14. MIOCENE CORBISEMA TRIACANTHA ZONE PHYTOPLANKTON FROM DEEP SEA DRILLING PROJECT SITES 415 AND 416, OFF NORTHWEST AFRICA

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SUMMARY

Cores 415-4 and 415-5 and Cores 416A-1 and 416A-2, from sites off the northwest coast of Africa (Figure 1), contain diverse Miocene coccoliths, diatoms, and silicoflagellates. All the cores contain silicoflagellate assemblages of the middle- and lower-Miocene Corbisema triacantha Zone (Figure 2). One sample from the bottom of Core 415-5 may belong to a new Naviculopsis ponticula Zone. Coccoliths of the lower- or middle-Miocene Helicosphaera ampliaperta Zone occur in Cores 415-5 and 416A-2; the next higher Sphenolithus heteromorphus Zone occurs in Cores 415-4 and 416A-1. Diatom zones are not identified from the assemblages (Figure 3), but the presence of short-rounded Annelius californicus and Raphidodiscus marylandicus suggests a diatom correlation near the boundary between lower and middle Miocene (Andrews, 1974; Ryan et al., 1974; Schrader and Fenner, 1976).

SILICOFLAGELLATES

Lower and middle Miocene silicoflagellates are common and well preserved at Sites 415 and 416. Like the associated diatoms they are restricted to Cores 4 and 5 in Hole 415 and Cores 1 and 2 in Hole 416A. Siliceous microfossils reported in Core 3 at Hole 416A are mainly sponge spicules — mostly tylostyles (Hyman, 1940, fig. 81-3; Bukry, 1978, pl. 13, figs. 10, 11, 13) broken into 20 to 30 µm lengths in Sample 416A-3-1, 116-117 cm (451 m).

The silicoflagellate assemblages of Sites 415 and 416 differ from those reported at nearby Sites 369 and 370. The absence of guide fossil Distephanus stauracanthus from the ocean-margin setting that was studied at Sites 415 and 416 supports the conclusion of Ernissee et al. (1977) that this species is restricted to the middle Miocene in the Atlantic basin.

Naviculopsis navicula and N. ponticula occur together in the bottom sample from Core 415-5 and suggest that the sample could be assigned to a new lower-Miocene Naviculopsis ponticula Zone on the basis of the presence of these two species and the absence of N. quadrate. This is tentative, because the relative ranges of Naviculopsis in the upper lower Miocene are not established.

Silicoflagellate taxonomy follows that in earlier DSDP volumes, especially volumes 41 and 44 (Bukry, 1978a, 1978b). See also Loeblich et al. (1968) for original references prior to 1968. The Miocene silicoflagellates from Sites 415 and 416 are shown on Plates 1, 2, and 3.

COCCOLITHS

Coccoliths are abundant and have slight to moderate overgrowth in the four cores. The middle-Miocene Sphenolithus heteromorphus Zone (Bramlette and Wilcoxon, 1967; Bukry, 1975) is represented by two samples: 415-4-5, 63-65 cm (214 m) and 416A-1-2, 7-8 cm (148 m). The presence of Cyclicargolithus floridanus, Cyclococcolithina macintyreii, Discoaster exilis, and Sphenolithus heteromorphus, together with the lack of Discoaster deflandrei and Helicosphaera ampliaperta, are the basis of the assignment. All of the other, deeper samples examined from Cores 415-5 and 416A-2 contain D. deflandrei, H. ampliaperta, and S. heteromorphus, indicating the lower- or middle-Miocene Helicosphaera ampliaperta Zone (Bramlette and Wilcoxon, 1967; Bukry, 1975; Ryan et al., 1974).
DIATOMS

Diatoms are abundant and diverse in the four cores. They are slightly to moderately dissolved in all cores except Core 415-5, in which the diatoms are well preserved. The co-occurrence and overlap of many distinctive species in the cores assures the correctness of correlation with the upper lower Miocene or lower middle Miocene. Diatom zonation of this interval is unsettled, because the relative ranges, and even the presence, of key guide fossils appear to be subject to ecologic conditions at the time of deposition (Abbott, 1978). This variability can be appreciated by comparing the occurrence patterns of such taxa as *Actinocyclus ingens*, *A. lanceolatus*, *Annellus californicus*, *Cestodiscus* spp., *Coscinodiscus lewisi*, *Craspedodiscus coscinodiscus*, *Denticula hustedti*, *D. nicobarica*, *Raphidodiscus marylandicus*, and *Coccolithus lewisi*, *D. lewisi*, and *D. nicobarica* occur in the middle-Miocene *Helicosphaera ampliaperta* Zone and the middle-Miocene *Sphenolithus heteromorphus* Zone. *C. coscinodiscus* and *R. marylandicus* occur only in the *H. ampliaperta* Zone and *D. hustedti* only in the *S. heteromorphus* Zone. All the diatom species occur within the *Corbisema triacantha* Zone or *Naviculopsis ponticula* Zone of silicoflagellates. The naviculoid variant of *Dictyocha brevispina ausonia* occurs at the same stratigraphic level in the upper lower Miocene on both sides of the Atlantic Ocean and is not a local aberration. Concurrent treatment of phytoplankton groups from the same samples will help distinguish cosmopolitan and ecologically controlled ranges for silicoflagellate and diatom guide fossils.

ACKNOWLEDGMENTS

I thank John Barron, U.S. Geological Survey, for discussions on Miocene diatom ranges and Yves Lancelot, University of Paris, for authorization to study additional core materials from Sites 415 and 416. The manuscript was improved by the reviews of Naja Mikkelsen, Scripps Institution of Oceanography, and John Barron, U.S. Geological Survey.
### MIOCENE PHYTOPLANKTON

<table>
<thead>
<tr>
<th>Species</th>
<th>Site 415 and 416 Samples (Interval in cm)</th>
<th>Mid</th>
<th>Early or Mid</th>
<th>Mid</th>
<th>Early or Mid</th>
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<td>Cannopilus schulzii</td>
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<td>2</td>
<td>1</td>
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<td>Corbisema triacantha triacantha</td>
<td>415-4-5: 63.65</td>
<td>48</td>
<td>14</td>
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<td>D. brevispina ausonia s. str.</td>
<td>415-4-5: 42.44</td>
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<td>13</td>
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<td>8</td>
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<td>D. fibula</td>
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<td>D. pulchella</td>
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<td>D. pulchella [deflandroid &amp; fibuloid]</td>
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<td>D. speculum binoculus</td>
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<td>1</td>
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<td>2</td>
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<td>M. sp. cf. M. elliptica [quadrato, smooth]</td>
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<td>1</td>
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<td>2</td>
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<td>N. navicula</td>
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<td>1</td>
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<tr>
<td>N. ponticula s. ampl.</td>
<td>416A-2: 1-37.29</td>
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<tr>
<td>N. sp. aff. N. quadrata</td>
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<tr>
<td>(Planifolia tribrachiata)</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Total specimens</td>
<td>416A-2: 1-37.29</td>
<td>100</td>
<td>100</td>
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Figure 2. Silicoflagellates, recorded in per cent, from Miocene sediments in Cores 415-4 and 415-5 and Cores 416A-1 and 416A-2. All samples are assigned to the Corbisema triacantha Zone, except 415-5-6, 18-20 cm, which may belong to the Naviculopsis ponticula Zone. * = specimens encountered after the count. X = presence of the endoskeletal dinoflagellate Planifolia tribrachiata (Ermissee, 1976).

### REFERENCES


### Table

<table>
<thead>
<tr>
<th>Species</th>
<th>Site 415 Depth (m)</th>
<th>Site 416 Depth (m)</th>
<th>Species</th>
<th>Site 415 Depth (m)</th>
<th>Site 416 Depth (m)</th>
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<tr>
<td>Actinocyclus ehrenbergii</td>
<td>415.4-4.5, 63-65</td>
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<td>Actinocyclus senarius</td>
<td>415-5, 5-6, 42-44</td>
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<td>A. lanceolatus</td>
<td>415.5-5, 5-6, 45-46</td>
<td>x</td>
<td>A. sp. cf. A. marylandicus</td>
<td>415.6-5, 18-20</td>
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<td>Annelius californicus</td>
<td>416A-1, 2-3, 7-39</td>
<td>x</td>
<td>Asterolampra marylandicus [6-, 7-segments]</td>
<td>416A-2, 2, 7-68</td>
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<td>Asteromphalus sp.</td>
<td>416A-2, 3, 32-34</td>
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<td>Auliscus sp. A</td>
<td>416A-2-4, 12-18</td>
<td>x</td>
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<tr>
<td>Biddulphia spp. s. ampl.</td>
<td>416A-4, 12-14</td>
<td>x</td>
<td>Cestodiscus kugleri</td>
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<tr>
<td>C. spp.</td>
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<td>Cocconeis spp.</td>
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<td>Coscinodiscus lewisi</td>
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<td>Craspedodiscus coscinodiscus</td>
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<td>Cussia paleacea</td>
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<td>Denticula hustedtii</td>
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<td>D. nicobarica</td>
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<td>Diploneis sp. A</td>
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<td>Eucamptia balaustium</td>
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<td>Eucamptia balaustium</td>
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<td>Paralia sulcata s. ampl.</td>
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<td>R2 sp. A</td>
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<td>Stephanogonia spp.</td>
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<td>Stephanopyxis spp.</td>
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<td>Synedra jouseana</td>
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<td>Xanthiopyxis cingulata</td>
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<td>X. oblonga</td>
<td>416A-4, 12-14</td>
<td>x</td>
<td>X. ovalis</td>
<td>416A-4, 12-14</td>
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**Figure 3.** Presence of selected diatom taxa in Miocene samples from Sites 415 and 416. X = present. Notable abundances of certain species are indicated (*).


PLATE 1
Miocene Silicoflagellates from Sites 415 and 416
Figures 1–5, 7–16 magnified 800×; scale bar equals 10 μm.
Figure 6 magnified 550×; scale bar equals 10 μm.

Figures 1, 2  *Cannopilus schulzii* Deflandre.
1. Sample 416A-2-2, 76–78 cm (300 m).

Figures 3, 4  *Corbisema triacantha triacantha* (Ehrenberg).
3. Sample 415-5-2, 58–60 cm (276 m).
4. Variant, Sample 415-5-6, 18–20 cm (281 m).

Figures 5, 6  *Dictyocha brevispina ausonia* (Deflandre).

7, 10. Sample 416A-2-2, 76–78 cm (300 m).
8, 9. Sample 416A-2-4, 17–18 cm (303 m).
12, 13. Sample 416A-2-1, 80–81 cm (299 m).

Figure 15  *Dictyocha* sp. cf. *D. brevispina ausonia* (Deflandre). Intermediate to *D. pulchella* group.
Sample 415-5-2, 58–60 cm (276 m).

Figure 16  *Dictyocha fibula* Ehrenberg.
Long bar suggests affinity with *D. brevispina ausonia* group.
Sample 415-5-2, 58–60 cm (276 m).
PLATE 2
Miocene Silicoflagellates from Sites 415 and 416
All figures magnified 800 x; scale bar equals 10 µm.

Figures 1, 2  Dictyocha fibula Ehrenberg.
Sample 415-5-2, 58-60 cm (276 m).

Figures 3–6  Dictyocha pulchella Bukry.
3. Sample 415-5-2, 58–60 cm (276 m).

Figure 7  Dictyocha sp. (large, asperoid).
Scarce spineless form.
Sample 416A-2-2, 76-78 cm (300 m).

Figures 8, 9  Distephanus crux (Ehrenberg) s. ampl.
8. Sample 416A-2-4, 17–18 cm (303 m).
9. Sample 415-5-6, 18–20 cm (281 m).

Figures 10, 11  Distephanus sp. cf. D. hannai (Bukry).
Sample 415-5-6, 18–20 cm (281 m).

Figure 12  Distephanus speculum speculum (Ehrenberg) s. ampl.
Sample 415-5-2, 58–60 cm (276 m).

Figure 13  Distephanus speculum triommata (Ehrenberg).
Sample 415-5-4, 42-44 cm (278 m).

Figures 14, 15  Mesocena apiculata curvata Bukry.
14. Sample 415-5-2, 58–60 cm (276 m).

Figure 16  Mesocena elliptica (Ehrenberg).
Sample 416A-2-3, 33–34 cm (301 m).
PLATE 3
Miocene Silicoflagellates and Diatoms from Sites 415 and 416
Figure 8 magnified, 1050 ×; scale bar equals 10 µm.
Figures 1-7, 9-12 magnified 800 ×; scale bar equals 10 µm.

Figures 1-3 *Naviculopsis ponticula* (Ehrenberg).
1. Normal, Sample 415-5-6, 18-20 cm (281 m).
2. Spined, Sample 416A-2-4, 17-18 cm (303 m).
3. Variant, Sample 415-5-6, 18-20 cm (281 m).

Figures 4, 5 *Naviculopsis navicula* (Ehrenberg).
4. Normal, Sample 415-5-6, 18-20 cm (281 m).
5. Variant, Sample 416A-2-1, 30-31 cm (298 m).

Figure 6 *Actinocyclus ehrenbergii* Ralfs.
Sample 416A-2-4, 17-18 cm (303 m).

Figure 7 *Actinocyclus lanceolatus* (Castracane).
Sample 415-5-2, 58-60 cm (276 m).

Figure 8 *Actinoptychus* sp. cf. *A. marylandicus* Andrews.
Sample 416A-2-4, 17-18 cm (303 m).

Figures 9, 10 *Anellus californicus* Tempere.
Sample 415-5-2, 58-60 cm (276 m).

Figure 11 *Asteromphalus* sp.
Sample 416A-2-3, 33-34 cm (301 cm).

Figure 12 *Auliscus* sp. A.
Sample 415-5-2, 58-60 cm (276 m).
PLATE 4
Miocene Diatoms from Sites 415 and 416
Figures 5-7, 13, 14 magnified 1050 ×; scale bar equals 10 µm.
Figures 1-4, 8-12, 15 magnified 800 ×; scale bar equals 10 µm.

Figures 1, 2  Biddulphia sp. s. ampl.
1. Sample 416A-2-1, 80-81 cm (299 m).

Figures 3, 4  Bruniopsis? sp. fragments. Sample 415-5-6, 18-20 cm (281 m).

Figures 5, 6  Cestodiscus kugleri Lohman.
5. Sample 415-5-2, 58-60 cm (276 m).
6. Sample 415-5-6, 18-20 cm (281 m).

Figures 7-11  Cestodiscus spp.
7. Mimic of Actinocyclus ingens, Sample 415-5-2, 58-60 cm (276 m).
8. Sample 416A-2-3, 33-34 cm (301 m).
9, 10. Low and high focus, Sample 415-5-2, 58-60 cm (276 m).
11. Sample 415-5-2, 58-60 cm (276 m).

Figures 12, 13  Cocconeis spp.
12. Sample 416A-2-3, 33-34 cm (301 m).
13. Sample 415A-4-5, 63-65 cm (214 m).

Figures 14-16  Coscinodiscus lewisianus Greville.
14, 16. Sample 415-5-2, 58-60 cm (276 m).
15. Sample 415-5-4, 42-44 cm (278 m).
PLATE 5
Miocene Diatoms from Sites 415 and 416
Figures 4, 5, 8-10, 15, 16, 18 magnified 1050 ×; scale bar equals 10 µm.
Figures 3, 6, 7, 11, 13, 14, 17 magnified 800 ×; scale bar equals 10 µm.
Figures 1, 2, 12 magnified 350 ×; scale bar equals 20 µm.

Figures 1, 2  *Craspedodiscus coscinodiscus* Ehrenberg.
Sample 415-5-2, 58-60 cm (276 m).

Figure 3  *Cussia paleacea* (Grunow).
Sample 415-5-2, 58-60 cm (276 m).

Figures 4, 5  *Denticula nicobarica* Grunow.
Sample 415-5-2, 58-60 cm (276 m).

Figure 6  *Diploneis* sp. A
Sample 416A-2-4, 17-18 cm (303 m).

Figures 7, 8  *Eucampia balaustium* Castracane.
7. Sample 415-5-6, 18-20 cm (281 m).
8. Sample 415-5-2, 58-60 cm (276 m).

Figure 9  *Hyalodiscus* sp.
Sample 416A-2-4, 17-18 cm (303 m).

Figure 10  *Liradiscus* sp. cf. *L. bipolaris* Lohman.
Sample 415-5-2, 58-60 cm (276 m).

Figure 11  *Pseudopyxilla* sp. cf. *P. directa* (Pantocsek).
Sample 415-4-5, 63-65 cm (214 m).

Figure 12  *Pseudopyxilla* sp. cf. *P. dubia* (Grunow).
Sample 416A-2-4, 17-18 cm (303 m).

Figure 13  *Pseudopyxilla* sp.
Sample 415-5-6, 18-20 cm (281 m).

Figures 14-18  *Raphidodiscus marylandicus* Christian.
14. Sample 415-5-2, 58-60 cm (276 m).
15. Isolated central area, Sample 415-5-6, 18-20 cm (281 cm).
16. Frustule, Sample 415-5-2, 58-60 cm (276 m).
17, 18. Sample 415-5-2, 58-60 cm (276 m).

Figure 19  *Rhaphoneis amphiceros* (Ehrenberg).
Sample 416A-2-4, 17-18 cm (303 m).
PLATE 6
Miocene Diatoms and *Planifolia* from Sites 415 and 416.
Figures 3, 7-10, 12, 14, 15 magnified 1050 ×; scale bar equals 10 µm.
Figures 1, 2, 4-6, 11, 13 magnified 800 ×; scale bar equals 10 µm.

Figures 1, 2  *Rhaphoneis diamantiella* Andrews.
Sample 415-5-6, 18-20 cm (281 m).

Figures 3-5  *Rhaphoneis fossile* (Grunow).
3, 4. Sample 416A-2-4, 17-18 cm (303 m).
5. Sample 416A-2-2, 76-78 cm (300 m).

Figure 6  *Rhaphoneis gemmifera* Ehrenberg.
Sample 415-5-4, 42-44 cm (278 m).

Figures 7, 8  *Rhaphoneis sachalinensis* Sheshukova-Poretskaya.
7. Sample 416A-2-2, 76-78 cm (300 m).
8. Sample 415-5-2, 58-60 cm (276 m).

Figures 9, 10  *Rhaphoneis?* sp. A.
Sample 415-5-2, 58-60 cm (276 m).

Figure 11  *Stephanogonia* sp.
Sample 415-5-6, 18-20 cm (281 m).

Figure 12  *Xanthiopyxis cingulata* Ehrenberg.
Sample 415-5-6, 18-20 cm (281 m).

Figure 13  *Xanthiopyxis oblonga* Ehrenberg.
Sample 416A-1-2, 37-39 cm (148 m).

Figures 14, 15  *Planifolia tribrachiata* Ernisse.
15. Sample 415-5-2, 58-60 cm (276 m).