

Marine Lower Oligocene sediments in Denmark as indicated by coccoliths in the Viborg Formation

NAJA MIKKELSEN



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Coccoliths have been studied in stratotype material of the Viborg Formation which, on the evidence of benthonic foraminifers, has previously been assigned to the Middle Oligocene (Christensen & Ulleberg, 1973). The coccoliths indicate, however, that the lower fossiliferous part of the formation belongs to the *Helicoponthosphaera reticulata* Zone of Bukry (1973), which is referred to the Lower Oligocene. Thus, marine Lower Oligocene sediments, comparable with the German Latdorf Beds, are recorded for the first time in Denmark.

Naja Mikkelsen, Institut for Historisk Geologi og Palæontologi, Øster Voldgade 10, DK-1350 København K, Denmark Present address: Scripps Institution of Oceanography, La Jolla, 92037 California, U.S.A. February 7th, 1975.

Early studies on the Danish Oligocene sequence were mainly concentrated on the molluscan faunas (Ravn, 1907; for further references see Christensen & Ulleberg, 1973). These faunas showed similarity to German Middle and Upper Oligocene faunas and thus it was previously generally accepted that Lower Oligocene marine sediments were missing in Denmark.

Although various authors have referred different deposits in Denmark to the Early Oligocene, these determinations have subsequently been questioned. Gottsche (1883) reported a Lower Oligocene molluscan fauna from blocks of erratic freshwater sandstones in Djursland, but recently these blocks have been proved to be of Jurassic age (Baartman & Christensen, 1974). On the basis of the presence of *Terebratulina nysti* Bosq., Ødum (1936) referred the marine, light and sticky clay (the Søvind Marl of Andersen, 1937) to the Lower Oligocene and this procedure was followed by Andersen (1937) and Flagler (1940). Eriksen (1937) also referred the Søvind Marl from Brejning to the Lower Oligocene. He mentioned, however, that the clay sequence resembled the Middle Oligocene 'Septarian Clay' and that sedimentation of this clay might have started in Early Oligocene, followed by a regression. Rasmussen (1961) and

Dinesen (1972) transferred the Søvind Marl from the Early Oligocene to the Late Eocene, and investigations of coccoliths in the Søvind Marl have demonstrated that the marl is Late Eocene (Perch-Nielsen, 1971).

Renewed investigation of the Danish Oligocene has recently been undertaken by Christensen & Ulleberg (1973, 1974). In the first paper, these authors formally designated as the Viborg Formation the clay sequence overlying the Søvind Marl in the Viborg 1 deep bore. The stratotype for the Viborg Formation in the Viborg 1 deep bore consists of 85.5 m of sticky clay with pyrite, some mica and glauconite. Lithological descriptions are also given in Flagler (1940) and Christensen (1969). Only the lowermost 71 m of the formation contains rich foraminiferal assemblages whereas the uppermost 15 m of the sequence is partly fossiliferous (Christensen & Ulleberg, 1974). The foraminiferal fauna was treated by Flagler (1940) and Christensen & Ulleberg (1974). On the basis of studies of the benthonic foraminifers Christensen & Ulleberg (1973) referred the Viborg Formation to the Middle Oligocene and suggested that when compared to the Middle Oligocene in northern Germany, the Viborg Formation might be of Lower Rupelian age, Rupel 2 of Spiegler (1965).

Calcareous nannofossils

Coccoliths are the skeletal remains of a group of marine planktonic algae that are important in worldwide stratigraphic correlation. Investigation of this calcareous nannofossil group in the Viborg Formation has been carried out on the basis of stratotype material from the Viborg 1 deep bore.

The abundance and preservation of coccoliths in the lowermost 7 m of the sequence is fairly poor, but improves towards the zone of maximum occurrence of planktonic foraminifers, about 15 m above the base of the formation (Christensen & Ulleberg, 1974). The abundance as well as the diversity decreases from about 57 m above base to 71 m, where 15 m of non-coccolith bearing sediments terminate the formation.

In the lower part of the fossiliferous Viborg Formation the common occurrence of *Reticulofenestra umbilica* (fig. 6), *Isthmolithus recurvus* (fig. 5) and *Cyclococcolithus formosus* (fig. 2) is characteristic of the *Helicoponthosphaera reticulata* Zone of Bukry (1973), which is comparable to the nannofossil standard zones NP21 and NP22 of Martini (1971) and referred to Early Oligocene. The fairly rich assemblage also includes *Ericsonia subdisticha*, *Ericsonia ovalis* (figs 3 & 4) *Rhabdosphaera tenuis*, *Ponthosphaera multipora*, *Dictyococcites bisectus* (fig. 1), *Zygrhablithus bijugatus* and *Sphenolithus moriformis* and is similar to the assemblage reported from the Latdorf Beds of Northern Germany (Martini, 1969). The Latdorf Beds are referred to the Early Oligocene by von Koenen (1889–1894). Except for *Sphenolithus moriformis* other sphenolith species, which normally are excellent zonal markers in Oligocene strata, are rare or absent in the investigated material.

Calcareous nannofossil assemblages from the type Rupelian, referred to the Middle Oligocene Nanno Fossil standard zone NP23 lack *Reticulofenestra umbilica*, *Cyclococcolithus formosus* and *Isthmolithus recurvus* (Roth, 1970, Müller, 1970) and are therefore quite different from the assemblage found in the lower fossiliferous part of the Viborg Formation.

The coccolith assemblage present in the Viborg Formation thus indicate that marine sedi-

ments were deposited in the Danish embayment during the Early Oligocene. Minor reworking at certain levels in the Viborg Formation is indicated by the presence of a few Cretaceous and Middle Eocene species, such as *Arkhangelskiella cymbiformis* and *Chiasmolithus grandis*. Reworking of Upper Eocene species into Oligocene sediments could not be demonstrated as short-ranged species restricted to the Upper Eocene were not found. In addition, no coccoliths from the Viborg Formation would clearly support reworking of Early Oligocene sediments into younger strata.

There is clearly considerable discrepancy in the stratigraphic age determinations suggested by the various fossil groups. Consequently, new studies of foraminifers, ostracods, coccoliths, and sediments are now in progress to further investigate the occurrence of marine Lower Oligocene strata in Denmark as indicated by nannofossils.

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Dansk sammendrag

En undersøgelse over coccolitherne i typematerialet for Viborg Formationen (Christensen & Ulleberg, 1973) er foretaget. Viborg Formationen er på grundlag af den benthoniske foraminiferfauna henført til det mellem oligocæne Rupel 2. (Christensen & Ulleberg, 1973).

Coccolithfloraen i den nedre del af Viborg Formationen repræsenterer imidlertid *Helicoponthosphaera reticulata* zonen, der er henført til nedre Oligocæn (Bukry 1973). Dette indikerer, at marine sedimenter blev aflejret i det danske sænkingsområde i nedre Oligocæn.

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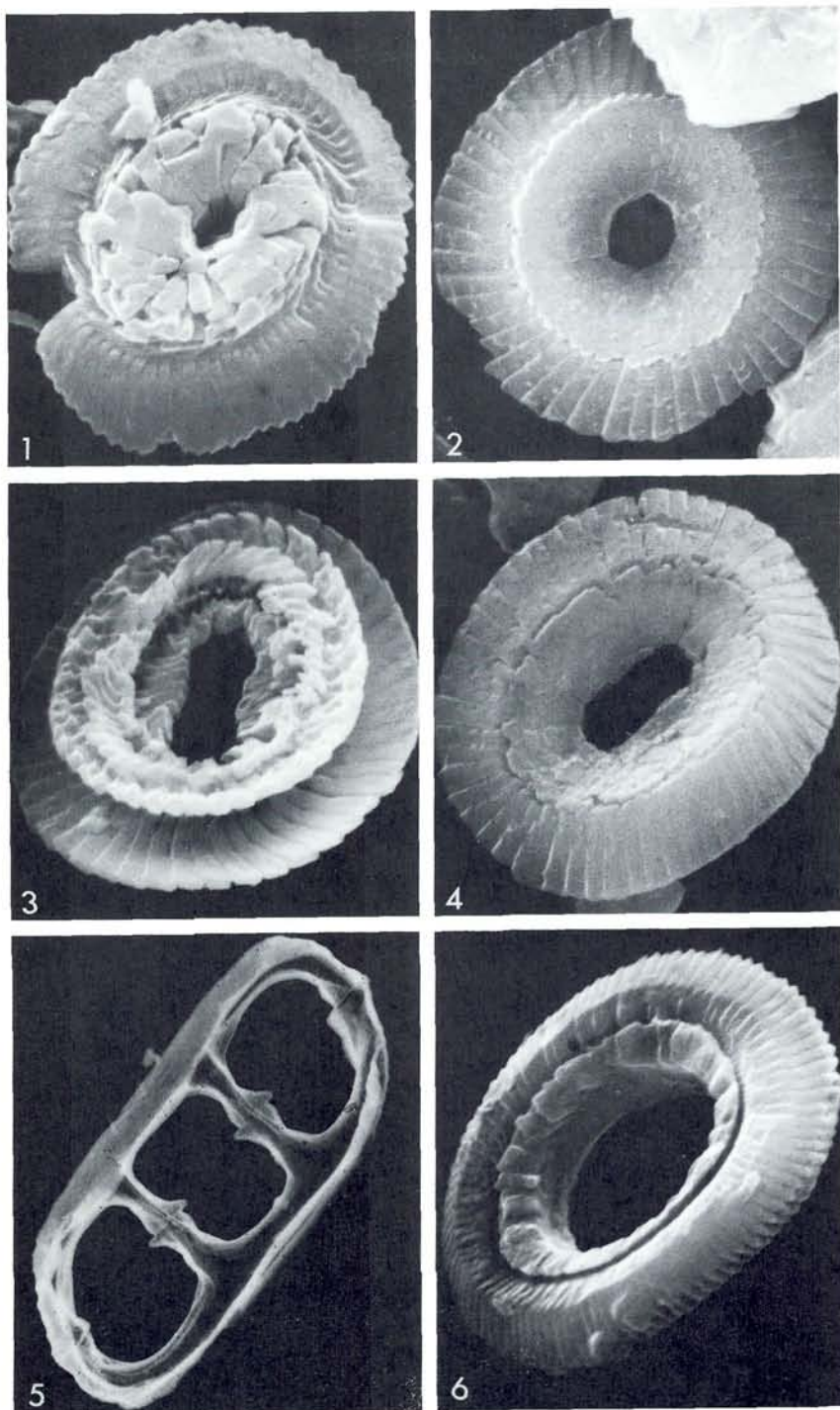


Fig. 1. *Dictyococcites bisectus*, distal view, SEM X 10200. (NM 1315, MMH 13380). Fig. 2. *Cyclococcolithus formosus*, distal view, SEM X 11500. (NM 1376, MMH 13381). Fig. 3. *Ericsonia ovalis*, proximal view, SEM X 9700. (NM 1357, MMH 13382). Fig. 4.

Ericsonia ovalis, distal view, SEM X 9100. (MN 1351, MMH 13383). Fig. 5. *Isthmolithus recurvus*, SEM X 9000. (NM 2169, MMH 13384). Fig. 6. *Reticulofenestra unbilica*, distal view, SEM X 11500. (NM 13385, MMH 13385).

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