DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2010/134

Fehmarn Belt Fixed Link Pre-Quaternary Biostratigraphy

- a final status report for Rambøll/Arup JV

Emma Sheldon & Henrik Nøhr-Hansen

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Strategy

The results from a multidisciplinary biostratigraphic analysis of selected samples from 46 wells from onshore Fehmarn, onshore Rødbyhavn, the Fehmarn Belt and offshore Lillebælt is presented. The wells have been drilled both to investigate the character of the Quaternary deposits and the nature of the Palaeogene strata and chalk (where encountered) underlying the Quaternary deposits in preparation for construction of the Fehmarn Belt Fixed Link. The biostratigraphic analysis is carried out to supplement and constrain the geological model based on sedimentological and seismic data obtained by Rambøll/Arup JV & Fugro Engineers BV. Emma Sheldon carried out nannofossil and microfossil analysis and Henrik Nøhr-Hansen carried out palynological analysis.

Methods

This report presents the results of a multidisciplinary biostratigraphic study of selected samples from 25 wells drilled in 2009 and 19 drilled in 2010 in the Fehmarn region and 2 wells drilled in 2010 offshore Lillebælt. The wells were drilled to a total depth (TD) of between 50 and ca. 100 m. All wells were totally cored in the pre-Quaternary deposits; the use of core material, rather than ditch cuttings samples, is important as it reduces errors in dating caused by caving. 1-10 core samples from each well were chosen by John Kærgaard Frederiksen, Rambøll/Arup JV for biostratigraphic analysis. Biostratigraphic dating using calcareous nannofossils was carried out on all samples. Based on these results, further analyses were carried out using microfossils and dinoflagellate cysts if required.

For this study, 170 samples were analysed using calcareous nannofossils. 110 were analysed for their microfossil content and palynological analysis was carried out on 90 samples. Nannofossils are particularly useful for dating in chalk and clay lithologies, microfossils in chalk, sand and clay, and palynomorphs in clay lithologies. This multidisciplinary biostratigraphic approach allowed rapid yet reliable dating of the samples to be performed. Chalk samples from 46.2 m - 46.25 m from well 09.A.006, 69.65 m from well 10.A.062 and 70.05 m from well 10.B.063 required particular analysis as they had a black amorphous material associated with them, they were analysed for both lithologies as described in the results section. Reworked material is denoted using 'RW'. If a biostratrigraphic discipline has not been used to date a sample, 'n/a' is used and if a formation cannot be identified, this is also noted.

The Palaeogene zonation schemes primarily used in the study are applicable to the North Sea area: the calcareous nannofossil zonation scheme of Varol (1998), the planktonic and benthic microfossil schemes of King (1989) and the dinoflagellate cyst schemes of Heilmann-Clausen (1985, 1988); Bujak & Mudge (1994) and Mudge & Bujak (1996). These are correlated against additional, standard zonation schemes, chronostratigraphy and lithostratigraphy in Figure 1 which is adapted from Schiøler *et al.* 2007. The Upper Cretaceous chalk samples were dated using the Boreal region nannofossil zonation of Burnett (1998) Figure 2, the microfossil zonation scheme of King *et al. (*1989), and the palynological schemes of Schiøler and Wilson (1993), Schmitz *et al*. (1996) and Slimani (2001). The south to north correlation of the two studied Lillebælt wells is illustrated on figure 3.
Figures 4-9 illustrate the studied formations/lithologies and the recorded stratigraphic characteristic nannofossils, microfossils and palynomorphs.

Studied samples

From south to north, the wells (with their terminal depth - TD) and selected samples examined in this project were:

Onshore Fehmarn

10.A.610A: 37.00-37.05 m, TD 50.20 m.

09.A.604: 8.30-8.35 m, 11.7-11.75 m, 18.75-18.80 m, 23.20-23.25 m, 35.30-35.35 m, 50.15-50.20 m, TD 50.70 m.

09.A.606: 46.15-46.20 m, TD 50.60 m.

09.A.603: 36.70-36.75 m, 39.15-39.25 m, 42.15-42.20 m, 48.35-48.40 m, 57.00-57.10 m, 75.10-75.15 m, 89.30-89.35 m, 101.70-101.80 m, TD 102.20 m.

10.A.607: 36.55-36.60 m, 59.05-59.10 m, 100.80-100.85 m, TD 101.10 m.

09.A.607: 5.20-5.25 m, 17.95-18.00 m, 31.20-31.25 m, TD 32.10 m.

09.A.601: 37.90-37.95 m, 77.30-77.35 m, TD 42.00 m.

09.A.602: 9.60-9.65 m, 14.20-14.25 m, 19.45-19.50 m, 20.90-20.95 m, 38.15-38.20 m, 49.50-49.55 m, TD 51.00 m.

Offshore Fehmarn Belt

10.A.072: 5.85-5.90 m, 37.55-37.60 m, TD 40.70 m.

10.A.051: 10.10-10.15 m, 43.90-43.95 m, 80.40-80.45 m, TD 80.50 m.

09.A.001: 11.90-11.95 m, 15.05-15.10 m, 29.00-29.05 m, 38.45-38.50 m, 48.85-48.90 m, TD 50.40 m.

10.A.052: 11.40-11.45 m, 21.1-21.15 m, 55.5-55.55 m, 65.4-65.45 m, TD 75.50 m.

09.A.002: 09.30-09.35 m, 10.55 m-10.60 m, 13.40-13.45 m, 21.35-21.40 m, 32.90-32.95 m, 42.30-42.35 m, 50.20-50.25 m, 59.35-59.40 m, 66.55-66.6 m, 79.65-79.70 m, 96.5-96.55 m, TD 100.10 m.

10.A.053: 5.80-5.85 m, 21.85-21.90 m, 53.30-53.35 m, 58.55-58.60, TD 75.20 m.

09.A.009: 16.55-16.60 m, 28.80-28.85 m, 40.15-40.20 m, 50.30-50.35 m, TD 50.60 m.

10.A.054: 28.9-28.95 m, 50.0-50.05 m, 54.2-54.25 m, TD 75.50 m.

09.A.003: 19.60-19.65 m, 32.65-32.7 m, 49.25-49.3 m, 49.25-49.30 m, TD 50.00 m.

10.A.055: 27.15-27.20 m, 40.65-40.70 m, 70.65-70.75 m, TD 75.10 m.

09.A.015: 28.85-28.90 m, 35.60-35.65 m, TD 35.80 m.

09.A.015A: 46.80-46.85 m, 61.65-61.70 m, 74.15-74.20 m, 86.15-86.20 m, TD 100.50 m.

09.A.010: 15.25-15.45 m, 21.40-21.45 m, 28.90-29.05 m, 43.65-43.70 m, 44.55-44.65 m, 49.80-49.85 m, TD 50.20 m.

10.A.056: 31.13-31.40 m, 45.65-45.70 m, 56.45-56.50 m, 72.85-72.90 m, TD 75.00 m.

10.A.057: 38.30-38.35 m, 54.55-54.70 m, 99.15-99.20 m, TD 100.50 m.

10.A.058: 20.55-20.60 m, 39.55-39.60 m, 51.35-51.40 m, 87.10-87.25 m, TD 100.10 m.

09.A.004: 28.60-28.65 m, 78.10-78.15 m, 85.20-85.25 m, 99.85-99.90 m, TD 100.00 m.

10.A.059B: 71.00-71.05 m, 84.70-84.75 m, 96.15-96.20 m, TD 49.50 m.

10.A.060: 62.10-62.15 m, Chalk 62.35-62.45 m, TD 74.90 m.

09.A.006: 45.70-45.75 m, 46.20-46.25 m, 46.20-46.25 m, 95.35 m (grey chalk) 95.35 m (white chalk), TD 99.90 m.

10.A.062: 39.10-39.15 m, 41.35-41.45 m, 69.65 m (chalk), 69.65 (black particles), TD 70.50 m.

09.A.007: 21.50-21.55 m, TD 50.10 m.

09.A.008: 25.60-25.65 m, 66.00-66.05 m, 99.90-99.95 m, TD 100.60 m.

10.A.063: 49.55-49.60 m, 51.35-51.40 m, TD 76.70 m.

10.B.063: 70.05 m (chalk), 70.05 m (black particles), TD 76.70 m.

09.A.019: 61.55 m, 86.75 m, TD 104.00 m.

09.A.013: 78.05-78.10 m, 82.65-82.70 m, 97.25-97.30 m, 99.25-99.30 m, TD 101.30 m.

10.A.064: 61.45-61.50 m, 66.95-67.00 m, 74.55-74.60 m, TD 75.70 m.

09.A.014: 66.25-66.40 m, 72.25-73.30 m, TD 75.20 m.

09.A.018: 59.80-59.85 m, 66.33 m, 70.20 m, TD 70.30 m.

10.A.065: 50.27-50.30 m, 67.55-67.60 m, 83.30-83.35 m, 94.85-94.90 m, TD 101.30 m.

10.A.071: 31.35-31.40 m, TD 41.10 m.

Onshore Rødbyhavn

09.A.701: 27.55-27.60 m, 40.00-40.05 m, 56.65-56.70 m, 63.95-64.00 m, 73.40-73.50 m, 89.85-89.90 m, TD 100.20 m.

09.A.702: 59.20-59.25 m, 71.05-71.15 m, 88.35-88.40 m, TD 88.40 m.

09.A.704: 25.30-25.35 m, 38.35-38.45 m, 48.70-48.75 m, TD 50.90 m.

09.A.703: 17.85-17.90 m, 30.85-30.90 m, 44.65-44.70 m, TD 50.90 m.

Offshore Lillebælt

10.A.801: 10.70-10.80 m, 23.80-23.85 m, 42.45-42.50 m, 59.00-59.05 m, 65.10-65.15 m, 72.60-72.65 m, TD 72.80 m.

10.A.802: 3.95-3.40 m, 20.45-20.50 m, 28.65-28.70 m, 39.95-40.00 m, TD 40.00 m.

Results

Detailed study of amorphous black material

Samples 46.2 m–46.25 m from well 09.A.006, 69.65 m from well 10.A.062 and 70.05 m from well 10.B.063 were analysed both for chalk and a 'greasy' black material. The chalk proved to be upper Maastrichtian in age, but the black material proved more puzzling. The black material was apparently not found in wells from an earlier drilling campaign (in 1996) which also encountered chalk, but appears 'perhaps smeared' into fractures in the chalk in the 2009 and 2010 wells. It was initially suggested that the black material could have resulted from lubricant used during drilling but this has been refuted by Fugro Engineers BV. The material was tested for traces of hydrocarbons at the GEUS sourcerock laboratory, but none were found. Palynological analysis indicates that the material from the 09.A.006 and the 10.B.063 wells are upper Selandian (Viborg Zone 3) dark grey non calcareous clay/?*Æbelø* Formation clay, whereas the few gram of 'greasy' black material obtained from sample 70.05 m from the well 10.A.062 only contained very few possible upper Cretaceous dinoflagellate cysts. Analysis of further samples of the black material from supplementary wells, in addition to re-examination of the 1996 campaign chalk wells is required for further interpretation.

Biostratigraphic results

A south to north correlation of the examined wells and samples from onshore Fehmarn to onshore Rødbyhavn can be seen on Enclosure 1. Results from offshore Lillebælt are found on Enclosure 2. The raw biostratigraphic data are provided on Tables 1a and b. A summary of the nannofossil, microfossil and palynological data is listed below for each sample, along with the formation the sample is attributed to, and its age.

Onshore Fehmarn

10.A.610A

37.00-37.05 m

Nannofossils: Upper Cretaceous
Microfossils: ?NSP6 (NSP5-7)
Palynology: upper part of Zone D9 = *Areosphaeridium diktyoplokus* Zone, E3b or upper part of E3a

Formation: beds L1 and L2 of the Lillebælt Clay Formation and maybe the upper part of the R6 bed of the Røsnæs Clay Formation. Most likely lower Lillebælt Clay Fm
Age: upper Ypresian

09.A.604

8.30-8.35 m

Nannofossils: barren
Microfossils: sparse, long ranging microfossils
Palynology: lower part of Zone D9 = *Areosphaeridium diktyoplokus* Zone, lower part of E3a
Formation: upper part of the R6 bed of the Røsnæs Clay Formation and maybe part of the beds L1 and L2 of the Lillebælt Clay Formation
Age: upper Ypresian

11.70-11.75 m

Nannofossils: barren
Microfossils: sparse, long ranging microfossils
Palynology: lower part of Zone D9 = *Areosphaeridium diktyoplokus* Zone, lower part of E3a
Formation: upper part of the R6 bed of the Røsnæs Clay Formation and maybe part of the beds L1 and L2 of the Lillebælt Clay Formation
Age: upper Ypresian

18.75-18.80 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: upper part of Zone D8 = *Charlesdowniea coleothrypta* Zone, ?lower part of E2c/E2b
Formation: upper part of the bed R5 and lower part of bed R6 of the Røsnæs Clay Formation
Age: middle Ypresian

23.20-23.25 m

Nannofossils: NNTe2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

35.30-35.35 m

Nannofossils: barren
Microfossils: NSB3b

Palynology: lower part of D8 = *Charlesdowniea colethrypta*, to upper subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: upper bed R5 & lower bed R6, and middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

50.15-50.20 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

09.A.606

46.15-46.20 m

Nannofossils: barren
Microfossils: sparse, long ranging microfossils
Palynology: lower part of Zone D9 = *Areosphaeridium diktyoplokus* Zone, lower part of E3a
Formation: upper part of the R6 bed of the Røsnæs Clay Formation and maybe part of the beds L1 and L2 of the Lillebælt Clay Formation
Age: upper Ypresian

09.A.603

36.70-36.75 m

Nannofossils: NNTe1D-NNTe2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

39.15-39.25 m

Nannofossils: barren
Microfossils: NSB3 with RW from NSB1b
Palynology: n/a
Formation: Røsnæs Clay Formation
Age: middle Ypresian

42.15-42.20 m

Nannofossils: ?NNTe1C-2
Microfossils: NSB3

Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

48.35-48.40 m

Nannofossils: NNTe1B-?2
Microfossils: NSB3 with RW from NSB1b
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

57.00-57.10 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

75.10-75.15 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

77.30-77.35 m

Nannofossils: NNTe1D
Microfossils: n/a
Palynology: n/a
Formation: base Røsnæs Clay Formation
Age: middle Ypresian

89.30-89.35 m

Nannofossils: sparse, long ranging nannofossils
Microfossils: NSB3 with RW from NSB1b
Palynology: n/a
Formation: Røsnæs Clay Formation
Age: middle Ypresian

101.70-101.80 m

Nannofossils: NNTe1C-NNTe2
Microfossils: NSB3 with RW from NSB1b
Palynology: n/a

Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

10.A.607

36.55-36.60 m

Nannofossils: barren
Microfossils: Middle-Upper Eocene
Palynology: n/a
Formation: not identified
Age: Middle-Upper Eocene

59.05-59.10 m

Nannofossils: ?NNTe1A-2
Microfossils: NSB3
Palynology: n/a
Formation: Røsnæs Clay Formation
Age: middle Ypresian

100.80-100.85 m

Nannofossils: barren
Microfossils: NSB3
Palynology: n/a
Formation: Røsnæs Clay Formation
Age: middle Ypresian

09.A.607

5.20-5.25 m

Nannofossils: barren
Microfossils: sparse, long ranging microfossils
Palynology: middle part of Zone D9 = *Areosphaeridium diktyoplokus* Zone, middle to upper part of E3a
Formation: upper part of the R6 bed of the Røsnæs Clay Formation and maybe part of the beds L1 and L2 of the Lillebælt Clay Formation
Age: upper Ypresian

17.95-18.00 m

Nannofossils: barren
Microfossils: sparse, long ranging microfossils
Palynology: lower to middle part of Zone D9 = *Areosphaeridium diktyoplokus* Zone, lower to middle part of E3a
Formation: upper part of the R6 bed of the Røsnæs Clay Formation and maybe part of the beds L1 and L2 of the Lillebælt Clay Formation

Age: upper Ypresian

31.20-31.25 m

Nannofossils: barren
Microfossils: NSB3, RW upper Paleocene & Upper Cretaceous (Campanian-Maastrictian)
Palynology: n/a
Formation: Tor Formation equivalent, upper Paleocene, Røsnæs Clay Formation
Age: Upper Cretaceous, upper Paleocene and middle Ypresian mix

09.A.601

37.90-37.95 m

Nannofossils: sparse, long ranging nannofossils
Microfossils: NSB3b
Palynology: n/a
Formation: middle Røsnæs Clay Formation
Age: middle Ypresian

09.A.602

9.60-9.65 m

Nannofossils: UC20d, NNTp2G-?, NNTe3-5
Microfossils: Coniacian-Maastrichtian, NSB1b, NSB3
Palynology: n/a
Formation: Tor Formation equivalent, Danian limestone, middle Røsnæs Clay Formation
Age: uppermost Maastrichtian, Danian, Ypresian

14.20-14.25 m

Nannofossils: barren
Microfossils: ?upper Paleocene
Palynology: lower part of Zone D9 = *Areosphaeridium diktyoplokus* Zone, lower part of E3a
Formation: upper part of the R6 bed of the Røsnæs Clay Formation and maybe part of the beds L1 and L2 of the Lillebælt Clay Formation
Age: upper Ypresian

19.45-19.50 m

Nannofossils: barren
Microfossils: ?NSB3-5a
Palynology: lower part of Zone D9 = *Areosphaeridium diktyoplokus* Zone, lower part of E3a

Formation: upper part of the R6 bed of the Røsnæs Clay Formation and maybe part of the beds L1 and L2 of the Lillebælt Clay Formation
Age: upper Ypresian

20.90-20.95 m

Nannofossils: barren
Microfossils: ?upper Paleocene
Palynology: lower part of Zone D9 = *Areosphaeridium diktyoplokus* Zone, lower part of E3a
Formation: upper part of the R6 bed of the Røsnæs Clay Formation and maybe part of the beds L1 and L2 of the Lillebælt Clay Formation
Age: upper Ypresian

38.15-38.20 m

Nannofossils: barren
Microfossils: long ranging microfossils
Palynology: lower part of Zone D9 = *Areosphaeridium diktyoplokus* Zone, lower part of E3a
Formation: upper part of the R6 bed of the Røsnæs Clay Formation and maybe part of the beds L1 and L2 of the Lillebælt Clay Formation
Age: upper Ypresian

49.50-49.55 m

Nannofossils: NNTe3
Microfossils: n/a
Palynology: n/a
Formation: middle Røsnæs Clay Formation
Age: middle Ypresian

Offshore Fehmarn Belt

10.A.072

5.85-5.90 m

Nannofossils: barren
Microfossils: barren
Palynology: lower to middle part of Zone D9 = *Areosphaeridium diktyoplokus* Zone, lower to middle part of E3a
Formation: upper part of bed R6 of the Røsnæs Clay Formation and maybe part of beds L1 and L2 of the Lillebælt Clay Formation
Age: upper Ypresian

37.55-37.60 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

10.A.051

10.10-10.15 m

Nannofossils: NNTe2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

43.90-43.95 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

80.40-80.45 m

Nannofossils: NNTe1D
Microfossils: n/a
Palynology: n/a
Formation: base Røsnæs Clay Formation
Age: lower to middle Ypresian

09.A.001

11.90-11.95 m

Nannofossils: NNTe2-3
Microfossils: n/a
Palynology: n/a
Formation: lower-middle Røsnæs Clay Formation
Age: middle Ypresian

15.05-15.10 m

Nannofossils: NNTe3
Microfossils: n/a
Palynology: n/a
Formation: middle Røsnæs Clay Formation
Age: middle Ypresian

29.00-29.05 m

Nannofossils: NNTe3
Microfossils: n/a
Palynology: n/a
Formation: middle Røsnæs Clay Formation
Age: middle Ypresian

38.45-38.50 m

Nannofossils: ?NNTe3-NNTe6
Microfossils: NSB3b with RW from NSB1b
Palynology: n/a
Formation: middle part of Røsnæs Clay Formation with middle Paleocene RW
Age: middle Ypresian

48.85-48.90 m

Nannofossils: NNTe1C-NNTe5
Microfossils: NSB3b with RW from NSB1b
Palynology: n/a
Formation: middle part of Røsnæs Clay Formation with middle Paleocene RW
Age: middle Ypresian

10.A.052

11.40-11.45 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

21.10-21.15 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

55.50-55.55 m

Nannofossils: barren
Microfossils: NSB3
Palynology: n/a
Formation: Røsnæs Clay Formation

Age: middle Ypresian

65.40-65.45 m

Nannofossils: barren
Microfossils: ?NSB3
Palynology: subzone D7a = *Eatonicysta ursulae* Zone and *Dracodinium solidum* Zone, E2a
Formation: upper part of the Knudshoved Member and in Bed R1 (Røsnæs Clay Formation) lower part of the red Røsnæs Clay facies i.e. in the lower part of the R4/R5 beds (Røsnæs Clay Formation)
Age: lower-middle Ypresian

09.A.002

9.30-9.35 m

Nannofossils: NNTe2-3
Microfossils: middle NSB3 (+ RW from upper Paleocene)
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

10.55-10.60 m

Nannofossils: NNTe1D- ?
Microfossils: NSB3
Palynology: n/a
Formation: Røsnæs Clay Formation
Age: middle Ypresian

13.40-13.45 m

Nannofossils: barren
Microfossils: barren
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

21.35-21.40 m

Nannofossils: NNTe2-5
Microfossils: middle NSB3 (+ RW from upper Paleocene)
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

32.90-32.95 m

Nannofossils: NNTe1D-2
Microfossils: middle NSB3 (+ RW from upper Paleocene), probably NSB3a
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

42.30-42.35 m

Nannofossils: NNTe2
Microfossils: middle NSB3 (+ RW from upper Paleocene), probably NSB3a
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

50.20-50.25 m

Nannofossils: NNTe2
Microfossils: middle NSB3 (+ RW from upper Paleocene), probably NSB3a
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

59.35-59.40 m

Nannofossils: NNTe1C-D
Microfossils: middle NSB3 (+ RW from upper Paleocene), probably NSB3a
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

66.55-66.60 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

79.65-79.70 m

Nannofossils: barren

Microfossils: NSB3/NSP5
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

96.50-96.55 m

Nannofossils: NNTe1C
Microfossils: n/a
Palynology: subzone D7a = *Eatonicysta ursulae* Zone and *Dracodinium solidum* Zone, E2a
Formation: upper part of the Knudshoved Member and Bed R1 (Røsnæs Clay Formation) and lower part of the red Røsnæs Clay facies i.e. in the lower part of the R4/R5 beds (Røsnæs Clay Formation)
Age: lower to middle Ypresian

10.A.053

5.80-5.85 m

Nannofossils: NNTe1B-2
Microfossils: RW from the Campanian
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

21.85-21.90 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

53.30-53.35 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

58.55-58.60

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation

Age: middle Ypresian

09.A.009

16.55-16.60 m

Nannofossils: NNTe1D
Microfossils: n/a
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

28.80-28.85 m

Nannofossils: NNTe1A- top NNTe5
Microfossils: barren
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

40.15-40.20 m

Nannofossils: barren
Microfossils: NSB3
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

50.30-50.35 m

Nannofossils: barren
Microfossils: NSB3
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

10.A.054

28.90-28.95 m

Nannofossils: barren
Microfossils: marker microfossils absent
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)

Age: middle Ypresian

50.00-50.05 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

54.20-54.25 m

Nannofossils: almost barren
Microfossils: NSB3
Palynology: n/a
Formation: Røsnæs Clay Formation
Age: middle Ypresian

09.A.003

19.60-19.65 m

Nannofossils: NNTe1C-D
Microfossils: NSB3 (+ RW from upper Paleocene)
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

32.65-32.70 m

Nannofossils: NNTe1C-D
Microfossils: NSB3 (+ RW from upper Paleocene)
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

49.25-49.30 m

Nannofossils: NNTe1C
Microfossils: NSB3a (+ RW from upper Paleocene)
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, or ?subzone D7a = *Eatonicysta ursulae* Zone and *Dracodinium solidum* Zone, E2b or ?E2a
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation), or ?upper part of the Knudshoved Member and in Bed R1 (Røsnæs Clay Formation) lower part of the red Røsnæs Clay facies i.e. in the lower part of the R4/R5 beds (Røsnæs Clay Formation)
Age: lower to middle Ypresian

10.A.055

27.15-27.20 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

40.65-40.70 m

Nannofossils: barren
Microfossils: NSB3
Palynology: n/a
Formation: Røsnæs Clay Formation
Age: middle Ypresian

70.65-70.75 m

Nannofossils: NNTe1D-2
Microfossils: NSB3-6a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

09.A.015

28.85-28.9 m

Nannofossils: barren
Microfossils: NSB2/NSP4
Palynology: probably uppermost part of Zone D4 = upper part of Viborg Zone 5, P6a
Formation: base Balder Formation / top Sele Formation (microfossils), or older dark grey non-calcareous clay (palynology)
Age: upper Paleocene / Lower Eocene

35.6-35.65m

Nannofossils: barren
Microfossils: NSB2/NSP4
Palynology: Viborg Zone 3, P4a
Formation: Æbelø Formation
Age: upper Selandian

09.A.015A

46.80-46.85 m

Nannofossils: barren
Microfossils: ?NSB4
Palynology: ?lower Middle Eocene, RW Lower Jurassic, Upper Cretaceous, upper Selandian
Formation: ?upper Lillebælt Clay Formation, or the ?lowermost part of the Søvind Marl Formation

61.65-61.70 m

Nannofossils: NNTe4/5 boundary (upper Paleocene RW)
Microfossils: NSB3b (upper Paleocene RW)
Palynology: subzone D7a = *Eatonicysta ursulae* Zone and *Dracodinium solidum* Zone
Formation: upper part of the Knudshoved Member and in Bed R1 (Røsnæs Clay Formation) lower part of the red Røsnæs Clay facies i.e. in the lower part of the R4/R5 beds (Røsnæs Clay Formation)
Age: lower-middle Ypresian

74.15-74.20 m

Nannofossils: NNTe1D-NNTe3 (upper Paleocene RW)
Microfossils: NSB3a (upper Paleocene RW)
Palynology: subzone D7a = *Eatonicysta ursulae* Zone and *Dracodinium solidum* Zone
Formation: upper part of the Knudshoved Member and in Bed R1 (Røsnæs Clay Formation) lower part of the red Røsnæs Clay facies i.e. in the lower part of the R4/R5 beds (Røsnæs Clay Formation)
Age: lower-middle Ypresian

83.60-83.65 m

Nannofossils: barren
Microfossils: ?NSB2/NSP4
Palynology: n/a
Formation: Ølst Formation
Age: lower Ypresian

86.15-86.20 m

Nannofossils: barren
Microfossils: NSB2/NSP4
Palynology: subzone D5b *Deflandrea oebisfeldensis* Zone = Viborg Zone 7, E1b
Formation: upper part of Ølst Formation
Age: lowermost Eocene

98.10-98.20 m

Nannofossils: barren
Microfossils: NSB2/NSP4
Palynology: subzone D5a *Apectodinium augustum* or lower part of the *Deflandrea oebisfeldensis* Zone = Viborg Zone 6 or lower part of Viborg Zone 7, L or P6
Formation: lower part of Ølst Formation
Age: lowermost Eocene / uppermost Paleocene

09.A.010

15.25-15.45 m

Nannofossils: barren
Microfossils: NSB2/NSP4
Palynology: Viborg Zone 7, ?E1b
Formation: probably upper part of the Ølst Formation
Age: lower Ypresian

21.40-21.45 m

Nannofossils: barren
Microfossils: NSP4/NSB2
Palynology: n/a
Formation: probably upper part of the Ølst Formation
Age: lower Ypresian

28.9-29.05 m

Nannofossils: barren
Microfossils: NSB2/NSP4
Palynology: n/a
Formation: Ølst Formation
Age: lower Ypresian

43.65-43.70 m

Nannofossils: NNTe1C-2
Microfossils: NSB3
Palynology: n/a
Formation: Røsnæs Clay Formation
Age: middle Ypresian

44.55-44.65 m

Nannofossils: NNTe1C-D
Microfossils: n/a
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, or ?Subzone D7a = *Eatonicysta ursulae* Zone and *Dracodinium solidum* Zone = E2b or ?E2a

Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation), or ?upper part of the Knudshoved Member and in Bed R1 (Røsnæs Clay Formation), lower part of the red Røsnæs Clay facies i.e. in the lower part of the R4/R5 beds (Røsnæs Clay Formation)
Age: lower to middle Ypresian

49.80-49.85 m

Nannofossils: barren
Microfossils: NSB3
Palynology: n/a
Formation: Røsnæs Clay Formation
Age: middle Ypresian

10.A.056

31.13-31.40 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

45.65-45.70 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

56.45-56.50 m

Nannofossils: NNTe1C-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: lower-middle Ypresian

72.85-72.90 m

Nannofossils: barren
Microfossils: NSB2/NSP4
Palynology: n/a
Formation: Ølst Formation
Age: lower Ypresian

10.A.057

38.30-38.35 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

54.55-54.70 m

Nannofossils: barren
Microfossils: rare RW from Turonian-Campanian
Palynology: subzone D5b *Deflandrea oebisfeldensis* Zone = upper part of Viborg Zone 7, E1b
Formation: upper Ølst Formation
Age: lower Ypresian

99.15-99.20 m

Nannofossils: barren
Microfossils: barren
Palynology: upper part of Viborg Zone 4, P5a
Formation: upper part of Holmehus Formation / green and brown non-calcareous clay
Age: upper Selandian

10.A.058

20.55-20.60 m

Nannofossils: barren
Microfossils: barren
Palynology: upper part of Viborg Zone 4, P5a
Formation: upper part of Holmehus Formation / green and brown non-calcareous clay
Age: upper Selandian

39.55-39.60 m

Nannofossils: barren
Microfossils: NSB4
Palynology: lower? part of Viborg Zone 4, P5a
Formation: upper part of Holmehus Formation / green and brown non-calcareous clay
Age: upper Selandian with some Upper and Lower Cretaceous reworking

51.35-51.40 m

Nannofossils: barren
Microfossils: ?NSB2
Palynology: lower? part of Viborg Zone 4, P5a
Formation: upper part of Holmehus Fm / green and brown non-calcareous clay
Age: upper Selandian with few reworked dinocysts from Upper and Lower Cretaceous

87.10-87.25 m

Nannofossils: barren
Microfossils: ?NSB4
Palynology: lower? part of Viborg Zone 4, P5a
Formation: upper part of Holmehus Formation / green and brown non-calcareous clay
Age: upper Selandian with some Upper and Lower Cretaceous reworking

09.A.004

28.60-28.65 m

Nannofossils: NNTe2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: lower to middle Ypresian

78.10-78.15 m

Nannofossils: barren
Microfossils: NSB3, (upper Paleocene) and Upper Cretaceous (Campanian-lower Maastrichtian) mix
Palynology: lower part of Zone D9 = *Areosphaeridium diktyoplokus* Zone, lower E3a
Formation: upper part of bed R6 of the Røsnæs Clay Formation and maybe part of the beds L1 and L2 of the Lillebælt Clay Formation
Age: upper Ypresian

85.20-85.25 m

Nannofossils: barren
Microfossils: ?Ølst Formation
Palynology: Viborg Zone 4, P5b
Formation: Holmehus Formation
Age: upper Selandian with RW Lower and Upper Cretaceous

99.85-99.90 m

Nannofossils: barren

Microfossils: Upper Cretaceous (Campanian-Maastrichtian), Ølst, NSP5-7 mix
Palynology: Viborg Zone 4, P5b
Formation: Holmehus Formation
Age: upper Selandian, with RW Lower and Upper Cretaceous

10.A.059B

71.00-71.05 m

Nannofossils: NNTe2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: lower-middle Ypresian

84.70-84.75 m

Nannofossils: barren
Microfossils: NSP5a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: lower-middle Ypresian

96.15-96.20 m chalk

Nannofossils: UC20c
Microfossils: n/a
Palynology: n/a
Formation: Tor Formation equivalent
Age: upper Maastrichtian

10.A.060

62.10-62.15 m

Nannofossils: barren
Microfossils: greensand
Palynology: upper part of Viborg Zone 3, P4a
Formation: dark grey non-calcareous clay / Æbelø Formation?
Age: upper Selandian

62.35-62.45 m chalk

Nannofossils: UC20c (RW UC19)
Microfossils: n/a
Palynology: n/a
Formation: Tor Formation equivalent
Age: upper Maastrichtian

09.A.006

45.70-45.75 m

Nannofossils: barren
Microfossils: greensand
Palynology: uppermost part of Viborg Zone 3, P4b
Formation: probably the lower part of Holmehus Formation green and brown non-calcareous clay or the underlying dark grey, non-calcareous clay
Age: upper Selandian

46.20-46.25 m chalk

Nannofossils: UC20c
Microfossils: n/a
Palynology: upper Maastrichtian or Viborg Zone 3, P4a
Formation: Tor Formation equivalent (nannofossils and palynology) with ?Æbelø Formation (palynology)
Age: upper, but not uppermost Maastrichtian chalk and upper Selandian clay

46.20-46.25 m black amorphous material

Nannofossils: Maastrichtian and NNTp4F
Microfossils: n/a
Palynology: Viborg Zone 3, P4a
Formation: Danian limestone and dark grey non-calcareous clay, Æbelø Formation?
Age: Danian/upper Selandian

95.35 m grey chalk

Nannofossils: UC18
Microfossils: n/a
Palynology: n/a
Formation: Tor Formation equivalent
Age: lower Maastrichtian or older

95.35 m white chalk

Nannofossils: UC16d
Microfossils: n/a
Palynology: n/a
Formation: Tor Formation equivalent
Age: Campanian

10.A.062

39.10-39.15 m

Nannofossils: UC18, NNTp2G and NNTe2 mix
Microfossils: n/a
Palynology: n/a
Formation: Tor Formation equivalent, Danian limestone and Røsnæs Clay Formation
Age: lower-mid Maastrichtian (Cretaceous) and Danian (Paleocene) chalk, and lower-middle Ypresian

41.35-41.45 m

Nannofossils: UC20c, NNTp4F-10, NNTe2-5,
Microfossils: greensand with white lithology
Palynology: lower part of Viborg Zone 3, P3b/Maastrichtian
Formation: Tor Formation equivalent, dark grey non-calcareous clay and Røsnæs Clay Formation mix
Age: upper Maastrichtian, upper Selandian and middle Ypresian mix

69.65 m chalk

Nannofossils: UC20
Microfossils: n/a
Palynology: n/a
Formation: Tor Formation equivalent
Age: upper, but not uppermost Maastrichtian

69.65 m black particles

Nannofossils: UC20C (from chalk in sample)
Microfossils: n/a
Palynology: Very few dinocyst, few possible Upper Cretaceous no determinable Palaeogene
Formation: ??
Age: ??

09.A.007

21.50-21.55 m

Nannofossils: UC20d & NNTp5B
Microfossils: n/a
Palynology: P3, lower part of Viborg Zone 3, ?upper part of Viborg Zone 2
Formation: Selandian dark grey clay
Age: Selandian clay (RW uppermost Maastrichtian)

09.A.008

25.60-25.65 m

Nannofossils: NP10-11

Microfossils: NSB3/NSP5
Palynology: Viborg Zone 3, P4a
Formation: dark grey non-calcareous clay, Æbelø Formation
Age: upper Selandian

66.00-66.05 m chalk

Nannofossils: ?UC19
Microfossils: FCS22b-23a
Palynology: *Alterbidinium acutulum* (*A. ac*) Interval Subzone
Formation: Tor Formation equivalent
Age: middle Maastrichtian (nannofossils & microfossils), uppermost lower Maastrichtian (palynology)

99.90-99.95 m chalk

Nannofossils: UC16c
Microfossils: FCS21b
Palynology: *Areoligera coronata* (*A. cor*) Zone
Formation: Tor Formation equivalent
Age: middle Upper Campanian

10.A.063

49.55-49.60 m

Nannofossils: barren
Microfossils: lack of marker species
Palynology: Viborg Zone 3. P4a/or ?P3b
Formation: dark grey non-calcareous clay / Æbelø Fm?
Age: upper Selandian

51.35-51.40 m

Nannofossils: barren
Microfossils: greensand
Palynology: Viborg Zone 3, P4a or ?P3b
Formation: dark grey non-calcareous clay / Æbelø Formation?
Age: upper Selandian

10.B.063

70.05 m chalk

Nannofossils: UC20c
Microfossils: n/a
Palynology: n/a
Formation: Tor Formation equivalent
Age: upper, but not uppermost Maastrichtian

70.05 m black particles

Nannofossils: UC20c (from chalk in sample)
Microfossils: n/a
Palynology: Viborg Zone 3, P4a/or ?P3b
Formation: dark grey non-calcareous clay / Æbelø Fm?
Age: upper Selandian

09.A.019

61.50 m

Nannofossils: UC20c
Microfossils: n/a
Palynology: n/a
Formation: Tor Formation equivalent
Age: upper, though not uppermost, Maastrichtian

86.75 m

Nannofossils: ?UC19
Microfossils: n/a
Palynology: n/a
Formation: Tor Formation equivalent
Age: middle Maastrichtian

09.A.013

78.05-78.1 m

Nannofossils: barren
Microfossils: NSB3/NSP5
Palynology: Viborg Zone 4 / ?lower part of Viborg Zone 5, P5b
Formation:?Holmehus Formation
Age: upper Selandian

82.65-82.70 m

Nannofossils: barren
Microfossils: NSB3/NSP5
Palynology: Viborg Zone 4 / ?lower part of Viborg Zone 5, P5b
Formation:?Holmehus Formation
Age: upper Selandian

97.25-97.30 m

Nannofossils: barren
Microfossils: NSB1b/NSP1 (tentatively, based on very rare fauna)

Palynology: Viborg Zone 3, P4a
Formation: dark grey non-calcareous clay, ?Æbelø Formation
Age: upper Selandian

99.25-99.30 m

Nannofossils: barren
Microfossils: NSB2/NSP4
Palynology: Viborg Zone 3, P4a
Formation: dark grey non-calcareous clay, ?Æbelø Formation
Age: upper Selandian

10.A.064

61.45-61.50 m

Nannofossils: barren
Microfossils: NSP4
Palynology: lower part of subzone D5b *Deflandrea oebisfeldensis* Zone = upper part of Viborg Zone 7, E1b
Formation: upper Ølst Formation
Age: lower Ypresian

66.95-67.00 m

Nannofossils: barren
Microfossils: NSP4/NSB2
Palynology: n/a
Formation: Ølst Formation
Age: lower Ypresian

74.55-74.60 m

Nannofossils: barren
Microfossils: ?NSP3
Palynology: lower part of subzone D5b *Deflandrea oebisfeldensis* Zone = upper part of Viborg Zone 7, E1b
Formation: upper Ølst Formation
Age: lower Ypresian

09.A.014

66.25-66.40 m

Nannofossils: barren
Microfossils: NSB3 / NSP5
Palynology: subzone D6b = *Wetzeliella meckelfeldensis* Zone, lower part of E2a or upper part of E1
Formation: lower part of the Knudshoved Member, Røsnæs Clay Formation

Age: lowermost Ypresian

72.25-73.30 m

Nannofossils: NP10-11
Microfossils: NSB2/NSP4
Palynology: subzone D5b = *Deflandrea oebisfeldensis* Zone, corresponds to the upper part of Viborg Zone 7, E1b
Formation: Fur and Ølst formations from near ash layer -19b towards the top of both formations
Age: lower Ypresian

09.A.018

59.80-59.85 m

Nannofossils: NP13
Microfossils: NSB3b/NSP5b
Palynology: subzone D7b = *Dracodinium varielongitudum* Zone, E2b
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: middle Ypresian

66.33 m

Nannofossils: barren
Microfossils: NSB3a/NSP5a
Palynology: subzone D7a = *Eatonicysta ursulae* Zone and *Dracodinium solidum* Zone, E2a
Formation: upper part of the Knudshoved Member and in Bed R1 (Røsnæs Clay Formation) lower part of the red Røsnæs Clay facies i.e. in the lower part of the R4/R5 beds (Røsnæs Clay Formation)
Age: lower to middle Ypresian

70.20 m

Nannofossils: barren
Microfossils: sparse and long ranging
Palynology: subzone D6a = *Wetzeliella astra* Zone, lower part of E2a
Formation: basal part of the Knudshoved Member (Røsnæs Clay Formation)
Age: lower-middle Ypresian

10.A.065

50.27-50.30 m

Nannofossils: barren
Microfossils: NSB3 & Rw Cretcaeous

Palynology: subzone D7a = *Eatonicysta ursulae* Zone and *Dracodinium solidum* Zone, E2a
Formation: upper part of the Knudshoved Member and in Bed R1 (Røsnæs Clay Fm) lower part of the red Røsnæs Clay facies i.e. in the lower part of the R4/R5 beds (Røsnæs Clay Fm)
Age: lower-middle Ypresian

67.55-67.60 m

Nannofossils: NNTe1C-2
Microfossils: n/a
Palynology: subzone D7a = *Eatonicysta ursulae* Zone and *Dracodinium solidum* Zone, E2a
Formation: upper part of the Knudshoved Member and in Bed R1 (Røsnæs Clay Fm) lower part of the red Røsnæs Clay facies i.e. in the lower part of the R4/R5 beds (Røsnæs Clay Fm)
Age: lower-middle Ypresian

83.30-83.35 m

Nannofossils: barren
Microfossils: NSP4/NSB2
Palynology: n/a
Formation: upper part of Ølst Formation
Age: lower Ypresian

94.85-94.90 m

Nannofossils: barren
Microfossils: ?NSP4
Palynology: subzone D5b *Deflandrea oebisfeldensis* Zone = upper part of Viborg Zone 7, E1b or E1c
Formation: upper Ølst Formation
Age: lower Ypresian

10.A.071

31.35-31.40 m

Nannofossils: UC16d, UC20c, NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: Tor Formation equivalent and lower Røsnæs Clay Formation
Age: Upper Campanian, upper Maastrichtian and middle Ypresian

38.70-38.75 m

Nannofossils: NNTe2
Microfossils: n/a

Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

Onshore Rødbyhavn

09.A.701

27.55-27.60 m

Nannofossils: barren
Microfossils: sparse and long ranging
Palynology: subzone D7b = *Dracodinium varielongitudum* or Subzone D7a = *Eatonicysta ursulae* Zone and *Dracodinium solidum* Zone, E2b or E2a
Formation: middle part of the red facies i.e. of the R4/R5 beds (Røsnæs Clay Formation)
Age: lower to middle Ypresian

40.0-40.05 m

Nannofossils: NNTe1D
Microfossils: n/a
Palynology: n/a
Formation: base Røsnæs Clay Formation
Age: lower to middle Ypresian

56.65-56.70 m

Nannofossils: barren
Microfossils: sparse and long ranging
Palynology: probably Viborg Zone 7, ?E1b
Formation: probably the upper part of the Ølst Formation
Age: lower Ypresian

63.95-64.00 m

Nannofossils: barren
Microfossils: mid-upper NSB2/NSP4
Palynology: n/a
Formation: Ølst Formation
Age: lower Ypresian

73.40-73.50 m

Nannofossils: barren
Microfossils: NSB2/NSP4
Palynology: n/a
Formation: Ølst Formation

Age: lower Ypresian

89.85-89.90 m

Nannofossils: barren
Microfossils: NSB1c
Palynology: n/a
Formation: Lista Formation
Age: Selandian-Thanetian

99.35-99.40 m

Nannofossils: barren
Microfossils: sparse, long ranging
Palynology: upper part of Viborg Zone 4, P5a
Formation: upper part of Holmehus Formation / or green and brown non-calcareous clay (Heilmann-Clausen 1985)
Age: upper Selandian

09.A.702

59.20-59.25 m

Nannofossils: NNTe2-5
Microfossils: NSB3
Palynology: n/a
Formation: Røsnæs Clay Formation
Age: middle Ypresian

71.05-71.15 m

Nannofossils: NNTe1C-2
Microfossils: NSB3
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

88.35-88.40 m

Nannofossils: barren
Microfossils: upper NSB2/NSP4
Palynology: n/a
Formation: Ølst Formation
Age: lower Ypresian

09.A.704

25.30-25.35 m

Nannofossils: barren
Microfossils: NSB1c
Palynology: upper part of Viborg Zone 4, P5a
Formation: upper part of Holmehus Formation / green and brown non-calcareous clay
Age: upper Selandian

38.35-38.45 m

Nannofossils: UC16, UC20c, NNTp4B & NP11/12 mix
Microfossils: FCS21b-23, NSB3
Palynology: n/a
Formation: Tor Formation equivalent, Danian limestone, Røsnæs Clay Formation mix
Age: Campanian-Maastrichtian, Danian, middle Ypresian mix

48.70-48.75 m

Nannofossils: barren
Microfossils: ?NSB2/NSP4
Palynology: upper part of Viborg Zone 4 or lowermost part of Viborg Zone 5, P5a or lowermost part of P5b
Formation: upper part of Holmehus Formation / green and brown non-calcareous clay or lowermost part of dark grey non-calcareous clay
Age: upper Selandian

09.A.703

17.85-17.90 m

Nannofossils: barren
Microfossils: sparse, long ranging
Palynology: upper part of Viborg Zone 4, P5a
Formation: upper part of Holmehus Formation / green and brown non-calcareous clay or lowermost part of dark grey non-calcareous clay
Age: upper Selandian

30.85-30.90 m

Nannofossils: barren
Microfossils: sparse, long ranging
Palynology: middle to upper part of Viborg Zone 4, P5a
Formation: middle to upper part of Holmehus Formation / green and brown non-calcareous clay
Age: upper Selandian

44.65-44.70 m

Nannofossils: barren

Microfossils: NSB1c
Palynology: n/a
Formation: Lista Formation
Age: Selandian-Thanetian

Offshore Lillebælt

10.A.801

10.70-10.80 m

Nannofossils: NNTe8A
Microfossils: n/a
Palynology: n/a
Formation: middle Lillebælt Clay Formation
Age: lower Lutetian

23.80-23.85 m

Nannofossils: NNTe8A
Microfossils: n/a
Palynology: n/a
Formation: middle Lillebælt Clay Formation
Age: lower Lutetian

42.45-42.50 m

Nannofossils: almost barren
Microfossils: almost barren
Palynology: upper part of D9 = *Dracodinium pachydermum* Zone, E4a,
Formation: upper L2 to lower L4, lower to middle part of the Lillebælt Clay Formation
Age: lower Lutetian

59.00-59.05 m

Nannofossils: NNTe7B
Microfossils: n/a
Palynology: n/a
Formation: lower Lillebælt Clay Formation
Age: uppermost Ypresian-lowermost Lutetian

65.10-65.15 m

Nannofossils: mid NNTe3-NNTe5
Microfossils: n/a
Palynology: n/a

Formation: middle-upper Røsnæs Clay Formation
Age: middle Ypresian

72.60-72.65 m

Nannofossils: NNTe1D-2
Microfossils: n/a
Palynology: n/a
Formation: lower Røsnæs Clay Formation
Age: middle Ypresian

10.A.802

3.95-4.00 m

Nannofossils: NNTe8A
Microfossils: n/a
Palynology: *Wetziella articulata ovalis* Zone, E4b
Formation: upper L4-lower L5, middle part of the Lillebælt Clay Formation
Age: lower Lutetian

20.45-20.50 m

Nannofossils: almost barren
Microfossils: upper NSB4-upper NSB5 (probably NSB5a)
Palynology: lower *Wetziella articulata ovalis* Zone, lower E4b
Formation: upper L4-lower L5, middle part of the Lillebælt Clay Formation
Age: lower Lutetian

28.65-28.70 m

Nannofossils: NNTe8A-9B
Microfossils: upper NSB4-upper NSB5 (probably NSB5a)
Palynology: lower *Wetziella articulata ovalis* Zone, lower E4b
Formation: upper L4-lower L5, middle part of the Lillebælt Clay Formation
Age: lower Lutetian

39.95-40.00 m

Nannofossils: barren
Microfossils: Eocene
Palynology: upper part of D9 = *Dracodinium pachydermum* Zone, E4a
Formation: upper L2-lower L4, lower to middle part of the Lillebælt Clay Formation
Age: lower Lutetian

Figures

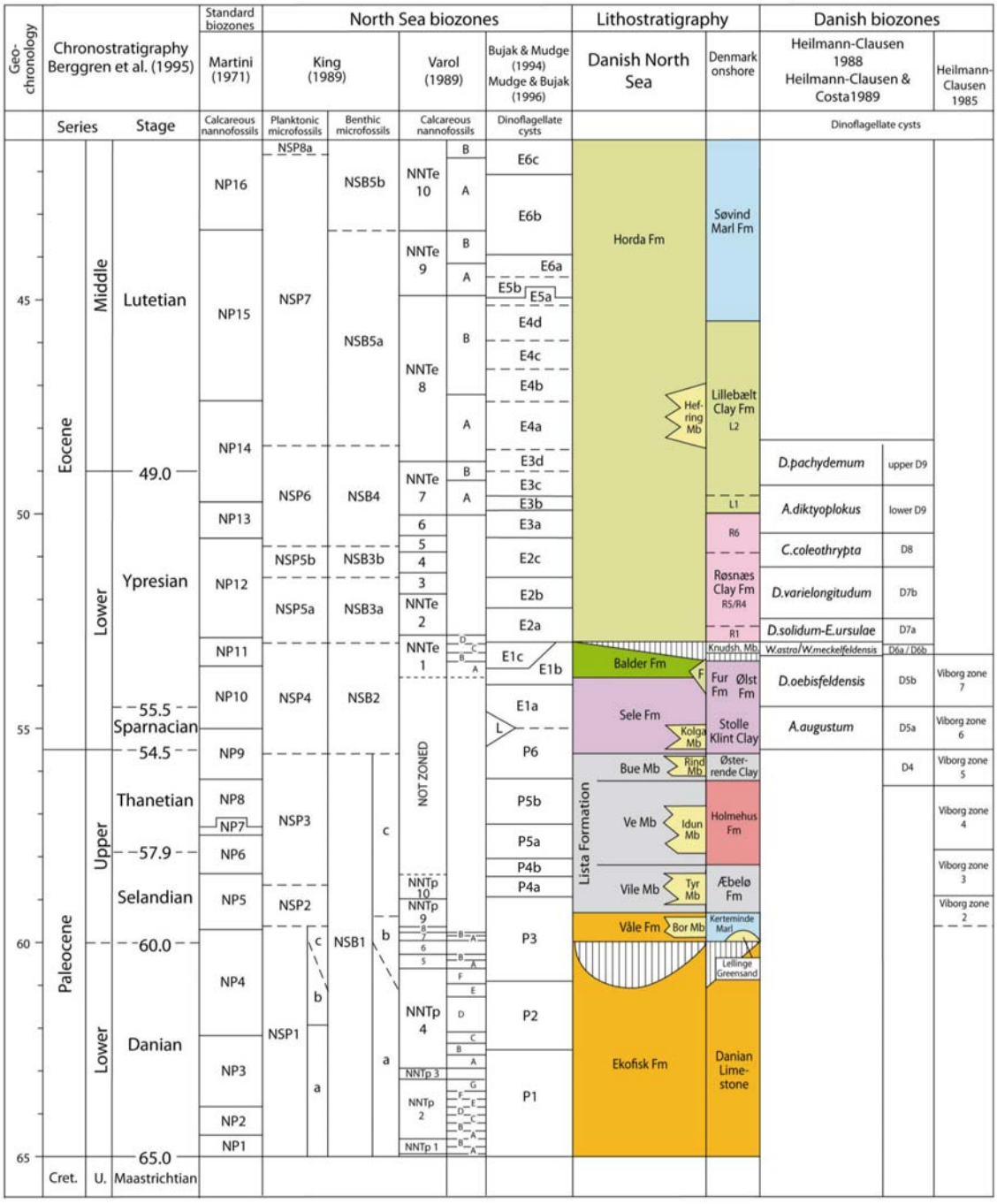


Figure 1: Chronostratigraphic, biostratigraphic and lithological correlation for onshore Denmark and the Danish Central Graben, North Sea. Adapted from Schiøler *et al*. (2007).

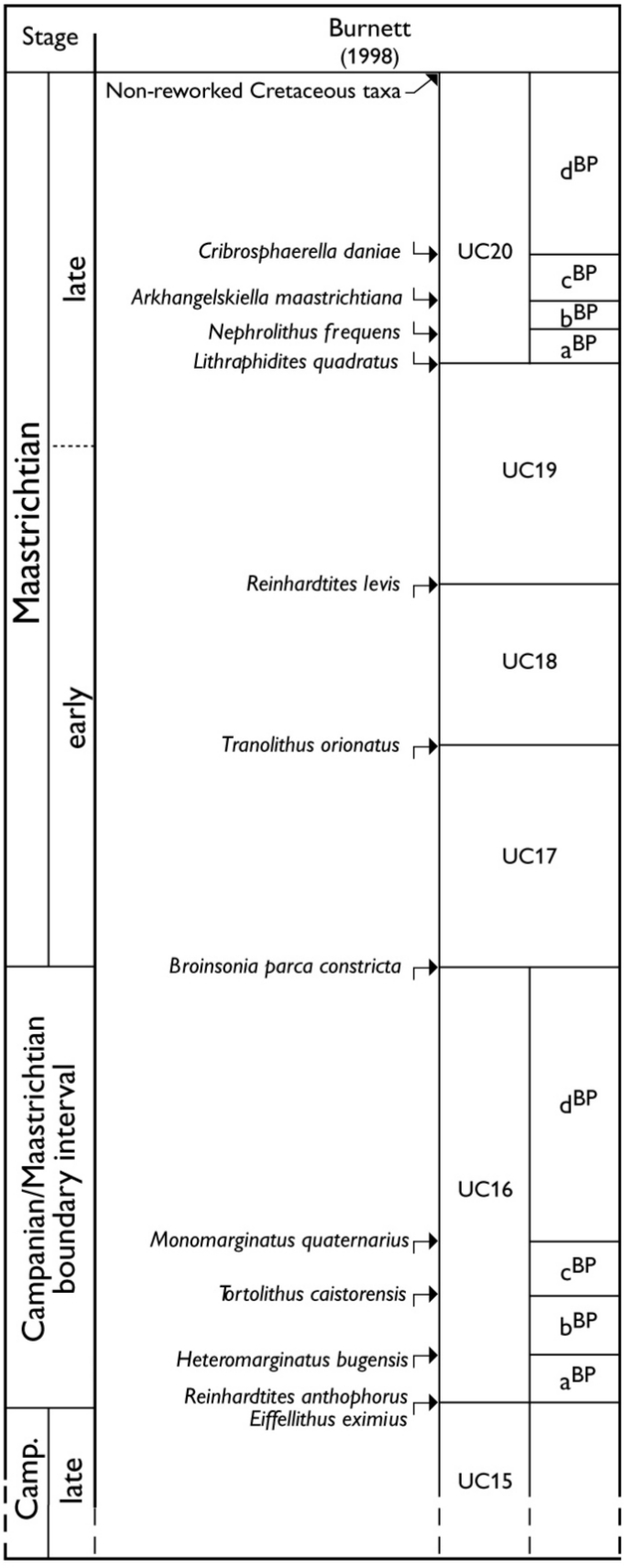


Figure 2: Upper Cretaceous nannofossil zonation scheme (Burnett 1998)

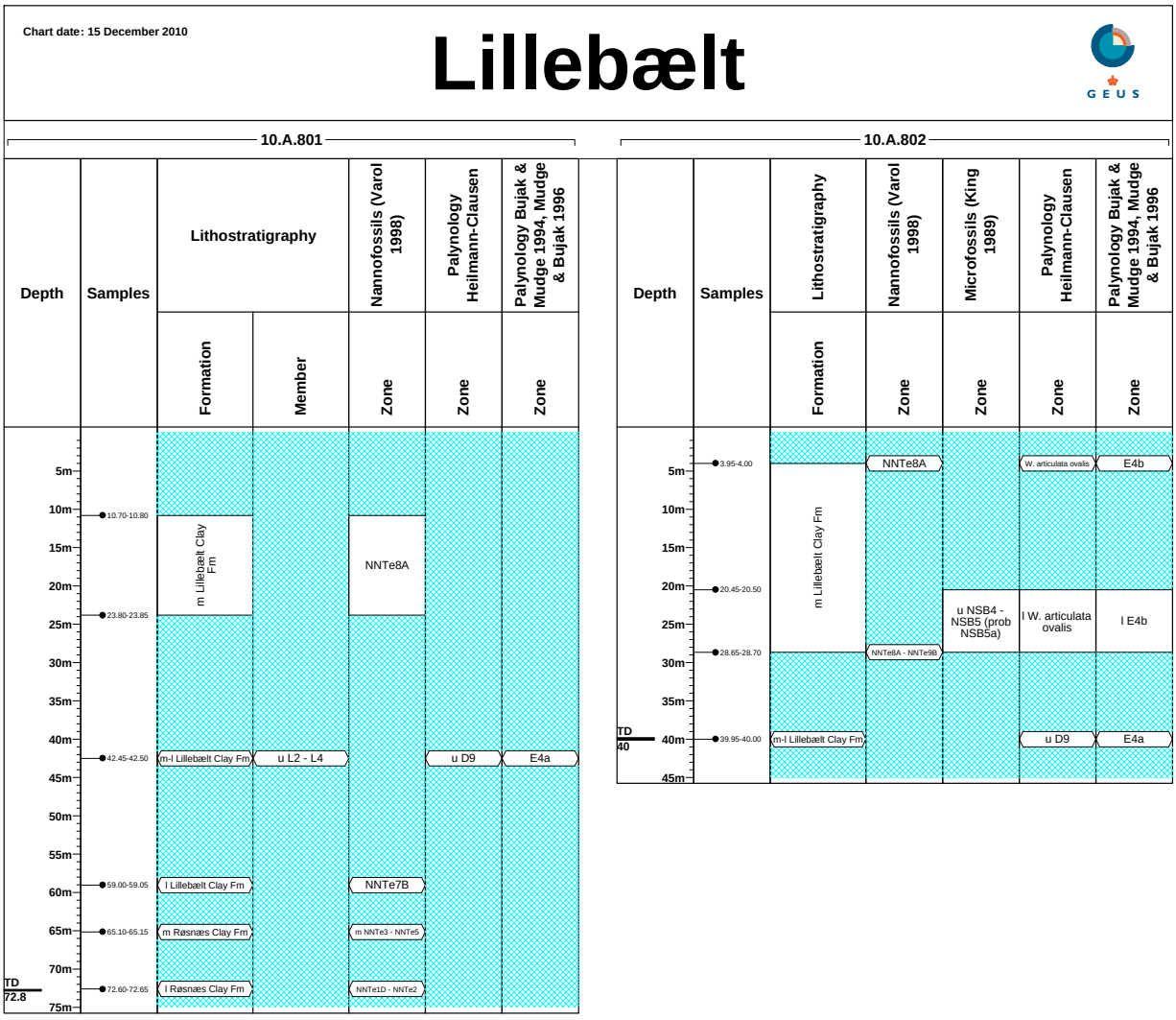
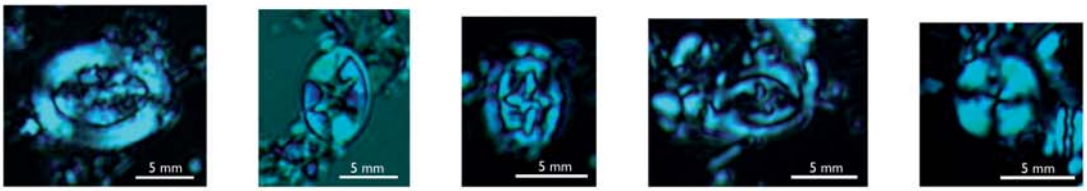


Figure 3: South to north correlation of 2 wells; Lillebælt

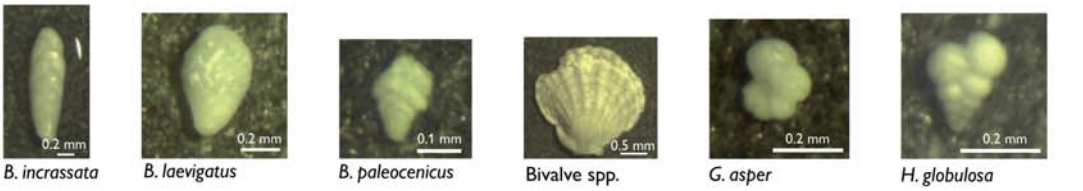
Tor Formation equivalent

Nannofossils

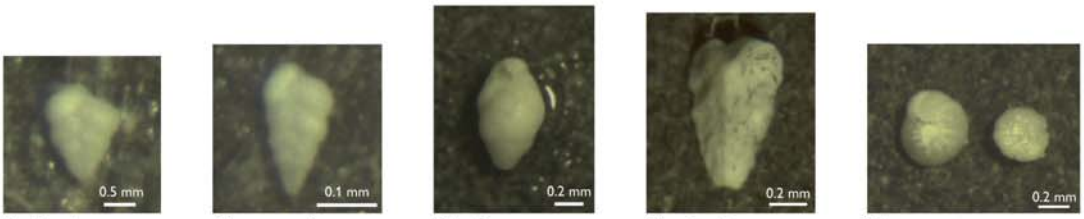


A. cymbiformis *E. turriseiffelii* *P. spinosa* *P. cf. P. fibuliformis* *C. reinhardtii*

Microfossils

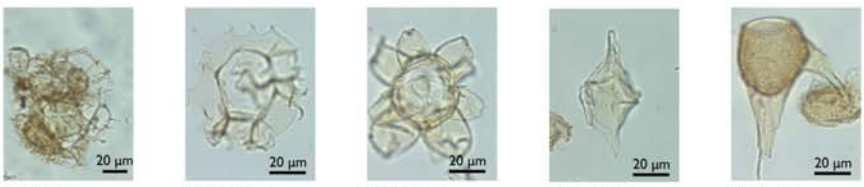


B. incrassata *B. laevigatus* *B. paleocenicus* Bivalve spp. *G. asper* *H. globulosa*



H. planata *H. moremani* *P. laevis* *R. szajnochae szajnochae* *S. pommerana*

Palynomorphs

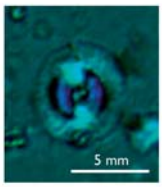


C. utinensis *M. aemiliana* *N. glabrum* *A. acutulum* *X. wetzelii*

Figure 4

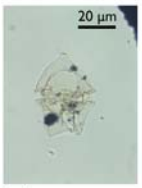
Ædelø Formation

Nannofossils



C. pelagicus

Palynomorphs

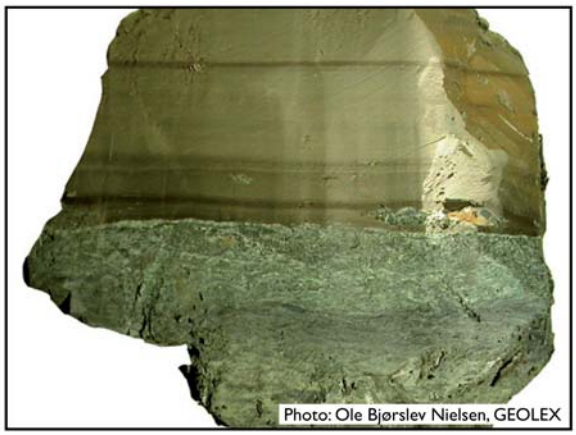


I. viborgense

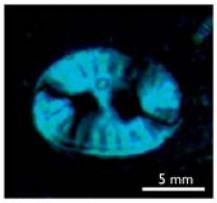
P. pyrophorum

Figure 5

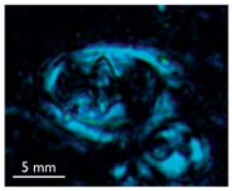
Holmehus Formation



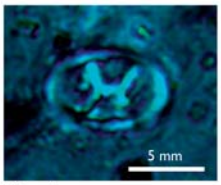
Nannofossils



T. pulcheroides



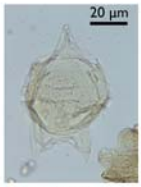
Z. adamas



N. protenus

Palynomorphs

Alisocysta sp. 1 Heilmann-Clausen 1985

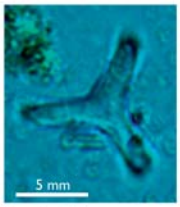


C. medcalfii

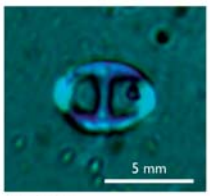
Figure 6

Ølst Formation

Nannofossils

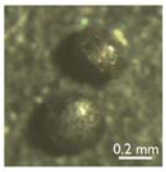


T. orthostylus

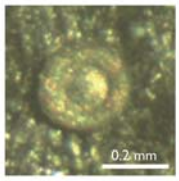


L. nascens

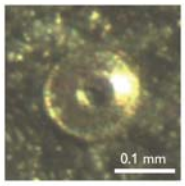
Microfossils



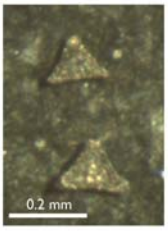
F. antiqua



C. morsianus moelleri

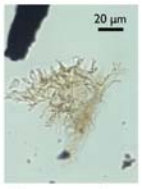


Diatom spp.



Triceratium spp.

Palynomorphs



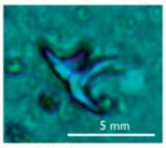
A. hyperacanthum

D. oebisfeldensis

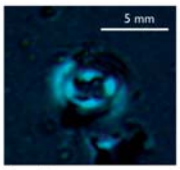
Figure 7

Røsnæs Clay Formation

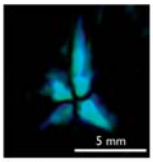
Nannofossils



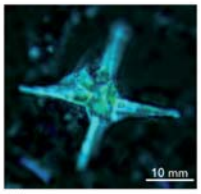
D. kuepperi



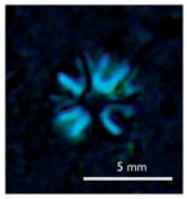
T. occulatus



S. radians

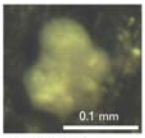


I. obscurus

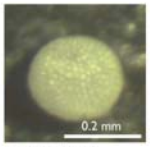


S. primus

Microfossils



P. wilcoxensis



Radiolaria spp.

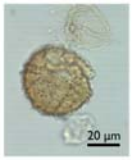
C. anglica

G. hiltermanni

Gastropod spp.

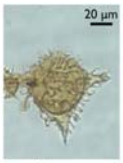
Palynomorphs

D. condylos



O. romanum

W. astra



D. solidum

E. ursulae

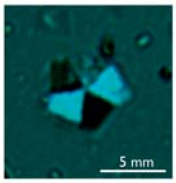
D. varielongitudum

H. teniuspinosum

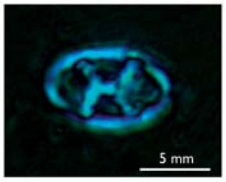
Figure 8

Lillebælt Clay Formation

Nannofossils



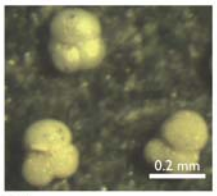
B. bigelowii



N. dubius

Microfossils

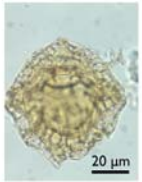
V. decoratus



G. linaperta

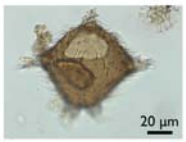
Palynomorphs

M. compressa



C. columna

E. furiensis



D. samlandicum

Figure 9

Enclosure 1: South to north correlation of 44 wells; Fehmarn-offshore Fehmarn Belt-Rødbyhavn

Table 1a: Biostratigraphic raw data
Table 1b: Biostratigraphic raw data (south-north)

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Berggren, W.A., Kent, D.V., Swischer III, C.C., and Aubry, M.-P. 1995: A revised Cenozoic geochronology and chronostratigraphy. In: Berggren, W.A. et al. (eds): Geochronology, time scale and global stratigraphic correlation. Society for Sedimentary geology (SEPM) Special Publication 54, 129-212.

Bujak, J. P. and Mudge, D. C. 1994: A high-resolution North Sea Eocene dinocyst zonation. Journal of the Geological Society, London, 151, 449–462.

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