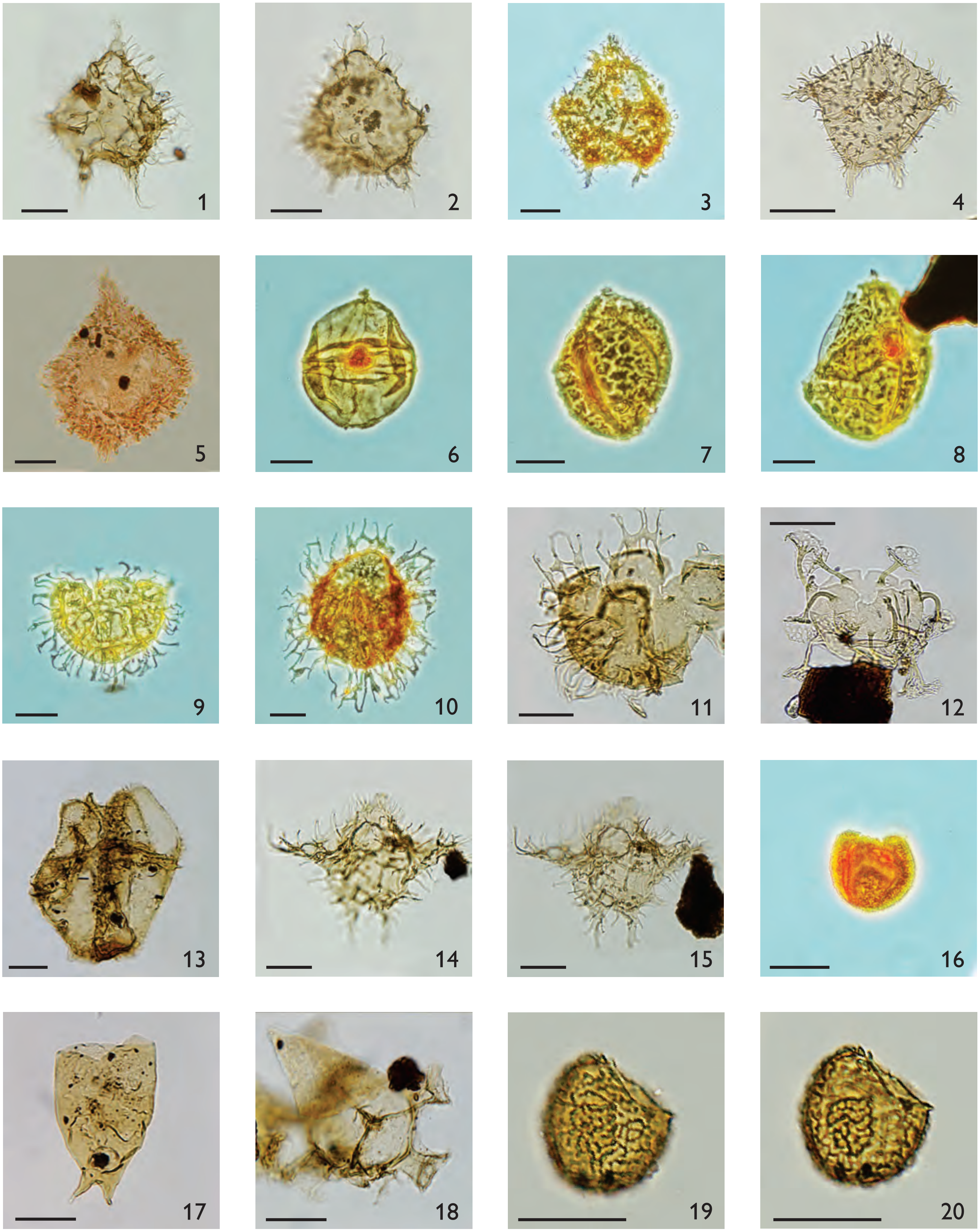

Plate 3

Fig. 1. *Cerodinium diebelii*, dorso-ventral view.
Location: Roberval K-92, 3160–3170 m. **Sample**: cs, P2008177, 1.
Optical parameters: C, 130 × 918, N20/0, × 40 bf.
Repository: GSC 137909.

Fig. 2. *Cerodinium diebelii*, ventral view of dorsal surface.
Location: Roberval K-92, 2500–2510 m. **Sample**: cs, P19229, 1.
Optical parameters: C, 100 × 1018, K31/0–2, × 50 bf.
Repository: GSC 137905.

Fig. 3. *Cerodinium diebelii*, dorsal view of dorsal surface.
Location: North Leif I-05, 2370–2380 m. **Sample**: cs, YD17608, 2.
Optical parameters: E, 39.6 × 16.1, L38/2, × 60 bf.
Repository: MGUH 31284.

Fig. 4. *Cerodinium diebelii*, dorso-ventral view.
Location: North Leif I-05, 2520–2530 m. **Sample**: cs, YD17613, 3.
Optical parameters: E, 23.8 × 18.7, H22/3, × 60 bf.
Repository: MGUH 31285.

Fig. 5. *Cannosphaeropsis passio*, oblique antapical view.
Location: Qulleq-1, 1847 m. **Sample**: sw, YD14581, 4.
Optical parameters: A, 38.4 × 108.0, J38/2, × 40 bf.
Repository: Statoil.

Fig. 6. *Cerebrocysta magna*, oblique right lateral view.
Location: Qulleq-1, 1862.1 m. **Sample**: sw, YD14587, 3.
Optical parameters: A, 29.8 × 100.7, Q30/3, × 60 bf.
Repository: Statoil/MGUH 26505.

Fig. 7. *Cerodinium glabrum*, dorsal surface.
Location: Gilbert F-53, 3420–3430 m. **Sample**: cs, P17040, 1.
Optical parameters: C, 158 × 1010, L30/2, × 50 bf.
Repository: GSC 137887.

Fig. 8. *Cerodinium glabrum*, dorsal surface.
Location: Gjoa O-37, 2400 m. **Sample**: cs, YD16097, 2.
Optical parameters: E, 21.4 × 25.3, B19/2, × 60 bf.
Repository: MGUH 31286.

Fig. 9. *Cerodinium kangiliense*, dorsal view of dorsal surface.
Location: Skolp E-07, 1460 m. **Sample**: cs, YD15605, 3.
Optical parameters: A, 52.0 × 102.8, N53/3, × 60 bf.
Repository: MGUH 31287.

Fig. 10. *Cerodinium kangiliense*, dorsal view, same specimen as fig. 9, focussed on ventral surface.
Location: Skolp E-07, 1460 m. **Sample**: cs, YD15605, 3.
Optical parameters: A, 52.0 × 102.8, N53/3, × 60 bf.
Repository: MGUH 31287.

Fig. 11. *Cerodinium striatum*, dorso-ventral view of dorsal surface.
Location: Gilbert F-53, 2410–2420 m. **Sample**: cs, P39493, 1.
Optical parameters: C, 70 × 1040, G34/1, × 50 bf.
Repository: GSC 137983.

Fig. 12. *Cerodinium striatum*, dorso-ventral view.
Location: Rut H-11, 2765–2775 m. **Sample**: cs, P39386, 1.
Optical parameters: D, 65 × 869, F29/2, × 40 pc.
Repository: GSC 137955.

Fig. 13. *Cerodinium speciosum*, dorso-ventral view of dorsal surface.
Location: Hekja O-71, 4510–4520 m. **Sample**: cs, P20645, 1.
Optical parameters: C, 50 × 1007, E30/0, × 50 bf.
Repository: GSC 137915.

Fig. 14. *Chatangiella madura*, dorsal view of dorsal surface.
Location: Skolp E-07, 1580 m. **Sample**: cs, JEH15613, 3.
Optical parameters: A, 31.0 × 112.8, C31/4, × 60 bf.
Repository: MGUH 31288.

Fig. 15. *Chatangiella madura*, dorsal view, same specimen as fig. 14, focussed on optical section.
Location: Skolp E-07, 1580 m. **Sample**: cs, JEH15613, 3.
Optical parameters: A, 31.0 × 112.8, C31/4, × 60 bf.
Repository: MGUH 31288.

Fig. 16. *Chatangiella tripartita*, dorsal view of dorsal surface.
Location: South Labrador N-79, 1230–1240 m. **Sample**: cs, P39761, 1.
Optical parameters: C, 178 × 988, S28/0–2, × 50 bf.
Repository: GSC 138081.

Fig. 17. *Chiropteridium galea*, dorsal view.
Location: Karlsefni A-13, 1051.57–1060.72 m. **Sample**: cs, P39556, 1.
Optical parameters: D, 228 × 1029, X46/1, × 40 pc.
Repository: GSC 138008.

Fig. 18. *Chiropteridium galea*, ventral view of ventral surface.
Location: Karlsefni A-13, 1079.01–1088.15 m. **Sample**: cs, P39557, 1.
Optical parameters: D, 170 × 991, R42/1, × 40 pc.
Repository: GSC 138009.

Fig. 19. *Chiropteridium galea*, ventral view.
Location: Karlsefni A-13, 1161.30–1170.45 m. **Sample**: cs, P39560, 1.
Optical parameters: D, 172 × 889, R31/2, × 40 pc.
Repository: GSC 138011.

Fig. 20. *Chatangiella tripartita*, ventral view of dorsal surface.
Location: Karlsefni A-13, 2267.74–2276.88 m. **Sample**: cs, P39599, 1.
Optical parameters: D, 192 × 926, T35/0, × 40 pc.
Repository: GSC 138029.

Plate 3

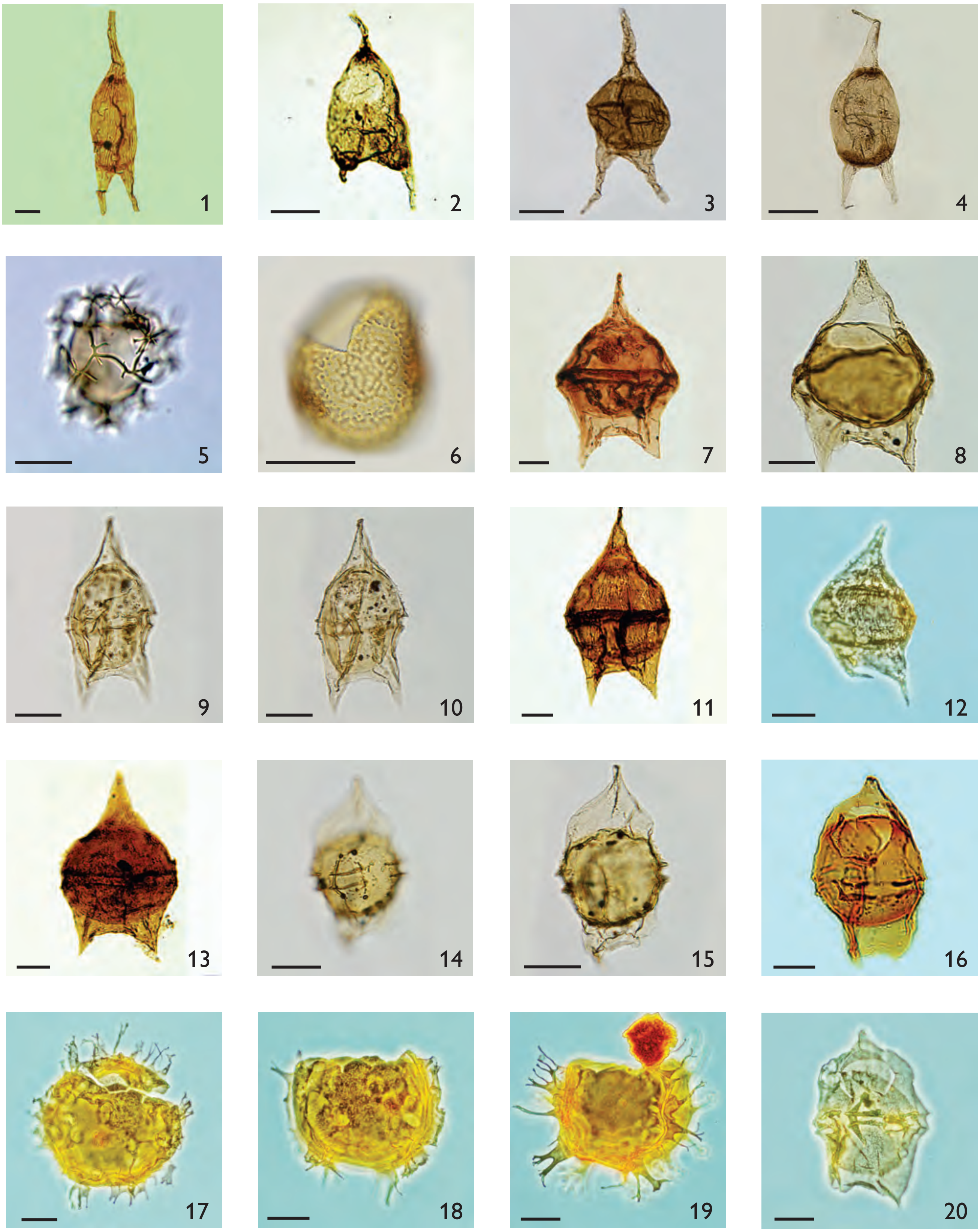

Plate 4

Fig. 1. *Chiropteridium gilbertii* sp. nov., dorso-ventral view.
Location: South Labrador N-79, 1440−1450 m. **Sample**: cs, P39768, 1.
Optical parameters: C, 56 × 1028, E32/4, × 50 bf.
Repository: GSC 138112.

Fig. 2. *Chiropteridium gilbertii* sp. nov., ventral view of dorsal surface.
Location: South Labrador N-79, 1560−1570 m. **Sample**: cs, P39772, 1.
Optical parameters: C, 168 × 1031, R33/1, × 50 bf.
Repository: GSC 138113.

Fig. 3. *Chiropteridium gilbertii* sp. nov., ventral view, same specimen as fig. 2, focussed on ventral surface.
Location: South Labrador N-79, 1560−1570 m. **Sample**: cs, P39772, 1.
Optical parameters: C, 168 × 1031, R33/1, × 50 bf.
Repository: GSC 138113.

Fig. 4. *Chiropteridium gilbertii* sp. nov., holotype, ventral view.
Location: Gilbert F-53, 1600−1610 m. **Sample**: cs, P39466, 1.
Optical parameters: C, 174 × 1060, R36/3, × 50 bf.
Repository: GSC 137976.

Fig. 5. *Chlamydophorella nyei*, left lateral view.
Location: South coast Bylot Island, section B, 1.8 m above base (sample HFB09-17A). **Sample**: os, P5148-4, C.
Optical parameters: C, 193 × 901, H57/0–1, × 50 bf.
Repository: GSC 138130.

Fig. 6. *Chlamydophorella* cf. *nyei*, dorso-ventral view.
Location: Ogmund E-72, 1620 m. **Sample**: cs, YD15740, 5.
Optical parameters: A, 19.5 × 110.5, F19/2, × 60 bf.
Repository: GSC 138145.

Fig. 7. *Chlamydophorella* cf. *nyei*, right lateral view.
Location: North Leif I-05, 2670–2680 m. **Sample**: cs, YD17618, 2.
Optical parameters: E, 18.6 × 19.5, G16/2, × 60 bf.
Repository: MGUH 31289.

Fig. 8. *Chlamydophorella* cf. *nyei*, dorso-ventral view.
Location: Skolp E-07, 1685 m. **Sample**: cs, JEH15620, 3.
Optical parameters: B, 30.47 × 5.36, X32/1, × 60 bf.
Repository: MGUH 31290.

Fig. 9. *Charlesdowniea coleothrypta*, ventral view of ventral surface.
Location: Gilbert F-53, 2050−2060 m. **Sample**: cs, P39481, 1.
Optical parameters: C, 57 × 1014, E31/3, × 50 bf.
Repository: GSC 137981.

Fig. 10. *Cleistosphaeridium elegantulum* sp. nov., apical view.
Location: Karlsefni A-13, 2203.73–2212.87 m. **Sample**: cs, P39597, 1.
Optical parameters: D, 122 × 866, M29/0−1, × 40 pc.
Repository: GSC 138026.

Fig. 11. *Cleistosphaeridium elegantulum* sp. nov., oblique apical view.
Location: Karlsefni A-13, 2203.73–2212.87 m. **Sample**: cs, P39597, 1.
Optical parameters: D, 230 × 894, X32/0, × 40 pc.
Repository: GSC 138027.

Fig. 12. *Cleistosphaeridium elegantulum* sp. nov., holotype, dorso-ventral view.
Location: Karlsefni A-13, 2286.03–2295.17 m. **Sample**: cs, P39600, 1.
Optical parameters: D, 179 × 1017, S44/2, × 40 pc.
Repository: GSC 138033.

Fig. 13. *Cleistosphaeridium palmatum* sp. nov., holotype, dorsal view of optical section.
Location: Roberval K-92, 2450−2460 m. **Sample**: cs, P17706, 1.
Optical parameters: C, 69 × 1006, G30/0–2, × 50 bf.
Repository: GSC 137897.

Fig. 14. *Cleistosphaeridium palmatum* sp. nov., holotype, dorsal view, focussed on dorsal surface.
Location: Roberval K-92, 2450−2460 m. **Sample**: cs, P17706, 1.
Optical parameters: C, 69 × 1006, G30/0–2, × 50 bf.
Repository: GSC 137897.

Fig. 15. *Cleistosphaeridium palmatum* sp. nov., dorso-ventral view.
Location: Rut H-11, 3005−3015 m. **Sample**: cs, P39394, 1.
Optical parameters: D, 141 × 905, O33/1, × 40 pc.
Repository: GSC 137960.

Fig. 16. *Cleistosphaeridium palmatum* sp. nov., dorso-ventral view.
Location: Rut H-11, 3275−3285 m. **Sample**: cs, P39403, 1.
Optical parameters: D, 140 × 925, N35/3−4, × 40 pc.
Repository: GSC 137966.

Fig. 17. *Chytroeisphaeridia hadra* sp. nov., dorsal surface showing the archaeopyle.
Location: Roberval K-92, 1700−1710 m. **Sample**: cs, P17681, 1.
Optical parameters: C, 48 × 1017, E30/2, × 50 bf.
Repository: GSC 137888.

Fig. 18. *Chytroeisphaeridia hadra*, sp. nov., holotype, optical section view.
Location: Roberval K-92, 3120−3140 m. **Sample**: cs, P17728, 1.
Optical parameters: C, 195 × 1098, U40/1, × 50 bf.
Repository: GSC 137902.

Fig. 19. *Cleistosphaeridium diversispinosum*, dorso-ventral view.
Location: Karlsefni A-13, 969.28–978.42 m. **Sample**: cs, P39553, 1.
Optical parameters: D, 163 × 971, Q40/0, × 40 pc.
Repository: GSC 138004.

Fig. 20. *Cleistosphaeridium diversispinosum*, operculum.
Location: Karlsefni A-13, 2203.73–2212.87 m. **Sample**: cs, P39597, 1.
Optical parameters: D, 115 × 972, L40/0, × 40 pc.
Repository: GSC 138025.

Plate 4

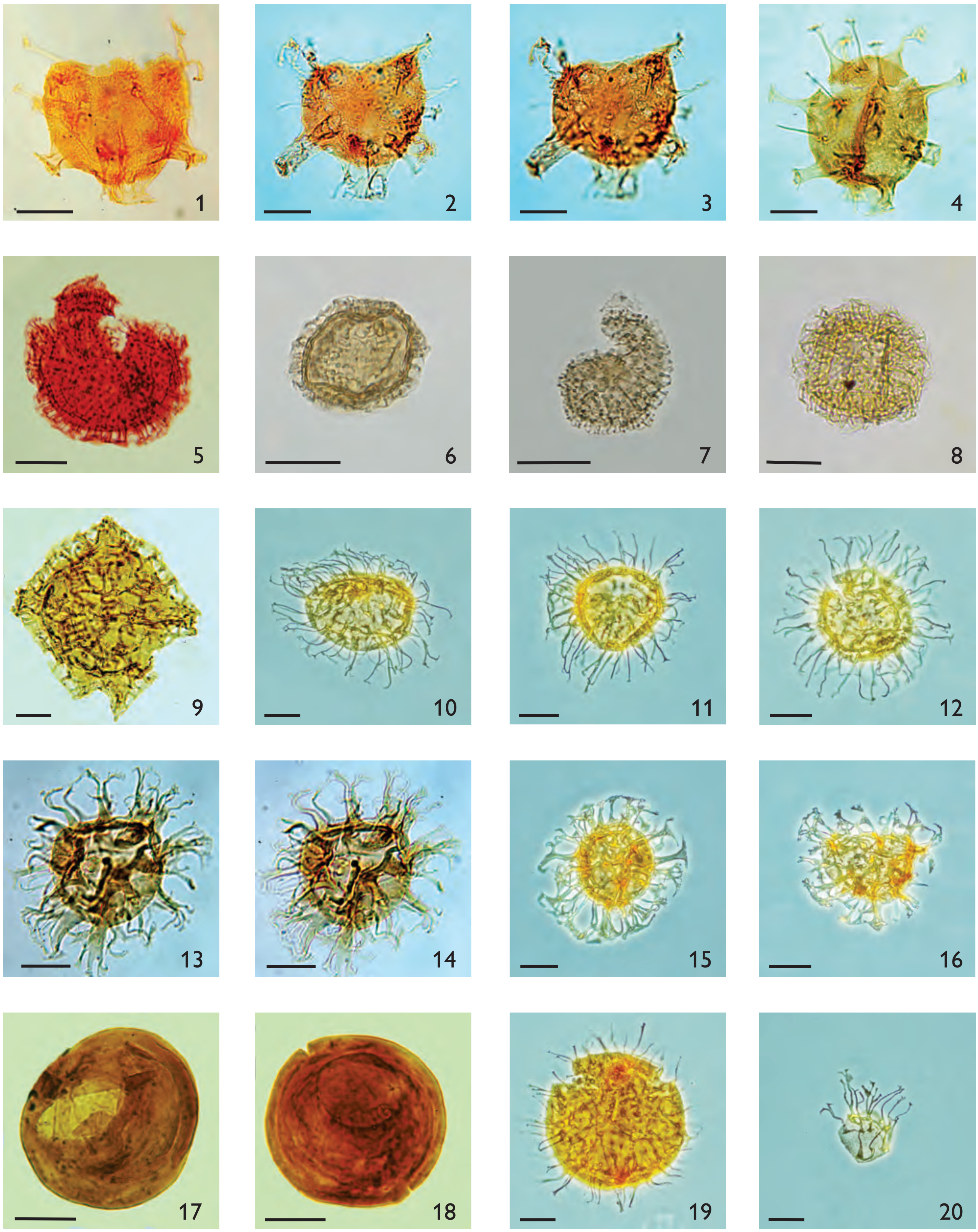

Plate 5

Fig. 1. *Cleistosphaeridium polypetellum*, dorso-ventral view.
Location: Karlsefni A-13, 2944.40–2953.55 m. **Sample**: cs, P39624, 1.
Optical parameters: D, 215 × 1017, V44/4, × 40 pc.
Repository: GSC 138047.

Fig. 2. *Cleistosphaeridium polypetellum*.
Location: Karlsefni A-13, 3054.13–3063.28 m. **Sample**: cs, P39628, 1.
Optical parameters: D, 151 × 896, P32/1−2, × 40 pc.
Repository: GSC 138048.

Fig. 3. *Cordosphaeridium delimurum*, dorso-ventral view.
Location: Karlsefni A-13, 2807.24–2816.39 m. **Sample**: cs, P39619, 1.
Optical parameters: D, 166 × 976, Q40/0−4, × 40 pc.
Repository: GSC 138046.

Fig. 4. *Cordosphaeridium delimurum*, dorso-ventral view, same specimen as fig. 3.
Location: Karlsefni A-13, 2807.24–2816.39 m. **Sample**: cs, P39619, 1.
Optical parameters: D, 166 × 976, Q40/0−4, × 40 pc.
Repository: GSC 138046.

Fig. 5. *Cordosphaeridium fibrospinosum*, oblique apical view.
Location: Karlsefni A-13, 3989.88–3999.02 m. **Sample**: cs, P39661, 1.
Optical parameters: D, 122 × 980, M41/0−1, × 40 pc.
Repository: GSC 138060.

Fig. 6. *Cordosphaeridium fibrospinosum*, dorsal view.
Location: Karlsefni A-13, 3989.88–3999.02 m. **Sample**: cs, P39661, 1.
Optical parameters: D, 126 × 897, M32/0, × 40 pc.
Repository: GSC 138061.

Fig. 7. *Cordosphaeridium cantharellus*, right lateral view.
Location: Rut H-11, 755−765 m. **Sample**: cs, P39319, 1.
Optical parameters: D, 110 × 978, L40/2, × 40 pc.
Repository: GSC 137922.

Fig. 8. *Cordosphaeridium funiculatum*, left lateral view.
Location: Ralegh N-18, 1525 m. **Sample**: cs, YD16219, 2.
Optical parameters: E, 43.3 × 23.8, C42/1, × 60 bf.
Repository: MGUH 31291.

Fig. 9. *Cordosphaeridium gracile*, dorsal surface.
Location: Karlsefni A-13, 3081.57–3090.71 m. **Sample**: cs, P39629, 1.
Optical parameters: D, 171 × 1030, R46/0, × 40 pc.
Repository: GSC 138049.

Fig. 10. *Cordosphaeridium inodes*, dorsal surface.
Location: Karlsefni A-13, 3931.97–3941.11 m. **Sample**: cs, P39659, 1.
Optical parameters: D, 97 × 910, J34/1−3, × 40 pc.
Repository: GSC 138059.

Fig. 11. *Dapsilidinium pseudoinsertum* sp. nov., dorso-ventral view.
Location: Karlsefni A-13, 2697.51–2706.66 m. **Sample**: cs, P39615, 1.
Optical parameters: D, 98 × 946, J37/4, × 40 pc.
Repository: GSC 138043.

Fig. 12. *Dapsilidinium pseudoinsertum* sp. nov., holotype, dorso-ventral view.
Location: Rut H-11, 2825−2835 m. **Sample**: cs, P39388, 1.
Optical parameters: D, 196 × 1051, U48/1−2, × 40 pc.
Repository: GSC 137957.

Fig. 13. *Dapsilidinium pseudocolligerum*.
Location: Gilbert F-53, 2020−2030 m. **Sample**: cs, P39480, 1.
Optical parameters: C, 45 × 1008, D30/0–4, × 50 bf.
Repository: GSC 137980.

Fig. 14. *Dapsilidinium simplex*, dorso-ventral view.
Location: Rut H-11, 3845−3855 m. **Sample**: cs, P39421, 1.
Optical parameters: D, 165 × 921, Q35/3, × 40 pc.
Repository: GSC 137974.

Fig. 15. *Deflandrea denticulata*, dorso-ventral view of dorsal surface.
Location: Karlsefni A-13, 4038.65–4047.79 m. **Sample**: cs, P39663, 1.
Optical parameters: D, 165 × 1014, Q44/0, × 40 pc.
Repository: GSC 138065.

Fig. 16. *Deflandrea denticulata*, dorso-ventral view of ventral surface.
Location: Karlsefni A-13, 4038.65–4047.79 m. **Sample**: cs, P39663, 1.
Optical parameters: D, 60 × 1068, E50/3, × 40 pc.
Repository: GSC 138064.

Fig. 17. *Deflandrea borealis* sp. nov., dorso-ventral view.
Location: Karlsefni A-13, 2697.51–2706.66 m. **Sample**: cs, P39615, 1.
Optical parameters: D, 169 × 929, Q35/4, × 40 pc.
Repository: GSC 138044.

Fig. 18. *Deflandrea borealis* sp. nov., dorso-ventral view.
Location: Rut H-11, 2915−2925 m. **Sample**: cs, P39391, 1.
Optical parameters: D, 198 × 883, U31/1, × 40 pc.
Repository: GSC 137959.

Fig. 19. *Deflandrea borealis* sp. nov., holotype, dorso-ventral view.
Location: Rut H-11, 3095−3105 m. **Sample**: cs, P39397, 1.
Optical parameters: D, 189 × 986, T41/2, × 40 pc.
Repository: GSC 137964.

Fig. 20. *Deflandrea borealis* sp. nov., dorso-ventral view.
Location: Gilbert F-53, 1810−1820 m. **Sample**: cs, P39473, 1.
Optical parameters: C, 175 × 1014, R31/3, × 50 bf.
Repository: GSC 137977.

Plate 5

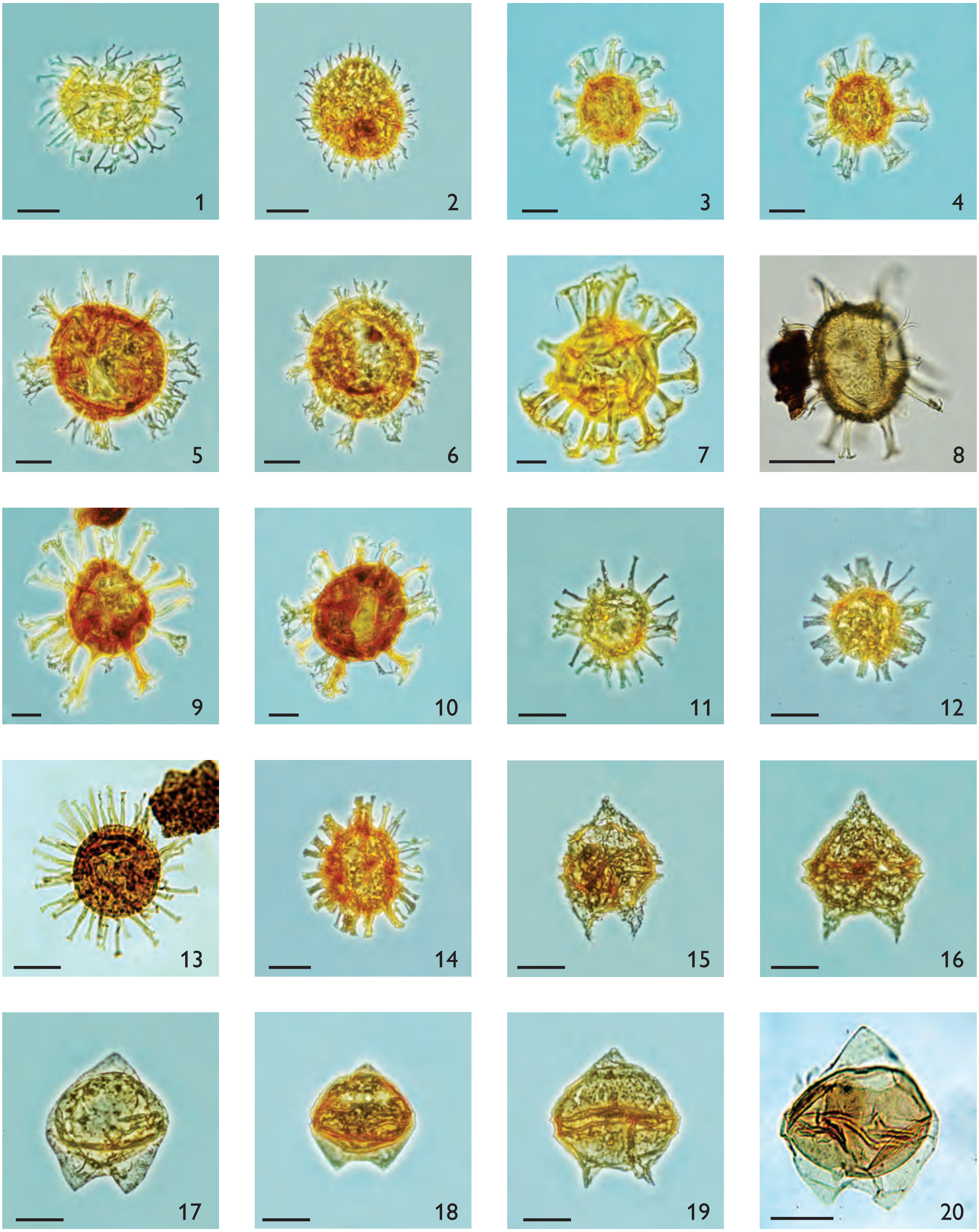

Plate 6

Fig. 1. *Deflandrea galeata*, dorso-ventral view of dorsal surface.
Location: Annertuneq, 388 m, GGU366591. **Sample**: os, C402-G, 5.
Optical parameters: A, 56.1 × 112.8, B556/4, × 60 bf.
Repository: MGUH 23924.

Fig. 2. *Deflandrea majae*, ventral view of ventral surface.
Location: Skolp E-07, 1055 m. **Sample**: cs, YD15579, 4.
Optical parameters: A, 45.7 × 96.9, T46/4, × 60 bf.
Repository: GSC 138142.

Fig. 3. *Deflandrea oebisfeldensis*, dorso-ventral view of ventral surface.
Location: Hekja O-71, 3360 m. **Sample**: cs, JEH16039, 3.
Optical parameters: E, 32.1 × 5.6, W31/1, × 60 bf.
Repository: MGUH 31292.

Fig. 4. *Deflandrea phosphoritica*, dorso-ventral view.
Location: Snorri J-90, 2249.45–2256.6 m. **Sample**: cs, P9747, 10.
Optical parameters: C, 220 × 1035, W33/0, × 50 bf.
Repository: GSC 138136.

Fig. 5. *Diphyes brevispinum*, dorso-ventral view.
Location: South Labrador N-79, 1920–1930 m. **Sample**: cs, P39782, 1.
Optical parameters: C, 118 × 1030, M32/2–M33/1, × 50 bf.
Repository: GSC 138114.

Fig. 6. *Diphyes brevispinum*, dorso-ventral view.
Location: South Labrador N-79, 1980–1990 m. **Sample**: cs, P39784, 1.
Optical parameters: C, 144 × 1042, O34/3, × 50 bf.
Repository: GSC 138117.

Fig. 7. *Diphyes ficusoides*, dorso-ventral view.
Location: Bjarni O-82, 1905–1915 m. **Sample**: cs, P39718, 1.
Optical parameters: C, 130 × 1061, N36/1–2, × 50 bf.
Repository: GSC 138071.

Fig. 8. *Diphyes ficusoides*, dorso-ventral view.
Location: Rut H-11, 3125–3135 m. **Sample**: cs, P39398, 1.
Optical parameters: D, 164 × 971, Q40/0, × 40 pc.
Repository: GSC 137965.

Fig. 9. *Disphaerogena carposphaeropsis*.
Location: Annertuneq, 451 m, GGU405093. **Sample**: os, YD11738, 3.
Optical parameters: A, 27.6 × 96.7, U27/2, × 40 bf.
Repository: MGUH 31293.

Fig. 10. *Cyclonephelium distinctum*, dorsal view of dorsal surface.
Location: Gilbert F-53, 3220–3230 m. **Sample**: cs, P39520, 1.
Optical parameters: C, 28 × 1026, B32/3–4, × 50 bf.
Repository: GSC 137990.

Fig. 11. *Dinogymnium longicorne*.
Location: Skolp E-07, 1895 m. **Sample**: cs, JEH15633, 4.
Optical parameters: A, 42.9 × 110.5, E43/4, × 60 bf.
Repository: MGUH 31294.

Fig. 12. *Diphyes colligerum*, dorso-ventral view.
Location: Gilbert F-53, 1990–2000 m. **Sample**: cs, P39479, 1.
Optical parameters: C, 194 × 1058, T35/4, × 50 bf.
Repository: GSC 137979.

Fig. 13. *Eatonicysta furensis*, dorsal view of dorsal surface.
Location: North Leif I-05, 2070–2080 m. **Sample**: cs, YD17598, 3.
Optical parameters: E, 19.3 × 15.7, M17/0, × 60 bf.
Repository: GSC 138153.

Fig. 14. *Eatonicysta ursulae*, dorso-ventral view.
Location: South Labrador N-79, 2220–2230 m. **Sample**: cs, P39792, 1.
Optical parameters: C, 56 × 1042, E34/3, × 50 bf.
Repository: GSC 138119.

Fig. 15. *Evittosphaerula*? *foraminosa* sp. nov., apical view.
Location: North Leif I-05, 2130–2140 m. **Sample**: cs, YD17600, 3.
Optical parameters: E, 23.7 × 10.0, S22/1, × 60 bf.
Repository: GSC 138155.

Fig. 16. *Evittosphaerula*? *foraminosa* sp. nov., apical view of apical surface.
Location: North Leif I-05, 2190–2200 m. **Sample**: cs, YD17602, 3.
Optical parameters: E, 36.5 × 26.0, A35/0, × 60 bf.
Repository: GSC 138160.

Fig. 17. *Evittosphaerula*? *foraminosa* sp. nov., oblique apical view of epicyst.
Location: North Leif I-05, 2130–2140 m. **Sample**: cs, YD17600, 3.
Optical parameters: E, 32.8 × 20.8, F31/3, × 60 bf.
Repository: GSC 138157.

Fig. 18. *Evittosphaerula*? *foraminosa* sp. nov., oblique antapical view.
Location: North Leif I-05, 2130–2140 m. **Sample**: cs, YD17600, 3.
Optical parameters: E, 34.2 × 5.7, W32/2, × 60 bf.
Repository: GSC 138158.

Fig. 19. *Evittosphaerula*? *foraminosa* sp. nov., holotype, right lateral view focussed on right lateral surface.
Location: North Leif I-05, 2130–2140 m. **Sample**: cs, YD17600, 3.
Optical parameters: E, 44.9 × 15.5, M43/0, × 60 bf.
Repository: GSC 138159.

Fig. 20. *Evittosphaerula*? *foraminosa* sp. nov., holotype, right lateral view, focussed on left lateral surface.
Location: North Leif I-05, 2130–2140 m. **Sample**: cs, YD17600, 3.
Optical parameters: E, 44.9 × 15.5, M43/0, × 60 bf.
Repository: GSC 138159.

Plate 6

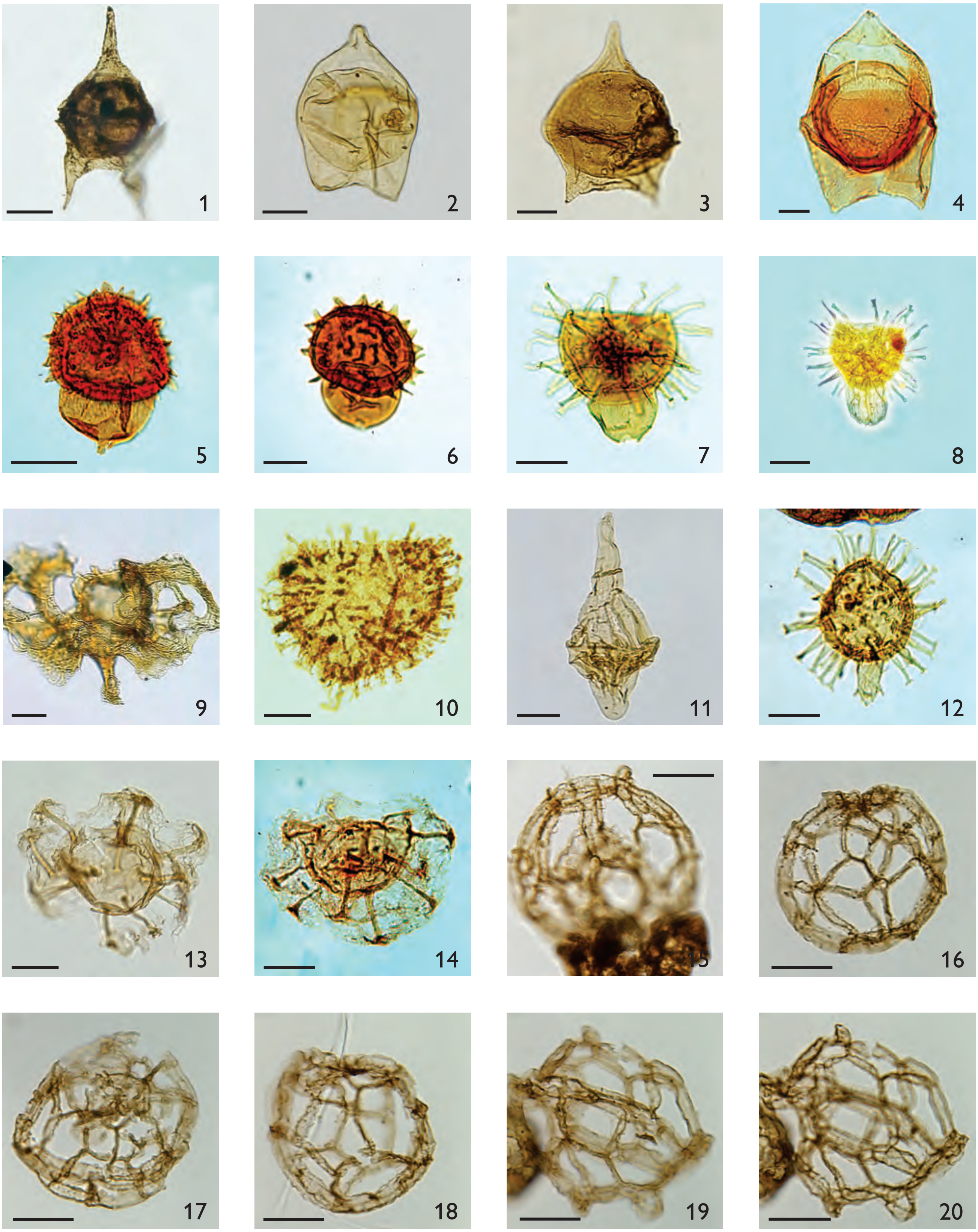

Plate 7

Fig. 1. *Enneadocysta magna*, ventral view.
Location: Rut H-11, 1205–1215 m. **Sample**: cs, P39334, 1.
Optical parameters: D, 100 × 990, J42/3, × 40 pc.
Repository: GSC 137929.

Fig. 2. *Enneadocysta magna*, ventral view.
Location: Rut H-11, 1235–1245 m. **Sample**: cs, P39335, 1.
Optical parameters: D, 216 × 859, V28/3–4, × 40 pc.
Repository: GSC 137933.

Fig. 3. *Eocladopyxis peniculata*.
Location: South Labrador N-79, 2310–2320 m. **Sample**: cs, P20171, 1.
Optical parameters: C, 190 × 1100, T41/0–3, × 50 bf.
Repository: GSC 137911.

Fig. 4. *Fibrocysta bipolaris*, right lateral view.
Location: Roberval K-92, 2390–2400 m. **Sample**: cs, P17704, 1.
Optical parameters: C, 33 × 1090, C39/0, × 50 bf.
Repository: GSC 137895.

Fig. 5. *Ginginodinium*? *flexidentatum* sp. nov., dorso-ventral view of ventral surface.
Location: North Leif I-05, 2010–2020 m. **Sample**: cs, YD17596, 3.
Optical parameters: E, 24.9 × 21.8, E23/3, × 60 bf.
Repository: GSC 138150.

Fig. 6. *Ginginodinium*? *flexidentatum* sp. nov., dorso-ventral view of dorsal surface.
Location: Ogmund E-72, 1340 m. **Sample**: cs, YD15727, 3.
Optical parameters: A, 43.4 × 96.5, U44/1, × 60 bf.
Repository: MGUH 31295.

Fig. 7. *Ginginodinium*? *flexidentatum* sp. nov., dorso-ventral view of ventral surface.
Location: Hekja O-71, 3090 m. **Sample**: cs, JEH16029, 2.
Optical paramaters: E, 35.6 × 20.8, F34/0, × 60 bf.
Repository: MGUH 31296.

Fig. 8. *Ginginodinium*? *flexidentatum* sp. nov., dorso-ventral view.
Location: Karlsefni A-13, 2807.24–2816.39 m. **Sample**: cs, P39619, 1.
Optical parameters: D, 146 × 1060, O49/0, × 40 pc.
Repository: GSC 138045.

Fig. 9. *Ginginodinium*? *flexidentatum* sp. nov., dorso-ventral view.
Location: North Leif I-05, 2010–2020 m. **Sample**: cs, YD17596, 3.
Optical parameters: A, 22.5 × 19.3, H20/0, × 60 bf.
Repository: GSC 138149.

Fig. 10. *Ginginodinium*? *flexidentatum* sp. nov., dorso-ventral view.
Location: Rut H-11, 2915–2925 m. **Sample**: cs, P39391, 1.
Optical parameters: D, 140 × 1029, O46/1, × 40 pc.
Repository: GSC 137958.

Fig. 11. *Ginginodinium*? *flexidentatum* sp. nov., holotype, dorso-ventral view.
Location: Bjarni O-82, 1815–1825 m. **Sample**: cs, P39715, 1.
Optical parameters: C, 36 × 1028, C32/4, × 50 bf.
Repository: GSC 138070.

Fig. 12. *Gillinia hymenophora*.
Location: Gilbert F-53, 3280–3290 m. **Sample**: cs, P39522, 1.
Optical parameters: C, 155 × 1045, P34/3–4, × 50 bf.
Repository: GSC 137991.

Fig. 13. *Habibacysta tectata*, right lateral view, showing detached operculum.
Location: Karlsefni A-13, 667.52–676.66 m. **Sample**: cs, P39542, 1.
Optical parameters: D, 180 × 979, S41/1, × 40 pc.
Repository: GSC 137995.

Fig. 14. *Glaphyrocysta exuberans*, dorso-ventral view.
Location: North Leif I-05, 1530–1540 m. **Sample**: cs, YD15580, 2.
Optical parameters: A, 38.8 × 23.5, C37/4, × 60 bf.
Repository: MGUH 31297.

Fig. 15. *Glaphyrocysta divaricata*, dorso-ventral view.
Location: Karlsefni A-13, 3438.19–3447.33 m. **Sample**: cs, P39642, 1.
Optical parameters: D, 194 × 1048, T48/3, × 40 pc.
Repository: GSC 138053.

Fig. 16. *Glaphyrocysta divaricata*, dorso-ventral view.
Location: Karlsefni A-13, 3438.19–3447.33 m. **Sample**: cs, P39642, 1.
Optical parameters: D, 188 × 1032, S46/3–4, × 40 pc.
Repository: GSC 138052.

Fig. 17. *Glaphyrocysta retiintexta*, ventral view.
Location: Karlsefni A-13, 4038.65–4047.79 m. **Sample**: cs, P39663, 1.
Optical parameters: D, 220 × 1066, W49/2–4, × 40 pc.
Repository: GSC 138066.

Fig. 18. *Histiocysta palla*, ventral view.
Location: Ogmund E-72, 1620 m. **Sample**: cs, YD15740, 4.
Optical parameters: A, 37.0 × 98.7, R37/4, × 60 bf.
Repository: MGUH 31298.

Fig. 19. *Histiocysta palla*, oblique right lateral view, same specimen as fig. 18.
Location: Ogmund E-72, 1620 m. **Sample**: cs, YD15740, 4.
Optical parameters: A, 37.0 × 98.7, R37/4, × 60 bf.
Repository: MGUH 31298.

Fig. 20. *Histiocysta palla*, dorsal surface.
Location: Bjarni O-82, 2300–2310 m. **Sample**: cs, P39731, 1.
Optical parameters: C, 140 × 996, O29/0, × 50 bf.
Repository: GSC 138073.

Plate 7

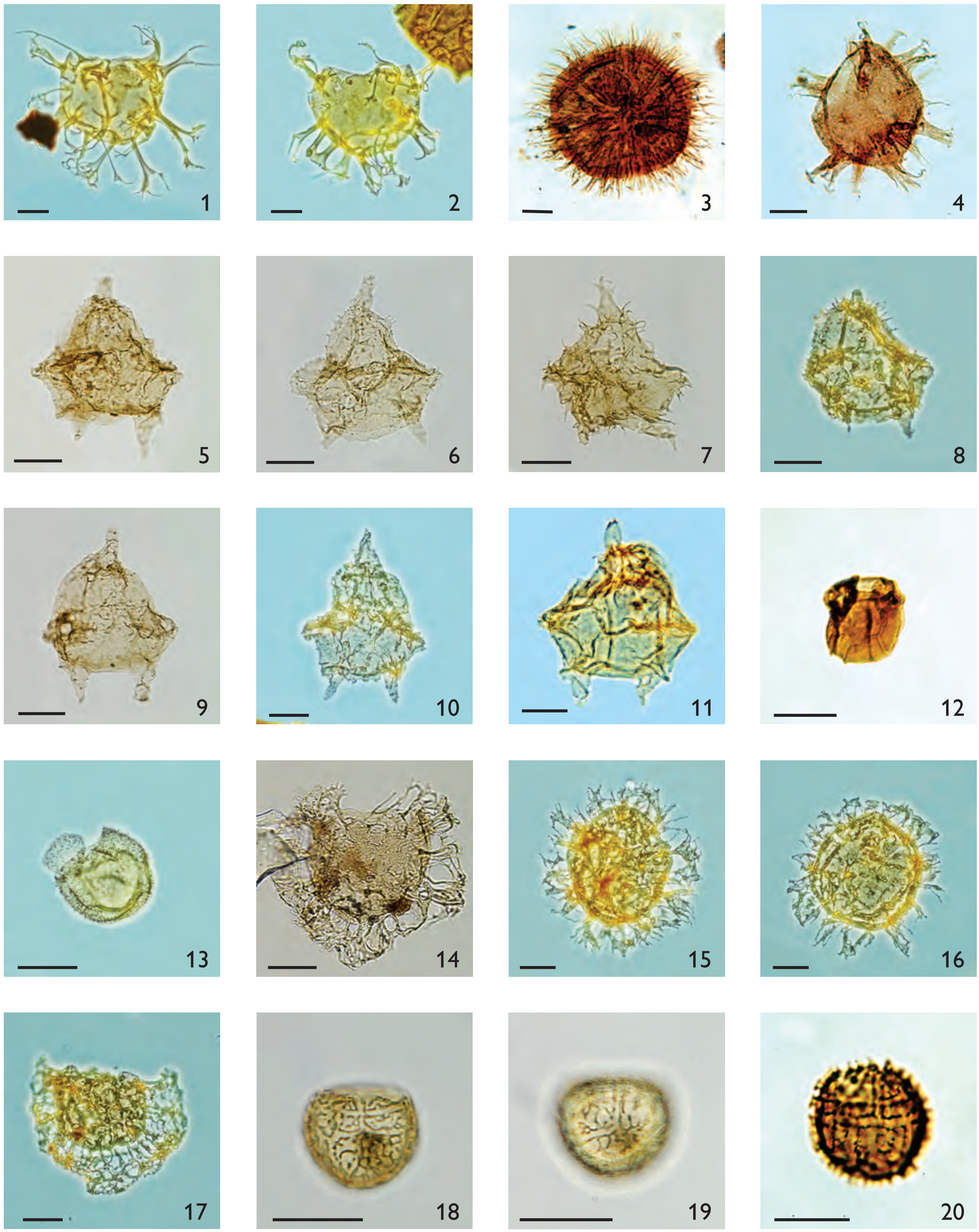

Plate 8

Fig. 1. *Glaphyrocysta texta*, oblique lateral view.
Location: North Leif I-05, 2100–2110 m. **Sample**: cs, YD17599, 4.
Optical parameters: E, 25.0 × 16.6, L23/2, × 60 bf.
Repository: MGUH 31299.

Fig. 2. *Glaphyrocysta vicina*, ventral view of ventral surface.
Location: Ralegh N-18, 1725 m. **Sample**: cs, YD16224, 2.
Optical parameters: E, 45.9 × 7.7, T45/3, × 60 bf.
Repository: MGUH 31300.

Fig. 3. *Heterosphaeridium bellii*.
Location: Gilbert F-53, 3460–3470 m. **Sample**: cs, P39528, 1.
Optical parameters: C, 62 × 1062, F36/0, × 50 bf.
Repository: GSC 137992.

Fig. 4. *Heterosphaeridium bellii.*
Location: North Leif I-05, 2670–2680 m. **Sample**: cs, YD17618, 3.
Optical parameters: E, 43.0 × 7.1, V41/2, × 60 bf.
Repository: GSC 138166.

Fig. 5. *Homotryblium tenuispinosum*, apical view, focussed on archaeopyle margin.
Location: Gilbert F-53, 1960–1970 m. **Sample**: cs, P39478, 1.
Optical parameters: C, 194 × 983, T28/3, × 50 bf.
Repository: GSC 137978.

Fig. 6. *Homotryblium tenuispinosum*, apical view, same specimen as fig. 5, focussed on hypocyst.
Location: Gilbert F-53, 1960–1970 m. **Sample**: cs, P39478, 1.
Optical parameters: C, 194 × 983, T28/3, × 50 bf.
Repository: GSC 137978.

Fig. 7. *Homotryblium tenuispinosum*, dorso-ventral view.
Location: South Labrador N-79, 1920–1930 m. **Sample**: cs, P39782, 1.
Optical parameters: C, 40 × 1061, D35/1, × 50 bf.
Repository: GSC 138116.

Fig. 8. *Heterosphaeridium difficile*, dorso-ventral view.
Location: South Labrador N-79, 3485–3495 m. **Sample**: cs, P20210, 1.
Optical parameters: C, 168 × 1128, R43/1–2, × 50 bf.
Repository: GSC 137912.

Fig. 9. *Homotryblium abbreviatum*, dorsal view.
Location: Snorri J-90, 2249.45–2256.6 m. **Sample**: cs, P9747, 10.
Optical parameters: C, 58 × 1092, F39/1–2, × 50 bf.
Repository: GSC 138138.

Fig. 10. *Homotryblium abbreviatum*, apical view.
Location: Snorri J-90, 2249.45–2266.6 m. **Sample**: cs, P9747, 10.
Optical parameters: C, 50 × 1000, E29/2, × 50 bf.
Repository: GSC 138137.

Fig. 11. *Hystrichokolpoma cinctum*, dorsal surface.
Location: Karlsefni A-13, 2642.65–2651.79 m. **Sample**: cs, P39613, 1.
Optical parameters: D, 128 × 920, M35/3, × 40 pc.
Repository: GSC 138041.

Fig. 12. *Hapsocysta*? *benteae*.
Location: North Leif I-05, 2310–2320 m. **Sample**: cs, YD17606, 4.
Optical parameters: E, 50.8 × 19.9, G50/3, × 60 bf.
Repository: MGUH 31301.

Fig. 13. *Hystrichokolpoma globulus*, left lateral view of left lateral surface.
Location: Snorri J-90, 2293,65 m. **Sample**: sw, P9370, 10.
Optical parameters: C, 181 × 1017, S31/0–4, × 50 bf.
Repository: GSC 138132.

Fig. 14. *Hystrichokolpoma globulus*, left lateral view, same specimen as fig. 13, focussed on right lateral surface.
Location: Snorri J-90, 2293,65 m. **Sample**: sw, P9370, 10.
Optical parameters: C, 181 × 1017, S31/0–4, × 50 bf.
Repository: GSC 138132.

Fig. 15. *Hystrichokolpoma globulus*, lateral view.
Location: Snorri J-90, 2441.48–2450.62 m. **Sample**: cs, P9751, 10.
Optical parameters: C, 102 × 1010, K30/4, × 50 bf.
Repository: GSC 138139.

Fig. 16. *Heteraulacacysta porosa*, antapical view of antapical surface.
Location: Ralegh N-18, 1525 m. **Sample**: cs, YD16219, 4.
Optical parameters: E, 36.3 × 20.5, G35/1, × 60 bf.
Repository: CNSOPB.

Fig. 17. *Hystrichosphaeridium quadratum* sp. nov., holotype, dorsal surface.
Location: Gilbert F-53, 2770–2780 m. **Sample**: cs, P39505, 1.
Optical parameters: C, 113 × 992, L/29/3, × 50 bf.
Repository: GSC 137988.

Fig. 18. *Hystrichosphaeridium quadratum* sp. nov., holotype, focussed on ventral surface.
Location: Gilbert F-53, 2770–2780 m. **Sample**: cs, P39505, 1.
Optical parameters: C, 113 × 992, L29/3, × 50 bf.
Repository: GSC 137988.

Fig. 19. *Hystrichosphaeridium quadratum* sp. nov., operculum, showing pre-apical process.
Location: Karlsefni A-13, 3904.54–3913.68 m. **Sample**: cs, P39658, 1.
Optical parameters: D, 125 × 999, M43/0–3, × 40 pc.
Repository: GSC 138057.

Fig. 20. *Hystrichosphaeridium tubiferum*, lateral view.
Location: Gjoa O-37, 2120 m. **Sample**: cs, YD16090, 4.
Optical parameters: E, 32.7 × 22.0, E31/0, × 60 bf.
Repository: CNSOPB.

Plate 8

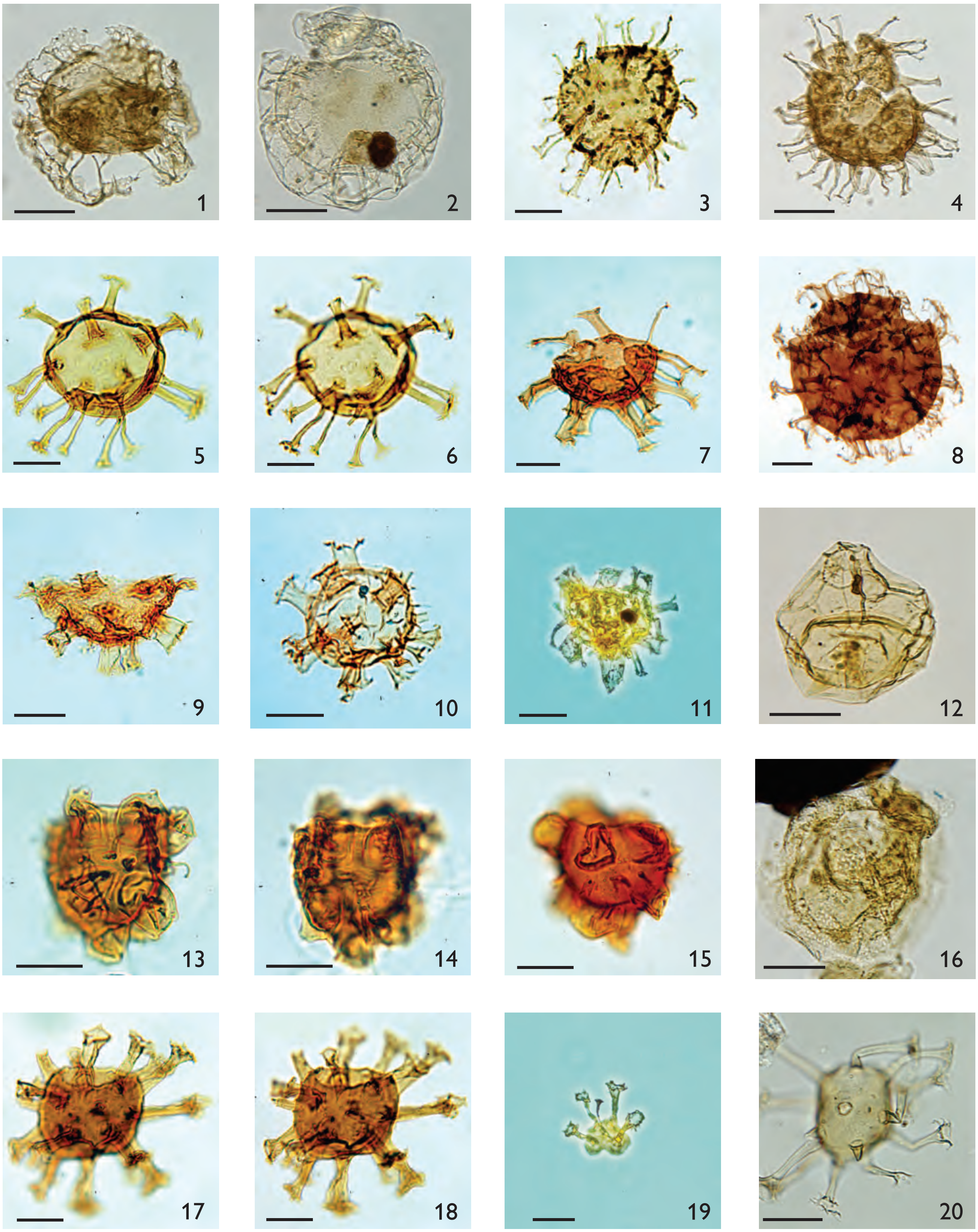

Plate 9

Fig. 1. *Hystrichostrogylon digitus* sp. nov., dorso-ventral view.
Location: Karlsefni A-13, 2267.74–2276.88 m. **Sample**: cs, P39599, 1.
Optical parameters: D, 200 × 878, U30/0, × 40 pc.
Repository: GSC 138030.

Fig. 2. *Hystrichostrogylon digitus* sp. nov., dorso-ventral view.
Location: Rut H-11, 2375–2385 m. **Sample**: cs, P39373, 1.
Optical parameters: D, 167 × 973, Q40/3–4, × 40 pc.
Repository: GSC 137950.

Fig. 3. *Hystrichostrogylon digitus* sp. nov., holotype, dorso-ventral view.
Location: Rut H-11, 2435–2445 m. **Sample**: cs, P39375, 1.
Optical parameters: D, 158 × 1050, Q48/1, × 40 pc.
Repository: GSC 137952.

Fig. 4. *Hystrichosphaeropsis perforata*, dorso-ventral view.
Location: Skolp E-07, 1250 m. **Sample**: cs, YD17614, 4.
Optical parameters: A, 43.3 × 101.4, P44/1, × 60 bf.
Repository: GSC 138164.

Fig. 5. *Impletosphaeridium apodastum* sp. nov., holotype.
Location: Hekja O-71, 4565–4575 m. **Sample**: cs, P18737, 1.
Optical parameters: C, 133 × 1080, N37/3, × 50 bf.
Repository: GSC 137903.

Fig. 6. *Impletosphaeridium apodastum* sp. nov.
Location: Karlsefni A-13, 3822.24–3831.38 m. **Sample**: cs, P39655, 1.
Optical parameters: D, 201 × 990, U42/1–3, × 40 pc.
Repository: GSC 138055.

Fig. 7. *Impletosphaeridium apodastum* sp. nov.
Location: Karlsefni A-13, 3989.88–3999.02 m. **Sample**: cs, P39661, 1.
Optical parameters: D, 193 × 1070, T50/0, × 40 pc.
Repository: GSC 138063.

Fig. 8. *Impletosphaeridium apodastum* sp. nov.
Location: Karlsefni A-13, 3989.88–3999.02 m. **Sample**: cs, P39661, 1.
Optical parameters: D, 173 × 899, R32/0, × 40 pc.
Repository: GSC 138062.

Fig. 9. *Impagidinium victorianum*, ventral view of ventral surface.
Location: Roberval K-92, 2270–2280 m. **Sample**: cs, P17700, 1.
Optical parameters: C, 66 × 1022, F32/3, × 50 bf.
Repository: GSC 137894.

Fig. 10. *Impagidinium victorianum*, ventral view, same specimen as fig. 9, despite lower focus, ventral surface clear.
Location: Roberval K-92, 2270–2280 m. **Sample**: cs, P17700, 1.
Optical parameters: C, 66 × 1022, F32/3, × 50 bf.
Repository: GSC 137894.

Fig. 11. *Impagidinium victorianum*, ventral view, same specimen as fig. 9, focussed on periphery.
Location: Roberval K-92, 2270–2280 m. **Sample**: cs, P17700, 1.
Optical parameters: C, 66 × 1022, F32/3, × 50 bf.
Repository: GSC 137894.

Fig. 12. *Hystrichosphaeropsis quasicribrata*, dorso-ventral view.
Location: North Leif I-05, 2550–2560 m. **Sample**: cs, YD17614, 4.
Optical parameters: E, 43.9 × 15.8, M43/2, × 60 bf.
Repository: GSC 138165.

Fig. 13. *Impagidinium victorianum*, dorsal view of ventral surface.
Location: Skolp E-07, 1175 m. **Sample**: cs, YD15587, 3.
Optical parameters: A, 34.2 × 99.0, S435/1, × 60 bf.
Repository: MGUH 31302.

Fig. 14. *Impagidinium victorianum*, dorsal view of dorsal surface, same specimen as fig. 13.
Location: Skolp E-07, 1175 m. **Sample**: cs, YD15587, 3.
Optical parameters: A, 34.2 × 99.0, S435/1, × 60 bf.
Repository: MGUH 31302.

Fig. 15. *Isabelidinium cretaceum*, dorso-ventral view.
Location: North Leif I-05, 2550–2560 m. **Sample**: cs, YD17614, 2.
Optical parameters: E, 17.4 × 20.3, G15/0, × 60 bf.
Repository: MGUH 31303.

Fig. 16. *Isabelidinium cretaceum*, dorso-ventral view.
Location: Roberval K-92, 3060–3070 m. **Sample**: cs, P17726, 1.
Optical parameters: C, 157 × 1085, Q38/2, × 50 bf.
Repository: GSC 137899.

Fig. 17. *Isabelidinium microarmum*, dorsal view of dorsal surface.
Location: Skolp E-07, 2285 m. **Sample**: cs, YD15659, 2.
Optical parameters: A, 24.4 × 93.5, X24/2, × 60 bf.
Repository: MGUH 31304.

Fig. 18. *Kleithriasphaeridium mantellii*, right lateral view.
Location: Maude Bight, Bylot Island, section 3 (V002181), 1 m above base (sample PB-57). **Sample**: os, P5189-46, H.
Optical parameters: C, 161 × 932, L54/1–3, × 50 bf.
Repository: GSC 138131.

Fig. 19. *Laciniadinium arcticum*, ventral view of ventral surface.
Location: Ogmund E-72, 1530 m (reworked specimen). **Sample**: cs, YD15734, 3.
Optical parameters: A, 23.6 × 98.0, S23/4, × 60 bf.
Repository: MGUH 31305.

Fig. 20. *Laciniadinium arcticum*, dorsal view of ventral surface.
Location: Skolp E-07, 1940 m. **Sample**: cs, JEH15635, 3.
Optical parameters: A, 19.5 × 104.7, L19/3, × 60 bf.
Repository: MGUH 31306.

Plate 9

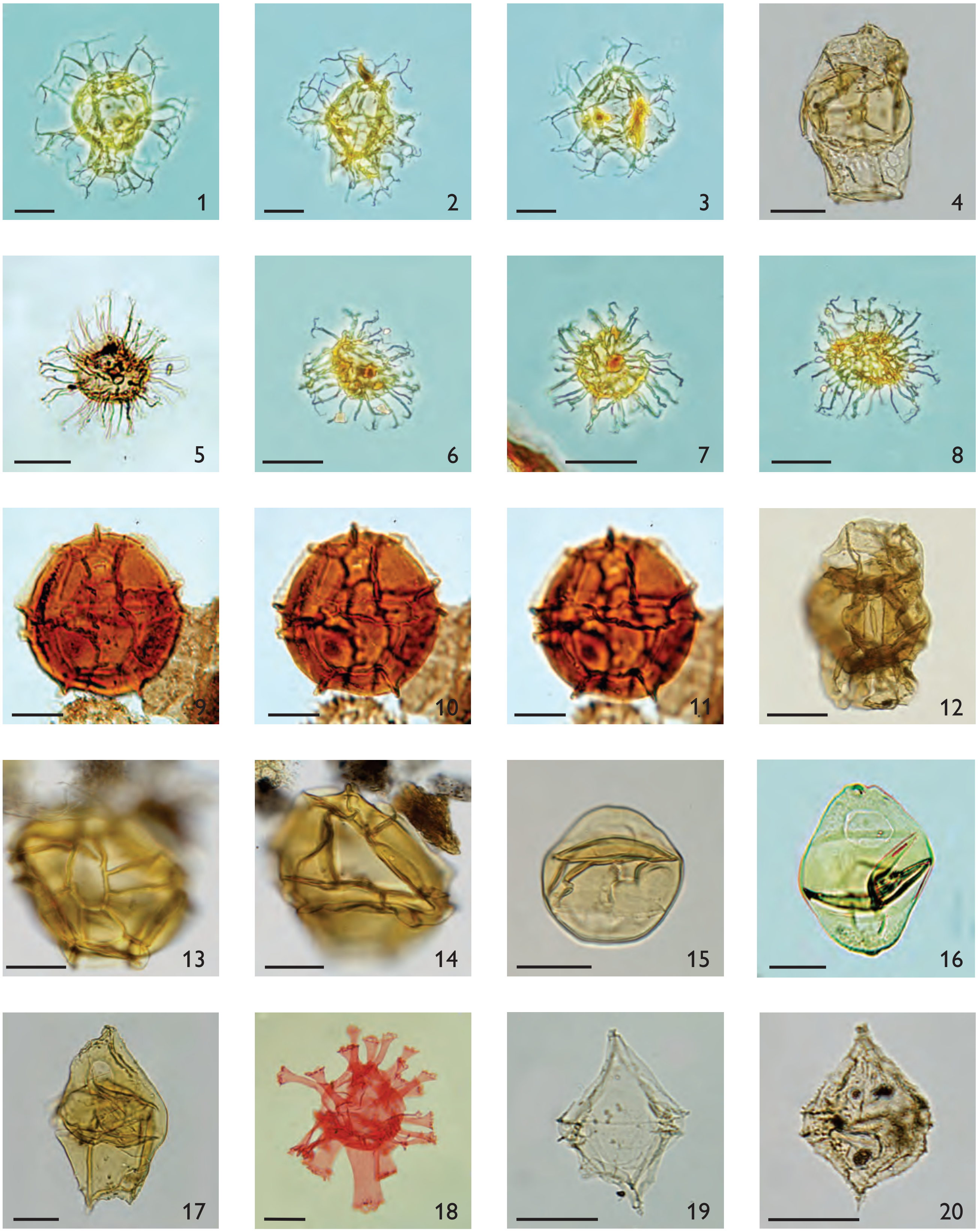

Plate 10

Fig. 1. *Lingulodinium funginum*.
Location: Karlsefni A-13, 2670.08–2679.22 m. **Sample**: cs, P39614, 1.
Optical parameters: D, 145 × 1047, O48/3, × 40 pc.
Repository: GSC 138042.

Fig. 2. *Lingulodinium funginum*.
Location: Rut H-11, 3035–3045 m. **Sample**: cs, P39395, 1
Optical parameters: D, 73 × 929, G36/1, × 40 pc.
Repository: GSC 137961.

Fig. 3. *Lingulodinium machaerophorum*.
Location: Rut H-11, 2585–2595 m. **Sample**: cs, P39380, 1.
Optical parameters: D, 105 × 900, K32/2, × 40 pc.
Repository: GSC 137954.

Fig. 4. *Lingulodinium machaerophorum*, dorso-ventral view showing attached operculum.
Location: Gjoa O-37, 1620 m. **Sample**: cs, YD16074, 2.
Optical parameters: E, 18.0 × 19.6, H16/1, × 60 bf.
Repository: MGUH 31307.

Fig. 5. *Nyktericysta davisii*, dorso-ventral view.
Location: North Leif I-05, 3180–3190 m. **Sample**: cs, YD17635, 4.
Optical parameters: E, 37.5 × 4.7, X36/0, × 40 bf.
Repository: GSC 138169.

Fig. 6. *Nyktericysta davisii*, dorso-ventral view.
Location: North Leif I-05, 3180–3190 m. **Sample**: cs, YD17635, 4.
Optical parameters: E, 20.9 × 12.4, P19/3, × 60 bf.
Repository: GSC 138168.

Fig. 7. *Nyktericysta dictyophora*, dorso-ventral view.
Location: Ogmund E-72, 1995 m. **Sample**: cs, YD15765, 3.
Optical parameters: A, 37.3 × 94.1, W38/3, × 60 bf.
Repository: MGUH 31308.

Fig. 8. *Nyktericysta dictyophora*, dorso-ventral view.
Location: Ogmund E-72, 1965 m. **Sample**: cs, YD15763, 3.
Optical parameters: A, 23.8 × 100.8, P23/4, × 60 bf.
Repository: MGUH 31309.

Fig. 9. *Lentinia serrata*, dorsal view of dorsal surface.
Location: South Labrador N-79, 2700–2710 m. **Sample**: cs, P39807, 1.
Optical parameters: C, 65 × 1027, F32/0–4, × 50 bf.
Repository: GSC 138122.

Fig. 10. *Palaeocystodinium golzowense*, dorso-ventral view.
Location: Rut H-11, 755–765 m. **Sample**: cs, P39319, 1.
Optical parameters: D, 61 × 1040, E47/3, × 40 pc.
Repository: GSC 137920.

Fig. 11. *Nyktericysta tripenta*, dorso-ventral view; endophragm visible apically.
Location: Ogmund E-72, 2550 m. **Sample**: cs, JEH15891, 3.
Optical parameters: A, 47.9 × 105.8, K49/3, × 60 bf.
Repository: MGUH 31310.

Fig. 12. *Nyktericysta tripenta*, dorso-ventral view, same specimen as fig. 11.
Location: Ogmund E-72, 2550 m. **Sample**: cs, JEH15891, 3.
Optical parameters: A, 47.9 × 105.8, K49/3, × 60 bf.
Repository: MGUH 31310.

Fig. 13. *Odontochitina porifera*, dorsal view.
Location: Skolp E-07, 1895 m. **Sample**: cs, JEH15633, 4.
Optical parameters: A, 33.2 × 107.7, H33/4, × 60 bf.
Repository: MGUH 31311.

Fig. 14. *Odontochitina ancala*, dorsal view.
Location: North Leif I-05, 2790–2800 m. **Sample**: cs, YD17622, 3.
Optical parameters: E, 20.1 × 18.5, J18/1, × 40 bf.
Repository: MGUH 31312.

Fig. 15. *Odontochitina costata*, dorsal view.
Location: Skolp E-07, 2345 m. **Sample**: cs, YD15663, 2.
Optical parameters: A, 40.3 × 111.8, D40/2, × 60 bf.
Repository: MGUH 31313.

Fig. 16. *Licracysta corymbus*, dorsal surface.
Location: Rut H-11, 1205–1215 m. **Sample**: cs, P39334, 1.
Optical parameters: D, 150 × 974, P40/1–2, × 40 pc.
Repository: GSC 137931.

Fig. 17. *Oligosphaeridium albertense*.
Location: Rut H-11, 1775–1785 m. **Sample**: cs, P39353, 1.
Optical parameters: D, 85 × 866, H29/0, × 40 pc.
Repository: GSC 137939.

Fig. 18. *Oligosphaeridium pulcherrimum*, dorso-ventral view.
Location: Gilbert F-53, 2705–2715 m. **Sample**: cs, P39503, 1.
Optical parameters: C, 24 × 1012, Y31/3, × 50 bf.
Repository: GSC 137986.

Fig. 19. *Oligosphaeridium pulcherrimum*.
Location: Rut H-11, 1745–1755 m. **Sample**: cs, P39352, 1.
Optical parameters: D, 168 × 880, Q30/4, × 40 pc.
Repository: GSC 137938.

Fig. 20. *Oligosphaeridium totum*.
Location: Rut H-11, 2225–2235 m. **Sample**: cs, P39368, 1.
Optical parameters: D, 154 × 1052, P48/0, × 40 pc.
Repository: GSC 137944.

Plate 10

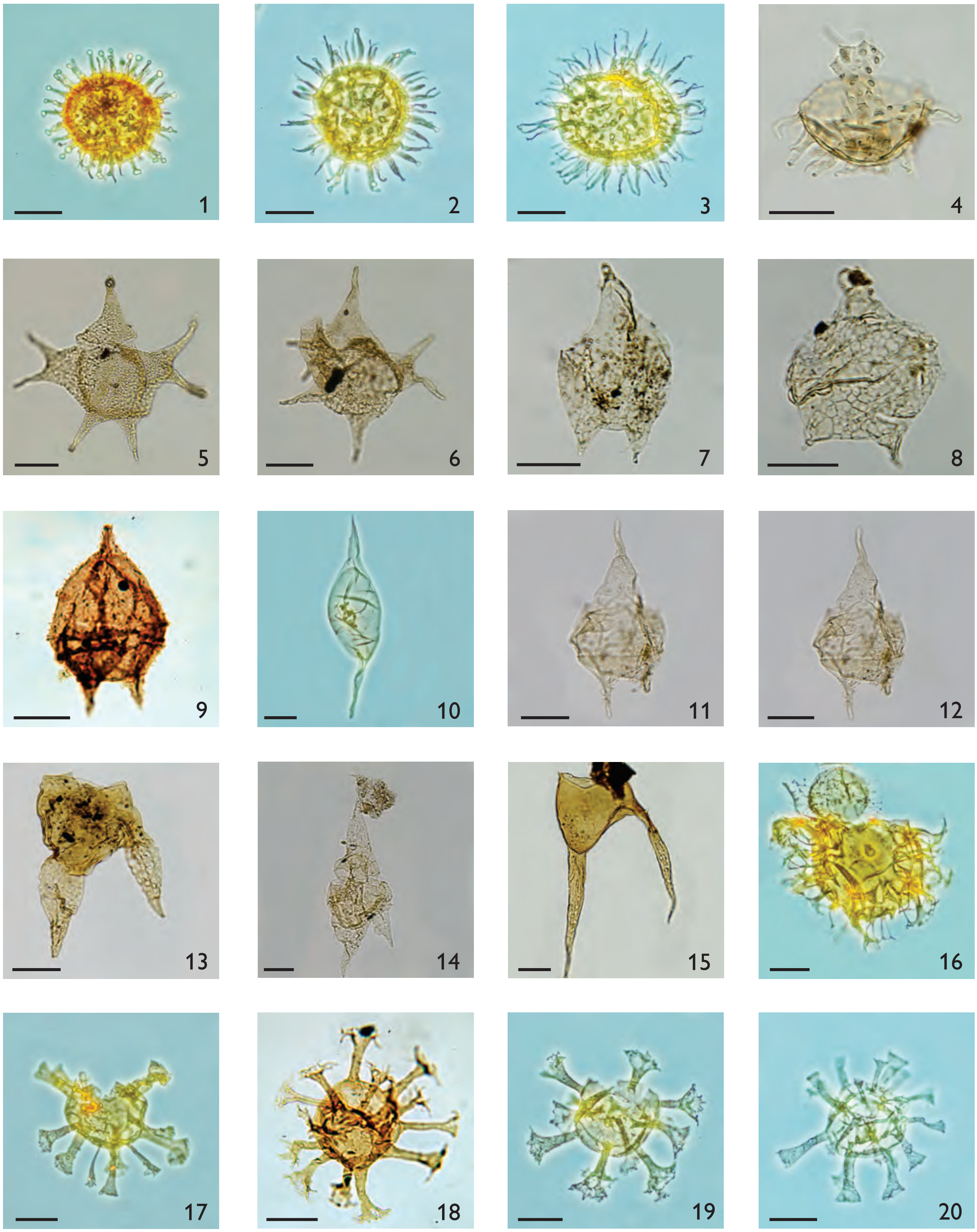

Plate 11

Fig. 1. *Palaeocystodinium bulliforme*, right lateral view.
Location: Gilbert F-53, 2470–2480 m. **Sample**: cs, P19228, 1.
Optical parameters: C, 163 × 1082, Q28/3, × 50 bf.
Repository: GSC 137904.

Fig. 2. *Palaeocystodinium bulliforme*.
Location: Ogmund E-72, 1545 m. **Sample**: cs, YD15735, 4.
Optical parameters: A, 30.6 × 110.6, E31/3, × 40 bf.
Repository: CNLOPB.

Fig. 3. *Palaeocystodinium teespinosum*, left lateral view.
Location: Karlsefni A-13, 969.28–978.42 m. **Sample**: cs, P39553, 1.
Optical parameters: D, 201 × 922, U35/1, × 40 pc.
Repository: GSC 138007.

Fig. 4. *Palaeohystrichophora infusorioides*, dorsal view.
Location: North Leif I-05, 3000–3010 m. **Sample**: cs, YD17629, 3.
Optical parameters: E, 25.0 × 20.2, G23/0, × 60 bf.
Repository: MGUH 31314.

Fig. 5. *Operculodinium centrocarpum*.
Location: Karlsefni A-13, 694.95–704.10 m. **Sample**: cs, P39543, 1.
Optical parameters: D, 143 × 996, O42/0, × 40 pc.
Repository: GSC 137996.

Fig. 6. *Operculodinium centrocarpum*, operculum.
Location: Karlsefni A-13, 722.38–731.53 m. **Sample**: cs, P39544, 1.
Optical parameters: D, 169 × 934, R36/1–2, × 40 pc.
Repository: GSC 137998.

Fig. 7. *Palaeoperidinium pyrophorum*, dorsal surface.
Location: Gilbert F-53, 2680–2690 m. **Sample**: cs, P39502, 1.
Optical parameters: C, 68 × 1101, F40/3–G40/1, × 50 bf.
Repository: GSC 137985.

Fig. 8. *Palaeoperidinium pyrophorum*, ventral view.
Location: Roberval K-92, 3070–3080 m. **Sample**: cs, P2008175, 1.
Optical parameters: C, 200 × 982, U27/4–U28/3, × 50 bf.
Repository: GSC 137907.

Fig. 9. *Palynodinium grallator*, apical view.
Location: Roberval K-92, 2840–2850 m. **Sample**: cs, P17719, 1.
Optical parameters: C, 30 × 1087, C38/2–C39/1, × 50 bf.
Repository: GSC 137898.

Fig. 10. *Palynodinium grallator*, dorsal view.
Location: North Leif I-05, 2520–2530 m. **Sample**: cs, YD17613, 4.
Optical parameters: E, 44.0 × 16.5, L46/3, × 60 bf.
Repository: GSC 138163.

Fig. 11. *Petalodinium condylos*, ventral view of dorsal surface.
Location: Roberval K-92, 2420–2430 m. **Sample**: cs, P17705, 1.
Optical parameters: C, 110 × 1018, Q31/2–4, × 50 bf.
Repository: GSC 137896.

Fig. 12. *Petalodinium condylos*, ventral view of dorsal surface.
Location: Roberval K-92, 2240–2250 m. **Sample**: cs, P17699, 1.
Optical parameters: C, 175 × 1052, S35/1, × 50 bf.
Repository: GSC 137892.

Fig. 13. *Phthanoperidinium coreoides*, dorsal surface.
Location: Rut H-11, 1145–1155 m. **Sample**: cs, P39332, 1.
Optical parameters: D, 126 × 991, M42/0, × 40 pc.
Repository: GSC 137928.

Fig. 14. *Phthanoperidinium coreoides*, dorsal surface.
Location: North Leif I-05, 720–730 m. **Sample**: cs, YD17553, 2.
Optical parameters: E, 46.7 × 11.2, Q46/1, × 60 bf.
Repository: MGUH 31315.

Fig. 15. *Phthanoperidinium levimurum*.
Location: Karlsefni A-13, 3273.59–3282.74 m. **Sample**: cs, P39636, 1.
Optical parameters: D, 100 × 1064, J50/3, × 40 pc.
Repository: GSC 138050.

Fig. 16. *Phthanoperidinium multispinum*, dorsal surface.
Location: South Labrador N-79, 1260–1270 m. **Sample**: cs, P39762, 1.
Optical parameters: C, 87 × 1017, J31/2, × 50 bf.
Repository: GSC 138110.

Fig. 17. *Phthanoperidinium multispinum*, ventral surface.
Location: Karlsefni A-13, 1956.84–1965.98 m. **Sample**: cs, P39588, 1.
Optical parameters: D, 194 × 1025, T45/4, × 40 pc.
Repository: GSC 138020.

Fig. 18. *Phthanoperidinium regale*, ventral view of ventral surface.
Location: Hellefisk-1, 1289 m. **Sample**: cs, 02B2097-4, 4.
Optical parameters: A, 48.5 × 105.9, K49/4, × 40 bf.
Repository: MGUH 26504.

Fig. 19. *Phthanoperidinium regale*, ventral view of dorsal surface, same specimen as fig. 18.
Location: Hellefisk-1, 1289 m. **Sample**: cs, 02B2097-4, 4.
Optical parameters: A, 48.5 × 105.9, K49/4, × 60 bf.
Repository: MGUH 26504.

Fig. 20. *Phthanoperidinium stockmansii*, ventral view of ventral surface.
Location: South Labrador N-79, 1230–1240 m. **Sample**: cs, P39761, 1.
Optical parameters: C, 67 × 1021, F32/3, × 50 bf.
Repository: GSC 138109.

Plate 11

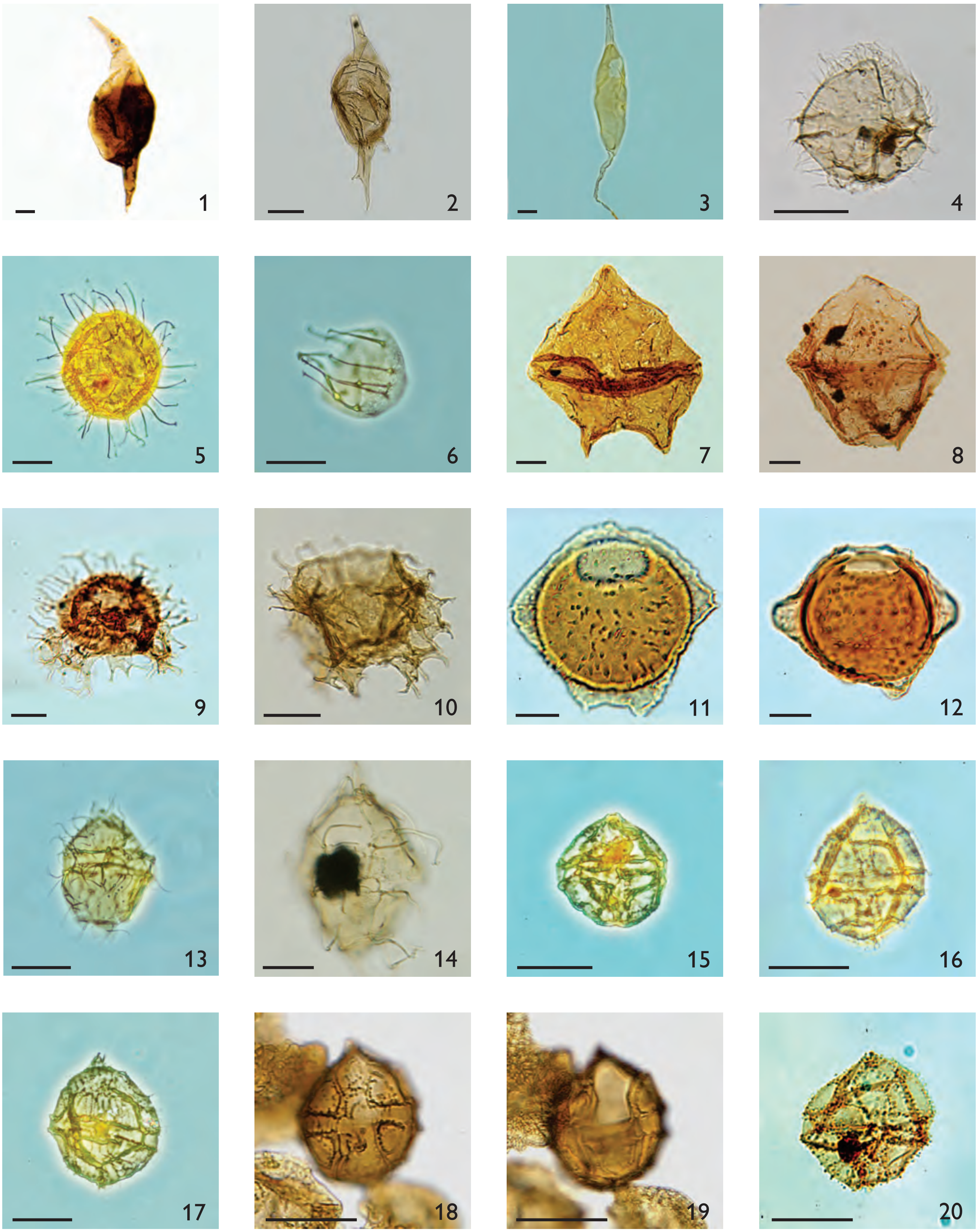

Plate 12

Fig. 1. *Phelodinium kozlowskii*, dorsal surface.
Location: Gilbert F-53, 2740–2750 m. **Sample**: cs, P39504, 1.
Optical parameters: C, 203 × 1020, U31/4–U32/3, × 50 bf.
Repository: GSC 137987.

Fig. 2. *Phelodinium kozlowskii*, oblique left lateral view.
Location: Bjarni O-82, 2175–2185 m. **Sample**: cs, P39727, 1.
Optical parameters: C, 139 × 993, O29/1, × 50 bf.
Repository: GSC 138072.

Fig. 3. *Phelodinium kozlowskii*, dorsal view showing dorsal and ventral surfaces.
Location: South Labrador N-79, 3030–3040 m. **Sample**: cs, P39818, 1.
Optical parameters: C, 218 × 1000, N29/2, × 50 bf.
Repository: GSC 138123.

Fig. 4. *Pseudoceratium* sp., ventral view.
Location: Roberval K-92, 3070–3080 m. **Sample**: cs, P2008175, 1.
Optical parameters: C, 210 × 993, V29/0–3, × 40 pc.
Repository: GSC 137908.

Fig. 5. *Piladinium columna*, ventral view of dorsal surface.
Location: Bjarni O-82, 1785–1795 m. **Sample**: cs, P39714, 1.
Optical parameters: C, 221 × 1054, W32/3–4, × 50 bf.
Repository: GSC 138069.

Fig. 6. *Piladinium columna*, dorsal view of dorsal surface.
Location: Roberval K-92, 2270–2280 m. **Sample**: cs, P17700, 1.
Optical parameters: C, 200 × 1014, U31/0, × 50 bf.
Repository: GSC 137893.

Fig. 7. *Piladinium edwardsii*, dorsal view of dorsal surface.
Location: Ogmund E-72, 1305 m. **Sample**: sw, JEH15551, 4.
Optical parameters: A, 27.3 × 98.6, T27/1, × 60 bf.
Repository: MGUH 31316.

Fig. 8. *Piladinium edwardsii*, dorsal view of dorsal surface.
Location: North Leif I-05, 2010–2020 m. **Sample**: cs, YD17596, 3.
Optical parameters: E, 21.0 × 10.6, R18/1, × 60 bf.
Repository: MGUH 31317.

Fig. 9. *Raphidodinium fucatum*, dorsal surface.
Location: Bjarni O-82, 2415–2425 m. **Sample**: cs, P39735, 1.
Optical parameters: C, 228 × 1077, X32/0–2, × 50 bf.
Repository: GSC 138074.

Fig. 10. *Raphidodinium fucatum*.
Location: Skolp E-07, 1475 m. **Sample**: cs, YD15606, 3.
Optical parameters: A, 43.7 × 94.7, W44/1, × 60 bf.
Repository: MGUH 31318.

Fig. 11. *Reticulatosphaera actinocoronata*.
Location: Karlsefni A-13, 722.38–731.53 m. **Sample**: cs, P39544, 1.
Optical parameters: D, 146 × 930, O36/3, × 40 pc.
Repository: GSC 137997.

Fig. 12. *Reticulatosphaera actinocoronata*.
Location: Rut H-11, 755–765 m. **Sample**: cs, P39319, 1.
Optical parameters: D, 89 × 1006, H43/4, × 40 pc.
Repository: GSC 137921.

Fig. 13. *Rhombodinium draco*, ventral view of dorsal surface.
Location: Snorri J-90, 1673.37–1682.52 m. **Sample**: cs, P9729, 10.
Optical parameters: C, 93 × 1007, J29/0, × 40 pc.
Repository: GSC 138134.

Fig. 14. *Rhombodinium draco*, ventral view of ventral surface.
Location: Bjarni O-82, 615–625 m. **Sample**: cs, P39675, 1.
Optical parameters: C, 148 × 1035, P33/0, × 40 bf.
Repository: GSC 138067.

Fig. 15. *Scalenodinium scalenum* sp. nov., holotype, left lateral view.
Location: Gilbert F-53, 2135–2145 m. **Sample**: cs, P38484, 1.
Optical parameters: C, 193 × 1065, T37/4, × 50 bf.
Repository: GSC 137916.

Fig. 16. *Scalenodinium scalenum* sp. nov., left lateral view.
Location: Gilbert F-53, 2135–2145 m. **Sample**: cs, P39484, 1.
Optical parameters: C, 48 × 1020, D32/3–D31/4, × 50 bf.
Repository: GSC 137982.

Fig. 17. *Scalenodinium scalenum* sp. nov.
Location: Ogmund E-72, 1391 m. **Sample**: sw, YD15553, 2.
Optical parameters: A, 26.8 × 107.0, J26/4, × 60 bf.
Repository: MGUH 31319.

Fig. 18. *Scalenodinium scalenum* sp. nov.
Location: Ralegh N-18, 3005 m. **Sample**: cs, YD16263, 4.
Optical parameters: E, 41.6 × 11.1, Q40/4, × 60 bf.
Repository: MGUH 31320.

Fig. 19. *Scalenodinium scalenum* sp. nov., oblique left lateral view.
Location: Ralegh N-18, 3045 m. **Sample**: cs, YD16264, 3.
Optical parameters: E, 28.9 × 19.9, G27/0, × 60 bf.
Repository: MGUH 31321.

Fig. 20. *Scalenodinium scalenum* sp. nov.
Location: North Leif I-05, 2130–2140 m. **Sample**: cs, YD17600, 3.
Optical parameters: E, 29.4 × 7.6, U27/2, × 60 bf.
Repository: GSC 138156.

Plate 12

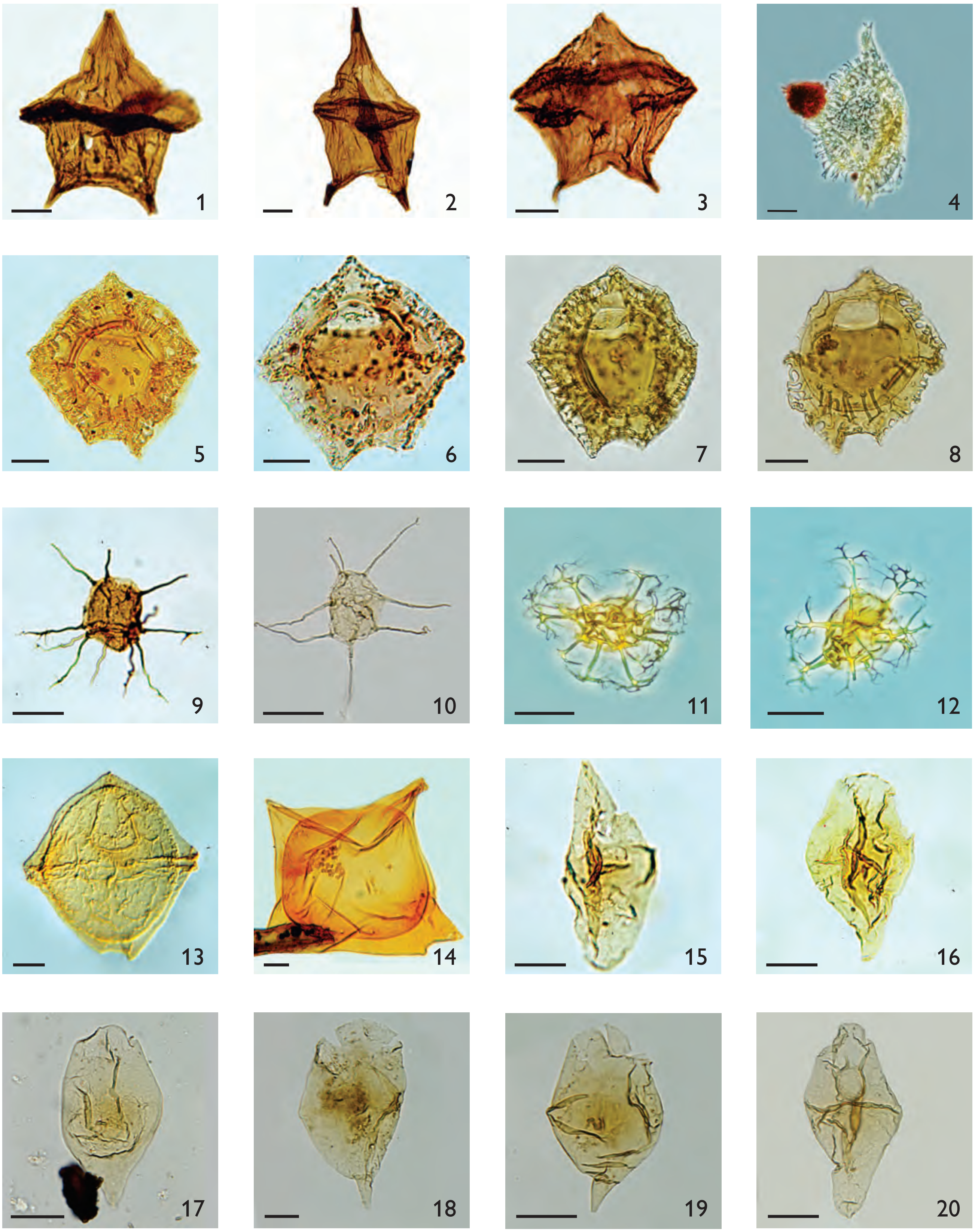

Plate 13

Fig. 1. *Rottnestia borussica*, right lateral view.
Location: South Labrador N-79, 2430–2440 m. **Sample**: cs, P39799, 1.
Optical parameters: C, 105 × 990, K28/4, × 50 bf.
Repository: GSC 138121.

Fig. 2. *Schematophora speciosa*, dorsal surface.
Location: South Labrador N-79, 1290–1300 m. **Sample**: cs, P39763, 1.
Optical parameters: C, 126 × 982, N28/1–N27/2, × 50 bf.
Repository: GSC 138111.

Fig. 3. *Senegalinium iterlaaense*, dorsal surface.
Location: Gjoa O-37, 3560 m. **Sample**: cs, YD16131, 5.
Optical parameters: E, 46.4 × 11.6, Q45/4, × 60 bf.
Repository: GSC 138146.

Fig. 4. *Senegalinium iterlaaense*, ventral view of dorsal surface.
Location: Gjoa O-37, 3610 m. **Sample**: cs, YD16132, 3.
Optical parameters: E, 37.1 × 3.9, X36/3, × 60 bf.
Repository: MGUH 31322.

Fig. 5. *Senoniasphaera inornata*, dorsal view.
Location: North Leif I-05, 2490–2500 m. **Sample**: cs, YD17612, 3.
Optical parameters: E, 41.2 × 8.3, T40/2, × 60 bf.
Repository: GSC 138162.

Fig. 6. *Senoniasphaera microreticulata*, dorsal view.
Location: North Leif I-05, 2820–2830 m. **Sample**: cs, YD17623, 2.
Optical parameters: E, 41.5 × 9.2, S40/2, × 60 bf.
Repository: MGUH 31323.

Fig. 7. *Senoniasphaera rotundata*, dorsal view of dorsal surface.
Location: South Labrador N-79, 3480–3490 m. **Sample**: cs, P39833, 1.
Optical parameters: C, 114 × 1037, L33/4, × 50 bf.
Repository: GSC 138126.

Fig. 8. *Sophismatia tenuivirgula*, dorso-ventral view.
Location: North Leif I-05, 1560–1570 m. **Sample**: cs, YD17581, 2.
Optical parameters: E, 49.0 × 14.2, N48/2, × 60 bf.
Repository: MGUH 31324.

Fig. 9. *Simplicidinium insolitum*.
Location: Rut H-11, 1205–1215 m. **Sample**: cs, P39334, 1.
Optical parameters: D, 152 × 871, P29/2, × 40 pc.
Repository: GSC 137932.

Fig. 10. *Simplicidinium insolitum*.
Location: Karlsefni A-13, 804.68–813.83 m. **Sample**: cs, P39547, 1.
Optical parameters: D, 162 × 1052, Q48/0, × 40 pc.
Repository: GSC 137999.

Fig. 11. *Spinidinium echinoideum*, dorsal view of ventral surface.
Location: Ogmund E-72, 1605 m. **Sample**: cs, YD15739, 3.
Optical parameters: A, 37.3 × 108.0, H38/1, × 60 bf.
Repository: MGUH 31325.

Fig. 12. *Spinidinium echinoideum*, dorsal view, same specimen as fig. 11, focussed on ambitus.
Location: Ogmund E-72, 1605 m. **Sample**: cs, YD15739, 3.
Optical parameters: A, 37.3 × 108.0, H38/1, × 60 bf.
Repository: MGUH 31325.

Fig. 13. *Spiniferites ovatus*, right lateral view.
Location: Rut H-11, 755–765 m. **Sample**: cs, P39319, 1.
Optical parameters: D, 135 × 933, N36/0, × 40 pc.
Repository: GSC 137923.

Fig. 14. *Spiniferites pseudofurcatus*.
Location: Rut H-11, 2285–2295 m. **Sample**: cs, P39370, 1.
Optical parameters: D, 128 × 956, M38/4, × 40 pc.
Repository: GSC 137947.

Fig. 15. *Spiniferites scabrosus*.
Location: Roberval K-92, 3010 m. **Sample**: sw, P2008173, 1.
Optical parameters: C, 210 × 1088, V38/3–4, × 50 bf.
Repository: GSC 137906.

Fig. 16. *Spongodinium delitiense*, apical view.
Location: Skolp E-07, 1070 m. **Sample**: cs, YD15580, 4.
Optical parameters: A, 46.1× 96.5, U47/1, × 60 bf.
Repository: GSC 138143.

Fig. 17. *Stichodinium lineidentatum*, dorsal view of ventral surface.
Location: Nukik-2, 1862 m. **Sample**: cs, 05B2163, 3.
Optical parameters: A, 43.6 × 111.4, D44/4, × 60 bf.
Repository: MGUH 31326.

Fig. 18. *Stichodinium lineidentatum*, dorsal view of dorsal surface, same specimen as fig. 17.
Location: Nukik-2, 1862 m. **Sample**: cs, 05B2163, 3.
Optical parameters: A, 43.6 × 111.4, D44/4, × 60 bf.
Repository: MGUH 31326.

Fig. 19. *Spongodinium obscurum*, dorsal surface.
Location: GGU 400712 borehole, 62.13–62.25 m. **Sample**: cc, D309-F, 3.
Optical parameters: A, 32.0 × 109.0, G32/3, × 60 bf.
Repository: MGUH 31327.

Fig. 20. *Spongodinium delitiense*, right lateral view.
Location: North Leif I-05, 2460–2470 m. **Sample**: cs, YD17611, 3.
Optical parameters: E, 29.2 × 18.0, J27/2, × 60 bf.
Repository: MGUH 31328.

Plate 13

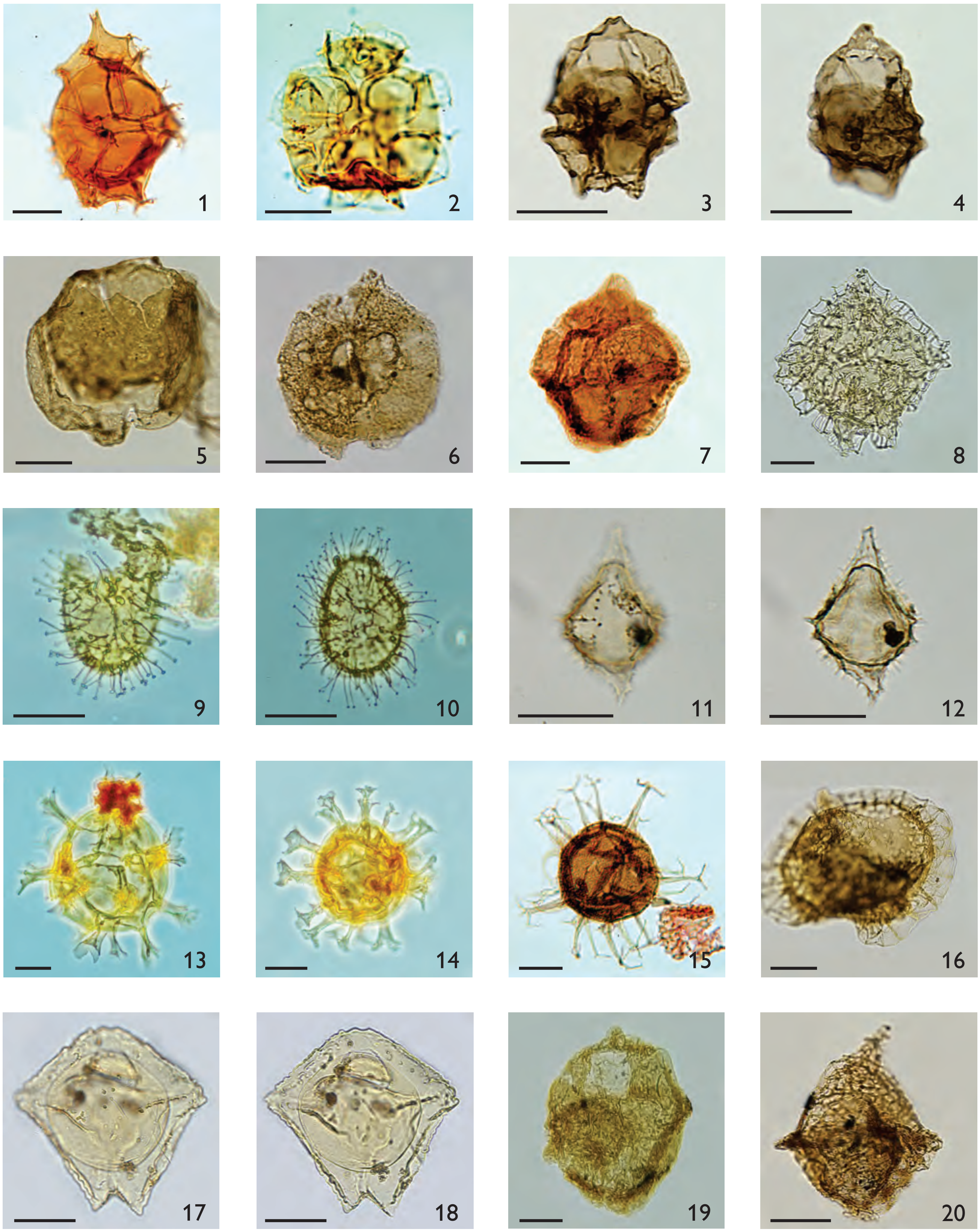

Plate 14

Fig. 1. *Spongodinium grossum*, oblique left lateral view.
Location: Skolp E-07, 1565 m. **Sample**: cs, JEH15612, 3.
Optical parameters: A, 29.5 × 110.6, E29/4, × 60 bf.
Repository: MGUH 31329.

Fig. 2. *Spongodinium grossum*, left lateral view.
Location: Skolp E-07, 1565 m. **Sample**: cs, JEH15612, 5.
Optical parameters: A, 27.3 × 98.5, S27/2, × 60 bf.
Repository: MGUH 31330.

Fig. 3. *Spongodinium grossum*, ventral surface.
Location: Bjarni O-82, 2445–2455 m. **Sample**: cs, P39736, 1.
Optical parameters: C, 181 × 991, S29/3, × 40 bf.
Repository: GSC 138075.

Fig. 4. *Spongodinium grossum*, same specimen as fig. 3, focussed on dorsal surface.
Location: Bjarni O-82, 2445–2455 m. **Sample**: cs, P39736, 1.
Optical parameters: C, 181 × 991, S29/3, × 40 bf.
Repository: GSC 138075.

Fig. 5. *Subtilisphaera perlucida*, dorsal surface.
Location: North Leif I-05, 2910–2920 m. **Sample**: cs, YD17626, 4.
Optical parameters: E, 23.4 × 19.2, H21/0, × 60 bf.
Repository: GSC 138167.

Fig. 6. *Surculosphaeridium convocatum* sp. nov., ventral surface.
Location: South Labrador N-79, 3510–3520 m. **Sample**: cs, P39834, 1.
Optical parameters: C, 148 × 982, P28/1, × 50 bf.
Repository: GSC 138127.

Fig. 7. *Surculosphaeridium convocatum* sp. nov., holotype, dorsal surface.
Location: South Labrador N-79, 3510–3520 m. **Sample**: cs, P39834, 1.
Optical parameters: C, 78 × 991, G29/3–H28/2, × 50 bf.
Repository: GSC 138128.

Fig. 8. *Surculosphaeridium convocatum* sp. nov., lateral view.
Location: North Leif I-05, 2760–2775 m. **Sample**: cs, YD17611, 2.
Optical parameters: E, 21.9 × 19.4, H20/1, × 60 bf.
Repository: MGUH 31331.

Fig. 9. *Talladinium*? *clathratum*, dorsal view, focussed on ambitus.
Location: Ralegh N-18, 1445 m. **Sample**: cs, YD16217, 2.
Optical parameters: E, 37.6 × 14.5, M36/4, × 40 bf.
Repository: MGUH 31332.

Fig. 10. *Talladinium*? *clathratum*, dorsal view, same specimen as fig. 9.
Location: Ralegh N-18, 1445 m. **Sample**: cs, YD16217, 2.
Optical parameters: E, 37.6 × 14.5, M36/4, × 60 bf.
Repository: MGUH 31332.

Fig. 11. *Talladinium pellis* sp. nov., holotype, dorsal view of dorsal surface.
Location: Gjoa O-37, 1840 m. **Sample**: cs, YD16082, 3.
Optical parameters: C, 21.9 × 22.0, E20/3, × 60 bf.
Repository: GSC 138082.

Fig. 12. *Talladinium pellis* sp. nov., holotype, dorsal view of ventral surface, same specimen as fig. 11.
Location: Gjoa O-37, 1840 m. **Sample**: cs, YD16082, 3.
Optical parameters: C, 21.9 × 22.0, E20/3, × 60 bf.
Repository: GSC 138082.

Fig. 13. *Taurodinium granulatum* sp. nov., holotype, dorso-ventral view.
Location: Ikermiut-1, 2340 m. **Sample**: cs, 2289 s-261, 3.
Optical parameters: B, 17.82 × 9.01, T19/1, × 60 bf.
Repository: MGUH 31333.

Fig. 14. *Taurodinium granulatum* sp. nov., dorso-ventral view.
Location: Ralegh N-18, 3045 m. **Sample**: cs, YD16264, 3.
Optical parameters: E, 23.6 × 14.8, M21/4, × 60 bf.
Repository: MGUH 31334.

Fig. 15. *Taurodinium granulatum* sp. nov., dorso-ventral view.
Location: Ralegh N-18, 3405 m. **Sample**: cs, YD16341, 3.
Optical parameters: E, 20.8 × 16.9, K19/3, × 60 bf.
Repository: MGUH 31335.

Fig. 16. *Talladinium pellis* sp. nov., ventral view.
Location: Gjoa O-37, 1840 m. **Sample**: cs, YD16082, 4.
Optical parameters: C, 18.56 × 15.03, L20/1, × 60 bf.
Repository: MGUH 31336.

Fig. 17. *Taurodinium granulatum* sp. nov., dorso-ventral view.
Location: Ralegh N-18, 3425 m. **Sample**: cs, YD16342, 4.
Optical parameters: E, 33.0 × 18.6, J31/2, × 60 bf.
Repository: GSC 138147.

Fig. 18. *Taurodinium granulatum* sp. nov.
Location: Hekja O-71, 3120 m. **Sample**: cs, JEH16030, 2.
Optical parameters: E, 24.9 × 23.6, C23/3, × 60 bf.
Repository: MGUH 31337.

Fig. 19. *Tenua hystrix*, ventral view of dorsal surface.
Location: Roberval K-92, 3090–3100 m. **Sample**: cs, P17727, 1.
Optical parameters: C, 175 × 1086, S38/2, × 50 bf.
Repository: GSC 137900.

Fig. 20. *Tenua hystrix*, lateral view.
Location: Two Snout Creek, Bylot Island, section 538080E, 105 m above base (sample HFB-09-42). **Sample**: os, P514833, D.
Optical parameters: C, 145 × 918, M55/3–4, × 50 bf.
Repository: GSC 138129.

Plate 14

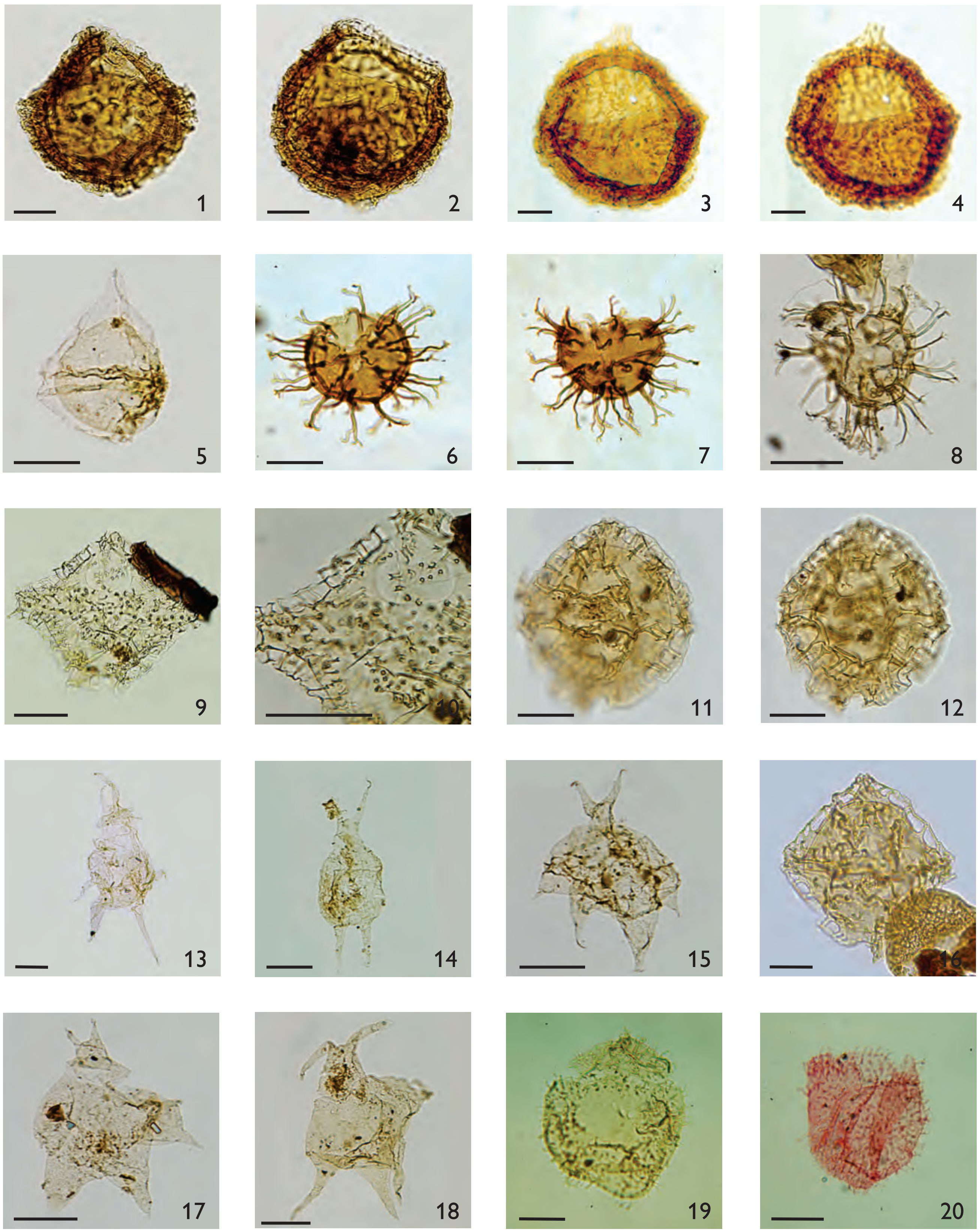

Plate 15

Fig. 1. *Thalassiphora delicata*, dorsal surface.
Location: North Leif I-05, 2370–2380 m. **Sample**: cs, YD17608, 4.
Optical parameters: E, 35.7 × 12.9, P34/1, × 60 bf.
Repository: MGUH 31338.

Fig. 2. *Thalassiphora fenestrata*, right lateral view.
Location: Ralegh N-18, 1445 m. **Sample**: cs, YD16217, 2.
Optical parameters: E, 32.5 × 20.5, F31/4, × 60 bf.
Repository: MGUH 31339.

Fig. 3. *Thalassiphora fenestrata*, left lateral view.
Location: Ralegh N-18, 1445 m. **Sample**: cs, YD16217, 2.
Optical parameters: E, 41.1 × 11.2, Q40/2, × 60 bf.
Repository: MGUH 31340.

Fig. 4. *Thalassiphora fenestrata*, dorso-ventral view.
Location: Ralegh N-18, 1605 m. **Sample**: cs, YD16221, 4.
Optical parameters: E, 32.8 × 6.2, V31/3, × 40 bf.
Repository: CNSOPB.

Fig. 5. *Thalassiphora pelagica*, dorso-ventral view.
Location: Rut H-11, 2765–2775 m. **Sample**: cs, P39386, 1.
Optical parameters: D, 181 × 906, S33/0, × 40 pc.
Repository: GSC 137956.

Fig. 6. *Thalassiphora pelagica*, dorsal surface.
Location: Karlsefni A-13, 2615.22–2624.36 m. **Sample**: cs, P39612, 1.
Optical parameters: D, 52 × 902, D33/3, × 40 pc.
Repository: GSC 138039.

Fig. 7. *Tanyosphaeridium xanthiopyxides*.
Location: Gilbert F-53, 2590–2600 m. **Sample**: cs, P39499, 1.
Optical parameters: C, 94 × 1004, J30/0, × 50 bf.
Repository: GSC 137984.

Fig. 8. *Trichodinium castanea*, oblique left lateral view.
Location: Skolp E-07, 1430 m. **Sample**: cs, YD15603, 3.
Optical parameters: A, 36.0 × 100.7, Q356/2, × 60 bf.
Repository: MGUH 31341.

Fig. 9. *Trithyrodinium*? *conservatum* sp. nov., dorso-ventral view, with focus on ambitus.
Location: Ikermiut-1, 1155 m. **Sample**: sw, 04E006504, 3.
Optical parameters: A, 33.0 × 112.8, C33/3, × 60 bf.
Repository: MGUH 26500.

Fig. 10. *Trithyrodinium*? *conservatum* sp. nov., dorso-ventral view.
Location: Ikermiut-1, 1155 m. **Sample**: sw, 04E006504, 2.
Optical parameters: A, 41.0 × 113.5, C41/2, × 60 bf.
Repository: MGUH 26501.

Fig. 11. *Trithyrodinium*? *conservatum* sp. nov., dorso-ventral view, same specimen as fig. 10, focussed on dorsal surface.
Location: Ikermiut-1, 1155 m. **Sample**: sw, 04E006504, 2.
Optical parameters: A, 41.0 × 113.5, C41/2, × 60 bf.
Repository: MGUH 26501.

Fig. 12. *Trithyrodinium*? *conservatum* sp. nov., holotype, dorsal surface.
Location: Ikermiut-1, 1155 m. **Sample**: sw, 04E006504, 2.
Optical parameters: A, 36.0 × 97.1, U36/1, × 60 bf.
Repository: MGUH 26502.

Fig. 13. *Trithyrodinium*? *conservatum* sp. nov., dorsal surface.
Location: Ralegh N-18, 1485 m. **Sample**: cs, YD16218, 2.
Optical parameters: E, 30.3 × 23.1, D29/1, × 60 bf.
Repository: MGUH 31342.

Fig. 14. *Trithyrodinium*? *conservatum* sp. nov., dorsal surface.
Location: Ralegh N-18, 1525 m. **Sample**: cs, YD16219, 2.
Optical parameters: E, 28.7 × 5.8, W27/2, × 60 bf.
Repository: MGUH 31343.

Fig. 15. *Trithyrodinium suspectum*, dorso-ventral view.
Location: Skolp E-07, 2375 m. **Sample**: cs, YD15665, 4.
Optical parameters: A, 39.0 × 107.4, H39/4, × 60 bf.
Repository: MGUH 31344.

Fig. 16. *Trithyrodinium quinqueangulare*, oblique dorso-ventral view.
Location: South Labrador N-79, 3300–3310 m. **Sample**: cs, P39827, 1.
Optical parameters: C, 223 × 1020, W32–X31, × 50 bf.
Repository: GSC 138125.

Fig. 17. *Trithyrodinium evittii*, oblique apical view.
Location: North Leif I-05, 2370–2380 m. **Sample**: cs, YD17608, 3.
Optical parameters: E, 24.5 × 11.0, Q23/3, × 60 bf.
Repository: MGUH 31345.

Fig. 18. *Trithyrodinium evittii*, dorsal surface.
Location: Gilbert F-53, 2920–2930 m. **Sample**: cs, P39510, 1.
Optical parameters: C, 100 × 1067, K36/3–4, × 50 bf.
Repository: GSC 137989.

Fig. 19. *Trithyrodinium evittii*, apical view.
Location: Roberval K-92, 3090–3100 m. **Sample**: cs, P17727, 1.
Optical parameters: C, 197 × 1095, U39/0–2, × 50 bf.
Repository: GSC 137901.

Fig. 20. *Tuberculodinium vancampoae*, apical view.
Location: Karlsefni A-13, 557.79–566.93 m. **Sample**: cs, P39538, 1.
Optical parameters: D, 146 × 1038, P46/2, × 40 pc.
Repository: GSC 137993.

Plate 15

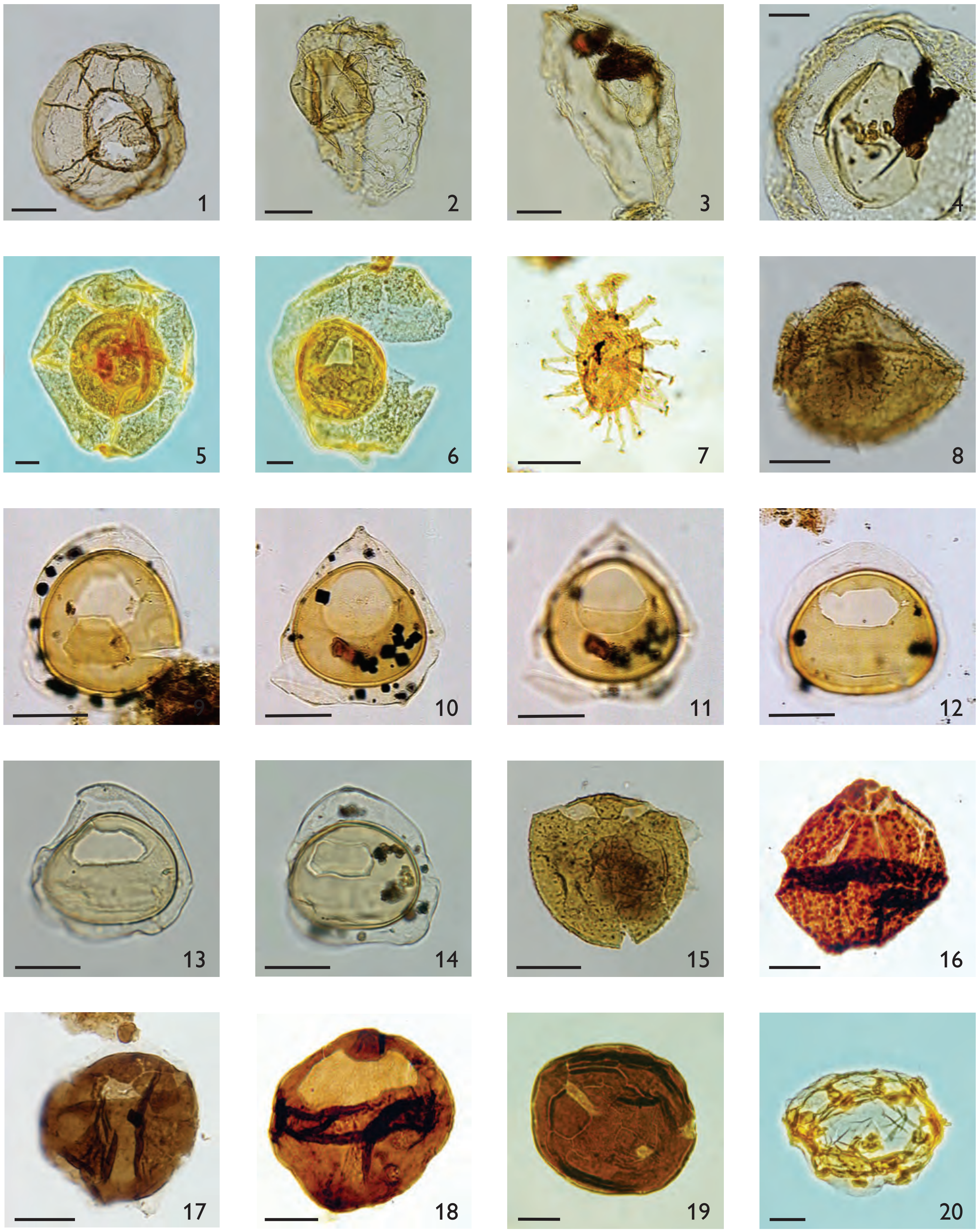

Plate 16

Fig. 1. *Vesperopsis longicornis*, dorso-ventral view.
Location: North Leif I-05, 3360–3370 m. **Sample**: cs, YD17641, 4.
Optical parameters: E, 55.6 × 10.1, R55/1, × 60 bf.
Repository: MGUH 31346.

Fig. 2. *Vesperopsis longicornis*, dorso-ventral view.
Location: North Leif I-05, 3360–3370 m. **Sample**: cs, YD17641, 3.
Optical parameters: E, 35.2 × 23.4, C34/1, × 60 bf.
Repository: MGUH 31347.

Fig. 3. *Wetzeliella articulata*, dorsal view.
Location: Rut H-11, 3725−3735 m. **Sample**: cs, P39417, 1.
Optical parameters: D, 152 × 847, P27/0, × 40 pc.
Repository: GSC 137971.

Fig. 4. *Wetzeliella articulata*, dorsal view.
Location: Rut H-11, 3095−3105 m. **Sample**: cs, P39397, 1.
Optical parameters: D, 81 × 949, G38/3, × 40 pc.
Repository: GSC 137963.

Fig. 5. *Wallodinium luna*, lateral view.
Location: Skolp E-07, 1610 m. **Sample**: cs, JEH15615, 3.
Optical parameters: A, 39.6 × 100.2, R40/1, × 60 bf.
Repository: MGUH 31348.

Fig. 6. *Xenascus wetzelii*, dorsal view of dorsal surface.
Location: Skolp E-07, 1475 m. **Sample**: cs, YD15606, 3.
Optical parameters: A, 41.0 × 111.2, E41/2, × 40 bf.
Repository: MGUH 31349.

Fig. 7. *Xenascus wetzelii*, dorsal view, same specimen as fig. 6, showing enlarged view of ventral surface.
Location: Skolp E-07, 1475 m. **Sample**: cs, YD15606, 3.
Optical parameters: A, 41.0 × 111.2, E41/2, × 60 bf.
Repository: MGUH 31349.

Fig. 8. *Xenascus wetzelii*, dorsal view, same specimen as fig. 6, showing enlarged view of dorsal surface.
Location: Skolp E-07, 1475 m. **Sample**: cs, YD15606, 3.
Optical parameters: A, 41.0 × 111.2, E41/2, × 60 bf.
Repository: MGUH 31349.

Fig. 9. *Xenascus ceratioides*, ventral view.
Location: Rut H-11, 2255−2235 m. **Sample**: cs, P39369, 1.
Optical parameters: D, 116 × 954, L38/0, × 40 pc.
Repository: GSC 137945.

Fig. 10. *Xenascus ceratioides*, dorsal view.
Location: Skolp E-07, 2435 m. **Sample**: cs, YD15669, 3.
Optical parameters: A, 24.6 × 107.9, H24/2, × 60 bf.
Repository: GSC 138144.

Fig. 11. *Fromea quadrangularis* sp. nov.
Location: Skolp E-07, 2075 m. **Sample**: cs, JEH15643, 3.
Optical parameters: A, 42.1 × 94.3, W43/3, × 60 bf.
Repository: MGUH 31350.

Fig. 12. *Fromea quadrangularis* sp. nov.
Location: Skolp E-07, 2090 m. **Sample**: cs, JEH15644, 5.
Optical parameters: A, 44.2 × 109.3, G45/1, × 60 bf.
Repository: GSC 137882.

Fig. 13. *Microsphaeridium ancistroides*.
Location: Rut H-11, 665−675 m. **Sample**: cs, P39316, 1.
Optical parameters: D, 108 × 900, K33/3, × 40 pc.
Repository: GSC 137917.

Fig. 14. *Microsphaeridium ancistroides*.
Location: Rut H-11, 1835−1845 m. **Sample**: cs, P39355, 1.
Optical parameters: D, 186 × 907, S33/3−4, × 40 pc.
Repository: GSC 137941.

Fig. 15. *Fromea quadrangularis* sp. nov.
Location: Skolp E-07, 2360 m. **Sample**: cs, YD15664, 2.
Optical parameters: A, 47.6 × 99.1, R45/4, × 60 bf.
Repository: MGUH 31351.

Fig. 16. *Fromea quadrangularis* sp. nov., holotype.
Location: Skolp E-07, 2375 m. **Sample**: cs, YD15665, 4.
Optical parameters: A, 30.9 × 111.9, D31/1, × 60 bf.
Repository: MGUH 31352.

Fig. 17. *Microsphaeridium ancistroides*.
Location: Karlsefni A-13, 667.52–676.66 m. **Sample**: cs, P39542, 1.
Optical parameters: D, 170 × 946, R37/2, × 40 pc.
Repository: GSC 137994.

Fig. 18. *Microsphaeridium ancistroides*.
Location: Rut H-11, 665–675 m. **Sample**: cs, P39316, 1.
Optical parameters: D, 135 × 1003, N43/0, × 40 pc.
Repository: GSC 137918.

Fig. 19. *Fromea nicosia*.
Location: Skolp E-07, 2360 m. **Sample**: cs, YD15664, 2.
Optical parameters: A, 25.5 × 93.1, X25/0, × 60 bf.
Repository: MGUH 31353.

Fig. 20. *Palambages* sp.
Location: Rut H-11, 2405−2415 m. **Sample**: cs, P39374, 1.
Optical parameters: D, 169 × 1003, R43/1−2, × 40 pc.
Repository: GSC 137951.

Plate 16

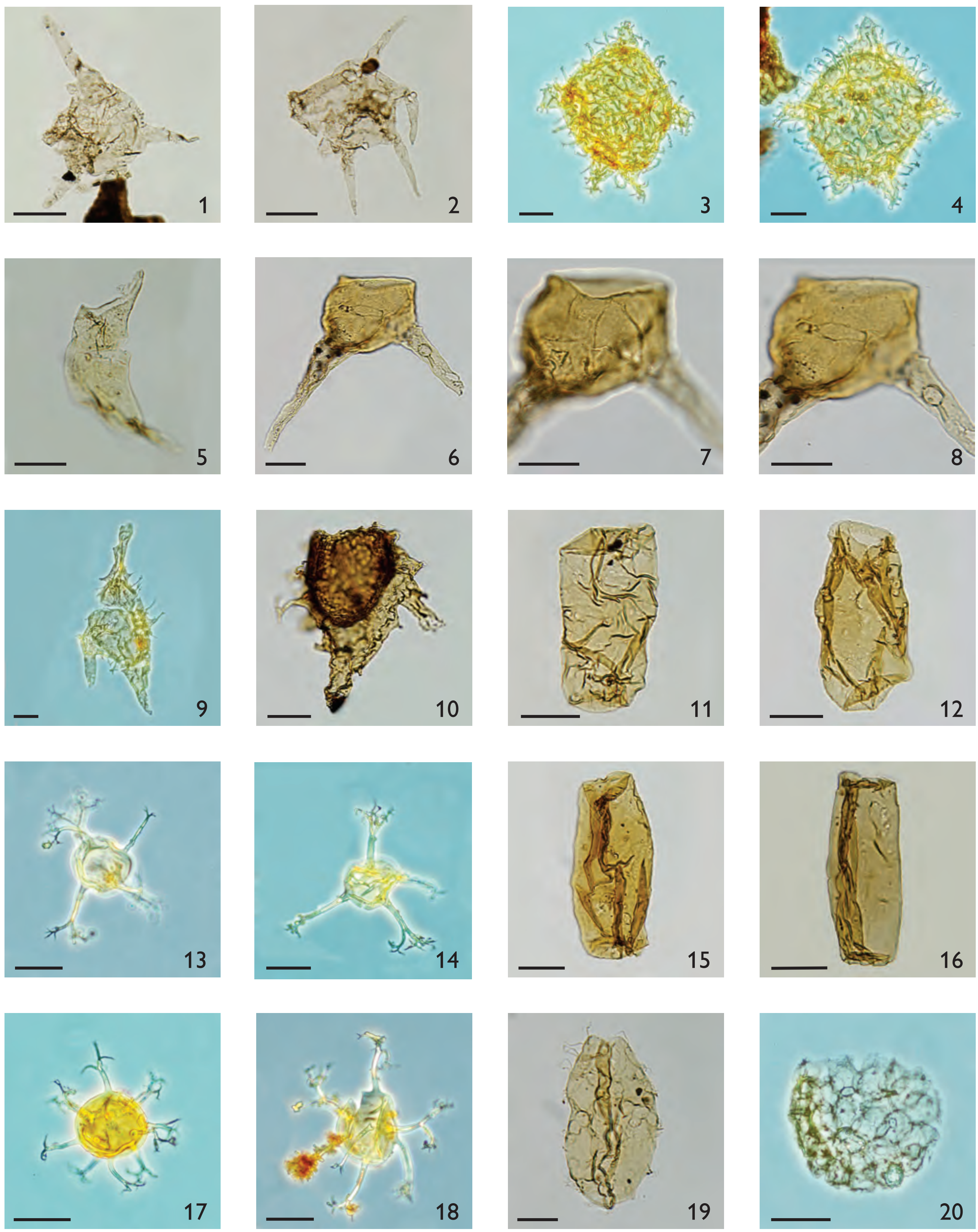

Plate 17

Fig. 1. *Paralecaniella indentata*.
Location: Karlsefni A-13, 2176.30–2185.44 m. **Sample**: cs, P39596, 1.
Optical parameters: D, 162 × 873, Q30/1, × 40 pc.
Repository: GSC 138024.

Fig. 2. *Paralecaniella indentata*.
Location: Hellefisk-1, 1588 m. **Sample**: sw, 02E6529-3, 3.
Optical parameters: A, 30.5 × 106.3, K30/0, × 60 bf.
Repository: MGUH 26544.

Fig. 3. *Pediastrum* sp.
Location: Rut H-11, 1865−1875 m. **Sample**: cs, P39356, 1.
Optical parameters: D, 136 × 1057, N49/3, × 40 pc.
Repository: GSC 137943.

Fig. 4. *Pediastrum* sp.
Location: Karlsefni A-13, 2286.03–2295.17 m. **Sample**: cs, P39600, 1.
Optical parameters: D, 167 × 1007, Q44/3, × 40 pc.
Repository: GSC 138032.

Fig. 5. *Tetraporina* sp. A.
Location: Gjoa O-37, 1680 m. **Sample**: cs, YD16076, 2.
Optical parameters: E, 23.1 × 14.4, N21/0, × 60 bf.
Repository: MGUH 31354.

Fig. 6. *Tetraporina* sp. A.
Location: North Leif I-05, 540−550 m. **Sample**: cs, YD17547, 3.
Optical parameters: E, 37.0 × 11.3, Q35/4, × 60 bf.
Repository: GSC 138148.

Fig. 7. *Tetraporina* sp. A.
Location: Karlsefni A-13, 2011.70–2020.85 m. **Sample**: cs, P39590, 1.
Optical parameters: D, 191 × 923, T35/0, × 40 pc.
Repository: GSC 138021.

Fig. 8. *Tetraporina* sp. B.
Location: Rut H-11, 3035−3045 m. **Sample**: cs, P39395, 1.
Optical parameters: D, 134 × 931, N36/0, × 40 pc.
Repository: GSC 137962.

Fig. 9. *Tetraporina* sp. B.
Location: Gjoa O-37, 1620 m. **Sample**: cs, YD16074, 4.
Optical parameters: A, 42.5 × 98.2, S43/0, × 60 bf.
Repository: MGUH 31355.

Fig. 10. *Tetraporina* sp. B.
Location: Gjoa O-37, 1620 m. **Sample**: cs, YD16074, 4.
Optical parameters: A, 34.0 × 105.0, L34/0, × 60 bf.
Repository: MGUH 31356.

Fig. 11. *Tetraporina* sp. B.
Location: Skolp E-07, 935 m. **Sample**: cs, YD15568, 4.
Optical parameters: A, 22.5 × 98.4, S22/2, × 60 bf.
Repository: GSC 138141.

Fig. 12. *Tetraporina* sp. B.
Location: Rut H-11, 3485−3495 m. **Sample**: cs, P39410, 1.
Optical parameters: D, 164 × 904, Q33/1−3, × 40 pc.
Repository: GSC 137968.

Fig. 13. *Translucentipollis contiguus*.
Location: Rut H-11, 3785−3795 m. **Sample**: cs, P39419, 1.
Optical parameters: D, 155 × 978, P40/4, × 40 pc.
Repository: GSC 137973.

Fig. 14. *Aquilapollenites quadrilobus.*
Location: Karlsefni A-13, 1956.84–1965.98 m. **Sample**: cs, P39588, 1.
Optical parameters: D, 138 × 1037, N47/3, × 40 pc.
Repository: GSC 138019.

Fig. 15. *Aquilapollenites quadrilobus*.
Location: Bjarni O-82, 799−800 m. **Sample**: cs, P39681, 1.
Optical parameters: C, 220 × 1048, W34/4, × 40 bf.
Repository: GSC 138068.

Fig. 16. *Parviprojectus reticulatus*.
Location: Rut H-11, 3605−3615 m. **Sample**: cs, P39413, 1.
Optical parameters: D, 198 × 855, U28/1, × 40 pc.
Repository: GSC 137969.

Fig. 17. *Aquilapollenites quadrilobus*.
Location: Hekja O-71, 2080 m. **Sample**: cs, JEH16005, 1.
Optical parameters: C, 145 × 1007, O30/4–P30/2, × 50 bf.
Repository: GSC 137884.

Fig. 18. *Afropollis* sp.
Location: Ogmund E-72, 1845 m. **Sample**: cs, YD15755, 3.
Optical parameters: A, 26.4 × 101.8, O26/4, × 60 bf.
Repository: MGUH 31357.

Fig. 19. *Afropollis* sp.
Location: Ogmund E-72, 1845 m. **Sample**: cs, YD15755, 3.
Optical parameters: A, 26.8 × 96.7, U27/1, × 60 bf.
Repository: MGUH 31358.

Fig. 20. *Appendicisporites potomacensis*.
Location: Ogmund E-72, 2340 m. **Sample**: cs, JEH15877, 3.
Optical parameters: A, 16.3 × 111.3, D16/3, × 60 bf.
Repository: MGUH 31359.

Plate 17

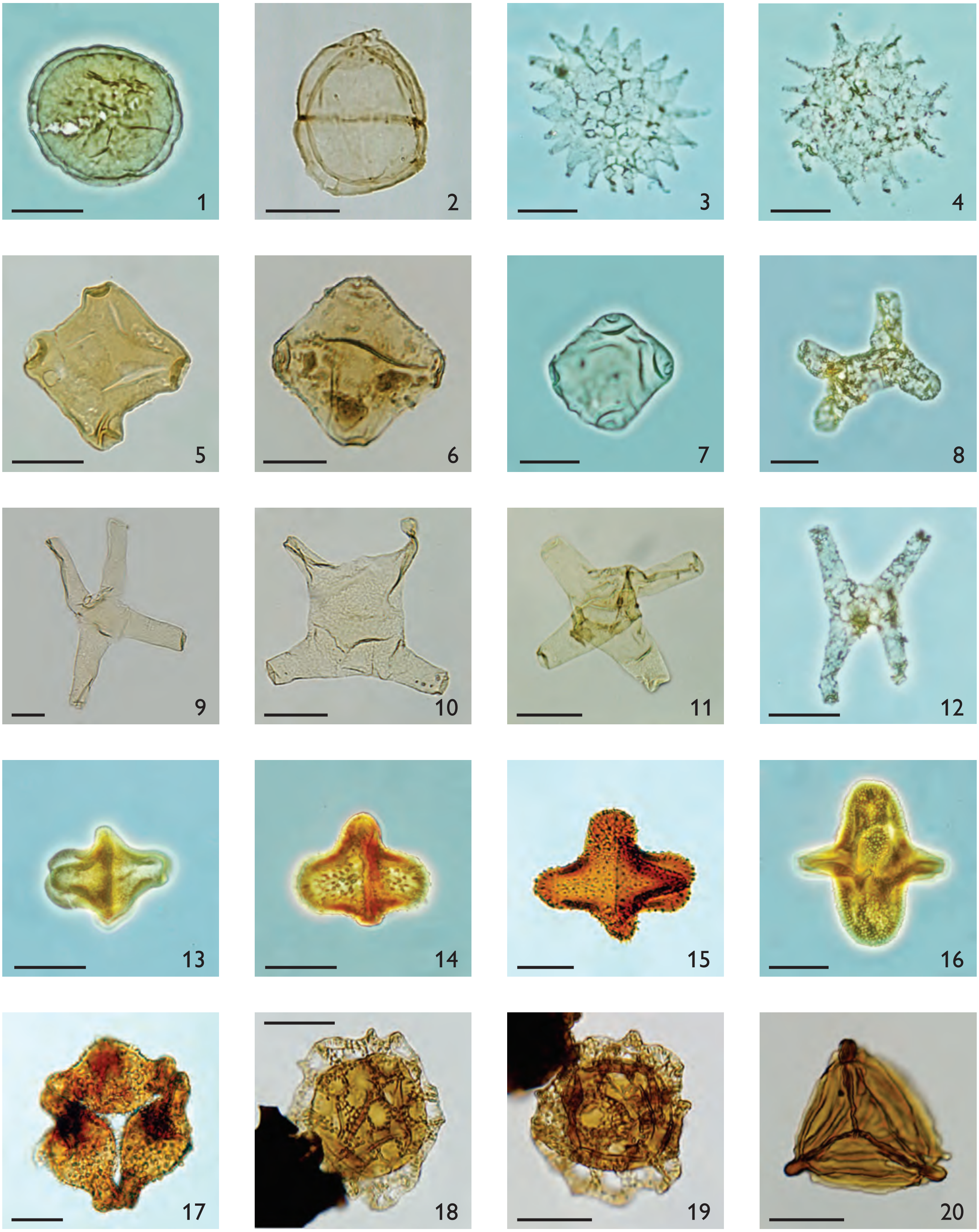

Plate 18

Fig. 1. *Appendicisporites unicus.*
Location: Ogmund E-72, 2205 m. **Sample**: cs, JEH15868, 3.
Optical parameters: A, 28.6 × 102.6, N28/4, × 60 bf.
Repository: GSC 137883.

Fig. 2. *Azolla* sp.
Location: Ralegh N-18, 2885 m. **Sample**: cs, YD16260, 3.
Optical parameters: E, 25.1 × 8.1, T23/2, × 60 bf.
Repository: MGUH 31360.

Fig. 3. *Azolla* sp.
Location: Gjoa O-37, 1858−1868 m. **Sample**: cs, P16963, 1.
Optical parameters: C, 50 × 1011, E31/1, × 50 bf.
Repository: GSC 137886.

Fig. 4. *Azolla* sp.
Location: Karlsefni A-13, 2395.76–2404.90 m. **Sample**: cs, P39604, 1.
Optical parameters: D, 153 × 1034, P46/2−4, × 40 pc.
Repository: GSC 138034.

Fig. 5. *Cicatricososporites eocenicus.*
Location: South Labrador N-79, 2040−2050 m. **Sample**: cs, P39786, 1.
Optical parameters: C, 187 × 1040, T32/1–T33/2, × 50 bf.
Repository: GSC 138118.

Fig. 6. *Baculatisporites crenulatus* sp. nov.
Location: Roberval K-92, 2090−2100 m. **Sample**: cs, P17692, 1.
Optical parameters: C, 45 × 1091, D39/0, × 50 bf.
Repository: GSC 137890.

Fig. 7. *Baculatisporites crenulatus* sp. nov.
Location: Roberval K-92, 2150−2160 m. **Sample**: cs, P17696, 1.
Optical parameters: C, 63 × 1073, F37/0, × 50 bf.
Repository: GSC 137891.

Fig. 8. *Baculatisporites crenulatus* sp. nov., holotype.
Location: Roberval K-92, 1790−1800 m. **Sample**: cs, P17684, 1.
Optical parameters: C, 106 × 1048, L34/2, × 50 bf.
Repository: GSC 137889.

Fig. 9. *Caryapollenites inelegans*.
Location: Karlsefni A-13, 969.28–978.42 m. **Sample**: cs, P39553, 1.
Optical parameters: D, 81 × 1060, H49/2, × 40 pc.
Repository: GSC 138003.

Fig. 10. *Caryapollenites inelegans*.
Location: Rut H-11, 845−855 m. **Sample**: cs, P39322, 1.
Optical parameters: D, 112 × 844, L27/1, × 40 pc.
Repository: GSC 137925.

Fig. 11. *Caryapollenites veripites*.
Location: Karlsefni A-13, 2231.16–2240.31 m. **Sample**: cs, P39598, 1.
Optical parameters: D, 191 × 993, T42/0, × 40 pc.
Repository: GSC 138028.

Fig. 12. *Caryapollenites veripites*.
Location: Karlsefni A-13, 3843.57–3852.72 m. **Sample**: cs, P39656, 1.
Optical parameters: D, 164 × 867, Q29/0, × 40 pc.
Repository: GSC 138056.

Fig. 13. *Momipites annellus*.
Location: Karlsefni A-13, 3904.54–3913.68 m. **Sample**: cs, P39658, 1.
Optical parameters: D, 175 × 911, R34/3, × 40 pc.
Repository: GSC 138058.

Fig. 14. *Momipites annellus*.
Location: Karlsefni A-13, 3301.02–3310.17 m. **Sample**: cs, P39637, 1.
Optical parameters: D, 122 × 917, M34/0, × 40 pc.
Repository: GSC 138051.

Fig. 15. *Momipites coryloides*.
Location: Snorri J-90, 1033.28−1043.43 m. **Sample**: cs, P9709, 10.
Optical parameters: C, 103 × 1078, K37–K38, × 50 bf.
Repository: GSC 138133.

Fig. 16. *Callialasporites dampieri*.
Location: Karlsefni A-13, 969.28–978.42 m. **Sample**: cs, P39553, 1.
Optical parameters: D, 196 × 1026, T45/4, × 40 pc.
Repository: GSC 138006.

Fig. 17. *Chenopodipollis* sp.
Location: Karlsefni A-13, 911.36–920.51 m. **Sample**: cs, P39551, 1.
Optical parameters: D, 115 × 930, L35/2−4, × 40 pc.
Repository: GSC 138001.

Fig. 18. *Compositoipollenites* sp. B. of Williams & Brideaux 1975.
Location: Karlsefni A-13, 1435.63–1444.77 m. **Sample**: cs, P39570, 1.
Optical parameters: D, 187 × 934, S36/3, × 40 pc.
Repository: GSC 138012.

Fig. 19. *Corsinipollenites oculusnoctis.*
Location: South Labrador N-79, 1110−1120 m. **Sample**: cs, P39757, 1.
Optical parameters: C, 200 × 1018, U31/1–4, × 50 bf.
Repository: GSC 138080.

Fig. 20. *Corsinipollenites oculusnoctis*.
Location: Karlsefni A-13, 1709.95–1719.09 m. **Sample**: cs, P39579, 1.
Optical parameters: D, 196 × 1042, T47/3, × 40 pc.
Repository: GSC 138014.

Plate 18

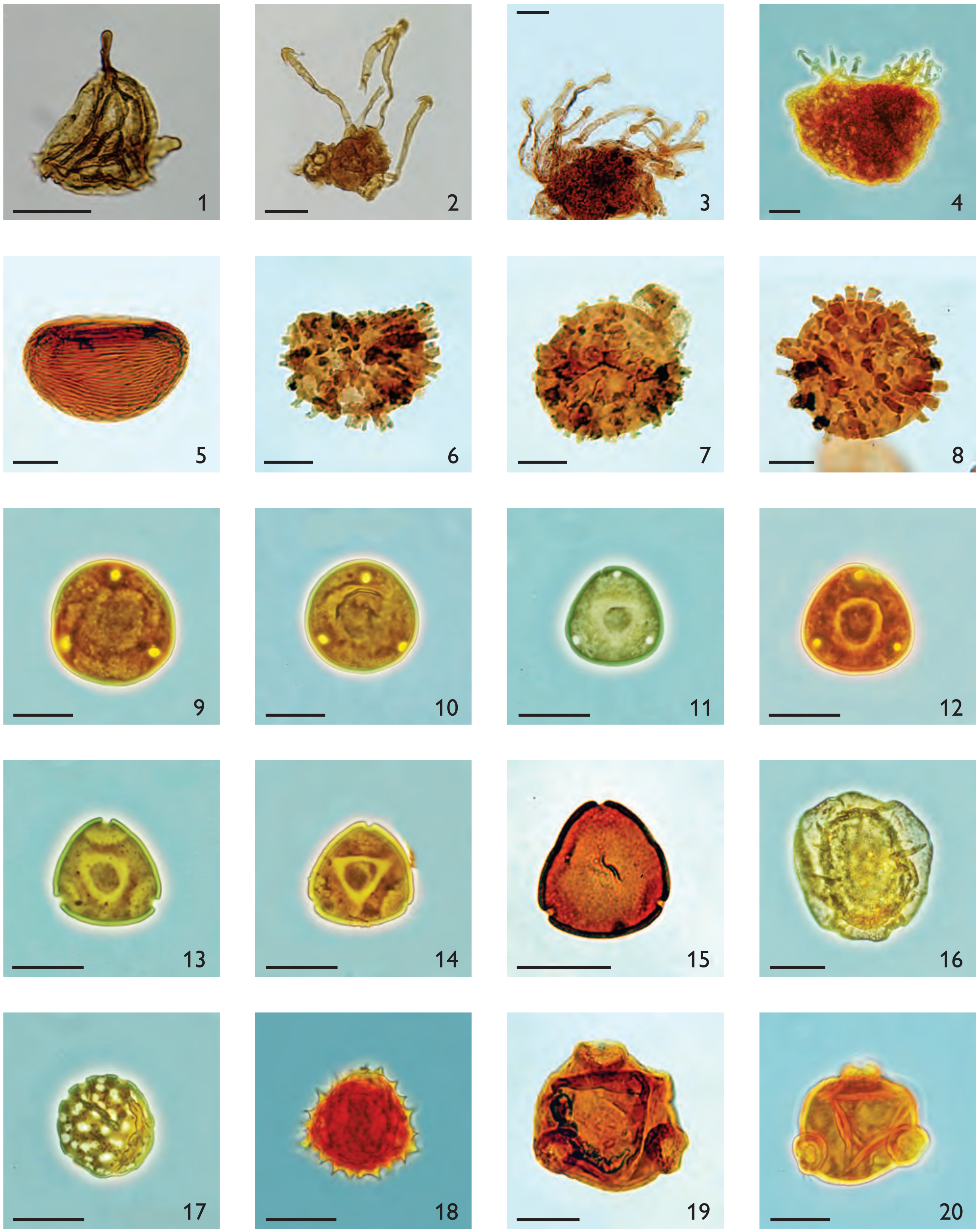

Plate 19

Fig. 1. *Cicatricosisporites ornatus*.
Location: Rut H-11, 2315–2325 m. **Sample**: cs, P39371, 1.
Optical parameters: D, 163 × 885, Q31/0, × 40 pc.
Repository: GSC 137949.

Fig. 2. *Cicatricosisporites ornatus*.
Location: Rut H-11, 1865–1875 m. **Sample**: cs, P39356, 1.
Optical parameters: D, 115 × 881, L30/2–4, × 40 pc.
Repository: GSC 137942.

Fig. 3. *Cicatricosisporites ornatus*.
Location: Karlsefni A-13, 2532.98–2542.08 m. **Sample**: cs, P39609, 1.
Optical parameters: D, 163 × 873, Q30/1–3, × 40 pc.
Repository: GSC 138038.

Fig. 4. *Cicatricosisporites ornatus*.
Location: Rut H-11, 3695–3705 m. **Sample**: cs, P39416, 1.
Optical parameters: D, 90 × 993, H42/3–4, × 40 pc.
Repository: GSC 137970.

Fig. 5. *Extratriporopollenites* sp.
Location: Gilbert F-53, 1540–1550 m. **Sample**: cs, P39464, 1.
Optical parameters: C, 180 × 1043, S34/0, × 50 bf.
Repository: GSC 137975.

Fig. 6. *Extratriporopollenites* sp.
Location: Hekja O-71, 1610–1620 m. **Sample**: cs, P20568, 1.
Optical parameters: C, 197 × 1032, U33/1, × 50 bf.
Repository: GSC 137914.

Fig. 7. *Extratriporopollenites* sp.
Location: Hekja O-71, 1420–1430 m. **Sample**: cs, P20562, 1.
Optical parameters: C, 80 × 1077, H37/2, × 50 bf.
Repository: GSC 137913.

Fig. 8. *Extratriporopollenites* sp.
Location: Snorri J-90, 1892.83–1901.98 m. **Sample**: cs, P9737, 1.
Optical parameters: C, 135 × 1020, N31/4–N32/3, × 50 bf.
Repository: GSC 138135.

Fig. 9. *Extratriporopollenites* sp.
Location: South Labrador N-79, 780–790 m. **Sample**: cs, P39746, 1.
Optical parameters: C, 154 × 1018, P31/4, × 50 bf.
Repository: GSC 138078.

Fig. 10. *Periporopollenites* sp.
Location: Karlsefni A-13, 2176.30–2185.44 m. **Sample**: cs, P39596, 1.
Optical parameters: D, 109 × 957, K38/4, × 40 pc.
Repository: GSC 138023.

Fig. 11. *Periporopollenites* sp.
Location: Rut H-11, 1305–1315 m. **Sample**: cs, P39337, 1.
Optical parameters: D, 148 × 859, O28/0, × 40 pc.
Repository: GSC 137935.

Fig. 12. *Graminidites* sp. A of Williams & Brideaux 1975.
Location: Rut H-11, 1685–1695 m. **Sample**: cs, P39350, 1.
Optical parameters: D, 177 × 882, R31/3, × 40 pc.
Repository: GSC 137937.

Fig. 13. *Pistillipollenites macgregorii*.
Location: Snorri J-90, 2441.48–2450.62 m. **Sample**: cs, P9751, 10.
Optical parameters: C, 30 × 910, C20/0, × 50 bf.
Repository: GSC 138140.

Fig. 14. *Pistillipollenites macgregorii*.
Location: Gjoa O-37, 1620–1630 m. **Sample**: cs, P16951, 1.
Optical parameters: C, 65 × 1174, F37/4, × 50 bf.
Repository: GSC 137885.

Fig. 15. *Quercoidites* sp.
Location: Rut H-11, 1205–1215 m. **Sample**: cs, P39334, 1.
Optical parameters: D, 119 × 869, L29/4, × 40 pc.
Repository: GSC 137930.

Fig. 16. *Quercoidites* sp.
Location: Rut H-11, 1305–1315 m. **Sample**: cs, P39337, 1.
Optical parameters: D, 102 × 957, K38/2, × 40 pc.
Repository: GSC 137934.

Fig. 17. *Tiliaepollenites crassipites*.
Location: South Labrador N-79, 1110–1120 m. **Sample**: cs, P39757, 1.
Optical parameters: C, 182 × 1009, S30/2, × 50 bf.
Repository: GSC 138079.

Fig. 18. *Tiliaepollenites crassipites*.
Location: South Labrador N-79, 780–790 m. **Sample**: cs, P39746, 1.
Optical parameters: C, 134 × 1023, N32/3, × 50 bf.
Repository: GSC 138077.

Fig. 19. *Tiliaepollenites* sp. A.
Location: Rut H-11, 1565–1575 m. **Sample**: cs, P39346, 1.
Optical parameters: D, 190 × 928, T35/2, × 40 pc.
Repository: GSC 137936.

Fig. 20. *Tiliaepollenites* sp. A.
Location: Karlsefni A-13, 911.36–920.51 m. **Sample**: cs, P39551, 1.
Optical parameters: D, 134 × 1000, N43/0, × 40 pc.
Repository: GSC 138002.

Plate 19

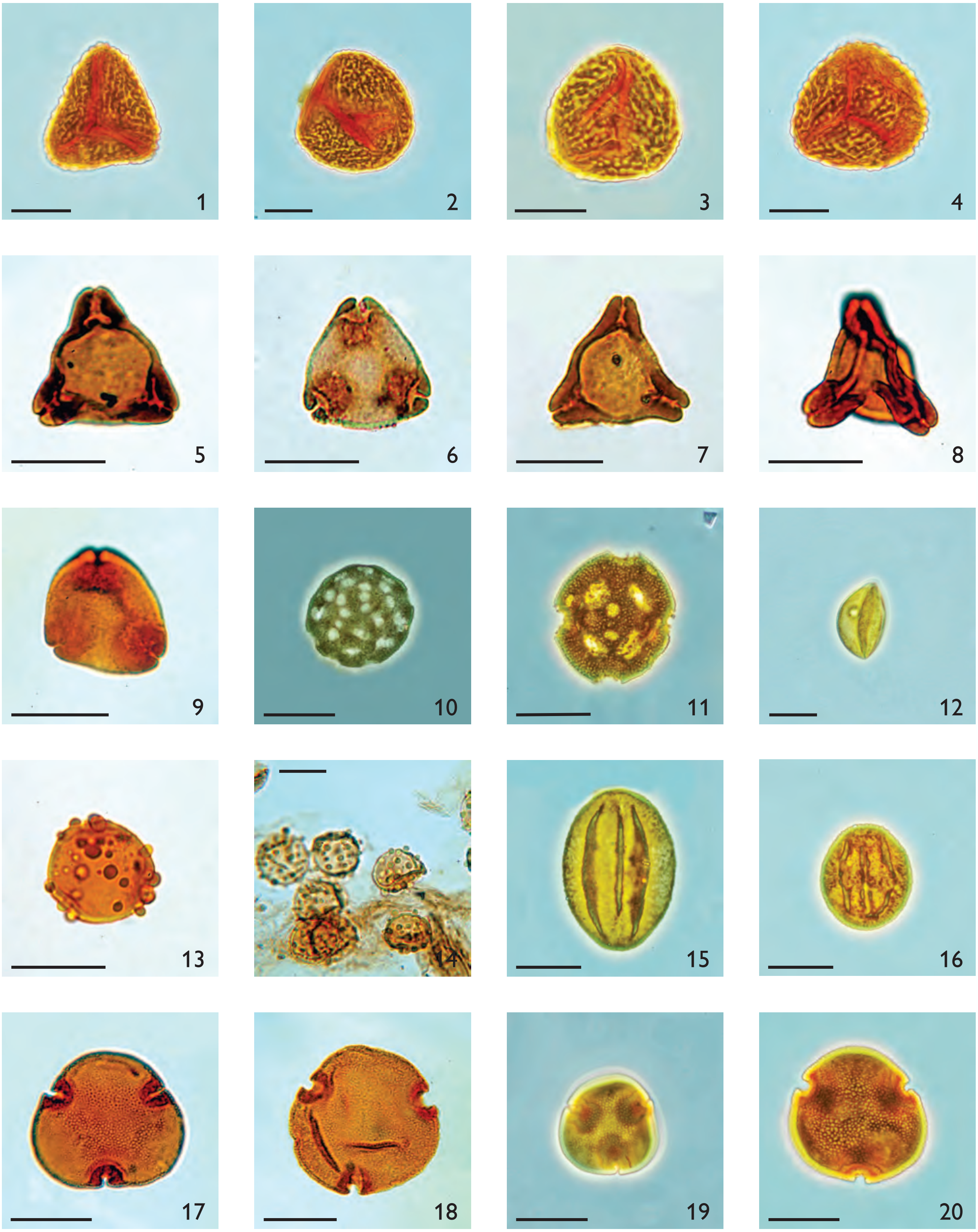

Plate 20

Fig. 1. *Osmundacidites wellmannii*.
Location: Rut H-11, 905–915 m. **Sample**: cs, P39324, 1.
Optical parameters: D, 191 × 968, T39/2, × 40 pc.
Repository: GSC 137927.

Fig. 2. *Rugubivesiculites* sp.
Location: Ogmund E-72, 1965 m. **Sample**: cs, YD15763, 3.
Optical parameters: A, 35.4 × 103.2, N35/2, × 60 bf.
Repository: MGUH 31361.

Fig. 3. *Wodehouseia spinata*.
Location: Skolp E-07, 1015 m. **Sample**: cs, YD15576, 3.
Optical parameters: A, 52.0 × 100.5, Q53/1, × 60 bf.
Repository: MGUH 31362.

Fig. 4. *Zlivisporis* sp.
Location: Karlsefni A-13, 1792.25–1801.39 m. **Sample**: cs, P39582, 1.
Optical parameters: D, 96 × 851, J27/2, × 40 pc.
Repository: GSC 138017.

Fig. 5. *Zlivisporis* sp.
Location: Rut H-11, 2285–2295 m. **Sample**: cs, P39370, 1.
Optical parameters: D, 133 × 1041, N47/0, × 40 pc.
Repository: GSC 137948.

Fig. 6. *Zlivisporis* sp.
Location: Karlsefni A-13, 2148.87–2158.01 m. **Sample**: cs, P39595, 1.
Optical parameters: D, 110 × 1047, K48/3, × 40 pc.
Repository: GSC 138022.

Fig. 7. *Zlivisporis* sp.
Location: Rut H-11, 1805–1815 m. **Sample**: cs, P39354, 1.
Optical parameters: D, 120 × 1031, M46/1, × 40 pc.
Repository: GSC 137940.

Fig. 8. *Zlivisporis* sp.
Location: Ogmund E-72, 1785 m. **Sample**: cs, YD15751, 3.
Optical parameters: A, 17.5 × 111.0, E17/2, × 60 bf.
Repository: MGUH 31363.

Fig. 9. *Zonalapollenites igniculus*.
Location: Karlsefni A-13, 859.55–865.64 m. **Sample**: cs, P39549, 1.
Optical parameters: D, 100 × 954, J38/3–4, × 40 pc.
Repository: GSC 138000.

Fig. 10. *Zonalapollenites igniculus*.
Location: Rut H-11, 845–855 m. **Sample**: cs, P39322, 1.
Optical parameters: D, 179 × 914, S34/1, × 40 pc.
Repository: GSC 137926.

Fig. 11. *Zonalapollenites igniculus*.
Location: South Labrador N-79, 720–730 m. **Sample**: cs, P39744, 1.
Optical parameters: C, 142 × 1009, O30/4–P30/2, × 50 bf.
Repository: GSC 138076.

Fig. 12. Fungal element: *Callimothallus.*
Location: Karlsefni A-13, 2478.05–2487.20 m. **Sample**: cs, P39607, 1.
Optical parameters: D, 161 × 1054, Q48/0, × 40 pc.
Repository: GSC 138035.

Fig. 13. Fungal element: *Diporicellaesporites.*
Location: Karlsefni A-13, 2505.49–2514.63 m. **Sample**: cs, P39608, 1.
Optical parameters: D, 127 × 964, M39/0, × 40 pc.
Repository: GSC 138036.

Fig. 14. Fungal element: *Fractisporonites.*
Location: Karlsefni A-13, 1737.38–1746.53 m. **Sample**: cs, P39580, 1.
Optical parameters: D, 179 × 889, R31/4, × 40 pc.
Repository: GSC 138015.

Fig. 15. Fungal element: *Fusiformisporites.*
Location: Rut H-11, 2285–2295 m. **Sample**: cs, P39370, 1.
Optical parameters: D, 106 × 906, K33/0, × 40 pc.
Repository: GSC 137946.

Fig. 16. Fungal element: *Microthallites.*
Location: Karlsefni A-13, 1764.81–1773.96 m. **Sample**: cs, P39581, 1.
Optical parameters: D, 108 × 887, K31/0, × 40 pc.
Repository: GSC 138016.

Fig. 17. Fungal element: *Staphlosporonites.*
Location: Karlsefni A-13, 2286.03–2295.17 m. **Sample**: cs, P39600, 1.
Optical parameters: D, 141 × 1071, O50/0, × 40 pc.
Repository: GSC 138031.

Fig. 18. Fungal element: *Multicellaesporites.*
Location: Karlsefni A-13, 1792.25–1801.39 m. **Sample**: cs, P39582, 1.
Optical parameters: D, 186 × 885, S31/0, × 40 pc.
Repository: GSC 138018.

Fig. 19. Fungal element: *Multicellaesporites.*
Location: Rut H-11, 3725–3735 m. **Sample**: cs, P39417, 1.
Optical parameters: D, 175 × 1043, R47/4, × 40 pc.
Repository: GSC 137972.

Fig. 20. Fungal element: *Pluricellaesporites*.
Location: Rut H-11, 2435–2445 m. **Sample**: cs, P39375, 1.
Optical parameters: D, 160 × 887, Q31/1–2, × 40 pc.
Repository: GSC 137953.

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