DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2008/79

Biostratigraphic (palynologically based) study of 3 Faroese wells, 2 Norwegian wells and correlation to outcrops from the Kangerlussuaq Basin, East Greenland

Report for the Sindri Group
Project C46-34-01
December 2008

Henrik Nøhr-Hansen

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF CLIMATE AND ENERGY

G E U S

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GEUS

Contents

Introduction

This report forms the final deliverable of the research project: C46-34-01 "Biostratigraphic (palynologically based) study of 3 Faroese wells, 2 Norwegian wells and correlation to outcrops from the Kangerlussuaq Basin, East Greenland" conducted by Henrik Nøhr-Hansen, the Geological Survey of Denmark and Greenland (GEUS).

Contract negotiations between GEUS and HESS started in September 2006 and were accepted by all Sindri partners in October 2006. Jarðfeingi finally approved the project in March 2007. The Faroese well samples were collected in Tórshavn in April 2007 after permissions and well data were received. A draft Sindri research agreement contract was received from Atlanticon and returned in August 2007, suggesting the official starting date to 1 September 2007. The Norwegian well samples and palynological slides were collected in Stavanger in November 2007 after permissions were received from the Norwegian Petroleum Directorate (NPD).
The final Sindri research agreement contract was received from Atlanticon and signed the 31 December 2007. The official starting date was set to 31 December 2007 and completion date 30 September 2008. However, in order to get a better understanding on the Cretaceous–Palaeogene transition, 84 extra samples have been analysed (i.e. 289 samples instead of the original proposed 205 samples) and a later completion date (31 October 2008) was approved by the Sindri's technical coordinator, Simon Passey.

The Project forms part of the Sindri programme: "Future Exploration Issues Programme of the Faroese Continental Shelf" (referred to as the Sindri programme) established by the Faroese Ministry of Petroleum and financed by the partners of the Sindri Group.
The current licensees of the Sindri Group are: Anadarko Faroes Company, Atlantic Petroleum P/F, BP Amoco Exploration (Faroes) Limited, British Gas International B.V., ChevronTexaco Føroyar ApS, DONG Energy Føroyar P/F, Eni Denmark B.V., Føroya Kolvetni P/F, GeysirPetroleum h/f , Hess (Faroes) Limited, OMV (Faroe Islands) Exploration GmbH, Shell U.K. Limited and StatoilHydro Færøyene A/S.

Abstract

Data gathered in the previous Sindri stratigraphy projects by GEUS has shown that biostratigraphic correlation problems occur in the Upper Cretaceous–Lower Palaeogene succession of the northern North Atlantic. The main reasons for the apparent correlation problems are the extensive erosion occurring at the K/T boundary at basin margins, poor preservation of palynomorphs due to intense heating by Palaeogene intrusions and extensive reworking of Upper Cretaceous strata.

The aim of the present biostratigraphic study is to correlate biostratigraphic zones and events of the three Faroese offshore wells: Marjun 6004/16-1 and the side track 6004/16-1Z, Longan 6005/15-1 and Svinoy 6004/12-1 and the side track 6004/12-1Z with GEUS´s previous Sindri-financed biostratigraphic studies of the Kangerlussuaq Basin (East Greenland) and two Norwegian offshore wells: 6305/5-1 and 6305/-7-1 from Ormen Lange, Møre Basin in order to improve the understanding of the prospective intervals in the areas around the Faroe Islands.

The advantage of the Norwegian wells is the presence of approximately 100 m core across the Cretaceous–Palaeogene boundary. The study of the Norwegian cores contributes with information from deep-water, distal gas reservoir deposits of the uppermost Cretaceous to lower Danian interval which is missing in the Kangerlussuaq Basin and which has not been reached in the sampled Faroese wells.

The correlation of the Upper Cretaceous to Lower Palaeogene successions in the three studied northern North Atlantic areas is based on recognition of 13 zones, 19 subzones and 44 palynological events.

The lower Eocene to uppermost Paleocene succession is represented in the three Faroese wells. The upper to lower Paleocene succession is represented in all three areas. The lowermost Paleocene to uppermost Cretaceous succession is represented in the Norwegian wells and the Upper Cretaceous succession is represented in the Norwegian wells and onshore East Greenland.

Geological setting

Previous sedimentological and biostratigraphic Sindri projects (Larsen *et al.* 2005, Nøhr-Hansen *et al.* 2006, 2007) have demonstrated that southern East Greenland allows a unique possibility to study at outcrop the sedimentary basins associated with rifting and break-up of the North Atlantic. Sub- and syn- basaltic sedimentary successions of Late Cretaceous and Palaeogene age are exposed at Kangerlussuaq (Fig. 1), whereas early post-basaltic sediments (Eocene–Oligocene) are exposed further north at Kap Dalton and Savoia Halvø. GEUS has carried out field work in Kangerlussuaq in 1995, 2000 and 2004 and at Kap Dalton and Savoia Halvø in

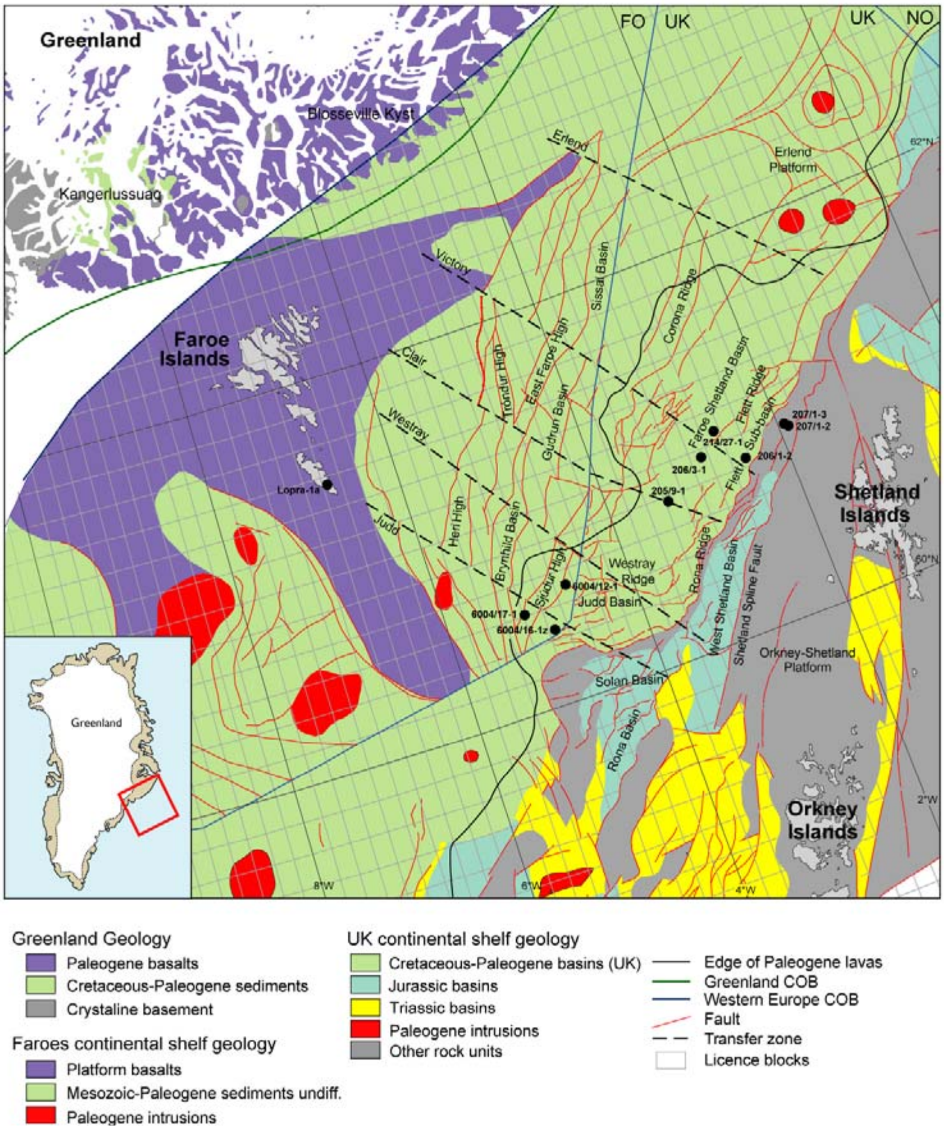


Figure 1. *Location map of East Greenland and the Faroe-Shetland region showing on- and offshore geology, main structural elements, transfer zones and wells from Larsen et al. 2005. Note that the position of Greenland relative to the Faroe-Shetland region is shown prior to Palaeogene sea-floor spreading.*

2001 and has established a comprehensive sample database for the Cretaceous and Palaeogene of East Greenland. The present background information is based on previous GEUS Sindri projects and GEUS's databases.

The sediments are formally assigned to the Kangerdlugssuaq (Barremian–Paleocene) and the Blosseville Group (Paleocene–?Eocene). Based on recent sedimentological, biostratigraphic and sequence stratigraphic studies a new lithostratigraphic scheme was established by Larsen *et al.* (2005, Fig. 2). The Kangerdlugssuaq Group was thus divided into the following

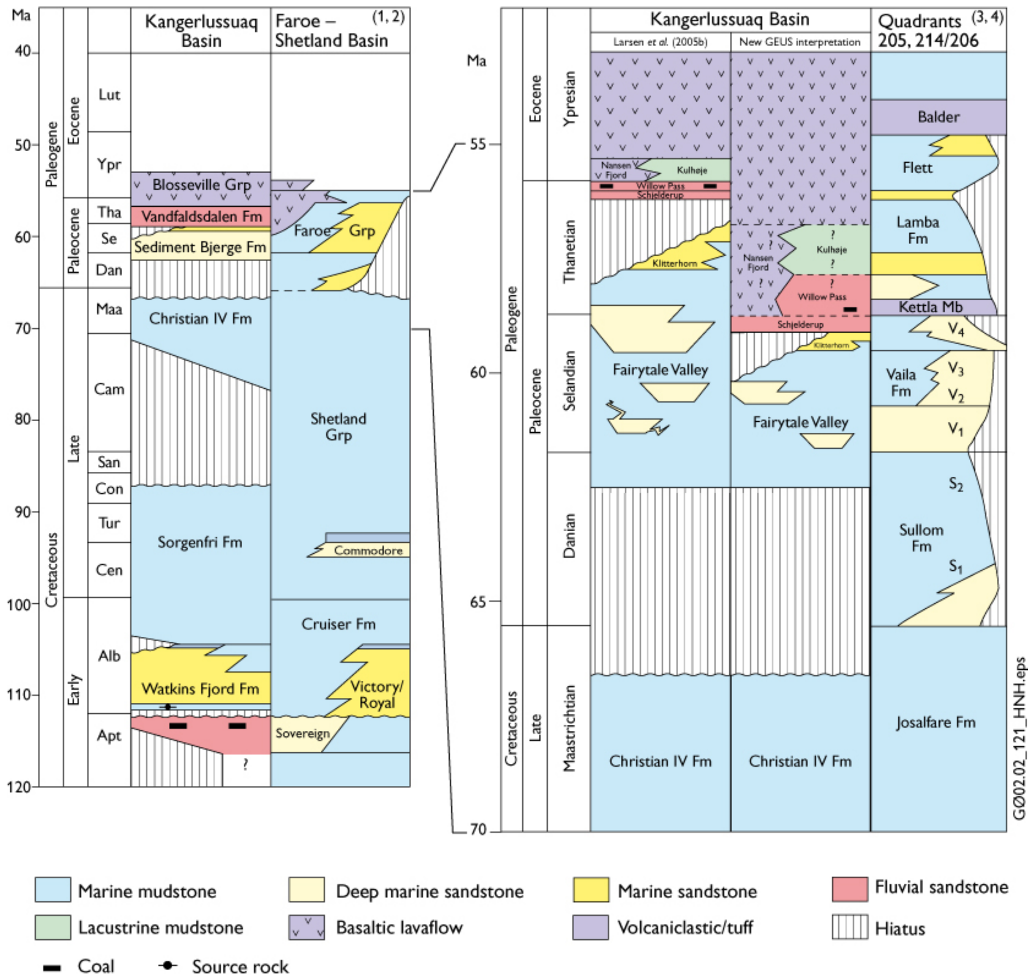


Figure 2. *Correlation of the Cretaceous – Early Palaeogene successions West of Shetland, the Faroes and in southern East Greenland from Larsen et al. 2005. Stratigraphic information in the Faroe-Shetland region from 1) Grant et al. 1999; 2) Ellis et al. 2002; 3) Knox et al. 1997; 4) Mudge and Bujak 2001. Timescale from Gradstein et al. 2004.*

formations: Watkins Fjord (new), Sorgenfri (redefined), Christian IV (new) and Sediment Bjerge (new) whereas the lower part of the Blosseville Group; the Vandfaldsdalen Formation was redefined. Six new members were defined within the succession.

With a pre-drift position only 100–150 km northwest of the present day Faroe Islands (Fig. 1) the Kangerlussuaq Basin in East Greenland probably forms the most important analogue for understanding the offshore sub-basaltic basins. Major unconformities in the Santonian–Early Campanian, Late Maastrichtian–Early Paleocene and mid-Paleocene (Fig. 2) may thus indicate periods of possible sediment input from the west to the Faroe-Shetland region.

The other important analogue is the Ormen Lange gas field from the Møre Basin at the Mid-Norwegian Shelf. The reservoir interval spans the Cretaceous–Palaeogene boundary without any major stratigraphic breaks and is represented by a Maastrichtian heterolitic unit, the Springar (Jorsalfare) Formation and the overlying Danian sandstone, the Egga Member of the Våle Formation (Gjelberg *et al.* 2005). Further landward, east of the Ormen Lange Field, the Cretaceous–Palaeogene boundary is characterised by a major unconformity, implying erosion and sediment by-pass, which may mirror the major Late Maastrichtian–Early Paleocene unconformity in the Kangerlussuaq Basin. Gjelberg *et al.* (2005) suggested that uplift and rotation of the provenance area to the eastern situated Norwegian midland took place in the early Danian time, which led to extensive erosion and redistribution of sandy sediments into the Møre Basin and caused the deposition of the Egga Member.

The wells drilled recently in the Faroese territory have demonstrated that a viable petroleum system is present in the southernmost basins. Sedimentation in this area is related to depositional systems known from hydrocarbon exploration in the UK and Norwegian sectors. The recently drilled wells form important correlation points in the southernmost part of the Faroese.

The Cretaceous–Palaeogene rift between the Faroe Islands and the Shetland Islands is characterised by the presence of a number of Cretaceous–Palaeogene sedimentary basins and sub-basins (Fig. 1). The largest of the sedimentary basins in the region is the Faroe-Shetland Basin.

The Palaeogene interval and basin evolution is currently the major focus of hydrocarbon exploration in the Faroe-Shetland region. The plays are focused on the pre basaltic Sullom and Vaila Fm and the intra basaltic Flett Fm, especially after the Rosebank discovery within a Palaeogene volcanic sequence (Passey, 2008; Helland-Hansen, 2006).

There are substantial thicknesses of sediment of this age in the basins to the west of Shetland with up to 2000 m in the Flett and Judd sub-basins (Lamers and Carmichael 1999). The initial fill of the basins consists of deep marine clastics. Substantial amounts of coarse clastic material were eroded from the Orkney-Shetland Platform and deposited in the basins west of Shetland by sediment gravity flow processes. The sandstones known as T10 (Danian) in the Sullom Formation and as T20–T25 (lower Selandian) in the Vaila Formation are sourced from this region (Fig. 2). Sandstones in T20–35 interval (lower Selandian to lower Thanetian) form the reservoirs in the West Shetland oilfields e.g. Foinaven, Schiehallion and Loyal. After T35 time (early Thanetian) a shelf succession prograded out from the Orkney-Shetland platform over delta slope and deep marine deposits. These shelf sediments are capped by a transgressive succession of fluvio-deltaic sandstones and coals. A sequence boundary was developed beneath this fluvio-deltaic succession and had its maximum basin ward extent in T40 time (latest Thanetian) (Roberts *et al.* 1999).

At the same time as sediment was being supplied to the basin from the east, volcanism in the west, in the Faroese region, built up substantial thicknesses of basaltic sediments and lavas

(Fig. 3). The onset of volcanism is poorly constrained, but the presence of air fall tuffs in sediments as old as T32 (late Selandian) in well 205/9-1 (Jolley and Whitham 2004), indicates that the initiation of volcanic activity can be traced at least this far back in time. Evidence for a western source of sediment is found in T36 (Thanetian) in the form of the Kettla Member (Foinaven Subbasin) and Andrew Tuff (Flett Subbasin), which contains volcanic material which can only be derived from the west (Lamers and Carmichael 1999).

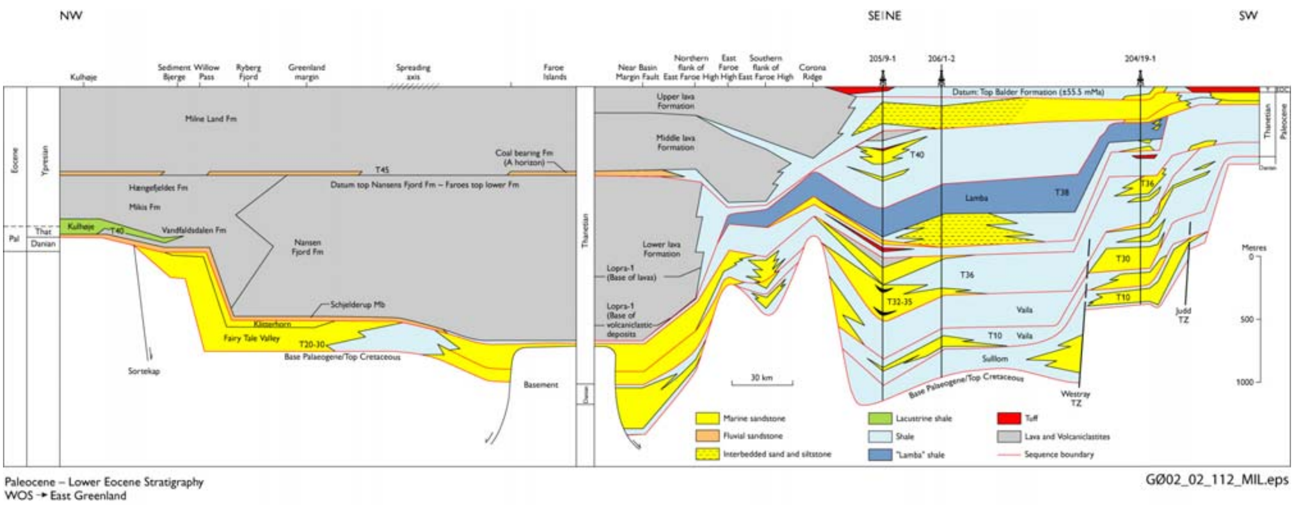


Figure 3. *Correlation of the early Palaeogene successions West of Shetland, the Faroes and in southern East Greenland from Larsen et al. 2005. Right hand side of the diagram from Ellis et al. (2002).*

The Faroese volcanic succession can be correlated geochemically with the volcanic succession of East Greenland (L.M Larsen *et al.* 1999). This work shows that the Nansen Fjord Formation in Kangerlussuaq and the Lower Lava Formation of the Faroe Island are time equivalents (Figs 2, 3).

The Nansen Fjord Formation recently has been dated to 59.2 ± 1.4 and 57.7 ± 0.5 Ma (late Selandian and early Thanetian) by $^{40}Ar/^{39}Ar$ (Storey *et al.* 2007). The top of the Nansen Fjord Formation is marked by a thin coal-bearing sedimentary unit. This is thought to correlate directly to the coal bearing strata marking the boundary between the Lower and Middle lava formation in the Faroe Island (L.M. Larsen *et al.* 1999; Ellis *et al.* 2002) (Figs 2, 3). Based on spore and pollen assemblages of the coal-bearing horizon in the Faroese, Jolley *et al.* (2005) suggested that the boundary is time equivalent with the topmost Flett Formation in the well 205/9-1.

Furthermore new brackish-water dinoflagellate cyst data obtained during the re-examination of the Kulhøje Member (Nøhr-Hansen *et al.* 2007), suggest an age within the Selandian to latest Thanetian /?earliest Ypresian range (Fig. 2). A Selandian age is in accordance with the earliest dating (61 Ma) of basaltic volcanism in southern East Greenland (Hansen *et al.* 2002), and may be supported by the resent dating of Storey *et al.* (2007, see above).

In summary, the combined evidence from the geochemical and palynological analyses suggest that volcanism had already started in East Greenland and the Faroese at the time of deposition of the uppermost Lamba and Flett formations in the Faroe-Shetland Basin. By the discovery of intrabasaltic hydrocarbon bearing Flett age sandstones in the Rosebank discovery the understanding of basalt/sediment interaction and the timing of volcanic pulses become crucial in future Faeroes exploration.

Material analysed

The study is based on data from 289 palynological samples from 5 offshore wells and 142 samples from 11 outcrop sections from the following three geographical separated areas in the northern North Atlantic (Fig. 4):

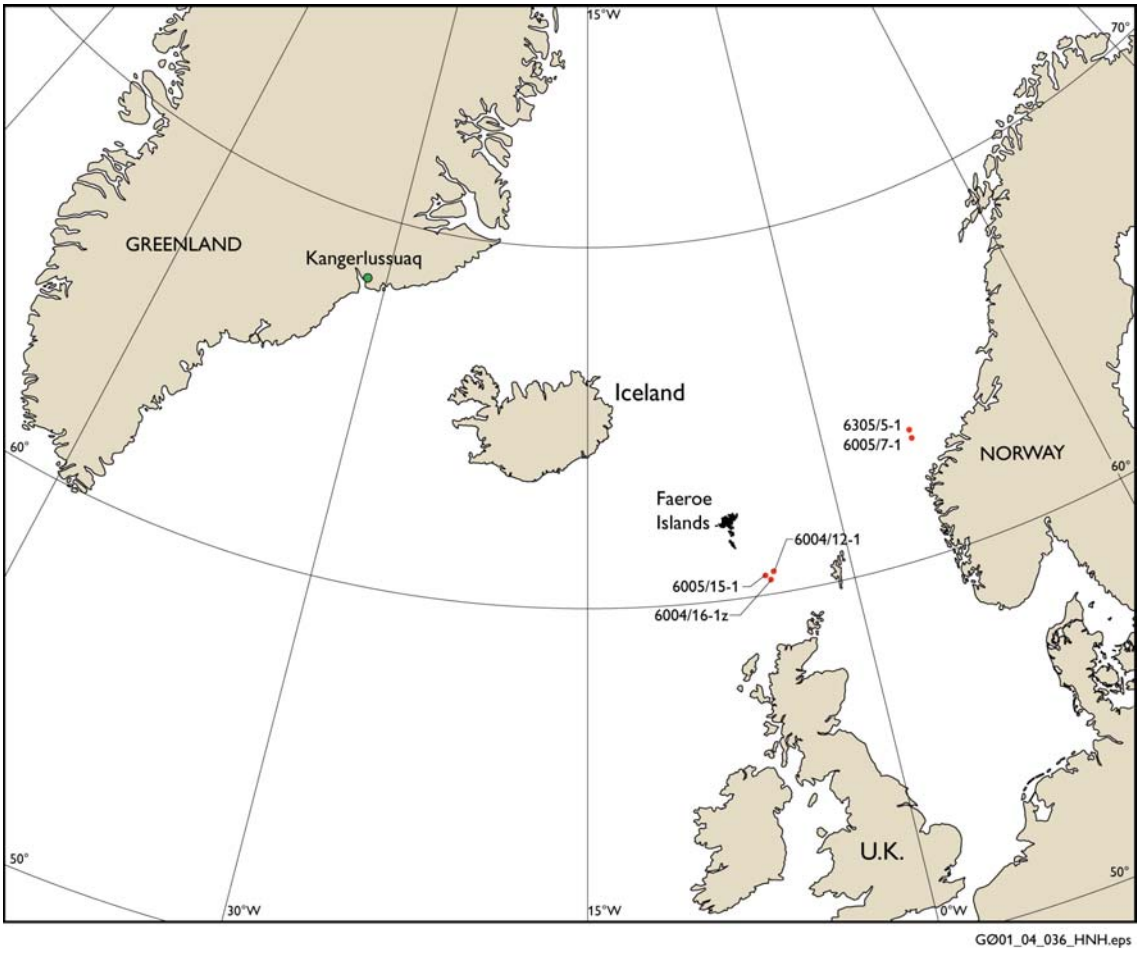


Figure 4. *Geographical position of the five studied wells and outcrops.*

1) Onshore south east Greenland:

The results from the outcrops from the Kangerlussuaq Basin in East Greenland are based on the study of 142 samples, from 11 sections which has been reported previously in the Sindri reports by Larsen *et al.* (2005a,b) and by Nøhr-Hansen *et al.* (2006, 2007).

2) Offshore Faroese Islands:

The results from the Faroe area are based on the study of the three offshore wells:

Marjun, 6004/16-1: 21 ditch cutting from 1484–2259 m

Marjun, 6004/16-1Z (side-track): 60 ditch cutting samples from 2228–4271 m

Longan, 6005/15-1: 64 ditch cutting samples from 1790–4025 m

Svinoy, 6004/12-1 and side-track 1Z: 54 ditch cutting samples from 2223–4583 m

3) Offshore Norway:

The results from Norway are based on the study of the two offshore Norwegian wells from the Ormen Lange, Møre Basin:

6305/5-1: 44 core samples and 18 ditch cutting samples from 2610.00–2816.15 m

6305/-7-1: 30 core samples from 2917.74–3010.67 m

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 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 in each slide whenever possible.

Correlation of the offshore wells and the onshore sections are illustrated in two schemes (Figs 3–4). The sample position and relative abundance of species referred to in the biostratigraphic zonation section (below) are illustrated on StrataBugs rangecharts (Enclosures 1–7) and 8 Summery/events Stratabugs charts (Enclosures 8–15).

Reworked specimens have been recorded and their occurrences have been illustrated separately on the enclosed rangecharts (Enclosures 1–7). Reworking of middle and upper Jurassic and lower to upper Cretaceous species are common in the 3 Faroese wells and reworking of middle Cretaceous species are common in the 2 Norwegian wells.

The figures 5–7 and enclosures 1–15 in the report are enclosed on a CD-ROM as high resolution PDFs.

Correlation

The correlation of the upper Cretaceous to lower Palaeogene successions in the three studied northern North Atlantic areas are based on recognition of 44 events grouped into 13 zones and 19 subzones, which have been described separately below and illustrated in a composite zonation scheme (Fig. 5).

The palynological based correlation of the three studied areas is shown on the two correlation charts (Figs 6–7).

The palynological based biostratigraphic data obtained in the present and in previous Sindri financed GEUS projects are presented in 7 enclosed StrataBugs rangecharts (Enclosures 1–7) and 8 enclosed StrataBugs summery/events charts (Enclosures 8–15).

The correlation charts (Figs 6–7) illustrate that the youngest lower Eocene (Ypresian) to upper Paleocene (Thanetian) succession only occur in the three Faroese wells, and is represented by 4 zones and 6 subzones.

The upper to lower Paleocene (Selandian to uppermost Danian) succession can be traced in all three areas, and is represented by 3 zones and 6 subzones.

The lowermost Paleocene (lower Danian) to uppermost Cretaceous (uppermost Maastrichtian) succession only occur in the two Norwegian wells, and is represented by 3 zones and 4 subzones.

The uppermost Cretaceous (upper to lower Maastrichtian) succession occurs in the two Norwegian wells and onshore East Greenland. The Norwegian wells are represented by 3 zones and 3 subzones, of which it only has been possible to recognise the lowermost *Alterbidinium acutulum* Subzone from the Maastrichtian succession in the Kangerlussuaq Basin. The palynomorphs from the Kangerlussuaq Basin are in a very poor state of preservation due to thermal influence; in spite of this it has been possible to correlate six palynological events between the two areas.

Zonation

? (E3) *Eatonicysta ursulae* Biozone of Bujak and Mudge (1994).

? (E3b) *Charlesdowniea columna* Subzone of Bujak and Mudge (1994).

The subzone correlates with the (E3b) *Charlesdowniea columna* interval of Nøhr-Hansen (2003).

Age: Early Eocene, late Ypresian.
Occurrence:
Longan 6005/15-1 1820–1860 m.

Palynological event: First down hole occurrence (FDO) of *Wetzeliella* endocyst Nøhr-Hansen 2003.

(E2) *Areoligera medusettiformis* Biozone of Bujak and Mudge (1994).

(E2b) *Dracodinium condylos* interval of Nøhr-Hansen (2003).

The interval correlates with the (E2b) *Dracodinium politum* Subzone of Bujak and Mudge (1994).

Age: Early Eocene, middle Ypresian.
Occurrence:
Longan 6005/15-1, 1860–1970 m
Marjun 6004/16-1, 1484–1519 m
Svinoy 6004/12-1, 2223–2265 m

Palynological events: FOD of *Dracodinium condylos*, *D. varielongitudum.*
Characteristics: FOD of *Dracodinium politum*, FOD of *Muratodinium fimbriatum*, common *Areoligera* spp.and *Cordosphaeridium* spp. and abundant *Spiniferites* spp., local acme of *Cribroperidinium giuseppei* in Marjun.

Figure 5. *Composite Upper Cretaceous to lower Palaeogene palynological event and biozonation zonation scheme for the three studied northern North Atlantic areas.*

Well Name : SINDRI Palyno Zonation

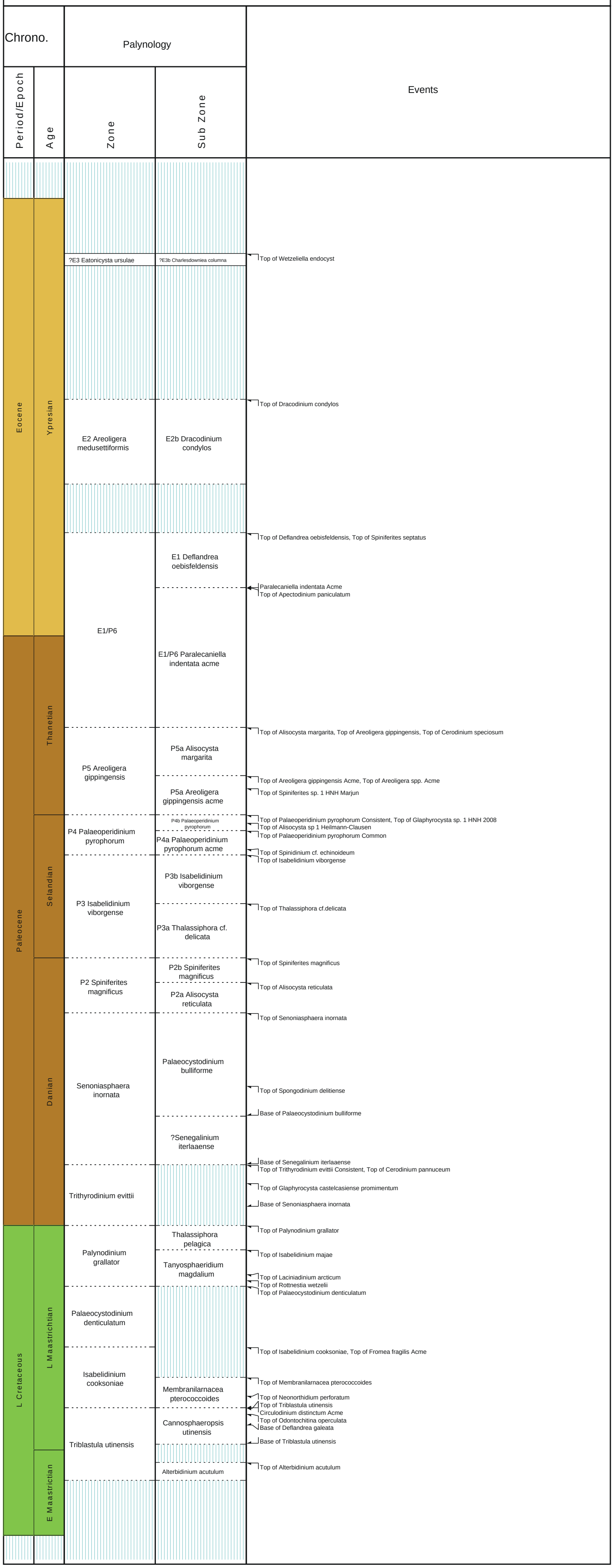
Interval : 48.00m - 71.00m

Scale : 1:50

Chart date : 29 October 2008

GEUS

Copenhagen



Interval E1–P6. Nøhr-Hansen (2003).

(E1) *Deflandrea oebisfeldensis* interval of Nøhr-Hansen (2003).

The interval correlates with the (E1b) *Deflandrea oebisfeldensis* Acme Subzone of Bujak and Mudge (1994).

Age: Early Eocene, earliest Ypresian.

Occurrence:

Longan 6005/15-1, 1970–2060 m

Marjun 6004/16-1, 1519–1540 m

Svinoy 6004/12-1, 2265–2391 m

Palynological events: FOD of *Deflandrea oebisfeldensis.*

Characteristics: FOD of *Apectodinium parvum*, *Paralecaniella indentata* and *Spiniferites septatus*.

(E1–P6) *Paralecaniella indentata* acme interval of Nøhr-Hansen (2003)/ ?(P6) *Apectodinium* acme interval of Nøhr-Hansen (2003).

The intervals correlate with the *Leiosphaeridia* Biofacies of Bujak and Mudge (1994)/ (P6) *Apectodinium augustum* Biozone of Mudge and Bujak (1996),

Age: Late Paleocene to Early Eocene.

Occurrence:

Longan 6005/15-1, 2060–?2485 m

Marjun 6004/16-1, 1540–?1717 m

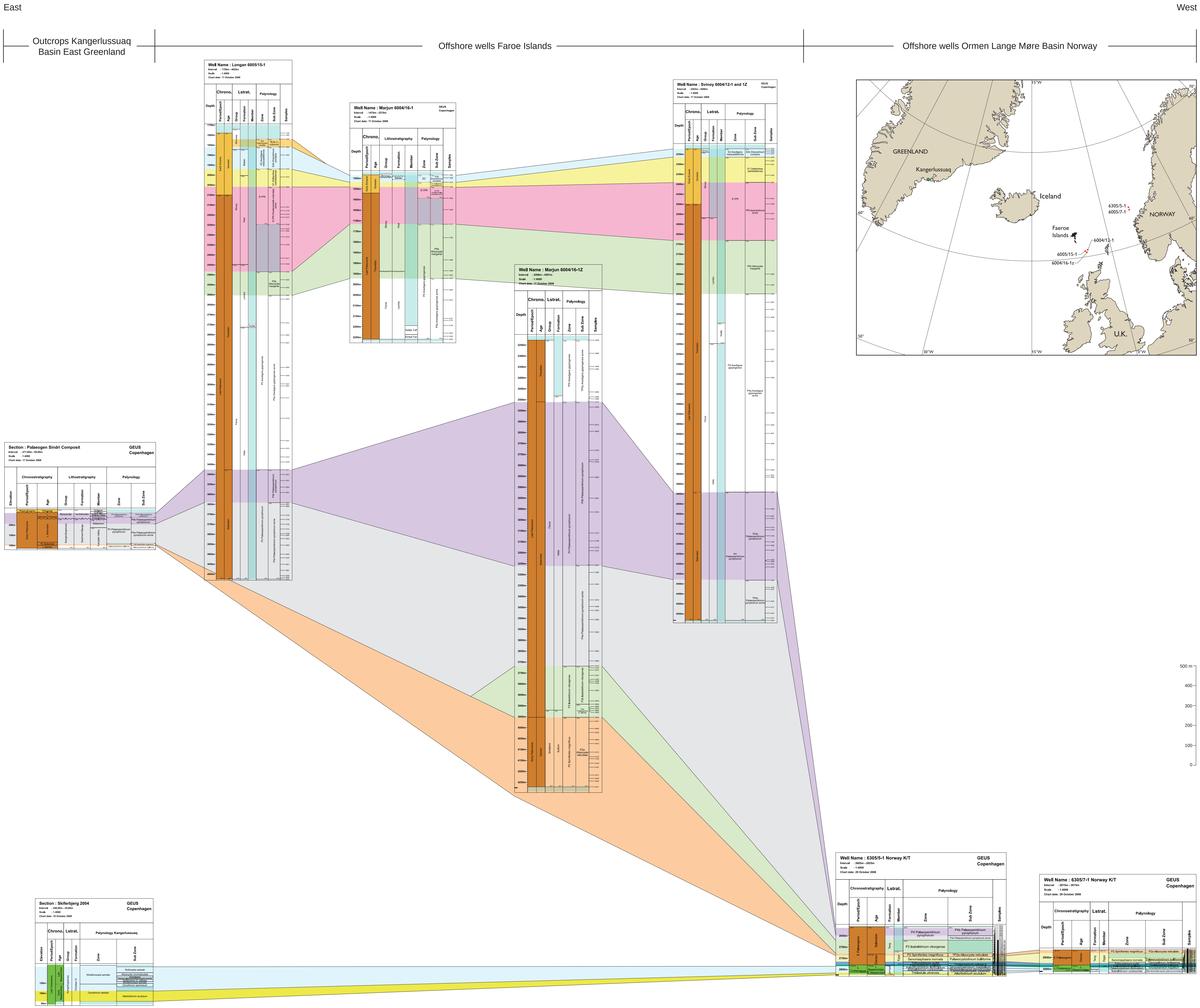
Svinoy 6004/12-1, 2391–2682 m

Palynological events: FOD of *Apectodinium paniculatum*.

Characteristics: Local acme of *Paralecaniella indentata* in Marjun.

Local acme of *Fibrocysta* spp., *Lingulodinium machaerophorum* and *Pediastrum* spp. in Longan. Increase in abundance (4) of *Apectodinium homomorphum* in Svinoy. Subzone generally poor in *in situ* dinoflagellate cysts.

Figure 6. *Palynological zonal correlation scheme of the Upper Cretaceous to lower Palaeogene successions in the three studied areas. Notice that the individual event schemes are at the same scales.*


East
West
Outcrops Kangerlussuaq Basin East Greenland
Offshore wells Faroe Islands
Offshore wells Ormen Lange Møre Basin Norway
Well Name : Longan 6005/15-1
Well Name : Marjun 6004/16-1
Well Name : Marjun 6004/16-1Z
Well Name : Svinoy 6004/12-1 and 1Z
Section : Palaeogen Sindri Composit
Section : Skiferbjerg 2004
Well Name : 6305/5-1 Norway K/T
Well Name : 6305/7-1 Norway K/T
GEUS Copenhagen
Chrono.
Lstrat.
Palynology
Chronostratigraphy
Lithostratigraphy
Palynology Kangerlussuaq
Depth
Elevation
Period/Epoch
Age
Group
Formation
Member
Zone
Sub Zone
Samples
GREENLAND
Kangerlussuaq
Iceland
Faeroe Islands
NORWAY
U.K.
6305/5-1
6005/7-1
6004/12-1
6005/15-1
6004/16-1z
500 m
400
300
200
100
0

(P5) *Areoligera gippingensis* Zone.

In the present report the zone correlates with the (P5b) *Alisocysta margarita* Subzone of Mudge and Bujak (1996).

Age: Late Paleocene, late Thanetian.

Occurrence:

Longan 6005/15-1, 2485–2603 m

Marjun 6004/16-1, 1717–1972 m

Svinoy 6004/12-1, 2682–2949 m

Palynological events: FOD of *Alisocysta margarita* and *Areoligera gippingensis*.

Characteristics: FOD of *Cerodinium speciosum* and *Cerodinium striatum*. Local acme of *Deflandrea oebisfeldensis*, *Areoligera* spp. and *Spiniferites* spp. in Longan

(P5a) *Areoligera gippingensis* Subzone of Mudge and Bujak (1996).

Age: Late Paleocene, early Thanetian.

Occurrence:

Longan 6005/15-1, 2603–3477 m

Marjun 6004/16-1, 1972–2259 m

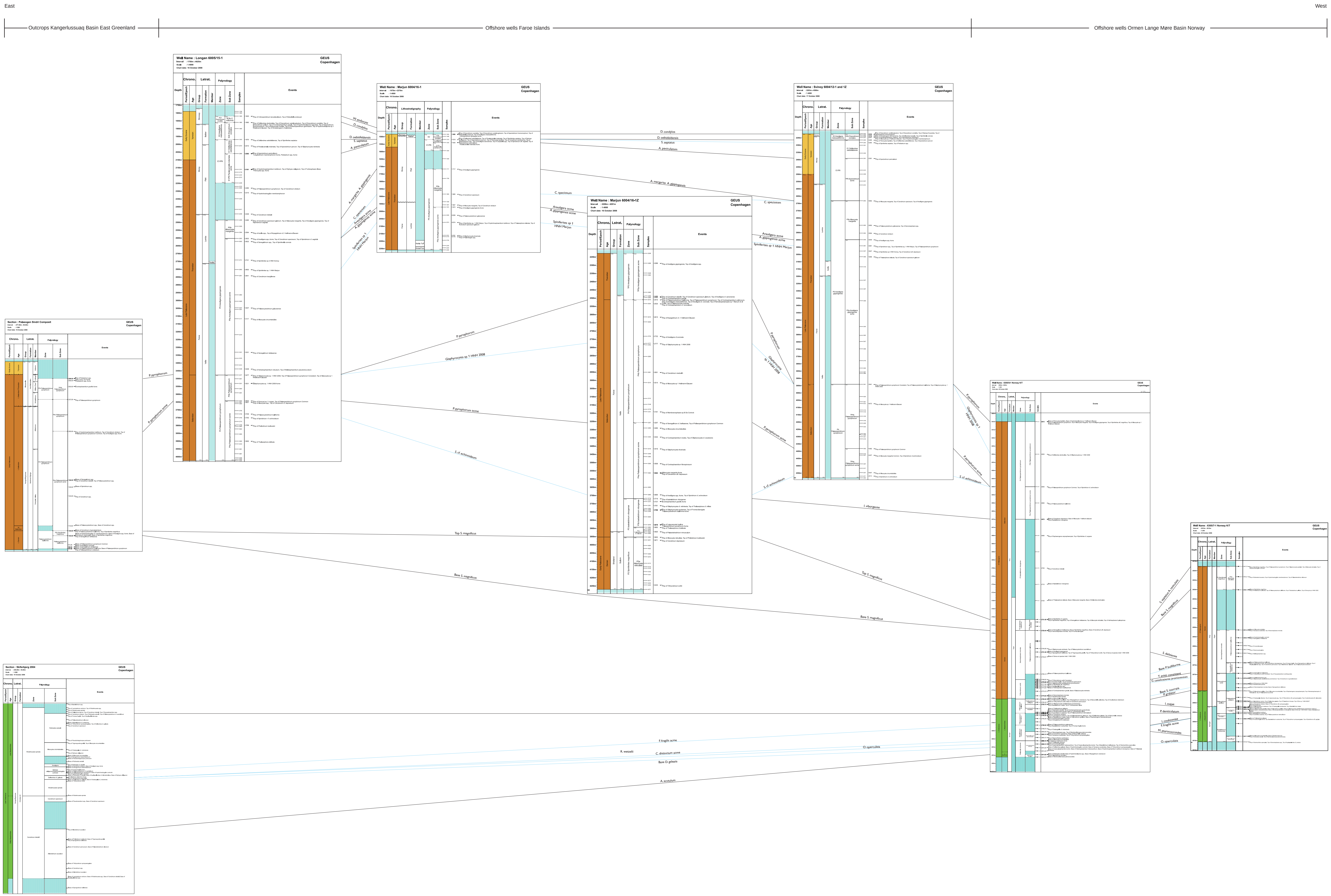
Marjun 6004/16-1Z, 2228–2510 m

Svinoy 6004/12-1, 2949–3941 m

Palynological events: FOD of common *Areoligera gippingensis*.

Characteristics: FOD of *Spiniferites* sp. 1 HNH Marjun, *Spiniferites* sp. 2 HNH Svinoy and *Thalassiphora delicata*. The subzone is characterised by abundant *Areoligera* spp. and *Spiniferites* spp. in the upper part.

Figure 7. *Palynological correlation events for the Upper Cretaceous to lower Palaeogene successions in the three studied areas. Black lines show correlation of characteristic zonal and subzonal species. Blue lines show correlation of characteristic intrazonal and intrasubzonal species. Notice that the individual event schemes are of different scales.*



East
West
Outcrops Kangerlussuaq Basin East Greenland
Offshore wells Faroe Islands
Offshore wells Ormen Lange Møre Basin Norway
Well Name : Longan 6005/15-1
Well Name : Marjun 6004/16-1
Well Name : Marjun 6004/16-1Z
Well Name : Svinoy 6004/12-1 and 1Z
GEUS Copenhagen
Chrono.
Lstrat.
Palynology
Events
D. condylos
D. oebisfeldensis
S. septatus
A. paniculum
C. speciosum
Areoligera acme
A. gippingensis acme
P. pyrophorum
P. pyrophorum acme
S. cf. echinoideum
Top S. magnificus
Base S. magnificus
I. viborgense
F. fragilis acme
R. wetzelii
C. distortum acme
O. operculata
A. scotulum
S. delicata
I. major
P. densiculum
I. cooksoniae

(P4) *Palaeoperidinium pyrophorum* Zone of Mudge and Bujak (1996).
(P4b) *Palaeoperidinium pyrophorum* Subzone of Mudge and Bujak (1996).

Age: Late Paleocene, latest Selandian.
Occurrence:
Kangerlussuaq, East Greenland, approximately 50 m thick
Longan 6005/15-1, 3477–3642 m
Marjun 6004/16-1Z, 2510–3257 m
Svinoy 6004/12-1, 3941–4382 m
6305/5-1 Norway, 2610–2650 m

Palynological events: FOD of consistent *Palaeoperidinium pyrophorum*.
Characteristics: FOD of *Alisocysta* sp. 1 Heilmann-Clausen 1985, FOD of *Glaphyrocysta* sp. 1 HNH 2008, FOD of *Palaeocystodinium bulliforme*, common *Alisocysta* sp. 1 Heilmann-Clausen 1985 and *Glaphyrocysta* sp. 1 HNH 2008.

(P4a) *Palaeoperidinium pyrophorum* acme Subzone of Mudge and Bujak (1996).

Age: Late Paleocene, late Selandian.
Occurrence:
Kangerlussuaq, East Greenland, approximately 100 m thick
Longan 6005/15-1, 3642–4025 m (TD)
Marjun 6004/16-1Z, 3257–3719 m
Svinoy 6004/12-1, 4382–4583 m (TD)
6305/5-1 Norway, 2650–2670 m

Palynological events: FOD of common *Palaeoperidinium pyrophorum*.
Characteristics: FOD of *Spinidinium* cf. *echinoideum*, common *Alisocysta margarita*, *Alisocysta* sp. 1 Heilmann-Clausen 1985, *Cerodinium striatum* and abundant *Areoligera* spp. in the lower-part of the subzone.

(P3) *Isabelidinium viborgense* Zone of Mudge and Bujak (1996).

Age: Late Paleocene, early to middle Selandian.
Occurrence:
Marjun 6004/16-1Z, 3719–3953 m
6305/5-1 Norway, 2670–2731.60 m

Palynological events: FOD of *Isabelidinium viborgense*.

(P3b) *Isabelidinium viborgense* Subzone of Mudge and Bujak (1996).

Age: Late Paleocene, middle Selandian.
Occurrence:
Marjun 6004/16-1Z, 3719–3893 m

Palynological events: FOD of *Isabelidinium viborgense*.
Characteristics: FOD of *Thalassiphora* cf. *inflata*, abundant *Areoligera* spp., common *Cordosphaeridium gracile*, *Palaeocystodinium bulliforme* and *Palaeoperidinium pyrophorum*.

(P3a) *Thalassiphora* cf. *delicata* Subzone of Mudge and Bujak (1996).

Age: Late Paleocene, early Selandian.
Occurrence:
Marjun 6004/16-1Z, 3893–3953 m

Palynological events: FOD of *Thalassiphora* cf. *delicata*.
Characteristics: Common *Areoligera* spp. and *Palaeoperidinium pyrophorum*.

(P2) *Spiniferites magnificus* Zone of Mudge and Bujak (1996).
(P2b) *Spiniferites magnificus* Subzone of Mudge and Bujak (1996).

Age: Late Paleocene, latest Danian.
Occurrence:
Kangerlussuaq, East Greenland, approximately 5 m thick
Palynological events: FOD of *Spiniferites magnificus*.
Characteristics: Common *Areoligera* spp.

(P2a) *Alisocysta reticulata* Subzone of Mudge and Bujak (1996).

Age: Late Paleocene, late Danian.
Occurrence:
Marjun 6004/16-1Z, 3953–4271 m (TD)
6305/5-1 Norway, 2731.60–2738.40 m
6305/7-1 Norway, 2917.74–2930.14 m
Palynological events: FOD of *Alisocysta reticulata* and LOD (last occurrence down hole) of *Spiniferites magnificus*.
Characteristics: Common *Areoligera* spp. and *Spiniferites* spp. FOD and common Dinocyst sp. 4 HNH 2002 at the base of the subzone in 6305/7-1.

***Senoniasphaera inornata* Zone**

The zone correlates with the upper part of the (P1) *Senoniasphaera inornata* Biozone of Mudge and Bujak (1996).

Age: Late Paleocene, middle Danian.
Occurrence:
6305/5-1 Norway, 2738.40–2768.50 m
6305/7-1 Norway, 2951.42–2974.39 m

Palynological events: FOD of *Senoniasphaera inornata*.

***Palaeocystodinium bulliforme* Subzone**

The subzone correlates with the *Palaeocystodinium bulliforme Z*one of Nøhr-Hansen *et al.* (2002) correlating with the upper part of the (P1) *Senoniasphaera inornata* Biozone of Mudge and Bujak (1996).

Age: Late Paleocene, middle Danian.
Occurrence:
Kangerlussuaq, East Greenland, approximately 23 m thick
6305/5-1 Norway, 2738.40–2765.10 m
6305/7-1 Norway, 2952.42–2968.77 m

Palynological events: FOD of *Senoniasphaera inornata*, LOD of *Palaeocystodinium bulliforme* at the base of the subzone.
Characteristics: FOD of *Spongodinium delitiense*, FOD of *Trithyrodinium evittii*. Common to abundant *Areoligera* spp. and *Palaeoperidinium pyrophorum*. Acme of *Genus et species indet* 1HNH 2008 in 6305/5-1

***Senegalinium iterlaaense* Subzone**

The subzone correlates with the *Senegalinium iterlaaense Z*one of Nøhr-Hansen *et al.* (2002) correlating with the middle part of the (P1) *Senoniasphaera inornata* Biozone of Mudge and Bujak (1996).

Age: Late Paleocene, middle Danian.
Occurrence:
6305/7-1 Norway, 2968.77–2974.39 m

Palynological events: LOD of *Senegalinium iterlaaense* at the base of the subzone. FOD of *Alterbidinium ulloriaki*.

***Trithyrodinium evittii* Zone of Nøhr-Hansen *et al.* (2002)**

The subzone correlates with the lower part of the (P1) *Senoniasphaera inornata* Biozone of Mudge and Bujak (1996).

Age: Early Paleocene, early Danian

Occurrence:

6305/5-1 Norway, 2768.50–2780.50 m

6305/7-1 Norway, 2974.39–2983.63 m

Palynological events: FOD of consistent *Trithyrodinium evittii*.

Characteristics: FOD of *Cerodinium pannuceum* and *Glaphyrocysta castelcasiense promimentum*, LOD of *Senoniasphaera inornata*. Common to abundant *Areoligera* spp. *Hystrichsphaeridium tubiferum*, *Palaeoperidinium pyrophorum* and *Trithyrodinium evittii*. Acme of *Senoniasphaera inornata* in the upper part of the zone.

***Palynodinium grallator* Zone of Hansen (1977).**

Age: Latest Cretaceous, latest Maastrichtian.

Occurrence:

6305/5-1 Norway, 2780.50–2790.50 m

6305/7-1 Norway, 2983.63–2995.67 m

Palynological events: FOD of *Palynodinium grallator*

***Thalassiphora pelagica* Subzone of Hansen (1977).**

Age: Latest Cretaceous, latest Maastrichtian.

Occurrence:

6305/5-1 Norway, 2780.50–2783.75 m

6305/7-1 Norway, 2983.63–2992.46 m

Palynological events: FOD of *Palynodinium grallator*,

Characteristics: FOD of *Disphaerogena carposphearopsis*, FOD and LOD of *Manumiella selandica*. Common to abundant *Cerodinium diebelii* and *Palaeoperidinium pyrophorum*.

***Tanyospharidium magdalium* Subzone of Hansen (1977).**

Age: Late Cretaceous, late Maastrichtian.

Occurrence:

Uppermost part of the Skiferbjerg 2004 section, Kangerlussuaq, East Greenland

6305/5-1 Norway, 2783.75–2789.20 m
6305/7-1 Norway, 2992.46–2995.67 m

Palynological events: FOD of *Isabelidinium majae*.
Characteristics: FOD of *Rottnestia wetzelii*, *Laciniadinium arcticum* and FOD of abundant *Impagidinium victorianum* in the lower part of the subzone, presence of the pollen species *Wodehouseia spinata*.

Correlation: The lower part of the subzone can bee correlated with the highest part of the Skiferbjerg 2004 section from the Kangerlussuaq, East Greenland, based on the FOD of *Rottnestia wetzelii* and *Laciniadinium arcticum* together with the presence of the upper Maastrichtian pollen marker species *Wodehouseia spinata* in both areas.

***Palaeocystodinium denticulatum* Interval Zone of Schiøler and Wilson (1993).**

Age: Late Cretaceous, late Maastrichtian.
Occurrence:
?Upper part of the Skiferbjerg 2004 section, Kangerlussuaq, East Greenland
6305/5-1 Norway, 2789.20–2796.50 m
6305/7-1 Norway, 2995.67–2998.45 m

Palynological events: FOD of *Palaeocystodinium denticulatum*
Characteristics: Acme of *Palaeoperidinium pyrophorum*, LOD of *Isabelidinium majae* and *Palynodinium grallator* in the uppermost part of the zone.

***Isabelidinium cooksoniae* Interval Zone of Schiøler and Wilson (1993).**

Age: Late Cretaceous, late Maastrichtian.
Occurrence:
Middle part of the Skiferbjerg 2004 section, Kangerlussuaq, East Greenland
6305/5-1 Norway, 2796.50–2806.15 m
6305/7-1 Norway, 2998.45–3010.67 m (TD of cored interval)

Palynological events: FOD of *Isabelidinium cooksoniae*
Characteristics: Acme of *Fromea fragilis*.

Correlation: The upper part of the zone may bee correlated with the middle part of the Skiferbjerg 2004 section from the Kangerlussuaq, East Greenland, based on an acme of *Fromea fragilis* in both areas.

***Membranilarnacea pterococcoides* Subzone of the present study.**

Age: Late Cretaceous, late Maastrichtian.

Occurrence:

6305/5-1 Norway, 2800.50–2806.15 m

6305/7-1 Norway, 3007.70–3010.67 m (TD of cored interval)

Palynological events: FOD of *Membranilarnacea pterococcoides*.

Characteristics: FOD of *Neonorthidium perforatum*

***Triblastula utinensis* Zone**

The zone correlates with the upper part of the *Triblastula utinensis* Range Zone of Schiøler and Wilson (1993**).**

Age: Late Cretaceous, early to late Maastrichtian.

Occurrence:

Middle and lower part of the Skiferbjerg 2004 section, Kangerlussuaq, East Greenland

6305/5-1 Norway, 2806.15–2816.15 m (TD of cored interval)

***Cannosphaeropsis utinensis* Interval Subzone of Schiøler and Wilson (1993).**

Age: Late Cretaceous, early to late Maastrichtian.

Occurrence:

Middle and lower part of the Skiferbjerg 2004 section, Kangerlussuaq, East Greenland

6305/5-1 Norway, 2806.15–2812.40 m

Palynological events: FOD of *Triblastula utinensis*.

Characteristics: FOD of *Cassiculosphaeridia tocheri*, *Odontochitina operculata*. Acme of *Circulodinium distinctum* in the upper part and LOD of *Cassiculosphaeridia tocheri* and *Deflandrea galeata* in the lower part of the subzone.

Correlation: The upper part of the subzone may bee correlated with the middle part of the Skiferbjerg 2004 section from the Kangerlussuaq, East Greenland, based on the *Circulodinium distinctum* acme followed by the FOD of *Odontochitina operculata* and LOD of *Deflandrea galeata* in both areas.

***Alterbidinium acutulum* Interval Subzone of Schiøler and Wilson (1993).**

Age: Late Cretaceous, early Maastrichtian.

Occurrence:

Lower part of the Skiferbjerg 2004 section, Kangerlussuaq, East Greenland
6305/5-1 Norway, 2814.60–2816.15 m (TD of cored interval)

Palynological events: FOD of *Alterbidinium acutulum*.
Characteristics: Presence of *Spongodinium delitiense* and species of *Aquilapollenites*.

Correlation: The upper part of the subzone may bee correlated with the lowermost part of the Skiferbjerg 2004 section from the Kangerlussuaq, East Greenland, based on the FOD of *Alterbidinium acutulum* and the presence of *Spongodinium delitiense* and species of *Aquilapollenites* in both areas.

Conclusions

A biostratigraphic zonation scheme for the Upper Cretaceous to Lower Palaeogene successions in three geographically separated areas in the northern North Atlantic has been established based on the study of 289 palynological samples from three Faroese offshore wells: Marjun 6004/16-1, Longan 6005/15-1 and Svinoy 6004/12-1 two Norwegian offshore wells: 6305/5-1 and 6305/-7-1 from Ormen Lange, Møre Basin and 142 palynological samples from 11 outcrop sections Kangerlussuaq Basin, East Greenland.

The zonation scheme represents 13 zones, 19 subzones and 44 palynological events, which has been correlated across the North Atlantic from the Kangerlussuaq Basin in west to the three Faroese wells and further on to the two Norwegian offshore wells in the east.

The youngest lower Eocene (Ypresian) to upper Paleocene (Thanetian) succession only occur in the three Faroese wells, and is represented by 4 zones and 6 subzones. The upper to lower Paleocene (Selandian to uppermost Danian) succession can be traced in all three areas, and is represented by 3 zones and 6 subzones. The lowermost Paleocene (lower Danian) to uppermost Cretaceous (uppermost Maastrichtian) succession only occur in the two Norwegian wells, and is represented by 3 zones and 4 subzones, whereas the uppermost Cretaceous (upper to lower Maastrichtian) succession occurs in the two Norwegian wells and onshore East Greenland. The Norwegian wells are represented by 3 zones and 3 subzones, of which it only has been possible to recognise the lowermost subzone from the Maastrichtian succession in the Kangerlussuaq Basin.

Core data from the Ormen Lange gas reservoir succession contributes with important information across the uppermost Cretaceous to lower Danian deep-water, distal deposits interval which is missing in the Kangerlussuaq Basin and which not yet has been reported from a Faroese well. The major unconformity and possible sediment by-pass into the Møre Basin from east of the area, at that time, and the possible analogue sediment by-pass eastward from the Kangerlussuaq Basin during latest Cretaceous to earliest Danian time may indicate that a similar reservoir could exist in the areas around the Faroe Islands.

The recent Rosebank discovery within a Palaeogene volcanic sequence also encourages future Sindri projects. The aim of such new projects could be to identify whether there is a consistency in timing of pulsing observed between sedimentary and volcanic upper Paleocene to lower Eocene deposition across the Faroe-Shetland region in order to better understand the sub-, syn- and early post-basaltic sedimentary succession offshore the Faroe Islands. Detailed biostratigraphy and log correlation of deposits where basalt were not deposited from the bordering UK areas would be essential in defining equivalent intra basaltic sedimentary intervals. Likewise would a detailed study of the intra basaltic sedimentary successions from the Kangerlussuaq Basin be of great interest.

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Enclosure 1. *Palynological rangechart: Skiferbjerg 2004 outcrop from the Kangerlussuaq Basin, East Greenland.*

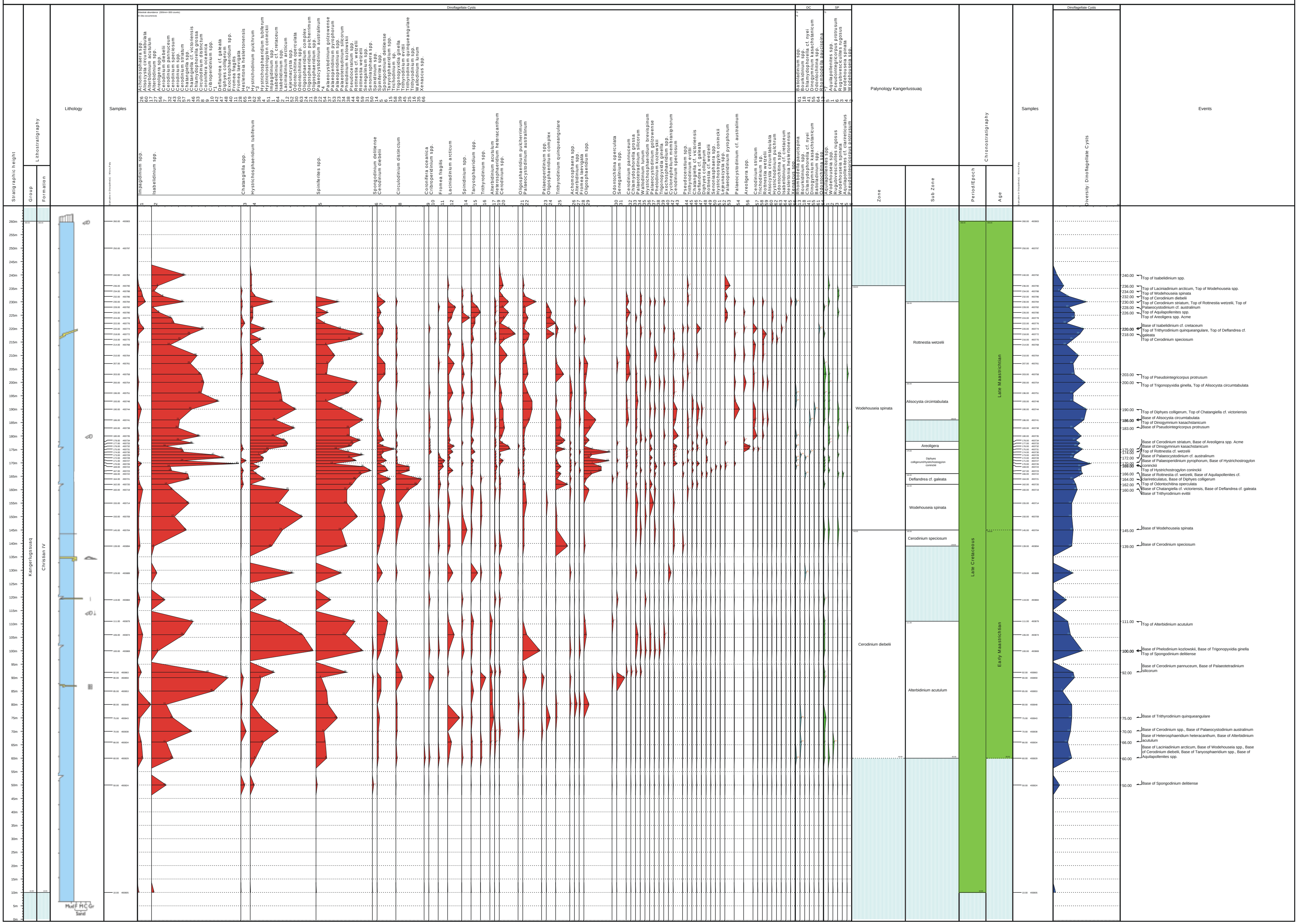
Section : Skiferbjerg 2004

Interval : 265m - 0m

Scale : 1:500

Chart date : 08 May 2007

Skiferbjerg 2004



Enclosure 2. *Palynological rangechart: Longan, 6005/15-1offshore Faroe Islands.*

Well Name : Longan 6005/15-1

Operator :

Well Code : LONGAN600515-1

Lat/Long : 0° 0' 0.00"N 0° 0' 0.00"E

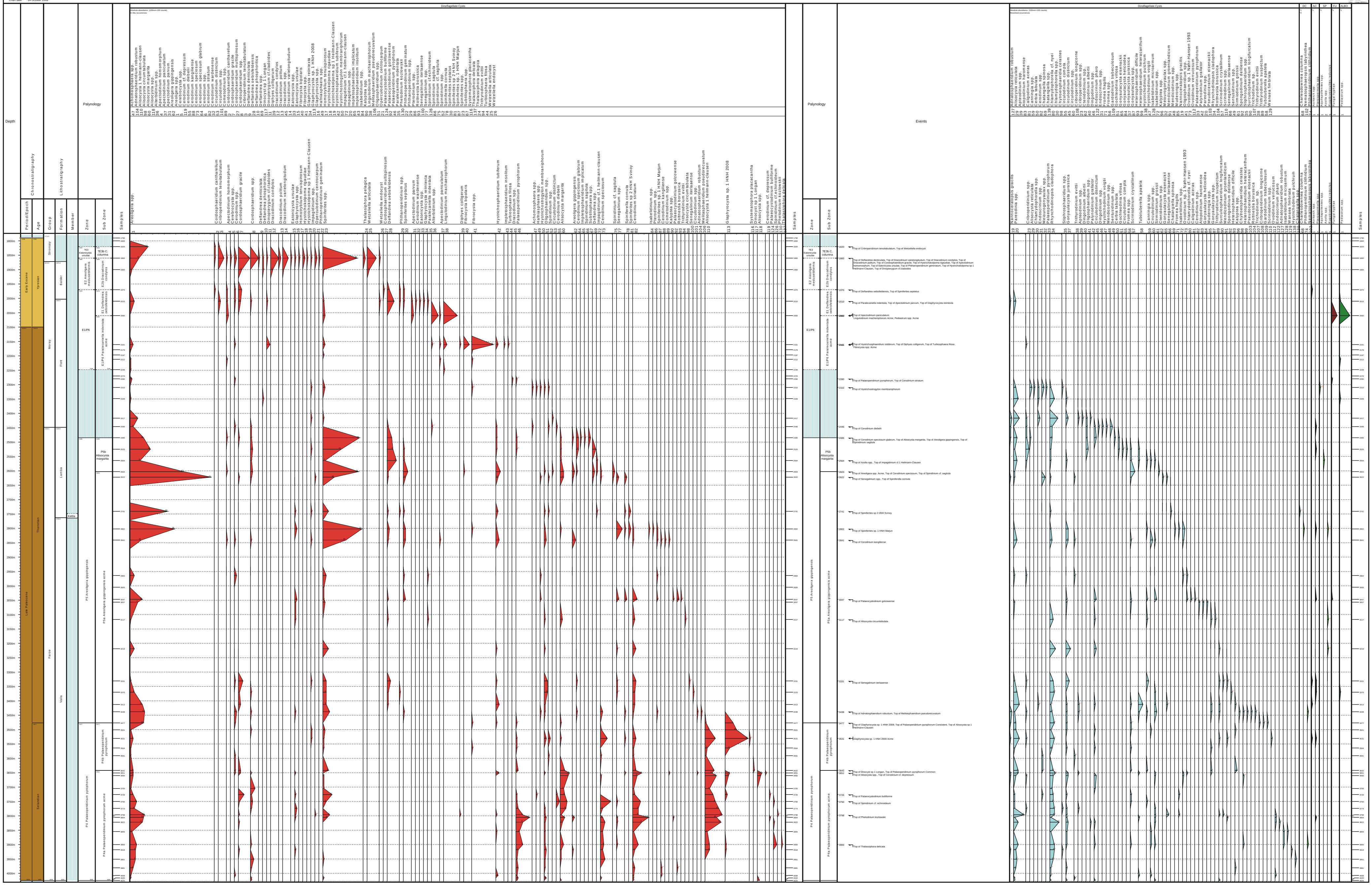
Interval : 1780m - 4025m

Scale : 1:4000

Chart date : 24 October 2008

Longan 6005/15-1

GEUS
Copenhagen



Enclosure 3. *Palynological rangechart: Marjun, 6004/16-1 offshore Faroe Islands.*

Well Name : Marjun 6004/16-1

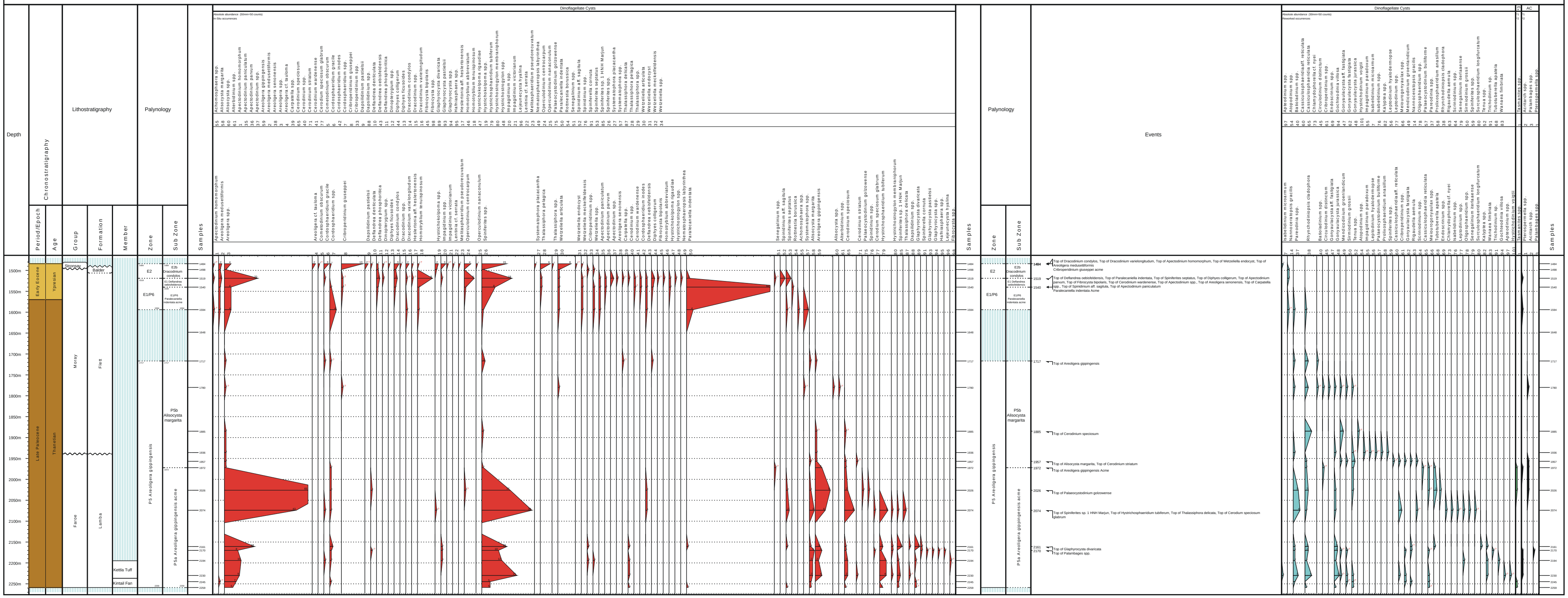
Interval : 1470m - 2270m

Scale : 1:4000

Chart date : 17 October 2008

Marjun 6004/16-1

GEUS
Copenhagen

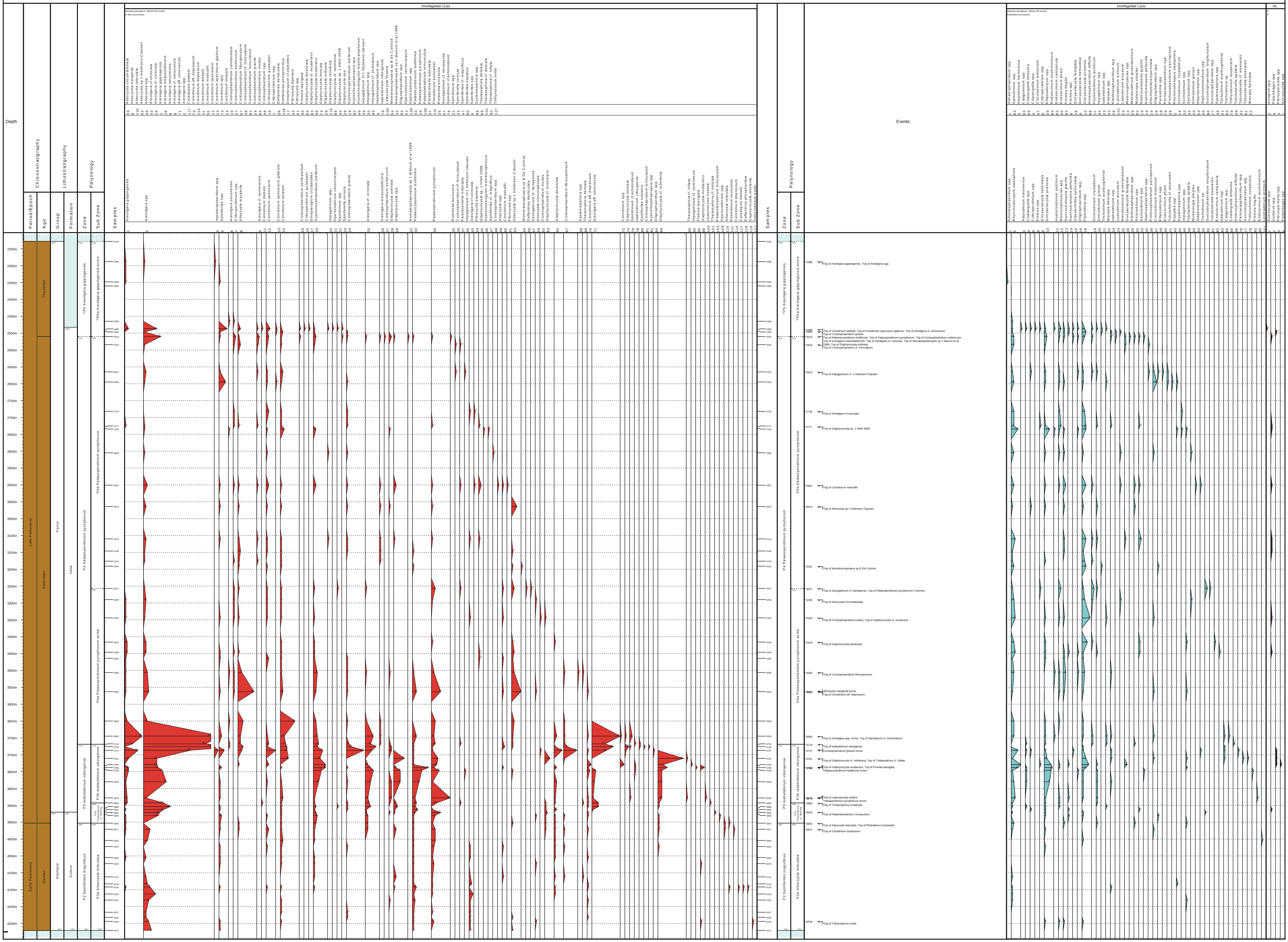


Enclosure 4. *Palynological rangechart: Marjun, 6004/16-Z (side-track) offshore Faroe Islands.*

Well Name : Marjun 6004/16-1Z
Interval : 2208m - 4291m
Scale : 1:4000
Chart date : 24 October 2008

Marjun 6004/16-1Z

GEUS
Copenhagen



Enclosure 5. *Palynological rangechart: Svinoy, 6004/12-1 and side-track 1Z offshore Faroe Islands.*

Well Name : Svinoy 6004/12-1 and 1Z

Operator :

Well Code : SVINOY600412-1

Lat/Long : 0° 0' 0.00"N 0° 0' 0.00"E

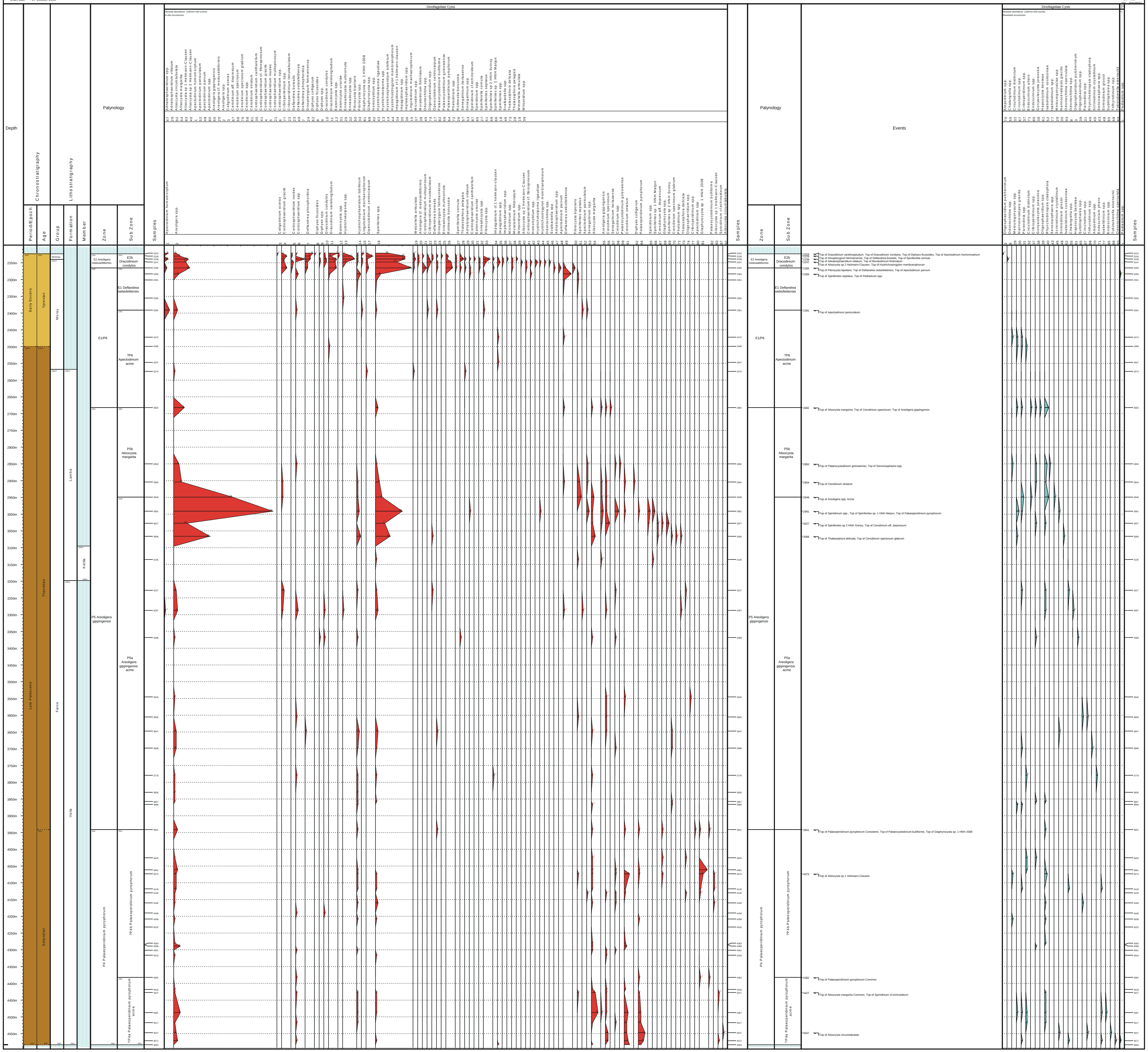
Interval : 2203m - 4590m

Scale : 1:4000

Chart date : 17 October 2008

Svinoy 6004/12-1 and 1Z

GEUS
Copenhagen



Enclosure 6. *Palynological rangechart: 6305/5-1 Ormen Lange, Møre Basin, offshore Norway.*

Well Name : 6305/5-1 Norway K/T

Interval : 2605m - 2825m

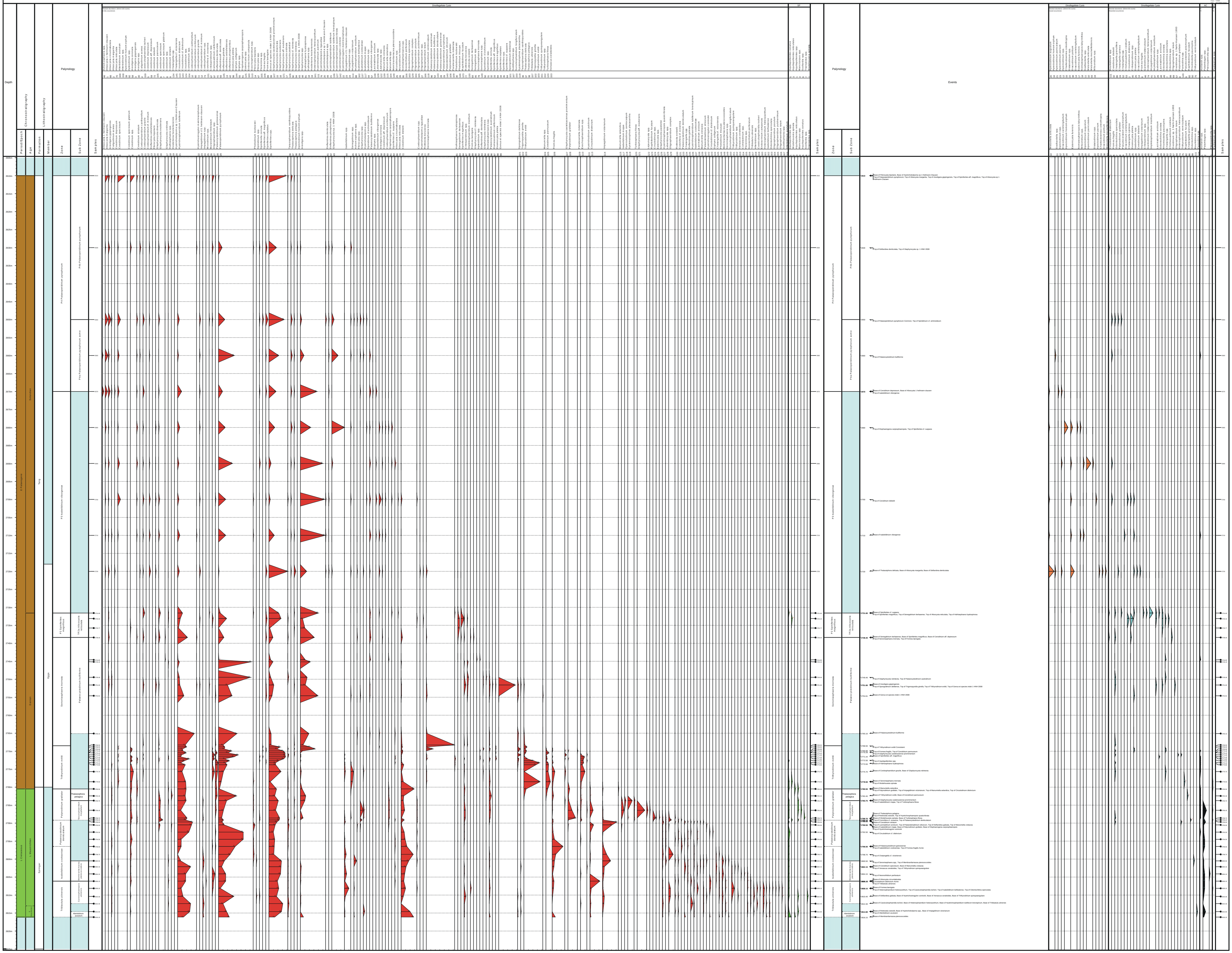
Scale : 1:250

Chart date : 27 October 2008

6305/5-1 Norway K/T

GEUS

Copenhagen

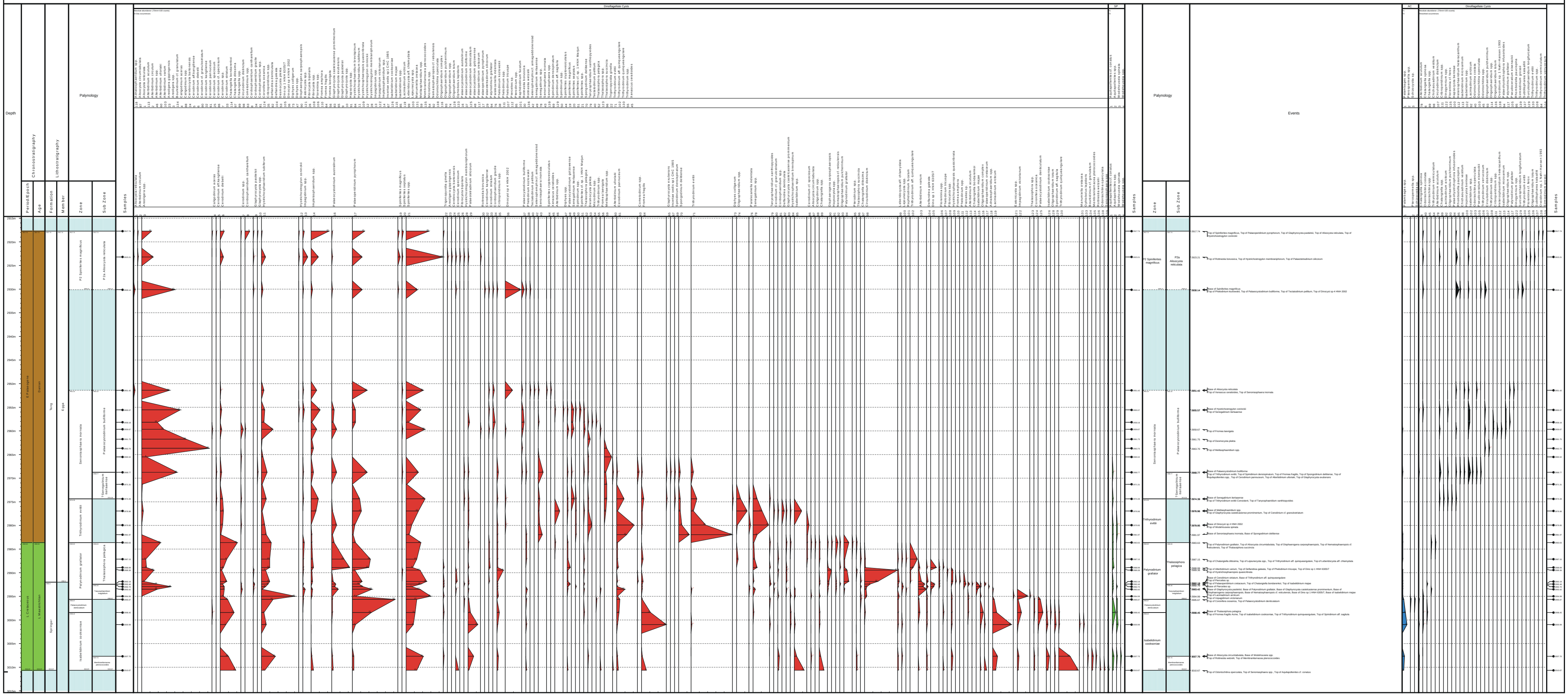


Enclosure 7. *Palynological rangechart: 6305/-7-1 Ormen Lange, Møre Basin, offshore Norway.*

Well Name : 6305/7-1 Norway K/T
Operator :
Interval : 2915m - 3015m
Scale : 1:250
Chart date : 27 October 2008

6305/7-1 Norway K/T

GEUS
Copenhagen



Enclosure 8. *Palynological summery/events chart: Palaeogene outcrops from the Kangerlussuaq Basin, East Greenland.*

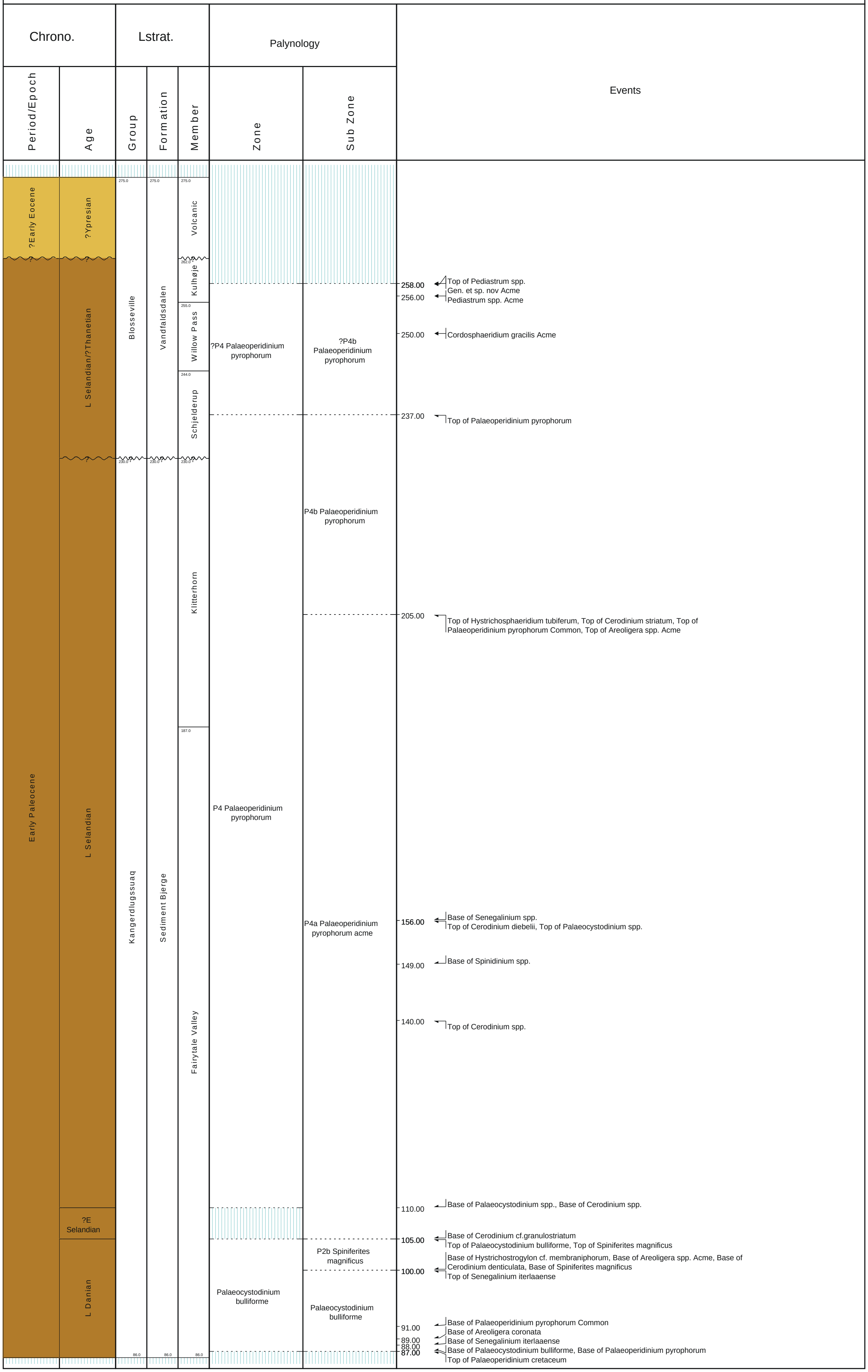
Section : Palaeogen Sindri Composit

Interval : 277.00m - 85.00m

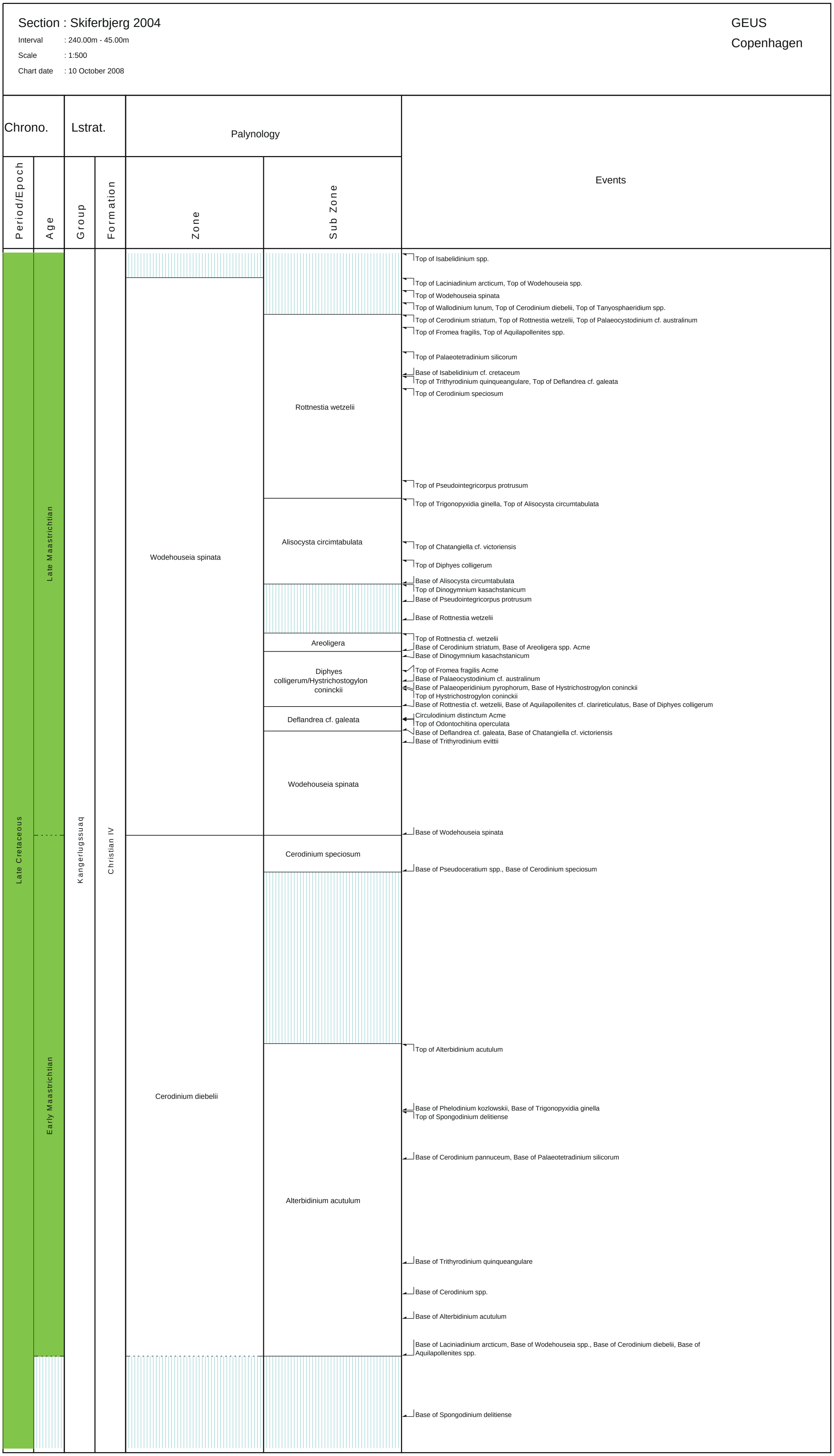
Scale : 1:500

Chart date : 16 October 2008

GEUS
Copenhagen



Enclosure 9. *Palynological summery/events chars: Skiferbjerg 2004 outcrop from the Kangerlussuaq Basin, East Greenland.*



Section : Skiferbjerg 2004
Interval : 240.00m - 45.00m
Scale : 1:500
Chart date : 10 October 2008
GEUS
Copenhagen
Chrono.
Lstrat.
Palynology
Events
Period/Epoch
Age
Group
Formation
Zone
Sub Zone
Late Cretaceous
Late Maastrichtian
Early Maastrichtian
Kangerlugssuaq
Christian IV
Wodehouseia spinata
Cerodinium diebelii
Rottnestia wetzelii
Alisocysta circimtabulata
Areoligera
Diphyes colligerum/Hystrichostogylon coninckii
Deflandrea cf. galeata
Wodehouseia spinata
Cerodinium speciosum
Alterbidinium acutulum
Top of Isabelidinium spp.
Top of Laciniadinium arcticum, Top of Wodehouseia spp.
Top of Wodehouseia spinata
Top of Wallodinium lunum, Top of Cerodinium diebelii, Top of Tanyosphaeridium spp.
Top of Cerodinium striatum, Top of Rottnestia wetzelii, Top of Palaeocystodinium cf. australinum
Top of Fromea fragilis, Top of Aquilapollenites spp.
Top of Palaeotetradinium silicorum
Base of Isabelidinium cf. cretaceum
Top of Trithyrodinium quinqueangulare, Top of Deflandrea cf. galeata
Top of Cerodinium speciosum
Top of Pseudointegricorpus protrusum
Top of Trigonopyxidia ginella, Top of Alisocysta circumtabulata
Top of Chatangiella cf. victoriensis
Top of Diphyes colligerum
Base of Alisocysta circumtabulata
Top of Dinogymnium kasachstanicum
Base of Pseudointegricorpus protrusum
Base of Rottnestia wetzelii
Top of Rottnestia cf. wetzelii
Base of Cerodinium striatum, Base of Areoligera spp. Acme
Base of Dinogymnium kasachstanicum
Top of Fromea fragilis Acme
Base of Palaeocystodinium cf. australinum
Base of Palaeoperidinium pyrophorum, Base of Hystrichostrogylon coninckii
Top of Hystrichostrogylon coninckii
Base of Rottnestia cf. wetzelii, Base of Aquilapollenites cf. clarireticulatus, Base of Diphyes colligerum
Circulodinium distinctum Acme
Top of Odontochitina operculata
Base of Deflandrea cf. galeata, Base of Chatangiella cf. victoriensis
Base of Trithyrodinium evittii
Base of Wodehouseia spinata
Base of Pseudoceratium spp., Base of Cerodinium speciosum
Top of Alterbidinium acutulum
Base of Phelodinium kozlowskii, Base of Trigonopyxidia ginella
Top of Spongodinium delitiense
Base of Cerodinium pannuceum, Base of Palaeotetradinium silicorum
Base of Trithyrodinium quinqueangulare
Base of Cerodinium spp.
Base of Alterbidinium acutulum
Base of Laciniadinium arcticum, Base of Wodehouseia spp., Base of Cerodinium diebelii, Base of Aquilapollenites spp.
Base of Spongodinium delitiense

Enclosure 10. *Palynological summery/events chars: Longan, 6005/15-1 offshore Faroe Islands.*

Well Name : Longan 6005/15-1

Interval : 1750m - 4025m

Scale : 1:4000

Chart date : 24 October 2008

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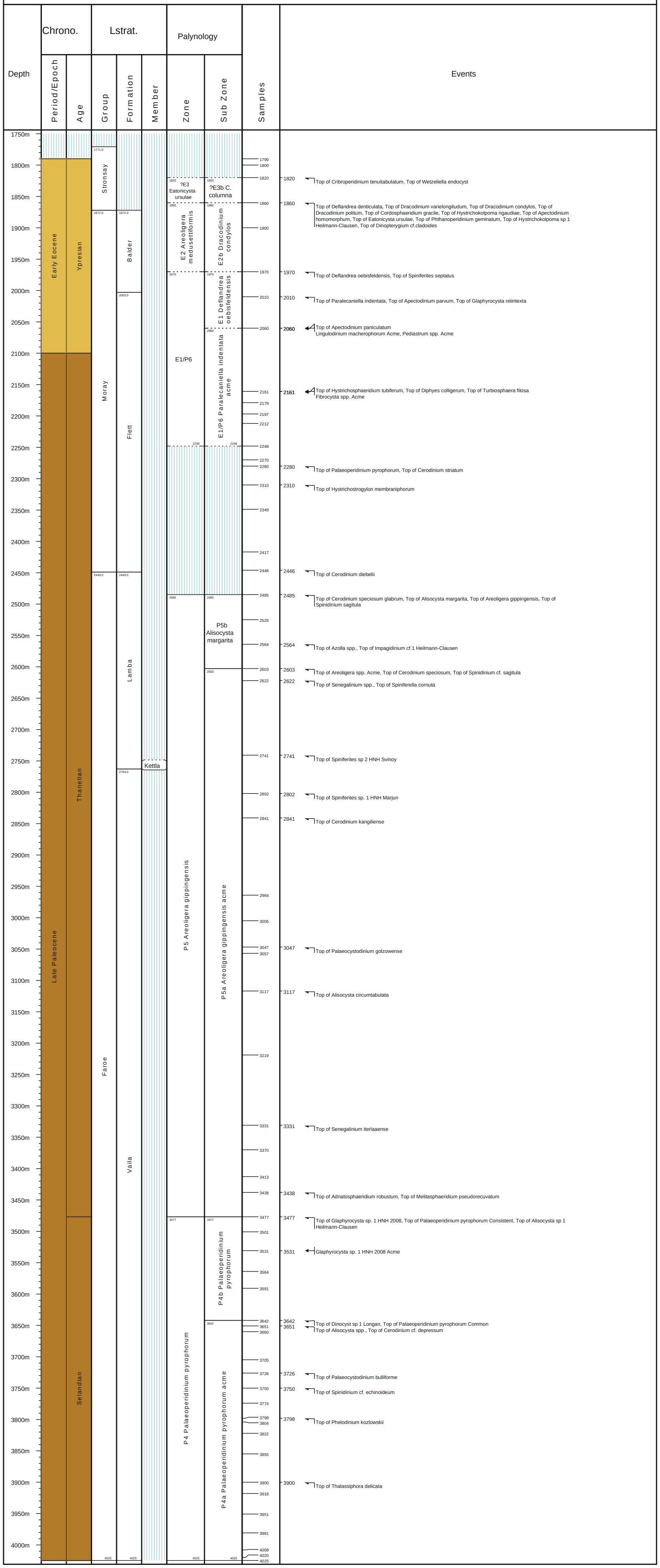

Enclosure 11. *Palynological summery/events chart: Marjun, 6004/16-1 offshore Faroe Islands.*

Well Name : Marjun 6004/16-1

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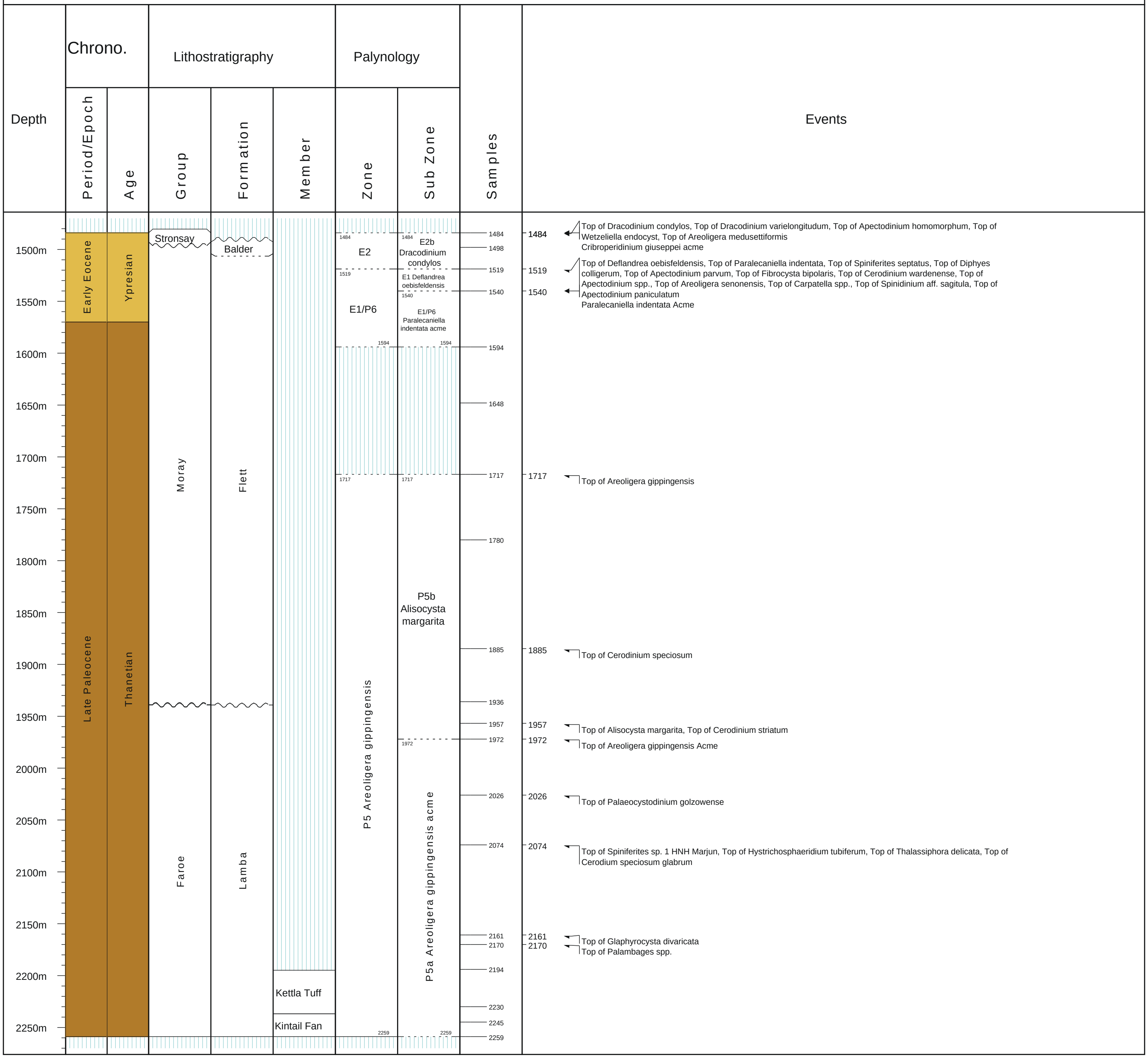
Interval : 1470m - 2270m

Scale : 1:4000

Chart date : 16 October 2008



Enclosure 12. *Palynological summery/events chart: Marjun, 6004/16-Z (side-track) offshore Faroe Islands.*

Well Name : Marjun 6004/16-1Z

Interval : 2208m - 4291m

Scale : 1:4000

Chart date : 24 October 2008

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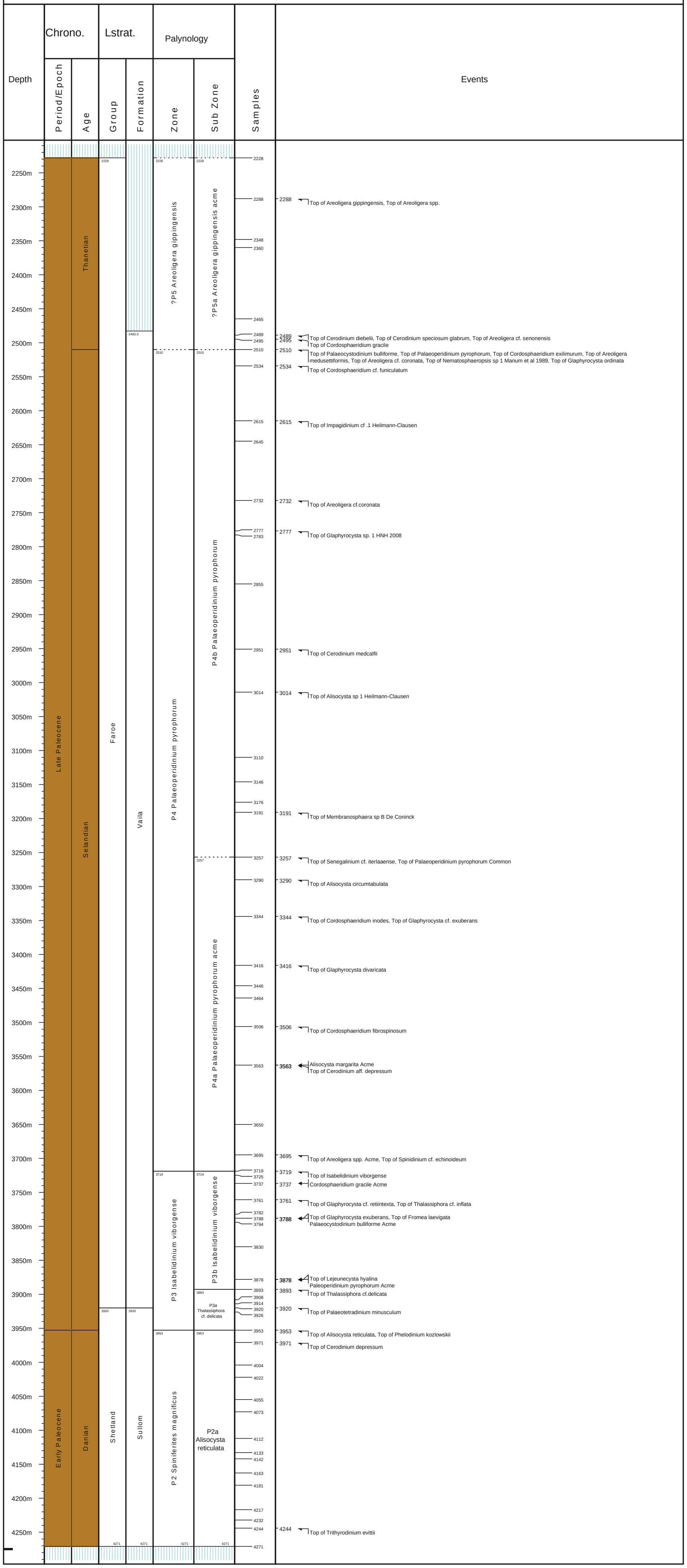

Enclosure 13. *Palynological summery/events chart: Svinoy, 6004/12-1 and side-track 1Z off-shore Faroe Islands.*

Well Name : Svinoy 6004/12-1 and 1Z

Interval : 2203m - 4590m

Scale : 1:4000

Chart date : 17 October 2008

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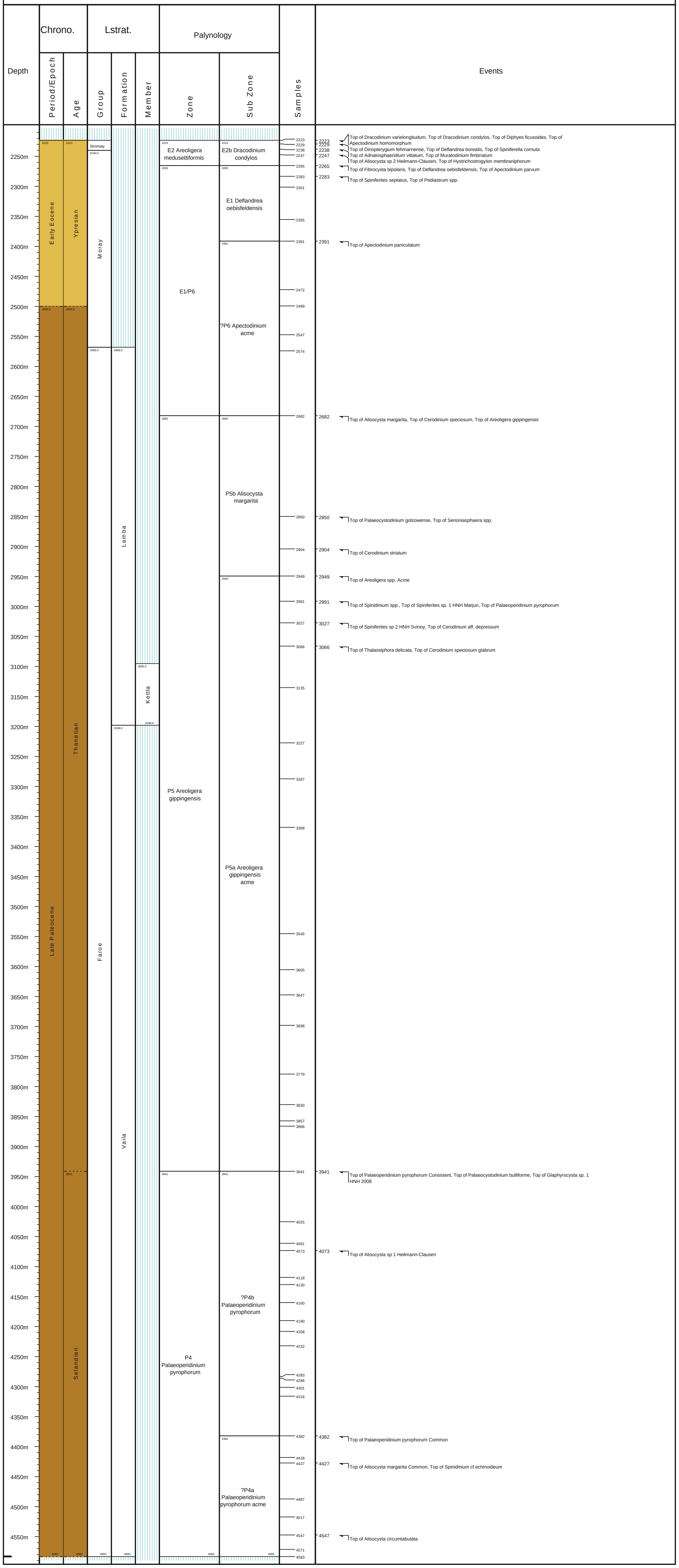
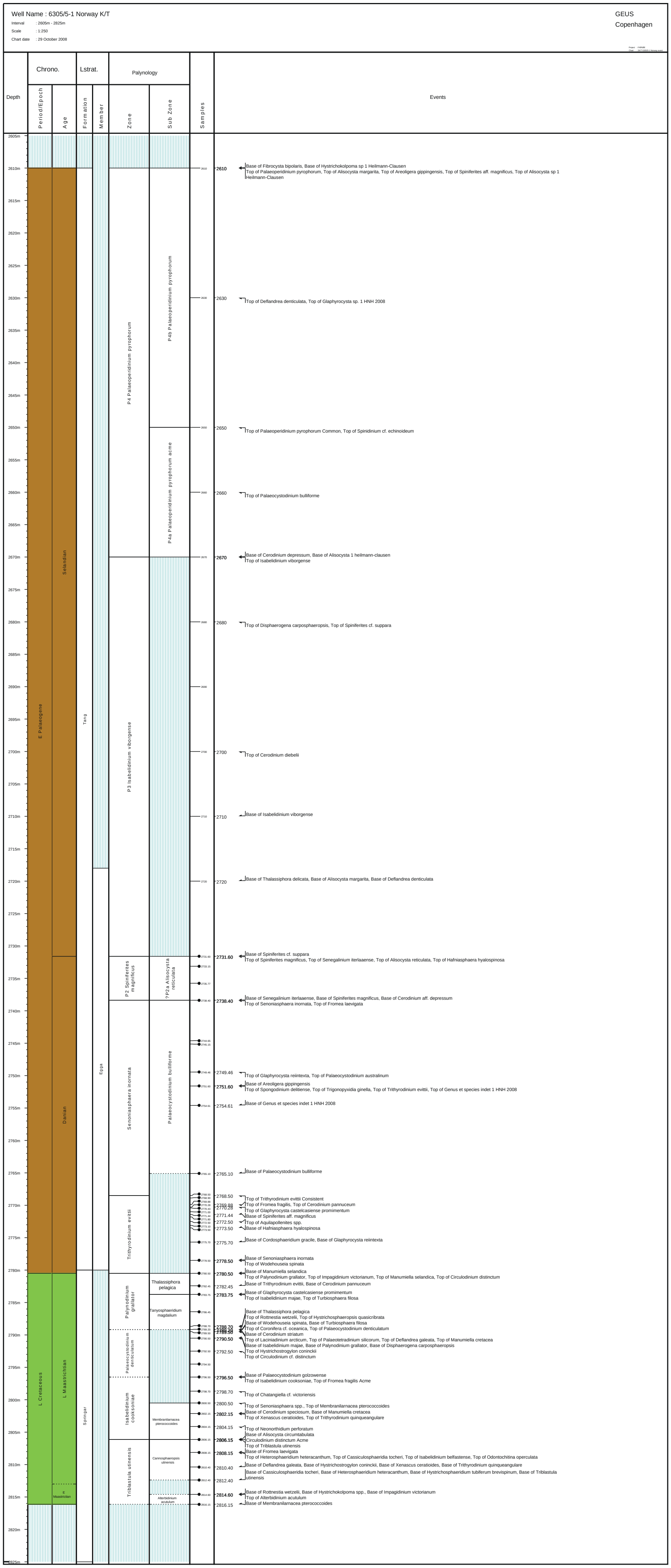


Enclosure 14. *Palynological summery/events chart: 6305/5-1 Ormen Lange, Møre Basin, off-shore Norway.*


Well Name : 6305/5-1 Norway K/T
Interval : 2605m - 2825m
Scale : 1:250
Chart date : 29 October 2008
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Depth
Chrono.
Period/Epoch
Age
Lstrat.
Formation
Member
Palynology
Zone
Sub Zone
Samples
Events
E Palaeogene
L Cretaceous
Selandian
Danian
L Maastrichtian
Tang
Egga
Springar
P4 Palaeoperidinium pyrophorum
P4b Palaeoperidinium pyrophorum
P4a Palaeoperidinium pyrophorum acme
P3 Isabelidinium viborgense
P2 Spiniferites magnificus
?P2a Alisocysta reticulata
Senoniasphaera inornata
Palaeocystodinium bulliforme
Trithyrodinium evittii
Palynodinium grallator
Thalassiphora pelagica
Tanyosphaeridium magdalium
Palaeocystodinium denticulatum
Isabelidinium cooksoniae
Membranilarnacea pterococcoides
Triblastula utinensis
Cannosphaeropsis utinensis
Alterbidinium acutulum
2610 Base of Fibrocysta bipolaris, Base of Hystrichokolpoma sp 1 Heilmann-Clausen
Top of Palaeoperidinium pyrophorum, Top of Alisocysta margarita, Top of Areoligera gippingensis, Top of Spiniferites aff. magnificus, Top of Alisocysta sp 1 Heilmann-Clausen
2630 Top of Deflandrea denticulata, Top of Glaphyrocysta sp. 1 HNH 2008
2650 Top of Palaeoperidinium pyrophorum Common, Top of Spinidinium cf. echinoideum
2660 Top of Palaeocystodinium bulliforme
2670 Base of Cerodinium depressum, Base of Alisocysta 1 heilmann-clausen
Top of Isabelidinium viborgense
2680 Top of Disphaerogena carposphaeropsis, Top of Spiniferites cf. suppara
2700 Top of Cerodinium diebelii
2710 Base of Isabelidinium viborgense
2720 Base of Thalassiphora delicata, Base of Alisocysta margarita, Base of Deflandrea denticulata
2731.60 Base of Spiniferites cf. suppara
Top of Spiniferites magnificus, Top of Senegalinium iterlaaense, Top of Alisocysta reticulata, Top of Hafniasphaera hyalospinosa
2738.40 Base of Senegalinium iterlaaense, Base of Spiniferites magnificus, Base of Cerodinium aff. depressum
Top of Senoniasphaera inornata, Top of Fromea laevigata
2749.46 Top of Glaphyrocysta reiintexta, Top of Palaeocystodinium australinum
2751.60 Base of Areoligera gippingensis
Top of Spongodinium delitiense, Top of Trigonopyxidia ginella, Top of Trithyrodinium evittii, Top of Genus et species indet 1 HNH 2008
2754.61 Base of Genus et species indet 1 HNH 2008
2765.10 Base of Palaeocystodinium bulliforme
2768.50 Top of Trithyrodinium evittii Consistent
2769.88 Top of Fromea fragilis, Top of Cerodinium pannuceum
2770.28 Top of Glaphyrocysta castelcasiense promimentum
2771.44 Base of Spiniferites aff. magnificus
2772.50 Top of Aquilapollenites spp.
2773.50 Base of Hafniasphaera hyalospinosa
2775.70 Base of Cordosphaeridium gracile, Base of Glaphyrocysta reiintexta
2778.50 Base of Senoniasphaera inornata
Top of Wodehouseia spinata
2780.50 Base of Manumiella selandica
Top of Palynodinium grallator, Top of Impagidinium victorianum, Top of Manumiella selandica, Top of Circulodinium distinctum
2782.45 Base of Trithyrodinium evittii, Base of Cerodinium pannuceum
2783.75 Base of Glaphyrocysta castelcasiense promimentum
Top of Isabelidinium majae, Top of Turbiosphaera filosa
Base of Thalassiphora pelagica
Top of Rottnestia wetzelii, Top of Hystrichosphaeropsis quasicribrata
2788.70 Base of Wodehouseia spinata, Base of Turbiosphaera filosa
2789.20 Top of Coronifera cf. oceanica, Top of Palaeocystodinium denticulatum
2789.50 Base of Cerodinium striatum
2790.50 Top of Laciniadinium arcticum, Top of Palaeotetradinium silicorum, Top of Deflandrea galeata, Top of Manumiella cretacea
Base of Isabelidinium majae, Base of Palynodinium grallator, Base of Disphaerogena carposphaeropsis
2792.50 Top of Hystrichostrogylon coninckii
Top of Circulodinium cf. distinctum
2796.50 Base of Palaeocystodinium golzowense
Top of Isabelidinium cooksoniae, Top of Fromea fragilis Acme
2798.70 Top of Chatangiella cf. victoriensis
2800.50 Top of Senoniasphaera spp., Top of Membranilarnacea pterococcoides
2802.15 Base of Cerodinium speciosum, Base of Manumiella cretacea
Top of Xenascus ceratioides, Top of Trithyrodinium quinqueangulare
2804.15 Top of Neonorthidium perforatum
2806.15 Base of Alisocysta circumtabulata
Circulodinium distinctum Acme
Top of Triblastula utinensis
2808.15 Base of Fromea laevigata
Top of Heterosphaeridium heteracanthum, Top of Cassiculosphaeridia tocheri, Top of Isabelidinium belfastense, Top of Odontochitina operculata
2810.40 Base of Deflandrea galeata, Base of Hystrichostrogylon coninckii, Base of Xenascus ceratioides, Base of Trithyrodinium quinqueangulare
2812.40 Base of Cassiculosphaeridia tocheri, Base of Heterosphaeridium heteracanthum, Base of Hystrichosphaeridium tubiferum brevispinum, Base of Triblastula utinensis
2814.60 Base of Rottnestia wetzelii, Base of Hystrichokolpoma spp., Base of Impagidinium victorianum
Top of Alterbidinium acutulum
2816.15 Base of Membranilarnacea pterococcoides

Enclosure 15. *Palynological summery/events chart: 6305/-7-1 Ormen Lange, Møre Basin, off-shore Norway.*

Well Name : 6305/7-1 Norway K/T

Interval : 2915m - 3015m

Scale : 1:250

Chart date : 29 October 2008

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