DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2003/25

Regional correlations of Mesozoic – Palaeogene sequences across the Greenland – Canada boundary

Regionalgeologisk korrelation af mesozoiske-palæogene sekvenser i det canadisk-grønlandske sokkelområde

Final Report for EFP-2001 Project
ENS J.nr. 1313/01-0022

Martin Sønderholm, Henrik Nøhr-Hansen,
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and Jan Audun Rasmussen

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GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF THE ENVIRONMENT

G E U S

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Comment to 2nd edition

This edition is identical to the first edition apart from an addied appendix (Appendix 2) showing the storage location of the palynological samples.

Contents

Exectutive summary

The separation of Canada and Greenland is normally regarded as a consequence of the opening of the Labrador Sea in late Mesozoic to early Cenozoic time resulting in a complex of linked rift basins stretching from the Labrador Sea to northern Baffin Bay. Two main phases of rifting and basin development have been documented during this time in the area; an episode of Early Cretaceous rifting, and a Late Cretaceous – Early Paleocene episode before sea-floor spreading started in mid-Paleocene time. However, recently acquired seismic data across the Davis Strait and northern Labrador Sea combined with modelling of gravity and magnetic data have shown that deep sedimentary basins with unknown stratigraphy are widespread in the region, suggesting that initial rifting in the region may have occurred significantly earlier.

Biostratigraphy

This study describes and correlates the palynology of the Cretaceous to Palaeogene succession from four selected wells offshore eastern Canada and six West Greenland on- and offshore wells. Twenty new palynological intervals are proposed here for the Cretaceous whereas the twenty-one palynological intervals from the Early Paleocene to the Late Eocene have been described earlier.

Data from the Canadian offshore wells have provided important new information leading to refinement and improving previous interpretations of the Cretaceous and Palaeogene successions in West Greenland.
The new, non-marine to brackish succession of Aptian to Cenomanian age described from the Canadian Ogmund E-72 well is important for further correlation with similar deposits onshore Nuussuaq.

The new data from the 1500 m thick continuous Lower Campanian to Upper Maastrichtian and lowermost Palaeogene marine succession in Skolp E-07 has provided new information to re-evaluate the dating of the youngest Cretaceous successions in the Greenland Ikermiut-1 and Qulleq-1 wells that both seem to be of Early Campanian age. A hiatus spanning the Late Campanian to early Paleocene is present in these two wells and is probably related to uplift during latest Maastrichtian or earliest Paleocene time. This event has been recorded in large parts of the areas offshore West Greenland but is only recorded as a minor hiatus onshore Nuussuaq, West Greenland. On parts of the Labrador Shelf the Upper Campanian to Maastrichtian succession is more or less complete.

In contrast to the onshore deposits on Nuussuaq in West Greenland, the Lower Paleocene (Danian) succession is generally thin or absent in the offshore Canadian and Greenland wells. The ^{40}Ar/^{39}Ar dating of the basaltic rocks overlying the Danian on Nuussuaq shows that the volcanism commenced in West Greenland between 60.9 and 61.3 Ma. This compares well with ages on basalts in the Gjoa G-37 well where basaltic rock have yielded 57.9 and 60.4 Ma, respectively. The Upper Paleocene is absent on Nuussuaq, whereas it is well represented in the Ikermiut-1 well and between the basalts in the lower part of the Gjoa G-37 and Hekja O-71 wells.

A limited number of microfossil samples were examined with the purpose to enhance the stratigraphic resolution of the palynological zonation. The microfossil content (foraminifera, diatoms and radiolarians) was, however, extremely low and of limited value both stratigraphically and palaeo-environmentally.

Well log correlation

A preliminary correlation of the seven selected exploration wells on the Labrador and South-East Baffin Island shelves and offshore and onshore West Greenland has been carried out. The lithological interpretation of the four Canadian wells is done on information from log data and the Master Log prepared by the mud logger. The log correlation is based on biostratigraphic data, and the biostratigraphic events are placed disregarding the log pattern.

Source rock evaluation

The knowledge on especially marine oil-prone source rock intervals in the northern Labrador Sea – Baffin Bay region is relatively sparse since source rock intervals have only been drilled in a few wells. However, both direct and indirect evidence of their presence exists from seeping oil in West Greenland and from some of the Canadian discovery wells.

A geochemical analysis of five Canadian wells (Ogmund E-72, Skolp E-07, Ralegh N-18, Hekja O-71 and Gjoa G-3) and eight Greenland wells (Qulleq-1, Nukik-1 and 2, Kangâmiut-1, Ikermiut-1, Hellefisk-1, GR0#3 and Umiivik-1) has been carried out in order to characterise possible source rocks intervals. However, only little or no petroleum source potential has been recorded with the possible exceptions of the Hekja O-71 and Umiivik-1 wells. Furthermore, the analyses of the five Canadian wells could not confirm that the organic rich marine mudstones of the Markland Formation and the Lower Cretaceous lignites and coals of the Bjarni Formation represent regional source rocks. It has earlier been proposed that the petroleum accumulations found in the Hekja O-71 well are sourced from surrounding Paleocene organic rich marine mudstones. This could not be confirmed since the mudstones are thermally immature in the area around the well.

Nevertheless, the presence of active hydrocarbon systems in the region shows that mature, oil-prone source rocks exist. The hydrocarbons are therefore probably generated from an as yet unknown source. Geochemical evidence from seeping oil in Greenland and from the stratigraphically deep Umiivik-1 well suggests that a marine source rocks of possible Cenomanian–Turonian age, comparable to the prolific source rock in the Kanguk Formation on Ellesmere Island, is present in West Greenland. However, knowledge on this – or maybe even older – source rock is still very sparse and depends on either results from stratigraphically deep exploration wells or from sea bed sampling of structurally inverted regions.

Introduction

Martin Sønderholm

Petroleum exploration activity in the Labrador Sea and Davis Strait has been carried out both on the Canadian and on the Greenland side. In Canada, exploration was carried out from 1971 to 1985 and during this time 28 exploration wells were drilled and more than 80,000 km of reflection seismic data were acquired. Several large gas discoveries were reported, mainly in Lower Cretaceous syn-rift reservoirs; however, none were put into production and all data are now open file.

In Greenland, the first phase of exploration was contemporaneous with exploration in Canada. In the mid-1970s, five exploration wells were drilled and approximately 40,000 km of reflection seismic data acquired. All wells were at that time declared dry, and exploration came to a stop in 1979 when all licences were relinquished. In 1987 the Survey initiated a re-evaluation of the seismic data and based on these results a major publicly financed seismic acquisition programme was carried out supplemented by detailed petroleum geological studies in the onshore areas during 1991–1995. These efforts led to the signing of three licences: one onshore licence and two offshore. In 1995, an onshore licence on Disko and Nuussuaq was awarded to a small Canadian company (grønArctic Energy) that drilled a deep exploration well (GRO#3) in 1996 which was declared dry by the company. In 1996, an offshore licence was awarded to a group of companies headed by Statoil and in 1998 another to a group headed by Phillips Petroleum. The renewed industry interest in Greenland resulted in further seismic acquisition by private companies (more than 30,000 km since 1995) and in the drilling of one new exploration well in the Statoil licence in the year 2000 (Qulleq-1). Although dry, the Qulleq-1 well provided a wealth of new stratigraphic data important to the evaluation of the petroleum geology of West Greenland. All these licences are now relinquished and data are open file. Exploration activities have, however, not ceased in West Greenland; following a licensing round in 2002 a new offshore exploration licence was awarded to EnCana and both public and private data acquisition is still being carried out, especially in the border region between Greenland and Canada.

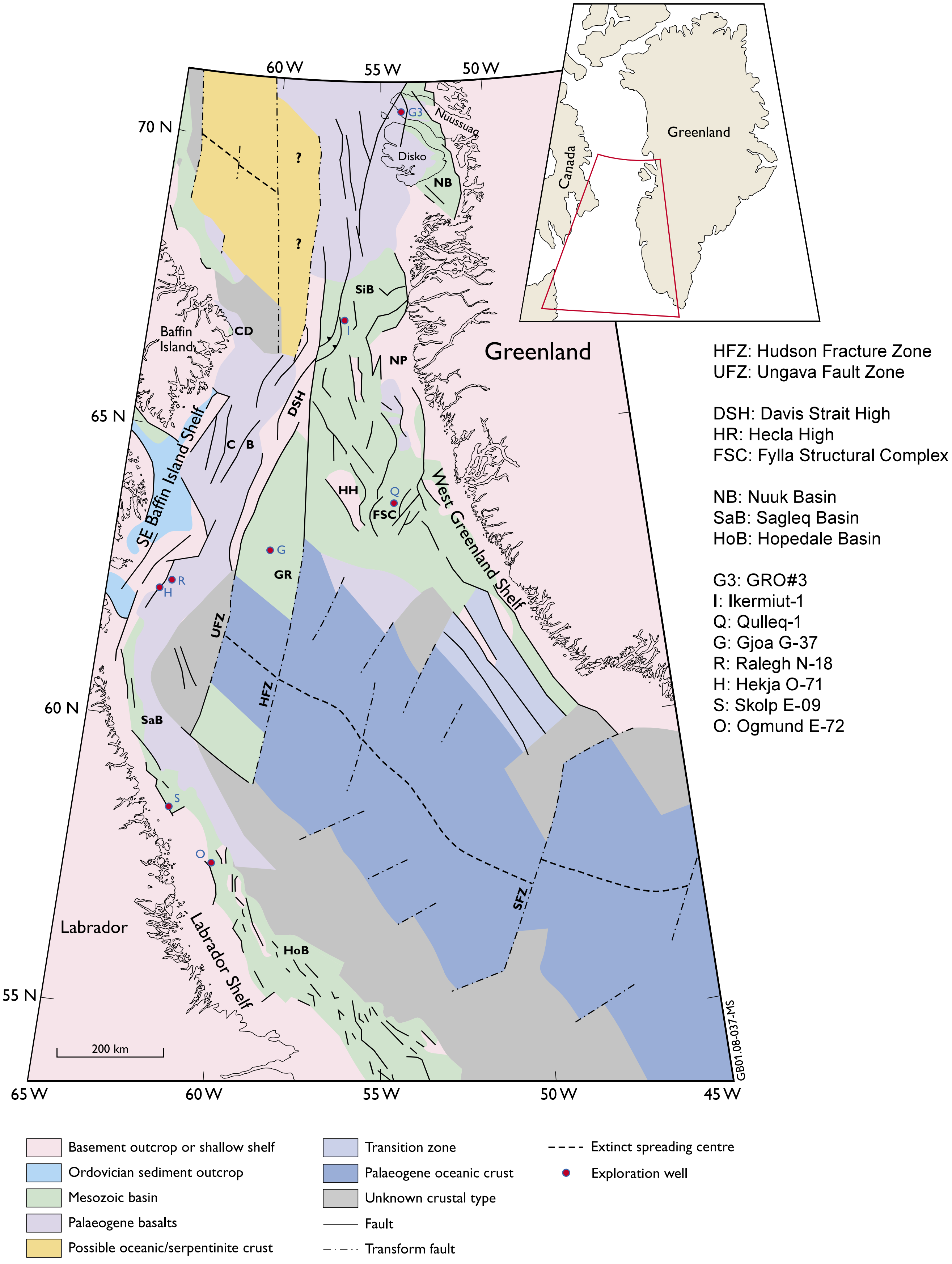
Since the Canadian exploration licences were relinquished in the mid-1980s neither well data nor seismic data have have been re-examined in any systematic way. In Greenland, however, the major public effort in promoting West Greenland to the industry since 1990 and the following exploration activities have created a wealth of new data resulting in major revisions in the interpretation of the geological evolution of the West Greenland offshore basins (cf. Chalmers & Pulvertaft 2001).

The combination of the huge amounts of data on the Canadian side combined with the new knowledge obtained in recent years in Greenland it seems pertinent to re-evaluate the geology of the entire Labrador Sea – Davis Strait – Baffin Bay region.

The main purpose of the present project is to establish an up-to-date correlation between the wells drilled offshore Greenland and Canada in the Labrador Sea and Davis Strait area as a first step in generating a revised regional geological and geotectonic model. The correlation is based on both new seismic and well data from Greenland and a new biostratigraphic processing and analysis of selected Canadian (Ogmund E-72, Skolp E-07, Hekja O-71, Gjoa G-37) and Greenland wells (Qulleq-1, Kangâmiut-1, Ikermiut-1, GR0#3 and Umiivik-1) and to compare this with known onshore successions in the Nuussuaq Basin, West Greenland. If feasible, the project should also try to explain the regional distribution of any possible source and reservoir intervals in the succession. For this purpose, a geochemical analysis of the wells has been carried out in order to characterise possible source rock intervals.

The project is closely linked to a regional geological reconstruction project and a geochemical source rock analysis project, both financed by the Bureau of Minerals and Petroleum, Government of Greenland.

The EFP-2001 project 'Regional correlation of Mesozoic–Palaeogene sequences across the Greenland–Canada boundary' was co-funded by the Geological Survey of Denmark and Greenland, the Bureau of Minerals and Petroleum, Government of Greenland, and Phillips Petroleum, Norway. This final report summarises the studies carried out under this heading but includes also related reports made under other projects (see list of contents).



HFZ: Hudson Fracture Zone
UFZ: Ungava Fault Zone

DSH: Davis Strait High
HR: Hecla High
FSC: Fylla Structural Complex

NB: Nuuk Basin
SaB: Sagleq Basin
HoB: Hopedale Basin

G3: GRO#3
I: Ikermiut-1
Q: Qulleq-1
G: Gjoa G-37
R: Ralegh N-18
H: Hekja O-71
S: Skolp E-09
O: Ogmund E-72

Fig. 1. Simplified geological map of the Labrador Sea – Davis Strait region. Modified from Chalmers & Pulvertaft (2001).

Geological setting and general stratigraphy

Martin Sønderholm

The Labrador Sea is an oceanic basin, approximately 900 km wide, that opens into the North Atlantic Ocean to the south-east. To the north it passes into the Davis Strait, a relatively shallow seaway approximately 300 km wide leading into Baffin Bay. The Labrador Sea is flanked by typical shallow Arctic shelves: the Labrador and South-East Baffin Island shelves to the west and the southern West Greenland shelf to the east (Fig. 1).

The separation of Canada and Greenland is normally regarded as a consequence of the opening of the Labrador Sea in late Mesozoic to early Cenozoic time (Chalmers & Pulvertaft 2001). This resulted in a complex of linked rift basins stretching from the Labrador Sea to northern Baffin Bay (Fig. 1). Two main phases of rifting and basin development have been documented during this time in the area; (1) an episode of Early Cretaceous rifting, and (2) a Late Cretaceous – Early Paleocene episode before sea-floor spreading started in mid-Paleocene time (Chalmers & Pulvertaft 2001). However, recently acquired seismic data across the Davis Strait and northern Labrador Sea combined with modelling of gravity and magnetic data have shown that deep sedimentary basins with unknown stratigraphy are widespread in the region (Chalmers *et al.* 2001), suggesting that initial rifting in the region may have occurred as early as during Jurassic or even Triassic time.

The geological history is best known from the sedimentary basins under or close to the continental shelves where petroleum exploration has taken place and from studies of the relatively sparse outcrops in the Nuussuaq Basin, West Greenland and at Cape Dyer, eastern Baffin Island. Outcrops of Cretaceous – Palaeogene sediments are also seen further north in Arctic Canada on Bylot Island (Miall *et al.* 1980; Miall 1986) and on Ellesmere Island (Núñez-Betelu 1994).

Over the Labrador shelf extensive seismic surveys were carried out in from 1971 to 1983 and 25 wells were completed (Fig. 2). Six discoveries of gas were made, but none of them have been exploited. On the South-East Baffin Island shelf three wells were drilled in the early 1980s, one of which (Hekja O-71) recovered condensate (see summary by Balkwill *et al.* 1990; Bell & Campbell 1990).

Cretaceous–Palaeogene stratigraphy

Labrador and South-East Baffin Island shelves

On the Labrador Shelf the initiation of the Early Cretaceous rifting episode is recorded by a major volcanic phase represented by the Alexis Formation of Valanginian – Early Aptian age (approx. 131–104 Ma; Umpleby 1979; Balkwill *et al.* 1990). The Alexis Formation is overlain by the Barremian–Albian Bjarni Formation which is recognised both on the Labrador Shelf (Hopedale Basin) and on the South-East Baffin Island Shelf (Saglek Basin; Fig. 3); it is dominated by nonmarine sandstone and argillaceous sandstone and coal beds (Balkwill *et*

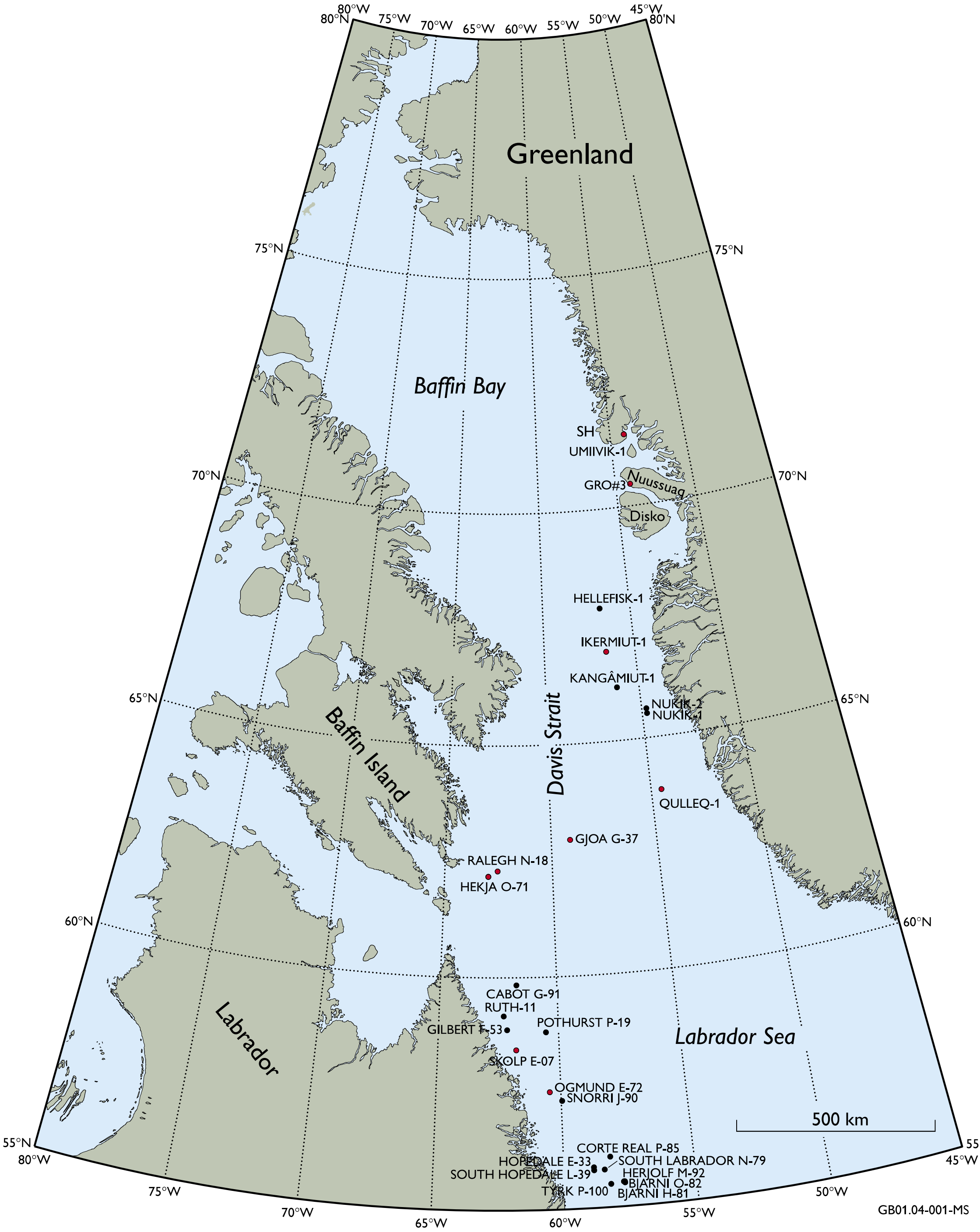


Fig. 2. Exploration wells drilled on the Labrador and South-East Baffin Island shelves and off- and onshore West Greenland.

al. 1990) and around Cape Dyer similar sandstone deposits of the same age are assigned to the Quqaluit Formation (Burden & Langille 1990). The Bjarni Formation is the most common hydrocarbon objective in the Labrador Shelf wells.

The Late Cretaceous – Early Paleocene rifting event is recorded by the Markland Formation in both the Hopedale and Saglek basins. The Markland Formation comprises marine shelf mudstone; more proximal sandstone-dominated facies are referred to the Freydis Member and lower Gudrid member of Cenomanian–Campanian age and Early Paleocene (Danian)

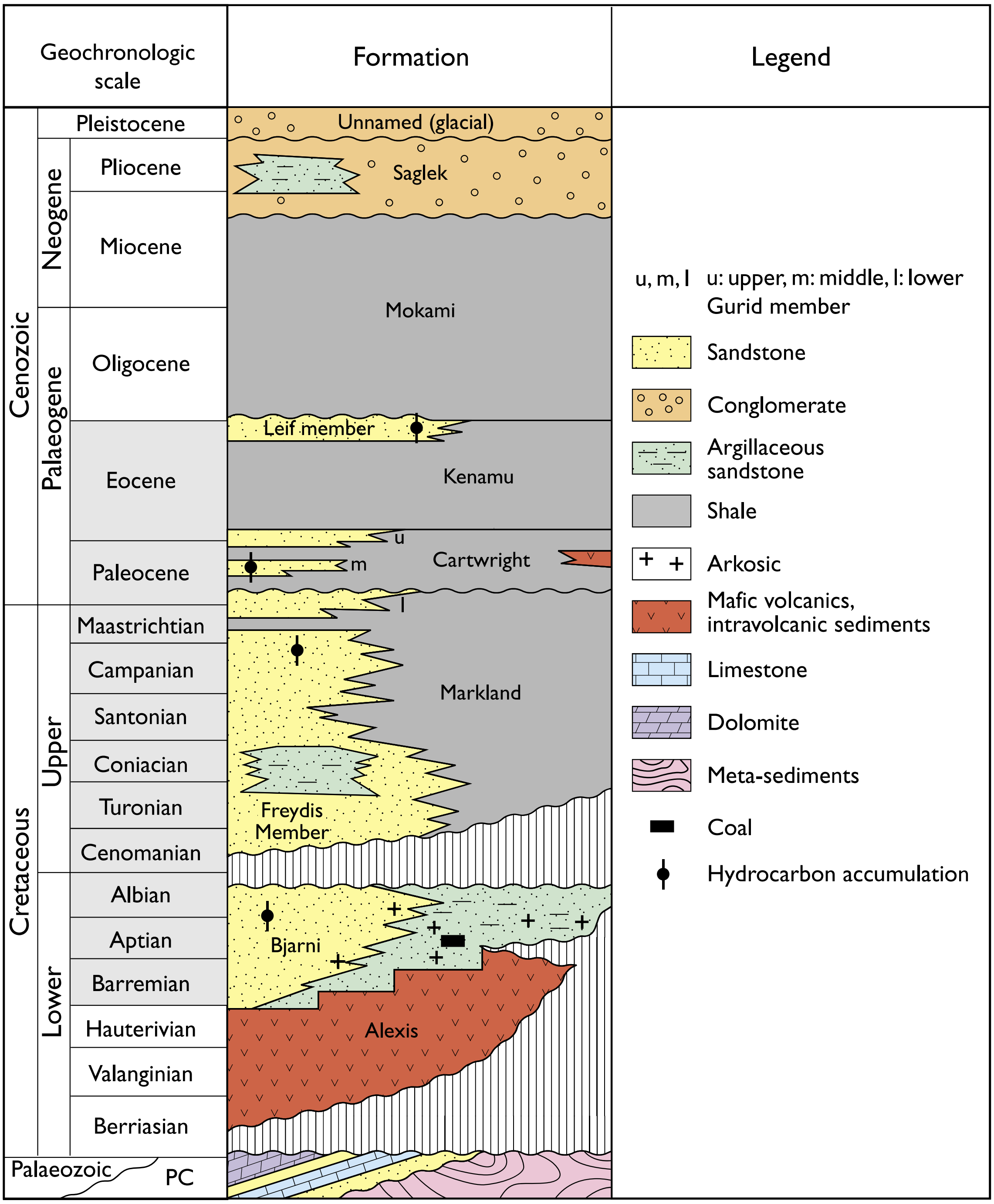


Fig. 3. Generalasied stratigraphy of the Labrador and South-East Baffin Island shelves. Basied on Balkwill *et al.* (1990). Grey shading denotes stratigraphy covered in this report.

age, respectively (Fig.3; Balkwill *et al.* 1990). At Cape Dyer this phase is probably not represented.

During Palaeogene sea-floor spreading, sedimentation in the Hopedale and Saglek basins is recorded by the Cartwright and Kenamu Formations which are dominated by marine mudstone. In the Saglek Basin, the Cartwright Formation is commonly interbedded with thick basaltic flows. Proximal shallow marine deltaic sandstones have, however, been recognised in both formations (Fig. 3) and are referred to the middle and upper Gudrid mem-

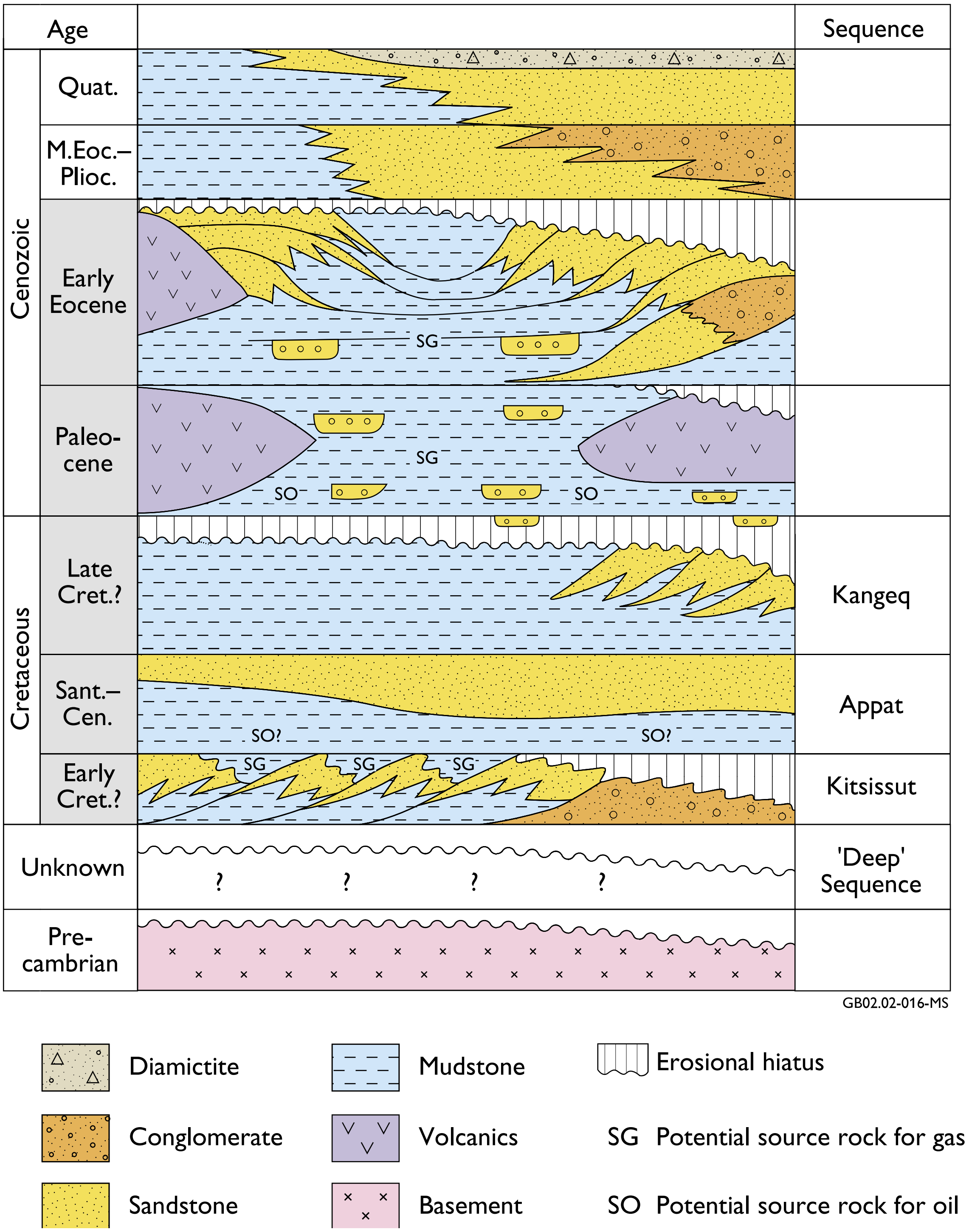


Fig. 4. Generalasied stratigraphy of the West Greenland basins Modified from GEUS (2002) and Chalmes & Pulvertaft (2001). Grey shading denotes stratigraphy covered in this report.

bers (Cartwright Formation) and to the Leif member (Kenamu Formation; for discussion on these informal units, see Balkwill *et al.* 1990). The Leif member contains the most important Palaeogene hydrocarbon reservoirs in the region and are especially well developed in the Hopedale Basin. At Cape Dyer, a very thin (<10 m) succession of alluvial sandstones of Early Paleocene age (Cape Searle Formation) underlies a several hundred metres thick succession of basalt breccias (Burden & Langille 1990).

West Greenland shelf

The earliest manifestations of Early Cretaceous rifting in West Greenland is characterised by a volcanic phase represented by a 380 km long coast-parallel basaltic dyke swarm yielding ages between 138 and 133 Ma (Berriasian – Valanginian; Larsen *et al.* 1999) – ages that are comparable to the Alexis Formation on the Labrador Shelf. Offshore West Greenland, sedimentary successions of this phase have not been drilled, but are recognised as the Kitsissut seismic sequence (Fig. 4; cf. Chalmers & Pulvertaft 2001). Coeval sediments may be found onshore northern Nuussuaq where outcrops of fluvial and shallow marine sandstones of possible Albian age and unconformably overlain by younger deposits are referred to the Kome (cf. Pulvertaft 1979; Nøhr-Hansen 1992; Midtgaard 1996).

The Late Cretaceous – Early Paleocene rifting event is represented by the Appat and Kangeq seismic sequences offshore West Greenland (Fig. 4; cf. Chalmers & Pulvertaft 2001). Rolle (1985) proposed a lithostratigraphy for the basins offshore West Greenland based on cuttings and logs from the five exploration wells drilled in the mid-1970s, but only two of these (Ikermiut-1 and Kangâmiut-1) reached Cretaceous strata. In the lowermost part of the Kangâmiut-1 well, Upper Cretaceous to Lower Paleocene syn-tectonic fan deposits were assigned to the Narssarmiut Formation and correlated with the Freydis Member of the Markland Formation on the Labrador Shelf (Rolle 1985; Bate 1997). Basinal deposits comprising mainly mudstone were assigned to the Ikermiut Formation of Campanian to Middle Eocene age (Rolle 1985). However, new biostratigraphic data from the Ikermiut-1 well and the Qulleq-1 well (drilled in 2000) have shown that a major hiatus, possibly spanning the Late Campanian to earliest Paleocene, is present in both wells (see below). Onshore West Greenland, Cenomanian to earliest Paleocene (early Danian) sediments are included in the Nuussuaq Group (Dam *et al.* 1998a; Dam & Nøhr-Hansen 2001; Dam & *et al.* in prep.) which includes fluvial, shallow marine and deep marine deposits. Uplift is also recorded in the onshore sediments by a system of deeply incised valleys which were filled during the following phase of sedimentation (Dam *et al.* 1998a; Dam & Sønderholm 1998).

Onset of Paleocene sea-floor spreading in West Greenland is marked by the extrusion of extensive flood basalts and coincided with a phase of rapid subsidence (Dam *et al.* 1998a) resulting in a thick and varied succession of sediments in the offshore basins (Fig. 4). These were assigned to the Hellefisk, Ikermiut and Nukik Formations and correlated with the Cartwright and Kenamu Formations on the Labrador Shelf (Rolle 1985). Onshore Nuussuaq, the uppermost part of the Nuussuaq Group comprises sandy fluvial valley fills overlain by estuarine deposits eventually followed by offshore mudstones before the eruption of hyaloclastic breccias filled the basin (Dam *et al.* 1998a; Dam & Sønderholm 1998).

Table 1: Technical data of the Canadian and Greenland wells used in the palynological studies

	Drilled/ Operator	**Position**	**Formation at TD/ Reference**	**Palynological study**
Ogmund E-72	1980 Petro Canada	Hopedale Basin, Labrador Shelf, offshore eastern Canada 57.525028°N; 60.442825°W (NAD83) Water depth: 156.2 m Rotary table: 12.8 m Total depth: 3094.0 m b.R.T.	Lower Cretaceous sandstones and conglomerates (Bujak Davies Group 1987c; Miller & d'Eon 1987)	Interval: 790–3090 m Eocene – ?Aptian Samples: 134 cutting samples 20 sidewall core samples
Skolp E-07	1978 Total Eastcan	Saglek Basin, Labrador Shelf, offshore eastern Canada 58.440322 °N; 61.768175°W (NAD83) Water depth: 166.5 m Rotary table: 12.0m Total depth: 2992 m b.R.T.	Precambrian gneiss (Miller & d'Eon 1987)	Interval: 925–2985 m L. Eocene – Albian Samples: 136 cutting samples
Hekja O-71	1979 Aquitaine	Saglek Basin, Davis Strait, offshore eastern Canada 62.181228° N; 62.978328°W (NAD83) Water depth: 350.8 m Rotary table: 12.5 m Total depth: 4566.0 m b.R.T.	?Upper Cretaceous shale (Bujak Davies Group 1987b; Miller & d'Eon 1987)	Interval 1465-4566 m U.Paleocene – U.Eocene Samples: 78 cutting samples 1 sidewall core sample
Gjoa G-37	1979 Esso H. B.	Davis Strait Basin, Davis Strait, offshore Eastern Canada 62.941275 °N; 59.106975°W (NAD83) Water depth: 1000 m Rotary table: 24.0 m Total depth: 3998 m b.R.T.	Lower Paleocene shales (Bujak Davies Group 1987a; Miller & d'Eon 1987)	Interval: 1510–3998 m M.Eocene – L.Paleocene Samples: 79 cutting samples 1 sidewall core sample
Qulleq-1	2000 Statoil	Fylla Structural Complex, offshore West Greenland 63º 48' 48.03" N; 54º 27' 06.61" W (WGS84) Water depth: 1152.3 m Rotary table: 36 m Total depth: 2973 m b.R.T.	?Upper Santonian sandstone (Nøhr-Hansen *et al.* 2000)	Interval 1862–2970 m L.Eocene – ?Santonian Samples: 30 cutting samples 50 sidewall core samples
Ikermiut-1	1979 Chevron Petroleum	Sisimiut Basin, close to the Ungava/ Ikermiut Fault Zone offshore West Greenland 66º 56' 12" N; 56º 35' 26" W (WGS84) Water depth: 447 m Rotary table: 12 m Total depth: 3619 m b.R.T.	?Campanian shales (Rolle 1985; Nøhr-Hansen 1998)	Interval: 1049–3616 m M.Eocene – ?L.Campanian Samples: 104 cutting samples 75 sidewall core samples
GRO#3	1995 grønArctic Energy Inc.	Nuussuaq Basin, Nuussuaq, onshore West Greenland 70º 27.765' N ; 54º 05.227' W (WGS84) Rotary table: 22,5 m a.m.s.l. Total depth: 2998 m b.R.T.	Cretaceous shales (Nøhr-Hansen 1997a)	Interval: 300–2950 m U.Paleocene – ?Coniacian Samples: 70 cuttings samples

Palynological study: correlation Canada – West Greenland

Henrik Nøhr-Hansen

Palynological material

The present palynological study of the Cretaceous to Palaeogene succession in the Labrador Sea – Davis Strait area is based on samples from the eastern Canadian offshore wells Ogmund E-72, Skolp E-07, Hekja O-71 and Gjoa G-37, the West Greenland offshore wells Qulleq-1 and Ikermiut-1, the West Greenland onshore wells GRO#3 and Umiivik-1, and outcrop samples from Svartenhuk Halvø and Nuussuaq (Figs 1, 2; Table 1).

The analysis of surface samples from Svartenhuk Halvø and from Kangilia and Slibestensfjeldet on northern Nuussuaq have earlier been reported on by Nøhr-Hansen (1992, 1996) and Nøhr-Hansen *et al.* (2002). Most of the studied West Greenland samples were processed or re-processed in the 1990s. However, the majority of the sidewall core samples from the Ikermiut-1 well are only available as original slides produced in 1977 and are of variable – and generally low – quality. All the Canadian samples were processed in 2001 and 2002.

Methods

Palynological preparation and studies of the samples were carried out at the Geological Survey of Denmark and Greenland (GEUS). Palynomorphs were extracted from 20 g of sediment from each sample by modified standard preparation techniques including treatment with hydrochloric (HCl) and hydrofluoric (HF) acids, sieving using a 20 μ nylon mesh and oxidation (3–10 minutes) with concentrated nitric acid (HNO_3). Finally, palynomorphs were separated from coal particles and woody material in most samples, using the separation method described by Hansen & Gudmundsson (1978) or by swirling. After each of the steps mentioned above the organic residues were mounted in a solid medium (Eukitt ®) or in glycerine gel. The palynological slides were studied with transmitted light using a Leitz Dialux 22 microscope (No. 512 742/057691). Dinoflagellate cysts, acritarchs and selected stratigraphically important spores and pollen species were recorded from the sieved, oxidised or gravity-separated slides. Approximately 100 specimens were counted whenever possible.

The sample depths and relative abundance of species referred to in the biostratigraphic section (below) are illustrated on range-charts of each well (Enclosures 1–8). The illustrations of dinoflagellate cysts from Ogmund E-72, Skolp E-07 and Gjoa G-37 (Plates 1–50) are marked with sample number, slide number and laser-video-record number (LVR) for later identification.

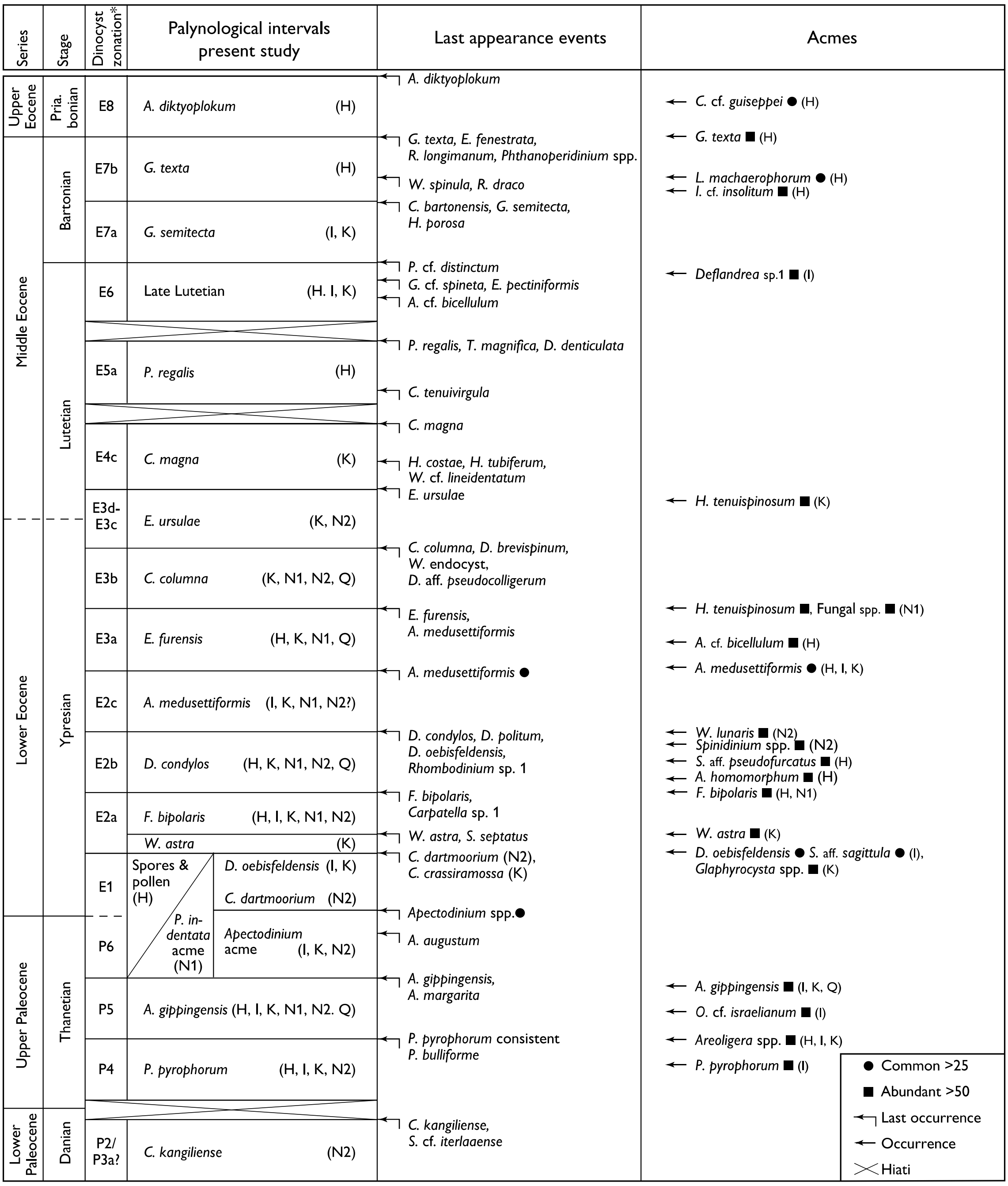


Fig. 5. Palaeogene palynological intervals and bioevents offshore West Greenland, correlated with the dinocyst zonations of Bujak & Mudge (1994) and Mudge & Bujak (1996a, b) and the foraminifera and microfossil intervals of Rasmussen & Sheldon (in press). From Nøhr-Hansen (in press).

Palynological results

Palynostratigraphic correlations of the Upper Cretaceous to Palaeogene West Greenland deposits have previously been presented by Nøhr-Hansen (1996, 1997a, 1997b, 1998), Dam *et al.* (1998b), Nøhr-Hansen & McIntyre (1998), Christiansen *et al.* (1999), Nøhr-Hansen *et al.* (2000, 2002) and Nøhr-Hansen (in press, see Appendix 3). There is no formal palynological zonation for the Cretaceous of the Labrador Shelf, but available data for the Cretaceous and Palaeogene have been summarised by Williams *et al.* (1990).

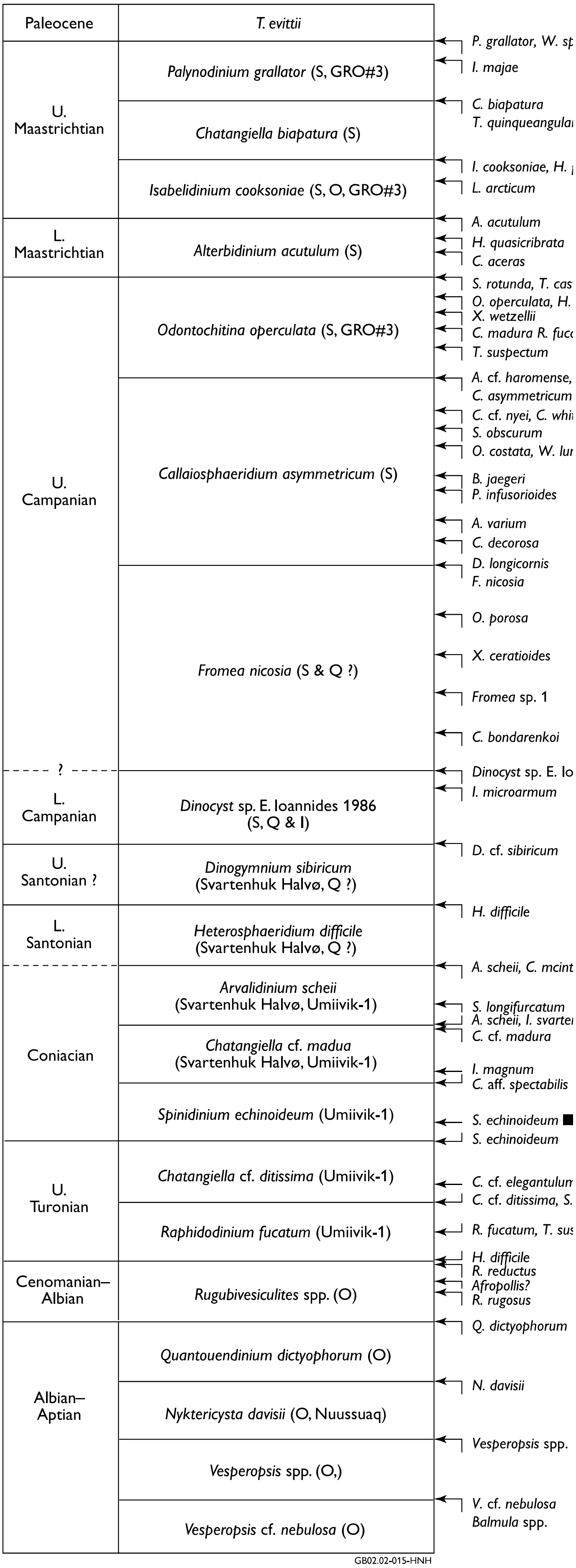


Fig. 6. Twenty preliminary Cretaceous palynological intervals and bioevents on- and offshore eastern Canada and West Greenland.

This study describes the palynology of the Cretaceous to Palaeogene succession of selected wells offshore eastern Canada and on- and offshore West Greenland. Twenty preliminary palynological intervals are proposed here for the Cretaceous (Fig. 5) and twenty-one palynological intervals have been erected from the Early Paleocene to the Late Eocene (Fig. 6; Nøhr-Hansen in press). The last appearance datum (LAD), first appearance datum (FAD) and abundance of stratigraphic marker species define the intervals.

The palynology of the Neogene offshore West Greenland is not included in this report but is described by Nøhr-Hansen *et al.* (2000) and Piasecki (in press).

Stratigraphic overview

In the present study new data from the Cretaceous successions in Ogmund E-72 and Skolp E-07 offshore eastern Canada are compared with data from the West Greenland exploration wells Qulleq-1, Ikermiut-1 and GRO#3 (Figs 7, 8), and from onshore exposures on Svartenhuk Halvø and Nuussuaq (Fig. 9). The Cretaceous dinoflagellate cyst stratigraphy presented here (Fig. 5) is mainly compared with the Cretaceous dinoflagellate cyst zonation from the North Sea described by Hansen (1977), Costa & Davey (1992) and Schiøler & Wilson (1993).

The new stratigraphy for the Cretaceous is preliminary mainly because several of the described intervals are only recorded from one well/locality and because some of the nonmarine to brackish intervals from Ogmund E-72 need correlation to fully marine sections. It is therefore strongly recommended that this preliminary stratigraphy should be tested and refined against other wells offshore eastern Canadian that contain Cretaceous marine successions (eg. North Leif I-05, Bjarni O-82 and Gilbert F-53) and onshore Cretaceous deposits on Bylot Island and Devon Island in the Canadian Arctic Archipelago.

A detailed dinoflagellate cyst stratigraphy for the Palaeogene succession offshore West Greenland has recently been established by Nøhr-Hansen (in press). Twenty-one palynological intervals were described from the Early Paleocene to the Late Eocene based on material from the Hellefisk-1, Ikermiut-1, Kangâmiut-1, Nukik-1, Nukik-2 and Qulleq-1 wells (Fig. 6).

Furthermore, a detailed dinoflagellate cyst zonation for the pre-volcanic part of the Danian (lowermost Paleocene) has been established by Nøhr-Hansen *et al.* (2002) based on material from three outcrop successions on northern Nuussuaq (Kangilia, Danienrygge and Annertuneq) and from four shallow, slim core wells (GANW#1, GRO#3, GANE#1 and GANK#1). Five zones and three subzones were described (Fig. 9).

The present study includes new data from the Palaeogene successions in the Ogmund E-72, Skolp E-07 and Gjoa G-37 wells offshore eastern Canada which have been correlated with the successions on- and offshore West Greenland (Fig. 10). The calibration to the Palaeogene dinocyst zones follows Bujak & Mudge (1994), Mudge & Bujak (1996a, b), Nøhr-Hansen *et al.* (2002) and Nøhr-Hansen (in press), see Figure 6.

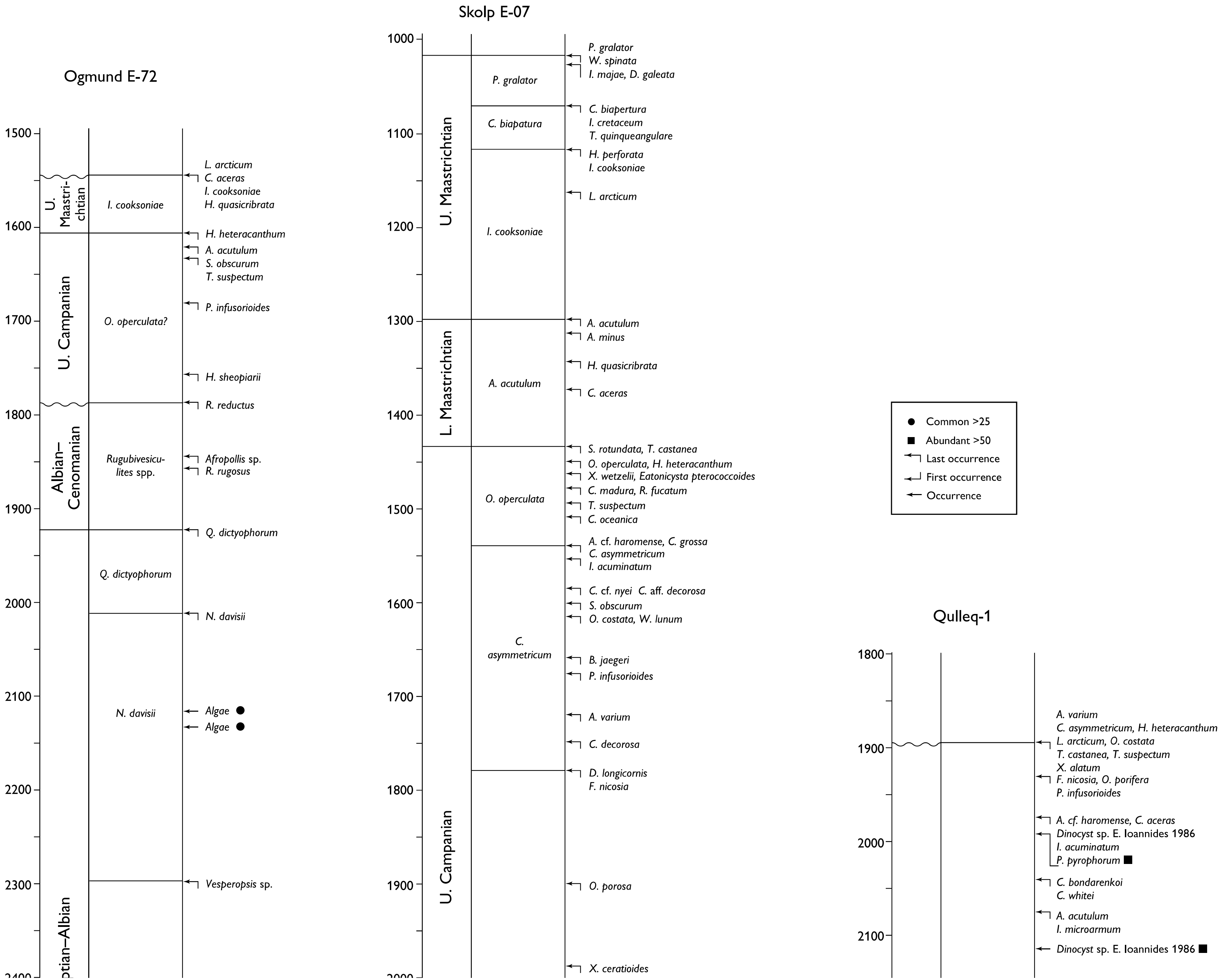
In Ogmund E-72 (Enclosure 1) the lower 1170 m of the well consists of a nonmarine to brackish succession of Aptian to Albian age followed by a 130 m thick nonmarine succession of presumably Albian to Cenomanian age (Fig. 7). The nonmarine deposits are unconformably overlain by marine Upper Campanian and Upper Maastrichtian deposits (140 m) followed by a lowermost Paleocene succession age (Fig. 7). The Palaeogene is represented by a very thin (15 m) lowermost Paleocene succession (P1) which is unconformably overlain by a 225 m thick Upper Paleocene to Lower Eocene succession (P5–E3b; Fig. 10). However, no indication of the lowermost Eocene (E1) has been recorded which may suggest a very condensed interval or an unconformity between the uppermost Paleocene to Lower Eocene (P6–E2a). A possibly more than 300 m thick Middle Eocene succession (most likely Bathonian, E7) unconformably overlies the Lower Eocene (Fig. 10).

In Skolp E-07 (Enclosure 2) the deepest part of the well consists of a 490 m thick succession of nonmarine deposits of presumably Albian to Cenomanian age unconformably overlain by a 1500 m thick and apparently continuous Lower Campanian to Upper Maastrichtian and lowermost Palaeogene marine succession (Fig. 7). The Palaeogene is represented a 20 m thick lowermost Paleocene succession (P1) unconformably overlain by a 70 m thick (condensed?) Lower Eocene succession (?E2b–?E2c; Fig. 10).

In Hekja 0-71 (Enclosure 8) the palynological content – especially the marine – of most of the Palaeogene is of very low diversity and lacks stratigraphic marker species making a detailed zonation difficult. The Upper Paleocene (P4–P6) in Hekja 0-71 is 1425 m thick; however, it also includes more than 1000 m of volcanic rocks. An ^{40}Ar/^{39}Ar age dating of basaltic rocks is in conflict with the biostratigraphic data since it has yielded a late Early to early Middle Eocene age of 49.1 ±" 1.3 Ma (Williamson *et al.* 2003). As in Skolp E-07, Gjoa G-37, Qulleq-1 and possibly also Ogmund E-72 the Upper Paleocene may be unconformably overlain by a Lower Eocene succession (?E2–?E3) which in Hekja O-71 is approximately 700 m thick. This is followed by an approximately 1000 m thick Middle to Upper Eocene succession (Fig. 10).

In Gjoa G-37 (Enclosure 3) the Palaeogene succession is probably represented by a 1680 m thick Upper Paleocene succession (P4–P6) which, however, may include a 440 m thick lower Paleocene (P2) succession in the lower part of the well (Fig. 10). The Paleocene deposits are interbedded with volcanic rocks with a total thickness of more than 500 m. As in Skolp E-07, Qulleq-1 and possibly also Ogmund E-72 an unconformity is present between the uppermost Paleocene and an approximately 640 m thick Lower Eocene succession (E2a/E2b–E3c). The Lower Eocene is conformable overlain by approximately 60 m of Middle Eocene (Lutetian, E3d–E4) deposits (Fig. 10).

The interpretation of the Cretaceous dinocyst stratigraphy in the Ikermiut-1 well (Fig. 8, Enclosure 5) is complicated due to a combination of reworking and extensive caving (see below). Therefore, 25 critical samples have been re-processed and all data available have been carefully evaluated. This has resulted in a revised stratigraphy of the well suggesting that the youngest Cretaceous succession in Ikermiut-1 is of Early Campanian age, suggesting a hiatus related to uplift during latest Maastrichtian to earliest Paleocene time as seen in the Qulleq-1 well (Fig. 10, Enclosure 4; Christiansen *et al.* 2001). This event has been recorded in large parts of the areas offshore West Greenland (Chalmers & Pulvertaft 2001) but is only seen as a minor hiatus onshore Nuussuaq, West Greenland (Nøhr-Hansen *et al.* 2002). On parts of the Labrador Shelf the Upper Campanian to Maastrichtian succession is more or less complete.


Ogmund E-72
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
U. Maastrichtian
U. Campanian
Albian–Cenomanian
Aptian–Albian
I. cooksoniae
O. operculata?
Rugubivesiculites spp.
Q. dictyophorum
N. davisii
L. arcticum
C. aceras
I. cooksoniae
H. quasicribrata
H. heteracanthum
A. acutulum
S. obscurum
T. suspectum
P. infusorioides
H. sheopiarii
R. reductus
Afropollis sp.
R. rugosus
Q. dictyophorum
N. davisii
Algae ●
Algae ●
Vesperopsis sp.
Skolp E-07
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
U. Maastrichtian
L. Maastrichtian
U. Campanian
P. gralator
C. biapatura
I. cooksoniae
A. acutulum
O. operculata
C. asymmetricum
P. gralator
W. spinata
I. majae, D. galeata
C. biapertura
I. cretaceum
T. quinqueangulare
H. perforata
I. cooksoniae
L. arcticum
A. acutulum
A. minus
H. quasicribrata
C. aceras
S. rotundata, T. castanea
O. operculata, H. heteracanthum
X. wetzelii, Eatonicysta pterococcoides
C. madura, R. fucatum
T. suspectum
C. oceanica
A. cf. haromense, C. grossa
C. asymmetricum
I. acuminatum
C. cf. nyei C. aff. decorosa
S. obscurum
O. costata, W. lunum
B. jaegeri
P. infusorioides
A. varium
C. decorosa
D. longicornis
F. nicosia
O. porosa
X. ceratioides
● Common >25
■ Abundant >50
Last occurrence
First occurrence
Occurrence
Qulleq-1
1800
1900
2000
2100
A. varium
C. asymmetricum, H. heteracanthum
L. arcticum, O. costata
T. castanea, T. suspectum
X. alatum
F. nicosia, O. porifera
P. infusorioides
A. cf. haromense, C. aceras
Dinocyst sp. E. Ioannides 1986
I. acuminatum
P. pyrophorum ■
C. bondarenkoi
C. whitei
A. acutulum
I. microarmum
Dinocyst sp. E. Ioannides 1986 ■

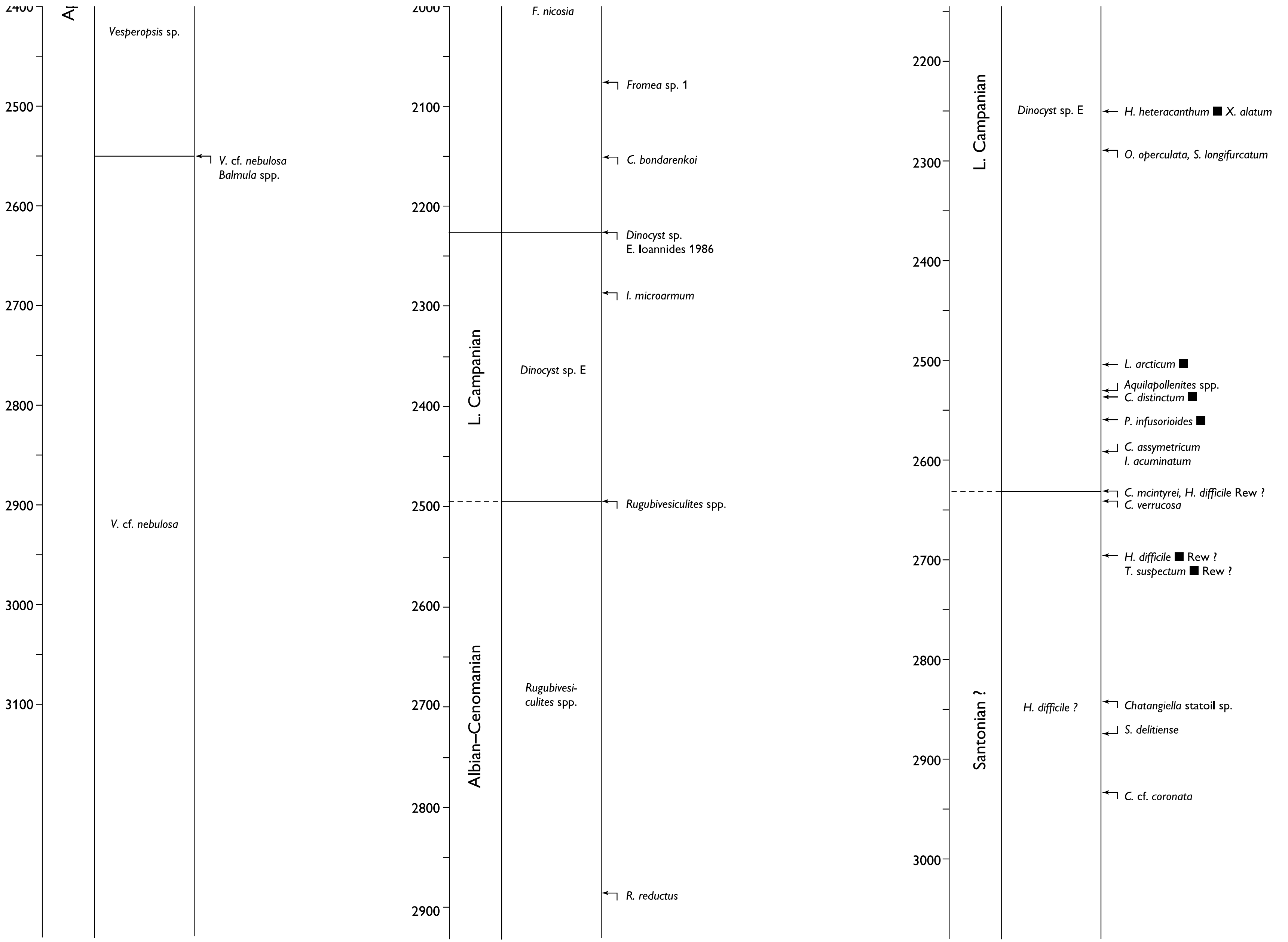
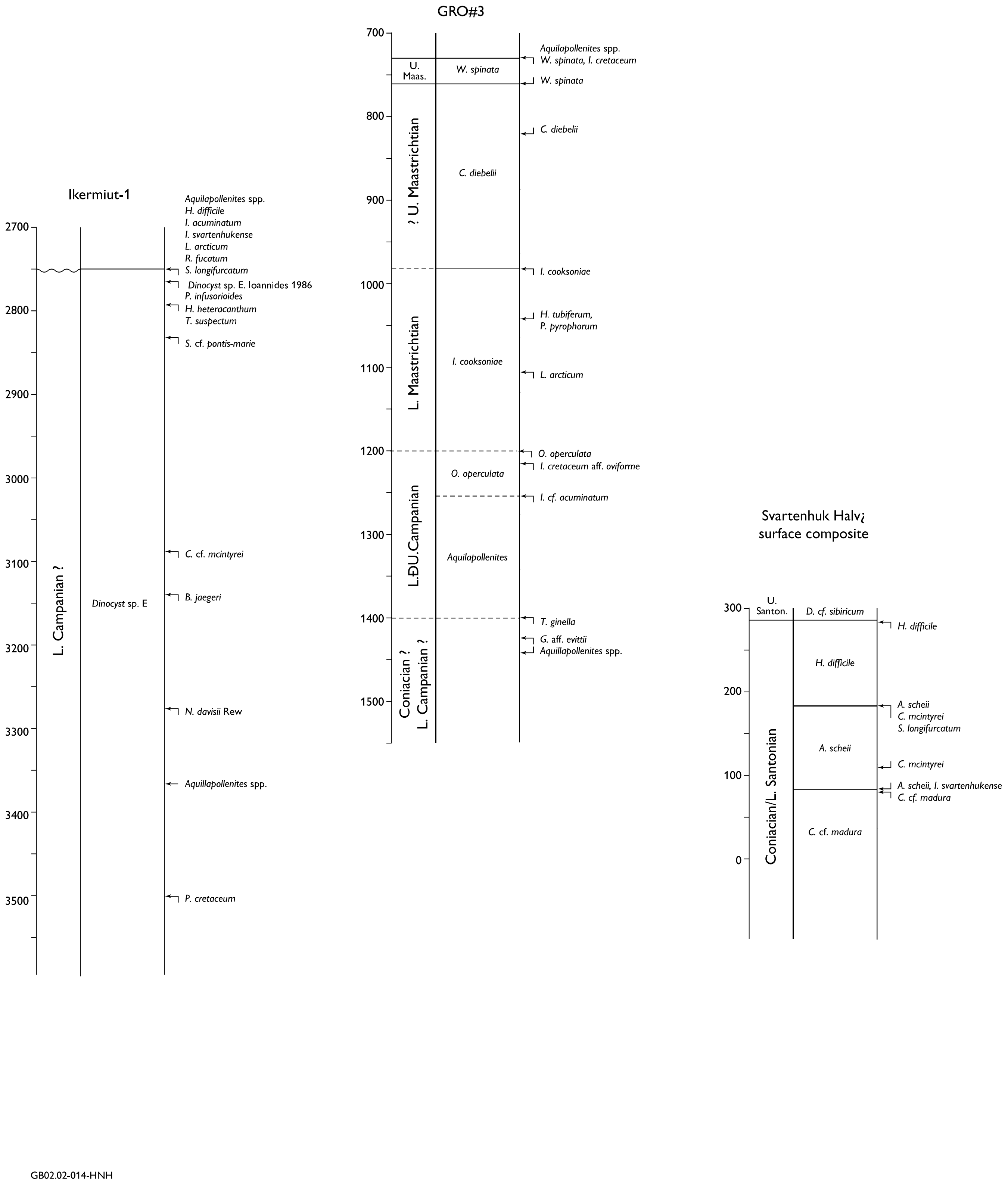


Fig. 7. Cretaceous palynological intervals and bioevents for the Ogmund E-72, Skolp E-07 and Qulleq-1 wells, offshore Eastern Canada and West Greenland. The stratigraphy is based on last appearance datum events, first appearance datum events and abundances of stratigraphically important species. Depth scales in metres.



In contrast to the onshore deposits on Nuussuaq in West Greenland, the Lower Paleocene (P1–P2, Danian) succession is generally thin or absent in the offshore Canadian and Greenland wells (Fig. 10; Nøhr-Hansen *et al.* 2002). The $^{40}Ar/^{39}Ar$ dating of the basaltic rocks overlying the Danian on Nuussuaq shows that the volcanism commenced in West Greenland between 60.9 and 61.3 Ma and that ~80% of the Paleocene lava pile was erupted in 1 million years or less (Storey *et al.* 1998). This compares well with ages on basalts in the Gjoa G-37

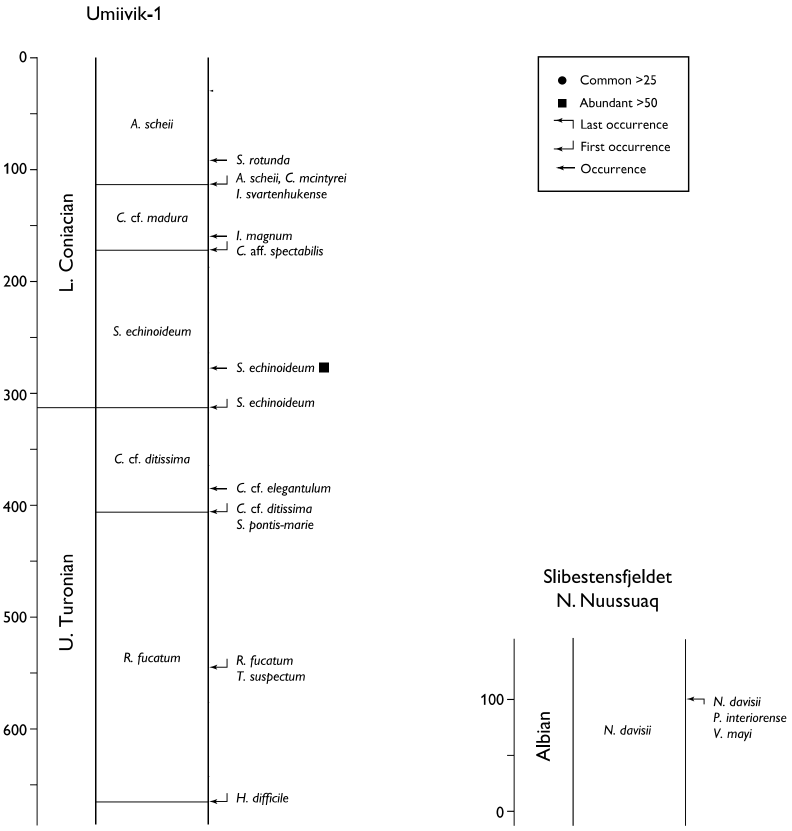


Fig. 8. Cretaceous palynological intervals and bioevents for the on- and offshore wells, and surface sections in West Greenland. The stratigraphy is based on last appearance datum events, first appearance datum events and abundances of stratigraphically important species. Depth scales in metres.

well where two samples of basaltic rock have yielded 57.9 ± 2.9 Ma and 60.4 ± 1.7 Ma, respectively (Williamson *et al.* 2003). The Upper Paleocene is absent on Nuussuaq, whereas it is well represented in the Ikermiut-1 well and between the basalts in the lower part of the Gjoa G-37 and Hekja O-71 wells.

Preliminary palynological zonation of the Cretaceous

Maastrichtian

Maastrichtian successions have been recorded from the Ogmund E-72, Skolp E-07 and GRO#3 wells and from outcrop sections on Nuussuaq (Figs 7, 8). Three Upper Maastrichian and one Lower Maastrichtian intervals are proposed (Fig. 5).

The top of the uppermost *Palynodinium grallator* interval is characterised by the LAD of *Palynodinium grallator* and *Wodehouseia spinata*, whereas *Isabelidinium majae* has its LAD in the middle part of the interval. From the Danish North Sea Schiøler & Wilson (1993) also recognised the FAD of *P. grallator* in the uppermost Maastrichtian *Palynodinium grallator* Zone of Hansen (1977) whereas they only recorded *I. majae* from Hansen's (1977) *Tanyosphaeridium magdalinium* Subzone (lower part of the *P. grallator* Zone).

> *Discussion*: Interval IV of the GRO#3 well (Enclosure 6), which Nøhr-Hansen (1997a) correlated with the *Wodehouseia spinata* interval of Nøhr-Hansen (1996), may be correlated with the *Palynodinium grallator* interval based on the LAD of *Wodehouseia spinata* which is seen in all three intervals.

The top of the Upper Maastrichtian *Chatangiella biapatura* interval is characterised by the LAD of *Chatangiella biapatura* and *Trithyrodinium quinqueangulare*. McIntyre (1975) described *C. biapatura* from the Upper Maastrichtian from the district of Mackenzie N.W.T., Canada.

> *Discussion*: The stratigraphic position of the *Chatangiella biapatura* interval of this study suggests that it correlates with interval V of the GRO#3 well, which Nøhr-Hansen (1997a) correlated with the *Cerodinium diebelii* interval of Nøhr-Hansen (1996).

The top of the Upper–Lower Maastrictian *Isabelidinium cooksoniae* interval is characterised by the LAD of *Hystrichosphaeropsis perforata* and *I. cooksoniae*, whereas *Laciniadinium arcticum* has its LAD in the upper part of the interval. Schiøler & Wilson (1993) also recognised the FAD of *H. perforata* in their lower Upper Maastrichtian *I. cooksoniae* Interval Zone from the North Sea.

> *Discussion*: Nøhr-Hansen (1997a) correlated interval VI of the GRO#3 well with the Upper Campanian *Isabelidinium cooksoniae* interval of Nøhr-Hansen (1996). The *Isabelidinium cooksoniae* interval was, however, not defined on the LAD of *I. cooksoniae* but on the abundance of the species. A re-study of the data from interval VI in GRO#3 suggests that the upper part (980–1170 m) of interval VI correlates with the Upper Maastrichtian *Isabelidinium cooksoniae* interval of this study based on the LAD of *I. cooksoniae* at 980 m and the LAD of *Laciniadinium arcticum* at 1110 m in GRO#3. It is therefore suggested that the Upper Campanian *Isabelidinium cooksoniae* interval of Nøhr-Hansen (1996) is replaced by the Upper Campanian *Odontochitina operculata* interval of this study since an LAD of *Odontochitina operculata*

> is also recognised at the top of the *Isabelidinium cooksoniae* interval in the Kangilia section on northern Nuussuaq (see below).

The top of the Lower Maastrichtian *Alterbidinium acutulum* interval is characterised by the LAD of *A. acutulum*, whereas *Hystrichosphaeropsis quasicribrata* and *Caligodinium aceras* have their LAD in the middle part of the interval. Schiøler & Wilson (1993) also recognised the FAD of *A. acutulum* in their Lower Maastrichtian *Alterbidinium acutulum* Interval Zone from the North Sea.

Campanian

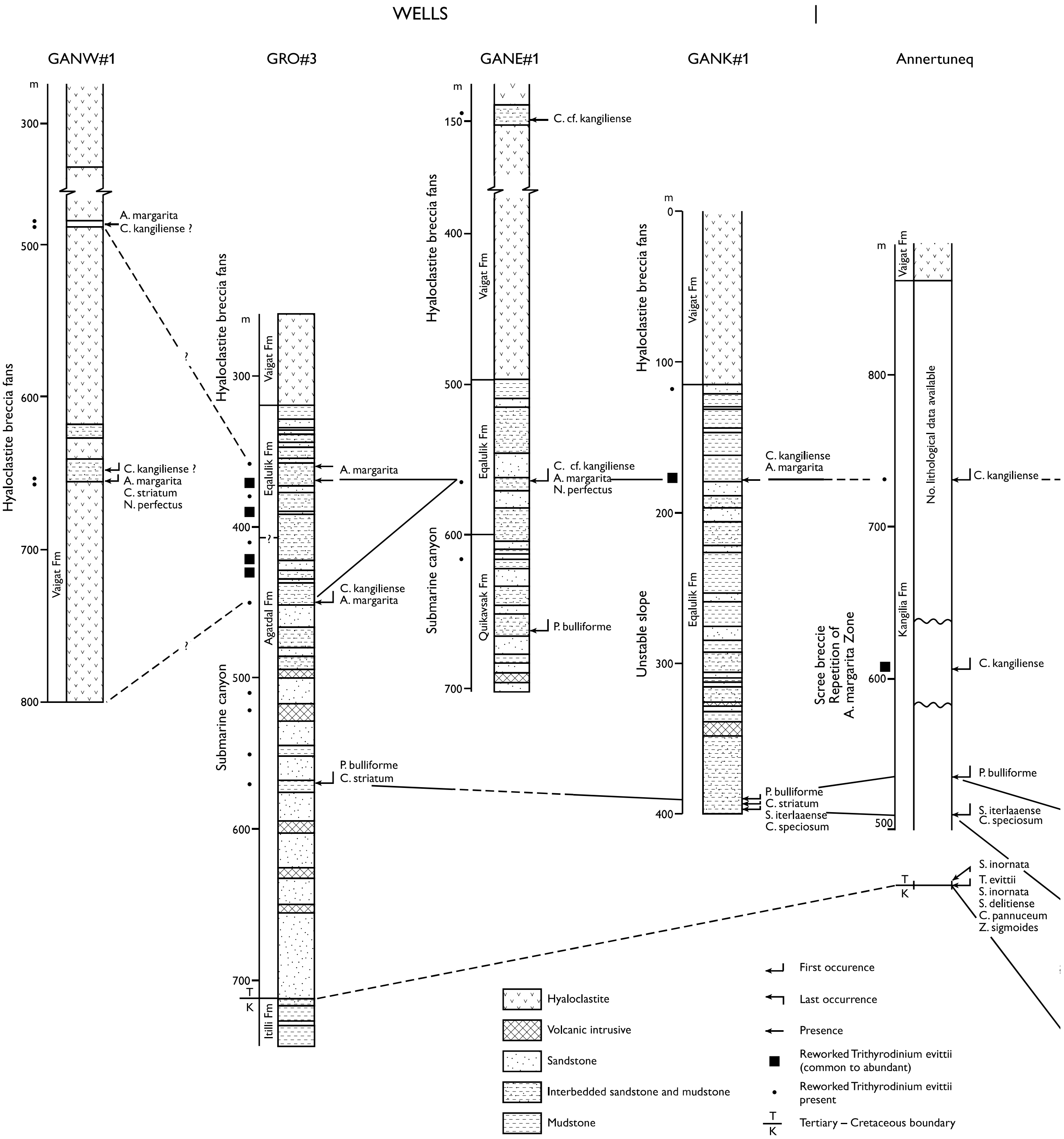
Campanian successions have been recorded from the Ogmund E-72, Skolp E-07, Qulleq-1 and GRO# 3 wells and from outcrop sections on Nuussuaq and possibly from the Ikermiut-1 well (Figs 7, 8; see discussion below). Three Upper to mid-Campanian and one Lower Campanian intervals are proposed (Fig. 5).

The upper part of the uppermost Campanian *Odontochitina operculata* interval is characterised by the LAD of *Heterosphaeridium heteracanthum*, *Odontochitina operculata*, *Senoniasphaera rotundata* and *Trichodinium castanea*, followed by the LADs of *Xenascus wetzellii*, *Eatonicysta pterococcoides*, *Raphidodinium fucatum* and *Trithyrodinium suspectum* in the middle to lower part of the interval. According to Schiøler & Wilson (2001) the last occurrence of the genera *Odontochitina* may be a good uppermost Campanian marker. Slimani (1996) described *Xenascus wetzellii* from Lower to Upper Campanian strata in Belgium and the Netherlands.

> *Discussion*: Nøhr-Hansen (1997a) correlated interval VI from GRO#3 with the Late Campanian *Isabelidinium cooksoniae* interval of Nøhr-Hansen (1996). A re-study of this interval suggests that the middle part of interval VI (1200–1250 m) correlates with the Upper Campanian *Odontochitina operculata* interval of this study based on the LAD of *Odontochitina operculata* in the top of the interval (1200 m) in the GRO#3 well (Fig. 8). As noted above it is suggested that the Upper Campanian *Isabelidinium cooksoniae* interval of Nøhr-Hansen (1996) is replaced by the Upper Campanian *Odontochitina operculata* interval of this study.

The top of the Upper to mid-Campanian *Callaiosphaeridium asymmetricum* interval is characterised by the LAD of *Atopodinium* cf. *haromense*, *Callaiosphaeridium asymmetricum*, *Chlamydophorella grossa*, *Chlamydophorella* cf. *nyei* and *Cometodinium whitei*. These are followed by the LADs of *Scriniodinium obscurum*, *Odontichitina costata*, *Wallodinium lunum*, *Batioladinium jaegeri*, *Palaeohystrichophora infusorioides*, *Alterbidinium varium* and *Chatangiella decorosa* in the middle to lower part of the interval. The LAD of *Callaiosphaeridium asymmetricum* is an intra-Campanian event close to the Lower–Upper Campanian boundary according to Costa & Davey (1992).

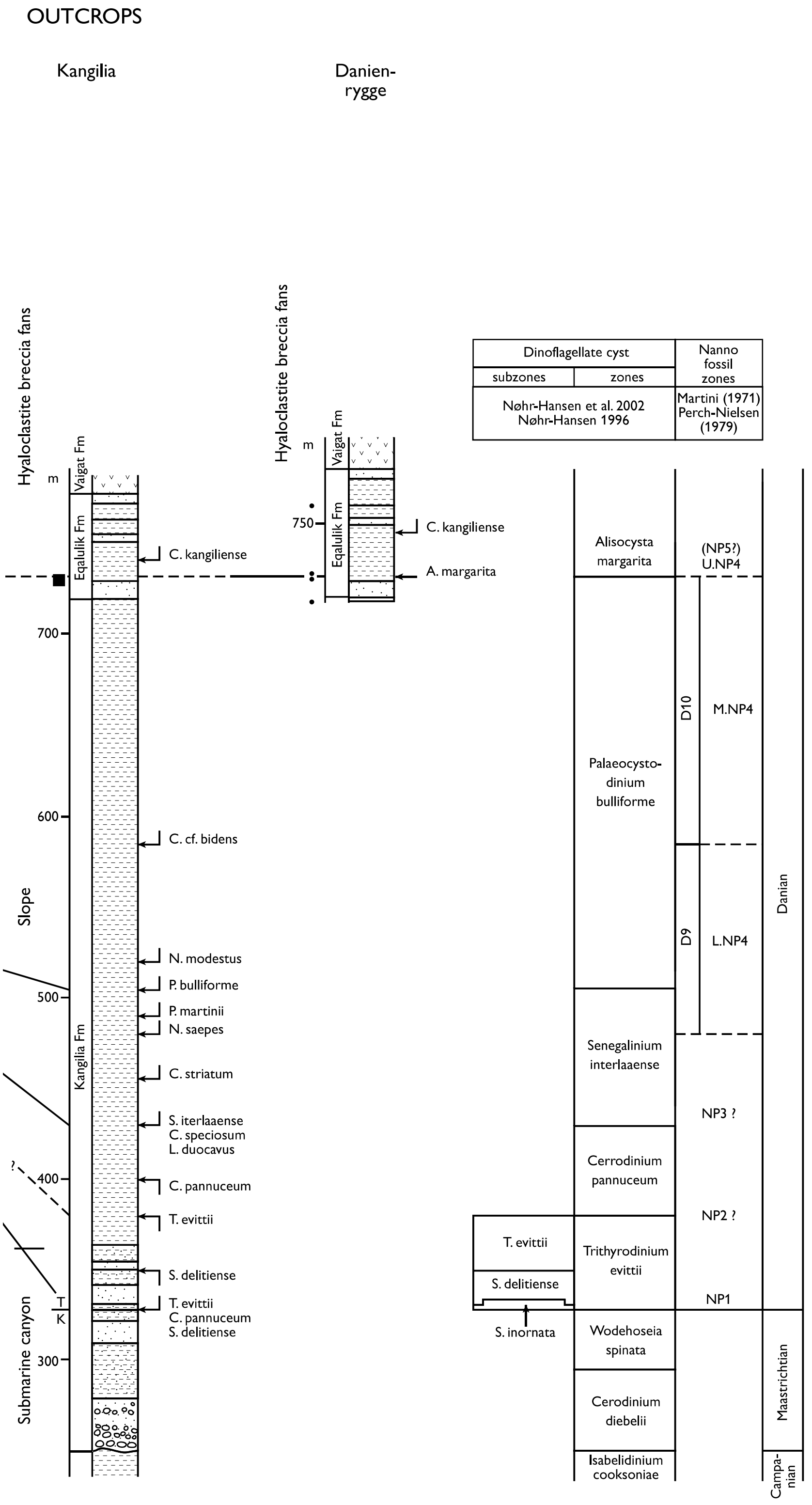
The top of the mid- or Lower Campanian *Fromea nicosia* interval is characterised by the LAD of *F. nicosia* and *Dinogymnium longicornis*, followed by the LADs of *Odontochitina porifera*, *Xenascus ceratioides*, *Fromea* sp. 1 and *Chatangiella bondarenkoi* in the middle to lower part



of the interval. Nøhr-Hansen (1996) recorded *C. bondarenkoi* from the Lower or mid-Campanian on West Greenland; Lentin & Vozzhennikova (1990) recorded the species from the Santonian to Campanian of Arctic Canada.

The top of the Lower Campanian Dinocyst sp. E. Ioannides 1986 interval is characterised by the LAD of Dinocyst sp. E. Ioannides 1986, followed by the LAD of *Isabellidinium micro-*

Fig. 9. Biostratigraphic correlation, dating and lithostratigraphy of the studied Palaeogene outcrops sections and wells from Nuussuaq, West Greenland, based on dinoflagellate cysts and nannofossils (figure 4 in Nøhr-Hansen *et al.* 2002).



armum in the middle part of the interval. Ioannides (1986) recorded his Dinocyst sp. E. from a possible Maastrichtian interval situated between a Santonian–Campanian interval and a Maastrichtian interval on Bylot Island, Canada. Dinocyst sp. E. Ioannides 1986 has its LAD in the Lower Campanian and *Isabellidinium microarmanum* has its LAD in the lowermost Lower Campanian according to B. Tocher (personal communication 2000).

Discussion: Parts of the Lower to mid-Campanian *Aquilapollenites* interval of Nøhr-Hansen (1996) may be correlated with the Lower Campanian Dinocyst sp. E. Ioannides 1986 interval of this study based on the LAD of *Isabellidinium microarmum* seen in the top of the *Aquilapollenites* interval on Nuussuaq (Nøhr-Hansen 1996). Nøhr-Hansen (1997a) correlated the lower part of interval VI from GRO#3 (1250–1400 m) with the Lower to mid-Campanian *Aquilapollenites* interval of Nøhr-Hansen (1996) based on the presence of *Aquilapollenites* spp. (Fig. 8); however, the palynological assemblage in the GRO#3 well is of low diversity and poorly preserved due to thermal alteration.

Santonian–Coniacian

Five Santonian to Coniacian intervals have been described based on outcrop sections and the stratigraphical well Umiivik-1 onshore Svartenhuk Halvø, West Greenland (Fig. 5, Enclosure 7; Nøhr-Hansen 1996, 1997b). Marine Coniacian to Santonian successions may – if not reworked – be recognised in the lower part of Qulleq-1 well (Fig. 7).

The base of the Upper Santonian or Lower Campanian *Dinogymnium* cf. *sibiricum* interval of Nøhr-Hansen (1996) is defined by the LAD of *Heterosphaeridium difficile* and the top by the LAD of *Dinogymnium* cf. *sibiricum*. *Dinogymnium sibiricum* has a Coniacian to Lower Santonian range according to Costa & Davey (1992), whereas McIntyre (1974) reported an Upper Santonian to Upper Campanian range for the almost identical species *Dinogymnium* cf. *sibiricum*. The absence of *Heterosphaeridium difficile* and the presence of *Spinidinium echinoideum* suggest a Late Santonian to Early Campanian age.

The top of the Coniacian to Lower Santonian *Heterosphaeridium difficile* interval of Nøhr-Hansen (1996) is defined by the LAD of *Heterosphaeridium difficile*. The interval is characterised by a poorly preserved, low diversity palynomorph assemblage. The frequency of *Chatangiella* specimens is very low but species such as *Chatangiella* cf. *ditissima*, *Heterosphaeridium difficile*, *Laciniadinium arcticum*, *Odontochitina striatoperforata*, *Palaeohystrichophora infusorioides* and *Spinidinium echinoideum* are present throughout the interval, whereas *Surculosphaeridium longifurcatum* has its LAD in the lowermost part of the interval. The last occurrences of *Heterosphaeridium difficile* and *Surculosphaeridium longifurcatum* indicate an age not younger than Early Santonian in agreement with the range given by Costa & Davey (1992). Based on the last occurrence of *H. difficile*, the interval may be correlated with the lower part of the Upper Coniacian to Lower Campanian Zone 3 described from the Kanguk Formation in Arctic Canada by Núñez-Betelu (1994).

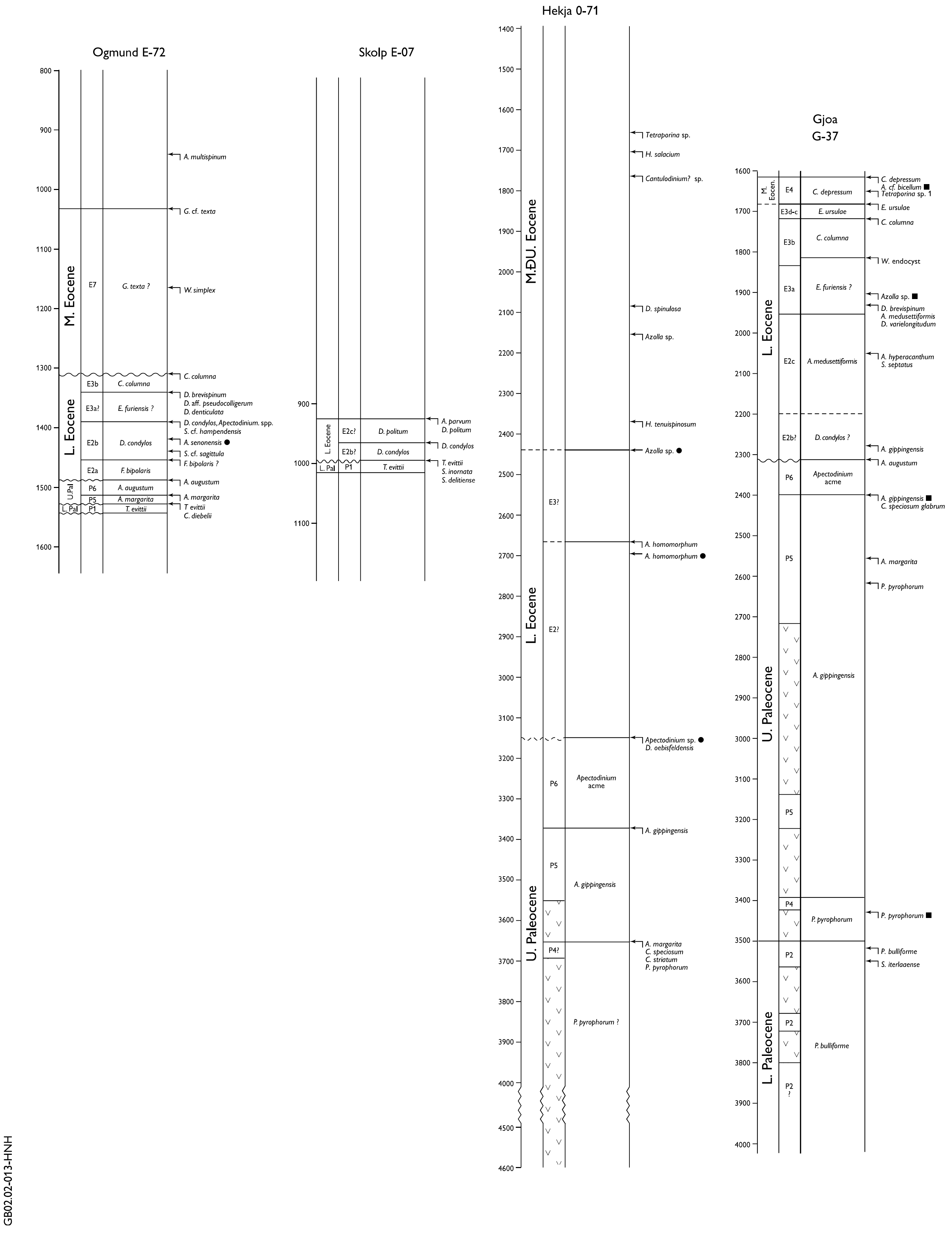
Nøhr-Hansen (1996) proposed a *Laciniadinium arcticum* interval of Early Coniacian age. The base of this interval was defined by the FAD of *Laciniadinium arcticum* and the top by the LAD of *Arvalidinium scheii*. The FAD of *Laciniadinium arcticum* was later recorded from much older sediments in the Umiivik-1 (Fig. 8; Nøhr-Hansen 1997b). It is therefore suggested that the *Laciniadinium arcticum* interval of Nøhr-Hansen (1996) is withdrawn and that the succession is included in an extended *Arvalidinium scheii* interval (see below).

The *Arvalidinium scheii* interval has been dated as Early Coniacian since it has been recorded below *in situ* ammonites of Early Coniacian age in the core hole GGU 400712 (Nøhr-Hansen 1996). The base of the interval was defined by the first occurrence of *Arvalidinium scheii* and *Isabelidinium svartenhukense* and the top was immediately below the FAD of *Laciniadinium arcticum*. As mentioned above, this definition is no longer valid and it is therefore suggested that the *Arvalidinium scheii* interval ranges from the LAD of *Arvalidinium scheii* to the FAD of *Arvalidinium scheii*, which expands the upper part of the *Arvalidinium scheii* interval of Nøhr-Hansen (1996) with the *Laciniadinium arcticum* interval of Nøhr-Hansen (1996). The interval is characterised by the presence of abundant *Arvalidinium* and *Chatangiella* specimens and common *Odontochitina striatoperforata*. The interval is also characterised by the incoming of the species *Chatangiella mcintyrei*, *Isabelidinium svartenhukense* and *Palaeotetradinium silicorum*.

> *Discussion*: Manum (1963) described *Arvalidinium scheii* (as *Deflandrea scheii*) from Graham Island, Arctic Canada. The dinoflagellate cyst assemblage reported by Manum & Cookson (1964) from Graham Island is quite similar to the assemblage recorded from the *A. scheii* interval on Svartenhuk Halvø. Manum (1963) and Manum & Cookson (1964) indicated that the samples were collected from the Upper Albian – Lower Cenomanian Hassel Formation, but Felix & Burbridge (1976) have argued that it is more likely that Manum's samples are from the Kanguk Formation of Late Cenomanian to Early Campanian age. Núñez-Betelu (1994) described some forms resembling *A. scheii*, from the base of his Upper Coniacian to Lower Campanian Zone 3; the level is dated Late Coniacian by the presence of the ammonite *Scaphites depressus* (Hills *et al.* 1994).

Nøhr-Hansen (1996) has proposed a Coniacian *Spinidinium echinoideum* interval. The base of this interval was defined by the FAD of *Spinidinium echinoideum* and the top was immediately below the FAD of *Arvalidinium scheii*. However, the FAD of *Spinidinium echinoideum* has later been recorded from much older sediments in the Umiivik-1 well (Fig. 8; Nøhr-Hansen 1997b) and it is therefore suggested here that the use of the *Spinidinium echinoideum* interval is withdrawn and that the succession is included in an extended *Chatangiella* cf. *madura* interval (see below).

The *Chatangiella* cf. *madura* interval is described as Coniacian but a Late Turonian or Early Santonian age can not be excluded (Nøhr-Hansen 1996). The interval was originally characterised by the occurrence of *Chatangiella* cf. *madura*, its upper limit being the FAD of *Spinidinium echinoideum*. As mentioned above, this definition is no longer valid and it is therefore suggested that the top of the *Chatangiella* cf. *madura* interval is now defined by the LAD of *Chatangiella* cf. *madura* immediately below the FAD of *Arvalidinium scheii*, which expands the upper part of the *Chatangiella* cf. *madura* interval of Nøhr-Hansen (1996) with the *Spinidinium echinoideum* interval of Nøhr-Hansen (1996). The genera *Chatangiella*, *Isabelidinium* and *Heterosphaeridium* dominate the assemblages and the following stratigraphically important species have been recorded: *Chatangiella* cf. *madura*, *Chatangiella* aff. *spectabilis*, *Florentinia* aff. *deanei*, *Heterosphaeridium difficile*, *Spinidinium echinoideum Surculosphaeridium? longifurcatum*, and *Trigonopyxidia ginella*. Furthermore, the stratigraphically important species *Isabelidinium magnum* is recorded from the middle part of the interval in the Umiivik-1 well (Fig. 8; Nøhr-Hansen 1997b). The absence of species with a last occurrence in the Turonian suggests that this interval may be of Coniacian age.


Ogmund E-72
800
900
1000
1100
1200
1300
1400
1500
1600
M. Eocene
L. Eocene
U.Pal
L. Pal
E7
E3b
E3a?
E2b
E2a
P6
P5
P1
G. texta ?
C. columna
E. furiensis ?
D. condylos
F. bipolaris
A. augustum
A. margarita
T. evittii
A. multispinum
G. cf. texta
W. simplex
C. columna
D. brevispinum
D. aff. pseudocolligerum
D. denticulata
D. condylos, Apectodinium. spp.
S. cf. hampendensis
A. senonensis ●
S. cf. sagittula
F. bipolaris ?
A. augustum
A. margarita
T evittii
C. diebelii
Skolp E-07
900
1000
1100
L. Eocene
L. Pal
E2c?
E2b?
P1
D. politum
D. condylos
T. evittii
A. parvum
D. politum
D. condylos
T. evittii
S. inornata
S. delitiense
Hekja 0-71
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
4000
4500
4600
M.ÐU. Eocene
L. Eocene
U. Paleocene
E3?
E2?
P6
P5
P4?
Apectodinium acme
A. gippingensis
P. pyrophorum ?
Tetraporina sp.
H. salacium
Cantulodinium? sp.
D. spinulosa
Azolla sp.
H. tenuispinosum
Azolla sp. ●
A. homomorphum
A. homomorphum ●
Apectodinium sp. ●
D. oebisfeldensis
A. gippingensis
A. margarita
C. speciosum
C. striatum
P. pyrophorum
Gjoa
G-37
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
4000
M. Eocen.
L. Eocene
U. Paleocene
L. Paleocene
E4
E3d-c
E3b
E3a
E2c
E2b?
P6
P5
P5
P4
P2
P2
P2 ?
C. depressum
E. ursulae
C. columna
E. furiensis ?
A. medusettiformis
D. condylos ?
Apectodinium acme
A. gippingensis
P. pyrophorum
P. bulliforme
C. depressum
A. cf. bicellum ■
Tetraporina sp. 1
E. ursulae
C. columna
W. endocyst
Azolla sp. ■
D. brevispinum
A. medusettiformis
D. varielongitudum
A. hyperacanthum
S. septatus
A. gippingensis
A. augustum
A. gippingensis ■
C. speciosum glabrum
A. margarita
P. pyrophorum
P. pyrophorum ■
P. bulliforme
S. iterlaaense
GB02.02-013-HNH

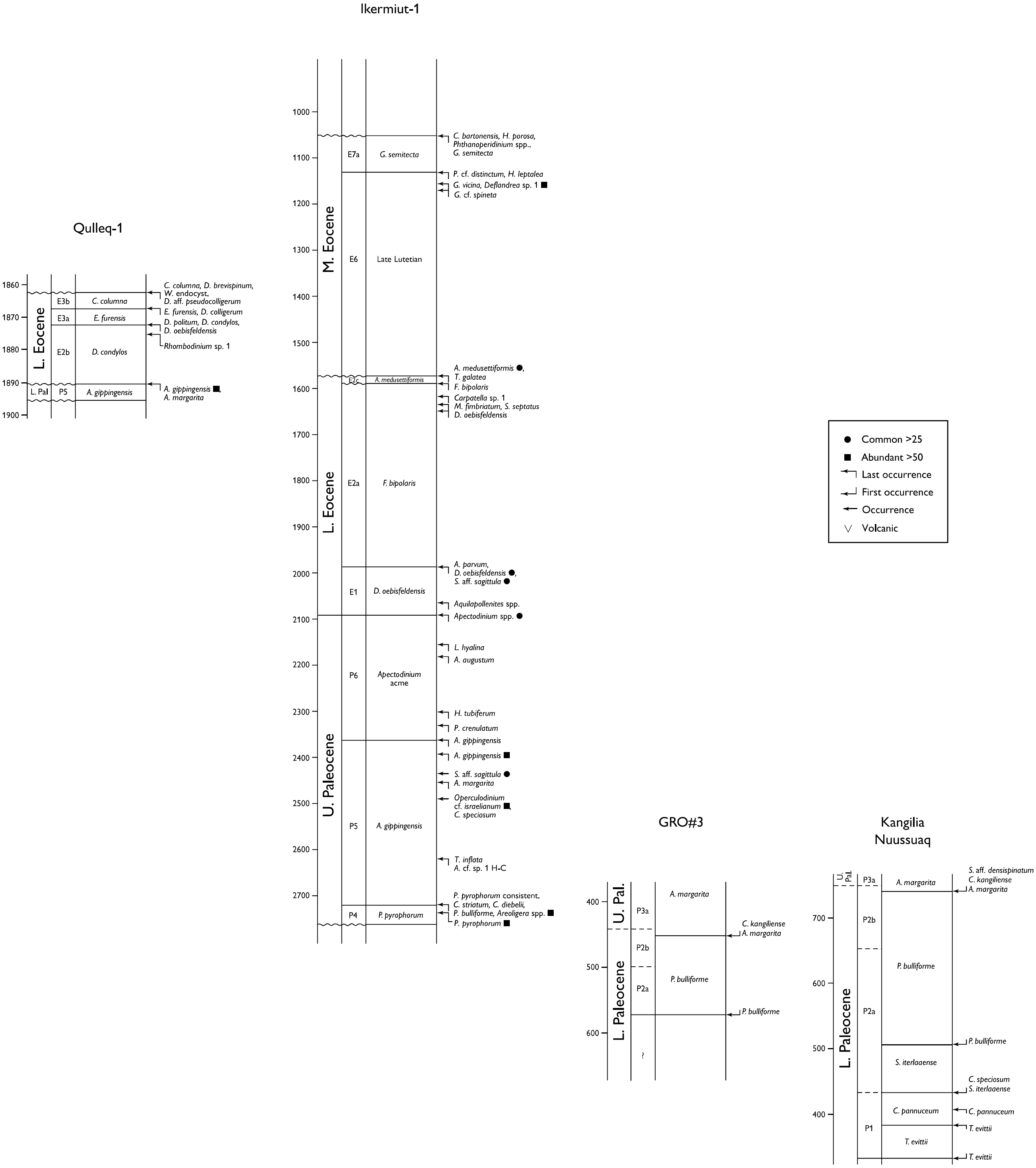


Fig. 10. Palaeogene palynological intervals and bioevents for the on- and offshore wells Eastern Canada and West Greenland correlated with the dinocyst zonations of Bujak & Mudge (1994) and Mudge & Bujak (1996a, b). The stratigraphy is based on last appearance datum, first appearance datum events and abundances of stratigraphically important species. Depth scales in metres.

> *Discussion*: According to the observations by Costa & Davey (1992) from the North Sea region, the presence of *Heterosphaeridium difficile* and *Surculosphaeridium? longifurcatum* throughout the interval indicates an age not younger than Early Santonian. *Florentinia deanei* and *Isabelidinium magnum* has its last occurrence in the latest Coniacian in Europe (Foucher 1979; Costa & Davey 1992). *Chatangiella madura* is described by Cookson & Eisenack (1970) from the Senonian (Upper Cretaceous) of Australia. Ioannides (1986) recorded *C. madura* from the lower part of his Santonian–Campanian palynological interval I on Bylot Island, Arctic Canada. Núñez-Betelu (1994) recorded the species from his Zone 2 (Upper Turonian to Upper Coniacian) and Zone 3 (Upper Coniacian to Lower Campanian) at Glacier Fiord, Arctic Canada. Kirsch (1991) reported *C. madura* from the lower part of his Coniacian to Santonian *Raetiaedinium truncigerum* Zone and from his Campanian *Areoligera coronata* Zone in Oberbayern, Germany.

Coniacian – Turonian

The *Spinidinium echinoideum* interval was described as interval III from the Umiivik-1 well (Nøhr-Hansen 1997b) and dated as ?Early Coniacian to latest Turonian (Fig. 8). The lower boundary of the interval is placed at the FAD of *Spinidinium echinoideum.* The species *Heterosphaeridium difficile* and *Circulodinium distinctum* are common in the upper part of the interval. *Spinidinium echinoideum* has an acme within the lower part of the interval, whereas *Raphidodinium fucatum* has an acme in the upper part. According to observations from the Paris Basin, France (Foucher 1979) the presence of *Raphidodinium fucatum* and *Spinidinium echinoideum* suggests an age not older than latest Turonian. The interval thus comprises deposits of latest Turonian to ?Early Coniacian age.

The *Chatangiella* cf. *ditissima* interval was described as interval IV from the Umiivik-1 well (Fig. 8; Nøhr-Hansen 1997b) and dated as Late Turonian. The lower boundary of the interval is placed by the incoming of *Subtilisphaera pontis-mariae*, *Chatangiella* cf. *ditissima* and *Isabelidinium* sp. nov. The species *Heterosphaeridium difficile*, and *Isabelidinium* sp. nov. are common in the interval. Within the interval the following stratigraphically important species have been recorded: *Chatangiella* cf. *ditissima, C. granulifera, Ctenidodinium* aff. *elegantulum, Florentinia* sp., *Heterosphaeridium difficile*, *Isabelidinium* sp. nov., *Raphidodinium fucatum*, *Odontochitina striatoperforata*, *Subtilisphaera pontis-mariae, Surculosphaeridium longifurcatum, Tanyosphaeridium* cf. *variecalamus* and *Trithyrodinium suspectum.*

> *Discussion*: According to observations from the Paris Basin, France (Foucher 1979) the presence of *Raphidodinium fucatum* and *Subtilisphaera pontis-mariae* suggest an age not older than Late Turonian. Foucher (1979) recorded the FAD of *Raphidodinium fucatum* and *Spinidinium echinoideum* from the uppermost Turonian and the FAD of *Subtilisphaera pontis-mariae* from the base of Upper Turonian in the Paris Basin. The presence of *Tanyosphaeridium* cf. *variecalamus* and *Raphidodinium fucatum* throughout the interval suggest an age not older than middle Turonian (Costa & Davey 1992).

The *Raphidodinium fucatum* interval was described as interval V from the Umiivik-1 well (Nøhr-Hansen 1997b) and dated as Turonian, possibly Upper Turonian (Fig. 8). The dinoflagellate specimens are all strongly thermally altered and in a poor state of preservation. It has been possible to identify black specimens of *Chatangiella* spp., possible *Heterosphaeridium difficile* and *Trithyrodinium suspectum* which according Costa & Davey (1992) date the interval not older than latest Cenomanian to Early Turonian. A questionable occurrence of *Raphidodinium fucatum* and *Heterosphaeridium difficile* may suggest an age not older than middle Turonian according to Costa & Davey (1992) and not older than latest Turonian according to Foucher (1979). However, the very sparse content of dinoflagellate cysts precludes a more precise dating and definition of the interval.

?Cenomanian to ?Late Albian

A possible Cenomanian to Upper Albian nonmarine succession has been recorded from the Ogmund E-72 and Skolp E-07 wells (Fig. 7).

The upper part of the ?Cenomanian to ?Late Albian *Rugubivesiculites* spp. interval is characterised by the LAD of *Rugubivesiculites rugusus*; within the interval the LAD's of *Ornamentifera baculata* and *Afropollis*? spp. is recorded (Fig. 5). Singh (1983) reported the LAD of *Rugubivesiculites rugusus* and *Ornamentifera baculatus* from the Cenomanian and Late Albian.

> *Discussion:* Williams (1975) proposed an Upper Albian *Rugubivesiculkites rugosus* Assemblage Subzone from wells on the Scotian Shelf and the Grand Banks offshore, eastern Canada. The subzone was characterised by the presence of *Rugubivesiculkites rugosus* and tricolpate pollen.

Albian to ? Aptian

Four brackish-water to nonmarine Albian to ?Aptian intervals are recorded in the Ogmund E-72 well (Fig. 7) one of which is also recognised from surface sections onshore northern Nuussuaq (Fig. 8). The species diversity of these intervals is, however, very low.

The top of the *Quantouendinium dictyophorum* interval is characterised by the LAD of the presumed brackish-water species *Quantouendinium dictyophorum*. Mao *et al.* (1999) described *Q. dictyophorum* from Aptian to Albian brackish-water deposits in China.

The top of the *Nyktericysta davisii* interval is characterised by the LAD of the presumed brackish-water species *Nyktericysta davisii* and the presence of *Quantouendinium dictyophorum*. *N.* davisii has been recorded from upper Middle to lower Upper Albian brackish-water deposits in the Western Interior, USA by Bint (1986) and from mid-Upper Albian successions onshore East and West Greenland, and Arctic Canada by Nøhr-Hansen (1992, 1993) and Nøhr-Hansen & McIntyre (1998).

The top of the *Vesperosis* spp. interval is characterised by the LAD of the presumed brackish-water genera *Vesperopsis* and the presence of *Quantouendinium dictyophorum*. *Ves-*

perosis species are described from Upper Albian brackish-water deposits in the Western Interior by Bint (1986) and the genus *Vesperopsis* has been recorded from Middle and Upper Albian successions onshore East and West Greenland, and Arctic Canada by Nøhr-Hansen (1992) and Nøhr-Hansen & McIntyre (1998).

The top of the *Vesperosis* cf. *nebulosa* interval is characterised by the LAD of the presumed brackish-water genera *Vesperopsis* cf. *nebulosa*, *Balmula* spp. and the presence of *Quantouendinium dictyophorum. Vesperosis nebulosa* and *Balmula* species have been recorded from lower Upper Albian brackish-water deposits in the Western Interior by Bint (1986) and from the Middle and Upper Albian successions onshore East and West Greenland, and Arctic Canada by Nøhr-Hansen (1992) and Nøhr-Hansen & McIntyre (1998).

Discussion of the ages of the Cretaceous successions in Ikermiut-1

The interpretation of the Cretaceous dinocyst stratigraphy in the Ikermiut-1 well is complicated due to a combination of reworking, extensive caving, and the generally poor preservation of the organic material.

Toxwenius (1986) dated the interval 2755–?2814m as ?Maastrichtian based on the presence of a an *Aquillapolenites* spp. from 2755 m (side wall core; SWC) and common *Palynodinium grallator* from three ditch cuttin samples (DCS) at 2763 m, 2814 m, and 2889 m. Nøhr-Hansen (1998) did not recognise any of these species; the dating was therefore based on the records of Santonian marker species such as *Heterosphaeridium difficile* and *Surculosphaeridium longifurcatum*. However, the present study has revealed new data that changes the previous interpretations.

The thirty sidewall cores taken in the Cretaceous interval of the Ikermiut-1 well were processed by Chevron in 1977 and the palynological slides are now held at GEUS. Apart from Cretaceous species, Paleocene species also occur, e.g. *Cerodinium striatum* which has been recorded from 2850 m, 2975 m, 3114 m, 3120 m, 3150 m, 3184 m, 3275m, 3301 m and 3487 m, *A. gippingensis* recorded from 3184 m, 3275 m and 3281 m, and a single specimen of *Alisocysta margarita* from 2850 m. This is interpreted as being the result of remaining drilling mud due to inadequate cleaning of the sidewall cores before processing of the samples.

Caved specimens of the Paleocene species such as *Areoligera* spp., *Glaphyrocysta* spp., *Cerodinium* spp. *Palaeoperidinium* spp. and *Allisocysta* spp. dominate the assemblages in most ditch cutting samples but Upper Cretaceous species are, nevertheless, present in the majority of these samples.

The first sample below the Paleocene in Ikermiut-1 is a sidewall core sample from 2755 m. A re-study of three slides from this sample revealed a single *Aquilapollenites* specimen together with *Heterosphaeridium difficile*, *Surculosphaeridium longifurcatum*, *Raphidodinium fucatum*, *Chatangiella granulifera*, *Isabelidinium acuminatum* and a single *Odontochitina* operculum. In addition, a single specimen may be recognised as *Palaeohystrichophora* *infusorioides* (Fig. 8). The presence of *Aquilapollenites* suggests a maximum age of latest Santonian/earliest Campanian according to Nichols & Sweet (1993). The first downhole appearence (FDA) of *Wallodinium lunum* is recorded at 2760 m (DCS) suggesting an age not younger than Late Campanian.

Toxwenius (1986) reported the Maastrichtian marker species *Palynodinium grallator* as common at 2763 m (DCS). In the present study an effort has been made to try to identify this species; however, the only common chorate specimens found that could be mistaken as *P. gralllator* are some caved *Glaphyrocysta* specimens that also are common in the succession above the Cretaceous. The LAD of reasonably well preserved *P. infusorioides* and the Dinocyst sp. E Ioannides 1986 was recorded at 2772 m (DCS). The new record of Dinocyst sp. E Ioannides 1986 is important, since this species has its LAD below the well documented Upper Campanian succession in Skolp E-07 (Fig. 7), indicating an Early Campanian age for the upper part of the Cretaceous succession in Ikermiut-1 (Fig. 8).

The re-study of the palynomorphs from 2805 m (DCS) revealed a confusing record of a very poorly preserved specimen that may resemble a *Wodehouseia* specimen suggesting a Maastrichtian age which could confirm the dating by Toxwenius (1986). Alternatively, the single record of a *Wodehouseia* specimen could be explained as a result of reworking of Maastrictian strata into the Paleocene – as seen in the Qulleq-1 well (Nøhr-Hansen *et al.* 2000) – followed by caving into the Campanian during drilling. The very poor *Wodehouseia* specimen is the only Maastrichtian marker species that has been recorded from the Ikermiut-1 well.

Aquilapollenites specimens have been recorded in the Cretaceous succession from SWCs at 2755 m, 2835 m, 3366 m and from DCSs at 2784 m and 2976 m (Fig. 8). Possible reworked *Aquilapollenites* specimens have been recorded at 2070 m (SWC) and 2492 m (SWC) in the Palaeogene succession. The presence of Dinocyst sp. E Ioannides 1986 and the presence of the few *Aquilapollenites* spp. suggest an Early Campanian age for the succession below 2755 m; the presence of the Santonian markers species *Heterosphaeridium difficile* and *Surculosphaeridium longifurcatum* is considered to be a result of reworking.

It therefore seems probable that a major unconformity separates the Lower Campanian strata from the Upper Paleocene (Figs 8, 10); this is supported by the maturity trend of the organic material observed in the well (see below).

Microfossils of the Ogmund E-72 and Skolp E-07 wells, Labrador Sea

Jan Audun Rasmussen

A limited number of microfossil samples were examined with the purpose to enhance the stratigraphic resolution of the biostratigraphic zonation of Nøhr-Hansen (this report). The microfossil content, both foraminifera, diatoms and radiolarians, was extremely low, and subsequently three nannofossil slides were prepared to test if this fossil group occurred in greater numbers than microfossils.

Samples and methods

Seventeen microfossil samples were prepared at GEUS during autumn 2002. The samples were wet-sieved, and the 0.063 – 0.5 mm fractions were subsequently separated in heavy liquid (δ=1.8 g/cm^3), which increases the microfossil concentration within the light fraction. Seven samples from Ogmund E-72 and nine samples from Skolp E-07 were investigated for their microfossil content. In addition, three nannofossil samples were prepared from Skolp E-07 by use of the smear slide method as described in Bown & Young (1998). All sample numbers refer to depths in metres measured from the rotary table.

The following samples were analysed.

Ogmund E-72	(7 microfossil samples):	1530 m, 1545 m, 1755 m, 1935 m, 2250 m, 2535 m, 3075 m
Skolp E-07	(9 microfossil samples):	995 m, 1295 m, 1445 m, 1520 m, 1760 m, 2075 m, 2330 m, 2600 m, 2975 m
Skolp E-07	(3 nannofossil samples):	1445 m, 2600 m, 2975 m

Stratigraphy

Microfossils

The number of microfossils was extremely low and many samples were barren. However, siliceous sponge spicules and ovate spheroids of unknown affinity (calcispheres?) are relatively common in Skolp-E07, while coal fragments are common in both wells (Fig. 11). The biostratigraphically non-diagnostic benthic foraminfer *Lenticulina* sp. and a specimen of an indeterminable triserial, calcareous benthic foraminfer was recorded from the uppermost part of Ogmund E-72.

Calcispheres? and sponge spicules are common throughout the Mesozoic succession of Qulleq-1 (Santonian – Early Campanian; Fig. 11); in Skolp E-07 they only occur in small numbers in the upper part of the Mesozoic section of (Late Campanian and Maastrichtian), while they are virtually absent in Ogmund E-72 (Albian, Early Turonian and Late Campanian?). The stratigraphical significance of these fossil groups is not clear with the limited data at hand.

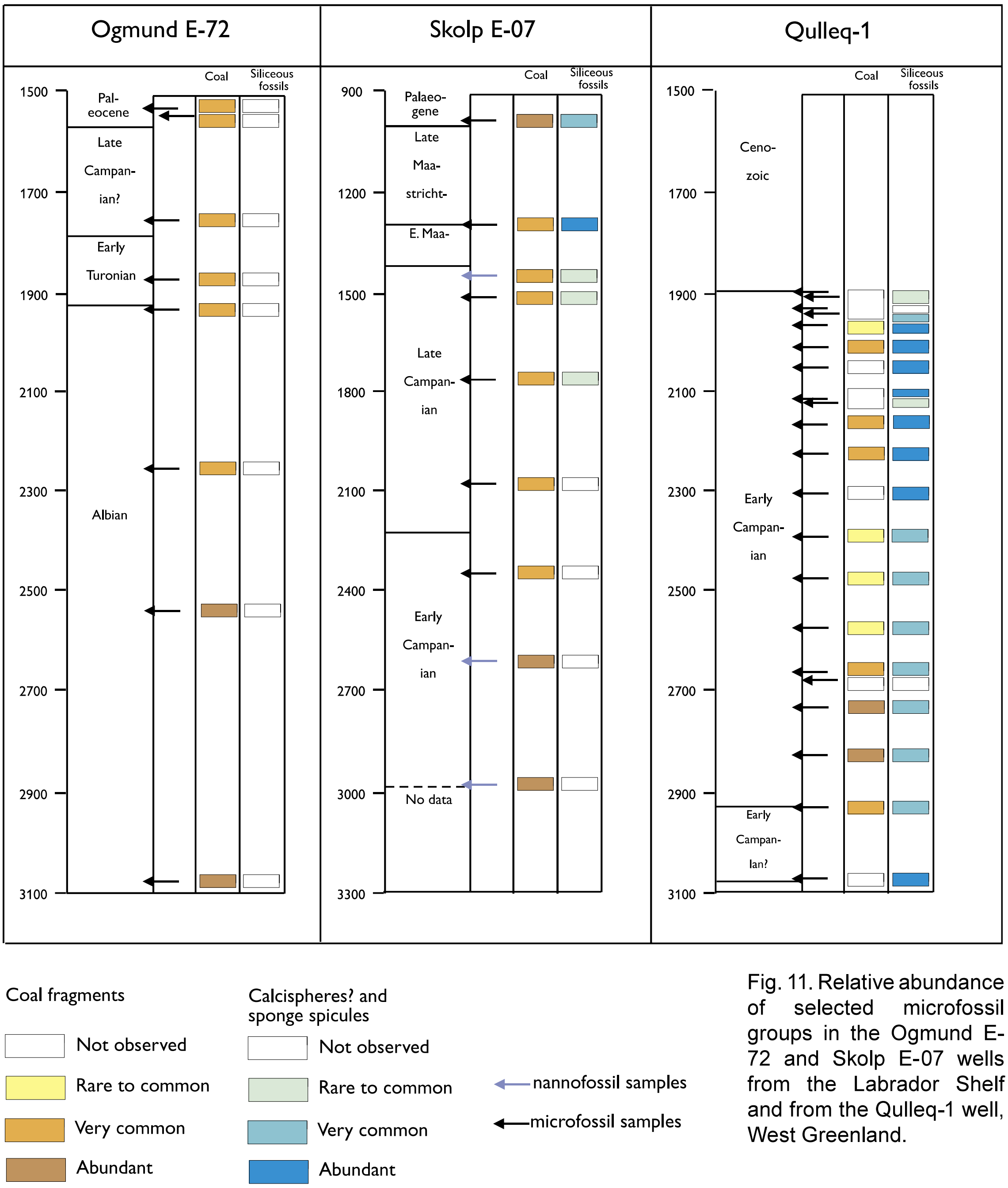


Fig. 11. Relative abundance of selected microfossil groups in the Ogmund E-72 and Skolp E-07 wells from the Labrador Shelf and from the Qulleq-1 well, West Greenland.

Nannofossils

Arkhangelskiella cymbiformis and other Upper Cretaceous nannofossils were found in the sample collected at 2975 m in the Skolp E-07 well indicating a Campanian to Maastricthtian age.The other samples did not contain stratigraphically diagnostic nannofossils.

Depositional setting

It is very difficult to interpret the depositional setting from the very few samples and parameters analysed here. Coal fragments are generally common in the Ogmund and Skolp wells, and this together with the low number of marine microfossils may, however, suggest a near-shore palaeoenvironment, possibly littoral or inner neritic.

Well log correlation

Finn Dalhoff

A correlation of the seven selected exploration wells on the Labrador and South-East Baffin Island shelves and offshore and onshore West Greenland is displayed in Enclosure 9. For location of wells, see Figure 2.

The log correlation is based on biostratigraphic data, and the biostratigraphic events are placed disregarding the log pattern. Digital uncorrected well log data of the four Canadian wells were obtained from the Canadian authorities and are tabulated below. Some of the petrophysical logs are in very bad shape and are in places unreliable or the baseline of the curve is drifting which make it impossible to compare specific lithological values from within the well.

The lithological interpretation of the four Canadian wells is done on information from log data and the Master Log prepared by the mud logger. It is primarily the Gamma Ray curve in combination with the density log curve (RHOB) and the Sonic log (DT) that has been used in the interpretation. The lithological column was calculated using well log characteristics and user-defined baselines (see tables in Appendix 2) combined with the Master Log and are displayed on Enclosure 9 together with the boistratigraphic correlation.

Table 2 : Available geophysidal log data from four Canadian exploration wells

Ogmund E-72

Curve Name	Top Depth	Base Depth	Log Max	Log Min
DT	401.00	3068.60	676.5600	108.6400
GR	397.00	3076.80	408.4950	23.2800
ILD	401.00	3081.00	2235.7844	0.8626
ILM	401.00	3081.00	2107.8022	0.8200
NPHI	401.00	3078.80	0.7596	-0.0052
RHOB	401.00	3082.60	2.6390	1.2092
SFLU	401.00	3081.00	1500.4789	0.2030
SP	401.00	3070.60	280.3600	-38.5800
CAX	401.00	3082.60	777.3500	303.5250

Skolp E-07

Curve Name	Top Depth	Base Depth	Log Max	Log Min
CALI	505.00	2982.00	422.1250	166.6500
GR	169.00	2982.00	118.7500	7.5000
ILD	505.00	2989.00	39.8685	0.9467
ILM	505.00	2989.00	2336.8447	0.9329
RHOB	505.00	2982.00	2.7020	1.0959
SP	509.00	2989.00	0.3200	-88.4300

Hekja O-71

Curve Name	Top Depth	Base Depth	Log Max	Log Min
DT	721.00	4527.40	294.9733	45.8175
GR	368.00	721.00	20.8650	4.8450
ILD	711.00	3613.00	1904.7146	0.6948
ILM	721.00	3613.00	1438.2352	0.7103
NPHI	3253.00	4527.20	0.5644	-0.0373
RHOB	722.00	4530.00	3.0085	1.3980
SFLU	721.00	3613.00	2088.4780	0.2067
SP	711.00	3613.00	-0.8900	-113.5800
NPSS	750.00	3253.00	0.7223	0.0614
GR1	722.20	4523.60	87.1200	4.1250

Gjoa G-37

Curve Name	Top Depth	Base Depth	Log Max	Log Min
DT	1402.20	3984.00	206.3190	50.4681
GR	970.00	3984.00	88.5271	5.4756
ILD	1404.00	3991.80	1993.0481	0.8616
ILM	1404.00	3991.80	2080.8640	0.8277
RHOB	1852.60	3995.00	2.9415	1.5379
SFLU	1404.00	3991.80	292.3303	0.4705
SP	1404.00	3991.80	-3.0182	-60.1275
NPSS	1857.80	3991.00	0.6441	-0.0261

Geochemical data – source rock evaluation

Jørgen A. Bojesen-Koefoed and *Martin Sønderholm*

Introduction

Although source rock intervals have only been drilled in a few wells in the northern Labrador Sea – Baffin Bay region, both direct and indirect evidence of their presence exist from seeping oil in West Greenland and from Canadian discovery wells.

On the Labrador Shelf two source rock sequences have been reported: (1) a Lower Cretaceous lignite and coal-bearing succession (Bjarni Formation), and (2) Upper Cretaceous – Paleocene organic rich mudstones (Fig. 3, Markland Formation; Bell & Campbell 1990). The Bjarni Formation lignites and coals have only been encountered in seven wells; in Skolp E-07 lignite beds account for 30–50 m of the Lower Cretaceous succession (Bell & Campbell 1990). However, this postulated source rock interval could not be confirmed in the Skolp E-07 and Ogmund E-72 wells analysed by GEUS and reported on below (for further details, see Bojesen-Koefoed 2002, Appendix 4). The Markland Formation contains mainly terrestrial organic matter (Balkwill *et al.* 1990; Bell & Campbell 1990), but Bujak *et al.* 1977a, b) have recorded high contents of amorphous kerogen. Nor could this source rock interval be confirmed in the wells mentioned above.

In the Davis Strait it is suggested that the gas and condensate pool at Hekja 0-71 was sourced by Paleocene shales both overlying and underlying the reservoir section in the well (Klose *et al.* 1982). Although some source rock potential of these intervals in the Hekja O-71 well has been documented by the GEUS analyses, they are also shown to be thermally immature, and it is therefore unlikely that they are the actual source for the hydrocarbons found in the well.

In West Greenland, several source rocks have been inferred on the basis of geochemical analysis of onshore oil seeps in the Disko – Nuussuaq – Svartenhuk Halvø region (Bojesen-Koefoed *et al.* 1999, 2003). Five distinct oil types have been documented. One oil type is of unknown origin and three are generated from deltaic source rocks with ages ranging probably from the Albian to the Paleocene; the Paleocene source rock has been documented by drilling of the GRO#3 well, whereas a Campanian-age source rock is known from the GANK-1 well. Furthermore, a low to moderately waxy oil type occurs showing a characteristic biomarker composition very similar to that shown by the prolific source rocks in the Kanguk Formation of Cenomanian–Turonian age on Ellesmere Island (Bojesen-Koefoed *et al.* 1999).

Geochemical analyses of wells

A geochemical analysis of five Canadian wells (Ogmund E-72, Skolp E-07, Ralegh N-18, Hekja O-71, Gjoa G-37) and eight Greenland wells (Qulleq-1, Nukik-1 and 2, Kangâmiut-1, Ikermiut-1, Hellefisk-1, GR0#3 and Umiivik-1) has been carried out in order to characterise possible source rocks intervals. The results are, however, generally disappointing regarding both the Canadian and Greenland wells since only little or no petroleum source potential has been recorded with the possible exceptions of the Hekja O-71 and Umiivik-1 wells. T_{max}-values generally vary between 415 and 440 indicating that they are predominantly thermally immature, even at great depth. This indicates a low geothermal gradient in most of the region.

A short summary of the results of each well is given below (see Table 3).

Ogmund E-72

134 samples have been analysed in the interval between 724 and 3090 m (Eocene – Aptian/Albian). Total organic carbon (TOC) contents are very variable showing values between 0.1% and 37.5% (average 3.1%). S_2 pyrolysis yields show wide variations with an average of 1.7 mg/g. Hydrogen Indices (HI) are, however, consistently low with a recorded maximum of 113. T_{max}-data show a rather irregular maturation trend with values between 420°C and 430°C. Although some coaly intervals in the lower part of the well show fairly high S_2-values, no potential petroleum source rock is present.

Skolp E-09

136 samples have been analysed in the interval between 925 and 2985 m (L. Eocene – Aptian/Cenomanian). TOC contents are variable showing values between 0.5% and 36.7% (average 5.3%). S_2 pyrolysis yields show wide variation with an average of 7.5 mg/g. Consequently, Hydrogen Indices (HI) range from 14 to 277. T_{max}-data show a rather irregular maturation trend with values between 420°C and 435°C. Based on Rock-Eval data minor petroleum source potential may be present in several intervals.

Ralegh N-18

76 samples have been analysed in the interval between 1365 and 3840 m (strat) . TOC contents are very variable showing values between 0.1% and 25.0% (average 2.5%). S_2 pyrolysis yields show wide variation with an average of 3.7 mg/g. Consequently, Hydrogen Indices (HI) are very variable with a maximum of 427. T_{max}-data show a rather irregular maturation trend with values between 420°C and 435°C. Although HI-values are generally below 100, several intervals, albeit immature, may possess some petroleum source potential.

Hekja O-71

69 samples have been analysed in the interval between 1465 and 4566 m (U. Eocene – U. Paleocene). TOC contents are very variable showing values between 0.0% and 25.7% (average 5.8%). S_2 pyrolysis yields show wide variation with an average of 8.6 mg/g. Consequently, Hydrogen Indices are also very variable, ranging from 0 to approximately 225. T_{max}-data show a rather irregular maturation trend with values between 415°C and 440°C. Although

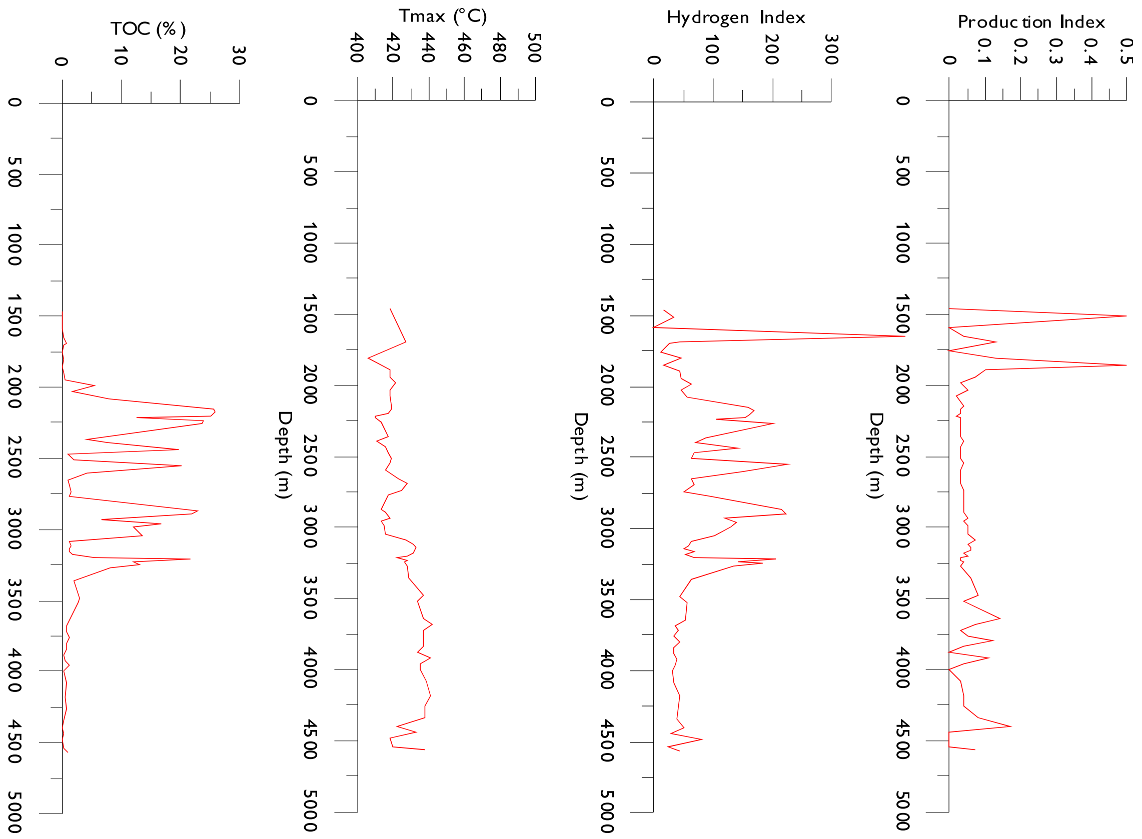


Fig. 12. Simple geochemical log of the Hekja O-71 well, Saglek Basin, South-East Baffin Island Shelf.

generally immature, several intervals within the 2100 – 3300 m interval may possess some petroleum source potential (Fig. 12).

Gjoa G-37

78 samples have been analysed in the interval between 1510 and 3998 m (U. Eocene – L. Paleocene). TOC contents are generally low (0.1% – 2.5%; average 1.1%). Hydrogen Indices never exceed 100. T_{max}-data are very variable but a depth trend varying between *c.* 430°C to *c.* 440°C may tentatively be identified. No petroleum source potential has been recorded.

Qulleq-1

149 samples have been analysed in the interval between 1282 and 2970 m (Cenozoic – U. Santonian). Organic geochemical analysis was hampered by the extensive use of polyethyleneglycol (PEG) as a mud additive; thus, geochemical data from the well are largely useless (Bojesen-Koefoed *et al.* 2000b). The data show, however, that no prolific source rock exists in the drilled succession. Vitrinite reflectance data show that the penetrated succession is immature with respect to petroleum generation (R_0<0.4%).

Nukik-1 and 2

42 prewashed samples (washed on rig) have been analysed in the interval between 1402 and 2557 m (M. Miocene – U. Paleocene). Organic geochemical analysis is difficult due to the very poor sample quality; extraction data suggest that that many samples are contaminated and therefore data are not very reliable. TOC-values vary between 0.12% and 11.06%. S_2 pyrolysis yields are variable, occasionally high, with values between 0 mg/g and 21 mg/g. Hydrogen Indices are in the range 15–500. T_{max}-data show a wide scatter; although a reliable maturity trend cannot be constructed there is no doubt that maturity is low. No petroleum source potential can be inferred from the samples available.

Kangâmiut-1

43 prewashed samples (washed on rig) have been analysed in the interval between 1956 and 3600 m (M. Miocene – U. Paleocene). The upper, mid-Eocene part of the well (above 2780 m) shows TOC-values in the range 0.25% and 1.5% whereas the deeper part shows values up to 3.5%. S_2 pyrolysis yields are invariably low to very low (<3 mg/g, generally < 1 mg/g) and Hydrogen Indices are <100. T_{max}-data show a generally well-constrained maturation trend with values between 415°C and 438°C. Seven samples have been analysed for biological markers; however, interpretation of data is strongly hampered by contamination and an overall low maturity. No petroleum source potential has been recorded.

During drilling of the Kangâmiut-1 well, high pressures were encountered in the section below 3706 m that necessitated the use of very heavy control mud. Gas-chromatograph readings of up to 9% were recorded with the gas consisting of C1 to C4 in measurable amounts and a trace of C5 (Bate 1997). Such readings commonly indicate that the well has penetrated an oil field, or at least a gas condensate field. A Drill-Stem Test (DST) performed over the interval 3674 to 3705 m which, however, only flowed water. Later testing of the water showed that it had the same chemistry as the drilling-mud fluids indicating that only drilling-mud liquids were produced during the DST. The evidence therefore strongly suggests that Kangâmiut-1 drilled through an oil or condensate accumulation with a so far unknown source (Bate 1997).

Ikermiut-1

77 prewashed samples (washed on rig) have been analysed in the interval between 1551 and 3607 m (U. Eocene – L. Campanian). The Eocene part of the succession (above 2075 m) shows low TOC (<1%), very low S_2 pyrolysis yields (<0.5 mg/g) and Hydrogen Indices <50. The Upper Paleocene part of the succession (2075 m – 2755 m) shows somewhat higher TOC (0.5–2%), low S_2 pyrolysis yields (<1.5 mg/g) and Hydrogen Indices <100. The Lower Campanian part shows relatively high TOC-values (generally >2%), but low low S_2 pyrolysis yields (1.5–4 mg/g) and HI-values (50–150). Twelve samples have been analysed for biological marker and they seem to represent marine mudstone carrying variable proportions of terrigenous organic matter. The Campanian rocks show a very high proportion of 28,30-bisnorhopane suggesting a marine anoxic depositional environment. However, no petroleum source potential has been recorded.

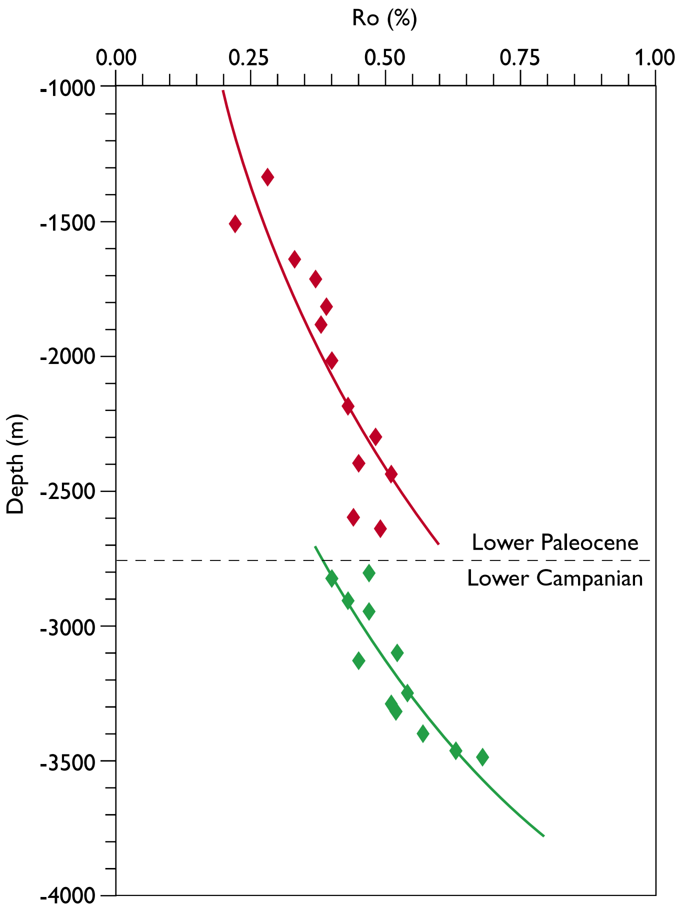


Fig. 13. Seledted vitrintie reflectance data from the Ikermiut-1 well, offshore West Greenland

T_{max}-values are in the range 420–445°C showing a rather irregular maturation trend including a possible reversal around 2700 m. This observation is supported by vitrinite reflectance data (Fig. 13) and the biomarker maturity trend. The complex maturity gradient in the Ikermiut-1 well may either be a result of major uplift during the latest Maastrichtian or earliest Paleocene or of repetition of strata due to thrusting since the well is situated in an area with flower structures (cf. Chalmers & Pulvertaft 2001). The biostratigraphic data indicate a major unconformity at 2755 m separating Lower Campanian and Upper Paleocene strata, but no indication of repetition of strata can be seen.

Hellefisk-1

26 prewashed samples (washed on rig) have been analysed in the interval between 1902 and 2515 m (L. Eocene). TOC-values are generally <1% with a few samples showing values up to 6.08%. S_2 pyrolysis yields are low throughout (<6mg/g; generally <1mg/g) and HI-values are <100). T_{max}-values range from 420°C to 433°C showing a fairly regular increasing trend with depth. Biological marker data are not very informative, but the 3 analysed samples seem to represent marine mudstone carrying some terrigenous organic matter. No petroleum source potential has been recorded.

GRO#3

114 samples have been analysed in the interval between 320 –2990 m (Cenozoic – Coniacian and older). T_{max}-values range from 431°C to 575°C showing a regular increasing trend with depth. Vitrinite reflectance shows a similar trend with values between 0.71% and 2.63%. TOC-values vary between 1.14% and 6.55% (average 4.46%) with a tendency for TOC for being slightly higher in the deeper part of the succession than in the Paleocene part. S_2 py-

rolysis yields are very variable ranging from 0.04 mg/g to 8.08 mg/g. Values greater than 2 mg/g are restricted to the upper 1700 m. Hydrogen Indices vary between 4 and 217 (average 50) showing a fairly regular decrease with depth. A shale succession at approximately 400 m b. rotary table has been identified as representing the source of the Marraat oil type, seeps of which are widespread on Nuussuaq.

Table 3: Summary of geochemical results from selected Canadian and Greenland wells

	# of samples	**sample interval** m	**TOC** %	**S_2** mg/g	**HI**	**T_{max}** °C
Ogmund E-72 [1]	134	724 – 3090	0.1 – 37.5 average 3.1	<22.9 average 1.7	< 113 average 46	420 – 430
Skolp E-07 [1]	136	925 – 2985	0.5 – 36.7 average 5.3	0.2 – 101.2 average 7.5	14 – 277 generally low	420 – 435
Ralegh N-18 [1]	76	1365 – 3840	0.1 – 25.0 average 2.5	<107.0 average 3.7	<427 generally low	420 – 435
Hekja O-71 [1]	69	1465 – 4566	0.0 – 25.7 average 5.8	<49.4 average 8.6	<225 generally low	415 – 440
Gjoa G-37[1]	78	1510 – 3998	0.1 – 2.5 average 1.1	<2.1 average 0.4	<100	430 – 440
Qulleq-1 [2]	149	1282 – 2970	< 7 recalculated data	<8 recalculated data	<120 recalculated data	no reliable data R_0 <0.4%
Nukik-1 and 2 [3]	42	1402 – 2557	0,12 – 11,06	<21 very variable	15 – 516 very variable	no reliable data
Kângamiut-1 [3]	43	1956 – 3600	0,25 –3,5	<3 generally <1	<100	415 – 440
Ikermiut-1 [3]	77	1551 – 3607	0,24 – 2,92	<4 generally <	<150	420 – 445
Hellefisk-1 [3]	26	1902 – 2515	0,07 –6,08 generally <1	<6 generally <1	<100	420 – 435
GRO#3 [4]	114	320 – 2990	1.15 – 6.55 average 4.5	0.04 –8.08 average 2.06	<217 average 50	431 – 575 regular trend
Umiivik-1 [5]	98	50 – 1200	<6 average 3.4	<6.3	<136	427 – >560

[1]: Bojesen-Koefoed (2002); [2]: Bojesen-Koefoed *et al.* (2000b); [3]: Bojesen-Koefoed *et al.* (2000a); [4]: Bojesen-Koefoed *et al.* (1997); [5]: Christiansen *et al.* (1997), Dam *et al.* (1998b)

Umiivik-1

98 samples have been analysed in the interval between 50 and 1200 m (L. Coniacian – U.Turonian). T_{max}-values in the upper part of the well range from 427°C to 441°C (average 434°C) with a high scatter. Vitrinite reflectance values in this interval are between 0.55% and 0.63%. Although a marine depostional environment is suggested for these mudstones, biomarker data suggest a significant contribution of terrestrial organic matter.

Below 405 m T_{max}-values are, however, very high, in most cases between 500°C and 560°C or even higher and controlled by the position of sills. In the lower part of the well vitrinite reflectance values are between 1.7% and 4.3%. TOC contents are moderate to high (2 – 6%; average 3.4%) in the upper 390 m of the well, whereas the deeper and thermally post-mature part shows significantly lower values (average 2.85%). This variation may be primary and not only be controlled by maturity level. S_2 pyrolysis yields are very variable ranging from 0 mg/g to 6.32 mg/g but are generally >3 mg/g in the upper part of the core. Hydrogen Indices are between 63 and 136 in the upper part of the well, but very low – typically <25 – in the lower part suggesting that all potential hydrocarbons have been generated and thermally cracked to gas (Christiansen *et al.* 1997). Head space analysis of gas containing core samples from the lower part of the well show that considerable amounts of gas were released from some intervals. Methane is the most abundant hydrocarbon gas but wet gases containing both normal and isobutane and pentane also occur (Dam *et al.* 1998b). Thus, the organic geochemical results suggest that a possible source rock is present in the deeper part of the Umiivik-1 well. Due to the high thermal maturity this possible Cenomanian–Turonian source rock cannot be dated in detail and it is not possible to document the detailed composition of the generated products and the generative potential (Dam *et al.* 1998b).

Conclusion

One of the aims of the present study was to try to explain the regional distribution of any possible source rock intervals in the Cretaceous – Palaeogene succession in the Labrador Sea – Baffin Bay area. However, the geochemical analyses of the five Canadian wells have not documented hitherto unknown source rock intervals nor could it be confirmed that the organic rich mudstones of the Markland Formation and the Lower Cretaceous lignites and coals of the Bjarni Formation represent regional source rocks. Furthermore, the geochemical analyses could not support that the Paleocene organic rich mudstones are the actual source for the petroleum accumulations found in the Hekja O-71 well since the mudstones are probably thermally immature in the area around the well. The hydrocarbons may therefore be generated from a deeper and as yet unknown source. Marine source rocks in West Greenland are so far only known indirectly and can thus not be regionally mapped.

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Enlosures 1–9

Range chart of the **Ogmund E-72** well: **Enclosure 1**

Range chart of the **Skolp E-07** well: **Enclosure 2**

Range chart of the **Gjoa G-37** well: **Enclosure 3**

Range chart of the **Qulleq-1** well: **Enclosure 4**

Range chart of the **Ikermiut-1** well: **Enclosure 5**

Range chart of the **GRO#3** well: **Enclosure 6**

Range chart of the **Umiivik-1** well: **Enclosure 7**

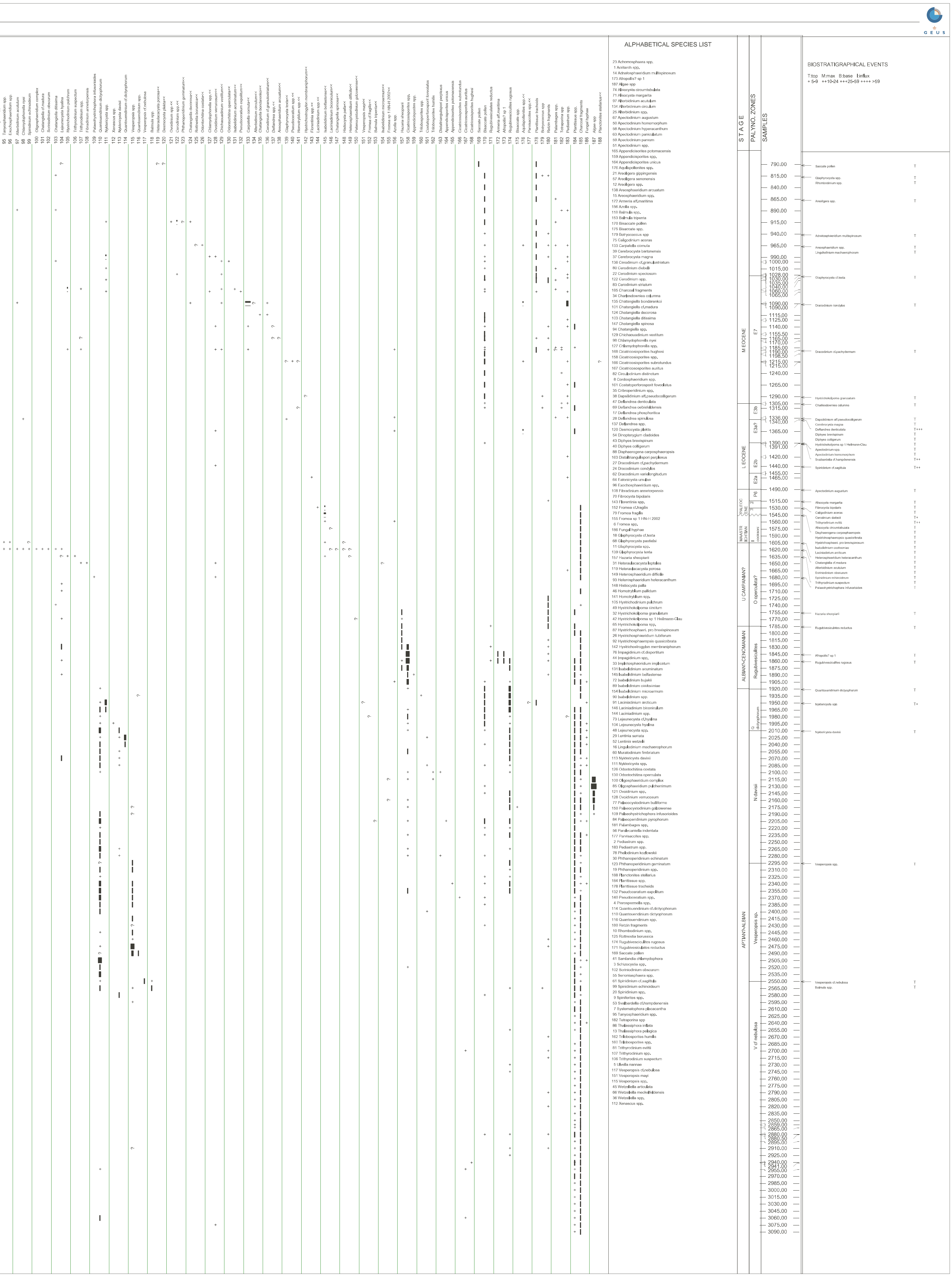
Range chart of the **Hekja O-71** well: **Enclosure 8**

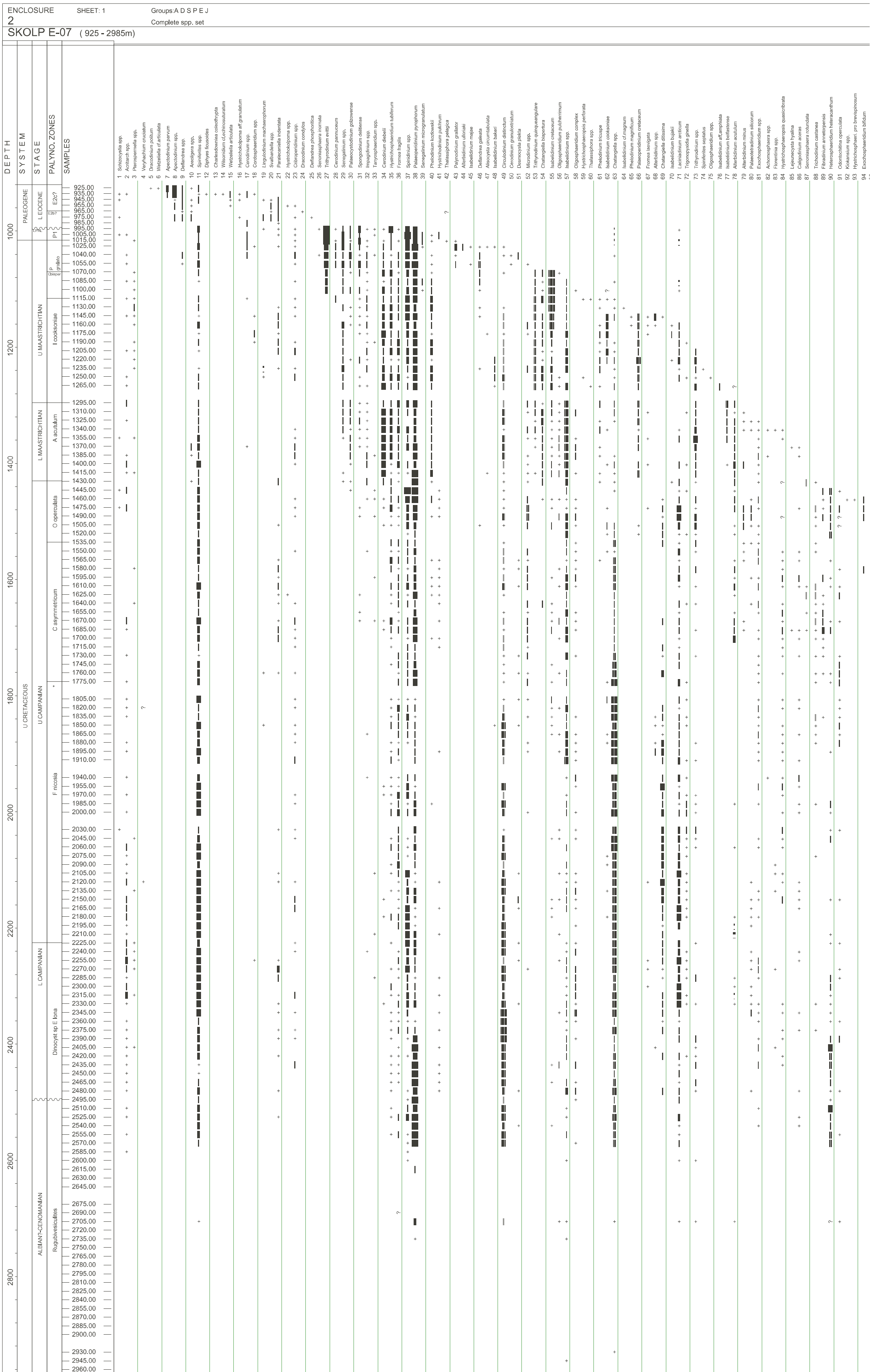
Well log correlations: **Enclosure 9**

ENCLOSURE SHEET: 1 Groups:A D S P E J
1 Complete spp. set

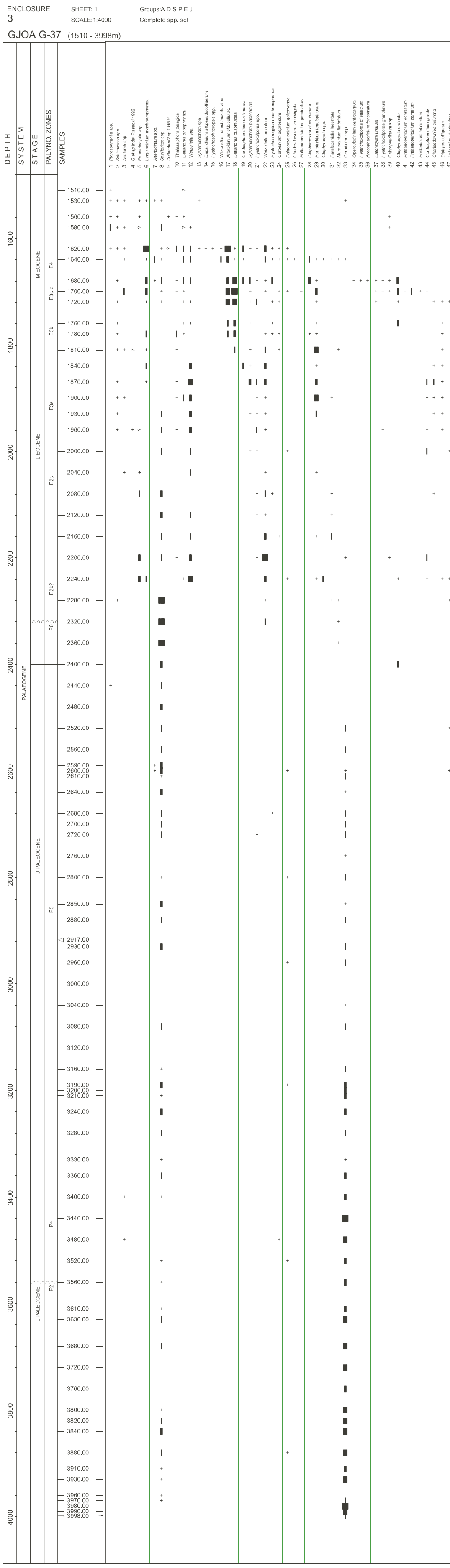
OGMUND E-72 (790 - 3090m)

Enclosure 1: Range chart of the Ogmund E-72 well
See CD-ROM for full-scale plot.

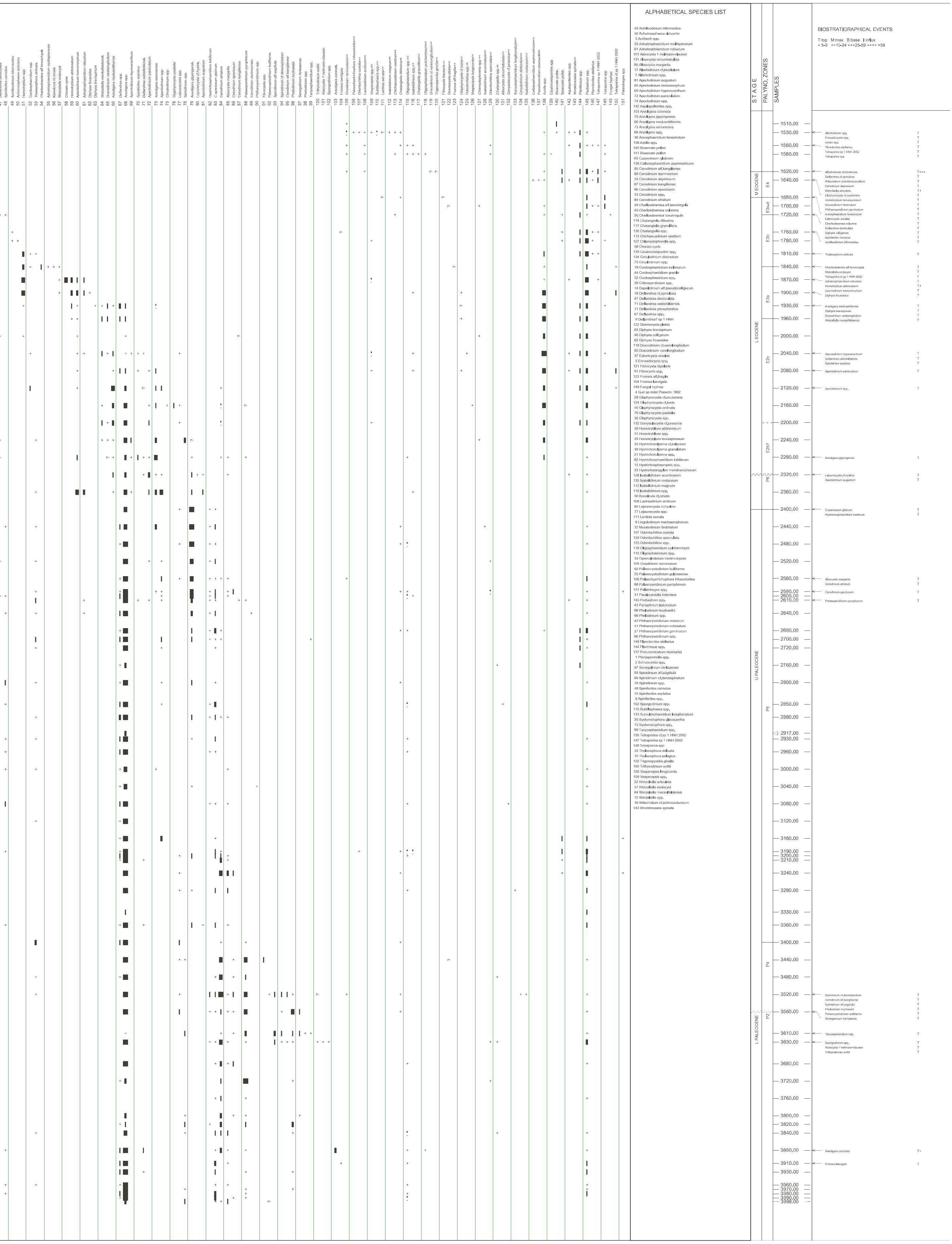


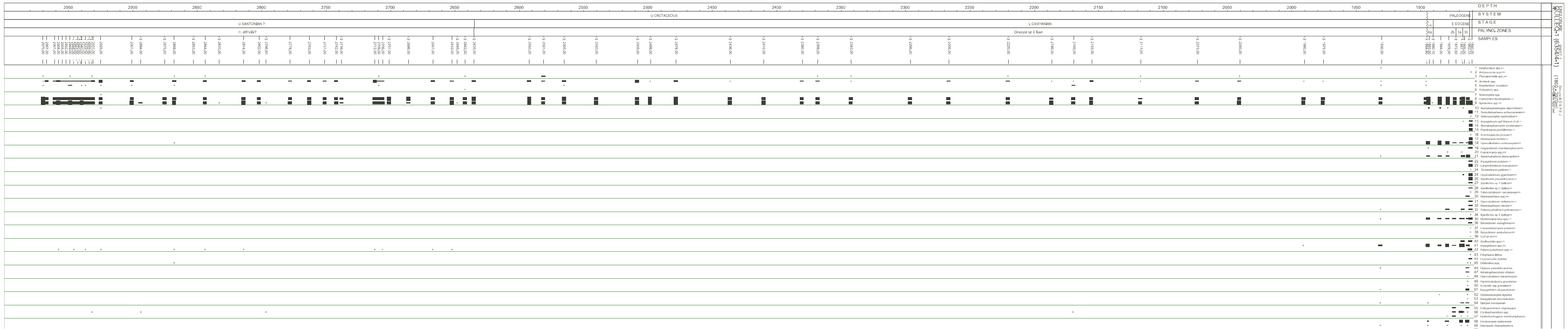

ENCLOSURE
2
SHEET: 1
Groups:A D S P E J
Complete spp. set
SKOLP E-07 (925 - 2985m)
DEPTH
SYSTEM
STAGE
PALYNO. ZONES
SAMPLES
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
PALEOGENE
U CRETACEOUS
L EOCENE
L PAL
U MAASTRICHTIAN
L MAASTRICHTIAN
U CAMPANIAN
L CAMPANIAN
ALBIAN?-CENOMANIAN
E2c?
E2b?
P1
P grallato
Cbiaper
I cooksoniae
A acutulum
O operculata
C asymmetricum
*
F nicosia
Dinocyst sp E Iona
Rugubivesiculites
925.00
935.00
945.00
955.00
965.00
975.00
985.00
995.00
1005.00
1015.00
1025.00
1040.00
1055.00
1070.00
1085.00
1100.00
1115.00
1130.00
1145.00
1160.00
1175.00
1190.00
1205.00
1220.00
1235.00
1250.00
1265.00
1295.00
1310.00
1325.00
1340.00
1355.00
1370.00
1385.00
1400.00
1415.00
1430.00
1445.00
1460.00
1475.00
1490.00
1505.00
1520.00
1535.00
1550.00
1565.00
1580.00
1595.00
1610.00
1625.00
1640.00
1655.00
1670.00
1685.00
1700.00
1715.00
1730.00
1745.00
1760.00
1775.00
1805.00
1820.00
1835.00
1850.00
1865.00
1880.00
1895.00
1910.00
1940.00
1955.00
1970.00
1985.00
2000.00
2030.00
2045.00
2060.00
2075.00
2090.00
2105.00
2120.00
2135.00
2150.00
2165.00
2180.00
2195.00
2210.00
2225.00
2240.00
2255.00
2270.00
2285.00
2300.00
2315.00
2330.00
2345.00
2360.00
2375.00
2390.00
2405.00
2420.00
2435.00
2450.00
2465.00
2480.00
2495.00
2510.00
2525.00
2540.00
2555.00
2570.00
2585.00
2600.00
2615.00
2630.00
2645.00
2675.00
2690.00
2705.00
2720.00
2735.00
2750.00
2765.00
2780.00
2795.00
2810.00
2825.00
2840.00
2855.00
2870.00
2885.00
2900.00
2930.00
2945.00
2960.00
2975.00
2985.00
1 Schizocystia spp.
2 Acritarch spp.
3 Pterospermella spp.
4 Veryhachium cruciatum
5 Dracodinium politum
6 Wetzeliella cf.articulata
7 Apectodinium parvum
8 Apectodinium spp.
9 Deflandrea spp.
10 Areoligera spp.
11 Spiniferites spp.
12 Diphyes ficusoides
13 Charlesdowniea coleothrypta
14 Wilsonidium cf.echinosuturatum
15 Wetzeliella articulata
16 Hystrichokolpoma aff.granulatum
17 Cerodinium spp.
18 Cordosphaeridium spp.
19 Lingulodinium machaerophorum
20 Svalbardella spp.
21 Paralecaniella indentata
22 Hystrichokolpoma spp.
23 Cribroperidinium spp.
24 Dracodinium condylos
25 Deflandrea phosphoritica
26 Senoniasphaera inornata
27 Trithyrodinium evittii
28 Cerodinium pannuceum
29 Senegalinium spp.
30 Palaeocystodinium golzowense
31 Spongodinium delitiense
32 Impagidinium spp.
33 Tanyosphaeridium spp.
34 Cerodinium diebelii
35 Hystrichosphaeridium tubiferum
36 Fromea fragilis
37 Spinidinium spp.
38 Palaeoperidinium pyrophorum
39 Senegalinium microgranulatum
40 Phelodinium kozlowskii
41 Hystrichodinium pulchrum
42 Thalassiphora pelagica
43 Palynodinium grallator
44 Alterbidinium ulloriaki
45 Isabelidinium majae
46 Deflandrea galeata
47 Alisocysta circumtabulata
48 Isabelidinium bakeri
49 Circulodinium distinctum
50 Cerodinium granulostriatum
51 Desmocysta plekta
52 Microdinium spp.
53 Trithyrodinium quinqueangulare
54 Chatangiella biapertura
55 Isabelidinium cretaceum
56 Oligosphaeridium pulcherrimum
57 Isabelidinium spp.
58 Oligosphaeridium complex
59 Hystrichosphaeropsis perforata
60 Thalassiphora spp.
61 Phelodinium tricuspe
62 Isabelidinium cooksoniae
63 Chatangiella spp.
64 Isabelidinium cf.magnum
65 Phelodinium magnificum
66 Palaeoperidinium cretaceum
67 Fromea laevigata
68 Alterbidinium spp.
69 Chatangiella ditissima
70 Isabelidinium bujakii
71 Laciniadinium arcticum
72 Trigonopyxidia ginella
73 Trithyrodinium spp.
74 Spiniferites septatus
75 Oligosphaeridium spp.
76 Isabelidinium aff.amphiata
77 Isabelidinium belfastense
78 Alterbidinium acutulum
79 Alterbidinium minus
80 Palaeotetradinium silicorum
81 Exochosphaeridium spp.
82 Achomosphaera spp.
83 Florentinia spp.
84 Hystrichosphaeropsis quasicribrata
85 Lejeunecysta hyalina
86 Caligodinium aceras
87 Senoniasphaera rotundata
88 Trichodinium castanea
89 Fibradinium annetorpensis
90 Heterosphaeridium heteracanthum
91 Odontochitina operculata
92 Kiokansium spp.
93 Hystrichosphaeri. pro brevispinosum
94 Exochosphaeridium bifidum
?

Enclosure 2: Range chart of the Skolp E-07 well
See CD-ROM for full-scale plot.

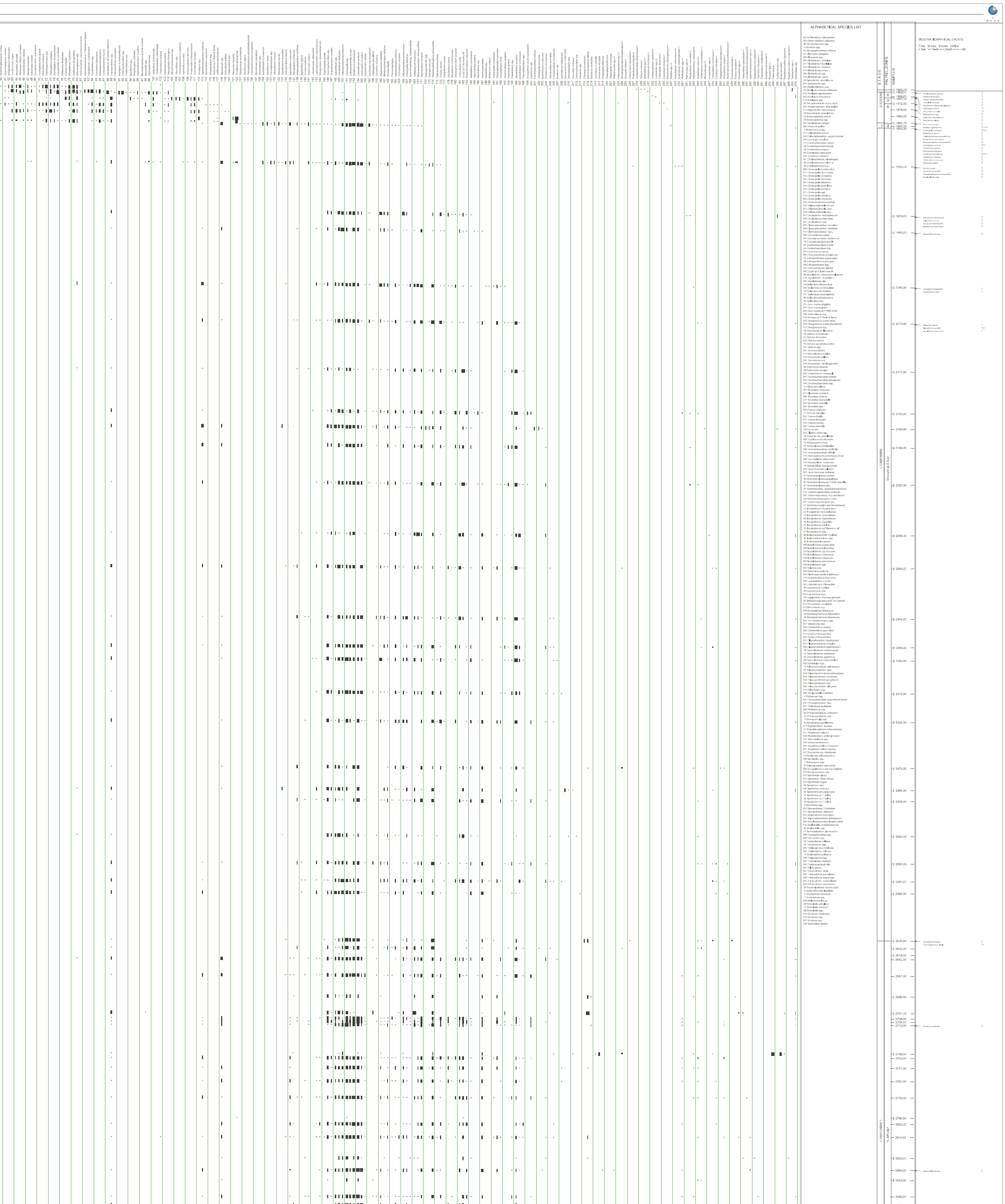

ENCLOSURE
3
SHEET: 1
SCALE:1:4000
Groups:A D S P E J
Complete spp. set
GJOA G-37 (1510 - 3998m)
DEPTH
SYSTEM
STAGE
PALYNO. ZONES
SAMPLES
1 Pterospermella spp.
2 Schizocystia spp.
3 Acritarch spp.
4 G.et sp indet Piasecki 1992
5 Enneadocysta spp.
6 Lingulodinium machaerophorum
7 Alterbidinium spp.
8 Spiniferites spp.
9 Deflandrea? sp 1 HNH
10 Thalassiphora pelagica
11 Deflandrea phosphoritica
12 Wetzeliella spp.
13 Systematophora spp.
14 Dapsilidinium aff.pseudocolligerum
15 Hystrichosphaeropsis spp.
16 Wilsonidium cf.echinosuturatum
17 Alterbidinium cf.bicellulum
18 Deflandrea cf.spinulosa
19 Cordosphaeridium exilimurum
20 Systematophora placacantha
21 Hystrichokolpoma spp.
22 Wetzeliella articulata
23 Hystrichostrogylon membraniphorum
24 Cerodinium depressum
25 Palaeocystodinium golzowense
26 Charlesdowniea tenuivirgula
27 Phthanoperidinium geminatum
28 Glaphyrocysta cf.exuberans
29 Homotryblium tenuispinosum
30 Glaphyrocysta spp.
31 Paralecaniella indentata
32 Muratodinium fimbriatum
33 Cerodinium spp.
34 Operculodinium centrocarpum
35 Hystrichokolpoma cf.salacium
36 Areosphaeridium fenestratum
37 Eatonicysta ursulae
38 Hystrichokolpoma granulatum
39 Cribroperidinium spp.
40 Glaphyrocysta ordinata
41 Phthanoperidinium echinatum
42 Phthanoperidinium comatum
43 Pentadinium laticinctum
44 Cordosphaeridium gracile
45 Charlesdowniea columna
46 Diphyes colligerum
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
M EOCENE
L EOCENE
PALAEOGENE
U PALEOCENE
L PALEOCENE
E4
E3c-d
E3b
E3a
E2c
E2b?
P6
P5
P4
P2
1510.00
1530.00
1560.00
1580.00
1620.00
1640.00
1680.00
1700.00
1720.00
1760.00
1780.00
1810.00
1840.00
1870.00
1900.00
1930.00
1960.00
2000.00
2040.00
2080.00
2120.00
2160.00
2200.00
2240.00
2280.00
2320.00
2360.00
2400.00
2440.00
2480.00
2520.00
2560.00
2590.00
2600.00
2610.00
2640.00
2680.00
2700.00
2720.00
2760.00
2800.00
2850.00
2880.00
2917.00
2930.00
2960.00
3000.00
3040.00
3080.00
3120.00
3160.00
3190.00
3200.00
3210.00
3240.00
3280.00
3330.00
3360.00
3400.00
3440.00
3480.00
3520.00
3560.00
3610.00
3630.00
3680.00
3720.00
3760.00
3800.00
3820.00
3840.00
3880.00
3910.00
3930.00
3960.00
3970.00
3980.00
3990.00
3998.00

Enclosure 3: Range chart of the Gjoa G-37 well
See CD-ROM for full-scale plot.




ENCLOSURE 4
QULLEQ-1 (6354/4-1)
SHEET: 1
(1860 - 2970m)
Groups: A D S P E J
Complete spp. set
DEPTH
SYSTEM
STAGE
PALYNO. ZONES
SAMPLES
2950
2900
2850
2800
2750
2700
2650
2600
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
2050
2000
1950
1900
U CRETACEOUS
PALEOGENE
U SANTONIAN ?
L CAMPANIAN
L PA
E EOCENE
H. difFicile?
Dinocyst sp E Ioan
5a
2b
3a
3b
1 Veryhachium spp.>>
2 Botryococcus spp.>>
3 Pterospermella spp.>>
4 Acritarch spp.
5 Veryhachium cruciatum
6 Pediastrum spp.
7 Schizocystia spp.
8 Unidentified dinoflagellate>>
9 Spiniferites spp.>>
10 Nematosphaeropsis labyrinthea>>
11 Reticulatosphaera actinocoronata>>
12 Selenopemphix nephroides>>
13 Impagidinium sp2 Manum et al>>
14 Nematosphaeropsis lemniscata>>
15 Pyxidinopsis pastilliformis>>
16 Invertocysta lacrymosa>>
17 Habibacysta tectata>>
18 Operculodinium centrocarpum>>
19 Lingulodinium machaerophorum>>
20 Lejeunecysta spp.>>
21 Systematophora placacantha>>
22 Impagidinium patulum>>
23 Labyrinthodinium truncatum>>
24 Tectatodinium pellitum>>
25 Operculodinium giganteum>>
26 Spiniferites pseudofurcatus>>
27 Spiniferites sp 1 Qulleq>>
28 Spiniferites sp 2 Qulleq>>
29 Tuberculodinium vancampoae>>
30 Batiacasphaera spp.>>
31 Operculodinium cinkianum>>
32 Batiacasphaera minuta>>
33 Palaeocystodinium golzowense>>
34 Spiniferites sp 3 Qulleq>>
35 Hystrichokolpoma spp.>>
36 Barssidinium evangelineae>>
37 Cannosphaeropsis passio>>
38 Apteodinium australiense>>
39 G.cf sp nov>>
40 Svalbardella spp.>>
41 Impagidinium spp.>>
42 Palaeocystodinium spp.>>
43 Filisphaera filifera
44 Lejeunecysta cf.fallax
45 Deflandrea spp.
46 Diphyes pseudoficusoides
47 Adnatosphaeridium vittatum
48 Operculodinium nanaconulum
49 Hystrichokolpoma granulatum
50 H.membr ssp granulatum
51 Impagidinium aff.paradoxum
52 Heteraulacacysta leptalea
53 Impagidinium brevisulcatum
54 Diphyes brevispinum
55 Cribroperidinium cf.giuseppei
56 Cordosphaeridium spp.
57 Hystrichostrogylon membraniphorum
58 Cerebrocysta bartonensis
59 Samlandia chlamydophora

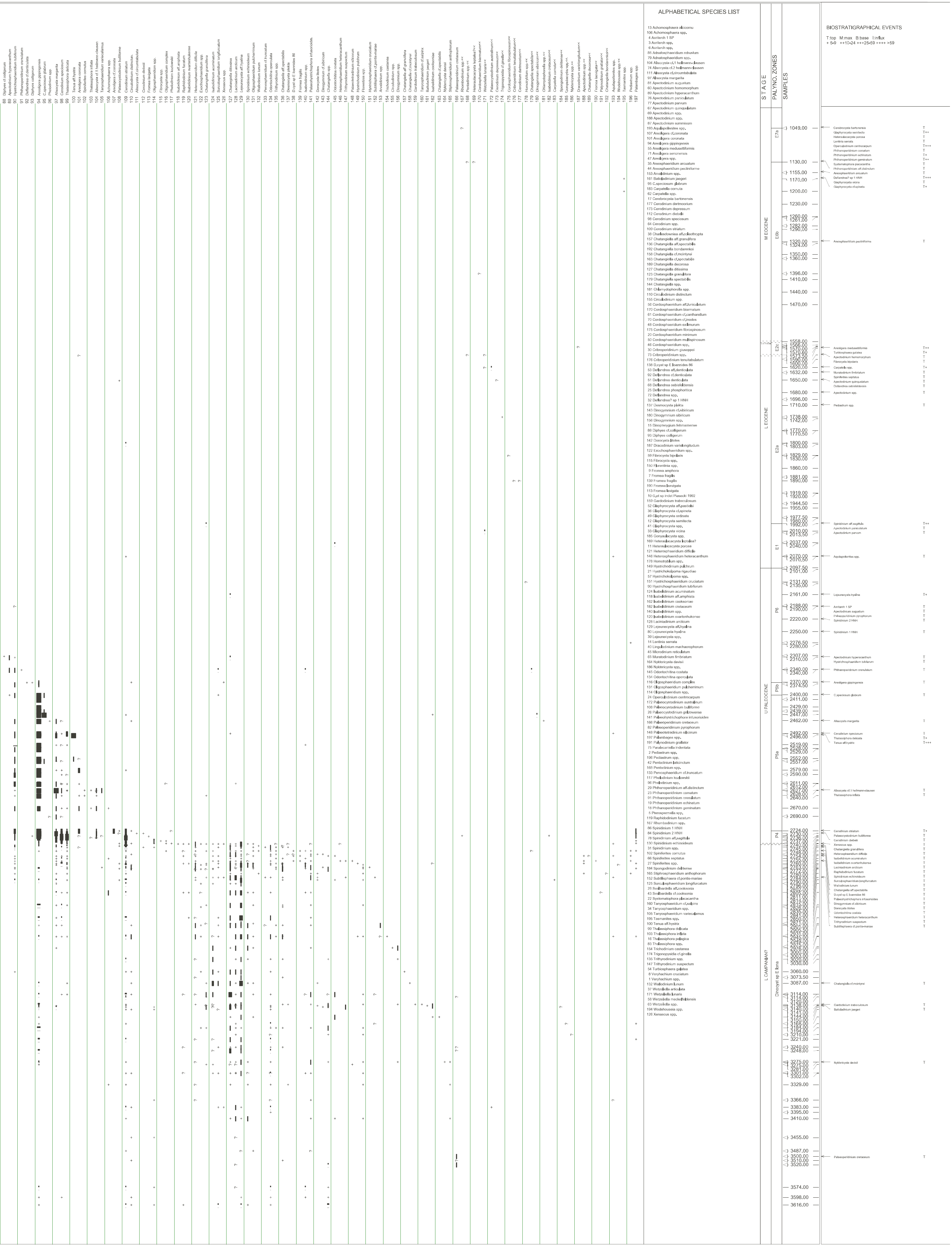
Enclosure 4: Range chart of the Qulleq-1 well
See CD-ROM for full-scale plot.

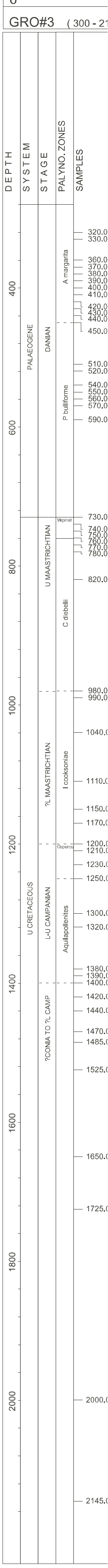



ENCLOSURE
5
SHEET: 1
Groups:A B S P L J
Complete spp. set
IKERMIUT-1 (1000 - 3619m)
DEPTH
SYSTEM
STAGE
PALYNO. ZONES
SAMPLES
PALEOGENE
U CRETACEOUS
M EOCENE
L EOCENE
U PALEOCENE
L CAMPANIAN?
E7a
E6b
E2c
E2a
E1
P6
P5b
P5a
P4
Dinocyst sp B Ima
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600

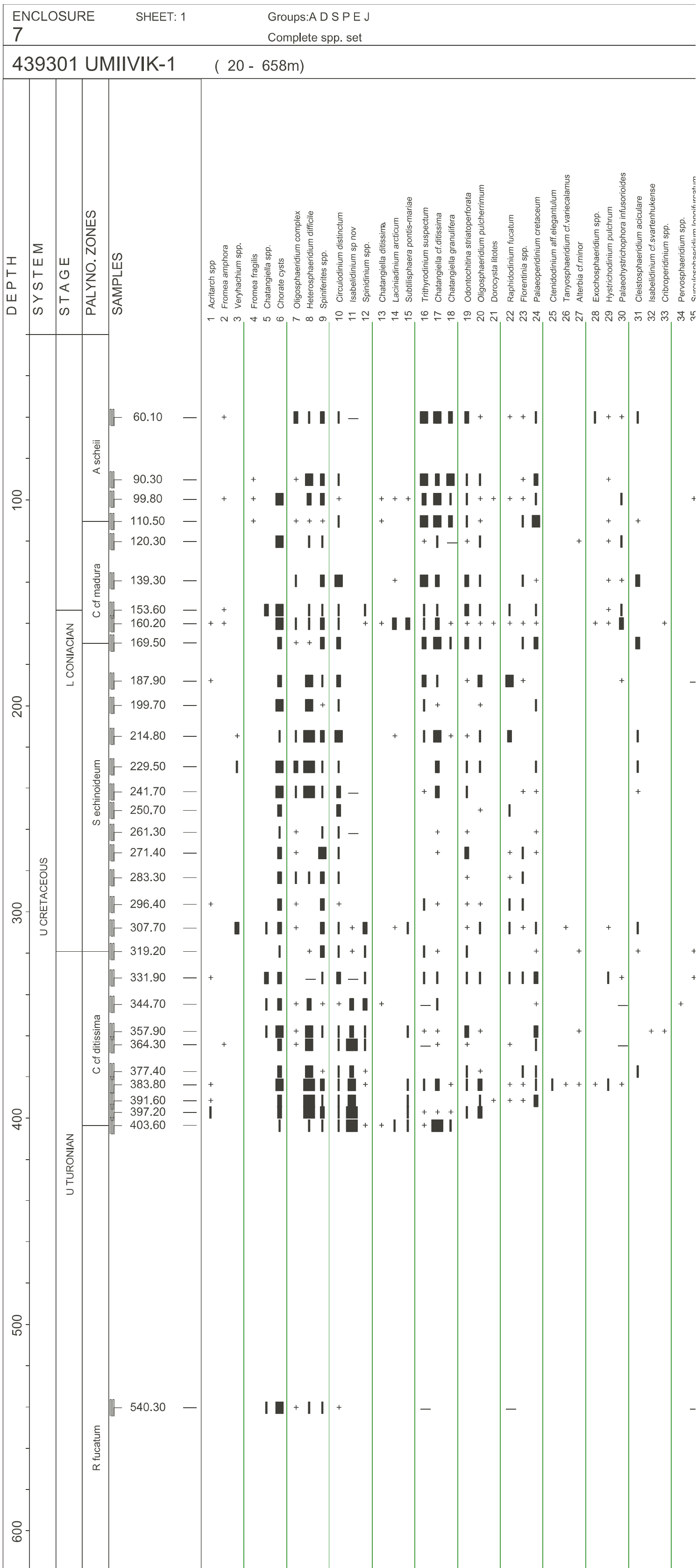
Enclosure 5: Range chart of the Ikermiut-1 well

See CD-ROM for full-scale plot.

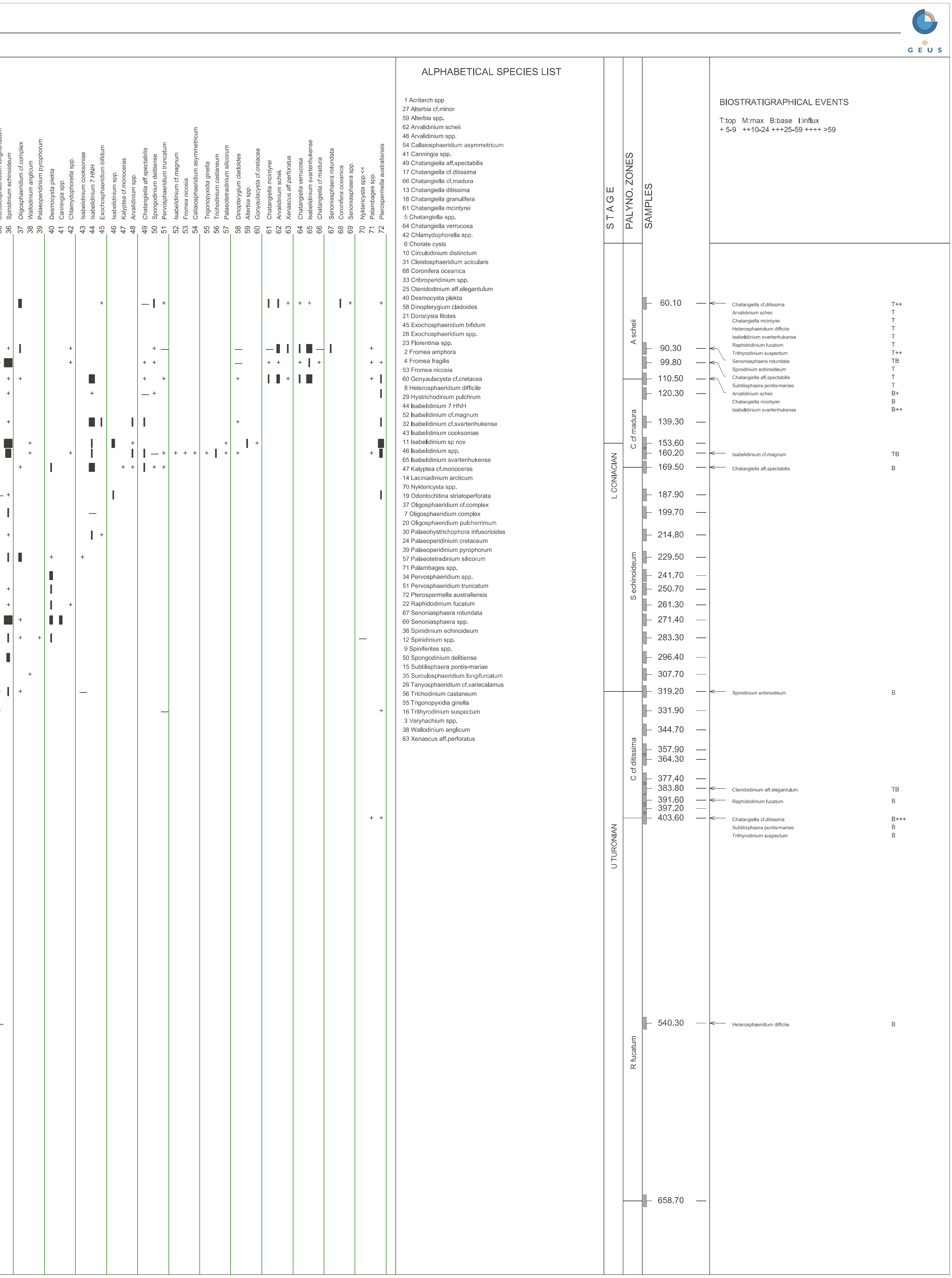



ENCLOSURE
6
SHE
GRO#3 (300 - 21
DEPTH
SYSTEM
STAGE
PALYNO. ZONES
SAMPLES
400
600
800
1000
1200
1400
1600
1800
2000
PALAEOGENE
U CRETACEOUS
DANIAN
U MAASTRICHTIAN
?L MAASTRICHTIAN
L-U CAMPANIAN
?CONIA TO ?L CAMP
A margarita
P bulliforme
W spinat
C diebelii
I cooksoniae
O operculata
Aquilapollenites
320.0
330.0
360.0
370.0
380.0
390.0
400.0
410.0
420.0
430.0
440.0
450.0
510.0
520.0
540.0
550.0
560.0
570.0
590.0
730.0
740.0
750.0
760.0
770.0
780.0
820.0
980.0
990.0
1040.0
1110.0
1150.0
1170.0
1200.0
1210.0
1230.0
1250.0
1300.0
1320.0
1380.0
1390.0
1400.0
1420.0
1440.0
1470.0
1485.0
1525.0
1650.0
1725.0
2000.0
2145.0

Enclosure 6: Range chart of the GRO#3 welll
See CD-ROM for full-scale plot.


ENCLOSURE
7
SHEET: 1
Groups:A D S P E J
Complete spp. set
439301 UMIIVIK-1
(20 - 658m)
D E P T H
S Y S T E M
S T A G E
PALYNO. ZONES
SAMPLES
1 Acritarch spp
2 Fromea amphora
3 Veryhachium spp.
4 Fromea fragilis
5 Chatangiella spp.
6 Chorate cysts
7 Oligosphaeridium complex
8 Heterosphaeridium difficile
9 Spiniferites spp.
10 Circulodinium distinctum
11 Isabelidinium sp nov
12 Spinidinium spp.
13 Chatangiella ditissima
14 Laciniadinium arcticum
15 Subtilisphaera pontis-mariae
16 Trithyrodinium suspectum
17 Chatangiella cf.ditissima
18 Chatangiella granulifera
19 Odontochitina striatoperforata
20 Oligosphaeridium pulcherrimum
21 Dorocysta litotes
22 Raphidodinium fucatum
23 Florentinia spp.
24 Palaeoperidinium cretaceum
25 Ctenidodinium aff.elegantulum
26 Tanyosphaeridium cf.variecalamus
27 Alterbia cf.minor
28 Exochosphaeridium spp.
29 Hystrichodinium pulchrum
30 Palaeohystrichophora infusorioides
31 Cleistosphaeridium aciculare
32 Isabelidinium cf.svartenhukense
33 Cribroperidinium spp.
34 Pervosphaeridium spp.
35
100
200
300
400
500
600
U CRETACEOUS
L CONIACIAN
U TURONIAN
A scheii
C cf madura
S echinoideum
C cf ditissima
R fucatum
60.10
90.30
99.80
110.50
120.30
139.30
153.60
160.20
169.50
187.90
199.70
214.80
229.50
241.70
250.70
261.30
271.40
283.30
296.40
307.70
319.20
331.90
344.70
357.90
364.30
377.40
383.80
391.60
397.20
403.60
540.30
658.70
?

Enclosure 7: Range chart of the Umiivik-1 well
See CD-ROM for full-scale plot.



ALPHABETICAL SPECIES LIST

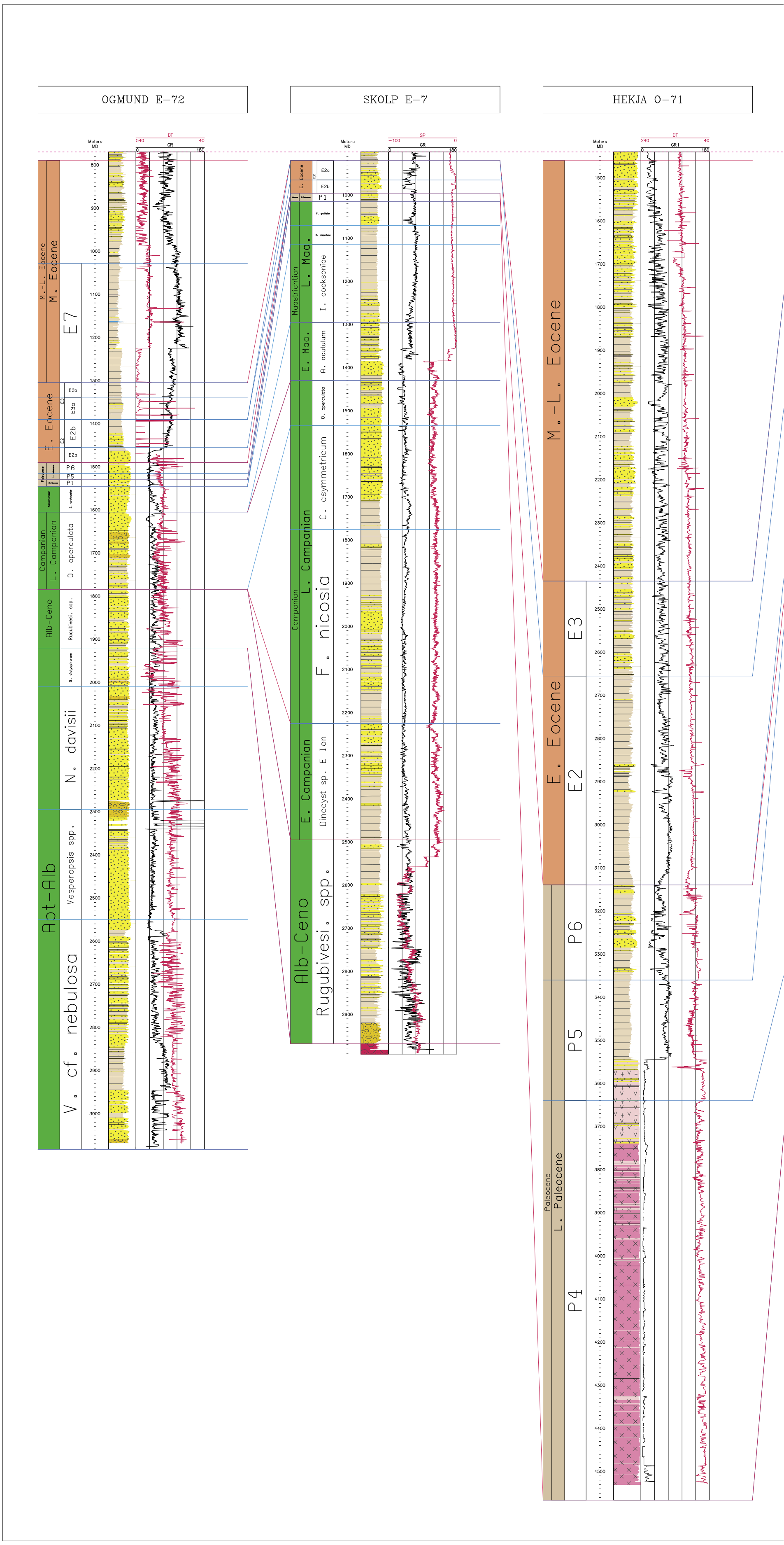
1 Acritarch spp
27 Alterbia cf.minor
59 Alterbia spp.
62 Arvalidinium scheii
48 Arvalidinium spp.
54 Callaiosphaeridium asymmetricum
41 Canningia spp.
49 Chatangiella aff.spectabilis
17 Chatangiella cf.ditissima
66 Chatangiella cf.madura
13 Chatangiella ditissima
18 Chatangiella granulifera
61 Chatangiella mcintyrei
5 Chatangiella spp.
64 Chatangiella verrucosa
42 Chlamydophorella spp.
6 Chorate cysts
10 Circulodinium distinctum
31 Cleistosphaeridium aciculare
68 Coronifera oceanica
33 Cribroperidinium spp.
25 Ctenidodinium aff.elegantulum
40 Desmocysta plekta
58 Dinopterygium cladoides
21 Dorocysta litotes
45 Exochosphaeridium bifidum
28 Exochosphaeridium spp.
23 Florentinia spp.
2 Fromea amphora
4 Fromea fragilis
53 Fromea nicosia
60 Gonyaulacysta cf.cretacea
8 Heterosphaeridium difficile
29 Hystrichodinium pulchrum
44 Isabelidinium 7 HNH
52 Isabelidinium cf.magnum
32 Isabelidinium cf.svartenhukense
43 Isabelidinium cooksoniae
11 Isabelidinium sp nov
46 Isabelidinium spp.
65 Isabelidinium svartenhukense
47 Kalyptea cf.monoceras
14 Laciniadinium arcticum
70 Nyktericysta spp.
19 Odontochitina striatoperforata
37 Oligosphaeridium cf.complex
7 Oligosphaeridium complex
20 Oligosphaeridium pulcherrimum
30 Palaeohystrichophora infusorioides
24 Palaeoperidinium cretaceum
39 Palaeoperidinium pyrophorum
57 Palaeotetradinium silicorum
71 Palambages spp.
34 Pervosphaeridium spp.
51 Pervosphaeridium truncatum
72 Pterospermella australiensis
22 Raphidodinium fucatum
67 Senoniasphaera rotundata
69 Senoniasphaera spp.
36 Spinidinium echinoideum
12 Spinidinium spp.
9 Spiniferites spp.
50 Spongodinium delitiense
15 Subtilisphaera pontis-mariae
35 Surculosphaeridium longifurcatum
26 Tanyosphaeridium cf.variecalamus
56 Trichodinium castaneum
55 Trigonopyxidia ginella
16 Trithyrodinium suspectum
3 Veryhachium spp.
38 Wallodinium anglicum
63 Xenascus aff.perforatus

BIOSTRATIGRAPHICAL EVENTS

T:top M:max B:base I:influx
+ 5-9 ++10-24 +++25-59 ++++ >59

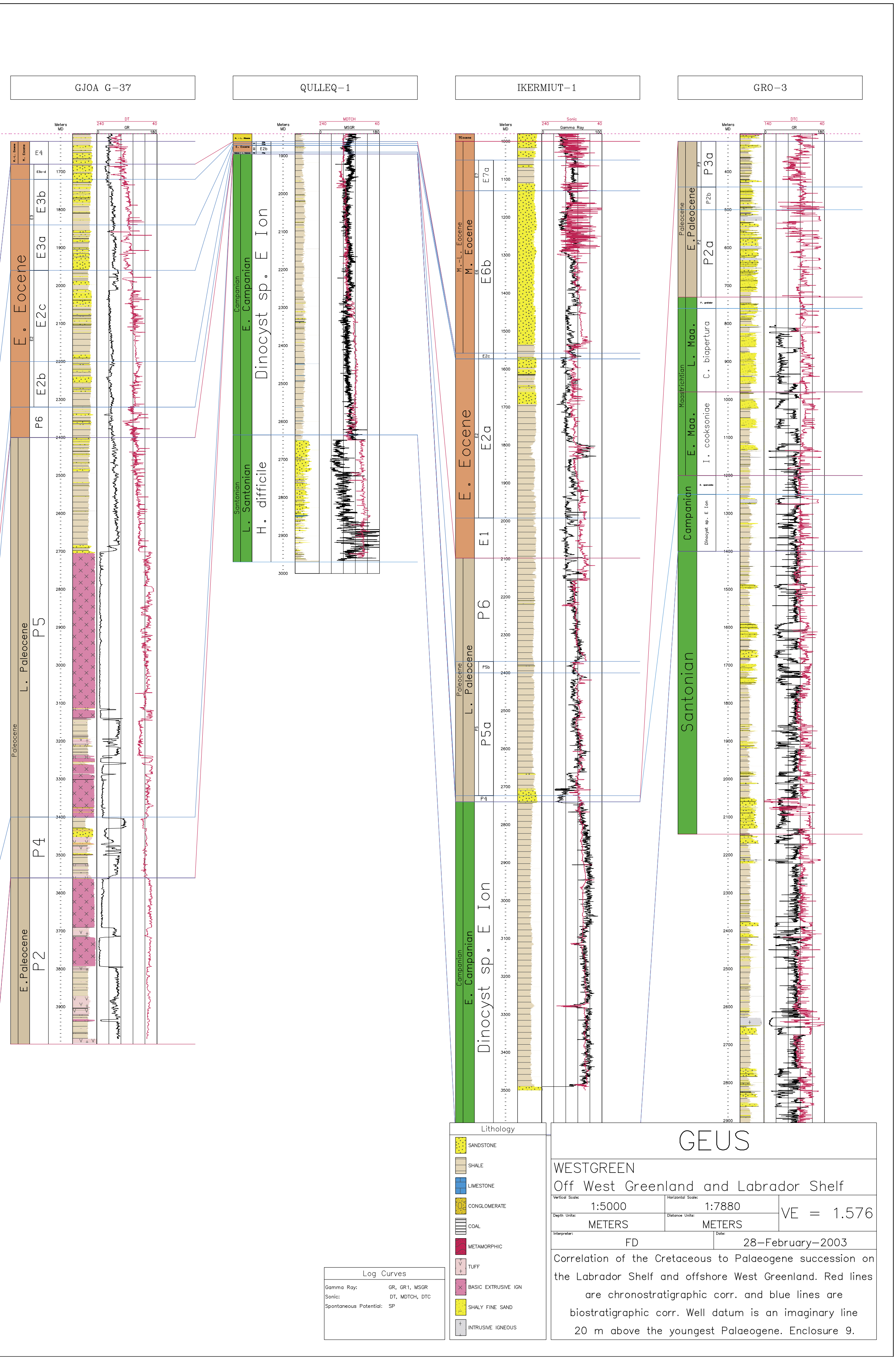
Chatangiella cf.ditissima	T++
Arvalidinium scheii	T
Chatangiella mcintyrei	T
Heterosphaeridium difficile	T
Isabelidinium svartenhukense	T
Raphidodinium fucatum	T
Trithyrodinium suspectum	T++
Senoniasphaera rotundata	TB
Spinidinium echinoideum	T
Chatangiella aff.spectabilis	T
Subtilisphaera pontis-mariae	T
Arvalidinium scheii	B+
Chatangiella mcintyrei	B
Isabelidinium svartenhukense	B++
Isabelidinium cf.magnum	TB
Chatangiella aff.spectabilis	B
Spinidinium echinoideum	B
Ctenidodinium aff.elegantulum	TB
Raphidodinium fucatum	B
Chatangiella cf.ditissima	B+++
Subtilisphaera pontis-mariae	B
Trithyrodinium suspectum	B
Heterosphaeridium difficile	B

Enclosure 8 Range chart of the: Hekja O-71 well
See CD-ROM for full-scale plot.


OGMUND E-72
SKOLP E-7
HEKJA O-71
Meters MD
DT
GR
SP
GR1
M.-L. Eocene
M. Eocene
E7
E. Eocene
E3b
E3a
E2b
E2a
E2c
P6
P5
P1
Maastrichtian
Campanian
L. Campanian
O. operculata
Alb-Ceno
Rugubivesi. spp.
N. davisii
Apt-Alb
Vesperopsis spp.
V. cf. nebulosa
L. Maa.
I. cooksoniae
E. Maa.
R. acutulum
C. asymmetricum
F. nicosia
E. Campanian
Dinocyst sp. E Ion
E3
E2
Paleocene
L. Paleocene
P4

Enclosure 9: Well log correlation of the

See CD-ROM for full-scale plot.



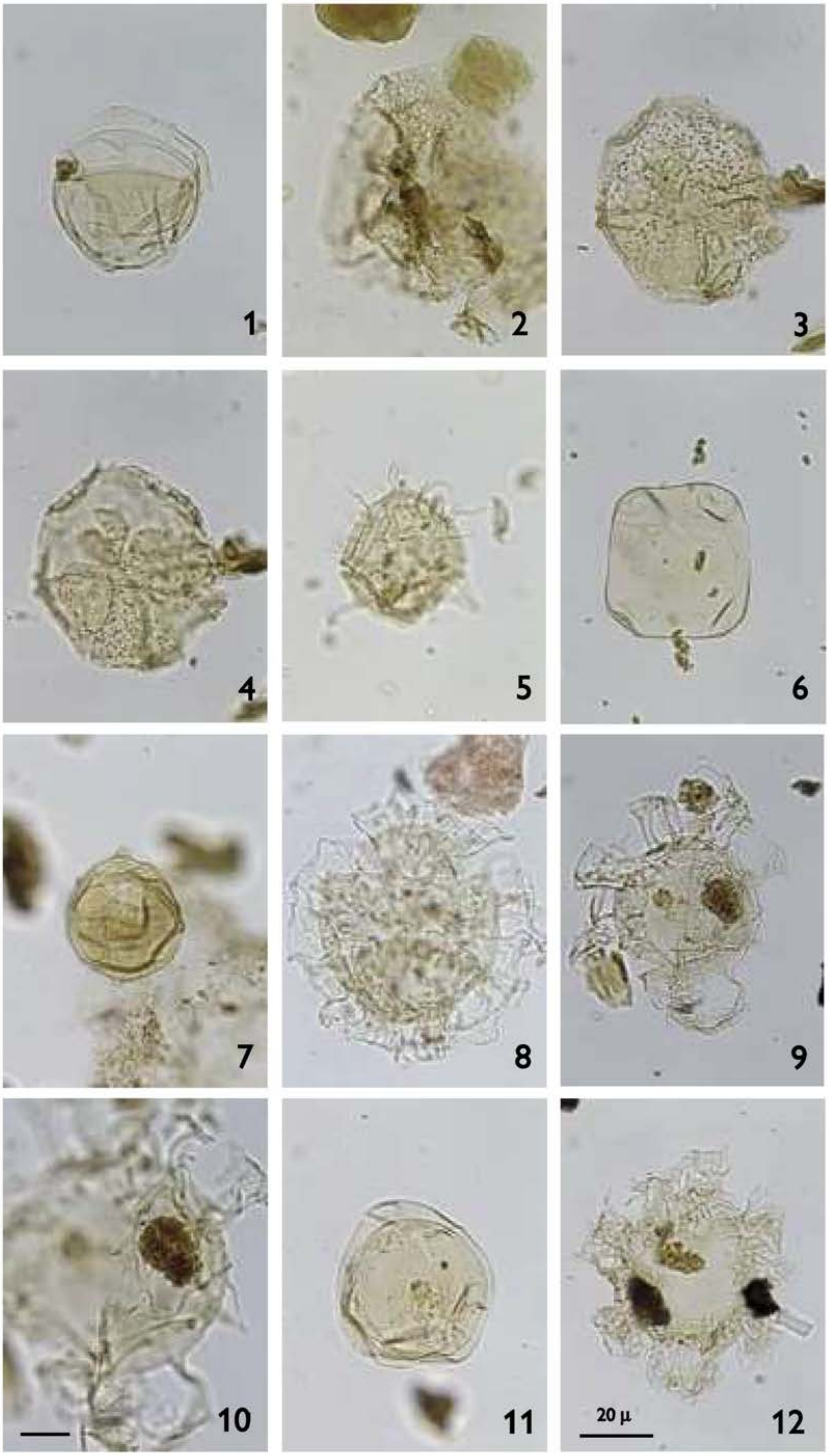
Correlation of the Cretaceous to Palaeogene succession on the Labrador Shelf and offshore West Greenland. Red lines are chronostratigraphic corr. and blue lines are biostratigraphic corr. Well datum is an imaginary line 20 m above the youngest Palaeogene. Enclosure 9.

Plates 1–50

Illustrations of dinoflagellate cysts from Ogmund E-72, Skolp E-07 and Gjoa G-37

OGMUND - PLATE 1

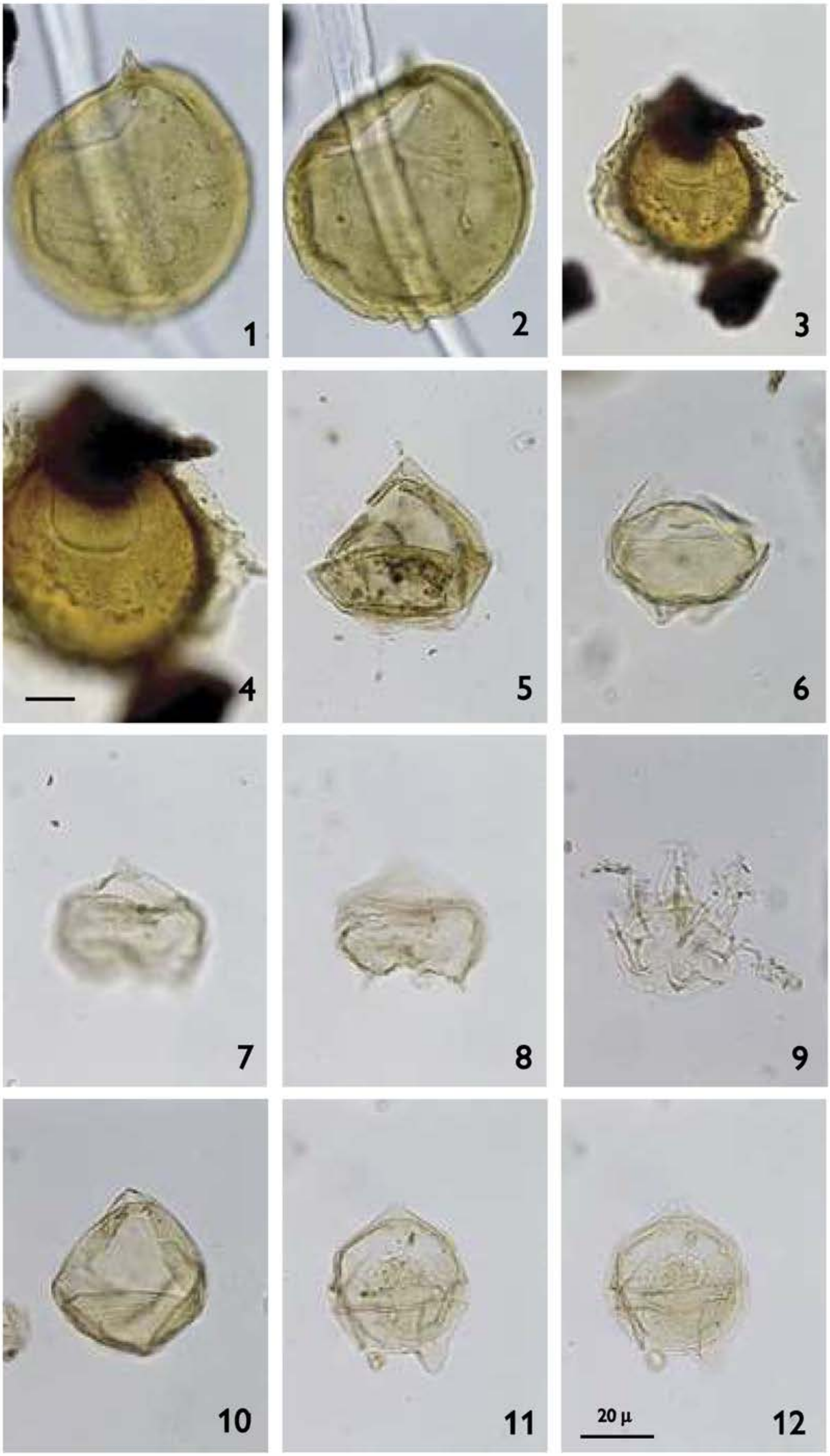
Fig. 1	*Deflandrea* cf. sp. 1 HNH 2002 44.0-109.5, 790m-2, LVR 25553
Fig. 2	*Heterosphaeridium porosa* 33.6-107.0, 790m-3, LVR 25555
Figs 3–4	*Phthanoperidinium coreoides/comatum* (Dino sp. 1 HNH 2003) 32.6-112.0, 840m-4, LVR 25558–59
Fig. 5	*Phthanoperidinium* sp. 20.4-95.9, 840m-5, LVR 25560
Fig. 6	*Tetraporina* sp. 45.6-101.8, 890m-2, LVR 25562
Fig. 7	*Phthanoperidinium geminatum* 28.7-99.0, 915m-5, LVR 25563
Fig. 8	*Glaphyrocysta “intritecta”?* 30.0-114.0, 940m-5, LVR 25565
Figs 9–10	*Glaphyrocysta texta?/“intritecta”?* 19.1-102.1, 965m-2, LVR 25567–68
Fig. 11	Dinocyst sp.1 HNH Ogmund 22.0-111.6, 915m-4, LVR 25570
Fig. 12	*Glaphyrocysta “intritecta”?* 25.4-107.8, 1030m-2 SWC, LVR 25571



Ogmund – Plate 1
1-2: 790 m; 3-5: 840 m;
6: 890 m; 7 & 11: 915 m;
8: 940 m; 9-10: 965 m; 12: 1030 m;
LVR: 25553-25571

OGMUND - PLATE 2

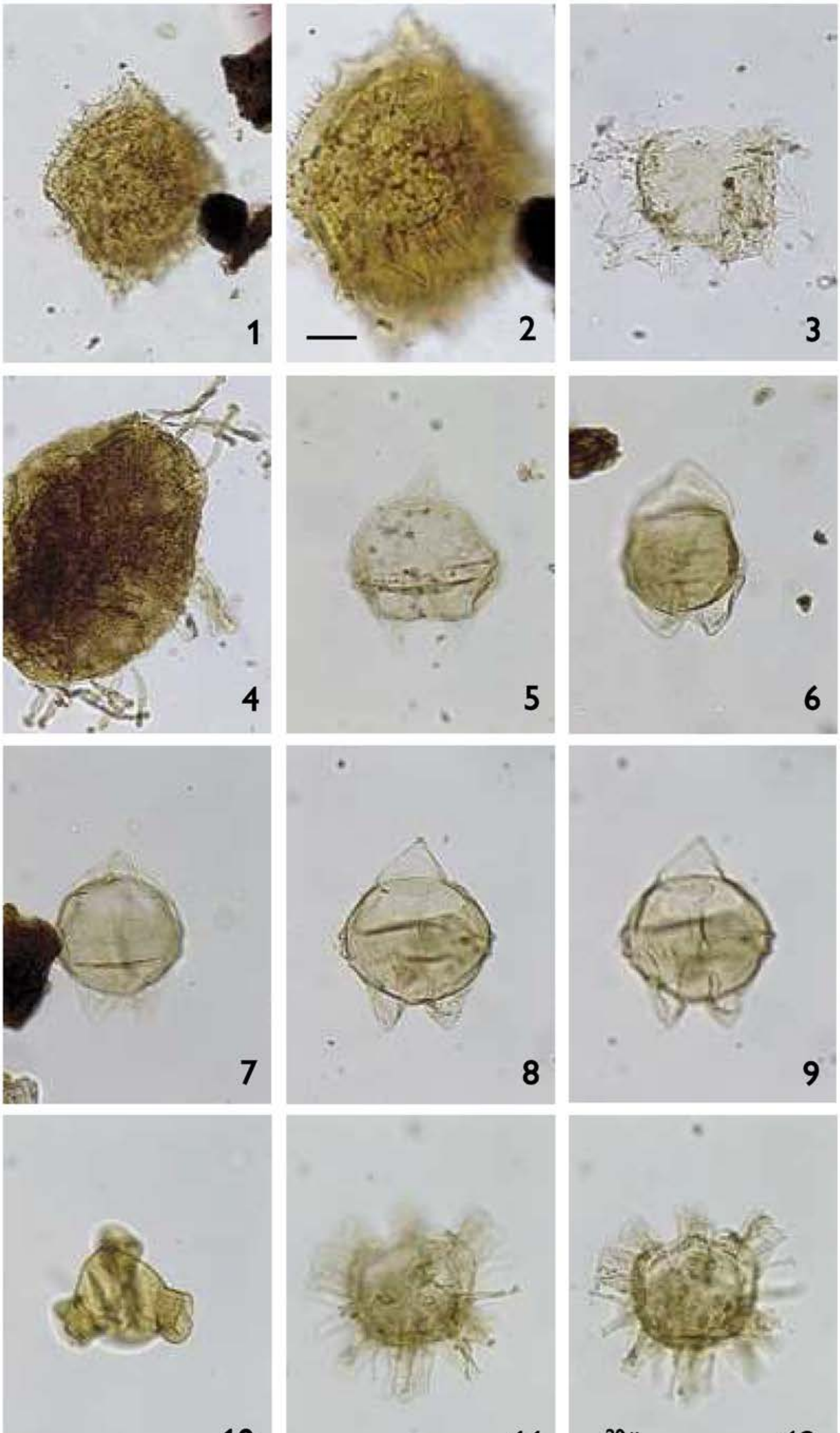
Figs 1–2	*Carpatella cornuta* (reworked) 20.1-104.9, 1090m-2 SWC, LVR 25573–74
Figs 3–4	*Dracodinium condylos* 30.5-111.3, 1090m-4 SWC, LVR 25575–76
Fig. 5	*Luxuadinium* sp. 21.0-111.4, 1140m-3, LVR 25578
Fig. 6	*Trithyrodinium* sp. 30.6-102.0, 1165m-4, LVR 25579
Figs 7–8	*Lentinia* aff. *serrata* 49.3-95.7, 1165m-4, LVR 25581–82
Fig. 9	*Cleithriasphaeridium polypetalum?* 39.6-101.0, 1165m-4, LVR 25584
Fig. 10	*Deflandrea* sp. HNH 31.8-93.7, 1185m-4, LVR 25585
Figs 11–12	*Deflandrea* sp.? HNH 32.4-97.0, 1190m-5, LVR 23903–904



Ogmund – Plate 2
1-4: 1090 m; 5: 1140 m;
6-9: 1165 m; 10: 1185 m;
11-12: 1190 m;
LVR: 25573-25585 & 23903-04

OGMUND - PLATE 3

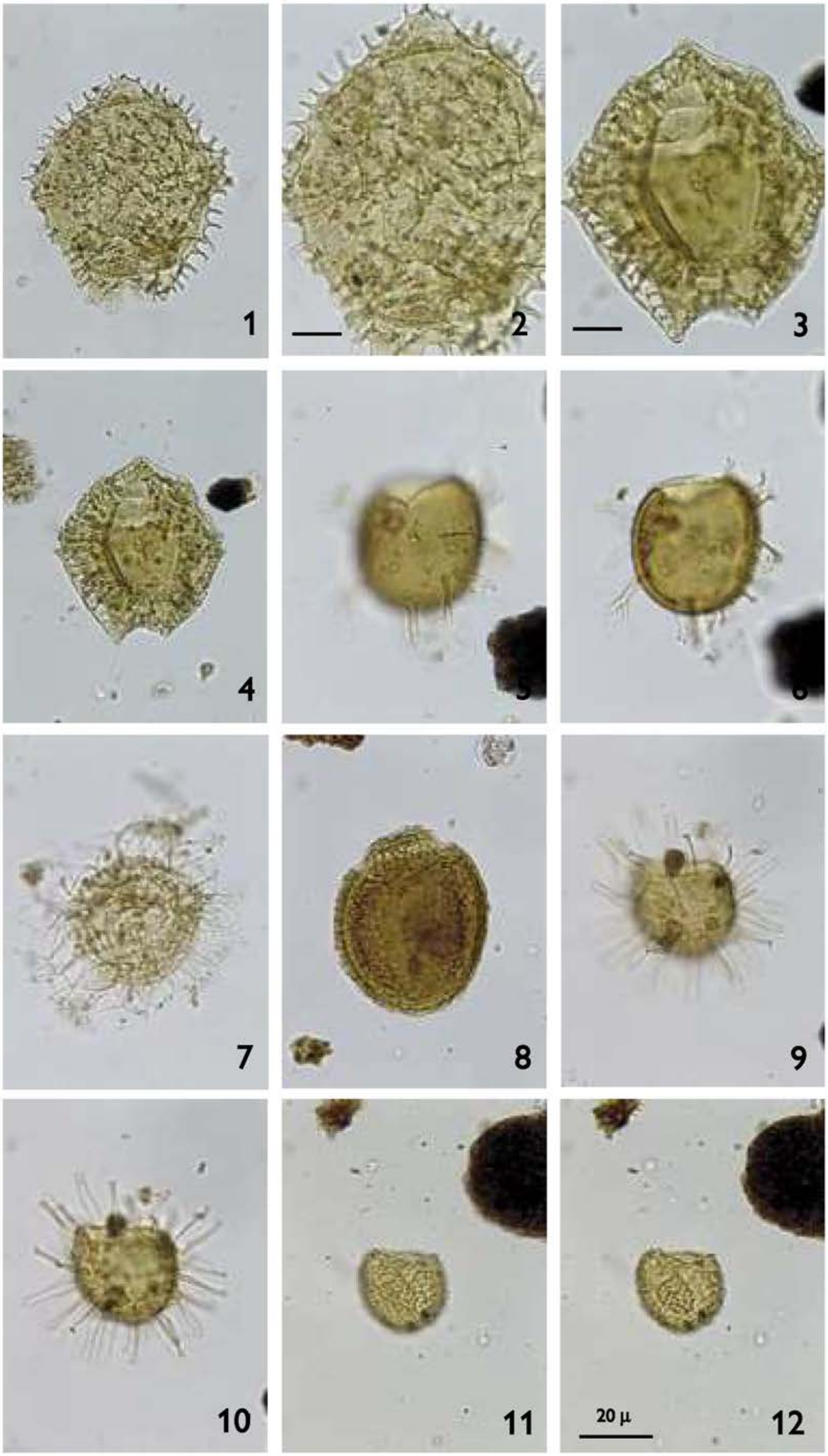
Figs 1–2	*Wetzeliella simplex* 15.4-103.0, 1190m-3, LVR 23905–906
Fig. 3	*Glaphyrocysta* cf. *pastilesii* 21.0-93.5, 1190m-4, LVR 23910
Fig. 4	*Azolla* sp. 32.5-104.9, 1190m-3, LVR 23914
Fig. 5	*Lentinia serrata?* 23.9-105.6, 1215m-4, LVR 23900
Fig. 6	*Deflandrea spinulosa* 32.3-99.0, 1265m-3, LVR 23897
Fig. 7	*Deflandrea spinulosa* 22.3-96.9, 1290m-2, LVR 23894
Figs 8–9	*Deflandrea spinulosa* 24.0-92.0, 1290m-2, LVR 23928–30
Fig. 10 *P*	*ollenites oculus* 18.0-95.6, 1290m-3, LVR 25588
Figs 11–12	*Hystrichocolpoma salicia* 20.4-106.9, 1290m-3, LVR 25590–91



Ogmund – Plate 3
1-4: 1190 m; 5: 1215 m;
6: 1265 m; 7-9: 1290 m;
10-12: 1290 m;
LVR: 23894-23930 & 25588-91

OGMUND - PLATE 4

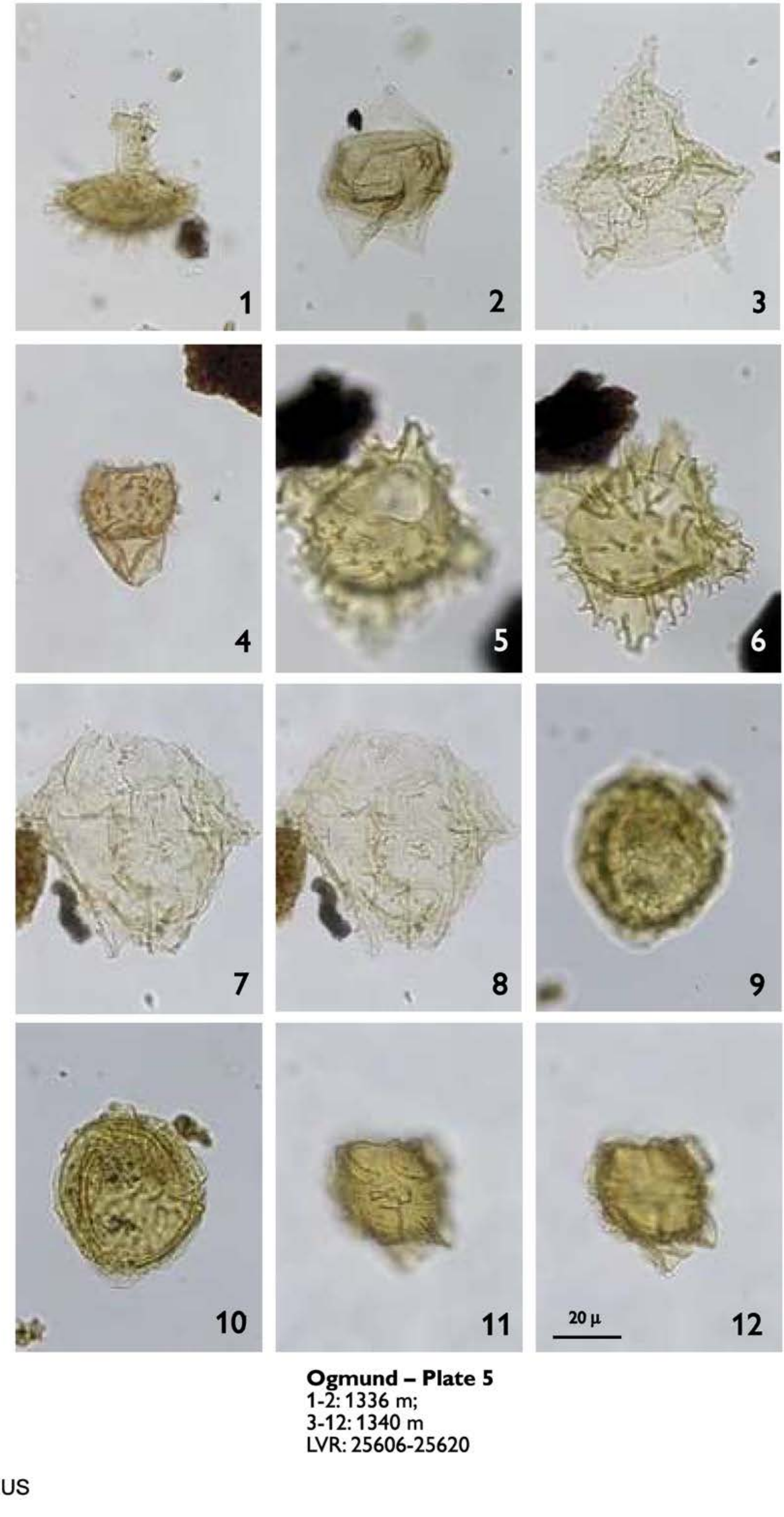
Figs 1–2	*Dracodinium* cf. *pachydermum* 25.6-107.0, 1290m-5, LVR 25592–93
Figs 3–4	*Charlesdowniea columna* 27.3-98.6, 1305m-4, LVR 22594–95
Figs 5–6	*Achomosphaera* sp.1 HNH Ogmund 29.2-96.1, 1305m-2, LVR 25596–97
Fig. 7	*Implectosphaeridium implicatum* 25.0-100.6, 1315m-5, LVR 25598
Fig. 8	*Pyxidiopsis waipawaensis* 45.2-100.0, 1336m-4, LVR 25599
Figs 9–10	*Dapsilidinium* cf. *pseudocolligerum* 41.0-95.6, 1336m-3, LVR 25600–601
Figs 11–12	*Cerebrocysta bartonensis* 39.8-107.7, 1336m-3, LVR 25604–605



Ogmund – Plate 4
1-2: 1290 m; 3-6: 1305 m;
7: 1315 m;
8-12: 1336 m;
LVR: 25592-25605

OGMUND - PLATE 5

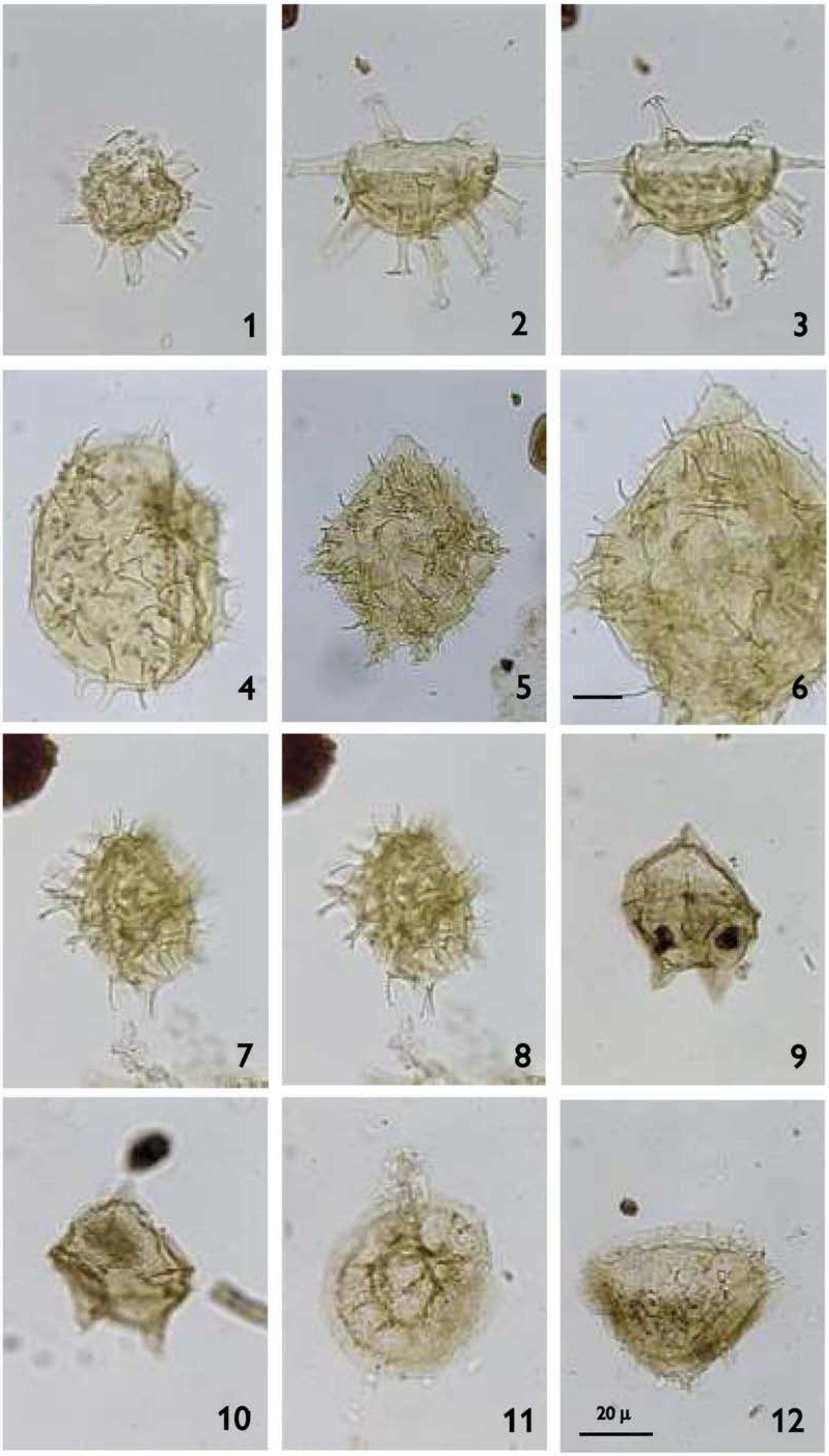
Fig. 1	*Lingulodinium machaerophorum* 42.0-108.1, 1336m-2, LVR 25606
Fig. 2	*Deflandrea spinulosa* 45.3-107.6, 1336m-2, LVR 25608
Fig. 3	*Deflandrea denticulata* 43.4-96.5, 1340m-3, LVR 25610
Fig. 4	*Diphyes brevispinosum* 16.2-108.5, 1340m-4, LVR 25611
Fig. 6	*Wetzeliella* sp. HNH Ogmund 20.1-110.1, 1340m-3, LVR 25612
Figs 7–8	*Dracodinium varielongitudum* 25.7-112.5, 1340m-3, LVR 25614–15
Figs 9–10	*Samlandia chlamydophora* 38.4-98.0, 1340m-3, LVR 25616–17
Figs11–12	*Hystrichokolpoma* sp. 1 Heilmann-Clausen 1989 21.6-101.6., 1340m-4, LVR 25618–20



Ogmund – Plate 5
1-2: 1336 m;
3-12: 1340 m
LVR: 25606-25620

OGMUND - PLATE 6

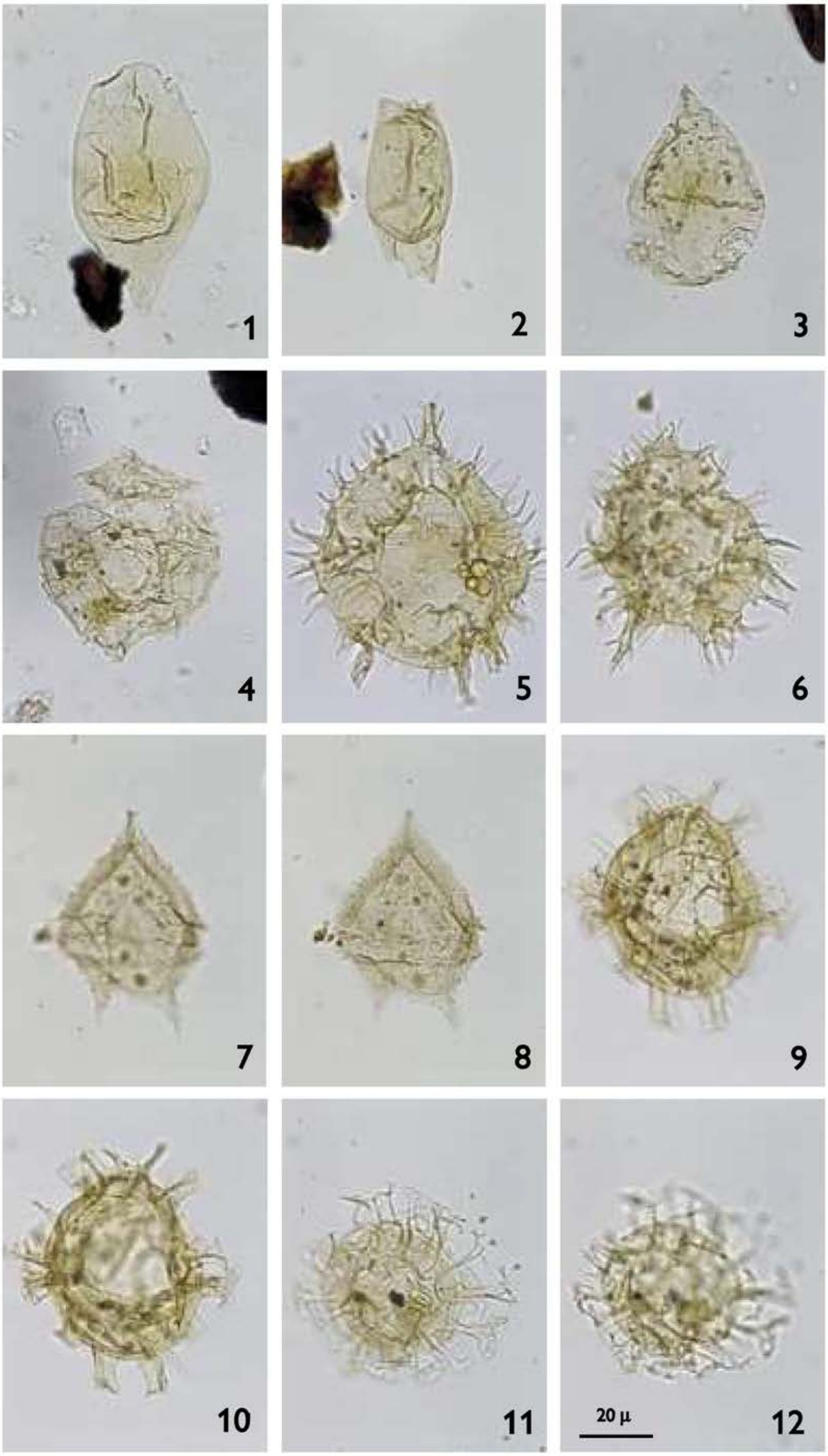
Fig. 1	*Diphyes colligerum* 24.0-93.6, 1340m-3, LVR 25621
Figs 2–3	*Homotryblium tenuispinosum* 24.6-105.5, 1365m-3, LVR 25622–23
Fig. 4	*Apteodinium* sp.?/*Wetzeliella* sp.? 32.3-98.0, 1365m-3, LVR 25624
Figs 5–6	*Wetzeliella* sp. 18.0-103.7, 1365m-4, LVR 25625–26
Figs 7–8	*Apteodinium homomorphum* 17.3-111.9, 1390m-4, LVR 25627–28
Fig. 9	*Cerodinium* sp. 41.1-113.7, 1391m-2 SWC, LVR 25629
Fig. 10	*Cerodinium* sp. 37.9-99.6, 1391m-2 SWC, LVR 25631
Fig. 11	*Dinopterygium* cf. *cladoides* 25.5-107.7, 1391m-2 SWC, LVR 25634
Fig. 12	*Dinopterygium* cf. *cladoides* 25.6-114.0, 1391m-2 SWC, LVR 25637



Ogmund – Plate 6
1: 1340 m;
2-6: 1365 m; 7-8: 1390 m;
9-12: 1391 m;
LVR: 25621-25637

OGMUND - PLATE 7

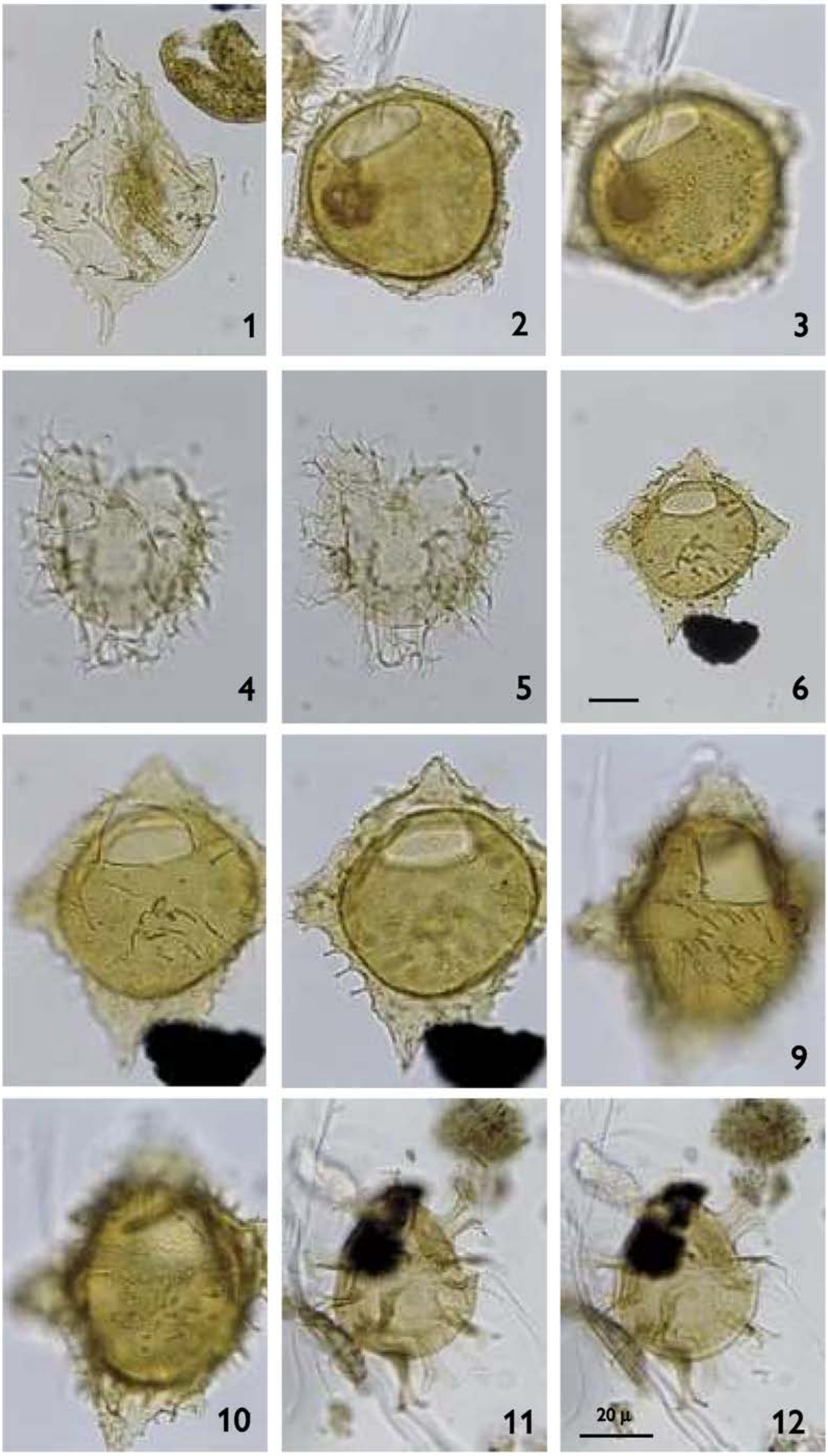
Fig. 1	*Svalbardella* sp. Ogmund 26.8-107.0, 1391m-2 SWC, LVR 25638
Fig. 2	*Svalbardella* cf. *hampdenensis* 24.1-92.1, 1391m-2 SWC, LVR 25639
Fig. 3	*Svalbardella* sp. Ogmund 39.0-95.2, 1391m-2 SWC, LVR 25640
Fig. 4	*Senoniasphaera* sp. Ogmund (or *Membranilarnacia* sp. cf. *Eatonicysta* De Coninck, 1996 Pl 4 Figs 1–7) 19.5-95.6, 1420m-2 SWC, LVR 25641
Fig. 5	*Apteodinium parvum* 21.7-113.1, 1440m-3, LVR 25642
Fig. 6	*Apteodinium parvum* 17.0-100.9, 1440m-3, LVR 25643
Figs 7–8	*Spinidinium* aff. *sagittula* 16.7-107.6, 1440m-3, LVR 25644–45
Figs 9–10	*Fibrocysta bipolaris* 21.2-98.8, 1440m-3, LVR 25648–49
Figs 11–12	*Enneadocysta* sp. ? 43.3-107.0, 1440m-3, LVR 25650–51



Ogmund – Plate 7
1-3: 1391 m;
4: 1420 m;
5-12: 1440 m;
LVR: 25638-25651

OGMUND - PLATE 8

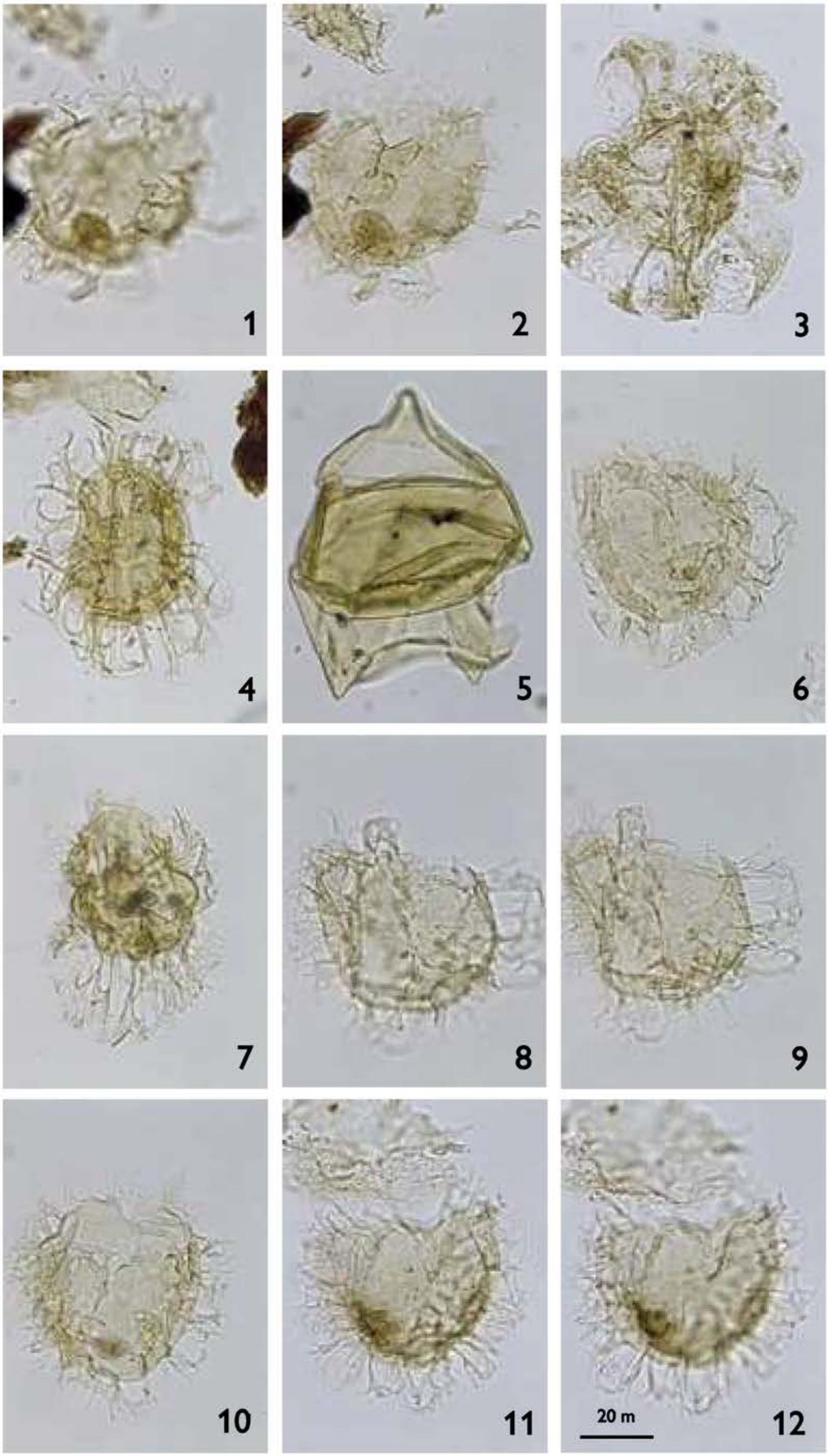
Fig. 1	*Dioxia* sp.? 37.1-106.4, 1440m-3, LVR 25652
Figs 2–3	*Dracodinium condylos* 43.0-96.8, 1440m-3, LVR 25653–54
Figs 4–5	*Areoligera senonensis* 29.7-93.0, 1440m-3, LVR 25655–56
Figs 6–8	*Dracodinium varielongitudum* 29.6-98.1, 1455m-3, LVR 25657–59
Figs 9–10	*Dracodinium varielongitudum* 26.5-95.9, 1455m-4, LVR 25660–61
Figs 11–12	*Fibrocysta bipolaris* 15.4-96.2, 1455m-1, LVR 25663–64



Ogmund – Plate 8
1-5: 1440 m;
6-12: 1455 m;
LVR: 25652-25664

OGMUND - PLATE 9

Figs 1–2	*Areoligera medusettiformis* 20.5-103.0, 1465m-3, LVR 25665–66
Fig. 3	*Eatonicysta* cf. *ursulae* 45.2-97.0, 1465m-2, LVR 25667
Figs 4–5	*Areoligera senonensis* 29.7-93.0, 1440m-3, LVR 25655–56
Fig. 6	*Glaphyrocysta pastielsii/exuberans?* 20.5-97.9, 1490m-3, LVR 25671
Fig. 7	*Glaphyrocysta pastielsii/exuberans?* 17.8-96.0, 1490m-3, LVR 25672
Figs 8–9	*Areoligera medusettiformis* 18.0-96.4, 1490m-3, LVR 25673–74
Fig. 10	*Areoligera senonensis* 19.0-112.5, 1490m-3, LVR 25675
Figs 11–12	*Glaphyrocysta ordinata/”preordinata”* 18.8-109.8, 1490m-3, LVR 25676–77



Ogmund – Plate 9
1-5: 1465 m;
6-12: 1490 m;
LVR: 25665-25678

OGMUND - PLATE 10

Fig. 1 *S*	*Pinidinium* aff. *sagittula* 27.0-109.9, 1490m-3, LVR 25679
Figs 2–3	*Thalassiphora patula/ Muratodinium fimbriatum* 28.0-99.6, 1490m-3, LVR 25680–81
Figs 4–5	*Wetzeliellla meckelfeldensis* 28.0-106.5, 1490m-3, LVR 25682–83
Fig. 6	*Apectodinium* cf. *augustum* 35.6-112.0, 1490m-4, LVR 25684
Fig. 7	*Areoligera senonensis/"circumsenonensis"* 19.7-95.8, 1515m-3, LVR 25690
Fig. 8	*Alisocysta margarita* 34.2-98.9, 1515m-3, LVR 25691
Figs 9–10	*Glaphyrocysta* sp. 37.8-109.2, 1515m-3, LVR 25693–94
Figs 11–12	*Glaphyrocysta* sp. 32.6-102.1, 1515m-3, LVR 25695–96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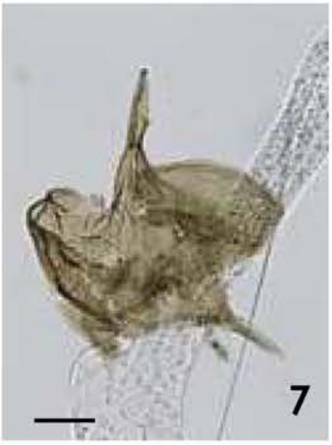
Ogmund – Plate 10
1-6: 1490 m;
7-12: 1515 m;
LVR: 25679-25696

OGMUND - PLATE 11

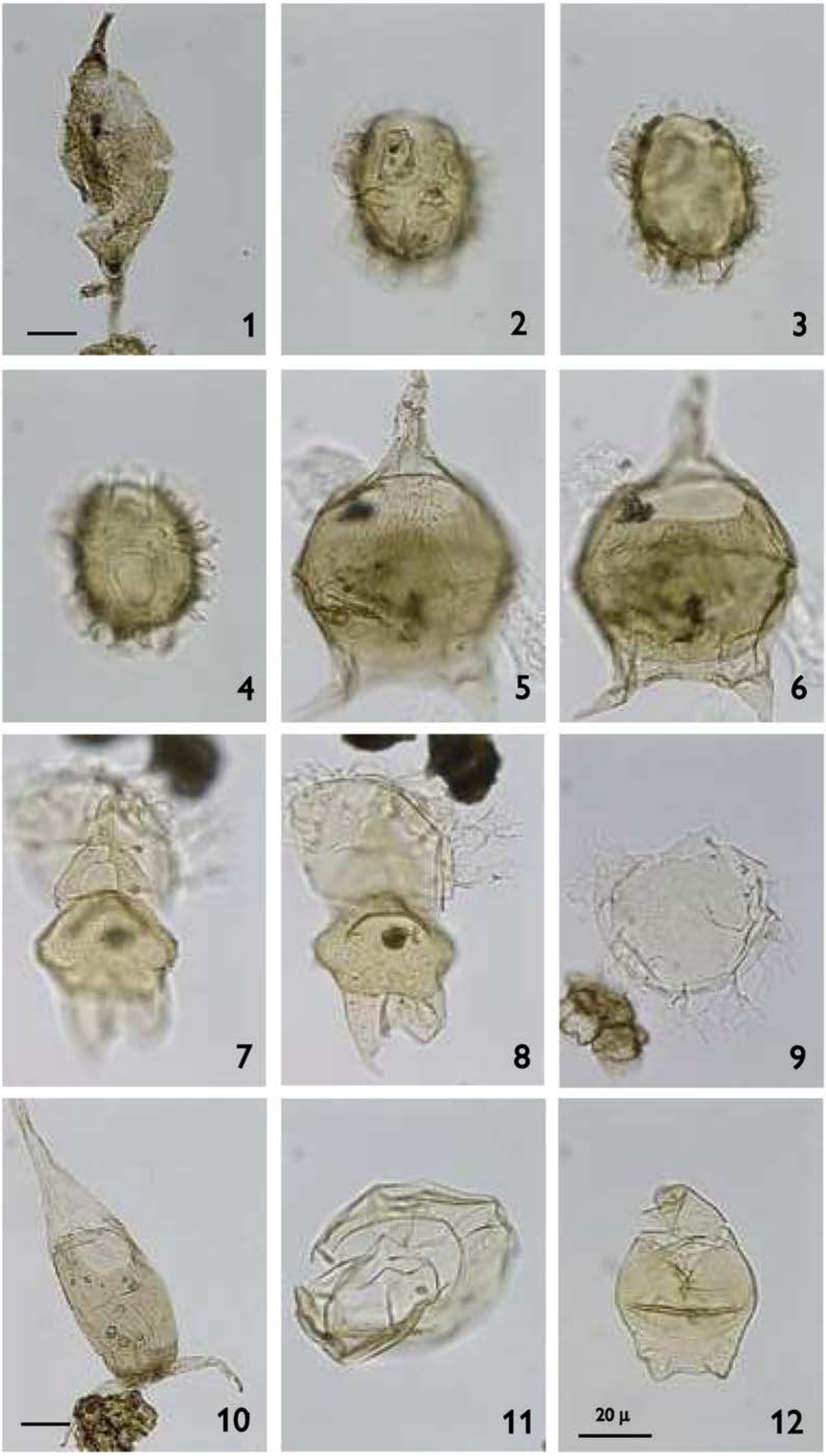
Fig. 1	*Laciniadinium arcticum* (reworked) 23.6-98.0, 1530m-3, LVR 25697
Fig. 2	*Isabelidinium bujakii* 29.6-102.1, 1530m-3, LVR 25698
Fig. 3	*Cerodinium diebelii* (small) 33.4-99.0, 1530m-3, LVR 25699
Fig. 4	*Cerodinium diebelii/leptodermum* (large) 29.9-105.2, 1530m-3, LVR 25700
Fig. 5	*Caligodinium aceras* 30.5-105.7, 1530m-3, LVR 25701
Fig. 6	*Palyperidinium pyrophorum* 29.5-104.8, 1530m-3, LVR 25702
Fig. 7	*Phelodinium kozlowskii* 31.0-104.6, 1530m-3, LVR 25703
Figs 8–9	*Trithyrodinium evittii* 42.3-92.5, 1530m-3, LVR 25704–705
Fig. 10	*Glaphyrocysta pastielsii* 35.8-110.1, 1530m-3, LVR 25706
Fig. 11	*Impagidinium* cf. *dispertitum* 37.3-94.2, 1530m-3, LVR 25707
Fig. 12	*Glaphyrocysta* sp. 37.6-111.3, 1515m-3, LVR 25708



Ogmund – Plate 11
1-12: 1530 m;
LVR: 25697-2570

OGMUND - PLATE 12

Fig. 1	*Palaeocystodinium bulliforme* 39.7-100.0, 1530m-3, LVR 25710
Figs 2–4	*Alisocysta circumtabulata* 41.4-92.6, 1530m-3, LVR 25711–13
Figs 5–6	*Cerodinium striatum* 44.6-104.6, 1530m-3, LVR 25714–15
Figs 7–8	*Isabelidinium belfastense* 28.5-102.8, 1545m-3, LVR 25717–18
Fig. 9	*Glaphyrocysta* sp. 21.0-107.1, 1545m-3, LVR 25720
Fig. 10	*Cerodinium diebelii/leptodermum* (large) 23.4-103.5, 1545m-3, LVR 25721
Fig. 11	*Thalassiphora inflata/delicata* 21.7-95.5, 1545m-3, LVR 25622
Fig. 12	*Isabelidinium cooksoniae* 22.1-105.4, 1545m-3, LVR 25623



Ogmund – Plate 12
1-9: 1530 m;
10-12: 1545 m;
LVR: 25710-25723

OGMUND - PLATE 13

Fig. 1	*Fromea fragile* 24.0-100.9, 1545m-3, LVR 25724
Fig. 2	*Oligosphaeridium pulcherrimum* 26.4-109.0, 1545m-3, LVR 25725
Figs 3–4	*Hystrichosphaeropsis quasicribrata* 31.4-103.1, 1545m-3, LVR 25726–27
Figs 5–6	*Hystrichosphaeridium tubiferum/brevispinum* 39.7-110.0, 1545m-3, LVR 25728–29
Figs 7–8	*Thalassiphora patula/ Disphaerogena carposphaeropsis* 29.6-103.8, 1545m-3, LVR 25730–31
Fig. 9	*Palaeocystodinium bulliforme* 30.6-110.6, 1545m-4, LVR 25732
Fig. 10	*Caligodinium aceras* 29.4-109.6, 1545m-4, LVR 25733
Fig. 11	*Laciniadinium arcticum* 33.5-106.6, 1545m-4, LVR 25734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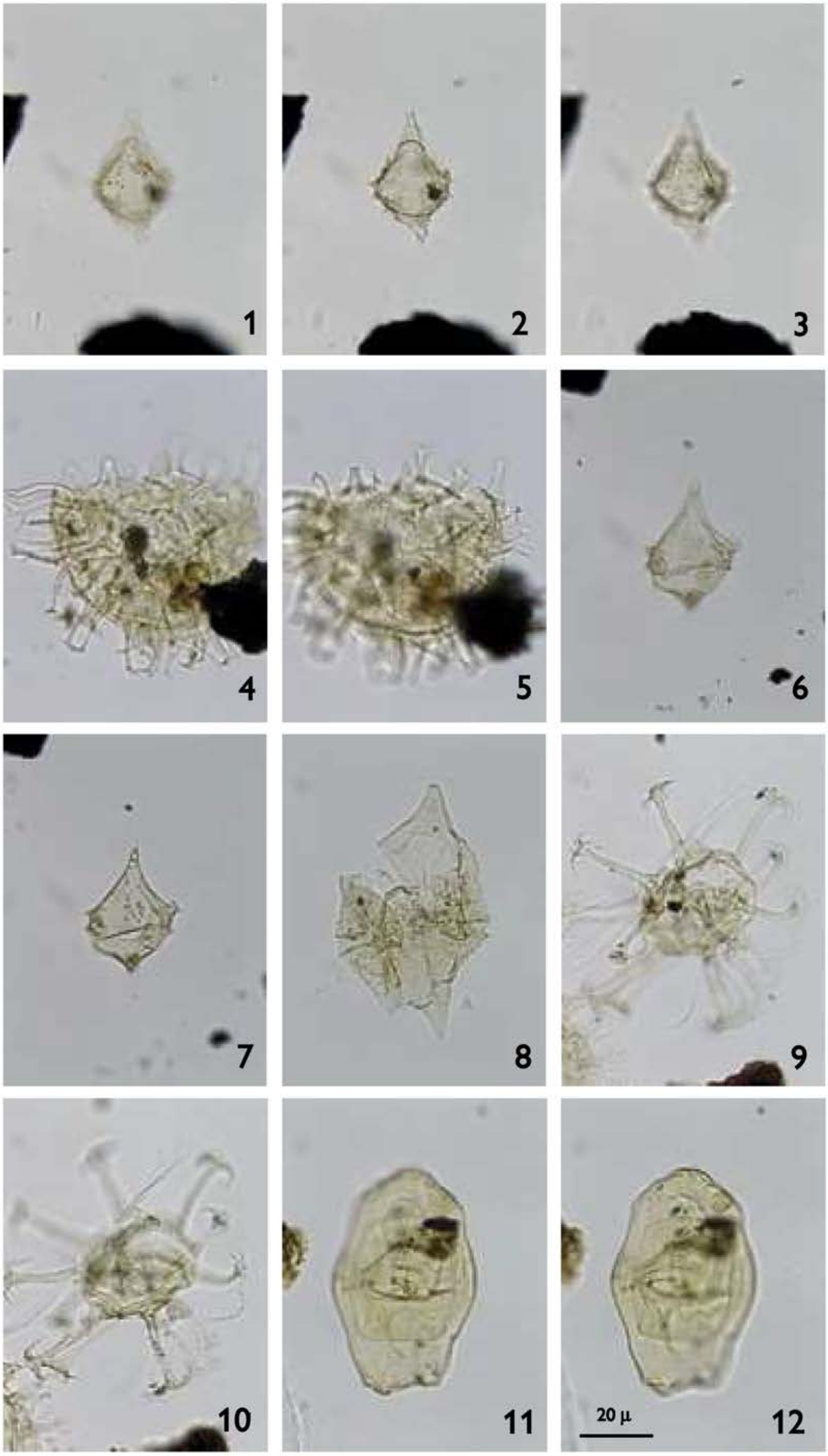
Ogmund – Plate 13
1-12: 1545 m;
LVR: 25724-25734

OGMUND - PLATE 14

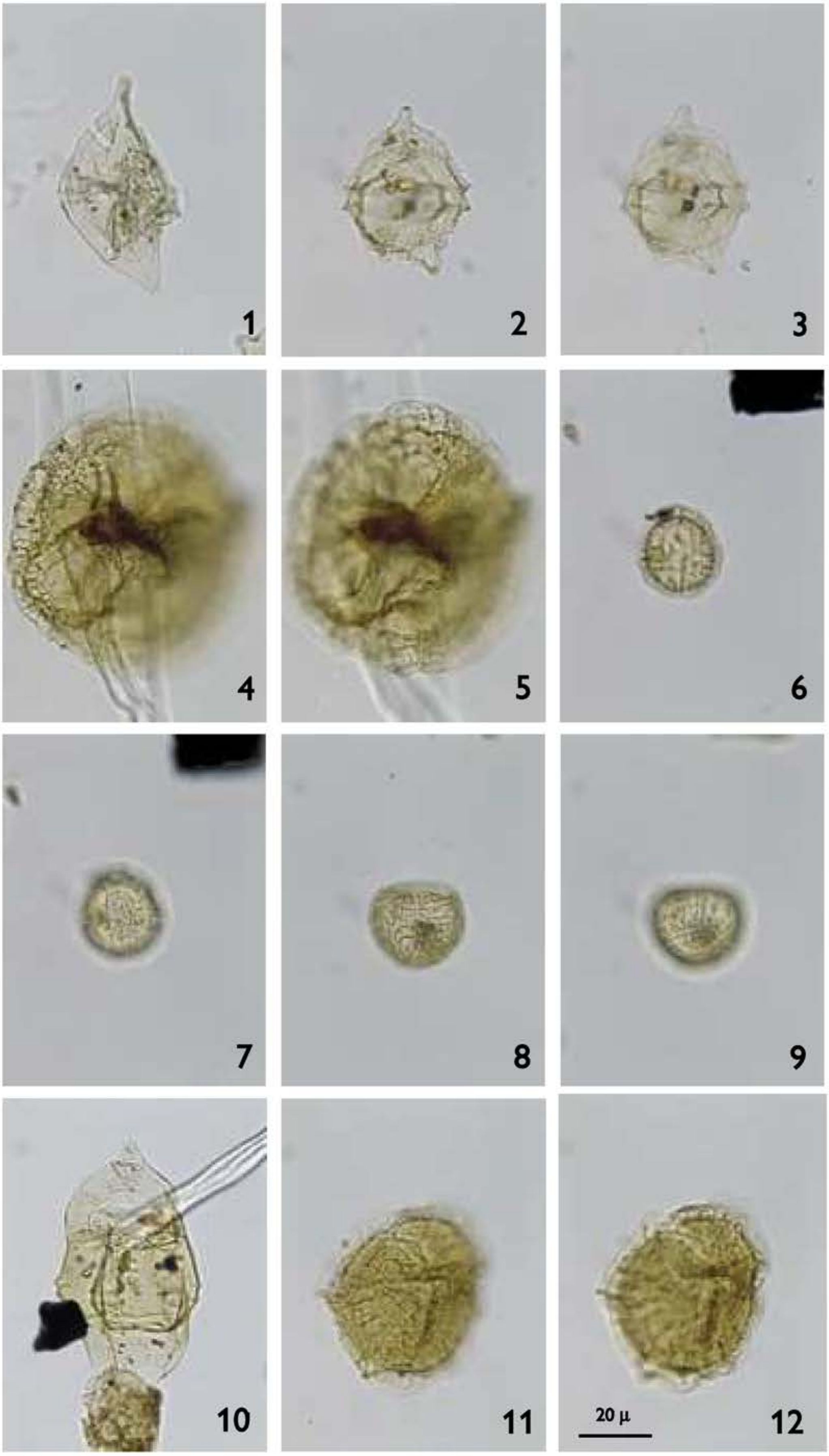
Figs 1–3	*Spinidinium* cf. *echinoideum* 37.3-108.0, 1605m-3, LVR 25760–62
Figs 4–5	*Heterosphaeridium heteracanthum* 43.7-111.6, 1605m-3, LVR 25763–64
Figs 6–7	*Laciniadinium arcticum* 24.1-98.1, 1620m-3, LVR 25765–66
Fig. 8	*Chatangiella* sp. 28.4-110.2, 1620m-3, LVR 25767
Figs 9–10	*Oligosphaeridium complex* 30.2-99.0, 1620m-3, LVR 25768–69
Figs 11–12	*Isabelidinium* sp. 32.1-101.3, 1620m-3, LVR 25770–71



Ogmund – Plate 14
1-4: 1605 m;
5-12: 1620 m;
LVR: 25760-25771

OGMUND - PLATE 15

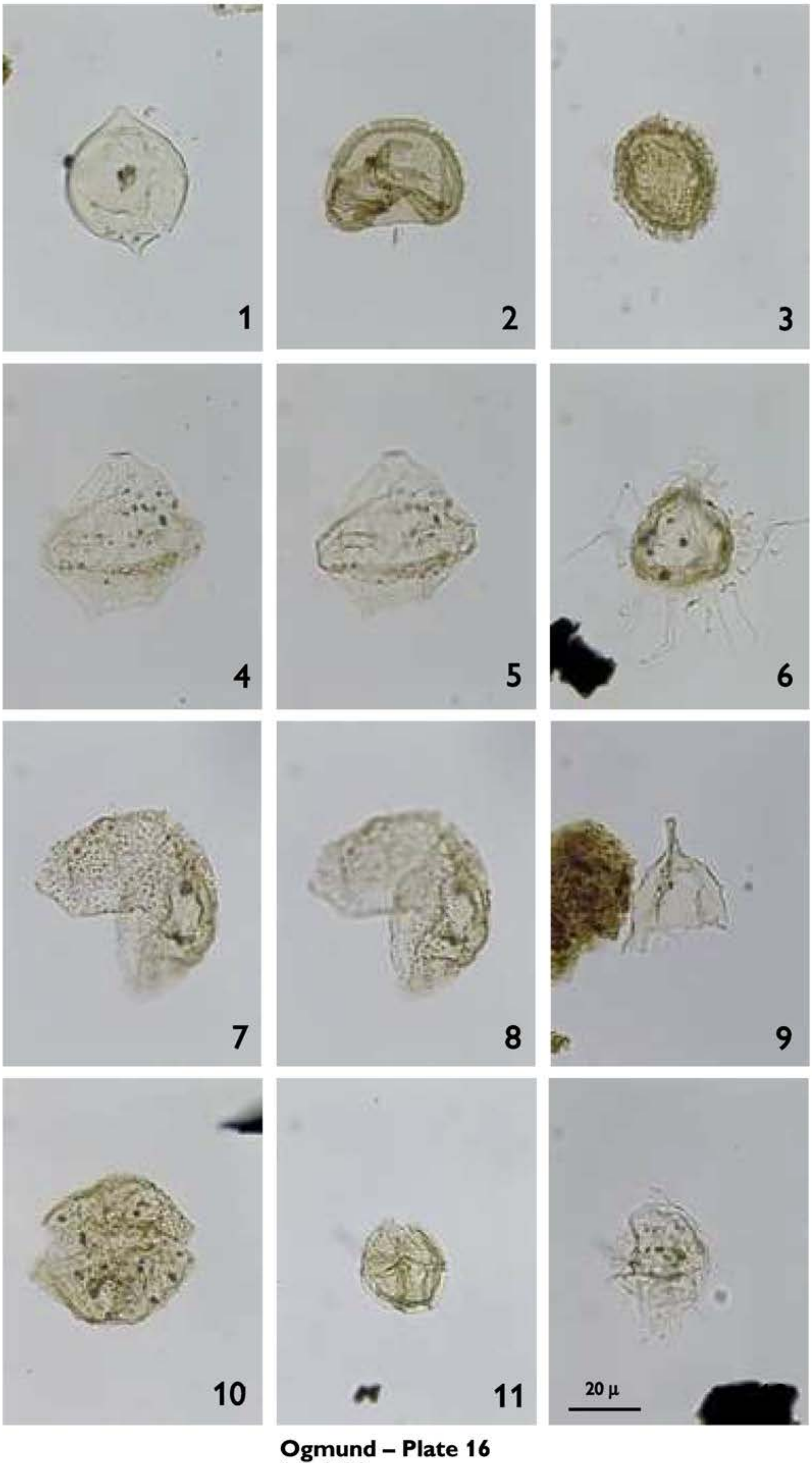
Fig. 1	*Alterbidinium acutulum* 47.5-106.0, 1620m-3, LVR 25772
Figs 2–3	*Chatangiella* cf. *madura* 46.3-107.3, 1620m-3, LVR 25773–74
Figs 4–5	*Scriniodinium obscurum* 49.4-105.1, 1620m-3, LVR 25775–76
Figs 6–7	*Histiocysta palla* 25.4-104.5, 1620m-4, LVR 25777–78
Figs 8–9	*Histiocysta palla* 37.0-98.7, 1620m-4, LVR 25779–80
Fig. 10	*Chatangiella ditissima* 43.7-101.0, 1620m-4, LVR 25781
Figs 11–12	*Senoniasphaera* sp. ? 29.3-94.0, 1620m-4, LVR 25784–85



Ogmund – Plate 15
1-12: 1620 m;
LVR: 25772-25786

OGMUND - PLATE 16

Fig. 1	*Isabelidinium* sp. 37.6-97.0, 1620m-4, LVR 25787
Fig. 2	*Selenopemphix* sp. (caved) 46.6-96.5, 1620m-4, LVR 25788
Fig. 3	*Chlamydophorella* cf. *nyeii* 19.5-110.5, 1620m-5, LVR 25789
Figs 4–5	*Alterbidinium* sp. 29.0-112.3, 1635m-3, LVR 25790–91
Fig. 6	*Hystrichodinium pulchrum* 34.0-113.2, 1635m-3, LVR 25792
Figs 7–8	*Trithyrodinium* sp.? 44.0-106.7, 1635m-4, LVR 25793–94
Fig. 9	*Isabelidinium microarmum* 28.0-102.0, 1650m-3, LVR 25795
Fig. 10	*Trithyrodinium* sp.? 26.0-100.4, 1650m-3, LVR 25796
Fig. 11	*Fibradinium annetorpense* 27.3-112.0, 1650m-3, LVR 25799
Fig. 12	*Palaeohystrichophora infusorioides* 27.0-104.1, 1680m-4, LVR 25800



Ogmund – Plate 16
1-3: 1620 m;
4-7: 1635 m; 8-11: 1650 m;
12: 1680 m;
LVR: 25787-25800

OGMUND - PLATE 17

Fig. 1 *Trithyrodinium* sp.? 16.5-106.9, 1695m-3, LVR 25801

Fig. 2 *Hazaria sheopariae* 18.5-108.4, 1755m-3, LVR 25802

Fig. 3 *Hazaria sheopariae* 22.5-98.7, 1755m-3, LVR 25803

Fig. 4 *“Levisporites”* 17.5-111.0, 1785m-3, LVR 25804

Fig. 5 *Rugubivesiculites rugusus* 24.9-101.0, 1785m-3, LVR 25805

Fig. 6 *Ornamentifera baculata* 48.0-99.6, 1815m-3, LVR 25806

Fig. 7 Spore? 45.6-103.0, 1815m-3, LVR 25807

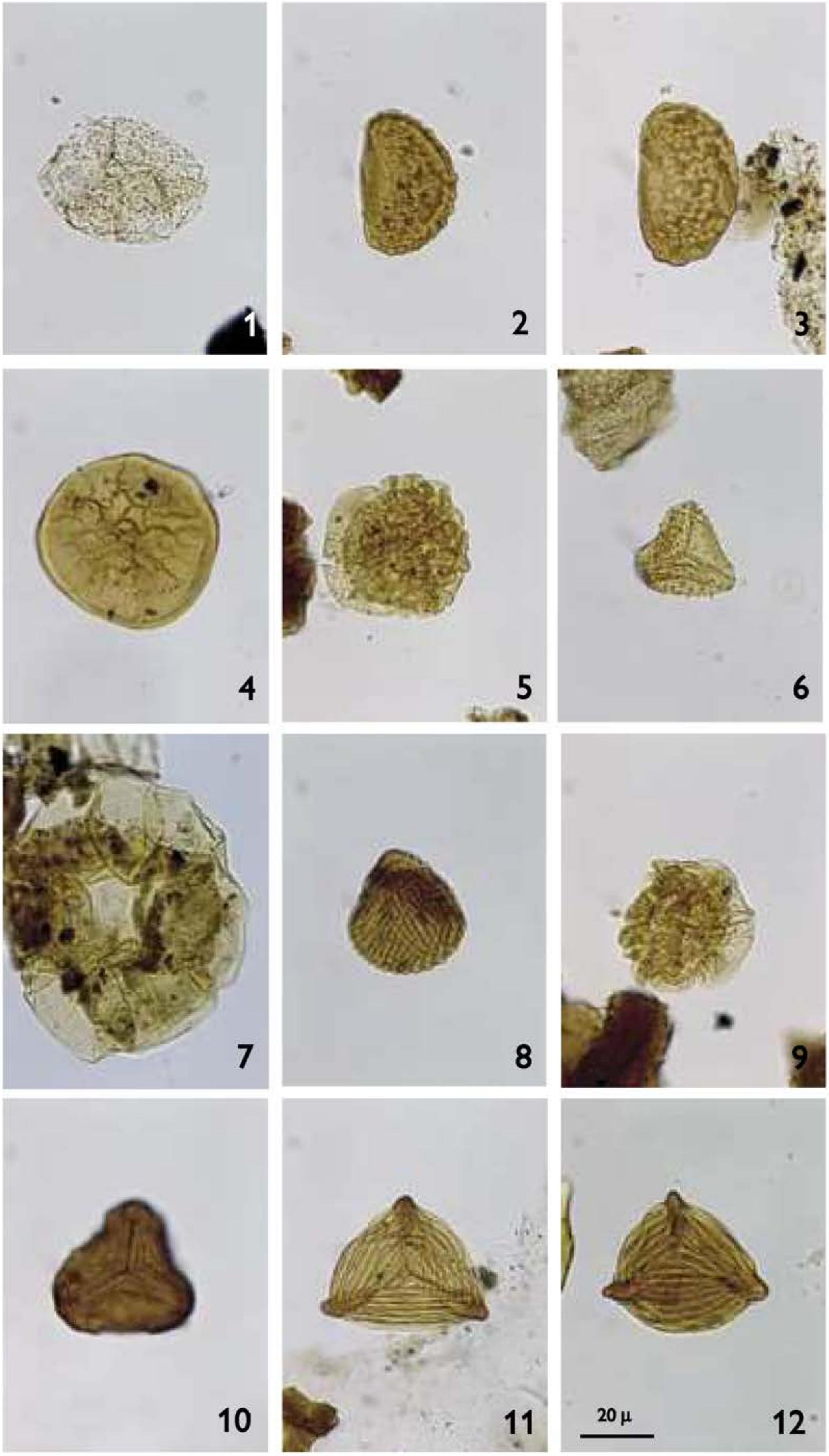
Fig. 8 *Cicatricosisporites annalatus* 19.0-112.5, 1815m-3, LVR 25808

Fig. 9 *Rugubivesiculites rugusus* 26.7-97.1, 1830m-3, LVR 25809

Fig. 10 *Vemiculites* sp. 27.3-111.7, 1830m-3, LVR 25810

Fig. 11 *Appendicisporites* sp. 46.7-111.5, 1830m-3, LVR 25812

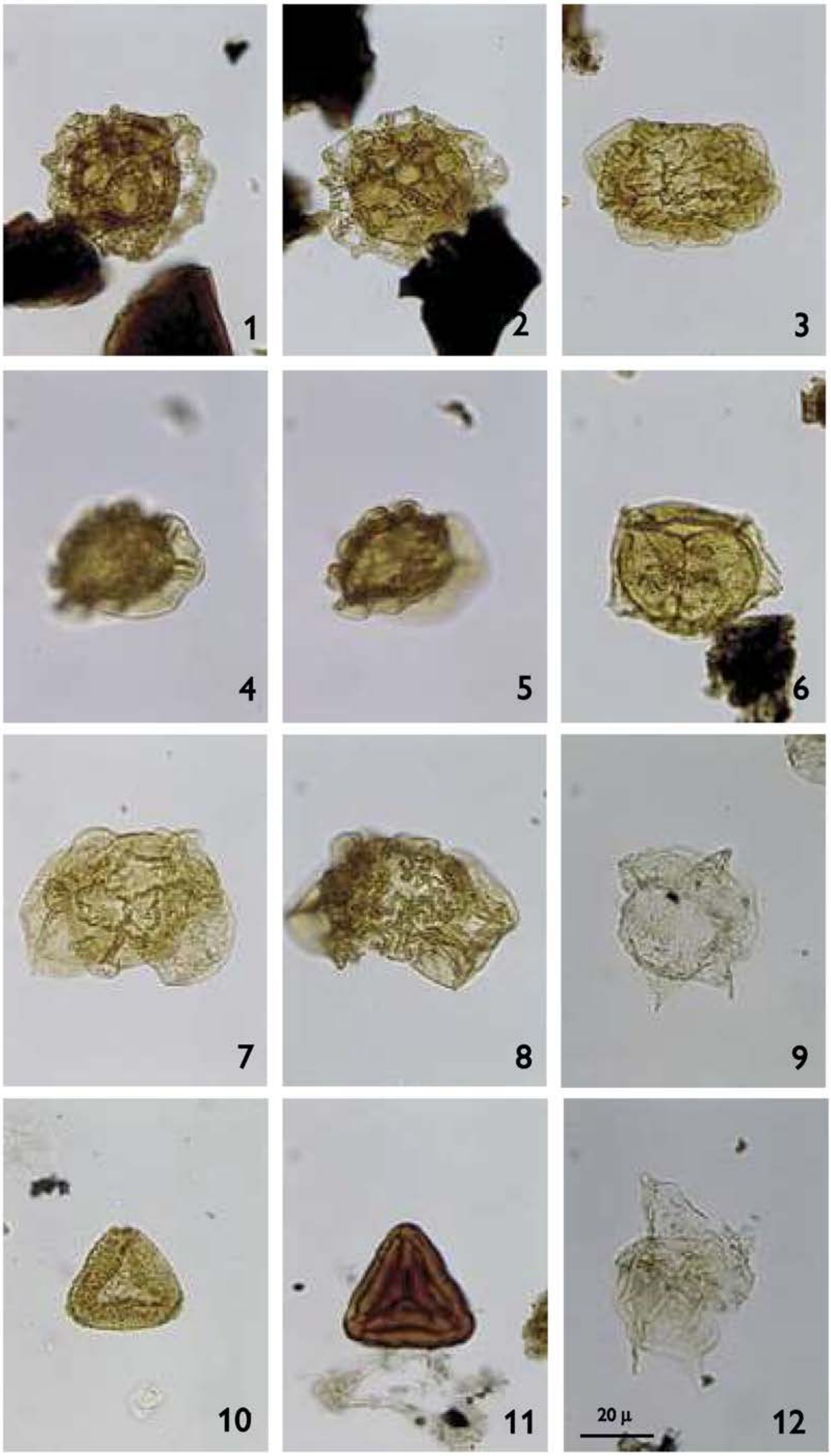
Fig. 12 *Appendicisporites potomacensis* 16.5-102.4, 1845m-3, LVR 25813



Ogmund – Plate 17
1: 1695 m; 2-3: 1755 m,
4-5: 1785 m; 6-8: 1815 m;
9-11: 1830 m;12: 1845 m;
LVR: 25787-25800

OGMUND - PLATE 18

Fig. 1	*Afropollis* sp.? 26.8-96.7, 1845m-3, LVR 25814
Fig. 2	*Afropollis* sp.? 26.4-101.8, 1845m-3, LVR 25815
Fig. 3	*Rugubivesiculites rugusus* 45.0-111.1, 1860m-3, LVR 25816
Fig. 4–5	*Rugubivesiculites rugusus* 49.6-113.6, 1860m-3, LVR 25817–18
Fig. 6	Trilete spore 38.5-98.4, 1860m-3, LVR 25819
Fig. 7	*Rugubivesiculites reductus* 34.4-103.0, 1875m-3, LVR 25820
Fig. 8	*Rugubivesiculites rugusus* 43.1-100.0, 1905m-3, LVR 25821
Fig. 9	*Quantouendinium dictyophorum* 48.9-112.4, 1920m-3, LVR 25822
Fig. 10	*Trilobosporites crasus* 39.4-100.1, 1935m-2, LVR 25823
Fig. 11	*Distaltriangulisporites perplexus* 18.7-106.9, 1935m-3, LVR 25824
Fig. 12	*Quantouendinium* sp. 32.8-108.0, 1935m-4, LVR 25825



Ogmund – Plate 18
1-2: 1845 m; 3-6: 1860 m;
7: 1875 m; 8: 1905 m;
9: 1920 m; 10-12: 1935 m;
LVR: 25814-25825

OGMUND - PLATE 19

Fig. 1	*Vesperopsis mayi* 30.7-94.0, 1950m-3, LVR 25826
Figs 2–3	*Quantouendinium* sp. 52.4-99.2, 1950m-3, LVR 25828–29
Figs 4–5	*Quantouendinium* sp. 36.4-93.6, 1950m-3, LVR 25830–31
Fig. 6	*Quantouendinium dictyophorum* 18.4-103.0, 1950m-4, LVR 25832
Fig. 7	*Quantouendinium* sp. 34.0-105.6, 1950m-5, LVR 25833
Fig. 8	*Rugubivesiculites rugusus* 23.8-113.6, 1965m-3, LVR 25834
Fig. 9	*Rugubivesiculites rugusus* 35.4-103.2, 1965m-3, LVR 25836
Figs 10–11	*Quantouendinium dictyophorum* 17.3-97.3, 1965m-3, LVR 25837–38
Fig. 12	*Quantouendinium dictyophorum* 23.8-100.8, 1965m-3, LVR 25839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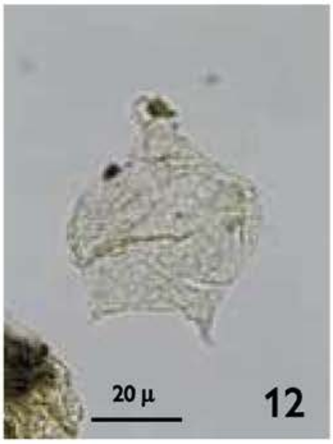

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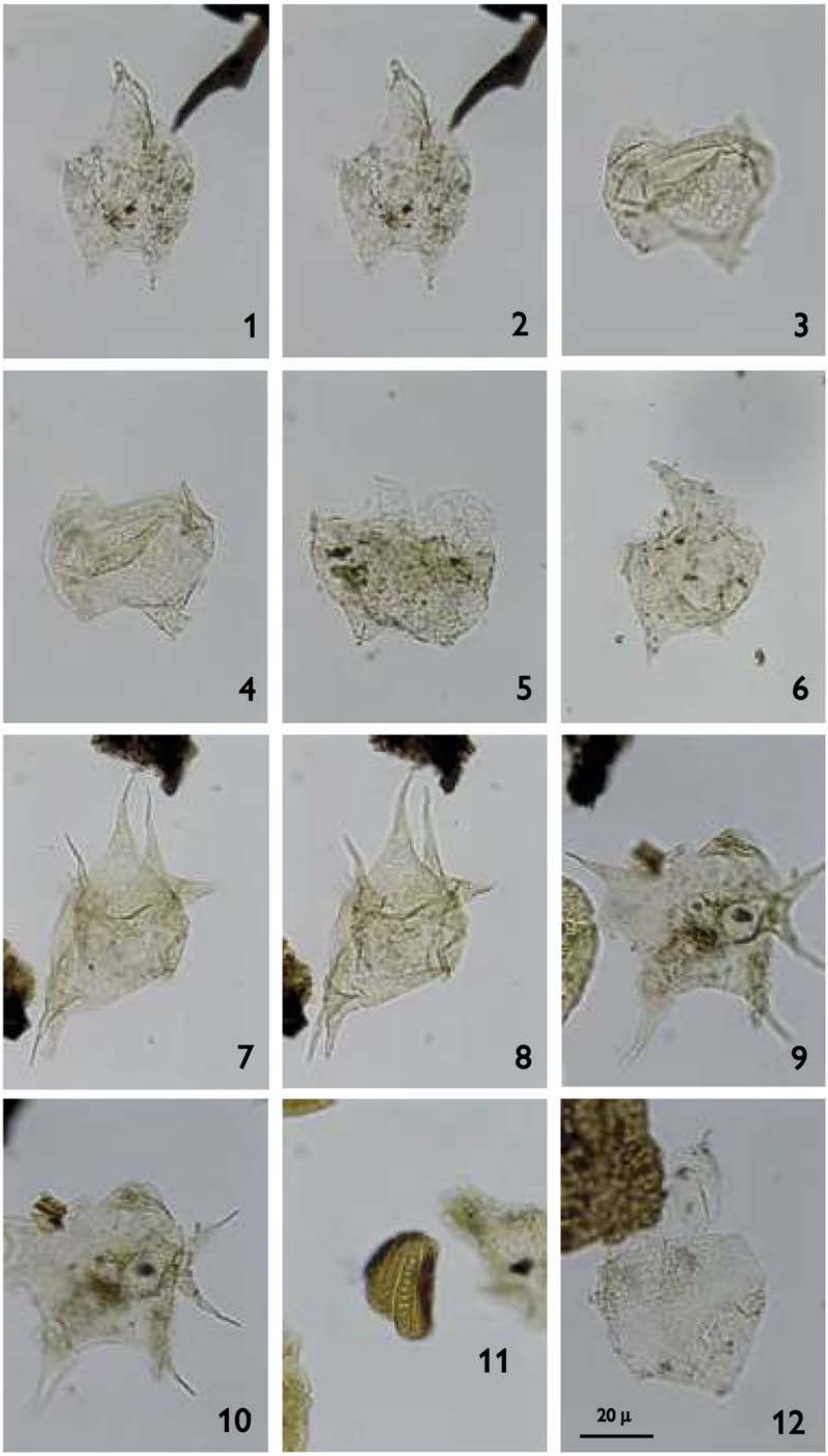
Ogmund – Plate 19
1-7: 1950 m;
8-12: 1965 m;
LVR: 25826-25839

OGMUND - PLATE 20

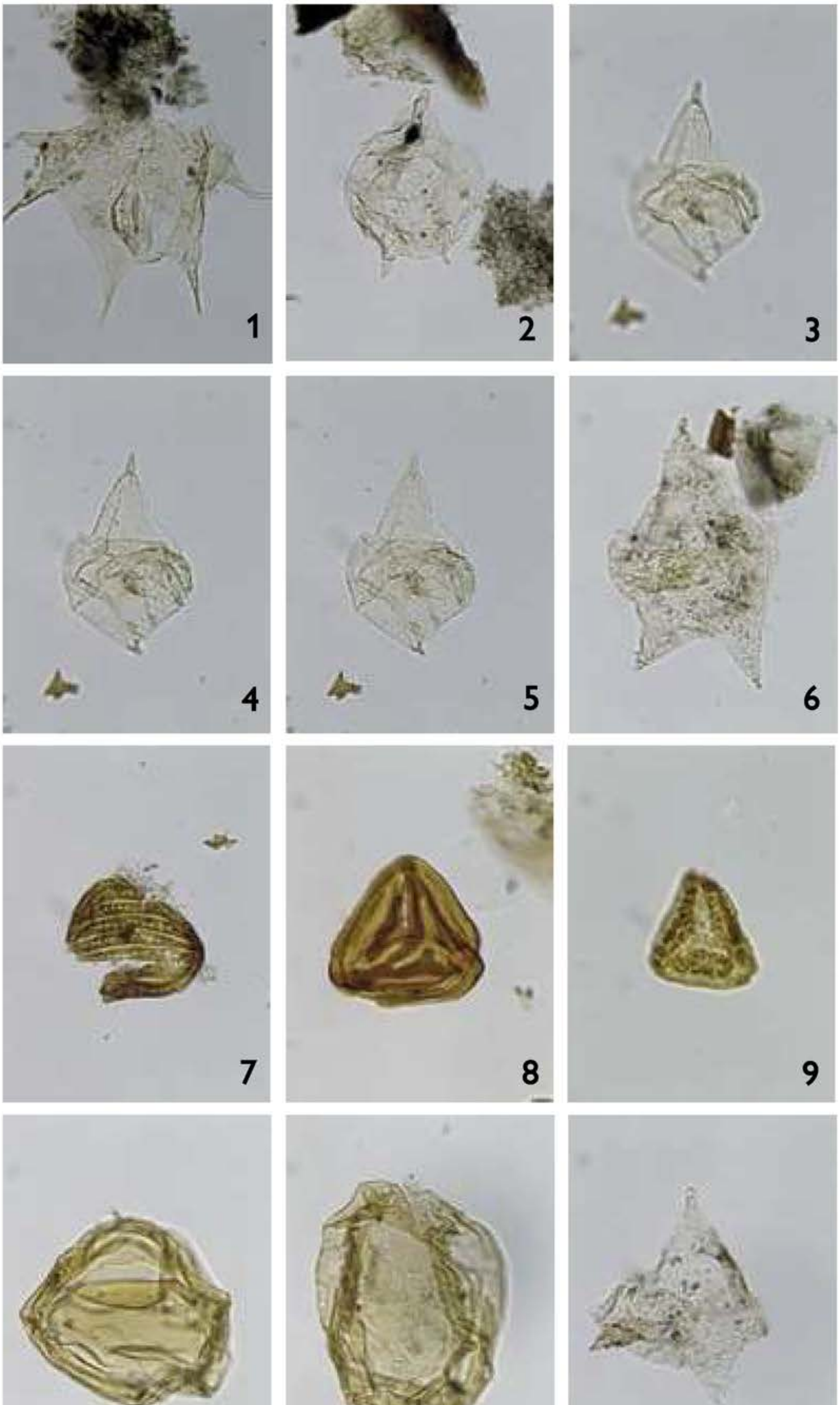
Figs 1–2	*Quantouendinium dictyophorum* 37.3-94.1, 1995m-3, LVR 25840–41
Figs 3–4	*Quantouendinium dictyophorum* 35.8-100.7, 1995m-6, LVR 25842–43
Fig. 5	*Quantouendinium dictyophorum* 27.7-111.9, 2010m-3, LVR 25844
Fig. 6	*Quantouendinium dictyophorum* 44.5-101.8, 2010m-3, LVR 25845
Figs 7–8	*Nyktericysta davisii* 47.6-100.0, 2010m-5, LVR 25846–47
Figs 9–10	*Nyktericysta davisii* 39.5-98.0, 2010m-5, LVR 25848–49
Fig. 11	*Costatoperforosporites foveolatus* 40.1-104.6, 2025m-3, LVR 25851
Fig. 12	*Quantouendinium dictyophorum* 19.8-106.0, 2025m-3, LVR 25852



Ogmund – Plate 20
1- 4: 1995 m;
5-10: 2010 m;
11-12: 2025 m;
LVR:25840-25852

OGMUND - PLATE 21

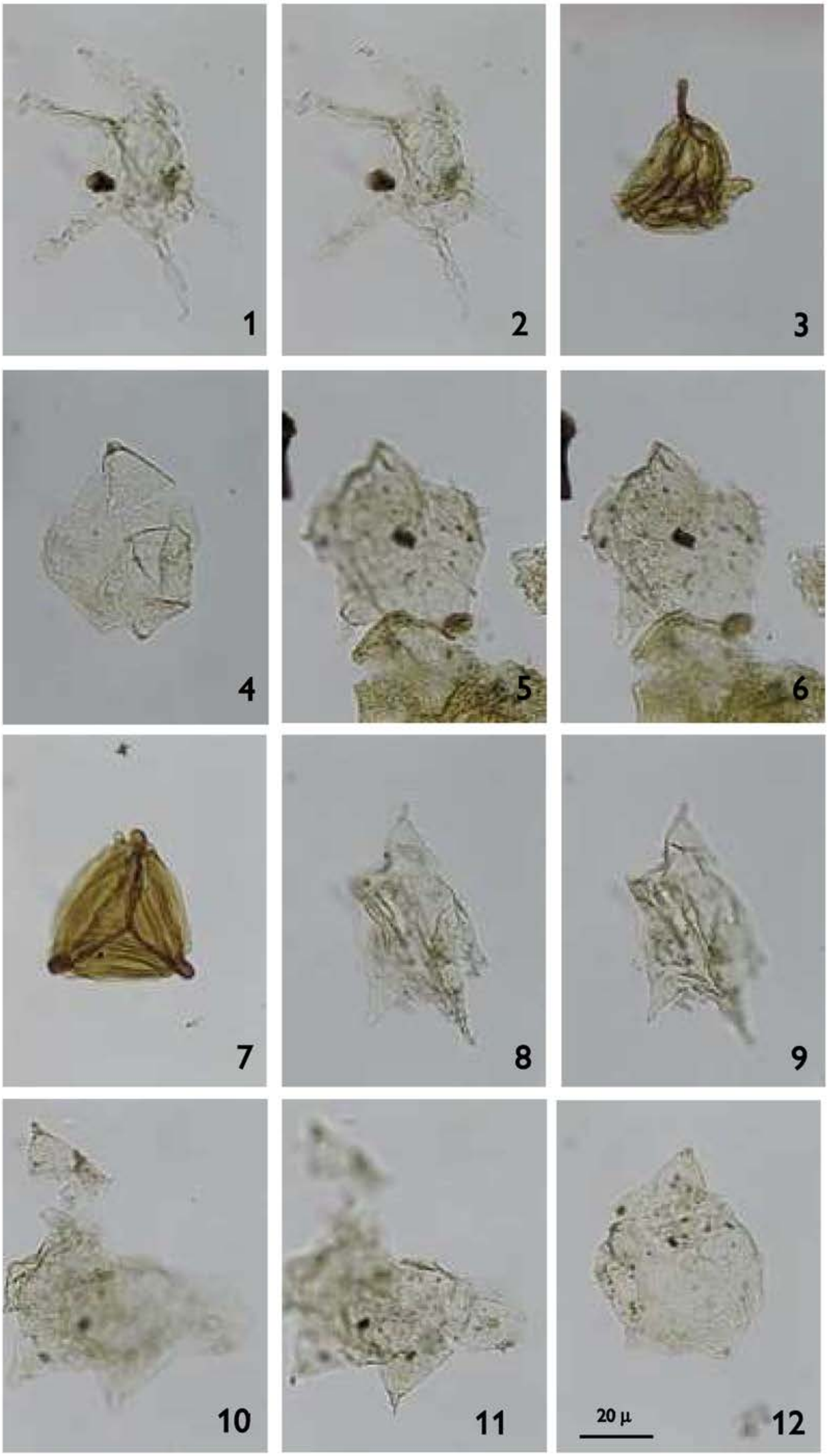
Fig. 1	*Nyktericysta davisii* 18.7-109.0, 2025m-3, LVR 25853
Fig. 2	*Quantouendinium dictyophorum* 48.0-103.0, 2025m-3, LVR 25854
Figs 3–5	*Quantouendinium dictyophorum* 18.6-96.7, 2055m-3, LVR 25855–57
Fig. 6	*Quantouendinium dictyophorum* 32.0-97.3, 2055m-3, LVR 25858
Fig. 7	*Costatoperforosporites foveolatus* 42.0-106.3, 2085m-3, LVR 25859
Fig. 8	*Distaltriangulisporites perplexus* 43.6-109.1, 2100m-3, LVR 25860
Fig. 9	*Trilobosporites humilis* 31.2-104.0, 2100m-3, LVR 25861
Fig. 10	Algae sp. 1 Ogmund 26.0-108.7, 2130m-3, LVR 25862
Fig. 11	Algae sp. 1 Ogmund 25.2-98.2, 2145m-3, LVR 25863
Fig. 12	*Quantouendinium dictyophorum* 25.6-112.9, 2190m-3, LVR 25864



Ogmund – Plate 21
1-2: 2025 m; 3-6: 2055 m;
7: 2085 m; 8-9: 2100 m;
10: 2130 m; 11: 2145 m; 12: 2190 m;
LVR: 25853-25864

OGMUND - PLATE 22

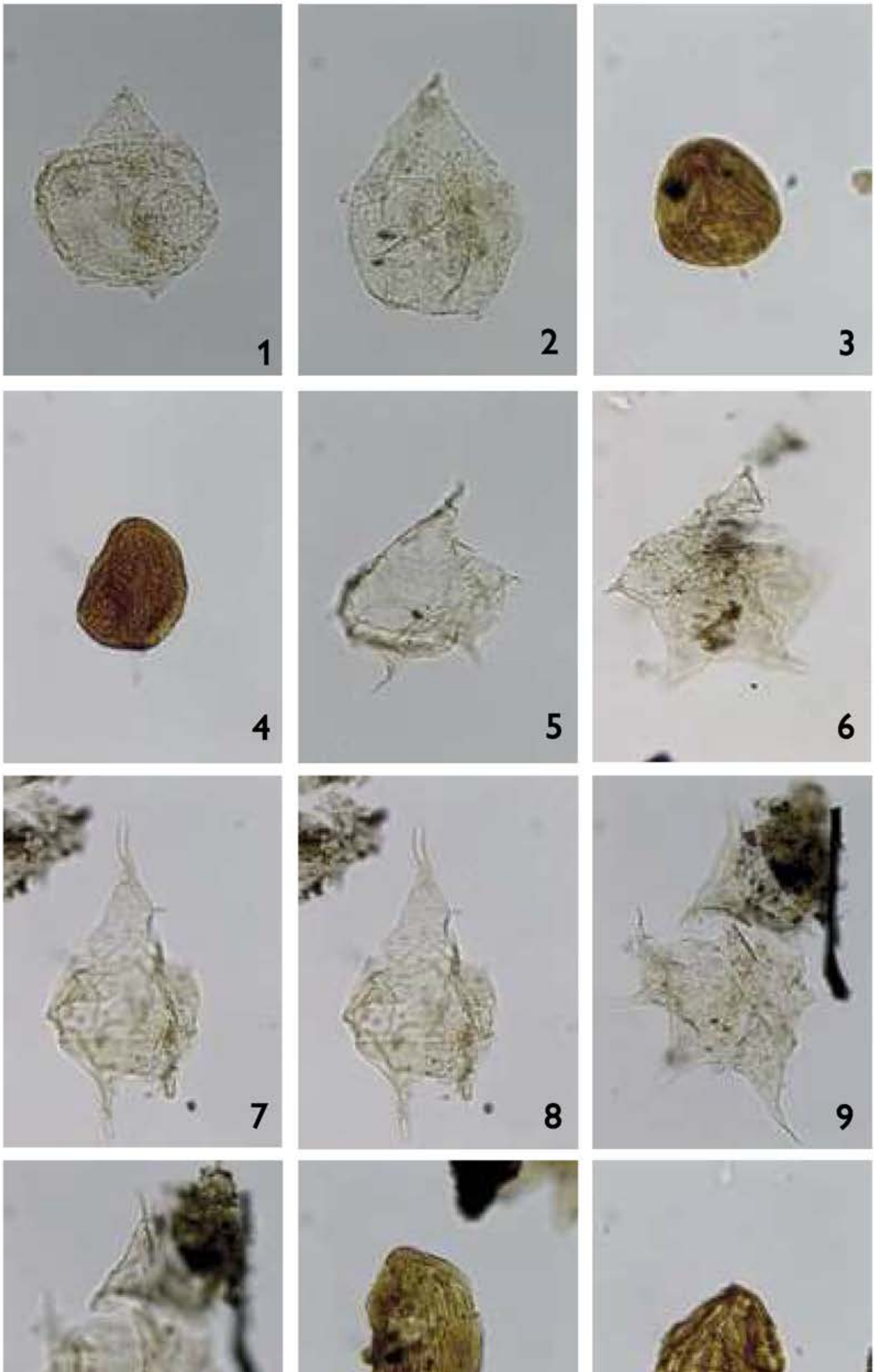
Figs 1–2	*Balmula* cf. *tripenta* 37.7-103.0, 2205m-4, LVR 25865–66
Fig. 3	*Appendicisporites unicus* 28.6-102.6, 2205m-3, LVR 25867
Fig. 4	*Quantouendinium dictyophorum* 30.5-101.5, 2265m-3, LVR 25868
Figs 5–6	*Vesperopsis* sp. Ogmund 47.3-94.0, 2295m-3, LVR 25869–72
Fig. 7	*Appendicisporites potomacensis* 16.3-111.3, 2340m-3, LVR 25873
Figs 8–9	*Vesperopsis* sp. Ogmund 29.0-112.0, 2340m-3, LVR 25874–75
Figs 10–11	*Vesperopsis* sp. Ogmund 33.0-93.6, 2340m-3, LVR 25876–77
Fig. 12	*Quantouendinium dictyophorum* 25.6-97.0, 2340m-3, LVR 25879



Ogmund – Plate 22
1- 3: 2205 m; 4: 2265 m;
5-6: 2295 m; 7-12: 2340 m;
LVR: 25865-25879

OGMUND - PLATE 23

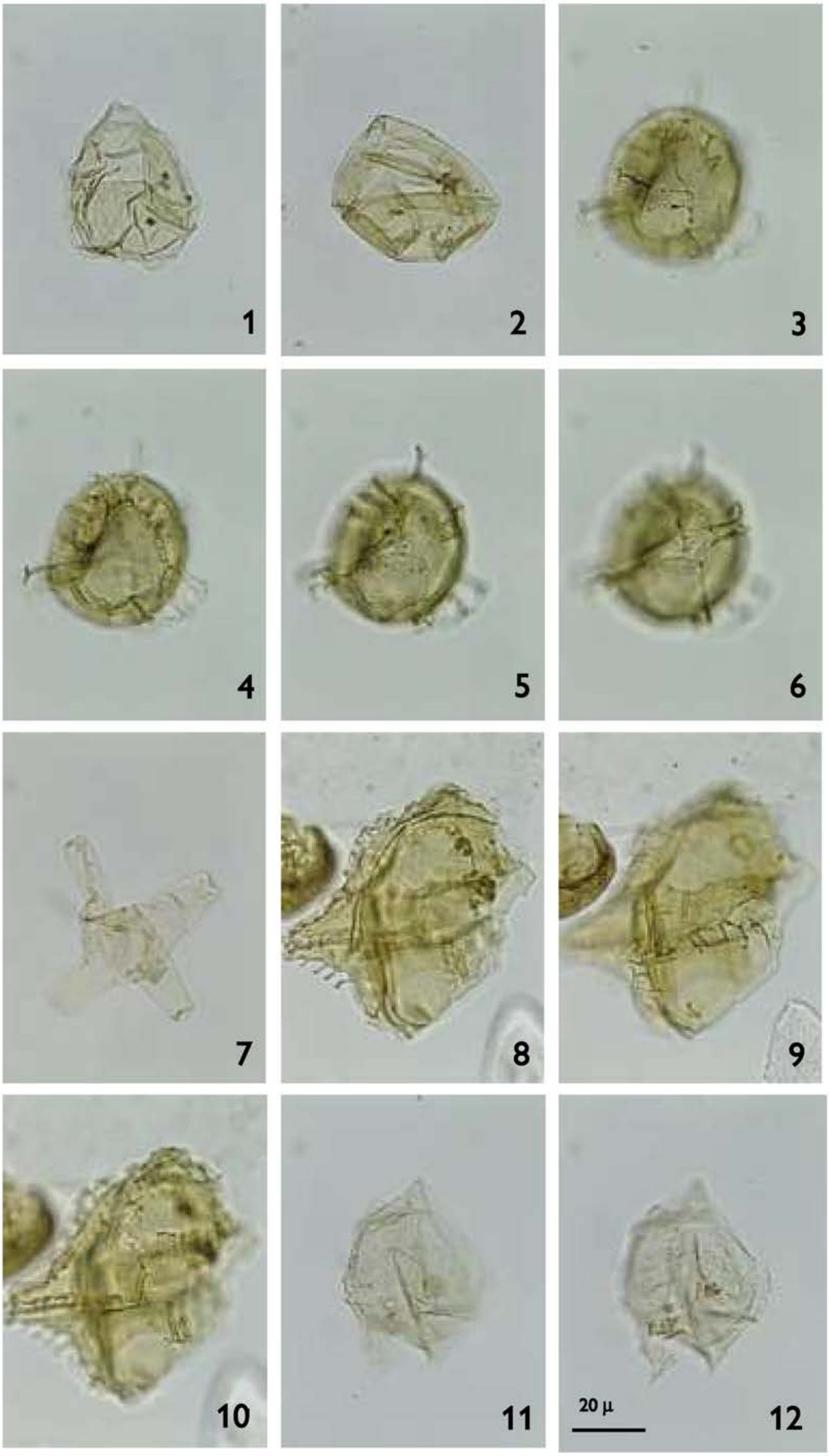
Fig. 1	*Quantouendinium dictyophorum* 26.4-110.5, 2355m-3, LVR 25880
Fig. 2	*Quantouendinium dictyophorum* 43.5-101.0, 2355m-3, LVR 25881
Fig. 3	*Cicatricosisporites subrotundus* 37.1-111.2, 2370m-3, LVR 25882
Fig. 4	*Costatoperforosporites foveolatus* 34.3-112.2, 2400m-3, LVR 25883
Fig. 5	*Vesperopsis* sp. Ogmund 39.1-95.1, 2490m-3, LVR 25884
Fig. 6	*Vesperopsis* cf. *nebulosa* 44.0-96.6, 2550m-2, LVR 25886
Figs 7–8	*Balmula* cf. *tripenta* 47.9-105.8, 2550m-3, LVR 25888–89
Figs 9–10	*Nyktericysta davisii* 46.4-112.8, 2580m-3, LVR 25897–98
Fig. 11	*Cicatricososporites auritus* 26.7-103.2, 2700m-4, LVR 25899
Fig. 12	*Cicatricosisporites hughesi* 46.3-99.4, 2941m-2 SWC, LVR 25900



Ogmund – Plate 23
1-2: 2355 m; 3: 2370 m; 4: 2400 m
5: 2490 m; 6-8: 2550 m; 9-10: 2580 m;
11: 2700 m; 12: 2941 m;
LVR: 25880-258900

SKOLP - PLATE 1

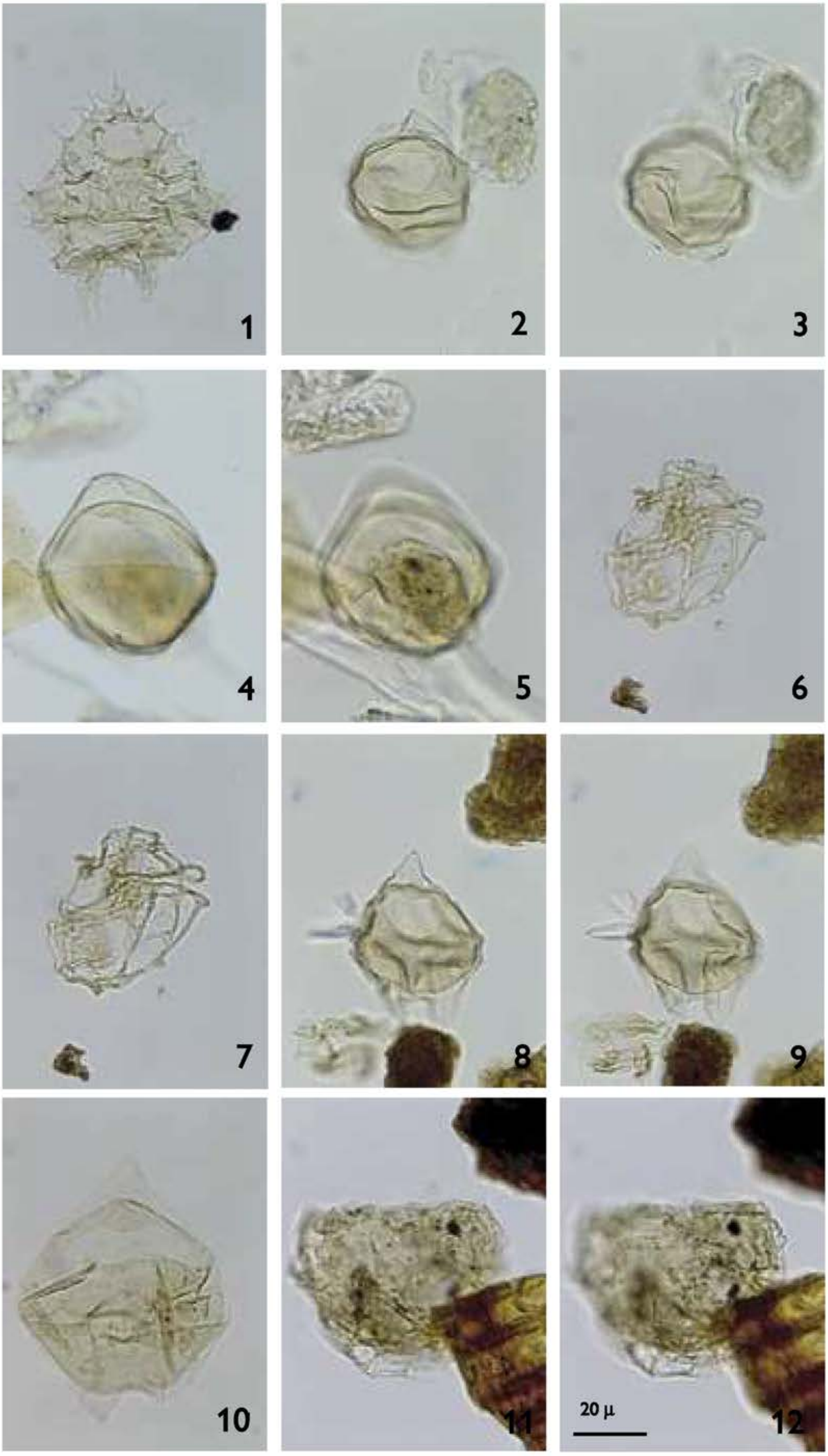
Fig. 1	*Lentinia* sp.? 39.0-110.5, 925m-3, LVR 25101
Fig. 2	*Cerodinium*? sp. 30.5-103.4, 925m-3, LVR 25103
Figs 3–6	*Spiniferites*? sp. 44.6-113.7, 925m-3, LVR 25110–13
Fig. 7	*Tetraporina* sp.1 HNH 22.5-98.4, 935m-4, LVR 25115
Figs 8–10	*Wilsonidinium* cf . *echinoideum/ simplex* 44.8-99.9, 935m-3, LVR 25116–18
Figs 11–12	*Lentinia*? sp. 43.7-91.7, 935m-3 LVR 25119–20



Skolp – Plate 1
1-6: 925 m;
7-12: 935 m;
LVR: 25101-25120

SKOLP - PLATE 2

Fig. 1	*Apectodinium parvum?* 19.5-98.7, 935m- 4 LVR 25121
Figs 2–3	*Cerodinium*? sp. 19.0–113.2, 945m-3 LVR 25122–23
Figs 4–5	*Luxuadinium* sp. (reworked?) 33.5-99.1, 945m-3 LVR 25124–25
Figs 6–7	*Phthanoperidinium distinctum* 27.3-101.7, 965m-3 LVR 25127–28
Figs. 8–9	*Cerodinium*? sp. 38.8-100.0, 985m LVR 25129–34
Fig. 10	*Trithyrodinium evittii* 47.0-109.3, 995m-34 LVR 25144
Figs 11–12	*Senoniasphaera inornata* 36,5-109.3, 995-3m LVR 25145–47



Skolp – Plate 2
1: 935 m; 2-5: 945 m; 6-7: 965 m;
8-9: 985 m; 10-12: 995 m;
LVR: 25121-25147

SKOLP - PLATE 3

Fig 1–2	*Cerodinium panuceum* 39.1-106.0, 995m- 3 LVR 25148–49
Fig.3	*Phelodinium kozlowski* 21.8-108.2, 1015m-3 LVR 25150
Fig. 4	*Celodinium diebelii* long 44.2-111.7, 1015m-3 LVR 25158
Fig. 5	*Celodinium diebelii* short 15.4-99.0, 1015m-3 LVR 25159
Figs. 6–8	*Palynodinium grallator* 12.8-107.80, 1015m-4 LVR 251600–62
Fig. 9	*Wodehouseia spinata* 52.0-100.5, 1015m-3 LVR 25163
Figs 10–12	*Alterbidinium ulloriaki* 20.9-109.6, 995-3m LVR 25164–66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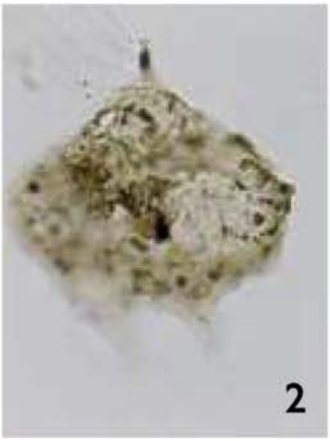
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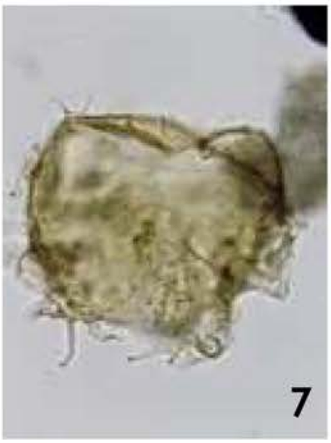
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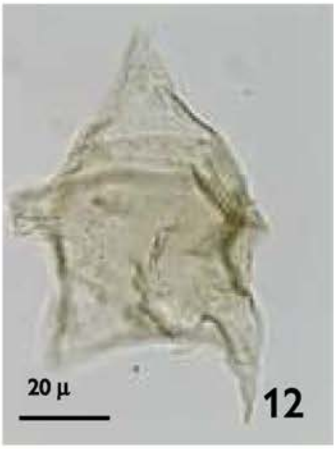

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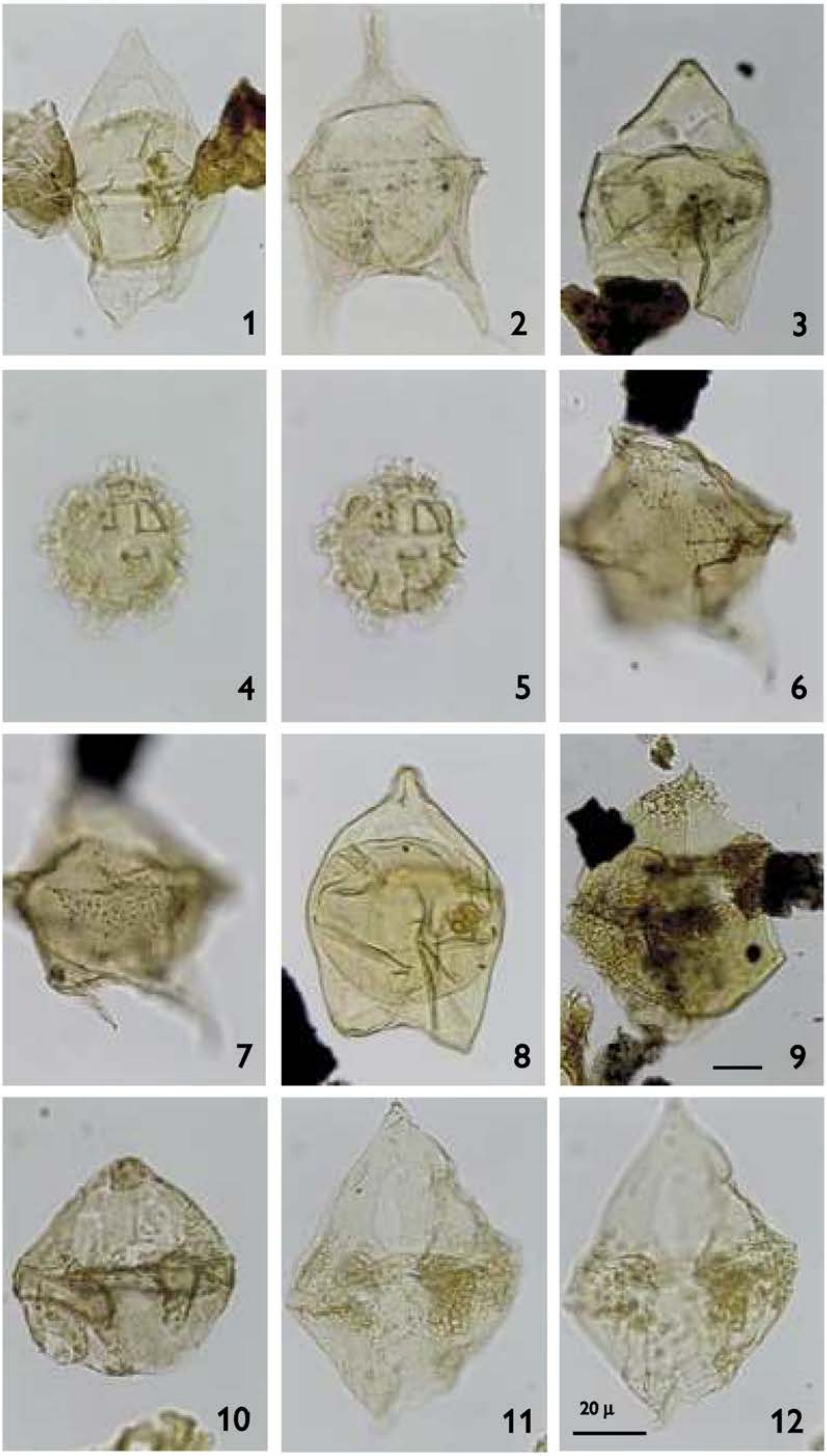
Skolp – Plate 3
1-2: 995 m; 3-9: 1015 m;
10-12: 1025 m;
LVR: 25148-25166

SKOLP - PLATE 4

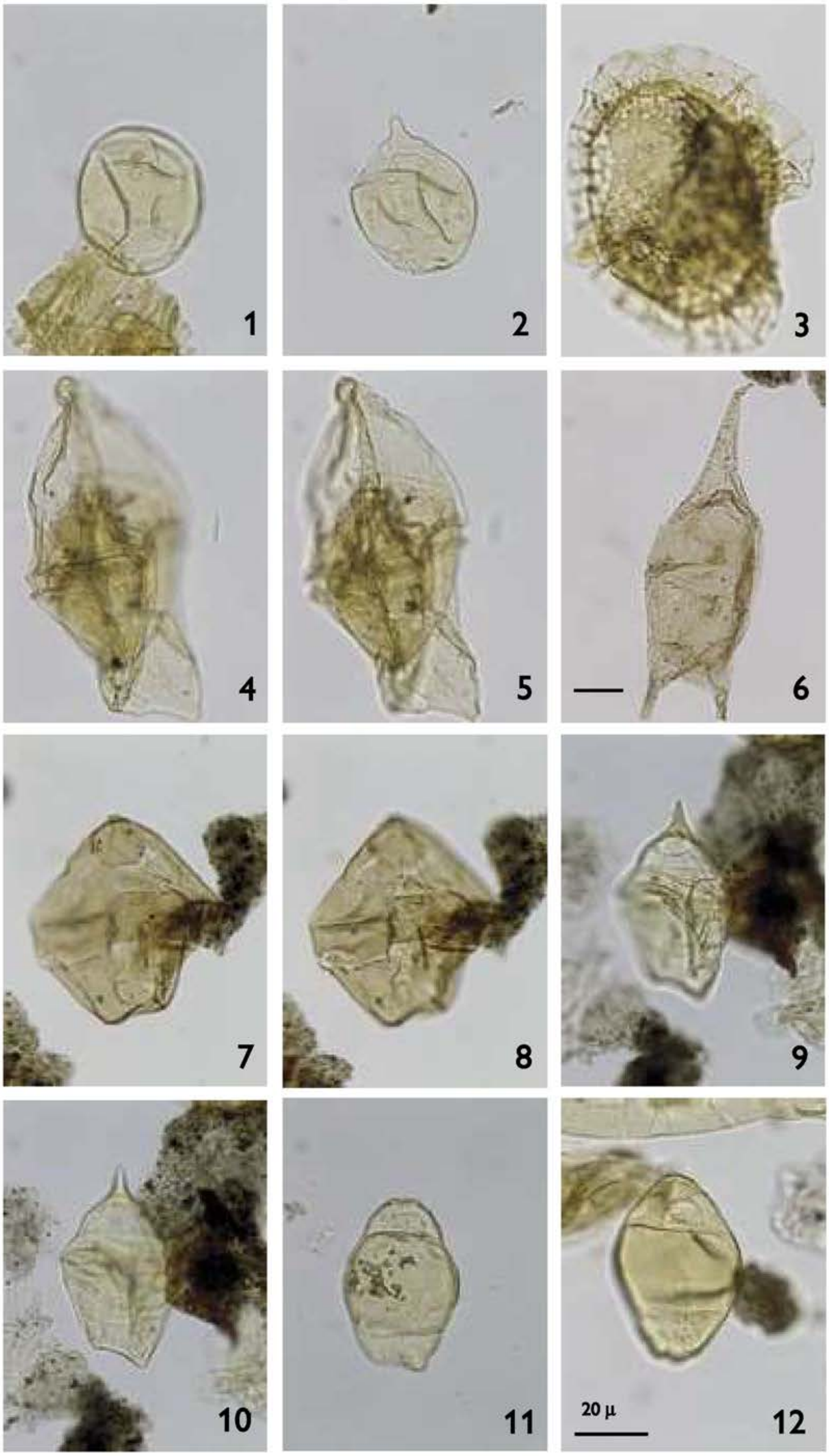
Fig. 1	*Isabelidinium bakeri?* 41.5-99.2, 1025m- 3 LVR 25167
Fig. 2	*Deflandrea galeata* 26.8-107.8, 1025m-4 LVR 25168
Fig. 3	*Isabelidinium majae* 42.6-108.0, 1025m-5 LVR 25169
Figs 4–5	*Alisocysta circumtabulata* 43.7-107.3, 1025m-5 LVR 25170–71
Figs 6–7	*Deflandrea galeata* 27.3-106.5, 1040m-3 LVR 25172–73
Fig. 8	*Isabelidinium majae* 45.7-96.9, 1055m-4 LVR 25175
Fig. 9	*Spongodinium delitiense* 24.2-104.5, 1055m-3 LVR 25177
Fig. 10	*Trithyrodinium quinqueangulare* 52.1-101.1, 1070m-3 LVR 25178
Figs 11–12	*Chatangiella biapatura* 19.6-96.4, 1070m-3 LVR 25179–80



Skolp – Plate 4
1-5: 1025 m; 6-7: 1040 m;
8-9: 1055 m; 10-12: 1070 m;
LVR: 25167-25180

SKOLP - PLATE 5

Fig. 1 *Isabelidinium cretaceum* 16.3-104.7, 1070m- 3 LVR 25181
Fig. 2 *Isabelidinium cretaceum?* 34.0-106.2, 1070m- 3 LVR 25182
Fig. 3 *Spongodinium delitiense* 46.1-96.5, 1070m-4 LVR 25183
Figs 4–5 *Chatangiella* sp. large 18.2-95.0, 1085m-3 LVR 25185–86
Fig. 6 *Cerodinium diebelii* large 25.5-105.1, 1085m-3 LVR 25187
Figs 7–8 *Trithyrodinium quinqueangulare* 36.9-106.1, 1085m-3 LVR 25188–89
Figs 9–10 *Isabelidinium cooksoniae?* 21.0-99.6, 1100m-3 LVR 25190–91
Fig. 11 *Isabelidinium cretaceum* 20.1-107.8, 1100m-3 LVR 25193
Fig. 12 *Isabelidinium cretaceum* 41.8-106.0, 1100m-3 LVR 25195



Skolp – Plate 5
1-3: 1070 m; 4-8: 1085 m;
9-12: 1100 m;
LVR: 25181-25196

SKOLP - PLATE 6

Figs 1–2	*Hystrichosphaeropsis perforata* 22.1-106.4, 1115m- 3 LVR 25197–98
Fig. 3	*Chatangiella biapatura* 46.0-96.0, 1115m- 3 LVR 25199
Fig. 4	*Phelodinium tricuspe* 52.3-99.2, 1130m-3 LVR 25200
Fig. 5	*Isabelidinium* cf. *magnum* 39.6-101.3, 1130m-3 LVR 25201
Figs 6–7	*Impagidinium* sp. 21.5-98.3, 1130m-3 LVR 25201–203
Fig. 8	*Chatangiella ditissima* 30.4-107.3, 1145m-3 LVR 25204
Fig. 9	*Isabelidinium* sp. 47.1-110.1, 1145m-3 LVR 25205
Fig. 10	*Isabelidinium bujakii* 53.8-110.4, 1160m-3 LVR 25206
Fig. 11	*Chatangiella “spinosa”* reworked? 33.2-98.5, 1175m-3 LVR 25207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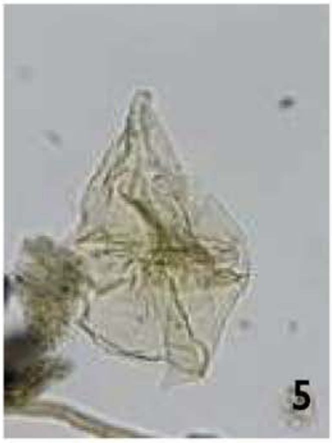
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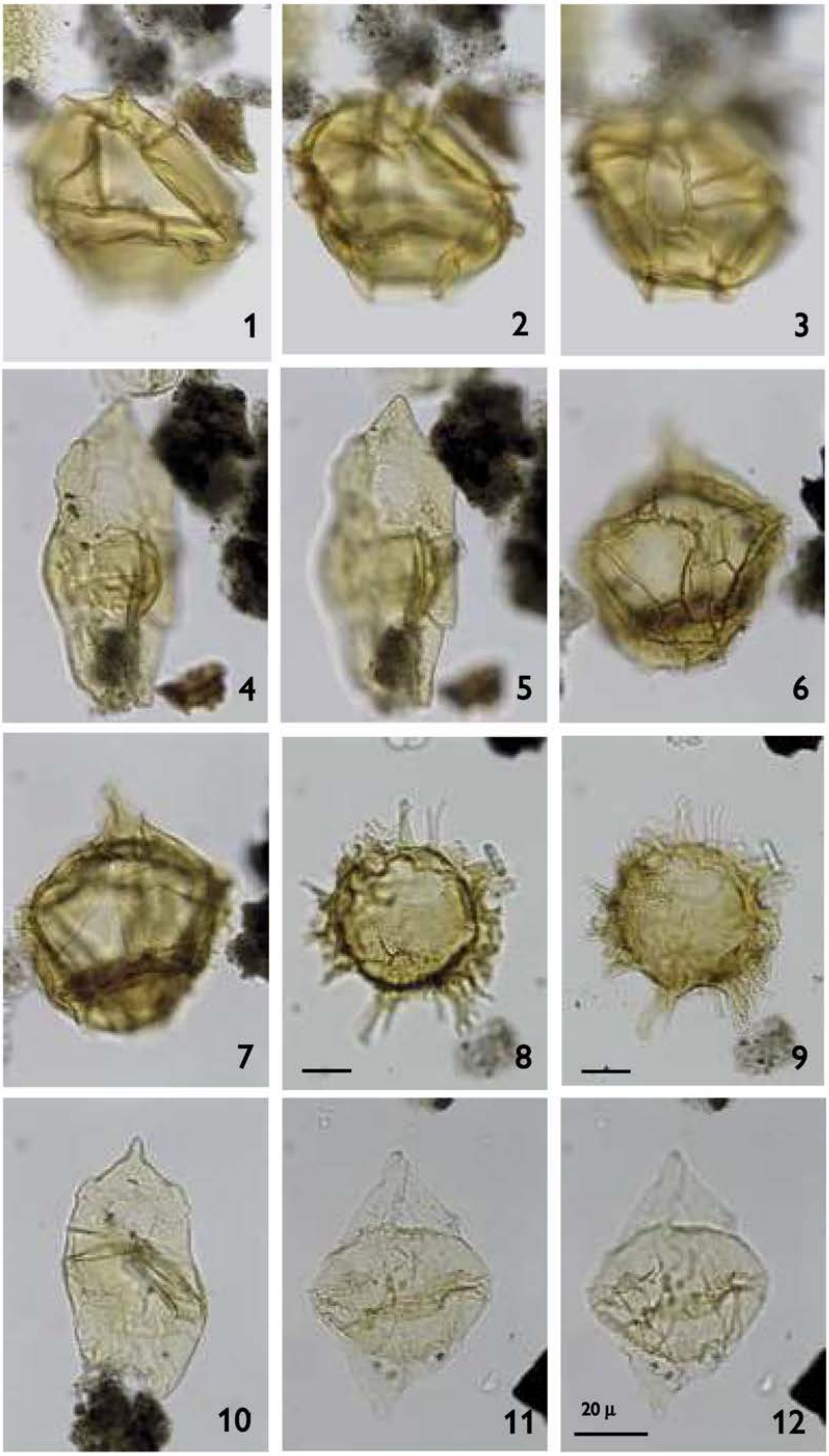
Skolp – Plate 6
1-3: 1115 m; 4-7 1130 m;
8-9: 1145 m; 10: 1160 m;
11: 1175 m;
LVR: 25197-25207

SKOLP - PLATE 7

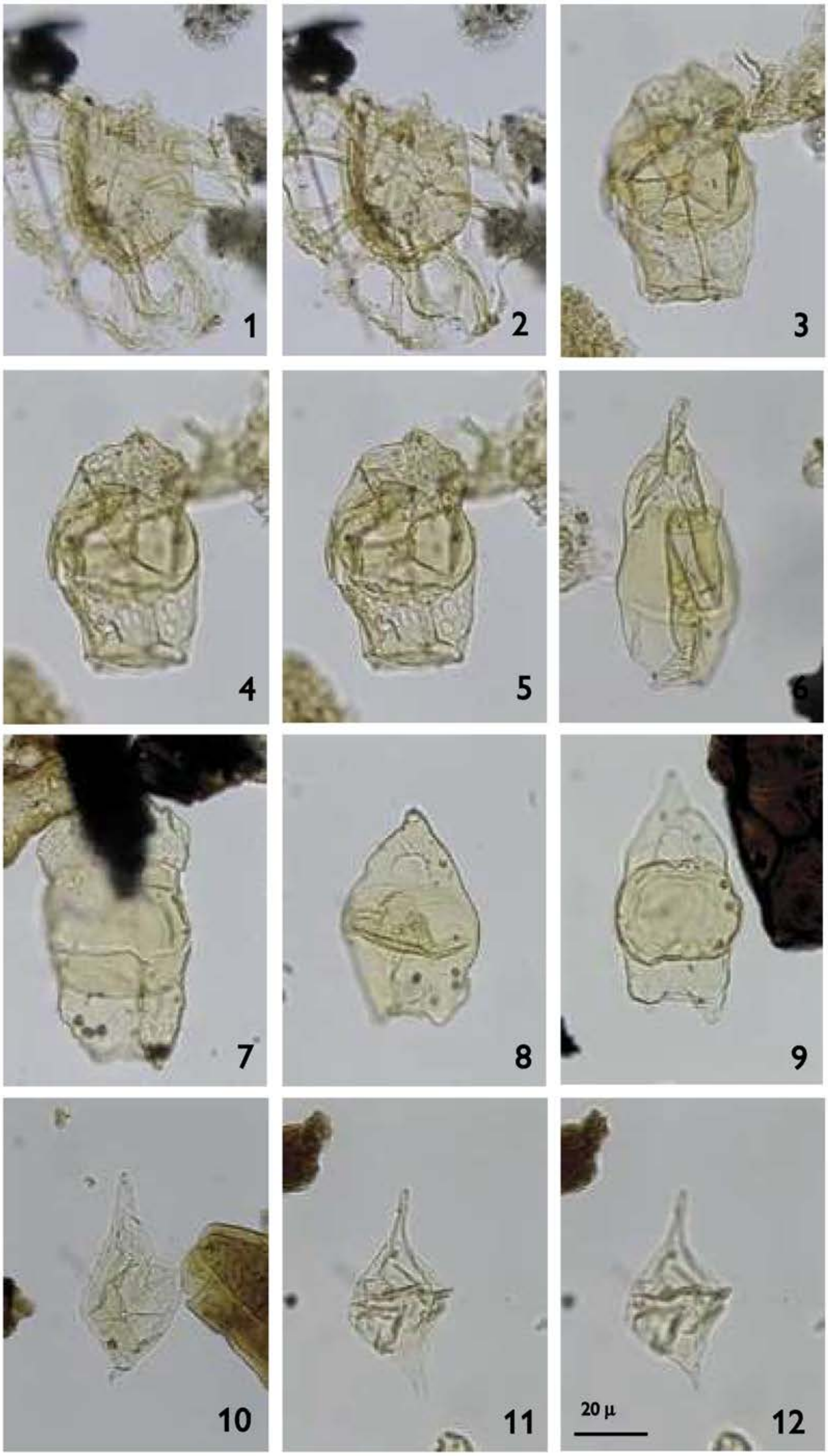
Figs 1–3	*Impagidinium* sp. 34.8-98.5, 1175m- 3 LVR 25208–210
Figs 4–5	*Isabelidinium belfastense* 34.2-99.0, 1175m- 3 LVR 25211–212
Figs 6–7	*Cribroperidinium edwardsii* 28.5-97.3, 1205m-3 LVR 25213–214
Figs 8–9	*Cordosphaeridium* sp. 33.5-107.5, 1205m-3 LVR 25215–216
Fig. 10	*Isabelidinium bujakii* 28.0-102.8, 1220m-3 LVR 25218
Figs 11–12	*Chatangiella biapatura* 25.2-98.0, 1250m-3 LVR 25219–220



Skolp – Plate 7
1-5: 1175 m; 6-9: 1205 m;
10: 1220 m; 11-12: 1250 m;
LVR: 25208-25220

SKOLP - PLATE 8

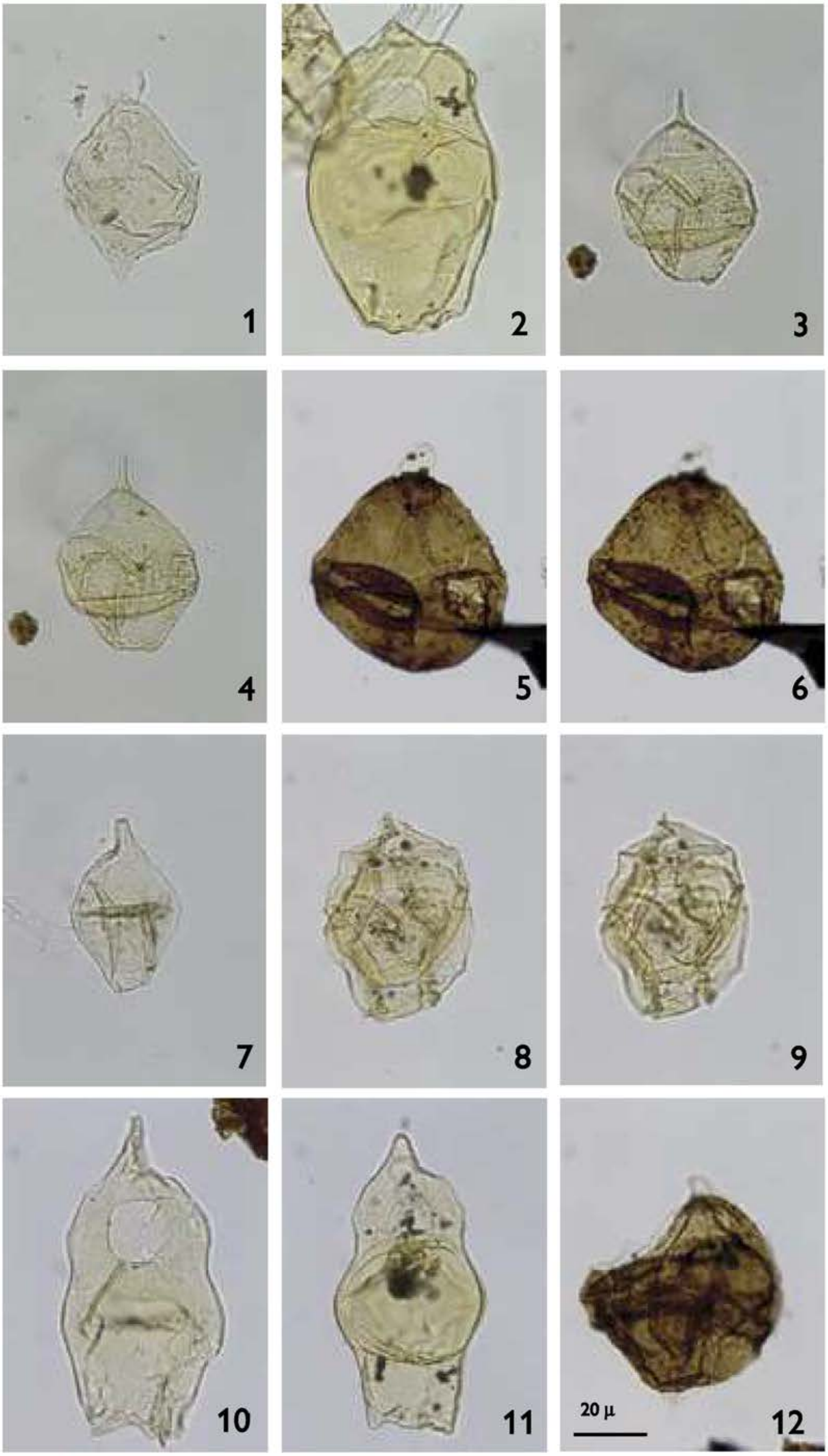
Figs 1–2	*Oligosphaeridium*? sp. 21.5-101.5, 1250m- 3 LVR 25221–222
Figs 3–5	*Hystrichosphaeropsis perforata* 43.3-101.4, 1250m- 4 LVR 25223–224, 234
Fig. 6	*Isabelidinium* sp. 47.0-106.1, 1265m-3 LVR 25235
Fig. 7	*Isabelidinium* sp. 40.4-110.1, 1265m-3 LVR 25236
Fig. 8	*Isabelidinium belfastense* 23.0-105.7, 1295m-3 LVR 25237
Fig. 9	*Isabelidinium belfastense* 23.7-99.0, 1295m-3 LVR 25238
Fig. 10	*Alterbidinium acutulum* 33.0-96.0, 1295m-3 LVR 25239
Figs 11–12	*Alterbidinium acutulum* 49.0-113.2, 1295m-3 LVR 25240–41



Skolp – Plate 8
1-5: 1250 m; 6-7: 1265 m;
9-12: 1295 m;
LVR: 25221-25241

SKOLP - PLATE 9

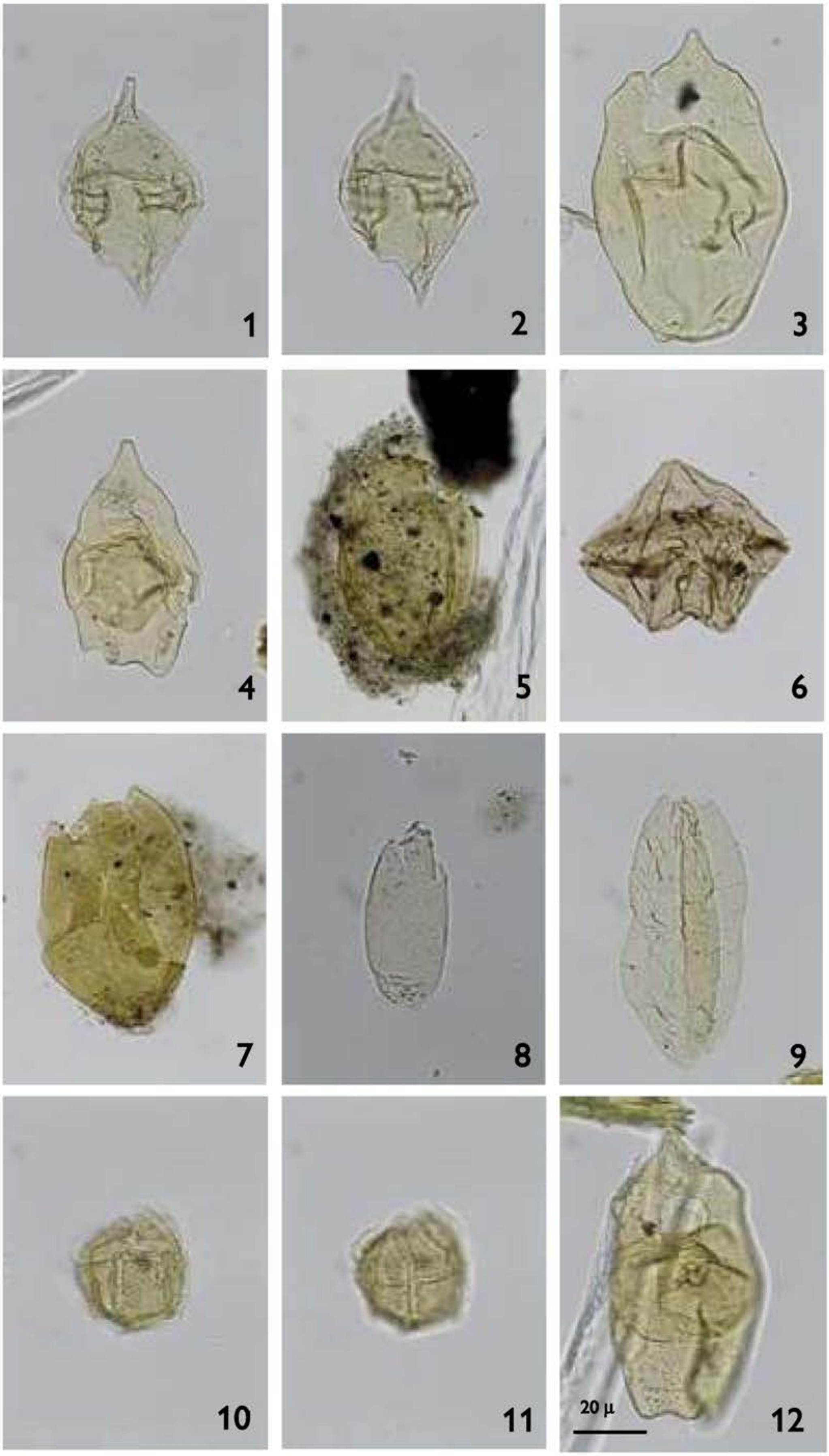
Fig. 1	*Alterbidinium minor* 29.6-96.1, 1310m-3 LVR 25242
Fig. 2	*Isabelidinium* sp. 42.2-100.1, 1310m- 3 LVR 25243
Figs 3–4	*Isabelidinium* sp. 20.0-104.0, 1325m- 3 LVR 25244–245
Figs 5–6	*Trithyrodinium* sp. 21.8-97.2, 1340m-3 LVR 25246–47
Fig. 7	*Alterbidinium minor* 29.2-99.9, 1340m-3 LVR 25248
Figs 8–9	*Hystrichosphaeropsis quasicribrata* 32.0-101.5, 1340m-3 LVR 25249–50
Fig. 10	*Isabelidinium* sp. 18.6-96.0, 1355m-3 LVR 25251
Fig. 11	*Isabelidinium* sp. 32.3-96.3, 1355m-3 LVR 25252
Fig. 12	*Trithyrodinium evittii* 22.4-107.3, 1355m-3 LVR 25253



Skolp – Plate 9
1-2: 1310 m; 3-4: 1325 m;
5-9: 1340 m; 10-12: 1355 m;
LVR: 25242-25253

SKOLP - PLATE 10

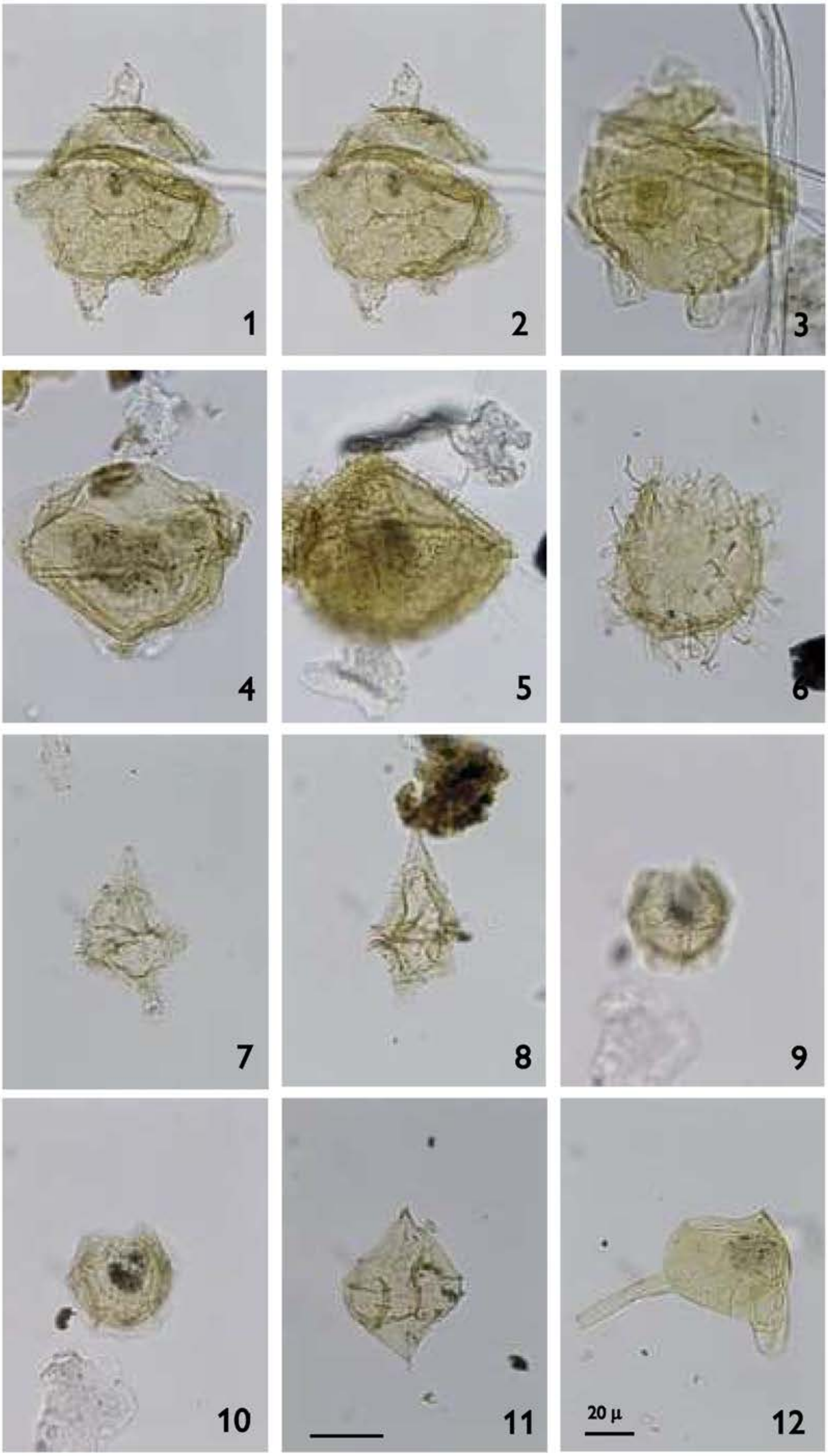
Figs 1–2	*Alterbidinium acutulum* (*“granulosum”*) 30.2-102.2, 1370m-3 LVR 25254–55
Fig. 3	*Isabelidinium* sp. 19.7-101.8, 1370m- 3 LVR 25256
Fig. 4	*Isabelidinium* cf. *magnum* 26.5-100.0, 1370m- 3 LVR 25257
Fig. 5	*Caligodinium aceras* 33.0-108.7, 1370m-3 LVR 25258
Fig. 6	*Lejeunecysta hyalina* 47.8-111.8, 1370m-3 LVR 25259
Fig. 7	*Caligodinium aceras* 28.9-93.7, 1385m-3 LVR 25260
Fig. 8	*Tanyosphaeridium*? sp. 16.4-106.0, 1400m-3 LVR 25261
Fig. 9	*Fromea fragilis* 18.3-106.8, 1400m-3 LVR 25262
Figs 10–11	*Microdinium* sp. 33.4-100.0, 1415m-3 LVR 25263–64
Fig. 12	*Isabelidinium bujakii* 27.2-102.8, 1430m-3 LVR 25265



Skolp – Plate 10
1-6: 1370 m; 7: 1385 m; 8-9: 1400 m;
11: 1415 m; 12: 1430 m;
LVR: 25254-25268

SKOLP - PLATE 11

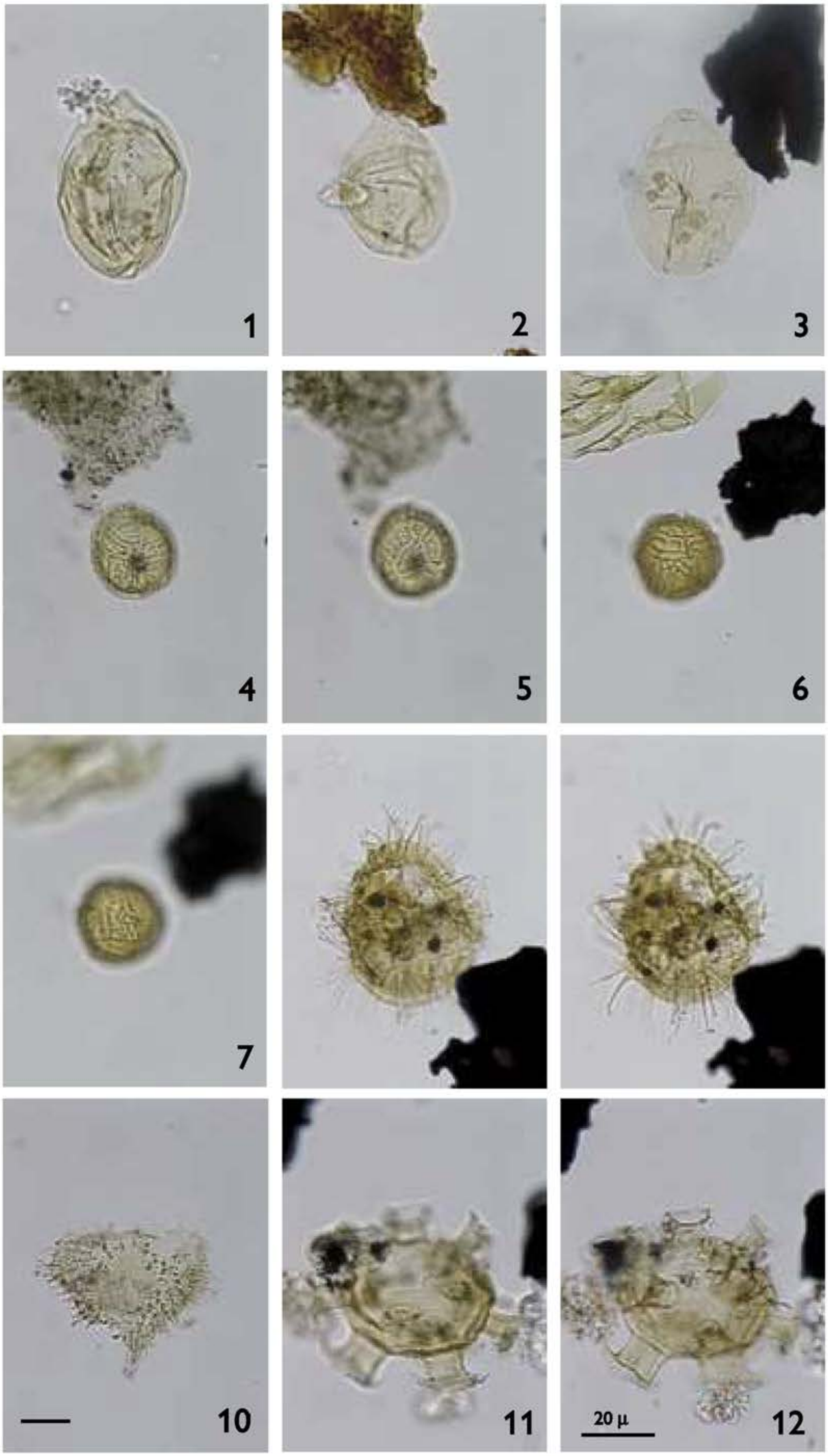
Figs 1–2	*Senoniasphaera rotundata* 30.6-109.5, 1430m-3 LVR 25269–70
Fig. 3	*Senoniasphaera rotundata* 46.0-98.2, 1430m-3 LVR 25271
Fig. 4	*Senoniasphaera rotundata* 48.5-92.8, 1430m-3 LVR 25272
Fig. 5	*Trichodinium castanea* 36.0-100.7, 1430m- 3 LVR 25274
Fig. 6	*Heterosphaeridium heteracanthum* 22.6-97.3, 1445m- 3 LVR 25276
Fig. 7	*Spinidinium* sp. 23.6-96.9, 1445m-3 LVR 25278
Fig. 8	*Spinidinium* sp. 27.2-96.0, 1445m-3 LVR 25280
Figs 9–10	*Fibradinium annetorpense* 27.3-96.3, 1445m-3 LVR 25282–83
Fig. 11	*Laciniadinium arcticum* 29.0-107.3, 1445m-3 LVR 25285
Fig. 12	*Odontochitina operculata* 30.0-92.1, 1445m-3 LVR 25286



Skolp – Plate 11
1-5: 1430 m;
6-12: 1445 m;
LVR: 25269-25287

SKOLP - PLATE 12

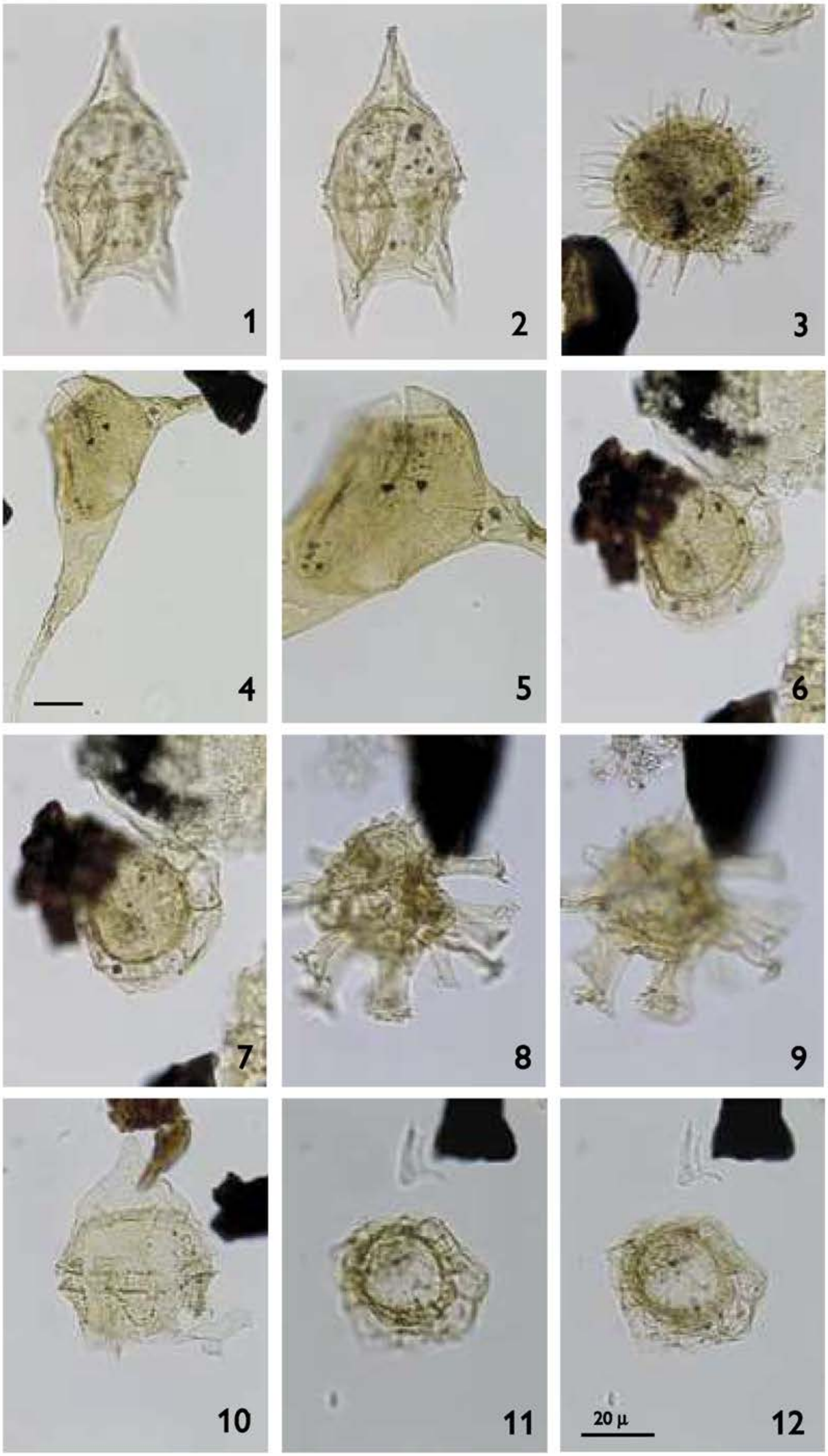
Fig. 1	*Isabelidinium* cf. *cretaceum*/*Nelsoniella*? sp. 23.1-107.1, 1460m-3 LVR 25288
Fig. 2	*Isabelidinium* cf. *cretaceum*/*Nelsoniella*? sp. 21.0-96.8, 1460m-3 LVR 25289
Fig. 3	*Isabelidinium* cf. *cretaceum*/*Nelsoniella*? sp. 15.5-113.7, 1460m-3 LVR 25290
Figs 4–5	*Histiocysta palla* 17.1-107.9, 1460m-3 LVR 25292–93
Figs 6–7	*Histiocysta palla* 21.0-111.4, 1460m-3 LVR 25294–95
Figs 8–9	*Exochosphaeridium bifidum* 17.0-102.0, 1460m-3 LVR 25296–97
Fig. 10	*Circulodinium* sp. 16.5-100.0, 1460m-3 LVR 25298
Figs 11–12	*Hystrichosphaeridium tubiferum/brevispinum* 23.0-104.5, 1460m-3 LVR 25299–300



Skolp – Plate 12
1-12: 1460 m;
LVR: 25288-25301

SKOLP - PLATE 13

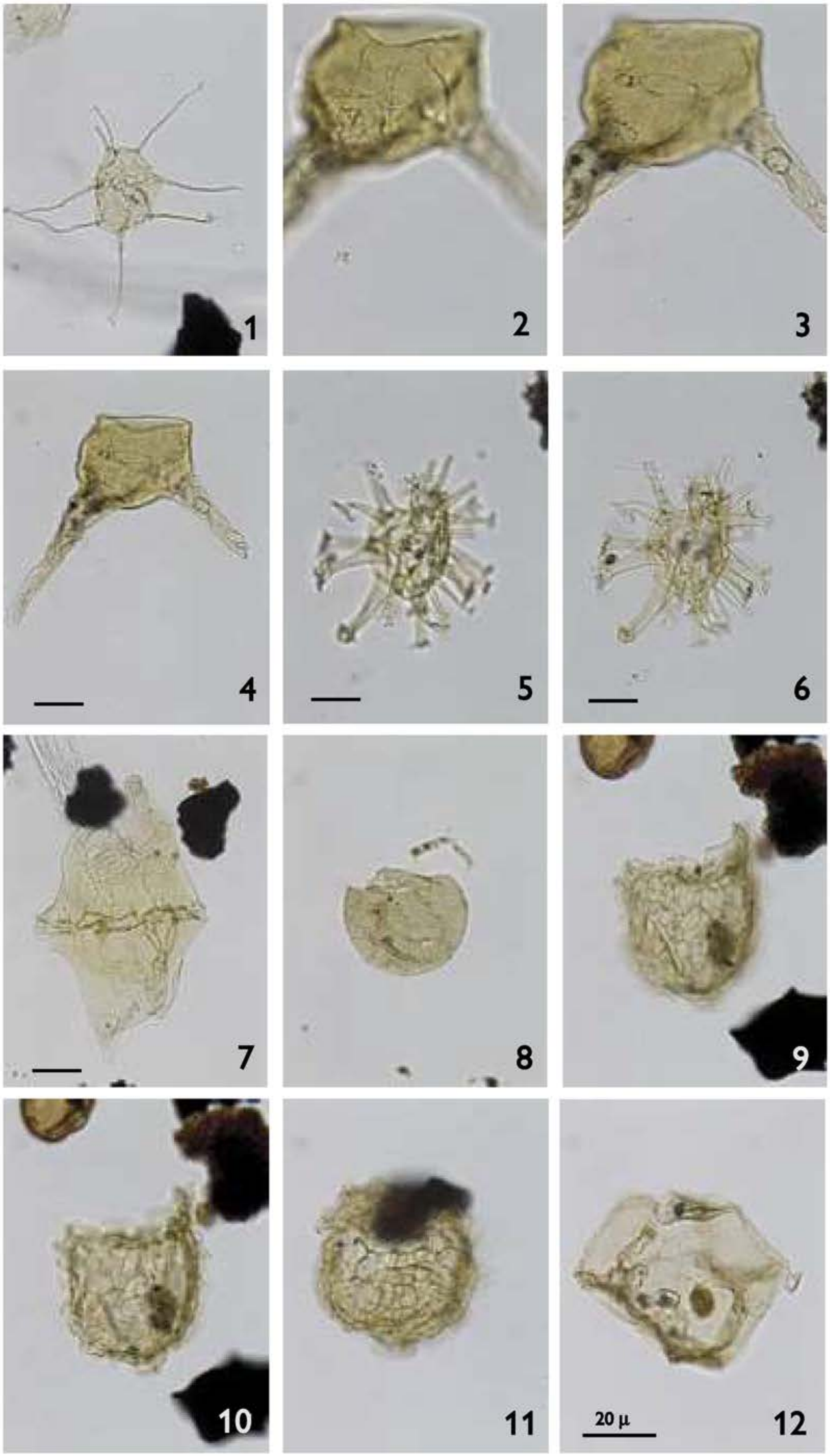
Figs 1–2	*Cerodinium kangiliense* (caved) 52.0-102.8, 1460m-3 LVR 25302–303
Fig. 3	*Exochosphaeridium bifidum* 22.0-111.0, 1460m-3 LVR 25304
Figs 4–5	*Xenascus wetzelii* 30.7-113.2, 1460m-3 LVR 25306–307
Figs 6–7	*Eatonicysta pterococcoides* 35.0-100.3, 1460m-3 LVR 25308–309
Figs 8–9	*Florentinia perforata*? 17.0-96.9, 1475m-3 LVR 25310–311
Fig. 10	*Chatangiella madura* 18.0-98.0, 1475m-3 LVR 25312
Figs 11–12	*Eatonicysta pterococcoides* 17.8-101.3, 1475m-3 LVR 25313–314



Skolp – Plate 13
1-7: 1460 m;
8-12: 1475 m;
LVR: 25302-25315

SKOLP - PLATE 14

Fig. 1	*Raphidodinium fucatum* 43.7-94.7, 1475m-3 LVR 25316
Figs 2–4	*Xenascus wetzelii* 41.0-111.2, 1475m-3 LVR 25317–319
Figs 5–6	*Florentinia stellata* 37.0-113.0, 1475m-3 LVR 25320–321
Fig. 7	*Chatangiella* cf. *spectabilis* 17.8-102.1, 1490m-3 LVR 25365
Fig. 8	*Trithyrodinium suspectum*? 21.6-92.3, 1490m-3 LVR 25366
Figs 9–10	Dinocyst sp. 1 HNH 2003 (*Samlandia*? sp.) 22.6-100.9, 1490m-3 LVR 25367–368
Fig. 11	Dinocyst sp. 1 HNH 2003 (*Samlandia*? sp.) 31.7-104.6, 1505m-3 LVR 25370
Fig. 12	*Atopodinium* cf. *haromense* 23.5-108.9, 1535m-3 LVR 25373



Skolp – Plate 14
1-6: 1475 m; 7-10: 1490 m;
11: 1505 m; 12: 1535 m;
LVR: 25316-25374

SKOLP - PLATE 15

Figs 1–2	*Chlamydophorella grossa* 39.1-93.1, 1535m-3 LVR 25375–76
Figs 3–4	*Callaiosphaeridium asymmetricum* 33.7-98.8, 1535m-3 LVR 25377–78
Fig. 5	*Atopodinium* cf. *haromense* 35.0-95.5, 1550m-5 LVR 25379
Figs 6–7	*Isabelidinium acuminatum* 28.0-105.6, 1550m-5 LVR 25380–81
Fig. 8	*Hystrichosphaeropsis quasicribrata* 18.4-98.5, 1565m-3 LVR 25382
Figs 9–10	*Chlamydophorella grossa* (*Samlandia carnavonensis?*) 29.5-110.6, 1565m-3 LVR 25383–84
Figs 11–12	*Chlamydophorella grossa* (*Samlandia carnavonensis?*) 27.3-98.5, 1565m-5 LVR 25385–86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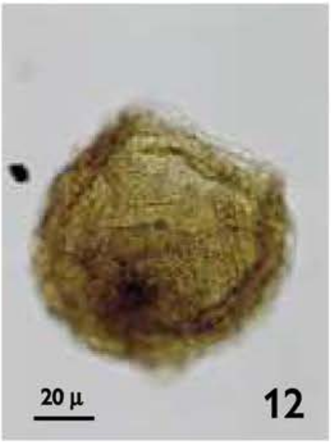
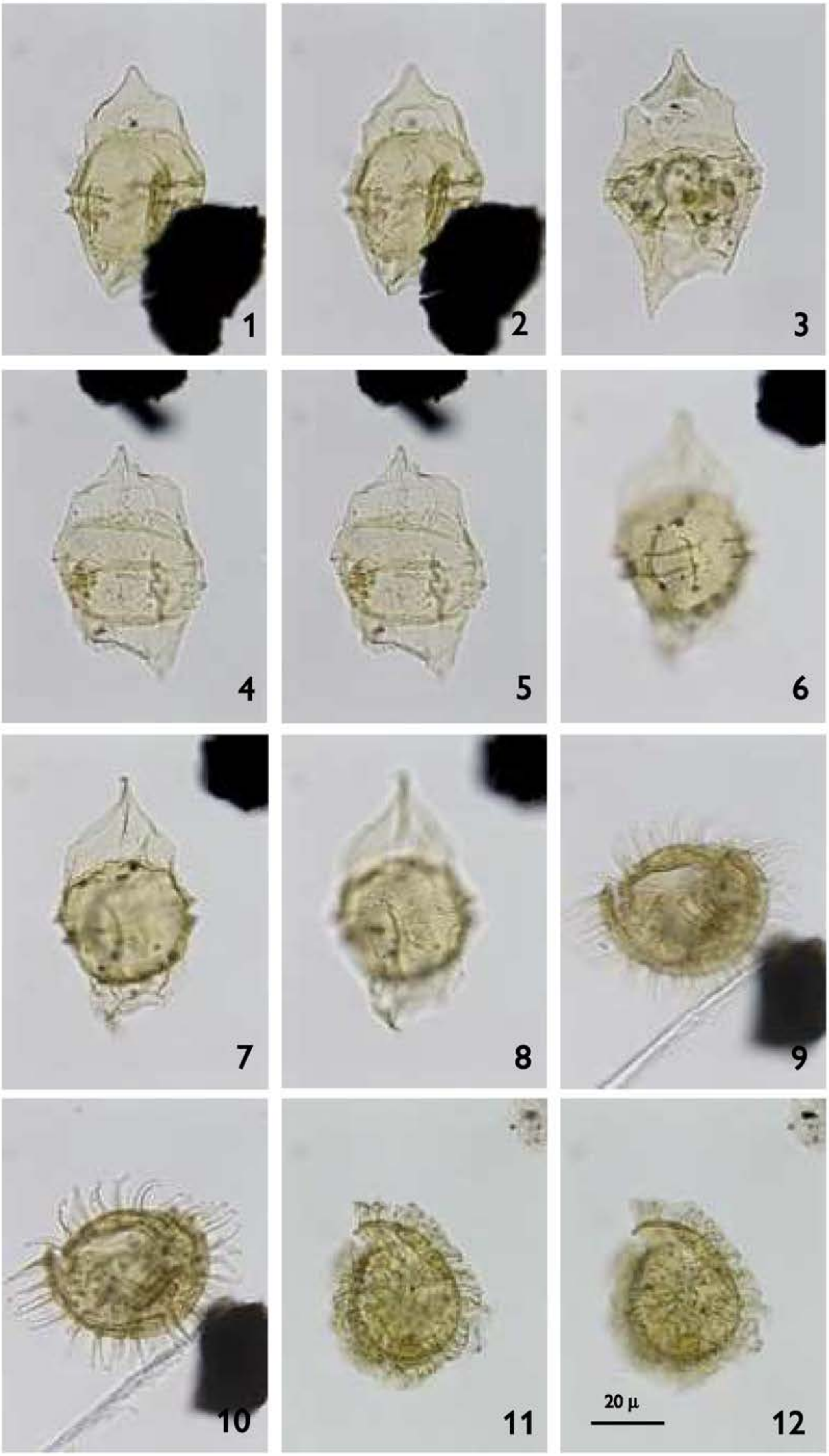


12

Skolp – Plate 15
1-4: 1535 m; 5-7: 1550 m;
8-12: 1565 m;
LVR: 25375-25386

SKOLP - PLATE 16

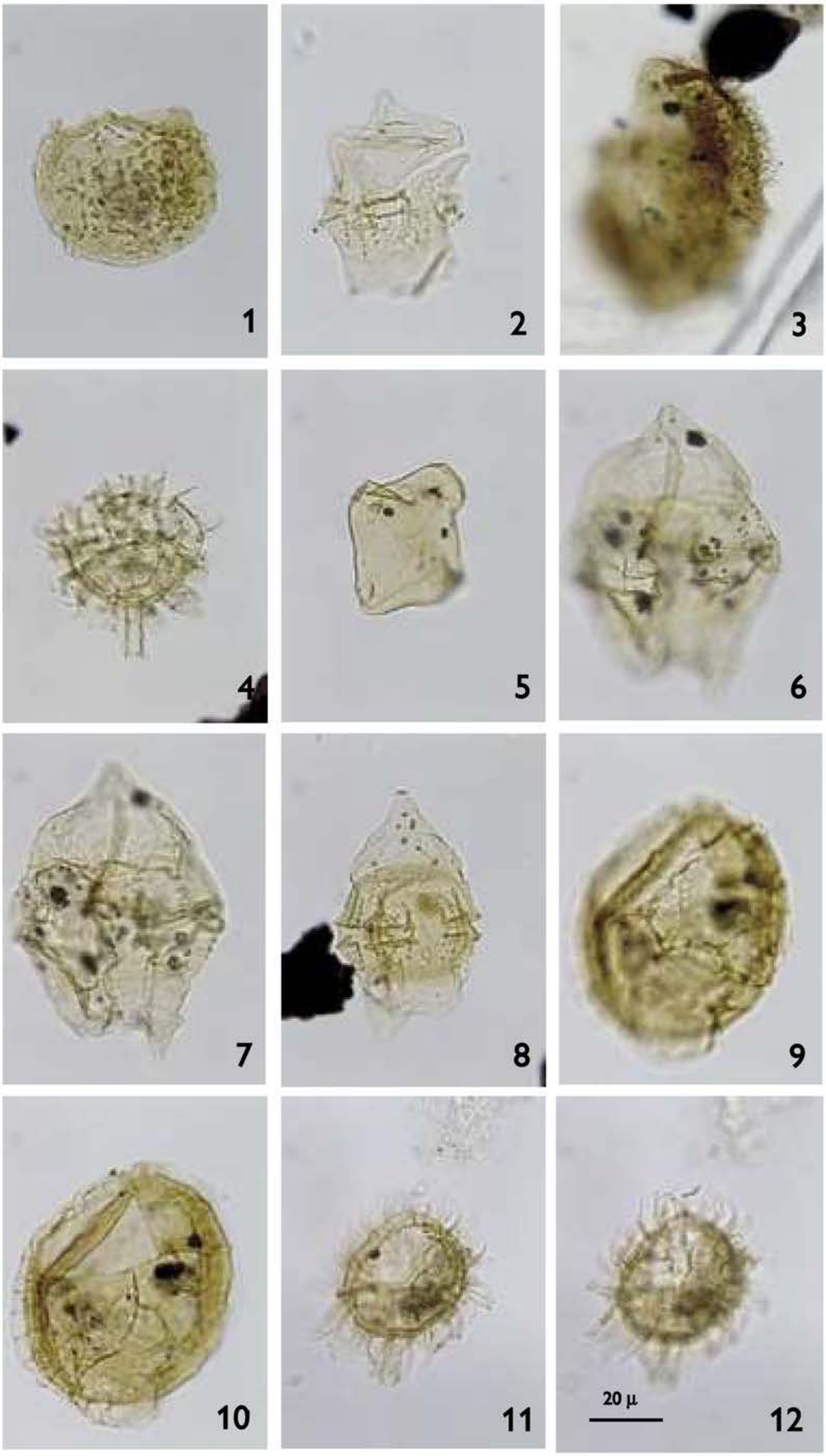
Figs 1–2	*Chatangiella* sp. 44.9-109.5, 1565m-5 LVR 25387–88
Fig. 3	*Chatangiella* cf. *decorosa* 29.4-92.0, 1580m-4 LVR 25389
Figs 4–5	*Chatangiella* cf. *decorosa* 46.0-100.7, 1580m-3 LVR 25390–91
Figs 6–8	*Chatangiella madura* 31.0-112.8, 1580m-3 LVR 25392–94
Figs 9–10	*Exochosphaeridium bifidum* 42.5-96.2, 1580m-3 LVR 25395–96
Figs 11–12	*Chlamydophorella* cf. *nyeii* 31.0-96.0, 1580m-3 LVR 25397–98



Skolp – Plate 16
1-2: 1565 m;
3-12: 1580 m;
LVR: 25388-25398

SKOLP - PLATE 17

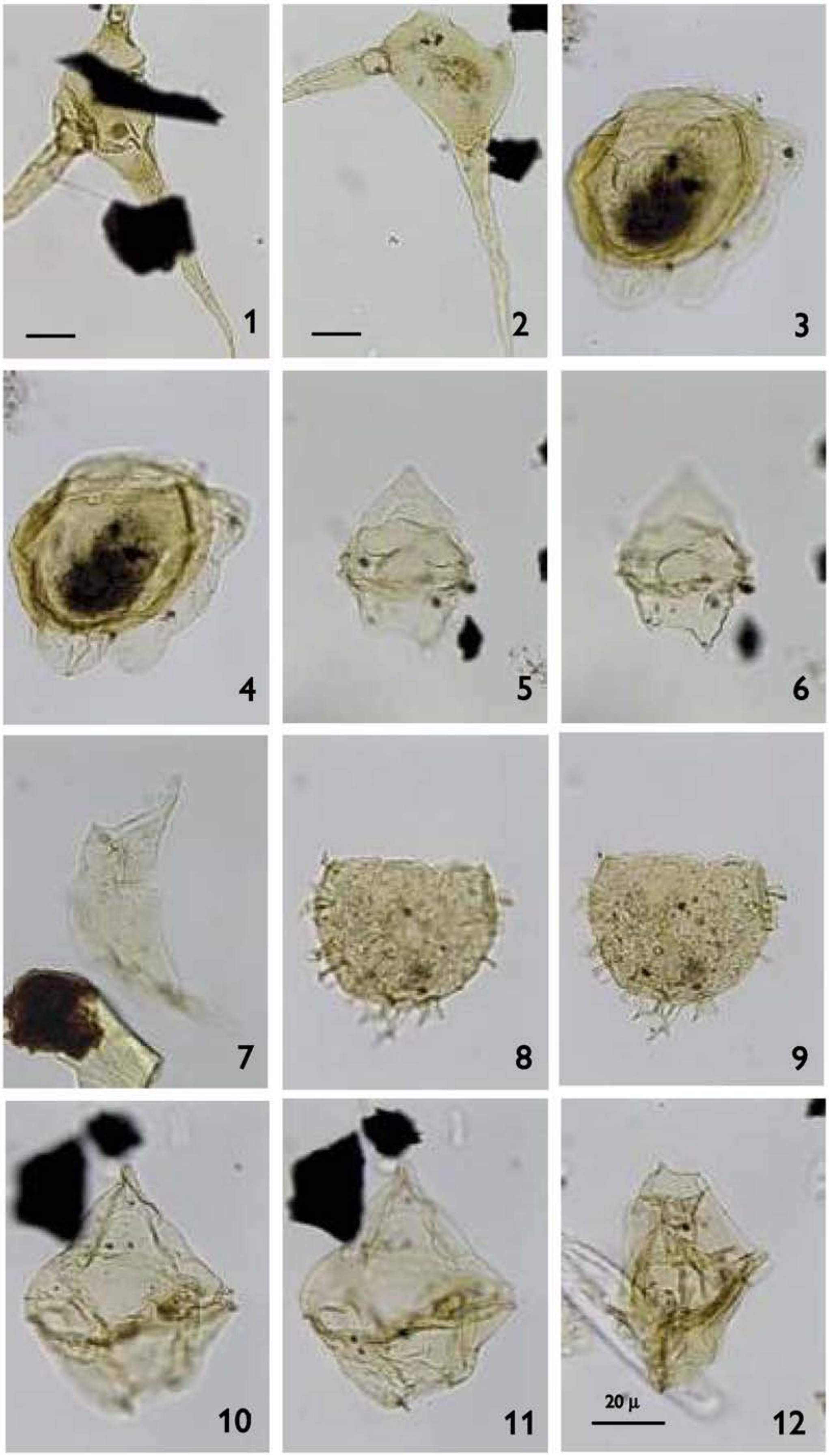
Fig. 1	*Trichodinium hirsutum*? 39.1-108.9, 1580m-3 LVR 25399
Fig. 2	*Chatangiella* cf. *decorosa* 44.1-97.7, 1580m-5 LVR 25400
Fig. 3	*Cometodinium whitei* 18.3-110.6, 1580m-5 LVR 25401
Fig. 4	*Coronifera* cf. *oceanica* 40.3-93.1, 1580m-5 LVR 25403
Fig. 5	*Tetraporina* sp. 22.2-95.8, 1595m-5 LVR 25405
Figs 6–7	*Chatangiella decorosa* 27.3-92.1, 1595m-5 LVR 25406–407
Fig. 8	*Chatangiella madura* 31.9-97.2, 1595m-3 LVR 25408
Figs 9–10	*Scriniodinium obscurum* 32.8-97.2, 1595m-5 LVR 25409–10
Figs 11–12	*Coronifera* cf. *oceanica* 33.0-109.9, 1595m-4 LVR 25412–13



Skolp – Plate 17
1-4: 1580 m;
5-12: 1595 m;
LVR: 25399-25413

SKOLP - PLATE 18

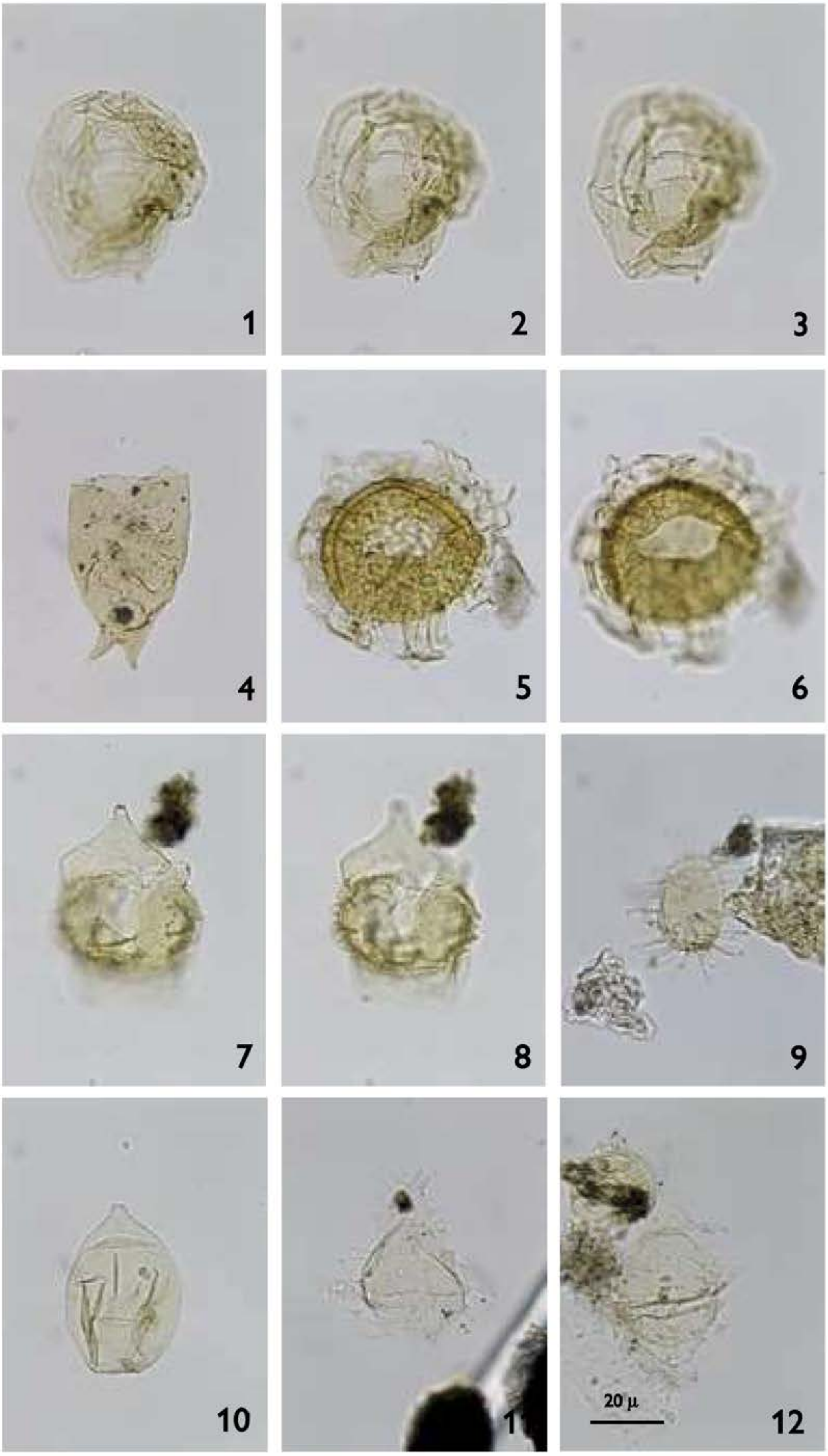
Fig. 1	*Odontochitina costata* 46.4-98.5, 1610m-6 LVR 25414
Fig. 2	*Odontochitina costata* 47.9-103.2, 1610m-6 LVR 25416
Figs 3–4	*Senoniasphaera rotundata* 31.9-105.1, 1610m-5 LVR 25418–19
Figs 5–6	*Chatangiella* sp. 36.9-106.2, 1610m-5 LVR 25420–21
Fig. 7	*Wallodinium luna* 39.6-100.2, 1610m-3 LVR 25422
Figs 8–9	Dinocyst sp. 2 HNH 2003 (*Circulodinium* cf. *distinctum?*) 23.4-102.8, 1625m-4 LVR 25424–25
Figs 9–10	*Chatangiella hexacalpis/biapatura* 20.5-98.5, 1640m-3 LVR 25426–27
Fig. 12	*Hystrichosphaeropsis quasicribrata* 34.3-111.5, 1640m-3 LVR 25428



Skolp – Plate 18
1-7: 1610 m; 8-9: 1625 m;
10-12: 1640 m;
LVR: 25414-25428

SKOLP - PLATE 19

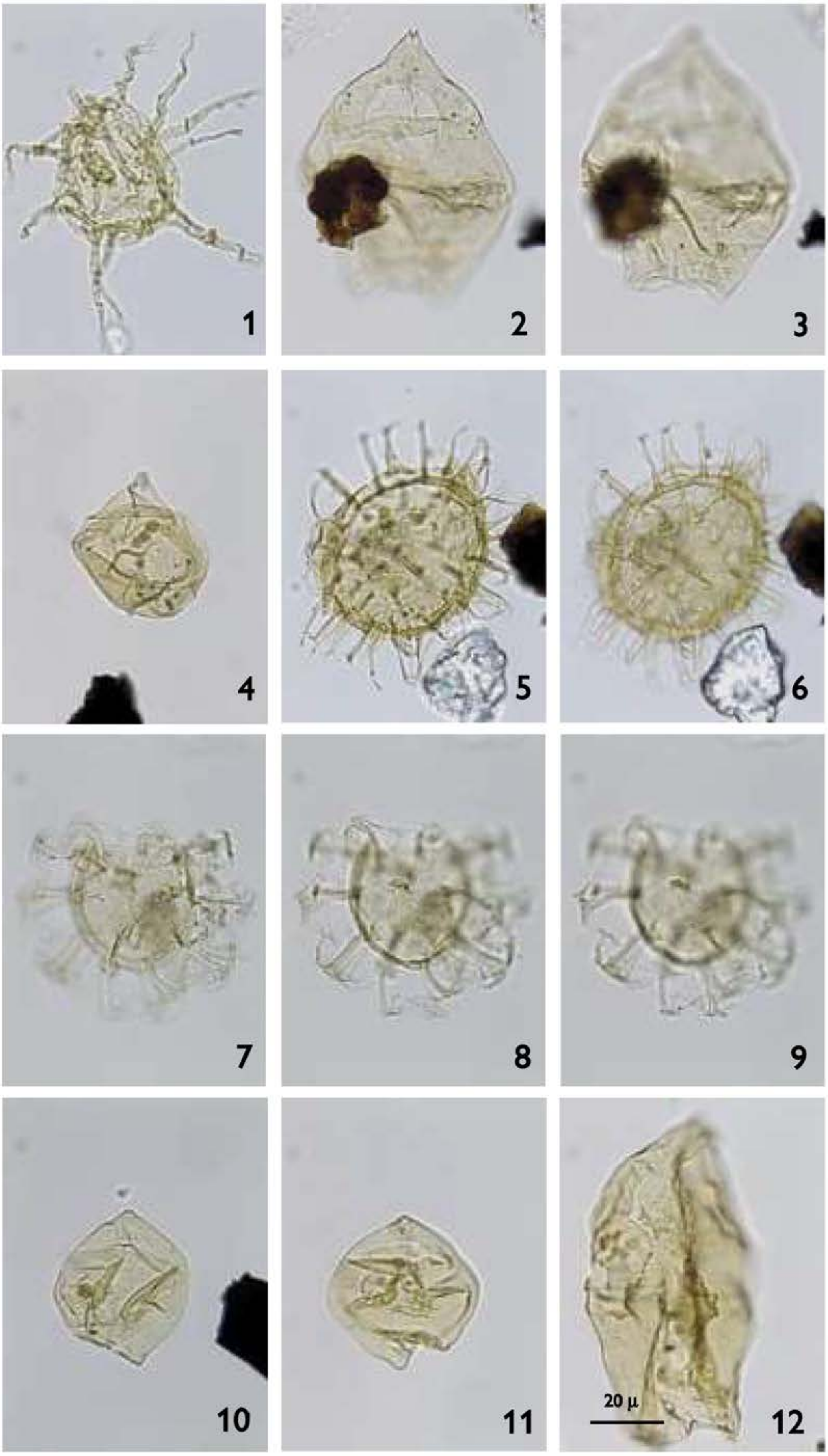
Figs 1–3	*Stephodinium* sp. 1 HNH 2003 31.4-100.0, 1655m-3 LVR 25429–31
Fig. 4	*Batioladinium jaegeri* 45.7-107.9, 1655m-3 LVR 25432
Figs 5–6	*Membranilanarcia polycladiata* 47.0-102.5, 1655m-6 LVR 25433-34
Figs 7–8	*Chatangiella madura* 36.4-107.3, 1670m-3 LVR 25438–39
Fig. 9	*Tanyosphaeridium* sp. 21.4-92.9, 1670m-3 LVR 25439
Fig. 10	*Isabelidinium* sp. 22.4-96.6, 1670m-3 LVR 25441
Fig. 11	*Palaeohystrichophora infusorioides* 30.5-98.6, 1670m-3 LVR 25442
Fig. 12	*Palaeohystrichophora infusorioides* 32.7-112.8, 1670m-3 LVR 25443



Skolp – Plate 19
1-6: 1655 m;
7-12: 1670 m;
LVR: 25429-25443

SKOLP - PLATE 20

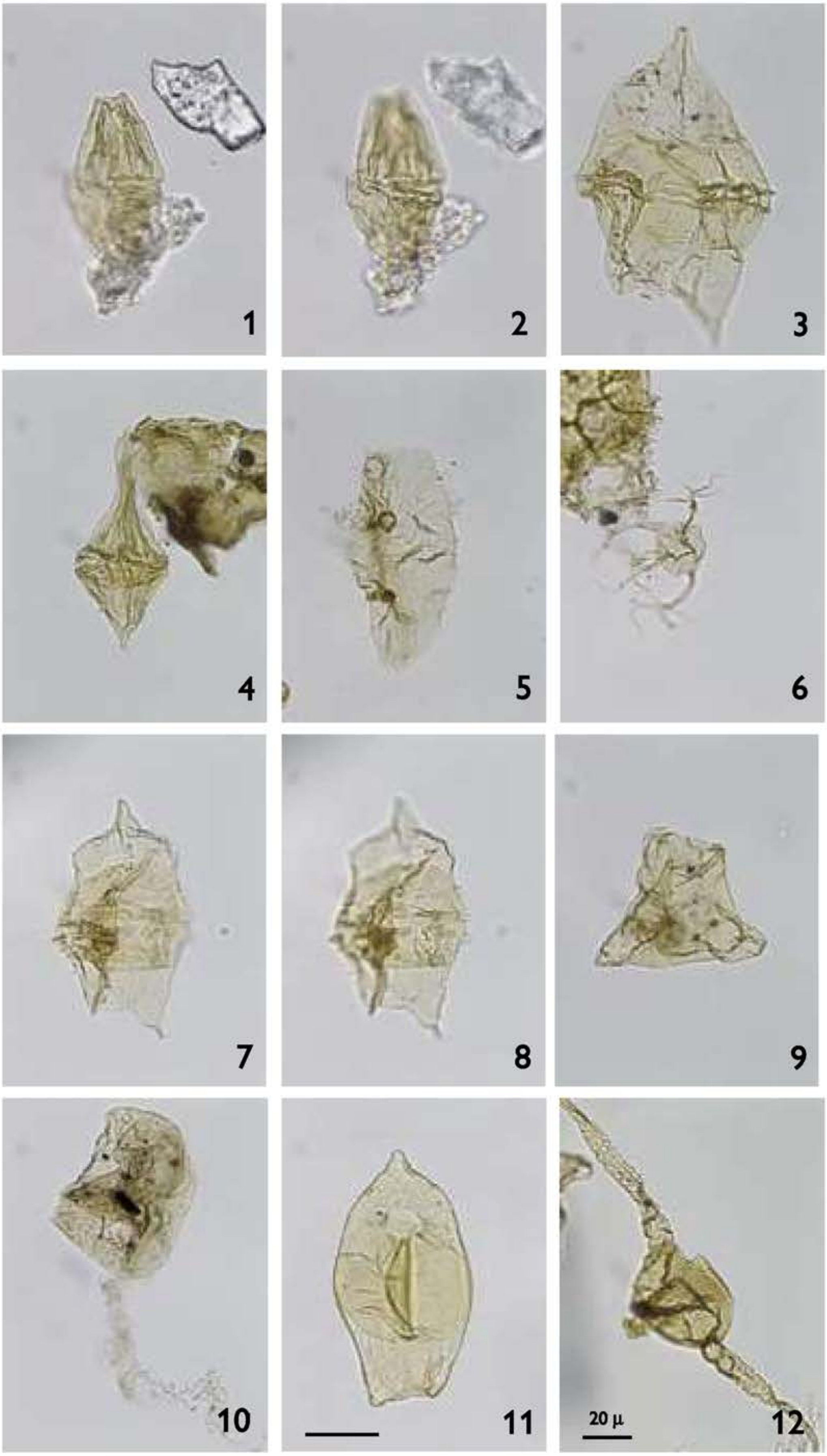
Fig. 1	Acritarch sp. 1 HNH 2003 43.0-96.4, 1670m-3 LVR 25445
Figs 2–3	*Chatangiella hexacalpis/biapatura* 26.6-99.0, 1685m-3 LVR 25446–47
Fig. 4	*Alterbidinium minus* 27.0-98.7, 1685m-3 LVR 25448
Figs 5–6	*Heterosphaeridium heteracanthum* 28.0-102.4, 1685m-3 LVR 25449-50
Figs 7–9	Chorat cyst sp. 1 HNH 2003 (caved?) 24.0-94.3, 1700m-3 LVR 25451–53
Fig. 10	*Alterbidinium varium* 40.0-103.7, 1715m-3 LVR 25454
Fig. 11	*Alterbidinium varium* 26.0-101.6, 1715m-5 LVR 25455
Fig. 12	*Chatangiella decorosa* 23.6-106.9, 1745m-3 LVR 25456



Skolp – Plate 20
1: 1670 m; 2-6: 1685 m; 7-9: 1700 m;
10-11 1715 m; 12: 1745 m;
LVR: 25445-25457

SKOLP - PLATE 21

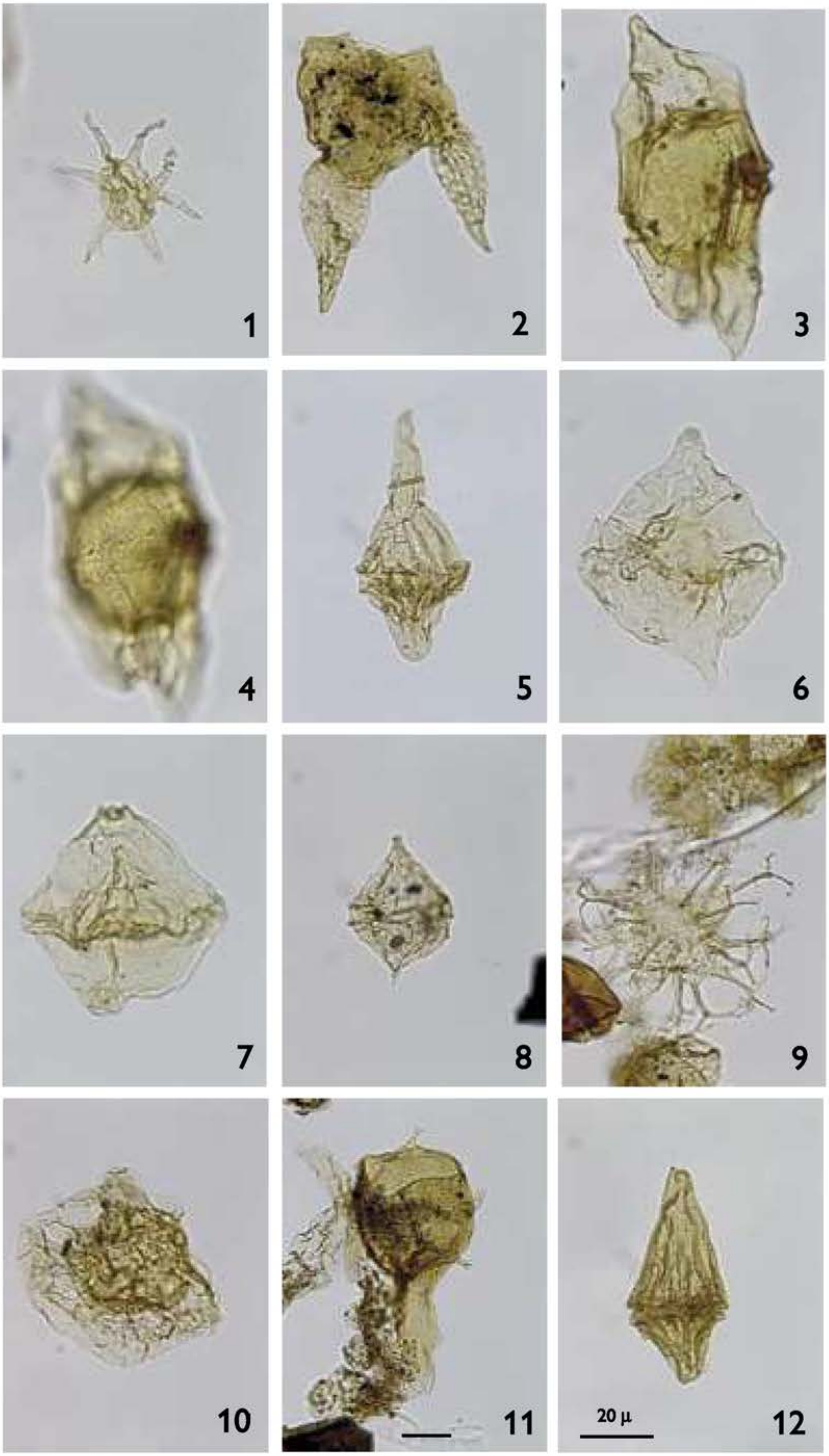
Figs 1–2	*Dinogymnium* sp. HNH 2003 40.9-107.1, 1745m-4 LVR 25458–59
Fig. 3	*Chatangiella ditissima* 23.1-98.8, 1760m-3 LVR 25460
Fig. 4	*Dinogymnium longicornis* 17.4-112.4, 1775m-3 LVR 25461
Fig. 5	*Fromea nicosia* 20.3-102.1, 1775m-3 LVR 25463
Fig. 6	*Veryhachium crusiatum* 22.2-101.4, 1820m-3 LVR 25464
Figs 7–8	*Chatangiella madura* 27.9-92.2, 1820m-3 LVR 25465–66
Fig. 9	*Trigonopyxidia ginella* 18.4-101.2, 1835m-3 LVR 25467
Fig. 10	*Desmocysta plekta* 21.4-113.2, 1850m-3 LVR 25468
Fig. 11	*Isabelidinium bakeri* 24.0-94.6, 1850m-3 LVR 25469
Fig. 12	*Odontochitina costata* 25.5-93.5, 1850m-3 LVR 25470



Skolp – Plate 21
1-2: 1745 m; 3: 1760 m; 4-5: 1775 m;
6-8: 1820 m; 9: 1835 m; 10-12: 1850 m;
LVR: 25458-25470

SKOLP - PLATE 22

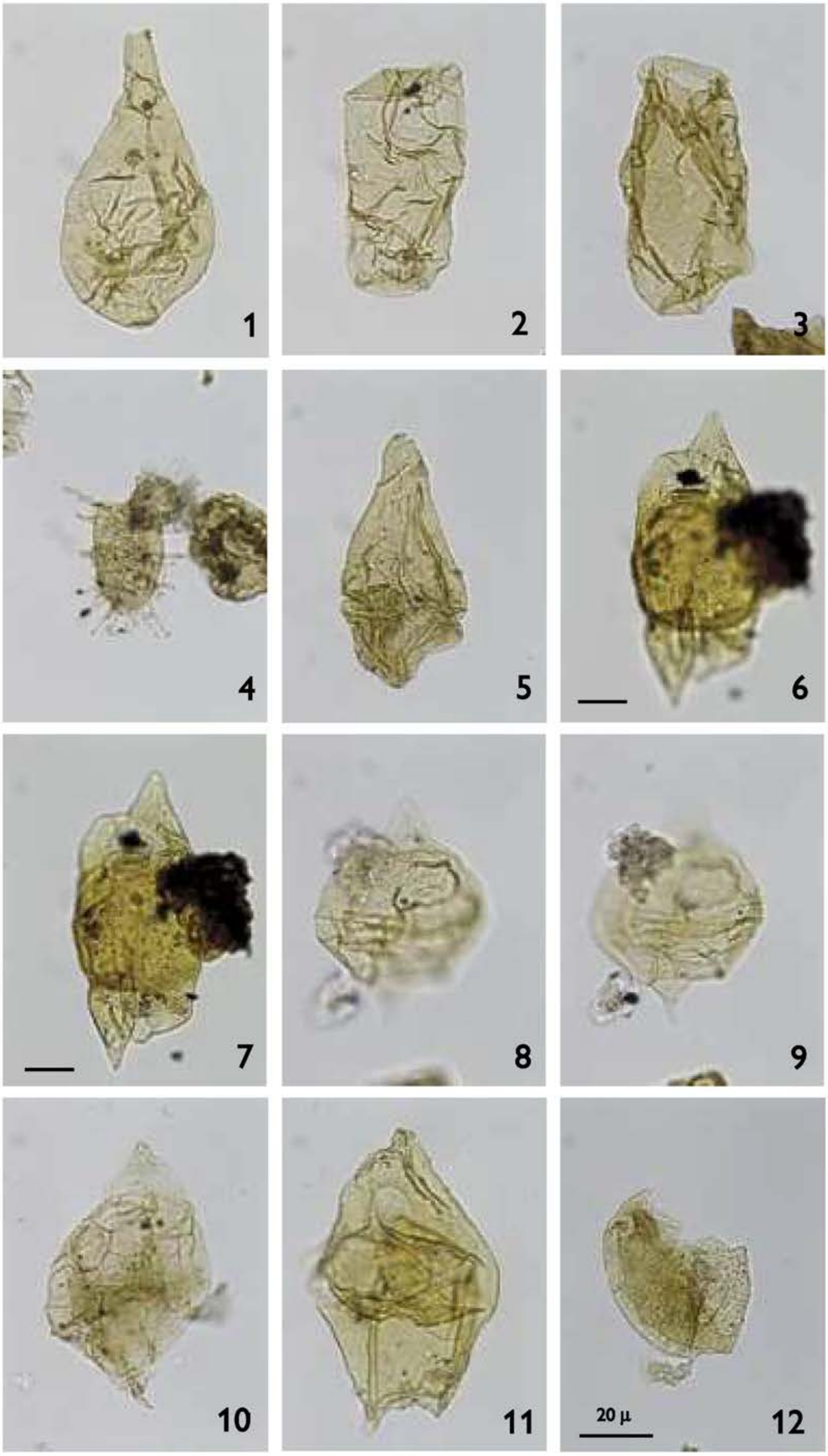
Fig. 1	Acritarch sp. 30.4-102.2, 1880m-4 LVR 25471
Fig. 2	*Odontochitina porifera* 33.2-107.9, 1895m-4 LVR 25472
Figs 3–4	*Chatangiella bondarenkoi* 30.8-92.5, 1895m-4 LVR 25475–76
Fig. 5	*Dinogymnium longicornis* 42.9-110.5, 1895m-4 LVR 25477
Fig. 6	*Isabelidinium acuminatum* 26.0-98.6, 1940m-3 LVR 25478
Fig. 7	*Isabelidinium acuminatum* 36.2-110.6, 1940m-3 LVR 25479
Fig. 8	*Laciniadinium arcticum* 19.5-104.7, 1940m-3 LVR 25480
Fig. 9	*Achomosphaera* sp. 1 HNH 2003 39.3-105.5, 1940m-3 LVR 25481
Fig. 10	*Eatonicysta pterococcoides?* 40.6-103.0, 1940m-3 LVR 25482
Fig. 11	*Xenascus ceratioides* 35.7-109.2, 1985m-3 LVR 25483
Fig. 12	*Dinogymnium* sp. 39.6-102.9, 2030m-4 LVR 25484



Skolp – Plate 22
1: 1880 m; 2-5: 1895 m; 6-10: 1940 m;
11: 1985 m; 12: 2030 m;
LVR: 25471-25484

SKOLP - PLATE 23

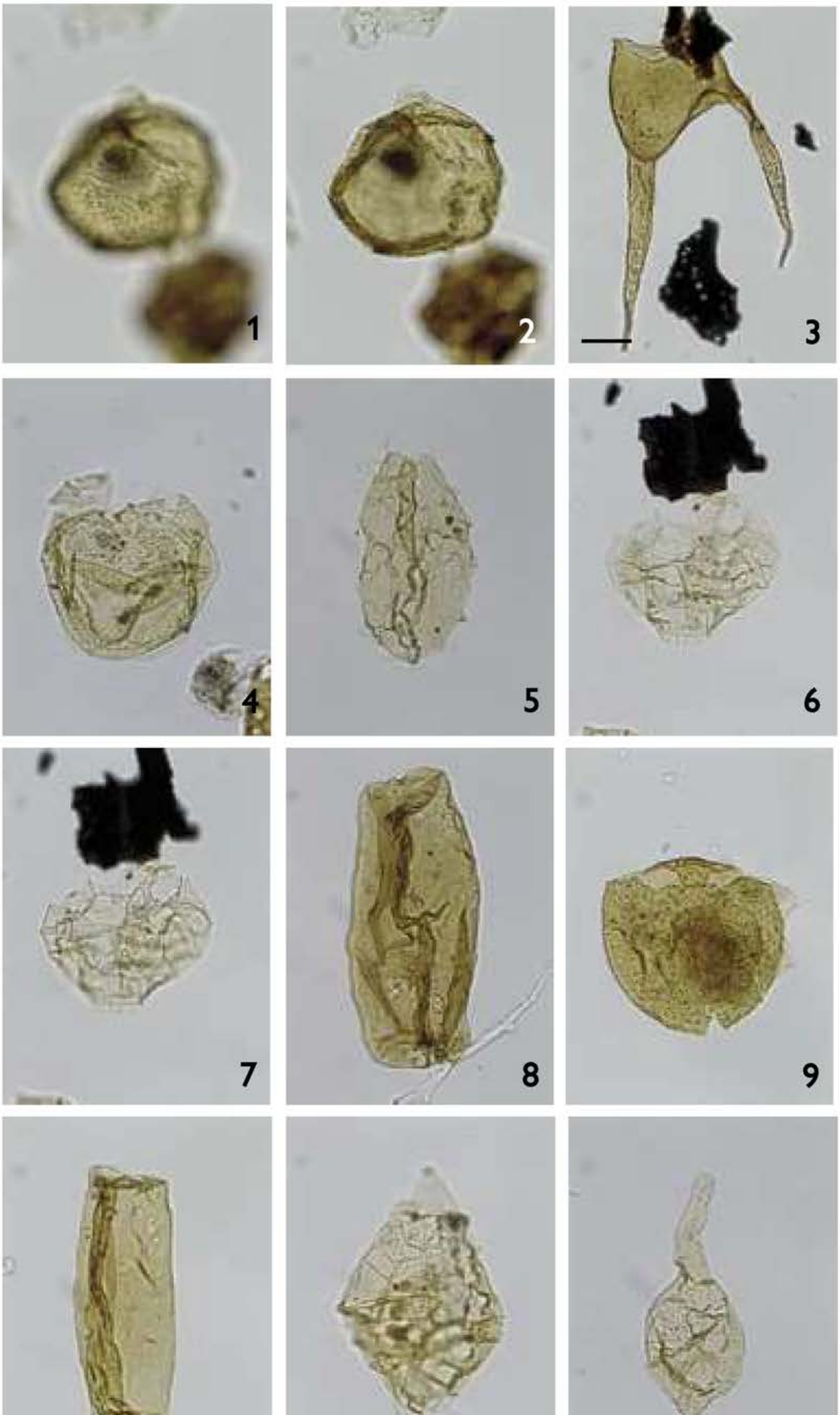
Fig. 1	*Alisogymnium* sp. 44.6-97.5, 2045m-4 LVR 25485
Fig. 2	*Fromea* sp. 1 HNH 2003 42.1-94.3, 2075m-3 LVR 25486
Fig. 3	*Fromea* sp. 1 HNH 2003 44.2-109.3, 2090m-5 LVR 25487
Fig. 4	*Tanyosphaeridium* sp. 43.0-106.0, 2105m-5 LVR 25488
Fig. 5	*Dinogymnium* sp. 20.7-95.7, 2135m-4 LVR 25489
Figs 6–7	*Chatangiella bondarenkoi* 53.3-97.1, 2150m-4 LVR 25490–91
Figs 8–9	Dinocyst sp. E Ioannides 1986 31.0-98.7, 2225m-2 LVR 25492–93
Fig. 10	Dinocyst sp. E Ioannides 1986 35.5-106.8, 2255m-2 LVR 25494
Fig. 11	*Isabelidinium microarmum* 24.4-93.5, 2285m-2 LVR 25495
Fig. 12	*Trithyrodinium suspectum* 19.0-111.5, 2285m-2 LVR 25496



Skolp – Plate 23
1: 2045 m; 2: 2075 m; 3: 2090; 4: 2105 m;
5: 2135 m; 6-7: 2150 m; 8-9: 2225 m;
10: 2255 m; 11-12: 2285 m;
LVR: 25484-25496

SKOLP - PLATE 24

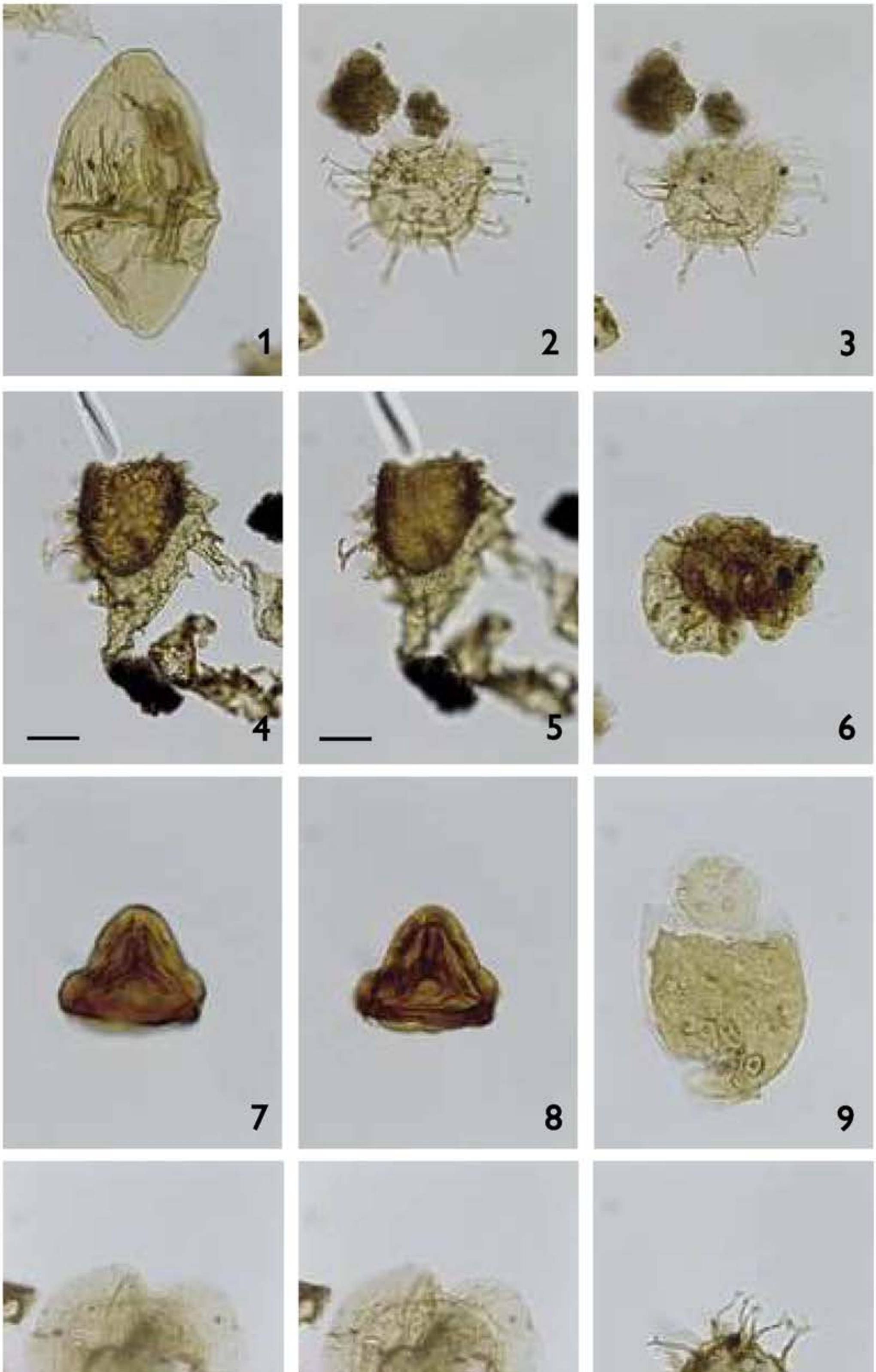
Figs 1-2	*Trithyrodinium suspectum/?vermiculatum* 22.6-96.7, 2285m-2 LVR 25497–98
Fig. 3	*Odontochitina costata* 40.3-111.8, 2345m-2 LVR 25499
Fig. 4	*Trithyrodinium suspectum* 44.8-100.1, 2345m-2 LVR 25500
Fig. 5	*Fromea nicosia* 25.5-93.1, 2360m-2 LVR 25501
Figs 6–7	Dinocyst sp. E Ioannides 1986 22.0-97.8, 2360m-2 LVR 25502–503
Fig. 8	*Fromea* sp. 1 HNH 2003 47.6-99.1, 2360m-2 LVR 25504
Fig. 9	*Trithyrodinium suspectum* 39.0-107.4, 2375m-4 LVR 25505
Fig. 10	*Fromea* sp. 1 HNH 2003 30.9-111.9, 2375m-4 LVR 25506
Fig. 11	Dinocyst sp. E Ioannides 1986 20.1-113.2, 2390m-2 LVR 25529
Fig. 12	*Dinogymnium* sp./*Alisogymnium* sp. 31.0-100.7, 2420m-2 LVR 25530



Skolp – Plate 24
1-2: 2285 m; 3-4: 2345;
5-8: 2360 m; 9-10: 2375 m;
11: 2390 m; 12: 2420 m;
LVR: 25497-25530

SKOLP - PLATE 25

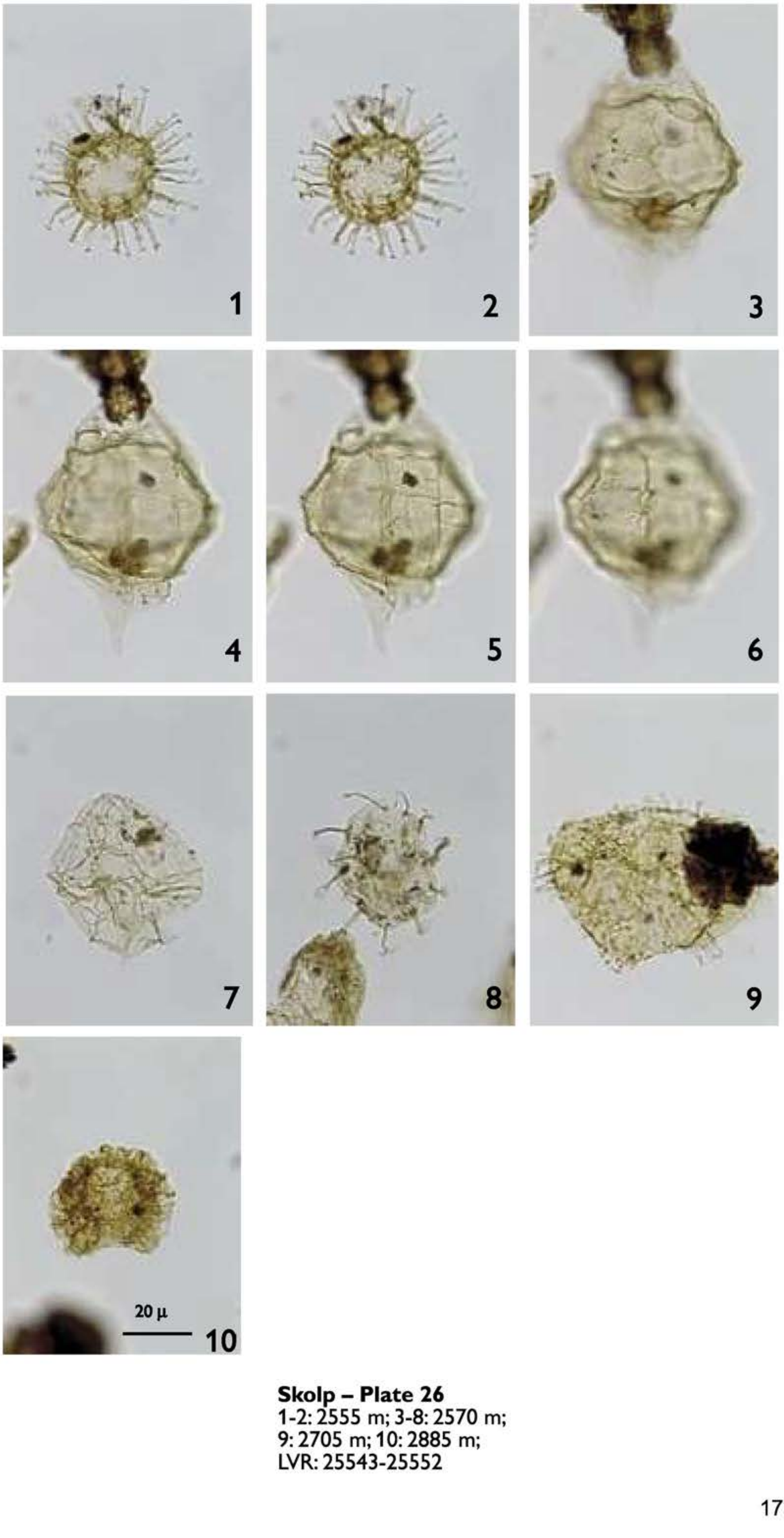
Fig. 1	*Dinogymnium* sp. 23.6-105.5, 2420m-3 LVR 25531
Figs 2–3	*Dapsilidinium* sp. ? HNH 2003 23.3-111.7, 2435m-3 LVR 25532–33
Figs 4–5	*Xenascus ceratioides* 24.6-107.9, 2435m-3 LVR 25534–35
Fig. 6	*Rugubivesiculites rugusus* 38.5-105.5, 2495m-3 LVR 25536
Figs 7–8	*Distaltriangulisporites perplexus* 38.3-108.2, 2495m-3 LVR 25537–38
Fig. 9	*Caligodinium aceras* 22.3-93.0, 2525m-2 LVR 25539
Figs 10–11	*Dinopterygium* cf. *cladoides* 27.0-107.2, 2540m-4 LVR 25540–41
Fig. 12	*Surculosphaeridium longifurcatum* 47.2-105.2, 2540m-4 LVR 25542



Skolp – Plate 25
1: 2420 m; 2-5: 2435 m;
6-8: 2495 m; 9: 2525 m;
11-12: 2540 m;
LVR: 25531-25542

SKOLP - PLATE 26

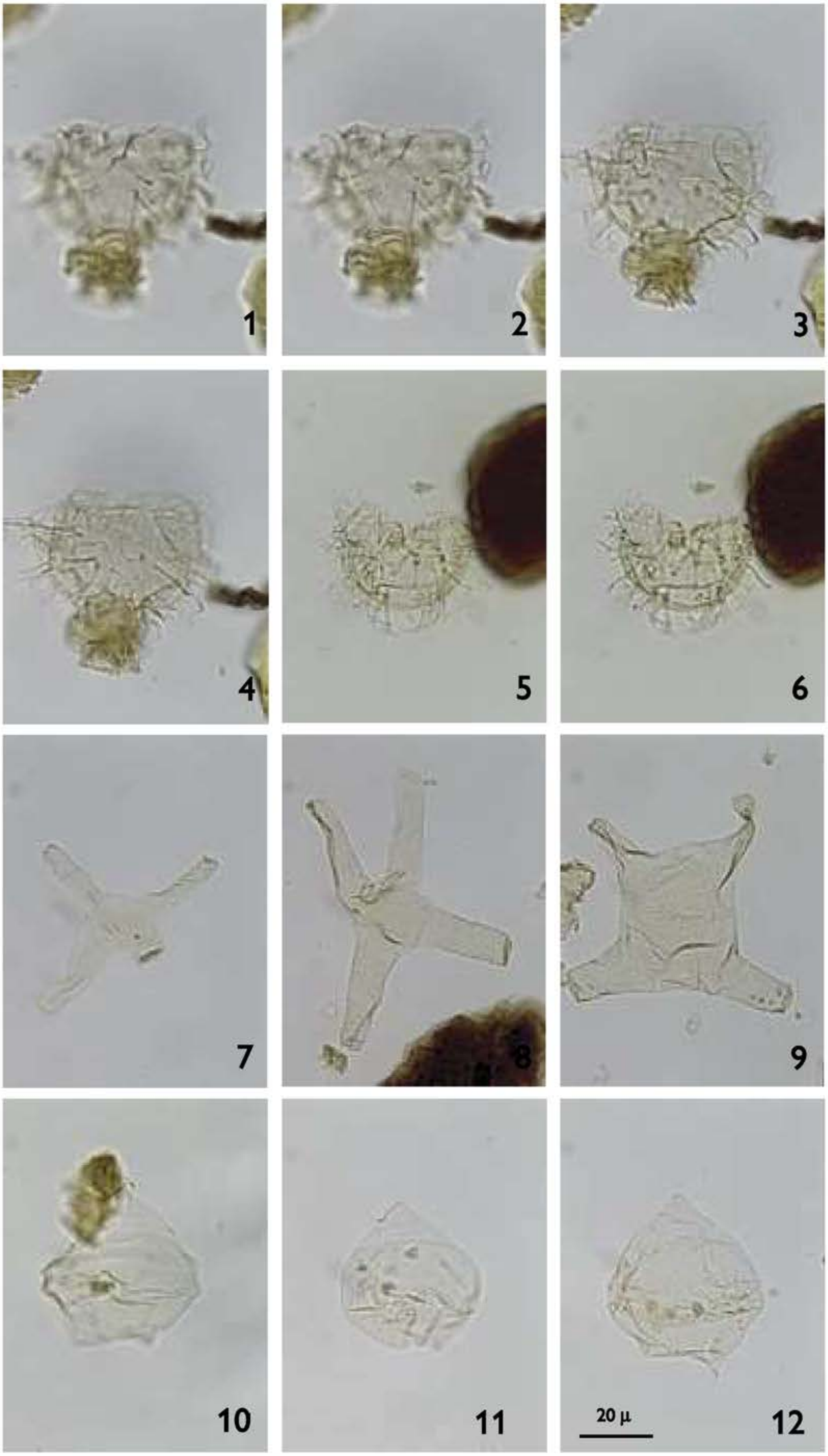
Figs 1–2	*Dapsilidinium* sp. ? HNH 2003 17.3-111.2, 2555m-4 LVR 25543–44
Figs 3–6	Dinocyst sp. E Ioannides 1986 49.4-95.5, 2570m-2 LVR 25545–48
Fig. 7	Dinocyst sp. E Ioannides 1986 24.5-99.7, 2570m-2 LVR 25549
Fig. 8	*Surculosphaeridium longifurcatum* 40.8-100.5, 2570m-2 LVR 25550
Fig. 9	*Circulodinium* sp. 45.1-113.3, 2705m-2 LVR 25551
Fig. 10	*Rugubivesiculites rugusus* 28.6-99.2, 2885m-2 LVR 25552



Skolp – Plate 26
1-2: 2555 m; 3-8: 2570 m;
9: 2705 m; 10: 2885 m;
LVR: 25543-25552

GJOA - PLATE 1

Figs 1–4	*Glaphyrocysta “semicomplexa?”* 21.2-109.6, 1560m-2, LVR 25901–904
Figs 5–6	*Glaphyrocysta “semicomplexa?”* 47.3-111.6, 1560m-4, LVR 25915–16
Fig. 7	*Tetraporina* sp. 1 HNH 47.6-100.0, 1620m-3, LVR 25905
Fig. 8	*Tetraporina* sp. 1 HNH 42.5-98.2, 1620m-4, LVR 25907
Fig. 9	*Tetraporina* sp. 1 HNH 34.0-105.0, 1620m-4, LVR 25908
Fig. 10	*Alterbidinium* cf. *bicellulum* 18.4-107.1, 1620m-2, LVR 25910
Fig. 11	*Alterbidinium* cf. *bicellulum* 16.2-100.0, 1620m-2, LVR 25912
Fig. 12	*Alterbidinium* cf. *bicellulum* 29.2-93.0, 1620m-2, LVR 25914



Gjoa – Plate 1
1-6: 1560 m;
6-12: 1620 m;
LVR: 25901-25916

Appendix 1 – Project staff and co-workers

Scientific participants and co-workers

GEUS - Geological Survey of Denmark and Greenland

Project manager, Head of Department, Flemming Getreuer Christiansen
Project leader, senior research scientist, Martin Sønderholm
Senior research scientist, Henrik Nøhr-Hansen, palynology
Senior research scientist, Jan Audun Rasmussen, micropalaeontology
Senior research adviser, Finn Dalhoff, log interpretation
Senior research scientist, Jørgen A. Bojesen-Koefoed, organic geochimstry

GSC – Geological Survey of Canada (Atlantic)
Dr. Robert Fensome,
Dr. Graham Williams

Newfoundland Offshore Petroleum Board
Dr. Neil DeSilva, Manager, Exploration
Lewis Manuel, Petroleum technologist, CET

Nova Scotia Offshore Petroleum Board
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Appendix 2 – Location of processed samples

Skolp E-07

Sample (DCS)	Slide 1	Slide 2	Slide 3	Slide 4	Slide 5	Slide 6
925m	GEUS	GEUS	GEUS	GSC	CNOPB	
935m	GEUS	GEUS	GEUS	GSC	CNOPB	
945m	GEUS	GEUS	GEUS	GSC	CNOPB	
955m	GEUS	GEUS	GEUS	CNOPB		
965m	GEUS	GEUS	GEUS	CNOPB		
975m	GEUS	GEUS	GEUS	GSC	CNOPB	
985m	GEUS	GEUS	GEUS	GSC	CNOPB	
995m	GEUS	GEUS	GEUS	GSC	CNOPB	
1005m	GEUS	GEUS	GEUS	GSC	CNOPB	
1015m	GEUS	GEUS	GEUS	GSC	CNOPB	
1025m	GEUS	GEUS	GEUS	GSC	CNOPB	
1040m	GEUS	GEUS	GEUS	GSC	CNOPB	
1055m	GEUS	GEUS	GEUS	GSC	CNOPB	
1070m	GEUS	GEUS	GEUS	GSC	CNOPB	
1085m	GEUS	GEUS	GEUS	GSC	CNOPB	
1100m	GEUS	GEUS	GEUS	GSC	CNOPB	
1115 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1130 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1145 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1160 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1175 m	GEUS	GEUS	GEUS	CNOPB		
1190 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1205 m	GEUS	GEUS	GEUS	CNOPB		
1220 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1235 m	GEUS	GEUS	GEUS	CNOPB		
1250 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1265 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1295 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1310 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1325 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1340 m	GEUS	GEUS	GEUS	CNOPB		
1355 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1370 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1385 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1400 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1415 m	GEUS	GEUS	GEUS	CNOPB		
1430 m	GEUS	GEUS	GEUS	CNOPB		
1445 m	GEUS	GEUS	GEUS	CNOPB		
1460 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1475 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1490 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1505 m	GEUS	GEUS	GEUS	CNOPB		

Sample (DCS)	Slide 1	Slide 2	Slide 3	Slide 4	Slide 5	Slide 6
1520 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1535 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1550 m	GEUS	GEUS	GEUS	GSC	GEUS	CNOPB
1565 m	GEUS	GEUS	GEUS	GSC	GEUS	CNOPB
1580 m	GEUS	GEUS	GEUS	GSC	GEUS	CNOPB
1595 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1610 m	GEUS	GEUS	GEUS	GSC	GEUS	CNOPB
1625 m	GEUS	GEUS	GEUS	GSC	GEUS	CNOPB
1640 m	GEUS	GEUS	GEUS	GSC	GEUS	CNOPB
1655 m	GEUS	GEUS	GEUS	GSC	GEUS	CNOPB
1670 m	GEUS	GEUS	GEUS	GSC	GEUS	CNOPB
1685 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1700 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1715 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1730 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1745 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1760 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1775 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1805 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1820 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1835 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1850 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1865 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1880 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1895 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1910 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1940 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1955 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1970 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1985 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2000 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2030 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2045 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2060 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2075 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2090 m	GEUS	GEUS	GEUS	GSC	GEUS	CNOPB
2105 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2120 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2135 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2150 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2165 m	GEUS	GSC	GEUS	CNOPB		
2180 m	GEUS	GEUS	GSC	CNOPB		
2195 m	GEUS	GEUS	GSC	CNOPB		
2210 m	GEUS	GEUS	GSC	CNOPB		
2225 m	GEUS	GEUS	GSC	CNOPB		
2240 m	GEUS	GEUS	GSC	CNOPB		

Sample (DCS)	Slide 1	Slide 2	Slide 3	Slide 4	Slide 5	Slide 6
2255 m	GEUS	GEUS	GSC	CNOPB		
2270 m	GEUS	GEUS	GSC	CNOPB		
2285 m	GEUS	GEUS	GSC	CNOPB		
2300 m	GEUS	GEUS	GSC	CNOPB		
2315 m	GEUS	GEUS	GSC	CNOPB		
2330 m	GEUS	GEUS	GSC	CNOPB		
2345 m	GEUS	GEUS	GSC	CNOPB		
2360 m	GEUS	GEUS	GSC	CNOPB		
2375 m	GEUS	GSC	CNOPB	GEUS		
2390 m	GEUS	GEUS	GSC	CNOPB		
2405 m	GEUS	GEUS	CNOPB			
2420 m	GEUS	GEUS	GSC	CNOPB		
2435 m	GEUS	GEUS	GSC	CNOPB		
2450 m	GEUS	GEUS	GSC	CNOPB		
2465 m	GEUS	GEUS	GSC	CNOPB		
2480 m	GEUS	GEUS	GSC	CNOPB		
2495 m	GEUS	GEUS	GEUS	CNOPB		
2510 m	GEUS	GEUS	GSC	CNOPB		
2525 m	GEUS	GEUS	GSC	CNOPB		
2540 m	GEUS	GEUS	CNOPB	GEUS		
2555 m	GEUS	GEUS	CNOPB	GEUS		
2570 m	GEUS	GEUS	GSC	CNOPB		
2585 m	GEUS	GEUS	GSC	CNOPB		
2600 m	GEUS	GEUS	GSC	CNOPB		
2615 m	GEUS	GEUS	GSC	CNOPB		
2630 m	GEUS	GEUS	GSC	CNOPB		
2645 m	GEUS	GEUS	GSC	CNOPB		
2675 m	GEUS	GEUS	GSC	CNOPB		
2690 m	GEUS	GEUS	GSC	CNOPB		
2705 m	GEUS	GEUS	GSC	CNOPB		
2720 m	GEUS	GEUS	GSC	CNOPB		
2735 m	GEUS	GEUS	GSC	CNOPB		
2750 m	GEUS	GEUS	GSC	CNOPB		
2765 m	GEUS	GEUS	GSC	CNOPB		
2780 m	GEUS	GEUS	GSC	CNOPB		
2795 m	GEUS	GEUS	GSC	CNOPB		
2810 m	GEUS	GEUS	GSC	CNOPB		
2825 m	GEUS	GEUS	GSC	CNOPB		
2840 m	GEUS	GEUS	GSC	CNOPB		
2855 m	GEUS	GEUS	GSC	CNOPB		
2870 m	GEUS	GEUS	GSC	CNOPB		
2885 m	GEUS	GEUS	GSC	CNOPB		
2900 m	GEUS	GEUS	GSC	CNOPB		
2930 m	GEUS	GEUS	GSC	CNOPB		
2945 m	GEUS	GEUS	GSC	CNOPB		
2960 m	GEUS	GEUS	GSC	CNOPB		

Sample (DCS)	Slide 1	Slide 2	Slide 3	Slide 4	Slide 5	Slide 6
2975 m	GEUS	GEUS	GSC	CNOPB		
2985 m	GEUS	GEUS	GSC	CNOPB		

GEUS: Geological Survey of Denmark and Greenland
GSC: Geological Survey of Canada Atlantic
CNOPB: Canada-Newfoundland Offshore Petroleum Board

DCS: Ditch cutting sample
SWC: Side wall core sample

Ogmund E-72

Sample (DCS)	Slide 1	Slide 2	Slide 3	Slide 4	Slide 5	Slide 6
790 m	GEUS	GEUS	GEUS	GSC	CNOPB	
815 m	GEUS	GSC	GEUS	GEUS	CNOPB	
840 m	GEUS	GSC	CNOPB	GEUS	GEUS	
865 m	GEUS	GEUS	GEUS	GSC	CNOPB	
890 m	GEUS	GEUS	GEUS	GSC	CNOPB	
915 m	GEUS	GEUS	GSC	GEUS	CNOPB	
940 m	GEUS	GSC	GEUS	CNOPB	GEUS	
965 m	GEUS	GEUS	GSC	CNOPB	GEUS	
990 m	GEUS	GSC	GEUS	GEUS	CNOPB	
1000 m swc	GEUS	GEUS	GSC	CNOPB		
1015 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1028 m swc	GEUS	GEUS	GSC	CNOPB		
1030 m swc	GEUS	GEUS	GEUS	GSC	CNOPB	
1035 m swc	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1040 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1060 m swc	GEUS	GEUS	GEUS	GSC	CNOPB	
1065 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1090 m swc	GEUS	GEUS	CNOPB	GEUS		
1090 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1115 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1125 m swc	GEUS	GEUS	GEUS	GSC	CNOPB	
1140 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1155,5 m swc	GEUS	GEUS	GEUS	GSC	CNOPB	
1165 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1170 m swc	GEUS	GEUS	CNOPB			
1185 m swc	GEUS	GEUS	GEUS	GSC	CNOPB	
1198,5 m swc	GEUS	GEUS	GEUS	GSC	CNOPB	
1215 m swc	GEUS	GEUS	CNOPB	GEUS		
1215 m	GEUS	GEUS	GSC	GEUS	CNOPB	
1240 m	GEUS	GCS	GEUS	GEUS	CNOPB	
1265 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1290 m	GEUS	GEUS	GSC	GEUS	CNOPB	
1305 m swc	GEUS	GEUS	GSC	GEUS	GEUS	CNOPB
1315 m	GEUS	GSC	GEUS	CNOPB	GEUS	
1336 m swc	GEUS	GEUS	GEUS	GSC	CNOPB	
1340 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1365 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1390 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1391 m swc	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1420 m swc	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1440 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1455 m swc	GEUS	GSC	GEUS	CNOPB		
1465 m	GEUS	GEUS	GEUS	GSC	CNOPB	

Sample (DCS)	Slide 1	Slide 2	Slide 3	Slide 4	Slide 5	Slide 6
1490 m	GEUS	CNOPB	GEUS	GEUS		
1515 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1530 m	GEUS	GSC	GEUS			
1545 m	GEUS	GSC	GEUS	CNOPB		
1560 m	GEUS	GSC	GEUS	CNOPB		
1575 m	GEUS	CNOPB	GEUS	GSC		
1590 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1605 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1620 m	GEUS	CNOPB	GEUS	GEUS	GSC	
1635 m	GEUS	CNOPB	GEUS	GSC		
1650 m	GEUS	CNOPB	GEUS	GSC		
1665 m	GEUS	CNOPB	GEUS			
1680 m	GEUS	GEUS	CNOPB	GEUS	GSC	
1695 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1710 m	GEUS	CNOPB	GEUS	GSC		
1725 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1740 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1755 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1770 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1785 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1800 m	GEUS	CNOPB	GEUS	GSC		
1815 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1830 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1845 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1860 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1875 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1890 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1905 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1920 m	GEUS	CNOPB	GEUS	GSC		
1935 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1950 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1965 m	GEUS	GEUS	GEUS	GSC	CNOPB	
1980 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
1995 m	GEUS	GEUS	GEUS	GSC	CNOPB	GEUS
2010 m	GEUS	GEUS	GEUS	GSC	GEUS	CNOPB
2025 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2040 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2055 m	GEUS	GEUS	GEUS	GSC	GEUS	CNOPB
2070 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2085 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2100 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2115 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2130 m	GEUS	CNOPB	GEUS	GSC		
2145 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2160 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2175 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB

Sample (DCS)	**Slide 1**	**Slide 2**	**Slide 3**	**Slide 4**	**Slide 5**	**Slide 6**
2190 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2205 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2220 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2235 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2250 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2265 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2280 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2295 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2310 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2325 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2340 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2355 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2370 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2385 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2400 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2415 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2430 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2445 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2460 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2475 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2490 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2505 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2520 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2535 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2550 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2565 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2580 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2595 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2610 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2625 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2640 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2655 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2670 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2685 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2700 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2715 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2730 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2745 m	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB
2760 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2775 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2790 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2805 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2820 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2835 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2850 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2859 m swc	GEUS	GEUS	GEUS	GEUS	GSC	CNOPB

Sample (DCS)	**Slide 1**	**Slide 2**	**Slide 3**	**Slide 4**	**Slide 5**	**Slide 6**
2865 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2880 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2880,5 m swc	GEUS	GEUS	GEUS	GSC	CNOPB	
2895 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2910 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2925 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2940 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2941 m swc	GEUS	GEUS	GSC	CNOPB		
2955 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2970 m	GEUS	GEUS	GEUS	GSC	CNOPB	
2985 m	GEUS	GEUS	GEUS	GSC	CNOPB	
3000 m	GEUS	GEUS	GEUS	GSC	CNOPB	
3015 m	GEUS	GEUS	GEUS	GSC	CNOPB	
3030 m	GEUS	GEUS	GEUS	GSC	CNOPB	
3045 m	GEUS	GEUS	GEUS	GSC	CNOPB	
3060 m	GEUS	GEUS	GEUS	GSC	CNOPB	
3075 m	GEUS	GEUS	GEUS	GSC	CNOPB	
3090 m	GEUS	GEUS	GEUS	GSC	CNOPB	

GEUS: Geological Survey of Denmark and Greenland
GSC: Geological Survey of Canada Atlantic
CNOPB: Canada-Newfoundland Offshore Petroleum Board

DCS: Ditch cutting sample
SWC: Side wall core sample

Appendix 3 – Well log lithology definitions

Ogmund E-72 lithology definitions

Interval 422–620	Gamma Ray	Sonic
Sandstone	< 48	
Shale	> 48	
Interval 620–980		
Sandstone	< 87.5	> 488.5
Shale	> 87.5	< 488.5
Interval 980–1060		
Sandstone	< 115	
Shale	> 115	
Interval 1060–1227		
Sandstone	< 102	> 307.5
Shale	> 102	
Limestone	< 102	< 307.5
Interval 1227–1455		
Sandstone	< 81.5	
Shale	> 81.5	
Interval 1455–2574		
Sandstone	< 51	
Shale	> 51	
Interval 1227–2825		
Sandstone	< 51	> 225
Shale	> 51	
Limestone	< 51	< 225
Interval 2825–3068		
Sandstone	< 71	
Shale	> 71	
Conglomerate	Manuel	

Skolp E-07 lithology definitions

Interval 700–1245	Gamma Ray	Sonic	RHOB	SP
Sandstone	< 65.5			
Shale	> 65.5			
Interval 1245–1385				
Sandstone	< 57.0			
Shale	> 57.0			
Interval 1385–1710				
Sandstone				< –31.5
Shale				> –31.5
Interval 1710–2590				
Sandstone	< 41			
Shale	> 41			
Interval 2590–2920				
Sandstone	< 41			
Shale	> 41		> 2.13	
Coal	> 41		< 2.13	
Interval 2920–2968				
Conglomerat	Manuel			
Interval 2968–2992				
Matamorphic	Manuel			

Hekja O-71 lithology definitions

Interval 760–1460	Gamma Ray	Sonic	RHOB
Sandstone	< 46		
Shale	> 46		
Interval 1460–1600			
Sandtone	< 28.5		
Shale	> 28.5		
Interval 1600–2600			
Sandtone	< 50		
Shale	> 50		
Interval 2600–2640			
Sandstone	< 58.5	< 104	
Shale	> 58.5		
Coal	< 58.5	> 104	
Interval 2640–2900			
Sandstone	< 44.5	< 108	
Shale	> 44.5	< 108	
Coal		> 108	
Interval 2900–3544			
Sandstone	< 44.5	< 110	
Shale	> 44.5	< 110	
Coal		> 110	
Interval 3544–3740			
Sandstone	10.45–15.60		
Shale	> 15.60		
Tuff	< 10.45		
Interval 3740–4566			
Tuff			< 2.49
Basic extrusive ign.			> 2.49

Gjoa G-37 lithology definitions

Interval 1400–1600	Gamma Ray
Sandstone	< 47
Shale	> 47
Interval 1600–1740	
Sandstone	< 35
Shale	> 35
Interval 1740–1870	
Sandstone	< 46
Shale	> 46
Interval 1870–2013	
Sandstone	< 54.5
Shale	> 54.5
Interval 2013–2170	
Sandstone	< 38
Shale	> 38
Interval 2170–2210	
Sandstone	< 46
Shale	> 46
Interval 2210–2400	
Sandstone	< 40
Shale	> 40
Interval 2400–2705	
Sandstone	< 50
Shale	> 50
Interval 2705–4000	
Sandstone	23–30
Shale	> 58.5
Basic extrusive igneous	< 23
Tuff	30–58.5

Appendix 4 – Included publication EFP-1313/99-0025 report

Dinoflagellate cyst stratigraphy of the Palaeogene strata from the Hellefisk-1, Ikermiut-1, Kangâmiut-1, Nukik-1, Nukik-2 and Qulleq-1 wells, offhshore West Greenland.
By: H. Nøhr-Hansen, Marine and Petroleum Geology 20, 987–1016.

Included as pre-print on CD-ROM

Appendix 5 – Included publication CENTUR-project data report

Petroleum geochemistry: selected wells from the eastern Canada offshore area. Data report: Gjoa G-37, Hekja O-71, Ogmund E-72, Ralegh N-18 and Skolp E-09 wells.
By: J. A. Bojesen-Koefoed, Danmarks og Grønlands Geologiske Undersøgelse Rapport 2002/114.

Included on CD-ROM