DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2012/41

Nannofossil biostratigraphy of the Tuba-13 well, Danish Basin

Emma Sheldon, Jon R. Ineson & Paul Bown

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
DANISH MINISTRY OF CLIMATE, ENERGY AND BUILDING

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Contents

Introduction

Detailed nannofossil biostratigraphy of the cored upper Maastrichtian – Danian section of the Tuba-13 well was carried out as part of the PhD study ‘Upper Maastrichtian – Danian nannofossils of the Danish Central Graben and the Danish Basin: a combined biostratigraphic – palaeoecological approach’ (Sheldon 2006). The Tuba-13 well (DGU 201.3080) was drilled in 1969 as a geotechnical borehole at Copenhagen Central Station (Figure 1). The following report presents a biostratigraphic breakdown of selected core samples from the well, based on nannofossils.

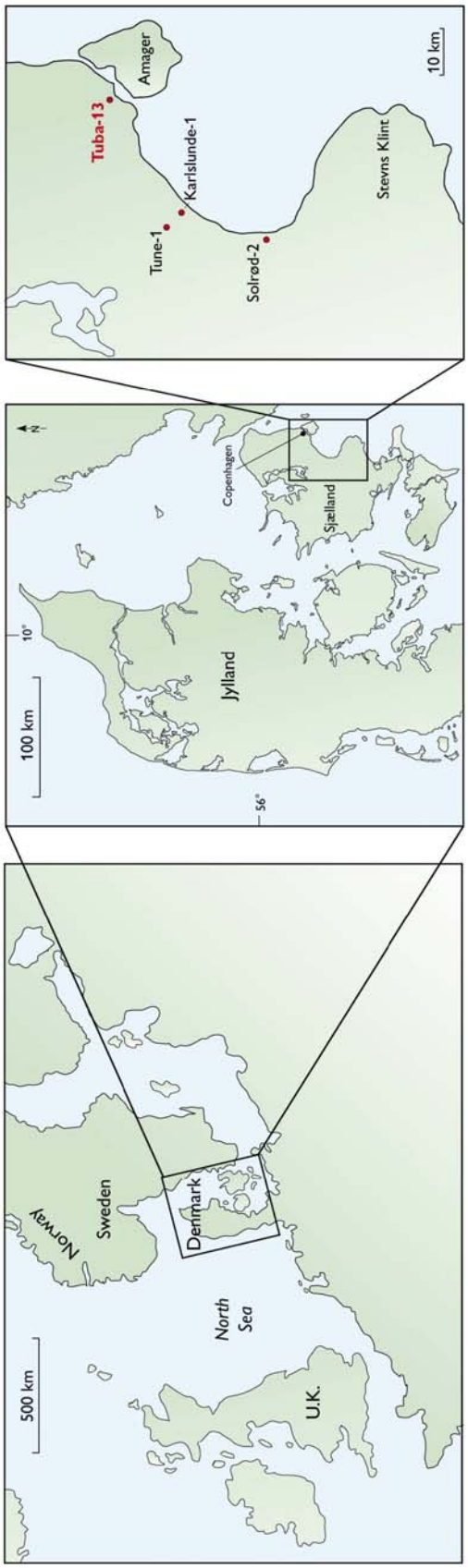


Figure 1. Location map, Danish Central Graben

Methods

21 samples were examined from the Tuba-13 well. Sampling was undertaken approximately every 1 m where recovery allowed, and at a higher resolution where it was necessary to check a nannofossil zonal boundary, and over the K/T (Cretaceous-Tertiary) boundary. Samples were taken in clean, uniform chalk, away from clay partings and stylolitic horizons. In order to avoid zones of excessive diagenetic alteration (e.g. due to stylolitisation), care was taken where possible to sample in uniform pelagic chalk, away from solution horizons and mineralised fractures.

Nannofossil smear slides were prepared using the simple smear slide technique described in Bown & Young (1998). The prepared slides were examined using a Leitz Labrolux 8 light microscope under x1250 magnification. All slides are stored at GEUS.

Simple relative abundance counting (Bown & Young 1998) was utilised in this study, i.e. a minimum of 300 specimens, which at the 95% confidence level provides representation of taxa present at 1% or greater. At important stratigraphic levels (i.e. close to zonal boundaries) extra counting was undertaken when necessary to check for the presence of key zonal marker taxa. Samples which upon initial examination appeared to be barren of nannofossils were subsequently examined for 10 length-traverses to obtain a rough species abundance. The quantitative data was recorded as a biostratigraphic range chart (Enclosure 1).

Nannofossil biozonation

The nannofossil zonation schemes used in this study are applicable to the northern high latitudes and North Sea area. The UC^{BP}scheme of Burnett (1998) is used for the Cretaceous, and the scheme of Varol (1998) is used for the Paleocene. Both schemes are modified using local observations from the Danish and Norwegian sectors of the North Sea (Fritsen 1999) (Figures 2 & 3). In this study, where cored intervals are assigned to a nannofossil zone or subzone, the 'Interval Zone' convention of Hedberg (1976) is followed. The timescale of Gradstein *et al.* (1994) is used for the Maastrichtian, and those of Berggren *et al.* (1995) and Haq *et al.* (1987) are used for the Danian.

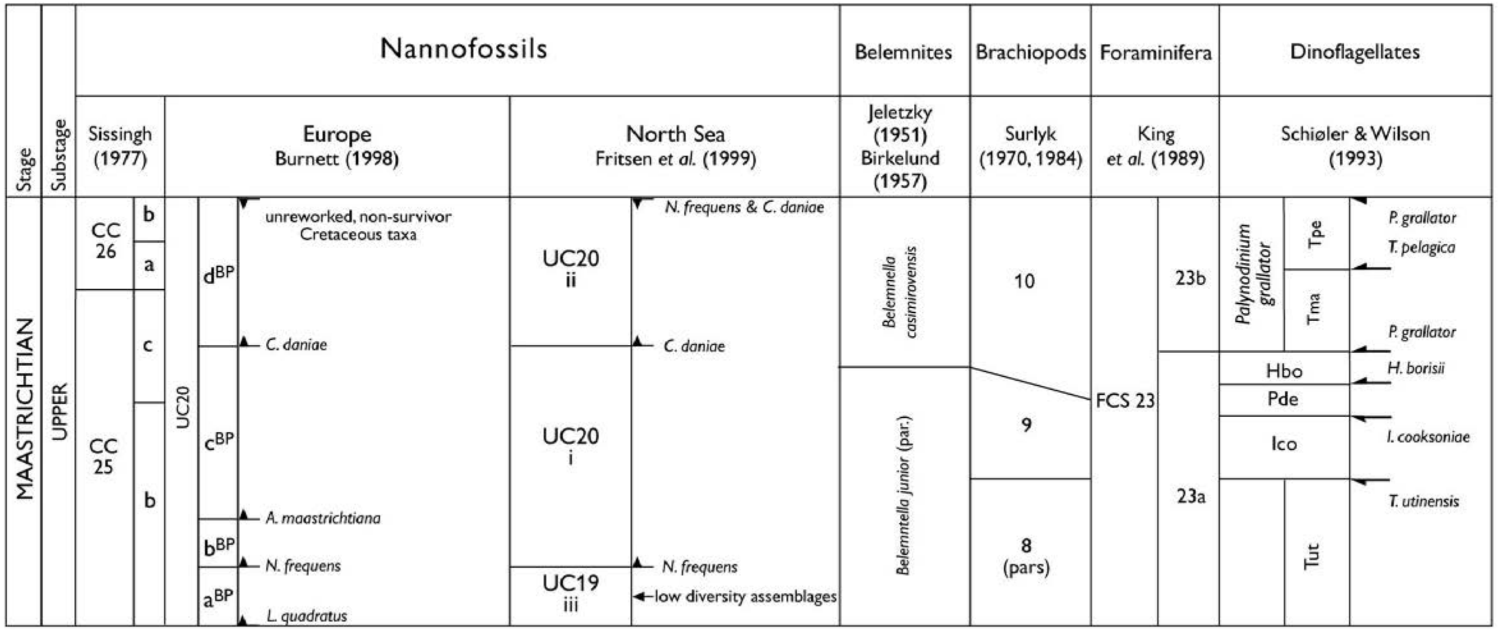
Terminology

In this study the use of 'FO' (First evolutionary Occurrence) and 'LO' (Last evolutionary Occurrence) is used. The sections from the Danish Basin are measured in metric units (metres

and centimetres), with M.U.T (Metres Under Terrain) commonly used. In this study, sample depths are referred to as M.D.f.b.R.L. (Measured Depth, feet below Reference Level).

Reworking and caving

As core material was used in this study, caving is not an issue. Although much of the chalk is thoroughly bioturbated, the scale of biogenic mixing is considered negligible with regard to the biozonation.



* BP = 'Boreal Province'

Figure 2. Upper Maastrichtian multidisciplinary biostratigraphic correlation

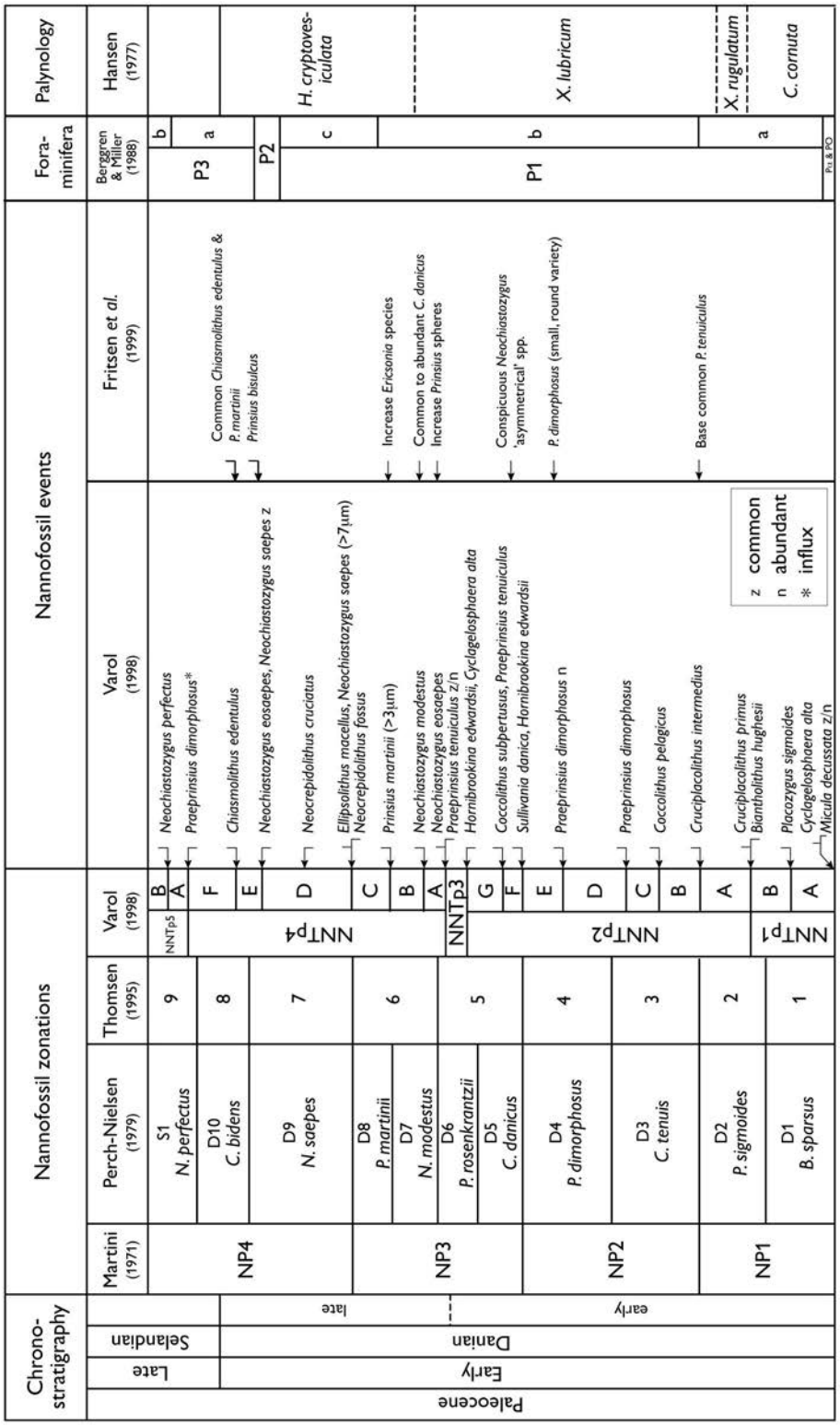


Figure 3. Danian multidisciplinary biostratigraphic correlation

Biostratigraphy

On the basis of nannofossil assemblage analysis, the cored upper Maastrichtian – Danian section of the Tuba-13 well is divided into upper Maastrichtian nannofossil subzone UC20d^{BP} and Danian NNTp1A and ?NNTp1B subzones (Figure 4, Enclosure 1, Table i).

	Base	Top	Thickness
Mixed Danian	102.50 m	102.50 m	
?NNTp1B	102.75 m	102.50 m	0.25 m
NNTp1A	104.00 m	102.75 m	1.25 m
UC20d^{BP}	125.00 m	104.00 m	21.00 m (minimum)

Table i *Nannofossil subzone thickness in Tuba-13*

Lithostratigraphy

The cored section is referred lithologically to the Tor Formation equivalent (Maastrichtian) and the Rødvig and Stevns Klint Formations (Danian), Figure 5. The following biostratigraphic breakdown is subdivided according to these broad lithological boundaries.

Tor Formation Equivalent

Subzone UC20d^{BP}

125.00 m (lowest sample examined) – 104.00 m

Definition

The base of subzone UC20d^{BP} of the 'boreal' province is defined by the FO of *Cribrosphaerella daniae*, and the top by the LO of unreworked, non-survivor taxa (Burnett 1998).

Floral characteristics

The diverse and abundant nannofossil assemblage comprises common *Watznaueria barnesiae*, *Prediscosphaera stoveri*, *Prediscosphaera cretacea*, *Micula decussata*, *Eiffelithus turriseiffelii*, *Cribrosphaerella ehrenbergii* and *Arkhangelskiella cymbiformis*. Other species include *Placozygus* cf. *P. fibuliformis*, *Lucianorhabdus cayeuxii*, *Nephrolithus frequens* and *Kamptnerius magnificus*. The coexistence of *C. daniae* with *N. frequens* assigns this inter-

val to upper Maastrichtian subzone UC20d^{BP}. Reworking from the Campanian is indicated by specimens of *Eiffelithus eximius, Broinsonia parca parca* and *Monomarginatus quaternarius*, from the Early Maastrichtian by fairly common *Reinhardtites levis,* and from the mid-Maastrichtian by *Calculites obscurus*.

Remarks

UC20d^{BP} coincides with subzone UC20ii (Fritsen 1999). Foraminiferal analysis of this interval assigns the section to Zone FC23 (Rasmussen & Sheldon 2004). Hansen (1977) indicated the presence of the *P. grallator* dinoflagellate Zone (equivalent to brachiopod Zone 10 of Surlyk (1970), and FCS23b of King *et al.* (1989) from the K/T boundary to 19 m below it. Kjellstrøm & Hansen (1981) however noted that the uppermost part of the Maastrichtian *P. grallator* Zone is missing in this well, suggesting a hiatus at this level. The important upper Maastrichtian marker bed, the Kjølby Gaard Marl (Troelsen 1955), is found at approximately 123 m (Rasmussen & Sheldon 2004).

Rødvig Formation

Subzone NNTp1A

104.00 m–102.75 m

Definition

The base of this subzone is marked by the LO of common *A. cymbiformis* with common *M. decussata* and/or the FO of *Biantholithus sparsus* (Romein 1979) and/or the FO of *Cyclagelosphaera alta* (Varol 1989). The top is marked by the FO of *Zeugrhabdotus sigmoides* (Varol 1998).

Floral characteristics

Rare *Z. sigmoides*, with *Biscutum harrisonii, Braarudosphaera bigeloweii, Neocrepidolithus dirimosus*, *Neocrepidolithus neocressus*, *Neocrepidolithus fossus* and *C. alta* are amongst the low diversity and abundance early Danian assemblage, assigned to subzone NNTp1A. *Thoracosphaera* spp. is rare. Upper Cretaceous reworking (38.8%) is fairly common as seen by *R. levis*, *W. barnesiae*, *A. cymbiformis, C. ehrenbergii* and *Gartnerego segmentatum*. Species surviving the K/T boundary event comprise 46% of the assemblage while newly evolved Danian species represent 15.2%.

Remarks

This interval, defined by 1 sample, contained very sparse nannofossils and abundant calcite crystals (attributed to the present hardground), therefore 10 length traverses were examined. Perch-Nielsen (1979) found *Z. sigmoides* to be absent or very rare in the Danish DI interval (equivalent to NNTp1A) while Varol (1989) questioned the occurrence of this species in the NNTp1A interval. According to Varol (1998), after Perch-Nielsen (1979), the FO of *Z. sigmoides* characterises the top of subzone NNTp1A. However, Varol (1998) notes that 'typical' specimens of this species are not found below subzone NNTp1B. Varol (1989) noted common to abundant reworking from the Maastrichtian and Campanian in Zone NNTp1. In the Tuba-13 well, reworking from the upper–mid-Maastrichtian is present, although no evidence of Campanian nannofossils has been found. Using dinoflagellate cysts, the *C. cornuta* Zonule was reported from 103.5 m – 102.0 m (Hansen 1977). Stenested (1976) reported a foraminiferal fauna of Danian age at 103.45 m. The sample at 104.00 m was barren of foraminifera except for 2 non-diagnostic taxa (Rasmussen & Sheldon 2004). Correlation with nannofossil data dates this interval as P1a–?P1b. The earliest Danian Fiskeler Member (Surlyk *et al.* 2006), previously known as the Fish Clay, was not reported from the Tuba-13 well. The earliest Danian subzone NNTp1A is also reported from the Solrød-2 and Tune-1 boreholes (Sheldon *et al.* 2012a and b).

Subzone NNTp1B?

102.75 m–102.50 m

Definition

The base of NNTp1B is characterised by the FO of *Z. sigmoides*, while the top is characterised by the LO of *B. hughesii* and/or the FO of *Cruciplacolithus primus* (Varol 1998).

Floral characteristics

A fairly low diversity and abundance early Danian assemblage comprising common *Z. sigmoides* and *Thoracosphaera* spp. with present *N. dirimosus*, *Cyclagelosphaera reinhardtii, Markalius inversus* and *B. harrisonii*. The high abundance of *Thoracosphaera* spp. and *Z. sigmoides* may indicate the presence of chalk from subzone NNTp1B. However rare specimens of *C. primus*, *Coccolithus pelagicus* and *Cruciplacolithus tenuis* suggest a younger (NNTp2C) influence. Reworking from the upper Maastrichtian is relatively common, represented by specimens of *A. cymbiformis*, *Placozygus* cf. *P. fibuliformis*, *N. frequens*, *P. cretacea* and *P. stoveri*, amongst others. Reworking from the early and mid-Maastrichtian is indicated by *Tranolithus orionatus* and *R. levis*. Relative percentages are 42.8% Maastrichtian, 51.4% survivor species and 5.8 % Danian specimens.

Remarks

There are no foraminiferal data from this interval, although as the overlying and underlying Danian material has been dated as P1a–?P1b, this age is also assigned to this unit. Nannofossil dating of this interval is tentative as rare occurrences of flora from NNTp2C suggest a younger Danian influence (due to mixing or burrowing). Using dinoflagellate cysts, the *C. cornuta* Zonule was reported from 103.5 m–102.0 m (Hansen 1977).

Mixed Danian - Rødvig Formation / Stevns Klint Formation

102.50 m (highest sample investigated)

Floral characteristics

A fairly high diversity mixed Maastrichtian/Danian assemblage comprising common *Z. sigmoides* and *Thoracosphaera* spp. along with *M. inversus*, *B. harrisonii, C. alta* and *N. dirimosus* from the early Danian. Also conspicuous are specimens of younger Danian nannofossils; *Neochiastozygus modestus*, *Chiasmolithus edwardsii*, *Cruciplacolithus intermedius* and *C. pelagicus*. The major part of the Danian assemblage particularly the high abundance of *Z. sigmoides* and *Thoracosphaera* spp. would assign this sample to subzone NNTp1B as in the previous sample. However the few younger Danian species indicate some influence of sediments as young as NNTp4B age. Upper Maastrichtian reworking is prevalent, with common *W. barnesiae* in addition to *Ahmuellerella octoradiata*, *N. frequens*, *P. cretacea* and *G. segmentatum*. Early and mid-Maastrichtian reworking is seen by the presence of *T. orionatus* and *R. levis* and mid-Campanian reworking by *E. eximius*. Relative percentages are 31.3% Maastrichtian, 55.7% survivor species and 13.8 % Danian specimens.

Remarks

Varol (1989) noted common to abundant reworking from the Maastrichtian and Campanian in Zone NNTp1; in this well, reworking from the upper and lower Maastrichtian and the Campanian is present, although whether these samples are indicative of Zone NNTp1 is uncertain. The dating of the Danian chalk in this well indicates the presence of NNTp1A and ?NNTp1B, but the highest sample examined comprises nannofossils from Danian biozone NNTp4B. It is possible (though unlikely) that the intervening biozones (NNTp2 and 3–4A) are missing due to a hiatus at this level. Using dinoflagellate cysts, the *C. cornuta* Zonule was reported from 103.5 m–102.0 m (Hansen 1977). Rasmussen & Sheldon (2004) dated this interval as P1a–?P1b.

The mixed nature (Campanian, Maastrichtian and Danian nannofossils) of samples at 102.75 m and 102.50 m is probably indicative of reworking in combination with piping of younger sediment at omission surfaces. In the Danish Basin, it has been noted that both conformable and unconformable sections overlie the upper Maastrichtian Tor Formation equivalent. The chronostratigraphic age of the hardground can be at the top of the Maastrichtian, or at a younger level (Surlyk 1997). The positioning of the hardground, unconformably overlain by younger Danian sediments could account for the nannofossils from NNTp4B.

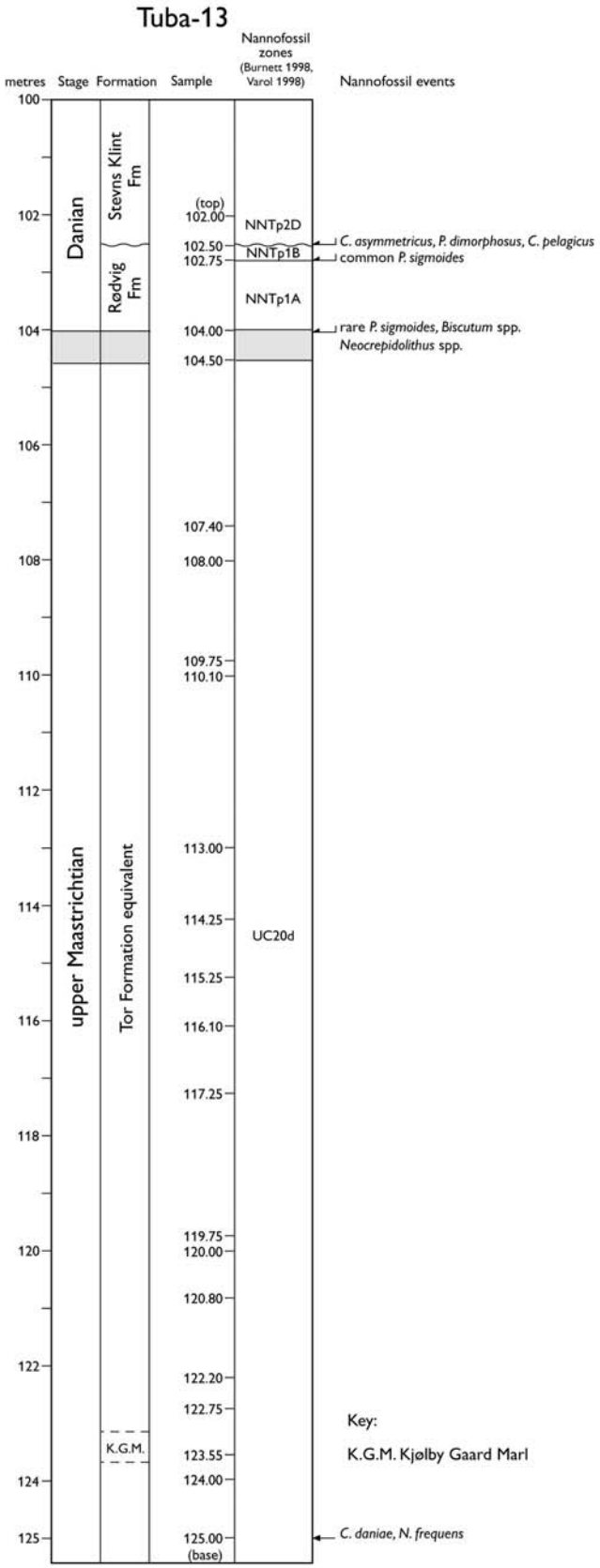


Figure 4. Tuba-13 nannofossil biostratigraphy

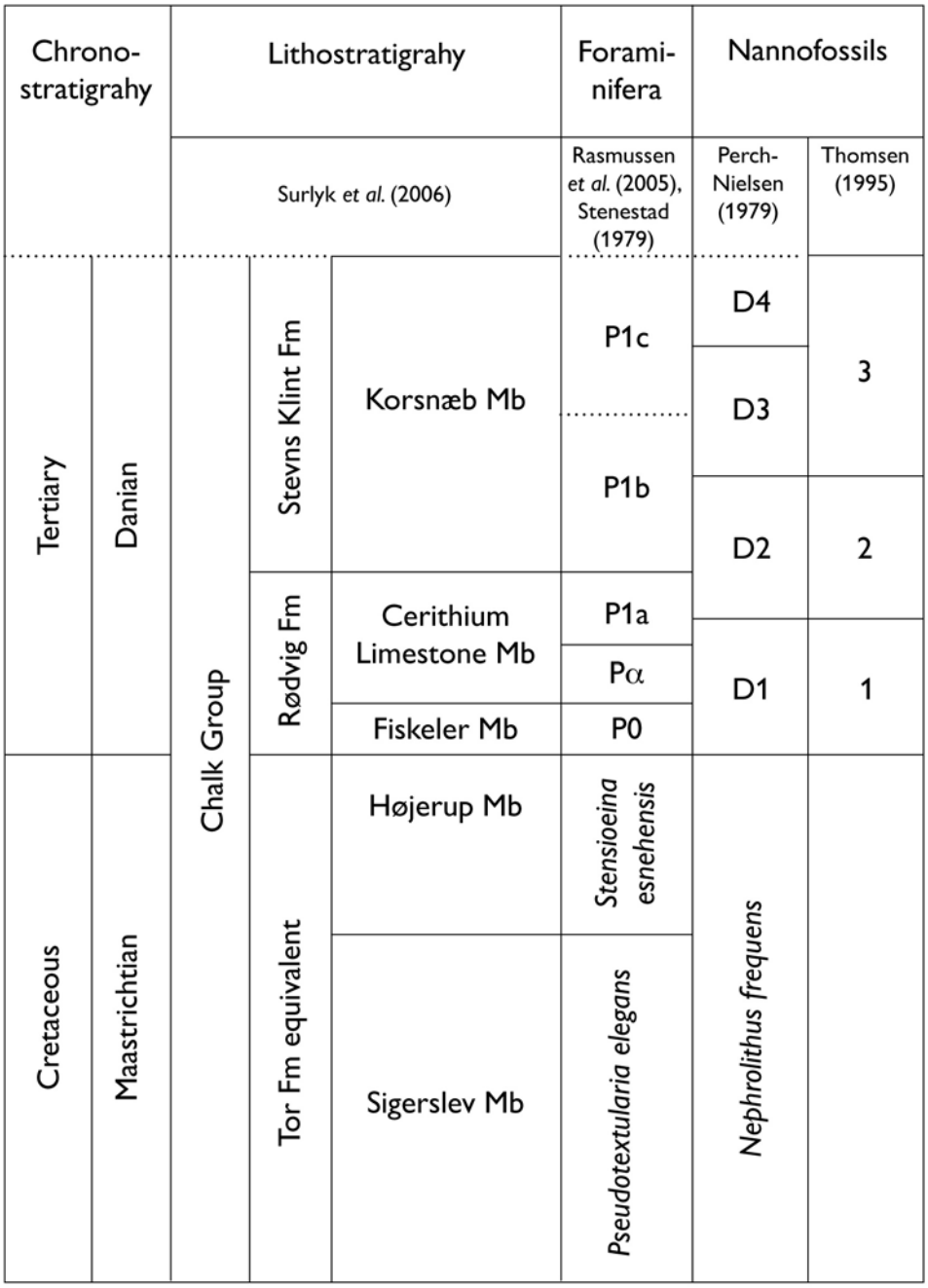


Figure 5. Maastrichtian-Danian stratigraphy (after Surlyk *et al.* 2006)

List of samples from Tuba-13 (in metres)

102.50	110.10	120.00
102.75	113.00	120.8
104.00	114.25	122.20
104.50	115.25	122.75
107.40	116.10	123.55
108.00	117.25	124.00
109.75	119.75	125.00

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