

# Neogene and Paleogene calcareous nannofossils from the Harre borehole, Denmark.

KATHARINA VON SALIS PERCH-NIELSEN

von Salis Perch-Nielsen, K., 1994: Neogene and Paleogene calcareous nannofossils from the Harre borehole, Denmark. *Aarhus Geoscience*, Vol. 1, pp. 45-51, Aarhus, 1994.

## ABSTRACT

Sediments of the Harre borehole have been referred to the standard nannofossil zonation. The borehole ended in Danian limestone. Danian limestone belonging to NP 3 is found below the cored interval. Kerteminde Marl of NP 4/5 is present. Substantial reworking of Cretaceous forms is seen in these sediments, while reworking is insignificant for the remaining Paleocene sequence. The ash series of the Ølst/Fur Formations contains no coccoliths. The Røsnæs Clay Formation belongs to NP 11 and the Lillebælt Clay Formation to NP 15. Reworked nannofossils are rare in the Eocene sediments. There is a significant stratigraphic gap between the Lillebælt Clay Formation and the Viborg Formation. The Viborg Formation, containing abundant reworked Eocene and Cretaceous fossils, is referred to NP 21 and 22, while most of the Branden Formation is referred to NP 24/25 and demonstrated to contain mainly Paleocene and Eocene reworked microfossils. The Vejle Fjord Formation contains only very rare synsedimentary nannofossils and is consequently not referred to any nannofossil zones. It contains mainly reworked fossils of Late Cretaceous age.

Katharina von Salis Perch-Nielsen, Geological Institute ETH-Z, CH - 8092 ZÜRICH, Switzerland.

## INTRODUCTION

The Harre borehole (Fig. 1 in the introductory chapter) penetrated 270 m of pre-Quaternary sediments and bottomed at 279 meter below surface (m.b.s.) in the Danian. After the Viborg 1 deep test (Thiede, Nielsen & Perch-Nielsen, 1980), it is the second cored hole in Denmark penetrating Neogene and Paleogene sediments to be investigated for calcareous nannofossils. Details about the location are given in the general introduction, and the lithology and lithostratigraphy can be found in Nielsen, Friis & Korsbech (1994, this volume).

For this investigation, smear slides were prepared in the way described in Perch-Nielsen (1985a). The authors of the species of the calcareous nannofossils and figures illustrating the species concepts used can also be found in Perch-Nielsen (1985a, b). The biozonation follows Martini (1971) with some changes discussed where appropriate.

## MIOCENE

The Miocene is represented by the Vejle Fjord Formation. Indigenous calcareous nannofossils are very rare in most samples and absent in some and are represented by long-ranging small Prinsiaceae, *Coccolithus pelagicus* and a single *Helicosphaera kamptneri* in sample 20.75 m.b.s.. They are usually accompanied by reworked Upper Cretaceous coccoliths and rarely by Paleogene forms. The distribution of cocco-

liths is shown in Fig. 1. None of the Miocene marker species of Martini (1971) could be found and thus this interval cannot be zoned.

## OLIGOCENE

The Oligocene is represented by the Branden Formation and the Viborg Formation. Calcareous nannofossils are few to common and poorly to moderately well preserved. Figs. 1 & 2 show the distribution of indigenous and reworked coccoliths. The classical marker species for the Upper Oligocene were not found; thus the co-occurrence of *Cyclicargolithus abisectus* and *Dictyococcites bisectus* above 109.75 m.b.s. are used to recognise the Upper Oligocene zones NP 24/25 (Fig. 1).

From 139.75 m.b.s. to 177.30 m.b.s., Lower Oligocene assemblages of NP 22 and 21 were found. This assignment is based on the presence of *Isthmolithus recurvus* while discshaped discoasters, which disappear at the end of the Eocene, are absent. Reworking both from the Upper Cretaceous and from the Eocene is evident in most samples but constitutes only a minor part of the assemblage (Fig. 2). Sample 177.30 m.b.s., the lowermost Oligocene sample above a barren interval at 177.65 m.b.s., includes an especially rich reworked Eocene flora. The Lower Oligocene assemblages are dominated by small Prinsiaceae and *Reticulofenestra umbilicus*. All other species are rare to very rare or occur only as single specimens, a condition previously described by Mikkelsen (1975).



## EOCENE

The Eocene encountered is less complete than the one described from the Viborg 1 deep test or from Danish outcrops. Only the Lillebælt Clay and Røsnæs Clay Formations are present, whereas the Søvind Marl Formation is missing. The calcareous nannofossil assemblages (Fig. 2) are generally less diverse than those found in the Danish outcrops (Perch-Nielsen, 1967, 1968a, b, 1971a, Thiede et al., 1980) or at Viborg 1. Sample 177.90 m.b.s. includes a rather poor Middle Eocene (NP 15 or Zone XVI of Steurbaut, 1988) assemblage with *Nannotetrina fulgens* and *N. cristata*. This sample overlies a series of barren or very poor samples without any marker species. The Lower Eocene is represented by 4 samples covering less than 2 m of coccolith-bearing sediment in between barren intervals. The presence of *Tribrachiatius orthostylus* while *Discoaster lodoensis* is absent assigns the interval to NP 11, the oldest Eocene calcareous nannofossil Zone found in Viborg 1 and in Danish outcrops. Samples 189.25 and 189.75 m.b.s. contain *Chiasmolithus eograndis*, *Lophodolithus nascens* and *Pontosphaera scissura*, all species which have their first occurrence at the base of Zone III of Steurbaut (1988). Since *Zygodiscus adamus*, *Z. plectopons* and *Rhabdosphaera truncata*, all typical of Zone IIIa, were not found, the samples could belong to either interval just below Zone III or to the top of Zone IIIa, since the base of Zone IIIb is defined by the first occurrence of *Discoaster lodoensis*, which was not found. NP 12 to 14 and 16 to 20, which have been found in Viborg 1, are not recorded in Harre. There is very little reworking observable.

## PALEOCENE/EOCENE BOUNDARY

The Paleocene/Eocene boundary is contained in an interval barren of calcareous nannofossils from 191.75 m.b.s. to 219.85 m.b.s., where siliceous fossils are rare to common.

## PALEOCENE

The coccolith-bearing Paleocene can be subdivided in an upper part with mainly caved Eocene forms and no or only very rare reworked Cretaceous or indigenous forms. In the middle part, reworked Cretaceous forms constitute up to 99% of the assemblage and indige-

nous forms are accordingly very rare to rare and not age diagnostic. In the lowermost part, the assemblages are dominated by Selandian and Danian forms and Cretaceous species are absent to very rare. The presence of *Neochiastozygus perfectus* and *Toweius selandianus* in sample 258.0 m.b.s. and above indicate the presence of S 2 of Perch-Nielsen (1979), which is correlatable to NP 4/5 despite the absence of *Fasciculithus tympaniformis* and *Ellipsolithus macellus*, the markers of NP 5 and NP 4 respectively. Samples 269.675 m.b.s. and 271.0 m.b.s. can be assigned to NP 3 based on the presence of *Chiasmolithus danicus* while *Ellipsolithus macellus* and *Chiasmolithus edentulus* are absent. The presence of *Prinsius martinii* suggests Subzone D 8 of Perch-Nielsen (1979) or the *Neochiastozygus saepes* Zone of van Heck & Prins (1987). The Danian and Selandian assemblages are not as rich as those found in Danish outcrops or in the Hvalløse borehole and described in Perch-Nielsen (1969, 1971b, 1979).

## MAASTRICHTIAN ?

The Maastrichtian may be represented by a marl/chalk sample from the bottom of the hole at 280.5 m.b.s.. It includes the marker species *N. frequens* and a poorly preserved, not very diverse Upper Maastrichtian assemblage and very rare contaminants from the Selandian (Fig. 3). The sample may, however, also be considered as caved Selandian, an interpretation favored by the geological setting of the borehole.

## CONCLUSIONS

While calcareous nannofossils could not be used for age determinations in the Neogene and the Upper Paleocene in the Harre borehole, they allowed for the recognition of 3 zones in the Oligocene and 2 in the Eocene as well as in the Paleocene.

Due to the generally poorer preservation and lower diversity than observable in Danish outcrops, no quantitative analysis were performed.

Intensity and source of reworking changed over time. It was practically absent during the Late Danian D 8. It increased slowly in the Selandian where, from sample 256.58 on upwards, it reached more than 50% and up to 99% of the coccoliths present. The reworked species include mainly Maastrichtian forms and

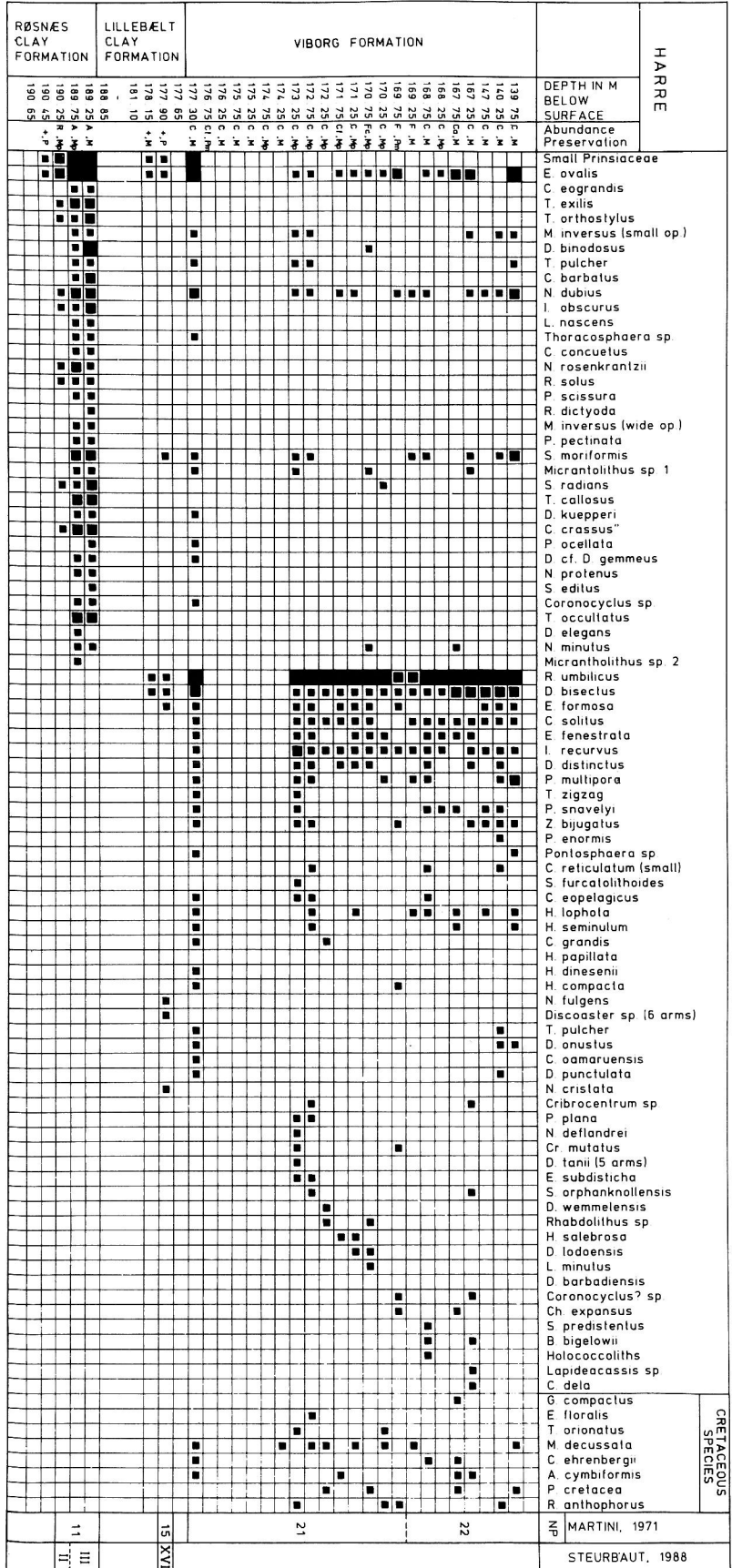


Fig. 2. Coccolith range chart. Eocene and Lower Oligocene.

only occasionally older species. The uppermost Paleocene and lowermost Eocene is barren also of reworked coccoliths and they are absent in the Lower Eocene Røsnæs Clay and the Middle Eocene Lillebælt Clay Formations. Reworked Maastrichtian/Campanian forms are very rare but consistently present in the Lower Oligocene Viborg Formation while they are absent from the Upper Oligocene Branden Formation, where only reworked Paleocene/Eocene forms were found. Maastrichtian/Campanian reworking is evident again above the barren interval between the latter and the Miocene Vejle Fjord Formation, where reworking from the Paleogene is extremely rare.

Shallow water or restricted conditions indicators such as species of *Braarudospahera*, *Micrantholithus* and *Pemma*, while present occasionally, were not found to be common in any sample.

#### ACKNOWLEDGMENTS

I would like to thank O. Bjørnslev Nielsen for making the material available and for being so patient in waiting for this report. The work was carried out at the Geological Institute of the ETH, Zürich and at the Institute for Earth Sciences of the Free University, Amsterdam, whom I thank for their support.

#### DANSK SAMMENDRAG

Baseret på nannofossil undersøgelser af sedimenter fra ca. 260 m kerner fra boringen ved Harre opstilles en biostratigrafi, der korreleres til den etablerede standard nannofossil zonerings. De Miocæne aflejringer har ikke kunnet zonerer på det foreliggende grundlag, da kun få og insignificant arter optræder. I Oligocæn er Branden Formationen henført til Øvre Oligocæn, NP Zone 24/25, medens Viborg Formationen er henført til Nedre Oligocæn, NP Zonerne 21 og 22. I denne formation findes hyppigt former oparbejdede fra Øvre Kridt og Eocæn. Især i den nederste del er Eocæne former hyppige. Søvind Mergel er ikke påvist, og af Lillebælt Ler Formationen findes kun NP Zone 15 fra Mellem Eocæn, men dele af formationen indeholder ingen nannofossiler. Nedre Eocæn er repræsenteret med Røsnæs Ler Formationen, men kun med former repræsenterende NP Zone 11. Også i denne formation findes intervaller uden nannofossiler. Der er altså flere stratigrafiske gab i Eocæn, nemlig mellem Røsnæs og Lillebælt Ler Formationerne

og mellem sidstnævnte og Viborg Formationen. Der er ikke registreret oparbejdede former i de Eocæne aflejringer. Ølst og Fur Formationen mangler totalt nannofossiler.

I den øverste og nederste del af den coccolithførende Paleocæne lagserie, svarende til henholdsvis Holmehusformationen/gråt kalkfattigt ler og Danian kalksten, er der kun få oparbejdede Cretassiske former, medens disse udgør ca. 99 % af selskabet i den mellemste del, svarende til Kertemindemergel.

Den nederste del af Kertemindemergelen henføres til NP 5, medens to af de spredte prøver i den underliggende kalk henføres til NP 3.

#### REFERENCES

- Martini, E., 1971:** Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In:* Farinacci, A. (ed.): Proc. 2nd Plankt. Conf. Rome 1970: pp. 785-793, (Edit. Tecnoscienza) Rome.
- Mikkelsen, N., 1975:** Marine Lower Oligocene sediments in Denmark as indicated by coccoliths in the Viborg Formation. *Bull. geol. Soc. Denmark*, 24, pp. 83-86.
- Nielsen, O.B., Friis, H. & Korsbech, U., 1994, this volume:** Lithology and lithostratigraphy of the Harre borehole, Denmark. *Aarhus Geoscience*, Vol. 1, pp. 5-14.
- Perch-Nielsen, K., 1967:** Nannofossilien aus dem Eozän von Dänemark. *Eclog. geol. Helv.*, 60, pp. 19-32.
- Perch-Nielsen, K., 1968a:** Beobachtungen im Elektronenmikroskop an *Micrantholithus mirabilis* und *Marthasterites obscurus* (Nannoplankton). *Dansk geol. Foren. Medd.*, 18, pp. 251-254.
- Perch-Nielsen, K., 1968b:** *Naninfula*, genre nouveau de nannofossiles calcaires du Tertiaire danois. *C.R. Acad. Sci. Paris*, 267, pp. 2298-2300.
- Perch-Nielsen, K., 1969:** Die Coccolithen einiger dänischer Maastrichtien- und Danienlokalitäten. *Bull. geol. Soc. Denmark*, 19, pp. 51-66.
- Perch-Nielsen, K., 1971a:** Elektronenmikroskopische Untersuchungen an Coccolithen und verwandten Formen aus dem Eozän von Dänemark. *K. Dan. Vidensk. Selsk. Biol. Skr.*, 18, pp. 1-76.
- Perch-Nielsen, K., 1971b:** Neue Coccolithen aus dem Paleozän von Dänemark, der Bucht von Biskaya und dem Eozän der Labrador See. *Bull. geol. Soc. Denmark*, 21, pp. 51-66.
- Perch-Nielsen, K., 1979:** Calcareous nannofossil zo-



nation at the Cretaceous/Tertiary boundary in Denmark. *Proc. Cret.-Tert. Boundary Events Symp.*, Copenhagen, 1, pp. 115-135.

**Perch-Nielsen, K., 1985a, b:** Mesozoic calcareous nannofossils; Cenozoic calcareous nannofossils. *In:* Bolli, H.M., Saunders, J.B. & Perch-Nielsen, K., (eds.): *Plankton Stratigraphy*, Cambridge University Press, pp. 329-427-554.

**Steurbaut, E., 1988:** New Early and Middle Eocene calcareous nannoplankton events and correlations in middle to high latitudes of the northern hemisphere. *Newsl. Stratigr.* 18 (2), pp. 99-115.

**Thiede, J., Bjørslev Nielsen, O. & Perch-Nielsen, K., 1980:** Litho-facies, Mineralogy and Biostratigraphy of Eocene Sediments in Northern Denmark (Deep Test Viborg 1). *N. Jb. Geol. Paläont. Abh.* 160 (2), pp. 149-171.

**Van Heck, S.E. & Prins, B., 1987:** A refined nannoplankton zonation for the Danian of the Central North Sea. *Abh. Geol. B.-A.*, 39, pp. 285-303, Wien.

