28. EOCENE TO PLEISTOCENE SILICOFLAGELLATES FROM THE NORWEGIAN-GREENLAND SEA (DSDP LEG 38)

Erlend Martini and Carla Müller, Geologisch-Paläontologisches Institut der Universität, Frankfurt am Main, Germany

INTRODUCTION

During Leg 38 of the Deep Sea Drilling Project, 17 sites (336 to 352) were occupied in the Norwegian-Greenland Sea (Figure 1). Material from most sites yielded silicoflagellates, although they were not represented at all sites. Intervals containing silicoflagellates include the middle Eocene to Quaternary. Unfortunately older sediments which, on the basis of silicoflagellates, may indicate direct correlation to diatomaceous deposits in the Paleocene/lower Eocene interval of the North Sea basin, especially Denmark and northern Germany, were not recovered during this cruise.

Since calcareous nannoplankton, which is commonly used for primary age determination, in these high latitudes is only present in sufficient numbers and diversified assemblages in a few horizons, and otherwise show rather meager assemblages with long-ranging species, the first age determinations are based mainly on silicoflagellates. Silicoflagellates proved to be the most important fossil group along with diatoms in this region. Although the worldwide distribution of most species and their tendency to develop regional “varieties” is still incompletely known, data from the Deep Sea Drilling Project material add a great deal to the understanding of the silicoflagellate distribution and evolution. Meanwhile, the first publication on the silicoflagellates of the Ehrenberg Collection has been published by Locker (1974), and it seems that quite a few commonly used silicoflagellate names have to be altered to avoid further confusion. In this paper, the Ehrenberg silicoflagellate types as illustrated by Locker (1974) are the basis for identification.

LOCALITIES AND ASSEMBLAGES RECOVERED

Geographical position of the DSDP holes drilled during Leg 38 are shown in Figure 1, and listed in Table 1 of Chapter 1 (this volume). With the exception of Sites 344, 347, 349, 351, and Holes 352 and 352A, silicoflagellates were generally encountered in certain intervals from the remaining holes. On the Iceland Plateau (Site 348) and Jan-Mayen Ridge (Sites 346 and 350) silicoflagellates were found only in the middle Miocene to Pliocene portions of the cored succession. In the Norway Basin (Site 337) silicoflagellates were encountered in the early Oligocene, whereas on the Iceland-Faeroe Ridge (Site 336) they are present only in the late Oligocene and lowest Miocene and on the Mohns Ridge (Site 345). They are present from the late Oligocene to the middle Miocene. Site 338 on the Outer Voring Plateau yielded the best silicoflagellate succession with assemblages from the upper Eocene to the upper Miocene. At Sites 339 and 340 on the Inner Voring Plateau silicoflagellate assemblages from the late Eocene and early Oligocene were recovered. Miocene to Pliocene assemblages were found in the two remaining holes on the Voring Plateau (Sites 341 and 342). The oldest silicoflagellate assemblages (early middle Eocene) were recovered at Site 343 in the Lofoten Basin.

Concurrent with the increase in the deposition of glacial material in the late Pliocene, a sudden occurrence of reworked late Paleogene and early Miocene silicoflagellates was noted at Sites 336 (Iceland-Faeroe Ridge), 339 and 341 (Voring Plateau), and at Site 343 (Lofoten Basin). A summary of silicoflagellate zones identified in the present material is given in Figure 2.

SILICOFLAGELLATE ZONATION IN THE NORWEGIAN-GREENLAND SEA

The silicoflagellate zonation used in this report for the early Eocene to Middle Miocene interval virtually the same as outlined in Martini (1971, 1972, 1974) with necessary correction in the upper Eocene (Figure 3). For the late Miocene to Quaternary interval, a combination of zones suggested by Ling (1973) and Bukry (1973) for North Pacific sediments is used. The zonation is summarized in Figure 3 together with correlations to the standard nannoplankton zonation (Martini, 1971), and includes the following zones:

**Dictyocha transitoria Zone**

**Definition:** Interval from the first to the last occurrence of *Dictyocha transitoria* Deflandre.

**Author:** Martini, 1974.

**Common species:** *Dictyocha transitoria* Deflandre, *Naviculopsis minor* (Schulz).

**Remarks:** Not recovered in the present material.

**Naviculopsis minor Zone**

**Definition:** Interval from the last occurrence of *Dictyocha transitoria* Deflandre to the first occurrence of *Corbisema bimucronata* Deflandre.

**Author:** Martini, 1974.

**Common species:** *Corbisema spinosa* Deflandre, *Corbisema apiculata* (Lemmermann), *Dictyocha rotundata* Jousé, *Distephanus quinquangellus* Bukry and Foster, *Naviculopsis foliacea* Deflandre, and *Naviculopsis minor* (Schulz).

**Remarks:** Present at Site 343, Cores 5 and 6.

**Naviculopsis foliacea Zone**

**Definition:** Interval from the first occurrence of *Corbisema bimucronata* Deflandre to the first occurrence of *Dictyocha quadria* (Mandra).
E. MARTINI AND C. MÜLLER

Figure 1. Sites occupied during Leg 38 in the Norwegian-Greenland Sea.

**Author:** Martini, 1971, emended this paper.

**Common species:** Mesoecena oamaruensis Schulz, Naviculopsis foliacea Deflandre, Distephanus quinquangellus Bukry and Foster, Corbisema spinosa Deflandre, Corbisema bimucronata Deflandre, Phylodictyocha schulzii Deflandre, Corbisema apiculata (Lemmermann).

**Remarks:** Probably recovered at Site 340, Samples 3, CC to 5, CC.

**Corbisema bimucronata Zone**

**Definition:** Interval from the first occurrence of *Dictyocha quadria* (Mandra) to the first occurrence of *Mesoecena apiculata* (Schulz).

**Author:** Martini, 1974, emended this paper.

**Common species:** *Dictyocha quadria* (Mandra), *Corbisema apiculata* (Lemmermann), Mesoecena oamaruensis Schulz, Corbisema spinosa Deflandre, Naviculopsis ponticula Perch-Nielsen, Corbisema flexuosa (Stradner), and Corbisema bimucronata Deflandre.

**Remarks:** In the present material, found at Site 338, Cores 27 to 29, and Site 340, Cores 1 to 3, 6 to 11.

**Dictyocha quadria Zone**

**Definition:** Interval from the first occurrence of *Mesoecena apiculata* (Schulz) to the last occurrence of *Dictyocha quadria* (Mandra).

**Authors:** Martini and Müller, this paper.

**Common species:** *Dictyocha quadria* (Mandra), Corbisema apiculata (Lemmermann), Corbisema spinosa Deflandre, Naviculopsis biaepiculata (Lemmermann), Mesoecena apiculata (Schulz), Dictyocha frenguellii Deflandre.

**Remarks:** In the present material, found at Site 338, Core 26.

**Naviculopsis biaepiculata Zone**

**Definition:** Interval from the last occurrence of *Dictyocha quadria* (Mandra) to the first occurrence of *Naviculopsis lata* (Deflandre).

**Author:** Martini, 1974, emended this paper.

**Common species:** Naviculopsis biaepiculata (Lemmermann), Mesoecena apiculata (Schulz), Distephanus crux (Ehrenberg), Cannopilus hemisphaericus (Ehrenberg).
<table>
<thead>
<tr>
<th>Sample (Interval in cm)</th>
<th>Cannopilus hemisphaericus</th>
<th>Cannopilus sp.</th>
<th>Corbisema apiculata</th>
<th>Corbisema flexuosa</th>
<th>Corbisema ovata</th>
<th>Corbisema sp.</th>
<th>Dictyocha cf. epiodon</th>
<th>Dictyocha cf. flabellata</th>
<th>Dictyocha petrella</th>
<th>Dictyocha quadra</th>
<th>Dictyocha torta</th>
</tr>
</thead>
<tbody>
<tr>
<td>7, CC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-2, 58-59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-3, 2-3</td>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-4, 85-86</td>
<td>X cf.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-1, 65-66</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9, CC</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-2, 135-136</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-1, 135-136</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-1, 135-136</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-4, 85-86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-2, 5-6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-2, 85-86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-2, 85-86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-6, 85-86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14-1, 95-96</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14-3, 85-86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-1, 20-21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-6, 130-131</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-1, 85-86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-6, 95-96</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17-1, 40-41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17-4, 85-86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-1, 50-51</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18, CC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-2, 10-11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-5, 123-124</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-2, 30-31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-5, 50-51</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-5, 100-101</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21-1, 67-68</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22-1, 89-90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23-3, 116-117</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24-2, 108-109</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.4 to 26.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Barren Interval</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. B.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36-2, 109-110</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36-5, 30-31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27-1, 129-130</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27-5, 71-72</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29-2, 30-31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29-1, 113-114</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29-2, 135-136</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29, CC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** X = rare to few, O = common or dominant, * = mass occurrence of diatom 340 (= Triceratium barbendense).
TABLE 2  
Silicoflagellates in Selected Samples from Site 339 Representing Part of the Early Oligocene and Part of the Glacial Interval

<table>
<thead>
<tr>
<th>Sample (Interval in cm)</th>
<th>Corbisema triacantha</th>
<th>Corbisema flexuosa</th>
<th>Uroneria flexuosa</th>
<th>Naviculopsis quadratum</th>
<th>Distephanus speculum</th>
<th>Distephanus quinquangellus</th>
<th>Mesocena apiculata</th>
<th>Naviculopsis biapiculata</th>
<th>Naviculopsis ponticola</th>
<th>Distephanus sp.</th>
<th>Mesocena circulus</th>
<th>Silicoflagellate Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-3, 39-40</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-2, 83-84</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-3, 61-62</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-1, 20-21</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-1, 130-131</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>cf</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-1, 145-146</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-3, 125-126</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: X = rare to few, O = common or dominant, D = displaced from older strata.

**Remarks**: In the present material, found at Site 337, Cores 9 to 12, Site 338, Cores 19 to 24, and Site 339, Cores 9 to 12.

**Naviculopsis lata Zone**

**Definition**: Interval from the last occurrence of *Naviculopsis lata* (Deflandre) to the first occurrence of *Naviculopsis navicula* (Ehrenberg).

**Author**: Martini, 1972.

**Common species**: *Naviculopsis lata* (Deflandre), *Distephanus crux* (Ehrenberg), *Mesocena apiculata* (Schulz), *Cannopilus triacantha* (Ehrenberg), *Distephanus speculum* (Ehrenberg), *Naviculopsis iberica* Deflandre.

**Remarks**: In the present material, found at Site 336, Cores 15 and 16, Site 338, Cores 18 and 19, Site 342, Core 6, Site 345, Cores 9 and 10.

**Naviculopsis navicula Zone**

**Definition**: Interval from the first occurrence of *Naviculopsis navicula* (Ehrenberg) to the last occurrence of *Naviculopsis quadratum* (Ehrenberg) [syn. *N. rectangularis* (Schulz)].

**Author**: Martini, 1972.

**Common species**: *Naviculopsis navicula* (Ehrenberg), *Naviculopsis iberica* Deflandre, *Distephanus crux* (Ehrenberg), *Corbisema triacantha* (Ehrenberg), *Cannopilus flexuosa* (Stradner), *Mesocena apiculata* (Schulz), and in the upper part *Naviculopsis quadratum* (Ehrenberg) [syn. *N. rectangularis* (Schulz)].

**Remarks**: In the present material, found at Site 338, Cores 12 to 17, Site 342, Core 6, and Site 345, Core 8.

**Corbisema triacantha Zone**

**Definition**: Interval from the last occurrence of *Naviculopsis quadratum* (Ehrenberg) to the last occurrence of *Corbisema triacantha* (Ehrenberg).

**Author**: Martini, 1971.

**Common species**: *Distephanus crux* (Ehrenberg), *Mesocena apiculata* (Schulz), *Distephanus speculum* (Ehrenberg), *Cannopilus hemisphaericus* (Ehrenberg), *Distephanus longispinus* (Schulz), *Corbisema triacantha* (Ehrenberg), and in the upper part *Mesocena diodon* Ehrenberg.

**Remarks**: In the present material, found at Site 338, Cores 8 to 11, Site 342, Cores 3 to 5, Site 345, Cores 6 to 7(?), Site 346, Cores 5 and 6.

**Mesocena circulus Zone**

**Definition**: Interval from the last occurrence of *Corbisema triacantha* (Ehrenberg) to the last occurrence of *Mesocena circulus* (Ehrenberg).

**Author**: Ling, 1973, emended this paper.


**Remarks**: In the present material found at Site 338, Cores 7 and 8, Site 341, Cores 25 to 34, and Site 348, Cores 11 to 18.

**Distephanus boliviensis Zone**

**Definition**: Interval from the last occurrence of *Mesocena circulus* (Ehrenberg) to the last occurrence of *Distephanus boliviensis* (Frenquelli).

**Author**: Bukry and Foster, 1973, emended this paper.

**Common species**: *Distephanus speculum* (Ehrenberg), *Distephanus boliviensis* (Frenquelli), *Distephanus quinquangellus* Bukry and Foster, *Distephanus crux* (Ehrenberg), and in the lower part *Mesocena diodon* Ehrenberg.
EOCENE TO PLEISTOCENE SILICOFLAGELLATES

<table>
<thead>
<tr>
<th>Silicoflagellate Zones</th>
<th>336</th>
<th>337</th>
<th>338</th>
<th>339</th>
<th>340</th>
<th>341</th>
<th>342</th>
<th>343</th>
<th>345</th>
<th>346</th>
<th>348</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quat.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. speculum Zone</td>
<td>8-9</td>
<td>6-8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. boliviensis Zone</td>
<td>7-8</td>
<td>25-34</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. circinus Zone</td>
<td>8-11</td>
<td>3-5</td>
<td>6-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. triaenantha Zone</td>
<td>12-17</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N. navicula Zone</td>
<td>15-16</td>
<td>18-19</td>
<td></td>
<td>9-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N. biapiculata Z.</td>
<td>9-12</td>
<td>19-24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. quadria Zone</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. bimucronata Z.</td>
<td>8-11</td>
<td>1-3</td>
<td>6-8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N. foliacea Zone</td>
<td>3-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N. minor Zone</td>
<td>6-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. transitoria Z.</td>
<td>6-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Silicoflagellate zones found in cores recovered in holes drilled during Leg 38. Brackets with star indicate reworked assemblages from the late Eocene to early Miocene redeposited during "glacial" time (probably in the Distephanus speculum Zone).

Remarks: In the present material found at Site 348 Cores 6 to 10.

**Distephanus speculum Zone**

**Definition:** Interval from the last occurrence of *Distephanus boliviensis* (Frenguelli) to the first occurrence of *Distephanus octangulatus* Wailes.

**Author:** Bukry, 1975, emended this paper.

**Common species:** *Distephanus speculum* (Ehrenberg), *Distephanus octonarius* (Ehrenberg).

**Remarks:** In the present material found at Site 336, Cores 8, 9, Site 348, Core 5. Reworked silicoflagellates from the upper Eocene to lower Miocene, masking the autochthonous assemblage, are present at Site 339, Cores 6 to 8, Site 340, Core 1, Site 341, Cores 4 to 7, Site 343, Core 3, which may belong to the Distephanus speculum Zone.

The youngest sediments at the sites above the Distephanus speculum Zone were barren of silicoflagellates, and the high latitude species *Distephanus octangulatus* Wailes has not been found. The first occurrence of this species was used by Ling to define the late Pleistocene to recent Distephanus octangulatus Zone in the North Pacific. It is assumed that this zone is represented at Site 348 by unfossiliferous sediments (Cores 3 and 4) and by nannoplankton (Zone NN 21) bearing sediments in Cores 1 and 2.

Perch-Nielsen (in press) recently suggested two silicoflagellate zones in the Norwegian Sea based on a piston core (Vema 28/43) from the Voring Plateau.

**Naviculopsis vemae Zone** (interval from the first to the last occurrence of *Naviculopsis vemae* Perch-Nielsen) and the Naviculopsis ponticula Zone (last occurrence of *Naviculopsis vemae* Perch-Nielsen to the last occurrence of *Naviculopsis ponticula* Perch-Nielsen). The position of these zones in the zonation used on Leg 38 is not entirely known, as *Naviculopsis vemae* was not encountered in the material recovered on the Voring Plateau, and *Naviculopsis ponticula* seems to range probably from the Naviculopsis foliacea Zone to the higher part of the Dictyocha quadria Zone, with a maximum in the Corbiscera bimucronata Zone. However, in the assemblage present in her Naviculopsis vemae Zone, Perch-Nielsen listed "Septamesocena" apiculata which has its first occurrence at the base of the Dictyocha quadria zone, restricting the Naviculopsis vemae Zone to a level within the Dictyocha quadria Zone, which is, however, not in accordance with the occurrence of Naviculopsis ponticula.

**CORRELATION TO THE NANNOPLANKTON ZONATION**

Correlation of the present material to the standard nannoplankton zonation is rather restricted as only a few horizons contain datable nannoplankton assemblages (Müller, this volume). Correlations shown in Figure 3 are based on other previously published data. The following nannoplankton zones have been determined, and can be used for correlation of the silicoflagellate assemblages. The Recent to late Pleistocene zone (NN 21) is present in Cores 1 and 2 of Site 348 (0.0-18.5 m). Cores 3 and 4 are barren of calcareous nannoplankton and silicoflagellates. The latter first
<table>
<thead>
<tr>
<th>Quaternary</th>
<th>Silicoflagellates</th>
<th>Datum indicators and additional species</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P. lanacoza assemblage</strong></td>
<td>D. oepemnum Zone</td>
<td>first D. ostantulatus</td>
</tr>
<tr>
<td><strong>P. lacunosa assemblage</strong></td>
<td>D. boliviensis Zone</td>
<td>last D. boliviensis</td>
</tr>
<tr>
<td><strong>H. ampliaperta assemblage</strong></td>
<td>M. cirsus Zone</td>
<td>last C. arenstinae</td>
</tr>
<tr>
<td><strong>R. pseudumbilica assemblage</strong></td>
<td>M. navicula Zone</td>
<td>last M. api•cutata, last D. longispinus</td>
</tr>
<tr>
<td><strong>R. umbo•liarla assemblage</strong></td>
<td>?</td>
<td>last C. triacantha</td>
</tr>
<tr>
<td><strong>R. umbo•liarla assemblage</strong></td>
<td>?</td>
<td>first M. diodon</td>
</tr>
<tr>
<td><strong>R. umbo•liarla assemblage</strong></td>
<td>?</td>
<td>last M. quadratrix</td>
</tr>
<tr>
<td><strong>R. umbo•liarla assemblage</strong></td>
<td>?</td>
<td>first M. navicula</td>
</tr>
<tr>
<td><strong>N. ciperoensis Zone</strong></td>
<td>?</td>
<td>last N. quadria</td>
</tr>
<tr>
<td><strong>N. ciperoensis Zone</strong></td>
<td>?</td>
<td>first N. iberica</td>
</tr>
<tr>
<td><strong>N. ciperoensis Zone</strong></td>
<td>?</td>
<td>first X. Zara</td>
</tr>
<tr>
<td><strong>N. ciperoensis Zone</strong></td>
<td>?</td>
<td>last C. bimorona</td>
</tr>
<tr>
<td><strong>N. ciperoensis Zone</strong></td>
<td>?</td>
<td>first C. bimorona</td>
</tr>
<tr>
<td><strong>N. ciperoensis Zone</strong></td>
<td>?</td>
<td>last D. transitoria</td>
</tr>
<tr>
<td><strong>N. ciperoensis Zone</strong></td>
<td>?</td>
<td>first D. transitoria</td>
</tr>
</tbody>
</table>

Figure 3. Silicoflagellate zonation used on Leg 38 and correlation to the standard nannoplankton zonation (Martini, 1971), and Leg 38 nannoplankton zonation.
appear in sufficient numbers in Core 5 (56.5-66.0 m) and can be attributed to the Distephanus speculum Zone.

The combined lower Miocene Zones NN 3/NZ 4 are present in Cores 24 and 25 (341.5-378.5 m) from Site 348. The overlying Cores 19 to 23 are barren of nanoplankton and silicoflagellates. Core 18 (256.0-265.0 m) is attributed to the Mesocena circulus Zone on basis of the rare occurrence of Mesocena circulus in Sample 18, CC. However, the common occurrence of this particular species is in Core 14, some 66 meters above Sample 18, CC. Since Corbisema triacantha is rather rare near its upper limit, part of the interval from Cores 15 to 18 may belong to the Corbisema triacantha Zone.

Nannoplankton Zone NP 24 is present at Site 338, Sections 19-2 to 26-1 (187.5-248.0 m). Silicoflagellates found in these cores belong to the Naviculopsis lata Zone (Core 18 and 19), and Naviculopsis biapiculata Zone (Cores 19 to 24). Cores 25 and 26, Section 1 are barren of silicoflagellates. In Core 26, Section 2, silicoflagellates of the upper Eocene Dictyocha quadria Zone are present, indicating a hiatus between Section 26-1 and 26-2, which includes the lower Oligocene and uppermost Eocene.

The lowest silicoflagellate assemblage at Site 338 can be attributed to the Corbisema bimucronata Zone, and is present in Cores 27 to 29, CC (257.5-285.0 m). Cores 30 and 31 are barren of silicoflagellates and calcareous nanoplankton. In Core 32 (304.0-313.5 m), calcareous nanoplankton of the lower Eocene nanoplankton Zone NP 12 is present. Standard nannoplankton Zone NP 12 is also present at Site 343 (Core 8, 212.0-221.5 m) and below. The first silicoflagellate assemblage occurs above in Core 6 (193.0-202.5 m) and can be attributed to the Naviculopsis minor Zone.

All these data are in accordance with the correlation concept shown in Figure 3.

SITE SUMMARIES

Site 336 — Iceland-Faeroe Ridge

Cores 1 to 8 (upper part) are barren of silicoflagellates. From Sample 8-5, 100-101 cm to Sample 12-2, 100-101 cm only few specimens of Distephanus speculum are present, together with sponge spicules and some diatoms. In Sample 9-4, 50-51 cm, rare specimens of Distephanus cf. octonarius were found. These samples (72.0-135.0 m) are tentatively placed in the Distephanus speculum Zone. Cores 10 to 14 lack silicoflagellates.

From Sample 15-1, 13-14 cm to Sample 16-4, 101-102 cm (168.5 to 184.5 m), the following assemblage was found: Corbisema triacantha, Distephanus crux, Distephanus speculum, Cannopilus hemisphaericus, Naviculopsis lata, Mesocena apiculata, and Rocella gemma. This assemblage belongs to the Naviculopsis lata Zone, which includes the stratigraphic interval of the upper Oligocene and the lowermost Miocene. Samples 16-5, 111-112 cm to 18-3, 28-29 cm (184.5-202.5 m) show a decrease in silicoflagellate species, and may represent the Naviculopsis lata Zone or Naviculopsis biapiculata Zone.
quadria, Mesocena apiculata, Dictyocha hexacanthes, Distephanus speculum, Dictyocha frenguellii. The assemblage below, which lacks Mesocena apiculata, can be attributed to the upper Eocene Corbisema bimucronata Zone. The sediments below Core 29 are barren of silicoflagellates.

Site 339 — Inner Voring Plateau

Siliceous ooze is intercalated in Quaternary sediments probably due to slumping. From Sample 6-3, 39-40 cm to Sample 8-1, 20-21 cm (51.0-67.0 m) mixed assemblages from the upper Eocene to lower Oligocene were noted. In Sample 7-3, 61-62 cm, a displaced assemblage of the Mesocena circulus Zone was found (Table 2). These assemblages were probably redepited during the time of deposition of the Distephanus speculum Zone elsewhere. In Sample 9, CC to Sample 12, CC (84.0-108.0 m) Corbisema triacantha, Corbisema apiculata, Corbisema flexuosa, Dictyocha challengeri, Dictyocha hexacanthes, Mesocena apiculata, Naviculopsis constricta, and probably a new species of Micromarsupium are present, indicating the late Eocene to middle Oligocene Naviculopsis biapiculata Zone.

Site 340 — Inner Voring Plateau

Silicoflagellates are present from Core 1, Section 4 to Sample 11, CC (6.0-106.5 m). The assemblages indicate a middle to late Eocene age. The sequence is mixed probably due to diapiric activities in this area. It is possible to recognize three units (A, B, and C) with typical assemblages (Table 3). Unit B (Core 1 to Core 3, Section 1 and Core 6 to Core 8 Section 3) consists of the Corbisema bimucronata Zone with the following species present: Corbisema triacantha, Distephanus crux, Naviculopsis ponticula, Mesocena apiculata, Dictyocha quadria, Dictyocha spinosa, Corbisema bimucronata, Naviculopsis follicula, and Corbisema flexuosa. In the lower part of Unit B, a mass occurrence of the diatom Triceratium barbadense (diatom 340 in Table 3) was noted. Unit C (Sample 8, CC to Sample 11, CC) belong to the Corbisema triacantha Zone of the lower Miocene to middle Miocene.

Site 341 — Inner Voring Plateau

Silicoflagellates observed in the siliceous ooze which is intercalated in Quaternary sediments of Sample 4, CC to Sample 7, CC (38.0-66.5 m) indicate a middle Miocene age, and represent displaced material with common Distephanus crux, Distephanus speculum, Cannopilus hemisphaericus, and rare Mesocena apiculata and Distephanus longispinus. Cores 8 to 25 (66.5-342.0 m) are barren of silicoflagellates. In Core 25, only sponge spicules, some diatoms, and archaeomonads were found. Silicoflagellate assemblage of Sample 25, CC to Sample 34, CC (342.0-456.0 m) consists of the following species: Distephanus crux, Mesocena diodon, Distephanus speculum, Cannopilus hemisphaericus, Mesocena circulus, Mesocena elliptica, Mesocena apiculata, and Dictyocha cf. fibula indicating a middle to late Miocene age (Mesocena circulus Zone). Archaeomonads are common in some samples.

Site 342 — Outer Voring Plateau

Silicoflagellates are not present in Cores 1 and 2, but are common in Sample 3-1, 95-96 cm to Core 6, CC (85.0-151.5 m). The assemblage of Sample 3-1, 95-96 cm to Sample 3-4, 45-46 cm consists of Distephanus crux, Mesocena diodon, and Distephanus speculum. From Sample 3-4, 145-146 cm to Sample 5-6, 115-116 cm, Distephanus longispinus, Cannopilus hemisphaericus, and Mesocena apiculata are present, while Mesocena diodon is missing. This interval belongs to the Corbisema triacantha Zone of the lower Miocene to middle Miocene.

The sequence from Sample 6-2, 30-31 cm to Sample 6-4, 65-66 cm belongs to the Naviculopsis navicula Zone of the lower Miocene, as indicated by the presence of rare Naviculopsis navicula and common Naviculopsis lata. In the Sample 6-4, 115-116 cm and Sample 6, CC, Naviculopsis navicula was not observed. This part seems to belong to the Naviculopsis lata Zone of upper Oligocene to lower Miocene.

Site 343 — Lofoten Basin

Displaced silicoflagellates were found in Sample 3-5, 84-85 cm in a siliceous ooze, which is intercalated into Quaternary sediments. The assemblage consists of Corbisema triacantha, Dictyocha frenguellii, Dictyocha cf. fibula, and Corbisema apiculata. From Sample 5-3, 100-101 cm to Sample 6-1, 128-129 cm (149.5-194.0 m) an assemblage (Table 4) consisting of Distephanus speculum, Corbisema spinosa, Naviculopsis follicula, Dictyocha rotundata, Dictyocha cf. fibula, Corbisema apiculata, Dictyocha deflandrei, Dictyocha frenguellii, and Naviculopsis cf. minor is present, probably belonging to the middle Eocene Naviculopsis minor Zone. This assemblage is similar to that of part of the so-called "Unter Eozän 4" of the micropaleontological subdivision of the Paleogene in northwestern Germany (Martini, 1974).

Site 345 — Mohns Ridge

First silicoflagellates were found in Sample 6-1, 123-124 cm (56.5 m): Mesocena apiculata, Cannopilus hemisphaericus, Distephanus speculum, Distephanus crux, Distephanus longispinus, indicating a middle Miocene age (probably Corbisema triacantha Zone). Corbisema triacantha and Naviculopsis quadratum are present in Sample 8-1, 139-140 cm (85.5 m), together with the same species as in Cores 6 and 7. According to Martini (1972), Naviculopsis quadratum in its typical form indicates an early Miocene age and is present in the upper part of the Naviculopsis navicula Zone.

In Core 9 (112.5-122.0 m) only very few silicoflagellates are present, such as Distephanus crux, Corbisema triacantha, Distephanus speculum, and Naviculopsis lata. They are more frequent in the upper part of Core 10 (131.5-141.0 m). The assemblage with Corbisema triacantha, Distephanus crux, Dictyocha fibula, Naviculopsis lata, Distephanus speculum, Mesocena...
TABLE 3
Silicoflagellates in Selected Samples from Site 340 Representing the Upper Eocene Interval

<table>
<thead>
<tr>
<th>Sample (Interval in cm)</th>
<th>Corbissea apiculata</th>
<th>Corbissea flexuosa</th>
<th>Corbissea hartii</th>
<th>Corbissea isidiforme</th>
<th>Dietyocha cf. flabella</th>
<th>Dietyocha frigida</th>
<th>Dietyocha fuscata</th>
<th>Dietyocha guttata</th>
<th>Dietyocha sp.</th>
<th>Dietyocha quinquangulata</th>
<th>Dithraphous speculum</th>
<th>Mesoceracoides corrugatus</th>
<th>Mesoceracoides curvatus</th>
<th>Naviculopsis boliviana</th>
<th>Naviculopsis cf. obtusa</th>
<th>Naviculopsis falcata</th>
<th>Naviculopsis hornii</th>
<th>Naviculopsis minor</th>
<th>Diatom 340 mass occurrence</th>
<th>Silicoflagellate Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5, 94-95</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-1, 110-111</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-1, 140-141</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-1, 115-116</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-3, 100-101</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-1, 110-111</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-1, 70-71</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-1, 95-96</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-4, 145-146</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-1, 140-141</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-3, 125-126</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-5, 65-66</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-1, 60-61</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-2, 100-101</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-2, 58-59</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: X = rare to few, O = common or dominant, O = mass occurrence of diatom 340 (= Triceratium barbadense). Note that the succession in this particular hole is not in order due to diapiric processes. Unit A probably is the oldest and Unit C is the youngest part.

TABLE 4
Silicoflagellates in Selected Samples from Site 343 Representing the Early Middle Eocene Interval

<table>
<thead>
<tr>
<th>Sample (Interval in cm)</th>
<th>Corbissea apiculata</th>
<th>Corbissea hartii</th>
<th>Corbissea isidiforme</th>
<th>Dithraphous speculum</th>
<th>Dithraphous quinquangulata</th>
<th>Mesoceracoides corrugatus</th>
<th>Mesoceracoides curvatus</th>
<th>Naviculopsis boliviana</th>
<th>Naviculopsis falcata</th>
<th>Naviculopsis minor</th>
<th>Silicoflagellate Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-3, 100-101</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Naviculopsis minor Zone</td>
</tr>
<tr>
<td>5-4, 25-26</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>Naviculopsis minor Zone</td>
</tr>
<tr>
<td>5-6, 35-36</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Naviculopsis minor Zone</td>
</tr>
<tr>
<td>5-6, 110-111</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Naviculopsis minor Zone</td>
</tr>
<tr>
<td>6-1, 128-129</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>Naviculopsis minor Zone</td>
</tr>
</tbody>
</table>

Note: X = rare to few, O = common or dominant.
apiculata probably belongs to the late Oligocene to early Miocene Naviculopsis lata Zone. In the lower part of Core 10, silicoflagellates are only sporadically present. Below Core 10, they are missing. Archaeomonads are common in some samples.

Site 346 — Jan-Mayen Ridge

Cores 1 to 3 and upper part of Core 4 are barren of silicoflagellates. They are rare from Sample 4-5, 40-41 cm to Sample 11-4, 75-76 cm (33.5-98.0 m), below only sponge spicules and archaeomonads were found. Few silicoflagellates were observed from Sample 4-5, 40-41 cm to Sample 5-2, 131-132 cm. They become more common from Sample 5-3, 50-51 cm to Sample 6-2, 84-86 cm. Below, a decrease in abundancy down to Sample 12, CC is noted. The assemblage consists of Corbisema triacantha, Distephanus crux, Mesocena apiculata, Cannopilus hemisphaericus, Dictyocha cf. fibula, and Distephanus speculum indicating the middle Miocene Corbisema triacantha Zone. Archaeomonads are generally abundant in all samples. Below Core 12, CC, sediments are barren of silicoflagellates.

Site 348 — Iceland Plateau

The first silicoflagellates are present in Core 5 (56.5-66.0 m) with Distephanus octonarius and several varieties of Distephanus speculum, indicating cold water temperatures. The assemblage belongs to the upper Pliocene-Pleistocene Distephanus speculum Zone. The Distephanus boliviensis Zone was noted from Sample 6-1, 105-106 cm to Sample 10, CC (66.0-142.0 m), and represents the uppermost Miocene to lower Pliocene. Species found include: Distephanus boliviensis, Distephanus speculum, Distephanus quinquangularis, and Mesocena diodon, which has its last occurrence within this zone (Table 5).

The Mesocena circulus Zone is determined from Sample 11-1, 20-21 cm to Sample 18, CC (151.5-265.0 m). The assemblage consists of Mesocena circulus, Mesocena diodon, Mesocena apiculata, Distephanus crux, Distephanus speculum, Mesocena elliptica, Cannopilus hemisphaericus, and Dictyocha fibula. The lower part of this interval lacks Mesocena circulus, except for one specimen in Sample 18, CC. As Corbisema triacantha is rather rare near its upper limit, part of the interval from Cores 15 to 18 may belong to the Corbisema triacantha Zone. Also, a strong increase in aberrant forms was noted in Cores 15 and 16 (A in Table 5), indicating abnormal conditions. Noteworthy is the mass occurrence of “diatom 348” (=Stephanogonia horridus) in the lower part of Core 16.

Site 350 — Jan-Mayen Ridge

Silicoflagellates were observed only in Core 3, CC (65.0 m) indicating a probable middle Miocene age. The assemblage consists of few specimens of Distephanus crux, Distephanus speculum, and Dictyocha cf. fibula.

Hole 352A — Iceland-Faeroe Ridge

Only few silicoflagellates were found in Sample 352A-3-1, 65-66 cm. The assemblage consists of Dictyocha speculum, and Cannopilus hemisphaericus. Nanoplankton above and below this sample indicates an Oligocene age. The sample is rich in volcanic glass.

SKELETAL CHARACTERISTICS OF SILICOFLAGELLATES

Spherical-like Protuberances in Silicoflagellates

Deflandre (1933) reported two cases of “sphères énigmatiques” in a study of skeletal abnormalities found in fossil silicoflagellates. One “sphère énigmatique” was present in the central bar of a “Dictyocha fibula Ehr. var brevispina Lemm.” from Sendai, Japan. According to the illustrations (Deflandre 1933, pl. 9 fig. 1, 2; pl. 10 fig. 1) and the description given, there is a globular thickening at the connecting point of the central bar with the two supporting bars. The second specimen with “sphères énigmatiques” probably represents an abnormal specimen of “Distephanus speculum (Ehr.) Haeck.” from Redondo, in which globular thickenings are again present at the connecting points, in this case between the supporting bars and the basal ring (Deflandre 1933, pl. 1 fig. 3-5; pl. 2 fig. 2).

Mesocena nodulifera Tsumura and Mesocena nodulifera var. triangula Tsumura, described in Tsumura (1963), and, showing globular thickenings on the basal ring, may also represent morbid specimens of already described species, in this case most likely Mesocena diodon Ehrenberg and Mesocena oamaruensis (Schulz). Mandra (1969) described several specimens of silicoflagellates found during the study of Vema cruise 17 (South Atlantic Ocean, lat 51°08.5'S, long 54°22'W) sediments. They had spherical protuberances at each of the four corners of the basal ring. As these structures seem to be unknown in any described silicoflagellate genus, Mandra erected the new genus Hannaites, and named the forms in Eocene sediments Hannaites quadria. During Leg 29, this species was recovered in late Eocene sediments at Sites 281 and 283 in the Tasman Sea (Perch-Nielsen, 1975; Bukry, 1975b).

In the late Eocene silicoflagellate assemblage at Site 340 (Leg 38, Inner Voring Plateau), aside from some broken corners with spheres, a complete specimen of Mesocena apiculata (Schulz) was found (Plate 10, Figure 5). This had spherical-like protuberances at each of the three corners of the basal ring, which are identical with those found in Hannaites quadria. The spherical protuberances in both species occupy corner positions in all specimens found so far. The surface of the spheres are covered by numerous bosses, which was noted by Mandra (1969), and are illustrated for the present species on Plate 10, Figures 3b, c (this paper). Unfortunately, these forms are relatively rare, and, up to now, were not investigated with the scanning electron microscope. However, it is speculated that the surface structures at the spheres are enlarged silicoflagellate fine structure of knobs, with connecting ridges and depressions in between.

Hannaites quadria is reported from the late Eocene from the South Atlantic and from the Tasman Sea. The same stratigraphic interval was recovered during Leg 7 in the equatorial Pacific (Hole 65/1), and during Leg 38
(Sites 338 and 340). However, **Hannaites quadria** with the typical spherical corners was not found. In the Norwegian-Greenland Sea (Sites 338 and 340), specimens identical with **Hannaites**, except in the corner protuberances were found in fair numbers in the interval in question (Plate 2, Figure 4; Plate 10, Figure 1). The corners of the Leg 38 specimens are rounded, whereas specimens encountered in Hole 65/1 in the equatorial Pacific show somewhat flattened corners, but without spines (Plate 8, Figure 15).

These occurrences, and the **Mesocena** specimens with spherical protuberances (Plate 10, Figures 3-5), lead to the conclusion that this peculiar structure cannot be used for generic differentiation, and that **Hannaites** Mandra is a synonym of **Dictyocha** Ehrenberg. The occurrence of **Dictyocha quadria** (Mandra) nov. comb. with spherical protuberances at the corners and obviously restricted to the southern hemisphere are too rare and incompletely known to give speculation on the global development of this species. However, they certainly represent an aberrant and morbid development as Deflandre (1933) suggested and described for the aberrant specimens of "**Dictyocha fibula var. brevispina**" and "**Distephanus speculum"**.

### Silicoflagellate Surface Ornamentation

Surface ornamentation of Neogene and Quaternary silicoflagellates were described by several authors (Deflandre, 1950; Jerković, 1969; Bachmann and Keck, 1969) as being a network of crests and depressions in most species investigated. A few specimens of the

---

**TABLE 5**

Silicoflagellates in Selected Samples from Site 348 Representing the Middle Miocene to Early "Glacial" Interval

<table>
<thead>
<tr>
<th>Sample (Interval in cm)</th>
<th>Campanulites depressus</th>
<th>Campanulites eburneus</th>
<th>Dicyocha d. fibula</th>
<th>Dicyocha g. spinata</th>
<th>Dictyocha longispina</th>
<th>Dictyocha quadria</th>
<th>Dictyocha speculum</th>
<th>Dritsophyllum s. polystyla</th>
<th>Mesocena circularis</th>
<th>Mesocena elliptica</th>
<th>Common aberrant forms</th>
<th>Diatom 348 mass occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-5, 145-146</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D. speculum Zone</td>
<td></td>
</tr>
<tr>
<td>6-1, 105-106</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D. boliviensis Z.</td>
<td></td>
</tr>
<tr>
<td>6, CC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M. circulus Zone</td>
<td></td>
</tr>
<tr>
<td>7-2, 30-31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-2, 100-101</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-5, 85-86</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7, CC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-3, 145-146</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-3, 80-81</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-4, 60-61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9, CC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10, CC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-1, 20-21</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-3, 70-71</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-5, 140-141</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-1, 120-121</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-6, 85-86</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-2, 90-91</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13, CC</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14-1, 90-91</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14, CC</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-1, 85-86</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-3, 85-86</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15, CC</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-1, 85-86</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-4, 85-86</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16, CC</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17, CC</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18, CC</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: X = rare to few, O = common or dominant, * = mass occurrence of diatom 348 (= Stephanogonia horridus) A = common occurrence of aberrant silicoflagellate specimens.
aberrant genus *Deflandryocha* were reported to lack surface ornamentation (Jerković, 1969), whereas specimens of *Distephanus speculum* seem to have only knots on the surface of the skeleton (Wornhardt, 1971).

Martini (in press) reported that Neogene and Quaternary silicoflagellates from the equatorial Pacific, in most cases, exhibit only small knots on an otherwise smooth surface, and that assemblages from California show better developed surface ornamentation. This probably indicates a dependence for the presence of surface structures on temperature, the presence of calcareous ingredients in the bottom sediment, and solution, Bachmann and Keck (1969) and Jerković (1969), on the other hand, related the development of surface ornamentation to the life span of silicoflagellates, inasmuch as well developed surface ornamentation is present only in the adult stage.

Silicoflagellates, found in sediments recovered in the Norwegian-Greenland Sea during Leg 38, can be divided into several groups with regard to their surface ornamentation, and are described below. Details of skeletons of several species are illustrated on Plates 5 and 6.

The first group is characterized by a system of long crests with rare ridge-like knots approximately 90° to the axis of the long crest. These were described in *Mesocena diodon* (Plate 6, Figure 7) and *Mesocena elliptica* (Plate 6, Figure 6). Closely related is the second group including *Corbisema triacantha* (Plate 1, Figures 8, 9), *Corbisema apiculata* (Plate 5, Figures 4, 5), and *Naviculopsis ponticula* (Plate 6, Figure 8), which show a similar ornamentation on the radial and supporting ridges. However, in this group, most of the basal ring and apical structure is covered by a net-like ornamentation of short crests and depressions. Also belonging to this group are forms in which the entire distal side is covered by net-like crests (some long and some short) and peaks like *Dictyocha pentagona* (Plate 5, Figure 11), *Dictyocha cf. epilobus* (Plate 5, Figure 7), and *Dictyocha cf. fibula* (Plate 5, Figure 8).

Net-like ornamentation, in which the crests are of almost equal length on the basal ring, are found in the fourth group which includes *Mesocena apiculata* (Plate 6, Figure 5), as well as *Dictyocha challengeri* (Plate 1, Figure 10) and *Dictyocha quadra* (Plate 1, Figure 9) with the same ornamentation on the basal ring, but with faint ornamentation of short crests and peaks or without on the apical structure.

A combination of the morphologic feature of groups 1 to 3 is present in another group including *Distephanus speculum* (Plate 6, Figures 1a-c) and *Cannopilus ernestinae* (Plate 6, Figures 2-4). The basal ring is covered by long crests (Plate 6, Figures 1a, 2), with a few knots on crossing points at the basal part (Plate 6, Figures 1b, 2) of the apical ring or structure. On the apical structure, knots and connecting ridges are most common on the higher parts (Plate 6, Figures 1c, 4), but apical spines seem to have a reduced number of knots (Plate 6, Figure 4). The last group is characterized by knots, which concentrate on the apical bar or apical structure, but are present also, to a lesser extent, on the basal ring. *Distephanus boliviensis* (Plate 5, Figure 12), and *Naviculopsis lata* (Plate 6, Figures 9, 10) belong to this group.

An extremely coarse surface ornamentation on silicoflagellate skeletons was noted in the late Eocene *Corbisema bimucronata* Zone of Hole 340, and in the early to middle Oligocene *Naviculopsis biapiculata* Zone of Hole 339, both from the Inner Voring Plateau. At Site 339, the following species are involved: *Corbisema apiculata*, *Dictyocha cf. fibula*, *Dictyocha quadra*, *Dictyocha pentagona*, *Mesocena oamaruensis*, *Naviculopsis biapiculata*, and at Site 340, *Cannopilus hemisphaericus*, *Corbisema triacantha*, *Dictyocha hexacantha*, *Dictyocha challengeri*, *Mesocena apiculata*, and *Mesocena schulzi* (Plates 1, 5, and 6).

A very peculiar surface ornamentation was noted in a specimen of *Corbisema sp.* (Plate 1, Figure 11) in Sample 339-7, CC (*Distephanus speculum* Zone), which may be reworked from older strata. The three apical bars form a plate (Plate 5, Figure 6), which shows a thickening along the rim of the otherwise smooth apical plate, with faint ridges pointing towards the center. The presence of well-developed surface ornamentation in almost all specimens found during electron-microscope studies of Leg 38 material, indicate a relation to temperature, and possibly solution. Some lower latitude species were reported (by some authors), to lack a well-developed surface ornamentation, or to exhibit only a faint one. However, a detailed study of some selected species on a more global scale is necessary to get a solid basis for the present theories.

**SYSTEMATIC PALEONTOLOGY**

In the description of species encountered during Leg 38 no attempt is made to give full references to all synonyma, but reference to the first description of a species and reference to a more recent description and figure will be given. In a few cases, a more detailed reference is presented, where in recent times different names have been used for the same taxa.

The present authors are not satisfied with the generic differentiation, especially between *Corbisema*, *Dictyocha*, *Distephanus*, and *Cannopilus*, as all gradations are present between these genera and aberrant forms of a given genus show often the characteristics of another genus. However, they remain in this paper with the differentiation used by most authors in order to avoid further confusion: *Corbisema* including triangular forms with apical rods or apical plate connected by rods to the basal ring; *Dictyocha* including four- to eight-sided forms with apical rods only; *Hannaites* is regarded as junior synonym of *Dictyocha*; *Distephanus* including four- and more sided forms with apical windows connected by rods to the basal ring; *Cannopilus* having at least a semiglobular apical structure with a number of apical windows; *Mesocena* including all forms consisting of an apical ring only; and *Naviculopsis* showing navicular outline and two radial spines in direction of the long axis.

Splitting of the mesocenid forms in a number of genera (Dumitrica, 1973; Bachmann, 1970; Locker, 1974), or extensive splitting of species in a vast number of "subspecies" (Bukry, 1975), seems unrealistic and not useful, and is not followed by the present authors.

Type specimens are deposited in the Natur-Museum und Forschungsinstitut Senckenberg, Frankfurt am Main, Germany, under catalogue numbers SM B 12796-12799.

**Class Silicoflagellatae** Borgt, 1891

**Family DICTYOCHACEAE** Lemmermann, 1901

**Genus CANNOPILUS** Haekel, 1887

*Cannopilus depressus* (Ehrenberg) (Plate 3, Figures 11, 12)

1854 [*Haliacylpta depressa* Ehrenberg, Mikrobiol., pl. 18, fig. 111.]

1974 [*Cannopilus depressus* (Ehrenberg), Locker, Ecol. Geol. Helv., v. 67, p. 639, pl. 4, fig. 3.]

868
Remarks: Included here, are globular forms which are similar or identical with those figured by Locker (1974) for the type material of Ehrenberg.

Occurrence: Rare specimens were encountered in the *Mesocena cirulis* Zone at Site 348 (Icelandic Plateau).

*Cannopilus ernestiae* Bachmann

(Plate 3, Figures 8-10; Plate 6, Figures 2-4; Plate 9, Figures 6, 7)

1962 *Cannopilus ernestiae* Bachmann, Mikrokosmos, v. 51, p. 255, fig. 1.

1969 *Cannopilus ernestiae* Bachmann, Bachmann and Keck, Mikrokosmos, v. 58, p. 204, pl. 2, fig. 2.

Remarks: Specimens found show well-developed apical horns and are identical with those described by Bachmann and Keck (1969) from the upper Miocene of Santa Barbara, California. Specimens commonly have six radial spines, but some with five radial spines were also found.

Occurrence: In the present material ranging from the upper part of the *Corbisema triacantha* Zone to the middle part of the *Mesocena cirulis* Zone at Sites 338 (Voring Plateau) and 348 (Icelandic Plateau).

*Cannopilus hemisphaericus* (Ehrenberg)

(Plate 3, Figure 7; Plate 9, Figure 5)


1974 *Cannopilus hemisphaericus* (Ehrenberg), Locker, Ecol. Geol. Helv., v. 67, p. 639, pl. 4, fig. 1, 4, 5, 7, 8.

Remarks: Basal ring and radial spines are generally in one plane. Apical structure semiglobular with varying number of apical "windows."

Occurrence: Rare occurrence in the *Naviculopsis minor* Zone at Site 343. Consistent occurrence from the *Naviculopsis biplicata* Zone to the top of the *Mesocena cirulis* Zone. Present at Sites 336, 338, 339, 340, 341, 343, 345, 348.

*Cannopilus* sp.

(Plate 8, Figure 10)

Remarks: A badly preserved single specimen possibly related to *Cannopilus depressus* was found in Sample 338-20-2, 30-31 cm in the upper part of the *Naviculopsis biplicata* Zone (Voring Plateau).

Genus *CORBISEMA* Hanna, 1928

*Corbisema apiculata* (Lemmermann)

(Plate 1, Figures 1-3; Plate 5, Figures 4, 5; Plate 7, Figures 1, 2)


Remarks: Basal ring and radial spines are generally in one plane. Apical structure semiglobular with varying number of apical "windows."

Occurrence: Consistent occurrence from the base of the *Naviculopsis minor* Zone at Site 333. Rare occurrence in the *Naviculopsis biplicata* Zone at Site 338. Specimens show rounded triangular outline with strongly concave sides, and very short radial spines pointing downwards. Some specimens have hooks on the supporting spines (Plate 7, Figure 3).

Occurrence: Rare or few in the *Naviculopsis minor* Zone at Site 343 (Lofoten Basin), in the *Naviculopsis biplicata* Zone at Site 340, and in the *Corbisema bimucronata* Zone at Sites 338 and 340 (Voring Plateau).

*Corbisema bimucronata* Deflandre

(Plate 7, Figure 9)


Remarks: Often confused with *Dictyocha hexacantha* by various authors. This species shows spiny apical spines on the apical rods, which are not in the same plane as the basal ring.

Occurrence: Rare to frequent in the *Naviculopsis minor* Zone to the top of the *Naviculopsis biplicata* Zone. Found at Sites 338, 339, 340 (Voring Plateau), and 343 (Lofoten Basin).

*Corbisema triacantha* (Ehrenberg)

(Plate 1, Figures 8, 9)


1974 *Corbisema triacantha* (Ehrenberg), Locker, Ecol. Geol. Helv., v. 67, p. 634, pl. 1, fig. 17, 22.

Remarks: A few specimens, some of which show very short radial spines illustrated as *Corbisema* sp. (Plate 7, Figure 6) may also belong to this species.

Occurrence: Very rare in the *Naviculopsis biplicata* Zone at Site 339 and a cf. specimen in Sample 340-9, CC (Corbisema bimucronata Zone) from the Voring Plateau.

*Corbisema hastata* (Lemmermann)

(Plate 1, Figure 10)


Remarks: This species, which was reported as common throughout the early Paleogene in warmer waters by Bukry and Foster (1974), is remarkably rare in the material from the Norwegian-Greenland Sea.

Occurrence: Rare in the *Naviculopsis biplicata* Zone at Site 339 and a cf. specimen in Sample 340-9, CC (Corbisema bimucronata Zone) from the Voring Plateau.

*Corbisema ovalis* Perch-Nielsen

(Plate 1, Figures 4, 5; Plate 7, Figures 3, 4)

In press *Corbisema ovalis* Perch-Nielsen, Geol. Soc. Denmark Bull., pl. 1, fig. 12, 13, pl. 2, fig. 7.

Remarks: Specimens show rounded triangular outline with strongly concave sides, and very short radial spines pointing downwards. Some specimens have hooks on the supporting spines (Plate 7, Figure 3).

Occurrence: Rare or few in the *Naviculopsis minor* Zone at Site 343 (Lofoten Basin), in the *Naviculopsis biplicata* Zone at Site 340, and in the *Corbisema bimucronata* Zone at Sites 338 and 340 (Voring Plateau).

*Corbisema spinosa* Deflandre

(Plate 7, Figure 9)


Remarks: Often confused with *Dictyocha hexacantha* by various authors. This species shows spiny apical spines on the apical rods, which are not in the same plane as the basal ring.

Occurrence: Rare to frequent in the *Naviculopsis minor* Zone to the top of the *Naviculopsis biplicata* Zone. Found at Sites 338, 339, 340 (Voring Plateau), and 343 (Lofoten Basin).

*Corbisema triacantha* (Ehrenberg)

(Plate 1, Figures 8, 9)


1974 *Corbisema triacantha* (Ehrenberg), Locker, Ecol. Geol. Helv., v. 67, p. 634, pl. 1, fig. 17, 22.

Remarks: A few specimens, some of which show very short radial spines illustrated as *Corbisema* sp. (Plate 7, Figure 6) may also belong to this species.

Occurrence: Very rare in the *Naviculopsis biplicata* Zone at Site 339 and a cf. specimen in Sample 340-9, CC (Corbisema bimucronata Zone) from the Voring Plateau.

*Corbisema spinosa* Deflandre

(Plate 7, Figure 9)


Remarks: Often confused with *Dictyocha hexacantha* by various authors. This species shows spiny apical spines on the apical rods, which are not in the same plane as the basal ring.

Occurrence: Rare to frequent from the *Naviculopsis biplicata* Zone to the top of the *Corbisema triacantha* Zone. Present at Sites 336 (Iceland-Faeroe Ridge), 337 (Norway Basin), 338, 339, 341, 342 (Voring Plateau), 345 (Mohns Ridge), and 346 (Jan-Mayen Ridge).

*Corbisema sp.*

(Plate 1, Figure 11)

Remarks: Rare specimens of a *Corbisema* species with a large flat apical plate, similar to *Corbisema flexuosa*, were found in the
Distephanus speculum Zone at Site 339, and may be reworked from older strata.

Genus DICTYOCHA Ehrenberg, 1840

**Dicytocha ausonia Deflandre**


**Remarks:** Forms included are within the variation of *Dicytocha ausonia* published by Deflandre (1950). Specimens found were covered by diatom debris and they are not illustrated.

**Occurrence:** Few to fairly common in the *Mesocena circulus* Zone at Site 338 (Vöring Plateau).

**Dicytocha challengeri n. sp.**

(Plate 2, Figure 8; Plate 5, Figure 10; Plate 8, Figure 3)

**Description:** Large pentagonal form with simple apical structure and short radial spines. Outline of the basal ring slightly concave at the connecting points with the apical rods. Apical structure triadate in the central part with two bifurcating rods and one straight rod, leading to the basal ring, resulting in three larger and two smaller “windows.” Surface ornamentation on the distal side of the basal ring net-like, apical structure with faint ornamentation of short crests and peaks, or without ornamentation.

**Size:** 110-125 µm.

**Remarks:** Distinguished from the similarly constructed *Dicytocha pentagona* by the large size and the concavity of the basal ring at the connecting points with the apical rods. Surface ornamentation similar to that of *Dicytocha quadria*.

**Occurrence:** Few in the late Eocene to middle Oligocene *Naviculopsis bicusculata* Zone at Site 339 (Vöring Plateau).

Holotype: SM.B 12796.

Type locality: Site 339 (Vöring Plateau) Core 12, Section 3.

**Dicytocha deflandrei Frenguellii**

(Plate 7, Figure 11)

1940 *Dicytocha deflandrei* Frenguellii, Rev. Mus. La Plata, ser. 2, v. 2, p. 65, fig. 14a-d.


**Occurrence:** Rare specimens have been found in the *Naviculopsis minor* Zone at Site 343 (Lofoten Basin), and in the *Dicytocha quadria* Zone at Site 338 (Vöring Plateau).

**Dicytocha cf. epiodon Ehrenberg**

(Plate 5, Figure 7; Plate 8, Figure 1)


**Remarks:** Although the type material of the Ehrenberg collection was recently revised by Locker (1974), the confusion within the “*Dicyticha fibula*” group and “*Dicyticha epiodon*” group is not solved. A detailed study and application of statistical methods seems necessary which is beyond the scope of the present paper. All forms of more or less quadrate outline with four radial spines, and vertical central bar supported by four apical rods are included here. A differentiation in subspecies or varieties was not attempted.

**Occurrence:** Rare in *Naviculopsis minor* Zone at Site 334 (Lofoten Basin), in the *Corbisema bimucronata* Zone, the *Naviculopsis navicula* Zone, and the *Mesocena circulus* Zone at Site 338 (Vöring Plateau). Few in the *Mesocena circulus* Zone at Site 348 (Icelandic Plateau). Also occasionally present at Site 336 (Iceland-Faeroe Ridge), 339 and 342 (Vöring Plateau), 345 (Mohns Ridge), and 346 (Jan-Mayen Ridge).

**Dicytocha freguellii Deflandre**

(Plate 2, Figure 9)

1950 *Dicytocha freguellii* Deflandre, Microscopie, v. 2, p. 194, fig. 188-193.


**Remarks:** The few specimens found show only short spines near the base of the apical rods supporting the basal ring. A five-sided specimen, with well-developed spines (Plate 2, Figure 9), was found in Sample 340-11, CC.

**Occurrence:** Present in the *Naviculopsis minor* Zone at Site 343 (Lofoten Basin), very rare in the *Corbisema bimucronata* Zone at Site 340, and few in the *Dicytocha quadria* Zone at Site 338 (both Vöring Plateau).

**Dicytocha hexacantha Schulz**

(Plate 2, Figure 7; Plate 7, Figure 10)

1928 *Dicyticha hexacantha* Schulz, Bot. Arch., v. 21, p. 255, fig. 43.


**Remarks:** This species is characterized by a triangular apical structure and six radial spines, three of which originate from the connecting point of the apical bars with the basal ring, and which are in the same plane as the basal ring.

**Occurrence:** In the present material found in the *Corbisema bimucronata* Zone and the *Naviculopsis bicusculata* Zone at Sites 340 and 346, more common in the *Mesocena circulus* Zone at Sites 338 and 340. More common in the *Naviculopsis navicula* Zone at Site 338 (both Vöring Plateau).

**Dicytocha pentagona (Schulz)**

(Plate 2, Figures 5, 6; Plate 5, Figure 11; Plate 8, Figures 5, 8, 9)

1928 *Dicyticha pentagona* Schulz, Bot. Arch., v. 21, p. 255, fig. 41a.

1973 *Dicyticha pentagona* (Schulz), Bukry and Foster, Initial Rept. Deep Sea Drilling Project, v. 16, p. 827, pl. 3, fig. 10.

**Remarks:** Forms included here are five- or six-sided, and show a crooked apical structure which is connected to the basal ring by five or six, respectively, bars of unequal length. They differ from *Dicyticha challengeri* in the smaller size and the more angular outline.

**Occurrence:** Present in fair number in the *Corbisema bimucronata* Zone and *Dicytocha quadria* Zone at Sites 338 and 340. More common in the *Mesocena circulus* Zone and *Naviculopsis navicula* Zone at Site 338 (Vöring Plateau).

**Dicytocha quadria (Mandra) nov. comb.**

(Plate 2, Figure 4; Plate 10, Figures 1, 2; Plate 5, Figure 9)


**Remarks:** As discussed earlier, “*Hannaites*” is a synonym of *Dicytocha*, and *Hannaites quadria* should be transferred to *Dicytocha quadria*, including forms with rounded corners, flattened or inflated corners. Typical is the outline of the basal ring, which is more or less concave at the connecting points with the four supporting rods of the apical bar.

**Occurrence:** It is present in the late Eocene *Corbisema bimucronata* Zone and *Dicytocha quadria* Zone, which can be correlated with...
most of the standard nanoplanckton Zone NP 17 (Discoster saipanensis Zone), to most of Zone NP 20 (Sphenolithus pseudoradians Zone). In the present material found at Site 340, Cores 1 to 3 and 6 to 11, and Site 338, Cores 26 to 29 (Tables 1 and 3). Also known from the equatorial Pacific (DSDP 65/1-8, CC) with flattened corners, and from the southwest Pacific Ocean (Tasman Sea, DSDP Site 281, Cores 14 to 16 and DSDP Site 283, Cores 3 to 6), and the South Atlantic Ocean (Vema 17-107), where it was reported the first time with spherical protuberances at the corners.

**Dictyochoa rotundata Jousé**

(Plate 7, Figure 16)


**Remarks:** Very small round forms of five or six irregular apical bars, which may be fused together like a small plate at the central part. Bars arched, counterfeiting corners on the basal ring.

**Occurrence:** Common in Cores 5 and 6 at Site 343 (Lofoten Basin), belonging to the Naviculopsis minor Zone.

**Dictyochoa torta n. sp.**

(Plate 8, Figure 7)

**Description:** Four-sided forms with radial spines of more or less equal length at the corners. Apical structure strongly arched and built of four apical bars. Connecting points of bars at the basal ring not in the same direction as crossing lines of bars at the top of the apical structure, resulting in an obvious curvature of bars when viewed from top or from below.

**Size:** of basal ring: 20-27 μm, length of radial spines: 10-12 μm.

**Remarks:** The curvature of apical bars distinguished this species from other forms with a cross-like apical structure like *Dictyochoa medusa* and *Dictyochoa deflandrei*, in which the central part of the apical structure is enlarged to an apical plate.

**Occurrence:** Few in the Corbicema bimucronata Zone (Unit C) at Site 340, in the Dictyochoa quadria Zone at Site 338, both from the Voring Plateau.

**Holotype:** SM.B 12797.

**Type locality:** DSDP Site 338 (Voring Plateau), Core 26, Section 1.

**Dictyochoa cf. transitoria Deflandre**

(Plate 7, Figure 14)


**Remarks:** The specimen illustrated shows some similarity with *Dictyochoa transitoria*, but the central bar in the apical structure is longer, and on one side of the basal ring a third spine, although very small, is present.

**Occurrence:** The only specimen was found in Sample 3435-5-4, 25-26 cm (Lofoten Basin), belonging to the Naviculopsis minor Zone.

**Dictyochoa sp.**

(Plate 7, Figures 8, 13)

**Remarks:** Elongated fibula-like form with four spines, of which those along the long axis are distinctly longer than those along the short axis. Apical structure built by a horizontal bar and four supporting rods.

**Occurrence:** Rare in Sample 3404-3, 100-101 cm from the Naviculopsis foliacea Zone (?).

**Genus DISTEPHANUS Stöhr, 1880**

**Distephanus antiquus Glezer**

(Plate 7, Figures 17, 18)


**Remarks:** Five or six short-spined, rounded forms with a large apical ring connected to the basal ring by short rods. Apical ring slightly smaller than basal ring.

**Occurrence:** Present in Cores 5 and 6 of Site 343 (Lofoten Basin), belonging to the Naviculopsis minor Zone.

**Distephanus biconicus (Ehrenberg)**

(Plate 9, Figure 1)


**Distephanus boliviensis (Fengiuell)**

(Plate 3, Figures 5, 6; Plate 5, Figure 12; Plate 9, Figure 3)

*1940 Dictyochoa boliviensis Fengiuelle, Rev. Mus. La Plata, ser. 2, v. 2, p. 44, fig. 4.*

**1975 Distephanus boliviensis jimlingii Bukry, Initial Rept. Deep Sea Drilling Project, v. 32, p. 683, pl. 1, fig. 6, 7; pl. 2, fig. 1.*

**Remarks:** Forms included here are relatively large and have an apical ring, which is subdivided to a number of small openings. The basal ring shows distinct supporting spines on its proximal side.

**Occurrence:** Present in Cores 6 to 8 at Site 348 (Icelandic Plateau) in the Distephanus boliviensis Zone, where it is especially common in the upper part of its occurrence.

**Distephanus crux (Ehrenberg)**

(Plate 2, Figures 10-12; Plate 7, Figure 15; Plate 9, Figure 2)


**1974 Distephanus crux (Ehrenberg), Locker, Ecol. Geol. Helv., v. 67, p. 637, Taf. 3, fig. 8, 10.*

**Remarks:** Included here are all forms which have a more or less quadrate basal ring, four radial spines of equal length, and an apical ring supported by four rods. Since all gradients, from specimens with small apical ring to specimens with large apical ring were found, and since the size varies considerably, no subdivision into varieties or subspecies was attempted.

**Occurrence:** Few or rare in the Naviculopsis foliacea Zone (?) and Corbicema bimucronata Zone at Sites 338 and 340 (Voring Plateau), common to abundant from the Distephanus lata Zone to the Mesocena circularis Zone at Site 338 (Voring Plateau), and fairly common in the Mesocena circularis Zone, but rare in the Distephanus boliviensis Zone at Site 348 (Icelandic Plateau). Also present at Site 336 (Iceland-Faeroe Ridge), and Site 342 (Voring Plateau).

**Distephanus longispinus (Schulz)**

(Plate 8, Figure 11)

*1928 Distephanus crux f. longispinus Schulz, Bot. Arch., v. 21, p. 256, fig. 44.*

**1973 Distephanus longispinus (Schulz), Bukry and Foster, Initial Rept. Deep Sea Drilling Project, v. 16, p. 828, pl. 4, fig. 7, 8.*

**Remarks:** The radial spines along the long axis are distinctly longer than those along the short axis. Otherwise, this form is similar to Distephanus crux.

**Occurrence:** Occasionally found from the Naviculopsis foliacea Zone to the lower part of the Mesocena circularis Zone, but in a few samples in far numbers. Present at Sites 338, 342 (Voring Plateau), 345 (Mohr Ridge), and 348 (Icelandic Plateau).

**Distephanus octonarius (Ehrenberg)**

(Plate 8, Figure 13)


**1974 Distephanus octonarius (Ehrenberg), Locker, Ecol. Geol. Helv., v. 67, p. 638, pl. 3, fig. 7.*

**Remarks:** This species commonly occurs with eight, and rarely with seven or nine radial spines. It is considered by many authors as being a variant of Distephanus speculum. Its occurrence, however, seems to be rather restricted, and in this paper it is treated as distinct species.

**Occurrence:** Rare to few in Core 5 at Site 348 (Icelandic Plateau), and in Core 9 at Site 336 in the Distephanus speculum Zone (Iceland-Faeroe Ridge).
**E. Martini and C. Muller**

**Mesocena concava Perch-Nielsen**

(Plate 11, Figure 1)

In press Mesocena concava Perch-Nielsen, Geol. Soc. Denmark Bull., pl. 1, fig. 11; pl. 2, fig. 9.

**Mesocena dionodon Ehrenberg**

(Plate 4, Figure 5; Plate 11, Figures 5, 7, 11; Plate 6, Figure 7)


**Mesocena elliptica Ehrenberg**

(Plate 4, Figures 5, 6; Plate 11, Figures 8, 9; Plate 6, Figure 6)


**Mesocena oamaruensis Schulz**

(Plate 5, Figure 10)


**Mesocena cf. aomaruensis Schulz**

(Plate 4, Figure 4; Plate 10, Figures 3-5)

1928 Mesocena oamaruensis Schulz, Bot. Arch., v. 21, p. 240, fig. 10a-b.


**Mesocena cf. oamaruensis Schulz**

(Plate 11, Figure 14)


**Mesocena concava Perch-Nielsen**

(Plate 11, Figure 1)

In press Mesocena concava Perch-Nielsen, Geol. Soc. Denmark Bull., pl. 1, fig. 11; pl. 2, fig. 9.

**Mesocena dionodon Ehrenberg**

(Plate 4, Figure 5; Plate 11, Figures 5, 7, 11; Plate 6, Figure 7)


**Mesocena elliptica Ehrenberg**

(Plate 4, Figures 5, 6; Plate 11, Figures 8, 9; Plate 6, Figure 6)


**Mesocena oamaruensis Schulz**

(Plate 5, Figure 10)


**Mesocena cf. aomaruensis Schulz**

(Plate 4, Figure 4; Plate 10, Figures 3-5)

1928 Mesocena oamaruensis Schulz, Bot. Arch., v. 21, p. 240, fig. 10a-b.


**Mesocena cf. oamaruensis Schulz**

(Plate 11, Figure 14)


**Mesocena concava Perch-Nielsen**

(Plate 11, Figure 1)

In press Mesocena concava Perch-Nielsen, Geol. Soc. Denmark Bull., pl. 1, fig. 11; pl. 2, fig. 9.

**Mesocena dionodon Ehrenberg**

(Plate 4, Figure 5; Plate 11, Figures 5, 7, 11; Plate 6, Figure 7)


**Mesocena elliptica Ehrenberg**

(Plate 4, Figures 5, 6; Plate 11, Figures 8, 9; Plate 6, Figure 6)


**Mesocena oamaruensis Schulz**

(Plate 5, Figure 10)


**Mesocena cf. aomaruensis Schulz**

(Plate 4, Figure 4; Plate 10, Figures 3-5)

1928 Mesocena oamaruensis Schulz, Bot. Arch., v. 21, p. 240, fig. 10a-b.


**Mesocena cf. oamaruensis Schulz**

(Plate 11, Figure 14)


**Mesocena concava Perch-Nielsen**

(Plate 11, Figure 1)

In press Mesocena concava Perch-Nielsen, Geol. Soc. Denmark Bull., pl. 1, fig. 11; pl. 2, fig. 9.

**Mesocena dionodon Ehrenberg**

(Plate 4, Figure 5; Plate 11, Figures 5, 7, 11; Plate 6, Figure 7)


**Mesocena elliptica Ehrenberg**

(Plate 4, Figures 5, 6; Plate 11, Figures 8, 9; Plate 6, Figure 6)


**Mesocena oamaruensis Schulz**

(Plate 5, Figure 10)


**Mesocena cf. aomaruensis Schulz**

(Plate 4, Figure 4; Plate 10, Figures 3-5)

1928 Mesocena oamaruensis Schulz, Bot. Arch., v. 21, p. 240, fig. 10a-b.


**Mesocena cf. oamaruensis Schulz**

(Plate 11, Figure 14)

illustrated by Perch-Nielsen from the late Eocene of Hole 280A to the west of Tasmania.

Mesocena shultzii n. sp.  
(Plate 11, Figures 3, 13)

1928 Mesocena oamurensis cf. quadrangula Schulz, Bot Arch., v. 21, p. 240, fig. 13.

Description: Quadrate ring with slightly concave sides and short spines at the four corners. Septae are commonly present, net-like surface ornamentation of crests and depressions as in Mesocena apiculata.

Size: Diameter 75 to 160 \( \mu m \).

Remarks: The rare, but consistent, occurrence in the interval from the uppermost Eocene to the lower Miocene and its distinct shape not present in any other Miocene Mesocena species seem to justify the erection of a new species. Extremely large specimens were found in the Naviculopsis biapiculata Zone at Site 339 (Vørnig Plateau).

Occurrence: Rare specimens in Samples 339-10-2, 50-51 cm (Naviculopsis biapiculata Zone) and 338-16-5, 50-51 cm (Naviculopsis navicula Zone), both from the Vørnig Plateau. Originally reported from the upper Eocene of Oamaru by Schulz (1928). Also present in the late Eocene and early Miocene of Leg 29, south of New Zealand.

Holotype: SM.B 12798.

Type locality: Sample 338-16-5, 50-51 cm (Vørnig Plateau).

Genus NAVICULOPSIS Frenguelli, 1940

Naviculopsis biapiculata (Lemmermann)  
(Plate 12, Figure 13)


Remarks: Navicular form with two long spines along the long axis and a small apical bridge. The basal ring is slightly concave at the connecting points of the apical bridge.

Occurrence: In the present material, found from the Corbisema binucronata Zone to the lower part of the Naviculopsis navicula Zone, with common occurrences in the Naviculopsis biapiculata Zone at Sites 338, 340, and 337 (Norway Basin).

Naviculopsis cf. biapiculata (Lemmermann)  
(Plate 12, Figure 14)

Remarks: Included are forms which have a broader basal ring, but are otherwise identical with the nominate form. They occur in a position just prior to the first occurrence of Naviculopsis lata and may be regarded as transitional forms of Naviculopsis biapiculata to Naviculopsis lata.

Occurrence: Rare to few in the upper Naviculopsis biapiculata Zone at Site 338 (Vørnig Plateau).

Naviculopsis constricta (Schulz)  
(Plate 5, Figure 1; Plate 12, Figure 8)

1928 Dictyocha navicula var. constricta Schulz, Bot Arch., v. 21, p. 245, fig. 21.
1975 Naviculopsis constricta (Schulz), Perch-Nielsen, Initial Rept. Deep Sea Drilling Project, v. 29, p. 689, pl. 12, fig. 16, 17, 23.

Remarks: Navicular form with long spines, and a rather broad apical bridge. Basal ring distinctly concave at the connecting points of the apical bridge.

Occurrence: Rare or few in the Naviculopsis foliacea Zone and Corbisema binucronata Zone at Site 340, and in the Naviculopsis biapiculata Zone at Site 339, both Vørnig Plateau.

Naviculopsis foliacea Deflandre  
(Plate 12, Figure 4)


Remarks: Slender navicular form with a very broad, but thin apical bridge. Closely related to Naviculopsis sicca.

Occurrence: Present in the Naviculopsis minor Zone at Site 343 (Lofoten Basin), in the Corbisema binucronata Zone at Site 340 (Vørnig Plateau), and rare cf. specimens in the Naviculopsis biapiculata Zone at Site 339 (Vørnig Plateau).

Naviculopsis iberica Deflandre  
(Plate 4, Figure 10; Plate 12, Figure 17)


Remarks: Although considered by some authors as synonym of Naviculopsis quadratum, this species with broad, but rounded basal ring, has a different range as the typical rectangular forms of Naviculopsis quadratum, and, therefore, is listed separately (compare Table 5). It is regarded as intermediate form between Naviculopsis lata and Naviculopsis quadratum.

Occurrence: Fairly frequent in the Naviculopsis lata Zone and lower part of the Naviculopsis navicula Zone at Site 338 (Vørnig Plateau).

Naviculopsis lata (Deflandre)  
(Plate 4, Figure 11; Plate 6, Figures 9, 10; Plate 12, Figure 15)

1972 Naviculopsis lata (Deflandre), Martini, Senckenberg. Lethaea, v. 51, p. 129, fig. 1.

Remarks: Short but broad navicular form with tubular apical bridge and two relatively short spines at the ends. Transitional forms to Naviculopsis biapiculata are listed separately as Naviculopsis cf. biapiculata.

Occurrence: Few to common in the Naviculopsis lata Zone and lower part of the Naviculopsis navicula Zone at Sites 336 (Iceland-Faeroe Ridge), 338, 342 (Vørnig Plateau), and 345 (Mohns Ridge).

Naviculopsis cf. minor (Schulz)  
(Plate 12, Figure 12)

1928 Dictyocha navicula var. minor Schulz, Bot Arch., v. 21, p. 246, fig. 22.
1966 Naviculopsis biapiculata var. minor (Schulz), Giezer, Cryptogamic Plants USSR, v. 7, p. 274, pl. 16, fig. 6-8; pl. 17, fig. 1-3, 6.

Remarks: Short navicular basal ring with arched and broad apical bridge. Specimens from the “lower Eocene” in Germany are more robust, but all are within the morphologic range as indicated by Giezer (1966).

Occurrence: In the present material, found as rare specimens in the lower part of Core 5 and upper part of Core 6 at Site 343 (Lofoten Basin), belonging in the Naviculopsis minor Zone. In northern Germany occurring in the Dictyocha transitoria Zone and Naviculopsis minor Zone of the local “lower Eocene,” a part of which, already belongs to the middle Eocene in the international sense.

Naviculopsis navicula (Ehrenberg)  
(Plate 4, Figure 9; Plate 12, Figure 16)

1972 Naviculopsis navicula (Ehrenberg), Martini, Senckenberg. Lethaea, v. 53, p. 120, fig. 2.
1974 Naviculopsis navicula (Ehrenberg), Eckles, Eclog. Geol. Helv., v. 67, p. 635, pl. 2, fig. 1, 2.

Remarks: Navicular basal ring, lacking distinct spines at the ends. End of the basal ring commonly broad and flat, somewhat rectangular or rounded, with or without very small horns instead of spines. Apical bridge tubular and slightly arched.

Occurrence: Frequent, found in the Naviculopsis navicula Zone at Sites 338, 342 (Vørnig Plateau) and 345 (Mohns Ridge).

Naviculopsis ponticula Perch-Nielsen  
(Plate 5, Figures 2, 3; Plate 6, Figure 8; Plate 12, Figures 1, 2)


873
Remarks: Specimens found are identical with the description and figures by Perch-Nielsen (in press), and includes navicular forms with a tubular bridge supported by two rods on each side.

Occurrence: Few to common in the Naviculopsis foliacea Zone (?), Corbisema bimucronata Zone, and lower part of the Dictyocha quadria Zone at Sites 338 and 340 (Vøring Plateau).

**Naviculopsis aff. ponticula Perch-Nielsen**

(Plate 12, Figures 9-11)

Remarks: Forms have a rather short navicular basal ring, with two long spines and a tubular bridge connected to the basal ring by two rods on each side. The apical bridge is strongly arched. It differs from typical Naviculopsis ponticula by the extremely short basal ring.

Occurrence: In fair numbers together with typical Naviculopsis ponticula at Site 338 (Vøring Plateau).

**Naviculopsis cf. ponticula Perch-Nielsen**

(Plate 12, Figure 3)

Remarks: Specimens similar to Naviculopsis ponticula, but instead of having a tubular bridge, these specimens have a slightly arched plate connected to the basal ring by four rather broad, but thin rods. Navicular ring not as broad as in typical Naviculopsis ponticula.

Occurrence: Common to frequent in the upper part of the Dictyocha quadria Zone, and are within the range of typical Naviculopsis ponticula.

**Naviculopsis quadratum (Ehrenberg)**

(Plate 4, Figure 12; Plate 12, Figure 18)


1928 *Dictyocha navicula rectangulare* Schulz, Bot Arch., v. 21, p. 243, fig. 17 a, b.

1972 *Naviculopsis navicula rectangulare* (Schulz), Martini, Senckenberg. Lethaea, v. 53, p. 120, fig. 3.

1974 *Naviculopsis quadratum* (Ehrenberg), Locker, Ecol. Geol. Helv., v. 67, p. 635, pl. 2, fig. 3.

Remarks: Typical rectangular basal ring with a short spine at each end. Apical bridge tubular and slightly arched. Not included here are rounded forms, as these have a different stratigraphic range (see Naviculopsis iberica).

Occurrence: Common to frequent in the upper part of the Naviculopsis navicula Zone at Sites 338, 342 (Vøring Plateau) and 345 (Mohns Ridge).

**Naviculopsis sicca n. sp.**

(Plate 12, Figures 5-7)

Description: Elongated and extreme slender form with a long spine at each end. The navicular basal ring is incorporated in the apical bridge, which is rather thin, but covers most of the space between the two spines. Only at each end of the navicular basal ring is a small opening present. Near the base of the radial spine a short supporting spine seems to be present in some specimens (Plate 12, Figure 6).

Size: Total length 100-150 µm, length of navicular basal ring 65-80 µm, width: 8-12 µm.

Remarks: Distinguished from the related Naviculopsis foliacea by the extreme slender form, and the very small openings near the ends of the basal body.

Occurrence: Present in fair numbers in the upper part of the Naviculopsis foliacea Zone (?) and in the lower part of the Corbisema bimucronata Zone at Site 340 and in Sample 29, CC at Site 338 (Corbisema bimucronata) Zone on the Vøring Plateau.

Holotype: SM.B 12799.

Type locality: Sample 340-5-1, 110-111 cm (Vøring Plateau).

REFERENCES


875
PLATE 1

Figure 1  
*Corbisema apiculata* (Lemmermann).  
Proximal side, SEM 500×;  
Sample 340-7, CC;  
*Corbisema bimucronata* Zone.

Figure 2  
*Corbisema apiculata* (Lemmermann).  
Proximal side, SEM 500×;  
Sample 339-12-3, 125-126 cm;  
*Naviculopsis biaipiculata* Zone.

Figure 3  
*Corbisema apiculata* (Lemmermann).  
Proximal side, SEM 500×;  
Sample 339-12-3, 125-126 cm;  
*Naviculopsis biaipiculata* Zone.

Figures 4-6  
*Corbisema ovalis* Perch-Nielsen.  
Sample 340-7, CC;  
*Corbisema bimucronata* Zone.  
4. Proximal side, SEM 525×.  
5. Distal side, SEM 475×.  
6. Distal side, SEM 525×.

Figure 7  
*Corbisema flexuosa* (Stradner).  
Distal side, SEM 500×;  
Sample 340-11, CC;  
*Corbisema bimucronata* Zone.

Figure 8, 9  
*Corbisema triacantha* (Ehrenberg).  
*Naviculopsis biaipiculata* Zone.  
8. Distal side, SEM 1050×;  
Sample 339-12-3, 55-56 cm.  
9. Proximal side, SEM 950×;  
Sample 339-12-3, 115-116 cm.

Figure 10  
*Corbisema hastata* (Lemmermann).  
Distal side, SEM 950×;  
Sample 339-10-2, 55-56 cm;  
*Naviculopsis biaipiculata* Zone.

Figure 11  
*Corbisema sp.*  
Distal side, SEM 950×;  
Sample 339-7, CC;  
*Distephanus speculum* Zone (displaced material).

Figure 12  
*Corbisema cf. apiculata* (Lemmermann).  
Distal side, SEM 450×;  
Sample 339-7, CC;  
*Distephanus speculum* Zone (displaced material).

PLATE 2

Figures 1, 2  
*Dictyocha cf. fibula* Ehrenberg.  
Sample 348-14-1, 90-91 cm;  
*Mesocena circulus* Zone.  
1. Distal side, SEM 455×.  
2. Proximal side, SEM 440×.

Figure 3  
*Dictyocha cf. fibula* Ehrenberg.  
Distal side, SEM 550×;  
Sample 340-7, CC;  
*Corbisema bimucronata* Zone.

Figure 4  
*Dictyocha quadria* (Mandra).  
Distal side, SEM 540×;  
Sample 340-11, CC;  
*Corbisema bimucronata* Zone.

Figures 5, 6  
*Dictyocha pentagona* (Schulz).  
Distal sides, SEM 550×;  
Sample 340-11, CC;  
*Corbisema bimucronata* Zone.

Figure 7  
*Dictyocha hexacantha* Schulz.  
Distal side, SEM 1000×;  
Sample 339-10-2, 55-56 cm;  
*Naviculopsis biaipiculata* Zone.

Figure 8  
*Dictyocha challengeri* n. sp.  
Distal side, SEM 225×;  
Sample 339-12-3, 115-116 cm;  
*Naviculopsis biaipiculata* Zone.

Figure 9  
*Dictyocha cf. frenguellii* Deflandre.  
Distal side, SEM 500×;  
Sample 340-11, CC;  
*Corbisema bimucronata* Zone.

Figure 10  
*Distephanus crux* (Ehrenberg).  
Proximal side, SEM 500×;  
Sample 340-11, CC;  
*Corbisema bimucronata* Zone.

Figures 11, 12  
*Distephanus crux* (Ehrenberg).  
Sample 348-11-2, 20-21 cm;  
*Mesocena circulus* Zone.  
(see page 878)
EOCENE TO PLEISTOCENE SILICOFLAGELLATES

PLATE 3

Figure 1  
*Distephanus quinquangularis* Bukry and Foster.  
Distal side, SEM 450×;  
Sample 348-14-1, 90-91 cm;  
*Mesocena circulus* Zone.

Figure 2  
*Distephanus speculum* (Ehrenberg).  
Distal side, SEM 540×;  
Sample 348-7-2, 30-31 cm;  
*Distephanus boliviensis* Zone.

Figure 3  
*Distephanus speculum* (Ehrenberg).  
Distal side, SEM 450×;  
Sample 348-11-2, 85-86 cm;  
*Mesocena circulus* Zone.

Figure 4  
*Distephanus speculum* (Ehrenberg).  
Proximal side, SEM 500×;  
Sample 348-11-1, 20-21 cm;  
*Mesocena circulus* Zone.

Figures 5, 6  
*Distephanus boliviensis* (Frenguelli).  
Sample 348-7-2, 30-31 cm;  
*Distephanus boliviensis* Zone.  
5. Distal side, SEM 540×.  

Figure 7  
*Cannopilus hemisphaericus* (Ehrenberg).  
Distal side, SEM 500×;  
Sample 339-10-2, 55-56 cm;  
*Naviculopsis biapiculata* Zone.

Figures 8-10  
*Cannopilus ernestinae* Bachmann.  
Sample 348-15, CC;  
*Mesocena circulus* Zone.  
8. Side view, SEM 925×.  
10. Oblique view from below, SEM 950×.

Figures 11, 12  
*Cannopilus depressus* (Ehrenberg).  
Distal sides, SEM 900×;  
*Mesocena circulus* Zone.  
11. Sample 348-15, CC.  
12. Sample 348-14-1, 90-91 cm.  
(see page 880)

PLATE 4

Figure 1  
*Mesocena apiculata* (Schulz).  
Triangular form, SEM 550×;  
Sample 339-12-3, 115-116 cm;  
*Naviculopsis biapiculata* Zone.

Figure 2  
*Mesocena apiculata* (Schulz).  
Rounded triangular form, SEM 500×;  
Sample 348-15, CC;  
*Mesocena circulus* Zone.

Figure 3  
*Mesocena oamarauensis* Schulz.  
SEM 450×;  
Sample 340-7, CC;  
*Corbisema binucronata* Zone.

Figure 4  
*Mesocena diodon* Ehrenberg.  
Normal two-spined form, SEM 550×;  
Sample 348-11-2, 20-21 cm;  
*Mesocena circulus* Zone.

Figures 5, 6  
*Mesocena elliptica* Ehrenberg.  
Normal four-spined form;  
*Mesocena circulus* Zone.  
5. Sample 348-11-1, 20-21 cm, SEM 550×.  

Figures 7, 8  
*Mesocena circulus* Ehrenberg.  
Sample 348-11-2, 20-21 cm;  
*Mesocena circulus* Zone.  
7. Flat view, SEM 550×.  
8. Side view, SEM 500×.

Figure 9  
*Naviculopsis navicula* (Ehrenberg).  
Distal side, SEM 550×;  
Sample 338-13-3, 5-6 cm;  
*Naviculopsis navicula* Zone.

Figure 10  
*Naviculopsis iberica* Deflandre.  
Distal side, SEM 500×;  
Sample 338-17, CC;  
*Naviculopsis navicula* Zone.

Figure 11  
*Naviculopsis lata* (Deflandre).  
Proximal side, SEM 500×;  
Sample 338-17, CC;  
*Naviculopsis navicula* Zone.

Figure 12  
*Naviculopsis quadratum* (Ehrenberg).  
Distal side, SEM 500×;  
Sample 338-13-3, 5-6 cm;  
*Naviculopsis navicula* Zone.  
(see page 881)
PLATE 5

Figure 1  Naviculopsis constricta (Schulz).
Distal side, SEM 500×;
Sample 339-10-2, 55-56 cm;
Naviculopsis navicula Zone.

Figures 2, 3  Naviculopsis ponticula Perch-Nielsen.
Sample 340-1, CC;
Corbisema bimucronata Zone.
2. Distal side, SEM 270×.

Figure 4  Corbisema apiculata (Lemmermann).
SEM 2500×;
Sample 339-7, CC;
Distephanus speculum Zone (reworked).

Figure 5  Corbisema apiculata (Lemmermann).
SEM 2550×;
Sample 340-11, CC;
Corbisema bimucronata Zone.

Figure 6  Corbisema sp. SEM 2300× (see Plate 1, Figure 11);
Sample 339-7, CC;
Distephanus speculum Zone (displaced).

Figure 7  Dictyocha cf. epiodon Ehrenberg.
SEM 2500×;
Sample 339-12-3, 125-126 cm;
Naviculopsis biapiculata Zone.

Figure 8  Dictyocha cf. fibula Ehrenberg.
SEM 2400×;
Sample 339-12-3, 125-126 cm;
Naviculopsis biapiculata Zone.

Figure 9  Dictyocha quadria (Mandra).
SEM 1000× (see Plate 2, Figure 4);
Sample 340-11, CC;
Corbisema bimucronata Zone.

Figure 10  Dictyocha challengeri n. sp.
SEM 1100× (see Plate 2, Figure 8);
Sample 339-12-3, 115-116 cm;
Naviculopsis biapiculata Zone.

Figure 11  Dictyocha pentagona (Schulz).
SEM 2250× (see Plate 2, Figure 5);
Sample 340-11, CC;
Corbisema bimucronata Zone.

Figure 12  Distephanus boliviensis (Frenguelli).
SEM 2500× (see Plate 3, Figure 6);
Sample 348-7-2, 30-31 cm;
Distephanus boliviensis Zone.

PLATE 6

Figure 1  Distephanus speculum (Ehrenberg).
Sample 348-11-2, 85-86 cm;
Mesocena circulus Zone.
a. SEM 2250×.
b. SEM 4500×.
c. SEM 4500×.

Figures 2-4  Cannopilus ernestinae Bachmann.
Sample 348-15, CC;
Mesocena circulus Zone.
2. SEM 2450× (see Plate 3, Figure 10).
3. SEM 2400× (see Plate 3, Figure 9).
4. SEM 2300×.

Figure 5  Mesocena apiculata (Schulz).
SEM 1000×;
Sample 339-12-3, 115-116 cm;
Naviculopsis biapiculata Zone.

Figure 6  Mesocena elliptica (Schulz).
SEM 5525× (see Plate 4, Figure 6);
Sample 348-11-1, 20-21 cm;
Mesocena circulus Zone.

Figure 7  Mesocena diodon Ehrenberg.
SEM 2650×;
Sample 348-11-1, 20-21 cm;
Mesocena circulus Zone.

Figure 8  Naviculopsis ponticula Perch-Nielsen.
SEM 2500×;
Sample 340-11, CC;
Corbisema bimucronata Zone.

Figures 9, 10  Naviculopsis lata (Deflandre).
Sample 338-17, CC;
Naviculopsis navicula Zone.
9. SEM 2500×.
10. SEM 2500× (see Plate 4, Figure 11).

(See page 884)
EOCENE TO PLEISTOCENE SILICOFLAGELLATES

PLATE 7
(All specimens LM and except Figure 12 approximately 400×)

Figures 1, 2  *Corbisema apiculata* (Lemmermann).
Proximal side.
  1. Sample 339-12-3, 125-126 cm;
  *Naviculopis biapiculata* Zone.
  2. Sample 343-5-4, 120-121 cm;
  *Naviculopis minor* Zone.

Figures 3, 4  *Corbisema ovalis* Perch-Nielsen.
  3. Proximal side;
  Sample 340-7, CC;
  *Corbisema bimucronata* Zone.
  4. Distal side;
  Sample 340-5, CC;
  *Naviculopis foliacea* Zone (?).

Figure 5  *Corbisema* cf. *archangelskiana* (Schulz).
Proximal side;
Sample 340-7, CC;
*Corbisema bimucronata* Zone.

Figure 6  *Corbisema* cf. *flexuosa* (Stradner).
Distal side;
Sample 339-12-3, 125-126 cm;
*Naviculopis bimucronata* Zone.

Figure 7  *Corbisema flexuosa* (Stradner).
Distal side;
Sample 339-13-2, 85-86 cm;
*Naviculopis foliacea* Zone.

Figure 8  *Dictyocha* sp.
Distal side;
Sample 340-4-3, 100-101 cm;
*Naviculopis foliacea* Zone (?).

Figure 9  *Corbisema spinosa* Deflandre.
Distal side, (a) high focus, (b) medium focus;
Sample 339-10, CC;
*Naviculopis biapiculata* Zone.

Figure 10  *Dictyocha hexacantha* Schulz.
Proximal side;

Figure 11  *Dictyocha deflandrei* Frenguelli.
Proximal side;
Sample 343-5-4, 25-26 cm;
*Naviculopis minor* Zone.

Figure 12  *Corbisema bimucronata* Deflandre.
Distal side, approx. 350×;
Sample 340-8, CC;
*Corbisema bimucronata* Zone.

Figure 13  *Dictyocha* sp.
Distal side, (a) medium focus, (b) high focus;
Sample 340-4-3, 100-101 cm;
*Naviculopis foliacea* Zone (?).

Figure 14  *Dictyocha* cf. *transitoria* Deflandre.
Distal side, (a) medium focus, (b) high focus;
Sample 343-5-4, 25-26 cm;
*Naviculopis minor* Zone.

Figure 15  *Distephanus crux* (Ehrenberg).
Distal side;
Sample 338-15-1, 95-96 cm;
*Naviculopis navicula* Zone.

Figure 16  *Dictyocha rotundata* Jousé.
Distal side, (a) medium focus, (b) high focus;
Sample 343-5-6, 110-111 cm;
*Naviculopis minor* Zone.

Figures 17, 18  *Distephanus antiquus* Glezer.
*Naviculopis minor* Zone.
  17. Five-sided specimen, medium focus;
  Sample 343-5-3, 100-101 cm.
  18. Six-sided specimen, (a) medium focus, (b) high focus;
  Sample 343-5-2, 125-126 cm.

(see page 886)
PLATE 8

(All specimens LM and except Figures 15-17 approximately 400X.)

Figure 1
*Dictyocha cf. epiodon* Ehrenberg.
Distal side;
Sample 348-14-1, 90-91 cm;
*Mesocena circulus* Zone.

Figure 2
*Dictyocha cf. fibula* Ehrenberg.
Proximal side;
Sample 348-14-6, 85-86 cm;
*Mesocena circulus* Zone.

Figure 3
*Dictyocha challengeri* n. sp.
Holotype SM.B 12796, proximal side;
Sample 339-12-3, 125-126 cm;
*Naviculopsis biapiculata* Zone.

Figure 4
*Dictyocha cf. fibula* Ehrenberg.
Proximal side;
Sample 339-7, CC;
*Distephanus speculum* Zone (re-worked).

Figure 5
*Dictyocha pentagona* (Schulz).
Distal side;
Sample 340-11, CC;
*Corbisema bimucronata* Zone.

Figure 6
*Dictyocha sp.*
Distal side;
Sample 339-10, CC;
*Naviculopsis biapiculata* Zone.

Figure 7
*Dictyocha torta* n. sp.
Holotype SM.B 12797, (a) medium focus, (b) high focus;
Sample 338-26-2, 109-110 cm;
*Dictyocha quadria* Zone.

Figure 8, 9
*Dictyocha pentagona* (Schulz).
*Naviculopsis navicula* Zone.
8. Five-sided specimen;
Sample 338-17-2, 25-26 cm.
9. Six-sided specimen;
Sample 338-17-2, 135-136 cm.

Figure 10
*Cannopilus* sp.
Side view;
Sample 338-20-2, 30-31 cm;
*Naviculopsis biapiculata* Zone.

Figure 11
*Distephanus longispinus* (Schulz).
Proximal side, (a) medium focus, (b) low focus;
Sample 338-10, CC;
*Corbisema triacantha* Zone.

Figure 12
*Distephanus speculum* (Ehrenberg).
Side view of tilted specimen;
Sample 348-6, CC;
*Distephanus boliviensis* Zone.

Figure 13
*Distephanus octonarius* (Ehrenberg).
Distal side;
Sample 348-5, CC;
*Distephanus speculum* Zone.

Figure 14
*Pseudoroccella corona* Deflandre.
Distal side;
Sample 338-17-2, 40-41 cm;
*Naviculopsis navicula* Zone.

Figure 15
*Dictyocha quadria* (Mandra).
Distal side, approx. 630X;
Sample 65/1-8, CC;
*Corbisema bimucronata* Zone.

Figure 16
Mass occurrence of diatom 340 (=*Triceratium barbadense*), approx. 380X;
Sample 340-7, CC;
*Corbisema bimucronata* Zone.

Figure 17
Mass occurrence of diatom 348 (=*Stephanogonia horridus*), approx. 380X;
Sample 348-16, CC;
*Mesocena circulus* Zone.

(see page 888)
PLATE 9
(All specimens LM and approximately 400×.)

Figure 1 *Distephanus binoculus* (Ehrenberg).
Distal side, (a) medium focus, (b) high focus;
Sample 348-11-1, 20-21 cm;
*Mesocena circulus* Zone.

Figure 2 *Distephanus crux* (Ehrenberg).
Distal side of aberrant specimen, (a) medium focus, (b) high focus;
Sample 338-7, CC;
*Mesocena circulus* Zone.

Figure 3 *Distephanus boliviensis* (Frenguelli).
Proximal side, (a) medium focus, (b) low focus;
Sample 348-6-1, 105-106 cm;
*Distephanus boliviensis* Zone.

Figure 4 *Distephanus quinquangellus* Bukry and Foster.
Distal side, (a) medium focus, (b) high focus;
Sample 348-12-4, 90-91 cm;
*Mesocena circulus* Zone.

Figure 5 *Cannopilus hemisphaericus* (Ehrenberg).
Distal side, (a) medium focus, (b) high focus;
Sample 338-19-4, 31-32 cm;
*Naviculopsis biapiculata* Zone.

Figures 6, 7 *Cannopilus ernestinae* Bachmann.
Tilted specimens, (a) medium focus, (b) high focus;
Sample 338-7, CC;
*Mesocena circulus* Zone.

(See page 890)

PLATE 10

Figure 1 *Dictyocha quadria* (Mandra).
Distal side, (a) medium focus, (b) high focus; LM 720×,
Sample 340-11, CC;
*Corbisema bimucronata* Zone.

Figure 2 *Dictyocha quadria* (Mandra).
Specimen with spherical-like protuberances on each corner;
Sample 283-6, CC (Leg 29);
*Dictyocha quadria* Zone.
a. Total view LM 680×.
b. Left corner, medium focus, LM 1750×.
c. Left corner, high focus, LM 1750×.

Figure 3 *Mesocena oamaruensis* Schulz.
Specimen with spherical-like protuberances on each corner;
Sample 340-9, CC,
*Corbisema bimucronata* Zone.
a. Total view, LM 680×.
b. Left corner, medium focus, LM 1750×.
c. Left corner, high focus, LM 1750×.

Figures 4, 5 *Mesocena cf. oamaruensis* Schulz.
Spherical-like protuberances of broken specimens;
*Corbisema bimucronata* Zone.
4a. Medium focus, LM 400×.
4b. High focus, LM 400×; Sample 340-9, CC.
5a. Medium focus, LM 400×.
5b. High focus, LM 400×; Sample 340-11-2, 58-59 cm.

(See page 891)
PLATE 11
(All specimens LM, and approximately 400×.)

Figure 1  
*Mesocena concava* Perch-Nielsen.  
Sample 340-7-4, 145-146 cm;  
*Corbisema bimucronata* Zone.

Figure 2  
*Mesocena apiculata* (Schulz).  
Sample 338-13-1, 125-126 cm;  
*Naviculopsis navicula* Zone.

Figure 3  
*Mesocena schulzii* n. sp.  
Holotype, SM.B 12798;  
Sample 338-16-5, 50-51 cm;  
*Naviculopsis navicula* Zone.

Figure 4  
*Mesocena circulus* Ehrenberg.  
Sample 348-11-5, 140-141 cm;  
*Mesocena circulus* Zone.

Figure 5  
*Mesocena diodon* Ehrenberg.  
Aberrant specimen;  
Sample 341-33-4, 130-131 cm;  
*Mesocena circulus* Zone.

Figure 6  
Almost circular specimen with reduced spines;  
Sample 338-8-4, 85-86 cm;  
*Corbisema triacantha* Zone.

Figure 7  
*Mesocena diodon* Ehrenberg.  
Aberrant specimen;  
Sample 348-17, CC;  
*Mesocena circulus* Zone.

Figure 8  
*Mesocena elliptica* Ehrenberg.  
Sample 348-11-1, 20-21 cm;  
*Mesocena circulus* Zone.

Figure 9  
*Mesocena elliptica* Ehrenberg.  
Sample 338-14-3, 85-86 cm;  
*Naviculopsis navicula* Zone.

Figure 10  
Sample 343-5-6, 35-36 cm;  
*Naviculopsis minor* Zone.

Figure 11  
*Mesocena diodon* Ehrenberg.  
Sample 338-7, CC;  
*Mesocena circulus* Zone.

Figure 12  
*Mesocena apiculata* (Schulz).  
Sample 339-11, CC;  
*Naviculopsis biapiculata* Zone.

Figure 13  
*Mesocena schulzii* n. sp.  
Sample 399-10-2, 55-56 cm;  
*Naviculopsis biapiculata* Zone.

Figure 14  
*Mesocena* cf. *oamaruensis* Schulz.  
Sample 343-5-3, 100-101 cm;  
*Naviculopsis minor* Zone.
Figures 1, 2  *Naviculopsis ponticula* Perch-Nielsen.  
Sample 340-11, CC;  
*Corbisema bimucronata* Zone.  
1. Distal side.  
2. Side view of tilted specimen.

Figure 3  *Naviculopsis* cf. *ponticula* Perch-Nielsen.  
Proximal side;  
Sample 340-3-1, 140-141 cm;  
*Corbisema bimucronata* Zone.

Figure 4  *Naviculopsis foliacea* Deflandre.  
Side view of slightly tilted specimen;  
Sample 340-1-4, 115-116 cm;  
*Distephanus speculum* Zone (re-worked).

Figures 5-7  *Naviculopsis sicca* n. sp.  
5. Holotype SM.B 12799, proximal side;  
Sample 340-5-1, 110-111 cm;  
*Naviculopsis foliacea* Zone (?).  
6. Proximal side;  
Sample 340-10-2, 100-101 cm;  
*Corbisema bimucronata* Zone.  
7. Side view;  
Sample 340-7, CC.  
*Corbisema bimucronata* Zone.

Figure 8  *Naviculopsis constricta* (Schulz),  
Sample 339-7, CC;  
*Distephanus speculum* Zone (re-worked).

Figures 9-11  *Naviculopsis aff. ponticula* Perch-Nielsen.  
Sample 338-29-1, 113-114 cm;  
*Corbisema bimucronata* Zone.

10. Distal view.  
11. Tilted specimen.

Figure 12  *Naviculopsis* cf. *minor* (Schulz).  
Tilted specimen;  
Sample 343-5-6, 110-111 cm;  
*Naviculopsis minor* Zone.

Figure 13  *Naviculopsis biapiculata* (Lemmermann).  
Distal side;  
Sample 338-21-1, 67-68 cm;  
*Naviculopsis biapiculata* Zone.

Figure 14  *Naviculopsis* cf. *biapiculata* (Lemmermann).  
Distal side;  
Sample 338-21-1, 67-68 cm;  
*Naviculopsis biapiculata* Zone.

Figure 15  *Naviculopsis lata* (Deflandre).  
Proximal side;  
Sample 338-17, CC;  
*Naviculopsis navicula* Zone.

Figure 16  *Naviculopsis navicula* (Ehrenberg).  
Distal side;  
Sample 338-15-1, 95-96 cm;  
*Naviculopsis navicula* Zone.

Figure 17  *Naviculopsis iberica* Deflandre.  
Proximal side;  
Sample 338-18, CC;  
*Naviculopsis lata* Zone.

Figure 18  *Naviculopsis quadratum* (Ehrenberg).  
Distal side;  
Sample 338-13-3, 5-6 cm;  
*Naviculopsis navicula* Zone.