26. TERTIARY AND QUATERNARY CALCAREOUS NANNOPLANKTON IN THE NORWEGIAN-GREENLAND SEA, DSDP, LEG 38

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ABSTRACT

Calcareous nannofossils were obtained from cores of all holes drilled in the Norwegian-Greenland Sea. They are present in lower Eocene to Pleistocene sediments. In some, nannoplankton is restricted only to "Glacial" sediments (mainly Pliocene and Quaternary). Generally, the sediments are poor in nannoplankton, and the assemblages are of low diversity. Therefore, nannoplankton is less useful for biostratigraphic investigations in high latitude areas. Similarities exist between high southern and high northern latitude assemblages. An attempt is made to compare the assemblages of the North Atlantic (Leg 12), northern Europe (mainly Denmark, Belgium, and northern Germany) with those from the Norwegian-Greenland Sea to recognize influences of North Atlantic water masses in the Norwegian-Greenland Sea.

INTRODUCTION

During Leg 38 17 holes were drilled at 17 sites in the Norwegian-Greenland Sea (Figure 1). The oldest sediments encountered are of early Eocene age (interval with *Imperiaster obscurus*) (Table 1). Sediments generally contain only a few nannofossils and the assemblages are of low diversity, indicating that low water temperatures existed in the region since at least early Eocene. Only during the middle-upper Oligocene were nannofossil oozes deposited. These are present on the southern flank of the Iceland-Faeroe Ridge (Hole 352A), the northern flank (Site 336), and on the Vøring Plateau (Site 338).

Species diversity is relatively high in lower Eocene sediments (interval with *Imperiaster obscurus*). The assemblages are the same as those described from the North Atlantic (Rockall Bank, Bukry, 1972) and from northern Europe (Martini, 1958, Perch-Nielsen, 1971). A distinct decrease of species diversity can be observed during middle and late Eocene. The most diversified nannoplankton assemblages are present in middle-late Oligocene sediments, comparable with those from the North Atlantic. The Neogene nannoplankton assemblages of the Norwegian-Greenland Sea consist mainly of long-ranging species without a high stratigraphic value (*Coccolithus pelagicus, Reticulofenestra pseudoumbilica*). Index fossils used for the zonation in low and mid latitudes are missing (discoasters, ceratoliths, sphenoliths). A few nannofossils, of a reduced assemblage, are present in Quaternary sediments.

Nannofossils of the Norwegian-Greenland Sea are generally smaller and more fragile compared to those of mid and low latitudes, due to low water temperature. The main reason for the low amount of nannofossils is low water temperatures which restrict most of the nannofossils. However nannofossils are also diminished by dilution due to a high amount of terrigenous sediment or siliceous microfossils and by dissolution.

Only light-microscope techniques were employed to study the nannoplankton from about 1600 samples.

NANNOFOSSIL BIOSTRATIGRAPHY

Low diversity nannoplankton assemblages, consisting of mainly long-ranging species and the absence of almost all index fossils used for zonation in low and mid latitudes, means that nannoplankton are not very useful for stratigraphic purposes in this area. Comparisons with the standard zonation (Martini, 1971) are only possible in the lower Eocene, middle-upper Oligocene, and Quaternary. This zonation can be used in northern Europe, at least for the Paleogene, and in the North Atlantic (Leg 12) with some exceptions for the Paleogene and Neogene (Perch-Nielsen, 1972; Bukry, 1972). The zonation described by Edwards and Perch-Nielsen (1975) from the southern high latitudes for the upper Eocene to Quaternary is also not useful in the Norwegian-Greenland Sea because the nannoplankton assemblages are still less diversified.

The zonation used in this paper for biostratigraphic investigations is given on Table 2. It also summarizes the biostratigraphic events used for age determinations on Leg 38 and the species present in the different zones or stratigraphic intervals. An attempt was made to use existing zones insofar as possible. Otherwise, only stratigraphic intervals are given which are characterized by the presence of a selected species.

NANNOPLANKTON ZONATION FOR THE NORWEGIAN-GREENLAND SEA

Eocene and Lower Oligocene

Interval With Imperiaster obscurus

Remarks: This interval is characterized by the presence of *Imperiaster obscurus* and corresponds approximately with the *Discoaster binodosus* Zone (NP 11) and *Marthasterites tribrachiatus* Zone (NP 12) of

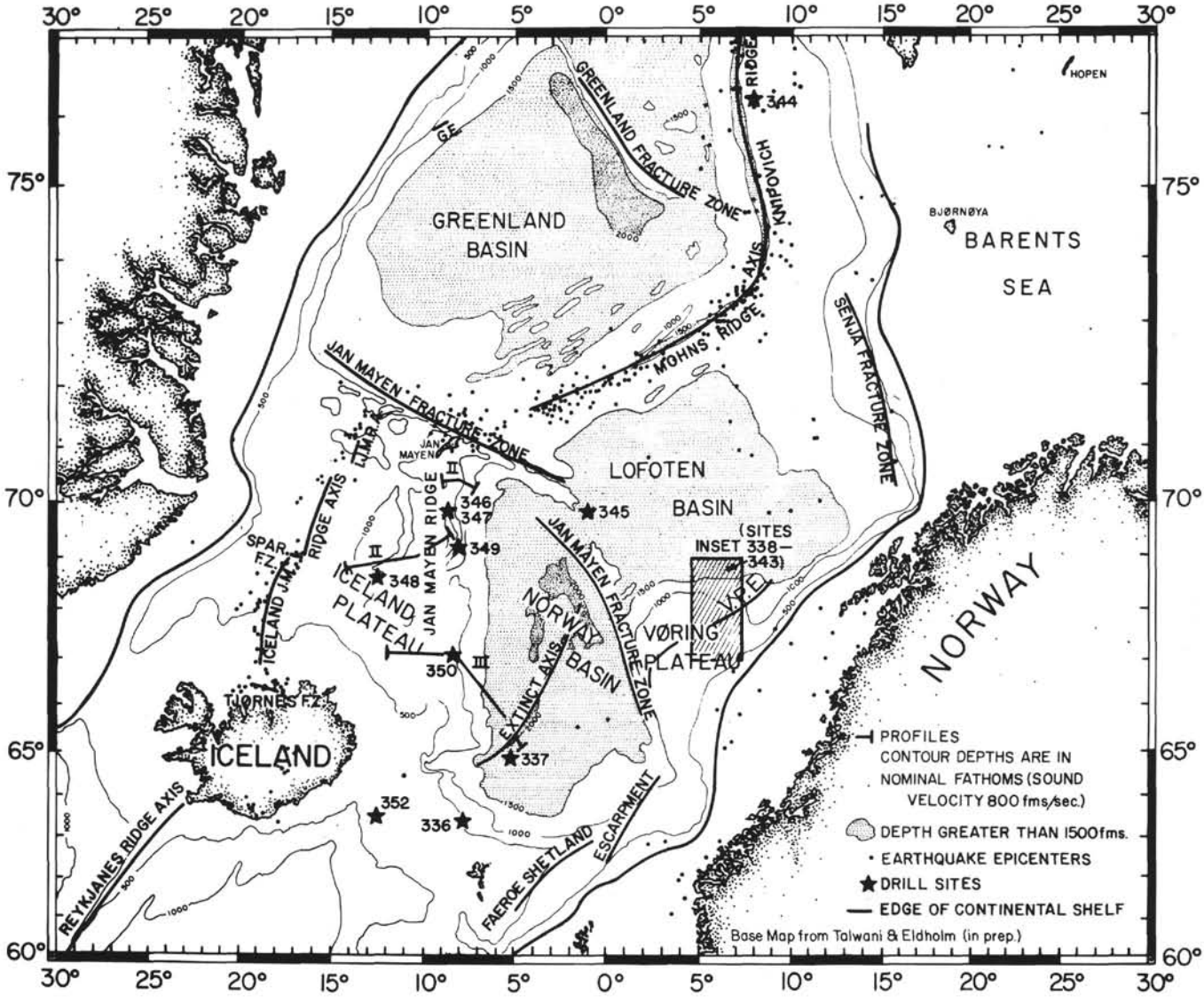

Figure 1. *Location of Leg 38 drilling sites, and bathymetry and structure of the Norwegian Greenland Sea. (Note: Site 351 was occupied but was not drilled. Its location has not been shown on this map.*

the standard zonation of the lower Eocene. The nannoplankton assemblage is the same described from the lower Eocene of the Rockall Bank (Bukry, 1972, Leg 12) and northern Germany (Martini, 1958; Müller, in preparation).

Reticulofenestra umbilica Zone

Definition: Interval from the first occurrence of *Reticulofenestra umbilica* to the first occurrence of *Isthmolithus recurvus.*

Author: Perch-Nielsen, 1972.

Remarks: The *Reticulofenestra umbilica* Zone includes the middle Eocene and the lower part of the upper Eocene (approximately NP 15 to NP 18 of the standard zonation). The nannoplankton assemblage of this stratigraphic interval is extremely poor and cannot be compared with the middle and upper Eocene assemblages of the North Atlantic and northern Europe.

Interval With Isthmolithus recurvus

Remarks: This interval includes the upper part of the upper Eocene and the lower Oligocene (approximately NP 19 to NP 22). It is distinguished by the presence of *Isthmolithus recurvus.* The Eocene/Oligocene boundary, defined by the extinction of *Discoaster saipanensis*, cannot be determined in the Norwegian-Greenland Sea due to the absence of discoasters in the Eocene.

Middle-Upper Oligocene

Sphenolithus distentus Zone

Definition: Interval from the first occurrence of *Coccolithus abisectus* to the first occurrence of *Discolithina enormis.*

Remarks: Due to the absence of sphenoliths in northern Europe, which are used to determine the Oligocene zones, it was necessary to find other species to define the boundaries of the zones. Investigations of

Oligocene sections in northern Europe (Müller, 1970; Benedek and Müller, 1974) and comparisons with the material from Trinidad have shown that *Coccolithus abisectus* and *Helicosphaera recta* have their first occurrence approximately at the boundary of the *Sphenolithus predistentus/Sphenolithus distentus* Zone (NP 23/NP 24) of the standard zonation. The top of the *Sphenolithus distentus* Zone, as used in regions without sphenoliths, is characterized by the first occurrence of *Discolithina enormis*. The nannoplankton assemblage of this zone is comparable with those of the North Atlantic, and very similar to the assemblage of the upper Rupelian (Müller, 1970). The lower part of the middle Oligocene (NP 23) could not be determined by nannoplankton in the Norwegian-Greenland Sea.

Sphenolithus ciperoensis Zone

Definition: Interval with *Discolithina enormis.*

Remarks: Investigations of upper Oligocene sections in northern Germany (Doberg and Lower Rhine Basin, Martini and Müller, 1975; Benedek and Müller, 1974) have shown that the presence of *Discolithina enormis* is typical for this stratigraphic interval. The first occurrence is used to define the boundary between the *Sphenolithus distentus* Zone (NP 24), and the *Sphenolithus ciperoensis* Zone (NP 25) in northern Germany and in other areas of Europe, due to the lack of *Sphenolithus distentus.* The extinction of this species is usually used to determine this boundary. The extinction of *Zygrhablithus bijugatus* may be useful to determine the top of this zone in regions where sphenoliths are missing.

Miocene to Lower Pliocene

Interval With Helicosphaera ampliaperta

Remarks: The interval with *Helicosphaera ampliaperta* of the lower Miocene was only encountered at Site 348 (Icelandic Plateau). It includes approximately the *Sphenolithus belemnos* Zone (NN 3), and the *Helicosphaera ampliaperta* Zone (NN 4) of the standard zonation. The lowermost part of the Miocene is barren of nannoplankton.

Interval With Reticulofenestra pseudoumbilica

Remarks: This interval includes at least the middle Miocene to lower Pliocene (approximately NN 5 to NN 15 of the standard zonation). This interval is characterized by an extremely poor nannoplankton assemblage, consisting mainly of *Coccolithus pelagicus* and *Reticulofenestra pseudoumbilica*, which makes further subdivisions of this interval impossible.

Upper Pliocene and Quaternary

Interval With Pseudoemiliania lacunosa

Remarks: This interval includes the upper Pliocene and the largest part of the Quaternary (Zones NN 16 to NN 19 of the standard zonation). The Plio/Pleistocene boundary, defined by the extinction of *Discoaster brouweri*, cannot be determined in this area due to the absence of discoasters. This interval is difficult to

TABLE 1
Nannoplankton zones and Stratigraphic Intervals of Cores From the Deep Sea Drilling Project Leg 38 in the Norwegian-Greenland Sea

Adopted Age	Nannoplankton Zones and Intervals	Site 336	Site 337	Site 338	Site 339	Site 340	Site 341	Site 342	Site 343	Site 345	Site 345	Site 346	Site 347	Site 348	Site 349	Site 350	Site 352	Site 352A
Quaternary	*Emiliania huxleyi*		1-1/1-2	1-1/1-3	1-1/2-2	1	1-1/2-1	1	1		1	1-2	1	1-2				
	Gephyrocapsa oceanica	1-7	1-2/3, CC	1-4/3-2	2-3/4-4		2-2/19, CC	2?	2-4	1/2-4	2	4?			1-2	1?	1-3	
	Pseudoemiliania lacunosa		4-1/5-4	3-3/6, CC	4, CC-8, CC		20/25-2			15-1/17-1	3-2/4-2							
Late Pliocene	*Reticulofenestra*													6-11				
Early Pliocene	*pseudoumbilica*						26-33			19, CC/33, CC								
Middle Miocene	*Helicosphaera ampliaperta*													24-4/26-5				
Lower Miocene	*Sphenolithus ciperoensis*		15-1/16-2														6, CC	1-3
Late Oligocene	*Sphenolithus distentus*		16-2/16-5	15-5/26-1														
Middle Oligocene																		
Early Oligocene															5-6/12-4	14-2		
Late Eocene (upper part)	*Isthmolithus recurvus*		22-6/30-2															
Late Eocene (lower part)	*Reticulofenestra umbilica*		30-3/37, CC										2-3					
Middle Eocene																		
Early Eocene	*Imperiaster obscurus*			32-1/42-1					7-1/16-3									

TABLE 2
Nannoplankton Zones and Stratigraphic Intervals Used in the Norwegian-Greenland Sea (Leg 38).

Adopted Age	Nannoplankton Zonation	Biostratigraphic Events	Species
Quaternary	*Emiliania huxleyi*	*Emiliania huxleyi*[a]	*Coccolithus pelagicus, Cyclococcolithus leptoporus, Discolithina japonica, Emiliania huxleyi, Gephyrocapsa ericsonii, Syracosphaera pulchra*
	Gephyrocapsa oceanica		*Coccolithus pelagicus, Cyclococcolithus leptoporus, Gephyrocapsa ericsonii, Helicosphaera carteri, Syracosphaera pulchra*
Late Pliocene	*Pseudoemiliania lacunosa*	*Pseudoemiliania lacunosa*[b]	*Coccolithus pelagicus, Cyclococcolithus leptoporus, Gephyrocapsa ericsonii, Gephyrocapsa* sp., *Helicosphaera carteri, Helicosphaera sellii, Pseudoemiliania lacunosa*
Early Pliocene Middle Miocene	*Reticulofenestra pseudoumbilica*	*Reticulofenestra pseudoumbilica*[b]	*Coccolithus pelagicus, Discolithina japonica, Reticulofenestra pseudoumbilica, Sphenolithus abies*
Early Miocene	*Helicosphaera ampliaperta*	Interval with *H. ampliaperta*	*Coccolithus pelagicus, Helicosphaera ampliaperta, Reticulofenestra* cf. *pseudoumbilica*
	?		same species as in the *Sphenolithus distentus* zone plus *Discolithina enormis*
Late Oligocene	*Sphenolithus ciperoensis*	*Discolithina enormis*[a]	
Middle Oligocene	*Sphenolithus distentus*		*Chiasmolithus altus, Coccolithus abisectus, Coccolithus pelagicus, Cyclococcolithus floridanus, Dictyococcites dictyodus, Discoaster deflandrei, Sicolithina desueta, Helicosphaera euphratis, Helicosphaera perch-nielsenae, Helicosphaera recta, Reticulofenestra elatrata, Reticulofenestra lockeri, Sphenolithus moriformis, Zygrhablithus bijugatus*
Middle Oligocene	?	*Coccolithus abisectus*[a] *Helicosphaera recta*[a]	*Chiasmolithus oamaruensis, Cribrocentrum reticulatum, Cyclococcolithus luminis, Discolithina pulcheroides, Isthmolithus recurvus, Reticulofenestra umbilica, Transversopontis obliquipons*
Early Oligocene Late Eocene	*Isthmolithus recurvus*	Interval with *Isthmolithus recurvus*	
Late Eocene (lower part) Middle Eocene	*Reticulofenestra umbilica*	*Reticulofenestra umbilica*[a]	*Braarudosphaera bigelowi, Reticulofenestra umbilica, Zygolithus dubius*
Early Eocene	?		*Braarudosphaera bigelowi, Chiasmolithus solitus, Cyclococcolithus luminis, Discoaster lodoensis, Discoasteroides kuepperi, Discolithina pulchra, Imperiaster obscurus, Marthasterites tribrachiatus, Micrantholithus mirabilis, Zygolithus dubius*
	Imperiaster obscurus	Interval with *Imperiaster obscurus*	

[a]First occurrence.
[b]Last occurrence.

recognize in the Norwegian-Greenland Sea due to the scarcity of *Pseudoemiliania lacunosa*.

Gephyrocapsa oceanica Zone

Definition: Interval from the last occurrence of *Pseudoemiliania lacunosa* to the first occurrence of *Emiliania huxleyi*.

Authors: Boudreaux and Hay, 1967 emend. Gartner, 1969.

Remarks: This zone is characterized in the Norwegian-Greenland Sea by the presence of a small species of the genus *Gephyrocapsa*, probably *Gephyrocapsa ericsonii*, however, it is not possible to determine whether it is only a small variety of *Gephyrocapsa oceanica* typical of cooler water.

Emiliania huxleyi Zone

Definition: Interval above the first occurrence of *Emiliania huxleyi*.

Authors: Boudreaux and Hay, 1967 emend. Gartner, 1969.

Remarks: This zone was recovered in most of the holes drilled in the Norwegian-Greenland Sea. Due to the small size of *Emiliania huxleyi*, it is sometimes difficult to determine this zone. Nannoplankton assemblage of this zone is of low diversity.

NANNOPLANKTON DISTRIBUTION IN THE NORWEGIAN-GREENLAND SEA

Eocene sediments are generally poor in nannoplankton, and the assemblages of middle-upper Eocene are of low species diversity. They are more diversified in the lower Eocene. A low productivity of calcareous microfossils in cold surface water can be assumed. The content of nannofossils may be diminished also by dilution due to the high amount of terrigenous sediment, as well as by dissolution of nannofossils associated with changes of the CCD during the time. Discoasters are missing or are present only sporadically in the lower Eocene sediments due to cold water temperatures which must have existed since Eocene times. Since discoasters are the most dissolution-resistant group of the nannoplankton, their absence cannot be explained by dissolution.

Lower Eocene

Lower Eocene sediments were recovered at Site 338 (Vøring Plateau) and at Site 343 (Lofoten Basin). Species of the lower Eocene (interval with *Imperiaster obscurus*) are: *Imperiaster obscurus, Zygolithus dubius, Micrantholithus mirabilis, Cyclococcolithus luminis, Discolithina pulchra, Coccolithus pelagicus, Discolithina fimbriata, Discoasteroides kuepperi, Braarudosphaera bigelowi*, and few specimens of *Discoaster lodoensis, Chiasmolithus solitus*, and *Marthasterites tribrachiatus. Chiasmolithus grandis* was only found in a sample of Core AS1-9 from the Norway Basin, described by Saito et al., 1967 as Paleocene. However, the nannoplankton assemblage of this sample belongs to the lower Eocene.

Discoaster barbadiensis and *Discoaster binodosus* are absent in the Norwegian-Greenland Sea, while they were found in the lower Eocene of northern Germany and in the North Atlantic. Also, only a few specimens of *Marthasterites tribrachiatus* were observed in the Norwegian-Greenland Sea, while this species is frequent in the North Atlantic and in northern Europe. This decrease of species is caused by latitudinal differentiation. Since all these species are dissolution-resistant forms, their scarcity or absence cannot be related to dissolution.

The presence of *Imperiaster obscurus* is characteristic for this stratigraphic interval in the Norwegian-Greenland Sea. This species is described from the *Discoaster binodosus* Zone (NP 11) and *Marthasterites tribrachiatus* Zone (NP 12) from northern Europe (north Germany, Denmark, Belgium, England) and from the lower Eocene of the Rockall Bank, Site 117A (Bukry, 1972), while it is missing in the lower Eocene at Site 111A (North Atlantic), and Sites 118 and 119 (Bay of Biscay). This species seems to be a cold-water form, and probably it also indicates a shallow-water environment. It is present together with neritic species such as *Micrantholithus mirabilis, Discolithina fimbriata*, and *Discolithina pulchra.* These species are also found in the assemblage of the Rockall Bank and of northern Europe. Berggren, 1975 gives a water depth of 100-200 meters for the Rockall Bank during the lower Eocene based on benthonic foraminifers.

Assemblages of the middle Eocene and/or lower part of the upper Eocene are of extreme low diversity (*Reticulofenestra umbilica, Discolithina pulcheroides, Zygolithus dubius*). It is impossible to determine one of the nannoplankton zones of the standard zonation. Discoasters, which are the most important group for age determinations of Eocene sediments, are missing in this interval in the Norwegian-Greenland Sea.

The upper part of the upper Eocene (probably NP 19 and NP 20) and the lower Oligocene (NP 21 and NP 22) are distinguished by the presence of *Isthmolithus recurvus*, together with *Reticulofenestra umbilica*, and *Cribrocentrum reticulatum. Chiasmolithus oamaruensis* was found only sporadically. This stratigraphic interval was encountered at Sites 336, 349, and 350.

Oligocene

The assemblages of the middle and upper Oligocene in the Norwegian-Greenland Sea are more diversified indicating a strong influx of warmer Atlantic water into the Norwegian-Greenland Sea. The regional distribution of the middle Oligocene nannofossil ooze indicates a current similar to the present Norwegian Current. The nannofossil ooze of the middle-upper Oligocene is restricted to the southeastern part of this area (south of the Iceland-Faeroe Ridge (Hole 352A), north of this ridge (Site 336), and on the Vøring Plateau (Site 338). The Oligocene was also determined at Site 337 (Norway Basin), Site 339 (inner Vøring Plateau), Site 345 (Mohns Ridge), probably at Sites 346 (Jan-Mayen Ridge) and 348 (Icelandic Plateau). At Sites 349 and 350 (Jan-Mayen Ridge) it was mainly based on the presence of arenaceous benthonic foraminifers. The nannoplankton assemblage of this interval consists of: *Chiasmolithus altus, Coccolithus abisectus, Coccolithus pelagicus, Cyclococcolithus floridanus, Dictyococcites dictyodus, Discoaster deflandrei, Discolithina desueta, Discolithina* cf. *distincta, Discolithina enormis, Helicosphaera euphratis, Helicosphaera recta, Reticulofenestra clatrata, Reticulofenestra lockeri, Sphenolithus moriformis*, and *Zygrhablithus bijugatus*. The assemblage is comparable with those described from the North Atlantic (Leg 12), with *Discoaster deflandrei* and *Chiasmolithus altus*. Both species indicate cooler water, they were also described from the southern high latitudes in this stratigraphic interval (Edwards and Perch-Nielsen, 1975; Burns, 1975). They are missing in the sediments of northern Germany and Denmark.

Sphenoliths, which are the index fossils of the Oligocene, are missing in the Norwegian-Greenland Sea, but they are described from the North Atlantic (Perch-Nielsen, 1972, Leg 12). The Oligocene assemblages are abundant in specimens of the genus *Reticulofenestra*, which probably indicate cooler water. They are also common in the Oligocene of northern Germany (Müller, 1970), and in land sections of New Zealand (Edwards, 1971), while they are missing in the tropical-subtropical open ocean environment. The lower part of the middle Oligocene (NP 23) of the Norwegian-Greenland Sea is barren of nannoplankton.

Miocene and Lower Pliocene

Sediments of this stratigraphic interval are mainly barren of nannoplankton, which are present only in some horizons. The diversity of the nannoplankton assemblages of the Neogene sequence of the Nor-

wegian-Greenland Sea is extremely low. Age determinations are based on siliceous microfossils. *Coccolithus pelagicus* and *Reticulofenestra pseudoumbilica* are present only in a few horizons. *Helicosphaera carteri, Cyclococcolithus leptoporus*, and *Discolithina japonica* were found only sporadically. The presence of these long-ranging species makes it impossible to give a detailed zonation for the Miocene and lower Pliocene sequence. Index fossils such as discoasters, ceratoliths, and sphenoliths are missing. The assemblages are the same which were described from the Neogene of northern Germany (Martini and Müller, 1973).

The lower Miocene (interval with *Helicosphaera ampliaperta*) was determined only at Site 348 (Icelandic Plateau) by the presence of *Helicosphaera ampliaperta*, together with *Coccolithus pelagicus* and *Reticulofenestra* cf. *pseudoumbilica*. This species seems to prefer cooler water because it is absent in the tropical zone of the Pacific and the Indian oceans. *Sphenolithus heteromorphus* was not observed in the Norwegian-Greenland Sea, probably due to low water temperatures, or by the separation of the Norwegian-Greenland Sea from the Atlantic.

Upper Pliocene and Quaternary

Upper Pliocene and Quaternary sediments are generally poor in nannofossils primarily due to unfavorable ecological conditions (cold water, ice cover), and secondarily to dilution by the high input of ice-rafted material. Nannofossils are enriched in some thin nannofossil ooze layers intercalated in the Pliocene and Quaternary sediments, which may indicate an influx of Atlantic water caused by climatic changes. However, these layers generally consist only of one or two species (*Coccolithus pelagicus*, and/or *Gephyrocapsa ericsonii*, see Plate 1). Some of these layers are distinguished by an abundance of coccospheres. *Coccolithus pelagicus* is smaller compared to forms from the transition zone. The small central opening is either uncovered, or spanned by a cross or cross-bar. The small species of the genus *Gephyrocapsa* is determined as *Gephyrocapsa ericsonii* based on the position of the bridge. However, it is not known if it is really a single species or only a variety of *Gephyrocapsa oceanica* due to different water temperatures.

The determination of the Plio/Pleistocene boundary (by the extinction of *Discoaster brouweri*) is impossible because discoasters are missing in the Neogene sequence of the Norwegian-Greenland Sea. Other species, such as *Cyclococcolithus macintyrei* and *Ceratolithus rugosus*, are also missing. Both species have their extinction approximately at the same time and can be used for the determination of the Plio/Pleistocene boundary in regions where discoasters are rare or are missing.

Only a few specimens of *Helicosphaera carteri, Cyclococcolithus leptoporus, Emiliania huxleyi, Syracosphaera pulchra, Gephyrocapsa ericsonii*, and *Pseudoemiliania lacunosa* were found in the Quaternary sediments. Only *Cyclococcolithus leptoporus* becomes frequent in some samples. This may be partially the result of selective dissolution of the more fragile species. The nannofossils are smaller and more fragile in the Norwegian-Greenland Sea than those from tropical and subtropical regions, due to lower water temperature.

The preservation of nannofossils is good in the nannofossil ooze, being slightly etched in most other samples. Reworked Cretaceous and Eocene species are generally common in almost all samples of "Glacial" sediments. Sometimes, they are the only nannofossils which are present. They are missing in the nannofossil ooze layers. A relationship can be observed between the proportion of reworked species and ice-rafted material. Reworked species were not found in sediments older than upper Pliocene.

SITE SUMMARIES

Site 336
(lat 63°21.06'N, long 07°47.27'W, water depth 811 m)

Nannoplankton are extremely rare in "Glacial" sediments recovered at Site 336 (Table 3). The assemblages are marked by low species diversity. The only species observed are *Coccolithus pelagicus* (small variety), *Cyclococcolithus leptoporus, Gephyrocapsa ericsonii*, and *Helicosphaera carteri*. The nannofossils are smaller and more fragile than in regions of warmer water. The low amount of nannoplankton may be due to the poor living conditions for nannofossils (low water temperatures), as well as dilution by high amounts of terrigenous sediment. Dissolution seems to be less important, because planktonic foraminifers and nannoplankton do not show traces of dissolution.

In Core 4, some nannofossil ooze layers are present consisting mainly of a very small species of the genus *Gephyrocapsa*. These horizons may indicate an influx of warmer water caused by climatic changes. In almost all samples, reworked species of the Cretaceous and Eocene were found. They are missing in the nannofossil ooze layers. A relationship exists between the amount of reworked species and the amount of ice-rafted material in the sediments. Core 8 to Sample 14, CC (64.0-168.5 m) are barren of nannoplankton. In this part of the profile, only sponge spicules, few diatoms, and silicoflagellates were present.

Samples 15-1, 13-14 cm to 16-5, 111-112 cm (168.5-187.5 m) are generally abundant in nannofossils. They are slightly to strongly etched. The assemblages belong to the middle/upper Oligocene (NP 24/NP 25). The boundary between both zones probably lies between Samples 16-2, 11-13 cm and 16-3, 16-17 cm, indicated by the occurrence of *Discolithina enormis*. The assemblage consists of *Coccolithus pelagicus, Cyclococcolithus floridanus, Discolithina desueta, Helicosphaera euphratis, Discoaster deflandrei, Discolithina enormis, Dictyococcites dictyodus, Reticulofenestra lockeri*, and only one specimen of *Helicosphaera perch-nielseniae, Zygrhablithus bijugatus*, and *Triquetrorhabdulus carinatus* (15-1, 113-114 cm). In some samples *Reticulofenestra lockeri* and/or species of the genus *Discolithina* are abundant. Samples 16-6, 5-7 cm to 22-5, 60-61 cm (178.0-243.0 m) are barren of nannoplankton.

TABLE 3
Nannoplankton of Some Selected Samples From Site 336 (Northern Flank of the Iceland-Faeroe Ridge)

Sample (Interval in cm)	Age	*Coccolithus pelagicus*	*Gephyrocapsa ericsonii*	*Cyclococcolithus leptoporus*	*Helicosphaera carteri*	*Cyclococcolithus floridanus*	*Discolithina desueta*	*Discolithina enormis*	*Helicosphaera euphratis*	*Helicosphaera perch-nielsenae*	*Discoaster deflandrei*	*Coccolithus abisectus*	*Dictyococcites dictyodus*	*Reticulofenestra* sp.	*Reticulofenestra clatrata*	*Zygrhablithus bijugatus*	*Sphenolithus moriformis*	*Discolithina* cf. *distincta*	*Isthmolithus recurvus*	*Reticulofenestra umbilica*	*Discolithina pulcheroides*	*Transversopontis obliquipons*	*Braarudosphaera bigelowi*	*Cyclococcolithus formosus*	*Chiasmolithus oamaruensis*	*Cribrocentrum reticulatum*	*Rhabdosphaera tenuis*	*Rhabdosphaera crebra*	*Sphenolithus radians*	*Cyclococcolithus luminis*	*Discoaster barbadiensis*	*Discoaster tani nodifer*	*Zygolithus dubius*	Preservation	Reworked Species
1, CC		F																															G	C/E
2-3, 29-30		R																															G	C/E
3-1, 82-83		F																															G	
4-2, 90-91		R	A	F																													G	
4, CC	Quaternary	R	A	T	F																												G	
5-3, 105-106		R	A																														G	
5-6, 10-11			A	T	T																												G	
6-3, 95-96		T			T																												G	
6-6, 62-63		T		T																													G	
8-1, 110-111																																		
14, CC																	Barren																	
15-1, 13-14		A				A	R	R	T		T	T	F	A																			G	
15, CC	Middle	A				A		F	R								R																G	
16-2, 10-11	Oligocene	F				F				T	T																						G	
16-3, 122-123		A				A			R		R	A	F		A		R	F															G	
16-6, 5-6																																		
22-5, 60-61																	Barren																	
22-6, 120-121		R																	R	R	R	T	T										G	
23-2, 90-91		R																	R	R		T											G	
26-1, 78-79		R																	R	R		T	R		T								G	
26-6, 61-62																				R				T									G	
27, CC																			T	R				T		F							G	
28-6, 82-83		R																	F	F	R	T		T		R							G	
29-1, 131-132	Late Eocene																		R	R						R								G	
30-2, 140-141																			T	R		T	T										G	
30-6, 140-141		T																		F			R										G	
31, CC		R																		R							T	T	T				G	
32, CC																				R			T					T		R	T	T	R	G	
33, CC																				R	R	T	R							R			R	G	
36, CC																				R								:					T	G	

Samples 22-6, 120-121 cm to 37, CC (243.0-463.0 m) contain Eocene nannofossils. The sediments are very poor in nannoplankton which become frequent only in some samples. The assemblage is of low diversity. Discoasters are missing in the Eocene indicating a cold subarctic environment. The nannoplankton assemblage from Samples 22-6, 120-121 cm to 30-2, 140-141 cm (243.0-333.0 m) consists of *Isthmolithus recurvus, Reticulofenestra umbilica, Coccolithus pelagicus, Braarudosphaera bigelowi, Transversopontis obliquipons, Dictyococcites dictyodus, Chiasmolithus oamaruensis, Discolithina pulcheroides,* and *Cribrocentrum reticulatum* indicating a late Eocene age (NP 19/20).

The assemblage from Samples 30-3, 110-111 cm to 37, CC (333.0-463.0 m) consists of *Reticulofenestra umbilica, Transversopontis obliquipons, Braarudosphaera bigelowi, Discolithina pulcheroides, Coccolithus pelagicus*, and few specimens of *Rhabdosphaera tenuis, Rhabdosphaera crebra, Sphenolithus radians, Zygrhablithus bijugatus*, and *Cyclococcolithus luminis*. This assemblage indicates middle to lower upper Eocene. It is impossible to give a more exact age determination.

Site 337
(lat 64°52.30'N, long 05°20.51'W, water depth 2631 m)

Nannoplankton are present in Core 1 to Core 5 (0-47.0 m). Cores 6 to 12 (47.0-113.5 m) are barren of nannofossils, with only siliceous microfossils found in this sequence. *Emiliania huxleyi, Coccolithus pelagicus, Gephyrocapsa ericsonii*, and few specimens of *Cyclococcolithus leptoporus* and *Helicosphaera carteri* were observed in Core 1-1 (top) to Sample 1-2, 30-31 cm indicating the *Emiliania huxleyi* Zone.

In Samples 1-2, 104-105 cm to 3, CC, *Coccolithus pelagicus, Gephyrocapsa ericsonii*, and few specimens of *Syracosphaera pulchra, Cyclococcolithus leptoporus, Discolithina japonica*, and *Helicosphaera carteri* are present. Some nannofossil ooze layers in Cores 4 and 5, Section 2 consist only of *Coccolithus pelagicus* and/or *Gephyrocapsa* sp. Within these layers many coccospheres were observed. Nannofossils are generally well preserved, being slightly etched only in some samples.

Reworked Cretaceous and Eocene species were found in Core 1 to Core 3, Section 2. They are rare in the uppermost part of Core 1, but they are more fre-

quent in the lower part of this core. Some samples from Cores 2 and 3 are abundant in reworked species, while autochthonous nannofossils are nearly missing in these samples.

In the interval of Samples 5-2, 97-98 cm to 5-4, 22-23 cm *Coccolithus pelagicus, Reticulofenestra pseudoumbilica*, and few specimens of *Cyclococcolithus leptoporus* and *Cyclococcolithus macintyrei* were observed. These species indicate an early Miocene to early Pliocene age. It is not possible to give a more exact age determination due to the absence of index fossils (discoasters, ceratoliths, sphenoliths).

Site 338
(lat 67°47.11'N, long 05°23.26'E, water depth 1297 m)

Quaternary sediments were recovered in Cores 1 through 6 (0-57.0 m) (Table 4). The sediments contain only few nannoplankton, except some layers of nannofossil ooze. Reworked species of the Cretaceous and Eocene are common in some samples. The increase of reworked species is associated with an increase of ice-rafted material. The section from Samples 1-1 (top) to 1-2, 124-125 cm belongs to the *Emiliania huxleyi* Zone (Quaternary) with the following species: *Emiliania huxleyi, Cyclococcolithus leptoporus, Coccolithus pelagicus, Helicosphaera carteri, Syracosphaera pulchra, Gephyrocapsa ericsonii.* From Samples 1-4, 106-107 cm to 3-2, 133-134 cm, the same assemblage is present, but without *Emiliania huxleyi*. This part belongs to the *Gephyrocapsa oceanica* Zone.

Very few specimens of *Pseudoemiliania lacunosa* were found in Samples 3-3, 96-97 cm and 5-2, 98-99 cm together with *Gephyrocapsa ericsonii* indicating a Quaternary age. *Gephyrocapsa ericsonii* is also present in Sample 6, CC. Core 7 to Sample 19-4, 85-86 cm (66.5-187.5 m) are barren of nannoplankton.

The nannoplankton assemblage of the middle/upper Oligocene is present in Samples 19-2, 123-124 cm to 26-

TABLE 4
Nannoplankton of Some Selected Samples From Site 338 (Outer Voring Plateau)

Sample (Interval in cm)	Age	*Coccolithus pelagicus*	*Emiliania huxleyi*	*Gephyrocapsa ericsonii*	*Syracosphaera pulchra*	*Cyclococcolithus leptoporus*	*Helicosphaera carteri*	*Pseudoemiliania lacunosa*	*Reticulofenestra pseudoumbilica*	*Coccolithus abisectus*	*Discoaster deflandrei*	*Cyclococcolithus floridanus*	*Dictyococcites dictyodus*	*Reticulofenestra clatrata*	*Helicosphaera euphratis*	*Helicosphaera recta*	*Discolithina* sp.	*Discolithina desueta*	*Sphenolithus moriformis*	*Chiasmolithus altus*	*Reticulofenestra lockeri*	*Discolithina pulchera*	*Zygolithus dubius*	*Chiasmolithus solitus*	*Sphenolithus radians*	*Cyclococcolithus luminis*	*Imperiaster obscurus*	*Markalius inversus*	*Towelus eminens*	*Zygolithus protenus*	*Discolithina fimbriata*	*Braarudosphaera bigelowi*	*Discoasteroides kuepperi*	*Discoaster lodoensis*	*Martasterites tribrachiatus*	Preservation	Reworked Species
1-1		T	A	F	R	A																													G	C
1-1, 145-146		F	R	F	R																														M	C/E
1-2, 26-27				A	T	A	R																												G	C/E
1-3, 124-125		A	A	F	T	A																													G	C/E
2-3, 47-48		A		A		F																													G	C
2, CC	Quaternary	A		A		R	T																												G	C
3-2, 133-134		A		A		R	T																												P	C
3-3, 103-104		A				T		T																											G	
5-2, 98-99		R		R		R		T																											G	
5-3, 23-24		T					T		R																										G	C/E
6; CC		R							T																										G	C/E
7, CC																																				
19-5, 65-66																	Barren																			
19-5, 123-124		R								A	F	F	R																						P	
20-1, 126-127		A								A		A	R	F	T		R																		G	
20-3, 20-21		A								T	T	A	R	F				R	R																M	
20-4, 100-101		A								F		A	A	A	T		A				A														M	
20-5, 100-101		A								A	T		F	A			R	A																	M	
21-1, 67-68		A								A		A	A	A	R		R	F	R																M	
22-0, 35-36	Middle/Late	A								A		A	R				R	A	T		A														M	
22-6, 93-94	Oligocene	A								F		F	A	F				T		R	A														G	
23-1, 63-64										R			R	A							A														M	
23-6, 17-18		A								F		R	A	A		T		R	R	A															M	
24-1, 30-31		A								F	T	R	A	A				F		F	A														G	
24-6, 33-34		A								F		R	A	A					T	R	F														G	
25-1, 140-141		A								R			A	A					T	F															G	
26-1, 67-68		R								A		F	A	A																					P	
26-2, 109-110																																				
30, CC																																				
32-1, 60-61		T																					F	R	T	T	F	T		F				M	
32-4, 33-34		F																				A	A				A	R	R	T	F	T			G	
32-4, 95-96		R																				A	A			T	A	T	F		F	T	T		G	
33-4, 60-61	Early Eocene	R																				R	R			T	R		R	T		R			G	
33, CC		R																				F	A		T		F		R			T	R	T	T	G	
37-2, 92-93																							R				T									G	

1, 86-87 cm (187.5-248.0 m). Nannofossils are slightly etched in some samples. The assemblage consists of *Dictyococcites dictyodus, Coccolithus abisectus, Discolithina desueta, Cyclococcolithus floridanus, Reticulofenestra clatrata, Discoaster deflandrei, Coccolithus pelagicus, Sphenolithus moriformis, Reticulofenestra lockeri, Helicosphaera euphratis, Helicosphaera recta,* and *Chiasmolithus altus.* Samples 26-2, 109-110 cm to 31, CC (248.0-304.0 m) are without nannoplankton.

From Sample 32-1, 60-61 cm (304.0 m) a nannoplankton assemblage of lower Eocene (NP 12) was observed. The nannofossil content is low, and nannofossils are restricted to some horizons. The following species were observed: *Discolithina pulchra, Discolithina fimbriata, Zygolithus dubius, Cyclococcolithus luminis, Imperiaster obscurus, Braarudosphaera bigelowi, Toweius eminens, Micrantholithus mirabilis, Markalius inversus, Discoasteroides kuepperi, Coccolithus pelagicus, Zygolithus protenus,* and only a few specimens of *Chiasmolithus solitus* (32-1, 60-61 cm) and *Discoaster lodoensis* and *Marthasterites tribrachiatus* (33, CC). Below Sample 33, CC, nannofossils are very rare. In Sample 42-1, 69-70 cm, *Zygolithus dubius* was found, which has its first occurrence in the *Marthasterites tribrachiatus* Zone (NP 12) of the lower Eocene.

Site 339
(lat 67°12.65′N, long 06°17.05′E, water depth 1262 m)

"Glacial" sediments were recovered in Core 1 to Core 8 (0-74.5 m). The lower part of this sequence is mixed with underlying siliceous oozes of Miocene and Eocene age. Core 1-1 (top) to probably Sample 2-2, 96-97 cm (0-10.0 m) belongs to the *Emiliania huxleyi* Zone with *Emiliania huxleyi, Coccolithus pelagicus, Cyclococcolithus leptoporus, Gephyrocapsa ericsonii,* and very few specimens of *Syracosphaera pulchra* and *Helicosphaera carteri.* Reworked species are generally abundant. The assemblage of Samples 2-3, 72-73 cm and 4-4, 98-99 cm (10.0-33.0 m) consists mainly of *Coccolithus pelagicus* and *Gephyrocapsa ericsonii* and belongs to the *Gephyrocapsa oceanica* Zone.

In Samples 4, CC and 6-2, 128-129 cm (36.5-49.0 m), a few specimens of *Pseudoemiliania lacunosa* (small) were observed. This part may belong to the interval with *Pseudoemiliania lacunosa.* The sediments of Core 6, Section 3 through Core 8 (49.0-74.5 m) are a mixture of "Glacial" sediments and underlying siliceous oozes.

In Sample 6-3, 39-40 cm, a few slightly etched nannofossils were found (*Coccolithus pelagicus, Reticulofenestra pseudoumbilica*) together with silicoflagellates of middle Miocene age. An Eocene silicoflagellate assemblage is present in Samples 7-2, 20-21 cm and 7-2, 83-84 cm with only few specimens of *Coccolithus pelagicus* and *Reticulofenestra umbilica.* Sample 7-3, 61-62 cm is abundant in nannoplankton with *Reticulofenestra pseudoumbilica, Helicosphaera carteri, Coccolithus pelagicus, Cyclococcolithus leptoporus, Braarudosphaera bigelowi, Sphenolithus abies, Discolithina japonica,* and *Discolithina* sp. together with a mixed silicoflagellate assemblage of Miocene and Eocene species. In Samples 7-3, 102-103 cm and 8-1, 20-21 cm, Eocene silicoflagellates are present together with Pleistocene nannofossils (*Gephyrocapsa ericsonii, Cyclococcolithus leptoporus*). In Sample 8, CC, only *Coccolithus pelagicus* was found with many reworked species of the Cretaceous and Eocene. Below this level, sediments are barren of nannoplankton.

Site 340
(lat 67°12.47′N, long 06°18.38′E, water depth 1217 m)

Nannofossils were only found in Core 1. The assemblage belongs to the *Emiliania huxleyi* Zone with *Emiliania huxleyi, Coccolithus pelagicus, Gephyrocapsa ericsonii,* and *Cyclococcolithus leptoporus.* In the lower part of this core, Quaternary sediments are mixed with underlying siliceous oozes.

Site 341
(lat 67°20.10′N, long 06°06.64′E, water depth 1439 m)

"Glacial" sediments were encountered in Cores 1 to 25 (0-335.5 m). The sequence can be subdivided into four units.

Unit 1: Cores 1 to 3 (0-28.5 m) with Quaternary species: *Coccolithus pelagicus, Gephyrocapsa ericsonii,* and a few specimens of *Helicosphaera carteri, Syracosphaera pulchra, Cyclococcolithus leptoporus. Emiliania huxleyi* was observed from Core 1-1 (top) to Sample 2-1, 112-113 cm. Nannofossils are rare, enriched only in nannofossil ooze layers. Reworked species of the Cretaceous and Tertiary are generally common in all samples except those of the nannofossil ooze.

Unit 2: Samples 4, CC to 7, CC (28.5-66.5 m) consist of a siliceous ooze with silicoflagellates and nannofossils of middle/late Miocene age. These sediments are intercalated in the Quaternary sequence. A few reworked nannofossils of the Cretaceous and Eocene were also found.

Unit 3: In Core 8 to Sample 19, CC (66.5-228.0 m) autochthonous nannofossils are rare: *Coccolithus pelagicus, Cyclococcolithus leptoporus, Pseudoemiliania* cf. *lacunosa.* The high amount of reworked Cretaceous and Eocene species corresponds to an increase of ice-rafted material.

Unit 4: In Cores 20 to 25 (237.5-342.0 m), well-preserved nannofossils are common with *Coccolithus pelagicus, Gephyrocapsa* sp., *Cyclococcolithus leptoporus, Helicosphaera carteri, Discolithina japonica,* and *Pseudoemiliania lacunosa.* This part of the profile may belong to the lower Quaternary or upper Pliocene. In Cores 26 to 33 (351.5-446.5 m), the nannoplankton assemblage consists of *Coccolithus pelagicus, Reticulofenestra pseudoumbilica, Discolithina japonica, Helicosphaera carteri,* and a few specimens of *Sphenolithus abies* indicating a Miocene to early Pliocene age. Nannofossils are restricted to several nannofossil ooze layers intercalated in siliceous sediments. In some layers they are etched.

Site 342
(lat 67°57.04′N, long 04°56.02′E, water depth 1303 m)

Nannoplankton are present in Cores 1 and 2 (0-47.0 m). The assemblage belongs to the Quaternary with following species: *Coccolithus pelagicus, Cyclococcolithus leptoporus, Gephyrocapsa ericsonii, Helicosphaera carteri,* and *Emiliania huxleyi.* Reworked Cretaceous and Eocene nannofossils were

found in most samples. Sediments of the lower part of the profile are barren of nannoplankton (85.0-151.5 m).

Site 343
(lat 68°42.91'N, long 05°45.73'E, water depth 3131 m)

Quaternary sediments were recovered in Cores 1 to 4 (0-107.5 m). Core 1 belongs to the *Emiliania huxleyi* Zone with an assemblage of *Coccolithus pelagicus, Emiliania huxleyi, Gephyrocapsa ericsonii, Cyclococcolithus leptoporus*, and very few specimens of *Syracosphaera pulchra* and *Helicosphaera carteri* (Table 5). Reworked species of the Cretaceous and Eocene are generally frequent. Some nannofossil ooze layers are present in Core 2, having abundant *Coccolithus pelagicus* and *Gephyrocapsa ericsonii*. Reworked species were observed only sporadically in these layers. In Core 3, Section 5 a thin layer of siliceous ooze is intercalated, probably displaced by slumping. Sample 4-3, 80-81 cm (98.0-107.5 m) still contains Quaternary species.

In Sample 5-3, 40-41 cm (145.5-155.0 m) a few specimens of poorly preserved *Discolithina pulcheroides* and *Micrantholithus* sp. were observed, indicating an Eocene age. In Samples 5-3, 100-101 cm to 7-1, 10-11 cm (150.0-203.5 m) nannoplankton is missing.

Sample 7-1, 95-96 cm contains *Imperiaster obscurus, Zygolithus dubius*, and *Micrantholithus mirabilis* which indicate an early Eocene age. This assemblage is present in Cores 7 through 16 (204.0-284.0 m) together with *Cyclococcolithus luminis, Braarudosphaera bigelowi, Discolithina pulchra, Coccolithus pelagicus. Discoaster lodoensis* and *Chiasmolithus solitus* were found in Samples 8, CC and 15-2, 105-106 cm. Nannofossils are rare in the Eocene sediments and are slightly etched.

Site 344
(lat 76°08.98'N, long 07°52.52'E, water depth 2156 m)

Nannofossils are present in only some horizons. Samples 1, CC, 2-2, 37-38 cm, and 2-2, 57-58 cm are abundant in well-preserved nannoplankton (1.5-11.0 m). The assemblage consists of *Coccolithus pelagicus, Gephyrocapsa ericsonii, Helicosphaera carteri*, and *Cyclococcolithus leptoporus*. Only a few reworked Cretaceous and Eocene species were found.

Cores 3 to 15 (11.0-134.5 m) are barren of nannofossils. Only in Core 7, Section 4 a layer of nannofossil ooze, contains abundant *Coccolithus pelagicus* and *Gephyrocapsa* cf. *caribbeanica*. The same species were found in Sample 14, CC (125.0 m), and in some samples of Core 15 (125.0-134.5 m), in which they are slightly etched.

Cores 16 through 19 (134.5-172.5 m) are without nannoplankton. The assemblage of Sample 19, CC with *Reticulofenestra pseudoumbilica, Coccolithus pelagicus, Helicosphaera sellii, Braarudosphaera bigelowi*, and *Cyclococcolithus leptoporus* indicates an early Miocene to early Pliocene age.

Cores 20 to 29 (172.5-286.5 m) are barren of nannoplankton. In some samples of Cores 30 to 33 (286.5-377.5 m), few nannofossils were observed: *Coccolithus pelagicus, Helicosphaera carteri, Reticulofenestra pseudoumbilica*, and *Cyclococcolithus leptoporus* indicating that the sediments are at least not older than Miocene.

Site 345
(lat 69°50.23'N, long 01°14.26'W, water depth 3195 m)

Nannofossils were found in Cores 1 to 4 (0-36.5 m). They are abundant in nannofossil ooze layers inter-

TABLE 5
Nannoplankton of Some Selected Samples From Site 343 (Lofoten Basin)

Sample (Interval in cm)	Age	*Coccolithus pelagicus*	*Gephyrocapsa ericsonii*	*Emiliania huxleyi*	*Cyclococcolithus leptoporus*	*Syracosphaera pulchra*	*Helicosphaera carteri*	*Discolithina pulchra*	*Chiasmolithus solitus*	*Zygolithus dubius*	*Discoaster lodoensis*	*Imperiaster obscurus*	*Cyclococcolithus luminis*	*Discoasteroides kuepperi*	Preservation	Reworked Species
1-1, top	Quaternary	A	A	F	R										G	C/E
1, CC		R	A	R	T	T	T								G	C/E
2-3, 80-81		A	A		R										G	C
2, CC		T	A												G	C
4-3, 80-81		R	A		F		R								G	C
5-3, 100-101		Barren														
6-1, 128-129																
8, CC	Lower Eocene	T						R	R	T	T			T	G	
11-1, 115-116		T						R		R		F	T		G	
11, CC		R						R		R		T	T		G	
15-2, 35-36												R	T		G	
15-2, 105-106								R		F	T	A	R		G	
16-3, 140-141								R		T		T	T		G	

calated in Quaternary sediments. Core 1 belongs to the *Emiliania huxleyi* Zone. The following species were determined: *Emiliania huxleyi, Coccolithus pelagicus, Gephyrocapsa ericsonii,* and a few specimens of *Syracosphaera pulchra, Cyclococcolithus leptoporus,* and *Helicosphaera carteri.* The same assemblage was observed in Core 2, but without *Emiliania huxleyi.* This core may belong to the *Gephyrocapsa oceanica* Zone. *Pseudoemiliania lacunosa* is present from Samples 3-2, 35-36 cm to 4-2, 42-43 cm, indicating the interval with *Pseudoemiliania lacunosa.*

Preservation of the nannoplankton is good in the nannofossil ooze, but they are slightly etched in other samples. Reworked Cretaceous and Eocene species were found in all samples. Below Core 4 (36.5-802.0 m), nannofossils are absent.

Site 346
(lat 69°53.35′N, long 08°41.14′W, water depth 732 m)

Nannofossils are present only in Core 1 and very few are present in Core 2 (0-16.0 m) of the Quaternary sediments. Core 1 belongs to the *Emiliania huxleyi* Zone with *Emiliania huxleyi, Coccolithus pelagicus, Gephyrocapsa ericsonii,* and some specimens of *Cyclococcolithus leptoporus.* Only a few reworked species of the Cretaceous and Eocene were found. All other cores are barren of nannoplankton. Only in Sample 4-2, 37-38 cm (25.5-35.0 m) were a few specimens of *Cyclococcolithus leptoporus, Coccolithus pelagicus,* and *Helicosphaera carteri* observed.

Site 347
(lat 69°52.31′N, long 08°41.80′W, water depth 745 m)

Nannofossils were found only in Cores 1 to 2 (0-128.0 m), below the sediments are barren of nannoplankton. *Coccolithus pelagicus* becomes very frequent and is the only species in thin nannofossil ooze layers. *Emiliania huxleyi* and *Gephyrocapsa ericsonii* are present in Core 1, Section 2. *Cyclococcolithus leptoporus* was observed sporadically. The amount of reworked Cretaceous and Eocene species is very low. In Core 2, Section 2 and Core 3, a few specimens of *Reticulofenestra* cf. *umbilica, Zygolithus dubius,* and *Discolithina* sp. were found, indicating a middle to lower late Eocene age (121.0-137.5 m).

Site 348
(lat 68°30.18′N, long 12°27.72′W, water depth 1763 m)

At Site 348 (Table 6) a probably complete section of upper Oligocene to Quaternary was recovered. Nannofossils are present in Cores 1 and 2 (0-18.5 m). Sample 1-1 (top) is abundant in well-preserved nannoplankton. The assemblage is of low diversity with *Coccolithus pelagicus, Emiliania huxleyi, Gephyrocapsa ericsonii,* and rare specimens of *Cyclococcolithus leptoporus.* The same assemblage was observed in the other samples of Cores 1 and 2, plus a few specimens of *Helicosphaera carteri.* The preservation is very good in the nannofossil ooze layers. Only a few reworked species were observed in these horizons.

Cores 3 to 5 (18.5-66.0 m) are barren of nannoplankton. In Cores 6 to 11 (66.0-161.0 m), some thin layers of nannofossil ooze are intercalated in the siliceous ooze, containing only *Coccolithus pelagicus.*

Cores 12 through 23 (161.0-332.0 m) are without nannoplankton. *Helicosphaera ampliaperta, Coccolithus pelagicus,* and *Reticulofenestra pseudoumbilica* were found in Samples 24-4, 118-119 cm to 26-3, 48-49 cm (341.5-408.0 m) indicating an early Miocene age (NN 3/NN 4). Cores 27 through 33 (427.0-541.0 m) are barren of nannofossils.

Site 349
(lat 69°12.41′N, long 08°05.80′E, water depth 915 m)

Sediments recovered at Site 349 are extremely poor in nannoplankton. In Cores 1 and 2 (0-63.0 m), *Coccolithus pelagicus, Cyclococcolithus leptoporus, Helicosphaera carteri, Gephyrocapsa ericsonii,* and reworked species of the Cretaceous and Eocene were found.

Cores 3 through 5 (91.5-120.0 m) are barren of nannoplankton. In Samples 5-6, 148-149 cm to 12-4, 84-85 cm (110.5-272.0 m) an assemblage was observed indicating a late Eocene age. Only a few nannofossils are present in some horizons of this interval, being slightly etched. The assemblage consists of *Isthmolithus recurvus, Reticulofenestra umbilica, Dictyococcites dictyodus, Cyclococco-lithus floridanus, Braarudosphaera bigelowi, Cyclococcolithus luminus, Cribrocentrum reticulatum.*

Site 350
(lat 67°03.34′N, long 08°17.68′W, water depth 1275 m)

Sediments recovered at Site 350 are extremely poor in nannofossils. They were found only in the Quaternary sediments of Core 1. *Coccolithus pelagicus* is very abundant in Core 1-1 (top), while *Gephyrocapsa ericsonii* is the only species found in Sample 1-2, 48-49 cm. Reworked Cretaceous and Eocene species are present in all samples, but they are missing in the nannofossil ooze layers. These layers probably indicate an influx of warmer water. In Sample 14-2, 43-44 cm a few specimens of *Isthmolithus recurvus* and *Reticulofenestra umbilica* were found, indicating a late Eocene to early Oligocene age.

Site 352
(lat 63°38.97′N, long 12°28.26′W, water depth 990 m)

The "Glacial" sequence recovered at Site 352 (Cores 1 through 6, 0-54.5 m) is poor in nannoplankton. The diversity of species is low, and the amount of nannofossils in the sediments is small. *Coccolithus pelagicus* and *Gephyrocapsa ericsonii* are the only species which are more frequent. *Cyclococcolithus leptoporus* and *Helicosphaera carteri* are very rare. Most of the samples contain only reworked Cretaceous and Eocene species.

Cores 4 and 5 (27.5-38.0 m) are barren of nannoplankton. In Sample 6, CC, some white sediment fragments were found containing a very rich nannoplankton assemblage of middle/late Oligocene age (*Sphenolithus distentus/Sphenolithus ciperoensis* Zone, NP 24/NP 25) with *Dictyococcites dictyodus, Zygrhablithus bijugatus, Coccolithus abisectus, Cyclococcolithus floridanus, Coccolithus pelagicus, Chiasmolithus altus, Sphenolithus moriformis, Helicosphaera euphratis,* and *Reticulofenestra clatrata.* It is supposed that in Sample 6, CC, the Oligocene was just touched, which is overlain by the "Glacial" sequence. At least, portions of the Pliocene and Miocene are missing.

TABLE 6
Nannoplankton of Some Selected Samples From Site 349 (Jan-Mayen Ridge)

Sample (Interval in cm)	Age	*Coccolithus pelagicus*	*Gephyrocapsa ericsonii*	*Emiliania huxleyi*	*Cyclococcolithus leptoporus*	*Helicosphaera carteri*	*Reticulofenestra umbilica*	*Reticulofenestra* sp.	*Braarudosphaera bigelowi*	*Cribrocentrum reticulatum*	*Isthmolithus recurvus*	*Transversopontis obliquipons*	*Cyclococcolithus luminis*	*Cyclococcolithus floridanus*	*Dictyococcites dictyodus*	Preservation	Reworked Species
1-1, top	Quaternary	A			T											G	
1-1, 85-86		T	A	R												G	C
2-1, 17-18		A				T										G	C/E
2-1, 140-141		Barren															
5-6, 80-81																	
5-6, 148-149	Early Oligocene-late Eocene						R							T	T	P	
6-2, 73-74							R	R	T	F	F		T	R		G	
6-3, 40-41							T				T					P	
6-4, 93-94							R					T				G	
6-5, 60-61							R	R								G	
9-3, 87-88							R	T	T		R			R	R	G	
10-5, 38-39							R	R			R				T	M	
10-6, 13-14							R				T				T	M	
12-4, 84-85							T										

The middle/upper Oligocene (NP 24) was encountered at Hole 352A at 94 meters. The sediments consist of a white nannofossil ooze, rich in foraminifers and sponge spicules, while diatoms, radiolarians, and silicoflagellates are missing.

The nannoplankton assemblage is of a high diversity consisting of: *Dictyococcites dictyodus, Cyclococcolithus floridanus, Coccolithus abisectus, Sphenolithus moriformis, Coccolithus pelagicus, Zygrhablithus bijugatus, Chiasmolithus altus, Helicosphaera recta, Discoaster deflandrei, Discolithina desueta, Helicosphaera euphratis, Braarudosphaera bigelowi,* and *Reticulofenestra clatrata.* The preservation is good in Core 1, but nannofossils are overgrown in Cores 2 and 3. *Zygrhablithus bijugatus* becomes very frequent in the Oligocene indicating a shallow-water environment. The assemblage is comparable with that observed at Site 336 (north of the Iceland-Faeroe Ridge), however, *Zygrhablithus bijugatus* is nearly absent at Site 336. The unconformity encountered at Holes 352 and 352A (Glacial to middle Oligocene) is also present at Site 336.

COMPARISON OF NANNOPLANKTON ASSEMBLAGES AND THEIR DISTRIBUTION IN THE NORWEGIAN-GREENLAND SEA, NORTH ATLANTIC (LEG 12) AND NORTHERN EUROPE

Comparison of nannoplankton distribution and nannoplankton assemblages of the Norwegian-Greenland Sea, North Atlantic, and northern Europe shows some differences due to latitudinal differentiations, and/or due to separation of the Norwegian-Greenland Sea from the Atlantic by a barrier in the Iceland-Faeroe area. The oldest sediments recovered during Leg 38 are of early Eocene age (interval with *Imperiaster obscurus,* approximately NP 11/NP 12 of the standard zonation). The relatively high diversified nannoplankton assemblage of this stratigraphic interval is comparable with the assemblage of the North Atlantic and northern Europe (Table 7). This observation indicates similar temperature conditions during the lower Eocene in the northern regions. However, a slight decrease of nannoplankton content and of specimens and species of the genus *Discoaster, Marthasterites tribrachiatus,* and *Chiasmolithus grandis* can be observed from the Bay of Biscay (Leg 12, Sites 118 and 119 45°N), to northern Europe, North Atlantic (54-57°N), and Norwegian-Greenland Sea (Vøring Plateau, Site 338, Lofoten Basin, Site 343, and Norway Basin, Core AS1-9, 66-68°N), caused by latitudinal differentiation.

The early Eocene nannoplankton assemblage of Rockall Bank (Site 117A, 57°N) and the Norwegian-Greenland Sea (Sites 338, 343, and Core AS1-9, 66-68°N) are very similar to those of northern Germany. Also, the benthonic foraminifera assemblages show elements from the north German "Eozän 3" (van Hinte, this volume; Berggren, 1975). *Imperiaster obscurus* and *Micrantholithus mirabilis* which are typical in the early Eocene sediments of the Norwegian-Greenland Sea were also reported from the Rockall Bank (Bukry, 1972) and northern Europe (Denmark, England, Belgium, and northern Germany) by Martini (1958, 1970), Perch-Nielsen (1968), Müller (in preparation). These species were not found in the lower Eocene at Site 111A (seamount "Orphan Knoll," 50°N) or at Sites 118 and 119 in the Bay of Biscay (45°N). *Imperiaster obscurus* is a cold water species and probably indicates also a shallow-water environment. It is unknown from early Eocene sediments of an open ocean environment. According to investigations of

TABLE 7
Comparison of the Nannoplankton Assemblages From the Norwegian-Greenland Sea, Rockall Bank, North Atlantic, and Northern Europe of the Lower Eocene

Species	Norwegian-Greenland Sea, 64°-67°N	Rockall Bank Site 117, 57°N	North Atlantic 45°-60°N	Northern Europe 52°-56°N
Chiasmolithus grandis	X	X	X	X
Chiasmolithus solitus	(X)[a]	–	X	X
Coccolithus pelagicus	X	X	X	X
Cyclococcolithus luminis	X	X	X	X
Discoaster barbadiensis	–	X	X	X
Discoaster binodosus	–	X	X	X
Discoaster lodoensis	(X)	X	X	X
Discoasteroides kuepperi	X	X	X	X
Discolithina fimbriata	X	X	X	X
Discolithina pulchra	X	X	X	X
Imperiaster obscurus	X	X	–	X
Lophodolithus nascens	–	X	X	X
Marthasterites tribrachiatus	(X)	X	X	X
Micrantholithus mirabilis	X	X	–	X
Zygolithus dubius	X	X	X	X

[a] (X) = traces.

benthonic foraminifera (Berggren, 1975), the Rockall Bank had a depth of 100-200 meters at this time. Also the presence of neritic species like *Micrantholithus mirabilis* and species of the genus *Discolithina* indicates shallow water. A separation of the Norwegian-Greenland Sea from the Atlantic is suggested for the middle Eocene until the upper Miocene-Pliocene, with a short interruption and influx of North Atlantic water during the middle-upper Oligocene.

The great differences existing between the middle Eocene nannoplankton assemblages of northern Europe (Denmark and northern Germany) and the North Atlantic (Site 112, Labrador Sea) compared with those of the Norwegian-Greenland Sea cannot be explained only by latitudinal differentiation (Table 8). The nannoplankton assemblages in the Norwegian-Greenland Sea are of extreme low diversity (*Reticulofenestra umbilica, Zygolithus dubius, Braarudosphaera bigelowi*), and the sediments are very poor in nannoplankton. However, the assumption that these assemblages are the result of dissolution due to the position of the CCD in the Norwegian-Greenland Sea would also indicate rather different conditions from those existing in northern Europe and the Atlantic during this stratigraphic interval. The nannoplankton assemblages of northern Europe and the North Atlantic are of high diversity, and the middle Eocene sediments of northern Germany have the highest amount of nannofossils, indicating an influx of Atlantic water with a high productivity.

The upper Eocene nannoplankton assemblage of the Norwegian-Greenland Sea is more diversified (*Isthmolithus recurvus, Reticulofenestra umbilica, Dictyococcites dictyodus, Cribrocentrum reticulatum, Discolithina pulcheroides,* and *Coccolithus pelagicus*), however, the nannofossil content is still very low.

Middle to upper Oligocene nannofossil ooze was recovered in the Norwegian-Greenland Sea at Holes 352A and 336 (south and north flank of the Iceland-Faeroe Ridge) and at Site 338 (Outer Vøring Plateau). Calcareous nannoplankton is missing in all other holes where Oligocene sediments were encountered. Age determination is based on the presence of arenaceous benthonic foraminifers and dinoflagellates. A high influx of Atlantic water across the Iceland-Faeroe Ridge into the Norwegian-Greenland Sea is assumed. The current pattern may be similar to the present Norwegian Current, reflected by the distribution of the nannofossil ooze in the Norwegian-Greenland Sea. The assemblages of this stratigraphic interval are of a high diversity in the Norwegian-Greenland Sea and are comparable with those from the North Atlantic with *Discoaster deflandrei* and *Chiasmolithus altus* (Table 9). They are missing in the middle-late Oligocene sediments of northern Germany.

Both species were also reported from the southern high latitudes (Burns, 1975; Edwards and Perch-Nielsen, 1975). An increase of calcareous nannoplankton and a more diversified assemblage of middle-late Oligocene sediments is also mentioned by Worsley, 1973 (Leg 19) and Wise, 1973 (Leg 18) from the North Pacific and Bering Sea. The same observation was published by Burns, 1975 (Leg 28) and Edwards and Perch-Nielsen, 1975 (Leg 29) in the southern high latitudes. These results indicate a worldwide event probably related to a change of the current pattern. This event, in northern Europe, is associated with a transgression.

Nannoplankton assemblages recovered at Hole 352A on the southern flank of the Iceland-Faeroe Ridge indicate a shallow-water environment. It is extremely rich in the neritic species *Zygrhablithus bijugatus*, which was also reported in great abundance from the middle Oligocene sediments of the Rockall Bank (Bukry, 1972). *Zygrhablithus bijugatus* is nearly absent at Sites 336 and 338. The Oligocene nannoplankton assemblage of all these areas is distinguished by the abundance of reticulate coccoliths. They are nearly absent in the tropical and subtropical zones of the open oceans. Sphenoliths (*Sphenolithus predistentus, Sphenolithus*

TABLE 8
Comparison of Nannoplankton Assemblages From the Norwegian-Greenland Sea, North Atlantic, and Northern Europe of the Middle and Upper Eocene

Species	Norwegian-Greenland Sea, 64°-74°N	North Atlantic Site 112, 54°N	Northern Europe 52°-56°N
Chiasmolithus gigas	–	X	–
Chiasmolithus grandis	–	X	X
Chiasmolithus oamaruensis	(X)[a]	X	X
Chiasmolithus solitus	–	X	X
Chiphragmalithus alatus	–	X	X
Coccolithus pelagicus	X	X	X
Coccolithus staurion	–	X	X
Cribrocentrum reticulatum	X	X	X
Cyclococcolithus floridanus	X	X	X
Cyclococcolithus formosus	–	X	X
Cyclococcolithus luminis	X	X	X
Dictyococcites dictyodus	X	X	X
Discoaster barbadiensis	–	X	X
Discoaster binodosus	–	X	X
Discoaster distinctus	–	X	X
Discoaster elegans	–	–	X
Discoaster lenticularis	–	X	X
Discoaster lodoensis	–	X	X
Discoaster saipanensis	–	X	X
Discoaster sublodoensis	–	X	X
Discoaster tani nodifer	(X)	X	X
Discolithina pulcheroides	X	X	X
Ericsonia fenestrata	–	X	X
Helicosphaera compacta	–	X	X
Helicosphaera seminulum	–	X	X
Isthmolithus recurvus	X	X	X
Rhabdosphaera gladius	–	–	X
Rhabdosphaera spinula	(X)	X	X
Transversopontis obliquipons	X	X	X
Zygolithus dubius	X	X	X
Zygrhablithus bijugatus	–	X	X

[a](X) = traces.

TABLE 9
Comparison of Nannoplankton Assemblages From the Norwegian-Greenland Sea, Rockall Bank, North Atlantic, and Northern Europe of the Middle Oligocene

Species	Norwegian-Greenland Sea, Site 352A, 63°N	Rockall Bank Sites 116, 117 57°N	North Atlantic 45°-54°N	Northern Europe 52°-56°N
Chiasmolithus altus	X	X	X	–
Coccolithus abisectus	X	X	X	X
Coccolithus pelagicus	X	X	X	X
Cyclococcolithus floridanus	X	X	X	X
Dictyococcites dictyodus	X	X	X	X
Discoaster deflandrei	X	X	X	–
Discolithina desueta	X	–	–	X
Discolithina cf. *distincta*	X	X	X	X
Helicosphaera euphratis	X	X	X	X
Helicosphaera recta	X	X	–	X
Reticulofenestra clatrata	X	–	–	X
Reticulofenestra lockeri	X	–	–	X
Sphenolithus ciperoensis	–	X	–	–
Sphenolithus distentus	–	X	X	–
Sphenolithus moriformis	X	X	X	X
Sphenolithus predistentus	–	X	X	(X)
Zygrhablithus bijugatus	X	X	–	X

distentus, and *Sphenolithus ciperoensis*) are missing or are present only sporadically in northern Europe. They are also absent in the Norwegian-Greenland Sea, while a few specimens were found in the North Atlantic, Sites 112 and 117 (Perch-Nielsen, 1972).

Nannoplankton content of Neogene sediments, and diversity of the assemblages from the Norwegian-Greenland Sea and northern Europe are very low (Table 10). The Oligocene/Miocene boundary in northern Germany is marked by an almost complete disappearance of nannoplankton (Martini and Müller, 1973) connected with a regressive phase. The *Helicosphaera ampliaperta* Zone (NN 4) and *Sphenolithus heteromorphus* Zone (NN 5) of the lower-middle Miocene are well represented in northern Europe (northern Germany and Belgium, Martini and Müller, 1973) and in the English Channel (Martini, 1974). This penetration of warmer Atlantic water further north is again associated with a transgression in northern Germany.

Sphenolithus heteromorphus, a species of warmer water is also present in the north Atlantic (Rockall Bank, Site 116) and few specimens were found in the northern North Sea (Müller, unpublished), probably coming through the English Channel. This species is missing in the Norwegian-Greenland Sea either due to latitudinal differentiation, or more likely due to separation of the Norwegian-Greenland Sea from the Atlantic by the Iceland-Faeroe Ridge, which still acted as a barrier at this time (Strauch, 1970). The unconformities noted at Sites 336 and 352 (respectively, on the northern and southern flank of this ridge), including the stratigraphic interval of the Miocene and a part of the Pliocene, may confirm this assumption. However, it is not known if these unconformities are caused by nondeposition or erosion.

Quaternary nannoplankton assemblages of the North Atlantic and the Norwegian-Greenland Sea are comparable. They are of low species diversity, and the sediments are generally poor in nannofossils due to dilution by the high input of ice-rafted material. Nannofossils are smaller and more fragile in these regions compared to low and mid latitudes, caused by lower water temperature. In the "Glacial" sediments, reworked Cretaceous and Eocene nannofossils were found in the Norwegian-Greenland Sea as well as in the North Atlantic (Perch-Nielsen, 1972).

LIST OF SPECIES USED IN THIS REPORT

Braarudosphaera bigelowi (Gran and Braarud) Deflandre, 1947
Chiasmolithus altus Bukry and Percival, 1971
Chiasmolithus oamaruensis (Deflandre and Fert) Hay, Mohler, and Wade, 1966
Chiasmolithus solitus (Bramlette and Sullivan) Locker, 1968
Coccolithus abisectus Müller, 1970
Coccolithus pelagicus (Wallich) Schiller, 1930
Cribrocentrum reticulatum (Gartner and Smith) Perch-Nielsen, 1971
Cyclococcolithus floridanus (Roth and Hay) Hay, 1970
Cyclococcolithus formosus Kamptner, 1963
Cyclococcolithus leptoporus (Murray and Blackman) Kamptner, 1954
Cyclococcolithus luminis Sullivan, 1965
Dictyococcites dictyodus (Deflandre and Fert) Martini, 1969
Discoaster deflandrei Bramlette and Sullivan, 1954
Discoaster lodoensis Bramlette and Riedel, 1954
Discoasteroides kuepperi (Stradner) Bramlette and Sullivan, 1961
Discolithina desueta Müller, 1970
Discolithina enormis Locker, 1967

TABLE 10
Comparison of Nannoplankton Assemblages From the Norwegian-Greenland Sea, Northern Europe and the North Atlantic of the Neogene

Species	Norwegian-Greenland Sea, 64°-74°N	Northern Europe 52°-54°N	North Atlantic, Site 112 Rockall Bank, Site 116 54°-57°N
Ceratolithus rugosus	–	–	X
Ceratolithus tricorniculatus	–	–	X
Coccolithus pelagicus	X	X	X
Cyclococcolithus leptoporus	X	X	X
Cyclococcolithus macintyeri	(X)[a]	–	X
Discoaster bollii	–	–	X
Discoaster brouweri	–	–	X
Discoaster calcaris	–	–	X
Discoaster deflandrei	–	–	X
Discoaster exilis	–	–	X
Discoaster hamatus	–	–	X
Discoaster neohamatus	–	–	X
Discoaster pentaradiatus	–	–	X
Discoaster surculus	–	–	X
Discoaster variabilis	–	–	X
Discolithina japonica	X	–	X
Helicosphaera ampliaperta	X	X	X
Helicosphaera carteri	X	X	X
Helicosphaera sellii	X	X	X
Pseudoemiliania lacunosa	X	–	X
Sphenolithus abies	(X)	–	X
Sphenolithus heteromorphus	–	X	X
Triquetrorhabdulus carinatus	–	–	X
Triquetrorhabdulus rugosus	–	–	X

[a](X) = traces.

Discolithina japonica Takayama, 1967
Discolithina pulchra (Deflandre and Fert) Levin, 1965
Discolithina pulcheroides (Sullivan) Levin and Joerger, 1967
Emiliania huxleyi (Lohmann) Hay and Mohler, 1967
Gephyrocapsa ericsonii McIntyre and Bé, 1967
Helicosphaera ampliaperta Bramlette and Wilcoxon, 1967
Helicosphaera carteri (Wallich) Kamptner, 1954
Helicosphaera euphratis Haq, 1966
Helicosphaera perch-nielseniae Haq, 1971
Helicosphaera recta Haq, 1966
Helicosphaera sellii Bukry and Bramlette, 1969
Imperiaster obscurus (Martini) Martini, 1970
Isthmolithus recurvus Deflandre, 1954
Marthasterites tribrachiatus (Bramlette and Riedel) Deflandre, 1959
Micrantholithus mirabilis Locker, 1965
Pseudocmiliania lacunosa (Kamptner) Gartner, 1969
Reticulofenestra clatrata Müller, 1970
Reticulofenestra lockeri Müller, 1970
Reticulofenestra pseudoumbilica (Gartner) Gartner, 1969
Reticulofenestra umbilica (Levin) Martini and Ritzkowski, 1968
Syracosphaera pulchra Lohmann, 1902
Sphenolithus abies Deflandre and Fert, 1954
Sphenolithus moriformis (Brönnimann and Stradner) Bramlette and Wilcoxon, 1967
Sphenolithus radians Deflandre, 1954
Transversopontis obliquipons (Deflandre and Fert) Hay, Mohler and Wade, 1960
Zygolithus dubius Deflandre and Fert, 1954
Zygrhablithus bijugatus (Deflandre) Deflandre, 1959

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PLATE 1

Figure 1 *Gephyrocapsa ericsonii* McIntyre and Bé, 1967. SEM 1000×. Sample 337-1-4, 60-61 cm.

Figure 2 *Coccolithus pelagicus* (Wallich) Schiller, 1930. SEM 5000×. Sample 337-3-5, 35-36 cm.

Figure 3 *Gephyrocapsa ericsonii* McIntyre and Bé, 1967. SEM 10,000×. Sample 337-1-4, 83-84 cm.

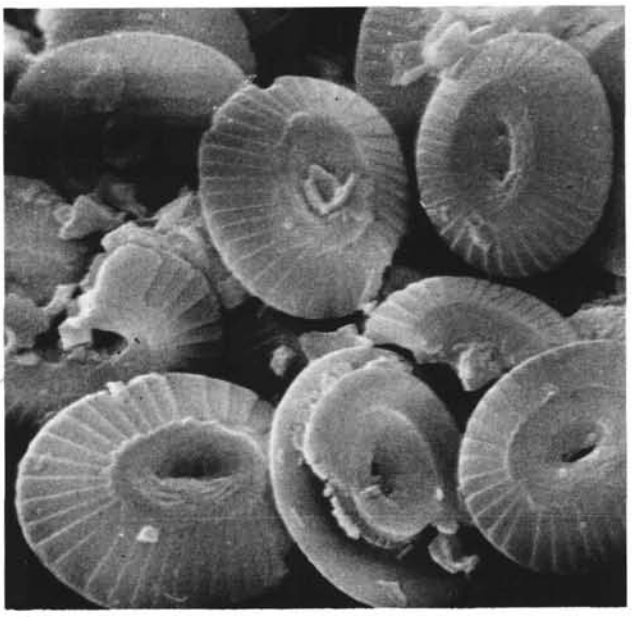
Figure 4 *Gephyrocapsa ericsonii* McIntyre and Bé, 1967. Distal side, SEM 20,000×. Sample 337-1-4, 60-61 cm.

Figure 5 *Coccolithus pelagicus* (Wallich) Schiller, 1930. Distal side, SEM 10,000×. Sample 337-3-5, 35-36 cm.

Figure 6 *Coccolithus pelagicus* (Wallich) Schiller, 1930. Proximal side, SEM 10,000×. Sample 337-3-5, 35-36 cm.

PLATE 1

1



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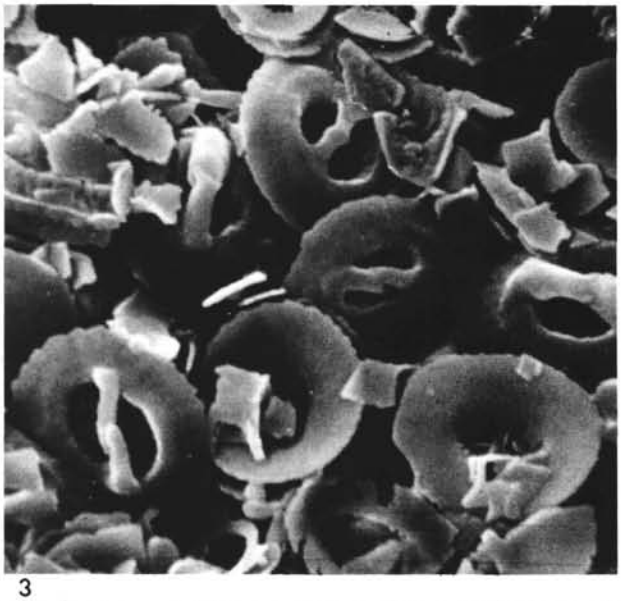

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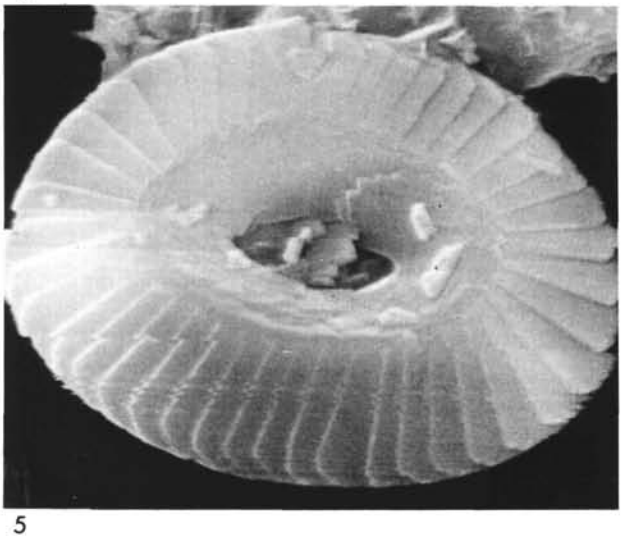

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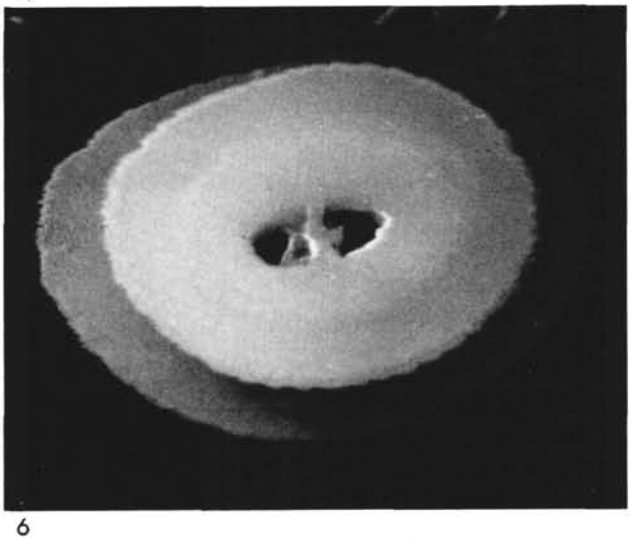

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